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2010 Limited Sampling Event Report Remedial Investigation/ Feasibility Study

Red Devil Mine, Alaska

December 10, 2010

Prepared for:

U.S. DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
Anchorage Field Office
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List of Abbreviations and Acronyms

% R	Percent recovery
µg/L	microgram per liter
ARI	Analytical Resources, Inc.
As	Arsenic
AST	aboveground storage tank
BLM	Department of the Interior Bureau of Land Management
BRL	Brooks Rand Labs
BTEX	benzene, toluene, ethyl benzene, and xylene
COC	Chemical of concern
COPC	chemicals of potential concern
DOT	U.S. Department of Transportation
DQO	data quality objectives
DRO	diesel range organics
E & E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FS	feasibility study
FSP	Field Sampling Plan
GPS	global positioning system
GRO	gasoline range hydrocarbons
Hg	Mercury
HHRA	human health risk assessment
IATA	International Air Transportation Association
IDW	investigation derived waste
J	estimated concentration
LCS	laboratory control sample
LSE	limited sampling event
mg/kg	milligram per kilogram
MS	matrix spike
MSD	matrix spike duplicate
ppm	parts per million
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RDM	Red Devil Mine
RI	remedial investigation
RPD	relative percent difference
RRO	residual range organics
Sb	Antimony

List of Abbreviations and Acronyms (cont.)

Site	Red Devil Mine Site
SLP	synthetic precipitation procedure
SOP	standard operating procedure
SSE	selected sequential extraction
SVOC	semi-volatile organic compound
TAL	Target Analyte List
TCLP	toxicity characteristic leaching procedure
TDD	Technical Direction Document
TSS	total suspended solids
TTD	total dissolved solids
USGS	U.S. Geologic Survey
VOC	volatile organic compounds
XRF	x-ray flourescene

1 Introduction and Background

This report summarizes field activities including inspection and field screening of surface soils, sample collection methods, and sample analysis. Additionally, this report provides a summary of analytical results and recommendations on key factors for the next phases of work. These activities were performed during the 2010 Limited Sampling Event (LSE) at the Red Devil Mine (RDM) site. The LSE was conducted in support of a Remedial Investigation/Feasibility Study (RI/FS) being conducted at the site by Ecology and Environment, Inc. (E & E) on behalf of the Department of the Interior Bureau of Land Management (BLM) under Delivery Order Number L09PD02160 and General Services Administration Contract Number GS-10F-0160J. A draft RI/FS Work Plan was submitted to BLM on August 18, 2010 (E & E 2010a). A final Field Sampling Plan (FSP) for the 2010 LSE activities was submitted to BLM on November 12, 2010 (E & E 2010b). Prior to finalizing the FSP, E & E implemented the LSE in September, 2010, due to impending winter weather. The LSE was conducted in accordance with the LSE FSP.

1.1 Site Description

The RDM site (the Site) is an abandoned mercury mine and ore processing site on the south bank of the Kuskokwim River in a remote area of Alaska, approximately 250 air miles west of Anchorage and 75 air miles northeast of the village of Aniak (see Figure 1-1). The Site is on public lands managed by the BLM and consists of four main geographic areas: the Surface Mined Area, the Main Processing Area, Red Devil Creek area, and Kuskokwim River area. Site features are illustrated in Figures 1-2 and 1-3 of this report. The Site description, history, and setting are further described in the draft RDM RI/FS Work Plan (E & E 2010a).

1.2 Goals and Objectives

In general, the main objectives of the LSE were to gather data to characterize the nature and extent and fate and transport of contaminants of potential concern (COPCs) at and near the Site; to provide data for human health and ecological risk assessments; and to provide data and information for use in the analysis of remedial alternatives. Specific objectives are detailed in Section 2 of this report. To accomplish the LSE objectives, E & E conducted a visual inspection and in-situ X-Ray Fluorescence (XRF) field screening for metals in surface soils and collected samples for off-site laboratory analysis of surface water, groundwater, sediment, and surface soils.

All work was conducted in accordance with the LSE Field Sampling Plan (E & E 2010b) except as noted below.

1.3 Relationship to the RI/FS

The work performed as part of the 2010 LSE constitutes a portion of the field activities identified for the RI/FS at RDM. The 2010 LSE was performed to accomplish some of the RI/FS fieldwork in 2010 and to provide data for making refinements to the RI/FS Work Plan. Additional RI/FS field activities, including subsurface exploration and any additional sampling to fill data gaps identified through the 2010 sampling work, will be conducted during the 2011 field season.

BLM intends to address agency comments on this document in two ways.

- Comments regarding data gaps will be addressed in a memorandum and will be incorporated into the final RI/FS Work Plan.
- Comments addressing other issues will be incorporated in the draft RI Report.

As such, a final version of this document will not be generated.

RED DEVIL MINE

Red Devil, Alaska

Figure 1-1
Site Location Map

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 1-2 main processing area site features.mxd 11/24/2010

🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

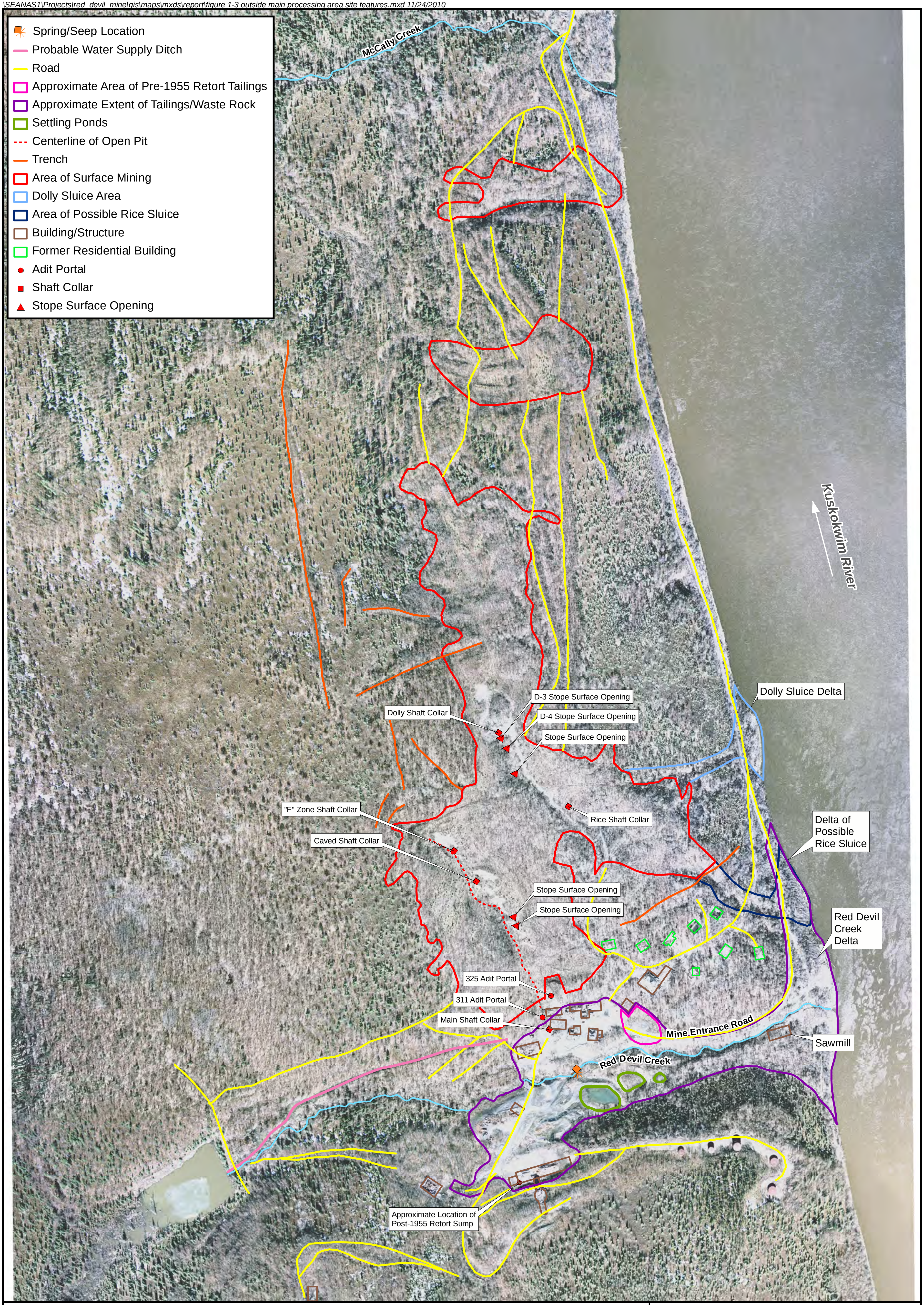
Red Devil, Alaska

Figure 1-2
Main Processing Area
Site Features

0 25 50 100 150
Feet
0 5 10 20 30 40 50
Meters
Scale 1:1,000

N

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 1-3 outside main processing area site features.mxd 11/24/2010



See Figure 1-3 for identification of Main Processing Area buildings/structures.

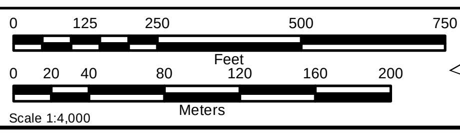
Aerial Photo Reference:
Aero-Metric, Inc., 5/29/2001.

Topographic Contour Reference:
Aero-Metric, Inc., 5/27/2010.

RED DEVIL MINE

Red Devil, Alaska

Figure 1-3
Outside Main Processing Area Site Features



2 Summary of Field Investigation Activities

This section describes the field activities conducted during the RDM RI/FS 2010 LSE and summarizes the study design for each component of the RDM RI/FS 2010 LSE. A detailed description of the study design is provided in the LSE FSP (E & E2010b).

The RI/FS sampling design was biased to target locations that were potential and/or known sources of COPCs as well as locations and media potentially impacted by migration of COPCs at the Site. Some sample locations were also selected to verify historical sample results or to provide new data because site conditions had changed since previous sampling events (e.g., movement of soil, construction activities associated with interim cleanup actions, and vehicle traffic).

The study design incorporated both field screening and fixed laboratory analyses. Field screening was conducted to provide data for two separate objectives.

- Field screening of in-situ soils was conducted within and around the Main Processing Area to provide data to assist in the determination of the lateral extent of tailings and waste rock.
- Field screening of soil samples was performed on soil samples collected for laboratory analysis to inform decisions about selection of samples for specific laboratory analyses.

Field activities were conducted in accordance with the FSP except, as noted in the sections below.

The RDM RI/FS 2010 LSE was conducted from September 9th through September 29th, 2010.

2.1 Visual Inspection and In Situ XRF Field Screening

Areas where tailings could be present at the surface based on historical data, historical photographs, and aerial imagery were evaluated in the field using a combination of visual observations and in-situ field screening for total metals using a portable XRF. Visual inspection and XRF field screening were also performed at locations where soil samples were collected for laboratory analysis (see Section 2.2.1). The objectives of the visual inspection and in-situ XRF field screening were to:

- Determine the concentration of total metals and the visual characteristics of the surface soils in areas where tailings could be present
- Determine if visual characteristics and total metals concentrations can be used to identify tailings
- Use the visual characteristics and total metals concentrations to determine the extent of tailings at the Site

XRF field screening was performed in-situ (on the soil surface) after removal of any surficial detritus that existed. XRF field screening procedures are discussed further in Chapter 4 of the FSP. The lateral coordinates of each field screening location were surveyed with global positioning system (GPS) instrumentation as described in Chapter 8 of the FSP.

2.1.1 Historical Data Review

Based on a review of historical aerial and other photographs, the extent of tailings during the period of mining operations was expected to include much of the Main Processing Area and areas within the Red Devil Creek drainage downstream of the Main Processing Area. Tailings were historically disposed of in the Red Devil Creek drainage, and piles of tailings along the banks of Red Devil Creek were subject to erosion by the creek. As such, tailings were expected to be mixed with alluvial materials within the Red Devil Creek drainage and its delta into the Kuskokwim River. The expected extent of the areas where tailings/waste rock and flotation tailings were disposed of and transported to during and subsequent to mine operations is illustrated in Figure 2-2 of the draft RI/FS Work Plan (E & E 2010a). The area where visual inspection and in situ XRF was conducted is illustrated in Figure 2-1.

Based on available historical data, tailings were generally expected to contain the key metals antimony (Sb), arsenic (As), and mercury (Hg), at concentrations significantly higher than in the native soil materials at most locations at the Site.

2.1.2 Initial Visual Observations and XRF Field Screening

Early in the RI/FS field event, visual observation and XRF field screening were performed in areas where historical information and visual observations indicated tailings were likely present (see RI/FS Work Plan Figure 2-2). The initial field screening commenced in the areas of the Site where tailings were known to exist at the surface (e.g., area between the Post-1955 Retort building and Red Devil Creek). Visual soil characteristics and XRF screening of total metals concentrations of the key metals in these tailings were recorded and used as a guide to identify tailings at other areas of the Site where the presence of tailings was not as readily observed.

Subsequently, field screening was conducted in areas where tailings were suspected based on historical photographs, but where the surface was presently vegetated and/or modified by subsequent construction activities (e.g., within the Red Devil Creek drainage downstream of the Main Processing Area).

The possible presence of tailings at these locations was assessed based on comparison of visual characteristics and XRF concentrations at these locations with those at locations where tailings were documented (e.g., Main Processing Area).

2.1.3 Grid Locations

After determining the characteristics of tailings in areas known to contain tailings, soils were assessed at locations within the area expected to contain tailings. To evaluate the extent of tailings and to assist in characterizing the nature of the tailings present at the Site, a square grid with 100-foot spacing was established within the area expected to contain tailings. One location within each grid square (Proposed Initial Field Screening Location, FSP Figure 2-1) was field screened for the presence of tailings. At each location, visual observations of soil characteristics and XRF field screening data were recorded. Actual grid locations from the 2010 LSE are illustrated in Figure 2-1. A total of 44 field screening locations were evaluated using the grid technique.

2.1.4 Transect Locations

Following evaluation of tailings at the grid locations, soils were evaluated at a series of transects located around the perimeter of the expected edge of tailings. The visual observations and XRF field screening was used to determine the edge of the tailings as well as characterize the nature of the tailings and to identify differences between the tailings and the native soils adjacent to the edge of tailings. At most locations, the expected edge of tailings was located where the topography changed from generally flat areas within the Red Devil Creek Valley and Main Processing Area to the steeper slopes of the valley walls.

A total of 33 transects were established along the expected edge of tailings/waste rock (see FSP Figure 2-1). Each transect line segment was oriented perpendicular to and straddled the expected lateral limit of tailings, with the starting point lying 15 feet inside of the expected lateral limit (Proposed Transect Station A) and the endpoint located 25 feet outside of the expected lateral limit (Proposed Transect Station B). Initially, field screening was performed at Station A and Station B along each transect. If tailings materials were identified at the Station B location along any transect, the transect line was extended outward an additional 25 feet from Station B and the soil was evaluated for the presence of tailings. Similarly, if it appeared that tailings were not present at the Station A position along a given transect, the transect line was extended inward approximately 25 feet from Station A. This process was repeated until the lateral extent of tailings at that transect location was identified, if possible. Only the final station locations and field screening data were recorded for each transect. Actual transect locations from the 2010 LSE are illustrated in Figure 2-1. A total of 66 field screening locations were recorded at the transect locations.

2.1.5 Visual Observations and XRF Field Screening Outside the Expected Area of Tailings

Based on the available information regarding site operational history, it was expected that tailings were locally present on roadways where these materials have been used as ballast or surface material. However, the identity of the roads on which tailings were used for such purposes was not known. The locations of roads developed during mining operations that were identified based on review of historical information and photographs are shown in Figure 2-2 of the draft RI/FS Work Plan (E & E 2010a). Due to schedule constraints created by impending winter weather, the evaluation of these roads for the presence of tailings was not conducted during the 2010 LSE. The evaluation of these roads will be performed during the 2011 field season.

2.2 Sample Locations and Types

2.2.1 Surface Soil

A total of 150 surface soil samples were collected for laboratory analysis. Surface soil sample locations are illustrated in Figures 2-2, 2-3, and 2-4. Surface soil sample results will be used as follows:

- Characterization of the nature and extent of COPCs in surface soil.
- Provision of data supporting the delineation of the areal extent of tailings on the ground surface.
- Identification and characterization of possible tailings at the reservoir dam
- Characterization of the soils within the area of surface mining and exploration.
- Characterization of soil characteristics that may affect contaminant fate, transport, and bioavailability.
- Characterization of chemical and physical characteristics of soils in background areas.
- Provision of data for the human health risk assessment (HHRA) to assess potential exposure to COPCs through direct contact, inhalation, and incidental ingestion. The HHRA will be provided under separate cover at a later date.
- Provision of data for the ecological risk assessment (ERA) to assess potential exposure of biota to COPCs through direct contact and ingestion. The ERA will be provided under separate cover at a later date.
- Characterization of geotechnical properties of tailings and soils that may be subject to excavation.
- Characterization of geotechnical properties of soils at a potential site for an onsite waste repository located within the area of surface mining approximately 700 feet north of the Dolly Shaft Collar.

Surface soil samples were collected from 0 to 6 inches below ground surface following removal of any surficial detritus on the ground surface. Specific sampling methodologies are provided in Section 2.3.1 of this report.

Background surface soil samples were collected from areas upland of the Main Processing Area and outside of areas of expected influence of aerial deposition from historical ore processing activities. (Refer to Appendix E of the August 2010 Draft RI/FS Work Plan.) Twenty upland background samples were proposed in the FSP.

Ten of these samples were targeted at Kuskokwim Group soils and 10 were targeted at soils derived from loess. Soils derived from the loess were not definitively identified within the area targeted for background soil sampling. A total of 10 background surface soil samples were collected from soils derived from the Kuskokwim Group.

All the surface soil samples were analyzed for target analyte list (TAL) inorganic elements. A subset of these samples was selected for analysis for mercury selective sequential extraction (SSE), arsenic speciation, synthetic precipitation leaching procedure (SPLP) TAL metals, toxicity characteristic leaching procedure (TCLP) Resource Conservation and Recovery Act (RCRA) metals, semi-volatile organic compounds (SVOCs), 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. In general, samples were selected for the additional analyses to achieve the following:

- Provide broad areal distribution of data.
- Obtain data for different tailings types (e.g., flotation tailings versus thermally processed tailings, including pre-1955 thermally processed tailings and post-1955 thermally processed tailings) that may be discernable based on chemical or physical characteristics and/or geographic position.
- Obtain data on disturbed soils within the area of surface mining.
- Obtain data for anticipated background locations.

2.2.2 Surface Water

Surface water grab samples were collected from nine locations along Red Devil Creek between the creek's mouth at the Kuskokwim River and a point upstream of the reservoir south of the Main Processing Area. Surface water sample locations between the Kuskokwim River and the reservoir were intended to characterize the contribution of COPCs from overland runoff from tailings and/or contaminated soil and from groundwater contribution. One surface water sample was collected from the seep in the Main Processing Area. One surface water sample was collected upstream of the reservoir. Surface water sample locations along Red Devil Creek were co-located with surface sediment sample locations. Surface sediment sample locations are described in Section 2.2.3 of this report. Surface water sample locations are illustrated in Figure 2-5. Sample results will be used as follows:

- Characterization of the nature and extent of COPCs in the surface water of Red Devil Creek.

- Characterization of the cation-anion signature of the surface water to assess contribution from groundwater sources.
- Characterization of chemical attributes affecting contaminant fate and transport of COPCs in the surface water Red Devil Creek.
- Provision of data for the human health risk assessment to assess potential exposure to COPCs through direct contact and incidental ingestion.
- Provision of data for the ecological risk assessment to assess potential exposure of creek biota to COPCs through direct contact and ingestion.

To the extent feasible, surface water samples were collected from mid-depth water in the creek. Specific sampling methodologies are summarized in Section 2.3.2 of this report.

All of the Red Devil Creek surface water samples were analyzed for total TAL inorganic elements, dissolved TAL inorganic elements, methyl mercury, low-level total mercury, low-level dissolved mercury, inorganic ions, nitrate/nitrite, carbonate/bicarbonate, TDS, and TSS. Selected surface water samples were also analyzed for arsenic speciation and SVOCs. Field measurements for pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity were collected at each sample station.

2.2.3 Sediment

Surface sediment grab samples were collected from nine locations along Red Devil Creek between the creek’s mouth at the Kuskokwim River and a point upstream of the reservoir south of the Main Processing Area. Surface sediment sample locations between the Kuskokwim River and the reservoir were intended to characterize the contribution of COPCs from overland runoff from tailings and/or contaminated soil and from groundwater contribution. One sediment sample was collected adjacent to the seep in the Main Processing Area. One surface sediment sample was collected upstream of the reservoir. Thirteen surface sediment samples were proposed to be collected from locations along the Kuskokwim River. Due to schedule constraints created by impending winter weather, only seven of the proposed locations were sample during the 2010 LSE. Surface sediment sample locations are illustrated in Figure 2-6. Sample results will be used as follows:

- Characterization of the nature and extent of COPCs in Red Devil Creek sediment.
- Characterization of chemical attributes affecting contaminant fate and transport of COPCs in surface sediment.
- Characterization of grain size distribution of sediment.
- Provision of data for the human health risk assessment to assess potential exposure to COPCs through direct contact and incidental ingestion.
- Provision of data for the ecological risk assessment to assess potential exposure of creek biota to COPCs through direct contact and ingestion.

Surface sediment samples were collected from the top 3 inches of the sediment bed. Specific sampling methodologies are summarized in Section 2.3.3 of this report.

All of the Red Devil Creek and Kuskokwim River surface sediment samples were analyzed for total TAL inorganic elements, methyl mercury, arsenic speciation, grain size, and total organic carbon. Selected sediment samples also were analyzed for mercury SSE.

2.2.4 Groundwater

During the 2010 LSE, groundwater samples were collected for laboratory analyses from five of the eight existing monitoring wells. No new monitoring wells associated with this RI/FS were installed during the 2010 LSE; although, it is expected that installation and sampling of new monitoring wells will be performed during the 2011 field season. The three wells not sampled as part of the LSE were installed and sampled in late July as part of the petroleum hydrocarbon investigation and were designed to address the characterization objectives of that effort. The location, depth interval, and groundwater data collected from the new wells will be reviewed and any well that can be used to meet RI objectives will be incorporated into the 2011 data collection effort.

Figure 2-7 illustrates the locations of existing monitoring wells sampling during the 2010 LSE. Groundwater monitoring results from the 2010 LSE will be combined with data collected in 2011 and used as follows:

- Characterization of the nature and extent of COPCs in groundwater.
- Characterization of the cation-anion signature of the groundwater to assess potential sources and migration patterns of groundwater and COPCs.
- Characterization of groundwater depth, flow direction, gradient, and migration patterns of COPCs.
- Assessment of groundwater-surface water interactions, including the potential for COPCs in groundwater to enter surface water.
- Provision of data for the human health risk assessment to assess potential exposure to COPCs through ingestion of drinking water.

Groundwater samples were collected from the existing monitoring wells using a low-flow sampling technique. Specific sampling methodologies are provided in Section 2.3.4 of this report.

At the beginning of the 2010 LSE, a round of static water level measurements was collected from all existing wells. The static water levels were measured during each round within the shortest time period possible.

Four of the five groundwater samples (excluding MW-7) were analyzed for total TAL inorganic elements, dissolved TAL inorganic elements, total low-level mercury, dissolved low-level mercury, methyl mercury, inorganic ions, nitrate/nitrite, carbonate/bicarbonate, total dissolved solids (TDS), and total suspended solids (TSS).

Several of these groundwater samples were also analyzed for arsenic speciation, SVOCs, DRO, RRO, and gasoline range hydrocarbons (GRO) and benzene, toluene, ethylbenzene, and xylenes (BTEX). The groundwater samples from existing monitoring well, MW-1, were analyzed for BTEX to evaluate the potential presence of benzene in groundwater based on historical sample results of benzene in soil at the Gravel Pad.

Due to inadequate recharge in existing monitoring well MW-7, this sample was only analyzed for dissolved TAL inorganic elements, inorganic ions and carbonate/bicarbonate.

Field measurements of pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity were collected for each groundwater sample.

Due to time constraints, a second round of static water level gauging was not conducted at the end of the sampling event as discussed in the FSP.

2.3 Sample Collection Methods

2.3.1 Surface Soil

Surface soil samples for laboratory analysis were collected from 0 to 6 inches below ground surface at each sample location. Large rocks, cobbles, and organic detritus were removed from the sampling site prior to sample collection.

The samples were collected by excavating a hole to a depth of 6 inches below the ground surface after surficial detritus had been removed. The sampling team excavated the hole with a dedicated durable plastic scoop. It was anticipated that at some sample locations, the targeted soil material may be too coarse and/or compacted to effectively excavate the hole with a plastic scoop. In the event that it was not possible or practical to excavate a hole with the plastic scoop, a clean stainless steel trowel and/or rock hammer pick was used to excavate a hole to 6 inches below the surface. Subsequently, a dedicated durable plastic scoop was used to remove the soil from the surface of the sidewall of the hole that may have been in contact with the trowel or rock hammer pick. This material was then discarded. A dedicated durable plastic scoop was then used to collect sample material from the sidewall of the hole from 0 to 6 inches below the surface, ensuring that the sample material collected did not come in contact with the material in contact with the trowel or rock hammer pick. Approximately 30% of the surface soil samples collected required the use of a trowel and/or rock hammer to excavate a hole. Collection of sample material for various laboratory analyses was performed as described below.

For those sample locations where the sample were selected for mercury SSE analysis (see FSP Table 2-1), an aliquot of the soil for mercury SSE analysis was collected by placing sample material directly into the appropriate sample container. The material was placed directly into the container without homogenizing, thereby reducing potential volatilization of any elemental mercury that could be present in the material.

Sample material for other inorganic analyses was placed into a clean dedicated resealable plastic bag. The bag was sealed and the material was homogenized by working the material manually within the sealed bag. This material was subsequently field screened with an XRF by testing the soil material directly through the bag. XRF field screening was performed in accordance with the XRF standard operating procedure (SOP). XRF field screening results were recorded and used for the selection of samples for additional laboratory analyses as indicated in FSP Table 2-1. Material for these analyses was transferred from the plastic bag into the appropriate pre-cleaned sample containers using a dedicated plastic scoop.

For those sample locations selected for analysis for DRO, RRO, and SVOCs, following collection of material for all the inorganic analyses, sample material was collected with a dedicated stainless steel spoon and placed into a dedicated stainless steel bowl and thoroughly homogenized. The homogenized material was placed into the appropriate pre-cleaned sample containers.

The lateral coordinates of each sampling location were surveyed with GPS instrumentation as described in Chapter 8 of the FSP.

2.3.2 Surface Water

At each surface water and sediment sampling location, the surface water sample was collected prior to the sediment sampling. Surface water samples from Red Devil Creek were collected first from near the confluence of Red Devil Creek and the Kuskokwim River. Sampling proceeded upstream to avoid disturbing sediments that could impact turbidity and contaminant concentrations in downstream locations.

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

Concurrent with surface water sampling, field parameters for dissolved oxygen, oxidation/reduction potential, pH, temperature, total dissolved solids, specific conductance, and turbidity were measured using a Horiba U-53 water quality meter and recorded on surface water sampling datasheets.

The lateral coordinates of each sampling location were surveyed with GPS instrumentation as described in Chapter 8 of the FSP.

2.3.3 Sediment

For those locations where both a surface water sample and a sediment sample were collected, the surface water sample was collected prior to the sediment sample collection. Sediment samples were collected from the most downstream locations first, with work progressing upstream to avoid disturbing sediments that could impact downstream sample locations. Accordingly, the following sequence for sediment samples was followed:

- Collect most down-river sample on Kuskokwim River first.
- Collect Kuskokwim River samples sequentially, moving up-river to Red Devil Creek.
- Collect Kuskokwim River sample up-river of Red Devil Creek.
- Collect Red Devil Creek sample near confluence of Kuskokwim River.
- Collect Red Devil Creek samples sequentially, moving upstream to the background sample location.

Sample locations were established in sediment depositional areas with a high percentage of fine sediment material. Areas containing a rocky substrate were avoided.

Sediment samples were collected from the top 3 inches of the bed sediments. Any organic debris that was present was removed from the sampling location prior to sample collection. The aliquot of sediment collected for laboratory analysis for mercury SSE was be placed directly into the sample container using a dedicated plastic scoop. This material was not homogenized, thus reducing potential volatilization of any elemental mercury that could be present in the sediment material. Sediment to be analyzed for the other laboratory analyses was placed into a dedicated plastic bowl using a dedicated plastic scoop. The collected sediment was thoroughly homogenized, and placed into pre-cleaned sample containers.

At each sediment sample location, physical characteristics of the sediment material were observed and recorded. Specific characteristics that were documented are as follows.

- Color
- Odor
- Grain size range and distribution
- Sediment particle mineralogy and lithology (e.g., greywacke or argillite of Kuskokwim group)
- Stratigraphy
- Observations of gross contamination, including sheen or staining and elemental mercury

- Mineralization, including sulfides (e.g., cinnabar, stibnite, and realgar, orpiment) and iron staining
- Observations of non-native materials (e.g., brick, wood, metal or other debris)

The lateral coordinates of each sampling location were surveyed with GPS instrumentation as described in Chapter 8 of the FSP.

2.3.4 Groundwater

Groundwater samples were collected from all existing monitoring wells within the Main Processing Area. To the extent practicable, groundwater sampling occurred in a progression from the least to the most contaminated wells, based on existing groundwater and soil sample data.

Prior to sample collection, each well was sounded with a decontaminated electronic water level meter to determine the static water level, measured to the nearest 0.01 feet. The water level measurements were used to determine groundwater elevation and to estimate the standing water volume contained within the well. The measurement was also used to determine the depth of the pump intake and to monitor water drawdown during low-flow purging and sampling, as described below.

If feasible, each well was purged and sampled using a low-flow purging and sampling technique following EPA's Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, EPA/540/S-95/504, dated April 1996. A battery-operated peristaltic pump outfitted with dedicated Teflon-lined tubing was used to purge and sample the monitoring wells. The tubing was lowered into the well to the targeted sample point at the middle of the water column within the screen interval. The well was purged at a target rate of less than 0.5 liter/minute. During purging, the water level was monitored with the water level indicator to measure well drawdown and to guide the adjustment of purge rate to minimize drawdown while purging. The sampling team attempted 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 was measured to determine when stabilization of the groundwater was achieved. Water quality parameters were measured using an in-line water quality meter (Horiba U50) and recorded on datasheets. Field parameters were measured every three minutes during purging. Field parameters were considered stabilized after all parameters have stabilized for three successive readings. Criteria for stabilization were three successive readings within the following limits.

- pH: ±0.1 pH units
- Temperature: ±1 degree Celsius
- Conductivity: ±10 (millivolts)
- Turbidity: ±10%
- Dissolved oxygen: ±10%

Upon stabilization of field parameters, groundwater samples were collected directly into the appropriate (pre-preserved, as applicable) sample containers. Dissolved metals aliquots were collected following collection of the other aliquots using a dedicated in-line 0.45-micrometer filter. The filter was inserted into the end of the sample tubing while the pump was still running to maintain a steady flow of water, minimizing potential disturbance of formation groundwater. Following installation of the filter, the dissolved water aliquot was collected directly into the appropriate sample container.

MW07 did not have adequate recharge to follow the prescribed sampling procedure. After attempting to purge and sample the determination was made that it was impossible to stabilize the parameters with the low amount of recharge that was encountered. The well was pumped almost dry using the battery-operated peristaltic pump outfitted with dedicated Teflon-lined tubing on the first day of groundwater sampling. The following day the water that had flowed into the casing overnight was pumped directly into a limited number of the sample jars using the peristaltic pump.

The lateral coordinates of each sampling location were surveyed with GPS instrumentation as described in Chapter 8 of the FSP.

2.4 Sample Handling

Transportation and handling of samples was accomplished in a manner that not only protected their integrity but also prevented any detrimental unnecessary exposure to sample handlers due to the possibly hazardous nature of the samples.

2.4.1 Sample Documentation

2.4.1.1 Sample Labels

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

Each sample label was attached firmly to the sample containers, and protected with Mylar tape. The sample label contained the following information.

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

2.4.1.2 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) were sealed in as many places as necessary to ensure security. Seals were signed and dated before use. Upon the containers' arrival at the laboratory, the custodian checked (and certify by completing the package receipt log) that seals are intact.

2.4.1.3 Chain-of-Custody Records

The Chain-of-Custody (COC) records were 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 contained the same level of detail found in the site logbook, except that the onsite measurement data was not recorded. The custody record included, 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 of the FSP)
- 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

The relinquishing individual recorded pertinent shipping data (e.g., air-bill number, organization, time, and date) on the original custody record, which was 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 ensured that all records are consistent and that they are made part of the permanent job file.

2.4.1.4 Field Logbooks and Data Forms

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

Minimum logbook content requirements are described in E & E's SOPs, *Preparation of Field Activities Logbooks,* a copy of which was kept on site during the RI/FS field activities. If corrections were necessary, they were 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 would be initialed and dated. Corrected errors may require a footnote explaining the correction.

2.4.1.5 Photographs

Photographs were 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 about photographs was noted in field logbooks.

- Date, time, and location photograph was taken
- Description of photograph
- Sequential number of photograph
- Direction

2.4.1.6 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; or
- Kept in a secured area that allows authorized personnel only.

2.4.2 Field Custody Procedures

The following guidance was used to properly control samples during fieldwork.

- As few people as possible will handle samples.
- Coolers or boxes containing cleaned bottles were 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, were not used.
- The sample collector was responsible for the care and custody of samples until they were transferred to another person or dispatched properly under COC rules.
- The sample collector recorded sample data in the field logbook.
- The site team leader determined whether proper custody procedures were followed during the fieldwork and decided whether additional samples were required.

When custody was transferred (e.g., samples are released to a shipping agent), the following applied:

- The coolers in which the samples were packed was sealed and accompanied by two COC records. When transferring samples, the individuals relinquishing and receiving them signed, dated, and noted the time on the COC record. This record documented sample custody transfer.

- Samples were dispatched to the laboratory for analysis with separate COC records accompanying each shipment. Shipping containers were sealed with custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information was entered in the COC record
- All shipments were accompanied by COC records identifying their contents. The original record accompanied the shipment. The other copies were distributed appropriately to the site team leader and site manager
- If samples were sent by common carrier, a bill of lading was used. Freight bills and bills of lading were retained as part of the permanent documentation

2.4.3 Laboratory Custody Procedures

A designated sample custodian at the laboratory accepted custody of the shipped samples from the carrier and entered 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 Quality Assurance Project Plan (QAPP).

2.4.4 Sample Containers and Preservation

Sample aliquots submitted to the analytical laboratories were placed in commercial certified pre-cleaned sample containers and preserved as identified in Table 2-1.

2.4.5 Sample Shipping

Due to the remote location of the RDM site, sample shipment to the analytical laboratories required careful logistical planning to ensure sample holding times were not exceeded and that samples arrived at the laboratories in good condition. In general, sample shipping logistics involved the following:

- The field team leader kept 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 contacted E & E’s Anchorage-based sample custodian to notify an aircraft charter service that a sample shipment flight was needed.
- When the sample shipment aircraft arrived at the Red Devil airstrip, the field team leader relinquished custody of the samples to the pilot.
- When the sample shipment aircraft arrived in Anchorage, E & E’s Anchorage-based sample custodian assumed custody of the samples. The custodian re-packed all sample shipping containers with fresh ice and relinquished custody of the samples to an overnight delivery service that shipped the samples to the analytical laboratories.
- E & E’s Anchorage-based sample custodian confirmed with the laboratories that all shipped samples were received.

Table 2-1 Sample Containers and Preservation

Matrix	Analysis	Maximum Holding Time	Preservation	Sample Containers
Soil/Sediment	TAL Inorganic Elements	6 months (28 days for Hg)	None, 0–4°C	4-oz glass jar
	Methyl Mercury	1 year (if aliquoted, weighed, and frozen ≤ –15°C at lab)	None, 0–4°C (shipment), ≤ –15°C (in lab)	4-oz glass jar
	Low-Level As, Sb, Pb, Hg	6 months (1 year for Low-Level Hg)	None, 0–4°C (None, 0–4°C (shipment), ≤ –15°C (in lab) for Low Level Hg)	4-oz glass jar
	SPLP Metals	6 months	None, 0–4°C	8-oz glass jar
	Mercury SSE	1 year	None, 0–4°C (shipment), ≤ –15°C (in lab)	4-oz glass jar
	Arsenic Speciation	1 year	None, 0–4°C (shipment), ≤ –15°C (in lab)	4-oz glass jar
	TCLP Metals	6 months (28 days for Hg)	None, 0–4°C	8-oz glass jar
	ASTM D2487, Particle Size and determination of Atterberg Limits	None	None	5-gallon bucket
	ASTM D2216 (Moisture Content)	10 days	None, 0–4°C	4-oz glass jar
	ASTM D3080 (Direct Shear Test)	None	None	5-gallon bucket
	ASTM D1557 (Compaction/Modified Proctor Test)	None	None	5-gallon bucket
	ASTM D5084 (Permeability), previously ASTM D2434	None	None	5-gallon bucket
	DRO/RRO (AK102/103)	14 days to extraction, 40 days from extraction to analysis	Cool to < 6°C or freeze to < -18°C.	8 oz. glass jar with Teflon-lined lid
	SVOCs with TICs	14 days to extraction, 40 days from extraction to analysis	Cool to < 6°C or freeze to < -18°C.	8 oz. glass jar with Teflon-lined lid
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

Table 2-1 Sample Containers and Preservation

Matrix	Analysis	Maximum Holding Time	Preservation	Sample Containers
	Methyl Mercury	6 months	0–4°C and dark immediately; HCl, pH<2	250-mL pre-tested fluoropolymer or glass bottle w/fluoropolymer-lined lids (no extra volume needed for MS/MSD)
	Dissolved Low-Level As, Sb, Pb, Hg	6 months (90 days for Low-Level Hg)	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
	Arsenic Speciation	28 days	0–4°C and dark immediately; HCl, pH<2	250-mL pre-tested fluoropolymer or glass bottle w/fluoropolymer-lined lids (no extra volume needed for MS/MSD)
	DRO/RRO	7 days for extraction, 40 days after extraction for analysis	None, 0–4°C	1-L amber bottle
	SVOCs with TICs	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 6°C	Four 40-mL amber glass vials, no headspace
	Total suspended solids	7 days	Cool to 6°C	1000 mL HDPE
	Total dissolved solids	7 days	Cool to 6°C	1000 mL HDPE
	Nitrate/Nitrite	28 days	2 mL H_2SO_4 perliter. Cool to 6°C	500 mL or 1-L HDPE
	Alkalinity	14 days	Cool to 6°C	500 mL HDPE

Table 2-1 Sample Containers and Preservation

Matrix	Analysis	Maximum Holding Time	Preservation	Sample Containers

Key:
°C = degrees Celsius
As = arsenic
ASTM = American Society for Testing and Materials
Br = bromine
Cl = chlorine
DRO/RRO = diesel range organics/residual 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
Pb = lead
Sb = antimony
SPLP = synthetic precipitation leaching procedure
SSE = selective sequential extraction
SVOC = semi-volatile organic compound
TAL = target analyte list
TCLP = toxicity characteristic leaching procedure
TIC = tentatively identified compound

2.4.6 Sample Packaging

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

- Sample bottle lids were never mixed. All sample lids stayed with the original containers.
- The sample volume levels were marked by placing the edge of the label at the appropriate sample height or by using a grease pencil. This helped the laboratory determine whether any leakage occurred during shipment. The label did not cover any bottle preparation QA/QC lot numbers.
- All sample bottles were placed in a plastic bag to minimize leakage in case a bottle breaks during shipment.
- The samples were cooled by placing on ice in sealed plastic bags. Ice was not 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 was material such as sawdust, newspaper, or sand used.
- The custody record was sealed in a plastic bag and placed in the shipping container. Custody seals must be affixed to the sample cooler.

2.4.7 Shipping Containers

The appropriate shipping container was determined by Department of Transportation (DOT) or International Air Transportation Association (IATA) regulations for the anticipated level of suspected contaminants. For the RDM RI/FS, all sample shipping containers were commercially available coolers.

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

Field personnel arranged transportation of samples to the laboratory. When custody is relinquished to a shipper, field personnel informed 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.

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

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

2.5 XRF Field Screening of Surface Soil Samples

At each field screening location that was evaluated for the presence of tailings, the XRF was used to field screen surface soils in-situ. Samples were not extracted from the sampling station or containerized. The XRF readings of the key metals (Hg, As, and Sb) were recorded in the field logbook. Three sets of XRF readings were recorded from each location. XRF concentrations of these and other metals analyzed also were recorded digitally by the XRF units. A rented Innov-X Alpha 4000 and/or BLM-owned Niton XL3t XRF device were used. Operation of the XRF units was in accordance with manufacturer specifications and the XRF SOP. The lateral coordinates of the field screening location were recorded using GPS instrumentation.

2.6 Decontamination and Management of Investigation-Derived Waste

2.6.1 Equipment Decontamination Procedures

Dedicated sampling equipment was used to collect all surface soil, sediment, surface water, and groundwater samples.

2.6.2 Investigation-Derived Waste Management

Investigation-derived wastes (IDW) that were generated during the 2010 sampling event included the following.

- Monitoring well purge water.
- Used dedicated sampling equipment.
- Non-dedicated sampling equipment decontamination fluids and used paper towels.
- Used personal protective equipment, including gloves.

IDW was 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).*

Based on sample results from groundwater sampling performed at the site in 2009 (E & E 2010), it was expected that purge water generated during sampling of the existing monitoring wells during the 2010 field event would have concentrations of RCRA metals and benzene below the RCRA TCLP limits. As such, purge water from these wells was disposed of onto the ground at the time of sampling. Disposal of this purge water was 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 infiltrated into the ground without ponding and did not enter surface water. Disposal was conducted in such a way that it did not transport sediment to surface water.

Used dedicated sampling equipment and personal protective equipment were rinsed if there was visible evidence of contamination, placed in sturdy plastic bags, shipped off site at the conclusion of the RI/FS field activities, and disposed of at a sanitary landfill in Anchorage.

2.7 Quality Control Samples

Following the requirements specified in the RI/FS QAPP, field quality control (QC) samples were collected for all matrices and analytes (except soil samples collected for XRF field screening, grain size, and geotechnical parameters). QC samples included the following.

- Field Duplicates – One field duplicate was collected for every 10 field samples of each matrix collected.
- Matrix Spike/Matrix Spike Duplicates (MS/MSD) – One MS/MSD was collected for every 20 field samples of each matrix collected.
- Trip Blanks – One trip blank was collected for every shipment of samples collected for BTEX analysis, Analytical Methods.

2.7.1 Field Quality Control

QC samples collected in the field included field duplicates and. Each type of QA/QC sample is briefly described below.

2.7.1.1 Field Duplicates

A field duplicate sample is a second sample collected at the same time and location as the original sample. Duplicated 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. Duplicate samples were collected at a minimum frequency of one field duplicate for every 10 samples for each matrix and each sampling event. A maximum relative percent difference (RPD) of 30% for waters and 50% for soil and sediment was used for evaluation of field duplicate comparability.

2.7.1.2 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 the best way to estimate how much mercury detected in a sample is from the site or can be attributed to contamination. These blanks were collected wherever low-level mercury in water was a concern.

2.7.1.3 Matrix Spikes/Matrix Spike Duplicates

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. Control limits for MSs are provided in the source methods and in the laboratory quality assurance manuals.

2.7.2 Laboratory Quality Control

QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of glassware and reagents. Each type of laboratory-based QC sample was analyzed at a rate of 5% or one per batch (batch is a group of up to 20 samples analyzed together), whichever was more frequent.

2.7.2.1 Method Blank

A method blank is a sample generated in the laboratory consisting of an analyte-free matrix (e.g., reagent water) that is taken through the entire sample preparation and analysis with the field samples. They are used to monitor for contamination that may be introduced into the samples during processing within the laboratory. Evaluation criteria are provided in the source methods and in the laboratory QA manuals.

2.7.2.2 Lab Duplicate

A laboratory duplicate consists of an aliquot of a field sample that is taken from the same container as the initial field sample and prepared and analyzed with the field samples. The laboratory duplicate is used to monitor the precision (in terms of RPD) of the analytical process. In conjunction with field duplicates, the sampling precision can then be inferred. Criteria for laboratory duplicates are provided in the source methods and in the laboratory QA manuals.

2.7.2.3 Laboratory Control Sample

A laboratory control sample (LCS) consists of a laboratory-generated sample that contains the analytes of interest at known concentrations. It may be prepared by the laboratory or purchased from an outside source. The LCS is taken through the same preparation and analytical procedures as the field samples. Analyte recoveries indicate the accuracy of the analytical system. LCSs and MSs together allow the overall accuracy of the sampling and analytical process to be determined. Criteria for LCS evaluation are provided in the source methods and in the laboratory QA manuals.

2.7.2.4 Additional QC Samples

Certain analytical methods may require additional QC elements not described above. These may include surrogates, serial dilutions, and other elements. Specific requirements and evaluation criteria are provided in the source methods and laboratory QA manuals.

2.8 Analytical Methods

Table 2-2 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 6010B (mass=121) (previously 6020A)
		EPA 6010B (mass=123) (previously 6020A)
	Arsenic	EPA 6010B
	Barium	EPA 6010B (mass=135) (previously 6020A)
		EPA 6010B (mass=137) (previously

Table 2-2 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
		6020A)
	Beryllium	EPA 6010B (previously 6020A)
	Cadmium	EPA 6010B (mass=111) (previously 6020A)
		EPA 6010B (mass=114) (previously 6020A)
	Calcium	EPA 6010B
	Chromium	EPA 6010B (mass=52) (previously 6020A)
		EPA 6010B (mass=53) (previously 6020A)
	Cobalt	EPA 6010B (previously 6020A)
	Copper	EPA 6010B (mass=63) (previously 6020A)
		EPA 6010B (mass=65) (previously 6020A)
	Iron	EPA 6010B (mass=54)
		EPA 6010B (mass=57)
	Lead	EPA 6010B
	Magnesium	EPA 6010B
	Manganese	EPA 6010B (previously 6020A)
	Nickel	EPA 6010B (mass=60) (previously 6020A)
		EPA 6010B (mass=62) (previously 6020A)
	Potassium	EPA 6010B
	Selenium	EPA 6010B (mass=82) (previously 6020A)
		EPA 6010B (mass=78) (previously 6020A)
	Silver	EPA 6010B (previously 6020A)
	Sodium	EPA 6010B
	Thallium	EPA 6010B (previously 6020A)
	Vanadium	EPA 6010B (previously 6020A)
	Zinc	EPA 6010B (mass=66) (previously 6020A)
		EPA 6010B (mass=67) (previously 6020A)
		EPA 6010B (mass=68) (previously 6020A)
Methyl Mercury	Methyl Mercury	EPA 1630, modified
Mercury Selective Sequential Extraction	Mercury	BRL SOP #BR-0013; Hg 5-step SSE and (www.epa.gov/esd/pdf-ecb/542asd95.pdf)
Arsenic Species	Arsenic Species	EPA 1632, modified As (inorganic)
		EPA 1632, modified As (III)
		EPA 1632, modified As (V)
SPLP Metals	TAL Metals	EPA 1312/6020A/7470A
TCLP Metals	Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, Silver	EPA 1311/6020A/7470A

Table 2-2 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
Analytical Group: Petroleum		
	Diesel Range Organics	AK 102
	Residual Range Organics	AK 103
	Benzene	EPA 8021B
	Toluene	EPA 8021B
	Ethylbenzene	EPA 8021B
	m/p-Xylene	EPA 8021B
	o-Xylene	EPA 8021B
Analytical Group: Conventional and Geotechnical Parameters		
	Particle Size/Atterberg Limits	ASTM D2487
	Total Organic Carbon (TOC)	EPA 9060 modified
	Moisture Content	ASTM D2216
	Permeability	ASTM D5084 (previously ASTM D2434)
	Compaction	ASTM D1557
Analytical Group: SVOCs		
	SVOCs + TICs	EPA 8270D
Matrix: Groundwater/Surface Water		
Analytical Group: Metals		
Total and Dissolved Metals	Total Mercury (low level)	EPA 1631
	Aluminum	EPA 6020A
	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 6020A
	Chromium	EPA 6020A (mass=52) EPA 6020A (mass=53)
	Cobalt	EPA 6020A
	Copper	EPA 6020A (mass=63) EPA 6020A (mass=65)
	Iron	EPA 6020A (mass=54) EPA 6020A (mass=57)
	Lead	EPA 6020A
	Magnesium	EPA 6020A
	Manganese	EPA 6020A
	Nickel	EPA 6020A (mass=60) EPA 6020A (mass=62)
	Potassium	EPA 6020A
	Selenium	EPA 6020A (mass=82) EPA 6020A (mass=78)
	Silver	EPA 6020A
	Sodium	EPA 6020A
	Thallium	EPA 6020A
	Vanadium	EPA 6020A
	Zinc	EPA 6020A (mass=66) EPA 6020A (mass=67) EPA 6020A (mass=68)

Table 2-2 Summary of Sample Analytical Methods

Subgroup	Analyte	Analytical Method
Methyl Mercury	Methyl Mercury	EPA 1630
Arsenic Speciation	Arsenic Species	EPA 1632, modified As (inorganic) EPA 1632, modified As (III) EPA 1632, modified As (V)
Analytical Group: Petroleum		
	Diesel Range Organics	AK 102
	Residual Range Organics	AK 103
	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 + TICs	EPA 8270D
Analytical Group: Conventional		
	Sulfate	EPA 300.0
	Chloride	EPA 300.0
	Fluoride	EPA 300.0
	Nitrate/Nitrite	EPA 353.2
	Alkalinity	EPA 310.1
	Total Suspended Solids	EPA 160.1
	Total Dissolved Solids	EPA160.2

Key:
EPA = Environmental Protection Agency
mL = milliliter
SVOC = Semi-Volatile Organic Compounds
SPLP = Synthetic Precipitation Leaching Procedure
TCLP = Toxicity Characteristic Leaching Procedure
TICs = Tentatively Identified Compounds

2.9 U.S. Geological Survey Geophysical Survey

The U.S. Geological Survey (USGS) geophysical survey report is anticipated to be completed in January 2011. The USGS will provide the draft report under separate cover.

2.10 Field Observations

2.10.1 Ecological Conditions

The following sections describe the environmental conditions assessed during the 2010 LSE. The objective of assessing the environmental conditions was to provide data for the ERA.

2.10.1.1 Climate

The RDM is located in the upper Kuskokwim River Basin and lies in a climatic transition between the continental zone of Alaska's interior and the maritime zone of the coastal regions. Average temperatures can vary from – 7 to 65 degrees Fahrenheit. Annual snowfall averages 56 inches, with a total mean annual precipitation of 18.8 inches. The Kuskokwim is ice-free from mid-June through October.

2.10.1.2 Vegetation

The vegetation around RDM is characterized by spruce-poplar forests and upland spruce-hardwood forests. There are no known rare plants in the area of the mine site, but there is a lack of survey data for a complete evaluation. *Aphragrnus eschscholtzianus*, *Thlaspi arcticum*, and *Arnica lessingii ssp. norbergi*, all rare or sensitive plant species, are found in the region (Wilder/HLA 1999).

During the 2010 sampling event, vegetation observations were recorded at surface soil sample locations (for samples taken after 9/18/2010). This included documenting the percent cover of vegetation in each of three strata categories: trees (woody vegetation with DBH > 3 inches and over 15 feet tall), samplings/shrubs (wood vegetation with DBH < 3 inches) and herbs (non-woody vegetation). The trees observed included Sitka alder (*Alnus sinuata*), black cottonwood (*Populus trichocarpa* Torr. & Gray), quaking aspen (*Populus Tremuloides*), and willow (*Salix sp.*). The saplings and shrubs observed included Sitka alder, black cottonwood, and willow. The dominant species in the herb strata included horsetail (*Equisetum sp.*), grass (*Poa sp.* and others unidentified), ferns (*Athyrium sp.*), various weedy plants (*Epilobium sp.* for example), and moss was noted.

Vegetative cover in the main processing areas was limited, often consisting of only moss and occasional patches of grass. Cover in these areas ranged widely, from approximately 0 to 90 percent, represented almost entirely by moss. If moss were removed from this category, vegetative cover would likely be less than approximately 10 percent. These areas offer limited soils and were heavily compacted in locations that were subject to vehicular travel, a majority of the surface material consisted of rock. On the perimeter of the disturbed areas, such as around the processing areas, on the sides of the roads, and along the slopes leading to the creek, saplings became more prevalent and consisted of between approximately 15 and 100 percent of the cover. Sitka alder and black cottonwood were the prevalent species occurring in this area. In the areas that showed no sign of disturbance in recent years, vegetation cover was dominated by trees (between approximately 10 and 75 percent) and saplings (between approximately 20 and 100 percent.

The area of Red Devil Creek north of the Main Processing Area, between the two roads and in the vicinity of the settling pond 2 and 3, was dominated by Sitka alder and black cottonwood trees and saplings with ferns, grasses, and horsetail in the lower strata. Settling pond 1 was dominated by horsetail.

In general, the disturbed (surface mining area) of the site had a thick growth of saplings and trees with moderate understory coverage. Vegetation in the upper strata consisted largely of Sitka alder saplings and trees with black cottonwood and occasional quaking aspen trees. The herb strata in this area was dominated by ferns, grasses, and weedy plants.

The vegetation in the Dolly Sluice and Rice Sluice areas was similar in nature, and neither appeared to have any distressed vegetation. The vegetation did not consist of any large alder trees in the channel area of either sluice.

2.10.1.3 Wildlife

Fish found in the Kuskokwim River in the vicinity of RDM include whitefish (*Coregonus sp.*), Arctic grayling (*Thymallus arcticus*), sheefish (*Stendous leucichthys nelma*), dolly varden (*Salvelinus mama Walbaum*), and Northern pike (*Esox lucius Linnaeus*), as well as Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), coho (*O. kisutch*), and chum salmon (*O. keta*) (Wilder/HLA 1999). Red Devil Creek is not listed as an anadromous stream by the Alaska Department of Fish and Game. Three river otters (*Lontra canadensis*) were observed in the Kuskokwim near the mouth of Red Devil Creek. Moose (*Alces* alces) and bear (*Ursus sp.*) tracks were observed near the upper pond and bear tracks were also observed near the mouth of Red Devil Creek. Moose, wolves, black bears, brown bears, lynx, martens, foxes, beavers, minks, muskrats, otters, and various small rodents are known to live in the area.

2.10.1.4 Avian

The bird species that migrate through the area are olive-sided flycatcher (*Contopus cooperi*), gray-cheeked thrush (*Catharus minimus*), Townsend's warbler (*Dendroica townsendi*), blackpoll warbler (*D. striata*), and Hudsonian godwit (*Limosa haemastica*) (Wilder/HLA 1999). A raptor survey done on the Kuskokwim River in July 2000 found an active peregrine falcon (*Falco* peregrinus) nest seven miles downstream of the Site (BLM 2001). Both the Arctic peregrine falcon and American peregrine falcons are listed as Alaska species of special concern. However, no data could be found on what kind of peregrine falcon nested near RDM. A large number of Spruce grouse (*Falcipennis* Canadensis) were observed both in the area surrounding the site and on the site. Also, an osprey (*Pandion* haliaetus) was observed foraging at the site.

2.10.1.5 Invertebrates and Aquatic Vegetation

Red Devil Creek runs through the middle of the mine site and divides the Main Processing Area in half. A historic bridge, now collapsed, crossed the creek and connected the two sides at the Main Processing Area. In the vicinity of where the bridge was, large piles of tailings or waste rock make up the banks of the stream. The creek contains some metal and other debris from the mining activities. The stream discharge was estimated to be somewhere between two and seven cubic feet per minute at the most upstream point where surface water and sediment were sampled.

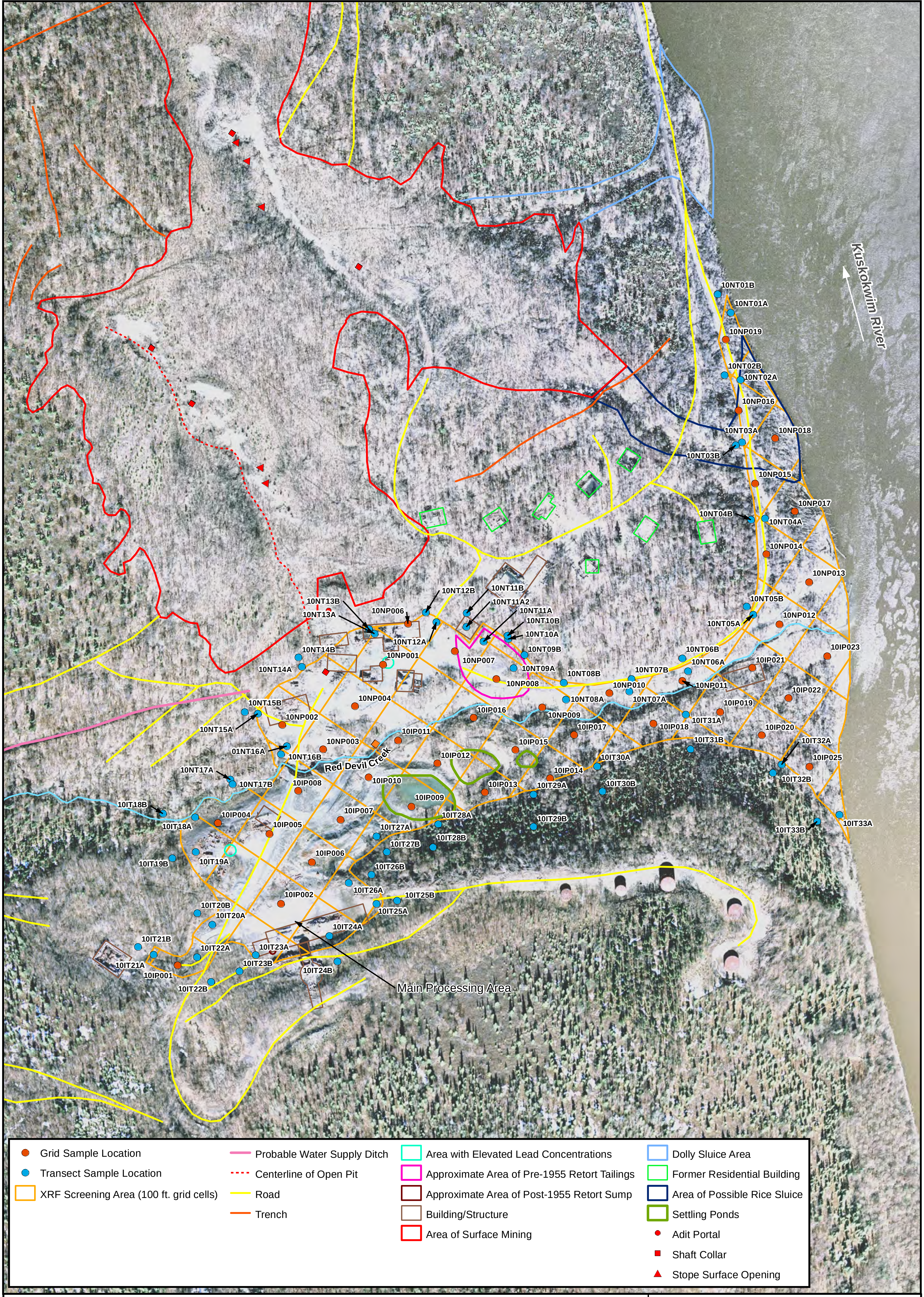
Near the confluence with the Kuskokwim River the discharge of Red Devil Creek was estimated to be fifteen to twenty cubic feet per minute. The creek depth at sampling locations varied from three to twelve inches at its deepest point. In Red Devil Creek numerous small (approximately 2 to 4 millimeters) larvae casings were observed on the underside of rocks throughout the reach within the sample area. An invertebrate ranging in size from approximately 3 to 6 millimeters was also observed throughout the reach crawling on the underside of rocks and is likely to be associated with the larvae casings. A 1.5 cm long opaque colored worm was observed upstream of the collapsed bridge in addition to opaque/white egg pods approximately 2 millimeters in diameter. At the most upstream location in Red Devil Creek, dark red colored worms less than a millimeter wide were found in the sediment. Aquatic vegetation was composed of moss and brown algae and generally appeared to trend toward increased coverage as sample locations progressed up the reach. However, not all sampling locations were found to have any aquatic vegetation. Stream speed appeared to decrease upstream of the processing areas and pool/riffle structure was more frequently observed in addition to woody material.

2.10.2 Previously Unknown or Undocumented Site Features

Site features that were previously unknown or undocumented were identified during the 2010 LSE. Site feature locations from the 2010 LSE are illustrated in Figure 2-8. These features included:

- The Kuskokwim River shoreline was surveyed to determine the relative distance from the waterline to the sediment and soil samples collected adjacent to the Kuskokwim River during the 2010 LSE.
- A Dump Site was identified in the Surface Mined Area that contained miscellaneous trash, three 2-feet by 4-inch mercury flasks, rusted pipe, and numerous beer cans.
- One rusty, unmarked, closed drum was identified upstream of the Main Processing Area within Red Devil Creek.
- Several groundwater seeps were identified along Red Devil Creek while conducting surface water sampling. One upstream of the Main Processing Area near the unmarked drum, and several upstream of the reservoir.

The lateral coordinates of each site feature was surveyed with GPS instrumentation as described in Chapter 8 of the FSP.



RED DEVIL MINE

Red Devil, Alaska

Figure 2-1
XRF Screening Locations

0 50 100 200 300 400
Feet
0 20 40 80 120
Meters
Scale 1:2,200

● Surface Soil Sample Location
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

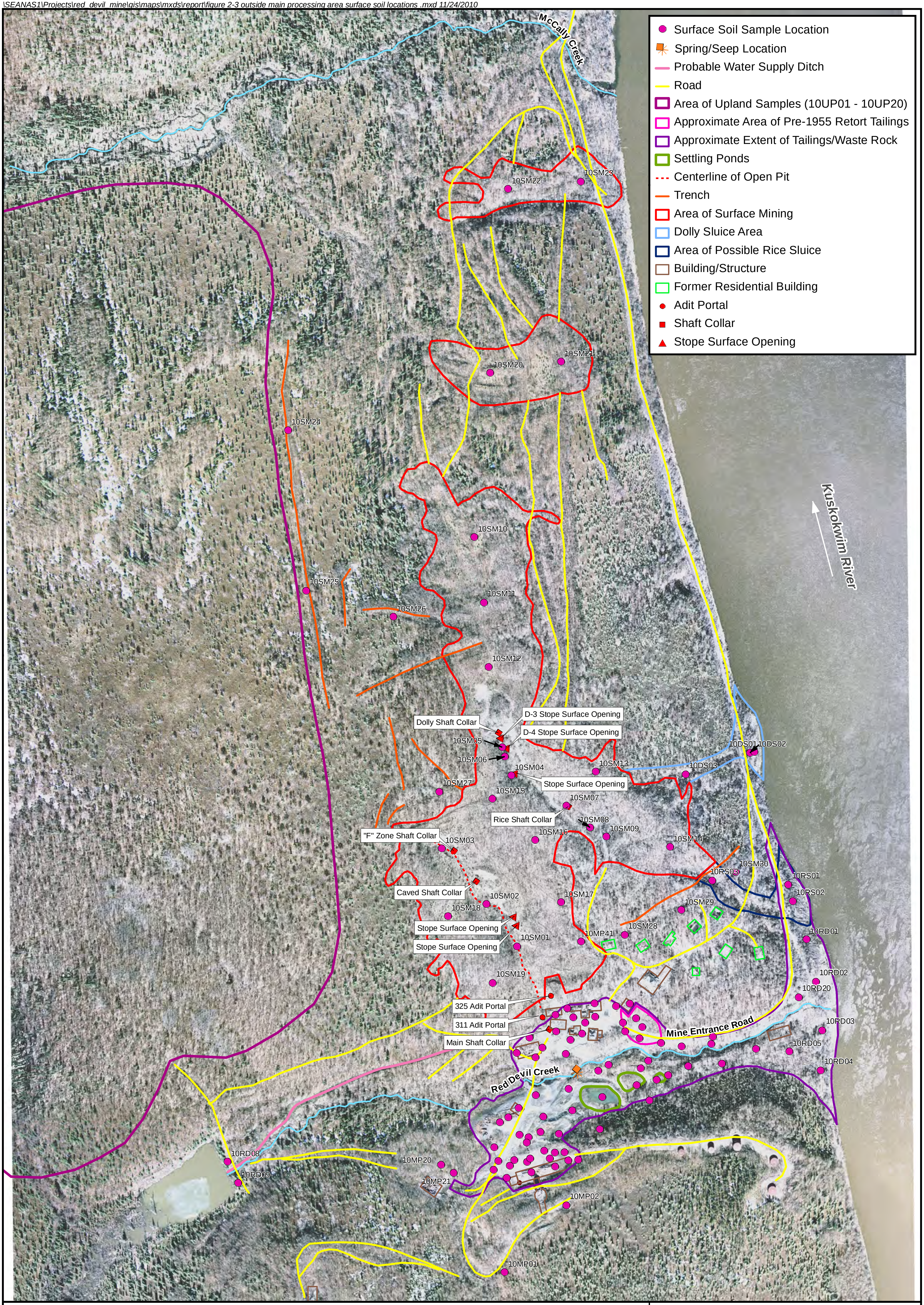
RED DEVIL MINE

Red Devil, Alaska

Figure 2-2
Main Processing Area Surface Soil Sample Locations

Scale 1:1,000

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 2-3 outside main processing area surface soil locations .mxd 11/24/2010



See Figure 1-3 for identification of Main Processing Area buildings/structures.

Aerial Photo Reference:
Aero-Metric, Inc., 5/29/2001.

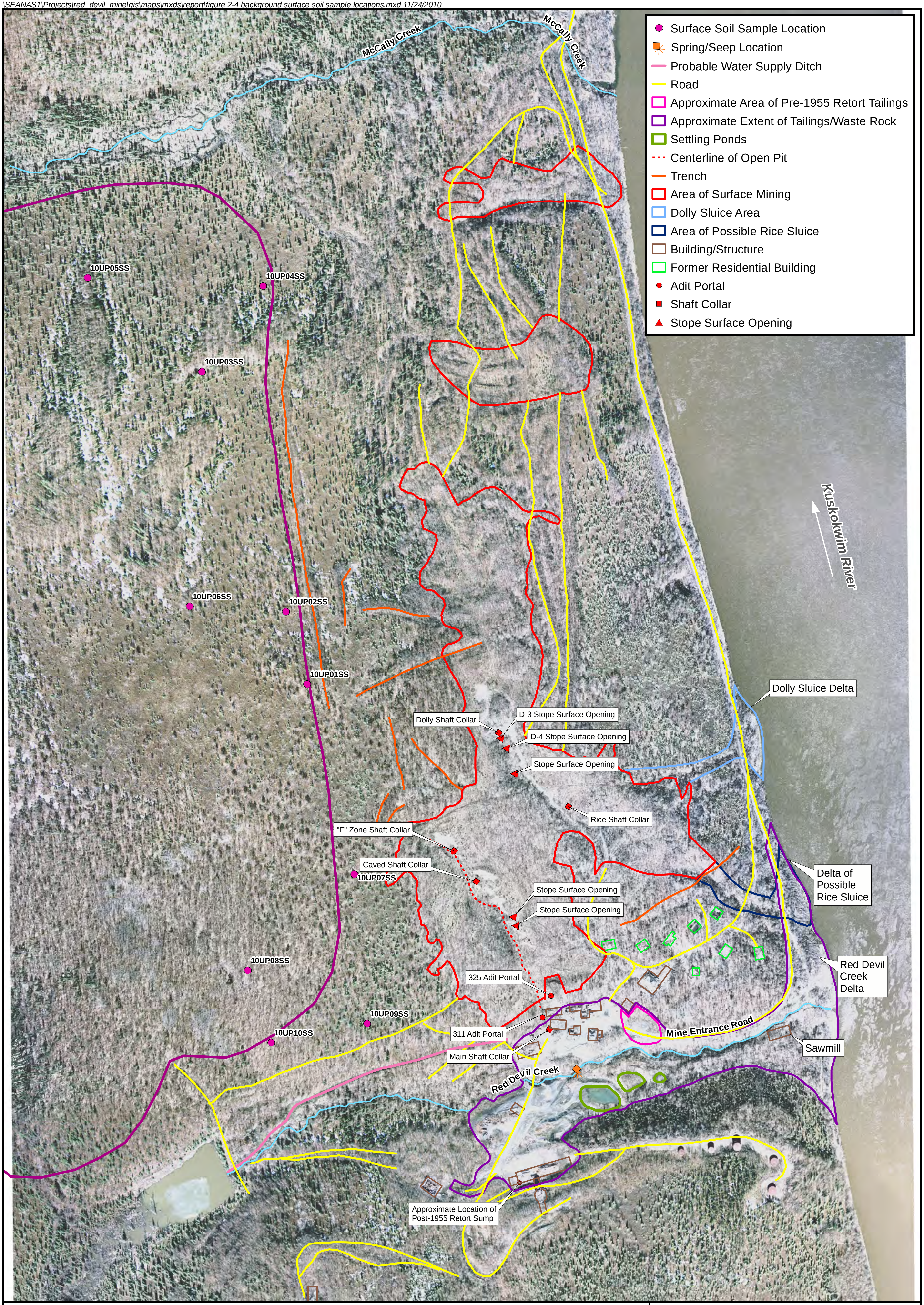
RED DEVIL MINE

Red Devil, Alaska

Figure 2-3
Outside Main Processing Area Surface Soil Sample Locations

0 125 250 500 750
Feet
0 25 50 100 150 200
Meters
Scale 1:4,000

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 2-4 background surface soil sample locations.mxd 11/24/2010



See Figure 1-3 for identification of Main Processing Area buildings/structures.

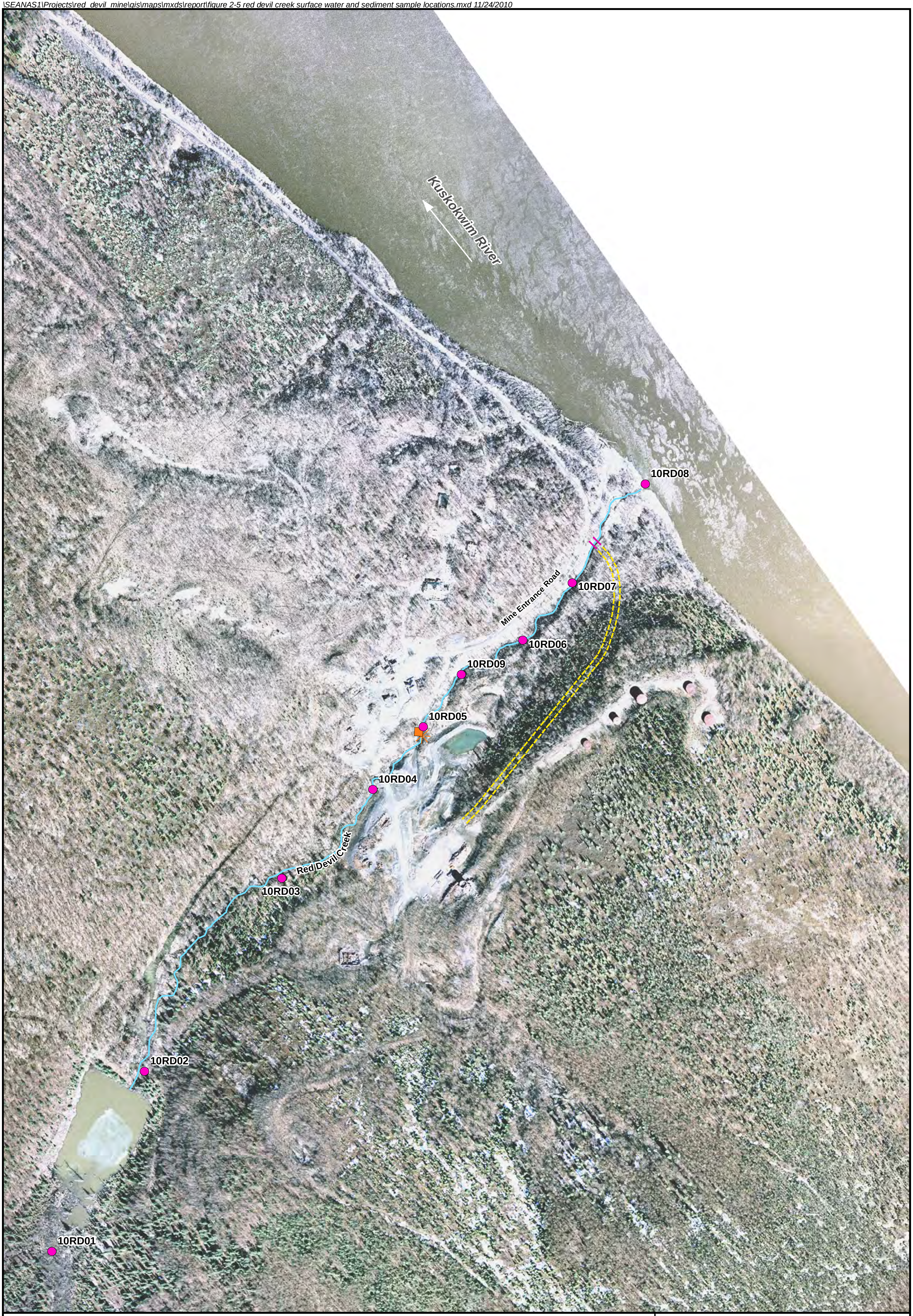
Aerial Photo Reference:
Aero-Metric, Inc., 5/29/2001.

RED DEVIL MINE

Red Devil, Alaska

Figure 2-4
Background Surface Soil Sample Locations

0 125 250 500 750
Feet
0 20 40 80 120 160 200
Meters
Scale 1:4,000
N



- ● Surface Water/Sediment Sampling Location
- Seep Location
- Approximate Location of New Road (2010)
- New Bridge Location (2010)

RED DEVIL MINE

Red Devil, Alaska

Figure 2-5
Red Devil Creek Surface Water and Sediment Sample Locations

Scale 1:3,200

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 2-6 kuskokwim river sediment sample locations.mxd 11/24/2010

RED DEVIL MINE

Red Devil, Alaska

Figure 2-6
Kuskokwim River Sediment Sample Locations

0 50 100 200 300 400
Feet
0 20 40 80 120
Meters
Scale 1:2,400

✚ Monitoring Well Sample Location
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-7
Groundwater Well Sample Locations

0 25 50 100 150
Feet
0 5 10 20 30 40 50
Meters
Scale 1:1,000

N

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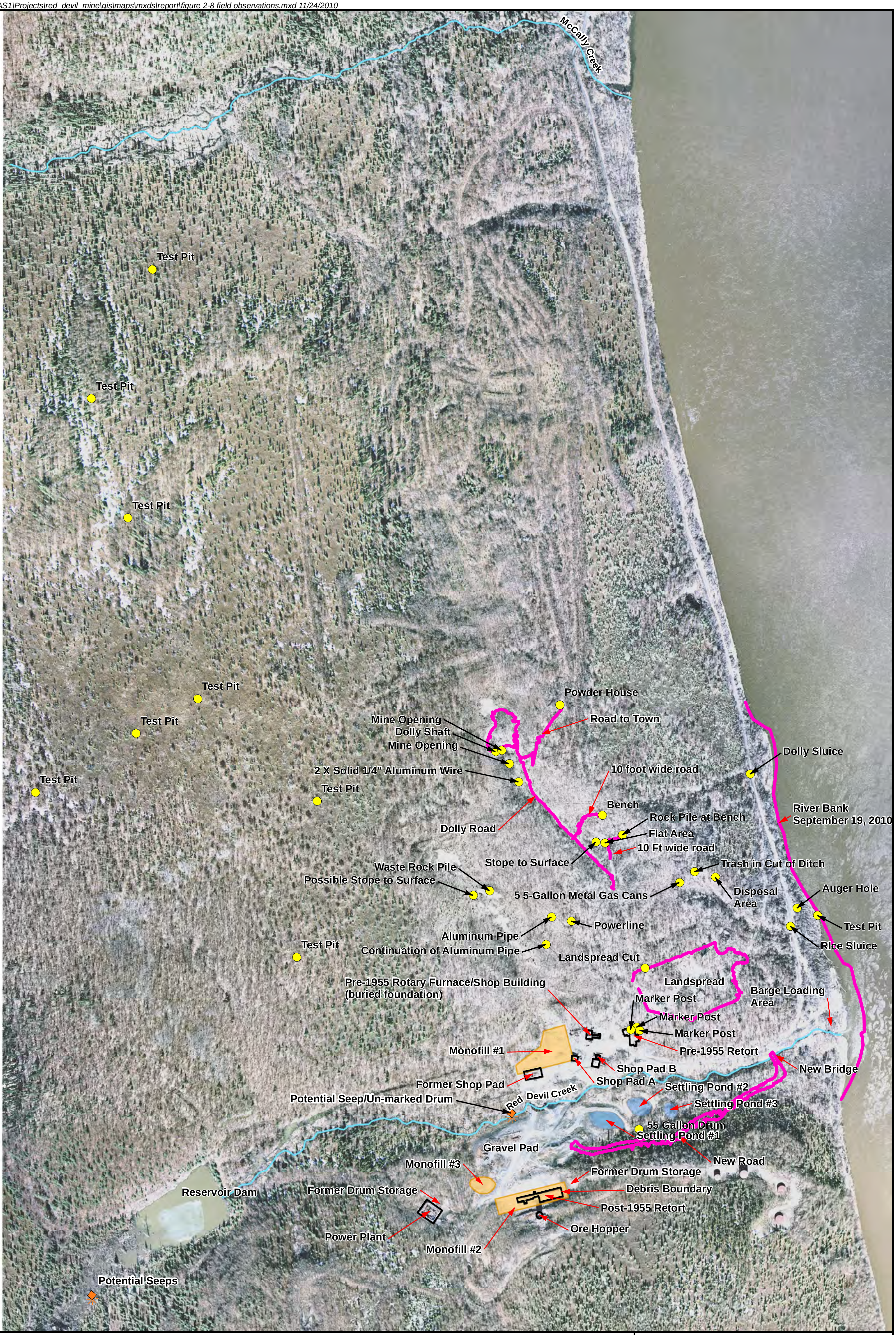


◆ Potential Seep
● Field Observation
— Field Observation Area
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-8
Field Observation Locations

0 100 200 400 600
Feet
0 20 40 80 120 160 200
Meters
Scale 1:4,000

3 Data Quality Assurance

3.1 Analytical Data Usability

The E & E project chemist performed validation of the data generated by Analytical Resources, Incorporated (ARI) and Brooks Rand Labs (BRL) in accordance with the *National Functional Guidelines for Inorganic Data Review* (EPA 2010); *National Functional Guidelines for Organic Data Review* (EPA 2008); and *Guidelines for Data Reporting, Data Reduction, and Treatment of Non-Detect Values* (ADEC 2008) in conjunction with the Quality Assurance/Quality Control (QA/QC) requirements specified in each specific analytical method and any project-specific QC defined in the Quality Assurance Project Plan. The quality of the analytical data was found to be acceptable for intended uses under this investigation. Data were found to be acceptable with qualification as definitive analytical data.

Analytical data were validated against criteria for:

- Holding times and sample integrity.
- Instrument performance checks.
- Initial and continuing calibrations.
- Blank analyses.
- Laboratory QC compounds and standards.
- Field duplicates analyses.
- Organic internal standard and surrogate performance.
- Compound identification and compound quantification.
- Reported detection limits.
- System performance and overall assessment of data.

Laboratory data were assessed for usability in accordance with the data quality objectives (DQOs) presented for the project. The following EPA (EPA 2000) guidance document was used to establish DQOs for this project: *Guidance for the Data Quality Objectives Process* (EPA QA/G-4), EPA/600/R-96/055.

Results that were less than the reporting limit, but exceeding the method detection limit, were qualified as estimated and used in calculations as a detected value. Both laboratory and field QA/QC data were also assessed for precision, accuracy, completeness, representativeness, and comparability.

3.1.1 Precision

Precision measures the reproducibility of the sampling and analytical methodology. Laboratory and field precision is defined as the RPD between duplicate sample analyses. The laboratory duplicate samples or MS/MSD samples measure the precision of the analytical method. The RPD values were reviewed for all commercial laboratory samples. Sample results were qualified based on duplicate QC outliers specified in the QAPP. Eighty-one sample results (approximately 1% of the data) were qualified as estimated quantities based on duplicate QC outliers.

3.1.2 Accuracy

Accuracy indicates the conformity of the measurements to fact. Laboratory accuracy is defined as the surrogate spike percent recovery (%R) or the MS %Rs for all laboratory analyses. The surrogate %R values were reviewed for all appropriate sample analyses. No sample results were qualified as estimated quantities based on surrogate QC outliers. The MS %R values were reviewed for all MS/MSD analyses. Two-hundred and ninety three sample results (approximately 4% of the data) were qualified as estimated quantities based on spike QC outliers.

3.1.3 Completeness

Data completeness is defined as the percentage of usable data (usable data divided by the total possible data). All laboratory data were reviewed for data validation and usability. No target analytes were rejected; therefore, the project DQO for completeness was met.

3.1.4 Representativeness

Data representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or environmental condition. The number and selection of samples were determined in the field to account accurately for site variations and sample matrices. The DQO for representativeness was met.

3.1.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Data produced for this site followed applicable field sampling techniques and specific analytical methodology. The DQO for comparability was met.

3.1.6 Field Duplicate Samples

Field duplicate split samples were collected to evaluate field sampling procedures at a rate of approximately one duplicate sample for every ten samples. Field duplicate samples collected for analysis met the specified target rate of 10%. Samples in which duplicates exceeded 35% RPD were qualified with a J (estimated) data validation qualifier. Five hundred and fifty sample results (approximately 7% of the data) were qualified as estimated quantities based on field duplicate QC outliers.

3.1.7 Rinse/Trip Blanks

Two water rinsate blanks were collected by pouring distilled water over the decontaminated sample collection device and capturing the water in the specified sampling containers. Rinse blanks were submitted for low level Mercury and Arsenic Speciation analysis. Mercury and Arsenic were not detected in the water rinsate blanks. The water trip blank was collected from a deionized water source. One water trip blank sample was collected during the field event; therefore, meeting the frequency criteria of one per cooler per 20 VOC samples. The target VOCs were not detected in the water trip blank sample.

Other data that were reviewed for verification of total sample integrity included:

- Sample handling and storage.
- Sample preparation logs.
- Instrument standards (primary and secondary records).
- Run logs for each instrument.

All corrections and/or notations based on QC outliers were added to the project database.

Annotated copies of the laboratory results pages and specific data validation or QA/QC issues are discussed in the Analytical Data Validation Summary Reports presented in Appendix A.

Data validation qualifiers, if necessary, were applied to the data as follows.

J	Estimated positive result, bias unknown
J+	Estimated positive result, possible negative bias
J-	Estimated positive result, possible positive bias
NJ	Tentatively identified at an estimated value
N	Tentatively identified
R	Rejected; unusable
U	Undetected
UJ	Undetected at an estimated value

The laboratory results are summarized in Section 4.

4 Investigation Results

This section describes the results for the surface soil, sediment, surface water, and groundwater samples collected during the RDM RI/FS 2010 Limited Sampling Event. The figures presented in this section illustrate the COPCs identified in the draft RI/FS Work Plan. The tables presented in this section present all analytes detected for the samples collected. This section is organized by sample type and source area. As appropriate, each subsection contains an interpretation of the data collected.

4.1 Soil Visual Inspection and In-Situ XRF Field Screening

Forty-four grid locations and 33 transect locations were visually inspected and field screened with the XRF. Field screening results for all inorganic elements are presented in Table 4-1. Soil descriptions from the visual inspection are presented in Table 4-1. In-situ XRF field screening results for total antimony, arsenic, and mercury are illustrated in Figures 4-1 through 4-3. A correlation between the visual inspection and the in-situ XRF data is illustrated in Charts 4-1 and 4-2.

4.1.1 Visual Inspection

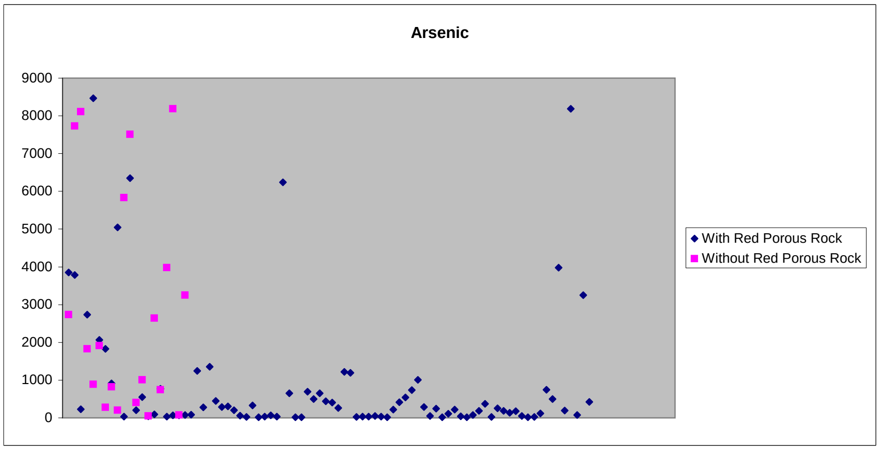
Results from the visual inspection confirmed that three types of native soil are present at the Site: alluvium associated with Red Devil Creek; loess; and soil derived from the Kuskokwim group bedrock. Results also indicated that the native soils within the Main Processing Area and throughout the Red Devil Creek Valley are mixed with tailings and waste rock from RDM. Two visual characteristics, red porous rock and mineralized vein material, were identified that may be used as indicators for elevated concentrations of total arsenic, antimony and mercury.

Visual inspection of grid samples resulted in the occurrence of red porous rock in 13 of the 48 grid samples collected. Mineralized veins were observed in gravels from 9 of the 48 grid samples collected.

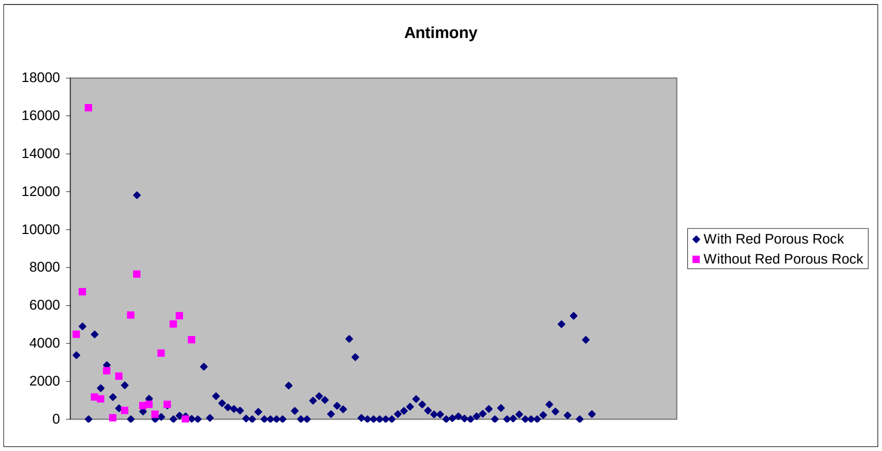
Visual inspection of transect samples resulted in the occurrence of red porous rock in 11 of the 66 grid samples collected. Mineralized veins were observed in gravels from 11 of the 66 grid samples collected.

Results from correlating the occurrence of red porous rock to concentrations of total arsenic, antimony and mercury indicate that on average soils that contain red porous rock are higher in total arsenic, antimony and mercury (Chart 4-1).

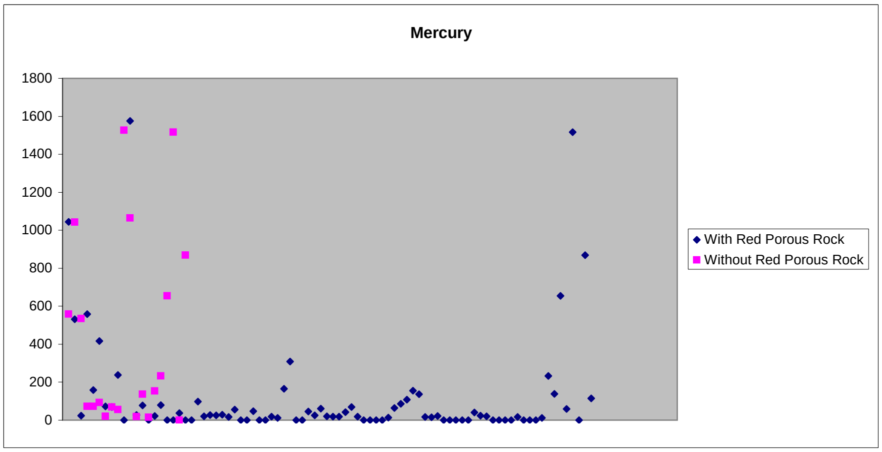
Chart 4-1 Red Porous Rock to In Situ XRF Data Correlation



Average As	
Without Red Porous Rock	900
With Red Porous Rock	2538

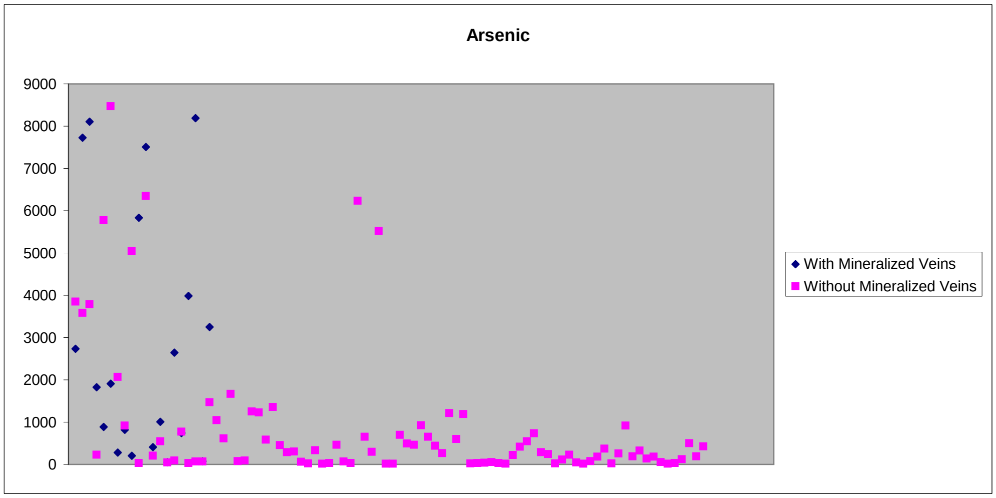


Average Sb	
Without Red Porous Rock	1303
With Red Porous Rock	2971

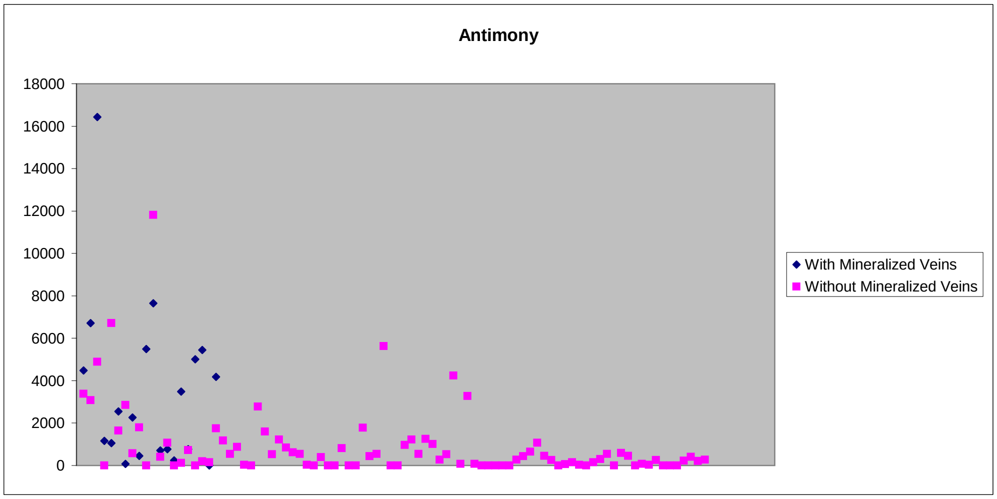


Average Hg	
Without Red Porous Rock	182
With Red Porous Rock	348

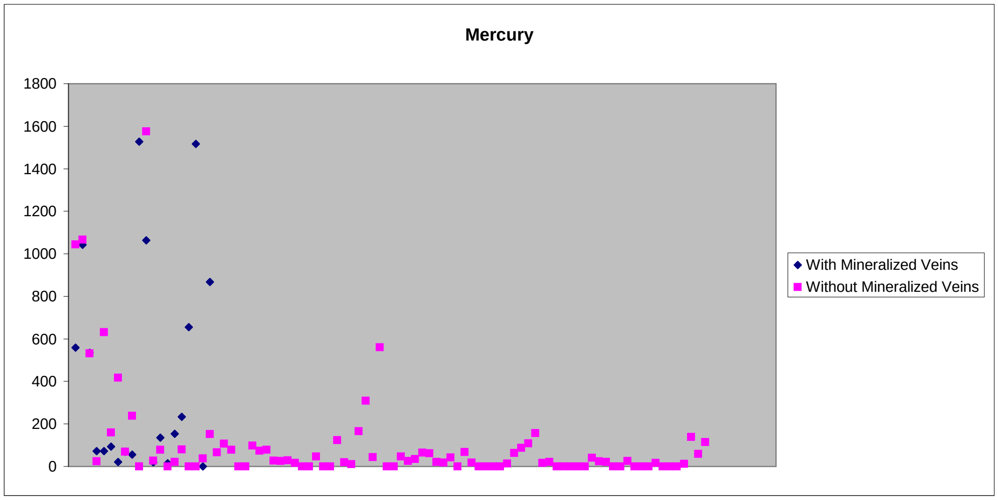
Chart 4-2 Minerlized Vein to In Situ XRF Data Correlation



Average As	
Without Minearlized Veins	890
With Minearlized Veins	2909



Average Sb	
Without Minearlized Veins	1240
With Minearlized Veins	3628



Average Hg	
Without Minearlized Veins	156
With Minearlized Veins	458

Results from correlating the occurrence of mineralized vein material to concentrations of total arsenic, antimony and mercury indicate that on average soils that contain mineralized vein material are higher in total arsenic, antimony and mercury (Chart 4-2).

4.1.2 Grid Samples

XRF field screening results for arsenic in soil tends to show the highest concentrations on the east side of Red Devil Creek in the MPA and settling pond area. The highest arsenic concentration was 8,107 parts per million (ppm) from sample 10IP008 on the east side of Red Devil Creek just north of the old Red Devil Creek bridge crossing. No samples collected from the west side of Red Devil Creek resulted in arsenic concentrations greater than 3,000 ppm. Arsenic concentrations tend to decrease with increased elevation, particularly on the east side of Red Devil Creek. Additionally, arsenic tends to decrease with increased distance from the Main Processing Area.

Mercury concentrations in grid samples tended to follow the same trend as arsenic concentrations, with the highest concentrations occurring on the east side of Red Devil Creek in the Main Processing Area and lesser concentrations in the settling pond area. The highest occurrence of mercury was found in sample 10IP016 on the east side of Red Devil Creek adjacent to settling pond 2, with a concentration of 1,575 ppm. Mercury concentrations on the west side of Red Devil Creek tended to have lower values than those on the east side of Red Devil Creek, only two samples from the west side of Red Devil Creek contained mercury concentrations greater than 100 ppm (10NP003 and 10NP001), both located within the MPA.

Antimony concentrations are highest in surface soils on the east side of Red Devil Creek in the Main Processing Area. The highest occurrence of antimony was from sample 10IP016 with a concentration of 11,816 ppm. Generally, antimony concentrations decreased with increased elevation on the east side of Red Devil Creek and also decreased with increased distance from the Main Processing Area.

4.1.3 Transect Samples

Arsenic concentration in transect samples were generally lower on the ‘B’ side of the transect and tended to have the highest overall concentrations near the post 1955 retort area. Additionally, arsenic concentrations tended to be elevated along the mine entrance road. One transect, 10IT21 had a significantly greater concentration of arsenic on the ‘B’ side (8,185 ppm) of the transect than on the ‘A’ side (191 ppm).

Mercury concentrations in transect samples generally were less in the ‘B’ side (closer to undisturbed area) of the transect than the ‘A’ side. Six ‘B’ side locations had mercury concentrations greater than 100 ppm, those six locations were concentrated around the post 1955 retort area. One of these transects, 10IT21, showed a higher ‘B’ side concentration than ‘A’ side concentration. On the west side of Red Devil Creek mercury concentrations tended to be less than 20 ppm on both ‘A’ side and ‘B’ side transects.

Similar to arsenic and mercury, antimony concentrations along transects tended to be less on the 'B' side of the transect and the highest concentrations of antimony occurred near the post 1955 Retort Area. Similar to arsenic, transect 10IT21 had a greater 'B' side antimony concentration than 'A' side concentration. Additionally, antimony concentrations tended to be elevated near the mine entrance road.

Overall, the concentrations of antimony, arsenic, and mercury were greater on side 'A' and less on side 'B' of the transects. The difference between the concentrations indicates that the transects worked to delineate the extent of tailings in the Red Devil Creek Valley.

4.2 Correlation of Laboratory and XRF Field Screening Data

One-hundred-thirty-five samples were submitted to ARI, Inc. for total metals analysis. Results of XRF field screening and laboratory analyses are presented in Tables 4-2 and 4-3, respectively. Results of the laboratory analysis were compared with the XRF field screening results for total antimony, arsenic, and mercury. For both field XRF screening and laboratory analysis, those samples which resulted in concentrations less than the instrument/method detection limit, were omitted from the correlation. Results were paired and a linear regression correlation coefficient was calculated for all of the sample pairs. Result of this comparison are illustrated in Charts 4-3 through 4-5. The calculated correlation coefficient for antimony, arsenic, and mercury are R^2 = 0.9072, 0.9013, and 0.9209 respectively. These R^2 values indicate that there was an excellent comparability between field and laboratory total metals data for these metals, and that the XRF data can be considered definitive. The following general trends were observed within the datasets:

- Laboratory arsenic results less than approximately 3,000 milligram per kilogram (mg/kg), tended to be higher than the corresponding field XRF results.
- Laboratory antimony results tend to be less than the corresponding field XRF result.
- Laboratory mercury concentrations less than 200 mg/kg, tended to be higher than the corresponding field XRF result.

4.3 Surface Soil Sample Results

4.3.1 Main Processing Area

Eighty four surface soil samples were collected in the Main Processing Area for laboratory analysis. Laboratory results for total TAL inorganic elements, mercury SSE, arsenic speciation, SPLP TAL metals, TCLP RCRA metals, SVOCs, DRO/RRO, grain size, moisture content, compaction, direct shear and permeability are presented in Table 4-3. Additionally, Table 4-4 presents lithologic soil descriptions of surface soil samples. Results for total antimony, arsenic, and mercury are illustrated in Figures 4-4 through 4-6.

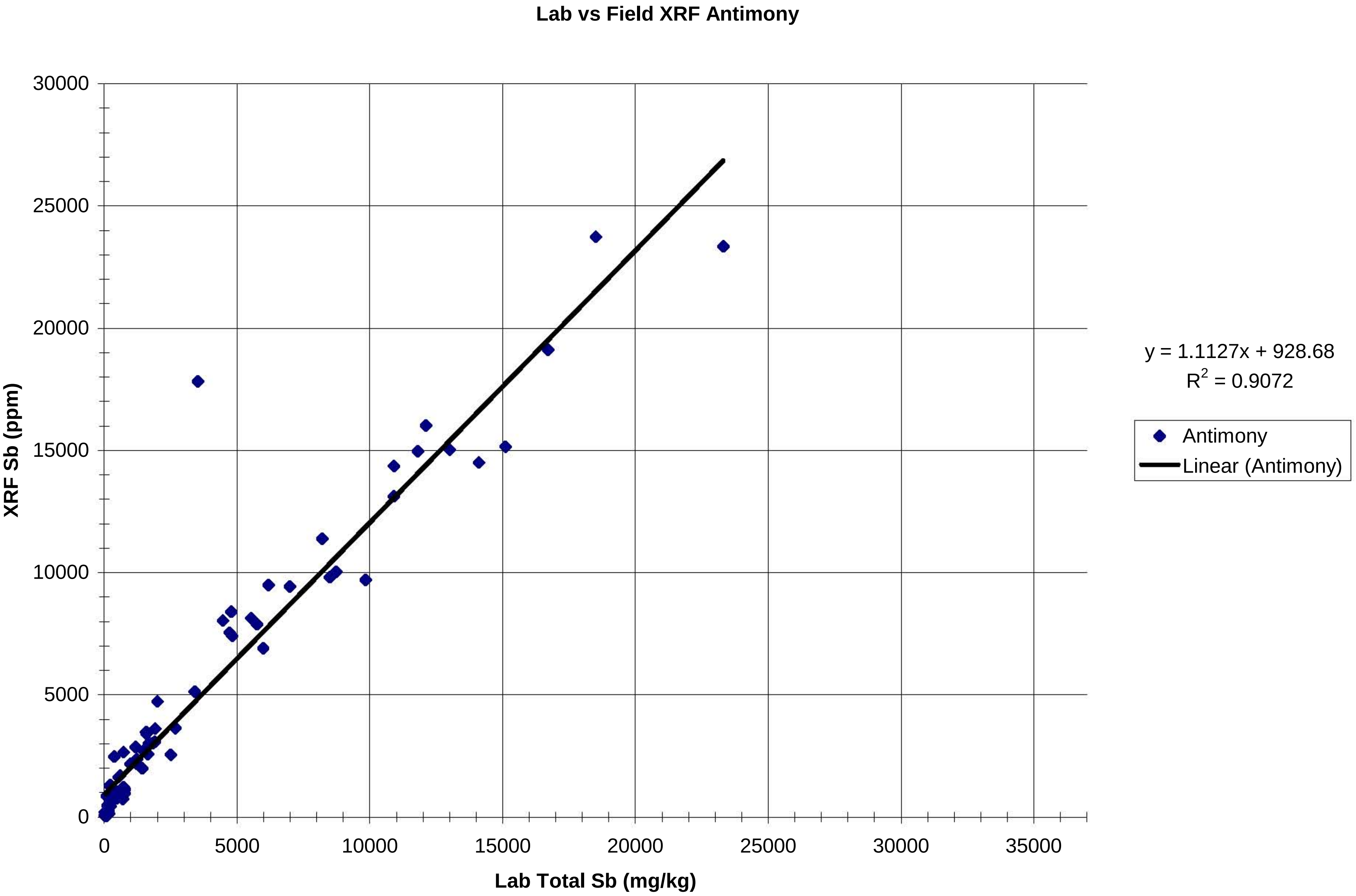


Chart 4-3. Linear Regression-Sb

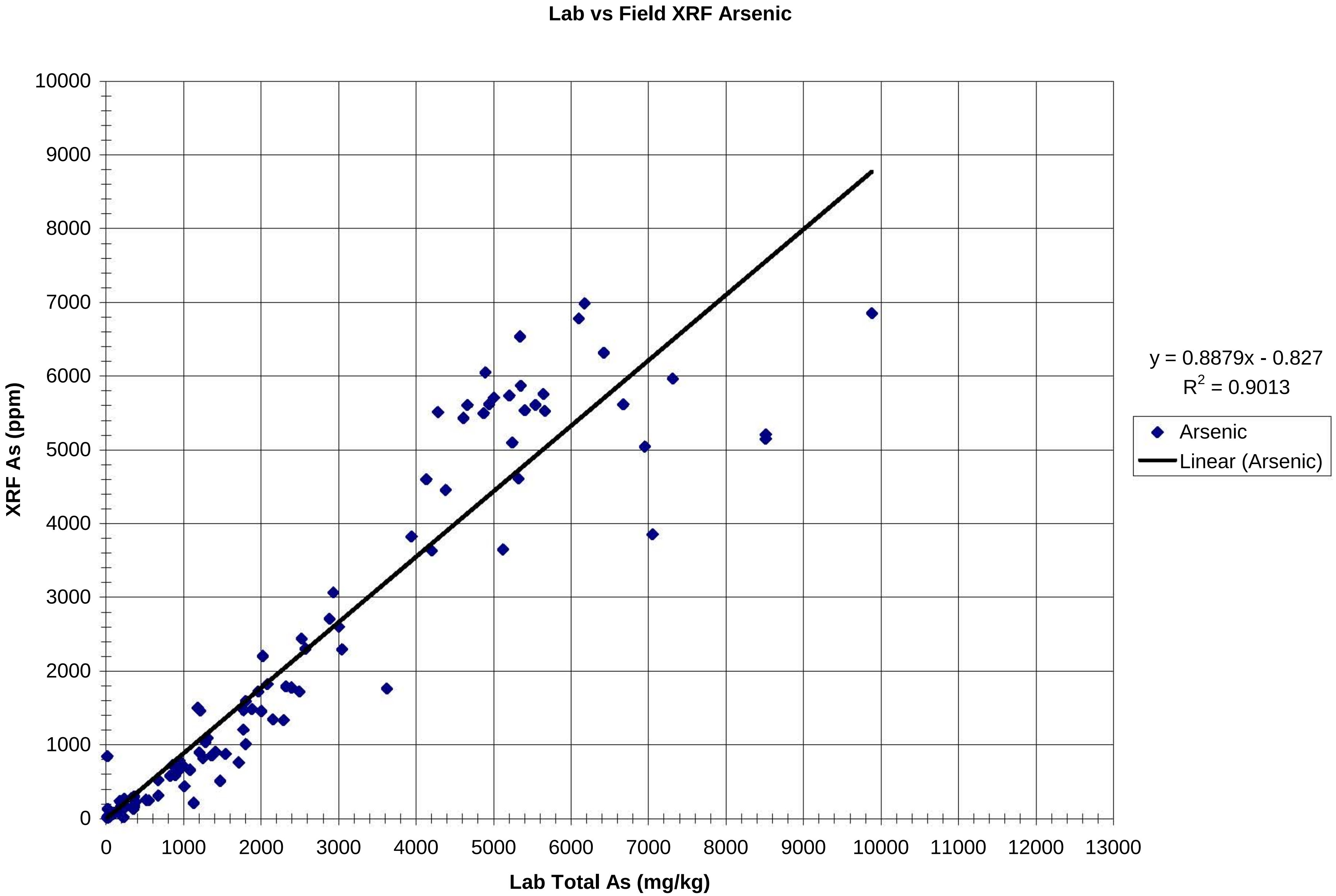


Chart 4-2. Linear Regression-As

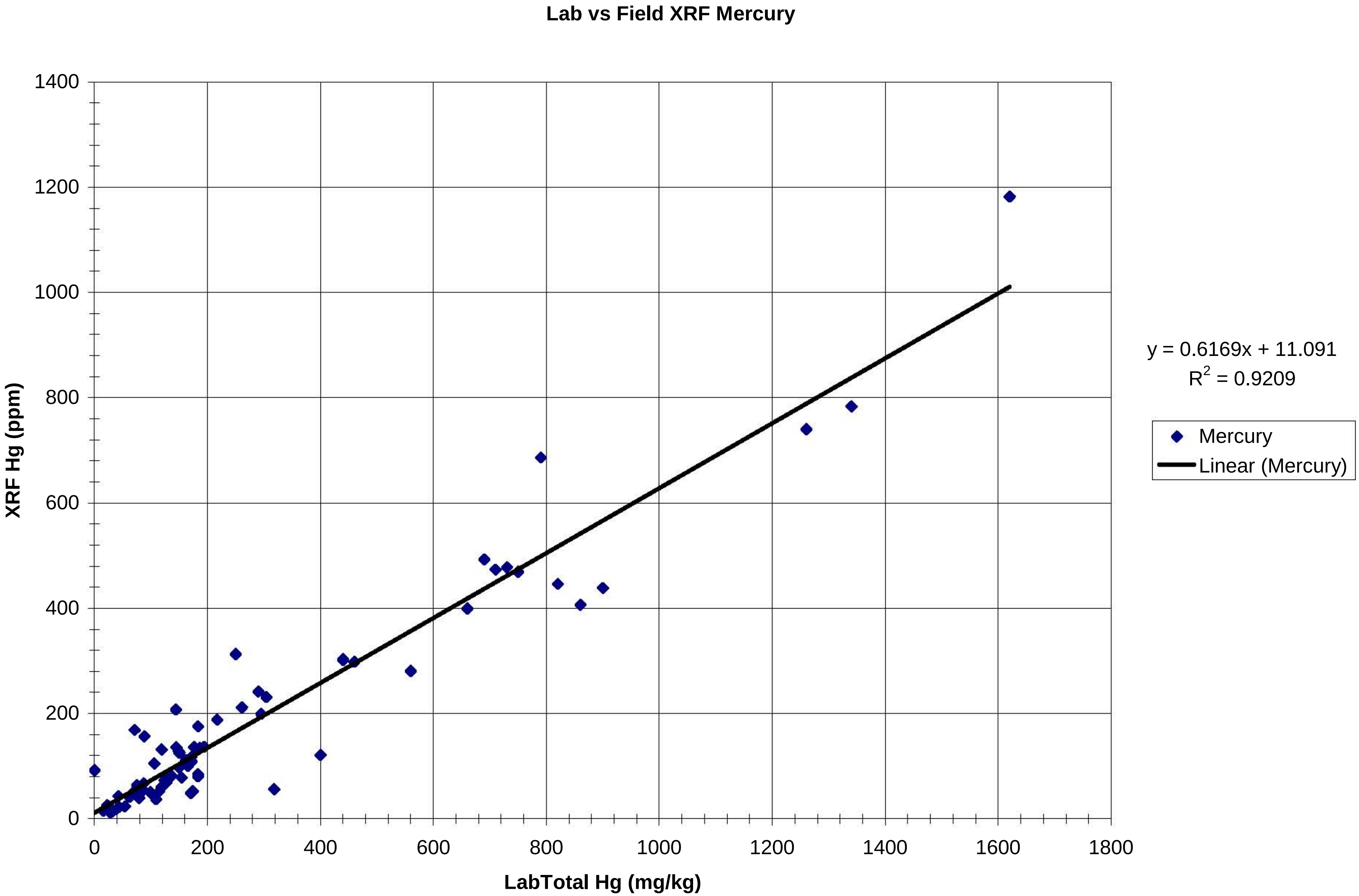


Chart 4-1. Linear Regression-Hg

Arsenic concentrations in the surface soil in the Main Processing Area range from 18 mg/kg to 9,880 mg/kg. Generally, the highest concentrations of arsenic in surface soil are present near the Post-1955 Retort and in the settling pond area.

Antimony concentrations in the Main Processing Area range from 7 mg/kg to 23,300 mg/kg. Generally, the highest concentrations of antimony in surface soil are present on the road below the Post-1955 Retort and in the area near the Pre-1955 Rotary Furnace.

Mercury concentrations in the surface soil in the Main Processing Area range from 0.28 mg/kg to 1,620 mg/kg. Generally, the highest concentrations of mercury in surface soil are present near the Post-1955 Retort.

Fourteen surface soil samples from the Main Processing Area were analyzed for mercury by SSE. The SSE technique was employed to approximate relative proportions of volatile, water soluble, weak acid soluble (stomach acid), organo-complexed, strong complexed, mercuric sulfide (cinnabar) and hydrofluoric acid extractable forms of mercury in the surface soil samples. Although this technique does not identify exact mineral or oxidation state, it does differentiate between and quantify groups of mercury species based upon solubility under various conditions. Each sequential extraction step dissolves a less soluble fraction. Mine site media that contain higher fractions of inorganic mercury in the water soluble, stomach acid soluble, and organo-complexed fractions are more readily methylated and more bioavailable than those containing most of their mercury in the strong-complexed and mercuric sulfide fractions (Bloom et al. 2003).

A summary of the selective extraction technique and typical species identified by each extraction step is provided below.

Step	Extractant	Fraction Description	Typical Compounds
F0	De-ionized Water	Volatile	
F1	De-ionized Water	Water soluble	$HgCl_2$, $HgSO_4$ (salts)
F2	pH 2 HCl/HOAc	Stomach acid soluble (weak acid)	HgO
F3	1 M KOH	Organo-complexed	Hg-humics, Hg_2Cl_2
F4	12 M HNO_3	Strong complexed	mineral lattice, Hg_2Cl_2, Hg_0
F5	Aqua Regia (concentrated HCl and HNO_3)	Mineral bound/cinnabar	HgS, m-HgS, HgSe, HgAu
F6	Hydrofluoric Acid		

Key:
HCL = Hydrochloric acid
HOAc = Acetic acid
M = Molar
KOH = Potassium hydrochloride
HNO_3 = Nitric acid

HgCl2 = Mercuric chloride
HgSO4 = Mercuric sulfate
HgO = Elemental mercury
Hg = Mercury
Hg2Cl2 = Mercurous chloride
HgS = Cinnabar
m-HgS = Metacinnabar
HgSe = Mercuric selenide
HgAu = Mercury-gold amalgam

Results of the mercury SSE analysis for the surface soil samples collected from the Main Processing indicated that the majority of the mercury is primarily present in the mineral bound fraction. Only sample 10MP01SS contained a large proportion of the organo-complexed fraction. Several of the samples also had detectable levels of mercury vapor.

Results for arsenic speciation indicate that the majority of the arsenic in the surface soils of the Main Processing Area are in the inorganic arsenic and arsenic (V) fractions.

Nineteen surface soil samples from the Main Processing Area were analyzed for total RCRA metals using the TCLP. Results indicated that arsenic, barium and mercury are leaching at detectible concentrations. Nine of these samples had concentrations of leachable arsenic greater than the TCLP regulatory value.

Visual soil observations of the eighty four Main Processing Area samples resulted with an occurrence of red porous rock in 28 of the samples, or approximately 33%. Mineralized veins were observed in 30 samples, or approximately 36%, and round river rock was observed in 18 of the samples, or approximately 21% of the samples.

4.3.2 Surface Mined Area

Thirty-eight surface soil samples were collected in the Surface Mined Area for laboratory analysis. Laboratory results for total TAL inorganic elements, mercury SSE, arsenic speciation, SPLP TAL metals, TCLP RCRA metals, SVOCs, DRO/RRO, grain size, moisture content, compaction, direct shear and permeability are presented in Table 4-3. Results for total antimony, arsenic and mercury are illustrated in Figures 4-7 through 4-9.

Arsenic concentrations in the surface soil in the Surface Mined Area range from non-detect to 8,510 mg/kg. Generally, the highest concentrations of arsenic in surface soil are present near the Dolly and Rice ore zone areas. The lowest concentrations of arsenic in surface soil are present near and northwest, of the potential site of the on-site repository.

Antimony concentrations in the Surface Mined Area range from non-detect to 140 mg/kg. Generally, the highest concentrations of antimony in surface soil are present near the Dolly Ore Zone area and in the trenched area west of residential structures.

Mercury concentrations in the surface soil in the Surface Mined Area range from 0.05 mg/kg to 174 mg/kg. Generally, the highest concentrations of mercury in surface soil are present near the Dolly and Rice ore zone areas. The lowest concentrations of mercury in surface soil are present near and northwest, of the potential site of the on-site repository.

Thirteen surface soil samples from the Surface Mined Area were analyzed for mercury by SSE. Results indicated that mercury is primarily present in both the mineral bound and organo-complexed fractions. Several of the samples also had detectable levels of mercury vapor.

Results for arsenic speciation indicate that the majority of the arsenic in the surface soils of the Surface Mined Area are in the inorganic arsenic and arsenic (V) fractions.

Visual soil observations of the thirty eight SMA samples resulted with no occurrences of red porous rock in samples. Mineralized veins were observed in 1 sample and round river rock was not observed in any of the SMA soil samples.

4.3.3 Red Devil Creek Valley

Fifteen surface soil samples were collected in the Red Devil Creek Valley for laboratory analysis. Laboratory results for total TAL inorganic elements, mercury SSE, arsenic speciation, SPLP TAL metals, TCLP RCRA metals, SVOCs, DRO/RRO, grain size, moisture content, compaction, direct shear and permeability are presented in Table 4-3. Results for total antimony, arsenic and mercury are illustrated in Figures 4-7 through 4-9.

Arsenic concentrations in the surface soil in the Red Devil Creek Valley range from non-detect mg/kg to 1,310 mg/kg. Generally, the highest concentrations of arsenic in surface soil are present near Red Devil Creek Delta. The lowest concentrations of arsenic in surface soil are present upstream from the Reservoir Dam.

Antimony concentrations in the Red Devil Creek Valley range from non-detect mg/kg to 974 mg/kg. Generally, the highest concentrations of antimony in surface soil are present near Red Devil Creek Delta. The lowest concentrations of antimony in surface soil are present upstream from the Reservoir Dam.

Mercury concentrations in the surface soil in the Red Devil Creek Valley range from non-detect mg/kg to 186 mg/kg. Generally, the highest concentrations of mercury in surface soil are present near Red Devil Creek Delta. The lowest concentrations of mercury in surface soil are present upstream from the Reservoir Dam.

Seven surface soil samples from the Red Devil Creek Valley were analyzed for mercury by SSE. Results indicated that mercury is primarily present in both the mineral bound and organo-complexed fractions. Sample 10RD18SS contained a large proportion of the hydrofluoric acid soluable fraction. Only sample 10RD04SS had detectable levels of mercury vapor.

Results for arsenic speciation indicate that the majority of the arsenic in the surface soils of the Red Devil Creek Valley are in the inorganic arsenic and arsenic (V) fractions.

Visual soil observations of the fifteen Red Devil Creek Valley samples resulted with the occurrence of red porous rock in 1 sample. Mineralized veins were observed in 1 sample and round river rock was not observed in any of the Red Devil Creek Valley soil samples.

4.3.4 Background

Eleven background surface soil samples were collected from upland area soils derived from the Kuskokwim Group for laboratory analysis. Laboratory results for total TAL inorganic elements, mercury SSE, arsenic speciation, SPLP TAL metals, TCLP RCRA metals, SVOCs, DRO/RRO, grain size, moisture content, compaction, direct shear and permeability are presented in Table 4-3. Results for total antimony, arsenic and mercury are illustrated in Figures 4-10 through 4-12.

Arsenic concentrations in the surface soil in the upland background area range from non-detect mg/kg to 23 mg/kg. Generally, the highest concentrations of arsenic in surface soil are present nearest the Main Processing Area.

Antimony concentrations in the surface soils in the upland background area were non-detect for all samples collected.

Mercury concentrations in the surface soil in upland background area range from 0.15 mg/kg to 0.32 mg/kg. Generally, the concentrations of mercury in the surface soil did not vary spatially within the upland background area.

Two surface soil samples from the Background Area were analyzed for mercury by SSE. Results indicated that mercury is primarily present in the organo-complexed fraction. None of the samples had detectable levels of mercury vapor.

Results for arsenic speciation indicate that the majority of the arsenic in the surface soils of the Background Area are in the inorganic arsenic and arsenic (V) fractions.

Visual soil observations of the eleven Background samples resulted with the occurrence of red porous rock in 1 sample. Mineralized veins were observed in 1 sample and round river rock was not observed in any of the Background soil samples.

4.4 Surface Water Sample Results

4.4.1 Red Devil Creek

Nine surface water samples were collected from Red Devil Creek for laboratory analysis. Laboratory results for total TAL inorganic elements, dissolved TAL inorganic elements, arsenic speciation, methyl mercury, low-level total mercury, low-level dissolved mercury, inorganic ions, nitrate/nitrite, carbonate/bicarbonate, SVOCs TDS, and TSS are presented in Table 4-4. Results for total antimony, arsenic, mercury, arsenic speciation and methyl mercury are illustrated in Figures 4-13 through 4-15.

Field measurements for pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity were collected at each sample station. These field measurements are presented in Table 4-4.

Arsenic concentrations in the surface water of Red Devil Creek range from 0.8 microgram per liter (µg/L) to 903 µg/L. The highest concentration of arsenic in the surface water is present near the seep in the Main Processing Area. The lowest concentrations are upstream from the seep in the Main Processing Area.

Antimony concentrations in the surface water of Red Devil Creek range from 1.3 µg/L to 170 µg/L. Generally, the concentrations of antimony in surface water increase in the downstream direction.

Mercury concentrations in the surface water of Red Devil Creek range from 1.92 nanogram per liter (ng/L) to 385 ng/L. Generally, the concentrations of mercury in surface water increase in the downstream direction.

4.5 Sediment Sample Results

4.5.1 Red Devil Creek

Eleven surface sediment samples were collected from Red Devil Creek for laboratory analysis. Laboratory results for total TAL inorganic elements, mercury SSE, methyl mercury, arsenic speciation, grain size, and total organic carbon are presented in Table 4-5. Results for total antimony, arsenic, mercury, arsenic speciation and mercury SSE are illustrated in Figures 4-13 through 4-15.

Arsenic concentrations in the sediment of Red Devil Creek range from 50 mg/kg to 130,000 mg/kg. The highest concentration of arsenic in sediment was collected below the seep in the Main Processing Area. Generally, the highest concentrations of arsenic in sediment are present within and downstream of the Main Processing Area.

Antimony concentrations in the sediment of Red Devil Creek range from non-detect to 4,060 mg/kg. Generally, the highest concentrations of antimony in sediment are present downstream of the Main Processing Area. Concentrations of antimony above the Main Processing Area are non-detect.

Mercury concentrations in the sediment of Red Devil Creek range from 0.18 mg/kg to 79 mg/kg. Generally, the concentrations of mercury in the sediment increase in the downstream direction.

Six surface sediment samples from the Red Devil Creek were analyzed for mercury by SSE. Results indicated that mercury is primarily present in both the mineral bound and organo-complexed fractions. Sample 10RD05SD, the sediment near the seep, contained a large proportion of the hydrofluoric acid soluable fraction. Only sample 10RD08SD had detectable levels of mercury vapor.

Generally, sedment samples above the Main Processing Area have a larger proportion of organo-complexed mercury than samples below the Main Processing Area.

Results for arsenic speciation indicate that the majority of the arsenic in the surface sediment of Red Devil Creek are in the inorganic arsenic and arsenic (V) fractions.

4.5.2 Kuskokwim River

Seven surface sediment samples were collected from the Kuskokwim River for laboratory analysis. Laboratory results for total TAL inorganic elements, mercury SSE, methyl mercury, arsenic speciation, grain size, and total organic carbon are presented in Table 4-5. Results for total antimony, arsenic, mercury, arsenic speciation and mercury SSE are illustrated in Figures 4-16 through 4-18.

Arsenic concentrations in the sediment of the Kuskokwim River range from 15 mg/kg to 1,790 mg/kg. Generally, the highest concentrations of arsenic in sediment are present at the Red Devil Creek and Dolly Sluice deltas.

Antimony concentrations in the sediment of the Kuskokwim River range from non-detect to 1,280 mg/kg. The highest concentration of antimony in sediment is present at the Red Devil Creek Delta.

Mercury concentrations in the sediment of the Kuskokwim River range from 0.09 mg/kg to 56 mg/kg. The highest concentration of mercury in sediment is present at the Red Devil Creek Delta.

Four surface sediment samples from the Kuskokwim River were analyzed for mercury by SSE. Results for samples 10KR02SD, 10KR04SD and 10KR07SD indicated that mercury is primarily present in the mineral bound fraction. Sample 10KR11SD, contained a mixture of the organo-complexed, strong complexed and mineral bound fractions. Only sample 10KR07SD had detectable levels of mercury vapor.

Results for arsenic speciation indicate that the majority of the arsenic in the surface sediment of the Kuskokwim River are in the inorganic arsenic and arsenic (V) fractions.

4.6 Groundwater Monitoring

Five groundwater samples were collected from five of eight existing monitoring wells for laboratory analysis. Laboratory results for total TAL inorganic elements, dissolved TAL inorganic elements, total low-level mercury, dissolved low-level mercury, methyl mercury, inorganic ions, nitrate/nitrite, carbonate/bicarbonate, arsenic speciation, SVOCs, DRO, RRO, GRO, BTEX, TDS, and TSS are presented in Table 4-6. Results for total antimony, arsenic and low-level mercury are illustrated in Figures 4-19 through 4-21. Total antimony and arsenic, and low level mercury were not analyzed for monitoring well MW07 as described in Section 2. The results on Figures 4-19 and 4-20 are for dissolved antimony and arsenic.

Field measurements for pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity were collected at each sample station. These field measurements are presented in Table 4-6.

Arsenic concentrations in the groundwater at RDM range from 0.4 µg/L to 57.8 µg/L. The highest concentration of arsenic in groundwater is present in the Settling Pond Area.

Antimony concentrations in the groundwater at RDM range from 4.9 µg/L to 748 µg/L. The highest concentration of antimony in groundwater is present in the Settling Pond Area.

Mercury concentrations in the groundwater at RDM range from 1.85 ng/L to 150 ng/L. The highest concentration of mercury in groundwater is present near Monofill #1.

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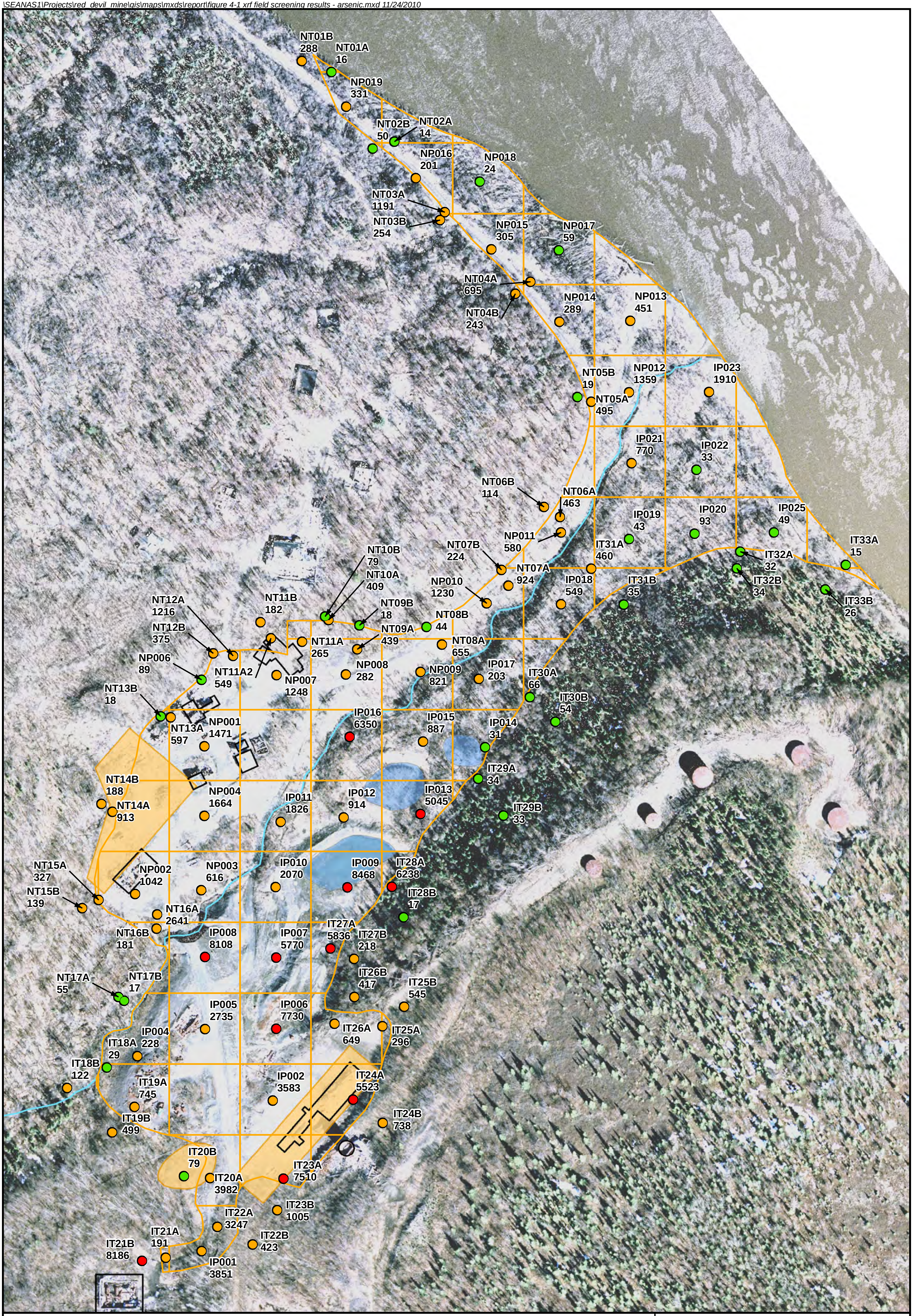
\\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-1 xrf field screening results - arsenic.mxd 11/24/2010



🟢 0 - 100 mg/kg
🟠 100 - 5,000 mg/kg
🔴 > 5,000 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-1
XRF Field Screening Results
Arsenic
(Only Grid And Transect Locations)

0 25 50 100 150 200 250
Feet
0 12.5 25 50 75
Meters
Scale 1:1,600

N

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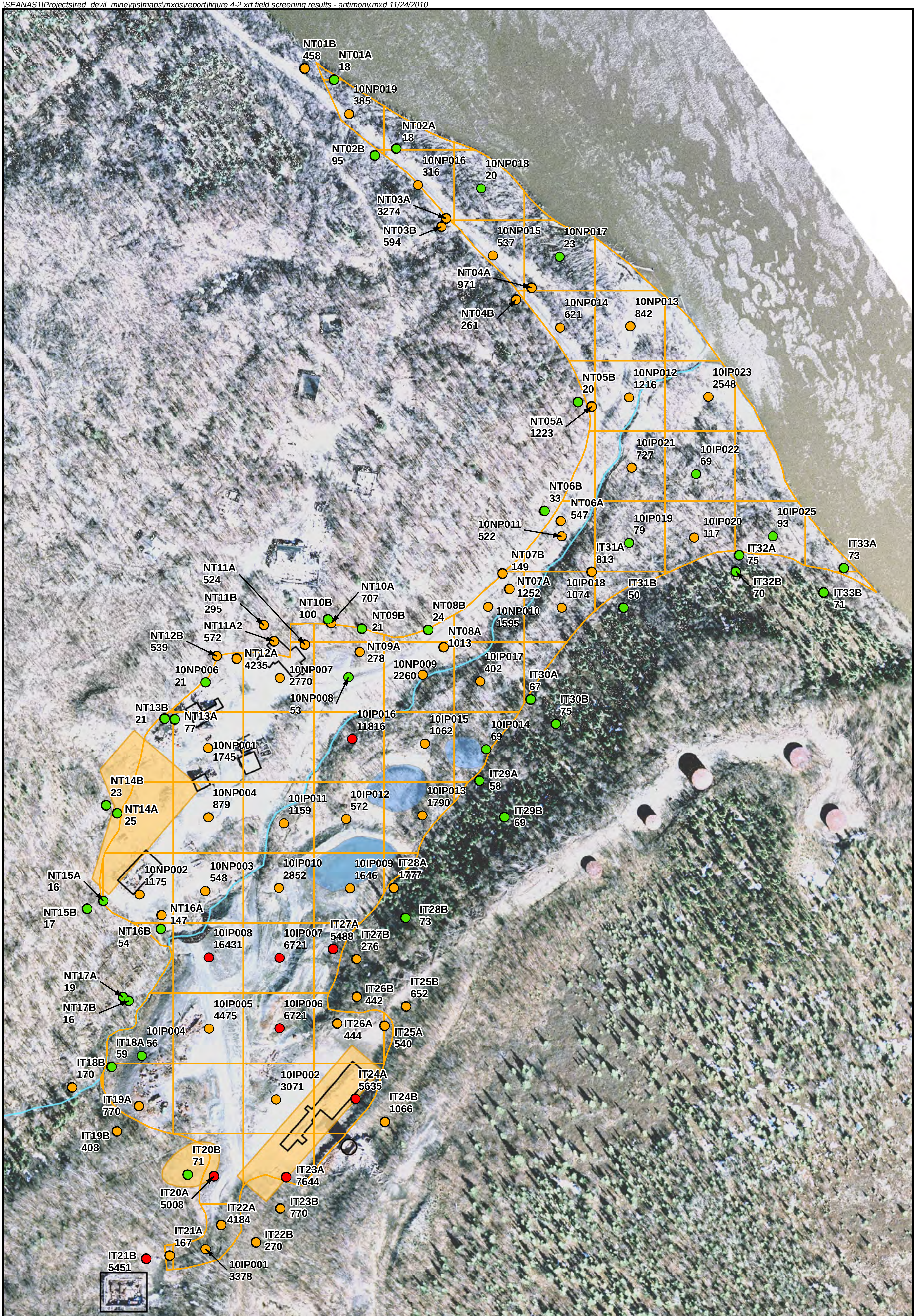
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-2 xrf field screening results - antimony.mxd 11/24/2010



● 0 - 100 mg/kg
● 100 - 5,000 mg/kg
● > 5,000 mg/kg
▨ Settling Pond
▨ Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-2
XRF Field Screening Results Antimony (Only Grid And Transect Locations)

0 25 50 100 150 200 250
Feet
0 12.5 25 50 75
Meters
Scale 1:1,600

N

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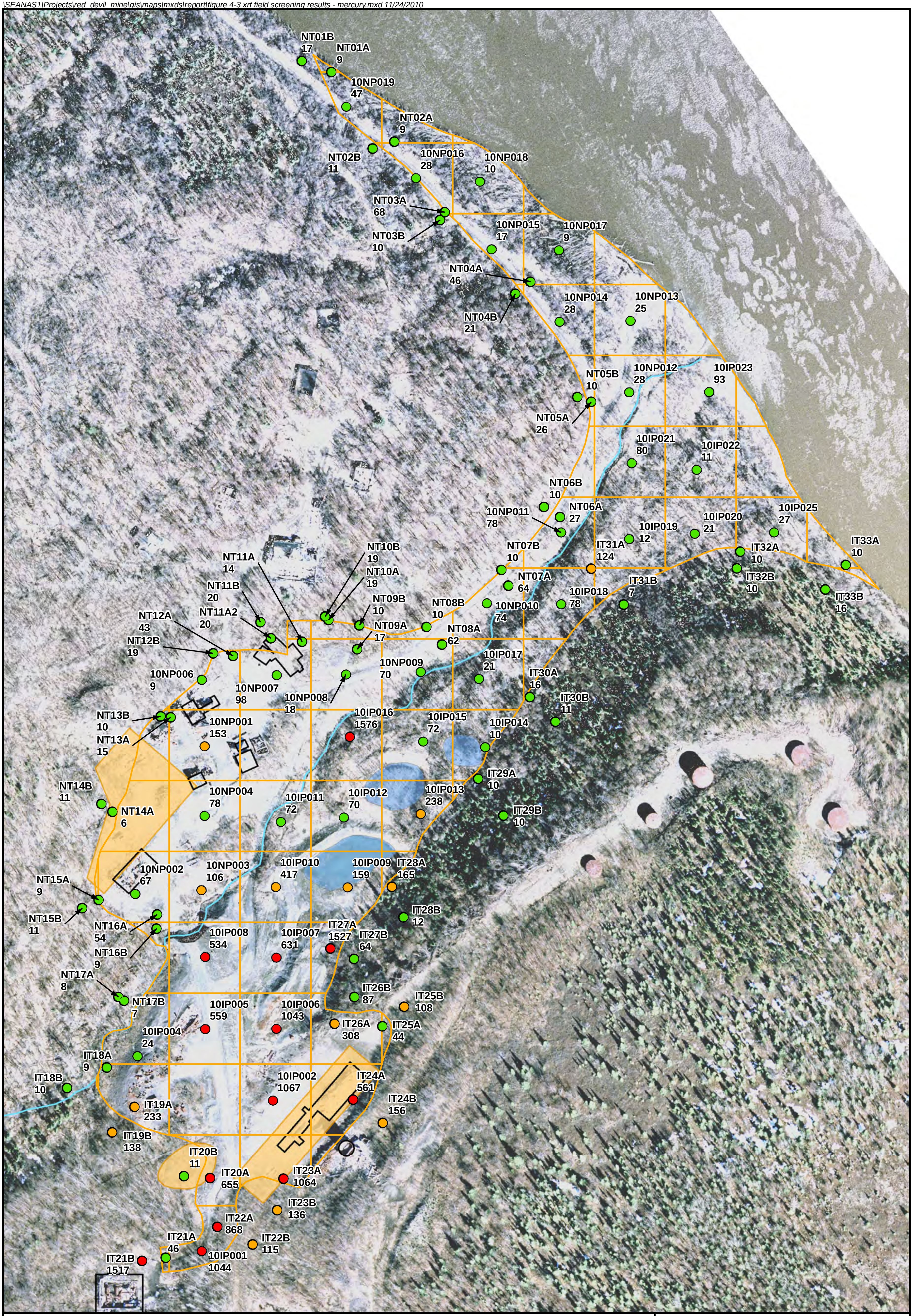
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-3 xrf field screening results - mercury.mxd 11/24/2010



🟢 0 - 100 mg/kg
🟠 100 - 500 mg/kg
🔴 > 500 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-3
XRF Field Screening Results
Mercury
(Only Grid And Transect Locations)

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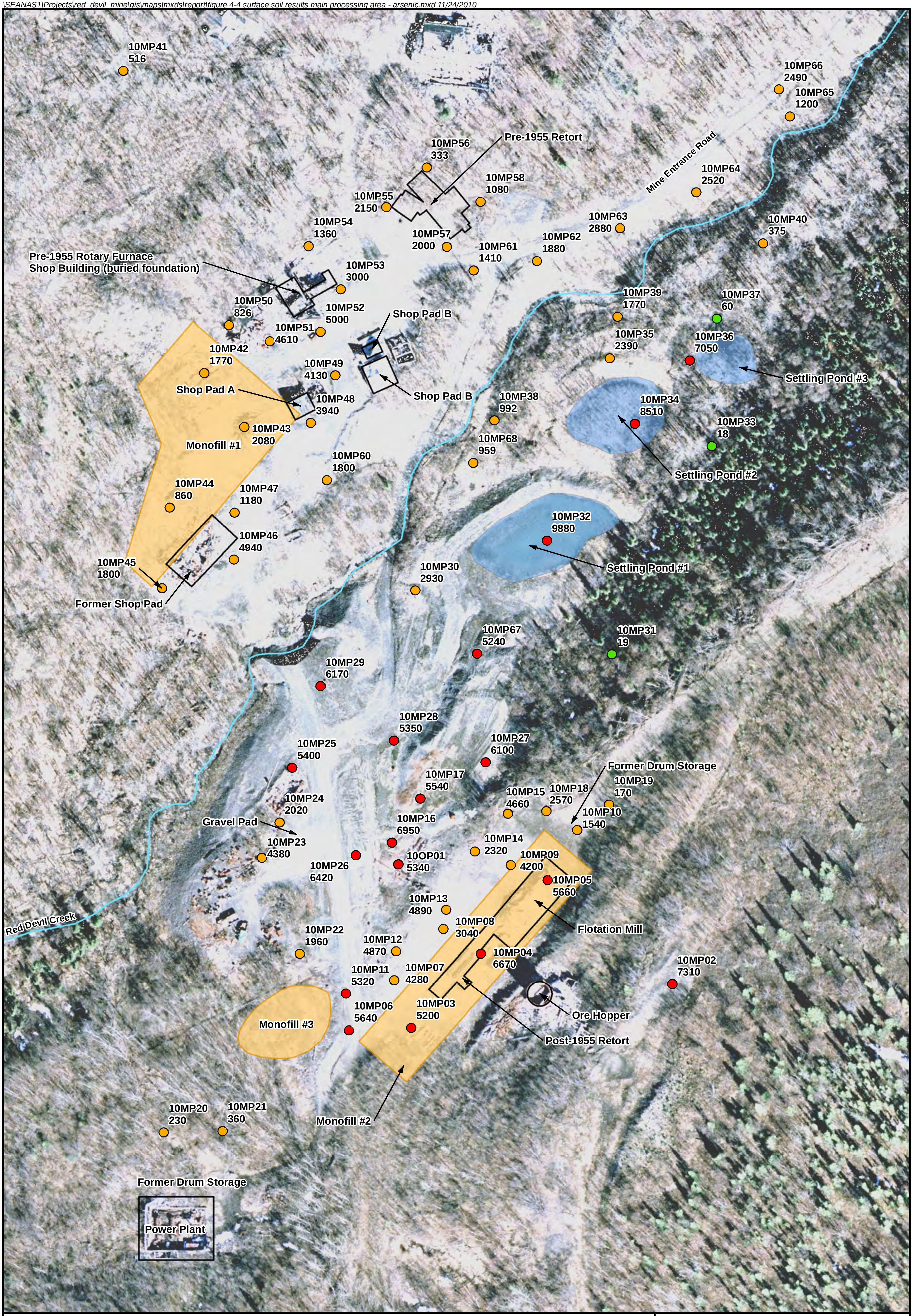
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-4 surface soil results main processing area - arsenic.mxd 11/24/2010



● 0 - 100 mg/kg
● 100 - 5,000 mg/kg
● > 5,000 mg/kg
▨ Settling Pond
▨ Monofill
☐ Historical Structure

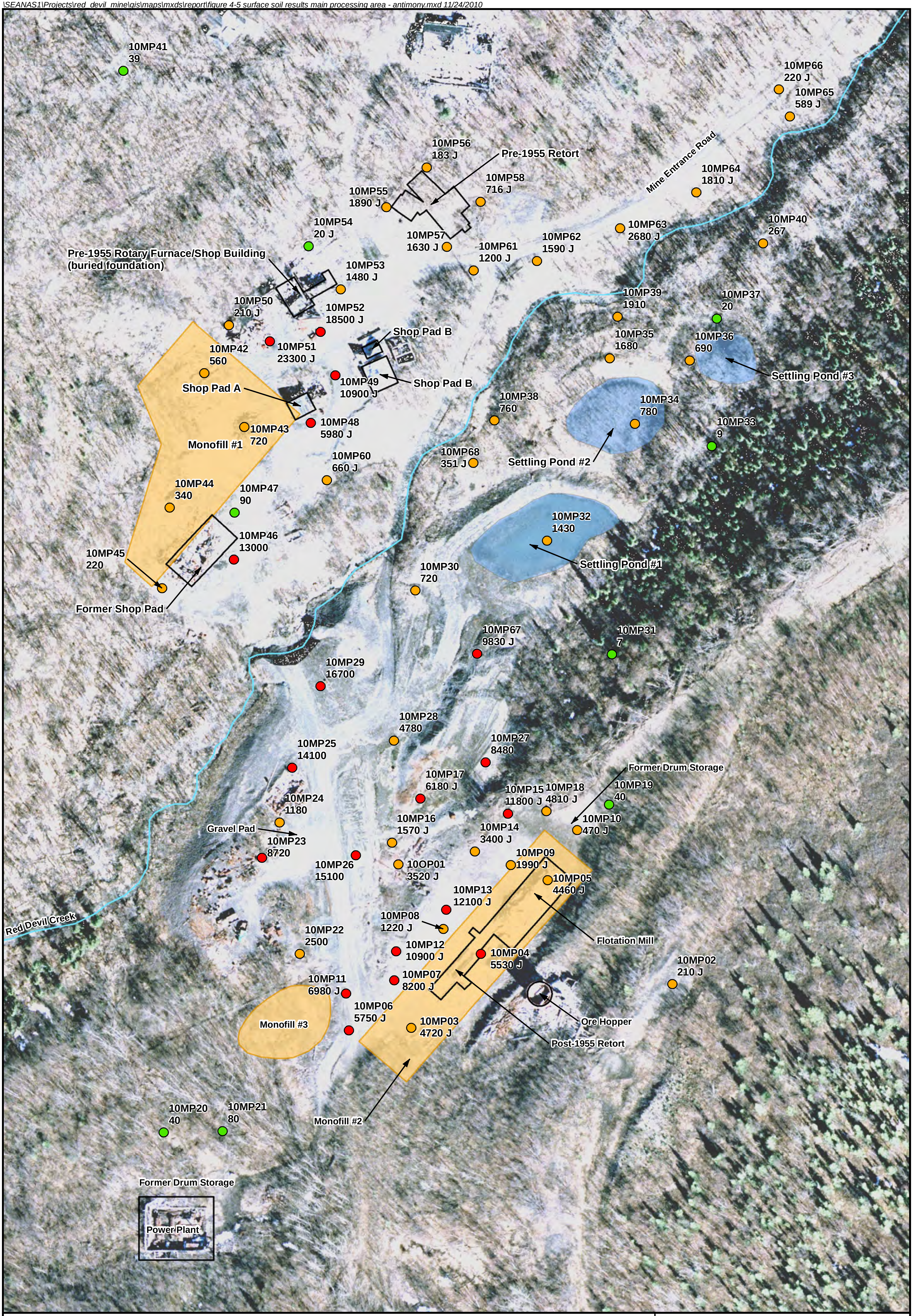
RED DEVIL MINE

Red Devil, Alaska

Figure 4-4
Surface Soil Results
Main Processing Area
Total Arsenic

0 25 50 100 150
Feet
0 5 10 20 30 40
Meters
Scale 1:2,000

N

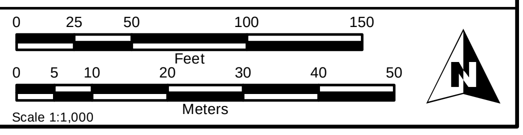


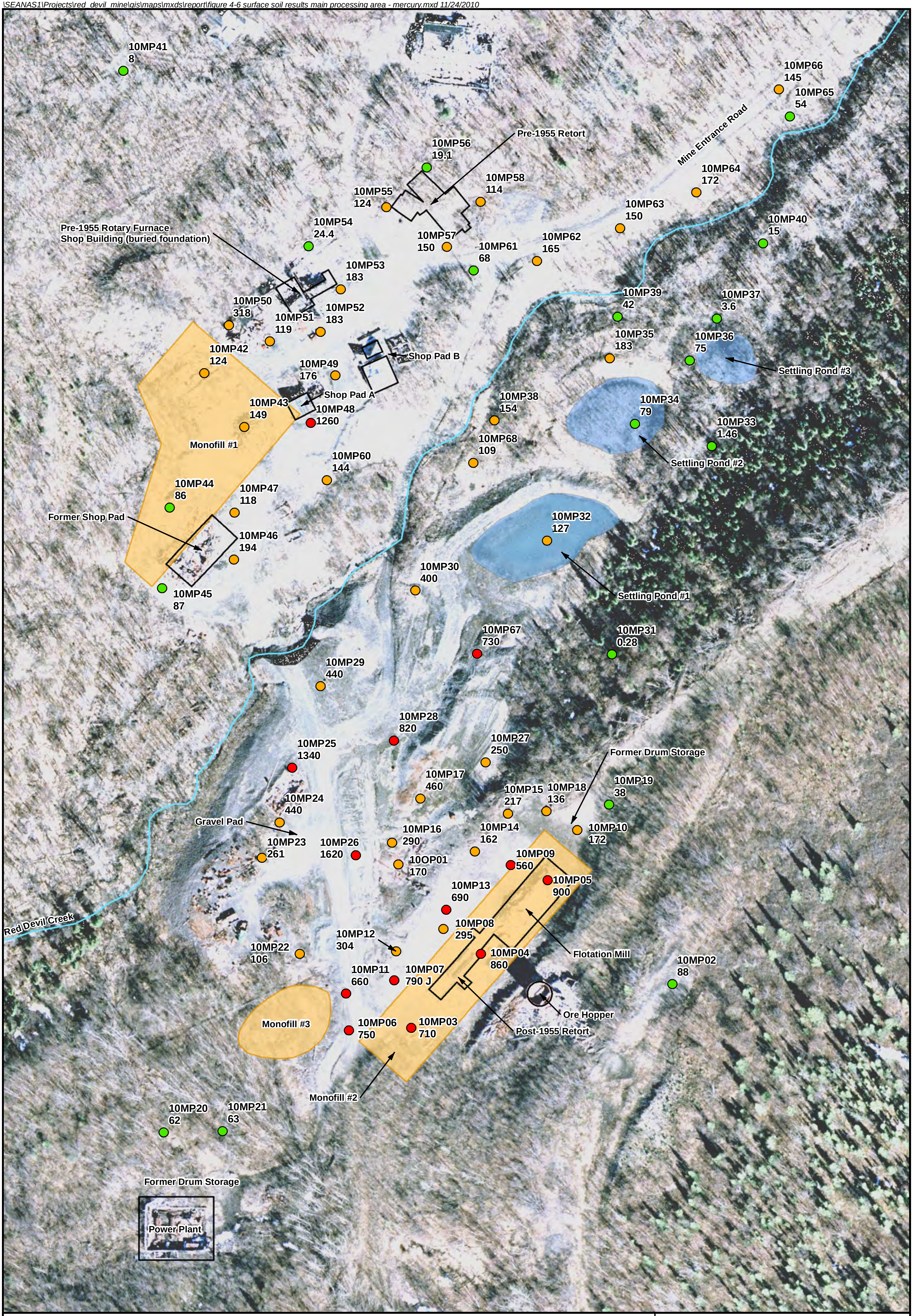
- 🟢 0 - 100 mg/kg
- 🟠 100 - 5,000 mg/kg
- 🔴 > 5,000 mg/kg
- 🟦 Settling Pond
- 🟧 Monofill
- ☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-5
Surface Soil Results Main Processing Area Total Antimony





● 0 - 100 mg/kg
● 100 - 500 mg/kg
● > 500 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

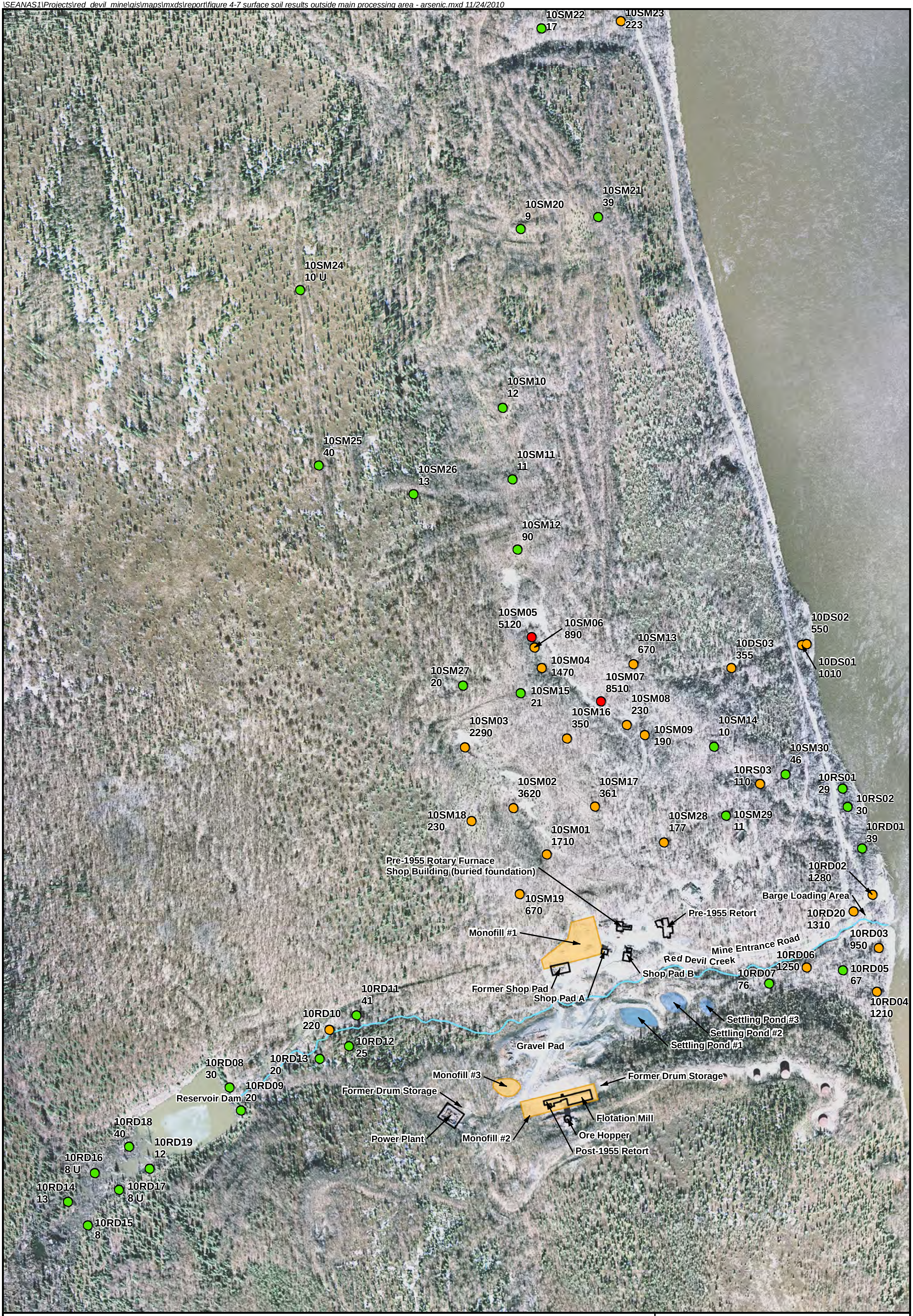
RED DEVIL MINE

Red Devil, Alaska

Figure 4-6
Surface Soil Results
Main Processing Area
Total Mercury

0 25 50 100 150
Feet
0 5 10 20 30 40 50
Meters
Scale 1:1,000

N



- 🟢 0 - 100 mg/kg
- 🟠 100 - 5,000 mg/kg
- 🔴 > 5,000 mg/kg
- 🟦 Settling Pond
- 🟧 Monofill
- ☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-7
Surface Soil Results Outside Main Processing Area Total Arsenic

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,700

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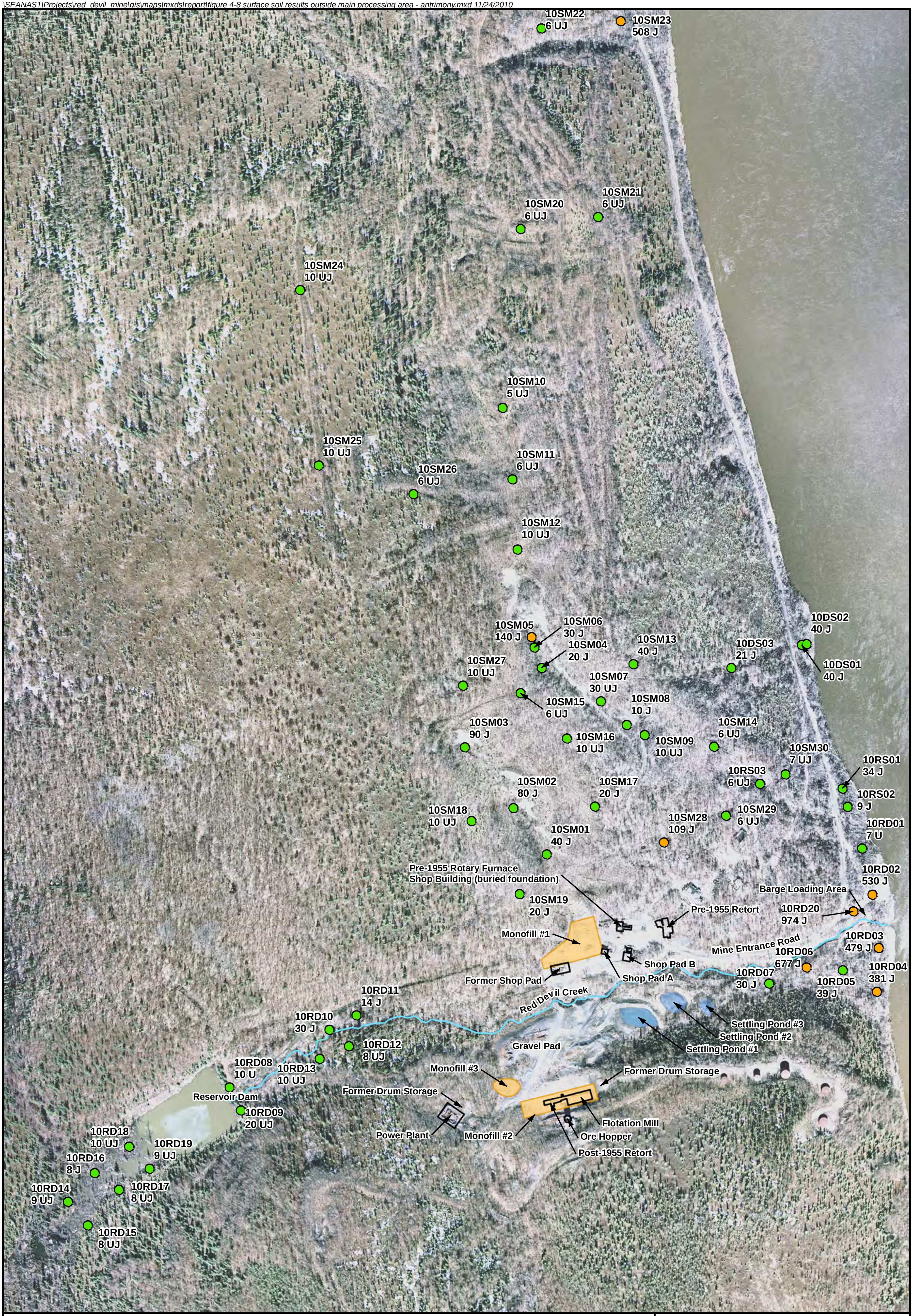
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-8 surface soil results outside main processing area - antrimony.mxd 11/24/2010



● 0 - 100 mg/kg
● 100 - 5,000 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

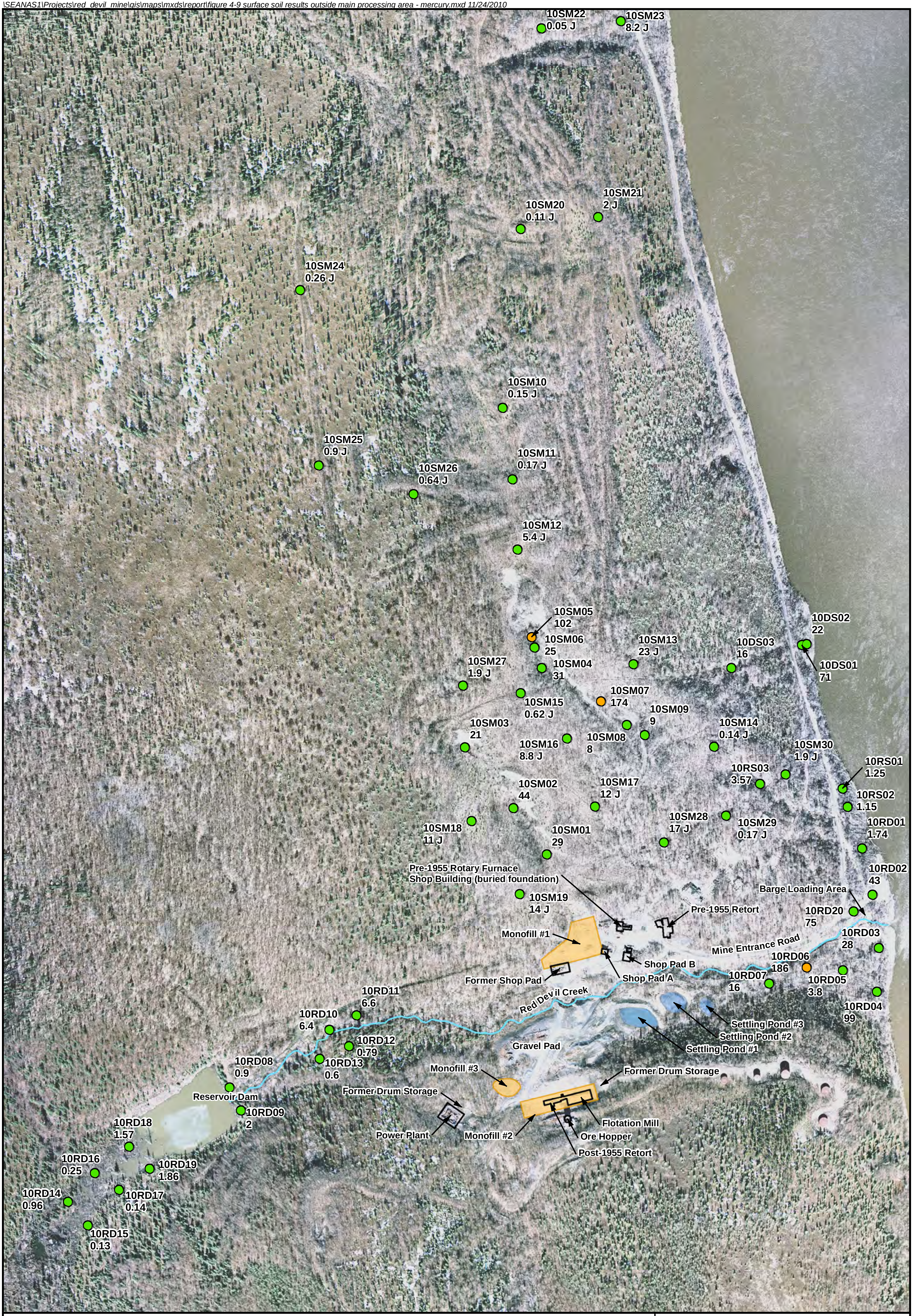
RED DEVIL MINE

Red Devil, Alaska

Figure 4-8
Surface Soil Results Outside Main Processing Area Antimony

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,700

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-9 surface soil results outside main processing area - mercury.mxd 11/24/2010



● 0 - 100 mg/kg
● 100 - 500 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-9
Surface Soil Results Outside Main Processing Area Total Mercury

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,700

● 0 - 100 mg/kg
▨ Settling Pond
▨ Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-10
Upland Background Surface Soil Results Total Arsenic

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,700

● 0 - 100 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-11
Upland Background Surface Soil Results Total Antimony

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,700

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\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-12 background surface soil results - mercury.mxd 11/24/2010

● 0 - 100 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-12
Upland Background Surface Soil Results Total Mercury

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,700

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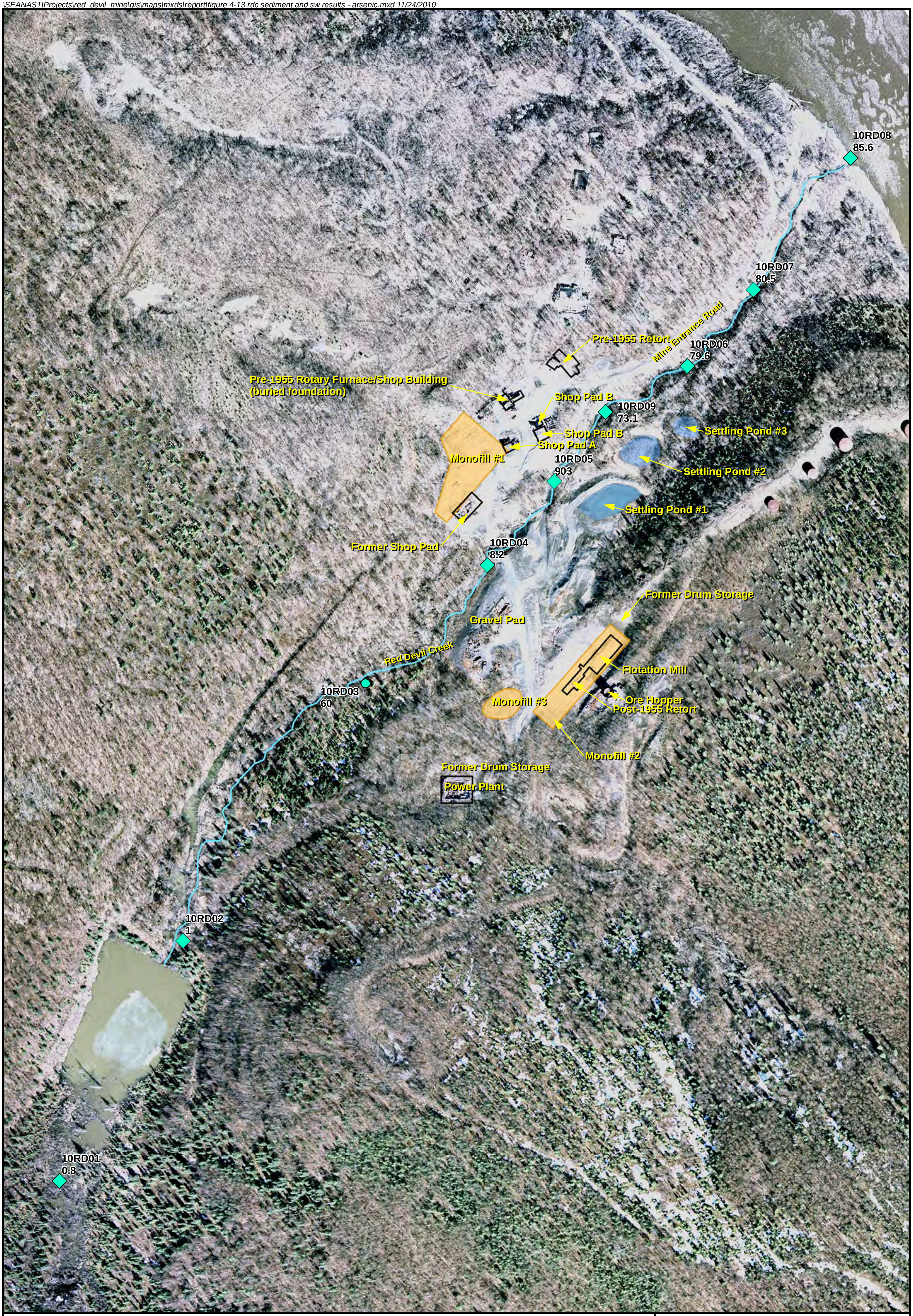
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-13 rdc sediment and sw results - arsenic.mxd 11/24/2010



Sediment

- ● 0 - 100 mg/kg

Surface Water

- ◆ 0 - 100 ug/l
- 🟦 Settling Pond
- 🟧 Monofill
- ☐ Historical Structure

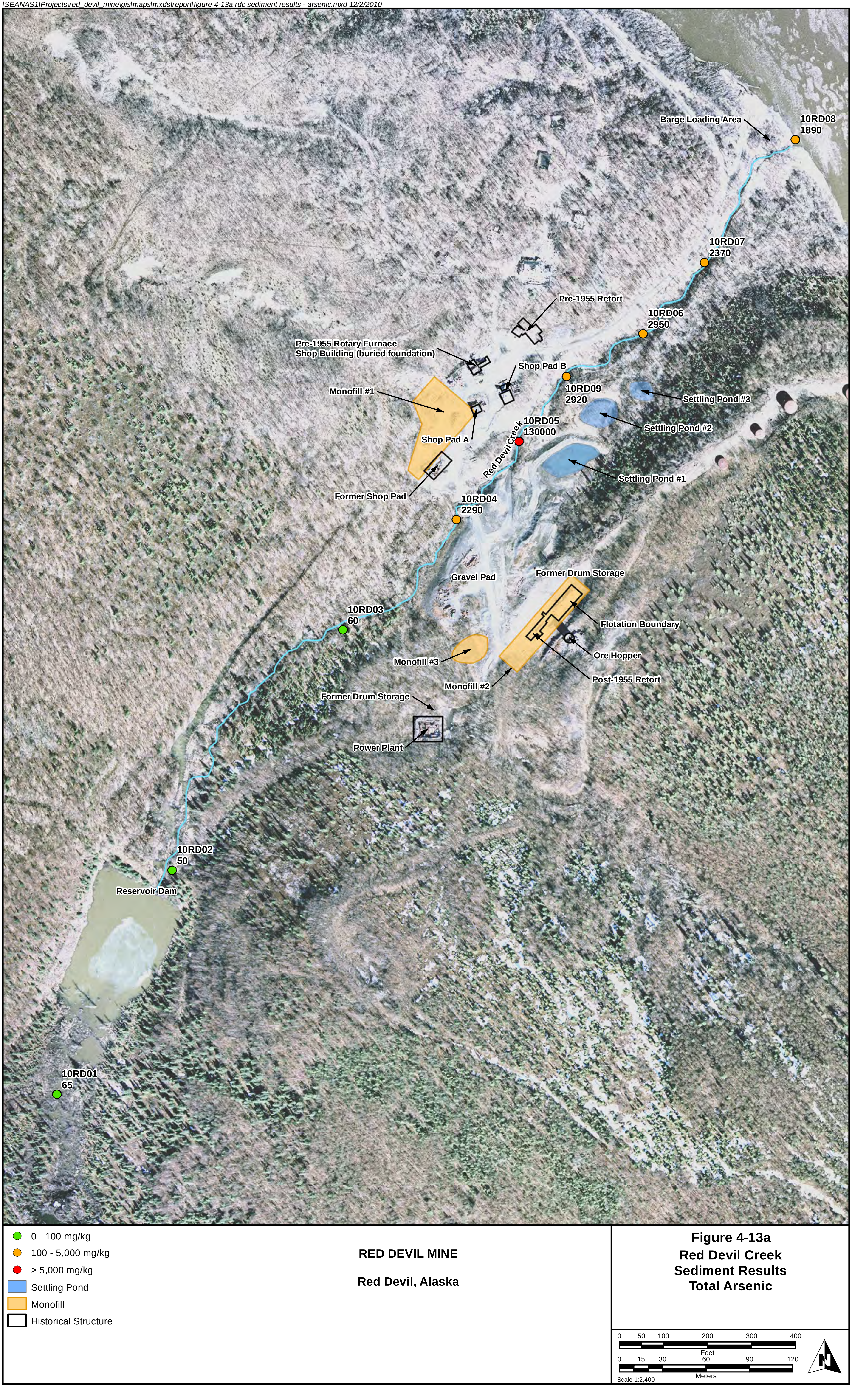
RED DEVIL MINE

Red Devil, Alaska

Figure 4-13
Red Devil Creek
Sediment And Surface Water Results
Arsenic

0 50 100 200 300 400
Feet
0 15 30 60 90 120
Meters
Scale 1:2,400

N



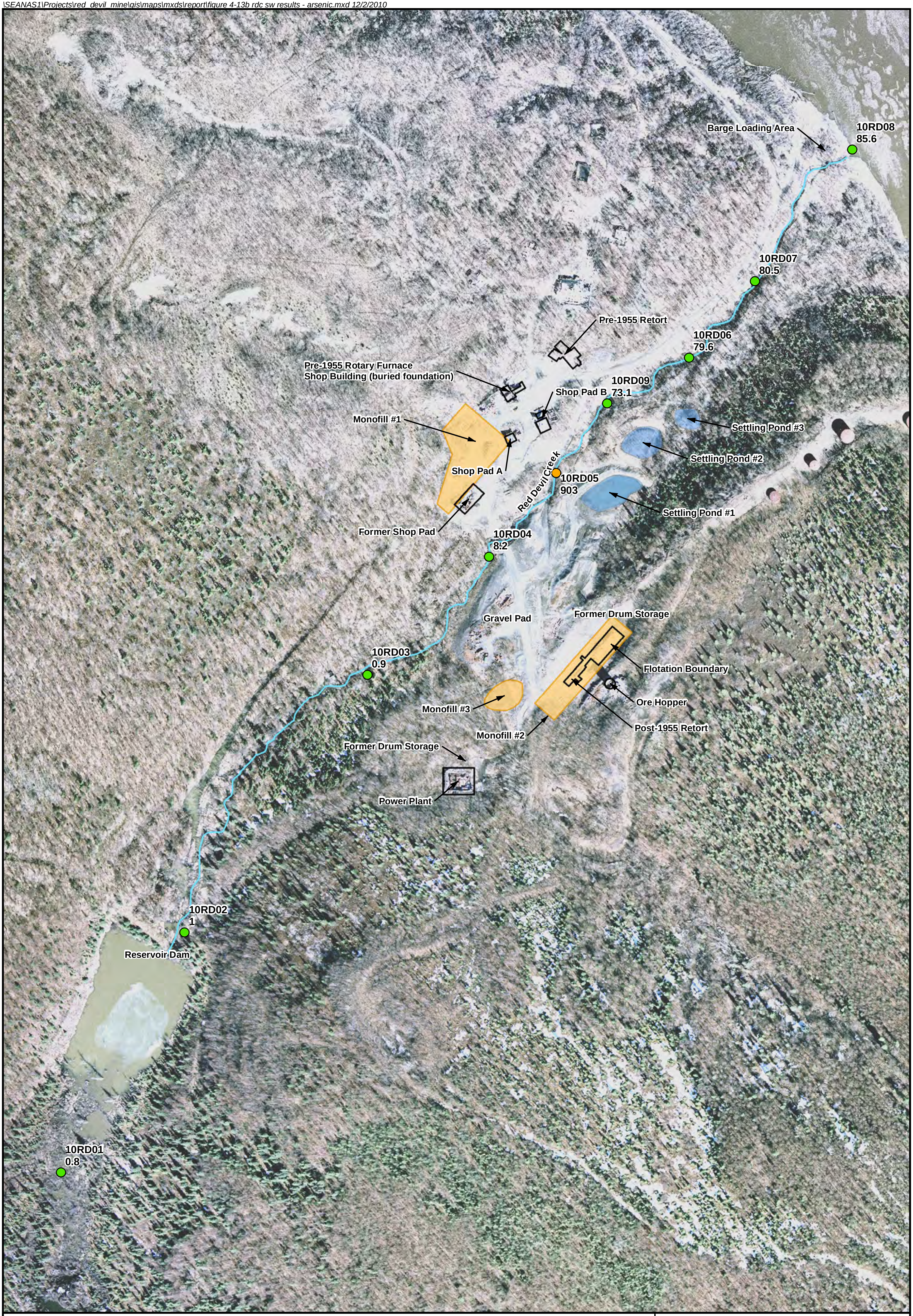
● 0 - 100 mg/kg
● 100 - 5,000 mg/kg
● > 5,000 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-13a
Red Devil Creek
Sediment Results
Total Arsenic

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-13b rdc sw results - arsenic.mxd 12/2/2010



● 0 - 100   g/L
● 100 - 5,000   g/L
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

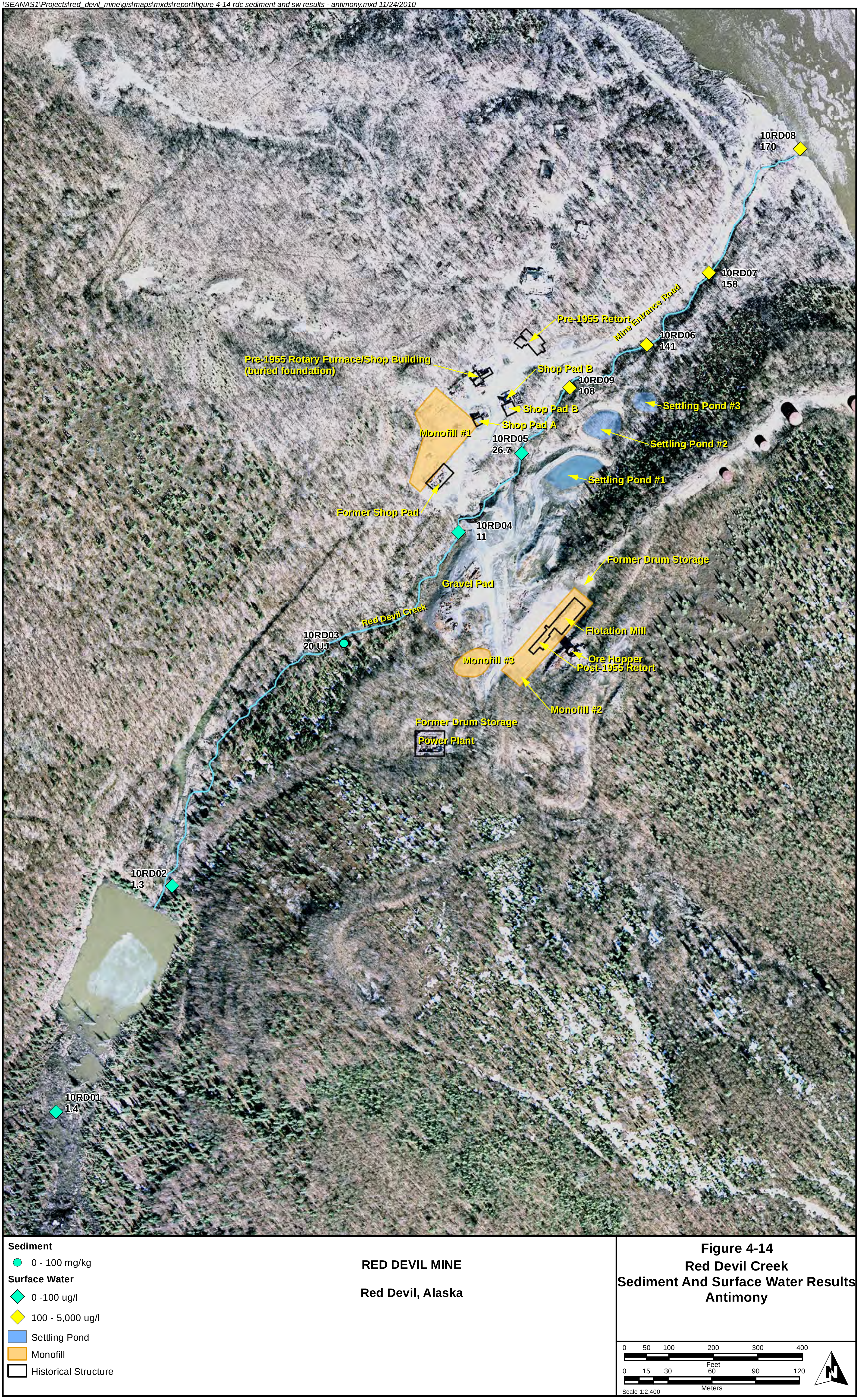
Red Devil, Alaska

Figure 4-13b
Red Devil Creek
Surface Water Results
Total Arsenic

0 50 100 200 300 400
Feet
0 15 30 60 90 120
Meters
Scale 1:2,400

N

Ecology & Environment, Inc.
\\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-14 rdc sediment and sw results - antimony.mxd 11/24/2010



RED DEVIL MINE

Red Devil, Alaska

Figure 4-14
Red Devil Creek
Sediment And Surface Water Results
Antimony

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-14a rdc sediment results - antimony.mxd 12/2/2010

● 0 - 100 mg/kg
● 100 - 5,000 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

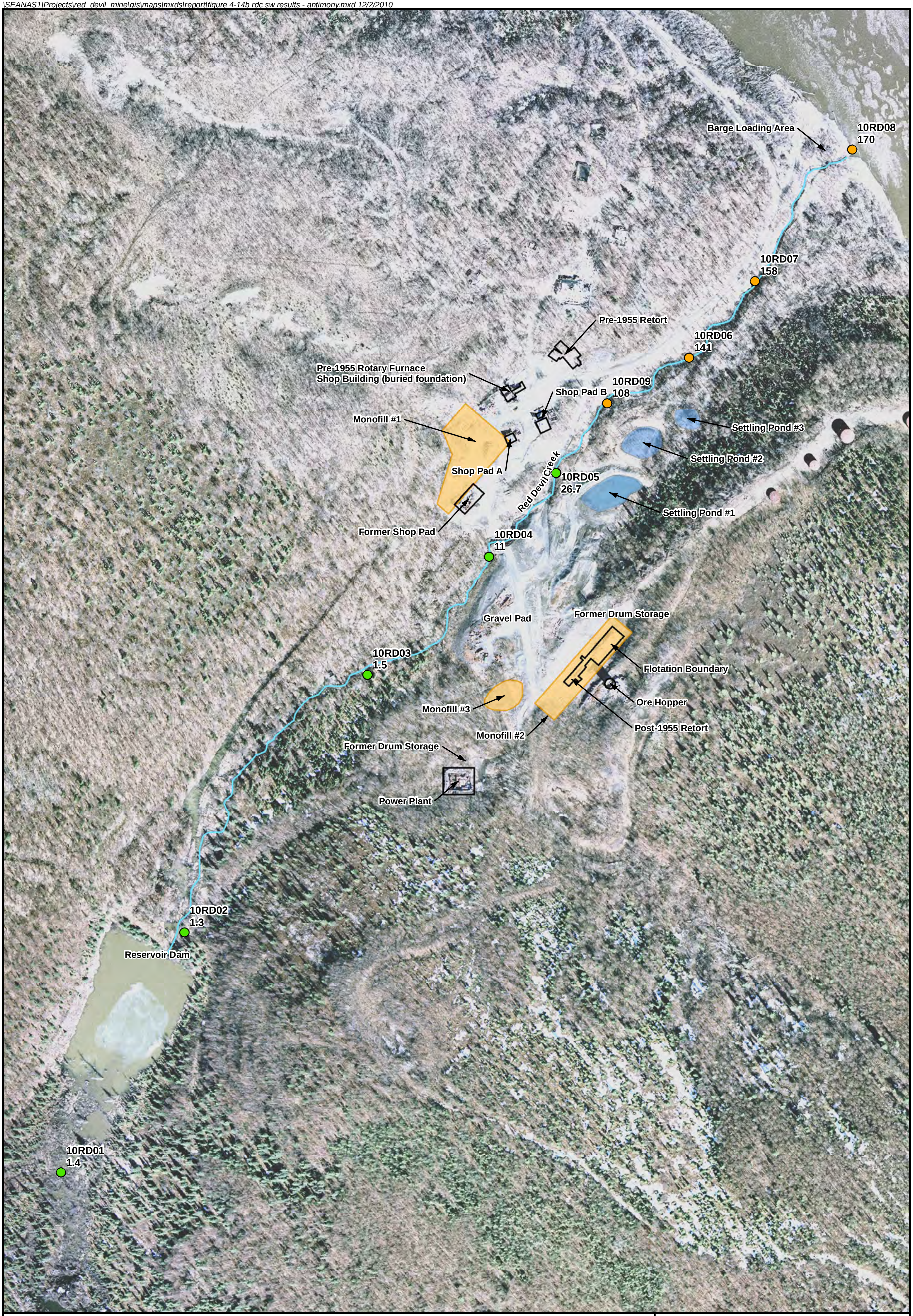
Red Devil, Alaska

Figure 4-14a
Red Devil Creek
Sediment Results
Total Antimony

0 50 100 200 300 400
Feet
0 15 30 60 90 120
Meters
Scale 1:2,400

N

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-14b rdc sw results - antimony.mxd 12/2/2010



- 🟢 0 - 100 g/L
- 🟠 100 - 5,000 g/L
- 🟦 Settling Pond
- 🟧 Monofill
- ☐ Historical Structure

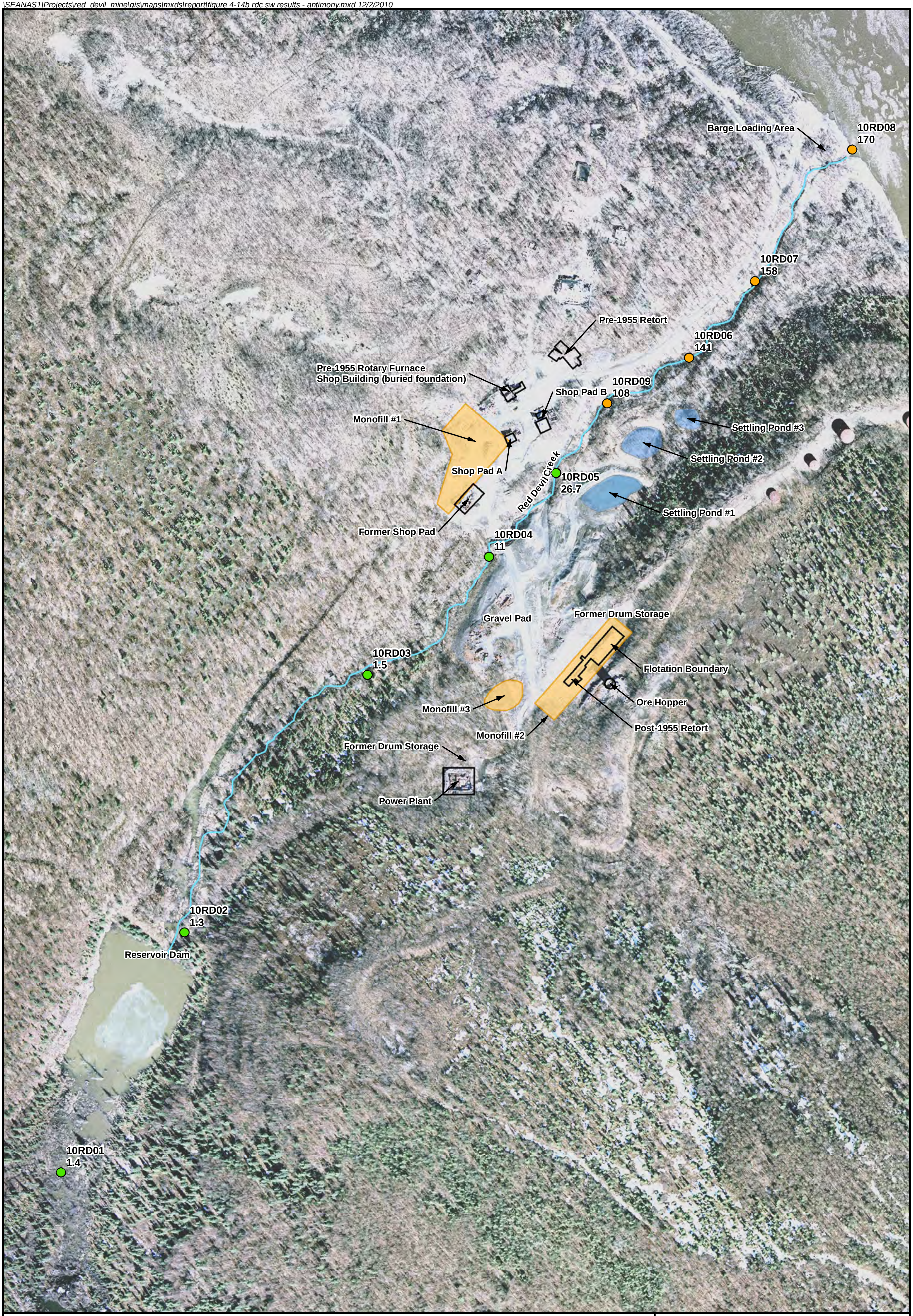
RED DEVIL MINE

Red Devil, Alaska

Figure 4-14b
Red Devil Creek Surface Water Results Total Antimony

0 50 100 200 300 400
Feet
0 15 30 60 90 120
Meters
Scale 1:2,400

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-14b rdc sw results - antimony.mxd 12/2/2010

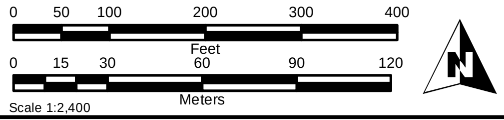


● 0 - 100 g/L
● 100 - 5,000 g/L
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

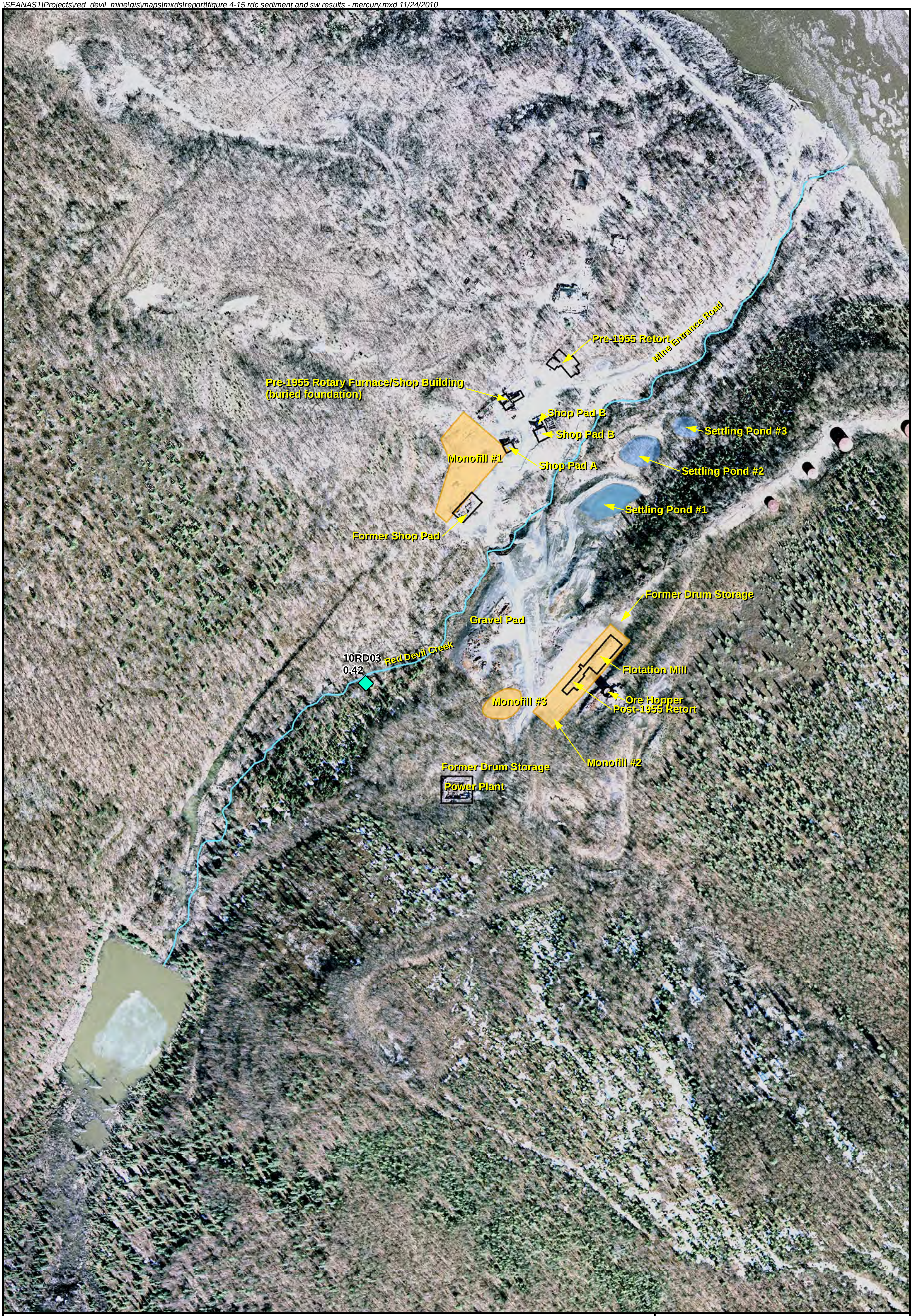
Red Devil, Alaska

Figure 4-14b
Red Devil Creek Surface Water Results Total Antimony



Scale 1:2,400

Ecology & Environment, Inc.
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-15 rdc sediment and sw results - mercury.mxd 11/24/2010



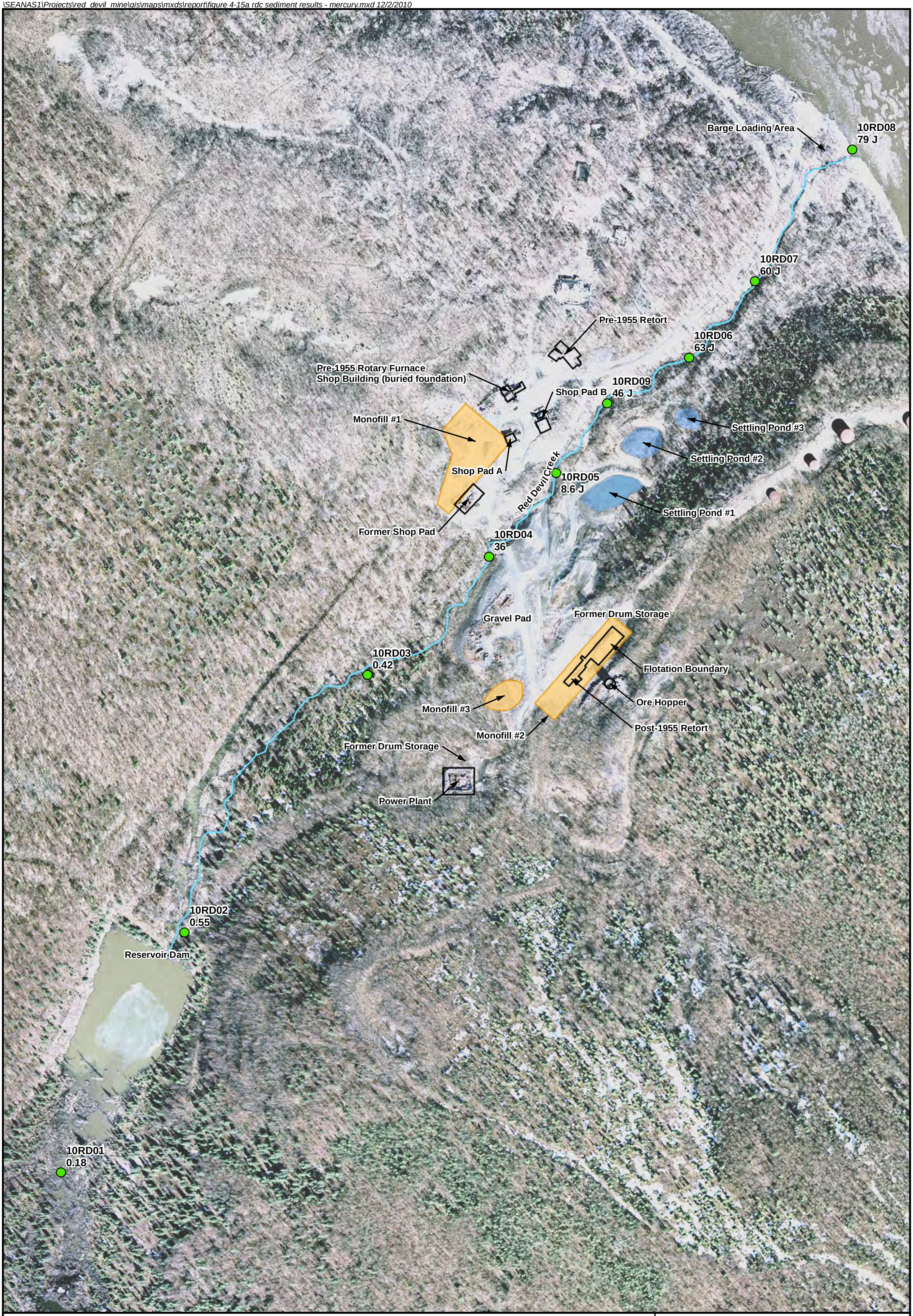
◆ 0 - 100 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-15
Red Devil Creek Sediment Results Mercury

0 50 100 200 300 400
Feet
0 15 30 60 90 120
Meters
Scale 1:2,400

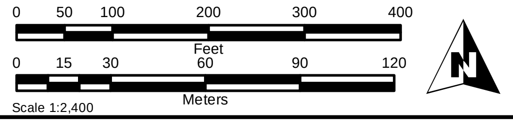


● 0 - 100 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-15a
Red Devil Creek
Sediment Results
Total Mercury



Scale 1:2,400

● 0 - 100 ng/l
● 100 - 500 ng/l
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-15b
Red Devil Creek Surface Water Results Total Mercury

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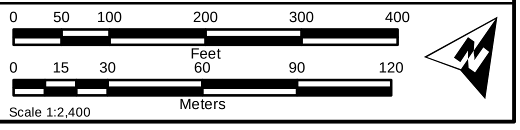
\SEANAS1\Projects\red_devil_mine\gis\maps\mxds\report\figure 4-16 kuskokwim river sediment results - arsenic.mxd 11/24/2010

🟢 0 - 100 mg/kg
🟠 100 - 5,000 mg/kg
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-16
Kuskokwim River Sediment Results Total Arsenic



Scale 1:2,400

● 0 - 100 mg/kg
● 100 - 5,000 mg/kg
▭ Settling Pond
▭ Monofill
▭ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-17
Kuskokwim River Sediment Results Total Antimony

Scale 1:2,400

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● 0 - 100 ng/l
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-18
Kuskokwim River Sediment Results Total Mercury

0 50 100 200 300 400
Feet
0 15 30 60 90 120
Meters
Scale 1:2,400

● 0 - 100 g/l
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-19
Monitoring Well Results
Total Arsenic

0 25 50 100 150
Feet
0 5 10 20 30 40 50
Meters
Scale 1:1,000

N

● 0 - 100 g/l
● 100 - 5,000 g/l
🟦 Settling Pond
🟧 Monofill
☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-20
Monitoring Well Results
Total Antimony

0 25 50 100 150
Feet
0 5 10 20 30 40 50
Meters
Scale 1:1,000

N

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as_hg_sb
result
- ● 0 - 100 ng/l
- ● 100 - 500 ng/l
- ▨ Settling Pond
- ▨ Monofill
- ☐ Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 4-21
Monitoring Well Results
Total Mercury

0 25 50 100 150
Feet
0 5 10 20 30 40 50
Meters
Scale 1:1,000

N

5 Conclusions

During the 2010 LSE, data was collected to characterize the nature and extent as well as the fate and transport of COPCs at and near the Site; to provide data for human health and ecological risk assessments; and to provide data and information for use in the analysis of remedial alternatives. The data presented in this report was used to identify data gaps not currently addressed in the RI/FS Work Plan. This report contains a limited summary of the data collected. A detailed summary and interpretation of the data and will be provided in the RI/FS Report at a later date.

Based on a review of the data collected during the LSE, the following data gaps were identified:

- The extent of elevated concentrations of COPCs on the roads at the Ste are not known.
- The extent of elevated concentrations of COPCs in river sediment at the mouth of Red Devil Creek is not known.
- The extent of elevated concentrations of COPCs in river sediment where the Dolly Sluice delta extends into the Kuskokwim River is not known.
- The surface extent of elevated concentrations of COPCs south and southeast of the Post-1955 Retort is not known.
- The extent of elevated concentrations of arsenic in the surface and subsurface of the Surface Mined Area is not known.
- The lateral extent of elevated concentrations of COPCs in the Dolly Sluice are not known.
- The presence of contamination in surface soils at the Dump Site identified in the Surface Mined Area during the 2010 LSE is not known.
- The presence of contamination in the surface soils at the Drum Disposal Area identified during the 2010 LSE is not known.

6 References

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7

Tables-Section 4

These tables are included on a separate CD.

Appendix A Laboratory Data and Data Quality Assurance Reports

This information is included on a DVD.

Appendix B Geophysical Survey Results

These results are not complete at this time.