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Work Plan for
2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization

Supplement to Remedial Investigation
Red Devil Mine, Alaska

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Prepared for:

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List of Abbreviations and Acronyms

bgs	below ground surface
BLM	Bureau of Land Management
BTEX	benzene, toluene, ethylbenzene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	contaminants of concern
COPCs	contaminants of potential concern
DOI	U.S. Department of the Interior
DQO	Data Quality Objective
DRO	diesel range organics
E & E	Ecology and Environment, Inc.
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FCM	food chain multiplier
FS	feasibility study
GRO	gasoline range organics
HHRA	human health risk assessment
mg/kg	milligrams per kilogram
NAVD88	North American Vertical Datum 1988
NTCRA	non-time critical removal action
PCBs	polychlorinated biphenyls
QAPP	Quality Assurance Project Plan
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RDM	Red Devil Mine
RG	remedial goal

List of Acronyms and Abbreviations (cont.)

RI	remedial investigation
RRO	residual range organics
SPLP	synthetic precipitation leaching procedure
SSE	selective sequential extraction
SVOCs	semivolatile organic compounds
TAL	target analyte list
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
UCL	upper confidence limit
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
XRF	X-ray fluorescence (spectroscopy)

1 Introduction

This document is a supplement to the final Remedial Investigation (RI)/Feasibility Study (FS) Work Plan for the Red Devil Mine (RDM) Site, Red Devil, Alaska (E & E 2011). The RDM consists of an abandoned mercury mine and ore processing facility located on public lands managed by the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) in southwest Alaska. The BLM initiated an RI/FS at the RDM in 2009 pursuant to its delegated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) lead agency authority. An 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. Results of the RI are presented in the final Remedial Investigation Report, Red Devil Mine, Alaska (E & E 2014a). An FS for the RDM is under development.

Data collected during the RI were used to define the site physical setting, the nature and extent of contamination, and the fate and transport of contaminants. The RI results were used to assess risk to human health and the environment due to exposure to site contaminants. This work plan supplement addresses data gaps associated with soil, groundwater, and Kuskokwim River sediments that were identified as part of the development of site-wide remedial alternatives during the preparation of the FS. This work plan supplement also addresses changes in the groundwater and surface water monitoring network and possible changes to the groundwater and surface water conditions at the RDM stemming from implementation of a non-time-critical removal action (NTCRA) performed by the BLM at the RDM during the summer of 2014. E & E prepared this work plan supplement on behalf of the BLM under Delivery Order Number L14PB00938 and BLM National Environmental Services Blanket Purchase Agreement Number L14PA00149.

Historical mining activities at the RDM included underground and surface mining. Ore processing 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 final RI/FS work plan and final RI report provide detailed background information on the RDM and information on the regulatory framework for the RI/FS and planned supplemental RI work addressed in this document. That information is not repeated in this work plan supplement.

Existing data and information regarding the RDM are presented in the final RI report and other documents and are summarized in Chapter 2.

1.1 Purpose and Objectives

The purpose of this work plan supplement is to present the supplemental RI activities, procedures, and methods that will be conducted to augment existing data to characterize soil, groundwater, surface water, and Kuskokwim River sediment. The objectives of the planned supplemental RI activities are to address data gaps identified during the development of the FS, address changes to site conditions resulting from the NTCRA, and support the development of site-wide remedial alternatives at the RDM.

1.2 Document Organization

The work plan supplement is organized into the following chapters.

Chapter 1, Introduction – Describes the purpose and objectives of the supplemental RI activities and baseline monitoring.

Chapter 2, Evaluation of Existing Information – Summarizes existing information and identifies data gaps.

Chapter 3, Data Quality Objectives – Identifies the major study questions related to the supplemental RI activities that need to be answered and outlines how the study questions will be addressed through supplemental RI activities.

Chapter 4, Overview of Supplemental RI Study Design – Summarizes the study design concept for the supplemental RI activities and baseline monitoring based on the outputs of the Data Quality Objectives (DQOs) process.

Chapter 5, References – Lists the guidance documents and literature resources cited in this document.

<u>Appendices</u>
A Field Sampling Plan
B Quality Assurance Project Plan Addendum
C Health and Safety Plan

2 Evaluation of Existing Information

Existing data and information regarding the RDM are presented in the final RI report and other documents. Key RI findings and information pertinent to the supplemental RI characterization for soil, groundwater, surface water, and Kuskokwim River sediment are summarized in Sections 2.1 through 2.4. Data gaps identified during the development of the FS are summarized in Section 2.5.

2.1 Red Devil Mine Remedial Investigation

Results of the RI are presented in the final Remedial Investigation Report, Red Devil Mine, Alaska (E & E 2014a).

2.1.1 Soil

Objectives of the surface soil and subsurface soil characterizations are detailed in Chapter 2 of the final RI report and are summarized briefly below:

- Determine the lateral and vertical extent of tailings/waste rock.
- Characterize the nature and extent of contaminants of potential concern (COPCs) in tailings/waste rock and surface and subsurface soil.
- Identify and characterize possible tailings/waste rock at the reservoir dam.
- Characterize the soils within the Surface Mined Area.
- Identify tailings/waste rock within alluvial deposits of Red Devil Creek, including its delta in the Kuskokwim River.
- Identify mining-related material within alluvial deposits of the Dolly Sluice delta and Rice Sluice delta.
- Assess soil characteristics that may affect contaminant fate, transport, bioavailability, and bioaccumulation.
- Characterize chemical and physical characteristics of soils in background areas.
- Provide data for the human health risk assessment (HHRA) and the ecological risk assessment (ERA) to assess potential exposure to COPCs.
- Characterize geotechnical properties of tailings/waste rock and soils that may be subject to excavation and construction activities.

Characterization of surface soil was performed in 2010 and 2011. Characterization of subsurface soil and additional characterization of surface soil were conducted in 2011. Additional subsurface soil characterization was conducted in September 2012 in an attempt to identify and characterize areas of natural mineralization in the Surface Mined Area.

Soil characterization included visual inspection of lithological and mineralogical characteristics; X-ray fluorescence spectroscopy (XRF) field screening for total metals; and laboratory analysis for total target analyte list (TAL) inorganic elements; mercury selective sequential extraction (SSE), arsenic speciation, arsenic bioavailability, synthetic precipitation leaching procedure (SPLP) TAL metals, toxicity characteristic leaching procedure (TCLP) Resource Conservation and Recovery Act (RCRA) metals, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), diesel range organics (DRO), and residual range organics (RRO). In addition, selected soil samples were analyzed for geotechnical parameters, including grain size/Atterburg limits, moisture content, compaction, direct shear, and permeability.

Results of the RI soil characterization are presented in Chapters 3 through 7 of the final RI report. Key RI results are summarized below.

Soil Types, Characteristics, and Distribution
The distribution and arrangement of soils and mine and ore processing wastes at the site play a significant role in determining the nature and extent of contamination, as well as the fate and transport of contaminants at the RDM. Native soils at the RDM site consist of loess, soils derived from Kuskokwim Group bedrock and alluvial deposits associated with the Kuskokwim River and Red Devil Creek. Non-native materials at the site comprise various types of mining and ore processing wastes and fill. Mining-related waste consists of waste rock, dozed and sluiced overburden, flotation tailings, and tailings (thermally processed ore, also known as calcines, burnt ore, and retorted ore). Tailings and waste rock are typically mixed and are referred to as tailings/waste rock in the final RI report and this document. Native materials have been removed, disturbed, relocated, covered, and/or mixed with other native soils and/or mine waste and tailings and fill locally across the site.

Multiple lines of evidence were used to identify the various mine wastes and soil types and to define their distribution. In conjunction with other information, visual observations of the presence of red porous rock and rock fragments with a distinctive rust-colored rind are shown to be useful to identify the presence of tailings. Visual observations of the presence of primary ore minerals cinnabar (mercury sulfide) and stibnite (antimony sulfide), and related gangue minerals realgar and orpiment (arsenic sulfides), and calcite and quartz veins, combined with other information, are useful to identify waste rock and naturally mineralized bedrock and rock fragments within native soils. Combined with other information, results of mercury SSE analysis is useful to identify the presence of cinnabar and other forms of mercury in soils.

Results of the efforts to delineate the lateral and vertical extents of tailings/waste rock, other mine wastes, and soil types are presented in Chapter 3 of the RI report.

Fate and Transport of Inorganics in Soil
The occurrence of contaminants at the RDM is chiefly dependent on the distribution of mine waste materials, consisting primarily of tailings, waste rock,

and flotation tailings. Inorganics also are present in disturbed soils and sluiced overburden from the Surface Mined Area. The present distribution of these materials is explained by historical mining and ore processing activities and subsequent modification by natural surface processes and cleanup actions. The distribution of these materials at the RDM is briefly discussed above.

Migration of contaminants associated with source materials has occurred via physical and chemical processes. Tailings/waste rock have historically been disposed of or eroded into Red Devil Creek within the Main Processing Area and downstream areas. In addition, naturally mineralized soils, particularly from the Surface Mined Area, have been eroded and transported into the Red Devil Creek valley. Tailings/waste rock and natural materials that enter Red Devil Creek by erosion and mass wasting have been in the past, and presently are, subject to surface water transport downstream within Red Devil Creek. Tailings/waste rock and natural materials have been deposited within and transported down the channel of Red Devil Creek to the Kuskokwim River, where they accumulated in a delta. Sluicing of overburden from the Surface Mined Area created the Dolly and Rice Sluice deltas in the Kuskokwim River. Some of these materials also migrated downriver to some extent in the Kuskokwim River.

Contaminants at the RDM presently are transported primarily by the groundwater and surface water pathways. Leaching of inorganics from tailings/waste rock and other sources is the primary mechanism of contamination of groundwater and surface water. Leached contaminants enter groundwater directly where/when groundwater locally immerses these source materials, and by leaching and downward transport toward groundwater where the groundwater levels are locally beneath the base of the source materials. Locally, soils have been impacted by such leaching and migration of contaminants from tailings/waste rock and other contaminant sources. For example, arsenic, mercury, and antimony have leached from tailings/waste rock and have been deposited (e.g., adsorbed or incorporated into minerals) onto soils/alluvium underlying the tailings in the Main Processing Area. This is evident in some RI soil borings that show a profile of decreasing concentrations of these metals below the base of the tailings/waste rock.

Nature and Extent of Contamination in Soil

For the purposes of delineating the extent of RDM-related contamination in soils, concentrations of inorganic analytes in mine wastes and soil were compared to concentrations in soil collected from background locations. In accordance with the RI work plan (E & E 2011), samples used for background value estimation were collected from locations outside 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. These background areas are located within the Upland Background Area and Red Devil Creek Upstream Alluvial Area for all media except Kuskokwim River sediment. Difficulties associated with the RI efforts to assess background soil concentrations are summarized in Section 4.1.7 of the final RI report.

Thirteen inorganic elements were detected above background values in surface soil samples and seventeen inorganic elements were detected above background values in subsurface soil samples. In addition, SVOCs, DRO, and RRO were detected in surface and/or subsurface soils that may require cleanup. Inorganic elements were detected above background values in all general 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 tailings/waste rock located in the Main Processing Area. These inorganic elements also were detected at concentrations above background in native and disturbed native soils, including Red Devil Creek alluvium, in the Main Processing Area, the Surface Mined Area, and other geographic areas of the site. Soil impacted as such by leaching from tailings/waste rock with inorganic element concentrations exceeding background values is considered contaminated. The depth of such deposition of inorganic elements in soils in parts of the Main Processing Area and Red Devil Creek Downstream Alluvial Area is not well known. Existing information on the depth of contamination was used to estimate depths and volumes of soils subject to remediation in the FS, discussed in Section 2.2.

Mercury, antimony, and arsenic are the primary COPCs at the RDM and are present at concentrations above risk-based and regulatory levels in mine wastes and media impacted by mine wastes that are subject to remedial action. These same metals occur naturally at concentrations above risk-based and regulatory levels in native bedrock, soil, and sediment, and groundwater and surface water that flow through them. Such naturally occurring concentrations represent pre-mining “background” conditions, and are thus not subject to remediation. Discriminating between mining-related contamination and impacts on soil of natural mineralization remains an important objective in developing appropriate and feasible remedial goals and objectives and site-wide remedial alternatives at the RDM.

Natural mineralization at the RDM comprises not only the discrete high grade mercury ore bodies targeted during mining, but also sub-ore grade zones peripheral to the ore bodies. This peripheral mineralization includes not only mercury and antimony sulfide minerals (primarily cinnabar and stibnite, respectively), but also gangue minerals arsenic sulfides (realgar and orpiment). Weathering of these natural sulfides, and possibly other minerals, results in naturally elevated levels of arsenic, mercury, and antimony in groundwater. Bedrock and soil in zones hydraulically downgradient of the mineralized zones also likely contain naturally elevated metals concentrations from deposition of the mobilized metals (e.g., oxidation of arsenic sulfide and adsorption of resulting arsenate onto clay particles or iron oxide/hydroxide).

Organic compounds, including DRO, RRO, SVOCs and PCBs were detected in soil in portions of the Main Processing Area at depths ranging up to 30 feet below ground surface (bgs). Concentrations of DRO in some samples exceeded regulatory criteria.

Risk Assessment
Potential risk to human and ecological receptors exposed to soil was assessed. Contaminants of concern (COCs) were identified. The primary COCs are antimony, arsenic, and mercury. Results of the HHRA and the ERA indicated significant risk to these receptors, in part due to direct contact or ingestion of soil. Results of the HHRA and the ERA are presented in Chapter 6 of the final RI report.

2.1.2 Groundwater
Objectives of the groundwater characterizations are detailed in Chapter 2 of the final RI report and are summarized briefly below:

- Characterize the nature and extent of COPCs in groundwater.
- Determine if the monofills are a source of groundwater contamination.
- Assess potential sources and migration patterns of groundwater and COPCs.
- Characterize groundwater depth, flow direction, gradient, and migration patterns of COPCs.
- Assess groundwater–surface water interactions, including the potential for COPCs in groundwater to enter surface water.
- Provide data to support the HHRA.

Baseline monitoring of groundwater, as well as surface water, was performed at the RDM in the spring and fall 2012. The purpose of the baseline monitoring was to augment the RI results and identify seasonal trends in groundwater and surface water flow and contaminant concentrations and loading. Specific objectives of the baseline monitoring were to:

- Characterize the seasonal variability in groundwater and surface water hydrology and chemistry;
- Characterize the long-term (multiple year) variability in groundwater and surface water hydrology and chemistry; and
- Characterize trends that are present in groundwater and surface water chemistry.

Groundwater samples were variously analyzed for total TAL metals, dissolved TAL metals, total low level mercury, dissolved low level mercury, methylmercury, arsenic speciation, inorganic ions, silicon, total dissolved solids (TDS), total suspended solids (TSS), nitrate and nitrite, carbonate and bicarbonate, SVOCs with tentatively identified compounds, DRO, RRO, gasoline range organics (GRO) and benzene, toluene, ethylbenzene, xylenes (BTEX), and PCBs.

Results of the RI groundwater characterization are presented in Chapters 3 through 7 of the final RI report. Results of the 2012 baseline monitoring were documented in the Final 2012 Baseline Monitoring Report, Red Devil Mine, Alaska, included as Appendix A in the final RI report, and incorporated as appropriate in the RI report. Key results of the groundwater characterization and baseline monitoring are summarized below.

Groundwater Occurrence and Flow Patterns

Groundwater occurs in native unconsolidated soil, mine wastes, and bedrock, including underground mine workings. Groundwater within bedrock and the overlying unconsolidated materials is generally hydraulically connected, although there is some hydraulic segregation locally at the site. Groundwater at the site generally flows toward Red Devil Creek and the Kuskokwim River, with groundwater potentiometric surface generally mimicking topography. Groundwater in a portion of the Surface Mined Area flows toward the Main Processing Area and the Red Devil Creek downstream alluvial area. Groundwater in these areas emerges into Red Devil Creek and enters the Kuskokwim River as surface water rather than as groundwater. Locally, groundwater flow at the RDM is complicated due primarily to complex modification of the natural hydrogeologic environment at the site. Flow within the unconsolidated materials is complicated by localized hydraulic segregation, variable gaining/losing conditions along Red Devil Creek, localized discharge from the underground mine workings, and seasonal variation in water levels and flow rates. The presence of an extensive network of underground mine workings at the site likely exerts a significant influence over groundwater flow patterns at the RDM. The mine workings likely provide a highly transmissive groundwater flow network that connects a large portion of the Surface Mined Area and the Main Processing Area. Assuming the mine workings are not plugged or caved, the mine workings and associated bedrock fractures likely exert a draining effect where the mine workings locally lie below the water table but above the highest nearby base level, which is the level of Red Devil Creek.

A map illustrating the configuration of the underground mine workings as of 1962 (based on Malone 1962 and MacKevett and Berg 1963) is presented on Figure 2-1. Information from a 1962 mine workings cross section (Alaska Mines and Minerals, Inc. and Decoursey Mountain Mining Co., Inc., 1962) is projected onto RI report geologic cross section B-B', presented on Figure 2-2 of this document. Information on estimated elevations of key underground mine features is summarized in Table 2-1. The elevation of Red Devil Creek where underground workings approach the surface beneath the creek (near the seep) is approximately 210 feet above mean sea level referenced to the North American Vertical Datum 1988.

Results of a geophysical survey conducted by the United States Geological Survey at the RDM site using surface-based, direct-current resistivity and electromagnetic induction methods, strongly support the presence of near-surface stopes described above (Burton and Ball 2011). The resistivity results indicated the presence of several anomalies in the subsurface along Red Devil Creek in the Main Processing Area, including two anomalies that appear likely to be associated with underground mine workings.

Anomaly D is interpreted to be an elongate conductive anomaly that underlies Red Devil Creek for a distance of at least approximately 200 feet. Anomaly E is interpreted to be a nearly vertical anomaly that extends to within approximately 6 feet of the surface. Anomaly E is in close proximity to the seep on the left bank of Red Devil Creek. The approximate locations of these resistivity anomalies are shown in Figure 2-2.

On a site-wide scale, Red Devil Creek exhibited predominantly gaining conditions. However, Red Devil Creek exhibited losing conditions locally. Losing conditions have apparently occurred in the vicinity of stations RD04 and RD05 on Red Devil Creek. Below the losing reach, the stream again exhibits gaining conditions (near surface water station RD09). Based on data from two sets of shallow/deep well pairs in the Main Processing Area, it is likely that along the axis of the Red Devil Creek valley, the vertical gradient within bedrock is predominantly upward, although interpretation of the data for one of the well pairs (MW16/MW17) is inconclusive. It is possible that the NTCRA (see Section 2.3) addressing Red Devil Creek sediment may have locally affected groundwater flow paths and groundwater-surface water interactions in part of the Main Processing Area.

Available data and interpretations of data pertaining to groundwater occurrence and flow patterns are detailed in Chapters 3 and 5 and Appendix A of the final RI report.

Fate and Transport of Inorganic Elements in Groundwater

The flow pathways of groundwater as well as surface water determine the chemical, physical, and biological environments in which leaching and mobilization of inorganic elements may occur. The groundwater flow pathways at the RDM are complex, as discussed above. Groundwater and surface water flow through each of the various environments results in various chemical impacts. Multiple interrelated factors and processes affect the mobility of inorganic elements, impacts on groundwater, and impacts of groundwater on other media. Available data and interpretations of such data are detailed in Chapter 5 of the final RI report.

Nature and Extent of Groundwater Impacts

As with soils, for the purposes of delineating the extent of RDM-related contamination, concentrations of inorganic analytes in groundwater were compared to concentrations in groundwater samples collected from background locations. Samples used for background groundwater value estimation were collected from locations within the Upland Background Area and the Red Devil Creek Upstream Alluvial Area. Efforts to assess background concentrations are detailed in Section 4.1.7 of the final RI report.

Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values.

Groundwater at the RDM is significantly impacted by leaching of inorganic contaminants from mine wastes, including tailings/waste rock, flotation tailings, and contaminated soils. The greatest impacts, particularly for antimony and arsenic, occur where tailings/waste rock materials within the Main Processing Area are within the saturated zone at least part of the time. Concentrations of total and dissolved antimony and arsenic are highest in the Post-1955 Main Processing Area. Mine waste materials also contribute to mercury groundwater contamination. Some of the groundwater impacts are associated with flow through naturally mineralized soil and bedrock and underground mine workings.

As noted above, mercury, antimony, and arsenic are present at concentrations above risk-based and regulatory levels in mine wastes and media impacted by mine wastes that are subject to remedial action, including groundwater. These same metals occur naturally at concentrations above risk-based and regulatory levels in native bedrock, soil, and sediment, and groundwater and surface water that flow through them. Such naturally occurring concentrations represent pre-mining "background" conditions, and are thus not subject to remediation. Discriminating between mining-related contamination and impacts on groundwater of natural mineralization is an important objective in developing appropriate and feasible remedial goals and objectives and site-wide remedial alternatives at the RDM.

As noted above, weathering of soil and bedrock containing naturally occurring sulfide minerals and possibly other minerals results in naturally elevated levels of arsenic, mercury, and antimony in groundwater. Bedrock and soil in zones hydraulically downgradient of these naturally mineralized materials likely contain naturally elevated metals concentrations from deposition of the mobilized metals (e.g., oxidation of arsenic sulfide and adsorption of resulting arsenate onto clay particles or iron oxide/hydroxide).

Existing data on background groundwater concentrations are from monitoring wells installed outside of the extent of the zone of natural mineralization and are not representative of groundwater affected by naturally mineralized bedrock and soil/alluvium. RI data have shown that groundwater affected by natural mineralization flows into the Main Processing Area.

In addition to inorganic elements, organic compounds were detected in some RI groundwater samples, including DRO, RRO, and several SVOCs. None of the organic compounds detected exceeded comparison criteria in any of the groundwater samples. The extent of organic compounds in groundwater has not been fully delineated.

Risk Assessment

Potential risk to human receptors exposed to groundwater was assessed. Results of the HHRA indicated significant risk to humans via ingestion of groundwater. Results of the HHRA are presented in Chapter 6 of the final RI report.

2.1.3 Surface Water

Objectives of the surface water characterizations are detailed in Chapter 2 of the final RI report and are summarized briefly below:

- Characterize the nature and extent of COPCs of Red Devil Creek and the seep adjacent to the creek in the Main Processing area.
- Assess contribution of COPCs in surface water from groundwater.
- Characterize conditions and factors affecting contaminant fate and transport of COPCs in the surface water Red Devil Creek.
- Provide data to support the HHRA and ERA.

Baseline monitoring of surface water and groundwater were performed at the RDM in the spring and fall 2012. The purpose of the baseline monitoring was to augment the RI results and identify seasonal trends in groundwater and surface water flow and contaminant concentrations and loading. Specific objectives of the baseline monitoring were to:

- Characterize the seasonal variability in groundwater and surface water hydrology and chemistry;
- Characterize the long-term (multiple year) variability in groundwater and surface water hydrology and chemistry; and
- Characterize trends that are present in groundwater and surface water chemistry.

Results of the RI surface water characterization are presented in Chapters 3 through 7 of the final RI report. Results of the 2012 baseline monitoring were documented in the Final 2012 Baseline Monitoring Report, Red Devil Mine, Alaska, included as Appendix A in the final RI report, and incorporated as appropriate in the RI report. Key results of the surface water characterization and baseline monitoring are summarized below.

Fate and Transport of Inorganic Elements in Surface Water

RI results indicate that transport of contaminants in surface water is occurring presently at the RDM. Contaminant loading (e.g., antimony, arsenic, mercury, and methylmercury) along Red Devil Creek as it flows through the Main Processing Area are attributable primarily to groundwater migration into the stream along gaining reaches. Groundwater emerges to surface water as baseflow within the Main Processing Area as well as at a seep located adjacent to the creek in the Main Processing Area. Sources of inorganics in groundwater include leaching from mine wastes, as well as naturally mineralized bedrock and native soils. Other sources of surface water loading along the creek may include entrainment of contaminants within or adsorbed to particulates and dissolution/desorption of contaminants from bed and suspended sediment.

Multiple, interrelated factors and processes affect the mobility of inorganic elements, impacts on groundwater and surface water, and interactions between groundwater and surface water. Available data and interpretations of such data are detailed in Chapter 5 of the final RI report.

Nature and Extent of Impacts in Surface Water
Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values in Red Devil Creek surface water and surface water sampled at the seep. In Red Devil Creek, starting at the upper end of the Main Processing Area, total and dissolved concentrations of antimony, arsenic, and mercury were significantly elevated above background in Red Devil Creek down to the mouth of Red Devil Creek. The highest arsenic concentrations were detected in the seep samples. Results of surface water characterization and baseline monitoring, including concentration profiles and contaminant loading calculations, are presented in Chapter 4 and Appendix A of the final RI report.

Risk Assessment
Potential risk to human and ecological receptors exposed to surface water was assessed. Results of the HHRA and ERA indicated risk to these receptors. Results of the HHRA and ERA are presented in Chapter 6 of the final RI report.

2.1.4 Kuskokwim River Sediment
During the RI, bed surface sediment samples were collected at 17 locations along the shoreline of the Kuskokwim River in 2010 and 2011, and from 55 offshore locations in 2011 and 2012. Objectives of the sampling were to:

- Characterize the nature and extent of CPOCs in river sediment;
- Characterize chemical attributes affecting fate and transport of COPCs;
- Provide data for the HHRA to assess potential exposure to COPCs through direct contact, incidental ingestion, and consumption of fish;
- Provide data for the ERA to assess potential exposure of river biota to COPCs through direct contact and ingestion; and
- Develop an estimate of the amount of material that may require remediation.

Key results of the RI characterization of Kuskokwim River sediment are summarized below.

Fate and Transport of Inorganic Elements in Kuskokwim River Sediment
Materials that enter Red Devil Creek by erosion and mass wasting have been in the past, and presently are, subject to surface water transport downstream within Red Devil Creek. Some of the materials transported down Red Devil Creek to its mouth have been deposited in the Red Devil Creek delta, where they may be subject to further erosion by Red Devil Creek as it flows over the delta, and by the Kuskokwim River. Similarly, sluiced overburden that was historically deposited in the Dolly Sluice and Rice Sluice deltas is presently subject to erosion by the Kuskokwim River. Results of Kuskokwim River bed sediment samples indicate that transportation of materials from Red Devil Creek and its delta, and likely the

Dolly and Rice Sluice deltas, has occurred. Detailed discussion of fate and transport of contaminants in Kuskokwim River sediment is presented in Chapter 5 of the final RI report.

Nature and Extent of Contamination in Kuskokwim River Sediment
In Kuskokwim River sediment samples collected during the RI, antimony, arsenic, and mercury concentrations were the COCs most highly elevated above background values. Methylmercury was detected above the background value in approximately half of the samples analyzed for methylmercury. Concentrations of antimony, arsenic, mercury, and methylmercury generally decrease downriver from the mouth of Red Devil Creek, but not in a regular pattern. The samples collected from some of the locations furthest downriver and distant from the shore exceed one or more of the background values. The extent of inorganic element contamination in river sediments has not been defined by RI sampling in either the downriver or the cross-river directions. Detailed discussion of the nature and extent of contaminants in Kuskokwim River sediment is presented in Chapter 4 of the final RI report.

Baseline human health and ecological risk assessments addressing RDM-related contamination in Kuskokwim River sediment and other media are presented in Chapter 6 of the final RI report. Elements of the risk assessments that pertain to supplemental Kuskokwim River sediment characterization are briefly outlined below.

2.1.4.1 Baseline Human Health Risk Assessment – Sediment

The HHRA addressed potential risk to a future onsite resident, a recreational visitor or subsistence user, and an industrial/mine worker. Of the media and exposure routes assessed, the following pertain to the Kuskokwim River: direct exposure (via dermal contact) to sediment in Red Devil Creek and the near-shore of the Kuskokwim River; and indirect exposure through ingestion of native wild foods, including fish from the Kuskokwim River and potentially, to a lesser extent, from Red Devil Creek.

The HHRA risk characterization results indicated that consumption of fish contributes significantly to the potential risk posed to all receptors at the site. To a lesser degree, direct exposure to sediment also contributed to potential risk to the receptors. Section 6.2.6 of the report identified uncertainties associated with the risk assessment.

Two areas of significant uncertainty associated with the Kuskokwim River are the estimation of concentrations of COPCs in fish consumed by receptors and the assumption that all wild food is harvested from the site, discussed further below.

For the HHRA, the concentrations of COPCs in game fish were estimated using a health-protective food chain multiplier (FCM) approach and results of a BLM study of Kuskokwim River, Red Devil Creek, and other tributaries to the Kuskokwim River near the RDM site, which included collection and analysis of forage fish (e.g., slimy sculpin [whole fish samples]) for site-related chemicals (BLM 2012). The resulting sculpin whole-fish tissue data from Red Devil Creek were used in the HHRA to estimate concentrations of COPCs in game fish consumed by receptors. For methylmercury, an FCM of three was assumed to account for biomagnification (i.e., the game fish concentration of methylmercury is set equal to three times the concentration in sculpin). For inorganic mercury and other metals, an FCM of one was assumed. It was assumed that the game fish of interest—Dolly Varden, sheefish, round whitefish, whitefish (other), burbot, grayling, and Northern pike—are one trophic level above the slimy sculpin, except for grayling, which feed at a slightly lower trophic level than sculpin. This is a health-protective assumption. Further, because sculpin are more resident than the fish taken from the Kuskokwim River, using the Red Devil Creek sculpin data to estimate game fish concentrations in the Kuskokwim River likely overestimates the true concentrations of fish that people are catching and consuming from the Kuskokwim River.

To improve the understanding of fish residence in the Kuskokwim River and tributaries, BLM (2012) conducted fish movement studies on northern pike and burbot. Preliminary results of the telemetric studies show that movements can be highly variable and difficult to predict for a given river system. Based on the BLM fish study data, sedentary fish (slimy sculpin, juvenile Dolly Varden, and juvenile Arctic grayling) and insects from Red Devil Creek and Cinnabar Creek had significantly greater mercury concentrations than the same fish in other tributaries. Northern pike, burbot (lush), and Arctic grayling collected in the rivers sampled had variable mercury levels across the area. Northern pike from the George River had significantly higher mercury concentrations compared to other pike. There were no spatial differences in mercury concentrations in sheefish (BLM 2012).

To evaluate the uncertainties identified above, contaminant concentrations in fish estimated using the FCM approach and Red Devil Creek sculpin data were compared to measured concentrations of antimony, arsenic, and mercury in muscle and liver tissue from northern pike collected by BLM (2012) from the section of the Kuskokwim near Red Devil Creek (Reach C). The measured concentrations of antimony, arsenic, and mercury in northern pike were significantly lower than the concentrations modeled from the sculpin from Red Devil Creek. For example, the 95-percent upper confidence limit (UCL) of measured arsenic in northern pike muscle is 0.626 milligrams per kilogram (mg/kg)-wet, compared to the modeled concentration of 12.98 mg/kg.

To evaluate the impact of assuming that all wild food is harvested from the site, an alternative approach was evaluated in which food intake rates are based instead on data obtained from the Alaska Department of Fish and Game survey of residents of Red Devil Village (Brown et al. 2012).

Using measured arsenic fish concentrations in northern pike (assuming 10 percent of the arsenic is in the inorganic form) and the alternative food intake assumptions, the excess lifetime cancer risk (ELCR) from ingestion of game fish is 6 x 10^{-5} for a recreational/subsistence user or residents in all exposure units, which is several orders of magnitude lower than the ELCR used in the risk assessment.

Ongoing analysis of fish movement study data is expected to further inform discussions about the transfer of mercury, arsenic, and antimony, their various chemical forms, and other trace elements within the middle Kuskokwim River region from cinnabar deposits, Red Devil, and other abandoned mines (BLM 2012).

2.1.4.2 Baseline Ecological Risk Assessment – Sediment

The baseline ecological risk assessment for the RDM site considered vegetation, soil invertebrates, terrestrial and aquatic wildlife, and aquatic biota (e.g., aquatic plants, amphibians, benthos, and fish) in Red Devil Creek and the Kuskokwim River. Four measures or assessment methods were used to evaluate potential risk to the benthic macroinvertebrate community in Red Devil Creek: (1) comparing sediment chemical concentrations to sediment screening levels; (2) benthic community composition in Red Devil Creek compared with nearby reference creeks (BLM 2012); (3) comparing contaminant concentrations in benthic macroinvertebrate composite samples from Red Devil Creek with tissue screening concentrations; and (4) comparing chemical concentrations in surface water with chronic water quality criteria for protection of freshwater aquatic life.
The results of the evaluation are summarized below:

- Measure 1 – Nine contaminants were predicted to be COCs for the benthic community based on comparing sediment contaminant concentrations with screening levels. However, confidence in the COC list and potential risks based on this assessment method is considered low because site-specific bioavailability is not considered.

- Measure 2 – The benthic survey conducted in Red Devil Creek identified no adverse impacts to abundance and diversity of benthic macroinvertebrates in Red Devil Creek compared with nearby reference creeks. The site-specific survey is considered to be a more reliable assessment method and suggests no impacts to the benthic community from site-related contaminants.

- Measure 3 – Comparing contaminant levels in macroinvertebrate tissues samples with critical tissue concentrations identified only a marginal potential risk from methylmercury. This measure also is considered superior to measure 1 because it considers site-specific bioavailability and bioaccumulation.

- Measure 4 – Comparing contaminant levels in surface water from Red Devil Creek and the seep on the bank of the creek identified five COCs for benthic macroinvertebrates and other aquatic biota. The greatest risks were for antimony, arsenic, and mercury in seep water discharging to the creek. Reliability in this assessment method is better than for measure 1, but not as good as measures 2 and 3 because site-specific bioavailability is not considered.

Although adequate data were available to use measures 1 to 4 to evaluate the benthic community in Red Devil Creek, only measure 1 could be used in the Kuskokwim River. No benthic survey data, benthic macroinvertebrate tissue data, or surface-water data were collected from the Kuskokwim River during the RI. Hence, potential risks to the benthic community in the Kuskokwim River are not well understood.

2.2 Red Devil Mine Feasibility Study

An FS for the RDM is under development. The purpose of the FS is to present remedial action objectives (RAOs) and remedial alternatives to address contamination characterized as part of the RI and documented in the RI report. The draft final FS report (E & E 2014b) is based on site characterization information presented in the RDM RI report (E & E 2013). In the draft final FS report, RAOs and remedial goals (RGs) have been identified for the following media of concern at the RDM: tailings/waste rock, contaminated soil, and contaminated Red Devil Creek sediment. Groundwater and Kuskokwim River sediment are not addressed in the FS. Information on the media pertinent to the planned supplemental RI activities is presented below.

2.2.1 Soil

Soil with total concentrations of antimony, arsenic, and/or mercury—the primary soil COCs at RDM—exceeding the soil RGs is targeted for remedial action. This encompasses all surface and subsurface soil containing tailings/waste rock and flotation tailings within the Main Processing Area and the Red Devil Creek Downstream Alluvial Area and Delta. It also includes sediment within Red Devil Creek that contains tailings/waste rock, some native soil beneath tailings/waste rock, and some surface soil in or adjacent to the Main Processing Area. The RGs for antimony, arsenic, and mercury were set at the background values based on RI data.

In general, estimated depths of soil targeted for remedial action are based on the soil boring data presented in the RI. Throughout most of the Main Processing Area, tailings/waste rock was identified in soil borings to varying depths. The tailings/waste rock material in the Main Processing Area is targeted for remedial action. Underlying native soils with concentrations of one or more or the primary COCs exceeding RGs also were identified.

As noted in the final RI report and Section 2.1.1 above, the depths below the base of tailings/waste rock of soil with concentrations exceeding background soil concentrations, and thus RGs, are not known at some soil boring locations. For the purposes of the FS, where the depth of exceedance of RGs is not fully defined by the RI data, the depth of RG exceedance was estimated by extrapolating below the depth of the soil boring.

2.2.2 Groundwater

As stated in the draft final FS report, it is anticipated that future active remediation of tailings/waste rock in the Main Processing Area will reduce contaminant loading to groundwater. It is possible that the NTCRA (see Section 2.3) addressing Red Devil Creek sediment may have affected groundwater flow paths, groundwater-surface water interactions, and contaminant concentrations and loading in part of the Main Processing Area.

The BLM plans to further characterize groundwater before site-wide remedial decision making is completed. The supplemental RI activities are intended to support site-wide remedial decision making.

2.2.3 Surface Water

As stated in the draft final FS report, it is anticipated that future active remediation of tailings/waste rock in the Main Processing Area will reduce contaminant loading to groundwater. Such reductions to groundwater loading would be expected to also reduce contaminant concentrations and loading to surface water. It is possible that the NTCRA (see Section 2.3) addressing Red Devil Creek sediment may have affected groundwater flow paths, groundwater-surface water interactions, and contaminant concentrations and loading in part of the Main Processing Area. Active remedies for Red Devil Creek surface water have not been developed, and RAOs, RGs, and general response actions for Red Devil Creek surface water are not presented in the FS.

2.2.4 Kuskokwim River Sediment

As stated in the draft final FS report, it is anticipated that future active remediation of tailings/waste rock in the Main Processing Area will reduce contaminant loading to the Kuskokwim River. The BLM plans to further characterize Kuskokwim River sediment before site-wide remedial decision making is completed. The supplemental RI activities are intended to support site-wide remedial decision making.

2.3 Non-Time-Critical Removal Action

The RI results indicated that tailings/waste rock located in the Main Processing Area were subject to active erosion along Red Devil Creek and transport to the Kuskokwim River. An Engineering Evaluation/Cost Analysis was prepared by E & E on behalf of the BLM to evaluate removal action alternatives intended to address this erosion and transport (E & E 2014c). The BLM issued a removal action memorandum (BLM 2014a) for an NTCRA at the RDM site in June 2014. As of the date of publication of this work plan supplement, a post-construction report detailing construction activities is not available. Details of the proposed construction activities, as provided in the removal action memorandum, are summarized below.

- Approximately 5,000 cubic yards of tailings and sediment would be excavated along the south side of Red Devil Creek and transported to a designated temporary storage area on site.

- A section of Red Devil Creek would be realigned and a sediment trap constructed downstream of the tailings piles. Depths and distances for excavation would be based on sampling results provided in the draft final RI report and observed geologic characteristics in the vicinity of Red Devil Creek.

- The excavation would extend along Red Devil Creek for approximately 200 feet within the Main Processing Area, limited to the south side of the stream, beginning at the existing centerline of Red Devil Creek below the processing area and proceeding in a straight upstream direction, realigning the creek and maintaining its natural gradient. The excavation would then terminate upstream of the processing area and rejoin the existing creek.

- The excavation would be 12 feet wide at the bottom and extend up at a 3:1 slope (horizontal to vertical) on the south side.

- The realigned channel sidewalls would be lined on each side with 3-foot gabion baskets to maintain the constructed alignment.

- A vertical gabion drop structure would be installed just upstream of the excavated area to act as a transition between the gradient of the excavated channel and the longitudinal gradient in the upstream section of Red Devil Creek.

- A sediment trap would be installed downstream of the realigned channel, immediately upstream of an existing bridge near the mouth of Red Devil Creek. This sediment trap would be sized to allow settling of medium-sized sand (0.50 millimeter) and greater, but would not allow re-suspension of material.

- Standard construction equipment would be used to remove sediment and load the material for transport to a temporary stockpile.

- Side slopes of the temporary stockpile would have a maximum slope of 2:1 (horizontal to vertical). To minimize stormwater infiltration into the sediment stockpile and prevent mobilization of fugitive dust, the stockpile would be covered with a 12-millimeter, ultraviolet-resistant, reinforced polyethylene geomembrane liner with tear-resistant polyester scrim. A soil or vegetation cover would not be required as the stockpile is anticipated to be temporary.

- Erosion and sediment control measures would be installed in the vicinity of the stockpiles as needed to prevent erosion of the excavated sediment.

- Restoration of the stream in the area of excavation would not be part of the proposed action.

- Upon completion of the excavation, the stream would be directed into the realigned channel and then allowed to flow through the current channel downstream of the Main Processing Area before entering the sediment trap.

The BLM performed NTCRA construction during the summer of 2014. The NTCRA activities locally modified the conditions at the RDM that existed at the time of the RI field activities.

Based on the elements identified in the removal action memorandum and post-construction as-built survey data (Marsh Creek 2014), the following key site physical characteristics have been modified:

- Distribution of tailings/waste rock in part of the Main Processing Area, including an area where tailings/waste rock have been shown to be immersed in groundwater.

- Topographic modifications, including removal and stockpiling of excavated material and regrading.

- Alignment and gradient of Red Devil Creek.

- Nature of substrate and banks of Red Devil Creek.

- Decommissioning of RI monitoring wells MW14, MW15, MW16, and MW17.

- Elimination of RI surface water monitoring stations RD04 and RD07.

Figures 2-3 and 2-4 illustrate the pre-NTCRA topography and Red Devil Creek stream alignment, as well as locations of RI soil borings, monitoring wells, and surface water monitoring stations. Figure 2-5 illustrates the post-NTCRA topography, stream alignment, and RI monitoring well and surface water monitoring locations.

The physical modifications of the site are expected to result in changes to the groundwater and surface water flow paths and interactions and consequently, groundwater and surface water concentrations and loading of inorganic elements.

2.4 Middle Kuskokwim River Investigations

Beginning in 2010, BLM began a study to comprehensively examine mercury, methylmercury, and other metals in the Kuskokwim River basin in proximity to the Red Devil Mine (BLM 2010). Specific objectives of the study were to:

- Estimate levels of metal bioaccumulation within components of the aquatic food web;

- Evaluate macroinvertebrate diversity within several watersheds using a variety of metrics to determine the level of variance between reference and test watersheds; and

- Work with local residents in Stony River, Crooked Creek, and Sleetmute to identify locations of subsistence harvest on the Kuskokwim River within the project area.

The results of this work were published in a several reports prepared by BLM with support from the U.S. Fish and Wildlife Service (USFWS), including:

- *Mercury, Arsenic, and Antimony in Aquatic Biota from the Middle Kuskokwim River Region, Alaska 2010–2011* (USFWS 2012); and

- *Quantification of Fish and Aquatic Insect Tissue Contaminants in the Middle Kuskokwim River, Alaska* (BLM 2012).

As a follow-up to this work, in 2012 and 2013, BLM undertook fish movement studies on northern pike and burbot, and analysis of watershed mercury methylation potential. As indicated in Section 2.1.4, results of this study are expected to provide important information regarding potential impacts of RDM contamination on fish harvested for consumption from the Kuskokwim River.

In 2014, BLM implemented a study to collect additional data that may be used to assess RDM-related impacts on Red Devil Creek and the Kuskokwim River near the RDM. Objectives of the 2014 study are presented in the *Field Operations Plan – 2014, Quantification of Fish and Aquatic Insect Tissue Contaminants in the Middle Kuskokwim River, Alaska* (BLM 2014b) and are summarized below:

- Collect additional data for mercury in slimy sculpin from Red Devil Creek.

- Determine concentrations of mercury in periphyton and/or macroinvertebrates in the near-shore environment of the Kuskokwim River near the RDM.

- Determine if macroinvertebrate assemblages vary upstream and downstream of Red Devil Creek in the Kuskokwim River based on various biotic indices.

Preliminary information regarding the field activities indicates that the attempts to collect periphyton samples were successful, but collection of benthic macroinvertebrates in the Kuskokwim River near the RDM was not successful. Based on visual observations by the BLM biologists at the time of the sampling event, it was decided to not attempt to collect benthic macroinvertebrates because of highly turbid conditions.

2.5 Data Gaps

As indicated above, during the development of the FS, data gaps were identified for several site media. In addition, the NTCRA is expected to have modified site conditions. Key results of the various studies and site activities, including findings pertinent to these data gaps, are presented in the sections above. In addition to the identified data gaps, the BLM plans to continue performing baseline groundwater and surface water monitoring at the site.

Data gaps and baseline groundwater and surface water monitoring to be addressed as part of the supplemental RI activities are discussed below. The approach to address the data gaps is presented in Chapter 3.

2.5.1 Soil

The following data gaps pertaining to soil will be addressed as part of the supplemental RI activities:

1) In parts of the Main Processing Area and Red Devil Creek Area, the depths and total inorganic element concentrations of soil below tailings/waste rock are not well understood.
2) In parts of the Main Processing Area and Red Devil Creek Area, one or more of the following subsurface conditions are not well understood: thickness of tailings/waste rock; lithology, thickness, and inorganic element concentrations of underlying soil/alluvium; depth to bedrock; and depth of the saturated zone(s).
3) Naturally mineralized soil and bedrock likely underlie parts of the Main Processing Area and Red Devil Creek Area that contain tailings/waste rock and contaminated soil that are subject to remediation. The locations and nature of such materials are not well understood.
4) Subsurface conditions in the Surface Mined Area, including thickness of soils and depth of bedrock, presence and thickness of any saturated intervals, and presence of natural mineralization are not well understood.

2.5.2 Groundwater

The following data gaps pertaining to groundwater will be addressed as part of the supplemental RI activities:

1) The impacts of naturally mineralized bedrock and underground mine workings on groundwater flow paths and inorganic element concentrations in the Surface Mined Area are not well characterized.
2) The impacts of the physical modifications of the site, due to the NTCRA, on groundwater and surface water flow paths and interactions, and consequently, on groundwater inorganic element concentrations, are not known.

3) RI monitoring wells were decommissioned as part of the NTCRA. New wells are necessary to provide ongoing groundwater monitoring data formerly available using these wells.
4) Additional multi-year baseline monitoring of groundwater conditions (including depth, hydraulic gradient, and concentrations of inorganic elements) is needed.
5) The extent of organic compounds in groundwater has not been fully delineated.

2.5.3 Surface Water

The following data gaps pertaining to surface water will be addressed as part of the supplemental RI activities:

1) The impacts of naturally mineralized bedrock and underground mine workings in the Surface Mined Area on groundwater flow paths and inorganic element concentrations, and consequently on surface water concentrations and loading in the Main Processing Area, are not well characterized.
2) The impacts of the physical modifications of the site, due to the NTCRA, on groundwater and surface water flow paths and interactions, and consequently, on surface water inorganic element concentrations and loading, are not known.
3) Additional multi-year baseline monitoring of surface water conditions (including flow rates and concentrations and loading of inorganic elements) is needed.

2.5.4 Kuskokwim River Sediment

The following data gaps pertaining to Kuskokwim River sediment will be addressed as part of the supplemental RI activities:

1) The potential toxicity of contaminated Kuskokwim River sediments is not known.
2) The downriver and cross-river extents of contamination of Kuskokwim River sediment have not been delineated.
3) The turbidity of Kuskokwim River water has not been measured.

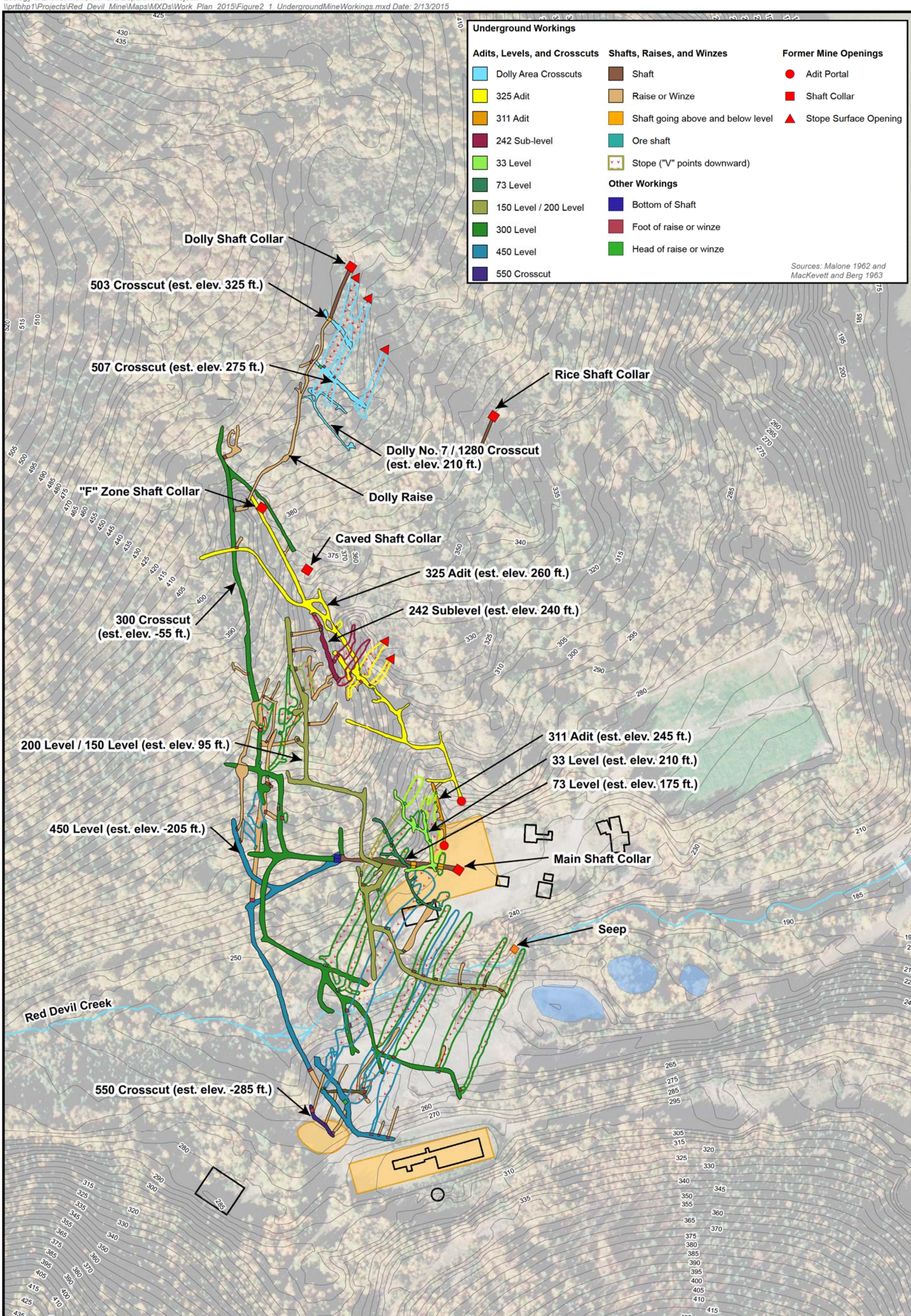
Table 2-1 Elevations of Underground Mine Workings

Underground Mine Feature	Approximate Elevation (feet above Mean Sea Level, NAVD88)
503 Crosscut	325
507 Crosscut	275
Dolly No. 7 Crosscut / 1280 Crosscut	210
325 Adit	260
242 Sublevel	240
311 Adit	245
33 Level	210
73 Level	175
150 Level / 200 Level	95
300 Level	-55
450 Level	-205
550 Crosscut	-285
600 Level	-355

Key:

NAVD88 = North American Vertical Datum 1988

Ecology & Environment, Inc. GIS Department Project:
\\prtbhp1\Projects\Red_Devil_Mine\Maps\MXDs\Work_Plan_2015\Figure2_1_UndergroundMineWorkings.mxd Date: 2/13/2015



2010 5-foot Contour
Red Devil Creek
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE

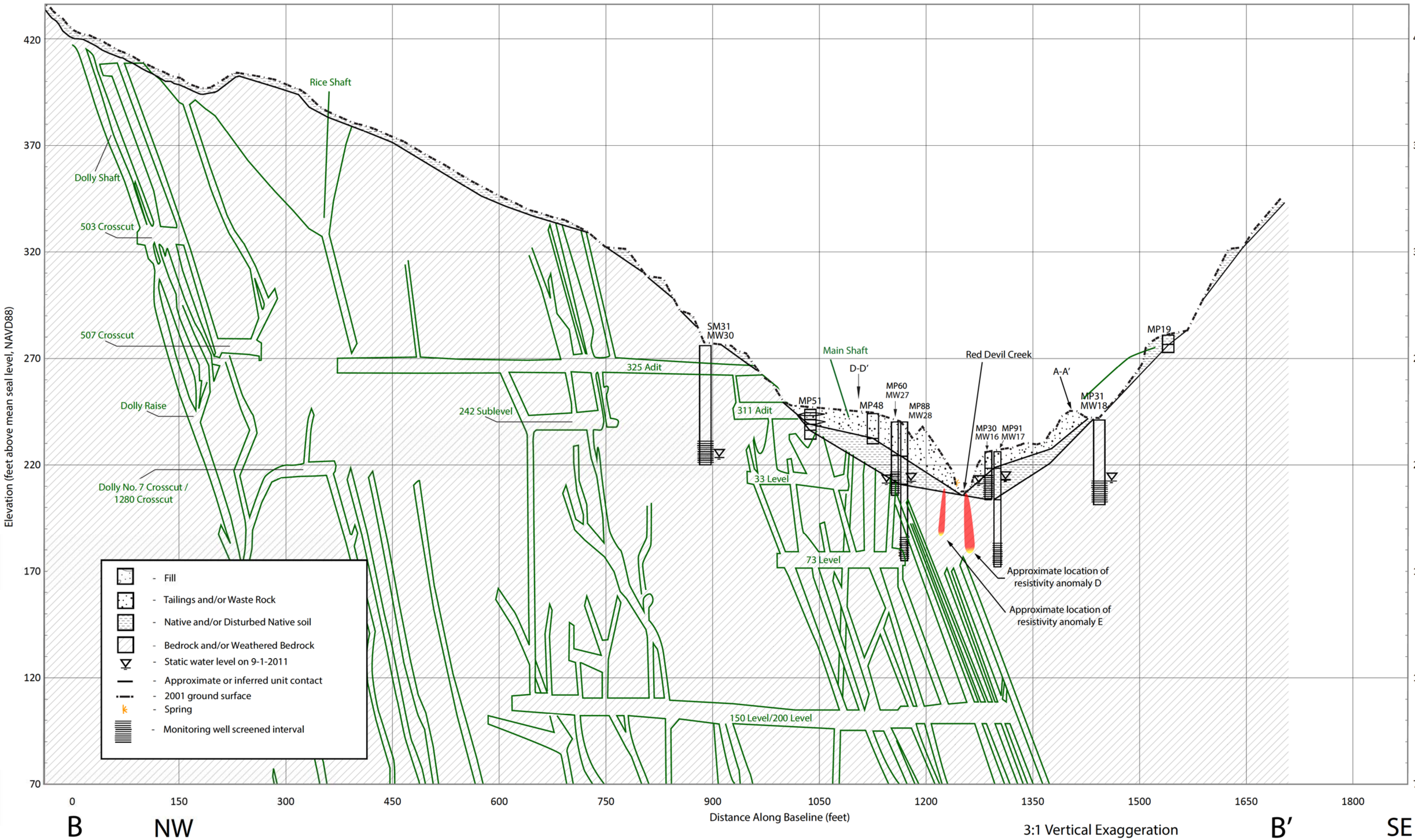
Red Devil, Alaska

Figure 2-1
Underground Mine Workings Map

0 37.5 75 150 225 300
Feet
0 10 20 40 60 80 100
Meters
Scale 1:2,000

Digital aerial orthophotograph taken on September 21, 2010 (AeroMetric 2010)

Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on September 21, 2010 (AeroMetric 2012)

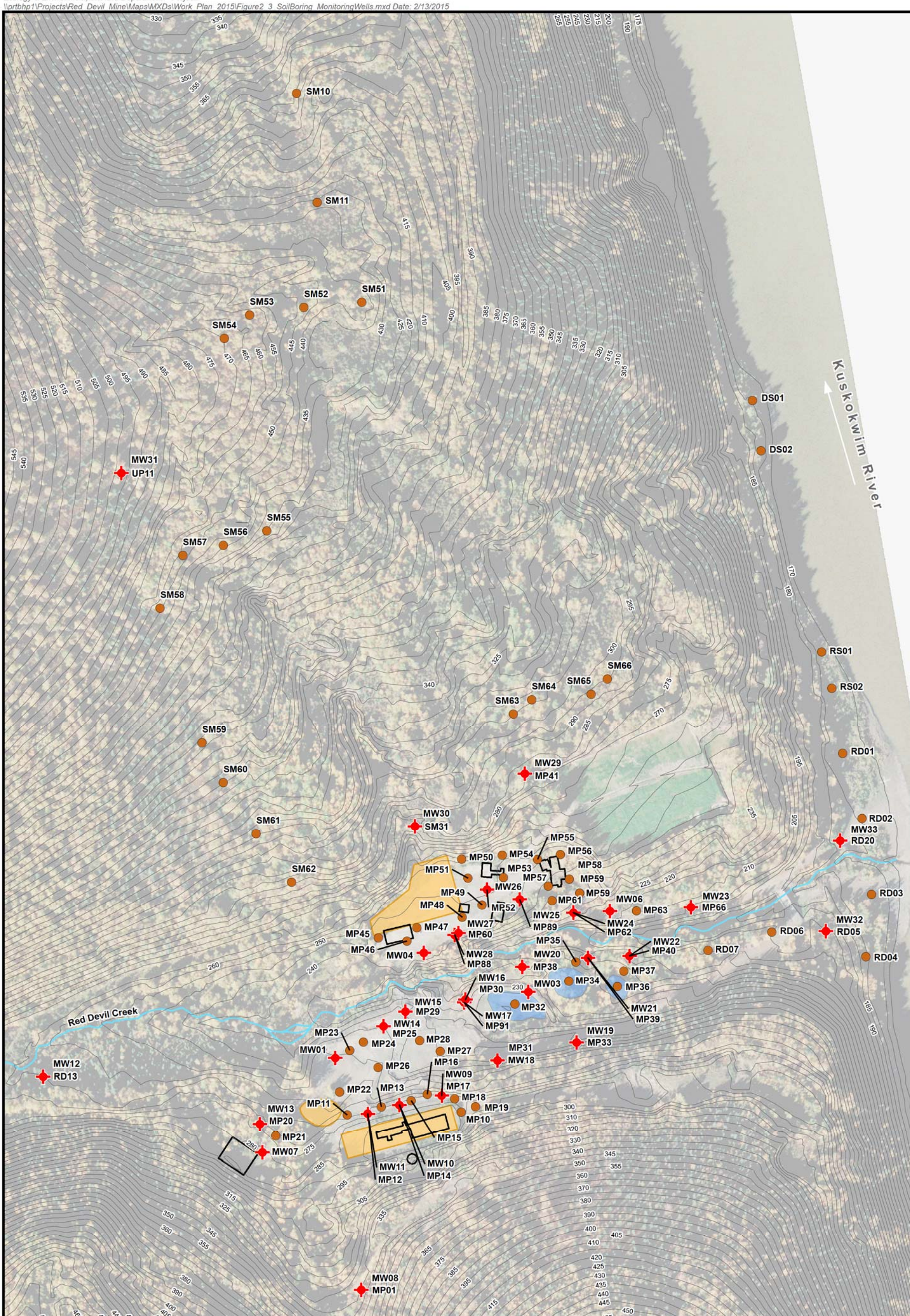


Notes: 1) Surface topography based on 5/27/2001 aerial photograph and topographic map (Aero-Metric, Inc. 2010)
2) Mine workings projected onto geological cross section based on March 1962 longitudinal projection (Alaska Mines and Minerals, Inc. and Decoursey Mountain Mining Co., Inc., 1962)
3) Approximate resistivity anomaly locations based on USGS (2011)

RED DEVIL MINE
Red Devil, Alaska

Figure 2-2
Geologic Cross Section and Underground Mine Workings

02:001095.0002.01



- Monitoring Well ID / Soil Boring ID
- Soil Boring
- 2010 5-foot Contour
- Red Devil Creek
- Settling Pond
- Monofill
- Historical Structure

RED DEVIL MINE

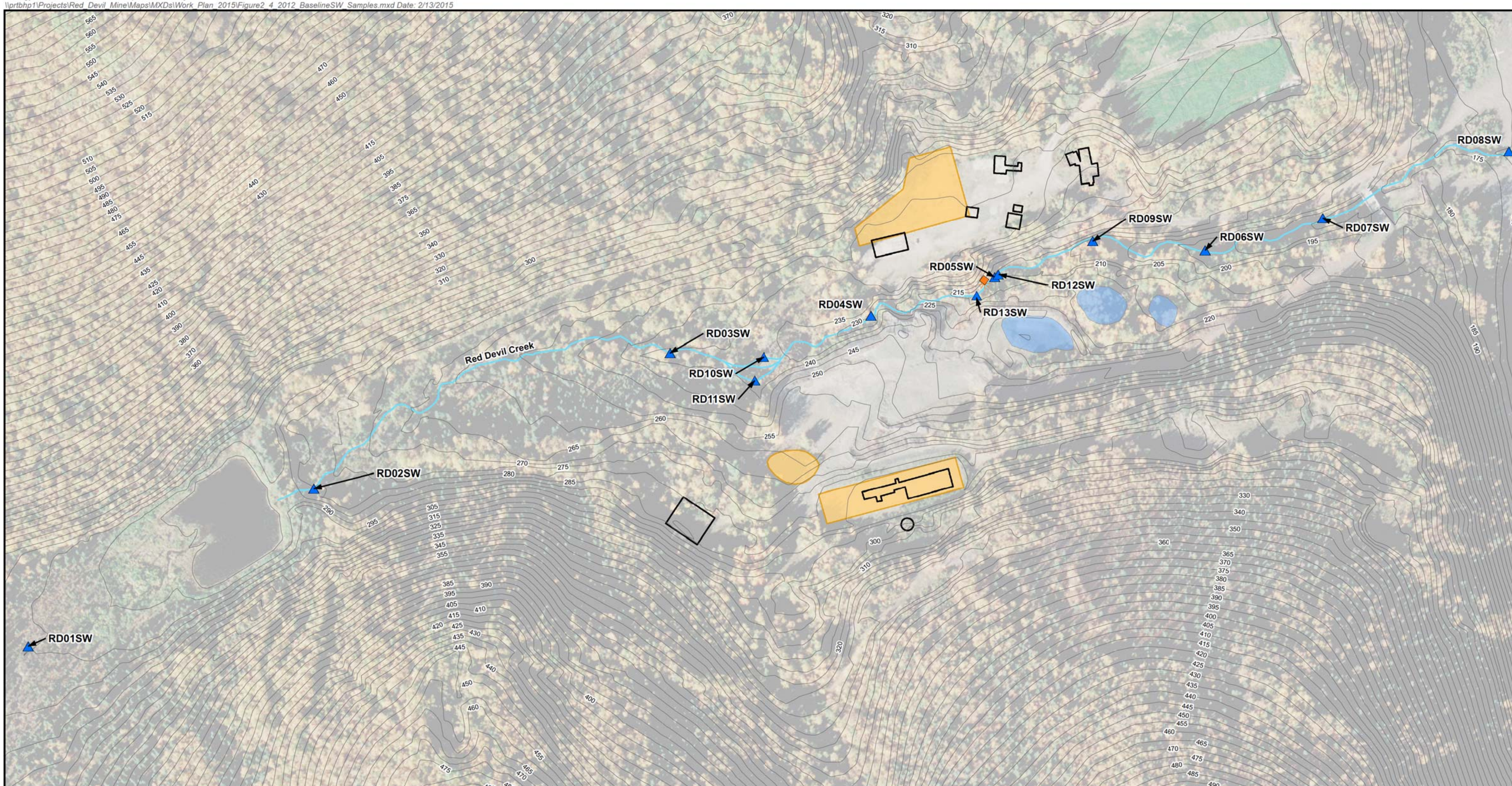
Red Devil, Alaska

Figure 2-3
RI Soil Boring and Monitoring Well Locations

0 50 100 200 300 400
Feet
0 12.5 25 50 75 100 125
Meters
Scale 1:2,500

Digital aerial orthophotograph taken on September 21, 2010 (AeroMetric 2010)

Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on September 21, 2010 (AeroMetric 2012)



Surface Water Sample Location
Seep Location
2010 5-foot Contour
Red Devil Creek
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE

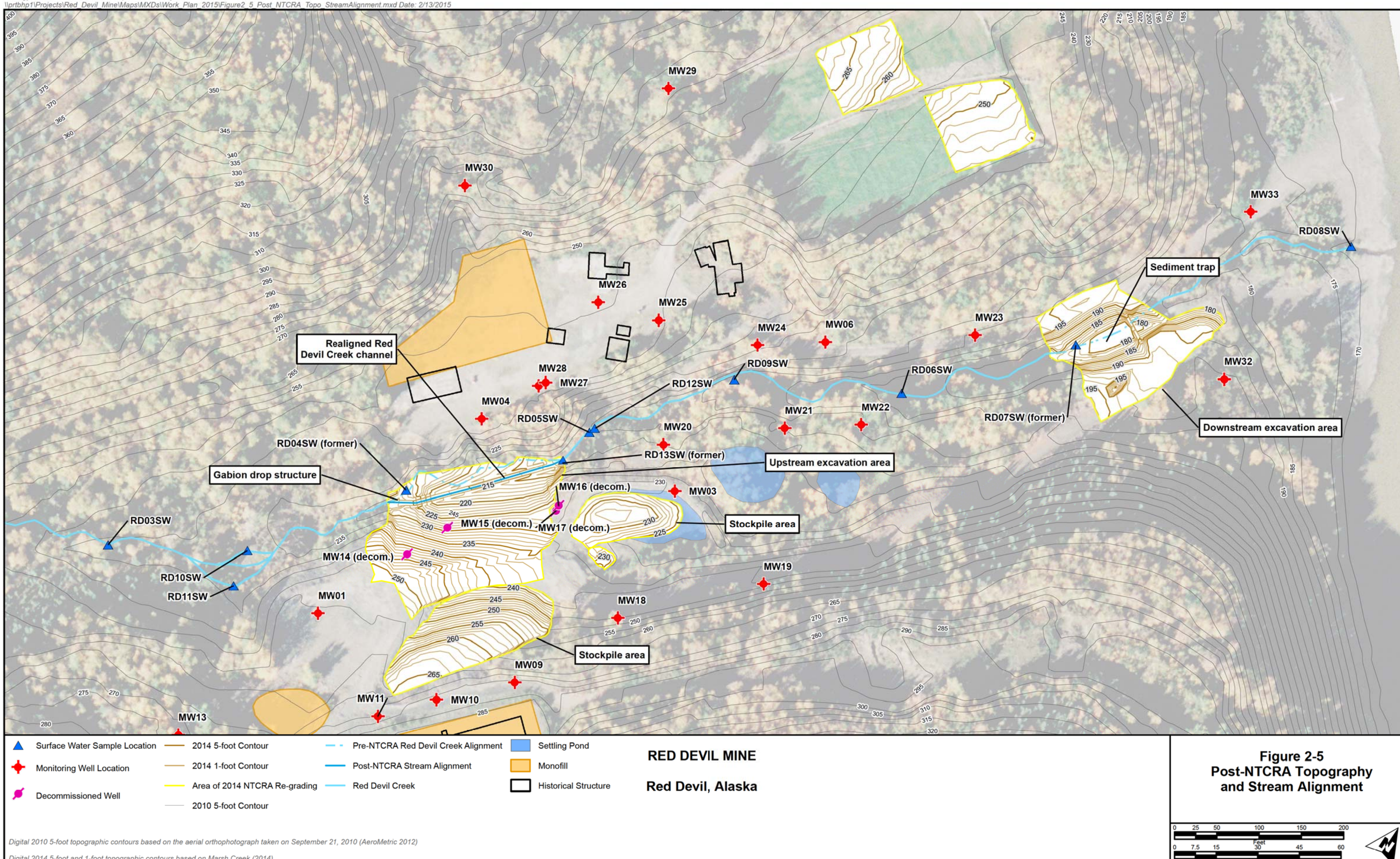
Red Devil, Alaska

Figure 2-4
RI and 2012 Baseline
Surface Water Sample Locations

0 37.5 75 150 225 300 Feet
0 12.5 25 50 75 100 Meters
Scale: 1:2,000

Digital aerial orthophotograph taken on September 21, 2010 (AeroMetric 2010)

Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on September 21, 2010 (AeroMetric 2012)



RED DEVIL MINE

Red Devil, Alaska

Figure 2-5
Post-NTCRA Topography and Stream Alignment

Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on September 21, 2010 (AeroMetric 2012)

Digital 2014 5-foot and 1-foot topographic contours based on Marsh Creek (2014)

3 Data Quality Objectives

The DQO process specifies project decisions, the data quality required to support those decisions, specific data types needed, and data collection requirements. It also ensures that analytical techniques used will generate the specified data quality (U.S. Environmental Protection Agency [EPA] 2000) and that the resources required to generate the data are justified. The DQO process consists of seven steps. The output from each step influences the choices that will be made later in the process.

The DQO steps are as follows.

1. State the problem.
2. Identify the decision.
3. Identify the inputs to the decision.
4. Define the study boundaries.
5. Develop a decision rule.
6. Specify tolerable limits on decision errors.
7. Optimize the design.

During the first six steps of the process, the planning team develops decision performance criteria (that is, the DQOs) that will be used to develop the data collection design. The final step involves refining the data collection design based on the DQOs. A discussion of these steps and their application to the supplemental Kuskokwim River sediment characterization is provided below.

3.1 Step 1: State the Problem

The key problem statements for the supplemental RI activities for soil groundwater, surface water, and Kuskokwim River sediment are presented below.

Soil

1) In parts of the Main Processing Area and Red Devil Creek Area, soil is locally impacted by migration of inorganic elements from tailings/waste rock. The depths and inorganic element concentrations of such impacted soils are not known well enough to fully inform risk management decisions.
2) In parts of the Main Processing Area and Red Devil Creek Area, one or more of the following subsurface conditions are not well understood: thickness of tailings/waste rock; lithology and mineralogy, thickness, and

inorganic element concentrations of underlying soil/alluvium; depth to bedrock; and depth of the saturated zone(s).

3) Although natural mineralization is known to have affected rock and soil present at the site, the presence, locations/depths, and nature of such naturally mineralized materials in soils in the Main Processing Area and Red Devil Creek Area are not understood well enough to support risk management decisions pertaining to soil.
4) In parts of the Surface Mined Area, the following subsurface conditions are not well understood: thickness of soils and depth of bedrock; presence and thickness of any saturated intervals; presence of natural mineralization; and concentrations of inorganic elements.

Groundwater

1) Although flow of groundwater through naturally mineralized soil and bedrock and associated underground mine workings is understood to affect concentrations of inorganic elements in groundwater, the impacts of such processes are not understood well enough to inform risk management decisions.
2) The impacts of the physical modifications of the site, due to the NTCRA, on groundwater and surface water flow paths and interactions, and consequently, on groundwater inorganic element concentrations, are not understood well enough to support future risk management decisions.
3) RI monitoring wells were decommissioned as part of the NTCRA. New wells are necessary to provide ongoing groundwater monitoring data formerly available using these wells.
4) Additional multi-year baseline monitoring of groundwater conditions (including depth, hydraulic gradient, and concentrations of inorganic elements) is needed.
5) The extent of organic compounds in groundwater has not been fully delineated.

Surface Water

1) Although naturally mineralized bedrock and underground mine workings in the Surface Mined Area impact groundwater flow paths and inorganic element concentrations, and consequently, surface water concentrations and loading in the Main Processing Area, these impacts are not characterized well enough to support risk management decisions.
2) The impacts of the physical modifications of the site, due to the NTCRA, on groundwater and surface water flow paths and interactions, and consequently, on surface water loading and inorganic element concentrations, are not known.
3) Additional multi-year baseline monitoring of surface water conditions (including flow rates and concentrations and loading of inorganic elements) is needed.

Kuskokwim River Sediment

1) The potential toxicity of contaminated Kuskokwim River sediments is not known.
2) The downriver and cross-river extents of contamination of Kuskokwim River sediment have not been delineated.
3) The turbidity of Kuskokwim River water has not been measured.

3.2 Step 2: Identify the Decision

To accomplish the objectives of the supplemental RI activities, key study questions (data gaps) are presented below for soil groundwater, surface water, and Kuskokwim River sediment.

Soil

The supplemental RI soil characterization addresses the following study questions:

1) In the Main Processing Area and Red Devil Creek Area, what are the depths and inorganic element concentrations of contamination due to deposition of inorganic elements leached from tailings/waste rock?
2) What are the subsurface conditions in parts of the Main Processing Area and Red Devil Creek Area containing tailings/waste rock for the following characteristics: thickness of tailings/waste rock; lithology and mineralogy, thickness, and inorganic element concentrations soil/alluvium; depth to bedrock; and depth of the saturated zone(s)?
3) Are soil and bedrock in parts of the Main Processing Area and Red Devil Creek Area affected by natural mineralization? If so, what are the locations and nature of such materials?
4) What are the subsurface conditions in the parts of the Surface Mined Area for the following characteristics: thickness of soils/depth to bedrock; presence and thickness of any saturated intervals; presence of natural mineralization; and concentrations of inorganic elements?

Groundwater

The supplemental RI groundwater characterization addresses the following study questions:

1) What are the groundwater flow patterns and groundwater quality (including inorganic element concentrations) in parts of the Surface Mined Area potentially impacted by naturally mineralized bedrock and mine workings?
2) What are the groundwater and surface water flow paths and interactions, and groundwater concentrations of inorganic elements in the area affected by the NTCRA?
3) What are the groundwater conditions in the part of the Main Processing Area near the former monitoring wells that were decommissioned as part of the NTCRA?

4) What is the temporal variability (e.g., seasonal and annual) of groundwater conditions (including depth, hydraulic gradient, and concentrations of inorganic elements) at the site?
5) What are the concentrations of organic compounds in groundwater in parts of the site?

Surface Water
The supplemental RI surface water characterization addresses the following study questions:

1) What is the quality of surface water (including concentration of inorganic elements) at the site, including surface water impacted by flow of groundwater that is impacted by naturally mineralized bedrock and underground mine workings in the Surface Mined Area?
2) What are the groundwater and surface water flow paths and interactions, and surface water quality (including concentrations and loading of inorganic elements) and flow rates in the area affected by the NTCRA?
3) What is the temporal variability (e.g., seasonal and annual) of surface water conditions (including flow rates and concentrations and loading of inorganic elements) at the site?

Kuskokwim River Sediment
The supplemental RI Kuskokwim river sediment characterization addresses the following study questions:
1) What is the potential toxicity of contaminated Kuskokwim River sediments?
2) What are the downriver and cross-river extents of contamination of Kuskokwim River sediment?
3) What is the turbidity of water in the Kuskokwim River?

3.3 Step 3: Identify the Inputs to the Decision
This section identifies the types of information needed to support resolution of the decisions. The specific types of information needed to address the decisions for soil groundwater, surface water, and Kuskokwim River sediment are presented below.

Soil
1) To address the lack of information in parts of the Main Processing Area and Red Devil Creek Area on depths of contamination and concentrations of inorganic elements in soil below tailings/waste rock that are impacted by deposition of inorganic elements leached from tailings/waste rock, the following types of additional information will be needed:
    a. Subsurface soil lithological, mineralogical, and total inorganic elements concentration data from additional subsurface soil sampling in soil borings to be installed in the Main Processing Area.

2) To address the lack of information in parts of the Main Processing Area and Red Devil Creek Area on subsurface conditions, the following types of additional information will be needed:
    a. Physical and chemical data for soil and bedrock sampled during installation of new soil borings, including: thickness of tailings/waste rock; lithological and mineralogical observations; concentrations of total inorganic elements of soil/alluvium underlying tailings/waste rock; thickness of various soil types; depth to bedrock; and presence, depth, and thickness of saturated interval(s).
3) To assess possible natural mineralization in the Main Processing Area and Red Devil Creek Area, the following types of additional information will be needed:
    a. Physical and chemical data for subsurface soil and bedrock sampled during installation of new soil borings including: lithological and mineralogical observations; total inorganic element concentrations; and results of mercury SSE analyses.
4) To address the lack of information on subsurface conditions in the Surface Mined Area, the following types of additional information will be needed:
    a. Physical and chemical data for subsurface soil and bedrock sampled during installation of new soil borings including: lithological and mineralogical observations; observations on the presence and depths of saturated intervals; and total inorganic element concentrations.

Groundwater

1) To address the lack of information on groundwater flow patterns and groundwater inorganic element concentrations in parts of the Surface Mined Area potentially impacted by naturally mineralized bedrock and mine workings, the following types of additional data will be needed:
    a. Information on soil and bedrock characteristics to be collected during installation and sampling of new monitoring wells in the Surface Mined Area (see Soil Item 4 above).
    b. Information on groundwater occurrence and depth to be collected during installation of new monitoring wells and static water level measurements in new and existing wells in the Surface Mined Area.
    c. Information on groundwater quality to be obtained by sampling groundwater from new and existing monitoring wells in the Surface Mined Area. Groundwater quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and mercury; dissolved mercury; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).

   d. Information on groundwater-surface water interactions in the Main Processing Area, and surface water discharge, and surface water quality (see Surface Water Item 1 below).

2) To address the lack of information on the groundwater and surface water flow paths and interactions and groundwater quality in the area affected by the NTCRA, the following types of additional data will be needed:
   a. Information on groundwater occurrence and depth to be collected during installation of new monitoring wells and static water level measurements in new and existing wells in the Main Processing Area.
   b. Information on groundwater quality to be obtained by sampling groundwater from new and existing monitoring wells in the Surface Mined Area. Groundwater quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and mercury; dissolved mercury; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).
3) To address the elimination of former RI monitoring wells that were decommissioned as part of the NTCRA, new monitoring wells will be installed in the Main Processing Area.
4) To address the lack of information on the temporal variability (e.g., seasonal and annual) of groundwater conditions at the site, the following types of additional baseline groundwater monitoring data will be needed for two baseline monitoring events planned for 2015:
   a. Information on groundwater depth to be collected during static water level measurements in new and existing wells at the site.
   b. Information on groundwater quality to be obtained by sampling groundwater from new and selected existing monitoring wells at the site. Groundwater quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and mercury; dissolved mercury; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).
5) To address the lack of information regarding organic compounds in groundwater, the following additional types of data will be needed:
   a. Groundwater sample analyses for SVOCs, DRO, GRO, and BTEX from selected monitoring wells.

Surface Water

1) To address the lack of information on the quality of surface water at the site, including surface water impacted by flow of groundwater that is impacted by naturally mineralized bedrock and underground mine workings in the Surface Mined Area, the following additional data will be needed:

a. Information on surface water discharge at locations along Red Devil Creek.
b. Information on surface water quality at locations along Red Devil Creek. Surface water quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and mercury; dissolved TAL metals and mercury; total organic carbon (TOC); TSS; TDS; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).

2) To address the lack of information on the groundwater and surface water flow paths and interactions and surface water quality in the area affected by the NTCRA, the following types of additional data will be needed:
   a. Information on surface water discharge at locations along Red Devil Creek.
   b. Information on surface water quality at locations along Red Devil Creek. Surface water quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and mercury; dissolved TAL metals and mercury; TOC; TSS; TDS; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).
3) To address the lack of information on the temporal variability (e.g., seasonal and annual) of surface water conditions at the site, the following types of additional baseline surface water monitoring data will be needed for two baseline monitoring events planned for 2015:
   a. Information on surface water discharge at locations along Red Devil Creek.
   b. Information on surface water quality at locations along Red Devil Creek. Surface water quality parameters include field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and mercury; dissolved TAL metals and mercury; TOC; TSS; TDS; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate).

Kuskokwim River Sediment

1) To address the question of whether contaminated sediment in the Kuskokwim River is toxic to benthic macroinvertebrates, the following types of additional data will be needed:
   a. Additional sediment characterization data, including results of sediment toxicity testing, analysis for total metals, mercury SSE, grain size, and TOC.

2) To address the lack of information on the downriver and cross-river extents of contamination of Kuskokwim River sediment, the following types of additional data will be needed:
    a. Additional sediment characterization data, including results of total metals, grain size, and TOC for samples collected from locations downriver and outboard of the extent of RI sediment samples collected in 2010, 2011, and 2012.
3) To address the lack of information on turbidity of Kuskokwim River water, the following types of additional data will be needed:
    a. Field turbidity measurement data for selected locations in the Kuskokwim River.

3.4 Step 4: Define the Study Boundaries

The supplemental RI activities will be performed within the upland area of the site (as shown on Figure 1-2 of the final RI report) and in the Kuskokwim River, including the area previously sampled during the RI, as well as from locations further downriver and outboard of the extent of RI sediment samples collected in 2010, 2011, and 2012. Locations of Kuskokwim River sediment samples collected during the RI are illustrated on Figures 2-10 and 2-11 of the final RI Report. Planned sampling locations for the supplemental RI activities are presented in Chapter 4.

3.5 Step 5: Develop a Decision Rule

It is anticipated that data collected as part of the supplemental RI activities will be used to support the development of site-wide remedial decisions at the RDM site. Decision rules for employing the results of the supplemental RI characterization to make risk management and cleanup decisions will be developed in consultation with the Alaska Department of Environmental Conservation and the EPA following review of the supplemental RI data and supporting information.

3.6 Step 6: Specify Tolerable Limits on Decision Errors

Tolerable limits on decision errors, which are established performance goals for the data collection design, are specified in this step. Because analytical data and other measurements can only estimate true values, decisions that are based on measurement data could be in error. These errors are as follows.

1. Concentrations may vary over time and space. Limited sampling may miss some features of this natural variation because it is usually impossible or impractical to measure every point of a population. Sampling design errors occur when the sampling design is unable to capture the complete extent of natural variability that exists in the true state of the environment.
2. Analytical methods and instruments are never perfect; hence, a measurement can only estimate the true value of an environmental sample. Measurement error refers to a combination of random and systematic errors that inevitably arise during the measurement process.

A sufficient number of samples will be collected to minimize the risks of decision errors. Decision errors also will be minimized through the appropriate selection of sample locations.

Quality control samples will be collected and analyzed with environmental samples to assure that data are of known precision and accuracy. Control limits on both precision and accuracy for soil, groundwater, surface water, and sediment samples for planned analyses are addressed in the Quality Assurance Project Plan (QAPP), contained in Appendix C of the RI/FS Work Plan and the QAPP Addendum, presented in Appendix B of this Work Plan Supplement.

3.7 Step 7: Optimize the Design for Obtaining Data

Data gaps were identified for soil, groundwater, surface water, and Kuskokwim River sediments during the development of the FS. These data gaps are presented in Chapter 2 and Section 3.2. Based on these data gaps and Steps 1 through 6 of this DQO process, a study design for the supplemental RI characterization and baseline monitoring has been developed. Details of the study design are presented in Chapter 4 of this work plan supplement.

4 Overview of Study Design

The planned supplemental RI activities presented in this document are intended to augment existing RI and other data to support the development of site-wide risk management decisions encompassing soil, groundwater, surface water, and Kuskokwim River sediment. The planned baseline monitoring activities are intended to provide additional temporal data on groundwater and surface water conditions at the site. The study design presented in this document addresses these needs and was developed following the DQO planning process presented in Chapter 3. An overview of the study design is presented below. Detailed field investigation locations, objectives, rationale, methodologies, and procedures are provided in the field sampling plan, provided as Appendix A of this work plan supplement.

4.1 Soil

Additional soil characterization will be performed to gather the types of additional information identified in Section 3.3. Additional soil characterization will be performed by installing additional soil borings at the site, including:

- Nine soil borings in the Main Processing Area (two of which will be converted to monitoring wells);
- Three soil borings in the Red Devil Creek Area; and
- Five soil borings in the Surface Mined Area (which will be converted to monitoring wells).

Soil and bedrock characterization will be performed using a combination of field observations, results of XRF field screening for total inorganic elements, and laboratory analysis for total TAL metals and mercury SSE. Planned locations of soil borings and details of soil characterization objectives, rationale, methodologies, and procedures are provided in the field sampling plan.

Data generated during the planned 2015 supplemental soil characterization will be presented in an RI report supplement.

4.2 Groundwater

Additional groundwater characterization will be performed to gather the types of additional information identified in Section 3.3. Additional groundwater characterization will include installing additional monitoring wells at the site and collecting groundwater data from new and existing monitoring wells. Planned new monitoring wells are:

- Five new monitoring wells in the Surface Mined Area; and

- Two new monitoring wells in the Main Processing Area.

It is anticipated that one round of groundwater monitoring will be performed using existing RI monitoring wells in the spring 2015. New wells will be installed subsequent to the spring 2015 monitoring, and samples will be collected from these wells immediately following their completion. A second round of groundwater monitoring of the RI and new wells will be performed in the fall 2015.

Static water levels will be measured in all existing monitoring wells. Selected wells, including all new monitoring wells, will be sampled for field and laboratory water quality parameters. Locations of planned new monitoring wells and existing monitoring wells planned for monitoring, objectives, rationale, methodologies, and procedures for monitoring well installation and monitoring are provided in the field sampling plan.

Data generated during the planned 2015 supplemental groundwater characterization and baseline groundwater monitoring will be presented in an RI report supplement.

After completion of the 2015 baseline monitoring effort, the baseline monitoring results will be reviewed for the purpose of revising the Baseline Monitoring Work Plan for the BLM to use for future baseline monitoring events beginning after 2015. Any trends in groundwater elevation and surface water discharge, groundwater and surface water contaminant concentrations (for arsenic, mercury, and antimony), and surface water contaminant loading identified during preparation of the RI report supplement will be evaluated to guide the selection of monitoring wells, surface water monitoring stations, and analytical parameters appropriate for the BLM's long-term monitoring at the site.

4.3 Surface Water

Additional surface water characterization will be performed to gather the types of additional information identified in Section 3.3. Additional surface water characterization will be performed at eight surface water monitoring stations, including the seep, along Red Devil Creek.

At selected surface water monitoring locations along Red Devil Creek and the seep, discharge rates will be measured and surface water will be sampled for field and laboratory water quality parameters. Locations of planned surface water monitoring stations, objectives, rationale, methodologies, and procedures for surface water characterization and monitoring are provided in the field sampling plan.

It is anticipated that one round of surface water monitoring will be performed in the spring 2015 and a second round will be performed in the fall 2015.

Data generated during the planned 2015 supplemental surface water characterization and baseline surface water monitoring will be presented in an RI report supplement.

After completion of the 2015 baseline monitoring effort, the baseline monitoring results will be reviewed for the purpose of revising the Baseline Monitoring Work Plan for the BLM to use for future baseline monitoring events beginning after 2015. Any trends in groundwater elevation and surface water discharge, groundwater and surface water contaminant concentrations (for arsenic, mercury, and antimony), and surface water contaminant loading identified during preparation of the RI report supplement will be evaluated to guide the selection of monitoring wells, surface water monitoring stations, and analytical parameters appropriate for the BLM's long-term monitoring at the site.

4.4 Kuskokwim River Sediment

The planned supplemental Kuskokwim River sediment characterization addressed in this document is intended to assess whether contaminated Kuskokwim River sediment is toxic to benthic macroinvertebrates and the downriver extent of contamination.

Additional sediment characterization will be performed at offshore sediment sample locations in the Kuskokwim River. Sediment samples will be analyzed for total TAL inorganic elements, TOC, grain size, mercury SSE, and toxicity (*Hyalella azteca* 42-day). Planned sediment sampling locations, objectives, rationale, methodologies, and procedures are provided in the field sampling plan.

Samples planned for sediment toxicity testing will be collected generally from within the footprint of sediment samples collected during the RI and most of the planned locations are collocated with selected RI sample locations. The selected RI sample locations are biased toward locations where, based on RI sampling results, larger proportions of finer grained materials (sand size and smaller) are expected to be present (to facilitate sample collection), TOC concentrations are expected to be fairly similar, and a wide range of total antimony, arsenic, and mercury concentrations are expected to be present. In addition, several of the samples planned for toxicity testing will be collocated with periphyton samples collected by BLM in 2014. Samples intended to assess cross-river and downriver extents of contamination will be collected from outside of the footprint of the RI sediment samples. A subset of these planned samples will be collocated with downriver periphyton samples collected by BLM in 2014.

At the time of the sediment sample collection, field measurement of turbidity of river water will be performed at selected sediment sample locations.

Results of the supplemental Kuskokwim River sediment characterization will be presented in an RI report supplement. Results of the proposed sediment toxicity testing and other tests will be used in conjunction with results of periphyton sampling performed by BLM in 2014 (BLM 2014) and recent fish tissue data for the middle Kuskokwim River region (USFWS 2012) to support the development of site-wide risk management decisions encompassing Kuskokwim River sediment impacted by the site.

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A Field Sampling Plan

DRAFT
Field Sampling Plan for
2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization

Supplement to Remedial Investigation
Red Devil Mine, Alaska

February 2015

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List of Abbreviations and Acronyms

°C	degree Celsius
As	arsenic
ASTM	ASTM International (formerly the American Society of Testing and Materials)
ATV	all-terrain vehicle
bgs	below ground surface
BLM	Bureau of Land Management
BrCl	bromine monochloride
BRL	Brooks Rand Labs
BTEX	benzene, toluene, ethylbenzene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
Cl	chlorine
COC	chain-of-custody
COPC	contaminant of potential concern
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DRO	diesel range organics
E & E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FSP	field sampling plan
GPS	Global Positioning System
GRO	gasoline range organics
H_2SO_4	sulfuric acid
HCl	hydrochloric acid
HDPE	high density polyethylene
Hg	mercury

List of Abbreviations and Acronyms (cont.)

HNO_3	nitric acid
IATA	International Air Transportation Association
IDW	investigation-derived waste
L	liter
mL	milliliter
MS	matrix spike
MSD	matrix spike duplicate
NSF	National Sanitation Foundation
NTCRA	non-time-critical removal action
oz	ounce
PCBs	polychlorinated biphenyls
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RDM	Red Devil Mine
RI	remedial investigation
RRO	residual range organics
SOP	standard operating procedure
SPLP	Synthetic Precipitation Leaching Procedure
SSE	selective sequential extraction
SVOC	semivolatile organic compound
TAL	target analyte list
TDS	total dissolved solids
TIC	tentatively identified compounds
TOC	total organic carbon
TSS	total suspended solids
USGS	U.S. Geological Survey
XRF	X-ray fluorescence (spectroscopy)

1 Introduction

This document is a field sampling plan (FSP) to be used for supplemental site characterization to be conducted during the 2015 field season at the Red Devil Mine (RDM) site, Red Devil, Alaska. The RDM consists of an abandoned mercury mine and ore processing facility located on public lands managed by the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) in southwest Alaska. The BLM initiated a remedial investigation (RI)/feasibility study (FS) at the RDM in 2009 pursuant to its delegated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) lead agency authority. An 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. Results of the RI are presented in the final Remedial Investigation Report, Red Devil Mine, Alaska (E & E 2014a). An FS for the RDM is under development.

The 2015 supplemental RI site characterization is being performed to supplement data collected during the RI for several site media. Data collected during the RI were used to define the site physical setting, the nature and extent of contamination, and the fate and transport of contaminants, and to assess risk to human health and the environment. The 2015 supplemental site characterization addresses data gaps associated with soil, groundwater, and Kuskokwim River sediments that were identified as part of the development of site-wide remedial alternatives during the preparation of the FS. The 2015 supplemental site characterization also addresses changes in the groundwater and surface water monitoring network and possible changes to the groundwater and surface water conditions at the RDM stemming from implementation of a non-time-critical removal action (NTCRA) performed by the BLM at the RDM during the summer of 2014.

This FSP is intended to be used in conjunction with the Work Plan for 2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization, Supplement to Remedial Investigation, Red Devil Mine, Alaska (work plan supplement). E & E prepared the work plan supplement and this FSP on behalf of the BLM under Delivery Order Number L14PB00938 and BLM National Environmental Services Blanket Purchase Agreement Number L14PA00149.

Existing data and information regarding the RDM are presented in the final RI report and other documents. Key RI findings and information pertinent to the supplemental RI characterization for soil, groundwater, surface water, and Kuskokwim River sediment are summarized in the work plan supplement. Information in the work plan supplement is not repeated in the FSP. This FSP is intended to be used as a streamlined guide for the field investigation team.

The purpose of this FSP is to provide specific methodology for the sampling and analysis at the RDM site. The results of the activities performed under this FSP will be used to support the development of site-wide remedial alternatives at the RDM.

2 Sample Locations, Types, and Rationale

This section describes the study design for each component of the 2015 supplemental site characterization activities at the RDM site. The study area for the 2015 supplemental site characterization activities includes the upland area of the site as shown on Figure 1-2 of the final RI report and in Kuskokwim River, including the area previously sampled during the RI, as well as from locations further downriver and outboard of the extent of RI sediment samples collected in 2010, 2011, and 2012. Locations of Kuskokwim River sediment samples collected during the RI are illustrated on Figures 2-10 and 2-11 of the final RI report.

The work plan supplement and final RI report detail the contaminant sources associated with the site and the contaminants of concern associated with these sources. The planned supplemental RI activities target soil, groundwater, surface water, and Kuskokwim River sediment impacted by these contaminants of concern. Inorganic elements, particularly antimony, arsenic, and mercury are the primary contaminants of concern at the site. In addition to inorganic elements, the following types of organic compounds were detected in one or more media at the site: semivolatile organic compounds (SVOCs), diesel range organics (DRO), residual range organics (RRO), and polychlorinated biphenyls (PCBs).

The study design incorporates both field screening and fixed laboratory analyses. Field screening will provide real-time data to inform selection of samples for laboratory analysis, as well as providing a large dataset to characterize total inorganic element concentrations in soil.

The following sections summarize the sample locations, types, and rationale for the planned 2015 soil, groundwater, surface water and sediment characterization.

2.1 Soil

The 2015 soil characterization activities will address data gaps associated with subsurface soil and bedrock. Additional soil characterization will be performed to gather the types of additional information identified in Section 3.3 of the work plan supplement. Soil characterization will be performed by installing additional soil borings at the site, including:

- Nine soil borings in the Main Processing Area (two of which will be converted to monitoring wells);
- Three soil borings in the Red Devil Creek Area; and
- Five soil borings in the Surface Mined Area (which will be converted to monitoring wells).

Soil and bedrock characterization will be performed using a combination of field observations, results of X-ray fluorescence spectroscopy (XRF) field screening for total inorganic elements, and laboratory analysis for total target analyte list (TAL) metals and mercury selective sequential extraction (SSE). Data gaps and the investigative approach for the subsurface soil investigation are presented in Chapters 3 and 4 of the work plan supplement. General objectives of the soil investigation are summarized below:

- Assess lithologic and mineralogical characteristics of subsurface soils and bedrock.
- Identify mine waste types and soil types.
- Determine thickness and inorganic element concentrations of tailings/waste rock where present.
- Determine concentrations of inorganic elements in tailings/waste rock where present.
- Identify and determine the thickness of types of native soil/alluvium.
- Determine concentrations of inorganic elements in soil/alluvium below tailings/waste rock from the base of tailings/waste rock to the top of bedrock to assess impacts on native soil/alluvium from deposition of inorganic elements leached from tailings/waste rock.
- Determine depth of bedrock.
- Visually assess whether the bedrock is naturally mineralized.
- Determine the presence, depth, and thickness of saturated interval(s).

Available information on the soil type and lithological and mineralogical characteristics and hydrogeologic conditions at the site is presented in the final RI report in Chapter 3 (Physical Characteristics of the Study Area) and Appendices B (Soil Types) and F (Summary of Surface Soil, Subsurface Soil, and Groundwater Data). This information was used in conjunction with information on the distribution of contaminants of potential concern (COPCs) presented in the final RI report in Chapter 4 (Nature and Extent of Contamination) to select the proposed soil boring locations and develop the planned investigative approach. This same information will be used, as appropriate, during the field investigation to guide the refinement of soil boring locations, installation of the soil borings, and interpretation of field lithological, mineralogical, and other observations.

Proposed soil boring locations are illustrated on Figure 2-1. The locations of the proposed soil borings are described in Table 2-1. The proposed positions of these boring locations are approximate. Actual boring locations will be refined during field investigation based on actual conditions encountered in the field.

Soil borings will be installed using a drill rig operated by a subcontracted, Alaska-licensed driller. Soil boring installation and subsurface soil sampling methodologies are discussed in Chapter 4. New monitoring wells will be installed within soil borings as specified in Section 2.2.

At each soil boring, if feasible, soil samples will be collected continuously from the ground surface to the top of bedrock while drilling in unconsolidated materials. While drilling in bedrock, drill cuttings will be collected at minimum intervals of 5 feet. The soil material recovered will be visually characterized and logged by the field geologist and field screened for total inorganic elements using an XRF. Specific field procedures are described in Chapter 4.

In general, if feasible, each soil boring will be advanced to the target depths specified in Table 2-1.

Selected soil samples will be collected for fixed laboratory analysis for total TAL metals and mercury SSE. The proposed frequency and the rationale for selection of soil samples for these laboratory analyses are presented in Table 2-1.

It is anticipated that the soil characterization activities will be performed in the spring/summer of 2015.

2.2 Groundwater

The 2015 groundwater characterization activities will address data gaps associated with groundwater. Additional groundwater characterization will be performed in the spring and fall of 2015 to gather the types of additional information identified in Section 3.3 of the work plan supplement. Additional groundwater characterization includes installing additional monitoring wells at the site and collecting groundwater data from new and existing monitoring wells. Planned new monitoring wells are:

- Five new monitoring wells in the Surface Mined Area; and
- Two new monitoring wells in the Main Processing Area.

Additional groundwater characterization will be performed using a combination of field data collection and the results of laboratory analysis for selected analytical parameters. Data gaps and the investigative approach for the groundwater characterization are presented in Chapters 3 and 4 of the work plan supplement. General objectives of the groundwater characterization are summarized below:

- Assess groundwater occurrence, depth, and quality in the Surface Mined Area.
- Assess groundwater occurrence, depth, and quality in the portions of the RDM site affected by the 2014 NTCRA construction.
- Provide additional information on baseline groundwater conditions at the site.

- Assess groundwater concentrations of SVOCs, DRO, gasoline range organics (GRO), and benzene, toluene, ethylbenzene, xylenes (BTEX) in selected wells.

Available information on the hydrogeologic conditions at the site is presented in the final RI report in Chapters 3 (Physical Characteristics of the Study Area), 4 (Nature and Extent of Contamination), and 5 (Contaminant Fate and Transport), and Appendices A (Final 2012 Baseline Monitoring Report, Red Devil Mine, Alaska) and F (Summary of Surface Soil, Subsurface Soil, and Groundwater Data). Available information on the 2014 NTCRA construction is summarized in Chapter 2 of the work plan supplement. This information was used to select the proposed monitoring well locations and develop the planned investigative approach. This same information will be used, as appropriate, during the field investigation to guide the refinement of monitoring well locations, installation of the monitoring wells, and interpretation of field observations.

Locations of proposed new monitoring wells are shown on Figure 2-1. The locations of the proposed new monitoring wells are described in Table 2-1. The proposed positions of the new monitoring wells are approximate. Actual boring locations will be refined during field investigation based on actual conditions encountered in the field. Monitoring wells will be installed using a drill rig operated by a subcontracted, Alaska-licensed driller. Monitoring well installation methodologies are discussed in Chapter 4.

Groundwater samples will be collected from the monitoring wells identified in Table 2-2, including all proposed new monitoring wells and selected existing monitoring wells. All groundwater samples will be collected for field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and low-level mercury; dissolved low-level mercury; inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate). In addition, samples from selected wells will be analyzed for SVOCs, DRO, GRO, and BTEX. Table 2-2 summarizes the proposed numbers of samples to be collected for selected laboratory analyses.

It is anticipated that one round of groundwater monitoring will be performed using existing RI monitoring wells in the spring 2015. New wells will be installed subsequent to the spring 2015 monitoring, and samples will be collected from these wells immediately following their completion. A second round of groundwater monitoring of the RI and new wells will be performed in the fall 2015.

At the beginning of spring and fall 2015 groundwater sampling events, a round of static water level measurement will be conducted at all existing wells. Following the completion of groundwater sampling near the end of the sampling event, another round of static water level gauging will be conducted at all new and previously existing monitoring wells. The static water levels will be measured during each round within the shortest time period possible.

Horizontal coordinates and elevations of all existing and newly installed monitoring wells will be surveyed by a subcontracted, Alaska-registered land surveyor. Well elevations will be surveyed to within the nearest 0.1 foot.

2.3 Surface Water

The 2015 surface water characterization activities will address data gaps associated with surface water. Additional surface water characterization will be performed in the spring and fall of 2015 to gather the types of additional information identified in Section 3.3 of the work plan supplement. Additional surface water characterization will be performed using a combination of field data collection and the results of laboratory analysis for selected analytical parameters. Data gaps and the investigative approach for the surface water characterization are presented in Chapters 3 and 4 of the work plan supplement. General objectives of the surface water characterization are summarized below:

- Assess potential impacts on surface water quality and flow rate by flow of groundwater that is impacted by naturally mineralized bedrock and underground mine workings in the Surface Mined Area.
- Assess groundwater quality and flow rate in the area affected by the 2014 NTCRA construction.
- Provide additional information on baseline surface water conditions at the site.

Available information on the surface water conditions at the site is presented in the final RI report in Chapters 3 (Physical Characteristics of the Study Area), 4 (Nature and Extent of Contamination), and 5 (Contaminant Fate and Transport), and Appendix A (Final 2012 Baseline Monitoring Report, Red Devil Mine, Alaska). Available information on the 2014 NTCRA construction is summarized in Chapter 2 of the work plan supplement. This information was used to select the proposed surface water monitoring well locations and develop the planned investigative approach.

Proposed surface water monitoring locations are shown on Figure 2-2 and are described in Table 2-3.

At the selected surface water monitoring locations along Red Devil Creek and the seep, discharge rate will be measured and surface water will be sampled for field and laboratory water quality parameters. Surface water samples will be collected for field water quality parameters (pH, specific conductance, oxidation reduction potential, turbidity, dissolved oxygen, and temperature) and the following laboratory analyses: total TAL metals and low-level mercury; dissolved TAL metals and low-level mercury; total organic carbon (TOC); total suspended solids (TSS); total dissolved solids (TDS); inorganic ions (chloride, fluoride, and sulfate); nitrate-nitrite as N; and alkalinity (as carbonate/bicarbonate). Table 2-3 summarizes the proposed numbers of samples to be collected for selected laboratory analyses.

It is anticipated that surface water monitoring activities will be performed in the spring and fall of 2015.

A visual survey will be conducted at the site to identify if additional springs or seeps are present. Surface water samples will be collected and discharge will be measured at any new springs identified during the 2015 sampling events.

It is anticipated that the creek will be shallow at most sample locations. To the extent feasible, surface water samples will be collected from mid-depth water in the creek. Specific sampling methodologies are summarized in Chapter 4 of this FSP.

2.4 Kuskokwim River Sediment

The 2015 Kuskokwim River sediment characterization activities will be performed to gather the types of additional information identified in Section 3.3 of the work plan supplement. Sediment characterization will be performed by collecting additional surface sediment samples at the site for various laboratory analyses. Data gaps and the investigative approach for the Kuskokwim River sediment characterization are presented in Chapters 3 and 4 of the work plan supplement. General objectives of the sediment investigation are summarized below:

- Assess toxicity of sediments to benthic macroinvertebrates.
- Assess the cross-river and downriver extents of contamination in Kuskokwim River sediment.

Proposed 2015 sediment sampling locations are illustrated on Figures 2-3 and 2-4. The locations of the proposed samples are described in Table 2-4. The proposed positions of these sampling locations are approximate. Actual sample locations will be refined during field investigation based on actual conditions encountered in the field.

Available information on the physical and chemical characteristics of Kuskokwim River sediment, including grain size, concentrations of COPCs, and other chemical data, are presented in the final RI report in Chapters 3 (Physical Characteristics of the Study Area) and 4 (Nature and Extent of Contamination). Information on Kuskokwim River sediment pertinent to the physical and chemical fate and transport processes are presented in Chapter 5 (Contaminant Fate and Transport) of the final RI report. Available information regarding other studies pertaining to Kuskokwim River sediment, including periphyton sampling performed by the BLM in 2014, is summarized in Chapter 2 of the work plan supplement. This information was used to select proposed sediment sampling locations and develop the planned investigative approach. This same information will be used, as appropriate, during the field investigation to guide the refinement of sediment sampling locations.

Samples planned for sediment toxicity testing will be collected generally from within the footprint of sediment samples collected during the RI and most of the planned locations are collocated with selected RI sample locations. The selected RI sample locations are biased toward locations where, based on RI sampling results, larger proportions of finer grained materials (sand size and smaller) are expected to be present (to facilitate sample collection), TOC concentrations are expected to be fairly similar, and a wide range of total antimony, arsenic, and mercury concentrations are expected to be present. In addition, several of the samples planned for toxicity testing will be collocated with periphyton samples collected by BLM in 2014. Samples intended to assess cross-river and downriver extents of contamination will be collected from outside of the footprint of the RI sediment samples. A subset of these planned samples will be collocated with downriver periphyton samples collected by BLM in 2014.

Sediment samples will be analyzed for the following laboratory analyses as summarized in Table 2-4: total TAL inorganic elements; TOC; grain size; mercury SSE; and toxicity (42-day *Hyalalla Azteca*).

At the time of the sediment sample collection, field measurement of turbidity of river water will be performed at selected sediment sample locations.

2.5 Quality Control Samples

Following the requirements specified in the RI/FS Quality Assurance Project Plan (QAPP), included in the final RI/FS work plan, field quality control (QC) samples will be collected for all matrices and analytes (except soil samples collected for XRF field screening). QC samples will be:

- **Field Duplicates**: A field duplicate sample is a second sample collected at the same time and location as the original sample. Field duplicate samples are collected simultaneously (an extra volume of one sample, which is then homogenized and split into equal aliquots) or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. The sample containers are assigned an identification number in the field such that they cannot be identified (blind duplicate) as duplicate samples by laboratory personnel performing the analysis. Duplicate sample results are used to assess precision of the overall sample collection and analysis process. For soil, groundwater, surface water, and sediment, field duplicate samples will be collected at a minimum frequency of one field duplicate for every 10 regular samples for each matrix and sampling method and/or type of equipment used.

- **Matrix Spike**: Matrix spikes (MSs) are used to assess the effect of the sample matrix on analyte recovery. An MS consists of an aliquot of a field sample to which the laboratory adds a known concentration of the analyte(s) of interest. An unspiked aliquot is also analyzed, and the %R for the spiked sample is calculated. Analysis of MSs requires collection of a sufficient volume of sample to accommodate the number of aliquots to be analyzed. The sample(s) chosen for MSs should be representative of the sample matrix but should not contain excessive concentrations of analytes or interfering substances. MSs are analyzed at a frequency of one MS per 20 or fewer samples for each matrix and each sampling event.

- **Rinsate Blanks:** Rinsate blanks are used to assess the effectiveness of equipment decontamination procedures when non-dedicated sampling equipment is used. A rinsate blank is a sample of ASTM Type II reagent grade water or equivalent (i.e., deionized), poured into or over the sampling device or pumped through it, collected in a sample container, and transported to the laboratory for analysis. Rinsate blanks will be collected immediately after the equipment has been decontaminated. The blank will be analyzed for all laboratory analyses requested for the environmental samples collected at the site. A minimum frequency of one rinsate blank per 20 field samples is required for each collection/decontamination method, by matrix and by sample type.

- **Equipment Blanks**: Equipment blanks are used to demonstrate that dedicated sampling equipment is adequately clean if a certificate is not available to demonstrate cleanliness. Equipment blanks will be analyzed for all laboratory analyses requested for the environmental samples collected at the site. One equipment blank sample for dedicated equipment will be collected at a rate of one for each set of dedicated equipment (i.e., bailers and sample tubing) of identical manufacturer's lot number.

- **Trip Blanks**: One trip blank will be collected for every shipment of samples collected for BTEX analysis.

- **Field Blanks**: Field blanks are laboratory-provided, mercury-free water samples that are processed and treated as a regular sample in all respects, including contact with sampling devices, equipment, sampling site conditions, and analytical procedures. Field blanks are used to determine whether mercury detected in a sample is from the site or can be attributed to contamination. Field blanks will be collected at a rate of one field blank for every 10 regular samples to be analyzed for low-level mercury.

Table 2-1 Summary of Soil Borings, Soil Sampling, and Monitoring Well Installation

Geographic Area	Sub Area	Location Description	Soil Boring ID	Targeted Total Drilling Depth Criteria	Anticipated Generalized Lithology	Laboratory Soil Sample Collection			Monitoring Well Installation		
						Total TAL Metals	Hg SSE	Sample Selection Criteria	Monitoring Well ID	Screen Interval Selection Target Criteria	Planned Screen Length (ft)
Main Processing Area	Post-1955 Main Processing Area	Near former shallow/deep RI well pair MW16 and MW17	MP092	Drill to minimum of approximately 30 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	MW37	Screen within bedrock. Bottom of screen approximately 25 to 30 feet below top of weathered bedrock/bedrock	10
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
		Near former shallow/deep RI well pair MW16 and MW17	MP093	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	MW38	Screen within unconsolidated materials. Base of screen at top of bedrock	10
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
		Near RI Soil Borings MP29 and MP30	MP094	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
		Near RI Soil Borings MP25 and MP29	MP095	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
		Near RI Soil Borings MP27 and MP28	MP096	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
		Near Red Devil Creek Alignment and RI Soil Borings MP29 and MP30	MP097	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
	Pre-1955-Main Processing Area	Near RI Soil Borings MP45, MP46, MP47, MP48 and MP60	MP098	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
		Near RI Soil Boring MP53	MP099	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			
		Near RI Soil Borings MP57 and MP58	MP100	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock	1	1	Select 1 sample of Tailings/Waste Rock from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	4	2	Select 4 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock to the top of bedrock. Select 2 samples (a subset of the total TAL metals samples) for Hg SSE with XRF mercury concentrations ranging from the highest to mid-range.			
					Bedrock	None	None	No laboratory samples			

Table 2-1 Summary of Soil Borings, Soil Sampling, and Monitoring Well Installation

Geographic Area	Sub Area	Location Description	Soil Boring ID	Targeted Total Drilling Depth Criteria	Anticipated Generalized Lithology	Laboratory Soil Sample Collection			Monitoring Well Installation		
						Total TAL Metals	Hg SSE	Sample Selection Criteria	Monitoring Well ID	Screen Interval Selection Target Criteria	Planned Screen Length (ft)
Near Red Devil Creek	Near Red Devil Creek Alignment in Main Processing Area	Near Red Devil Creek Alignment and RI Soil Boring MP38	MP101	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium	1	1	Select 1 sample of Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	2	1	Select 2 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium to the top of bedrock. Select 1 sample (a subset of the total TAL metals samples) for Hg SSE with the highest XRF mercury concentration.			
					Bedrock	None	None	No laboratory samples			
	Near Red Devil Creek in Red Devil Creek Downstream Alluvial Area	Near Red Devil Creek Alignment and RI Soil Borings MP40 and RD07	RD21	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium	1	1	Select 1 sample of Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	2	1	Select 2 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium to the top of bedrock. Select 1 sample (a subset of the total TAL metals samples) for Hg SSE with the highest XRF mercury concentration.			
					Bedrock	None	None	No laboratory samples			
		Near Red Devil Creek Alignment and RI Soil Borings RD07 and RD06	RD22	Drill to approximately 2 feet into weathered bedrock/bedrock	Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium	1	1	Select 1 sample of Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium from the base of the interval for total TAL metals and Hg SSE.	NA		
					Native Soil/Alluvium	2	1	Select 2 samples for total TAL metals from intervals selected to provide data to define concentration gradients of arsenic, mercury, and antimony from the base of Tailings/Waste Rock or Mixed Tailings/Waste Rock and Native Soil/Alluvium to the top of bedrock. Select 1 sample (a subset of the total TAL metals samples) for Hg SSE with the highest XRF mercury concentration.			
					Bedrock	None	None	No laboratory samples			
Surface Mined Area	Surface Mined Area	Northeast of Dolly Shaft and south and assumed downgradient of proposed repository location	SM67	Drill to minimum depth required to meet well installation criteria	Unconsolidated Materials	Up to 1 (see Sample Selection Criteria)	None	Collect a total of 3 samples from amongst the 5 borings installed in the Surface Mined Area for TAL metals. Select samples from the borings/intervals with the highest XRF arsenic, mercury, and antimony concentrations.	MW39	Target groundwater in bedrock, with at least 50% of 20 foot screen submerged under static water level. However, if a saturated zone is encountered above bedrock and continued drilling does not indicate that upper saturated zone is perched, then install well with 10 foot screen within unconsolidated materials.	20
					Bedrock	None	None	No laboratory samples			
		Near Dolly Area Crosscuts	SM68	Drill to minimum depth required to meet well installation criteria	Unconsolidated Materials	Up to 1 (see Sample Selection Criteria)	None	Collect a total of 3 samples from amongst the 5 borings installed in the Surface Mined Area for TAL metals. Select samples from the borings/intervals with the highest XRF arsenic, mercury, and antimony concentrations.	MW40	Target groundwater in bedrock, with at least 50% of 20 foot screen submerged under static water level. However, if a saturated zone is encountered above bedrock and continued drilling does not indicate that upper saturated zone is perched, then install well with 10 foot screen within unconsolidated materials.	20
					Bedrock	None	None	No laboratory samples			
		Near Dolly Area Crosscuts	SM69	Drill to minimum depth required to meet well installation criteria	Unconsolidated Materials	Up to 1 (see Sample Selection Criteria)	None	Collect a total of 3 samples from amongst the 5 borings installed in the Surface Mined Area for TAL metals. Select samples from the borings/intervals with the highest XRF arsenic, mercury, and antimony concentrations.	MW41	Target groundwater in bedrock, with at least 50% of 20 foot screen submerged under static water level. However, if a saturated zone is encountered above bedrock and continued drilling does not indicate that upper saturated zone is perched, then install well with 10 foot screen within unconsolidated materials.	20
					Bedrock	None	None	No laboratory samples			
		Near 325 Adit and 242 Sublevel	SM70	Drill to minimum depth required to meet well installation criteria	Unconsolidated Materials	Up to 1 (see Sample Selection Criteria)	None	Collect a total of 3 samples from amongst the 5 borings installed in the Surface Mined Area for TAL metals. Select samples from the borings/intervals with the highest XRF arsenic, mercury, and antimony concentrations.	MW42	Target groundwater in bedrock, with at least 50% of 20 foot screen submerged under static water level. However, if a saturated zone is encountered above bedrock and continued drilling does not indicate that upper saturated zone is perched, then install well with 10 foot screen within unconsolidated materials.	20
					Bedrock	None	None	No laboratory samples			
		Near 33 Sublevel	SM71	Drill to minimum depth required to meet well installation criteria	Unconsolidated Materials	Up to 1 (see Sample Selection Criteria)	None	Collect a total of 3 samples from amongst the 5 borings installed in the Surface Mined Area for TAL metals. Select samples from the borings/intervals with the highest XRF arsenic, mercury, and antimony concentrations.	MW43	Target groundwater in bedrock, with at least 50% of 20 foot screen submerged under static water level. However, if a saturated zone is encountered above bedrock and continued drilling does not indicate that upper saturated zone is perched, then install well with 10 foot screen within unconsolidated materials.	20
					Bedrock	None	None	No laboratory samples			

Notes

1) At each boring, unconsolidated materials will be collected continuously from the ground surface to the boring total depth using split spoon or continuous core samplers. Weathered bedrock/bedrock material will be collected continuously with split spoon or continuous core samplers, if possible, or by collecting drill cuttings at a minimum frequency of every 1 foot.

2) The material recovered, including unconsolidated materials (e.g., tailings/waste rock, fill, native soil/alluvium) and weathered bedrock/bedrock, will be field screened with an XRF at a minimum frequency of every 1 foot.
3) If possible, each boring will be advanced to the depths specified. For those borings to be converted to monitoring wells, the borings will be advanced to a depth deep enough to install a well as specified based on the site geologist's judgment.

Key:
Hg SSE = Mercury selective sequential extraction
TAL = Target analyte list
XRF = X-ray fluorescence spectroscopy

Table 2-2 Summary of 2015 Groundwater Samples

General Geographic Area	Sub-Area	Location Description	Soil Boring ID	Monitoring Well ID	Number of Samples													
					Total TAL Metals	Total Low-Level Hg	Dissolved Low-Level Hg	Inorganic Ions (chloride, fluoride, sulfate)	Nitrate/Nitrite as N	Carbonate, Bicarbonate	Total Suspended Solids	Nitrate/Nitrite as N	Carbonate, Bicarbonate	SVOCs	DRO	GRO/ BTEX
Main Processing Area	Post-1955 Main Processing Area	Upgradient of Post-1955 Main Processing Area	11MP01	MW08	1	1	1	1	1	1	1	1	1			
		Upgradient of Settling Ponds #2 and #3	11MP33	MW19	1	1	1	1	1	1	1	1	1	1	1	1
		Downgradient from Monofill #2 / Post-1955 Retort Building	11MP14	MW10	1	1	1	1	1	1	1	1	1			
		Gravel Pad / Downgradient from Monofill #3	Pre-RI boring/well previously referred to as MW-1	MW01	1	1	1	1	1	1	1	1	1			
		Near former shallow/deep RI well pair MW16 and MW17 (decommissioned)	MP092 (proposed 2015 soil boring)	MW37 (proposed 2015 monitoring well)	1	1	1	1	1	1	1	1	1			
			MP093 (proposed 2015 soil boring)	MW38 (proposed 2015 monitoring well)	1	1	1	1	1	1	1	1	1			
		Berm / Downgradient of Settling Pond #3	11MP40	MW22	1	1	1	1	1	1	1	1	1	1	1	1
	Pre-1955 Main Processing Area	Pre-1955 Main Processing Area	11MP52	MW26	1	1	1	1	1	1	1	1	1			
		Shallow/deep well pair near seep on bank of Red Devil Creek / Downgradient of former mine openings / Tailings	11MP88	MW27	1	1	1	1	1	1	1	1	1			
			11MP60	MW28	1	1	1	1	1	1	1	1	1			
		Downgradient of Pre-1955 Retort Area	Pre-RI boring/well previously referred to as MW-6	MW06	1	1	1	1	1	1	1	1	1			
Red Devil Creek Downstream Alluvial Area and Delta	Red Devil Creek Downstream Alluvial Area and Delta	Red Devil Creek Downstream Alluvial Area and Delta	11RD05	MW32	1	1	1	1	1	1	1	1	1			
		Red Devil Creek Downstream Alluvial Area and Delta	11RD20	MW33	1	1	1	1	1	1	1	1	1			
Surface Mined Area	Surface Mined Area	Northeast of Dolly Shaft and south and assumed downgradient of proposed repository location	SM67 (proposed 2015 soil boring)	MW39 (proposed 2015 monitoring well)	1	1	1	1	1	1	1	1	1			
		Near Dolly Area Crosscuts	SM68 (proposed 2015 soil boring)	MW40 (proposed 2015 monitoring well)	1	1	1	1	1	1	1	1	1			
		Near Dolly Area Crosscuts	SM69 (proposed 2015 soil boring)	MW41 (proposed 2015 monitoring well)	1	1	1	1	1	1	1	1	1			
		Near 325 Adit and 242 Sublevel	SM70 (proposed 2015 soil boring)	MW42 (proposed 2015 monitoring well)	1	1	1	1	1	1	1	1	1			
		Near 33 Sublevel	SM71 (proposed 2015 soil boring)	MW43 (proposed 2015 monitoring well)	1	1	1	1	1	1	1	1	1			
		Upgradient from Pre-1955 Main Processing Area	11MP41	MW29	1	1	1	1	1	1	1	1	1			
		Upgradient from Pre-1955 Main Processing Area	11SM31	MW30	1	1	1	1	1	1	1	1	1			
Upland Area West of Surface Mined Area	Upland Area West of Surface Mined Area	Upland Area West of Surface Mined Area	11UP11	MW31	1	1	1	1	1	1	1	1	1			

Key:
BTEX = Benzene, toluene, ethylbenzene, and xylenes
DRO = Diesel range organics
GRO = Gasoline range organics
Hg = Mercury
SVOCs = Semivolatile organic compounds
TAL = Target Analyte List

Table 2-3 Summary of 2015 Surface Water Samples

General Geographic Area	Location Description	Sample Location ID	Number of Samples									
			Total TAL Metals	Total Low-Level Hg	Dissolved TAL Metals	Dissolved Low-Level Hg	Total Organic Carbon	Total Suspended Solids	Total Dissolved Solids	Inorganic Ions (chloride, fluoride, sulfate)	Nitrate/Nitrite as N	Carbonate, Bicarbonate
Red Devil Creek, Main Processing Area	Red Devil Creek, near upstream end of the Main Processing Area	RD10SW	1	1	1	1	1	1	1	1	1	1
	Red Devil Creek, new station immediately upstream of the newly aligned section (post-NTCRA) of Red Devil Creek, near former station RD04SW	RD14SW	1	1	1	1	1	1	1	1	1	1
	Red Devil Creek, new station immediately downstream of the newly aligned section (post-NTCRA) of Red Devil Creek, near former baseline monitoring station RD13SW	RD15SW	1	1	1	1	1	1	1	1	1	1
	Seep on left bank of Red Devil Creek	RD05SW	1	1	1	1	1	1	1	1	1	1
	Red Devil Creek, new station downstream of seep area between RD12 and RD09	RD16SW	1	1	1	1	1	1	1	1	1	1
	Red Devil Creek, near Settling Pond #2	RD09SW	1	1	1	1	1	1	1	1	1	1
	Red Devil Creek, near Settling Pond #3	RD06SW	1	1	1	1	1	1	1	1	1	1
Red Devil Creek Downstream Alluvial Area and Delta	Red Devil Creek, near confluence of Red Devil Creek and Kuskokwim River, downstream of sediment trap constructed during NTCRA	RD08SW	1	1	1	1	1	1	1	1	1	1

Key:

Hg = mercury
TAL = Target Analyte List

Table 2-4 Summary of 2015 Kuskokwim River Sediment Samples

General Geographic Area	Location Description	Sample Location ID	Number of Samples: Total TAL Metals	Grain Size	TOC	Hg SSE	Sediment Toxicity - *Hyalella azteca* (42 day)
Upriver of Red Devi Creek Delta	Near BLM periphyton sample location Kusko-14-PERI-13	KR082	1	1	1		1
	Near RI sediment sample location KR26	KR083	1	1	1		1
Red Devil Creek Delta Area	Near RI sediment sample location KR29	KR084	1	1	1	1	1
	Near RI sediment sample location KR02	KR085	1	1	1	1	1
	Near RI sediment sample location KR54	KR086	1	1	1		1
Downriver of Red Devil Creek Delta	Near RI sediment sample location KR37	KR087	1	1	1		1
	Near BLM periphyton sample location Kusko-14-PERI-14	KR088	1	1	1		1
	Near RI sediment sample location KR43	KR089	1	1	1	1	1
	Near RI sediment sample location KR45	KR090	1	1	1		1
	Near RI sediment sample location KR60	KR091	1	1	1	1	1
	Near BLM periphyton sample location Kusko-14-PERI-15	KR092	1	1	1		1
	Near RI sediment sample location KR72	KR093	1	1	1	1	1
	Outboard of RI sediment sample locations, near locations KR55 and KR56	KR094	1	1	1		
	Outboard of RI sediment sample locations, near location KR73	KR095	1	1	1		
	Downriver of RI sediment sample locations, near BLM periphyton sample location Kusko-14-PERI-16	KR096	1	1	1		
	Downriver of RI sediment sample locations, near right bank	KR097	1	1	1		
	Downriver of RI sediment sample locations, near BLM periphyton sample location Kusko-14-PERI-26	KR098	1	1	1		
	Downriver of RI sediment sample locations, near right bank	KR099	1	1	1		
	Downriver of RI sediment sample locations, near BLM periphyton sample location Kusko-14-PERI-19	KR100	1	1	1		
	Downriver of RI sediment sample locations, near right bank	KR101	1	1	1		
	Downriver of RI sediment sample locations, near BLM periphyton sample location Kusko-14-PERI-22	KR102	1	1	1		
	Downriver of RI sediment sample locations, near right bank	KR103	1	1	1		
	Downriver of RI sediment sample locations, near BLM periphyton sample location Kusko-14-PERI-27	KR104	1	1	1		
	Downriver of RI sediment sample locations, near right bank	KR105	1	1	1		

Key:
Hg SSE = Mercury selective sequential extraction
TAL = Target Analyte List
TOC = Total organic carbon

3 Sample Identification

Each sample collected during the 2015 supplemental RI characterization will be assigned a unique alphanumeric code. Sample codes will be recorded in field logbooks, on sample containers, and on chain-of-custody (COC) forms. The field team leader will be responsible for maintaining a master database or spreadsheet of samples to be collected and samples obtained to ensure that all planned samples are collected during the field investigation, that sample designation codes are not used twice for different locations, and that the correct analytical parameters are identified on laboratory documentation.

Tables 3-1 through 3-4 describe the sample coding system.

Subsurface Soil

Subsurface soil samples collected for fixed laboratory analysis and XRF field screening will be assigned sample identifiers as specified in Table 3-1. Pre-assigned sample location identifiers for proposed soil borings are presented in Table 2-1 and illustrated on Figure 2-1.

Table 3-1 Sample Identification Coding System: Subsurface Soil

Characters	Purpose	Code	Description
1–2	Sample collection year	15	Last two digits of year
3–4	Geographic area	MP	Main Processing Area
		RD	Red Devil Creek Downstream Alluvial Area
		SM	Surface Mined Area
5–7	Location number	092, 093, etc.	Consecutive number within area/location
8–9	Matrix	SB	Subsurface soil
10–11	Depth	02, 04, 06, etc.	Depth in feet below ground surface as measured at the bottom of the subsurface soil sample interval

Field duplicate samples for subsurface soil samples will be identified by selecting a unique location number not used for the regular sample or any subsequent samples. All samples will be cross-referenced in the field logbooks and in the sample master database to sample locations.

Example sample codes for subsurface soil:

- 15MP092SB06: The regular subsurface soil sample collected from soil boring MP092 in the Main Processing Area, collected from a depth interval of 4 to 6 feet below ground surface (bgs) in 2015.
- 15MP131SB06: The field duplicate subsurface soil sample collected from a soil boring in the Main Processing Area (e.g., MP092), collected from a depth interval of 4 to 6 feet bgs in 2015.

Groundwater
Groundwater samples will be collected for laboratory analyses from existing and new monitoring wells during sampling events in 2015. Groundwater samples will be collected from the wells identified in Table 2-2, and shown on Figure 2-2. Groundwater samples will be assigned sample identifiers as specified in Table 3-2.

Table 3-2 Sample Identification Coding System: Groundwater

Characters	Purpose	Code	Description
1–2	Sample collection month	XX	Numerical month designation (e.g., "05" for May)
3–4	Sample collection year	15	Last two digits of year
5–8	Monitoring well identification number	MW08, etc.	See final RI report for existing monitoring wells. New monitoring wells identification numbers will be assigned identification numbers as specified in Table 2-1.
9–10	Matrix	GW	Groundwater

Field duplicate samples for groundwater samples will be identified by selecting a unique monitoring well identification number not used for any actual monitoring wells. All samples will be cross-referenced in the field logbooks and in the sample master database to monitoring well designations.

Example sample codes for groundwater:

- 0515MW08GW: The regular groundwater sample collected from existing monitoring well MW08 in May 2015.
- 0515MW90GW: The field duplicate groundwater sample collected from existing monitoring well MW08 in May 2015.

Surface Water
Surface water samples will be assigned sample identifiers as specified in Table 3-3. Pre-assigned sample location identifiers for proposed surface water samples are presented in Table 2-3 and on Figure 2-2.

Table 3-3 Sample Identification Coding System: Surface Water

Characters	Purpose	Code	Description
1–2	Sample collection month	XX	Numerical month designation (e.g., “05” for May)
3–4	Sample collection year	15	Last two digits of year
5–8	Surface water monitoring station identification number	RD10, etc.	See Table 2-3 and Figure 2-2 for descriptions and locations of existing and proposed new surface water monitoring stations.
9–10	Matrix	SW	Surface water

Field duplicate samples for surface water samples will be identified by selecting a unique location number not used for any actual samples. All samples will be cross-referenced in the field logbooks and in the sample master database to sample locations.

Example sample codes for surface water:

- 0515RD10SW: The regular surface water sample collected from surface water sampling station RD10 in Red Devil Creek in May 2015.
- 0515RD20SW: The field duplicate surface water sample collected from surface water sampling station RD10 in Red Devil Creek in May 2015.

Kuskokwim River Sediment
Sediment samples will be assigned sample identifiers as specified in Table 3-4. Pre-assigned sample location identifiers for proposed sediment samples are presented in Table 2-4 and on Figures 2-3 and 2-4.

Table 3-4 Sample Identification Coding System: Kuskokwim River Sediment

Characters	Purpose	Code	Description
1–2	Sample collection year	15	Last two digits of year
3–4	Area	KR	Kuskokwim River
5–7	Location number	082, 083, etc.	Consecutive number within area
8–9	Matrix	SD	Sediment

Field duplicate samples for sediment will be identified by selecting a unique location number not used for any actual samples. All samples will be cross-referenced in the field logbooks and in the sample master database to sample locations.

Example sample codes for Kuskokwim River sediment:

- 15KR082SD: The regular sediment sample collected from proposed sampling location KR082 in 2015.
- 15KR150SD: The field duplicate sediment sample collected from proposed sampling location KR082 in 2015.

4 Sampling and Other Field Procedures

This chapter describes the procedures and equipment to be used in the collection of samples and field observations during the 2015 field activities. E & E standard operating procedures (SOPs) are referred to in this chapter and subsequent chapters. Copies of all applicable E & E SOPs will be on site during the implementation of the 2015 field work.

All surface water and groundwater sampling conducted for the 2015 field activities will be conducted using ultraclean sampling methods (U.S. Environmental Protection Agency [EPA] Method 1669). In summary, ultraclean sampling methods involve the following procedures:

- Sampling equipment and containers that have been cleaned using detergent, mineral acids, and reagent water, filled with weak acid solution, and individually double-bagged for storage and shipment are obtained from the laboratory.
- On site, one member of the two-person sampling team is designated as "dirty hands;" the second member is designated as "clean hands." All operations involving contact with the sample container and transfer of the sample from the sample collection device to the sample container are handled by the individual designated as "clean hands."
- A new pair of 8-millimeter nitrile gloves will be worn during each sample collection.
- All sampling equipment and sample containers used will be non-metallic and free from any material that may contain metals.
- Sampling personnel will wear clean, non-talc gloves when handling sampling equipment and sample containers.
- Surface water samples will be collected facing upstream and upwind (when possible) to minimize introduction of contamination.
- Acid preservatives will be placed in sample containers in a clean area prior to sample collection.

4.1 Soil Boring Installation and Subsurface Soil Sampling

Subsurface soil samples will be collected at soil boring locations identified in Section 2.1. Soil borings will be installed using a drill rig operated by a subcontracted, Alaska-licensed driller. A track-mounted drill rig capable of direct push, hollow-stem auger, and air-rotary/down-the-hole hammer drilling techniques will be used to advance the soil borings. The type of drilling method and equipment to be used will depend on the types of subsurface material anticipated and encountered. In general, it is anticipated that direct-push and hollow-stem auger equipment/methods will be used for overburden soils, and air rotary down-the-hole hammer equipment/method will be used for drilling in bedrock. A 2-foot-long split spoon sampler will be used for subsurface soil sampling using direct-push and hollow-stem auger drilling methods. Soil cores will be collected continuously from the ground surface to the base of the unconsolidated materials. While drilling in bedrock, drill cuttings will be collected at a minimum at 5-foot intervals.

Drilling and soil coring will continue at each borehole to the targeted depth if possible. The target depth of each borehole will depend on the specific objective for that borehole and conditions encountered during drilling, as described below. Targeted drilling depth criteria for soil borings are summarized in Table 2-1.

Each borehole will be logged by a project geologist. Observations of soil materials will include the following:

- Soil type (consistent with soil type designations presented in the final RI report);
- Soil group classification (using United Soil Classification System);
- Color;
- Odor;
- Lithology and mineralogical characteristics and grain shape and size of clasts;
- Grain size range and distribution;
- Gradation;
- Soil particle lithology;
- Hardness;
- Plasticity;
- Bedding or sedimentary structures;
- Moisture content;
- Observations of gross contamination, including sheen and elemental mercury;
- Qualitative description of matrix porosity;
- Mineralization, including sulfides and iron staining; and
- Weathering.

In addition to those observations listed above for soil materials, observations will include:

- Lithology and mineralogical characteristics of bedrock; and
- Bedrock fracture characteristics (e.g., dip angle, spacing, smoothness/planarity, void width, weathering, fracture-filling mineralogy, and stain thickness) will be made if feasible (e.g., if the materials can be penetrated and samples with a split spoon sampler).

Following initial visual observation of the recovered soil material, an aliquot of the soil will be collected for possible laboratory analysis for mercury SSE by placing the material directly into the sample container without homogenizing, thereby reducing potential volatilization of any elemental mercury that could be present in the material. Following collection of an aliquot for mercury SSE, sample material will be placed into a clean, dedicated, re-sealable, plastic bag and the bag will be sealed. This material will be homogenized by working the material manually within the sealed bag. This material will then be field screened with an XRF obtain total metals concentration data for the subject interval. This data will be used in the field for the selection of samples for additional analyses as described below.

A subset of subsurface soil samples collected will be selected for laboratory analysis for total TAL metals and mercury SSE. Planned sampling for analytical laboratory analysis and the rationale for selection of samples are summarized in Table 2-1.

After boreholes have been successfully advanced, unless they are converted to monitoring wells, they will be abandoned at the completion of sampling or the end of the day. Soil borings will be abandoned in accordance with State of Alaska regulations. Management of drill cuttings will be performed as specified in Chapter 7. Monitoring wells will be installed as described in Section 4.2.

4.2 Monitoring Well Installation, Construction, and Development

New monitoring wells will be installed within selected soil borings at the locations identified in Section 2.2. Wells will be installed in accordance with State of Alaska regulations and as described below.

The monitoring wells will be constructed of 2-inch inside-diameter, Schedule 40, National Sanitation Foundation (NSF)-approved, PVC flush-threaded joints. The wells will be screened with one 10-foot or 20-foot section of 2-inch, 0.010-inch slot PVC screen, or equivalent. Sections of prefabricated sand pack filter/screen (“pre-pack” screens) may be used for construction of some new monitoring wells. Prefabricated “pre-pack” screens may be used to achieve a consistent sand pack thickness throughout the entire screened interval in wells installed in bedrock or unconsolidated materials. The inner diameter of the “pre-pack” screen section is consistent with the casing sections, and the outer diameter is 4 inches. A 1-foot, 2-inch diameter, schedule 40, matching thread, NSF-approved sump will be attached to the base of the well screen. The monitoring wells will be completed to ground surface using schedule 40 PVC riser. All PVC casing joints will be of matching flush-threaded design with Viton O-rings and will be screwed together without the use of glues, epoxies, or petroleum-based lubricants. All materials will be cleaned and placed in polyethylene bags at the factory; the bags will remain sealed until the time of installation.

The monitoring well screen intervals will be selected at the time of well installation by the project geologist. Selection of screen intervals will be based on the target criteria specified in Table 2-1. For wells screened in bedrock, the screen interval will be selected to straddle an interval that, based on observations made during drilling, is expected to produce water; such intervals are expected to consist of fractured bedrock. If the selected well screen interval lies above the total depth of the boring, the boring will be backfilled with bentonite pellets to a depth corresponding to the base of the sump. A minimum one-hour period will be allotted for hydration of the bentonite prior to well installation.

The annular space between the well screen and borehole will be filled with a uniform sand pack (i.e., conforming to the selected screen size) to serve as a filter media. The top of the sand pack will extend to approximately 2 to 3 feet above the top of the well screen.

A minimum 2-foot-thick bentonite pellet seal will be installed directly above the sand pack. A measured volume of clean water will be added and a specified time period (minimum one hour) will be allotted for maximum hydration. The remaining annulus will be filled with high solids bentonite grout or hydrated bentonite pellets or chips. The bentonite grout will consist of a mixture of powdered bentonite with the recommended volume of water to achieve an optimal seal. The grout will contain at least 30 percent solids by weight and have a density of 11 pounds per gallon or greater. Grout will be emplaced to approximately 3 feet bgs using a tremie pipe from the bottom of the annular space upwards to the surface.

A concrete or cement surface seal will be used to finish grouting the annular space during well completions as discussed below. The monitoring wells will be completed with a 2.5-foot steel riser with locking monument above the ground surface. A locking well cap will secure the well inside the monument.

Prior to well development, grout will be allowed to cure for a minimum of 24 to 72 hours to allow sufficient time for the bentonite seal to cure. For wells installed below the water table, grout will be allowed a minimum of 72 hours curing time prior to development. For wells in which the bentonite seal is above the water table, development may proceed after a minimum of 24 hours.

Well development will be accomplished by a combination of mechanical surging, bailing, and pumping with a submersible pump. The wells will be mechanically surged, depending on the geologic characteristics of the screened interval, to remove fines from inside the screen and casing and to flush the formation around the filter pack throughout the entire screened interval. Fines will be removed from the borehole periodically during the surging process using a bailer to minimize the re-entry of fines into the formation. The monitoring wells will then be pumped with a submersible pump until the measured water quality parameters are stabilized. Water will be removed throughout the entire water column by periodically lowering and raising the pump intake. Development will be considered complete when all water introduced during drilling, if any, plus a minimum of 5 to 10 well-bore volumes have been removed from the well, and the water is chemically stable and as free of sediment as possible. Water produced from the well will be considered chemically stable when field parameters, measured by E & E (pH, temperature, specific conductance, and turbidity) remain within 10 percent of the previous measurement for at least three successive measurements. Water produced from the well will be considered free of sediment when it is clear or turbidity has stabilized for at least three successive borehole measurements. The pump, tubing, and all other equipment used during development will be decontaminated between each use. All development water generated will be collected in 55-gallon drums. The development water will be disposed of as described in Section 7.3.

4.3 Groundwater Sampling

During the 2015 groundwater sampling events, groundwater samples will be collected from existing and new monitoring wells specified in Table 2-2. To the extent practicable, groundwater sampling will occur in a progression from the least to the most contaminated wells, based on existing groundwater sample data.

In general, each well will be sampled following the EPA's Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA 542-S-02-001 (EPA 2002). The expected sampling approach is specified below.

Prior to groundwater sampling, a round of static water level measurements will be performed at each well. Depth to groundwater will be measured to the nearest 0.01 foot using an electronic water level meter. The locking cover and protective cap will be removed, and the static water level depth will be measured from the surveyed measuring point (usually the north side of the top of the inside well casing). If the casing cap is airtight as evidenced by release or drawing of air upon removal of the well cap, time will be allowed prior to water level measurement for equilibration of pressures after the cap is removed. Measurements will be repeated until the water level is stabilized. The water level meter will be cleaned with an environmental grade non-phosphate detergent before prior to sounding the well. All parts of the water level meter that will contact groundwater will be rinsed with distilled water before placement in the well. Groundwater levels in all monitoring wells will be measured within as short a period of time as feasible, not to exceed one day, in order to provide data representative of the potentiometric surface(s) at the time of the sampling event. The water level measurements will be used to determine groundwater elevation and to estimate the standing water volume contained within the well. The measurement will also be used to determine the depth of the pump intake and to monitor water drawdown during low-flow purging and sampling, as described below.

Groundwater purging and sampling will be performed using a low-flow technique at each well, if feasible. If it is determined that it is not feasible to use a low-flow technique at a given well, the well will be purged utilizing an alternate technique with a pump and/or disposable bailers as described below.

Low-Flow Purging Technique
Low-flow purging/sampling will be performed following the EPA's Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA 542-S-02-001 (EPA 2002) and Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (Puls and Barcelona, 1996). Low-flow purging and sampling will be performed using a submersible pump, a bladder pump, or a battery-operated peristaltic pump outfitted with dedicated, disposable tubing.

The tubing/pump intake will be carefully lowered into the well to the targeted sample point (e.g., at the middle of the water column within the screen interval). The well will be purged at a target rate of less than 0.5 liter per minute. During purging, the water level will be monitored with the water level indicator to measure well drawdown and to guide the adjustment of purge rate to minimize drawdown while purging. The water level will be monitored continuously during purging and the sampling team will attempt to maintain less than 0.1 meter of drawdown during purging.

During purging, field water quality parameters, including pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity, will be measured to determine when stabilization of the groundwater is achieved. Water quality parameters will be measured using an in-line water quality meter (e.g., Horiba U50 or similar equipment) and recorded in the field logbook. Field parameters will be measured every 3 to 5 minutes during purging. Field parameters will be considered stabilized after all parameters have stabilized for three successive readings. Criteria for stabilization are three successive readings within the following limits include:

- pH: ±0.1 pH units;
- Temperature: ±1 degree Celsius (°C);
- Specific electrical conductance (conductivity): ±3%;
- Turbidity: ±10% (when turbidity is greater than 10 nephelometric turbidity units);
- Dissolved oxygen: ±0.3 milligrams per liter; and
- Oxidation Reduction Potential: ±10 millivolts.

Upon stabilization of field parameters, groundwater samples will be collected directly into the appropriate (pre-preserved, as applicable) sample containers.

The use of peristaltic pumps to collect groundwater samples is limited by the ability of peristaltic pumps to draw water from depths of greater than approximately 25 feet. If it is not possible to collect a groundwater sample from a given well using a peristaltic pump, the sampling team will attempt to use a decontaminated, positive-pressure pump (bladder pump or electric submersible pump) to purge and sample the well using low-flow techniques.

Following successful purging, samples will be collected as described below.

If the drawdown and/or field water quality parameter criteria cannot be met, then the well will be sampled using an alternate purging technique, described below.

Alternate Purging Technique
If low-flow technique is not successful at a given well, purging will be accomplished using a positive pressure pump (e.g., submersible pump) and/or a dedicated, disposable Teflon-lined bailer. A minimum of three casing volumes of water will be purged prior to sample collection unless the well runs out of recoverable water. Field water quality parameters will be measured in the first water extracted from the well and subsequently after each time a casing volume is purged. If a bailer is used, water quality parameters will be measured by pouring a volume of water from a bailer into a container and submerging the water quality meter probe into the container. It may not be possible to achieve the stabilization criteria outlined above using a bailer to purge the well. In this case, sample collection will be performed after six well volumes have been purged from the well.

In the event that the well runs dry during purging, the well will be allowed to recharge for up to 24 hours. Upon resumption of pumping, field water quality parameters will be measured, and samples will be immediately collected.

Sample Collection
Samples will be collected for the parameters specified in Table 2-2. Samples will be collected in bottles provided by the analytical laboratory. Bottle sets will be filled in the following general order: non-filtered, non-preserved aliquots; followed by non-filtered preserved aliquots; followed by filtered, non-preserved aliquots; followed by filtered preserved aliquots. Aliquots for dissolved constituents will be field-filtered using a dedicated 0.45-micrometer filter.

For those wells sampled for BTEX, if a positive-pressure pump is not used to purge and sample the well, the aliquot for BTEX will be collected with a bailer following collection of all other aliquots.

For samples collected using a low-flow purging technique, samples will be collected immediately following stabilization of water quality parameters with the pump still running at the stabilized purge rate. For filtered aliquot collection, the filter will be inserted into the end of the sample tubing while the pump is still running in order to maintain a steady flow of water, minimizing potential disturbance of formation groundwater. Following installation of the filter, water will be allowed to run through the filter for several filter volumes prior to sample collection. The dissolved sample aliquot will then be collected directly into the appropriate sample container.

Samples collected by bailer will be poured directly into the appropriate pre-cleaned sample containers. Filtered aliquots will be collected by pouring water from the bailer into a dedicated transfer container and pumping the water into the sample container using a peristaltic pump outfitted with dedicated tubing and in-line 0.45 micrometer filter.

4.4 Surface Water Sampling

Surface water samples from locations specified in Table 2-3 and illustrated in Figure 2-3, including locations along Red Devil Creek and the seep on the left bank of the creek. Sampling will start at the most downstream location and proceed upstream to avoid disturbing sediments that could impact turbidity and contaminant concentrations in downstream locations.

Samples will be collected for the parameters specified in Table 2-3. Samples will be collected in bottles provided by the analytical laboratory. Bottle sets will be filled in the following general order: non-filtered, non-preserved aliquots; followed by non-filtered preserved aliquots; followed by filtered, non-preserved aliquots; followed by filtered preserved aliquots. Aliquots for dissolved constituents will be field-filtered using a dedicated 0.45-micrometer filter.

Samples will be collected using a battery-operated peristaltic pump outfitted with dedicated silicone tubing. The water sample will be collected from a single location within the middle of the stream channel at the mid-depth water level. Dissolved metals aliquots will be collected following collection of the other aliquots using a dedicated in-line 0.45-micrometer filter.

In the event that it is not possible to collect the water samples using a peristaltic pump, the samples will be collected by hand-dipping the sample container directly into the creek water. For sample containers that have been pre-preserved, a separate dedicated bottle may be used as a transfer container.

Following sample collection at each location, field parameters for pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity will be measured using a calibrated water quality meter and then recorded in the field logbook.

4.5 Stream and Seep Discharge Measurement

Surface water discharge will be measured using the Mid-Section method at each surface water sampling location where the estimated discharge is greater than 2.0 cubic feet per second (cfs) and a portable weir plate will be used for stream sections with smaller discharge rates. Discharge will be measured in accordance with Measurement and Computation of Streamflow: Volume 1, Measurement of Stage and Discharge (Rantz et al. 1982) and Techniques of Water-Resources Investigations Reports (U.S. Geological Survey [USGS] 2011).

4.5.1 Measurement Methods

The following sections detail the methods to be used. Field staff will determine which of the two proposed methods will be applied based on the flow rate during the measurement event.

4.5.1.1 Mid-Section Method

The Mid-Section method involves measuring the channel area and water velocities at a stream cross section. This method will be used where sufficient stream flow is available to allow the channel to be divided into rectangular subsections. After dividing the stream into subsections, the depth, discharge, and distance from the bank will be measured at the center of the stream subsection.

The preferred number of subsections across the width of the stream is 20 to 30, with a minimum of 10. If the stream width is less than 5 feet, the width of the subsections should not be less than 0.5 foot. Not more than 5 percent of stream discharge should occur within a single subsection. Subsections do not have to be the same width. For water depths greater than 2.5 feet, velocity will be measured at two depths, 20 and 80 percent of the total subsection depth, and averaged. For water depths less than 2.5 feet, velocity only will be measured at 60 percent of the total subsection depth.

Appropriate locations for stream cross sections are straight reaches where the streambed is uniform, free of boulders and aquatic vegetation, and where the stream flow is uniform.

4.5.1.2 Portable Weir Plates

Portable weir plates will be used where Red Devil Creek is too small or velocities too low to reliably use the above Mid-Section method. This is typically where stream widths are shallow and flows are less than 2.0 cfs. Weir plates are constructed with a staff gage on the upstream side, far enough away from the notch so it is not impacted by the drawdown of flow through the notch. Once a steady-state discharge through the weir has been reached, the height behind the weir plate is recorded to determine the flow rate through the weir. These are intended to be short-term measurement devices and are removed after each use.

4.5.2 Discharge Calculation

The general equation for calculating discharge is:

Discharge (Q) = Velocity (v) x Cross sectional area of stream channel (A)

For the Mid-Section method, stream discharge will be calculated for each subsection (q) and then summed together to obtain total discharge (Q).

$q_{1,2,3,etc.} = V_{1,2,3,etc.}$ x Depth at $\text{Midpoint}_{1,2,3,etc.}$ x Width of $\text{Subsection}_{1,2,3,etc.}$

and,

$Q = q_1 + q_2 + q_3 + q_{etc.}$

For the Portable Weir Plate method, the following equation will be used:

Q = Ch^(5/2)

where,

Q = Discharge (cfs);
h = Static head above the bottom of the notch (mean gage height), in feet; and
C = Coefficient of discharge. A standard value of 2.47 will be used for C assuming a 90 degree notched V-weir.

4.5.3 Equipment

Stream discharge measurement will require the following equipment:

Mid-Section Method: A Marsh McBirney or similar flow meter, top-setting wading rod, long tape measure, waders, and calculator.

Portable Weir Plate: Portable weir plate, constructed to USGS standard specifications, shovel, carpenter's level, rebar to stabilize the weir (as needed), and canvas or similar to prevent downstream undercutting.

4.5.4 Stream Measurements

4.5.4.1 Mid-Section Method

After identifying a suitable location for the stream cross section, a reference point on one bank will be selected. A tape measure will be stretched across the stream, fixing it to the reference point on one bank and another point on the opposite bank, while ensuring that the tape is oriented perpendicular to the stream flow.

Using the measured channel width, the appropriate number of subsections will be determined based on the guidelines in Section 4.5.1.

From the mid-point of each subsection, the stream velocity will be measured at the depths provided in Section 4.5.1. When measuring the stream velocity, the wading rod and flow meter should be located upstream from the field personnel to ensure that stream flow is not disrupted.

Discharge will then be calculated as described in Section 4.5.2 and the velocity of each subsection will be checked to ensure that it is less than 5 percent of the total stream discharge. If any subsection contains more than 5 percent of the stream discharge, additional subsections will be measured.

4.5.4.2 Portable Weir Plate

The weir plate would be pushed into the stream bed perpendicular to the flow, with an effort made to channel all of the stream flow through the weir by using stream bed material to pack around the weir and/or channelize the flow towards the opening of the weir plate. As needed, an estimation of flow around the weir will be made and noted. A carpenter's level will then be used to ensure that the weir is horizontal after insertion and that the weir is vertical. This will be done to provide an accurate and consistent measurement relative to the water surface. Weir plates will not be submerged on either the up or downstream sides also to increase accurate readings.

Once the pool height has stabilized on the upstream side of the weir, gage readings will be recorded every 30 seconds for three minutes. The mean value of these readings will then be used to compute discharge.

4.6 Kuskokwim River Sediment Sampling

Samples of Kuskokwim River sediment will be collected from offshore locations specified in Table 2-4 and illustrated in Figures 2-4 and 2-5. Samples will be collected for the analyses specified in Table 2-4.

Sediment samples will be collected using a combination of manual van Veen grab sampler and hand coring sediment sampling equipment deployed from a 20-foot, flat-bottomed boat. The sampling vessel will be outfitted with an A-frame and electric winch, fathometer, and Global Positioning System (GPS). The vessel and sampling equipment will be operated by Kinnetic Laboratories, Inc. under subcontract to E & E. An E & E sampler will oversee the operation of the sediment sampling equipment and will perform the collection and handling of sediment samples on board the vessel.

Samples will be collected using methods and equipment similar to those used to collect RI Kuskokwim River offshore sediment samples in 2011 and 2012. During the 2011 and 2012 Kuskokwim River sediment sampling events, sediment samples were collected using a manual van Veen grab sampler or hand coring equipment/method depending on water depth and river bottom substrate encountered at a given location. At many locations, the van Veen sampler was ineffective due to coarse sediment conditions. Where bottom sediment was not dominated by gravel and cobbles, sampling with a van Veen surface sediment grab sampler was attempted. At most locations, a hand auger was used. The sampling methods using these techniques are discussed below.

It is anticipated that sediment bed and river conditions will be similar to those encountered during the 2011 and 2012 sampling events. To collect adequate sediment volume to perform all proposed sediment analyses, including sediment toxicity, a volume of approximately 3 liters of sediment will be required for each sample. Based on RI sediment sampling efforts performed in 2011 and 2012, the sediment texture at some locations is very coarse grained (gravelly and cobbly) and not amenable to sampling or appropriate for the types of analyses planned.

Therefore, for those 2015 locations intended to be collocated with previous RI samples, selection of sample locations is biased toward locations where, based on RI sampling results, larger proportions of finer grained materials (sand size and smaller). In addition, the selected locations are biased toward RI sample locations that exhibited fairly similar TOC concentrations and a wide range of total antimony, arsenic, and mercury concentrations.

The vessel will be positioned on the sampling locations using an anchoring system or live-boating.

Based on past RI sampling efforts, it may not be possible to collect sufficient sediment from some proposed sample locations due to the swift current and/or the gravel/cobble nature of the bottom. In the event that a sample cannot be obtained at a given location, the sampling team will relocate, at the discretion of the E & E field team leader, to a secondary nearby location with potentially better bottom conditions for obtaining a sample. This new location will be selected based on similar location characteristics and using best professional judgment. In the event that a sediment sample cannot be obtained at the secondary location, the station will be abandoned and the E & E project manager and BLM will be notified.

Surface sediment samples will be collected from the 0- to 10-centimeters (0- to 4-inches) interval. As detailed above, multiple grabs may be required to obtain an adequate sample volume for all analyses. Compositing and homogenization of samples is described below.

For all sampling, field data will be recorded in a logbook and field forms.

Sediment sampling equipment will be decontaminated with phosphate-free detergent and a de-ionized water rinse between uses.

Van Veen Sampler Procedure

For samples collection using a van Veen grab sampler, the steps below will be followed:

1) Position the vessel at the sample location.
2) Set the van Veen sampler jaws in the open position, place the sampler over the edge of the boat, and lower the sampler to the bottom.
3) Trip the sampler to collect the sample.
4) Record the horizontal location coordinates of the sample location using the GPS and record the water depth.
5) Retrieve the sampler and place it securely in the sampling vessel.
6) Examine the sample for the following sample acceptance criteria; if criteria are not achieved, the sample will be rejected and another collection attempt will be made.
    a. The sampler is not overfilled with sample material (to prevent the sediment surface from pressing against the top of the sampler).

b. The sample does not contain large foreign objects such as trash or debris. A sample that is predominately rock/gravel will be rejected in favor of finer-grained material.
c. Overlying water is present in the sampler (indicates minimal leakage of material from the sampler).
d. The overlying water is not excessively turbid (indicates minimal disturbance of the sample).
e. The sediment surface is relatively flat (indicates minimal disturbance or winnowing of the sample).
f. The depth of sediment in the sampler is several centimeters greater than the targeted sample depth of 10 centimeters (indicates the desired penetration depth into the bed sediment is achieved).

7) Siphon off any overlying surface water.
8) Measure and collect the top 10 centimeters (4 inches) of sediment with a disposable plastic scoop, avoiding any sediment that is in contact with the inside surface of the grab sampler, then place the sediment into a dedicated, disposable, plastic bowl and cover with aluminum foil.
9) Record the following observations of sediment sample characteristics:
   a. Texture (grain-size distribution)
   b. Color
   c. Biological organisms or structures
   d. Bedding or sedimentary structures
   e. Presence of debris (natural or anthropogenic objects)
   f. Presence of obvious tailings, waste rock, or gross contamination
   g. Lithology of sediment particles
   h. Mineralization, including metal sulfides and iron staining
   i. Odor (for example, hydrogen sulfide or petroleum)
10) If more sample volume is required, repeat steps 1 through 9.
11) Once sufficient sediment volume has been collected, homogenize the sample by mixing with a dedicated, disposable, plastic scoop until a consistent color and texture are achieved. Place sample material in the appropriate, pre-cleaned, labeled sample containers, place in a cooler maintained at 4°Celsius, and prepare for shipment to the analytical laboratory.
12) Confirm all relevant documentation has been completed, entries are accurate, and paperwork has been signed.
13) Wash excess sediment back into the water away from any areas remaining to be sampled.
14) Decontaminate all sampling equipment before proceeding to the next sampling location.

Hand Coring Procedure

For sample collection using hand coring equipment, the steps below will be followed:

1) Position the vessel at the sample location.
2) Lower the hand coring tool from the side of the vessel and collect and retrieve a sediment core.

3) Record the horizontal location coordinates of the sample location using the GPS and record the water depth.
4) Retrieve the sampler and place it securely in the sampling vessel.
5) Examine the sample for the following sample acceptance criteria; if criteria are not achieved, the sample will be rejected and another collection attempt will be made.
    a. The sampler is not overfilled with sample material (to prevent the sediment surface from pressing against the top of the sampler).
    b. The sample does not contain large foreign objects such as trash or debris. A sample that is predominately rock/gravel will be rejected in favor of finer-grained material.
    c. The sediment surface is relatively flat (indicates minimal disturbance or winnowing of the sample).
    d. The depth of sediment in the sampler is several centimeters greater than the targeted sample depth of 10 centimeters (indicates the desired penetration depth into the bed sediment is achieved).
6) Siphon off any overlying surface water.
7) Measure and collect the top 10 centimeters (4 inches) of sediment with a disposable, plastic scoop, then place the sediment into a dedicated, disposable, plastic bowl and cover with aluminum foil.
8) Record the following observations of sediment sample characteristics:
    a. Texture (grain-size distribution)
    b. Color
    c. Biological organisms or structures
    d. Bedding or sedimentary structures
    e. Presence of debris (natural or anthropogenic objects)
    f. Presence of obvious tailings, waste rock, or gross contamination
    g. Lithology of sediment particles
    h. Mineralization, including metal sulfides and iron staining
    i. Odor (for example, hydrogen sulfide or petroleum)
9) If more sample volume is required, repeat steps 1 through 9.
10) Once sufficient sediment volume has been collected, homogenize the sample by mixing with a dedicated, disposable, plastic scoop until a consistent color and texture are achieved. Place sample material in the appropriate, pre-cleaned, labeled sample containers, place in a cooler maintained at 4°Celsius, and prepare for shipment to the analytical laboratory.
11) Confirm all relevant documentation has been completed, entries are accurate, and paperwork has been signed.
12) Wash excess sediment back into the water, away from any areas remaining to be sampled.
13) Decontaminate all sampling equipment before proceeding to the next sampling location.

5 Sample Analytical Methods

Sample analytical methods, including holding times and method detection limits, are presented in the QAPP, provided as Appendix C of the final RI/FS work plan (E & E 2011). For reference, Table 5-1 summarizes the sample analytical methods.

Table 5-1 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
Matrix: Soil/Sediment		
Analytical Group: Metals		
Total Metals	▪ Mercury	▪ EPA 7471A
	▪ Mercury (low level)	▪ EPA 1631
	▪ Aluminum	▪ EPA 6010B
	▪ Antimony	▪ EPA 6020A (mass=121)
		▪ EPA 6020A (mass=123)
	▪ Arsenic	▪ EPA 6010B
	▪ Arsenic (low level)	▪ EPA 6020A
	▪ Barium	▪ EPA 6020A (mass=135)
		▪ EPA 6020A (mass=137)
	▪ Beryllium	▪ EPA 6020A
	▪ Cadmium	▪ EPA 6020A (mass=111)
		▪ EPA 6020A (mass=114)
	▪ Calcium	▪ EPA 6010B
	▪ Chromium	▪ EPA 6020A (mass=52)
		▪ EPA 6020A (mass=53)
	▪ Cobalt	▪ EPA 6020A
	▪ Copper	▪ EPA 6020A (mass=63)
		▪ EPA 6020A (mass=65)
	▪ Iron	▪ EPA 6010B (mass=54)
		▪ EPA 6010B (mass=57)
	▪ Lead	▪ EPA 6010B
	▪ Magnesium	▪ EPA 6010B
	▪ Manganese	▪ EPA 6020A
	▪ Nickel	▪ EPA 6020A (mass=60)
		▪ EPA 6020A (mass=62)
	▪ Potassium	▪ EPA 6010B
	▪ Selenium	▪ EPA 6020A (mass=82)
		▪ EPA 6020A (mass=78)
	▪ Silver	▪ EPA 6020A
	▪ Sodium	▪ EPA 6010B
	▪ Thallium	▪ EPA 6020A
	▪ Vanadium	▪ EPA 6020A
	▪ Zinc	▪ EPA 6020A (mass=66)
		▪ EPA 6020A (mass=67)
		▪ EPA 6020A (mass=68)
Mercury Selective Sequential Extraction (SSE)	▪ Mercury	▪ BRL SOP #BR-0013; Hg 5-step SSE and (www.epa.gov/esd/pdf-ecb/542asd95.pdf)
Analytical Group: Conventionals		
	▪ Grain Size Analysis	▪ ASTM D422
	▪ Total Organic Carbon (TOC)	▪ EPA 9060 modified
Analytical Group: Toxicity		
***Hyalella Azteca* (42-day)**	Toxicity	▪ EPA 100.4

Table 5-1 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
Matrix: Groundwater/Surface Water		
Analytical Group: Metals		
▪ **Total and Dissolved Metals**	▪ Mercury (low level)	▪ EPA 1631
	▪ Aluminum	▪ EPA 6010B
	▪ Antimony	▪ EPA 6020A (mass=121)
		▪ EPA 6020A (mass=123)
	▪ Arsenic	▪ EPA 6020A
	▪ Barium	▪ EPA 6020A (mass=135)
		▪ EPA 6020A (mass=137)
	▪ Beryllium	▪ EPA 6020A
	▪ Cadmium	▪ EPA 6020A (mass=111)
		▪ EPA 6020A (mass=114)
	▪ Calcium	▪ EPA 6010B
	▪ Chromium	▪ EPA 6020A (mass=52)
		▪ EPA 6020A (mass=53)
	▪ Cobalt	▪ EPA 6020A
	▪ Copper	▪ EPA 6020A (mass=63)
		▪ EPA 6020A (mass=65)
	▪ Iron	▪ EPA 6010B (mass=54)
		▪ EPA 6010B (mass=57)
	▪ Lead	▪ EPA 6020A
	▪ Magnesium	▪ EPA 6010B
	▪ Manganese	▪ EPA 6010B
	▪ Nickel	▪ EPA 6020A (mass=60)
		▪ EPA 6020A (mass=62)
	▪ Potassium	▪ EPA 6010B
	▪ Selenium	▪ EPA 6020A (mass=82)
		▪ EPA 6020A (mass=78)
	▪ Silver	▪ EPA 6020A
	▪ Sodium	▪ EPA 6010B
	▪ Thallium	▪ EPA 6020A
	▪ Vanadium	▪ EPA 6020A
	▪ Zinc	▪ EPA 6020A (mass=66)
		▪ EPA 6020A (mass=67)
		▪ EPA 6020A (mass=68)
Analytical Group: Petroleum		
	▪ Gasoline Range Organics	▪ AK 101
	▪ Diesel Range Organics	▪ AK 102
	▪ Benzene	▪ EPA 8021B (15.0 mL)
		▪ EPA 8021B (5.0 mL)
	▪ Toluene	▪ EPA 8021B (15.0 mL)
		▪ EPA 8021B (5.0 mL)
	▪ Ethylbenzene	▪ EPA 8021B (15.0 mL)
		▪ EPA 8021B (5.0 mL)
	▪ m/p-Xylene	▪ EPA 8021B (15.0 mL)
		▪ EPA 8021B (5.0 mL)
	▪ o-Xylene	▪ EPA 8021B (15.0 mL)
		▪ EPA 8021B (5.0 mL)
Analytical Group: SVOCs		
	▪ SVOCs	▪ EPA 8270D

Table 5-1 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
Analytical Group: Conventionals		
	▪ Sulfate ▪ Chloride ▪ Fluoride ▪ Nitrate/Nitrite ▪ Carbonate/Bicarbonate ▪ Total Suspended Solids ▪ Total Dissolved Solids ▪ Total Organic Carbon	▪ EPA 300.0 ▪ EPA 300.0 ▪ EPA 300.0 ▪ EPA 353.2 ▪ EPA 310.1 ▪ EPA 160.2 ▪ EPA 160.1 ▪ EPA 9060

Key:

ASTM = ASTM International (formerly American Society of Testing and Materials)
BRL = Brooks Rand Labs
EPA = U.S. Environmental Protection Agency
Hg = mercury
mL = milliliter
SOP = standard operating procedure
SVOCs = semivolatile organic compounds

6 Sample Handling, Preservation, and Shipping

Transportation and handling of samples must be accomplished in a manner that not only protects their integrity, but also prevents any detrimental unnecessary exposure to sample handlers due to the possibly hazardous nature of the samples.

6.1 Sample Documentation

6.1.1 Sample Labels

Sample labels attached to or fixed around the sample container will be used to identify all samples collected in the field. The sample labels will be placed on bottles so as not to obscure any quality assurance/quality control (QA/QC) lot numbers on the bottles, and sample information will be printed legibly. Field identification will be sufficient to enable cross-reference with the project logbook.

To minimize handling of sample containers, labels will be filled out before sample collection. Each sample label will be written in waterproof ink, attached firmly to the sample containers, and protected with Mylar tape. The sample label will contain the following information:

- Sample designation code
- Date and time of collection
- Analysis required
- pH and preservation (when applicable)

6.1.2 Custody Seals

Custody seals are preprinted, adhesive-backed seals with security slots designed to break if the seals are disturbed. Sample shipping containers (e.g., coolers) will be sealed in as many places as necessary to ensure security. Seals will be signed and dated before use. Upon the containers' arrival at the laboratory, the custodian will check (and certify by completing the package receipt log) that seals are intact.

6.1.3 Chain-of-Custody Records

The COC records will be completed fully, at least in duplicate, by the field technician designated by the site manager as responsible for sample shipment. Information in the COC record will contain the same level of detail found in the site logbook, except that the onsite measurement data will not be recorded. The custody record will include, among other things, the following information:

- Name and company or organization of person collecting the samples;
- Date of sample collected;
- Matrix of sample collected (soil/water);
- Location of sampling station (using the sample designation code system described in Chapter 3);
- Number and type of containers shipped;
- Analysis requested;
- Signature of the person relinquishing samples to the transporter, with the date and time of transfer noted, and signature of the designated sample custodian at the receiving facility.

If samples require rapid laboratory turnaround, the person completing the COC record will note these or similar requirements in the remarks section of the custody record.

The relinquishing individual will record pertinent shipping data (e.g., air-bill number, organization, time, and date) on the original custody record, which will be transported with the samples to the laboratory and retained in the laboratory's file. Original and duplicate custody records with the air bill or delivery note constitute a complete custody record. The field team leader will ensure that all records are consistent and that they are made part of the permanent job file.

6.1.4 Field Logbooks and Data Forms

Field logbooks (or daily logs) and data forms are necessary to document daily activities and observations. Documentation will be sufficient to enable reconstruction of events that occurred during the project accurately and objectively at a later time. All daily logs will be kept in a bound notebook containing numbered pages, and all entries will be made in waterproof ink, dated, and signed. No pages will be removed for any reason.

Minimum logbook content requirements are described in E & E's SOPs, *Preparation of Field Activities Logbooks*, a copy of which will be kept on site during the field activities. If corrections are necessary, they will be made by drawing a single line through the original entry (so that the original entry is still legible) and writing the corrected entry alongside it. The correction will be initialed and dated. Corrected errors may require a footnote explaining the correction.

6.1.5 Photographs

Photographs will be taken as directed by the team leader. Documentation of a photograph is crucial to ensure its validity as a representation of an existing situation.

The following information on photographs will be noted in field logbooks:

- Date, time, and location photograph was taken;
- Weather conditions;
- Description of photograph;
- Reasons photograph was taken;
- Sequential number of photograph; and
- Direction.

After the photographs are processed, the information recorded in the field logbook will be summarized in captions in the digital photo log.

6.1.6 Custody Procedures

The primary objective of COC procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is considered to be in custody if it is:

- In someone's physical possession,
- In someone's view,
- Locked up, and
- Kept in a secured area that allows authorized personnel only.

6.1.6.1 Field Custody Procedures

The following guidance will be used to properly control samples during fieldwork:

- As few people as possible will handle samples.
- Coolers or boxes containing cleaned bottles will be sealed with custody tape during transport to the field or while in storage before use. Sample bottles from unsealed coolers or boxes, or bottles that appear to have been tampered with, will not be used.
- The sample collector will be responsible for the care and custody of samples until they are transferred to another person or dispatched properly under COC rules.
- The sample collector will record sample data in the field logbook.
- The site team leader will determine whether proper custody procedures were followed during the fieldwork and decide whether additional samples are required.

When custody is transferred (e.g., samples are released to a shipping agent), the following will apply:

- The coolers in which the samples are packed will be sealed and accompanied by two COC records. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the COC record. This record documents sample custody transfer.
- Samples will be dispatched to the laboratory for analysis with separate COC records accompanying each shipment. Shipping containers will be sealed with custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information will be entered in the COC record.
- All shipments will be accompanied by COC records identifying their contents. The original record will accompany the shipment. The other copies will be distributed appropriately to the site team leader and site manager.
- If samples are sent by common carrier, a bill of lading will be used. Freight bills and bills of lading will be retained as part of the permanent documentation.

6.1.6.2 Laboratory Custody Procedures

A designated sample custodian at the laboratory will accept custody of the shipped samples from the carrier and enter preliminary information about the package into a package or sample receipt log, including the initials of the person delivering the package and the status of the custody seals on the coolers (e.g., broken versus unbroken). Additional details on laboratory custody procedures are found in the QAPP.

6.2 Sample Containers and Preservation

Sample aliquots submitted to the analytical laboratories will be placed in commercial certified pre-cleaned sample containers and preserved as identified in Table 6-1.

6.3 Sample Shipping

Due to the remote location of the RDM site, sample shipment to the analytical laboratories will require careful logistical planning to ensure sample holding times are not exceeded and that samples arrive at the laboratories in good condition. In general, sample shipping logistics will involve the following:

- The field team leader will keep records of sample collection dates. Based on the dates of samples being held on site and the number of samples ready for shipment, the field team leader will contact E & E's Anchorage-based sample custodian to notify an aircraft charter service that a sample shipment flight is needed.
- When the sample shipment aircraft arrives at the Red Devil airstrip, the field team leader will relinquish custody of the samples to the pilot.
- When the sample shipment aircraft arrives in Anchorage, E & E's Anchorage-based sample custodian will assume custody of the samples. The custodian will re-pack all sample shipping containers with fresh ice

and relinquish custody of the samples to an overnight delivery service that will ship the samples to the analytical laboratories.

- E & E's Anchorage-based sample custodian will confirm with the laboratories that all shipped samples have been received.

Table 6-1 Sample Containers and Preservation

Matrix	Analysis	Maximum Holding Time	Preservation	Sample Containers
Soil/Sediment	Total TAL Inorganic Elements (EPA 6010B/6020A/7471A)	6 months (28 days for Hg)	None, 0–4°C	4-oz glass jar
	Mercury SSE with total Hg	1 year	None, 0–4°C (shipment), ≤ –15°C (in lab)	4-oz glass jar
	Total Organic Carbon (EPA 9060)	28 days	None, cool to 4°C ± 2°C	4-oz glass jar
	Grain Size (ASTM D422)	None	None, 0–4°C	16-oz glass or plastic jar
	Toxicity – *Hyalella Azteca (42-day)* (EPA 100.4)	8 weeks	None, 0–4°C	Per laboratory
Water	Total TAL Inorganic Elements	6 months (28 days for Hg)	HNO_3, pH<2, 0–4°C	500-mL plastic bottle
	Dissolved TAL Inorganic Elements	6 months	HNO_3, pH<2, 0–4°C	500-mL plastic bottle
	Total Low-Level Hg	90 days	HNO_3, pH<2, 0–4°C (BrCl in lab within 28 days of collection for low-level Hg)	500-mL (for MS/MSD sample) or 250-mL plastic bottle; pre-tested fluoropolymer or glass bottle w/fluoropolymer-lined lids
	Dissolved Low-Level Hg	90 days	HNO_3, pH<2, 0–4°C (BrCl in lab within 28 days of collection for low-level Hg)	500-mL (for MS/MSD sample) or 250-mL plastic bottle; pre-tested fluoropolymer or glass bottle w/fluoropolymer-lined lids
	Total Organic Carbon	28 days	HCl or H_2SO_4 to pH <2, cool to 4°C ± 2°C	1-L HDPE
	SVOCs	7 days for extraction, 40 days after extraction for analysis	None, 0–4°C	1-L amber bottle
	DRO	7 days for extraction, 40 days after extraction for analysis	None, 0–4°C	1-L amber bottle
	GRO and BTEX	14 days preserved, 7 days unpreserved.	HCl to pH <2, cool to 4°C	Four 40-mL amber glass vials, no headspace
	Total suspended solids	7 days	Cool to 6°C	1-L HDPE
	Total dissolved solids	7 days	Cool to 6°C	1-L HDPE
	Inorganic Ions (chloride, fluoride, sulfate)	28 days	Cool to 4°C	HDPE

Table 6-1 Sample Containers and Preservation

Matrix	Analysis	Maximum Holding Time	Preservation	Sample Containers
	Carbonate/Bicarbonate	14 days	Cool to 6°C	500 mL HDPE
	Nitrate/Nitrite as N	28 days	2 mL H_2SO_4 per liter. Cool to 6°C	500 mL or 1-L HDPE

Key:

°C = degrees Celsius
ASTM = American Society for Testing and Materials
BTEX = benzene, toluene, ethylbenzene, xylenes
BrCl = bromine monochloride
DRO = diesel range organics
GRO = gasoline range organics
HCl = hydrochloric acid
Hg = mercury
HDPE = high density polyethylene
HNO_3 = nitric acid
H_2SO_4 = sulfuric acid
L = liter
mL = milliliter
MS/MSD = matrix spike/matrix spike duplicate
oz = ounce
SSE = selective sequential extraction
SVOC = semivolatile organic compound
TAL = target analyte list

6.3.1 Sample Packaging

Samples will be packaged carefully to avoid breakage or contamination and will be shipped to the laboratory at proper temperatures. The following sample package requirements will be followed:

- Sample bottle lids must never be mixed. All sample lids must stay with the original containers.
- The sample volume level may be marked by placing the edge of the label at the appropriate sample height or by using a grease pencil. This will help the laboratory determine whether any leakage occurred during shipment. The label should not cover any bottle preparation QA/QC lot numbers.
- All sample bottles will be placed in a plastic bag to minimize leakage in case a bottle breaks during shipment.
- The samples will be cooled by placing on ice in sealed plastic bags. Ice is not to be used as a substitute for packing materials.
- Any remaining space in the sample shipping container should be filled with inert packing material. Under no circumstances should material such as sawdust, newspaper, or sand be used.
- The custody record must be sealed in a plastic bag and placed in the shipping container. Custody seals must be affixed to the sample cooler.

6.3.2 Shipping Containers

The appropriate shipping container will be determined by U.S. Department of Transportation (DOT) or International Air Transportation Association (IATA) regulations for the anticipated level of suspected contaminants. For the RDM 2015 field events, it is anticipated that all sample shipping containers will be commercially available coolers.

Shipping containers will be custody-sealed for shipment, as appropriate. The custody seals will be affixed so that access to the container can be gained only by breaking a seal.

Field personnel will arrange transportation of samples to the laboratory. When custody is relinquished to a shipper, field personnel will inform the laboratory sample custodian by telephone of the expected arrival time of the sample shipment and advise him or her of any time constraints on sample analysis.

Suggested guidelines for marking and labeling shipping containers are presented below. In all cases, DOT or IATA regulations will be consulted for appropriate marking and labeling requirements, which include the following:

- Use abbreviations only where specified.
- The words “This End Up” or “This Side Up” must be printed clearly on the top of the outer package. Upward-pointing arrows should be placed on the sides of the package.
- After a shipping container is sealed, two COC seals must be placed on the container, one on the front and one on the back. To protect the seals from accidental damage, clear strapping tape must be placed over them.

7 Decontamination and Management of Investigation-Derived Waste

7.1 Equipment Decontamination Procedures

Samples will be collected using either dedicated, disposable sampling equipment or non-dedicated equipment as indicated in Chapter 4. Procedures for decontaminating non-dedicated equipment are described below. Detailed information on decontamination procedures is provided in E & E's SOP, Sampling Equipment Decontamination.

Soil Boring Installation, Soil Sampling, and Monitoring Well Installation
Borehole drilling equipment (e.g., auger flights, drill rods, cutting shoe, sampler rods) and other non-dedicated drilling equipment will be decontaminated between sampling locations. Soil sampling equipment that contacts soil materials (e.g., split spoon soil sampler) will be decontaminated between each sample. Drilling equipment will be decontaminated using a high-pressure water washer before the start of work and between each borehole to minimize the potential for cross-contamination between sampling locations. Non-dedicated soil sampling equipment will be decontaminated using the following process:

- Phosphate-free detergent (e.g., Alconox®) and water wash
- Potable water rinse
- 10% nitric acid/water solution rinse
- Distilled water final rinse
- Air dry

Monitoring Well Development and Groundwater Sampling
Non-dedicated well development and sampling equipment (e.g., surge block, submersible pump, water level indicator) will decontaminated between sampling locations using the following steps:

- Physical removal – Remove solid material using a dry brush or paper towels.
- Wash – Scrub with a solution of non-phosphate detergent (e.g., Alconox®) and tap water. A 5-gallon bucket lined with a clean garbage bag or a 3-foot long by 4-inch diameter polyvinylchloride (PVC) pipe will be filled with non-phosphate detergent and tap water. Materials and

equipment will be scrubbed with a brush in the solution. The detergent solution will be flushed through the submersible pump.
- Deionized water rinse – A 3-foot long by 4-inch diameter PVC pipe will be filled with deionized water. Equipment will be rinsed by flushing with deionized water.
- Dry: Air dry materials and equipment prior to use.
- Decontamination solutions will be changed out between each sampling location to prevent cross contamination.

Surface Water Sampling
Dedicated, disposable sampling equipment will be used to collect all surface water samples.

Kuskowim River Sediment Sampling
Following the collection of each sediment sample, the sampling device will be thoroughly rinsed with river water. Following this rinse, the device will be cleaned with non-phosphate detergent (e.g., Alconox®) and rinsed with deionized water.

7.2 Vehicle Decontamination Procedures
Vehicles will be used to facilitate completion of the field activities. During the 2015 field events, vehicle use at the site will include all-terrain vehicles (ATVs) used to transport staff and equipment between Red Devil and the site and drill rigs and associated support vehicles. It is not expected that the planned use of the vehicles will result in significant contamination of the ATVs. In the event that the ATVs are subjected to significant contamination, they will be decontaminated by scrubbing with a brush and will be rinsing with potable water.

Equipment will be decontaminated within the site Main Processing Area, away from Red Devil Creek. Gross contamination (e.g., soil, mud) will be removed by washing with potable water and phosphate-free detergent. Any equipment with loose paint chips or that is badly rusted will be scrubbed with a wire brush prior to steam cleaning. Once all visible contaminants are removed, the equipment will be rinsed with potable water.

7.3 Investigation-Derived Waste Management
Investigation-derived waste (IDW) that is expected to be generated during the 2015 sampling events includes the following:

- Used dedicated, disposable sampling equipment;
- Used personal protective equipment (PPE), including gloves and booties;
- Used paper towels;
- Equipment decontamination fluids;
- Soil cuttings from drilling operations;
- Monitoring well development water;
- Monitoring well purge water; and

- Waste sediment (Kuskokwim River).

In general, IDW will be managed in accordance with criteria established in the document, *Management of Investigation-Derived Wastes During Site Inspections* (EPA/540/G-91/009), and guidelines outlined in EPA guidance, *Guide to Management of Investigation-Derived Wastes* (OSWER Publication 9345.3-03FS). IDW will he managed as further described below.

Used dedicated sampling equipment, PPE, and paper towels will be grossly decontaminated if there is visible evidence of contamination (soil), placed in sturdy plastic bags, and shipped offsite at the conclusion of the field activities and disposed of at a sanitary landfill in Anchorage.

Soil Boring Installation, Soil Sampling, and Monitoring Well Installation
The decontamination fluids generated from non-dedicated sampling equipment and the drill rig and related equipment will be allowed to run onto the ground within the boundaries of the site. Disposal of the decontamination fluid will be conducted in such a way that the water fully infiltrates into the ground without ponding and does not enter surface water. Disposal will also be conducted in such a way that it does not transport sediment to surface water.

Soil cuttings from drilling operations will be handled as follows:

- For any soil borings installed in the vicinity of the former ore processing facilities—Pre-1955 Retort, Pre-1955 Furnace, and Post-1955 Retort (Monofill #2)—and the settling ponds, drill cuttings will be temporarily stockpiled between the two “Stockpile Areas” shown in Work Plan Figure 2-5.
- For those soil borings installed at other locations where tailings/waste rock are expected, soil cuttings will be collected by the subcontractor and temporarily stockpiled between the two “Stockpile Areas” shown in Work Plan Figure 2-5.
- For any soil borings in which visible elemental mercury is encountered, drill cuttings will be collected by the subcontractor in 55-gallon drums, sampled for toxicity characteristic leaching procedure (TCLP) TAL metals, and stored on-site pending laboratory analysis.
- For those soil borings installed outside of the Main Processing Area and other locations where tailings/waste rock is not expected, and in which monitoring wells are not installed, drilling cuttings will be returned to the borehole. This is expected to include soil borings in the Surface Mined Area. The soil cuttings will be emplaced starting from the bottom of the hole. If monitoring wells are installed, the soil cuttings will be spread on the ground in the area of the well.

Dedicated, disposable sampling equipment used to collect soil samples will include dedicated, disposable scoops, spoons, and re-sealable plastic bags. These items and used PPE will be managed as described above.

Monitoring Well Development and Groundwater Sampling
Well development and purge water generated at the planned new wells and existing wells targeted for sampling in 2015 will be disposed of onto the ground at the time of sampling. Disposal of this purge water will be conducted in the area of the well following completion of sampling by pouring slowly onto the ground surface in such a way that the water fully infiltrates into the ground without ponding and does not enter surface water. Disposal will also be conducted in such a way that it does not transport sediment to surface water. Based on existing RI and baseline groundwater monitoring data, the potential for comparatively high concentrations of arsenic (greater than the RCRA TCLP limit of 5 milligrams per liter) in these wells is low.

Dedicated, disposable sampling equipment used to collect groundwater samples will include dedicated, disposable sample tubing. These materials and used PPE will be managed as described above.

Surface Water Sampling
Dedicated, disposable sampling equipment used to collect surface water samples will include dedicated, disposable sample tubing. These materials and used PPE will be managed as described above.

Kuskowim River Sediment Sampling
Investigation derived waste that will be generated from the Kuskokwim River off-shore sediment sampling effort will include the following.

- Waste sediment;
- Aqueous decontamination fluids;
- Used dedicated, disposable sampling bowls and scoops/spoons; and
- Used disposable PPE (e.g. gloves).

Waste sediment will be returned to the river by scooping unwanted sediment material from the sampling device into the river at the sample site. Aqueous decontamination fluids (phosphate-free detergent solution) will be containerized and shipped off-site for disposal at a properly licensed facility in Anchorage. Used disposable sampling equipment and PPE and will be managed as described above.

8 Surveying and Station Positioning

Horizontal coordinates of new soil boring and monitoring well locations will be surveyed using a resource grade GPS device. Coordinates of planned sample locations will be determined prior to mobilization and uploaded into the GPS units to serve as waypoints to facilitate the navigation to planned sample locations in the field. Coordinates will be recorded using a Trimble GeoXT or GeoXH series or equivalent handheld GPS device. Anticipated horizontal accuracy will be contingent on conditions encountered in the field. GPS data will be differentially corrected as necessary to maximize accuracy.

A subcontracted, Alaska-registered land surveyor will survey the vertical and horizontal coordinates of newly installed monitoring wells and new surface water monitoring locations. Elevations will be surveyed to within the nearest 0.1 foot.

A GPS will be used for station positioning for all Kuskokwim River sediment sampling stations. The sampling vessel will have navigation equipment that provides station positioning and water depths measurement and recording. The GPS receiver will be capable of surveying positions accurate to within 3-5 meters. Before sediment sampling is initiated, a control check point will be established that can be accessed by the sampling vessel. At the beginning and end of each day of sampling, the check point will be surveyed from the vessel and compared to the known coordinates. The control check point position as recorded by the vessel should not differ by more than 2 meters from the land-surveyed coordinates. During sampling, the GPS receiver will be placed above the sampling device to record the actual positions of the samples collected. Water depths will be measured at sampling locations directly by lead line. Coordinates of the proposed sediment sampling stations will be uploaded as waypoints into the vessel's GPS and used to guide the vessel to the appropriate locations.

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9 Deviations from the Field Sampling Plan

Deviations from the FSP are inevitable. Deviations may arise from changed field conditions, adjustment of sampling methods, inability to obtain samples from a planned location, and other circumstances. All deviations to the FSP will be carefully documented by the field team leader using the form presented in Figure 9-1. The nature and reason for FSP deviations will be documented in the RI report.

Red Devil Mine 2015 Sampling Event
FSP Deviation Documentation

Date:	Name:
Description of Problem:	
Location of Problem:	
Description of Deviation to Address Problem:	
Other Means Considered but Rejected to Address Problem:	

Figure 9-1 FSP Deviation Documentation Form

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10 References

EPA (U.S. Environmental Protection Agency). 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA 542-S-02-001, May 2002.

Puls, Robert W. and Barcelona, Michael J. 1996. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. EPA/540/S-95/504.

Rantz, S.E. et al. 1982. Measurement and Computation of Streamflow Volume 1. Measurement of Stage and Discharge. USGS Water Supply Paper 2175.

USGS (U.S. Geological Survey). 2011. Techniques of Water-Resources Investigations Reports. http://pubs.usgs.gov/twri. Accessed January 31, 2011.

Figures

Ecology & Environment, Inc. GIS Department Project: \\prtbhp1\Projects\Red_Devil_Mine\Maps\MXDs\Work_Plan_2015\Field_Sampling_Plan\Figure2_1_Proposed2015_SoilBoring_MonitoringWell_Locations.mxd Date: 2/16/2015

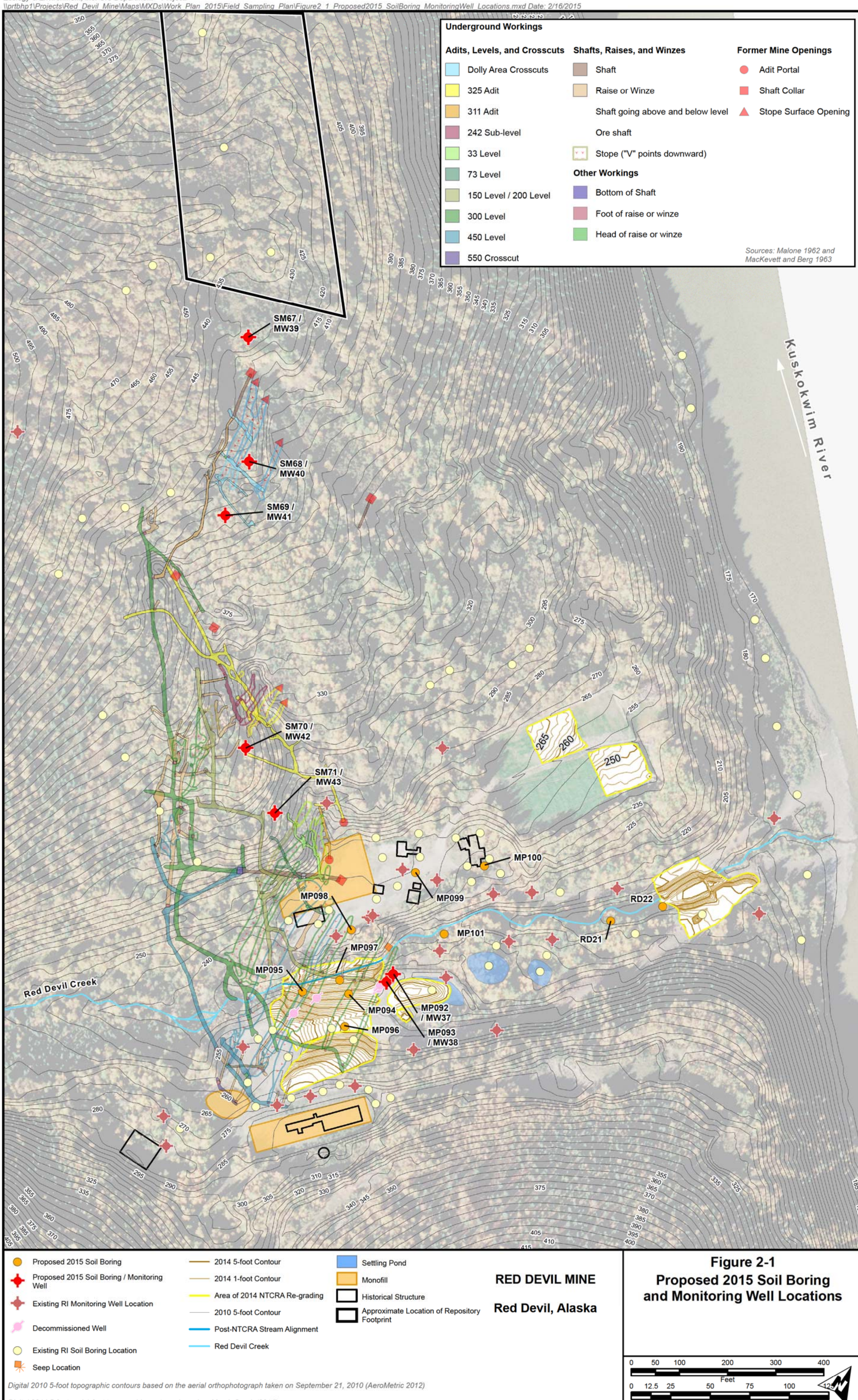
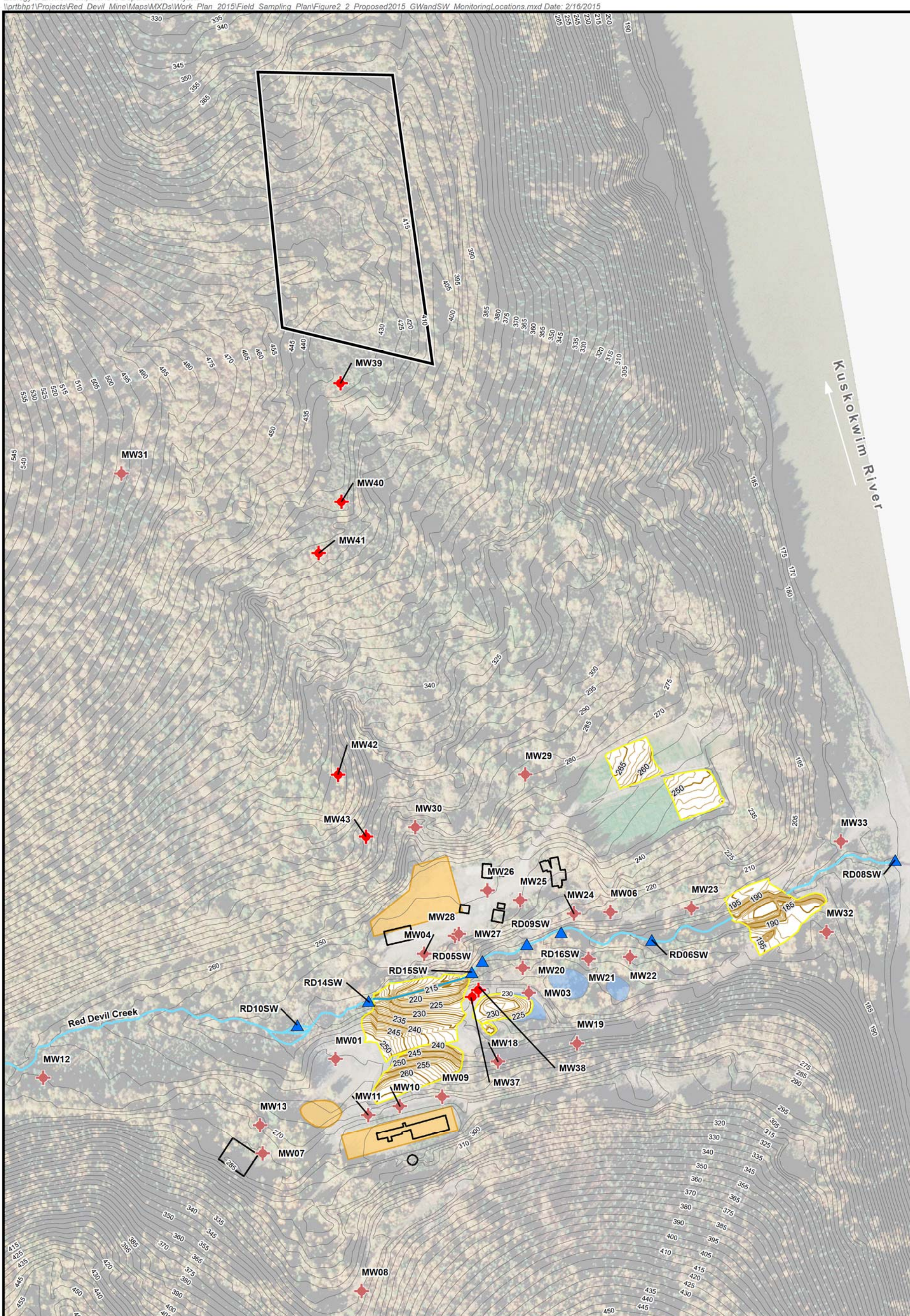


Figure 2-1
Proposed 2015 Soil Boring and Monitoring Well Locations



Proposed 2015 Monitoring Locations

- Proposed New Monitoring Well
- Existing RI Monitoring Well
- Surface Water
- 2014 5-foot Contour
- 2014 1-foot Contour
- Area of 2014 NTCRA Re-grading
- 2010 5-foot Contour
- Post-NTCRA Stream Alignment
- Red Devil Creek
- Settling Pond
- Monofill
- Historical Structure
- Approximate Location of Repository Footprint

RED DEVIL MINE

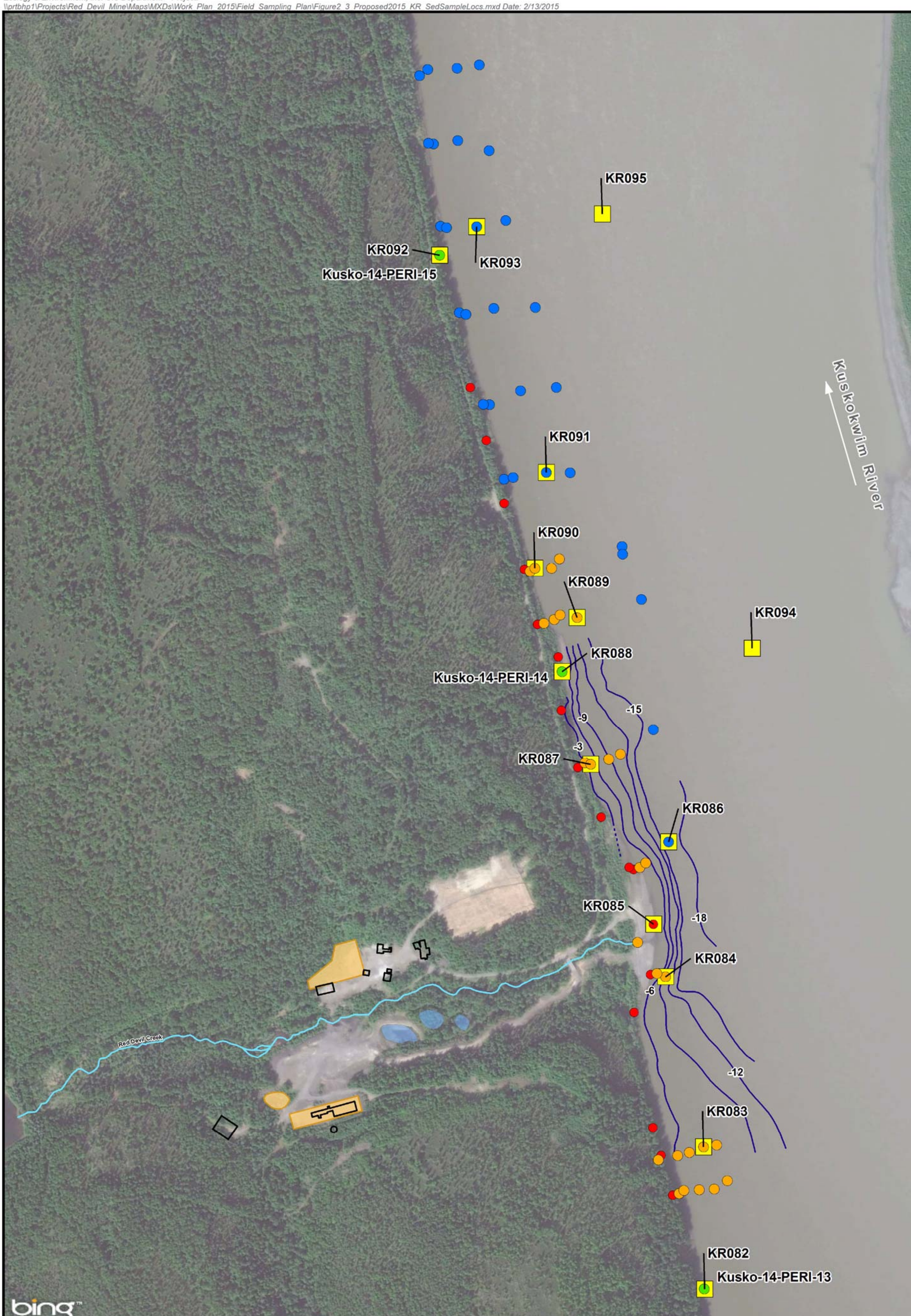
Red Devil, Alaska

Figure 2-2
Proposed 2015 Groundwater and Surface Water Monitoring Locations

0 50 100 200 300 400
Feet
0 12.5 25 50 75 100 125
Meters
Scale 1:2,500

Digital 2010 5-foot topographic contours based on the aerial orthophotograph taken on September 21, 2010 (AeroMetric 2012)

Digital 2014 5-foot and 1-foot topographic contours based on Marsh Creek (2014)



Proposed 2015 Sediment Sample Location
2014 BLM Periphyton Sample Location
2012 RI Sediment Sample Location
2011 RI Sediment Sample Location
2010 RI Sediment Sample Location
Bathymetric contour (feet)

Settling Pond
Monofill
Historical Structure

Bathymetric contours represent approximate depths below river surface on September 25, 2011

RED DEVIL MINE

Red Devil, Alaska

Figure 2-3
Proposed 2015 Kuskokwim River Sediment Sample Locations - Near Red Devil Mine Site

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

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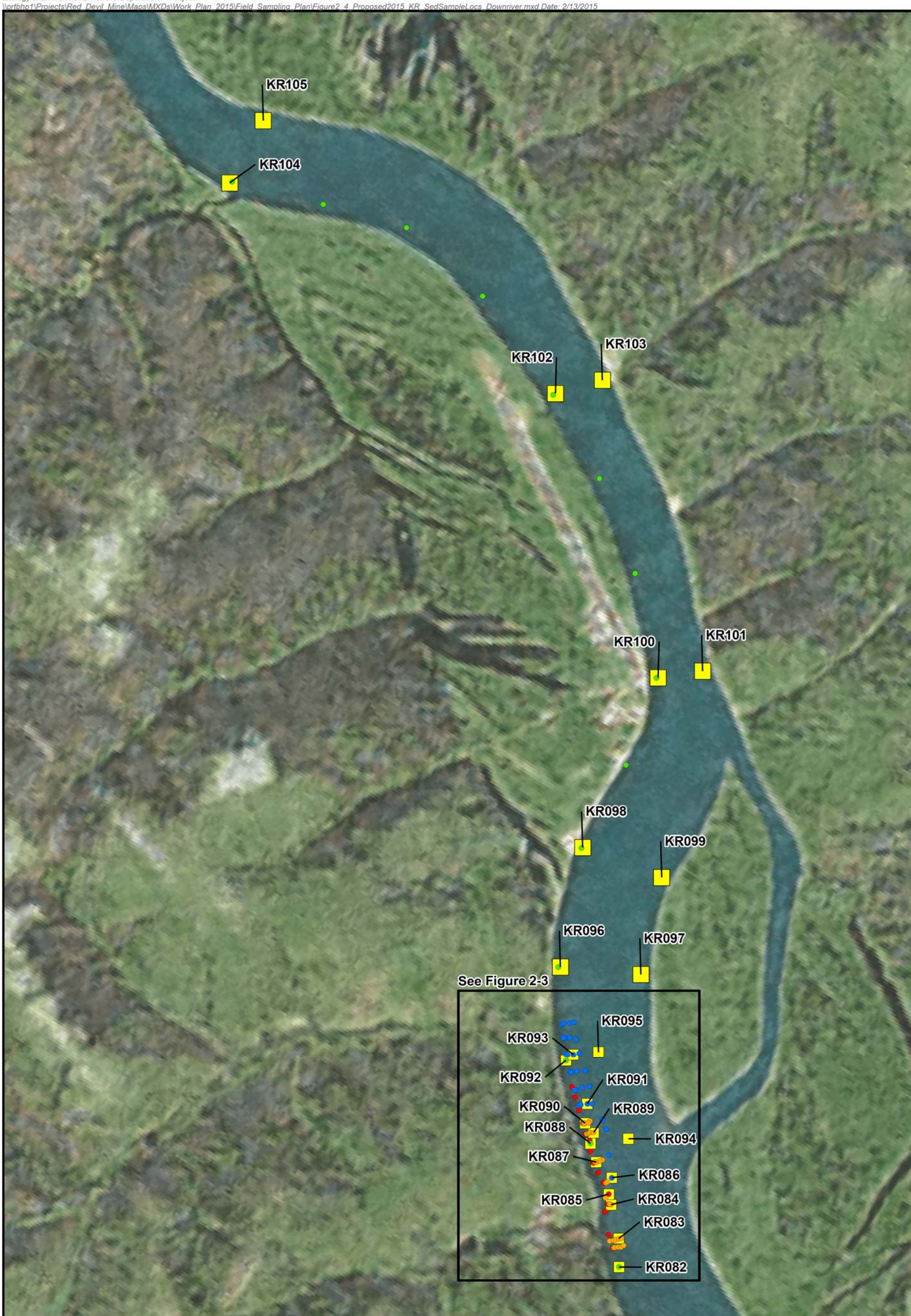


Proposed 2015 Sediment Sample Locations
2014 BLM Periphyton Sample Locations
2012 RI Sediment Sample Locaiton
2011 RI Sediment Sample Location
2010 RI Sediment Sample Location

RED DEVIL MINE

Red Devil, Alaska

Figure 2-4
Proposed 2015 Kuskokwim River Sediment Sample Locations - Near Red Devil Mine Site and Downriver

0 0.075 0.15 0.3 0.45 0.6
Miles
0 0.125 0.25 0.5 0.75 1
Kilometers
Scale 1:2,500

B

Quality Assurance Project Plan Addendum

Quality Assurance Project Plan Addendum for
2015 Soil, Groundwater, Surface Water, and Kuskokwim River Sediment Characterization
Supplement to Remedial Investigation
Red Devil Mine, Alaska

Prepared by Ecology and Environment, Inc., Seattle, WA

Prepared for United States Department of the Interior, Bureau of Land Management (BLM), Anchorage Field Office, Anchorage, AK

January 2015

This Quality Assurance Project Plan (QAPP) addendum was prepared to supplement the Final Quality Assurance Project Plan, Remedial Investigation/Feasibility Study (RI/FS), Red Devil Mine, Alaska (E & E 2011) to address additional site characterization planned for 2015. The QAPP addendum provides updated information needed for the planned 2015 site characterization.

Specifically, this addendum augments the following elements of the final QAPP:

- Project Organization (QAPP Figure 1-1);
- Contact Information (QAPP Table 1-1);
- Laboratory Reports (QAPP Section 1.6.2);
- Analytes, Analytical Methods, and Related Details (QAPP Table 1-2); and
- Sample Handling (QAPP Section 2.3).

These elements are discussed below.

Project Organization (QAPP Figure 1-1)
Figure 1-1 in the final QAPP identifies the key project staff and their roles, as wells as subcontractors retained by E & E to support RI/FS activities at the RDM site. Identities and roles of key project staff and the addition of subcontract laboratory Northwestern Aquatic Sciences (NAS), are provided in the revised project organization figure (Figure 1).

Contact Information (QAPP Table 1-1)
Table 1-1 in the final QAPP provides contact information for key organizations supporting the RI/FS at the RDM site. The following table augments QAPP Table 1-1 to include NAS.

Table 1-1 Contact Information (supplemental)

Organization	Contact	Title	Telephone	Address
Northwestern Aquatic Sciences (contract laboratory)	Gerald Irissarri	Director	541-265-7225 tel. 541-265-2799 fax girissarri@nwaquatic.com	3814 Yaquina Bay Rd. P.O. Box 1437, Newport, OR 97365

Laboratory Reports (QAPP Section 1.6.2)
This subsection of the final QAPP was specific to chemical analytical laboratories. The following text augments Section 1.6.2 to cover the sediment toxicity testing report that will be prepared by NAS.

- The bioassay laboratory will submit its standard sediment toxicity testing report to the E & E PM. This deliverables will include the following:

- Case narrative, including any problems encountered, protocol modifications, and corrective actions taken;
- Site and reference sample results for growth, survival, and reproduction;
- Laboratory control results for growth, survival, and reproduction compared with QA/QC limits for these parameters provided in USEPA (2000) for Method 100.4 (42-day *Hyalella azteca* survival, growth, and reproduction test);
- Statistical comparison of site sample results with reference and control sample results as per methods described in USEPA (2000);
- All testing protocols used; and
- Sample custody records (including original chain-of-custody forms).

Analytes, Analytical Methods, and Related Details (QAPP Table 1-2)

Table 1-2 in the final QAPP lists analytes, analytical methods, detection limits, and risk-based screening levels for chemical analysis of environmental samples from the RDM site. The following table augments Table 1-2 to cover the sediment bioassays that will be conducted by NAS.

Table 1-2 Analytes, Analytical Methods, Method Detection Limits, Screening Limits, and Risk Assessment Criteria (supplemental)

Analysis Type	Analysis Description	Method	Analyte	Units	Method Detection Limit	Method Reporting Limit
Sediment Toxicity	Toxicity, *Hyalella azteca*	EPA 100.4	Survival	%	--	--
			Growth	mg	--	--
			Reproduction	number of offspring	--	--

Key: -- (dash) = not applicable to bioassay samples

Risk-based screening levels are not applicable to bioassay results and thus are not listed. Survival, growth, and reproduction in site samples are evaluated relative to survival, growth, and reproduction in reference and control samples, not against predetermined values.

Section 2.3 — Sample Handling

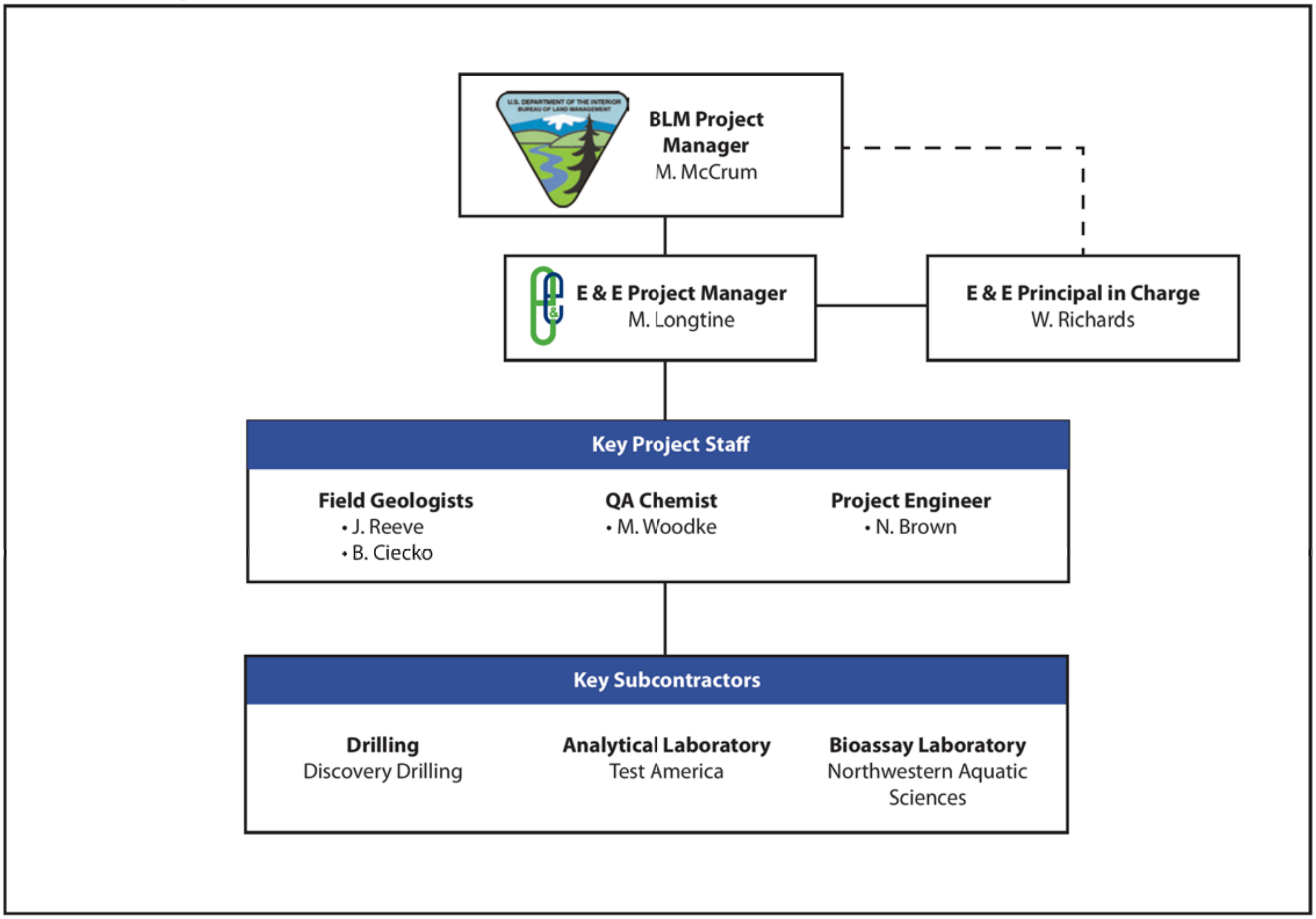
Collection, storage, manipulation, and characterization of Kuskokwim River sediment for toxicity testing will be consistent with USEPA (2000) and ASTM (1993), as noted in the Field Sampling Plan addendum for the 2015 RDM site work.

References

American Society of Testing and Materials (ASTM), 1993. *Guide for Collection, Storage, Manipulation, and Characterization of Sediments for Toxicological Testing,* ASTM Standard E1391-90, *In*: ASTM Standards on Aquatic Toxicology and Hazard Evaluation, ASTM, Philadelphia, PA.

Ecology and Environment, Inc. (E & E). 2011. *Final Quality Assurance Project Plan, Remedial Investigation/Feasibility Study (RI/FS), Red Devil Mine, Alaska.* Prepared for United States Department of the Interior, Bureau of Land Management, Anchorage Field Office, Anchorage, Alaska by E & E, Seattle, Washington.

USEPA. 2000. *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates, Second Edition*. Office of Research and Development, Mid-Continental Ecology Division, Duluth, MN and Office of Water, Washington, DC. EPA 600/R-99/064.



SOURCE: Ecology and Environment, Inc. 2015

Figure 1 Project Organization

C Health and Safety Plan

The Site-Specific Health and Safety Plan will be included in the Final Work Plan.