Draft
Feasibility Study Supplement
Red Devil Mine, Alaska

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Executive Summary

[Executive summary to be provided following agency review of this draft.]

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List of Abbreviations and Acronyms

µg/L	micrograms per liter
AAC	Alaska Administrative Code
AC	Access Control
ADEC	Alaska Department of Environmental Conservation
AOC	Area of Contamination
ARAR	applicable or relevant and appropriate requirement
AST	aboveground storage tank
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BLM	U.S. Department of the Interior Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
E & E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
GRA	general response action
HHRA	Human Health Risk Assessment
IC	Institutional Control
km	kilometers
LOE	line(s) of evidence
MCL	maximum contaminant level
MNA	Monitored Natural Attenuation

List of Abbreviations and Acronyms (Cont.)

MNR	Monitored Natural Recovery
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
ng/g	nanograms per gram
NTCRA	non-time-critical removal action
O&M	operation and maintenance
PRB	permeable reactive barrier
RAO	remedial action objective
RBCL	risk-based cleanup level
RCRA	Resource Conservation and Recovery Act
RDM	Red Devil Mine site
RG	remedial goal
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
WOE	weight-of-evidence

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1 Introduction

This Feasibility Study (FS) Supplement report addresses groundwater and Kuskokwim River sediment at the Red Devil Mine site (RDM). The RDM consists of an abandoned mercury mine and ore processing facility located near the village of Red Devil in southwest Alaska (see Figure 1-1). Historical mining activities at the RDM included underground and surface mining. Ore processing at the site included crushing, retorting/furnacing, milling, and flotation. Historical mining operations left tailings and other remnants that have affected local soil, surface water, sediment, and groundwater. The RDM encompasses the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of a response action, including public lands managed by the U.S. Department of the Interior Bureau of Land Management (BLM). The BLM initiated a Remedial Investigation (RI)/FS at the RDM in 2009 pursuant to its delegated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) lead agency authority.

The RI was performed by Ecology and Environment, Inc. (E & E) on behalf of the BLM under Delivery Order Number L09PD02160 and General Services Administration Contract Number GS-10F-0160J. Data collected during the RI were used to define the physical setting, nature and extent of contamination, and fate and transport of contaminants at the RDM (E & E 2014). The RI results were used to assess risk to human health and the environment due to exposure to site contaminants. Results of the final baseline Human Health Risk Assessment (HHRA) and baseline Ecological Risk Assessment (BERA) for the RDM are included in the final RI report (E & E 2014). Results of the RI are presented in the Final Remedial Investigation Report, Red Devil Mine, Alaska, referred to herein as the 2014 RI report (E & E 2014).

An FS was performed based on results documented in the 2014 RI report. Results of the FS are presented in the Final Feasibility Study, Red Devil Mine, Alaska, referred to herein as the 2016 FS report (E & E 2016a). The 2016 FS addressed contaminated tailings/waste rock, soil, and Red Devil Creek sediments (E & E 2016a).

Neither the 2014 RI nor the 2016 FS fully evaluated possible site impacts to the adjacent Kuskokwim River. The FS did not address remedies for groundwater or Kuskokwim River sediments because the need for, and extent of, cleanup of these media had not yet been completely assessed. The BLM is presently finalizing an RI Supplement to address data gaps associated with subsurface soil and bedrock, groundwater, and Kuskokwim River sediments that were identified as part of the development of site-wide remedial alternatives during the preparation of the 2016 FS. The RI Supplement is being performed by E & E on behalf of the BLM under BLM National Environmental Services Blanket Purchase Agreement Number L14PA00149, Delivery Order Numbers L14PB00938 and L17PB00236. Detailed background information on the RDM and information on the regulatory framework for the RI/FS Supplement are provided in the 2014 RI report.

The RI Supplement is being conducted per applicable CERCLA statutes, regulations, and guidance following the Final Work Plan for 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (E & E 2015). As part of the RI Supplement, an HHRA Supplement is being performed to address data gaps associated with Kuskokwim River sediments that were not addressed as part of the 2014 RI effort, specifically to assess the risks and hazards from potential exposure to contaminants of potential concern through direct contact and incidental ingestion of sediment, and consumption of fish from the Middle Kuskokwim River region. In addition, a BERA supplement is being performed to assess potential risks to aquatic-dependent receptors that use the Kuskokwim River near and downstream from the RDM. The HHRA and BERA Supplements are being performed in accordance with the final Proposed Technical Approach for Kuskokwim River Risk Assessment Supplement, Red Devil Mine, Alaska (BLM 2017). Results of the RI Supplement, including the HHRA, and BERA Supplements, are presented in the draft final Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska report (E & E 2017a). RI Supplement results that are pertinent to this FS Supplement are summarized below.

The BLM is presently performing additional characterization of groundwater and tailings/waste rock at the RDM. This hydrogeologic characterization is designed to generate additional information that may help facilitate a more detailed hydrologic analysis of the proposed repository and to support the development of a groundwater monitoring network for the repository proposed under 2016 FS Alternatives 3a and 3c. This characterization is designed to generate additional information to assist the design efforts associated with outlining the extent of excavation for tailings/waste rock and impacted soil from the Main Processing Area. E & E is performing the additional characterization on behalf of the BLM under National Environmental Services Blanket Purchase Agreement Number L14PA00149 and Delivery Order Number L17PB00325. The additional 2017 characterization activities are being conducted in accordance with the Final Work Plan for 2017 Groundwater Monitoring Well Installation and Tailings/Waste Rock Characterization, Red Devil Mine, Alaska (E & E 2017b). Selected results of the 2017 characterization are used to support the development of this FS Supplement. Those results are presented in sections below.

Like the RI Supplement, this FS Supplement focuses on groundwater and sediment in the Kuskokwim River. This document references:

- Site characterization information presented in the 2014 RI report (E & E 2014);
- The draft final RI Supplement report (E & E 2017a);
- Results of the 2016 FS of tailings/waste rock, soil and sediment in Red Devil Creek (E & E 2016a); and
- Pertinent preliminary results of the additional 2017 groundwater and tailings/waste rock characterization (E & E 2017b).

The remedial action alternatives in this FS Supplement report complement those evaluated in the 2016 FS. A preferred site-wide remedial action alternative will incorporate alternatives from both the 2016 FS and this FS Supplement.

All of the primary CERCLA documents developed for the RDM can be accessed online via the Administrative Record quick link presented on the Red Devil Mine Project page (https://www.blm.gov/programs/public-safety-and-fire/abandoned-mine-lands/regional-information/alaska/projects/red-devil-mine).

1.1 Purpose and Organization of Report

The purpose of the FS Supplement report is to present remedial action objectives (RAOs) and develop and evaluate remedial alternatives to address groundwater and Kuskokwim River sediment contamination as documented in the 2014 RI and RI Supplement reports. This FS Supplement report includes a comparative analysis of the remedial alternatives being considered for the site remedy. In accordance with U.S. Environmental Protection Agency (EPA) guidance, the comparative analysis is based on nine criteria to support an informed risk management decision regarding the most appropriate remedy (EPA 1988). The preferred remedial alternative will be identified in a Proposed Plan (separate document) that will be made available for public review and comment.

This FS Supplement report consists of the following sections:

- **Section 1: Introduction** – Provides a summary of background information, including a description of the area investigated, summary of historical activities, overview of the nature and extent of contamination and contaminant fate and transport, and summaries of the baseline HHRA and BERA and a weight-of-evidence (WOE) discussion for potential risks associated with Kuskokwim River fish and sediments.
- **Section 2: Identification and Screening of Technologies** – Presents the RAOs, remedial goals, general response actions (GRAs), and identification and screening of technology types and process options based on effectiveness, implementability, and cost.

- **Section 3: Development of Alternatives** – Develops and describes the remedial action alternatives and describes the major actions to be undertaken for each alternative.
- **Section 4: Analysis and Evaluation of Alternatives** – Presents a detailed analysis of each alternative and a comparative analysis of the alternatives based on nine evaluation criteria.
- **Section 5: References** – Lists the reports and other documents used in the preparation of this FS Supplement report.
- **Appendix A: Supplemental Soil and Groundwater Information** – Provides summaries of preliminary data generated as part of the 2017 additional groundwater and tailings/waste rock characterization and RI Supplement used to support the FS Supplement.
- **Appendix B: Cost Information** – Provides tables presenting FS Supplement cost information.

1.2 Background Information

This section briefly summarizes background information for the RDM presented in the final RI report (E & E 2014) and the draft final RI Supplement report (E & E 2017a).

1.2.1 Site Description

The RDM is approximately 250 air miles west and 1,500 marine/river barge miles from Anchorage, Alaska. The mine site was established on the southwest bank of the Kuskokwim River approximately 2 miles from the village of Red Devil and approximately 8 miles from the village of Sleetmute. The RDM is generally located on the Kuskokwim River in Township 19 North, Range 44 West, within the southwest quarter of section 5, southeast quarter of section 6, northeast quarter section 7 and northwest quarter of section 8, Sleetmute D-4, Seward Meridian. The site encompasses the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary to perform the response action.

Historical mining operations left tailings and other remnants that have affected local soil, surface water, sediment, and groundwater. Key areas of the RDM are described below and illustrated in Figure 1-2:

- The Main Processing Area.
- The area west of the Main Processing Area where historical surface exploration and mining occurred, referred to as the Surface Mined Area. The Surface Mined Area is underlain by a network of underground mine workings. The “Dolly Sluice” and “Rice Sluice” and their respective deltas on the bank of the Kuskokwim River are associated with the Surface Mined Area.

- Red Devil Creek, extending from a reservoir upstream of the Main Processing Area to the Red Devil Creek delta at the creek's confluence with the Kuskokwim River.
- The Red Devil Creek delta, which consists of mixed tailings/waste rock, Red Devil Creek alluvium, and soil located at the confluence of Red Devil Creek and the Kuskokwim River.
- Sediments in the Kuskokwim River. The riverbed sediments are located within submerged lands of the Kuskokwim River owned by the State of Alaska and managed by the Alaska Department of Natural Resources.

The Main Processing Area contains most of the former mine structures and is the location where ore beneficiation and mineral processing were conducted. The area is split by Red Devil Creek. Underground mine openings (shafts and adits) and ore processing and mine support facilities (e.g., housing and warehousing) were located on the west side of Red Devil Creek until 1955. After 1955, all ore processing was conducted at structures and facilities on the east side of Red Devil Creek. The Main Processing Area includes three monofills. The monofills contain demolished mine structure debris and other material. Two monofills are unlined (Monofills #1 and #3). Monofill #2, on the east side of Red Devil Creek, is an engineered and lined containment structure for building debris and materials from the demolished Post-1955 Retort structure.

The east side of Red Devil Creek is also the former location of petroleum above-ground storage tanks (ASTs), which were used to store fuel for mine operations. The AST area was the subject of a separate investigation and remediation project (Marsh Creek 2010).

1.2.2 Historical Activities

The 2014 RI report provides an in-depth discussion of historical mining operations, ore processing, mining and ore processing wastes, and petroleum-related wastes. That information is not repeated in this FS Supplement report.

1.2.3 Nature and Extent and Fate and Transport of Contamination

As presented in the RI report, background concentrations of inorganic analytes were used to determine chemical concentrations that define the lateral and vertical extents of contamination. Inorganic element concentrations that exceed the recommended background values presented in 2014 RI report Section 4.1 are considered "contamination." In several instances, the concentrations of a given inorganic element in background samples were below detection limits; in such cases, samples with detected concentrations of those analytes also were treated as contamination in this report. For organic analytes, all positive detections are considered to represent site-related contamination.

As noted above, the 2016 FS addressed contaminated tailings/waste rock, soil, and Red Devil Creek sediments. The soil materials addressed in the 2016 FS include materials located in the upper portion of the Red Devil Creek delta, the surface of which is subaerially exposed when the Kuskokwim River is at low and moderate stages but submerged during flood stages (E & E 2016a). Red Devil Creek surface water was not addressed in the 2016 FS because RI sample results indicate that ambient water just above the mouth of Red Devil Creek does not contain contaminant concentrations above State of Alaska surface water quality criteria. The 2016 FS did not address remedies for groundwater or Kuskokwim River sediments because the need for, and extent of, cleanup of these media had not yet been completely assessed.

Contaminated media addressed in this FS Supplement report are:

- Groundwater.
- Materials in the Red Devil Creek delta below an elevation of 164 feet. The Red Devil Creek delta extends from the Red Devil Creek alluvial area into the Kuskokwim River. Depending on the stage of the Kuskokwim River, portions of the delta may be subaerially exposed or submerged by the river. For the purpose of the 2016 FS, an elevation of 164 feet was assumed to represent a low river stage elevation at the delta. Contaminated soil addressed under Alternatives 3 and 4 in the 2016 FS include the Red Devil Creek delta materials situated above an elevation of 164 feet. Materials in the portion of the Red Devil Creek delta below an elevation of 164 feet, referred to in this Supplemental FS as the lower delta, are addressed in this FS Supplement.
- Kuskokwim River sediment located downriver of the Red Devil Creek delta.

The need for remediation and exposure controls for these media is evaluated further in Chapter 2 of this FS Supplement report. The nature and extent of contamination in both media is summarized below based on data presented in the 2014 RI and RI Supplement reports and augmented by preliminary results of the 2017 groundwater monitoring well installation and tailings/waste rock characterization (E & E 2017b).

1.2.3.1 Soil and Bedrock

Seventeen inorganic elements were detected above background values in subsurface soil samples collected during the RI. In addition, semivolatile organic compounds, diesel range organics, and residual range organics were detected in sub-surface soil samples. Inorganic elements were detected above background values in all geographic areas of the site. Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values. The highest concentrations of these inorganic elements were in the tailings and tailings/waste rock soil types in the Pre-1955 and Post-1955 portions of the Main Processing Area. These inorganic elements were also detected at concentrations well above background levels in subsurface soil in parts of the Surface Mined Area. At many of those locations, the elevated concentrations were concluded to be likely attributable to naturally mineralized Kuskokwim group–derived soils (E & E 2014).

In accordance with the RI Work Plan, samples used for background value estimation were collected from locations outside of and upgradient of the areas recognized as potentially impacted by mining, ore processing, waste disposal operations, and potential deposition of emissions from thermal ore processing (E & E 2011). RI soil data and geological information indicated that the areas where background soil samples were collected exhibit little natural mineralization compared to areas where mining activity occurred. The extent of such natural mineralization has not been fully delineated but includes portions of the Main Processing Area and Surface Mined Area that are subject to remediation.

Naturally mineralized soils pre-date mining activities and thus represent pre-mining “background” conditions. Historical mining and ore processing activities, including disposition of the tailings and waste rock, occurred within the Main Processing Area and Surface Mined Area, where naturally mineralized rock and soil are expected to be locally present in the shallow subsurface. Impacts of mine activities throughout most of the Main Processing Area and Surface Mined Area make it difficult to positively identify naturally mineralized conditions. Therefore, it was not possible during the RI to determine the extent and concentration ranges of inorganic elements of naturally mineralized soil (E & E 2014). Consequently, the background levels used to identify contamination in the RI, particularly those for subsurface soil and groundwater, likely locally underestimate pre-mining background concentrations of inorganic elements at parts of the RDM that are subject to remediation.

The objectives of the RI Supplement included additional characterization of naturally mineralized bedrock and soils and the impacts of naturally mineralized bedrock and underground mine workings on groundwater flow paths and inorganic element concentrations. Results of the soil and bedrock RI Supplement investigation are presented in Chapter 2 of the draft final RI Supplement report (E & E 2017a). Results of the RI Supplement that are pertinent to the delineation of the nature and extent and fate and transport of contamination addressed in this FS Supplement report are summarized below

Naturally mineralized bedrock was observed in most of the RI Supplement boreholes installed in the Surface Mined Area and within one borehole installed in the Main Processing Area. The impacts of naturally mineralized bedrock and underground mine workings on groundwater flow paths and inorganic element concentrations at the RDM are presented in Chapter 3 of the draft final RI Supplement report (E & E 2017a) and summarized in Section 1.2.3.2, below.

Results of the RI (E & E 2014) were used to estimate the depths and volume of tailings/waste rock and contaminated soil proposed for excavation under Alternatives 3 and 4 in the 2016 FS report. It is anticipated that data collected as part of the RI Supplement soil investigation (E & E 2017a) will be used to refine the estimated depths and volume.

As noted above, the BLM also is performing additional characterization of tailings/waste rock and soil in the Main Processing Area (see E & E 2017b). The 2017 tailings/waste rock characterization activities in the Main Processing Area are intended to address data gaps regarding the lateral and vertical extents of tailings/waste rock in this area that are expected to have toxicity characteristic leaching procedure (TCLP) concentrations greater than the Resource Conservation and Recovery Act (RCRA) limit for arsenic. The 2017 tailings/waste rock activities also may be useful for further refining the estimates of depths and volume of tailings/waste rock and contaminated soil proposed for excavation under Alternatives 3 and 4 in the 2016 FS report. Preliminary results of the RI Supplement and 2017 tailings/waste rock characterization used to support this FS Supplement are presented in Appendix A. Locations of soil borings installed in the Main Processing Area in 2017 are illustrated in Figure A-1. Preliminary data gathered during installation of the 2017 Main Processing Area soil borings are presented in Appendix A, Table A-1. Preliminary results of laboratory analysis of total arsenic and TCLP arsenic in soil samples collected as part of the 2017 tailings/waste rock characterization are summarized in Table A-2.

Preliminary estimates of depths of excavation under 2016 FS Alternatives 3 and 4 based on RI Supplement and the 2017 tailings/waste rock characterization activities are presented in Appendix A, Table A-3. Table A-3 also summarizes pertinent groundwater depth and elevation data collected through 2017. Based on these results, it is preliminarily anticipated that excavation performed under 2016 FS Alternatives 3 and 4 would extend to the top of bedrock throughout most of the Main Processing Area and much of the Red Devil Creek downstream alluvial area (see Table A-3). Borehole locations where excavation is preliminarily expected to extend to the top of bedrock are illustrated in Appendix A, Figure A-2.

1.2.3.2 Groundwater

Seventeen inorganic elements (including both total and dissolved analyses) and methylmercury were detected above background values in the groundwater samples collected during the RI. In addition, semivolatile organic compounds, diesel range organics, and residual range organics were detected in groundwater samples, as well. Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above their background values. Concentrations of total and dissolved antimony and arsenic were found to be highest in the Post-1955 Main Processing Area, particularly where groundwater comes into contact with tailings/waste rock (E & E 2014).

The RI Supplement groundwater characterization activities were designed to address data gaps associated with groundwater in the Main Processing Area, the Red Devil Creek downstream alluvial area, and the Surface Mined Area. As part of the RI Supplement, new monitoring wells were installed in the Surface Mined Area to provide additional information on groundwater conditions in the Surface Mined Area in the vicinity (laterally and vertically) of the underground mine workings (E & E 2017a).

RI Supplement groundwater elevation results demonstrate that the mine workings dominate groundwater depth and gradient within the parts of the Surface Mined Area where the mine workings lie below the water table within the host bedrock but above the nearby base level, which is the level of Red Devil Creek. The mine workings provide a highly transmissive hydraulic connection that serves to depress the water table in those areas and establish a hydraulic gradient toward the mine workings. The results indicate that the mine workings provide a preferential flow pathway of groundwater in areas drained by the mine workings from the Surface Mined Area to the Red Devil Creek valley, where it emerges into Red Devil Creek and enters the Kuskokwim River as surface water rather than as groundwater (E & E 2017a).

RI Supplement results also support the conclusion that naturally mineralized bedrock such as that associated with the mine workings is a source of some of the arsenic, antimony, and mercury groundwater impacts at the RDM. RI Supplement groundwater sample results from the newly installed wells contained concentrations of total antimony and arsenic ranging up to 250 micrograms per liter (µg/L) and 610 µg/L, respectively. Dissolved mercury concentrations in those samples ranged as high as 48.2 nanograms per liter. These concentrations are significantly higher than observed previously in the groundwater samples collected elsewhere in the Surface Mined Area from wells not installed in close proximity to the underground mine workings. These results demonstrate that the groundwater that flows into the underground mine workings network is impacted by the natural mineralization associated with the Red Devil Mine ore zones targeted by the mining. Red Devil Creek exhibits predominantly gaining conditions within the Main Processing Area. Therefore, the groundwater impacted by naturally mineralized bedrock in the Surface Mined Area is expected to emerge within the Red Devil Creek valley (E & E 2017a).

Preliminary results of the 2017 groundwater monitoring well installation and tailings/waste rock characterization (E & E 2017b), as well as the 2016 and 2017 baseline groundwater monitoring performed in accordance with the final Work Plan, Groundwater and Surface Water Baseline Monitoring, Red Devil, Alaska (E & E 2016b), provide further support for the RI Supplement conclusions described above. Pertinent preliminary results of the 2017 groundwater characterization activities and baseline groundwater monitoring activities are presented in Appendix A. Locations of monitoring wells installed in 2017 are illustrated in Appendix A, Figure A-3. Preliminary data gathered during installation of the 2017 boreholes and monitoring wells are presented in Appendix A, Table A-4. Depth to groundwater measurements and calculated groundwater elevations for monitoring wells installed during the 2017 effort, as well as those installed previously, are presented in Appendix A, Table A-5. Based on static water elevations and stream elevations along Red Devil Creek, a preliminary groundwater potentiometric surface map for fall 2017 has been generated, presented as Figure A-4 in Appendix A. As noted for wells installed as part of the RI Supplement, groundwater in the vicinity of some of the wells installed in 2017 (see E & E 2017b) is hydraulically upgradient of the Main Processing Area and Red Devil Creek valley (see Figure A-4).

Groundwater samples were collected in September 2017 from the wells installed as part of the 2017 groundwater characterization. Groundwater collected from those wells is representative of conditions within bedrock at those areas of the Surface Mined Area. As observed in several wells installed as part of the RI Supplement, groundwater from some of the 2017 wells is representative of conditions in locally mineralized bedrock. Groundwater sample results from the new 2017 wells contained concentrations of total antimony and arsenic ranging up to 8.9 µg/L and 490 µg/L, respectively. Dissolved mercury concentrations in those samples ranged as high as 39 nanograms per liter. Preliminary laboratory results of analysis for antimony, arsenic, and mercury in these samples, along with samples collected previously from other monitoring wells, are presented in Appendix A, Table A-6.

Presently, the Main Processing Area and Red Devil Creek valley contain mixed tailings/waste rock and alluvial and other soils. Under present conditions, the groundwater that originates in the Surface Mined Area and emerges in the Main Processing Area and Red Devil Creek valley is expected to mix with the shallow groundwater impacted by tailings/waste rock and contaminated soils (see final RI report Section 5.4). As stated in Section 1.2.3.1, it is anticipated that excavation performed under 2016 FS Alternatives 3 and 4 would extend to the top of bedrock throughout most of the Main Processing Area and much of the Red Devil Creek downstream alluvial area. The shallow contaminated groundwater would be removed along with the tailings/waste rock and soil to be excavated under 2016 FS Alternatives 3 and 4. Groundwater flowing into and through the Main Processing Area and Red Devil Creek valley following such excavation is expected to consist of the groundwater flowing from the bedrock in the Surface Mined Area, as well as that from the southwest side of Red Devil Creek and the Red Devil Creek valley upstream of the mine.

Based on the conclusions summarized above, it is expected that the quality of groundwater that would emerge from bedrock in the Main Processing Area and Red Devil Creek valley can be evaluated based on the groundwater quality observed at hydraulically upgradient locations. The quality of such groundwater can be approximated based on groundwater sample results for selected wells installed during the RI, RI Supplement (E & E 2017a), and 2017 groundwater characterization (E & E 2017b) that are hydraulically upgradient of the Main Processing Area and Red Devil Creek valley. A list of such wells is provided in Appendix A, Table A-7. Results of groundwater samples collected from these wells can be used to estimate concentrations of contaminants of concern (COCs) that are generally representative of upgradient COC levels, referred to in this FS Supplement report as refined background levels. Results of the refined background level evaluation are summarized in Appendix A, Table A-8.

1.2.3.3 Red Devil Creek Delta

As noted above, the Red Devil Creek delta extends into the Kuskokwim River from the Red Devil Creek alluvial area. For the purpose of the 2016 FS, an elevation of 164 feet was assumed to represent a low river stage elevation at the delta. Contaminated soil addressed under Alternatives 3 and 4 in the 2016 FS includes the Red Devil Creek delta materials situated above an elevation of 164 feet. Materials within the portion of the Red Devil Creek delta situated below an elevation of 164 feet, referred to in this FS Supplemental report as the lower delta, are addressed in this FS Supplement report.

Based on nearshore sediment samples and soil samples collected from soil borings installed on the face of the delta, the delta consists of mixed tailings/waste rock, Red Devil Creek alluvium, and soil, and contains elevated concentrations of COCs. The extent of these materials is approximated based on a combination of sediment sample data, bathymetry, and data from soil borings installed on the face of the delta, and is illustrated in Figures 1-3 and 1-4.

Soil and sediment present at the Red Devil Creek delta may be subject to future erosion and downriver transport by the Kuskokwim River. Sediment samples collected from the delta are included in the body of data used to evaluate Kuskokwim River sediment, discussed in Section 1.2.3.4.

1.2.3.4 Kuskokwim River Sediment

Seventeen inorganic elements and methylmercury were detected above background values in the Kuskokwim River sediment samples collected during the RI. Antimony, arsenic, and mercury were the most highly elevated contaminants above background values in the Kuskokwim River sediment samples. Concentrations generally decreased downriver from the mouth of Red Devil Creek, but the extent of inorganic element contamination in river sediments was not defined by RI sampling in either the downriver or cross-river direction (E & E 2014).

The RI Supplement sediment characterization activities were designed to address data gaps associated with sediment in the Kuskokwim River near and downriver of Red Devil Creek. The RI Supplement sediment characterization was designed to assess the following:

- Cross-river and downriver extents of contamination in Kuskokwim River sediment.
- Turbidity of Kuskokwim River water.
- Toxicity of sediments to benthic macroinvertebrates.

- Potential for methylation and bioaccumulation of mercury.

Results of the RI Supplement sediment characterization are summarized below.

Beginning in 2010, the BLM began a study to comprehensively examine mercury, methylmercury, and other metals in the Kuskokwim River basin in proximity to the RDM. Studies that are pertinent to the evaluation of Kuskokwim River sediment near the RDM include fish movement and tissue sampling studies, periphyton sampling, and benthic macroinvertebrate sampling. Pertinent results of the BLM investigations are presented in Section 5.2 of the draft final RI Supplement report (E & E 2017a) and summarized below.

Updated Kuskokwim River Sediment Background Levels
The RI report presented background values for Kuskokwim River sediment (E & E 2014). The background values were updated in the draft final RI Supplement report to include results of additional background sediment samples collected as part of the RI Supplement. The revised background sediment values are presented in Section 5.3.1 of the draft final RI Supplement report (E & E 2017a) and include the updated background value of 13.4 milligrams per kilogram (mg/kg) for total arsenic.

Cross-River and Downriver Extent of Sediment Contamination
Concentrations of total antimony, arsenic, and mercury decrease with distance away from the riverbank near the RDM, and with distance downriver from the Red Devil Creek delta. Concentrations generally decrease to values near background levels for total antimony, arsenic, and mercury in the most downriver samples collected in the RI Supplement. The general trends toward decreasing concentrations downriver from the Red Devil Creek delta changes to a less regular pattern farther downriver. The change in pattern includes increases in concentrations approximately 1 kilometer (km) downriver from the Red Devil Creek delta and an even more pronounced increase in concentrations approximately 4.4 km downriver from the Red Devil Creek delta. Deviations from the general trend of decreasing concentrations with distance downriver are likely attributable to other non-RDM mineral occurrences. Other non-RDM mineral occurrences are discussed below.

Mineral Occurrences near Red Devil Mine
The RDM lies within a mineralized region (e.g., Miller et al. 1989). This regional mineralization influences the concentrations of antimony, arsenic, mercury, and other metals in the environment, including sediment in the Kuskokwim River and some of its tributaries. Section 5.4.2 of the draft final RI Supplement report (E & E 2017a) presents information on mineral occurrences in the area near the RDM based on Miller et al. (1989), including the type of occurrence (i.e., lode or placer), degree of development (e.g., occurrence of mineralization, prospect, mine), and minerals present, including cinnabar (mercury sulfide), stibnite (antimony sulfide), and realgar and orpiment (arsenic sulfides), which are the primary

sources of mercury, antimony, and arsenic at the RDM. Draft final RI Supplement report Figure 5-18 illustrates the locations of the mineral occurrences described by Miller et al. (1989). Most of the subject mineral occurrences drain into a reach of the Kuskokwim River that lies within the extent of sediment samples collected during the RI Supplement Kuskokwim River sediment sampling event. Six of the mineral occurrences lie within the watershed of McCally Creek, which empties into the Kuskokwim River approximately 1 km downriver from the Red Devil Creek delta. Another mineral occurrence, the Alice and Bessie claim group (formerly known as the Parks prospect), is located near the northeast bank of the Kuskokwim River approximately 4.2 km downriver from the Red Devil Creek delta. The RI Supplement sediment samples collected at the nearest locations downriver from McCally Creek and the Alice and Bessie claim group exhibit relative increases in total antimony, arsenic, and mercury concentrations. It is likely that these increases in COC concentrations are attributable, at least in part, to inputs from these other mineral occurrences.

Methylmercury in Sediment

Methylmercury was detected in RI samples from 2010 to 2012 at concentrations ranging from 0.15 to 3.73 nanograms per gram (ng/g). The methylmercury concentration in 14 of 26 of the 2010 to 2012 samples exceeded the recommended RI background level of 0.49 ng/g. In general, concentrations of methylmercury in the RI and RI Supplement Kuskokwim River sediment samples are low compared with the national average for rivers (1.6 ng/g) (Scudder 2009). Concentrations in all 14 RI Supplement samples were found to be below the national average, and for the 26 RI samples, concentrations in only four samples were above the national average. These results are consistent with the observation that the environmental conditions of the Kuskokwim River near the RDM generally are not conducive to mercury methylation.

Sediment Toxicity

A 28-day growth and survival test with *Hyalella azteca* (freshwater amphipod) was conducted with sediment from 10 locations in the Kuskokwim River downstream from the Red Devil Creek delta and from two upstream reference samples. The following results are noteworthy:

- Seven of 10 samples collected downstream from the Red Devil Creek delta showed no effects on survival or biomass compared with the upstream reference samples or laboratory control sample. The remaining three samples showed a moderate reduction in amphipod survival and biomass compared with reference samples, which was attributed to differences in sediment texture and/or total organic carbon content and/or non-COC metals.
- No effect on growth was observed in nine of 10 samples collected downstream from the Red Devil Creek delta.

- There was no correlation between *Hyalella* survival and sediment concentrations of antimony, arsenic, mercury, or methylmercury.

Kuskokwim River Periphyton
In 2014, the BLM collected periphyton samples from the nearshore environment of the Kuskokwim River at 13 locations downstream from the Red Devil Creek delta and 13 locations upstream form the Red Devil Creek delta. The samples were analyzed for metals, methylmercury, inorganic arsenic, and percent solids. The following results are noteworthy:

- Antimony, arsenic, and mercury were elevated in periphyton samples collected downstream from the Red Devil Creek delta compared with upstream samples. The greatest difference was for mercury, which was about 20 times greater on average in periphyton samples collected downstream from the Red Devil Creek delta compared with upstream samples. Inorganic arsenic was not elevated in samples collected downstream from the Red Devil Creek delta.
- Methylmercury was not detected in the periphyton samples. Hence, despite the fact the total mercury levels were elevated in periphyton samples collected downstream from the Red Devil Creek delta, there is no indication that this pattern of total mercury contamination resulted in greater methylmercury levels at the base of the benthic food web.

Kuskokwim River Fish
Between 2011 and 2014, the BLM Alaska State Office, in cooperation with the U.S. Fish and Wildlife Service and Alaska Department of Fish and Game, measured mercury concentrations in small muscle biopsies from northern pike and burbot equipped with radio transmitters, and related the concentrations to fish location and movements in the middle Kuskokwim River region. The study design and methods are described in Matz et al. (2017). Matz et al. (2017) divided the mainstream Kuskokwim River and major tributaries within the study area into eight watersheds or reaches for their investigation. The following results are noteworthy:

- Total mercury levels in pike and burbot from the Kuskokwim River reach that includes the RDM were among the lowest measured in the study.
- Only about 10% of burbot and 40% of pike captured in the Kuskokwim River reach that includes the RDM remained in that river reach. Low fidelity of burbot and pike to this reach has the effect of reducing their exposure to mercury and other contaminants from the RDM.
- Low fidelity of pike to the Kuskokwim River reach near the RDM likely is due to the physical and biological characteristics of the reach. The reach is characterized by strong current, high turbidity, linear shorelines, and low density of shoreline wetlands, which make this reach unattractive to pike.

- The greatest total mercury levels in pike were found in the Takotna, Holitna, and George River watersheds. All three watersheds have extensive areas of oxbows with abundant wetland habitat, ideal habitat for pike and other fish, and important sites for mercury methylation.

Matz et al. (2017) found no relationship between pike total mercury levels and the number of mercury-containing mines or mercury-containing occurrences and prospects in a given watershed.

1.2.4 Baseline Risk Assessment

1.2.4.1 Human Health Risk Assessment

An HHRA was conducted for the RDM as part of the RI in accordance with Alaska State and EPA human health risk assessment guidance (E & E 2014). The following potential receptors were evaluated in the HHRA: future residents, current and future recreational or subsistence users, and future mine workers. As applicable, child receptors were also evaluated. The HHRA was conducted with contaminant data from surface and subsurface soil, nearshore sediment, groundwater, surface water, and biota data.

The potential cancer risks at the site exceed both Alaska Department of Environmental Conservation (ADEC) and EPA criteria for all receptors assessed. In general, exposure to arsenic in soil and groundwater posed the greatest risk. Likewise, the potential hazards at the site exceed both ADEC and EPA criteria for all receptors evaluated in the HHRA. In general, exposure to antimony, arsenic, and mercury in soil, groundwater, and fish from Red Devil Creek posed the greatest hazard. Risks and hazards were the highest for future residents potentially exposed to COCs.

Potential risk-based cleanup levels (RBCLs) were proposed for the COCs and determined in the HHRA. RBCLs were developed for arsenic, antimony, and mercury in a number of media, including soil, groundwater, and biota. RBCLs were also developed for the other COCs at the RDM for the media of concern (see Sections 6.4.1 and 6.4.2 of the 2014 RI report; E & E 2014). RBCLs were not developed for Kuskokwim River sediment in the RI.

As part of the RI Supplement, an HHRA Supplement was performed to address data gaps associated with Kuskokwim River sediments that were not addressed as part of the initial RI effort, specifically to assess the risks and hazards from potential exposure to contaminants of potential concern through direct contact and incidental ingestion of sediment, and consumption of fish from the Middle Kuskokwim River region. Additional results from sediment sampling and fish tissue sampling were used to develop the HHRA Supplement (E & E 2017a).

Results of the HHRA Supplement are detailed in Chapter 6 of the RI Supplement report and conclusions are summarized below.

The HHRA Supplement for the Kuskokwim River assessment area indicated that direct exposure (incidental ingestion and dermal exposure) to Kuskokwim River sediment near the RDM results in non-cancer hazards below EPA and ADEC standards. Cancer risks from exposure to Kuskokwim River sediment for all receptors are within the acceptable EPA excess cancer risk range of 1 in 10,000 to 1 in 1,000,000. For residents and recreational/subsistence users, the excess cancer risk is slightly above the ADEC standard of 1 in 100,000. Arsenic is the only substance associated with carcinogenic risk at the site. Localized background sediment levels contribute approximately 4% to the overall site cancer risk from direct exposure to sediment and approximately 10% to the overall noncarcinogenic hazard from this pathway.

Potential exposure to methylmercury and arsenic in muscle samples from fish collected from the middle Kuskokwim River region, consisting of the approximately 410 km stretch of the Kuskokwim River from Aniak to just upriver of McGrath, including the reach that contains the RDM, resulted in cancer risk levels above both ADEC and EPA cancer risk and noncancer hazard standards. The cancer risks are primarily driven by consumption of arsenic in northern pike and whitefish. The noncancer hazards are primarily driven by consumption of methylmercury in northern pike, and arsenic and methylmercury in whitefish.

Assessment of potential cancer risks and noncancer hazards from exposure to fish on a regional basis are not specifically tied to the RDM. Northern pike are mobile and migratory. In the BLM study, northern pike tended to stay in tributaries of the mainstem Kuskokwim and had greater mercury concentrations when they were in more mineralized watersheds, although northern pike that stayed in the mainstem Kuskokwim had overall lower mercury concentrations in spite of being in proximity to mercury sources (Matz et al. 2017). The turbid and swift conditions of the Kuskokwim River provide limited habitat for pike or conditions conducive to mercury methylation (wetlands). There were no spatial differences identified in mercury concentrations in sheefish (inconnu), which are anadromous in the area (Matz et al. 2017).

1.2.4.2 Ecological Risk Assessment

A BERA was conducted for the RDM as part of the RI in accordance with ADEC and EPA ecological risk assessment guidance (E & E 2014). An assortment of ecologically relevant assessment endpoints were evaluated, including terrestrial plants, soil invertebrates, benthic macroinvertebrates, fish and other aquatic biota, terrestrial wildlife, and aquatic-dependent wildlife. The BERA was conducted using contaminant data from two primary sources: (1) surface soil, sediment, surface water, and vegetation data collected for the RI; and (2) fish (slimy sculpin) and benthic macroinvertebrate contaminant data collected from Red Devil Creek by the BLM as part of a larger study examining contaminants in aquatic biota in the Middle Kuskokwim River. Results of the BERA are presented in Chapter 6 of the final RI report (E & E 2014).

As part of the RI Supplement, a BERA Supplement was performed to address data gaps associated with Kuskokwim River sediments that were not addressed as part of the initial RI effort. The BERA Supplement is focused on aquatic-dependent receptors that may use the Kuskokwim River near the RDM, including benthos, fish, and wildlife. Since the final RI report was completed, E & E and the BLM have both collected substantial additional data from the Kuskokwim River near the RDM and from the middle Kuskokwim River region in general. These data were used to help understand potential risks to aquatic-dependent receptors that use the Kuskokwim River near and downstream from the RDM (E & E 2017a).

Overall, the BERA Supplement for the Kuskokwim River assessment area identified only marginal risks to the assessment endpoints evaluated when conservative approaches were used to model bioaccumulation. For benthos, there was no relationship between sediment levels of antimony, arsenic, and/or mercury and survival, growth, or biomass in toxicity tests conducted with Kuskokwim River sediment collected near the RDM (see RI Supplement report Section 7.5.2 and Table 7-20). For aquatic-dependent wildlife, the BERA supplement identified only marginal risks to some of the model species evaluated (see RI Supplement report Table 7-20), and those risks resulted from background exposures (see RI Supplement report Section 7.5.4) or were found to be biased high when more realistic estimates of exposure were considered (see draft final RI Supplement report Section 7.6). (E & E 2017a)

1.2.5 Weight-of-Evidence Discussion for Potential Risks Associated with Kuskokwim River Fish and Sediments

The draft final RI Supplement report (E & E 2017a) presented a detailed discussion of the findings of a number of factors that are critical to understanding site-specific and regional risk at the RDM and the Kuskokwim River. That discussion is summarized below.

1.2.5.1 Kuskokwim River Fish

A WOE evaluation was developed to consider multiple lines of evidence (LOE) relevant to understanding human exposure to methylmercury and arsenic in fish. The WOE evaluation combines the results of the risk assessment with additional LOE presented in the RI and RI Supplement reports. A principal objective of the WOE evaluation is to consider all relevant data in addressing the primary questions and provide critical information to risk managers. Each individual LOE is considered independently in regards to Kuskokwim River risk, and the LOE are considered collectively as part of the overall WOE evaluation. In addition to the results of the risk assessment supplements, the other LOE fall into four groups: (1) site characteristics; (2) contaminant bioavailability; (3) fish movement and local fishing patterns; and (4) effects of recent and planned remediation on potential exposure and risk. The interrelationships between these LOE are shown graphically in Figure 8-1 of the draft final RI Supplement report (E & E 2017a) and summarized below.

The LOE related to RDM and Kuskokwim River characteristics are:

- Kuskokwim River Characteristics near the RDM;
- Regional and Local Background Issues; and
- Kuskokwim River Sediment Data.

The LOE related to contaminant bioavailability are:

- Sediment Toxicity Tests;
- Periphyton Data;
- Bioaccumulation Factors; and
- Mercury Selective Sequential Extraction Results.

The LOE related to fish movement and local fishing practices are:

- Telemetry Data;
- Fish Tissue Data; and
- Local Fishing Patterns.

The LOE related to recent and planned remediation actions to reduce site risks are:

- Previous source control efforts; and
- Planned future remedial actions.

Each LOE is discussed in detail in the draft final RI Supplement report (E & E 2017a).

Based on the WOE evaluation, the overall evidence supports the conclusion that, although the RDM has contributed mercury and arsenic to the Kuskokwim River, the mercury and arsenic levels measured in pike, burbot, and whitefish reflect primarily regional exposure, and there is no demonstrable RDM-specific increase in fish consumption risk. The mercury and arsenic levels measured in fish from the middle reach of the Kuskokwim and its tributaries are consistent with state-wide levels reported by the ADEC (2017a, 2017b), suggesting that regional levels of mercury and arsenic in the Kuskokwim are not appreciably different than those across the state.

Based on full consideration of the multiple LOE included in this evaluation, several specific risk questions were addressed in the draft final RI Supplement report (E & E 2017a), as follows:

- Question 1: Are releases of mercury from the RDM a primary contributor to elevated levels of methylmercury in upper trophic level, subsistence fish in the middle reach of the Kuskokwim River?
    - Answer: Although the RDM has been shown to be a source of total mercury to the river, the cumulative evidence does not indicate that the RDM is contributing significantly to methylmercury levels in subsistence fish from the middle Kuskokwim River region.
- Question 2: To what extent are the potential risks associated with exposure to metals, specifically methylmercury and arsenic, in fish from the middle reach of the Kuskokwim River attributable to the RDM versus other sources?
    - Answer: Methylmercury and arsenic levels in fish that live primarily in upgradient tributaries, or that range widely in the Kuskokwim River, are comparable to those collected from the river near the RDM. Furthermore, the fish of interest do not spend much time near the RDM due to poor habitat; hence, their tissue levels reflect bioaccumulation from the locations where they live and eat (i.e., the large tributaries for pike and the entire middle and lower Kuskokwim River for burbot). These results suggest that the RDM, while a historical source of contaminant input to the river, is not contributing significantly to risks associated with exposure to methylmercury and arsenic in subsistence fish.

1.2.5.2 Kuskokwim River Sediment

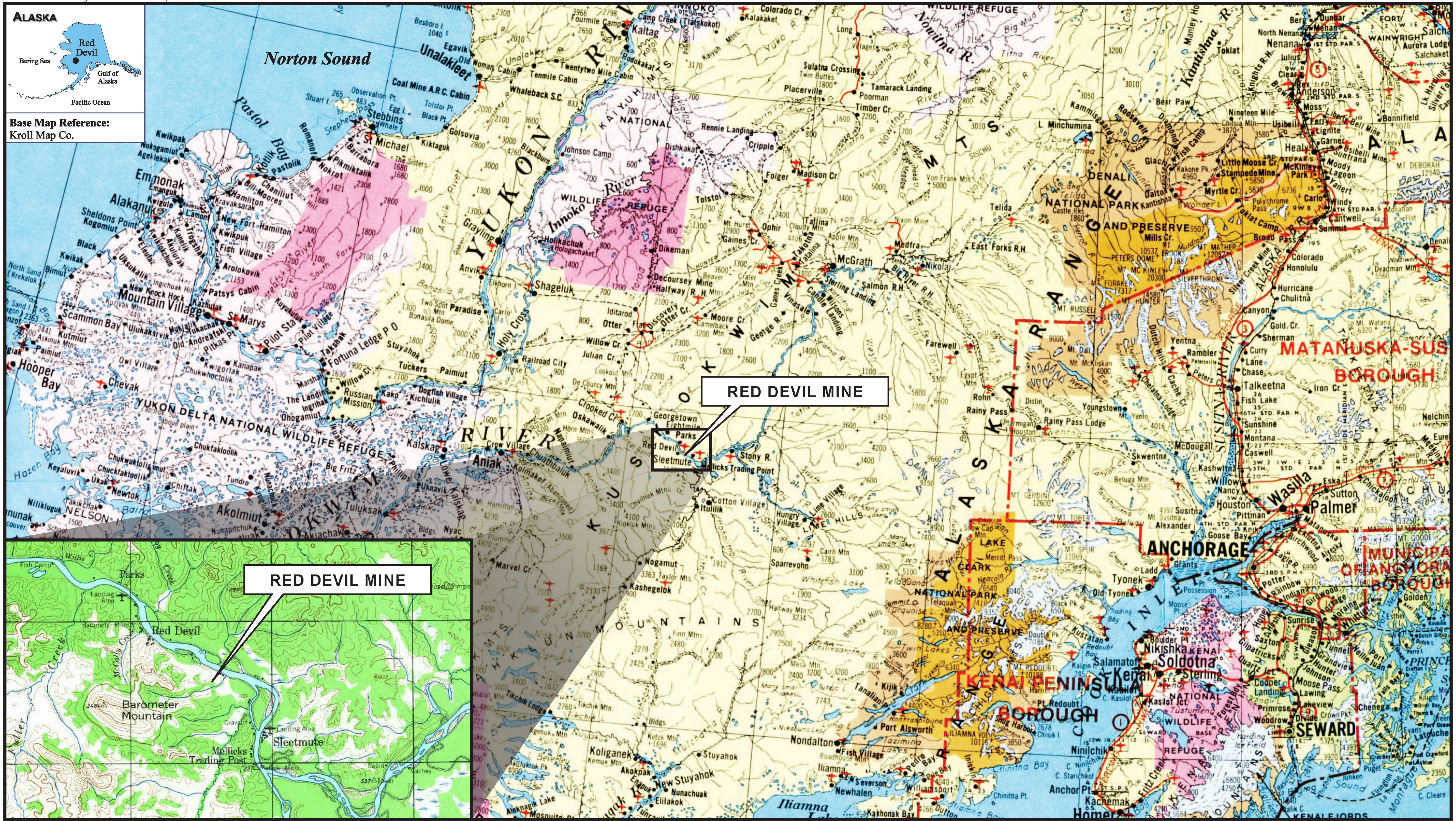
This section summarizes the LOE associated with direct human exposure to sediments in the Kuskokwim River. Non-cancer hazards from exposure to inorganic compounds in Kuskokwim River sediment near the RDM, including the downriver portion, are at levels considered acceptable by the EPA and ADEC. Cancer risks from exposure to inorganic contaminants in Kuskokwim River sediment for all receptors are within the acceptable EPA cancer risk range. For residents and recreational/subsistence users, the cancer risk is slightly above the ADEC acceptable cancer risk level. Arsenic is the only carcinogenic contaminant in sediment at the site.

Alternatives 3 and 4 of the 2016 FS include excavation and removal of the tailings in the Main Processing Area and downstream Red Devil Creek alluvial area. This action is expected to include much of the material in the Red Devil Creek delta, further reducing exposure of human and ecological receptors to site-related contaminants (including arsenic and mercury) in the Kuskokwim River near the RDM. Many of the high concentration sediment samples for arsenic and mercury were collected in the delta directly offshore from the RDM. Remediation and removal of the mine waste at the Red Devil Creek delta is expected to reduce the risk estimates since it will lower the concentrations of arsenic and mercury to which a person may be exposed directly. Given the modest exceedance of the

ADEC's cancer risk level, the BLM anticipates that future remedial efforts will remove sufficient waste material to reduce risks to below ADEC standards.

An additional LOE relates to site activity levels assumed to occur at the delta in the HHRA Supplement (E & E 2017a). As discussed above, the Kuskokwim River near the RDM does not provide attractive habitat for burbot or northern pike. This stretch of the river is not productive for fishing, and the RDM area lacks road access and boat docks.

Overall, several LOE suggest that potential risks from sediment exposure are unlikely to be a genuine concern near the RDM currently or in the future. First, the amount of assumed sediment exposure likely was overestimated in the HHRA Supplement. Second, future risks after site remediation are expected to be even lower due to the planned removal of much of the tailings material from Red Devil Creek delta.



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International Specialists in the Environment
Seattle, Washington

0 40 80
Approximate Scale in Miles

RED DEVIL MINE
Red Devil, Alaska

Figure 1-1
SITE LOCATION MAP

Date: 04/18/13	JSS	02:EE-001096-0070-08

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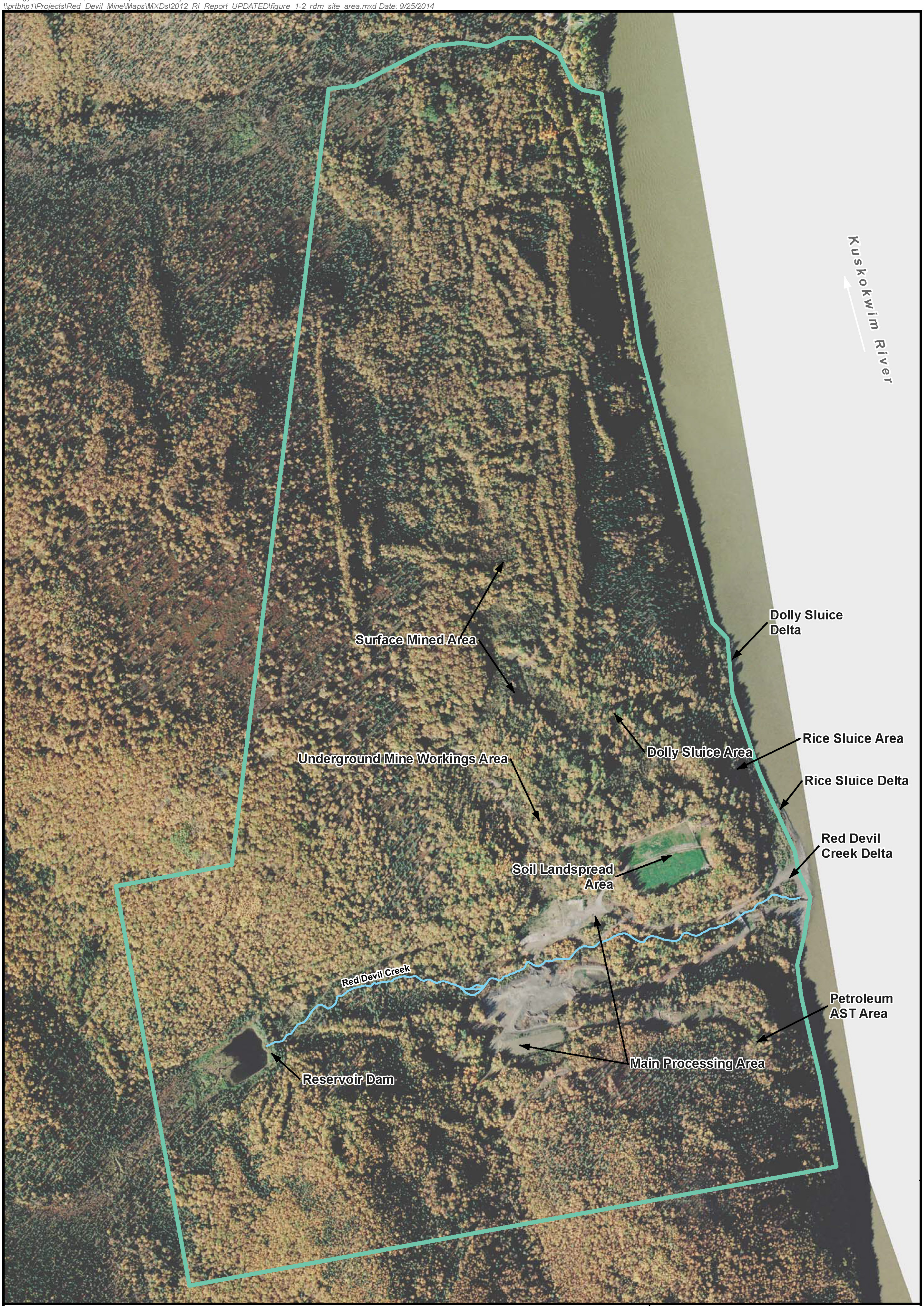

Upland Area Encompassed by Remedial Investigation

RED DEVIL MINE

Red Devil, Alaska

Figure 1-2
Upland Area Encompassed by Remedial Investigation

0 75 150 300 450 600 750
Feet
0 37.5 75 150 225
Meters
Scale 1:4,562

Image Source: Aero-Metric, Inc. 2010a

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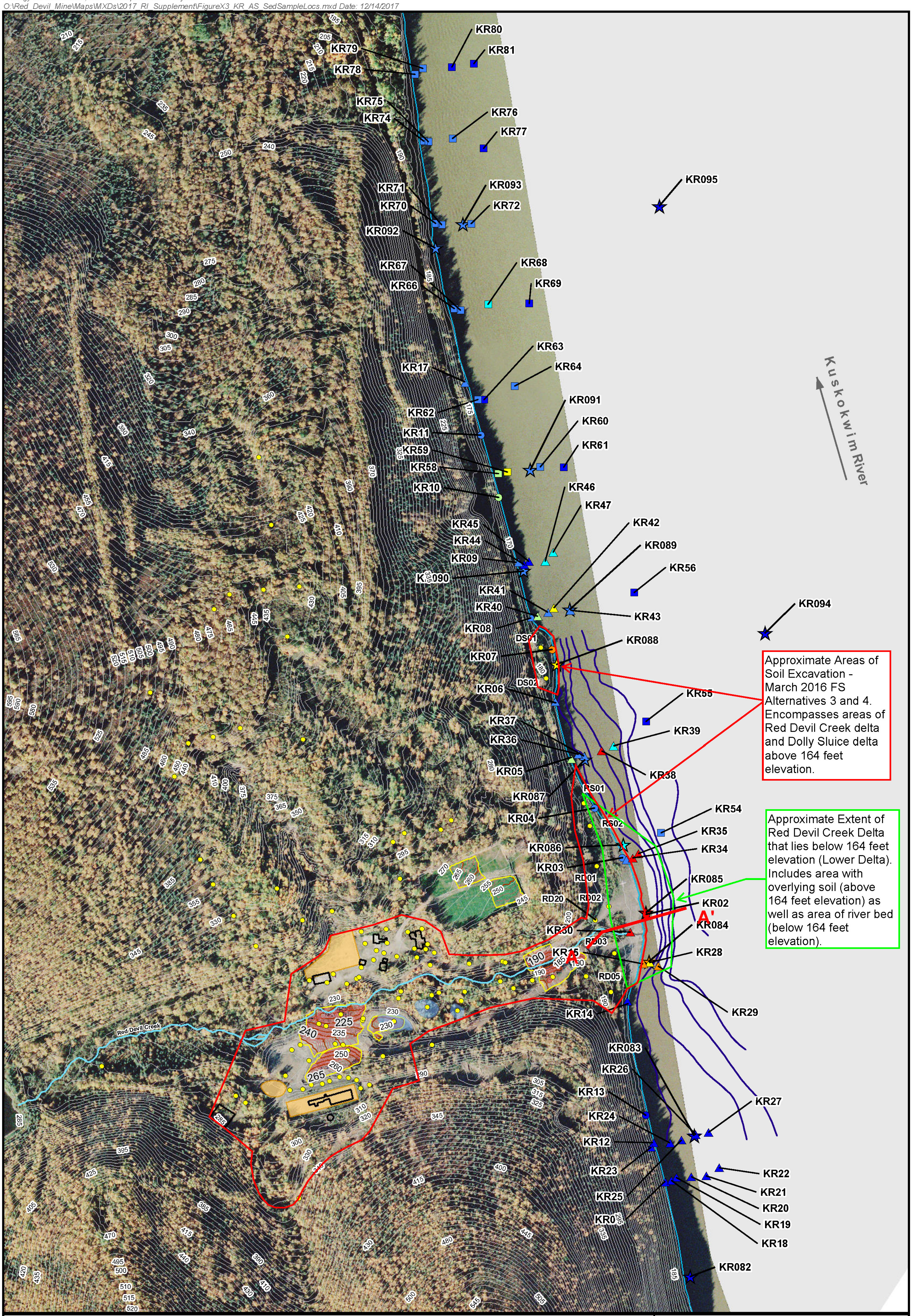

2010 Total Arsenic (mg/kg)	2011 Total Arsenic (mg/kg)	2012 Total Arsenic (mg/kg)	2015 Total Arsenic (mg/kg)
> 800	> 800	> 800	> 800
400 to 800	400 to 800	400 to 800	400 to 800
200 to 400	200 to 400	200 to 400	200 to 400
100 to 200	100 to 200	100 to 200	100 to 200
69 to 100	69 to 100	69 to 100	69 to 100
13.4 to 69	13.4 to 69	13.4 to 69	13.4 to 69
≤ 13.4 background	≤ 13.4 background	≤ 13.4 background	≤ 13.4 background

Soil Boring
Bathymetric contour (feet)
2010 5-foot Contour
River level (elevation 165.78 feet) on 9/21/2010
Area of 2014 NTCRA Red Devil Creek Sediment Trap
2014 5-foot Contour
2014 1-foot Contour
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE
Red Devil, Alaska

Figure 1-3

Red Devil Creek Delta Area

0 75 150 300 450 600
Feet
0 15 30 60 90 120 150
Meters
Scale 1:2,500

1. Aerial image collected on 9/21/2010 (Aerometric 2012)
2. Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on 9/21/2010 (AeroMetric 2012)
3. Kuskokwim River elevation on date aerial orthophotographic survey (9/21/2010) was 165.78 feet (Aerometric 2012)
4. Bathymetric contours represent approximate depths below river surface on 9/25/2011
5. Digital 2014 5-foot and 1-foot topographic contours based on Marsh Creek (2014)

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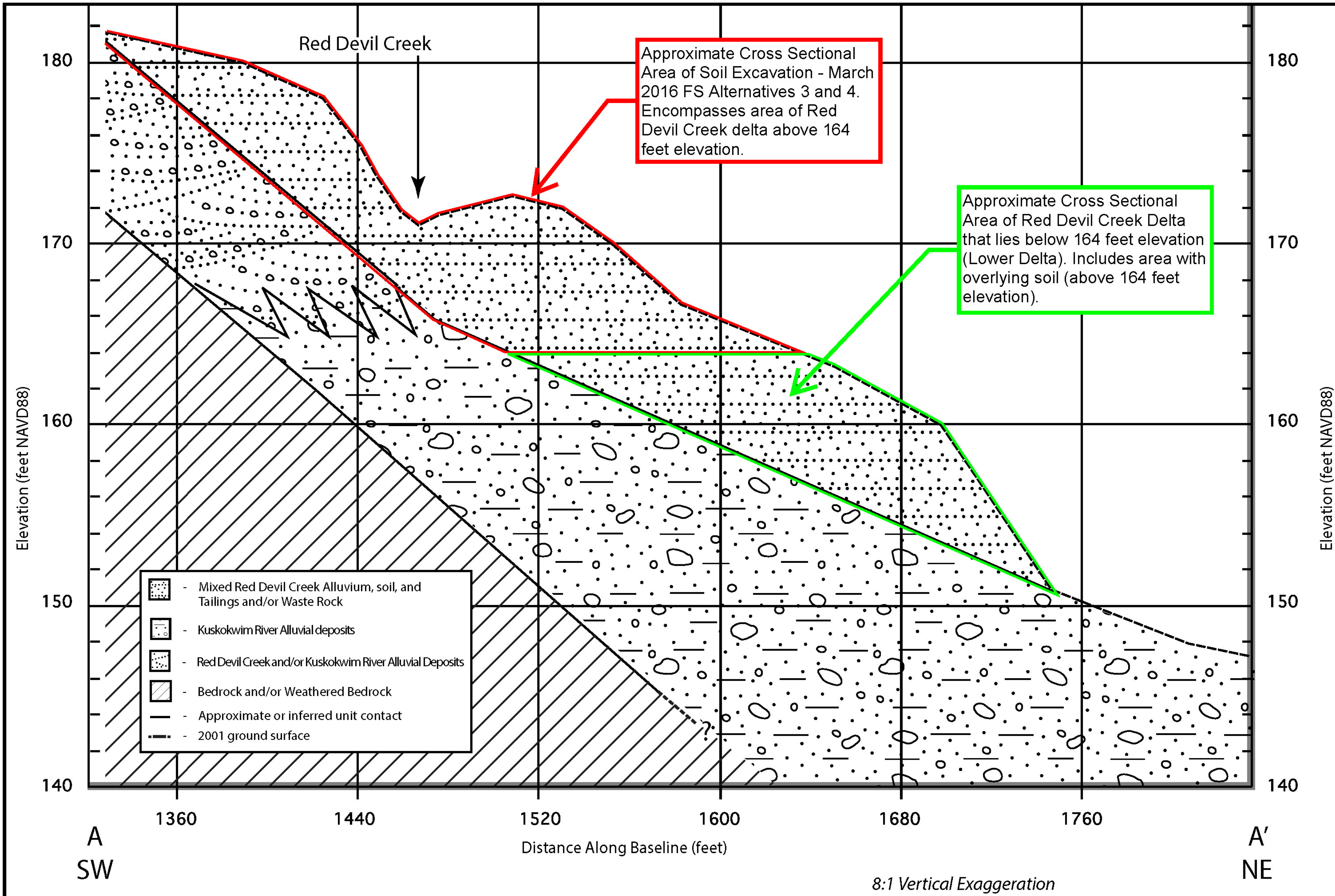

Note: 1. Geologic cross section is modified from final RI report Figure 4-17.
2. Surface topography is based on 5/27/2001 aerial orthophotograph and topographic map (AeroMetric 2010b).

RED DEVIL MINE

Red Devil, Alaska

Figure 1-4
Geologic Cross Section A-A'
Red Devil Creek Delta

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2 Identification and Screening of Remedial Technologies

This chapter presents the RAOs and remedial goals (RGs), applicable or relevant and appropriate requirements (ARARs), general response actions (GRAs), and identification and screening of remedial technology types and specific process options to address contaminated media that may pose unacceptable risks to human health and the environment. "General response actions" refers to broad categories of remedial actions, "technology types" refers to categories of remedial technologies, and "process options" refers to processes within each technology type (EPA 1988). Remedial technology types and specific process options retained at the conclusion of screening are carried forward and incorporated into Chapter 3 for the development of remedial alternatives.

2.1 Overview

In the 2016 FS report, RAOs, RGs, and site-wide remedial alternatives were identified for tailings/waste rock, contaminated soil, and contaminated Red Devil Creek sediment (E & E 2016a). On-site groundwater and Kuskokwim River sediment were not addressed in the 2016 FS report because the BLM, at that time, decided that additional site characterization was necessary to evaluate the need for, and best approaches to remedies for, these media. Since the 2016 FS report was finalized, the BLM has completed additional site characterization to further enhance the development and evaluation of remedies for groundwater and Kuskokwim River sediments.

The risk assessment portion of the RI Supplement focused on human health risks posed by exposure to Kuskokwim River sediments and consumption of fish from the Kuskokwim River, and ecological risks posed by exposure of Kuskokwim River sediments to aquatic-dependent wildlife, benthic organisms, and fish.

The RI baseline risk assessment indicated that on-site groundwater poses potential risks to future human receptors at the RDM (E & E 2014). RAOs, RGs, and remedial alternatives for groundwater are included in this FS Supplement report.

The RI Supplement report details multiple LOE supporting the conclusion that there is no clear linkage between releases from the RDM and elevated risks associated with consumption of subsistence fish harvested from the Kuskokwim

River. The HHRA Supplement concluded that direct exposure to nearshore (areas accessible for wading and fishing) Kuskokwim River sediment near the RDM results in non-cancer hazards below EPA and ADEC standards for all receptors. Cancer risks from exposure to the river sediment for all human receptors are within the acceptable EPA excessive risk range; however, for future residents and recreational/subsistence receptors, arsenic concentrations represent excess cancer risk slightly above the ADEC standard of 1×10^{-5} (1 in 100,000). The BERA Supplement concluded that marginal risks to ecological assessment endpoints are posed by Kuskokwim River sediments (E & E 2017a).

The Red Devil Creek delta includes the portion of the delta below an elevation of 164 feet (lower delta). The approximate extent of the Red Devil Creek delta is based on a combination of soil boring, sediment, and bathymetric data collected during the RI, and is depicted in Figures 1-3 and 1-4. The materials within the lower delta may be subject to erosion and migration to downriver locations, potentially including nearshore sediment locations to which human receptors could be exposed.

2.2 Contaminants of Concern

Based on the results of the baseline risk assessment, the COCs identified for groundwater include antimony, arsenic, and inorganic mercury due to human health risks (E & E 2014).

Based on the HHRA Supplement, arsenic is identified as a COC in nearshore Kuskokwim River sediments due to a slight exceedance of ADEC's standard of 1×10^{-5} (1 in 100,000) excess lifetime cancer risk for residential and recreational/subsistence users. All non-carcinogen hazards are at or below 1.0, both EPA and ADEC standards (E & E 2017a).

For ecological receptors, no COCs are identified because the BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints (E & E 2017a).

2.3 Remedial Action Objectives and Goals

The overall goal of the remedial action at the RDM is to protect human health and the environment from elevated risks associated with COCs in on-site contaminated media, including groundwater and nearshore Kuskokwim River sediments. RAOs are medium-specific statements for protecting human health and the environment that address specific chemicals, exposure route(s) and receptors. RGs are numeric values that define a chemical concentration that correlates to an acceptable level of risk, generally referred to as cleanup levels.

2.3.1 Groundwater Remedial Action Objectives

To develop site-specific RAOs for groundwater, results of the baseline HHRA were used to identify the receptors requiring protection (see Table 2-1). Accordingly, the RAO for groundwater is:

- Prevent or reduce human future resident exposure (through ingestion, inhalation, or dermal contact) to antimony, arsenic, and mercury in groundwater at concentrations above RGs.

2.3.2 Kuskokwim River Remedial Action Objectives

To develop site-specific RAOs for the Kuskokwim River, results of the risk assessment supplement were used to identify the receptors requiring protection (see Table 2-1). Accordingly, the RAOs for nearshore Kuskokwim River sediment and materials within the lower delta are:

- Reduce human future resident and recreation/subsistence user exposure (through dermal contact and incidental ingestion) to arsenic in materials within the lower delta and nearshore Kuskokwim River sediments at concentrations above RGs.
- Reduce potential migration of materials within the lower delta to downriver locations where human exposure to nearshore sediments at concentrations above RGs could occur.

The BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints (E & E 2017a). Therefore, Kuskokwim River sediment RAOs based on protection of ecological receptors were not developed.

Table 2-1 Summary of Media and Receptors of Concern

Exposure Medium	Receptor(s)	Exposure Route(s)	Cancer Risk(1)	Hazard Index(1)
Groundwater	Human – Future Resident	Ingestion Inhalation Dermal Contact	2×10^{-1}	3205
Kuskokwim River Nearshore Sediments and Materials within the Lower Delta	Human – Future Resident and Recreation/Subsistence User	Dermal Contact Incidental Ingestion	4×10^{-5}	1.0

Notes:
(1) Cancer Risks and Hazard Indices listed for groundwater exposure are based on a future child resident scenario for the Main Processing Area.

2.3.3 Remedial Goals

Proposed RGs for groundwater, materials within the lower delta, and nearshore Kuskokwim River sediments were developed based on the RAOs listed above. The proposed RGs are identified and discussed below:

- Site-specific, risk-based cleanup levels, also known as RBCLs, in accordance with 18 Alaska Administrative Code (AAC) 75.340;
- Chemical-specific ARARs for groundwater in accordance with18 AAC 75.345, Table C; and
- Site-specific background values.

2.3.3.1 Site-Specific Risk-Based Cleanup Levels

Groundwater RBCLs were presented in Section 6.4 of the RI report (E & E 2014) and are carried forward into this FS Supplement. RBCLs were not developed for Kuskokwim River sediment in the RI. As summarized in Section 1.2.4.1, based on the results of the HHRA Supplement for Kuskokwim River sediments, all non-carcinogen hazards are at or below both EPA and ADEC standards. Therefore, an RBCL for non-cancer endpoints was not developed for any chemical. The cancer risk for a residential and recreational/subsistence user was within the EPA's risk range but above the ADEC's cancer risk standard. Arsenic is the only carcinogen in Kuskokwim River sediment. Based on the exposure scenarios for the resident and recreational/subsistence user—a risk-based concentration in Kuskokwim River sediment equivalent to a cancer risk of 1 in 100,000, ADEC's cancer risk standard—an RBCL for arsenic in sediment has been developed. The Kuskokwim River sediment RBCL for this scenario for arsenic is 69.1 mg/kg.

As summarized in Section 1.2.4.2, the BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints. Therefore, no RBCLs for Kuskokwim River sediment for ecological receptors were developed.

2.3.3.2 Site-Specific Background Levels

As discussed in Section 1.2.3.2, based on results presented in the draft final RI Supplement report (E & E 2017a) and preliminary results of the 2017 groundwater monitoring well installation and 2016 and 2017 baseline groundwater monitoring (see Appendix A), results of groundwater samples collected from selected wells can be used to estimate conditions, including COC concentrations, that are generally representative of conditions upgradient of the Main Processing Area and Red Devil Creek valley. Such COC concentrations can be considered representative of "background" groundwater concentrations for the Main Processing Area and Red Devil Creek valley and are presented as refined background levels in this FS Supplement report.

As discussed in Section 1.2.3.4, the Kuskokwim River sediment background values were updated to include results of additional background sediment samples collected as part of the RI Supplement. The revised background sediment value for arsenic is 13.4 mg/kg.

2.3.3.3 Remedial Goal Selection

RGs were selected through a process that balances applicable regulatory criteria, site-specific RBCLs, and site-specific background levels relevant to the media addressed in this FS Supplement report. The RG selection process was conducted as follows:

- If chemical-specific ARAR concentrations and site-specific RBCLs were below background levels, the background value was selected as the RG.
- If chemical-specific ARAR concentrations and site-specific RBCLs were above background levels, the lowest of the ARAR concentration or RBCL was selected as the RG.
- If either the chemical-specific ARAR concentration or site-specific RBCL was greater than the background level, the lesser value of the ARAR or site-specific RBCL was selected as the RG.

Table 2-2 summarizes the proposed RG values for groundwater. Table 2-3 summarizes the proposed RG values for Kuskokwim River sediments, including the materials within the lower delta.

Table 2-2 Proposed Groundwater Remedial Goal Values

Groundwater Contaminant of Concern	Groundwater Chemical-specific ARAR Concentration (µg/L)	Groundwater Human Health RBCL for Future Resident (µg/L)	Refined Groundwater Background Level (µg/L)
Antimony	7.8	6.0	19.8
Arsenic	10	0.27	539
Mercury	2.0	4.3	1.23

Key:
µg/L = micrograms per liter
ARAR = applicable and relevant or appropriate requirement
RBCL = risk-based cleanup level

Table 2-3 Proposed Kuskokwim River Remedial Goal Values

Kuskokwim River Media of Concern	Kuskokwim River Contaminant of Concern	Kuskokwim River Sediment Human Health RBCL for Future Resident (mg/kg)	Kuskokwim River Sediment Background Level (mg/kg)
Nearshore Sediments and Materials within the Lower Delta	Arsenic	69.1	13.4

Key:
mg/kg = milligrams per kilogram
RBCL = risk-based cleanup level

Table 2-4 presents the selected RGs for groundwater, Kuskokwim River nearshore sediment, and materials within the lower delta, and summarizes their ability to achieve the RAOs.

Table 2-4 Selected Remedial Goals and Remedial Action Objective Conformity

Media and Contaminant of Concern	Selected Remedial Goal	RAO Conformity
Groundwater		
Antimony	19.8 µg/L	Selected RG is the refined background level. **RAO Conformity: Cleanup below selected RG is impracticable because RG represents the naturally occurring background level of antimony in upgradient groundwater, thus making cleanup to MCLs or RBCL unachievable at the site.**
Arsenic	539 µg/L	Selected RG is the refined background level. **RAO Conformity: Cleanup below selected RG is impracticable because RG represents the naturally occurring background level of arsenic in upgradient groundwater, thus making cleanup to MCLs or RBCL unachievable at the site.**
Mercury	2.0 µg/L	Selected RG is the ARAR (MCL). **RAO Conformity: Protective of human health.**
Nearshore Kuskokwim River Sediments and Materials within the Lower Delta		
Arsenic	69.1 mg/kg	Selected RG is the human health RBCL. **RAO Conformity: Protective of human health.**

Key:
µg/L = micrograms per liter
MCL = maximum contaminant level
mg/kg = milligrams per kilogram
RAO = remedial action objective
RBCL = risk-based cleanup level
RG = remedial goal

2.4 Areas and Volumes of Media to Be Addressed by the Remedial Action

2.4.1 Groundwater

Groundwater contamination exists throughout the Main Processing Area and Red Devil Creek downstream alluvial area. It is most concentrated in areas where groundwater exists within tailings/waste rock material, which is distributed throughout much of the Main Processing Area and Red Devil Creek valley.

As noted in Section 1.2.3.2, under present conditions, the groundwater that originates in the Surface Mined Area appears to flow into the Main Processing Area and Red Devil Creek valley and mix with the shallow groundwater impacted by tailings/waste rock and contaminated soils. As stated in Section 1.2.3.1, it is anticipated that excavation performed under 2016 FS Alternatives 3 and 4 would extend to the top of bedrock throughout most of the Main Processing Area and much of the Red Devil Creek downstream alluvial area. Where excavation would extend to the top of bedrock, the shallow contaminated groundwater also would be removed. Under this scenario, it is expected that only small, discontinuous areas of residual soil with COC concentrations below RGs would remain in place in the Main Processing Area and Red Devil Creek valley. Based on review of soil and groundwater elevation data (see Appendix A, Table A-3 and Figure A-1), it is expected that the groundwater would occur in thin, laterally discontinuous zones. Of these potential saturated zones, concentrations of COCs could potentially exceed one or more groundwater RGs. For the purposes of this FS Supplement, it is assumed that up to two such areas that could occur at the areas depicted in Figure 2-1.

2.4.2 Materials within the Lower Delta

Based on RI soil characterization results, materials within the upper portion of the Red Devil Creek delta include tailings/waste rock materials and alluvium. It is expected that materials within the lower delta are similar to those in the upper portion of the delta. The extent of the Red Devil Creek delta is approximated based on a combination of sediment sample data, bathymetry, and data from soil borings installed on the face of the delta (see Figures 2-2 and 1-4).

The volume of unconsolidated materials within the lower delta is estimated to be approximately 18,000 cubic yards.

2.4.3 Nearshore Kuskokwim River Sediments

The estimated volume of nearshore Kuskokwim River sediments targeted for remedial action is 300 cubic yards. This volume estimate is based on delineations of two separate areas where contamination exceeds the RG for arsenic (see Figure 2-2).

2.5 Applicable or Relevant and Appropriate Requirements

This section identifies ARARs and other standards, criteria, and guidance “to be considered” (TBC) for remedial activities pertaining to groundwater, materials within the lower delta, and Kuskokwim River nearshore sediment. Identification of ARARs and TBCs is used in assessing the feasibility of remedial action alternatives; however, ARARs and TBCs are identified iteratively throughout the RI/FS process leading up to the Record of Decision.

ARARs are defined by the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] 300.5). Applicable requirements are cleanup and control standards, as well as other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be considered applicable.

Relevant and appropriate requirements, while not applicable requirements, do address problems or situations sufficiently similar to those encountered at a particular CERCLA site that their use is well suited to that site.

TBCs are non-promulgated federal or state advisories, guidance, or proposed rules that are not legally binding and do not have the status of a potential ARAR but are useful in determining the necessary level of cleanup for protection of human health and the environment if ARARs are unavailable.

ARARs and TBCs are divided into three categories:

- Chemical-specific ARARs and TBCs – usually health- or risk-based numerical values or methodologies that establish an acceptable amount or concentration of a chemical in the ambient environment;
- Action-specific ARARs and TBCs – usually technology- or activity-based requirements for remedial actions; and
- Location-specific ARARs and TBCs – restrictions placed on the concentration of hazardous substances or the conduct of activity solely because they occur in special locations.

Chemical-, location-, and action-specific ARARs and TBCs for groundwater, materials within the lower delta, and nearshore Kuskokwim River sediment remedies at the RDM were identified based on existing site data and are presented in Table 2-5. If both federal and state laws address the same issues that are applicable, appropriate, and relevant, the more stringent or specific one is cited below to reduce redundancy. In addition, many regulations refer to other regulations for specific guidance. In these cases, the substantive guidance has been cited.

Table 2-5 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC
Chemical-Specific			
Federal			
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC
State			
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate
Location-Specific			
Federal			
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department of the Interior to do so.	Applicable
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable

Table 2-5 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate

Table 2-5 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC
State			
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871-.901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable
Action-Specific			
Federal			
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the EPA gives states the authority to implement the NPDES program.	Applicable
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or off site.	Applicable
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable

Table 2-5 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable

Key:
AAC = Alaska Administrative Code
ARAR = Applicable or Relevant and Appropriate Requirement
AS = Alaska Statutes
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
EO = Executive Order
ESA = Endangered Species Act
NPDES = National Pollutant Discharge Elimination System
MCL = maximum contaminant Level
RCRA = Resource Conservation and Recovery Act
TBC = To Be Considered
USC = United States Code
WQS = Water Quality Standards

2.6 General Response Actions

GRAs are broad categories of remedial actions that may, either individually or in combination, achieve the RAOs established in Section 2.1 and, like RAOs, are medium-specific. The identification of GRAs is the first step in the identification of remedial technology types and specific process options.

The following GRAs are applicable for addressing groundwater, materials within the lower delta, and nearshore Kuskokwim River sediment at the RDM:

- The *No Action Alternative* is included as a baseline for comparing other potential response actions. Consideration of a no action approach is required by the NCP (40 CFR 300.430).
- *Institutional Controls (ICs)* may restrict access to and uses of land and contaminated material, thereby limiting exposure. ICs may include administrative and/or legal controls, public awareness efforts, and/or a combination of these to minimize the potential for exposure to contaminants.
- *Access Controls (ACs)* may limit direct contact with contaminated material, thereby limiting exposure. ACs may include physical barriers, such as fencing and gates, and warning signs.
- *Stabilization/Containment* limits contaminant mobility via technologies such as sediment capping or pumping for groundwater capture, thus substantially reducing pathways of potential exposure.
- *Treatment* addresses the toxicity, mobility, or volume of contaminants through physical, chemical, or biological processes. Treatment of contaminated material includes remedial actions that can be conducted in situ or ex situ.
- *Removal/Disposal* limits exposure by addressing the mobility and volume of contaminants by removal (via extraction, excavation, dredging, or other technology) and containment in an approved disposal facility (on site or off site).

2.7 Identification, Screening, and Evaluation of Remedial Technology Types and Process Options

This section further refines the GRAs into potentially applicable remedial technology types and specific process options to address groundwater, materials within the lower delta, and nearshore Kuskokwim River sediments at the RDM. A description is provided for each remedial technology type and process option, followed by the rationale for retaining or eliminating it from further consideration.

The goal of screening is to identify one process option to represent each technology type to further refine the development of alternatives (Chapter 3). In some cases, more than one process option may be selected per technology type provided two or more process options are sufficiently different in their performance that one would not adequately represent the other.

Remedial technology types and specific process options were identified based on the current understanding of site conditions, previous mine site and FS experience, a review of literature, and vendor information. The following guidance documents were reviewed to aid in the identification of potentially applicable remedial technology types:

- Mining Waste Treatment Technology Selection, Web-Based Technical and Regulatory Guidance Document (ITRC 2011).
- Abandoned Mine Site Characterization and Cleanup Handbook (EPA 2000).
- Arsenic Treatment Technologies for Soil, Waste, and Water (EPA 2002).
- Treatment Technologies for Mercury in Soil, Waste, and Water (EPA 2007).
- Technical Guide: Monitored Natural Recovery at Contaminated Sediment Sites (ESTCP 2009).
- Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action and Underground Storage Tank Sites (EPA 1999).
- Guidance for Evaluation the Technical Impracticability of Ground-Water Restoration (EPA 1993).

Three evaluation criteria are used to screen remedial technologies and specific process options:

- Effectiveness – The degree to which the technology or process option is (1) capable of handling the estimated areas or volumes of contaminated media and meeting the RGs identified in the RAOs (i.e., reduces the toxicity, mobility, or volume of contaminants); (2) protective of human health and the environment during the construction and implementation phase (i.e., minimizes short-term impacts); and (3) proven and reliable with respect to site-specific contaminants and conditions.
- Implementability – The technical feasibility (i.e., the applicability in regard to the areas and volumes of contaminated media and the types of contaminants) and administrative feasibility (i.e., the ability to comply with ARARs; the availability and capacity of treatment, storage, and disposal services; and the availability of necessary equipment and skilled workers) of implementing the technology or process option.
- Cost – The cost (capital and operation and maintenance) of the technology or process option.

GRAs, remedial technology types, and specific process options that do not satisfy RAOs and/or are inconsistent with the above three evaluation criteria were not retained for further consideration.

Remedy technologies for addressing groundwater, materials within the lower delta and nearshore Kuskokwim River sediments focus on conditions that are likely to exist following removal of tailings/waste rock, contaminated soil, and contaminated creek sediment as described in Remedial Alternatives 3 and 4 of the 2016 FS report. This is not considered presumptive since source material removal Alternatives 3 and 4 are the only alternatives that met threshold criteria in the 2016 FS report. Section 2.7.1 describes remedial technology types and process options that are applicable to the media addressed in this FS Supplement report (i.e., groundwater, materials within the lower delta, and nearshore Kuskokwim River sediments); Section 2.7.2 describes remedial technology types and process options that are relevant to groundwater only, and Section 2.7.3 describes remedial technology types and process options that are relevant to materials within the lower delta and nearshore Kuskokwim River sediments.

2.7.1 Remedial Technology Types and Process Options for Groundwater, Materials within the Lower Delta, and Nearshore Kuskokwim River Sediments

The following remedial technology types and process options were considered potentially applicable for all media addressed within this FS Supplement report (groundwater, materials within the lower delta, and nearshore Kuskokwim River sediments). Table 2-6 summarizes the screening and evaluation of these remedial technologies and process options and identifies which remedial technologies and process options were retained for further consideration.

2.7.1.1 Institutional Controls

ICs are non-engineered controls intended to minimize the potential for human exposure to contamination and/or protect the integrity of a remedy by limiting land or resource use. ICs do not actively address contamination, but rather attempt to meet the RAOs by reducing the potential for exposure to contamination. ICs are often used in conjunction with an active technology and/or ACs (e.g., fencing or warning signs). Technologies considered under this GRA include administrative and/or legal controls and public awareness.

Administrative and/or Legal ICs

Administrative and/or legal controls use the regulatory authority of a government entity to impose restrictions on citizens or property under its jurisdiction, custody, or control to ensure long-term protection of contaminated or remediated sites. Process options include land use restrictions, zoning restrictions, and special permits.

- Land Use Restrictions – Restrictions that may impose a variety of limitations and conditions on the use of property (e.g., limit future land uses, sediment management, groundwater use, etc.).
- Zoning Restrictions – Restrictions that specify land uses for particular areas (e.g., a local government could prohibit residential development in a contaminated or remediated area).
- Special Permits – Permits that outline specific requirements that must be met before an activity can be authorized (e.g., building, groundwater use, etc.).

These process options would provide limitations on future land use; however, mine wastes would remain at the site in their current condition. These process options would not reduce contaminant mobility, toxicity, or volume, but could meet RAOs when combined with other remedial actions. No technical or administrative issues are known that would adversely affect the implementation of these process options, capital costs are considered to be low, and operation and maintenance (O&M) costs are considered to be negligible to low. This alternative would not address ecological risks.

Public Awareness ICs
Public awareness process options include deed notices, public advisories, and public outreach, which inform landowners and the public about potential risks at a site.

- Deed Notices – Non-enforceable, informational documents filed in public land records to alert anyone searching the records to important information about the property.
- Public Advisories – Warnings, usually issued by public health agencies, either at the federal, state, or local level, that provide notice to potential users of land, surface water, or groundwater of potential risks associated with their use (e.g., fishing advisories).
- Public Outreach – Informational meetings, programs or pamphlets that alert potential users of land, surface water, or groundwater of potential risks associated with their use.

These process options may educate potential land users of potential risks associated with the site; however, mine wastes would remain at the site in their current condition. These process options would not reduce contaminant mobility, toxicity, or volume but could meet RAOs when combined with other remedial actions. Furthermore, there are few effective means for ensuring that public awareness efforts will result in reduced exposure to mine waste. No technical or administrative issues are known that would adversely affect the implementation of these process options. Capital and O&M costs associated with these process options are considered to be low.

2.7.1.2 Access Controls

ACs are physical controls put in place to prevent human and ecological receptor exposure to contamination and/or to protect the integrity of a remedy by limiting direct contact with particular areas of concern. Similar to ICs, ACs do not actively address contamination but rather attempt to address the intent of RAOs by reducing the potential for exposure to contamination. ACs are often used in conjunction with an active remedy and/or ICs. ACs considered under this GRA include physical barriers, such as fencing and gates, and warning signs.

Physical barriers and warning signs can be readily installed with minimal disturbance of existing contaminated material, but ongoing O&M would be required. Physical barriers may prevent exposure of both humans and large ecological receptors, but would not likely be effective in reducing contaminant exposure to smaller ecological receptors. Warning signs, however, would not be effective in preventing ecological receptors from exposure to mine-contaminated material. These process options would not reduce contaminant mobility, toxicity, or volume but could meet RAOs when combined with other remedial actions. No technical or administrative issues are known that would adversely affect the implementation of these process options. Physical barriers and warning signs were addressed and costed in the 2016 FS, and therefore were not retained for further consideration in this FS Supplement in order to eliminate potential duplication of cost.

2.7.2 Remedial Technology Types and Process Options for Groundwater

As noted in Section 2.4.1, source removal as described under Alternatives 3 and 4 would result in excavation of tailings/waste rock and contaminated soil, and it is preliminarily anticipated that the excavation would extend to the top of bedrock throughout much of the Main Processing Area and Red Devil Creek valley. Contaminated groundwater would be expected to occur only in small, thin, discontinuous zones. Such groundwater could contain arsenic contamination at concentrations above the above the RG. Technologies associated with reducing arsenic concentrations in groundwater include Monitored Natural Attenuation (MNA), passive treatment, and active treatment. Table 2-7 summarizes the screening and evaluation of these remedial technologies and process options and identifies which were retained for further consideration. The following text summarizes the remedial technology types and process options that were considered potentially applicable to address groundwater contamination at the RDM.

2.7.2.1 Monitored Natural Attenuation

MNA is a remedial technology that makes use of naturally occurring physical, chemical, and biological processes to reduce contaminant concentrations, which then reduces the associated risks to receptors and ultimately meets site-specific RAOs. MNA processes identified for the RDM can reduce risk to human and ecological receptors by reducing their toxicity, or otherwise limiting access and exposure pathways. Examples of natural attenuation processes include sorption, dilution, and chemical reactions. Monitoring is necessary to assess the rate and magnitude of contaminant reduction through natural recovery processes.

MNA is most likely to be effective after source removal has been completed. Due to the slow rate at which natural processes reduce contaminant levels, MNA is unlikely to be effective where source materials continue to contribute to ongoing releases.

This technology is expected to reduce contaminant concentrations through naturally occurring processes to meet RAOs. Capital and O&M costs associated with this process option are low.

2.7.2.2 Treatment

Technology types considered for the RDM under the groundwater treatment GRA were ex situ and in situ chemical and physical treatment of contaminated material. No potentially applicable biological treatment methods were identified since metal ions in groundwater cannot be biologically "broken down" into simpler compounds. The technologies considered use physical or chemical processes to reduce contaminant mobility, toxicity, and volume to meet RAOs. Process options for treatment are passive treatment (no electrical input needed) or active treatment (electricity required for running process equipment).

2.7.2.3 Passive Treatment

Passive treatment technologies rely on natural chemical processes to remove contaminants from solution without a power supply. One passive in-situ groundwater treatment system identified for the RDM is a permeable reactive barrier (PRB). PRBs allow contaminated groundwater to naturally flow through a buried, porous reactive medium that either precipitates, degrades, or adsorbs the contaminants. The most common medium used in PRBs for treating arsenic is zero valent iron, which adsorbs arsenic by electrostatic interactions.

Capital costs for a PRB are moderate to high, depending on the depth and volume of media required, while O&M costs would be low. The success of a PRB depends on adequate design inputs and an understanding of hydrogeological conditions. A properly designed PRB would meet RAOs by reducing contaminant concentrations below RGs.

2.7.2.4 Active Treatment

Active treatment systems typically depend on electrical and mechanical processes that require regular professional staff and dedicated control systems. An active system for treating groundwater at the RDM would consist of a series of extraction wells to pump contaminated groundwater to a central treatment system. Active arsenic treatment technologies for groundwater include:

- Precipitation/coprecipitation
- Precipitation/coprecipitation
- Membrane filtration
- Adsorption
- Ion exchange

Precipitation is a multiple step process that typically includes pH adjustment, flocculation, and filtration. While this process will be effective at removing arsenic so as to reduce its concentration, a residual metals-laden sludge will be created that requires dewatering and subsequent disposal. Given that arsenic is being removed, it is probable that the sludge will be classified as a hazardous waste, which will increase operations and maintenance costs.

Membrane filtration is a technology that drives contaminated water through a membrane that separates arsenic from the water. This process can be considered a molecular sieve. This technology typically requires extensive pre-treatment depending on other constituents that may exist in the untreated water. It also produces quantities of residual wastes that require handling and disposal, which increases costs.

Adsorption technology utilizes a granular medium, placed in a pressure vessel, onto which negatively charged arsenic ions bind. The most commonly used adsorption media are modified activated alumina and iron-based materials. Eventually, adsorption media will become spent and require disposal. Adsorption media are proven to remove arsenic very efficiently and are simple to operate.

Ion exchange is a process that removes arsenic from solution by the exchange of anions between arsenic and a strong base resin. The resin is packed in a fixed bed or column that can be regenerated by acid washing to remove contaminants and replenish the exchange ions. This process produces a backwash and waste regeneration solution that requires handling and disposal. Ion exchange systems are vulnerable to fouling from the presence of organics, suspended solids, calcium, and iron and tend to have higher O&M costs due to the high volume of salt required.

Each of the active treatment systems would require a constant and reliable power supply, which does not currently exist at the RDM. These process options could meet RAOs by reducing contaminant concentrations below RGs; however, capital and O&M costs associated with each of the active treatment options are considered to be prohibitive and are therefore omitted from further consideration.

2.7.3 Remedial Technology Types and Process Options for Materials within the Lower Delta and Nearshore Kuskokwim River Sediments

The following remedial technology types and process options were considered potentially applicable for materials within the lower delta and nearshore Kuskokwim River sediments. Table 2-8 summarizes the screening and evaluation of these remedial technologies and process options and identifies which remedial technologies and process options were retained for further consideration.

2.7.3.1 Stabilization/Containment

Sediment capping serves to stabilize and contain contaminated sediment by burying with a sufficiently thick layer of clean material to withstand erosive and scour forces. Multiple process options for sediment capping exist, including gravel, sand, and geotextile caps. Due to site-specific conditions, sediment capping was determined to be unlikely to be effective—scour from ice flow and high velocity currents could remove gravel or sediment caps or undermine geotextile layers. Sediment capping has been omitted from further evaluation.

2.7.3.2 Monitored Natural Recovery

Monitored Natural Recovery (MNR) is a remedial technology that makes use of naturally occurring physical, chemical, and biological processes to reduce risks to receptors and meet site-specific RAOs. MNR processes reduce risk to human and ecological receptors by destroying or transforming contaminants, reducing their toxicity, or otherwise limiting access and exposure pathways. In general, examples of natural recovery processes include biodegradation, dispersion, and burial with clean sediment. The Red Devil Creek delta and the contaminated sediment downriver from the Red Devil Creek delta are situated on a cut bank of the Kuskokwim River and are thus likely subject to net erosion at most locations. Although net sedimentation could potentially occur locally, it is expected that the primary MNR processes at the RDM would be sediment mixing and dispersion. Monitoring is necessary to assess the rate and magnitude of contaminant reduction through natural recovery processes.

Monitored natural recovery is will only be effective after source control actions have been completed. Due to the slow rate at which natural processes reduce contaminant levels, MNR is likely to be less effective where source materials continue to contribute to ongoing releases.

This technology is expected to reduce contaminant concentrations in sediment through naturally occurring processes to meet RAOs. One technical issue that could impact the effectiveness of this technology is the status of source control actions (Remedial Alternatives 3 and 4 of the 2016 FS). Capital and O&M costs associated with this process option are considered to be low.

2.7.3.3 Removal

Nearshore sediments would be removed by dredging. Delineation of materials to be removed by dredging will be prepared beforehand by mapping or established by in-field measurements. Off-site disposal would entail loading dredged material onto barges and transporting to an approved disposal facility. On-site disposal would entail consolidation of material within the repository using heavy equipment such as loaders, dozers, and compactors. On-site repository and off-site disposal remedial technologies are discussed in detail in the 2016 FS report.

Process options considered for dredging (i.e., hydraulic and mechanical dredging) are described in the following subsections.

2.7.3.4 Hydraulic Dredging

Hydraulic dredging uses a pump to generate suction to fluidize bed material with the surrounding water, enabling it to be transported or removed. A slurry of dredged bed material and water is discharged via the suction pipe to a staging area for dewatering. Suction pipe ends may be plain or equipped with a cutter-head to excavate resistant bed materials such as gravel and bedrock.

Hydraulic dredging using suction allows for more targeted removal of contaminated materials than typical mechanical dredging. Technical limitations may include:

- Dewatering of dredged sediment slurry;
- Access challenges for barge-mounted dredging rigs due to fast moving river currents; and
- Difficulty removing oversized, well armored, and/or cemented bed materials.

This process option would meet RAOs for materials within the lower delta, and nearshore Kuskokwim River sediments by reducing contaminant volume through removal. Capital and O&M cost associated with this process option is considered moderate to high. Costs could be further increased if cobbles, boulders, or large woody debris were encountered, as hydraulic dredging is not well suited to handling large material. For these reasons, hydraulic dredging would be considered a “maximum effort alternative” and has not been retained for further analysis.

2.7.3.5 Mechanical Dredging

Mechanical dredging (also referred to as “grab dredging”) involves the removal of sediments with a mechanical apparatus equipped with a bucket or clamshell that is operated via a mechanical arm or cable system. Mechanical dredging rigs may be shore- or barge-mounted.

Mechanical dredging is capable of removing large or cemented bed materials. Technical limitations may include:

- Access challenges for barge-mounted dredging rigs due to high river currents; and
- Difficulty reaching deep or horizontally distant materials with a shore-mounted dredging rig.

This process option would meet RAOs by reducing contaminant volume through removal. Mechanical dredging is a commonly used technology that can be readily implemented. This technology has a high potential of achieving RAOs for materials within the lower delta and sediments. Mechanical dredging would require infrastructure such as docks and offloading areas. Capital costs associated with this process option are considered moderate to high. This technology was retained for removal of materials within the lower delta materials and Kuskokwim River sediments.

Table 2-6 Evaluation of Remedial Technology Types and Process Options Applicable to All Site Media – Groundwater, Materials within the Lower Delta, and Nearshore Kuskokwim River Sediments

General Response Actions	Remedial Technology Type	Process Option	Effectiveness	Implementability	Cost	Screening Comments
No Action	NA	NA	Does not meet RAOs or reduce toxicity, mobility, or volume of contaminants	Implementable	Negligible to low	Retained as required by NCP
Institutional Controls	Administrative and/or Legal Controls	Land Use Restrictions	Depends on continued future use at the site; does not reduce contamination	Implementable. All processes and methods are established.	Low capital costs; negligible to low O&M costs	Potentially applicable in combination with other remedial actions
		Zoning Restrictions				
		Special Permits				
	Public Awareness	Deed Notices	Difficult to ensure that information reaches parties or ensure that the parties will heed the notice; does not reduce contamination	Implementable. All processes and methods are established.	Low capital and O&M costs	Potentially applicable in combination with other remedial actions
		Public Advisories				
		Public Outreach				
Access Controls	Physical Barriers	Fences and Gates	Depends on continued future implementation; does not reduce contamination	Implementable although effectiveness for groundwater and in/near Kuskokwim River is low.	Low capital and O&M costs, unable to maintain fencing in/near Kuskokwim River due to ice flow	Not retained
	Warning Signs	NA	Difficult to ensure that the parties will heed the notice	Implementable	Low capital and O&M costs	Retained

Key:
NA = not applicable
NCP = National Oil and Hazardous Substance Pollution Contingency Plan
O&M = operations and maintenance
RAO = remedial action objective

Table 2-7 Evaluation of Remedial Technology Types and Process Options Applicable to Groundwater

General Response Actions	Remedial Technology Type	Process Option	Effectiveness	Implementability	Cost	Screening Comments
Monitored Natural Attenuation	NA	NA	Considered most effective after source control actions	Implementable. All processes and methods are established.	Low capital and O&M cost	Potentially applicable in combination with other remedial actions
Treatment	Passive Treatment	Permeable Reactive Barrier	Effective. Requires thorough understanding of aquifer conditions	Implementable. Sizing and media selection are challenging	Moderate to high capital costs; low O&M costs	Retained
	Active Treatment	Precipitation/ Coprecipitation	Can meet RAOs; reduces mobility and volume of contaminants	Implementable. All processes and methods are established.	High capital and O&M cost	Not retained
		Membrane Filtration	Can meet RAOs; reduces mobility and volume of contaminants	Implementable. All processes and methods are established.	High capital and O&M cost	Not retained
		Adsorption	Can meet RAOs; reduces mobility and volume of contaminants	Implementable. All processes and methods are established.	High capital and O&M cost	Not retained
		Ion Exchange	Can meet RAOs; reduces mobility and volume of contaminants	Implementable. All processes and methods are established.	High capital and O&M cost	Not retained

Key:
NA = not applicable
O&M = operations and maintenance
RAO = remedial action objective

Table 2-8 Evaluation of Remedial Technology Types and Process Options Applicable to Materials within the Lower Delta and Nearshore Kuskokwim River Sediments

General Response Actions	Remedial Technology Type	Process Option	Effectiveness	Implementability	Cost	Screening Comments
Stabilization / Containment	Capping	Rock	Reduces mobility of contaminants but not toxicity or volume	Not easily Implemented or maintained	Low to moderate capital cost; high O&M costs	Not retained. Unlikely to result in a stable, long-term remedy due to ice scour
		Synthetic Material (e.g., concrete mat)	Reduces mobility of contaminants but not toxicity or volume	Not easily Implemented or maintained	Moderate to high capital cost; moderate O&M costs	Not retained. Unlikely to result in a stable, long-term remedy due to ice scour
Monitored Natural Recovery	NA	NA	Considered most effective after source control actions	Implementable. All processes and methods are established.	Low capital and O&M cost	Potentially applicable in combination with other remedial actions
Removal	Dredging	Hydraulic Dredging	Reduces mobility of contaminants, considered a maximum effort alternative	Not implementable due to potential for oversized materials	Moderate to high capital cost	Not retained for further analysis due to implementation issues
		Mechanical Dredging	Can meet RAOs; reduces mobility of contaminants	Implementable. All processes and methods are established.	Moderate to high capital cost	Retained for further analysis

Key:
NA = not applicable
O&M = operations and maintenance
RAO = remedial action objective

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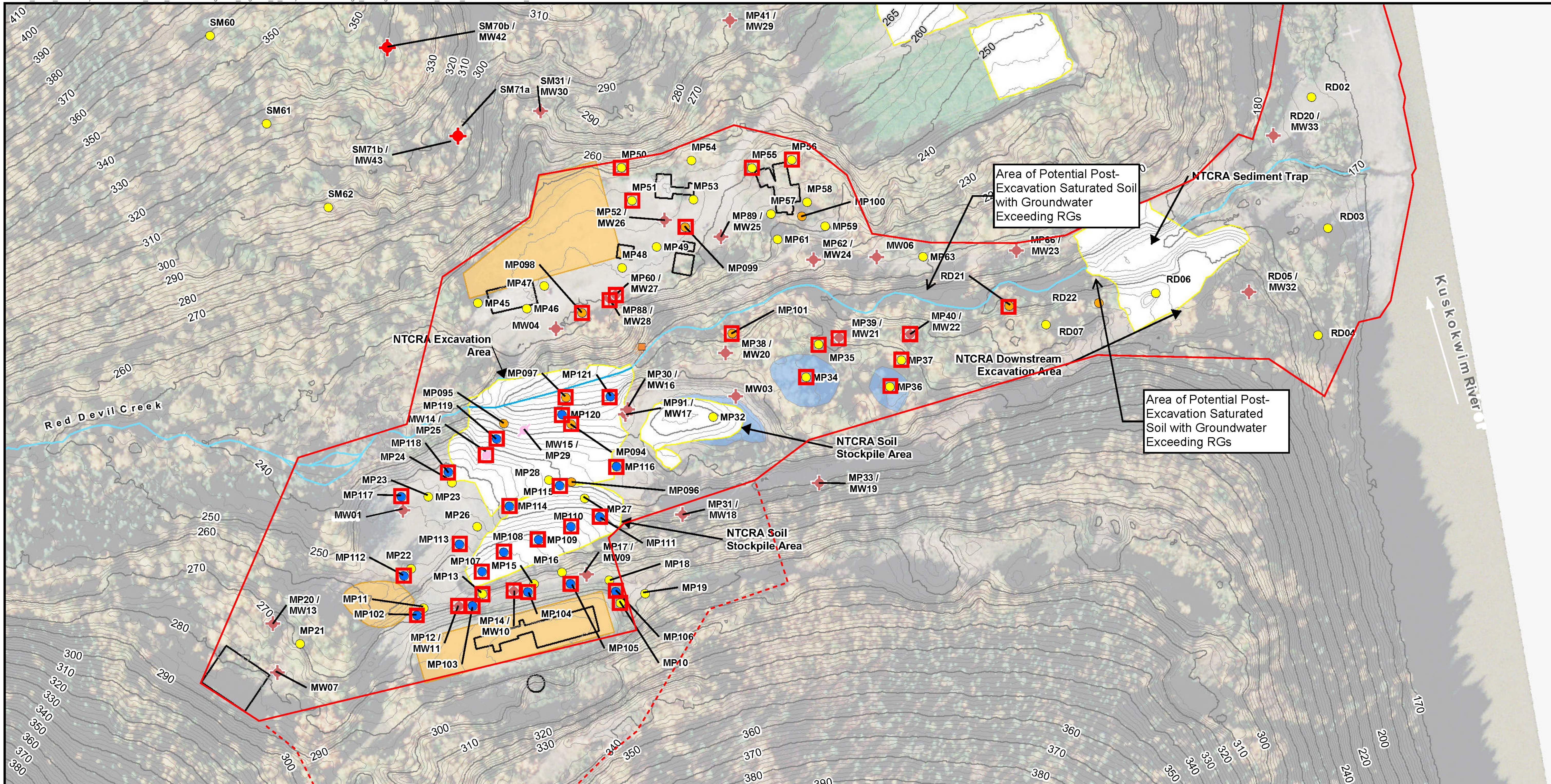

2017 Soil Boring Location	2015 2-foot Contour
2015 Soil Boring	2015 10-foot Contour
RI Soil Boring / Monitoring Well	Area of 2014 NTCRA Re-grading
Decommissioned Well	Post-NTCRA Stream Alignment
RI Soil Boring	Red Devil Creek
	Approximate Lateral Extent of Soil Excavation Described under 2016 FS Alternatives 3 and 4.
	Soil Boring in which Soil COC Concentrations Exceeding RGs Extend to Top of Bedrock.

Settling Pond
Monofill
Historical Structure
Approximate Location of Proposed Repository Footprint
Seep Location

Digital 2015 5-foot topographic contours based on Octobr 10, 2015 LiDAR Survey (Quantum Spatial 2015).

RED DEVIL MINE

Red Devil, Alaska

Figure 2-1
Areas of Potential Groundwater Contamination in Residual Soil Under 2016 FS Alternatives 3 and 4

0 25 50 100 150 200
Feet
0 7.5 15 30 45 60 75
Meters
Scale 1:1,500

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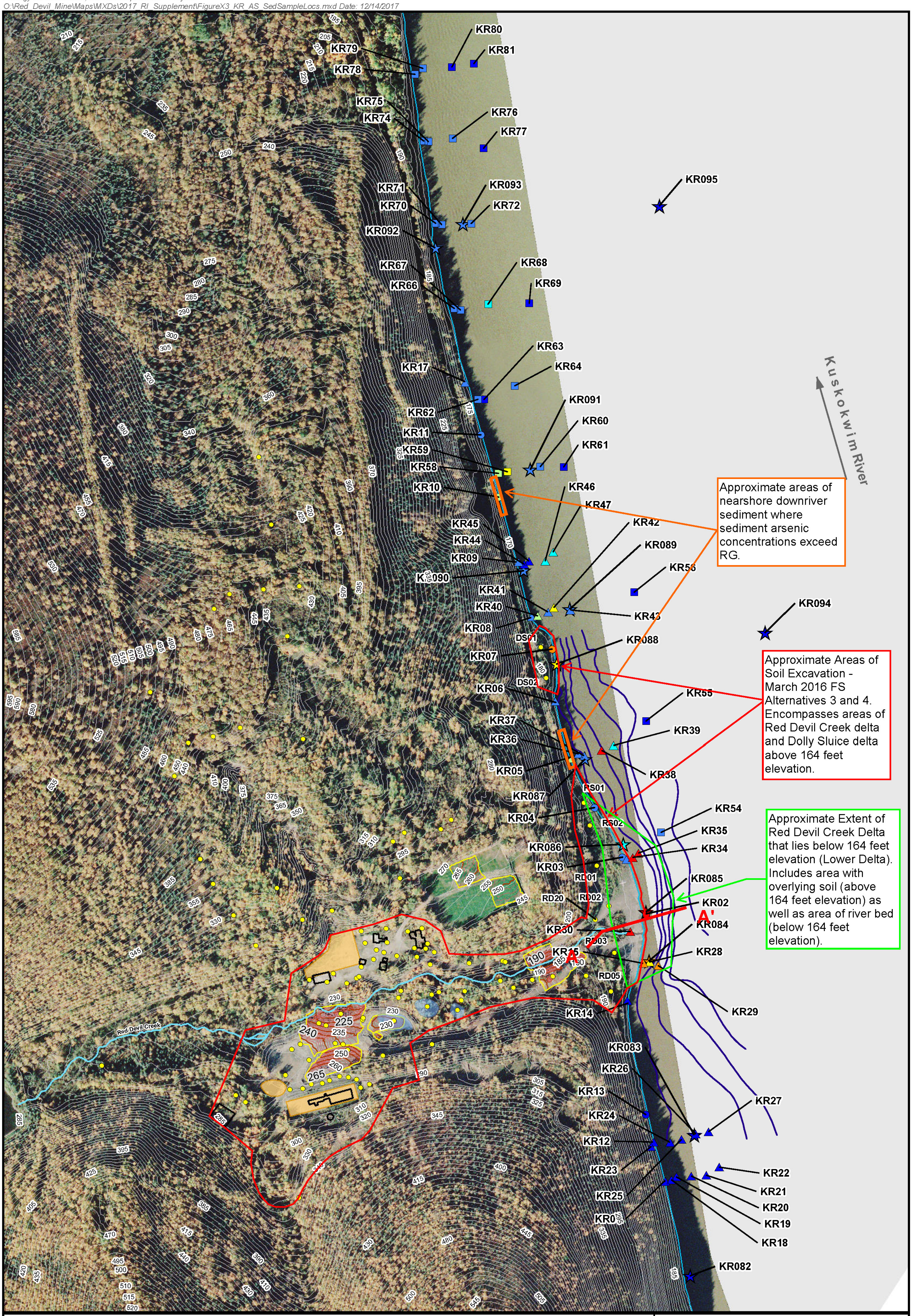

2010 Total Arsenic (mg/kg)	2011 Total Arsenic (mg/kg)	2012 Total Arsenic (mg/kg)	2015 Total Arsenic (mg/kg)
> 800	> 800	> 800	> 800
400 to 800	400 to 800	400 to 800	400 to 800
200 to 400	200 to 400	200 to 400	200 to 400
100 to 200	100 to 200	100 to 200	100 to 200
69 to 100	69 to 100	69 to 100	69 to 100
13.4 to 69	13.4 to 69	13.4 to 69	13.4 to 69
≤ 13.4 background	≤ 13.4 background	≤ 13.4 background	≤ 13.4 background

Soil Boring
Bathymetric contour (feet)
2010 5-foot Contour
River level (elevation 165.78 feet) on 9/21/2010
Area of 2014 NTCRA Red Devil Creek Sediment Trap
2014 5-foot Contour
2014 1-foot Contour
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE
Red Devil, Alaska

Figure 2-2
Red Devil Creek Delta and Areas of Kuskokwim River Nearshore Sediment Exceeding Arsenic Remedial Goal

Feet: 0 75 150 300 450 600
Meters: 0 15 30 60 90 120 150
Scale 1:2,500

1. Aerial image collected on 9/21/2010 (Aerometric 2012)
2. Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on 9/21/2010 (AeroMetric 2012)
3. Kuskokwim River elevation on date aerial orthophotographic survey (9/21/2010) was 165.78 feet (Aerometric 2012)
4. Bathymetric contours represent approximate depths below river surface on 9/25/2011
5. Digital 2014 5-foot and 1-foot topographic contours based on Marsh Creek (2014)

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3 Identification of Remedial Alternatives

In this chapter, medium-specific remedial technology types and process options retained for further consideration in Chapter 2 are combined to form remedial alternatives for groundwater, materials within the lower delta, and nearshore Kuskokwim River sediments at the RDM. The primary objective of this phase of the FS Supplement is to develop an appropriate range of remedial alternatives for groundwater and the Kuskokwim River that will contribute to achieving the project's RAOs. The alternatives were developed based on their capacity to achieve media-specific protectiveness, combining different remedial technology types to address different volumes of media and/or areas of the site. They were further refined in regard to process option details (i.e., containment or treatment system sizing, remediation timeframe, spatial requirements, transportation distances, required permits, etc.).

This chapter describes each alternative in detail. Due to the setting of the site, the type of contamination (i.e., COCs listed in Table 2-4), and the volume of material to be addressed, a limited number of technology types and process options were retained for discussion in Chapter 2. Therefore, a screening of alternatives was not required in order to select a reasonable number of alternatives for detailed analysis.

Alternatives for addressing groundwater, materials within the lower delta, and nearshore Kuskokwim River sediments focus on conditions that are likely to exist following removal of tailings/waste rock, contaminated soil, and contaminated creek sediment as described in Remedial Alternatives 3 and 4 of the 2016 FS report. This is not considered presumptive since source material removal Alternatives 3 and 4 are the only alternatives that met threshold criteria in the 2016 FS report.

3.1 Development of Remedial Alternatives for Groundwater

The following remedial alternatives were developed to address residual groundwater contamination following source removal actions that would be performed under 2016 FS Alternatives 3 and 4:

- Alternative GW 1: No Action

- Alternative GW 2: Institutional and Access Controls
- Alternative GW 3: Monitored Natural Attenuation
- Alternative GW 4: Passive Groundwater Treatment

3.1.1 Alternative GW 1 – No Action

The No Action alternative is included as a requirement of the NCP. This alternative is a baseline against which other alternatives are measured and is included for comparative purposes.

Under the No Action alternative, contaminated groundwater at the site would remain and no action would be taken to reduce the potential for human or ecological receptor exposure to COCs or to reduce migration. Maintenance or monitoring would not be performed under this alternative.

3.1.2 Alternative GW 2 – Institutional and Access Controls

The following key components characterize Alternative GW 2:

- Land use restrictions
- Signage
- Five-year review

Under Alternative GW 2, implementation of ICs in the form of a Notice of Environmental Contamination would be performed. ACs will entail warning signs. Establishing ICs and ACs that may restrict future land use has implications for long-term management of the land. The long-term retention or disposal of the site lands by the government will involve development of a site management strategy separate from the CERCLA process. Five-year reviews are a requirement under CERCLA when contamination is left on site.

3.1.2.1 Alternative Summary

Groundwater contamination would be left in place under Alternative GW 2, and no active remediation would be initiated. An Area of Contamination (AOC) would be established with warning signs installed along the perimeter at intervals of approximately 100 yards. Signs would require annual inspections and maintenance to ensure effectiveness. ICs in the form of land use restrictions would be established at the site to restrict future human exposure by limiting activity, use, and access to the property. The long-term retention or disposal of the site lands by the government will involve development of a site management strategy separate from the CERCLA process.

Because contaminated groundwater would not be directly addressed under this alternative, five-year reviews that meet the requirements in Section 121 of CERCLA would need to be performed as described in Section 3.2.2.

3.1.3 Alternative GW 3 - Monitored Natural Attenuation

The following key components characterize Alternative GW 3:

- A site-specific monitoring plan for periodic monitoring of groundwater COCs will be developed.
- Naturally occurring processes that reduce toxicity through physical isolation of contaminated groundwater, such as dispersion or dilution, to reduce potential routes of exposure associated with COCs.
- Data collected as a part of the monitoring plan will be analyzed to assess trends in contaminant reduction and assist in the preparation of the five-year reviews.

Alternative GW 3 will be implemented in conjunction with GW 2 to mitigate residual risk during monitored natural attenuation.

3.1.3.1 Alternative Summary

Under alternative GW 3, naturally occurring groundwater processes would be used to reduce the toxicity and bioavailability of COCs. It is assumed that up to ten new groundwater monitoring wells would be installed to further characterize the existing groundwater plume(s). This alternative includes the implementation of a site-specific monitoring plan that contains provisions for triggering contingency actions such as additional monitoring or development of an appropriate response as needed. It is anticipated that monitoring would occur on an annual basis and that five-year reviews would be conducted to meet the requirements in Section 121 of CERCLA.

3.1.4 Alternative GW 4 – Passive Groundwater Treatment

Alternative GW 4 includes the installation of a passive groundwater treatment system to remove residual contamination that may exist following source removal actions. The following key components characterize Alternative GW 4:

- Install two permeable reactive barriers using iron-based adsorptive media immediately downgradient of suspected contaminant plumes.
- Conduct maintenance and monitoring, including installation of 10 additional monitoring wells.

3.1.4.1 Alternative Summary

Under Alternative GW 4, groundwater contamination will be addressed using two permeable reactive barriers filled with iron-based adsorptive media. Zero valent iron contains a high adsorption capacity for arsenic and antimony, which are the primary COCs expected to remain in groundwater following source-removal activities. This alternative assumes that two separate zones of contaminated groundwater may exist. A PRB would be constructed immediately downgradient of each zone, resulting in two PRBs. For the purposes of the FS Supplement, each

PRB is assumed to be 200 feet long, 10 feet deep, and 5 feet wide. It is assumed that adsorptive media would be placed in the bottom 5 feet of the trench, which is the assumed saturated zone thickness requiring treatment.

This alternative also assumes that groundwater monitoring will be performed to measure contaminant breakthrough of the PRB. Monitoring will be performed as described under Alternative GW 3, in which up to 10 new monitoring wells will be installed for annual sampling and analysis. Additionally, five-year reviews would be conducted to meet the requirements of Section 121 of CERCLA.

3.2 Development of Remedial Alternatives for Sediment

A range of remedial alternatives was developed to address the media of concern. The following alternatives were developed for materials within the lower delta and nearshore Kuskokwim River sediment:

- Alternative KR 1: No Action
- Alternative KR 2: Institutional and Access Controls
- Alternative KR 3: Monitored Natural Recovery
- Alternative KR 4a: Limited Dredging of Materials within the Lower Delta for Disposal in an On-Site Repository
- Alternative KR 4b: Limited Dredging of Materials within the Lower Delta for Off-Site Disposal
- Alternative KR 5a: Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediment for Disposal in an On-Site Repository
- Alternative KR 5b: Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediment for Off-Site Disposal

3.2.1 Alternative KR 1 – No Action

The No Action alternative is included as a requirement of the NCP. This alternative is a baseline against which other alternatives are measured and is included for comparative purposes.

Under the No Action alternative, contaminated sediments at the site would remain at their current location and in their current condition. No action would be taken to reduce the potential for human or ecological receptor exposure to COCs or to prevent their off-site migration. Maintenance and monitoring would not be performed under this alternative.

3.2.2 Alternative KR 2 – Institutional and Access Controls

The following key components characterize Alternative KR 2:

- Land use restrictions

- Signage
- Five-year review

Alternative KR 2 requires implementation of ICs in the form of a Notice of Environmental Contamination and ACs (signage) to warn human receptors. Establishing ICs and ACs that may restrict future land use has implications for long-term management of the land. The long-term retention or disposal of the site lands by the government will involve development of a site management strategy separate from the CERCLA process. Five-year reviews are a requirement under CERCLA when contamination is left on site.

3.2.2.1 Summary of Alternative KR 2
Under Alternative KR 2, contaminated sediments would be left in place, and active remediation would be limited to erecting warning signs to reduce the potential for human receptors to become exposed to on-site COCs. Under the 2016 FS, an AOC would be established for the entire signed zone. Warning signs would be installed along the Kuskokwim River shoreline at intervals of approximately 100 yards at the RDM. ICs in the form of land use restrictions would be established at the site to restrict future human exposure by limiting activity, use, and access to the property. The long-term retention or disposal of the site lands by the government will involve development of a site management strategy separate from the CERCLA process.

With contaminated sediments being left in place, five-year reviews meeting the requirements in Section 121 of CERCLA would need to be performed. The intent of five-year review is to assess the protectiveness of the remedy (i.e., alternative) by evaluating whether the remedy is functioning as intended, exposure assumptions are still valid, and new data have been obtained that could alter its effectiveness. If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

3.2.3 Alternative KR 3 - Monitored Natural Recovery
The following key components characterize Alternative KR 3:

- A site-specific monitoring plan for periodic monitoring of sediment COC concentrations and other chemical and physical parameters will be developed.
- Naturally occurring processes that reduce COC concentrations through physical processes such as surface sediment dilution and dispersion will reduce potential risk over time.

- Data collected per the monitoring plan will be analyzed to assess trends in contaminant reduction and assist in the development of the five-year review.

Alternative KR 3 would be implemented in conjunction with KR 2 to mitigate residual risk during monitored natural recovery.

3.2.3.1 Summary of Alternative KR 3

Under Alternative KR 3, contaminated sediments would be left undisturbed in place. Naturally occurring processes in the Kuskokwim River and Red Devil Creek delta are expected to reduce the COC concentrations in sediments. The Red Devil Creek delta and the contaminated downriver sediments are situated on a cut bank of the Kuskokwim River, and are thus likely subject to net erosion at most locations. Although net sedimentation could potentially occur locally, the primary MNR processes would be sediment mixing and dispersion.

Based on information developed in the September 2017 HHRA Supplement (E & E 2017a), the primary exposure pathway of concern is human exposure through direct contact with and incidental ingestion of nearshore sediments. It is expected that, over time, natural recovery mechanisms can effectively reduce the potential for human receptors to come in contact with contaminated sediments.

The effectiveness of KR 3 is also related to source removal actions within the RDM. Interim actions performed as a part of the 2014 non-time-critical removal action included grading to remove actively eroding tailings piles, and the construction of a sediment trap to prevent further transport of contaminated materials to the Red Devil Creek delta and Kuskokwim River. Removal of contaminated mine tailings and soil in the upland portions of the site, as described by remedial Alternatives 3 and 4 in the 2016 FS report, would further eliminate sources of contaminant transport into the delta and downriver areas. Due to the decrease in source deposition as a result of these existing and proposed remedial actions, it is expected that natural recovery mechanisms will result in decreased potential for exposure over time.

Active remediation under alternative KR 3 is limited to implementation of the site-specific monitoring plan. The monitoring plan should include provisions for triggering contingency actions such as additional monitoring or development of an appropriate response as needed. Detailed development of the monitoring plan and associated contingency plan will take place during engineering design. With contaminated sediments being left in place, five-year reviews meeting the requirements in Section 121 of CERCLA would need to be performed. The intent of five-year review is to assess the protectiveness of the remedy (i.e., alternative) by evaluating whether the remedy is functioning as intended, exposure assumptions are still valid, and new data have been obtained that could alter its effectiveness.

3.2.4 Alternative KR 4 (a and b) – Limited Dredging of Materials within the Lower Delta

The following key components characterize Alternative KR 4a (on-site disposal) and 4b (off-site disposal):

- Approximately 18,000 cubic yards of materials within the lower delta will be removed by mechanical dredging. Shallow lower delta materials will be removed using long-stick excavators from shore, and deep lower delta materials will be removed from a barge-mounted dredge.
- Dredged spoils will be transported to a staging and material handling area adjacent to the Red Devil Creek delta.
- Dredged spoils will be passively dewatered using site controls to minimize the potential for erosion and transport of dredged sediments back into Red Devil Creek and the Kuskokwim River. Water emerging from the dewatering area will be monitored to ensure compliance with water quality criteria prior to discharging to the Kuskokwim River.
- Dewatered dredged spoils will be transported and disposed of in accordance with the selected alternative as presented in the 2016 FS report. Estimated costs are included in this FS Supplement report for consolidation in an on-site repository (KR 4a) and at an approved off-site landfill (KR 4b).

3.2.4.1 Alternative Summary

The extent of dredging would be limited to materials within the lower delta, as depicted in Figures 1-4 and 2-2.

A proposed sequence of dredging operations is as follows:

1. Excavate and grade as needed to create a material handling area adjacent to the delta.
2. Excavate delta sediments from shore to the extent possible, using a long-reach excavator to remove target sediments within approximately 100 feet horizontally from shore down to a depth of approximately 5 feet, as needed. Dredged spoils will be dewatered within the material handling area.
3. Excavate deep sediments using an excavator on an anchored barge. Dredged spoils would be dewatered within the material handling area.
4. Dispose of dewatered dredged spoils in accordance with the selected alternative as presented in the 2016 FS report. Estimated costs are included in this FS Supplement report for disposal of the sediments in an on-site repository (KR 4a) and at an approved off-site landfill (KR 4b).

Costs associated with mechanical dredging are expected to be moderate to high and would also require the construction of infrastructure such as docks and offloading areas.

3.2.5 Alternative KR 5 (a and b) – Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments

The following key components characterize Alternative KR 5a (on-site disposal) and KR 5b (off-site disposal):

- Approximately 18,000 cubic yards of materials within the lower delta will be excavated as described under Alternative KR 4a and KR 4b. In addition, 300 cubic yards of nearshore Kuskokwim River sediments will be removed by mechanical dredging, which will require a barge-mounted dredge.
- Dredged spoils will be transported to a staging and material handling area adjacent to the Red Devil Creek delta.
- Dredged spoils will be passively dewatered using site controls to minimize the potential for erosion and transport of dredged sediments back into Red Devil Creek and the Kuskokwim River. Water emerging from the dewatering area will be monitored to ensure compliance with water quality criteria prior to discharging to the Kuskokwim River.
- Dewatered dredged spoils will be transported and disposed of in accordance with the selected alternative as presented in the 2016 FS report. Estimated costs are included in this FS Supplement report for consolidation in an on-site repository (KR 5a) and at an approved off-site landfill (KR 5b).

3.2.5.1 Alternative Summary

The extent of dredging would include the Red Devil Creek the lower delta and areas of nearshore Kuskokwim River sediments where arsenic concentrations exceed the RG (depicted in Figures 1-4 and 2-2).

A preliminary sequence of dredging operations is as follows:

1. Excavate and grade as needed to create a material handling area adjacent to the delta.
2. Excavate target nearshore sediments with a long-reach excavator, operating from shore to the extent possible, within approximately 100 feet horizontally from shore down to a depth of approximately 5 feet as needed. Dredged spoils will be transported to a dewatering pad within the material handling area
3. Excavate deep sediments and downriver sediments using an excavator on an anchored barge. Dredged spoils would be temporarily loaded on a

second barge and transported to shore for offloading to a dewatering pad within the material handling area.

4. Dewatered dredged spoils will be disposed of in accordance with the selected alternative as presented in the 2016 FS. At the time of writing of this FS Supplement report, a disposal alternative for contaminated site materials has not yet been selected. However, estimated costs are included in this FS Supplement report for disposal of the sediments in an on-site repository (KR 5a) and at an approved off-site landfill (KR 5b).

Costs associated with mechanical dredging are expected to be moderate to high and would require the construction of infrastructure such as docks and offloading areas.

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4 Detailed Analysis of Remedial Alternatives

This chapter presents the NCP evaluation criteria and provides detailed individual and comparative analyses of the remedial alternatives.

4.1 Evaluation Criteria

The NCP specifies nine evaluation criteria. The first two relate to statutory requirements and are considered threshold criteria, which each remedial alternative must satisfy in order to be eligible for selection. The next five are referred to as primary or balancing criteria and are used to evaluate the technical aspects of a remedial alternative. The final two criteria are considered modifying criteria and are addressed in the Record of Decision after comments are received on the RI and RI Supplement and FS and FS Supplement reports and the Proposed Plan.

The nine NCP evaluation criteria are:

Threshold Criteria:

1. Overall Protection of Human Health and the Environment
2. Compliance with ARARs

Primary Criteria:

3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, and Volume through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost

Modifying Criteria:

8. State Acceptance
9. Community Acceptance

The following subsections describe each evaluation criterion.

4.1.1 Overall Protection of Human Health and the Environment

This criterion is used to assess the ability of a remedial alternative to protect human health and the environment from identified risks. The overall assessment of protection draws on the assessments conducted under other evaluation criteria and describes how site risks posed through each pathway addressed by the FS are eliminated, reduced, or controlled through treatment, engineering controls, or ICs. Based on findings from the HHRAs and BERAs and the development of site-specific background concentrations, protectiveness of human health and the environment is evaluated based on the remedial alternative's ability to reduce contaminant concentrations to meet the RAOs and/or reduce or eliminate exposure pathways.

4.1.2 Compliance with ARARs

This criterion is used to determine whether a remedial alternative would meet the federal and state ARARs identified in Chapter 2, Table 2-5. This section also includes a table identifying whether and/or how each alternative, except the No Action alternative, complies with the pertinent individual ARARs.

The ability of a remedial alternative to comply with certain ARARs that have been identified for the remedial action can depend entirely on the manner in which the remedy is implemented. For evaluation purposes, it is assumed that any action remedy selected would be implemented in a manner that would meet these ARARs.

4.1.3 Long-Term Effectiveness and Permanence

This criterion is used to assess the long-term ability of the remedial alternative to address the threshold criteria by (1) assessing the risk remaining at the site after implementation of the remedial alternative, and (2) evaluating the long-term adequacy and reliability of the remedial alternative, including requirements for management and monitoring.

4.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment

This criterion is used to assess the ability of a remedial alternative to reduce the inherent risk of the waste material through treatment. Treatment technologies that permanently and significantly reduce toxicity, mobility, or volume are preferred over alternatives that manage untreated waste.

4.1.5 Short-Term Effectiveness

This criterion is used to assess the risks posed to the community, workers, and the environment during implementation of the remedial action. Measures that would be taken to mitigate these risks are addressed under this criterion. This criterion also considers the time required to achieve RGs.

4.1.6 Implementability

The implementability criterion addresses the constructability of a given remedy, including the presence of the necessary support infrastructure and the permitting requirements. This criterion involves analysis of the technical feasibility, administrative feasibility, and availability of services and materials.

4.1.7 Cost

This criterion is used to assess the anticipated capital and annual O&M and monitoring costs associated with a remedial alternative over a 30-year period. Capital costs consist of direct (construction) and indirect (non-construction and overhead) costs. Capital and annual costs in this FS Supplement report are presented in 2017 dollars, shown as net present worth costs calculated with a 3.5% discount factor. Detailed cost estimates are provided in Appendix B. A summary of capital and annual costs is provided in the detailed evaluation for each alternative.

4.1.8 State Acceptance

This assessment evaluates technical and administrative issues and concerns that the State (or support agency) may have regarding each of the remedial alternatives. State acceptance is not part of the evaluation process provided within this document. Following the issuance of a Proposed Plan for the RDM, this criterion would then be evaluated.

4.1.9 Community Acceptance

This assessment evaluates issues and concerns the public may have regarding each of the remedial alternatives. Community acceptance is not part of the evaluation process provided within this document. As with State acceptance, this criterion would then be evaluated following the issuance of a Proposed Plan for the RDM.

4.2 Individual Analysis of Groundwater Remedial Alternatives

Each evaluation criterion is broken down into sub-criteria to evaluate each alternative. The following subsections summarize the major components of each remedial alternative and, where necessary, provide additional information pertinent to the analysis. It is important to note that the groundwater remedies outlined below pertain to a scenario in which a source removal action has been selected and executed, such as described in Alternatives 3 and 4 in the 2016 FS. This scenario recognizes that residual contamination may be present in the groundwater immediately following the removal action. The remedies detailed in this FS Supplement report do not address groundwater in the event that source materials remain in place. Details of each remedial alternative were presented in Chapter 3.

4.2.1 Alternative GW 1 – No Action

Under Alternative GW 1, a groundwater remedy would not be implemented; therefore, groundwater at the RDM would remain in its current state. The evaluation of Alternative GW 1 is provided below.

4.2.1.1 Overall Protection of Human Health and the Environment
Since no action would be implemented, this alternative offers no protection of human health. The baseline risk assessment did not identify risk to ecological receptors. To a degree, some human risks identified in the RI would remain, albeit significantly reduced over time following source removal.

4.2.1.2 Compliance with ARARs
Because no action is being taken, this alternative would not meet water quality standards. Since this alternative provides no controls, current and potential site risks would remain, with no mechanism for tracking contaminant concentrations over time. It should be noted that under any alternative, cleanup to maximum contaminant levels (MCLs) for antimony and arsenic is not achievable at the site.

4.2.1.3 Long-Term Effectiveness and Permanence
The No Action alternative does not offer any mechanism for determining long-term effectiveness or permanence.

4.2.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment
There is no reduction in mobility and volume, nor any mechanism for determining toxicity, under this alternative. In time, contaminant concentrations may be reduced through naturally occurring processes.

4.2.1.5 Short-Term Effectiveness
With no action being taken, there are no short-term risks associated with construction activities under this alternative.

4.2.1.6 Implementability
While technically implementable in the sense that no action would be taken, Alternative GW 1 is not considered to be administratively implementable.

4.2.1.7 Cost
Since no action would be taken, no construction or O&M costs are associated with Alternative GW 1.

4.2.2 Alternative GW 2 – Institutional and Access Controls
Under Alternative GW 2, posted warning signs would be installed along the perimeter of the site and ICs would be implemented.

4.2.2.1 Overall Protection of Human Health and the Environment
The use of warning signs would reduce potential human contact with contaminated groundwater. Land use restrictions could be crafted such that public access to the site would be limited and performed in a manner that reduced the potential for exposure. Consequently, intrusive activities resulting in ingestion, inhalation, and dermal contact from potential human receptors would be prevented. Therefore,

Alternative GW 2 provides a limited amount of additional protection for human health. The baseline risk assessment did not identify risk to ecological receptors.

4.2.2.2 Compliance with ARARs

ICs could be implemented and warning signs posted in a way that achieves compliance with action- and location-specific ARARs (see Table 4-1). An AOC would be established within the signed zone. Land use restrictions could be crafted such that public access to the site would be limited and performed in a manner that reduced the potential for exposure. However, compliance with chemical-specific ARARs would not be achieved—specifically, the Safe Drinking Water Act, Alaska Water Quality Standards, and Clean Water Act Water Quality Standards. It should be noted that under any alternative, cleanup to MCLs for antimony and arsenic is not achievable at the site and ICs will be required.

4.2.2.3 Long-Term Effectiveness and Permanence

Once implemented, the risk of human exposure to groundwater containing concentrations of contaminants above the RGs would be reduced. Provided that warning signs are maintained and land use is restricted to reduce potential exposure to contaminated groundwater, Alternative GW 2 does offer a long-term effective and permanent solution for human exposure. This alternative would not be effective in reducing contaminant migration from the site; however, contaminant concentrations in groundwater would gradually decrease until they were fully flushed from the system. Therefore, overall permanence is provided for under this alternative.

4.2.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Under Alternative GW 2, there would be no reduction of toxicity, mobility, or volume through treatment. In time, contaminant concentrations may be reduced through naturally occurring processes.

4.2.2.5 Short-Term Effectiveness

Given that the installation of signage does not require heavy equipment, and installation is limited to installation of signposts, with post installation requiring the use of hand tools to dig approximately 4 feet below ground surface, Alternative GW 2 would pose minimal risks to the community, workers, and the environment during its implementation.

4.2.2.6 Implementability

Technically, Alternative GW 2 is implementable. Deed restrictions are established and have well-documented procedural methods. Fence installation and sign preparation are straightforward and common construction activities. Even with the remote nature of the RDM, no problems are anticipated in obtaining and transporting the materials, labor, and equipment to the site.

4.2.2.7 Cost

ICs and ACs would be implemented as described in the 2016 FS. As a result, no additional capital or O&M costs would be required under this alternative.

4.2.3 Alternative GW 3 – Monitored Natural Attenuation

Alternative GW 3 assesses the rate and magnitude of contaminant reduction through naturally occurring physical and chemical processes to meet site-specific RAOs. It is assumed that 10 groundwater monitoring wells would be installed for sample collection and analysis. It is anticipated that ICs and ACs intended to restrict site access would be implemented as described in the 2016 FS to enhance the effectiveness of this alternative.

4.2.3.1 Protection of Human Health and the Environment

Under this alternative, human health would be protected by implementing ICs and ACs as described for Alternative GW 2. Consequently, intrusive activities resulting in ingestion, inhalation, and dermal contact from potential human receptors would be reduced while MNA is performed. ICs and ACs would need to be implemented to reduce the risk to human health even after RGs are met. The baseline risk assessment did not identify risk to ecological receptors.

4.2.3.1 Compliance with ARARs

This alternative could be implemented in a manner that complies with the ARARs by developing a site-specific monitoring plan to obtain data of a sufficient nature to determine whether a specific area has met RGs (see Table 4-2). As a part of the site-specific monitoring plan, criteria for contingency actions would be evaluated and selected based on effectiveness and meeting the necessary protectiveness established by the pertinent ARAR. It should be noted that under any alternative, cleanup to MCLs for antimony and arsenic is not achievable at the site and ICs will be required following alternative completion. Therefore, Alternative GW 3 is expected to provide for compliance with identified ARARs.

4.2.3.2 Long-Term Effectiveness and Permanence

Alternative GW 3 may provide a long-term and permanent solution if sufficient evidence of contaminant reduction through natural processes is obtained. Implementation of ICs and ACs in conjunction with this alternative would further increase its effectiveness.

4.2.3.3 Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative allows for the reduction of residual contaminant concentrations through naturally occurring processes after source materials have been removed. Residual groundwater contamination would be addressed through naturally occurring processes that would offer an overall risk reduction. However, no reduction of toxicity, mobility, and volume through treatment would be achieved.

4.2.3.4 Short-Term Effectiveness
Since groundwater monitoring and reporting are the major work items, there are limited adverse effects in the short term associated with Alternative GW 3.

4.2.3.5 Implementability
Alternative GW 3 is implementable, both technically and administratively. A groundwater monitoring well network has already been installed at the RDM, and extensive groundwater monitoring has been conducted. Under this alternative, a drill rig would be mobilized to the site to install up to 10 new groundwater monitoring wells. Following initial implementation, annual monitoring would be conducted to collect and analyze groundwater samples to demonstrate whether contaminant concentration reductions are occurring. A site-specific monitoring plan would be developed to evaluate this alternative's effectiveness, future sampling frequency, and criteria for contingency actions. This alternative also includes five-year reviews to assess whether the remedy is effective at meeting RGs.

4.2.3.6 Cost
The total capital cost associated with Alternative GW 3 is $260,000. The annual O&M cost is estimated to be $36,000, and the 30-year present worth cost has been determined to be $920,000. A summary of the key cost components is presented in Table 4-3, with additional supporting information provided in Appendix B.

4.2.4 Alternative GW 4 – Passive Groundwater Treatment
Alternative GW 4 includes treating residual groundwater to meet site-specific RAOs. Given the remote nature of the site and lack of nearby power supply, the treatment system would consist of a permeable reactive barrier that uses the naturally occurring hydraulic gradient to drive the groundwater through a porous, iron-based medium, causing the metals to be adsorbed onto it. Additionally, ICs and ACs intended to restrict site access would be implemented as described for Alternative GW #2.

4.2.4.1 Protection of Human Health and the Environment
This alternative is protective of human health and the environment because it removes contaminants from solution in the groundwater, preventing them from mobilizing downgradient and entering surface water. By implementing ICs and ACs as described for Alternative GW 2, intrusive activities resulting in ingestion, inhalation, and dermal contact from potential human receptors would be reduced while passive treatment is performed. ICs and ACs would need to be implemented to reduce the risk to human health even after RGs are met. The baseline risk assessment did not identify risk to ecological receptors.

4.2.4.2 Compliance with ARARs
This alternative could be implemented in a manner that complies with the ARARs by developing a site-specific monitoring plan to obtain data of a sufficient nature to determine whether RGs have been met (see Table 4-4). It should be noted that

under any alternative, cleanup to MCLs for antimony and arsenic is not achievable at the site and ICs will be required following alternative completion. Therefore, Alternative GW 4 is expected to provide for compliance with identified ARARs.

4.2.4.3 Long-Term Effectiveness and Permanence

Treatment of potential residual groundwater contamination would provide a long-term and permanent solution for reducing human and ecological exposure to contaminants and reduce potential for continued contaminant migration from the site. Provided that an appropriate confirmation sampling and analysis plan is implemented as part of the remedy, this alternative would provide a high level of certainty that areas of contamination would meet RGs.

4.2.4.4 Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative reduces the mobility of residual contaminant concentrations in groundwater through adsorption in a permeable reactive barrier. While the contaminants would be immobilized, this alternative does not reduce the toxicity or volume of contamination but rather contains it within a smaller area.

4.2.4.5 Short-Term Effectiveness

Given that any residual contamination in groundwater lies in the subsurface, Alternative GW 4 would pose minimal risk to the community, workers, and the environment during its implementation. Workers involved in constructing a permeable reactive barrier would be subject to health and safety risks associated with heavy construction equipment in a remote setting and exposure to media containing elevated concentrations of arsenic, which may be mitigated through the use of personal protective equipment.

4.2.4.6 Implementability

Alternative GW 4 is implementable, both technically and administratively. Proper design and construction of PRBs requires a strong understanding of site hydrogeological conditions, which may require additional site characterization and analysis. However, groundwater hydraulic conductivity, depth, and contaminant concentrations are expected to be relatively low, indicating that construction of PRBs at the RDM may be constructed using equipment that will be used for source removal actions. This alternative also includes installing 10 new monitoring wells for annual monitoring as described for Alternative GW 3. A site-specific monitoring plan would be developed to evaluate this alternative's effectiveness, as well as to evaluate criteria for contingency actions.

4.2.4.7 Cost

The total capital cost associated with Alternative GW 4 is $1,450,000. The annual O&M cost is estimated to be $43,000, and the 30-year present worth cost has been determined to be $2,240,000. A summary of the key cost components is presented in Table 4-5, with additional supporting information provided in Appendix B.

4.3 Individual Analysis of Kuskokwim River Remedial Alternatives

Each evaluation criterion is broken down into sub-criteria to evaluate each alternative. The following subsections summarize the major components of each remedial alternative and, where necessary, provide additional information pertinent to the analysis. Details of each remedial alternative are presented in Chapter 3, above.

4.3.1 Alternative KR 1 – No Action

Under Alternative KR 1, no remedy would be implemented; therefore, materials within the lower delta and nearshore sediments would remain in place. The evaluation of Alternative KR 1 is provided below.

4.3.1.1 Overall Protection of Human Health and the Environment

Since no action would be implemented, this alternative offers no protection of human health and the environment. The risks to human receptors identified in the RI would remain. For ecological receptors, no COCs are identified because the BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints (E & E 2017a); therefore, protection of the environment is already achieved. Since this alternative provides no controls, current and potential site risks would remain, with no mechanism for tracking contaminant concentrations over time.

4.3.1.2 Compliance with ARARs

This alternative complies with ARARs.

4.3.1.3 Long-Term Effectiveness and Permanence

The No Action alternative does not offer any mechanism for determining long-term effectiveness or permanence.

4.3.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment

There is no reduction in mobility and volume nor any mechanism for determining toxicity under this alternative. In time, contaminant concentrations may be reduced through naturally occurring processes.

4.3.1.5 Short-Term Effectiveness

With no action being taken, there are no short-term risks associated with construction activities under this alternative.

4.3.1.6 Implementability

While technically implementable in the sense that no action would be taken, Alternative KR 1 is not considered to be administratively implementable. With no equipment or materials needed, the No Action alternative is implementable from this vantage point.

4.3.1.7 Cost
Given that no action would be taken, there are no construction or O&M costs associated with Alternative KR 1.

4.3.2 Alternative KR 2 – Institutional and Access Controls
Under Alternative KR 2, ICs and ACs intended to restrict site access would be implemented to enhance the effectiveness of this alternative. Warning signs would be installed along the Kuskokwim River shoreline.

4.3.2.1 Overall Protection of Human Health and the Environment
The use of warning signs would reduce potential human exposure associated with direct contact with contaminated sediments. However, warning signs would not reduce migration of contamination. Land use restrictions could be crafted such that public access to the site would be limited and performed in a manner that reduces the potential for exposure. Consequently, the potential for direct contact, intrusive activities, and potential human exposure would be reduced as well. Therefore, Alternative KR 2 provides a limited amount of protection for human health. For ecological receptors, no COCs are identified because the BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints (E & E 2017a); therefore, protection of the environment is already achieved.

4.3.2.2 Compliance with ARARs
Alternative KR 2 complies with chemical-specific ARARs and could be implemented to be compliant with location- and action-specific ARARs (see Table 4-6).

4.3.2.3 Long-Term Effectiveness and Permanence
Once implemented, the risk of human exposure to sediments containing concentrations of contaminants above the RG would be reduced. Provided that the warning signs are maintained, and land use is restricted to reduce potential exposure to contaminated material, Alternative KR 2 does offer a long-term effective and permanent solution for human exposure. However, it offers no reduction with regard to ecological exposure. Additionally, this alternative would not be effective in reducing contaminant migration from the site. Therefore, overall permanence is not provided for under this alternative.

4.3.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment
Under Alternative KR 2, there would be no reduction of toxicity, mobility, or volume of contaminated sediments through treatment. In time, contaminant concentrations may be reduced through naturally occurring processes.

4.3.2.5 Short-Term Effectiveness

Given that the installation of signage does not require heavy equipment, Alternative KR 2 would pose minimal risks to the community, workers, and the environment during its implementation.

4.3.2.6 Implementability

Technically, Alternative KR 2 is implementable. Deed restrictions are established and have well-documented procedural methods. Sign installation is a straightforward and common construction activity. Even with the remote nature of the RDM, no problems are anticipated in obtaining and transporting the materials, labor, and equipment to the site.

4.3.2.7 Cost

The total capital cost associated with Alternative KR 2 is $18,000. The annual O&M cost is estimated to be $6,000, and the 30-year present worth cost has been determined to be $130,000. A summary of the key cost components is presented in Table 4-7, with additional supporting information provided in Appendix B.

4.3.3 Alternative KR 3 – Monitored Natural Recovery

Under Alternative KR 3, contaminated sediments would be left in place. Naturally occurring processes in the Kuskokwim River and Red Devil Creek delta are expected to reduce the volume of contaminants at the site. Assuming that source reduction is performed, the volume of in-place contaminated sediments will also be reduced. The geomorphic setting of the Red Devil Creek delta is that of a scour environment with heavily armored bed sediments. Based on this environment, the primary recovery mechanisms are expected to be surface sediment dilution, consolidation, and bed armoring. A site-specific monitoring plan will be implemented to assess trends in contaminant reduction and trigger contingency actions if necessary. In addition to O&M in the form of monitoring costs, Alternative KR 3 would also require implementation of ICs, signage, and five-year reviews. Sediment sampling has been successfully conducted at the RDM using sediment augers from a small vessel.

4.3.3.1 Overall Protection of Human Health and the Environment

Alternative KR 3 does not remove, stabilize, or treat the contaminated sediments. However, a site-specific monitoring program would be developed for this alternative to ascertain the effectiveness of surface sediment dilution, consolidation, and bed armoring, and provide for contingency actions if necessary. This alternative also implements ICs and ACs that would reduce potential human exposure associated with direct contact of contaminated sediments. As a result, this alternative offers limited protection of human health. For ecological receptors, no COCs are identified because the BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints (E & E 2017a); therefore, protection of the environment is already achieved.

4.3.3.2 Compliance with ARARs

Alternative KR 3 complies with chemical-specific ARARs and could be implemented to be compliant with location- and action-specific ARARs (see Table 4-8).

4.3.3.3 Long-Term Effectiveness and Permanence

Alternative KR 3 may provide a long-term and permanent solution if sufficient evidence of contaminant reduction through natural processes is obtained. ICs and ACs would need to be implemented to reduce the risk to human health until the RG is met.

4.3.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative allows for the reduction of residual contaminant concentrations through naturally occurring processes. While the risk associated with the sediment will be reduced under this alternative, there is no reduction of toxicity, mobility, and volume through treatment.

4.3.3.5 Short-Term Effectiveness

The only activities proposed under this alternative are periodic sediment sampling and annual maintenance of ICs and ACs, which do not present a significant increase in short-term risks.

4.3.3.6 Implementability

Alternative KR 3 can be implemented both technically and administratively. Sediment sampling has been successfully performed at the RDM during remedial investigations, and this alternative provides a means to demonstrate whether contaminant concentration reductions are occurring. It also allows for five-year reviews to assess whether the remedy is effective at meeting the RG. Implementation of ICs and ACs in conjunction with this alternative would further increase its effectiveness.

4.3.3.7 Cost

The total capital cost associated with Alternative KR 3 is $18,000. The annual O&M cost is estimated to be $91,000, and the 30-year present worth cost has been determined to be $1,670,000. A summary of the key cost components is presented in Table 4-9, with additional supporting information provided in Appendix B.

4.3.4 Alternative KR 4a – Limited Dredging of Materials within the Lower Delta for Disposal in On-site Repository

Alternative KR 4a includes the excavation of approximately 18,000 cubic yards of materials within the lower delta, as depicted in Figure 2-2. This alternative does not address approximately 300 cubic yards of nearshore contaminated sediments located downstream of the delta. A material handling area would be constructed on shore adjacent to the delta for drying and stockpiling dredged sediments. Long-reach excavators would be used to remove target sediments within approximately 100 feet horizontally from shore down to a depth of approximately 5 feet. Dredged spoils would be dewatered within the material handling area and allowed to passively drain. Deep sediments would then be excavated from an anchored spud barge and temporarily loaded onto a second barge and transported to shore for offloading to a dewatering pad. Dewatered dredged spoils would be disposed of in accordance with the selected alternative as presented in the 2016 FS. At the time of writing of this FS Supplement report, a disposal alternative for contaminated site materials has not yet been selected. Under this alternative, it is assumed that sediments are consolidated in an on-site repository.

4.3.4.1 Overall Protection of Human Health and the Environment

By excavating materials within the lower delta and consolidating them into a repository, Alternative KR 4a would largely provide protection of human health. For ecological receptors, no COCs are identified because the BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints (E & E 2017a); therefore, protection of the environment is already achieved.

While this alternative would involve no reduction in the contaminant concentrations, the overall risk would be reduced by consolidating the contaminated sediments in a repository. Repository configurations were evaluated in the 2016 FS.

Approximately 300 cubic yards of contaminated nearshore Kuskokwim River sediment downstream of the delta would require ICs and ACs. Based on removal of the materials within the lower delta, the overall risk posed by nearshore Kuskokwim River sediment is expected to drop to levels protective of human health. For this reason, the remaining downstream nearshore Kuskokwim River sediment would not require removal to meet risk criteria.

4.3.4.2 Compliance with ARARs

Alternative KR 4a complies with chemical-specific ARARs and could be implemented to be compliant with location- and action-specific ARARs (see Table 4-10).

It should be noted that during the remedial design as individual components are developed, ARAR compliance will be a key evaluation criterion. Not only does the final product need to meet its intended goal, it also needs to meet with the appropriate ARAR.

During the design phase, ARARs would be further reviewed, and their requirements could be incorporated into the design. Dredging would therefore be designed and implemented in a manner compliant with action- and location-specific ARARs.

4.3.4.3 Long-Term Effectiveness and Permanence

Consolidating materials within the lower delta with concentrations above the RG into a dedicated repository can provide a long-term and permanent solution. Additionally, this alternative would reduce human and ecological exposure to contaminants and reduce potential for continued contaminant migration from the site. Provided that an appropriate confirmation sampling and analysis plan is implemented as part of the remedy, this alternative would provide a high level of certainty that areas of contamination would be removed to meet the RG.

However, nearshore Kuskokwim River sediments that exceed the RG would be left in place under this alternative. There would be no reduction in contaminant migration of these sediments. While human exposure can be reduced through ICs and ACs, ecological exposure would remain unchanged.

4.3.4.4 Reduction of Toxicity, Mobility, and Volume through Treatment

There is no on-site treatment component associated with this alternative. However, the mobility of contaminants would be reduced by removing materials within the lower delta materials above the RG and consolidating them in an on-site repository.

4.3.4.5 Short-Term Effectiveness

During dredging operations, contaminated sediments may become mobilized and migrate downstream, which may present a limited short-term risk associated with the local population. Workers involved in remedial action would be subject to health and safety risks associated with heavy construction equipment in a remote setting and exposure to media containing elevated concentrations of arsenic, which may be mitigated through the use of personal protective equipment.

4.3.4.6 Implementability

Alternative KR 4a is both technically and administratively implementable. Mechanical dredging of contaminated sediments is a common and effective practice. Water management may be difficult in and along the Kuskokwim River, which may require water quality monitoring during dredging and dewatering activities. Sediment dewatering times should be carefully considered during the design phase to ensure that dredging activities are completed during the limited construction season.

Given the remote location, mobilization of heavy construction equipment would be a major logistical component that would require barging materials over long distances. However, mobilizing the resources needed to implement Alternative KR 4a is feasible.

Repository configurations are detailed and evaluated in the 2016 FS and have been determined to be both technically and administratively implementable.

4.3.4.7 Cost

The total capital cost associated with Alternative KR 4a is $6,060,000. The annual O&M cost is estimated to be $17,000, and the 30-year present worth cost has been determined to be $6,370,000. A summary of the key cost components is presented in Table 4-11, with additional supporting information provided in Appendix B.

4.3.5 Alternative KR 4B4b – Limited Dredging of Materials within the Lower Delta for Off-Site Disposal

Alternative KR 4b includes the excavation of materials within the lower delta as described for Alternative KR 4a, but with disposal at an off-site facility. Contaminated sediments would be containerized and shipped to an approved landfill in the contiguous United States (assumed to be located in Oregon for FS Supplement costing purposes).

4.3.5.1 Overall Protection of Human Health and the Environment

By excavating materials within the lower delta and disposing of them off site, Alternative KR 4b would largely provide protection of human health. For ecological receptors, no COCs are identified because the BERA Supplement for the Kuskokwim River identified only marginal risks to the assessment endpoints (E & E 2017a); therefore, protection of the environment is already achieved.

While this alternative would involve no reduction in contaminant concentrations, the overall risk would be reduced by disposing of them in a secured, permitted landfill.

Approximately 300 cubic yards of contaminated nearshore Kuskokwim River sediment downstream of the delta would require ICs and ACs. Based on removal of the materials within the lower delta, the overall risk posed by nearshore Kuskokwim River sediment is expected to drop to levels protective of human health. For this reason, the remaining downstream nearshore Kuskokwim River sediment would not require removal to meet risk criteria.

4.3.5.2 Compliance with ARARs

Alternative KR 4b complies with chemical-specific ARARs and could be implemented to be compliant with location- and action-specific ARARs (see Table 4-10). With regard to shipping, approximately 18,000 cubic yards of material would be disposed of in the contiguous United States. Based on RI sample results, dredged sediments are not expected to be classified as a hazardous waste. The sampling plan described above will outline the method for sampling and classifying material prior to shipping.

The remedial design will also outline the specifics associated with U.S. Department of Transportation requirements associated with transport for each state that the material will pass through. As part of the 2016 FS, barges permitted to haul hazardous waste were contacted to obtain price quotes. Once the material has left the RDM and arrived at a modern port (Anchorage, Seward, Bethel, etc.), it will be handled by port operations that are familiar with and equipped to handle hazardous waste and meet the required safety and shipping protocols.

It should be noted that during the remedial design as individual components are developed, ARAR compliance will be a key evaluation criterion. Not only does the final product need to meet its intended goal, it also needs to meet the pertinent ARAR.

During the design phase, ARARs would be further reviewed, and their requirements could be incorporated into the design. Dredging would therefore be designed and implemented in a manner compliant with the ARARs.

4.3.5.3 Long-Term Effectiveness and Permanence

Excavation of materials within the lower delta having contaminant concentrations above the RG and transporting them to an appropriately licensed and maintained landfill located in the contiguous United States could provide a long-term and permanent solution. Removing the contaminated materials from the lower delta would provide an effective means of reducing human and ecological exposure, as well as future migration of contaminants from the site. Removal effectiveness would be demonstrated by confirmation sampling and analysis.

Under this alternative, nearshore Kuskokwim River sediments that exceed the RG would be left in place. There would be no reduction in contaminant migration of these sediments. While human exposure can be reduced through ICs and ACs, ecological exposure would remain unchanged.

4.3.5.4 Reduction of Toxicity, Mobility, and Volume through Treatment

There is no on-site treatment component associated with this alternative. However, the mobility of contaminants would be reduced by disposing of the materials within the lower delta materials that exceed the RG in a secured, permitted landfill.

4.3.5.5 Short-Term Effectiveness

During dredging operations, some contaminated sediments may be mobilized downstream in the Kuskokwim River, which may present a limited short-term risk associated with the local population. Workers involved in remedial action would be subject to health and safety risks associated with heavy construction equipment in a remote setting and exposure to media containing elevated concentrations of arsenic, which may be mitigated through the use of personal protective equipment.

4.3.5.6 Implementability

Alternative KR 4b is both technically and administratively implementable. Mechanical dredging of contaminated sediments and off-site disposal is a common and effective practice. Water management may be difficult in and along the

Kuskokwim River, and may require water quality monitoring during dredging and dewatering activities.

Given the remote location, mobilization of heavy construction equipment would be a major logistical component that would require barging materials over long distances. However, mobilizing the resources needed to implement Alternative KR 4b is feasible.

4.3.5.7 Cost

The total capital cost associated with Alternative KR 4b is $16,650,000. The annual O&M cost is estimated to be $17,000, and the 30-year present worth cost has been determined to be $16,960,000. A summary of the key cost components is presented in Table 4-12, with additional supporting information provided in Appendix B.

4.3.6 Alternative KR 5a – Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediment for Disposal at an On-site Repository

Alternative KR 5a includes the excavation of materials within the lower delta and nearshore Kuskokwim River sediments as depicted in Figure 2-2. This alternative would be executed as described for Alternative KR 4a, with the addition of approximately 300 cubic yards of nearshore sediments located downstream of the Red Devil Creek delta.

4.3.6.1 Overall Protection of Human Health and the Environment

By excavating the lower delta and nearshore, downriver sediments and consolidating them into a repository, Alternative KR 5a would provide protection of human health and the environment. While this alternative would involve no reduction in the contaminant concentrations, the overall risk would be reduced by consolidating the contaminated sediments in a repository and eliminating exposure pathways. Human health and the environment are protected by preventing direct human exposure to the sediments. Repository configurations were evaluated in the 2016 FS.

4.3.6.2 Compliance with ARARs

Alternative KR 5a complies with chemical-specific ARARs and could be implemented to be compliant with location- and action-specific ARARs (see Table 4-13). As part of the remedial design for the RDM, the BLM will work in coordination with agency stakeholders to develop a comprehensive multimedia sampling plan to obtain data of sufficient quality to allow for a determination as to whether a specific area has met the cleanup criteria. Sediment dredging methods will be evaluated and selected based on their effectiveness and whether they meet the necessary protectiveness established by the pertinent ARARs.

4.3.6.3 Long-Term Effectiveness and Permanence
Consolidating excavated material with concentrations above the RG into a dedicated repository provides a long-term and permanent solution. Additionally, this alternative would reduce human and ecological exposure to contaminants and reduce potential for continued contaminant migration from the site. Removal effectiveness would be demonstrated by confirmation sampling and analysis.

4.3.6.4 Reduction of Toxicity, Mobility, and Volume through Treatment
There is no on-site treatment component associated with this alternative. However, the mobility of contaminants would be reduced by removing materials within the lower delta and nearshore Kuskokwim River sediments above the RG and consolidating them in an on-site repository.

4.3.6.5 Short-Term Effectiveness
During dredging operations, some contaminated sediments may be mobilized downstream in the Kuskokwim River, which may present a limited short-term risk associated with the local population. Workers involved in remedial action would be subject to health and safety risks associated with heavy construction equipment in a remote setting and exposure to media containing elevated concentrations of arsenic, which may be mitigated through the use of personal protective equipment.

4.3.6.6 Implementability
Alternative KR 5a is both technically and administratively implementable. Mechanical dredging of contaminated sediments is a common and effective practice. Water management may be difficult in and along the Kuskokwim River, and may require water quality monitoring during dredging and dewatering activities.

Given the remote location, mobilization of heavy construction equipment would be a major logistical component that would require barging materials over long distances. However, mobilizing the resources needed to implement Alternative KR 5a is feasible.

Repository configurations are detailed and evaluated in the 2016 FS. This disposal method is both technically and administratively implementable.

4.3.6.7 Cost
The total capital cost associated with Alternative KR 5a is $6,160,000, and annual O&M would not be required because no contaminated sediments would remain in the river. A summary of the key cost components is presented in Table 4-14, with additional supporting information provided in Appendix B.

4.3.7 Alternative KR 5b – Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments for Off-site Disposal

Alternative KR 5b includes the excavation of materials within the lower delta and contaminated sediments as described for Alternative KR 5a, but with disposal at an off-site facility. Contaminated sediments would be containerized and shipped to an approved landfill in the contiguous United States (assumed to be located in Oregon for FS Supplement costing purposes).

4.3.7.1 Overall Protection of Human Health and the Environment

By excavating the lower delta and nearshore, downriver sediments and consolidating them into a repository, Alternative KR 5a provides protection of human health and the environment. While this alternative would involve no reduction in the contaminant concentrations, the overall risk would be reduced by encapsulating the contaminated sediments in a repository and eliminating exposure pathways. Human health and the environment are protected from the sediments that are consolidated in the repository. Repository configurations were evaluated in the 2016 FS.

4.3.7.2 Compliance with ARARs

Alternative KR 5b complies with chemical-specific ARARs and could be implemented to be compliant with location- and action-specific ARARs (see Table 4-13). As part of the remedial design for the RDM, the BLM will work in coordination with agency stakeholders to develop a sampling and analysis protocol to verify that RAOs are met. Sediment dredging methods will be evaluated and selected based on their effectiveness and whether they meet the necessary protectiveness established by the pertinent ARARs.

With regard to shipping, approximately 18,300 cubic yards of material will be disposed of in the contiguous United States. Based on RI sample results, dredged sediments are not expected to be classified as a hazardous waste. The sampling plan described above will outline the method for sampling and classifying material prior to shipping.

The remedial design will also outline the specifics associated with United States Department of Transportation requirements associated with transport for each state that the material will pass through. As part of the 2016 FS, barges permitted to haul hazardous waste were contacted to obtain price quotes. Once the material has left the RDM and arrived at a modern port (Anchorage, Seward, Bethel, etc.), it will be handled by port operations that are familiar with and equipped to handle hazardous waste and meet the required safety and shipping protocols.

During the design phase, ARARs would be further reviewed, and their requirements could be incorporated into the design.

4.3.7.3 Long-Term Effectiveness and Permanence

Excavation of material having contaminant concentrations above the RG would be disposed of in an appropriately licensed and maintained landfill located in the contiguous United States, providing a long-term and permanent solution. Removing the contaminated materials from materials within the lower delta would provide an effective means of reducing human and ecological exposure, as well as future migration of contaminants. Removal effectiveness would be demonstrated by confirmation sampling and analysis.

4.3.7.4 Reduction of Toxicity, Mobility, and Volume through Treatment

There is no on-site treatment component associated with this alternative. However, the mobility of contaminants would be reduced by dredging the materials within the lower delta and nearshore Kuskokwim River sediments above the RG and consolidating them in an on-site repository.

4.3.7.5 Short-Term Effectiveness

During dredging operations, some contaminated sediments may be mobilized downstream in the Kuskokwim River, which may present a limited short-term risk associated with the local population. Workers involved in remedial action would be subject to health and safety risks associated with heavy construction equipment in a remote setting and exposure to media containing elevated concentrations of arsenic, which may be mitigated through the use of personal protective equipment.

4.3.7.6 Implementability

Alternative KR 5b is both technically and administratively implementable. Mechanical dredging of contaminated sediments and off-site disposal is a common and effective practice. Water management may be difficult in and along the Kuskokwim River, and may require water quality monitoring during dredging and dewatering activities. Sediment dewatering times should be carefully considered during the design phase to ensure dredging activities are completed during the limited construction season.

Given the remote location, mobilization of heavy construction equipment would be a major logistical component that would require barging materials over long distances. However, mobilizing the resources needed to implement Alternative KR 5b is feasible.

4.3.7.7 Cost

The total capital cost associated with Alternative KR 5b is $16,920,000, and annual O&M would not be required because no contaminated sediments would remain in the river. A summary of the key cost components is presented in Table 4-15, with additional supporting information provided in Appendix B.

4.4 Comparative Analysis of Remedial Alternatives for Groundwater

A comparative analysis of groundwater remedial alternatives is provided in the following subsections.

4.4.1 Overall Protection of Human Health and the Environment

Of the four alternatives, Alternative GW 4 offers the highest level of protection of human health and the environment because it involves engineered treatment of residual groundwater contamination. Alternative GW 3 would also be protective of human health and the environment; however, due to unknown rates of reduction in COCs via naturally occurring processes, GW 4 could potentially achieve greater reductions in COC concentrations over a shorter timeframe than GW 3.

Of the two remaining alternatives, Alternative GW 2, while limited, does offer some reduction in human health risk exposure by reducing the public's ability to access the site. While Alternative GW 2 does not address contaminant migration, it provides more protection than Alternative GW 1, which does not provide any reduction in human exposure and/or risk.

4.4.2 Compliance with ARARs

All three "action" alternatives to address groundwater contamination could be implemented to be fully compliant with the ARARs even while acknowledging that cleanup to MCLs for antimony and arsenic is not achievable at the site and ICs will be required.

4.4.3 Long-Term Effectiveness and Permanence

Alternative GW 1 does not provide for long-term effectiveness or permanence. Alternative GW 2 offers slightly more effectiveness and permanence than Alternative GW 1, but not nearly as much as the remaining alternatives.

Alternative GW 3 may provide a long-term and permanent solution if sufficient evidence of contaminant reduction through natural processes is obtained. However, the degree to which natural attenuation processes occurs is unknown at the site; for this reason, a site-specific monitoring plan is an essential component of Alternative GW 3.

GW 4 provides for a higher level of long-term effectiveness and permanence by reducing the mobility of contaminants in the groundwater through passive treatment. Similar to Alternative GW 3, a site-specific monitoring plan would be essential in evaluating effectiveness of the treatment system.

4.4.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Of the alternatives presented to address groundwater contamination at the site, only GW 4 provides for treatment of contaminants, which would be effective at reducing mobility, but not toxicity or volume. Alternative GW 3 allows for the reduction of residual contaminant concentrations through naturally occurring processes; however, no reduction of toxicity, mobility, and volume through treatment would be achieved.

Alternatives GW 1 and GW 2 do not provide for treatment to reduce toxicity, mobility, and volume of contaminated groundwater. Therefore, under these two alternatives, there is still the potential for contaminated groundwater to migrate off site.

4.4.5 Short-Term Effectiveness

No construction activities are proposed under Alternatives GW 1 and GW 2. Site activity under Alternative GW 2 is limited to installation of signposts, with post installation requiring the use of hand tools to dig approximately 4 feet below ground surface. Therefore, Alternative GW 2 would pose minimal risks to the community, workers, and the environment during its implementation.

Alternatives GW 3 and GW 4 would require minimal worker interaction with contaminated groundwater because groundwater is directly accessible only at small springs and seeps that occur along the creek. Alternatives GW 3 and GW 4 would pose minimal risk to the community, workers, and the environment during their implementation.

4.4.6 Implementability

All of the action alternatives can be implemented. In terms of technical, administrative, and logistical concerns, Alternative GW 2 would be the easiest to implement. Installing warning signs and deed restrictions are straightforward processes that are commonly implemented at sites undergoing some type of environmental remediation and/or restoration. Even with the remoteness of the RDM, signage material, labor, and installation equipment can be readily obtained and transported to the site.

Alternative GW 3 involves development and implementation of a site-specific monitoring plan. The monitoring plan would be similar in scope to monitoring conducted during the RI. In comparison with Alternative GW 3, Alternative GW 4 includes the additional logistical component of transporting treatment media and installation on site, as well as removal and disposal of depleted treatment media. No technical or administrative issues would preclude implementation of any of the action alternatives.

In comparison with the action alternatives, Alternative GW 1 is the easiest alternative to implement due to the fact that no work would be performed.

4.4.7 Cost

Alternative GW 4 is the most expensive alternative, with a present worth cost of $2,240,000. The cost of Alternative GW 4 is 2.5 times greater than the next most costly alternative, Alternative GW 3, which has a present worth cost of $920,000.

The present worth cost associated with Alternative GW 2 is $0, as this alternative would be implemented in conjunction with Alternative 2, as described in the 2016 FS report. As a result, no additional capital or O&M costs would be required under Alternative GW 2. There is no cost associated with Alternative GW 1. Table 4-16 provides a summary of the individual alternative costs for groundwater.

4.5 Comparative Analysis of Remedial Alternatives for Materials within the Lower Delta Materials and Nearshore Kuskokwim River Sediment

A comparative analysis of remedial alternatives for materials within the lower delta and nearshore Kuskokwim River sediment is provided in the following subsections.

4.5.1 Overall Protection of Human Health and the Environment

Of the seven alternatives, Alternative KR 5b offers the most protection of human health and the environment because materials within the lower delta materials and nearshore sediments from the Kuskokwim River are removed and disposed of in a permitted landfill. Although Alternatives KR 4a and KR 4b do not remove the downriver nearshore sediments that exceed the RG, they lower overall risk to levels that are similar to those under KR 5b.

Alternative KR 3 provides insight into the rate at which natural processes reduce sediment concentrations. Because KR 3 provides information needed to assess remedial progress, it is more protective than Alternatives KR 1 and KR 2.

4.5.2 Compliance with ARARs

All six “action” alternatives could be implemented to be fully compliant with the ARARs. While Alternatives KR 2, KR 3, KR 4a, and KR 4b could be implemented in a manner that complies with the ARARs, contaminated sediment would initially remain in certain locations above the RG.

4.5.3 Long-Term Effectiveness and Permanence

Alternative KR 1 does not provide for long-term effectiveness and/or permanence. Alternatives KR 2 and KR 3 offer slightly more effectiveness and permanence than Alternative KR 1. Of Alternatives KR 1 through KR 3, KR 3 is most effective, but not nearly as much as the remaining alternatives.

Alternatives KR 4a and KR 4b provide removal of most of the areas containing contaminant concentrations above the RG and consolidating the material in a secured area. However, both alternatives would leave a small amount of contaminated material in the river.

Alternatives KR 5a and KR 5b both involve the removal of materials within the lower delta and nearshore Kuskokwim River sediments above the RG. Alternative KR 5a would employ an on-site repository, while KR 5b includes disposal at a licensed landfill. With a licensed landfill being continuously monitored and maintained, Alternative KR 5b takes advantage of closure plans and related administrative processes already established for the disposal facility. While an on-site repository can be designed and implemented in a way that matches the protectiveness of a secure landfill, the RDM's remote location increases the cost and complexity of long-term monitoring and O&M that is typically performed at such a facility. Therefore, an existing landfill provides marginally better long-term effectiveness and permanence than an on-site repository, which requires some level of O&M as described in the 2016 FS report.

4.5.4 Reduction of Toxicity, Mobility, and Volume through Treatment

None of the alternatives involve treatment of contaminated sediments. However, Alternatives KR 4a, KR 4b, KR 5a, and KR 5b include removal and disposal of contaminated sediments into a landfill or repository, which would achieve a considerable reduction in contaminant mobility.

Alternatives KR 1, KR 2, and KR 3 do nothing to prevent surface water from coming into contact with impacted sediments. Therefore, under these alternatives, there is still marginal potential for metals to impact human health and the environment.

4.5.5 Short-Term Effectiveness

Under Alternative KR 4b and KR 5b, approximately 18,000 cubic yards of material would be transported several thousand miles to a final disposal site. As a result, these two alternatives offer the least short-term effectiveness and generate the most adverse risk. For these alternatives, contaminated material would be loaded and off-loaded multiple times, so there is also an increase in the risk of a release. Material transfers at several ports, and transport over long distances in both brown water and blue water, present the potential for spills and other mishaps.

Of the remaining alternatives, Alternatives KR 4a and KR 5a would generate adverse short-term risk, but considerably less than KR 4b and KR 5b. Hauling dried sediment materials and consolidation in a repository could generate dust containing COCs. Water trucks and personal protective equipment could be used to reduce the potential for exposure. Alternative KR 4a would involve slightly less adverse risk than Alternative KR 5a in that there would be less material excavated and hauled associated with leaving the downriver, nearshore sediments in place. It should be noted that these material handling risks also apply to Alternatives KR 4b and KR 5b.

With no action being performed, Alternative KR 1 has the least amount of adverse short-term risk. While there is a finite amount of site work being performed (i.e., sign installation), Alternative KR 2 has slightly more adverse short-term risk than Alternative KR 1 and far less than the previously discussed alternatives. Alternative KR 3 contains slightly more short-term risk due to periodically sampling the sediments.

4.5.6 Implementability

All of the action alternatives can be implemented. In terms of technical, administrative, and logistical concerns, Alternative KR 2 would be the easiest to implement. Installing warning signs and deed restrictions are straightforward processes that are commonly implemented at sites undergoing some type of environmental remediation and/or restoration. Even with the remoteness of the RDM, signage material, labor, and installation equipment can be readily obtained and transported to the site.

Alternatives KR 4a, KR 4b, KR 5a, and KR 5b involve excavation of contaminated sediments. Alternatives KR 4a and KR 5a are considered to be more implementable because they do not require the dredged spoils to be transported thousands of miles by barge and rail.

Given that no work would be performed, Alternative KR 1 is the easiest alternative to implement.

4.5.7 Cost

Alternatives KR 4b and KR 5b, which include off-site disposal of contaminated sediments, are the most expensive alternatives. Alternative KR 4b contains the highest present worth cost, at $16,960,000, because it leaves contaminated sediments in place, which requires implementation of ICs and AC that contain annual O&M costs. The present worth for Alternative 5b is $16,920,000, which satisfies removal action goals and does not require O&M. Alternatives KR 4a and KR 5a include disposal in an on-site repository and involve present worth costs $6,370,000 and $6,160,000, respectively.

The present worth cost associated with Alternative KR 3 is $1,670,000, Alternative KR 2 is $130,000, and there is no cost associated with Alternative KR 1. Table 4-17 summarizes the individual alternative costs for materials within the lower delta and nearshore Kuskokwim River sediment.

Table 4-1 Alternative GW 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Chemical-Specific				
Federal				
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate	Cleanup to MCLs for antimony and arsenic is not achievable at the site. This Alternative could place restrictions on the use of groundwater.
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate	ARAR not triggered. Alternative does not involve construction.
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate	ARAR not triggered. Groundwater does not contribute contaminants above water quality standards in Red Devil Creek.
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC	TBC not triggered. Alternative does not address sediment.
State				
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate	Alternative will not achieve WQSs. This Alternative could place restrictions on the use of groundwater.

Table 4-1 Alternative GW 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Location-Specific				
Federal				
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department on the Interior to do so.	Applicable	ARAR not triggered. Alternative would not include any activity that could impact archaeological or historic resources.
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable	ARAR not triggered. Alternative would not include any ground disturbing activity.
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable	ARAR not triggered. Alternative would not include any ground disturbing activity that could affect wetlands.
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable	ARAR not triggered. Alternative would not include development within a floodplain.

Table 4-1 Alternative GW 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable	ARAR not triggered. No surface waters affected under this Alternative.
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable	ARAR not triggered. No habitat affected under this Alternative.
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable	ARAR not triggered. No habitat affected under this Alternative.
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable	ARAR not triggered. No habitat affected under this Alternative.
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate	ARAR not triggered. No surface waters affected under this Alternative.

Table 4-1 Alternative GW 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
State				
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable	ARAR not triggered. Alternative would not include any activities that could impact archaeological or historic resources.
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate	ARAR not triggered. No waste would be moved under this Alternative.
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871- .901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable	ARAR not triggered. No habitat affected under this Alternative.
Action-Specific				
Federal				
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the EPA gives states the authority to implement the National Pollutant Discharge Elimination System program.	Applicable	ARAR not triggered. Alternative would not involve discharges of wastewater or newly generated stormwater to surface water.

Table 4-1 Alternative GW 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or offsite.	Applicable	ARAR not triggered. Alternative would not involve any placement of fill material in surface water or wetlands.
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable	ARAR will not achieve WQSs.
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve any dredging of creek or river sediments.
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve construction of a solid waste disposal facility.
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable	Alternative could be implemented in compliance with this order.

Table 4-1 Alternative GW 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance

Key:
AAC = Alaska Administrative Code
ARAR = Applicable or Relevant and Appropriate Requirements
AS = Alaska Statutes
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
EO = Executive Order
ESA = Endangered Species Act
NPDES = National Pollutant Discharge Elimination System
MCL = Maximum Contaminant Level
RCRA = Resource Conservation and Recovery Act
RDM = Red Devil Mine
TBC = To Be Considered
USC = United States Code
WQS = Water Quality Standards

Table 4-2 Alternative GW 3 (Monitored Natural Attenuation) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Chemical-Specific				
Federal				
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate	Alternative could lead to eventual compliance with RGs. Cleanup to MCLs for antimony and arsenic is not achievable at the site.
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate	ARAR not triggered. Alternative unlikely to involve disturbance greater than 1 acre.
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate	ARAR not triggered. Groundwater does not contribute contaminants above water quality standards in Red Devil Creek.
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC	TBC not triggered. Alternative does not address sediment.
State				
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate	Alternative could lead toward eventual compliance with WQSs.

Table 4-2 Alternative GW 3 (Monitored Natural Attenuation) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Location-Specific				
Federal				
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department on the Interior to do so.	Applicable	Alternative could be implemented in compliance with this act.
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable	Alternative could be implemented in compliance with this act.
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable	Alternative could be implemented in compliance with this act.
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable	Alternative could be implemented in compliance with this act.
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable	Alternative could be implemented in compliance with this act.
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-2 Alternative GW 3 (Monitored Natural Attenuation) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable	Alternative could be implemented in compliance with this act.
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable	Alternative could be implemented in compliance with this act.
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
State				
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable	Alternative could be implemented in compliance with these requirements.
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate	Alternative could be implemented in compliance with these regulations.
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871- .901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-2 Alternative GW 3 (Monitored Natural Attenuation) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Action-Specific				
Federal				
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the EPA gives states the authority to implement the National Pollutant Discharge Elimination System program.	Applicable	ARAR not triggered. Alternative would not involve discharges of wastewater or newly generated stormwater to surface water.
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or offsite.	Applicable	ARAR not triggered. Alternative would not involve any placement of fill material in surface water or wetlands.
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable	ARAR not immediately met. Alternative would be implemented to attain eventual compliance with this act.
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve any dredging of creek or river sediments.
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environ-ment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve construction of a solid waste disposal facility.

Table 4-2 Alternative GW 3 (Monitored Natural Attenuation) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable	Alternative could be implemented in compliance with this order.

Key:
AAC = Alaska Administrative Code
ARAR = Applicable or Relevant and Appropriate Requirements
AS = Alaska Statutes
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
EO = Executive Order
ESA = Endangered Species Act
NPDES = National Pollutant Discharge Elimination System
MCL = Maximum Contaminant Level
RCRA = Resource Conservation and Recovery Act
RDM = Red Devil Mine
TBC = To Be Considered
USC = United States Code
WQS = Water Quality Standards

Table 4-3 Cost Estimate Alternative GW 3 — Monitored Natural Attenuation

Item	Description	Quantity	Unit	Cost/Unit	Cost
Direct Capital Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
DC1	Mobilization/Demobilization	1	lump sum	$101,000	$101,000
DC2	Install Groundwater Monitoring Wells	1	lump sum	$85,000	$85,000
Total Direct Capital Costs (rounded to nearest $10,000)					***$186,000***
Indirect Capital Costs					
	Engineering and Design (5%)	5%			$9,000
	Administration (4%)	4%			$7,000
	Legal Fees and License/Permit Costs (4%)	4%			$7,000
	3rd Party Construction Oversight (5%)	5%			$9,000
Total Indirect Capital Costs					***$32,000***
Total Capital Costs					
	Subtotal Capital Costs				$218,000
	Contingency Allowance	20%			$44,000
Total Capital Cost (rounded to nearest $10,000)					**$260,000**
Annual Direct Operation & Maintenance Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
OM1	Groundwater Sampling, Analysis and Reporting	1	lump sum	$13,275	$13,275
ES	5-Year Review	1	lump sum	$10,000	$10,000
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$23,000*
Total Annual Direct O&M Costs with Location Factor of 1.198 (Rounded to Nearest $1,000)					*$28,000*
Annual Indirect O&M Costs					
	Administration	5%			$1,400
	Insurance, Taxes, Licenses	3%			$840
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$2,000*
Total Annual O&M Costs					
	Subtotal Annual O&M Costs				*$30,000*
	Contingency Allowance	20%			$6,000
Total Annual O&M Cost (Rounded to Nearest $1,000)					$36,000
30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)					
Total Capital Costs					260,000
Present Worth of 30 Years O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)					$660,000
Total Cost (Rounded to Nearest $10,000)					**$920,000**

Notes:

(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*

(2) ES stands for Engineer's Estimate.

Table 4-4 Alternative GW 4 (Passive Groundwater Treatment) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Chemical-Specific				
Federal				
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate	Alternative could be implemented in compliance with this act. Cleanup to MCLs for antimony and arsenic is not achievable at the site.
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate	ARAR not triggered. Groundwater does not contribute contaminants above ambient water quality criteria in Red Devil Creek.
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC	TBC not triggered. Alternative does not address sediment.
State				
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate	Alternative could lead toward eventual compliance with WQSs.

Table 4-4 Alternative GW 4 (Passive Groundwater Treatment) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Location-Specific				
Federal				
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department on the Interior to do so.	Applicable	Alternative could be implemented in compliance with this act.
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable	Alternative could be implemented in compliance with this act.
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable	Alternative could be implemented in compliance with this act.
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable	Alternative could be implemented in compliance with this order.
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable	Alternative could be implemented in compliance with this act.
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-4 Alternative GW 4 (Passive Groundwater Treatment) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable	Alternative could be implemented in compliance with this act.
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable	Alternative could be implemented in compliance with this act.
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
State				
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable	Alternative could be implemented in compliance with this act.
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871- .901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-4 Alternative GW 4 (Passive Groundwater Treatment) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Action-Specific				
Federal				
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the EPA gives states the authority to implement the National Pollutant Discharge Elimination System program.	Applicable	Alternative could be implemented in compliance with this act.
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or offsite.	Applicable	ARAR not triggered. Alternative would not involve any placement of fill material in surface water or wetlands.
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable	ARAR not immediately met. Alternative would be implemented to attain eventual compliance with this act.
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve any dredging of creek or river sediments.
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve construction of a solid waste disposal facility.

Table 4-4 Alternative GW 4 (Passive Groundwater Treatment) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable	Alternative could be implemented in compliance with this order.

Key:

AAC	=	Alaska Administrative Code
ARAR	=	Applicable or Relevant and Appropriate Requirements
AS	=	Alaska Statutes
CFR	=	Code of Federal Regulations
EPA	=	U.S. Environmental Protection Agency
EO	=	Executive Order
ESA	=	Endangered Species Act
NPDES	=	National Pollutant Discharge Elimination System
MCL	=	Maximum Contaminant Level
RCRA	=	Resource Conservation and Recovery Act
RDM	=	Red Devil Mine
TBC	=	To Be Considered
USC	=	United States Code
WQS	=	Water Quality Standards

Table 4-5 Cost Estimate Alternative GW 4 — Passive Groundwater Treatment

Item	Description	Quantity	Unit	Cost/Unit	Cost
Capital Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
DC1	Mobilization/Demobilization	2	lump sum	$101,000	$202,000
DC2	Install Groundwater Monitoring Wells	1	lump sum	$85,000	$85,000
DC3	Passive Groundwater Treatment System, Permeable Reactive Barrier	1	lump sum	$696,837	$696,837
Total Direct Capital Costs (rounded to nearest $10,000)					***$983,837***
Indirect Capital Costs					
	Engineering and Design (10%)	10%			$98,000
	Administration (4%)	4%			$39,000
	Legal Fees and License/Permit Costs (4%)	4%			$39,000
	3rd Party Construction Oversight (5%)	5%			$49,000
Total Indirect Capital Costs					***$225,000***
Total Capital Costs					
	Subtotal Capital Costs				$1,208,837
	Contingency Allowance	20%			$242,000
Total Capital Cost (rounded to nearest $10,000)					**$1,450,000**
Annual Operation & Maintenance Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
OM3	Groundwater Sampling, Analysis and Reporting	1	lump sum	$13,275	$13,275
ES	5-Year Review	1	lump sum	$20,000	$20,000
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$33,000*
Annual Indirect O&M Costs					
	Administration	5%			$1,650
	Insurance, Taxes, Licenses	3%			$990
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$3,000*
Total Annual O&M Costs					
	Subtotal Annual O&M Costs				*$36,000*
	Contingency Allowance	20%			$7,200
Total Annual O&M Cost (Rounded to Nearest $1,000)					$43,000
30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)					
Total Capital Costs					$1,450,000
Present Worth of 30 Years O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)					$790,000
Total Cost (Rounded to Nearest $10,000)					**$2,240,000**
Notes:					
(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*					
(3) ES stands for Engineer's Estimate.					

Table 4-6 Alternative KR 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Chemical-Specific				
Federal				
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate	ARAR not triggered. Kuskokwim River does not exceed MCLs.
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate	ARAR not triggered. Alternative does not involve construction.
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate	ARAR not triggered.
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC	Alternative uses site-specific RBCL as RG. Use of TBC not warranted.
State				
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate	ARAR not triggered. Kuskokwim River does not exceed WQSs.

Table 4-6 Alternative KR 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Location-Specific				
Federal				
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department on the Interior to do so.	Applicable	ARAR not triggered. Alternative would not include any deep ground disturbing activity or other activities that could impact archaeological or historic resources.
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable	ARAR not triggered. Alternative would not include any deep ground disturbing activity.
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable	ARAR not triggered. Alternative would not include any ground disturbing activity that could affect wetlands.
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable	ARAR not triggered. Alternative would not include development within a floodplain.

Table 4-6 Alternative KR 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable	ARAR not triggered. No surface waters affected under this Alternative.
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable	ARAR not triggered. No habitat affected under this Alternative.
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable	ARAR not triggered. No habitat affected under this Alternative.
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable	ARAR not triggered. No habitat affected under this Alternative.
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate	ARAR not triggered. No surface waters affected under this Alternative.

Table 4-6 Alternative KR 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
State				
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable	ARAR not triggered. Alternative would not include any activities that could impact archaeological or historic resources.
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate	ARAR not triggered. No waste would be moved under this Alternative.
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871- .901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable	ARAR not triggered. No habitat affected under this Alternative.

Table 4-6 Alternative KR 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Action-Specific				
Federal				
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the EPA gives states the authority to implement the National Pollutant Discharge Elimination System program.	Applicable	ARAR not triggered. Alternative would not involve discharges of wastewater or newly generated stormwater to surface water.
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or offsite.	Applicable	ARAR not triggered. Alternative would not involve any placement of fill material in surface water or wetlands.
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable	Implementation of Alternative would not affect water quality.
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve any dredging of creek or river sediments.

Table 4-6 Alternative KR 2 (Institutional and Access Controls) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve construction of a solid waste disposal facility.
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable	Alternative could be implemented in compliance with this order.

Key:
AAC = Alaska Administrative Code
ARAR = Applicable or Relevant and Appropriate Requirements
AS = Alaska Statutes
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
EO = Executive Order
ESA = Endangered Species Act
NPDES = National Pollutant Discharge Elimination System
MCL = Maximum Contaminant Level
RBCL = Risk-Based Cleanup Level
RCRA = Resource Conservation and Recovery Act
RDM = Red Devil Mine
TBC = To Be Considered
USC = United States Code
WQS = Water Quality Standards

Table 4-7 Cost Estimate Alternative KR 2 — Institutional and Access Controls

Item	Description	Quantity	Unit	Cost/Unit	Cost
Direct Capital Costs					
DC1	Install Warning Signs	1	lump sum	$14,500	$14,500
Total Direct Capital Costs (rounded to nearest $1,000)					***$15,000***
Indirect Capital Costs					
	Engineering and Design (5%)	5%			$1,000
	Administration (4%)	4%			$1,000
	Legal Fees and License/Permit Costs (4%)	4%			$1,000
	3rd Party Construction Oversight (5%)	5%			$1,000
Subtotal Indirect Capital Costs (rounded to nearest $10,000)					***$0***
Subtotal Capital Costs					$15,000
Contingency Allowance (20%)					$3,000
Total Capital Cost (rounded to nearest $1,000)					**$18,000**
Annual Direct Operation & Maintenance Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
OM1	Operation and Maintenance Cost	1	lump sum	$2,750	$2,750
ES	5-Year Review	1	lump sum	$2,000	$2,000
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$5,000*
Annual Indirect O&M Costs					
	Administration	5%			$250
	Insurance, Taxes, Licenses	3%			$150
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$0*
	Subtotal Annual O&M Costs				*$5,000*
	Contingency Allowance	20%			$1,000
Total Annual O&M Cost (Rounded to Nearest $1,000)					**$6,000**
30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)					
Total Capital Costs					18,000
Present Worth of O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)					$110,000
Total Present Worth Cost for Alternative (Rounded to Nearest $10,000)					**$130,000**

Notes:

(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*

(3) ES stands for Engineer's Estimate.

Table 4-8 Alternative KR 3 (Monitored Natural Recovery) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Chemical-Specific				
Federal				
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate	ARAR not triggered. Kuskokwim River does not exceed MCLs.
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate	ARAR not triggered. Alternative does not involve construction.
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate	ARAR not triggered.
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC	Alternative uses site-specific RBCL as RG. Use of TBC not warranted.
State				
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate	ARAR not triggered. Kuskokwim River does not exceed WQSs.
Location-Specific				
Federal				
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department on the Interior to do so.	Applicable	ARAR not triggered. Alternative does not involve construction.

Table 4-8 Alternative KR 3 (Monitored Natural Recovery) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable	ARAR not triggered. Alternative does not involve construction.
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable	ARAR not triggered. Alternative does not involve construction.
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable	ARAR not triggered. Alternative does not involve construction.
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable	Alternative could be implemented in compliance with this act.
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable	Alternative could be implemented in compliance with this act.
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-8 Alternative KR 3 (Monitored Natural Recovery) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable	Alternative could be implemented in compliance with this act.
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
State				
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable	ARAR not triggered. Alternative does not involve construction.
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate	Alternative could be implemented in compliance with these regulations.
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871- .901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable	Alternative could be implemented in compliance with this act.
Action-Specific				
Federal				
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the U.S. EPA gives states the authority to implement the National Pollutant Discharge Elimination System program.	Applicable	ARAR not triggered. Alternative would not involve discharges of wastewater or newly generated stormwater to surface water.

Table 4-8 Alternative KR 3 (Monitored Natural Recovery) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or offsite.	Applicable	ARAR not triggered. Alternative would not involve any placement of fill material in surface water or wetlands.
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable	Alternative could be implemented in compliance with this act.
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve any dredging of creek or river sediments.
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable	ARAR not triggered. Alternative would not involve construction of a solid waste disposal facility.
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable	Alternative could be implemented in compliance with this order.

Table 4-8 Alternative KR 3 (Monitored Natural Recovery) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance

Key:
AAC = Alaska Administrative Code
ARAR = Applicable or Relevant and Appropriate Requirements
AS = Alaska Statutes
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
EO = Executive Order
ESA = Endangered Species Act
NPDES = National Pollutant Discharge Elimination System
MCL = Maximum Contaminant Level
RBCL = Risk-Based Cleanup Level
RCRA = Resource Conservation and Recovery Act
RDM = Red Devil Mine
TBC = To Be Considered
USC = United States Code
WQS = Water Quality Standards

Table 4-9 Cost Estimate Alternative KR 3 — Monitored Natural Recovery

Item	Description	Quantity	Unit	Cost/Unit	Cost
Direct Capital Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
	No Capital Costs Required	1	lump sum	$0	$0
Total Direct Capital Costs (rounded to nearest $10,000)					***$0***
Indirect Capital Costs					
	Engineering and Design (5%)	5%			$0
	Administration (4%)	4%			$0
	Legal Fees and License/Permit Costs (4%)	4%			$0
	3rd Party Construction Oversight (5%)	5%			$0
Total Indirect Capital Costs					***$0***
Total Capital Costs					
	Subtotal Capital Costs				$0
	Contingency Allowance	20%			$0
Total Capital Cost (rounded to nearest $10,000)					**$0**
Annual Direct Operation & Maintenance Costs					
Item Description		**Quantity**	**Unit**	**Cost/Unit**	**Cost**
OM2	Sediment Sampling, Analysis and Reporting (9 events over 30 years)	0.33	lump sum	$137,000	$45,210
ES	5-Year Review	1	lump sum	$25,000	$25,000
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$70,000*
Annual Indirect O&M Costs					
	Administration	5%			$3,500
	Insurance, Taxes, Licenses	3%			$2,100
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$6,000*
Total Annual O&M Costs					
	Subtotal Annual O&M Costs				*$76,000*
	Contingency Allowance	20%			$15,200
Total Annual O&M Cost (Rounded to Nearest $1,000)					$91,000
30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)					
Total Capital Costs					0
Present Worth of 30 Years O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)					$1,670,000
Total Cost (Rounded to Nearest $10,000)					**$1,670,000**

Notes:

(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*

(2) ES stands for Engineer's Estimate.

Table 4-10 Alternative KR 4 (Limited Dredging of Materials within the Lower Delta) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Chemical-Specific				
Federal				
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate	ARAR not triggered. Kuskokwim River does not exceed MCLs.
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate	ARAR not triggered.
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC	Alternative uses site-specific RBCL as RG. Use of TBC not warranted.
State				
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate	Alternative could be implemented in compliance with these standards.

Table 4-10 Alternative KR 4 (Limited Dredging of Materials within the Lower Delta) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Location-Specific				
Federal				
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department on the Interior to do so.	Applicable	Alternative could be implemented in compliance with this act.
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable	Alternative could be implemented in compliance with this act.
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable	ARAR not triggered. Alternative does not involve construction in wetlands.
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable	ARAR not triggered. Alternative would not involve development within floodplains.
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-10 Alternative KR 4 (Limited Dredging of Materials within the Lower Delta) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable	Alternative could be implemented in compliance with this act.
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable	Alternative could be implemented in compliance with this act.
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable	Alternative could be implemented in compliance with this act.
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
State				
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable	Alternative could be implemented in compliance with these requirements.
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate	Alternative could be implemented in compliance with these regulations.

Table 4-10 Alternative KR 4 (Limited Dredging of Materials within the Lower Delta) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871- .901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable	Alternative could be implemented in compliance with this act.
Action-Specific				
Federal				
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the EPA gives states the authority to implement the National Pollutant Discharge Elimination System program.	Applicable	ARAR not triggered. Alternative would not involve discharges of wastewater or newly generated stormwater to surface water.
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or offsite.	Applicable	Alternative could be implemented in compliance with this act.
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-10 Alternative KR 4 (Limited Dredging of Materials within the Lower Delta) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable	Alternative could be implemented in compliance with this act.
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable	Alternative could be implemented in compliance with this act.
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable	Alternative could be implemented in compliance with this order.

Key:
AAC = Alaska Administrative Code
ARAR = Applicable or Relevant and Appropriate Requirements
AS = Alaska Statutes
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
EO = Executive Order
ESA = Endangered Species Act
NPDES = National Pollutant Discharge Elimination System
MCL = Maximum Contaminant Level
RBCL = Risk-Based Cleanup Level
RCRA = Resource Conservation and Recovery Act
RDM = Red Devil Mine
TBC = To Be Considered
USC = United States Code
WQS = Water Quality Standards

Table 4-11 Cost Estimate Alternative KR 4a — Limited Dredging of Materials within the Lower Delta for Disposal in an On-Site Repository

Direct Capital Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
DC2	Mobilization/Demobilization	1	lump sum	$2,513,776	$2,513,776
DC3	Field Overhead and Oversight	3	month	$216,468	$649,403
DC4	Site Preparation	1	lump sum	$446,237	$446,237
DC5	Excavate Contaminated Sediments; Haul and Dispose in Repository	1	lump sum	$463,926	$463,926
DC9	Construction Completion	1	lump sum	$138,302	$138,302
Total Direct Capital Costs (rounded to nearest $10,000)					***$4,210,000***
Indirect Capital Costs					
	Engineering and Design (7%)	7%			$295,000
	Administration (4%)	4%			$168,000
	Legal Fees and License/Permit Costs (4%)	4%			$168,000
	3rd Party Construction Oversight (5%)	5%			$211,000
Total Indirect Capital Costs					***$842,000***
Total Capital Costs					
	Subtotal Capital Costs				$5,052,000
	Contingency Allowance	20%			$1,010,000
Total Capital Cost (rounded to nearest $10,000)					**$6,060,000**
Annual Direct Operation & Maintenance Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
OM1	Operation and Maintenance Cost	1	lump sum	$2,750	$2,750
ES	5-Year Review	1	lump sum	$10,000	$10,000
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$13,000*
Annual Indirect O&M Costs					
	Administration	5%			$650
	Insurance, Taxes, Licenses	3%			$390
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$1,000*
Total Annual O&M Costs					
	Subtotal Annual O&M Costs				*$14,000*
	Contingency Allowance	20%			$2,800
Total Annual O&M Cost (Rounded to Nearest $1,000)					$17,000
30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)					
Total Capital Costs					$6,060,000
Present Worth of 30 Years O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)					$310,000
Total Cost (Rounded to Nearest $10,000)					**$6,370,000**

Notes:

(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*

(2) A 6 month work season and a 6 day work week were assumed.

(3) One month for pre-construction and one month for post-construction activities were assumed.

(4) ES stands for Engineer's Estimate.

Table 4-12 Cost Estimate Alternative KR 4b — Limited Dredging of Materials within the Lower Delta for Disposal Off Site

Direct Capital Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
DC2	Mobilization/Demobilization	1	lump sum	$2,513,776	$2,513,776
DC3	Field Overhead and Oversight	3	month	$216,468	$649,403
DC4	Site Preparation	1	lump sum	$446,237	$446,237
DC6	Excavate Contaminated Sediments; Haul and Dispose in Off-Site Landfill	1	lump sum	$7,812,786	$7,812,786
DC9	Construction Completion	1	lump sum	$138,302	$138,302
Total Direct Capital Costs (rounded to nearest $10,000)					***$11,560,000***
Indirect Capital Costs					
	Engineering and Design (7%)	7%			$809,000
	Administration (4%)	4%			$462,000
	Legal Fees and License/Permit Costs (4%)	4%			$462,000
	3rd Party Construction Oversight (5%)	5%			$578,000
Total Indirect Capital Costs					***$2,311,000***
Total Capital Costs					
	Subtotal Capital Costs				$13,871,000
	Contingency Allowance	20%			$2,774,000
Total Capital Cost (rounded to nearest $10,000)					**$16,650,000**
Annual Direct Operation & Maintenance Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
OM2	Operation and Maintenance Cost	1	lump sum	$2,750	$2,750
ES	5-Year Review	1	lump sum	$10,000	$10,000
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$13,000*
Annual Indirect O&M Costs					
	Administration	5%			$650
	Insurance, Taxes, Licenses	3%			$390
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$1,000*
Total Annual O&M Costs					
	Subtotal Annual O&M Costs				*$14,000*
	Contingency Allowance	20%			$2,800
Total Annual O&M Cost (Rounded to Nearest $1,000)					$17,000
30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)					
Total Capital Costs					$16,650,000
Present Worth of 30 Years O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)					$310,000
Total Cost (Rounded to Nearest $10,000)					**$16,960,000**

Notes:

(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*

(2) A 6 month work season and a 6 day work week were assumed.

(3) One month for pre-construction and one month for post-construction activities were assumed.

(4) ES stands for Engineer's Estimate.

Table 4-13 Alternative KR 5 (Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Chemical-Specific				
Federal				
Safe Drinking Water Act	42 USC 300f et seq.	Establishes MCLs for priority contaminants in drinking water systems, including groundwater and surface water bodies used as public drinking water supplies.	Relevant and Appropriate	ARAR not triggered. Kuskokwim River does not exceed MCLs.
Clean Water Act	42 USC 402	Establishes NPDES for remedial activities greater than 1 acre in size. Substantive requirements of the construction stormwater permit may be applicable.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
Clean Water Act	33 USC 1251 et seq.	Establishes ambient water quality criteria necessary to support designated surface water body uses.	Relevant and Appropriate	ARAR not triggered.
Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	MacDonald et al. 2000.	Provides consensus-based sediment quality guidelines for 28 chemicals of concern.	TBC	Alternative uses site-specific RBCL as RG. Use of TBC not warranted.
State				
Alaska Water Quality Standards	18 AAC 70.020	Establishes water quality standards that apply if contaminated water is encountered during remedial actions.	Relevant and Appropriate	Alternative could be implemented in compliance with these standards.

Table 4-13 Alternative KR 5 (Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Location-Specific				
Federal				
Archaeological and Historic Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Provides for the preservation of historical and archaeological data that might otherwise be lost as a result of terrain alterations. If any remedial action could cause irreparable loss to significant scientific, pre-historical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department on the Interior to do so.	Applicable	Alternative could be implemented in compliance with this act.
Archaeological Resources Protection Act of 1979	16 USC 470aa-mm 43 CFR Part 7	Requires permits for excavation of archaeological resources on public or tribal lands.	Applicable	Alternative could be implemented in compliance with this act.
Protection of Wetlands, Executive Order 11990	40 CFR 6	Requires federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, and to preserve the values of wetlands.	Applicable	ARAR not triggered. Alternative does not involve construction in wetlands.
Flood Plain Management, Executive Order 11988	40 CFR 6	Requires federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative.	Applicable	ARAR not triggered. Alternative would not involve development within floodplains.
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq. 40 CFR 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Service for the protection of fish and wildlife when a proposed action may result in modifications to stream, river, or other surface water of the U.S.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-13 Alternative KR 5 (Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Migratory Bird Treaty Act	16 USC 703 50 CFR 10.13	Provides for the protection of international migratory birds. Requires remedial actions to conserve critical habitat and consultation with the U.S. Department of the Interior if any critical habitat is to be impacted.	Applicable	Alternative could be implemented in compliance with this act.
Endangered Species Act	16 USC 1531 40 CFR 6.302(b) 50 CFR 17, 402	Provides for the protection of fish, wildlife, and plants that are threatened with extinction. Federal agencies are required under Section 7 of the ESA to ensure that their actions will not jeopardize the continued existence of a listed species or result in destruction of or adverse modification to its critical habitat. If the proposed action may affect the listed species or its critical habitat, consultation with the U.S. Fish and Wildlife Service may be required.	Applicable	Alternative could be implemented in compliance with this act.
Bald and Golden Eagles Protection Act	16 USC 668	Provides for the protection of bald and golden eagles.	Applicable	Alternative could be implemented in compliance with this act.
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801-1884	Establishes rules and process for essential fish habitat in marine and freshwater environments.	Relevant and Appropriate	Alternative could be implemented in compliance with this act.
State				
Alaska Historic Preservation Requirements	11 AAC 16	Provides for the protection of historic places on State of Alaska lands.	Applicable	Alternative could be implemented in compliance with these requirements.
Alaska Solid Waste Regulations	18 AAC 60.217 18 AAC 60.233(1)	Provides requirements for separation of landfills from groundwater, placement of waste in landfills, and location standards for monofills.	Relevant and Appropriate	Alternative could be implemented in compliance with these regulations.

Table 4-13 Alternative KR 5 (Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Alaska Department of Fish and Game Anadromous Fish Act	AS 16.05.871- .901	Provides for the protection of fish and game habitats in the State of Alaska. Consultation with the Alaska Department of Fish and Game is required for any activities that could impede fish passage or that could divert, obstruct, pollute, or change the natural flow or bed of an anadromous water body. Tidelands (to mean low water at the mouth) are included.	Applicable	Alternative could be implemented in compliance with this act.
Action-Specific				
Federal				
Clean Water Act – NPDES	40 CFR 122-125 and 403	Establishes discharge limits and monitoring requirements for direct discharges of treated effluent and stormwater runoff to surface waters of the EPA gives states the authority to implement the National Pollutant Discharge Elimination System program.	Applicable	ARAR not triggered. Alternative would not involve discharges of wastewater or newly generated stormwater to surface water.
Clean Water Act, Section 404	33 USC 1344 40 CFR 230 33 CFR 320-330	Restricts discharge of dredged or fill material into surface waters of the U.S., including wetlands. If there is no practicable alternative to impacting navigable waters of the U.S., then the impact must be minimized and unavoidable loss must be compensated for through mitigation on site or offsite.	Applicable	Alternative could be implemented in compliance with this act.
Clean Water Act – WQS	40 CFR 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health. States are given the responsibility of establishing and revising the standards, and the authority to develop standards more stringent than required by Clean Water Act.	Applicable	Alternative could be implemented in compliance with this act.

Table 4-13 Alternative KR 5 (Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments) ARARs Compliance

Standard, Requirement, Criteria, or Limitation	Citation	Description	ARAR or TBC	ARAR Compliance
Rivers and Harbors Act, Section 10	33 USC 403 33 CFR 320-330	Prohibits unauthorized obstruction or alternation of navigable waters of the U.S. Any remedial alternative that includes dredging of river sediment would have to meet these requirements.	Applicable	Alternative could be implemented in compliance with this act.
RCRA – Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257 42 USC 6944	Provides criteria by which solid waste disposal facilities and processes must operate to prevent adverse effects on human health or the environment. Facilities failing to meet these criteria are classified as open dumps, which are prohibited. Any remedial alternative that includes construction of a solid waste disposal facility would have to meet these requirements.	Applicable	Alternative could be implemented in compliance with this act.
Invasive Species EO	EO 13112	Prevents the introduction of invasive species and provides guidance for their control.	Applicable	Alternative could be implemented in compliance with this order.

Key:
AAC = Alaska Administrative Code
ARAR = Applicable or Relevant and Appropriate Requirements
AS = Alaska Statutes
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
EO = Executive Order
ESA = Endangered Species Act
NPDES = National Pollutant Discharge Elimination System
MCL = Maximum Contaminant Level
RBCL = Risk-based Cleanup Level
RCRA = Resource Conservation and Recovery Act
RDM = Red Devil Mine
TBC = To Be Considered
USC = United States Code
WQS = Water Quality Standards

Table 4-14 Cost Estimate Alternative KR 5a — Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments for Disposal in On-Site Repository

Direct Capital Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
DC2	Mobilization/Demobilization	1	lump sum	$2,513,776	$2,513,776
DC3	Field Overhead and Oversight	3	month	$216,468	$649,403
DC4	Site Preparation	1	lump sum	$446,237	$446,237
DC7	Excavate Contaminated Sediments; Haul and Dispose in Repository	1	lump sum	$531,562	$531,562
DC9	Construction Completion	1	lump sum	$138,302	$138,302
Total Direct Capital Costs (rounded to nearest $10,000)					***$4,280,000***
Indirect Capital Costs					
	Engineering and Design (7%)	7%			$300,000
	Administration (4%)	4%			$171,000
	Legal Fees and License/Permit Costs (4%)	4%			$171,000
	3rd Party Construction Oversight (5%)	5%			$214,000
Total Indirect Capital Costs					***$856,000***
Total Capital Costs					
	Subtotal Capital Costs				$5,136,000
	Contingency Allowance	20%			$1,027,000
Total Capital Cost (rounded to nearest $10,000)					**$6,160,000**
Annual Direct Operation & Maintenance Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
	Operation and Maintenance Cost	1	lump sum	$0	$0
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$0*
Annual Indirect O&M Costs					
	Administration	5%			$0
	Insurance, Taxes, Licenses	3%			$0
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$0*
Total Annual O&M Costs					
	Subtotal Annual O&M Costs				*$0*
	Contingency Allowance	20%			$0
Total Annual O&M Cost (Rounded to Nearest $1,000)					$0
30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)					
Total Capital Costs					6,160,000
Present Worth of 30 Years O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)					$0
Total Cost (Rounded to Nearest $10,000)					**$6,160,000**

Notes:

(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*

(2) A 6 month work season and a 6 day work week were assumed.

(3) One month for pre-construction and one month for post-construction activities were assumed.

(4) ES stands for Engineer's Estimate.

Table 4-15 Cost Estimate Alternative KR 5b — Limited Dredging of Materials within the Lower Delta and Nearshore Kuskokwim River Sediments for Off-Site Disposal

Direct Capital Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
DC2	Mobilization/Demobilization	1	lump sum	$2,513,776	$2,513,776
DC3	Field Overhead and Oversight	3	month	$216,468	$649,403
DC4	Site Preparation	1	lump sum	$446,237	$446,237
DC8	Excavate Contaminated Sediments; Haul and Dispose in Repository	1	lump sum	$8,002,853	$8,002,853
DC9	Construction Completion	1	lump sum	$138,302	$138,302
Total Direct Capital Costs (rounded to nearest $10,000)					***$11,750,000***
Indirect Capital Costs					
	Engineering and Design (7%)	7%			$823,000
	Administration (4%)	4%			$470,000
	Legal Fees and License/Permit Costs (4%)	4%			$470,000
	3rd Party Construction Oversight (5%)	5%			$588,000
Total Indirect Capital Costs					***$2,351,000***
Total Capital Costs					
	Subtotal Capital Costs				$14,101,000
	Contingency Allowance	20%			$2,820,000
Total Capital Cost (rounded to nearest $10,000)					**$16,920,000**
Annual Direct Operation & Maintenance Costs					
Item	**Description**	**Quantity**	**Unit**	**Cost/Unit**	**Cost**
	Operation and Maintenance Cost	1	lump sum	$0	$0
Total Annual Direct O&M Costs (Rounded to Nearest $1,000)					*$0*
Annual Indirect O&M Costs					
	Administration	5%			$0
	Insurance, Taxes, Licenses	3%			$0
Total Annual Indirect O&M Costs (Rounded to Nearest $1,000)					*$0*
Total Annual O&M Costs					
	Subtotal Annual O&M Costs				*$0*
	Contingency Allowance	20%			$0
Total Annual O&M Cost (Rounded to Nearest $1,000)					$0

30-Year Cost Projection (Assume Discount Rate Per Year: 3.5%)	
Total Capital Costs	16,920,000
Present Worth of 30 Years O&M assuming 3.5% Discount Factor (Rounded to Nearest $10,000)	$0
Total Cost (Rounded to Nearest $10,000)	**$16,920,000**

Notes:

(1) Unit costs provided by Means were taken from *RSMeans Heavy Construction Cost Data, 31st Ed., 2017, adjusted for Anchorage, AK.*

(2) A 6 month work season and a 6 day work week were assumed.

(3) One month for pre-construction and one month for post-construction activities were assumed.

(4) ES stands for Engineer's Estimate.

Table 4-16 Summary of Individual Alternative Costs for Groundwater

Alternative	Total Capital Cost	Yearly O&M Cost	Present Worth O&M Cost	Total Present Worth Cost
GW 1	$0	$0	$0	$0
GW 2	$0	$0	$0	$0
GW 3	$220,000	$36,000	$660,000	$880,000
GW 4	$1,400,000	$43,000	$790,000	$2,190,000

Table 4-17 Summary of Individual Alternative Costs for Materials within the Lower Delta and Kuskokwim River Sediment

Alternative	Total Capital Cost	Yearly O&M Cost	Present Worth O&M Cost	Total Present Worth Cost
KR 1	$0	$0	$0	$0
KR 2	$18,000	$6,000	$110,000	$130,000
KR 3	$0	$91,000	$1,670,000	$1,670,000
KR 4A	$6,060,000	$91,000	$1,670,000	$7,730,000
KR 4B	$16,650,000	$91,000	$1,670,000	$18,320,000
KR 5A	$6,160,000	$91,000	$1,670,000	$7,830,000
KR 5B	$16,920,000	$91,000	$1,670,000	$18,590,000

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A Supplemental Soil and Groundwater Information

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Table A-1 Soil Characterization Summary, 2017 Tailings/Waste Rock Characterization

Soil Boring ID	Sample Depth Interval (feet bgs) Top	Sample Depth Interval (feet bgs) Bottom	Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations: Red Porous Rock	Vitrious "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor	Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Mercury Conc. (ppm)	XRF Mercury Error
MP102	0	4	well-graded Gravel with silt and sand well-graded Gravel with silt and sand	0.0 - 1.3 ft.: Moist, dark gray silty Gravel with sand. Mostly fine to medium, angular, weathered greywacke and argillite gravel. Some gravel has distinctive red rind, some has vein material. Some silt and few coarse to fine sand likely tailings/waste rock material. 1.3 - 2.9 ft.: As above, but without tailings/waste rock, and medium to dark brown in color. 2.9 - 4.0 ft.: No recovery.	Moist						X	X	X	X	X			2630	8	3757	29	7178	35	225	10
MP102	4	8	well-graded Gravel with silt and sand sandy Silt with gravel	4 - 6 ft.: Moist to wet, dark gray silty Gravel with sand. No indications of tailings/waste rock. 6 - 7 ft.: Moist sandy Silt with gravel. Mostly medium stiff silt, some very fine sand, and trace fine to medium, angular greywacke gravel. 7 - 8 ft.: No recovery.	Moist to Wet													1610	18	1755	19	2893	23	16	5
MP102	8	12	well-graded Gravel with silt and sand Organic soil silty Gravel with sand	8.0 - 9.0 ft.: Wet, grayish brown silty Gravel with sand. Mostly fine to coarse, angular greywacke gravel. 9.0 - 9.3 ft.: Moist organic layer, moss and roots; possible buried former ground surface. 9.3 - 10.5 ft.: Wet, medium to light grayish brown, silty Gravel with sand. Mostly fine to coarse angular, weathered greywacke gravel, with some medium stiff silt, and some medium to very fine sand. 10.5 - 12.0 ft.: No recovery.	Wet													520	0.432	213	7	49	10	<LOD	6
MP102	12	16	sandy Silt with gravel silty Gravel with sand	12 - 13 ft.: Moist, grayish brown, sandy Silt with gravel. Mostly medium stiff silt with some fine to very fine sand and trace medium, angular weathered greywacke gravel. 13 - 15 ft.: Moist, orangish brown to gray, silty gravel with sand. Mostly subrounded to angular, fine to coarse, weathered greywacke and shale gravel. Some medium stiff silt, and few medium to fine sand. 15 - 16 ft.: No recovery.	Moist													231	0.187	124	6	98	10	<LOD	6
MP102	16	20	Weathered Bedrock - Shale, Argillite, and Greywacke	16.0 - 19.3 ft.: Moist, orangish brown weathered shale/argillite and greywacke bedrock. 19.3 - 20.0 ft.: No recovery.	Moist																				
MP102	20	24	Weathered Bedrock	Moist, dark gray weathered bedrock.	Moist																				
MP103	0	4	silty Gravel with sand	0.0 - 3.2 ft.: Moist, dark grayish brown silty Gravel with sand. Gravel is mostly fine to very coarse angular, weathered greywacke and argillite gravel. Some medium stiff silt and few medium to fine sand. 3.2 - 4.0 ft.: No recovery.	Moist													606	1.78	372	9	136	11	7	4
MP103	4	8	silty Gravel with sand sandy Silt with gravel	4.0 - 5.2 ft.: Moist, dark brown, as above, silty Gravel with sand. 5.2 - 6.0 ft.: Medium to dark brown, moist, sandy Silt with gravel. Mostly medium stiff silt, some very fine sand and trace fine to medium, angular greywacke and argillite gravel. 6.0 - 8.0 ft.: No recovery.	Moist													787	2.46	278	8	125	10	56	5
MP103	8	12	well-graded Gravel with silt and sand sandy Silt silty Gravel with sand	8.0 - 9.0 ft.: Moist to wet, brown sandy Gravel with silt. Mostly angular to subangular, fine to coarse greywacke gravel. Some fine to very fine sand, and few silt. 9.0 - 9.9 ft.: Wet, brown sandy Silt. Mostly soft. Silt with few very fine sand. 9.9 - 11.2 ft.: Moist, medium brown silty Gravel with sand. Mostly angular to subangular fine to very coarse greywacke and argillite gravel. Some medium stiff silt, and few fine to very fine sand. 11.2 - 12.0 ft.: No recovery.	Moist to Wet													172	0.078	2063	18	93	9	<LOD	5
MP103	12	16	silty Gravel with sand	12.0 - 15.5 ft.: Moist, brownish gray, as above, silty gravel with sand. 15.5 - 16.0 ft.: No recovery..	Moist													174	0.05 U	116	5	<LOD	13	<LOD	6
MP103	16	20	silty Gravel with sand Weathered Bedrock - Shale	16 - 18.4 ft.: Moist, dark reddish gray, as above, silty Gravel with sand. Silt grading into clay. Gravel consists of greywacke and argillite. 18.4 - 19.2 ft.: Weathered shale bedrock. 19.2 - 20.0 ft.: No recovery.	Moist													218	0.05 U	113	5	<LOD	13	<LOD	6
MP103	20	24	Weathered bedrock	Moist, brown weathered bedrock.	Moist																				

Table A-1 Soil Characterization Summary, 2017 Tailings/Waste Rock Characterization

Soil Boring ID	Sample Depth Interval (feet bgs)		Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations												Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic		XRF Antimony		XRF Mercury	
	Top	Bottom				Red Porous Rock	Vitrious "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor			Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error
MP104	0	4	silty Gravel with sand silty Gravel with sand	0.0 - 0.3 ft.: Moist, brown, silty Gravel with sand. Mostly fine to medium, angular, weathered greywacke and argillite gravel. Some gravel has distinctive red rind, some has vein material, and some is red porous rock. Some silt and few coarse to fine sand. Likely tailings/waste rock material. 0.3 - 3.2 ft.: Moist, medium grayish brown silty Gravel with sand. Mostly subrounded to angular, fine to cobble, greywacke and argillite gravel. Some medium stiff silt, and few fine to very fine sand. Does not appear to be tailings/waste rock material. 3.2 - 4.0 ft.: No recovery.	Moist	X							X	X	X			923	2.23	644	12	1484	18	40	5
	4	8	silty Gravel with sand	4.0 - 6.6 ft.: Moist, brown, as above, silty Gravel with sand. 6.6 - 8.0 ft.: No recovery.	Moist													97	0.05 U	75	5	<LOD	14	<LOD	6
	8	12	silty Gravel with sand	8.0 - 10.9 ft.: Moist, grayish brown, as above, silty Gravel with sand. 10.9 - 12.0 ft.: No recovery.	Moist													117	0.05 U	32	4	<LOD	14	<LOD	6
	12	16	silty Gravel with sand sandy Silt with gravel silty Gravel with sand	12.0 - 12.9 ft.: Moist to wet, brown, as above, moist silty Gravel with sand. 12.9 - 13.8 ft.: Moist to wet, brown sandy Silt with gravel. Mostly medium stiff silt, with some very fine sand, and few angular to subangular, medium to coarse weathered greywacke gravel. 13.8 - 15.2 ft.: Moist, medium grayish brown silty Gravel with sand. Mostly angular, fine to very coarse, greywacke and argillite gravel. Some medium stiff silt, and few medium to very fine sand. 15.2 - 16.0 ft.: No recovery.	Moist to Wet													194	0.05 U	57	4	<LOD	13	<LOD	5
	16	20	silty Gravel with sand	16.0 - 19.5 ft.: Moist, brown, as above, silty Gravel with sand. Darker brown in color. 19.5 - 20.0 ft.: No recovery.	Moist													621	0.05 U	84	5	<LOD	13	<LOD	5
	20	24	silty Gravel with sand	20.0 - 23.6 ft.: Moist, dark grayish brown, as above, silty Gravel with sand. 23.6 - 24.0 ft.: No recovery.	Moist to Wet													183	0.05 U	150	7	31	10	<LOD	6
	24	28	silty/clayey Gravel with sand	24.0 - 27.1 ft.: Moist to wet, grayish brown, as above, with silt transitioning into clay. 27.1 - 28.0 ft.: No recovery.	Moist to Wet													139	0.05 U	76	5	<LOD	13	<LOD	5
	28	32	clayey Gravel with sand Weathered Bedrock - Greywacke	28.0 - 29.5 ft.: Moist to wet, grayish brown, as above, clayey Gravel with sand. 29.5 - 31.2 ft.: Weathered greywacke bedrock. 31.2 - 32.0 ft.: No recovery.	Moist to Wet													65	0.05 U	35	4	<LOD	15	<LOD	6
MP105	0	4	silty Gravel with sand	0.0 - 3.4 ft.: Moist, grayish brown silty Gravel with sand. Mostly fine to coarse angular weathered greywacke gravel with some stiff silt and trace to few coarse to very fine sand. 3.4 - 4.0 ft.: No recovery.	Moist													1340	1.62	1503	17	3956	25	60	6
	4	8	silty Gravel with sand	4.0 - 6.2 ft.: Moist, brown, as above, silty Gravel with sand. 6.2 - 8.0 ft.: No recovery.	Moist													39	0.05 U	27	4	<LOD	13	6	4
	8	12	silty Gravel with sand	8.0 - 10.8 ft.: Moist, brown, as above, silty Gravel with sand. 10.8 - 12.0 ft.: No recovery.	Moist													62	0.05 U	35	4	<LOD	13	<LOD	5
	12	16	silty Gravel with sand	12.0 14.8 ft.: Moist, brown, as above, with slightly less gravel. 14.8 - 16.0 ft.: No recovery.	Moist													68	0.05 U	41	4	<LOD	13	<LOD	6
	16	20	silty Gravel with sand	16.0 - 19.5 ft.: Moist, brown, as above, silty Gravel with sand. 19..5 - 20.0 ft.: No recovery.	Moist													114	0.05 U	72	5	78	9	<LOD	5
	20	24	silty Gravel with sand	20.0 - 23.2 ft.: Moist, brown, as above, Silty gravel with sand. Diesel odor from 22.0 - 23.2 ft. 23.2 - 24.0 ft.: No recovery.	Moist												X	87	0.05 U	59	5	<LOD	15	<LOD	7
	24	28	silty Gravel with sand	24.0 - 27.4 ft.: Moist, brown, as above, except some gravel is subrounded, and silt is stiff. Diesel odor from 24 - 25 ft. 27.4 - 28.0 ft.: No recovery.	Moist												X	45	0.05 U	26	4	<LOD	14	<LOD	6
	28	32	Weathered Bedrock - Shale	28.0 - 31.7 ft.: Moist, dark grayish brown, weathered shale bedrock . 31.7 - 32.0 ft.: No recovery.	Moist																				
MP106	0	4	NR	NR	NR													1290	1.45	39	5	706	12	990	15
	4	8	NR	NR	NR													37	0.05 U	<LOD	5	22	3	<LOD	13
	8	12	NR	NR	NR													62	0.05 U	<LOD	6	35	4	<LOD	14
	12	16	Weathered Bedrock	Bedrock	NR																				
MP107	0	4	well-graded Gravel with silt and sand	Moist, black Gravel with silt and sand, tailings/waste rock.	Moist	X				X		X	X		X			5290	10	5450	37	17644	56	235	11
	4	8	well-graded Gravel with silt and sand	As above. > 4 cm fragment of siltstone reduced recovery.	Moist	X						X	X	X	X			6100	14	5126	35	14009	50	358	12

Table A-1 Soil Characterization Summary, 2017 Tailings/Waste Rock Characterization

Soil Boring ID	Sample Depth Interval (feet bgs)		Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations												Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic		XRF Antimony		XRF Mercury	
	Top	Bottom				Red Porous Rock	Vitreous "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor			Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error
MP107	8	12	silty Gravel	As above to 8.5 ft., then dark gray silty Gravel. Gravel is angular siltstone and greywacke, 1 - 4 cm. Some fine sand. Apparent disturbed native soil. 10.5 - 11.3 ft. is tailings/waste rock again, dark gray.	Moist	X							X	X				1420	0.691	840	12	2099	18	123	6
	12	16	silty Gravel with sand	Moist, gray silty Gravel with sand, with calcines and red porous rock. More silt and lighter color than tailings/waste rock above, may be tailings/waste rock mixed with disturbed native soil. Gravel fine to 2 cm angular Kuskokwim Group. At 13.8 ft. abrupt transition to tan silty Gravel. 13.8 ft. gravel is 3 to > 4 cm siltstone, some dark gray fine greywacke. Angular, no tailings/waste rock.	Moist	X												2390	2.44	1508	18	2494	21	343	10
	16	20	silty Gravel with sand	Moist, brown, as above, some shale in angular gravel.	Moist													574	0.551	373	9	43	9	25	4
	20	24	silty Gravel with sand Weathered Bedrock - Siltstone, Greywacke	As above to 20.7 ft., then transition to wet weathered bedrock of siltstone and greywacke. Apparent bedding dip 30 degrees.	Wet													251	0.223	177	6	22	9	6	3
	24	28	Weathered Bedrock - Siltstone, Greywacke, Shale	Moist, grayish brown weathered bedrock. 24.0 - 26.0 ft. siltstone. 26.0 to 26.7 ft. greywacke, some light gray. 26.7 to 27.7 ft. shale. 27.7 to 28.0 ft. siltstone. Apparent bedding dip 45 degrees.	Moist															30	4	<LOD	14	<LOD	6
MP108	0	4	Gravel with sand and silt	Moist black Gravel with sand and silt. Tailings/waste rock, includes igneous dike clasts. Mostly siltstone and argillite, trace greywacke.	Moist	X	X			X		X	X		X			5180	14	5671	37	17396	55	191	10
	4	8	Gravel with sand and silt	Moist black Gravel with sand and silt. Igneous dike clasts. Tailings/waste rock. Gravel is shale, greywacke, and calcines.	Moist	X				X			X	X	X			7110	7	5181	36	15235	53	241	11
	8	12	Gravel with sand and silt Silt with gravel	8.0 - 10.4 ft.: Moist black Gravel with silt and sand, tailings/waste rock. Gravel is > 4 cm greywacke, some shale, igneous dike, gangue. 10.4 - 11.7ft.: Olive Silt with gravel. Gravel is vein material, greywacke, and igneous dike.	Moist	X				X			X		X			4570	7	4314	31	12052	44	257	10
	12	16	poorly graded Gravel with sand	As above to 13.5 ft., with trace wood debris, then abrupt transition at 13.5 ft. to very red tailings/waste rock. Red tailings/waste rock has abundant sand-sized calcines. At 15.0 ft. is thin band of black, glassy, porous material. Moist, overall color is dusky red.	Moist	X	X						X	X				2150	10	1812	19	4222	27	41	5
	16	20	poorly graded Gravel with silt and sand	As above to 17 ft., black tailings/waste rock below. Gravel is red porous rock, shale, siltstone, greywacke. Moist.	Moist	X	X					X	X	X	X			4230 J	30	4611	31	11611	42	56	6
	20	24	poorly graded Gravel with silt and sand Silt with gravel	As above to 21.9 ft., wet at 21.0 ft. Very dark gray. 21.9 - 23.5 ft. is wet, light brown Silt with gravel. Silt is non-plastic, with trace organics, native. Gravel is 4 cm angular siltstone and greywacke. Transition at 23 ft. to weathered bedrock, apparent bedding dip of 30 degrees.	Wet													3440	14	3089	28	4291	29	1635	23
	24	28	Weathered Bedrock - Siltstone, Greywacke	Moist, light brownish gray weathered bedrock. Apparent bedding dip of 30 - 60 degrees. Siltstone and greywacke, trace iron stain.	Wet											X		206	0.434	191	7	75	10	8	4
MP109	0	4	silty Gravel with sand	0.0 - 3.1 ft.: Moist, dark gray silty Gravel with sand. Mostly fine to medium, angular to subrounded, weathered greywacke and argillite gravel. Some gravel has distinctive red rind, some has vein material, and some is red porous rock. Some silt and few coarse to fine sand. Likely tailings/waste rock material. 3.1 - 4.0 ft.: No recovery.	Moist	X							X	X				4490	9	4121	30	11876	44	255	10
	4	8	silty Gravel with sand	4.0 - 6.2 ft.: As above, tailings/waste rock. One cobble encountered from 4.6 - 5.1 ft. 6.2 - 8.0 ft.: No recovery.	Moist	X							X	X				4730	10	4853	34	13114	48	216	10
	8	12	silty Gravel with sand	8.0 - 11.5 ft.: As above, tailings/waste rock. 11.5 - 12.0 ft.: No recovery.	Moist	X		X					X	X	X			4980	10	5165	35	13984	49	292	11
	12	16	silty Gravel with sand	12.0 - 14.8 ft.: As above, tailings/waste rock. 14.8 - 16.0 ft.: No recovery.	Moist	X							X	X				4820	10	4245	30	7916	36	221	9
	16	20	silty Gravel with sand	16.0 - 16.6 ft.: Moist to wet, dark grayish brown, as above, tailings/waste rock. Water at 16.5 ft. 16.6 - 18.5 ft.: Medium to dark brown, moist with wet sections, gravelly Silt with sand. Mostly medium stiff to stiff silt, some angular to subrounded, fine to coarse, greywacke gravel and few very fine sand. 18.5 - 20.0 ft.: No recovery.	Moist to Wet	X							X	X				2320	8	2094	19	2067	18	40	5
	20	24	clayey Gravel with sand	Moist, brown clayey to silty Gravel with sand. Mostly fine to coarse, angular to subrounded, weathered greywacke gravel. Some stiff silt/clay, and few very fine sand.	Moist													186	0.05 U	66	5	25	9	<LOD	6
	24	28	clayey Gravel with sand Weathered Bedrock - Shale	24 - 25.3 ft.: As above, clayey Gravel with sand. 25.3 - 27.0 ft.: Moist, brown, weathered shale bedrock. 27.0 - 28.0 ft.: No recovery.	Moist													79	0.05 U	64	5	<LOD	15	<LOD	6

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Soil Boring ID	Sample Depth Interval (feet bgs)		Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations												Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic		XRF Antimony		XRF Mercury	
	Top	Bottom				Red Porous Rock	Vitrious "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor			Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error
MP110	0	4	silty Gravel with sand	0.0 - 3.2 ft.: Moist, dark gray silty Gravel with sand. Mostly fine to medium, angular to subrounded, weathered greywacke and argillite gravel. Some gravel has distinctive red rind, some has vein material, and some is red porous rock. Some silt and few coarse to fine sand. Faint diesel odor. Likely tailings/waste rock material. 3.2 - 4.0 ft.: No recovery.	Moist	X							X	X			X	3100	5	2600	22	8625	35	117	7
MP110	4	8	silty Gravel with sand	4.0 - 6.4 ft.: As above, tailings/waste rock. 6.4 - 8.0 ft.: No recovery.	Moist	X							X	X				4370	6	4166	31	10236	42	145	8
MP110	8	12	silty Gravel with sand	8.0 - 11.2 ft.: As above, but dark grayish brown. Tailings/waste rock. 11.2 - 12.0 ft.: No recovery.	Moist	X				X			X	X	X			5410	5	3687	29	10077	42	156	9
MP110	12	16	gravelly Silt with sand	12.0 - 14.2 ft.: Moist, brown gravelly Silt with sand. Mostly medium stiff silt with some, fine to coarse angular to subangular, weathered greywacke gravel and few very fine sand; gravelly loess. Gravel decreases in abundance with depth. 14.2 - 16.0 ft.: No recovery.	Moist													794	0.706	483	9	988	14	11	4
MP110	16	20	clayey Gravel with silt and sand	16 - 18 ft.: Moist, brown clayey Gravel with silt and sand. Mostly medium to very coarse, angular to subangular, weathered greywacke gravel. Some medium stiff clay/silt, and few very fine sand. 18 - 20 ft.: No recovery.	Moist													71	0.05 U	35	4	120	11	<LOD	6
MP110	20	24	Weathered Bedrock - Greywacke, Shale	Moist, grayish brown weathered greywacke and shale bedrock. Apparent bedding dip of 30 degrees.	Moist																				
MP111	0	4	silty Gravel with sand	0.0 - 3.2 ft.: Moist, dark gray silty Gravel with sand. Mostly fine to medium, angular, weathered greywacke and argillite gravel. Some gravel has distinctive red rind, some has vein material, and some is red porous rock. Some silt and few coarse to fine sand. Likely tailings/waste rock material. 3.2 - 4.0 ft.: No recovery.	Moist	X							X	X				6300	6	2843	25	10664	42	91	7
MP111	4	8	silty Gravel with sand	4.0 - 6.9 ft.: As above, tailings/waste rock. Diesel odor near 6 ft. 6.9 - 8.0 ft.: No recovery.	Moist	X		X					X	X	X		X	3570	4.79	2843	28	8607	43	92	8
MP111	8	12	silty Gravel with sand sandy Silt	8.0 - 10.3 ft.: As above, tailings/waste rock with faint diesel odor. 10.3 - 10.8 ft.: Medium brown, sandy Silt. Mostly medium stiff silt, few very fine sand. 10.8 - 12.0 ft.: No recovery.	Moist	X							X	X			X	3930	3.39	3066	25	8574	36	102	7
MP111	12	16	silty Gravel with sand	12.0 - 14.6 ft.: As above, but brown. Loess. Trace to few, medium to coarse, subrounded to subangular greywacke gravel. 14.6 - 16.0 ft.: No recovery.	Moist													42	0.05 U	19	4	27	10	<LOD	6
MP111	16	20	clayey Gravel with sand Weathered Bedrock - Shale, Greywacke	16.0 - 18.4 ft.: Moist, grayish brown clayey Gravel with sand. Mostly medium to coarse subrounded to angular, weathered greywacke and argillite gravel. Some medium stiff to stiff clay, and few fine to very fine sand. 18.4 - 19.3 ft.: Weathered shale and greywacke bedrock. 19.3 - 20.0 ft.: No recovery.	Moist													64	0.05 U	32	4	<LOD	15	<LOD	6
MP112	0	4	silty Sand with gravel	0.0 - 1.7 ft.: Moist, dark brown silty Sand with gravel. Mostly medium to very fine sand, some soft. silt and few, fine to very coarse, angular greywacke gravel. Some of the gravel had abundant veins and some mineralization including realgar and orpiment. Woody debris from 1 - 1.4 ft. 1.7 - 4.0 ft.: No recovery.	Moist						X	X	X		X			3170	1.7	1527	18	3110	24	94	7
MP112	4	8	silty Gravel with sand	4.0 - 5.3 ft.: Moist, dark gray silty Gravel with sand. Mostly fine to very coarse, angular, greywacke and argillite gravel. Some medium stiff silt and trace very fine sand. 5.3 - 8.0 ft.: No recovery.	Moist													394	0.05 U	413	9	764	14	59	5
MP112	8	12	silty Gravel sandy Silt	8.0 - 9.6 ft.: As above, silty Gravel. Moist to 9.2 ft., then wet. 9.6 - 10.9 ft.: Wet, dark grayish brown sandy Silt. Mostly medium stiff silt, some to few very fine sand. Diesel odor noted at 10.9 ft. 10.9 - 12.0 ft.: No recovery.	Moist to Wet								X				X	503	0.062	145	12	1092	31	26	11
MP112	12	16	gravelly Silt with sand gravelly Clay	12.0 - 13.9 ft.: Wet, Medium to dark gray gravelly Silt with sand. Diesel odor. Mostly medium stiff silt. some angular, medium to very coarse weathered greywacke gravel, and few very fine sand. 13.9 - 14.9 ft.: Moist, dark gray gravelly Clay and silt. Mostly very stiff clay and silt with some angular to subrounded, medium to coarse, weathered greywacke and argillite gravel. Trace very fine sand. 14.6 - 16.0 ft.: No recovery.	Moist to Wet												X	66	0.05 U	209	6	98	9	8	4
MP112	16	20	silty Gravel with sand	16.0 - 19.3 ft.: Moist to wet, dark grayish brown silty Gravel with sand. Mostly angular to subangular, fine to cobble, weathered greywacke, shale and argillite gravel. Some med stiff to stiff silt/clay. Few very fine sand. Diesel odor from 16 - 18.3 ft. 19.3 - 20.0 ft.: No recovery.	Moist to Wet												X	34	0.05 U	33	5	<LOD	17	<LOD	8
MP112	20	24	Weathered Bedrock - Shale	20 - 23 ft.: Moist to wet, dark grayish brown weathered shale bedrock. 23 - 24 ft.: No recovery.	Moist to Wet																				

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Soil Boring ID	Sample Depth Interval (feet bgs)		Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations												Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic		XRF Antimony		XRF Mercury	
	Top	Bottom				Red Porous Rock	Vitrious "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor			Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error
MP113	0	4	well-graded Gravel with silt and sand	0.0 - 3.4 ft.: Moist, dark gray sandy Gravel with silt. Mostly well-graded fine to coarse subangular gravel, with some well-graded medium to very coarse sand and few silt. Gravel consists of greywacke, argillite and vein material with evidence of processing via distinctive red rind and common mineralization observed including stibnite, realgar, and orpiment. Likely tailings/waste rock. 3.4 - 4.0 ft.: No recovery.	Moist			X			X	X	X	X	X			8300	17	6734	41	16204	54	549	14
	4	8	well-graded Gravel with silt and sand	4 - 7 ft.: As above. Tailings/waste rock. 7 - 8 ft.: No recovery.	Moist	X		X			X	X	X	X	X			6260	24	5781	38	14623	51	541	14
	8	12	well-graded Gravel with silt and sand	8.0 - 10.3 ft.: As above, but moist. Tailings/waste rock. 10.3 - 12.0 ft.: No recovery.	Moist	X		X			X	X	X		X			8060	28	8873	48	19115	60	584	15
	12	16	well-graded Gravel with silt and sand	12 - 14.7 ft.: As above. Tailings/waste rock. 14.7 - 16 ft.: No recovery.	Moist	X		X			X	X	X	X	X			11400	19	11805	65	29405	87	5403	50
	16	20	well-graded Gravel with silt and sand Woody Debris sandy Silt with gravel	16.0 - 16.3 ft.: As above. Tailings/waste rock. 16.3 - 16.9 ft.: Medium grayish brown sandy Gravel with silt. Moist to 16.7 ft., wet below. Mostly fine to medium angular greywacke gravel, some fine to very coarse sand and few silt. 16.9 - 17.4 ft.: Woody debris, possibly a large rotten root. 17.4 - 18.7 ft.: Top of undisturbed material. Medium brown to gray, wet, sandy Silt with gravel. Mostly medium stiff silt, some very fine sand and trace medium angular weathered greywacke gravel. 18.7 - 20.0 ft.: No recovery.	Moist to Wet	X							X	X				3960	7	11217	55	24491	70	1347	23
	20	24	silty Gravel with sand gravelly Silt	20 - 21.3 ft.: Wet, grayish brown silty Gravel with sand. Mostly round to subrounded, medium to coarse, weathered greywacke gravel; some soft. silt, and fine to very fine sand. 21.3 - 23.2 ft.: Medium orangish brown, gravelly silt. Mostly very stiff silt, with some to some angular, medium to very coarse, weathered greywacke gravel. 23.2 - 24.0 ft.: No recovery.	Wet													411	1.05	659	11	36	9	39	5
	24	28	gravelly Silt	24.0 - 27.2 ft.: Moist, grayish brown gravelly Silt. Mostly very stiff silt, with few to some subrounded to angular, medium to very coarse, weathered greywacke and argillite gravel. 27.2 - 28.0 ft.: No recovery.	Moist													345	0.24	432	11	<LOD	15	18	5
	28	32	gravelly Silt Weathered Bedrock - Greywacke, Argillite	28.0 - 28.9 ft.: As above, but wet. 28.9 - 31.3 ft.: Wet, grayish brown weathered greywacke and argillite bedrock. Bedding dip approximately 75 degrees. 31.3 - 32.0 ft.: No recovery.	Wet													138	0.073	181	6	<LOD	13	<LOD	5
MP114	0	4	well-graded Gravel with silt and sand	0.0 - 2.9 ft.: Moist, dark gray sandy Gravel with silt. Mostly well-graded fine to coarse subangular gravel, with some well-graded medium to very coarse sand and few silt. Gravel consists of greywacke, argillite and vein material. Distinctive red rind, red porous rock, and abundant evidence of mineralization including stibnite, realgar, and orpiment. Gray tarp material observed at 1.2 ft. Likely tailings/waste rock. 2.9 - 4.0 ft.: No recovery.	Moist	X		X			X	X	X	X	X			3610	12	3963	31	10235	43	254	10
	4	8	sandy Gravel with silt silty Gravel with sand	4.0 - 5.5 ft.: As above, tailings/waste rock. 5.5 - 6.6 ft.: Medium grayish brown, moist, silty Gravel with sand. Mostly well-graded, fine to cobble, angular to subangular, weathered greywacke gravel, some medium stiff silt, and trace to few medium to fine sand. 6.6 - 8.0 ft.: No recovery.	Moist			X					X	X	X			2740	13	1604	19	3923	27	83	7
	8	12	silty Gravel with sand sandy Silt with gravel	8.0 - 8.4 ft.: As above, silty Gravel with sand, but moist to wet and dark gray.. 8.4 - 11.0 ft.: Dark brownish gray, moist, sandy Silt with gravel. Mostly medium stiff silt with few very fine sand and trace medium, angular, argillite and greywacke gravel. 11.0 - 12.0 ft.: No recovery.	Moist to Wet													180	0.055	46	4	42	9	<LOD	5
	12	16	sandy Silt with gravel	12.0 - 14.7 ft.: Moist to wet, dark grayish brown, as above, sandy Silt with gravel. 14.7 - 16.0 ft.: No recovery.	Moist to Wet													51	0.064	24	3	69	8	<LOD	5
	16	20	gravelly Silt with sand	16.0 - 18.5 ft.: Moist to wet, dark grayish brown gravelly Silt with sand. Mostly very stiff silt (possibly clay), with some medium to very coarse subangular to subrounded weathered greywacke gravel, and some very fine sand. 18.5 - 20.0 ft.: No recovery.	Moist to Wet													83 J-	0.05 U	20	3	<LOD	13	<LOD	5
	20	24	silty Gravel with sand Weathered Bedrock - Shale, Argillite	20.0 - 21.2 ft.: Moist, brown, silty Gravel with sand. Mostly well-graded angular to subangular, fine to medium weathered greywacke gravel, some stiff silt (possibly clay) and some fine to very fine sand. It is difficult to tell if the 20 - 21.2 ft. interval is weathered bedrock or unconsolidated material. 21.2 - 23.5 ft.: Weathered shale and argillite bedrock. 23.5 - 24.0 ft.: No recovery.	Moist													162	0.05 U	172	7	20	10	<LOD	7

Table A-1 Soil Characterization Summary, 2017 Tailings/Waste Rock Characterization

Soil Boring ID	Sample Depth Interval (feet bgs)		Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations												Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic		XRF Antimony		XRF Mercury	
	Top	Bottom				Red Porous Rock	Vitrious "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor			Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error
MP114	24	28	Weathered Bedrock - Greywacke, Argillite	24.0 - 26.8 ft.: Moist, grayish brown weathered greywacke and argillite bedrock. 26.8 - 28.0 ft.: No recovery.	Moist																				
MP115	0	4	well-graded Gravel with silt and sand	0.0 - 3.5 ft.: Moist, dark gray sandy Gravel with silt. Mostly well-graded fine to coarse subangular gravel, with some well-graded medium to very coarse sand and few silt. Gravel consists of greywacke, argillite and vein material. Distinctive red rind and abundant mineralization observed including stibnite, realgar, and orpiment. Likely tailings/waste rock. 3.5 - 4.0 ft.: No recovery.	Moist			X			X	X	X	X	X			5590	12	2833	28	5892	36	266	11
MP115	4	8	well-graded Gravel with silt and sand sandy Silt with gravel	4.0 - 4.9 ft.: As above, tailings/waste rock. 4.9 - 7.5 ft.: Medium brown to gray, moist, sandy Silt with gravel. Mostly medium stiff silt with few very fine sand and trace, fine to coarse, angular, weathered greywacke gravel. 7.5 - 8.0 ft.: No recovery.	Moist			X			X	X	X	X	X			3680	6	3487	29	4386	29	172	9
MP115	8	12	sandy Silt with gravel sandy Silt	8.0 - 8.8 ft.: As above, sandy Silt with gravel, except gray. 8.8 - 10.8 ft.: Moist, medium gray sandy Silt. Mostly medium stiff silt, and few very fine sand. 10.8 - 12.0 ft.: No recovery.	Moist													75	0.05 U	10	3	<LOD	12	<LOD	5
MP115	12	16	sandy Silt	12.0 - 15.2 ft.: As above except dark gray, sandy Silt with some woody debris. 15.2 - 16.0 ft.: No recovery.	Moist													15.4	0.05 U	8	3	<LOD	11	<LOD	4
MP115	16	20	sandy Silt silty Gravel with sand	16.0 - 16.7 ft.: As above, sandy Silt. 16.7 - 18.8 ft.: Reddish-brown to gray, moist silty Gravel with sand. Mostly medium to coarse, subrounded to subangular weathered greywacke gravel, some stiff silt, and few fine to very fine sand. 18.8 - 20.0 ft.: No recovery.	Moist													173	0.05 U	56	4	30	9	<LOD	5
MP115	20	24	sandy Silt Weathered Bedrock - Greywacke	20.0 - 21.1 ft.: Moist sandy Silt. Mostly medium stiff silt with few very fine sand. 21.1 - 22.7 ft.: Medium brown, moist, weathered greywacke bedrock. 22.7 - 24.0 ft.: No recovery.	Moist													92	0.05 U	27	4	<LOD	13	<LOD	5
MP115	24	28	Weathered Bedrock - Greywacke	24.0 - 26.9 ft.: As above, weathered bedrock. 26.9 - 28.0 ft.: No recovery.	Moist																				
MP116	0	4	well-graded Gravel with silt and sand	0.0 - 3.1 ft.: Moist, dark gray sandy Gravel with silt. Mostly well-graded fine to coarse subangular gravel, with some well-graded medium to very coarse sand and few silt. Gravel consists of greywacke, argillite and vein material. Distinctive red rind and mineralization observed including stibnite and orpiment. Likely tailings/waste rock. 3.1 - 4.0 ft.: No recovery.	Moist			X				X	X	X	X			6890	14	4733	32	10716	41	672	15
MP116	4	8	well-graded Gravel with silt and sand	4.0 - 6.9 ft.: As above. Tailings/waste rock. Moist to 6.2 ft., wet below. 6.9 - 8.0 ft.: No recovery.	Moist to Wet			X		X		X	X	X	X			6610	7	4612	33	10882	43	432	12
MP116	8	12	well-graded Gravel with silt and sand sandy Silt with gravel	8.0 - 8.9 ft.: As above, sandy Gravel with silt. Tailings/waste rock. Wet. 8.9 - 10.9 ft.: Medium brown, moist, sandy Silt with gravel. Mostly medium stiff silt, some very fine sand, and trace to few, coarse, subangular weathered greywacke gravel. 10.9 - 12.0 ft.: No recovery.	Moist to Wet			X		X		X		X	X			4150	5	2824	25	14069	47	23	6
MP116	12	16	sandy Silt silty Gravel with sand	12.0 - 12.5 ft.: Moist, brown sandy Silt. Mostly medium stiff silt with some very fine sand. 12.5 - 15.1 ft.: Medium brown silty Gravel with sand. Mostly well-graded; fine to very coarse, angular to subrounded, weathered greywacke gravel. Some stiff silt, and trace fine sand. 15.1 - 16.0 ft.: No recovery.	Moist													241	0.115	146	6	569	13	<LOD	6
MP116	16	20	silty Gravel with sand sandy Silt	16.0 - 17.0 ft.: As above. 17.0 - 18.7 ft.: Moist, dark gray sandy Silt. Mostly medium stiff silt with few very fine sand. 18.7 - 20.0 ft.: No recovery.	Moist													184	0.05 U	76	5	75	10	<LOD	5
MP116	20	24	sandy Silt silty Gravel with sand sandy Silt Weathered Bedrock	20.0 - 20.4 ft.: As above, moist dark gray sandy Silt. 20.4 - 21.4 ft.: Medium brown, moist, silty Gravel with sand. Mostly fine to coarse, subrounded to subangular weathered greywacke gravel, some stiff silt and some fine to very fine sand. 21.4 - 22.2 ft.: Moist, dark gray, sandy Silt. Mostly medium stiff silt with some very fine sand. 22.2 - 22.8 ft.: Gray to orangish-brown, moist, clayey Gravel (weathered greywacke bedrock). 22.8 - 24.0 ft.: No recovery.	Moist													147	0.05 U	50	4	<LOD	13	<LOD	5
MP116	24	28	Weathered Bedrock - Greywacke, Shale	24.0 - 26.7 ft.: Moist, dark brown, weathered greywacke and shale bedrock. 26.7 - 28.0 ft.: No recovery.	Moist																				

Table A-1 Soil Characterization Summary, 2017 Tailings/Waste Rock Characterization

Soil Boring ID	Sample Depth Interval (feet bgs) Top	Sample Depth Interval (feet bgs) Bottom	Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations: Red Porous Rock	Vitrious "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor	Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Mercury Conc. (ppm)	XRF Mercury Error
MP117	0	5	well-graded Sand with silt and gravel well-graded Sand with silt and gravel	0.0 - 2.0 ft.: Moist, dark gray gravelly Sand with silt. Mostly fine to very fine sand with some fine to coarse, angular gravel and few silt. Gravel consists mostly of greywacke and weathered greywacke, some with orangish staining along fractures, few friable argillite, and trace light brown/tan fine grained sandstone-like material (possibly firebrick). 2.0 - 2.5 ft.: Moist, dark gray gravelly Sand with silt. Mostly fine to very fine sand with some fine to coarse, angular gravel and few silt. Gravel consists mostly of greywacke and weathered greywacke, some with orangish staining along fractures, some friable argillite. 2.5 - 5.0 ft.: No recovery.	Moist													466	0.05 U	440	10	104	11	24	5
MP117	5	10	well-graded Gravel with sand	5 - 7 ft.: Moist, dark gray, mostly fine to very coarse angular Gravel, some fine to very fine sand and few silt. Gravel consists mostly of greywacke and weathered greywacke, some with orangish staining along fractures, some friable argillite, and trace weathered or altered igneous dike material, and trace white vein material. 7 - 10 ft.: No recovery.	Moist								X			X		2740	0.183	2505	26	575	15	220	10
MP117	10	12	silty Gravel with sand	Moist, dark gray, silty Gravel with sand. Mostly fine to very coarse, angular gravel with some silt and few very fine to fine sand. Gravel consists mostly of shale with some greywacke, and few argillite. Some of the greywacke had a distinctive tan/orange rind. Trace vein material observed.	Moist								X	X				3980	0.542	878	14	438	13	30	5
MP117	12	16	well-graded Gravel with silt	Mostly fine to coarse, angular gravel, some to few silt. Gravel consists mostly of greywacke and weathered greywacke, some of which has a distinctive rind. some friable argillite, and trace mineralization and vein material. Vein material contained cinnabar, stibnite, and orpiment. Woody debris in cutting shoe.	Moist			X		X		X	X	X	X			6830	1.55	3751	30	1929	21	55	6
MP117	16	20	poorly graded Gravel sandy Silt with gravel	16.0 - 16.5 ft.: Moist, dark gray, greywacke cobble with white vein material. 16.6 - 18.0 ft.: Sandy Silt with gravel. Mostly silt, medium stiff, some very fine to fine sand, and trace coarse, angular gravel consisting of weathered greywacke. Trace to few woody debris. 18.0 - 20.0 ft.: No recovery.	Moist								X					639	0.05 U	20	3	<LOD	12	<LOD	4
MP117	20	22	sandy Silt with gravel	Moist, dark reddish gray sandy Silt with few gravel. Mostly silt with some fine to very fine sand and trace medium to coarse, angular gravel. Silt is medium stiff. Gravel consists of argillite and greywacke.	Moist													51	0.05 U						
MP117	22	24	sandy Silt with gravel silty Gravel with sand	22.0 - 22.5 ft.: As above. 22.5 - 23.3 ft.: Wet, dark gray silty Gravel with sand. Gravel consists of medium to very coarse, angular weathered greywacke. 23.3 - 24.0 ft.: No recovery.	Wet															37	3	<LOD	11	<LOD	4
MP117	24	28	silty Gravel	24.0 - 26.4 ft.: Wet, brown, mostly medium to very coarse, angular gravel with some silt. Gravel consists of weathered greywacke ranging in color from dark gray to rusty orange. The orangish fragments are much soft.er. Trace argillite. 26.4 - 28.0 ft.: No recovery.	Wet													73	0.05 U	54	4	<LOD	12	6	3
MP117	28	32	Silt	28.0 - 30.8 ft.: Moist, dark gray, stiff Silt with trace medium to coarse, angular argillite. 30.8 - 32.0 ft.: No recovery.	Moist													34	0.05 U	69	5	<LOD	14	<LOD	5
MP117	32	36	Silt silty Gravel silty Gravel with sand	32.0 - 32.7 ft.: As above. Wet, dark brown. 32.7 - 33.8 ft.: Wet, reddish-brown, silty Gravel. Mostly medium to very coarse, angular weathered greywacke, some Silt, medium stiff. 33.8 - 35.4 ft.: Wet, silty Gravel with sand. Mostly fine to medium, angular argillite, with some soft. silt and trace fine to very fine sand. 35.4 - 36.0 ft.: No recovery.	Wet															77	5	<LOD	15	<LOD	6
MP118	0	4	silty Gravel	0 - 2 ft.: Moist, dark gray, mostly medium to very coarse, angular Gravel with some silt and trace fine sand. Gravel consists mostly of greywacke and weathered greywacke, and some argillite and few shale. Few greywacke were light gray in color and had a distinctive rind, trace greywacke had orangish staining along fractures, and one fragment had pyrite mineralization. Trace argillite had orangish staining along fractures. 2 - 4 ft.: No recovery.	Moist									X	X	X		383	0.05 U	161	7	115	11	<LOD	6
MP118	4	8	silty Gravel	4.0 - 5.5 ft.: Moist, dark gray, mostly fine to very coarse, angular Gravel, some to few silt and trace fine sand. Gravel consists of mostly greywacke with trace weathered greywacke, few argillite and trace shale. Trace greywacke had distinctive rind, and trace greywacke and argillite had orangish staining along fractures. 5.5 - 8.0 ft.: No recovery.	Moist									X		X		326	0.05 U	248	8	<LOD	15	<LOD	6
MP118	8	12	silty Gravel	8.0 - 9.8 ft.: Moist, dark gray, mostly fine to very coarse Gravel with some silt and trace fine sand. Gravel consists mostly of friable weathered shale, some argillite and some greywacke. Pyrite crystals (cubic form) observed in several fragments of very fine grained greywacke. 9.8 - 12.0 ft.: No recovery.	Moist								X		X			430	0.05 U	468	12	17	11	23	5
MP118	12	16	silty Gravel	12.0 - 13.3 ft.: Moist, dark gray, mostly fine to very coarse Gravel with some silt and trace fine sand. Gravel consists mostly of greywacke with few argillite and few shale. Several large pieces of vein material. 13.3 - 14.0 ft.: No recovery.	Moist								X					660	0.05 U	543	12	92	11	79	7

Table A-1 Soil Characterization Summary, 2017 Tailings/Waste Rock Characterization

Soil Boring ID	Sample Depth Interval (feet bgs)		Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations												Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic		XRF Antimony		XRF Mercury	
	Top	Bottom				Red Porous Rock	Vitreous "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor			Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error
MP118	16	20	silty Gravel	16.0 - 18.3 ft.: Wet, dark gray, mostly fine to coarse Gravel with some silt and trace fine sand. Gravel consists mostly of greywacke and weathered greywacke with some argillite and few shale. Trace vein material observed in greywacke. Notably different light gray, soft. clay encountered at ~17.9 ft. 18.3 - 20.0 ft.: No recovery.	Wet								X					7420	29	5088	35	6783	35	1396	21
MP118	20	24	sandy Silt gravelly Silt sandy Silt silty Gravel	20.0 - 20.8 ft.: Wet, dark gray to orangish brown mottled, micaceous, very fine sandy Silt. 20.8 - 21.6 ft.: Moist to wet medium brown gravelly Silt. Gravel is medium to coarse, subangular, weathered greywacke and argillite. 21.6 - 22 ft.: Moist, dark gray to orangish-brown mottled, micaceous, very fine sandy Silt. 22.0 - 22.7 ft.: Moist to wet, silty Gravel. Gravel is fine to very coarse, angular to subangular and consists of weathered greywacke that is orangish-brown in color. 22.7 - 24.0 ft.: No recovery.	Wet													1050	2.86	452	14	166	15	<LOD	9
MP118	24	26	silty Gravel with sand	Wet, dark gray, well-graded silty Gravel with sand. Mostly medium to coarse subrounded to subangular weathered greywacke gravel. Some silt, and few very fine to coarse sand.	Wet													112	0.069	70	5	<LOD	14	<LOD	6
MP118	26	28	Weathered Bedrock	26 - 27 ft.: Moist, brown weathered bedrock. 27 - 28 ft.: No recovery.	Moist																				
MP119	0	4	silty Gravel	0.0 - 2.1 ft.: Moist to wet, dark brownish gray, mostly subangular to subrounded, fine to coarse Gravel with some silt and few medium to very coarse sand. Gravel consists primarily of greywacke and argillite with vein material. Some fragments had one or more of the following, red porous rock, distinctive red rind, stibnite, realgar, and orpiment. 2.1 - 4.0 ft.: No recovery.	Moist to Wet	X		X			X	X	X	X	X			3970	15	2847	28	11080	47	28	6
MP119	4	8	silty Gravel with sand gravelly Silt with sand	4.0 - 5.5 ft.: Moist to wet, dark brownish gray silty Gravel with sand. Mostly medium to very coarse, subangular gravel, some silt, and few very fine sand. Gravel consists of brownish weathered greywacke. 5.5 - 6.8 ft.: Dark brownish gray gravelly Silt with sand. Mostly silt with few to trace subangular to subrounded, coarse gravel, and trace very fine sand. Gravel consists of weathered greywacke. 6.8 - 8.0 ft.: No recovery.	Moist to Wet													167	0.05 U	44	4	219	10	<LOD	5
MP119	8	12	silty Gravel Silt silty Sand with gravel	8.0 - 8.8 ft.: Moist, dark brown, mostly subangular, coarse Gravel with some silt. Gravel consists of weathered greywacke and trace weathered argillite. 8.8 - 9.8 ft.: Moist, dark gray to black, stiff Silt with decomposing woody debris. 9.8 - 10.6 ft.: Dark grayish-brown, moist, silty Sand with gravel. Mostly very fine sand with some silt and trace subangular, weathered greywacke. 10.6 - 12.0 ft.: No recovery.	Moist													81	0.05 U	99	6	<LOD	15	<LOD	6
MP119	12	16	well-graded Sand with silt and gravel	12 - 15 ft.: Moist, dark brownish gray gravelly Sand with silt. Mostly very fine sand with some gravel and some silt. Gravel is medium to very coarse subrounded to angular, consisting of weathered greywacke. 15 - 16 ft.: No recovery.	Moist													62	0.05 U	68	5	35	10	<LOD	6
MP119	16	20	silty Gravel	16.0 - 18.5 ft.: Moist to wet, dark brownish gray, mostly angular to subrounded, fine to very coarse Gravel, with some silt and few fine to very fine sand. Gravel consists of weathered bedrock. 18.5 - 20.0 ft.: No recovery.	Moist to Wet													105	0.05 U	53	5	64	12	<LOD	7
MP119	20	24	Silt	20.0 - 23.2 ft.: Moist, dark gray, mostly stiff Silt with trace gravel and few very fine sand. Gravel is fine to very coarse, subrounded to angular weathered greywacke. 23.2 - 24.0 ft.: No recovery.	Moist													14	0.05 U	53	6	50	11	<LOD	7
MP119	24	27	silty Gravel	24.0 - 26.8 ft.: Moist to wet, dark grayish brown, mostly medium to very coarse angular Gravel with some silt and few fine to very fine sand. Gravel consists of weathered greywacke. Wet from 25.7 to 26.4 ft.	Moist to Wet													148	0.05 U	120	7	27	11	<LOD	7
MP119	27	28	Weathered Bedrock - Greywacke	26.8 - 27.3 ft.: Moist to wet, reddish brown weathered greywacke bedrock, dipping at approximately 45 degrees. 27.3 - 28.0 ft.: No recovery.	Moist to Wet																				
MP120	0	4	silty Gravel Silt	0.0 - 1.7 ft.: Moist to wet, dark gray, mostly subangular to subrounded, fine to coarse Gravel with some silt and few medium to very coarse sand. Gravel consists primarily of greywacke and argillite with vein material. Some fragments included one or more of the following: red porous rock, distinctive red rind, stibnite, realgar, and orpiment. 1.7 - 3.0 ft.: Moist, dark brown Silt with few very fine sand. Silt is medium stiff with low plasticity, and trace large woody debris. 3.0 - 4.0 ft.: No recovery.	Moist	X		X			X	X	X	X	X			3110	3.03	1054	14	3630	23	56	5
MP120	4	8	Sand with silt	4.0 - 6.6 ft.: Moist, dark grayish brown, mostly very fine Sand with some medium stiff silt and few gravel. Silty Sand lenses from 5.1 - 5.5 ft. and 6.3 - 6.6 ft. Gravel consists of angular to subangular, medium to coarse weathered greywacke. 6.6 - 8.0 ft.: No recovery.	Moist													269	0.05 U	144	6	117	10	7	4

Table A-1 Soil Characterization Summary, 2017 Tailings/Waste Rock Characterization

Soil Boring ID	Sample Depth Interval (feet bgs) Top	Sample Depth Interval (feet bgs) Bottom	Lithology	Lithological Description	Moisture Observed in Soil Sample or Drill Cuttings	Mineralogical/Lithological Observations: Red Porous Rock	Vitrious "Slag	Stibnite	Elemental Mercury	Cinnabar	Realgar	Orpiment	Vein Material	Red Rind	Sulfides	Iron Stain	Odor	Lab Total Arsenic (mg/kg)	Lab TCLP Arsenic (mg/L)	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Mercury Conc. (ppm)	XRF Mercury Error
MP120	8	12	silty Sand sandy Silt with gravel silty Gravel with sand	8.0 - 8.5 ft.: Wet, dark brownish gray silty Sand. Sand is very fine, silt is soft. 8.5 - 9.4 ft.: Medium to dark brown sandy Silt with gravel. Mostly stiff silt, some fine to very fine sand and trace to few coarse angular weathered greywacke gravel. 9.4 - 10.6 ft.: Medium to dark brown silty Gravel with sand. Mostly fine to very coarse, subangular to angular, weathered greywacke gravel, with some medium stiff silt, and few fine to very fine sand. 10.6 - 12.0 ft.: No recovery.	Wet													90	0.05 U	31	3	<LOD	12	<LOD	5
MP120	12	16	silty Gravel with sand gravelly Silt with sand	12.0 - 14.1 ft.: Wet, brown, as above, silty Gravel with sand. 14.1 - 14.9 ft.: Moist, gravelly Silt with sand. Mostly stiff silt with some fine angular weathered argillite and greywacke gravel and few very fine sand. 14.9 - 16.0 ft.: No recovery.	Wet													74	0.05 U	55	4	32	9	<LOD	5
MP120	16	20	gravelly Silt with sand silty Gravel with sand Weathered Bedrock - Greywacke	16.0 - 16.6 ft.: Moist to wet, dark brown, as above, gravelly Silt with sand. 16.6 - 18.3 ft.: Medium brown to dark gray, moist to wet, silty Gravel with sand. Mostly well-graded angular, very fine to coarse weathered greywacke and argillite gravel, some stiff silt and trace medium to coarse sand. Wet from 17.3 - 18.4 ft. on top of weathered bedrock. 18.3 - 18.9 ft.: Weathered greywacke bedrock with ~45 degree bedding dip. 18.9 - 20.0 ft.: No recovery.	Moist to Wet													104	0.05 U	56	4	<LOD	13	<LOD	5
MP121	0	4	silty Gravel with sand silty Sand with gravel	0.0 - 2.1 ft.: Moist to wet, dark gray silty Gravel with sand. Mostly well-graded, fine to coarse angular gravel consisting of weathered argillite and greywacke; some with distinctive red rind and some with vein material. Some silt medium stiff and few coarse to med sand. Likely tailings/waste rock. 2.1 - 2.3 ft.: Wet, dark gray silty Sand with gravel. Mostly fine to very fine sand, with some med stiff silt and trace coarse angular greywacke gravel. 2.3 - 4.0 ft.: No recovery.	Moist to Wet								X	X				3020	1.67	2517	28	2648	27	186	10
MP121	4	8	gravelly Silt with sand silty Gravel with sand	4.0 - 4.5 ft.: Moist, dark brown gravelly Silt with sand. Mostly stiff silt with some medium, angular argillite gravel, and few very fine sand. Appears to be undisturbed native material. 4.5 - 6.6 ft.: Moist, medium to dark brown, silty Gravel with sand. Well-graded from fine to cobble sized, angular greywacke gravel, some stiff silt and few medium to fine sand. 6.6 - 8.0 ft.: No recovery.	Moist													1120	3.34	431	9	362	11	9	4
MP121	8	12	silty Gravel with sand sandy Silt with gravel gravelly Silt with sand	8.0 - 8.8 ft.: As above, but dark gray. 8.8 - 10.2 ft.: Moist, dark gray, sandy Silt with gravel. Mostly medium stiff silt with few very fine sand and trace med to fine, subrounded to subangular argillite gravel. 10.2 - 10.8 ft.: Medium brown, moist, gravelly Silt with sand. Mostly medium to very coarse subangular weathered greywacke gravel, some stiff silt and few medium to fine sand. Appears to be weathered greywacke bedrock. 10.8 - 12.0 ft.: No recovery.	Moist													249	0.168	98	4	49	8	5	3
MP121	12	16	Weathered Bedrock - Greywacke	12 - 15 ft.: Moist to wet, dark brown weathered greywacke bedrock. 15 - 16 ft.: No recovery.	Moist to Wet																				

Key

<LOD = Less than level of detection for XRF
As = Arsenic
bgs = Below ground surface
ft. = Feet
Conc. = Concentration
Hg = Mercury
mg/kg = Milligrams per kilogram
mg/L = milligrams per liter
NR = Not reported
ppm = Parts per million
Sb - Antimony
XRF = X-ray fluoresence spectroscopy

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Table A-2 2017 Main Processing Area Tailings/Waste Rock Characterization Soil Sample Results

Soil Boring ID Sample Interval Depth (feet bgs)	Total Arsenic (mg/kg)	TCLP Arsenic (mg/L)
MP102		
0-4	2630	7.99
4-8	1610	17.8
8-12	520	0.432
12-16	231	0.187
MP103		
0-4	606	1.78
4-8	787	2.46
8-12	172	0.078
12-16	174	0.05 U
16-18.4	218	0.05 U
MP104		
0-4	923	2.23
4-8	96.8	0.05 U
8-12	117	0.05 U
12-16	194	0.05 U
16-20	621	0.05 U
20-24	183	0.05 U
24-28	139	0.05 U
28-29.5	65.3	0.05 U
MP105		
0-4	1340	1.62
4-8	38.5	0.05 U
8-12	62.2	0.05 U
12-16	68	0.05 U
16-20	114	0.05 U
20-24	86.8	0.05 U
24-28	44.6	0.05 U
MP106		
0-4	1290	1.45
4-8	37	0.05 U
8-12	62.1	0.05 U
MP107		
0-4	5290	9.69
4-8	6100	13.5
8-12	1420	0.691
12-16	2390	2.44
16-20	574	0.551
20-24	251	0.223
MP108		
0-4	5180	13.9
4-8	7110	7.45
8-12	4570	7.24
12-16	2150	10.3
16-20	4230 J	29.7
20-24	3440	13.6
24-28	206	0.434
MP109		
0-4	4490	8.91
4-8	4730	9.73
8-12	4980	10.4
12-16	4820	10.2
16-20	2320	7.5
20-24	186	0.05 U
24-25.5	78.9	0.05 U
MP110		
0-4	3100	5.2
4-8	4370	5.97
8-12	5410	5.19
12-16	794	0.706
16-20	70.8	0.05 U
MP111		
0-4	6300	5.63
4-8	3570	4.79
8-12	3930	3.39
12-16	41.9	0.05 U
16-18.4	64.2	0.05 U
MP112		
0-4	3170	1.7
4-8	394	0.05 U
8-12	503	0.062
12-16	65.9	0.05 U
16-20	34.2	0.05 U
MP113		
0-4	8300	17.4
4-8	6260	23.7

Table A-2 2017 Main Processing Area Tailings/Waste Rock Characterization Soil Sample Results

Soil Boring ID Sample Interval Depth (feet bgs)	Total Arsenic (mg/kg)	TCLP Arsenic (mg/L)
8-12	8060	28.1
12-16	11400	18.5
16-20	3960	6.74
20-24	411	1.05
24-28	345	0.24
28-29	138	0.073
MP114		
0-4	3610	12.3
4-8	2740	13.3
8-12	180	0.055
12-16	50.7	0.064
16-20	83 J-	0.05 U
20-21.2	162	0.05 U
MP115		
0-4	5590	12.3
4-8	3680	5.76
8-12	75.3	0.05 U
12-16	15.4	0.05 U
16-20	173	0.05 U
20-21.2	91.6	0.05 U
MP116		
0-4	6890	13.6
4-8	6610	7.29
8-12	4150	5.28
12-16	241	0.115
16-20	184	0.05 U
20-22.2	147	0.05 U
MP117		
0-4	466	0.05 U
4-8	2740	0.183
8-12	3980	0.542
12-16	6830	1.55
16-20	639	0.05 U
20-24	50.9	0.05 U
24-28	73.1	0.05 U
28-32	34.3	0.05 U
MP118		
0-4	383	0.05 U
4-8	326	0.05 U
8-12	430	0.05 U
12-16	660	0.05 U
16-20	7420	29.2
20-24	1050	2.86
24-26	112	0.069
MP119		
0-4	3970	15
4-8	167	0.05 U
8-12	81.1	0.05 U
12-16	61.5	0.05 U
16-20	105	0.05 U
20-24	14	0.05 U
24-27	148	0.05 U
MP120		
0-4	3110	3.03
4-8	269	0.05 U
8-12	89.5	0.05 U
12-16	74.2	0.05 U
16-18.3	104	0.05 U
MP121		
0-4	3020	1.67
4-8	1120	3.34
8-12	249	0.168

Key

J = The analyte was detected. The associated result is estimated.

mg/kg = Milligrams per kilogram.

mg/L = Milligrams per liter.

U = The analyte was analyzed for but not detected. The value provided is the method detection limit.

Table A-3 Supplemental Soil and Groundwater Elevation Data

General Area	Year Installed	Borehole ID	Monitoring Well ID	Borehole Total Depth (feet bgs)	Monitoring Well Total Depth (feet bgs)	Monitoring Well Screened Interval (feet bgs)	2015 Ground Surface Elevation (feet NAVD88) Based on Topography from 2015 LiDAR Survey	Original Ground Surface Elevation on Date of Borehole Installation (feet NAVD88) Based on Topography from 2010 Orthophotograph	2011 Ground Surface Elevation (feet NAVD88) Based on Topographic Survey	Depth to Top of Bedrock on Date of Borehole Installation (feet bgs)	Elevation of Top of Bedrock (feet NAVD88)	2016 FS Estimated Bottom Depth of Soil Excavation Under FS Alternatives 3 and 4 (feet bgs)	Preliminary Supplemental Estimated Bottom Depth of Soil Excavation under 2016 FS Alternatives 3 and 4 (feet bgs)	Basis for Estimation of Bottom Depth of Soil Excavation under 2016 FS Alternatives 3 and 4 (feet bgs)	2016 FS Elevation of Bottom of Excavation under 2016 FS Alternatives 3 and 4 (feet NAVD88)	Preliminary Supplemental Estimated Elevation of Bottom of Excavation under 2016 FS Alternatives 3 and 4 (feet NAVD88)	Thickness of Soil below Preliminary Bottom Depth of Excavation under 2016 FS Alternatives 3 and 4 (feet)	Maximum Groundwater Elevation Measured in Well from 2007 to 2017 (feet NAVD88)	Maximum Thickness of Saturated Interval in Residual Soil above Top of Bedrock from 2007 to 2017 (feet)
Post-1955 Main Processing Area	2000	MW01	MW01	31	29.5	19.0 - 29.1	254		254.51			24		RG Exceedance	230.51			237.15	
Post-1955 Main Processing Area	2000	MW03	MW03	26	25.5	15.0 - 25.0	228		228.37			20		RG Exceedance	208.37			208.17	
Post-1955 Main Processing Area	2000	MW07	MW07	21	21.5	11.0 - 21.0	278		278.39			0		NA (no exceedances)	NA		NA	257.72	
Post-1955 Main Processing Area	2011	MP10		6			279			2	277	2		Bedrock	277		0		
Post-1955 Main Processing Area	2011	MP11		8			267					10		Extrapolated below TD of 8 ft.	257				
Post-1955 Main Processing Area	2011	MP12	MW11	22	23	12.0 - 22.0	269		268.7	15	253.7	15		Bedrock	253.7		0	246.1	0
Post-1955 Main Processing Area	2011	MP14	MW10	60	61	50.0 - 60.0	274		274.31	28	246.31	28		Bedrock	246.31		0	242.69	0
Post-1955 Main Processing Area	2011	MP16		10			272					14		Extrapolated below TD of 10 ft.	258				
Post-1955 Main Processing Area	2011	MP17	MW09	32	31	20.0 - 30.0	274		274.88	31	243.88	14		RG Exceedance	260.88		17	247.06	3.18
Post-1955 Main Processing Area	2011	MP18		22			276					20		RG Exceedance	256				
Post-1955 Main Processing Area	2011	MP19		32			280			4	276	2		RG Exceedance	278		2		
Post-1955 Main Processing Area	2011	MP20	MW13	31	32	21.0 - 31.0	274		274.3	14	260.3	6		RG Exceedance	268.3		8	246.65	0
Post-1955 Main Processing Area	2011	MP21		16			269					4		RG Exceedance	265				
Post-1955 Main Processing Area	2011	MP22		16			257					18		Extrapolated below TD of 16 ft.	239				
Post-1955 Main Processing Area	2011	MP23		22			253					24		Extrapolated below TD of 22 ft.	229				
Post-1955 Main Processing Area	2011	MP24		22			251					25		Extrapolated below TD of 22 ft.	226				
Post-1955 Main Processing Area	2011	MP25	MW14	36	36	25.0 - 35.0	243		246.71	36	210.71	36		Bedrock	210.71		0	218.5	0
Post-1955 Main Processing Area	2011	MP26		18			255					20		Extrapolated below TD of 18 ft.	235				
Post-1955 Main Processing Area	2011	MP27		6			245	239				8		Extrapolated below TD of 6 ft.	231				
Post-1955 Main Processing Area	2011	MP28		10			241	243				14		Extrapolated below TD of 10 ft.	229				
Post-1955 Main Processing Area	2011	MP29	MW15	26	26	15.0 - 25.0	228		242.63			30		Extrapolated below TD of 26 ft.	212.63			225.29	
Post-1955 Main Processing Area	2011	MP30	MW16	24	22	11.0 - 21.0	226		226.06	23	203.06	16		RG Exceedance	210.06		7	212.87	7
Post-1955 Main Processing Area	2011	MP32		14			231	224				16		Extrapolated below TD of 14 ft.	208				
Post-1955 Main Processing Area	2011	MP34		22			216			18	198	18		Bedrock	198		0		
Post-1955 Main Processing Area	2011	MP35		22			212			16	196	16		Bedrock	196		0		
Post-1955 Main Processing Area	2011	MP36		16			214			10	204	10		Bedrock	204		0		
Post-1955 Main Processing Area	2011	MP37		22			212			14	198	14		Bedrock	198		0		
Post-1955 Main Processing Area	2011	MP38	MW20	16	15.5	4.5 - 14.5	213		212.9			17		Extrapolated below TD of 16 ft.	195.9			206.6	
Post-1955 Main Processing Area	2011	MP39	MW21	16.5	17.5	6.5 - 16.5	208		208.23	12	196.23	12		Bedrock	196.23		0	200.68	0
Post-1955 Main Processing Area	2011	MP40	MW22	14.5	15.5	4.5 - 14.5	203		203.1	9.5	193.6	9.5		Bedrock	193.6		0	194.65	0
Post-1955 Main Processing Area	2011	MP91	MW17	51.5	52.5	41.5 - 51.5	226		226.36	23	203.36	16		See MP30	210.36		7	208.73	5.37
Post-1955 Main Processing Area	2015	MP094		24			227			20	207		20	Bedrock		207	0		
Post-1955 Main Processing Area	2015	MP097		16			217			14	203		14	Bedrock		203	0		
Post-1955 Main Processing Area	2015	MP101		17.5			208			14	194		14	Bedrock		194	0		
Post-1955 Main Processing Area	2017	MP102		24			269			16	253		16	Bedrock		253	0		
Post-1955 Main Processing Area	2017	MP103		24			271			18.4	252.6		18.4	Bedrock		252.6	0		
Post-1955 Main Processing Area	2017	MP104		32			275			29.5	245.5		29.5	Bedrock		245.5	0		
Post-1955 Main Processing Area	2017	MP105		32			275			28	247		28	Bedrock		247	0		
Post-1955 Main Processing Area	2017	MP106		12			278			12	266		12	Bedrock		266	0		
Post-1955 Main Processing Area	2017	MP107		28			265			20.7	244.3		20.7	Bedrock		244.3	0		
Post-1955 Main Processing Area	2017	MP108		28			264			23	241		23	Bedrock		241	0		
Post-1955 Main Processing Area	2017	MP109		28			261			25.3	235.7		25.3	Bedrock		235.7	0		
Post-1955 Main Processing Area	2017	MP118		28			251			26	225		26	Bedrock		225	0		
Post-1955 Main Processing Area	2017	MP119		28			235			27	208		27	Bedrock		208	0		
Post-1955 Main Processing Area	2017	MP120		20			224			18.3	205.7		18.3	Bedrock		205.7	0		
Pre-1955 Main Processing Area	2000	MW04	MW04	34	30.5	20.0 - 30.0	240		239.92			30		RG Exceedance	209.92			213.51	
Pre-1955 Main Processing Area	2000	MW06	MW06	24	23.5	13.0 - 23.0	215		214.99			20		RG Exceedance	194.99			198.29	
Pre-1955 Main Processing Area	2011	MP13		6			271			28	243	28		See MP14	243		0		
Pre-1955 Main Processing Area	2011	MP15		8			274					10		Extrapolated below TD of 8 ft.	264				
Pre-1955 Main Processing Area	2011	MP45		12			243					16		Extrapolated below TD of 12 ft.	227				
Pre-1955 Main Processing Area	2011	MP46		20			243					24		Extrapolated below TD of 20 ft.	219				
Pre-1955 Main Processing Area	2011	MP47		26			242					27		Extrapolated below TD of 26 ft.	215				
Pre-1955 Main Processing Area	2011	MP48		14			243					18		Extrapolated below TD of 14 ft.	225				
Pre-1955 Main Processing Area	2011	MP49		14			243					15		Extrapolated below TD of 14 ft.	228				
Pre-1955 Main Processing Area	2011	MP50		6			252			3.5	248.5	3.5		Bedrock	248.5		0		
Pre-1955 Main Processing Area	2011	MP51		14			246			10.5	235.5	10.5		Bedrock	235.5		0		
Pre-1955 Main Processing Area	2011	MP52	MW26	42	43	32.0 - 42.0	244		244.03	16	228.03	6		RG Exceedance	238.03		10	208.69	0
Pre-1955 Main Processing Area	2011	MP53		8			243					14		Extrapolated below TD of 8 ft.	229				
Pre-1955 Main Processing Area	2011	MP54		8			245					12		Extrapolated below TD of 8 ft.	233				
Pre-1955 Main Processing Area	2011	MP55		6			239			6	233	6		Bedrock	233		0		
Pre-1955 Main Processing Area	2011	MP56		10			237			8	229	8		Bedrock	229		0		
Pre-1955 Main Processing Area	2011	MP57		10			232					12		Extrapolated below TD of 10 ft.	220				
Pre-1955 Main Processing Area	2011	MP58		14			234					16		Extrapolated below TD of 14 ft.	218				
Pre-1955 Main Processing Area	2011	MP59		16			231					18		Extrapolated below TD of 16 ft.	213				
Pre-1955 Main Processing Area	2011	MP60	MW27	33	34	23.0 - 33.0	241		241.04	29	212.04	29		Bedrock	212.04		0	208.53	0
Pre-1955 Main Processing Area	2011	MP61		6			229					8		Extrapolated below TD of 6 ft.	221				
Pre-1955 Main Processing Area	2011	MP62	MW24	29	30	19.0 - 29.0	221		221.41	12	209.41	4		RG Exceedance	217.41		8	204.49	0
Pre-1955 Main Processing Area	2011	MP63		6			212					8		Extrapolated below TD of 6 ft.	204				
Pre-1955 Main Processing Area	2011	MP66	MW23	28	29	18.0 - 28.0	202		201.96	6	195.96	2		RG Exceedance	199.96		4	186.53	0
Pre-1955 Main Processing Area	2011	MP88	MW28	63	64	53.0 - 63.0	240		239.94	29	210.94	29		See MP60	210.94		0	211.81	0
Pre-1955 Main Processing Area	2011	MP89	MW25	41	42	31.0 - 41.0	239		237.56	22	215.56	12		RG Exceedance	225.56		10	205.89	0
Pre-1955 Main Processing Area	2015	MP095		22			227			16	211		15	RG Exceedance		212	1		

Table A-3 Supplemental Soil and Groundwater Elevation Data

General Area	Year Installed	Borehole ID	Monitoring Well ID	Borehole Total Depth (feet bgs)	Monitoring Well Total Depth (feet bgs)	Monitoring Well Screened Interval (feet bgs)	2015 Ground Surface Elevation (feet NAVD88) Based on Topography from 2015 LiDAR Survey	Original Ground Surface Elevation on Date of Borehole Installation (feet NAVD88) Based on Topography from 2010 Orthophotograph	2011 Ground Surface Elevation (feet NAVD88) Based on Topographic Survey	Depth to Top of Bedrock on Date of Borehole Installation (feet bgs)	Elevation of Top of Bedrock (feet NAVD88)	2016 FS Estimated Bottom Depth of Soil Excavation Under FS Alternatives 3 and 4 (feet bgs)	Preliminary Supplemental Estimated Bottom Depth of Soil Excavation under 2016 FS Alternatives 3 and 4 (feet bgs)	Basis for Estimation of Bottom Depth of Soil Excavation under 2016 FS Alternatives 3 and 4 (feet bgs)	2016 FS Elevation of Bottom of Excavation under 2016 FS Alternatives 3 and 4 (feet NAVD88)	Preliminary Supplemental Estimated Elevation of Bottom of Excavation under 2016 FS Alternatives 3 and 4 (feet NAVD88)	Thickness of Soil below Preliminary Bottom Depth of Excavation under 2016 FS Alternatives 3 and 4 (feet)	Maximum Groundwater Elevation Measured in Well from 2007 to 2017 (feet NAVD88)	Maximum Thickness of Saturated Interval in Residual Soil above Top of Bedrock from 2007 to 2017 (feet)
Pre-1955 Main Processing Area	2015	MP096		32			239			28	211		21	RG Exceedance		218	7		
Pre-1955 Main Processing Area	2015	MP098		46			239			35	204		35	Bedrock		204	0		
Pre-1955 Main Processing Area	2015	MP099		26			242			23	219		23	Bedrock		219	0		
Pre-1955 Main Processing Area	2015	MP100		37.5			233			36	197		21	RG Exceedance		212	15		
Pre-1955 Main Processing Area	2017	MP110		24			257			20	237		20	Bedrock		237	0		
Pre-1955 Main Processing Area	2017	MP111		20			251			18.4	232.6		18.4	Bedrock		232.6	0		
Pre-1955 Main Processing Area	2017	MP112		24			256			20	236		20	Bedrock		236	0		
Pre-1955 Main Processing Area	2017	MP113		32			258			28.9	229.1		28.9	Bedrock		229.1	0		
Pre-1955 Main Processing Area	2017	MP114		28			247			21.2	225.8		21.2	Bedrock		225.8	0		
Pre-1955 Main Processing Area	2017	MP115		28			241			21.1	219.9		21.1	Bedrock		219.9	0		
Pre-1955 Main Processing Area	2017	MP121		16			219			10.2	208.8		10.2	Bedrock		208.8	0		
Red Devil Creek Delta	2011	RD01		16			170	173				0		NA (no exceedances)	NA		NA		
Red Devil Creek Delta	2011	RD02		14			173	174				10		RG Exceedance	164				
Red Devil Creek Delta	2011	RD03		16			177	177				14		RG Exceedance	163				
Red Devil Creek Delta	2011	RD04		14			180	181				4		RG Exceedance	177				
Red Devil Creek Downstream Alluvial Area	2011	RD05	MW32	25	25	14.0 - 24.0	194		194.38	14	180.38	2		RG Exceedance	192.38		12	175.25	0
Red Devil Creek Downstream Alluvial Area	2011	RD06		14			194	195		10	185	8		RG Exceedance	187		2		
Red Devil Creek Downstream Alluvial Area	2011	RD07		12			197	198		10	188	2		RG Exceedance	196		8		
Red Devil Creek Downstream Alluvial Area	2011	RD20	MW33	23	23	12.0 - 22.0	177		176.62	16	160.62	5		RG Exceedance	171.62		11	169.69	9.07
Red Devil Creek Downstream Alluvial Area	2015	RD21		8			191			6	185		6	Bedrock		185	0		
Red Devil Creek Downstream Alluvial Area	2015	RD22		20			195			17	178		3	RG Exceedance		192	14		
Red Devil Creek Downstream Alluvial Area	2017	MP116		28			236			22.2	213.8		22.2	Bedrock		213.8	0		
Red Devil Creek Downstream Alluvial Area	2017	MP117		36			253			32	221		32	Bedrock		221	0		

Key

bgs = Below ground surface.
ft. = Feet
NAVD88 = North American Vertical Datum 1988.
RG = Remedial goal.
TD = Total depth.

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet		Llithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM72	0	2	Silt with sand Silt with sand and gravel	0 - 1 ft.: Moist, grayish brown loess. Thin (5 mm thick) bands of iron stain in very fine sand. 1 - 2 ft.: Silt with sand and gravel. Gravel is dark gray siltstone, blocky, 1-3 cm. Sand is very fine to fine. Silt low plasticity. Trace roots. At this location drill pad was established by scraping approx. 3 ft. of soft. soil to make flat, stable surface.																			Moist		MW44	
	2	4	Silt with sand and gravel Weathered Bedrock - Greywacke Weathered Bedrock - Siltstone Weathered Bedrock - Shale	2.0 - 2.2 ft.: As above, but brownish gray. 2.2 - 4.0 ft.: Weathered bedrock at 2.2 ft. with > 4cm cobbles of well-lithified greywacke. Greywacke is dark gray, silty, very fine sandstone with occasional weathered to brown with iron staining. Interstitial silt is stiff, sand is very fine to fine. 2.6 to 3.3 ft. is dark gray siltstone. 3.3 to 3.8 ft. is black shale with apparent 30 degree bedding dip. Shale is friable, weathered to clay in places.											X								Moist			
	4	6	Weathered Bedrock - Shale, Argillite	Moist, dark gray weathered bedrock. Mostly black friable shale, locally weathered to clay, with some blocky argillite. Apparent bedding dip 30 degrees.																			Moist			
	6	8	Weathered Bedrock - Argillite, Shale	As above, but moist, with more blocky argillite than friable shale. Iron stain 7.5 - 7.9 ft. Apparent bedding dip 30 degrees.											X								Moist			
	8	10	Weathered Bedrock - Shale	Moist, dark gray weathered bedrock. Friable black shale readily weathered to brown clay. Apparent bedding dip of 45 degrees on iron-stained bedding planes.											X								Moist			
	10	12	Weathered Bedrock - Shale, Greywacke	As above, with band of dark gray, poorly-lithified greywacke at 10.5 to 11.0 ft. between shale layers.																			Moist			
	12	14	Weathered Bedrock - Shale	Moist, dark grayish brown shale weathering significantly to tight, lean clay. Vey stiff. Apparent bedding dip 45 degrees. Direct push becoming difficult.																			Moist			
	14	15	Weathered Bedrock - Argillite	As above transitioning to blockier argillite at 14.7 ft. Refusal by direct push at 15 ft.																			Moist			
	15	17	Bedrock - Argillite, Greywacke, Shale	Argillite and greywacke with iron staining. Some shale possible. Dry, dark brown.											X								Dry			
	17	19.5	Bedrock - Greywacke, Silstone	Greywacke and brown siltstone. Dry.																			Dry			
	19.5	22	Bedrock - Shale, Argillite	Cuttings are mostly pulverized rock (suspected friable shale). Very few flat black shale cuttings and few blocky argillite cuttings. Orangish-yellow iron stain in argillite. Dry, very dark gray.											X								Dry			
	22	24.5	Bedrock - Argillite, Shale, Siltstone	Dry, very dark gray, blocky to platy weak argillite and friable shale. Few brown siltstone with brownish-yellow iron stain.											X								Dry			
	24.5	27	Bedrock - Siltstone, Greywacke	Siltstone and weak brownish-gray greywacke. Some iron stain. Dry, dark grayish brown.											X								Dry			
	27	29.5	Bedrock - Greywacke	Dry, dark brown, greywacke.																			Dry			
	29.5	32	Bedrock - Argillite, Siltsone, Shale	Dry, very dark gray argillite and very dark brown siltstone. Some platy shale.																			Dry	29.84		
	32	34.5	Bedrock - Greywacke	Dry, gray greywacke .																			Dry			
	34.5	37	Bedrock - Shale, Argillite, Greywacke	Mostly shale, very few cuttings and very light colored pulverized rock. Some Argillite and greywacke. Dry, dark gray.																			Dry			
	37	39.5	Bedrock - Argillite, Shale	Dry black argillite and shale.																			Dry			
	39.5	42	Bedrock - Greywacke	Weak greywacke with a salt and pepper appearance, with visible grains of quartz and calcite. Drill returns have fine white dust. Few cuttings. Dry, light gray.																			Dry			
	42	44.5	Bedrock - Argillite	Black, blocky argillite with brown iron stain on fractures. Larger cuttings. Moist at 44 ft.											X								Moist			
	44.5	47	Bedrock - Argillite	Dry black argillite, smaller cuttings.																			Dry			
	47	49.5	Bedrock - Siltstone	Dry black siltstone, angular to blocky, trace iron stain.											X								Dry			48 - 68
	49.5	52	Bedrock - Siltstone	Dark gray siltstone, subangular, with brown iron stain on fractures. Moist from 50 to 51 ft.																			Dry			
	52	54.5	Bedrock - Greywacke	Dry, mostly light gray pulverized cuttings, with medium gray greywacke with visible quartz and calcite. Poorly lithified.																			Dry			
	54.5	57	Bedrock - Siltstone, Argillite	Dry black siltstone and argillite, blocky to platy.																			Dry			
	57	59.5	Bedrock - Argillite, Siltstone	Dry black argillite with some very dark gray siltstone.																			Dry			
	59.5	62	Bedrock - Argillite, Siltstone	As above with more siltstone.																			Dry			
	62	64.5	Bedrock - Argillite, Siltstone	As above, but very dark gray. Occasional quartz veins in siltstone. Moist at 64 ft.																			Moist			
	64.5	67	Bedrock - Siltstone, Greywacke	Gray, siltstone and greywacke. Trace quartz. Moist below 65 ft.																			Moist			
	67	69	Bedrock - Greywacke	Gray greywacke with quartz veins. Iron staining in veins. Slower rate of penetration due to harder rock compared to intervals above. Wet below 68 ft.											X								Wet			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet		Llithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM73	0	2	Silt with sand Silt with gravel	0.0 - 0.8 ft.: Moist, light reddish brown loess with low plasticity. Occasional rootlets and reddish streaks of decomposing organics. 0.8 - 2.0 ft.: Firm Silt with gravel. Loess, disturbed. Occasional pieces of fissile shale with subrounded to subangular gravel. Gravel is 5 mm to 2 cm.													<LOD	12	17	3	<LOD	5	Moist		MW45	
	2	4	Silt	Moist light reddish brown, firm Silt with trace gravel. Disturbed loess. Low plasticity and rootlets and evidence of decomposition throughout. Base of interval is moist peat layer, 1" thick (suspected pre-mining soil surface).													<LOD	12	12	3	<LOD	4	Moist			
	4.2	6	Peat Silt	4.0 - 4.2: Moist, very dark brown Peat. Suspected pre-mining soil surface. 4.2 - 5.3 ft.: No recovery. 5.3 to 6 ft.: Firm inorganic Silt with bands of red and grey throughout interval. Trace angular gravel 2 mm to 5mm. Low plasticity. Loess.													<LOD	12	12	3	<LOD	4	Moist			
	6	8	Silt with sand Silt with gravel	6.0 - 6.3 ft.: Moist, light reddish brown, inorganic silt with low-mod plasticity. Very firm loess throughout. 6.3 - 7.3 ft.: Some subangular to angular gravel, 1-3 cm, mostly siltstone with iron staining (weathering). 7.3 - 8.0 ft.: No recovery.											X		<LOD	12	16	3	<LOD	5	Moist			
	8	10	Silt Weathered Bedrock - Greywacke, Shale	8.0 - 8.4 ft.: Moist, light reddish brown, very firm inorganic Silt with low to moderate plasticity. 8.4 - 8.9 ft.: Weathered greywacke and highly weathered shale. 8.9 - 10.0 ft.: No recovery.													<LOD	14	51	4	<LOD	6	Moist			
	10	12	Weathered Bedrock - Graywack, Siltstone	Moist, weathered bedrock consisting of dark gray Gravel with Silt. Greywacke and siltstone. Dense silt throughout. Iron staining present on siltstone.											X		<LOD	13	30	3	<LOD	5	Moist			
	12	14	Weathered Bedrock - Siltstone	Moist, weathered bedrock consisting of dark gray gravel with silt. 12.0-12.5 ft.:: Siltstone with visible quartz grains and iron staining (weathering) along fracture planes. No bedding apparent. 12.5 - 14.0 ft.: siltstone with less Fe weathering. Apparent bedding dip at base of interval is approximately 45 degrees.											X		<LOD	13	39	4	<LOD	6	Moist			
	15	17	Weathered Bedrock - Siltstone	Dry, dark gray siltstone with iron staining (weathering) along bedding planes.											X		<LOD	13	34	4	<LOD	5	Dry			
	17	19.5	Weathered Bedrock - Siltstone	Dry, dark grayish brown siltstone with apparent grains of quartz and iron staining (weathering).								X			X		<LOD	13	30	4	<LOD	5	Dry			
	19.5	22	Weathered Bedrock - Siltstone, Argillite	Dry, very dark gray siltstone with iron staining (weathering). Some argillite.											X		<LOD	12	31	4	<LOD	5	Dry			
	22	24.5	Weathered Bedrock - Greywacke	Comparably larger fragments of greywacke. Iron staining and possible realgar. Dry, brownish gray.						X				X	X		<LOD	13	68	5	<LOD	6	Dry			
	24.5	27	Weathered Bedrock - Greywacke	As above, except dark gray.						X				X	X		<LOD	13	30	4	<LOD	6	Dry			
	27	29.5	Weathered Bedrock - Shale, Greywacke	Dry, dark reddish brown weathered shale with very small cuttings of possible greywacke.													<LOD	13	27	3	<LOD	5	Dry			
	29.5	32	Weathered Bedrock - Shale	Dry, dark reddish brown weathered shale with some iron staining.											X		<LOD	13	23	3	<LOD	6	Dry			
	32	34.5	Bedrock - Siltstone	Dry, dark reddish brown siltstone with iron staining.											X		<LOD	14	18	3	<LOD	6	Dry			
	34.5	37	Bedrock - Siltstone	As above, but dark gray.											X		<LOD	13	11	3	<LOD	6	Dry			
	37	39.5	Bedrock - Greywacke	Dry, dark grayish brown greywacke with iron staining along fracture planes.											X		<LOD	14	13	3	<LOD	6	Dry			
	39.5	42	Weathered Bedrock - Shale	Dry, dark reddish brown weathered shale.													<LOD	13	16	3	5	4	Dry			
	42	44.5	Weathered Bedrock - Siltstone	Dry, dark grayish brown siltstone with iron staining (weathering).											X		<LOD	13	20	3	<LOD	6	Dry	42.39		
	44.5	47	Weathered Bedrock - Shale	Dry, dark gray weathered shale. Iron staining (weathering) apparent along bedding or fracture planes.											X		<LOD	13	31	4	<LOD	5	Dry			
	47	49.5	Bedrock - Siltstone	Dry, dark gray siltstone. Larger cuttings (harder) than siltstone above.													<LOD	14	36	4	<LOD	6	Dry			
	49.5	52	Weathered Bedrock -Shale	Dry, dark gray weathered shale.													<LOD	12	50	4	<LOD	5	Dry			
	52	54.5	Bedrock - Greywacke, Silstone	Dry, dark gray, greywacke with few siltstone with visible quartz grains. Pulverized rock cuttings.													<LOD	13	26	3	<LOD	5	Dry			
	54.5	57	Weathered Bedrock - Greywacke	Comparably larger (up to 2 cm) cuttings of greywacke. Visible grains and iron staining (weathering). Pulverized cuttings. Dry, dark gray.											X		<LOD	13	25	3	<LOD	5	Dry			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet		Llithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM73	57	59.5	Weathered Bedrock - Greywacke	Dry, dark gray, greywacke, heavily weathered to reddish brown. Iron staining. Pulverized cuttings.											X		<LOD	12	24	3	<LOD	5	Dry	42.39	MW45	
	59.5	62	Weathered Bedrock - Greywacke	Dry, dark gray, greywacke, heavily weathered to reddish brown. Iron staining. Pulverized cuttings.											X		<LOD	13	32	3	<LOD	5	Dry			61 - 81
	62	64.5	Bedrock - Greywacke, Argillite	Dry, black, greywacke and possible argillite. Pulverized cuttings.													<LOD	13	45	4	<LOD	5	Dry			
	64.5	67	Bedrock - Greywacke	Greywacke with visible quartz grains and iron staining throughout. Greywacke grainsize slightly larger (fine sand) than previous intervals. Reported by driller as hardest drilling in boring. Cuttings are moist much water in returns. Wet below 66 ft.								X			X		<LOD	14	47	4	<LOD	6	Wet			
	67	69.5	Bedrock - Argillite, Greywacke	Black argillite and greywacke. Argillite has iron staining along fractures. Cuttings slightly moist. Wet.											X		<LOD	13	66	5	<LOD	6	Wet			
	69.5	72	Weathered Bedrock - Greywacke	Dark reddish brown weathered greywacke. Cuttings are mostly pulverized loose fines with some greywacke weathered to brownish red. Iron staining. Cuttings slightly moist. Wet.											X		<LOD	13	87	5	<LOD	6	Wet			
	72	74.5	Bedrock - Greywacke	As above. Cuttings slightly moist. Wet.											X		<LOD	13	59	4	<LOD	6	Wet			
	74.5	77	Bedrock - Greywacke	As above, but color is light reddish brown.											X		<LOD	13	85	5	<LOD	5	Wet			
	77	79.5	Bedrock - Greywacke	As above. but dark reddish brown and dry.											X		<LOD	13	56	4	<LOD	5	Wet			
	79.5	82	Bedrock - Argillite, Greywacke, Shale	Dark gray argillite and some weathered greywacke and weathered shale with minimal iron staining. Dry.													<LOD	13	62	4	<LOD	6	Wet			
SM74	0	2	silty Gravel Clay Weathered Bedrock - Argillite, Shale	0.0 - 1.4 ft.: Moist, grayish brown silty Gravel. Gravel is fine to 4 cm, decomposed greywacke with iron staining, and fine friable black shale. 1.4 to 1.6 ft.: Clay. 1.6 - 2.0 ft.: weathered bedrock: argillite, shale.											X		<LOD	13	64	4	<LOD	5	Moist		MW46	
	2	4	Weathered Bedrock - Shale, Siltstone	Moist weathered bedrock. Mostly shale with some siltstone. Iron stain in siltstone, shale weathered to clay in places. Apparent bedding dip in shale 30 degrees.											X		<LOD	13	46	4	<LOD	5	Moist			
	4	6	Weathered Bedrock - Shale, Siltstone	Dry, light brownish gray weathered bedrock, mostly siltstone with iron staining in shale. Shale weathered to clay.											X		<LOD	14	85	5	<LOD	6	Dry			
	6	8	Weathered Bedrock - Shale, Siltstone	Dry, light brownish gray weathered bedrock, mostly siltstone with iron staining, bottom 0.3 ft. is shale weathered to clay.											X		<LOD	14	97	5	<LOD	6	Dry			
	8	10	Weathered Bedrock - Shale	Moist, light brownish gray weathered bedrock, shale weathered to clay. Apparent 45 degree bedding dip. Trace vein material								X					<LOD	13	119	6	<LOD	6	Moist			
	10	12	Weathered Bedrock - Shale, Siltstone	Moist, light reddish brown weathered bedrock. Interbedded shale and siltstone with iron staining. heavy iron staining in shale at 11.5 ft.											X		<LOD	15	80	5	<LOD	6	Moist			
	12	14	Weathered Bedrock - Greywacke, Shale	Moist, brownish gray weathered bedrock. Greywacke with iron staining 12.0 to 12.5 ft., above shale weathered to clay. Vein material at 13.5 ft.								X			X		<LOD	14	66	5	<LOD	6	Moist			
	14	15	No recovery.	No recovery.																			No Recovery			
	15	17	Bedrock - Shale	Dry, brownish gray friable shale.													<LOD	13	58	4	<LOD	6	Dry			
	17	19.5	Bedrock - Argillite, Siltstone	Dry, dark gray argillite and siltstone with iron staining along bedding planes.											X		<LOD	14	78	5	<LOD	6	Dry			
	19.5	22	Bedrock - Greywacke	Dry, dark reddish brown greywacke with some iron staining.											X		<LOD	14	88	5	<LOD	6	Dry			
	22	24.5	Weathered Bedrock - Greywacke, Shale	Dry, dark reddish brown greywacke weathered to brown, with few shale.													<LOD	13	75	4	<LOD	5	Dry			
	24.5	27	Weathered Bedrock - Greywacke, Shale	Dry, dark reddish brown greywacke weathered to brown, with pulverized clay.													<LOD	13	53	4	<LOD	6	Dry			
	27	29.5	Weathered Bedrock - Greywacke, Shale	Dry, dark reddish brown greywacke weathered to brown with pulverized clay.													<LOD	13	36	4	<LOD	5	Dry			
	29.5	32	Bedrock - Siltstone	Dry, dark gray siltstone with iron staining.											X		<LOD	13	47	4	<LOD	6	Dry	28.93		
	32	34.5	Weathered Bedrock - Greywacke	Dry, brownish gray greywacke weathered to brown.													<LOD	14	28	4	<LOD	6	Dry			
	34.5	37	Bedrock - Siltstone	Dry, dark gray siltstone with iron staining.											X		<LOD	13	28	4	<LOD	6	Dry			36 - 56
	37	39.5	Bedrock - Siltstone	Dry, dark gray siltstone with some iron staining.											X		<LOD	14	54	5	<LOD	6	Dry			
	39.5	42	Bedrock - Argillite, Shale	Darky gray argillite with weathered shale (clay). Wet below 41 ft.													<LOD	14	46	5	<LOD	6	Wet			
	42	44.5	Weathered Bedrock - Greywacke	Dark grayish brown greywacke weathered to brown. Wet.													<LOD	14	37	4	<LOD	6	Wet			
	44.5	47	Weathered Bedrock - Greywacke	Dark reddish brown greywacke weathered to brown. Wet.													<LOD	13	35	4	<LOD	5	Wet			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet: Top	Sample Depth Interval (feet: Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony: Conc. (ppm)	XRF Antimony: Error	XRF Arsenic: Conc. (ppm)	XRF Arsenic: Error	XRF Mercury: Conc. (ppm)	XRF Mercury: Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Groundwater Observations: Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Installation: Monitoring Well Screened Interval (feet bgs)
SM74	47	49.5	Bedrock - Siltstone	Dark grayish brown siltstone with iron staining. Wet.											X		<LOD	13	35	4	<LOD	6	Wet	28.93	MW46	36 - 56
	49.5	52	Bedrock - Shale, Greywacke	Grayish brown pulverized shale with greywacke. Wet.													<LOD	12	31	3	<LOD	5	Wet			
	52	54.5	Bedrock - Siltstone	Dark gray siltstone and quartz vein with visible calcite and quartz crystals. Wet.								X					<LOD	13	37	4	<LOD	6	Wet			
	54.5	57	Bedrock - Greywacke, Silstone	Wet, dark gray greywacke and siltstone with some quartz crystals.								X					<LOD	13	47	4	<LOD	5	Wet			
SM75	0	2	silty Gravel Gravel with silt Silt with sand	0.0 - 0.7 ft.: Moist, brown silty Gravel (disturbed) placed over 0.7 to 1 ft. interval of organics (wood compost with green color). 1.0 to 1.7 ft.: Moist Gravel with silt. 1.7 to 2 ft.: Moist loess.																			Moist		MW47	
	2	4	Loess Weathered Bedrock - Greywacke	2.0 to 2.6 ft.: Moist, light brown Loess. 2.6 to 4.0 ft.: Moist weathered greywacke with iron staining.											X								Moist			
	4	6	Weathered Bedrock - Siltstone,	Moist, brownish gray weathered bedrock, mostly siltstone with iron staining, few shale.											X								Moist			
	6	8	Weathered Bedrock - Shale, Siltstone	Moist, brownish gray weathered bedrock, mostly shale weathered to clay, some siltstone with calcite along bedding planes at 6.2 to 6.4 ft.								X											Moist			
	8	10	Weathered Bedrock - Greywacke	Dry, reddish brown, slightly weathered greywacke.																			Dry			
	10	12.5	Weathered Bedrock - Greywacke, Shale	Dry, brownish gray, greywacke weathered to brown, some iron staining and few shale weathered to clay.											X								Dry			
	12.5	15	Bedrock - Greywacke	Dry, grayish brown, greywacke with iron staining.											X								Dry			
	15	17.5	Bedrock - Siltstone	Dry, reddish brown, siltstone with iron staining.											X								Dry			
	17.5	20	Bedrock - Greywacke, Shale	Dry, reddish brown, mostly greywacke with iron staining with pulverized shale, vein material on greywacke								X			X								Dry			
	20	22.5	Bedrock - Shale, Greywacke	Dry, brownish gray, mostly pulverized shale with some greywacke																			Dry			
	22.5	25	Bedrock - Siltstone, Greywacke, Shale	Dry, dark grayish brown, mostly siltstone with few greywacke and trace weathered shale (clay)																			Dry			
	25	27.5	Bedrock - Siltstone	Dry, dark gray siltstone with iron staining.											X								Dry			
	27.5	30	Bedrock - Siltstone	Dry, dark gray, siltstone with some iron staining at bedding planes.											X								Dry			
	30	32.5	Bedrock - Greywacke, Silstone	Dry, dark grayish brown greywacke and trace siltstone.																			Dry			
	32.5	35	Bedrock - Greywacke	Dry, dark gray greywacke with trace iron staining.											X								Dry	32.88		
	35	37.5	Weathered Bedrock - Shale, Greywacke	Dry, brown, mostly weathered shale (clay), with trace greywacke.																			Dry			
	37.5	40	Bedrock - Silstone	Dry, dark gray siltstone with iron staining along bedding surfaces.											X								Dry			
	40	42.5	Bedrock - Silstone, Greywacke	Dry, dark gray siltstone with iron staining, with reddish brown greywacke.											X								Dry			
	42.5	45	Bedrock - Argillite	Dry, black, argillite, blocky.																			Dry			
	45	47.5	Weathered Bedrock - Siltstone, Greywacke	Dry, reddish brown siltstone with iron staining and greywacke weathered to brown.											X								Dry			46 - 66
	47.5	50	Bedrock - Siltstone	Dry, dark gray, siltstone with iron staining along bedding planes.											X								Dry			
	50	52.5	Bedrock - Siltstone	Dry, dark gray siltstone with iron staining, blocky.											X								Dry			
	52.5	55	Weathered Bedrock - Greywacke	Wet, dark gray greywacke starting to weather to brown. Some visible quartz.								X											Wet			
	55	57.5	Bedrock - Argillite	Wet, black argillite, blocky.																			Wet			
	57.5	60	Bedrock - Greywacke	Wet, dark gray greywacke with trace quartz, quartz has yellow stain.								X											Wet			
	60	62.5	Bedrock - Siltstone, Greywacke	Wet, dark gray, mostly siltstone, few greywacke containing calcite/quartz along fractures with iron staining.								X			X								Wet			
	62.5	65	Bedrock - Siltstone	Wet, dark gray siltstone, blocky, larger pieces.																			Wet			
	65	67	Bedrock - Greywacke, Shale	Wet, dark gray, small pieces of greywacke with pulverized shale.																			Wet			
SM76	0	2	Silt with gravel	Moist, yellowish brown Silt with sand and gravel. Disturbed by establishment of drilling pad. Gravel is angular to subangular 1-3 cm Kuskokwim Group. Sand is very fine, silt is low plasticity. Disturbed loess.													42	10	169	7	6	4	Moist		MW48	
	2	4	Silt with sand	Moist, grayish brown disturbed loess. Some large 2 - 4 cm gravel (greywacke), low plasticity.													<LOD	13	50	4	<LOD	5	Moist			
	4	6	Silty Sand	Moist, brownish gray silty Sand with gravel. Gravel is 1 - 4 cm greywacke occasionally weathered to brown, well lithified, angular. Sand is very fine to fine grained, occasionally dark gray. Occasional iron staining. Disturbed soil.											X		61	10	217	7	11	4	Moist			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet) Top	Sample Depth Interval (feet) Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Mercury Conc. (ppm)	XRF Mercury Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
	6	8	Weathered Bedrock - Argillite, Shale, Greywacke	Moist, orangish brown weathered bedrock. Black, blocky argillite layer shows apparent bedding dip of 50 degrees. Shale below argillite is weathered and iron-stained clay. 7.0 - 8.0 ft. is weathered brown greywacke with no obvious bedding dip.											X		<LOD	13	60	4	7	4	Moist			
	8	10	Weathered Bedrock - Siltstone, Argillite	Moist, orangish brown weathered bedrock. Siltstone and argillite appear to have a bedding dip of 30 degrees. Occasional iron stain.											X		<LOD	14	36	4	<LOD	6	Moist			
	10	12	Weathered Bedrock - Greywacke, Siltstone, Shale	Moist, grayish brown weathered bedrock. Greywacke and siltstone to 11.0 ft., shale to 11.4 ft., greywacke below. Occasional iron stain 11.0 ft. Shale has bedding dip of 30 degrees.											X		<LOD	14	56	5	<LOD	6	Moist			
	12	14.2	Weathered Bedrock - Siltstone, Greywacke	Moist, grayish brown weathered bedrock. Poorly lithified siltstone and greywacke. Greywacke is occasionally weathered to gray sand. Iron staining in thin veins that form fracture surfaces. No bedding dip apparent. Low moisture.											X		<LOD	14	78	5	7	4	Moist			
	14.2	15	No Recovery	No recovery.													<LOD	16	42	5	<LOD	8	No Recovery			
	15	17	Bedrock - Siltstone, Greywacke	Moist, dark gray siltstone and greywacke. Poorly lithified.																			Moist	16.59		
SM76	17	19.5	Bedrock - Siltstone	Dark grayish brown siltstone with occasional iron stain in fractures. Possible pulverized shale.											X		<LOD	13	61	4	<LOD	5	Moist		MW48	
	19.5	22	Bedrock - Argillite	Black argillite. Blocky, well lithified. Occasional Fe accretions in fractures.											X		<LOD	14	58	5	<LOD	6	Moist			
	22	24.5	Bedrock - Argillite	Black argillite in large chips, trace iron stain.											X		<LOD	13	39	4	<LOD	6	Moist			
	24.5	27	Bedrock - Argillite, Siltstone, Shale	Very dark gray blocky argillite and dark gray siltstone. Some shale (pulverized light gray coating on larger cuttings).													<LOD	13	47	4	<LOD	6	Moist			
	27	29.5	Bedrock - Siltstone	Wet, dark gray siltstone, blocky.													<LOD	9	31	3	<LOD	4	Wet			
	29.5	32	Bedrock - Argillite	Wet, black argillite. Trace iron stain.											X		<LOD	12	40	4	<LOD	5	Wet			
	32	34.5	Bedrock - Argillite, Shale	Wet, black argillite with some friable shale. Trace iron stain.													<LOD	10	25	3	4	2	Wet			23 - 43
	34.5	37	Bedrock - Argillite	Wet, black argillite, blocky.													<LOD	15	31	4	<LOD	6	Wet			
	37	39.5	Weathered Bedrock - Siltstone, Shale	Wet, dark gray siltstone, weaker lithification than the argillite above. Trace iron stain. Some thin friable shale.											X		<LOD	12	33	3	<LOD	5	Wet			
	39.5	42	Bedrock - Siltstone	Wet, dark gray blocky siltstone. Trace quartz vein.								X					<LOD	14	31	4	<LOD	6	Wet			
	42	44	Bedrock - Argillite	Wet, black to very dark gray argillite. Blocky to platy, moderately well lithified.													<LOD	14	38	4	<LOD	6	Wet			
	0	2	Silt with sand	Moist, grayish brown silt with sand. Sand is very fine, silt is firm, trace organic debris, roots and sand increasing with depth. Loess.													<LOD	12	8	3	<LOD	5	Moist			
	2	5	Silt with sand	Wet, grayish brown, as above, more very fine sand. Occasional bands of iron stain. Loess.											X		<LOD	12	9	3	<LOD	5	Wet			
	5	6	Silt with gravel	Moist, grayish brown, as above to 5.5 ft., then Silt with gravel. Gravel is coarse angular.													<LOD	12	5	2	<LOD	4	Moist			
	6	8	silty Gravel	Moist, grayish brown silty Gravel, gravel content increasing with depth. Gravel is angular argillite.													<LOD	14	142	6	11	4	Moist			
	8	10	gravelly Silt	Moist, brownish yellow gravelly Silt. Gravel is abundant, mostly black angular argillite with some very weathered shale. Stiff.													<LOD	15	79	5	<LOD	7	Moist			
	10	12	silty Gravel	Moist, grayish brown silty Gravel. 1 - 4 cm black angular siltstone fragments. Interstitial silt is firm, soil is dense.													<LOD	14	57	5	<LOD	6	Moist			
SM77	12	14	poorly graded Gravel with silt and sand	Moist, grayish brown Gravel with silt and sand. Gravel is fine to 4 cm, angular, composed of siltstone, shale, and sandstone. Weathered in place, dense. Silt and clay is gray weathered shale.													<LOD	15	56	5	8	4	Moist		MW49	
	14	16	poorly graded Gravel with silt and sand	Moist, gray, as above, weathered bedrock with faint bedding, shale transitioning to clay appears to have 30 degree bedding dip.													<LOD	14	41	4	<LOD	6	Moist			
	16	18	clayey Gravel	Moist, grayish brown silty, clayey Gravel. 1 - 4 cm angular shale cuttings and occasional dark brown greywacke.													<LOD	15	49	5	9	4	Moist			
	18	20	silty Gravel	Moist, brown silty Gravel, some clay where shale is decomposing. Silt is low to medium plasticity. Gravel is fine to 4 cm angular weathered Kuskokwim Group shale, greywacke, and occasional siltstone. Dense.													<LOD	14	46	4	10	4	Moist			
	20	22	Weathered Bedrock - Shale, Greywacke, Siltstone	Moist, grayish brown weathered bedrock. Kuskokwim Group shale, greywacke, and siltstone. Shale shows apparent bedding dip of 30 degrees.													<LOD	14	27	4	<LOD	6	Moist			
	22	24	Weathered Bedrock - Siltstone, Greywacke	Dry, brown weathered bedrock, very dense. 30 degree apparent bedding dip. Siltstone and greywacke.													<LOD	13	27	4	<LOD	5	Dry			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet) Top	Sample Depth Interval (feet) Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Mercury Conc. (ppm)	XRF Mercury Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM77	24	25	Weathered Bedrock	Dry, grayish brown Gravel with silt, as above. Refusal of direct push drilling at 25 ft.													<LOD	13	30	3	<LOD	5	Dry		MW49	
	25	32	No recovery	No recovery.																			No Recovery	25.18		
	32	34.5	Bedrock - Siltstone, Greywacke	Dry, black siltstone and dark brown greywacke. Occasional iron stain.											X		<LOD	13	49	4	<LOD	5	Dry			
	34.5	37	Bedrock - Greywacke	Dry, dark gray greywacke. Sand grains are very fine, well lithified. Trace iron stain.											X		<LOD	13	64	4	<LOD	6	Dry			
	37	39.5	Bedrock - Shale, Siltstone	Dry, dark gray. Black shale and occasional dark gray siltstone.													<LOD	13	39	4	<LOD	8	Dry			
	39.5	42	No Recovery	No recovery.																			No Recovery			40 - 60
	42	44.5	Bedrock - Greywacke	Greywacke, fine grained. Pulverizes readily.													<LOD	13	16	3	<LOD	6	Dry			
	44.5	47	Bedrock - Greywacke	Wet, dark gray greywacke as above. Trace iron stain, trace quartz. Productive fracture(s).													<LOD	12	25	3	<LOD	5	Wet			
	47	49.5	Bedrock - Greywacke	Moist, dark gray, as above, trace stibnite.			X							X			15	10	20	4	<LOD	6	Moist			
	49.5	52	Bedrock - Greywacke, Siltstone, Shale	Dry, dark grayish brown. dark gray greywacke and siltstone, with shale appearing as a light gray coating of clay on cuttings. Trace quartz.								X					<LOD	13	19	3	<LOD	5	Dry			
	52	54.5	Bedrock - Greywacke, Siltstone, Shale	Wet, dark grayish brown, as above, trace quartz and trace stibnite.			X					X		X			<LOD	11	36	3	<LOD	4	Wet			
	54.5	57	Bedrock - Greywacke, Shale	Wet, dark gray greywacke and shale (pulverized). Trace iron stain, occasional stibnite, trace cinnabar.			X		X					X			<LOD	15	24	4	8	4	Wet			
	57	59.5	Bedrock - Greywacke, Shale	Wet, dark gray, as above. No cinnabar, less stibnite, less shale.			X							X			<LOD	11	28	3	<LOD	4	Wet			
	59.5	62	Bedrock - Greywacke, Shale	Wet, dark gray, as above. No visible minerals.													<LOD	12	18	3	<LOD	5	Wet			
SM78	0	1	silty Sand	Moist, brown silty Sand. Fine sand grains with some iron staining. Some well-graded angular gravel, trace organics (roots) disturbed from drilling pad construction.											X		<LOD	12	81	4	<LOD	5	Moist		MW50	
	1	2	silty Sand	Moist, light reddish brown silty Sand As above, with few gravel consisting of mostly siltstone and trace shale.													<LOD	13	10	3	<LOD	5	Moist			
	2	3	Silt	Moist, grayish brown silt with few fine to very fine loose sand grains. Loess.													<LOD	12	8	3	<LOD	5	Moist			
	3	4	Silt	Dry, light brown, as above.													<LOD	12	5	3	<LOD	5	Dry			
	4	5	No Recovery	No recovery.																			No Recovery			
	5	6	Silt	Dry, light brown Silt with few fine to very fine loose sand grains. Loess.													<LOD	13	6	3	<LOD	5	Dry			
	6	7	Silt	Dry, light brown, as above, with trace iron staining.											X		<LOD	13	6	3	<LOD	5	Dry			
	7	8	Silt	Dry, light brownish gray, as above, with trace wood at 7.8 ft.													<LOD	12	5	3	<LOD	5	Dry			
	8	9	Silt	Dry, grayish brown, as above, with thin color change to dusky red at 8.3 and 8.5 ft.													<LOD	12	9	3	<LOD	4	Dry			
	9	10	No recovery	No recovery.																			No Recovery			
	10	11	Silt	Reddish brown Silt with fine to very fine loose sand, becomes moist at 10.5'. Loess.													<LOD	12	9	2	<LOD	4	Dry to Moist			
	11	12	Silt	Wet, gray Silt with fine to very fine sand, Loose. Organics (wood and roots) at 11.9 ft. with decomposing organic matter odor. Loess.													<LOD	11	5	2	<LOD	4	Wet			
	12	13	Silt	Moist, gray Silt with very fine to fine sand, loose. Loess. 12 - 12.5 ft. is brown to dark brown with organics (woody material). 12.5 ft. color changes to gray with more moisture.													<LOD	12	7	3	<LOD	4	Moist			
	13	14	Silt	Wet, grayish brown, as above.													<LOD	12	24	3	<LOD	5	Wet			
	14	15	No Recovery	No recovery.																						
	15	16	Silt	As above, but dark reddish brown. Some iron staining, very wet.													<LOD	11	10	3	<LOD	4	Wet			
	16	17	Silt	Reddish brown Silt with very fine to fine sand, with trace fine gravel. Loess. Change in color at 16.6 ft. to brown. Wet.													<LOD	12	12	3	<LOD	4	Wet			
	17	18	Weathered Bedrock - Shale, Greywacke	Reddish brown, as above until weathered bedrock at 17.6 ft., mostly weathered shale (clay) below 17.6 ft. with some angular greywacke weathered to brown. Wet to moist.													<LOD	12	20	3	<LOD	5	Moist to Wet			
	18	19	Weathered Bedrock - Greywacke Shale	Moist, dark reddish gray weathered bedrock. Mostly fine grained greywacke weathered to brown with trace quartz and some dark gray shale, with apparent bedding dip of 35 degrees. At 18.2 ft. becomes dry.								X					<LOD	15	310	9	8	4	Dry to Moist			
	19	20	No Recovery	No recovery.																			No Recovery			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet: Top	Sample Depth Interval (feet: Bott-om	Llithology	Lithological Description	Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Mercury Conc. (ppm)	XRF Mercury Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Groundwater Observations: Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Installation: Monitoring Well Screened Interval (feet bgs)
SM78	20	21	Weathered Bedrock - Shale, Siltstone	Dry, dark reddish brown weathered bedrock. Mostly shale weathered to clay with few siltstone and iron staining.											X		<LOD	13	142	6	15	4	Dry	47.40	MW50	
	21	22	Weathered Bedrock - Greywacke	Dry, reddish gray weathered bedrock. Mostly coarse grained greywacke weathered to brown.													<LOD	13	262	8	13	4	Dry			
	22	23	Weathered Bedrock - Shale, Greywacke, Siltstone	Dry, dark reddish gray weathered bedrock. 22.3 to 22.9 ft. is shale weathered entirely to a low plasticity clay, below 22.9 ft. is greywacke weathered to brown. Trace siltstone with iron staining.											X		<LOD	13	1040	14	16	4	Dry			
	23	24	Weathered Bedrock - Shale, Siltstone	Dry, yellowish brown weathered bedrock. Mostly shale weathered to clay with few siltstone, iron staining.											X		<LOD	14	214	7	14	4	Dry			
	24	25	Weathered Bedrock - Shale, Siltstone	Dry, reddish brown weathered bedrock. Mostly shale weathered to clay with iron staining. Trace siltstone with iron staining.											X		36	10	347	9	<LOD	7	Dry			
	25	27.5	Bedrock - Greywacke, Shale	Dry, reddish gray. Small pieces of coarse grained greywacke, with evidence of shale (pulverized clay clumps).																			Dry			
	27.5	30	Bedrock - Siltstone, Shale	Dry, dark grayish brown. Mostly siltstone, subangular with iron staining. Evidence of shale (pulverized clay).											X								Dry			
	30	32.5	Bedrock - Argillite, Shale	Dry, dark gray. Mostly small pieces of poorly indurated argillite with trace iron staining and evidence of shale (pulverized clay clumps).											X								Dry			
	32.5	35	Weathered Bedrock - Greywacke, Shale	Moist, reddish brown. Mostly small cuttings of coarse grained greywacke weathered to brown, with evidence of shale pulverized to clay.																			Moist			
	35	37.5	Bedrock - Argillite, Siltstone	Dry, dark gray argillite. Trace siltstone with iron staining.											X								Dry			
	37.5	40	Bedrock - Siltstone, Argillite	Dry, dark grayish brown. Mostly blocky to small pieces of subangular siltstone with iron staining and few argillite.											X								Dry			
	40	42.5	Weathered Bedrock - Shale, Greywacke	Dry, brown. Mostly pulverized shale (clay), with small pieces of coarse grained greywacke weathered to brown.																			Dry			
	42.5	45	Bedrock - Argillite	Dry, dark gray. Small pieces of argillite with trace iron staining.											X								Dry			
	45	47.5	Bedrock - Argillite	Dry, dark gray, argillite with some iron staining. Slow drilling.											X								Dry			
	47.5	50	Bedrock - Argillite	Dry, dark gray, as above, without iron staining.																			Dry			
	50	52.5	Bedrock - Argillite	Dry, dark gray, as above, with larger cuttings. Continued slow drilling.																			Dry			
	52.5	55	Bedrock - Argillite	Dry, dark gray, as above, but with smaller cuttings.																			Dry			
	55	57.5	Bedrock - Argillite	Dry, dark gray, as above, but with trace evidence of shale (clay chunks in cuttings). Trace iron staining.											X								Dry			
	57.5	60	Bedrock - Argillite, Greywacke	Dry, dark gray, argillite with few fine grained greywacke, with some iron staining. Slow drilling.											X								Dry			
	60	62.5	Weathered Bedrock - Greywacke	Dry, dark gray greywacke, some weathered to brown, with trace unidentified tan mineral.																			Dry			
	62.5	65	Bedrock - Greywacke, Argillite	Dry, dark gray, mostly greywacke with trace iron staining and quartz. Trace argillite.								X			X								Dry			
	65	67.5	Bedrock - Argillite	Dry, dark gray, argillite. Slow drilling.																			Dry			
	67.5	70	Bedrock - Argillite	Dry, dark gray, as above.																			Dry			
	70	72.5	Bedrock - Argillite	Dry, dark gray, as above, but with quartz, slow drilling.								X											Dry			71 - 91
	72.5	75	Bedrock - Argillite	Dry, dark gray, as above, but with quartz/calcite. Slow drilling.								X											Dry			
	75	77.5	Bedrock - Argillite	Dry, dark gray, as above, with trace calcite/quartz. Slow drilling.								X											Dry			
	77.5	80	Weathered Bedrock - Greywacke, Argillite	Gray, mostly fine grained greywacke, some weathered to brown. Some quartz/calcite, trace argillite. Wet.								X											Wet			
	80	82.5	Bedrock - Shale, Argillite, Siltstone	Dark grayish brown, mostly pulverized shale observed as clumps of clay, with few argillite and siltstone. Wet.																			Wet			
	82.5	85	Bedrock - Argillite, Greywacke	Moist, dark gray, mostly argillite with trace fine grained greywacke.																			Moist			
	85	87.5	Bedrock - Greywacke, Argillite	Moist, dark gray to gray, medium grained greywacke with some calcite/quartz and trace argillite.								X											Moist			
	87.5	90	Bedrock - Greywacke, Shale	Moist, gray, fine grained greywacke with calcite/quartz veins, trace shale (clay).								X											Moist			
	90	92	Bedrock - Greywacke, Shale	Moist, dark gray, as above, but with abundant calcite/quartz veins and iron staining on quartz.								X			X								Moist			
SM79	0	1	silty Sand	Moist, brown silty Sand. Fine to very fine poorly-graded sand.													<LOD	12	9	3	<LOD	5	Moist		MW51	

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet) Top	Sample Depth Interval (feet) Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Mercury Conc. (ppm)	XRF Mercury Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM79	1	2	silty Sand	Moist, brown silty Sand, as above.													<LOD	12	7	3	<LOD	5	Moist		MW51	
	2	3	silty Sand	Moist, brown silty Sand, as above.													<LOD	12	8	3	<LOD	5	Moist			
	3	4	silty Sand	Moist, light reddish brown silty Sand, sand is fine to very fine and poorly-graded. Dark reddish brown layer at 3.1 - 3.2 ft. transitioning to orangish yellow.													<LOD	12	8	3	<LOD	5	Moist			
	4	5	silty Sand	Moist, light reddish brown silty Sand. As above with more silt.													<LOD	12	6	3	<LOD	5	Moist			
	5	6	silty Sand	Moist, light reddish brown silty Sand. Sand is fine to very fine, poorly-graded. Trace organics (roots) and iron staining.											X		<LOD	12	6	3	<LOD	5	Moist			
	6	7	silty Sand	Moist, light reddish brown silty Sand, as above.											X		<LOD	12	<LOD	4	<LOD	5	Moist			
	7	8	silty Sand	Moist, light reddish brown silty Sand, as above.											X		<LOD	12	8	3	<LOD	5	Moist			
	8	9	silty Sand	Moist, light reddish brown silty Sand, as above with more iron staining.											X		<LOD	12	9	3	<LOD	5	Moist			
	9	10	silty Sand	Moist, light reddish brown silty Sand, as above.											X		<LOD	11	6	2	<LOD	4	Moist to Wet			
	10	11	Silt	Wet, light brownish gray Silt with very fine sand and trace clay. Some iron staining. At 10.7 ft., color changes to light gray with a dark reddish brown layer.											X		<LOD	12	8	3	<LOD	5	Wet			
	11	12	Silty Sand Weathered Bedrock - Shale, Siltstone	11.0 - 11.3 ft.: Wet to Moist, light gray silty Sand. Sand is fine. 11.3 - 12.0 ft.: Wet to moist well-graded Gravel with silt (weathered bedrock), consisting mostly of weathered shale with few siltstone, with some iron staining. Weathered bedrock is dark gray to dark reddish brown .											X		<LOD	12	23	3	<LOD	5	Moist to Wet			
	12	13	Weathered Bedrock - Shale, Greywacke	Moist, dark grayish brown well-graded Gravel with clay. Weathered bedrock is mostly shale weathered to clay with few blocky greywacke weathered to brown.													<LOD	11	172	5	<LOD	5	Moist			
	13	14	Weathered Bedrock - Greywacke, Shale	Moist to dry, dark grayish brown well-graded Gravel with silt. Weathered bedrock is mostly greywacke with some weathered to brown and some shale weathered to clay.													46	9	654	11	15	4	Dry to Moist			
	14	15	No Recovery	No recovery.																			No Recovery			
	15	16	Weathered Bedrock - Greywacke, Siltstone, Shale	Dry, reddish brown well-graded Gravel with silt. Weathered bedrock is mostly blocky greywacke weathered to brown with siltstone and few shale weathered to clay.													<LOD	15	161	7	<LOD	6	Dry			
	16	17	Weathered Bedrock - Greywacke	Dry, reddish brown well-graded Gravel with silt. Weathered bedrock with apparent bedding dip of 20 degrees is mostly blocky greywacke weathered to brown. Greywacke sand grains are medium to fine grained.													<LOD	13	131	6	<LOD	6	Dry			
	17	18	Weathered Bedrock - Shale, Siltstone	Dry, dark grayish brown poorly-graded Gravel with clay. Weathered bedrock is mostly shale weathered to clay. Trace siltstone.													<LOD	13	172	7	<LOD	6	Dry			
	18	19	Weathered Bedrock - Shale	Moist to dry, dark grayish brown poorly-graded Gravel with clay. Weathered bedrock is heavily weathered shale (clay.) Competent shale bedrock at 18.8 ft.													<LOD	13	101	5	<LOD	5	Dry to Moist			
	19	20	No Recovery	No recovery.																			No Recovery			
	20	22.5	Weathered Bedrock - Shale, Greywacke	Moist, brown. Mostly pulverized shale (clay), few very small pieces of fine grained greywacke weathered to brown.													<LOD	14	101	5	<LOD	6	Moist			
	22.5	25	Bedrock - Shale	Moist, light brownish gray pulverized shale (clay), small poorly indurated shale fragments present in clay.													<LOD	14	142	6	<LOD	6	Moist			
	25	27.5	Bedrock - Silstone	Dry, dark grayish brown siltstone, angular with iron staining.											X		<LOD	14	95	5	<LOD	6	Dry			
	27.5	30	Weathered Bedrock - Greywacke, Shale	Dry, dark grayish brown. Small fragments of mostly fine grained greywacke weathered to brown. Shale seen as pulverized clay and poorly indurated shale pieces.													<LOD	15	81	5	<LOD	7	Dry			
	30	32.5	Weathered Bedrock - Shale, Greywacke, Siltstone	Dry, dark grayish brown. Mostly poorly indurated shale with some pulverized to clay. Some coarse grained greywacke weathered to brown and some siltstone with iron staining.											X		<LOD	13	76	5	<LOD	5	Dry			
	32.5	35	Bedrock - Argillite, Siltstone	Dry, dark gray, blocky argillite with iron staining. Trace siltstone.											X		<LOD	13	157	6	<LOD	6	Dry			
	35	37.5	Weathered Bedrock - Greywacke	Dry, dark reddish gray greywacke in mostly small fragments with significant weathering to brown.													<LOD	14	77	5	<LOD	6	Dry	36.02		
	37.5	40	Weathered Bedrock - Greywacke	Dry, dark reddish gray, as above, but with less weathering to brown.													<LOD	15	112	6	<LOD	7	Dry			
	40	42.5	Bedrock - Greywacke, Argillite	Dry, dark reddish gray, as above, but with trace argillite.													28	9	46	4	<LOD	6	Dry			
	42.5	45	Bedrock - Siltstone, Argillite	Dry, dark gray, mostly poorly indurated siltstone. Trace argillite.													<LOD	14	87	5	<LOD	6	Dry			
	45	47.5	Bedrock - Siltstone	Dry, dark gray, poorly indurated siltstone, angular cuttings, with trace iron staining.													<LOD	15	85	5	<LOD	6	Dry			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet) Top	Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Mercury Conc. (ppm)	XRF Mercury Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
	47.5	50	Bedrock - Siltstone	Dry, dark gray, as above, but with larger fragments.													<LOD	14	95	5	<LOD	6	Dry	36.02		
	50	52.5	Bedrock - Siltstone, Argillite	Dry, dark gray, blocky siltstone with some argillite and trace iron staining.											X		<LOD	14	128	6	<LOD	6	Dry			
	52.5	55	Bedrock - Argillite, Siltstone	Dry, dark gray, mostly blocky argillite with few siltstone. Some iron staining.											X		<LOD	14	87	5	<LOD	6	Dry			
	55	57.5	Bedrock - Argillite, Siltstone	Dry, dark gray, as above.											X		<LOD	14	64	5	<LOD	6	Dry			
	57.5	60	Bedrock - Argillite, Siltstone	Dry, dark grayish brown. Mostly argillite with some brownish gray blocky medium grained, poorly indurated greywacke.													<LOD	14	67	5	<LOD	6	Dry			
	60	62.5	Bedrock - Siltstone, Argillite	Dry, dark reddish gray, siltstone with iron staining. Trace argillite.											X		<LOD	15	101	6	<LOD	6	Dry			
SM79	62.5	65	Weathered Bedrock - Greywacke, Shale	Wet, dark reddish gray, blocky greywacke weathered to brown. Some shale pulverized to clay.													<LOD	14	89	5	<LOD	6	Wet		MW51	
	65	67.5	Weathered Bedrock - Greywacke	Wet, dark reddish brown, blocky greywacke, mostly weathered to brown.													<LOD	15	62	5	<LOD	6	Wet			56 - 76
	67.5	70	Weathered Bedrock - Greywacke	Wet, dark grayish brown, as above, but with less weathering to brown, and trace shale (clay).													<LOD	13	46	4	<LOD	6	Wet			
	70	72.5	Weathered Bedrock - Greywacke	Wet, dark gray, coarse grained greywacke, with some weathering to brown.													<LOD	11	46	3	<LOD	4	Wet			
	72.5	75	Bedrock - Argillite, Siltstone, Shale	Wet, dark gray, argillite. Trace siltstone and shale (clay).													<LOD	11	68	4	<LOD	5	Wet			
	75	77	Bedrock - Greywacke	Wet, dark gray, greywacke with trace iron staining.											X		<LOD	10	37	3	<LOD	4	Wet			
	0	2	Silt Silt	0.0 - 0.3 ft.: Moist brown Silt with gravel and organics, previously disturbed. 0.3 - 1.0 ft.: Moist, light brownish gray, Silt with gravel and organics. Silt has some very fine sand and trace small gravel, gravel decreases with depth. Thin layer of fine sand, brown to reddish brown, at 0.9 ft.																			Moist			
	2	4	Silt	Moist to wet, brown Silt with very fine sand. Notable increase in moisture at 2.9 ft. At 3.6 ft. thin layer with iron staining. Clear transition to gray color below 3.9 ft.											X								Moist to Wet			
	4	5	SIlt	Moist, gray to dusky red Silt with very fine sand and trace organics (roots), trace clay. Soft. At 4.7 ft. dusky red silty clay with few fine sand grains. Possible perched water zone.																			Moist			
	5	6	Gravel with silt Weathered Bedrock - Shale	5.0 - 5.2 ft.: Moist, reddish brown, well-graded Gravel with clay and silt, iron staining. Gravel is weathered siltstone. 5.2 - 6.0 ft.: Weathered shale with clay.											X								Moist			
	6	8	Weathered Bedrock - Siltstone, Shale	Moist, dark grayish brown weathered bedrock is mostly siltstone with trace amounts of shale weathered to clay. At 7.3 ft. is reddish brown shale weathered to clay with iron staining and white vein material.											X								Moist			
	8	10	Weathered Bedrock - Shale,	Dry, dark gray weathered shale with few blocky siltstone.																			Dry			
	10	12	Weathered Bedrock - Siltstone, Greywacke	Dry, dark grayish brown weathered blocky siltstone with iron staining and greywacke weathered to brown.											X								Dry			
SM80	12	14	Weathered Bedrock - Greywacke, Shale, Argillite, Siltstone	Dry, dark grayish brown Greywacke weathered to brown, some shale weathered to clay, with trace white clay. Argillite and shale weathered to clay at 13 - 13.7 ft., with small layer of siltstone.																			Dry		MW52	
	14	15	No Recovery	No recovery.																			No Recovery			
	15	17.5	Bedrock - Argillite, Siltstone	Dry, dark gray, mostly argillite with some siltstone. Iron staining.											X								Dry			
	17.5	20	Bedrock - Siltstone, Greywacke	Dry, brown siltstone with iron staining. Few greywacke.											X								Dry			
	20	22.5	Bedrock - Greywacke	Dry, dark gray greywacke. Sand grains are fine, iron staining.											X								Dry			
	22.5	25	Bedrock - Greywacke	Dry, dark gray greywacke with trace amount of iron staining, Sand grains are fine.											X								Dry			
	25	27.5	Bedrock - Shale	Dry, dark gray shale. Small, poorly indurated lithic fragments. Laminated. Iron staining.											X								Dry	26.75		
	27.5	30	Bedrock - Greywacke	Dry, dark grayish brown greywacke with iron staining.											X								Dry			
	30	32.5	Weathered Bedrock - Shale,	Dry, light brownish gray shale (weathered to clay) and siltstone with some iron staining.											X								Dry			
	32.5	35	Weathered Bedrock - Greywacke	Dry, dark reddish brown, fine grained greywacke weathered to brown.																			Dry			
	35	37.5	Bedrock - Greywacke	Dry, dark grayish brown, fine grained greywacke with iron staining.											X								Dry			
	37.5	40	Weathered Bedrock - Greywacke, Shale	Dry, dark grayish brown greywacke weathered to brown, fine cuttings. Some shale weathered to clay.																			Dry			35 - 55
	40	42.5	Bedrock - Argillite	Dry, black argillite. No visible grains, blocky.																			Dry			
	42.5	45	Bedrock - Argillite	Wet, black argillite. Blocky, with trace iron staining.											X								Wet			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet: Top	Sample Depth Interval (feet: Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony: Conc. (ppm)	XRF Antimony: Error	XRF Arsenic: Conc. (ppm)	XRF Arsenic: Error	XRF Mercury: Conc. (ppm)	XRF Mercury: Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Groundwater Observations: Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Installation: Monitoring Well Screened Interval (feet bgs)
SM80	45	47.5	Bedrock - Argillite, Greywacke, Shale	Wet, dark gray. Lots of fines in cuttings. Argillite with quartz veins, few fine grained greywacke, and trace shale as pulverized clay. Iron stained.								X			X								Wet	26.75	MW52	35 - 55
	47.5	50	Weathered Bedrock - Shale, Greywacke, Argillte	Wet, dark gray. Mostly shale weathered to clay in clumps, few fine grained greywacke and argillite with quartz veins.								X											Wet			
	50	52.5	Bedrock - Argillite	Wet, dark gray argillite with quartz/calcite veins in many cuttings.								X											Wet			
	52.5	55	Bedrock - Argillite	Wet, dark gray argillite with quartz veins and trace pyrite.								X		X									Wet			
	55	56	Bedrock - Argillite	Wet, dark gray, as above but without pyrite.								X											Wet			
SM81	0	1	silty Sand Silt with sand Silt with sand	0.0 - 0.3 ft.: Moist, light brown silty sand, sand is fine. 0.3 - 0.8 ft.: Color changes to light reddish gray to dark reddish brown Silt with fine sand. Organics (roots) and organic layer of woody debris observed 0.3 - 0.4 ft. Moist. 0.8 - 1.0 ft.: Moist, reddish brown Silt with fine sand.													4	2	<LOD	4	<LOD	10	Moist		MW53	
	1	2	Silt	Moist, light brown Silt with fine to very fine sand. Loose. Loess.													5	3	<LOD	5	<LOD	12	Moist			
	2	3	Silt	Moist, light brown Silt with fine to very fine sand. Loose. Loess. Small iron stained layers.											X		10	3	<LOD	5	<LOD	12	Moist			
	3	4	Silt	As above, but becomes wet at 3.3 ft.													7	3	<LOD	5	<LOD	13	Wet			
	4	5	No Recovery	No recovery.																			No Recovery			
	5	6	Silt Silt Silt	Wet, brown Silt with low plasticity. 5.0 - 5.6 ft.: As above, but medium brown. 5.6 - 5.7 ft.: Color change to reddish brown with some well-graded gravel. 5.7 - 6.0 ft.: Color change to gray Silt with fine to very fine sand, trace clay. Loose. Loess.													6	3	<LOD	5	<LOD	12	Wet			
	6	7	silty Clay, Shale	Moist, dark reddish gray silty Clay with low plasticity. Few fine sand, becomes more clayey with depth below 6.3 ft. Thin iron staining layers interbedded with dark gray. Few gravel of subangular shale.											X		7	3	<LOD	5	<LOD	12	Moist			
	7	8	Clay with gravel Weathered Bedrock - Shale, Greywacke	7.0 - 7.3 ft.: Moist gray Clay with some well-graded gravel of subangular shale 7.3 - 8.0 ft.: Moist, grayish brown weathered bedrock, mostly shale with clay and some fine grained greywacke.													55	5	<LOD	6	<LOD	14	Moist			
	8	9	Weathered Bedrock - Greywacke	Moist, brown weathered bedrock, greywacke weathered to brown, very compact.													57	4	<LOD	5	<LOD	13	Moist			
	9	10	No Recovery	No recovery.																			No Recovery			
	10	11	Weathered Bedrock - Greywacke, Siltstone	Dry, reddish brown to brown weathered bedrock, mostly gray medium grained greywacke weathered to brown. Trace siltstone with trace quartz deposits.								X					58	4	<LOD	6	<LOD	14	Dry			
	11	12	Weathered Bedrock - Greywacke Weathered Bedrock - Shale, Siltstone	11.0 - 11.5 ft.: Dry reddish brown weathered bedrock, mostly greywacke weathered to reddish brown. Subangular cuttings. 11.5 - 12.0 ft.: Dry, dark gray, mostly subangular cuttings of shale weathered to clay, with few iron staining and some siltstone.											X		115	5	<LOD	6	<LOD	13	Dry			
	12	13	Weathered Bedrock - Siltstone, Shale	Dry, dark brown to brown weathered bedrock, mostly blocky siltstone with iron staining. Trace shale weathered to clay. Competent bedrock at 12.1 ft., apparent bedding dip of 75 degrees.													66	5	<LOD	6	<LOD	14	Dry			
	13	14	Weathered Bedrock - Greywacke	Dry, light reddish brown, competent bedrock. Mostly coarse grained greywacke weathered to brown sand.													129	6	<LOD	6	<LOD	13	Dry			
	14	15	Weathered Bedrock - Greywacke	Dry, light reddish brown, as above.													113	5	<LOD	6	<LOD	14	Dry			
	15	17.5	Weathered Bedrock - Greywacke, Shale	Dry, reddish brown, coarse grained greywacke weathered to brown, with some shale pulverized to clay.													<LOD	13	131	6	<LOD	6	Dry			
	17.5	20	Weathered Bedrock - Greywacke, Argillite	Dry, dark grayish brown, mostly coarse to medium grained greywacke weathered to brown, with few argillite .													56	11	59	5	<LOD	7	Dry			
	20	22.5	Weathered Bedrock - Greywacke	Dry, dark reddish gray, coarse grained greywacke weathered to brown.													<LOD	13	410	9	7	4	Dry			
	22.5	25	Bedrock - Argillite, Siltstone, Greywacke	Dry, dark gray, cuttings of argillite and larger cuttings of siltstone. Trace reddish brown greywacke.													<LOD	14	73	5	<LOD	6	Dry			
	25	27.5	Weathered Bedrock - Greywacke	Dry, dark grayish brown, subrounded to subangular cuttings of greywacke weathered to brown.													<LOD	13	108	5	<LOD	6	Dry	26.94		
	27.5	30	Weathered Bedrock - Greywacke	Dry, dark grayish brown, as above.													<LOD	13	140	6	8	4	Dry			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet		Llithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM81	30	32.5	Weathered Bedrock - Shale	Dry, gray shale weathered to clay.													<LOD	13	68	5	<LOD	6	Dry	26.94	MW53	
	32.5	35	Bedrock - Greywacke	Dry, gray, coarse grained greywacke. Very friable, most is pulverized.													<LOD	13	53	4	<LOD	6	Dry			
	35	37.5	Bedrock - Argillite	Dry, dark gray, argillite, with iron staining.											X		<LOD	14	76	5	<LOD	6	Dry			
	37.5	40	Bedrock - Argillite, Siltstone	Dry, dark gray, mostly argillite with trace quartz veins. Few blocky siltstone with iron staining.								X			X		<LOD	14	66	5	<LOD	6	Dry			
	40	42.5	Bedrock - Argillite	Dry, dark gray, argillite.													<LOD	15	84	5	9	5	Dry			41 - 61
	42.5	45	Bedrock - Argillite	Dry, dark gray, mostly pulverized friable argillite with trace quartz veins.								X					<LOD	13	112	5	11	4	Dry			
	45	47.5	Bedrock - Greywacke	Dry, gray, greywacke with few calcite/quartz veins.								X					<LOD	13	71	4	7	4	Dry			
	47.5	50	Bedrock - Greywacke	Wet, light gray greywacke.													<LOD	13	32	4	6	4	Wet			
	50	52.5	Bedrock - Greywacke	Moist, dark gray, as above.													<LOD	13	50	4	<LOD	6	Moist			
	52.5	55	Bedrock - Argillite	Moist, dark gray argillite.													<LOD	13	59	4	6	4	Moist			
	55	57.5	Weathered Bedrock - Greywacke	Dry, dark grayish brown, coarse grained greywacke with localized weathering to brown. Fine to pulverized cuttings.													<LOD	13	50	4	7	4	Dry			
	57.5	60	No Recovery	No recovery.													<LOD	13	43	4	7	4	Dry			
	60	62	Bedrock - Argillite	Dry, black, argillite.													<LOD	14	79	5	12	4	Dry			
SM82	0	1	silty Sand	Moist, light brown, silty Sand. Sand is fine to very fine.																			Moist		MW54	
	1	2	silty Sand	Moist, light reddish brown silty Sand. Sand is fine to very fine. Thin iron stained layers, with a dark brown to black layer at 1.6 ft.											X		7	3	<LOD	4	<LOD	11	Moist			
	2	3	Sand with silt	Moist to Wet, brown, fine Sand with silt, appears wet at 2.4 ft.													9	3	<LOD	4	<LOD	11	Moist to Wet			
	3	4	Sand with silt Organic Silt	3.0 - 3.3 ft.: As above. Moist. 3.3 - 3.6 ft.: Moist, dark brown organic Silt. Roots, wood, possibly former ground surface.													6	3	<LOD	5	<LOD	13	Moist			
	4	5	No Recovery	No recovery.																			No Recovery			
	5	6	silty Sand	Wet, dark reddish brown silty Sand. Fine to very fine grained, becomes more grayish at 5.6 ft.													6	2	<LOD	4	<LOD	11	Wet			
	6	7	Silt	Moist, dark reddish gray Silt, medium dense, iron staining, with trace fine, poorly-graded sand.											X		21	5	<LOD	9	<LOD	19	Moist			
	7	8	Gravel with silt Weathered Bedrock - Shale	7.0 - 7.3 ft.: As above. 7.3 - 8.0 ft.: Moist, dark reddish brown weathered bedrock. Shale weathered to clay, some iron stained siltstone.											X		77	5	<LOD	6	<LOD	14	Moist			
	8	9	Weathered Bedrock - Shale Weathered Bedrock - Shale	8.0 - 8.6 ft.: As above. 8.6 - 9.0 ft.: Moist, white to dusky red, lean Clay from weathered shale. Some silt and very fine sand in the dusky red color change at 9.0 ft.'. Dense.													127	6	9	4	16	10	Moist			
	9	10	Weathered Bedrock - Shale	Moist, gray to dusky red shale weathered to clay, iron staining and multiple color layers of black, gray, tan and reddish white.											X		131	5	<LOD	5	<LOD	12	Moist			
	10	11	Weathered Bedrock - Shale Weathered Bedrock - Shale	10.0 - 10.1 ft.: As above. 10.1 - 11.0 ft.: Moist, tan to yellowish orange Shale weathered to lean clay with silt and fine sand. Iron staining.											X		174	6	<LOD	6	<LOD	13	Moist			
	11	12	Weathered Bedrock - Shale, Siltstone	Moist, tan to yellowish orange, as above, with layer of iron stained siltstone with quartz veins at 11.7 ft.								X			X		191	7	8	4	<LOD	14	Moist			
	12	13	Weathered Bedrock - Shale, Siltstone	12.0 - 12.3 ft.: As above. 12.3 - 13.0 ft.: Moist, tan to yellowish orange weathered siltstone, blocky with quartz veins, angular, becomes dark grayish brown at 12.7 ft.								X					347	10	8	5	<LOD	15	Moist			
	13	14	Weathered Bedrock - Shale, Siltstone	Moist, dark grayish brown weathered bedrock, mostly shale, with few blocky angular siltstone cuttings containing broken quartz.								X					122	6	9	4	<LOD	13	Moist			
	14	15	No Recovery	No recovery.																			No Recovery			
	15	17.5	Bedrock - Shale, Greywacke	Dry, dark gray shale pulverized to clay (in clumps and loose fines). Few greywacke with calcite deposits.								X					<LOD	13	276	7	<LOD	6	Dry			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet		Llithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM82	17.5	20	Weathered Bedrock - Siltstone, Greywacke	Dry, dark grayish brown siltstone, angular, weathered to brown, with trace greywacke.								X					25	11	182	8	8	5	Dry		MW54	
	20	22.5	Weathered Bedrock - Greywacke, Shale	Dry, dark reddish gray, coarse grained greywacke weathered to brown, with some shale as indicated by clay coating larger cuttings.													<LOD	14	551	11	8	4	Dry			
	22.5	25	Bedrock - Shale, Siltstone	Dry, dark gray, mostly competent shale with some siltstone. Shale is very friable and some is pulverized to clay, iron staining present.											X		<LOD	14	133	6	8	4	Dry			
	25	27.5	Bedrock - Siltstone, Argillite	Dry, dark grayish brown, mostly siltstone with iron staining on some surfaces. Few black argillite present.											X		<LOD	14	166	7	<LOD	7	Dry	27.07		
	27.5	30	Weathered Bedrock - Greywacke, Argillite	Dry, dark grayish brown, mostly small pieces of greywacke weathered to brown with few argillite. Greywacke has iron staining on some surfaces.											X		<LOD	14	125	6	8	4	Dry			29 - 49
	30	32.5	Bedrock - Shale, Greywacke	Dry, brown, mostly shale pulverized to clay as seen in clumps. Trace greywacke present in small fragments, iron staining on the greywacke.											X		<LOD	14	563	11	<LOD	6	Dry			
	32.5	35	Bedrock - Argillite, Greywacke	Moist, dark gray argillite with trace calcite veins. Some greywacke with iron staining.								X			X		<LOD	14	132	6	8	4	Moist			
	35	37.5	Bedrock - Argillite	Wet, dark gray argillite. Larger fragments have quartz coating on surfaces.								X					<LOD	15	232	8	14	5	Wet			
	37.5	40	Bedrock - Argilite, Quartz Vein	Wet, dark gray, trace fragments of argillite with 5 cm chunks of quartz. Slow drilling (possible quartz vein).								X					<LOD	16	135	7	11	5	Wet			
	40	42.5	Bedrock - Igneous Dike	Wet, light gray igneous dike. Blocky, poorly indurated with small fragments of clay mineral (dickite?) on most surfaces, and limonite on few cuttings. Trace quartz pieces less than 3 cm, very hard, drilling difficult.								X					<LOD	15	150	7	18	5	Wet			
	42.5	45	Bedrock - Igneous Dike	Wet, light gray, as above, without limonite, thin quartz veins.								X					17	10	63	5	15	5	Wet			
	45	47.5	Bedrock - Igneous Dike	Wet, light gray, as above, with more clay mineral (dickite?) present and trace black mineral (possibly stibnite). Abundant water.			X					X		X			<LOD	11	135	5	11	3	Wet			
	47.5	50	Bedrock - Igneous Dike	Wet, light gray, as above, with a lot more quartz as both veins and individual pieces 2 - 5 cm. Trace orpiment.							X	X		X			<LOD	11	97	4	8	3	Wet			
SM83	0	2	Silt	Moist, brown Silt with well-graded gravel. Gravel consists of greywacke with quartz veins and secondary black mineral. Appears to be disturbed overburden, with a mix of well-graded gravel and silt.								X											Moist		MW55	
	2	4	Silt	Moist, grayish brown Silt with well-graded gravel. At 2.6 ft. a distinct color change to gray occurs. Gravel is greywacke with cinnabar and quartz.					X			X		X									Moist			
	4	6	Silt	Moist, dark grayish brown. 5.0 - 5.3 ft.: Mostly dark gray to black organic Silt, possibly the original ground surface (soil) before disturbance. 5.3 - 6.0 ft.: brown inorganic Silt. Loess.																			Moist			
	6	8	Silt	Moist, dark gray Silt with trace gravel. Iron staining seen at 7.2 - 7.5 ft. Loess.										X									Moist			
	8	10	Silt	Moist, dark grayish brown Silt with trace coarse to fine gravel. Fine sand below 8.7 ft. Loess.																			Moist	9.44		
	10	12	Silt	Moist, dark grayish brown Silt, with trace fine to medium sand and angular fine gravel. White banding in sandy Silt from 11.3 - 11.7 ft.																			Moist			10 - 20
	12	14	Silt	Moist to Wet, dark grayish brown Silt with clay and fine sand, trace fine to coarse angular gravel. Gravel is angular siltstone, increases below 13 ft.																			Moist to Wet			
	14	16	Silt	Moist, dark grayish brown Silt with white material at 15.7 ft.																			Moist			
	16	18	Weathered Bedrock - Greywacke, Siltstone, Shale	Wet, dark grayish brown weathered bedrock, mostly greywacke with beds of siltstone and shale. Greywacke weathered to brown at 17.5 ft., trace fine sand at 17.1 - 17.4 ft.																			Wet			
	18	20	Weathered Bedrock - Greywacke, Siltstone, Shale Shale, Siltstone	Wet, dark grayish brown. 18.0 - 18.2 ft.: As above. 18.2 - 20.0 ft.: Bedrock. Tan to black shale overlying reddish brown siltstone with iron staining.											X								Wet			
	20	22	Bedrock - Shale	Moist, dark gray bedrock, composed of weak dark gray shale. Apparent bedding dip of 80 degrees. Trace quartz veins.								X											Moist			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet bgs)		Lithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
SM83	22	24	Bedrock - Shale Bedrock - Greywacke	Moist to Dry, dark reddish Greywacke bedrock. 22.0 - 22.3 ft.: As above. 22.3 - 24.0 ft.: Greywacke with iron staining. Quartz/calcite veins.								X			X								Dry to Moist	9.44		
SM83	24	25	Bedrock - Greywacke	Dry, dark grayish brown, as above.								X			X								Dry			10 - 20
SM83	25	27	Bedrock - Argillite, Greywacke	Dry, dark gray bedrock, mostly argillite with quartz veins, trace orpiment. Trace greywacke.							X	X		X									Dry			
SM84	0	2	Silt	Moist, grayish brown Silt with gravel. Silt is soft., low plasticity, with some very fine sand. Trace organics. Gravel is 3 cm to >4 cm greywacke, weathered greywacke, and shale. Disturbed loess.													59	9	224	7	<LOD	5	Moist			
SM84	2	5	Silt	Moist, dark grayish brown. 2.0 - 2.5 feet: dark brown, organic-rich Silt. 2.5 to 4 ft.: Loess with trace subrounded gravel. Silt is firm, low to medium plasticity.													<LOD	14	55	4	<LOD	6	Moist			
SM84	5	7	Silt Weathered Bedrock - Shale	Moist, grayish brown Silt with gravel to 6.6 ft. Abundant gravel includes various Kuskokwim Group lithologies, subangular to angular. Silt has some very fine sand, no plasticity, is stiff. 6.6 to 7.0 ft. is beginning of weathered bedrock with decomposed shale showing apparent bedding dip of 30 degrees. Trace vein material at 6.6 ft.								X					<LOD	14	127	6	<LOD	6	Moist			
SM84	7	10	Weathered Bedrock - Siltstone, Shale	Moist, reddish gray weathered bedrock, significantly decomposed. Siltstone, crumbly gray sandy greywacke with iron staining in fractures, and shale decomposing to clay. Iron stain throughout, apparent bedding dip of 60 degrees at 8.6 ft.											X		<LOD	13	102	5	<LOD	6	Moist			
SM84	10	12	Weathered Bedrock - Siltstone, Greywacke	Moist, grayish brown weathered bedrock, dense. Siltstone and greywacke, some iron staining. Interstitial silt and very fine sand.											X		<LOD	13	108	5	11	4	Moist			
SM84	12	14	Weathered Bedrock - Greywacke, Siltstone	Moist, dark grayish brown weathered greywacke with very fine sand grains, and some siltstone. Trace vein material at 12.1 ft.								X					<LOD	14	164	7	7	4	Moist			
SM84	14	15	No Recovery	No recovery.													<LOD	14	157	6	<LOD	6	No			
SM84	15	17	Bedrock - Siltstone, Greywacke	Dry, dark gray micaceous siltstone grading to greywacke.													<LOD	14	318	8	7	4	Dry		MW55	
SM84	17	19.5	Weathered Bedrock - Greywacke	Dry, brownish gray greywacke weathered to brown, one grain of stibnite noted.			X							X			<LOD	13	527	10	11	4	Dry			
SM84	19.5	22	Bedrock - Siltstone, Greywacke	Dry, dark gray siltstone with one grain of stibnite. Some greywacke and iron stain.			X							X	X		<LOD	15	257	8	11	5	Dry			
SM84	22	24.5	Bedrock - Shale	Dry, gray shale. Almost no larger cuttings, mostly clumps of pulverized clay.													<LOD	13	96	5	7	4	Dry			
SM84	24.5	27	Bedrock - Argillite	Dry, black argillite. Weakly indurated, blocky.													30	10	203	7	6	4	Dry			
SM84	27	29.5	Bedrock - Greywacke	Dry, gray greywacke. Very fine grained, with iron staining on fractures.											X		<LOD	13	183	7	<LOD	6	Dry			
SM84	29.5	32	Bedrock - Shale, Argillite	Dry, black shale and argillite. Argillite is blocky.													<LOD	14	116	6	<LOD	6	Dry	29.92		
SM84	32	34.5	Bedrock - Siltstone, Greywacke	Dry, dark gray siltstone grading to very fine greywacke. One stibnite crystal.			X							X			<LOD	13	106	5	8	4	Dry			
SM84	34.5	37	Bedrock - Shale	Dry, black shale. Occasionally black and friable cuttings, otherwise light gray clay clumps.													<LOD	13	127	6	6	4	Dry			
SM84	37	39.5	Bedrock - Argillite, Siltstone	Dry, black argillite and siltstone. Trace quartz.								X					<LOD	13	167	6	<LOD	6	Dry			
SM84	39.5	42	Bedrock - Greywacke	Dry, gray greywacke. Fine grained, trace very fine stibnite and quartz grains. Iron stain in fractures.			X					X		X	X		<LOD	13	61	4	6	4	Dry			
SM84	42	44.5	Bedrock - Greywacke, Shale	Dry, dark gray greywacke and shale.													<LOD	13	78	5	6	4	Dry			
SM84	44.5	47	Bedrock - Shale, Greywacke	Dry, dark gray shale, some greywacke. Very few cuttings, mostly fines.													<LOD	13	75	5	<LOD	6	Dry			
SM84	47	49.5	Weathered Bedrock - Greywacke	Dry, brownish gray, weak greywacke, weathered brown, few cuttings.													<LOD	13	109	5	<LOD	6	Dry			
SM84	49.5	52	Bedrock - Greywacke	Dry, dark gray, as above.													<LOD	14	350	9	<LOD	6	Dry			
SM84	52	54.5	Bedrock - Greywacke	Dry, gray, as above, trace quartz.								X					<LOD	13	1733	18	10	4	Dry			
SM84	54.5	57	Bedrock - Argillite	Dry, black, argillite with quartz veins.								X					<LOD	14	120	6	<LOD	6	Dry			55 - 75
SM84	57	59.5	Bedrock - Argillite	Dry, black, blocky argillite with quartz veins.								X					<LOD	13	73	5	<LOD	6	Dry			
SM84	59.5	62	Bedrock - Argillite, Siltstone	Wet, very dark gray, argillite and hard dark gray siltstone.													<LOD	13	69	5	<LOD	6	Wet			
SM84	62	64.5	Bedrock - Argillite	Wet, black argillite, hard, blocky, with trace quartz.								X					<LOD	14	73	5	<LOD	6	Wet			
SM84	64.5	67	Bedrock - Greywacke, Argillite	Wet, black to dark gray greywacke and argillite. Trace iron stain.											X		<LOD	13	83	5	<LOD	6	Wet			
SM84	67	69.5	Bedrock - Greywacke	Wet, gray, greywacke with slightly larger grain size (fine sand). Trace quartz veins.								X					<LOD	14	48	4	<LOD	6	Wet			
SM84	69.5	72	Bedrock - Argillite	Wet, black argillite with trace quartz vein. Blocky to platy, larger cuttings.								X					<LOD	13	86	5	<LOD	6	Wet			
SM84	72	74.5	Bedrock - Siltstone, Shale	Wet, very dark gray micaceous siltstone, occasionally iron stained brown. Some shale (as clumps of clay).											X		<LOD	14	73	5	<LOD	6	Wet			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet		Llithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Erro r	Conc. (ppm)	Erro r	Conc. (ppm)	Erro r	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Complete d Well, 9/26/17 (feet bgs)	Monitorin g Well ID	Monitoring Well Screened Interval (feet bgs)
SM84	74.5	76	Bedrock - Siltstone	Wet, black siltstone. Trace quartz.								X					<LOD	13	65	4	<LOD	6	Wet	29.92	MW55	55 - 75
	0	1	Silt	Moist, medium brown Silt. Loess.																			Moist			
	1	2	Silt	Medium brown, moist to wet Silt. Loess. Moist from 1 - 1.5 ft., wet from 1.5 - 2 ft. Medium stiff.																			Moist to Wet			
	2	3	Silt	Medium brown, moist to wet Silt. Loess. Wet from 2.0 - 2.5 ft., moist from 2.5 - 3.0 ft. Medium stiff.																			Moist to Wet			
	3	3.5	Silt	Medium brown, moist to wet Silt. Loess. Medium stiff.																			Moist			
	3.5	5	No Recovery	No recovery.																			No Recovery			
	5	7	Silt	Brown, wet, Silt. Soft. Color changes from brown to gray brown and red brown as depth increases. Angular gravel (fine to medium) occurs from 6.5 - 7 ft. Moisture changes from wet to moist from 6 - 7 ft.																			Moist to Wet			
	7	8.5	silty Sand	Moist light gray to reddish brown silty Sand. Appears to be a mixing of weathered sandstone and loess.																			Moist			
	8.5	10	No Recovery	No recovery.																			No Recovery			
	10	12	Gravel with sand	Moist, poorly-graded Gravel with sand. Gravel is broken weathered bedrock.																			Moist			
	12	13.75	Weathered Bedrock - Shale	Dark, reddish gray weathered shale bedrock. Fragments of competent shale with clayey/silty friable weathered shale bedrock.																			Moist			
	13.75	15	No Recovery	No recovery.																			No Recovery			
	15	17	Bedrock - Shale, Siltstone	Dry, dark brown, mostly weak and small friable shale cuttings with significant pulverized shale (clay) and few larger siltstone cuttings, with some iron staining.											X								Dry			
SM85	17	19.5	Bedrock - Shale, Siltstone	Dry, dark brown friable shale with some siltstone cuttings, easily broken. Some iron staining along bedding/fractures.											X								Dry		MW57	
	19.5	22	Bedrock - Shale	Dry, dark gray fragments of shale, some more friable than others. Orangish staining observed along fractures.											X								Dry			
	22	24.5	Bedrock - Shale	Dry, dark grayish brown. Dark gray friable shale with few more competent fragments. One fragment of yellowish white vein material observed. Fragments also had orangish staining in fractures.								X			X								Dry			
	24.5	27	Bedrock	Moist, brown, cuttings contained no fragments larger than coarse sand.																			Moist			
	27	29.5	Bedrock - Shale	Moist, brown, few rock fragments in recovery. Mostly friable shale. Orangish staining observed along fractures.											X								Moist	27.84		
	29.5	32	Bedrock - Greywacke, Shale	Dry, reddish brown, greywacke and few shale.																			Dry			
	32	34.5	Bedrock - Greywacke	Moist, reddish brown, hard to somewhat friable greywacke.																			Moist			
	34.5	37	Weathered Bedrock - Greywacke	Moist, reddish brown, weathered greywacke, in small fragments.																			Moist			
	37	39.5	Weathered Bedrock - Greywacke	Dry, reddish brown weathered greywacke. Fine to medium fragments. Some whiteish vein material.								X											Dry			
	39.5	42	Weathered Bedrock - Greywacke, Shale	Dry, gray, fine to medium angular fragments of roughly equal parts weathered greywacke and hard shale.																			Dry			
	42	44.5	Bedrock - Argillite, Shale	Dry, dark gray argillite/shale with trace white vein material.								X											Dry			
	44.5	47	Bedrock - Greywacke	Dry, light gray, greywacke. Some with orangish brown staining along fractures.											X								Dry			37.5 - 57.5
	47	49.5	Bedrock - Shale	Moist, dark gray, small subangular shale fragments. Friable.																			Moist			
	49.5	52	Bedrock - Argillite, Shale	Moist, dark gray argillite with few shale and some white vein material.								X											Moist			
	52	54.5	Bedrock - Siltstone	Wet, dark gray, siltstone with some white vein material.								X											Wet			
	54.5	57	Bedrock - Greywacke, Shale	Moist, dark gray, medium sized fragments of greywacke with small fragments of shale.																			Moist			
	57	59.5	Bedrock - Shale, Argillte	Moist, dark gray, mostly shale with some argillite and some vein material.								X											Moist			
	0	1	Silt	0.0 - 0.3 ft.: Wet dark brown organic material (tundra). 0.3 - 1.0 ft.: Medium brown, wet, medium stiff Silt, with trace fine rounded gravel.													<LOD	10	3	2	<LOD	4	Wet			
SM86	1	2	Silt	Medium brown, wet, Silt, with trace coarse angular gravel. Stiffness increases with depth.													<LOD	9	3	2	<LOD	3	Wet		MW58	
	2	3	Silt	Medium brown to gray, wet to moist, medium stiff Silt, with few fine angular gravel.													<LOD	11	11	3	<LOD	4	Wet			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet		Llithology	Lithological Description	Mineralogical/Lithological Observations												XRF Antimony		XRF Arsenic		XRF Mercury		Groundwater Observations		Monitoring Well Installation	
	Top	Bott-om			Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	Conc. (ppm)	Error	Conc. (ppm)	Error	Conc. (ppm)	Error	Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
	3	4	No Recovery	No recovery.																			No Recovery			
	4	5	No Recovery	No recovery.																			No Recovery			
	5	6	silty Gravel	Moist, brown to gray silty Gravel with sand. Mostly angular gravel, fine to coarse. Some silt, few sand, fine. Gravel consists of friable sandstone and shale.													<LOD	14	23	3	<LOD	6	Moist			
	6	7	silty Gravel	As above.													<LOD	13	20	4	<LOD	6	Moist			
	7	8	silty Gravel	As above.													<LOD	13	17	3	<LOD	5	Moist			
	8	9	silty Gravel	As above.													<LOD	12	24	3	<LOD	5	Moist			
	9	10	No Recovery	No recovery.																			No Recovery			
	10	12.5	Bedrock - Shale, Siltstone	Dry, dark gray to brown, mostly weak small friable shale cuttings with significant shale (pulverized to clay) and few larger siltstone cuttings, some iron staining.											X								Dry			
	12.5	15	Bedrock - Greywacke	Dry, dark gray to brown, fine grained micaceous greywacke.																			Dry			
	15	17.5	Bedrock - Siltstone, Shale	Dry, dark grayish brown, mostly angular Siltstone in small cuttings with iron staining. Trace shale pulverized to clay.											X								Dry			
	17.5	20	Bedrock - Shale, Greywacke	Dry, dark grayish brown, weak friable shale, mostly pulverized to clay. Few larger pieces with iron staining. Trace greywacke.											X								Dry			
	20	22.5	Weathered Bedrock - Greywacke, Argillite	Dry, dark reddish gray, mostly fine to medium grained greywacke weathered to brown, with trace argillite.																			Dry			
SM86	22.5	25	Bedrock - Siltstone, Argillite	Dry, gray, siltstone with few iron staining and argillite.											X								Dry		MW58	
	25	27.5	Bedrock - Shale	Dry, dark grayish brown, weak friable shale, mostly pulverized to clay.																			Dry	25.96		
	27.5	30	Bedrock - Siltstone, Argillite	Dry, grayish brown, mostly siltstone with few iron staining. Few argillite cuttings.											X								Dry			
	30	32.5	Weathered Bedrock - Greywacke, Argillite	Dry, dark grayish brown, mostly fine grained, micaceous greywacke weathered to brown. Trace argillite.																			Dry			
	32.5	35	Weathered Bedrock - Argillite, Greywacke	Dry, dark gray to brown, mostly argillite, with some fine grained, greywacke weathered to brown.																			Dry			
	35	37.5	Bedrock - Argillite, Greywacke	Dry, dark gray to brown, as above, but with less greywacke.																			Dry			
	37.5	40	Weathered Bedrock - Greywacke	Dry, gray to brown, fine to medium grained greywacke with few fragments weathered to brown. Trace quartz veins, difficult drilling, larger cuttings.								X											Dry			
	40	42.5	Weathered Bedrock - Greywacke	Dry, gray to brown, as above, but with more weathering to brown and smaller cuttings size.								X											Dry			
	42.5	45	Weathered Bedrock - Greywacke	Moist, gray, as above, with less weathering to brown and quartz veins. Greywacke is coarser, mostly medium grained.								X											Moist			
	45	47.5	Bedrock - Siltstone, Shale	Dry, gray, large cuttings of siltstone with some quartz veins, subangular, with trace shale as pulverized clay.								X											Dry			36.6 - 56.6
	47.5	50	Bedrock - Greywacke, Shale	Moist, gray, mostly micaceous, medium grained greywacke with quartz veins. Small cuttings. Evidence of shale pulverized to clay (clumps).								X											Moist			
	50	52.5	Bedrock - Siltstone	Wet, dark gray siltstone with trace quartz veins.								X											Wet			
	52.5	55	Bedrock - Siltstone	Wet, dark gray, as above, but with larger cuttings and more quartz veins.								X											Wet			
	55	58	Bedrock - Siltstone, Argillite	Wet, dark gray, mostly subangular siltstone with quartz as veins and individual pieces up to 3 cm. Trace argillite.								X											Wet			
	0	2	Silt	Moist, grayish brown, mostly Silt with few greywacke gravel fragments and trace sand.																			Moist			
	2	4	Silt	Moist, grayish brown, medium stiff Silt (loess).																			Moist			
	4	5	No Recovery	No recovery.																			No Recovery			
SM87	5	7	Silt	Same as above. Medium stiff Silt.																			Moist		MW59	
	7	8.5	Silt	Moist to wet, grayish brown, mostly soft. Silt with few very fine sand.																			Moist to wet			
	8.5	10	No Recovery	No recovery.																			No Recovery			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet) Top	Sample Depth Interval (feet) Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Mercury Conc. (ppm)	XRF Mercury Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Screened Interval (feet bgs)
	10	12	Gravel Weathered Bedrock - Shale, Greywacke	10.0 - 10.4 ft.: As above. Moist, dark brown. 10.4 - 12.0 ft.: Weathered bedrock consisting mostly of gravel, coarse, angular (shale and greywacke) and some silt.																			Moist			
	12	14	Weathered Bedrock - Shale, Greywacke	Moist, dark brown weathered bedrock consisting mostly of gravel, coarse, angular shale and greywacke, and some silt.																			Moist			
	14	15	No Recovery	No recovery.																			No Recovery			
	15	17	Weathered Bedrock - Greywacke	Moist, reddish brown, weathered greywacke. Mostly silt in cuttings, some to few greywacke fragments.																			Moist			
	17	19.5	Weathered Bedrock - Shale, Argillite	Dry, very dark grayish brown, mostly silt, few fragments of friable shale and weathered argillite.																			Dry			
	19.5	22	Bedrock - Greywacke	Moist, grayish brown. Mostly light gray medium stiff silt/clay with medium to fine sand embedded. Trace fine grained greywacke fragments.																			Moist			
	22	24.5	Weathered Bedrock - Greywacke	Moist, light reddish brown, mostly fine grained greywacke with greenish orange staining along fractures. Slightly weathered.											X								Moist			
	24.5	27	Bedrock - Greywacke, Silstone	Dry, light brownish gray. Mostly orangish gray, very fine grained greywacke. Few to trace siltstone. Greywacke had orangish staining along fractures.											X								Dry			
	27	29.5	Weathered Bedrock - Greywacke, Argillite	Mostly slightly weathered greywacke, few weathered argillite. Greywacke has orangish staining along fractures.											X								Dry			
	29.5	32	Bedrock - Greywacke	Dry, reddish brown, very fine grained greywacke with orangish staining along fractures.											X								Dry			
	32	34.5	Weathered Bedrock - Greywacke, Argillite	Moist, reddish brown weathered greywacke with trace white vein material. Argillite had orangish staining along fractures.								X			X								Moist			
	34.5	37	Bedrock - Greywacke, Argillite	Moist, reddish brown, as above, with no white vein material observed.											X								Moist			
	37	39.5	Bedrock - Greywacke	Moist, reddish brown, as above. Greywacke. No vein material.											X								Moist			
	39.5	42	Weathered Bedrock - Argillite	Moist, dark gray, weathered friable argillite.																			Moist			
SM87	42	44.5	Bedrock - Greywacke, Argillite	Moist, dark reddish gray, mostly greywacke with orangish staining along fractures, and few friable argillite fragments.											X								Moist		MW59	
	44.5	47	Bedrock - Argillite	Moist, dark gray, somewhat friable argillite with some orangish staining along fractures.											X								Moist			
	47	49.5	Bedrock - Argillite	Moist, dark gray, as above. Friable argillite.											X								Moist			
	49.5	52	Bedrock - Argillite, Greywacke	Moist, dark gray, mostly friable argillite with few greywacke. Some argillite is micaceous. Greywacke has orangish staining along fractures.											X								Moist			
	52	54.5	Bedrock - Greywacke	Moist, reddish brown, greywacke with orangish staining along fractures.											X								Moist			
	54.5	57	Bedrock - Greywacke, Argillite, Shale	Moist, grayish brown, mostly greywacke with few friable argillite and trace shale. Some of the greywacke had organgish staining along fractures, some was a light gray color.											X								Moist			
	57	59.5	Bedrock - Argillite, Greywacke	Dry, dark gray, mostly argillite with few greywacke. Argillite friable with some orangish staining along fractures.											X								Dry			
	59.5	62	Bedrock - Greywacke	Moist, gray greywacke with trace white vein material and trace orangish staining along fractures.								X			X								Moist			
	62	64.5	Bedrock - Greywacke	Moist, gray greywacke with some orangish staining along fractures.											X								Moist			
	64.5	67	Bedrock - Greywacke	Moist, dark reddish brown greywacke with orangish staining along fractures and trace white vein material.								X			X								Moist			
	67	69.5	Bedrock - Argillite	Moist, dark reddish brown argillite with orangish staining along fractures and trace white vein material.								X			X								Moist			
	69.5	72	Bedrock - Argillte, Greywacke	Dry, dark reddish brown argillite and greywacke with orangish staining along fractures and trace white vein material.								X			X								Dry			
	72	74.5	Bedrock - Argillite	Dry, dark gray, somewhat friable argillite.																			Dry			
	74.5	77	Bedrock - Greywacke	Dry, dark reddish brown greywacke with some orangish staining along fractures.											X								Dry			
	77	79.5	Bedrock - Argillite	Dry, dark gray argillite.																			Dry			
	79.5	82	Bedrock - Argillite	Dry, dark gray argillite.																			Dry			
	82	84.5	Bedrock - Greywacke	Dry, dark gray greywacke. Few orangish staining along fractures.											X								Dry			
	84.5	87	Bedrock - Argillite, Shale	Dry, dark gray, mostly argillite with some shale.																			Dry			

Table A-4 Field Data Summary, 2017 Groundwater Monitoring Well Installation

Soil Boring ID	Sample Depth Interval (feet) Top	Sample Depth Interval (feet) Bott-om	Llithology	Lithological Description	Mineralogical/Lithological Observations: Red Por-ous Rock	Vitri-ous "Slag"	Stib-nite	Elem-ental Mer-cury	Cinna-bar	Real-gar	Orpi-ment	Vein Mater-ial	Red Rind	Sul-fides	Iron Stain	Odor	XRF Antimony Conc. (ppm)	XRF Antimony Error	XRF Arsenic Conc. (ppm)	XRF Arsenic Error	XRF Mercury Conc. (ppm)	XRF Mercury Error	Groundwater Observations: Moisture Observed in Soil Sample or Drill Cuttings	Groundwater Observations: Static Water Level in Completed Well, 9/26/17 (feet bgs)	Monitoring Well Installation: Monitoring Well ID	Monitoring Well Installation: Monitoring Well Screened Interval (feet bgs)
SM87	87	89.5	Bedrock - Greywacke	Dry, dark gray greywacke with trace white vein material and trace orangish staining along fractures.								X			X								Dry		MW59	
	89.5	92	Bedrock - Greywacke	Dry, gray greywacke with trace orangish staining along fracture.											X								Dry			
	92	94.5	Bedrock - Argillte, Shale	Dry, dark gray, mostly argillite with few shale and few white to yellowish vein material.								X											Dry			
	94.5	97	Bedrock - Argillite, Greywacke	Dry, dark gray argillite with trace greywacke.																			Dry			
	97	99.5	Bedrock - Argillite	Dry, dark gray argillite.																			Dry			
	99.5	102	Bedrock - Argillite	Dry, dark gray argillite with trace white vein material.								X											Dry			
	102	104.5	Bedrock - Argillite, Shale	Moist, dark gray, mostly argillite with few to some shale.																			Moist			
	104.5	107	Bedrock - Argillite	Dry, dark gray, argillite with few to some white vein material.								X											Dry			
	107	109.5	Bedrock - Greywacke	Dry, dark gray greywacke with trace white vein material.								X											Dry			
	109.5	112	Bedrock - Argillite, Greywacke	Dry, dark gray, mostly argillite with few greywacke.																			Dry			
	112	114.5	Bedrock - Argillite, Greywacke	Dry, dark gray mostly argillite with few greywacke and few white vein material.								X											Dry			
	114.5	117	Bedrock - Argillite, Shale	Dry, dark gray, mostly argillite with some shale.																			Dry			
	117	119.5	Bedrock - Argillite	Dry, dark gray argillite.																			Dry			
	119.5	122	Bedrock - Argillite	Dry, dark gray argillite.																			Dry			
	122	124.5	Bedrock - Argillite	Dry, dark gray argillite with trace white vein material.								X											Dry			
	124.5	127	Bedrock - Argillite	Dry, dark gray argillite with trace white vein material.								X											Dry			
	127	129.5	Bedrock - Greywacke	Dry, dark gray greywacke. No vein material, no staining.																			Dry			
	129.5	132	Bedrock - Greywacke	Dry, dark gray greywacke with trace white vein material.								X											Dry			
	132	134.5	Bedrock - Greywacke	Dry, dark gray, fine to very fine grained greywacke with trace white vein material.								X											Dry			
	134.5	137	Bedrock - Greywacke, Argillite	Dry, dark gray, mostly greywacke with some argillite and trace white vein material.								X											Dry	134.92		
	137	139.5	Bedrock - Argillite	Dry, dark gray argillite with trace to few white vein material.								X											Dry			
	139.5	140	No Recovery	No recovery.																			Dry			
	140	142	Bedrock - Argillite	Dry, dark gray argillite with some vein material.								X											Dry			140 - 160
	142	144.5	Bedrock - Greywacke	Dry, dark gray greywacke with trace vein material.								X											Dry			
	144.5	147	Bedrock - Argillite	Dry, dark gray argillite.																			Dry			
	147	149.5	Bedrock - Greywacke, Argillite	Dry, dark gray, mostly greywacke with few argillite and few vein material.								X											Dry			
	149.5	152	Bedrock - Greywacke	Dry, dark gray greywacke with trace vein material.								X											Dry			
	152	154.5	Bedrock - Greywacke	Wet, dark gray, as above.								X											Wet			
	154.5	157	Bedrock - Greywacke	Wet, dark gray, as above, slightly smaller fragment size.								X											Wet			
	157	159.5	Bedrock - Greywacke	Dry, dark gray, as above.								X											Dry			
	159.5	161	NR	NR																			No Record			

Key
<LOD = Less than level of detection for XRF
As = Arsenic
bgs = Below ground surface
ft. = Feet
Conc. = Concentration
Hg = Mercury
NR = Not reported
ppm = Parts per million
Sb - Antimony
XRF = X-ray fluoresence spectroscopy

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		21.72	8/14/2000	NR	235.79
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.87	9/5/2007	13:15	237.64
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		22.16	9/18/2008	13:28	235.35
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.62	6/19/2009	NR	237.89
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		22.27	10/6/2009	17:30	235.24
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		20.04	9/20/2010	18:18	237.47
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.46	8/24/2011	16:38	238.05
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.55	9/1/2011	16:03	237.96
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		17.56	5/26/2012	14:32	239.95
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		18.62	9/9/2012	17:05	238.89
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		19.43	6/17/2015	13:03	238.08
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		20.80	8/12/2015	12:15	236.71
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD		21.03	9/2/2015	9:50	236.48
MW01	B01	29.5	19.0 - 29.0	254.51	257.51	17.8 - TD	29.82	20.36	9/10/2015	NR	237.15
MW01	B01	29.5	19.0 - 29.1	254.51	257.51	17.8 - TD	29.80	18.26	9/28/2016	13:05	239.25
MW01	B01	29.5	19.0 - 29.1	254.51	257.51	17.8 - TD	29.76	19.46	5/26/2017	1202	238.05
MW01	B01	29.5	19.0 - 29.1	254.51	257.51	17.8 - TD	29.76	18.56	9/26/2017	1332	238.95
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		22.28	8/14/2000	NR	208.49
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		20.68	9/5/2007	14:40	210.09
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		22.57	9/18/2008	14:11	208.20
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.51	6/19/2009	NR	211.26
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		23.01	10/7/2009	13:20	207.76
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		20.95	9/20/2010	19:50	209.82
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.44	8/26/2011	10:18	211.33
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.96	9/1/2011	15:41	210.81
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		15.47	5/26/2012	15:17	215.30
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		17.24	9/9/2012	17:10	213.53
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		19.74	6/17/2015	10:54	211.03
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		21.83	8/12/2015	12:33	208.94
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD		22.20	9/2/2015	9:45	208.57
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD	27.98	21.92	9/10/2015	NR	208.85
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD	27.85	16.77	9/28/2016	13:10	214.00
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD	NR	22.6	9/26/2017	11:21	208.17
MW03	B03	25.5	15.0 - 25.0	228.37	230.77	19.0 - TD	27.75	18.96	9/26/2017	1255	211.81
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		27.77	8/14/2000	NR	214.35
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.78	9/5/2007	12:25	215.34
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.82	9/18/2008	12:32	215.30
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		25.43	6/19/2009	NR	216.69
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		27.77	10/6/2009	18:55	214.35
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.79	9/20/2010	16:09	215.33
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		25.24	8/22/2011	16:02	216.88
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		25.99	9/1/2011	15:00	216.13
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		21.72	5/26/2012	16:47	220.40
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		23.72	9/10/2012	14:15	218.40
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		26.95	6/17/2015	15:13	215.17
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		NR	8/12/2015	NR	--
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD		28.61	9/2/2015	11:40	213.51
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD	33.11	28.32	9/10/2015	NR	213.80
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD	33.02	23.81	9/28/2016	12:42	218.31
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD	NR	28.26	8/14/2000	12:11	213.86
MW04	B04	30.5	20.0 - 30.0	239.92	242.12	25.3 - TD	32.83	24.86	9/26/2017	1729	217.26
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.29	8/14/2000	NR	198.20
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.63	9/5/2007	15:30	198.86
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.08	9/18/2008	11:35	198.41
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		17.90	6/19/2009	NR	199.59
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.29	10/7/2009	17:25	198.20

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.03	9/20/2010	13:22	198.46
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.78	8/24/2011	14:56	198.71
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.70	9/1/2011	15:09	198.79
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		16.25	5/26/2012	16:02	201.24
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.29	9/9/2012	11:45	199.20
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		18.24	6/17/2015	14:25	199.25
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.17	8/12/2015	11:03	198.32
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD		19.20	9/2/2015	11:15	198.29
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD	26.19	19.18	9/10/2015	NR	198.31
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD	26.19	17.64	9/28/2016	13:38	199.85
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD	26.12	19.05	5/26/2017	12:52	198.44
MW06	B06	23.5	13.0 - 23.0	214.99	217.49	20.0 - TD	26.12	18.16	9/26/2017	1644	199.33
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		Dry	8/14/2000	NR	Dry (Water Elevation <257.4 ft bgs)
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.42	9/5/2007	14:00	260.47
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		Dry	9/18/2008	NR	Dry (Water Elevation <257.4 ft bgs)
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.10	6/19/2009	NR	260.79
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		Dry	10/7/2009	NR	Dry (Water Elevation <257.4 ft bgs)
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.40	9/21/2010	10:20	260.49
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		19.51	8/26/2011	9:12	261.38
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		19.97	9/1/2011	16:14	260.92
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		19.68	5/26/2012	13:36	261.21
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		20.57	9/9/2012	16:45	260.32
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		21.10	6/17/2015	12:25	259.79
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		21.97	8/12/2015	11:54	258.92
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD		22.36	9/2/2015	10:50	258.53
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD	23.67	22.41	9/10/2015	NR	258.48
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD	23.70	20.4	9/28/2016	12:40	260.49
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD	NR	23.17	5/26/2017	13:23	257.72
MW07	B07	21.5	11.0 - 21.0	278.39	280.89	14.8 - TD	23.47	20.13	9/26/2017	1444	260.76
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		13.70	8/30/2011	9:21	317.62
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		13.65	9/1/2011	16:28	317.67
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		11.64	5/26/2012	13:23	319.68
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		12.74	9/9/2012	16:10	318.58
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		13.54	6/17/2015	12:41	317.78
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		14.87	8/12/2015	11:58	316.45
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD		15.04	9/2/2015	10:35	316.28
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD	17.61	14.89	9/10/2015	NR	316.43
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD	17.68	12.99	9/28/2016	14:32	318.33
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD	17.63	13.89	5/26/2017	13:07	317.43
MW08	11MP01SB	16.0	5.0 - 15.0	328.92	331.32	2.5 - 4.0, 10.5 - TD	17.63	12.95	9/26/2017	1534	318.37
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		>31.56	8/29/2011	18:21	--
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		28.11	9/1/2011	16:43	249.17
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		26.67	5/26/2012	14:04	250.61
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.88	9/9/2012	15:30	249.40
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.81	9/11/2012	11:20	249.47
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.60	6/17/2015	11:31	249.68
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		27.93	8/12/2015	12:04	249.35
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD		28.30	9/2/2015	10:00	248.98
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD	34.72	29.38	9/10/2015	NR	247.90
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD	34.63	26.05	9/28/2016	NR	251.23
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD	34.62	30.22	5/26/2017	12:40	247.06
MW09	11MP17SB	31.0	20.0 - 30.0	274.88	277.28	14.0 - 16.0, 31.0 - TD	34.62	26.9	9/26/2017	1356	250.38
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		30.60	8/29/2011	16:15	245.61
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		29.17	9/1/2011	16:38	247.04
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		25.62	5/26/2012	14:14	250.59
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		26.39	9/9/2012	15:45	249.82

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		26.88	9/10/2012	11:35	249.33
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		28.98	6/17/2015	11:37	247.23
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		32.90	8/12/2015	12:09	243.31
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD		33.52	9/2/2015	10:25	242.69
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD	63.54	31.02	9/10/2015	NR	245.19
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD	63.97	25.92	9/28/2016	NR	250.29
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD	63.53	30.19	5/26/2017	12:46	246.02
MW10	11MP14SB	61.0	50.0 - 60.0	274.31	276.21	48.0 - TD	63.53	26.03	9/26/2017	1347	250.18
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		Dry	8/29/2011	12:00	Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		Dry	9/1/2011	16:34	Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		22.60	5/26/2012	14:24	248.70
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		24.24	9/9/2012	16:00	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		23.69	6/17/2015	15:52	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		24.08	8/12/2015	12:11	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry		24.36	9/2/2015	10:30	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry	25.70	24.16	9/10/2015	NR	Suspected Dry (Water Elevation <246.7 ft bgs)
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry	25.63	21.60	9/28/2016	NR	249.70
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry	NR	25.20	5/26/2017	12:56	246.10
MW11	11MP12SB	23.0	12.0 - 22.0	268.70	271.30	dry	25.42	21.26	9/26/2017	1341	250.04
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		3.72	8/31/2011	13:34	261.90
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		3.70	9/1/2011	16:20	261.92
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		2.46	5/26/2012	11:04	263.16
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		3.30	9/9/2012	16:39	262.32
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		5.02	6/17/2015	13:18	260.60
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		6.80	8/12/2015	11:46	258.82
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD		6.98	9/2/2015	11:00	258.64
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD	17.68	5.97	9/10/2015	NR	259.65
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD	17.60	4.49	9/28/2016	10:40	261.13
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD	NR	6.49	5/26/2017	13:29	259.13
MW12	11RD13SB	15.0	4.0 - 14.0	263.22	265.62	1.0 - TD	17.39	4.81	9/26/2017		260.81
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		30.05	8/30/2011	18:04	246.65
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		29.70	9/1/2011	16:09	247.00
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		18.41	5/26/2012	13:45	258.29
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		24.06	9/9/2012	16:50	252.64
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		29.85	6/17/2015	12:13	246.85
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		DRY	8/12/2015	11:51	Dry (Water Elevation <243.3 ft bgs)
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD		DRY	9/2/2015	10:45	Dry (Water Elevation <243.3 ft bgs)
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD	31.70	DRY	9/10/2015	NR	Dry (Water Elevation <243.3 ft bgs)
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD	31.65	24.35	9/28/2016	12:55	252.35
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD	31.65	DRY	5/26/2017	NR	Dry (Water Elevation <243.3 ft bgs)
MW13	11MP20SB	32.0	21.0 - 31.0	274.30	276.70	27.0 - TD	31.65	25.9	9/26/2017	1454	250.80
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		30.51	8/31/2011	10:05	218.50
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		30.01	9/1/2011	16:00	219.00
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		24.40	5/26/2012	14:45	224.61
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		27.34	9/10/2012	17:35	221.67
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW14	11MP25SB	36.0	25.0 - 35.0	246.71	249.01	25.7 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		19.64	8/30/2011	10:35	225.29
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		19.59	9/1/2011	15:56	225.34
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		18.33	5/26/2012	14:56	226.60
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		18.3	9/8/2012	13:00	226.63
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW15	11MP29SB	26.0	15.0 - 25.0	242.63	244.93	16.2 - TD		--	--	--	Decommissioned in 2014 NTCRA
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		13.84	8/30/2011	11:35	214.25
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		14.90	9/1/2011	15:50	213.19
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		6.17	5/26/2012	15:08	221.92

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		8.88	9/8/2012	14:30	219.21
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		13.13	6/18/2015	19:52	214.96
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		14.80	8/12/2015	12:19	213.29
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD		15.19	9/2/2015	9:35	212.90
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD	24.14	14.81	9/10/2015	NR	213.28
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD	24.10	8.58	9/28/2016	13:33	219.51
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD	24.08	15.09	5/26/2017	11:46	213.00
MW16	11MP30SB	22.0	11.0 - 21.0	226.09	228.09	16.0 - TD	24.08	10.32	9/26/2017	1314	217.77
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		15.00	8/30/2011	9:20	213.66
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		13.78	9/1/2011	15:52	214.88
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		8.20	5/26/2012	15:03	220.46
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		10.79	9/8/2012	16:20	217.87
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		15.03	6/18/2015	19:40	213.63
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		17.01	8/12/2015	12:18	211.65
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD		17.28	9/2/2015	9:36	211.38
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD	55.02	19.93	9/10/2015	NR	208.73
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD	54.80	10.58	9/28/2016	13:22	218.08
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD	54.77	17.19	5/26/2017	11:35	211.47
MW17	11MP91SB	52.5	41.5 - 51.5	226.36	228.66	25.0 - 33.0, 33.0 - TD	54.77	12.18	9/26/2017	1312	216.48
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		29.66	8/31/2011	15:47	214.17
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		29.87	9/1/2011	15:37	213.96
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		21.82	5/26/2012	13:10	222.01
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		24.83	9/9/2012	17:20	219.00
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		29.17	6/17/2015	10:46	214.66
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		31.43	8/12/2015	12:31	212.40
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD		31.65	9/2/2015	9:30	212.18
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD	41.57	31.20	9/10/2015	NR	212.63
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD	41.38	23.85	9/28/2016	13:55	219.98
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD	NR	30.85	5/26/2017	11:14	212.98
MW18	11MP31SB	40.0	29.0 - 39.0	241.33	243.83	38.0 - TD	41.14	25.66	9/26/2017	1246	218.17
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		19.47	9/1/2011	15:32	220.53
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		11.54	5/26/2012	12:59	228.46
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		16.02	9/9/2012	17:25	223.98
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		18.48	6/17/2015	10:31	221.52
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		23.48	8/12/2015	12:33	216.52
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD		24.95	9/2/2015	9:20	215.05
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD	45.70	23.94	9/10/2015	NR	216.06
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD	45.50	14.67	9/28/2016	14:00	225.33
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD	45.50	27.02	5/26/2017	11:05	212.98
MW19	11MP33SB	43.0	32.0 - 42.0	237.70	240.00	39.0 - TD	45.50	15.9	9/26/2017	1238	224.10
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		6.89	8/31/2011	8:53	208.31
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		6.97	9/1/2011	15:43	208.23
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		4.82	5/26/2012	15:26	210.38
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		5.53	9/9/2012	10:10	209.67
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		7.11	6/17/2015	10:18	208.09
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		7.92	8/12/2015	12:39	207.28
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD		8.12	9/2/2015	9:10	207.08
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD	17.70	7.96	9/10/2015	NR	207.24
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD	17.70	5.35	9/28/2016	14:15	209.85
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD	NR	8.6	5/26/2017	10:50	206.60
MW20	11MP38SB	15.5	4.5 - 14.5	212.90	215.20	6.5 - TD	17.47	6.32	9/26/2017	1303	208.88
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.80	8/31/2011	10:16	201.33
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.82	9/1/2011	17:10	201.31
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		7.91	5/26/2012	15:36	202.22
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.29	9/8/2012	17:35	201.84
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		8.55	6/17/2015	10:08	201.58

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		9.10	8/12/2015	12:39	201.03
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD		9.45	9/2/2015	9:00	200.68
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD	10.67	9.14	9/10/2015	NR	200.99
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD	19.60	8.01	9/28/2016	14:30	202.12
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD	NR	8.91	5/26/2017	10:34	201.22
MW21	11MP39SB	17.5	6.5 - 16.5	208.23	210.13	7.0 - TD	19.39	8.13	9/26/2017	1229	202.00
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		8.20	8/31/2011	11:08	196.90
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		8.48	9/1/2011	17:04	196.62
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		5.55	5/26/2012	15:44	199.55
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		7.77	9/9/2012	17:35	197.33
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		8.47	6/17/2015	9:46	196.63
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		10.01	8/12/2015	12:43	195.09
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD		10.33	9/2/2015	8:50	194.77
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD	17.74	10.19	9/10/2015	NR	194.91
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD	17.66	6.65	9/28/2016	14:40	198.45
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD	NR	10.45	5/26/2017	10:21	194.65
MW22	11MP40SB	15.5	4.5 - 14.5	203.10	205.10	7.8 - TD	17.50	7.23	9/26/2017	1220	197.87
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.02	8/30/2011	16:31	188.14
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.01	9/1/2011	15:14	188.15
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		14.60	5/26/2012	15:56	189.56
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		15.56	9/9/2012	17:47	188.60
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		15.88	6/17/2015	14:15	188.28
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.92	8/12/2015	11:06	187.24
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD		16.63	9/2/2015	11:10	187.53
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD	30.95	16.54	9/10/2015	NR	187.62
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD	28.86	15.53	9/28/2016	13:46	188.63
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD	NR	17.63	5/26/2017	13:00	186.53
MW23	11MP66SB	29.0	18.0 - 28.0	201.96	204.16	20.0 - TD	30.58	15.86	9/26/2017	1634	188.30
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		17.70	8/30/2011	14:51	205.81
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		17.61	9/1/2011	15:06	205.90
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		14.59	5/26/2012	16:15	208.92
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		16.45	9/9/2012	14:00	207.06
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		16.89	6/17/2015	14:31	206.62
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		17.88	8/12/2015	10:58	205.63
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD		19.02	9/2/2015	11:12	204.49
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD	32.30	17.88	9/10/2015	NR	205.63
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD	32.22	15.40	9/28/2016	13:26	208.11
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD	NR	18.21	5/26/2017	12:48	205.30
MW24	11MP62SB	30.0	19.0 - 29.0	221.41	223.51	20.0 - TD	31.97	15.96	9/26/2017	1651	207.55
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		31.85	8/30/2011	18:02	207.91
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		31.88	9/1/2011	14:50	207.88
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		29.74	5/26/2012	16:22	210.02
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		33.87	9/9/2012	10:30	205.89
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		31.81	6/17/2015	14:40	207.95
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		32.48	8/12/2015	10:56	207.28
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD		32.60	9/2/2015	11:20	207.16
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD	44.43	32.45	9/10/2015	NR	207.31
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD	40.24	30.38	9/28/2016	13:22	209.38
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD	NR	32.73	5/26/2017	12:41	207.03
MW25	11MP89SB	42.0	31.0 - 41.0	237.56	239.76	32.0 - TD	44.44	30.99	9/26/2017	1705	208.77
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.25	8/30/2011	11:35	209.68
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.30	9/1/2011	14:47	209.63
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		32.76	5/26/2012	16:30	213.17
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		34.01	9/9/2012	17:55	211.92
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.04	6/17/2015	14:48	209.89
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		36.98	8/12/2015	10:50	208.95

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD		37.24	9/2/2015	11:25	208.69
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD	45.13	36.42	9/10/2015	NR	209.51
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD	45.05	33.09	9/28/2016	13:10	212.84
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD	45.01	35.53	5/26/2017	12:35	210.40
MW26	11MP52SB	43.0	32.0 - 42.0	244.03	245.93	34.0 - TD	45.01	33.20	9/26/2017	1710	212.73
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		30.30	8/30/2011	16:50	212.64
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		30.37	9/1/2011	14:58	212.57
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		26.28	5/26/2012	16:38	216.66
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		28.64	9/9/2012	12:50	214.30
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		34.41	6/17/2015	14:58	Suspected Dry (Water Elevation <208.4 ft)
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		NR	8/12/2015	NR	--
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD		31.42	9/2/2015	22:30	211.52
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD	35.77	31.24	9/10/2015	NR	211.52
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD	35.70	27.51	9/28/2016	12:46	215.43
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD	35.65	31.52	5/26/2017	12:30	211.42
MW27	11MP60SB	34.0	23.0 - 33.0	241.04	242.94	29.0 - TD	35.65	28.83	9/26/2017	1718	214.11
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		25.50	8/30/2011	14:57	216.44
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		28.61	9/1/2011	14:53	213.33
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		24.19	5/26/2012	16:41	217.75
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		27.01	9/10/2012	15:43	214.93
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		28.90	6/17/2015	15:08	213.04
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		29.88	8/12/2015	10:46	212.06
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD		30.10	9/2/2015	11:35	211.84
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD	65.87	29.95	9/10/2015	NR	211.99
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD	65.65	25.74	9/28/2016	13:00	216.20
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD	65.58	30.13	5/26/2017	12:25	211.81
MW28	11MP88SB	64.0	53.0 - 63.0	239.94	241.94	49.0 - TD	65.58	27.05	9/26/2017	1721	214.89
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		63.21	9/1/2011	13:20	219.04
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		52.65	5/26/2012	17:09	229.60
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		61.20	9/9/2012	16:22	221.05
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		64.08	6/17/2015	15:41	218.17
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		66.60	8/12/2015	11:12	215.65
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD		66.89	9/2/2015	12:11	215.36
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD	71.75	66.81	9/10/2015	NR	215.44
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD	71.59	55.01	9/28/2016	12:11	227.24
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD	71.52	55.68	5/26/2017	11:45	226.57
MW29	11MP41SB	70.0	59.0 - 69.0	280.35	282.25	61.0 - TD	71.52	58.36	9/26/2017	1818	223.89
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		53.53	9/1/2011	14:35	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		52.63	5/26/2012	16:58	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		NR	9/9/2012	NR	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		54.25	6/17/2015	19:33	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		54.28	8/12/2015	11:19	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD		54.32	9/2/2015	12:15	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD	55.63	54.45	9/10/2015	NR	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD	55.40	54.22	9/28/2016	12:24	Suspected Dry (Water Elevation <223.7 ft)
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD	55.35	54.23	5/26/2017	11:35	223.18
MW30	11SM31SB	53.0	42.0 - 52.0	275.71	277.41	45.0 - TD	55.35	54.27	9/26/2017		223.14
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		37.75	8/29/2011	13:51	460.24
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		37.51	9/1/2011	14:05	460.48
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		34.12	5/26/2012	10:10	463.87
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		36.29	9/9/2012	18:10	461.70
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		39.31	6/22/2015	19:09	458.68
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		42.25	8/12/2015	11:31	455.74
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD		43.07	9/2/2015	12:45	454.92
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD	47.10	41.75	9/10/2015	NR	456.24
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD	47.10	35.22	10/1/2016	11:15	462.77

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD	47.07	44.95	5/26/2017	NR	453.04
MW31	11UP11SB	44.8	33.8 - 43.8	495.79	497.99	34.0 - TD	47.07	35.22	9/26/2017		462.77
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		18.90	8/31/2011	15:55	177.68
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		18.86	9/1/2011	15:26	177.72
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		16.71	5/26/2012	12:45	179.87
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		17.21	9/8/2012	15:40	179.37
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		19.03	6/17/2015	9:30	177.55
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		19.49	8/12/2015	12:47	177.09
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD		20.17	9/2/2015	12:45	176.41
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD	26.73	20.05	9/10/2015	NR	176.53
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD	26.43	18.35	9/28/2016	14:13	178.23
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD	26.70	21.33	5/26/2017	9:53	175.25
MW32	11RD05SB	25.0	14.0 - 24.0	194.38	196.58	16.5 - TD	26.70	18.00	9/26/2017	1212	178.58
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		8.14	8/31/2011	17:57	170.78
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		8.19	9/1/2011	15:20	170.73
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		3.98	5/26/2012	12:33	174.94
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		5.97	9/8/2012	12:30	172.95
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		8.50	6/17/2015	14:04	170.42
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		9.05	8/12/2015	11:09	169.87
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD		9.23	9/2/2015	8:40	169.69
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD	24.26	9.12	9/10/2015	NR	169.80
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD	24.38	4.49	9/28/2016	13:56	174.43
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD	24.40	8.96	5/26/2017	13:10	169.96
MW33	11RD20SB	23.0	12.0 - 22.0	176.62	178.92	10.5 - TD	24.40	6.67	9/26/2017	1158	172.25
MW34	AST5 MW1	NR	NR	290.95	294.25			15.57	9/1/2011	16:49	278.68
MW34	AST5 MW1	NR	NR	290.95	294.25			15.82	6/22/2015	11:54	278.43
MW34	AST5 MW1	NR	NR	290.95	294.25			17.11	9/2/2015	10:20	277.14
MW34	AST5 MW1	NR	NR	290.95	294.25		22.80	16.38	9/10/2015	NR	277.87
MW34	AST5 MW1	NR	NR	290.95	294.25		65.80	29.66	9/28/2016	NR	264.59
MW34	AST5 MW1	NR	NR	290.95	294.25		NR	49.88	5/26/2017	12:30	244.37
MW34	AST5 MW1	NR	NR	290.95	294.25		65.5	30.03	9/26/2017	1409	264.22
MW35	AST5 MW2	NR	NR	285.76	289.26			41.97	9/1/2011	16:55	247.29
MW35	AST5 MW2	NR	NR	285.76	289.26			40.01	6/22/2015	11:58	249.25
MW35	AST5 MW2	NR	NR	285.76	289.26			44.94	9/2/2015	10:15	244.32
MW35	AST5 MW2	NR	NR	285.76	289.26		55.30	44.42	9/10/2015	NR	244.84
MW35	AST5 MW2	NR	NR	285.76	289.26		55.20	36.03	9/28/2016		253.23
MW35	AST5 MW2	NR	NR	285.76	289.26		NR	47.78	5/26/2017	12:13	241.48
MW35	AST5 MW2	NR	NR	285.76	289.26		54.95	36.34	9/26/2017	1417	252.92
MW36	AST5 MW3	NR	NR	286.33	290.03			35.81	9/1/2011	16:57	254.22
MW36	AST5 MW3	NR	NR	286.33	290.03			33.16	6/22/2015	12:08	256.87
MW36	AST5 MW3	NR	NR	286.33	290.03			40.89	9/2/2015	10:10	249.14
MW36	AST5 MW3	NR	NR	286.33	290.03		65.38	39.39	9/10/2015	NR	250.64
MW36	AST5 MW3	NR	NR	286.33	290.03		22.73	15.30	9/28/2016		274.73
MW36	AST5 MW3	NR	NR	286.33	290.03		NR	15.63	5/26/2017	12:26	274.40
MW36	AST5 MW3	NR	NR	286.33	290.03		22.60	15.46	9/26/2017	1427	274.57
MW39	SM67	84.0	63 - 83	432.83	435.26			85.11	8/3/2015	9:00	Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26			Dry (>84)	8/12/2015	11:25	Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26			Dry (>84)	9/2/2015	12:35	Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26		86.02	Dry (>84)	9/10/2015	NR	Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26		85.95	85.82	9/28/2016	11:40	Dry (Water Elevation <349.8 ft)
MW39	SM67	84.0	63 - 83	432.83	435.26		85.89	84.76	5/26/2017	10:59	350.50
MW39	SM67	84.0	63 - 83	432.83	435.26		85.89	84.90	9/26/2017		350.36
MW40	SM68c	140.0	119 - 139	392.86	395.18	135		131.11	8/12/2015	11:37	264.07
MW40	SM68c	140.0	119 - 139	392.86	395.18	135		131.49	9/2/2015	12:25	263.69
MW40	SM68c	140.0	119 - 139	392.86	395.18	135	142.45	131.60	9/10/2015	NR	263.58

Table A-5 Well Construction and Groundwater Depth Information

Monitoring Well ID	Soil Boring ID	Reported Well Total Depth As Constructed (feet bgs)	Reported Screened Interval (feet bgs)	Surveyed Ground Elevation (feet NAVD88)	Surveyed Top of Casing Elevation (feet NAVD88)	Groundwater Observed During Drilling (feet bgs)	Measured Well Total Depth (feet below TOC)	Static Water Level			Ground Water Elevation (feet NAVD88)
								Depth (feet below top of casing)	Date	Time	
MW40	SM68c	140.0	119 - 139	392.86	395.18		143.38	127.64	9/28/2016	11:50	267.54
MW40	SM68c	140.0	119 - 139	392.86	395.18		142.35	132.03	5/26/2017	11:20	263.15
MW40	SM68c	140.0	119 - 139	392.86	395.18		142.35	128.72	9/26/2017		266.46
MW42	SM70b	140.0	119 - 139	339.85	342.34	99		NR	8/12/2015	NR	--
MW42	SM70b	140.0	119 - 139	339.85	342.34	99		129.10	9/2/2015	11:50	213.24
MW42	SM70b	140.0	119 - 139	339.85	342.34	99	142.97	129.01	9/10/2015	NR	213.33
MW42	SM70b	140.0	119 - 139	339.85	342.34			125.24	9/28/2016	9:57	217.10
MW42	SM70b	140.0	119 - 139	339.85	342.34		142.45	128.87	5/26/2017	NR	213.47
MW42	SM70b	140.0	119 - 139	339.85	342.34		142.45	126.60	9/26/2017	1750	215.74
MW43	SM71b	118.5	98 - 118	300.87	303.69	94		90.25	8/12/2015	10:33	213.44
MW43	SM71b	118.5	98 - 118	300.87	303.69	94		90.42	9/2/2015	12:00	213.27
MW43	SM71b	118.5	98 - 118	300.87	303.69	94	121.13	90.34	9/10/2015	NR	213.35
MW43	SM71b	118.5	98 - 118	300.87	303.69		12.85	86.53	9/28/2016	10:17	217.16
MW43	SM71b	118.5	98 - 118	300.87	303.69		120.78	90.26	5/26/2017	NR	213.43
MW43	SM71b	118.5	98 - 118	300.87	303.69		120.78	87.83	9/26/2017	1740	215.86
MW44	SM72	69	48 - 68	378.92	381.59	64, possibly 50.	71.73	32.51	9/26/2017	1900	349.08
MW45	SM73	82	61 - 81	397.70	400.37	66	79.78	45.06	9/26/2017	1924	355.31
MW46	SM74	57	36 - 56	399.62	402.50	41	60.04	31.81	9/26/2017	1934	370.69
MW47	SM75	67	46 - 66	380.67	383.67	51	70.2	35.88	9/26/2017	1941	347.79
MW48	SM76	44.5	23 - 43	348.87	351.51	28	46.76	19.23	9/26/2017	1850	332.28
MW49	SM77	61.7	40 - 60	301.15	303.78	45	64.14	27.81	9/26/2017	1839	275.97
MW50	SM78	92	71 - 91	439.58	442.65	75 (estimated	96.71	50.47	9/26/2017	2037	392.18
MW51	SM79	77	56 - 76	422.38	425.05	61	80.4	38.69	9/26/2017	2056	386.36
MW52	SM80	56	35 - 55	383.91	386.83	40	59.72	29.67	9/26/2017	1949	357.16
MW53	SM81	62	41 - 61	460.82	463.78	46	65.6	29.90	9/26/2017	2118	433.88
MW54	SM82	50	29 - 49	423.01	425.74	34	53.5	29.80	9/26/2017		395.94
MW55	SM83	27	10 - 20	341.26	344.09	13	23.92	12.27	9/26/2017		331.82
MW56	SM84	76	55 - 75	408.55	411.33	60	79.72	32.70	9/26/2017	1913	378.63
MW57	SM85	60	37.5 - 57.5	461.00	463.81	44	61.45	30.65	9/26/2017	2107	433.16
MW58	SM86	58	36.6 - 56.6	469.84	472.72	42	60.63	28.84	9/26/2017	2128	443.88
MW59	SM87	161.5	140 - 160	432.63	435.48	152	167.67	137.77	9/26/2017		297.71

Notes

Elevation datum: NAVD88 calculated using GEOID09.

Top of casing (TOC) refers to the top of PVC inner well casing.

Key

bgs	= Below ground surface
NAVD88	= North American Vertical Datum 1988
NR	= Not Recorded
TD	= Total depth
TOC	= Top of Casing

Table A-6 Groundwater Antimony, Arsenic, and Mercury Concentrations, 2010-2017

Well ID	Sample Collection Date	Units	Total Antimony	Dissolved Antimony	Total Arsenic	Dissolved Arsenic	Total Low Level Mercury	Dissolved Low Level Mercury
MW01	September-10	µg/L	1.8	1.4	10.6	9	0.0167	0.0085
MW01	August-11	µg/L	1.9	1.64	3.3	3	0.0254	0.00619
MW01	May-12	µg/L	5.46	1.6	39	2 U	0.271	0.005
MW01	June-15	µg/L	11		130		0.532	0.00452
MW01	September-15	µg/L	1.8 U		6.8 U		0.0169 U	0.0538
MW01	September-16	µg/L	2.3		17		0.0932	0.00647
MW01	May-17	µg/L	2.1		14		0.00606	0.00234
MW01	September-17	µg/L	1.7 J		1.8 J		0.0658	0.00238
MW03	September-10	µg/L	748	724	57.8	55.8	0.0165	0.00647
MW03	August-11	µg/L	917	861	58.9	56	0.0477	0.00909
MW04	September-10	µg/L	29.1	30	8.8	8.8	0.15	0.149
MW04	August-11	µg/L	27.9	27.2	8	7.8	0.155	0.0838
MW04	May-12	µg/L	51.3	32.1	12	7	0.211	0.057
MW04	September-12	µg/L	32.7		10		0.197 J	0.05 J
MW06	September-10	µg/L	5.4	5.2	28.1	26.3	0.00185	0.00015 U
MW06	August-11	µg/L	5.51	5.3	25.8	24.8	0.00725	0.0009 J
MW06	May-12	µg/L	9.87		53		0.016	0.007
MW06	September-12	µg/L	6.19		34		0.001 UJ	0.001 UJ
MW06	June-15	µg/L	6.1		34		0.004	0.00051
MW06	September-15	µg/L	7.3		48		0.0129	0.00019
MW06	October-16	µg/L	7.6		46		0.0248	0.0003 J
MW06	May-17	µg/L	6.4		39		0.0237	0.00753
MW06	September-17	µg/L	7.6		42		0.0457	0.00072 J
MW07	September-10	µg/L		4.9		0.4	0	0.0121
MW08	August-11	µg/L	1.59	1.58	0.6	0.5 J	0.0215	0.001
MW08	May-12	µg/L	0.68		2 U		0.009	0.003
MW08	June-15	µg/L	0.24 J		0.27 J		0.00235	0.00148
MW08	September-15	µg/L	0.44		0.39 J		0.00849	0.00045 U
MW08	October-16	µg/L	0.59 U		1.4 U		0.00554	0.00426
MW08	May-17	µg/L	1.1 J		1.4 U		0.00892	0.00349
MW08	September-17	µg/L	2 U		5 U		0.00731 U	0.00393 U
MW09	September-12	µg/L	11.7		13		0.172 J	0.011 J
MW09	September-15	µg/L	7.8		7.6 U		1.02	0.00546
MW09	October-16	µg/L	13		14		0.561	0.0378
MW09	May-17	µg/L	8.8		6.9		0.172	0.167
MW09	September-17	µg/L	12		11		0.511	0.0569
MW10	August-11	µg/L	6.49	0.5	96.9	92.1	0.532	0.00062 J
MW10	May-12	µg/L	1.23		148		0.032	0.001 UJ
MW10	September-12	µg/L	2.65		110		0.001 UJ	0.001 UJ
MW10	June-15	µg/L	0.21 J		95		0.00795	0.00232
MW10	September-15	µg/L	0.56 U		100 J		0.0261 U	0.0323 J
MW10	October-16	µg/L	0.4 U		100		0.0216	0.00126
MW10	May-17	µg/L	1.7 J		110		0.133	0.00028 J
MW10	September-17	µg/L	2 U		100		0.0163 U	0.00025 U
MW12	August-11	µg/L	0.505 J	0.522 J	13.5	13.9	0.0541	0.00114
MW12	May-12	µg/L	0.56		21		0.008	0.001
MW13	May-12	µg/L	924	1.6	396	2 U	0.051	0.007
MW14	August-11	µg/L	79.5 J	53.8 J	6650	6660	0.759	0.141
MW14	May-12	µg/L	103	26	7030	6340		
MW14	September-12	µg/L	74.8		9710		0	0.254 J*
MW15	August-11	µg/L	13100	13100	5620	5590	2.91	2.2
MW15	May-12	µg/L	6440		4570			
MW15	September-12	µg/L	8430		5370			2 J*
MW16	August-11	µg/L	678	658	1020	1010	1.21	0.285
MW16	May-12	µg/L	2.2		2 U		1.33	0.077
MW16	September-12	µg/L	757		830			0.285 J*
MW16	September-15	µg/L	570		1700		1.54	0.702
MW16	October-16	µg/L	1100		1500		1.39	1.23
MW16	May-17	µg/L	420		1400		0.881	0.896
MW16	September-17	µg/L	2600		2500		0.315	0.171
MW17	August-11	µg/L	53.9	9.16	28.5	4.9	6.07	0.00949
MW17	May-12	µg/L	10.7		3		0.035	0.007

Table A-6 Groundwater Antimony, Arsenic, and Mercury Concentrations, 2010-2017

Well ID	Sample Collection Date	Units	Total Antimony	Dissolved Antimony	Total Arsenic	Dissolved Arsenic	Total Low Level Mercury	Dissolved Low Level Mercury
MW17	September-12	µg/L	6.44		3		0.01 J	0.001 U
MW17	September-15	µg/L	9.3		5.3 U		0.361 J	0.00798
MW17	September-16	µg/L	75		21		2.59	1.1
MW17	May-17	µg/L	12		6.7		0.161	0.00732
MW17	September-17	µg/L	30		14		1.34	0.234
MW18	August-11	µg/L	1.04 J	0.654 J	1.3	0.7	0.0504	0.0027
MW19	August-11	µg/L	0.6 J	0.317 J	5.6	2.9	0.413	0.00054 J
MW19	May-12	µg/L	0.49		2 U		0.002	0.001
MW19	June-15	µg/L	0.21 J		0.55 J		0.00201 U	0.00091
MW19	September-15	µg/L	0.33 J		0.62 J		0.00329	0.00115 U
MW19	October-16	µg/L	0.56 U		3 J		0.00332	0.00061 UJ
MW19	May-17	µg/L	0.55 U		1.4 U		0.0123	0.00514
MW19	September-17	µg/L	2		5 U		0.0044	0.00107 U
MW20	August-11	µg/L	566 J	616 J	161	173	1.61	0.277
MW20	May-12	µg/L	985		662			
MW20	September-12	µg/L	871		221			0.85 J*
MW21	August-11	µg/L	5860	5950	1760	1770	0.141	0.0802
MW21	May-12	µg/L	9100		2540			
MW21	September-12	µg/L	9490		2510			0.131 J*
MW22	August-11	µg/L	297	294	80.4	77.3	0.981	0.527
MW22	June-15	µg/L	340		59		0.246	0.108
MW22	September-15	µg/L	280		61		0.401	0.323
MW22	October-16	µg/L	400		190		0.2	0.0798
MW22	May-17	µg/L	1000		51		0.423	0.262
MW22	September-17	µg/L	510		130		0.214	0.103
MW23	August-11	µg/L	2.4 J	1.87 J	9.2	8	0.261	0.00239
MW24	August-11	µg/L	101 J	79.9 J	7.4	5.1	56.5	0.00611
MW24	May-12	µg/L	99		4		10.6	0.008
MW24	September-12	µg/L	108		5		0.035 J	0.001 UJ
MW25	August-11	µg/L	5.86 J	3.71 J	6.2	3.6	0.452	0.0447
MW25	May-12	µg/L	7.97		7			
MW25	September-12	µg/L	69.6		1160		0	0.138 J*
MW26	August-11	µg/L	26.2	32.3	78	68.3	0.237	0.0338
MW26	June-15	µg/L	37		1300		0.483	0.0324
MW26	September-15	µg/L	28		490		0.216	0.0347
MW26	October-16	µg/L	66		1200		2.02	0.432
MW26	May-17	µg/L	170		1400		1.16	0.158
MW26	September-17	µg/L	59		1100		0.534	0.242
MW27	August-11	µg/L	9.16 J	8.48 J	22.6	22.1	0.411	0.277
MW27	May-12	µg/L	12.7		37			
MW27	September-12	µg/L	12.9		31		0.112 J	0.06 J
MW27	June-15	µg/L	11		29		0.663	0.131
MW27	September-15	µg/L	8.3		27		0.401	0.253
MW27	October-16	µg/L	8.1		22		0.336	0.203
MW27	May-17	µg/L	7.6		32		0.41	0.407
MW27	September-17	µg/L	7.6		32		0.367	0.207
MW28	August-11	µg/L	19.3 J	9.18 J	32.8	8.4	4	0.0109
MW28	May-12	µg/L	13.2	3.3	73	39	1.34	0.038
MW28	September-12	µg/L	17.4		68			0.026 J
MW28	June-15	µg/L	7		75		1.89	0.0275
MW28	September-15	µg/L	16		130		1.32 J	0.294
MW28	October-16	µg/L	5.3		100		0.384	0.0599
MW28	May-17	µg/L	9.5		110		1.08	0.0433
MW28	September-17	µg/L	7.1		75		0.542	0.0807
MW29	August-11	µg/L	1.21	0.837	36.9	31.1	0.247	0.00071 J
MW29	May-12	µg/L	6.52	2.3	102	20	0.006	0.001
MW29	September-12	µg/L	1.34		44		0.008 J	0.007 J
MW29	June-15	µg/L	0.75 J		75		0.215	0.00145
MW29	September-15	µg/L	0.23 U		35		0.0117 U	0.00569
MW29	October-16	µg/L	1.2 U		56		0.125	0.0187
MW29	May-17	µg/L	0.9 J		69		0.0261	0.00071
MW29	September-17	µg/L	0.62 J		60		0.0249 U	0.00105 U

Table A-6 Groundwater Antimony, Arsenic, and Mercury Concentrations, 2010-2017

Well ID	Sample Collection Date	Units	Total Antimony	Dissolved Antimony	Total Arsenic	Dissolved Arsenic	Total Low Level Mercury	Dissolved Low Level Mercury
MW31	August-11	µg/L	0.098	0.027 J	0.1 U	0.1 U	0.0584	0.0007 J
MW31	June-15	µg/L	0.36 J		4.1		0.376	0.0145
MW31	September-15	µg/L	0.14 U		0.82 U		0.0355 U	0.00112 U
MW31	October-16	µg/L	0.4 U		1.4 U		0.0153	0.00102
MW31	May-17	µg/L	1.3 J		2.8 J		0.15	0.00158
MW31	September-17	µg/L	2 U		5 U		0.00487 U	0.00042 U
MW32	August-11	µg/L	2.15 J	1.74 J	7.3	6.3	0.306	0.00365
MW32	May-12	µg/L	4.35		2		0.151	0.031
MW32	September-12	µg/L	6.35		3		0.19 J	0.028 UJ
MW32	June-15	µg/L	1.2		0.65 J		0.0479	0.0185
MW32	September-15	µg/L	1.9		1		0.114	0.0359
MW32	September-16	µg/L	3.8		2.6 J		0.221	0.02
MW32	May-17	µg/L	5.2		1.4 U		0.108	0.02
MW32	September-17	µg/L	2.7		5 U		0.0309 U	0.00186 U
MW33	August-11	µg/L	427 J	420 J	15.2	14.4	0.115	0.00458
MW33	May-12	µg/L	391		31		0.21	0.007
MW33	September-12	µg/L	417		29		0.01 J	0.003 J
MW33	June-15	µg/L	430		23		0.745	0.00584
MW33	September-15	µg/L	460		25		0.00821	0.00302
MW33	October-16	µg/L	450		26		0.171	0.00616
MW33	May-17	µg/L	380		24		0.0481	0.00312
MW33	September-17	µg/L	450		24		0.0401	0.00891 U
MW40	September-15	µg/L	6.2		85		0.0309 U	0.00187 U
MW40	October-16	µg/L	8.5		120		0.286	0.00153
MW40	May-17	µg/L	5.1		160		0.0043	0.0001 U
MW40	September-17	µg/L	10		220		0.0259 U	0.00031 U
MW42	September-15	µg/L	250		610		0.259 U	0.0482
MW42	October-16	µg/L	260		360		2.52	0.205
MW42	May-17	µg/L	240		310		0.0284	0.00078
MW42	September-17	µg/L	170		480		0.0938 U	0.0169
MW43	September-15	µg/L	9.2		38		0.0743 U	0.00755 J
MW43	October-16	µg/L	4.2		240		0.00677 U	0.00056
MW43	May-17	µg/L	7		230		0.00577	0.0003 J
MW43	September-17	µg/L	8		270		0.05 U	0.00404 U
MW44	September-17	µg/L	0.4 U		0.64 J		0.00602 U	0.00025 U
MW45	September-17	µg/L	0.4 U		1.4		0.0341	0.0101 U
MW46	September-17	µg/L	0.21 J		0.73 J		0.0388	0.00263 U
MW47	September-17	µg/L	0.11 J		0.77 J		0.0474	0.00959 U
MW48	September-17	µg/L	0.75		0.47 J		0.0216	0.0043 U
MW49	September-17	µg/L	0.48		3.3		0.198	0.0123
MW50	September-17	µg/L	7.3		490		1.13	0.0148
MW51	September-17	µg/L	0.4 U		2.2		0.0272 U	0.00089 U
MW52	September-17	µg/L	0.34 J		5.5		0.0239 U	0.00238 U
MW53	September-17	µg/L	0.29 J		2.6		0.186	0.0184
MW54	September-17	µg/L	2.2		34		0.381	0.00148 U
MW55	September-17	µg/L	6.5		14		0.321	0.039
MW56	September-17	µg/L	0.13 J		2.3		0.0263 U	0.0007 U
MW57	September-17	µg/L	0.15 J		2.5		0.119	0.0136
MW58	September-17	µg/L	0.56		3		0.00878 U	0.00043 U
MW59	September-17	µg/L	8.9		78		0.312	0.00743 U

Key

J = The analyte was analyzed for but not detected. The value provided is the method detection limit.

µg/L = Micrograms per liter

U = The analyte was analyzed for but not detected. The value provided is the method detection limit.

UJ = The analyte was analyzed for but not detected. The associated reporting limit is estimated.

Table A-7 Monitoring Well Selection for Proposed Alternate Groundwater Background Evaluation

Well ID	Year Installed	Selected for 2014 RI Background Evaluation	Selected for Alternate Background Evaluation	Rationale for Selection for Alternate Background Evaluation
MW12	2011	X	X	Represents Red Devil Creek upstream alluvial area upgradient to MPA
MW29	2011		X	Represents portion of SMA ugradient of MPA
MW31	2011	X	X	Represents upland background area evaluated for background in RI
MW40	2015		X	Represents portion of SMA ugradient of MPA
MW42	2015		X	Represents portion of SMA ugradient of MPA
MW43	2015		X	Represents portion of SMA ugradient of MPA
MW50	2017		X	Represents portion of SMA ugradient of MPA
MW56	2017		X	Represents portion of SMA ugradient of MPA
MW57	2017		X	Represents portion of SMA ugradient of MPA
MW59	2017		X	Represents portion of SMA ugradient of MPA

Key

MPA = Main Processing Area

SMA = Surface Mined Area

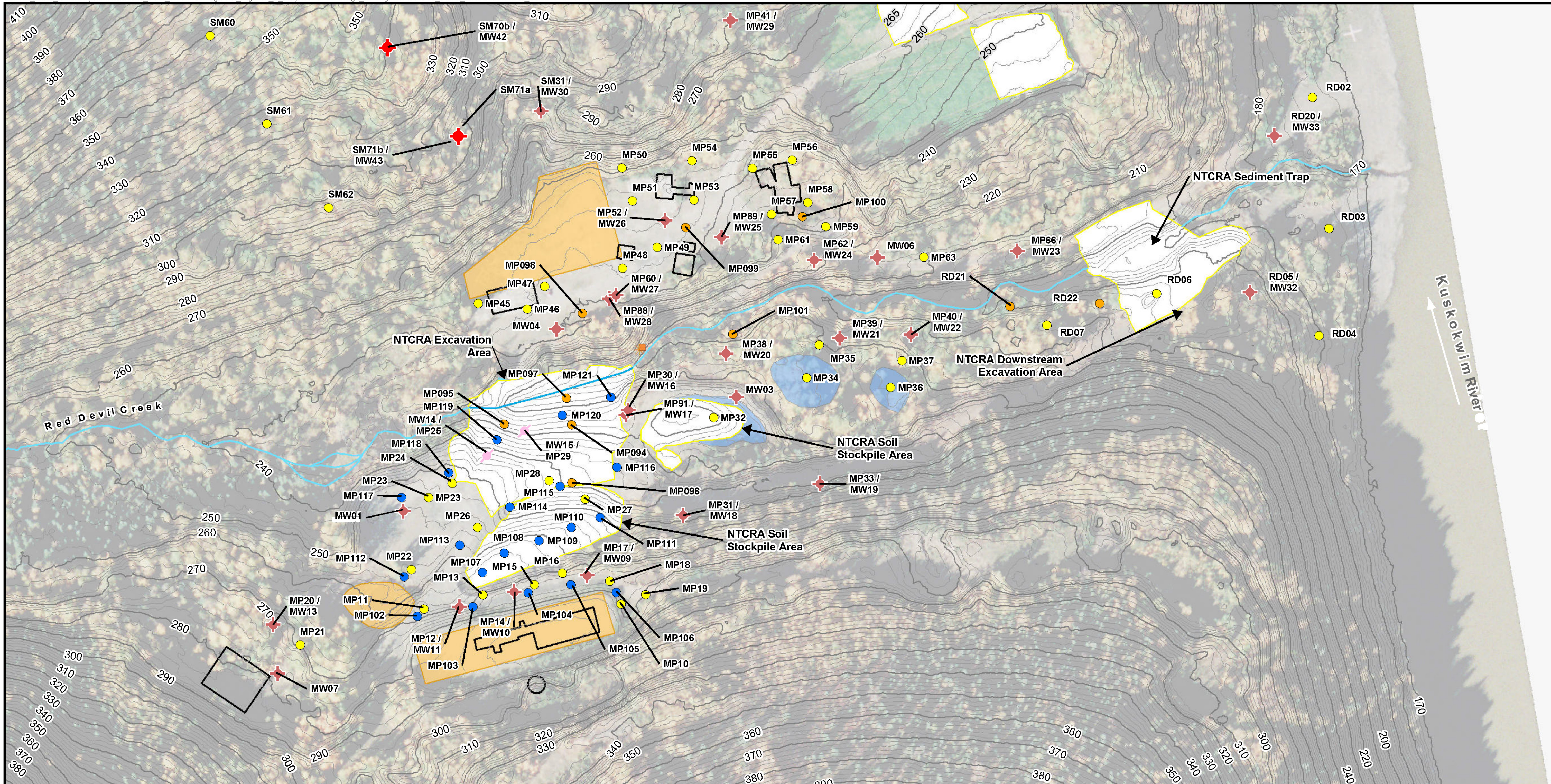
Table A-8 Evaluation of Proposed Alternate Background Levels for Groundwater

Analyte	Units	Number of Observations	Number of Detections	Mean (detects)	Standard Deviation (detects)	Recommended Alternate Background Level	Background Rationale
Antimony, Dissolved	µg/L	3	3	0.706	0.787	1.613	Upper Simultaneous Limit
Antimony, Total	µg/L	9	9	3.73	3.808	19.77	Upper Simultaneous Limit
Arsenic, Dissolved	µg/L	3	2	19.72	8.238	25.19	Upper Simultaneous Limit
Arsenic, Total	µg/L	10	10	143.2	181.9	539	Upper Simultaneous Limit
Mercury, Dissolved, Low Level	ng/L	10	8	13.5	22.58	55.9	Upper Simultaneous Limit
Mercury, Total, Low Level	ng/L	10	9	283.9	379.5	1232	Upper Simultaneous Limit

Key

µg/L = Micrograms per liter

ng/L = Nanograms per liter



2017 Soil Boring Location
2015 Soil Boring
RI Soil Boring / Monitoring Well
Decommissioned Well
RI Soil Boring
2015 2-foot Contour
2015 10-foot Contour
Area of 2014 NTCRA Re-grading
Post-NTCRA Stream Alignment
Red Devil Creek
Settling Pond
Monofill
Historical Structure
Approximate Location of Proposed Repository Footprint
Seep Location

Digital 2015 5-foot topographic contours based on Octobr 10, 2015 LiDAR Survey (Quantum Spatial 2015).

RED DEVIL MINE

Red Devil, Alaska

Figure A-1

Soil Boring Locations 2017 Tailings / Waste Rock TCLP Characterization

0 25 50 100 150 200 Feet
0 7.5 15 30 45 60 75 Meters
Scale 1:1,500

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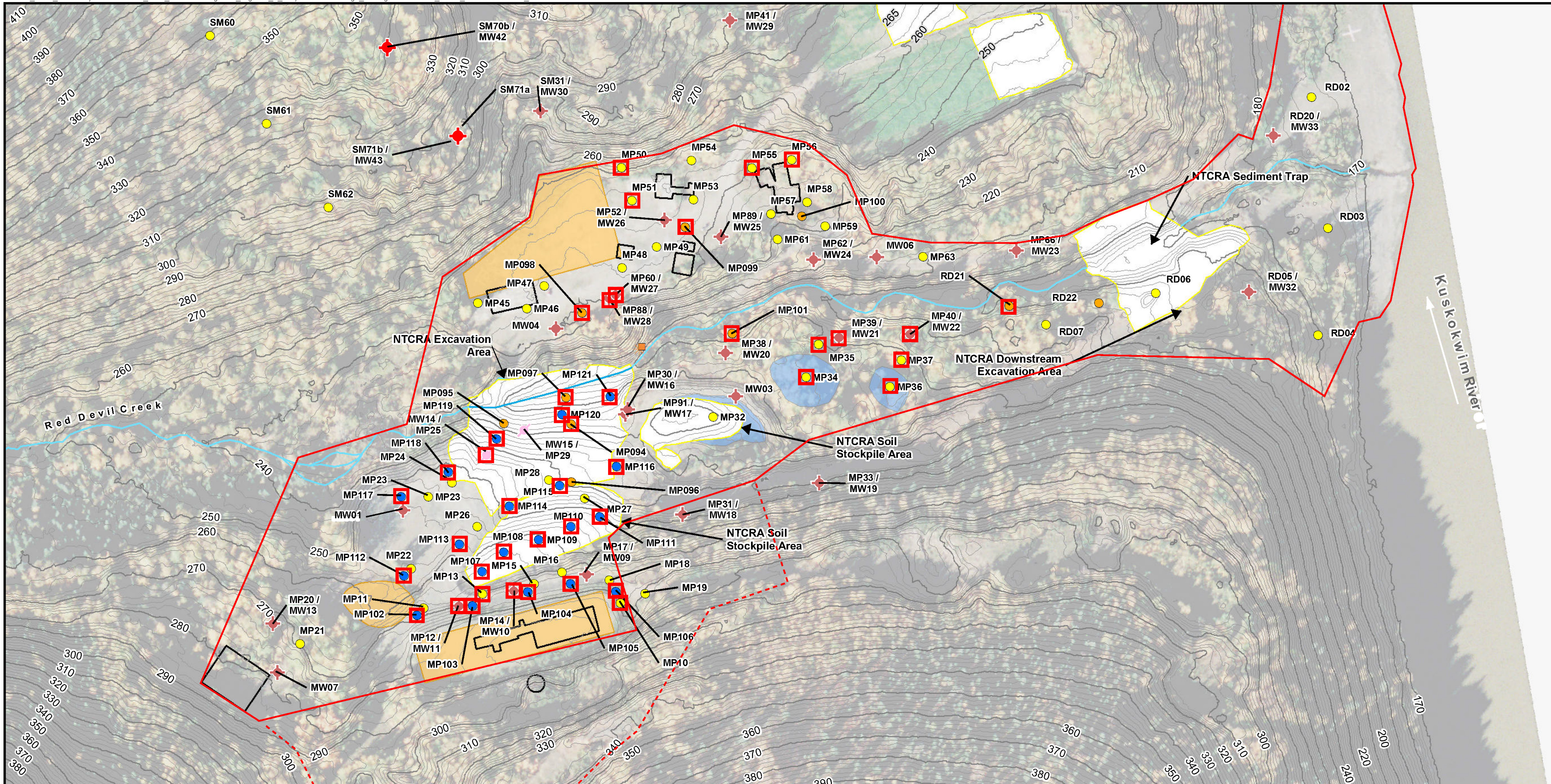
Ecology & Environment, Inc. GIS Department Project:
O:\Red_Devil_Mine\Maps\MXDs\Work_Plan_2017\working\FSP_Figure2_2_ProposedSoilBorings_TailingsWasteRock_TCLP_Characterization_ML.mxd Date: 12/14/2017



2017 Soil Boring Location	2015 2-foot Contour	Settling Pond
2015 Soil Boring	2015 10-foot Contour	Monofill
RI Soil Boring / Monitoring Well	Area of 2014 NTCRA Re-grading	Historical Structure
Decommissioned Well	Post-NTCRA Stream Alignment	Approximate Location of Proposed Repository Footprint
RI Soil Boring	Red Devil Creek	Seep Location
	Approximate Lateral Extent of Soil Excavation Described under 2016 FS Alternatives 3 and 4.	
	Soil Boring in which Soil COC Concentrations Exceeding RGs Extend to Top of Bedrock.	

Digital 2015 5-foot topographic contours based on Octobr 10, 2015 LiDAR Survey (Quantum Spatial 2015).

RED DEVIL MINE

Red Devil, Alaska

Figure A-2

Preliminary Areas of Soil Excavation to Bedrock Under 2016 FS Alternatives 3 and 4

Feet: 0 25 50 100 150 200

Meters: 0 7.5 15 30 45 60 75

Scale 1:1,500

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Ecology & Environment, Inc. GIS Department Project:
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2017 Soil Boring / Monitoring Well	Red Devil Creek
2015 Monitoring Well	Settling Pond
RI Monitoring Well	Monofill
Abandoned RI Monitoring Well	Historical Structure
2015 2-foot Contour	Approximate Location of Proposed Repository Footprint
2015 10-foot Contour	Area of 2014 NTCRA Re-grading
Post-NTCRA Stream Alignment	Seep Location

Digital 2015 topographic contours based on October 10, 2015 LiDAR Survey (Quantum Spatial 2015).

Aerial photograph taken on 9/21/2010 (AeroMetric 2012)

RED DEVIL MINE

Red Devil, Alaska

Figure A-3

2017 Monitoring Well Locations

0 50 100 200 300 400
Feet
0 10 20 40 60 80 100
Meters
Scale 1:3,000

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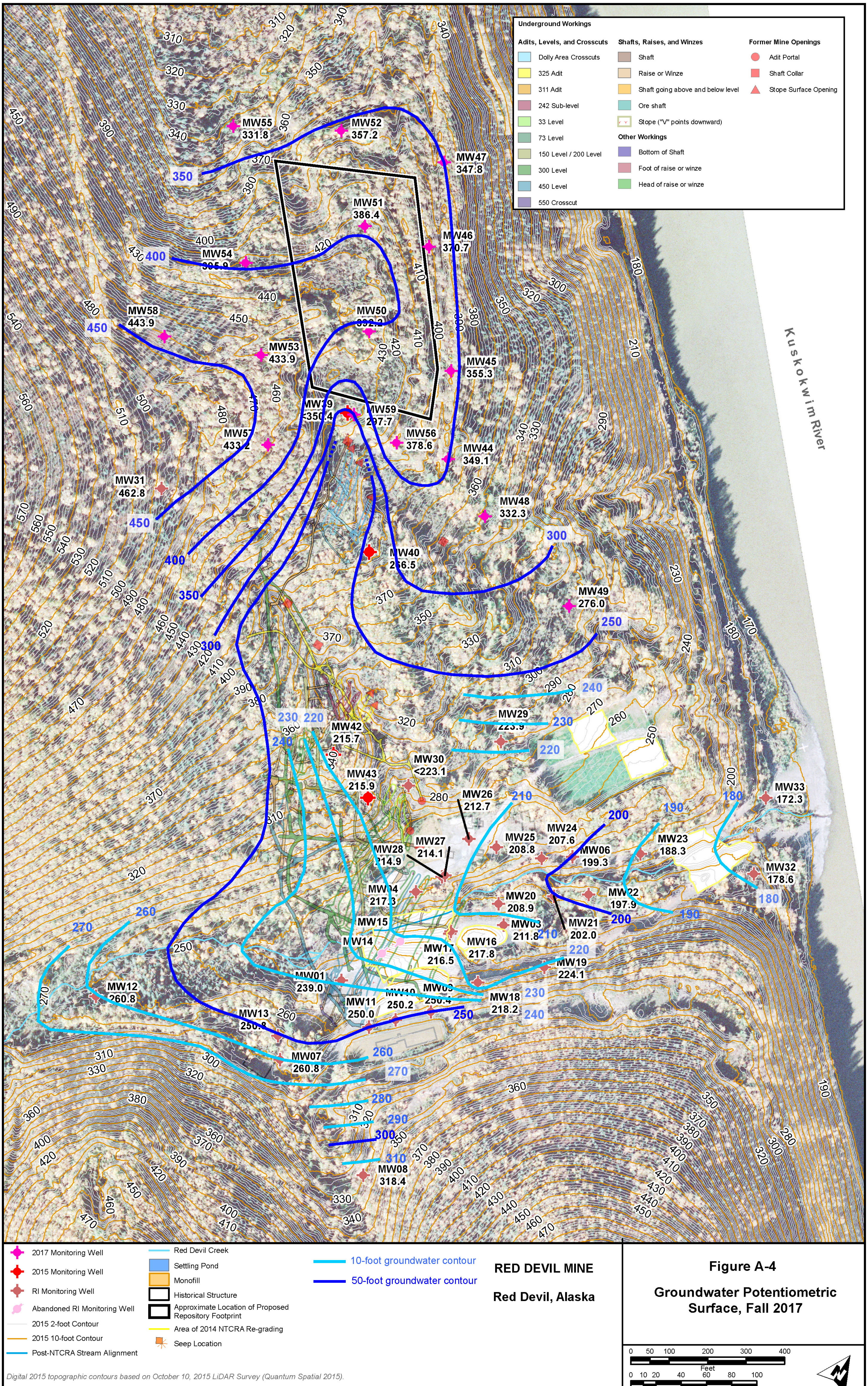

RED DEVIL MINE

Red Devil, Alaska

Figure A-4
Groundwater Potentiometric Surface, Fall 2017

Digital 2015 topographic contours based on October 10, 2015 LiDAR Survey (Quantum Spatial 2015).

Aerial photograph taken on 9/21/2010 (AeroMetric 2012)

B Cost Information

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Table B-1 Derived Costs for Groundwater Remedial Alternatives

Derived Cost DC1 - Mobilization/Demobilization (Alt GW 3 and GW 4)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Drill Rig	1	lump sum	$101,000	$101,000	Actual cost for recent RDM drilling	-
			DCIC1 Subtotal	*$101,000*		

Derived Cost DC2 - Install Monitoring Wells (Alt GW 3 and GW 4)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Install Groundwater Monitoring Wells	10	ea	$8,500	$85,000	Actual cost for recent RDM drilling	50' depth through bedrock or difficult drilling
			DC14a Subtotal	*$85,000*		

Derived Cost DC3-Passive Arsenic GW Treatment System (Alt GW 4)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Excavate PRB Trench	833	cubic yard	$4.64	$3,867	2017 RSMeans 31 23 16.13 1330	Two 200' long PRBs, 10' deep, 5' wide
Shoring	4000	SF Wall	$1.58	$6,320	2017 RSMeans 31 23 16.13 1391	
Purchase Adsorptive Media	911.1	ton	$750	$683,333	Engineer Estimate	
Backfill Treatment Zone with Adsorptive Media	370	cubic yard	$3.98	$1,474.07	2017 RSMeans 31 23 16.13 3020	Assume aquifer is 5' thick
Backfill Trench Above Treatment Zone	463	cubic yard	$3.98	$1,842.59	2017 RSMeans 31 23 16.13 3020	
			GWT1 Subtotal	$696,836.67		

Derived Cost OM1- Sampling and Analysis (Alt GW 3 and GW 4)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Mobilized 2 man field crew & expenses	1	lump sum	$10,000	$10,000	Actual cost for recent RDM sampling	-
Sample and Analyze 10 groundwater samples for total and diss. metals	1	lump sum	$3,275	$3,275	Actual cost for recent RDM sampling	
			OM3a Subtotal	*$13,275*		

Table B-2 Derived Costs for Kuskokwim River Remedial Alternatives

Derived Cost DC1 - Install Access Controls (Alt KR 2)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Mobilization and Demobilization	2	lump sum	$2,000	$4,000	Engineer Estimate	Travel/Lodging/Per Diem
Ship Signs and Post Hole Digger	1	each	$500	$500	Engineer Estimate	-
Install Warning Signs on Posts	20	each	$500	$10,000	Engineer Estimate	Assume one for every 100 feet of shoreline.
			DCIC1 Subtotal	*$14,500*		

Derived Cost DC2 - Mobilization/Demobilization (Alt KR 4 and KR 5)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Backhoe	3	each	$700	$2,100	2017 RSMeans, 01 54 36.50 1300	-
Dozer	1	each	$700	$700	2017 RSMeans, 01 54 36.50 1300	-
Front End Loader	2	each	$700	$1,400	2017 RSMeans, 01 54 36.50 1300	-
Dump Truck	3	each	$700	$2,100	2017 RSMeans, 01 54 36.50 1300	-
Diesel Generator	2	each	$451	$903	2017 RSMeans, 01 54 36.50 1200	-
Boom Crane	1	each	$700	$700	2017 RSMeans, 01 54 36.50 1300	-
Lodging Trailer Transport	1	each	$37,803	$37,803	2013 Vendory Quote, AATCO Structures	
Barge Delivery Cost	2	each	$1,209,600	$2,419,200	2013 Vendor Quote, Crowley Maritime Corp	
Flexifloat Delivery Cost	3	each	$10,000	$30,000	2017 Vendor Quote, Flexifloat	
Flexifloat Excavator Spud Barge Rental	1	each	$14,370	$14,370	2017 Vendor Quote, Flexifloat	
Flexifloat Sediment Barge Rental	3	each	$1,500	$4,500	2017 Vendor Quote, Flexifloat	
			DC2Subtotal	*$2,513,776*		

Derived Cost DC3 - Field Overhead and Oversight (Alt KR 4 and KR 5)

Description	Quantity	Unit	Unit Cost	Cost/Month	Reference	Notes
Superintendent	1	month	$13,800	$13,800	2017 RSMeans, 01 31 13.20 0260	-
Clerk	1	month	$2,920	$2,920	2017 RSMeans, 01 31 13.20 0020	-
Trailer	1	month	$343	$343	2017 RSMeans, 01 52 13.20 0350	-
Porta John (2)	1	month	$396	$396	2017 RSMeans, 01 54 33 40 6410	-
Field Office Expenses	1	month	$282	$282	2017 RSMeans, 01 52 13.40 0100	-
Air Monitoring Instrument Rental	1	month	$8,100	$8,100	2013 Vendor Quote, Field Environmental	Assume four DataRam 4000s @ $1,350/unit/month, and four Personal DataRams @ $675/unit/month
Pressure Washer for Deconning	1	month	$564	$564	2017 RS Means, 01 54 33 5450	
3/4 Ton Pickup Rental	5	each	$3,000	$15,000	2013 Vendor Quote, ABC Motorhome & Car Rentals	Assume 5 trucks required for the site.
Diesel-Engine-Driven Generators	1	month	$4,950	$4,950	2013 Vendor Quote, Craig Taylor Equipment	50-65 kW. $2,475/unit. Assume two generators are needed for duration of field activity.
Diesel Fuel For Generators and Pickup Trucks	1	month	$9,600	$9,600	Engineer Estimate	Estimate based on ~3000 gallons/month @ $3.20/gallon (current average $/gal for diesel in Alaska)
Lodging Trailer Rental	4	each	$4,350	$58,000	Vendor Quote, AATCO	each Unit houses 6 people. 12'x54', 3 moth lease: assume 15 people total
Lodging Trailer Transport	1	each	$37,803	$37,803	Vendory Quote, AATCO	
Propane for Lodging Trailers	1	montth	$810	$810	Engineer Estimate	Assume 225lbs of propane used/trailer/month @ $0.90/lb.
Per Diem	1	month	$63,900	$63,900	Engineer Estimate	Assume $142/person/day. Assume 15 people
			DC2 Subtotal	*$216,468*		

Table B-2 Derived Costs for Kuskokwim River Remedial Alternatives

Derived Cost DC4 - Site Preparation (Alt KR 4 and KR 5)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Silt Fencing	1,000	linear foot	$2.51	$2,510	2017 RS Means, 31 25 14.16 1000	
Hay Bales	1,000	linear foot	$6.96	$6,960	2017 RSMeans, 31 25 14.16 1250	-
Staging Area Geotextile	1,111	square yard	$1.74	$1,933	2017 RSMeans, 31 32 19.16 1500	Assumed 100' X 100'
Staging Area Aggregate Base	10,000	square foot	$7.99	$79,900	2017 RSMeans, 32 11 23.23 0100	-
Dewatering Pad Geotextile	1,111	square foot	$1.74	$1,933	2017 RSMeans, 31 32 19.16 1500	Assumed 100' X 100'
Dewatering Pad Aggregate Base	10,000	square foot	$7.99	$79,900	2017 RSMeans, 32 11 23.23 0100	-
Dewatering Pad Liner	10,000	square foot	$2.16	$21,600	2017 RSMeans, 33 47 13.53 1100	30 mil thickness
Temporary Barge Mooring Construction	1	lump sum	$200,000	$200,000	Engineer Estimate	-
River Access Structure Construction	1	lump sum	$51,500	$51,500	Engineer Estimate	-
			DC3a Subtotal	*$446,237*		

Derived Cost DC5 - Excavate Materials within Lower Delta and Dispose of in Repository (Alt KR 4a)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Excavate Contaminated Sediments from Shore for Dewatering	10,800	cubic yard	$1.93	$20,844	2017 RSMeans, 31 23 16.42 0305	Assume 60% sediments removed from shore
Excavate Contaminated Sediments from Spud Barge, Load onto Sediment Barge	7,200	cubic yard	$1.93	$13,896	2017 RSMeans, 31 23 16.42 0305	Assume 40% sediments removed from barge
Excavator Barge Rental	3	month	$14,370.00	$43,110	vendor quote, Flexifloat	
Sediment Barge Rental	3	month	$1,500.00	$4,500	vendor quote, Flexifloat	Assume 3 sediment barges
Transport Sediment Barge to Shore	50	hour	$2,500.00	$125,000	Engineer Estimate	-
Off-Load Sediment Barge to Shore for Dewatering	7,200	cubic yard	$1.93	$13,896	2017 RSMeans, 31 23 16.42 0305	
Load Dewatered Sediments onto Trucks	18,000	cubic yard	$1.74	$31,320	2017 RSMeans, 31 23 16.42 1650	
Haul Sediments to Repository Site	18,000	cubic yard	$5.14	$92,520	2017 RSMeans 31 23 23.20 5000	-
Spread dumped material, by dozer, no compaction	18,000	cubic yard	$2.98	$53,640	2017 RSMeans, 31 23 23.17 0020	-
Compaction- riding, vibrating roller, 12" lifts, 2 passes	18,000	cubic yard	$0.38	$6,840	2017 RSMeans, 31 23 23.23 5060	-
Confirmation Sampling	20	each	$200	$4,000	Engineer Estimate	DEC estimate, includes shipping
Water truck-soil wetting	18,000	cubic yard	$3.02	$54,360	2017 RSMeans, 31 23 23.23 9000	-
			DC4a Subtotal	*$463,926*		

Derived Cost DC6 - Excavate Materials within Lower Delta and Dispose Off-Site (Alt KR 4b)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Excavate Contaminated Sediments from Shore for Dewatering	10,800	cubic yard	$1.93	$20,844	2017 RSMeans, 31 23 16.42 0305	Assume 60% sediments removed from shore
Excavate Contaminated Sediments from Spud Barge, Load onto Sediment Barge	7,200	cubic yard	$1.93	$13,896	2017 RSMeans, 31 23 16.42 0305	Assume 40% sediments removed from barge
Excavator Barge Rental	3	month	$14,370.00	$43,110	vendor quote, Flexifloat	
Sediment Barge Rental	3	month	$1,500.00	$4,500	vendor quote, Flexifloat	Assume 3 sediment barges
Transport Sediment Barge to Shore	50	hour	$2,500.00	$125,000	Engineer Estimate	-
Off-Load Sediment Barge to Shore for Dewatering	7,200	cubic yard	$1.93	$13,896	2017 RSMeans, 31 23 16.42 0305	-
Load Dewatered Sediments into Super Sacks	18,000	cubic yard	$1.74	$31,320	2017 RSMeans, 31 23 16.42 1650	-
Purchase Super Sacks	12,000	each	$14.30	$171,600	2013 Vendor Quote	-
Load Super Sack Containers on to River Barge	18,000	cubic yard	$2.42	$43,560	2017 RSMeans, 31 23 23.14 5400	-
Barge Transport from Red Devil to Seward	18,000	cubic yard	$172	$3,096,000	2013 Vendor Quote, Crowley Maritime Corp	-
Load Super Sack Containers from Barge to Train	18,000	cubic yard	$5	$92,700	2017 RSMeans, 31 23 16.13 1346	-
Train Transport	18,000	cubic yard	$153	$2,745,360	2013 Vendor Quote, Alaska Railroad	-
Non-Hazardous Waste Disposal	23,400	ton	$60	$1,404,000	2017 Vendor Quote, Waste Management	
Confirmation Sampling	20	each	$350	$7,000	Engineer Estimate	DEC estimate, includes shipping
			DC4b Subtotal	*$7,812,786*		

Table B-2 Derived Costs for Kuskokwim River Remedial Alternatives

Derived Cost DC7 - Excavate Materials within Lower Delta and Nearshore Kuskokwim River Sediments and Dispose of in Repository (Alt 5a)						
Description	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Reference**	**Notes**
Excavate Contaminated Sediments from Shore for Dewatering	10,800	cubic yard	$1.93	$20,844	2017 RSMeans, 31 23 16.42 0305	Assume 60% sediments removed from shore
Excavate Contaminated Sediments from Spud Barge, Load onto Sediment Barge	7,500	cubic yard	$1.93	$14,475	2017 RSMeans, 31 23 16.42 0305	Assume 40% sediments removed from barge
Excavator Barge Rental	3	month	$14,370.00	$43,110	vendor quote, Flexifloat	-
Sediment Barge Rental	3	month	$1,500.00	$4,500	vendor quote, Flexifloat	Assume 3 sediment barges
Transport Sediment Barge to Shore	75	hour	$2,500.00	$187,500	2017 RSMeans, 31 23 16.42 0305	-
Off-Load Sediment Barge to Shore for Dewatering	7,500	cubic yard	$1.93	$14,475	2017 RSMeans, 31 23 16.42 0305	-
Load Dewatered Sediments onto Trucks	18,300	cubic yard	$1.74	$31,842	2017 RSMeans, 31 23 16.42 1650	-
Haul Sediments to Repository Site	18,300	cubic yard	$5.14	$94,062	2017 RSMeans 31 23 23.20 5000	-
Spread dumped material, by dozer, no compaction	18,300	cubic yard	$2.98	$54,534	2017 RSMeans, 31 23 23.17 0020	-
Compaction- riding, vibrating roller, 12" lifts, 2 passes	18,300	cubic yard	$0.38	$6,954	2017 RSMeans, 31 23 23.23 5060	-
Confirmation Sampling	20	each	$200	$4,000	Engineer Estimate	DEC estimate, includes shipping
Water truck-soil wetting	18,300	cubic yard	$3.02	$55,266	2017 RSMeans, 31 23 23.23 9000	-
			DC4a Subtotal	*$531,562*		

Derived Cost DC8 - Excavate Materials within Lower Delta and Nearshore Kuskokwim River Sediments and Dispose of Off-Site (Alt 5b)						
Description	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Reference**	**Notes**
Excavate Contaminated Sediments from Shore for Dewatering	10,800	cubic yard	$1.93	$20,844	2017 RSMeans, 31 23 16.42 0305	Assume 60% sediments removed from shore
Excavate Contaminated Sediments from Spud Barge, Load onto Sediment Barge	7,500	cubic yard	$1.93	$14,475	2017 RSMeans, 31 23 16.42 0305	Assume 40% sediments removed from barge
Excavator Barge Rental	3	month	$14,370.00	$43,110	vendor quote, Flexifloat	-
Sediment Barge Rental	3	month	$1,500.00	$4,500	vendor quote, Flexifloat	Assume 3 sediment barges
Transport Sediment Barge to Shore	75	hour	$2,500.00	$187,500	Engineer Estimate	-
Off-Load Sediment Barge to Shore for Dewatering	7,500	cubic yard	$1.93	$14,475	2017 RSMeans, 31 23 16.42 0305	-
Load Dewatered Sediments into Super Sacks	18,300	cubic yard	$1.74	$31,842	2017 RSMeans, 31 23 16.42 1650	-
Purchase Super Sacks	12,200	each	$14.30	$174,460	2013 Vendor Quote	-
Load Super Sack Containers on to River Barge	18,300	cubic yard	$2.42	$44,286	2017 RSMeans, 31 23 23.14 5400	-
Barge Transport from Red Devil to Seward	18,300	cubic yard	$172	$3,147,600	2013 Vendor Quote, Crowley Maritime Corp	-
Load Super Sack Containers from Barge to Train	18,300	cubic yard	$5	$94,245	2017 RSMeans, 31 23 16.13 1346	-
Train Transport	18,300	cubic yard	$153	$2,791,116	2013 Vendor Quote, Alaska Railroad	-
Non-Hazardous Waste Disposal	23,790	ton	$60	$1,427,400	2017 Vendor Quote, Waste Management	
Confirmation Sampling	20	each	$350	$7,000	Engineer Estimate	DEC estimate, includes shipping
			DC4b Subtotal	*$8,002,853*		

Table B-2 Derived Costs for Kuskokwim River Remedial Alternatives

Derived Cost DC9 - Construction Completion (Alt KR 4 and KR 5)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Haul Road Removal	1,000	square yard	$12.51	$12,510	2017 RSMeans, 02 41 13.17 5050	-
Staging Area Removal	1,111	square yard	$12.51	$13,900	2017 RSMeans, 02 41 13.17 5050	-
Dewatering Pad Removal	1,111	square yard	$12.51	$13,900	2017 RSMeans, 02 41 13.17 5050	-
Temporary Barge Mooring Removal	1	each	$42,954	$42,954	Engineer Estimate	-
River Access Structure Removal	1	each	$32,216	$32,216	Engineer Estimate	-
Regrade excavated areas to match existing topography	30000	square yard	$0.26	$7,800	2017 RSMeans, 31 22 16.10 3300	
Seeding	270	MSF	$36	$9,842	2017 RSMeans, 32 92 19.14 4600	slope mix, tractor spread
Equipment Decontamination	1	lump sum	$5,180	$5,180	2017 RSMeans, Crew B-1D	1 Laborer + 1 Pressure Washer. Assume 6 days.
			DC13a Subtotal	*$138,302*		

Derived Cost OM1 - Operation and Maintenance Costs (Alt KR 3)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Mobilization and Demobilization	1	lump sum	$2,000	$2,000	Engineer Estimate	Travel/Lodging/Per Diem
Post and Sign Maintenance	1	lump sum	$750	$750	Engineer Estimate	-
			OM1 Subtotal	*$2,750*		

Derived Cost OM2- Sediment Sampling and Analysis (Alt KR 3, KR 4, and KR 5)

Description	Quantity	Unit	Unit Cost	Cost	Reference	Notes
Mobilized 2 man field crew & expenses	1	lump sum	$5,000	$5,000	Engineer Estimate	Based on actual sediment sampling costs at RDM
Sampling Vessel Operation	1	lump sum	$80,000	$80,000		
Sampling Crew Labor	160	hours	$125	$20,000		
Sampling Analysis	20	each	$350	$7,000		
Reporting	1	lump sum	$25,000	$25,000		includes work plan
			OM3a Subtotal	*$137,000*		