Final Site Characterization Report
Ross-Adams Mine Site

Tongass National Forest, Prince of Wales Island, Alaska

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EXECUTIVE SUMMARY

Introduction

The Ross-Adams Mine Site (Site) is a former uranium mine located in the Tongass National Forest (TNF) near the southern end of Prince of Wales (POW) Island, Alaska (Figure ES-1). On April 17, 2009, Newmont USA Limited and Dawn Mining Company LLC (Companies) entered into an Administrative Settlement Agreement and Order on Consent (ASAOC) with the USDA Forest Service (USFS) to perform an Engineering Evaluation/Cost Analysis (EE/CA) for the Site. The Statement of Work (SOW), attached as Appendix B to the ASAOC, describes the work to be performed. The work includes performing an Expanded Site Investigation (ESI) to address identified data gaps at the Site, and to provide the data, information and Site characterization necessary for preparation of a human health and ecological risk assessment and an EE/CA. Preparation of the risk assessments and EE/CA will follow completion of the Site Characterization Report (SCR) in accordance with the ASAOC and SOW. The data and information provided by the SCR will be further analyzed in the risk assessments to define exposure units and characterize pathways, receptors and risk. This risk information will be an element of the EE/CA development and evaluation of removal action alternatives to reduce the release or threat of release of hazardous substances from the former mining operations and mitigate Site risk from historic mining activities.

The purpose of the ESI is to address data gaps identified by a previous Preliminary Assessment/Site Investigation (PA/SI) (KSI, 2004) by collecting additional data and information to characterize the physical, chemical and radiological conditions of the Site. Additional data collection in the ESI provides information to characterize the nature and extent of chemical and radiological conditions of the mine features and potential migration/exposure pathways in media (ambient air, soil, surface water, stream sediment and marine sediment). The ESI also included an engineering assessment of mine-related and natural features, an ecological assessment, an inventory of miscellaneous solid wastes, and an assessment of land use conditions of the Site and subsistence resource use in the regional area. These data, information and characterization will be used in the risk assessments and the EE/CA to develop and evaluate removal action alternatives as set out in the ASAOC.

This *Site Characterization Report* (SCR) *for the Ross-Adams Mine Site* describes the work conducted and provides the results and conclusions of the ESI and incorporates responses to comments received from the USFS, the State of Alaska and USEPA on the Draft SCR submitted to the USFS in March 2010. The agency comments and responses are provided in Appendix I.

Ross-Adams Mine and Site Description

The Ross-Adams Uranium Mine is located on the southeastern slopes of Bokan Mountain within the Kendrick Creek watershed. The Ross-Adams ore deposit outcropped at an elevation of approximately 970 feet on the southeastern flank of Bokan Mountain. The mine was initially developed by open-pit mining in 1957 and later by underground operations from three portals. The mine has three major surface expressions, named after their approximate elevations: the “900-Foot Level”; the “700-Foot Level”; and the “300-Foot Level”. In the late 1950s, the ore deposit was mined from an open pit at the 900-Foot Level. After the surficial deposit was mined, ore was mined in the early 1960s by driving an approximately 500-foot long tunnel at the 700-Foot Level to intersect the ore deposit, with a raise connecting it to the open pit. An additional phase of underground mining occurred in 1971 by driving the 300-Foot Level adit tunnel. Mine rock, including rock developed in driving the 700-Foot Level and 300-Foot Level tunnels, was placed near the portals at all levels. Ore produced from all levels was conveyed via haul roads to ore staging areas and barge loading docks on the north shore of the west Arm of Kendrick Bay. All ore was shipped offsite for processing.

The Bokan Mountain Intrusive Complex, in which the Ross-Adams deposit is located, is comprised of rare rock types and is unique in southeast Alaska. Emplacement of the Bokan Intrusive Complex included uranium, thorium and rare earth element mineralization. Mineral exploration continues in the Bokan Mountain region. At the present time, active exploration for both uranium and rare earth ore deposits is occurring in the Kendrick Creek watershed under USFS permit. More than 30 uranium and rare earth element (REE) occurrences have been identified at Bokan Mountain that are related to the Bokan Intrusive Complex (Figure ES-2). The enrichment (mineralization) of the Bokan Intrusive Complex rocks with uranium and thorium results in a radioactive signature distinctive from that of the surrounding non-mineralized rocks (Figure ES-3). The I&L Zone, which is a nearby smaller and lower grade deposit immediately to the northwest of the 900-Foot Level, represents an analogue for conditions that potentially existed at the 900-Foot Level prior to mining.

The Site is defined in the SOW to the ASAOC (USFS, 2009) to include the mine, haul roads, ore staging area, former barge loading area, and downstream potentially impacted areas including the Kendrick Creek delta (Figure ES-4). An access road between the 900-Foot Level haul road and the I&L Zone was constructed at some point during regional exploration, using mine rock in some areas; the lower portion of the I&L access road is included in the Site definition.

The principal surface features associated with former mine operations include:

- 900-Foot Level - open pit, mine portal and air vent shaft, north and south mine rock piles, and mine rock embankments at specific locations along the access road to the 700-Foot Level;
- 700-Foot Level - mine portal and mine rock pile;
- 300-Foot Level - mine portal with mine water drainage and mine rock pile;
- Former Ore Staging Area (OSA) – located on the northern shore of the west Arm of Kendrick Bay, with residual ore materials including some oversized rock at the ground surface and piled along the eastern perimeter;
- Former Ore Loading Docks – Two remnant rock ramps (western and eastern) extend from the OSA area into the west Arm of Kendrick Bay and the remnants of a third and older ramp are located approximately 600 feet west of the existing floating dock;
- Mine and Haul Roads (including the I&L access road) - primary roads constructed for exploration and mine access which served as haul roads connecting the 700-Foot, 900-Foot and 300-Foot levels to the OSA and loading docks at Kendrick Bay.

The Site is approximately 38 air miles southwest of Ketchikan, Alaska. The nearest towns are Metlakatla, 28 miles to the northeast across Clarence Strait and Hydaburg, 33 miles to the northwest on the western side of POW Island. The Site is located within the semi-remote recreational area of the TNF within the Eudora Roadless System (USFS, 2003). While access is unrestricted, the Site is remote and only accessible by float plane or boat, or overland by hiking through several miles of trail-less rugged terrain. A floating dock at the location of one of the historic barge loading docks remains functional. There are no established USFS roads or hiking trails connecting the Site to either other USFS or POW communities or roads. The Site has one permanent structure, which is a small cabin owned and maintained by the Dotson family.

Site terrain varies from moderate slopes along the margin of the west Arm of Kendrick Bay shoreline and around the OSA to rugged, steep slopes with dense forest cover and incised steam channels that restrict access even by foot. Soil conditions at the Site are also variable, ranging from barren rock, rock rubble and thin patches of poorly drained soils at higher elevations, such as at the 700-Foot and 900-Foot levels, to moderately deep, moderately to well drained organic soil with forest litter cover at lower elevations.

Kendrick Creek and its main tributaries, Mine Fork Creek and Cabin Creek, drain the eastern side of Bokan Mountain. Mine Fork Creek originates above the 900-Foot Level and joins with Kendrick Creek at the 300-Foot Level. The 700-Foot Level Creek, a minor tributary to Kendrick Creek, originates near the 700-Foot Level. Kendrick Creek flows to the east into the west Arm of Kendrick Bay. Cabin Creek joins with Kendrick Creek near the west Arm of Kendrick Bay.

Kendrick Bay is a five-mile long fiord that opens to Clarence Strait on the east side of POW Island. Typical of fiords in southwest Alaska, Kendrick Bay is characterized by a steep, narrow intertidal zone between the low and high water lines, and a subtidal zone below the low water line. Commercial fishing is known to occur at the mouth of Kendrick Bay, and an aquaculture facility is located on the South Arm of Kendrick Bay; however, both these uses occur several miles from the Site.

The climate of the area is maritime, due to the close proximity of the Pacific Ocean. The area experiences frequent and relatively heavy precipitation, with October through December usually the wettest months. The annual total precipitation averages over 100 inches, with snow occurring at higher elevations.

Current uses of the Site include occasional recreational visitors, USDA Forest Service workers, and subsistence hunting-gathering. In addition, the TNF Land and Resource Management Plan (USFS, 2008a) has designated the Site for mineral exploration and timber production. Mineral exploration is occurring in areas adjacent to the Site.

Previous Investigations

Two environmental investigations were previously performed at the Site to evaluate the nature and extent of mine-related materials and migration/exposure pathways in media to potential receptors. A Removal Preliminary Assessment (RPA) (BLM, 1998) was conducted by the U.S. Bureau of Land Management (BLM) that summarizes environmental data collected in 1995 and 1997. In 2004, the USFS conducted the PA/SI (KSI, 2004). Data and information from these previous investigations were used to identify data gaps for additional sampling and data collection activities defined in the SOW and guided the development of the ESI. In addition, numerous mineral investigation and economic geology studies have been performed at the Site and regional area. The information provided by these investigations has also been used to provide additional characterization of the mineralization which occurs in the Bokan Mountain area of the Site.

Expanded Site Investigation

Tetra Tech, with assistance from the Prince Of Wales Tribal Enterprise Consortium (POWTEC) and R&M Engineering-Ketchikan, Inc., performed the ESI for the Companies. Field work was performed during three events in June, July and September 2009. Data were collected to characterize the physical, chemical and radiological conditions of the mine features and environmental media consisting of soil, surface water, stream sediment, marine sediment, and air. Field investigations included gamma radiation surveys, radon air monitoring, and sampling of soil, surface water, stream sediment, and marine sediment. Over 182,000 data points representing approximately 185 acres were generated during the gamma radiation surveys. A total of 86 soil samples, 45 surface water samples, 12 stream sediment samples, 30 marine sediment samples, and 26 long-term and four short-term radon measurements were obtained. Soil, surface water, and stream and marine sediment samples were analyzed for metals and radionuclides in the natural thorium (Th) and uranium (U) decay series, as described by the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) (Tetra Tech, 2009a & b).

Gamma radiation surveys, material sampling (soil) and radon (air) monitoring of mine features and adjacent areas, including the mine rock piles at the 900-Foot, 700-Foot and 300-Foot levels, mine and haul roads, ore storage area, and loading dock areas were completed. Gamma radiation surveys were also conducted along the Kendrick Creek channel from its mouth upstream to the 300-Foot Level mine rock pile, within the Kendrick Creek Bay delta intertidal area, and a limited area of the naturally mineralized and un-mined I&L zone. Short-term and long-term radon monitoring was also performed at the open pit and portals at the 900-Foot (including the air shaft), 700-Foot and 300-Foot levels.

Samples were collected at 18 surface water locations in Kendrick Creek and tributaries in June, July and September and at 12 stream sediment locations in July. Water quality samples were collected of the mine drainage from the 300-Foot Level portal in June, July and September. Precipitation data for 2009, from the closest weather station to the Site, Annette Island, shows that the timing of these sampling events captured the range of flow conditions, dry to wet season, typical for the Site. In addition, surface water quality sampling data show that constituent concentrations generally decreased during the higher flow conditions, with uniformly low sulfate concentrations across the Site and throughout the three sampling events. The surface water pH values were relatively constant, with observed fluctuations attributable to the natural unbuffered geochemical conditions at the Site. Due to the unbuffered characteristics of the natural geologic system, any acid rock drainage would have a pronounced effect on surface water pH levels. These data indicate that acid rock drainage due to the native mineralization and from mining activities is not an environmental issue at the Site. The Site geologic information demonstrates the low sulfide mineral content and therefore the lack of acid rock generation potential.

Water samples of a spring (groundwater expression) near the OSA were also collected in June, July and September. Marine sediment was collected at 22 intertidal sampling locations within the Kendrick Creek Bay delta and at eight subtidal sampling locations in the west Arm of Kendrick Bay in July.

Samples were collected at locations upstream and/or distant from the mine features to provide background reference data for air (radon), soils, surface water, stream sediment and marine sediment. The background reference data are compared to the media data collected at other locations to evaluate the extent of mine-related impacts and to provide information to support human health and ecological risk assessments. Gamma radiation surveys were performed to define the spatial extent of the mine feature areas and to define local background gamma exposure rates. A limited gamma radiation survey was also performed in the I&L Zone to provide additional data to evaluate background gamma exposure rates in an unmined, mineralized area.

Several mine camps were operated over the life of mining operations and significant exploration occurred after mining ended leaving behind debris, particularly at the OSA and 300-Foot Level. An inventory was conducted to catalogue the types, locations and quantities of miscellaneous solid wastes, petroleum products, abandoned vehicles and other materials that remain at the Site. Soil samples were collected at four of the waste locations and analyzed for gasoline range organics (GROs) and diesel range organics (DROs), with one sample from the vicinity of the former generator shack at the 300-Foot Level analyzed for polychlorinated biphenyls (PCBs).

As part of the ESI, an engineering assessment was performed to document the physical/engineering aspects of both mine-related and natural features. The engineering assessment included the visual inspection, mapping, surveying, and description of the physical dimensions, locations, conditions and stability of mine-related features (mine rock piles, water diversion structures, roads, and mine openings) and natural features (landslides). Civil surveying was also performed to delineate the physical footprints of mine rock piles and road embankments in the 900-Foot and 700-Foot levels, and the perimeter of the OSA. Surveying of the 300-Foot Level mine rock pile boundary could not be performed due to rugged, steep terrain and dense vegetation. The assessment was performed to refine material quantities, define engineering constraints and identify constructability conditions in support of the EE/CA.

A biologic assessment of the Site was conducted in July to identify the main habitat types and associated aquatic and terrestrial species for use in the exposure pathways analyses of the ecological and human health risk assessments. Additional literature-based research was performed to augment the field survey data. Literature-based research was also performed to assess land use conditions of the Site and subsistence resource use in the regional area in support of the risk assessments.

The above data and information addresses previously identified data gaps and, along with the data and information provided by previous investigations, provide the interpretive basis for the characterization presented in this SCR, which will provide the data and information for conducting the risk assessments and the EE/CA. The Screening-Level Human Health Risk Assessment (SLHHRA) and the Screening-Level Ecological Risk Assessment (SLERA), which will be included in the EE/CA, will use the ESI data and information to define exposure units, pathways, and receptors in assessing human and ecological risk related to Site mining activities. The results and conclusions of the ESI are summarized below.

Engineering Assessment

An engineering field reconnaissance was conducted during the second sampling event to support the Engineering Assessment of the man-made and natural features at the Site. The field reconnaissance included visual inspection and observation of the key site features, including mine rock piles, portals, mine and haul roads, and the ore staging areas. Key observations of the field reconnaissance regarding the open pit, portals, and mine rock materials include the following:

- Open Pit: Colluvial material has accumulated in the floor of the pit over the years, which presently supports dense brush vegetation along most of the floor. Civil surveying indicates that the open pit has a volume of approximately 17,260 cubic yards in its present condition.
- Mine Portals: The 900-Foot, 700-Foot, and 300-Foot level portals were open with unrestricted access during each 2009 site visit. The 900-Foot Level portal is within the open pit and is partially blocked with rock that appears to have been both intentionally placed to block access and fallen from above the portal face. No drainage was observed from the 700-Foot Level portal, which is consistent with the geometry of the 700 Level adit. A shallow pool of water was observed immediately inside the 700-Level portal, which likely represents accumulation of infiltrating water from the bedrock immediately above the adit. Water was observed flowing from the 300-Foot Level portal at variable rates during each of the three sampling events.
- Mine Materials: Nine mine rock piles were visually inspected, including the 900-Foot Level North and South mine rock piles, the 700-Foot Level mine rock pile, six minor piles consisting of roadway embankment fills between the 700-Foot and 900-Foot levels, and the 300-Foot Level mine rock pile. Additional areas containing mine materials include the OSA, three rock loadout ramps, and locations along the haul road. The combined quantity of these mine materials is estimated to be 62,100 cubic yards.

A key finding of the engineering assessment was that the mine rock piles and roads constructed of mine and non-mineralized material exhibited a high degree of stability. No slope failures or progressive raveling of material from the surface of the mine rock piles were noted. At all mine rock piles, there are insufficient fines content in the surficial materials to facilitate the development of rilling or gullying. Exceptions were noted in a few isolated and highly localized areas of the haul road surfaces, where concentrated runoff was observed to have created shallow ruts and/or gullies; however, deposition of the eroded material was not observed beyond the discernable road embankment toes. No materials were observed on the mine rock piles and haul road surfaces which were judged to be sufficiently fine as to be susceptible to wind transport; dense canopy and ground cover, where present, also effectively prevent wind erosion.

Overall, no evidence was observed of the migration of materials beyond the toes of the mine rock piles. Although some material may have been transported short distances by gravity and/or water prior to stabilization of the surfaces and toes by vegetation, the mine rock piles appear to have been relatively stable for many years. The apparent stability of the mine rock piles and road embankments can be attributed to several primary factors, including 1) the coarse grain size and correspondingly higher internal friction angle (a measure of soil strength) of the materials; 2) pile and embankment slopes do not exceed the maximum natural angle (angle of repose) for the materials; and 3) where present, dense and damp to wet ground cover serve to stabilize the surfaces from wind and runoff erosion. Based on these observations, it is apparent that the mine rock piles and road embankments are relatively stable, and have not been susceptible to observable off-site migration by wind or water erosion processes.

Biological Assessment

A qualitative biological assessment of the Site was conducted in July to identify the main habitat types and associated aquatic and terrestrial species for use in the exposure pathways analyses of the ecological and human health risk assessments. During the biological survey, an emphasis was placed on characterizing food chain exposure pathways to wildlife and humans for refining the Conceptual Site Model (CSM). Additional literature-based research was performed to augment the field survey. Wildlife observations during each of the three sampling events were included in the survey. Results of the biological assessment include the following:

- The biologic assessment identified four main habitat types at the Site: the Subalpine Zone, Western Hemlock-Sitka Spruce Forest, Intertidal Zone, and Marine Zone.
- The biologic assessment identified and characterized the fresh water stream habitats with respect to potential spawning and rearing habitat. The survey concluded that Kendrick Creek up to between 150 and 200 feet above sea level (ASL) has moderate to low/negligible available spawning area (ASA) and moderate available rearing area (ARA) for salmonids. Between 200 and 250 feet ASL, the stream has moderate ASA and ARA for Dolly Varden and low to negligible ASA and ARA for all other salmonids. Above 250 feet ASL, including the 300-Foot Mine Level, the stream has a steep gradient, with both Kendrick Creek and Mine Fork Creek considered negligible spawning and rearing habitat for all salmonids (Figure ES-5).
- The intertidal zone is bounded by the low and high water lines of Kendrick Bay and includes the upper portion of the Kendrick Creek delta and areas adjacent to the rock loadout ramps. An abundant and diverse array of plants, algae and aquatic invertebrates was observed in the intertidal zone of the west Arm of Kendrick Bay. The subtidal zone is contiguous with the intertidal zone and includes the marine waters of the west Arm of Kendrick Bay below the low water line.

Land Use Evaluation

The purpose of the land use evaluation was to document the current and likely future land uses of the Site and, in so doing, identify human receptors that could potentially be exposed to mine related constituents. The land use evaluation considered USFS land use information (KSI, 2004) and the natural, physical setting of the Site as well as the regional demographic and geographic setting. Site land uses include the following:

- Current use of the Site is minimal due to its remote location. Access to the Site, while unrestricted, is by float plane or boat. Hiking to the Site from the South Prince of Wales Wilderness Area to the west or from Moira Sound to the north is possible, but would involve navigating through several miles of trail-less rugged terrain as the Site is located within the Eudora Roadless Area of TNF (USFS, 2003).
- The Site has one permanent structure - a small cabin that is owned and maintained by the Dotson family. The cabin is reportedly seasonally used although no one occupied the cabin during the time Tetra Tech was at the Site in 2009. Other current Site visitors could include occasional recreational visitors, USDA Forest Service workers, and subsistence hunter-gatherers.
- In addition to recreational use, the TNF Land and Resource Management Plan (USFS, 2008a) has designated the Site for mineral exploration and timber production. For the past three years (2007, 2008 and 2009) prior to the preparation of this SCR, mineral exploration activities of a few months duration have occurred on Bokan Mountain in the Site vicinity. Mineral exploration also occurred during the 2010 field season.
- Commercial fishing occurs at the mouth of Kendrick Bay, and an aquaculture facility is located on the South Arm of Kendrick Bay; however, both these uses occur several miles from the Site.

- Subsistence use of land and marine resources is an important facet of native Alaskan traditional practices. As such, subsistence use of land and marine resources at the Site will be addressed and evaluated in the SLHHRA considering the location of native Alaskan population centers, Site access, and subsistence resources.

Gamma Radiation Surveys

Comprehensive, high-density gamma radiation surveys were conducted to define the range and extent of gamma exposure rates for the mine features (900-Foot, 700-Foot and 300-Foot levels, mine and haul roads, and the OSA and ore loading docks) and adjacent areas. Gamma surveys were also performed of the Kendrick Creek stream channel, Kendrick Bay intertidal zone, and a limited area of the I&L Zone. Correlations were established between measured gamma exposure rates and the activity of uranium, thorium, radium and other radionuclides in surface soil. The gamma surveys and radionuclide correlations provide detailed information to define the limits of mine rock areas and to characterize adjacent areas.

Figures ES-6 through ES-9 summarize the results of the gamma radiation surveys for the Site. Data presented on these figures represent unshielded gamma exposure rates measured at three feet above the ground surface in interval units of microroentgen per hour (μR/hr). The lowest interval of less than 20 μR/hr corresponds to the upper range of background gamma exposure rates determined for non-mineralized areas at the Site. The unshielded gamma measurements define the limits of gamma exposure rates representative of the radiation exposure and risk to humans at a specific location; however, the measurements likely overestimate the extent and boundaries of mine rock areas.

Figure ES-6 illustrates the Site-wide results of the gamma radiation surveys for the mine and haul roads, Kendrick Creek stream channel, Kendrick Bay intertidal zone, and the I&L Zone. Figures ES-7 through ES-9 depict the gamma exposure rates measured in the 300-Foot Level, combined 700-Foot and 900-Foot levels, and the OSA and loading docks. Pertinent results of the gamma radiation surveys include:

- *Kendrick Creek Channel:* The Kendrick Creek stream channel between the 300-Foot Level and the mouth of the creek were surveyed. With the exception of limited areas downstream of the 300-Foot Level, the measured gamma exposure rates in the Kendrick Creek channel are relatively low (<20 to 30 μR/hr). Isolated areas of gamma readings ranging up to approximately 160 μR/hr were measured downstream of the 300-Foot Level mine rock pile in the primary channel of Kendrick Creek. These gamma exposure rates are due to individual mine rocks observed in the channel downstream of the 300-Foot Level mine rock pile. Visual observations and the gamma measurements indicate that mineralized durable, cobble- and boulder-sized mine rock are the sources of the gamma radiation. This is an important characteristic and contrasts with more widely distributed fine-grained material resulting from the breakdown and erosion of the mine rock.

- *Kendrick Bay Intertidal Zone:* Gamma exposure rates ranging up to 2,858 μR/hr in the intertidal zone are limited to a localized area immediately adjacent to the remnant rock loadout ramps and are associated with individual ore rocks. Gamma exposure rates of the intertidal zone west of the dock area, including the majority of the Kendrick Creek delta, are relatively low (<20 μR/hr).

- *I&L Zone:* While the gamma rates are variable, gamma values as high as 2,124 μR/hr were measured over the naturally mineralized and un-mined I&L Zone.

- *Mine and Haul Roads:* Gamma exposure rates ranging up to a maximum of approximately 850 μR/hr were measured in specific areas of the upper portion of the original haul road to the 900-Foot Level, the upper portion of the haul road to the 300-Foot Level, and near the OSA. Gamma exposure rates along the lower southern reach of the I&L spur road ranged up to a maximum of 874 μR/hr. The identified areas of the mine and haul roads may result from the use of mine rock to repair the roads or from ore spilled during haulage. In areas where the roads were constructed with mine rock or where ore may have been spilled during haulage, visual observations and the gamma measurement indicate that mineralized coarse durable cobbles and boulders are the sources of the gamma radiation, rather than distributed fine-grained soils that are subject to erosion.

- *300-Foot Level:* Gamma exposure rates of up to 2,460 μR/hr were measured for the mine rock pile at the 300-Foot Level. The extent of the mine rock pile was defined by lower gamma measurements around the perimeter of the 300-Foot Level area except for an area downslope of the haul road on the eastern side; the steepness and/or dense vegetation in this area prohibited access.

- *700-Foot Level:* Gamma readings of up to 4,206 μR/hr were measured for the 700-Foot level mine rock pile. With the exception of the area to the east-southeast of the 700-Foot Level portal, the extent of the 700-Foot Level rock pile was delineated by lower gamma measurements surrounding the pile.

- *Open Pit and 900–Foot Level:* Gamma exposure rates of up to 3,353 μR/hr are present over the open pit and the area immediately south of the pit. Gamma readings of up to 2,623 μR/hr and 1,700 μR/hr were measured for the north and south mine rock piles, respectively, at the 900-Foot Level. The extent of the 900-Foot Level rock piles were delineated by lower gamma measurements in the area surrounding the piles.

- *OSA and Former Ore Loading Docks:* A maximum gamma exposure rate of 4,100 μR/hr was measured in the central portion of the OSA. A deposit of mine rock was identified on the eastern perimeter of the OSA with gamma readings of about 2,000 μR/hr. The gamma survey extended to the intertidal zone, encompassing the two remnant rock loadout ramps. In the intertidal zone, measured gamma exposure rates ranging up to 2,858 μR//hr are limited to an area about 100 feet east of the remnants of the rock loadout ramp for the 1971 dock and to about 150 feet west of the existing dock ramp. The gamma survey and visual inspection indicates that pieces of ore in the immediate vicinity of the rock ramps represent the source of direct gamma radiation. Visual observations and the gamma measurements indicate that the coarse durable pieces of ore are the sources of the gamma radiation, rather than distributed fine-grained sediments that are subject to erosion. The unshielded surveys overestimate the areal extent and exposure rates of materials in a variable or low gamma field due to shine from higher gamma-emitting scattered rocks.

The gamma surveys also provide information to assess background gamma exposure rates for mineralized and non-mineralized areas of the Site. Quantifying background conditions at a former uranium mine in complex geologic conditions such as the Ross-Adams Site is a difficult task in the absence of actual pre-mining data. The Bokan Mountain Intrusive Complex is a circular stock of approximately three kilometers in diameter. The peralkaline granite stock is surrounded by a metamorphic zone consisting of quartz monzonite and quartz diorite intrusives. The general enrichment (mineralization) of uranium, thorium and other rare metals in the Bokan Intrusive Complex peralkaline granite and the surrounding quartz monzonite and quartz diorite intrusives requires the use of different background levels when discussing select environmental media (e.g., soils, gamma radiation) as various features are underlain by differing rock assemblages (mineralized versus non-mineralized) at the Site.

Due to the complex geologic conditions at the Site, local background gamma exposure rates are highly variable and require that different background levels be defined that reflect the natural variability (Figure ES-3). Background gamma radiation levels were determined separately for mineralized (peralkaline granite) and non-mineralized (undifferentiated granite and diorite intrusives) areas of the Site. Due to the extreme variability of exposure rates in undisturbed mineralized areas, it is not reasonable to establish a single background gamma value. The fact that the Ross-Adams ore deposit was discovered by an aerial radiometric survey and that initial mining was performed via an open shallow pit confirms that natural, pre-mining gamma exposure rates on and near the ore deposit were likely very high.

Gamma exposure rate measurements taken in the I&L Zone are assumed to represent the minimum for pre-mining background in the mineralized area at the Site. The I&L Zone has been prospected for uranium, but never mined. Since it has not been mined, the I&L Zone is assumed to be of lower grade and less mineralized than the Ross-Adams deposit, and thus, pre-mining background gamma levels of the Ross-Adams deposit were likely higher. Gamma exposure rates for the I&L Zone ranged from approximately 10 μR/hr to 1,700 μR/hr, with a maximum measured value of 2,124 μR/hr.

Background gamma exposure rates for non-mineralized areas were determined by independent evaluation of gamma data measured in the OSA, Kendrick Creek channel, and the west Arm of Kendrick Bay intertidal area. Evaluation of the gamma data for these separate areas resulted in comparable background ranges in the gamma exposure rates for non-mineralized areas. Gamma exposure surveys indicate that the background gamma radiation rates for undisturbed non-mineralized areas vary up to approximately 20 μR/hr.

Soil Media

Soil samples were collected that are representative of fine-grained material within the rock pile areas or fine-grained soil at the margins of the mine features that likely have been influenced by historic mining activities. The extent of soils influenced by the mine features is limited to identified areas immediately adjacent to mine rock at the 300-Foot, 700-Foot, and 900-Foot levels, along defined areas of the mine and haul roads, and in the OSA and rock loadout ramps associated with the ore loading docks.

The concentrations of metals and activities of radionuclides of soil samples collected from and adjacent to the mine rock areas vary over a wide range. Arsenic, lead, total uranium, and radium-226 in soil from and adjacent to the mine rock areas illustrate the distribution and trends in other metal and radionuclide parameters. Median concentrations of arsenic, lead, total uranium, and radium-226 in soil are 2.7 mg/Kg, 58 mg/Kg, 155 mg/Kg, and 70.9 ρCi/g at the 300-Foot Level; 2.3 mg/Kg, 44 mg/Kg, 215 mg/Kg, and 136 ρCi/g at the 700-Foot Level; and 3.1 mg/Kg, 76 mg/Kg, 650 mg/Kg, and 351 ρCi/g at the 900-Foot Level.

Based on the gamma radiation survey results, soil samples have been affected in identified areas within the OSA to varying degrees. Median concentrations of arsenic, lead, uranium, and radium-226 are 2.1 mg/Kg, 15 mg/Kg, 240 mg/Kg, and 55.2 ρCi/g for affected soil samples at the OSA. Soil along the mine and haul roads have also been affected by mine rock used to repair the roads or from spills during ore haulage. Median concentrations of arsenic, lead, uranium, and radium-226 are 0.95 mg/Kg, 7.7 mg/Kg, 31 mg/Kg, and 13.4 ρCi/g for soil samples collected from the mine and haul roads.

Similar to background gamma radiation, soil background levels were determined separately for mineralized (peralkaline granite) and non-mineralized (undifferentiated granite and diorite intrusives) areas of the Site. The OSA and 300-Foot Level locations are considered to be underlain by essentially non-mineralized bedrock, and the 700-Foot and 900-Foot levels are considered to be underlain by mineralized bedrock to varying degrees. Soil samples collected at locations away from the mine features were used to assess the local background levels for the mineralized and non-mineralized areas. Maximum arsenic, lead, and uranium concentrations of 5.1, 15, and 11 mg/Kg and a maximum radium-226 activity of 7.1 ρCi/g were determined for soil in non-mineralized areas. Maximum arsenic, lead, and uranium concentrations of 4.9, 190, and 140 mg/Kg and a maximum radium Ra-226 activity of 95 ρCi/g were determined for mineralized areas.

Surface Water Media

Based on available data, water flows continuously from the 300-Foot Level portal and drains to Mine Fork Creek upstream of its confluence with Kendrick Creek, which subsequently flows along the 300-Foot Level mine rock pile. Flow rates measured in 2009 from the portal were 18 gpm during the June and July sampling events, and increased to 91 gpm during the September sampling event due to increased precipitation.

The drainage from the 300-Foot Level portal has the highest metal concentrations and radionuclide activities of surface water quality samples collected at the Site. Total uranium concentrations in water samples collected at the portal in 2009 ranged from 0.11 to 0.24 mg/L, lead concentrations ranged from 0.00022 to 0.00028 mg/L, total zinc concentrations ranged from 0.024 to 0.038 mg/L, arsenic concentrations were below the laboratory reporting limit of 0.01 mg/L, and radium-226 activity ranged from 4.3 to 7.8 ρCi/L. These parameters are representative of the distribution and trends in metal concentrations and radionuclide activities. The State of Alaska has established freshwater chronic criteria for aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium and zinc. The maximum aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel and selenium concentrations for samples collected from the 300-Foot Level portal drainage were below the criteria. The zinc concentration of the sample collected from the portal drainage in September 2009 slightly exceeded the freshwater chronic criteria; however, the zinc concentrations of samples collected during the other two sampling events were less than the zinc criteria.

Concentrations of metals, including zinc, and radionuclides are the highest in Kendrick Creek adjacent to the 300-Foot Level mine rock pile, but decrease downstream. The steep gradient of Kendrick Creek to below the 300-Foot Level is considered negligible spawning and rearing habitat for all salmonids. Except for aluminum, the metal concentrations in Kendrick Creek were less than Alaska chronic freshwater criteria. Aluminum concentrations at the background surface water locations also exceeded the criteria and the aluminum concentrations in Kendrick Creek were less than the range of concentrations at background surface water locations. Concentrations continue to decrease in the lower portions of Kendrick Creek. In lower reaches of Kendrick Creek where the habitat is physically more amenable to salmonid spawning and rearing, the concentration of metals and radionuclides were typically within the range of background surface water quality and/or less than the chronic freshwater criteria. Constituent concentrations generally decreased with increased stream flow during the September sampling event. Low sulfate concentrations were measured at all sampling locations during all three sampling events. The mildly acidic to neutral pH of ambient surface water and localized fluctuations in measured pH values are consistent with the low buffering capacity of the natural granitic environment. These water quality observations, along with the mineralogy of the Site geology and ore body, demonstrate that acid rock drainage (ARD) is not an environmental condition at the Site.

The concentrations of several metals and activities of radionuclides in samples collected from Mine Fork Creek and drainages originating in the vicinity of the 700-Foot Level mine rock pile and the 900-Foot Level open pit and mine rock piles exceeded background surface water concentrations. The lower reaches of both Mine Fork and the 700-Foot Level Creek have substantial physical barriers to upstream fish movement. Except for aluminum concentrations at most sampling locations and the zinc concentration of one sample collected from Mine Fork Creek, surface water quality in Mine Fork Creek and Kendrick Creek meets the State of Alaska chronic freshwater criteria for metals. As described above, aluminum concentrations at the background surface water locations also exceeded the chronic freshwater criteria and the aluminum concentrations in Kendrick Creek and Mine Fork Creek were less than the range of concentrations at background surface water locations.

Local background reference concentrations of metals and radionuclides in surface water were evaluated using data from sampling locations upstream of the mine feature areas. These sampling locations are considered representative of surface water quality above the outcrop area of the Ross-Adams mine. Background that includes the influence of the natural mineralization of the Ross-Adams area prior to mining is not possible due to the influence of the mine rock, but these upstream samples are considered to be the best data available for evaluating background surface water quality. These background samples likely underestimate the metal concentrations and radionuclide activities of surface water from the mineralized area prior to mining. Data at these upstream locations are dependent on specific sampling locations in Kendrick Creek and Mine Fork Creek and were used to evaluate the potential effects of mine features at downstream locations.

Stream Sediment Media

Most metals and radionuclides exhibit similar trends in streambed sediments. The maximum observed metals concentrations and radionuclides activities in stream sediment occurs at the sample collected from the 300-Foot Level portal drainage. As a result, the highest observed metal concentrations and radionuclide activities in Kendrick Creek sediment, particularly for uranium and radionuclides, typically occur at the sample location immediately downstream of the 300-Foot Level mine rock pile.

Similar to surface water, the concentrations of metals in Kendrick Creek sediments decrease in samples downstream of the 300-Foot Level and, in lower reaches of Kendrick Creek where the habitat is physically more amenable to salmonid spawning and rearing, sediment metal concentrations are low. Radionuclide activities of stream sediment in Kendrick Creek also quickly decrease in the downstream direction and, by a point just above the Cabin Creek confluence, the activities of radionuclides are at or below the background radionuclide activities for stream sediment.

Similar to surface water, background reference values for stream sediment were determined from sampling locations upstream of the mine features and the outcrop of the Ross-Adams mine deposit. Due to the present influence of the mine rock, background that reflects the natural mineralization of the Ross-Adams area prior to mining is not possible. These upstream samples are considered to be the best data available for evaluating background stream sediment quality, but likely underestimate the metal concentrations and radionuclide activities of stream sediment from the mineralized area prior to mining. Data at these upstream locations were used to evaluate the potential effects of mine features at downstream locations.

Groundwater

Due to the generally thin soils and exposed bedrock at the higher elevations of the Site, including the 700-Foot and 900-Foot levels, the occurrence of shallow groundwater is likely to be very minimal and discontinuous. In addition, the steepness of the creeks in their upper reaches inhibits the accumulation of alluvial material, and bedrock exposure in the creek beds is common. Within the lower reaches of Kendrick Creek, the stream gradient decreases sufficiently to allow the development of alluvium. Due to the likely interaction with surface water and shallow alluvial groundwater in lower Kendrick Creek, the quality of shallow groundwater is represented by surface water quality.

Kendrick Bay Marine Sediments

Drainage from the mineralized terrain in the Kendrick Creek watershed is to the west Arm of Kendrick Bay. The numerous uranium, thorium and rare earth REE mineral deposits present on Bokan Mountain and located in the Kendrick Creek watershed have been actively explored for over 50 years. Available information indicates that metal concentrations and radionuclide activities of the marine sediments in the west Arm of Kendrick Bay reflect the natural weathering processes of the naturally mineralized terrain.

Kendrick Creek enters the bay in the westernmost portion of the west Arm of Kendrick Bay. The delta formed by Kendrick Creek has a relatively flat gradient which results in a wide intertidal area. This area possesses a very diverse and abundant array of marine life. Away from the Kendrick Creek delta the intertidal zone is much steeper, resulting in a narrower band that is exposed during low tide and typical of fiords. Boulders and cobbles dominate the intertidal zone away from the Kendrick Creek delta. Marine sediment samples in the west Arm of Kendrick Bay were collected from the intertidal zone (between the low and high water lines) and from the subtidal zone (below the low water line).

The gamma survey and physical inspection documented the presence of pieces of ore within the intertidal zone in a discrete area limited to approximately 100 feet east of the remnants of the 1971 rock loadout ramp and to approximately 150 feet west of the existing dock rock ramp. The ore was likely spilled during ore loading operations. Intertidal zone sediments in the swale between the two ramps confirm the presence of ore-related metals and radionuclides in this area. The intertidal zone sediment sample data indicate that the intertidal zone sediments on the Kendrick Creek delta represent a local background population.

Sub-marine gamma survey results (KSI, 2004) and the subtidal zone sediment sample data indicate the influence of spilled ore is limited to the immediate vicinity of the rock loadout ramps. Gamma values, concentrations of metals, and the activities of uranium and thorium and their decay products are highest in the sediments closest to the former floating dock, with the highest values closer to shore. The subtidal sediment sample data indicate that the metals (e.g., arsenic and lead) concentrations and radionuclide activities in the subtidal sediments a further distance from the rock loadout ramps represent local background. Furthermore, arsenic concentrations in the subtidal sediments are consistent with regional southeastern Alaska data and correlate with the organic rich marine sediments.

Air Media (Radon)

Radon concentrations at the Site are variable depending on the locations of the radon monitoring stations with respect to the mine features (mine rock piles and portals), the presence of naturally occurring mineralized background conditions, and localized atmospheric and topographic conditions. Pertinent results of radon monitoring of the mine features, measured as the average concentration over the detector exposure period, include:

- *Portals and Open Pit:* The portals and air shaft present avenues for radon emissions from the underground mine workings. A radon concentration of 373 ρCi/L was measured at the central portion of the open pit. Long-term radon concentrations measured at the 900-Foot Level portal and the air shaft were 163.3 ρCi/L and 39.2 ρCi/L, respectively. The long-term radon concentration measured at the 700-Foot Level portal was 22.3 ρCi/L.

  The highest radon concentration of 445 ρCi/L was measured at the 300-Foot Level portal. However, radon concentrations were lower at downstream monitoring locations in the steep-sided Kendrick Creek channel below the portal. The radon concentration measured approximately 100 feet southeast and topographically below the portal was 136 ρCi/L. Further downstream, approximately 300 feet from the 300-Foot Level portal, the measured radon concentration was 76.3 ρCi/L.

- *Mine Rock Piles:* Radon concentrations at the 300-Foot Level mine rock pile ranged from 5.8 to 22.3 ρCi/L. Radon concentrations up to 40.1 ρCi/L were measured at the 700-Foot Level mine rock pile. Radon levels associated with the mine rock piles at the 900-Foot Level varied from 133.4 ρCi/L (north pile) to 192 ρCi/L (south pile).

- *OSA and Loading Docks:* Radon concentrations of 64.1 ρCi/L and 92.9 ρCi/L were measured at detectors located at the perimeter of the OSA and near the existing dock. Radon concentrations less than the non-mineralized background value were attained at the radon monitoring locations that ring the OSA at distances ranging from approximately 150 to 300 feet.

Radon quickly disperses in the atmosphere and radon levels approach background levels within short distances from the mine features. The one exception to this is in the steep-sided Kendrick Creek channel downstream of the 300-Foot Level portal, where higher radon levels persist for more than 300 feet below the portal.

Based on radon measurements performed at background locations and areas away from mine feature areas, a radon concentration of 5.8 ρCi/L is considered to represent the maximum background value for non-mineralized areas away from areas of naturally occurring mineralization and economic mineral deposits.

Air Dust and Particulates

Site air quality is not impacted by mine material dust or particulates because the topography, vegetation and wet climatic conditions at the Site and the generally coarse nature of the mine materials inhibit the generation of wind-born material.

Conclusions and Recommendations

The ESI provides the data and information necessary to characterize the physical, chemical and radiological conditions of the Site and address the data gaps identified in the PA/SA (KSI, 2004), as required by the SOW. The data collected under the ESI includes sufficient information to allow the design and costing of potential removal actions for evaluation in the EE/CA, and to support assessment of current and future (post removal action) risks to appropriate human and ecological receptors. Physical data, mapping and topographic survey data were collected to allow design and costing of a variety of potential removal action alternatives.

The results of the ESI indicate that the influences of mining activities related to the Ross-Adams mine are limited to the vicinity of the mine feature areas. These mine features are:

- The open pit
- The mine portals (900-Foot, 700-Foot, and 300-Foot levels) and air shaft
- The mine rock piles at the 900-Foot, 700-Foot, and 300-Foot levels and adjacent soils
- Specific areas of Site mine and haul roads
- The OSA and adjacent soils
- The rock loadout ramps

The data and information collected in the ESI (chemical, radiologic and physical) is sufficient to determine the chemical and radiological characteristics and the boundaries/locations of mine features at the Site. The gamma radiation survey data provide definitive information to differentiate between the boundaries of the mine features, adjacent areas, and natural mineralized background conditions. Further, the gamma correlation sample results demonstrate that gamma exposure measurements provide a reliable method to assess the radionuclide activities of soils. The results of the gamma radiation surveys and soil sampling indicate that the influences from the mine rock piles at the 300-Foot, 700-Foot, and 900-Foot levels, mine rock along areas of the haul roads, the OSA and rock loadout ramps are confined to discrete and defined areas. The concept of local background is critical to the understanding of the Site conditions because of the influence of the natural mineralization exposed at the surface throughout the 900-Foot and 700-Foot Levels.

The PA/SI (KSI, 2004) presented a conceptual site model (CSM), developed using the information and data available at that time, to describe the relation between potential sources and receptors via pathways and media at the Site. In general, the CSM defines the potential sources; the release mechanism for those sources; the environmental medium to which the constituents are released; and the exposure route to each potential receptor for the affected environmental media. The CSM does not determine if exposure or risk occurs but only identifies the route that constituents of potential concern can travel. The information and data collected by the ESI and evaluated in this SCR provides a basis for updating the CSM with respect to quantification of sources, media and pathways as discussed in the following.

Mine features at the Site are the underground mine workings; mine rock piles and associated soil at the 900-Foot and 700-Foot levels; the mine rock pile and portal drainage at the 300-Foot Level; and mine materials present in the mine and haul roads, the Ore Staging Area, and the loadout ramps. The area and location of these mine features and the nature and extent of the chemical and radiological constituents have been documented and quantified. In addition to mine features, the drums and stained soils at the generator shack area of the 300-Foot Level are considered a source for petroleum hydrocarbons.

The release mechanisms from the underground mine workings are radon emissions to air and leaching of other radionuclides and metals to mine water drainage. The portals and air shaft present avenues for radon emissions from the underground mine workings. Radon emissions also occur from the mine rock piles. Radon quickly disperses in the atmosphere and radon levels approach background levels within short distances from the mine features. The one exception is the radon concentration in the air flow from the 300-Foot Level portal, which has the highest measured radon concentration at the Site, with higher radon levels persisting for more than 300 feet downstream of the portal in the steep-sided Kendrick Creek channel. The exposure to radon would be through inhalation to receptors below the portal. Other radon sources include background radon emissions from the naturally mineralized geology.

Mine water drainage, primarily from the 300-Foot Level portal, reports to surface water in Kendrick Creek, and surface water is considered an exposure medium through which human and ecological receptors (terrestrial and freshwater aquatic) could be exposed to certain metals and radionuclide constituents through ingestion, direct contact, and food chain pathways. However, the steep gradient of Kendrick Creek to below the 300-Foot Level is considered negligible spawning and rearing habitat for all salmonids. Except for aluminum concentrations, which are less than the range of background surface water concentrations, the metal concentrations in Kendrick Creek are less than Alaska chronic freshwater criteria. Concentrations of metals and radionuclides decrease downstream and in the lower reaches of Kendrick Creek, where spawning and rearing habitat for salmonids is of higher quality, the concentration of metals and radionuclides are typically within the range of background surface water quality and/or less than Alaska chronic freshwater criteria.

Mine rock present at the 900-Foot, 700-Foot and 300-Foot levels, haul and mine roads, the OSA and at the rock loadout ramps are potential sources of metals and radionuclides that can cause exposure by direct contact, direct gamma radiation, or be released to soils, surface water, sediments and air media. Potential release mechanisms include erosion, leaching, runoff, dust emissions and radon emissions.

Direct exposure to gamma radiation within or in close proximity to the mine features is a potentially complete pathway to humans and terrestrial ecological receptors. The gamma radiation survey data provide definitive information to differentiate between the boundaries of the mine features, adjacent soils, and natural mineralized background conditions. The gamma measurements define the limits of gamma exposure representative of the radiation exposure to receptors at a specific location. In addition, the gamma radiation measurements have been demonstrated to provide reliable information for soil radionuclide activities.

Erosion of mine rock piles has the potential to affect soils outside of the physically disturbed mine feature areas. As demonstrated by the results of soil sampling, however, Site soils that are not in immediate contact with mine rock are not impacted by the mine features except in isolated locations where discrete pieces of ore or sub-ore grade rocks are present that were spilled during haulage or ore loading operations. The generation of dust/air particulate emission does not occur due to the topography, vegetation and wet climatic conditions at the Site and because the generally coarse nature of the mine materials inhibit the generation of wind-born material.

Leaching of radionuclides and select metals or runoff from mine rock piles to surface water can result in human and ecological receptors potentially being exposed through direct contact with, ingestion of, or food chain exposures of surface water and stream sediment. The results of surface water samples collected from Mine Fork Creek and drainages originating in the vicinity of the 700-Foot Level mine rock pile and the 900-Foot Level open pit and mine rock piles indicates that leaching and runoff from mine rock represents a minimal release mechanism for metals and radionuclides. In addition, there is no indication of suspended solids transport from mine features to surface water indicating that runoff from mine rock piles is not affecting surface water quality. The lower reaches of both Mine Fork and the 700-Foot Level Creek also have substantial physical barriers to upstream fish movement. Trends in the metal concentrations and radionuclide activities of stream sediment in Kendrick Creek are similar to surface water quality. The highest observed metal concentrations and radionuclide activities in Kendrick Creek sediment typically occur at the sample location immediately downstream of the 300-Foot Level mine rock pile. Metal concentrations and radionuclide activities in stream sediment decrease downstream and in lower reaches of Kendrick Creek, where the habitat is physically more amenable to salmonid spawning and rearing, metal concentrations and radionuclide activities are at or below the background values for stream sediment.

Marine sediments can present potential direct contact exposure pathways as well as external radiation and food-chain exposures to both humans and ecological receptors. Except where discrete ore rocks are present in a limited area of the rock loadout ramps, the metal concentrations and radionuclide activities of sediment within the intertidal and subtidal zones are within local background levels.

The information and data collected in the ESI are sufficient to establish the nature and extent of the impacts due to the Ross-Adams mine features, to identify and characterize the chemical and radiological conditions of these features and media, and to define the physical and engineering features of the Site. The ESI provides the necessary data and information to support the evaluation of exposure pathways and to conduct the risk assessments. Therefore, no additional data collection or evaluation is proposed for the completion of the EE/CA. Finalization of the risk assessments may identify that, in specific areas, uncertainty remains and that additional data collection and/or risk analysis would address those uncertainties. However, the ESI, in conjunction with other Site investigations, provides sufficient characterization of sources, release mechanisms and media, and of the engineering and physical conditions for identification and evaluation of removal actions in the EE/CA that will effectively address and mitigate risks associated with historic uranium mining at the Site.

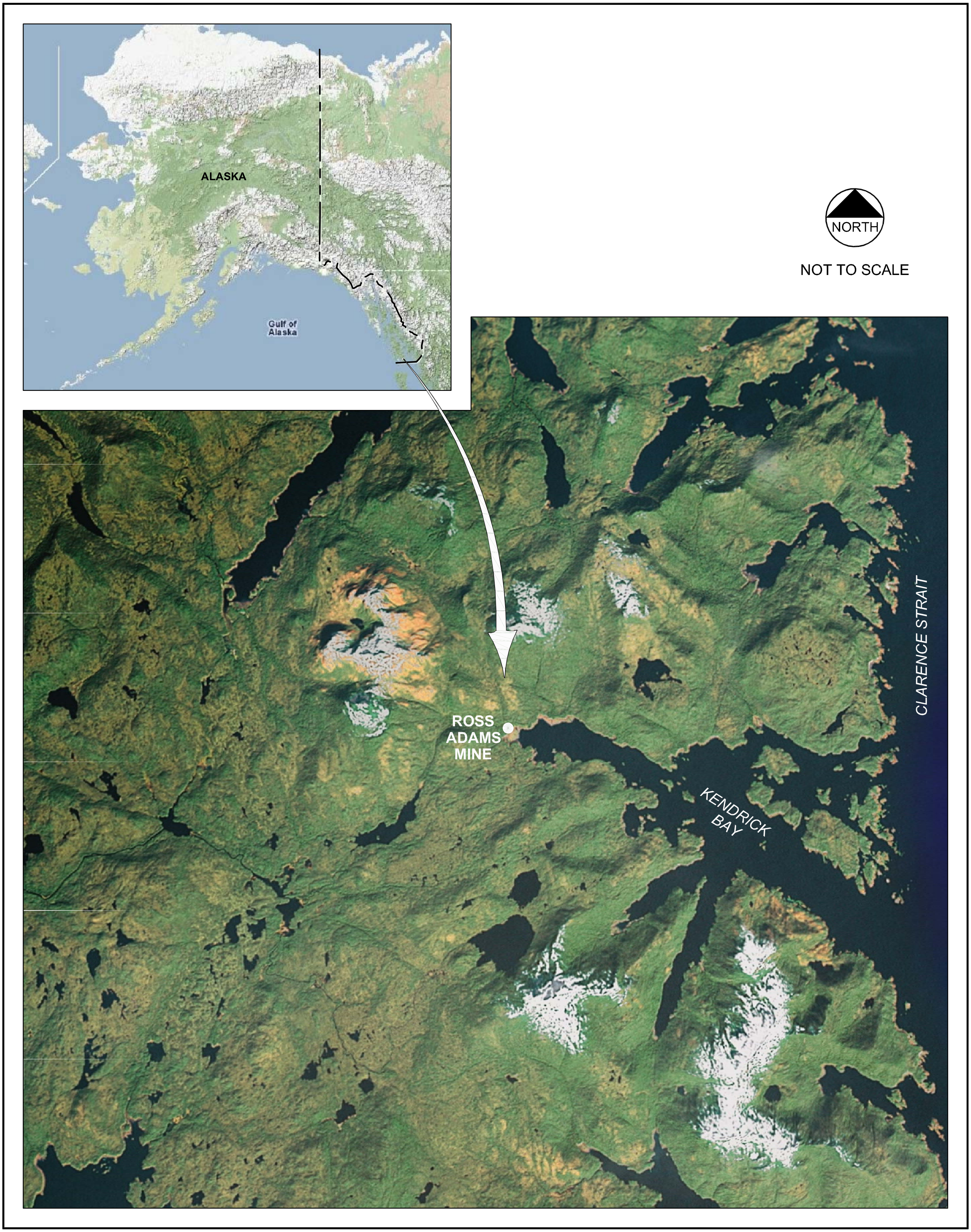

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Figure ES-1
Ross-Adams Site Location

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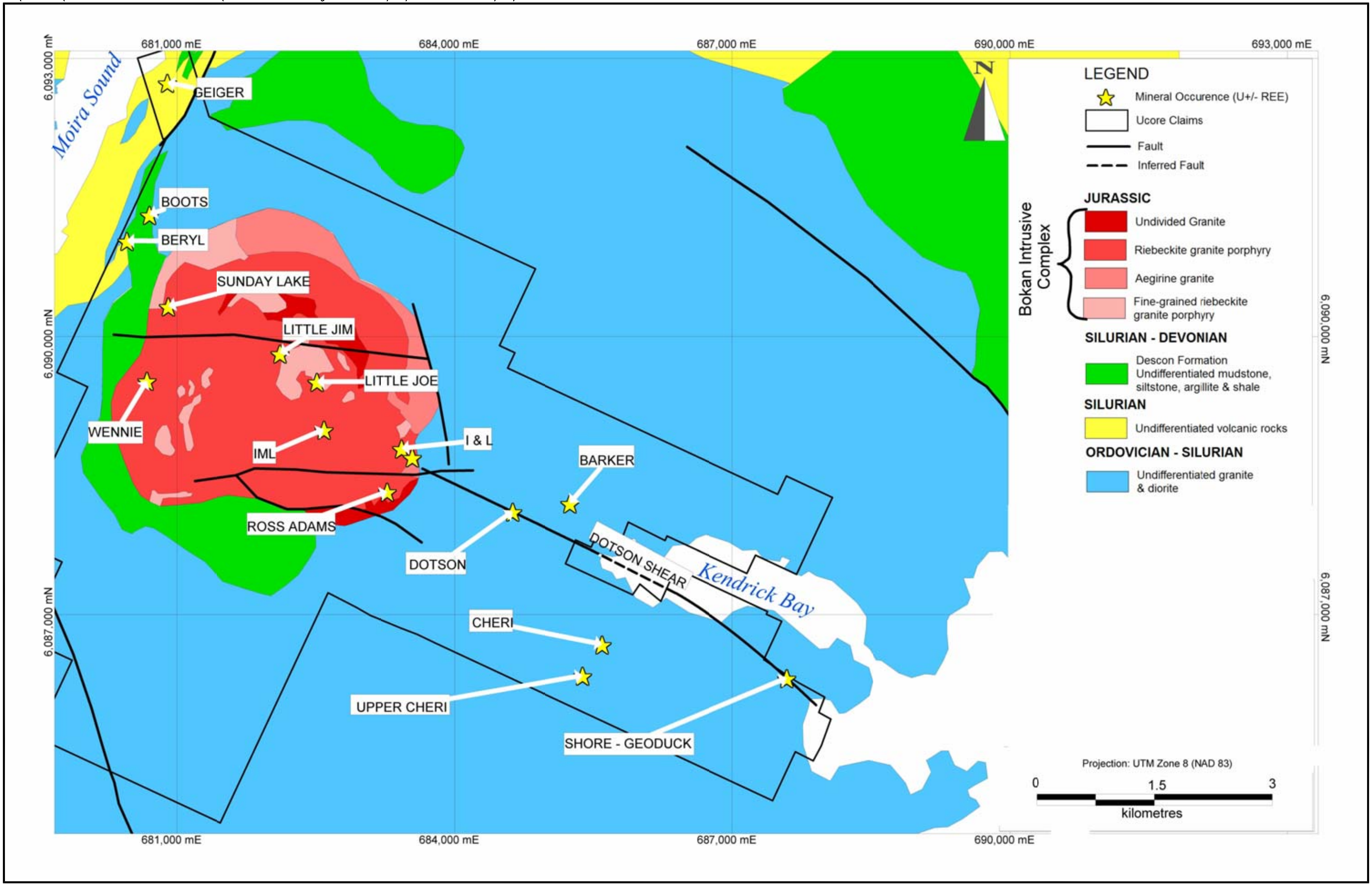

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Source: www.ucoreuranium.com

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Figure ES-2
Ross-Adams Site
Regional Geology and Mineral Occurrences

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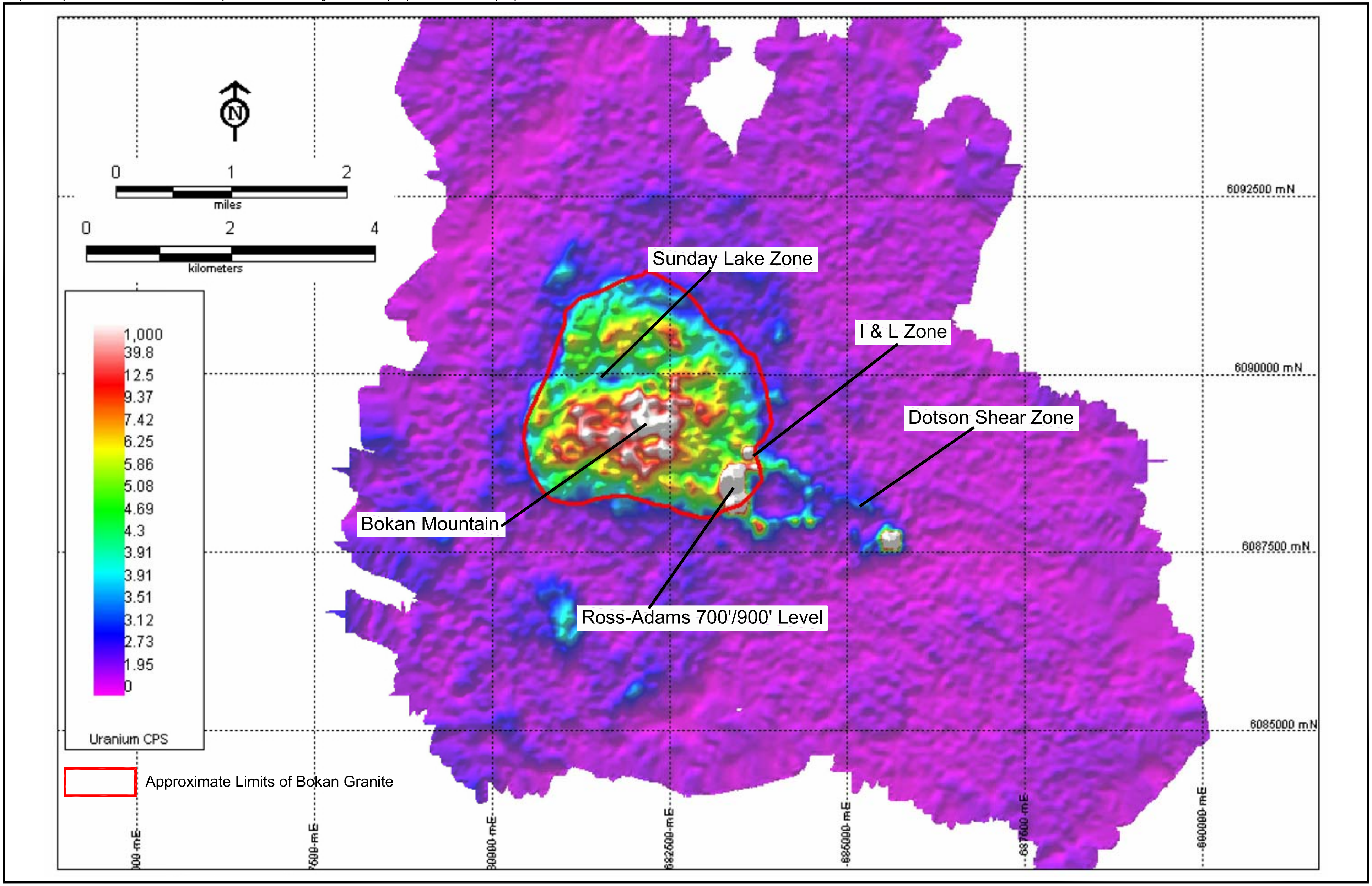

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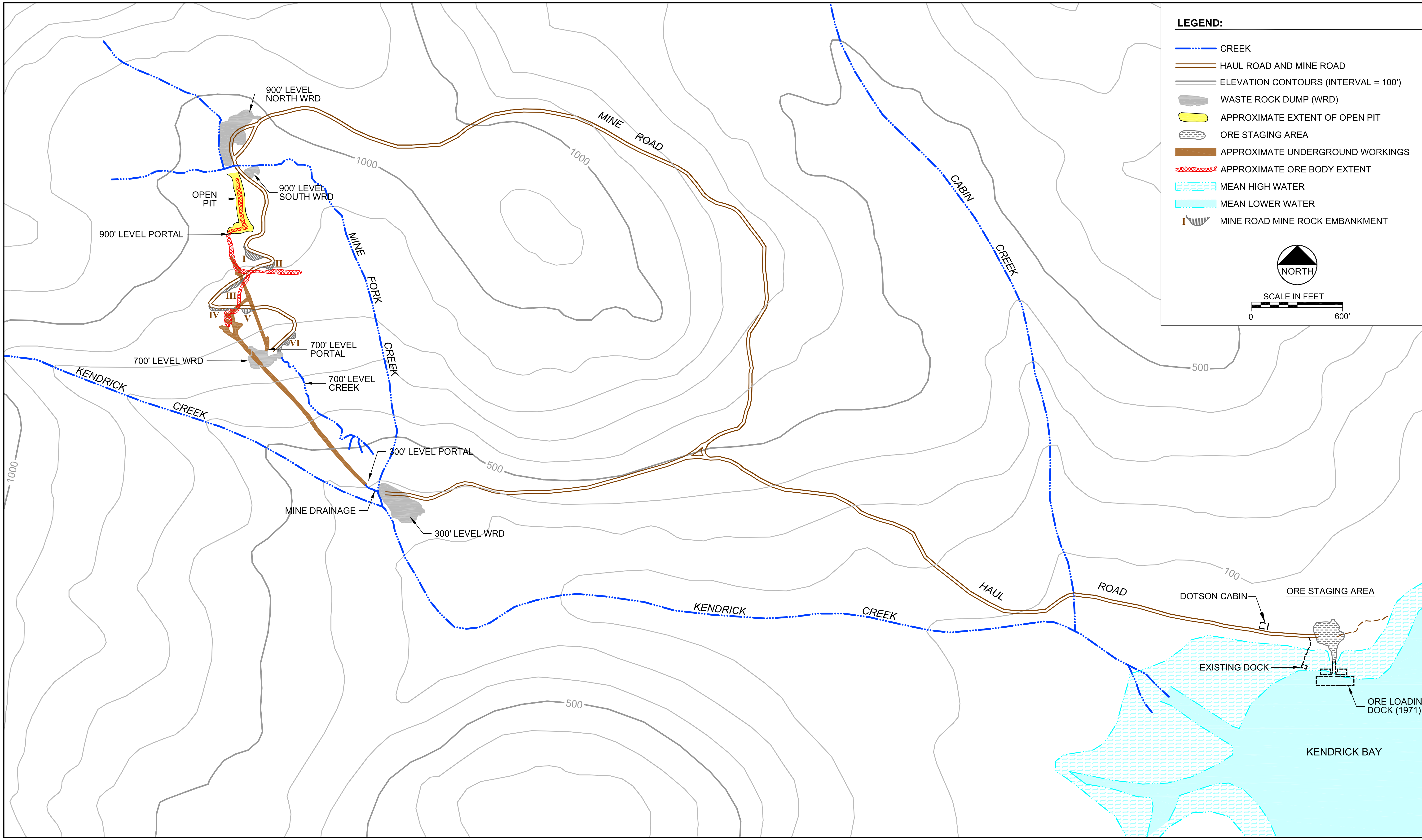
Notes:
1. Used By Permission From Ucore Uranium.
2. UTM Grid WGS 84 Zone 8.

Figure ES-3
Bokan Mountain Airborne Radiometric Survey (2007)



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Base Map Reproduced from Kent & Sullivan, 2004

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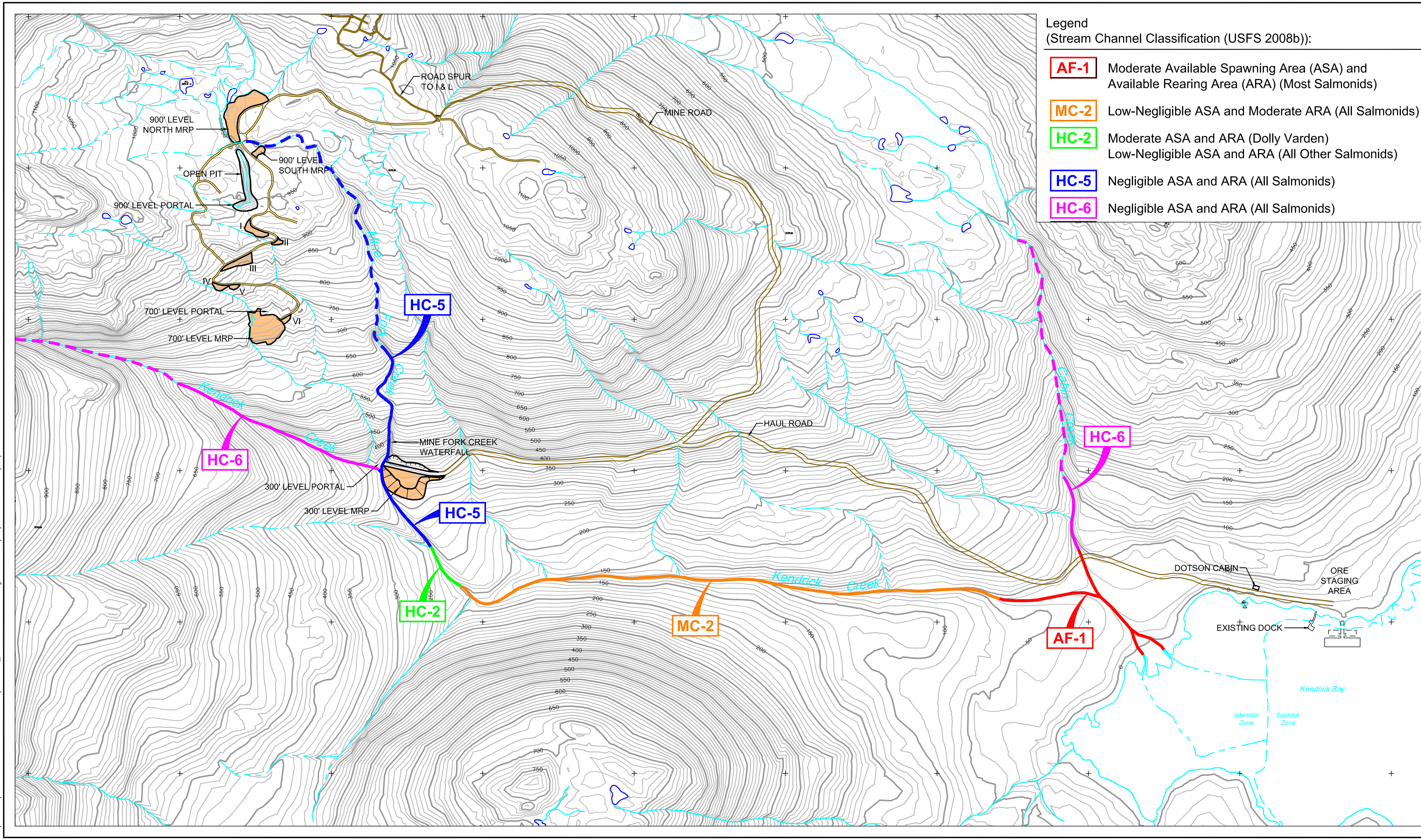
Figure ES-4
Ross-Adams Site
Major Site Features



E:\181862\Final SCR – November 2010\FIG-5-1_ES-5 Fish Zones.dwg SAVED: 11/18/10 PRINTED: 11/18/10 BY: THOMAS.BOEHLER

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Figure ES-5
Ross-Adams Site
Kendrick Creek Fish Habitat Zones

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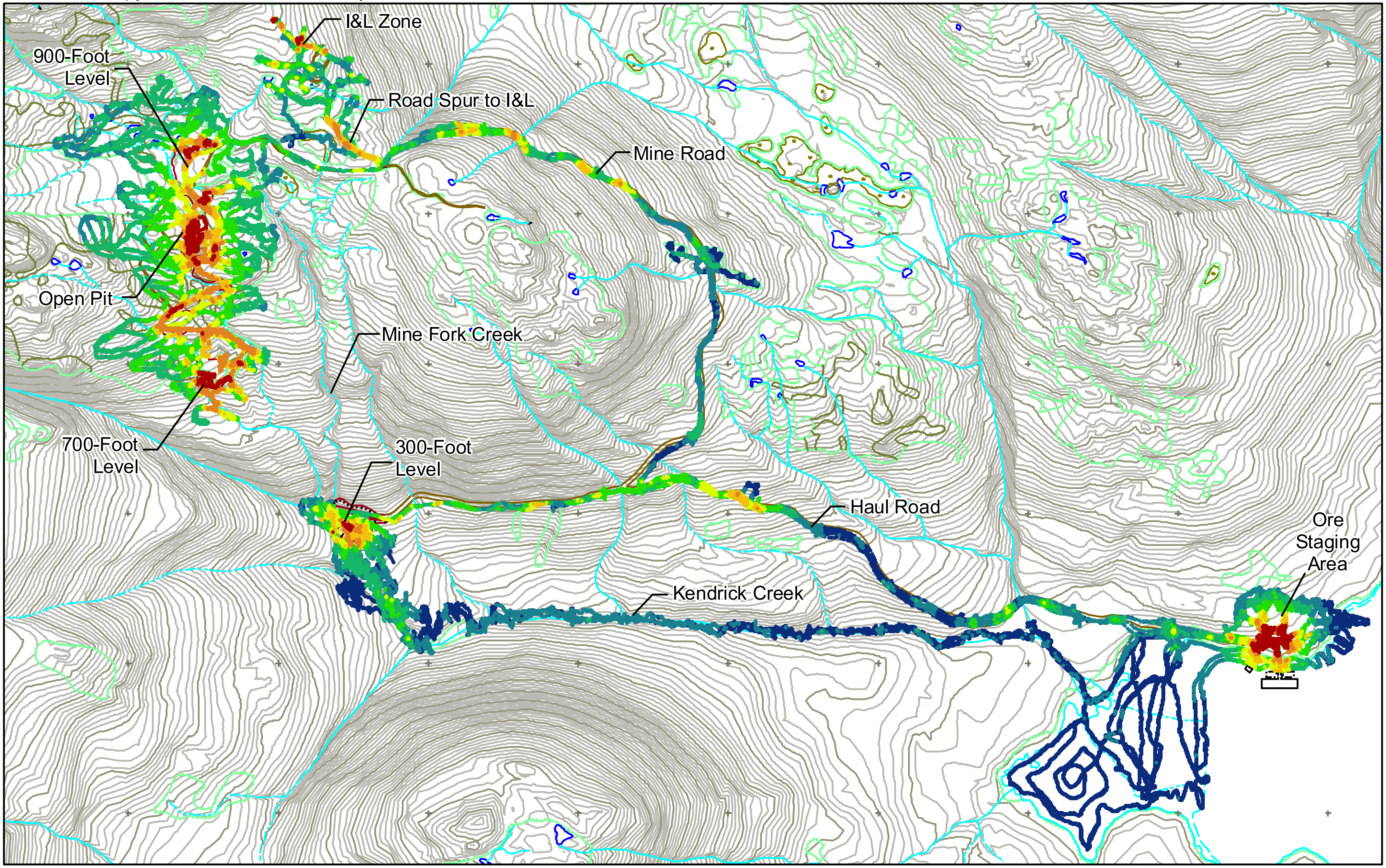

Gamma Exposure Rate (uR/hr)

<20	80-160	631-1250
20-40	160-316	>1250
40-80	316-631	

N

Feet

0 1,000

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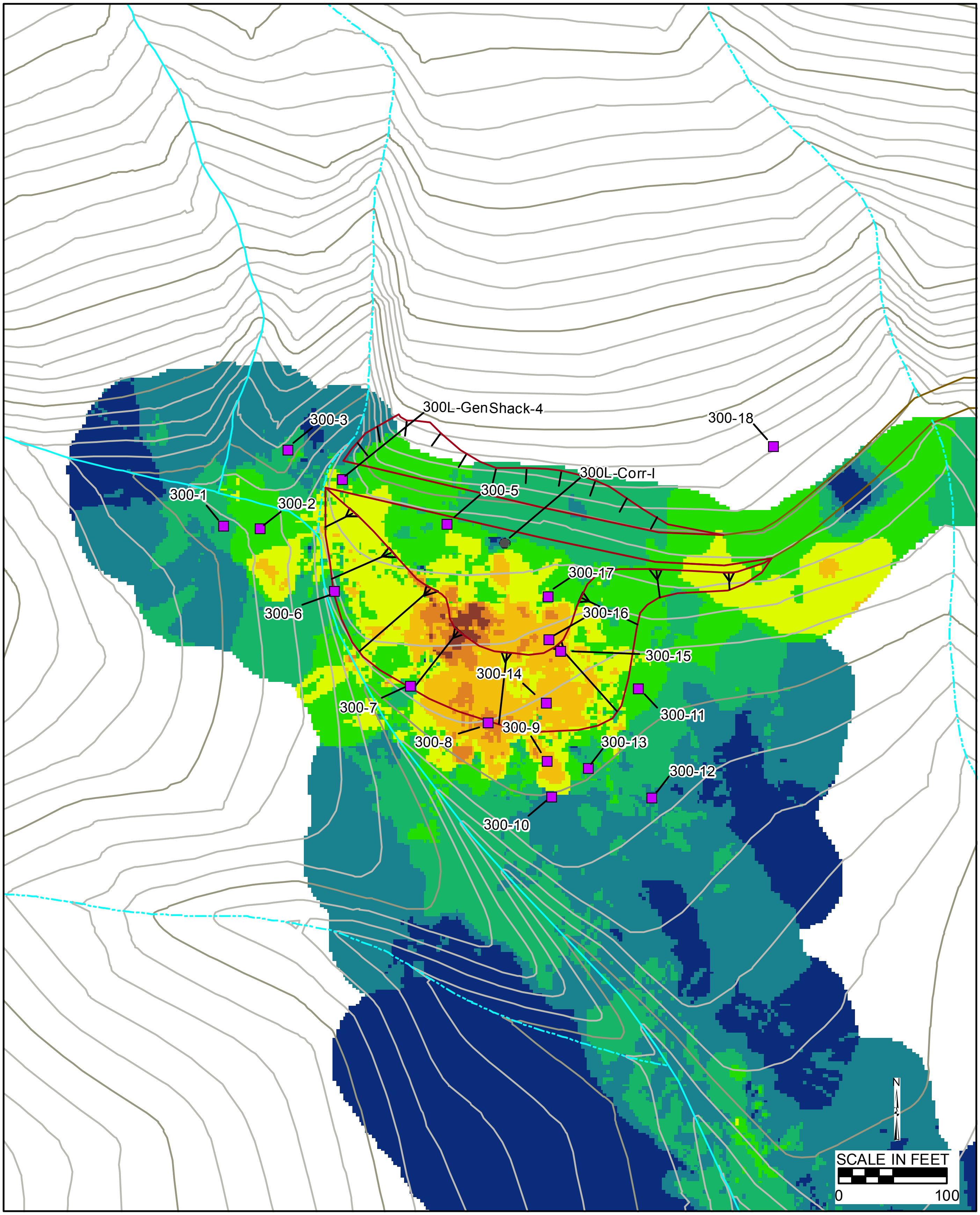
Figure ES-6
Ross-Adams Site
Unkriged Site Map



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Gamma Exposure Rate (uR/hr)

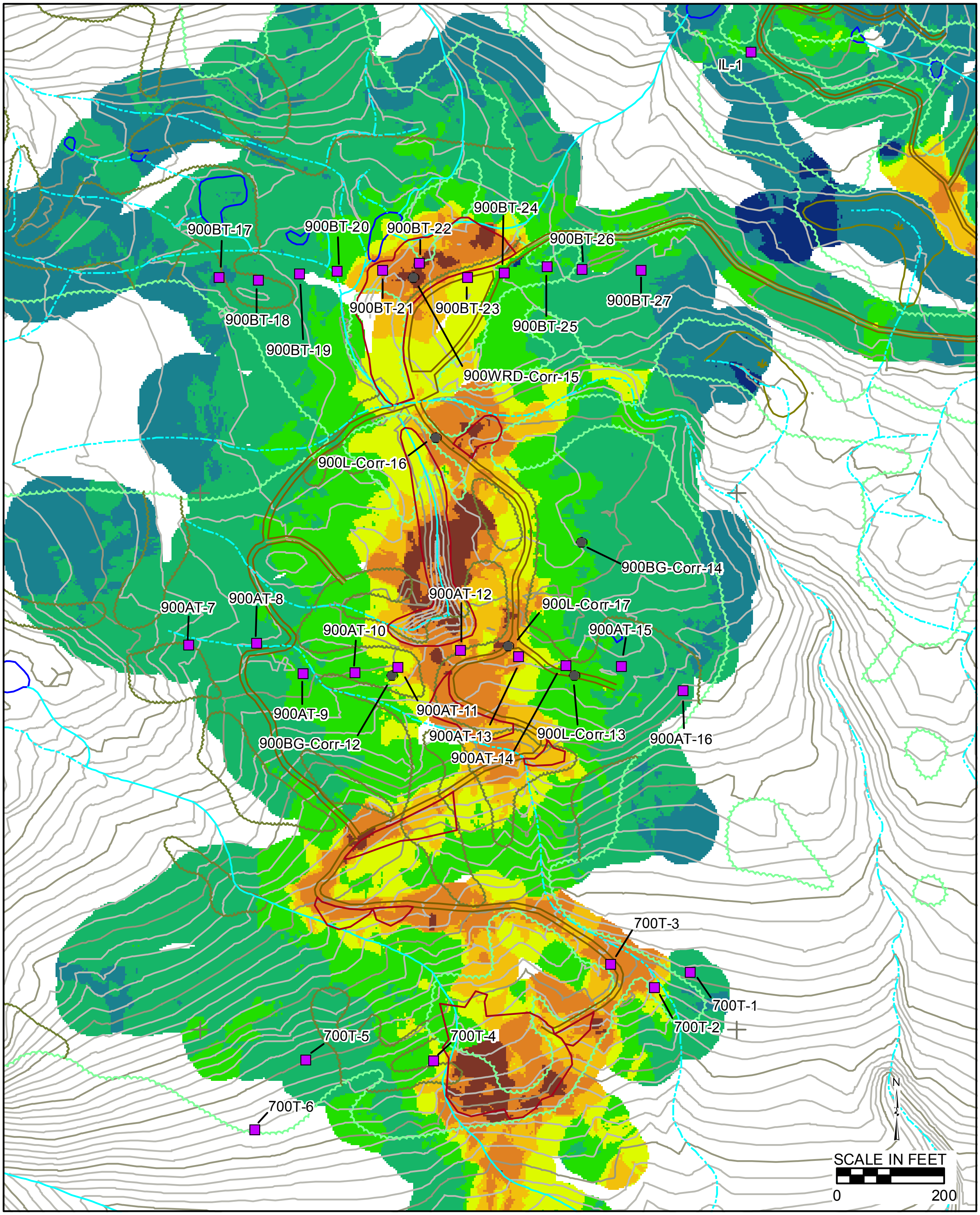
<20	80-160	631-1250
20-40	160-316	>1250
40-80	316-631	

Outside of Limits of Gamma Survey

Gamma/Soil Correlation Plot Sample

Discrete Soil Sample

Figure ES-7
Ross-Adams Site
Gamma Survey
300 Level Kriged Site Map



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Gamma Exposure Rate (uR/hr)

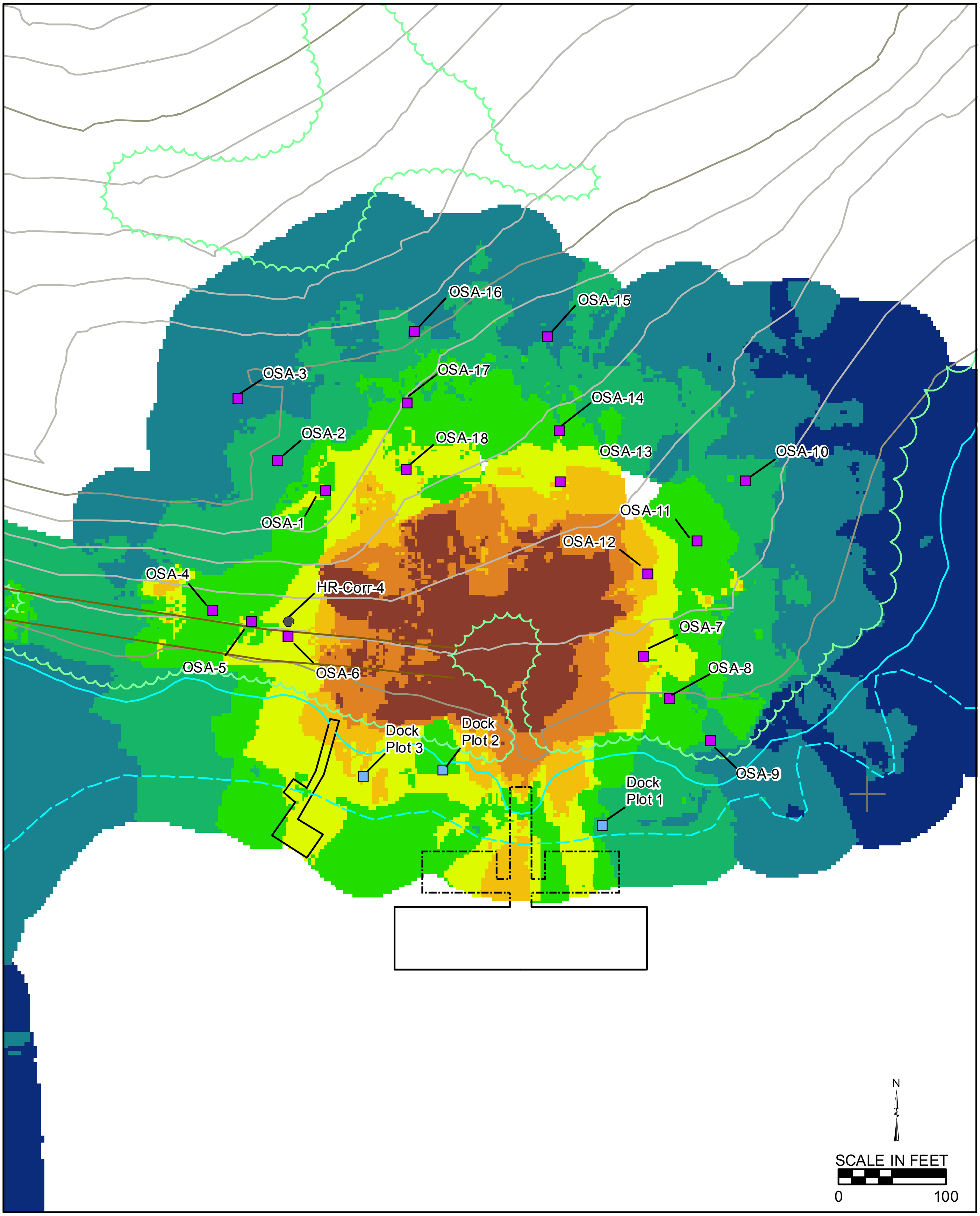
- <20
- 20-40
- 40-80
- 80-160
- 160-316
- 316-631
- 631-1250
- >1250

Outside of Limits of Gamma Survey

Gamma/Soil Correlation Plot Sample

Discrete Soil Sample

Figure ES-8
Ross-Adams Site
Gamma Survey
900/700 Level Kriged Site Map



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Gamma Exposure Rate (uR/hr)

<20	80-160	631-1250
20-40	160-316	>1250
40-80	316-631	

Outside of Limits of Gamma Survey

Gamma/Soil Correlation Plot Sample

Discrete Soil Sample

Mine Rock Point Count Plot

Figure ES-9
Ross-Adams Site
OSA Level
Kriged Site Map

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Appendix I: Agency Comments on the Draft Site Characterization Report and Newmont/Dawn Responses

ABBREVIATIONS

ADEC	Alaska Department of Environmental Conservation
AGL	Above Ground Level
ARD	Acid Rock Drainage
ASAOC	Administrative Settlement Agreement and Order on Consent
BLM	U.S. Bureau of Land Management
BOM	U.S. Bureau of Mines
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chain of Custody
COPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
DOT	Department of Transportation
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ESI	Expanded Site Investigation
GW	Groundwater Samples
HDPE	High Density Polyethylene
HPIC	High Pressure Ion Chamber
IAEA	International Atomic Energy Agency
IDW	Investigation Derived Wastes
KSI	Kent & Sullivan, Inc.
MS	Marine Sediment
NAD 83	Continental US 1983 Datum
NaI	Sodium Iodide
NELAP	National Environmental Laboratory Accreditation Program
PA/SI	Preliminary Assessment/Site Inspection
PARCC	Precision, Accuracy, Representativeness, Completeness and Comparability
POW	Prince of Wales Island
PPE	Personal Protective Equipment
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAD	Radon Samples
REE	Rare Earth Elements
RPA	Removal Preliminary Assessment

SAP	Sampling Analysis Plan
SCR	Site Characterization Report
SLERA	Screening-Level Ecological Risk Assessment
SLHHRA	Screening-Level Human Health Risk Assessment
SOI	Soil Samples
SOP	Standard Operating Procedure
SOW	Statement of Work
SS	Stream Sediment Samples
SSHP	Site Safety and Health Plan
SW	Surface Water Samples
TAL	Target Analyte List
TDS	Total Dissolved Solids
TNF	Tongass National Forest
TSS	Total Suspended Solids
Ucore	Ucore Uranium, Inc.
USDA	U.S. Department of Agriculture
USFS	U.S. Department of Agriculture Forest Service
XRF	X-ray fluorescence

1.0 INTRODUCTION

This Site Characterization Report (SCR) presents the results of activities conducted to characterize the existing physical and environmental conditions at the Ross-Adams Site (Site), located in the Tongass National Forest (TNF) near the southern end of Prince of Wales Island (POW), Alaska. This work was conducted in accordance with Newmont USA Limited and Dawn Mining Company's requirements of the Administrative Settlement Agreement and Order on Consent (ASAOC) (USFS, 2009) for an Engineering Evaluation/Cost Analysis (EE/CA) at the Site (executed April 17, 2009) pursuant to CERCLA and NCP requirements. This SCR incorporates responses to comments received from the USFS, the State of Alaska and the USEPA on the Draft SCR submitted in March 2010 in accordance with the ASAOC. The comments and responses are provided in Appendix I.

1.1 ASAOC

Newmont USA Limited and Dawn Mining Company (Companies) entered into an Administrative Settlement Agreement and Order on Consent with the USDA Forest Service on April 17, 2009 to perform a non-time-critical removal action at the Site. The Statement of Work (SOW) appended to the ASAOC identified these major tasks:

- Preparation of Site plans – which include the submitted and approved SAP, QAPP and Health and Safety Plan (HASP).
- Performance of an ESI – conducted in three sampling events in June, July and September 2009.
- Preparation of a SCR – which includes the submittal of a draft report for agency comment in March 2010 (Tetra Tech, 2010), response to agency comments in June 2010 (Appendix I), preparation of a draft final report in September 2010 incorporating responses to comments for agency review, and subsequent finalization of the SCR and approval by the USFS.
- Preparation of an EE/CA Report that includes human health and ecological risk assessment – the data and information provided by the SCR will be utilized for risk assessment and removal action development and evaluation. The risk assessments will use the data and information provided to define exposure units, pathways, media concentrations and receptors as part of the risk assessment process. The EE/CA will use all data and information provided by the risk assessments and the SCR to develop and evaluate removal actions for mitigation of Site risk posed by mining activities. A draft EE/CA report will be submitted to the USFS within 90 days after approval of the SCR.

1.2 Purpose of Report

The purpose of this SCR is to document the data and information collected during an Expanded Site Investigation (ESI) at the Site which was conducted by Tetra Tech (TT) in 2009. These data and information were used to characterize the Site and will be further analyzed in the risk assessments. These data, information and risk assessment will provide the basis for development of the EE/CA as set out in the ASAOC. The ESI data collection activities were performed under an approved Sampling and Analysis Plan (SAP) (Tetra Tech, 2009a), Quality Assurance Project Plan (QAPP) (Tetra Tech, 2009b) and Site Safety and Health Plan (SSHP) (Tetra Tech, 2009c). This SCR fulfills the requirements of the ASAOC to document the activities conducted and conclusions drawn during the ESI.

1.3 Site Definition

The Site is defined in the SOW to include the mine, haul roads, ore staging area, former barge loading area, and downstream potentially impacted areas including the Kendrick Creek delta. An access road between the 900-Foot Level and an adjacent exploration claim known as the I&L Zone was constructed using mine rock at some point during regional exploration; the lower portion of the I&L Zone access road is included in the Site definition.

1.4 Site Background

The Site is a former uranium mine located in the TNF near the southern end of POW approximately 38 miles southwest of Ketchikan, Alaska (Figure 1-1). The Site is located on the southeast flank of Bokan Mountain in the Kendrick Creek watershed, above the western terminus of the West Arm of Kendrick Bay. Major Site features are shown on Figure 1-2.

The Ross-Adams deposit was initially developed as an open-pit mine in 1957. The mine has three major surface expressions, named after their approximate elevations: the "900-Foot Level"; the "700-Foot Level; and the "300-Foot Level". After the surficial deposit was mined from an Open Pit at the 900-Foot Level, an approximately 500-foot long tunnel was driven at the 700-Foot Level toward the ore body, with a raise which connected it to the Open Pit and created the 900-Foot Level portal. An additional phase of underground mining occurred in 1971 which resulted in the 300-Foot Level features as described below. Ore produced from all levels was conveyed via haul roads to staging areas and then loaded on barges from ore loadout ramps and floating dock facilities on the north shore of the West Arm of Kendrick Bay. Information regarding the stockpiling and loading of ore on barges prior to the 1971 operations has not been made available and the specifics of these pre-1971 Site features are not known except that the remnants of the rock loadout ramps remain; however, data collected during the ESI can be used to infer the location of the pre-1971 ore loading dock.

The most recent mining operations at the Site occurred in 1971. This stage involved driving the 300-Foot Level adit roughly horizontally for a distance of approximately 1,300 feet toward the Ross-Adams mine, and accessing the ore body from there with vertical raises. Produced ore was hauled from the 300-Foot Level to an Ore Staging Area (OSA) on the north shore of the west Arm of Kendrick Bay. The staged ore was loaded onto barges from the loadout ramps. Although the ore loading docks are no longer present, the rock loadout ramps associated with them still remain. At the conclusion of these operations, efforts were made to remove mining-related industrial wastes and to smooth-grade and reclaim disturbed areas, as documented in an October 12, 1971 letter to the Alaska Department of Natural Resources (Appendix H).

Subsequent to the Site cleanup work in 1971, other parties have performed mineral exploration activities in and around the Ross-Adams deposit and at other locations on Bokan Mountain. Post-1971 exploration activities have resulted in disturbances to areas addressed in the 1971 Site clean-up. For example, much of the solid waste present at the 300-Foot Level and vehicles abandoned at the Site post-date 1971. A description of the miscellaneous solid waste at the Site is presented in Section 6.4.

The most recent (2007 through 2009) exploration efforts in the Bokan Mountain region have been performed by Landmark Alaska LP (Landmark), a partnership formed by Ucore Uranium, Inc. and Landmark Minerals, Inc. Based on literature and their own exploration results, Landmark has identified more than 30 uranium and rare earth element (REE) occurrences at Bokan Mountain that are related to the Bokan Intrusive Complex (Figure 1-3). Mining at the

Ross-Adams site focused on the relatively high grade uranium resources. As described in Warner and Barker (1989) and more recently by Ucore Uranium (Ucore 2009), REE mineralization has been characterized to be in an inverse relationship with uranium concentrations, with the best REE values found distal to the high grade uranium deposits. Ucore's 2009 exploration program is focused on the Dotson Trend, Shore-Geoduck (Geoduck), Cheri, and Sunday Lake areas (Figure 1-3).

1.5 Previous Investigations

Because of its geology and mineralization, the Bokan Mountain region has been studied and reported on by numerous authors including MacKevett (1963), Eakins (1970), Warner and Barker (1989), Thompson (1997) and Philpotts and others (1998). In addition, the USDA Forest Service has performed two environmental investigations at the Site which have provided data and information used in the development of the ESI:

- Removal Preliminary Assessment (BLM, 1998)
- Preliminary Assessment/Site Inspection (Kent & Sullivan Inc. [KSI], 2004)

Data collected during these investigations is discussed in Section 2. Historic environmental sampling locations are shown in Figure 1-4.

1.6 Report Organization

This SCR contains the elements required in Section III.E (Site Characterization Results) of the SOW, and is organized thusly:

- An Executive Summary is presented at the front of the report
- Section 2 provides a summary of previous investigations
- Section 3 and Appendices A through E describe the site characterization methods for field activities supporting the EE/CA , including figures illustrating sample locations and tabulated survey locations
- Section 4 presents a description of the physical characteristics of the Site and the natural processes interacting at the Site
- Section 5 describes the ecological characterization of the site, and presents human uses of the Site and regional resources
- Section 6 discusses the chemical and radiological characterization of the Site
- Section 7 presents the conclusions and recommendations resulting from the investigation
- Photographs, field documentation, and data quality evaluation information for each of the 2009 sampling events are presented in the appendices, along with other supporting documentation. The appendices are provided electronically on a compact disk, which is included inside the front of the report binder

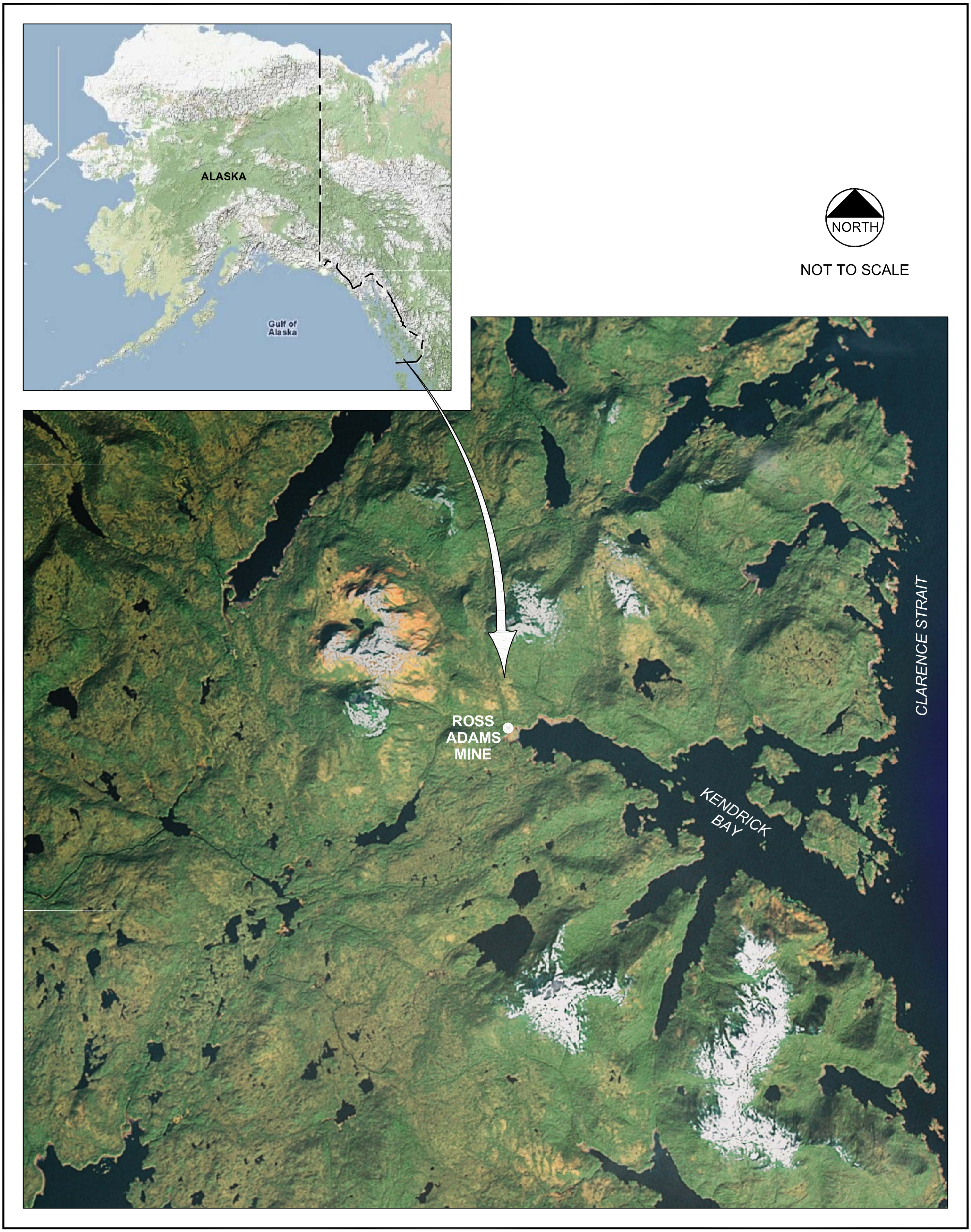

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Figure 1-1
Ross-Adams Site Location

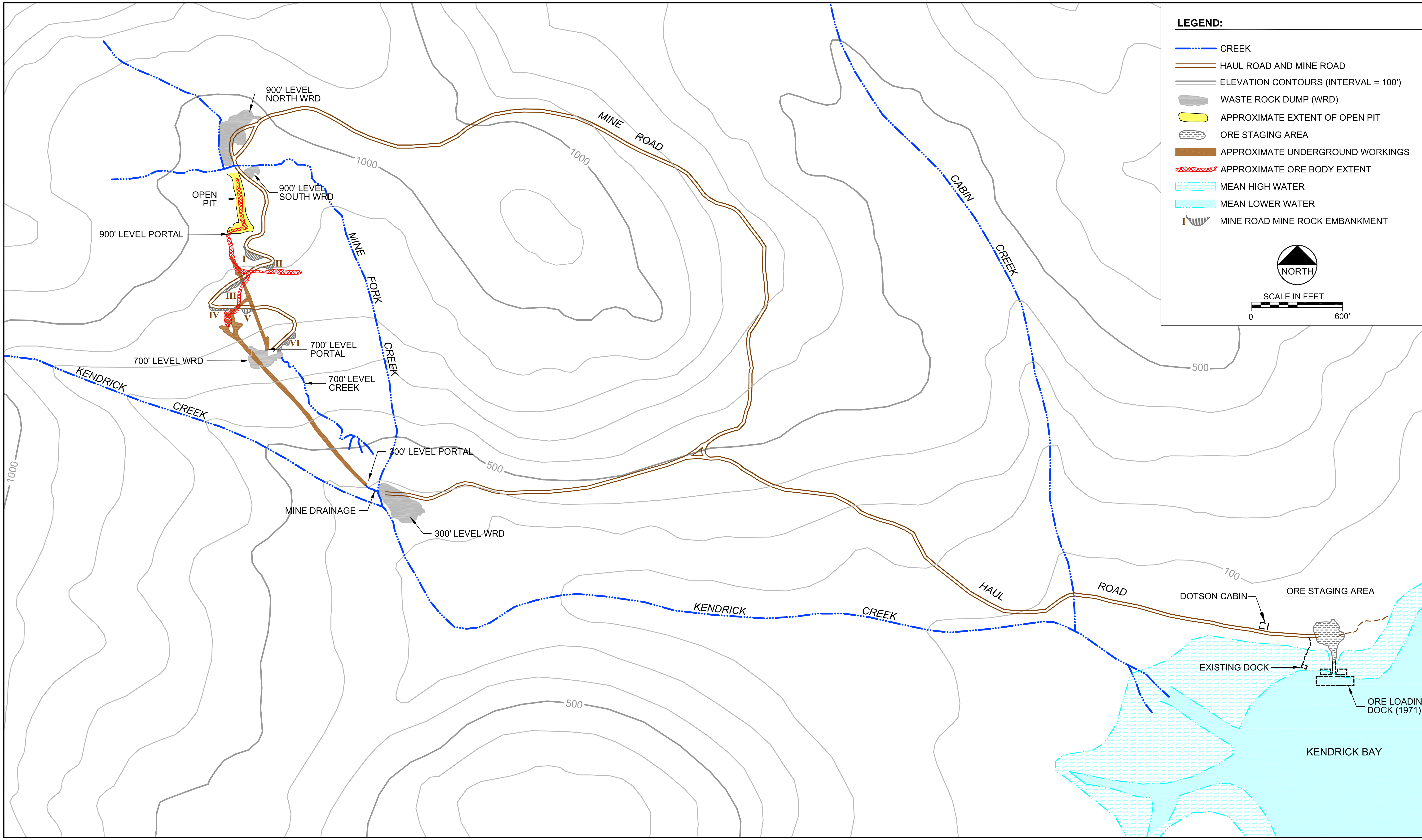

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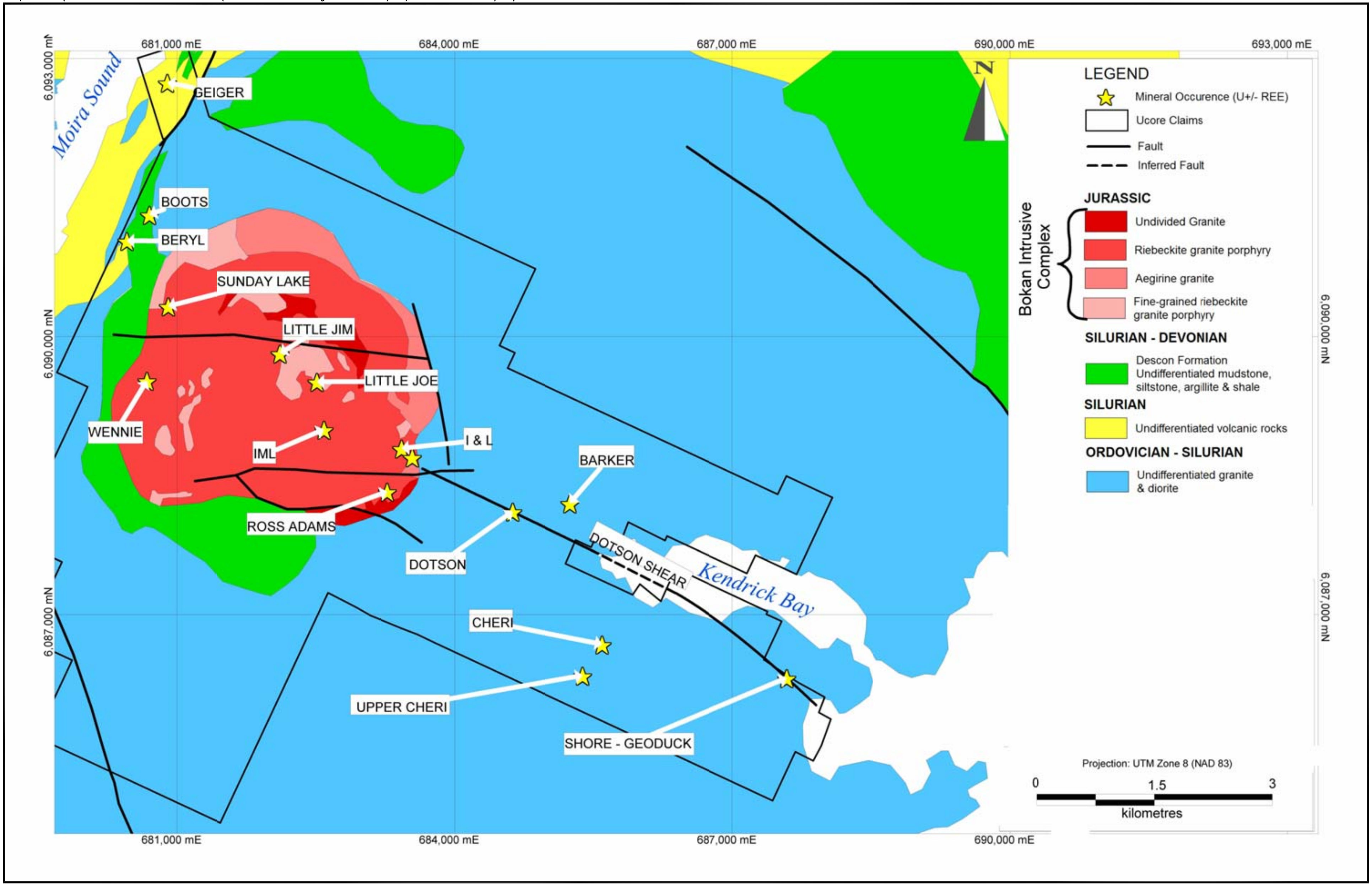
Figure 1-2
Ross-Adams Site
Major Site Features



Project No. 181862

Source: www.ucoreuranium.com

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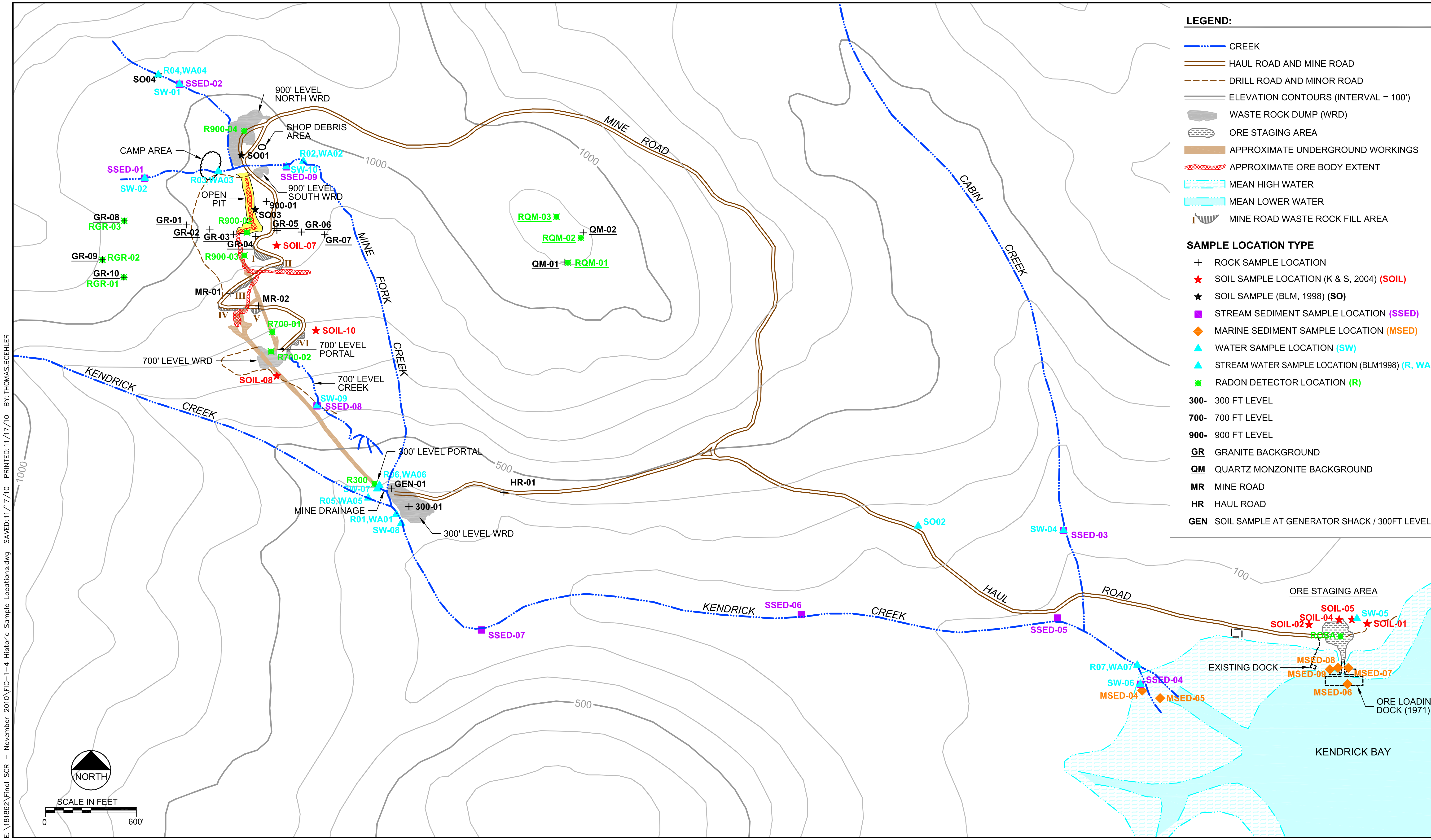
Figure 1-3
Ross-Adams Site
Regional Geology and Mineral Occurrences



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Base Map Reproduced from Kent & Sullivan, 2004, Including Data from BLM, 1998

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Figure 1-4
Ross-Adams Site
Historic Sample Locations

2.0 PREVIOUS INVESTIGATIONS

This section provides a summary of the previous mineral resource, geologic and environmental studies performed at and around the Ross-Adams site. Because of the unique geologic setting of the Bokan Intrusive Complex and the related mineral resources a number of private and publicly funded economic geological investigations have been performed. The Ross Adams site has also been the subject of several recent environmental investigations to evaluate the potential effects related to historic mining and exploration activities. Information and data from both the environmental and economic geological investigations have provided information useful for the development of the SAP and for the completion of the ESI.

2.1 Previous Mineral Resources and Geological Studies

The high natural radioactivity of the uranium and thorium mineralization at the surface of the Ross-Adams deposit led to its discovery by airborne radiometric survey of the area in 1955. The exposure of the high-grade Ross-Adams uranium deposit at the surface allowed for the initial mining to be performed via a shallow (less than 30 feet deep) open pit. Figure 2-1 provides a photograph of the Ross-Adams Open Pit during mining operations in 1957 and a photo of the Open Pit in 2009. In addition to the Ross-Adams uranium deposit, numerous other uranium-thorium and REE deposits in the Bokan Intrusive Complex have been identified since exploration began in the mid-1950s (Figure 1-3). Exploration of these deposits is ongoing (Section 2.3).

MacKevett (1963) provides a discussion of the discovery and early open pit mining history at the Ross-Adams deposit, and of the economic geology of the numerous other radioactive deposits that are included in what he termed the 71 square-mile “Bokan Mountain uranium-thorium area”. MacKevett (1963) describes the Ross-Adams ore body as a core of high grade ore enveloped by an uraniferous zone (less than 0.5 percent U_30_8) from 2 to 20 feet thick. Local pods of ore with as much as 3 percent U_30_8 and 5.66 percent thorium were present. In addition to the uranium-thorium minerals, some sulfides (pyrite and galena) were also present in the Open Pit. A semi-quantitative analysis of Ross-Adams ores indicated lead concentrations ranging from 0.01 to 0.3 percent (approximately 100 to 3,000 ppm) and arsenic concentrations of 0.01 percent (approximately 100 ppm). MacKevett (1963) also present information on several nearby deposits in the Kendrick Creek watershed (e.g., IML and I&L) and others along the south shore of the west arm of Kendrick Bay (e.g., Cheri) (Figure 1-3). These deposits, all of which within the watershed that drains to Kendrick Bay, possess high uranium and thorium concentrations, and some exhibit the same lead and arsenic concentrations as the Ross-Adams deposit.

Eakins (1970) performed a geobotanical study on and adjacent to the Site in 1970. Eakins collected over 400 samples in a grid-like pattern from a variety of plants and trees, berries, mulch and soil, and stream sediment to assess the utility of the various sample types for uranium exploration in Alaska. The following summarizes the Eakins (1970) study.

- Eakins classified only four samples as soils – the vast majority being mulch – so these data are of minimal use to the current study.
- Stream sediments possessed a maximum uranium concentration of 554 ppm immediately downstream of the 700-Foot Level portal in the 700-Foot Level Creek; uranium concentrations in stream sediments from Kendrick Creek ranged from 77 to 291 ppm, and generally decreased in the downstream direction. Uranium concentrations in

stream sediments collected from Mine Fork Creek upstream of the Open Pit were 7 ppm; two samples immediately downstream of the 900-Foot Level dumps possessed uranium of 8 and 33 ppm.

- Uranium was found in some large plant species ashed samples, with up to 2,400 ppm in lodgepole pine, 2,100 ppm in cedar, and 900 ppm in hemlock. The analyzed plant samples consisted of 6 to 10 inch cuttings of branch tips including leaves, needles and cones.
- Only two of the 19 blueberry samples possessed uranium above the detection limits. The sampling procedures are not discussed in Eakins (1970).
- Three crowberry samples contained concentrations of uranium ranging from less than 6 to 832 ppm.

Staatz (1978) provides the following information on samples collected from the I&L vein system (Figure 1-3):

- Uranium content ranges from 0.005 to 2.8 percent (28,000 ppm)
- Thorium content ranges from 0.0033 to more than 10 percent (100,000 ppm)
- Total rare earth content ranges from 0.023 to more than 10 percent (100,000 ppm)

Staatz (1978) also noted that the I&L Zone possessed "abnormal" amounts of beryllium, niobium, zirconium, barium, strontium, tin, lead, zinc, copper and molybdenum.

Prior investigators, while focusing on radioactive minerals, noted the presence of REEs at some of the deposits associated with the Bokan Intrusive Complex. Warner and Barker (1989) investigated numerous deposits near Bokan Mountain to assess the reserves of strategic minerals and metals, including columbium, REEs and uranium. The investigators found that mineralized dikes contain most of the REE resources; whereas, shear zones and fracture-related deposits, like those at the Ross-Adams mine, contain the majority of the uranium resources. Information provided by Warner and Barker (1989) on deposits in the Kendrick Creek watershed are summarized below:

Ross-Adams: Sixteen samples of low-grade ore were collected from the west open pit wall. Uranium concentrations ranged from 12 to 3,560 ppm; thorium concentrations ranged from 60 to 2,340 ppm; arsenic concentrations ranged from <90 to 400 ppm; lead concentrations ranged from <20 to 700 ppm. While the ore sampled in the Open Pit was low in REE, drill core samples also evaluated by Warner and Barker (1989) indicated that the ore zone at depth was "relatively" enriched with REEs.

I&L: Located north-northeast of the Ross-Adams Open Pit, the I&L Zone are a series of mineralized dikes. Rock samples collected from the various I&L Zone contained concentrations of uranium ranging from 4 to 55,300 ppm (5.5%), thorium from below detection limits to 139,000 ppm (13.9%), lead from below detection limits to 5,000 ppm (numerous values above 1,000 ppm), and arsenic from below detection limits to 700 ppm. Several sulfide minerals were noted in the dikes, including pyrite, galena and sphalerite.

Dotson Shear: Several mineralized areas are present along the Dotson Shear, a linear feature extending more than a mile from the I&L Zone to Kendrick Bay. The zone likely extends southeastward under the west Arm of Kendrick Bay and continues on the south side of the bay (Figure 1-3). The Dotson Shear zone is up to several hundred feet wide in places and, where mineralization is present, it occurs in several parallel dikes. Warner and Barker (1989) estimated over 2 million tons (4 billion pounds) of REE, yttrium, thorium, columbium and uranium resources, with an inferred resource of almost 8.5 million tons (17 billion pounds). Lead concentrations up to 6,000 ppm and arsenic concentrations up to 400 ppm were present in the samples analyzed by the report authors. The Dotson Shear is wholly located within the Kendrick Creek watershed and likely is present beneath Kendrick Bay.

Warner and Barker (1989) also evaluated the potential for placer metal enrichment in the west Arm of Kendrick Bay. The placer deposits represent *"deeper ancient channel ways"* originating during prior glacial periods. The source of the metals concentrated in the placer deposits would be the Ross-Adams, I&L Zone, Dotson Shear and other deposits present in the Kendrick Creek watershed. Warner and Barker (1989) noted the presence of a seaward bedrock obstruction in the west Arm of Kendrick Bay approximately 3,000 feet east of the mouth of Kendrick Creek. The bedrock outcrop, mapped as extending up to 40 feet above the seafloor, was noted to contain pyrite (Figure 2-2). Warner and Barker (1989) collected 8 samples of the gravelly material underlying the surficial fine-grained, organic-rich sediment layer; six of the samples were collected from the inland side of the bedrock obstruction. The placer gravel samples were "tabled" and the minus 16 mesh concentrate fraction (less than 1mm) analyzed. Warner and Barker (1989) concluded that *"low grade placer enrichment"* was present in the samples collected up to 1,000 feet offshore from the mouth of Kendrick Creek (sample numbers 16-1 through 16-4 on Figure 2-2). Concentrations in the four near-shore samples ranged from 22 to 75 ppm for uranium, 50 to 193 ppm for thorium, and 2 to 8 ppm for arsenic.

Thompson (1997) postulated that uranium-thorium-REE deposits on Bokan Mountain were associated with a caldera collapse and that the (minor) sulfide mineralization followed their emplacement. His analysis indicated that sulfides constituted less than 2 percent of the ore and included pyrrhotite, pyrite, chalcopyrite, galena, sphalerite, marcasite, acanthite, bornite and molybdenite. Philpotts, et al. (1998) performed a geochemical and petrographic analysis of ore and host rocks collected from Bokan Mountain to assess the origin and nature of the REE enrichment.

2.2 Previous Environmental Investigations

Two previous environmental investigations have been performed at the Site to provide initial data and characterization of potential environmental impacts from historic mining. These environmental investigations are summarized below and the environmental sampling locations from these investigations are shown in Figure 1-4.

The BLM performed a Removal Preliminary Assessment (PA) (BLM 1998) which was based on Site data collected by the BLM in 1995 and 1997. Data collected and evaluated by the BLM included:

- Water samples
- Gamma radiation survey

- Alpha track radon monitors (within the underground workings)
- Soil and rock samples

In the PA, the BLM concluded that:

- There were no water quality exceedances (metal or radionuclide) in Kendrick Creek downstream of the Site.
- A release of hazardous substances had occurred based on the gamma radiation levels measured at the Ore Stockpile Area (beach dump), and at the 300-Foot, 700-Foot and 900-Foot mine rock deposits.
- The approximately 300 gallons of petroleum products of various types scattered throughout the Site posed a potential for release.

A Preliminary Assessment/Site Inspection (PA/SI) (KSI 2004) performed for the USFS by Kent & Sullivan, Inc. (KSI) in 2004 and included the collection and analyses of samples from these potentially impacted media:

- Mine rock and soil (21 samples)
- Surface water (6 samples)
- Stream sediment (7 samples)
- Marine sediment (6 samples)

Samples from 28 locations classified as “background” by KSI, of each media were also collected. Additionally, radon detectors were placed at 17 locations throughout the Site, six of which were background locations. The PA/SI presented the following summary with respect to its sampling and analysis:

- Concentrations of arsenic, lead, uranium and the activity of numerous radionuclides in theU-235, U-238 and Th-232 decay chains exceeded background reference values (established in the PA/SI) in mine rock, soil, stream sediment and marine sediment matrices
- Concentrations of uranium and the activities of Ra-226 and Ra-228 exceeded background reference values (established in the PA/SI) in surface water samples

The PA/SI concluded that the Site data met the requirements for a removal action under 40 CFR 300.415.

The PA/SI presented a conceptual site model (CSM) based on the data and information developed (reproduced in Figure 2-3).

The information and data provided by all previous investigations of the Site and surrounding area have been used to provide overall Site understanding and in the development of the 2009 ESI field program (Section 3.2).

2.3 Current Exploration Efforts

Ucore and its partners have actively explored the Bokan Mountain area for the past three years (2007-2009). In the first two years, Ucore focused predominately on the I&L Zone, drilling 9 holes in 2007 and 37 holes in 2008. In 2009, Ucore expanded its exploration to include the Dotson Shear, with additional drilling on the Geoduck, Cheri and Sunday Lake areas (Figure 1-3). Ucore's planned 27 drill hole locations for 2009 are provided in their Mineral Exploration Plan of Operations (Landmark Alaska LP, 2009).

Ucore's 2007, 2008 and 2009 drilling appears to confirm the work performed by Warner and Barker (1989) that the Dotson Shear and associated deposits (e.g., I&L Zone) are enriched in rare earth elements and related metals, including yttrium, zirconium, beryllium, and niobium, in addition. On their website, Ucore states that the distribution of uranium and rare earth elements is suggestive of an inverse relationship between uranium and rare earth elements. Specifically, Ucore has determined that most of the uranium mineralization is located near the margin of the Bokan Intrusive Complex, while the majority of deposits enriched in REEs are found more distant to the intrusive complex. Updated information on their Bokan Mountain project can be found on Ucore's website at www.ucoreuranium.com/bokan.asp.

2.4 Summary

The Bokan Mountain area hosts a variety of potential economic mineral resources from uranium-thorium deposits to REE deposits. These deposits are strongly radioactive, posses elevated concentrations of radionuclides and other metals and, in many cases, are present at or near the surface. The result of this mineralization is a landscape of highly variable radioactive emissions and associated soils with variable radionuclide and metals content. Creeks, stream sediments and marine sediments receiving drainage from these naturally mineralized areas may possess levels of radionuclides and metals above similar media in unmineralized watersheds.

A: During active surface mining operations in 1957
Source: MacKevett (1963)

B: July 2009
Source: Tetra Tech

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Figure 2-1
Ross-Adams Site
Ross Adams Open Pit

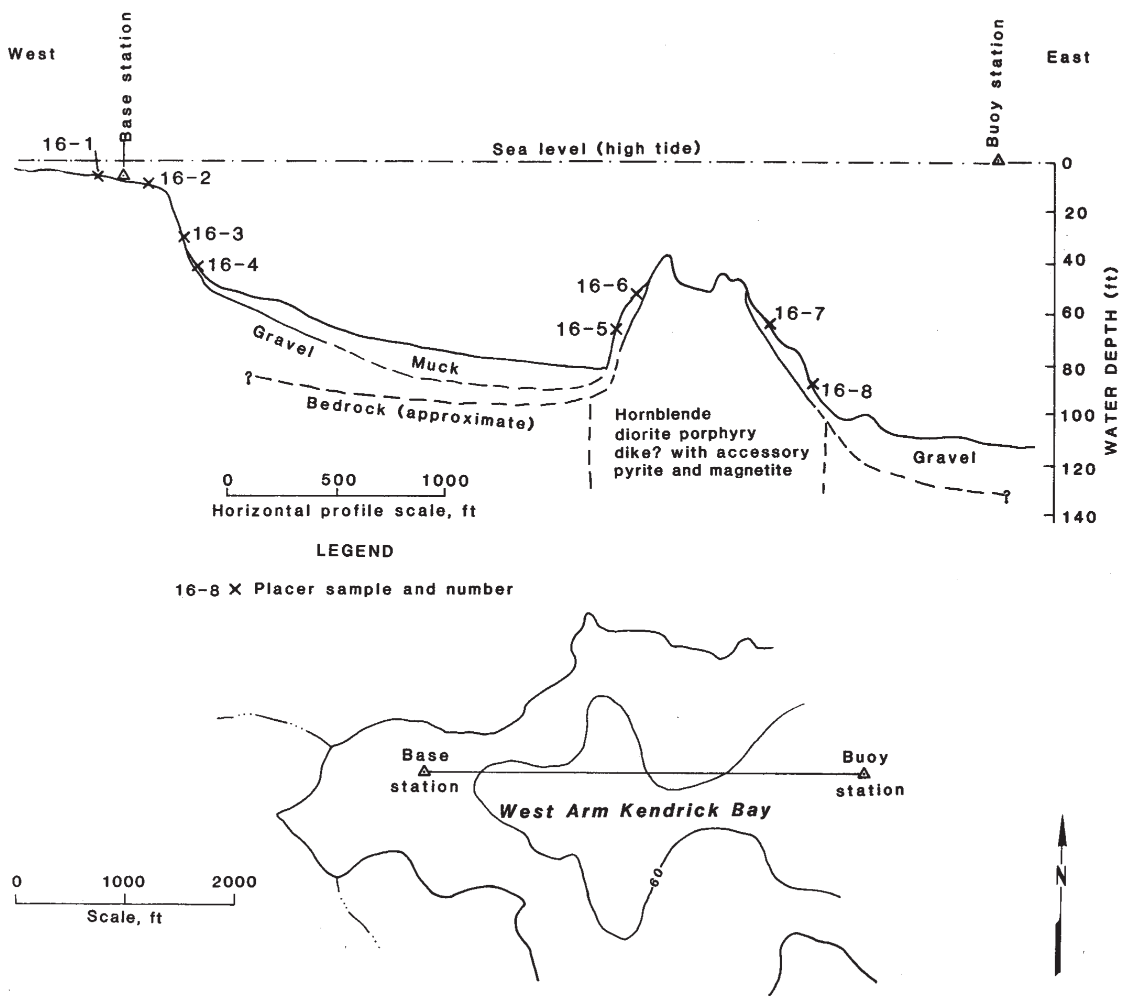

Figure 30 - Profile of Kendrick Bay.

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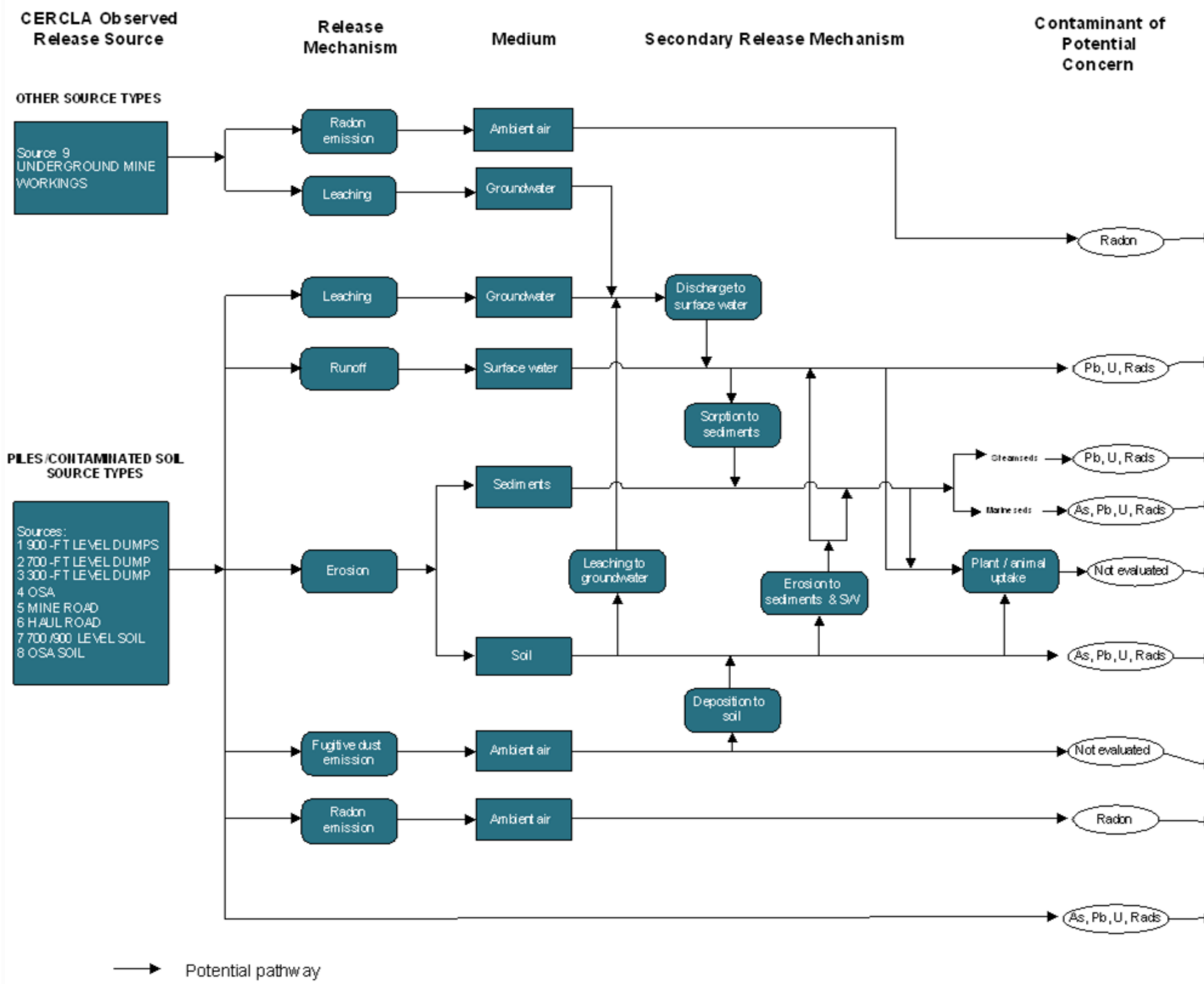
*Modified from Warner and Barker (1989)

Figure 2-2

Ross-Adams Site

Profile of West Arm of Kendrick Bay



Contaminant of Potential Concern	Exposure Route	Commercial/Private Fisher	Off Site Worker	Off Site Resident	On Site Worker	On Site Resident	Subsistence Hunter/Gather	Area Visitor	Terrestrial	FW Aquatic	Marine Aquatic
		Human							Biota		
Radon	Inhalation	●	○	○	○	○	●	●	●		
Pb, U, Rads	Ingestion				○	○	●	●	●	●	
	Direct contact				○	○	●	●	●	●	
	Food-chain exposure	●			○	○	●		●	●	
Pb, U, Rads / As, Pb, U, Rads	Direct contact	●								●	●
	Ingestion	●								●	●
	External irradiation	●			○	○	●	●	●	●	●
	Food-chain exposure	●			○	○	●		●	●	●
Not evaluated	Ingestion	●			○	○	●	●	●	●	●
As, Pb, U, Rads	Direct contact				○	○	●	●	●		
	Ingestion				○	○	●	●	●		
	External irradiation				○	○	●	●	●		
	Food-chain exposure				○	○	●		●		
Not evaluated	Inhalation	●			○	○	●	●	●		
Radon	Inhalation	●	○	○	○	○	●	●	●		
As, Pb, U, Rads	Direct contact				○	○	●	●	●		
	Ingestion				○	○	●	●	●		
	External irradiation				○	○	●	●	●		
	Food-chain exposure				○	○	●		●		

●	Potential current exposure pathway and receptor
○	Potential future exposure pathway and receptor
	Pathway is not applicable or the potential risk associated with the pathway appears low

Figure 2-3
Ross-Adams Site
2004 Kent & Sullivan Conceptual Site Model

3.0 SITE CHARACTERIZATION SCOPE OF ACTIVITIES

The SOW portion of the ASAOC specified the 2009 field data collection activities. The project-specific plans and methods for data collection and analysis were described in the approved Site Sampling and Analysis Plan (SAP) (Tetra Tech, 2009a) and the Quality Assurance Project Plan (QAPP) (Tetra Tech, 2009b). Field sampling activities were performed in accordance with the Site Safety and Health Plan (Tetra Tech, 2009c). This section provides a summary of the 2009 field data collection and analysis activities. A detailed discussion of the field sampling events is provided in Appendix A.

3.1 Data Objectives

Tetra Tech developed the SAP to provide additional data for Site characterization in support of the risk assessment and EE/CA. The objectives of the sampling program were to characterize the physical and the chemical and radiological conditions of mine features and Site media, including local background. The planning process employed to develop these objectives and the criteria used to measure the precision, accuracy, representativeness, comparability and completeness of the data acquired during the ESI are described in the QAPP (Tetra Tech, 2009b). The evaluation of data quality for each sampling event is described in Appendices B-3, C-3, and D-3.

In addition to chemical and radiological data for characterization, the SAP included collection of data and information to conduct an engineering assessment and a qualitative biologic assessment. Further, as part of the Site characterization, but not included in the SAP, was an assessment of Site land use discussed in Section 5.

3.2 Sampling and Analysis Plan

The SAP and associated QAPP provided the sampling and analysis protocols in terms of sample types and locations, analytical methods, and the quality evaluation methods for the samples collected during the ESI. The SAP provided plans for gamma survey measurements and the collection of samples from the following media as well as mine materials at the mine features:

- Surface water
- Stream sediment
- Marine sediment
- Soil
- Groundwater
- Air

The SAP describes the sampling procedures and sample handling protocols, the field data to be collected, and the parameters to be analyzed and the laboratory analytical methods to be used. Tables 3-1 and 3-2 provide the water quality parameters and soil/sediment parameters respectively along with the analytical methods used for laboratory analysis of these parameters. In addition to the field parameters specified in Table 3-1, stream flow measurements were collected at water quality sample locations according to the SAP. Soil is defined for purposes of the ESI as fine-grained materials (grain size limits are described in the SAP) present in native areas as well as at the mine features. The SAP also identified proposed sampling locations which guided sampling but which, in some cases, were modified in the field based on conditions encountered at the time of sampling, including accessibility, safety, and sample availability. The field location of media sampling locations was documented at the time of sampling using GPS instrumentation. The GPS coordinates for sampling locations were recorded as part of the sample database. Media and mine material sampling locations and the parameters analyzed were selected to provide the information necessary to establish local background conditions, the nature and extent of mine materials within and outside the boundaries of mine features, and the data necessary to perform risk assessment and develop appropriate removal actions.

In addition to the chemical and radiologic sampling and analysis of media, gamma survey data were collected using methods developed by Tetra Tech and described in Appendix E-1. The gamma survey yielded Site-wide gamma exposure data that provided a real-time picture of the nature (relative concentration) and extent (the presence or absences) of the radionuclides associated with the Ross-Adams Mine uranium ore body. In addition, the SAP included an investigation to determine if a correlation exists between gamma exposure rate and x-ray diffraction (XRF) with radionuclide and/or metals concentration in soils or mine materials. Correlation with gamma survey and/or XRF were identified as potentially valuable tools for the ESI and EE/CA.

The biologic assessment was conducted using a qualitative pedestrian survey and literature review of the terrestrial, freshwater aquatic, and marine aquatic species (biota inventory) and habitat and wildlife functional groups evaluations. The biologic assessment emphasized those plants or animals that are important components at the Site with respect to subsistence use and for risk assessment. The biologic survey was conducted during the second (July) sampling event.

The engineering assessment incorporated physical measurements and observations of natural and mining-related Site features to document and assess the engineering aspects of the Site that will be included in the EE/CA. These included:

- Quantities of potentially mine-influenced material
- Potential sources of on-Site borrow material for use in removal action work
- Surveying to provide more detailed topographic data in select areas
- Areas suitable for construction of a material storage repository

3.3 Sampling Execution

Three sampling events were conducted during June, July, and September of 2009 to collect data and information for the ESI. Data collection and sampling was performed by Tetra Tech field crews for each sampling event. During the second and third sampling events, an environmental specialist from Prince Of Wales Tribal Enterprise Consortium (POWTEC) assisted in data collection activities. R&M Engineering-Ketchikan, Inc. (R&M Engineering) of Ketchikan, AK performed professional land surveying work at the Site during the July sampling event. Laboratory analysis was performed on field samples by ALS Laboratory Group (ALS) of Fort Collins, Colorado. Validation of the analytical data was performed by Tetra Tech on the basis of ALS data reports. The validation of data from each sampling event is reported in Appendices B-3, C-3 and D-3. At the time of the original analysis, the laboratory analyzed all soil, stream sediment, and marine sediment samples by EPA Method 6010 (ICP). To provide a more complete dataset for statistical analysis, the laboratory was requested to report the additional Method 6010 metal parameters from the original analysis where the Method 6010 method detection limits were appropriate for characterization and statistical evaluation. The Method 6010 method detection limits were too high for antimony, mercury, silver, and thallium to provide useful data. The validation reports of these additional data are included in Appendix C-3, and the additional parameter concentrations are included in data tables.

In addition to professional land surveys performed by R&M Engineering, Tetra Tech field crews collected geo-referenced spatial data (latitude and longitude) for all the sample locations. Limited elevation data was also collected. A handheld Garmin GPS system and Trimble GeoXH differential GPS unit with a high-accuracy Hurricane Antenna were utilized for each of the sampling events. Data from the Trimble unit were collected in real time for at least 30 seconds at each sample location and then post-processed using the National Geodetic Survey Continuously Operating Reference Station (NGS-CORS) on Annette Island. The GPS systems had varying accuracies based on interference at each sample location caused by dense vegetation and/or steep vegetation, which limited sky viewing in some areas. Summaries of sample and data collection for each media are provided in the following sections, and a detailed description of the sampling events is provided in Appendices B, C and D.

3.3.1 Surface Water

Surface water samples were collected within the various drainages at identified locations upstream and downstream of mine rock piles during each of the three sampling events. Sample locations are described in Table 3-3 and shown on Figure 3-1. These drainages included: Kendrick Creek, Mine Fork Creek, 700-Level Creek, Cabin Creek, and ephemeral drainages. As described in Section 6.2.4, four of the 18 sampling locations represent local background. In addition to surface water in streams, the 300-Foot Level portal and a seep (SPR/SW/01/A) located at the OSA were also sampled during all three events and are included on Table 3-3 and Figure 3-1.

3.3.2 Air Radon

Radtrack® track-etch radon detectors were installed at 34 locations during the first sampling event and retrieved during the third event to provide long-term measurement of air radon concentration at the Site. Short-term track-etch radon detectors were also deployed at four of these locations during the second sampling event. The radon detector locations are described in Table 3-4 and illustrated in Figure 3-2.

3.3.3 Gamma Surveys

Gamma surveys were performed during all three events to collect gamma exposure rate measurements using the survey protocol described in Appendix E-1. Gamma surveys included the following areas: 900-Foot, 700-Foot, and 300-Foot levels and adjacent areas; Ore Staging Area and the Loading Docks; Mine and Haul Roads, including the I&L Zone access road; Kendrick Creek Channel from its mouth to the 300-Foot Level mine rock pile; and the Kendrick Bay delta area.

The gamma survey employed in-field gamma exposure rate measurements to guide the direction of data gathering. Gamma exposure rate surveys were performed using an unshielded Ludlum Model 44-10 sodium iodide (NaI) scintillation detector coupled to a Ludlum Model 2350 data logger, and a GPS unit linked to the detector data recorder. Gamma exposure rates were measured at a height of three feet above the ground surface. Up to two detector sets were carried by survey field teams in backpack mounts, allowing gamma exposure rate measurements to be collected as the survey team moved over the Site. Limited gamma surveying of the Site roads was performed from ATVs with detectors mounted at the same height as the backpack systems. By following the gamma measurements in real time, field teams could collect data across areas of higher to lower exposure rate measurement thus delineating known or indicated mine materials based on gamma signatures. Delineation of mine material using gamma surveys was only limited by access and topography. The gamma surveys produced over 182,000 points of data, which included both gamma exposure and GPS location. Survey data were stored in data loggers for subsequent download to a database and mapping program. Gamma surveying also included investigation with paired shielded and unshielded gamma detectors to provide data regarding "shine" for gamma-emitting sources, as discussed in Section 6.1.3.

3.3.4 Soil

Soil sampling was performed, in conjunction with gamma surveys, to provide data for the characterization and delineation of mine features, and to document background conditions in mineralized and non-mineralized areas away from the boundaries of the mine features. Discrete soil samples were taken based on gamma exposure measurements to provide soil concentration data associated with both mine features and adjacent non-affected (background) areas. Preliminary maps of the gamma exposure data were developed in the field during the July sampling event and this mapping, combined with visual observations, was used to delineate the boundaries of the mine features and to establish the locations for discrete soil sampling. Sample locations were within the boundaries of the mine features and at the transition zones or margins surrounding the mine rock pile areas and ore storage area (OSA) to characterize the extent of the area influenced by the mine features. Gamma survey and data from previous investigations augment the data provided by discrete soil sampling for characterization of conditions within the mine features. Background soil samples were also selected at locations adjacent to the mine features in areas with lower measured gamma exposure rates. The resolution of the preliminary gamma mapping resulted in more soil samples being collected within the mine-affected areas (i.e. the mineralized area than in non-mineralized background areas). The soil metals and radionuclide concentration data provided by these discrete soil samples confirm the effectiveness of gamma to delineate boundaries and provide sufficient soil background data to address the study objectives. Soil sampling locations are described in Table 3-5 and shown on Figure 3-3, with the results of the soil sampling discussed in Sections 6.2.2 and 6.3.1.

3.3.5 Gamma Correlation

A gamma correlation investigation was performed to provide data necessary to determine if gamma exposure rate measurements could be correlated with soil metal and/or radionuclide concentrations. Fifteen gamma correlation field plots were established during the first sampling event at which gamma exposure measurements and composite soil sampling was conducted. Based on the data provided by these first correlation plots, two additional gamma correlation plots were established and sampled. The location of the correlation plots are shown on Figure 3-3 and described in Table 3-5. The gamma correlation test procedures are described in Appendix E-1 and the results of the correlation investigation are discussed in Section 6.1.4. XRF correlation testing was also performed at the gamma correlation plots.

3.3.6 Stream Sediments

Stream sediment samples were collected at or near ten of the surface water sample locations, and at two locations (KBD-SS-01-A and -B) in the Kendrick Creek delta, during the second sampling event (Figure 3-1). Sediment samples were collected from the following drainages:

Kendrick Creek, Mine Fork Creek and ephemeral tributaries, and Cabin Creek. Stream sediment samples were to be collected at the same locations that surface water samples were collected. However, sediment sample protocol dictated that if sufficient sample within the grain size limits was not present, sample collection would be completed at the nearest location where an appropriate sample was available. The sediment sample collection protocol is described in the SAP. In all cases, the sediment sample collection location was documented by GPS. Two sediment samples, KBD-MS-01-R and -S, were collected in the lower Kendrick Creek channel as it meandered across the intertidal zone during low tide; these samples likely represent re-worked intertidal sediments more than fresh water sediments and are therefore indentified as intertidal sediments. Stream sediment locations are described in Table 3-6 and illustrated on Figure 3-1.

3.3.7 Marine Sediments

Marine sediments were collected from both the intertidal and subtidal zones of the West Arm of Kendrick Bay during the second sampling event. Marine sediment sampling was performed during the new moon phase in July 2009, when the “spring” tides resulted in extreme low and high tides. Intertidal zone samples were collected between the low and high water lines experienced at that time, and subtidal samples were collected below the low water line. Twenty-two intertidal and eight subtidal marine sediment samples were collected during July. The marine sediment sample locations are described in Table 3-7 and shown on Figure 3-4.

3.3.8 Groundwater

Groundwater at the Site is generally confined to stream channel alluvium by the geologic conditions of near-surface, low permeability bedrock. The stream channels are shallow and cobbly due to the deeply incised bedrock stream channels. The PA/SI (KSI, 2004) concluded that groundwater was not an element of Site interest, and that groundwater in the stream channel alluvium is intimately connected to surface water. The ESI included alluvial groundwater sampling to attempt to confirm this model and, if possible, obtain samples for quality analysis. The SAP called for placement of drive-point piezometers in the alluvium at the mouth of Kendrick Creek. Attempts to install these drive-point piezometers were made during the July sampling event. However, boulders and cobbles present in the shallow subsurface at the sampling locations prevented the field crew from advancing the drive points deep enough to intercept alluvial groundwater. As a result, no alluvial groundwater quality data was obtained. One shallow seep was located at the OSA and was sampled during each of the three events. This seep sample location, SPR/SW/01/A, is included in Table 3-3 and in Figure 3-1.

3.3.9 Air Measurements

Air monitoring stations were installed, as described in Appendix A, at each of the portals during the third sampling event. These stations collected continuous temperature, wind, and barometric pressure at locations inside the portal and at the face of the portal, and recorded ambient temperature at a distance outside of the portal influence to provide data that may potentially be used in the EE/CA to predict/model portal air flow. The data collected at the monitoring stations is provided in Appendix G-3.

3.3.10 Biologic and Engineering Assessment

The qualitative pedestrian biologic survey, civil land surveying and engineering assessment were performed during the second sampling event. The biologic assessment results are provided in Appendix F. The engineering assessment results are discussed in Section 4.

3.3.11 Miscellaneous and Solid Wastes and Petroleum Products

Previous investigations reported miscellaneous solid waste and petroleum products present at the Site. An inventory was conducted during the second and third sampling events to identify the types, locations and quantities of miscellaneous solid wastes and petroleum products, including abandoned vehicles, collapsed buildings and other materials. Soil samples were collected at four of the waste locations and analyzed for gasoline range organics (GROs) and diesel range organics (DROs), with one sample from the vicinity of the former generator shack analyzed for polychlorinated biphenyls (PCBs). The soil sample from the generator shack was analyzed for PCBs due to the potential for electrical transformers containing PCBs to have previously been located at this shack. Section 6.4 provides details of the inventory and sampling results.

3.3.12 XRF Correlation

In conjunction with the gamma data collection at the correlation plots, the correlation of XRF readings with soil metal concentration was also investigated. The XRF correlation is further discussed in Section 6.3.1.5.

3.3.13 Sampling Event Descriptions

A general description of the three sampling events is provided in Appendix A. In addition, Appendix A includes summaries of sampling data and a summary of the deviations from the planned sampling activities. Appendices B, C and D provide photographic logs, field documentation, and assessments of the laboratory data quality and copies of the laboratory analytical results for each sampling event. The gamma survey methodology is presented in Appendix E. The biological survey methods and results are provided in Appendix F. Graphical summaries of water quality, stream sediment and air monitoring data are included in Appendix G.

3.4 Data Usability Assessment

The laboratory data generated from each sampling event was assessed for precision, accuracy, representativeness, comparability and completeness to validate the data and to assess its usability. Qualifiers, if added, were based on USEPA CLP (2004) and MARLAP (2004) guidance. Based on this validation and usability assessment, the data generated in the ESI are judged to have met the QAPP performance criteria and are useable for the SCR and the EE/CA and associated risk assessment activities. The validation and assessment process for each sampling event is discussed in detail in Appendices B-3, C-3 and D-3 and summarized in the following subsections.

The usability of the gamma survey data conducted at the Site was determined on the basis of implementation of gamma survey quality assurance/quality control (QA/QC) protocols, developed by Tetra Tech specifically for gamma surveying, as detailed in Appendix E. The results obtained from the QA/QC protocols conducted for the gamma surveys are presented in Appendix E and confirm the usability of the ESI gamma exposure data.

Environmental data reported in the PA/SI (KSI, 2004) were also collected according to a workplan and supporting plans that describe the sampling rationale, sampling procedures, and analytical program. Sample collection and analysis were conducted according to defined QA/QC procedures and the resulting data were reviewed and validated by KSI (2004) according to prescribed guidelines. Data qualifications were described and identified in the data validation report provided in the PA/SI (KSI, 2004). Based on review of the information provided by KSI

(2004), the KSI data were determined to be useable for characterization purposes, as described in the SCR, and for the EE/CA and associated risk assessment activities. The description, applicability and specific use of the KSI environmental data are discussed in subsequent sections of the SCR.

3.4.1 Sampling Data Validation and Usability Assessment Process

Metals, radiochemical, inorganic and organic analyses conducted by ALS Laboratory Group (ALS) in Fort Collins, CO were reviewed and validated according to the project QAPP (Tetra Tech 2009). Individual data validation reports and ADEC laboratory review checklists were generated for each sample delivery group laboratory report, as well as the additional analyte concentration data for soils, stream sediments and marine sediments reported in August 2010 from the original Method 6010 (ICP) analysis of the July 2009 samples. These validation reports are included in Appendices B-3, C-3, and D-3.

Laboratory data generated from each sampling event were assessed for sample receipt, including preservation, chain-of-custody and holding times, as outlined in the QAPP and based on USEPA CLP (2004) and MARLAP (2004) guidance. Laboratory QC was assessed for measures of accuracy, precision, representativeness, comparability and completeness. Accuracy was measured based on method blanks and recovery of laboratory control samples (LCS), LCS duplicates (LCSD), matrix spike (MS) and MS duplicate (MSD) samples. Laboratory precision was measured on LCS/LCSD, MS/MSD, or analytical duplicate relative percent differences (RPDs) for the metals and inorganic analyses, and either the LCS/LCSD or MS/MSD duplicate error ratio (DERs) for the radiochemical analyses. In addition to accuracy and precision measures, water data for which both total and dissolved metals analyses were performed were compared and evaluated according to the QAPP. Field QC samples, field duplicates and field (equipment) blanks, were also evaluated according to the QAPP, with details listed in Appendices B-3, C-3 and D-3. The field QC samples that were collected are summarized in Table 3-8.

Evaluation of completeness for the data generated during the three sampling events is a qualitative assessment based on the number of samples planned compared to the number of samples taken to provide sufficient data to satisfy the data objectives defined in the SAP. As acknowledged in the QAPP, the ability to obtain a planned sample could be affected by field conditions (sample availability and safe access). Because not all of the planned samples could be collected, additional opportunistic samples were collected to augment the sampling that was not possible. Deviations from the planned sampling are documented in Appendix Tables A-8, A-9 and A-10.

Qualifiers, if added, were based on USEPA CLP (2004) and MARLAP (2004) guidance, and are summarized for all three sampling events in Appendices B-3, C-3, and D-3. No data were rejected as a result of the validations. The results of the validations for the metals, radiochemistry, inorganic and organic analyses are summarized below by sampling event.

3.4.2 June Sampling Event

Fifteen water samples (including one groundwater sample) and sixteen soil samples were analyzed from the June 2009 sampling event. The sample receipt was reviewed, including preservation and holding times and chain of custodies. Details are presented in Appendix B-3. No samples were qualified as a result of preservation or holding time exceedances.

Laboratory accuracy measured by method blanks, LCS and MS/MSD recoveries were reviewed for all analyses according to the QAPP. The method blanks were all below the method detection limits (MDLs) and radiochemical minimum detection concentrations (MDCs) with the exceptions of some water metals, and soil radiochemical, metals and mercury blanks, which are detailed in Appendix B-3 along with the applied qualifiers. The percent recoveries were all within project control limits for the LCS, MS and MSD results. The laboratory duplicate precision data were reviewed for the metals and radiochemical analysis. There were a few water metal RPDs and one soil inorganic parameter RPD that exceeded limits (Appendix B-3). The radiochemistry DERs were all within limits.

The comparison of water dissolved vs. total metals showed 17 percent of the total/dissolved sample pairs where the dissolved value was greater than the total value. Of those samples, 23 percent exceeded the limits defined in the QAPP. However, 7 of the 12 sample pairs that exceeded the limits, were below the reporting limit (B qualified), thus not considered either accurate or precise at that concentration.

The field duplicate sample comparison was within limits for the soil samples, and exceeded project limits for one water metal. Qualifications are summarized in Appendix B-3. There were no equipment rinsate blanks collected for this sampling event.

Based on the data evaluation, all results from the June sampling event were deemed usable as reported, with no data rejected. Results qualified as a result of the validation are detailed in Appendix B-3.

3.4.3 July Sampling Event

Thirty-seven surface water samples (including one groundwater sample), sixty-seven soil samples, twelve stream sediment samples, and thirty marine sediment samples were analyzed from the July 2009 sampling event. The sample receipt was reviewed, including preservation and holding times and chain of custodies. Details are presented in Appendix C-3. No samples were qualified as a result of preservation; however, the soil organics analyses were qualified for holding time exceedances.

Laboratory accuracy measured by method blanks, LCS and MS/MSD recoveries were reviewed for all analyses according to the QAPP. The method blanks were all below the method detection limits (MDLs) and radiochemical minimum detection concentrations (MDCs) with the exceptions of some water metals, soil radiochemical, DRO, metals and mercury blanks, which are detailed in Appendix C-3, along with the qualifiers applied. The LCS, MS and MSD percent recoveries that exceeded limits for select samples included water Ra-228 LCS, water mercury MS, soil GRO MS, soil zinc MS, and soil Gamma Spectroscopy LCS. The LCS, LCSD, MS and MSD were all within project control limits for all remaining results. The laboratory duplicate precision data were reviewed for the metals and radiochemical analysis. RPDs and DERs were within limits for all water metal, inorganic and radiochemical duplicates. RPDs exceeded limits for select soil metals and DERs for two soil radiochemistry parameters. These are summarized in Appendix C-3.

The comparison of water dissolved vs. total metals showed 13 percent of the total/dissolved sample pairs where the dissolved value was greater than the total value. Of those samples, 71 percent exceeded the limits defined in the QAPP. However, 16 of those 17 sample pairs that exceeded the limits, were below the reporting limit (B qualified), thus not considered either accurate or precise at that concentration.

The field duplicate sample comparison was within limits for all sample media. The field blanks and equipment rinsate blank that were collected are discussed in Appendix C-3. There were no qualifications based on field and equipment rinsate blanks.

Based on the data evaluation, all results from the July sampling event were deemed usable as reported with no data rejected. Results qualified as a result of the validation are detailed in Appendix C-3.

3.4.4 September Sampling Event

Thirty-six water samples (including one groundwater sample) were analyzed from the September 2009 sampling event. The sample receipt was reviewed, including preservation and holding times and chain of custodies. Details are presented in Appendix D-3. No samples were qualified as a result of preservation or holding time exceedances.

Laboratory accuracy measured by method blanks, LCS and MS/MSD recoveries were reviewed for all analyses according to the QAPP. The method blanks with detections above the method detection limits (MDLs) and radiochemical minimum detection concentrations (MDCs) are listed in Appendix D-3, along with the qualifiers applied. The percent recoveries were all within project control limits for the LCS, MS and MSD results, with the exception of Ra-228 for one report. The laboratory duplicate precision data was reviewed for the metals and radiochemical analysis. RPDs and DERs were within limits for all water metal, inorganic and radiochemical duplicates.

The comparison of water dissolved vs. total metals showed 26 percent of the total/dissolved sample pairs where the dissolved value was greater than the total value. Of those samples, 48 percent exceeded the limits defined in the QAPP. However, 27 of the 31 sample pairs that exceeded the limits, were below the reporting limit (B qualified), thus not considered either accurate or precise at that concentration.

The field duplicate sample comparison for the water samples was within limits. There were no equipment rinsate blanks collected for this sampling event.

Based on the data evaluation, all results from the September sampling event were deemed usable as reported with no data rejected. Results qualified as a result of the validation are detailed in Appendix D-3.

Table 3-1. Water Sample Analysis Parameters and Methods

Analyte Group	Constituent	Method Number	Method Detection Limit[4] (mg/L)
Field Parameters	pH	150.1	0.1 (s.u.)
	Specific Conductance	120.1	1 (uohms/cm)
	Temperature	170.1	0.1 (°C)
Metals[1]	Aluminum	200.7 ICP	0.03
	Antimony	200.8 ICP-MS	0.0004
	Arsenic	200.7 ICP	0.04
	Barium	200.8 ICP-MS	0.0001
	Beryllium	200.8 ICP-MS	0.0001
	Cadmium	200.8 ICP-MS	0.0001
	Chromium	200.8 ICP-MS	0.0001
	Cobalt	200.8 ICP-MS	0.0001
	Copper	200.8 ICP-MS	0.0005
	Iron	200.7 ICP	0.02
	Lead	200.8 ICP-MS	0.0001
	Manganese	200.7 ICP	0.005
	Mercury	M1631	0.0002 (µg/L)
	Molybdenum	200.7 ICP	0.01
	Nickel	200.8 ICP-MS	0.0006
	Selenium	200.8 ICP-MS	0.0001
	Silver	200.8 ICP-MS	0.0001
	Thallium	200.8 ICP-MS	0.0001
	Uranium	200.8 ICP-MS	0.0001
	Vanadium	200.7 ICP	0.005
	Zinc	200.7 ICP	0.01
Radionuclides[2]	U-234, -235, -238	ASTM D3972[5]	0.2 ρCi/L
	Ra-226	903.1	0.4 ρCi/L
	Ra-228	904.0	1 ρCi/L
	Pb-210	PAI 7045	1 ρCi/L
	Po-210	ASTM D3972[5]	0.5 ρCi/L
	Th-228, -230, -232	ASTM D3972[5]	0.2 ρCi/L
Major Cations[2]	Calcium	200.7 ICP	0.2
	Potassium	200.7 ICP	0.3
	Magnesium	200.7 ICP	0.2
	Sodium	200.7 ICP	0.3
Major Anions[2]	Alkalinity	SM 2320B	2
	Chloride	300.0 Ion Chrom[5]	0.5
	Sulfate	375.3 Gravimetric[5]	10
Miscellaneous[3]	Organic Carbon*	415.1[5]	1
	Total Dissolved Solids	160 Gravimetric	10
	Total Suspended Solids*	160.2 Gravimetric	5

NOTES:
1. Dissolved and total recoverable forms for surface water samples; dissolved form only for groundwater/seep samples
2. Dissolved form only
3. Parameters noted by asterisk "*" for surface water samples only
4. The actual sample detection limits may vary depending on the effects of dilutions or matrices.
5. Analytical method differs from that proposed in SAP; however, the analytical methods utilized and listed in the table are comparable to the analytical methods proposed in the SAP and are considered an industry-accepted alternative.

Table 3-2. Soil/Sediment Analysis Parameters and Methods

Analyte Group	Constituent	Method Number	Method Detection Limit[4] (mg/kg)
Metals[1]	Aluminum	6010 ICP	3
	Antimony	6020 ICP-MS[6]	0.7
	Arsenic	6020 ICP-MS	0.05
	Barium	6010 ICP	0.3
	Beryllium	6010 ICP	0.2
	Cadmium	6010 ICP	0.5
	Chromium	6010 ICP	1
	Cobalt	6010 ICP	1
	Copper	6010 ICP	1
	Iron	6010 ICP	2
	Lead	6010 ICP	4
	Manganese	6010 ICP	0.5
	Mercury	7471 CVAA	0.04
	Molybdenum	6010 ICP	1
	Nickel	6010 ICP	1
	Selenium	6010 ICP	4
	Silver	6010 ICP	1
	Thallium	6020 ICP-MS[6]	0.1
	Uranium	6020 ICP-MS	0.05
	Vanadium	6010 ICP	0.5
	Zinc	6010 ICP	1
Radionuclides[5]	U-234, -235, -238	ASTM D3972	0.1 ρCi/g
	Ra-226	901.1 M	0.4 ρCi/g
	Ra-228	901.1 M	1 ρCi/g
	Pb-210	PAI 704	1 ρCi/g
	Po-210	ASTM D3972	0.25 ρCi/g
	Th-228, -230, -232	ASTM D3972	0.1 ρCi/g
Organics[2]	PCBs	M8082 GC/ECD	0.01-0.02
	GRO	SW8015B	0.07-0.08
	DRO	SW8015MB	1.6
Miscellaneous[3]	Organic Carbon*	ASA No. 9 29-2,2,4 IC Combustion (leco)	0.1 %
	Acid Volatile Sulfides (AVS)*	EPA 08/09 Draft	
	Paste pH	USDA No. 60 (21a)	0.1 s.u.
	Particle size distribution	ASA No. 9 15-4.2.2	0.1 %

NOTES:
1. Initial sampling event. List may be reduced for other events.
2. Samples collected from stained soils at miscellaneous waste locations.
3. Parameters noted by asterisk "*" for stream sediment samples only.
4. The actual sample detection limits may vary depending on the effects of dilutions or matrices.
5. Radionuclide suite expanded from that proposed in SAP to match that on the water sample table.
6. Method changed from that proposed in the SAP (ICP) to achieve lower detection limit.

Table 3-3. Surface Water Sample Location Descriptions

Sample ID	Coordinates[1]					Location Description	SAMPLE COLLECTED		
	Latitude	Longitude	Horizontal Precision (ft)	Vertical Precision (ft)	Elevation (ft. msl)		June	July	September
300L/SW/01/A	54.9041111	-132.1349444	n/a	n/a	321	Kendrick Creek, below confluence with Mine Fork Creek at 300 Level	X	X	X
300L/SW/01/B	54.9043544	-132.1351949	1.6	1.9	355	Kendrick Creek, above confluence with Mine Fork Creek at 300 Level	X	X	X
300L/SW/01/C	54.9043332	-132.1350833	n/a	n/a	380	Mine Fork Creek, below mine drainage at 300 Level	X	X	X
300L/SW/01/D	54.9046797	-132.1350388	2.5	2.5	368	Mine Fork Creek, above mine drainage at 300 Level	X	X	X
300L/SW/01/E	54.9046285	-132.1354313	2.1	2.0	363	Just outside 300 Level portal	X	X	X
300L/SW/01/F	n/a	n/a	n/a	n/a	n/a	Mouth of 48-inch corrugated pipe running parallel to Kendrick Creek, below confluence of Mine Fork Creek and portal stream, and above confluence with Kendrick Creek		X	
700L/SW/01/A	54.9066667	-132.1435556	n/a	n/a	720	Upper reach of Kendrick Creek at 700 Level	X	X	X
700L/SW/01/B	54.9074350	-132.1373229	1.4	1.9	748	700 Level Creek, right below 700 Level Mine Rock Dump		X	X
900L/SW/01/A	54.9104505	-132.1387375	0.8	1.0	960	Mine Fork Creek at 900 Level	X	X	X
900L/SW/01/B	54.9102787	-132.1400886	1.0	1.1	971	South Tributary of Mine Fork Creek at 900 Level	X	X	X
900L/SW/01/C	54.9117226	-132.1403197	1.1	1.1	978	Upper reach of north Tributary of Mine Fork Creek at 900 Level	X	X	X
900L/SW/01/D	54.9105374	-132.1396601	0.8	1.2	969	Lower reach of north Tributary of Mine Fork Creek at 900 Level	X	X	X
900L/SW/01/E	54.90936	-132.139198	1.1	2.2	937	South end of 900-Level Open Pit			X
900L/SW/01/F	54.91010	-132.139228	1.2	2.2	961	North end of 900-Level Open Pit			X
CONF/SW/01/C	54.9021701	-132.1128950	1.3	2.6	46	Cabin Creek, above confluence with Kendrick Creek	X	X	X
CONF/SW/01/K	54.9020078	-132.1132624	2.3	2.8	36	Kendrick Creek, above confluence with Cabin Creek	X	X	X
CONF/SW/01/KC	54.9018649	-132.1123972	2.7	3.5	39	Kendrick Creek, below confluence with Cabin Creek	X	X	X
CONF/SW/01/K2	54.90225	-132.118472	n/a	n/a	n/a	Kendrick Creek, downstream of CONF/SW/01/KC		X	
SPR/SW/01/A	54.9023611	-132.1054722	n/a	77	n/a	Spring near Ore Staging Area	X	X	X

NOTES:
1. All coordinates are presented in NAD83 Alaska Zone 1, US Survey Feet

Table 3-4. Radon Detector Locations and Gamma Measurements

Radon Station ID	Latitude[1] (DD North)	Longitude[1] (DD West)	Description	Date Deployed	Date Collected	Gamma Measurement (µR/hour)
OSA-RAD-1	54.90142	-132.10577	Near existing floating dock	6/8/2009	9/23/2009	1000
OSA-RAD-2	54.9018	-132.10446	150+ feet east of OSA center, near drainage/seep area	6/8/2009	9/23/2009	60
OSA-RAD-3	54.90227	-132.10519	100+ feet NE of OSA center	6/8/2009	9/23/2009	147
OSA-RAD-4	54.90163	-132.10512	Perimeter of OSA open area near drums	6/8/2009	9/23/2009	2000
OSA-RAD-5	54.90214	-132.10623	NW of central OSA area, near seep and drum	6/8/2009	9/23/2009	67
DOT-RAD-6	54.9022	-132.10689	100 feet W of OSA-RAD-5	6/8/2009	9/23/2009	29
DOT-RAD-7	54.90209	-132.10935	Near Dotson Cabin	6/8/2009	9/23/2009	14
DOT-RAD-8	54.90287	-132.10944	150 feet N of Dotson Cabin	6/8/2009	N/A	5
DOT-RAD-9	54.90263	-132.11035	150 feet NW of Dotson Cabin	6/8/2009	N/A	5
DOT-RAD-10	54.90282	-132.11312	25 feet north of haul road on E side of Cabin Creek	6/8/2009	9/23/2009	8
700L-RAD-11	54.90707	-132.13969	200 feet WSW of 700 Level portal	6/9/2009	9/23/2009	60
700L-RAD-12	54.90697	-132.13805	150 SE of 700 Level portal	6/9/2009	9/23/2009	610
700L-RAD-13	54.9074	-132.13856	Mouth of 700 Level portal	6/9/2009	9/23/2009	200
700L-RAD-14	54.90715	-132.13899	100 feet WSW of 700 Level portal	6/9/2009	9/23/2009	2500
700L-RAD-15	54.90728	-132.13766	200 ESE of 700 Level portal	6/9/2009	9/23/2009	900
OP-RAD-16	54.90928	-132.13934	900 Level portal	6/9/2009	9/22/2009	500
OP-RAD-17	54.90975	-132.13915	Floor of Open Pit	6/9/2009	9/24/2009	2000
OP-RAD-18	54.90906	-132.13954	South of Open Pit	6/9/2009	9/23/2009	150
OP-RAD-19	54.90881	-132.13959	Air shaft	6/9/2009	9/23/2009	200
900L-RAD-20	54.91031	-132.13869	S of WRD of 900 Level, S bank of Mine Fork Creek	6/9/2009	9/23/2009	800
900L-RAD-21	54.91053	-132.14023	Former camp site west of 900 Level	6/9/2009	9/23/2009	75
900L-RAD-22	54.91117	-132.13913	900 Level WRD, NW of split in haul road	6/9/2009	9/23/2009	1000
900L-RAD-23	54.91-132	-132.13858	900 Level N WRD, N of split in haul road	6/9/2009	9/23/2009	1500
900L-RAD-24	54.91177	-132.1384	N of 900 Level WRD in background area	6/9/2009	9/23/2009	50
900L-RAD-25	54.91099	-132.13872	Island bounded by split in haul road	6/9/2009	9/23/2009	125
MR-RAD-26	54.91145	-132.13062	Mine road E of road to I&L Zone	6/9/2009	9/23/2009	500
MR-RAD-27	54.90473	-132.12669	W of haul road split to 300 Level portal	6/9/2009	9/23/2009	113
300L-RAD-28	54.90449	-132.13417	300 feet east of end of road at 300 Level	6/9/2009	9/23/2009	40
300L-RAD-29	54.90467	-132.13551	Mouth of 300 Level portal	6/9/2009	9/23/2009	55
300L-RAD-30	54.90453	-132.13527	100 feet SE of 300 Level portal	6/9/2009	9/23/2009	70
300L-RAD-31	54.90431	-132.13466	400 feet SE of 300 Level mine portal	6/9/2009	9/23/2009	220
300L-RAD-32	54.9043	-132.13441	100 feet E of 300L-RAD-31	6/9/2009	9/23/2009	1350
300L-RAD-33	54.90424	-132.13392	200 feet E of 300L-RAD-32	6/9/2009	9/23/2009	300
300L-RAD-34	54.90409	-132.13458	100 feet SE of 300L-RAD-31	6/9/2009	9/23/2009	220

NOTES: 1. All coordinates are presented in NAD83 Alaska Zone 1, US Survey Feet

Table 3-5. Soil Sample Location Descriptions

Sample ID	Sample Type	Coordinates[1]		Location	Description	Gamma Value (µR/hr)
		Latitude	Longitude			
Soil Sampling June 2009						
300L-CORR-1R	Correlation	54.90444	-132.13427	At 300 Level WRD	Correlation plot soil sample	95.9
HR-CORR-2R	Correlation	54.90464	-132.12784	Southern part of Mine Road, near 500' elevation	Correlation plot soil sample	20.7
HR-CORR-3R	Correlation	54.90423	-132.11958	Western part of haul road, near 300' elevation	Correlation plot soil sample	19.3
OSA-CORR-4R	Correlation	54.90182	-132.10606	Just west of OSA, at eastern edge of haul road	Correlation plot soil sample	232
HR-CORR-5R	Correlation	54.90266	-132.11662	Central part of haul road, approximately 150' elevation	Correlation plot soil sample	12.1
HR-CORR-6R	Correlation	54.90451	-132.12175	Western end of haul road, near 400' elevation	Correlation plot soil sample	148
HR-CORR-7R	Correlation	54.9058	-132.12346	Southeast edge of Mine Road, approximately 550' elevation	Correlation plot soil sample	41.5
HR-CORR-8R	Correlation	54.90915	-132.12309	East edge of Mine Road, near 700' elevation	Correlation plot soil sample	48.0
HR-CORR-9R	Correlation	54.91143	-132.13008	North edge of Mine Road, near 900' elevation	Correlation plot soil sample	195
IL-CORR-10R	Correlation	54.91304	-132.13574	North end of Road Spur to I&L Zone	Correlation plot soil sample	75
IL-CORR-11R	Correlation	54.91118	-132.13408	Southeast end of Road Spur to I&L, near Mine Road	Correlation plot soil sample	445
900BG-CORR-12R	Correlation	54.9091	-132.13954	At 900 Level, at portal	Correlation plot soil sample	175
900L-CORR-13R	Correlation	54.90908	-132.13792	At 900 Level, east of portal	Correlation plot soil sample	108
900BG-CORR-14R	Correlation	54.90976	-132.13783	Background at 900 Level, southeast of south WRD	Correlation plot soil sample	84
900WRD-CORR-15R	Correlation	54.91113	-132.13927	At 900 Level WRD	Correlation plot soil sample	1496
Soil Sampling July 2009						
300-1	Discrete	54.904500	-132.135510	300 Level	Discrete soil sample	
300-10	Discrete	54.903789	-132.134084	300 Level	Discrete soil sample	
300-11	Discrete	54.904060	-132.133690	300 Level	Discrete soil sample	
300-12	Discrete	54.903780	-132.133640	300 Level	Discrete soil sample	
300-13	Discrete	54.903860	-132.133920	300 Level	Discrete soil sample	
300-14A	Discrete	54.904030	-132.134100	300 Level	Discrete soil sample	
300-15A	Discrete	54.904160	-132.134030	300 Level	Discrete soil sample	
300-15B	Discrete	54.904160	-132.134030	300 Level	Discrete soil sample	
300-16	Discrete	54.904190	-132.134080	300 Level	Discrete soil sample	
300-17	Discrete	54.904300	-132.134080	300 Level	Discrete soil sample	
300-18	Discrete	54.904670	-132.133070	300 Level	Discrete soil sample	
300-2	Discrete	54.904490	-132.135350	300 Level	Discrete soil sample	
300-3	Discrete	54.904690	-132.135220	300 Level	Discrete soil sample	
300-5	Discrete	54.904490	-132.134520	300 Level	Discrete soil sample	
300-6	Discrete	54.904329	-132.134852	300 Level	Discrete soil sample	
300-7	Discrete	54.904141	-132.134614	300 Level	Discrete soil sample	
300-8	Discrete	54.903947	-132.134356	300 Level	Discrete soil sample	
300-9	Discrete	54.903880	-132.134100	300 Level	Discrete soil sample	
700T-1	Discrete	54.907550	-132.136950	700 Level transect	Discrete soil sample	
700T-2	Discrete	54.907480	-132.137270	700 Level transect	Discrete soil sample	
700T-3	Discrete	54.907600	-132.137650	700 Level transect	Discrete soil sample	
700T-4	Discrete	54.907130	-132.139240	700 Level transect	Discrete soil sample	
700T-5	Discrete	54.907150	-132.140370	700 Level transect	Discrete soil sample	

Table 3-5. Soil Sample Location Descriptions (continued)

Sample ID	Sample Type	Coordinates[1]		Location	Description	Gamma Value (µR/hr)
		Latitude	Longitude			
Soil Sampling July 2009						
700T-6	Discrete	54.906800	-132.140840	700 Level transect	Discrete soil sample	
900 BT-17	Discrete	54.911150	-132.140990	700 Level transect	Discrete soil sample	
900 BT-18	Discrete	54.911130	-132.140640	700 Level transect	Discrete soil sample	
900 BT-19	Discrete	54.911160	-132.140270	900 Level transect	Discrete soil sample	
900 BT-20	Discrete	54.911170	-132.139940	900 Level transect	Discrete soil sample	
900 BT-21	Discrete	54.911170	-132.139540	900 Level transect	Discrete soil sample	
900 BT-22	Discrete	54.911200	-132.139210	900 Level transect	Discrete soil sample	
900 BT-23	Discrete	54.911120	-132.138789	900 Level transect	Discrete soil sample	
900 BT-24	Discrete	54.911140	-132.138460	900 Level transect	Discrete soil sample	
900 BT-25	Discrete	54.911170	-132.138080	900 Level transect	Discrete soil sample	
900 BT-26	Discrete	54.911150	-132.137770	900 Level transect	Discrete soil sample	
900 BT-27	Discrete	54.911140	-132.137250	900 Level transect	Discrete soil sample	
900AT-10	Discrete	54.909120	-132.139860	900 Level transect	Discrete soil sample	
900AT-11	Discrete	54.909140	-132.139480	900 Level transect	Discrete soil sample	
900AT-12	Discrete	54.909220	-132.138920	900 Level transect	Discrete soil sample	
900AT-13	Discrete	54.909180	-132.138410	900 Level transect	Discrete soil sample	
900AT-14	Discrete	54.909130	-132.137990	900 Level transect	Discrete soil sample	
900AT-15	Discrete	54.909120	-132.137500	900 Level transect	Discrete soil sample	
900AT-16	Discrete	54.908990	-132.136960	900 Level transect	Discrete soil sample	
900AT-7	Discrete	54.909280	-132.141330	900 Level transect	Discrete soil sample	
900AT-8	Discrete	54.909280	-132.140730	900 Level transect	Discrete soil sample	
900AT-9	Discrete	54.909120	-132.140320	900 Level transect	Discrete soil sample	
900L-CORR-16	Correlation	54.910310	-132.139100	900 Level transect	Correlation plot soil sample	867
900L-CORR-17	Correlation	54.909240	-132.138500	900 Level transect	Correlation plot soil sample	1118
C1 (OSA-2,-8,-10,-14)	Composite	N/A	N/A	Ore Stockpile Area	Composite soil sample	
C2 (OSA-3,-9,-15,-16)	Composite	N/A	N/A	Ore Stockpile Area	Composite soil sample	
DOTSON 1	Discrete	54.909050	-132.122710	Near Dotson Cabin	Duplicate soil sample	
IL-1	Discrete	54.912240	-132.136230	I&L Zone	Discrete soil sample	
IL-2	Discrete	54.913040	-132.135280	I&L Zone	Discrete soil sample	
OSA-1	Discrete	54.902150	-132.105880	Ore Stockpile Area	Discrete soil sample	
OSA-11	Discrete	54.902000	-132.104240	Ore Stockpile Area	Discrete soil sample	
OSA-12	Discrete	54.901920	-132.104460	Ore Stockpile Area	Discrete soil sample	
OSA-13	Discrete	54.902160	-132.104840	Ore Stockpile Area	Discrete soil sample	
OSA-17	Discrete	54.902370	-132.105510	Ore Stockpile Area	Discrete soil sample	
OSA-18	Discrete	54.902200	-132.105520	Ore Stockpile Area	Discrete soil sample	
OSA-4	Discrete	54.901850	-132.106390	Ore Stockpile Area	Discrete soil sample	
OSA-5	Discrete	54.901820	-132.106220	Ore Stockpile Area	Discrete soil sample	
OSA-6	Discrete	54.901780	-132.106060	Ore Stockpile Area	Discrete soil sample	
300L-GENSHACK	Discrete	54.904610	-132.134980	300 Level Generator Shack/Mineral Custody Shed	Discrete soil sample	
3TANK-TPH	Discrete	54.90702	-132.13812	Below 700-foot level portal	Discrete soil sample	
900L-BATT	Discrete	54.91098	-132.13846	900 Level Solid Waste Dump	Discrete soil sample	
OSA-UST DOCK	Discrete	54.901656	-132.105422	2 Large Storage Tanks at OSA Dock Area	Discrete soil sample	

NOTE: 1. All coordinates are presented in NAD83 Alaska Zone 1, US Survey Feet

Table 3-6. Stream Sediment Sample Location Descriptions

Stream Sediment		Coordinates[1]		Location Description
Sample ID	Sample Type	Latitude	Longitude	
300L/SS/01/A	Sediment	54.90411111	-132.1349444	Kendrick Creek, right below confluence with Mine Fork Creek at 300 Level
300L/SS/01/B	Sediment	54.90435444	-132.1351949	Kendrick Creek, right above confluence with Mine Fork Creek at 300 Level
300L/SS/01/E	Sediment	54.90462852	-132.1354313	Just outside 300 Level Portal
900L/SS/01/A	Sediment	54.91045047	-132.1387375	Mine Fork Creek at 900 Level
900L/SS/01/B	Sediment	54.91027865	-132.1400886	South Tributary of Mine Fork Creek at 900 Level
900L/SS/01/C	Sediment	54.91172264	-132.1403197	Upper reach of North Tributary of Mine Fork Creek at 900 Level
CONF/SS/01/KC	Sediment	54.90186493	-132.1123972	Kendrick Creek, right below confluence with Cabin Creek
CONF/SS/01/C	Sediment	54.90217014	-132.112895	Cabin Creek, right before confluence with Kendrick Creek
CONF/SS/01/K	Sediment	54.90200781	-132.1132624	Kendrick Creek, right before confluence with Cabin Creek
CONF/SS/01/K-2	Sediment	54.90225	-132.118472	Kendrick Creek, midway between Cabin Creek and 300 Level
KBD-SS-01-A	Sediment	54.90112808	-132.1110875	Kendrick Creek delta interface
KBD-SS-01-B	Sediment	54.90120117	-132.1113594	Kendrick Creek delta interface

NOTES:

1. All coordinates are presented in NAD83 Alaska Zone 1, US Survey Feet

Table 3-7. Marine Sediment Sample Location Descriptions

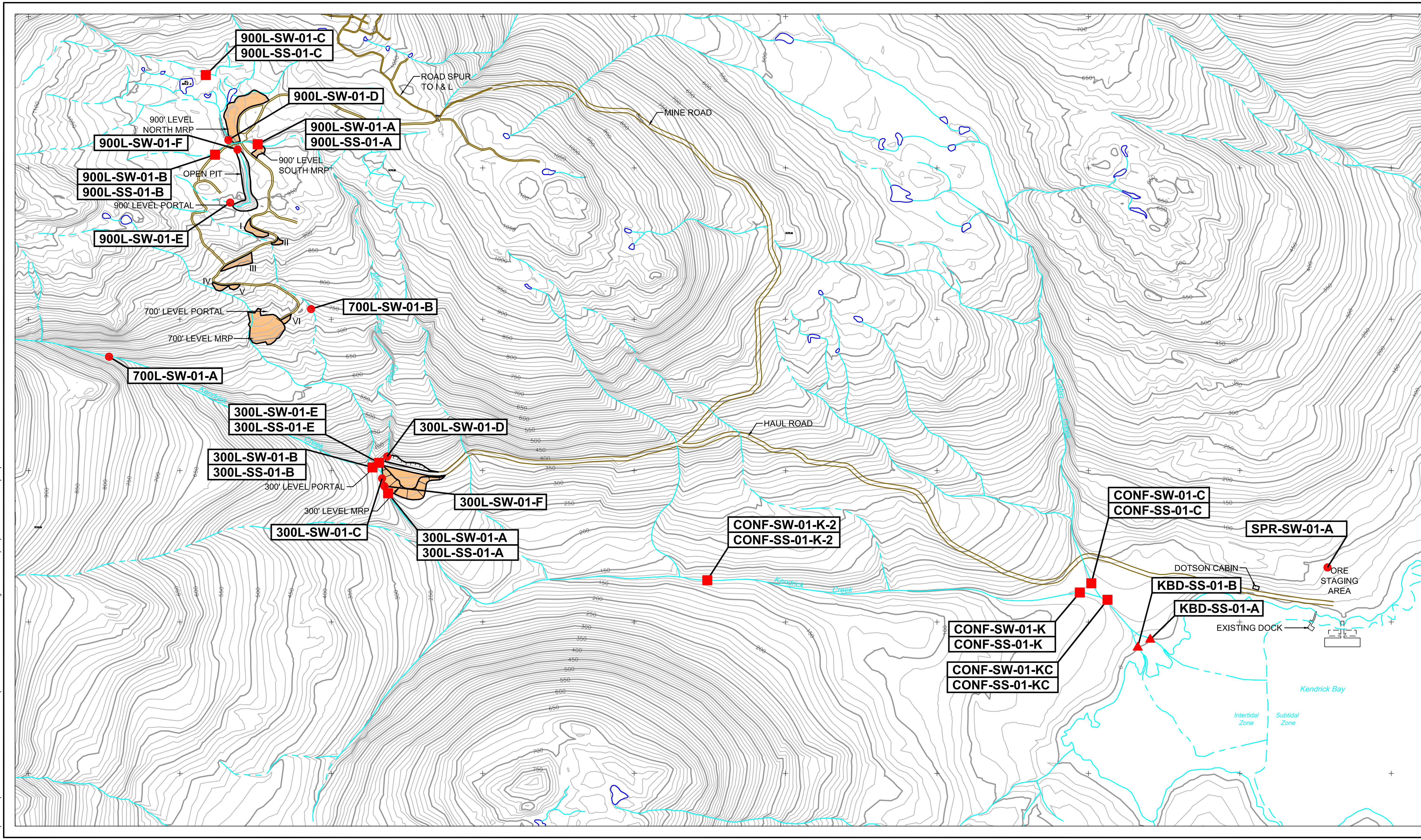
Sample ID	Sample Type	Coordinates[1]		Location
		Latitude	Longitude	
KBD-MS-01-C	Sediment	54.900739	-132.104254	Subtidal
KBD-MS-01-D	Sediment	54.900744	-132.105295	Subtidal
KBD-MS-01-E	Sediment	54.900730	-132.104791	Subtidal
KBD-MS-01-F	Sediment	54.900559	-132.106637	Subtidal
KBD-MS-01-G	Sediment	54.901019	-132.105750	Subtidal
KBD-MS-01-H	Sediment	54.900399	-132.105479	Subtidal
KBD-MS-01-I	Sediment	54.900024	-132.107210	Subtidal
KBD-MS-01-J	Sediment	54.901017	-132.106643	Subtidal
KBD-MS-01-K	Sediment	54.901427	-132.104284	Intertidal
KBD-MS-01-L	Sediment	54.901431	-132.105619	Intertidal
KBD-MS-01-M	Sediment	54.900766	-132.110688	Intertidal
KBD-MS-01-N	Sediment	54.900368	-132.111659	Intertidal
KBD-MS-01-O	Sediment	54.900124	-132.110642	Intertidal
KBD-MS-01-P	Sediment	54.899673	-132.111743	Intertidal
KBD-MS-01-Q	Sediment	54.899435	-132.110736	Intertidal
KBD-MS-01-R	Sediment	n/a*	n/a*	Intertidal
KBD-MS-01-S	Sediment	n/a*	n/a*	Intertidal
KBD-MS-01-T	Sediment	54.899643	-132.108627	Intertidal
KBD-MS-01-U	Sediment	54.899876	-132.109692	Intertidal
KBD-MS-01-V	Sediment	54.900216	-132.110116	Intertidal
KBD-MS-01-W	Sediment	54.900428	-132.109779	Intertidal
KBD-MS-01-X	Sediment	54.901280	-132.109565	Intertidal
KBD-MS-01-Y	Sediment	54.900378	-132.110594	Intertidal
KBD-MS-01-Z	Sediment	54.900658	-132.109975	Intertidal
KBD-MS-01-AA	Sediment	54.900728	-132.109449	Intertidal
KBD-MS-01-BB	Sediment	54.900442	-132.108144	Intertidal
KBD-MS-01-CC	Sediment	54.901088	-132.108318	Intertidal
KBD-MS-01-DD	Sediment	54.901639	-132.108762	Intertidal
KBD-MS-01-EE	Sediment	54.901318	-132.105400	Intertidal
KBD-MS-01-FF	Sediment	n/a	n/a	Intertidal

NOTES:
1. All coordinates are presented in NAD83 Alaska Zone 1, US Survey Feet
* Sampling location coordinates were not obtained

Table 3-8. Field QC Sample Summary

Sample Event	Sample Media	# Samples Collected	# Field Duplicates Collected	Field Duplicate ID	#Equipment Blanks Collected	Equipment Blank ID
June, 2009	Surface water[1]	14	1	900L/SW/01/B (DUP)	0	
	Soil	15	1	HR-CORR-8RDUP	0	
July, 2009	Surface water[1]	17	1	900L-SW-02-A	3[1]	TB-1, TB-2, TB-3
	Soil	67	2	DOTSON 1 DUP OSA-4 DUP	0	
	Stream sediment	12	1	900L-SS-02-A	0	
	Marine sediment	28	1	KBD-MS-01-I (DUP)	1	VV-Rinsate
Sept, 2009	Surface water	17	1	900L-SW-02-A	0	

Notes:
[1] These 3 equipment blanks were collected only for Mercury analysis



E:\181862\Final SCR -- November 2010\FIG-3-1-SAMP-SS-SW.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER

Project No. 181862

November 2010

LEGEND

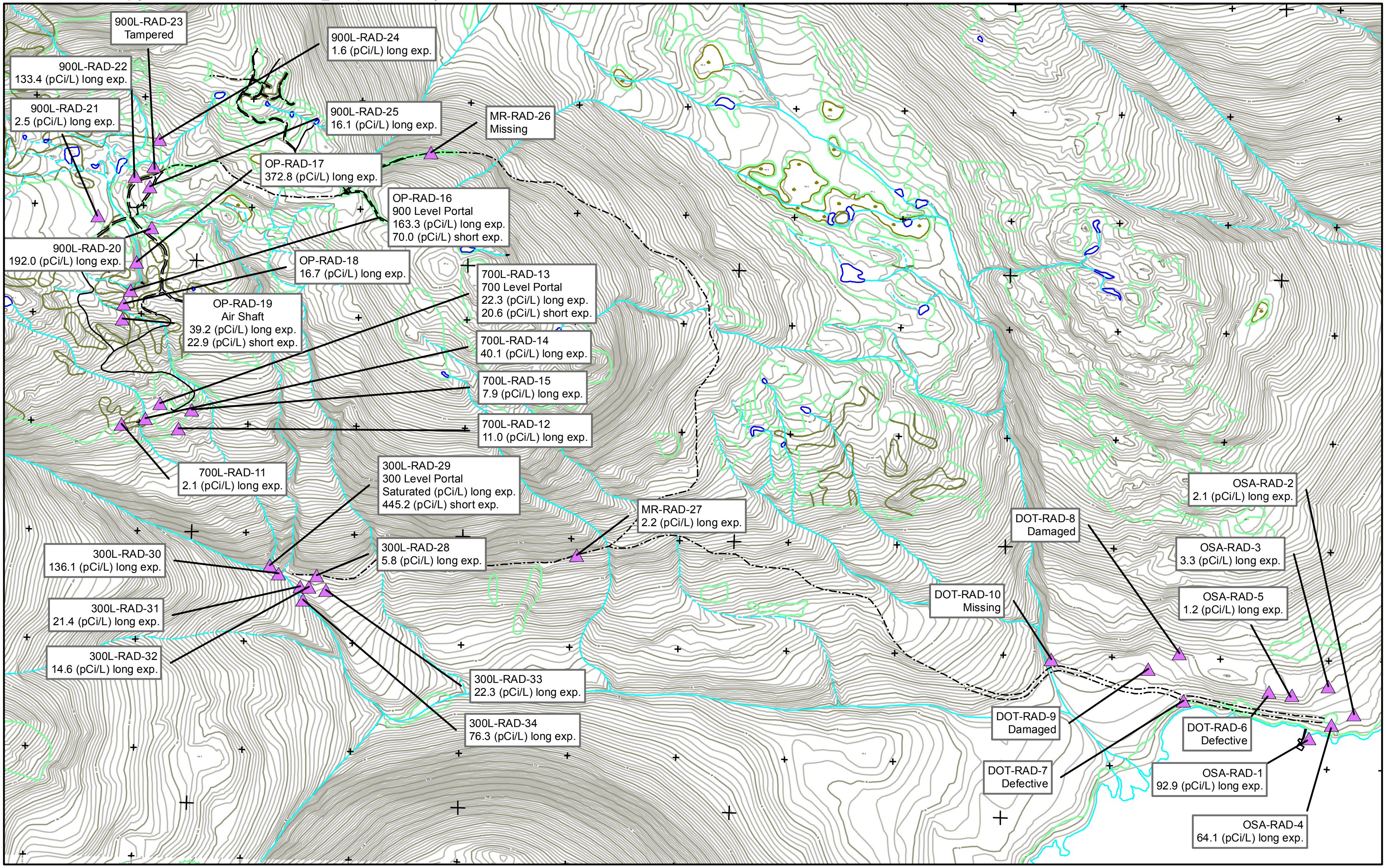
- SURFACE WATER AND SEEP SAMPLE ONLY
- SURFACE WATER AND STREAM SEDIMENT SAMPLES
- STREAM SEDIMENT SAMPLE ONLY

NORTH

SCALE IN FEET 0 600

Figure 3-1
Ross-Adams Site
Surface Water and Stream Sediment Sampling Locations

OCT 13, 2009 N:\arcprj2\Gamma\181862\mxd\Radon_Samples.mxd BY:jesse.carver



November 2010

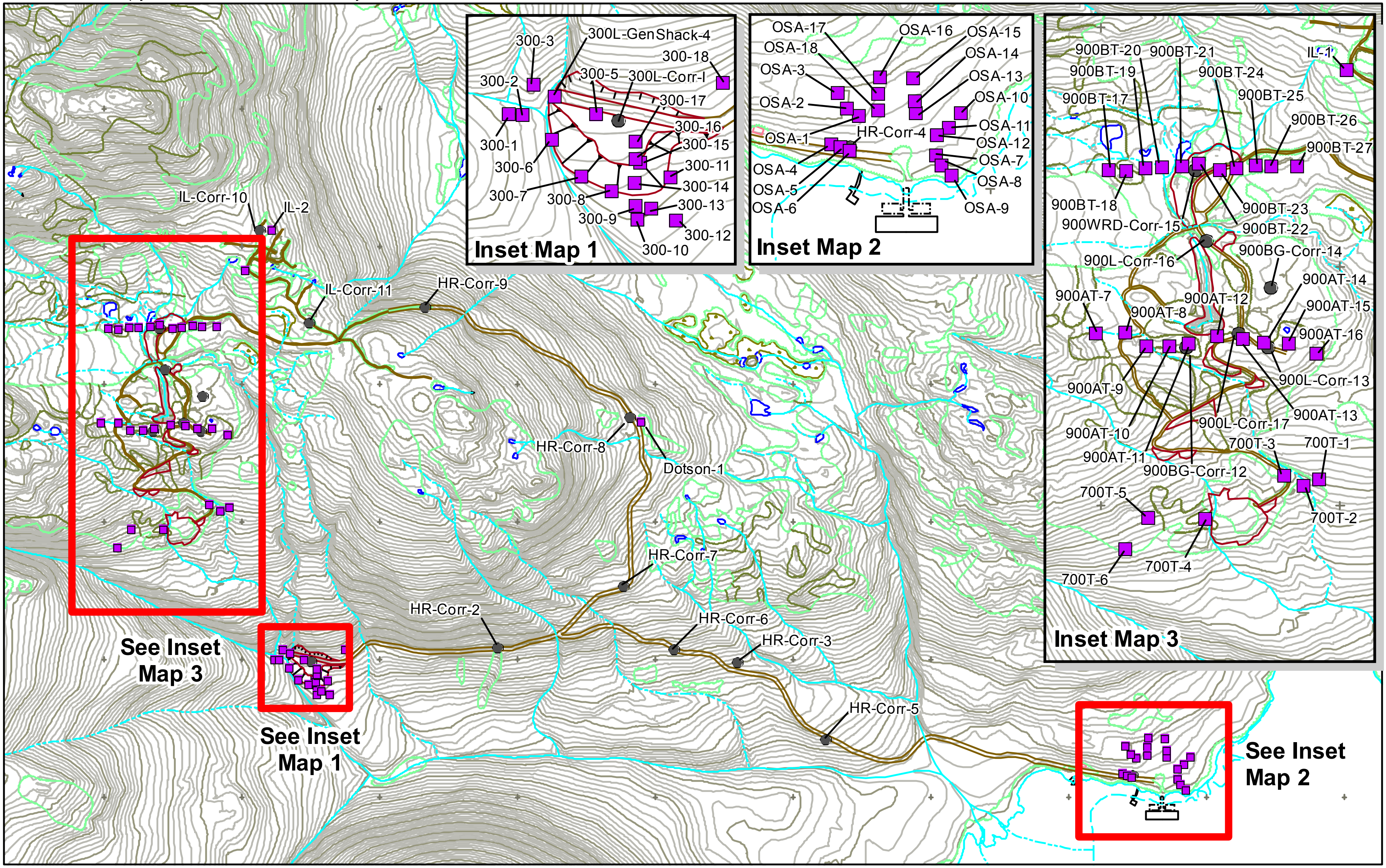
Legend

Radon Monitoring Station
long exp: 06/09/09 - 09/23/09
short exp: 07/20/09 - 07/27/09

Note:
Defective- Laboratory testing equipment was defective or damaged
Saturated- Radon concentration exceeded max of 140,000 pCi/L-days
Tampered- Radon station was tampered with but still submitted to lab
Missing- Test equipment taken from station
Damaged- Test equipment found on ground and water damaged

Figure 3-2
Ross-Adams Site
Radon Station Locations and Measurement Data

MAR 03, 2010 N:\arcprj2\Gamma\181862\mxd\3-3.mxd BY:jesse.carver



Gamma/Soil Correlation Plot

Discrete Soil Sample

N

Feet

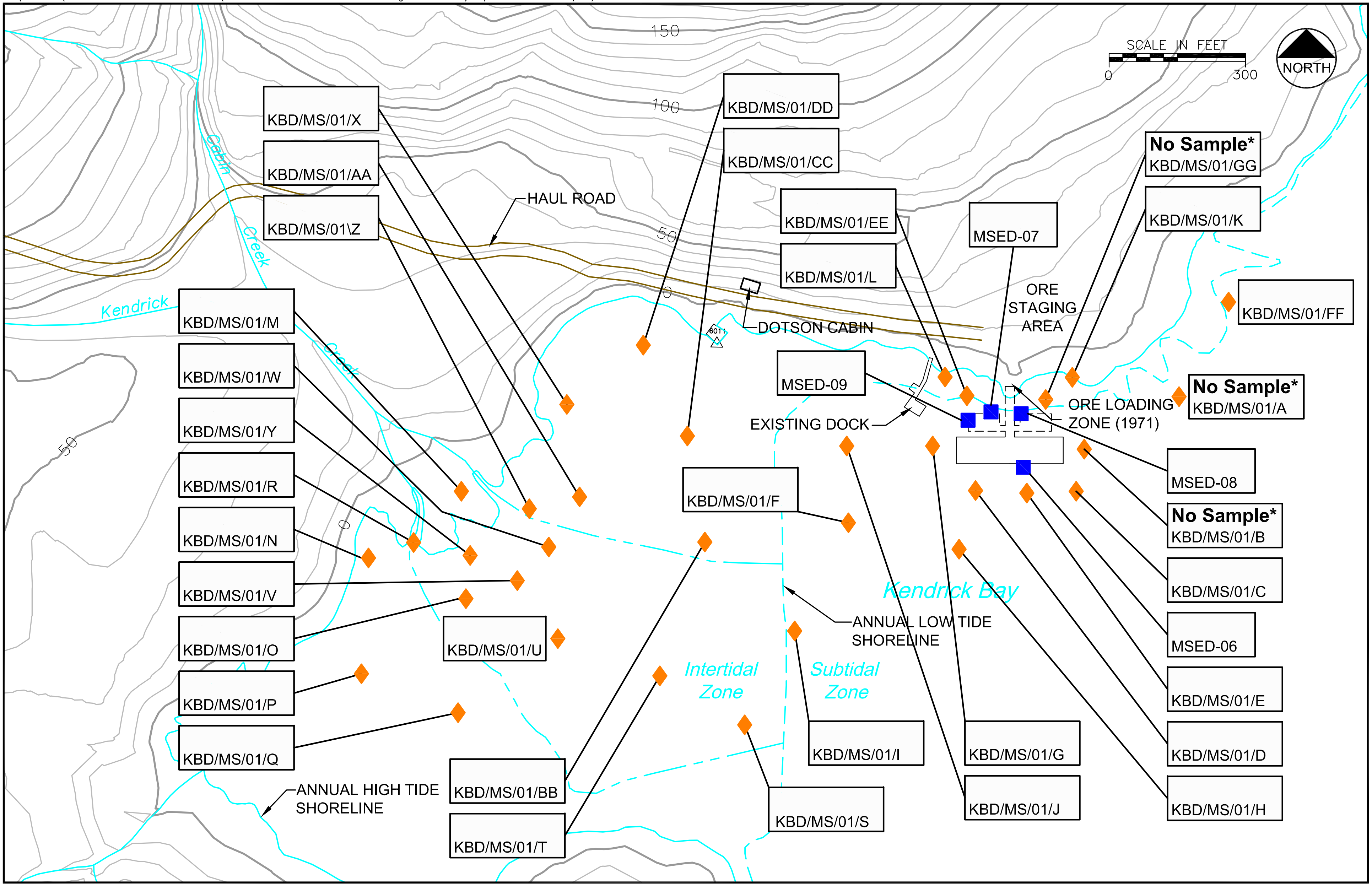
0 1,000

November 2010

Figure 3-3

Ross Adams Site
Soil Sample Locations

E:\181862\Final SCR – November 2010\FIG-3-4-SAMPLE-M-SED-01.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER



Project No. 181862

November 2010

◆ Tetra Tech Sample Location

■ Kent & Sullivan Sample Location

KBD/MS/01/T Sample ID

* Note: Unable to collect sample at this location due to sediment quantity.

Figure 3-4
Ross-Adams Site
Marine Sediment Sample Locations

4.0 PHYSICAL CHARACTERISTICS OF THE ROSS-ADAMS SITE

This section discusses the existing conditions at the Ross-Adams Site as observed during the 2009 ESI and as reported in published literature. The discussion includes sections on climate, topography, hydrology, geology and soils, flora and fauna, and a description of mine features.

4.1 Climate

The nearest climatological station to the Site is located at Annette Island, directly east of Kendrick Bay across Clarence Strait. The weather station is located near sea level. Although the Site ranges in elevation from sea level to over 900 feet above sea level and will have a correspondingly wide range of climatic conditions, the Annette Island station represents nearby regional climatic conditions at and near sea level.

The climate of the region is maritime due to the close proximity of the Pacific Ocean. As shown in Table 4-1, temperatures near sea level are relatively mild, with average monthly temperatures ranging from a high of 65 degrees Fahrenheit in July and August to a low of 30 degrees Fahrenheit in January. Sub-freezing temperatures at sea level seldom extend longer than ten days, and a minimum reading below zero is rare. Likewise, extreme high temperatures are rare during summer months (NOAA, 2009).

The region experiences frequent and relatively heavy precipitation, with October through December usually the wettest months (Table 4-2). The annual total precipitation averages over 100 inches. Rain comprises the greatest percentage of precipitation at sea level, even in winter months. When snow does occur at sea level, it rarely accumulates to depths greater than 12 inches, and snow cover seldom lasts beyond two weeks (NOAA, 2009). In contrast, snow cover and duration at the Site increase with increasing elevation, and can linger for months at the upper elevations.

Total monthly precipitation data in 2009 from Annette Island, the nearest meteorological station to the Site, is presented on Figure 4-1. The average monthly precipitation (1941-2008) and the total precipitation for the 30-day period preceding the end of the June, July, September 2009 sampling events are also depicted on the figure. The trends exhibited by the Annette Island precipitation data are considered representative of precipitation at the Site, indicating that precipitation during the first two sampling events (June and July) were representative of the dry season and that precipitation preceding the September sampling event was significantly greater than the historical average and representative of precipitation during the wet season. As shown on Figure 4-1, June 2009 precipitation was slightly greater than the historical average and July 2009 precipitation was less than the historical average. The 30-day precipitation preceding the June and July sampling events were consistent with the historical monthly average precipitation. Monthly precipitation in June and July 2009 were representative of the dry season. Precipitation in September 2009 was significantly greater than the average monthly precipitation and nearly the same as the maximum average monthly precipitation that occurs in October. The 30-day precipitation preceding the late September sampling event was significantly greater than the historical average monthly precipitation. Precipitation preceding and during the September sampling event was representative of precipitation during the wet season, resulting in stream flows representative of high flow conditions during the wet season.

From October through March, strong southeasterly winds are frequent (Table 4-3). Wind speeds with the highest frequency range from approximately 5 to 11 miles per hour (2 to 5 m/s) (Figure 4-2). Figures 4-3 and 4-4 illustrate wind speed and frequency distribution; wind speed is generally higher in winter (January) than summer (July), and is predominantly out of the southeast for both months, although winds out of the northwest do occur in summer. Thick fog is infrequent and short in duration, but cloudiness does persist over the region (NOAA, 2009).

4.2 Topography

The topography of the Site is characterized by mild slopes coming out of the Kendrick Bay delta (sea level), to steep, rocky, subalpine slopes of Bokan Mountain (El. 2,157 feet above mean seal level (amsl)). The highest elevations at the Site are at the 700-Foot and 900-Foot Levels, where elevations range from approximately 720 to 985 feet amsl, respectively. Elevations at the 300-Foot Level range from approximately 290 to 350 feet amsl. Elevations at the OSA range from approximately sea level to 40 feet amsl.

The OSA is located on gently sloping ground immediately above the north shore of Kendrick Bay and the southeast toe of a steep hillside. The area is characterized by a reasonably uniform slope of approximately 6 to 7 degrees toward the southeast, and is densely vegetated.

The topography of the 300-Foot Level mine rock pile is characterized by end-placed mine rock fill along a mountainside with pre-mining slopes ranging from approximately 22 degrees below the haul road to 30 degrees above the haul road. Mine Fork Creek passes between the mine rock pile and the 300-Foot Level portal, and runs along the western toe of the pile for several hundred feet before continuing south toward Kendrick Bay.

The topography in the general vicinity of the 900-Foot Level is generally mild and rolling, but steepens quickly to the north toward Bokan Mountain, and similarly drops steeply toward the 700-Foot Level and beyond to the south. The area immediately south and east of the 700-Foot Level mine rock pile is densely vegetated with old-growth forest. Most of the ground surface at the 700-Foot and 900-Foot Levels is comprised of exposed bedrock outcrops.

Combined with steep local topography, dense ground vegetation precludes full visual identification of the spatial extents of mine features at the OSA, the 300-Foot Level mine rock pile, the area immediately south of the 700-Foot Level mine rock pile, and at the toe of most of the haul road embankments. However, the general limits of disturbance based on physical features were readily identifiable in the field. In addition to the limitations on visual inspection, the steep topography and dense vegetation combined to impede or prevent GPS-based surveying. The removal of several small diameter trees in various locations within the OSA was required to perform a civil survey of the OSA and adjacent areas.

4.3 Hydrology

The Site lies wholly within the Kendrick Creek drainage basin (Figure 1-2). Mine Fork Creek originates above the 900-Foot Level and is diverted around the Open Pit area before joining with Kendrick Creek at the 300-Foot Level. The 700-Foot Level Creek, a minor tributary with headwaters near the 700-Foot Level portal, joins Kendrick Creek just upstream of Mine Fork Creek. After joining with Mine Fork Creek, Kendrick Creek flows to the east, emptying into Kendrick Bay at a point west/southwest of the existing floating dock and Ore Staging Area. The confluence of Kendrick Creek with Cabin Creek, another major drainage within the basin, is located approximately 750 feet from the bay. Kendrick and Cabin Creeks are characterized by steep, high-gradient channels with beds comprised primarily of boulders, cobbles and gravels, with some local pool areas containing more sandy material.

The Kendrick Creek drainage basin covers approximately 1,400 acres on the southeast slope of Bokan Mountain. The Cabin Creek sub-basin comprises about 560 of these acres, or approximately 40 percent of the total watershed. Elevations in the Kendrick Creek basin range from sea level at the creek mouth to approximately 2,157 feet near the summit of Bokan Mountain.

Maritime province streams in southeast Alaska have flow rates that mimic the seasonal precipitation pattern. Typical seasonal stream flow is depicted in Figure 4-5, adapted from Pacific Rim Planners (1979). In the early winter months of the year, stream flow is at a low level, as some precipitation is locked up in the snow pack in the mountains. However, stream flow in low-elevation watersheds shows a higher discharge in the winter as most of the precipitation that falls closer to sea level is in the form of rain. As spring arrives, rising temperatures, melting snow pack, and increasing rainfall results in a steadily rising stream flow. Precipitation then falls off after May or June, and with the decreasing snow pack, stream flow can decrease drastically. The rainy season begins in September, and autumn storms result in maximum stream flows for the year (Pacific Rim Planners, 1979).

Stream flow data in 2009 for Old Tom Creek near Kasaan, Alaska (USGS station 15085100), the nearest USGS stream gauging station to the Site, are shown on Figure 4-6. The variations in stream flows are consistent with the monthly precipitation data for Annette Island (Figure 4-1) and with the typical Alaskan stream flow patterns (Figure 4-5). The stream flow data for Old Tom Creek are also considered representative of trends in stream flows at the Site in 2009. Consistent with the monthly precipitation records, stream flows in June 2009 were higher than in July 2009, with low stream flows in both June and July being representative of conditions during the dry season. Daily mean discharge data for Old Tom Creek indicate that stream flows during late September 2009 were significantly greater than the 60-year median daily flow and, therefore, representative of stream flows typically experienced during the wet season. The Annette Island precipitation and USGS stream gauging records demonstrate that the June, July and September sampling events encompassed the range of dry and wet season conditions at the Site and that stream flows during the September sampling event were typical of high flow conditions at the Site during the wet season.

4.4 Geology and Soils

4.4.1 Geology

The area surrounding the west Arm of Kendrick Bay and Bokan Mountain is underlain by Late Ordovician and Silurian plutonic and metasedimentary rocks that are intruded by the Jurassic Bokan Mountain granite (see Figure 1-3). The Ordovician and Silurian plutonic rocks are part of the Cape Chacon plutonic province, and consist of quartz diorite intruded by quartz monzonite. The eastern part of the area, including most of the shoreline, is underlain by quartz diorite. The area between the Ross-Adams mine and the bay is underlain by quartz monzonite, which occurs west and northwest of the quartz diorite. Descon Formation metasedimentary rocks are intruded by the quartz monzonite pluton.

The Bokan Mountain Intrusive Complex is a circular stock comprised of concentrically-zoned peralkaline (sodium + potassium > aluminum) granite. The stock is approximately 3 kilometers in diameter and intrudes into the older quartz monzonite-quartz diorite and Descon Formation metasedimentary rocks (Figure 1-3). The peralkaline granite stock is surrounded by a 3 km wide contact metamorphic zone (Philpotts, et al., 1998) where the quartz monzonite and quartz diorite is albitized and locally silicified. Pegmatites and aplites that are genetically related to the peralkaline stock occur both within the area underlain by the stock and in the surrounding area underlain by the older rocks.

The Bokan Intrusive Complex rocks are enriched in uranium, thorium, rare-earth elements (REE) and other rare elements (Philpotts et al., 1998). Concentration of these elements through the late-stage fractionation process resulted in the higher, and in some cases ore-grade level, accumulation of these elements in pegmatites and aplites emplaced in the veins, dikes and pipe-like bodies present throughout the Site. These local geologic features, referred to as 'mineralized zones', commonly extend to or very near to the ground surface. While the Ross-Adams represents the only mine developed at the Site to date, current exploration activities attest to the ongoing interest in the uranium, thorium and REE mineralization related to the Bokan Intrusive Complex rocks.

The higher incidence of radionuclide minerals within these near-surface mineralized zones creates a strong radiometric signature, as illustrated in a 2007 airborne radiometric survey (Figure 4-7). The contrast in radiometric signatures between the Bokan Intrusive Complex and the surrounding monzonite areas is evidenced in Figure 4-7 as zones of higher 'Uranium CPS' (counts per second) associated with near-surface mineral deposits such as Ross-Adams, I&L Zone, and those along the Dotson Shear Zone. For clarification, 'Uranium CPS' can be interpreted as an indication of the presence of gamma radiation-emitting daughter products of Ra-226 associated with naturally occurring uranium deposits. The very high concentrations of radioactive and non-radioactive minerals in veins and dikes of the Bokan Intrusive Complex result in naturally occurring and highly variable concentrations of metals in soils, radon in air, and gamma exposure rates over short distances across the Site. Data from the numerous undeveloped economic mineral occurrences at the Site (Figure 1-3) can be used to deduce the pre-mining background conditions at the Ross-Adams deposit.

4.4.2 Uranium and Thorium Mineralogy of the Ross-Adams Deposit

Information on the mineralogy of the Ross-Adams deposit is available from prior studies as summarized in Section 2.1. MacKevett's (1963) work indicated that "primary minerals account for almost all the uranium and thorium values" in the Ross-Adams deposit, with the dominant ore minerals being uranothorite and uranoan thorianite; minor amounts of coffinite are also present. The primary ore minerals are disseminated in altered granite as crystals up to 2 mm in diameter. Thompson (1997) reports that the principal ores present in the Ross-Adams deposit are uranothorite and uranite, with uranothorite dominating. Thompson (1997) further summarizes the deposit. The Ross Adams deposit was discovered in 1955 as a result of radiometric anomaly from fixed wing over-flight and subsequent ground survey of the surface outcrop of the deposit. Three types of uranium-thorium deposits are known in the Bokan Granite Complex: irregular cylindrical pipes; steep shear zone-localized pods or lenses referred to as veins, and quartz-hosted deposits. Only the first two types yielded uranium ore. The Ross-Adams Mine is developed on a southward-plunging, crudely pipe-like zone approximately 50 feet in diameter and was surrounded by a sub-ore-grade zone two to 20 feet thick. Within the pipe- and shear zone-type orebodies, the ThO_2/U_3O_8 ratio ranged from 0.75 to >20 with a mean of 2.75. U_3O_8 concentrations ranged as high as 2.96 percent. The U_3O_8 content of the ore recovered during mining of the lower portion of the orebody in 1971 was 1.0 percent.

MacKevett (1963) reported only minor amounts of secondary uranium minerals present in the near-surface environment at Ross-Adams, including gummite, sklodowskite, beta-uranophane, bassetite, and novacekite. Thompson (1997) indicates that sulfide minerals, the source of potential acid generation and ARD constituted less than 2 percent of the ore and included pyrrhotite, pyrite, chalcopyrite, galena, sphalerite, marcasite, acanthite, bornite and molybdenite.

The uranium- and thorium-bearing minerals reported in the Ross-Adams deposit are summarized in Table 4-4. The PA/SI (KSI, 2004) also provides a detailed summary of the overall mineralization present at the Site.

4.4.3 Soils

The terrain at the higher elevations on Bokan Mountain is comprised of rock outcrop, rock rubble, and thus soils are thin, patchy, and poorly drained. Many of the middle and higher areas where soil is thin support only stunted trees and scrub brush, with swamps and muskeg present where drainage is poor (BLM, 1998).

The area surrounding the 900-Foot and 700-Foot Levels is comprised essentially of bare rock. Soils, where present, are only a few inches thick and generally less than one-foot thick (Eakins, 1970). Dense forest with unknown soil thickness is present to the south and east of the 700- and 900-Foot Level. A swampy area is located to the northwest of the Open Pit, consisting of a thin layer of muskeg atop bedrock.

At lower elevation of the Site the three main soil types present are Kaikli soils, Helm soils, and Tonowek soils (BLM, 1998):

- Kaikli soils are moderately deep, and are characterized by very poorly drained red and black mucky peat with a high organic content. These soils are found north of the 900-Foot Level and continue to the intersection of the 300-Foot Level road (BLM, 1998).

- Helm soils are generally thin and moderately to poorly drained, consisting of un-decomposed and decomposed forest litter over loam (USDA, 1994). This soil type is found between the Kaikli and Tonowek soil types, and includes areas to the south and east of the I&L Zone and areas extending south of the topographic saddle near the intersection with the 300-Foot Level road and then halfway along the haul road towards the beach (BLM, 1998).

- The Tonowek soils are located near the remaining half of haul road, the 300-Foot Level mine rock pile, and OSA. This soil type is moderately to well drained, and supports Sitka spruce, Western hemlock, devils club, and alder (BLM, 1998).

As discussed in Section 6, a thick organic mat has developed over much of the OSA since it was cleared following the 1971 mining activities (Appendix A).

4.5 Flora and Fauna

The Site falls within the “Southeast Ecoregion” as defined by the Alaska Department of Environmental Conservation (ADEC, 1999a, b). The main ADEC ecological subregions characterizing the Ross-Adams Site are the “Southeast Coastline/Estuary” and “Coastal Western Hemlock-Sitka Spruce Forest”. The “Pacific Ocean” subregion characterizes the open waters of Kendrick Bay. The biological survey of the Site conducted by Tetra Tech (Appendix F) identified the following four main habitat types, which are considered consistent with the ecological subregions described by ADEC: Subalpine Zone, Western Hemlock-Sitka Spruce Forest, Intertidal Zone, and Marine Zone. These habitats and their associated plants and animals are described below.

4.5.1 Subalpine Zone

This area is found at the 900-Foot Level and is characterized by barren rock and plants adapted to the colder and windier environment at this higher elevation. Vegetation in this zone includes mountain hemlock, yellow cedar, and the dwarf form of the shore pine. Wildlife in the subalpine zone includes Sitka black-tailed deer, black bear, ptarmigan, and songbirds such as thrush and dark-eyed junco.

4.5.2 Western Hemlock-Sitka Spruce Forest

This habitat type consists of old growth forest extending from sea level to approximately 900 feet ASL and is dominated by Western Hemlock and Sitka-Spruce. Other important vegetation includes red alder, western red cedar, Devil's club, and a variety of ferns and berries. The old growth forest supports a variety of songbirds, as well as mammals such as the Sitka black-tailed deer, black bear, and mink. Kendrick Creek drains through the forested area and is joined by its tributaries Mine Fork Creek and Cabin Creek. Kendrick Creek could be used by some salmonid species. A run of spawning pink salmon was observed in lower Kendrick Creek during field work in September 2009.

As discussed in Appendix F and Section 5.2.2, the mouth of Kendrick Creek up to between 150 and 200 feet ASL has moderate to low/negligible available spawning area (ASA) and moderate available rearing area (ARA) for salmonids, as indicated by stream classification information from the TNF (USFS, 2008c). Between 200 and 250 feet ASL, the stream steepens and has moderate ASA and ARA for Dolly Varden and low to negligible ASA and ARA for all other salmonids. Above 250 feet ASL, including the 300-Foot Mine Level, the stream has a very steep gradient, with both Kendrick Creek and Mine Fork Creek considered negligible spawning and rearing habitat for all salmonids. Additionally, both Kendrick Creek and Mine Fork Creek have steep waterfall sections above their confluence, which serve as effective barriers for salmonids. The inaccessible upper portion of Mine Fork Creek, as well as Cabin Creek, are also negligible habitat for all salmonids based on stream classification.

4.5.3 Intertidal Zone

This habitat type includes the water and underlying bottom habitat that is bounded by the low and high tides of Kendrick Bay. The Intertidal Zone receives freshwater input from Kendrick Creek and runoff from the surrounding uplands, and is connected to the open waters of the northwest end of Kendrick Bay. The breadth of the intertidal zone is determined by the local nearshore bathymetry. Consequently the shallow sloping delta at the mouth of Kendrick Creek forms an expansive intertidal area of approximately 25 acres. Sediments in the delta consist of coarse gravels and cobble, with occasional gravelly sand bars. Beyond the Kendrick Creek delta, the local nearshore bathymetry becomes much steeper, resulting in a much narrower intertidal zone. The substratum in the intertidal zone in the vicinity of the ore loading facility is predominantly boulder and large cobble.

During the biological survey, 16 species of plants and algae and 24 species of aquatic invertebrates were observed in this zone. Common plants and algae include rockweed, eelgrass, sugar kelp and bull kelp. Marine invertebrates are common in the intertidal zone particularly along the shoreline, including a variety of clams, crabs, and starfish, as well as chitons, worms, amphipods, isopods, and sea cucumbers. Birds using the intertidal zone include gulls, shorebirds, waterfowl, crows, belted kingfisher, and bald eagle. During the biological inventory, mink were observed in the intertidal zone, and black bear and Sitka black-tailed deer were observed around the perimeter of this zone.

4.5.4 Marine Zone

This habitat type is contiguous with the Intertidal Zone and includes the waters and seafloor of the west Arm of Kendrick Bay below the low tide line. Wildlife in this area includes sea otter, harbor seal, gulls, and loons. The marine zone also supports a variety of fish and invertebrates.

4.6 Mining Features

An Engineering Assessment of the man-made and natural features at the Site was conducted as part of the ESI. The engineering assessment documented and assessed the engineering aspects of the following:

- The adequacy of diversion structures to control runoff inflow to mine openings
- Development of an inventory of man-made structures and other mine-related structures present on the Site that includes mapping, description of physical dimensions and locations, and an assessment of condition
- The stability and competency of mine openings in terms of public safety and possible hazard mitigation work and/or sealing of the openings
- Potential sources of on-Site borrow material for possible use in response action work, in terms of material type, amounts available and development practicality
- Siting studies to evaluate potential engineering constraints on in-place encapsulation of mine rock piles and potential repository locations
- Site constructability conditions and logistics that could affect implementation of response action work

This section documents the field observations, measurements and assessments that were conducted during the second sampling event in July 2009, which support the Engineering Assessment. Mining-related features that remain from past mining activities were inventoried to indentify the physical limits and quantities of mine rock and other materials, and to identify potential borrow sources for potential reclamation activities. Estimated quantities of mine materials are presented at the end of this section, and are summarized in Table 4-5. Mine rock piles and limits of disturbance were evaluated based on the following criteria:

- Visual observations of physical boundaries
- KSI (2004) boundaries
- Aerial photographs from 1971, 2007, and 2009
- 2007 aerial survey DTM (Ucore, 2009)
- 2009 gamma surveying
- 2009 topographic surveying

The limits of visible disturbance identified during the ESI for the 700-Foot/900-Foot Levels, 300-Foot Level, and OSA are presented in Figures 4-6 through 4-8.

4.6.1 Underground Workings

For safety reasons, the underground workings were not characterized during the 2009 field work. However, the portals at the 300-Foot Level, 700-Foot Level and 900-Foot Level, and also the 900-Foot Level air shaft, were observed and measured, as described in the following sections. The observed air flow and continuous water flow from the 300-Foot Level portal indicate that the underground workings between the 700-Foot and 900-Foot Levels and the 300-Foot Level are interconnected by mine voids to some degree.

4.6.2 700- and 900-Foot Levels

4.6.2.1 Open Pit

Features that remain which were associated with historic mining of the Open Pit include the pit itself and the 900-Foot Level portal, which opens from the Open Pit into the 900-Foot Level mine workings (Figure 4-8). After the pit was mined, it served as the entrance ramp to the 900-Foot Level portal, which is located at the southwest end of the pit (Figure 2-1). The Open Pit has an L-shaped perimeter with its long axis trending roughly north-south, and its short axis trending east-west at the south end. The pit is approximately 350 feet long on its north-south axis, and 150 feet long on its east-west axis, and ranges in width at the rim from 50 to 70 feet on both axes. The pit has a maximum depth of approximately 35 feet at the west end of the shorter axis where the portal is located, and grades uniformly upward toward the existing ground surface at the north end of the longer axis. Once a smoothly graded mining road during active mining, the floor of the pit over the years has accumulated colluvial material falling from the side walls and sediment washing in from the perimeter, which presently supports dense brush vegetation along most of the floor (Figure 4-11). Topographic surveying conducted during the July sampling visit indicates that the Open Pit has a volume of approximately 17,260 cubic yards in its present condition.

Water was observed to be flowing into the 900-Foot Level portal. Besides incident precipitation falling directly into the pit, the primary sources of water observed to flow into the pit were seepage from a dike at the north end, and from surface runoff flowing into the pit at the southwest end immediately west of the portal. In addition to the dike at the north end, a low berm was constructed to divert flow coming from the north and west around the Open Pit to the south. The dike and berm are described in more detail in following sections. Flowing water was observed at the floor of the long axis of the pit for several small stretches (Figure 4-12); surface expression of flow is intermittent due to the coarse makeup of the colluvium at the floor. Water was also observed seeping into the pit from both sidewalls from fractures beginning 10 feet below the rim (Figure 4-13). Although the weather was clear for several days prior to the July visit, heavy, persistent rain occurred for 5 days or longer prior to clearing. Staining of the sidewalls in several locations indicates that water flows directly into the pit during periods of heavy runoff. Two water quality samples were collected from flowing water on the pit floor during the September 2009 sampling event.

4.6.2.2 Open Pit Dike

A dike was constructed at the north end of the Open Pit and was apparently intended to prevent flow from Mine Fork Creek from entering the pit and the 900-Foot Level portal (Figure 4-8). Tetra Tech conducted a visual inspection of the dike to assess its present condition and integrity. The dike appears to have been constructed of mine rock and/or other locally available materials. The axis of the dike trends roughly east-west. The dike is approximately 100 feet long and averages 4 feet high, and has a crest width of approximately 5 feet. The north toe of the dike has thick deposits of course alluvium from Mine Fork Creek along its full length (Figure 4-14). The surface of the dike is densely vegetated with immature evergreen species, low deciduous trees and shrubs, and native grasses and subalpine herbaceous species (Figure 4-15). The dense vegetation prevented inspection of most of the crest and downstream face. However, visual inspection of accessible portions of the dike showed no indications of damage from scour, erosion, overtopping, or other detrimental processes. Seepage was observed to be coming from the downstream toe of the dike, the heaviest seepage occurring in the vicinity of the central axis of the Open Pit (Figure 4-16). Although several areas where the seepage is heaviest had very thin to no vegetation, no detrimental seepage-related or piping-related erosion was observed at the downstream face and toe. At the time of the inspection, an estimated 1 to 2 gallons per minute of flow at the surface was observed to be seeping from the dike, as observed just below the head of the Open Pit.

4.6.2.3 Open Pit Low Berm

A low berm was constructed approximately 200 feet west of the Open Pit, apparently to divert surface runoff, coming from the north and west, to the south, thus preventing it from entering the pit (Figures 4-6 and 4-16). The berm, constructed of sands and gravels, is approximately 100 feet long, 1 to 2 feet high on its upstream side, and 6 to 10 feet wide, with a generally rounded but otherwise unformed crest. The berm is vegetated with grasses and immature trees and shrubs. Small breaches in the berm and seepage from the berm were observed. Evidence of mild overtopping during higher flow events was also observed along the berm crest, although no severe overtopping-related erosion was noted. The inefficiency of the berm has lead to pooling of water in the area immediately northwest of the portal (Figure 4-17), which then flows into the Open Pit at its southwest corner (Figure 4-18).

4.6.2.4 900-Foot Level Portal

The 900-Foot Level portal, which is located within the Open Pit, was open with unrestricted access during each 2009 site visit (Figure 4-19). The portal and stope have approximate dimensions of 15 feet wide by 30 feet high. The portal was partially blocked with rock that appears to have been both intentionally placed to block access and also rock which had fallen from above the portal face. The restricted opening is approximately 15 feet wide by 15 feet high. As the highest floor at the restricted opening was approximately 15 feet above the true floor just inside the portal, no water was flowing into the portal at that elevation. However, water was observed seeping from the rock pile just inside the portal, and was observed to create shallow pooling and low flow into the mine across much of the floor inside the portal for as far as could be seen (Figure 4-20).

4.6.2.5 700-Foot Level Portal and Adit

The 700-Foot Level portal was open with unrestricted access during each 2009 Site visit (Figure 4-21). The portal has approximate dimensions of 9 feet wide by 7½ feet high. No significant rock accumulation which had fallen from above the portal was observed. A shallow pool of water was observed immediately inside the portal face, which extended as far as could be seen (80± feet). Water was not observed flowing from the portal at the ground surface during any of the Tetra Tech 2009 sampling events.

The 700-Foot adit was constructed to provide access to the ore body beneath the 900-Level workings. The absence of water flow from the 700 Foot Level portal is explained by the geometry of the 700 Foot adit shown in a cross section of the mine (Figure 4, KSI 2004). This cross section shows that the 700-Foot Level adit extends a distance of approximately 300 feet inward from the portal to the intersection of the near-vertical shaft connecting the 300-Foot Level. The 700-Foot Level adit extends through the undivided granite and does not intersect the ore body until near the intersection with the near-vertical shaft. Therefore, the 300-Foot Level adit effectively captures and drains water that enters the mine workings above it. The only flow reporting to the 700-Foot Level adit, and thus the 700-Foot Level portal is fracture inflow from bedrock intercepted along 700-Foot Level adit itself. Even during the high-flow period sampled in the September sampling event, flow from the 700-Foot Level adit was absent. In contrast, drainage from the 300-Foot Level portal increased significantly (from 0.04 cfs (18 gpm) during the July sampling event to 0.2 cfs (91 gpm) during the September sampling event) in response to precipitation. Based on the geometry of the 700-Level adit, the absence of flow from the 700-Level portal observed during the ESI sampling events and other investigations is indicative of normal conditions.

4.6.2.6 900-Foot Level Air Shaft

The 900-Foot Level air shaft was open with semi-restricted access during each 2009 Site visit (Figures 4-6 and 4-20). The air shaft is approximately 3 feet in diameter, and has a surface access 'portal' with approximate dimensions of 4 feet wide by 6 feet long by 5 feet deep. Access to the shaft is partially restricted by wire mesh supported over two large logs which have been laid across the shaft. A steel ladder has been constructed into the rock beginning at the top of the shaft; the ladder continues out of sight. Historic drawings of the underground workings suggest that the shaft was constructed to provide ventilation of the workings between the 700- and 900-Foot Levels. Observation of the ground surface surrounding the shaft indicates that although precipitation and runoff are not restricted from the shaft, there are no preferred pathways for surface water to enter the shaft.

4.6.2.7 Mine Rock Piles

Mine rock piles were identified at various locations across the 700- and 900-Foot Levels. Piles include the north and south Mine Rock Piles at the 900-Foot Level, The 700-Foot Level Mine Rock Pile, and six or more smaller embankments at various locations between the 700- and 900-Foot levels that were placed to construct a mine road between these areas (Figure 4-8). Visual observations indicate the mine rock piles generally consist of uniformly graded coarse-grained materials smaller than about 6 inches. The main mine rock piles at the 700- and 900-Foot levels have boulders as large as 2 feet scattered about their surfaces.

The north Mine Rock Pile at the 900-Foot Level is located just north of the north end of the Open Pit, and comprises the outside of the embankment of the haul road (Figure 4-23). The pile is approximately 400 feet long, ranges in width from 60 to 100 feet, and has a maximum depth of approximately 12 feet. Topographic surveying conducted during the July sampling event indicates the pile contains an estimated 8,600 cubic yards of mine rock. A smaller pile, the south Mine Rock Pile, is located approximately 80 feet east of the north end of the Open Pit (Figure 4-24). This pile contains an estimated 600 cubic yards of mine rock.

The 700-Foot Level Mine Rock Pile (Figure 4-25) is located immediately south of the 700-Foot Level portal. This pile occupies an area of approximately 4,413 square feet, with an estimated volume of 7,355 cubic yards. The grain size distribution is similar to the 900-Foot Level piles.

Mine rock was used to construct portions of the mine road between the 700- and 900-Foot Levels. Six primary roadway embankments were constructed using mine rock, which are labeled as piles I through VI on Figure 1-2. These embankments comprise a total of approximately 3,000 cubic yards of mine rock, consisting of a maximum thickness of roughly 5 feet of rock placed to construct road segments with lengths ranging from 50 to 230 feet in steeper areas of the roadway alignment. The embankments were constructed on either exposed bedrock or on thin surficial soils over bedrock. Figure 4-26 presents a photo looking northeast over Mine Rock Pile III, which illustrates the typical thickness and material size of all of the mine rock piles used to construct roads between these two levels of the mine.

4.6.2.8 700/900-Foot Level Ground Surface Cover

The 700- and 900-Foot Levels lie in a subalpine environment at the southeast toe of Bokan Mountain. The topography is generally characterized by steep, rocky terrain. In addition to the discrete piles of mine rock, thin layers of mine rock and mining-related soils are present in the vicinity of the Open Pit and in the areas immediately adjacent to the piles and roads.

Vegetative cover varies across the Site from being completely absent in areas of exposed bedrock to dense evergreen forests in areas with a sufficiently thick soil profile to support the trees. Figure 4-27 presents a north-looking aerial photo illustrating the ground surface cover across the 700- and 900-Foot Levels. The Open Pit is seen in the upper center of the photo, and the 700-Foot Level mine rock dump is seen at the lower left corner. The photo illustrates that a significant portion of the ground surface to the south of the north end of the Open Pit is bare rock, with sparse vegetation growing in the thin mantle soils. Figure 4-28 graphically shows the various ground surface cover types across the site.

4.6.3 300-Foot Level

The features present at the 300-Foot Level include the portal and mine rock pile (Figure 4-9). A large variety of solid waste is also present here, including collapsed trailers and buildings, two snow machines, crumbling stacks of core, etc. Several hardhats bearing the insignia Standard Metals were present in one of the partially collapsed structures. A small volume of petroleum-contaminated soils is present near the Generator Shack (or Mineral Custody Shed).

4.6.3.1 300-Foot Level Portal

The 300-Foot Level portal was open with unrestricted access during each 2009 Site visit (Figure 4-29). The portal has approximate dimensions of 20 feet wide by 17 feet high and quickly narrows to the dimensions of the adit. A small (3± ft high) pile of rock had fallen from overhead at the fall line, partially blocking drainage from the pit. A small boat on a trailer is located inside the portal.

4.6.3.2 300-Foot Level Mine Rock Pile

The mine rock pile at the 300-Foot Level is the largest pile at the Site. Historic documents report that a portion of the pile consists of development rock which was generated during construction of the 300-Foot Level adit. The adit is approximately 16 feet wide, 13 feet high, and approximately 1300 feet long. Using these dimensions and a bulking factor of 20 percent yields an estimated 12,000 cubic yards of development rock. Additional development rock produced to connect the 300-Foot Level adit to the 700- and 900-Foot Level workings could provide an additional estimated 1,700 cubic yards of rock. The approximate limits of visible disturbance presented in Figure 4-8 were taken from KSI (2004), and confirmed by observation and hand-held GPS to the extent possible during the July sampling event. Base topography, site observations, and pile topography from KSI (2004) were used to calculate an estimated 28,854 cubic yards of mine rock at the 300-Foot Level. Using an estimate of approximately 1300 feet of development tunnel through the non-mineralized quartz monzonite material, approximately 48 percent of the mine rock at this site is comprised of development rock. Some or all of this development rock may be unmineralized.

The surface of this pile is densely vegetated, which severely impedes or prohibits observation of the surface, foot travel, and topographic surveying (Figure 4-30). The upper surface of the pile is generally hummocky. Based on methods used to generate the development rock, it is anticipated that it has a coarser size fraction than the mine rock at the 700- and 900-Foot

Levels. The toe of the 300-Foot Level pile contains much larger size fraction rock than the side slopes and upper surface of the pile, with boulders larger than 1 to 2 feet in many areas along the toe (Figure 4-31).

4.6.4 Ore Staging Area

The Ore Staging Area (OSA) is surrounded by an earthen berm constructed to divert surface runoff from the north around the OSA to the east and south. The visible limits of the OSA were topographically surveyed during the July sampling event (Figure 4-10). Tetra Tech overlaid the 2009 survey topography on the Ucore DTM and 1971 aerial photograph to confirm the disturbed area footprint of the OSA. Observations made during collection of soil samples from the OSA indicate that a dense organic mat on the order of 12- to 18-inches thick has developed across the majority of the disturbed area. Only in the central portion of the OSA is bare soil exposed. The depth of mine-influenced soil beneath the organic mat is unknown. Due to the dense vegetation at the site, Tetra Tech was unable to estimate the grain size distribution of the materials below the organic mat; however, based on knowledge of previous cleanup and demobilization activities, it is likely to be similar to or finer than the mine rock piles at the 700- and 900-Foot Levels. Additionally, a pile consisting of 12 or more 5-foot +/- diameter radioactive boulders was found along the eastern perimeter of the OSA. The assumptions and estimated quantities are presented in Section 4.6.8.

4.6.5 Rock Loadout Ramps and Ore Loading Docks

Two rock loadout ramps, which were associated with the ore loading docks, extend from the OSA area into the Kendrick Bay intertidal zone. A third and older ramp is located approximately 600 feet west of the existing floating dock as shown on Figures 1-2 and 4-30. The middle ramp was constructed prior to the 1971 activities; the existing boat dock is present at this ramp. The rock ramp on the eastern side was constructed in 1971 to connect to the ore loading dock, which was used to load ore onto barges. A photo of these two rock loadout ramps is presented in Figure 4-33. The source of the rock used to construct the ramps is unknown. The estimated quantities of material comprising the west and east ramps are 370 and 580 cubic yards, respectively.

4.6.6 Roads

Roads constructed for exploration and mining at the Site included primary haul roads connecting the loading docks at Kendrick Bay to the 900- and 300-Foot Levels, and smaller mine roads connecting the 700- and 900-Foot levels.

4.6.6.1 Haul Roads

The haul road between the OSA and the 300-Foot Level (300-Foot Level haul road) is approximately 6,785 feet long, and that between the 300-Foot Level road and the 900-Foot Level (900-Foot Level haul road) is approximately 5,850 feet long. Based on construction sequencing, the roads would have to have been initially constructed to provide access to the mines, and consequently would have been constructed of non-mineralized materials.

The roads were cut using conventional cut and fill methods, whereby a cut is made into the hillside, and the fill generated in the process is placed over the downhill edge, providing additional road width. Additional coarse roadbed material was likely mined from the intertidal zone. As the hillsides across which the roads are constructed are moderately to very steep in most areas, the uphill and downhill edges of the road are as steep or steeper than the natural terrain. The downhill edges are loose from the presence of unconsolidated fill. These conditions, combined with dense ground-level vegetation and wet, mossy conditions above and below the roads, severely impedes or prevents safe foot travel (Figure 4-34).

Measurements taken during 2009 indicate the haul roads range in width from 27 feet to 32 feet. Several areas identified on the 900-Foot Level road were as narrow as 23 feet at rock outcrops and tight corners. Natural revegetation since 1971 operations has reduced the passable road width to 8 feet to 12 feet (Figure 4-35).

Gamma surveys by Tetra Tech in 2009 and by KSI (2004) identified numerous areas along the road surfaces where gamma readings were found to be higher than surrounding areas (Figure 4-36). Areas identified by Tetra Tech were consistent with those identified by KSI. Tetra Tech identified 10 areas along the 300-Foot Level Road and 9 along the 900-Foot Level Road with these higher gamma exposure readings. Considering that the road surfaces must have been uncontaminated immediately prior to hauling the first ore produced, it is likely that the materials causing higher gamma readings in these areas were from reconstruction of damaged portions of the roads for exploration purposes, or for work related to mining and/or from spillage of ore along the haul routes. This type of spillage would be in the form of a thin surface veneer; for quantity estimation purposes, Tetra Tech assumed the roadway mine rock fill causing higher gamma readings was 1-foot thick in identified areas. Estimated quantities of mine rock materials are presented below and summarized in Table 4-5.

4.6.6.2 I&L Zone

A short spur was also constructed off of the 900-Foot Level haul road several hundred feet east of the Open Pit to provide access to the I&L Zone (Figure 4-37). The road is 16 to 21 feet wide, approximately 500 feet long, and 1 to 2 feet thick. Beyond this fill section, the I&L Zone access road is predominantly on original ground. Gamma survey results from 2009 suggest this road was constructed of mine rock sources from the 900-Foot Level.

4.6.6.3 Landslides

During the initial 2009 site visit conducted in April, Tetra Tech identified a landslide on the 300-Foot Level haul road approximately 700 feet east of the 300-Foot Level. The landslide began just below the south edge of the road and ran for several hundred feet. Tetra Tech personnel directed a flyover of this area during the July sampling event to visually survey the landslide, and identified a second and smaller landslide immediately west of the initial slide. Figure 4-38 shows an aerial photo of the landslides.

A geotechnical engineer from Tetra Tech conducted a visual field survey of the landslide sites to surmise the present condition and possible causes of the landslides. The slides appear in the Ucore (2009) aerial photo (which was taken in 2005), but do not appear in the 1971 photograph. The west landslide is approximately 60 to 70 feet wide and 200 feet long, with its head scarp located approximately 20 feet below the south edge of the road (Figure 4-39). The east landslide is approximately 450 feet long, with its head scarp located immediately at the south edge of the road (Figure 4-40). The upper half of the slide is approximately 100 feet wide, and narrows to approximately 80 feet wide for its lower half. Both slides can be classified as slips of shallow mantle (surficial) soils over or immediately above a saturated bedrock surface. Observation of the head and flanks of both slides show them to be slides in the upper 2 to 4 feet of the soil surface. The saturated bedrock surface was exposed near the head of the west slide.

Geologic mapping (MacKevett 1963) shows the bedrock beneath the slides to be quartz monzonite and granodiorite. Soils observed in the slide flanks consist of up to 4 feet of low plasticity, colluvial silty sand to sandy silt overlain by an 8- to 12-inch thick organic mat. At the time of our site visit, the soils above the bedrock were observed to be saturated (Figure 4-41). The hillside on which the slides occurred has a slope of approximately 21 degrees. Observations of mature trees (12-inch to 16-inch diameter) at the flanks of both slides showed pistol-butting of these trees (Figures 4-40 and 4-41), which is evidence that these soils have been creeping downhill over the surface of the bedrock for many years, and likely predates the construction of the 300-Foot Level road. The observed conditions at the Site indicate that the processes which caused the slope failures have been ongoing for at least as long as the oldest trees in the area.

4.6.7 Stability of Mine Rock Piles and Road Embankments

The following general observations were made regarding the apparent stability of the piles as assessed by visual inspection. No slope failures or progressive raveling of material from the surface of the mine rock piles were noted. At all mine rock piles, there is insufficient fines content in the surficial materials to facilitate the development of rilling or gullying. Exceptions were noted in a few isolated and highly localized areas of the haul road surfaces, where concentrated runoff was observed to have created shallow ruts and/or gullies; these features were limited to the road surface, and deposition of the eroded material was not observed beyond the discernable road embankment toes. No materials were observed at the pile and haul road surfaces which were judged to be sufficiently fine as to be susceptible to wind transport; dense canopy and ground cover, where present, also effectively prevent wind erosion.

Overall, no evidence was observed of the migration of materials beyond the toes of the piles. Although some ongoing downhill creep is possible for steeper pile slopes and for piles on steeper natural slopes, the observed development of vegetation along the slope toes indicates that any such creep is occurring very slowly, if at all. Further, although some material may have been transported short distances by gravity and/or water prior to stabilization of the surfaces and toes by vegetation, the piles appear to have been relatively stable for many years.

The apparent stability of the piles and road embankments can be attributed to several primary factors, including 1) the coarse grain size and correspondingly higher internal friction angle (a measure of soil strength) of the materials; 2) pile and embankment slopes do not exceed the maximum natural angle (angle of repose) for materials of this constituency; and 3) where present, dense and damp to wet ground cover serve to stabilize the surfaces from wind and runoff erosion. Based on these observations, it is apparent that the mine rock piles and road embankments are relatively stable in place, and have not been susceptible to observable off-site migration by wind or water erosion processes.

4.6.8 Mine Rock Material Quantities

Quantities of mine rock materials were estimated from the results of Tetra Tech's 2009 field studies. Estimated quantities of source materials are presented in Table 4-5. Quantities reported by KSI are included in the table for comparison.

Quantities reported by KSI (2004) and those estimated from 2009 field activities are generally consistent, with several exceptions. Significant variations between KSI and Tetra Tech estimates were found for the 700-Foot Level and 300-Foot Level mine rock piles and the OSA.

Tetra Tech surveyed the perimeter of the 700-Foot Level mine rock pile, and laid this detailed topography over the Ucore DTM. The results indicated an approximate area and volume of

4,413 square yards and 7,355 cubic yards, respectively. Tetra Tech compared the surveyed footprint with a 1971 aerial photograph of the site, and confirmed that the surveyed footprint is consistent with mining activities at the time of the 1971 photo. These estimates are significantly higher than KSI's estimates of 2,061 square yards and 4,350 cubic yards, respectively.

Tetra Tech was unable to survey the 300-Foot Level mine rock pile due to dense vegetation across the site. Consequently, quantities were estimated by reconstructing KSI's (2004) mine pile topography from Figure 9 of the Ucore (2009) DTM. The results indicated an approximate area and volume of 5,900 square yards and 29,000 cubic yards, respectively. These estimates are higher than KSI's (2004) estimates of 4,700 square yards and 23,000 cubic yards, respectively.

The estimated volume of the OSA materials was developed from site observations, topographic survey, review of historic aerial photography, and knowledge of cleanup and demobilization activities performed after mining ceased. The disturbed area of the OSA, as discussed in Section 4.6.4, was confirmed based on the 2009 survey and comparison with the recent Ucore mapping and aerial photography. Based on this information, the total disturbed surface area of the OSA is 6,758 square yards (1.4 acres). Of this surface area, approximately 758 square yards is exposed bare soil in the central portion of the OSA. Therefore, the estimated volume of material in the OSA is comprised of an assumed 18-inch thick surficial organic mat over 6,000 square yards of the OSA and two feet of affected soil over the total surface area of 6,758 square yards of the OSA. The total estimated material volume of the OSA is 7,500 cubic yards as summarized in Table 4-5.

The mining-influenced materials on the OSA and 300-900 haul roads were identified by gamma survey. Contaminated segments were generally consistent with those identified in KSI (2004), and are shown on Figure 4-36. When estimating quantities of contaminated materials on the haul roads, it was assumed that contamination is limited to the upper foot of the road surface.

As described previously, discrete pieces of ore were found scattered among the native materials within the intertidal zone surrounding the loadout ramps at the OSA. Pieces of ore ranging in size from 3 to 30 inches were identified on and between the loadout ramps, and higher gamma was measured in an area extending from approximately 100 feet east of the 1971 ramp to approximately 150 feet west of the ramp hosting the existing dock. Extending this area out from the shoreline into the bay to a point approximately where the southern edge of an ore barge anchored at the loadout dock (approximately 170 feet out from the high tide line at the dock) encompasses an area of approximately 12,300 square yards (2.5 acres).

4.6.9 Potential Borrow Sources and Repository Locations

Potential borrow sources and repository locations were evaluated during the July sampling event as part of the field engineering reconnaissance. The field assessment identified no practically useable areas with suitable materials of sufficient volume for fine-grained materials. Potential repository locations were also evaluated during the field reconnaissance. Three potential repository locations were identified and will be further assessed during the EE/CA.

Table 4-1. Annette, Alaska Average Temperature and Rainfall by Month

Month	Average High Temperature (ºF)	Average Low Temperature (ºF)	Average Rainfall (inches)
January	39	30	10.07
February	42	32	8.79
March	45	34	7.89
April	50	37	7.79
May	56	42	6.03
June	61	48	4.67
July	65	52	4.27
August	65	52	6.15
September	60	48	9.28
October	52	42	15.47
November	44	35	11.67
December	40	31	11.20

Based on a 29-year record
Source: WRCC, 2009

Table 4-2. Annette, Alaska Maximum Precipitation and Snowfall by Month

Month	Precipitation (inches)				Snowfall (inches)	
	Year	Maximum Monthly Precipitation	Normal Precipitation	Departure from Normal	Year	Observed Snowfall
January	1958	20.69	10.07	10.62	1974	36.3
February	1965	18.06	8.79	9.27	1974	33.4
March	1960	23.57	7.89	15.68	1971	46.9
April	1949	21.35	7.79	13.56	1971	22.2
May	1966	14.68	6.03	8.65	1964	5.0
June	1956	10.4	4.67	5.73	1988	Trace
July	1959	10.85	4.27	6.58	N/A	0
August	1958	20.72	6.15	14.57	N/A	0
September	1987	17.4	9.28	8.12	N/A	0
October	1958	34.87	15.47	19.4	1956	4.2
November	1959	28.09	11.67	16.42	1994	24.8
December	1959	28.9	11.2	17.7	1964	44.8

Source: WRCC, 2009

Table 4-3. Annette, Alaska Average Wind Speed and Prevailing Direction

Month	Average Wind Speed (mph)	Prevailing Direction Through 1964
January	12.0	ESE
February	12.3	SE
March	11.0	SE
April	11.2	SSE
May	9.3	SSE
June	9.0	SSE
July	8.0	SSE
August	8.3	SSE
September	9.3	SE
October	12.0	SE
November	12.4	ESE
December	12.6	ESE

Source: WRCC, 2009

Table 4-4. Uranium and Thorium Minerals in the Ross-Adams Deposit

Mineral		Chemical Formula
Primary Minerals	Uranothorite	$(Th,U)SiO_4$
	Uranoan Thorianite	$(Th,U)O_2$
	Uraninite	UO_2
	Coffinite	$U(SiO_4)_{1-x}(OH)_x$
Secondary Minerals	Gummite	A mixture of uraninite and secondary uranium minerals of variable composition
	Sklodowskite	$Mg(UO_2)_2Si_2O_7$ • 6H2O
	Beta-uranophane	$Ca(UO_2)_2[HSiO_4]_2 \cdot 5H_2O$
	Bassetite	$Fe^{2+}(UO_2)_2(PO_4)_2 \cdot 8H_2O$
	Novacekite	$Mg(UO_2)_2(AsO_4)_2 \cdot 12(H_2O)$

Table 4-5. Ross-Adams Source Material Quantity Estimates

Source	Estimated Area (SY)	Estimated Volume (CY)	Comments and Assumptions
700- Foot and 900-Foot Levels			
900-Foot Level			
North Mine Rock Pile (TT 2009)	4,693	8,604	Surveyed/Ucore DTM, 5.5' Avg. Thickness
South Mine Rock Pile (TT 2009)	588	588	Surveyed/Ucore DTM, 3' Avg. Thickness
Subtotal	***5,281***	***9,192***	
Adjusted Subtotal		***10,111***	Volume inflated 10% for lateral variation
North Mine Rock Pile (KSI 2004)	4,645	10,840	GPS, Assumed 7' Avg. Thickness
South Mine Rock Pile (KSI 2004)	558	700	GPS, Assumed 3.8' Avg. Thickness
Subtotal	*5,203*	*11,540*	
700-Foot Level			
700-Foot Level Mine Rock Pile (TT 2009)	***4,413***	***7,355***	Surveyed/Ucore DTM, 5' Avg. Thickness
700-Foot Level Mine Rock Pile (KSI 2004)	2,061	4,350	GPS, Assumed 6.3' Average Thickness
Adjusted Subtotal		***8,091***	Volume inflated 10% for lateral variation
Mine Road Embankments			
I (TT 2009)	630	945	Surveyed/Ucore DTM, 4.5' Avg. Thickness
II (TT 2009)	209	313	Surveyed/Ucore DTM, 4.5' Avg. Thickness
III (TT 2009)	910	910	Surveyed/Ucore DTM, 3' Avg. Thickness
IV (TT 2009)	269	448	Surveyed/Ucore DTM, 5' Avg. Thickness
V (TT 2009)	149	248	Surveyed/Ucore DTM, 5' Avg. Thickness
VI (TT 2009)	161	161	Surveyed/Ucore DTM, 3' Avg. Thickness
Subtotal	***2,328***	***3,025***	
I (KSI 2004)	681	740	GPS, Assumed 3.2' Average Thickness
II (KSI 2004)	298	290	GPS, Assumed 2.9' Average Thickness
III (KSI 2004)	490	440	GPS, Assumed 2.8' Average Thickness
IV (KSI 2004)	418	220	GPS, Assumed 1.6' Average Thickness
V (KSI 2004)	287	270	GPS, Assumed 2.8' Average Thickness
VI (KSI 2004)	490	440	GPS, Assumed 2.6' Average Thickness
Subtotal	*2,664*	*2,400*	
700-Foot/900-Foot Levels Subtotal (TT 2009)	***12,022***	***21,227***	
300 Level			
300-Foot Level Mine Rock Pile (TT 2009)	***5,929***	***28,854***	KSI (2004) Fig. 9 & Ucore (2009) DTM
300-Foot Level Adit Development Rock		***13,724***	13' x 16' x 1,300' plus 8' x 8' x 600', 20% bulking factor
300-Foot Level Mine Rock Pile (KSI 2004)	4,700	23,240	GPS. Assumed 14.8' Average Thickness
Ore Staging Area			
OSA (KSI 2004)	3,360	2,800	GPS, Assumed 2.5' Average Thickness
OSA (TT 2009)	6,000	3,000	2009 Survey/Ucore DTM, Assumed 1.5' Thick organic mat
OSA (TT 2009)	6,758	4,500	2009 Survey/Ucore DTM, Assumed 2' cont. soil
OSA Subtotal (TT 2009)	***6,758***	***7,500***	
East Loadout Ramp (TT 2009)		580	2009 Survey/Ucore DTM
West Loadout Ramp (TT 2009)		370	2009 Survey/Ucore DTM
Original Ramp (TT 2009)		150	Contaminant reduction zone

Table 4-5. Ross-Adams Source Material Quantity Estimates (continued)

Source	Estimated Area (SY)	Estimated Volume (CY)	Comments and Assumptions
Haul Road Contamination			
OSA - 300 (TT 2009)			
Section 1	1,544	514	Based on Gamma survey, 1' thick
Section 2	510	170	Based on Gamma survey, 1' thick
Section 3	657	219	Based on Gamma survey, 1' thick
Section 4	312	104	Based on Gamma survey, 1' thick
Section 5	99	33	Based on Gamma survey, 1' thick
Section 6	306	102	Based on Gamma survey, 1' thick
Section 7	466	155	Based on Gamma survey, 1' thick
Section 8	255	85	Based on Gamma survey, 1' thick
Section 9	215	71	Based on Gamma survey, 1' thick
Section 10	435	145	Based on Gamma survey, 1' thick
Subtotal	***4,799***	***1,598***	
300 - 900 (TT 2009)			
Section 1	163	54	Based on Gamma survey, 1' thick
Section 2	625	208	Based on Gamma survey, 1' thick
Section 3	444	148	Based on Gamma survey, 1' thick
Section 4	684	228	Based on Gamma survey, 1' thick
Section 5	619	206	Based on Gamma survey, 1' thick
Section 6	150	50	Based on Gamma survey, 1' thick
Section 7	365	121	Based on Gamma survey, 1' thick
Section 8	97	32	Based on Gamma survey, 1' thick
Section 9	1,215	404	Based on Gamma survey, 1' thick
Subtotal	***4,362***	***1,451***	
I & L Spur (TT 2009)	1,028	343	Based on Gamma survey, 1' thick
Total Haul Road Contamination	***10,189***	***3,392***	
Total Mine Affected Materials (TT 2009)	***34,898***	***62,073***	900-Foot Level Mine Rock Piles (10,111 CY), 700-Foot Level Mine Rock Pile (8,091 CY), Mine Road Embankments (3,025 CY), 300-Foot Level Mine Rock Pile (28,854 CY), OSA (7,500 CY), Loadout Ramps (1,100 CY), and Haul Roads (3,392 CY)
Open Pit Volume		17,258	

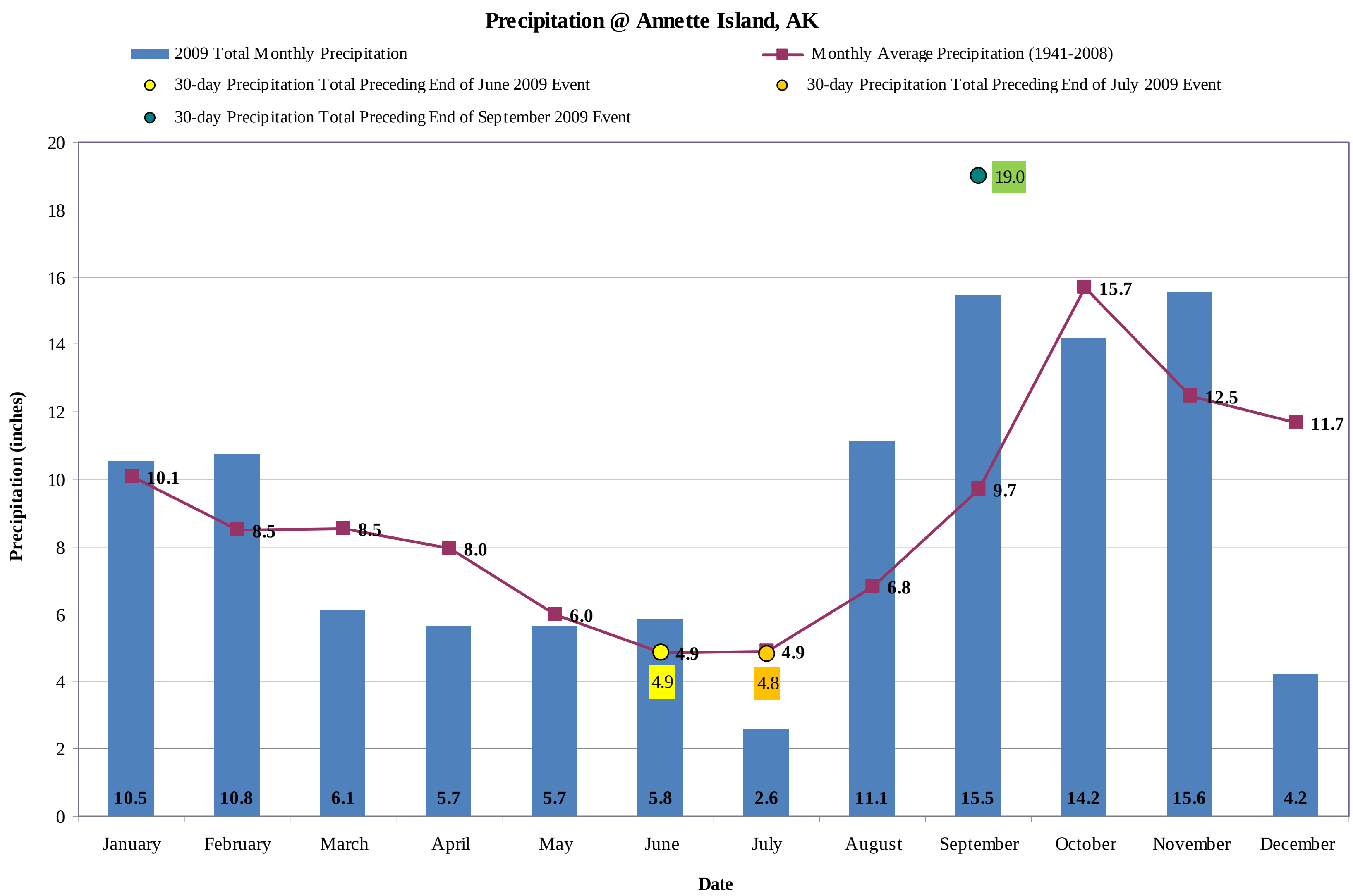
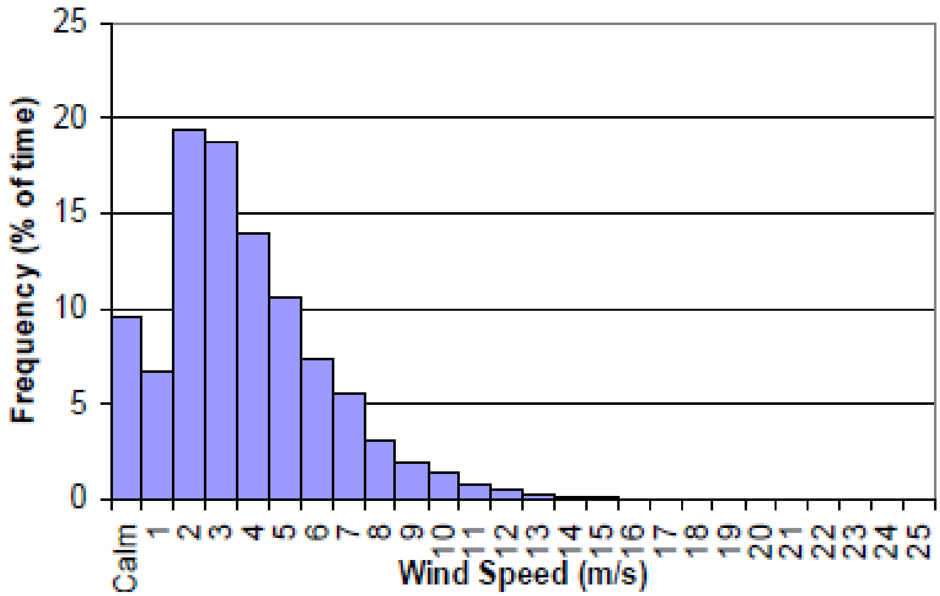
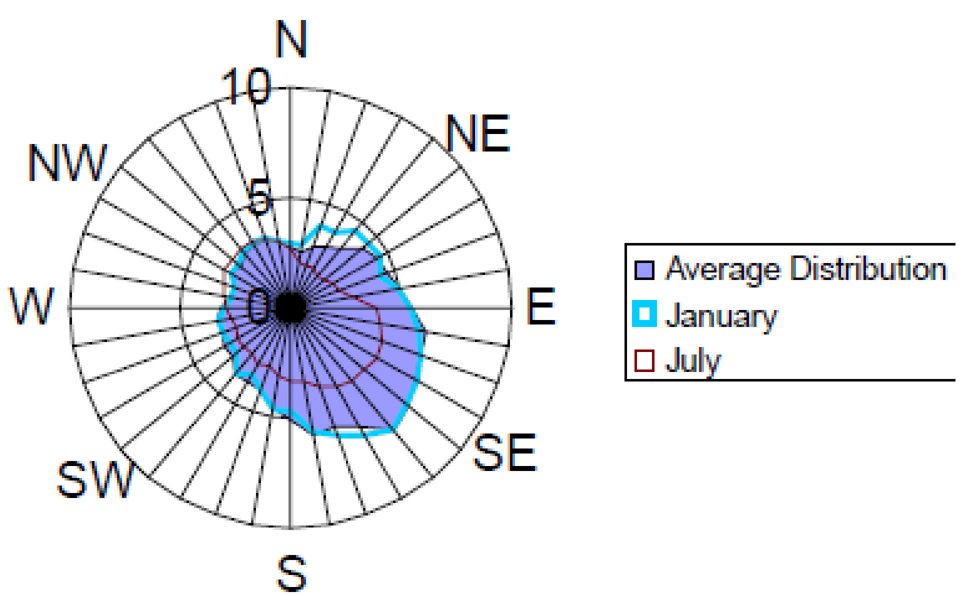


Figure 4-1
Ross-Adams Mine Site
Precipitation at Annette Island, AK



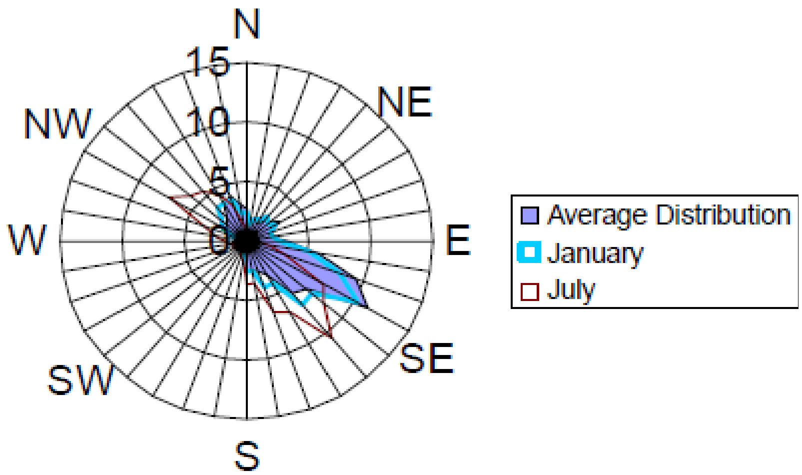
Source: Alaska Energy Authority 2005

Figure 4-2. Wind Speed Frequency Distribution



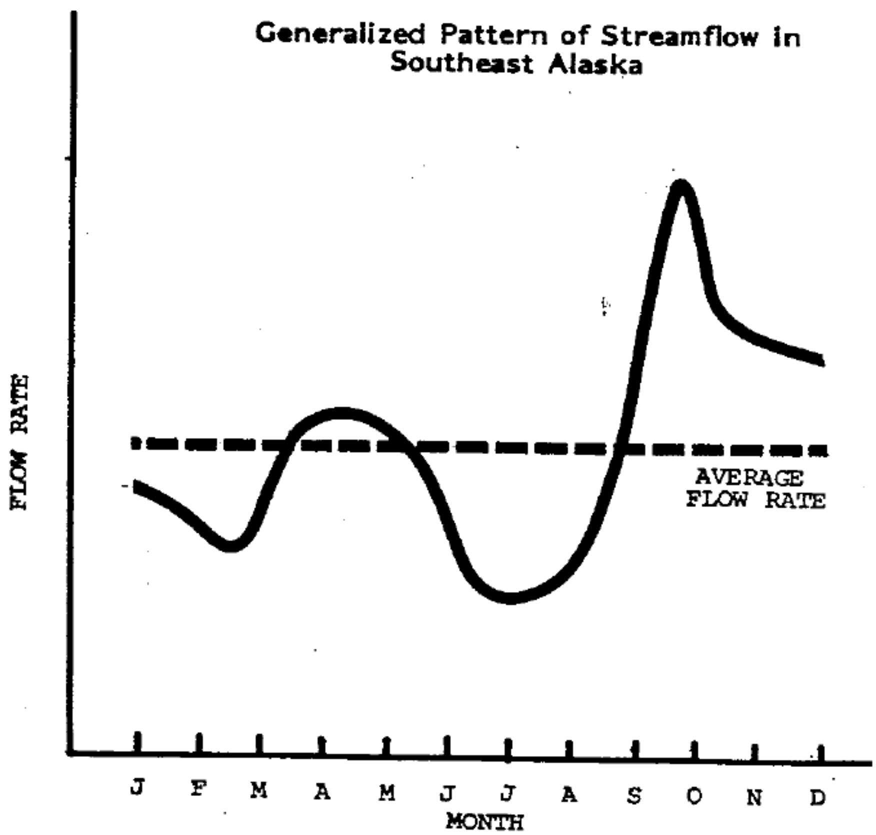
Source: Alaska Energy Authority 2005

Figure 4-3. Wind Speed Distribution Rose (m/s)



Source: Alaska Energy Authority 2005

Figure 4-4. Wind Frequency Distribution Rose (% of Time)



Source: Pacific Rim Planners, 1979

Figure 4-5. Typical Seasonal Stream Flow-Southeast Alaska

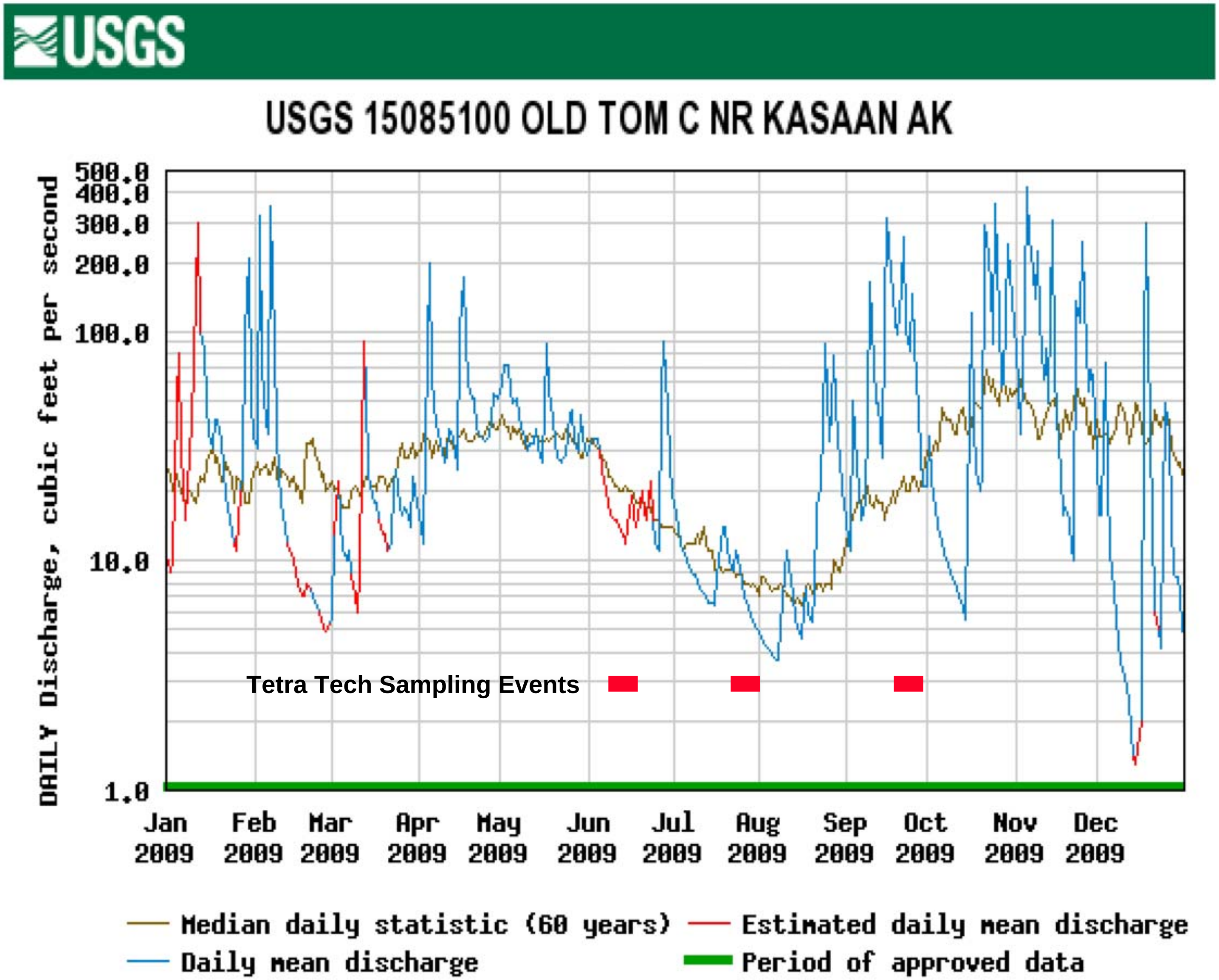
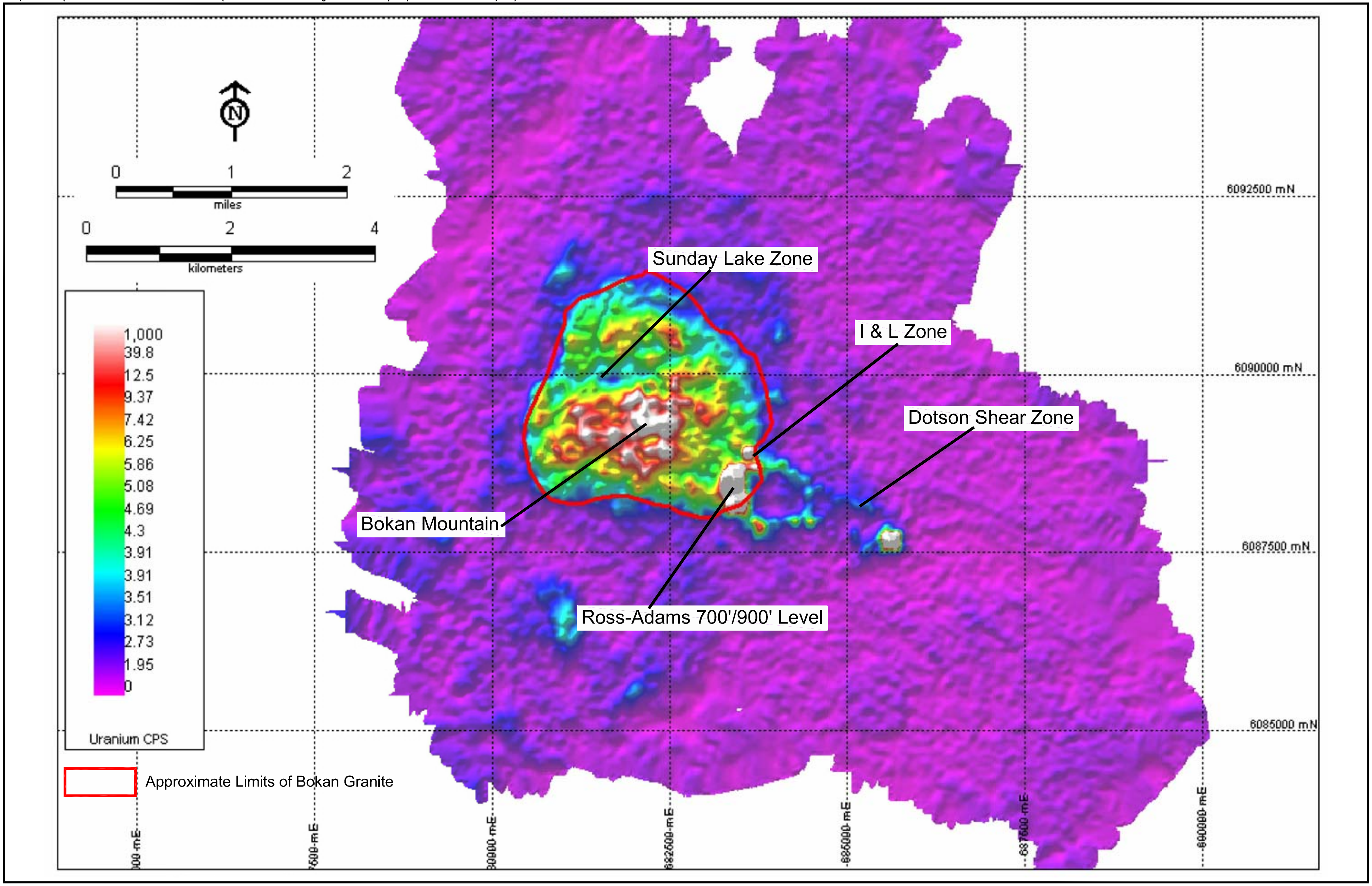


Figure 4-6
Ross-Adams Mine Site
Daily Stream Flow for Old Tom Creek Near Kasaan, AK



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Notes:
1. Used By Permission From Ucore Uranium.
2. UTM Grid WGS 84 Zone 8.

Figure 4-7
Bokan Mountain Airborne Radiometric Survey (2007)

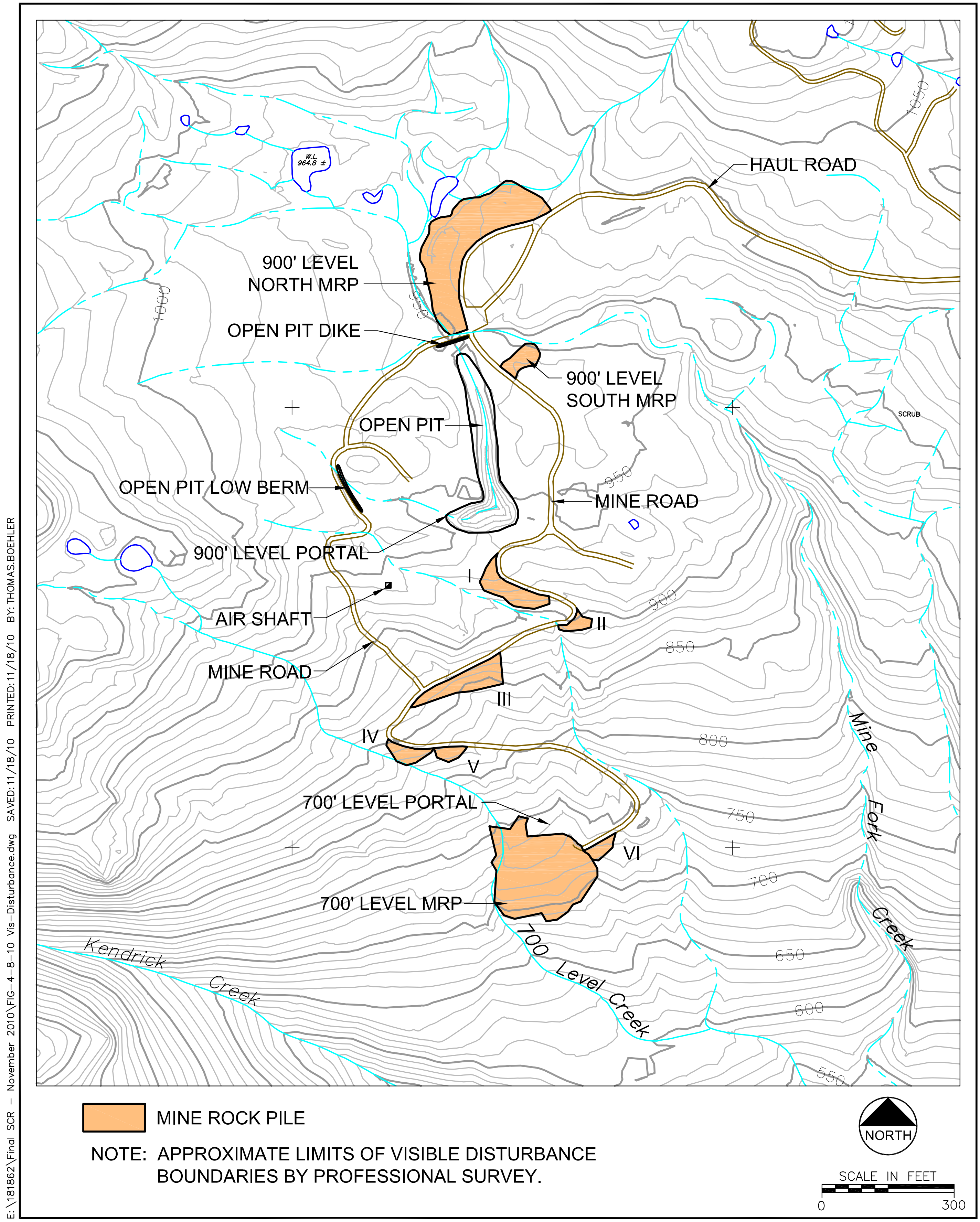

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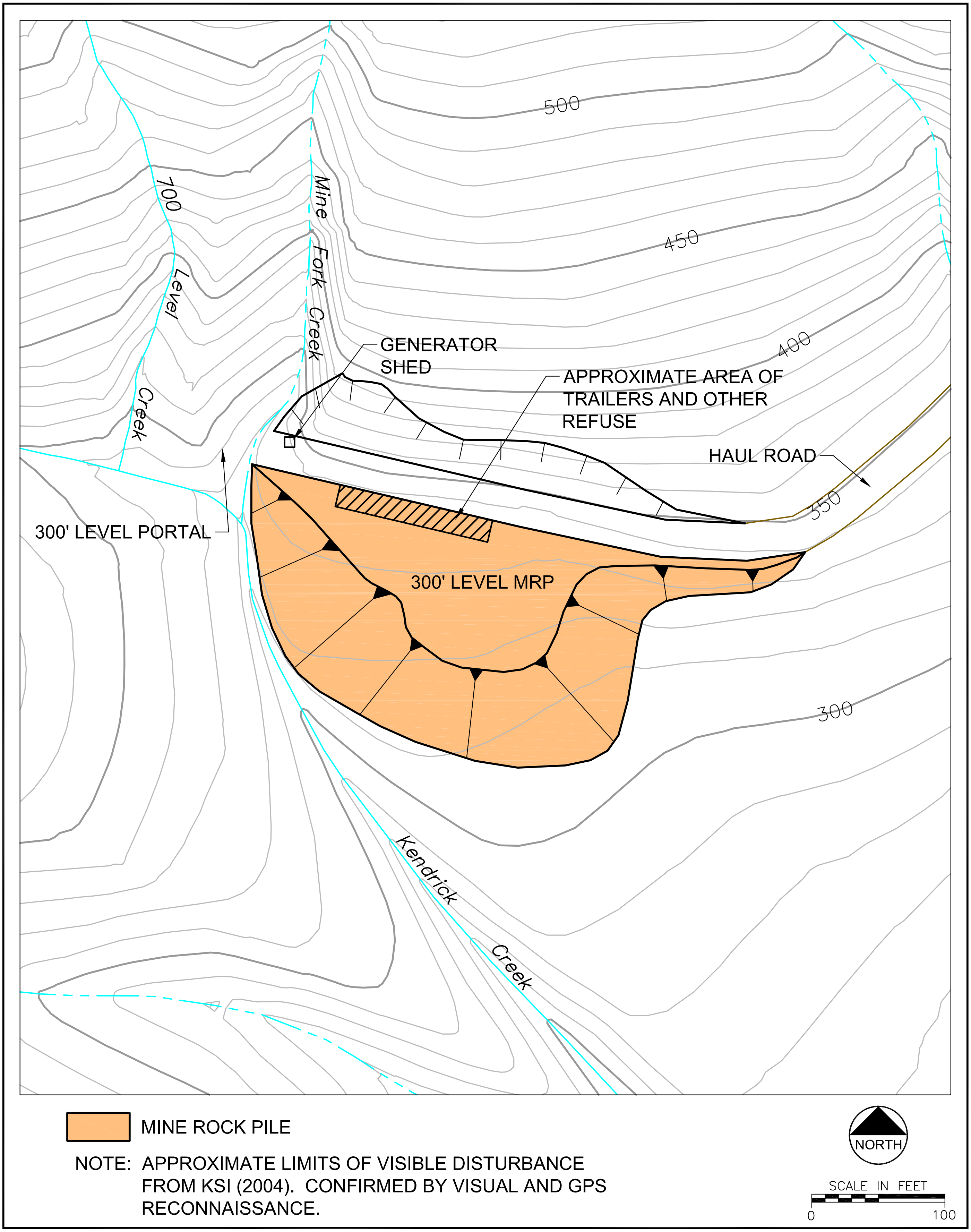
Figure 4-8
Ross-Adams Site
700-Foot and 900-Foot Levels: Limits of Visible Disturbance



NOTE: APPROXIMATE LIMITS OF VISIBLE DISTURBANCE FROM KSI (2004). CONFIRMED BY VISUAL AND GPS RECONNAISSANCE.

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Figure 4-9
Ross-Adams Site
300-Foot Level: Limits of Visible Disturbance

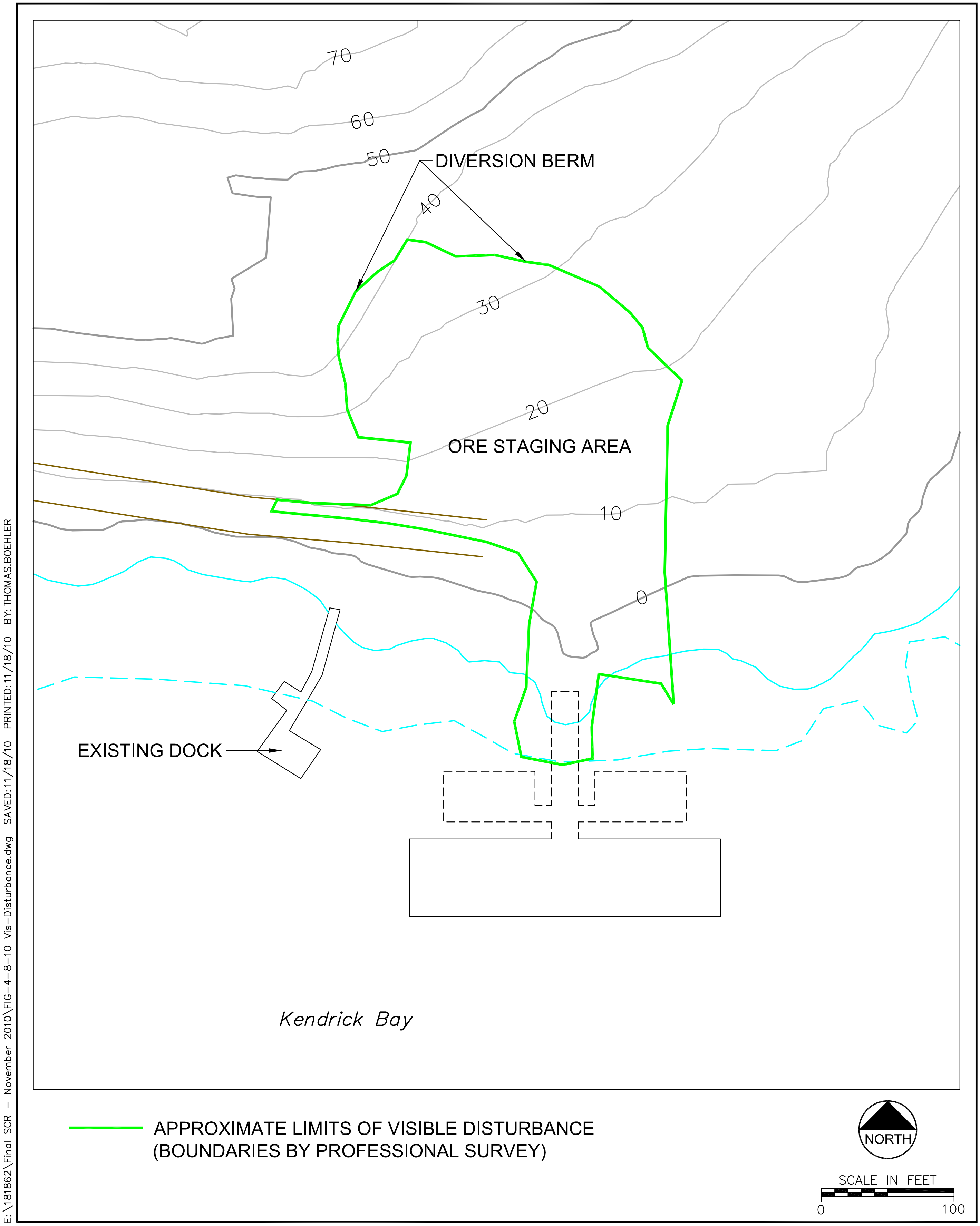

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Figure 4-10
Ross-Adams Site
Ore Staging Area (OSA): Limits of Visible Disturbance

Figure 4-11. Photo looking north over the long axis of the Open Pit from the south end, showing colluvial deposits along the floor and dense brush vegetation

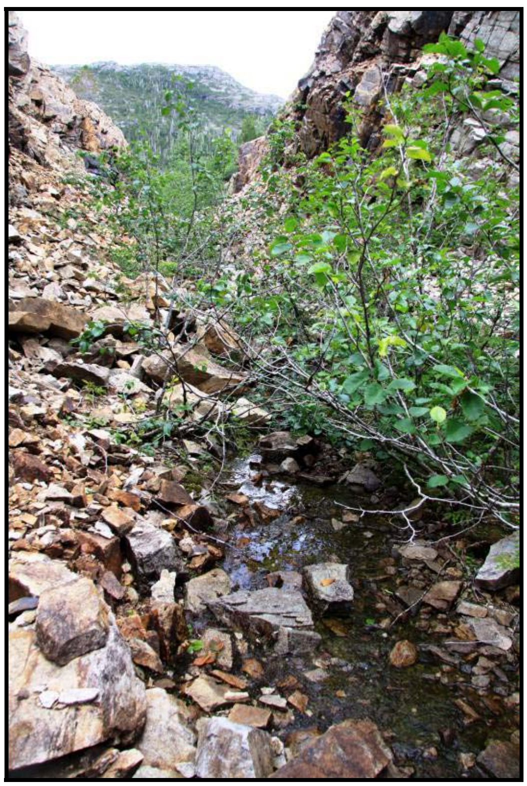


Figure 4-12. Photo looking north from the floor of the Open Pit, showing a short, shallow surface expression of flow toward the portal
(The flow at the time of the photo was estimated at several gallons per minute. Photo taken from approximately 70 feet north of portal).

Figure 4-13. Photo looking north on the west wall of the Open Pit, showing groundwater seepage from bedrock fractures
(The wall was dry for approximately 10 feet below the rim).

Figure 4-14. Photo looking west along the south fork of Mine Fork Creek and the upstream face (left) of the dike at the north end of the Open Pit, showing the dense vegetation and heavy alluvial deposition
(Photo taken from immediately west of the confluence of the north and south forks of Mine Fork Creek).

Figure 4-15. Photo looking north at the downstream face of the dike, illustrating the type and species of vegetation which have developed over the surface

Figure 4-16. Photo looking north at the seepage coming from the downstream (south) toe of the Open Pit dike

Figure 4-17. Photo looking southeast toward the southwest corner of the Open Pit, which is just beyond the pool at the upper left
(Note: The Open Pit low berm on the far right side diverts surface runoff around the pit to the south, as seen in the upper right corner. The sources of the pooled water seen in the upper left include flow through small breaches in the berm, seepage through the berm, and overtopping during higher flow events.)

Figure 4-18. Photo looking southwest down into the Open Pit and 900-Foot Level portal showing the point at which surface runoff from the north and west (seen on the right side) enters the pit
(Note: Flow at the time the photo was taken was on the order of several gallons per minute.)

Figure 4-19. Photo looking southwest at the 900-Foot Level portal

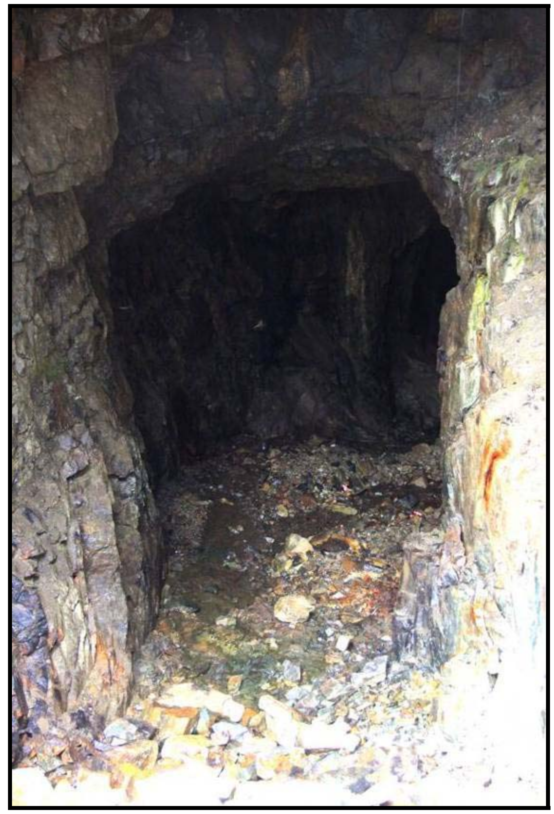


Figure 4-20. Photo looking south into the 900-Foot Level portal, showing water flowing from the rock pile which partially blocks the portal
(The photo also shows the adit bending toward the right (west) approximately 100 feet inside the portal.)

Figure 4-21. Photo of 700-Foot Level portal

Figure 4-22. Photo looking over the 900-Foot Level air shaft
(Note the rust-colored radon-monitoring canisters on the right).

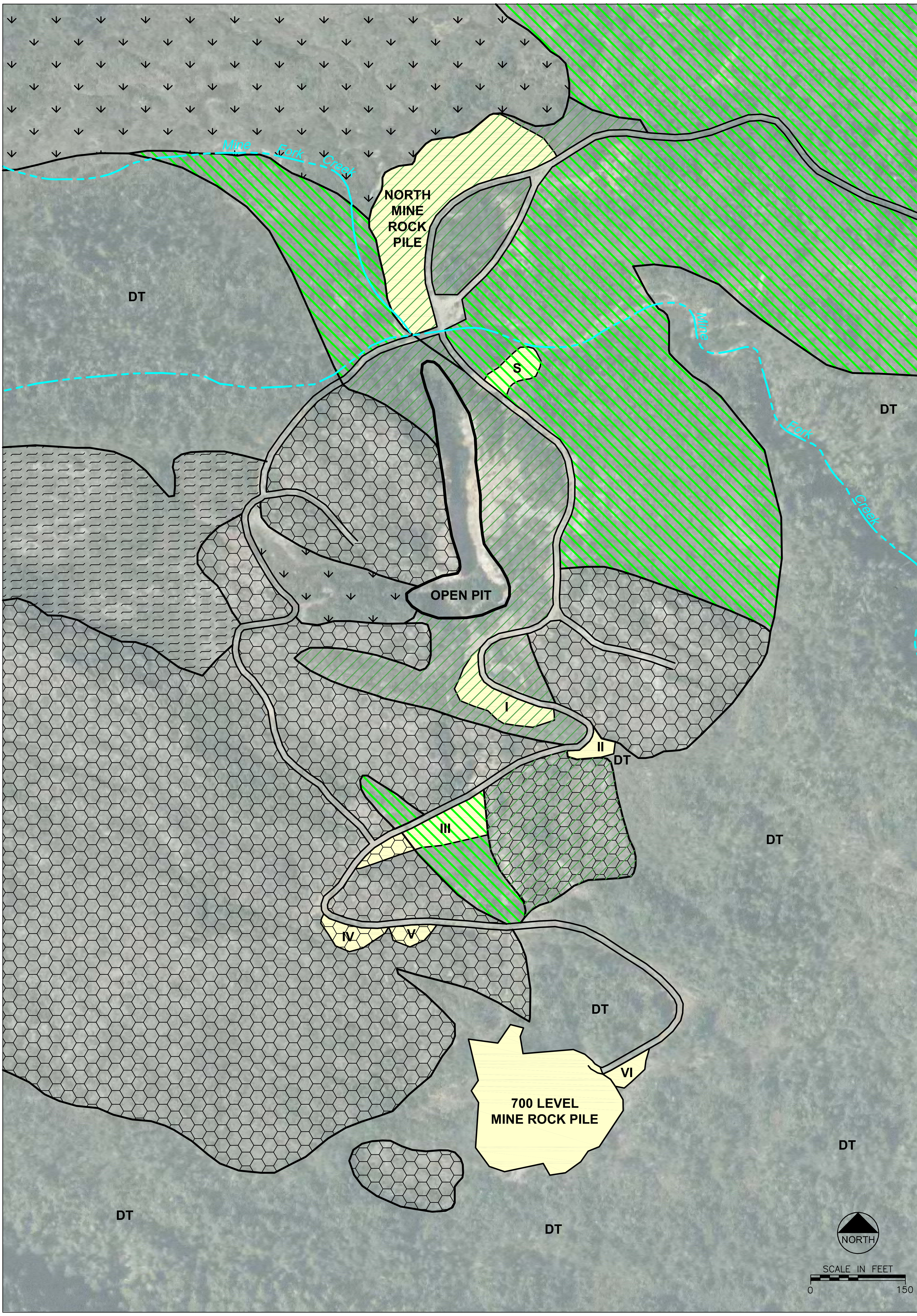
Figure 4-23. Photo looking south over the north Mine Rock Pile
(The pile is seen at the lower middle to left side of the photo and borders the outside edge of the lower half of the loop in the road. The Open Pit is seen at the top center of the photo).

Figure 4-24. Photo looking south from Mine Fork Creek at the south Mine Rock Pile

Figure 4-25. Photo looking north over the northwest corner of the 700-Foot Level Mine Rock Pile

Figure 4-26. Photo looking northeast along the south side of Mine Rock Pile III between the 700- and 900-Foot Levels
(This photo shows the typical thickness and material size of all of the mine rock used to construct roads between these two levels of the mine).

Figure 4-27. Aerial photo of the 700- and 900-Foot Levels, illustrating the various surface cover conditions across the site
(For reference, the 700-Foot Level mine rock pile can be seen at the lower left and the Open Pit is seen in the upper center of the photo. Mine Fork Creek runs vertically down the right side of the photo).



LEGEND

- BARE ROCK WITH SPARSE, THIN VEGETATION
- MEADOW: THIN SOILS WITH SPARSE GRASS OVER BEDROCK
- MUSKEG/MARSH: THIN, WET SOILS OVER BEDROCK
- MEDIUM DENSE TO DENSE, YOUNG VEGETATION
- MEDIUM DENSE, MATURE VEGETATION (TREES AND SHRUBS)
- DT DENSE, MATURE TREES AND VEGETATION
- VI MINE ROCK PILE

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Figure 4-28
Ross-Adams Mine Site
700' and 900' Level Surface Cover Conditions

Figure 4-29. Photo of 300-Foot Level portal

Figure 4-30. Photo looking northeast from the south edge of the crest of the 300-Foot Level mine rock pile, illustrating the dense vegetation which has develop across the pile

Figure 4-31. Photo looking east across the toe of the 300-Foot Level mine rock pile, illustrating the large rock that comprises many areas along the toe of the pile

Figure 4-32. Photo looking north at the older and westernmost rock loadout ramp (Note: Dotson Cabin in the upper right).

Figure 4-33. Photo looking northwest at the two rock loadout ramps
(The Ore Staging Area is just beyond the docks).

Figure 4-34. Photo looking over the downhill edge of the 900-Foot Level haul road, illustrating the typically steep, loose, dense vegetation along the embankment slopes

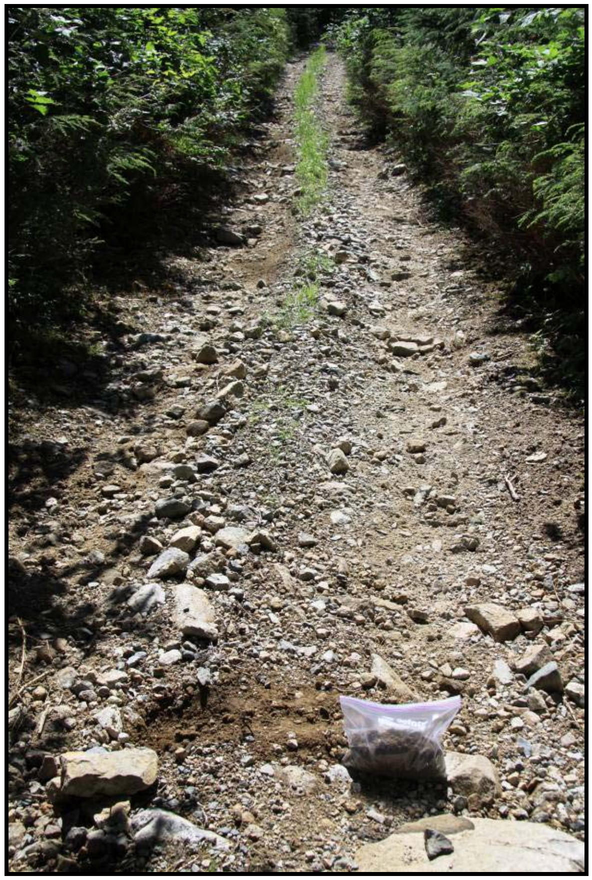
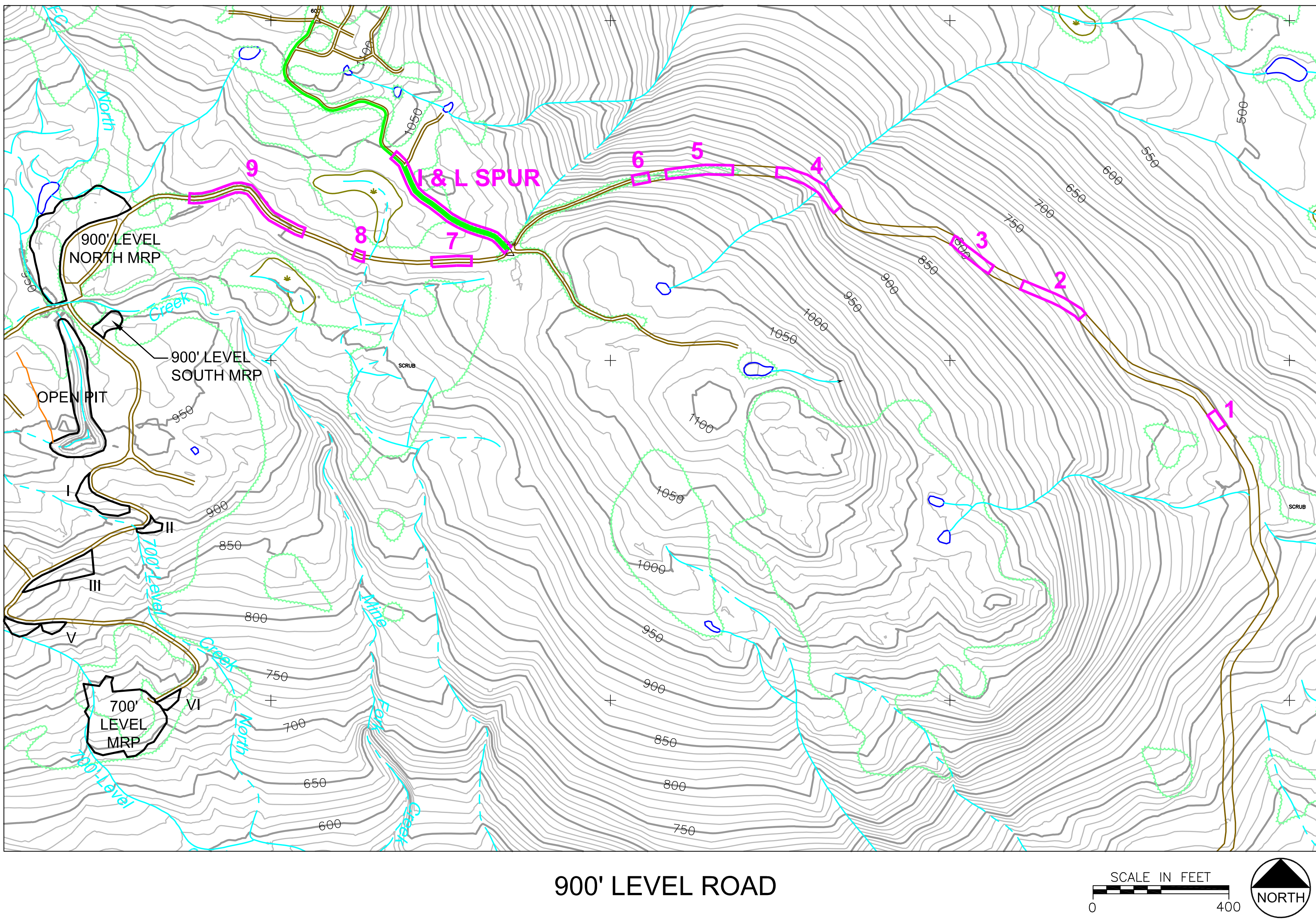
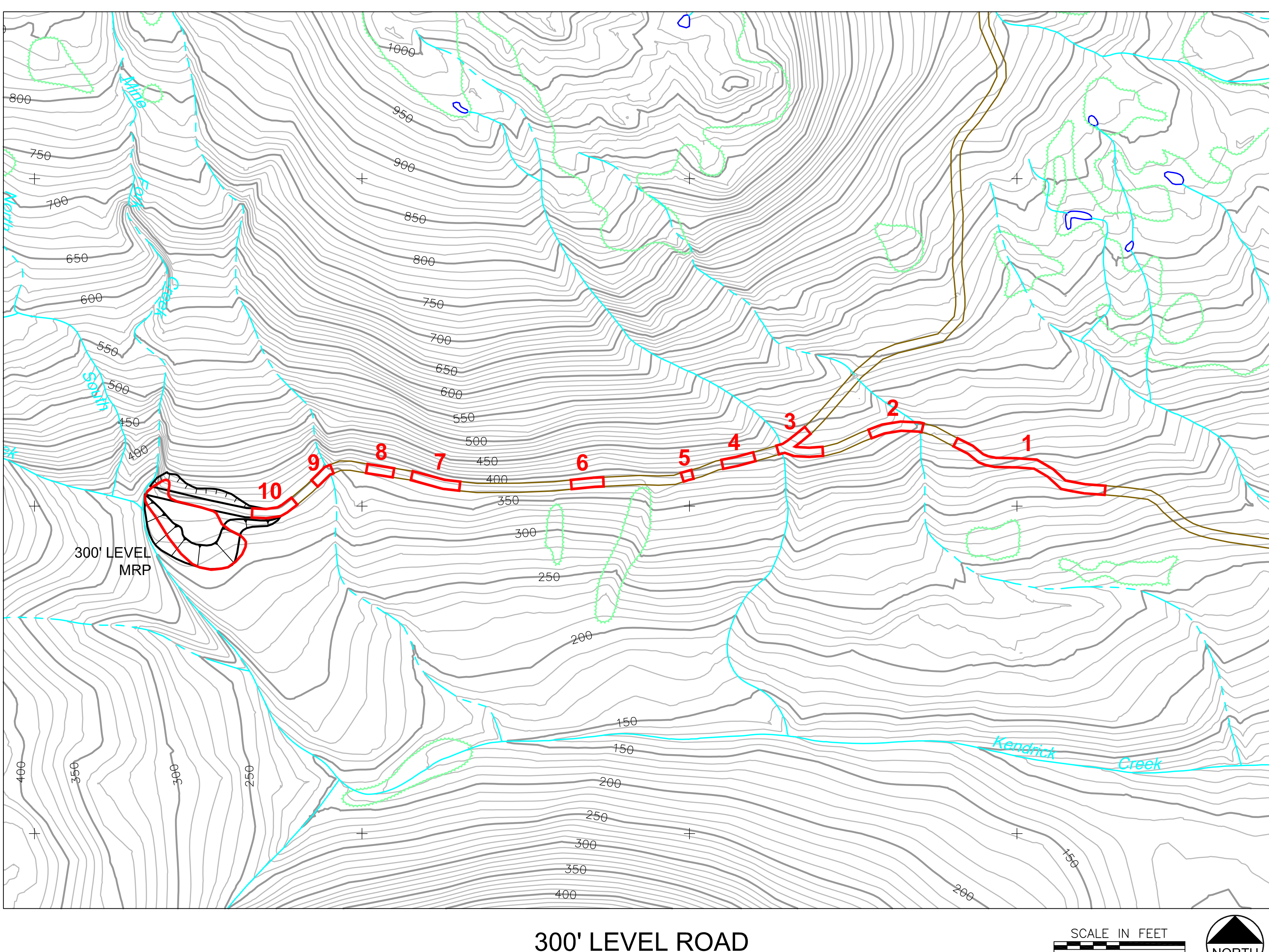


Figure 4-35. Photo looking northwest up the 900-Foot Level haul road, illustrating how dense vegetation has narrowed the road widths



900' LEVEL ROAD



300' LEVEL ROAD

Figure 4-36
Ross-Adams Site
Haul Road Areas

Figure 4-37. Photo looking north at the I&L access road taken from just north of the 900-Foot Level haul road

Figure 4-38. Aerial photo looking north across the OSA-300 haul road showing the east (right) and west landslides that are located approximately 700 feet east of the 300-Foot Level

(Note: The road fork to the 900-Foot Level is seen in the upper right corner. Kendrick Creek is just below the bottom of the photo).

Figure 4-39. Photo looking uphill at the head scarp of the west landslide, illustrating the shallow nature of the slide
(Note: The saturated bedrock surface is exposed in the lower center of the photo).

Figure 4-40. Photo looking uphill at the head scarp of the east landslide, illustrating the shallow nature of the slide
(Note: The south edge of the 300-Foot Level haul road is located at the upper edge of the head scarp).

Figure 4-41. Photo showing the soil profile in the road cut immediately above the east landslide, illustrating the distinct soil types and saturation of the local soils

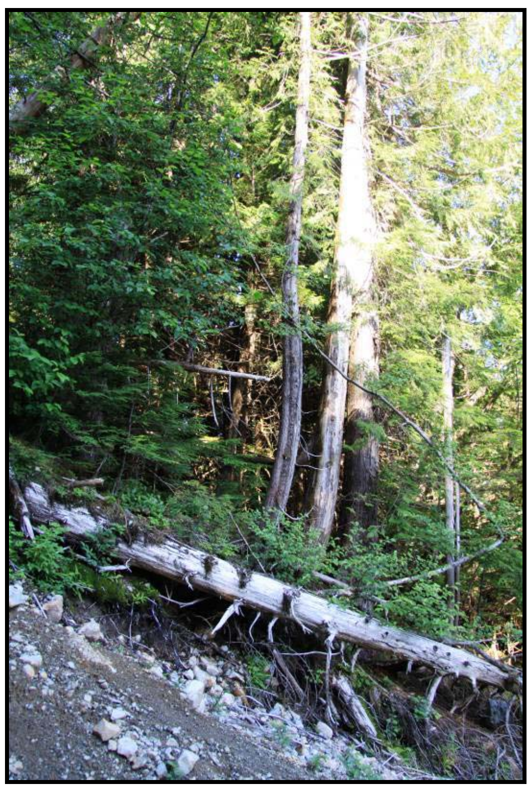


Figure 4-42. Photo looking at the east flank of the east landslide, illustrating the pistol-butting of mature trees

Figure 4-43. Photo looking at the west flank of the west landslide, illustrating the pistol-butting of mature trees

5.0 BIOLOGIC AND LAND USE ASSESSMENTS

Biologic and land use assessments were conducted during the ESI to provide data and information for both the Site characterization and the risk assessments to be performed in support of the EE/CA. The results of those assessments are presented here.

5.1 Introduction

The Site is located within the TNF. In addition to recreational use, the TNF Land and Resource Management Plan (USFS, 2008a) has designated the Site for mineral exploration and timber production, surrounded by areas of semi-remote recreational uses with old growth forests to the northwest and by the Prince of Wales Wilderness Area to the west. The Site has one permanent structure, which is a small cabin owned and maintained by the Dotson family (also referred to as the Seraphan cabin).

Access to the Site, while unrestricted, is generally by float plane or boat. Hiking to the Site from the Prince of Wales Wilderness Area to the west or from Moira Sound to the north is possible, but would involve hiking through several miles of rugged, trailless terrain. There are no roads to the area per the USFS Master Plan Map and the Site is not on the Prince of Wales Road Network; it is located within the Eudora Roadless Area of TNF (USFS, 2003).

The following subsections describe current, future, and subsistence uses of the Site, as well as a discussion of off-Site land uses within 4 miles of the Site.

5.2 Biologic Assessment

The objectives of the biologic assessment were to identify the main habitat types and associated aquatic and terrestrial species, to document functional wildlife groups and to interpret the biologic information with regard to subsistence uses. The biologic assessment included a pedestrian survey during the July 2009 sampling event and literature review. The results of the assessment are documented in a "Biological Inventory Memorandum" dated December 29, 2009, provided in Appendix F. The results of the biologic assessment are summarized in the following.

5.2.1 Habitat Types

The Site falls within the Southeast Ecoregion as defined by the Alaska Department of Environmental Conservation (ADEC, 1999a, b). The main ADEC ecological subregions characterizing the Ross-Adams Site are the Southeast Coastline/Estuary and Coastal Western Hemlock-Sitka Spruce Forest. The Southeast Coastal/Estuary subregion characterizes the open waters of Kendrick Bay.

The biological survey conducted during July 2009 identified four main habitat types, which are considered consistent with the ecological subregions; Subalpine Zone, Western Hemlock-Sitka Spruce Forest, Intertidal Zone, and Marine Zone. The Subalpine Zone habitat is found at the 900-Foot and 700-Foot Levels, and is characterized by barren rock and plants adapted to the colder and windier environment at this higher elevation. The Western Hemlock-Sitka Spruce Forest habitat consists of old growth forest extending from sea level to approximately 900 feet ASL, and is dominated by Western Hemlock and Sitka-Spruce. The 300-Foot Level, the OSA, and the haul roads are located within this type of habitat. Kendrick Creek drains through the forested area and is joined by its tributaries Mine Fork Creek and Cabin Creek. The Intertidal Zone habitat is bounded by the low and high tides of Kendrick Bay. This zone also receives freshwater input from Kendrick Creek and runoff from the surrounding uplands, and is connected to the open waters of the northwest end of Kendrick Bay. The Marine Zone habitat is contiguous with the Intertidal Zone and includes the waters of the west Arm of Kendrick Bay below the low tide line.

5.2.2 Species Observed

The species were observed during the July pedestrian survey and as reported by field personnel during all sampling events. The list of species observed is presented in Table 5-1. The species are grouped by the major habitat areas at the Site: Intertidal and Marine Zones, Western Hemlock-Sitka Spruce Forest and Subalpine Zone, and Freshwater Habitats within the forest and subalpine areas. The table also includes notes on relative abundance, location/elevation observed, and other pertinent information. Species (or genera) observed in the intertidal zone and the nearshore portion of Kendrick Bay included: 16 aquatic plants and algae, 24 aquatic invertebrates, 2 fish, 6 mammals, and 8 birds. Species (or genera) observed in terrestrial habitats included 56 plants, 2 invertebrates, 3 mammals, and 4 birds. Very few species (or genera) were observed in the freshwater environments, including 1 aquatic invertebrate, 2 fish, and 1 amphibian. It is important to note that the survey was conducted over a short time span and most likely did not record all of the aquatic and terrestrial wildlife species that may utilize the area. This is particularly likely for species that are nocturnal or are present at other times of the year.

Based on review of current lists from U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Alaska Department of Game and Fish, no terrestrial threatened and endangered (T&E) wildlife or plant species are expected at the Site. In addition, none of the bat species that may potentially occur at the Site are listed T&E species.

Salmonid habitat and the presence and importance of this species at the Site can be assessed based on stream habitat. In general, based on field observations and review of the literature, it is expected that the lower portions of Kendrick Creek could be used by some andromonous salmonid species, but streams in upper portions of the Site are not likely useable due to steep gradients and physical barriers. A run of spawning pink salmon were observed in lower Kendrick Creek during the September 2009 sampling event up to just above the confluence with Cabin Creek. This run of pink salmon is consistent with stream classification information from the Tongass National Forest (USFS 2008c) which has classified the streams at the Site with respect to spawning and rearing habitat. As shown on Figure 5-1, and more fully discussed in Appendix F, salmon spawning and rearing habitat is limited to the lower portion of Kendrick Creek, and even in this portion of the stream habitat is classified as moderate to low/negligible. Therefore, while andromonous salmon species may use the Site for spawning and rearing, useable habitat is limited to the lower portion of Kendrick Creek where this habitat is only of moderate quality at best.

5.2.3 Wildlife Functional Groups

The biologic assessment provides the information to identify wildlife functional groups at the Site. These wildlife functional groups are based on a species' taxonomic group (i.e., avian, mammalian), primary foraging habitat (i.e., marine, freshwater, terrestrial) and feeding strategy based on the composition of the bulk of the species' diet (i.e., herbivore, carnivore, piscivore, invertivore). ADEC's guidance was used to characterize the species of birds and mammals observed at the Site into functional groups. These wildlife functional groups are presented in Table 5-2 along with additional information on diet composition. The information in Table 5-2 will be used in the risk assessment to provide the "default Primary Indicator Species" for the

Site. These default indicator species are the belted kingfisher, mallard, dark-eyed junco, harbor seal, sea otter, and mink.

5.2.4 Subsistence Use

The possible subsistence hunting and gathering use of the Site, based on the species and habitats present, can be identified. This potential subsistence use will be used in the human health risk assessment.

Based on the Site species and habitats and information regarding subsistence use, a number of plants and animals observed at the Site have potential for subsistence use, such as berries, blue mussels, bull kelp, clams, crabs, deer, fish, and sea cucumber (ADFG 2000). In addition, subsistence use of black bear, deer, and wolves is possible. However, a state hunting license and harvest tickets are required rather than a subsistence use permit. No subsistence permits for finfish or shellfish have been issued for Kendrick Bay, and thus subsistence fishing is not allowed in this area under Alaska regulations (Mike Turek, ADFG, personal communication, September 2009).

5.3 Land Use Assessment

Land uses of the Site have been assessed based on observed and public information. The current, future and subsistence uses of the Site are described in the following.

5.3.1 Current Land Use

Current use of the Site is restricted by its remote location. Access to the Site, while unrestricted, is by float plane or boat. Hiking to the Site from the Prince of Wales Wilderness Area to the west or from Moira Sound to the north is possible, but would involve navigating through several miles of wilderness area as the Site is located within the Eudora Roadless Area of TNF (USFS, 2003). The nearest population centers are the Towns of Metlakatla, 28 miles to the northeast across Clarence Strait, and Hydaburg, 33 miles to the northwest on the west side of POW Island.

Current use of the Site is primarily mineral exploration. The Site is designated for mineral exploration or timber production as permitted by the USFS (USFS, 2008a), but there is no evidence or record of timber harvest in the recent past. Mineral exploration has been on-going since the 1950s, which led to the uranium mining, and active exploration has been occurring in the areas around the Site for the past 3 years (2007 – 2009). Other current uses of the Site could be an occasional area visitor, or a USFS worker.

Occasional, seasonal use of the Site by the Dotson Family is possible to work its mining claims. The Dotson's cabin is located approximately 200 yards from the OSA. Neither the duration of seasonal use of the Dotson cabin nor the duration for which this ownership right will exist are known. The USFS Forest Management plan for the Site areas does not envision that residential use and construction of temporary shelters, while allowed, must be permitted.

Recreational visitors occasionally use the site although there is no record of visitor use. The Site is part of the TNF and designated as semi-remote recreational land. In addition, USDA Forest Service personnel visit the Site and subsistence hunting-gathering use possibly occurs. The presence of the floating dock, maintained by the mineral exploration company, provides access to the Site that is not commonly available at other similar areas. The dock provides what could be considered an "attractive nuisance" element.

Commercial fishing can occur in Kendrick Bay and an aquaculture facility is located in the south Arm of Kendrick Bay. A report by the ADNR (1998) indicates that intense harvest occurs at the entrance to Kendrick Bay. Occasional recreational fishing use of the bay is also likely.

5.3.2 Future Site Use

The USFS Master Plan for the TNF has designated the Site for mineral exploration or timber production, as well as being semi-remote recreational land. The most likely future land use is mineral exploration. Timber harvest could also occur. Both uses are controlled by permit and would be of limited duration. If the land is used for timber production purposes, it is unlikely that recreational visitors will simultaneously use the land, both for safety reasons and desirability of recreational experience. The USFS Master Plan for the TNF does not appear to include any other type of development for this Site.

5.3.3 Subsistence Use

Subsistence use of land and marine resources is an important facet of native Alaskan traditional practices and may occur at the Site, currently and in the future. However, the Site is remote from any native Alaskan population centers on POW and the Site does not provide unique harvesting opportunities for subsistence use not available in closer proximity, with easier access, to populations.

5.3.4 Off-Site Land Use

Kendrick Bay is used for commercial and recreational fishing. A commercial aquaculture facility, owned by the Southern Southeast Regional Aquaculture Association, is located in the South Arm of Kendrick Bay and consists of juvenile salmon holding pens. It is part of a terminal fishery for chum salmon (SSRAA, 2009). Within 15 miles of the Site, Kendrick Bay waters may be used for commercial fishing of shrimp, sea cucumbers, and red urchins. Subsistence fishing within all parts of Kendrick Bay could occur.

Table 5-1. Plant and Animal Species Observed during Biota Inventory at Ross-Adams Site [1]

Common Name	Scientific Name	Notes [2]
Intertidal and Marine Zones		
Aquatic and Wetland Plants		
Eelgrass	*Zostera sp.*	low intertidal
Sugar Kelp	*Laminaria saccharina*	low intertidal
Bull Kelp	*Nereocystis luetkeana*	low intertidal area; found frequently
Giant Kelp	*Macrocystis integrifolia*	low intertidal
Green Excelsior	*Chaetomorpha sp.*	mid-intertidal
Cornrow Sea Lettuce	*Ulva intestinalis*	mid-intertidal
Sea Sacs	*Halosaccion glandiforme*	mid-intertidal; uncommon
Black Pine	*Neorhodomela larix*	within creek channel in mid-intertidal; a red algae
Rockweed	*Fucus gardneri*	Dominant in intertidal area; high to mid-intertidal
Sea Asparagus	*Salicornia depressa*	high intertidal
Sea Arrow-grass	*Triglochin maritimum*	high intertidal
Brown Tuft	*Ectocarpus sp.*	high intertidal
Alaska Plantain	*Plantago macrocarpa*	high intertidal
Lyngby's Sedge	*Carex lyngbyei*	high intertidal
Yarrow	*Achillea millefolium*	high intertidal and perimeter above intertidal
Vetch	*Vicia sp.*	high intertidal and perimeter above intertidal
Marine Invertebrates		
Sea cucumber	*Holothuroidea sp.*	Observed in eelgrass beds near existing dock and ore loading dock; some individuals greater than 1 ft in length; low intertidal
Blue mussel	*Mytilus edulis*	low to mid-intertidal; common, associated with rockweed
Acorn barnacle	*Balanus glandula*	low to mid-intertidal
Clams (unidentified species)	NA	low intertidal
Cockle	*Clinocardium sp.*	low intertidal
Northern Striped Dogwinkle	*Nucella osterina*	low intertidal
Periwinkle	*Littorina sp.*	low intertidal
Limpet (unidentified species)	NA	low intertidal
Tusk coneworm	*Pectinaria granulata*	low intertidal
Polychaete (unidentified species)	NA	low intertidal
Oligochaete (unidentified species)	NA	low intertidal
Chiton	*Tonicella sp.*	low intertidal
Amphipod (unidentified species)	NA	low intertidal
Isopod	*Gnorimosphaeroma oregonensis*	low intertidal; observed on undersides of cobble near shoreline
Crabs (unidentified species)	NA	low intertidal
Green shore crab	*Hemigrapsus oregonensis*	low intertidal; common
Hermit crab (unidentified species)	NA	low intertidal
Shrimp (unidentified species)	NA	low intertidal
Mottled star	*Evasterias troschelii*	low intertidal

Table 5-1. Plant and Animal Species Observed during Biota Inventory at Ross-Adams Site (1) (continued)

Common Name	Scientific Name	Notes (2)
Marine Invertebrates (continued)		
Purple sea star	*Pisaster ochraceus*	low intertidal; common
Sunflower star	*Pycnopodia helianthoides*	low intertidal
Leather star	*Dermasterias imbricate*	low intertidal
Water jellyfish	*Aequorea sp.*	Low intertidal
Cross jellyfish	*Mitrocoma cellularia*	Observed in bay adjacent to existing dock
Marine Fish		
Black prickelback	*Xiphister atropurpureus*	low intertidal; in beach sediments & gravel
Flounder (unidentified species)	NA	observed underwater at several marine sediment sampling locations
Mammals		
Sitka Black-Tailed Deer (3)	*Odocoileus hemionus sitkensis*	Observed in rocky area on east side of bay and tracks found in drainage in upper Intertidal Zone
Black Bear (3)	*Ursus americanus*	Grassy area at north end of intertidal zone
Harbor Seal	*Phoca vitulina*	Observed in site vicinity in Kendrick Bay
Sea Otter	*Enhydra lutris*	Observed near existing dock
Mink	*Mustela vison*	Observed near existing dock and intertidal zone during first sampling event, June 2009
Humpback Whale (4)	*Megaptera novaeangliae*	Observed in northwest end of Kendrick Bay, several hundred meters south of the existing dock; observed during June 2009 sampling event
Birds		
Bald Eagle (3)	*Haliaeetus leucocephalus*	In large trees on southwest side of bay
Belted Kingfisher	*Megaceryle alcyon*	Fairly common around bay
Loon	*Gavia sp.*	Kendrick Bay
Greater Yellowlegs	*Tringa melanoleuca*	Kendrick Bay shoreline
Mallard	*Anas platyrhynchos*	Kendrick Bay shoreline
Northwestern Crow	*Corvus caurinus*	Kendrick Bay shoreline
Mew Gull	*Larus canus*	Common – observed on beach near shoreline and mouth of Kendrick Creek, and on Kendrick Bay
Steller's Jay	*Cyanocitta stelleri*	Intertidal zone
Western Hemlock-Sitka Spruce Forest and Subalpine Zone		
Trees, Shrubs, & Other Plants		
Western Hemlock	*Tsuga heterophylla*	Dominant in old growth forest up to 700L
Sitka Spruce	*Picea sitcchensis*	Common to 700L
Red Alder	*Alnus rubra*	Common to 700L
Western Red Cedar	*Thuja plicata*	Up to 700L
Salmonberry	*Rubus spectabilis*	Adjacent to lower Kendrick Creek; in forest just above intertidal zone
Devil's Club	*Oplopanax horridus*	Adjacent to lower Kendrick Creek; in forest just above intertidal zone
Silverweed	*Potentilla sp.*	Adjacent to lower Kendrick Creek; in forest just above intertidal zone
Skunk Cabbage	*Lysichiton americanum*	Adjacent to lower Kendrick Creek; in forest just above intertidal zone
False Lily-of-the-valley	*Maianthemum dilatum*	Adjacent to lower Kendrick Creek; in forest just above intertidal zone

Table 5-1. Plant and Animal Species Observed during Biota Inventory at Ross-Adams Site [1] (continued)

Common Name	Scientific Name	Notes [2]
Trees, Shrubs, & Other Plants (continued)		
Western Rattlesnake Root	*Prenanthes alata*	Adjacent to lower Kendrick Creek; in forest just above intertidal zone
Marsh-marigold	*Caltha biflora*	Adjacent to lower Kendrick Creek; in forest just above intertidal zone
Fireweed	*Epilobium angustifolium*	Above tidal zone, disturbed area near crib and fire ring north of dock
Alaska Blueberry	*Vaccinum alaskaensis*	Up to 700L
Oval-leafed Blueberry	*Vaccinum ovalifoilum*	Up to 700L
Red Elderberry	*Sambucus racemosa*	Up to 700L
False Azalea	*Menziesia ferruginea*	Up to 700L
Dwarf Dogwood	*Cornus canadensis*	Up to 700L
Twistedstalk	*Streptopus amphlexifolius*	Up to 700L
Foamflower	*Tiarella trifoliata*	Up to 700L
Five-leafed Bramble	*Rubus pedatus*	Up to 700L
Fern-leaved Goldthread	*Coptis asplenifolia*	Up to 700L
Deer Fern	*Blechnum spicant*	Up to 700L
Oak Fern	*Gymnocarpium dryopteris*	Up to 700L
Shield Fern	*Dryopteris expansa*	Up to 700L
Lady Fern	*Athyrium filixfemina*	Up to 700L
Red Huckleberry	*Vaccinum parvifolium*	700L
Alpine Azalea	*Loiseleuria procumbens*	700L
Common Harebell	*Campanula rotundifolia*	700L
Labrador Tea	*Ledum groenlandicum*	700L
Running Clubmoss	*Lycopodium clavatum*	700L
Salal	*Gaultheria shallon*	700L to 900L sub-alpine
Subalpine Daisy	*Erigeron peregrinus*	700L to 900L sub-alpine
Deer Cabbage	*Fauria crista-galli*	700L to 900L sub-alpine
Variable Willow	*Salix commutata*	700L to 900L sub-alpine
Mountain Hemlock	*Tsuga mertensiana*	700L to 900L sub-alpine
Yellow Cedar	*Chamaecyparis nootkatensis*	700L to 900L sub-alpine
Bog Blueberry	*Vaccinum ulignosum*	700L to 900L sub-alpine
Burnett	*Sanguisorba sp.*	700L to 900L sub-alpine
Reindeer Lichen	*Cladina sp.*	700L to 900L sub-alpine
Cotton Grass	*Eriophus sp.*	700L to 900L sub-alpine
Bog Rosemary	*Andromeda polifolia*	900L, wetter sites
Round-leaved Sundew	*Drosera rotundifolia*	900L, wetter sites
Bog Orchid	*Habenaria saccata*	900L
Apargidium	*Micoseris borealis*	900L
Swamp Gentian	*Gentiana douglasiana*	900L
Bog Cranberry	*Oxycoccus oxycoccos*	900L
Mountain Cranberry	*Vaccinium vitis-idaea*	900L
Shore Pine	*Pinus contorta* var. *contorta*	At 900L sub-alpine area; dwarf form

Table 5-1. Plant and Animal Species Observed during Biota Inventory at Ross-Adams Site [1] (continued)

Common Name	Scientific Name	Notes [2]
Trees, Shrubs, & Other Plants (continued)		
Club Moss	*Lycopodium sp.*	Observed at 900L near road and waste dump area.
White Clover	*Trifolium repens*	roadside
Creeping Buttercup	*Ranunculus repens*	roadside
Oxeye Daisy	*Leucanthemum vulgare*	roadside
Dandelion	*Taraxacum*	roadside
Stink Current	*Ribes bracteosum*	roadside
Maiden Hair Fern	*Adiatum pedatum*	roadside: 300L to 700L
Indian Hellebore	*Veratrum viride*	roadside: 300L to 700L
Terrestrial Invertebrates		
Pacific Banana Slug	*Ariolimax columbianus*	Observed in old growth forest adjacent to Kendrick Creek and along haul road; yellow, white, and olive color variants
Dragonfly (unidentified species)	NA	Observed at all levels up to 900L
Mammals		
Sitka Black-Tailed Deer (3)	*Odocoileus hemionus sitkensis*	Observed at 900L
Black Bear (3)	*Ursus americanus*	scat at 900L
Gray Wolf	*Canis lupus*	Unconfirmed observation during first sampling event, June 2009
Birds		
Ptarmigan	*Lagopus sp.*	Adults observed with young along the main road near I&L spur, during June 2009 sampling event. Also observed at 900L during September 2009 sampling event.
Rufous Hummingbird	*Selasphorus rufus*	In trees between haul road and intertidal area
Hermit or Swainson's Thrush	*Catharus sp.*	At 900L
Dark-eyed Junco	*Junco hyemalis*	Along road to 900L
Freshwater Habitats		
Freshwater Invertebrates		
Stonefly (unidentified species)	NA	Uncommon; observed in Kendrick Creek near 700L
Freshwater Fish		
Pink Salmon	*Oncorhynchus gorbuscha*	Run of pink salmon observed on lower Kendrick Creek up to sampling location "CONF-SW-01-K"; observed during September 2009 sampling event.
unidentified fish species	NA	Small or juvenile fish in pool in Kendrick Creek, just above intertidal zone
Amphibians		
Rough-skinned Newt	*Taricha granulosa*	One specimen found at pond at I&L area

(1) Identification primarily based on Lamb and Hanby 2005, Armstrong 2008, Alaska Geographic Society 1996, and Pojar and MacKinnon 1994.
(2) 300L = 300-Foot Level; 700L = 700-Foot Level; 900L = 900-Foot Level
(3) Management Indicator Species (MIS) for Tongass National Forest (USFS 2008d).
(4) A Federal and Alaska endangered species (ANHP 2009).

Table 5-2. Functional Groups of Birds and Mammals Observed at the Ross-Adams Site

Taxonomic Group/Species	Functional Group [1,2]	Diet Composition [3]
Birds		
Bald Eagle	Marine/Freshwater avian piscivore	Fish is main diet item (including herring, flounder, pollock, salmon); also sea urchins, crabs, clams, waterfowl, small mammals, and carrion
Belted Kingfisher (4)	Freshwater avian piscivore	Diet is primarily fish, also may include crustaceans, insects, and amphibians (EPA 1993)
Loon	Freshwater avian piscivore	Fish, also aquatic vegetation, molluscs, insects, and frogs
Greater Yellowlegs	Freshwater semi-aquatic avian invertivore	Fish (e.g., sculpins, sticklebacks), aquatic insects, sand fleas, intertidal amphipods; also terrestrial invertebrates (e.g., ants, grasshoppers, snails, spiders, and worms)
Mallard (4)	Freshwater semi-aquatic avian herbivore	Plants (including seeds, tubers, stems), insects, snails, worms, and crustaceans (EPA 1993)
Northwestern Crow	Terrestrial avian carnivore	Feeds heavily on blue mussel (Armstrong 2008)
Mew Gull	Marine/Freshwater avian invertivore	Primarily scavengers, diet includes insects, earthworms, molluscs, crustaceans, sea urchins, fish, young birds, mice (USFWS 2006)
Steller's Jay	Terrestrial avian herbivore	Diet consists of approximately 57 to 88% plant matter depending on the season, including berries, seeds, and nuts. The balance of the diet is comprised of insects such as wasps, beetles, and grasshoppers (Martin et al. 1961).
Ptarmigan	Terrestrial avian herbivore	Buds, twigs, and vegetation of willow, birch, and alder; berries, seeds, and insects (e.g., caterpillars and beetles)
Rufous Hummingbird	Terrestrial avian herbivore	Nectar from plants such as blueberries, salmonberries, and rusty menziesia; also eat insects (O'Clair et al. 2007).
Hermit or Swainson's Thrush	Terrestrial avian invertivore	Thrush diets are primarily insectivorous (e.g., beetles, ants, caterpillars), and may also include fleshy fruits such as berries, cherries, and grapes (Martin et al. 1961).
Dark-eyed Junco (4)	Terrestrial avian herbivore	Primarily plants (approximately 50 to 95% depending on the season), the balance of the diet is insects (such as beetles, ants, caterpillars, grasshoppers) (Martin et al. 1961).
Mammals		
Sitka Black-Tailed Deer	Terrestrial mammalian herbivore	Vegetation, evergreen forbs (e.g., bunchberry, trailing bramble), woody browse (e.g., yellow cedar, hemlock)
Black Bear	Terrestrial mammalian herbivore	Opportunistic and widely varied: berries, vegetation, ants, grubs, and other insects, fish, carrion
Harbor Seal (4)	Marine mammal piscivore	Fish, octopus, and squid
Sea Otter (4)	Marine mammal invertivore	Sea urchins, crabs, clams, mussels, octopus, other marine invertebrates, and fish
Mink (4)	Freshwater semi-aquatic mammalian carnivore	Fish, crabs, clams, birds, bird eggs, small mammals, insects; prefer streams, ponds, beaches, or marshes
Humpback Whale	Marine mammalian piscivore	Fish, krill
Gray Wolf	Terrestrial mammalian carnivore	Sitka black-tailed deer, mountain goats, and beaver are main diet items; summer diet also may include small mammals and occasionally birds and fish

(1) Based on "Default Assessment Endpoints and Primary Indicator Species" for the "Southeast" Ecoregion, which includes Prince of Wales Island; per ADEC's "User's Guide for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaska Ecoregions" (ADEC 1999a,b)
(2) Piscivore - feeds primarily on fish; Invertivore - feeds primarily on invertebrates; Herbivore - feeds primarily on plant matter; Carnivore - feeds primarily on meat.
(3) Diet information, unless otherwise indicated, is from ADFG Wildlife Notebook Series http://www.adfg.state.ak.us/pubs/notebook/notehome.php.
(4) A "Default Primary Indicator Species" as per ADEC guidance (ADEC 1999a,b).

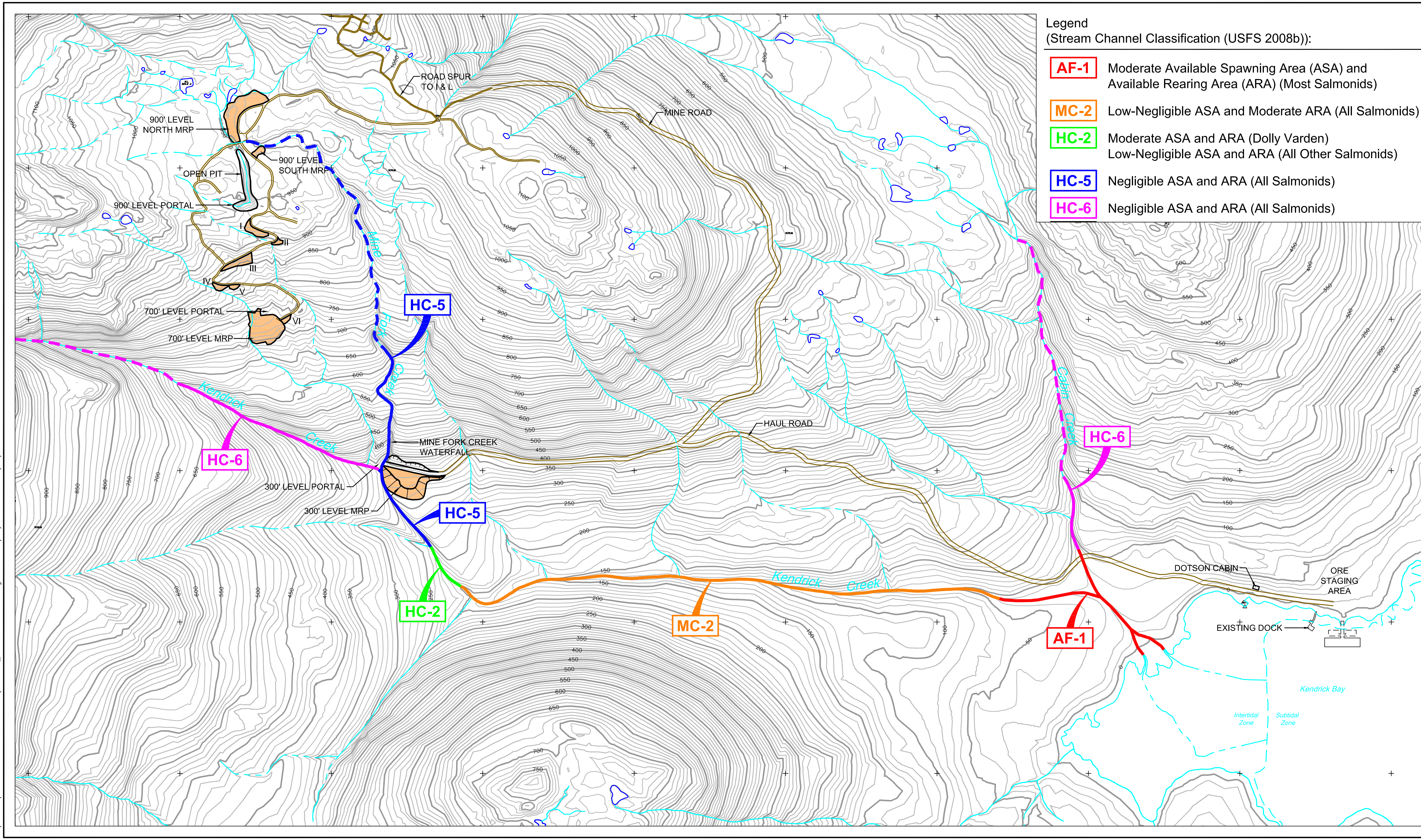


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Figure 5-1
Ross-Adams Site
Kendrick Creek Fish Habitat Zones

6.0 CHEMICAL AND RADIOLOGICAL CHARACTERIZATION

As described in Section 2.0, the ESI included the collection of additional environmental data and information to further characterize the physical, chemical and radiological conditions of the Site. This section presents and summarizes the chemical and radiological characterization of the mine features and environmental media (soil, surface water, stream sediment, groundwater, marine sediment, and air). Gamma radiation surveys were conducted to define gamma exposure rates of the mine features and surrounding areas and undisturbed areas at the Site. Samples of the various media were also collected at specific locations and were analyzed for major elements and compounds, trace metals and radionuclides. The sampling results provide data to characterize the chemical and radiological conditions for the respective media and to establish local background conditions.

As described in Section 3.0, soil, surface water, stream sediment, and marine sediment samples were analyzed for metals and radionuclides to ensure that data for relevant parameters were developed to verify the constituents of potential concern identified by the previous KSI (2004) investigation. Samples collected during the June sampling event were analyzed for the full suite of metals and radionuclides listed in Tables 3-1 and 3-2. As described in the Work Plans for Human Health and Ecological Risk Assessment (Appendix A and Appendix B of the SAP; Tetra Tech, 2009a), analytical results from the June sampling event were evaluated by comparison to human health and ecological screening values to verify the constituents of potential concern. The evaluation was used to adjust the parameters analyzed for subsequent samples collected during the July and September sampling events. Most radionuclides were retained for analysis. Arsenic, lead, selenium, and uranium were identified as metals of potential concern. Selected samples collected in July and September were analyzed for the full suite of 21 metals, with the laboratory reporting arsenic, lead, selenium, and uranium for all samples. Review of the July and September sample results analyzed for the full suite of metals was performed to confirm the metal constituents of potential concern. These data were presented in the SCR (Tetra Tech, 2010). At the time of the original analysis, the laboratory analyzed all soil, stream sediment, and marine sediment samples collected in July 2009 by EPA Method 6010 (ICP). To provide a more complete dataset for statistical analysis, the laboratory was requested to report the additional Method 6010 metal parameters from the original analysis of these samples where the Method 6010 method detection limits were appropriate for characterization and statistical evaluation. The remaining metal parameters for these samples were reported by the laboratory, except for antimony, mercury, silver and thallium where the Method 6010 method detection limits were too high to provide useful data.

In accordance with the ASAOC and SOW, a Screening-Level Ecological Risk Assessment (SLERA) and Screening-Level Human Health Risk Assessment (SLHHRA) will be prepared and included as part of the EE/CA. Further evaluation of the data, including statistical analysis will be provided in the SLHHRA and SLERA in evaluating potential risks to human and ecological receptors.

The following section (Section 6.1) summarizes the results of the gamma radiation surveys conducted at the Site. The gamma radiation survey results define the Site characteristics by providing mapped and contoured extents of the mine features, natural mineralization and background conditions. As discussed in detail in Section 6.1, radiological characterization using gamma radiation is a unique and powerful tool for clearly defining the Site characterization. Section 6.2 provides an assessment of the local background chemical and radiological conditions, including gamma exposure rates, for the environmental media. As discussed in detail in Section 6.2, the concept of local background is critical to the understanding of the Site conditions because of the influence of the natural mineralization exposed at the surface throughout the 900-Foot and 700-Foot Levels. Section 6.3 summarizes the media characterization for the soil, surface water and groundwater, stream sediment, marine sediment, and air at the Site.

As described in Section 2.0, previous investigations at the Site reported various miscellaneous waste and petroleum products that are associated with several previous exploration and mine camps at the Site. An inventory and sampling was performed of the miscellaneous solid waste and petroleum products remaining at the Site, as described in Section 6.4.

6.1 Gamma Survey Results

Comprehensive, high-density gamma surveys were conducted to define the range and extent of gamma exposure rates for the mine features (900-Foot, 700-Foot and 300-Foot levels, mine and haul roads, and the OSA and ore loading docks) and adjacent areas. Gamma surveys were also performed of the Kendrick Creek channel, Kendrick Bay intertidal zone at the delta, and a limited area of the I&L Zone. The gamma surveys provide comprehensive and detailed information to define the limits of mine features, characterize radiological conditions in adjacent and undisturbed areas, and to assess exposure rates in background areas.

As defined in the SOW and SAP, correlations between measured gamma exposure rates and the activity of radionuclides in surface mine rock and soil were established. The correlations demonstrate that gamma surveying can be used to assess the boundaries of the mine features and soils with varying levels of radionuclides at the Site. Measured gamma exposure rates and soil sampling data were also compared to assess the relationships between both gamma radiation and radionuclides activities with non-radioactive metals (e.g., lead and arsenic) concentrations that might be associated with the Ross-Adams deposit. The results of the gamma exposure rate and correlations with radionuclides and non-radioactive metals are described in Section 6.1.4.

The Site-wide results of the gamma radiation surveys are shown on Figure 6-1. Figures 6-2 through 6-5 present the gamma exposure rate data at a larger scale for the 300-Foot Level, combined 900-Foot and 700-Foot levels, the OSA and loading docks, and the I&L Zone, respectively. The gamma exposure rates are presented in interval units of microroentgen per hour (µR/hr) with values less than 20 µR/hr as the lowest interval, which corresponds to the upper range of background gamma exposure rates determined for non-mineralized areas (Section 6.2.1) at the Site. Data presented on these figures represent unshielded gamma exposure rates measured at three feet above the ground surface using the NaI detection system. As further described in Section 6.1.3, the unshielded gamma rates are representative of the radiation exposure to humans at a specific location, but may overestimate the specific radiological concentrations of the surface material at that location. The gamma exposure rates can be converted to dose rates in microrem per hour (µrem/hr), as described in Appendix E-1.

The gamma exposure rate data presented on Figures 6-2 through 6-4 represent “kriged” values. Kriging is a geostatistical technique for interpolating the values at unobserved locations based on the observations at nearby locations. Kriging was used to provide contoured exposure rates that clearly define the gamma boundaries for each natural and mine related Site feature. The unkriged versions of these figures are provided in Appendix E-3.

The results of the gamma radiation surveys for the mine features, (300-Foot Level, combined 700-Foot and 900-Foot Levels, and the OSA and ore loading docks), as depicted on the larger scale maps (Figures 6-2 through 6-4), and the mine and haul roads (Figure 6-1), are discussed in Section 6.1.1. Gamma radiation survey results for the areas outside of the mine features, which consist of the Kendrick Creek stream channel and Kendrick Bay intertidal zone (Figure 6-1) and the I&L Zone (Figure 6-5), are summarized in Sections 6.1.2.

6.1.1 Mine Feature Gamma Survey Results

6.1.1.1 300-Foot Level

Figure 6-2 presents the distribution of kriged gamma exposure rates in the vicinity of the 300-Foot Level. Mine rock occurs in a discrete pile outside and downslope of the 300-Foot Level portal. Because the 300-Foot Level adit was driven over 1,300 feet prior to reaching the Ross-Adams deposit, a significant portion of the rock present at this location is likely comprised of non-mineralized development rock consisting of a mixture of peralkaline granites and undifferentiated granites and diorites. Gamma readings of up to 2,460 µR/hr are associated with the mine rock pile. While the extent of the gamma survey conducted by Tetra Tech was more comprehensive, the range of measured gamma exposure rates are consistent with the data presented in BLM (1998).

The spatial limits of the mine rock pile were determined by lower gamma measurements around the perimeter of the 300-Foot Level area except for an area downslope of the haul road on the eastern side; the steepness and/or dense vegetation in this area prohibited the safe collection of gamma data beyond the limits of the survey. The forest is quickly reclaiming the 300-Foot Level mine rock pile, as thick canopy and surface vegetation is present over much of this pile. The termination of gamma scanning due to terrain hazards was limited to a relatively small area at the 300-Foot Level that does not compromise the gamma activity characterization of the mine rock pile. The gamma activity in the area can be inferred from the pattern of gamma activity in immediately adjoining areas. An isolated area of higher gamma activity, which is visible in the lower right hand corner of Figure 6-2, is likely associated with a few mine rocks in a secondary channel downstream of the 300-Foot Level. Visual observations and gamma measurements indicate that the source of the gamma radiation is a few discrete mineralized rocks that are durable and cobble to boulder in size. This is an important characteristic and contrasts with more widely distributed fine-grained material resulting from the breakdown and erosion of the mine rock. As described in Section 6.1.3, the unshielded surveys overestimate the areal extent and exposure rates in a variable or low gamma field due to shine from scattered higher gamma-emitting rocks.

6.1.1.2 700-Foot and 900-Foot Levels

Figure 6-3 presents the kriged gamma survey results in the vicinity of the 700-Foot and 900-Foot levels. Mine rock at the 900-Foot Level is present at the north end of the Open Pit in two discrete piles designated as the north and south mine rock piles (Figure 1-2). Additional areas of mine rock occur throughout the area east and south of the Open Pit. Gamma radiation levels as high as 3,563 µR/hr were measured at the floor of the Open Pit and the area immediately south of the pit; the area south of the pit was shown as a "dump" in maps from MacKevett (1963). Gamma readings of up to 2,623 µR/hr and 1,700 µR/hr were measured for the north and south mine rock piles, respectively at the 900-Foot Level. The spatial limits of the mine rock piles at the 900–Foot Level are defined by lower gamma measurements in the surrounding areas. In addition, the mine rock piles at the 900-Foot Level are generally free of cover and it is relatively easy to visually discern the limits of disturbance. Figure 6-6 shows the current condition of the north mine rock pile at the 900-Foot Level.

Mine rock also occurs in a discrete pile outside and downslope of the 700-Foot Level portal. Gamma readings of up to 4,206 µR/hr were measured for the 700-Foot Level mine rock pile. With the exception of the area to the east-southeast of the 700-Foot Level portal, Tetra Tech was able to define the extent of the 700-Foot Level mine rock by lower gamma measurements at the perimeter; the steepness, looseness of the rock and/or dense vegetation to the south and southeast of the 700-Foot Level portal prohibited the safe collection of gamma data beyond the limits of our survey. The termination of gamma scanning due to terrain hazards was limited to a relatively small area at the 700-Foot Level that does not compromise the gamma activity characterization of the mine rock pile. The gamma activity in the area can be inferred from the pattern of gamma activity in immediately adjoining areas. The road between the 700-Foot and 900-Foot levels appears as a sinuousoidal gamma line source, with gamma levels quickly decreasing on either side of the road. While the extent of the gamma survey conducted by Tetra Tech was more comprehensive, the range of measured gamma exposure rates for the 700-Foot and 900-Foot levels is consistent with those presented in BLM (1998).

6.1.1.3 OSA and Ore Loading Docks

The results of the gamma survey in the vicinity of the OSA and rock loadout ramps associated with the ore loading docks are illustrated in Figure 6-4. A maximum gamma exposure rate of 4,100 µR/hr was measured in the central portion of the OSA. A deposit of large mine rock was encountered on the east perimeter of the OSA during the survey; gamma readings of about 2,000 µR/hr were measured emanating from these rocks. While the gamma survey conducted by Tetra Tech was more comprehensive and extensive, the range of measured gamma exposure rates in the OSA is consistent with those in BLM (1998).

The gamma survey extended to the intertidal zone, encompassing the two remnant rock loadout ramps that are associated with the ore loading docks. The results of the gamma scanning in the intertidal zone are presented in Figure 6-1 and Figure 6-4. Following the gamma survey in the intertidal area around the remnant rock ramps, a semi-quantative inventory was performed of the number and size of ore pieces present in three separate 100 m^2 plots (see Dock Plot Nos. 1, 2 and 3 on Figure 6-4). Gamma exposure rates up to 2,858 µR/hr extend from the OSA to both the 1971 rock ramp and the rock ramp supporting the current dock. In the intertidal zone, higher measured gamma exposure rates are limited to the area about 100 feet east of the remnants of the rock ramp for the1971 dock and to about 150 feet west of the existing dock ramp.

Visual inspection of the cobbles and boulders in the intertidal zone in this area indicated the presence of discrete pieces of ore scattered among the native material (Figure 6-7). The gamma levels in the intertidal area are likely the result of such discrete pieces of ore randomly distributed throughout the intertidal zone. Testing of the suspected ore with a handheld gamma probe confirmed the presence of ore. As described in Section 6.1.3, unshielded surveys overestimate the areal extent and exposure rates of native surface soil and rock material in a variable gamma field due to shine from scattered higher gamma-emitting rocks.

Tetra Tech inventoried the amount of ore present at three locations (see Dock Plot 1, 2 and 3 on Figure 6-4). The inventory was performed over an approximate 100 m^2 grid at each location. Pieces of ore were identified visually and confirmed with a handheld gamma meter. The pieces of ore present in the test plots were counted and measured; only ore present at the surface was inventoried. The plots were also surveyed using the backpack gamma system similar to the procedures employed for the gamma plots. Results of the inventory are summarized in Table 6-1.

Dock Plot 1 was performed on the eastern shoulder of the rock ramp constructed for the 1971 dock; the number of ore pieces increased both towards the ramp (west) and towards the shore (north). Dock Plot 2 was performed in the swale between the 1971 rock ramp and the rock ramp of the existing floating dock; a few small pieces of ore are scattered through this area. Dock Plot 3, performed on the eastern shoulder of the rock ramp of the existing floating dock, possessed the highest density of ore and the largest sized ore.

Ore pieces were randomly distributed throughout the surveyed area, and showed the impact of individual fragments on the overall gamma survey results. In general, visual observations and the gamma measurements indicate that mineralized coarse, durable cobbles and boulders are the source of the gamma radiation. This is an important characteristic and contrasts with a scenario where more widely distributed fine grained material has resulted from the breakdown and erosion of the ore pieces.

Based on the results of the gamma survey and the ore inventory, it appears that the rock ramp of the existing floating dock was part of a historic ore loading facility. Information on the origin of the existing floating dock and associated rock ramp are not available.

With the exception of the subtidal zone south of the floating dock, the extent of the OSA and dock area was defined by relatively low gamma rate measurements around the perimeter of the OSA. Relatively higher gamma exposure rates were measured by KSI (2004) in the subtidal zone immediately south of the floating dock, as depicted on Figure 6-8, with gamma rates decreasing to relatively low values in the subtidal zone further south of the floating dock. Submarine gamma survey data for the area south of the dock (Figure 6-8) are available in KSI (2004).

6.1.1.4 Mine and Haul Roads

The results of the gamma survey along the mine and haul roads at the Site are shown on Figure 6-1. Although no records exist, the road to the 900-Foot Level was likely originally advanced using coarse material mined locally (cut and fill) and potentially augmented by rock mined from the intertidal area to serve as road base. Once mining began, the mine rock material likely provided a more useable source for road repairs and new road construction. The gamma survey data appear to support this theory, with long stretches of the original haul road exhibiting minimal (<20 μR/hr) gamma exposure rates (Figure 6-1).

In contrast, the “newer” roads at the Site, such as the 300-Foot Level spur, the I&L spur and the mine roads connecting the 700-Foot and 900-Foot levels have a higher percentage of roadbed areas exhibiting higher gamma levels. The gamma survey identified 10 areas along the 300-Foot Level road and 9 areas along the 900-Foot Level road that had gamma exposure rates ranging up to 850 μR/hr. As shown on Figure 6-1, these areas occur along the upper portion of the original haul road to the 900-Foot Level, along the 300-Foot Level spur and the main haul road immediately below the juncture with the 300-Foot Level spur, and as the haul road approaches the OSA. Gamma exposure rates along the lower southern reach of the I&L spur road ranged up to a maximum of 874 μR/hr. The identified areas of the mine and haul roads may result from the use of mine rock to repair the roads or from ore spilled during haulage. Mine rock may have been used to construct the I&L access road. While more comprehensive, the gamma exposure rate data presented on Figure 6-1 for the roads are consistent with that presented in BLM (1998).

In areas where the roads were constructed with mine rock or where ore may have been spilled during haulage, visual observations and the gamma measurement indicate that mineralized coarse durable cobbles and boulders are the source of the gamma radiation, rather than distributed fine-grained soils that are subject to erosion. As described in Section 6.1.3, the unshielded surveys overestimate the areal extent and exposure rates of native surface soil and rock material in a variable gamma field due to shine from scattered higher gamma-emitting rocks.

Dense vegetation and steep terrain generally prohibited the safe collection of gamma data in most areas away from the haul road. However, where the survey team could safely traverse (e.g., near soil sample locations HR-CORR-6, HR-CORR-8 IL-CORR-11), gamma readings were taken in the immediate vicinity of the road.

6.1.2 Site-Wide Gamma Results for Adjacent and Undisturbed Areas

The gamma survey results for the Kendrick Creek stream channel, Kendrick Bay intertidal zone, and the I&L Zone are summarized in the following sections.

6.1.2.1 Kendrick Creek Channel

Figure 6.1 summarizes the gamma exposure rates for Kendrick Creek stream channel. The Kendrick Creek stream channel was surveyed between the 300-Foot Level and the mouth of the creek. With the exception of limited areas downstream of the 300-Foot Level, the measured gamma exposure rates in the Kendrick Creek channel are relatively low (<20 to 30 μR/hr). The survey included occasional secondary channels which are likely active only during high flow events. Isolated areas of gamma readings ranging up to 160 μR/hr were measured downstream of the 300-Foot Level mine rock pile in the primary channel of Kendrick Creek. These gamma exposure rates are due to individual mine rocks observed in the channel immediately downstream of the 300-Foot Level mine rock pile that may have been transported a short distance during high flow events or rolled down the sideslope of the pile. Similarly, a measured gamma reading of 250 μR/hr associated with a small accumulation of mine rock was encountered approximately 600 feet downstream of the 300-Foot Level in a secondary drainage channel just east of Kendrick Creek. Visual observations and the gamma measurements indicate that mineralized durable, cobble- and boulder-sized mine rocks in the channels are the source of the gamma radiation. Again, this is an important characteristic and contrasts with more widely distributed fine-grained material resulting from the breakdown and erosion of the mine rock.

6.1.2.2 Kendrick Bay Intertidal Zone

Figure 6.1 also summarizes the gamma exposure rates measured in the west Arm of Kendrick Bay intertidal zone. As described in Section 6.1.1.3, measured gamma exposure rates ranging up to 2,858 μR/hr in the intertidal zone are limited to a localized area immediately adjacent to the loading docks. Gamma exposure rates of the intertidal zone west of the dock area, including the majority of the Kendrick Creek delta, are low (<20 μR/hr). Background gamma exposure rates within the Kendrick Creek delta area are further described in Section 6.2.1.

6.1.2.3 I&L Zone

Unkriged gamma exposure rates within the I&L Zone are presented on Figure 6-5. A limited gamma radiation survey was performed over the naturally mineralized and unmined I&L Zone to provide additional exposure rate data to assess background levels in an undisturbed, mineralized area. Tetra Tech measured higher gamma exposure rates over the naturally mineralized and unmined I&L Zone, which is consistent with findings in MacKevett (1963). While the gamma rates are variable, gamma values up to 2,124 μR/hr were measured over the unmined I&L Zone. A discussion of background gamma radiation over the naturally mineralized areas present throughout the Bokan Mountain region is presented in Section 6.4.1.

6.1.3 Unshielded and Shielded Gamma Survey Comparison

As previously indicated, the gamma surveys performed by Tetra Tech utilized an unshielded NaI detector. Unshielded detectors, which detect gamma radiation from all directions, provide information on the total gamma exposure rate at any location. Based on previous observations and experience in the field under similar scanning geometries, the horizontal radius of NaI detector response to significantly elevated planar (non-point) gamma sources at the ground surface is estimated to be approximately 4 to 5 feet (at approximately 50 percent of maximum), giving each detector an approximate field of view 8 to 10 feet in diameter at the ground surface. This does not imply that a detector could distinguish gamma readings from a moderate activity point source 5 feet away, but suggests that photons from larger elevated source areas are likely to be detected at that distance. Within this framework, the scan radius for an individual detector is estimated to be 15 to 17 feet. While the unshielded gamma measurements represent the total gamma exposure rate to humans at the specific location, the unshielded surveys overestimate the areal extent of gamma-emitting surface soil and rock material in a highly variable gamma field. This effect, commonly referred to as “shine,” can be compensated to a limited extent by performing a gamma survey with a shielded detector.

During the September sampling event, additional gamma measurements were collected at the various transects at the Site. These scanning transects involved the use of a tungsten-shielded NaI detection system in conjunction with an identical non-shielded NaI detection system. Gamma exposure rates were taken in conjunction with GPS readings as described in Appendix E-1. The purpose of these scans was to assess the impact of shine on gamma exposure rate measurements in the different areas. Side-by-side shielded and unshielded gamma measurements were performed to evaluate the effect of shine on delineating the boundaries of areas potentially impacted by gamma-emitting radionuclides. Tetra Tech performed paired measurements along three transects: two at the 900-Foot Level and one at the OSA. The results of these surveys are illustrated in Figures 6-9 through Figure 6-11.

The impacts of shine at the 900-Foot Level are best illustrated in a transect performed just south of the Open Pit (Figure 6-9). Figure 6-9 includes: shielded and unshielded gamma data; uranium, lead and arsenic concentrations in soil; photographs of soil sample locations; and geologic information. Examination of the data along the transect shown in Figure 6-9 indicates that the shielded gamma detector values better reflect the soil chemistry data (uranium, lead and arsenic). Specifically, soil sample locations 900AT-11 and 900AT-14 appear to represent background conditions (Section 6.4.2). While the shielded gamma values reflect this condition, the higher unshielded gamma readings are influenced by the high gamma exposure rates of mineralization within and adjacent to the Open Pit.

The second transect at the 900-Foot Level bisects the Open Pit (Figure 6-10). Of note on this transect is the increase in both shielded and unshielded gamma measurements at a distance of approximately 200 feet as the pit is approached from the west. The western portion of this transect is predominately bare rock or covered with a thin veneer of soil (Eakins, 1970 and Figure 4-28). These results highlight the challenges and the need to establish a “local” background as further discussed in Section 6.2. Areas of mineralized bare rock are likely covered with mined material in many locals in and around the 900-Foot and 700-Foot levels.

Unshielded gamma exposure rate measurements were taken across the 900-Foot Level north mine rock pile (Figure 6-11). The uranium concentrations in surface soils were consistent with the exposure rate measurements.

The fourth transect was scanned from the western portion (near the existing dock) of the OSA to the eastern edge. Figure 6-12 shows the comparison between the shielded and unshielded gamma values along the transect in the OSA from west to east versus distance along the transect. The unshielded gamma exposure rate is consistently higher than the shielded gamma exposure rate for the entire transect. The tungsten-shielded gamma exposure rates ranged between 18 μR/hr and 1,562 μR/hr, and the unshielded gamma exposure rates ranged between 100 μR/hr and 3,285 μR/hr.

Figure 6-13 shows the ratio of paired OSA shielded exposure rate measurements to the unshielded measurements. At relatively low measured gamma exposure rates, the unshielded exposure rate was due primarily to shine from higher gamma sources. At the highest exposure rates, the measured exposure rate from surface gamma at the measurement point was approximately equal to the exposure rate from shine. This indicates that ratios of shielded to unshielded measurements may be useful in defining the boundaries of the higher gamma mine rock areas. The use of shielded gamma detectors is needed to define the actual on the ground lateral extent of mineralized boundaries that would be needed as part of any remedial action.

The unshielded gamma readings likely overestimate the extent and boundaries of mine rock areas as a result of shine from nearby gamma-emitting sources. However, the unshielded gamma surveys provide a conservative and reliable method to delineate the mine rock material and adjacent soil areas. The unshielded gamma measurements define the limits of gamma exposure representative of the radiation exposure and risk to humans at a specific location.

6.1.4 Gamma Correlation Results

As described in Section 3.3.3, the results of gamma surveying and soil sampling of correlation plots were used to establish a correlation between measured gamma exposure rates and concentrations of radionuclides in surface soils. A secondary objective was to assess the relationships between the gamma/radionuclides and non-radioactive metals (e.g., lead and arsenic) concentrations. The goal of the correlation plot sampling was to demonstrate the use of gamma surveying to assess the boundaries of areas with differing concentrations of radionuclides and metals in the Site soils. Additionally, the application of portable XRF technology to screen soil samples was assessed using the correlation plot samples, as discussed in Section 6.3.1.5.

6.1.4.1 Gamma and Radionuclide Correlation

The correlation plot sampling and gamma surveying methodology are described in Appendix E-1. Gamma exposure rates were measured and composite soil samples were collected from a total of 17 correlation plots. The average measured gamma exposure rates and laboratory radionuclide data for each plot are provided in Table 6-2. The laboratory analytical data are summarized in tables provided in Appendix A.

Bivariate graphs of radionuclide activity concentrations in the correlation plot soil samples versus the plot's average measured gamma exposure rate are provided in Figures 6-14 through 6-19. Sound linear relationships were identified between specific radionuclides of interest and measured gamma exposure rates. The r-squared values for these relationships are provided in Table 6-3. The high coefficient of determination for the individual radionuclides implies a high degree of colinearity, such that measurement of the gamma exposure rate or analysis of an individual radionuclide is predictive of all radionuclides analyzed. The strength of the correlations between gamma and soil radionuclide activity concentrations of individual chemicals demonstrate that gamma surveying can be used without qualification to assess the boundaries and quantify radionuclide activity concentrations of the mine features and surrounding soils at the Site.

6.1.4.2 Gamma and Non-Radioactive Metal Correlation

Relationships between gamma and the concentration of the non-radioactive metals in the correlation plot soil samples were also evaluated. Bivariate graphs of metals concentrations in the correlation plot soil samples versus the plot's average gamma signature are provided in Appendix E-2.

None of the metals exhibit a statistically significant relationship with gamma. However, the following information and conclusions can be drawn based on the correlation plot results:

- The concentrations of mercury, selenium, silver and thallium in the correlation samples were all below detection limits for the correlation samples. The analytical method for thallium in soils was changed following the June sampling event to achieve a lower detection limit.
- While not statistically significant, many metals appear to exhibit an inverse relationship with gamma. Lower metals concentrations are associated with higher gamma exposure rates. Metals potentially exhibiting an inverse relationship include: aluminum, antimony, chromium, cobalt, nickel and vanadium. This inverse relationship suggests that these particular metals are depleted in the uranium-thorium rich Ross-Adams deposit. Several metal concentrations appear to be independent of gamma.
- Metals exhibiting no apparent relationship with gamma include: beryllium, copper, iron, manganese, and zinc.
- Lead and arsenic, while not exhibiting a statistically significant relationship with gamma, may be bimodally distributed. For example, the median concentrations of arsenic and lead in correlation plot soil samples with gamma values greater than about 100 μR/hr are 2.5 and 46 mg/kg, respectively. In contrast, the median concentrations of arsenic and lead in correlation plot soil samples with gamma values less than about 100 μR/hr are 1 and 8 mg/kg, respectively. This suggests that gamma may be useful in delineating areas with higher arsenic and lead concentrations in soils.

Since the metals did not exhibit a statistically significant correlation with gamma, discrete soil sampling was conducted around the mine feature areas during July to characterize the distribution of metals concentrations in soil. The distribution of the metals in Site soils and their relationships to gamma are further discussed in Section 6.3.

6.2 Background Assessment

As previously described, gamma radiation surveys and samples were collected at locations upstream, distant from or in areas outside the mine features to provide background reference data for air (radon), soils, surface water, stream sediment and marine sediment. The background reference data are compared to the media data collected at other locations to define the distribution and trends in concentrations for media and to provide information for the human health and ecological risk assessments.

Quantifying background conditions at a former uranium mine in complex geologic conditions such as the Ross-Adams Site is a difficult task in the absence of actual pre-mining data. The Bokan Mountain Intrusive Complex is a circular stock approximately three kilometers in diameter comprised of peralkaline granite. The peralkaline granite stock is surrounded by a metamorphic zone consisting of quartz monzonite and quartz diorite intrusives. The general enrichment (mineralization) of uranium, thorium and other rare metals in the Bokan Intrusive Complex rocks requires the use of different background levels when discussing select environmental media (e.g., soils, gamma radiation) as various features are underlain by differing rock assemblages (mineralized versus non-mineralized) at the Site. Additionally, the concentration of both radioactive and non-radioactive minerals in veins, dikes and other geologic structures (e.g. Dotson Shear) results in naturally occurring and highly variable concentrations of metals in soils, radon in air, and gamma emissions over short distances throughout the Site.

The higher incidence of radionuclide minerals within the near-surface mineralized zones creates a strong radiometric signature, as illustrated in a 2007 airborne radiometric survey (Figure 4-7). The contrast in radiometric signatures between the Bokan Intrusive Complex and the surrounding monzonite areas is evidenced in the figure as zones of higher 'Uranium CPS', which is indicative of gamma radiation-emitting daughter products of radium associated with naturally occurring uranium deposits (Figure 4-7).

The following sections provide a discussion on local background for gamma radiation, radon concentrations in air, and chemical and radiological concentrations in media at the Site. Metal and radionuclide data representative of background soil concentrations were determined for mineralized (peralkaline granite) and non-mineralized (undifferentiated quartz monzonite and quartz diorite intrusives) areas of the Site using soil sampling locations where lower gamma radiation rates were measured away from the mine features. Gamma radiation data were used to define the boundaries segregating the mine features and mine-influenced soils at the Site from unaffected or adjacent areas. Radon measurements were performed at detector locations that provide data to define local background in areas not influenced by the mine features. In addition, radon measurements at all the detectors are evaluated to define the distribution of radon for the Site, including local background.

The following sections summarize the background data for gamma radiation, chemical and radiological concentrations for media, and air radon concentrations. For site characterization purposes, the maximum concentrations of background mineralized and non-mineralized soils (Section 6.2.2) are used to evaluate soil conditions at the mine features. In a similar manner, the maximum background concentrations for surface water (Section 6.2.4) and background stream sediment (Section 6.2.5) are used to characterize surface water and stream sediment conditions. As described in Section 6.0, the SLHHRA and the SLERA will further evaluate the background data presented in this SCR and will use the appropriate statistical method for defining background values, consistent with applicable guidance, in evaluating potential risks to human and ecological receptors. The results of the SLHHRA and the SLERA will be included in the EE/CA as specified by the ASAOC.

6.2.1 Background Gamma Radiation

As described above, quantifying background gamma radiation requires different background levels that reflect the natural variability in gamma radiation due to the complex geologic conditions of the Site. Due to this natural variability, the background gamma radiation data are defined as the range in gamma exposure rates. It is noteworthy that the natural radiation exposure levels in the area were sufficiently high to have led to the discovery of the Ross-Adams deposit during an airborne radiometric survey performed in the mid-1950s. The fact that the initial mining was performed via an open pit and that the 15,000 tons of ore produced from the shallow (less than 30 feet deep) pit possessed an average U_3O_8 concentration of 0.8 percent confirms that natural, pre-mining gamma exposure rates on and near the deposit were likely very high. Radiation levels measured by MacKevett (1963) at several nearby unmined deposits and measurements performed by Tetra Tech at the unmined I&L Zone indicate what the range for gamma exposure rates in the area might have been prior to mining of the Ross-Adams deposit.

MacKevett (1963) does not report radiological data for the Ross-Adams mine, but provides gamma “radioactivity” data (measured using Geiger-Mueller and scintillation detectors) for several other uranium prospects on Bokan Mountain. MacKevett assigned values ranging from 0.02 milliroentgens/hr (mR/hr) to 0.03 mR/hr (20 to 30 μR/hr) as non-mineralized background. Maximum radioactivity values for the various deposits on Bokan Mountain published in MacKevett (1963) are summarized below.

- Atom Marietta No. 4 Prospect: maximum value of 1,500 μR/hr, 75 times the lower range of non-mineralized background (20 μR/hr).
- Carol Ann Prospects: Maximum value of 600 μR/hr, 30 times non-mineralized background.
- I and L [I&L] Prospects: Maximum value of 5,500 μR/hr, 275 times non-mineralized background.
- I, L, and M Prospects: Maximum value of 3,000 μR/hr, 100 times non-mineralized background.
- Little Jim Prospect: Maximum value of 900 μR/hr, 45 times non-mineralized background.
- Old Crow Prospect: Maximum value of 100 μR/hr, 5 times non-mineralized background.
- Wennie Prospect: Maximum value of 5,500 μR/hr, 275 times non-mineralized background.

Eakins (1970) provides a map showing the results of a gamma radiation exposure rate survey of the Ross-Adams Open Pit area performed using a scintillometer. Eakins (1970) measured values as high as 3,000 μR/hr in the Open Pit; the highest exposure rate, in excess of 5,000 μR/hr, was measured south of the pit in an area shown as a “dump” in MacKevett (1963). Eakins suggested that background radiation was approximately 20 μR/hr, similar to the values used by MacKevett (1963). Perpendicular to the Open Pit (i.e., east and west), readings of 20 μR/hr were measured at a distance of about 50 feet from the edge of the pit. The contrast between Eakins’ background and maximum value is at least 250 times, which is similar to the contrast between background and the gamma values measured over local, unmined deposits reported in MacKevett (1963).

BLM (1998) reported on two surveys performed at the Site in 1995 and 1997. Both surveys were performed using the same type of instruments: a Victoreen Model 190 with a 489-50 probe, and a Ludlum Model 19. The readings from both instruments were reportedly compared to each other twice a day at the same location three feet above ground level (AGL). These side-by-side readings were reportedly within 10% of each other. BLM employed a lead shield during their survey. BLM (1998) estimated the background shielded radiation in the granites comprising the Bokan Intrusive Complex at 44 µR/hr; this includes the 700-Foot and 900-Foot levels and the upper portion (approximately 1,000 feet) of the haul road. BLM (1998) also estimated the background shielded radiation in the intrusive rocks surrounding the Bokan Intrusive Complex at 13 µR/hr; this includes the 300-Foot Level, the OSA, the loadout dock and the majority of the haul road. Surveys performed by Tetra Tech (Section 6.1.3) indicate that unshielded gamma values are approximately three to five times higher than shielded values in low gamma exposure rate areas at the Site.

KSI (2004) used a Ludlum Model 19 microR meter to measure gamma radiation levels at their mine rock and soil sample locations. The meter was equipped with an internal 1-inch by 1-inch NaI scintillator detector. The meter was factory calibrated approximately 5½ months prior to the field work; instrument performance was checked at least daily with a NIST-traceable Cs-137 source. KSI (2004) established a background gamma radiation "reference" level as two times the mean value measured at three feet AGL. The following summarizes their measured background values and their reference levels:

- Bokan Intrusive Complex (this includes the 700-Foot and 900-Foot levels and the upper portion (approximately 1,000 feet) of the haul road). The mean gamma level at 10 sample locations was 58 µR/hr, which resulted in a calculated reference level of 116 µR/hr.
- Intrusive rocks (quartz monzonite) surrounding the Bokan Intrusive Complex (this includes the 300-Foot Level and the majority of the haul road). The mean gamma level at five sample locations was 5 µR/hr, which resulted in a calculated reference level of 10 µR/hr.
- The shoreline area (this includes the OSA and the rock loadout ramps). The gamma levels at two sample locations were both 30 µR/hr. Although not calculated by KSI (2004), a reference level of 60 µR/hr would result following their methodology.

KSI (2004) also measured marine sediment gamma radiation levels *in-situ* using a Ludlum Model 12 meter equipped with a Model 133-2-1 waterproof Geiger-Mueller detector attached to an 80-foot long cable. The meter was factory calibrated approximately two weeks prior to the field work; instrument performance was checked at least daily with a NIST-traceable Cs-137 source.

Tetra Tech performed extensive gamma radiation surveys in 2009, generating over 182,000 individual data points. Tetra Tech's gamma survey methodology is described in appendix E-1. Results of the surveys are discussed in Section 6.1, and illustrated in Figures 6-1 (Site-wide map), Figure 6-2 (300-Foot Level), Figure 6-3 (700- and 900-Foot Levels), Figure 6-4 (OSA and ore loading docks), and Figure 6-5 (I&L Zone).

The Site background is highly variable due to the extent of mineralization, necessitating the assignment of "local" background ranges. For the purpose of this Site characterization, the background gamma radiation levels were determined separately for mineralized (peralkaline granite) and non-mineralized (undifferentiated granite and diorite intrusives) areas of the Site. The OSA and 300-Foot Level locations are considered to be underlain by essentially non-mineralized bedrock, and the 700-Foot and 900-Foot levels are considered to be underlain by mineralized bedrock to varying degrees. The background range and variability for each of these areas was estimated based on a graphical and statistical analysis of the gamma scan data as discussed below.

6.2.1.1 Background Determination for Non-Mineralized Areas

Background gamma exposure rates for non-mineralized areas were determined by independent evaluation of gamma data measured in the OSA, Kendrick Creek channel, and the west Arm of Kendrick Bay intertidal area. Evaluation of the gamma data for these separate areas resulted in comparable background ranges in the gamma exposure rates for non-mineralized areas.

The gamma scan of the OSA covered undisturbed and disturbed areas. Based on previous gamma measurements and individual exposure rate measurements at locations known to represent undisturbed natural background (Dotson Cabin area), the data set was truncated at 50 µR/hr. The data set was truncated at 50 µR/hr to allow closer examination of the lower range of gamma exposure rates. Figure 6-20 presents a histogram of the truncated data set. The histogram of the truncated data set shows a bimodal distribution of gamma measurements with one peak centered on a mean of approximately 14 µR/hr and a range of approximately 8 to 20 µR/hr. A second peak is centered on a value of approximately 35 µR/hr with a range of 20 to 50 µR/hr. The lower exposure rate distribution has been interpreted to represent undisturbed background in non-mineralized areas with a maximum of 20 µR/hr. While the lower peak and distribution appears to be normal based on the shape of the histogram, the standard deviation for the distribution was estimated to be 0.25 times the range of the measurements or approximately 3 µR/hr.

The mean background exposure rate was converted to a dose rate using the regression equation developed from the cross correlation between the NaI detector and the energy independent microrem meter (Appendix E-1). The mean background dose rate for non-mineralized areas is assumed to be 5.8 microrem per hour (µrem/hr) with a range of 3.3 to 8.4 µrem/hour.

Histograms of the gamma measurements for Kendrick Creek channel and the west Arm of Kendrick Bay intertidal area were also developed, as shown on Figure 6-21. Since the gamma scan of the Kendrick Creek channel covered undisturbed and disturbed areas, the data set was truncated at 50 µR/hr similar to that for the OSA. While the entire distribution for the truncated Kendrick Creek channel is skewed by higher gamma measurements, the histogram also shows a bimodal distribution of gamma measurements with one peak centered on a mean of approximately 16 µR/hr with a range of approximately 8 to 26 µR/hr. The mean and range of exposure rates observed from the histogram are consistent with the lower gamma distribution at the OSA interpreted to represent undisturbed background in non-mineralized areas. A second flatter distribution is evident with a peak centered on a value of approximately 40 µR/hr and ranging from approximately 26 to 50 µR/hr.

The entire gamma scan of the west Arm of Kendrick Bay intertidal area was also evaluated, without truncation. The results of the gamma survey in the intertidal area likely represent gamma exposure rates due to a combination of non-mineralized, naturally mineralized and mine-influenced sediment and rock. The obvious statistical differences between the actual mineralized rock and fine grained sediment are striking, with the sediment very close to non-mineralized background, and allow the intertidal sediments to be used as a representative background. The histogram of the data set shows a bimodal distribution of gamma measurements with a distribution of measurements centered with a peak of approximately 7 µR/hr and a range of approximately 6 to 11 µR/hr (Figure 6-22). A second, higher distribution is observed with a peak centered at approximately 16 µR/hr and a range of approximately 11 to 20 µR/hr.

Evaluation of gamma data measured in the OSA, Kendrick Creek channel, and the west Arm of Kendrick Bay intertidal area indicates that background gamma exposure rates in undisturbed non-mineralized areas ranges up to approximately 20-25 μR/hr.

6.2.1.2 Background Determination for the Mineralized Areas

The gamma exposure rate measurements taken in the I&L Zone are assumed to represent the minimum for pre-mining background in the mineralized area at the Site. The I&L Zone has been prospected for uranium, but never mined. Since it has not been mined, the I&L Zone is assumed to be of lower grade and less mineralized than the Ross-Adams deposit, and thus, pre-mining background gamma levels of the Ross-Adams deposit were likely higher. The I&L Zone is sufficiently remote from the mined area as to be unaffected by shine from the mined area and is a reasonable surrogate for evaluating pre-mining background in the mineralized area.

The gamma exposure rate scan data for the I&L Zone were segregated from the entire scan data set for the purpose of determining representative background values. The scan data for the I&L Spur road that likely was constructed using mine rock were deleted from the I&L data set. The remaining data were plotted as a cumulative distribution, that is, the cumulative frequency of the observations was plotted against the measured exposure rate. Due to the very wide range of values, the data were converted to common logarithms before plotting. As shown on Figure 6-23, the exposure rate measurements ranged from approximately 10 μR/hr to over 1,700 μR/hr.

Due to the extreme variability of exposure rates in undisturbed mineralized areas, it is not reasonable to establish a single background value, but rather identify the local background ranges. A cumulative frequency plot of the data indicates that there are potentially three populations (Figure 6-23):

- approximately 10 μR/hr to 25 μR/hr – similar to the non-mineralized background,
- approximately 25 μR/hr to 60 μR/hr – representing a mixture of mineralized and non-mineralized zones and “shine” from the mineralized areas, and
- approximately 60 μR/hr to over 1,700 μR/hr representing the mineralized areas, the highest single measurement at 2,100 μR/hr.

The gamma values measured by Tetra Tech are consistent with the values reported from other characterization efforts. As noted previously, MacKevett (1963) measured exposure rates in excess of 5,000 μR/hr over the unmined I&L Zone.

The gamma scan over the I&L Zone did not encompass the entire mineralized area as much of the terrain was too steep and rugged for safe scanning, nor was it a random scan. The frequency of the measurements is weighted toward the non-mineralized and partially mineralized areas. While the I&L gamma scan data do not provide a statistically robust estimate of the mean and variability of pre-mining background exposure rates, the data are strong evidence of an extremely variable pre-mining radiation environment.

The cumulative frequency plot of the gamma exposure rates measured for the I&L Zone and the correlations determined (Section 6.1.4) between gamma exposure rates and total uranium, total thorium, radium and specific radionuclides were used to estimate the activity of selected radionuclides that may be present in soil and underlying bedrock at the I&L Zone. The 50 percentile, 90 percentile and 95 percentile of the I&L Zone gamma radiation cumulative frequency plot are approximately 94 µR/hr, 740 µR/hr, and 1,165 µR/hr, respectively. The estimated concentration of uranium and activity of radium and specific radionuclides corresponding to these gamma radiation percentiles, as determined by the linear regression correlations, are summarized in Table 6-4. The estimated radionuclide activities vary considerably due to the variability of the measured gamma exposure rates. Uranium concentrations and radium-226 activity in soil and rock likely range up to 800 mg/Kg and 500 ρCi/g or greater in the mineralized I&L Zone, and are representative of pre-mining background in the mineralized area at the Site.

6.2.2 Background Soil

Similar to background gamma radiation, soil background levels were determined separately for mineralized (peralkaline granite) and non-mineralized (undifferentiated granite and diorite intrusives) areas of the Site. The OSA and 300-Foot Level are considered to be essentially non-mineralized, and the 700-Foot and 900-Foot levels are considered to be mineralized. Soil samples collected at locations away from the mine features were used to assess the local background levels for the mineralized and non-mineralized areas. The SAP initially defined the distribution of the sample locations to characterize the local background in the mineralized and non-mineralized areas. Based on the observed variability in gamma exposure rates and understanding of the natural variability of soil concentrations in the mineralized area, a greater number of background samples were designated in the mineralized area than in the non-mineralized area to capture the expected variability. The large data set of gamma exposure rate values provides additional information concerning background levels and variability in the mineralized area and led to additional soil sampling in the mineralized area during the ESI.

In addition to the chemical and radiological analyses, the background soil samples were tested for paste pH and texture. These data are summarized in Table 6-5. The background soils range from moderately to strongly acidic. In general, the higher the elevation at the Site, the more acidic (based on paste pH) and the sandier the soils.

6.2.2.1 Background Determination for Non-Mineralized Areas

Soil sample data collected in the OSA and 300-Foot Level are available from KSI (2004) and Tetra Tech. Tables 6-6 and 6-7 summarize the metals and radionuclide data for these background soil samples. Soil sampling locations from the KSI event are shown on Figure 1-4. The Tetra Tech soil sample locations are shown on Figure 3-3.

Tetra Tech collected one background sample in the 300-Foot Level (300-18) and two background samples at the OSA (OSA-1 and OSA-17). Table 6-8 provides summary statistics (minimum, maximum, mean and median) of the data for these non-mineralized samples. The full suite of 21 metals was analyzed for only one sample (OSA-17), with all three samples analyzed for arsenic, lead, selenium, and uranium. As described in Section 6.0, data for the additional metal parameters from the initial analysis of these samples were recently obtained from the laboratory and are included in Tables 6-6 and 6-8. Radiochemistry data are also summarized in Table 6-8. The maximum metal concentrations and activity of radionuclides shown in the table are considered to represent Site background soil data for non-mineralized areas. The maximum arsenic, lead, and uranium concentrations are 5.1, 15, and 11 mg/Kg. The maximum radium-226 activity of the samples is 7.1 ρCi/g.

KSI (2004) reported maximum lead and uranium concentrations of 1.9 and 0.6 mg/Kg, respectively, and a maximum radium-226 activity of 1.4 ρCi/g from two quartz monzonite bedrock (i.e. not soil) background samples. KSI also collected two background soil samples, SOIL-01 and SOIL-02, within the OSA. However, review of the uranium concentrations (210 mg/Kg and 73 mg/Kg) reported by KSI for the two samples suggest that the samples may not be representative of background concentrations in the non-mineralized area. KSI (2004) acknowledged that the higher uranium concentrations and radionuclide activities of soil samples SOIL-01 and SOIL-02 collected in the OSA may reflect soil enrichment, differences in bedrock concentrations, or dispersal from the OSA to the surrounding undisturbed forest soils. Comparison of concentrations for the two KSI soil samples and mine affected soil samples collected during the ESI within the OSA (Section 6.3.1.3) suggests that KSI samples SOIL-01 and SOIL-02 may have been influenced by OSA operations and are not representative of background soils. ESI soil samples OSA-2 and OSA-10 were collected at approximately the same locations as the KSI samples SOIL-01 and SOIL-02, respectively (Figures 1-4 and 6-4). ESI soil samples OSA-2, OSA-10, OSA- 8 and OSA-14 comprised the OSA composite sample C-1, with a uranium concentration of 120 mg/Kg (Table A-3b). The uranium concentration of sample C-1 is within the range of values reported by KSI for samples SOIL-01 (210 mg/Kg) and SOIL-02 (73 mg/Kg). The KSI samples (SOIL-01 and SOIL-02) and the four ESI samples comprising composite sample C-1 (OSA-2, OSA-8, OSA-10 and OSA-14) are interpreted as being collected from areas influenced by historic operations at the OSA. Due to the higher uranium concentrations, the two KSI soil samples are not considered to be representative of non-mineralized background levels. Accordingly, these two samples are not used for characterization of background soils, but are included as mine affected at the OSA (Section 6.3.1.3). OSA soil samples OSA-1 and OSA-17 provide data that are considered representative of background soils in non-mineralized areas.

6.2.2.2 Background Determination for Mineralized Areas

Soil background data in the 700-Foot and 900-Foot levels are available from samples collected by Tetra Tech, as shown in Tables 6-6 and 6-7. Soil sampling locations are shown on Figure 3-3. The background soil sample locations were selected to characterize conditions representative of the transition zone away from the mineralized ore deposit. A total of 23 background soil samples were collected in the 700-Foot and 900-Foot levels: 18 from the 900-Foot Level, three from the 700-Foot Level, and two from the I&L Zone. The limited samples (IL-1 and IL-2) collected from the I&L Zone represent soil samples near naturally mineralized but unmined areas. Ten of the samples were analyzed for the full suite of 21 metals, with all samples initially analyzed for arsenic, lead, selenium, and uranium. Data for the remaining metal parameters for all soil samples were recently obtained from the laboratory (Section 6.0) and are included in Table 6-6.

Table 6-9 provides summary statistics (minimum, maximum, mean and median) of the metals and radiochemistry data for these samples. For site characterization purposes, the maximum metal concentrations and activity of radionuclides shown in the table are considered to represent Site background for soils at the 700-Foot and 900-Foot levels. Arsenic, lead, uranium, and radium-226 are illustrative of the range in concentrations and activities of other parameters. The maximum arsenic, lead, and uranium concentrations are 4.9, 190, and 140 mg/Kg, respectively. The maximum radium-226 activity of the samples is 95 ρCi/g. KSI (2004) reported maximum arsenic, lead and uranium concentrations of 2.8, 24, and 19 mg/Kg, respectively, and a maximum radium-226 activity of 8.6 ρCi/g from ten granite bedrock (i.e. not soil) background samples.

6.2.3 Background Radon

Background radon levels were assessed using data collected by KSI (2004) and Tetra Tech. KSI (2004) deployed 19 radon detectors at the Site. KSI considered six radon detectors representative of background locations that were underlain by granite and by quartz monzonite. The detectors were deployed for 95 to 100 hours (approximately 4 days). Three of their background radon detectors yielded radon concentrations below the detection limit of 0.4 pCi/L. The remaining three background radon detectors yielded radon concentrations of 2.1, 4.4 and 5.3 pCi/L, with the two highest concentrations from detectors located in areas underlain by quartz monzonite.

Tetra Tech deployed radon detectors at 34 locations across the Site (Table 3-4 and Figure 3-2) for a period of 106 to 107 days (short duration detectors were also deployed at the portals and air shaft during the July event). Valid results were returned from 26 of these locations (Table 6-10). The radon values reported in Table 6-10 represent the average concentrations over the exposure periods calculated from the vendor's calibration factors. For long-term exposure, the radon detectors were deployed for a period of 106 to 107 days from June 8 or June 9, 2009 through September 23, 2009, as shown in Table 3-4. The radon detectors for short-term exposure measurements were deployed for a six-day period during the July sampling event. As shown in Table 6-10, several of the radon detectors were damaged or malfunctioned. However, as described in Section 6.3.5, a causal relationship exists between radon generation and mined materials defined by gamma exposure rates.

Several of the locations yielding no results were, unfortunately, anticipated to represent background conditions. However, radon detector results from the remaining six locations are considered representative of background at the Site:

- OSA Area: OSA-RAD-2, OSA-RAD-3 and OSA-RAD-5
- 700-Foot Level: 700-RAD-11
- 900-Foot Level: 900-RAD-21 and 900-RAD-24.

Radon concentrations from the three detectors deployed in the OSA area were reported as 1.2, 2.1 and 3.3 pCi/L (Table 6-10). The radon concentration from the detector deployed at the 700-Foot Level was 2.1 pCi/L, and concentrations from the detectors deployed around the 900-Foot Level were 1.6 and 2.5 pCi/L (Table 6-10).

A cumulative frequency plot of all the radon concentration data from the combined KSI (2004) and Tetra Tech data set is illustrated in Figure 6-24. The radon measurements appear to fall into 4 groupings, as described below:

- **Group 1**: Radon concentrations range from <0.4 to 5.8 ρCi/L, with radon detectors located in undisturbed to minimally disturbed areas.
- **Group 2**: Radon concentrations range from 7.9 to 40.1 ρCi/L, with radon detectors located in disturbed areas, such as the 300-Foot, 700-Foot, and 900-Foot Level South mine rock piles, and naturally mineralized areas.
- **Group 3**: Radon concentrations range from 64.1 to 192 ρCi/L. Radon detectors were located in areas of major disturbance such as the 900-Foot Level North mine rock pile, adjacent to the Open Pit, the 900-Foot Level portal, downgradient from the 300-Foot Level portal and the OSA.
- **Group 4**: Radon concentrations range from 322 to 445 ρCi/L, with radon detectors located inside the Open Pit and at the 300-Foot Level portal.

The 14 radon detector locations comprising Group 1 appear to represent background radon concentrations for non-mineralized areas at the Site. The seven Tetra Tech samples included in Group 1 are (Figure 3-2):

- OSA Area: OSA-RAD-2, OSA-RAD-3 and OSA-RAD-5
- 300-Foot Level: 300L-RAD-28
- 700-Foot Level: 700-RAD-11
- 900-Foot Level: 900-RAD-21 and 900-RAD-24.

Of the seven KSI (2004) locations included in Group 1, three detectors (RGR-02-95, RGR-03-95, RQM-01-100) yielded radon concentrations below the detection limit of 0.4 pCi/L. The remaining four KSI (2004) locations (RGR-01-95, RQM-02-100, RQM-03-100, MR-RAD-27) possessed radon concentrations ranging from 2.1 to 5.3 ρCi/L.

The maximum Group 1 radon concentration value of 5.8 ρCi/L (Tetra Tech location 300L-RAD-28) is considered to represent the maximum background value for non-mineralized areas away from economic level mineral deposits.

There are numerous undeveloped uranium- and thorium-bearing deposits on Bokan Mountain. Readings taken inside the Ross-Adams mine workings by the BLM (1998) demonstrated that these deposits can generate radon concentrations of several hundred ρCi/L in a semi-enclosed area. Radon flux from a uranium/thorium deposit exposed to the atmosphere would be limited to some degree by fracturing (i.e., secondary porosity) in the deposit, given the relatively short half lives of both radon isotopes (Rn-222 = 3.8 days; Rn-220 = 55 seconds). However, it is reasonable to assume that radon concentrations immediately over an exposed uranium/thorium deposit, such as the Ross-Adams deposit prior to mining and the several nearby undeveloped prospects, would be higher than radon concentrations away from these deposits, such as those comprising the background (Group 1) data set described above.

6.2.4 Background Surface Water

As identifed in the SOW and SAP, background surface water conditions at the Site were evaluated using data from sampling locations upstream of mine feature areas. Site surface water data are available from five sampling events. Single sampling events were performed by the BLM (1998) in August 1995 and KSI (2004) in May 2004. Surface water sampling locations from these two events are shown on Figure 1-4. Tetra Tech performed three surface water sampling events in 2009, in June, July and September. Tetra Tech surface water sampling locations are shown on Figure 3-1.

Four sample locations in these data sets are considered representative of surface water quality above the outcrop area of the Ross Adams mine, as these locations are upstream of mine feature areas. Background that includes the influence of the natural mineralization of the Ross Adams area prior to mining is not possible now due to the influence of the mine rock and so these upstream samples are considered to be the best data available for evaluating background surface water quality. These background samples likely underestimate the metal concentrations and radionuclide activities of surface water from the mineralized area prior to mining. These background samples are:

- Mine Fork Creek (north tributary) upstream of the 900-Foot Level North mine rock pile
- Mine Fork Creek (south tributary) upstream of the 900-Foot Level North mine rock pile
- Kendrick Creek upstream of the 300-Foot Level
- Cabin Creek, upstream of the confluence with Kendrick Creek.

Tetra Tech collected samples at all four of these locations. The other entities collected samples at three of these locations each, with the BLM (1998) omitting Cabin Creek and KSI (2004) omitting Kendrick Creek. A background surface water sample was not collected for 700-Foot Level Creek, nor did the SOW and SAP (Section 3.0) provide for collection of a background sample for this creek. The primary sources of water for 700-Foot Level Creek are surface runoff from mine-affected areas of the 700-Foot and 900-Foot levels and any drainage from the 700-Foot Level portal. Because of these conditions, an un-impacted background water quality sample could not be collected for this creek.

Each entity analyzed their samples for a different suite of parameters. BLM (1998) analyzed surface water samples for 13 metals, while KSI (2004) presents background data for four metals (aluminum, cadmium, lead and uranium). Tetra Tech analyzed surface water samples for 21 metals. All three entities analyzed samples for hardness or the variables used to calculate hardness (i.e., calcium and magnesium). It is not clear if the BLM (1998) data represent total or dissolved metals. The KSI (2004) data represent total concentrations. Tetra Tech analyzed surface water samples for both dissolved and total metal forms.

The total metals concentrations analyzed by each entity at the background locations are summarized in Table 6-11. Also shown on the table are the maximum concentrations at each location and an overall maximum value. For site characterization purposes, the overall maximum value for each metal is considered the background surface water concentration for the Site. The concentrations are compared to Alaska freshwater chronic water quality criteria (WQC)[1] for dissolved metal concentrations; background surface water concentrations exceeding these criteria are noted. Comparison of the total metal concentrations to the WQC for dissolved metals provides a conservative evaluation of the metal data. Note that total aluminum concentrations routinely exceeded the WQC for aluminum at all four background locations. Additionally, in the north tributary of Mine Fork Creek, one cadmium and one copper value exceeded their respective WQC values.

Radiochemistry data for samples collected at the four background locations by the BLM (1998), KSI (2004) and Tetra Tech are summarized on Table 6-12. The BLM's analyses for radioactive isotopes were limited to total radium, while KSI analyzed their background surface water samples for radium-226 and radium-228. Tetra Tech analyzed the background water quality samples for the isotopes of thorium (Th-228, Th-230 and Th-232), isotopes of uranium (U-234, U-235 and U-238), radium-226 and radium-228, lead-210 and polonium-210. The maximum activity concentration of these isotopes at each location and an overall maximum value are shown on Table 6-12. For purposes of site characterization, the overall maximum value for each nuclide is considered the Site background surface water activity concentration.

[1] State of Alaska criteria exist for 11 of the 21 parameters analyzed.

6.2.5 Background Stream Sediment

Simiar to surfacce water, background reference values for stream sediment were determined from sampling locations upstream of the mine features and the outcrop of the Ross Adams mine deposit. Background that reflects the natural mineralization of the Ross Adams area prior to mining is not possible due to the influence of the mine rock. These upstream samples are considered to be the best data available for evaluating background stream sediment quality, but likely underestimate the metal concentrations and radionuclide activities of stream sediment from the mineralized area prior to mining. Stream sediment data are available from three sampling events performed by Eakins (1970), KSI in May 2004 and Tetra Tech in July 2009. Stream sediment sampling locations from the KSI event are shown on Figure 1-4. The Tetra Tech stream sediment sampling locations are shown on Figure 3-1.

Three locations in these data sets are considered representative of background stream sediment at the Site. These are:

- Mine Fork Creek (north tributary) upstream of the 900-Foot Level mine rock pile
- Mine Fork Creek (south tributary) upstream of the 900-Foot Level mine rock pile
- Cabin Creek, upstream of the confluence with Kendrick Creek.

KSI (2004) and Tetra Tech collected samples at all three of these locations. Eakins (1970) only sampled the north tributary of Mine Fork Creek and due to the relatively high laboratory detection limits, the Eakins data are not suitable for background determination. KSI and Tetra Tech analyzed their samples for a different suite of parameters. KSI (2004) presents data for six metals in their background samples; aluminum, arsenic, iron, lead, manganese and uranium. Tetra Tech analyzed stream sediment samples collected in the Mine Fork Creek (south tributary) and cabin Creek for 21 metals, including the metals analyzed by KSI. The sediment sample collected from Mine Fork Creek (north tributary) was analyzed for selected metals consisting of arsenic, lead, selenium, and uranium.

The metals concentrations analyzed by each entity at the background stream sediment locations are summarized in Table 6-13. Also shown in the table are the maximum concentrations at each location and an overall maximum value. The overall maximum value is considered the Site background concentration. The overall maximum arsenic, lead, and uranium concentrations are 10, 22, and 4.1 mg/Kg.

Radiochemistry data for samples collected at the three background locations by KSI (2004) and Tetra Tech are summarized in Table 6-14. The maximum activity concentrations of these nuclides at each location and an overall maximum value are shown in the table. The overall maximum value is considered the Site background activity concentration. The overall maximum radium-226 activity of the samples is 4.9 ρCi/g.

In addition to the chemical and radiological analyses, Tetra Tech tested the three background stream sediment samples for pH, total organic carbon (TOC), acid volatile sulfides (AVS) and texture. The background stream sediments possessed few fines, with the combined clay and silt content ranging from 5 to 12.5 percent. The pH was moderately acidic, ranging from 5.2 to 5.9. The TOC and AVS contents were all below detection limits.

6.2.6 Background Marine Sediment

Drainage from the mineralized terrain in the Kendrick Creek watershed is to the west Arm of Kendrick Bay. The numerous uranium, thorium and rare earth elements (REE) mineral deposits located in the Kendrick Creek watershed have been actively explored for over 50 years (Figure 1-3). Warner and Barker (1989) collected samples of relic glaciofluvial deposits underlying the more recent marine sediments from the west Arm of Kendrick Bay and concluded that *"…it is evident that low grade placer enrichment has occurred"*. Warner and Barker (1989) also mapped a sulfide mineral-bearing (pyrite) bedrock ridge in the west Arm of Kendrick Bay (Figure 2-2). This research suggests that the marine sediments in the west Arm of Kendrick Bay may have naturally elevated concentrations of radionuclides and metals due to natural weathering processes. The deposits present on Bokan Mountain represent the only uranium deposits in southeastern Alaska. Therefore, locating an analogous location to establish background conditions for marine sediments is not practicable.

KSI (2004) collected three "background" marine samples from an unnamed bay approximately 2 miles seaward of the Site (small bay just east of the Shore-Geoduck deposit shown on Figure 1-3). Tetra Tech believes that the marine sediments collected by KSI (2004) in the distant bay do not serve as an analogy to pre-mining conditions in the west Arm of Kendrick Bay because of the lack of significant mineralization in the watershed draining to this bay. In Section 6.3.4, the range in background concentrations specific to the west Arm of Kendrick Bay are discussed in context with the marine sediment sampling results.

6.3 Environmental Media

The following sections summarize the chemical and radionuclide data collected during the three sampling events in 2009 to characterize environmental media at the Site. These environmental media consist of soil, surface water and groundwater, stream sediment, marine sediment, and air. The potential effects of the mine features on the chemical and radionuclide quality of the environmental media are also evaluated.

KSI (2004) collected mine rock samples from mine feature areas to characterize the maximum metal concentrations and radionuclide activities of the mine rock referring to the samples as high-grade rock samples. The high-grade rock samples were collected at locations with the highest gamma radiation level. KSI also collected composite rock samples at the 300-Foot, 700-Foot, and 900-Foot levels, OSA, and roads. One high-grade rock sample at the 700-Foot Level, 900-Foot Level and the OSA were analyzed for the full metal suite KSI (2004), with the remaining samples analyzed for a subset of metals (aluminum, arsenic, iron, lead, manganese, and uranium). All samples were analyzed for the radionuclide isotopes. KSI determined that arsenic, lead, and uranium concentrations and most radionuclides of the rock samples exceeded background reference values. Laboratory analyses of soil, surface water, stream sediment, and marine sediment samples collected by KSI also focused on the subset of metals (aluminum, arsenic, iron, lead, manganese, and uranium) and radionuclide isotopes.

Media samples collected in this ESI included the analysis of additional metals and radionuclides than those constituents of potential concern identified by KSI. As described in Section 3.0, soil, surface water, stream sediment, and marine sediment samples were analyzed for metals and radionuclides to ensure that data for all relevant parameters were developed to verify the constituents of potential concern. As described in Section 6.0, samples collected during the June sampling event were analyzed for the full suite of metals and radionuclides listed in Tables 3-1 and 3-2. Selected samples collected in July and September were analyzed for the full suite of 21 metals, with the laboratory reporting arsenic, lead, selenium, and uranium for all samples.

However, at the time of the original analysis, the laboratory analyzed all soil, stream sediment, and marine sediment samples by EPA Method 6010 (ICP). Following preparation and submittal of the Draft SCR (Tetra Tech, 2010), it was determined that a more complete dataset would be useful for characterization purposes and statistical analysis. The laboratory was requested to report the additional Method 6010 metal parameters from the original analysis where the Method 6010 method detection limits were appropriate for characterization and statistical evaluation. The remaining metal parameters for these samples were reported by the laboratory, except for antimony, mercury, silver and thallium where the Method 6010 method detection limits were too high to provide useful data.

In the following sections, analytical results are summarized in tables or figures for indicator parameters or summary statistics of the analytical data for all chemical and radiological parameters are presented in tables. These indicator constituents vary to some degree for each media and were selected to illustrate the distributions and trends in metal concentrations and radionuclide activities. The selection of indicator parameters is discussed for each media in the following sections.

Analytical data for all samples collected by Tetra Tech are presented in Appendix A, with copies of laboratory analytical reports, data quality evaluation reports, field measurements and records, and photographs provided in Appendices B, C and D for the three individual sampling events conducted in June, July and September 2009. The data tables in Appendix A are included as a hard copy attachment to this SCR to assist in reviewing the environmental data collected during the ESI. The remaining appendices are included in electronic format only.

6.3.1 Soil Media

The identification of background soils is described in Section 6.2.2 and was based on the sample location and concentration of metals and radionuclides. Those samples identified to represent background conditions are included in Tables 6-6 and Tables 6-7. Soil samples were also collected within or at the margins of the mine features. Soil sampling locations were selected based on mapping of the preliminary gamma survey results and visual observations. These soil samples are representative of fine-grained material within the rock pile areas or fine-grained soil at the margins of the mine features that likely have been influenced by historic mining activities. Since the soil sampling locations are specific to the mine features, the soil sampling results are described separately for each of the mine feature areas in the following sections.

Statistical summaries of the soil sample data are provided in tables separately for the mine features (mine rock piles at the 300-Foot, 700-Foot, and 900-Foot levels, the OSA, mine and haul roads, and the I&L spur road). As described in Section 6.0, the SLHHRA and the SLERA will provide further evaluation of the data, including statistical analysis of the data as appropriate for each risk exposure unit. The mine feature areas, along with ecological features and human use characteristics of the Site, will be used to identify risk exposure units appropriate to the SLHHRA and SLERA. While the risk assessments will define the exposure units, it is anticipated that the individual mine features and the summary statistic tables for the mine features will correspond to the risk exposure units.

The gamma correlation results demonstrated a statistical relationship between gamma and the activity of radionuclides in soils (Section 6.2.1). Combining the gamma survey results and the soil data (Figures 6-25, 6-26 and 6-27) indicates an overall good agreement between the gamma data and the soils designated as background or influenced by mine features.

As discussed in Section 6.1.3 and illustrated in the shielded/unshielded gamma transects (Figures 6-9 through 6-12), unshielded gamma probes present a macro-view of the lateral extent of gamma exposure rates due to influence from distant gamma-emitting sources ("shine"). This macro-view of the gamma accurately reflects the dose rate for a person standing at that location and is of significant value for characterizing the current radiometric conditions at the Site. Shielded gamma detectors are needed to define the actual on the ground lateral extent of mineralized boundaries that would be needed as part of any remedial actions.

An assessment was performed to evaluate the field screening of soil samples using a portable XRF instrument for metals, particularly lead and arsenic. The results of the XRF assessment are provided in Section 6.3.1.5.

6.3.1.1 700-Foot and 900-Foot Levels

The Tetra Tech soil samples at the 700-Foot and 900-Foot levels are shown along with the gamma survey results on Figure 6-25. The background soil locations are associated with lower gamma values. Mine rock occurs at discrete locations through the area, such as the north and south 900-Foot Level mine piles, the area south of the 900-Foot Level portal mapped by MacKevett (1963), the mine roads and associated embankments, and the 700-Foot Level mine rock pile. Soils are distributed throughout this area although much of the area adjacent to the Open Pit is bare rock. Tetra Tech samples focused on fine-grained soils within or at the margins of the mine rock areas. As shown on Figure 6-25, the discrete soil sample locations within or at the margins of the mine rock areas have correspondingly higher gamma values.

Tables 6-15 and 6-16 summarize the range, mean and median concentrations of metals and activity of radionuclides of samples collected by Tetra Tech from mine rock piles and soils adjacent to the mine rock piles at the 700-Foot and 900–Foot levels, respectively. As shown in the tables, the concentration of metals and activity of radionuclides of the rock/soil samples vary over a wide range for each mine rock pile area. Arsenic, lead, total uranium, and radium-226 are used to illustrate the chemical and radiological characteristics of soil. Median concentrations of arsenic, lead, total uranium, and radium-226 in rock/soil are 2.3 mg/Kg, 44 mg/Kg, 200 mg/Kg, and 136 ρCi/g at the 700-Foot Level, and 3.1 mg/Kg, 76 mg/Kg, 580 mg/Kg, and 351 ρCi/g at the 900-Foot Level. Table 6-17 summarizes the maximum concentrations of uranium, arsenic and lead of samples collected at individual mine rock piles by Tetra Tech and KSI (2004). The maximum metals concentrations shown in the table are from high-grade rock samples collected by KSI (2004) where maximum gamma radiation levels were observed.

6.3.1.2 300-Foot Level

As depicted in Figure 6-26, soil and gamma results at the 300-Foot Level are also in good agreement. Table 6-18 summarizes the range, mean and median concentrations of metals and activity of radionuclides of the soil samples collected by Tetra Tech from within and at the margins of the 300-Foot Level mine rock pile. Concentrations of metals and activities of radionuclides of the rock/soil samples vary over a wide range depending on the location of the samples relative to the mine rock pile. Median concentrations of arsenic, lead, total uranium, and radium-226 in rock/soil at the 300-Foot Level are 2.7 mg/Kg, 58 mg/Kg, 155 mg/Kg, and 70.9 ρCi/g.

6.3.1.3 Ore Storage Area

The soil sample locations and gamma results from the OSA are shown in Figure 6-27. As previously discussed (and also experienced by KSI), the thick mat of organic cover at the OSA inhibited the collection of soil samples. Although Tetra Tech collected more samples than shown, several samples had to be composited by the laboratory when, upon drying, insufficient mass was available to perform all the requested analyses.

Table 6-19 summarizes the range, mean and median concentrations of metals and activities of radionuclides of soil samples collected by Tetra Tech from the OSA. The soil samples included in the table are judged to have been influenced by the OSA operations to varying degrees. These OSA soil samples include Sample nos. OSA-4, -5, -6, -11, -12, -13 and composite samples C1 and C2. The concentration of metals and activity of radionuclides of these soil samples vary considerably. Median concentrations of arsenic, lead, uranium, and radium-226 are 2.1 mg/Kg, 15 mg/Kg, 240 mg/Kg, and 55.2 ρCi/g. The maximum concentrations of arsenic, lead, and uranium in samples collected at the OSA by KSI (2004) are summarized in Table 6-20, which were defined as high-grade rock samples where maximum gamma radiation levels where observed. In comparison, the maximum concentrations of arsenic, lead, and uranium in soil samples collected by Tetra Tech were 6.8 mg/kg, 41 mg/Kg, and 460 mg/Kg.

6.3.1.4 Mine and Haul Roads

Gamma surveying and soil sampling also indentified portions of the mine roads that are comprised of, or have been impacted by, mine rock. These areas are illustrated on the Site-wide gamma map shown on Figure 6-1. Table 6-21 summarizes the concentrations of metals and activities of radionuclides of seven soil samples collected by Tetra Tech from the mine and haul roads, at the locations depicted on Figure 3-3. These consist of the soil samples (HR-CORR) that were collected on the mine and haul roads and used in the correlation analysis for gamma emissions. With a few exceptions, the variations in the concentrations of most metals were relatively low (coefficients of variation less than 50 percent). Uranium concentrations and most radionuclide activities exhibited greater variation (coefficients of variation greater than 100 percent). Median concentrations of arsenic, lead, uranium, and radium-226 are 0.95 mg/Kg, 7.7 mg/Kg, 31 mg/Kg, and 13.4 ρCi/g.

Table 6-22 summarizes the concentrations of metals and activities of radionuclides of two soil samples collected by Tetra Tech from the I&L spur road, at the locations depicted on Figure 3-3. These consist of the correlation soil samples (IL-CORR-10 and IL-CORR-11). Most of the higher concentrations of metals and activities of radionuclides occurred on the lower reach of the I&L Spur road, as represented by sample IL-CORR-11.

6.3.1.5 XRF Technology Evaluation

As described in the SOW and SAP, field screening of soil samples using a portable XRF instrument for metals, particularly lead and arsenic, was also evaluated. The key in using XRF as a field screening tool is to develop a statistically meaningful relationship between field XRF readings and laboratory analytical data. The 15 correlation plot soil samples collected in June were tested in the field using Tetra Tech's hand-held Niton XLp Model 702 XRF instrument, which uses a cadmium-109 (Cd-109) sealed source. Soil samples were submitted to ALS for analysis. In the case of lead and arsenic, two samples were submitted to the laboratory: one field processed using a No. 60 Sieve for comparison to the XRF analyses, and a second bulk sample for gamma correlation.

Arsenic concentrations of the samples reported by laboratory analyses ranged from 0.11 to 5.9 mg/Kg, which are below the detection limit of the XRF instrument (typically around 20 mg/Kg depending on the composition of the soil). Consequently, the use of portable XRF technology in the field for determining arsenic concentrations in soils is not viable given the range of arsenic concentrations at the Site.

Both the XRF and laboratory analyses for lead reported concentrations above detection limits (Appendix A). Least-squares linear regression analyses of the laboratory-determined lead concentration versus the XRF lead data indicated a reasonably good correlation, with an r-squared value of 0.89. However, as illustrated on Figure 6-28, the field XRF data were biased high (1:1 correlation line added for clarity). Further investigation revealed that the resolution of the Niton XLp Model 702 XRF instrument likely allows radiation energy from both the thorium and uranium decay chains to contribute to the detected energies for lead, resulting in an artificially elevated lead concentration (high bias). The bias varies dependent on the variation in the thorium and uranium activity. The accuracy of the metal concentrations determined by field XRF measurements is also dependent on soil moisture content. The initial soil sampling, which was performed under relatively dry conditions, still required prolonged drying of the soil samples prior to XRF analyses. Given the bias in lead concentrations and the logistics of drying soil samples at the Site, the field XRF technology was not considered practical for further Site-wide soil sampling. Additional discrete soil sampling was conducted during July to provide additional data to characterize the distribution of metal concentrations in soils.

6.3.1.6 Soil Media Summary

Fine-grained discrete soil samples were collected of material within the mine rock pile areas at the 300-Foot, 700-Foot and 900-Foot levels and at the margins to evaluate the influence of the mine rock pile areas. Soil samples were also collected within the OSA and at areas along the mine and haul roads. The soil sampling results are specific to each mine feature. As described in Section 6.2.2, soil samples collected at locations away from mine features were used to assess the local background levels for the mineralized and non-mineralized areas. Evaluation of the metal and radionuclide analytical results indicates that soil at the margins of the mine feature areas at specific sampling locations have been influenced by mine rock.

The statistical relationship between gamma and soil radionuclide activities and comparison of the metal and radionuclide data at soil sample locations with the gamma exposure rates demonstrates that the gamma radiation data define the extent of mine-impacted soils for the mine features at the Site. As previously discussed, measured gamma exposure rates and soil sampling data were compared to assess the relationships between gamma exposure rates and both radionuclide and non-radioactive metal constituents. The comparison provided in Section 6.1.4.1 demonstrated that statistically significant relationships exist between gamma exposure rates and soil radionuclide activities at the Site. In Section 6.1.4.2, the relationship between gamma exposure and lead and arsenic is discussed. While not statistically significant, higher concentrations of lead and arsenic are associated with higher gamma exposure rates indicative of mine features or undisturbed mineralized areas such as the I&L. In addition, examination of the soil metal concentration summary data presented in Tables 6-8, 6-9, 6-15, 6-16, 6-18 and 6-19, shows that the background soils (non-mineralized and mineralized) have a distinctly lower concentration range for these ore-related metals (lead, arsenic and uranium), than do the mine affected soils sampled at the 900-Foot, 700-Foot, and 300-Foot levels and OSA. The concentration differences between background and mine-affected soils coincide with gamma exposure measurement changes at the visual boundaries of mine features and disturbance. Comparison of arsenic, lead, and uranium concentration data with the gamma exposure rates, as shown in Figures 6-9 and 6-11, demonstrates that the gamma exposure data effectively defines the extent of mine-affected soils for both radionuclides and non-radioactive metals.

6.3.2 Surface Water and Groundwater Media

The mine features potentially impacting water resources in Kendrick Creek and its tributaries include: the mine rock piles present at the 300-Foot, 700-Foot and 900-Foot levels, and drainage from the underground mine at the 300-Foot Level portal and possibly from the 700-Foot Level portal. Drainage from the 700-Foot Level portal appears to seldom occur and the flow rate of the drainage from the 300-Foot Level portal is low with respect to flows observed in Kendrick Creek (Section 4.4.2).

In general, ambient surface water quality at the Site is characterized by low total dissolved solids (TDS) concentrations (<20 mg/L), calcium/sodium-bicarbonate waters of low ionic strength and low buffering capacity, typical of granitic environments. Ambient waters have a mildly acidic to neutral pH. Total suspended solids (TSS) were below detection (<4 mg/L) in all water samples collected, even during periods of increased flow due to precipitation.

6.3.2.1 Surface Water

The quality of surface water in Mine Fork Creek from above the 900-Foot level to its confluence with Kendrick Creek, and then in Kendrick Creek to the mouth is exhibited on a series of graphs presented in Appendix G-2. Analytical data for all individual samples collected by Tetra Tech are presented in Appendix A. Select graphs for total arsenic, lead, uranium, zinc, and radium-226 are presented in Figures 6-29 through 6-33 to illustrate the distribution and trends in metal concentrations and radionuclide activities. These data are also shown on Figures 6-34 and 6-35. Arsenic, lead, uranium, zinc, and radium-226 were selected as indicator parameters of surface water quality in the Kendrick Creek watershed since they were frequently detected at most sampling locations; were detected in water samples collected in drainages associated with mine features; exceeded background surface water concentrations (Section 6.2.4) at least one or more sampling locations; had the potential to exceed State of Alaska chronic freshwater criteria (zinc only); and illustrate the distribution and trends in concentrations of other parameters.

The hydrology of the Kendrick Creek drainage basin is discussed in Section 4.3. The lower reaches of Kendrick Creek present moderate to low/negligible available spawning (ASA) and moderate rearing (ARA) areas for salmonids. Proceeding inland, the quality of both ASA and ARA quickly decreases. From between 200 and 250 feet in elevation above sea level (asl), the ASA and ARA in Kendrick Creek is low/negligible for salmonids but still presents moderate opportunities for Dolly Varden. Above an elevation of 250 feet asl, including the 300-Foot Mine Level, the stream has a steep gradient, with both Kendrick Creek and Mine Fork Creek considered negligible spawning and rearing habitat for all salmonids.

As described in Section 4.3, variations in stream flow are dependent on seasonal precipitation patterns. Peak stream flows normally occur at the onset of the rainy season in September since most of the precipitation occurs as rain, with minimal stream flows occurring during the dry summer months. The three surface water sampling events performed for the ESI provide data to characterize surface water flow and water quality for both the low-flow and high-flow periods. As shown in Table A-1a, measured stream flows during the June and July sampling events were relatively low and representative of the dry period. In contrast, measured stream flows during the September sampling event were significantly higher at all sampling locations and representative of the wet season.

Precipitation records from Annette Island, as shown on Figure 4-1, indicate that precipitation during the sampling events in June and July were representative of low precipitation. Precipitation immediately preceding the September sampling event was significantly greater than the historical average and representative of precipitation during the wet season, resulting in stream flows representative of high flow conditions during the wet season. As depicted on Figure 4-6 daily mean discharge data for Old Tom Creek near Kasaan indicate that stream flows during late September 2009 were representative of stream flows during the wet season. The higher stream flows measured at the Site coupled with the Annette Island precipitation and USGS stream gauging records demonstrate that the September sampling event was representative of high flow conditions at the Site during the wet season.

Comparison of water quality data collected during the three sampling events at the Site allows the effects of higher precipitation and higher stream flows on water quality to be evaluated. Water quality generally improves with increased stream flow. The concentrations of key constituents sampled at stations in Kendrick Creek downstream of mine features decrease or are similar during the higher stream flows in September compared to the June and July sampling events. As shown on Figures 6-34 and 6-35, uranium, zinc, and radium concentrations in Kendrick Creek downstream of the 300-Foot Level mine rock pile at 300L-SW-01-A decrease during the higher stream flows in September compared to the lower stream flows in either the June and July sampling events. Uranium and radium concentrations of the drainage from the 300-Foot Level portal (300L-SW-01-E) also decreased due to the significantly higher flow observed from the 300-Foot Level portal in response to precipitation in September.

The mineralogy of the ore body is summarized in Section 4.4.2. The mineralogy of the ore body and the results of water quality sampling demonstrate that the mine rock is not acid generating, as may be observed in other mineralized mining districts that contain sulfide minerals. Where abundant sulfide mineral content is present, the weathering and oxidation of the sulfides results in acid generation that increases metal solubility and transport upon contact with water. Under these conditions, metal concentrations may increase with increasing flow. Such is not the case at the Ross-Adams Mine. Due to low sulfide mineral content, metal concentrations are controlled by the rate of weathering, with metals concentrations in storm water runoff being affected by dilution during higher precipitation periods. As evidenced by increased flows during the late September sampling event, metals and radionuclides did not exhibit an increase in concentrations during periods of higher precipitation that was indicative of acid rock drainage. Sulfate concentrations, a key indicator of acid rock generation, are negligible in surface water samples downstream of mine features, even in drainage from the 300-Foot Level portal, and decrease at the surface water sampling stations downstream of the mine features in September. In addition, pH values at the surface water sampling stations remained relatively constant during the three sampling events.

Except for aluminum concentrations at most sampling locations and zinc concentrations at two sampling locations, the water quality in Mine Fork Creek and Kendrick Creek meets chronic, freshwater criteria established by the State of Alaska. The State of Alaska establishes chronic, freshwater criteria for 11 metals: aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc. Of the parameters detected in all samples collected in 2009, only aluminum and zinc exceeded the criteria. Aluminum concentrations exceeded the criteria at many of the sampling locations in Kendrick Creek and in Mine Fork Creek; however, aluminum concentrations at the background surface water locations (Section 6.2.4) also exceeded the criteria. Aluminum concentrations in Kendrick Creek and in Mine Fork Creek were also less than or within the range of concentrations at the background surface water locations. Zinc concentrations exceeded the criteria in only one sample collected in Mine Fork

Creek immediately upstream of the 300-Foot Level portal (300L-SW-01-D) and in only one sample collected from the 300-Foot Level portal (300L-SW-01-E). The zinc concentrations are below the criteria downstream in Kendrick Creek (Figures 6-32 and 6-34). As shown on Figure 34 and 6-29, arsenic concentrations were below detection limits at all mainstem sampling locations.

The maximum concentrations for metals and select radionuclides in surface water samples collected downstream of the mine rock piles at the 300-, 700- and 900-Foot Levels are summarized in Table 6-23. The 300-Foot Level sample was collected downstream of all mine workings, including the 300-Foot Level mine rock pile. Sample locations are shown on Figures 1-4 and 6-34. With the exception of aluminum, the maximum concentrations observed for all these parameters were below the Alaska water quality freshwater chronic criteria. As described above, aluminum concentrations at the background surface water locations also exceeded the criteria and aluminum concentrations in surface water samples downstream of the mine rock piles were less than or within the range of concentrations at the background surface water locations. The following samples were used to compile these maximum values:

- Mine Fork Creek (900-Foot Level): WA02 (BLM, 1998); SW-10 (KSI, 2004); 900L-SW-01-A (Tetra Tech)
- 700-Foot Level Creek: SW-09 (KSI, 2004), 700L-SW-01-B (Tetra Tech)
- Kendrick Creek (300-Foot Level): WA01 (BLM, 1998); SW-08 (KSI, 2004); 300L-SW-01-A (Tetra Tech).

The range of pH values (4.71 to 6.18) and relatively low sulfate concentrations (1.0 to 2.5 mg/L) measured for these surface water samples collected downstream of the mine rock piles are comparable to the range of pH values (4.40 to 6.45) and sulfate concentrations (<1.0 to 2.4 mg/L) measured at background surface water sample locations. As such, the mine rock piles are not indicative of acid rock drainage. Due to the low buffering capacity of the ambient surface waters, any acid rock drainage would have a recognizable influence on water quality.

Water quality in samples collected from minor Site tributaries suggests localized impact from the mine features. The concentrations of several metals and radionuclides in samples collected from the short drainage originating in the vicinity of the 700-Foot Level by Tetra Tech (700L-SW-01-B) and KSI (2004) exceeded background surface water concentrations (Figures 34 and 35). The 700-Foot Level Creek was dry in June 2009, and the flows in July and September were low (9 and 22 gpm, respectively). Uranium and the combined radium-226/228 concentrations were below drinking water samples in both samples collected from the 700-Foot Level Creek in 2009.

The Open Pit is a topographically closed feature with inward drainage. The pit serves as a catch basin for surface water, which can subsequently enter the mine workings via the 900-Foot Level portal. Surface water was observed flowing into the pit at the southwest corner on several occasions during and following rain events and seeping through the dike at the north end of the pit. Two water samples, 900L-SW- 01-E and –F, were collected within the Open Pit during the September sampling event. The concentrations of metals and radionuclides in these two samples were similar to those observed in the water draining from the 300-Foot Level portal in September 2009. The combined measureable flow at the two pit locations was estimated to be approximately 4 gallons per minute (gpm). The Open Pit serves as a source of water to enter the subsurface mine workings via the 900-Foot Level portal. The 900-Foot Level portal and the air shaft represent potential locations for surface water to enter the subsurface mine workings.

The lower 700- and 300-Foot Level portals represent potential avenues for this water to exit the workings, along with groundwater that may infiltrate into the subsurface workings.

Mine water flows continuously from the 300-Foot Level portal and drains to Mine Fork Creek upstream of its confluence with Kendrick Creek. Flow rate measurements at the 300-Foot Level portal are summarized in Table 6-24. Flow rates measured from the 300-Foot Level portal range from about 18 to 91 gpm, with the lowest rates coinciding with the annual low flow period typical of southeastern Alaskan streams (Section 4.3).

The maximum measured flow of 0.2 cubic feet per second (cfs), or 91 gpm, was collected at the 300-Foot Level portal by Tetra Tech in September 2009. More precipitation occurred prior to and during the September 2009 sampling event than experienced in June and July. Precipitation prior to and during the September sampling event was representative of the wet season. The measured flow rate at the 300-Foot Level portal reflects this relative increase in precipitation, with the measured flow rate in September being approximately five times greater than that observed over the summer months.

As a general indication of water quality, the TDS concentration in September (20 mg/L) was less than that measured in June (66 mg/L) and July (51 mg/L), with TDS being inversely related to flow rate. The variation in sulfate concentrations in September (2.7 mg/L), June (9.4 mg/L), and July (7.1 mg/L) were consistent with the trend in TDS concentrations. Likewise, major cation and anion concentrations were lower in September compared to June and July. However, the concentrations of metals observed in the 300-Foot Level portal drainage were similar during each of the three 2009 events. The volume and quality of water observed in June and July 2009 likely represent base flow conditions (Section 4.3). The pH values measured of the portal drainage during the three sampling events varied from 6.58 to 6.85, with no apparent seasonal variation. The pH values of the portal drainage were greater than the range of pH values of 4.40 to 6.45 measured at background surface water sample locations.

The portal drainage enters Mine Fork Creek within a short distance, and the combined flows enter Kendrick Creek after another approximately 100 feet. Flows measured by Tetra Tech in Mine Fork Creek were approximately 2 to 32 times greater than the flows measured from the portal. Flows measured in Kendrick Creek immediately below the 300-Foot Level mine rock pile were even greater, exceeding the portal flow by an approximate factor of 7 or more.

Maximum concentrations for metals and selected radionuclides in samples from the 300-Foot Level portal are summarized in Table 6-25. Alaska freshwater chronic criteria are also provided in the table for comparison. The maximum observed concentrations of metals are below their respective criteria, with the exception of zinc. As previously described, the maximum zinc concentration of the drainage from the 300-Foot Level portal slightly exceeds the freshwater chronic criteria; however, the zinc concentrations of samples collected during the other two sampling events were less than the zinc criteria.

The mine geometry and absence of flow observed during the ESI sampling events and other investigations indicates that drainage from the 700-Foot Level portal is likely to be minimal and occur only intermittently during periods of high precipitation. As such, any drainage from the portal has a minimal potential to affect the water quality of 700-Foot Level Creek. As described in Section 4.6.2.5, mine mapping shows that the 700-Foot Level adit is a cross-cut tunnel that extends through undivided granite a distance of approximately 300 feet inward from the portal to the intersection of the near-vertical shaft connecting the 300-Foot Level. The 700-Foot Level adit does not intersect the ore body until near the intersection with the near-vertical shaft.

Based on the mine mapping, flow reporting to the 700-Foot Level adit is due only to bedrock fracture inflow through the overlying granite that is intercepted along the 300-foot length of the 700-Foot Level adit. The 300-Foot Level adit effectively captures and drains water that enters the mine workings.

Based on available information, no water quality samples have been collected from the 700-Foot Level portal. The BLM (1998), which was onsite in both 1995 and 1997, reported that the 700-Foot Level workings were flooded with water up to two feet deep; however, they indicated that *"no continuous flow discharges from the 700-level portal or crosses the 700-level dump."* KSI (2004) did not observe water discharging from the 700-Foot Level portal in May 2004; however, KSI indicated through a personal communication that a *"continuous flow from the [700-Foot Level] adit and onto the waste rock dump was observed in November 2004."* Tetra Tech visited the 700-Foot Level portal several times during each of the three 2009 sampling events (June, July and September). Although standing water was present at and inside the portal mouth, Tetra Tech did not observe water flowing from the 700-Foot Level portal during any occasion in 2009.

The drainage characteristics of the 700-Foot Level adit are confirmed by the absence of flow during any of the three sampling events, even during the September sampling event, which was performed immediately following a period of above average precipitation. In contrast, flow from the 300-Foot Level portal increased significantly (from 0.04 cfs (18 gpm) during the July sampling event to 0.2 cfs (91 gpm) during the September sampling event) in response to precipitation, yet no flow was observed from the 700-Foot Level portal in September. As such, the standing water observed inside the portal mouth and the potential for intermittent yet minimal drainage from the 700-Foot Level portal does not represent a significant potential for impact to the surface water quality of 700-Level Creek.

The concentrations of uranium in Mine Fork and Kendrick Creeks are shown in Figure 6-31 and Figure 6-34. Uranium concentrations remain low as Mine Fork Creek passes through the 900-Foot Level area, increasing at the 300-Foot Level. Mine features in this area include the 300-Foot Level portal and mine rock pile. The uranium concentrations in water samples collected at the portal in 2009 ranged from 0.11 to 0.24 mg/L, but significantly decrease within a short distance downstream in Kendrick Creek (300-SW-01-A, immediately downstream of the 300-Foot Level mine rock pile), and then continue to decrease at downstream locations. With the exception of the samples collected from the 300-Foot Level portal and inside the Open Pit, uranium concentrations measured at the Site in 2009 were all below the USEPA drinking water standard, with values in lower Kendrick Creek at least an order of magnitude below the drinking water standard.

The activity concentrations of radium-226 in Mine Fork and Kendrick Creeks are shown in Figures 6-33 and 6-35. The influence of radium-226 activities of the 300-Foot Level portal water on Kendrick Creek exhibit similar trends to the uranium concentrations. The radium-226 activities of the portal samples ranged from 4.3 to 7.8 ρCi/L, but significantly decrease within a short distance downstream in Kendrick Creek (300-SW-01-A) and continue to decrease at downstream locations.

The radium-226 concentrations in twelve of the 25 samples collected during 2009 in the mainstems of Mine Fork and Kendrick Creeks were below detection limits. For radium-228 (Appendix G-2), the proportion of non-detects is greater, with 15 of 25 mainstem samples below the detection limit. With the exception of the samples collected from the 300-Foot Level portal and inside the Open Pit, the combined radium-226/228 concentrations measured at the Site in

2009 were all below the USEPA drinking water standard for total radium. Many of the radioactive isotopes exhibit similar behavior to radium-226, reaching maximum values in Kendrick Creek below the 300-Foot Level, and then decreasing in the downstream direction. At Kendrick Creek sample locations downstream of the 300-Foot Level sample location (i.e. downstream of 300L-SW-01-A), only about 25 percent of the isotopes analyzed in the 2009 surface water samples were above the detection limits with some parameters (i.e., lead-210 and polonium-210) always below detection.

KSI (2004) provides one sample for surface water collected in an apparent diversion channel on the northeast and east side on the OSA (SW-05 on Figure 1-4). Flow in this small channel is sluggish. Concentrations of a few metals (i.e., aluminum, cadmium, iron, and lead) and radionuclides in the OSA surface water sample were slightly above surface water background concentrations. The maximum concentrations for metals and selected radionuclides for this surface water sample are summarized in Table 6-26. The concentrations of aluminum and cadmium in the OSA creek sample (KSI (SW-05) exceeded the Alaska WQC.

6.3.2.2 Groundwater

The bedrock at the Site is comprised of dense, igneous intrusives. Groundwater flow in this rock type will primarily be through secondary porosity, such as fractures and faults. The underground workings intercept these fractures and faults, providing an avenue for bedrock groundwater to move to the surface. The June and July sampling events coincided with the annual low flow period typical of southeastern Alaskan streams (Section 4.3). The flow measured from the 300-Foot Level portal during both events, approximately 18 gpm, is assumed to represent the baseflow contribution from the groundwater to the underground workings. The quality of the groundwater flowing into the underground workings is not known.

The generally thin soils in the vicinity of the major mine features at the Site suggest that there is minimal opportunity for shallow groundwater to develop. In addition, the steepness of the creeks in their upper reaches inhibits the accumulation of alluvial material, and bedrock exposure in the creek beds is common. Within the lower reaches of Kendrick Creek, the stream gradient decreases sufficiently to allow the development of alluvium. Attempts to installed drive point piezometers in the lower reaches of the Site were thwarted by the layers of cobbles and boulders (Section 3.3.7); however, it is assumed that a shallow alluvial groundwater system is likely associated with the surface water in the lower reaches of Kendrick Creek. As described above and as illustrated by the selected constituents in Figures 6-29 through 6-33, surface water quality in the lower reaches of Kendrick Creek is generally good. Shallow alluvial groundwater in lower Kendrick Creek is expected to be of similar quality to surface water.

Groundwater sampling at the Site was limited to a surface expression (spring) along the northern margin of the OSA (SPR-SW-01-A shown on Figure 3-1). A sample was collected from the spring during all three 2009 sampling events. The maximum concentrations for metals and selected radionuclides for these samples are summarized in Table 6-26. The maximum concentrations of arsenic, copper, lead and zinc were below the respective Alaska water quality criteria.

6.3.2.3 Surface Water and Groundwater Summary

The three surface water sampling events provide sufficient data to characterize surface water conditions during the low-flow and high-flow periods. Measured stream flows during the June and July sampling events were relatively low and representative of the dry period, while measured stream flows during the September sampling event were significantly higher at all sampling locations and representative of the wet season. Based on water quality data collected during the three sampling events, surface water quality at the Site generally improves with increased stream flow. The concentrations of key constituents sampled at stations in Kendrick Creek downstream of mine features and from the 300-Foot Level portal decreased during the higher stream flows in September compared to the June and July sampling events. In addition, metals and radionuclides did not exhibit an increase in concentrations during increased flows in September, which is not indicative of acid rock drainage. Further, sulfate concentrations, a key indicator of acid rock generation, are negligible, even in drainage from the 300-Foot Level portal, and decrease at the surface water sampling stations downstream of the mine features in September.

The 300-Foot Level portal drainage has the highest metal and radionuclide concentrations of surface water quality samples collected at the Site. After flowing a short distance the portal flow joins Mine Fork Creek, and then Mine Fork Creek joins Kendrick Creek, which subsequently flows along the 300-Foot level mine rock pile. This reach of Kendrick Creek is considered negligible spawning and rearing habitat for all salmonids. The zinc concentration in only one sample collected from the 300-Foot Level portal exceeded the Alaska chronic freshwater criteria. Concentrations of metals, including zinc, and radionuclides of the 300-Foot Level portal water decrease within a short distance downstream in Kendrick Creek, and below the 300-Foot Level mine rock pile are less than Alaska chronic freshwater criteria. Concentrations continue to decrease in the lower portions of Kendrick Creek. In the lower reaches of Kendrick Creek, where spawning and rearing habitat for salmonids is of higher quality, the concentrations of metals and radionuclides are typically within the range of background surface water quality and/or less than Alaska chronic freshwater criteria.

The 700-Foot Level Creek and, to a lesser extent, Mine Fork Creek, show localized impacts from mine rock in piles, mine rock used for road construction, and associated soils. Both these drainages are upstream of the waterfall at the 300-Foot Level, which presents a formidable barrier to migrating salmonids.

The biological survey (Section 5.2) concluded that Kendrick Creek up to between 150 and 200 feet above sea level (ASL) has moderate to low/negligible available spawning area (ASA) and moderate available rearing area (ARA) for salmonids. Between 200 and 250 feet ASL, the stream has moderate ASA and ARA for Dolly Varden and low to negligible ASA and ARA for all other salmonids. Above 250 feet ASL, including the 300-Foot Mine Level, the stream has a steep gradient, with both Kendrick Creek and Mine Fork Creek (Figure 5-1).

Groundwater resources at the Site are likely to be minimal based on the relatively impermeable bedrock and the lack of alluvial and colluvial materials. Bedrock groundwater intercepted by the entire underground workings, based on portal discharge measurements is a maximum of 18 gpm during base flow conditions. The thin soils present near most of the mine piles likely inhibit the development of a substantial shallow groundwater system. Significant alluvium does not develop in the Kendrick Creek channel until the stream gradient decreases in the lower reaches. Because surface water is the predominant recharge source for an alluvial groundwater system in the lower portion of Kendrick Creek, the quality of the groundwater, if present, can be assumed to be similar to the surface water.

6.3.3 Stream Sediment

The quality of stream sediment in Mine Fork Creek from above the 900-Foot level to its confluence with Kendrick Creek, and then in Kendrick Creek to the west Arm of Kendrick Bay is exhibited on a series of graphs presented in Appendix G-1. Graphs for arsenic, lead, uranium, zinc, and radium-226 are reproduced as Figures 6-36 through 6-39 to illustrate the distribution and trends in metal concentrations and radionuclide activities in stream sediment. These data are also shown on Figures 6-40 and 6-41. Intertidal sediment sample KBD-MS-01-R is depicted on Figures 6-36 through 6-41, as the sample represents sediment in the transition from the Kendrick Creek delta to the intertidal zone.

Arsenic, lead, uranium, zinc, and radium-226 were selected as indicator parameters of sediment quality in the Kendrick Creek watershed since they were frequently detected at most sampling locations; were detected in sediment samples collected in drainages associated with mine features; exceeded background sediment concentrations (Section 6.2.5) at least one or more sampling locations; and illustrate the distribution and trends in concentrations of other parameters.

Most metals and radionuclides exhibit a similar trend in streambed sediments. The maximum observed arsenic, lead and uranium concentrations and radionuclide activities in sediment occur at the sample collected from the 300-Foot Level portal (300L-SS-01-E). As a result, the highest observed arsenic and uranium concentrations and radionuclide activities in Kendrick Creek sediment occur at the sample location immediately downstream of the 300-Foot Level mine rock pile (300L-SS-01-A). Concentrations of several metals in sediment, including lead and zinc, are highest in Kendrick Creek above Mine Fork Creek (300L-SS-01-B). The sediment concentrations of most metals decrease in the downstream samples; however, several show a slight increase near the mouth of Kendrick Creek. As illustrated by radium-226 on Figure 6-39, radionuclide activities are lower downstream and, by a point just above the Cabin Creek confluence (Figure 6-41), the levels of the radionuclides in the stream sediments are at or below the background radionuclide sediment activities (Section 6.2.5).

The distribution of arsenic in the Kendrick Creek stream sediments is unique compared to other metals (Figures 6-36 and 6-40). While arsenic concentrations in Kendrick Creek decrease downstream of the 300-Foot Level portal (300L-SS-01-E), the arsenic concentrations increase at the mouth of Kendrick Creek at the delta (KBD-SS-01-A and KBD-SS-01-B). The arsenic concentration then decreases at KBD-MS-01-R located at the Kendrick Creek delta.

The maximum concentrations for selected metals and radionuclides in stream sediments collected downstream of the mine rock piles at the 300-Foot, 700-Foot and 900-Foot levels are summarized in Table 6-27. The following samples were used to compile these maximum values:

- Mine Fork Creek (900-Foot Level): SSED-09 (KSI, 2004); 900L-SS-01-A (Tetra Tech)
- 700-Foot Level Creek : SSED-08 (KSI, 2004)
- Kendrick Creek (300-Foot Level): SSED-07 (KSI, 2004); 300L-SS-01-A (Tetra Tech).

The sediment samples at the 700-Foot and 900-Foot levels were collected at locations primarily influenced by the mine rock piles. Whereas, the sediment samples collected in Kendrick Creek downstream of the 300-Foot Level rock pile are influenced by all upstream mine workings. The metals concentrations and radionuclides activities are lowest in the stream sediments collected downstream of the 900-Foot Level mine rock piles and highest in the small drainage below the 700-Foot Level mine rock pile.

In summary, the steam sediments in Kendrick Creek immediately downstream of the 300-Foot Level area exhibit the highest arsenic, lead and uranium concentrations and radionuclides activities in mainstream sediments. The concentrations are lower in the downstream direction, and in some cases the concentrations in the lower the portion of Kendrick Creek are similar to or lower than the background sediment levels. The metals concentrations and radionuclides activities in Kendrick Creek are generally lowest in the stretch determined to have the highest quality salmonid spawning and rearing habitat (Section 5.2.3).

6.3.4 Marine Sediment

Marine sediment samples were collected from both the intertidal and subtidal zones. Kendrick Creek enters the bay in the westernmost portion of the west Arm of Kendrick Bay. The delta formed by Kendrick Creek has a relatively flat gradient which results in a wide intertidal area. This area possesses a very diverse and abundant array of marine life (Section 5.2.2). Away from the Kendrick Creek delta the intertidal zone is much steeper, resulting in a narrower band that is exposed during low tide. Boulders and cobbles dominate the intertidal zone away from the Kendrick Creek delta.

Intertidal and subtidal sediments differ texturally: Intertidal zone sediments average 89 percent sand and 11 percent fines (silt + clay), while the subtidal samples average 51 percent sand and 49 percent fines. Subtidal zone sediments also have an average organic matter content of over 7 percent. In contrast, the sandier intertidal sediments average 1 percent organic matter.

Arsenic, lead and uranium concentrations of the marine sediment samples are shown on Figures 6-42 through 6-44, and radium-226, radium-228 and total thorium (sum of thorium-228, -230, -232, and -234) activities are depicted on Figures 6-45 through 6-47. Arsenic, lead and uranium were selected as indicator parameters since concentrations were detected in all the intertidal and subtidal sediment samples and exhibit variability between the locations of the intertidal and subtidal sediment samples. Radium-226, radium-228 and total thorium were selected as indicator parameters since activities were detected in all the intertidal and subtidal sediment samples, exhibit variability between intertidal and subtidal sediment sampling locations, and are representative of the spatial distribution of the other radionuclides. As described in the following sections, total thorium and total radium (radium-226 and radium-228) activities of marine sediment samples are also used to define discrete and limited areas in the vicinity of the remnant rock ramps that likely have been impacted by ore spilled during the loading operations.

6.3.4.1 Intertidal Zone Sediments

The gamma survey of the intertidal zone indicated that the gamma exposure rates of the Kendrick Creek delta are relatively low and within the background range (<20 μR/hr) for non-mineralized areas (Section 6.2.1.1). However, the gamma survey around the remnant rock ramps (Figure 6-4) revealed the presence of gamma-emitting material. Closer inspection of the larger fragments located in the area on and between the rock loadout ramps indicated that pieces of ore were scattered among the cobbles and boulders (Figure 6-7). An inventory of the material in this portion of the shore confirmed the presence of ore on and between the remnant rock ramps (Section 6.1.1.3).

The concentrations of uranium, radium-226, radium-228 and thorium in the marine sediments are illustrated in Figures 6-44 through Figures 6-47. In the intertidal zone, the concentrations of the uranium and thorium decay series nuclides are lowest in the samples collected from the west Arm of Kendrick Bay delta, on the westernmost side of the bay. The amount of fine-grained material present in the intertidal zone deceases to the east as the northern shoreline is more exposed to the open bay. Nevertheless, two intertidal zone samples (KBD-MS-01-L and –EE) were collected from the swale between the two rock ramps. These samples were collected in the vicinity of the ore inventory Dock Plots 2 and 3 (Section 6.1.1.3). The concentrations of uranium, thorium and their decay series nuclides in these two samples were the highest of all the intertidal zone samples. To the east of the 1971 rock ramp, a scarcity of fine-grained material prevented sampling of several planned locations due to lack of appropriately sized material. However, the concentrations of uranium, thorium and their radioactive daughters in two intertidal samples collected east of the 1971 rock ramp (KBD-MS-01-K and –FF) were low, indicating that ore-related material are not located along this portion of the shoreline. The gamma survey data (Figure 6-4) confirm these results.

An assessment of the marine sediment data was performed to evaluate which areas in the intertidal zone exhibit a significant radioactive component. For this assessment, the KSI (2004) and Tetra Tech data sets were combined and the average concentrations for select radionuclides calculated. The average concentration was then subtracted from the individual sample concentrations to compute residual values for these radionuclides in each of the intertidal zone samples. A negative residual value indicates that the sample concentration was less than the group average, whereas a positive residual value indicates that the sample concentration was greater than the group average. Residual values are plotted on a bar graph. In a normally distributed population, there should be a similar number of equally sized positive and negative bars on a residual plot. Outliers appear as anonymously positive bars.

Residual concentration plots for uranium, total thorium and total radium are provided in Figures 6-48 through 6-50. Sample KBD-MS-01-L exhibits the largest residual value for total thorium and total radium; whereas, sample KBD-MS-01-EE exhibits the largest uranium residual. As discussed above, the proximity of these two samples to the remnant rock ramps, the observed presence of ore in the same area and higher gamma exposure rates supports the conclusion that the intertidal sediments in these discrete areas are impacted by ore spilled during the loading operations. Conversely, the low gamma signature and lack of ore throughout the majority of the intertidal zone confirms that the remaining intertidal zone samples do not contain a significant component of radioactive ore. These intertidal zone sediment samples are judged to be representative of background sediment concentrations, as further described in Section 6.3.4.3.

6.3.4.2 Subtidal Zone Sediments

The bathymetric survey data from KSI (2004) are reproduced in Figure 6-8. The outline of the ore loading dock that was operational in 1971 and the outline of a barge tied up at the dock are shown on the figure. The bathymetric contour lines indicate the presence of an east-west channel approximately 200 feet south of the 1971 dock. The presence of the channel would restrict the southward, gravity-driven transport of material from the dock area. The results of the KSI (2004) submarine gamma survey are also shown on Figure 6-8; a value of 18 μR/hr was measured on the line surveyed furthest away from the dock, south of the channel noted above. The four highest gamma readings measured by KSI (2004), 90 to 270 μR/hr, are clustered close to the ramp in 20 feet of water or less. Approximately half of the gamma readings in the area between the outline of the former dock and barge are less than 18 μR/hr.

The concentrations of uranium, radium-226 and -228, and thorium in marine sediments are illustrated in Figures 6-44 through 6-47. KSI (2004) samples MSED-07, MSED-08 and MSED-09 were collected in the area with the highest submarine gamma values (Figure 6-8). The concentrations of the uranium and thorium decay series nuclides are generally the highest in the three KSI (2004) samples. Tetra Tech sample KBD-MS-01-G, which was collected just west of the barge outline, also exhibits higher radionuclide concentrations.

Residual concentration plots for uranium, total thorium and total radium were calculated for the subtidal zone samples as described in Section 6.3.4.1 and are illustrated in Figures 6-51 through 6-53. Samples MSED-08 exhibits the largest residual value for uranium and total thorium; whereas, sample MSED-07 exhibits the largest total radium residual. Subtidal zone samples MSED-09 and KBD-MS-01-G also exhibit positive residuals. As discussed above, the proximity of these samples to the remnant rock ramps, the observed presence of ore in the intertidal zone adjacent to the ramps, and the submarine gamma values demonstrates that the subtidal sediments in the immediate vicinity of the rock ramps are influenced by ore spilled during the loading operations. Conversely, the low to negative residual values for other subtidal zone samples indicate that they do not contain a significant component of radioactive ore.

The maximum arsenic and lead concentrations are present in sample MSED-09 (Figures 6-42 and 6-43). The arsenic concentration of sample MSED-08 and the lead concentrations of samples MSED-07 and KBD-MS-01-G are higher relative to other sediment samples. In addition, evaluation of other metal parameters for the sediment samples indicates that aluminum and iron concentrations of KSI sample MSED-06 are higher relative to the other sediment samples. Sample MSED-06 was collected just south of the barge outline. The distribution of metals in the submarine samples can be evaluated by a consideration of materials, sediment texture, and organic matter. Arsenic is selected for this discussion because of the extensive data base and the fact that it, like uranium, is sensitive to redox conditions. KSI (2004) collected samples from mine feature areas, focusing on accumulations of mine rock in the OSA and 300-, 700- and 900-Foot Levels where concentrations would likely be greatest. These "ore" samples possessed uranium up to 10,000 mg/kg (1%), arsenic to 61 mg/kg, and total thorium activity approaching 2,700 pCi/g. The spilled ore present on and adjacent to the rock loadout ramps should have concentrations similar to these samples. The thorium activity and uranium concentration of select KSI "ore" samples[2] were plotted versus arsenic concentrations (Figures 6-54 and 6-55) along with the marine intertidal and subtidal samples collected by Tetra Tech and KSI (2004). As discussed in Kipp, et al. (2009), thorium is *"sparingly soluble at environmental pH levels and insensitive to redox conditions"*; whereas, arsenic and uranium are more mobile and *"are greatly influenced by redox conditions."* Therefore, within the west Arm of Kendrick Bay, thorium should primarily remain in the mineral (solid) form and be transported by physical processes as the ore mechanically breaks down and disperses. Uranium and arsenic, while subject to physical transport, can also dissolve in and be transported by seawater; however, uranium and arsenic would precipitate from solution once they encountered the organic rich sediments present throughout the west Arm of Kendrick Bay[3].

As illustrated in Figure 6-54 thorium and arsenic are poorly correlated in the marine sediment samples. With the exception of sample MSED-09, those samples with higher arsenic concentrations have low thorium activity. Consequently, it is unlikely that the arsenic concentrations in the distal subtidal samples are the result of physical transport of ore away

[2] The sample from each area with the highest uranium and thorium concentrations was chosen to represent the Ross-Adams "ore". These were KSI samples 900-2, 700-1, 300-1 and OSA-1.

[3] Based on samples collected in the subtidal zone, spilled ore would be located on and potentially covered by organic-rich sediments. In such an environment, uranium and arsenic dissolved from the ore would likely precipitate very close to the source.

from the rock loadout ramps by wave or tidal action as these samples lack a thorium signature. Subtidal samples MSED-07, MSED-08, MSED-09 and KBD-MS-01-G and intertidal zone sample KBD-MS-01-L have a thorium signature suggestive of ore. Uranium concentrations also show little correlation with arsenic in the marine sediments (Figure 6-55).

Arsenic concentrations in the west Arm of Kendrick Bay marine sediments exhibit a moderately good correlation with organic carbon (Figure 6-56; r-squared = 0.76) and fines (Figure 6-57 r-squared = 0.84). Intertidal zone sediments, present in a higher energy zone that is exposed to the atmosphere twice a day, have a lower content of both organic matter and fines (clay and silt) than do the subtidal sediments. Given the geochemical behavior (sensitivity to redox conditions), the organic rich subtidal marine sediments logically should posses higher arsenic concentrations than the intertidal sediments.

6.3.4.3 Marine Sediment Background

As described above, the radiological data indicate that the quality of marine sediments have been influenced by the mine features in a limited area in the vicinity of the rock loadout ramps associated with the ore loading docks. The physical data and the gamma survey data support this interpretation. Figure 6-58, 6-59, and 6-60 illustrate the distribution of uranium concentrations, total radium activity and total thorium activity of the 24 intertidal marine sediment samples. The majority of the intertidal samples shown on these histograms likely represent the local background population; whereas, the few outliers (KBD-MS-01-L and KBD-MS-01-EE) present in this population are samples collected in the vicinity of the rock loadout ramps. Figure 6-61, 6-62, and 6-63 illustrate the distribution of uranium concentrations, and total radium and total thorium activities of the 12 subtidal marine sediment samples. Seven of the 12 subtidal samples likely represent a local background population; whereas, the five outliers (MSED-06, MSED-07, MSED-08, MSED-09 and KBD-MS-01-G) present in the subtidal marine sediment population represent samples collected in the vicinity of the rock loadout ramps. Table 6-29 summarizes the background metals concentrations and radionuclide activity for the intertidal and subtidal sediment samples.

Arsenic data from multiple studies conducted in southeastern Alaska were compiled and compared to the levels observed in the west Arm of Kendrick Bay subtidal samples. The regional data included samples from EMAP (2004), Ward Cove (1996-1997), Moser Bay (1997), Bucko Point, Thimbleberry, Jamestown Bay, Galankin Island, Herring Cove, Klag Bay, and Sawmill. In total, samples from 100 locations unlikely to have been impacted by potential anthropogenic contaminant sources were evaluated. The arsenic data in this regional marine sediment database followed a log-normal distribution with a mean of 13.8 mg/kg and ranged from 2.1 to 46.9 mg/kg. Data collected from the west Arm of Kendrick Bay are consistent with the regional data.

6.3.4.4 Marine Sediment Summary

The ore inventory documented the presence of pieces of ore in the intertidal zone around the two remnant rock ramps. Intertidal zone sediments in the swale between the two ramps confirm the presence of ore-related metals and radionuclides in finer-grained sediments in this area. The intertidal zone sediment sample data indicate that the intertidal zone sediments on the Kendrick Creek delta and along the shoreline east of the 1971 rock ramp represent a local background population. The gamma data indicate that higher gamma values are limited to the area approximately 100 feet east of the remnants of the 1971 rock loadout ramp to approximately 150 feet west of the existing dock rock ramp.

The submarine gamma survey results and the subtidal zone sediment sample data indicate the influence of spilled ore is limited to the immediate vicinity of the rock loadout ramps. Gamma values and concentrations of uranium and thorium and their decay products (Figures 6-44 through 6-47) are highest in the waters closest to the former floating dock, with the highest values closer to shore. The data collected by Tetra Tech and KSI indicate that the metals (e.g., arsenic and lead) concentrations in the subtidal sediments a further distance from the rock loadout ramps represent the local background concentrations. Arsenic concentrations in the west Arm of Kendrick Bay are consistent with regional southeastern Alaska data.

6.3.5 Air

Radon measurements at the Site are variable depending on the locations of the radon detector stations with respect to the mine features (mine rock piles and portals), the presence of naturally occurring mineralized background conditions, and localized atmospheric and topography conditions. The radon station locations are depicted on Figure 3-2 and the radon monitoring results are presented in Table 6-10. As discussed in Section 6.2.3, a radon concentration of 5.8 ρCi/L is considered to represent the maximum background value for non-mineralized areas away from areas of naturally occurring mineralization and economic level mineral deposits. Radon concentrations in naturally mineralized areas would be expected to be higher. Because the high-grade ore deposit at Ross-Adams was exposed at the surface, it is likely that radon concentrations at the 900-Foot Level would have been considerably higher prior to mining.

The portals and air shaft present avenues for radon emissions from the underground mine workings. Table 6-28 summarizes the short-term and long-term radon concentrations measured at the portals and air shaft in 2009, together with previous radon data collected by BLM in 1998 and KSI in 2004. The variations in radon measurements between the ESI, KSI and BLM investigations are primarily related to the locations of the radon detector stations with respect to the mine features. The BLM radon data were collected inside the mine workings and therefore the radon concentrations would be expected to be greater, as they are, than concentrations measured outside of the mine workings some distance from the portal openings. The variation between the KSI data and the ESI data is likely due to location of detectors, duration of data collection and the climatic conditions at the time of data collection.

In 2009, the highest radon concentration of 445 ρCi/L was measured at the 300-Foot Level portal. Radon emissions from the portal migrate down the steep-sided Kendrick Creek channel below the portal. In addition to the radon detector placed at the mouth of the 300-Foot Level portal, two radon detectors were located in the steep-sided Kendrick Creek channel below the portal at stations 300L-RAD-30 and 300L-RAD-34 (Figure 3-2). Radon concentrations from the portal are substantially and sequentially lower at the downstream stations. The radon concentration measured at Station 300L-RAD-30, which is located approximately 100 feet southeast and topographically below the portal, was 136 ρCi/L (Table 6-10). Further downstream, approximately 300 feet from the 300-Foot Level portal, the radon concentration at Station 300L-RAD-34 was measured at 76.3 ρCi/L.

The long-term radon concentration measured at the 700-Foot Level portal (700L-RAD-13) was 22.3 ρCi/L. Long-term radon concentrations measured at the 900-Foot Level portal (OP-RAD-16) and the air shaft (OP-RAD-19) were 163.3 ρCi/L and 39.2 ρCi/L, respectively. As shown in Table 6-10, a radon concentration of 372.8 pCi/L was measured at OP-RAD-17, located in the central portion of the Open Pit. At OP-RAD-18, located south of the Open Pit, the radon concentration was 16.7 pCi/L.

Radon monitoring was also performed within and/or adjacent to mine rock piles at the 300-Foot, 700-Foot, and 900-Foot levels, within and around the perimeter of the OSA, and near the existing dock. Again, the radon measurements are variable depending on the locations of the radon detector stations relative to these mine features. Radon concentrations at the 300-Foot Level range from 5.8 to 22.3 ρCi/L at detectors associated with the mine rock pile. Radon concentrations measured at the 700-Foot Level ranged from 2.1 to 40.1 ρCi/L. Radon levels associated with the mine rock piles at the 900-Foot Level varied from 133.4 ρCi/L (north mine rock pile) to 192 ρCi/L (south mine rock pile). At 900L-RAD-25, located on the haul road southeast of the north mine rock pile, the radon concentration was 16.1 pCi/L.

Radon concentrations of 64.1 ρCi/L and 92.9 ρCi/L were measured at detectors located at the OSA (OSA-RAD-4) and near the existing dock (OSA-RAD-1). Radon concentrations less than the non-mineralized background value were attained at the three radon detectors that ring the OSA at distances ranging from approximately 150 to 300 feet: 2.1 ρCi/L (OSA-RAD-2), 3.3 ρCi/L (OSA-RAD-3), and 1.2 ρCi/L (OSA-RAD-5), as shown on Figure 3-2.

With the exception of the 300-Foot Level portal, radon concentrations appear to be localized and associated with mine features defined by higher gamma exposure rates. The association between radon generation and mined materials demonstrates the relationship between radon and gamma radiation. Even at the maximum radon levels measured at the Site, the relative radon concentration is very low with respect to other atmospheric gases and radon quickly mixes with the atmosphere. The exception is the rapid dispersion of radon at the 300-Foot Level portal, where radon-bearing air emanating from the portal appears to be migrating at least 300 feet down the steep-sided Kendrick Creek channel.

6.4 Miscellaneous Solid Wastes and Petroleum Products

Previous investigations at the Site reported various miscellaneous waste present at the Site (Section 2.0). The PA, prepared by BLM (1998), concluded that approximately 300 gallons of petroleum products of various types were scattered throughout the Site posed a potential for release. They also reported that various unknown chemicals were present at various locations around the Site (BLM 1998). Additionally, KSI (2004) collected three soil samples at the 300-Foot Level that were analyzed for hydrocarbons. The miscellaneous solid wastes and petroleum products present at the Site are associated with several exploration camps and mine camps, which operated over the life of mining operations.

An inventory was performed of the miscellaneous solid waste remaining at the Site. The objective of the solid waste inventory was to catalogue the locations, quantity, and potential for contamination of the miscellaneous waste items that remain at the Site. The solid waste inventory field reconnaissance consisted of volume estimates, soil sampling, geo-referencing waste locations, physical descriptions, and photographic documentation. The inventory included various items such as abandoned vehicles, large above-ground storage petroleum tanks (AST), empty and partly filled unmarked/marked 55-gallon drums, fiberglass piping, core boxes, battery plates, collapsed structures, blasting caps, and old camp sites. Volume estimates and soil sampling and results from the solid waste inventory are discussed below. The analytical results of four soil samples collected during the inventory are provided in Table A-3a of Appendix A. Figure 6-64 shows the locations of the solid waste items identified at the Site, and includes the soil sampling locations.

The following summarizes the items present at the areas:

- Three 55-gallon drums located off the haul road; minimal fluid present in the drums, no access to fluid due to rusted bungs; Soil sample (3TANK-TPH) collected beneath drums in stained soil; GPS location recorded.
- Miscellaneous empty 55-gallon drums throughout the OSA were observed, no soil staining present; GPS location recorded on one drum.
- Three abandoned Jeeps located off the haul road west of the OSA; Label on one Jeep says "Regulations Applicable to 1974 Model Year New Motor Vehicles"; GPS location recorded.
- Two Chevrolet pickup trucks (blue 1969 model, orange 1972+ model) located in OSA; GPS location recorded.
- Small transformer located in vicinity of 700-Foot Level WRD, no soil sample collected due to large quantity waste rock below the item; GPS location recorded.
- Six fiberglass pipes (approximately 20 feet long, 0.3 feet diameter) located in 900-Foot Level area north of air shaft; Additional 3 fiberglass pipes found in 300-Foot Level area, same diameter, 40 feet long; GPS location recorded.
- A 55-gallon drum of fluid located at OSA dock, label reads "Mobilfluid 424 High Performance Tractor Hydraulics/Transmission Fluid"; GPS location recorded.
- Approximately 300 feet of 2" diameter PVC pipe located off haul road near Cabin Creek.
- Core boxes located near Dotson Cabin (approximately 12 ft^3); GPS location recorded.
- Generator shack at 300-Foot Level area (referred to as "Mineral Custody Shed"); Volume estimate = 27 yd^3; Soil sample (300L-GENSHACK) collected; GPS location recorded; GPS location recorded.
- Various items inside mouth of 300-Foot Level portal: Core Boxes (66 yd^3), 10 foot boat, 4 pipes approximately 200 feet long, 3" diameter PVC piping; GPS location recorded.
- Various items located 30 feet east of Mineral Custody Shed: Core Boxes (32 yd^3); 2 Polaris snowmobiles; GPS location recorded.
- Trailer and miscellaneous debris piles located in south side of 300-Foot Level haul road; Collapsed trailer (39 yd^3), Shack (64 yd^3), and miscellaneous debris (333 yd^3); GPS location recorded.
- Abandoned dynamite shack located in the 900-Foot Level, includes 30 yd^3 of miscellaneous waste such as blue flame kerosene heater, collapsed shack, gloves, PVC pipes, and rugs; GPS location recorded. No sample was collected at this location, as no evidence of remnant explosive materials or soil staining was observed other than miscellaneous waste.
- Solid waste dump located at 900-Foot Level, includes 50 yd^3 of miscellaneous waste such as used oil filters, aluminum cans, empty 55-gallon drums, drilling bits, wood debris, and gloves; GPS location recorded.
- Battery plates from lead acid batteries at the 900-Foot Level; plates appear to be deteriorated; Soil sample (900L-BATT) collected beneath plates; GPS location recorded.
- Two large ASTs located in the OSA; Soil surrounding the tank appears to be heavily stained, and fluid still present in the tanks; Tank 1 (6 feet diameter x 18 feet), Tank 2 (5

feet diameter x 12.5 feet); Soil sample collected (OSA-UST-DOCK) in stained soil; GPS location recorded.

- Multiple 55-gallon drums located throughout the 900-Foot Level and 700-Foot Level.

KSI (2004) reported data on three samples collected from petroleum-stained soils near the generator shed at the 300-Foot Level that (GEN-01, -02 and -03). These samples contained between 1,200 and 12,000 mg/Kg diesel range organics (DRO) and between 4,700 and 43,000 mg/Kg residual range organics (RRO). Tetra Tech collected one soil sample (300L-GENSHACK) from the petroleum-stained soils at this location and analyzed it for DRO, gasoline range organics (GRO) and PCBs. The soil sample from the generator shed was analyzed for PCBs due to the potential for electrical transformers containing PCBs to have previously been located at this shed. The DRO of the Tetra Tech sample was 3,200 mg/Kg, the GRO had a concentration of 0.44 mg/Kg and the PCBs were all below detection limits (Appendix A).

Tetra Tech collected a soil sample (OSA-UST-DOCK) beneath the ASTs in the OSA. The DRO of this sample was 7,000 mg/Kg and the GRO was 0.19 mg/Kg (Table A-3a of Appendix A). Additional soil samples were collected, as discussed above, below the three 55-gallon drums (3TANK-TPH) off the haul road west of the OSA and beneath the 900-Foot Level battery plates (900L-BATT). The analytical results of these samples are provided in Table A-3a of Appendix A. The DRO and GRO were 630 mg/Kg and 0.11 mg/Kg, respectively, for the sample collected beneath the three drums. The DRO and GRO were 32 mg/Kg and 0.43 mg/Kg, respectively for the sample collected beneath the battery plates.

Sampling results indicate that stained-soils directly beneath the ASTs and three 55-gallon drums contain hydrocarbon related constituents. The GRO and DRO results of the samples collected by Tetra Tech were compared to the State of Alaska Method 2 soil criteria (18 AAC 75.341 – Soil Cleanup Levels; Tables). Method 2 lists cleanup levels for GRO and DRO as 1,400 mg/kg and 8,250 mg/kg, respectively. The GRO and DRO concentrations of all four soil samples were below the Method 2 soil cleanup criteria. The highest GRO and DRO concentrations were 0.44 mg/kg (300L-GENSHACK) and 7,000 mg/kg (OSA-UST DOCK), respectively. While the DRO concentrations of the soil samples are less than the State of Alaska Method 2 soil criteria (18 AAC 75.341 – Soil Cleanup Levels; Tables) for GRO and DRO, the ASTs and three drums contain residual petroleum and given their proximity to the west Arm of Kendrick Bay represent a continued potential risk for release of petroleum products if not managed appropriately. Based on visual inspections during the inventory, the remaining miscellaneous wastes are not considered to represent a significant potential for release.

Table 6-1. Summary of Intertidal Zone Ore Inventories

Measurement	Dock Plot 1	Dock Plot 2	Dock Plot 3
Mean Gamma (µR/hr)	230	152	406
Number of Ore Rocks	39	5	48
Mean Size (inches)	7.1	2.4	10.6
Maximum Size (inches)	12	3	30

Table 6-2. Average Gamma Exposure Rates and Radionuclide Concentrations for Correlation Plot Soil Samples

Correlation Plot Sample	Mean NaI Gamma Reading (µR/hr)	Uranium (mg/kg)	Total Thorium (ρCi/g)	Th-232 (ρCi/g)	Pb-210 (ρCi/g)	Ra-226 (ρCi/g)	Ra-228 (ρCi/g)
300L-CORR-1R	95.9	110	212.2	62	24.9	20.2	25.6
HR-CORR-2R	20.7	6	9.84	2.4	3.65	1.88	0.9
HR-CORR-3R	19.3	9.2	31.7	8	3.62	6.16	3.3
HR-CORR-4R	232	220	170	35.1	62	63.7	31.5
HR-CORR-5R	12.1	7.1	11.94	2.7	2.41	2.62	1.2
HR-CORR-6R	148	100	160.9	28.3	41.1	60.5	44.8
HR-CORR-7R	41.5	31	42.5	9.6	11.2	13.4	7.1
HR-CORR-8R	48.0	67	43.1	6.7	10.2	17.2	7.4
HR-CORR-9R	195	160	204.2	30.9	63	97	33
IL-CORR-10R	75	27	58.9	13.5	10.4	15.6	8.1
IL-CORR-11R	445	420	911	187	150	245	110
900BG-CORR-12R	175	14	40.2	9.9	6.9	11.2	4.74
900L-CORR-13R	108	12	25.51	3.96	7.9	12.5	5.2
900BG-CORR-14R	84	1.5	6.79	0.63	2.99	4.94	1.18
900WRD-CORR-15R	1496	1000	1678	285	510	631	235
900L-CORR-16R	867	720	1006	164	210	351	152
900L-CORR-17R	1117.5	580	1038	170	237	383	157

Table 6-3. R-Squared Values for Radionuclides vs. Gamma Exposure Rates in Correlation Plots

Parameter	Regression Type	R-Squared
Uranium (Unat)	Linear	0.94
Thorium (total)	Linear	0.93
Th-232	Linear	0.87
Pb-210	Linear	0.93
Ra-226	Linear	0.97
Ra-228	Linear	0.95

Notes:
1. Unat = chemically analyzed uranium. All other parameters represent radiological analyses.
2. Thorium (total) represents the sum of the Th-228, Th-230, Th-232 and Th-234 isotopic analyses.

Table 6-4. Summary of Estimated Radionuclide Concentrations in I&L Soils based on Gamma Values

Estimated Radionuclide Concentrations in Soils at I&L based on 50th, 90th and 95th Percentile Gamma Values				90%		95%		50%	
				X	Y	X	Y	X	Y
Parameter	Units	Slope	Y-intercept	Gamma	Concentration	Gamma	Concentration	Gamma	Concentration
Uranium	mg/kg	0.6615	3.514	741	494	1165	774	94	66
Th (total)	ρCi/g	1.1077	-4.9969	741	816	1165	1286	94	99
Th-232	ρCi/g	0.184	3.9476	741	140	1165	218	94	21
Pb-210	ρCi/g	0.2967	-10.532	741	209	1165	335	94	17
Ra-226	ρCi/g	0.4097	-10.864	741	293	1165	467	94	28
Ra-228	ρCi/g	0.1582	0.5255	741	118	1165	185	94	15

Table 6-5. Median pH and Texture Data for Tetra Tech Background Soils

Location	pH	% Sand	% Fines	N
900-Foot Level	4.4	78	22	18
700-Foot Level	4.5	64	36	3
300-Foot Level	5.2	56	44	1
Haul Roads	5.0	83	17	4
OSA	4.5	58	42	2

Table 6-6. Metals Concentrations at Background Soil Locations

Sample ID	Entity	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Ag	Tl	U	V	Zn
		Parameter - All Concentrations in mg/kg																				
Mineralized Areas																						
900-Foot Level																						
900 BT-17	Tetra Tech	680	0.025	0.41	<9.9	<0.49	<0.49	0.13	<0.99	0.095	1,900	8.1	2.1	<0.033	<0.99	0.072	0.26	<0.99	<0.02	1.7	1.5	2.1
900 BT-18	Tetra Tech	500		0.23	1.3	<0.19	<0.48	0.2	0.96	0.2	2000	5.2	14		<0.96	0.076	0.36			1.4	1.1	14
900 BT-19	Tetra Tech	850	0.033	0.7	<9.9	<0.49	<0.49	0.29	<0.99	0.27	2,400	13	31	<0.033	<0.99	0.1	<0.49	<0.99	0.032	1.9	3	6.9
900 BT-20	Tetra Tech	2,300		0.94	6.2	0.22	<0.5	0.81	<1	0.41	5300	34	4.4		<1	0.25	1.4			4.7	5.1	5.3
900 BT-25	Tetra Tech	5,200	0.087	0.83	12	1.3	<0.48	0.48	<0.96	1.4	18,000	45	340	0.066	<0.96	0.16	<0.48	<0.96	0.075	13	1.4	140
900 BT-26	Tetra Tech	8,600		0.7	5.2	0.34	<0.5	0.8	0.16	<0.99	46,000	30	160		0.47	0.17	0.91			5.8	<2.5	140
900 BT-27	Tetra Tech	1,000	0.022	<0.2	<9.8	<0.49	<0.49	0.4	<0.98	1.6	390	13	1.8	<0.033	<0.98	0.15	<0.49	0.047	<0.02	2	0.72	1.9
900BG-CORR-14R	Tetra Tech	220	<2	<0.2	1.7	0.036	<0.49	<0.98	<0.98	0.48	850	4	4.6	<0.033	0.13	0.18	<0.49	<0.98	<0.98	1.5	0.94	4.4
900AT-7	Tetra Tech	380		0.17	0.87	0.061	<0.49	0.46	<0.98	0.28	860	5.5	2.9		<0.98	<0.98	0.065			2.3	1.3	3.3
900AT-8	Tetra Tech	310	0.024	0.046	<9.9	<0.5	<0.5	0.29	<0.99	0.2	650	3.4	3.3	<0.033	<0.99	<2	<0.5	<0.99	<0.02	2.5	1.1	3.1
900AT-9	Tetra Tech	940		0.21	1.7	0.14	<0.5	0.42	<0.99	0.36	3,500	9.9	7.3		0.92	0.2	0.5			3.9	1.8	10
900AT-10	Tetra Tech	300		0.16	1.6	0.022	<0.48	0.2	<0.97	0.5	2,400	4.8	9.1		0.46	<0.97	0.035			2	1.9	3.8
900BG-CORR-12R	Tetra Tech	540	<2	1.9	2.5	0.09	<0.5	<0.99	0.16	1.8	1,900	11	13	<0.033	1.7	0.18	<0.5	<0.99	<0.99	14	2.2	7.7
900AT-11	Tetra Tech	550		0.35	2.1	0.056	<0.49	0.25	<0.98	0.5	2,400	7	9.1		0.9	0.12	0.19			9.9	2.5	10
900AT-14	Tetra Tech	270		0.046	1.1	<0.2	<0.49	0.24	<0.98	0.32	340	2.1	3.8		<0.98	0.084	0.24			4.1	0.71	1.9
900L-CORR-13R	Tetra Tech	1,200	<1.9	0.32	2.3	0.11	<0.48	<0.96	<0.96	0.88	1,700	11	4.9	<0.033	0.49	0.31	0.65	<0.96	<0.96	12	1.6	6.3
900AT-15	Tetra Tech	130		0.12	0.56	<0.2	<0.5	0.11	<1	<1	1,100	0.79	18		0.23	<1	<0.1			2.2	0.47	2.4
900AT-16	Tetra Tech	920	0.014	0.024	<9.9	<0.5	<0.5	0.25	<0.99	0.75	550	6.4	2.5	<0.033	<0.99	0.091	0.53	<0.99	<0.02	2.1	0.45	2.7
700-Foot Level																						
700T-6	Tetra Tech	5,500	0.05	4.9	11	<0.5	<0.5	10	1.5	2.4	17,000	28	98	<0.033	16	2.3	1.5	<0.99	0.075	2.8	26	34
700T-5	Tetra Tech	1,100		0.49	2.2	0.12	<0.49	0.72	0.083	1.1	6,000	21			3.9	0.27	0.48			3.1	3.8	30
700T-1	Tetra Tech	15,000		0.38	14	1.3	0.15	5.8	6.5	6.5	4,200	61			3.9	2.7	3.2			10	4.9	26
I&L Area																						
IL-1	Tetra Tech	4,300		1.1	5.7	0.57	0.097	1	0.95	0.67	12,000	96	390		2.2	0.51	0.77			7.7	8.3	350
IL-2	Tetra Tech	1,000		0.39	9.7	1.3	<0.49	0.72	1.6	3.6	9,700	190	310		3.2	1.1	0.24			140	4.9	49
Maximum Value of Mineralized Areas		15,000	0.087	4.9	12	1.3	<0.5	10	6.5	6.5	46,000	190	390	0.066	16	2.7	3.2	<0.99	<0.99	140	26	350
Non-Mineralized Areas																						
300-Foot Level																						
300-18	Tetra Tech	21,000		5.1	8.9	0.58	<0.49	19	18	13	43,000	15	4,000		9.5	2.9	2.7			3	54	24
OSA																						
SSOIL-01[1]	KSI (2004)	14,000		<3.1							33,000	31	310							210		
SOIL-02[1]	KSI (2004)	11,000		<1.9							26,000	19	290							73		
OSA-1	Tetra Tech	8,900		0.91	6.1	0.21	<0.5	11	3.8	0.34	54,000	2.7	130		0.95	2.5	0.6			10	92	9.5
OSA-17	Tetra Tech	6,400	0.051	0.19	<10	<0.5	<0.5	21	2.8	4.1	10,000	7.4	150	0.055	1	6.9	0.44	<1	0.023	11	32	15
Maximum Value of Non-Mineralized Areas		21,000	0.051	5.1	<10	<0.5	<0.5	21	18	13	54,000	15	4,000	0.055	9.5	6.9	2.7	<1	0.023	11	92	24

Footnote: *1. Not used in determination of maximum background values.*

Table 6-7. Radiochemistry Activity at Background Soil Locations

All Soil Activity in pCi/g												
Sample ID	**Entity**	**Radium-226**	**Radium-228**	**Thorium-228**	**Thorium-230**	**Thorium-232**	**Thorium-234**	**Uranium-234**	**Uranium-235**	**Uranium-238**	**Lead-210**	**Polonium-210**
Mineralized Areas												
900-Foot Level												
900 BT-17	Tetra Tech	4.27	1.22	1.62	2.26	1.19	<2.6	2.06	<0.33	2.12	2.01	1.36
900 BT-18	Tetra Tech	2.29	1.46	1.67	1.6	1.68	<1.1		<0.16		1.74	0.49
900 BT-19	Tetra Tech	3.41	1.29	1.27	1.7	1.16	<-1.4	1.56	<-0.72	1.31	2.75	2.17
900 BT-20	Tetra Tech	6.12	3.1	2.5	3.28	2.13	<4.7		<0.5		2.76	2.24
900 BT-25	Tetra Tech	11.7	11.1	14.4	10.1	11.6	11.8	8.6	<0.26	9.4	8.9	6.1
900 BT-26	Tetra Tech	3.25	2.85	4.57	3.88	4.37	<1.4		<0.65		3.4	3.1
900 BT-27	Tetra Tech	2.69	1.11	1.23	1.7	1.56	<2.8	1.96	<0.06	1.87	1.83	0.79
900BG-CORR-14R	Tetra Tech	4.94	1.18	0.93	2.53	0.63	<2.7		<0.08		2.99	
900AT-7	Tetra Tech	4.05	2.69	2.42	3.17	2.08	5.4		<0.57		2.66	0.47
900AT-8	Tetra Tech	3.39	1.26	1.31	1.7	1.12	<2.5	1.94	<0.19	1.87	1.66	0.35
900AT-9	Tetra Tech	8	3.31	4	4.82	5.02	5.7		<0.32		5.2	2.5
900AT-10	Tetra Tech	6.94	2.89	1.24	2.19	1.19	8		<-0.38		2.88	1.59
900BG-CORR-12R	Tetra Tech	11.2	4.74	9.4	12.3	9.9	8.6		<0.68		6.9	
900AT-11	Tetra Tech	8.8	5.07	6.1	9.5	6.6	6.3		<0.05		6.5	4.46
900AT-14	Tetra Tech	5.39	5.16	5.4	4.56	5	7.2		<0.4		3.65	1.53
900L-CORR-13R	Tetra Tech	12.5	5.2	5.15	7.3	3.96	9.1		<1		7.9	
900AT-15	Tetra Tech	4.07	3.1	1.75	2.37	1.53	<2.9		<0.03		2.33	0.32
900AT-16	Tetra Tech	2.33	1.35	0.81	1.6	0.81	<1.7	1.85	<0.08	1.84	2.38	1.19
700-Foot Level												
700T-6	Tetra Tech	4.78	2.2	2.68	3.31	2.74	5	2.92	<-0.16	3.15	4.2	3.94
700T-5	Tetra Tech	6.73	2.84	3.25	2.87	2.53	<4.3		<0.7		3.07	1.36
700T-1	Tetra Tech	4.81	2.9	1.89	1.61	0.99	<5.3		<-0.2		7.3	10.4
I&L Area												
IL-1	Tetra Tech	5.89	16	13.3	4.24	9.4	14.8		<0.1		4.6	3.4
IL-2	Tetra Tech	95	57.2	59	83	56	94		<0.55		38	31.2
Maximum Value of Mineralized Area		95	57.2	59	83	56	94	8.6	<0.72	9.4	38	31.2
Non-Mineralized Areas												
300-Foot Level												
300-18	Tetra Tech	1.95	<0.73	0.93	1.22	0.91	<0.5		<0.33		2.89	3.13
OSA												
SSOIL-01[1]	KSI (2004)	11.7	15.4	15.2	28.1	18	30.4	20.1	1.09	20.6		
SOIL-02[1]	KSI (2004)	12.7	9.6	10.5	18.2	11.1	20.3	13.6	0.77	14		
OSA-1	Tetra Tech	1.98	1.13	1.14	2.38	1.19	<1.6		<0.1		0.9	0.6
OSA-17	Tetra Tech	7.1	2.2	1.6	2.56	1.24	8.9	4.52	<0.2	4.46	3.69	4.09
Maximum Value of Non-Mineralized Area		7.1	2.2	1.6	2.56	1.24	8.9	4.52	<0.33	4.46	3.69	4.09

Footnote:

1. Not used in determination of maximum background values.

Table 6-8. Summary Statistics for Background Non-Mineralized Soil Samples

Type	Constituent	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metal Concentrations for Background Non-Mineralized Soil Samples (mg/Kg)								
Metals (mg/Kg)	Aluminum	3	0	6,400	21,000	12,100	8,900	7,808
	Antimony	1	0	0.051	--	--	--	--
	Arsenic	3	0	0.19	5.1	2.1	0.91	2.7
	Barium	3	1	6.1	<10	<8.3	<8.9	2.0
	Beryllium	3	1	0.21	0.58	0.43	0.5	0.19
	Cadmium	3	3	<0.49	<0.5	<0.50	<0.5	--
	Chromium	3	0	11	21	17.0	19	5.3
	Cobalt	3	0	2.8	18	8.2	3.8	8.5
	Copper	3	0	0.34	13	5.81	4.1	6.50
	Iron	3	0	10,000	54,000	35,667	43,000	22,898
	Lead	3	0	2.7	15.0	8.4	7.4	6.2
	Manganese	3	0	130	4,000	1,427	150	2,229
	Mercury	1	0	0.055	--	--	--	--
	Molybdenum	3	0	0.95	9.5	3.8	1	4.9
	Nickel	3	0	2.5	6.9	4.1	2.9	2.4
	Selenium	3	0	0.44	2.7	1.2	0.6	1.3
	Silver	1	1	<1	--	--	--	--
	Thallium	1	0	0.023	--	--	--	--
	Uranium	3	0	3.0	11	8.0	10.0	4.4
	Vanadium	3	0	32	92	59.3	54	30.4
	Zinc	3	0	9.5	24	16.2	15	7.3
Summary of Radionuclide Activity for Non-Mineralized Background Soil Samples (pCi/g)								
Radionuclides (pCi/g)	Ra- 226	3	0	2.0	7.1	3.7	2.0	3.0
	Ra- 228	3	1	<0.73	2.2	1.4	1.1	0.8
	Th-228	3	0	0.93	1.6	1.2	1.1	0.3
	Th-230	3	0	1.2	2.6	2.1	2.4	0.7
	Th-232	3	0	0.91	1.2	1.1	1.2	0.2
	Th-234	3	2	<0.5	8.9	3.7	1.6	4.6
	U-234	1	0	4.52	--	--	--	--
	U-235	3	3	<0.1	<0.33	<0.21	<0.20	0.12
	U-238	1	0	4.5	--	--	--	--
	Pb-210	3	0	0.90	3.7	2.5	2.9	1.4
	Po- 210	3	0	0.60	4.1	2.6	3.1	1.8

Notes: 1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-9. Summary Statistics for Background Mineralized Soil Samples

Type	Constituent	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metal Concentrations for Mineralized Background Soil Samples (mg/Kg)								
Metals (mg/Kg)	Aluminum	23	0	130	15,000	2,252	920	3,518
	Antimony	10	3	0.014	<2	<0.62	<0.042	0.93
	Arsenic	23	2	0.024	4.9	0.64	0.35	1.0
	Barium	23	5	0.56	14	5.7	5.2	4.4
	Beryllium	23	8	0.022	1.3	0.40	0.22	0.40
	Cadmium	23	21	<0.066	<0.5	<0.44	<0.49	--
	Chromium	23	3	0.11	10	1.20	0.46	2.25
	Cobalt	23	16	0.083	6.5	1.16	0.98	1.22
	Copper	23	2	0.095	6.5	1.13	0.67	1.44
	Iron	23	0	340	46,000	6,076	2,000	10,096
	Lead	23	0	0.79	190	26.5	11.0	42.2
	Manganese	22	0	1.8	390	66.1	8.2	120.6
	Mercury	10	9	<0.033	0.066	0.036	0.033	0.010
	Molybdenum	23	8	0.13	16	1.9	0.98	3.2
	Nickel	23	4	0.072	2.7	0.61	0.2	0.77
	Selenium	23	7	0.035	3.2	0.63	0.49	0.67
	Silver	10	9	0.047	<0.99	<0.89	<0.99	0.30
	Thallium	10	7	<0.02	<0.99	<0.32	<0.054	--
	Uranium	23	0	1.4	140	10.9	3.1	28.4
	Vanadium	23	1	0.45	26	3.4	1.8	5.3
	Zinc	23	0	1.9	350	37.2	6.9	78.5
Summary of Radionuclide Activity for Mineralized Background Soil Samples (pCi/g)								
Radionuclides (pCi/g)	Ra- 226	23	0	2.3	95.0	9.7	4.9	18.8
	Ra- 228	23	0	1.1	57.2	6.1	2.9	11.7
	Th-228	23	0	0.81	59.0	6.3	2.5	12.1
	Th-230	23	0	1.6	83.0	7.5	3.2	16.7
	Th-232	23	0	0.63	56.0	5.8	2.1	11.4
	Th-234	23	12	<-1.4	94.0	9.0	5.0	18.9
	U-234	7	0	1.6	8.6	3.0	2.0	2.5
	U-235	23	23	<-0.38	<0.72	<0.23	<0.19	--
	U-238	7	0	1.3	9.4	3.1	1.9	2.8
	Pb-210	23	0	1.7	38.0	5.5	3.1	7.4
	Po- 210	20	0	0.3	31.2	3.9	1.9	6.8

Notes: 1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-10. Radon Detector Results

Radon Station ID	Radon Concentration	
	Long Exposure (pCi/L)	Short Exposure (pCi/L)
OSA-RAD-1	92.9	
OSA-RAD-2*	2.1	
OSA-RAD-3*	3.3	
OSA-RAD-4	64.1	
OSA-RAD-5*	1.2	
DOT-RAD-6	Defective	
DOT-RAD-7	Defective	
DOT-RAD-8	Damaged	
DOT-RAD-9	Damaged	
DOT-RAD-10	Missing	
700L-RAD-11*	2.1	
700L-RAD-12	11	
700L-RAD-13	22.3	20.6
700L-RAD-14	40.1	
700L-RAD-15	7.9	
OP-RAD-16	163.3	70.0
OP-RAD-17	372.8	
OP-RAD-18	16.7	
OP-RAD-19	39.2	22.9
900L-RAD-20	192	
900L-RAD-21*	2.5	
900L-RAD-22	133.4	
900L-RAD-23	Tampered	
900L-RAD-24*	1.6	
900L-RAD-25	16.1	
MR-RAD-26	Missing	
MR-RAD-27	2.2	
300L-RAD-28	5.8	
300L-RAD-29	Saturated	445.2
300L-RAD-30	136.1	
300L-RAD-31	21.4	
300L-RAD-32	14.6	
300L-RAD-33	22.3	
300L-RAD-34	76.3	

NOTES:
Radon concentrations are the average concentrations over the exposure periods. Long exposure concentrations refer to radon detectors deployed for a period of 106 to 107 days from June 8 or June 9, 2009 through September 23, 2009, as shown in Table 3-4. Short exposure concentrations refer to radon detectors deployed for a six-day period during the July sampling event.
Defective- Laboratory testing equipment was defective or damaged
Missing- Test equipment taken from station
Tampered- Radon station was tampered with but still submitted to lab
Saturated- Radon concentration exceed max of 140,000 pCi/L-days
Damaged- Test equipment found on ground and water damaged
Sample ID's noted with a "*" indicate station is background

Table 6-11. Metals Concentrations at Background Surface Water Locations

	Entity	Sample ID	Parameter - All Concentrations in μg/L																				
			Al	**Sb**	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Hg**	**Mo**	**Ni**	**Se**	**Ag**	**Tl**	**U**	**V**	**Zn**
Mine Fork Creek, north tributary	BLM (1998)	WA04		<5	<0.5		<1	<0.2	<20		<2		<2		<0.2		<10	<5	<0.5	<1			<10
	KSI (2004)	SW-01	**94**					<0.3					<0.5								<0.1		
	Tetra Tech	900L-SW-01-C	71	<0.03	<10	1.2		0.034	<1	0.035	0.092	15	0.12	0.78	0.011	<10	<0.5	0.1	0.01	0.0051	0.014	<10	<10
			71				0.24	0.033			<3				0.0012						0.17		6.1
			150					0.046			0.42										1.6		4.8
Location Maximum Detected Value			**150**			1.2	0.24	0.046		0.035	0.42	15	0.12	0.78	0.011			0.1	0.01	0.0051	1.6		6.1
Mine Fork Creek, south tributary	BLM (1998)	WA03		<5	<0.5		<1	<0.2	<20		<2		<2		<0.2		<10	<5	<0.5	<1			<10
	KSI (2004)	SW-02	**130**					**0.3**					<0.5								0.11		
	Tetra Tech	900L-SW-01-B	**200**	<0.03	<10	2.7	0.23	0.061	<1	0.04	0.04	<100	0.14	3	<0.1	<10	0.3	0.089	0.01	0.0019	0.13	<10	<20
			120	<0.3	<10	2.8	<3	0.049	<10	0.19	**3**	12	<0.5	3.4	0.0004	<10	0.64	<1	<0.1	<0.2	0.18	<10	5.8
			160					0.048			<3										0.19		7.2
Location Maximum Detected Value			**200**			2.8	0.23	**0.3**		0.19	**3**	12	0.14	3.4	0.0004		0.64	0.089	0.01	0.0019	0.19		7.2
Kendrick Creek upstream of 300-Foot Level	BLM (1998)	WA05		<5	<0.5		<1	<0.2	<20		<2		<2		<0.2		<10	<5	<0.5	<1			<10
	Tetra Tech	700L-SW-01-A	**200**	0.0082	<10	8.7	0.035	0.043	<1	0.05	0.4	<100	0.16	4.6	<0.1	<10	0.85	0.17	0.01	0.0013	0.077	<10	<20
			180	0.17	<10	7.1	0.16	0.033	0.45	<1	<3	81	0.44	12	0.001	0.84	<5	0.12	<0.1	<0.2	0.11	<10	18
			120					**0.12**			0.97										0.14		
Location Maximum Detected Value			**200**	0.17		8.7	0.16	**0.12**	0.45	0.05	0.97	81	0.44	12	0.001	0.84	0.85	0.17	0.01	0.0013	0.14		18
Cabin Creek	KSI (2004)	SW-04	**88**					<0.3					<0.5								0.18		
	Tetra Tech	CONF-SW-01-C	52	<0.03	<10	1.8	<0.3	0.005	<1	0.05	0.03	43	<0.1	3.2	0.01	<10	<0.5	0.075	0.01	<0.02	0.11	<10	28
			180	0.092	<10	1.4	0.15	0.026	<10	<1	<3	140	0.03	4	0.0017	<10	<5	0.086	<0.1	<0.2	0.38	<10	3.6
			180					0.045			<3										0.29		<20
Location Maximum Detected Value			**180**	0.092	<10	1.8	0.15	0.045		0.05	0.03	140	0.03	4	0.01			0.086	0.01		0.38		28
Overall Maximum Detected Value			**200**	0.17		8.7	0.24	**0.3**	0.45	0.19	3	140	0.44	12	0.011	0.84	0.85	0.17	0.01	0.0051	1.6		28
Alaska WQC[1]			87	NA	150	NA	NA	0.1	23	NA	2.9	1000	0.54	NA	0.77	NA	16	5	NA	NA	NA	NA	37

Notes:
1 Alaska Water Quality Criteria (WQC), from ADEC (2008); values are chronic criteria for freshwater
2 Hardness dependent, value is for hardness = 25 mg/L $CaCO_3$
Bold values exceed Alaska WQC
Blank cells indicate that parameter was not analyzed

Table 6-12. Radiochemistry Activity at Background Surface Water Locations

			Parameter - All Concentrations in pCi/L										
	Entity	**Sample ID**	**Total Radium[1]**	**Ra-226**	**Ra-228**	**Th-228**	**Th-230**	**Th-232**	**U-234**	**U-235**	**U-238**	**Pb-210**	**Po- 210**
Mine Fork Creek, north tributary	BLM (1998)	WA04											
	KSI (2004)	SW-01		<0.03	<0.17								
	Tetra Tech	900L-SW-01-C		<-0.26	<-0.05	0.15	<-0.003	<0.018	0.125	<0.032	<0.057	<0.16	<0.06
				<0.76	<0.03							<-0.29	<0.13
				<0.58	<0							<0.22	
Location Maximum Detected Value						0.15			0.125				
Mine Fork Creek, south tributary	BLM (1998)	WA03	0.8										
	KSI (2004)	SW-02		<0.07	<0.36								
	Tetra Tech	900L-SW-01-B		0.72	<0.23	<0.036	<-0.012	0.015	0.18	<0.041	0.15	0.87	<0.12
				0.88	<0.11	0.079	0.159	<0.011	0.075	<0.024	0.077	<0.41	<-0.05
				<0.24	<0.15							<0.44	
Location Maximum Detected Value				0.88		0.079	0.159	0.015	0.18		0.15	0.87	
Kendrick Creek upstream of 300-Foot Level	BLM (1998)	WA05	0										
	Tetra Tech	700L-SW-01-A		<0.04	<0.13	<0.027	<0.083	<0.011	<0.012	<-0.003	<0.036	<0.16	<0.02
				<0.06	<0.01	0.046	<0.056	0.032	<0.072	<-0.001	<0.08	0.68	<-0.09
				<0.07	<0							<0.22	
Location Maximum Detected Value						0.046		0.032				0.68	
Cabin Creek	KSI (2004)	SW-04		<0.09	<0.23								
	Tetra Tech	CONF-SW-01-C		<0.02	<-0.01	<0.014	<0.049	0.013	0.15	<0.013	0.043	<-0.16	<0.053
				<0.1	<0.04	<-0.011	<0.057	<0.007	0.193	0.031	0.165	<0.26	<0.03
				<0.15	<0.13							<0.47	
Location Maximum Detected Value								0.013	0.193	0.031	0.165		
Overall Maximum Detected Value			0.8	0.88		0.15	0.159	0.032	0.193	0.031	0.165	0.87	

Notes: 1. BLM (1998) reported total radium. KSI (2004) and Tetra Tech reported separate Ra-226 and Ra-228 values.
Blank cells indicate that parameter was not analyzed

Table 6-13. Metals Concentrations at Background Stream Sediment Locations

Entity	Sample ID	Parameter - All Concentrations in mg/kg																				
		Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Ag	Tl	U	V	Zn
Mine Fork Creek, north tributary																						
KSI (2004)	SSED-02	680		10							4,900	10	39							3		
Tetra Tech	900L-SS-01-C	880		0.68	5	2.7	<0.49	0.14	0.13	<0.98	1,900	20	29		0.21	<0.98	<0.098			4.1	3.1	6
Location Maximum Detected Value		880		10	5	2.7		0.14	0.13		4,900	20	39		0.21					7	3.1	6
Mine Fork Creek, south tributary																						
KSI (2004)	SSED-01	960		1.9							5,600	16	86							2.5		
Tetra Tech	900L-SS-01-B	1,100	0.043	2.1	<9.9	0.59	<0.49	0.19	0.25	<0.99	3,800	22	130	0.0088	<0.99	<2	<0.49	<0.99	0.042	3.3	1.7	13
Location Maximum Detected Value		1,100	0.043	2.1		0.59		0.19	0.25		5,600	22	130	0.0088					0.042	3.3	1.7	13
Cabin Creek																						
KSI (2004)	SSED-03	13,000		2.3							31,000	6.7	1,500							3.2		
Tetra Tech	CONF-SS-01-C	8,400	0.022	2.4	16	0.57	0.12	13	6.7	5.6	19,000	5.2	830	<0.033	1.2	7	<0.49	0.05	0.061	2.1	28	64
Location Maximum Detected Value		13,000	0.022	2.4	16	0.57	0.12	13	6.7	5.6	31,000	6.7	1,500		1.2	7		0.05	0.061	3.2	28	64
Overall Maximum Detected Value		13,000	0.043	10	16	0.59	0.12	13	6.7	5.6	31,000	22	1,500	0.0088	1.2	7		0.05	0.061	7	28	64

Notes: Blank cells indicate that parameter was not analyzed

Table 6-14. Radionuclide Activity Concentrations at Background Stream Sediment Locations

Entity	Sample ID	*Parameter - All Activity in pCi/g*										
		Ra-226	Ra-228	Th-228	Th-230	Th-232	Th-234	U-234	U-235	U-238	Pb-210	Po-210
Mine Fork Creek, north tributary												
KSI (2004)	SSED-02	0.67	0.76	1	1.65	1.83	2.25	1.25	0.042	1.17		
Tetra Tech	900L-SS-01-C	2.07	0.85	0.68	1.53	0.87	<1.7		<0.61		2.23	1.99
Location Maximum Detected Value		2.07	0.85	1	1.65	1.83	2.25	1.25	0.042	1.17	2.23	1.99
Mine Fork Creek, south tributary												
KSI (2004)	SSED-01	1.99	2.27	1.32	1.85	1.3	<1.8	1.43	0.07	1.55		
Tetra Tech	900L-SS-01-B	4.9	2.04	2.41	3	2.45	<3.3	2.72	<0.06	2.46	3.19	2.28
Location Maximum Detected Value		4.9	2.27	2.41	3	2.45		2.72	0.07	2.46	3.19	2.28
Cabin Creek												
KSI (2004)	SSED-03	1.49	0.99	0.83	4.63	0.75	<1.4	1.16	<0.034	0.86		
Tetra Tech	CONF-SW\S-01-C	2.17	1.02	1.32	1.96	1.04	<1	1.91	<0.23	1.93	2.9	2.83
Location Maximum Detected Value		2.17	0.99	1.32	4.63	1.04		1.91		1.93	2.9	2.83
Overall Maximum Detected Value		4.9	2.27	2.41	4.63	2.45	2.25	2.72	0.07	2.46	3.19	2.83

Notes: Blank cells indicate that parameter was not analyzed

Table 6-15. Summary Statistics for Mine Affected 700-Foot Level Soil Samples

Type	Constituents	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metals Concentrations for Mine Affected 700-Foot Level Soil Samples (mg/Kg)								
Metals (mg/Kg)	Aluminum	3	0	1900	2900	2533	2800	551
	Antimony	1	0	0.031	--	--	--	--
	Arsenic	3	0	1.8	2.9	2.3	2.3	0.55
	Barium	3	0	10	42	27.0	29.0	16.1
	Beryllium	3	1	<0.5	1.2	0.77	0.6	0.38
	Cadmium	3	3	<0.48	<0.49	<0.49	<0.49	-
	Chromium	3	0	1.4	7.2	3.7	2.6	3.1
	Cobalt	3	0	0.69	1.8	1.2	1.2	0.6
	Copper	3	0	2.5	4.7	3.63	3.7	1.10
	Iron	3	0	7300	12000	9767	10000	2359
	Lead	3	0	32.0	54.0	43.3	44.0	11.0
	Manganese	3	0	93	740	478	600	340
	Mercury	1	0	0.033	--	--	--	--
	Molybdenum	3	0	1.5	4.6	3.5	4.3	1.7
	Nickel	3	0	0.73	1.8	1.1	0.74	0.6
	Selenium	3	1	0.25	<0.48	<0.35	<0.32	0.12
	Silver	1	0	<0.96	--	--	--	--
	Thallium	1	0	0.038	--	--	--	--
	Uranium	3	0	140	230	190	200	45.8
	Vanadium	3	0	5.2	10	6.9	5.4	2.7
	Zinc	3	0	19	130	76.3	80	55.6
Summary of Radionuclides Concentrations for Mine Affected 700-Foot Level Soil Samples (pCi/g)								
Radionuclides (pCi/g)	Th-232	3	0	26.7	123	65.3	46.1	50.9
	Ra-228	3	0	22.1	71.2	50.9	59.3	25.6
	Th-228	3	0	24.4	81.0	48.1	39.0	29.4
	Pb-212	3	0	23.2	78.3	56.4	67.7	29.2
	Bi-212	3	0	27.7	68.0	54.6	68.0	23.3
	U-235	3	1	<1.5	6.3	4.6	6.0	2.7
	U-238	1	0	30.4	--	--	--	--
	Th-234	3	0	43.5	126	96.8	121	46.3
	U-234	1	0	28.7	--	--	--	--
	Th-230	3	0	36.7	221	108	66.0	99.0
	Ra-226	3	0	31.6	139	102	136	61.2
	Pb-214	3	0	25.1	118	85.0	112	52.0
	Bi-214	3	0	24.2	105	75.7	98.0	44.8
	Pb-210	3	0	24.0	147	96.7	119	64.5
	Po-210	3	0	23.7	121	69.6	64.2	48.9
	Tl-208	3	0	7.6	23.6	17.2	20.5	8.5

Notes: 1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-16. Summary Statistics for Mine Affected 900-Foot Level Soil Samples

Type	Constituents	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metals Concentrations for Mine Affected 900-Foot Level Soil Samples (mg/Kg)								
Metals (mg/Kg)	Aluminum	9	0	830	5,000	2,337	2,200	1,222
	Antimony	5	0	0.060	0.49	0.16	0.10	0.18
	Arsenic	9	0	0.43	11.0	3.9	3.1	3.1
	Barium	9	1	3.7	190	75.6	57	67.4
	Beryllium	9	0	0.14	1.2	0.76	0.76	0.34
	Cadmium	9	8	<0.49	1.8	0.64	0.5	0.43
	Chromium	9	1	0.17	<0.99	<0.5	<0.44	0.2
	Cobalt	9	2	0.1	<0.98	<0.5	<0.56	0.3
	Copper	9	1	<0.98	11	5.7	5.4	3.6
	Iron	9	0	4,900	27,000	13,411	11,000	6,800
	Lead	9	0	11.0	120	72.3	76.0	35.7
	Manganese	9	0	71	770	467	440	240
	Mercury	5	4	<0.033	0.039	0.034	0.033	0.003
	Molybdenum	9	0	0.64	7.9	2.47	1.4	2.30
	Nickel	9	0	0.087	0.39	0.2	0.2	0.1
	Selenium	9	3	0.025	0.99	0.41	0.49	0.28
	Silver	5	5	<0.98	<9.9	<2.8	<0.99	--
	Thallium	5	1	0.042	<0.99	<0.27	<0.084	0.40
	Uranium	9	0	27.0	1000	541	580	377
	Vanadium	9	0	0.26	6.2	3.4	3.9	1.8
	Zinc	9	0	31	2700	383	84	870
Summary of Radionuclides Concentrations for Mine Affected 900-Foot Level Soil Samples (pCi/g)								
Radionuclides (pCi/g)	Th-232	9	0	6.7	307	150	164	110
	Ra-228	9	0	6.2	272	136	152	95.1
	Th-228	9	0	7.0	359	164	143	124
	Pb-212	9	0	6.3	277	144	155	101
	Bi-212	9	0	7.3	298	155	166	112
	U-235	9	2	<-0.1	19.5	9.8	10.2	7.5
	U-238	4	0	12.5	317	222	279	142
	Th-234	9	0	11.6	420	213	223	147
	U-234	4	0	12.0	298	205	255	131
	Th-230	9	0	11.3	680	332	427	247
	Ra-226	9	0	12.9	631	313	351	231
	Pb-214	9	0	11.0	561	262	277	198
	Bi-214	9	0	8.1	479	239	271	177
	Pb-210	9	0	8.7	510	213	210	176
	Po-210	8	0	6.0	527	201	192	181
	Tl-208	9	0	1.9	86.0	44.1	49.7	30.6

Notes: 1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-17. Summary of Data Collected from Major Mine Rock Piles

Mine Rock Pile	Maximum Gamma (μR/hr)	Maximum Radon (ρCi/L)	Maximum Uranium (mg/Kg)	Maximum Arsenic (mg/Kg)	Maximum Lead (mg/Kg)
900 Level, North Pile	2,623	133	490	3.4	62
900 Level, South Pile	1,700	192	1,400	25	110
900 Level, Misc. Piles	nm	nm	10,000	24	470
700 Level Pile	4,206	40	10,000	61	410
300 Level Pile	2,460	22	8,200	15	330

Note: nm = not measured.

Table 6-18. Summary Statistics for Mine Affected 300-Foot Level Soil Samples

Type	Constituent	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metals Concentrations for Mine Affected 300-Foot Level Soil Samples (mg/Kg)								
Metals (mg/Kg)	Aluminum	18	0	690	57,000	9,763	6,500	13,042
	Antimony	4	0	0.15	0.8	0.4	0.2	0.3
	Arsenic	18	0	0.21	33.0	4.52	2.70	7.3
	Barium	18	1	<9.9	120	52	45.5	31
	Beryllium	18	1	0.46	13	2.43	0.95	3.60
	Cadmium	18	1	0.1	9.5	0.98	0.27	2.22
	Chromium	18	0	0.73	62	15	11.5	14
	Cobalt	18	0	0.28	54	10.0	5.7	13.4
	Copper	18	0	3.2	65	17.9	12	16.3
	Iron	18	0	5,100	36,000	17,950	15,500	8,603
	Lead	18	0	12.0	180	70.8	58.0	48.3
	Manganese	14	0	130	6,700	1,255	555	1,757
	Mercury	4	0	<0.033	0.15	0.1	0.1	0.1
	Molybdenum	18	0	1.9	18	7.1	6.3	4.6
	Nickel	18	0	0.34	130	18.1	5.7	33.4
	Selenium	18	5	0.02	3.5	0.9	0.5	1.1
	Silver	4	3	<0.98	<0.99	<1.0	<1.0	--
	Thallium	4	0	0.03	0.39	0.7	0.4	0.9
	Uranium	18	0	3.1	1,900	277	155	456
	Vanadium	18	0	1.3	50	18.7	18	13.8
	Zinc	18	0	15	1,800	218	105	410
Summary of Radionuclide Concentrations for Mine Affected 300-Foot Level Soil Samples (pCi/g)								
Radionuclides (pCi/g)	Th-232	18	0	1.2	136	52.8	45.6	41.8
	Ra-228	18	0	1.7	178	50.6	34.3	48.2
	Th-228	18	0	1.5	143	59.4	51.3	46.5
	Pb-212	18	0	2.0	190	55.0	38.5	52.1
	Bi-212	18	1	<2.9	206	57.9	37.4	55.8
	U-235	18	13	<0.4	50.0	6.4	2.6	11.6
	U-238	3	0	2.2	700	362	385	349
	Th-234	18	0	4.1	1,030	144	61.2	239
	U-234	3	0	2.1	730	387	428	366
	Th-230	18	0	2.0	222	67.7	55.4	58.1
	Ra-226	18	0	3.7	447	100	70.9	109
	Pb-214	18	0	3.1	356	81.9	56.4	87.5
	Bi-214	18	0	2.6	337	73.9	53.6	81.4
	Pb-210	18	0	2.7	138	47.7	38.4	39.5
	Po-210	17	0	2.3	187	62.2	49.9	52.6
	Tl-208	18	0	0.4	60.2	17.2	11.8	16.6

Notes: 1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-19. Summary Statistics for Ore Staging Area Soil Samples

Type	Constituent	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metals Concentrations for Mine Affected OSA Soil Samples (mg/Kg)								
Metals (mg/Kg)	Aluminum	8	0	3,000	10,000	6,813	7,150	2,095
	Antimony	4	0	0.021	0.37	0.12	0.049	0.17
	Arsenic	8	0	0.32	6.8	2.7	2.1	2.5
	Barium	8	1	<9.6	39	23.0	22	10.0
	Beryllium	8	3	0.25	0.85	0.55	0.52	0.17
	Cadmium	8	5	0.078	<0.5	<0.34	<0.485	0.21
	Chromium	8	0	3	18	11.8	13.5	5.1
	Cobalt	8	0	1.9	7.2	4.2	3.9	1.7
	Copper	8	0	6.5	36	13.5	7.8	10.4
	Iron	8	0	6,900	20,000	14,612.5	14,500	4,025
	Lead	8	0	2.9	41.0	18.5	15.0	11.9
	Manganese	8	0	150	480	300	285	122
	Mercury	4	2	<0.033	0.060	0.046	0.045	0.015
	Molybdenum	8	1	0.46	1.3	0.90	0.89	0.27
	Nickel	8	0	2.1	10	6.6	7.6	2.7
	Selenium	8	3	0.19	<0.96	<0.47	<0.44	0.25
	Silver	4	4	<0.96	<1	<0.99	<0.99	--
	Thallium	4	1	0.024	<1	<0.27	<0.027	0.49
	Uranium	8	0	20.0	460	200	240	147
	Vanadium	8	0	15	52	28.6	28	11.6
	Zinc	8	0	15	61	38.3	43.5	17.0
Summary of Radionuclides Concentrations for Mine Affected OSA Soil Samples (pCi/g)								
Radionuclides (pCi/g)	Th-232	8	0	2.39	60.0	34.8	36.7	22.2
	Ra-228	8	0	4.0	70.2	32.5	27.8	23.9
	Th-228	8	0	3.6	70.0	36.9	37.0	23.5
	Pb-212	8	0	4.6	78.8	36.4	30.8	26.4
	Bi-212	8	1	<3.4	82.0	37.0	29.4	27.5
	U-235	8	3	<0.04	12.4	3.9	2.4	4.1
	U-238	3	0	9.5	43.5	30.5	38.5	18.4
	Th-234	8	0	9.6	254	79.9	57.0	79.5
	U-234	3	0	9.1	44.5	31.2	39.9	19.2
	Th-230	8	0	4.9	101	61.0	66.5	36.1
	Ra-226	8	0	11.1	148	63.3	55.2	45.1
	Pb-214	8	0	9.4	119	52.4	47.6	36.0
	Bi-214	8	0	7.9	109	46.6	41.1	33.2
	Pb-210	8	0	6.9	163	56.7	52.6	49.4
	Po-210	7	0	6.7	179	63.6	52.6	58.3
	Tl-208	8	0	1.5	23.0	10.8	9.4	7.7

Notes:
1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-20. Summary of Data Collected from OSA

Maximum Gamma (μR/hr)	Maximum Radon (ρCi/L)	Maximum Uranium (mg/Kg)	Maximum Arsenic (mg/Kg)	Maximum Lead (mg/Kg)
4,100	93	7,800	9.9	470

Table 6-21. Summary Statistics for Haul Road Soil Samples

Type	Constituent	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metals Concentrations for Haul Roads (mg/Kg)								
Metals (mg/Kg)	Aluminum	7	0	3,300	15,000	8,471	7,300	4,412
	Antimony	7	0	0.26	0.76	0.48	0.53	0.19
	Arsenic	7	0	0.22	1.3	0.87	0.95	0.33
	Barium	7	0	15.0	39.0	27.6	29.0	9.3
	Beryllium	7	0	0.24	1.0	0.60	0.59	0.32
	Cadmium	7	3	0.067	<0.5	<0.27	<0.18	0.22
	Chromium	7	0	2.8	28.0	11.8	11.0	9.1
	Cobalt	7	0	1.2	13.0	5.1	3.4	4.4
	Copper	7	0	4.1	15.0	8.5	7.7	4.0
	Iron	7	0	11,000	30,000	18,143	18,000	6,866
	Lead	7	0	4.4	50.0	20.5	7.7	19.5
	Manganese	7	0	180	770	370	330	196
	Mercury	7	7	<0.033	<0.033	<0.033	<0.033	-
	Molybdenum	7	0	0.36	2.2	0.97	1.1	0.64
	Nickel	7	0	1.5	13	5.8	5.1	4.6
	Selenium	7	6	0.43	<0.99	<0.63	<0.49	0.25
	Silver	7	7	<0.99	<1	<0.99	<0.99	--
	Thallium	7	7	<0.99	<2	<1.28	<0.99	--
	Uranium	7	0	6.0	160	54.3	31.0	58.5
	Vanadium	7	0	6.1	52.0	24.6	20.0	16.9
	Zinc	7	0	24.0	74.0	47.9	48.0	18.8
Summary of Radionuclides Concentrations for Haul Roads (pCi/g)								
Radionuclides (pCi/g)	Th-232	7	0	2.4	30.9	12.7	8.0	11.9
	Ra-228	7	0	0.9	44.8	14.0	7.1	17.6
	Th-228	7	0	2.8	28.7	12.2	7.9	10.8
	Pb-212	7	0	1.5	45.0	14.8	7.6	17.8
	Bi-212	7	2	<0.5	49.0	14.7	6.1	18.7
	U-235	7	6	<-0.58	4.4	1.1	1.2	1.8
	U-238	0	0	--	--	--	--	--
	Th-234	7	--	1.3	64.6	24.0	11.5	28.2
	U-234	0	--	--	--	--	--	--
	Th-230	7	0	3.2	80.0	23.1	12.1	28.2
	Ra-226	7	0	1.9	97.0	28.4	13.4	36.4
	Pb-214	7	0	1.8	83.7	23.7	10.8	31.0
	Bi-214	7	0	1.3	74.9	21.6	10.3	27.9
	Pb-210	7	0	2.4	63.0	19.3	10.2	23.5
	Po-210	0	--	--	--	--	--	--
	Tl-208	7	0	0.4	14.3	4.7	2.3	5.6

Notes:
1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-22. Summary Statistics of I&L Soil Samples

Type	Constituent	No. of Samples	No. of Non-Detects	Minimum Conc.	Maximum Conc.	Mean Conc.	Median Conc.	Standard Deviation
Summary of Metals Concentrations for I&L Soil Samples (mg/Kg)								
Metals (mg/Kg)	Aluminum	2	0	2,100	2,900	2,500	2,500	566
	Antimony	2	1	0.35	<2	<1.2	<1.2	1.2
	Arsenic	2	0	1.1	2.5	1.8	1.8	1.0
	Barium	2	0	3.9	130.0	67.0	67.0	89.2
	Beryllium	2	0	0.48	0.8	0.66	0.66	0.25
	Cadmium	2	1	0.12	<0.49	<0.31	<0.31	0.26
	Chromium	2	0	1.0	1.7	1.4	1.4	0.5
	Cobalt	2	0	0.29	0.58	0.44	0.44	0.21
	Copper	2	0	1.8	5.8	3.8	3.8	2.8
	Iron	2	0	5,800	19,000	12,400	12,400	9,334
	Lead	2	0	31.0	100	65.5	65.5	48.8
	Manganese	2	0	32.0	540	286	286	359
	Mercury	2	2	<0.033	<0.033	<0.033	<0.033	--
	Molybdenum	2	0	1.8	6.4	4.1	4.1	3.3
	Nickel	2	0	0.39	0.53	0.46	0.46	0.10
	Selenium	2	2	<0.49	<0.5	<0.5	<0.5	--
	Silver	2	2	<0.98	<0.99	<0.99	<0.99	--
	Thallium	2	2	<0.98	<0.99	<0.99	<0.99	--
	Uranium	2	0	27.0	420	224	224	278
	Vanadium	2	0	4.3	6.2	5.3	5.3	1.3
	Zinc	2	0	18.0	160	89.0	89.0	100
Summary of Radionuclides Concentrations for I&L Soil Samples (pCi/g)								
Radionuclides (pCi/g)	Th-232	2	0	13.5	187	100	100	123
	Ra-228	2	0	8.1	110	59.1	59.1	72.1
	Th-228	2	0	11.1	180	95.6	95.6	119
	Pb-212	2	0	8.0	114	61.0	61.0	75.0
	Bi-212	2	0	8.1	118	63.1	63.1	77.7
	U-235	2	1	<0.7	6.9	3.8	3.8	4.4
	U-238	0	--	--	--	--	--	--
	Th-234	2	0	13.1	198	106	106	131
	U-234	0	--	--	--	--	--	--
	Th-230	2	0	21.2	346	184	183.6	230
	Ra-226	2	0	15.6	245	130	130	162
	Pb-214	2	0	12.4	209	111	111	139
	Bi-214	2	0	11.8	192	102	102	127
	Pb-210	2	0	10.4	150	80.2	80.2	98.7
	Po-210	0	--	--	--	--	--	--
	Tl-208	2	0	2.6	35.3	18.9	18.9	23.2

Notes:
1. Detection limit value used where concentration was reported at less than detection
2. Concentration shown as minimum where only one sample result is available

Table 6-23. Maximum Concentration of Select Metals, Metalloids and Radionuclides in Surface Water Samples Collected Downstream of Mine Rock Piles

Parameter	Alaska WQC	900-Foot Level (Mine Fork Creek)	700-Foot Level (700-Foot Level Creek)	300-Foot Level (Kendrick Creek)
Aluminum	87	130	160	150
Arsenic	150	<10	nm	<10
Barium	na	1.9	nm	48
Beryllium	na	0.17	nm	0.051
Cadmium	0.1	0.044	0.053	0.05
Chromium	23	<1	nm	<1
Copper	2.9	0.76	0.73	0.5
Iron	1000	11	nm	21
Lead	0.54	0.12	<0.5	0.072
Manganese	na	1.8	nm	2.2
Mercury	0.77	0.10	0.0008	0.0014
Molybdenum	na	<10	nm	<10
Nickel	16	<0.5	nm	0.3
Selenium	5	0.08	nm	0.095
Thallium	na	0.0041	nm	0.0017
Uranium	na	1.5	29	18
Zinc	37	10	23	7.5
Gross Alpha	na	4.4	15.8	13.7
Gross Beta	na	1.7	12.3	5.0
Total Thorium	na	3.46	nm	3.35
Radium-226	na	0.34	1.14	0.36
Radium-228	na	0.8	2.49	0.64
Lead-210	na	0.44	2.68	0.4

Notes:
1. Metal/metalloid concentrations in µg/L; radionuclide concentrations in pCi/L
2. Alaska Water Quality Criteria (WQC) shown are freshwater chronic values
3. na = no standard available
4. nm = not measured

Table 6-24. Summary of Flow Measurements made at the 300-Level Portal

(all measurements in cfs)

Date	Organization	Flow
8/26/1995	BLM (1998)	<0.1
5/03/2004	KSI (2004)	nm
6/10/2009	Tetra Tech	0.04
7/26/2009	Tetra Tech	0.04
9/23/2009	Tetra Tech	0.2

Notes: 1. nm = not measured.

Table 6-25. Maximum Concentration of Selected Metals and Radionuclides in 300-Foot Level Portal Samples

Parameter	Alaska WQC	300-Foot Level Portal Maximum
Aluminum	87	83
Arsenic	150	<10
Barium	na	28
Beryllium	na	0.17
Cadmium	0.1	0.075
Chromium	23	0.64
Copper	2.9	0.56
Iron	1000	11
Lead	0.54	0.28
Manganese	na	100
Mercury	0.77	<0.10
Molybdenum	na	6.2
Nickel	16	<5
Selenium	5	<1
Thallium	na	0.013
Uranium	na	240
Zinc	37	38
Total Thorium	na	3.68
Radium-226	na	7.8
Radium-228	na	7.2
Lead-210	na	1.81

1. Metal/metalloid concentrations in µg/L; radionuclide concentrations in pCi/L
2. Alaska Water Quality Criteria (WQC) shown are freshwater chronic values
3. na = no standard available

Table 6-26. Maximum Concentration of Select Metals, Metalloids and Radionuclides in Surface Water Samples Collected at the OSA

Parameter	Alaska WQC	OSA Creek (KSI SW-05)	OSA Spring (Tetra Tech SPR-SW-01-A)
Aluminum	87	290	270
Arsenic	150	<10	<0.01
Barium	na	<100	0.61
Beryllium	na	nm	<0.3
Cadmium	0.1	0.31	0.036
Chromium	23	<10	1.5
Copper	2.9	<2	0.3
Iron	1,000	630	450
Lead	0.54	0.5	0.13
Manganese	na	<10	23
Mercury	0.77	<0.2	0.0052
Molybdenum	na	nm	<10
Nickel	16	<5	0.63
Selenium	5	<5	0.13
Thallium	na	<0.2	0.02
Uranium	na	0.79	0.38
Zinc	37	<20	20
Gross Alpha	na	1.83	nm
Gross Beta	na	1.64	nm
Total Thorium	na	0.43	3.6
Radium-226	na	0.3	0.21
Radium-228	na	<0.46	<0.49
Lead-210	na	<0.23	1.09

1. Metal/metalloid concentrations in µg/L; radionuclide concentrations in pCi/L
2. Alaska Water Quality Criteria (WQC) shown are freshwater chronic values
3. na = no standard available
4. nm = not measured

Table 6-27. Maximum Concentrations of Select Metals, Metalloids and Radionuclides in Stream Sediment Samples Collected Downstream of Mine Rock Piles

Parameter	900-Foot Level (Mine Fork Creek)	700-Foot Level (700-Foot Level Creek)	300-Foot Level (Kendrick Creek)
Arsenic	2.2	6.3	5
Barium	<9.9	nm	70
Beryllium	2.7	nm	1.8
Cadmium	<0.49	nm	0.82
Copper	0.99	nm	25
Lead	22	48	64
Manganese	170	1400	2,600
Molybdenum	<0.99	nm	11
Thallium	0.042	nm	0.2
Uranium	24	180	270
Zinc	22	nm	230
Total Thorium	32.4	190	37.9
Radium-226	7.5	67	15.8
Radium-228	5.96	34.1	6.8
Lead-210	3.25	nm	7.8

Notes:
1. Metal/metalloid concentrations in mg/kg; radionuclide concentrations in pCi/g
2. nm = not measured

Table 6-28. Summary of Radon Measurements, Underground Mine Workings

(all measurements in ρCi/L)

Location\Source	BLM (1998)	KSI (2004)	Tetra Tech (2009)
Airshaft	nm	40	39.2 22.9
900-Foot Level	261	24	163 70.0
700-Foot Level	212	87 80	22.3 20.6
300-Foot Level	541	396 336 322	445

Notes: 1. nm = not measured.
2. BLM (1998) measurements taken inside of mine workings. KSI and Tetra Tech measurements taken at entrances.

Table 6-29. Select Metals Concentrations and Radiochemistry Data for Background Subtidal and Intertidal Sediment Samples

Sample ID	Source	Arsenic (mg/Kg)	Lead (mg/Kg)	Uranium (mg/Kg)	Total Thorium (pCi/g)	Total Radium (pCi/g)
Summary for Background Subtidal Sediment Samples						
KBD-MS-01-C	Tetra Tech (2009)	22	12	13	18.36	6.8
KBD-MS-01-D	Tetra Tech (2009)	19	14	19	23.47	6.23
KBD-MS-01-E	Tetra Tech (2009)	22	36	15	20.33	7.4
KBD-MS-01-F	Tetra Tech (2009)	20	16	14	19.59	7.67
KBD-MS-01-H	Tetra Tech (2009)	21	17	16	26.85	6.42
KBD-MS-01-I	Tetra Tech (2009)	15	19	12	22.69	6.66
KBD-MS-01-J	Tetra Tech (2009)	9.8	8	8.9	15.54	4.82
Maximum Concentration of Subtidal Sediment Samples		22	36	19	27	8
Summary for Background Intertidal Sediment Samples						
KBD-MS-01-AA	Tetra Tech (2009)	4.2	10	9.2	11.85	4.62
KBD-MS-01-BB	Tetra Tech (2009)	3.4	8	2.4	3.93	2.42
KBD-MS-01-CC	Tetra Tech (2009)	3.8	6.1	3.8	6.88	2.76
KBD-MS-01-DD	Tetra Tech (2009)	4	5	2.1	4.28	2.53
KBD-MS-01-FF	Tetra Tech (2009)	1.5	1.3	0.7	3.34	1.2
KBD-MS-01-K	Tetra Tech (2009)	1.6	2.3	2.8	4.87	1.82
KBD-MS-01-M	Tetra Tech (2009)	2.7	8.4	3.2	12.31	4.19
KBD-MS-01-N	Tetra Tech (2009)	3.3	6.9	1.6	8.88	3.91
KBD-MS-01-O	Tetra Tech (2009)	3.3	9.9	6.4	13.2	3.85
KBD-MS-01-P	Tetra Tech (2009)	4	21	3	7.96	3.94
KBD-MS-01-Q	Tetra Tech (2009)	3.7	9.7	2.5	6.51	3.62
KBD-MS-01-R	Tetra Tech (2009)	1.4	6.7	2.7	7.38	3.05
KBD-MS-01-S	Tetra Tech (2009)	4.7	6.8	1.7	6.88	3.33
KBD-MS-01-T	Tetra Tech (2009)	2.9	8.6	2.5	13.44	5.21
KBD-MS-01-U	Tetra Tech (2009)	3.7	10	9.4	22.03	8.84
KBD-MS-01-V	Tetra Tech (2009)	2.6	8.2	4.5	15.07	11.28
KBD-MS-01-W	Tetra Tech (2009)	3.4	9	3.3	13.17	5.61
KBD-MS-01-X	Tetra Tech (2009)	1.8	3.6	1.0	2.95	1.74
KBD-MS-01-Y	Tetra Tech (2009)	2.7	11	3.1	8.38	3.46
KBD-MS-01-Z	Tetra Tech (2009)	2.7	6.6	2	5.18	2.96
MSED-04	KSI (2004)	2.5	9.7	5.4	10.76	3.9
MSED-05	KSI (2004)	5	20	17	21.24	6.15
Maximum Concentration of Intertidal Sediment Samples		5	21	17	22	11

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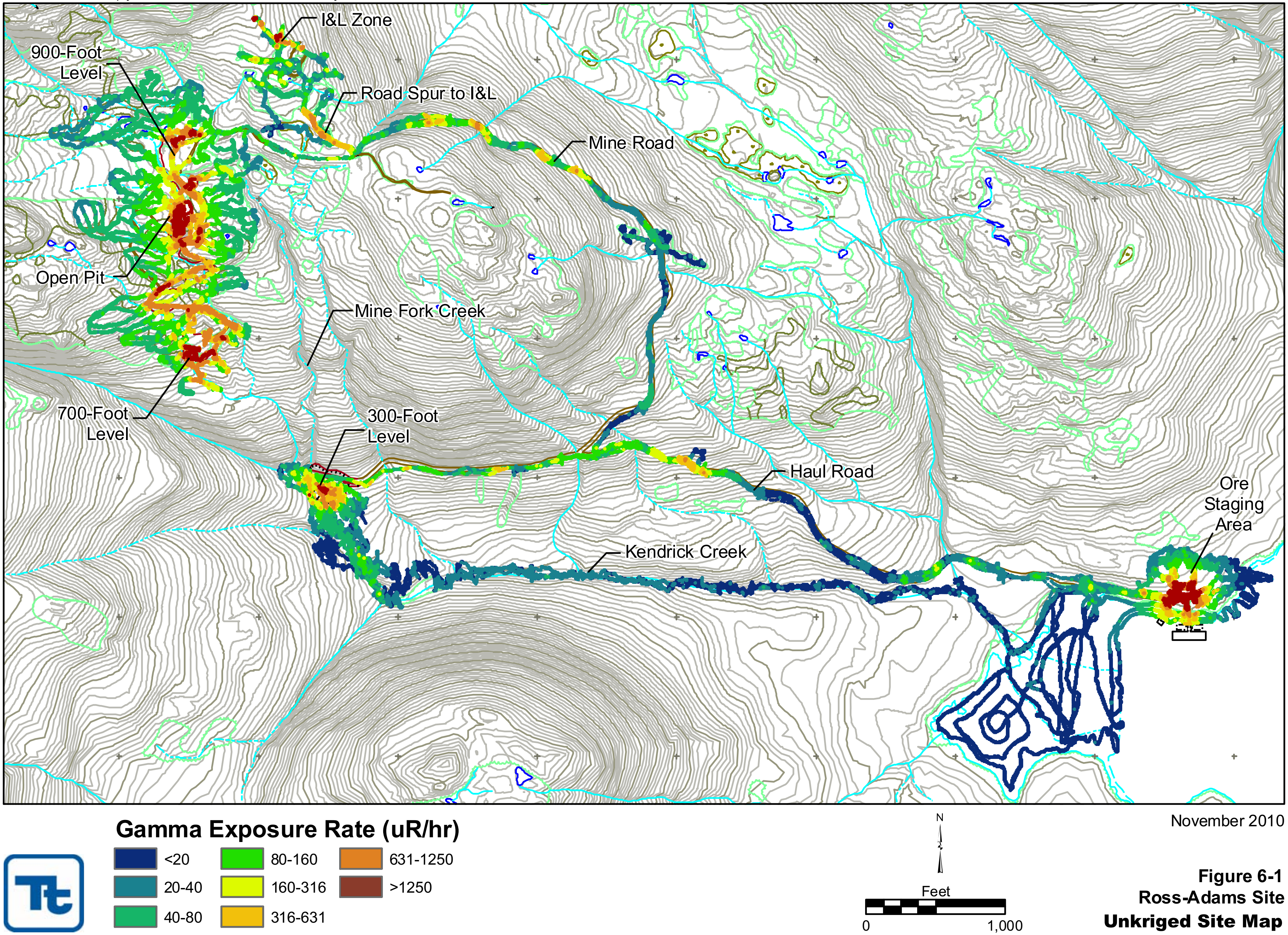
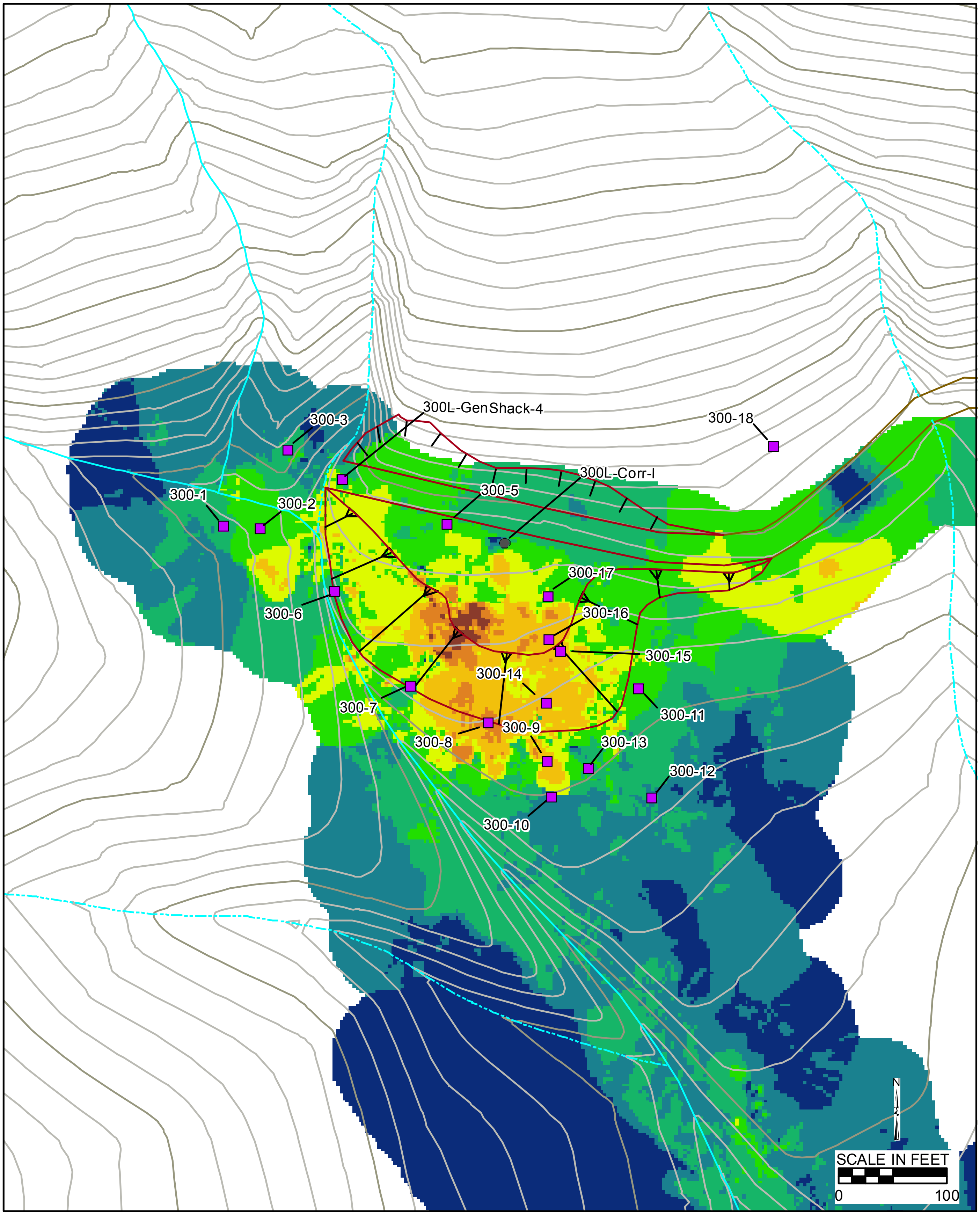


November 2010

Figure 6-1
Ross-Adams Site
Unkriged Site Map



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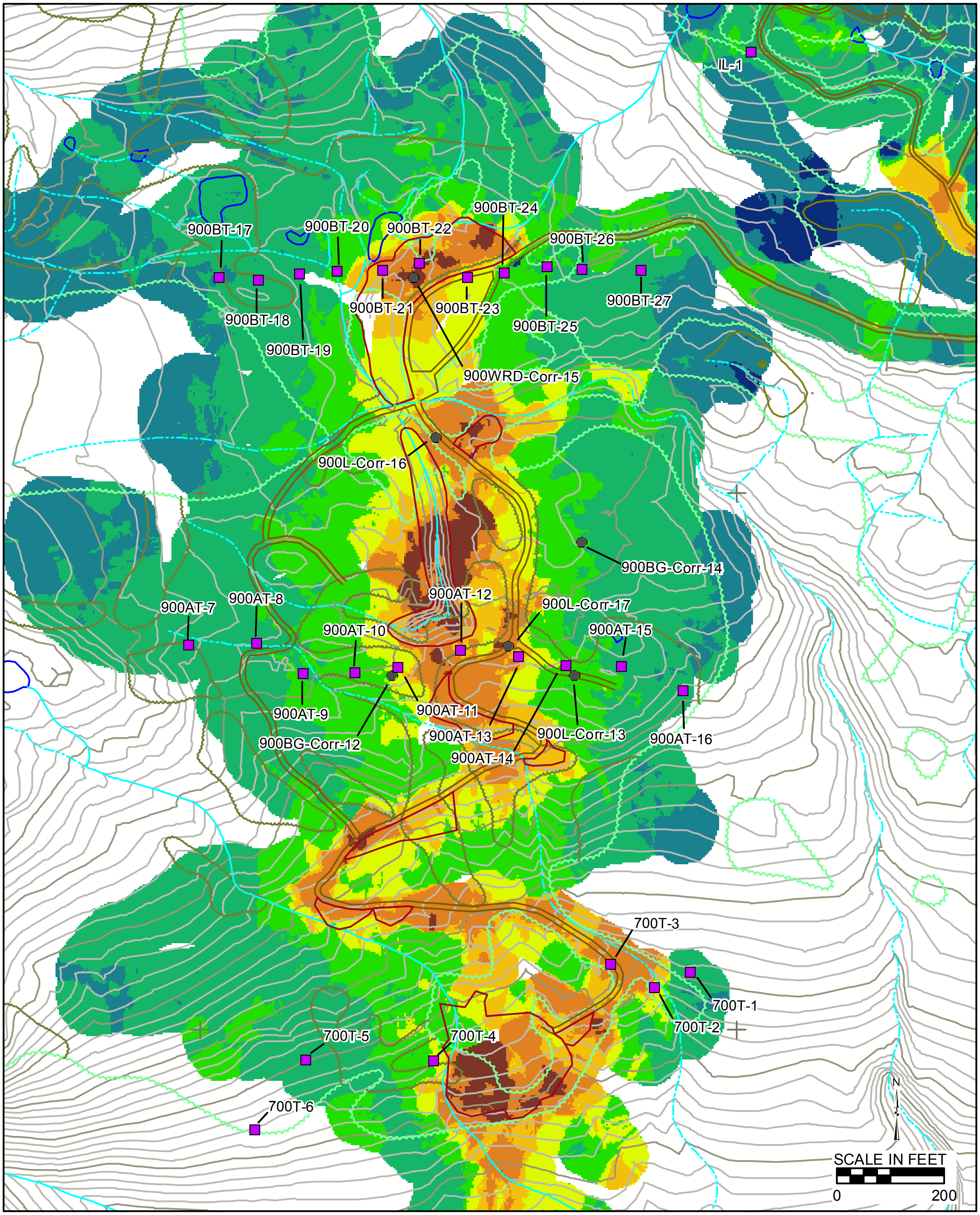
Gamma Exposure Rate (uR/hr)

November 2010

- <20
- 20-40
- 40-80
- 80-160
- 160-316
- 316-631
- 631-1250
- >1250
- Outside of Limits of Gamma Survey
- Gamma/Soil Correlation Plot Sample
- Discrete Soil Sample

Figure 6-2
Ross-Adams Site
Gamma Survey
300 Level Kriged Site Map



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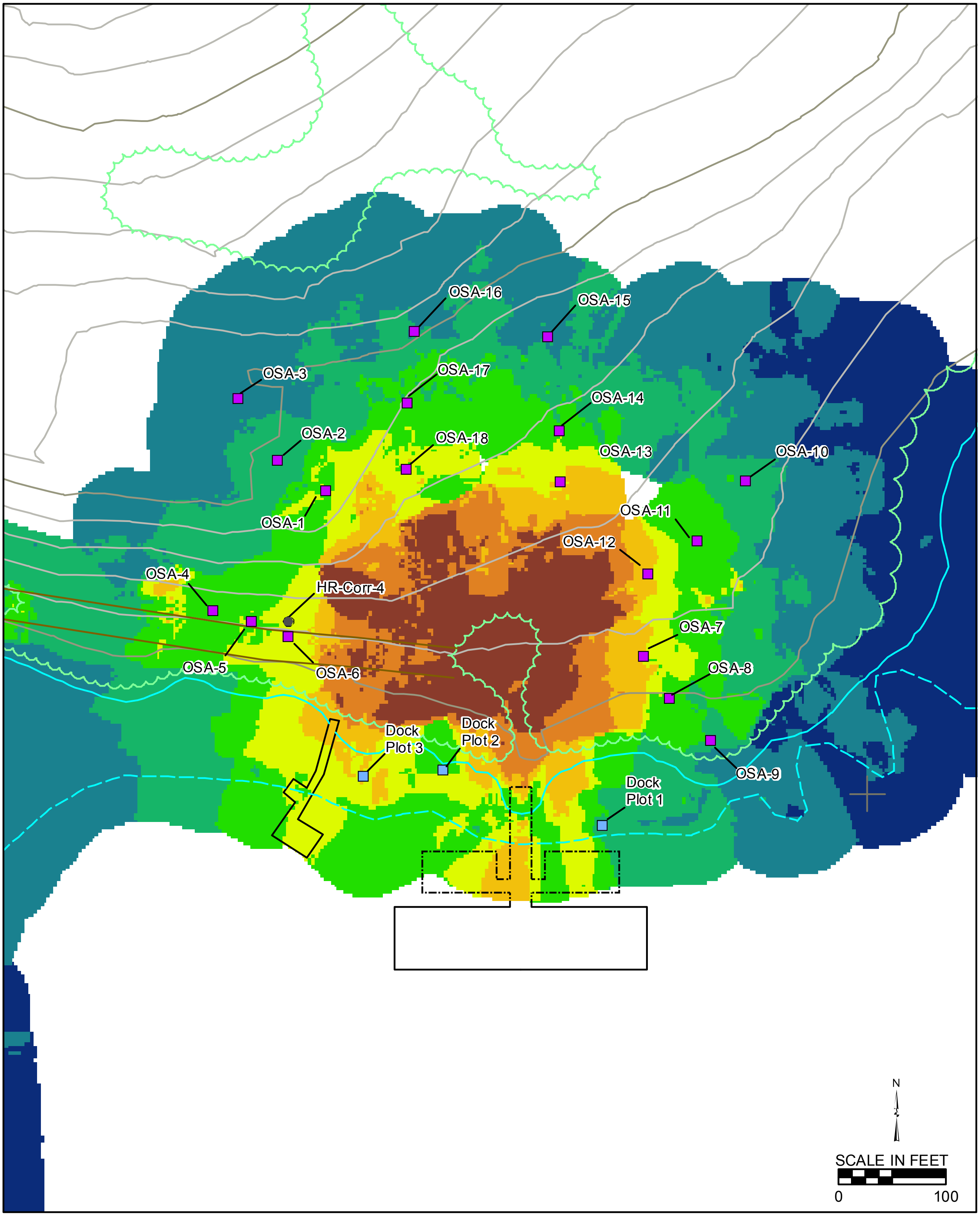
November 2010

Gamma Exposure Rate (uR/hr)

- <20
- 20-40
- 40-80
- 80-160
- 160-316
- 316-631
- 631-1250
- >1250
- Outside of Limits of Gamma Survey
- Gamma/Soil Correlation Plot Sample
- Discrete Soil Sample

Figure 6-3
Ross-Adams Site
Gamma Survey
900/700 Level Kriged Site Map



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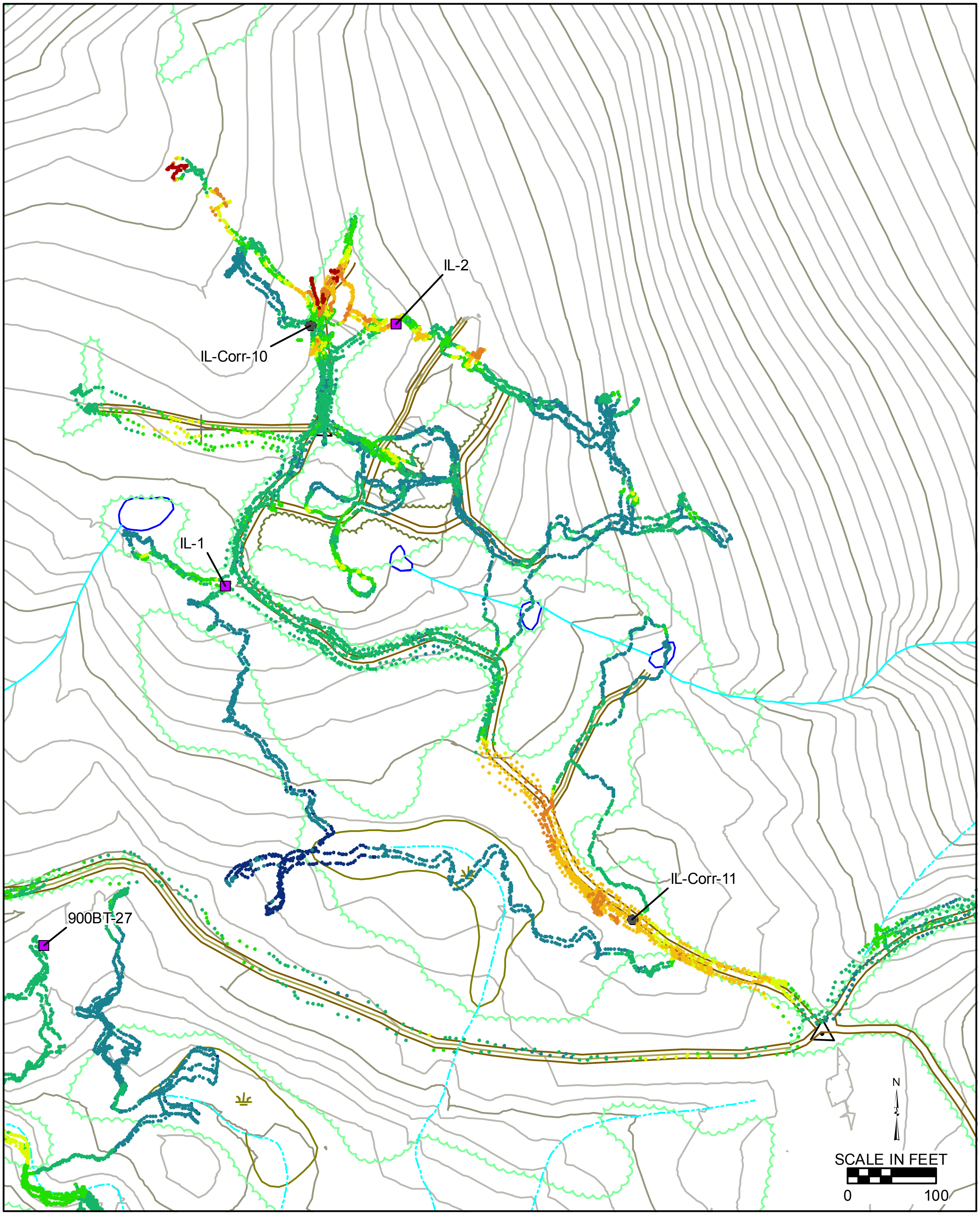
November 2010

Gamma Exposure Rate (uR/hr)

- <20
- 20-40
- 40-80
- 80-160
- 160-316
- 316-631
- 631-1250
- >1250

- Outside of Limits of Gamma Survey
- Gamma/Soil Correlation Plot Sample
- Discrete Soil Sample
- Mine Rock Point Count Plot

Figure 6-4
Ross-Adams Site
OSA Level
Kriged Site Map



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Gamma Exposure Rate (uR/hr)

<20
20-40
40-80
80-160
160-316
316-631
631-1250
>1250

Outside of Limits of Gamma Survey

Gamma/Soil Correlation Plot Sample

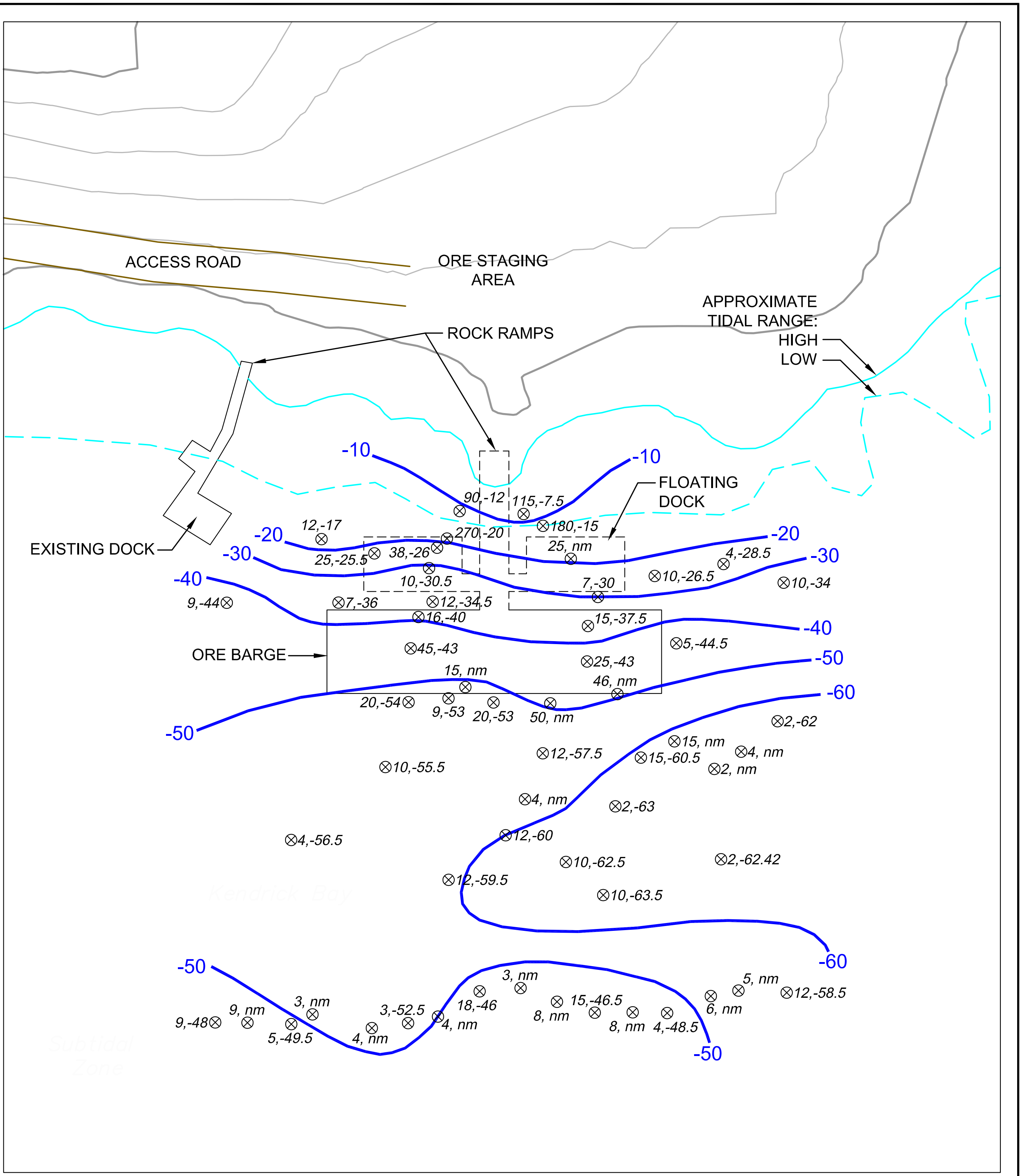
Discrete Soil Sample

November 2010

Figure 6-5
Ross-Adams Site
I&L Zone
Un-Kriged Site Map

Figure 6-6. 900 Level North Mine Rock Pile

Figure 6-7. Ore Present in the Intertidal Area Adjacent to the Dock



-10 Bathymetry contour (Feet, MSL)

4,-56.5 ⊗ Submarine Gamma Radiation Survey Point, Gamma Reading (uR/hr) and Bottom elevation (MSL) Shown

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Project No. 181862 | Note: Modified from Kent & Sullivan, 2004 | November 2010

Figure 6-8
Ross-Adams Site
Bathymetry and Submarine Gamma Survey Results Former Ore Loading Dock Areas


900AT-7


900AT-8


900AT-9

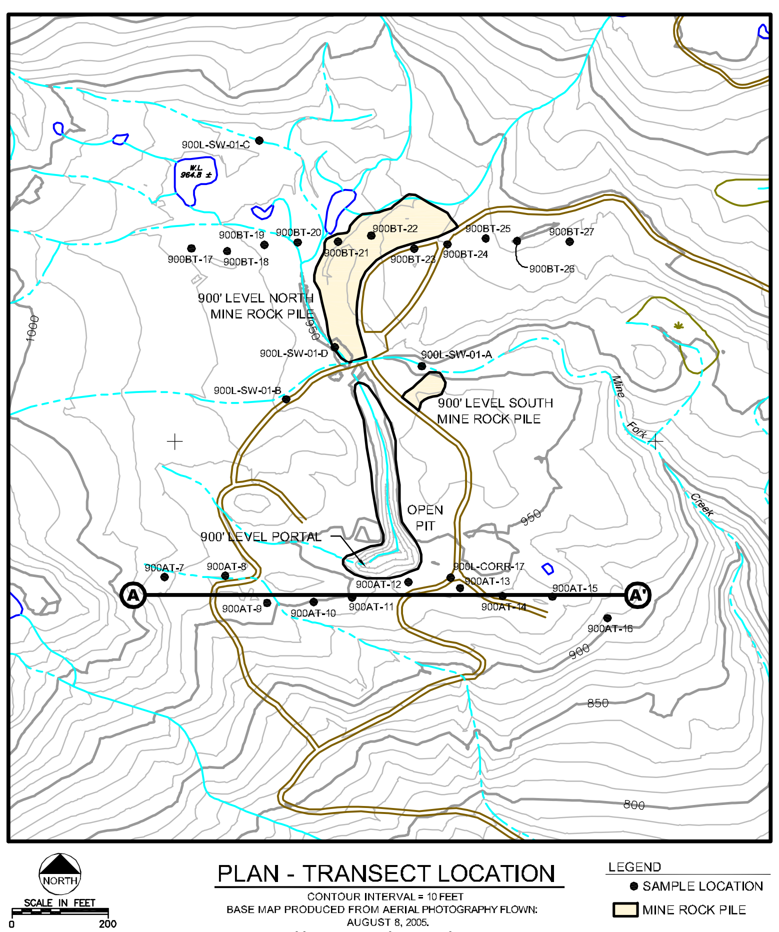

900AT-10


900AT-11


900AT-12


900AT-13

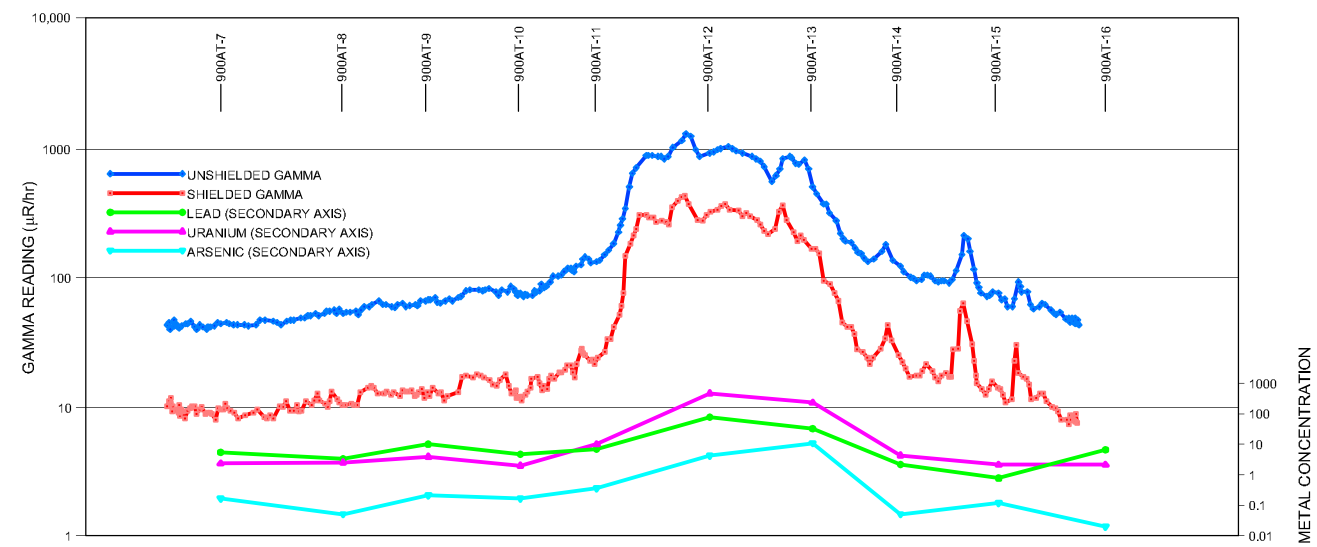

900AT-15

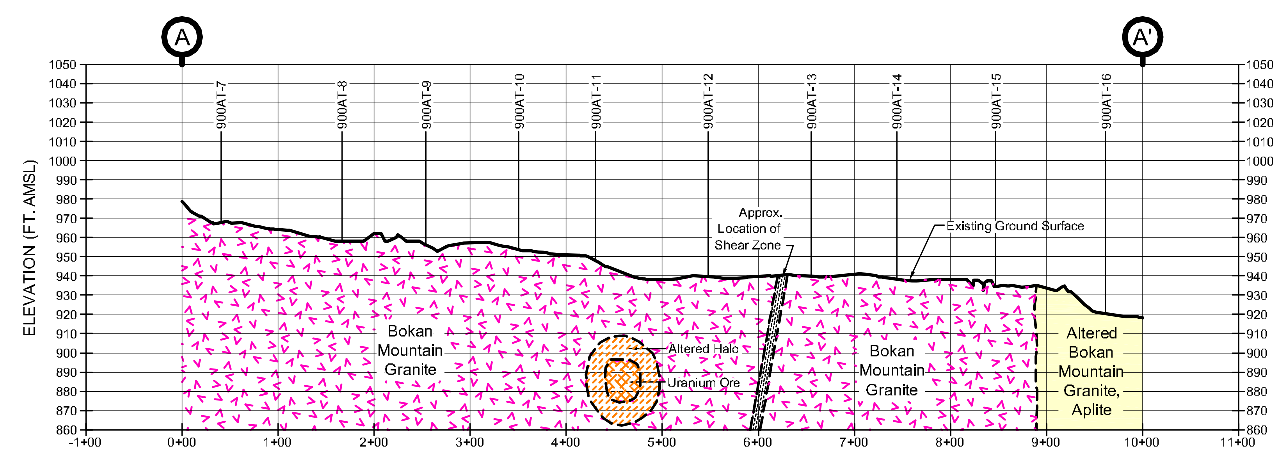


PLAN - TRANSECT LOCATION

CONTOUR INTERVAL = 10 FEET
BASE MAP PRODUCED FROM AERIAL PHOTOGRAPHY FLOWN: AUGUST 8, 2005.
COMPILED BY: EAGLE MAPPING LTD.

LEGEND
- SAMPLE LOCATION
- MINE ROCK PILE





Geologic Sources:
1. MacKevett (1963).
2. Warner and Barker (1988).
3. Thompson (1997).

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		-	-	-
		-	-	-

ENGINEER'S SEAL

ISSUED FOR

ISSUED BY

TETRA TECH

SCALE:	AS SHOWN
DESIGNED BY:	ASO
DRAWN BY:	TGB
CHECKED BY:	MSA
APPROVED BY:	BTM
FILE NAME:	TRANSECTS-1

ROSS-ADAMS SITE

TOPOGRAPHIC, GEOLOGIC, AND GAMMA PROFILE 900'-LEVEL TRANSECT A-A'

PROJECT NO.: 181862 DATE: NOVEMBER 2010

REVISION 0

DRAWING NO. 6-9

North View at West End of Transect B-B'

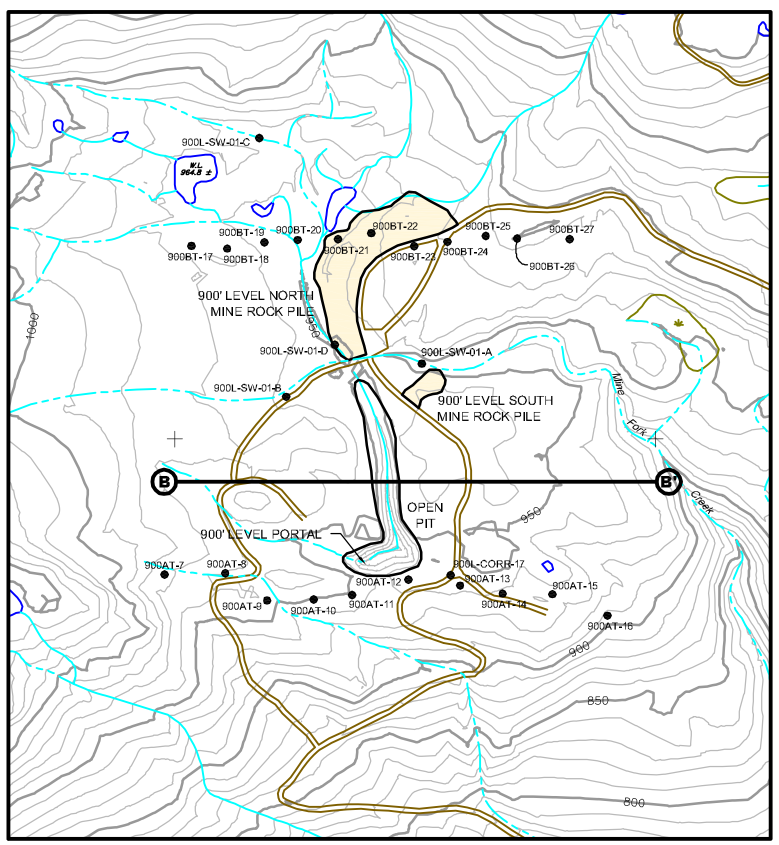
Open Pit

Open Pit

Open Pit

Open Pit

900'-Level Portal

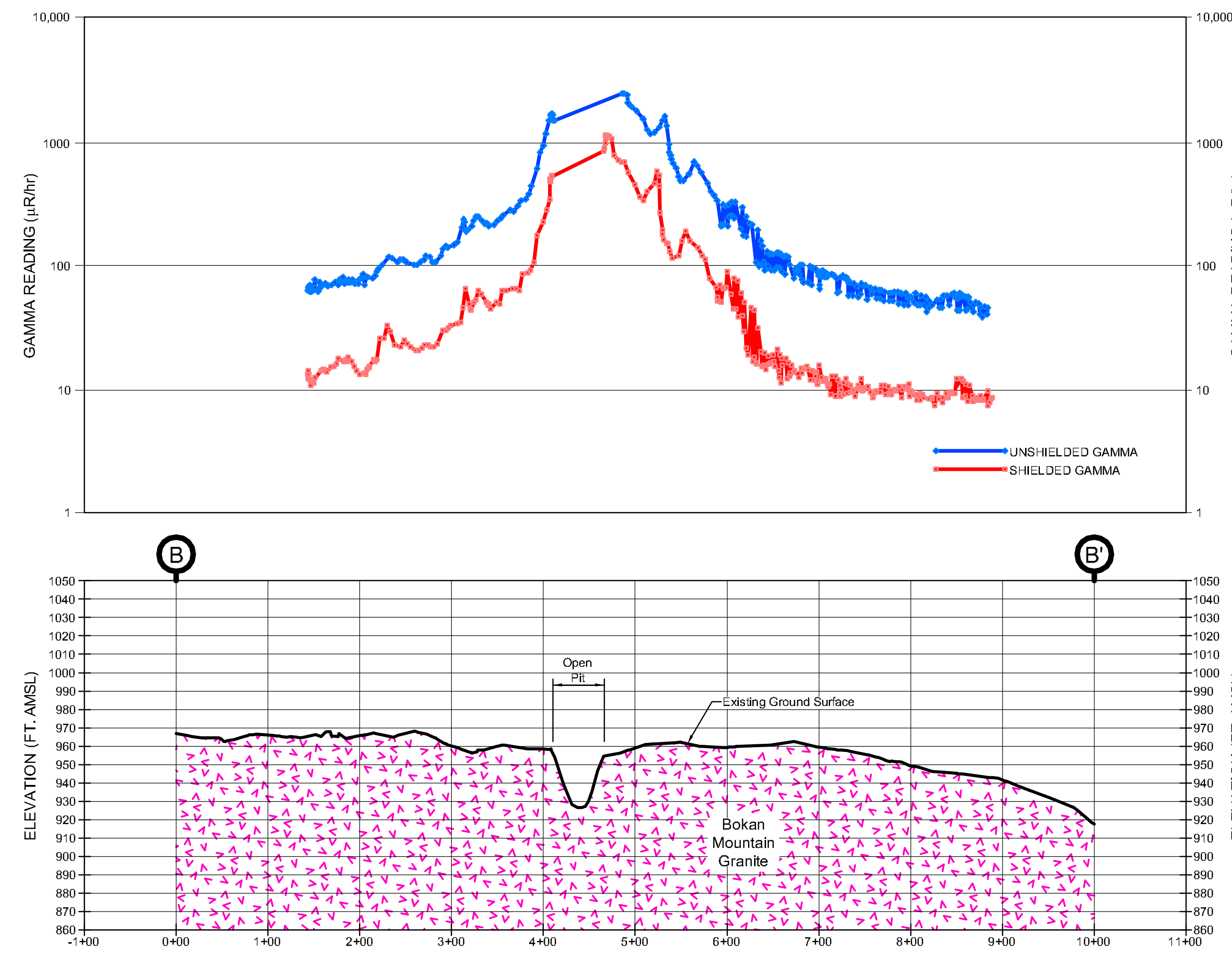


PLAN - TRANSECT LOCATION

CONTOUR INTERVAL = 10 FEET
BASE MAP PRODUCED FROM AERIAL PHOTOGRAPHY FLOWN: AUGUST 8, 2005.
COMPILED BY: EAGLE MAPPING LTD.

NORTH
SCALE IN FEET 0 200

LEGEND
● SAMPLE LOCATION
MINE ROCK PILE



Geologic Sources:
1. MacKevett (1963).
2. Warner and Barker (1988).
3. Thompson (1997).

REFERENCE	NO.	REVISIONS	BY	DATE
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	-	-	-	-
	-	-	-	-
	-	-	-	-

ENGINEER'S SEAL

ISSUED FOR

ISSUED BY

TETRA TECH

SCALE:	AS SHOWN
DESIGNED BY:	ASO
DRAWN BY:	TGB
CHECKED BY:	MSA
APPROVED BY:	BTM
FILE NAME:	TRANSECTS-1

ROSS-ADAMS SITE

TOPOGRAPHIC, GEOLOGIC, AND GAMMA PROFILE 900'-LEVEL TRANSECT B-B'

PROJECT NO.: 181862 DATE: NOVEMBER 2010

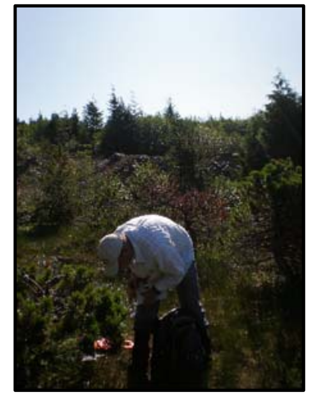
REVISION 0

DRAWING NO. 6-10


900BT-17


900BT-18


900BT-19


900BT-20

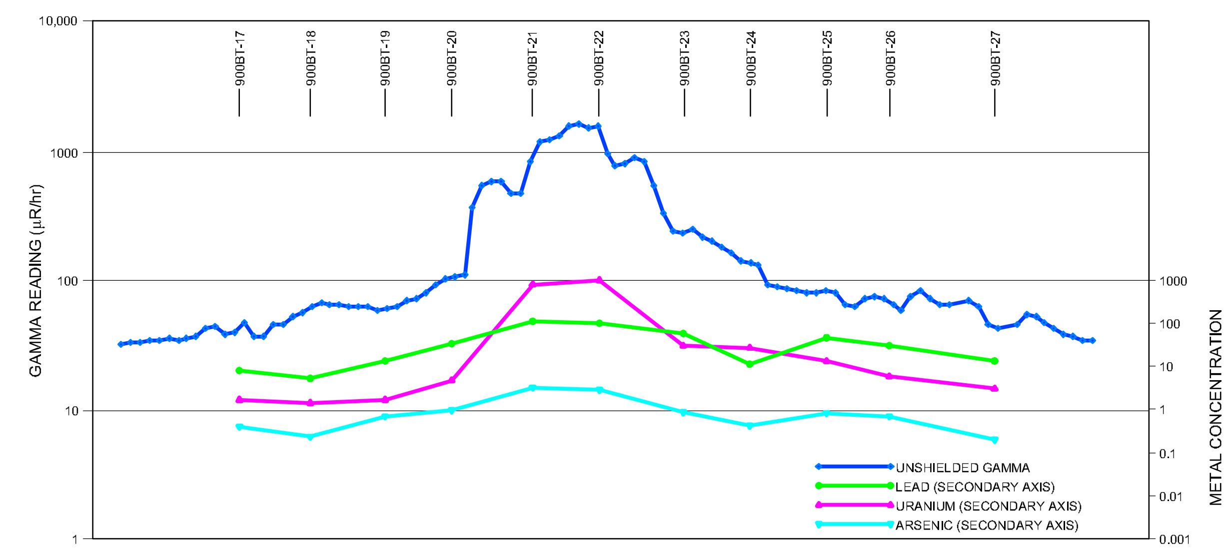

900BT-21


900BT-22


900BT-23


900BT-24


900BT-25

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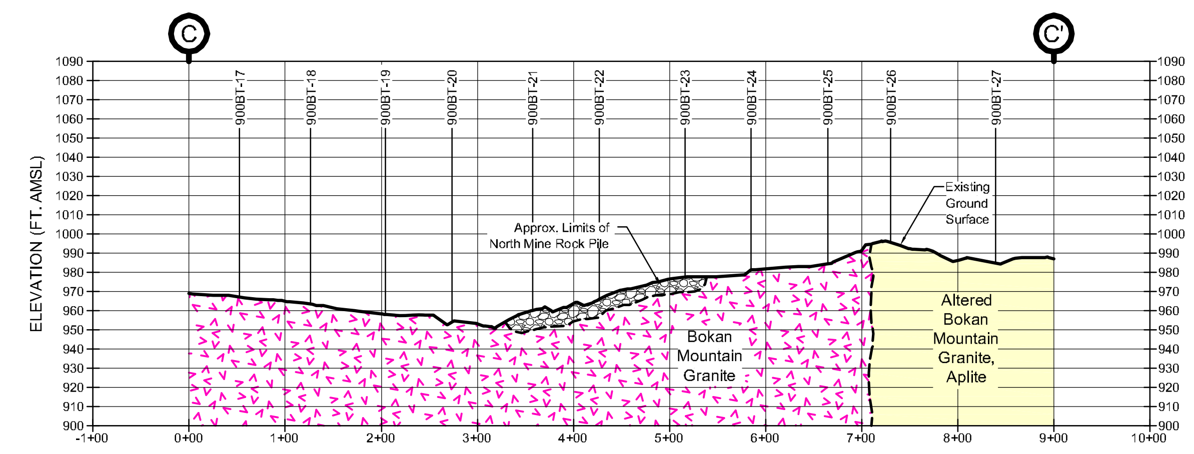
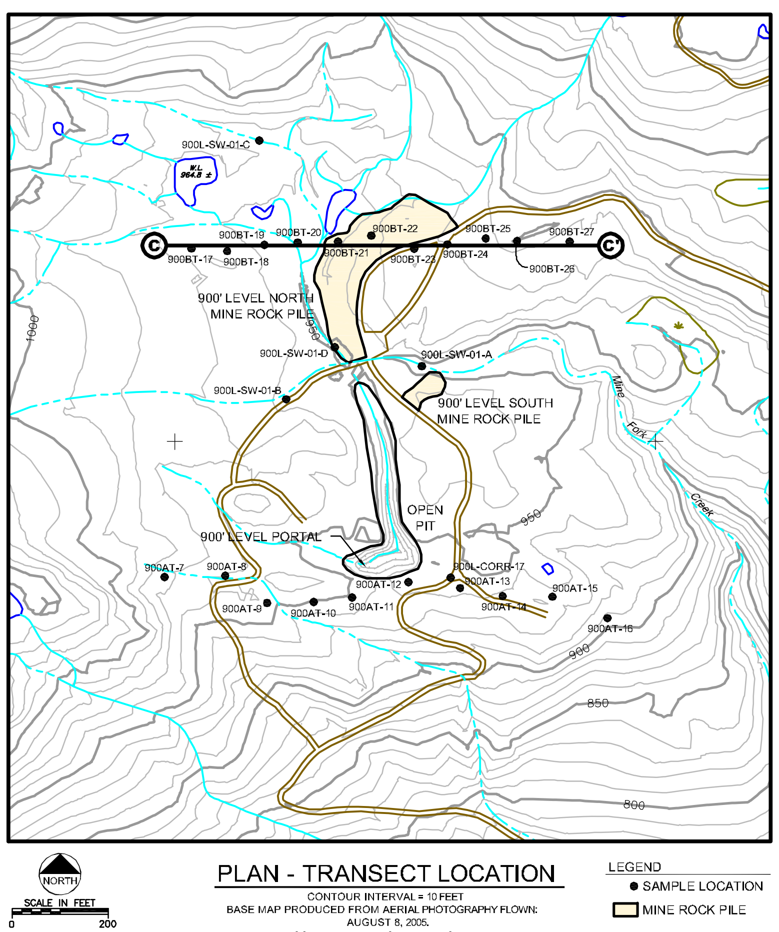



900BT-27



PLAN - TRANSECT LOCATION

CONTOUR INTERVAL = 10 FEET
BASE MAP PRODUCED FROM AERIAL PHOTOGRAPHY FLOWN: AUGUST 8, 2005.
COMPILED BY: EAGLE MAPPING LTD.

LEGEND
- SAMPLE LOCATION
- MINE ROCK PILE

Geologic Sources:
1. MacKevett (1963).
2. Warner and Barker (1988).
3. Thompson (1997).

REFERENCE	NO.	REVISIONS	BY	DATE
		-	-	-
		-	-	-
		-	-	-
		-	-	-
		-	-	-
		-	-	-
		-	-	-
		-	-	-

ENGINEER'S SEAL

ISSUED FOR

ISSUED BY

TETRA TECH

SCALE:	AS SHOWN
DESIGNED BY:	ASO
DRAWN BY:	TGB
CHECKED BY:	MSA
APPROVED BY:	BTM
FILE NAME:	TRANSECTS-1

ROSS-ADAMS SITE

TOPOGRAPHIC, GEOLOGIC, AND GAMMA PROFILE 900'-LEVEL TRANSECT C-C'

PROJECT NO.: 181862 DATE: NOVEMBER 2010

REVISION 0

DRAWING NO. 6-11

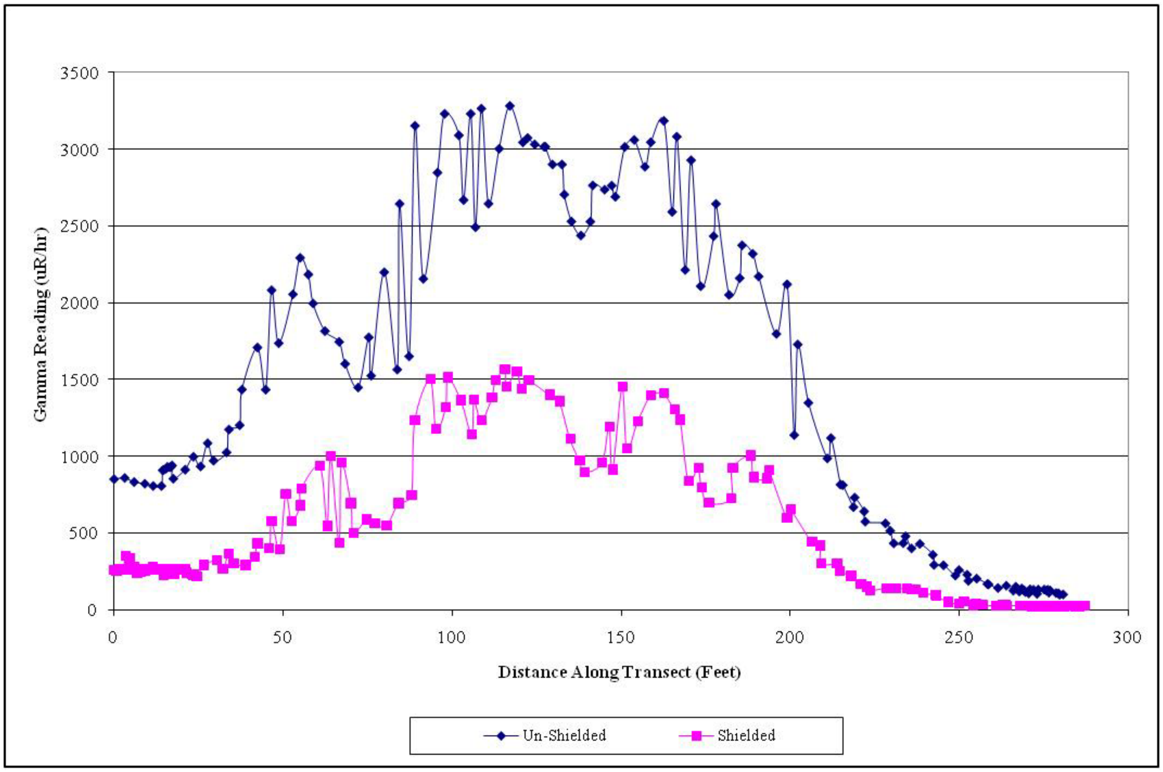


Figure 6-12. OSA Transect Gamma Profile Shielded vs. Unshielded Analysis

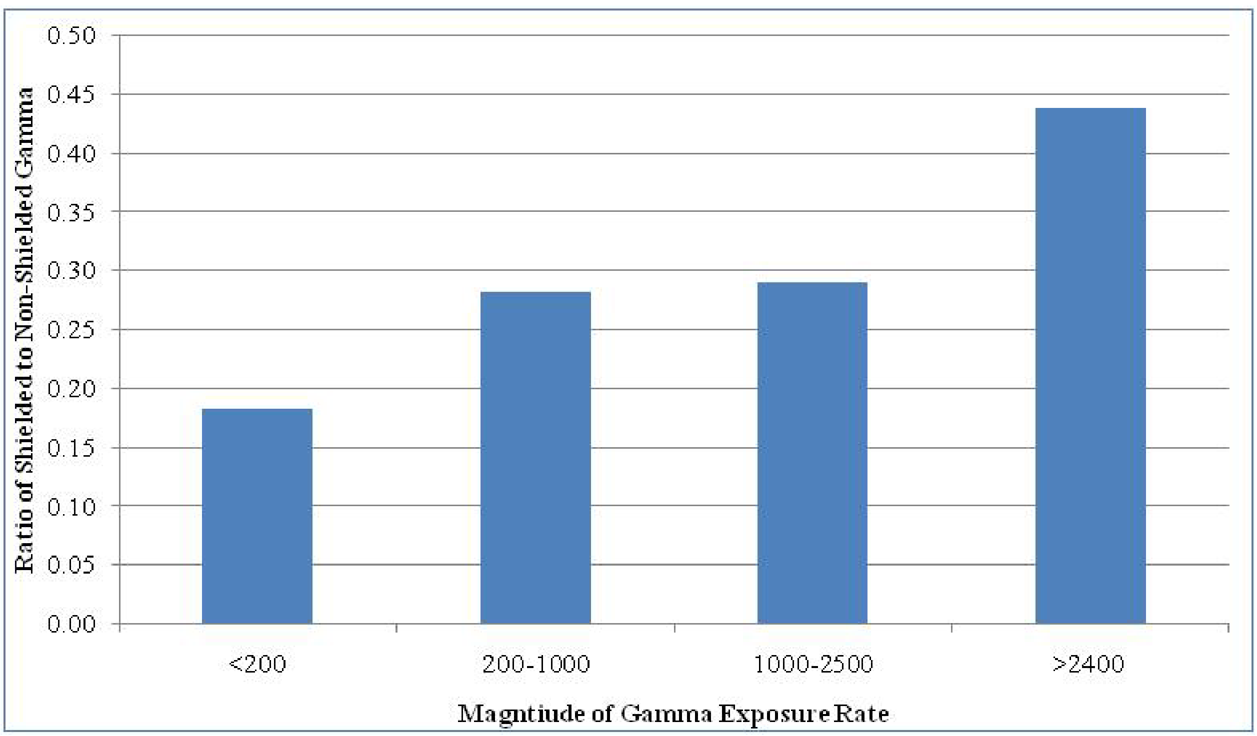


Figure 6-13. Ratio of Shielded to Non-Shielded NaI Gamma Readings vs. Magnitude of Non-Shielded Gamma Readings

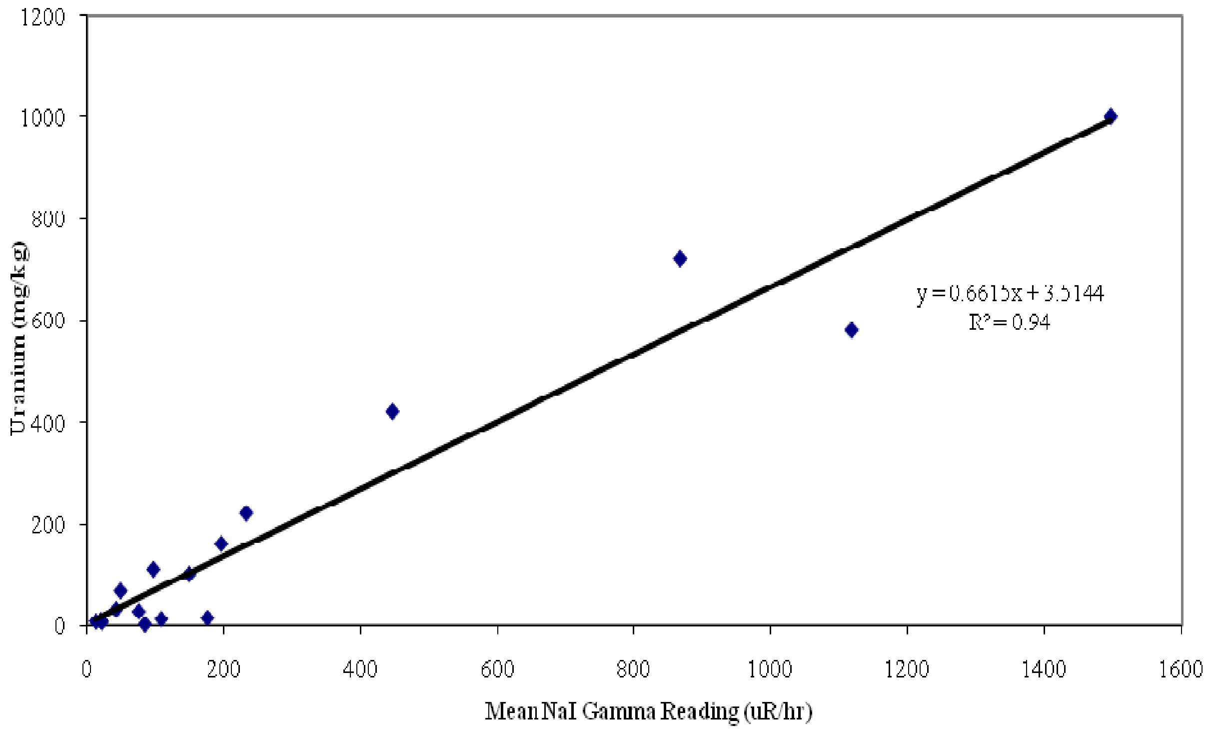


Figure 6-14. Uranium vs. Gamma Reading Soil Correlation Plot - Linear Regression Model

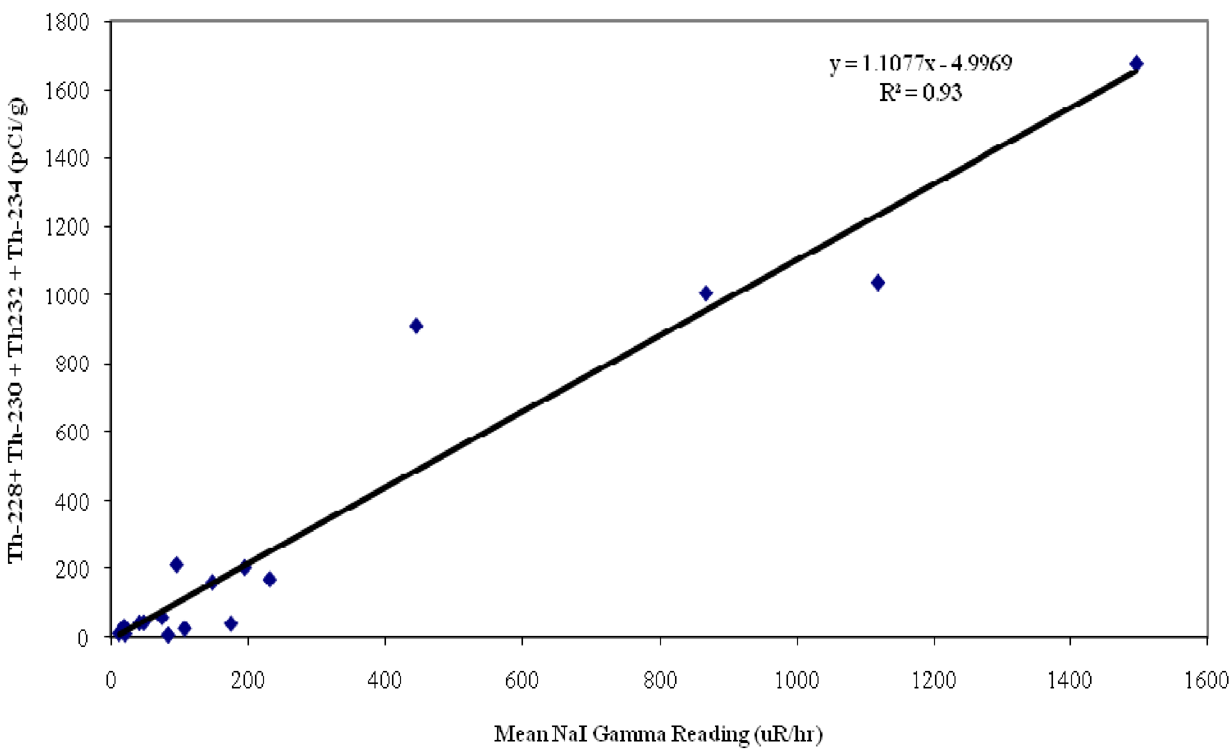


Figure 6-15. Total Thorium vs. Gamma Reading Soil Correlation Plot – Linear Regression Model

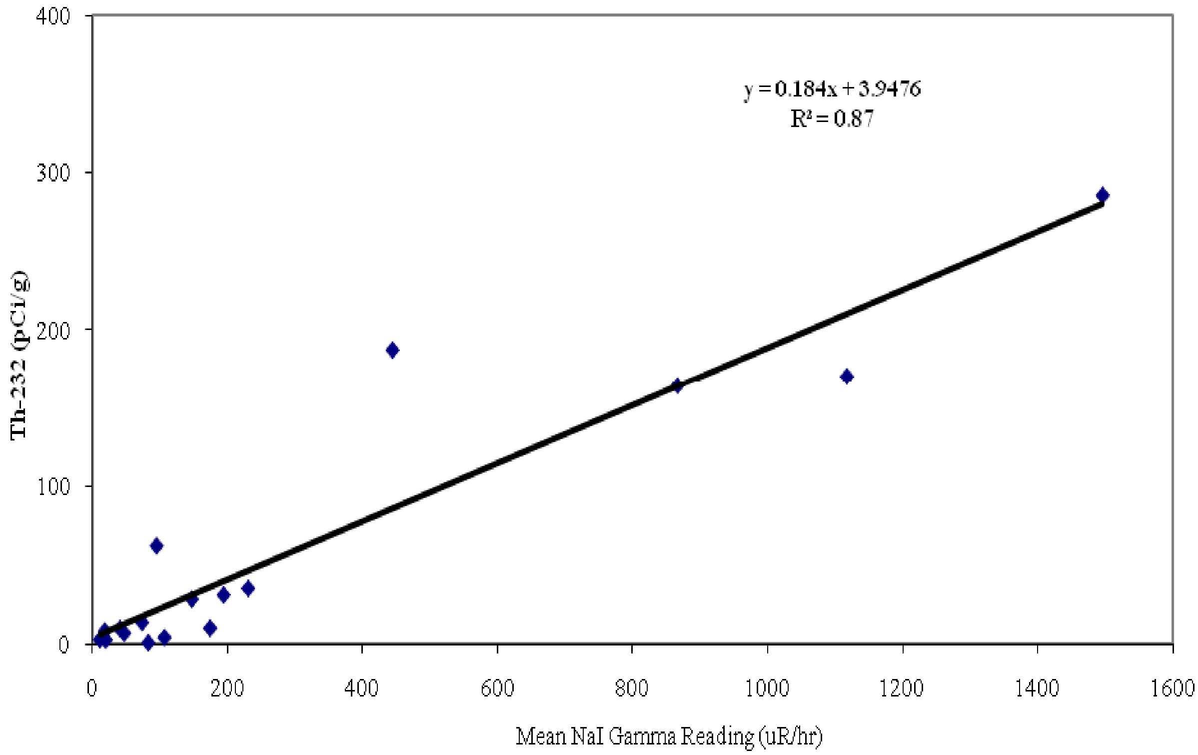


Figure 6-16. Th-232 vs. Gamma Reading Soil Correlation Plot – Linear Regression Model

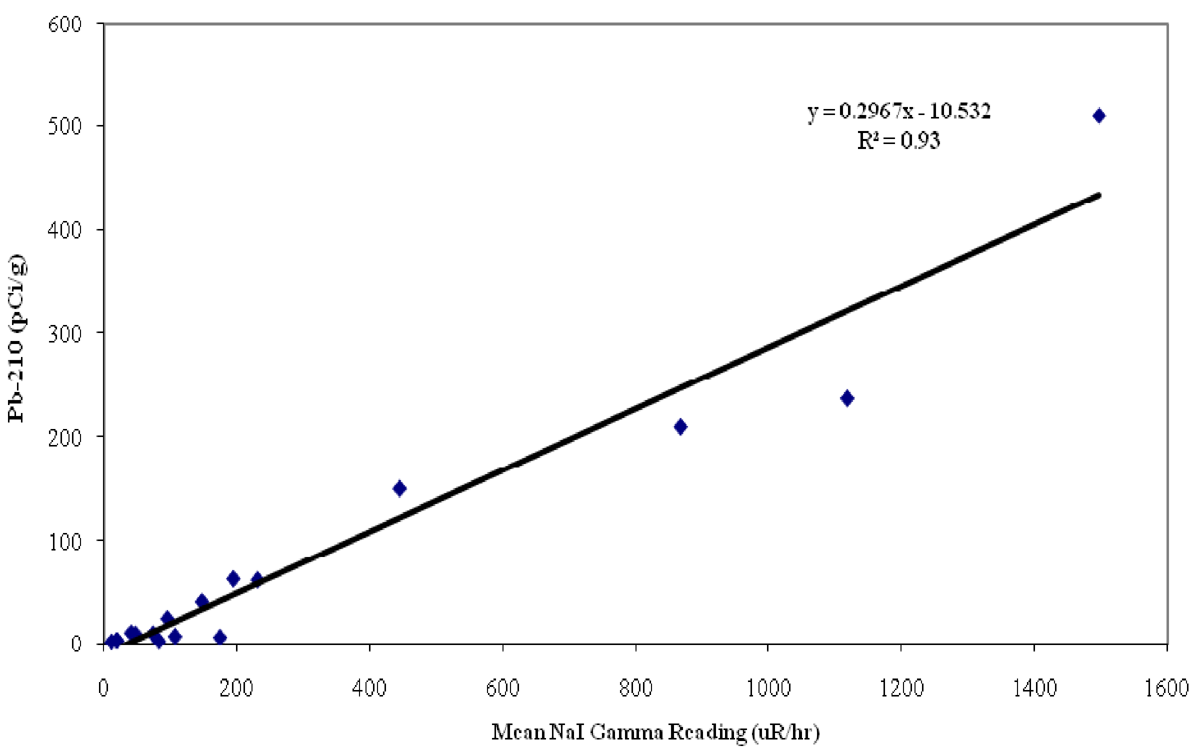


Figure 6-17. Pb-210 vs. Gamma Reading Soil Correlation Plot – Linear Regression Model

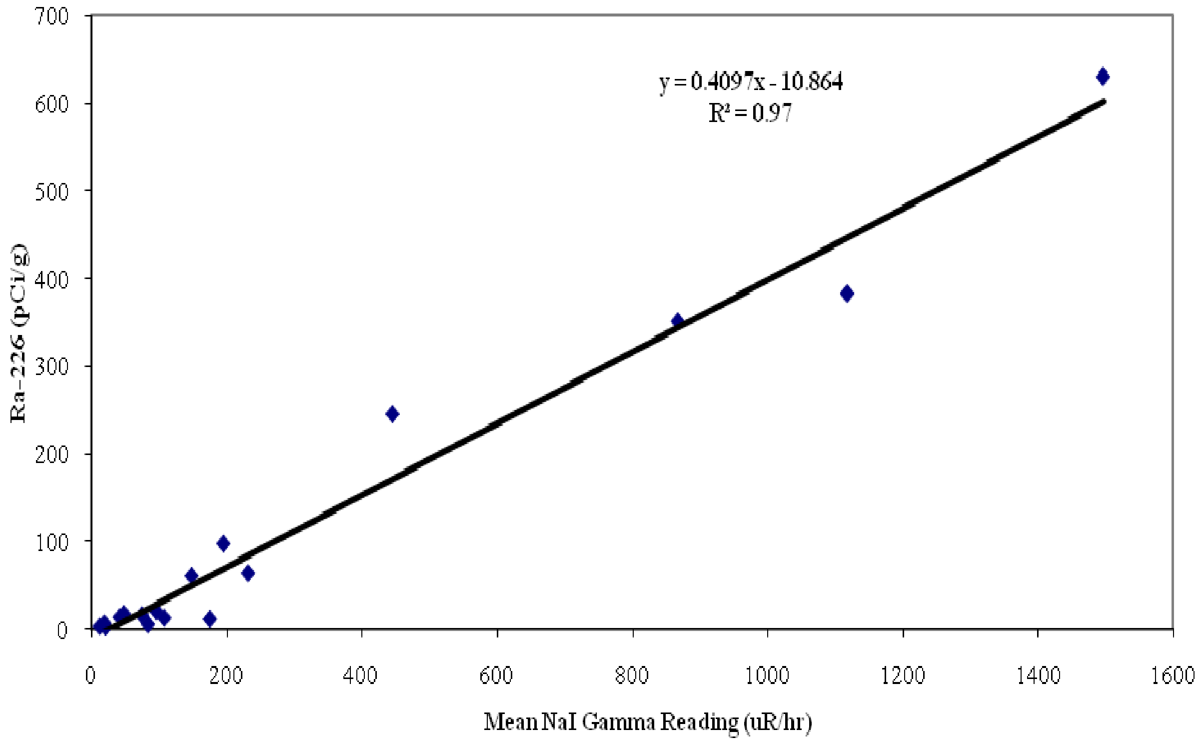


Figure 6-18. Ra-226 vs. Gamma Reading Soil Correlation Plot – Linear Regression Model

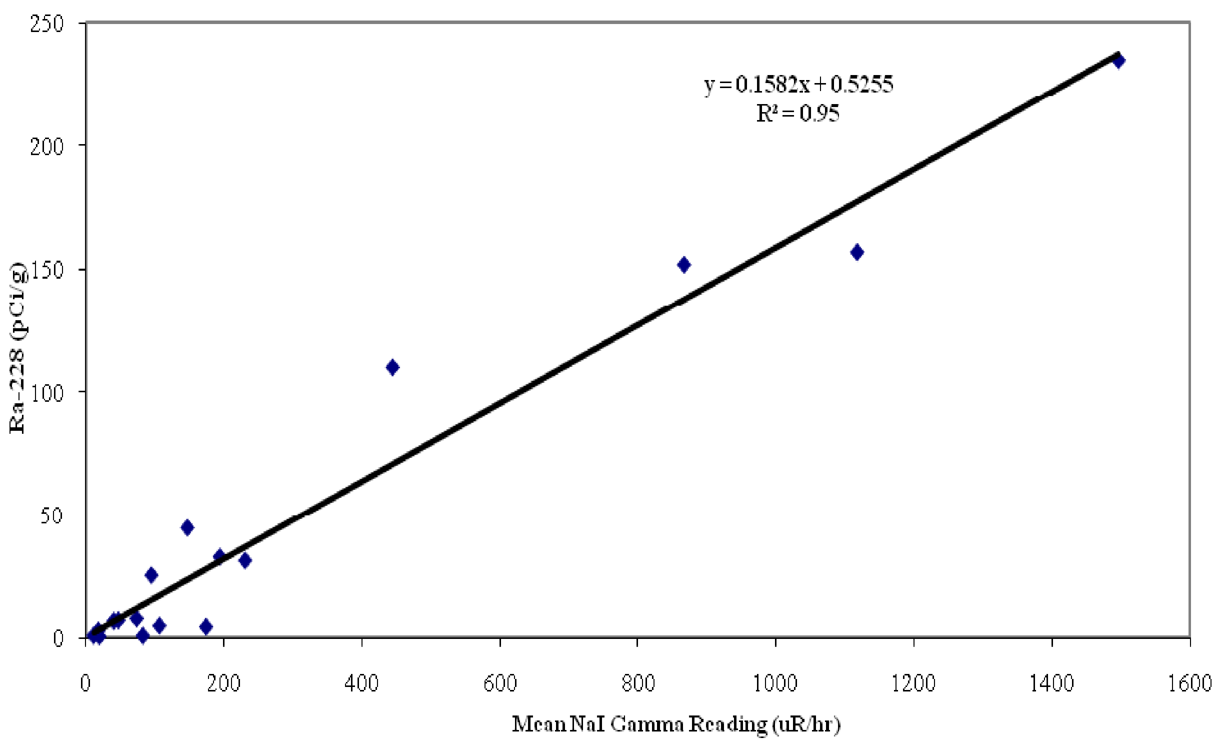


Figure 6-19. Ra-228 vs. Gamma Reading Soil Correlation Plot – Linear Regression Model

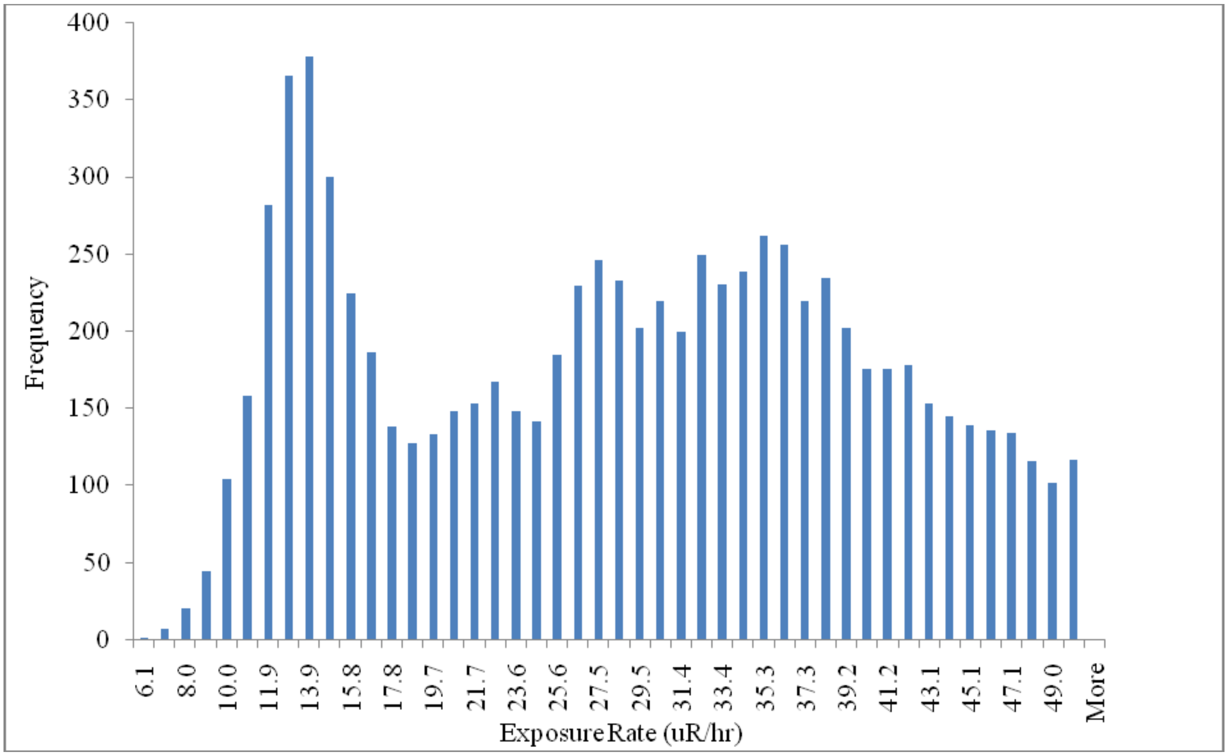


Figure 6-20. Relative Frequency Histogram of OSA Gamma Data (<50 μR/hr)

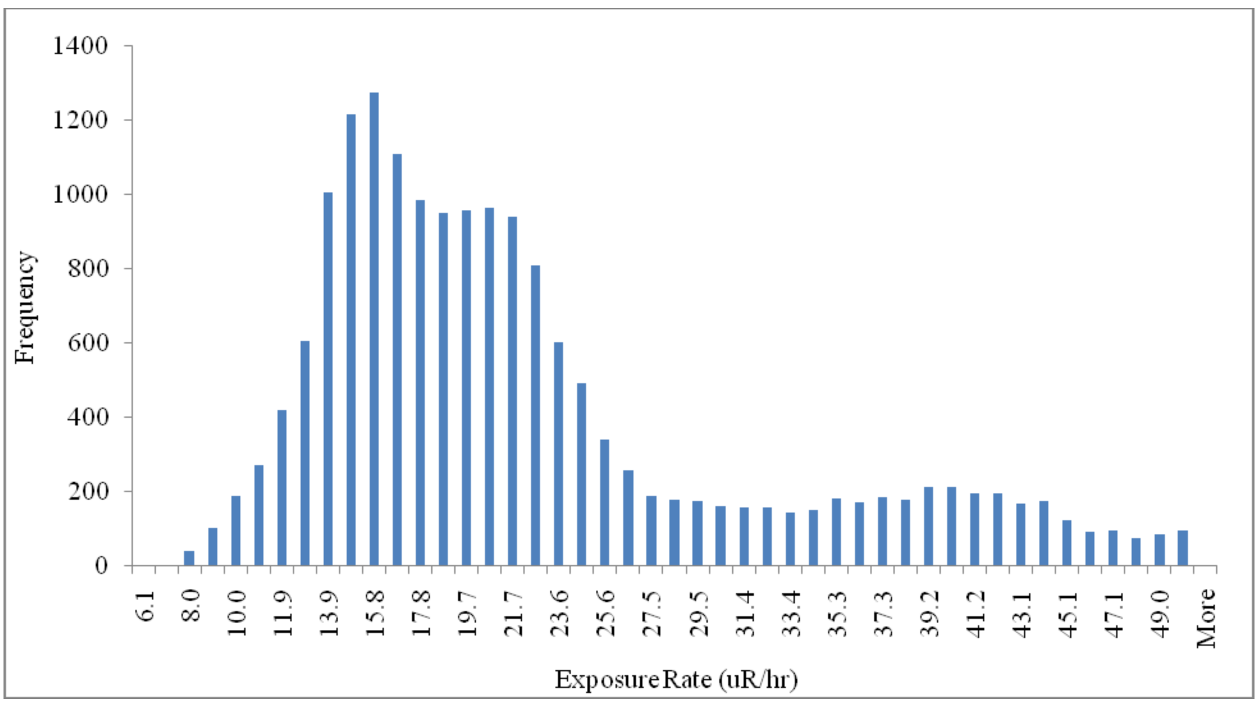


Figure 6-21. Relative Frequency Histogram of Kendrick Creek Floodplain Gamma Data (<50 μR/hr)

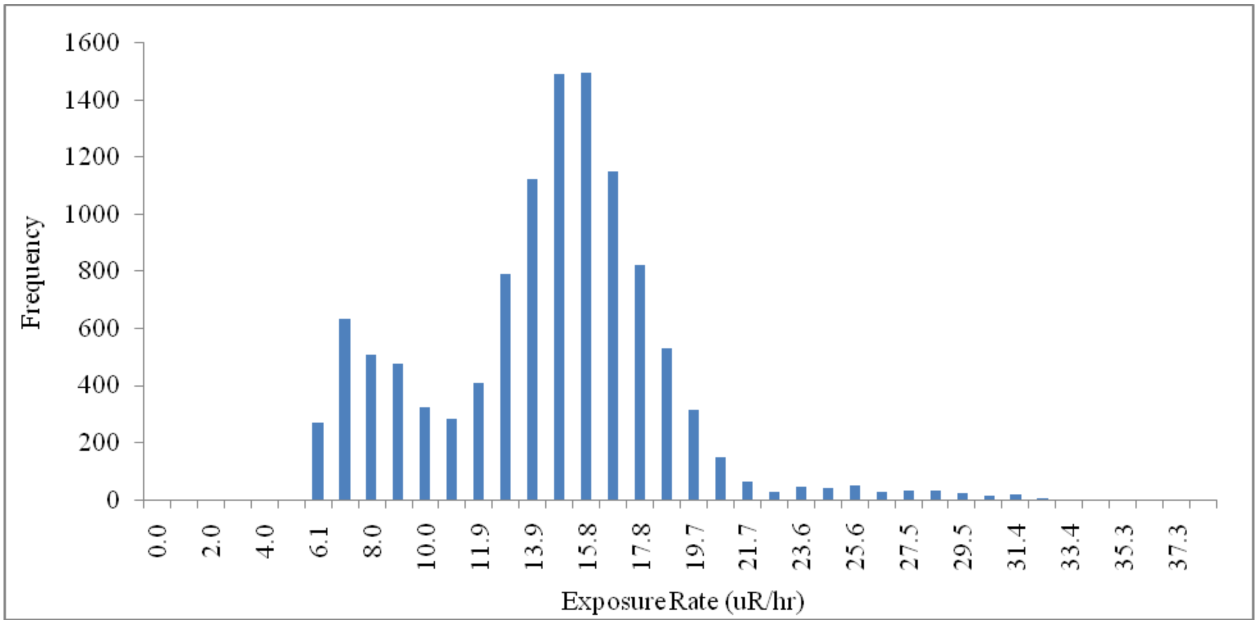


Figure 6-22. Relative Frequency Histogram of Kendrick Bay Intertidal Zone Gamma Data

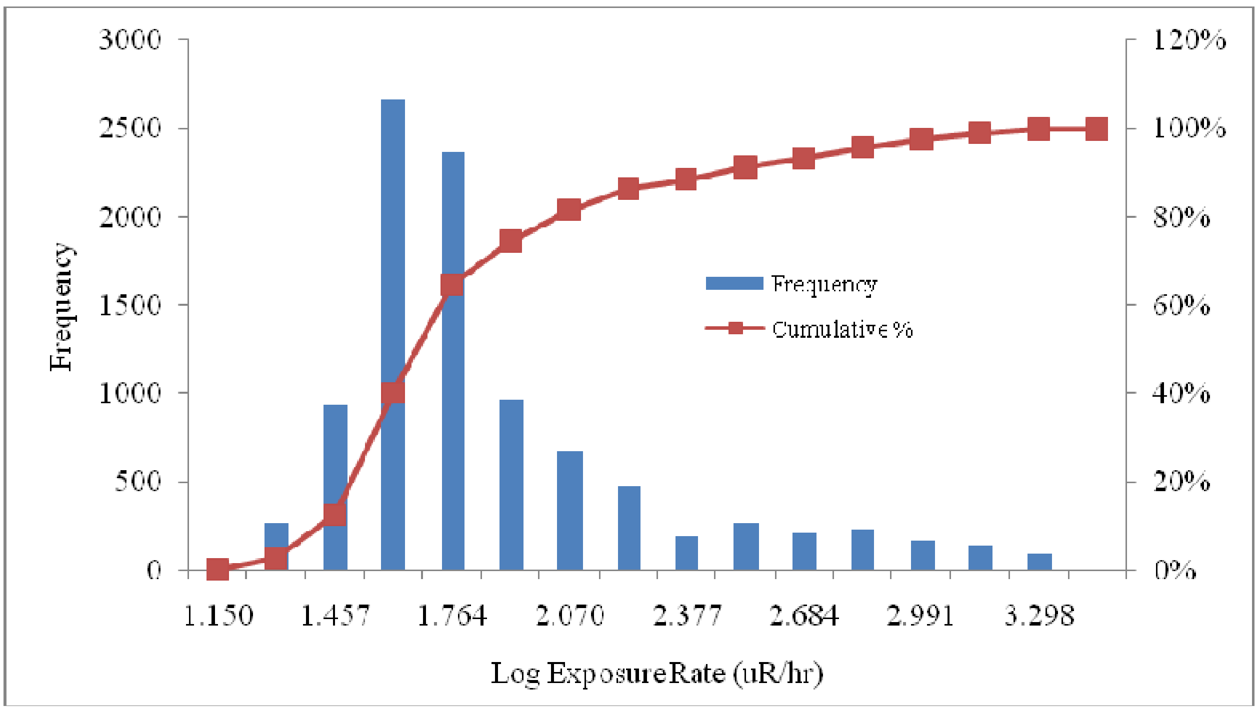


Figure 6-23. Cumulative Frequency Distribution and Histogram of I&L Log Exposure Rate (μR/hr) Data

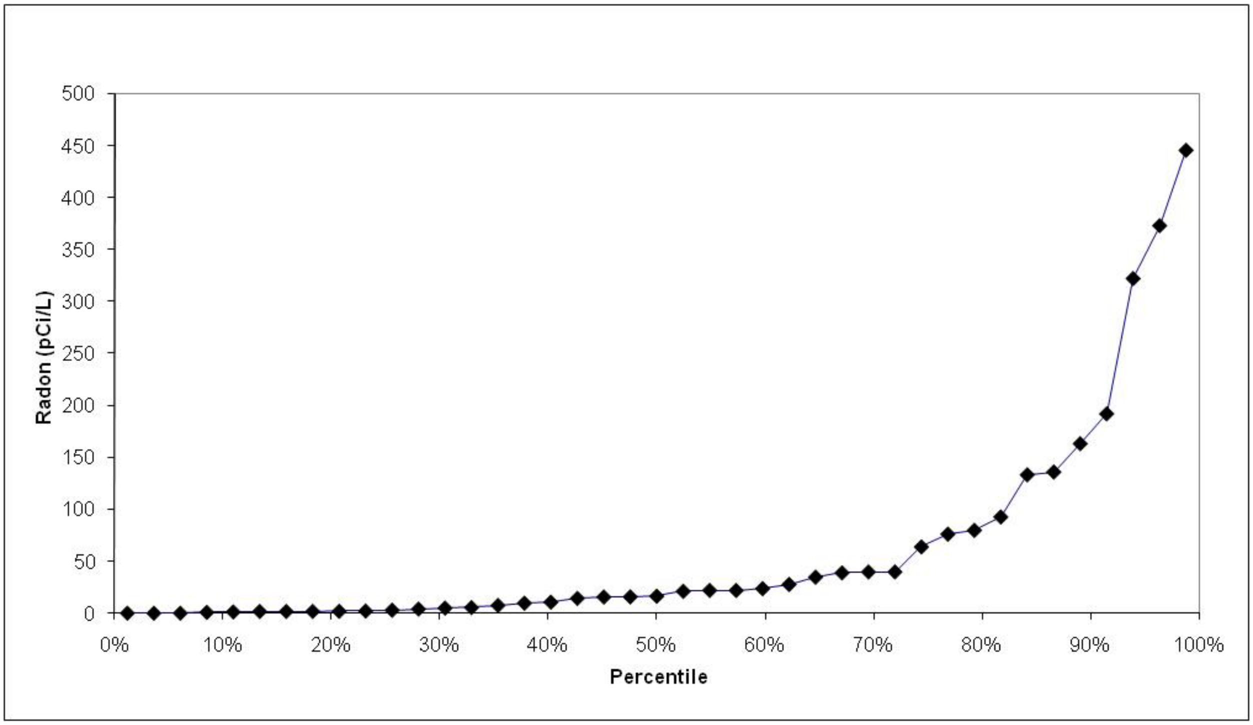
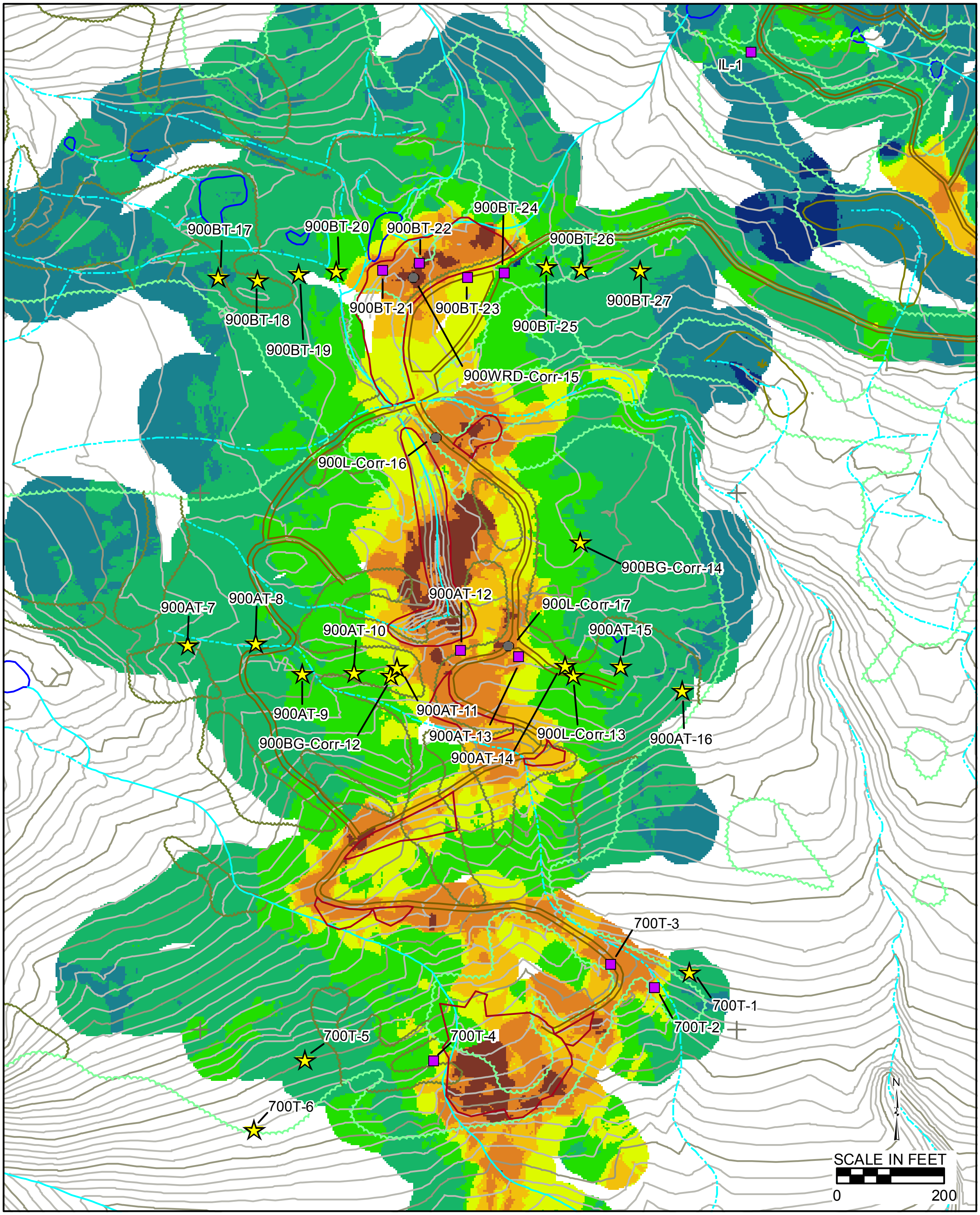


Figure 6-24. Cumulative Frequency Plot of Ross-Adams Radon Concentrations



MAR 04, 2010 N:\arcprj2\Gamma\181862\mxd\6-25.mxd BY:jesse.carver

Gamma Exposure Rate (uR/hr)

<20	80-160	631-1250
20-40	160-316	>1250
40-80	316-631	

Outside of Limits of Gamma Survey

Background Soil Sample

Gamma/Soil Correlation Plot Sample

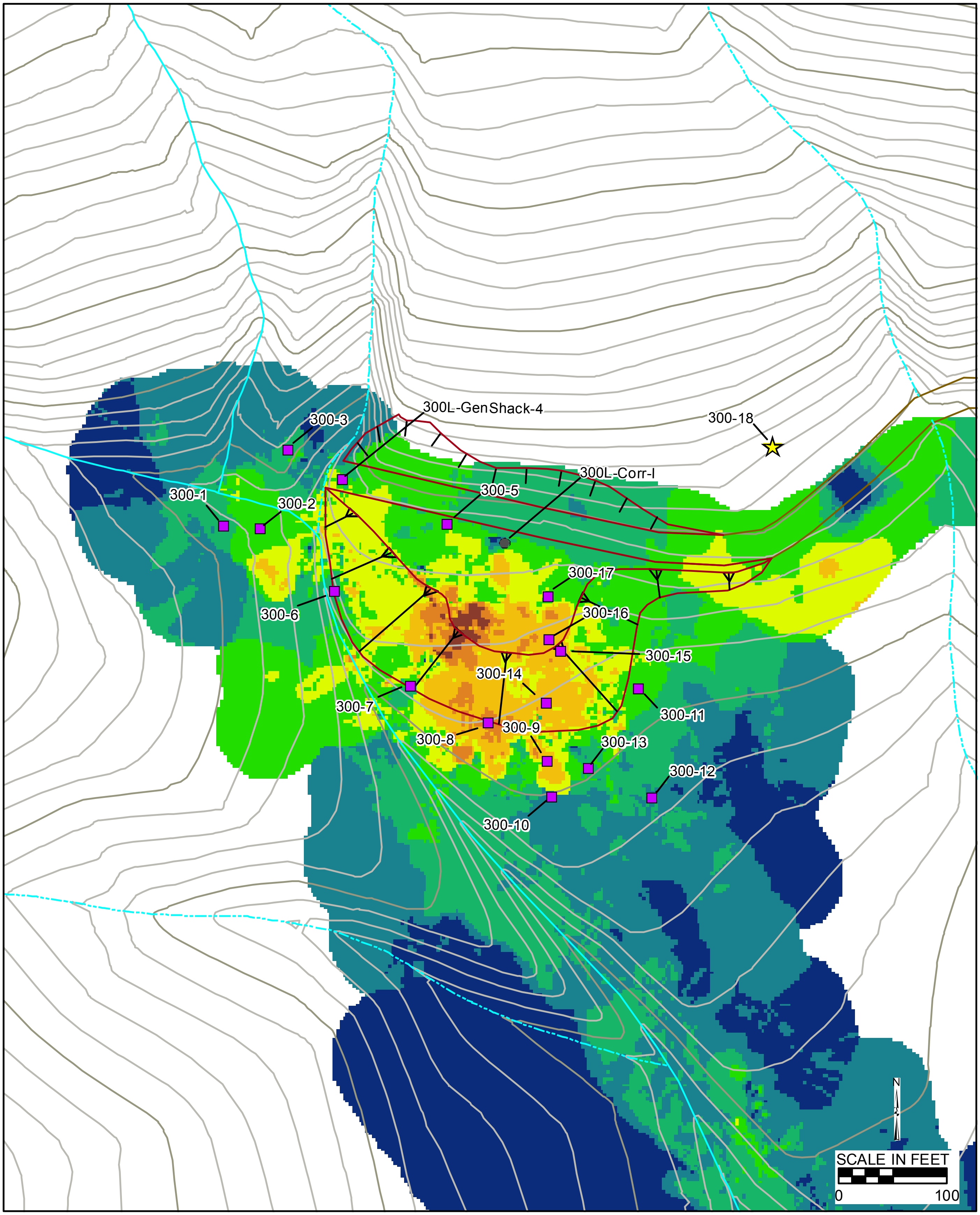
Discrete Soil Sample

November 2010

Figure 6-25

Ross-Adams Site

Background Soil Sample Locations and Gamma Survey Results, 700- and 900-Foot Levels



MAR 04, 2010 N:\arcprj2\Gamma\181862\mxd\6-26.mxd BY:jesse.carver

Gamma Exposure Rate (uR/hr)

<20
20-40
40-80
80-160
160-316
316-631
631-1250
>1250

Outside of Limits of Gamma Survey

Background Soil Sample

Gamma/Soil Correlation Plot Sample

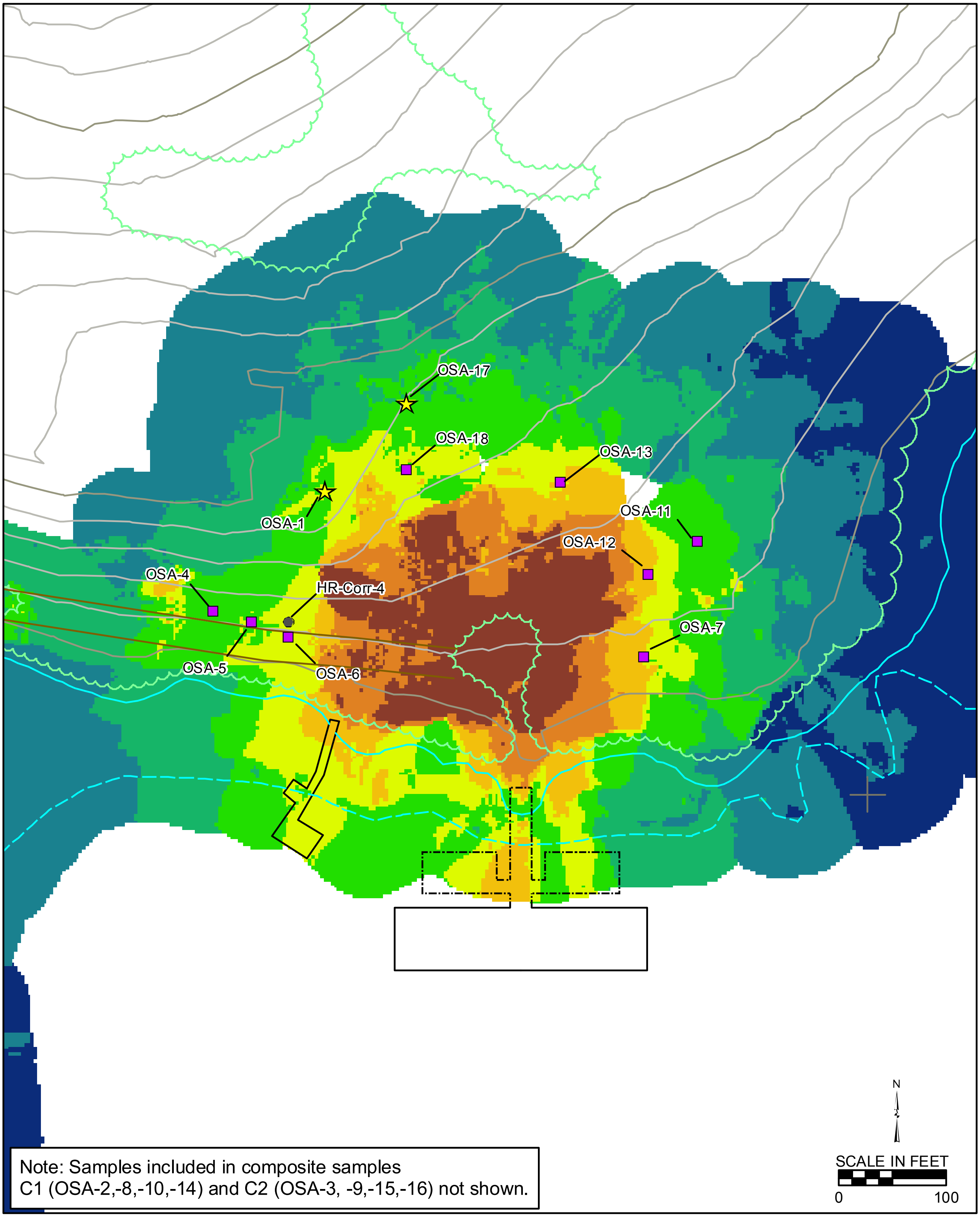
Discrete Soil Sample

November 2010

Figure 6-26

Ross-Adams Site

Background Soil Sample Locations and Gamma Survey Results, 300-Foot Level



Note: Samples included in composite samples C1 (OSA-2,-8,-10,-14) and C2 (OSA-3, -9,-15,-16) not shown.

MAR 04, 2010 N:\arcprj2\Gamma\181862\mxd\6-27.mxd BY:jesse.carver

Gamma Exposure Rate (uR/hr)

- <20
- 20-40
- 40-80
- 80-160
- 160-316
- 316-631
- 631-1250
- >1250

- Outside of Limits of Gamma Survey
- Gamma/Soil Correlation Plot Sample
- Discrete Soil Sample
- Background Soil Sample

November 2010

Figure 6-27
Ross-Adams Site
Background Soil Sample Locations and Gamma Survey Results, OSA

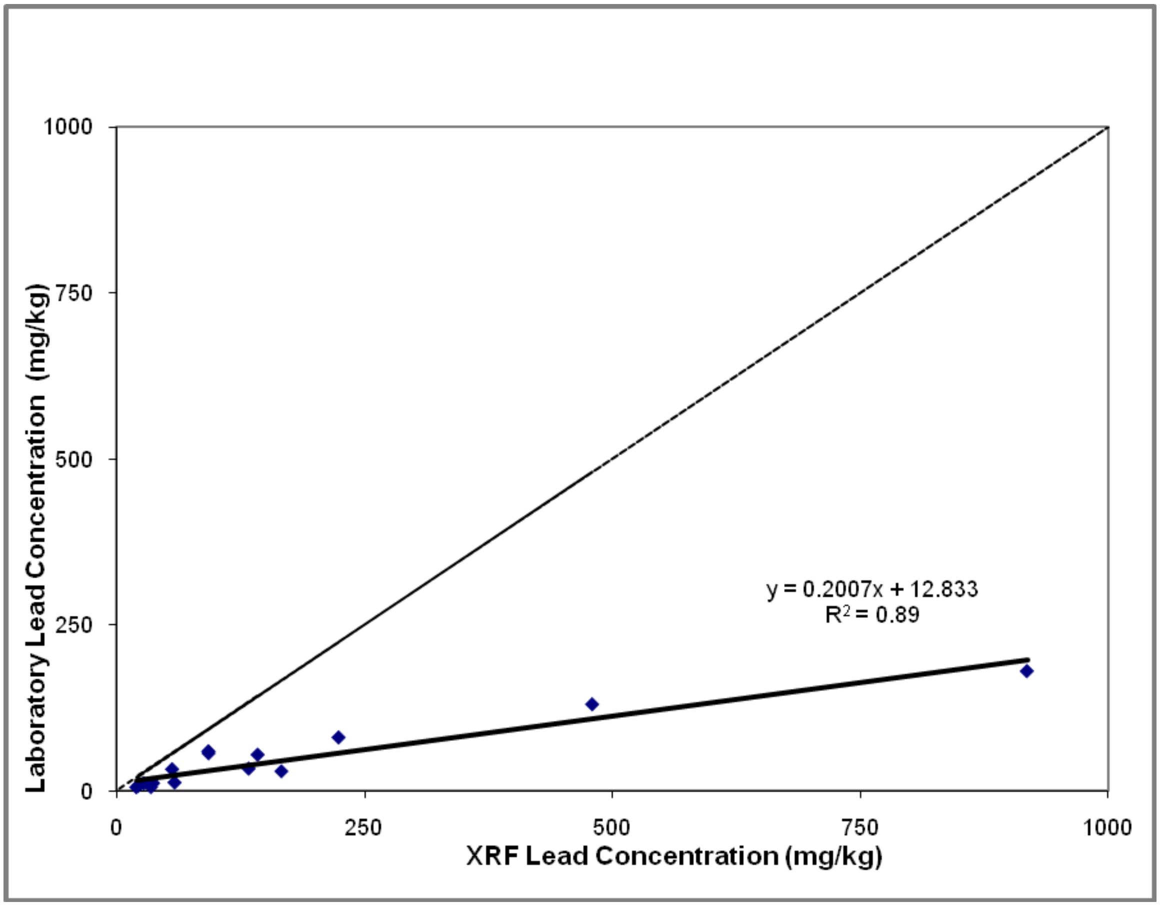


Figure 6-28. Laboratory Lead Concentrations vs. Field XRF Lead Concentrations

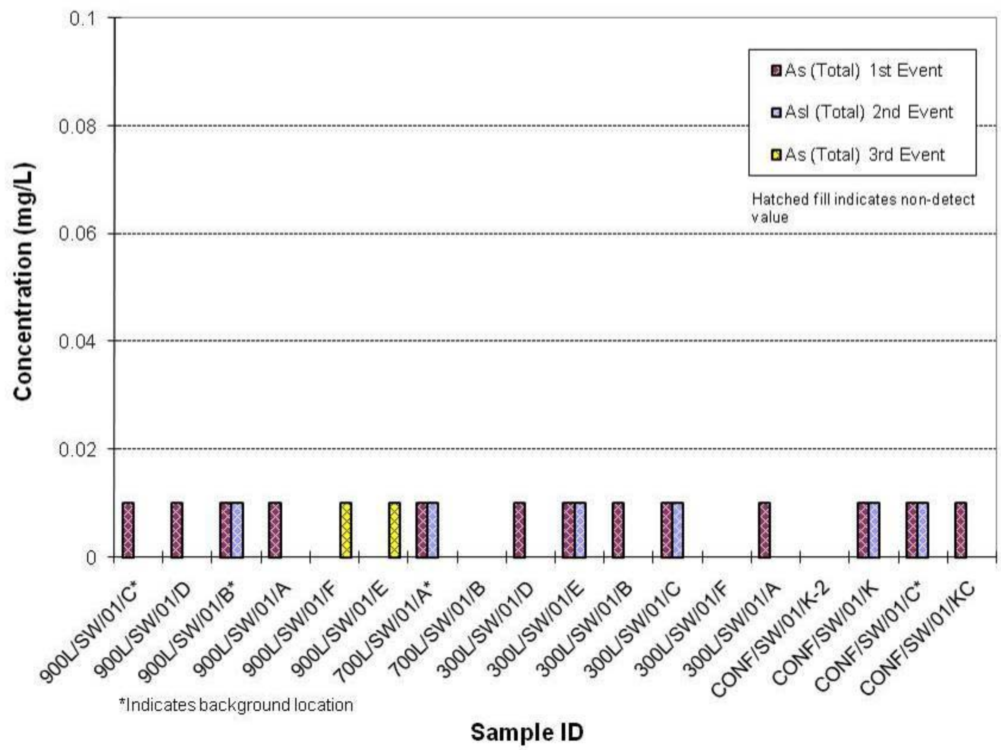


Figure 6-29. Arsenic in Surface Water

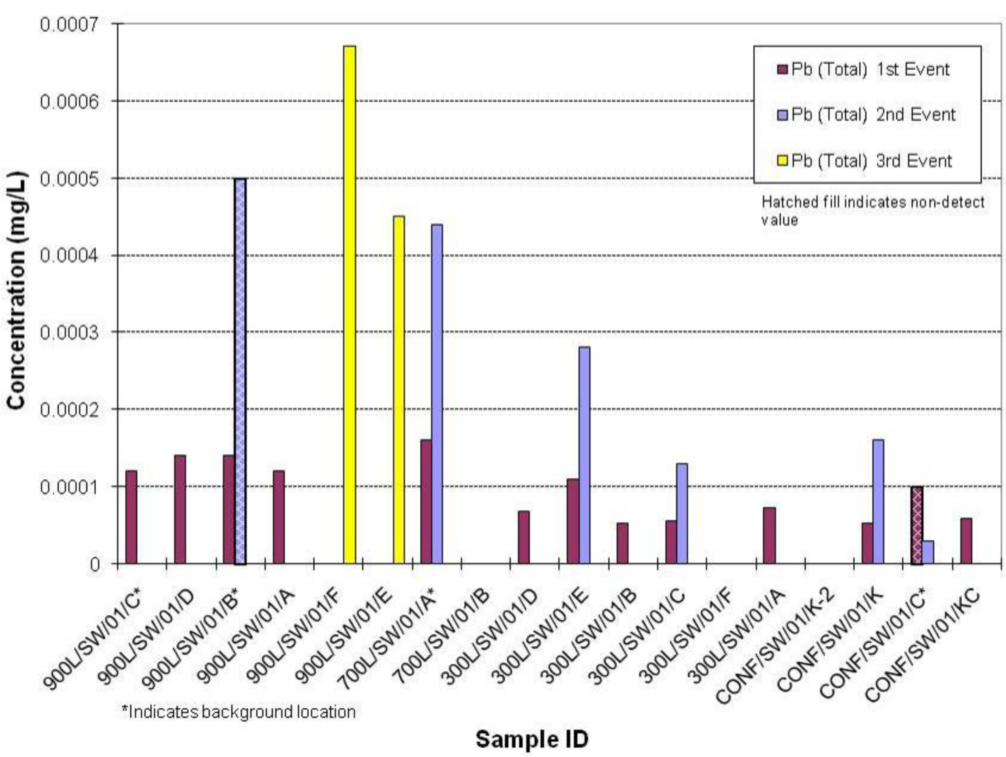


Figure 6-30. Lead in Surface Water

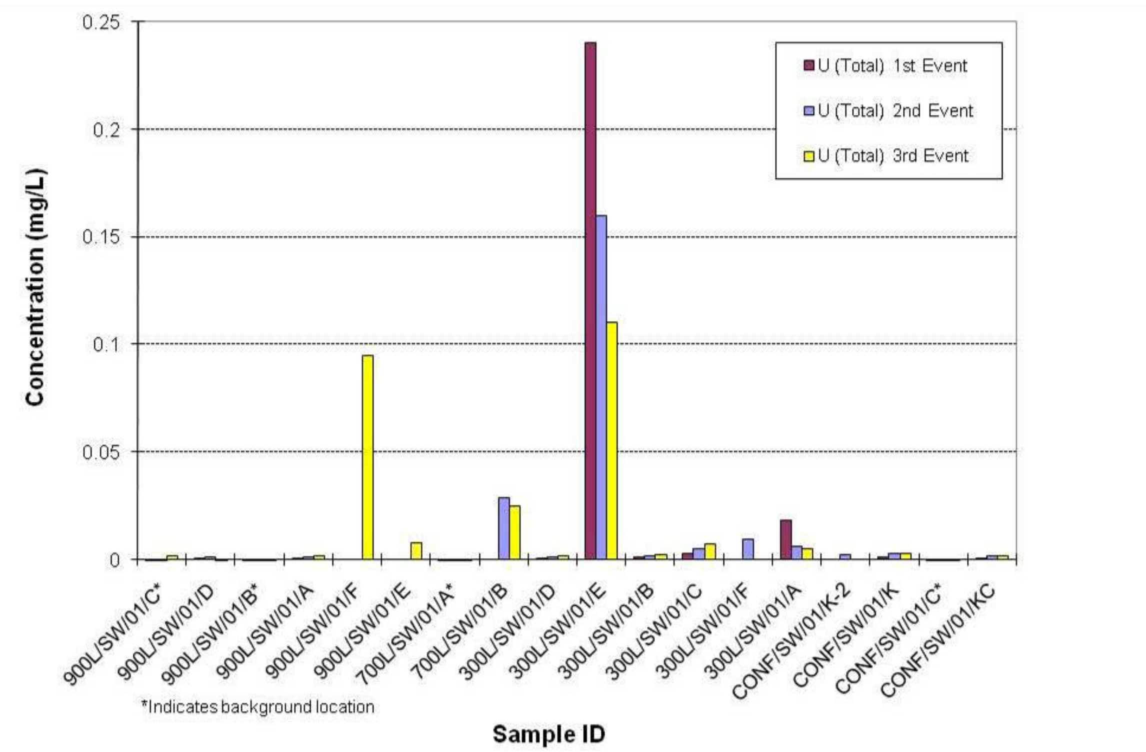


Figure 6-31. Uranium in Surface Water

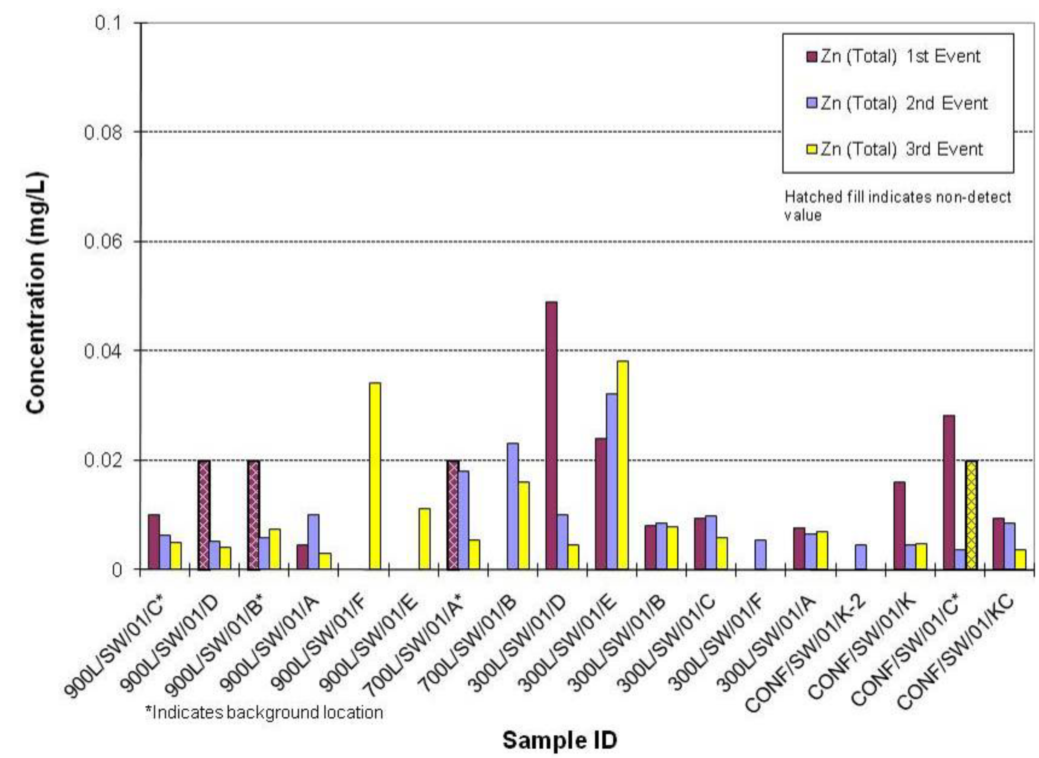


Figure 6-32. Zinc in Surface Water

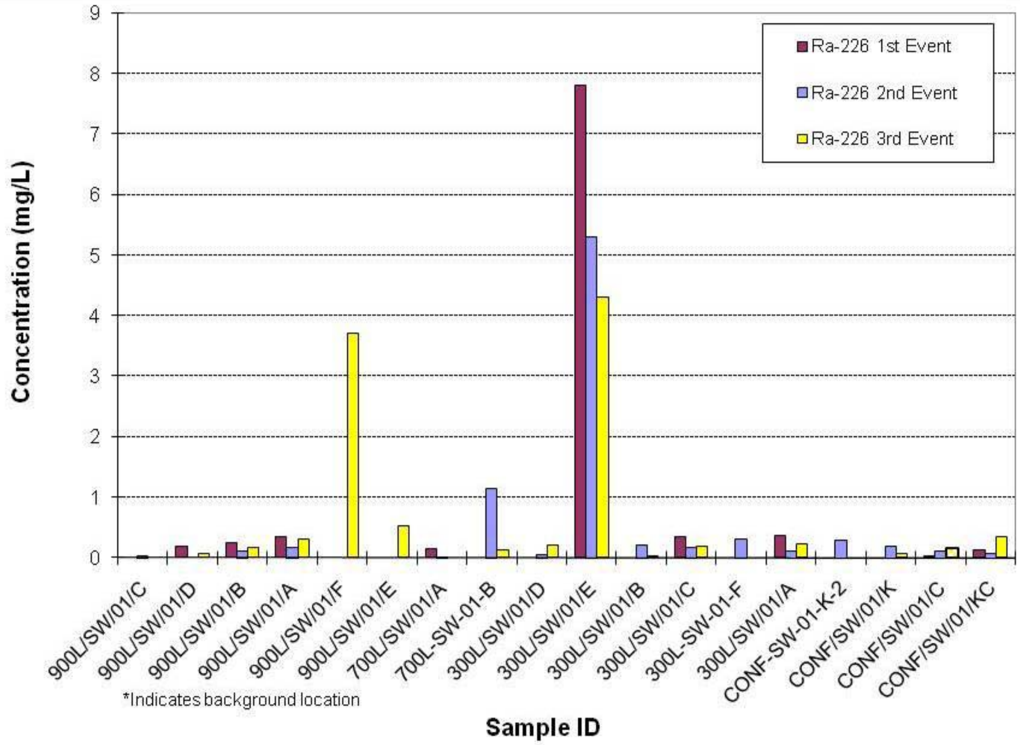
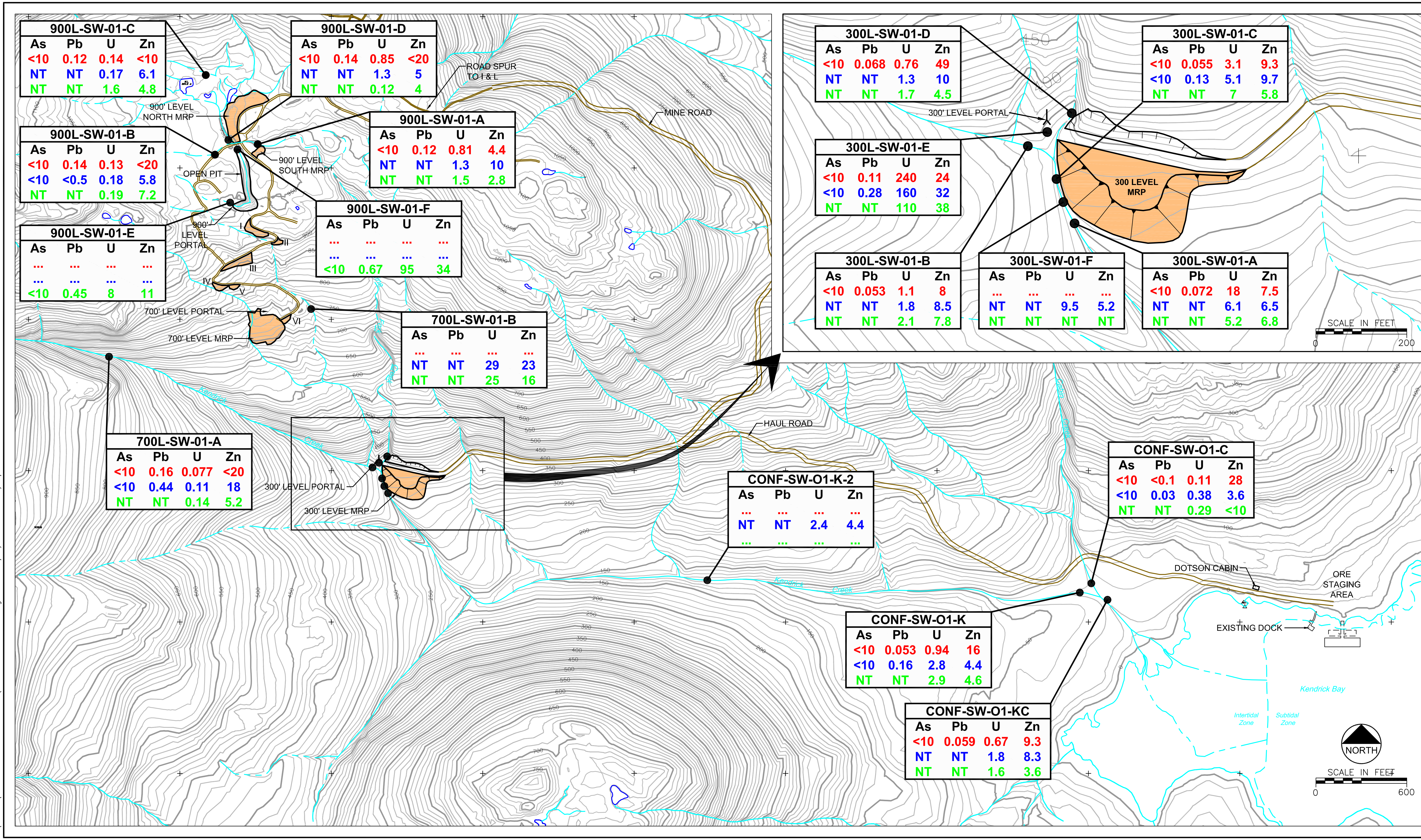


Figure 6-33. Ra-226 in Surface Water

E:\181862\Final SCR – November 2010\FIG-6-34 SW-Metals.dwg SAVED:11/18/10 PRINTED:11/18/10 BY: THOMAS.BOEHLER

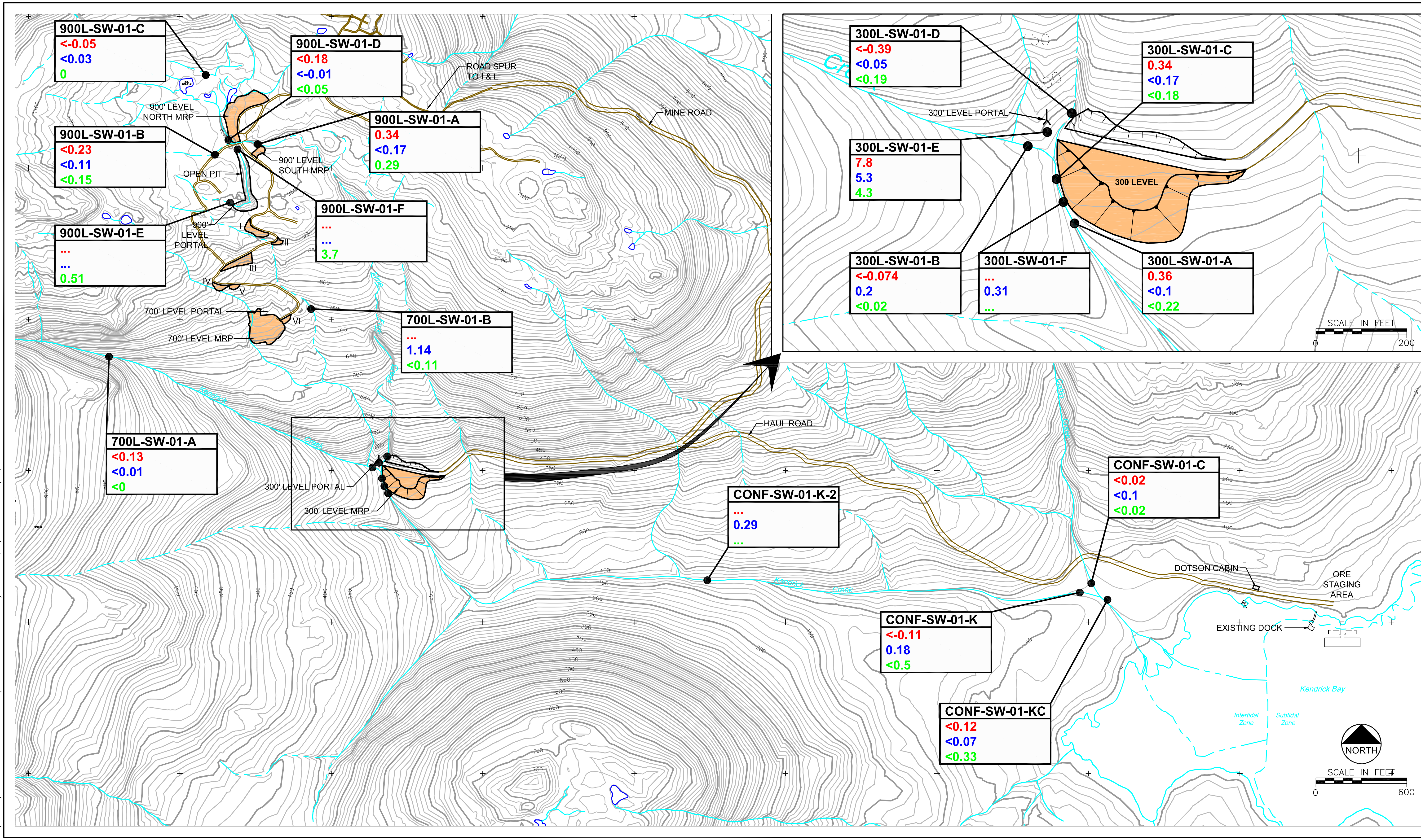


Project No. 181862

November 2010

LEGEND
- ● SURFACE WATER SAMPLING LOCATION
- X TOTAL METALS CONCENTRATION ug/L) IN JUNE 2009 SAMPLING EVENT
- X TOTAL METALS CONCENTRATION (ug/L) JULY SAMPLING EVENT
- X TOTAL METALS CONCENTRATION (ug/L) SEPTEMBER SAMPLING EVENT
- ... NOT SAMPLED DURING EVENT
- NT SAMPLED BUT NOT TESTED

Figure 6-34
Ross-Adams Site
Metals Concentrations in Surface Water Samples



E:\181862\Final SCR – November 2010\FIG-6-35 SW-Ra-226.dwg SAVED: 11/18/10 PRINTED: 11/18/10 BY: THOMAS.BOEHLER

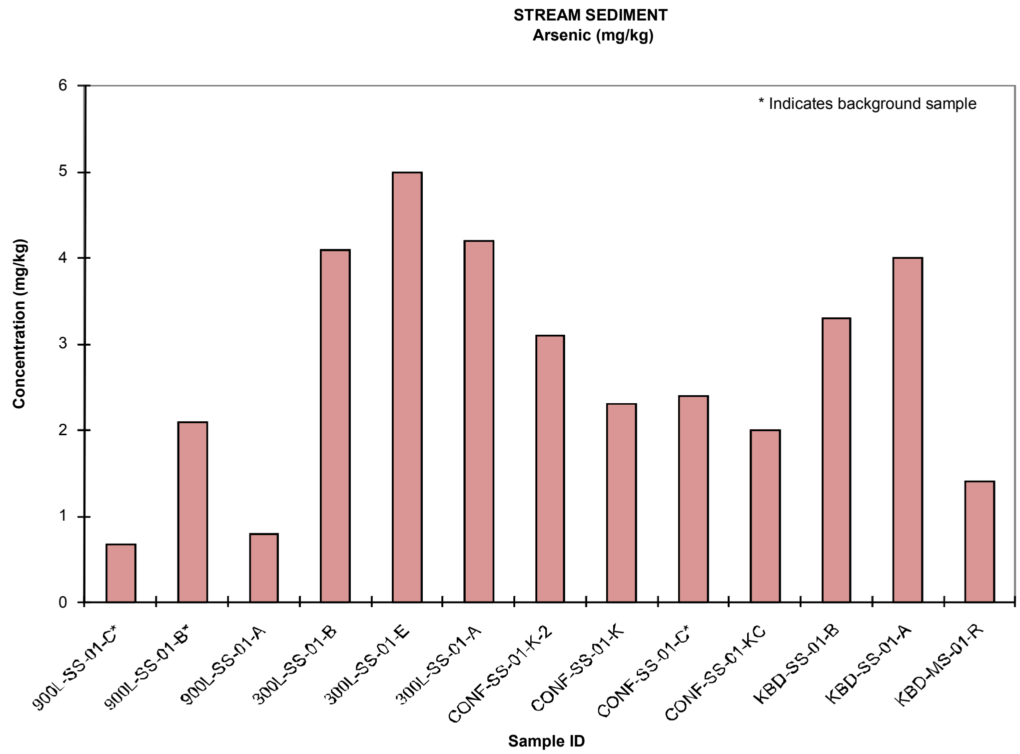
Project No. 181862

November 2010

LEGEND

- ● SURFACE WATER SAMPLING LOCATION
- X Ra-226 CONCENTRATION (pCi/L) IN JUNE 2009 SAMPLING EVENT
- X Ra-226 CONCENTRATION (pCi/L) JULY SAMPLING EVENT
- X Ra-226 CONCENTRATION (pCi/L) SEPTEMBER SAMPLING EVENT
- ... NOT SAMPLED DURING EVENT

Figure 6-35
Ross-Adams Site
Concentration of Ra-226 in Surface Water Samples



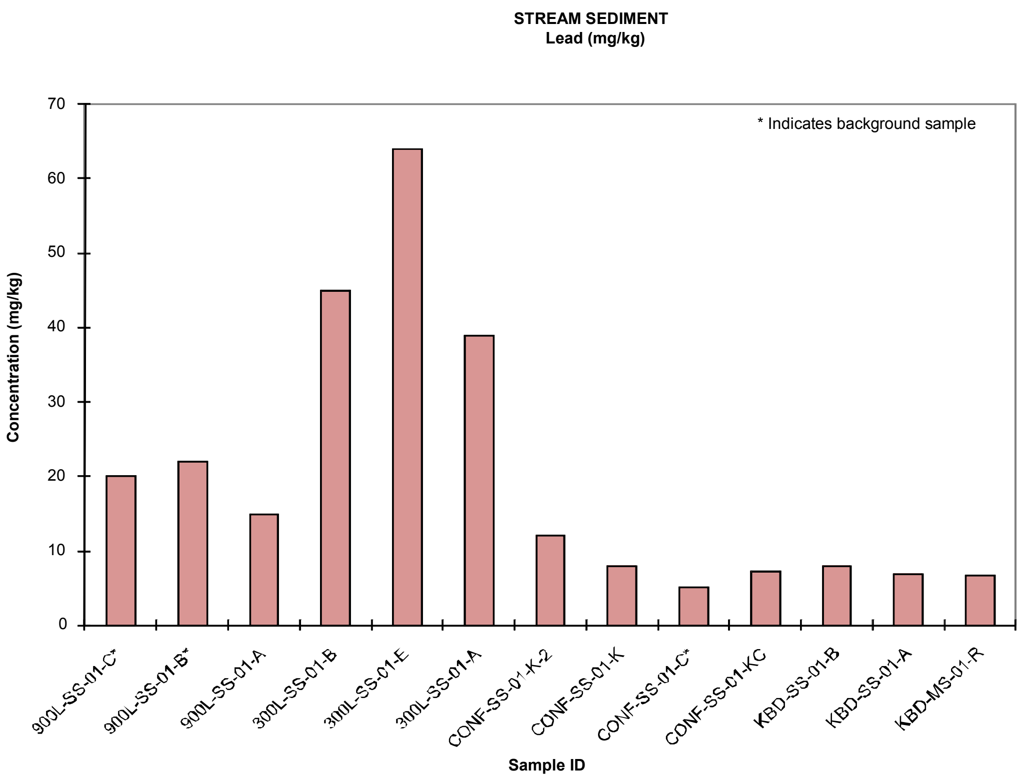


Figure 6-36. Arsenic and Lead in Stream Sediment

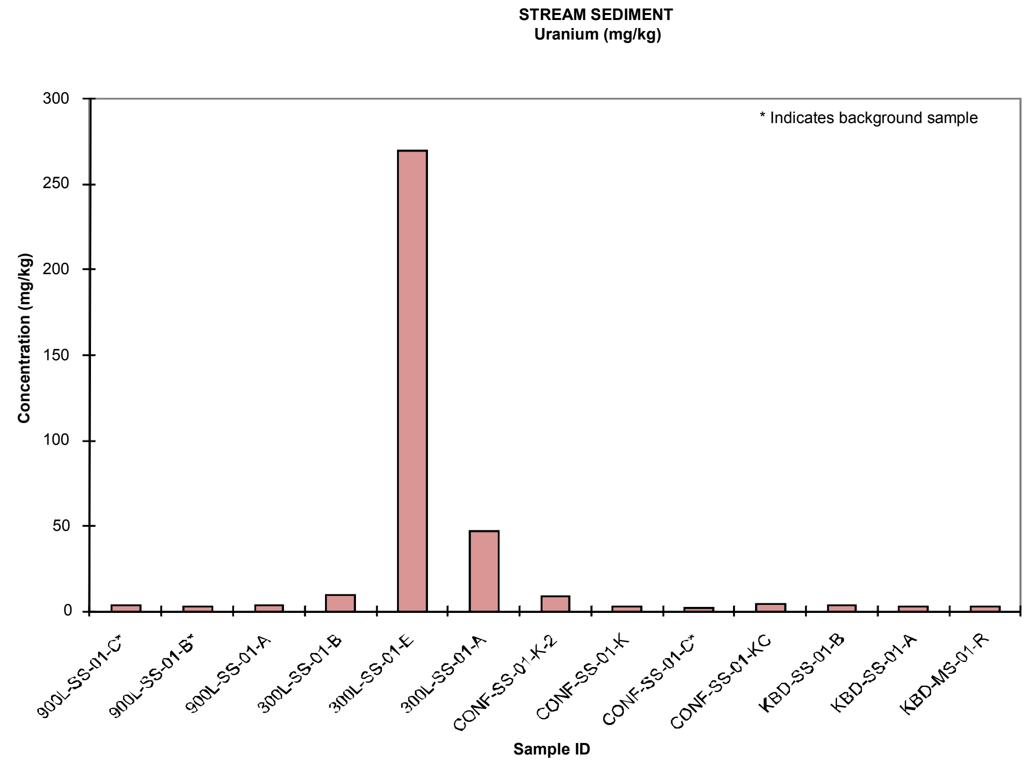


Figure 6-37. Uranium in Stream Sediment

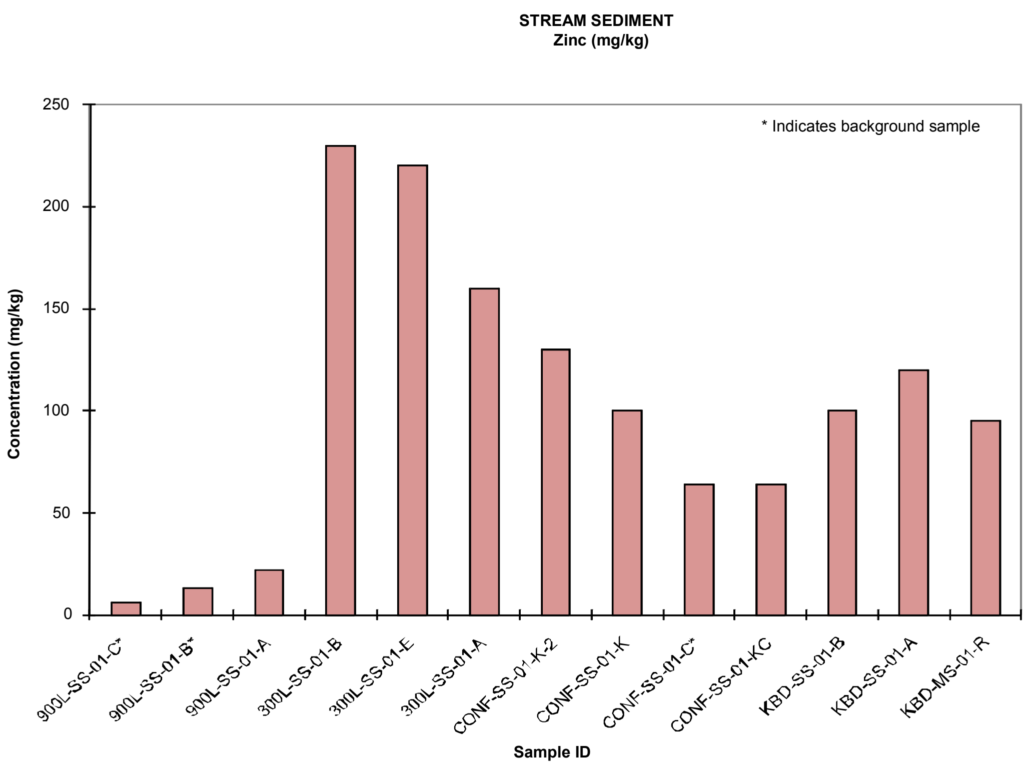


Figure 6-38. Zinc in Stream Sediment

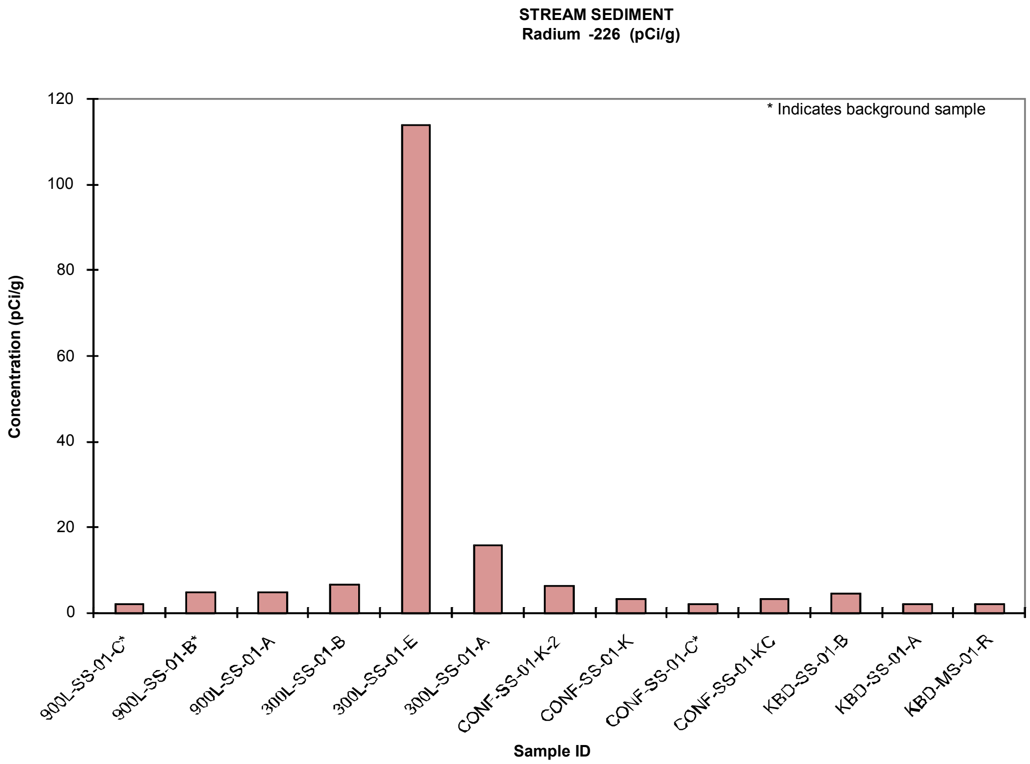
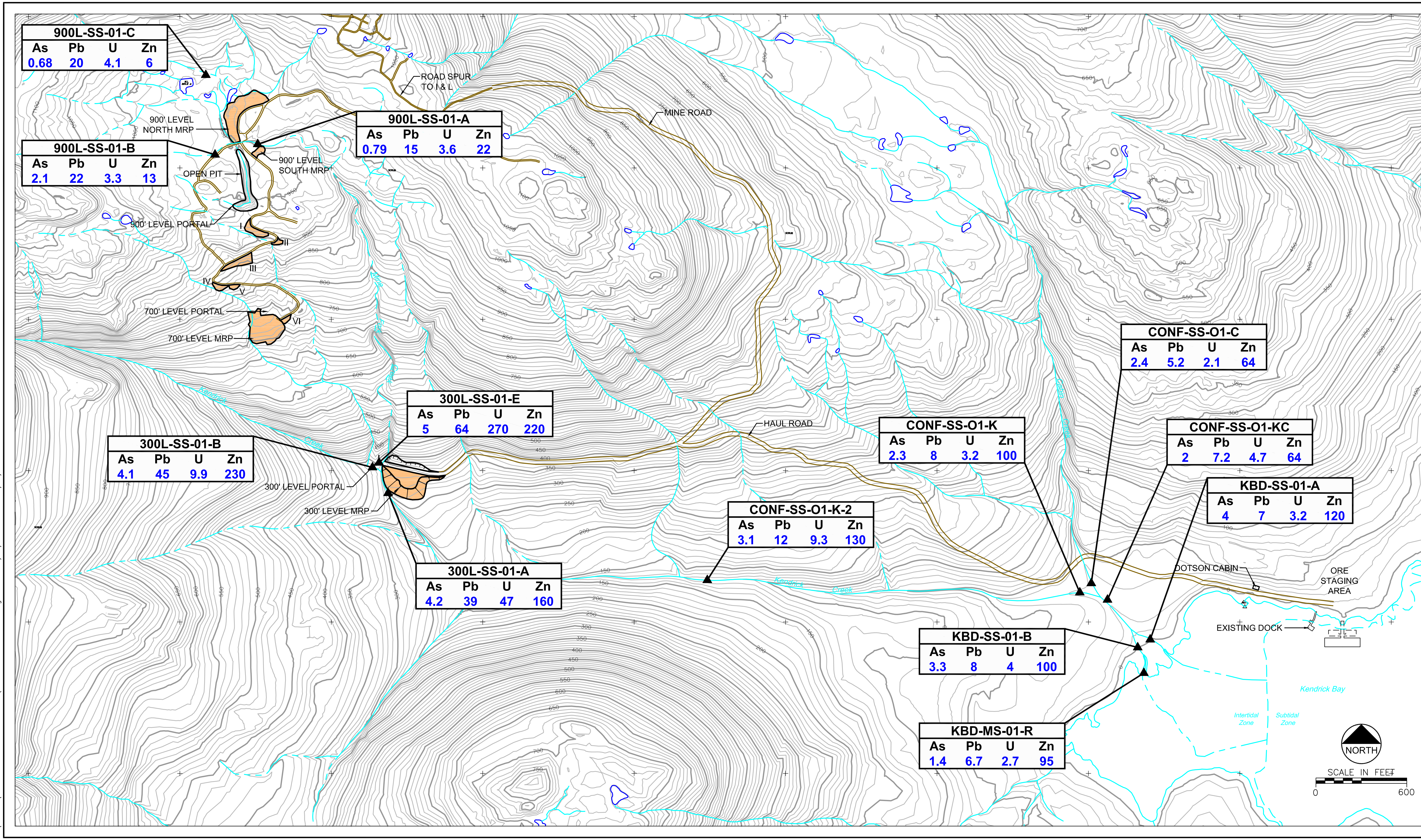


Figure 6-39. Radium-226 in Stream Sediment



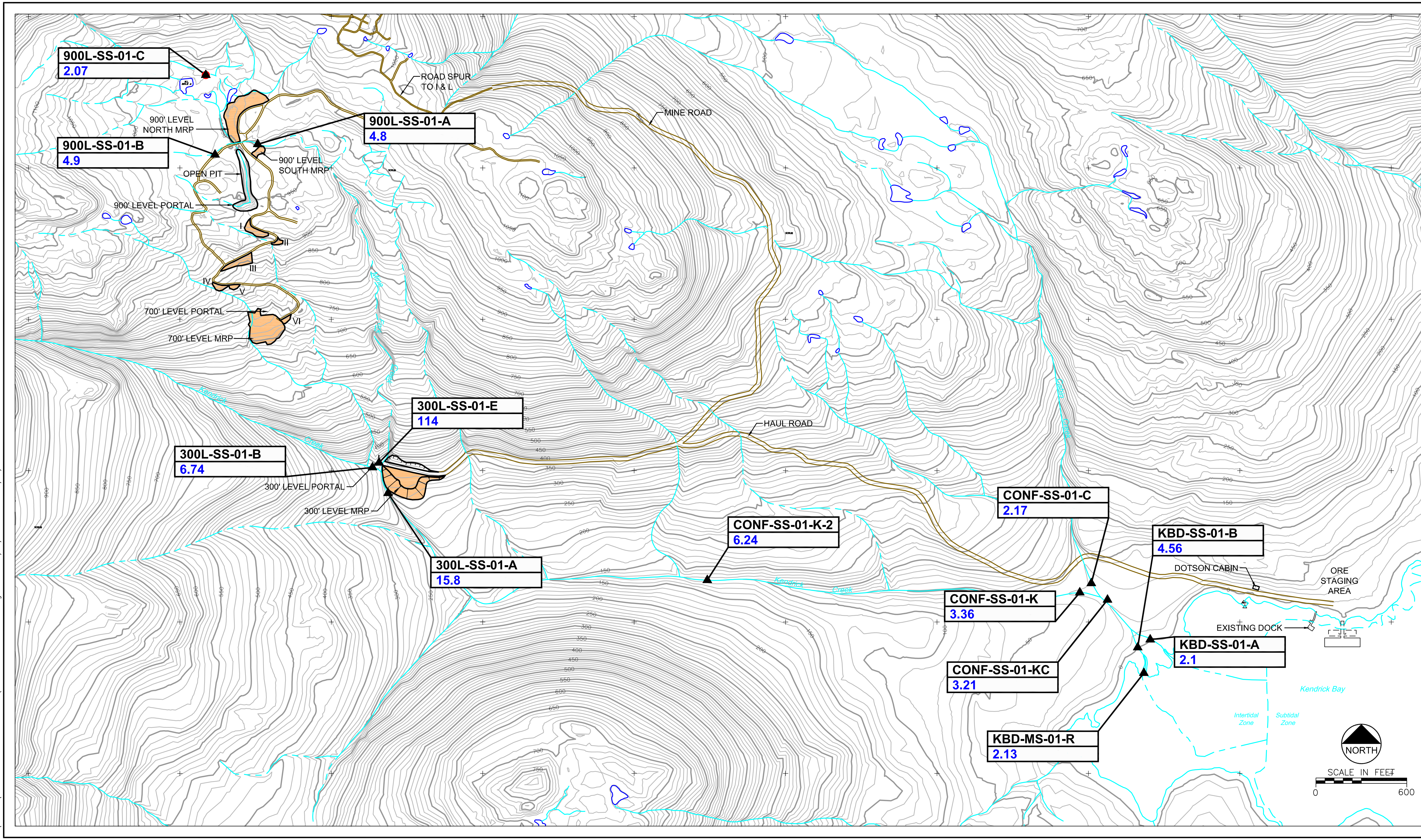
E:\181862\Final SCR – November 2010\FIG-6-40-SS-Metals.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER

Project No. 181862

November 2010

LEGEND
- ● STREAM SEDIMENT SAMPLING LOCATION
- X METALS CONCENTRATION (mg/Kg) JULY SAMPLING EVENT
- NT SAMPLED BUT NOT TESTED

Figure 6-40
Ross-Adams Site
Metals Concentrations in Stream Sediment Samples



E:\181862\Final SCR – November 2010\FIG-6-41-SS-Ra-226.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER

Project No. 181862

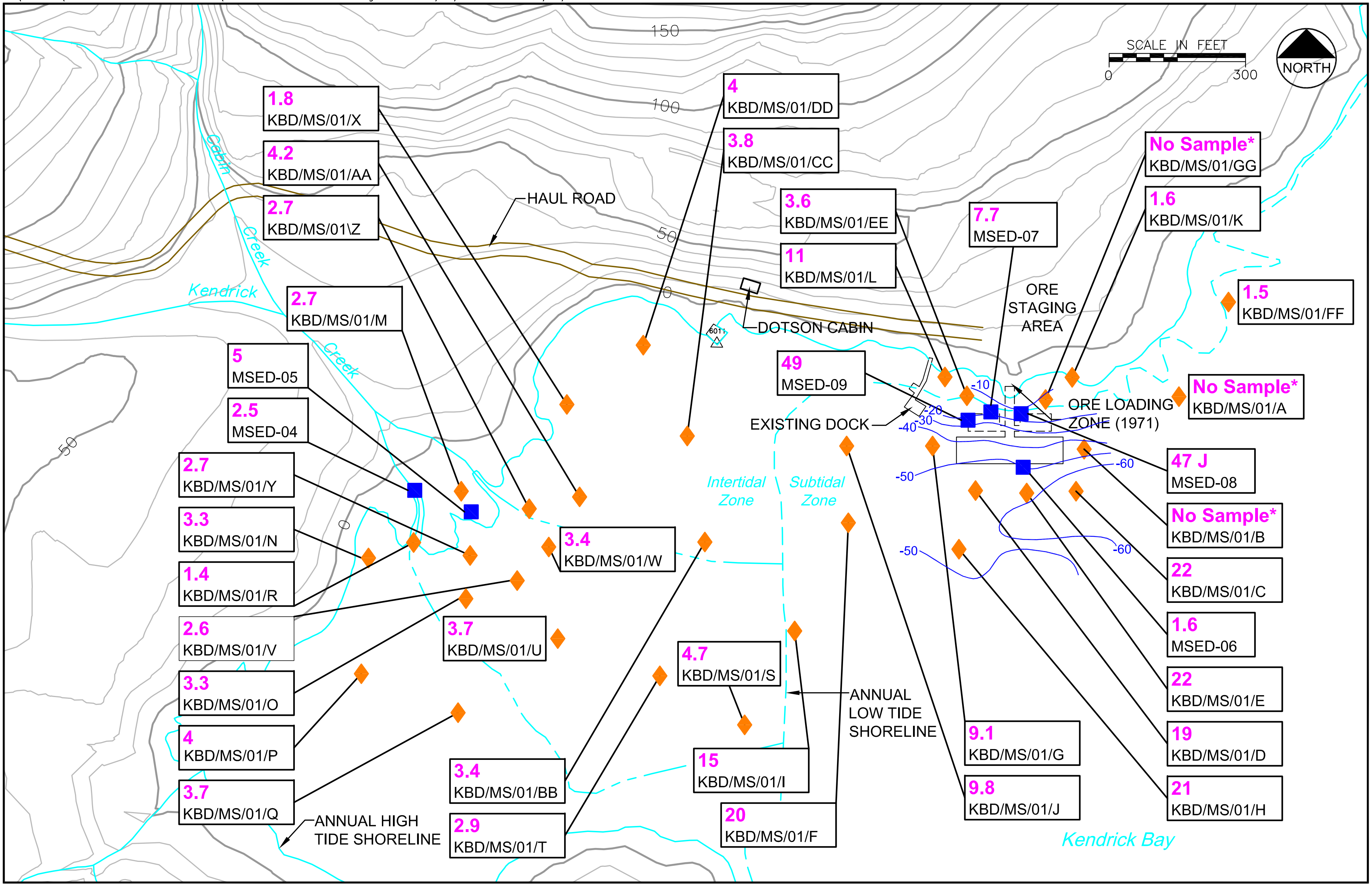
November 2010

LEGEND

- ● STREAM SEDIMENT SAMPLING LOCATION
- X Ra-226 CONCENTRATION (pCi/g) JULY SAMPLING EVENT

Figure 6-41
Ross-Adams Site
Concentration of Ra-226 in Stream Sediment Samples

E:\181862\Final SCR – November 2010\FIG-6-42-45-SAMPLES.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER



Project No. 181862

November 2010

Tetra Tech Sample Location

Kent & Sullivan Sample Location

KBD/MS/01/T Sample ID

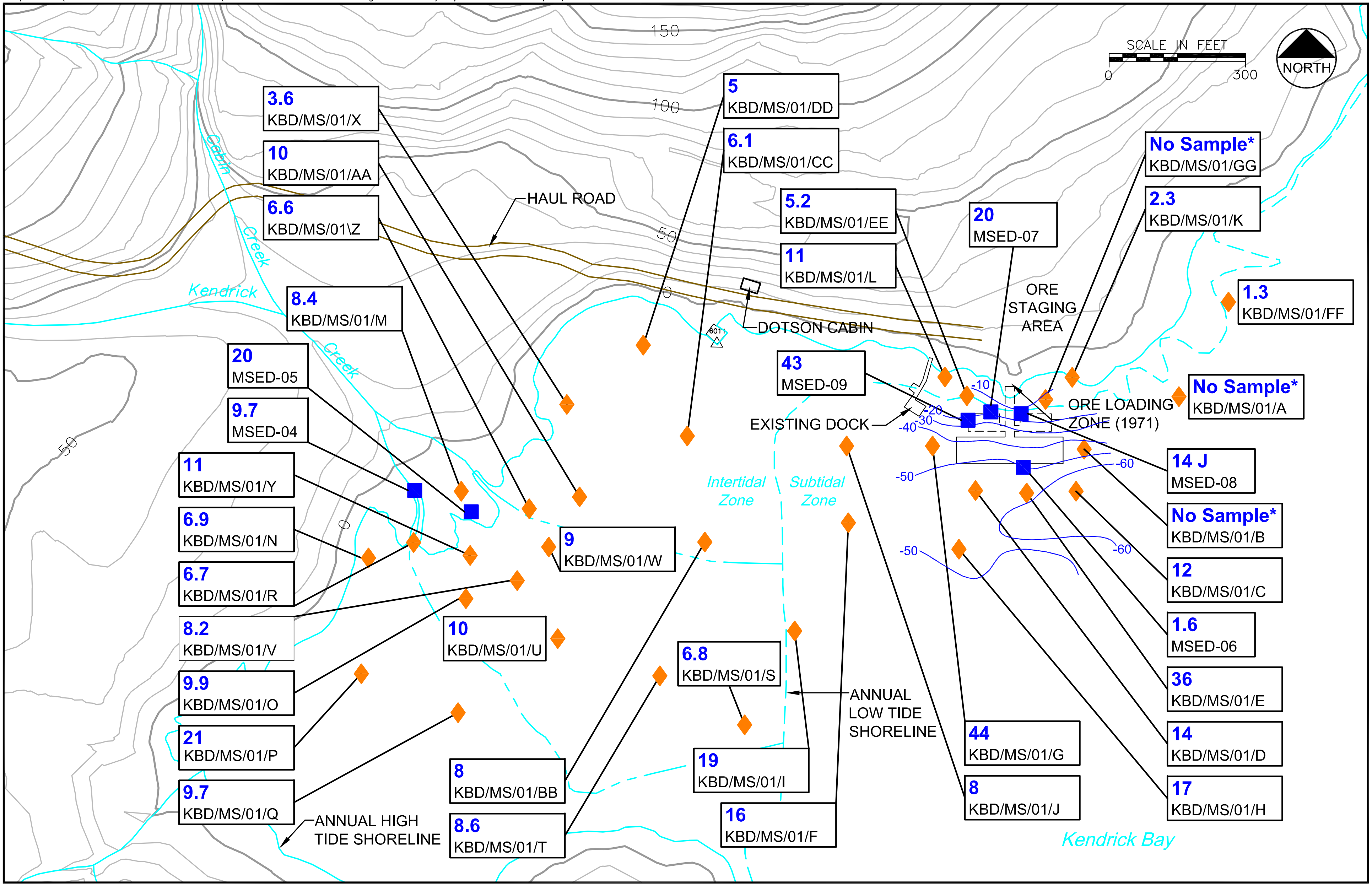
2.9 Arsenic Concentration (mg/Kg)

Bathymetry Contours (Feet, MSL)

* Note: Unable to collect sample at this location due to sediment quantity.

Figure 6-42
Ross-Adams Site
Concentration of Arsenic in Marine Sediment Samples

E:\181862\Final SCR – November 2010\FIG-6-42-45-SAMPLES.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER



Project No. 181862

November 2010

◆ Tetra Tech Sample Location

■ Kent & Sullivan Sample Location

KBD/MS/01/T Sample ID

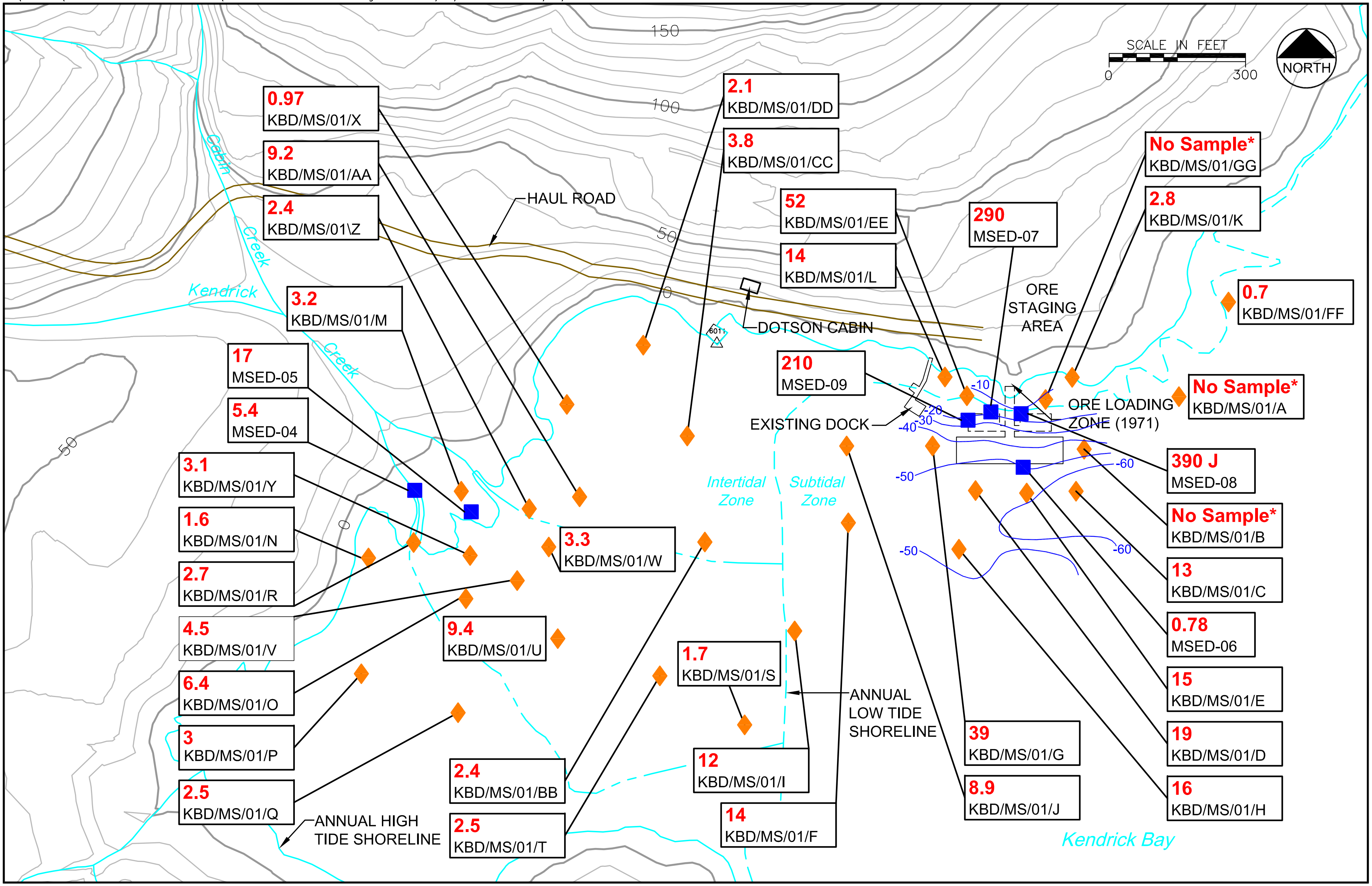
8.6 Lead Concentration (mg/Kg)

— Bathymetry Contours (Feet, MSL)

* Note: Unable to collect sample at this location due to sediment quantity.

Figure 6-43
Ross-Adams Site
Concentration of Lead in Marine Sediment Samples

E:\181862\Final SCR – November 2010\FIG-6-42-45-SAMPLES.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER



Project No. 181862

November 2010

Tetra Tech Sample Location

Kent & Sullivan Sample Location

KBD/MS/01/T Sample ID

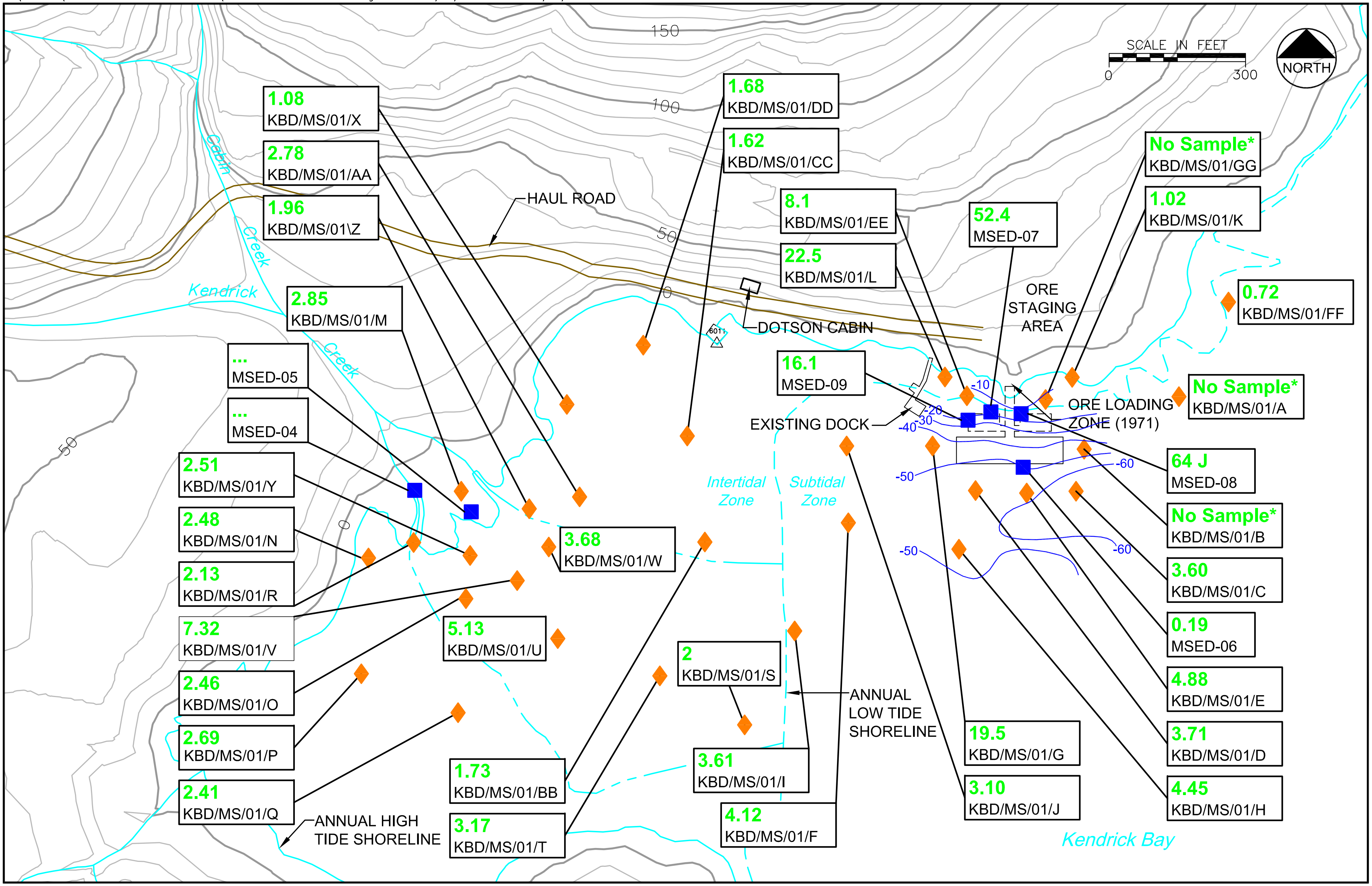
2.5 Uranium Concentration (mg/Kg)

Bathymetry Contours (Feet, MSL)

* Note: Unable to collect sample at this location due to sediment quantity.

Figure 6-44
Ross-Adams Site
Concentration of Uranium in Marine Sediment Samples

E:\181862\Final SCR – November 2010\FIG-6-42-45-SAMPLES.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER



Project No. 181862

November 2010

Tetra Tech Sample Location

Kent & Sullivan Sample Location

KBD/MS/01/T Sample ID

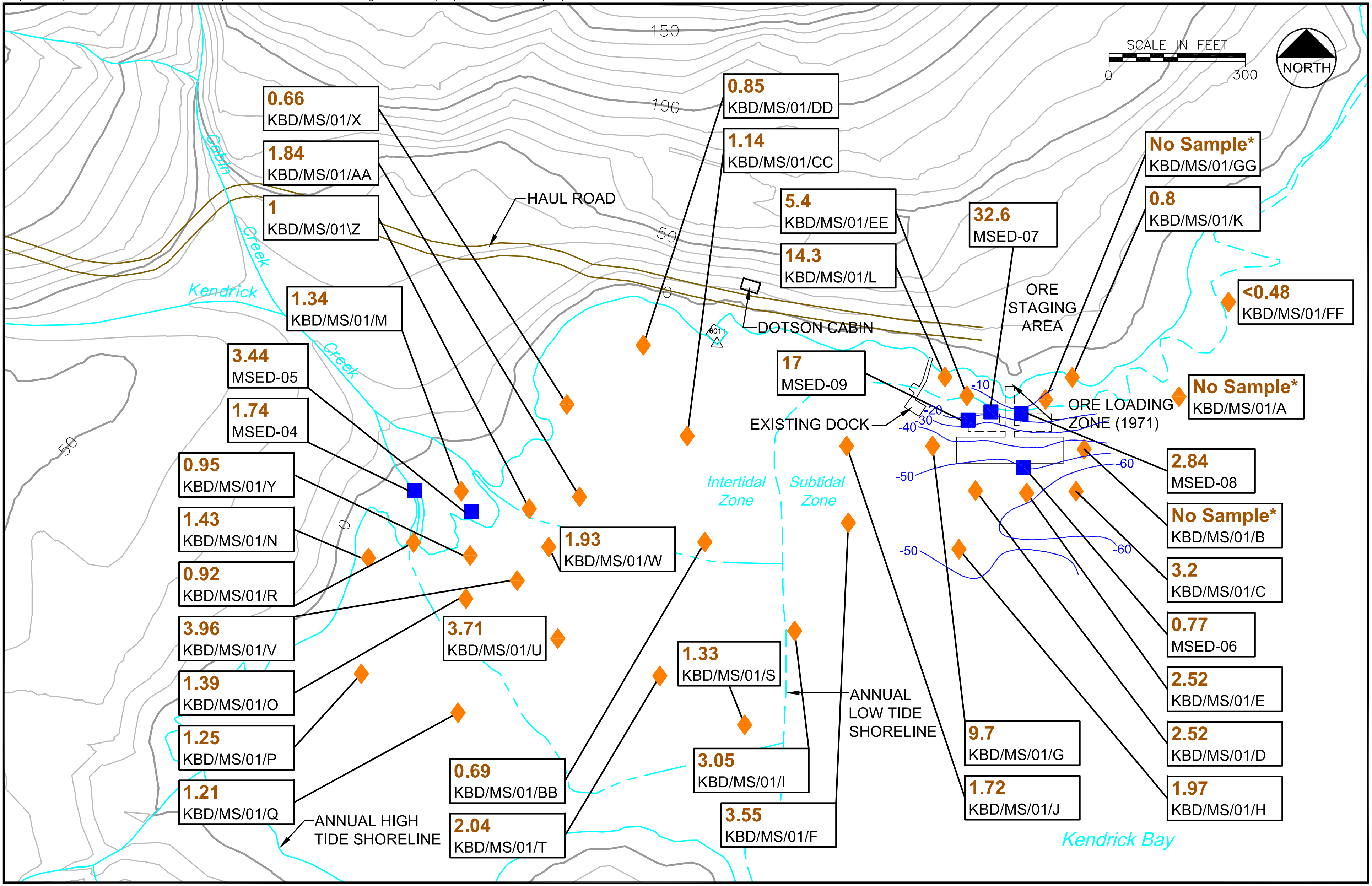
3.17 Ra-226 Concentration (pCi/g)

Bathymetry Contours (Feet, MSL)

* Note: Unable to collect sample at this location due to sediment quantity.

Figure 6-45
Ross-Adams Site
Concentration of Ra-226 in Marine Sediment Samples

E:\181862\Final SCR – November 2010\FIG-6-46-47-SAMPLES.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER



Project No. 181862

November 2010

◆ Tetra Tech Sample Location

■ Kent & Sullivan Sample Location

KBD/MS/01/T Sample ID

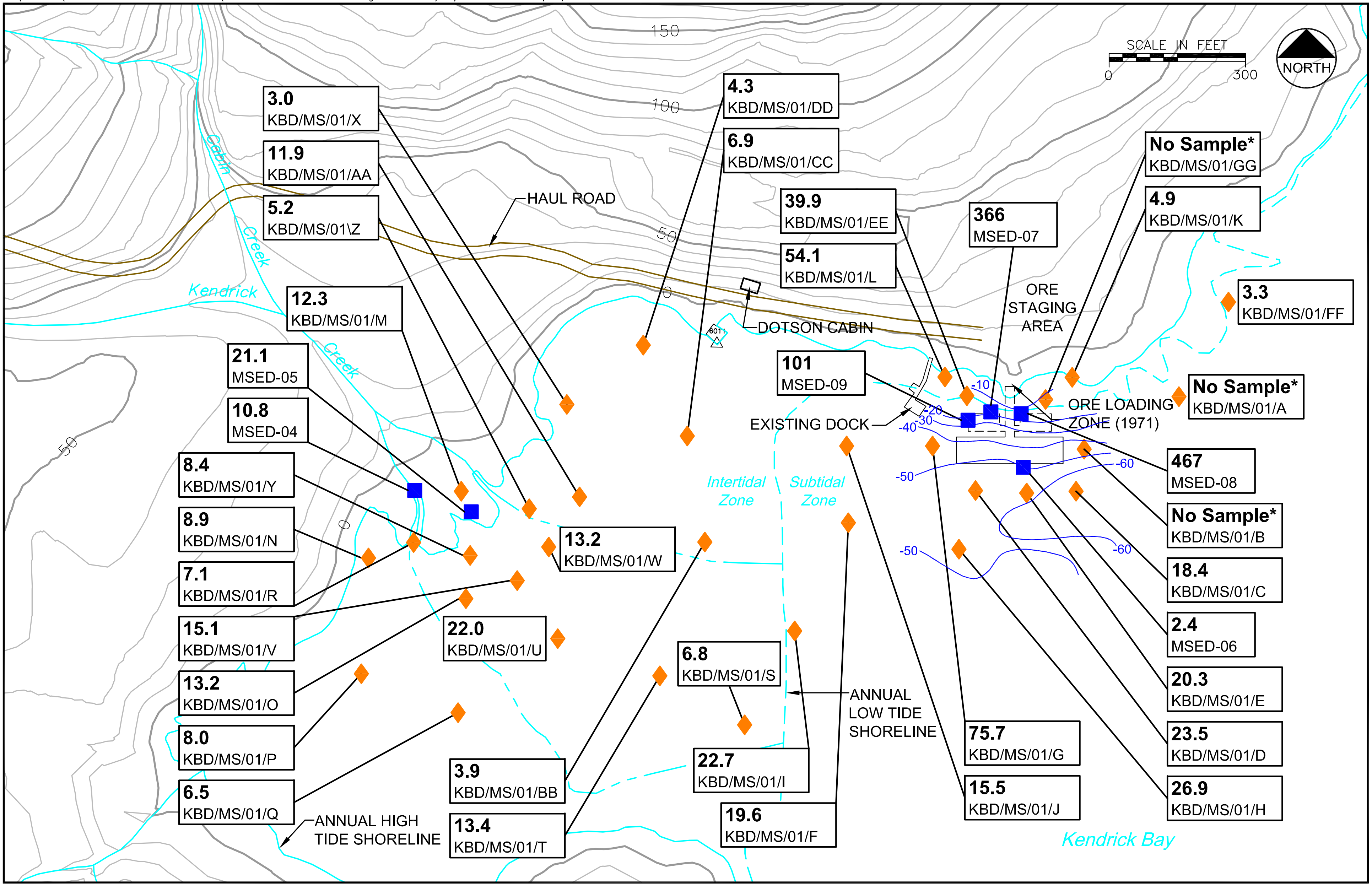
0.69 Ra-228 Concentration (pCi/g)

— Bathymetry Contours (Feet, MSL)

* Note: Unable to collect sample at this location due to sediment quantity.

Figure 6-46
Ross-Adams Site
Concentration of Ra-228 in Marine Sediment Samples

E:\181862\Final SCR – November 2010\FIG-6-46-47-SAMPLES.dwg SAVED: 11/17/10 PRINTED: 11/17/10 BY: THOMAS.BOEHLER



Project No. 181862

November 2010

◆ Tetra Tech Sample Location

■ Kent & Sullivan Sample Location

KBD/MS/01/T Sample ID

3.9 Thorium Concentration (pCi/g)

— Bathymetry Contours (Feet, MSL)

* Note: Unable to collect sample at this location due to sediment quantity.
Thorium Values Equal Sum of Th-228, Th-230, Th-232 and Th-234.

Figure 6-47
Ross-Adams Site
Concentration of Thorium in Marine Sediment Sample

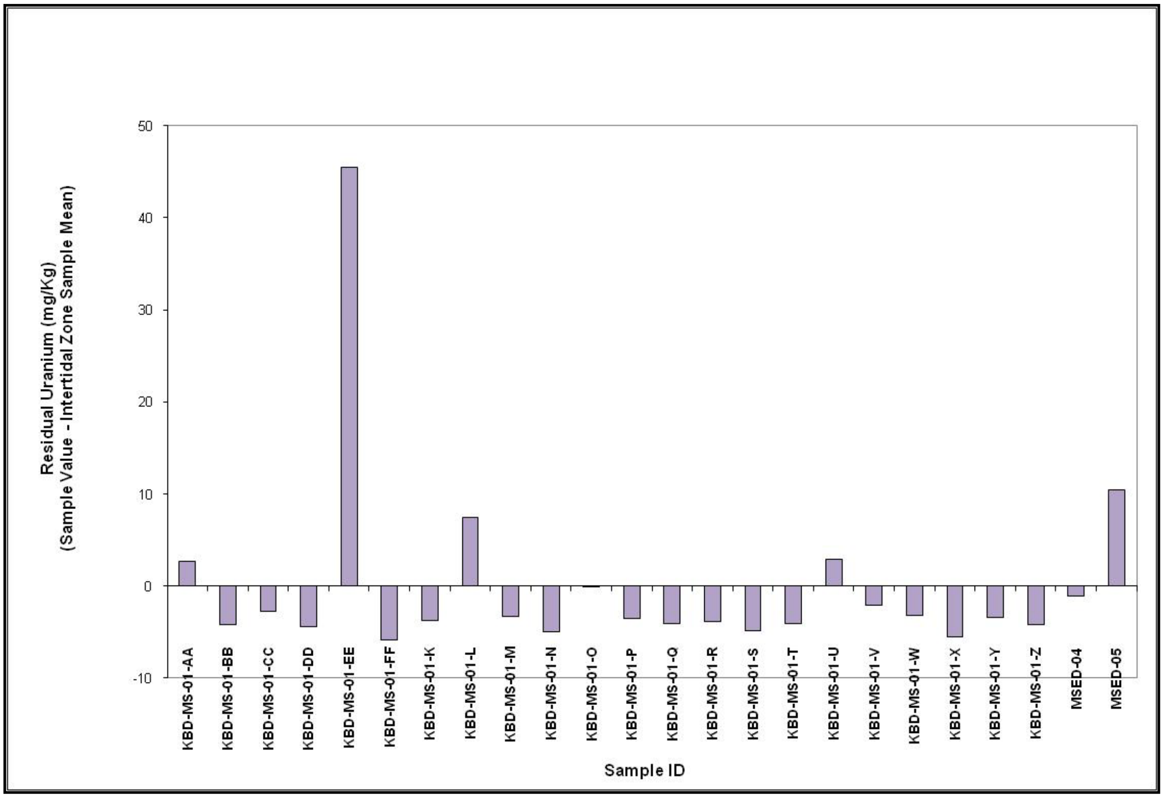


Figure 6-48. Residual Plot of Uranium in Intertidal Zone Marine Sediment Samples

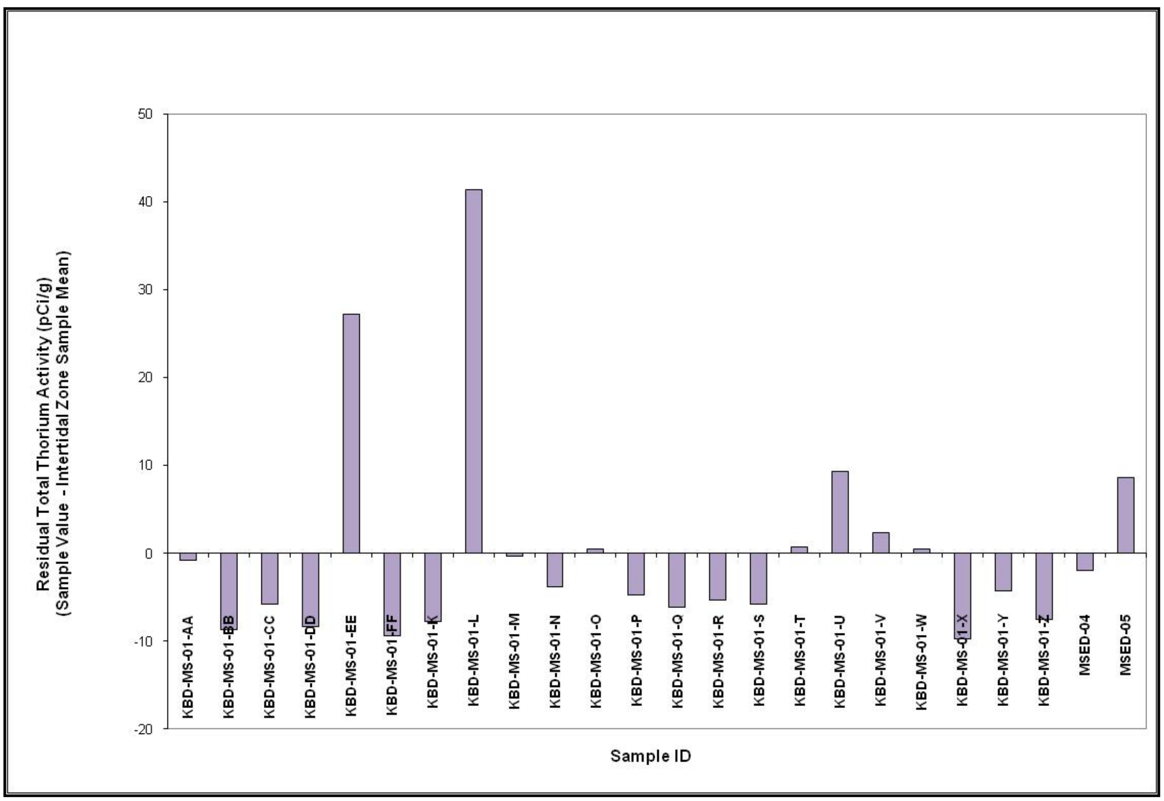


Figure 6-49. Residual Plot of Total Thorium in Intertidal Zone Marine Sediment Samples

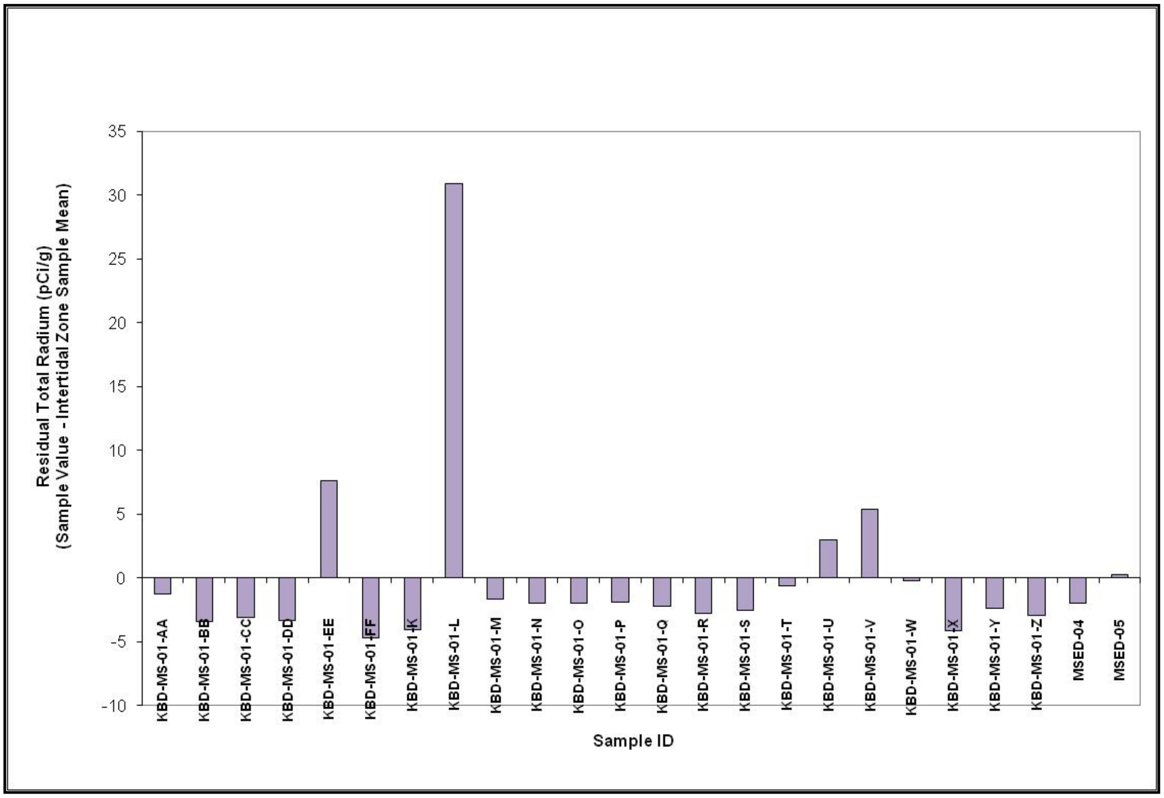


Figure 6-50. Residual Plot of Total Radium in Intertidal Zone Marine Sediment Samples

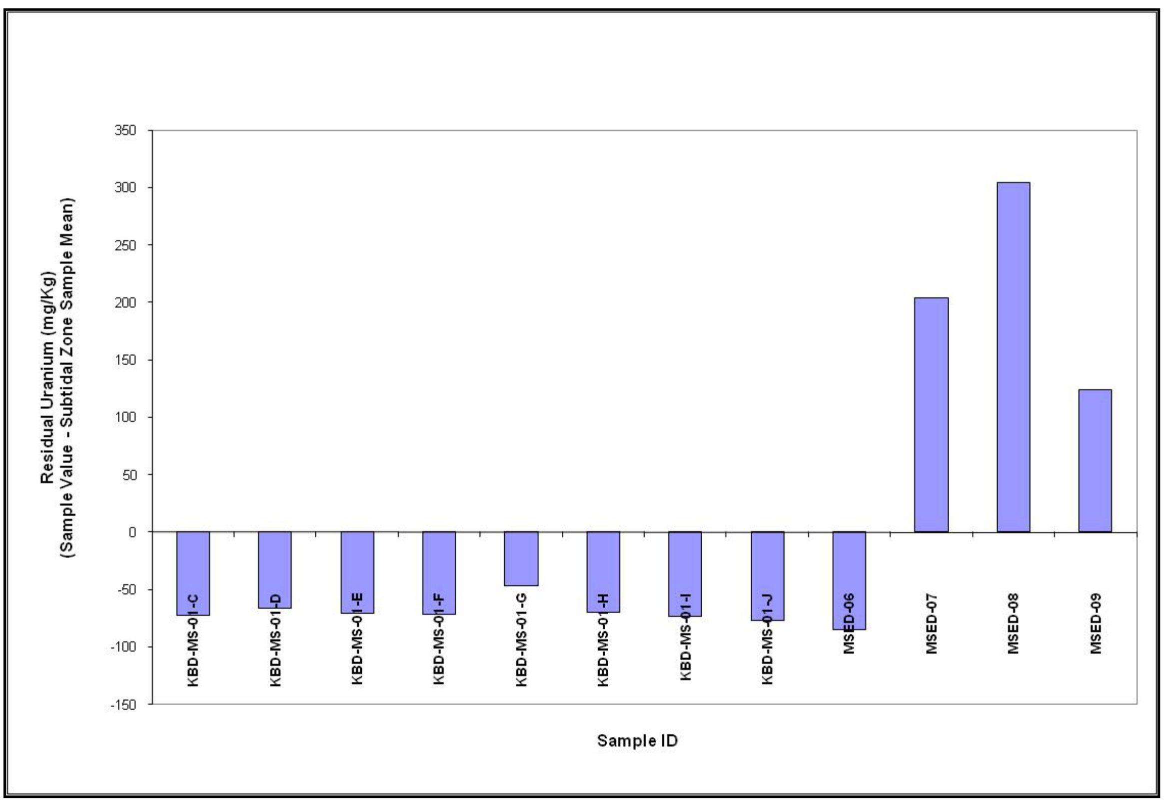


Figure 6-51. Residual Plot of Uranium in Subtidal Zone Marine Sediment Samples

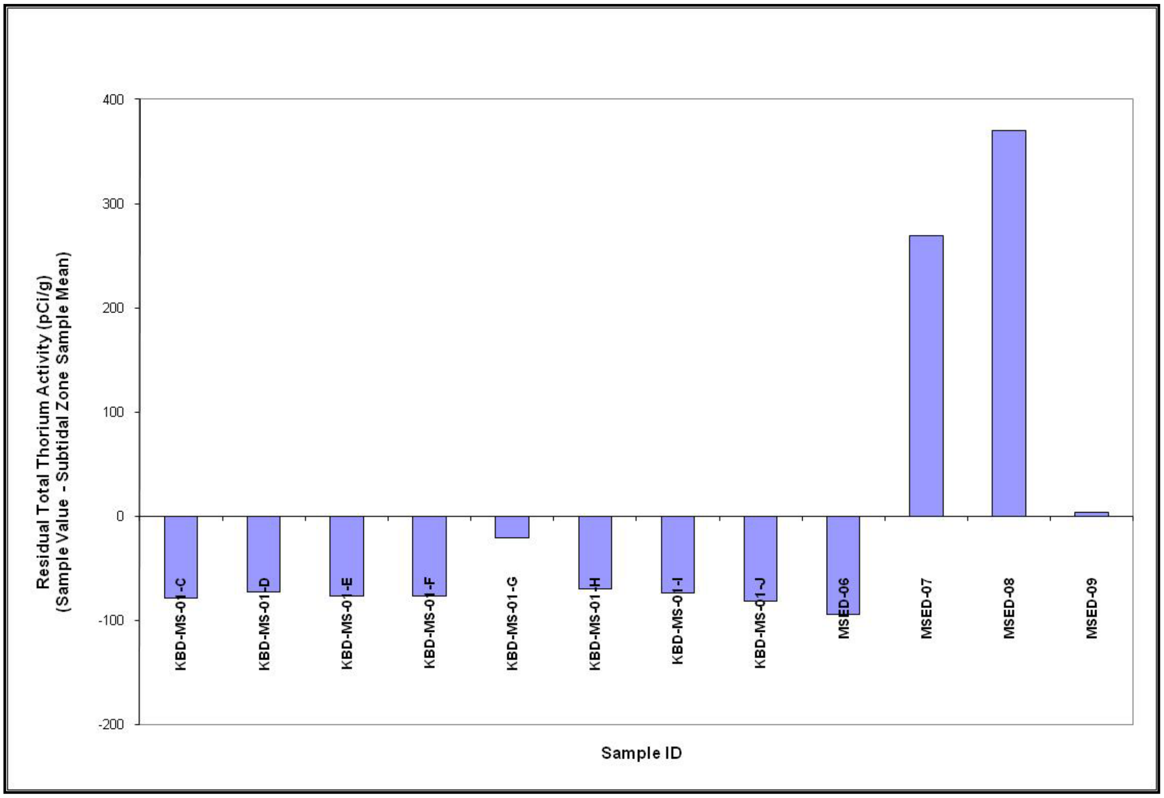


Figure 6-52. Residual Plot of Total Thorium in Subtidal Zone Marine Sediment Samples

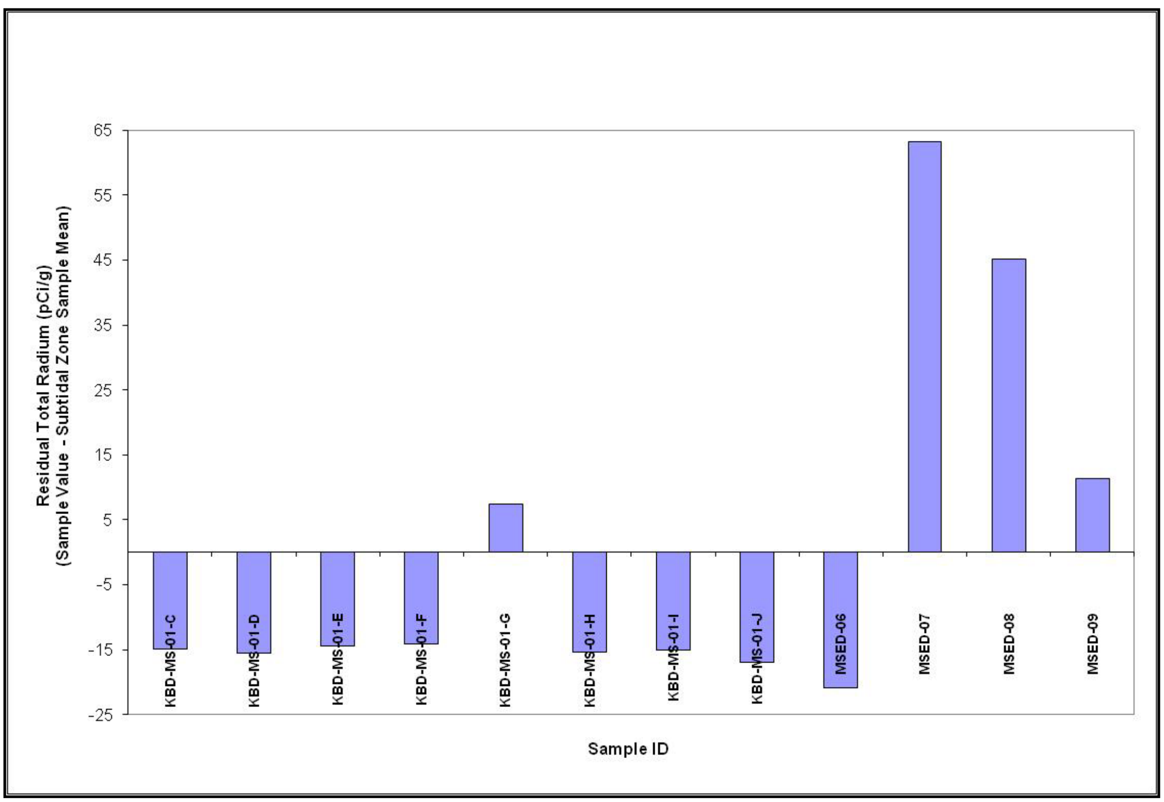


Figure 6-53. Residual Plot of Total Radium in Subtidal Zone Marine Sediment Samples

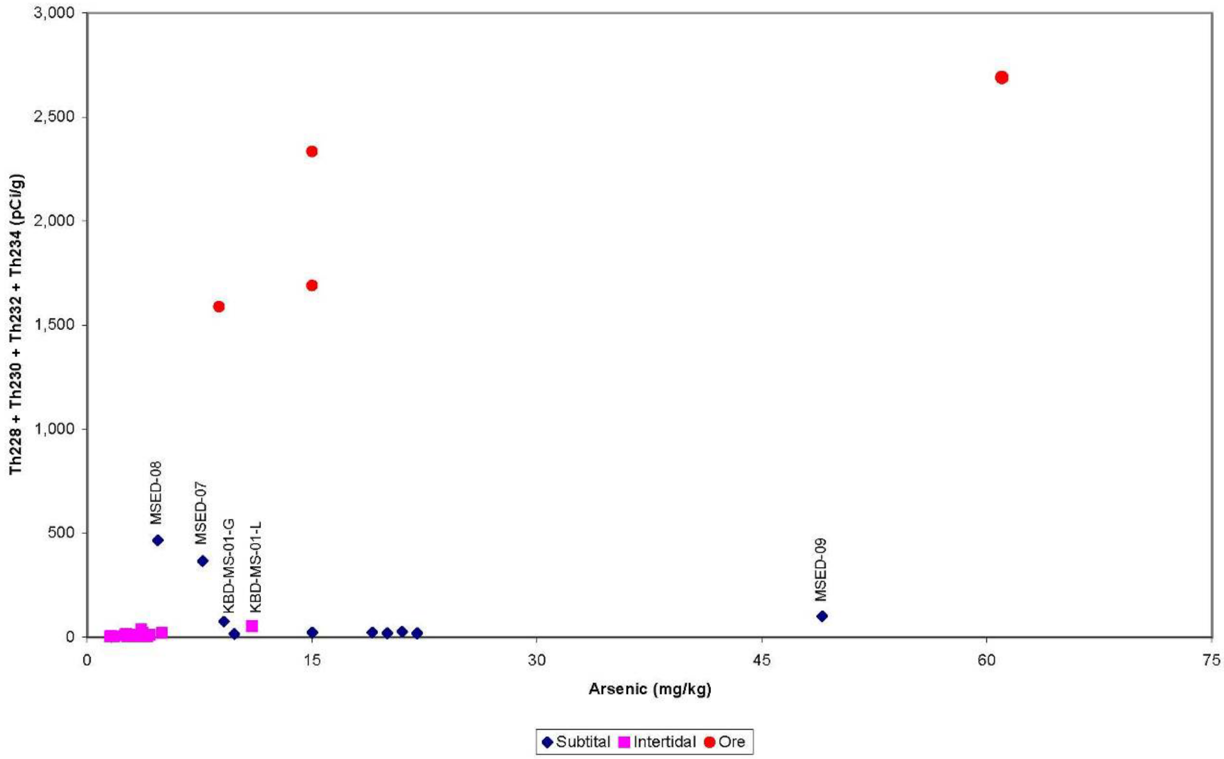


Figure 6-54. Marine Sediments – Thorium vs. Arsenic

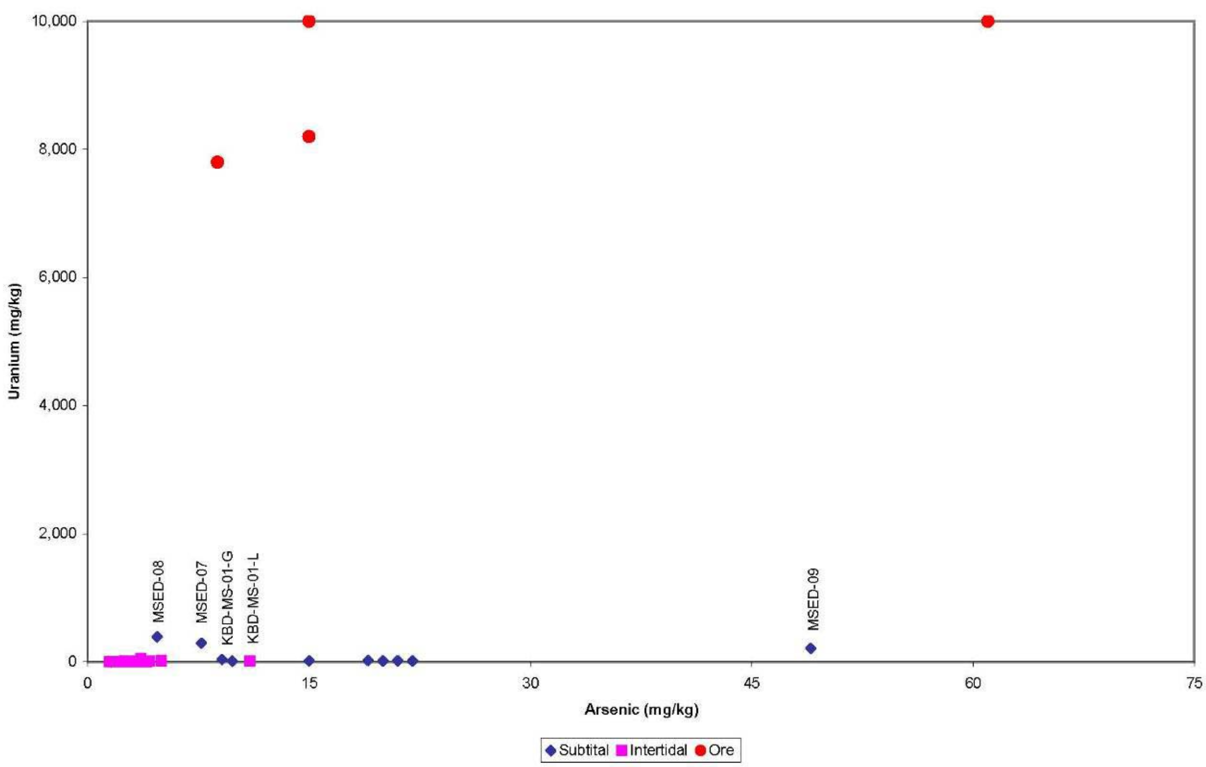


Figure 6-55. Marine Sediments – Uranium vs. Arsenic

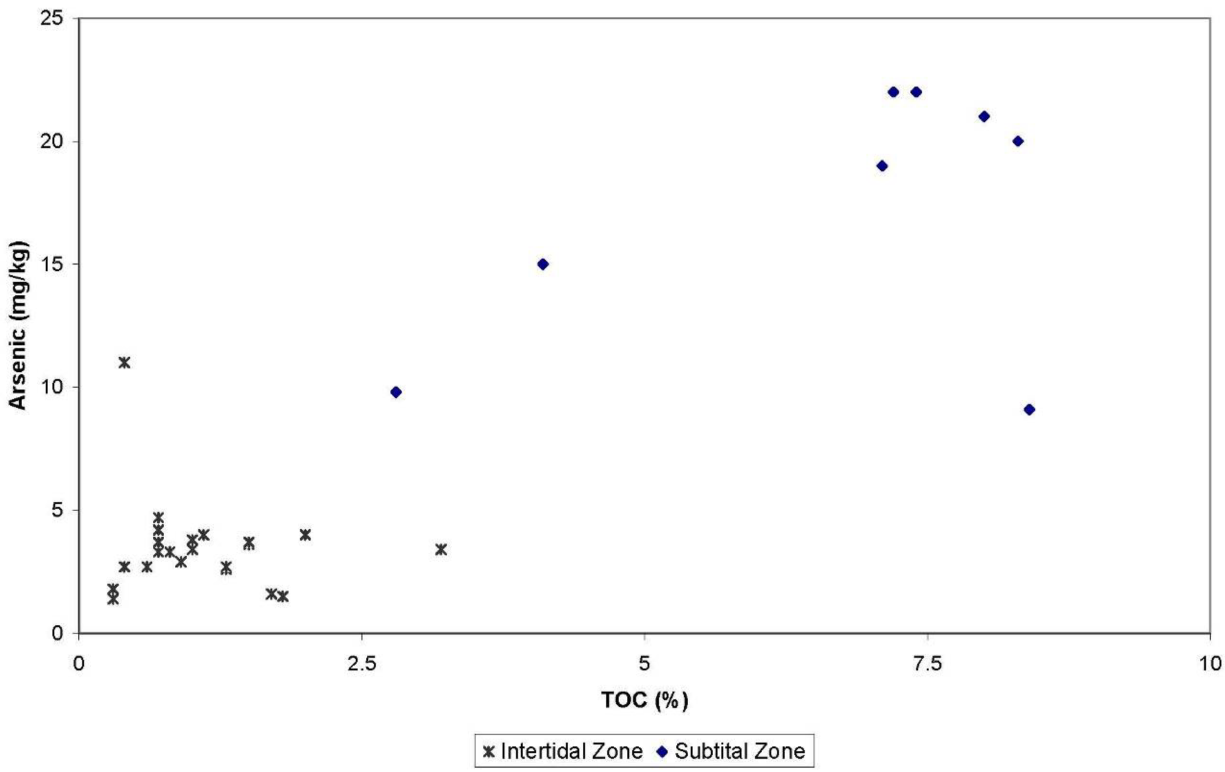


Figure 6-56. Marine Sediments – Arsenic vs. TOC

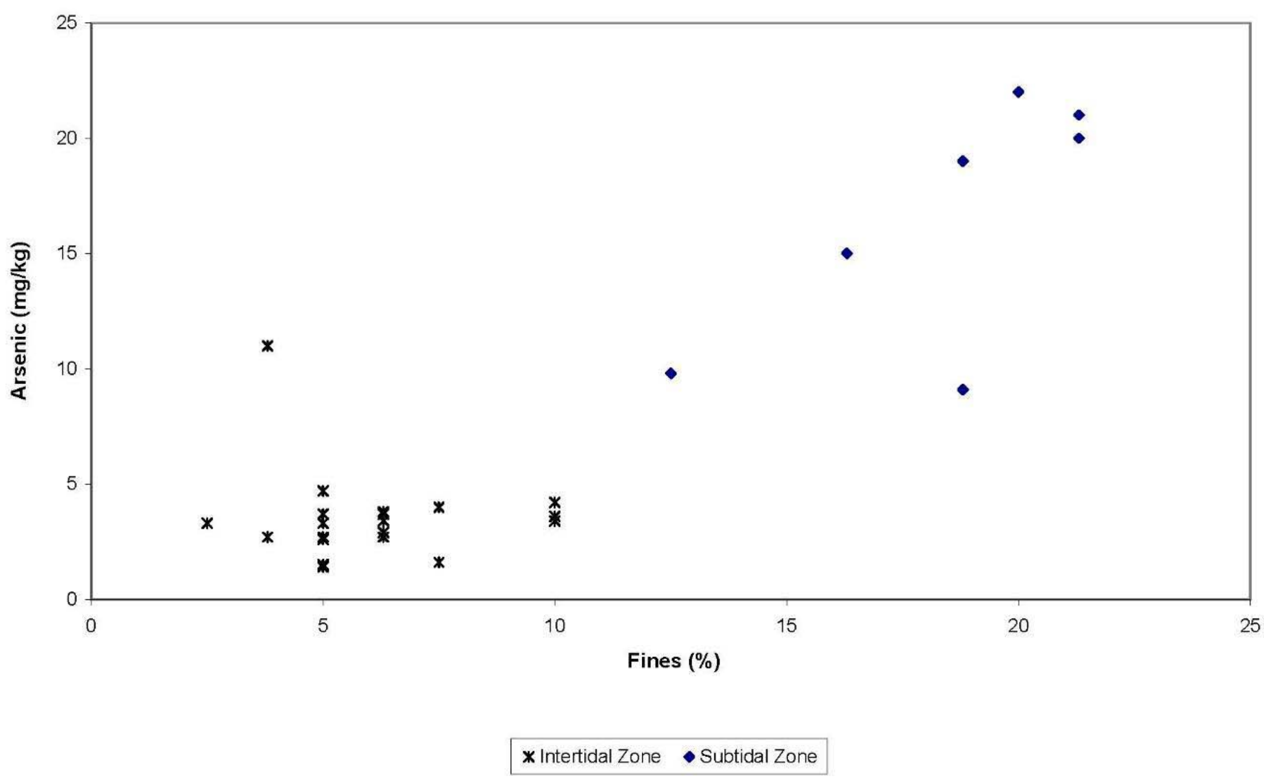


Figure 6-57. Marine Sediments – Arsenic vs. Fines

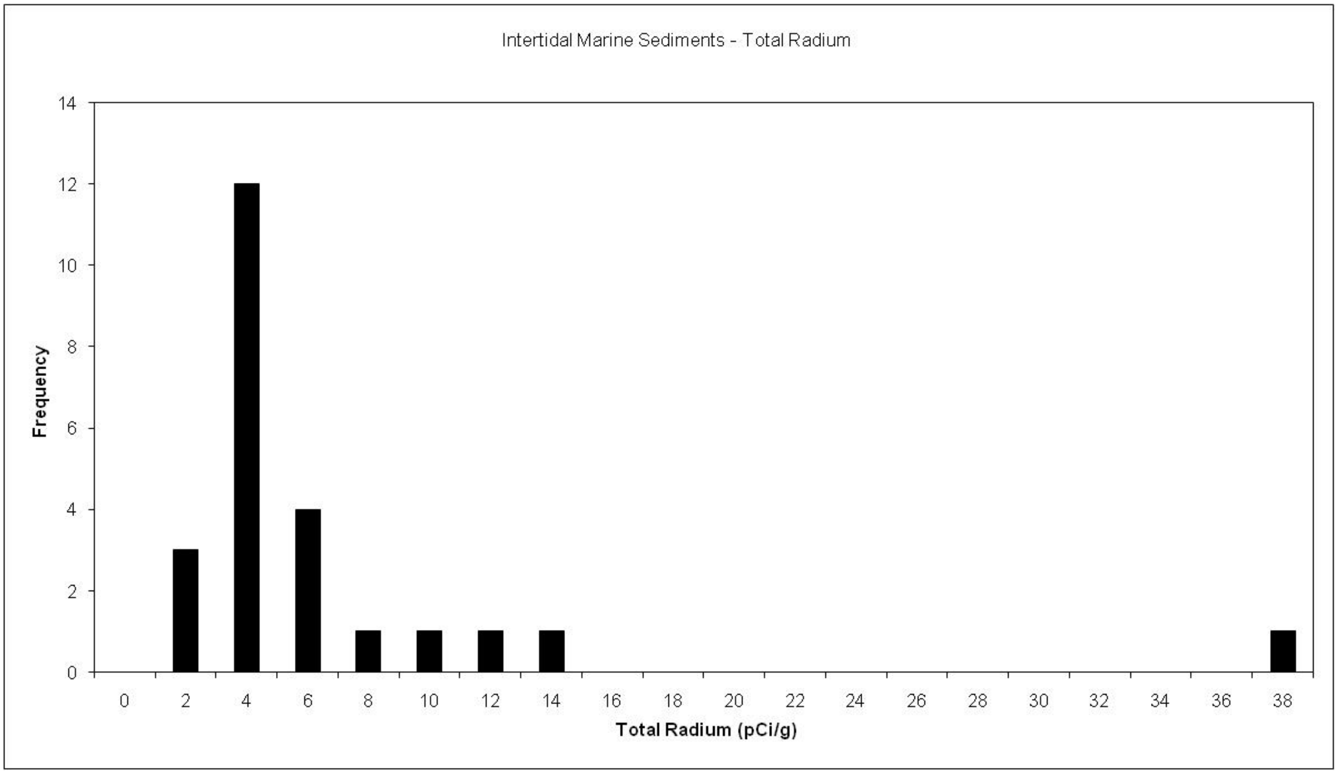


Figure 6-58. Histogram of Total Radium in Intertidal Marine Sediments

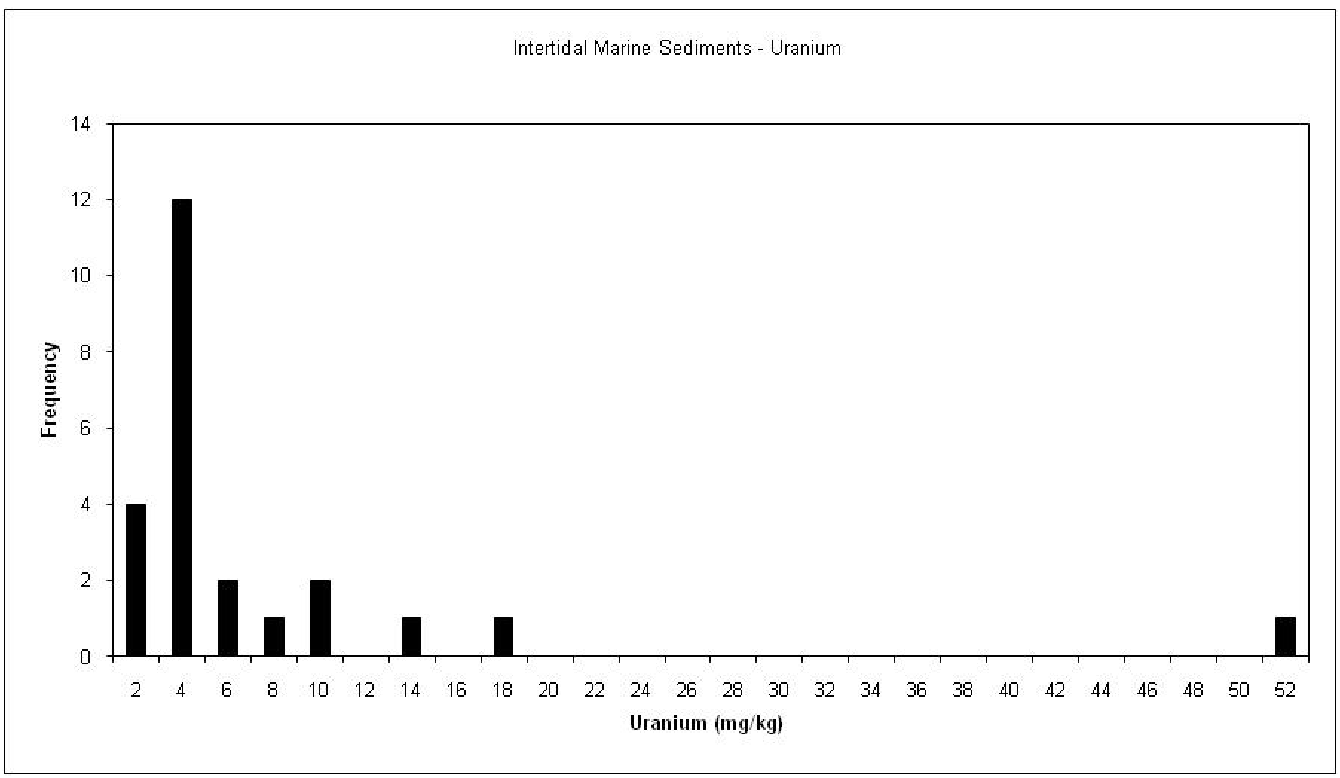


Figure 6-59. Histogram of Uranium in Intertidal Marine Sediments

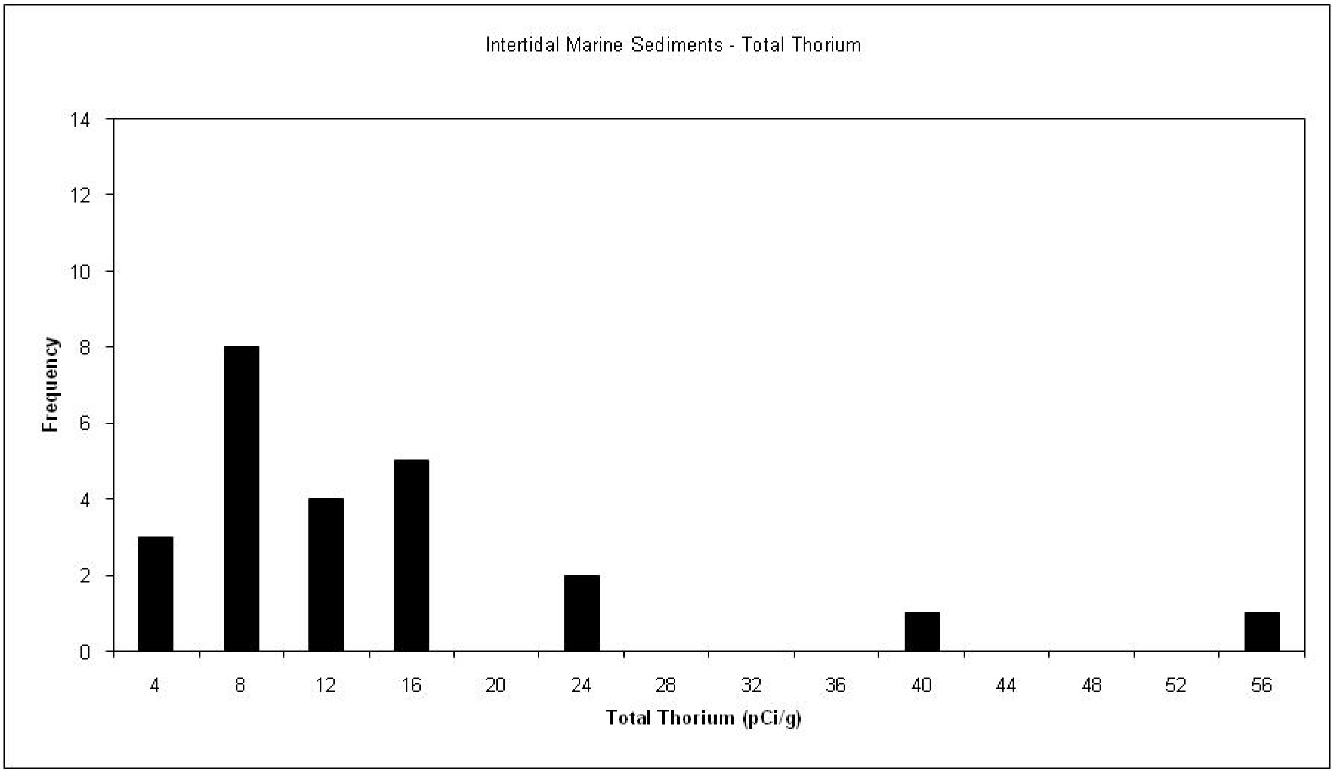


Figure 6-60. Histogram of Total Thorium in Intertidal Marine Sediments

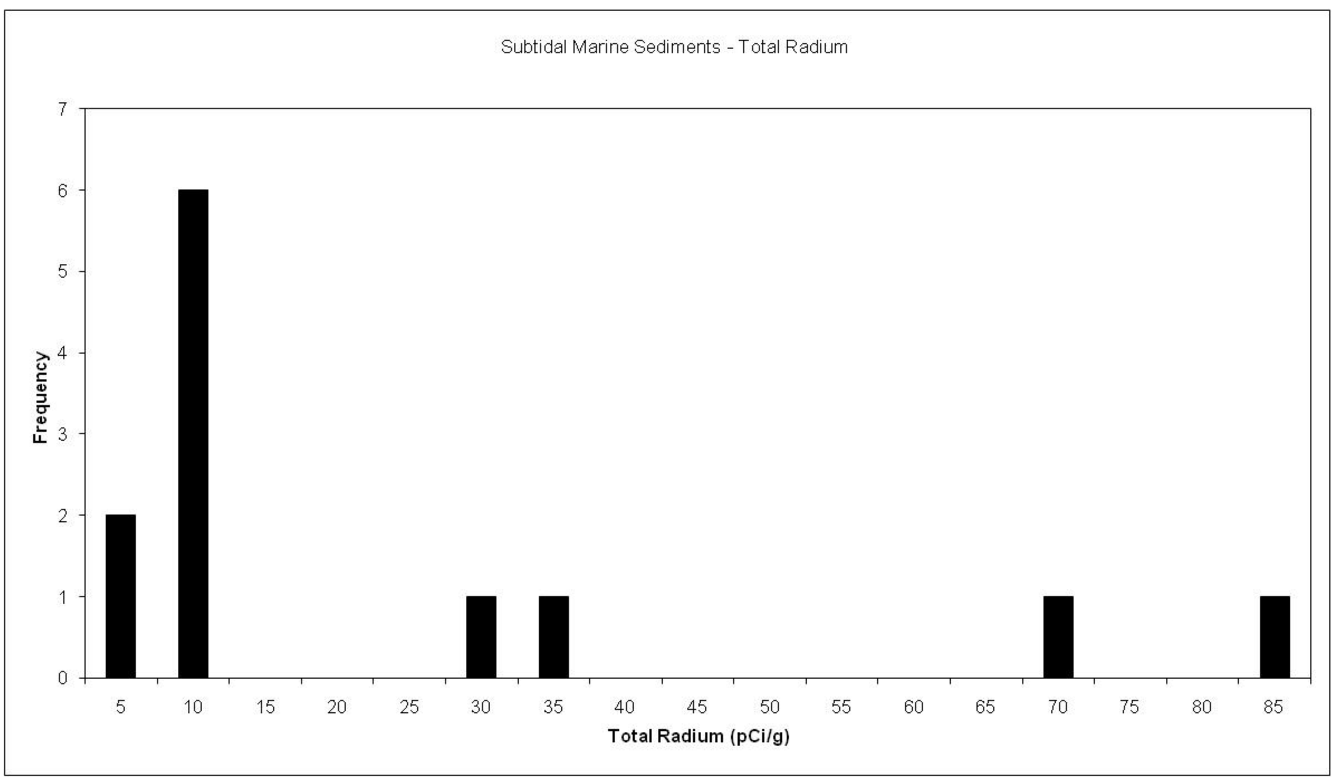


Figure 6-61. Histogram of Total Radium in Subtidal Marine Sediments

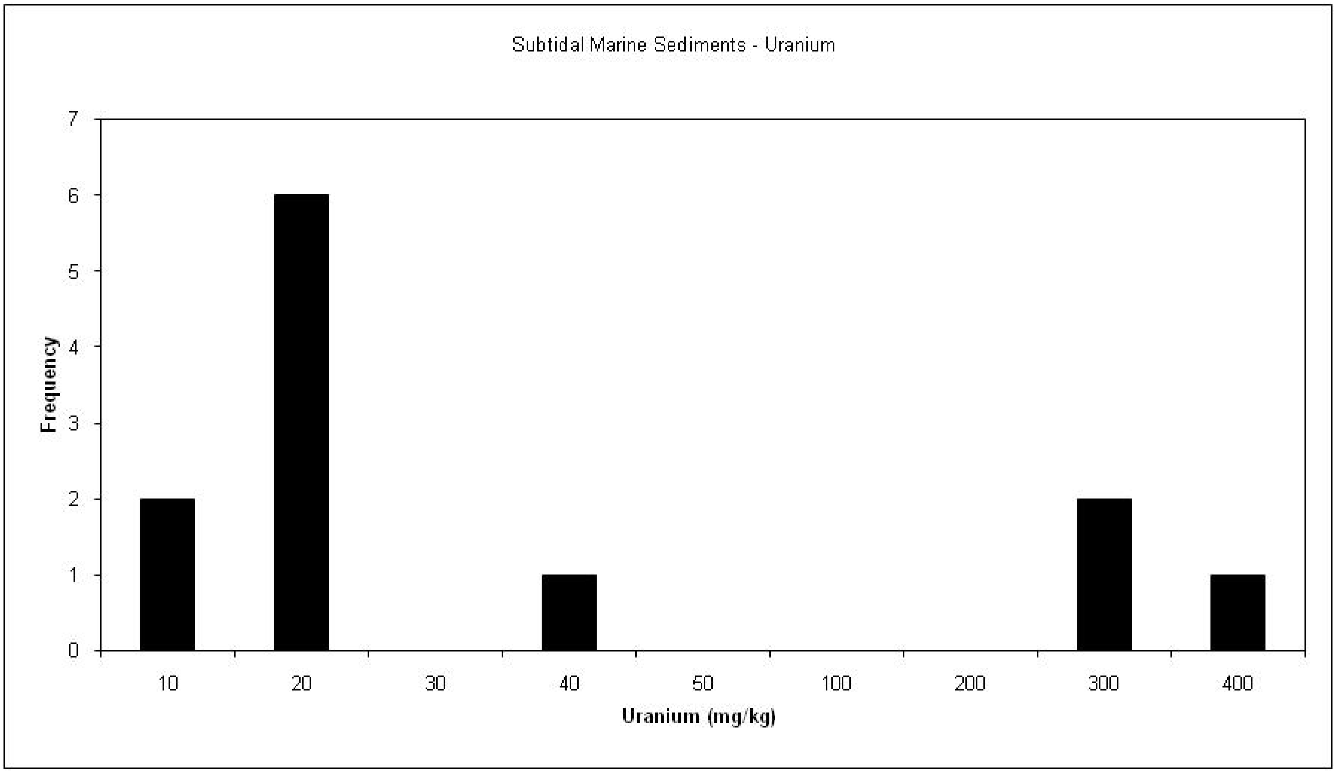


Figure 6-62. Histogram of Uranium in Subtidal Marine Sediments

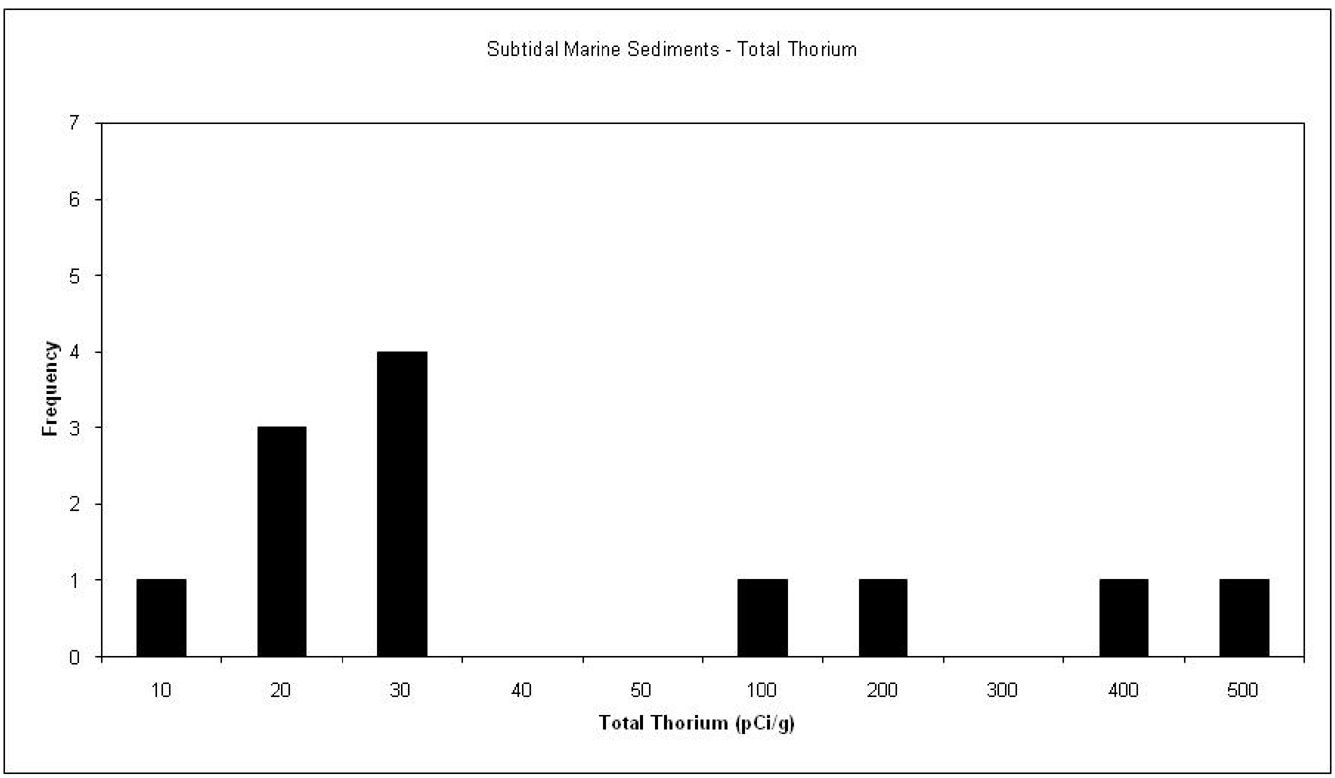


Figure 6-63. Histogram of Total Thorium in Subtidal Marine Sediments

7.0 CONCLUSIONS AND RECOMMENDATIONS

The ESI provides the data and information necessary to characterize the physical, chemical and radiological conditions of the Site and address the data gaps identified in the PA/SA (KSI, 2004), as required by the SOW. The data collected under the ESI includes sufficient information to allow the design and costing of potential removal actions for evaluation in the EE/CA, and to support assessment of current and future (post-removal action) risks to appropriate human and ecological receptors. Physical soil data, mapping and topographic survey data were collected to allow design and costing of a variety of potential removal action alternatives. Conclusions resulting from the Site characterization and the ESI are summarized in Section 7.1 and Section 7.2 presents recommendations.

7.1 Conclusions

The results of the ESI indicate that impacts of the mining activities related to the Ross-Adams mine are limited to the vicinity of the mine feature areas. These mine features are:

- The Open Pit
- The mine portals (900-Foot, 700-Foot, and 300-Foot levels) and air shaft
- The mine rock piles at the 900-Foot, 700-Foot, and 300-Foot levels and adjacent soils
- Specific areas of Site mine and haul roads
- The OSA and adjacent soils
- The rock loadout ramps

The data and information collected in the ESI (chemical, radiologic and physical) is sufficient to determine the chemical and radiological characteristics and the boundaries/locations of mine features at the Site. The gamma radiation survey data provide definitive information to differentiate between the boundaries of the mine features, adjacent areas, and natural mineralized background conditions. Further, the gamma correlation sample results demonstrate that gamma exposure measurements provide a reliable method to assess the radionuclide activities of soils. The results of the gamma radiation surveys and soil sampling indicate that the boundaries of mine rock piles at the 300-Foot, 700-Foot, and 900-Foot levels, mine rock along areas of the mine and haul roads, the OSA and rock loadout ramps are confined to discrete and defined areas.

The concept of local background is critical to the understanding of the Site conditions because of the influence of the natural mineralization exposed at the surface throughout the 900-Foot and 700-Foot Levels. An important aspect is that variably mineralized bedrock underlies the relatively thin soils and mine rock piles at the 900-Foot and 700-Foot Levels. Due to the observed variability in the gamma exposure rates and the expected variability in mineralized soil metal and radionuclide concentrations, a greater number of background soil samples were collected and analyzed in the mineralized area. A sufficient number of soil samples were collected to determine the variation in background mineralized soil and to allow statistical evaluation, as appropriate, in the SLHHRA and the SLERA.

In addition, the extensive gamma survey data set provides information to assess the variability in the mineralized area and define the boundaries of the mine rock piles at the 900-Foot and 700-Foot levels. Gamma correlation with radionuclide soil concentrations provides reasonable estimates of the Ra-226 concentrations and other radionuclides in areas for which soil sample data are not available and thus effectively delineate background radionuclide concentrations.

The PA/SI (KSI 2004) presented a conceptual site model (CSM), developed using the information and data available at that time, to describe the relation between potential sources and receptors via pathways and media at the Site. In general, the CSM defines the potential sources; the release mechanism for those sources; the environmental medium to which the constituents are released; and the exposure route to each potential receptor for the affected environmental media. The CSM does not determine if exposure or risk occurs but only identifies the route that constituents of potential concern can travel. The information and data collected by the ESI and evaluated in this SCR provides a basis for updating the CSM with respect to quantification of sources, media and pathways as discussed in the following.

Mine features at the Site are the underground mine workings; mine rock piles and associated soil at the 900-Foot and 700-Foot levels; the mine rock pile and portal drainage at the 300-Foot Level; and mine materials present in the mine and haul roads, the Ore Staging Area, and the loadout ramps. The area and location of these mine features and the nature and extent of the chemical and radiological constituents have been documented and quantified. In addition to mine features, the drums and stained soils at the generator shack area of the 300-Foot Level are considered a source for petroleum hydrocarbons.

The release mechanisms from the underground mine workings are radon emissions to air and leaching of other radionuclides and metals to mine water drainage. The portals and air shaft present avenues for radon emissions from the underground mine workings. Radon emissions also occur from the mine rock piles. Radon quickly disperses in the atmosphere and radon levels approach background levels within short distances from the mine features. The one exception is the radon concentration in the air flow from the 300-Foot Level portal, which has the highest measured radon concentration at the Site, with higher radon levels persisting for more than 300 feet downstream of the portal in the steep-sided Kendrick Creek channel. The exposure to radon would be through inhalation to receptors below the portal. Other radon sources include background radon emissions from the naturally mineralized geology.

Mine water drainage, primarily from the 300-Foot Level portal, reports to surface water in Kendrick Creek, and surface water is considered an exposure medium through which human and ecological receptors (terrestrial and freshwater aquatic) could be exposed to certain metals and radionuclide constituents through ingestion, direct contact, and food chain pathways. However, the steep gradient of Kendrick Creek to below the 300-Foot Level is considered negligible spawning and rearing habitat for all salmonids. In addition, the metal concentrations, with the exception of aluminum, are less than Alaska chronic freshwater criteria. Concentrations of metals and radionuclides decrease downstream and, in the lower reaches of Kendrick Creek where spawning and rearing habitat for salmonids is of higher quality, the concentration of metals and radionuclides are typically within the range of background surface water quality and less than Alaska chronic freshwater criteria.

Mine rock present at the 900-Foot, 700-Foot and 300-Foot levels, haul and mine roads, the OSA and at the former rock loadout ramps are potential sources of metals and radionuclides that can cause exposure by direct contact, direct gamma radiation, or be released to soils, surface water, sediments and air media. Potential release mechanisms include erosion, leaching, runoff, dust emissions and radon emissions.

Direct exposure to gamma radiation within or in close proximity to the mine features is a potentially complete pathway to humans and terrestrial ecological receptors. The gamma radiation survey data provide definitive information to differentiate between the boundaries of the mine features, adjacent soils, and natural mineralized background conditions. The gamma measurements define the limits of gamma exposure representative of the radiation exposure to receptors at a specific location. In addition, the gamma radiation measurement has been demonstrated to provide reliable information for soil radionuclide activities.

Erosion of mine rock piles has the potential to affect soils outside of the physically disturbed mine feature areas. As demonstrated by the results of soil sampling, however, Site soils that are not in immediate contact with mine rock are not impacted by the mine features except in isolated locations where discrete pieces of ore or sub-ore grade rocks are present that were spilled during haulage or ore loading operations. The generation of dust/air particulate emission does not occur due to the topography, vegetation and wet climatic conditions at the Site and because the generally coarse nature of the mine materials inhibit the generation of wind-born material.

Leaching of radionuclides and select metals or runoff from mine rock piles to surface water can result in human and ecological receptors potentially being exposed through direct contact with, ingestion of, or food chain exposures of surface water and stream sediment. The results of surface water samples collected from Mine Fork Creek and drainages originating in the vicinity of the 700-Foot Level mine rock pile and the 900-Foot Level Open Pit and mine rock piles indicates that leaching and runoff from mine rock represents a minimal release mechanism for metals and radionuclides. The lower reaches of both Mine Fork and the 700-Foot Level Creek also have substantial physical barriers to upstream fish movement. Trends in the metal concentrations and radionuclide activities of stream sediment in Kendrick Creek are similar to surface water quality. The highest observed metal concentrations and radionuclide activities in Kendrick Creek sediment typically occur at the sample location immediately downstream of the 300-Foot Level mine rock pile. Metal concentrations and radionuclide activities in stream sediment decrease downstream and, in the lower reaches of Kendrick Creek where the habitat is physically more amenable to salmonid spawning and rearing, metal concentrations and radionuclide activities are at or below the background values for stream sediment

Marine sediments can present potential direct contact exposure pathways as well as external radiation and food-chain exposures to both humans and ecological receptors. Except where discrete ore rocks are present in a limited area of the rock loadout ramps, the metal concentrations and radionuclide activities of sediment within the intertidal and subtidal zones are within local background levels.

7.2 Recommendations

The information and data collected in the ESI is sufficient to establish the nature and extent of the impacts due to the Ross-Adams Mine features, to identify and characterize the chemical and radiological conditions of these features and media, and to define the physical and engineering features of the Site. The ESI provides the necessary data and information to support the evaluation of exposure pathways and to conduct the risk assessments. Therefore, no additional data collection or evaluation is proposed for the completion of the EE/CA. Finalization of the risk assessments may identify that, in specific areas, uncertainty remains and that additional data collection and/or risk analysis would address those uncertainties. However, the ESI provides sufficient characterization of sources, release mechanisms and media, and of the engineering and physical condition of the Site for identification and evaluation of removal actions in the EE/CA that will effectively address and mitigate risks associated with historic uranium mining at the Site.

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