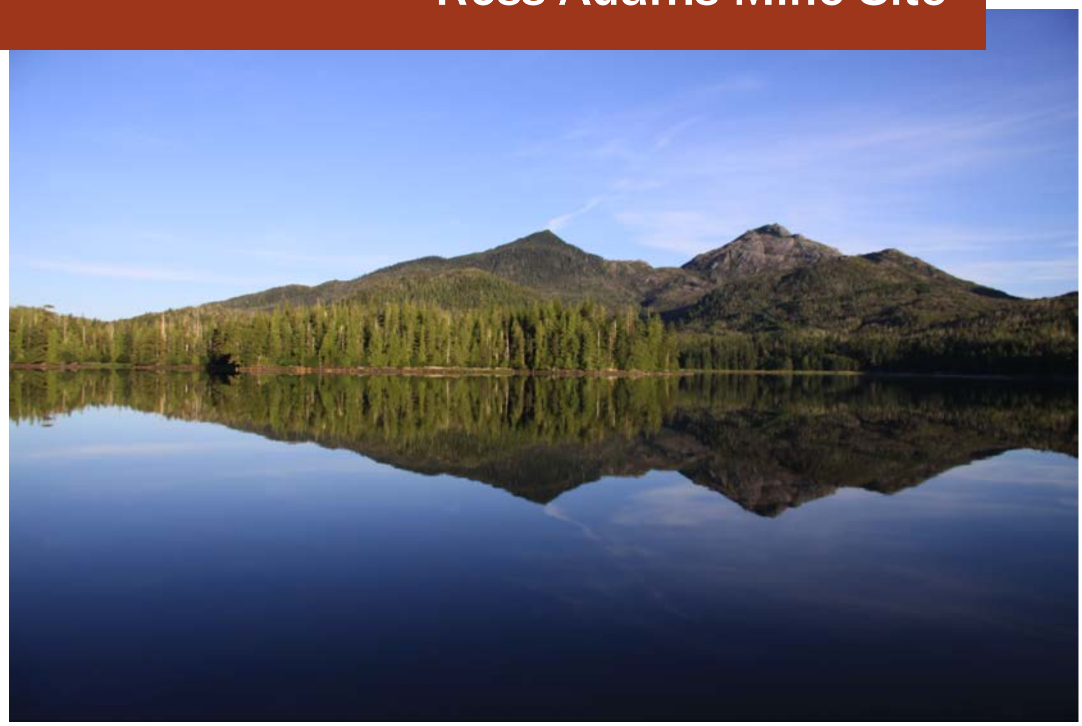
Engineering Evaluation/Cost Analysis
Ross-Adams Mine Site



Tongass National Forest
Prince of Wales Island, Alaska
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Abbreviations

95UPL	95 Percent Upper Prediction Limit
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
ARAR	Applicable or Relevant and Appropriate Requirements
ARD	Acid Rock Drainage
ASAOC	Administrative Settlement Agreement and Order on Consent
BLM	U.S. Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COPC	Constituents of Potential Concern
COPEC	Constituents of Potential Ecological Concern
CSM	Conceptual Site Model
CY	cubic yards
DOT	Department of Transportation
DRO	Diesel Range Organics
EE/CA	Engineering Evaluation/Cost Analysis
EPC	Exposure Point Concentrations
EPA	U.S. Environmental Protection Agency
ESI	Expanded Site Investigation
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPIC	High Pressure Ion Chamber
HQ	Hazard Quotient
KSI	Kent & Sullivan, Inc.
LOAEL	Lowest Observed Adverse Effects Level
M&M	Monitoring and Maintenance
MRP	Mine Rock Pile(s)
MS	Marine Sediment

Abbreviations (Continued)

NAD 83	Continental US 1983 Datum
NaI	Sodium Iodide
NCP	National Contingency Plan
NOAEL	No Observed Adverse Effects Level
NRHP	National Register of Historic Places
OSA	Ore Staging Area
OSC	On-Scene Coordinator
OVK	Organized Village of Kasaan
PA/SI	Preliminary Assessment/Site Inspection
PEC	Probable Effect Concentration
POW	Prince of Wales Island
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAG	Remedial Action Goals
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
REE	Rare Earth Elements
RPA	Removal Preliminary Assessment
SAP	Sampling Analysis Plan
SCR	Site Characterization Report
SHPO	State Historic Preservation Office
SLERA	Screening-Level Ecological Risk Assessment
SLRA	Screening-Level Human Health Risk Assessment
SOP	Standard Operating Procedure
SOW	Statement of Work
SSHP	Site Safety and Health Plan
SSRA	Site-Specific Human Health Risk Assessment
SY	square yards
TBC	To Be Considered
TEC	Threshold Effect Concentration
TNF	Tongass National Forest
Ucore	Ucore Uranium, Inc.
USFS	U.S. Department of Agriculture Forest Service

Executive Summary

Introduction

This Engineering Evaluation/Cost Analysis (EE/CA) presents the detailed analysis of removal action alternatives that address potential human health and ecological risks resulting from historic mining activities at the Ross-Adams Mine Site. 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 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, preparing a Site Characterization Report (SCR) to present the results and conclusions of the ESI and previous investigations, and preparing an EE/CA report, including human health and ecological risk assessments, that describes, analyzes and recommends a removal action for the Site. The Final SCR (Tetra Tech, 2010) provides the data, information and Site characterization for preparation of the human health and ecological risk assessments and the EE/CA. The risk assessments are an element of the EE/CA that provide an estimate of potential risks associated with exposure pathways to ecological and human receptors for existing conditions at the Site. The human health and ecological risk assessments identify the media, exposure pathways and potential risks to be addressed by the removal action alternatives in the EE/CA to support reasonable risk-based management decisions for defining the removal action at the Site.

This *Engineering Evaluation/Cost Analysis (EE/CA) for the Ross-Adams Mine Site* identifies and evaluates removal action alternatives to reduce the release or threat of release of hazardous substances from the former mining operations and to mitigate Site risk from historic mining activities. The human health risk assessment (HHRA) and the Screening-Level Ecological Risk Assessment (SLERA) are included as appendices, and the results of the risk assessments are incorporated in this EE/CA. This EE/CA recommends a removal action that addresses the mine features and mine-affected areas associated with the former Ross-Adams mine operations. The USFS will select the removal action for the Site in collaboration with the State of Alaska and the US Environmental Protection Agency (EPA).

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 off-site for processing; therefore, no milling operations were conducted at the Site that would have generated tailing or other process materials.

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 deposits of rare earth elements 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. 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-2). 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 I&L Zone represents a group of radioactive mineral prospects on the east flank of Bokan Mountain northwest of the Ross-Adams deposit, with ground surface exposed mineralization. Mineral exploration has been conducted on the I&L Zone, but it has never been mined and is not part of the Site as defined in the ASAOC.

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-3). 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 (Spur) 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;
- 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;

- Haul and Mine Roads (including the I&L access road) - primary roads constructed for exploration and mine access which served as haul roads connecting the 900-Foot and 300-Foot Levels to the OSA and loading docks at the West Arm of Kendrick Bay, and the mine road connecting the 900-Foot and 700-Foot Levels.

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 (USFS, 2003). While access is unrestricted, the Site is remote and only accessible by float plane or boat, or overland by hiking through many 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 TNF area surrounding the Site is included in the Eudora Roadless System (USFS, 2003).

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 (Figure ES-3). 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.

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, USFS workers, and occasional subsistence hunting-gathering. The TNF Land and Resource Management Plan (USFS, 2008) has designated the Site for mineral exploration and timber production. Mineral exploration is occurring in areas adjacent to the Site. Future Site use is projected to be consistent with current use, including mineral exploration or timber harvesting, as well as for semi-remote recreational use. Mineral exploration is expected to continue to occur in areas immediately adjacent to the Site and future use of the general area may include mining.

Site Characterization Report

The Final SCR (Tetra Tech, 2010) presents the results and conclusions of the ESI conducted in 2009 and previous investigations and forms the basis for development of the EE/CA and supporting risk assessments. The ESI addressed 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. As described in the SCR, additional data were collected in the ESI 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 (radon). 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. Correlations were established between measured gamma exposure rates and radionuclide concentrations in surface soil. The SCR also presented the results of the 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.

The SCR concludes 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 at the 900-Foot, 700-Foot, and 300-Foot Levels and the 900-Foot Level air vent shaft;
- The mine rock piles at the 900-Foot, 700-Foot, and 300-Foot Levels and adjacent soils;
- Specific segments of the haul roads, the mine road embankments and the I&L Spur road;
- The OSA;
- The rock loadout ramps due to ore spilled during former ore loading operations;
- The drainage from the 300-Foot Level portal.

The SCR provides the physical, chemical and radiological characteristics of the above mine features, adjacent areas and media at the Site to support assessment of the current and future (post removal action) risks to human and ecological receptors and the identification and evaluation of removal action alternatives. Direct exposure to gamma radiation within or in close proximity to the mine features represents an exposure pathway to humans and terrestrial ecological receptors. The gamma radiation survey data, in conjunction with visible observation, provide definitive information to differentiate between the boundaries of the mine features, adjacent soils, and natural mineralized background conditions. Further, the gamma correlation sample results demonstrate that gamma exposure measurements provide a reliable method to assess the radionuclide concentrations 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 gamma measurements define the limits of gamma exposure representative of the radiation exposure to receptors at a specific location, and together with soil data provide the necessary information to assess risks for human and ecological receptors associated with these exposure pathways.

As described more fully below, highly variable gamma exposure rates and soil radionuclide concentrations are dependent on the local natural mineralogy and geologic conditions within the area of the mineral deposit. The boundaries of mine rock and mine-affected areas are not clearly differentiated from background conditions in the naturally mineralized area by measured gamma exposure rates and soil sampling results alone. Visual observation, together with measured gamma exposure rates and soil sampling results, is essential in defining mine rock boundaries and mine-affected areas in the mineralized area. In addition, the mineralogy of the Site geology and ore body, along with water quality observations, demonstrates that the mine rock piles do not generate acid rock drainage (ARD).

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 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. 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. The radon data for the mine rock piles and the portals provide information to evaluate human health risks associated with inhalation of radon decay products. Other radon sources include background radon emissions from the naturally mineralized geology.

Mine water drainage from the 300-Foot Level portal flows to Mine Fork Creek upstream of its confluence with Kendrick Creek, which subsequently flows along the 300-Foot Level mine rock pile. Surface water samples collected during the ESI indicate that the drainage from the 300-Foot Level portal has the highest metal and radionuclide concentrations of surface water quality samples collected at the Site. Surface water, primarily associated with the drainage from the 300-Foot Level portal, 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. Water quality in Kendrick Creek below the confluence with Mine Fork Creek and the 300-Foot Level portal drainage, as documented in the SCR, meets Alaska water quality standards for all designated freshwater uses or is within the range of background surface water quality. While below applicable water quality standards or background, concentrations of certain metals and radionuclides in Kendrick Creek are higher adjacent to the 300-Foot Level mine rock pile primarily due to the 300-Foot Level portal drainage but decrease downstream in Kendrick Creek. According to stream classification information from the Tongass National Forest (USFS, 2008) and confirmed by the biological assessment conducted during the ESI (Tetra Tech, 2010), Kendrick Creek to below the 300-Foot Level is considered negligible spawning and rearing habitat for all salmonids due to the steep gradient and physical barriers. In lower reaches of Kendrick Creek, the habitat is physically more amenable to salmonid spawning and rearing. Although Kendrick Creek is not used as a drinking water supply, water quality in Kendrick Creek also meets Alaska water quality criteria for drinking water.

Due to the influence of the natural mineralization, an understanding of background conditions at the Site is critical to the assessment of human and ecological risks and the evaluation of removal action alternatives. As described in the SCR, 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. Due to the complex geologic conditions and the general enrichment (mineralization) of uranium, thorium and other rare metals in the Bokan Intrusive Complex at the Site, local background conditions are highly variable. This requires that different background levels be defined for select environmental media (e.g., soils, gamma radiation, radon) as various mine features are underlain by differing rock assemblages (mineralized versus non-mineralized). The Bokan Mountain Intrusive Complex is a circular stock of peralkaline granite approximately three kilometers in diameter surrounded by a metamorphic zone consisting of quartz monzonite and quartz diorite intrusive. Natural mineralization is exposed at the surface, to varying degrees, throughout the 900-Foot and 700-Foot Levels. Human health and ecological risks due to external gamma radiation, radon, and soil exposure pathways from naturally mineralized background conditions exceed acceptable risk levels. The OSA and 300-Foot Level are considered to be underlain by essentially non-mineralized bedrock.

In the SCR, 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 were used 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.

Similar to background gamma radiation, soil background levels were determined separately for mineralized and non-mineralized areas of the Site. While other media at the Site, including surface water and stream sediment, are also reflective of the natural mineralization, local background reference concentrations of metals and radionuclides were defined using data from sampling locations above the outcrop area of the Ross-Adams Mine and upstream of the mine feature areas. 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 were considered to be the best data available for evaluating background quality. These background samples likely underestimate the metal concentrations and radionuclide activities of surface water and stream sediment from the mineralized area prior to mining.

Human Health Risk Assessment (HHRA) Results

The HHRA was performed to evaluate potential risks to human receptors for exposure pathways associated with existing Site conditions based on current and future uses of the Site. Residential use of the Site is not allowed by the TNF Land and Resource Management Plan, and the preliminary risk screening is based on other uses of the Site. The HHRA included both a screening level human health risk assessment (SLRA) and a Site-specific human health risk assessment (SSRA). Figure ES-4 summarizes the results of the HHRA. The SLRA compared maximum Site concentrations of each analyte for the media to occupational screening levels to identify constituents of potential concern (COPCs). The default occupational parameters provide a very conservative screen compared to anticipated Site exposures. The screening levels included ingestion, dermal contact, inhalation, and external exposures for each media as appropriate. Based on the results of the SLRA the following COPCs were retained for the SSRA:

- Radon in Air
- Gamma Radiation
- Soil: Arsenic, Uranium, Th-232, Ra-228, Th-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210, Po-210
- Surface Water: Manganese, Uranium; Gross alpha, Gross beta, Ra-228, Ra-226, Th-228, Th-230, Po-210, U-234, U-235, U-238, Pb-210
- Stream Sediment: Th-232, Ra-228, U-234, U-235, U-238, Th-230, Ra-226, Pb-210
- Marine Sediment: Arsenic; Th-232, Ra-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210

Based on current and anticipated future uses of the Site, the SSRA evaluated existing risks to potential human receptors consisting of an area recreational visitor, a mineral exploration worker, an USFS worker, and an occasional subsistence hunting-gathering user using Site-specific exposure pathways and parameters. The area visitor was assumed to be present at the Site for 14 days per year for 30 years. The exposure frequency and duration are considered upper-bound estimates as the remote location and lack of facilities at the Site would likely limit the length of time an area visitor would spend at the Site. The area visitor was assumed to be exposed to Site media through incidental soil and sediment ingestion, dermal contact with soil and sediment, inhalation of particulates, external exposure to soil and sediment, ingestion of surface water, inhalation of radon, and gamma radiation exposure. Exposure parameters were selected to be representative of both child and adult exposures.

Exposure frequency and duration for the occupational worker receptors were 120 days/year for 3 years for the mineral exploration worker and 10 days/year for 25 years for the USFS worker. The occupational receptors were assumed to be exposed to Site media through incidental soil and sediment ingestion, dermal contact with soil and sediment, inhalation of particulates, external exposure to soil and sediment, inhalation of radon, and gamma radiation exposure. While the Site is not frequently used by communities in the region for hunting or fishing, the SSRA also considered the occasional subsistence hunting-gathering food pathway. Subsistence food pathways were evaluated for deer and local berries in the terrestrial subsistence scenario; and for seaweed, sea cucumbers and flounder in the marine environment.

The results of the HHRA demonstrate that estimated risks due to radiation exposure drive the overall human health risk at the Site. Figure ES-4 summarizes the results of the HHRA for exposure pathways and receptors with a risk greater than 1E-5 above background. A risk level of 1E-5 is defined as an excess probability of one in 100,000 of developing cancer over a lifetime due to exposure to mine-affected materials. Overall, pathways contributing the majority of risk to occupational and recreational users of the Site consist of external exposure to direct gamma radiation from mine rock and inhalation of radon decay products generated from mine rock and mine openings. Radon accounts for approximately 90 to 95 percent of the radiation risk, exclusive of background. The estimated potential lifetime risks due to radiation exposure for the area visitor and occupational workers range from 2E-3 to 4E-3. Risks for all other radionuclide and non-radionuclide (metals) exposure pathways to the mineral exploration or USFS worker were below 1E-5.

Under current conditions, ingestion of soil containing radionuclides at and adjacent to the mine rock piles could hypothetically pose a risk of 3E-5 for area visitors, but risks are below 1E-5 for the more likely occupational receptors. Surface water is also associated with a hypothetical risk of 2E-5 for area visitors if the drainage from the 300-Foot Level portal is used as a drinking water supply. Given that other surface water sources, such as Kendrick Creek or Cabin Creek are close to the shoreline and more accessible, it is not likely that drainage from the portal would be used as a drinking water supply. Again, the risk from surface water ingestion is due to combined ingestion of radionuclides.

Risks to the subsistence receptor assume that the entire annual intake of each food substance was harvested from the Site, fractionated for areal extent of mine-affected areas relative to the entire area available for subsistence activities at the Site. The total hypothetical risk to the subsistence receptor for all food substances was below 1E-5.

Risks to human receptors from radiation exposures to the natural background conditions in the mineralized area of the 700-Foot and 900-Foot Levels prior to mining were also estimated in the HHRA. While no pre-mining site background gamma exposure rate data are available for the Ross-Adams deposit, data from the I&L Zone provide a reasonable surrogate for pre-mining conditions in the mineralized area. 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 radiation levels of the Ross-Adams deposit were likely higher. The potential background risk from inhalation of radon decay products was calculated based on the maximum measured background radon concentration of 5.8 pCi/L. The estimated hypothetical lifetime risks for the area visitor and occupational workers due to background radiation exposure in the mineralized area range from 3E-4 to 6E-4. Approximately 30 percent of the total projected background risk is due to direct gamma exposure with inhalation of radon decay products accounting for nearly all of the remainder of the risk. Inhalation of radionuclides in airborne particulate matter and inadvertent soil ingestion contribute a small fraction of the total risk, less than two percent in all cases. Based on the projected exposure to background radiation in the naturally mineralized area, human health risks exceed 1E-5. Removal action alternatives would not reduce the human health risk to less than background levels.

Screening-Level Ecological Risk Assessment (SLERA) Results

The SLERA was performed to evaluate potential risks for exposure pathways to ecological receptors for terrestrial and aquatic environments, including freshwater and marine environments, based on existing Site conditions. Figure ES-5 summarizes the results of the SLERA for pathways, receptors and chemicals of concern with hazard quotients greater than one.

The Site is located within Alaska's Southeast Ecoregion and is comprised of subalpine, old growth western hemlock-spruce forest, marine intertidal, and marine subtidal habitats (Tetra Tech, 2010). No threatened and endangered (T&E) species are expected at the Site. The subalpine habitat is characterized by barren rock and plants adapted to the colder and windier environment. Subalpine vegetation 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.

The old-growth habitat is characteristically dominated by western hemlock and Sitka-spruce. Other common 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 and its tributaries drain through the forested area and is joined by Cabin Creek at the head of the West Arm of Kendrick Bay.

The marine intertidal zone is bounded by the low and high tides and occupies approximately 27 acres at the head of the West Arm of Kendrick Bay. The intertidal vegetative community includes many species of plants and algae including rockweed, eelgrass, sugar kelp, and bull kelp. Marine and estuarine invertebrates are common and include 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. Mink are present in the intertidal zone and black bear and Sitka black-tailed deer inhabit the perimeter of this zone. Many of these plant and animal species extend into the contiguous subtidal waters. Wildlife in the subtidal zone includes sea otter, harbor seal, gulls, and loons and a variety of fish and invertebrates.

Major components of the SLERA included problem formulation, characterization of exposure and effects, and characterization of risk for assessment endpoints. Assessment endpoints are parts of the ecosystem that are important either to the overall health of the ecosystem or to a component of the ecosystem that is of particular value. The assessment endpoints included indicator species that are representative of various functional avian and mammalian wildlife groups in the region and community receptors for the Site consisting of terrestrial plants, terrestrial soil invertebrates, stream surface water invertebrates and fish, stream benthic invertebrates, and marine benthic invertebrates. Eight avian and mammalian wildlife indicator species were selected for risk evaluation.

Potential risks to community receptors and wildlife indicator species are expressed as hazard quotients. Hazard quotients less than one indicate no potential risk and do not warrant further evaluation given the conservative assumptions used to derive estimates of exposure, toxicity and risk. In evaluating the hazard quotients that are greater than one, it is important to fully consider uncertainties, assumptions and other factors that contribute to the overall weight of evidence for the risk estimate and which should be considered in support of risk-management and Site-management decisions concerning removal action alternatives.

For terrestrial, stream and marine community receptors, the hazard quotient is expressed as the exposure point concentration (EPC) for metals and radionuclides in each exposure medium (soils, stream sediment, stream surface water, intertidal, and subtidal sediments) for Site exposure units divided by a media-specific ecological benchmark. Potential exposures to constituents of potential ecological concern (COPECs) by wildlife indicator species was based on chemical intake via consumption of food or water and by incidental ingestion of soil or sediment while foraging. Dietary concentrations of COPECs were estimated from EPCs in soil, sediment and or water based on bioaccumulation models. Potential risk to wildlife species are based on an estimated dose derived from EPCs divided by a toxicity reference value expressed as a No Observed Adverse Effects Level (NOAEL) or Lowest Observed Adverse Effects Level (LOAEL). For radionuclides, the hazard quotient for aquatic animal and riparian animal receptors is calculated from the daily dose rate divided by recommended daily dose limits for each receptor group.

As summarized in Figure ES-5, hazard quotients for six metals (cobalt, manganese, cadmium, lead, uranium and zinc) exceed one for terrestrial plants, soil invertebrates or terrestrial wildlife. However, hazard quotients are often in the low range (2 to 5) and dominated by a few samples in localized areas. Hazard quotients for trace metals in stream surface water, stream sediment, and marine sediment were not significantly elevated for either the community receptors or indicator wildlife species in these habitats. Hazard quotients for radionuclides (Ra-226 and Ra-228) were elevated for terrestrial plants and wildlife, and nominally for cumulative risk to stream-dependent riparian wildlife. For terrestrial plants and animals, exposure point concentrations and hazard quotients for Ra-226 and Ra-228 are higher at the 700-

Foot/900-Foot Levels within the mineralized area in comparison to the 300-Foot Level and OSA within the non-mineralized area. Radium activity in soil and exposure to terrestrial plants and animals also appears to be correlated with soil concentrations of manganese and zinc. Based on the hazard quotients and weight of evidence, potential risks are not expected for stream aquatic-dependent wildlife indicator species, intertidal and subtidal aquatic-dependent wildlife receptors, and intertidal and subtidal community receptors.

For terrestrial community receptors, hazard quotients exceeded one for two metals (manganese and zinc) in plants or soil invertebrates at the 700-Foot/900-Foot Levels and at the 300-Foot Level. The hazard quotient also exceeded one for cobalt only in plants at the 300-Foot Level. The hazard quotient for cobalt in plants is marginally elevated above one and is based on an EPC that is only incrementally above background. For soil invertebrates, zinc is the only metal with a hazard quotient greater than one and with incremental risks greater than background. The hazard quotients for manganese and zinc are associated with locally elevated soil concentrations and appear to be correlated with Ra-226 and Ra-228 concentrations. Hazard quotients exceeded one for Ra-226 in terrestrial plants at the 900-Foot/700-Foot Level.

For terrestrial wildlife indicator species consisting of the dark-eyed junco, American robin, and masked shrew, hazard quotients based on comparisons to LOAELs exceeded one for three metals (lead, uranium, zinc) at the 700-Foot/900-Foot Level, two metals (cadmium and lead) at the 300-Foot Level, and one metal (lead) at the OSA. Hazard quotients for exposure to Ra-226 and Ra-228 for terrestrial animals exceeded one at the 700-Foot/900-Foot Level, the 300-Foot Level, and the OSA. At the 700-Foot/900-Foot Level, lead hazard quotients range from three to six for dark-eyed junco and American robin respectively. However, the EPC for lead is less than the maximum background concentration, and only one of 20 soil samples exceeds the 95 percent upper prediction limit (95UPL) background concentration. This indicates that the potential risk from lead is localized to the area of the maximum concentration, and lead is not expected to pose an area-wide risk at the 700-Foot/900-Foot Level. Likewise, only the maximum concentration of uranium and zinc results in a LOAEL hazard quotient greater than one for the American robin, and therefore the potential risk from uranium and zinc is expected to be localized around the area of the maximum concentration. At the 300-Foot Level, LOAEL hazard quotients for lead range from two to four for the dark-eyed junco and American robin. The majority of soil samples have lead concentrations above background indicating that exposure and risk is more evenly distributed at the 300-Foot Level. The cadmium hazard quotient for the masked shrew is two at the 300-Foot Level and appears to be localized in the vicinity of three sample locations. At the OSA, the lead hazard quotient for the American robin is dominated by two soil sampling locations within the mine-affected area. Consequently, risk attributed to lead appears to be highly localized within the mine-affected area at the OSA.

For stream community receptors, the risk to aquatic and riparian animals in surface water and stream sediments is below levels of concern for individual chemicals and exposure pathways at the Site and in background areas. However, the hazard quotient for cumulative exposure to Ra-226 and Ra-228 in combined surface water and stream sediments for riparian animals is nominally two (rounded up from 1.7) at the 700-Foot/900-Foot Level and at the 300-Foot Level.

Site-wide hazard quotients for cumulative exposure did not exceed one. Risks at the 700-Foot/900-Foot Level and 300-Foot Level are localized due to elevated concentrations in a few sample locations and are dominated by surface water exposure.

EE/CA

The EE/CA identifies and provides detailed analysis of viable removal action alternatives that address potential human health and ecological risks due to mine-affected areas associated with historic mining activities at the Site. The EE/CA:

- Defines removal action objectives (RAOs) and removal action goals (RAGs) pertinent to Site-specific conditions that address the identified exposure pathways and risks for existing conditions defined by the human health and ecological risk assessments and defines potential applicable or relevant and appropriate requirements (ARARs) for the removal action alternatives;
- Screens removal action technologies and general response actions that are potentially applicable to the Site;
- Identifies detailed Site-specific removal action alternatives retained from the screening of removal action technologies;
- Performs detailed analysis of the Site-specific removal action alternatives based on the evaluation criteria of effectiveness, implementability and cost;
- Provides a comparative analysis to evaluate the relative advantages and disadvantages of the removal action alternatives.

Based on the results of the HHRA and SLERA and the evaluation of ARARs, the following RAOs were defined:

- Reduce risk for recreational users and occupational workers from exposure to direct gamma radiation from mine rock and mine openings;
- Reduce risk for recreational users and occupational workers from exposure due to inhalation of radon decay products from mine rock and mine openings;
- Reduce risk for recreational users from exposure due to potential ingestion of soil from the mine rock piles and potential ingestion of surface water drainage from the 300-Foot Level portal;
- Reduce or eliminate safety hazards related to the mine openings and access to the underground mine workings;
- Reduce risk or eliminate exposure pathways for terrestrial plants, terrestrial invertebrates, terrestrial wildlife from exposure to metals and radionuclides defined as constituents of concern in mine rock and soil associated with mine-affected areas via direct contact, ingestion, and food-chain exposure;
- Reduce risk or eliminate exposure pathways for riparian animals from exposure to radium in surface water at the 700-Foot/900-Foot Levels and the drainage from the 300-Foot Level portal.

In addition, the following RAOs were identified based on land-use management plans for the Site and vicinity:

- Minimize disturbance to existing undisturbed areas;
- Minimize reliance on long-term active maintenance.

Quantitative preliminary removal action goals (RAGs) were established to address these RAOs. For evaluating the effectiveness of the removal action, these goals are expressed in terms of reducing the identified risks or eliminating the exposure pathways to human and ecological receptors. The overall goal of the removal action is to reduce human and ecological risk that is attributable to the mine-affected areas to an acceptable level. The primary goals are to:

- Reduce risk for recreational users and occupational workers from exposure to radon inhalation and direct gamma radiation attributable to mine rock and mine openings above background on a Site-wide basis to below the EPA excess dose criterion of 15 mrem/year or a cancer risk of less than 1E-5 above background.
- Reduce risks for terrestrial plants, invertebrates, and wildlife from exposure to metals and radionuclides defined as constituents of concern in mine rock and soil in mine-affected areas, and for riparian animals from exposure to radium in surface water to an acceptable risk-based level (defined as a HQ less than one) above background.

The EE/CA identified, evaluated, and screened potentially applicable technologies for reducing identified human health and ecological risks posed by the mine-affected areas of the Site. The applicable technologies were then assembled into candidate removal action alternatives. Five removal action alternatives for mine rock areas and four removal actions for mine portals were evaluated. These alternatives represent well established and proven technologies that have been implemented at similar uranium mine sites to address similar conditions.

The removal action alternatives for mine rock include:

- Alternative M-1 – No Action
- Alternative M-2 – In-Place Stabilization with Stormwater and Institutional Controls
- Alternative M-3 – In-Place Covering of Mine Rock Piles
- Alternative M-4 – Excavation, Consolidation and Cover at Mine Affected Areas
- Alternative M-5 – Excavation, Consolidation and Cover at Open Pit Repository

The removal action alternatives for mine portals include:

- Alternative P-1 – No Action
- Alternative P-2 – Close Upper Mine Openings with 300-Foot Level Portal Gate
- Alternative P-3 – Close Upper Mine Openings with 300-Foot Level Portal Rock Backfill Closure
- Alternative P-4 – Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead

Tables ES-1a and ES-1b provides a description of each alternative with respect to the individual mine features. All the mine portal alternatives are compatible with and could be implemented independently from the mine rock alternatives; except that mine rock consolidation in the Open Pit for Mine Rock Alternatives M-4 and M-5 would require closure of the 900-Foot Level portal.

In accordance with EPA guidance (EPA, 1993a), the above alternatives were individually evaluated against three main evaluation criteria: effectiveness, implementability, and cost. A comparative analysis of the alternatives was performed using the three evaluation criteria to assess the relative advantages and disadvantages of the removal action alternatives. The results of the comparative analysis are used to identify key tradeoffs among alternatives and determine the alternative that best satisfies the evaluation criteria. The results of the comparative analysis are summarized in Tables ES-2 and ES-3.

Alternative 1 (No Action) for both mine rock and mine portals would not be protective of human health and the environment and would not be effective in achieving the RAOs. Mine Rock Alternative M-2 would require institutional and/or access controls to be protective of human health, but may not be protective of ecological receptors. Portal Alternatives P-2 and P-3 also would require institutional and/or access controls to be protective of human health. The remaining alternatives would be protective of human health and the environment and effective in achieving RAOs and ARARs. Institutional controls consisting of land use and access restrictions, including installation of signs and barriers, would be required for all alternatives to protect the integrity of implemented removal action.

All alternatives are considered to be implementable. The total costs, including direct and indirect capital costs and monitoring and maintenance (M&M) costs are summarized in Tables ES-2 and ES-3. There are no costs associated with Alternative 1 (No Action) since no construction or M&M would be implemented. The total estimated costs for Mine Rock Alternatives M-2, M-3, M-4, and M-5 are approximately $1,427,000, $3,986,000, $3,592,000, and $6,373,000, respectively. The total estimated costs for Mine Portal Alternatives P-2, P-3, and P-4 are approximately $724,000, $813,000, and $864,000, respectively.

Based on the detailed individual evaluation and comparative analysis of the removal action alternatives, the combination of Mine Rock Alternative M-5 and Mine Portal Alternate P-4 best satisfies the evaluation criteria. These alternatives are protective of human health and the environment in reducing or eliminating the exposure pathways and risks identified by the HHRA and the SLERA. Both alternatives are effective in reducing incremental radiation risks due to external gamma radiation and inhalation of radon decay products associated with mine rock and the inhalation of radon decay products associated with the mine openings. In addition, both alternatives are effective in eliminating or substantially reducing the exposure pathways to constituents of concern in mine rock and soil in mine-affected areas for terrestrial plants, invertebrates and wildlife and to radium concentrations in surface water for riparian animals. The alternatives achieve the identified RAOs and RAGs, and comply with potential ARARs. However, the alternatives will not eliminate the Site-wide risk to human health, as radiation risks from background gamma radiation and radon in the naturally mineralized area exceed the acceptable human health risk criterion.

Mine Rock Alternative M-5 includes the following components:

- Removal of ore rock within the intertidal zone associated with former loading ramps and ore loading operations and consolidation at the Open Pit Repository;
- Removal of the miscellaneous solid waste and debris and transport for off-site recycling and disposal, except for drill core that would be consolidated at the Open Pit Repository;
- Excavating, transporting and consolidating the mine-affected material from the OSA, and the mine rock piles from the 300-Foot Level; 700-Foot Level, and 900-Foot Level (North and South piles) at the Open Pit Repository;
- Excavating and consolidating the I&L Spur road materials in the Open Pit and closing the road;
- Removing and consolidating the identified mine road (between the 700-Foot and 900-Foot Levels) embankments in the Open Pit and closing the mine road;
- Excavating the mine rock from the identified segments of the haul road and consolidating the material in the Open Pit;
- Placing a 2-foot thick cover over a synthetic geomembrane on the mine rock materials consolidated at the Open Pit Repository from the on-site borrow source and constructing stormwater controls to protect the covered areas; and
- Implementing institutional controls, access controls, and/or land use restrictions to protect the integrity of the removal action.

Portal Alternative P-4 consists of the following components:

- Closure of the upper mine openings consisting of the 900-Foot Level portal, Air Vent Shaft and 700-Foot Level portal;
- Constructing a concrete bulkhead at the 300-Foot Level portal, with a water collection and piping system to convey the drainage from the portal directly to Kendrick Creek; and
- Implementing institutional controls, access controls, and/or land use restrictions to protect the integrity of the portal closures.

The primary factors that result in selection of Mine Rock Alternative M-5 and Mine Portal Alternative P-4 as the recommended removal action include:

- Mine Rock Alternative M-5 will be effective in achieving the RAOs for the removal action areas, including reducing the predicted dose to less than 15 mrem/year and the risk to less than 1E-5 above background for occupational workers and recreational users of the Site;
- Mine Rock Alternative M-5 will provide permanent containment of the mine-affected materials by consolidating mine rock and mine-affected materials in the Open Pit Repository, reducing the overall mine rock footprint and requiring less cover material;
- Mine Rock Alternative M-5 will remove the more easily accessible OSA materials near the shoreline of the West Arm of Kendrick Bay, significantly reducing human health exposures to gamma radiation and radon for site visitors and occupational workers;

- Mine Rock Alternative M-5 would remove the 300-Foot Level mine rock pile located in the relatively steep area adjacent to Kendrick Creek, eliminating potential concerns with the long-term geotechnical and erosional stability and permanence of the 300-Foot Level mine rock pile;
- Mine Rock Alternative M-5 will return all mine rock and mine-affected materials to the Open Pit Repository where the characteristics of the materials are consistent with the naturally mineralized area and where the flatter topography is more suitable for long-term mine rock containment and cover stability;
- Mine Rock Alternative M-5 will reduce the gamma and radon emanation at the cover surface of the Open Pit Repository by placing the lower gamma activity material from the 300-Foot Level mine rock pile over higher gamma activity mine rock;
- Mine Rock Alternative M-5 will allow closure of the I&L Spur road, the haul road to the 300-Foot Level, and the mine road from the 700-Foot Level to the 900-Foot Level, reducing human access to the 300-Foot and 700-Foot Levels;
- Mine Rock Alternative M-5 will require that institutional and access controls and/or land use restrictions be implemented at only one isolated location, where access to the 900-Foot Level is already limited compared to other areas of the Site;
- Mine Rock Alternative M-5 will consolidate mine rock and place a cover on the Open Pit, reducing the inflow of water into the underground mine via the 900-Foot Level portal; thereby reducing drainage from the 300-Foot Level portal;
- Portal Alternative P-4 will significantly reduce radon exhalation from the mine openings, significantly reducing the human health exposure pathway and risk due to inhalation of radon decay products from the mine openings;
- Portal Alternative P-4 has the least uncertainty of alternatives in achieving the RAOs for protection of human health and the environment by significantly reducing radon exhalation from the mine openings;
- Portal Alternative P-4 will reduce human and ecological pathways associated with direct contact with the drainage water by collecting and piping the 300-Foot Level portal drainage to Kendrick Creek;
- Portal Alternative P-4 will eliminate the potential for water drainage from the 700-Foot Level portal.

The total estimated cost of the recommended removal action consists of the combined cost of Mine Rock Alternative M-5 and Portal Alternative P-4 of approximately $7,237,000. Depending on the construction force, including the availability of personnel and equipment, the recommended removal action could potentially be completed in two construction seasons. Two construction seasons would likely be required to complete Mine Rock Alternative M-5 due to logistical challenges associated with sequencing of multiple construction activities, including removing mine materials and rehabilitation of the existing haul and mine roads, excavating, transporting and consolidating mine rock, and transporting and placing cover materials using the same roads.

Table ES-1a. Summary of Removal Action Alternatives for Mine Rock

Alternative	Area of Site	Process Options Included
Alternative M-1 **No Action**	All	Present conditions remain at Site, with no measures to reduce risk or monitor conditions
Alternative M-2 **In Place Stabilization and Stormwater and Institutional Controls**	900-Foot, 700-Foot, and 300-Foot Levels Mine Rock	Regrade and stabilize mine rock adjacent to stream channels, and implement stormwater controls to minimize run-on. Regrade mine rock piles where necessary for construction of stormwater controls.
	900-Foot Level Open Pit	Enhance existing or implement additional stormwater controls to minimize run-on into pit.
	Ore Staging Area	Implement stormwater controls to minimize run-on and enhance natural vegetation development.
	Mine and Haul Roads	No action – materials are presently stable
	I&L Spur Road	No action – materials are presently stable
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Localized removal of ore from intertidal zone near ore loading ramps for consolidation (common element to all alternatives) in the OSA.
	Miscellaneous Wastes & Debris	Removal with off-site disposal (common element to all alternatives).
Alternative M-3 **Cover in Place**	900-Foot, 700-Foot, and 300-Foot Levels Mine Rock	Cover following regrading of mine rock to isolate mine rock with earthen cover (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on.
	900-Foot Level Open Pit	Enhance existing or implement additional stormwater controls to minimize run-on into pit.
	Ore Staging Area	Cover to isolate OSA with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on.
	Mine and Haul Roads	Excavate 1 foot of material in identified Mine Road and Haul Road segments, and replace with 1 foot of borrow material (sourced on-site from Kendrick Creek delta).
	I&L Spur Road	Remove road materials and consolidate at 900-Foot Level North mine rock pile. Close road to preclude vehicle access.
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Same as Alternative M-2 - Localized removal of ore from intertidal zone near ore loading ramps for consolidation in the OSA or 300-Foot Level Mine Rock Pile.
	Miscellaneous Wastes & Debris	Same as Alternative M-2 - Removal with off-site disposal (common element to all alternatives).

Table ES-1a. Summary of Removal Action Alternatives for Mine Rock (Continued)

Alternative	Area of Site	Process Options Included
Alternative M-4 **Excavation, Consolidation, and Cover at Mine Affected Areas**	900-Foot and 700-Foot Levels Mine Rock	Excavate and consolidate mine rock in 900-Foot Level Open Pit, and cover with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation.
	900-Foot Level Open Pit	Cover consolidated mine rock and road materials with synthetic geomembrane and earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	Ore Staging Area	Excavate and consolidate mine rock at 300-Foot Level cover with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation.
	300-Foot Level Mine Rock	Cover consolidated mine rock and OSA with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	Mine and Haul Roads	Mine Road (900-Foot Level to 700-Foot Level) - Remove materials from identified mine road embankments and road surface, consolidate and cover in 900-Foot Level Open Pit, and close road to preclude access. Haul Road (900-Foot Level to intersection with south Haul Road) - Remove materials from identified road segments, replace with borrow (sourced on-site from Kendrick Creek delta), and consolidate and cover in 900-Foot Level Open Pit. Haul Road (300-Foot Level to OSA) - Remove materials from identified road segments, replace with borrow (sourced on-site from Kendrick Creek delta), and consolidate and cover at 300-Foot Level or 900-Foot Level Open Pit.
	I&L Spur Road	Remove road materials and consolidate in 900-Foot Level Open Pit, and close road to preclude vehicle access.
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Same as Alternative M-2 - Localized removal of ore from intertidal zone near ore loading ramps for consolidation at the 300-Foot Level.
	Miscellaneous Wastes & Debris	Same as Alternative M-2
Alternative M-5 **Excavation, Consolidation in Open Pit Repository at 900-Foot Level**	900-Foot, 700-Foot, and 300-Foot Levels Mine Rock	Excavate and consolidate mine rock in 900-Foot Level Open Pit Repository, cover with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	900-Foot Level Open Pit	Cover consolidated mine rock and road materials with synthetic geomembrane and earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation and reduce infiltration. Construct stormwater controls to minimize run-on and concentrated runoff.
	Ore Staging Area	Excavate and consolidate mine-affected material in 900-Foot Level Open Pit Repository, cover with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	Mine and Haul Roads	Mine Road (900-Foot Level to 700-Foot Level) - Remove materials from identified mine road embankments and road surface, consolidate and cover in 900-Foot Level Open Pit Repository, and close road to preclude vehicle access. Haul Road (300-Foot Level to intersection with north Haul Road) - Remove materials from identified road segments, consolidate and cover in 900-Foot Level Open Pit Repository, and close road to preclude vehicle access Haul Road (OSA to 900-Foot Level) - Remove materials from identified road segments, replace with borrow (sourced on-site from Kendrick Creek delta), consolidate and cover in 900-Foot Level Open Pit Repository.
	I&L Spur Road	Remove road materials and consolidate in 900-Foot Level Open Pit Repository, and close road to preclude vehicle access following material removal
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Same as Alternative M-2 - Localized removal of ore from intertidal zone near ore loading ramps for consolidation in 900-Foot Level Open Pit Repository
	Miscellaneous Wastes & Debris	Same as Alternative M-2

Table ES-1b. Summary of Removal Action Alternatives for Portals

Alternative Name	Area of Site	Process Options Included
Alternative P-1 **No Action**	900-Foot Level Portal, 900-Level Vent Shaft, 700-Foot Level Portal, 300-Foot Level Portal	Present conditions remain at portals, with no measures to reduce risk or monitor conditions
Alternative P-2 **Close Upper Mine Openings and Gate at 300-Foot Level Portal**	900-Foot Level Portal, 900-Foot Level Vent Shaft, 700-Foot Level Portal	Close upper mine openings to reduce air entry into underground mine. Would allow water drainage of Open Pit and water inflow into underground mine via 900-Foot Level Portal (common element to all alternatives)
	300-Foot Level Portal	Install Gate to prevent human access, air exhalation significantly reduced by eliminating air entry by closure of upper mine openings, and water outflow would still occur. Outflow could be piped directly to Kendrick Creek.
Alternative P-3 **Close Upper Mine Openings and Rock Backfill at 300-Foot Level Portal**	900-Foot Level Portal, 900-Foot Level Vent Shaft, 700-Foot Level Portal	Same as Alternative P-2
	300-Foot Level Portal	Backfill portal with aggregate or mine rock to prevent access, reduce air outflow and radon exhalation, and construct engineered outflow structure to pipe portal drainage directly to Kendrick Creek.
Alternative P-4 **Close upper Mine Openings and Concrete Bulkhead at 300-Foot Level Portal**	900-Foot Level Portal, 900-Foot Level Vent Shaft, 700-Foot Level Portal	Same as Alternative P-2
	300-Foot Level Portal	Install concrete bulkhead to prevent access, eliminate air outflow and radon exhalation, and construct engineered outflow structure to pipe portal drainage directly to Kendrick Creek.

Table ES-2. Summary Evaluation of Removal Action Alternatives for Mine Rock

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
EFFECTIVENESS					
Protection of human health and the environment	Would not achieve RAOs. Not protective of human or ecological receptors. Institutional and/or access controls required for all mine-affected areas.	Would not achieve all RAOs. Not protective of human or ecological receptors, except within intertidal zone due to removal of spilled ore at former loading docks. Protection of human health is dependent on implementing institutional and/or access controls. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Reduces riparian animal exposure by removing and stabilizing mine rock piles adjacent to stream channels. Institutional and/or access controls required for all mine-affected areas.	Would achieve RAOs for mine rock piles and OSA, but not for Open Pit unless institutional and/or access controls are implemented. Protective; covering of mine rock piles at OSA, and 300-Foot, 700-Foot and 900-Foot Levels significantly reduces exposure pathways from surface mine rock materials and reduces exposure from radon emanation and external gamma radiation for human receptors. Significantly reduces ecological exposure pathways to mine rock piles. Covering mine rock piles eliminates or substantially reduces the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife, and reduces potential exposure pathway for riparian animals. Would not reduce radiation risks for human and ecological receptors associated with Open Pit. Institutional and/or access controls required for protection of human health. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Reduces human and ecological exposure pathways to haul roads and mine roads by excavating one-foot of mine rock and replacing with clean material in identified haul and mine road segments; thereby isolating remaining mine rock by covering. Institutional and/or access controls required for covered areas, including Open Pit.	Would achieve RAOs. Protective; mine rock removal significantly reduces human and ecological risk at OSA, mine road mine rock, and at 700-Foot Level and 900-Foot Level mine rock piles. Mine rock consolidation and cover placement at 300-Foot Level and Open Pit reduces exposure pathways from surface mine rock materials and reduces radon emanation and external gamma radiation for human receptors. Significantly reduces exposure pathways from mine rock piles to ecological receptors. Covering mine rock at 300-Foot Level and Open Pit eliminates or substantially reduces the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife, and reduces potential exposure pathway for riparian animals. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Significantly reduces human and ecological exposure pathways by removal of mine rock and closing of mine road from 700-Foot to 900-Foot Levels and I&L Spur road. Reduces human and ecological exposure pathways to haul roads by excavating one-foot of mine rock and replacing with clean material in identified haul road segments; thereby isolating remaining mine rock by covering. No institutional and/or access controls required at OSA and mine rock piles at 700-Foot and 900-Foot Levels. Institutional and/or access controls required for covered areas at 300-Foot Level and the Open Pit.	Would achieve RAOs. Protective; mine rock removal significantly reduces human and ecological risk at OSA and at 300-Foot Level, 700-Foot Level and 900-Foot Level mine rock piles. Mine rock consolidation and cover placement at Open Pit reduces exposure pathways from surface mine rock materials and reduces radon emanation and external gamma radiation for human receptors. Significantly reduces exposure pathways from mine rock to ecological receptors. Covering mine rock at Open Pit eliminates or substantially reduces the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife, and reduces potential exposure pathway for riparian animals. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Significantly reduces human and ecological exposure pathways by removal of mine rock and closing of mine road from 700-Foot to 900-Foot Levels, I&L Spur road, and haul road from OSA to 300-Foot Level, and removal of mine rock from identified haul road segments from OSA to 900-Foot Level. No institutional and/or access controls required for mine rock at OSA, and at 300-Foot, 700-Foot, and 900-Foot Levels. Institutional and/or access controls required for covered area at the Open Pit.
Ability to achieve ARARs	Would not comply with potential chemical-specific ARARs defining acceptable risk for human and ecological receptors. The alternative would not comply with Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E 5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would not comply with potential chemical-specific ARARs defining acceptable risk for human and ecological receptors. The alternative would not comply with chemical-specific ARARs, including Alaska regulations (18 AAC 75) which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is 1E-4 to 1E-6 for radionuclides.	Would comply with potential ARARs. On-Site activities associated with removal of ore rocks from loadout ramps and on-site Kendrick Creek delta borrow source within intertidal zone may be subject to substantive requirements of the State of Alaska permitting programs.	Would comply with potential ARARs. On-Site activities associated with removal of ore rocks from loadout ramps and on-site Kendrick Creek delta borrow source within intertidal zone may be subject to substantive requirements of the State of Alaska permitting programs.	Would comply with potential ARARs. On-Site activities associated with removal of ore rocks from loadout ramps and on-site Kendrick Creek delta borrow source within intertidal zone may be subject to substantive requirements of the State of Alaska permitting programs.

Table ES-2. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
Short-term effectiveness	No short-term impacts.	Short term impacts may include radiation exposure and erosion during grading operations. Regrading mine rock and placing rock protection adjacent to stream channels increases the potential for erosion during construction activities. Regrading of the mine rock piles may also increase the potential for leaching of metal and radionuclide constituents from the mine rock. While mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in stormwater runoff from the mine rock piles during and following construction. Potential risks could be managed by implementing worker safety measures and appropriate stormwater and erosion control measures.	Short term impacts may include radiation exposure, dust generation and erosion during grading operations. Removal of existing vegetation at 300-Foot Level and OSA mine rock piles required for regrading, which may increase short-term potential for erosion. Short-term impacts associated with on-site borrow material excavation, transport, and cover placement. Existing haul roads would require rehabilitation following mine rock removal in identified haul road segments for cover material transport, potentially resulting in short-term increase in erosion and dust generation during road rehabilitation and material transport. Regrading of the mine rock piles may increase the potential for leaching of metal and radionuclide constituents from the mine rock during construction prior to cover placement. Regrading may also increase the potential for erosion and sediment transport during construction. While mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in stormwater runoff from the mine rock piles prior to cover placement. Potential risks could be properly managed by implementing worker safety measures and appropriate dust and stormwater erosion control measures.	Short term impacts may include radiation exposure, dust generation and erosion during mine rock excavation, transport and consolidation. Also potential for spill or release during mine rock transport. Removal of existing vegetation at 300-Foot Level and OSA mine rock piles required, which would increase short-term potential for erosion. Short-term impacts associated with on-site borrow material excavation, transport, and cover placement. Existing haul roads would require rehabilitation following mine rock removal in identified haul road segments for transport of mine rock and cover material, potentially resulting in short-term increase in erosion and dust generation during road rehabilitation and material transport. Backfilling the Open Pit may increase the potential for leaching of metal and radionuclide constituents from the mine rock. While the mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in the drainage from the 300-Foot Level Portal for some time period. Leaching of the mine rock and potential effects on the 300-Foot Level Portal drainage would be significantly reduced by the synthetic geomembrane installed as part of the cover. Potential risks could be properly managed by implementing worker safety measures and appropriate dust and stormwater erosion control measures.	Short term impacts may include radiation exposure, dust generation and erosion during mine rock excavation, transport and consolidation. Also potential for spill or release during mine rock transport. Removal of existing vegetation required at 300-Foot Level mine rock pile and at OSA, which would increase short-term potential for erosion. Short-term impacts associated with on-site borrow material excavation, transport, and cover placement. Existing haul roads would require rehabilitation following mine rock removal in identified haul road segments for cover material transport, potentially resulting in short-term increase in erosion and dust generation during material transport. Backfilling the Open Pit may increase the potential for leaching of metal and radionuclide constituents from the mine rock. While the mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in the drainage from the 300-Foot Level Portal for some time period. Leaching of the mine rock and potential effects on the 300-Foot Level Portal drainage would be significantly reduced by the synthetic geomembrane installed as part of the cover. Potential risks could be properly managed by implementing worker safety measures and appropriate dust and stormwater erosion control measures.

Table ES-2. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
Long-term effectiveness and permanence	Not effective and permanent. Risks to human and ecological receptors remain unchanged.	Somewhat effective and permanent, but would not reduce existing human or ecological exposure to surface mine rock materials, or radon emanation and external gamma radiation from mine rock piles and Open Pit. Would rely on institutional and/or access controls to reduce human exposures. Removal of spilled ore rocks from former loading docks eliminates risk to human receptors within the intertidal zone, and removing and stabilization of mine rock piles adjacent to stream channels reduces exposure to riparian animals. Regrading mine rock piles adjacent to stream channels and stormwater controls would increase pile stability and reduce potential for erosion of mine rock. Stormwater controls would reduce run-on into Open Pit; reducing inflow into underground mine, but stormwater intercepted by Open Pit would still be conveyed to underground mine.	Effective and permanent for reducing risks from mine rock to human and ecological receptors. Isolates mine rock with cover and reduces radon emanation and external gamma radiation. Radon and gamma radiation from Open Pit would remain unchanged. Would rely on institutional and/or access controls to reduce human exposures to radiation risks from Open Pit. Stormwater controls would reduce run-on into Open Pit; thereby reducing inflow into underground mine. Stormwater intercepted by Open Pit would still be conveyed to underground mine.	Effective and permanent for reducing risks from mine rock to human and ecological receptors. Isolates mine rock with covers at the 300-Foot Level and Open Pit, and reduces radon emanation and external gamma radiation from mine rock, including that occurring from the Open Pit. Human health and ecological risks due to mine rock piles at OSA, 700-Foot and 900-Foot Levels would be significantly reduced or eliminated. Cover on Open Pit reduces radon emanation and external gamma radiation from Open Pit. Reduces mine rock and cover footprint. Stormwater controls and cover, which includes synthetic geomembrane barrier, reduces water infiltration into Open Pit; thereby reducing potential for leaching of the mine rock, water inflow into underground mine, and drainage from the 300-Foot Level Portal.	Effective and permanent for reducing risks from mine rock to human and ecological receptors. Isolates mine rock with cover at the Open Pit, and reduces radon emanation and external gamma radiation from mine rock, including that occurring from the Open Pit. Human health and ecological risks due to mine rock piles at OSA, 300-Foot, 700-Foot and 900-Foot Levels would be significantly reduced or eliminated. Cover on Open Pit reduces radon emanation and external gamma radiation from Open Pit. Consolidates all mine rock in Open Pit area within naturally mineralized area and radiological characteristics of mine rock are consistent with naturally mineralized area. Minimizes mine rock and cover footprint. Stormwater controls and cover, which includes synthetic geomembrane barrier, reduces water infiltration into Open Pit; thereby reducing potential for leaching of the mine rock, water inflow into underground mine, and drainage from the 300-Foot Level Portal.
Reduction of toxicity, mobility, or volume through treatment	No reduction of toxicity, mobility, or volume would be achieved. No treatment provided.	No reduction of toxicity or volume would be achieved. Limited reduction in mobility due to stormwater controls and pile grading. No treatment provided.	No reduction of toxicity or volume would be achieved. Reduction in mobility due to physical isolation of mine rock and reduction in radon emanation and external gamma radiation by cover. No treatment provided.	No reduction of toxicity or volume would be achieved. Reduction in mobility due to physical isolation of mine rock and reduction in radon emanation and external gamma radiation by cover. No treatment provided.	No reduction of toxicity or volume would be achieved. Reduction in mobility due to physical isolation of mine rock and reduction in radon emanation and external gamma radiation by cover. No treatment provided.

Table ES-2. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
IMPLEMENTABILITY					
Technical feasibility/constructability	No construction required.	Removal action components are readily constructible. Enhanced erosion and sediment controls required to protect intertidal zone during removal of spilled ore rock at former ore loading ramps. Regrading of mine rock piles necessary in some locations to provide access for stormwater controls. Enhanced erosion and sediment controls also required during regrading of mine rock piles due to wet climate.	Removal action components are readily constructible. Requires regrading of piles to achieve acceptable geotechnical slope and surface stability for cover placement. Minimum 3H:1V sideslopes required for cover slope stability based on available information. Need to verify suitability of the type and properties of on-site borrow material available within the intertidal zone of the Kendrick Creek delta for cover construction. Enhanced erosion and sediment controls required to protect intertidal zone during borrow material excavation and excavation would be sequenced with low tide. Improvements to existing haul roads for equipment access and cover material transport is feasible, but requires enhanced erosion and sediment controls. Enhanced erosion and sediment controls also required due to wet climate.	Removal action components are readily constructible. Requires regrading of piles to achieve acceptable geotechnical and surface stability for cover placement. Minimum 3H:1V sideslopes required for cover slope stability based on available information. Need to verify suitability of the type and properties of on-site borrow material available within the intertidal zone of the Kendrick Creek delta for cover construction. Enhanced erosion and sediment controls required to protect intertidal zone during borrow material excavation and excavation would be sequenced with low tide. Need to verify volume of OSA materials to be excavated for consolidation, as capacity available at 300-Foot Level mine rock pile is limited. If additional volume of material excavation is required and exceeds volume that can be consolidated at 300-Foot Level, material could be consolidated at Open Pit. Improvements to existing haul roads for equipment and transport of mine rock and cover material is feasible, but requires enhanced erosion and sediment controls. Enhanced erosion and sediment controls also required due to wet climate.	Removal action components are readily constructible. Need to verify suitability of the type and properties of on-site borrow material available within the intertidal zone of the Kendrick Creek delta for cover construction. Enhanced erosion and sediment controls required to protect intertidal zone during borrow material excavation and excavation would be sequenced with low tide. Need to verify volume of OSA materials to be excavated, but Open Pit consolidation not sensitive to uncertainty in OSA material quantity. Improvements to existing haul roads for equipment and transport of mine rock and cover material is feasible, but requires enhanced erosion and sediment controls. Enhanced erosion and sediment controls also required due to wet climate.
M&M requirements	No M&M required.	Inspections will be performed annually for the first three years and every five years thereafter for 30 years to confirm stability of regraded mine rock piles and stormwater controls, and any necessary maintenance and are readily implementable.	Inspections of mine rock pile covers, stormwater controls, and any necessary maintenance will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Inspections and any necessary maintenance would be required at multiple locations.	Inspections of mine rock pile covers, stormwater controls, and any necessary maintenance will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Inspections and any necessary maintenance would be required at reduced number of locations.	Inspections of Open Pit cover, stormwater controls, and any necessary maintenance will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Inspections and any necessary maintenance would be required at only one location.
Reliability and performance	Not applicable.	Stormwater controls are proven and reliable. Institutional controls may be effective in reducing human exposures, but will not protect ecological receptors.	Cover placement is a proven and reliable technology. Cover performance is dependent on the type and properties of available on-site borrow material. Useful life of cover is indefinite with properly designed cover and stormwater controls, routine inspections and maintenance.	Cover placement is a proven and reliable technology. Cover performance is dependent on the type and properties of available on-site borrow material. Useful life of cover is indefinite with properly designed cover and stormwater controls, routine inspections and maintenance.	Cover placement is a proven and reliable technology. Cover performance is dependent on the type and properties of available on-site borrow material. Useful life of cover is indefinite with properly designed cover and stormwater controls, routine inspections and maintenance.

Table ES-2. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
Time to Implement	Not applicable.	One construction season estimated.	One to two construction seasons estimated.	Two construction seasons likely.	Two construction seasons likely.
Availability of equipment, personnel and services	Not applicable.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house personnel during work.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house personnel during work.
Administrative feasibility	Requires institutional controls, access controls, and/or land use restrictions to reduce disturbance of mine rock and to reduce human exposures to mine-affected areas. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Compatible with future mining scenarios for the Site. No adverse impact to the historic features that make the Site eligible to the NRHP.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of re-graded mine rock piles and to reduce human exposures to mine-affected areas. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Removal action alternative most compatible with future mining at the Site. Potential for an adverse impact to the historic features that currently make the Site eligible to the NRHP	Requires institutional controls, access controls, and/or land use restrictions to protect integrity of covers on mine rock piles. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Would reduce current access for potential future mining at the Site. Would likely remove the Site from NRHP eligibility.	Requires institutional controls, access controls, and/or land use restrictions to protect integrity of covers at 300-Foot Level and Open Pit. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Would preclude future mining access to the Open Pit. Will adversely impact the integrity of the historic site and remove the Site from NRHP eligibility.	Requires institutional controls, access controls, and/or land use restrictions to protect integrity of cover on Open Pit. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Would preclude future mining access to the Open Pit. Will adversely impact the integrity of the historic site and remove the Site from NRHP eligibility.
RELATIVE COST					
Capital – Direct & Indirect	None	$1,222,000	$3,780,000	$3,441,000	$6,240,000
M&M Cost	None	$206,000	$206,000	$152,000	$133,000
Total Project Cost	None	$1,427,000	$3,986,000	$3,592,000	$6,373,000

Table ES-3. Summary Evaluation of Removal Action Alternatives for Portals

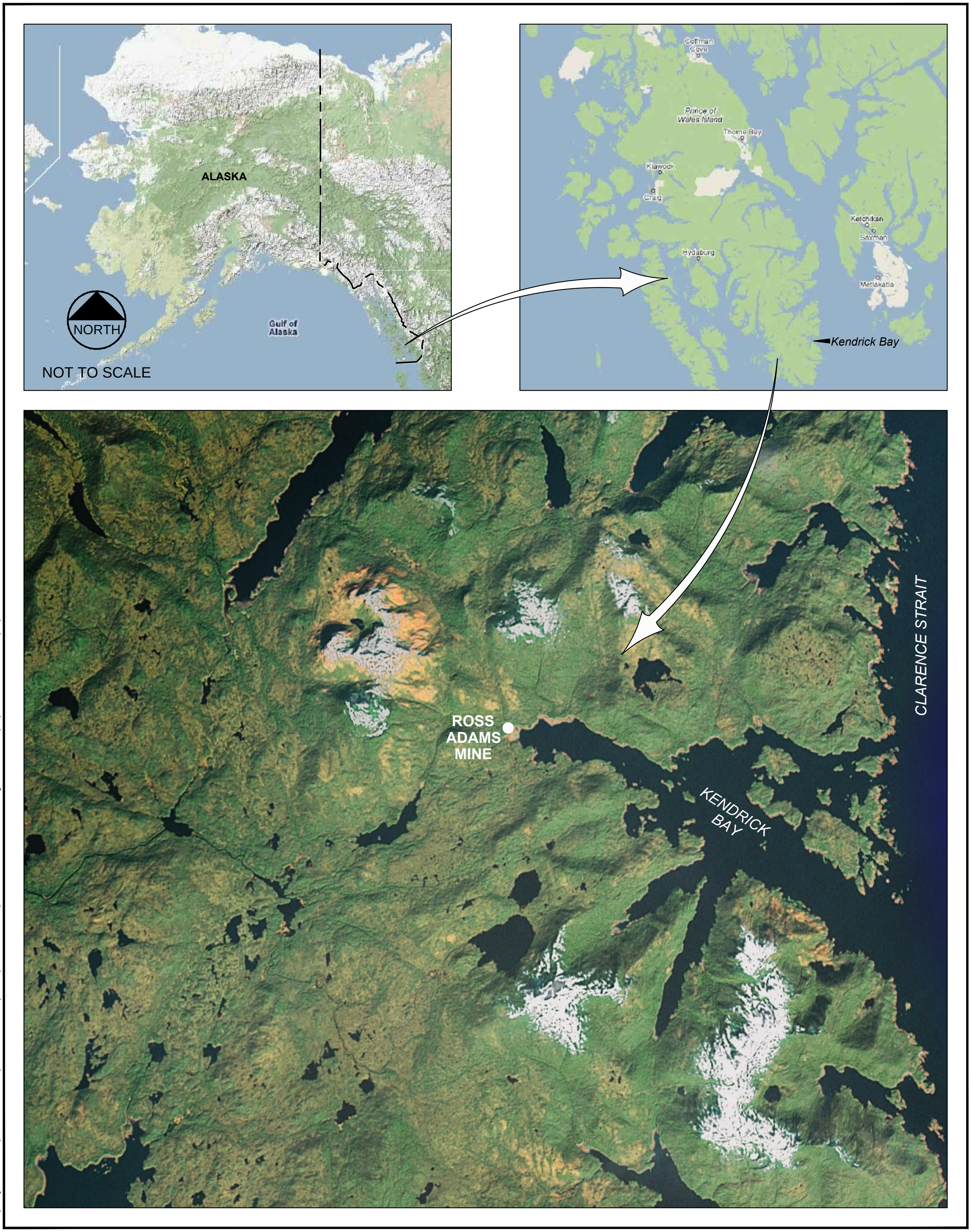
Evaluation Criterion	Alternative P-1 No Action Alternative	Alternative P-2 Close Upper Mine Openings and 300-Foot Level Portal Gate	Alternative P-3 Close Upper Mine Openings and 300-Foot Level Portal Rock Backfill	Alternative P-4 Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead
EFFECTIVENESS				
Protection of human health and the environment	Would not achieve RAOs. Not protective of human or ecological receptors. Radon exhalation would continue from mine openings. Water inflow to underground workings would continue at 900-Foot Level Portal. Unrestricted human access would continue. Institutional controls required for all mine openings.	Would not achieve RAOs. Potentially protective of human and ecological receptors. Eliminates radon exhalation from 900-Foot Air Shaft and Portal and 700-Foot Level Portal. Closure of upper mine openings significantly reduces air inflow into mine workings and air outflow from 300-Foot Level Portal, potentially reducing radon exhalation from 300-Foot Level Portal. However, the reduction in radon exhalation resulting from reduced air outflow from the 300-Foot Level Portal is indeterminable. Due to the uncertain reduction in radon exhalation, Alternative P-2 might not be protective of a Site visitor, mineral exploration worker, or a USFS worker, and might not achieve RAOs. Does not eliminate human health and ecological exposure pathways to mine drainage water from 300-Foot Level Portal. Closure of 700-Foot Level Portal eliminates potential for drainage from portal. In conjunction with Mine Rock Alternatives M-4 and M-5, backfilling and covering of Open Pit reduces water inflow to underground mine reducing water flow from the 300-Foot Level Portal. Unrestricted human access eliminated by closure of upper mine openings and gate at 300-Foot Level. Institutional controls may be required to restrict access at 300-Foot Level Portal.	Would likely achieve RAOs. Protective; closure of upper mine openings eliminates radon exhalation and air inflow to underground mine. Backfilling of 300-Foot Level Portal further reduces radon exhalation from 300-Foot Level Portal. However, the reduction in radon exhalation resulting from reduced air outflow and backfilling of 300-Foot Level Portal is indeterminable. Due to the uncertain reduction in radon exhalation, Alternative P-3 might not be protective of a Site visitor, mineral exploration worker, or a USFS worker, and might not achieve RAOs. Closure of 700-Foot Level Portal eliminates potential for drainage from portal. In conjunction with Mine Rock Alternatives M-4 and M-5, backfilling and covering of Open Pit reduces water inflow to underground mine reducing water flow from the 300-Foot Level Portal. Reduced water outflow from 300-Foot Level Portal piped to Kendrick Creek eliminates direct human (area visitor) and ecological (riparian animal) exposure pathways to mine drainage water. Unrestricted human access eliminated by closure of all mine openings. Institutional controls not required to restrict access to mine openings.	Would achieve RAOs. Protective; closure of upper mine openings eliminates radon exhalation and air inflow to underground mine. Concrete bulkhead in 300-Foot Level Portal eliminates radon exhalation from 300-Foot Level Portal. Closure of 700-Foot Level Portal eliminates potential for drainage from portal. In conjunction with Mine Rock Alternatives M-4 and M-5, backfilling and covering of Open Pit reduces water inflow to underground mine reducing water flow from the 300-Foot Level Portal. Reduced water outflow from 300-Foot Level Portal piped to Kendrick Creek eliminates direct human (area visitor) and ecological (riparian animal) exposure pathways to mine drainage water. Unrestricted human access eliminated by closure of all mine openings. Institutional controls not required to restrict access to mine openings.
Ability to achieve ARARs	Would not comply with potential chemical-specific ARARs defining acceptable human health risk. The alternative would not comply with Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would potentially comply with potential ARARs defining acceptable human health risk. Due to uncertainty in radon reduction, alternative may not comply with chemical-specific ARARs, including Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would potentially comply with potential ARARs. Due to uncertainty in radon reduction, alternative may not comply with chemical-specific ARARs, including Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would comply with potential ARARs.
Short-term effectiveness	No short-term impacts.	Short term impacts may include radiation and radon exposure during work activities at mine openings and sediment disturbance during gate installation at the 300-Foot Level Portal. Potential risks could be properly managed by implementing worker safety measures and sediment control measures. Potential bat habit will be reduced by closure of the upper mine openings.	Short term impacts may include radiation and radon exposure during work activities at mine openings and disturbance of water and sediment during backfilling at the 300-Foot Level Portal. Potential risks could be properly managed by implementing worker safety measures and sediment control measures. Potential bat habit will be eliminated by closure of the upper mine openings and backfilling of the 300-Foot Level portal.	Short term impacts may include radiation and radon exposure during work activities at mine openings and disturbance of water and sediment during bulkhead construction at the 300-Foot Level Portal. Potential safety hazards to workers during concrete bulkhead installation within 300-Foot Level Portal. Potential risks could be properly managed by implementing worker safety measures and sediment control measures. Potential bat habit will be eliminated by closure of the upper mine openings and closure of the 300-Foot Level Portal.

Table ES-3. Summary Evaluation of Removal Action Alternatives for Portals (Continued)

Evaluation Criterion	Alternative P-1 No Action Alternative	Alternative P-2 Close Upper Mine Openings and 300-Foot Level Portal Gate	Alternative P-3 Close Upper Mine Openings and 300-Foot Level Portal Rock Backfill	Alternative P-4 Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead
Long-term effectiveness and permanence	Not effective and permanent. Risks to human and ecological receptors remain unchanged.	Effective and permanent for reducing radon risks to human receptors. While closure of the upper mine workings will significantly reduce air outflow from the 300-Foot Level Portal, the predicted reduction in radon exhalation from the 300-Foot Level Portal is uncertain.	Effective and permanent for reducing radon risks to human receptors. Closure will eliminate radon exhalation from the upper mine workings and significantly reduce air outflow from the 300-Foot Level Portal, but the predicted reduction in radon exhalation from the 300-Foot Level Portal is uncertain. Backfilling of 300-Foot Level Portal will further reduce radon exhalation from portal. Effective and permanent for reducing direct human and ecological pathways to mine water.	Effective and permanent for reducing radon risks to human receptors. Closure will eliminate radon exhalation from the upper mine workings. Bulkhead will eliminate radon exhalation from the 300-Foot Level Portal. Effective and permanent for reducing direct human and ecological pathways to mine water.
Reduction of toxicity, mobility, or volume through treatment	No reduction of toxicity, mobility, or volume would be achieved. No treatment provided.	No reduction of toxicity would be achieved. Reduction in water outflow from the 300-Foot Level Portal and possible reduction in mobility by reducing water inflow to underground mine. No treatment provided.	No reduction of toxicity would be achieved. Reduction in water outflow from the 300-Foot Level Portal and possible reduction in mobility by reducing water inflow to underground mine. No treatment provided.	No reduction of toxicity would be achieved. Reduction in water outflow from the 300-Foot Level Portal and possible reduction in mobility by reducing water inflow to underground mine. No treatment provided.
IMPLEMENTABILITY				
Technical feasibility/ constructability	No construction required.	Removal action components are readily constructible. Sediment controls required during gate installation at 300-Foot Level Portal. Closure of 900-Foot Level Portal will need to be coordinated if mine rock is consolidated in Open Pit.	Removal action components are readily constructible. Need to verify upper range of outflow from 300-Foot Level Portal for water collection system and pipe design. Sediment and water controls required during backfilling of 300-Foot Level Portal. Closure of 900-Foot Level Portal will need to be coordinated if mine rock is consolidated in Open Pit.	Removal action components are readily constructible. Need to verify upper range of outflow from 300-Foot Level Portal for water collection system and pipe design. Concrete bulkhead requires installation in competent rock inside portal, requiring rehabilitation of portal for worker safety. Sediment and water controls required during backfilling of 300-Foot Level Portal. Closure of 900-Foot Level Portal will need to be coordinated if mine rock is consolidated in Open Pit.
M&M requirements	No M&M required.	Inspections of closures at upper mine workings and gate at 300-Foot Level Portal will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Direct inspection and any maintenance of 900-Foot Level Portal closure not possible if mine rock is consolidated in Open Pit. Post-removal water quality monitoring will be performed in Kendrick Creek at a location downstream of the confluence with Mine Fork Creek and the drainage from the 300-Foot Level Portal. Water quality samples will be collected twice a year annually for the first five years and then once every five years thereafter, if determined necessary, from review of the resulting data.	Inspections of closures at upper mine workings and backfill at 300-Foot Level Portal will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Direct inspection and any maintenance of 900-Foot Level Portal closure not possible if mine rock is consolidated in Open Pit. Post-removal water quality monitoring will be performed in Kendrick Creek at a location downstream of the confluence with Mine Fork Creek and the drainage from the 300-Foot Level Portal. Water quality samples will be collected twice a year annually for the first five years and then once every five years thereafter, if determined necessary, from review of the resulting data.	Inspections of closures at upper mine workings and concrete bulkhead at 300-Foot Level Portal will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Direct inspection and any maintenance of 900-Foot Level Portal closure not possible if mine rock is consolidated in Open Pit. Post-removal water quality monitoring will be performed in Kendrick Creek at a location downstream of the confluence with Mine Fork Creek and the drainage from the 300-Foot Level Portal. Water quality samples will be collected twice a year annually for the first five years and then once every five years thereafter, if determined necessary, from review of the resulting data.
Reliability and performance	Not applicable.	Portal closure is a proven and reliable technology.	Portal closure is a proven and reliable technology.	Portal closure is a proven and reliable technology.
Time to Implement	Not applicable.	One construction season.	One construction season.	One construction season.

Table ES-3. Summary Evaluation of Removal Action Alternatives for Portals (Continued)

Evaluation Criterion	Alternative P-1 No Action Alternative	Alternative P-2 Close Upper Mine Openings and 300-Foot Level Portal Gate	Alternative P-3 Close Upper Mine Openings and 300-Foot Level Portal Rock Backfill	Alternative P-4 Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead
Availability of equipment, personnel and services	Not applicable.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house personnel during work.
Administrative feasibility	Requires institutional controls, access controls, and/or land use restrictions to preclude access to mine openings and to reduce human exposures to radon exhalation from mine openings. Controls could include signage, physical barriers, and inclusion in USFS land use management plans and land status records. Institutional controls are readily implementable. Compatible with potential future mining at Site.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of mine opening closures and to reduce residual radon from 300-Foot Level Portal to human receptors. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of locations from mineral entry. Institutional controls are readily implementable. Reduces access to Ross-Adams mineral deposit via existing mine openings for potential future exploration or mining.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of mine opening closures. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of locations from mineral entry. Institutional controls are readily implementable. Reduces access to Ross-Adams mineral deposit via existing mine openings for potential future exploration or mining.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of mine opening closures. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of locations from mineral entry. Institutional controls are readily implementable. Reduces access to Ross-Adams mineral deposit via existing mine openings for potential future exploration or mining.
		RELATIVE COST		
Capital – Direct & Indirect	None	$694,000	$719,000	$770,000
M&M Cost	None	$30,000	$94,000	$94,000
Total Project Cost	None	$724,000	$813,000	$864,000



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April 2015

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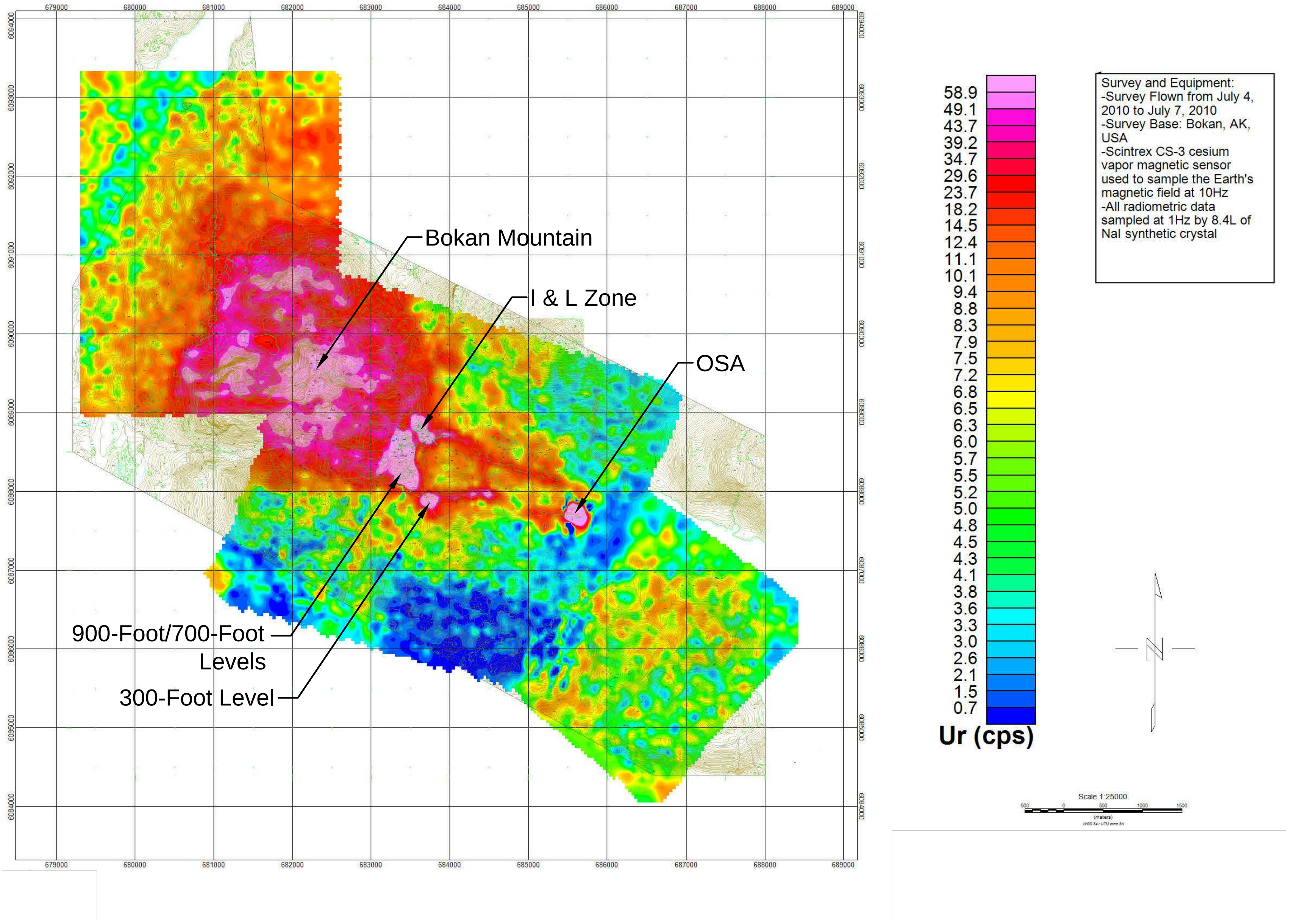
Figure ES-1
Ross-Adams Site
Location

Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\FIG-2-4.dwg SAVED: 4/2/15 PRINTED: 4/2/15 BY: TOM



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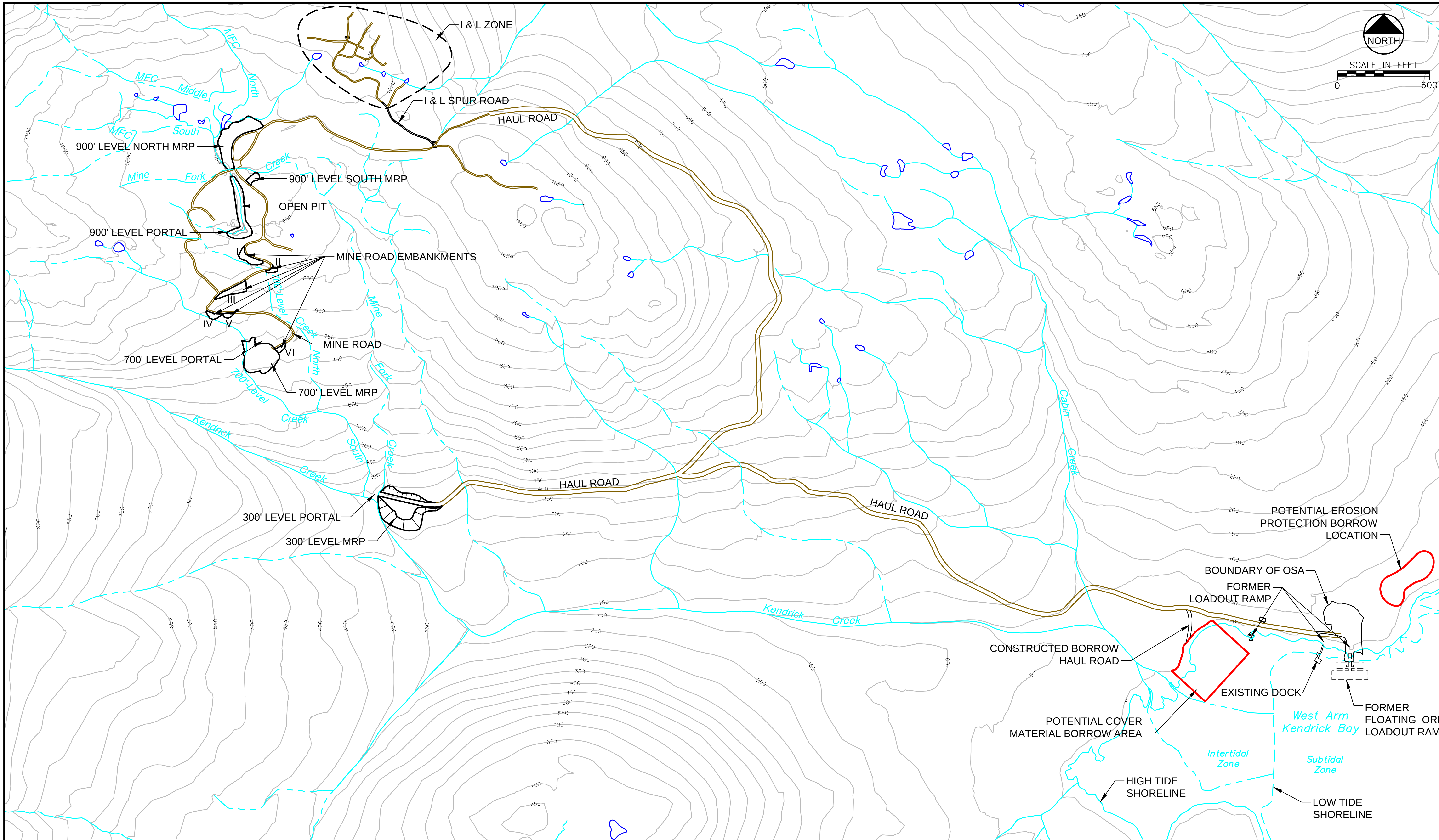
Notes:
1. Used By Permission From Ucore Uranium.
2. UTM Grid WGS 84 Zone 8.

Figure ES-2
Bokan Mountain Airborne Radiometric Survey (2007)



CONTOUR INTERVAL = 50 FEET
BASE MAP PRODUCED FROM AERIAL PHOTOGRAPHY FLOWN: AUGUST 8, 2005.
COMPILED BY: EAGLE MAPPING LTD.

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Figure ES-3
Ross-Adams Site
Major Site Features

COPCs retained from SLRA based on risk-based screening levels, further evaluated in the SSRA:

SOIL:
As, Th-232, Ra-228, Th-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210, Po-210

SURFACE WATER:
Mn, U, Ra-226, Ra-228, Th-228, Th-230, Po-210, U-234, U-235, U-238, Pb-210

STREAM SEDIMENT:
Ra-228, Ra-226, Th-230, Th-232, Pb-210, U-234, U-235, and U-238

MARINE SEDIMENT:
As, Th-232, Ra-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210

Pathways evaluated in SSRA:

SOIL:
Soil Ingestion
Dermal Contact/External Exposure to Soil
Particulate Inhalation of Soil
Deer Harvesting
Berry Harvesting

STREAMS:
Ingestion of Stream Sediment
Dermal Contact/External Exposure to Stream Sediment
Ingestion of Surface Water (Area Visitor only)

MARINE SEDIMENT:
Ingestion of Marine Sediment
Dermal Contact/External Exposure to Marine Sediment
Sea Cucumber Harvesting
Sea Weed Harvesting
Flounder Harvesting

SSRA results for scenarios posing risk above 1E-5 by receptor and pathway

Site-Specific Mineral Exploration Worker:
Radon in Air
Gamma Exposure

Site-Specific USFS Worker:
Radon in Air
Gamma Exposure

Area Visitor:
Radon in Air
Gamma Exposure
Soil Ingestion:
combined radionuclides (2.7E-5)
Surface Water Ingestion:
combined radionuclides (2.0E-5)

Subsistence Resource User: None

April 2015

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Figure ES-4
Summary of the Human Health Risk Assessment

SLERA

COPEC Retained from Screening Evaluation

Soils: Al, Sb, As, Cd, Cr, Co, Pb, Mn, Mo, Ni, Se, Th, Zn, U, Ra-226, Ra-228

Stream Surface Water: Ag, Al, Ba, Cd, Fe, Mg, Hg, Pb, Zn, U, Ra-226, Ra-228

Stream Sediments: Ba, Cd, Co, Cu, Pb, Mn, Hg, Mo, Ni, Se, Ag, Th, Va, Zn, U, Ra-226

Marine Sediment: Ag, Al, As, Be, Fe, Pb, U

SLERA

Lines of Evidence for COPEC

Terrestrial Habitat – Metals & radionuclides

- Plants & soil invertebrate communities
- Wildlife indicator species

Stream Habitat – Metals & Radionuclides in Sediments, Surface Water:

- Aquatic communities (plants, fish, invertebrates)
- Aquatic-dependent wildlife

Marine Habitat – Intertidal and Subtidal Sediments:

- Benthic invertebrate community
- Marine-dependent wildlife

SLERA

Pathways, Receptors and Chemicals of Concern with HQ > 1

Terrestrial Plants: Co, Mn, Zn, Ra-226

Terrestrial Invertebrates: Mn, Zn

Terrestrial Wildlife: Cd, Pb, U, Zn, Ra-226, Ra-228

Stream Surface Water Community: Ra-226, Ra-228

Stream Sediment Community: Ra-226

Stream Wildlife: None

Marine Benthic Community: None

Marine Wildlife: None

Figure ES-5.
Summary of the Screening Level Ecological Risk Assessment

1.0 Introduction

This Engineering Evaluation/Cost Analysis (EE/CA) presents the detailed analysis of removal action alternatives to address potential human health and ecological risks resulting from historic mining activities 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 EE/CA was performed 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.

1.1 ASAOC

Newmont USA Limited and Dawn Mining Company (Companies) entered into the ASAOC with the USFS on April 17, 2009. The Statement of Work (SOW) appended to the ASAOC identified these major tasks:

- Site plans – preparation of plans for performing an Expanded Site Investigation (ESI), including a Sampling and Analysis Plan (SAP), Quality Assurance and Project Plan (QAPP) and Health and Safety Plan (HASP). The Site plans were submitted and approved by the USFS in 2009.
- ESI – conducting Site investigations in 2009 to obtain additional environmental data and information necessary to perform an EE/CA and supporting risk assessments.
- Site Characterization Report (SCR) – presents the results and conclusions of the ESI and previous investigations as a basis for EE/CA development and supporting risk assessments. The Final SCR (Tetra Tech, 2010) was approved by the USFS on December 10, 2010.
- EE/CA Report – describes, analyzes and recommends a removal action for the Site, incorporating Site-specific conditions and human health and ecological risk assessments.

1.2 Purpose and Objectives of Report

Pursuant to the ASAOC, this EE/CA was prepared in accordance with EPA's Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA (EPA, 1993a). The overall purpose of this EE/CA is to:

- Summarize the results of the SCR, which provides a description of the Site, the Site history, background information, and the source, nature and extent of environmental media, mine features, and mine-affected areas associated with the former Ross-Adams mine operations.
- Present and summarize the results of the focused human health and ecological risk assessments that evaluate potential risks to human and ecological receptors associated with exposure pathways for existing conditions at the Site.

- Provide a framework for screening, identifying and evaluating removal action technologies and alternatives to support risk-based management decisions for selecting the recommended removal action for the Site.

This EE/CA recommends a removal action that addresses the mine features and mine-affected areas associated with the former Ross-Adams mine operations. However, the USFS will select the removal action for the Site in collaboration with the State of Alaska and the EPA. The recommended removal action was identified by:

- Defining removal action objectives (RAOs) pertinent to Site-specific conditions that address the identified exposure pathways and risks for existing conditions defined by the human health and ecological risk assessments and defining potential applicable or relevant and appropriate requirements (ARARs) for the removal actions.
- Screening of removal action technologies and general response actions that are potentially applicable to the Site.
- Identifying detailed Site-specific removal action alternatives retained from the results of the screening of removal action technologies.
- Performing detailed analysis of the Site-specific removal action alternatives based on the evaluation criteria of effectiveness, implementability and cost.
- Performing a comparative analysis to evaluate the relative advantages and disadvantages of the removal action alternatives.
- Recommending a preferred removal action alternative for USFS consideration.

1.3 Site Definition

The Ross-Adams Mine 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 access road (I&L Spur Road) is included in the Site definition. The I&L Zone represents a group of radioactive mineral prospects on the east flank of Bokan Mountain northwest of the Ross-Adams deposit, with exposed mineralization. Mineral exploration has been conducted on the I&L Zone, but it has never been mined and is not part of the Site as defined in the ASAOC.

1.4 Report Organization

This EE/CA contains the elements required in Section III.F (EE/CA Report) of the SOW, and is organized as follows:

- An Executive Summary provides the overview of the EE/CA results and is presented at the front of this report.

- Section 2 summarizes the results of the SCR, which describes the physical, chemical and radiological characterization of the Site, including the results of previous investigations.
- Section 3 summarizes the results of the Human Health Risk Assessment (HHRA) and the Screening-Level Ecological Risk Assessment (SLERA), which are provided in Appendices A and C.
- Section 4 describes the removal action objectives and removal action goals considering the results of the HHRA and SLERA and identifies the potential applicable or relevant and appropriate requirements (ARARs) for the removal actions.
- Section 5 presents the screening of potentially applicable removal action technologies and general response actions for development of the removal action alternatives.
- Section 6 provides a detailed description of the removal action alternatives for the Site retained from the screening of technologies and general response actions.
- Section 7 describes the detailed analysis of the removal action alternatives based on the evaluation criteria of effectiveness, implementability and cost.
- Section 8 provides the comparative analysis of the relative advantages and disadvantages of the removal action alternatives that identifies key tradeoffs and differences among the alternatives that would affect selection of a recommended removal action.
- Section 9 identifies the recommended removal action for the Site that best satisfies the evaluation criteria based upon the comparative analysis.
- Section 10 provides a summary of the Community Engagement Plan for the Site.

2.0 Site Description and Summary Characterization

This section provides a description and characterization of the Site based on the information and understanding gained from the 2009 ESI and development of the Ross-Adams Site Characterization Report (SCR) (Tetra Tech, 2010). The SCR provides the details of the 2009 ESI and a complete summary of the historic Site data and information.

2.1 Site Description and Background

2.1.1 Location and Setting

The Site is located on the western side of Prince of Wales Island (POW) at the western end of the West Arm of Kendrick Bay (Figure 2-1) in the Tongass National Forest (TNF). It is approximately 38 air miles from Ketchikan, Alaska, 33 air miles from Hydaburg, the nearest town on POW, and 28 air miles to Metlakatla, the nearest town, northeast across Clarence Strait. 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. There are no USFS roads or hiking trails connecting the Site to other areas of the TNF or to POW communities or roads. The Site can be accessed only by helicopter, float plane or boat, or by hiking overland through many miles of trail-less, rugged terrain.

The Site encompasses the elements of the historic Ross-Adams Mine. The elements or mine features include the open pit, underground mine workings and portals, the mine rock piles, mine and haul roads, and the ore staging area (OSA) and ore loading ramps. The Site extends from the intertidal zone along the western shore of the West Arm of Kendrick Bay up the southeastern flank of Bokan Mountain to an elevation of approximately 970 feet at the top of the Ross-Adams Mine (the 900-Foot Level) within the Kendrick Creek drainage. 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”. In addition, an access road between the 900-Foot Level haul road and the I&L Zone is included in the Site. Figure 2-2 shows the general boundary of the Site and the historic mine features and other Site features. The mine features occupy approximately 17 acres of the Kendrick Creek drainage which is approximately 1,400 acres in size.

The terrain of the Site varies from gently to moderately sloping along the margin of the West Arm of Kendrick Bay shoreline to steeply sloping up the flank of Bokan Mountain. The Site is densely vegetated with forest and brush communities characteristic of the region and the terrain in the upper portion of the Site is steeply incised by steam channels. The dense vegetation and steep and incised terrain restrict access even by foot. In the upper areas of the Site, mineralized bedrock is very near the surface and often exposed. Figure 2-3 shows the exposure of bedrock around the top of the Site in the area of the 900-Foot Level mine workings with dense vegetation developed around the bedrock exposures extending up and down the mountain.

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. Flow and water quality data collected during the 2009 ESI show that the sampling performed captured both the low flow and high flow precipitation runoff conditions typical of the Site.

The Site falls within the "Southeast Ecoregion" as defined by the Alaska Department of Environmental Conservation (ADEC, 1999a, 1999b). The biological assessment conducted in 2009 identified four main habitat types. These are the Subalpine Zone in the higher elevations of the Site on Bokan Mountain, the Western Hemlock-Sitka Spruce Forest at lower elevations, the Intertidal Zone around the shoreline of the West Arm of Kendrick Bay, and Marine Zone within the West Arm of Kendrick Bay. The vegetation of the terrestrial habitats is dense and natural revegetation of areas disturbed by historic mining is occurring making access to and observation of these areas very difficult in some locations. These habitats and their associated plants and animals are described in detail in the SCR.

Current uses of the Site include active mineral exploration, occasional recreational visitors and USFS workers, and occasional subsistence hunting-gathering-fishing occurs in the area. The TNF Land and Resource Management Plan (USFS, 2008) has designated the Site for mineral exploration and timber production. Further, 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. Future Site use is projected to be consistent with current use as designated by the USFS, including mineral exploration or timber harvesting, as well as for semi-remote recreational use. Mineral exploration is expected to continue to occur in areas immediately adjacent to the Site and future use of the general area may include mining.

2.1.2 Historic Uranium Mining and Geology/Mineralogy

The Ross-Adams ore deposit outcropped at an elevation of approximately 970 feet on the southeastern flank of Bokan Mountain. The uranium ore deposit was discovered by aerial survey which is indicative of the high level of background radiation exposed at the surface (Figure 2-4). The mine was initially developed by open-pit mining in 1957 and later by underground operations from three portals. 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 the ore staging area and barge loading docks on the north shore of the West Arm of Kendrick Bay. All ore was shipped off-site for processing; therefore no milling operations were conducted at the Site that would have generated tailing or other process materials. As such, the potential for dust generation from the Site during and after mining is minimal because no milling of ore occurred at the Site that would have produced fine-grained tailing.

The Bokan Mountain Intrusive Complex, in which the Ross-Adams ore deposit is located, is comprised of rare rock types and is unique in southeast Alaska. Emplacement of the Bokan Intrusive Complex, the parent rock of the Ross-Adams deposit, included uranium, thorium and rare earth element mineralization. Mineral exploration continues in the Bokan Mountain region. At the present time, active exploration for deposits of rare earth elements is occurring in the Kendrick Creek watershed under USFS permit. More than 30 uranium and rare earth elements (REE) occurrences have been identified at Bokan Mountain that are related to the Bokan Intrusive Complex (Figure 2-4). The enrichment (mineralization) of the Bokan Intrusive Complex with uranium and thorium results in a radioactive signature distinctive from that of the non-mineralized bedrock. Generally, mineralized bedrock extends down the southeastern flank of Bokan Mountain to an elevation immediately above the 300-Foot Level. Below this elevation non-mineralized bedrock occurs. The 900-Foot Level and 700-Foot Levels are located in the mineralized zone and the 300-Foot Level and OSA are in the non-mineralized zone. The radiation signature shown in Figure 2-4 is indicative of the radionuclide content of the mineralized bedrock and shows the boundary between the mineralized and non-mineralized zones. Figure 2-4 indicates elevated uranium concentrations in the bedrock for the entire Bokan Mountain area above approximately 350 feet in elevation. A number of naturally occurring hot spots are visible on both sides of the peak of Bokan Mountain. The I&L Zone, which is an outcropping of the ore body slightly northwest of the Ross-Adams deposit and visible on Figure 2-4, represents an analogue of the surface mineralization that existed within the mineralized area of the Ross-Adams deposit prior to mining.

The Ross-Adams Mine was developed on a southward-plunging, crudely pipe-like ore zone of the Bokan Granite Complex, approximately 50 feet in diameter and surrounded by a sub-ore-grade zone two to 20 feet thick. Economic mineral investigations reported only minor amounts of secondary uranium minerals present in the near-surface geologic environment at Ross-Adams, and that the sulfide mineral content, the source of potential acid generation and ARD, was also minimal. Because of the paucity of sulfide mineralization, natural weathering of the mineralized rock (mine rock and exposed bedrock) is minimal. This favorable environmental/mineralogical condition is evident from visual observation of the disturbed and undisturbed areas of the Site and from surface water quality data of mine drainage and stream samples. Details of the previous geologic investigations are provided in the SCR.

2.2 Previous Site Investigations and Actions

Two environmental investigations were performed at the Site prior to the 2009 EIS. In 1995-1997, the Bureau of Land Management conducted a Removal Preliminary Assessment (RPA) (BLM, 1998) and in 2004 the USFS conducted the Preliminary Assessment/Site Investigation (PA/SI) (KSI, 2004). Data and information from these investigations were incorporated in the development of the ESI and are incorporated in the SCR. In addition, numerous mineralogical/economic geologic investigations have been performed at the Site and in the area because of the economic potential represented by the geology of the Site and area. These investigations provided useful information and data about the Site and were also used in the development of the ESI and incorporated in the SCR.

2.3 Ross-Adams Mine Features (Physical Characteristics)

The following subsections provide a description of the Ross-Adams Mine features. These features include the surface (OSA, mine rock piles and roads) and the subsurface (portals, adits, and air shaft) elements of the mining activities that took place at the 900-Foot Level, the 700-Foot Level, and the 300-Foot Level, the mine road, as well as the OSA and ore loading facilities at the shore of the West Arm of Kendrick Bay and the haul roads that connected the shoreline to the mine levels. In addition, to these mine features, the I&L Spur road is included as part of the Site. Figure 2-2 shows the location of these features within the Site. The 900-Foot Level and 700-Foot Level are located in the mineralized area of the Site and the 300-Foot Level and OSA are in the non-mineralized area. Included in the EE/CA are miscellaneous solid waste debris and petroleum products, including a small area of petroleum-contaminated soil, associated with several exploration camps and mine camps, which operated over the life of mining operations.

The SCR (Tetra Tech, 2010) provided the estimated quantities of mine rock materials for each mine feature based on topographic survey, visual observations of the physical mine feature boundaries, and review of aerial photography. The visual and topographic survey boundaries are considered the most precise physical boundaries of the mine rock piles and OSA. The estimated area and volume of mine rock materials for the mine features are summarized in Table 2-1.

As described in the following sections, Site observations and the results of the gamma surveys and soil sampling conducted during the ESI indicate that mine-affected material in specific locations extend beyond the physically defined boundaries of several mine features, particularly at the 300-Foot Level and OSA. Visual inspection and gamma survey results indicate that mine rock exist in discrete locations near the toe and adjoining the western boundary of the 300-Foot Level mine rock pile. Scattered mine rock also exists in discrete areas beyond the physical footprints of the mine rock piles at the 700-Foot and 900-Foot Levels. In addition to the mine rock embankments identified for the mine road between the 700-Foot and 900-Foot Levels, gamma survey results indicate that scattered mine rock or ore spilled during hauling may exist on the surface of the mine road. At the OSA, the results of the gamma survey indicate that mine-affected materials exist in defined areas beyond the surveyed physical boundary of the OSA. For EE/CA evaluation, the estimated volumes presented in the SCR for the mine rock piles, mine road and the mine-affected materials at the OSA have been increased by 10 percent to account for the specific locations where mine material extends beyond the physical boundaries of these mine features.

2.3.1 900-Foot Level

<u>900-Foot Level Open Pit</u>

Mining of the Ross-Adams ore body began 1957 with the development of the 900-Foot Level Open Pit. The Open Pit and the rest of the 900-Foot Level workings are at the top of the Site and represent the first stage of the Ross-Adams Mine operations. Following surface mining at the Open Pit, the 900-Foot Level portal, which is located within the Open Pit, provided access to the adit developed for underground mining of the deeper portions of the ore body.

The 900-Foot Level Open Pit has an L-shaped perimeter with its long axis trending roughly north-south and its short axis trending east-west (Figure 2-5). 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 pit rim from 50 to 70 feet on both axes and has a maximum depth of approximately 35 feet. The floor of the Open Pit has accumulated rock rubble that has fallen from the side walls and is covered with dense brush vegetation. Photographs of the Open Pit are shown in Figures 2-6, 2-7, 2-8 and 2-9. The current topography, determined by the 2009 topographic survey, is shown in Figure 2-10. Based on the current topography, the estimated volume of the Open Pit is approximately 17,260 cubic yards. This volume does not include the voids of the underground workings associated with the 900-Foot Level portal.

<u>900-Foot Level Portal</u>

The 900-Foot Level portal is located at the southwest end of the Open Pit and is approximately 15 feet wide by 30 feet high. The portal opening is partially blocked with the rock rubble that has accumulated on the floor of the pit and the unrestricted opening is now approximately 15 feet wide by 15 feet high. The adit from the 900-Foot Level slopes rather steeply downward from the portal for about 20 feet then flattens and turns to the right to join the near vertical shaft that connects to the 700-Foot Level mine workings. The location of the 900-Foot Level portal in the Open Pit is shown on Figure 2-5. Figures 2-11 and 2-12 are photographs that show the current condition of the 900-Foot Level portal. Figure 2-13 shows the location of the 900-Foot Level portal and adit in relationship to the rest of the Ross-Adams Mine underground workings.

Water (precipitation and runoff) that collects in the Open Pit drains into the portal and underground workings through the pit bottom rubble. An estimate of the amount of water entering the underground from the 900-Foot Level Open Pit is not available.

<u>Open Pit Dike and Berm</u>

A dike and berm were constructed around the perimeter of the Open Pit during mining to prevent runoff from the surrounding areas from entering the Open Pit and underground workings. The location of the dike and berm are shown in Figure 2-5. The dike and the berm were constructed to prevent flow and runoff from entering the Open Pit from nearby streams and terrain. The dike and berm are approximately 2 to 4 feet high, constructed with mine rock and stream alluvium. They are generally still intact and heavily revegetated (Figure 2-14).

<u>900-Foot Level Air Shaft</u>

The 900-Foot Level air vent shaft was constructed to provide ventilation air for the underground workings between the 700-Foot and 900-Foot Levels. It is located southwest of the 900-Foot Level Open Pit (Figure 2-5). The air shaft dimensions are approximately 4 feet by 6 feet from the surface to a depth of about 5 feet, and then narrow to a diameter of approximately 3 feet. The surface opening to the shaft is partially restricted by wire mesh supported over two large logs (Figure 2-15). No structures are present to restrict runoff from entering the air shaft.

2.3.2 700-Level Portal and Adit

The 700-Foot Level portal and adit are located south of the 900-Foot Level (Figure 2-5) and were developed to access the ore body beneath the 900-Foot Level workings. The 700-Foot Level portal is approximately 9 feet wide and 7½ feet high. The portal opening is stable and provides unrestricted access to the 700-Foot Level adit (Figure 2-16). The relationship of the 700-Foot Level adit to the underground workings is shown in Figure 2-13.

Water does not discharge from the 700-Foot Level portal but does pool at the portal and inside the adit. The absence of flow from the 700-Foot Level portal is explained by the geology through which the adit is constructed and its relationship to the rest of the underground workings, as shown in Figure 2-13. As shown in Figure 2-13, the 700-Foot Level adit extends a distance of approximately 300 feet inward from the 700-Foot Level portal to the intersection of the near-vertical raise connecting it to the 300-Foot Level. It is constructed through undivided granite and does not intersect the ore body until near the intersection with the near-vertical raise. Therefore, the only flow reporting to the 700-Foot Level adit, and thus the 700-Foot Level portal, is fracture inflow from bedrock intercepted along the length of the 700-Foot Level adit. The 300-Foot Level adit captures and effectively drains all of the mine workings. Drainage from the 700-Foot Level portal has not been observed during any Site investigations even during the high precipitation sampling event during the ESI.

2.3.3 900-Foot Level and 700-Foot Level Mine Rock Piles

Mine rock piles are located at the 700-Foot and 900-Foot Levels. These mine rock piles are identified as the north and south 900-Foot Level mine rock piles and the 700-Foot Level mine rock pile. The material present in the 900-Foot Level and 700-Foot Level mine rock piles has similar material characteristics and is described, based on visual inspection, as generally uniformly graded, coarse-grained materials, smaller than about 6 inches with occasional scattered boulders up to 2 feet in size. In addition, there are six embankments along the mine road connecting the 700-Foot Level and 900-Foot Level that are constructed of mine rock. Figure 2-5 shows the locations of the mine rock piles and the mine rock road embankments. The photographs shown in Figures 2-3 and 2-17 depict the 900-Foot and 700-Foot Level areas showing the mine rock piles, mine road, Open Pit, and the exposed mineralized bedrock. The 900-Foot Level and 700-Foot Level mine rock piles are located in close proximity to creeks in the headwaters of Mine Fork Creek and 700-Foot Level Creek, with mine rock encroaching into local stream channels at specific locations.

Figures 2-18 and 2-19 provide the current topography of the north and south 900-Foot Level mine rock piles and the 700-Foot Level mine rock pile, respectively, developed from the 2009 topographic survey. The estimated volume of material present in these mine rock piles determined from the topographic survey is summarized in Table 2-1. Visual inspection and gamma survey results indicate that scattered mine rock also exists in discrete areas beyond the physical footprints of the mine rock piles at the 700-Foot and 900-Foot Levels. In Table 2-1, the estimated volumes for the mine rock piles have been increased by 10 percent to account for scattered mine rock near the mine rock piles.

2.3.4 300-Foot Level

The features present at the 300-Foot Level include the portal and mine rock pile. Figure 2-20 shows the location of these features.

300-Foot Level Portal and Adit

The 300-Foot Level portal and adit were constructed in 1971 to provide access to the ore body below the 700-Foot Level workings. The portal is open and is approximately 20 feet wide and 17 feet high at the entrance but quickly narrows to the adit dimensions of approximately 16 feet wide by 13 feet high (Figure 2-21). The adit is approximately 1,300 feet long (Figure 2-13). The 300-Foot Level adit drains the entire Ross-Adams underground mine. Flow of mine water drainage from the 300-Foot Level portal is believed to occur year-round and was observed during all seasons when Site investigations were conducted. The 300-Foot Level portal drainage is the primary source of mine drainage water to surface streams. The rate of drainage varies seasonally and likely peaks in the wet season. Sampling data show that water quality of the drainage improves during the high flow period, which is characteristic of the non-reactive, non-acid generating, nature of the ore body and host rock geology.

The 300-Foot Level portal is also the primary source of radon exhalation to air as it is the primary exit point for air flow through the underground mine workings. The other portals also contribute radon to air, but at lower measured concentrations as shown by the 2009 ESI radon monitoring results in Table 2-4. The results of the 2009 radon monitoring are summarized in Section 2.5.6.

300-Foot Level Mine Rock Pile

The mine rock pile at the 300-Foot Level is the largest mine rock pile at the Site. The topography of this mine rock pile is shown in Figure 2-20 and is based, as described in the SCR (Tetra Tech, 2010), on topography presented in the PA/SI (KSI, 2004) and confirmed by visual observations during the ESI. Topographic surveying of the 300-Foot Level mine rock pile was not possible during the ESI since the dense vegetation and steep side slopes limited access by the survey crew. The toe of the mine rock pile contains large mine rocks (Figure 2-22) and visual inspection and gamma survey results identified several locations below the 300-Foot Level mine rock pile where these large mine rocks had rolled-off the steep side slope of the mine rock pile.

The 300-Foot Level mine rock pile is comprised of both non-mineralized development rock generated during development of the 300-Foot Level adit and mineralized mine rock from the ore body. It is estimated that approximately 48 percent of the 300-Foot Level mine rock pile is non-mineralized development rock. The estimated area and volume of the 300-Foot Level mine rock pile are provided in Table 2-1. As described above, visual inspection and gamma survey results indicate that mine rock exist in discrete locations near the toe and west of the 300-Foot Level mine rock pile. In Table 2-1, the estimated volume for the mine rock pile has been increased by 10 percent to account for mine rock in these discrete areas.

2.3.5 Ore Staging Area

The Ore Staging Area (OSA) is located on the northern shoreline area of the West Arm of Kendrick Bay and was the location where ore was stored or staged prior to loading on barges for off-site shipment (Figure 2-2). Cleanup of the OSA occurred in 1971. The OSA is surrounded by an earthen berm constructed to divert surface runoff around the area and which provides a visual boundary for the OSA. Natural revegetation of the area is taking place, with trees and a thick mat of organic material present across most of the surface of the OSA. As described in the SCR (Tetra Tech, 2010), the disturbed area at the OSA was determined from site observations, topographic survey, review of historical aerial photography, and knowledge of cleanup and demobilization activities performed after mining ceased. The visible limits of the OSA, as defined by the earthen berm, were topographically surveyed and delineate the area as shown in Figure 2-23. Visible ore is not present within the OSA except in one pile of large radioactive boulders along the eastern perimeter.

The estimated volume and area of the OSA is summarized in Table 2-1. The volume is based on the physical area of the OSA determined from the topographic survey and the assumed 18-inch thick surficial organic mat over most of the area of the OSA and an underlying 2-foot thick layer of affected soil over the total area of the OSA, although no subsurface sampling has been performed to verify the affected soil depth. As described below in Section 2.5.1, the results of the gamma survey and soil sampling conducted during the ESI within the OSA indicate that mine-affected material extends beyond the surveyed boundary of the OSA. Mine-affected material exists in localized areas that adjoin the surveyed boundary of the OSA on the east side and along the access road on the west side. In Table 2-1, the estimated volume of the mine-affected materials within the OSA has been increased by 10 percent to account for these adjoining areas.

2.3.6 Rock Loadout Ramps and 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. The locations of the loadout ramps are shown in Figure 2-2. Photographs of these remnant rock loadout ramps, to which floating ore loading docks were attached, are provided in Figures 2-24 and 2-25. The oldest of these rock loadout ramps is located approximately 600 feet west of the existing floating dock, the second or middle ramp is relatively small at the existing floating dock, and the third is directly south of the OSA and was used during the last period of mining. The rock used to construct the eastern ramp was obtained from a non-mineralized basalt outcrop located along the northern shoreline a short distance east of the OSA. The topographic survey of the largest, most easterly rock loadout ramp is included in Figure 2-23, which includes the current topography of the OSA. The estimated volume of the west and east ramps, including the basalt rock used to construct the ramps, is approximately 370 and 580 cubic yards, respectively. The middle rock loadout ramp is relatively small, with an estimated volume of approximately 150 cubic yards.

The gamma surveys conducted in this area show that mine-affected materials exist around the loading ramps, but the ramps themselves consist of native rock. The affected area around the loading ramps is due to spillage of ore during former barge loading operations. This condition was documented by detailed visual and gamma survey of investigation plots ("dock plots") established in the intertidal zone around the loading ramps, as described in the SCR (Tetra Tech, 2010). Figure 2-23 shows the location of these dock plots. The dock plot investigation confirmed that the elevated gamma measurements in the intertidal zone around the loading ramps were due to discrete, durable individual ore rocks ranging from 1-inch to 30-inch in size scattered on the surface as a result of spills during former ore loading operations, rather than fine-grained material interspersed with native material. Table 2-3 summarizes the results of the dock plot investigation. The presence of spilled ore rock likely extends from the loading ramps to the immediate vicinity surrounding the former floating dock within the subtidal zone. Figure 2-26 shows a photograph of a typical ore rock identified during the dock plot investigation. Based on the dock plot results, a volume of approximately 20 cubic yards of ore rock is estimated to be scattered within the intertidal zone south of the OSA in the vicinity of the ore loading ramps.

2.3.7 Mine and Haul Roads

Mine and haul roads constructed for exploration and mining at the Site included primary haul roads connecting the OSA and loading docks at the West Arm of Kendrick Bay to the 900-Foot and 300-Foot Levels, and the mine road connecting the 700-Foot and 900-Foot Levels.

Haul Roads

The haul roads were constructed to provide access to the mine workings and for transport of the ore to the OSA and loading facilities. These haul roads were initially constructed of material provided by road cuts and borrowed from the intertidal zone of the Kendrick Creek delta. From the OSA to the 300-Foot Level, the haul road is approximately 6,785 feet long, and from the 300-Foot Level road intersection to the 900-Foot Level the haul road is approximately 5,850 feet long (Figure 2-2). Because the haul roads were originally constructed of native material, the identified segments of the haul roads exhibiting elevated gamma exposure rates are the result of ore rock spilled on the road surface during hauling to the OSA and probable use of mine rock for repair and maintenance of specific road segments. Figure 2-27 shows the location of the haul road segments identified by elevated gamma exposure rates determined from gamma surveys. For purposes of the EE/CA evaluation, it is estimated that the top one foot of the haul roads are affected by mine materials in these segments. Table 2-1 summarizes the estimated volume of mine-affected material within the identified haul road segments. Two landslide areas were identified during the Engineering Assessment on the steep native hillside beneath the haul road to the 300-Foot Level, as described in the SCR (Tetra Tech, 2010). Figure 2-27 also shows the location of the two landslide areas.

900-Foot Level to 700-Foot Level Mine Road

The 900-Foot Level to 700-Foot Level mine road was constructed using mineralized mine rock to connect the 700-Foot and 900-Foot Levels (Figure 2-5). There are six primary roadway embankments constructed with mine rock; labeled I through VI. Mineralized bedrock or thin native soils developed from mineralized bedrock underlie the mine road embankments and the entire length of the mine road surface from the 700-Foot Level to the 900-Foot Level. Relatively high and variable background gamma exposure rates are associated with the mineralized bedrock. In addition to a thin veneer of native soil and mineralized bedrock along the mine road surface, the results of the gamma survey, as summarized in Section 2.5.1, indicate that scattered mine rock or potentially ore spilled during hauling may be present on the surface of the mine road. The estimated area and volume of the mine road embankments are presented in Table 2-1, and the topographic survey of mine road embankments is provided in Figure 2-28. For EE/CA evaluation, the estimated volume of the mine road embankments has been increased by 10 percent in Table 2-1 to account for scattered mine rock along the mine road surface.

I&L Zone Spur Road

The I&L Spur road is a short section of road constructed from the 900-Foot Level haul road to provide access to the I&L Zone (Figure 2-27). The road is approximately 500 feet long and constructed of either mine rock or native mineralized bedrock. While the SCR assumed that mine rock comprised only the upper one-foot of the I&L Spur road, for purposes of this EE/CA the entire road thickness (approximately 3 to 4 feet) is assumed to be comprised of mine rock. Table 2-1 provides the area and estimated volume for the I&L Spur road.

2.3.8 Miscellaneous Wastes

The 2009 ESI identified and inventoried the types, quantities and locations of the miscellaneous solid wastes and petroleum products present at the Site. As described in the SCR (Tetra Tech, 2010), the miscellaneous solid wastes and petroleum products, include abandoned vehicles, empty and partially filled 55-gallon drums, two above-ground petroleum storage tanks, collapsed buildings, drill core, and other materials. Petroleum-stained soils were sampled and characterized. The locations of these miscellaneous wastes are described in the SCR.

2.4 Engineering Assessment

The engineering assessment conducted as part of the 2009 ESI evaluated the engineering aspects of the Site to develop information to be used in the EE/CA. The elements of the engineering assessment and the findings are summarized in the following.

2.4.1 Mine Rock Piles and Road Stability

The stability of the mine rock piles and mine and haul roads were assessed in terms of the physical stability (i.e. slope and erosional stability). The assessment indicated that these features exhibited a high degree of stability. No slope failures or progressive raveling of material from the surface of the mine rock piles were observed and the coarse nature of the mine rock prevented rill and gully development. Further, the general coarse and competent nature of the mineralized and non-mineralized rock and the lack of fine-grain material preclude wind and water erosion of surfaces. However, at isolated areas along the haul road where the roads cross drainages, concentrated runoff created shallow ruts and small gullies.

2.4.2 On-Site Repository Sites

The engineering assessment evaluated the Site for possible locations for construction of new repositories for mine materials and concluded that no suitable sites existed except at the 900-Foot Level Open Pit. The conclusion was based on the lack of currently undisturbed sites that had sufficient area for a repository and where slopes were reasonably shallow and near surface bedrock was not present. A repository at the 900-Foot Level Open Pit was determined acceptable because the capacity of the Open Pit and adjacent area provides sufficient volume to consolidate mine material.

2.4.3 On-Site Borrow Sources

The engineering assessment evaluated sources of on-Site borrow. The assessment identified an on-site borrow material source at the Kendrick Creek delta within the intertidal zone of the West Arm of Kendrick Bay. This source was used in the construction of haul roads during mining. A basalt outcrop on the shoreline east of the OSA was also previously used as a source of rock to construct the ore loadout ramp, and could potentially represent a source of on-site borrow for rock. No other on-Site sources of borrow material were identified during the engineering assessment.

2.4.4 Topographic Survey

A topographic survey was conducted as part of the ESI to establish the surface configuration and boundaries of the mine features, as described in the SCR (Tetra Tech, 2010). The boundaries surveyed were determined based on visual identification in the field using material properties, vegetation and terrain. The surveyed boundaries for each feature, depicted in figures in this EE/CA of the existing conditions for the features, are generally consistent with the boundaries of mine features determined based on gamma survey and soil sampling results, as described in the SCR. Access in some areas, particularly at the 300-Foot Level mine rock pile, limited or prevented topographic survey.

2.5 Chemical and Radiological Characterization

2.5.1 Soil Sampling and Gamma Survey

The soil sampling and gamma survey results were used to characterize mine materials and native soils at the Site with respect to radionuclide and metal concentrations. In addition, gamma survey and soil sampling, along with visual observation, were used to identify the extent of mine-affected materials adjacent to the physical boundaries of the mine features (mine rock piles, roads and loading facilities). In addition, gamma survey and soil sampling provided data to correlate gamma exposure rates with soil radionuclide and metal concentrations. The correlations provide a reliable and accurate method to calculate the concentrations of important radionuclides in soil using the extensive gamma exposure rate measurement results. The distribution of mine related soil metal concentrations were encompassed by those mine-affected areas delineated by the results of the gamma survey. The gamma exposure rates and the correlation with soil radionuclide concentrations are most useful in defining the boundaries of mine rock and mine-affected areas in the non-mineralized area of the Site. In the mineralized area, highly variable gamma exposure rates and soil radionuclide concentrations are dependent on the local natural mineralogy and geologic conditions within the area of the mineral deposit. Therefore, the boundaries of mine rock and mine-affected areas are not clearly differentiated from background conditions in the mineralized area by measured gamma exposure rates and soil sampling results. In the mineralized area, visual observation is an essential element of boundary delineation.

Soil Sampling

Soil samples were taken of the fine-grained fraction of mine materials on the mine rock piles and native soils at the transitions of the piles and adjacent surrounding undisturbed areas. The soil sampling was used to augment and confirm the information provided by the gamma survey for boundary determination, to develop data for background soil concentration characterization, and to provide soil concentrations for ecological and human health risk assessment. Soil sampling of mine features was concentrated at the boundaries of features where the mine features transitioned into the natural setting. Extensive sampling within the mine features was not performed during the ESI because the gamma surveys and soil sample correlation provided the necessary information and since sampling of the mine features performed in previous investigations provided sufficient information to characterize the mine rock.

The results of the soil sampling and measured gamma exposure rates presented in the SCR (Tetra Tech, 2010), as discussed in the following section, were used to define the mean gamma exposure rates for each mine feature. The average concentrations of selected radionuclides for each mine feature were determined from the mean gamma exposure rate using the correlations established in the SCR between gamma exposure rates and radionuclide concentrations. Table 2-2 summarizes the average gamma exposure rates and the average concentrations of selected radionuclides for each mine feature.

Gamma Survey

The gamma survey provided extensive coverage of the mine features and accessible areas of the Site areas outside of the mine features. The gamma survey provided real time data output that was used in the field to guide the survey. The gamma survey collected over 182,000 individual gamma exposure rate measurements over an area of approximately 185 acres. These measurements provide a graphic delineation of mine-affected areas and the characteristics of the naturally mineralized background area of the Site. Figure 2-29 shows the distribution of gamma exposure rates at the Site.

The gamma survey was conducted using unshielded sensors located one-meter above the ground surface. Because of this, the gamma measurements include radiation “shine” from sources away from the point of measurement. The amount of shine is a function of the strength and distance of other sources. During the gamma survey, the survey team observed elevated gamma exposure rates in localized areas beyond the physical boundaries of the mine features and upon investigation identified individual mine rocks that were the cause of the unanticipated elevated gamma exposure rate measurements. Several deposits of large mine rocks were identified in specific areas adjacent to the toe of the 300-Foot Level mine rock pile along Kendrick Creek. The large mine rocks had either rolled-off the steep side slope of the pile to areas near the toe of the pile and adjacent to the stream channel or had been displaced by concentrated surface water flow prior to vegetation growth on the surface and side slopes of the pile. The side slopes of the pile are currently stable due to the dense vegetation and future rock displacement is not anticipated. As described in Section 2.3.6, elevated gamma exposure rates were also measured in the area around the loading ramps beyond the physical boundary of the OSA. The elevated gamma exposure rate measurements in the intertidal zone around the loading ramps were due to discrete, durable individual ore rocks scattered on the surface as a result of spills during former barge loading operations. The visual observations and the results of the gamma surveys indicate that elevated gamma measurements in localized areas result from individual mine or ore rocks rather than fine-grained material interspersed with native material.

The gamma survey and soil sampling results were used to delineate the extent of mine-affected materials away from mine features and establish their boundaries. Table 2-2 provides the average gamma exposure rates for each mine feature. The gamma survey data for the 900-Foot and 700-Foot Levels, the 300-Foot Level, and the OSA are shown on Figures 2-30, 2-31 and 2-32. The same gamma exposure rate data were presented on figures in the SCR, except that the data in the SCR were presented as “kriged” values (figures presenting the unkriged data were presented in Appendix E of the SCR). Kriging is a geostatistical technique for interpolating the values at unobserved locations based on the observations at nearby locations. The gamma exposure rate data presented on Figures 2-30, 2-31 and 2-32 represent the unkriged data from the gamma exposure rate measurements. The unkriged data are more useful in precisely delineating the boundaries of the mine feature areas in conjunction with visual observations and topographic survey information.

As previously described, the physical boundaries (footprints) of the mine features areas were defined based on visual observations and topographic surveying. The visual and topographic survey boundaries are considered the most precise physical boundaries of the mine rock piles. The physical boundaries of the piles are consistent with the measured gamma exposure rates, except in a few discrete areas described below. It is important to note that the gamma survey exposure rates were measured at three feet above the ground surface, and do not necessarily represent the source material gamma exposure rate for that exact location. The survey detectors receive gamma radiation from as far away as 15 feet.

The results of the gamma surveys and soil sampling indicate that mine-affected material in specific locations extend beyond the physically defined boundaries of the 300-Foot Level mine rock pile and at the OSA. As shown on Figure 2-31, elevated gamma exposure rates extend beyond the physical boundary of the 300-Foot Level mine rock pile in an area adjacent to the toe of the mine rock pile and in an area adjoining the western boundary of the mine rock pile. The elevated gamma measurements are associated with several deposits of large mine rocks that were identified adjacent to the toe of the 300-Foot Level mine rock pile. Mine rock was also observed adjoining the western boundary of the mine rock pile west of Kendrick Creek. The results of the HHRA and SLERA (Section 3) indicate that soil samples contributing risk to human and ecological receptors are coincident with the elevated gamma exposure rates in these areas. These areas are delineated on Figure 2-31 and are included as part of the mine-affected area at the 300-Foot Level mine rock pile for evaluation in this EE/CA. The estimated volume of mine rock at the 300-Foot Level mine rock pile has been increased by 10 percent to account for the mine-affected material that extends beyond the physical boundary of the mine rock pile in these areas.

Figure 2-32 presents the gamma exposure rate measurements for the OSA in relation to the surveyed boundary of the OSA. Elevated gamma exposure rates extend beyond the surveyed boundary of the OSA in an area adjoining the boundary of the OSA on the east side and in an area along the access road on the west side. The elevated gamma measurements are likely associated with mine-affected material in these two areas. The results of the HHRA and SLERA (Section 3) indicate that soil samples contributing risk to human and ecological receptors are coincident with the elevated gamma exposure rates in these areas. These areas are delineated on Figure 2-32 and are included as part of the mine-affected area at the OSA for evaluation in this EE/CA. The estimated volume of mine materials at the OSA has been increased by 10 percent to account for mine-affected material in these areas adjoining the surveyed boundary of the OSA.

Mine Rock

Soil sampling and gamma survey were used to characterize the mine rock present in the mine rock piles, the OSA and the roads. The information indicate that the mine rock present at the 900-Foot, 700-Foot and 300-Foot Levels, the OSA and in certain areas of the haul and mine roads contain elevated concentrations of metals and radionuclides. The average gamma exposure rates and concentrations of selected radionuclides for each mine feature are provided in Table 2-2. Because of the physical and erosional stability of the mine rock, the effect on soils and sediments at the boundaries of the mine features is limited to defined down-slope areas at the toe of mine rock piles and in the locations where the mine rock piles encroach into stream channels. In other areas, individual mine rocks have rolled-off the side slopes of the mine rock piles or ore rocks have been spilled during hauling along haul roads or ore loading at the loadout ramps.

2.5.2 Surface Water

The surface water sample locations from the SCR are shown on Figure 2-33. Surface water quality at the Site is characterized by calcium/sodium-bicarbonate waters of low ionic strength and low buffering capacity, typical of granitic environments; with mildly acidic to neutral pH, and low concentrations of sulfate, total dissolved solids (TDS), and total suspended solids (TSS) even during periods of increased flow due to precipitation. The mine features potentially affecting surface water 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 300-Foot Level portal (Figure 2-2). The water quality data, along with the mineralogy of the Site geology and ore body, demonstrate that ARD is not an environmental condition at the Site.

The 300-Foot Level portal drainage has the highest metal and radionuclide concentrations of surface water quality samples collected at the Site. As described in the SCR, metal concentrations of samples collected from the 300-Foot Level portal drainage were below Alaska chronic freshwater criteria for aquatic life and/or background surface water quality, except for the zinc concentration in one sample. Uranium, radium (combined Ra-226 and Ra-228), and manganese concentrations of water samples collected from the portal drainage were greater than Alaska water quality criteria for drinking water. After flowing a short distance the drainage from the portal joins Mine Fork Creek, and then Mine Fork Creek joins Kendrick Creek, which subsequently flows along the 300-Foot Level mine rock pile. As described in the SCR, the steep gradient of Kendrick Creek to below the 300-Foot Level is classified by the USFS as "Deeply Incised Mountainslope channel" with negligible spawning and rearing habitat for all salmonids.

Water quality in Kendrick Creek below the confluence with Mine Fork Creek and the 300-Foot Level portal drainage, as documented in the SCR, meets Alaska water quality standards for all designated freshwater uses (except the chronic aluminum standard for freshwater aquatic life). While above the chronic standard for freshwater aquatic life, aluminum concentrations in Kendrick Creek were less than the range of background surface water concentrations and not attributable to the drainage from the 300-Foot Level portal. Aluminum concentrations at the background surface water locations also exceeded the chronic standard for freshwater aquatic life. While below applicable water quality standards or background, concentrations of certain metals and radionuclides are highest in Kendrick Creek adjacent to the 300-Foot Level mine rock pile due primarily to the drainage from the 300-Foot Level portal, but decrease downstream. Due to the steep gradient, Kendrick Creek to below the 300-Foot Level is considered negligible spawning and rearing habitat for all salmonids. Concentrations continue to decrease in the lower portions of Kendrick Creek. In the lower reaches of Kendrick Creek, habitat is physically more amenable to salmonid spawning and rearing. Although Kendrick Creek is not used as a drinking water supply, water quality in Kendrick Creek also meets Alaska water quality criteria for drinking water.

Surface water quality for the 700-Foot Level Creek and, to a lesser extent, Mine Fork Creek, show localized affects from mine rock piles and associated soils. The concentrations of several metals and radionuclides in 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 exceeded background surface water concentrations. The lower reaches of both Mine Fork Creek and the 700-Foot Level Creek have physical barriers to upstream fish movement and are upstream of the waterfall at the 300-Foot Level. 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 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. The surface water quality data and potential exposure pathways for human and ecological receptors are further evaluated in the risk evaluations presented in the HHRA and the SLERA (Section 3).

2.5.3 Stream Sediment

Stream sediments were sampled at locations in Kendrick Creek and its tributaries at locations above the mining area, downstream of mine rock piles, and downstream in Kendrick Creek to the Kendrick Creek delta (Figure 2-33). Due to the high gradient of most stream channels, including Kendrick Creek, the presence of fine-grain sediment is limited to localized stream reaches and is discontinuous. The absence of fine-grained stream sediments precluded the collection of sediments at several locations during the ESI, as described in the SCR (Tetra Tech, 2010). Cobble and gravel dominate the composition of the streambed sediments.

The observed distribution and trends of most metals and radionuclides in stream sediment were similar to surface water. Similar to surface water, metal and radionuclide concentrations in stream sediment show some effect from mine rock and drainage from the 300-Foot Level portal. The highest metal and radionuclide concentrations in stream sediment occur in the drainage from the 300-Foot Level portal and typically in Kendrick Creek immediately downstream of the 300-Foot Level mine rock pile. Stream sediment metal and radionuclide concentrations decrease downstream in Kendrick Creek, 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 concentrations in Kendrick Creek stream sediment also decrease downstream and, by a point just above the Cabin Creek confluence, radionuclide concentrations are at or below the background radionuclide concentrations for stream sediment. The stream sediment data and potential exposure pathways for human and ecological receptors are further evaluated in the risk evaluations presented in the HHRA and the SLERA (Section 3).

2.5.4 Groundwater

Groundwater is not considered a relevant resource at the Site. Shallow groundwater, where present, either occurs in the very shallow, discontinuous and poorly developed soils or in the shallow and discontinuous alluvium in the stream channels. Shallow groundwater is not expected to be distinct in quality from surface water. Bedrock groundwater only exists in fractures and does not constitute a resource or media.

2.5.5 Kendrick Bay Marine Sediments

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), as presented in the SCR (Tetra Tech, 2010) and shown on Figure 2-34. 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 in the upper portion of the Kendrick Creek watershed.

Sediment sampling and gamma surveying in the intertidal zone accessible during low tide in 2009 indicate that intertidal marine sediments have not been adversely affected by historic mining activities except in the immediate area around the ore loadout ramps. As described previously, the detailed dock plot data demonstrate that the elevated unshielded gamma exposure rate measurements resulted from individual ore rocks spilled on the surface during former ore loading operations. Figure 2-26 shows an example of the ore rocks present in the ore loadout area. The subtidal zone sediment sample data indicate the influence of spilled ore is also limited to the immediate vicinity of the rock loadout ramps and the former floating dock. Gamma exposure rates and the concentrations of metals and radionuclides are highest in the subtidal sediments closest to the former floating dock, with the highest values closer to shore. Metal and radionuclide concentrations in intertidal and subtidal sediment samples located further distance from the rock loadout ramps represent local background.

2.5.6 Air - 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. As presented in the SCR (Tetra Tech, 2010), the radon concentrations measured at the Site during the ESI are shown in Figure 2-35.

The measured radon concentrations indicate that air flow from the 300-Foot Level portal is the most significant source of radon at the Site but that radon air concentrations also occur from the other portals and the Open Pit. The highest radon concentration of 445 ρCi/L was measured at the 300-Foot Level portal. 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. A radon concentration of 373 pCi/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.

Evaluation of the radon concentrations from the individual mine rock piles to overall Site radon concentrations is evaluated qualitatively based on the location of the radon measurement with respect to the pile location. 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). 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 loadout ramps. 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.

As shown from the radon concentrations in Figure 2-35, except for the 300-Foot Level portal, radon quickly disperses in the atmosphere and radon levels approach background levels within short distances from the mine features. However, the qualitative effects of local wind and topography on the change in radon air concentration are also evident. 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. The background radon air concentrations at the Site are high when compared to background levels in Alaska and the U.S., reflecting the highly mineralized nature of the Site as well as the significance of the radon sources such as the portals.

Ventilation modeling performed of the Ross-Adams mine workings confirmed that the upper mine openings, the 900-Foot Level portal, the air shaft and the 700-Foot Level portal, are the source of air inflow into the underground mine workings, with air exiting the mine at the 300-Foot Level portal. The modeling predicted that closure of the upper mine openings would significantly reduce air flow from the 300-Foot Level portal. The effect on radon concentrations at or downwind of the portals due to the predicted reduction in air flow by closure of the upper mine openings is not possible based on the available data. However, elimination of air inflow at the upper mine openings would significantly reduce air flow, and possibly reduce radon exhalation from the 300-Foot Level portal.

2.5.7 Air - Dust and Particulates

Dust and particulates are not a Site media of concern. Site air quality is not materially affected by mine material dust or particulates, or natural exposure of bare soil or bedrock, because the topography, vegetation and wet climatic conditions at the Site and the generally coarse nature of the mine and natural materials inhibit the generation of wind-born material.

Table 2-1. Summary of Volumes of Mine Affected Materials

Source	Estimated Area (SY)	Estimated Volume (CY)	Comments and Assumptions
900-Foot Level			
North Mine Rock Pile	4,693	8,604	Surveyed/Ucore DTM, 5.5' Avg. Thickness
South Mine Rock Pile	588	588	Surveyed/Ucore DTM, 3' Avg. Thickness
Subtotal	***5,281***	***9,192***	
900-Foot Level Adjusted Subtotal		***10,111***	Volume inflated 10% for lateral variation
700-Foot Level			
700-Foot Level Mine Rock Pile	***4,413***	***7,355***	Surveyed/Ucore DTM, 5' Avg. Thickness
700-Foot Level Adjusted Subtotal		***8,091***	Volume inflated 10% for lateral variation
Mine Road Embankments (900-Foot Level to 700-Foot Level)			
I	630	945	Surveyed/Ucore DTM, 4.5' Avg. Thickness
II	209	313	Surveyed/Ucore DTM, 4.5' Avg. Thickness
III	910	910	Surveyed/Ucore DTM, 3' Avg. Thickness
IV	269	448	Surveyed/Ucore DTM, 5' Avg. Thickness
V	149	248	Surveyed/Ucore DTM, 5' Avg. Thickness
VI	161	161	Surveyed/Ucore DTM, 3' Avg. Thickness
Subtotal	***2,328***	***3,025***	
Adjusted Subtotal		***3,328***	Volume inflated 10% for lateral variation
700-Foot/900-Foot Levels Subtotal	***12,022***	***21,530***	
300-Foot Level			
300-Foot Level Mine Rock Pile	***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
Subtotal		***28,854***	
300-Foot Level Adjusted Subtotal		***31,739***	Volume inflated 10% for lateral variation
Ore Staging Area			
OSA	6,000	3,000	2009 Survey/Ucore DTM, Assumed 1.5' Thick organic mat
OSA	6,758	4,500	2009 Survey/Ucore DTM, Assumed 2' cont. soil
OSA Subtotal	***6,758***	***7,500***	
OSA Adjusted Subtotal		***8,250***	Volume inflated 10% for lateral variation
Scattered Ore Rock in Intertidal Area		**20**	Estimated based on dock plots from Tetra Tech, 2010

Table 2-1. Summary of Volumes of Mine Affected Materials (Continued)

Source	Estimated Area (SY)	Estimated Volume (CY)	Comments and Assumptions
Haul Road			
OSA to 300-Foot Level			
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***	
Intersection to 900-Foot Level			
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***	
Total Haul Road Material Volume	***9.161***	***3,049***	
I & L Spur	**1,028**	**1,200**	Based on Gamma survey, approx. 3.5' thick
Total Mine Affected Materials		***65,788***	900-Foot Level Mine Rock Piles (10,111 CY), 700-Foot Level Mine Rock Pile (8,091 CY), Mine Road Embankments (3,328 CY), 300-Foot Level Mine Rock Pile (31,739 CY), OSA (8,250 CY), Scattered Ore (20 CY), Haul Roads (3,049 CY) and I&L Spur (1,200 CY)

Table 2-2. Average Gamma Exposure Rates and Radionuclide Concentrations for Mine-Affected Areas

Mine-Affected Areas	Measured Gamma Exposure Rate (uR/hr)				Correlated Radionuclide Concentrations			
	No. of Measurements	Minimum	Maximum	Mean	Uranium (mg/Kg)	Th-232 (pCi/g)	Ra-226 (pCi/g)	Ra-228 (pCi/g)
Mine Rock Piles								
OSA	4689	20	4103	1253	832	234	502	199
300-Foot Level Mine Rock	4276	42	2460	341	229	67	129	55
700-Foot Level Mine Rock	2367	129	4207	960	639	181	383	152
900-Foot Level North Mine Rock	2195	160	2623	683	456	130	269	109
900-Foot Level South Mine Rock	509	444	1730	1020	678	192	407	162
900-Foot Level Open Pit	3867	177	2727	960	639	181	383	152
Mine Road (700-Foot to 900-Foot Levels)								
Mine Rock Embankment I	75	511	1275	852	567	161	338	135
Mine Rock Embankment II	154	283	657	509	340	98	198	81
Mine Rock Embankment III	390	133	1367	573	382	109	224	91
Mine Rock Embankment IV	279	536	1196	839	559	158	333	133
Mine Rock Embankment V	250	252	1046	698	465	132	275	111
Mine Rock Embankment VI	251	349	1216	621	414	118	244	99
Haul Road OSA to 300-Foot Level								
Segment 1	1893	38	683	277	187	55	102	44
Segment 2	153	63	187	118	82	26	38	19
Segment 3	204	20	177	82	58	19	23	14
Segment 4	192	50	220	114	79	25	36	19
Segment 5	38	44	174	88	61	20	25	14
Segment 6	44	38	535	212	144	43	76	34
Segment 7	46	24	152	109	76	24	34	18
Segment 8	28	43	357	146	100	31	49	24
Segment 9	27	54	169	100	69	22	30	16
Segment 10	61	59	355	160	110	33	55	26

Table 2-2. Average Gamma Exposure Rates and Radionuclide Concentrations for Mine-Affected Areas (cont.)

Mine-Affected Areas	Measured Gamma Exposure Rate (uR/hr)				Correlated Radionuclide Concentrations			
	No. of Measurements	Minimum	Maximum	Mean	Uranium (mg/Kg)	Th-232 (pCi/g)	Ra-226 (pCi/g)	Ra-228 (pCi/g)
Haul Road 300-Foot to 900-Foot Levels								
Segment 1	74	30	151	61	44	15	14	10
Segment 2	194	38	662	236	160	47	86	38
Segment 3	125	52	528	230	156	46	83	37
Segment 4	172	54	738	268	180	53	99	43
Segment 5	507	55	661	179	122	37	62	29
Segment 6	71	42	275	102	71	23	31	17
Segment 7	12	95	292	181	123	37	63	29
Segment 8	6	71	194	108	75	24	33	18
Segment 9	144	47	149	79	56	18	21	13
I&L Spur Road	1321	34	874	483	323	93	187	77

Table 2-3. 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 2-4. 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. 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

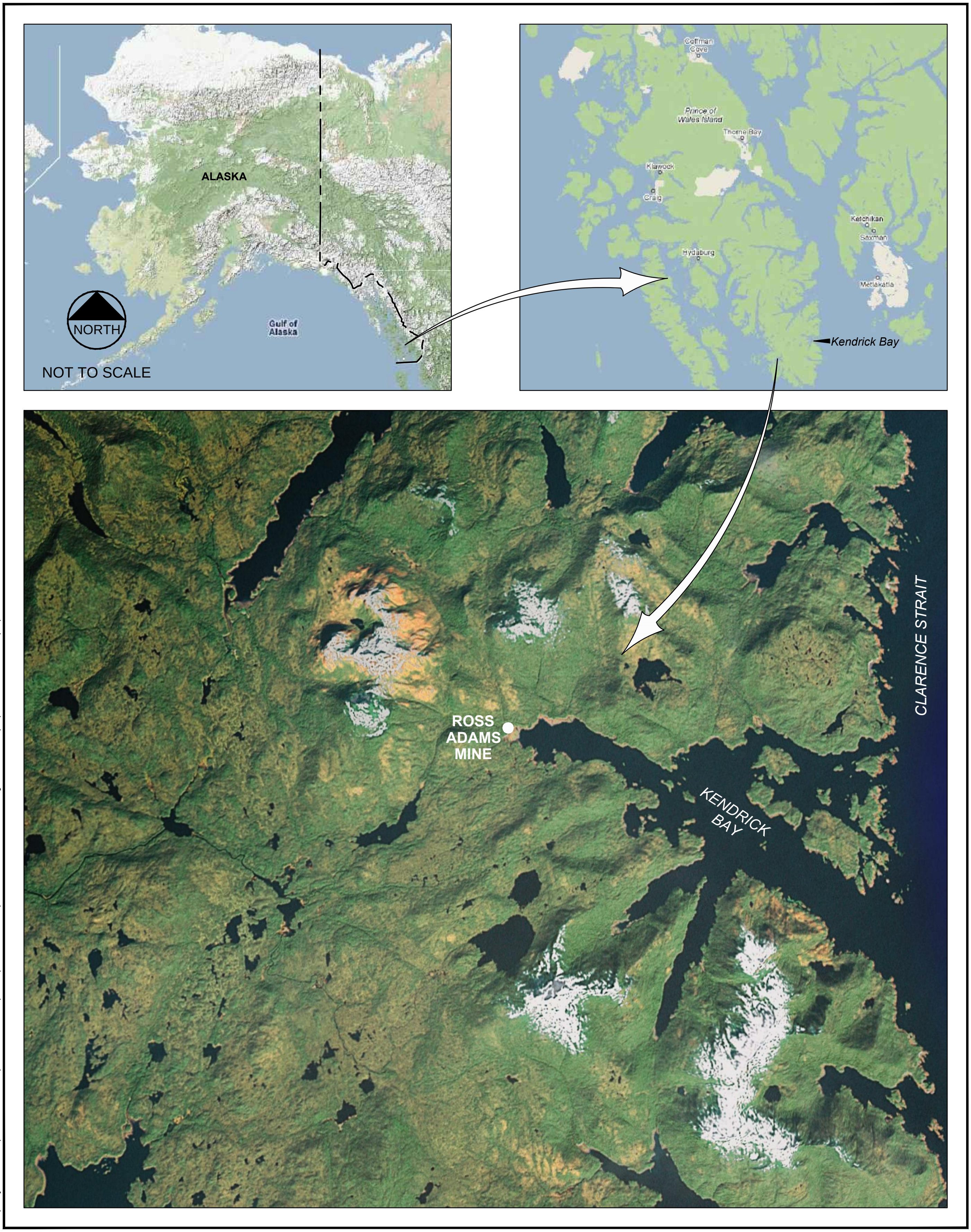
Missing- Test equipment taken from station

Tampered- Radon station was tampered with but still submitted to lab

Saturated- Radon concentration exceed maximum of radon detector for total time period

Damaged- Test equipment found on ground and water damaged

Sample ID's noted with a "*" indicate station is background



Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\FIG-2-01 Location.dwg SAVED: 4/2/15 PRINTED: 4/2/15 BY: TOM

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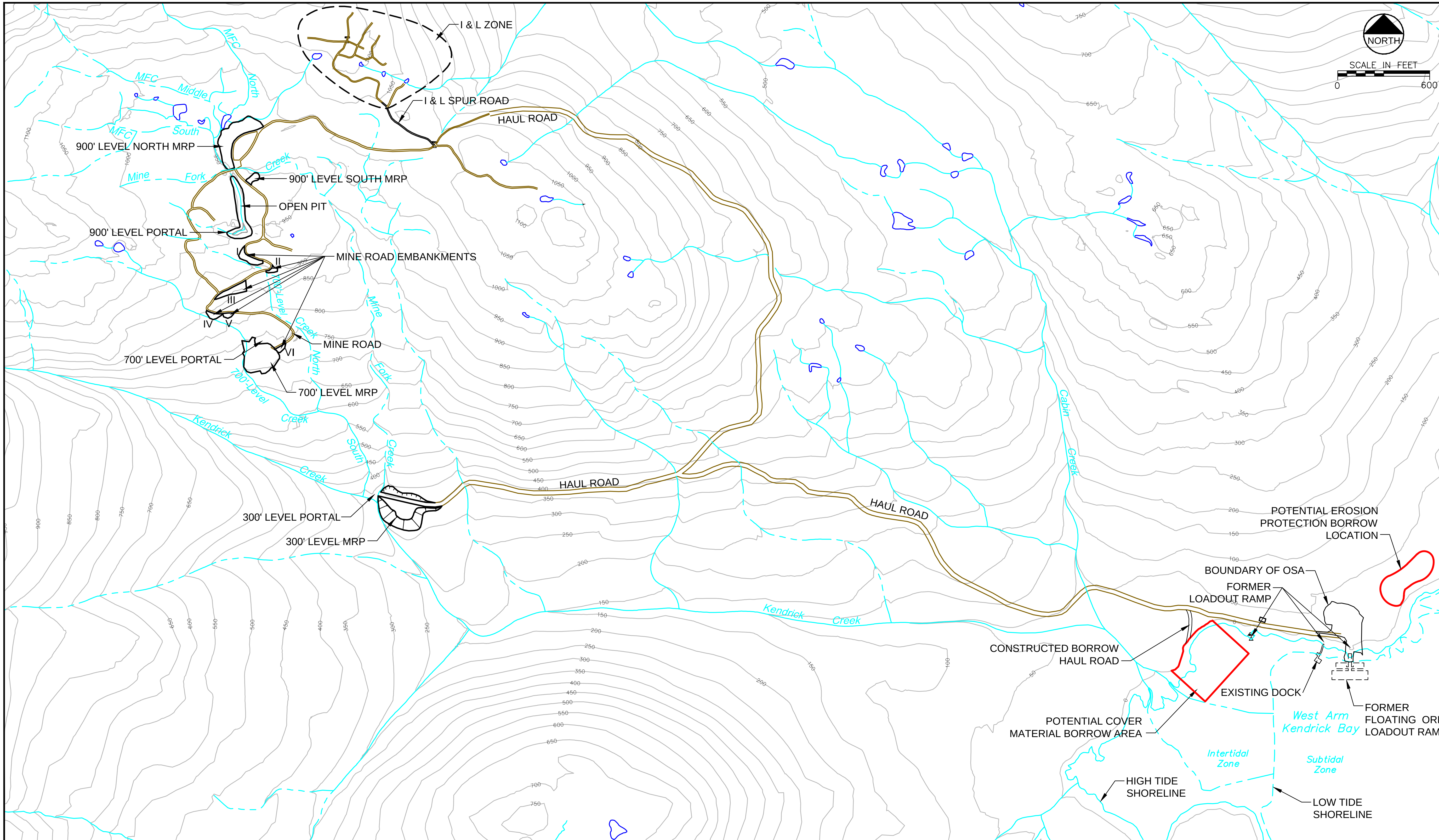
Figure 2-1
Ross-Adams Site Location



Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\FIG-2-02 Major Features.dwg SAVED: 10/8/14 PRINTED: 4/2/15 BY: TOM

CONTOUR INTERVAL = 50 FEET
BASE MAP PRODUCED FROM AERIAL PHOTOGRAPHY FLOWN: AUGUST 8, 2005.
COMPILED BY: EAGLE MAPPING LTD.

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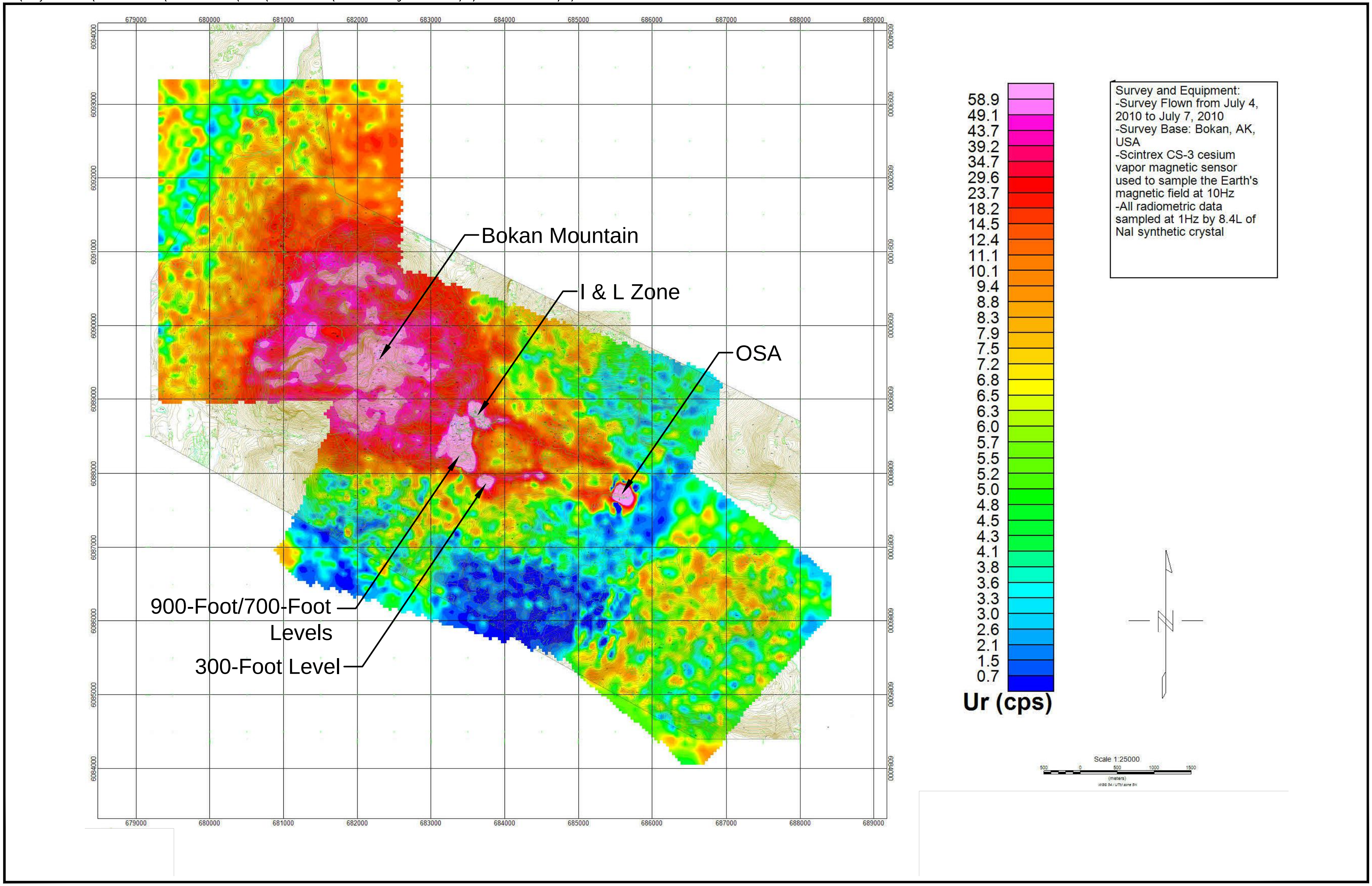
Figure 2-2
Ross-Adams Site
Major Site Features

Figure 2-3. Aerial photograph 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).

Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\FIG-2-4.dwg SAVED: 4/2/15 PRINTED: 4/2/15 BY: TOM



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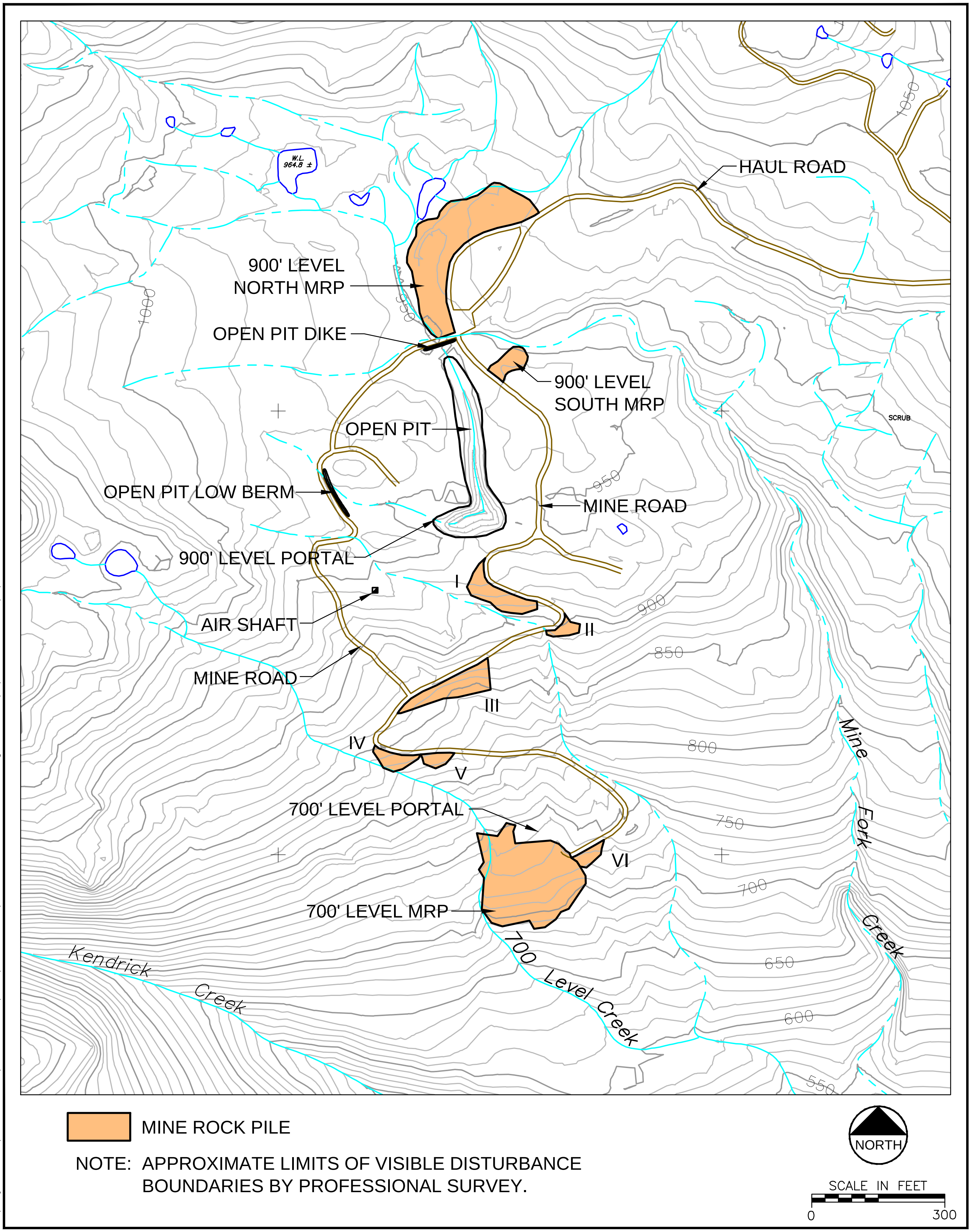
Notes:
1. Used By Permission From Ucore Uranium.
2. UTM Grid WGS 84 Zone 8.

Figure 2-4
Bokan Mountain Airborne Radiometric Survey (2007)

FROM SCR (TETRA TECH 2010)



Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\FIG-2-5 Vis-Disturbance.dwg SAVED: 4/2/15 PRINTED: 4/2/15 BY: TOM

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Figure 2-5
Ross-Adams Site
700-Foot and 900-Foot Levels: Limits of Visible Disturbance

Figure 2-6. Photograph Looking North Over the Long Axis of the Open Pit from the south end, showing colluvial deposits along the floor and dense brush vegetation

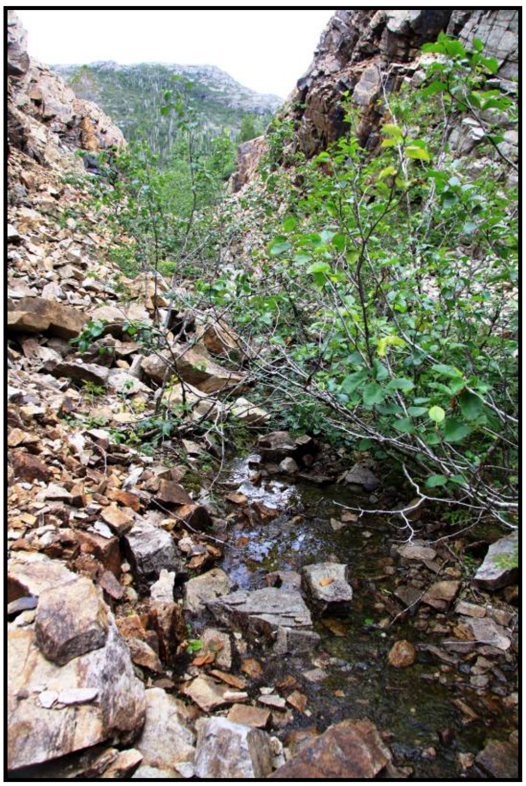
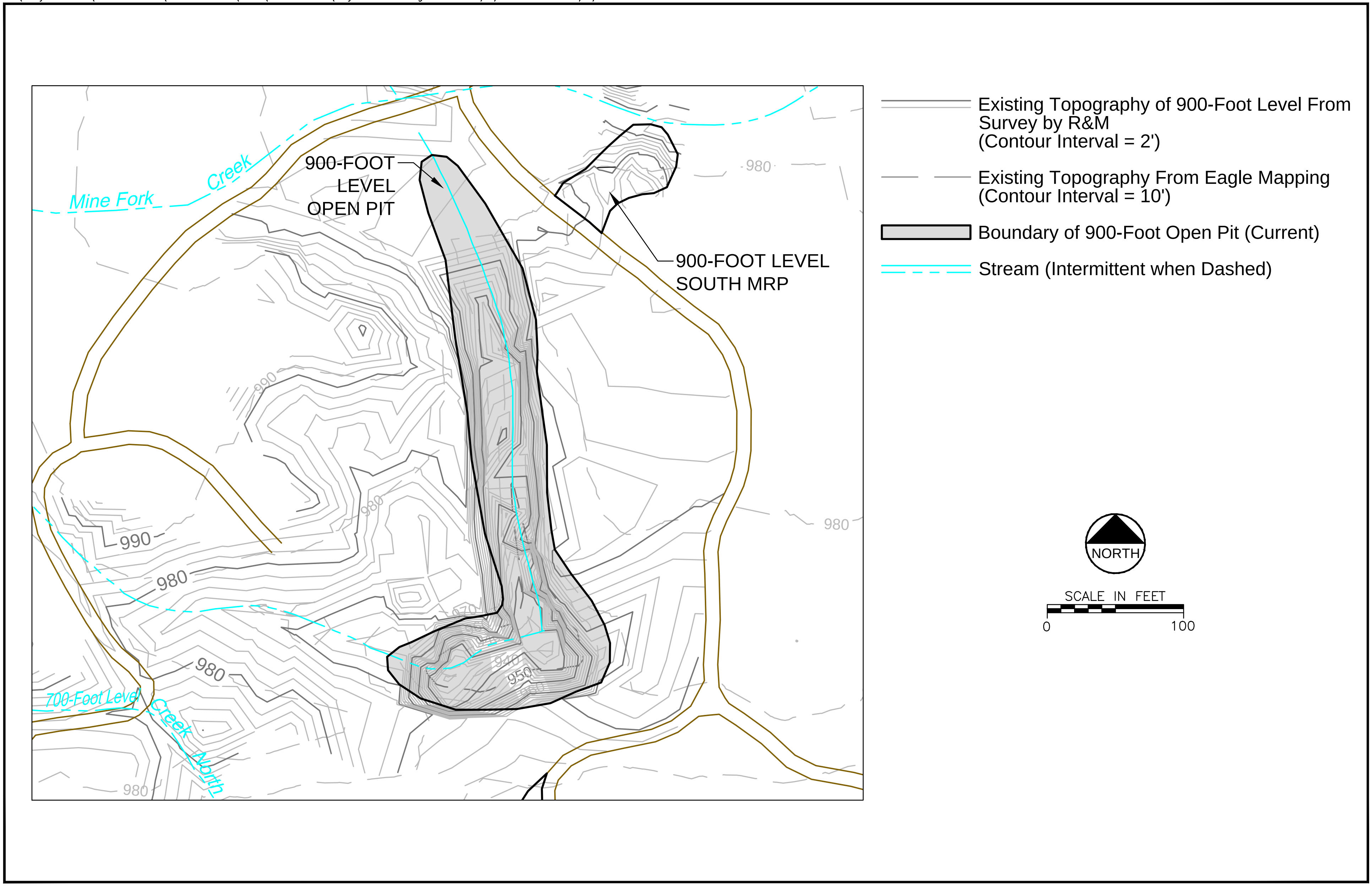


Figure 2-7. Photo looking north from the floor of the Open Pit, showing a short, shallow surface expression of flow toward the portal.
(The flow at the time of the photo was estimated at several gallons per minute. Photo taken from approximately 70 feet north of portal).

Figure 2-8. Photograph 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 2-9. Photograph 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.)



Note: Eagle Mapping Adjustment +23'

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Figure 2-10
900-Foot Level Open Pit

Figure 2-11. Photograph Looking Southwest at the 900-Foot Level Portal

Figure 2-12. Photograph Looking South in 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.)

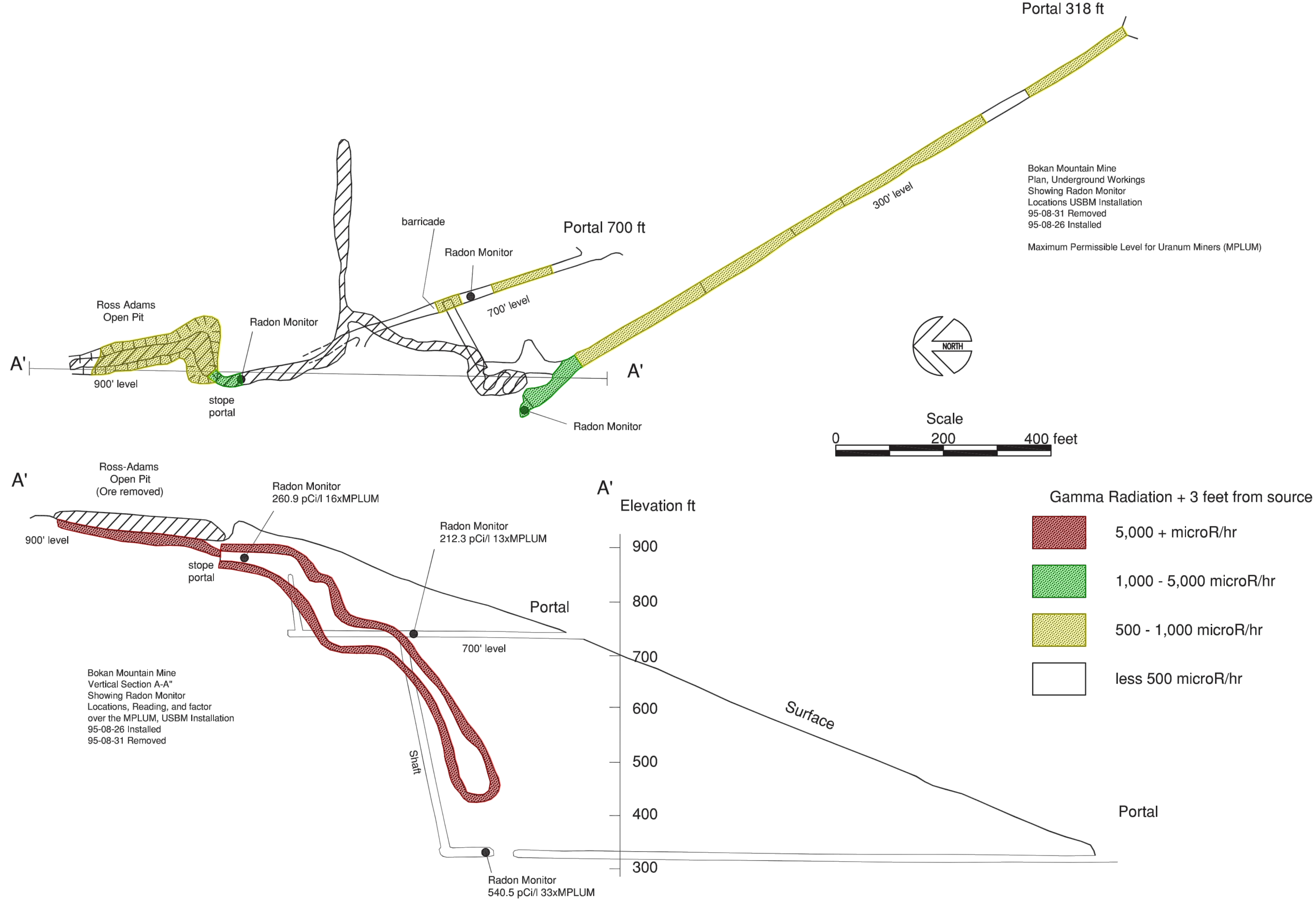


Figure 2-13
Underground Workings Map

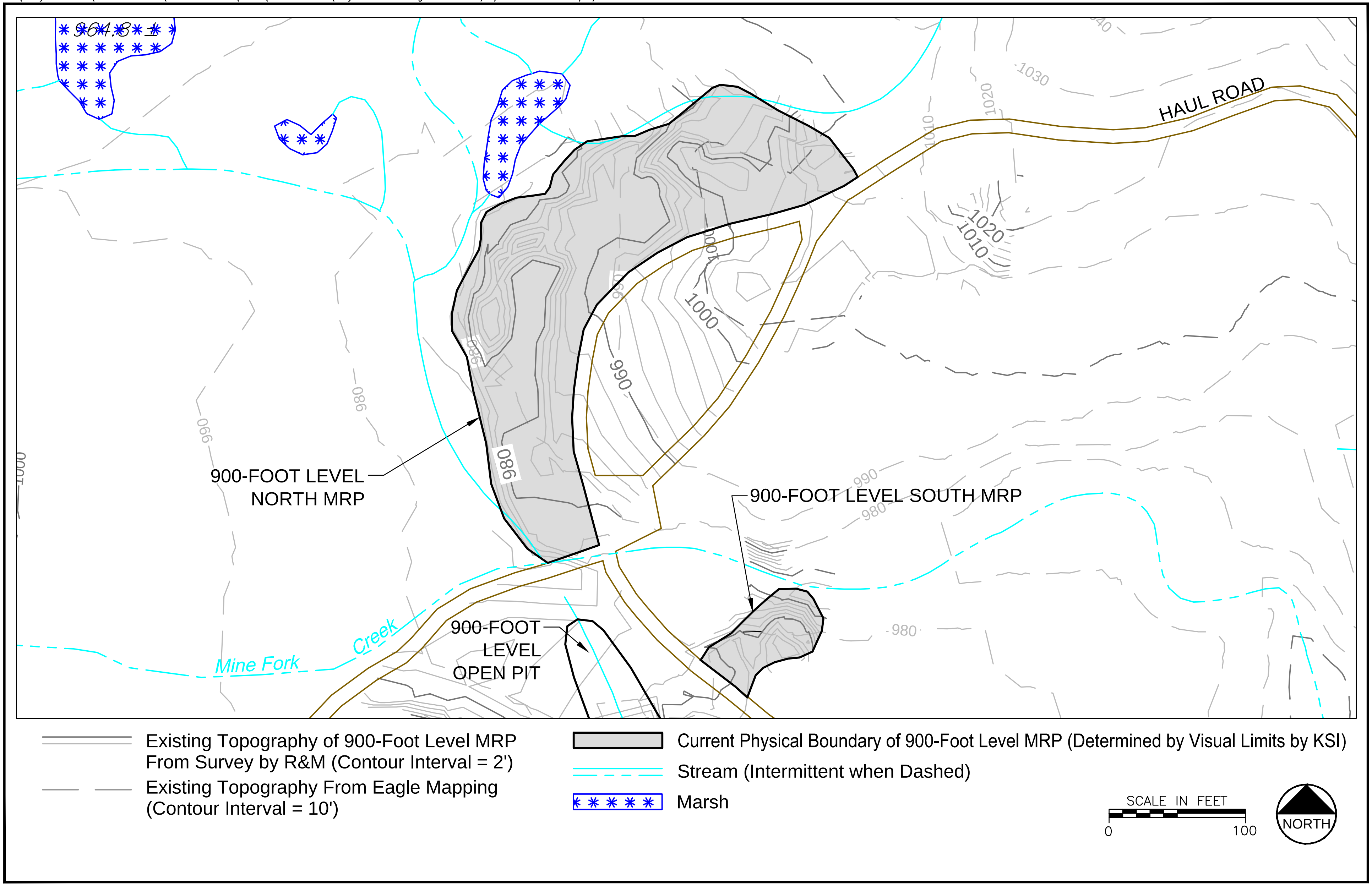
Adapted from PA/SI Figure 4 (KSI 2004)

Figure 2-14. Photograph Looking North at the Downstream Face of the Dike, illustrating the type and species of vegetation which have developed over the surface.

Figure 2-15. Photograph Looking Over the 900-Foot Level Air Shaft
(Note the rust colored radon monitoring canisters on the right.)

Figure 2-16. Photograph of 700-Foot Level Portal

Figure 2-17. Photograph 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).



Note: Eagle Mapping Adjustment +23'

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Figure 2-18
900-Foot Level

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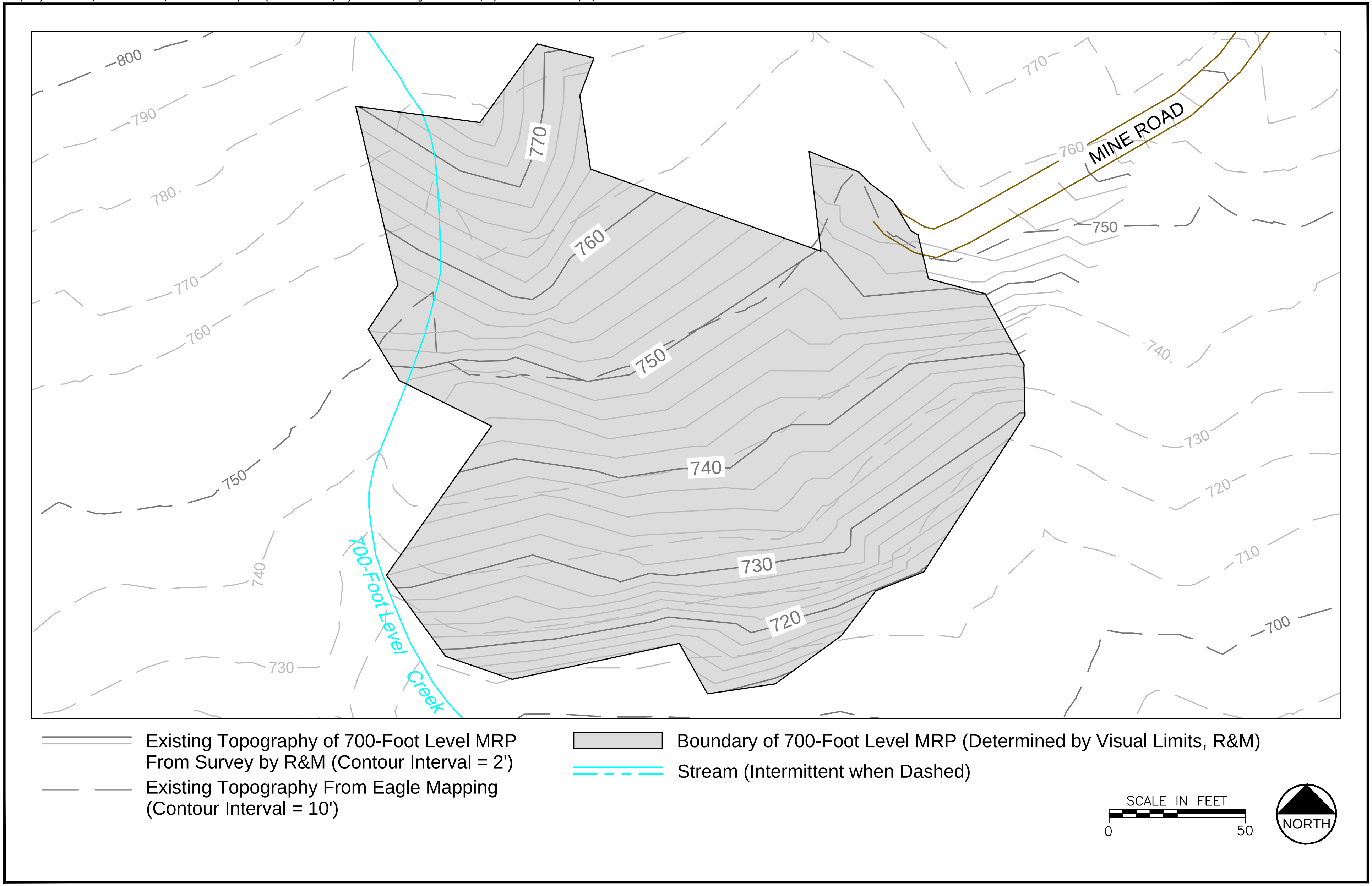

Note: Eagle Mapping Adjustment +21'

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Figure 2-19
700-Foot Level MRP

Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\Regrade-300L-03.dwg SAVED: 4/2/15 PRINTED: 4/2/15 BY: TOM

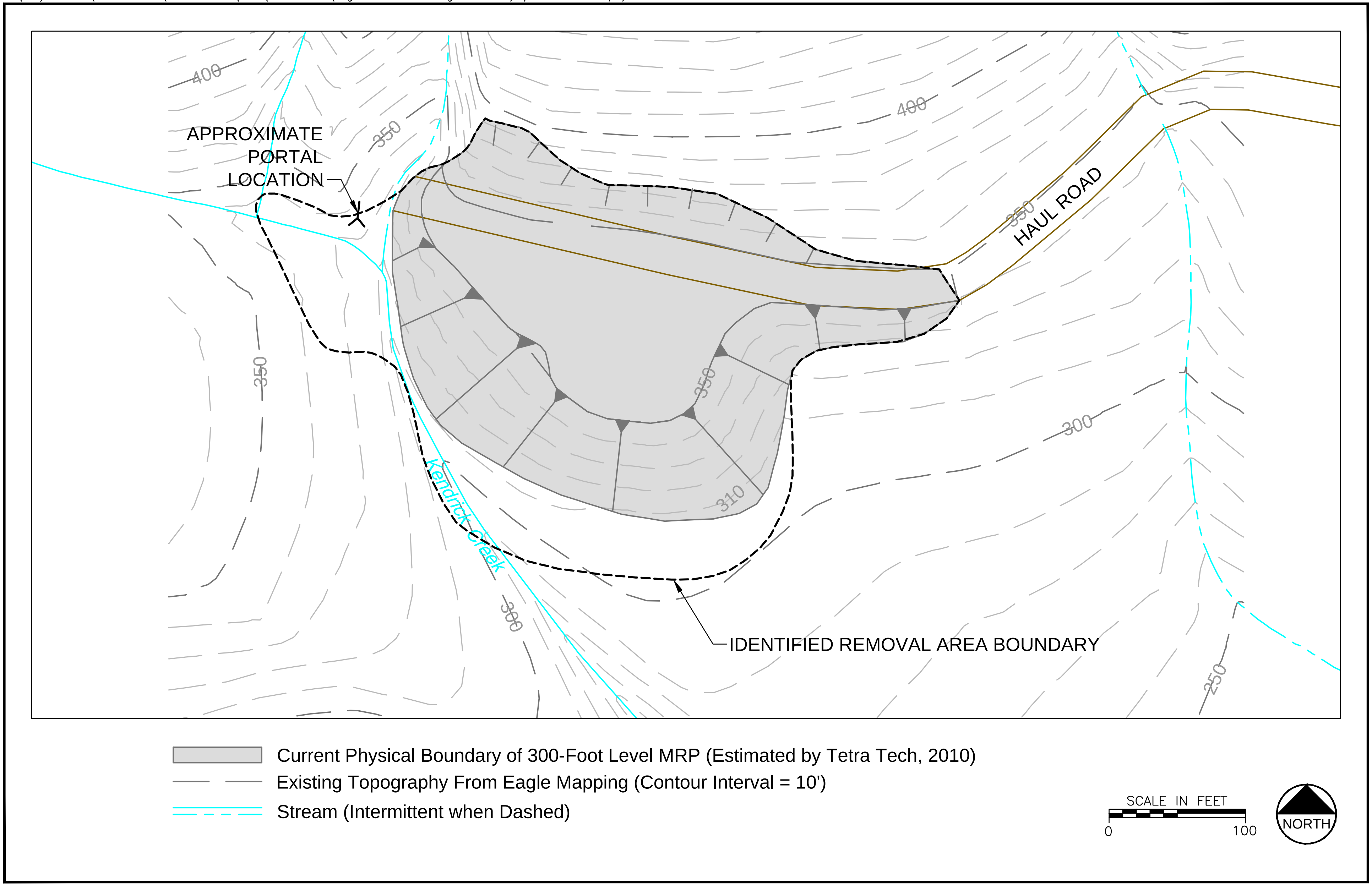

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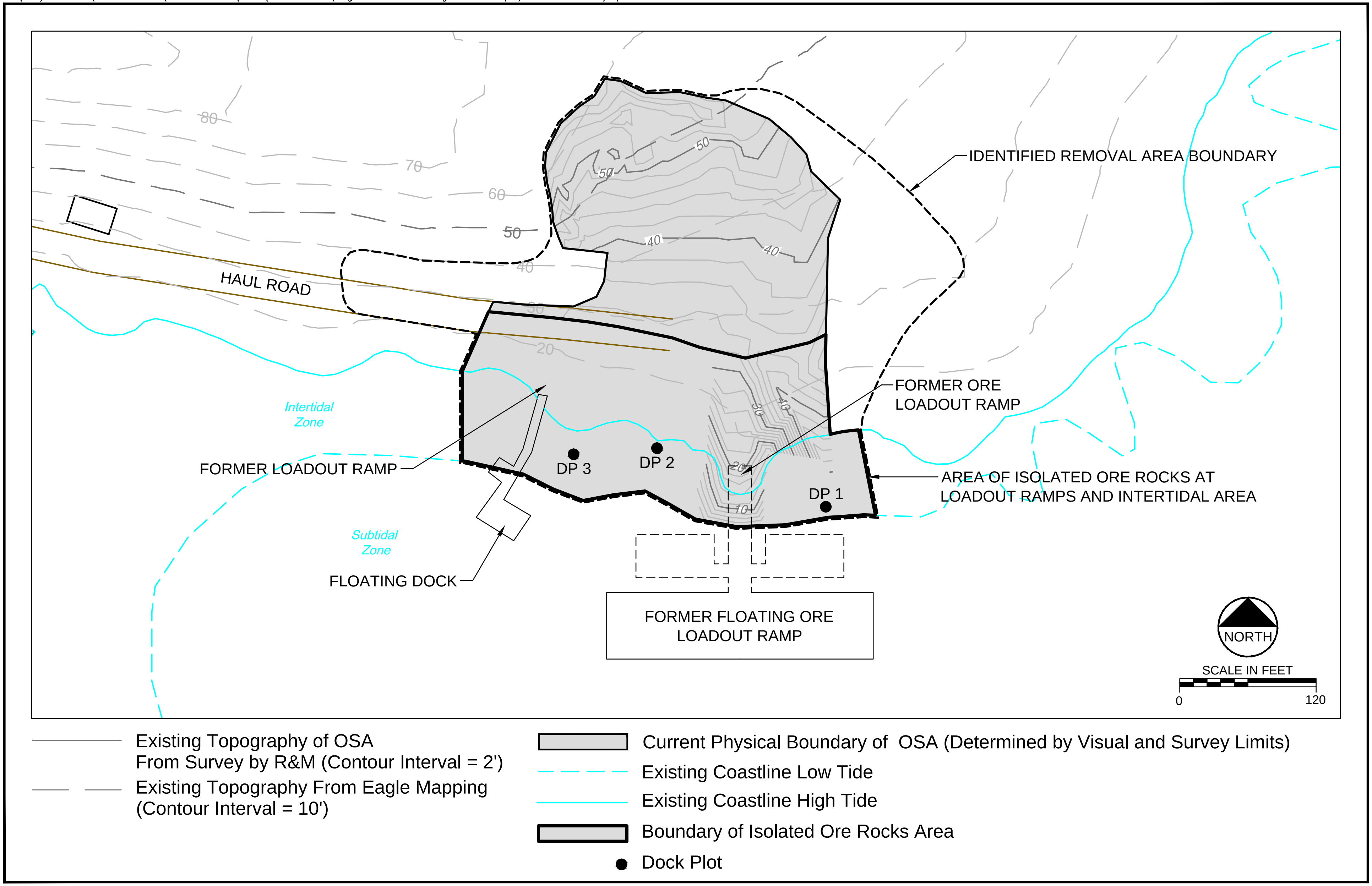
Figure 2-20
300-Foot Level MRP

Figure 2-21. Photograph of 300-Foot Level Portal

Figure 2-22. Photograph 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.

Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\Regrade-OSA-01.dwg SAVED: 4/2/15 PRINTED: 4/2/15 BY: TOM



Note: Eagle Mapping Adjustment +20'

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Figure 2-23
OSA

Figure 2-24. Photograph Looking Northwest at the Two Rock Loadout Ramps.
(The Ore Staging Area is just beyond the docks.)

Figure 2-25. Photograph Looking North at the Older and Westernmost Rock Loadout Ramp
(Note: Dotson Cabin in the upper right.)

Figure 2-26. Photograph of Ore Present in the Intertidal Area Adjacent to the Dock.

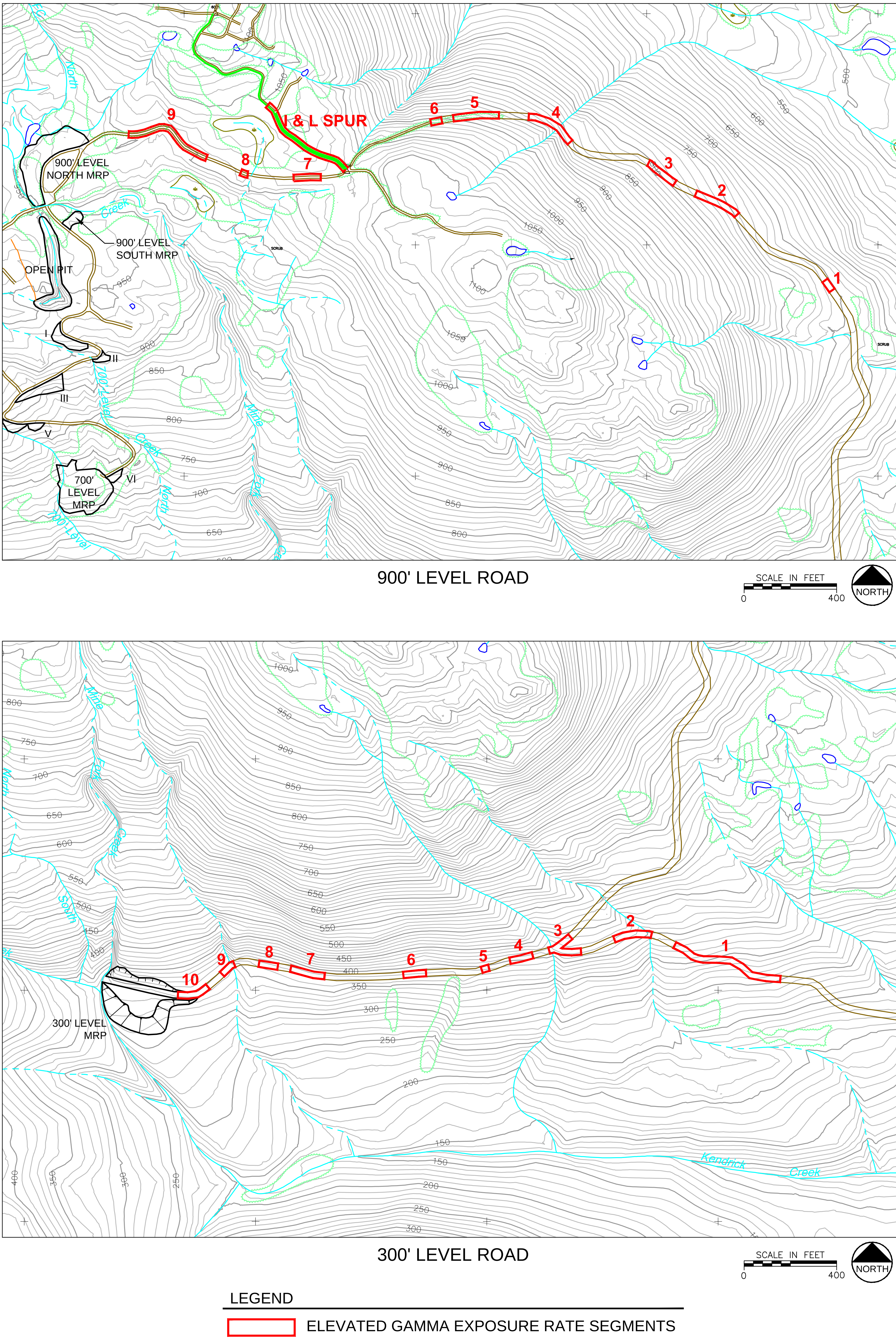

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Figure 2-27
Ross-Adams Site
Haul Road Areas

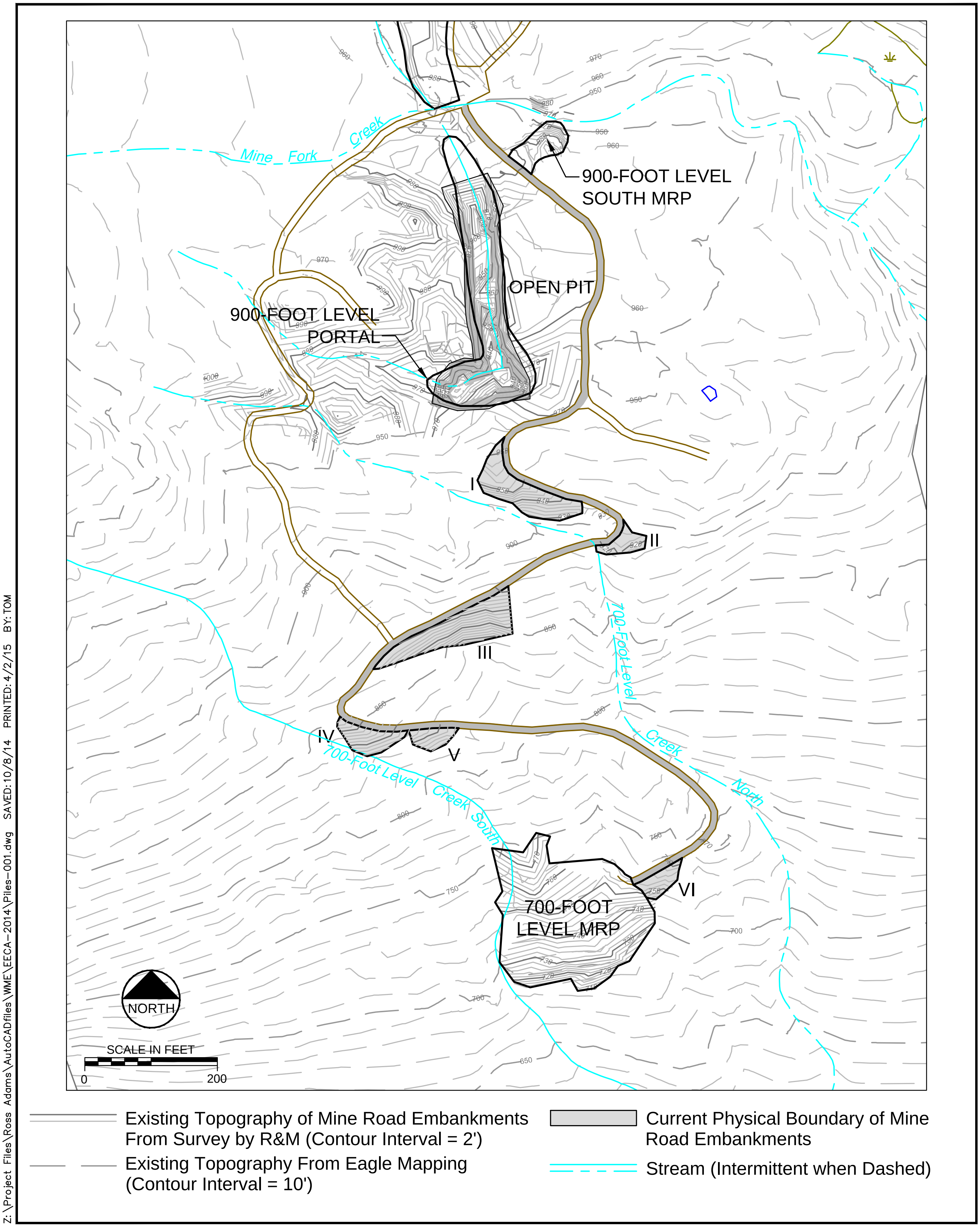

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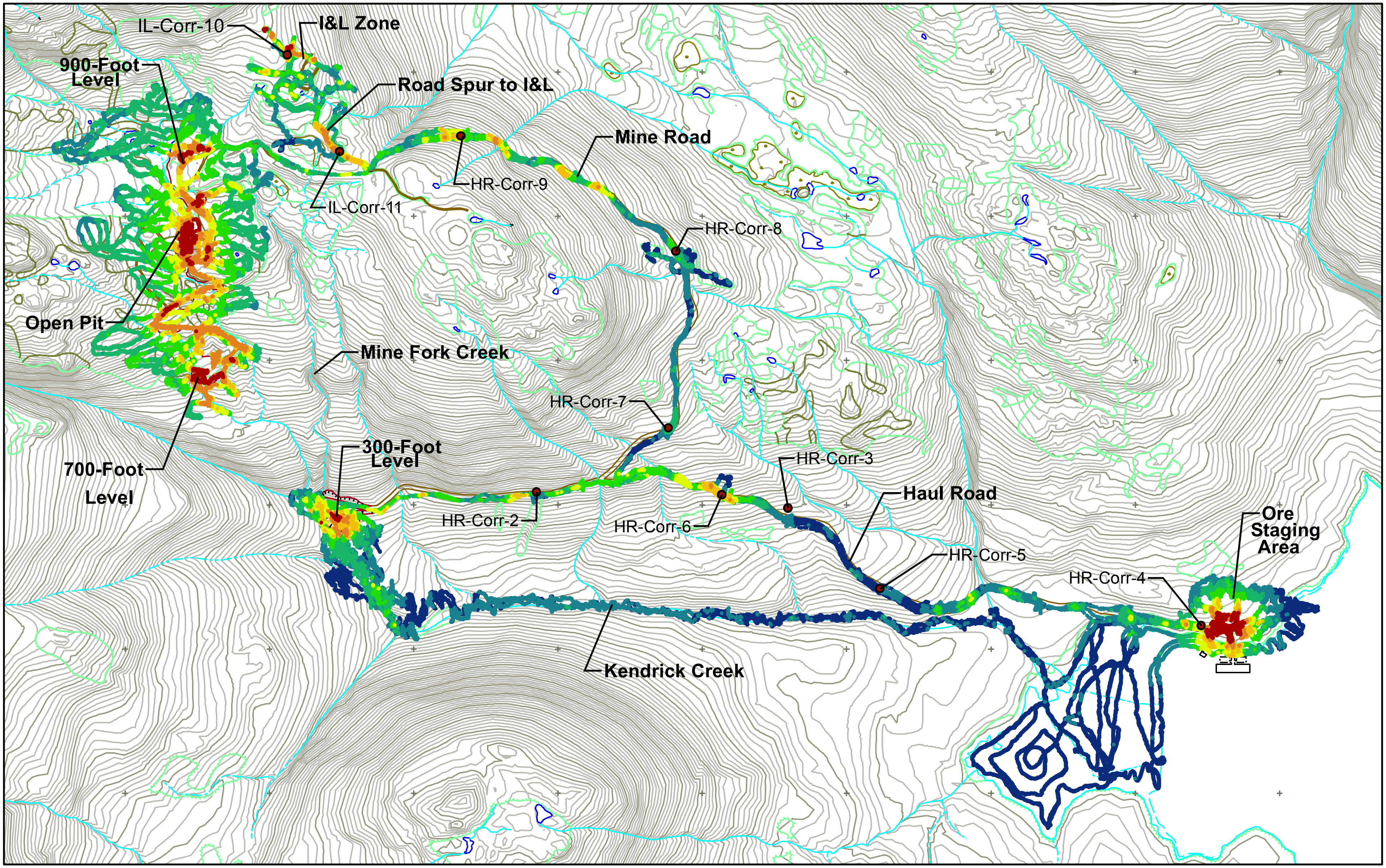
Figure 2-28
Mine Road Embankments



Gamma Exposure Rate (uR/hr)

- <20
- 20-40
- 40-80
- 80-160
- 160-316
- 316-631
- 631-1250
- >1250
- Gamma/Soil Correlation Plot Sample

N

Feet

0 1,000

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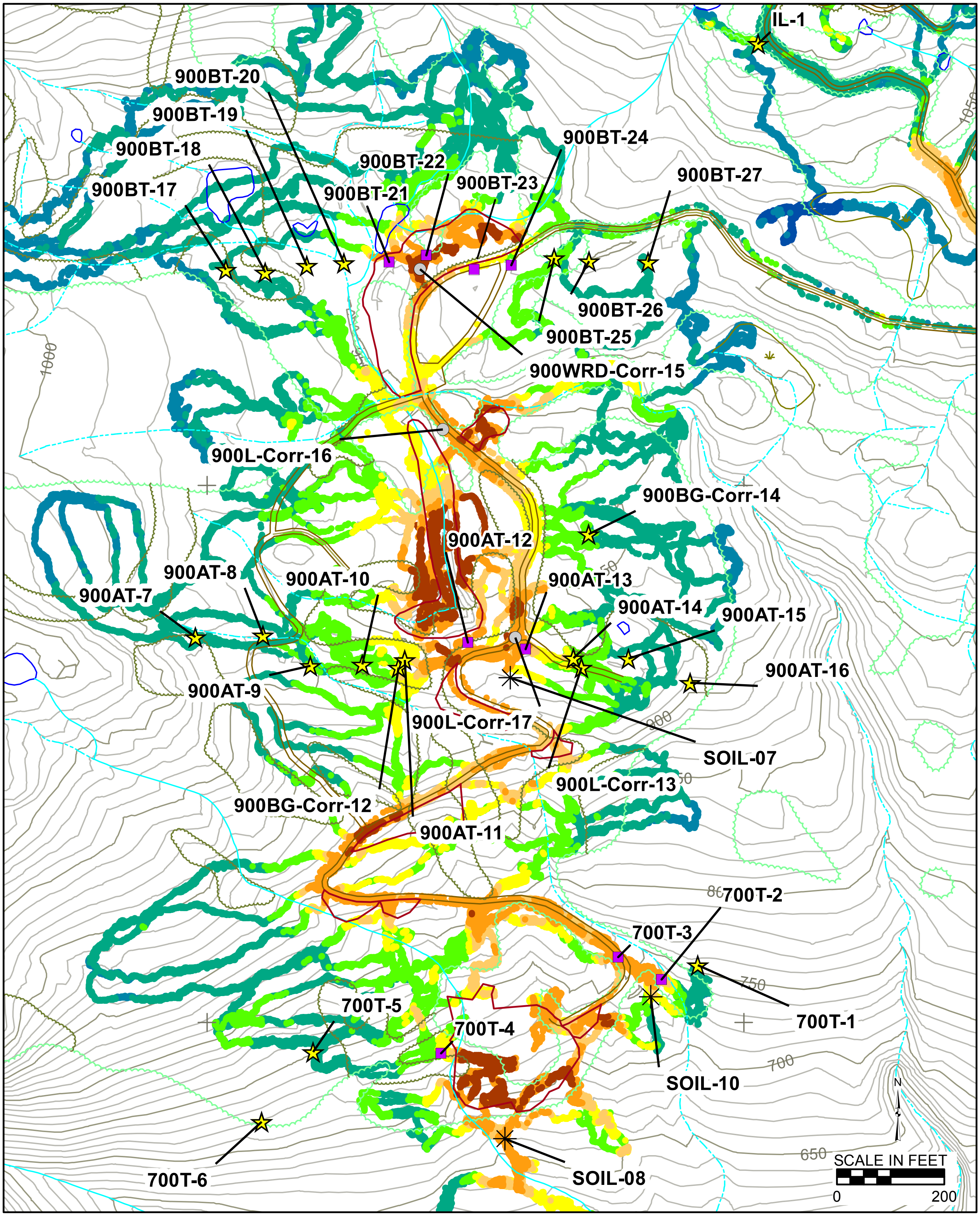
Figure 2-29
Ross-Adams Site
Site Gamma Survey Data
Unkriged Site Map



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
- KSI Soil Sample
- Background Soil Sample

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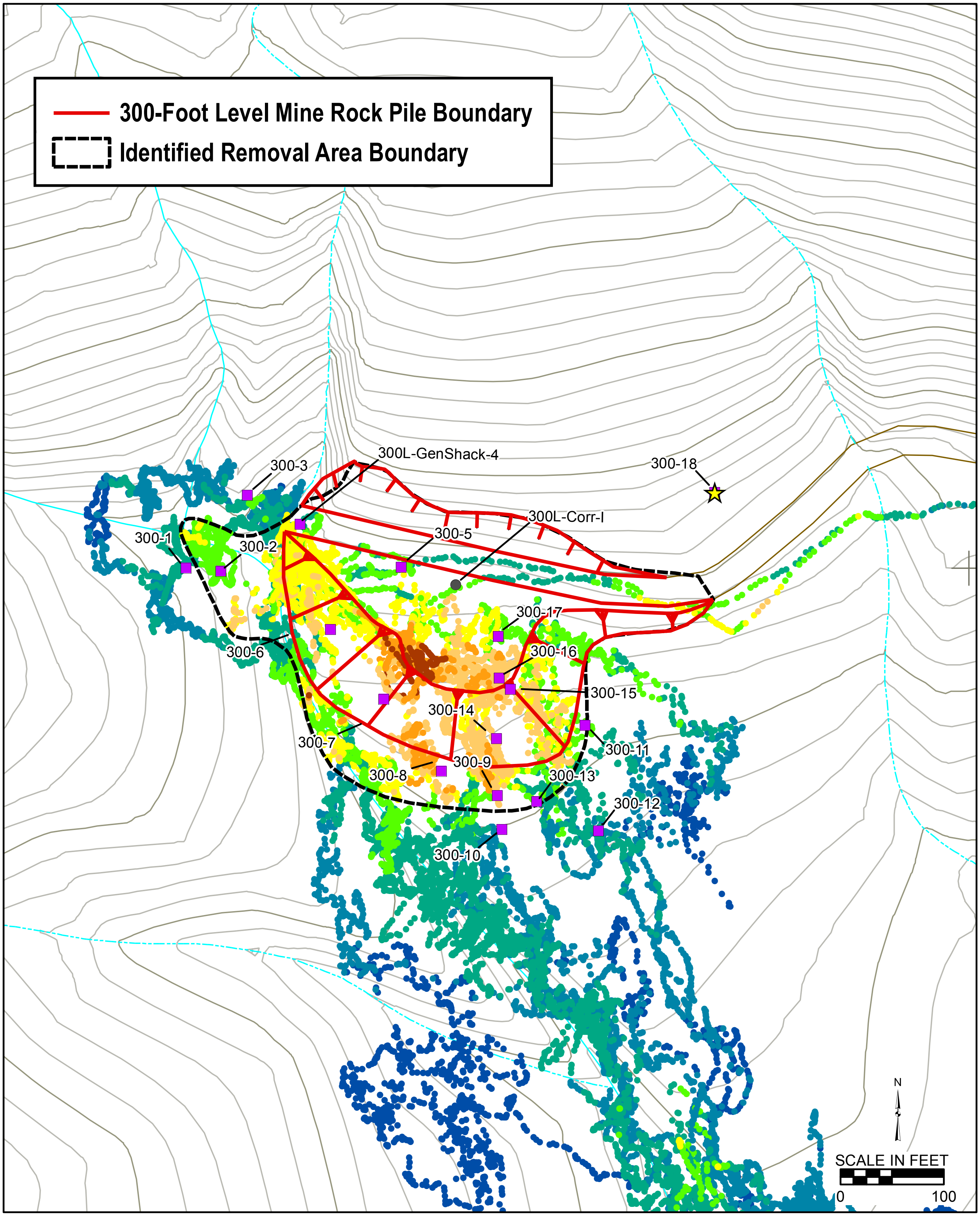
Figure 2-30
Ross-Adams Site
Gamma Survey Data
700- and 900-Foot Levels



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Gamma Exposure Rate (uR/hr)

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

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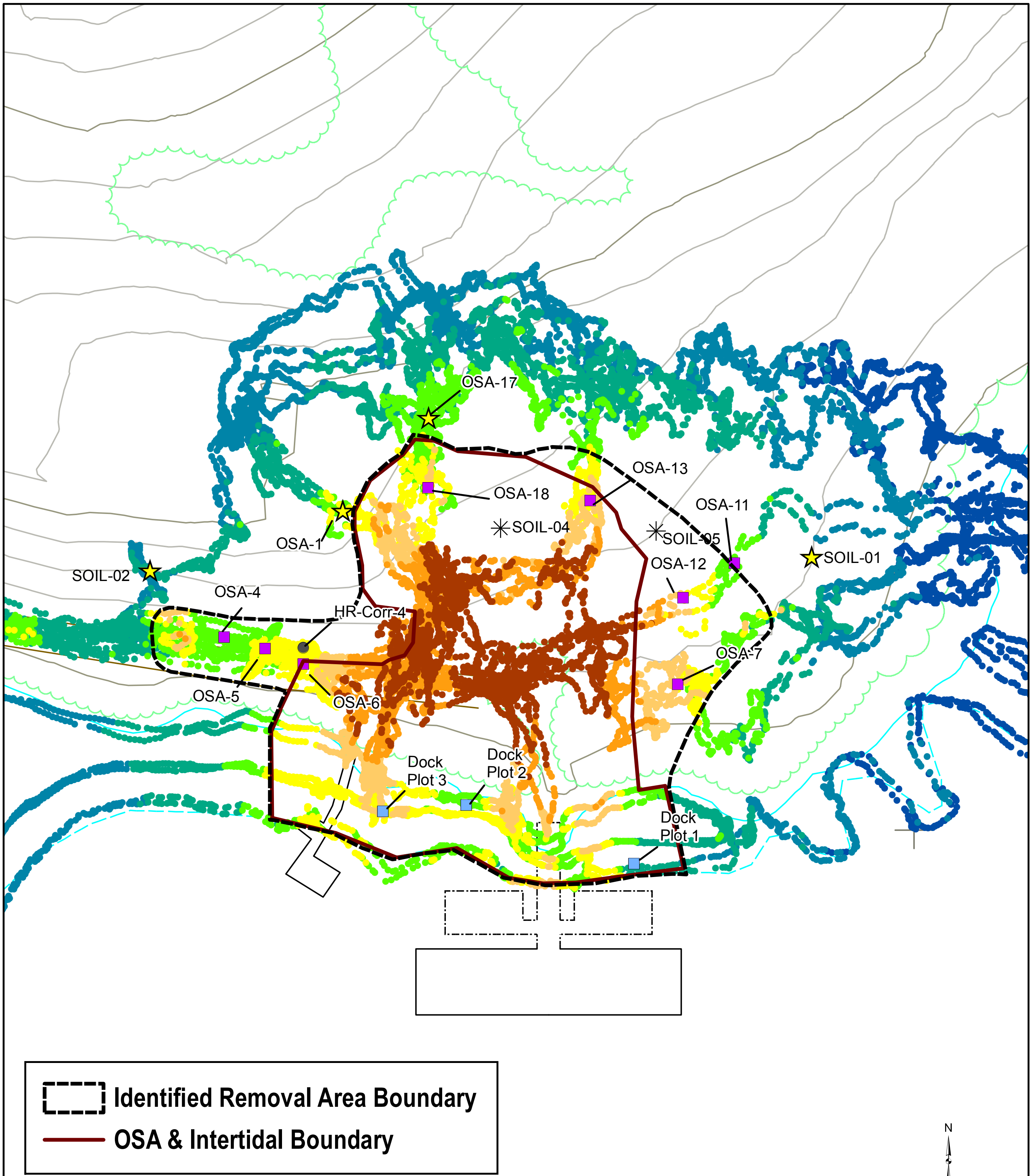
Figure 2-31
Ross-Adams Site
Gamma Survey Data
300-Foot Level



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

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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
- KSI Soil Sample
- Background Soil Sample
- Mine Rock Point Count Plot

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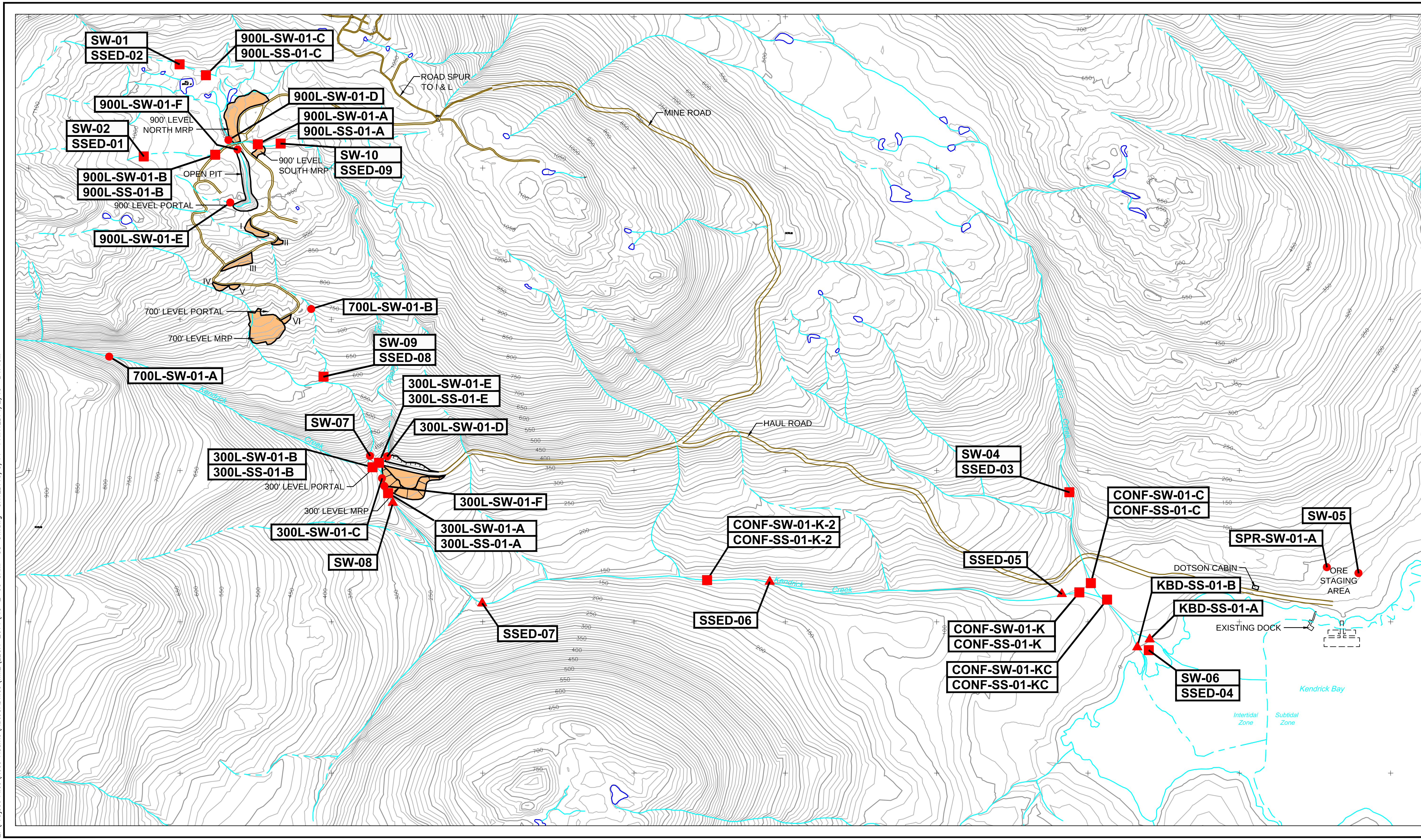
Figure 2-32
Ross-Adams Site
OSA Gamma Survey Data



Z:\Project Files\Ross Adams\AutoCADfiles\WME\ECCA-2014\FIG-2-33 SAMP-SS-SW.dwg SAVED: 10/8/14 PRINTED: 4/2/15 BY: TOM

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LEGEND

- ● SURFACE WATER AND SEEP SAMPLE ONLY
- ■ SURFACE WATER AND STREAM SEDIMENT SAMPLES
- ▲ STREAM SEDIMENT SAMPLE ONLY

NORTH

SCALE IN FEET

0 600

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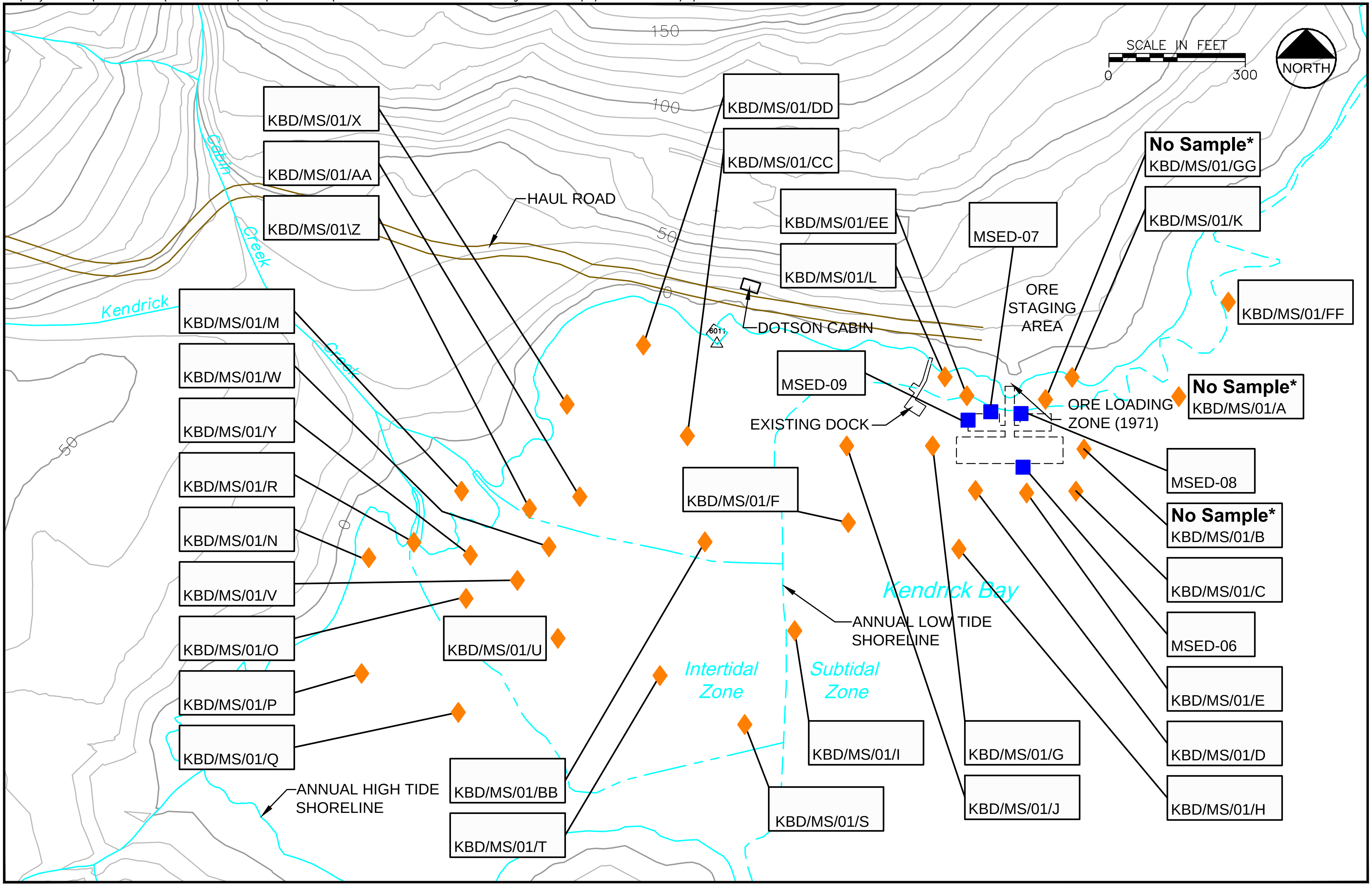
Figure 2-33
Ross-Adams Site
Surface Water and Stream Sediment Sampling Locations

Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\FIG-2-34 SAMPLE-M-SED-01.dwg SAVED: 10/8/14 PRINTED: 4/2/15 BY: TOM



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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.

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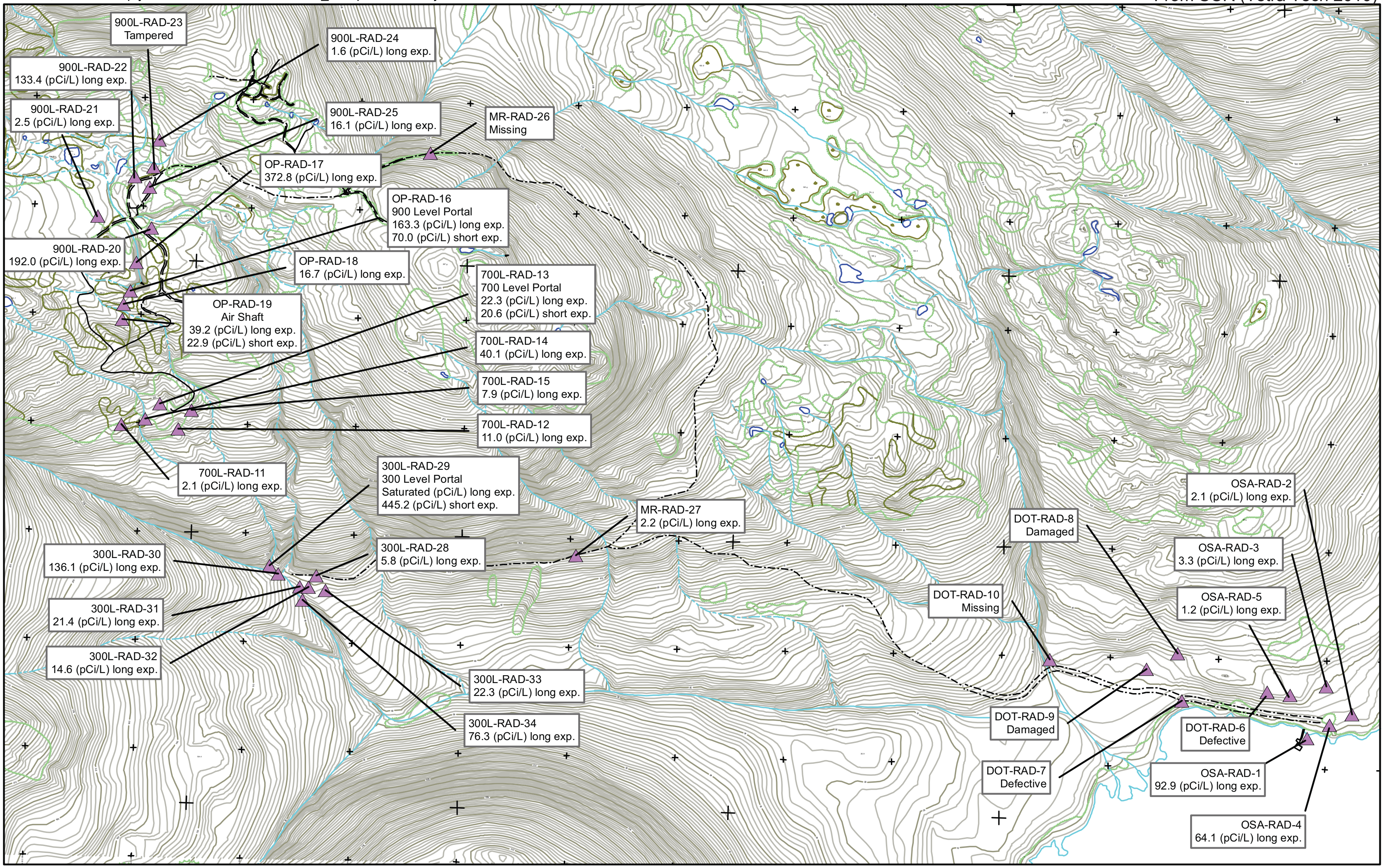
Figure 2-34
Ross-Adams Site
Marine Sediment Sample Locations

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

From SCR (Tetra Tech 2010)



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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

N

Feet

0 1,000

Figure 2-35

Ross-Adams Site

Radon Station Locations and Measurement Data

3.0 Human Health and Ecological Risk Assessment

The Screening-Level Ecological Risk Assessment (SLERA) is provided in Appendix A, and is summarized below in Section 3.1. The Human Health Risk Assessment (HHRA) is provided in Appendix C, and is summarized below in Section 3.2.

3.1 Ecological Risk Evaluation

The SLERA was conducted in support of the EE/CA and related evaluation of removal action alternatives and Site-management decisions. Major components of the SLERA are problem formulation, characterization of exposure and effects, and characterization of risk. Each of these components and the results of the SLERA are summarized below. The complete SLERA with additional details of the risk analysis is provided as Appendix A.

3.1.1 Problem Formulation

The problem formulation provides important background information and establishes the goals of the risk assessment. It includes an understanding of the environmental setting and potential ecological receptors that may be present, development of a conceptual site model that links sources of chemicals to potential receptors, determination of chemicals of potential ecological concern, and selection of assessment endpoints and indicator species for further characterization of exposure and risk.

3.1.1.1 Environmental Setting and Potential Receptors

The Site falls within Alaska's Southeast Ecoregion (ADEC, 1999a, 1999b) and is comprised of subalpine, old growth western hemlock-spruce forest, marine intertidal, and marine subtidal habitats (Appendix F in Tetra Tech, 2010).

The subalpine habitat is characterized by barren rock and plants adapted to the colder and windier environment. Subalpine vegetation 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.

The old-growth habitat is characteristically dominated by western hemlock and Sitka-spruce. Other common 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 and discharges to the head of the West Arm of Kendrick Bay.

The marine intertidal zone is bounded by the low and high tides and occupies approximately 27 acres at the head of the West Arm of Kendrick Bay. The intertidal vegetative community includes many species of plants and algae including rockweed, eelgrass, sugar kelp, and bull kelp. Marine and estuarine invertebrates are common and include 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. Mink are present in the intertidal zone and black bear and Sitka black-tailed deer inhabit the perimeter of this zone. Many of these plant and animal species extend into the contiguous subtidal waters. Wildlife in this zone includes sea otter, harbor seal, gulls, and loons and a variety of fish and invertebrates.

3.1.1.2 Conceptual Site Model

An ecological conceptual site model (CSM) was developed for the Site based on review and knowledge of the environmental setting, constituents present at the Site, constituent fate and transport in the environment, the potential environmental receptors, and the potential exposure pathways to those receptors. The CSM presented in the SLERA (Figure 2-1 in Appendix A) illustrates the potentially complete exposure pathways for ecological receptors for terrestrial and aquatic environments, including freshwater and marine environments. However, identifying a pathway as complete does not automatically mean there is actual harm or risk to the environment (ADEC, 2005).

3.1.1.3 Identification of Chemicals of Potential Ecological Concern

Data from the PA/SI (KSI, 2004) and from the SCR (Tetra Tech, 2010) were screened to identify chemicals of potential ecological concern (COPEC). Chemical analytes that exceed Site-specific background concentrations and conservative ecological screening benchmarks established by ADEC were selected for further evaluation in the risk assessment (Table 3-1). Overall 20 metals and two radionuclides were identified as COPECs.

3.1.1.4 Selection of Assessment Endpoints and Indicator Species

Assessment endpoints are parts of the ecosystem that are important either to the overall health of the ecosystem or to a component of the ecosystem that is of particular value (ADEC, 2010). They can be identified at the individual, population, or community level of biological organization (ADEC, 2010). Following ADEC (1999b) guidance, indicator species that are representative of various functional groups in Alaska's Southeast Ecoregion were selected for evaluation of risks to wildlife. All but one of the eight avian and mammalian wildlife species selected for risk evaluation are ADEC default indicator species. The mew gull was selected as an indicator species for marine avian invertivores because it was observed at the Site and the black oystercatcher, which is the default receptor, was not observed at the Site.

Specific indicator species are not used for some functional groups because the toxicity information used to judge risk is based on chemical concentrations in exposure media rather than on chemical uptake (e.g., ingestion). In these cases, community receptors, rather than individual species, are evaluated based on toxicity characteristics of the exposure medium. Community receptors evaluated for the Site were terrestrial plants; terrestrial soil invertebrates; stream surface water invertebrates and fish; stream benthic invertebrates; and marine benthic invertebrates.

3.1.2 Ecological Exposure Assessment

Exposure point concentrations (EPCs) for metals and radionuclides in each exposure medium (soils, stream sediment, stream surface water, intertidal, and subtidal sediments) are based on the upper 95 percent confidence limit of the mean (95UCL) for Site exposure units. Maximum concentrations were used where 95UCL values could not be determined or where the 95UCL was greater than the maximum concentration.

EPCs were compared directly to ecological benchmarks described in Section 3.1.3 (Ecological Effects Assessment) to determine risk for terrestrial, stream and marine community receptors. However, potential exposures to COPECs by wildlife indicator species was based on chemical intake via consumption of food or water and by incidental ingestion of soil or sediment while foraging. Dietary concentrations of COPECs were estimated from EPCs in soil, sediment and or water based on bioaccumulation models. Ingestion rates for food, water, soil and sediment and other exposure factors were based primarily on ADEC's (2010) risk assessment guidance and EPA (1993b) *Wildlife Exposure Factors Handbook.*

3.1.3 Ecological Effects Assessment

3.1.3.1 Terrestrial, Stream and Marine Communities

Media-specific toxicological benchmarks were selected for judging ecological risks to terrestrial plants, soil-dwelling invertebrates, freshwater aquatic biota, freshwater benthic invertebrates, and marine benthic invertebrates. Key sources for media-specific toxicity benchmarks were:

- Soils – EPA's ecological soil screening levels (Eco-SSLs)
- Stream sediments – Consensus-based sediment quality benchmarks
- Stream surface water – Federal or Alaska chronic water quality criteria, supplement by Tier II Secondary Chronic Values or other state water quality standards
- Marine sediments – Effects range low (ER-L) and effects range median (ER-M) values supplemented by the Washington State Sediment Management Standards.

3.1.3.2 Terrestrial and Aquatic-dependent Wildlife

For avian and mammalian wildlife in terrestrial, freshwater and marine habitats, no observed adverse effect levels (NOAELs) and lowest observed adverse effects levels (LOAELs) compiled primarily from EPA's EcoSSL documents were selected as toxicity reference values (TRVs). Where Eco-SSL values were not available, TRVs developed by Oak Ridge National Laboratory (Sample et al. 1996) were used.

3.1.3.3 Radionuclides in Soils, Surface Water and Stream Sediment

DOE's (2010) ecological risk assessment model[1] was used to evaluate risks to radionuclide COPECs (Ra-226, Ra-228) in soil, stream surface water and sediments. Exposure point concentrations for Ra-226 and Ra-228 in soil, surface water and sediments were used in conjunction with the default assumptions for generic terrestrial (plants and animals), aquatic animal and riparian animal receptors to calculate a daily dose rate.

3.1.4 Risk Characterization

Potential risks to community receptors and wildlife indicator species are expressed as hazard quotients. For community receptors, the hazard quotient is expressed as the EPC divided by a media specific ecological benchmark. Potential risk to wildlife species are based on an estimated dose derived from EPCs divided by a toxicity reference value expressed as a NOAEL or LOAEL. For radionuclides, the hazard quotient for aquatic animal and riparian animal receptors is calculated from the daily dose rate divided by recommended daily dose limits for each receptor group. Hazard quotients are presented herein for only those pathways and receptors where the hazard quotient exceeded one. Detailed presentation of hazard quotients for all COPEC, exposure media and receptors is provided in Appendix A.

Hazard quotients less than one indicate no potential risk and do not warrant further evaluation given the conservative assumptions used to derive estimates of exposure, toxicity and risk. In evaluating the hazard quotients that are greater than one, it is important to fully consider uncertainties, assumptions and other factors that contribute to the overall weight of evidence for the risk estimate and which should be considered in support of risk-management and Site-management decisions concerning removal actions and alternatives.

A summary of the risk characterization is provided below. Risks for metals exposure are provided first for each habitat, community type and wildlife indicator species in Sections 3.1.4.1 through Section 3.1.4.6. Risks for radionuclide exposure are summarized separately in Section 3.1.4.7.

3.1.4.1 Terrestrial Community Receptors

For terrestrial community receptors, hazard quotients exceeded one for two metals (manganese and zinc) at the 700/900-Foot Level and at the 300-Foot Level predominantly in plants (Table 3-2). Hazard quotients also exceeded one for cobalt and selenium in plants at the 300-Foot Level but are not identified as chemicals of concern. The hazard quotient for cobalt in plants is marginally elevated above one and is based on an EPC (19.5 mg/kg) that is only incrementally above background (18 mg/kg). The hazard quotient for selenium in plants is less than that for background.

Hazard quotients for manganese and zinc in plants are both greater than one and elevated above background levels, with the exception of manganese at the 300-Foot Level, which is

[1] RESRAD-BIOTA Version 1.5.

below background. For soil invertebrates, zinc is the only metal with a hazard quotient greater than one and with incremental site risks greater than background. The hazard quotients for manganese and zinc also appear to be associated with locally elevated soil concentrations (Figure 3-1 and Figure 3-2). Soil concentrations of manganese and zinc also appear to be correlated with Ra-226 and Ra-228 (see Section 3.1.4.7).

3.1.4.2 Terrestrial Wildlife Indicator Species

The ADEC (2010) Risk Assessment Procedures Manual states a preference for TRVs that are based on NOAELs for initial screening estimates for wildlife to ensure that risk is not underestimated. Consequently, an initial screening of the data was conducted using NOAEL values to identify chemicals of interest for further evaluation. However, risk evaluation beyond the initial screen included LOAEL values as described in Appendix A.

For terrestrial wildlife, hazard quotients based on comparisons to LOAELs exceeded one for three metals (lead, uranium, zinc) in the 700-Foot/900-Foot Level, three metals (aluminum, cadmium, lead) in the 300-Foot Level, and two metals (aluminum, lead) in the ore staging area (OSA) (Table 3-3). Of these, aluminum at the 300-Foot Level and the OSA is not considered a chemical of concern because the EPCs in the 300-Foot Level and the OSA are effectively the same as those in background areas, yielding minor differences in risks for dark-eyed junco, American robin, and masked shrew that are attributed to rounding hazard quotients to one significant figure.

700-Foot/900-Foot Level

Lead hazard quotients range from three to six for dark-eyed junco and American robin respectively. However, the EPC for lead (137 mg/kg) is less than the maximum background concentration (190 mg/kg), and only one of 20 site samples exceeds the maximum background concentration. This indicates that the potential risk from lead is localized to the area of the maximum concentration, and lead is not expected to pose an area-wide risk at the 700-Foot/900-Foot Level. Likewise, out of 20 samples, only the maximum concentration of uranium results in a LOAEL hazard quotient greater than one, and therefore the potential risk from uranium is expected to be localized around the area of the maximum concentration. This is also the case for zinc, where only the maximum concentration of zinc (2,700 mg/kg) results in a LOAEL hazard quotient greater than one, and therefore the potential risk from zinc is expected to be localized around the area of the maximum concentration.

300-Foot Level

LOAEL hazard quotients for lead range from two to four for the dark-eyed junco and American robin. The majority of soil samples (17 of 27) have lead concentrations above background indicating that exposure and risk is more evenly distributed at the 300-Foot Level. The cadmium hazard quotient for the masked shrew is two and appears to be localized in the vicinity of three sample locations with cadmium concentrations that range from 1.8 to 9.5 mg/kg. Cadmium at all other non-background locations within the 300-Foot Level range from below detection limits to 0.42 mg/kg.

OSA

The lead hazard quotient for the American robin is dominated by two locations with concentrations (41 to 87 mg/kg) that exceed the range of background values (2.7 to 31 mg/kg). Consequently, risk attributed to lead appears to be highly localized within the mine-affected area of the OSA (Figure 3-3).

3.1.4.3 Stream Community Receptors

Metals in Surface Water

Hazard quotients for COPEC in surface water exceeded one for barium at the 700-Foot/900-Foot Level and the 300-Foot Level, and for aluminum at the OSA (Table 3-4). However, exposure point concentrations for barium and aluminum at the 300-Foot Level and the OSA are based on very small sample sizes and high 95UCL values, which resulted in default comparisons to maximum values. Consequently, all of the surface water data were aggregated to yield sample sizes and upper-bound exposure point concentrations (95UCL values) that are representative of potential exposure on a Site-wide geospatial scale. In addition, the surface water in the OSA originates from a spring that is not connected to Kendrick Creek, but rather re-infiltrates into the soil and local groundwater within a few feet. Consequently, the OSA spring has no direct influence on the local stream and is more relevant to exposure risks of wildlife that may drink from the spring (see Section 3.1.4.4 below).

Based on EPCs for Site-wide exposure, barium is the only COPEC with a hazard quotient greater than one. However, barium in background locations is also elevated in comparison to the toxicity reference value, indicating that local mineralogy for barium may also be elevated. In water, the solubility of barium is often limited by the presence of sulfate and carbonate, which bind barium in sparingly soluble forms, including barium sulfate and barium carbonate compounds. These results indicate that the weight of evidence is low for barium toxicity in stream surface water. The barium toxicity reference value adopted for the ecological risk assessment is a Tier II Secondary Chronic Value developed by Oak Ridge National Laboratory for screening data. The Tier II values are inherently conservative and, in the case of barium, are likely to overestimate risk. In reviewing barium toxicity, EPA (1986) concluded that the soluble barium concentration in fresh water would generally have to exceed 50 mg/L before toxicity to aquatic life would be expected and that in most natural waters, there is sufficient sulfate or carbonate to precipitate the barium present in the water as a virtually insoluble, non-toxic compound. These results indicate that the weight of evidence is low for barium toxicity in stream surface water. Consequently, development of management and removal action objectives is not recommended for barium or other trace metals in stream surface water.

Metals in Stream Sediments

Hazard quotients based on threshold effect concentrations (TECs) exceeded one for manganese at the 700-Foot/900-Foot Level, and manganese and zinc at the 300-Foot Level (Table 3-4). The hazard quotient based on probable effect concentrations (PECs) were less than or equal to one for both manganese and zinc in all areas of concern.

The EPCs for manganese and zinc at the 700-Foot/900-Foot Level and 300-Foot Level are based on small sample sizes and high 95UCL values, which often resulted in default comparisons to maximum values. Consequently, all of the stream sediment data were aggregated to yield sample sizes and upper-bound EPCs that are representative of potential exposure on a Site-wide geospatial scale. Based on upper-bound estimates for Site-wide exposure, manganese is the only COPEC that exceeded a hazard quotient of one based on comparison to the TEC but did not exceed a hazard quotient of one based on comparison to the PEC. Elevated levels of manganese in both Site and background locations with concentrations below probable effects concentrations indicate that the weight of evidence is low for sediment toxicity in stream sediments. Consequently, development of sediment management and removal action objectives is not recommended for manganese or other trace metals in stream sediments.

3.1.4.4 Stream Aquatic-Dependent Wildlife

All of the LOAEL hazard quotients for the belted kingfisher are less than or equal to one, with the exception of mercury (Table 3-5). Mercury is not expected to pose a risk because the NOAEL hazard quotient is approximately two (rounded up from 1.7) and the LOAEL hazard quotient is less than one. Furthermore, mercury was detected in stream sediments in only one of seven Site samples, and was at a very low concentration (0.0088 mg/kg) that was below the reporting limit at other locations. Based on these results, the weight of evidence is low and potential risks are not expected for the belted kingfisher using freshwater streams at the Site. Consequently, development of sediment management and removal action objectives are not recommended for mercury in the stream habitat.

3.1.4.5 Intertidal and Subtidal Community Receptors

Hazard quotient based on low effect levels (ERLs) exceeded one for arsenic in areas potentially influenced by the Site (Table 3-4). However, the hazard quotient for arsenic that is based on comparison to median effect levels (ERMs) was less than one in both non-background and background locations. Local excursions in the data from non-background areas explain the incremental difference in the ERL hazard quotient between background and non-background areas. The ERL hazard quotient is driven by a single sample at location MSED-09 near the location of the former ore-loading dock (Figure 3-4). Arsenic concentrations in sediment from other non-background locations are all within the range of that in the background locations and none exceeded the ERM-based hazard quotient for arsenic. Also, review of the toxicity information supporting the ERL and ERM benchmarks indicates a low likelihood of toxicity attributable to arsenic alone (Long et al. 1995). Consequently, arsenic is not considered a chemical of concern in marine sediments because concentrations are below the ERM, there is a low likelihood of toxicity and there is an absence of other chemicals with elevated hazard quotients.

3.1.4.6 Intertidal and Subtidal Aquatic-Dependent Wildlife

The NOAEL- and LOAEL-based hazard quotients for wildlife indicator species utilizing the marine habitat are less than one with the exception of the NOAEL hazard quotient for belted kingfisher exposure to aluminum (Table 3-5). However, no significant risk is expected from aluminum because the LOAEL hazard quotient is less than one. Consequently, aluminum is not considered a chemical of concern for marine sediments.

3.1.4.7 Radiological Risk Characterization

Hazard quotients for exposure to Ra-226 and Ra-228 in terrestrial and stream habitats are summarized in Table 3-6. Hazard quotients for terrestrial plants exceeded one at the 700-Foot/900-Foot Level. Hazard quotients for terrestrial animals exceeded one at the 700-Foot/900-Foot Level, the 300-Foot Level, and the OSA. In general, hazard quotients were higher at the 700-Foot/900-Foot Level, decreasing to lower hazard quotients at the OSA (Figure 3-5). Radium activity in soil and exposure to terrestrial plants and animals also appears to be correlated with co-located soil concentrations of manganese and zinc (Figure 3-6).

Hazard quotients for aquatic animal exposure to Ra-226 and Ra-228 in stream sediments and surface water were less than one for exposure to individual chemicals and pathways and for cumulative exposure via all chemicals and pathways at the Site and in background areas.

Hazard quotients for riparian animal exposure to Ra-226 and Ra-228 in stream surface water and sediments did not exceed one for individual chemicals and pathways at the Site and in background areas. However, cumulative risk for riparian animals via exposure to Ra-226 and Ra-228 in sediments and water was nominally two (rounded up from 1.7) at the 700-Foot/900-Foot Level and at the 300-Foot Level. Site-wide hazard quotients for cumulative exposure did not exceed one. Risks at the 700-Foot/900-Foot Level and 300-Foot Level appear to be localized to elevated concentrations in a few sample locations (Figure 3-7 and Figure 3-8) and to be dominated by surface water exposure. Concentrations of Ra-226 and Ra-228 in stream surface water accounted for 74 to 80 percent of the cumulative risk in these areas.

3.1.5 SLERA Summary

A summary of the SLERA is provided in Figure 3-9. Hazard quotients for six metals (cobalt, manganese, cadmium, lead, uranium and zinc) exceed one for terrestrial plants, soil invertebrates and terrestrial wildlife. However, hazard quotients are often in the low range (2 to 5) and dominated by a few samples in localized areas. These localized occurrences are generally within the mine rock affected areas. Hazard quotients for trace metals in stream surface water, stream sediment, and marine sediment were not significantly elevated for either the community receptors or indicator wildlife species in these habitats.

Hazard quotients for radionuclides (Ra-226, Ra-228) were elevated for terrestrial plants and wildlife and for cumulative risk to stream-dependent riparian wildlife. For terrestrial receptors, hazard quotients for radionuclides are highest at the 700-Foot/900-Foot Level within the mineralized area, decreasing to lower values at the 300-Foot Level and the OSA within the non-mineralized area (Figure 3-5). Radium activity in soil and exposure to terrestrial plants and animals also appears to be correlated with soil concentrations of manganese and zinc (Figure 3-6). Radionuclide risk for riparian wildlife at the 700-Foot/900-Foot Level and 300-Foot Level appear to be localized to elevated concentrations in a few sample locations (Figure 3-7 and Figure 3-8) and are driven primarily by surface water exposure. Based upon the findings of the

SLERA, proposed cleanup levels, expressed as risk-based preliminary remediation goals (PRGs), for chemicals of concern in soils in the non-mineralized area have been developed. These are detailed in Appendix B and described in Section 4.

3.2 Human Health Risk Evaluation

A two-tiered human health risk assessment, composed of a screening level human health risk assessment (SLRA), and a Site-specific human health risk assessment (SSRA), were performed for the Site. The risk assessment was performed to support the evaluation of removal alternatives in this EE/CA. The risk assessment uses historic and recently collected Site data and information described fully in the SCR (Tetra Tech, 2010). The risk assessment also evaluated the inherent risks at the Site due to natural background conditions. As described in Section 2, the Ross-Adams Mine is located in a naturally mineralized area that includes significant outcrops of geologic formations with elevated concentrations of natural uranium and thorium. The nearby explored but undeveloped I&L Zone exhibits radiological characteristics similar in nature to those observed at the Site during the characterization surveys. This indicates that pre-mining gamma radiation and radon concentrations would have been significantly elevated over regional background. The mined areas of the Site include mine rock that is composed of coarse, durable rock rather than unconsolidated materials (soils). Because of the mineralized nature of the Site, the potential risks from exposure to background gamma radiation and inhalation of radon decay products were also estimated.

The nature of the Site is such that risks to human health were assessed for non-radionuclide (chemical) exposures and, radionuclide exposure through direct contact pathways, as well as risks from inhalation of radon decay products, and direct gamma radiation exposures. Receptors of concern were identified as theoretical mineral exploration worker, USFS Worker, Site Visitor, and Subsistence Receptor. Media of concern were soil, surface water, stream sediment, marine sediment, radon in air, and gamma radiation.

3.2.1 Screening Level Risk Assessment (SLRA)

In the SLRA, the maximum observed concentrations of diesel range organics (DRO), gasoline range organics (GRO), metals and radionuclides were evaluated as a conservative screening level exposure scenario, and used to select chemicals of potential concern (COPCs) for the subsequent SSRA. The SLRA compared maximum observed Site concentrations of each analyte to published occupational screening levels (EPA, 2007, 2010) for the media of concern. Screening levels based on default occupational exposure parameters were chosen for selecting COPCs for this Site, because the default occupational parameters provide a very conservative screen to anticipated Site exposures. The screening levels included ingestion, dermal contact, inhalation, and external exposures for each medium as appropriate. Soil was evaluated on a mine-level basis, but data for all other media were not divided into exposure areas.

Based on the screening level risk evaluation, the following substances pose little to no risk to human health at the Site and therefore were eliminated as COPCs: DROs, GROs, aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. The following were retained as COPCs for the detailed SSRA:

- Radon in Air
- Gamma Radiation
- Soil: Arsenic, Uranium, Th-232, Ra-228, Th-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210, Po-210
- Surface Water: Manganese, Uranium; Gross alpha, Gross beta, Ra-228, Ra-226, Th-228, Th-230, Po-210, U-234, U-235, U-238, Pb-210
- Stream Sediment: Th-232, Ra-228, U-234, U-235, U-238, Th-230, Ra-226, Pb-210
- Marine Sediment: Arsenic; Th-232, Ra-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210

3.2.2 Site-Specific Risk Assessment (SSRA)

The SSRA was conducted using the COPCs selected in the screening level evaluation for more detailed evaluation of potential risks. The SSRA evaluated subsistence activities, as well as direct contact pathways, using exposure parameters more specific to the Site. Data were aggregated for soil, radon and gamma to calculate an exposure point concentration while the maximum detected value was retained as the exposure point concentration for all other media. Site-specific occupational workers, Site visitors and subsistence food pathways were evaluated in the SSRA.

Site-specific occupational workers included both a Mineral Exploration Worker and a USFS Worker, consistent with planned future use of the Site. These occupational receptors were assumed to be exposed to Site media through incidental soil and sediment ingestion, dermal contact with soil and sediment, inhalation of particulates, external exposure to soil and sediment, inhalation of radon, and gamma radiation exposure. Exposure frequency and duration for the Mineral Exploration Worker were 120 days/year for 3 years; for the USFS Worker, they were 10 days/year for 25 years. Most other exposure parameters were similar for these two receptors, and were based on typical adult exposures.

The Site Visitor was assumed to be present at the Site for 14 days per year for 30 years. These are considered upper-bound estimates of exposure frequency and duration as the remote location and lack of facilities at the Site, along with the fact that there are numerous other USFS sites in the vicinity that offer similar recreational opportunities, would likely limit the length of time a Site Visitor would choose to spend there. In addition, if mineral exploration or development activities are occurring at the Site, it is not likely to be a desirable location for recreational activities. The Site Visitor was assumed to be exposed to Site media through incidental soil and sediment ingestion, dermal contact with soil and sediment, inhalation of particulates, external exposure to soil and sediment, ingestion of surface water, inhalation of radon, and gamma radiation exposure. Exposure parameters were selected to be representative of both child and adult exposures.

The subsistence food pathway was evaluated for deer, berries, seaweed, sea cucumbers, and fish. These food substances are present at the Site and represent a substantial portion of native subsistence diets. Ingestion rates of these foods were estimated from Alaska Department of Fish and Game Subsistence Food Division databases for the community of Hydaburg, with additional information for the community of Craig when data were not available for Hydaburg. Ingestion of potentially affected deer meat was assessed by fractionating the amount of time a deer could spend in contact with the mine-affected materials at the mine levels relative to the typical grazing range for a deer. For berries, the fraction of fruit collected from potentially mine-affected areas was determined by dividing the total acreage of mine-affected soil by the total acreage of the Site. These are conservative estimates, as the mine levels and roads containing mine-affected soil are minimally vegetated and do not constitute prime foraging areas. For marine food substances, the amount of food that could be collected from the affected dock area relative to the area of the West Arm of Kendrick Bay was estimated by dividing the affected acreage by the acreage of the West Arm of Kendrick Bay.

The following sections present the results from the SSRA for radon, gamma radiation, direct contact, and subsistence exposures to Site receptors.

3.2.2.1 Calculated Annual Dose and Lifetime Risk from Exposure to Radon in Air

Inhalation of Rn-222 decay products represents the most significant component of background radiation exposure, excluding medical procedures, received by all members of the public regardless of where they reside (NCRP, 2009). Radon concentrations across the Site are extremely variable, ranging from measured values at background (less than 5.8 pCi/L) to a concentration of 445.2 pCi/L at the 300-Foot Level portal. Given the size of the Site and the average wind speed, the average equilibrium fraction for radon would be less than 0.1. A 95 Upper Confidence Limit on the Mean (UCLM) of measured ambient radon concentrations from the 2009 field study, excluding the concentrations measured at the portals, was used to calculate risks to workers and Site visitors. This calculation assumes they would spend all of their time in the areas represented by the radon measurements. This is a conservative assumption, as the radon measurements were purposively collected for site characterization rather than to obtain a true average for the Site and likely overestimate true exposure concentrations. However, based on the very conservative calculation, inhalation of the decay products of Rn-222 constitutes the greatest single contributor to the total risk to a Site visitor or worker on the Site. The following presents the results from the annual estimated doses and risks from inhalation of radon decay products to the three receptors:

Site Visitor:
Dose = 170 mrem/y; Risk = 3.3E-3

Mineral Exploration Worker:
Dose = 730 mrem/y; Risk = 4.2E-3

USFS Worker:
Dose = 60 mrem/y; Risk = 2.0E-3

According to ADEC guidance (ADEC, 2010), a risk level below 1E-5 is considered acceptable. A risk level of 1E-5 is defined as an excess probability of one in 100,000 of developing cancer over a lifetime due to exposure to mine-affected materials. The estimated lifetime risks from inhalation of radon decay products ranging from 2.0E-3 to 4.2E-3 for the three receptors (Site Visitor, Mineral Exploration Worker, and USFS Worker) are greater than 1E-5, and therefore, exceed the acceptable risk level. The estimated lifetime risks for occupational and recreational users of the Site from background radon concentrations also exceed the acceptable risk level of 1E-5.

3.2.2.2 Calculated Annual Dose and Risk from Exposure to Direct Gamma Radiation

The potential annual radiation doses from direct gamma radiation exposure were calculated using the dose rate and annual frequency of exposure for each receptor. The annual dose for external gamma exposure was multiplied by a dose conversion factor to obtain the annual effective dose (UNSCEAR, 2000). The lifetime risks under the defined exposure scenarios were estimated using the International Commission on Radiological Protection (ICRP) detriment-adjusted risk coefficient (ICRP, 2007). The external and dermal risks for contact with soils with elevated radionuclide concentrations were estimated using a risk calculator as described in the SSRA.

The annual radiation dose rates to the hypothetical Mineral Exploration Worker, USFS Worker, and Site Visitor were calculated assuming the individuals divide their time on the Site per their predicted activities on the Site. The Site Visitor was assumed to camp on the OSA, thus spending a larger fraction of his or her time in that area. The workers were assumed to be at the Site daily, thus spending a larger fraction of their time in the mined areas rather than the OSA. The fractional distribution was based on best professional judgment, but it is worth noting that different assumptions regarding the fraction of time spent on the OSA would not change the annual dose by more than a factor of two.

The dose rates for the adult Site visitor and workers were modified to calculate an effective dose that takes into account self-shielding of sensitive organs by the body. For adults the dose rates were multiplied by a factor of 0.7 to obtain the effective dose (UNSCEAR, 2000). The effective dose for a child Site visitor was obtained by multiplying the dose rate by a factor of 0.8.

The calculated annual effective doses and lifetime risks are given in the Table 3-7.

The estimated radiation doses and risks are summarized in Tables 3-8 and 3-9, inclusive of doses and risks from inhalation of radon decay products. Approximately 90 to 95 percent of the projected radiation risk to the hypothetical receptor from the entire Site area is from inhalation of radon decay products.

3.2.2.3 Calculated Risks from Direct Contact Exposures and Subsistence Food Exposures

In addition to the gamma and radon assessments, the SSRA estimated the potential risks and noncarcinogenic hazard indices (HI) associated with direct exposures and exposure through subsistence food pathways to chemicals and radionuclides in soil, sediment and surface water.

For the subsistence resource user, the total potential risk from all subsistence foods was 9.97E-7, which is well below levels of concern, and not likely to be achieved as there is no indication that the Site or the dock area are a subsistence hunting or gathering area.

Non-radionuclides in soil, sediment, or water do not pose a risk above 1E-5 or HI above 1.0 by any pathway.

With the exception of soil ingestion by the Site Visitor receptor, all soil-related risks from radionuclides are below 1E-5 and are acceptable per ADEC guidance (ADEC, 2010). The risk from ingestion of soil is higher for the Site Visitor than for other receptors, despite a limited exposure frequency, because the soil ingestion rate for children is twice as high as that for adults.

The SSRA evaluated risks to the Site Visitor and occupational workers (Mineral Exploration Worker and USFS Worker) from incidental ingestion and direct contact with stream and marine sediments for those COPCs identified by the SLRA. The SSRA also evaluated risks from exposure to marine sediments associated with subsistence food pathways. The maximum concentrations of the COPCs for stream and marine sediments were used in the SSRA. All stream and marine sediment risks from radionuclides via ingestion and contact exposures combined are below 1E-5 and are within acceptable ranges defined by ADEC guidance (ADEC, 2010). Exposure to radionuclides in marine sediments posed a total risk (combined ingestion and dermal/external risk) of 2.2E-6 for the Site Visitor. Direct contact and ingestion of stream sediment posed a total risk of 1.2E-6 for the Site Visitor. Exposure to radionuclides in both stream and marine sediment for the occupational workers were below 1E-6. As described in the SSRA, these risks are likely overestimated since they were calculated assuming daily exposure to the maximum detected concentration of each isotope for marine or stream sediments. It is improbable that the Site Visitor would contact the maximum concentrations on a daily basis. In addition, the presence of water would act to further shield from external or direct contact exposures.

Surface water ingestion was evaluated only for the Site Visitor, as occupational receptors would have their own water supply. The potential surface water risk totaled 1.95E-5, which is an overestimate because it was conservatively estimated using the maximum detected concentration of each radionuclide COPC. It is unlikely that any receptor would consistently be exposed to the maximum detected concentrations of COPC in surface water, which for radionuclides all occurred in drainage from the 300-Foot Level portal. Concentrations of radionuclides downstream and outside of the portal area range from below laboratory detection limits to half as high as those at the portal. Surface water in Kendrick Creek downstream of the portal, which is a more likely source of drinking water, has sampling results that are less than 0.5 pCi/L for most radionuclides, and many results are below laboratory detection limits. Risks associated with those concentrations would be one order of magnitude or more lower than risks based on the maximum concentrations.

The results indicate that potential risks are less than 1E-5 to the Site-specific USFS Worker across all pathways and COPCs. The results from the risk assessment to the Site-specific Mineral Exploration Worker show that there is no one pathway or COPC that presents risks greater than 1E-5, although the cumulative potential risks across all pathways and COPCs are estimated at 1.16E-5.

3.2.3 Human Health Risk Assessment Conclusions

Figure 3-10 summarizes the results of the SSRA, providing a tabulated view of COPCs assessed, pathways assessed, and a list of the COPCs that posed potential risks in excess of 1E-5 by media and pathway after evaluation in the SSRA. Of the COPCs listed, radon and direct gamma radiation contribute the major portion of the estimated theoretical risk to occupational and recreational users of the Site, with inhalation of radon decay products accounting for approximately 90 to 95 percent of the potential radiation risk. The estimated theoretical lifetime risks ranged from 2E-3 to 4E-3. All estimated radiation risks are very conservative in that they assume the individuals spend all of their time in the 17.4 acre mining affected area.

While no pre-mining radiation measurements are available for the Site, the background gamma doses were estimated using the unmined I&L Zone gamma radiation measurements as a surrogate. The distribution of gamma exposure rate measurements for the mineralized areas of the Site is similar to the distribution of measurements in the unmined I&L Zone. No radon data were available for the unmined I&L area so pre-mining radon risk was estimated based on the maximum background measurement. Table 3-10 provides the estimated total annual dose and lifetime risks due to background to occupational and recreational users of the Site. Approximately 30 percent of the total projected background dose is due to direct gamma exposure with inhalation of radon decay products accounting for nearly all of the remainder of the dose. Inhalation of radionuclides in airborne particulate matter and inadvertent soil ingestion contribute a small fraction of the total dose, less than two percent in all cases. The estimates indicate that the background dose and lifetime risk to occupational and recreational users of the Site are greater than 15 mrem/year and 1E-4.

Based on the results of the SSRA, risks from radon and gamma exposures are used to guide the analysis of removal action alternatives in the EE/CA.

3.3 Conclusions and Updated Conceptual Site Model

The conclusions from the HHRA and SLERA and the information and data presented in the SCR provide the basis for development of an updated conceptual site model (updated CSM). The updated human health CSM and updated ecological CSM are provided in Figures 3-11 and 3-12, respectively. Figure 3-11 summarizes the results of the HHRA for exposure pathways and receptors with a risk greater than 1E-5 and Figure 3-12 summarizes the results of the SLERA for exposure pathways and receptors with hazard quotients greater than one. The updated CSMs accurately describe the current conditions of the Site with respect to sources, release mechanisms, exposure pathways, chemicals of concern, and exposure routes for receptors used to guide development of RAOs for evaluation of the removal action alternatives and EE/CA decision making.

A conceptual site model (CSM) provides a visual representation of the route and exposure pathway by which a constituent could migrate into the environment from a source to a potential receptor or receptor populations for a site. The CSM is designed to provide a visual representation of possible exposure pathways but does not quantify the exposure or health risks presented by that exposure (ADEC, 2005). Further, identifying a pathway as complete does not mean there is actual harm or risk to the environment (ADEC, 2005). In general, the CSM shows 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, and includes both human and ecological receptors. The CSM is a useful tool for describing and understanding the potential source and exposure relationships that exist at a site and is valuable at various stages of the decision process.

A preliminary conceptual site model for the Site was presented in the PA/SI (KSI, 2004) based on the information and data available at that time. The preliminary CSM was based upon the knowledge of the environmental setting, constituents believed to be present at the Site, fate and transport in the environment, the potential environmental receptors, and the potential exposure pathways to those receptors available at the time from the PA/SI. The CSM presented in the PA/SI was revised based on the additional information and data provided in the SCR (Tetra Tech, 2010) as part of the problem formulation for the HHRA and the SLERA. The revised human health CSM is provided in the HHRA (Appendix C) and the revised ecological CSM is provided in the SLERA (Appendix A). The results and conclusions of the HHRA and the SLERA, in conjunction with the SCR, provide the basis for updating the CSMs to accurately describe the current conditions of the Site with respect to sources, release mechanisms, exposure pathways, chemicals of concern, and exposure routes for Site receptors.

The updated CSMs illustrate the potentially complete exposure pathways where the estimated risk exceeds the applicable criterion for the human receptors consisting of the Site Visitor, Mineral Exploration Worker, and USFS Worker, and ecological receptors consisting of terrestrial plants and invertebrates, terrestrial wildlife, and freshwater wildlife (riparian animals). As shown in the far left column of Figures 3-11 and 3-12, the sources at the Site are the underground mine workings; mine rock piles at the 900-Foot Level, 700-Foot Level, and the 300-Foot Level; mine-affected soil and residual ore rock at the OSA and load out ramps, and mine rock at the mine and haul roads. From these sources, releases of metals or radionuclides may occur. In addition, the miscellaneous solid waste debris present at the Site, including drums, tanks and petroleum-contaminated soils, are considered a separate source for petroleum hydrocarbons, as shown on the human health CSM in Figure 3-11. However, the human health risk assessment found that the drums, tanks and stained soils at the generator shack area posed no potential risk to Site receptors.

As described previously, risks to human receptors from radiation exposures due to background conditions in the naturally mineralized area exceed acceptable risk levels. The exposure pathways and risks associated with human health exposure from background gamma radiation and radon in the naturally mineralized area are not included in the CSM on Figure 3-11. Likewise, the risks to ecological receptors from background concentration of soil, surface water and stream sediments in the mineralized area are not depicted on Figure 3-12.

The release mechanisms from the underground mine workings are radon emissions to ambient air and leaching of metal and radionuclide constituents to mine water. The human health risk assessment concluded that radon emissions to ambient air are a potentially significant source of risk to human receptors. Because mine water drainage from the 300-Foot Level portal drains to surface water, surface water is considered an exposure medium through which receptors could be exposed to constituents through ingestion, direct contact, and food chain pathways. The human health risk assessment determined that ingestion of cumulative radionuclides in water directly from the 300-Foot Level portal drainage poses a potential risk to the Site Visitor receptor.

Soil sources are affected by the processes of erosion, leaching, runoff, dust emissions, and radon emissions (release mechanisms) as well as being a direct exposure medium. Runoff from soil to surface water results in receptors potentially being exposed through direct contact with, ingestion of, or food chain exposures of surface water and stream sediment constituents. The results of the ecological risk assessment determined that cumulative exposure to radium in surface water and stream sediment poses a potential risk to riparian animals. Radium concentrations in stream surface water account for the majority of the cumulative risk.

Erosion of soil creates sediments or soils that present a secondary soil exposure medium. The stream and marine sediments present direct contact exposure pathways as well as external radiation and food-chain exposures to receptors. Further, plant and animal uptake of constituents from soil presents a secondary release mechanism and potential exposure route to ecological receptors. The ecological risk assessment determined that exposure to identified constituents of concern in soils on the mine rock piles and native soils at the transitions of the piles is a potential risk to terrestrial plants, invertebrates, and wildlife. The potential incidental ingestion of combined radionuclides in soil was determined to be a complete exposure pathway for the Site Visitor.

Evaluation of exposures in the marine environment is based on marine sediments. Based on the hazard quotients and weight of evidence, potential risks are not expected for exposure to stream or marine sediments for ecological receptors consisting of stream aquatic-dependent wildlife indicator species, intertidal and subtidal aquatic-dependent wildlife receptors, and intertidal and subtidal community receptors.

The risk characterization results provided by the HHRA and SLERA were used to evaluate whether removal action alternatives are necessary for marine and freshwater stream sediments. As summarized in Section 3.2.2.3, the SSRA evaluated risks to the Site Visitor and occupational workers (Mineral Exploration Worker and USFS Worker) from incidental ingestion and direct contact with stream and marine sediments for those COPCs identified by the SLRA. The SSRA also evaluated risks from exposure to marine sediments associated with subsistence food pathways. All human health risks for both stream and marine sediment are below 1E-5 and are acceptable per ADEC guidance (ADEC, 2010). For the Site Visitor, stream sediment posed a total risk of 1.2E-6 and marine sediments posed a total risk of 2.2E-6, even though these risks were conservatively estimated assuming daily exposure to the maximum detected concentration of each isotope for stream or marine sediments. Stream sediment and marine sediment related risks for the occupational worker receptors were below 1E-6. For the subsistence resource user, the total risk from all subsistence foods was 1E-6. Moreover, even this low risk level is likely conservative as there is no indication that the Site or the dock area are a subsistence hunting or gathering area. As summarized on Figure 3-11, the exposure pathway for stream and marine sediments for current Site conditions was determined to result in acceptable risk to human receptors. Based on the results of the HHRA, removal actions to address the marine and freshwater stream sediments are not necessary.

The results of the ecological exposure assessment for exposure to stream and marine sediments are summarized in Section 3.1.4. Potential risks from exposure to metals are not expected for stream community receptors or stream aquatic-dependent wildlife using freshwater streams at the Site. Hazard quotients are less than one for aquatic animal exposure to radium in stream sediments and surface water for exposure to individual chemicals and pathways and for cumulative exposure via all chemicals and pathways at the Site. Development of removal action objectives for stream sediments at the Site is not necessary for exposure to metals in the stream habitat or for the aquatic animal receptor. For riparian animals, Site-wide hazard quotients did not exceed one for cumulative exposure to radionuclides (Ra-226 and Ra-228) in stream surface water and sediments. Hazard quotients for riparian animal exposure to Ra-226 and Ra-228 in stream surface water and stream sediment also did not exceed one for individual chemicals and pathways at the Site. However, hazard quotients exceeded one for riparian animals via cumulative exposure to Ra-226 and Ra-228 in surface water and stream sediments at the 700-Foot/900-Foot Level and at the 300-Foot Level, but the risks were dominated by elevated concentrations at a few sample locations in these areas. At these areas, Ra-226 and Ra-228 concentrations in stream surface water accounted for the majority of the cumulative risk, with hazard quotients for surface water-only exposure being approximately one. Hazard quotients for sediment-only exposure were all less than or equal to 0.5. The highest metal and radionuclide concentrations in water and stream sediment occur in the drainage from the 300-Foot Level portal (Section 2.5.3). As shown in Figure 3-12, riparian animal exposure to Ra-226 in stream sediments and surface water was retained as a potentially complete exposure pathway due to the cumulative exposure in surface water and stream sediment having a hazard quotient greater than one. In this case, removal actions may be appropriate to reduce the cumulative exposure, but could consist of either removal actions for stream sediments or surface water.

As summarized in Section 3.1.4 and more fully described in the SLERA, hazard quotients for trace metals in marine sediment are not significantly elevated for either the benthic community receptors or indicator wildlife species utilizing the intertidal and subtidal habitats. For those limited instances where the hazard quotients exceeded one for community receptor exposure to arsenic in marine sediment and for belted kingfisher exposure to aluminum in subtidal sediment, no significant risk is expected since the hazard quotients are only slightly above one and are driven by the concentration of a single sample. Hazard quotients for wildlife indicator species utilizing the intertidal area are less than one. As summarized on Figure 3-12, potential risks from exposure to marine sediment are not expected for benthic community receptors or indicator wildlife species utilizing the intertidal and subtidal habitats.

Mine rock fugitive dust emissions from soil and radon emissions affect ambient air that receptors may be exposed to through inhalation. It is possible the fugitive dust could redeposit in soil and become part of the soil exposure pathways. Both volatilization and inhalation of wind-borne particles would be minimized given the presence of vegetated cover on surface soils. In addition, none of the Site-specific COPCs were considered volatile. Therefore, both of these pathways are likely to be insignificant and incomplete for ecological receptors. In addition, the inhalation pathway is not typically evaluated in ecological risk assessments because the methodology for evaluating inhalation exposures to wildlife is not well developed and exposure factors and toxicity reference values are limited. Therefore, the inhalation pathway was not further assessed for ecological receptors. Fugitive dust emissions/particulate inhalation of non-radionuclides was evaluated in the human health risk assessment, and found to result in insignificant risk to human receptors. Inhalation of radon decay products from mine rock represents a potentially significant source of risk to the Site Visitor and occupational workers.

Finally, direct exposure to mine rock and any associated soil is a potentially complete pathway to human and terrestrial ecological receptors. Exposure to gamma radiation from mine rock represents a potentially significant risk to the Site Visitor and occupational workers. However, risks to human receptors from radiation exposures due to background conditions in the naturally mineralized area also exceed acceptable risk levels. From an ecological standpoint, the route of exposure for mine rock and soil was conservatively characterized. As reported in the SCR, soil samples were taken of the fine-grained fraction of mine materials on the mine rock piles and native soils at the transitions of the piles and adjacent surrounding undisturbed areas. Consequently, the soil characterization was biased toward the mine rock piles and immediately adjacent areas that may have been affected by erosion and redeposition of fine-grained material from the mine rock piles.

Table 3-1. Summary of Chemicals and Recommended Assessment Methodologies for Functional Receptor Groups of Potential Ecological Concern in Stream Surface Water, Stream Sediments, and Marine Sediments

	Fish and Aquatic Invertebrates Comparisons to Benchmarks			Birds/Mammals Wildlife Exposure Model		
Analyte	**Stream Surface Water**	**Freshwater Sediments**	**Marine Sediments**	**Stream Surface Water**	**Freshwater Sediments**	**Marine Sediments**
Aluminum	X		X			X
Antimony						
Arsenic			X			X
Barium	X	X			X	
Beryllium			X			
Cadmium	X				X	
Chromium						
Cobalt					X	
Copper					X	
Iron			X	X		X
Lead	X	X	X			
Magnesium				X		
Manganese		X			X	
Mercury				X	X	
Molybdenum		X			X	
Nickel		X				
Selenium		X			X	
Silver				X	X	X[a]
Thallium		X				
Vanadium		X			X	
Zinc	X	X			X	
Uranium	X	X	X		X	X
Ra-226[b]	X	X		X	X	
Ra-228[b]	X			X		

[a] Selected as a chemical of potential ecological concern based on maximum concentration greater than background, but note maximum value was undetected
[b] Identified as chemical of potential ecological concern in preliminary screen for chemicals of interest.

Table 3-2. Areas and Analytes Where Hazard Quotients Exceed One for Terrestrial Plants and Soil Invertebrates

		Site Risk		Background Risk	
Exposure Unit	**Metal**	**Plants**	**Soil Invertebrates**	**Plants**	**Soil Invertebrates**
700/900-Foot Level	Manganese	**2.E+00**	1.E+00	8.E-01	4.E-01
	Zinc	**3.E+00**	**4.E+00**	5.E-01	7.E-01
300-Foot Level	Cobalt	**2.E+00**	NA	1.E+00	NA
	Manganese	**1.E+01**	**5.E+00**	**2.E+01**	**9.E+00**
	Selenium	**3.E+00**	<1	**5.E+00**	<1
	Zinc	**2.E+00**	**2.E+00**	2.E-01	2.E-01

Notes:

Bold = HQ>1

NA = no available TRV

Table 3-3. Areas and Analytes Where Hazard Quotients Exceed One for Avian and Mammalian Receptors in the Terrestrial Environment

		Site Hazard Quotients								Background Hazard Quotients							
		Dark-eyed Junco		American Robin		Masked Shrew		Vole		Dark-eyed Junco		American Robin		Masked Shrew		Vole	
Exposure Unit	**Metal**	**NOAEL HQ**	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**
700/900-Foot Level	Lead	**4.E+00**	**3.E+00**	**7.E+00**	**6.E+00**	<1	<1	<1	<1	**2.E+00**	1.E+00	**3.E+00**	**3.E+00**	<1	<1	<1	<1
	Uranium	**7.E+00**	1.E+00	**8.E+00**	**2.E+00**	**3.E+00**	1.E+00	<1	<1	1.E-01	3.E-02	1.E-01	3.E-02	5.E-02	2.E-02	<1	<1
	Zinc	1.E+00	1.E+00	**2.E+00**	**2.E+00**	<1	<1	<1	<1	2.E-01	2.E-01	3.E-01	3.E-01	<1	<1	<1	<1
300-Foot Level	Aluminum	**7.E+00**	1.E+00	**7.E+00**	1.E+00	**5.E+01**	**5.E+00**	**9.E+00**	<1	**8.E+00**	**2.E+00**	**8.E+00**	**2.E+00**	**5.E+01**	**5.E+00**	**1.E+01**	<1
	Cadmium	<1	<1	**2.E+00**	1.E+00	**2.E+00**	**2.E+00**	<1	<1	<1	<1	2.E-01	1.E-01	2.E-01	2.E-01	<1	<1
	Lead	**3.E+00**	**2.E+00**	**5.E+00**	**4.E+00**	<1	<1	<1	<1	4.E-01	3.E-01	7.E-01	6.E-01	<1	<1	<1	<1
	Nickel	<1	<1	<1	<1	**2.E+00**	1.E+00	<1	<1	<1	<1	<1	<1	2.E-01	1.E-01	<1	<1
	Selenium	<1	<1	1.E+00	<1	<1	<1	<1	<1	**2.E+00**	1.E+00	**2.E+00**	**2.E+00**	1.E+00	1.E+00	<1	<1
	Uranium	**2.E+00**	<1	**2.E+00**	<1	<1	<1	<1	<1	1.E-02	<1	1.E-02	<1	<1	<1	<1	<1
OSA	Aluminum	**7.E+00**	1.E+00	**7.E+00**	1.E+00	**4.E+01**	**4.E+00**	**9.E+00**	<1	**5.E+00**	1.E+00	**5.E+00**	1.E+00	**3.E+01**	**3.E+00**	**7.E+00**	<1
	Lead	**2.E+00**	1.E+00	**3.E+00**	**2.E+00**	<1	<1	<1	<1	1.E+00	8.E-01	**2.E+00**	1.E+00	<1	<1	<1	<1
	Uranium	**3.E+00**	<1	**3.E+00**	<1	1.E+00	<1	<1	<1	8.E-01	<1	8.E-01	<1	3.E-01	<1	<1	<1

Notes:

Bold = HQ>1

NOAEL = no observed adverse effects level

LOAEL = lowest observed adverse effects level

Table 3-4. Areas and Analytes Where Hazard Quotients Exceed One for Aquatic Receptors in Stream Surface Water and Sediments

Area	Analyte	HQ Surface Water		Sediments			
				$HQ_{threshold}$[a]		$HQ_{probable}$[b]	
		Site	Background	Site	Background	Site	Background
700/900-Foot Level	Barium	3.E+00	2.E+00	--	--	--	--
	Manganese	NC	NC	2.E+00	2.E-01	9.E-01	8.E-02
300-Foot Level	Barium	4.E+00	5.E-01	--	--	--	--
	Manganese	NC	NC	3.E+00	3.E+00	1.E+00	1.E+00
	Zinc	2.E-01	8.E-02	2.E+00	5.E-01	4.E-01	1.E-01
Ore Staging Area	Aluminum	3.E+00	ND	NC	NC	NC	NC
Site-Wide	Barium	4.E+00	2.E+00	--	--	--	--
	Manganese	NC	NC	3.E+00	2.E+00	1.E+00	1.E+00
Intertidal + Subtidal	Arsenic[c]	NC	NC	4.E+00	1.E+00	5.E-01	2.E-01

Notes:

-- = SQB not available.

HQ = hazard quotient

ND = no data

NC = Not a COPEC in this medium.

[a]TEC benchmarks used for freshwater sediments, effects range low benchmarks used for marine sediments.

[b]PEC benchmarks used for freshwater sediments, effects range median benchmarks used for marine sediments.

[c]Hazard quotients for arsenic and lead are based on effects range low/effects range median values. Hazard quotients for aluminum and iron are based on the apparent effects threshold.

Table 3-5. Areas and Analytes Where Hazard Quotients Exceed One for Avian and Mammalian Wildlife in the Freshwater Stream and Marine Environments

Exposure Unit	Metal	Belted Kingfisher (Freshwater)		Belted Kingfisher (Marine)		Mew Gull (Herring Gull)		Sea Otter		Harbor Seal	
		NOAEL Hazard Quotient	LOAEL Hazard Quotient	NOAEL Hazard Quotient	LOAEL Hazard Quotient	NOAEL Hazard Quotient	LOAEL Hazard Quotient	NOAEL Hazard Quotient	LOAEL Hazard Quotient	NOAEL Hazard Quotient	LOAEL Hazard Quotient
Stream Surface Water & Sediments	Mercury	**2**	<1	N/A	N/A	N/A	N/A	-	-	-	-
Marine Sediments	Aluminum	N/A	N/A	**3**	<1	<1	<1	<1	<1	<1	<1

Notes:

Bold = HQ>1

N/A = value not available

- = risk not calculated because of a lack of toxicity data

NOAEL = no observed adverse effects level

LOAEL = lowest observed adverse effects level

Table 3-6. Summary of Hazard Quotients for Radionuclide COPECs in Soils, Stream Sediments, and Surface Water

			700-Foot/900-Foot Level			300 –Foot Level			Ore Staging Area		
Location	**Habitat-Receptor Group**	**Analyte**	**Hazard Quotient Ra-226**	**Hazard Quotient Ra-228**	**Hazard[a] Index**	**Hazard Quotient Ra-226**	**Hazard Quotient Ra-228**	**Hazard[a] Index**	**Hazard Quotient Ra-226**	**Hazard Quotient Ra-228**	**Hazard[a] Index**
Site Areas	Terrestrial Habitat - Plant	Soil	2.E+00	1.E+00	3.E+00	8.E-01	5.E-01	1.E+00	3.E-01	2.E-01	5.E-01
	Terrestrial Habitat - Animal	Soil	1.E+01	6.E+00	2.E+01	5.E+00	3.E+00	8.E+00	2.E+00	1.E+00	3.E+00
	Stream Habitat - Riparian Animal	Sediment	5.E-01	NA	5.E-01	2.E-01	NA	2.E-01	--	--	--
		Surface Water	6.E-01	7.E-01	1.E+00	6.E-01	7.E-01	1.E+00	7.E-02	7.E-02	1.E-01
		Cumulative Exposure	1.E+00	7.E-01	2.E+00	9.E-01	7.E-01	2.E+00	7.E-02	7.E-02	1.E-01
	Stream Site - Aquatic Animal	Sediment	3.E-03	NA	3.E-03	2.E-03	NA	2.E-03	--	--	--
		Surface Water	2.E-01	3.E-01	5.E-01	3.E-01	3.E-01	6.E-01	3.E-02	3.E-02	6.E-02
		Cumulative Exposure	2.E-01	3.E-01	5.E-01	3.E-01	3.E-01	6.E-01	3.E-02	3.E-02	6.E-02
Background Areas	Terrestrial Habitat - Plant	Soil	9.E-02	7.E-02	2.E-01	7.E-03	1.E-03	8.E-03	4.E-02	6.E-02	1.E-01
	Terrestrial Habitat - Animal	Soil	5.E-01	4.E-01	9.E-01	4.E-02	8.E-03	5.E-02	3.E-01	3.E-01	6.E-01
	Stream Background - Riparian Animal	Sediment	2.E-02	NC	2.E-02	2.E-02	NC	2.E-02	--	--	--
		Surface Water	9.E-03	5.E-02	6.E-02	1.E-02	3.E-02	4.E-02	--	--	--
		Cumulative Exposure	3.E-02	5.E-02	8.E-02	3.E-02	3.E-02	7.E-02	--	--	--
	Stream Background - Aquatic Animal	Sediment	1.E-04	8.E-05	2.E-04	1.E-04	4.E-05	2.E-04	--	--	--
		Surface Water	6.E-03	5.E-02	5.E-02	7.E-03	1.E-02	2.E-02	--	--	--
		Cumulative Exposure	6.E-03	5.E-02	5.E-02	7.E-03	1.E-02	2.E-02	--	--	--

Note:

-- No Data.

NC = Not a COPEC for this exposure medium

[a]The hazard index is the sum of risks (hazard quotients) for individual substances and exposure media.

Table 3-7. Calculated Annual Effective Dose and Lifetime Risk from Gamma Radiation Exposure

	Annual Effective Dose (mrem/y)	Lifetime Risk
Site Visitor – Adult	31	5.1E-4
Site Visitor – Child	35	5.3E-4
Mineral Exploration Worker	108	1.3E-4
USFS Worker	9	9.2E-5

Note: Values in excess of non-mineralized background radon and gamma radiation.

Table 3-8. Summary of Estimated Lifetime Radiation Risks

Lifetime Radiation Risk Estimates	Site Visitor	Mineral Exploration Worker	USFS Worker
Radon Decay Product Inhalation	3.3E-3	4.2E-3	2.0E-3
Direct Gamma Exposure	5.1E-4	1.3E-4	9.2E-5
Total Risk	3.8E-3	4.3E-3	2.1E-3

Note: Values in excess of non-mineralized background radon and gamma radiation.

Table 3-9. Summary of Estimated Annual Radiation Dose

Annual Dose Estimates	Site Visitor* (mrem/y)	Mineral Exploration Worker (mrem/y)	USFS Worker (mrem/y)
Radon Decay Product Inhalation	170	730	60
Direct Gamma Exposure	31 (35)	108	9
Total Annual Dose	201 (205)	838	69

*parentheses indicate results for child site visitor

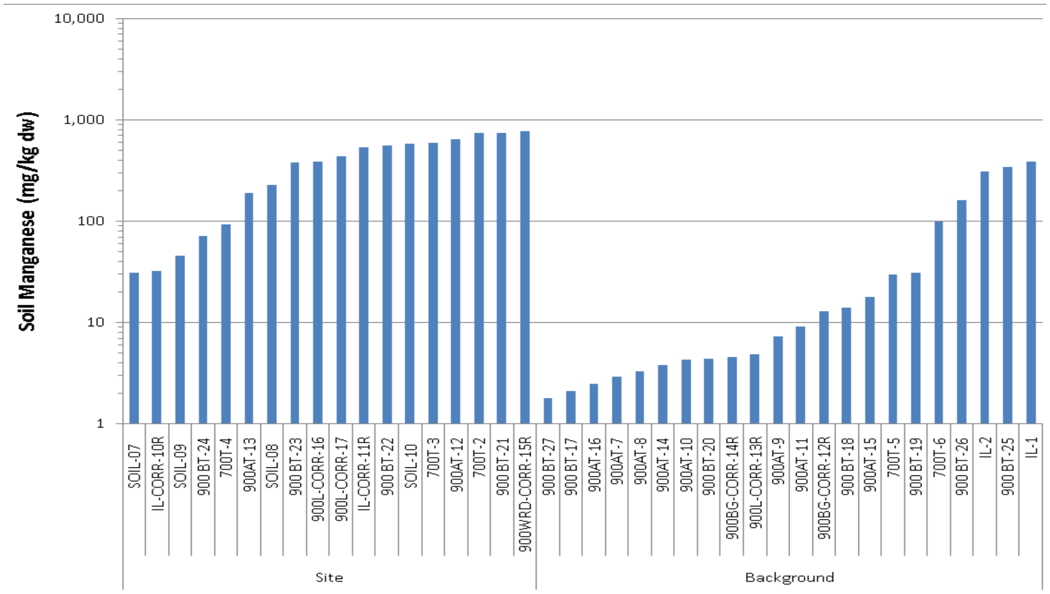
Note: Values in excess of non-mineralized background radon and gamma radiation.

Table 3-10. Summary of Estimated Annual Radiation Dose and Lifetime Risk due to Background

	Total Annual Dose (mrem/y)*	Lifetime Risk
Site Visitor	38 (40)	6.0E-4
Mineral Exploration Worker	254	3.6E-4
USFS Worker	21	2.6E-4

*parentheses indicate results for child site visitor

A. 700/900 Level



B. 300 Level

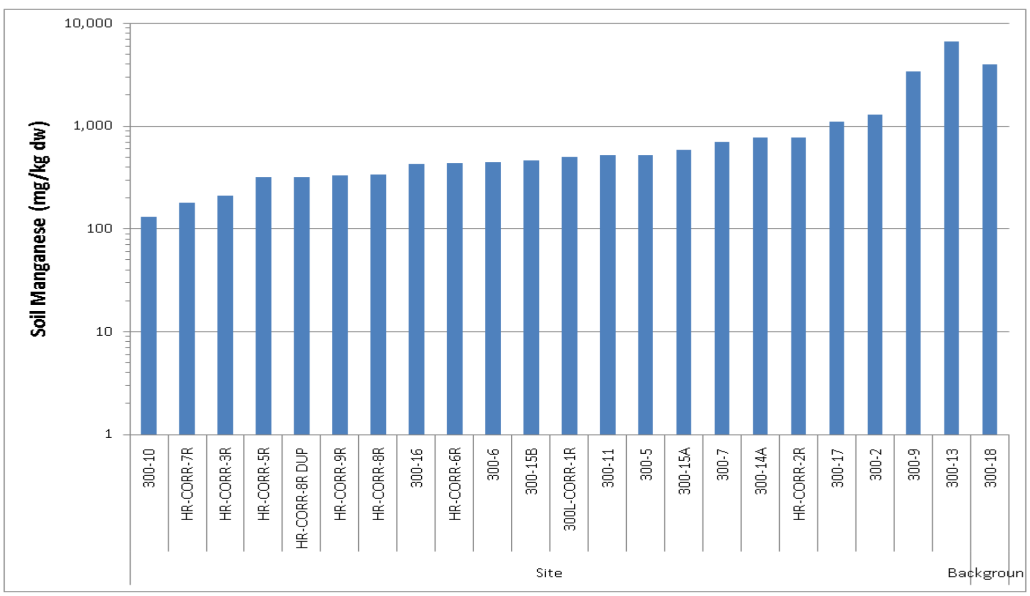


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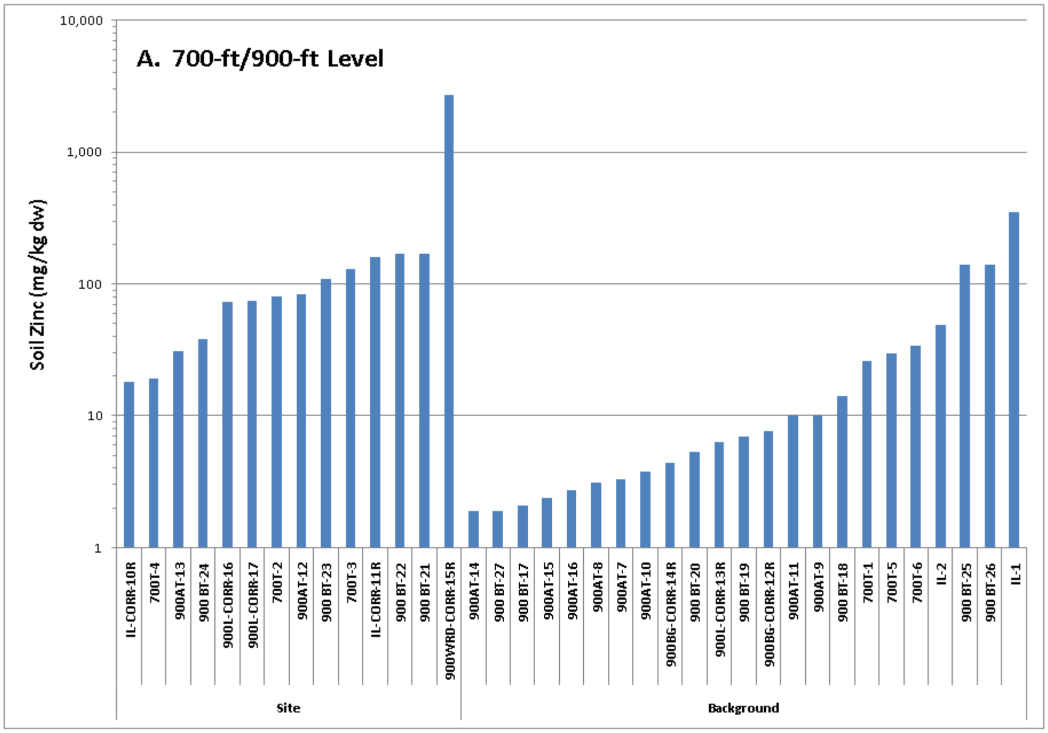
Figure 3-1.
Soil Manganese in the 700/900 Level and Local Background Areas



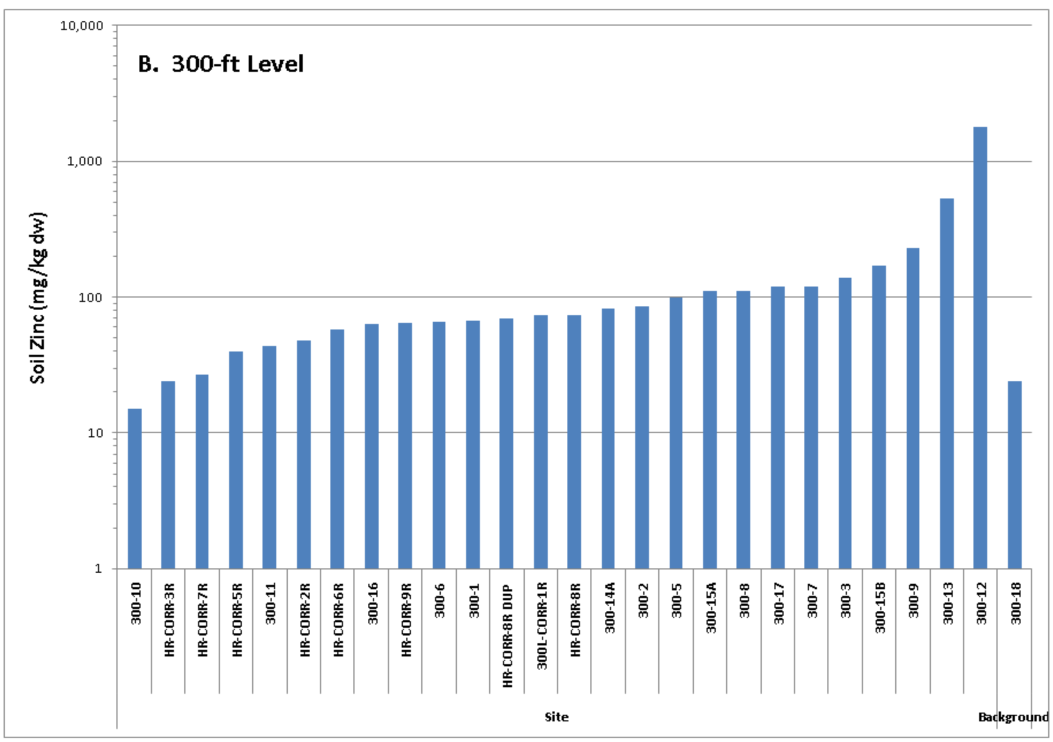


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Figure 3-2.
Soil Zinc in the 700/900 Level and
Local Background Areas

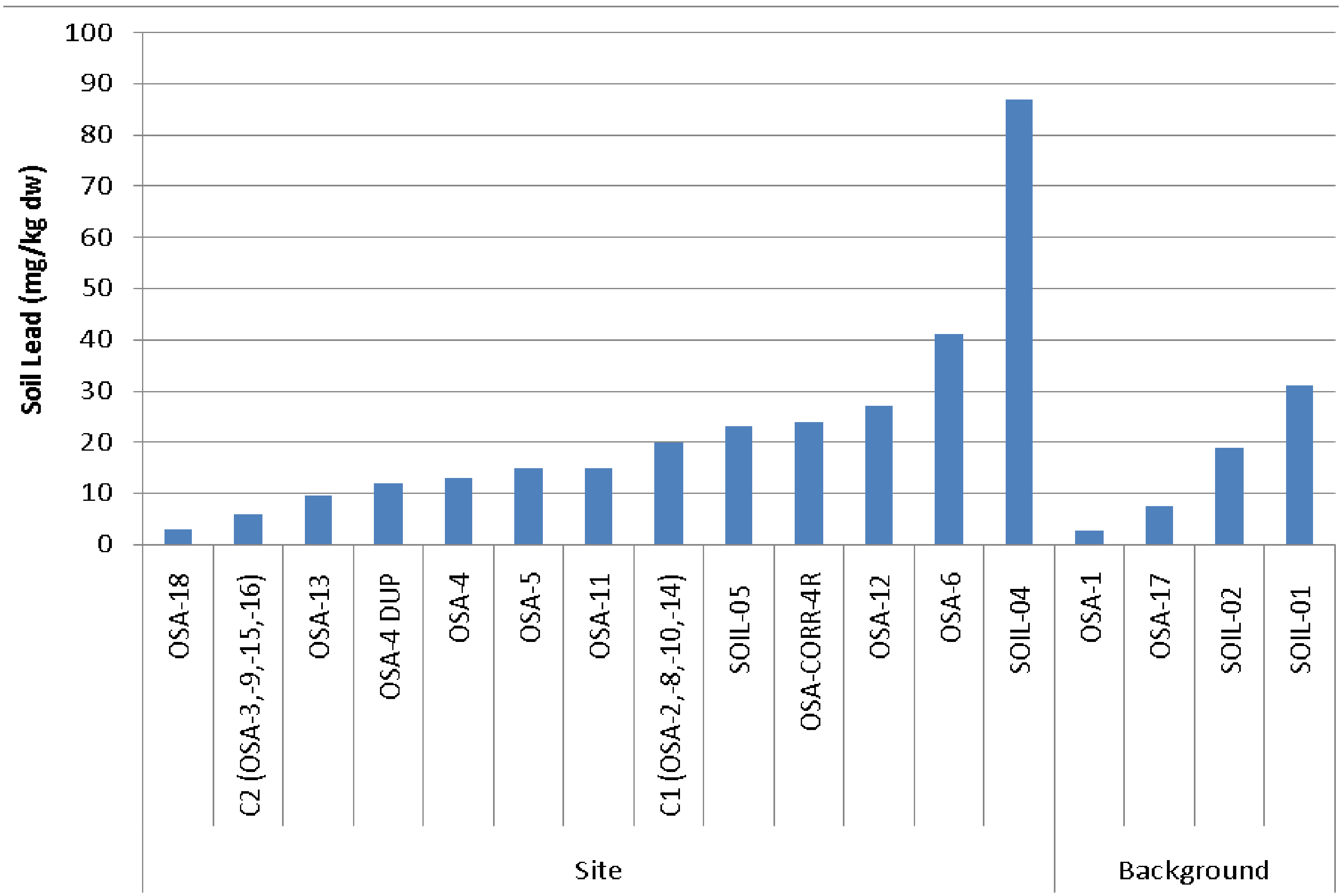

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Figure 3-3.
Soil lead concentrations for samples located in the OSA and local background areas

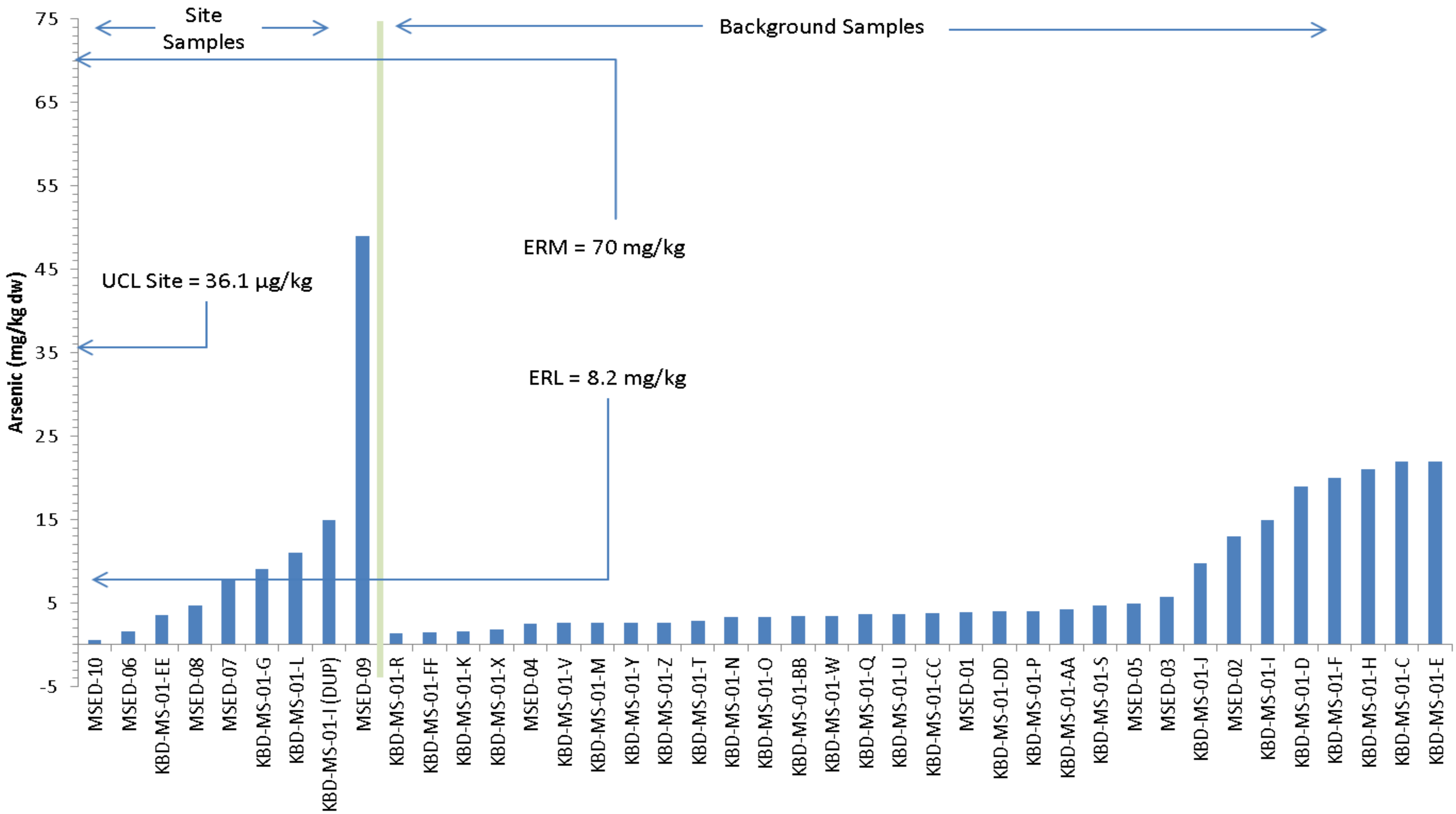

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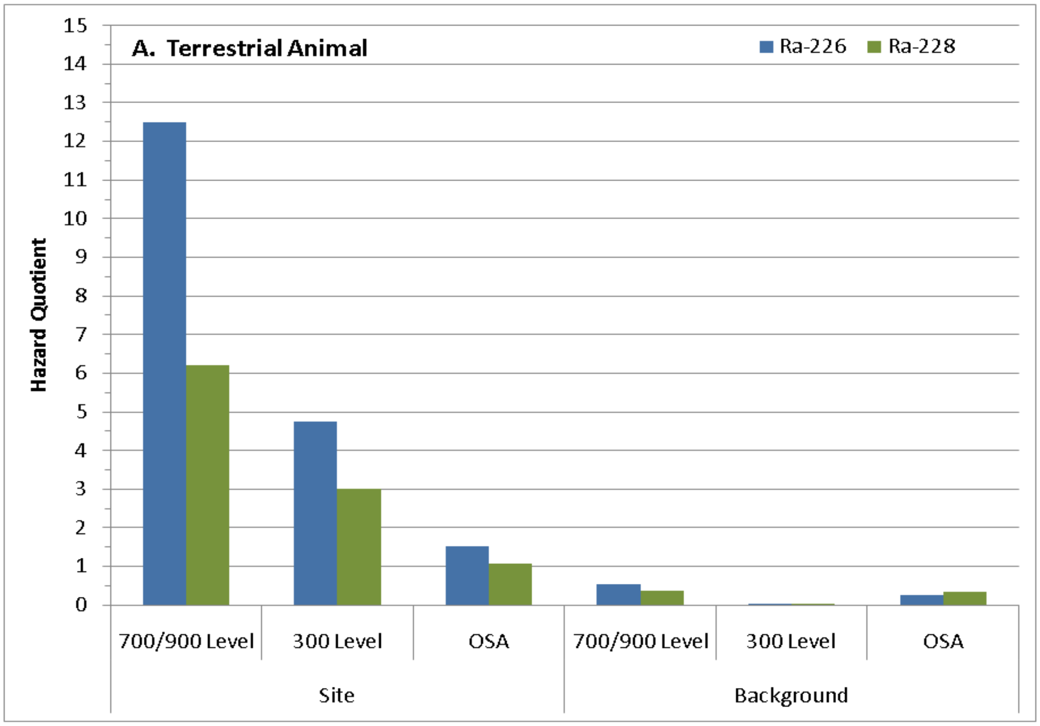
Figure 3-4.
Arsenic Concentrations in Marine Sediments from Site and Background Areas



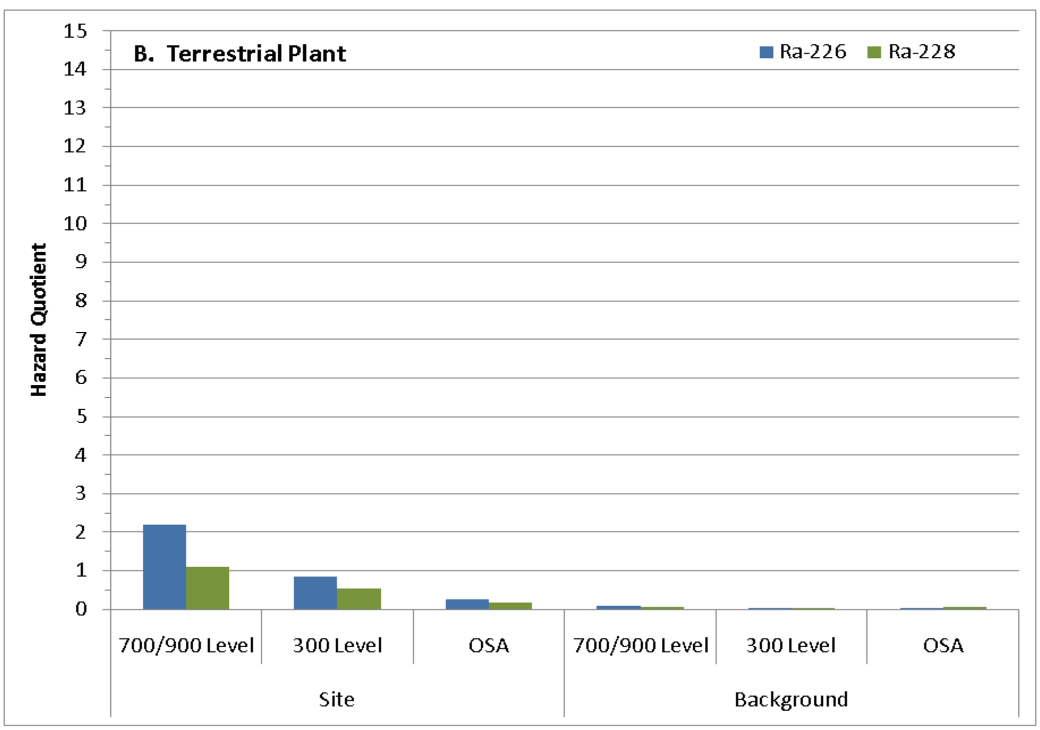


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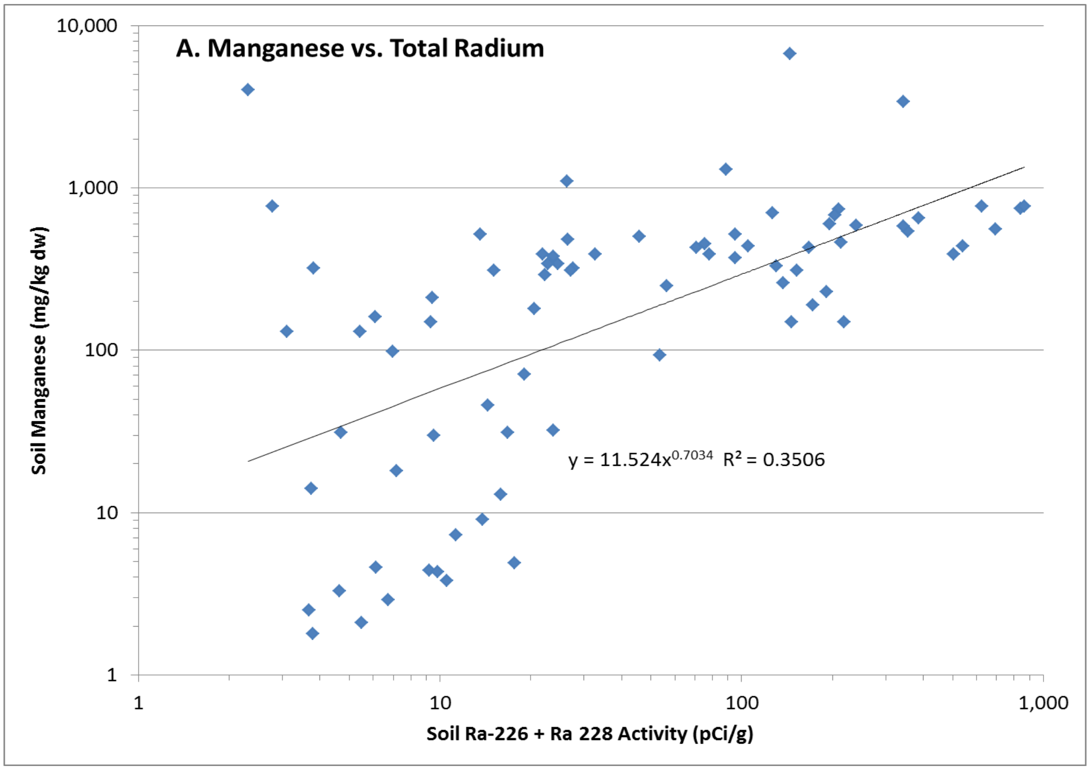
Figure 3-5.
Hazard Quotients for Ra-226 and Ra-228 in Terrestrial Habitat



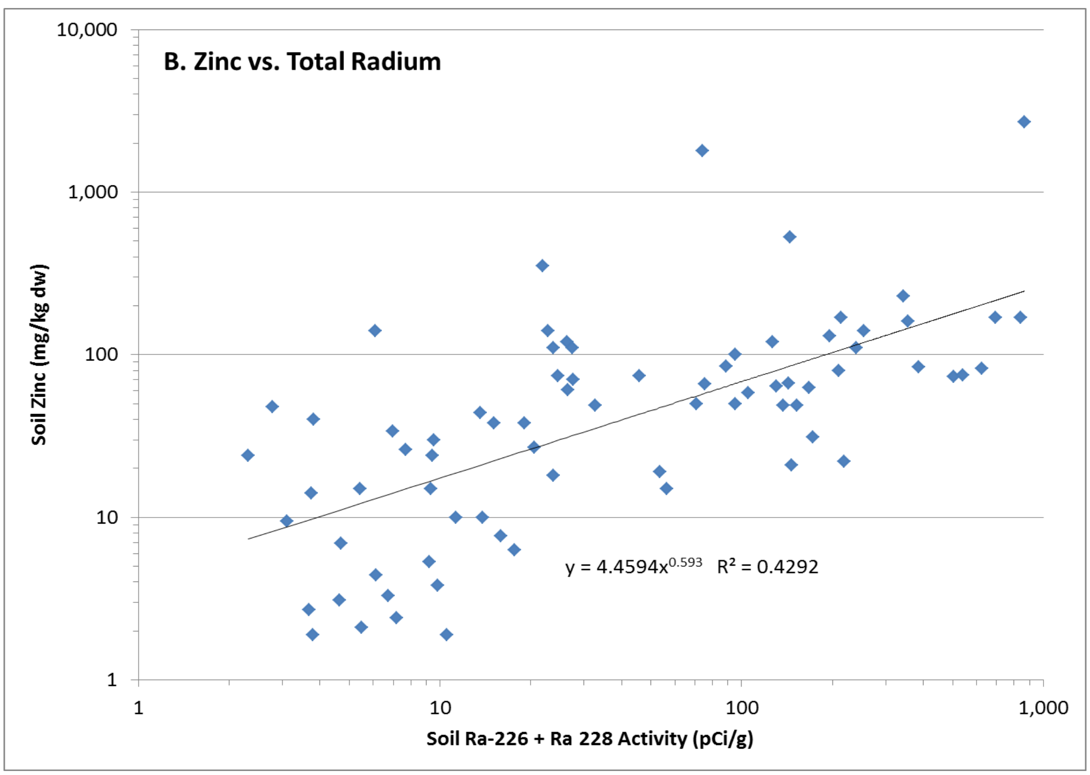


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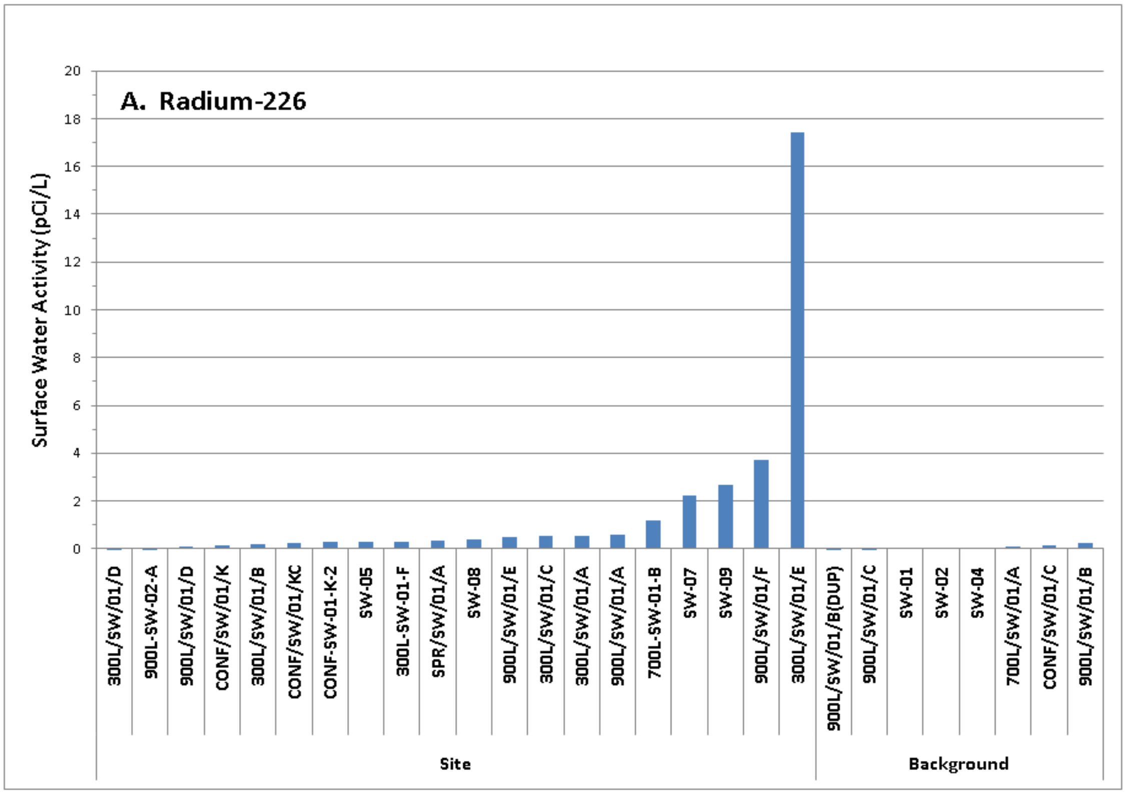
Figure 3-6.
Total Radium Activity Correlations with Manganese and Zinc



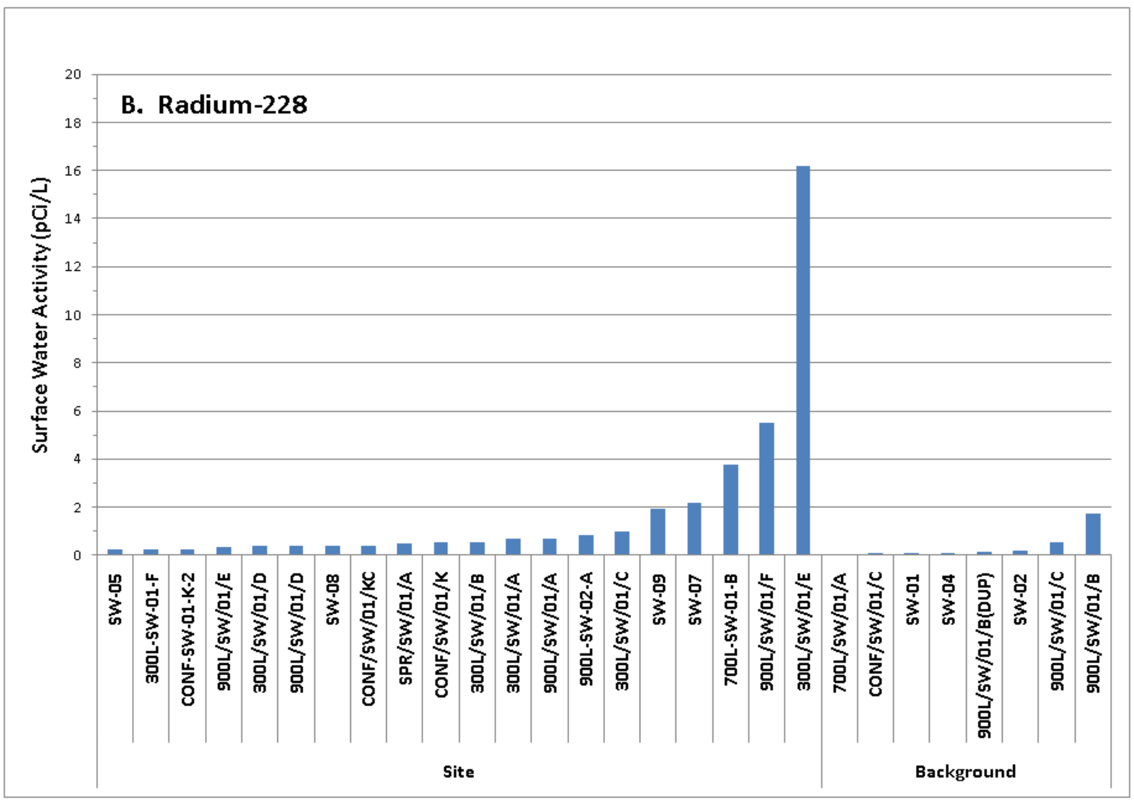


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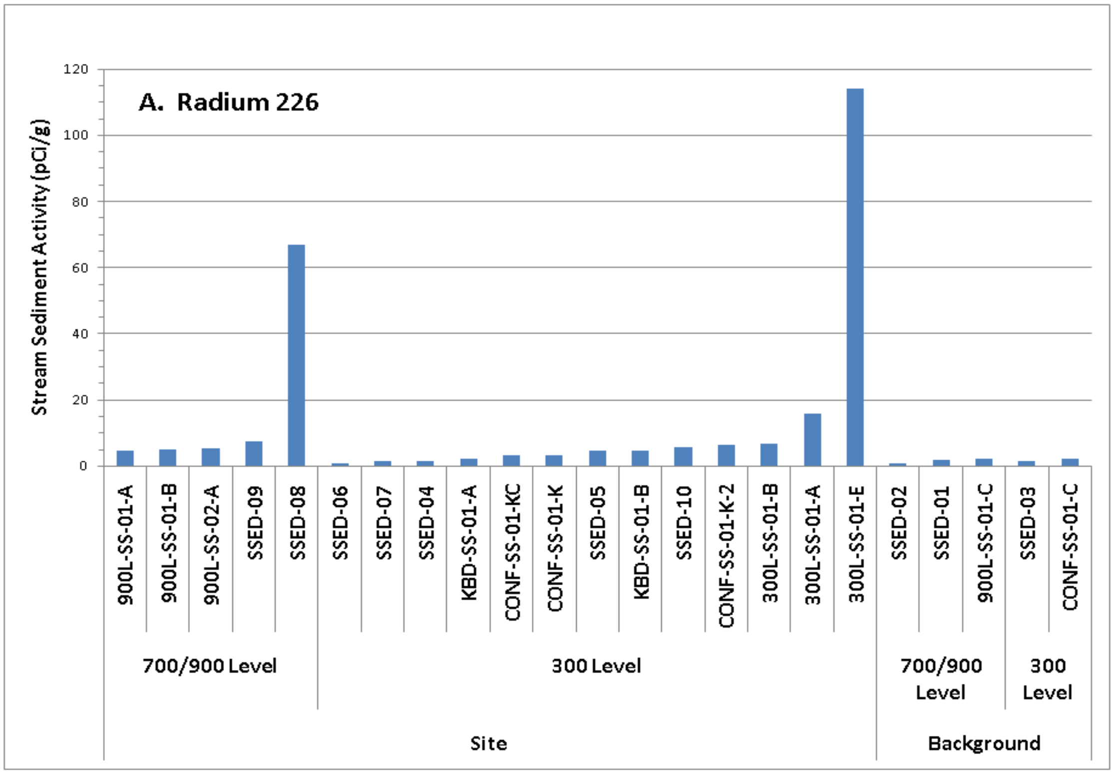
Figure 3-7.
Activity of Ra-226 and Ra-228 in stream surface water at the site and background locations



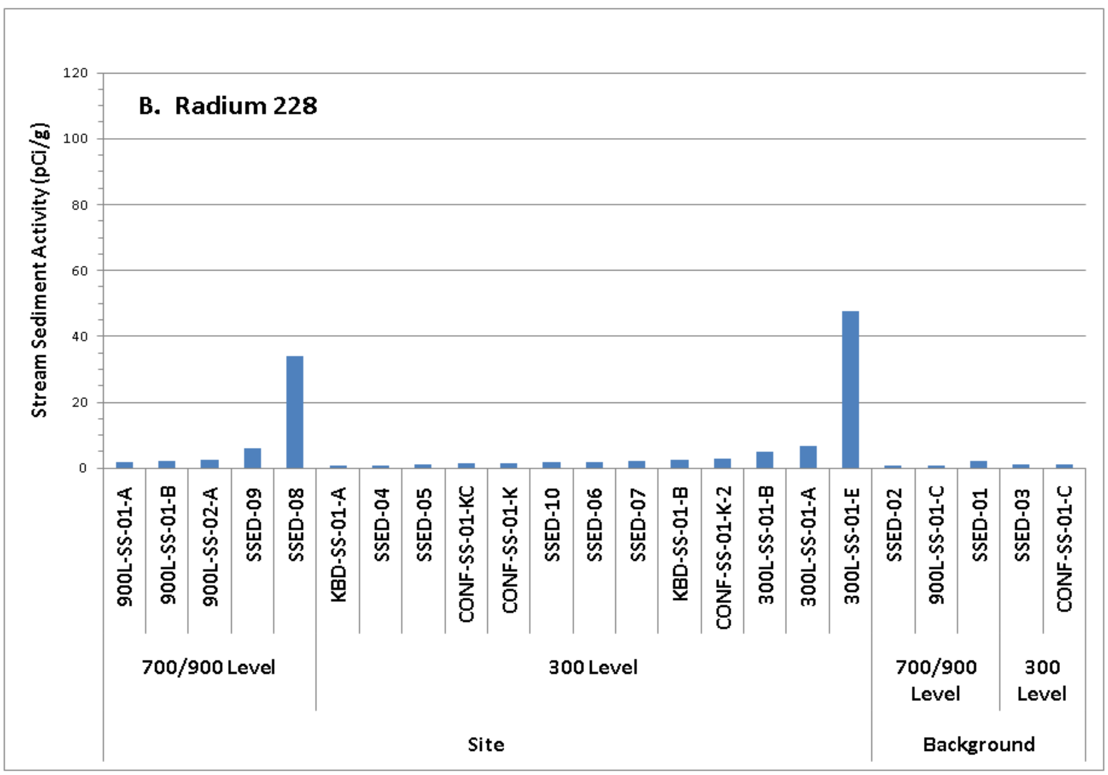


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Figure 3-8.
Activity of Ra-226 and Ra-228 in stream sediments at the site and background locations

SLERA

COPEC Retained from Screening Evaluation

Soils: Al, Sb, As, Cd, Cr, Co, Pb, Mn, Mo, Ni, Se, Th, Zn, U, Ra-226, Ra-228

Stream Surface Water: Ag, Al, Ba, Cd, Fe, Mg, Hg, Pb, Zn, U, Ra-226, Ra-228

Stream Sediments: Ba, Cd, Co, Cu, Pb, Mn, Hg, Mo, Ni, Se, Ag, Th, Va, Zn, U, Ra-226

Marine Sediment: Ag, Al, As, Be, Fe, Pb, U

SLERA

Lines of Evidence for COPEC

Terrestrial Habitat – Metals & radionuclides

- Plants & soil invertebrate communities

- Wildlife indicator species

Stream Habitat – Metals & Radionuclides in Sediments, Surface Water:

- Aquatic communities (plants, fish, invertebrates)

- Aquatic-dependent wildlife

Marine Habitat – Intertidal and Subtidal Sediments:

- Benthic invertebrate community

- Marine-dependent wildlife

SLERA

Pathways, Receptors and Chemicals of Concern with HQ > 1

Terrestrial Plants: Co, Mn, Zn, Ra-226

Terrestrial Invertebrates: Mn, Zn

Terrestrial Wildlife: Cd, Pb, U, Zn, Ra-226, Ra-228

Stream Surface Water Community: Ra-226, Ra-228

Stream Sediment Community: Ra-226

Stream Wildlife: None

Marine Benthic Community: None

Marine Wildlife: None

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Figure 3-9.
Summary of the Screening Level Ecological Risk Assessment

COPCs retained from SLRA based on risk-based screening levels, further evaluated in the SSRA:

SOIL:
As, Th-232, Ra-228, Th-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210, Po-210

SURFACE WATER:
Mn, U, Ra-226, Ra-228, Th-228, Th-230, Po-210, U-234, U-235, U-238, Pb-210

STREAM SEDIMENT:
Ra-228, Ra-226, Th-230, Th-232, Pb-210, U-234, U-235, and U-238

MARINE SEDIMENT:
As, Th-232, Ra-228, U-235, U-238, U-234, Th-230, Ra-226, Pb-210

Pathways evaluated in SSRA:

SOIL:
Soil Ingestion
Dermal Contact/External Exposure to Soil
Particulate Inhalation of Soil
Deer Harvesting
Berry Harvesting

STREAMS:
Ingestion of Stream Sediment
Dermal Contact/External Exposure to Stream Sediment
Ingestion of Surface Water (Area Visitor only)

MARINE SEDIMENT:
Ingestion of Marine Sediment
Dermal Contact/External Exposure to Marine Sediment
Sea Cucumber Harvesting
Sea Weed Harvesting
Flounder Harvesting

SSRA results for scenarios posing risk above 1E-5 by receptor and pathway

Site-Specific Mineral Exploration Worker:
Radon in Air
Gamma Exposure

Site-Specific USFS Worker:
Radon in Air
Gamma Exposure

Area Visitor:
Radon in Air
Gamma Exposure
Soil Ingestion:
combined radionuclides (2.7E-5)
Surface Water Ingestion:
combined radionuclides (2.0E-5)

Subsistence Resource User: None

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Figure 3-10
Summary of the Human Health Risk Assessment

Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\FIG-3-11 H-H CONCEPTUAL MODEL.dwg SAVED:10/8/14 PRINTED:4/2/15 BY:TOM

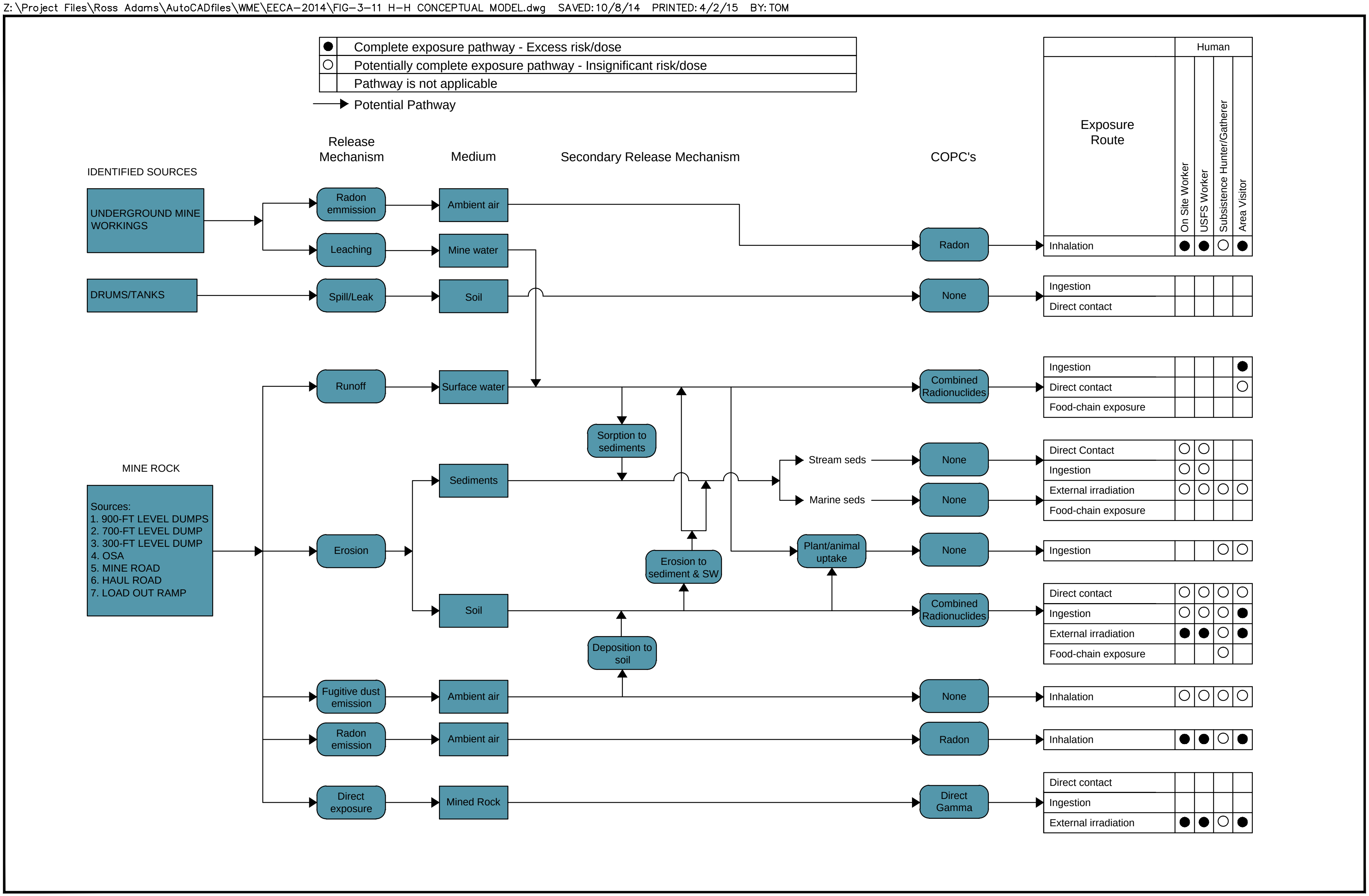

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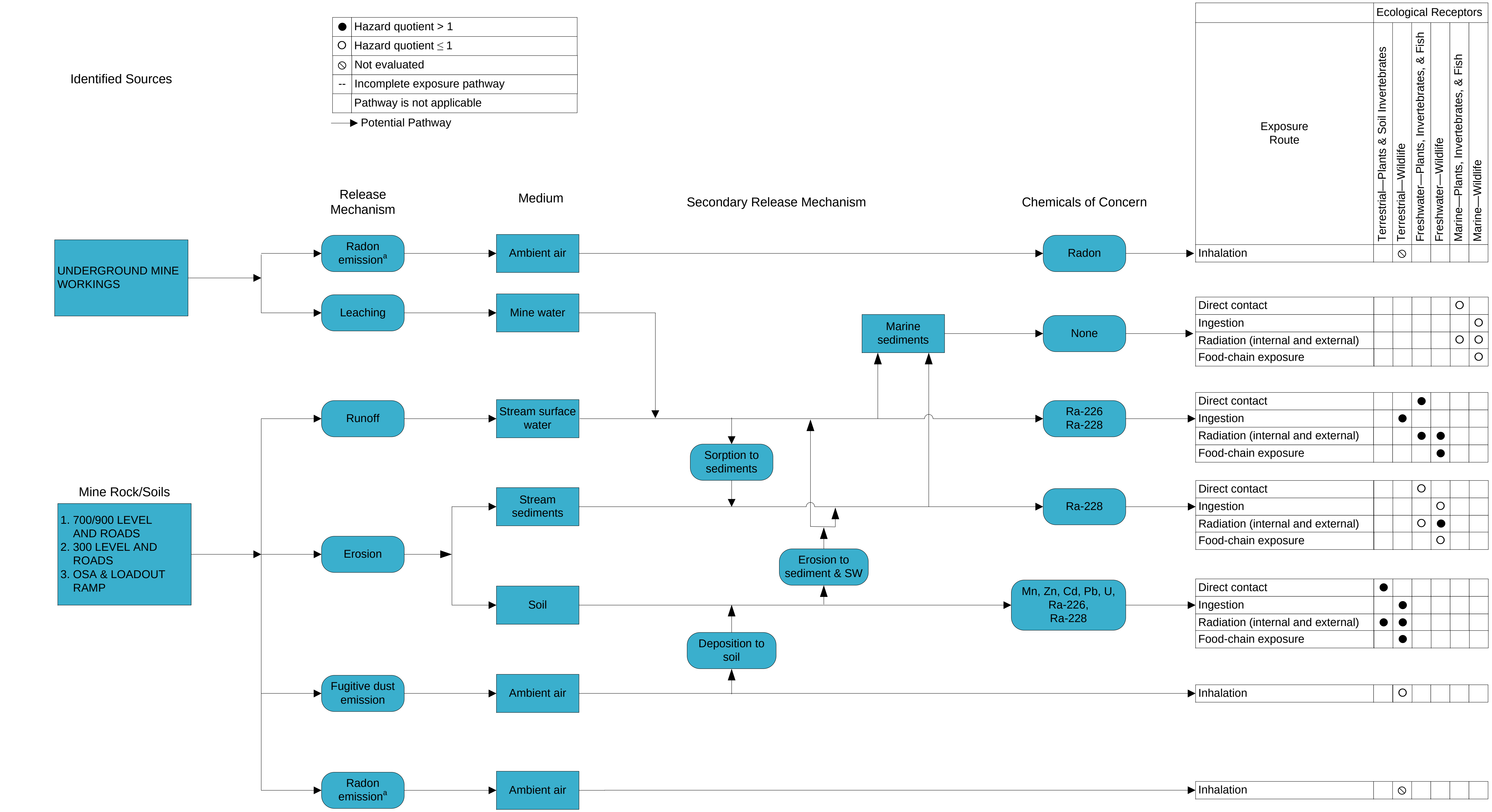
Figure 3-11
Updated Human Health Conceptual Site Model



[a]Rn-222 is a short-lived daughter product of Ra-226. Exposure to Ra-226 is evaluated in soils for terrestrial plants and animals and in water and sediment for riparian and aquatic animals.

Figure 3-12.
Conceptual Site Model

4.0 Identification of Removal Action Objectives

The overall objective of the Ross-Adams EE/CA is to develop and evaluate viable removal action alternatives to support decision making for selection of a removal action that satisfies removal action objectives and evaluation criteria, which includes protection of human health and the environment. This section defines the scope of the removal action, identifies the removal action objectives (RAOs) for the Site, presents potential applicable, relevant and appropriate requirements (ARARs), including potential ARARs that provide risk-based criteria for evaluation of the removal action alternatives. RAOs provide a general description of the qualitative goals and define the appropriate quantitative criteria that are used to evaluate the effectiveness of the removal action in reducing potential human health and ecological risk that is protective of human health and the environment. The RAOs and goals defined in this EE/CA are typical of those used for removal and cleanup actions at former uranium mine sites.

4.1 Removal Action Scope

The scope of this removal action addresses the mine rock and mine portals associated with the former Ross-Adams mine operations. As described in Section 2.0, these areas include:

- 900-Foot Level - open pit, mine portal and air vent shaft, north and south mine rock piles;
- 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 Ramps – residual ore materials spilled during former ore loading operations on the two remnant rock load-out ramps (western and eastern) extending from the OSA area within the intertidal zone of the West Arm of Kendrick Bay and the remnants of a third and older ramp located approximately 600 feet west of the existing floating dock;
- Haul and Mine Roads – identified segments of the haul roads connecting the 900-Foot and 300-Foot Levels to the OSA, mine rock embankments at specific locations along the mine road connecting the 900-Foot and 700-Foot Levels, and the I&L access road.
- Miscellaneous Solid Wastes – debris, solid wastes, empty drums and drums containing petroleum products, above-ground petroleum storage tanks, battery plates and any associated lead-contaminated soil, abandoned vehicles and other materials that remain at the Site at specific areas.

The primary exposure media consist of mine rock at and adjacent to the piles at the 300-Foot, 700-Foot, and 900-Foot Levels, at embankments at specific locations along the mine road, along the I&L access road and within identified segments of the haul road, and residual ore rocks at the OSA and at the former ore load-out ramps. The mine rock and residual ore rock contain naturally mineralized metal and radionuclide constituents and are a source of gamma radiation and radon emanation. As described in the SCR, the mine rock and residual ore rocks are mineralized coarse-grained durable rocks. The overall approach for identifying the scope of the removal action for mine rock and residual ore rock was to define the physical boundaries of the piles and adjacent areas based on visual observations and gamma exposure rate measurements provided by the SCR. The scope of the removal action for mine rock includes the mine rock piles shown on Figure 2-2.

Radon exhalation occurs from the portals at the 300-Foot, 700-Foot and 900-Foot Levels, the air vent shaft at the 900-Foot Level, and the Open Pit. Air entry into the underground mine via the portals at the 700-Foot and 900-Foot Levels and the air vent shaft is exhausted from the underground mine at the 300-Foot Level portal. Stormwater intercepted by the Open Pit flows into the underground mine via the 900-Foot Level portal increasing water outflow at the 300-Foot Level portal. The scope of the removal action includes the three portals, air vent shaft and Open Pit.

Several mine camps were operated over the life of mining operations and significant exploration occurred after mining ended leaving behind miscellaneous debris and solid wastes, particularly at the OSA and 300-Foot Level. The miscellaneous debris and solid wastes, as inventoried in the SCR, include empty and partially-filled 55-gallon drums containing petroleum products, two above-ground petroleum storage tanks, several abandoned vehicles, drill core, battery plates, other debris and solid waste materials. The removal action scope also includes the miscellaneous debris and solid wastes.

The scope of the removal action includes residual ore materials spilled during former ore loading operations, which exist within the intertidal zone of the West Arm of Kendrick Bay extending from the OSA to the vicinity of the former ore loading ramps. The residual ore rock contains naturally mineralized metal and radionuclide constituents and is a source of gamma radiation and radon exposure to human receptors within the OSA. The removal action scope does not include freshwater stream sediment, the intertidal zone outside of the ore loading ramps, ore rock potentially within the subtidal zone at the former loading dock, and subtidal sediments. Nor are remedial action objectives (RAOs) developed in Section 4.2 for marine sediments within the intertidal and subtidal zones.

As described in Section 3.3, all human health risks for exposure to metals and radionuclides in stream sediment are below the acceptable risk value of 1E-5. Potential risks from exposure to metals in stream sediments are not expected for stream community receptors or stream aquatic-dependent wildlife at the Site. Hazard quotients for stream community receptors or stream aquatic-dependent wildlife exposure to radionuclides in stream sediment are also less than one. The hazard quotient for cumulative exposure to Ra-226 and Ra-228 in combined surface water and stream sediments exceeds one for riparian animals due to a few sample locations at the 700-Foot/900-Foot Level and at the 300-Foot Level, with surface water accounting for the majority of the cumulative risk. Due to the high gradient of most stream channels, including Kendrick Creek, the presence of fine-grain sediment is limited to localized stream reaches and is discontinuous (Section 2.5.3). Access to the stream channels is also limited by the steep terrain and dense vegetation. Given the limited risk posed to riparian animals, removal actions to address stream sediment would result in minimal risk reduction but would cause significant disturbance to the stream channels, adjacent areas, and existing habitat.

Except for residual ore material within the intertidal zone associated with the ore loading ramps, the removal action scope does not include, nor are RAOs developed in Section 4.2 for intertidal sediments. The results of sediment sampling and gamma radiation surveys within the intertidal zone, including the Kendrick Creek Delta, outside of the influence of the ore loading ramps indicate that the intertidal sediments have not been adversely affected by historic mining activities and represent background conditions (Tetra Tech, 2010). As described in Section 3.3, all human health risks for exposure to metals and radionuclides in marine sediment and subsistence food pathways are below the acceptable risk value of 1E-5. Hazard quotients for wildlife indicator species utilizing the intertidal area are less than one. Potential risks from exposure to marine sediment are not expected for benthic community receptors or indicator wildlife species utilizing the intertidal area. Removal actions to address the marine and freshwater stream sediments are not necessary and would result in minimal risk reduction and would cause significant disturbance to the existing habitat.

Subtidal sediments are also not included within the scope of the removal action. Submarine gamma and subtidal zone sediment sampling data indicate the influence of spilled ore is limited to the immediate vicinity of the rock loadout ramps and the former floating dock. The influence of spilled ore is documented by four subtidal samples (three KSI samples and one ESI sample) in the immediate vicinity of the former floating dock. The remaining subtidal sediment samples were determined in the SCR to represent local background. Risks to human receptors from exposure to marine sediment via ingestion and direct contact exposures are within or below acceptable risk ranges defined by ADEC guidance (ADEC, 2010) and sediment quality benchmarks for chemicals of potential concern. As described in Section 3.3, potential risks are not expected for exposure to marine sediment for ecological receptors consisting of subtidal benthic community receptors and aquatic-dependent wildlife receptors. As such, RAOs are not defined for subtidal sediments.

The Site as defined by the ASAOC and SOW encompasses all the above features and areas, including the mine, mine roads, haul roads, lower portion of the I&L access road, ore staging area, former barge loading area, and downstream potentially impacted areas including the Kendrick Creek delta. All removal action activities, including activities within the intertidal zone of the Kendrick Creek delta and associated with the ore load-out ramps, would be conducted on-Site, except for activities related to the off-site transport and disposal of materials.

4.2 Removal Action Objectives and Goals

As described in Section 3.0, the HHRA and the SLERA identified the media, and transport and exposure pathways for receptors to support reasonable risk-based management decisions for evaluating the removal action at the Site. The two-tiered HHRA included both a screening level human health risk assessment (SLRA) and a Site-specific human health risk assessment (SSRA). The results of the HHRA demonstrate that risks due to radiation exposure drive the overall human health risk at the Site. Overall, pathways contributing the majority of risk to occupational and recreational users of the Site consist of external exposure to direct gamma radiation from natural mineralization and mine rock and inhalation of radon decay products generated from natural mineralization, mine rock and mine openings. Radon accounts for approximately 90 to 95 percent of the radiation risk, exclusive of background. As described in Section 3.2, human health radiation risks in the naturally occurring mineralized area exceed acceptable levels.

The results of the SLERA indicate that hazard quotients exceed one for terrestrial plants, soil invertebrates and terrestrial wildlife for cobalt, cadmium, lead, manganese, uranium and zinc concentrations in mine rock and mine-affected soils, predominantly at the 700-Foot/900-Foot Levels and at the 300-Foot Level. Hazard quotients exceeded one for exposure to Ra-226 concentrations in mine rock and mine-affected soils for terrestrial plants at the 900-Foot/700-Foot Level and to combined radium (Ra-226 and Ra-228) for terrestrial animals at the 700-Foot/900-Foot Level, the 300-Foot Level, and the OSA. Radium concentrations in stream surface water account for the majority of the cumulative exposure to radium in combined surface water and stream sediments for riparian animals at the 700-Foot/900-Foot Level and the 300-Foot Level. The drainage from the 300-Foot Level has the highest surface water radium concentrations.

Removal action objectives (RAOs) include qualitative goals and quantitative criteria to address the identified risks defined by the HHRA and SLERA associated with the exposure pathways for human and ecological receptors. The RAOs are used to evaluate the effectiveness of the removal action. The RAOs identified include the following:

- Reduce risk for recreational users and occupational workers from exposure to direct gamma radiation from mine rock and mine openings.
- Reduce risk for recreational users and occupational workers from exposure due to inhalation of radon decay products from mine rock and mine openings.
- Reduce risk for recreational users from exposure due to potential ingestion of soil from the mine rock piles and potential ingestion of surface water drainage from the 300-Foot Level portal.
- Reduce or eliminate safety hazards related to the mine openings and access to the underground mine workings.
- Reduce risk or eliminate exposure pathways for terrestrial plants, terrestrial invertebrates, and terrestrial wildlife from exposure to metals and radionuclides defined as constituents of concern in mine rock and soil associated with mine-affected areas via direct contact, ingestion, and food-chain exposure.
- Reduce risk or eliminate exposure pathways for riparian animals from exposure to radium in surface water at the 700-Foot/900-Foot Levels and the drainage from the 300-Foot Level portal.

In addition, the following RAOs were identified based on land-use management plans for the Site and vicinity:

- Minimize disturbance to existing undisturbed areas.
- Minimize reliance on long-term active maintenance.

Quantitative removal action goals were established to address these RAOs. For evaluating the effectiveness of the removal action, these goals are expressed in terms of reducing the identified risks or eliminating the exposure pathways to human and ecological receptors. The overall goal of the removal action is to reduce the incremental human and ecological risks attributable to mine rock and mine portal openings recognizing that local mineralized background risk exceeds human health risk-based criteria for radon and gamma radiation. The goal of the removal action is to reduce the incremental human and ecological risk that is attributable to the mine rock and mine portals to an acceptable level. While the goals are discussed in the context of ARARs in the following section, the primary goals are to:

- Reduce risk for recreational users and occupational workers from exposure to radon inhalation and direct gamma radiation attributable to mine rock and mine openings above background on a Site-wide basis to below the EPA excess dose criterion of 15 mrem/year or a lifetime cancer risk of less than 1E-5.
- Reduce risks for terrestrial plants, invertebrates, and wildlife from exposure to metals and radionuclides defined as constituents of concern in mine rock and soil in mine-affected areas, and for riparian animals from exposure to radium in surface water to an acceptable risk-based level (defined as a HQ less than one) above background.

The removal action may be effective in reducing risk by removing the exposure pathway, where possible, and/or reducing the exposure to an acceptable risk-based level. Based upon the findings of the SLERA, proposed cleanup levels, expressed as risk-based PRGs, for chemicals of concern in soils have been developed for the non-mineralized area. These are detailed in Appendix B, and summarized here. The natural variability in background soil concentrations in the mineralized area precludes development of cleanup levels in the mineralized area (WME 2013). The SLERA identified six chemicals of potential ecological concern with LOAEL-based HQs greater than one and exposure point concentrations greater than background for terrestrial ecological receptors exposed to soil at the Site. However, two of the six chemicals (manganese and uranium) are not recommended for PRG development because they were not identified as chemicals of concern in the non-mineralized area. Consequently, four chemical-receptor pairs with a HQ greater than one and an EPC greater than background were used for the development of the following ecological PRGs:

- Cadmium – 1.3 mg/Kg (alternative cleanup level based on EPA exposure model);
- Cobalt – 18 mg/kg (background threshold value);
- Lead – 31 mg/kg (alternative cleanup level based on EPA exposure model); and
- Zinc – 120 mg/kg (soil SLV).

Source control and removal of the exposure pathway are the appropriate means to reduce risks to riparian animals from exposure to radium in surface water. Ra-226 and Ra-228 were also identified as chemicals of concern in soil for ecological receptors (terrestrial animals) in the non-mineralized areas. However, activity levels of radium are highly correlated with gamma radiation, and reduction of risks from gamma exposure to acceptable levels for human receptors will address the risk to ecological receptors. Gamma exposure rates protective of human health will be developed by further gamma exposure surveys during removal action design (Senes 2013).

4.3 Identification of Potential Applicable or Relevant and Appropriate Requirements

This section identifies and describes potential federal and State of Alaska ARARs for the removal action alternatives retained for detailed analysis in Section 6 of this EE/CA. Removal actions must attain potential ARARs to the extent practical considering Site-specific conditions, including the urgency of the situation, the scope of the removal action, and the impact of potential ARARs on cost and duration of the removal action. Under Section 121(e) of CERCLA, federal, state or local permits are not required for response actions taken on-Site. The NCP defines on-Site as the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action (40 CFR 300.5). On-Site removal actions are only required to achieve the substantive requirements of potential ARARs. Administrative and procedural requirements of potential ARARs, such as permits, do not apply. However, both the substantive and administrative requirements of potential ARARs apply to removal actions that involve off-site management of hazardous substances. The substantive requirements of potential ARARs for the removal action at the Ross-Adams Site were identified from review of federal and State of Alaska environmental laws.

As described below, ARARs are identified on a site-specific basis involving a two-part analysis: first determining whether a given substantive requirement is legally applicable; then if it is not applicable, determining whether the requirement is both relevant and appropriate. A requirement may be applicable or relevant and appropriate, but not both. In addition, To-Be-Considered requirements are also evaluated.

As defined by the NCP (40 CFR Part 300), applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites or the law or regulation directly address the circumstances at the Site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not “applicable” to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. State environmental standards are ARARs if they are promulgated, are identified by the state in a timely manner, are more stringent than federal requirements, and are consistently applied. To-Be-Considered requirements are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. To-Be-Considered requirements may be useful for guiding decisions regarding cleanup levels or methodologies when regulatory criteria are not available.

ARARs may be waived on a case-by-case basis under certain circumstances including where compliance with the ARAR would result in greater risk to human health and the environment, where compliance with the ARAR is technically impracticable, an equivalent standard of performance is applied, or compliance with the ARAR would result in inconsistent application of state requirements. Given the highly variable background radiological soil and rock conditions in the naturally mineralized area, compliance with ARARs that specify conservative risk-based cleanup levels are technically impracticable.

Potential ARARs include chemical, location, and action specific requirements. Chemical-specific ARARs are human health or ecological risk-based criteria or standards that are used to define acceptable concentrations for site-specific conditions. Location-specific ARARs are requirements that constrain or impose additional requirements for activities associated with a removal action due to the location of the removal action. Action-specific ARARs are technology or activity based restrictions that apply to the type of removal action being considered.

Table 4-1 summarizes the potential ARARs for removal actions at the Site based on chemical, location, and action specific requirements.

4.3.1 Chemical Specific ARARs

Potential chemical-specific ARARs are human health or ecological risk-based numerical values for COCs that are considered acceptable for site-specific conditions.

Alaska Water Quality Standards in 18 AAC 70 are potentially relevant and appropriate to surface water at the Site. These identify designated beneficial uses for surface water and groundwater in the state and establish ambient criteria for constituents to protect those designated uses. Under 18 AAC 70.005, the provisions in these regulations applicable to groundwater do not apply to CERCLA response actions that meet the Alaska site cleanup rules at 18 AAC 75.325 - 18 AAC 75.390. Pursuant to 18 AAC 70.050, all designated use classes for state freshwaters apply to Kendrick Creek and other surface water at the Site since the streams have not been reclassified according to Part 18 AAC 70.230. Designated freshwater use classes consist of water supply, water recreation, and growth and propagation of fish, shellfish, other aquatic life, and wildlife. Water quality standards for the designated freshwater uses are set forth in 18 AAC 70.020 and in the Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances. Substantive requirements of the Alaska Pollutant Discharge Elimination System (APDES) Program (18 AAC 83) are also potentially relevant and appropriate for the discharge of water from a point source at the Site to waters of the state.

Alaska Oil and Other Hazardous Substance Pollution Control Regulations in 18 AAC 75 are potentially relevant and appropriate. These include the "site cleanup rules" which establish the administrative process and criteria to determine the degree of cleanup to protect human health, safety, and welfare, and the environment at a site where a hazardous substance is located. These regulations do not provide soil cleanup levels for radionuclides, but do provide methodology for establishing risk-based site-specific cleanup levels. The regulations establish a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one across all exposure pathways in determining the applicable cleanup level. As described in Section 3 and Section 4.2, the Human Health and Ecological Risk Assessments determined that direct exposure to gamma radiation and inhalation of radon decay products is the driver for cleanup at the Site. These risk assessments were performed pursuant to Method 4 of the Alaska site cleanup rules.

4.3.2 Location Specific ARARs

Potential location-specific ARARs are requirements that affect the management of hazardous substances due to the location of the Site. These requirements may limit the type or method of removal action that can be implemented at the Site. A complete list of location-specific ARARs is provided in Table 4-1.

The 2001 Roadless Area Conservation Rule limits road construction and timber cutting on inventoried roadless areas within the National Forest. This rule is not applicable to the Site as it is outside the inventoried roadless areas within the Tongass National Forest (Figure 4-1).

Section 10 of the Rivers and Harbors Act is potentially relevant and appropriate for potential removal action alternatives that require excavation in Kendrick Bay. This act governs the permit process for excavation and dredging in navigable waters of the United States. While permit requirements are not applicable to on-Site removal actions under CERCLA, the substantive requirements may be relevant and appropriate if excavation or dredging occurs within Kendrick Bay.

The Alaska Department of Natural Resources Land Use Planning provides guidelines for management of State owned land in the planning area, including tidelands. These guidelines are potentially relevant and appropriate for removal actions that include activities in Kendrick Bay.

The National Historic Preservation Act is potentially applicable to the Site. A detailed historic inventory of the mining features and artifacts present at the Site was prepared by the Tongass National Forest, Craig Ranger District. The State of Alaska has concurred that the Ross-Adams Mine is eligible for Listing in the National Register of Historic Places (NRHP) at the state level. A cultural mitigation plan will be required according to NHPA requirements for any removal action alternative that could affect the resource.

4.3.3 Action Specific ARARs

Potential action-specific ARARs are usually technology or activity based requirements on actions taken with respect to hazardous substances. These potential requirements are triggered by the particular removal action alternative, and set performance, design, or other standards that will be used to implement the proposed removal action. Potential action-specific ARARs do not affect the selection of the removal action, but instead may pose restrictions on methods by which a selected alternative may be achieved. A complete list of action-specific ARARs is located in Table 4-1.

The Criteria for Classification of Solid Waste Disposal Facilities and Practices is potentially applicable to the solid waste present at the Site. Miscellaneous solid waste debris and petroleum products (abandoned vehicles, battery plates, empty and partially filled 55-gallon drums, above-ground petroleum storage tanks, collapsed buildings, and other materials) associated with several exploration and mine camps are present at the Site and would be removed and transported for off-site recycling and disposal. The debris would be scanned for radiological activity and characterized prior to removal from the Site. To the extent the debris is classified as hazardous waste, regulations relevant to handling, transport, and disposal of hazardous wastes (40 CFR and 49 CFR) would be potentially applicable to the materials.

Alaska Solid Waste Regulations (18 AAC 60) are potentially applicable to the Site for any removal alternative that would include on-Site disposal of solid waste. The regulations set forth requirements for final grading and cover over waste disposal areas and other provisions to ensure that solid waste management is protective of human health and the environment. However, waste rock from mining operations is exempt from the requirements of these regulations unless mixed with nonexempt waste, there is a public health, safety or welfare threat or environmental problem associated with management of the waste, or the waste is managed in a manner that causes or contributes to a nuisance.

4.3.4 Other Guidance to be Considered

To-Be-Considered requirements are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. To-Be-Considered requirements may be useful for guiding decisions regarding cleanup levels or methodologies when regulatory criteria are not available.

EPA Directive No. 9200.4-18 – Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination provides guidance to be considered in evaluating removal action alternatives to address human exposure to radioactive materials, including radon, at the Site. This directive provides guidance for cleanup levels expressed as a risk, exposure, or dose level and not as a soil concentration level. The guidance indicates that the concentration level for various media that corresponds to a given risk level should be determined on a site-specific basis, based on factors such as the assumed land use and the physical characteristics at the Site. The guidance concludes that effective dose equivalent of less than or equal to 15 mrem/yr or an excess lifetime cancer risk in the target range of 1E-6 to 1E-4 above background are protective.

Executive Order 13112 Invasive Species prohibits federal agencies from taking actions that are likely to cause the introduction of invasive species. This order provides guidance to be considered in evaluating removal action alternatives to minimize the potential for introduction of non-native or invasive species.

The Magnuson-Stevens Fishery Conservation and Management Act Requires federal agencies to consider the effect of federal actions on designated Essential Fish Habitat (EFH). The National Marine Fisheries Service (NMFS) has designated Kendrick Bay as EFH for salmon species. If the removal action is determined to adversely affect EFH, then conservation measures to protect the EFH would be considered, consistent with the existing Fishery Management Plan for the Salmon Fisheries and guidance to minimize adverse effects to EFH from non-fishing activities.

Table 4-1. List of Potential Federal and State ARARS and Guidance To Be Considered

Regulation	Description	Potential ARAR		To Be Considered	Rationale
		Potentially Applicable	Potentially Relevant and Appropriate		
Chemical-Specific					
Resource Conservation and Recovery Act (40 CFR Part 261	These regulations address the requirements for identification and characterization of solid and hazardous waste.	X			Miscellaneous solid waste debris present at the Site that is scheduled for off-site disposal would be characterized to determine whether it is subject to regulation as hazardous waste, unless the debris is excluded from regulation as a solid waste (e.g. scrap metal being recycled) or a hazardous waste. Solid waste from the extraction, beneficiation, and processing of ores and minerals (including mining of uranium ore) are exempt from regulation as a hazardous waste.
Alaska Water Quality Standards (18 AAC 70)	Water quality standards identify designated beneficial uses for surface and ground water in the State and establish ambient criteria for constituents to protect the designated uses.	X			Water quality standards are potentially relevant and appropriate to ambient surface water quality for protection of designated beneficial uses. Under 18 AAC 70.005, the provisions in these regulations applicable to groundwater do not apply to CERCLA response actions that meet the Alaska site cleanup rules at 18 AAC 75.325 - 18 AAC 75.390.
Alaska Oil and Other Hazardous Substance Pollution Control Regulations (18 AAC 75)	These regulations include the Alaska “site cleanup rules,” which establish standards for the cleanup of hazardous substance releases (18 AAC 75.325 to 18 AAC 75.390). These include requirements for site characterization, soil and groundwater cleanup levels, and requirements for conducting cleanup operations. Regulations establish a cumulative carcinogenic risk-based level of $1x10^{-5}$ and a cumulative non-carcinogenic hazard index of one across all exposure pathways in determining the applicable cleanup level.		X		May be relevant and appropriate in establishing criteria for cleanup of hazardous substances at the Site.

Table 4-1. List of Potential Federal and State ARARS and Guidance To Be Considered (Continued)

Regulation	Description	Potential ARAR		To Be Considered	Rationale
		Potentially Applicable	Potentially Relevant and Appropriate		
Office of Solid Waste and Emergency Response (OWSER) Directive No. 9200.4-18 – Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination	This guidance presents clarifying guidance for establishing cleanup levels protective of human health for radioactive contamination at CERCLA sites. The cleanup levels are expressed as a risk, exposure, or dose level and not as a soil concentration level. The guidance provides that the appropriate risk range for radionuclides is 1E-4 to 1E-6. The acceptable risk level established for cleanup depends on the exposure pathways and land use at a site. The guidance concludes that levels of less than or equal to 15 mrem/yr effective dose equivalent are protective.			X	This EPA directive provides guidance to be considered in developing removal action alternatives to address exposure to radioactive materials at the Site.
Location-Specific					
2001 Roadless Area Conservation Rule	These regulations limit road construction and timber cutting on inventoried roadless areas within the National Forest System.	N/A			This rule does not constitute an ARAR since the Ross-Adams mine site is not within an inventoried roadless area based on the Alaska roadless inventory map. Moreover, under 36 CFR 294.12(b)(2), the prohibition on construction and reconstruction of roads in inventoried roadless areas does not apply where the responsible officer determines that road construction or reconstruction is needed to conduct a response action under CERCLA.
Protection of Wetlands (Executive Order No. 11990, 40 CFR Part 6)	Directs federal agencies to minimize the destruction, loss or degradation of wetlands, and to avoid construction in wetlands if a practicable alternative exists.			X	Guidance would be considered if Inventoried wetlands exist within Site boundaries.

Table 4-1. List of Potential Federal and State ARARS and Guidance To Be Considered (Continued)

Regulation	Description	Potential ARAR: Potentially Applicable	Potential ARAR: Potentially Relevant and Appropriate	To Be Considered	Rationale
Section 404 of Clean Water Act (33 USC 1344; 33 CFR Parts 320 - 330, 40 CFR Part 230)	Prohibits discharge of dredged or fill material into jurisdictional waters and wetlands without a permit. Establishes substantive requirements for authorizing such discharges.		X		Permit requirements are not applicable to on-Site removal actions under CERCLA. The substantive requirements may be relevant and appropriate if there is a discharge of dredged or fill material into surface waters (including wetlands) that qualify as waters of the United States.
Section 10 of Rivers and Harbors Act (33 USC § 403, 33 CFR Part 322)	Requires permit for excavation and dredging in navigable waters of the United States, including waters of the United States that are subject to the ebb and flow of the tide.		X		Permit requirements are not applicable to on-Site removal actions under CERCLA. The substantive requirements may be relevant and appropriate if excavation or dredging occurs within Kendrick Bay.
Alaska Department of Natural Resources Land Use Planning (AS 38.04.065, 11 AAC 55)	Alaska Department of Natural Resources adopted a revision to the Prince of Wales Area Plan in 1998, which provides guidelines for managing State-owned uplands, submerged lands and tidelands in the planning area.		X		State lands within Kendrick Bay are covered by Management Unit 15 of the Prince of Wales Island Area Plan (ADNR, 1998). The plan does not apply to federal lands. The plan provides guidelines for management of state-owned lands in the planning area.
National Historic Preservation Act (32 CFR Part 229, 40 CFR § 6.301(b), 36 CFR Part 800)	Requires federal agencies to take into account the effect of federal undertakings on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historical Places.	X			Only applicable if Site features are eligible for inclusion in the National Register.
Alaska Historic Preservation Requirements (AS 41.35 and 11 AAC 16)	Provides for the protection of historic places on State lands, including tidelands and submerged lands.	X			Not applicable to federal lands at the Site. Would apply only to collection of historic, prehistoric or archaeological resources of the State, if any occur at the Site.

Table 4-1. List of Potential Federal and State ARARS and Guidance To Be Considered (Continued)

Regulation	Description	Potential ARAR		To Be Considered	Rationale
		Potentially Applicable	Potentially Relevant and Appropriate		
Endangered Species Act (16 USC 1531-1544; 50 CFR Parts, 17, 222 and 402)	Provides for protection and conservation of listed threatened and endangered species and designated critical habitat.	N/A			The ESA would be applicable if the removal action would affect listed species or designated critical habitat. Listed threatened or endangered species were not identified as being present at the Site on species lists provided by the U.S. Fish and Wildlife Service, the National Marine Fisheries Service and Alaska Department of Game and Fish. Listed species were not observed at the Site during the 2009 Site investigation. Consequently the ESA is likely not an ARAR.
Bald Eagle and Golden Eagle Protection Act (16 USC 668 et seq.)	Establishes federal requirements for protection of bald and golden eagles.	X			Potentially applicable because areas of the Site are bald eagle habitat.
Migratory Bird Treaty Act (16 USC 703-712)	Governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests.	X			Potentially applicable ARAR as some species observed at the Site are on the migratory bird list.
Magnuson-Stevens Fishery Conservation and Management Act (50 CFR Part 600	Requires federal agencies to consider the effect of federal actions on designated Essential Fish Habitat (EFH). Fishery Management Plans provide guidance for potential conservation recommendations to protect designated EFH.			X	The National Marine Fisheries Service (NMFS) has designated Kendrick Bay as EFH for salmon species. If the removal action is determined to adversely affect EFH, then conservation measures to protect the EFH would be considered, consistent with the existing Fishery Management Plan for the Salmon Fisheries and guidance for addressing impacts to EFH from non-fishing activities. The EFH conservation recommendations are advisory, non-binding, and may include measures to avoid or minimize adverse effects to EFH.

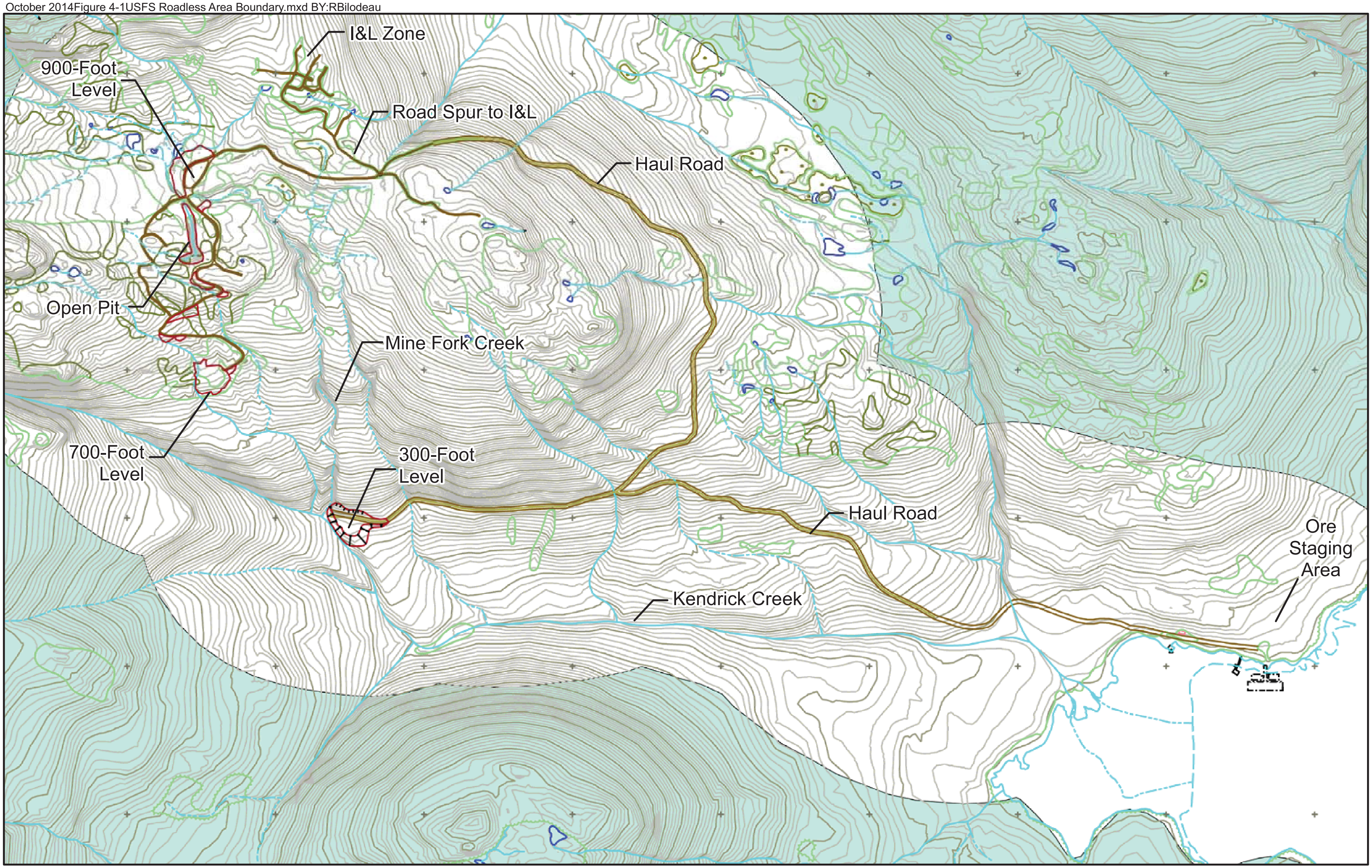
Table 4-1. List of Potential Federal and State ARARS and Guidance To Be Considered (Continued)

Regulation	Description	Potential ARAR		To Be Considered	Rationale
		Potentially Applicable	Potentially Relevant and Appropriate		
Management of National Forest System Lands (36 USC § 1604) and Tongass National Forest Land and Resource Management Plan (2008) (LRMP)	National Forest System lands are to be managed in accordance with land management plans. The Tongass LRMP provides management direction, including prescriptions, standards and guidelines, for managing lands and resources within the Tongass National Forest. Kendrick Bay area is designated for timber production and mineral extraction.	X			Is applicable to the Site as it is located entirely within the Tongass National Forest.
Action-Specific					
Standards Applicable to Generators of Hazardous Waste (40 CFR Part 262)	Regulations establish standards for generators of hazardous waste and generators who transport or offer for transport a hazardous waste for off-site treatment, storage, or disposal.	X			Regulations apply to miscellaneous solid waste debris present at the Site intended for off-site disposal to the extent the debris is classified as hazardous waste.
Standards Applicable to Transporters of Hazardous Waste (40 CFR Part 263)	Establishes standards for off-site transport of hazardous waste.	X			Regulations apply to the off-site transport of miscellaneous solid waste debris present at the Site to the extent the debris is classified as hazardous waste.
Hazardous Materials Transportation Act (49 CFR Parts 107, 171-180, 383, 391-397)	Governs the transport of hazardous materials, including labeling, marking, placarding, using proper containers, and reporting discharges.	X			Requirements apply to the off-site transport of miscellaneous solid waste debris present at the Site to the extent the debris is classified as hazardous waste.
Land Disposal Restrictions (40 CFR Part 268)	Identifies certain hazardous wastes that are restricted from land disposal and provides standards for treatment of hazardous waste prior to land disposal.	X			Regulations potentially apply to off-site disposal of miscellaneous solid waste debris present at the Site to the extent the debris is classified as hazardous waste.
Standards for Management of Universal Wastes (40 CFR Part 273)	Provides requirements for the management, regeneration, reclamation or disposal of used batteries.	X			Batteries present at the Site will be managed and disposed at an off-site facility.

Table 4-1. List of Potential Federal and State ARARS and Guidance To Be Considered (Continued)

Regulation	Description	Potential ARAR		To Be Considered	Rationale
		Potentially Applicable	Potentially Relevant and Appropriate		
CERCLA "Off-Site Rule" (40 CFR Part 300.440)	Establishes procedures for planning and implementing actions involving the off-site transfer of any hazardous substance pursuant to a CERCLA cleanup.	X			Regulations apply to the off-site transport and disposal of miscellaneous solid waste debris present at the Site to the extent the debris is classified as hazardous waste.
Alaska Solid Waste Regulations (18 AAC 60)	Regulations set forth standards for the transport, storage and disposal of solid wastes, including siting, construction, operational and monitoring requirements.	X			Sets standards governing management of solid waste. However, under 18 AAC 60.005(c), waste rock from mining operations is exempt from the requirements of these regulations unless mixed with nonexempt waste, there is a public health, safety or welfare threat or environmental problem associated with management of the waste, or the waste is managed in a manner that causes or contributes to a nuisance.
Alaska Pollutant Discharge Elimination System (APDES) Program (18 AAC 83)	Establishes permitting program and standards for the discharge of pollutants from a point source to waters of the U.S. within the State of Alaska, including storm water discharges.		X		Permit requirements are not applicable to removal actions under CERCLA. Provisions governing discharge conditions may be relevant and appropriate if there are on-Site point source discharges of pollutants, including any applicable storm water discharges.
Alaska Air Quality Control Regulations (18 AAC 50)	The regulation states that "A person who causes or permits bulk materials to be handled, transported, or stored, or who engages in an industrial activity or construction project shall take reasonable precautions to prevent particulate matter from being emitted into the ambient air."	X			This is a potentially applicable ARAR to handling and transporting bulk materials at the Site.
Invasive Species (Executive Order 13112)	Prohibits federal agencies from taking actions that are likely to cause the introduction or spread of invasive species.			X	A potential exists for the introduction of nonnative invasive species.

October 2014Figure 4-1USFS Roadless Area Boundary.mxd BY:RBilodeau



April 2015

USFS Prince of Wales Roadless Areas

Feet

0 1,000

NORTH

WORTHINGTON
MILLER
ENVIRONMENTAL, LLC.

Figure 4-1

USFS Roadless Area Boundary at the Site

Ross-Adams Site

5.0 Removal Action Technology Screening and Alternative Development

This section documents the process of identifying removal, containment, or treatment activities that are potentially applicable to the Ross-Adams Mine Site. Potentially applicable technologies are identified based on available site characterization data and known physical site conditions. Each technology is evaluated and either retained for further consideration or screened out, based on its ability to effectively address the Site. The technologies that are retained for further consideration are then assembled into removal action alternatives to address the Site-specific RAOs.

The following sections present the results of the technology identification and screening process, as summarized in Table 5-1.

5.1 Technology Identification and Screening

5.1.1 No Action

According to EPA Guidance (EPA, 1993a), evaluation of the no action scenario is included in the EE/CA as a baseline condition against which other removal actions are compared.

5.1.2 Monitored Natural Attenuation

EPA uses the term “monitored natural attenuation” (MNA) when referring to the reliance on natural attenuation processes to achieve site-specific RAOs within a timeframe that is reasonable compared to more active technologies. MNA includes continued monitoring of naturally-occurring processes that decrease the mass, toxicity, mobility, volume, or concentration of contaminants in soil, groundwater and surface water systems. Natural attenuation is commonly used for remediation of contaminated sites. Natural attenuation is potentially applicable to stream sediment and surface water at the Site, where baseline characterization has been performed, and active removal of the materials would result in additional environmental impacts. Natural attenuation is not applicable at mine-affected areas because it would not achieve RAOs in a reasonable time frame.

Assisted natural attenuation is a method to enhance natural recovery through the use of organic amendments or plantings (phytoremediation). Assisted natural attenuation is commonly used at petroleum affected sites, and other remedial areas where natural attenuation would be effective. Assisted natural attenuation is not expected to be any more effective at the Site than natural attenuation alone.

5.1.3 Institutional and Access Controls

Land Use Restrictions

Land use restrictions may include modifying current conditions of the property or land, or changes in the USFS management plan to limit certain types of land uses at the Site. These restrictions would control current and future land use to mitigate risk and/or prevent potential exposure, and ensure removal action performance. Land use restrictions may be a standalone measure, or may supplement other actions taken as part of an overall Site remedy.

Signage and Education

Signage and education may include signs at the boundaries of mine feature areas to educate recreational users, future miners, or other site visitors about the Site conditions, and to discourage accidental encounters with mine-affected areas of the Site. Education as to the nature of the risks involved in occupying restricted areas could be included on the signage. Signage and education are retained for further consideration because they are a reliable method of controlling radiological exposure resulting from accidental direct human access to mine-affected areas at the Site. This may be a stand-alone measure, or may supplement other actions taken as part of an overall Site remedy.

Fencing and Other Barriers

Fencing and other barriers prevent access for recreational users, future miners, or other site visitors to mine features at the Site. At this Site, fencing is not a viable means of preventing wildlife access. However, this may include large boulders or other heavy barriers placed at human access points to prevent motor vehicles and ATVs from accessing a particular area. Physical access restrictions are retained for further consideration because they are a reliable method of controlling radiological exposure resulting from accidental human access to mine-affected areas at the Site. This may be a standalone measure, or may supplement other actions taken as part of an overall Site remedy.

Removal of Infrastructure

Removal of infrastructure reduces access for recreational users, future miners, or other site visitors to mine-affected areas of the Site. This would include removal of the mine road between the 700-Foot and 900-Foot Levels, removal of the haul roads from the OSA to the 300-Foot and 900-Foot Levels, removal of the I&L Spur Road, and/or removal of existing docks. Removal of infrastructure is retained for further consideration because it is a reliable method of controlling radiological exposure resulting from accidental human access to mine-affected areas at the Site. This may be a standalone measure, or may supplement other actions taken as part of an overall Site remedy.

5.1.4 Surface Controls/In-Place Stabilization

Grading

Grading is used to alter the ground surface contour of an area such that surface water run-on and runoff is directed along desired routes. Site plans are developed to establish an overall grading design to optimize surface water conveyance around and away from mine-affected areas of the Site. Grading is retained for further consideration, as it is necessary to restore excavated areas, to construct a cover over mine materials, and to alter the ground surface to minimize surface area exposure and erosion, all of which minimize radiological and chemical exposure pathways for human and ecological receptors.

Stormwater/Overland Flow Run-on and Runoff Controls

Stormwater controls can be in the form of diversion structures (e.g., berms, ditches, and channels), detention ponds, water control bars, and conveyance structures (e.g., culverts, pipes, lined and unlined swales). Stormwater controls are typically implemented to direct surface water, to control runoff and run-on, and to control sediment transport during large precipitation events. Due to the large amount of annual precipitation at the Site, both temporary and permanent stormwater control features are likely to be necessary. Temporary stormwater controls will potentially be necessary during the removal action.

Permanent stormwater controls in the form of diversion structures may be necessary around the Open Pit and 900-Foot Level portal, in order to direct overland flow away from the pit and portal. Stormwater could potentially be directed toward well-defined drainages at the Site. Diversion structures may include construction of new features or modification of existing features, including ditches, channels, and berms to direct or divert surface water flow down slope and away from mine-affected areas. A diversion structure is considered applicable up-gradient of the Open Pit and waste rock dumps to avoid run-on to these features in removal action alternatives where these features remain on Site. A conveyance structure is considered potentially applicable to control drainage from the 300-Foot Level portal and direct it toward Kendrick Creek. These structures may require periodic maintenance.

Surface Stabilization

Surface stabilization includes measures that provide erosion control of mine-affected areas such as waste rock dumps and the OSA. Stabilization measures include revegetation, stabilization with synthetic materials or rock armor. Surface stabilization is not necessary to prevent leaching of metal or radionuclide constituents to surface water, but is necessary to prevent future erosion in areas that will be regraded at the Site.

Revegetation following grading or placement of clean fill or soil covers will mitigate erosion due to water and wind, will reduce surface water infiltration and runoff, and will provide mechanical stabilization of materials through root embedment. For this Site, revegetation includes topsoil replacement and planting native ground cover. Revegetation would include use of native seed mixtures, and would follow guidance provided in the Revegetation Manual for Alaska (ADNR 2008). Revegetation is retained for further consideration.

Surface stabilization through use of synthetic materials at the Site is not applicable due to the stable nature of the existing mine rock piles and road embankments.

Surface stabilization with rock armor could be performed in conjunction with other technologies such as cover in place, or consolidation and cover. Stabilization with rock armor could be performed in areas that are not amenable to revegetation (i.e., at the 900-Foot Level).

5.1.5 Portal Controls

Portal Hydraulic Controls

Hydraulic controls at the portals are mechanisms that eliminate or control inflow into the mine portals and/or outflow from the mine portals. Hydraulic controls could include diversion structures (berm, water bar, or ditch), a partial dam, a porous plug, a bulkhead, or piping water to Kendrick Creek or the West Arm of Kendrick Bay. Portal hydraulic controls are potentially applicable in conjunction with other technologies. Portal hydraulic controls would not eliminate direct exposure to radon, but would control water flow to minimize exposure pathways to the discharge water. Portal hydraulic controls are potentially applicable in some instances, and may be used in conjunction with other technologies. Portal hydraulic controls are retained for further consideration.

Piping the drainage from the 300-Foot Level portal to the West Arm of Kendrick Bay would require a buried pipe that would parallel either the haul road or Kendrick Creek. Piping the outflow to Kendrick Bay is not implementable without significant site disturbance to previously undisturbed areas. It would also involve difficult construction, and crossing of several mapped landslides. Therefore, piping portal outflow water to the West Arm of Kendrick Bay is not retained for further consideration.

Portal Closure

Closure of the portals would prevent physical access, minimize radon emanation and could also prevent water inflow and outflow. Closure could include filling, plugging or capping the mine portals, and could be performed with nonacid-forming, free-draining materials, polyurethane foam or reinforced concrete. Portal closure would prevent wildlife from entering the portals. Portal closure is potentially applicable at portal locations that do not discharge water. Closure is not applicable at portals that discharge water due to the uncertainty regarding development of pressure head behind the barrier and potential redirection of blocked water and possible seepage through unidentified fractures in an unknown manner. Closure of portals that do not discharge water is retained for further consideration.

Portal Barriers

Portal barriers are physical access restrictions placed at portals to prevent access for recreational users, future exploration workers, or other site visitors to the underground mine workings. This may include large boulders, bat gates, or other heavy barriers placed at the portals. The barriers would prevent human and most wildlife access, but would allow bats to access the underground mine workings. The barriers would not eliminate or minimize water outflow from portals, and may not reduce or eliminate radon emanation from portals. Portal barriers may be used in conjunction with other technologies. Physical barriers to portals are retained for further consideration because they are a reliable method of controlling human access to the underground mine workings.

5.1.6 In-Place Containment/Stabilization

Covers

Covers can be used to contain mine rock and adjacent mine-affected soil, eliminate or reduce radon and gamma radiation emanation, eliminate exposure pathways to human and ecological receptors, eliminate infiltration, and provide a media for revegetation. For in-place containment, a cover would be placed on localized mine-affected areas, such as the mine rock piles, road embankments, and the OSA. In-place containment with a cover contains the mine-affected materials and eliminates exposure pathways without the need for excavation and transportation of the mine-affected materials to an on-Site repository. Covering an on-Site repository of consolidated mine rock materials reduces the footprint of the mine rock materials, and isolates the mine rock from the environment. Covers can vary in complexity from an earthen material to a multi-layered system consisting of natural and synthetic components. At the surface, covers can be revegetated or armored with a rock facing. Factors to consider in the design of a cover include the physical properties of the materials, topography, geotechnical and erosional stability, leachability, site hydrogeology, and precipitation.

Covers are limited to those that can be feasibly constructed given the Site conditions and the remoteness of the Site. At this Site, covers can include either all natural materials or a combination of natural and synthetic materials. Earthen materials suitable for cover at the Site are limited in quantity. Potential borrow sources for cover material include the mine road, haul roads, and the Kendrick Creek delta. Potential borrow sources for rock armor exist at the basalt outcrop east of the OSA and screened material in the Kendrick Creek delta. Additional off-site sources of cover also exist, but would necessitate haulage to the Site via barge. A barrier layer, such as a synthetic geomembrane, can be used as a component of a cover system, and is typically used to reduce infiltration into the materials underlying the cover. A barrier layer can also be used to reduce radon emanation, but it provides no gamma radiation shielding from mine rock. In-place containment with a cover is considered a feasible option and is retained for further consideration.

Capping of Sediments
Like covers for mine rock areas, capping of sediments would reduce or eliminate the exposure pathways. With the constant exposure to water movement, large cobble or boulder size material would be necessary to be an effective cover for sediments. While capping of sediments is a potentially applicable technology, sediment does not pose an unacceptable risk at the Site as described in Section 3; therefore, a removal action for sediments is not warranted.

5.1.7 On-Site Consolidation

On-Site consolidation involves grouping similar types of mine-affected materials in a common area for subsequent containment or management. On-Site consolidation could include excavation of mine-affected materials and placement in an on-Site repository within and surrounding the Open Pit. Repositories are typically capped with an engineered cover system, and may be revegetated or armored with rock. Consolidation in an on-Site repository and subsequent covering will minimize the overall footprint of mine-affected areas, eliminate or reduce radon emanation, and eliminate exposure pathways to human and ecological receptors. Consolidation in an on-Site repository involves excavation to physically remove mine-affected materials, and transportation to the repository. On-Site consolidation is potentially applicable in conjunction with other technologies and is retained for further consideration.

5.1.8 Off-site Removal

Off-site removal is a potentially applicable technology for the miscellaneous solid wastes (debris, metal drums, vehicles, etc.). While possible, off-site removal for the mine rock and mine affected areas of the Site is considered infeasible and presents a variety of transportation exposure risks. Due to the remote location of the Site, and the radiological characteristics of the mine-affected materials, off-site removal would be a multi-segmented process. Off-site removal would involve excavation and segregation of mine-affected materials, hauling to a constructed on-site dock, loading of materials into specialized containers for barge transport, barge transport to Ketchikan, re-handling the containers for barge transport to a port city in Washington, loading the containers onto a train, shipment via rail to a spur nearest the disposal facility, transportation by truck to the disposal facility, and unloading and placement of material at an approved and permitted disposal facility.

Off-site removal would require segregation of the material by activity level prior to leaving the Site. For off-site disposal, mine rock with uranium concentrations greater than 500 mg/kg would potentially be classified as source material and have more restrictive disposal requirements. The volume of mine rock at the Site with uranium concentrations greater than 500 mg/kg has been estimated as described below based upon sampling results presented in the SCR.

Sample results indicate that the 900-Foot Level and 700-Foot Level mine rock piles have uranium concentrations greater than 500 mg/kg. Portions of the 300-Foot Level mine rock pile and the OSA would also likely be classified as source material based on uranium concentrations. Uranium concentrations at the 300-Foot Level mine rock pile are predominantly less than 500 mg/kg; therefore, it is assumed that 10% of the mine rock pile, excluding adit development rock, would have uranium concentrations greater than 500 mg/kg. Only the central portion of the OSA has material with uranium concentrations greater than 500 mg/kg. Based on gamma survey and limited sample results, it is assumed that all of the 700-Foot Level mine road embankments have uranium concentrations greater than 500 mg/kg. In addition, it is estimated that 30% of material within the identified haul road segments and all the I&L Spur road would have uranium concentrations greater than 500 mg/kg. Of the total quantity of mine rock material at the Site, it is estimated that approximately 28,550 cubic yards (CY) of the mine rock would be classified as source material for disposal purposes, with the remaining 33,950 CY being classified as non-source material.

For off-site removal, equipment and materials would be mobilized to the Site by barge and temporary living facilities for Site workers would be developed. Dock facilities would have to be constructed in the West Arm of Kendrick Bay near the OSA to support material handling and barge traffic. Improvements to the existing haul roads would be required for transport of mine rock from the 900-Foot, 700-Foot and 300-Foot levels to the OSA. Mine rock would be excavated by its classification (source material or non-source material) and hauled to the OSA for loading into specially prepared 20-ton containers for barge transport. The on-Site cost, including mobilization, dock construction, site preparation, haul road improvements, stormwater, erosion, and dust controls, excavation and hauling of mine rock, restoration of disturbed areas, and demobilization is estimated to be approximately $5 million.

Off-site transport would include transport of the 20-ton containers by barge to Ketchikan, unloading/loading the containers onto a barge/cargo vessel for transport to Seattle or Tacoma, unloading/loading the containers for rail transport to a spur nearest the disposal facility, and then truck transport of the containers to the disposal facility. Coordination and management of material transport represents a technical and administrative challenge due to the radioactive properties of the material. Both U.S. and Canadian manifests would be required to transport the material to Seattle by barge/cargo vessel. Approximately 4,220 containers would be required to transport the mine rock. The total cost for off-site transport, including loading the mine rock and transport from the Site to the disposal facility is estimated to range from $26 million to $31 million, depending on the facility location. Loading and transport of the containers from the Site would likely be limited to the dry season. Assuming 25 containers could be loaded onto a barge and transported each week to Ketchikan, approximately 400 containers could be transported each construction season, which would require approximately ten years to complete off-site removal of the mine rock materials.

A limited number of facilities exist in the U.S. that are currently permitted to accept radioactive materials for disposal. Only the Hanford facility in Washington and the US Ecology facility in Grandview, Idaho are currently permitted to accept radioactive wastes consistent with the characteristics of the mine-affected material. The lower-level radioactive materials (uranium concentrations less than 500 mg/Kg) could likely be disposed at the US Ecology facility in Idaho. However, the higher activity level material would need to be transported to a different facility. The Hanford facility in Washington is the only facility in the U.S. that could potentially accept the higher activity level material. However, the Hanford facility is not currently permitted to accept large quantities of material, such as the volumes of the mine rock. Disposal at the Hanford facility would likely necessitate a permit revision to allow disposal of the mine rock. In addition, disposal at Hanford would require that the material be disposed in the original shipping containers without voids.

Permitting of a new disposal facility is uncertain and would require significant time and cost. Alternatively, the mine rock classified as source material could be transported to a uranium mill for uranium recovery, with permanent custodial management of mill tailings at the facility. Currently, the White Mesa Uranium Mill near Blanding, Utah, is the only conventional uranium mill operating in the U.S. It is not certain if the White Mesa facility would accept the mine rock for processing and uranium recovery.

The estimated fee for disposal of the mine rock not classified as source material at the US Ecology Idaho facility is $10 per cubic foot (CF), resulting in a disposal cost of $9.2 million for 33,950 CY. If disposal at Hanford would be possible, the current fees are approximately $100 per CF, resulting in a disposal cost of $77 million for the 28,550 CY. Therefore, the estimated disposal cost for the mine rock is approximately $86.2 million. Alternatively, if the White Mesa Mill would accept the 28,550 CY of source material for uranium recovery, the estimated processing fee is $150 per ton, resulting in a processing cost of approximately $5.8 million. Therefore, the cost for uranium recovery of the estimated quantity of source materials and disposal of the non-source material would be approximately $15 million.

The total estimated cost of off-site disposal, including on-Site and off-site transportation costs and a 20% contingency, is approximately $134 million. The total estimated cost for off-site removal with uranium recovery and disposal, including on-Site and off-site transportation costs and a 20% contingency, is estimated to be $54 million.

Off-site removal of the mine-affected materials for off-site disposal or off-site processing is not a viable technology compared to on-site management due to the uncertainties associated with permitting, multi-segmented transportation through international waters and across international boundaries, and whether the limited number of disposal or processing facilities could accept the materials. Short-term risks for the general public and environment during off-site material transport would be significant compared to other removal action technologies. In addition, the cost and timeframe required for off-site removal would be significantly greater than on-site management of the materials. The cost of excavation, transportation, and off-site disposal is extreme compared with other removal technologies. On-site management of the materials is consistent with the naturally occurring radioactive materials that exist at the Site, and involves less risk than transporting them to a location where naturally occurring radioactive materials do not exist.

5.1.9 Dredging of Sediments

Dredging is a method of underwater excavation of materials from the bottom of lakes, rivers, streams, harbors, and bays. It is potentially applicable to marine sediments at the Site. Subtidal sediment does not pose an unacceptable risk at the Site as described in Section 3; therefore, a removal action for marine sediments is not warranted.

5.1.10 Treatment

Physical/Chemical Treatment of Solids

Physical and/or chemical treatment of solids involves treatment to stabilize, decrease toxicity and/or mobility, and/or decrease leaching potential of solid materials. Treatment can include in-situ and ex-situ methods, and could be performed in place at the current location, or in-place at an on-site repository. Physical or chemical treatment could include physical mixing, chemical stabilization, chemical solidification, or rock washing. Treatment to stabilize the solids or decrease mobility of the solids is not necessary, as they are stable in their current configuration. Furthermore, the effectiveness of any treatment to decrease toxicity is highly uncertain with the radiological characteristics of the mine rock. The mine rock is not readily leached by water, and therefore treatment to reduce the leaching potential is not applicable. Rock washing is an ex-situ remediation technique to reduce metal concentrations that involves mechanical and/or chemical scrubbing to remove constituents through particle size separation. Rock washing is most effective when the material can be selectively separated based on its size or specific gravity, which is not applicable to the material at the Site. Physical and chemical treatment of solids is not applicable at this Site and is not retained for further consideration.

Biological/Passive Treatment of Water

Biological or passive treatment of water involves elimination of exposure pathways to the environment by passive water treatment. Treatment could involve buried permeable reactive barriers or surface wetlands to treat contaminated water. The potential effectiveness of passive water treatment is highly uncertain at this Site due to the site-specific water chemistry, site topography and lack of surficial soils, and total land available. This technology is not applicable to the Site and is not retained for further consideration.

Chemical Treatment of Water

Chemical treatment of water includes active water treatment with ex-situ chemical methods. Active water treatment at this remote Site is not applicable due to the long-term maintenance requirements and the significant operation requirements. This technology is not applicable and is not retained for further consideration.

5.1.11 Mining

On-site mineral processing could potentially represent a technology that would recover uranium from the existing mine rock and mine-affected materials. Given the relatively small tonnage of the mine rock and mine-affected materials, the substantial capital costs of building a new mill and current expected return for the uranium that could be recovered from the mine rock, on-site processing would not be economically viable at this time.

Future mining at the Site could also represent an applicable technology by incorporating Site cleanup requirements for the existing and future mine-affected materials in the mine plan. The Site is within an area designated by USFS as having high mineral potential and to be managed for mineral exploration and development. Mineral exploration is currently ongoing nearby. However, it is not possible for the Companies to develop a removal action alternative based on mining of the Ross-Adams Site, as the mineral claims are controlled by others and future mine plans have not been defined. Furthermore, the USFS, as the land manager, does not have the authority to require that claim holders mine specific claims or incorporate a removal action for the Site into their mine plans. The potential for future mining could provide the basis for an interim removal action that would clean up those Site features located outside of the expected future mine areas and implement institutional and/or access controls for remaining Site features to reduce human health risks due to exposure from gamma radiation and radon from mine rock and mine openings until mining occurs. This would reduce Site risks identified in the HHRA and SLERA, would be compatible with potential future mining activities consistent with the USFS land use plan, and would avoid potential "un-doing" of cleanup actions and unnecessary re-handling of materials that may be associated with future mining. At this time, future mining does not represent a viable removal action alternative given that a targeted economic mineral reserve has not been identified, a future mine plan has not been developed and an operator that would develop and implement any future mine plan has not been identified.

Table 5-1. Removal Action Technologies Screening Table

General Response Actions	Response Action Technology	Process Options	Description/Purpose	Screening Comment	Areas Technology Potentially Applicable							
					MRD	OSA	Stream Sediment	Roads	Surface Water	Portals	Docks / Ramps	Misc. Waste
No Action	Not applicable		No action	Potentially applicable to the entire Site or to specific areas within the Site.	X	X	X	X	X	X	X	X
Monitored Natural Attenuation	Not applicable	• Continued monitoring	Continued monitoring of natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods.	Potentially applicable to specific areas at the Site; would require ongoing monitoring.			X		X			
Institutional and Access Controls	Land Use Restrictions	• Changes in USFS management plan • Permitting • Specific use restrictions	Implement restrictions to control current and future land use to mitigate risk and/or prevent potential exposure, and to ensure removal action performance.	Potentially applicable and implementable in conjunction with other technologies or with a No Action decision. Would require periodic but on-going maintenance.	X	X	X	X	X	X	X	X
	Signage and Education	• Warning signs • Education of nearby users (i.e. timber or mining lessees)	Warning and educational signage at boundaries of mine affected areas to educate visitors and discourage human access.	Potentially applicable in conjunction with other technologies. Would require periodic but on-going maintenance.	X	X	X	X	X	X	X	X
	Fencing and Other Barriers	• Boulders • Timbers • Fencing • Jersey barriers • Bat gate	Install fencing or barriers to prevent or minimize intentional and accidental access to Site areas by humans and/or animals.	Potentially applicable in conjunction with other technologies. Would require periodic but on-going maintenance.	X	X	X	X	X	X	X	X
	Removal of Infrastructure	• Access roads • Loading docks	Remove infrastructure at the Site that provides access and thus serves as an "attractive" nuisance to the Site and to specific areas of the Site.	Potentially applicable in conjunction with other technologies or with a No Action decision.				X			X	
Surface Controls/In-Place Stabilization	Grading		Alter ground surface to control surface water runoff, run-on, and minimize surface area.	Necessary with certain other technologies.	X	X		X				X
	Stormwater/Overland Flow Run-on and Runoff Controls	• Diversion structures • Detention ponds • Conveyance structures (lined and unlined)	Constructed systems that eliminate or control stormwater and overland flow run-on and runoff to prevent or mitigate surface erosion, and infiltration, and to ensure landform stability.	Diversion structures (berms, water control bars, ditches, etc., to control water around Open Pit and all waste areas, and to control portal discharges to minimize exposure pathways. Potentially applicable in conjunction with other technologies. May require periodic maintenance.	X	X		X		X		X
	Surface Stabilization	• Vegetation • Rock armor • Synthetic materials	Measures that provide erosion control of mine affected areas. Plant vegetation or construct synthetic materials or rock armor to stabilize mine affected areas and reduce erosion.	Potentially applicable in conjunction with other technologies. Necessary in areas that will be regraded. Not applicable by itself due to stable nature of surficial materials.	X	X		X				X
Adit Controls	Adit Hydraulic Controls	• Diversion structures at portals • Bulkhead/barrier • Porous plug • Partial dam • Infiltration galleries • Piping water to bay • Piping water to Kendrick Creek	Reduce or eliminate inflow into mine portals, and prevent or direct outflow from mine portals to minimize exposure pathways to mine water.	Potentially applicable in conjunction with other technologies. Would not limit direct exposure to radon. Would not in all cases limit access to portals for humans or animals. Piping outflow water to Kendrick Bay not implementable without significant site disturbance. Piping outflow to Kendrick Bay would involve pipe burial; difficult construction involving landslide crossings, and/or significant site disturbance to relatively undisturbed areas, therefore piping the outflow to Kendrick Bay is not applicable.						X		
	Adit Closure	• Cap • Plug	Close adit/portal to prevent physical access, eliminate radon emissions, and eliminate water discharge and inflow.	Potentially applicable at locations without water discharge. Reduces exposure to radon in air and prevents access into mine portals. Not applicable at portals that discharge water due to the uncertainty regarding development of pressure head behind plug and potential seepage of water through unknown fractures in an uncontrolled manner.						X		

Table 5-1. Removal Action Technologies Screening Table (Continued)

General Response Actions	Response Action Technology	Process Options	Description/Purpose	Screening Comment	Areas Technology Potentially Applicable							
					MRD	OSA	Stream Sediment	Roads	Surface Water	Portals	Docks / Ramps	Misc. Waste
Adit Controls (continued)	Adit Barriers	• Gate • Jersey barrier	A barrier at the portal opening.	Potentially applicable in conjunction with other technologies. Prevents physical access by humans to portals. Allow access for bats and small animals. Would not prevent water discharge or inflow.						X		
In-Place Containment/ Stabilization	Covers	• Earthen covers • Multi-layered cover system (natural and synthetic elements)	Containment of mine affected areas by covering with earthen material or multi-layer cover system.	Limits direct exposure to gamma radiation and radon by isolation of affected areas from environment. Readily implementable, and would not require as much land disturbance as consolidation and cover, but would likely require importation and transportation of off-site cover materials. Many surface controls will apply during cover construction.	X	X		X				
On-Site Consolidation	Excavation and Placement within an on-site repository	• With cover • Without cover • Backfill existing mine workings	Excavation of mine affected areas and consolidation into an on-site repository in either an existing disturbed area, in a new undisturbed area, or placement in the existing mine workings.	Potentially applicable in conjunction with other technologies. In conjunction with cover, limits direct exposure to gamma radiation and radon. Would require transportation of mine affected materials to on-site repository and importation and transportation of off-site cover materials. Many surface controls will apply during construction. Placement of materials in existing mine workings would require an unknown degree of rehabilitation and stabilization of mine portals and tunnels to provide equipment access and a safe working environment. This technology results in an uncertain effect on water quality. Backfilling of existing mine workings is not applicable at the Site due to the uncertainties involved with the technology.	X	X	X	X			X	X
Off-Site Removal	Excavation and placement within an approved and permitted disposal facility	• Off-Site	Excavate affected materials and removal to an approved and permitted disposal or processing facility.	Not applicable to mine rock or mine affected materials (other than misc. debris and waste) due to 1) the nature of material and the limited number of facilities that are permitted to accept radioactive material, 2) multi-segmented transportation via barge, truck and train, un-necessary exposure to members of the general public during transportation, 3) uncertainties related to permits, timeframe, and travel through international waters, 4) significant cost of disposal and transportation.								X
Treatment	Physical/Chemical Treatment of Solids	• Physical mixing • Chemical stabilization • Chemical solidification • Soil/rock washing	Physical or chemical treatment to stabilize; decrease toxicity and/or mobility, as well as leaching potential of solid materials. Can include in-situ or ex-situ methods. Can be performed in-place at the current location, or in-place at a new consolidated repository.	Potential effectiveness highly uncertain with mine affected materials and radioactive constituents at Site. Soil washing or sieving is most effective when the material can be selectively separated based on its size or specific gravity, which is not applicable to the material at the Site. The radioactive constituents in the mine affected material at the Site are not readily leached. This type of technology is not applicable to the Site.								
	Biological / Passive Treatment of Water	• Wetland • Permeable reactive barrier	Passive treatment through design buried PRBs or surface wetlands.	Potential effectiveness is highly uncertainty due to site-specific water chemistry, site topography and soils, and total land available. This technology is not applicable to the Site.								
	Chemical Treatment of Water	• Active water treatment	Chemical treatment of water. Includes ex-situ methods.	Significant operation and maintenance requirements. Not reasonably implemented at this remote Site.								
Mining	Future Mining	• Surface or subsurface mining operations	Relates to any future surface or subsurface mining activity at the Site.	Future mining operations at the Site would need to address all existing and future mine affected areas including waste rock dumps, the ore stockpile area, roads, sediments, portals, miscellaneous waste, and docks and ramps, as identified in this EE/CA. This technology must comply with the RAOs for the Site. Mining is not an applicable removal action option at the Site without an identified mining proponent and mining plan.								

6.0 Alternative Development

Based on characterization of Site conditions described in Section 2.0, the results of the risk assessments summarized in Section 3.0 and the RAOs developed in Section 4.0, this section identifies and assesses removal action alternatives. The removal action alternatives have been divided between those related to mine rock and those related to the mine portals to allow flexibility in analyzing and selecting a recommended removal action alternative for the different mine features.

The alternatives identified and analyzed in the following subsections are considered proven remedies because they have been selected in the past at similar sites and/or for similar conditions and constituents. Remedial technologies were screened and assembled into the removal action alternatives listed below. These alternatives will be described in detail in this section.

Mine Rock Alternatives

- Alternative M-1 – No Action Alternative
- Alternative M-2 – In Place Stabilization with Stormwater and Institutional Controls
- Alternative M-3 – Cover in Place
- Alternative M-4 – Excavation, Consolidation and Cover at Mine Affected Areas
- Alternative M-5 – Excavation, Consolidation in Open Pit Repository at 900-Foot Level

Portal Alternatives

- Alternative P-1 – No Action Alternative
- Alternative P-2 – Close Upper Mine Workings and 300-Foot Level Portal Gate
- Alternative P-3 – Close Upper Mine Workings and 300-Foot Level Portal Rock Backfill
- Alternative P-4 – Close Upper Mine Workings and 300-Foot Level Portal Concrete Bulkhead

Radiological hazards present at the Site unrelated to historic mining activities, such as the naturally-occurring radioactivity of the Site soils and bedrock, as well as the natural radioactivity of Bokan Mountain above the elevation of 350 feet are outside the scope of this EE/CA.

The removal action alternatives developed for consideration are summarized in Tables 6-1a and 6-1b and are described in the following Sections.

6.1 Mine Rock Alternatives

6.1.1 Common Elements of the Mine Rock Alternatives

Legal and/or physical access restrictions may exist in every mine rock alternative except the no action alternative to either control access to remaining mine-affected areas or to protect the integrity of the implemented removal action. No roads currently access the Site from the remainder of POW Island, so all equipment and materials required to implement the removal action would be mobilized to the Site via tug and barge. Equipment and materials required could include earthwork construction equipment, ATVs for personnel transportation on-site, electricity and fuel to operate equipment, and temporary living facilities for work crews. Equipment and unused materials would be demobilized from the Site after completing the selected removal action.

Roads will need to be improved for equipment access for each of the alternatives other than the No Action Alternative. Road improvement is assumed to consist of regrading and widening to allow equipment access, as well as construction of turn outs along the roads to allow haul trucks to pass during the removal action. The Haul Road in the vicinity of the landslides will need to be reinforced to allow for equipment access between the OSA and 300-Foot Level.

Other significant common elements to the mine rock alternatives are 1) removal of scattered ore rock spilled on the ore loadout ramps within the intertidal zone and consolidation with other mine rock; 2) tree removal with development of access, staging areas, and construction of the removal action; 3) establishing erosion and sediment control measures and procedures during excavation activities, including collection and temporary re-routing of stormwater; 4) removal of miscellaneous on-Site debris including drums, vehicles, batteries, and metal and plastic debris; 5) cover materials will be sourced on-site from Kendrick Creek delta, or other suitable source, and rock armor, channel protection, and mine rock pile toe protection materials will be sourced on-site from either the Kendrick Creek delta or the basalt outcrop east of the OSA; 6) procedures to delineate, control and confirm excavation of mine rock and mine-affected materials; 7) re-vegetation after the removal action in areas that are currently vegetated; and 8) monitoring and maintenance (M&M) of the completed removal action.

Actions conducted at the Site would need to comply with the substantive requirements of Section 106 of the National Historic Preservation Act to mitigate potential damage to historical features at the Site, as appropriate.

Removal of Spilled Ore Rock on the Loadout Ramps in the Intertidal Zone

Miscellaneous ore rock present in the intertidal zone consists of rock spilled during loading operations in the immediate area of the ore loading ramps. The identified area for removal of spilled ore rock is defined in Figure 6-3. This material will be picked up by hand and consolidated with other mine rock. Consolidation of the ore will be at the OSA for Alternatives M-2 and M-3, at the 300-Foot Level mine rock pile for Alternative M-4, and at the Open Pit for Alternative M-5. This will be discussed further in the descriptions of the alternatives.

Removal of Vegetation

Trees will have to be cleared for all removal action alternatives to provide access and staging areas, and for construction of the removal action. The cleared trees would be left on-site and may be chipped or staged across the Site as part of an institutional control or stormwater control measure. Chipped trees will be used as vegetative amendment to cover materials that will be re-vegetated following the removal action.

Removal of Miscellaneous Site Debris

Miscellaneous debris will be removed from the Site and hauled to the appropriate disposal facility. Debris will be scanned for radiological activity prior to removal from the Site and decontaminated, as necessary. If non-hazardous debris cannot be decontaminated to achieve applicable transport requirements, the debris will be consolidated with the mine rock. All debris classified as hazardous waste will be scanned and decontaminated, as necessary, and disposed at an off-site facility licensed to accept the debris. Any hazardous debris that cannot be decontaminated will be disposed at an offsite facility licensed to accept radioactive hazardous waste, provided that applicable transport requirements can be met. The vehicles will be disposed of as scrap metal and will be transported off-island for recycling or disposal. The metal drums will be transported off-island and will be disposed of at a petroleum disposal facility. The remaining miscellaneous debris will be taken to the landfill in Ketchikan. Drill core will be consolidated with the mine rock.

Removal Action Excavation Control and Confirmation Plan

Methods for establishing the extent of mine rock and mine-affected materials are necessary for Alternatives M-3, M-4, and M-5, where mine rock and/or mine-affected materials are to be excavated. While the preliminary extent has been defined, further field verification will be necessary during removal activities to guide excavation and confirm material has been removed to the extent necessary to achieve PRGs. While the bulk of the mine rock can be distinguished using visual observation, other mine-affected materials are not readily distinguishable using visual methods alone. Other methods using gamma exposure measurements and confirmation sampling will be necessary in those areas where material is to be excavated. Senes (2013) presents the technical basis and methodology that would be necessary for visual observation and gamma exposure survey methods to define the extent and confirm excavation of mine rock and mine-affected materials. Additional sample collection and laboratory analyses would be conducted to confirm complete removal of mine-affected materials. Detailed verification and confirmation plans and procedures would be developed during removal action design.

Cover Material Sources and Analysis of Cover Thickness

Cover materials are required for Alternatives M-3, M-4, and M-5. Covering of mine-affected materials reduces risk and eliminates exposure pathways for human and ecological receptors from exposure to gamma radiation and radon. The thickness and geotechnical properties of the cover are designed to reduce external gamma radiation and radon flux from the mine rock.

Sources of Cover Material

Cover materials are required for Alternatives M-3, M-4, and M-5, including a larger diameter material for rock mulch on top of the cover. Materials are also required for erosion protection for Alternatives M-2 through M-5. Materials for mine rock pile toe protection are similar in size to rock mulch (4 inch to 6 inch diameter). Both on-site and off-site sources of the cover and protection materials exist. The following paragraphs provide a summary of a borrow investigation conducted for both on-site and off-site sources of cover material, and the benefits and drawbacks of each.

Off-site cover materials exist within the POW Island and in the regional area. Three off-site sources of cover material exist, all of which would need to be hauled to the Site via tug boat and barge. Table 6-4 summarizes the types of materials available, and the supplier of each material. The off-site borrow sources include a borrow site identified by Southeast Road Builders in Klawock, Alaska, a borrow site in Ketchikan operated by Ketchikan Ready-Mix, and a third site at the Aggregate Mine at Swamp Point on the Portland Canal operated by Ascot Resources Ltd of Vancouver B.C. Fine-grained material is preferable for construction of the cover, in order to minimize radon emanation from the underlying mine rock. The most suitable material identified by Southeast Road Builders is a sand/silt (SM or ML). Other materials identified by Southeast Road Builders include a crushed aggregate. The most suitable material contained within the borrow site operated by Ketchikan Ready Mix is a silty sand (SM). Other materials available from Ketchikan Ready Mix include a crushed aggregate or a washed sand. The Aggregate Mine operated by Ascot Resources is located between Prince Rupert B.C. and Stewart/Hyder approximately 100 miles from Kendrick Bay. The Aggregate Mine materials are generally coarse-grained, but organic soil and growth media are also available from the Ascot Resources mine.

The borrow investigation did not identify any off-site sources of a suitable fine-grained material that would justify the costs and risks associated with importing the material to the Site via barge. Numerous barge trips would be required to import cover material, increasing concerns with safe transport of material in inclement weather, offload of the materials, and staging of the materials. Importing cover materials would significantly increase the cost and the time to implement Alternatives M-3, M-4, and M-5.

Materials for construction of the cover, as well as larger diameter materials for construction of rock mulch and toe protection could be sourced on-site. The cover material could be sourced from the Kendrick Creek delta in the intertidal zone. Cobble and boulder size material necessary for construction of rock armor or erosion protection could be sourced on-site from either the Kendrick Creek delta or the basalt outcrop east of the OSA. Potential on-site borrow locations are shown in Figure 6-1. Figure 6-1 also shows the volume of material available from each borrow area. Table 6-2 presents the volumes of cover required for Alternatives M-3, M-4, and M-5 for a cover thickness of one foot for roadway areas and two feet for cover over mine rock piles and repositories. Table 6-3 presents the volumes of materials required for rock armor and erosion protection for Alternatives M-2 through M-5. As shown on Figure 6-1 and in Tables 6-2 and 6-3, the Kendrick Creek delta contains a sufficient amount of material for use as cover and protective cobble size material.

Use of on-site material is preferable for cover and erosion protection, due to the high cost of importing material, the risks associated with transportation of the materials via open barge in inclement weather, off-loading of the material, potential construction delays, as well as the fuel consumption required and greenhouse gas emissions generated during transportation of off-site material to the Site. The results of the limited borrow investigation indicate that none of the potential off-site borrow sources identified would provide material properties that would be significantly more suitable than the identified on-site borrow source. Therefore, evaluation of the removal action alternatives in this EE/CA is premised on utilizing the on-site source of borrow material for cover construction.

Kendrick Creek is a high energy creek with a low sediment load, and based on visual observations and the surrounding geomorphology, the Kendrick Creek delta is estimated to be composed of coarse material, ranging in size from fine-grained sand to boulders and cobbles, and having less than 10 percent silt and clay. Screening of the delta material to a particle size less than 2-inch will be necessary to generate cover material. A temporary screening operation will be constructed on-site to obtain the required cover material for Alternatives M-3, M-4, and M-5. Access to the borrow area of Kendrick Creek delta will be provided via a temporary access road which will be graded in prior to construction of the chosen removal action. The approximate location of this access road is shown in Figure 6-1.

Correspondence with ADNR, Division of Mining, Land, and Water indicates that the identified borrow area would require further evaluation and submittal of a proposal to develop the area as a material development site and that ADNR would need to evaluate the proposal and assess the adherence to the Prince of Wales Island Area Plan, which sets forth ADNR's land use plan for State owned land on the Island (Johnson, 2012). The process would require public review and ADNR would need to issue a final finding and decision prior to the area being developed as a borrow source. For purposes of this EE/CA, it is assumed that the Kendrick Creek delta is the borrow source, as no other feasible on-site sources were identified in the SCR. Following excavation of borrow materials in the Kendrick Creek delta, the excavated area will be regraded and the borrow area access road will be removed.

Analysis of Cover Thickness

Reduction in gamma radiation rates resulting from cover placement was calculated using MicroShield® (Grove Software 2010), and the reduction in radon emanation resulting from a two-foot thick cover was calculated using the RADON model (NRC, 1989). The analyses and results are discussed further below.

Calculation of Radon Emanation through Cover

The RADON model utilizes the one-dimensional radon diffusion equation, which uses the physical and radiological characteristics of the mine rock and overlying materials to calculate the rate of radon emanation from the mine rock through the cover. The RADON Code (NRC, 1989) was used to calculate radon flux through a cover at the OSA, 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles, as well as the mine road embankments. Cover materials will be sourced on-site from the Kendrick Creek delta in the intertidal zone. Based on visual observations and the surrounding geomorphology, the Kendrick Creek delta is estimated to be composed of coarse material, ranging in size from fine-grained sand to boulders and cobbles with less than 10 percent silt and clay. Based on the estimated material properties, the following geotechnical properties of the cover material were estimated as well, all of which are input parameters for the RADON Code:

- Porosity: 0.31
- Density/unit weight: 1.93 g/cc
- Long-term moisture content: 5.0%

For purposes of modeling the radon flux from the mine rock pile surface, the mine rock pile or mine road embankment material was conservatively assumed to be 16 feet thick, the default RADON Code value for an infinitely thick source, for all areas except the OSA. The thickness of the OSA was maintained at two feet, as described in the SCR (Tetra Tech, 2010). The emanation coefficient for the mine rock was estimated to be 0.05 (Sakoda et al., 2009). The average radium activity for each mine rock area was determined from the measured gamma exposure rate data for individual mine rock areas using the correlation established by the SCR (Tetra Tech, 2010) between the gamma exposure rates and radionuclide soil concentrations. The exit radon flux calculated for the mine rock surface and at the cover surface over the mine rock for the OSA, 300-Foot, 700-Foot, and 900-Foot Levels mine rock piles, as well as the Open Pit and mine road embankments are presented in Tables 6-5a through 6-5e. While the synthetic geomembrane will reduce radon emanation from the cover on the Open Pit repository, this reduction in radon was not included in the model calculations. Input parameters and output files from the RADON Code are presented in Appendix D.

<u>Calculation of Gamma Radiation through Cover</u>

MicroShield® (Grove Software 2010) is used to calculate exposure rates from the calculated concentrations of uranium and thorium decay products in the mine features. It is used to design shields for gamma radiation and estimate source strength from radiation measurements. The MicroShield® program was used to calculate gamma radiation rates after cover placement at the OSA, 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles, and the Open Pit. As in the RADON (NRC, 1989) analysis, cover materials will be sourced on-site from Kendrick Creek delta in the intertidal zone. The MicroShield® analysis incorporates the same physical properties of the cover material as discussed above.

A combination of GPS-based gamma radiation measurements and soil samples collected at the Site (Tetra Tech, 2010) was used to estimate U-238 and Th-232 decay chain radionuclide activity concentrations for mine rock materials at specific locations. Values of the other variables selected to support each code execution are presented in Appendix D. The code output was used to develop curves of radiation exposure rates for soil cover thicknesses ranging from 0.5 to 3.5 feet. Shield thickness vs. exposure rate curves were developed for the OSA materials, the 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles, and the Open Pit. The gamma radiation exposure rate estimates associated with the specific mine rock materials were analyzed and background radiation levels are not included in the calculated exposure rates. Figure 6-2 presents the results of the analysis. Figure 6-2 shows the following:

1) All six source areas (the OSA, 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles, and the Open Pit) are attenuated to less than 6 uR/hr at compacted soil cover thicknesses of 2 feet.
2) All source areas are attenuated to less than 2 uR/hr at cover thicknesses of 2.5 feet.
3) All source areas are attenuated to less than 1 uR/hr at cover thicknesses of 3 feet.

Revegetation
Depending on the removal action, revegetation would be performed at the OSA and 300-Foot Level following regrading, excavation, and/or cover placement. For alternatives that involve removal of the OSA materials or 300-Foot Level mine rock pile, the disturbed footprint of the removal area would be regraded to provide positive surface water drainage prior to revegetation. The excavated footprint or surface of the cover at the OSA and the 300-Foot Level mine rock pile will be amended with organic material removed prior to construction (i.e., chipped vegetation) to support native vegetation. Revegetation of disturbed areas will include use of native seed mixtures, and will follow guidance provided in the Revegetation Manual for Alaska (ADNR, 2008).

Minimal vegetation currently exists at the 700-Foot and 900-Foot Levels, and revegetation would not be performed at these elevations. For alternatives that involve removal of the 700-Foot Level or 900-Foot Level mine rock piles, the disturbed footprint of the removal area would be graded to provide positive surface water drainage, if the area has not already been returned to a bedrock surface. Protection of cover materials at the 700-Foot and 900-Foot Levels will be provided by a surficial layer of rock armor on top of the cover.

Monitoring and Maintenance
Monitoring and maintenance is a common element for all mine rock removal action alternatives, however different levels of monitoring and maintenance will be required for each alternative. These are described further below.

Each alternative will have specific design and construction criteria to assure the RAOs are achieved with a minimum of continuing monitoring and maintenance. Due to the remoteness and access to the Site, technologies that require continued operation and/or frequent maintenance are not viable. The design of alternatives must also account for the physical limitations imposed by Site terrain and topography consisting of rugged, steep slopes, dense forest cover and incised steam channels, except along the margin of the West Arm of Kendrick Bay shoreline and around the OSA, and the wet climate. Access to some areas of the Site is restricted even by foot.

Design Criteria
Design criteria consist of surface erosional stability, slope stability, channel flow capacity and stability, and ability to implement institutional and access controls.

Surface Erosion Stability. During design of the removal action, remediated surfaces will be assessed to provide acceptable erosional stability based on the types and properties of material and the surface cover. Erosional stability of cover surfaces may be achieved with a vegetated surface or rock mulch. Vegetated surfaces are appropriate where slopes are gentler and environmental conditions (elevation, topography climate, soils, etc.) are conducive to establishment of vegetation. Rock mulch is appropriate where slopes are steeper, surface flows are concentrated, and environmental conditions are not conducive to vegetation establishment, such as may exist at the 700-Foot and 900-Foot Levels.

Slope Stability. During design of the removal action, permanent slopes and covers will be designed using sound engineering practice to achieve a static safety factor of 1.5 or higher and a pseudo-static safety factor of 1.0 or better according to the type and properties of the material. Based on preliminary evaluations for this EE/CA, these criteria indicate that for removal alternatives that involve in-place stabilization or in-place covering of mine rock piles that the slopes of mine rock piles and earthen covers be regraded to slopes not exceeding 3H:1V. The required slope will be further evaluated and refined during design of the removal action.

Channel Flow Capacity and Stability. During design of the removal action, diversion channels or ditches will be sized to convey water and be designed to be erosionally stable. Design flows and channel protection will be determined using commonly accepted methods. In addition, the erosional stability of mine rock piles, such as the toe of a pile adjacent to a stream channel may be required to be protected by rock. For removal alternatives that involve in-place stabilization or in-place covering of mine rock piles, the mine rock will be removed or set-back a minimum of ten feet from stream channels and the toe of mine rock piles adjacent to stream will be protected with riprap. The actual set-back distance and extent of riprap protection will be further evaluated and refined during design of the removal action.

Institutional and Access Controls. All removal alternatives will require institutional controls to restrict land use in areas where mine rock would remain after implementation of the removal action to protect the integrity of the action. Institutional and access controls would also be required for all removal actions for mine openings to either restrict access to portals that remain open or to protect the closure integrity implemented for the mine openings. Controls could include signage, advisories, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry.

6.1.2 Mine Rock Alternative M-1 – No Action

This alternative is retained throughout the process and represents a baseline condition against which other removal action alternatives are compared. Under the No Action alternative, mine rock in all mine-affected areas would remain in its current condition, with no reduction in exposure pathways or reduction in existing risk to human or ecological receptors. Access by humans and wildlife would remain the same as currently exists. It is not expected that mine rock characteristics or Site conditions would change in the future that would reduce or alter currently existing risks to human health and the environment. This alternative is compatible with potential future mining. Figures depicting Alternative M-1 are presented in Figures 6-3 through 6-6. The “A – A’” and “B – B’” lines on these figures indicate the location of vertical cross sections shown on later figures.

6.1.3 Mine Rock Alternative M-2 – In Place Stabilization and Institutional and Stormwater Controls

Under this alternative, institutional controls would be implemented to reduce human exposures to mine-affected areas and stormwater controls would be constructed to minimize run-on to mine-affected areas. Institutional controls could consist of legal restrictions such as land use restrictions and physical access restrictions to the mine-affected areas such as signage and physical barriers. Stormwater controls could consist of diversion channels or berms to prevent run-on to mine-affected areas. Conceptual drawings of Alternative M-2 at the OSA, 300-Foot Level mine rock pile, 700-Foot Level mine rock pile, and 900-Foot Level mine rock pile areas, and the Open Pit are presented in Figures 6-7 through 6-11, respectively. The “A – A’” and “B – B’” lines on these figures indicate the location of vertical cross sections shown on later figures, which contrast the components of all of the alternatives.

Mine rock at the 300-Foot, 700-Foot and 900-Foot Levels would be stabilized by setting back the toe of the mine rock slopes a minimum of 10 feet from adjacent stream channels to minimize run-on and erosion. Where observable mine rock exists in the areas depicted on Figures 6-7 and 6-8 beyond the physical boundaries of the OSA and 300-Foot Level mine rock piles, the mine rock will be removed and placed onto the pile. Where mine rock exists in stream channels in the specific areas where the pile toe will be set back from the stream channels, the mine rock will be removed from the channel and placed onto the regraded mine rock pile. Streams that currently flow across mine rock piles will be reconstructed a minimum distance of 10 feet from the toe of the piles. Rock armor will be placed at the toe of the mine rock piles where the pile is located adjacent to a stream channel, in order to protect the pile from erosion. The mine rock piles will be regraded to constructible slopes (3:1, horizontal:vertical) in order to facilitate construction of stormwater controls and toe protection. Much of the pile area will be left unmodified unless necessary for construction of erosion protection or stormwater controls. Stormwater controls, such as berms or diversion ditches, will be constructed upgradient of the mine rock piles and the OSA to reduce stormwater run-on. Spilled ore rock in the intertidal zone near the historical ramps will be removed by hand and placed in the OSA. The existing berm at the OSA will be left in place and will be rehabilitated during construction if necessary to prevent stormwater run-on. Revegetation of disturbed, revegetated areas will be performed following construction. Cross sections through the OSA, 300-Foot Level, 700-Foot Level and 900-Foot Level mine rock piles are provided in Figures 6-12 through 6-15, respectively.

Alternative M-2 does not include any removal action at the Mine Road, Haul Road or the I&L Spur Road, as the road materials are presently stable. Therefore, Alternative M-2 is the removal action alternative most compatible with future mining at the Site, because it does not include road closure and preclusion of vehicle access.

Institutional controls including land use restrictions and physical access restrictions would be implemented to prevent disturbance of regraded mine rock piles and to reduce human exposures to mine-affected areas. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Appropriate signage would be posted along access points to the mine features warning of risks to humans. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary. A summary of costs for construction of Alternative M-2 is presented in Table 6-6. Supporting documentation for cost development is included in Appendix E.

6.1.4 Mine Rock Alternative M-3 – Cover In-Place

Alternative M-3 includes all the activities included under Alternative M-2 (In Place Stabilization with Stormwater and Institutional Controls), along with additional regrading of mine rock piles and the OSA, covering of mine rock piles and the OSA, excavation and covering of select portions of the Haul Road and Mine Road, and removal of the I&L Spur Road. As in Alternative M-2, institutional controls could consist of legal restrictions such as land use restrictions and physical access restrictions such as signage and physical barriers. Stormwater controls would be constructed to minimize run-on to mine-affected areas. Conceptual drawings of Alternative M-3 at the OSA and the 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles are presented in Figures 6-16 through 6-19, respectively. The “A – A’” and “B – B’” lines on these figures indicate the location of vertical cross sections shown on other figures which contrast the components of all of the alternatives. For Alternative M-3, the Open Pit would remain in its present condition, as depicted in Figure 6-11.

Current boundaries of the mine rock piles at the OSA, 300-Foot, 700-Foot, and 900-Foot Levels are shown on Figure 6-16 through 6-19. Boundaries were determined based on visual observations of the extent of disturbed areas. The visual and topographic survey boundaries shown in Figures 6-16 through 6-19 are considered the most precise boundaries of the mine rock piles. The physical boundaries of the piles are consistent with the measured gamma exposure rates, except for the localized areas defined by elevated gamma exposure rates beyond the physical boundaries of the 300-Foot Level mine rock pile and OSA, as described in Section 2.5. The mine rock within the localized areas adjoining the physical boundaries at the 300-Foot Level and OSA is included as part of the mine-affected area.

Mine rock piles at the OSA and the 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles will be regraded to 3:1 (horizontal:vertical) and covered, as shown in Figures 6-16 through 6-19. Where observable mine rock exists within the areas defined on Figures 6-16 and 6-17 beyond the physical boundaries of the OSA and 300-Foot Level mine rock pile, the mine rock will be removed and placed onto the pile prior to covering. Spilled ore rock in the intertidal zone near the historical ramps will be removed by hand and placed in the OSA prior to cover placement. Mine rock at the 900-Foot, 700-Foot and 300-Foot Levels would be regraded to maximum 3:1 (horizontal:vertical) side slopes in order to facilitate placement of the cover. The toe of the mine rock piles will be reconstructed a minimum of 10 feet from adjacent stream channels to minimize run-on and erosion. Streams that currently flow across mine rock piles will be reconstructed to a minimum distance of 10 feet from the toe of the piles. Where mine rock exists in stream channels in areas where the toe of the pile will be set back from the stream channels, the mine rock will be removed from the stream channels and placed within the regraded mine rock pile prior to placement of cover. Cross sections showing the OSA, 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles for this alternative are provided in Figures 6-12 through 6-15, respectively.

Mine-affected materials identified along the Mine Road and Haul Road segments will be excavated to a depth of one foot and replaced with one foot of on-site borrow material, in order to maintain vehicle access to the covered mine rock piles. Borrow material for replacement of excavated road areas will be sourced on-site from the Kendrick Creek delta intertidal area. The I&L Spur Road will be removed and road materials will be consolidated at the 900-Foot Level North mine rock pile prior to placement of cover at the pile. The I&L Spur Road will subsequently be closed to preclude vehicle access. One-foot of material would be excavated from the road surface of the identified segments of the haul and mine roads and replaced with one-foot of material from the On-site borrow source. Spilled ore rock in the ramp intertidal zone will be removed by hand and placed in the OSA prior to cover placement.

Mine rock piles at the 900-Foot, 700-Foot and 300-Foot Levels and the OSA would be constructed with a two-foot thick cover designed to accomplish the following objectives:

- Reduce external gamma radiation and radon emanation from the mine rock and OSA materials;
- Prevent exposure by dermal contact, inhalation, or incidental ingestion of mine rock or mine-affected soils;
- Prevent access of burrowing animals and root penetration;
- Provide geotechnical and physical stability against slope failure and erosion; and
- Promote runoff and reduce surface water contact with mine rock.

Cover materials will be sourced on-site from the Kendrick Creek delta intertidal area. Cover materials would likely be composed of sandy gravel. A two-foot thick cover will be constructed at each of the mine rock piles. The surface of the cover at the 700-Foot and 900-Foot Levels mine rock piles will be constructed of rock armor consisting of cobbles ranging from 4 to 6-inches in diameter. The surface of the cover at the OSA and at the 300-Foot Level mine rock pile will be amended with organic material removed from the Site prior to construction (i.e., chipped vegetation). Approximately 20,978 cubic yards of cover material is required for Alternative M-3, as shown in Table 6-2.

Stormwater controls such as berms or diversion ditches will be constructed upgradient of the mine rock piles and OSA to eliminate run-on and erosion of the cover. Toe protection in the form of cobbles and boulders will be placed at the toe of the covered mine rock piles where the pile is located adjacent to a stream channel, in order to protect the pile from erosion. Volumes of material required for toe protection are shown in Table 6-3. Stormwater controls will be constructed at the 900-Foot Level to minimize run-on into the Open Pit. Revegetation of disturbed areas will be performed following construction.

Institutional controls including land use restrictions and physical access restrictions would be implemented to protect the integrity of covers on the OSA and mine rock piles and to reduce human exposures to the Open Pit. Controls could include signage, road closures, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Appropriate signage would be posted along access points to the mine feature areas warning of risks to humans. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary.

Conventional heavy excavation and hauling equipment will be necessary to implement Alternative M-3. To excavate and haul borrow material, excavate road sections, as well as to regrade mine rock piles and construct a cover, earth moving and hauling equipment such as an excavator, bulldozer, front end loader, and haul trucks will be necessary. Silt fencing and temporary stormwater controls will be constructed during the removal action. A summary of costs for construction of Alternative M-3 is presented in Table 6-7. Supporting documentation for cost development is included in Appendix E.

6.1.5 Mine Rock Alternative M-4 – Excavation, Consolidation and Cover at Mine Affected Areas

Alternative M-4 includes many of the activities included under Alternative M-3 (Cover In-Place), however the OSA will be consolidated at the 300-Foot Level mine rock pile and covered, and the 700-Foot Level and 900-Foot Level mine rock piles will be consolidated into the Open Pit and covered. Alternative M-4 also includes removal and closure of the Mine Road and the I&L Spur Road, and excavation and replacement of identified sections of the Haul Road. As in Alternative M-3, institutional controls could consist of legal restrictions such as land use restrictions and physical access restrictions such as signage and physical barriers. Stormwater controls would be constructed to minimize run-on to the repositories. Conceptual drawings of Alternative M-4 at the 300-Foot Level and 900-Foot Level Open Pit repositories are presented in Figures 6-20 and 6-21, respectively. Conceptual drawings of post-removal conditions at the OSA, 700-Foot Level, and 900-Foot Level mine rock piles are presented in Figures 6-22 through 6-24, respectively. The “A – A’” and “B – B’” lines on these figures indicate the location of vertical cross sections shown on other figures which contrast the components of all of the alternatives.

Current boundaries of the mine rock piles at the OSA, 300-Foot, 700-Foot, and 900-Foot Levels are shown on Figures 6-20 and 6-22 through 6-24. Boundaries were determined based on visual observations of the extent of disturbed areas. The visual and topographic survey boundaries shown in the figures are considered the most precise physical boundaries of the mine rock piles. The physical boundaries of the piles are consistent with the measured gamma exposure rates, except for the localized areas defined by elevated gamma exposure rates beyond the physical boundaries of the 300-Foot Level mine rock pile and OSA, as described in Section 2.5. The mine rock within the localized areas adjoining the physical boundaries at the 300-Foot Level and OSA is included as part of the mine-affected area.

Mine rock and mine-affected soils at the OSA will be removed and consolidated at the 300-Foot Level mine rock pile. Removal of the OSA will be performed to the extent of the area shown in Figure 6-22. Where observable mine rock exists within the area delineated on Figure 6-22 beyond the physical boundary of the OSA, the mine rock will be removed and placed onto the 300-Foot Level repository. Where observable mine rock exists within the area shown on Figure 6-20 beyond the physical boundary of the 300-Foot Level mine rock pile, the mine rock will be removed and placed onto the 300-Foot Level repository. Impacted areas will be excavated down to bedrock or discernable native soil. The estimated volume of OSA material that will be removed is 8,250 cubic yards. The OSA will be regraded to provide positive surface water drainage after the materials are removed. Figure 6-12 provides a cross section of the OSA.

Spilled ore rock in the ramp intertidal zone will be removed by hand and consolidated at the 300-Foot Level mine rock pile prior to cover placement. The OSA material and spilled ore rock will be strategically consolidated, to the extent practicable, at the 300-Foot Level pile to cover the OSA material with the lower gamma radiation activity material from the 300-Foot Level mine rock pile in order to reduce external gamma radiation and radon emanation at the cover surface.

The 700-Foot Level and 900-Foot Level mine rock piles will be removed and consolidated into the Open Pit. Removal of the 700-Foot Level and 900-Foot Level mine rock piles will be performed to the extents of the piles shown in Figures 6-23 and 6-24, respectively. Removal will include the area within the limits shown in Figures 6-23 and 6-24, and will include all observable mine rock, including mine rock that has rolled beyond the defined boundary of the pile and/or mine-affected soils around the boundary of the pile. Mine rock will be excavated down to bedrock or discernable native soil. The area of removal will be regraded to provide positive surface drainage, if the area has not already been excavated to a bedrock surface. Cross sections of the 700-Foot Level and 900-Foot Level mine rock piles are provided on Figures 6-14 and 6-15, respectively.

Alternative M-4 includes removal of the entire I&L Spur Road and the Mine Road embankments between the 900-Foot Level and 700-Foot Level, and placement of the road material in the Open Pit repository. The I&L Spur Road and the Mine Road between the 900-Foot Level and 700-Foot Level will subsequently be closed to preclude vehicle access. Sections of the Haul Road identified in Figure 2-27 will be excavated to a depth of one foot and replaced with one foot of borrow material to maintain open access to the 300-Foot Level and Open Pit repositories.

The total volume of additional material placed at the 300-Foot Level repository, including the OSA and the isolated ore rock from the intertidal area near the historical ramps, includes approximately 8,270 cubic yards, as shown in Table 2-1. The total volume of material that will be placed in the Open Pit repository, including the 700-Foot Level mine rock pile, the north and south 900-Foot Level mine rock piles, the Mine Road between the 900-Foot Level and the 700-Foot Level, identified segments along the Haul road, and the I&L Spur Road is 25,779 cubic yards (CY), as shown in Table 2-1. The materials will be placed in the Open Pit in a manner that positions materials with higher gamma radiation activity as deep in the profile as possible, and covering those with material having lower gamma radiation activity, in order to reduce external gamma radiation and radon emanation at the surface of the repository. The order of placement of materials in the Open Pit will consist of the 900-Foot Level south mine rock pile at the bottom, followed by the 700-Foot Level mine rock pile, the mine road embankment material, and the 900-Foot Level north mine rock pile at the top of the Open Pit repository.

The repositories at the 300-Foot Level and Open Pit will be regraded to a maximum slope of 3:1 (horizontal:vertical) in order to facilitate placement of the cover. The toe of the mine rock repositories at the 300-Foot Level and the Open Pit will be constructed a minimum of 10 feet from adjacent stream channels to minimize run-on and erosion.

Mine rock repositories at the 300-Foot Level and the Open Pit will be constructed with a cover designed to accomplish the following objectives:

- Reduce external gamma radiation and radon emanation from the mine rock and OSA materials;
- Prevent exposure by dermal contact, inhalation, or incidental ingestion of mine rock or mine-affected soils;
- Prevent access of burrowing animals and root penetration;
- Provide geotechnical and physical stability against slope failure and erosion; and
- Promote runoff and reduce surface water contact with mine rock.

Cover materials would likely be sourced on-site from the Kendrick Creek delta intertidal area. Cover materials would likely be composed of sandy gravel. A two-foot thick cover will be constructed at each of the repositories, with the addition of a synthetic geomembrane barrier at the Open Pit Repository. Approximately 12,531 cubic yards of cover material is required for Alternative 4, as shown in Table 6-2. The surface of the repository cover at the Open Pit repository will be constructed of rock armor consisting of cobbles ranging from 4 to 6-inches in diameter. The surface of the repository cover at the 300-Foot Level will be amended with organic material removed prior to construction (i.e., chipped vegetation) to support native vegetation regrowth. Cross sections through the 300-Foot Level repository and the Open Pit repository are included as Figures 6-13 and 6-25, respectively.

Stormwater controls such as berms or diversion ditches will be constructed upgradient of the repositories to eliminate run-on and erosion of the cover. At the Open Pit repository, berms will divert streams that currently empty into the Open Pit. The synthetic geomembrane barrier would minimize infiltration of precipitation into the Open Pit. At the 300-Foot Level repository, rock armor will be placed at the toe of the covered repository that is adjacent to the stream channel in order to protect the pile from erosion. A diversion channel will be constructed at the base of the uphill toe of the pile, to divert water away from the mine rock pile. Volumes of material required for toe protection are shown in Table 6-3. Revegetation of disturbed areas will be performed following construction.

Institutional controls including land use restrictions and physical access restrictions would be implemented to protect the integrity of the covers. Controls could include signage, road closure, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Appropriate signage would be posted along access points to the mine feature areas warning of risks to humans. Less monitoring and maintenance is required for Alternative M-4 than Alternatives M-2 and M-3 because the mine-affected materials will be limited to two repositories, and therefore inspections and maintenance would be limited to two locations. Implementation of Alternative M-4 would preclude access to the Ross-Adams Open Pit. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary.

Conventional heavy excavation and hauling equipment will be necessary to implement Alternative M-4. Earth moving and hauling equipment such as an excavator, bulldozer, front end loader, and haul trucks will be necessary to excavate and haul borrow material and mine-affected material, excavate road sections, regrade mine rock piles and construct repository covers. Silt fencing and temporary stormwater controls will be constructed during the removal action. A summary of costs for construction of Alternative M-4 is presented in Table 6-8. Supporting documentation for cost development is included in Appendix E.

6.1.6 Mine Rock Alternative M-5 – Excavation, Consolidation in Open Pit Repository at 900-Foot Level

Alternative M-5 includes many of the activities included under Alternative M-4 (Excavation, Consolidation, and Cover at Mine Affected Areas); however, all mine rock piles and affected road segments will be consolidated into the Open Pit repository and covered. Alternative M-5 also includes removal and closure of the Mine Road, I&L Spur Road and the Haul Road from the 300-Foot Level to the intersection with the northern segment of the Haul Road. As in Alternative M-4, institutional controls could consist of legal restrictions such as land use restrictions and physical access restrictions such as signage and physical barriers. Stormwater controls would consist of diversion channels or berms to prevent run-on to the repository. A conceptual drawing of Alternative M-5 at the Open Pit repository is presented in Figure 6-26. Conceptual drawings of post-removal conditions at the OSA, 700-Foot Level, and 900-Foot Level mine rock piles are presented in Figures 6-22 through 6-24, respectively. A conceptual drawing of post-removal conditions at the 300-Foot Level is presented in Figure 6-27.

Current boundaries of the mine rock piles at the OSA, 300-Foot, 700-Foot, and 900-Foot Levels are shown on Figures 6-22 through 6-24, and 6-27. Boundaries were determined based on visual observations of the extent of disturbed areas. The visual and topographic survey boundaries shown in the figures are considered the most precise boundaries of the mine rock piles. The physical boundaries of the piles are consistent with the measured gamma exposure rates, except for the localized areas defined by elevated gamma exposure rates beyond the physical boundaries of the 300-Foot Level mine rock pile and OSA, as described in Section 2.5. The mine rock within the localized areas adjoining the physical boundaries at the 300-Foot Level and OSA is included as part of the mine-affected area.

Mine rock and mine-affected soils at the OSA, 300-Foot Level, 700-Foot Level and 900-Foot Level will be removed and consolidated into the Open Pit repository. Spilled ore rock in the ramp intertidal zone will also be removed by hand and placed in the Open Pit repository. Where observable mine rock exists within the area defined on Figures 6-22 and 6-27 beyond the physical boundaries of the OSA and 300-Foot Level mine rock pile, the mine rock will be removed and placed onto the Open Pit repository. At the 300-Foot Level mine rock pile, this includes the mine rock that has rolled beyond the toe of the slope and mine-affected soils within the delineated area beyond the physical boundary of the mine rock pile. The limits of removal at the 700-Foot Level and 900-Foot Level mine rock piles will include the area within the limits shown in Figures 6-23 and 6-24, including mine rock that has rolled beyond the defined limits of the piles and/or mine-affected soils at the boundaries of the piles. Where mine rock exists in the stream channel immediately adjacent to the 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles, the material will be excavated and placed in the Open Pit repository. Mine rock will be excavated down to bedrock or discernable native soil. Areas will be regraded to provide positive surface drainage after removal of materials, if the area has not been excavated to a bedrock surface already. Cross sections through the OSA, 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles are provided on Figures 6-12 through 6-15, respectively.

Similarly to Alternative M-4, Alternative M-5 includes complete removal of the I&L Spur Road and the Mine Road between the 900-Foot Level and 700-Foot Level, and placement of the road embankment material into the Open Pit repository. The I&L Spur Road and the Mine Road between the 900-Foot Level and 700-Foot Level will subsequently be closed to preclude vehicle access. Segments of the Haul Road embankment between the 300-Foot Level and the intersection with the northern portion of the Haul Road identified on Figure 2-27 will be excavated and consolidated into the Open Pit repository. The Haul Road between the 300-Foot Level and the intersection with the northern Haul Road will be closed to preclude future vehicle access. Segments of the Haul Road between the OSA and the 900-Foot Level identified on Figure 2-27 will be excavated to a depth of one foot and replaced with one foot of borrow material to maintain vehicle access to the Open Pit repository.

The total volume of material that will be placed in the Open Pit repository, including the 300-Foot Level, 700-Foot Level and 900-Foot Level mine rock piles, the isolated ore rock in the intertidal zone near the historic ramps, the Mine Road between the 900-Foot Level and the 700-Foot Level, identified segments along Haul Road, and the I&L Spur Road is 65,788 CY, as shown in Table 2-1. The materials will be placed in the Open Pit in a manner that positions materials with higher gamma radiation activity as deep in the profile as possible, and covering it with material having lower gamma radiation activity, in order to reduce external gamma radiation and radon emanation at the surface. Based on measured gamma exposure rates, the anticipated placement of materials in the in the Open Pit will consist of the OSA at the bottom, followed by the 900-Foot Level South mine rock pile, the 700-Foot Level mine rock pile, the Mine Road embankment material, the 900-Foot Level North mine rock pile, and the 300-Foot Level mine rock pile at the top of the Open Pit repository.

The repository will be regraded to a maximum slope of 3:1 (horizontal:vertical) in order to facilitate placement of the cover. The Open Pit repository will be constructed with a cover designed to accomplish the following objectives:

- Reduce external gamma radiation and radon emanation from the consolidated mine rock;
- Prevent exposure by dermal contact, inhalation, or incidental ingestion of mine rock or mine-affected soils;
- Prevent access of burrowing animals and root penetration;
- Provide geotechnical and physical stability against slope failure and erosion; and
- Promote runoff and reduce surface water contact with mine rock.

Cover materials will be sourced on-site from the Kendrick Creek delta intertidal area. Cover materials are assumed to be composed of sandy gravel. A two-foot thick cover over a synthetic geomembrane barrier will be constructed at the repository. Approximately 11,615 cubic yards of cover material is required for Alternative M-5, as shown in Table 6-2. The surface of the repository cover at the Open Pit will be constructed of rock armor consisting of cobbles ranging from 4 to 6-inches in diameter. A cross section through the Open Pit repository is included as Figure 6-25.

Berms will divert streams that currently empty into the Open Pit to prevent run-on to the repository. The synthetic geomembrane barrier would further reduce infiltration of precipitation into the Open Pit. Revegetation of disturbed areas will be performed following construction.

Institutional controls including land use restrictions and physical access restrictions would be implemented to protect the integrity of the cover on the Open Pit repository. Controls could include signage, road closures, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Appropriate signage would be posted along access points to the mine feature areas warning of risks to humans. Implementation of Alternative M-5 would preclude any future access to the Ross-Adams Open Pit. Less monitoring and maintenance is required for Alternative M-5 than the other mine rock alternatives because the mine-affected materials will be limited to one repository, and therefore inspections and maintenance would be limited to one location. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary.

Conventional heavy excavation and hauling equipment will be necessary to implement Alternative M-5. To excavate and haul borrow material and mine-affected material, excavate road sections, as well as to regrade mine rock piles and construct repository covers, earth moving and hauling equipment such as an excavator, bulldozer, front end loader, and haul trucks will be necessary. Silt fencing and temporary stormwater controls will be constructed. A summary of costs for construction of Alternative M-5 is presented in Table 6-9. Supporting documentation for cost development is included in Appendix E. A cost comparison of all Mine Rock Alternatives is presented in Table 6-10.

6.2 Mine Portal Alternatives

6.2.1 Common Elements of the Mine Portal Alternatives

Legal and/or physical access restrictions may exist in every portal alternative except the no action alternative. No roads currently access the Site from the remainder of POW Island, so it is assumed that all equipment and materials required to implement the selected removal action will be mobilized to the Site via tug and barge. Equipment and materials required could include excavation equipment for construction of the concrete bulkhead, ATVs for transportation on-site, electricity and fuel to operate equipment, and temporary living facilities for work crews. Equipment and unused materials would be demobilized from the Site after completing the selected removal action.

The portal alternatives assume that roads would be improved as part of the chosen mine rock alternative, as construction equipment will need to access the 300-Foot, 700-Foot and 900-Foot Levels portals, as well as the 900-Foot Level vent shaft.

Other significant common elements to the portal removal action alternatives are 1) closure of the 900-Foot Level vent shaft to prevent air and water entry, 2) closure of the 900-Foot Level portal to prevent air entry but allow water entry, 3) closure of the 700-Foot Level portal to prevent air entry but allow water entry, and 4) re-vegetation after the removal action in areas that are currently vegetated. Closure of the 900-Foot Level vent shaft, 900-Foot Level portal and 700-Foot Level portal should significantly reduce air inflow into the mine workings and air outflow from the 300-Foot Level portal, thereby reducing radon exhalation from the 300-Foot Level portal. Construction sequencing will be necessary during construction at the portals and mine rock piles. Access will need to be maintained to the portals during construction.

<u>Closure of the 900-Foot Level Vent Shaft</u>

The 900-Foot Level vent shaft will be closed to prevent air and water entry. One type of closure for the 900-Foot Level vent shaft is with an injectable, expandable, polyurethane foam. The closure should prevent access for humans, animals, air and water. The closure will eliminate radon exhalation from the 900-Foot Level vent shaft thereby eliminating human exposure to radon. A conceptual detail depicting closure of the 900-Foot Level vent shaft is presented in Figure 6-28.

<u>Closure of the 900-Foot Level Portal</u>

The 900-Foot Level portal will be closed to prevent air entry but allow water entry. Two options for portal closure are 1) a half dam with rock backfill, or 2) a solid concrete plug. The closure will prevent access for humans, animals, and air, however it will allow water that enters the Open Pit to flow through the portal closure and into the underground mine workings. Water flow into the Open Pit and thus into the 900-Foot Level portal is expected to be reduced, as Mine Rock Alternatives M-2 through M-5 all include provisions to reduce stormwater inflow into the Open Pit. Closure of the 900-Foot Level portal will eliminate radon exhalation from the 900-Foot Level portal thereby eliminating human exposure to radon at portal. Conceptual details depicting closure of the 900-Foot Level portal are presented in Figures 6-29 and 6-30.

Closure of the 700-Foot Level Portal

The 700-Foot Level portal will be closed to prevent air entry but allow water discharge. The closure should prevent access for humans, animals, and air; however, it should be designed to allow water to flow out through the 700-Foot Level portal. The closure will eliminate radon exhalation from the 700-Foot Level portal thereby eliminating human exposure to radon. A conceptual detail depicting closure of the 700-Foot Level portal is presented in Figure 6-31. The exact dimensions of the 700-Foot Level portal are unknown and have been estimated in Figure 6-31. Actual dimensions will be verified during final design.

Removal of Vegetation

Trees will have to be cleared for all removal action alternatives to construct access and staging areas. The trees cleared would be left on-site and may be chipped or staged across the Site as part of an institutional control. Chipped trees will be used as vegetative amendment to cover materials that will be re-vegetated following the chosen mine rock removal action.

Revegetation

Revegetation will be performed of areas disturbed during the removal action. Minimal vegetation currently exists at the 700-Foot and 900-Foot Levels, and revegetation will only be performed where vegetation currently exists. Revegetation will include use of native seed mixtures, and will follow guidance provided in the Revegetation Manual for Alaska.

Monitoring and Maintenance

Monitoring and maintenance is a common element to all portal alternatives, except the no action alternative. As described in Section 2.5.2, drainage from the 300-Foot Level portal flows to Mine Fork Creek a short distance (approximately 100 feet) upstream of its confluence with Kendrick Creek. Kendrick Creek subsequently flows along the 300-Foot Level mine rock pile. Water quality in Kendrick Creek below the confluence with Mine Fork Creek and the 300-Foot Level portal drainage, as documented in the SCR, meets Alaska water quality standards for all designated freshwater uses (except aluminum which is consistent with background surface water concentrations). Monitoring would be performed to confirm that water quality standards for the designated freshwater uses continue to be achieved in Kendrick Creek (except the chronic aluminum standard for freshwater aquatic life) following the removal action.

A monitoring point would be located in the reach of Kendrick Creek downstream of the 300-Foot Level where habitat is physically more amenable to salmonid spawning and rearing. The monitoring point would be located during design of the removal action in consultation with the USFS and ADEC. Two primary factors that would be considered in identifying the monitoring point in Kendrick Creek are the location of suitable physical habitat for salmonid spawning and rearing and accessibility for sample collection. Monitoring would be performed annually for a five-year period following completion of the removal action and then once every five years, if determined necessary, from review of the resulting data. Water quality samples would be collected twice a year, preferably in June and September, when Kendrick Creek can be safely accessed. At a minimum, the water samples would be analyzed for uranium, radium (Ra-226 and Ra-228), manganese and zinc, as these parameters have a reasonable potential to exceed standards for designated freshwater uses in the drainage from the 300-Foot Level portal. The resultant data would be submitted to the USFS and ADEC for review. Sampling and analysis methods, quality assurance and control plans, and data review procedures would be specified in a sampling and analysis plan, which would be developed and submitted as part of removal action design following USFS selection of the preferred removal action.

Maintenance activities required for the portal alternatives would include inspections and maintenance of portal closures and institutional controls. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary. Maintenance activities are described further below.

6.2.2 Portal Alternative P-1 – No Action

This alternative is retained throughout the process and represents a baseline condition against which other portal removal actions are compared. The No Action Alternative consists of allowing the portals to remain in their present condition, with no measures taken to reduce or monitor existing conditions; therefore, no reduction in exposure pathways or reduction in existing risk to human or ecological receptors would be achieved. In the long-term, it is not expected that mine portal characteristics or Site conditions would change that would reduce or alter currently existing risks to human health and the environment.

6.2.3 Portal Alternative P-2 – Close Upper Mine Openings and Gate at 300-Foot Level Portal

Portal Alternative P-2 includes installation of a gate at the 300-Foot Level portal to prevent human access but allow animal access and water outflow from the mine workings. Institutional controls for Alternative P-2 would include physical access restrictions such as signage and physical barriers. A conceptual drawing of Alternative P-2 at the 300-Foot Level portal is presented in Figure 6-32.

The gate constructed at the 300-Foot Level will be founded in the mine walls. The gate will allow access to the underground workings by bats and other small animals, but will prevent human access. As a result of stormwater controls upgradient of the Open Pit, water outflow from the 300-Foot Level portal is expected to decrease from current volumes, however outflow is still expected. The drainage from the 300-Foot Level portal will flow freely through the gated portal to Mine Fork Creek, as presently occurs. Another option would be to construct a collection system behind the gate to collect and pipe the drainage directly to Kendrick Creek. Vegetated areas disturbed during construction will be revegetated after construction is complete.

Institutional controls including land use restrictions and physical access restrictions would be implemented to reduce exposure pathways to radon exhalation and water outflow at the 300-Foot Level portal. Controls could include signage and physical barriers. As described in Section 6.2.1, monitoring would be performed at a designated location in Kendrick Creek downstream of the 300-Foot Level to confirm that water quality standards for the designated freshwater uses continue to be achieved in Kendrick Creek. Monitoring and maintenance required for Alternative P-2 will include inspections and maintenance of portal closures and institutional controls. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary.

Conventional heavy construction equipment will be necessary to implement Portal Alternative P-2. Silt fencing and temporary stormwater controls will be constructed prior to construction work. A summary of costs for construction of Alternative P-2 is presented in Table 6-11. Supporting documentation for cost development is included in Appendix E.

6.2.4 Portal Alternative P-3 - Close Upper Mine Openings and Rock Backfill at 300-Foot Level Portal

Portal Alternative P-3 includes backfilling the 300-Foot Level portal with rock from the on-site borrow source or mine rock depending on its characteristics to prevent human and animal access but allow water outflow from the mine workings. Institutional controls for Alternative P-3 would include physical access restrictions such as signage and physical barriers. A conceptual drawing of Alternative P-3 at the 300-Foot Level portal is presented in Figure 6-33.
Mine rock would be used to backfill the 300-Foot Level portal under Alternative P-3. The backfill will prohibit human and animal access. As a result of stormwater controls upgradient of the 900-Foot Level Open Pit, water outflow from the 300-Foot Level portal is expected to decrease from current rates, however outflow is still expected. A water collection system will be constructed at the base of the rock backfill to collect and pipe the portal drainage through the backfill. The drainage will be piped directly to Kendrick Creek. Vegetated areas disturbed during construction will be revegetated after construction is complete.

Institutional controls including land use restrictions and physical access restrictions would be implemented to reduce exposure pathways to radon and gamma radiation from the mine rock backfill, and water outflow at the 300-Foot Level portal. Controls could include signage and physical barriers. Monitoring and maintenance required for Alternative P-3 would include inspections and maintenance of portal closures and institutional controls. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary. As described in Section 6.2.1, monitoring would be performed at a designated location in Kendrick Creek downstream of the 300-Foot Level to confirm that applicable water quality standards or background (for aluminum) continue to be achieved in Kendrick Creek.

Conventional heavy excavation and construction equipment will be necessary to implement Portal Alternative P-3. Silt fencing and temporary stormwater controls will be constructed prior to work activities. A summary of costs for construction of Alternative P-3 is presented in Table 6-12. Supporting documentation for cost development is included in Appendix E.

6.2.5 Portal Alternative P-4 – Close Upper Mine Openings and Concrete Bulkhead at 300-Foot Level Portal

Portal Alternative P-4 includes plugging the 300-Foot Level portal with a concrete bulkhead to prevent human and animal access but allow water outflow from the mine workings. Institutional controls for Alternative P-4 would include physical access restrictions such as signage and physical barriers. A conceptual drawing of Alternative 4 at the 300-Foot Level portal is presented in Figure 6-34.

A reinforced concrete wall founded in the mine tunnel rock would be constructed at the 300-Foot Level under Alternative P-4. The bulkhead will prohibit human and animal access into the mine workings and would eliminate radon exhalation at the 300-foot level. As a result of stormwater controls upgradient of the 900-Foot Level Open Pit, water outflow from the 300-Foot Level portal is expected to decrease from current rates, however outflow is still expected. A water collection system will be constructed to collect and pipe the portal drainage at the base of the bulkhead. The drainage will be piped directly to Kendrick Creek. Vegetated areas disturbed during construction will be revegetated after construction is complete.

Institutional controls including land use restrictions and physical access restrictions would be implemented to reduce exposure pathways to water outflow at the 300-Foot Level portal. Controls could include signage and physical barriers. Monitoring and maintenance required for Alternative P-4 would include inspections and maintenance of portal closures and institutional controls. Inspections would be performed on an annual basis for the first three years following construction, and thereafter every 5 years, to inspect the completed removal action, and perform maintenance as necessary. As described in Section 6.2.1, monitoring would be performed at a designated location in Kendrick Creek downstream of the 300-Foot Level to confirm that applicable water quality standards or background concentrations (for aluminum) continue to be achieved in Kendrick Creek.

Conventional heavy excavation and construction equipment will be necessary to implement Portal Alternative P-4. Silt fencing and temporary stormwater controls will be constructed prior to work activities. A summary of costs for construction of Alternative P-4 is presented in Table 6-13. Supporting documentation for cost development is included in Appendix E. A cost comparison of all Portal Alternatives is presented in Table 6-14.

Table 6-1a. Summary of Removal Action Alternatives for Mine Rock

Alternative	Area of Site	Process Options Included
Alternative M-1 **No Action**	All	Present conditions remain at Site, with no measures to reduce risk or monitor conditions.
Alternative M-2 **In Place Stabilization and Stormwater and Institutional Controls**	900-Foot, 700-Foot, and 300-Foot Levels Mine Rock	Regrade and stabilize mine rock adjacent to stream channels, and implement stormwater controls to minimize run-on. Regrade mine rock piles where necessary for construction of stormwater controls.
	900-Foot Level Open Pit	Enhance existing or implement additional stormwater controls to minimize run-on into pit.
	Ore Staging Area	Implement stormwater controls to minimize run-on and enhance natural vegetation development.
	Mine and Haul Roads	No action – materials are presently stable.
	I&L Spur Road	No action – materials are presently stable.
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Localized removal of ore from intertidal zone near ore loading ramps for consolidation (common element to all alternatives) in the OSA.
	Miscellaneous Wastes & Debris	Removal with off-site disposal (common element to all alternatives).
Alternative M-3 **Cover in Place**	900-Foot, 700-Foot, and 300-Foot Levels Mine Rock	Cover following regrading of mine rock to isolate mine rock with earthen cover (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on.
	900-Foot Level Open Pit	Enhance existing or implement additional stormwater controls to minimize run-on into pit.
	Ore Staging Area	Cover to isolate OSA with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on.
	Mine and Haul Roads	Excavate 1 foot of material in identified Mine Road and Haul Road segments, and replace with 1 foot of borrow material (sourced on-site from Kendrick Creek delta).
	I&L Spur Road	Remove road materials and consolidate at 900-Foot Level North mine rock pile. Close road to preclude vehicle access.
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Same as Alternative M-2 - Localized removal of ore from intertidal zone near ore loading ramps for consolidation in the OSA or 300-Foot Level Mine Rock Pile.
	Miscellaneous Wastes & Debris	Same as Alternative M-2 - Removal with off-site disposal (common element to all alternatives).

Table 6-1a. Summary of Removal Action Alternatives for Mine Rock (Continued)

Alternative	Area of Site	Process Options Included
Alternative M-4 **Excavation, Consolidation, and Cover at Mine Affected Areas**	900-Foot and 700-Foot Levels Mine Rock	Excavate and consolidate mine rock in 900-Foot Level Open Pit, and cover with synthetic geomembrane and earthen materials (sourced on-site from Kendrick Creek delta) to reduce infiltration, radon emanation and gamma radiation.
	900-Foot Level Open Pit	Cover consolidated mine rock and road materials with synthetic geomembrane and earthen materials (sourced on-site from Kendrick Creek delta) to reduce infiltration, radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	Ore Staging Area	Excavate and consolidate mine rock at 300-Foot Level and cover with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation.
	300-Foot Level Mine Rock	Cover consolidated mine rock and OSA with earthen materials (sourced on-site from Kendrick Creek delta) to reduce radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	Mine and Haul Roads	Mine Road (900-Foot Level to 700-Foot Level) - Remove materials from identified mine road embankments and road surface, consolidate and cover in 900-Foot Level Open Pit, and close road to preclude access. Haul Road (900-Foot Level to intersection with south Haul Road) - Remove materials from identified road segments, replace with borrow (sourced on-site from Kendrick Creek delta), and consolidate and cover in 900-Foot Level Open Pit. Haul Road (300-Foot Level to OSA) - Remove materials from identified road segments, replace with borrow (sourced on-site from Kendrick Creek delta), and consolidate and cover at 300-Foot Level or 900-Foot Level Open Pit.
	I&L Spur Road	Remove road materials and consolidate in 900-Foot Level Open Pit, and close road to preclude vehicle access.
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Same as Alternative M-2 - Localized removal of ore from intertidal zone near ore loading ramps for consolidation at the 300-Foot Level.
	Miscellaneous Wastes & Debris	Same as Alternative M-2
Alternative M-5 **Excavation, Consolidation in Open Pit Repository at 900-Foot Level**	900-Foot, 700-Foot, and 300-Foot Levels Mine Rock	Excavate and consolidate mine rock in 900-Foot Level Open Pit Repository, and cover with synthetic geomembrane and earthen materials (sourced on-site from Kendrick Creek delta) to reduce infiltration, radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	900-Foot Level Open Pit	Cover consolidated mine rock and road materials with synthetic geomembrane and earthen materials (sourced on-site from Kendrick Creek delta) to reduce infiltration, radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	Ore Staging Area	Excavate and consolidate mine-affected material in 900-Foot Level Open Pit Repository, and cover with synthetic geomembrane and earthen materials (sourced on-site from Kendrick Creek delta) to reduce infiltration, radon emanation and gamma radiation. Construct stormwater controls to minimize run-on and concentrated runoff.
	Mine and Haul Roads	Mine Road (900-Foot Level to 700-Foot Level) - Remove materials from identified mine road embankments and road surface, consolidate and cover in 900-Foot Level Open Pit Repository, and close road to preclude vehicle access. Haul Road (300-Foot Level to intersection with north Haul Road) - Remove materials from identified road segments, consolidate and cover in 900-Foot Level Open Pit Repository, and close road to preclude vehicle access. Haul Road (OSA to 900-Foot Level) - Remove materials from identified road segments, replace with borrow (sourced on-site from Kendrick Creek delta), consolidate and cover in 900-Foot Level Open Pit Repository.
	I&L Spur Road	Remove road materials and consolidate in 900-Foot Level Open Pit Repository, and close road to preclude vehicle access following material removal.
	Spilled Ore in Intertidal Zone at Ore Loading Ramps	Same as Alternative M-2 - Localized removal of ore from intertidal zone near ore loading ramps for consolidation in 900-Foot Level Open Pit Repository.
	Miscellaneous Wastes & Debris	Same as Alternative M-2

Table 6-1b. Summary of Removal Action Alternatives for Portals

Alternative Name	Area of Site	Process Options Included
Alternative P-1 **No Action**	900-Foot Level Portal, 900-Level Vent Shaft, 700-Foot Level Portal, 300-Foot Level Portal	Present conditions remain at portals, with no measures to reduce risk or monitor conditions.
Alternative P-2 **Close Upper Mine Openings and Gate at 300-Foot Level Portal**	900-Foot Level Portal, 900-Foot Level Vent Shaft, 700-Foot Level Portal	Close upper mine opening to reduce air entry into underground mine. Would allow water drainage of Open Pit and water inflow into underground mine via 900-Foot Level Portal (common element to all alternatives).
	300-Foot Level Portal	Install Gate to prevent human access, air exhalation significantly reduced by eliminating air entry by closure of upper mine openings, and water outflow would still occur. Outflow could be piped directly to Kendrick Creek.
Alternative P-3 **Close Upper Mine Openings and Rock Backfill at 300-Foot Level Portal**	900-Foot Level Portal, 900-Foot Level Vent Shaft, 700-Foot Level Portal	Same as Alternative P-2
	300-Foot Level Portal	Backfill portal with aggregate or mine rock to prevent access, reduce air outflow and radon exhalation, and construct engineered outflow structure to pipe portal drainage directly to Kendrick Creek.
Alternative P-4 **Close upper Mine Openings and Concrete Bulkhead at 300-Foot Level Portal**	900-Foot Level Portal, 900-Foot Level Vent Shaft, 700-Foot Level Portal	Same as Alternative P-2
	300-Foot Level Portal	Install concrete bulkhead to prevent access, eliminate air outflow and radon exhalation, and construct engineered outflow structure to pipe portal drainage directly to Kendrick Creek.

Table 6-2. Estimated Volume of Cover Required for Alternatives M-3, M-4, and M-5

Alternative	Location	Area[1] (sy)[2]	Cover Volume Required Based on Cover Thickness (CY)[2]	
			1-Foot	2-Feet
M-3	OSA	4,883	N/A	3,256
	300-Foot Level MRP	11,741	N/A	7,827
	700-Foot Level MRP	4,086	N/A	2,724
	900-Foot Level MRP (North)	4,423	N/A	2,949
	900-Foot Level MRP (South)	588	N/A	392
	Mine Road 700-Foot to 900-Foot Levels	2,328	776[3]	N/A
	Haul Road OSA to 300-Foot Level	4,799	1,600[3]	N/A
	Haul Road – Intersection to 900-Foot Level	4,362	1,454[3]	N/A
Total Volume of Cover Required for Alternative M-3 (CY)			**20,978**	
M-4	300-Foot Level Repository[4]	11,248	N/A	7,499
	Open Pit Repository[5]	2,967	N/A	1,978
	Haul Road OSA to 300-Foot Level	4,799	1,600[3]	N/A
	Haul Road – Intersection to 900-Foot Level	4,362	1,454[3]	N/A
Total Volume of Cover Required for Alternative M-4 (CY)			**12,531**	
M-5	Open Pit Repository[6]	12,842	N/A	8,561
	Haul Road – Intersection to 900-Foot Level	4,362	1,454[3]	N/A
Total Volume of Cover Required for Alternative M-5 (CY)			**11,615**	

Note:

1) Area of mine rock piles are areas after in-place stabilization and prior to covering
2) SY = Square yards, CY = Cubic yards
3) Roads will only be covered with one-foot of cover material; other thicknesses are not applicable to road areas.
4) Includes OSA material and ore rock from intertidal area.
5) Includes 700-Foot Level mine rock, 900-Foot Level mine rock piles (north and south), I&L Spur Road, Mine Road embankment materials, and select areas of Haul Roads.
6) Includes OSA, 300-Foot Level mine rock, 700-Foot Level mine rock, 900-Foot Level mine rock piles (north and south), I&L Spur Road, Mine Road embankment materials, and select areas of Haul Roads.

Table 6-3. Summary of Required Volumes of Rock Armor and Mine Rock Pile Protection for Alternatives M-2 through M-5

Alternative	Location	Material Volumes Required (CY) [1]			
		Area of Geotextile Filter Cover (sy)[1]	Cobble/Boulder Toe Protection	Upgradient Stormwater Control Ditch	Rock Armor Over Select Covered Areas
M-2[2]	300-Foot Level MRP	187	83	N/A	N/A
	700-Foot Level MRP	148	164	N/A	N/A
	900-Foot Level MRP (N and S)	380	169	N/A	N/A
	900-Foot Level Open Pit[3]	30	13	N/A	N/A
Total Area/Volume for Alternative M-2		**745**	**430**	N/A	**N/A**
M-3	OSA	4,883	N/A	N/A	N/A
	300-Foot Level MRP	11,741	83	308	N/A
	700-Foot Level MRP	4,086	164	160	681
	900-Foot Level MRP (N and S)	4,423	169	279	835
	900-Foot Level Open Pit[3]	588	13	N/A	N/A
Total Area/Volume for Alternative M-3		**25,721**	**430**	**747**	**1,516**
M-4	300-Foot Level MRP	11,248	74	308	N/A
	900-Foot Level Open Pit[3]	2,967	N/A	N/A	495
Total Area/Volume for Alternative M-4		**14,215**	**74**	**308**	**495**
M-5	900-Foot Level Open Pit[3]	12,842	N/A	N/A	2,140
Total Area/Volume for Alternative M-5		**12,842**	N/A	N/A	**2,140**

Note:
1) SY = Square yards, CY = Cubic yards
2) The upgradient stormwater control ditches constructed in Alternative M-2 will be constructed with the mine rock from the mine rock pile.
3) At the 900-Foot level Open Pit, cobble/boulder materials will be used to construct berms as shown in Figures 6-11, 6-21 and 6-26, respectively.
4) N/A = not applicable at this location

Table 6-4. Summary of Material Types and Suppliers of Off-Site Cover Material

Material Source (Location)	Material Name (USCS Classification if known)	Material Cost Delivered to Site and Stockpiled (Cost/CY)
Ketchikan Ready Mix (Ketchikan, AK)	Silty Sand (SM)	$27.00 - $30.00
	Crushed product ranging from 6" minus down to 3/8" minus	$62.42
	Washed sand	$90.00
Ascot Resources (Stewart, BC)	3/8" minus (SP)	$24.31
	¼" minus crushed (SM)	$24.31
	Reject Blend Sand (3/8"minus)	$20.64
	Embankment Peat Soil/Growth Medium	$18.02
	Screened Peat Soil/Growth Medium	$19.07
SE Road Builders (Klawock, AK)	Sand/Silt (SM or ML)	$58.00
	½" minus crushed	$44.00

Note: Material costs from 2011

Table 6-5a. Radon Flux from Mine Rock Areas – Mine Rock Alternative M-1 – No Action

Location	Exit Flux (pCi/m^2*s)
OSA	83.7
300-Foot Level MRP	22.0
700-Foot Level MRP	65.4
900-Foot Level North MRP	45.9
900-Foot Level South MRP	69.4
900-Foot Level Open Pit	65.4

Table 6-5b. Radon Flux from Mine Rock Areas – Mine Rock Alternative M-2 – In Place Stabilization and Institutional and Stormwater Controls

Location	Exit Flux (pCi/m^2*s)
OSA	83.7
300-Foot Level MRP	22.0
700-Foot Level MRP	65.4
900-Foot Level North MRP	45.9
900-Foot Level South MRP	69.4
900-Foot Level Open Pit	65.4

Table 6-5c. Radon Flux from Mine Rock Areas – Mine Rock Alternative M-3 – Cover in Place

Location	Exit Flux (pCi/m^2*s)
OSA with Cover	33.5
300-Foot Level MRP with Cover	14.9
700-Foot Level MRP with Cover	44.1
900-Foot Level North MRP with Cover	31.0
900-Foot Level South MRP with Cover	46.9
900-Foot Level Open Pit	65.4

Table 6-5d. Radon Flux from Mine Rock Areas – Mine Rock Alternative M-4 – Excavation, Consolidation, and Cover at Mine Affected Areas

Location	Exit Flux (pCi/m^2*s)
300-Foot Level Repository with Cover	20.0
Open Pit Repository with Cover	31.2

Note: In Alternative M-4, the OSA will be placed on top of the 300-Foot Level mine rock pile and then covered with material from the 300-Foot Level pile and then the cover material. The order of placement of mine-affected materials in the in the Open Pit will consist of the 900-Foot Level South mine rock pile at the bottom, followed by the 700-Foot Level mine rock pile, the mine road embankment material, and the 900-Foot Level North mine rock pile at the top of the Open Pit repository before cover material is placed.

Table 6-5e. Radon Flux from Mine Rock Areas – Mine Rock Alternative M-5 – Excavation, Consolidation in Open Pit Repository at 900-Foot Level

Location	Exit Flux (pCi/m^2*s)
Open Pit Repository with Cover	16.2

Note: In Alternative M-5, the order of placement of materials in the in the Open Pit will consist of the OSA at the bottom, followed by the 900-Foot Level South mine rock pile, the 700-Foot Level mine rock pile, the mine road embankment material, the 900-Foot Level North mine rock pile, and the 300-Foot Level mine rock pile at the top of the Open Pit repository before the cover material is placed.

Table 6-6. Summary of Costs - Mine Rock Alternative M-2 - In Place Stabilization and Institutional and Stormwater Controls

Item	Unit Cost	Unit	Quantity	Cost (2014$)
CAPITAL DIRECT COSTS				
Mobilization	$108,077	LS	1	$114,561
Radiation Safety, Decon and Monitoring	$72,010	LS	1	$76,331
Site Preparation	$70,100	LS	1	$74,306
Common Elements	$338,471	LS	1	$358,779
Stabilize In Place	$82,083	LS	1	87,008
Institutional Controls	$15,000	LS	1	$15,000
SUBTOTAL DIRECT CAPITAL COST				**$725,986**
Stormwater, Erosion, and Dust Controls		**%**	**5%**	**$36,299**
TOTAL DIRECT CAPITAL COST				**$762,285**
INDIRECT CAPITAL COSTS				
Engineering Design		%	10%	$76,228
Permitting	$25,000	LS	1	$25,000
Regulatory Compliance		%	4%	$30,491
Construction QA and Management		%	8%	$60,983
Owners Management		%	15%	$114,343
Direct Capital Cost Contingency		%	20%	$152,457
TOTAL INDIRECT CAPITAL COST				**$459,502**
TOTAL CAPITAL COST (Indirect + Direct)				**$1,221,787**
M&M Present Worth (30 year)				**$205,690**
Total Project Cost				**$1,427,477**

Note: A discount rate of 3.9% was used in the engineering economic analysis. Unit costs are in 2011 dollars and construction related costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

Table 6-7. Summary of Costs - Mine Rock Alternative M-3 - Cover in Place

Item	Unit Cost	Unit	Quantity	Cost (2014$)
CAPITAL DIRECT COSTS				
Mobilization	$414,640	LS	1	$439,518
Health and Safety	$196,906	LS	1	$208,721
Site Preparation	$105,200	LS	1	$111,512
Common Elements	$413,539	LS	1	$438,351
Cover Material	$309,274	LS	1	$327,831
Cover and Stabilize In Place	$585,995	LS	1	$621,155
Institutional Controls	$15,000	LS	1	$15,000
SUBTOTAL DIRECT CAPITAL COST				**$2,162,087**
Stormwater, Erosion, and Dust Controls		**%**	**5%**	**$108,104**
TOTAL DIRECT CAPITAL COST				**$2,270,192**
INDIRECT CAPITAL COSTS				
Engineering Design		**%**	10%	$227,019
Permitting	$125,000	LS	1	$125,000
Regulatory Compliance		**%**	4%	$90,808
Construction QA and Management		**%**	8%	$181,615
Closure Documentation		**%**	4%	$90,808
Owners Management		**%**	15%	$340,529
Direct Capital Cost Contingency		**%**	20%	$454,038
TOTAL INDIRECT CAPITAL COST				**$1,509,817**
TOTAL CAPITAL COST (Indirect + Direct)				**$3,780,009**
M&M Present Worth (30 year)				**$205,690**
Total Project Cost				**$3,985,698**

Note: A discount rate of 3.9% was used in the engineering economic analysis. Unit costs are in 2011 dollars and construction related costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

Table 6-8. Summary of Costs - Mine Rock Alternative M-4 – Excavation, Consolidation, and Cover at Mine Affected Areas

Item	Unit Cost	Unit	Quantity	Cost (2014$)
CAPITAL DIRECT COSTS				
Mobilization	$299,950	LS	1	$317,947
Radiation Safety, Decon and Monitoring	$144,457	LS	1	$153,125
Site Preparation	$105,200	LS	1	$111,512
Common Elements	$417,847	LS	1	$442,917
Cover Material	$188,204	LS	1	$199,496
Excavate to 300-Foot Level and Open Pit and Cover	$733,270	LS	1	$777,266
Institutional Controls	$9,000	LS	1	$9,000
SUBTOTAL DIRECT CAPITAL COST				**$2,011,263**
Stormwater, Erosion, and Dust Controls		**%**	**5%**	**$100,563**
TOTAL DIRECT CAPITAL COST				**$2,111,826**
INDIRECT CAPITAL COSTS				
Engineering Design		%	10%	$211,183
Permitting	$125,000	LS	1	$125,000
Regulatory Compliance		%	4%	$84,473
Construction QA and Management		%	8%	$168,946
Owners Management		%	15%	$316,774
Direct Capital Cost Contingency		%	20%	$422,365
TOTAL INDIRECT CAPITAL COST				**$1,328,741**
TOTAL CAPITAL COST (Indirect + Direct)				$3,440,567
M&M Present Worth (30 year)				$151,523
Total Project Cost				**$3,592,090**

Note: A discount rate of 3.9% was used in the engineering economic analysis. Unit costs are in 2011 dollars and construction related costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

Table 6-9. Summary of Costs - Mine Rock Alternative M-5 – Excavation, Consolidation in Open Pit Repository at 900-Foot Level

Item	Unit Cost	Unit	Quantity	Cost (2014$)
CAPITAL DIRECT COSTS				
Mobilization	$780,785	LS	1	$827,633
Radiation Safety, Decon and Monitoring	$366,446	LS	1	$388,433
Site Preparation	$105,200	LS	1	$111,512
Common Elements	$462,358	LS	1	$490,100
Cover Material	$141,775	LS	1	$150,282
Excavate to Open Pit and Cover	$1,636,260	LS	1	$1,734,435
Institutional Controls	$7,000	LS	1	$7,000
SUBTOTAL DIRECT CAPITAL COST				**$3,709,394**
Stormwater, Erosion, and Dust Controls		**%**	**5%**	**$185,470**
TOTAL DIRECT CAPITAL COST				**$3,894,864**
INDIRECT CAPITAL COSTS				
Engineering Design		**%**	10%	$389,486
Permitting	$125,000	LS	1	$125,000
Regulatory Compliance		**%**	4%	$155,795
Construction QA and Management		**%**	8%	$311,589
Owners Management		**%**	15%	$584,230
Direct Capital Cost Contingency		**%**	20%	$778,973
TOTAL INDIRECT CAPITAL COST				**$2,345,072**
TOTAL CAPITAL COST (Indirect + Direct)				$6,239,936
M&M Present Worth (30 year)				$133,467
Total Project Cost				**$6,373,403**

Note: A discount rate of 3.9% was used in the engineering economic analysis. Unit costs are in 2011 dollars and construction related costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

Table 6-10. Cost Comparison for Mine Rock Alternatives

Alternative Scenario	Total Direct Capital Costs	Total In-Direct Capital Costs	Total Capital Cost	Present Worth M&M Costs	Total Project Present Worth
Mine Rock Alternative M-2	$762,285	$459,502	$1,221,787	$205,690	**$1,427,477**
Mine Rock Alternative M-3	$2,270,192	$1,509,817	$3,780,009	$205,690	**$3,985,698**
Mine Rock Alternative M-4	$2,111,826	$1,328,741	$3,440,567	$151,523	**$3,592,090**
Mine Rock Alternative M-5	$3,894,864	$2,345,072	$6,239,936	$133,467	**$6,373,403**

Table 6-11. Summary of Costs – Portal Alternative P-2 – Close Upper Mine Openings and Gate at 300-Foot Level Portal

	Unit Cost	Unit	Quantity	Cost (2014$)
CAPITAL DIRECT COSTS				
Mobilization	$118,650	LS	1	$125,769
Radiation Safety, Decon and Monitoring	$39,700	LS	1	$42,082
300-Foot Level Closure- Metal Gate	$25,585	LS	1	$27,120
Closure of Upper Mine Openings	$228,150	LS	1	$241,839
Institutional Controls	$5,000	LS	1	$5,000
TOTAL DIRECT CAPITAL COST				**$441,810**
INDIRECT CAPITAL COSTS				
Engineering Design		%	10	$44,181
Regulatory Compliance		%	4	$17,672
Construction QA and Monitoring		%	8	$35,345
Owner's Management		%	15	$66,272
Direct Capital Cost Contingency		%	20	$88,362
TOTAL INDIRECT CAPITAL COST				**$251,832**
TOTAL CAPITAL COST (Indirect + Direct)				**$693,642**
M&M Present Worth (30 year)				**$30,093**
Total Project Cost				**$723,735**

Note: A discount rate of 3.9% was used in the engineering economic analysis. Unit costs are in 2011 dollars and construction related costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

Table 6-12. Summary of Costs – Portal Alternative P-3 – Close Upper Mine Openings and Rock Backfill at 300-Foot Level Portal

Item	Unit Cost	Unit	Quantity	Cost (2014$)
CAPITAL DIRECT COSTS				
Mobilization	$118,650	LS	1	$125,769
Radiation Safety, Decon and Monitoring	$39,700	LS	1	$42,082
300-Foot Level Closure- Rock Backfill	$18,250	LS	1	$19,345
Closure of Upper Mine Openings	$228,150	LS	1	$241,839
300-Foot Level Portal Water Collection System	$22,400	LS	1	$23,744
Institutional Controls	$5,000	LS	1	$5,000
TOTAL DIRECT CAPITAL COST				**$457,779**
INDIRECT CAPITAL COSTS				
Engineering Design		%	10	$45,778
Regulatory Compliance		%	4	$18,311
Construction QA and Monitoring		%	8	$36,622
Owner's Management		%	15	$68,667
Direct Capital Cost Contingency		%	20	$91,556
TOTAL INDIRECT CAPITAL COST				**$260,934**
TOTAL CAPITAL COST (Indirect + Direct)				**$718,713**
M&M Present Worth (30 year)				**$94,040**
Total Project Cost				**$812,753**

Note: A discount rate of 3.9% was used in the engineering economic analysis. Unit costs in 2011 dollars and construction related costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

Table 6-13. Summary of Costs – Portal Alternative P-4 – Close Upper Mine Openings and Concrete Bulkhead at 300-Foot Level Portal

Item	Unit Cost	Unit	Quantity	Cost (2014$)
CAPITAL DIRECT COSTS				
Mobilization	$118,650	LS	1	$125,769
Radiation Safety, Decon and Monitoring	$39,700	LS	1	$42,082
300-Foot Level Closure- Concrete Bulkhead	$49,075	LS	1	$52,020
Closure of Upper Mine Openings	$228,150	LS	1	$241,839
300-Foot Level Portal Water Collection System	$22,400	LS	1	$23,744
Institutional Controls	$5,000	LS	1	$5,000
TOTAL DIRECT CAPITAL COST				**$490,454**
INDIRECT CAPITAL COSTS				
Engineering Design		%	10	$49,045
Regulatory Compliance		%	4	$19,618
Construction QA and Monitoring		%	8	$39,236
Owner's Management		%	15	$73,568
Direct Capital Cost Contingency		%	20	$98,091
TOTAL INDIRECT CAPITAL COST				**$279,558**
TOTAL CAPITAL COST (Indirect + Direct)				**$770,012**
M&M Present Worth (30 year)				**$94,040**
Total Project Cost				**$864,052**

Note: A discount rate of 3.9% was used in the engineering economic analysis. Unit costs in 2011 dollars and construction related costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

Table 6-14. Cost Comparison of Portal Alternatives

Alternative Scenario	Total Capital Cost	Total M&M Present Worth	Total Project Present Worth
Portal Alternative P-2	$693,642	$30,093	**$723,735**
Portal Alternative P-3	$718,713	$94,040	**$812,753**
Portal Alternative P-4	$770,012	$94,040	**$864,052**

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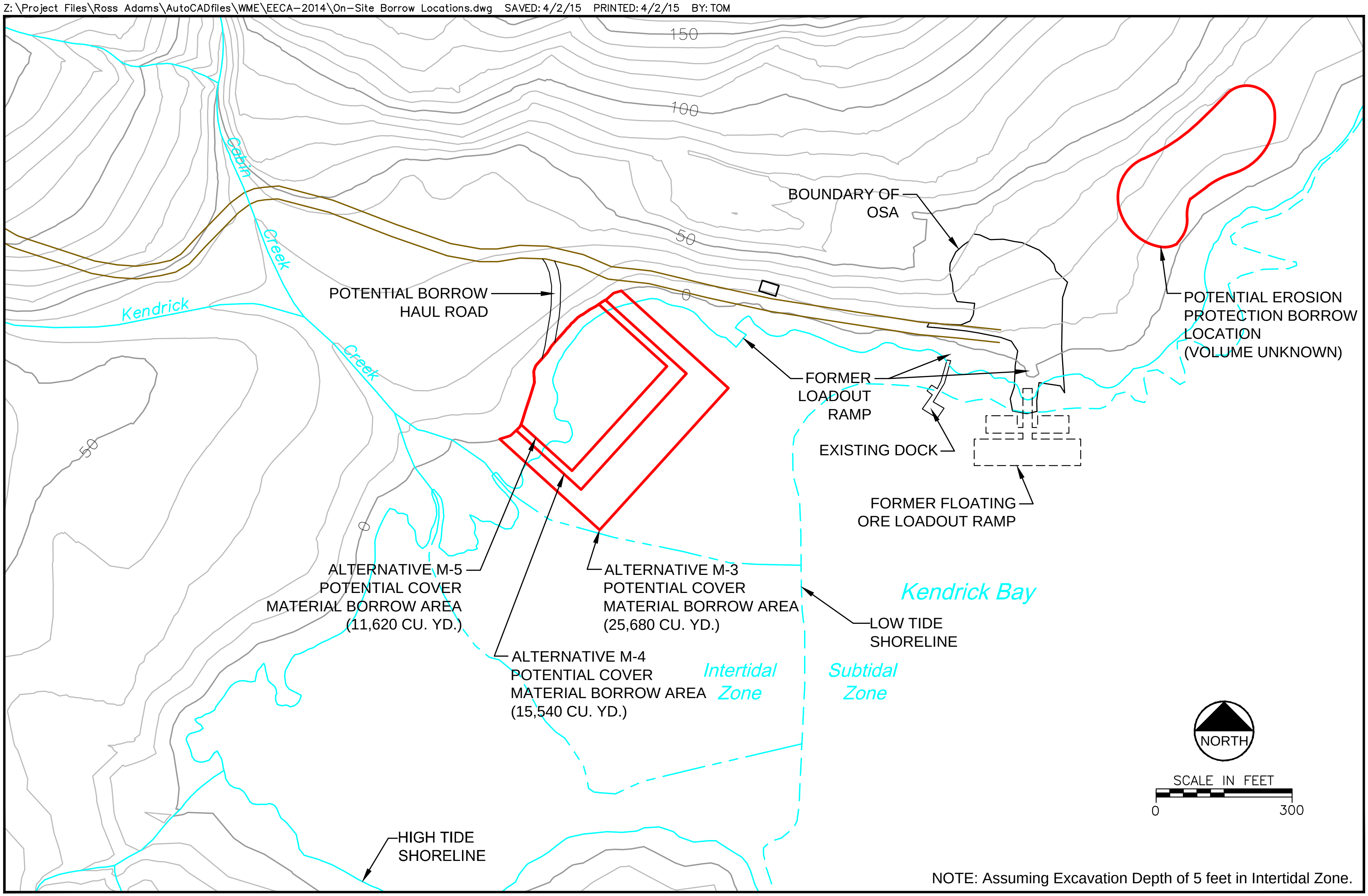

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Figure 6-1
Potential On-Site Borrow Locations

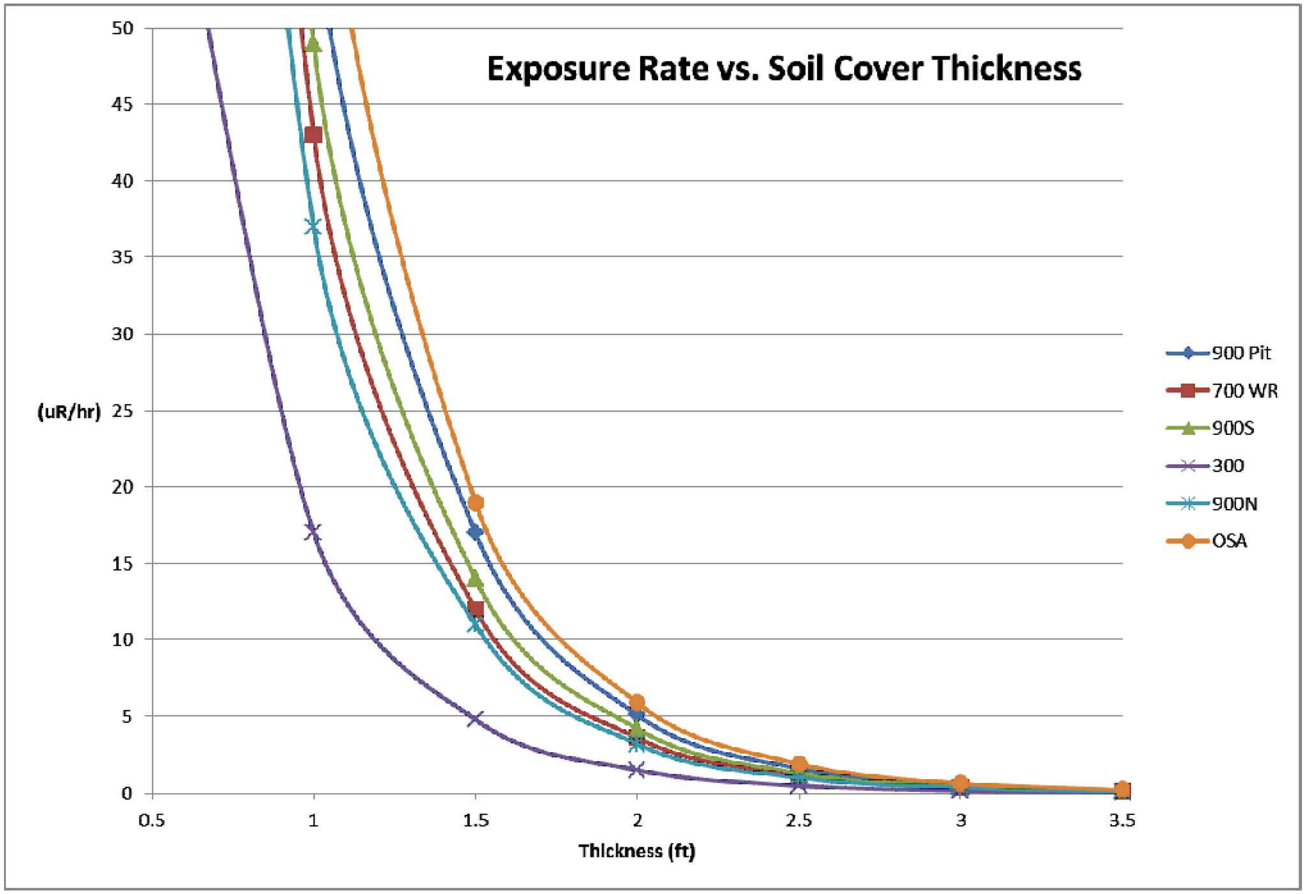

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Figure 6-2
Results of MicroShield Analysis Showing Shielded Exposure Rates for Cover Thickness up to 3.5 Feet

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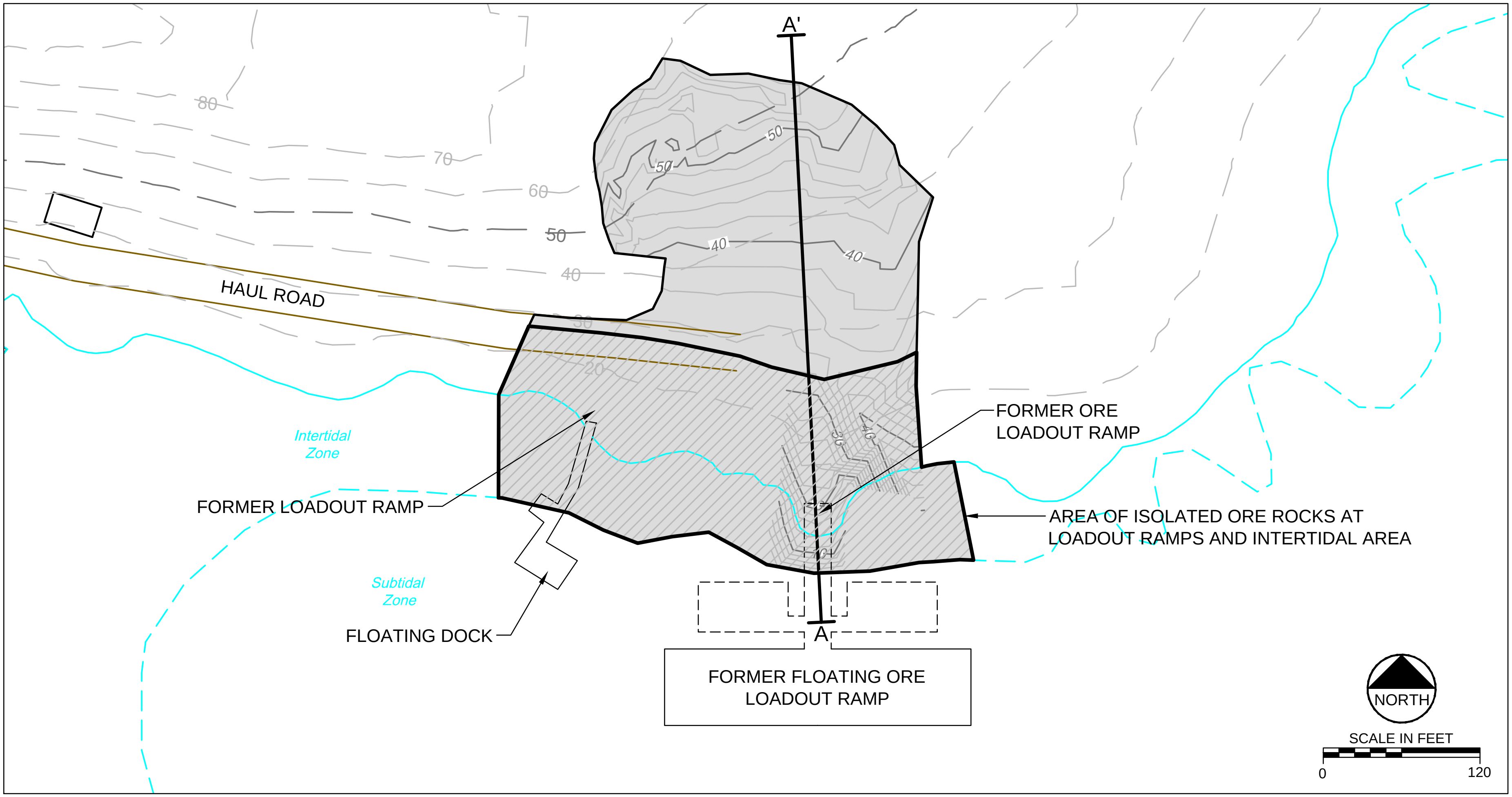

Existing Topography of OSA From Survey by R&M (Contour Interval = 2')

Existing Topography From Eagle Mapping (Contour Interval = 10')

Current Physical Boundary of OSA (Determined by Visual and Survey Limits)

Boundary of Isolated Ore Rocks Area

Existing Coastline Low Tide

Existing Coastline High Tide

Note: Eagle Mapping Adjustment +20'

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Figure 6-3
Mine Rock Alternative M-1 - No Action
OSA

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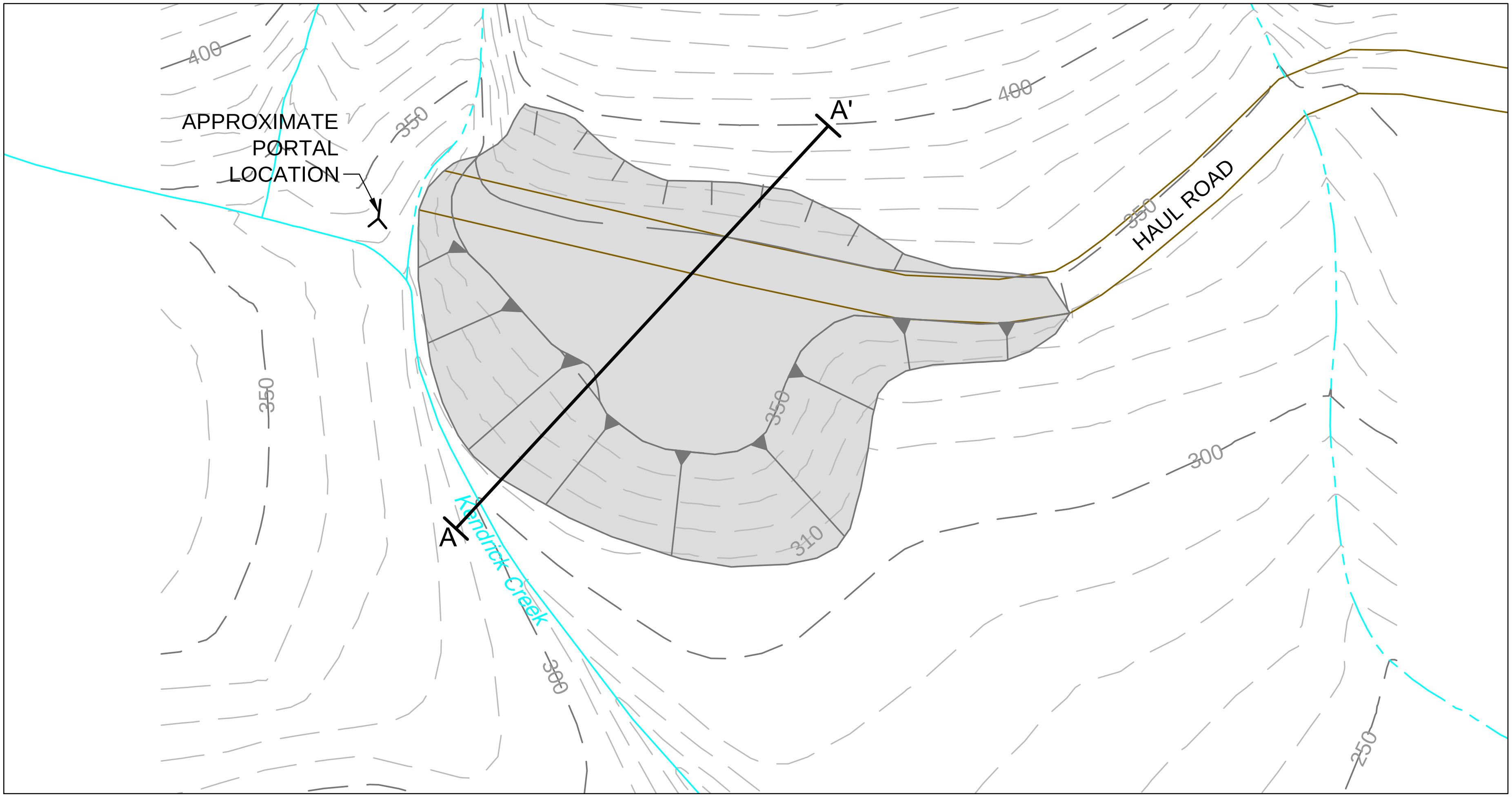

Current Physical Boundary of 300-Foot Level MRP (Estimated by Tetra Tech, 2010)

Existing Topography From Eagle Mapping (Contour Interval = 10')

Stream (Intermittent when Dashed)

SCALE IN FEET
0 100

NORTH

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Figure 6-4
Mine Rock Alternative M-1 - No Action
300-Foot Level

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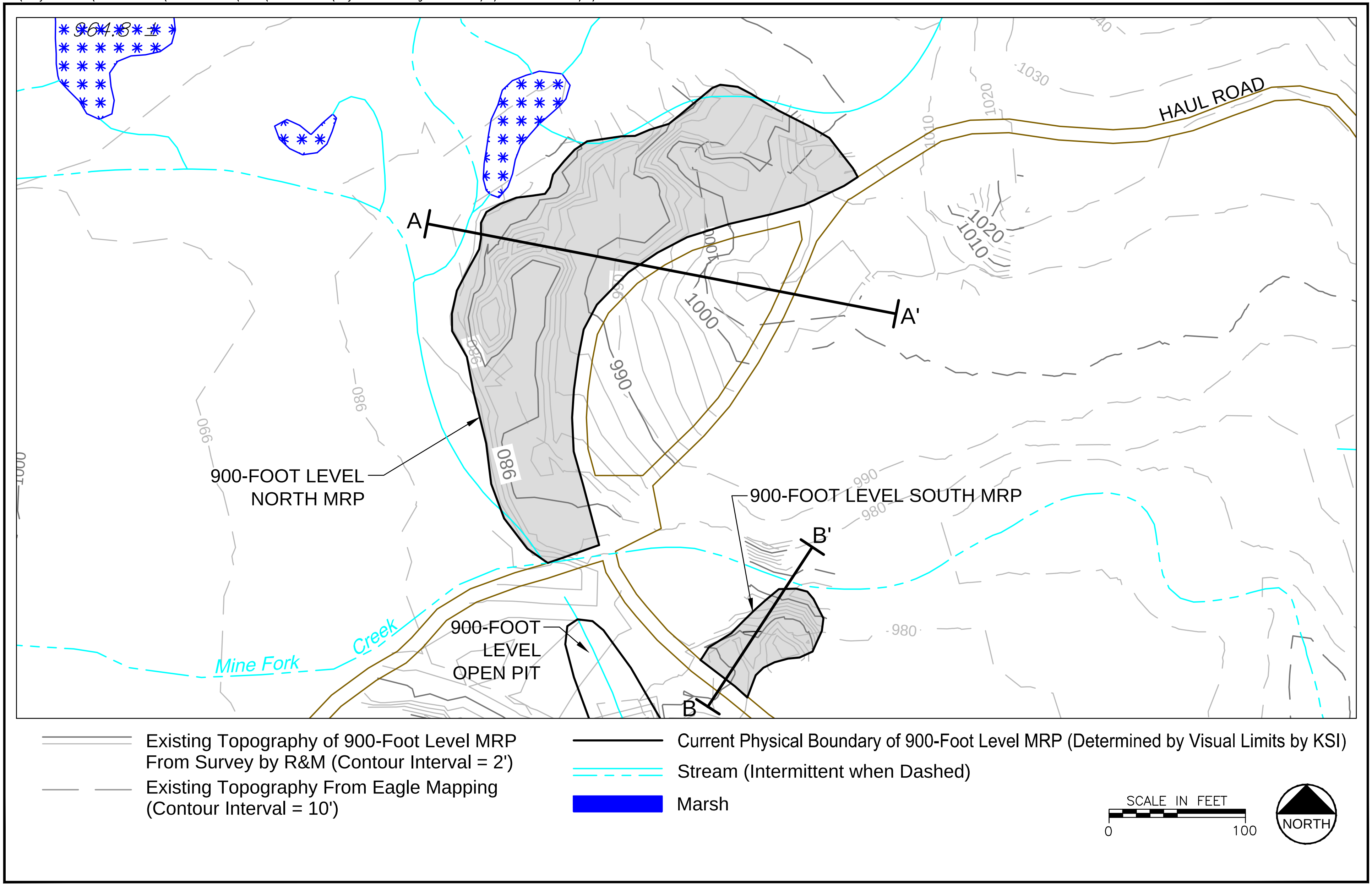

Note: Eagle Mapping Adjustment +23'

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Figure 6-5
Mine Rock Alternative M-1 - No Action
900-Foot Level

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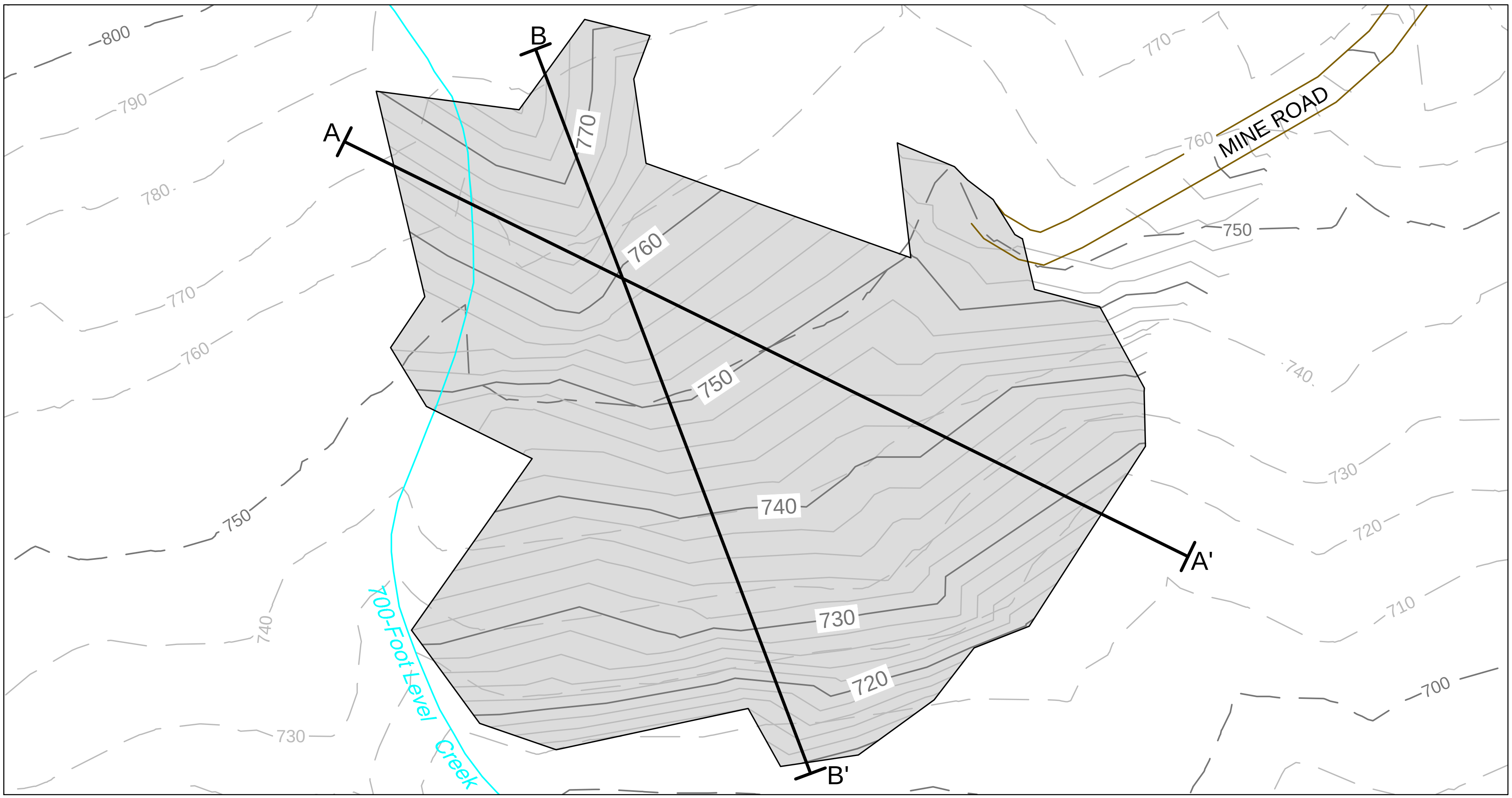

Existing Topography of 700-Foot Level MRP From Survey by R&M (Contour Interval = 2')

Existing Topography From Eagle Mapping (Contour Interval = 10')

Current Physical Boundary of 700-Foot Level MRP (Determined by Visual and Survey Limits)

Stream (Intermittent when Dashed)

SCALE IN FEET
0 50

NORTH

Note: Eagle Mapping Adjustment +21'

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Figure 6-6
Mine Rock Alternative M-1 - No Action
700-Foot Level

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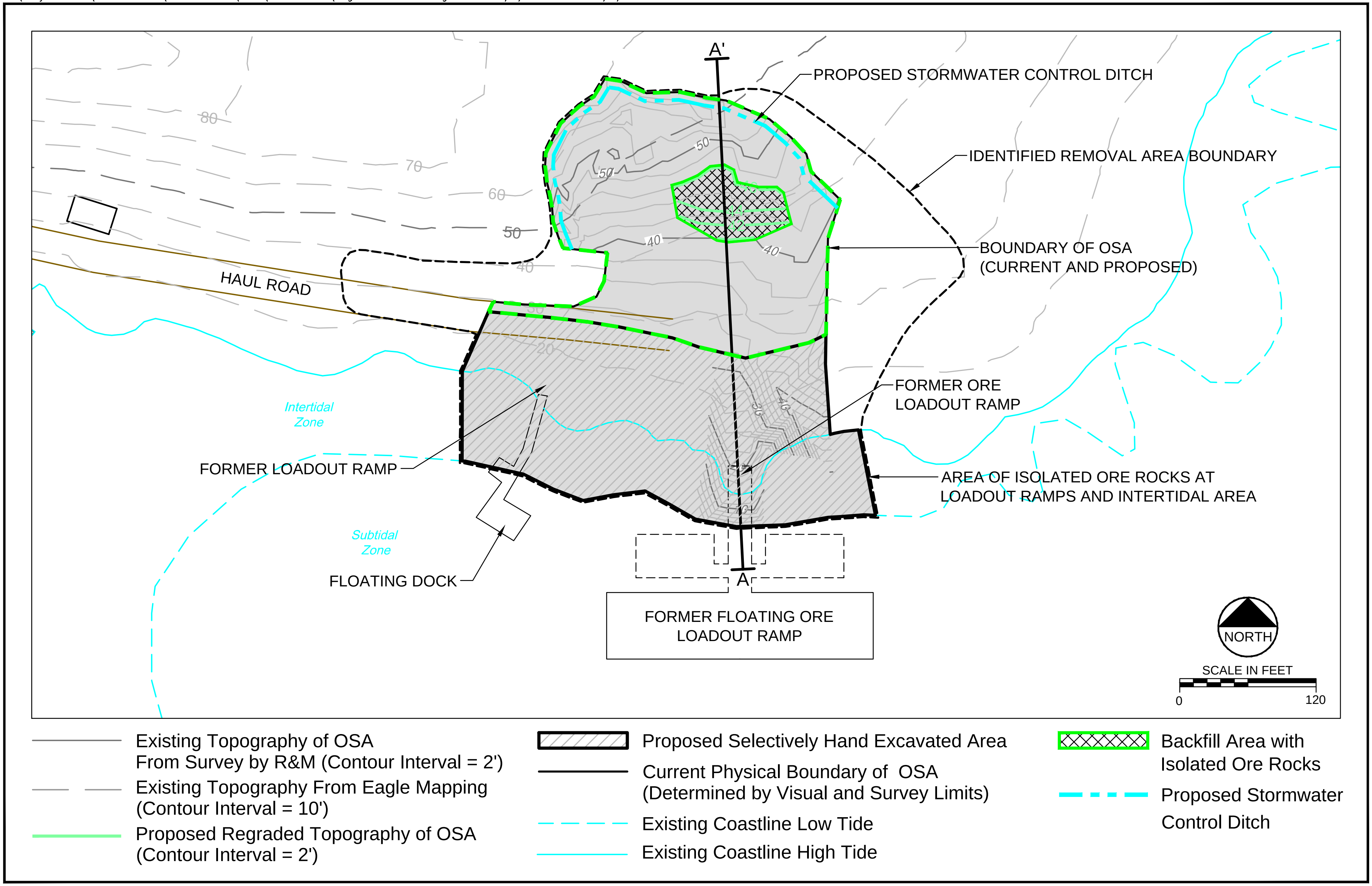

Note: Eagle Mapping Adjustment +20'

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Figure 6-7
Mine Rock Alternative M-2 - In Place Stabilization with Stormwater and Institutional Controls
OSA

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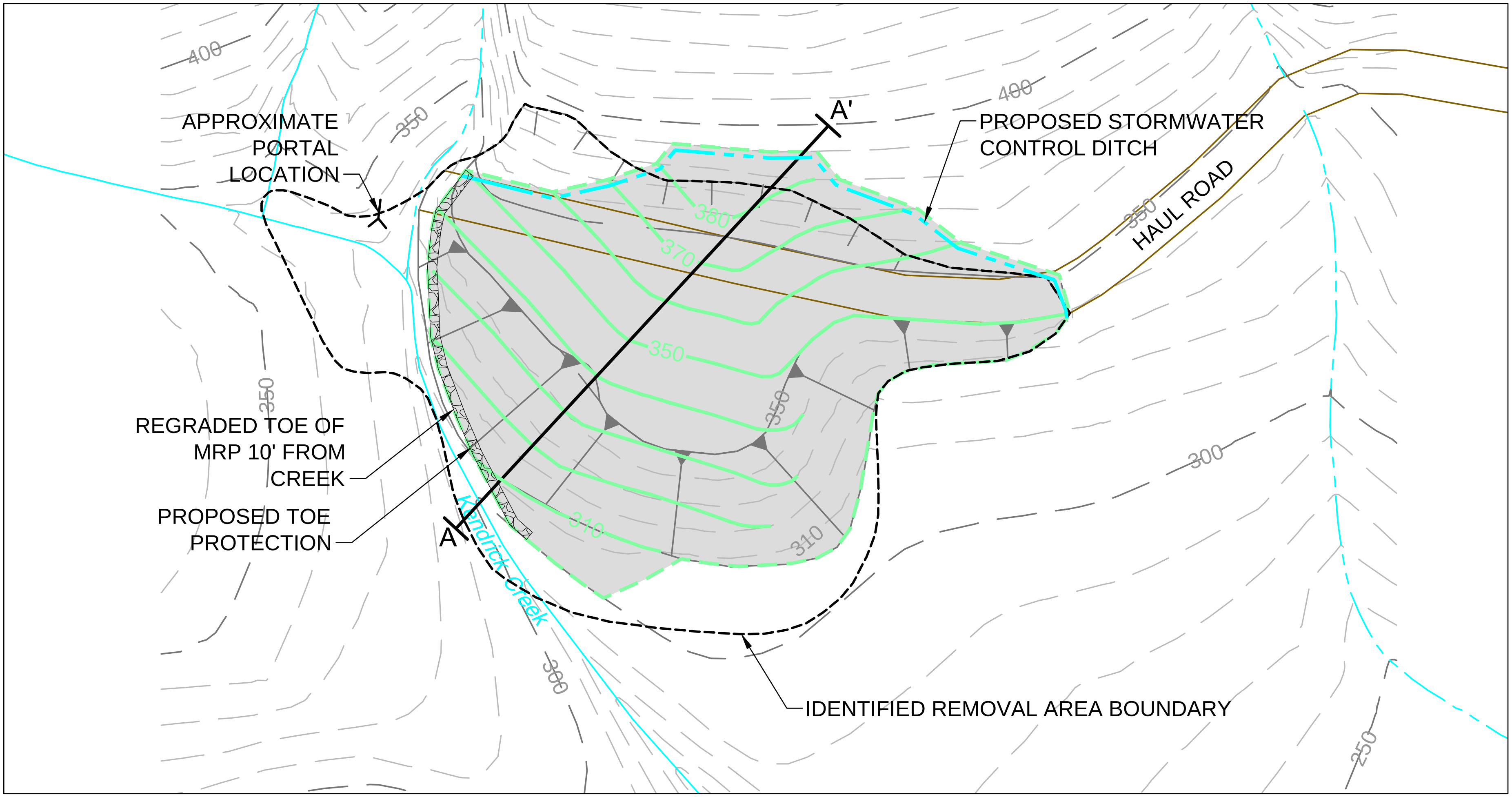

Current Physical Boundary of 300-Foot Level MRP (Estimated by Tetra Tech, 2010)
Existing Topography From Eagle Mapping (Contour Interval = 10')
Proposed Regraded Topography of 300-Foot Level MRP (Contour Interval = 10')
Proposed (Regraded) Boundary of 300-Foot Level MRP
Stream (Intermittent when Dashed)
Proposed Toe Protection
Proposed Stormwater Control Ditch

SCALE IN FEET
0 100
NORTH

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Figure 6-8
Mine Rock Alternative M-2 - In Place Stabilization with Stormwater and Institutional Controls
300-Foot Level

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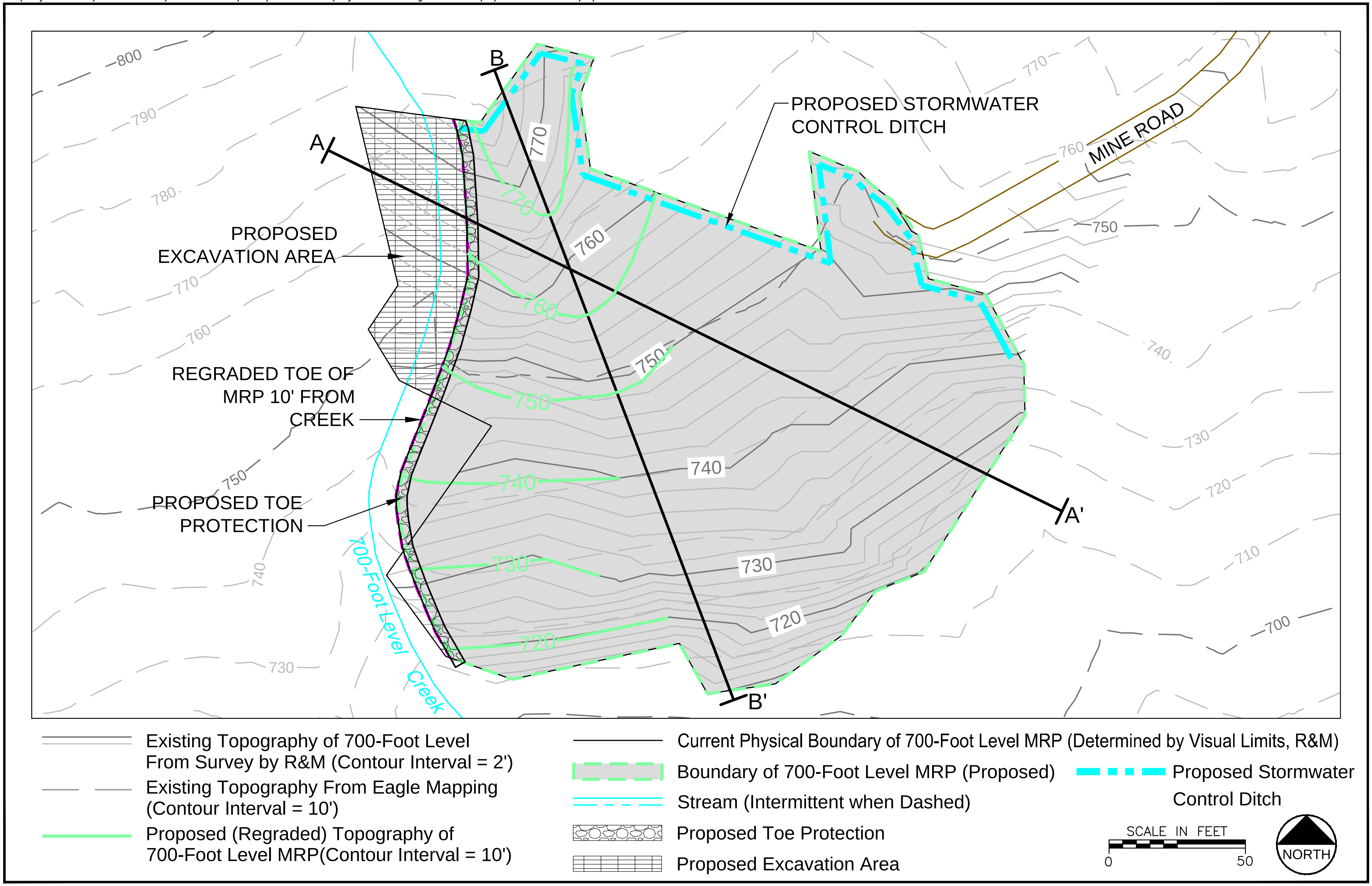

Note: Eagle Mapping Adjustment +21'

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Figure 6-9
Mine Rock Alternative M-2 - In Place Stabilization with Stormwater and Institutional Controls
700-Foot Level

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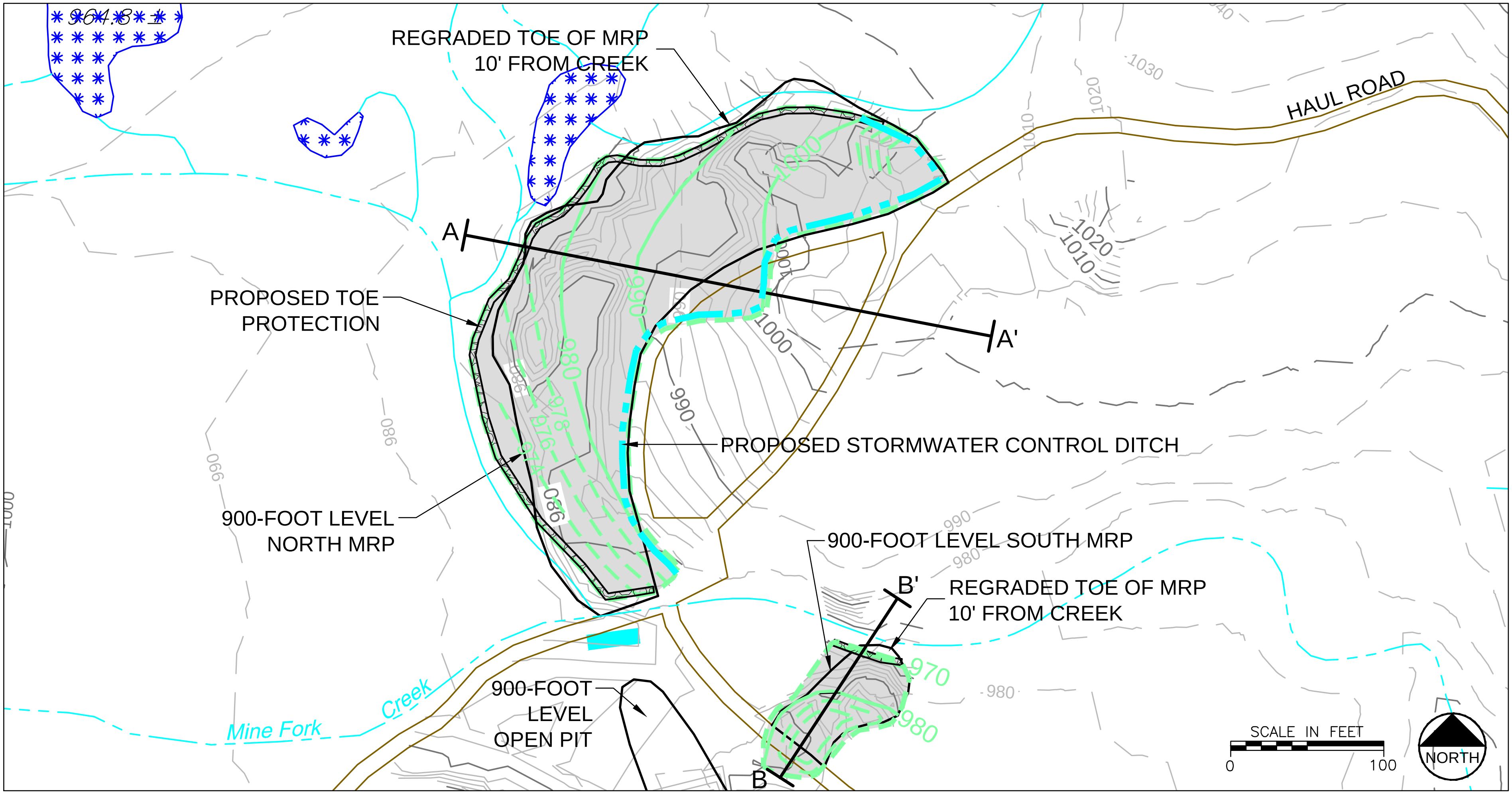

Existing Topography of 900-Foot Level MRP From Survey by R&M (Contour Interval = 2')

Existing Topography From Eagle Mapping (Contour Interval = 10')

Proposed Topography of 900-Foot Level MRP Contour Interval = 10' (2' Where Dashed)

Current Physical Boundary of 900-Foot Level MRP (Determined by Visual Limits by KSI)

Boundary of 900-Foot Level MRP (Proposed)

Stream (Intermittent when Dashed)

Marsh

Proposed Toe Protection

Proposed Stormwater Control Berm

Proposed Stormwater Control Ditch

Note: Eagle Mapping Adjustment +23'

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Figure 6-10
Mine Rock Alternative M-2 - In Place Stabilization with Stormwater and Institutional Controls
900-Foot Level

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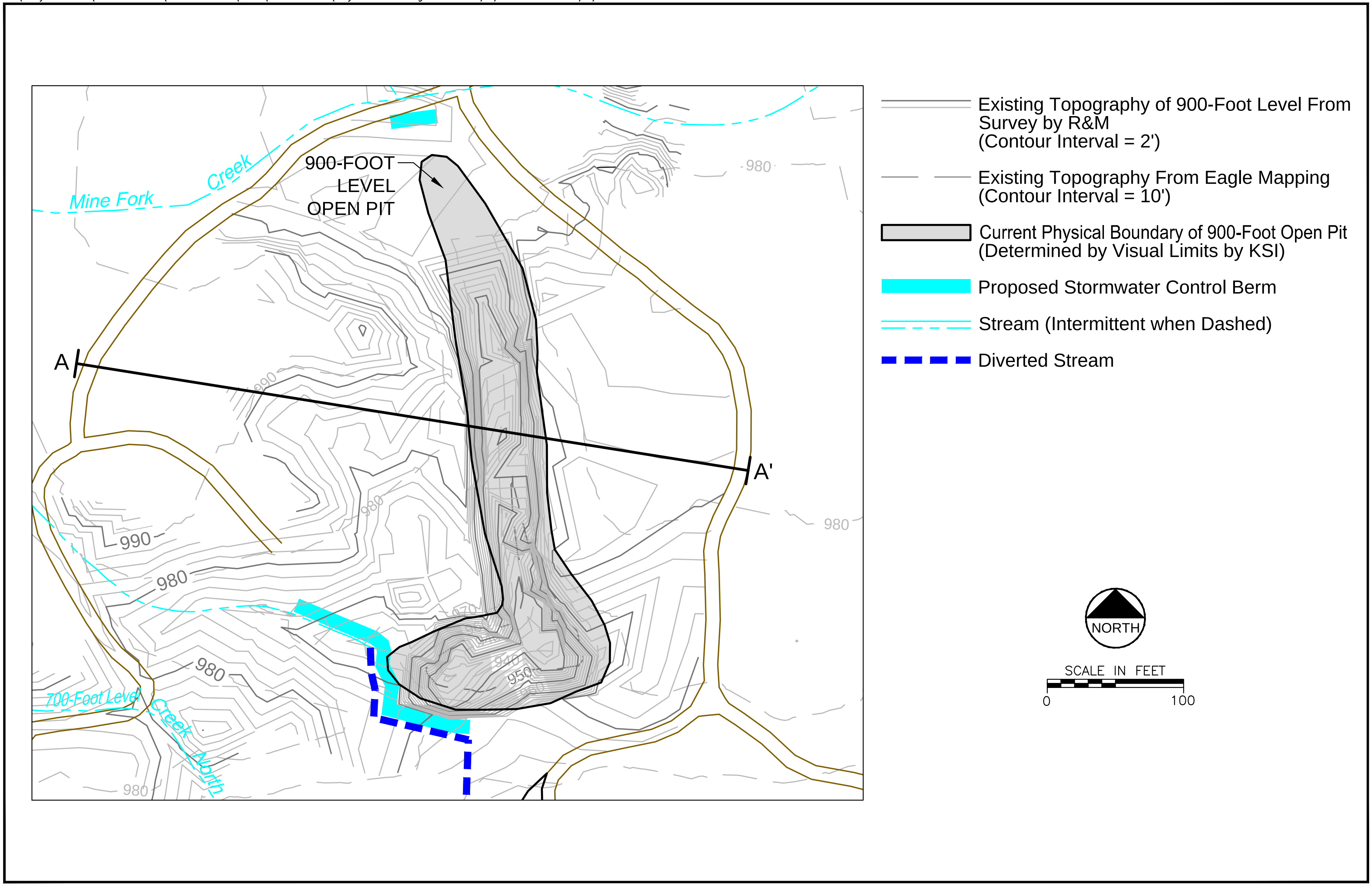

Note: Eagle Mapping Adjustment +23'

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Figure 6-11
Mine Rock Alternatives M-2 and M-3
900-Foot Level Open Pit

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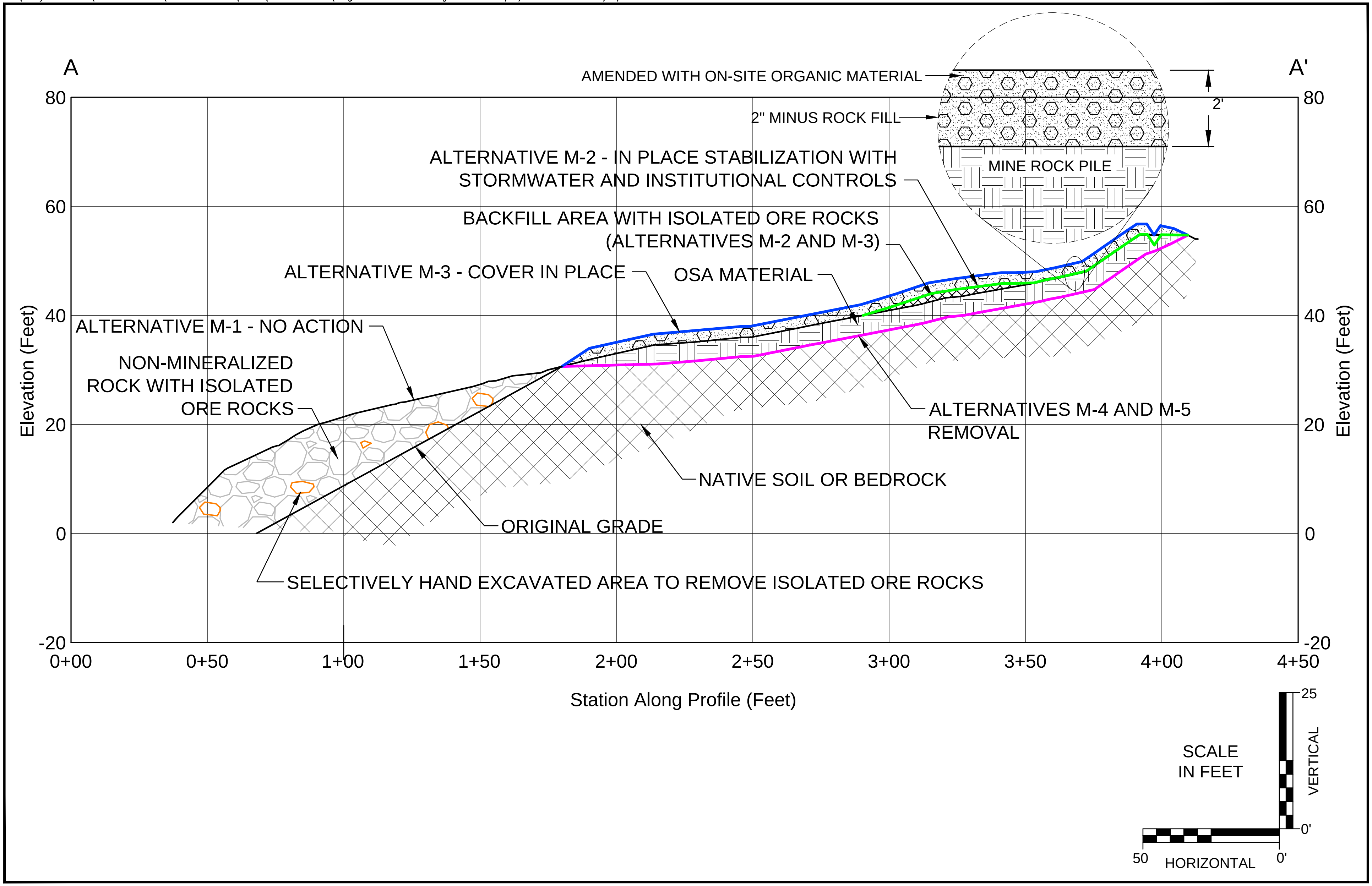

Note: Eagle Mapping Adjustment +20'

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Figure 6-12
Mine Rock Alternatives M-1 through M-5
Cross-Section through OSA

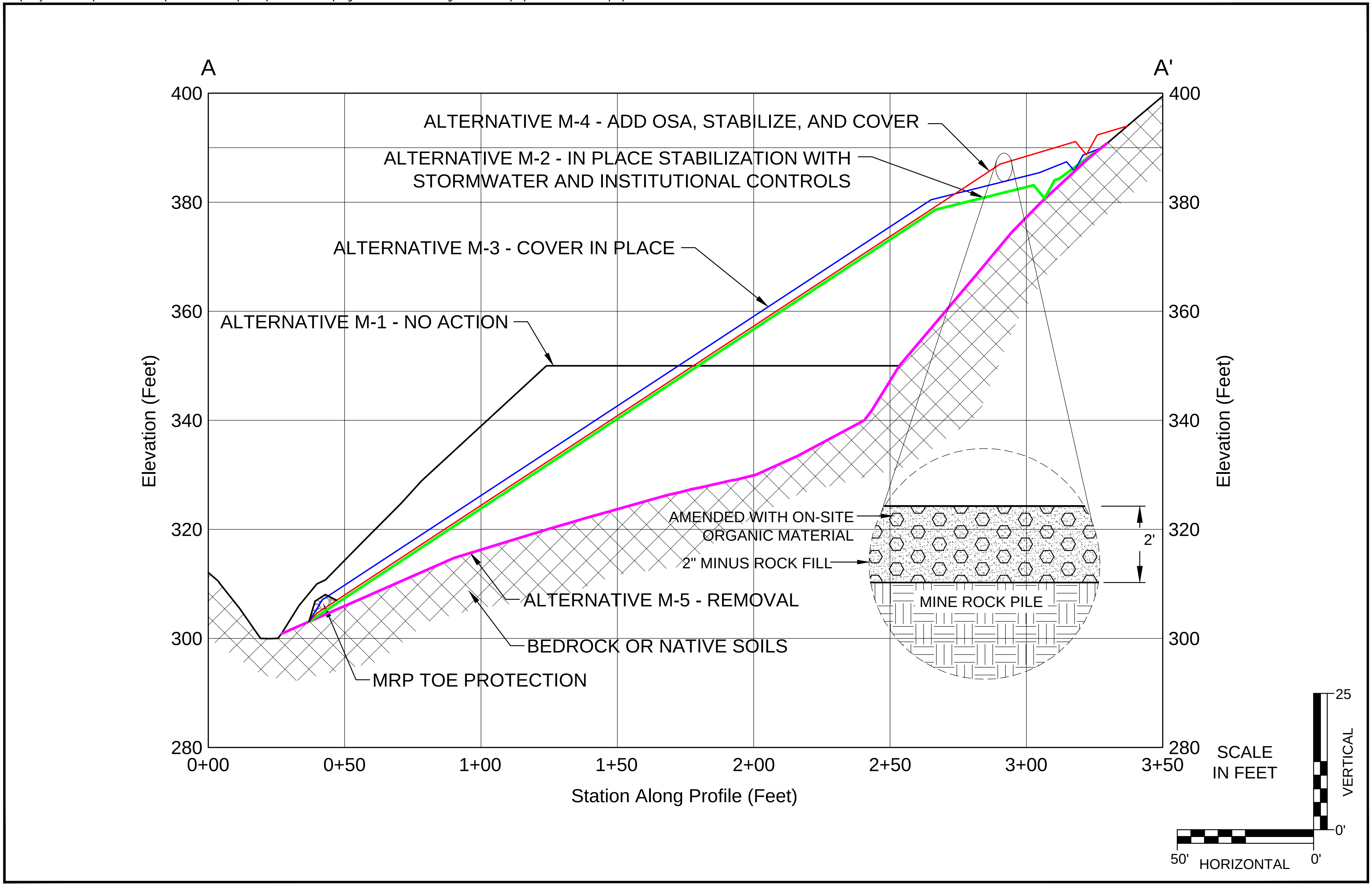

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Figure 6-13
Mine Rock Alternatives M-1 through M-5
Cross Section through 300-Foot Level

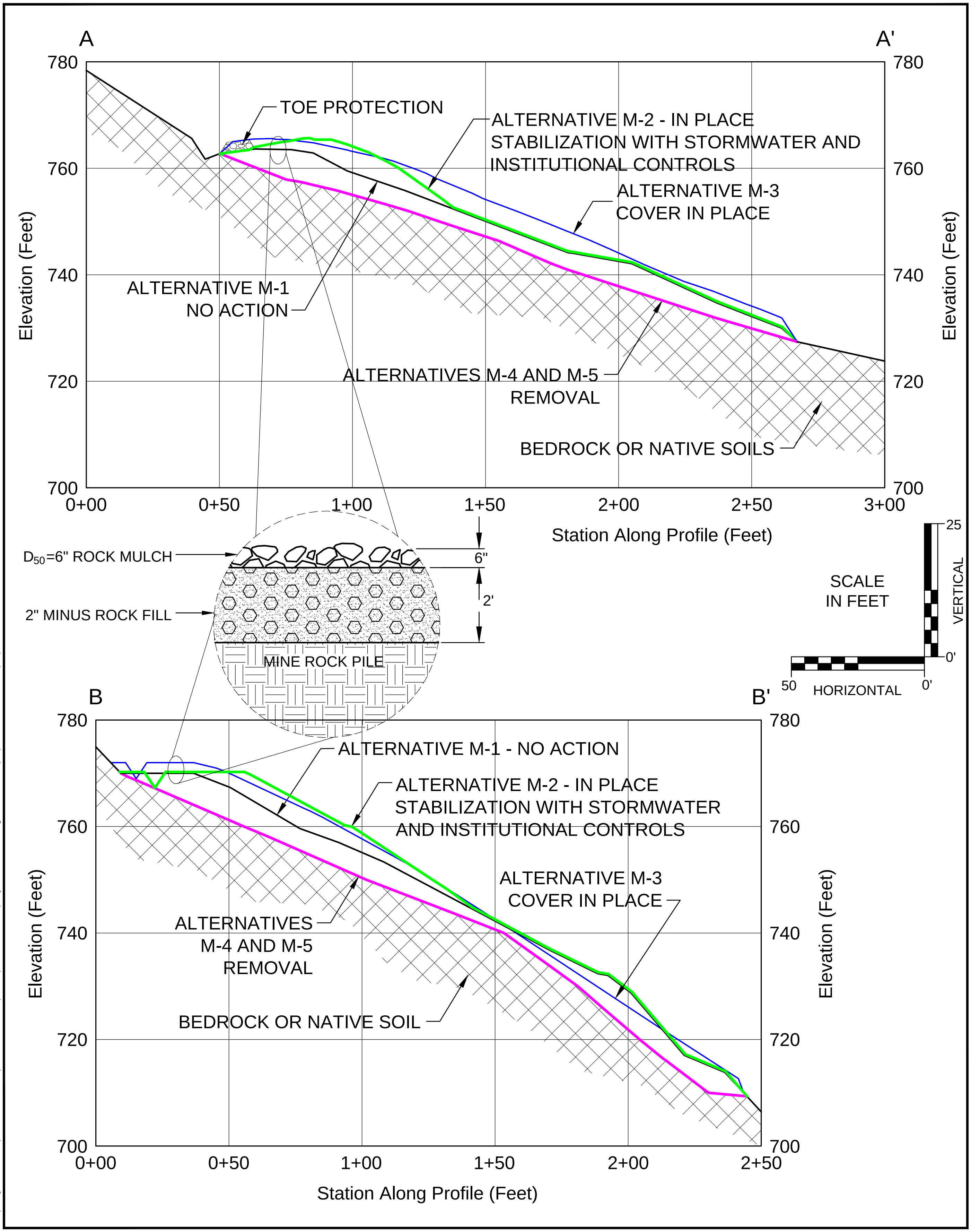

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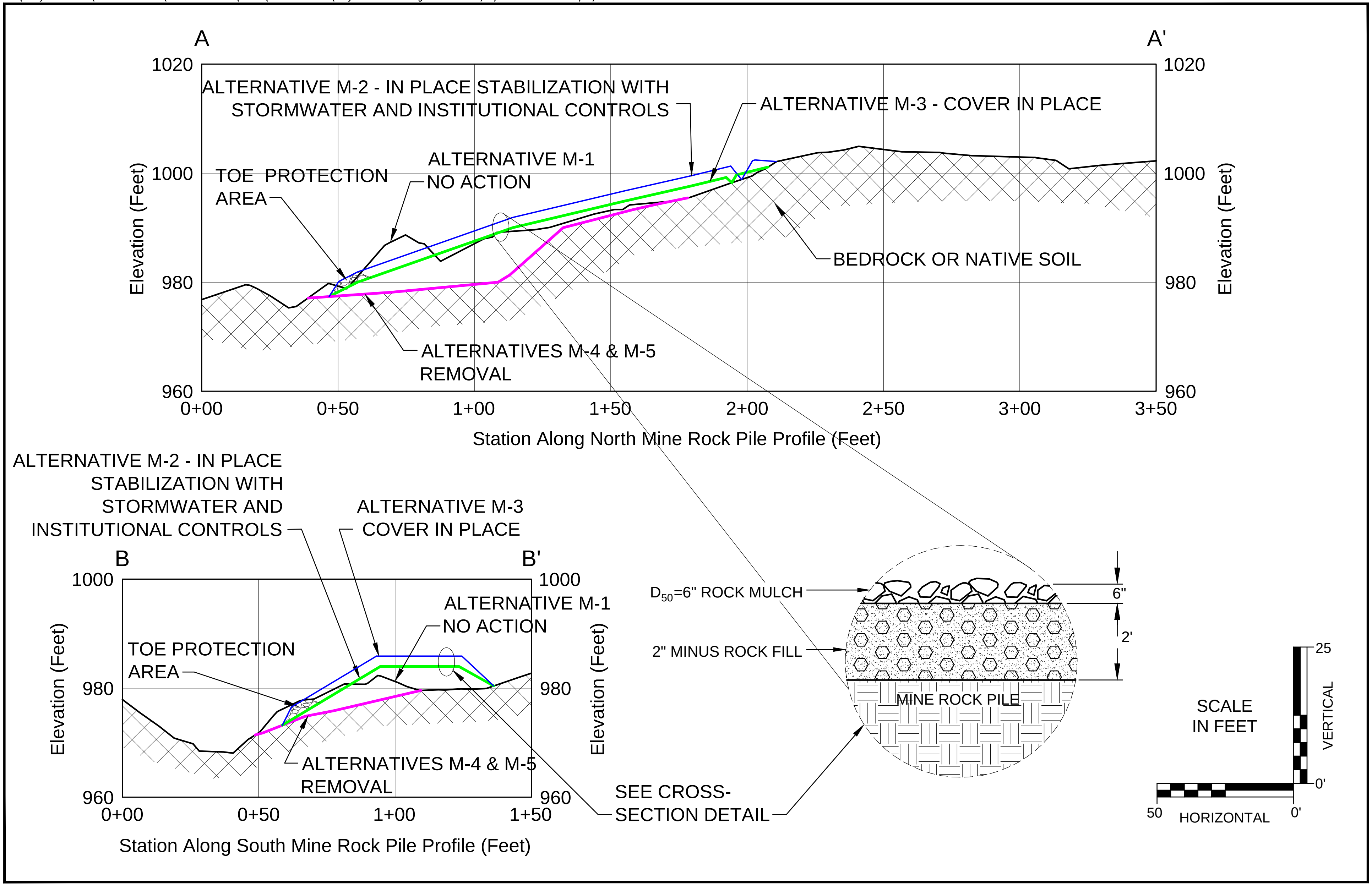
Figure 6-14
Mine Rock Alternatives M-1 through M-5
Cross Section through 700-Foot Level



Note: Eagle Mapping Adjustment +23'

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Figure 6-15
Mine Rock Alternatives M-1 through M-5
Cross Section through 900-Foot Level MRP's

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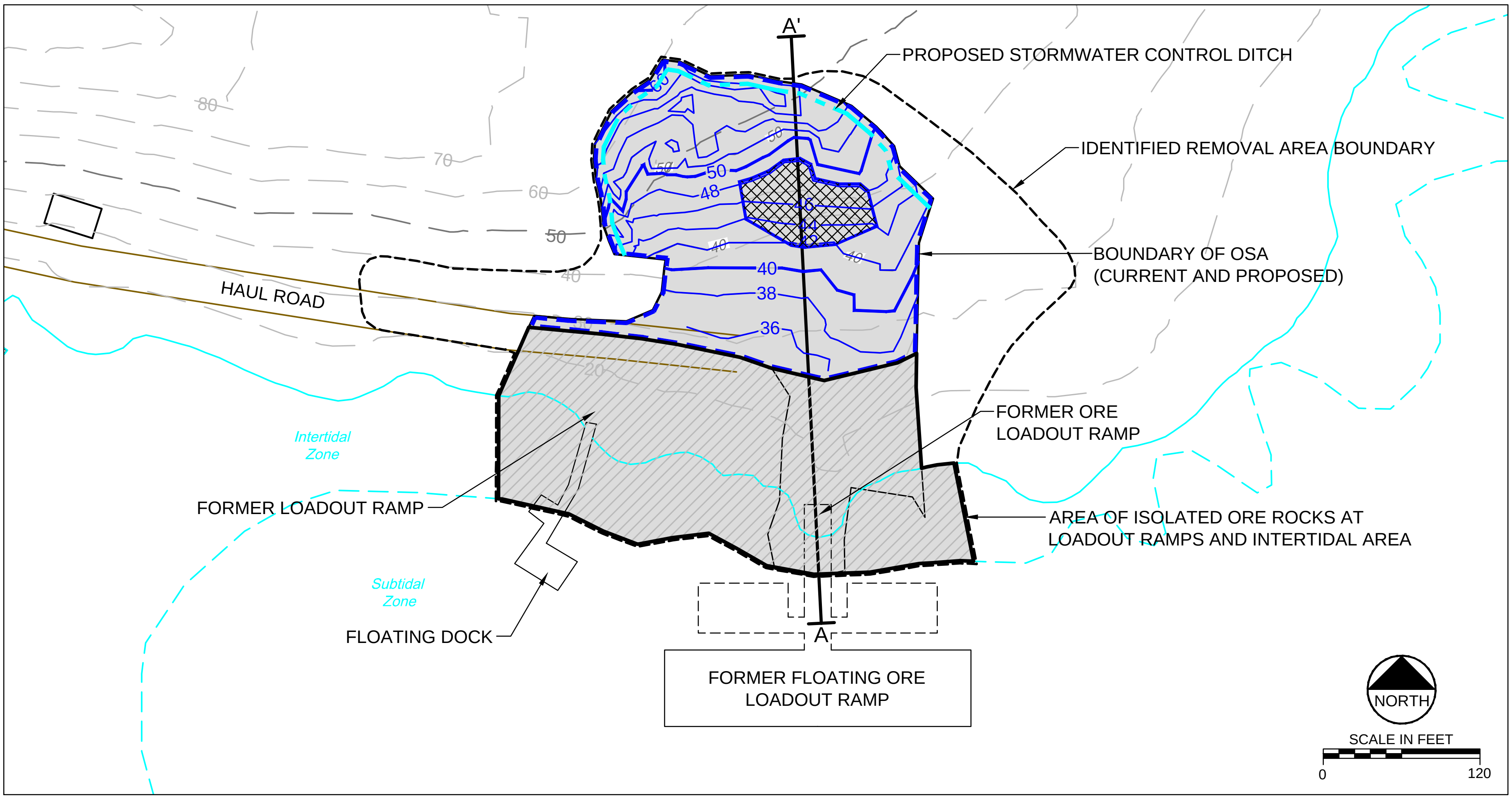

Existing Topography of OSA From Survey by R&M (Contour Interval = 2')

Existing Topography From Eagle Mapping (Contour Interval = 10')

Proposed (Regraded and Covered 2 ft.) OSA Topography (Contour Interval = 2')

Proposed Selectively Hand Excavated Area

Current Physical Boundary of OSA (Determined by Visual and Survey Limits)

Existing Coastline Low Tide

Existing Coastline High Tide

Backfill Area with Isolated Ore Rocks

Proposed Stormwater Control Ditch

Note: Eagle Mapping Adjustment +20'

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Figure 6-16
Mine Rock Alternative M-3 - Cover in Place
OSA

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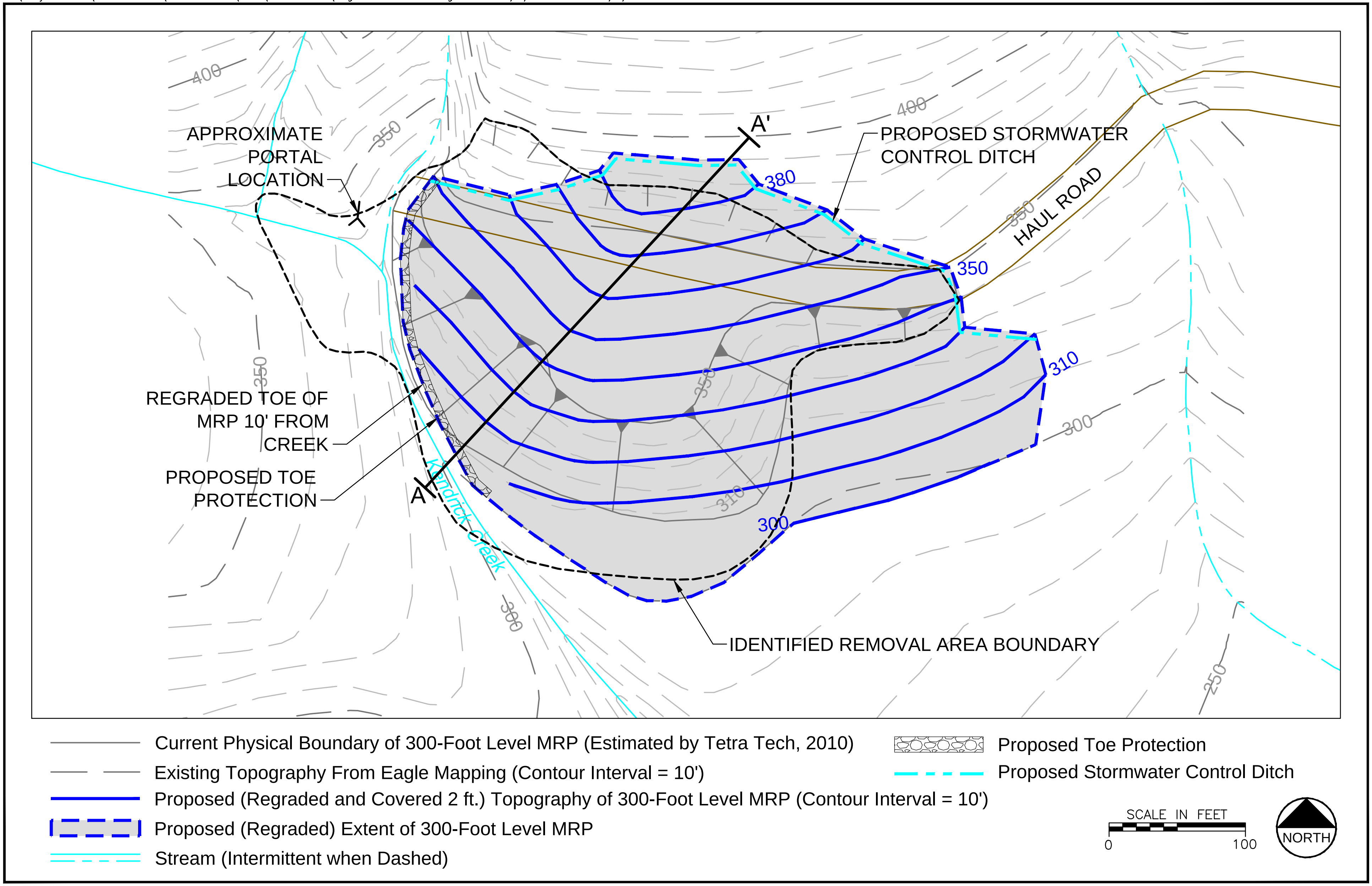

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Figure 6-17
Mine Rock Alternative M-3 - Cover in Place
300-Foot Level

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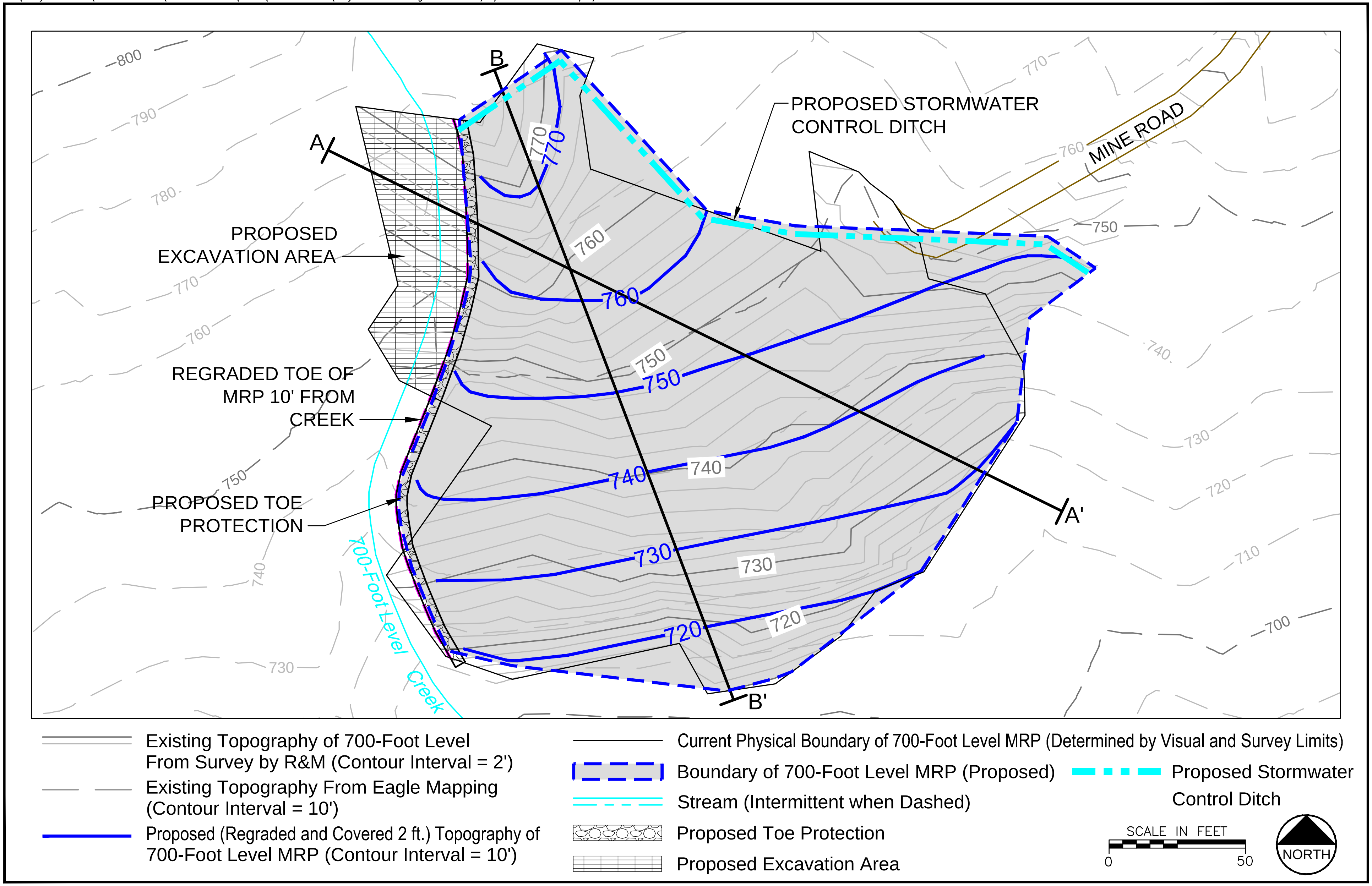

Note: Eagle Mapping Adjustment +21'

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Figure 6-18
Mine Rock Alternative M-3 - Cover in Place
700-Foot Level

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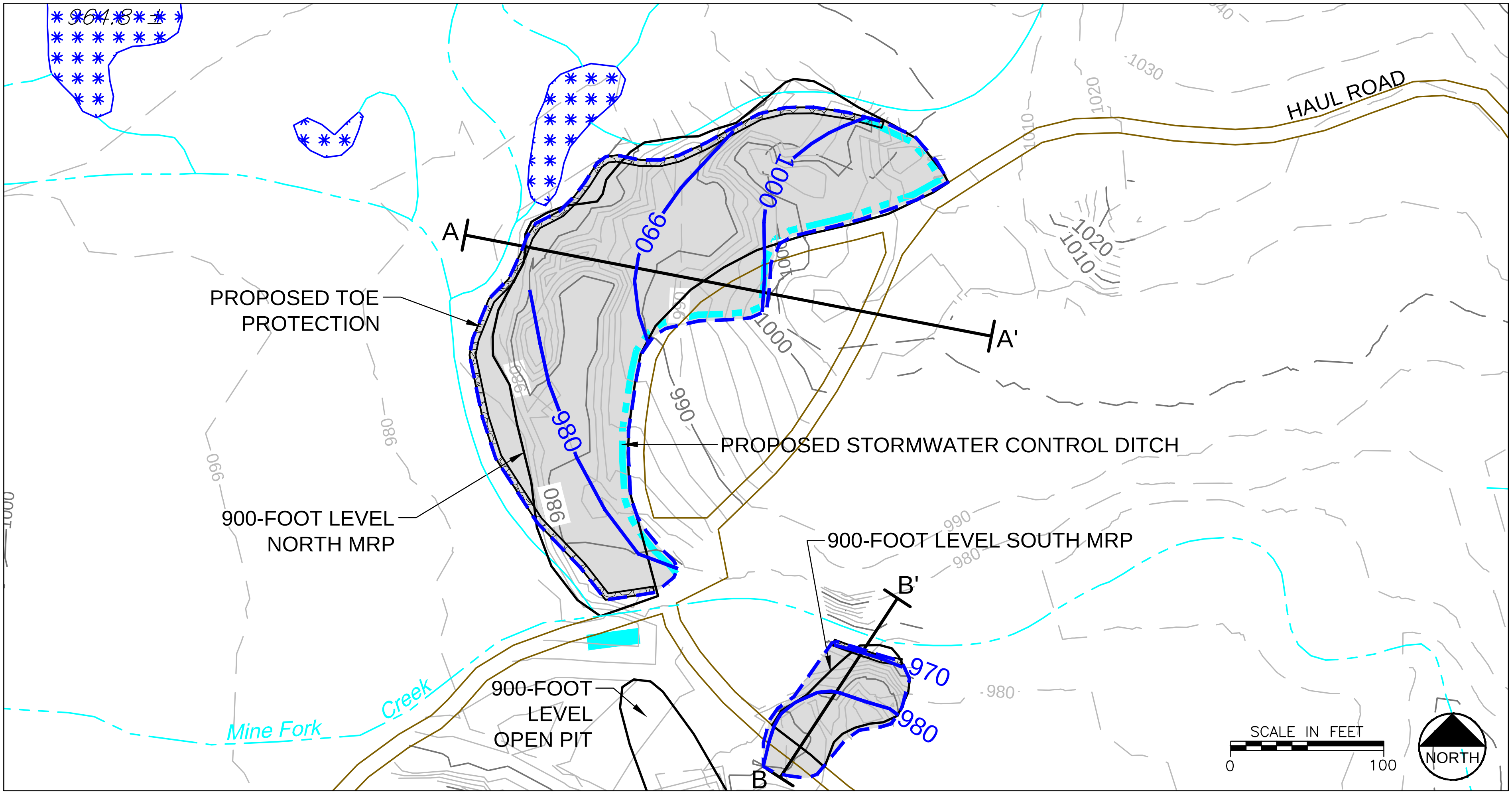

Existing Topography of 900-Foot Level MRP From Survey by R&M (Contour Interval = 2')	Current Physical Boundary of 900-Foot Level MRP (Determined by Visual Limits by KSI)
Existing Topography From Eagle Mapping (Contour Interval = 10')	Boundary of 900-Foot Level MRP (Proposed)
Proposed (Regraded and Covered 2 ft.) Topography of 900-Foot Level MRP (Contour Interval = 10')	Stream (Intermittent when Dashed)
	Marsh
	Proposed Toe Protection
	Proposed Stormwater Control Berm
	Proposed Stormwater Control Ditch

Note: Eagle Mapping Adjustment +23'

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Figure 6-19
Mine Rock Alternative M-3 - Cover in Place
900-Foot Level

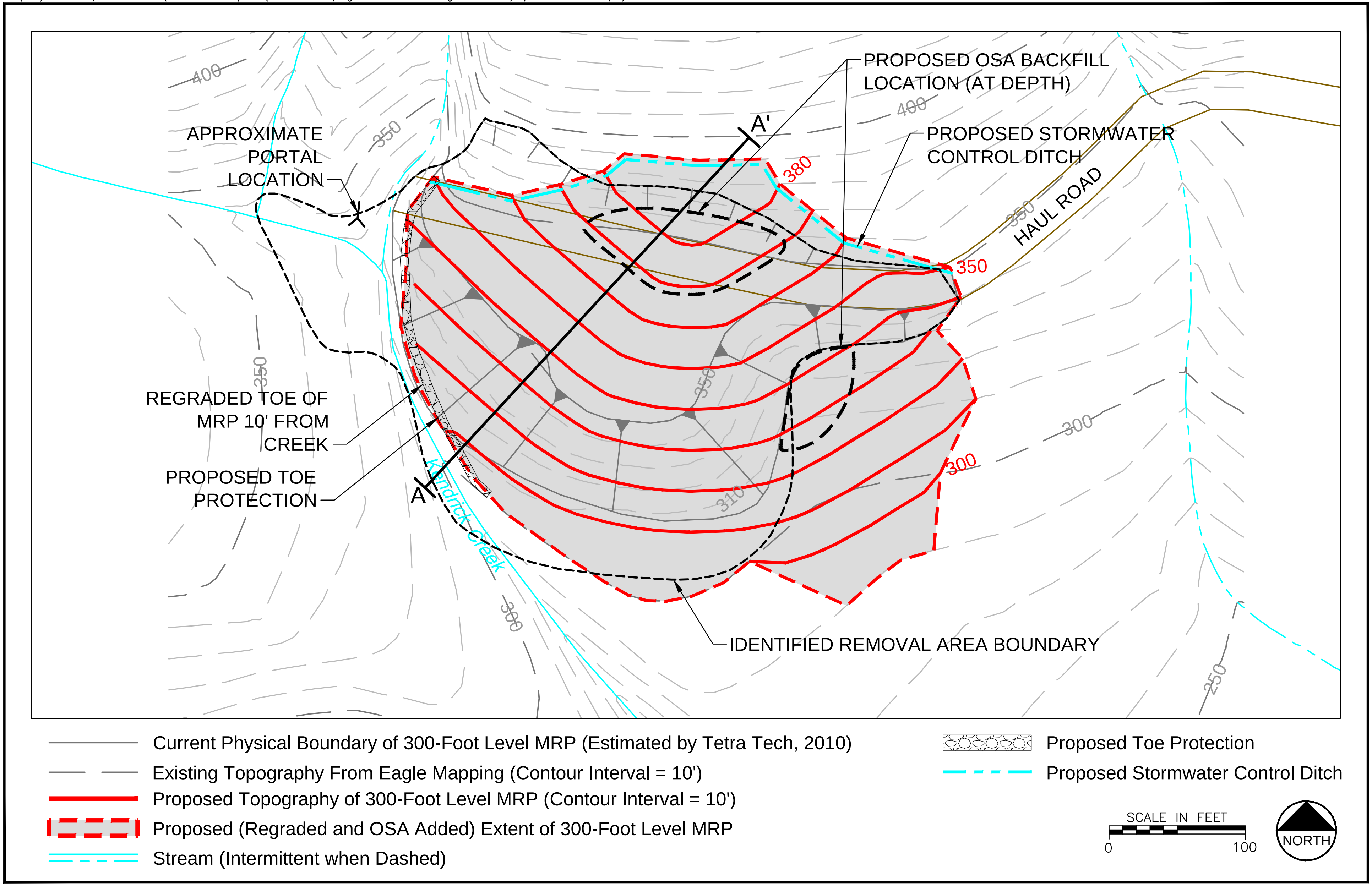

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Figure 6-20
Mine Rock Alternative M-4 - Excavation, Consolidation and Cover at Mine Affected Areas
300-Foot Level

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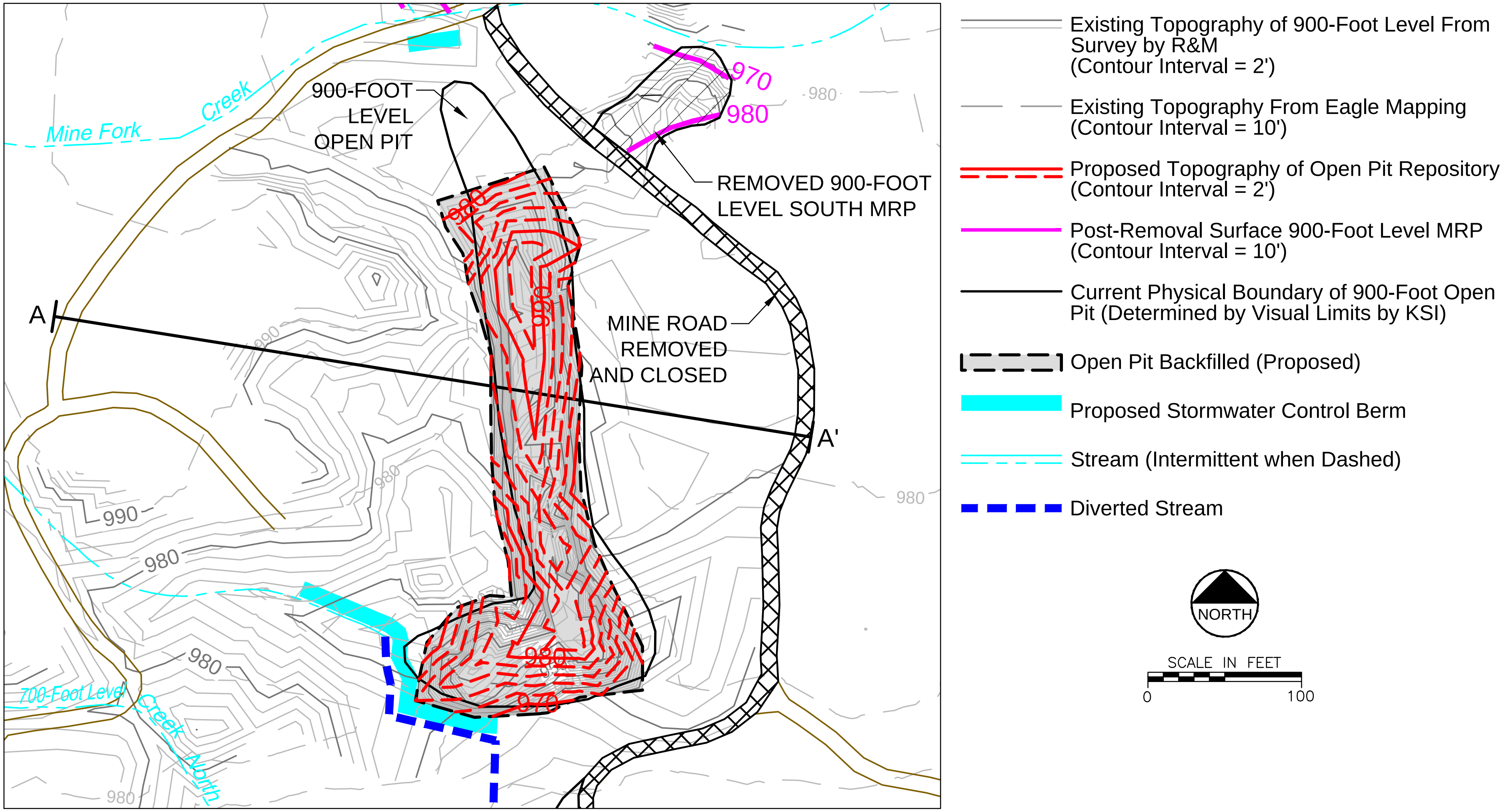

Note: Eagle Mapping Adjustment +23'

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Figure 6-21
Mine Rock Alternative M-4
Excavation, Consolidation and Cover at Mine Affected Areas - 900-Foot Level Repository

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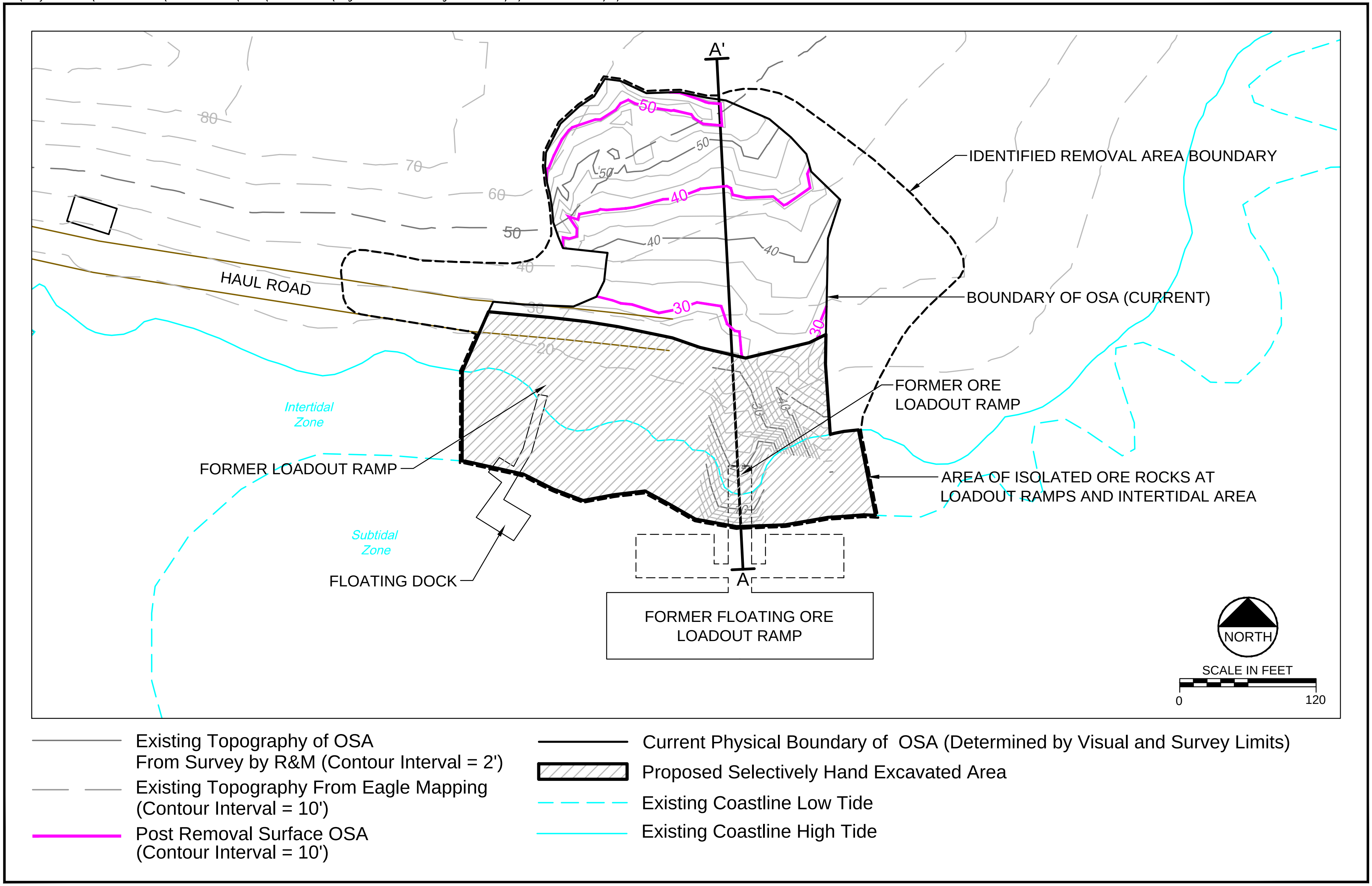

Note: Eagle Mapping Adjustment +20'

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Figure 6-22
Mine Rock Alternatives M-4 and M-5 - Removal OSA

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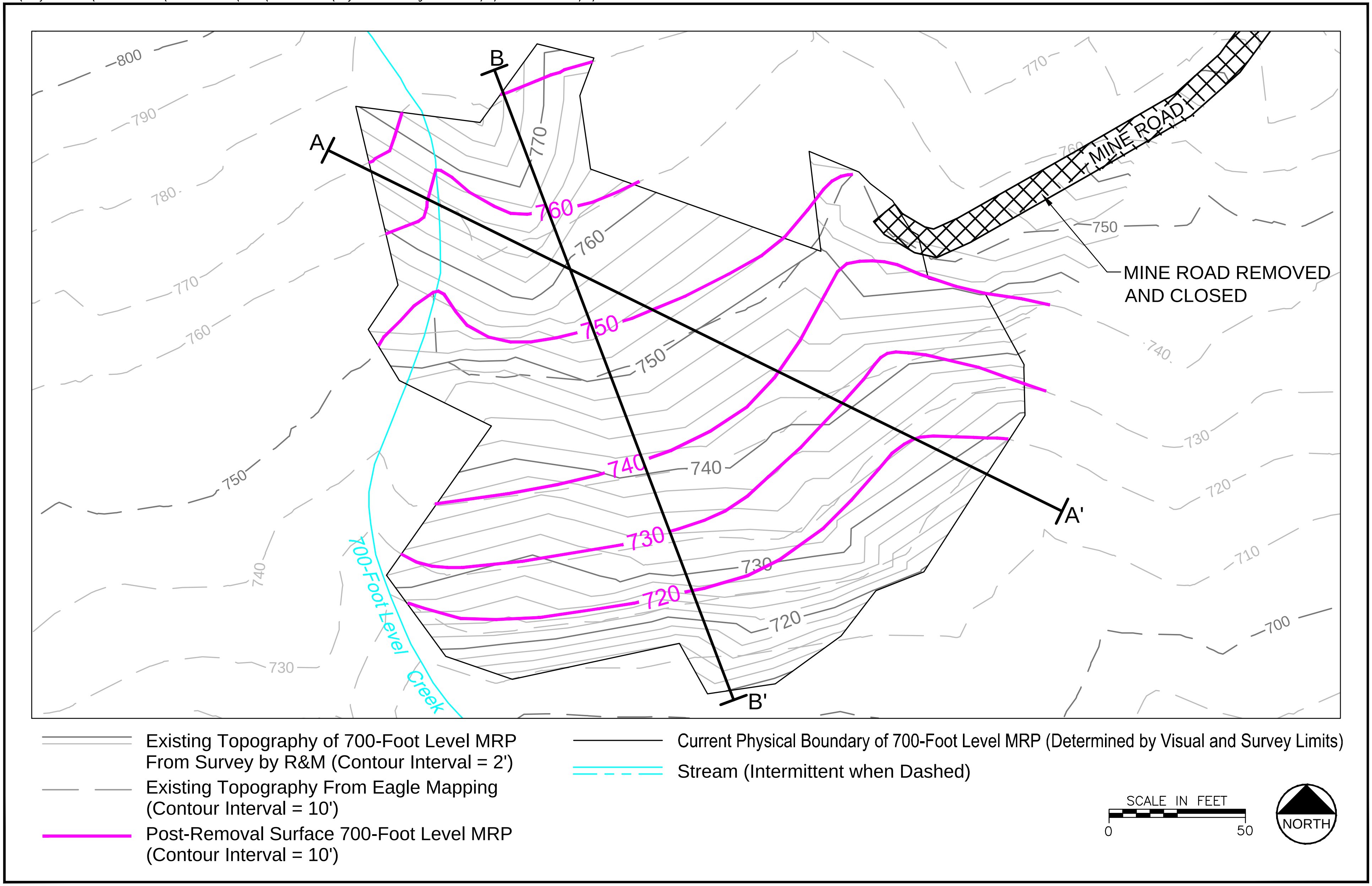

Note: Eagle Mapping Adjustment +21'

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Figure 6-23
Mine Rock Alternatives M-4 and M-5 - Removal
700-Foot Level

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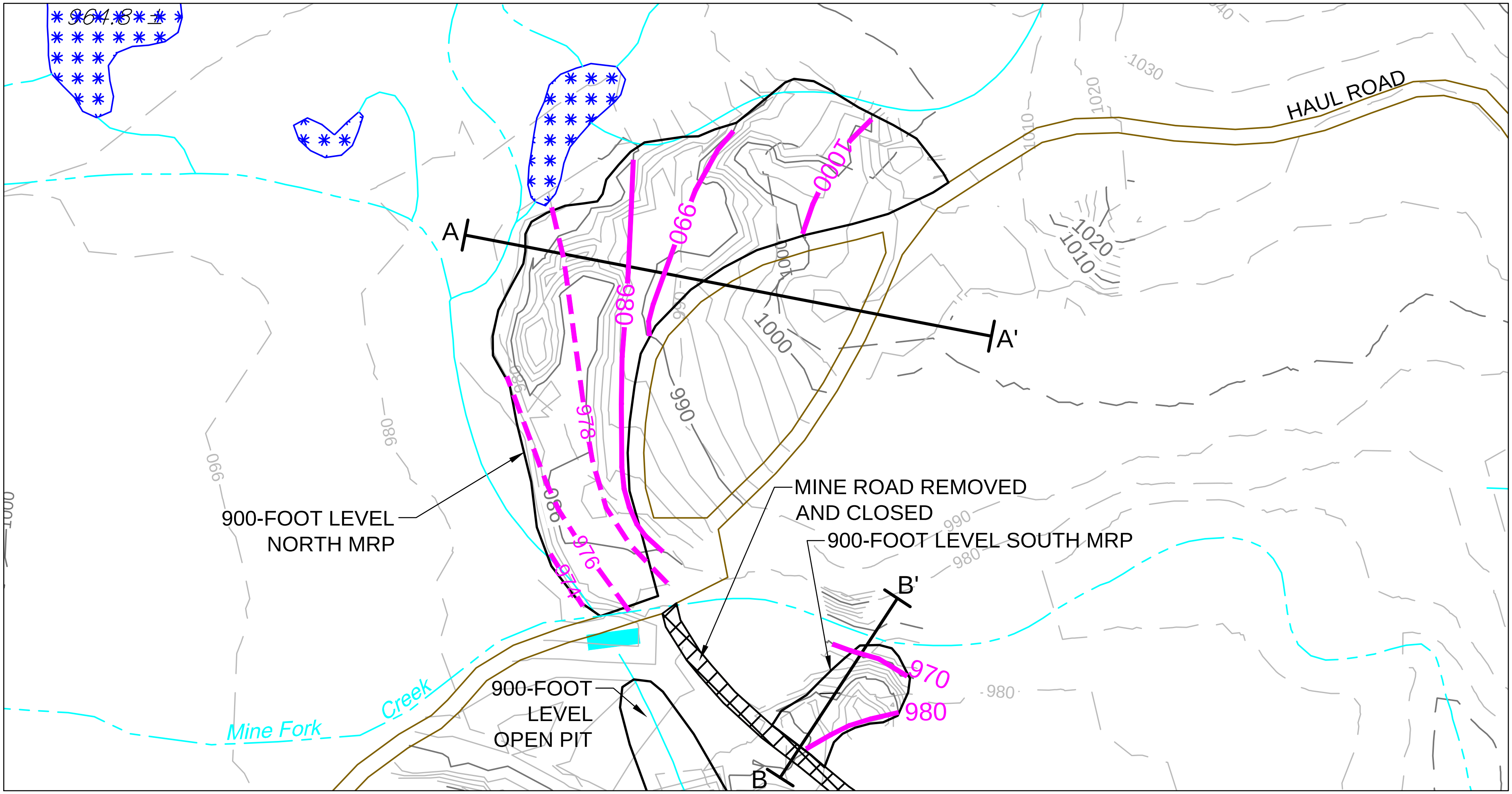

Existing Topography of 900-Foot Level MRP From Survey by R&M (Contour Interval = 2')

Existing Topography From Eagle Mapping (Contour Interval = 10')

Post-Removal Surface 900-Foot Level MRP (Contour Interval = 10' or 2' When Dashed)

Current Physical Boundary of 900-Foot Level MRP (Determined by Visual and Survey Limits)

Stream (Intermittent when Dashed)

Marsh

Proposed Stormwater Control Berm

Note: Eagle Mapping Adjustment +23'

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Figure 6-24
Mine Rock Alternatives M-4 and M-5 - Removal
900-Foot Level

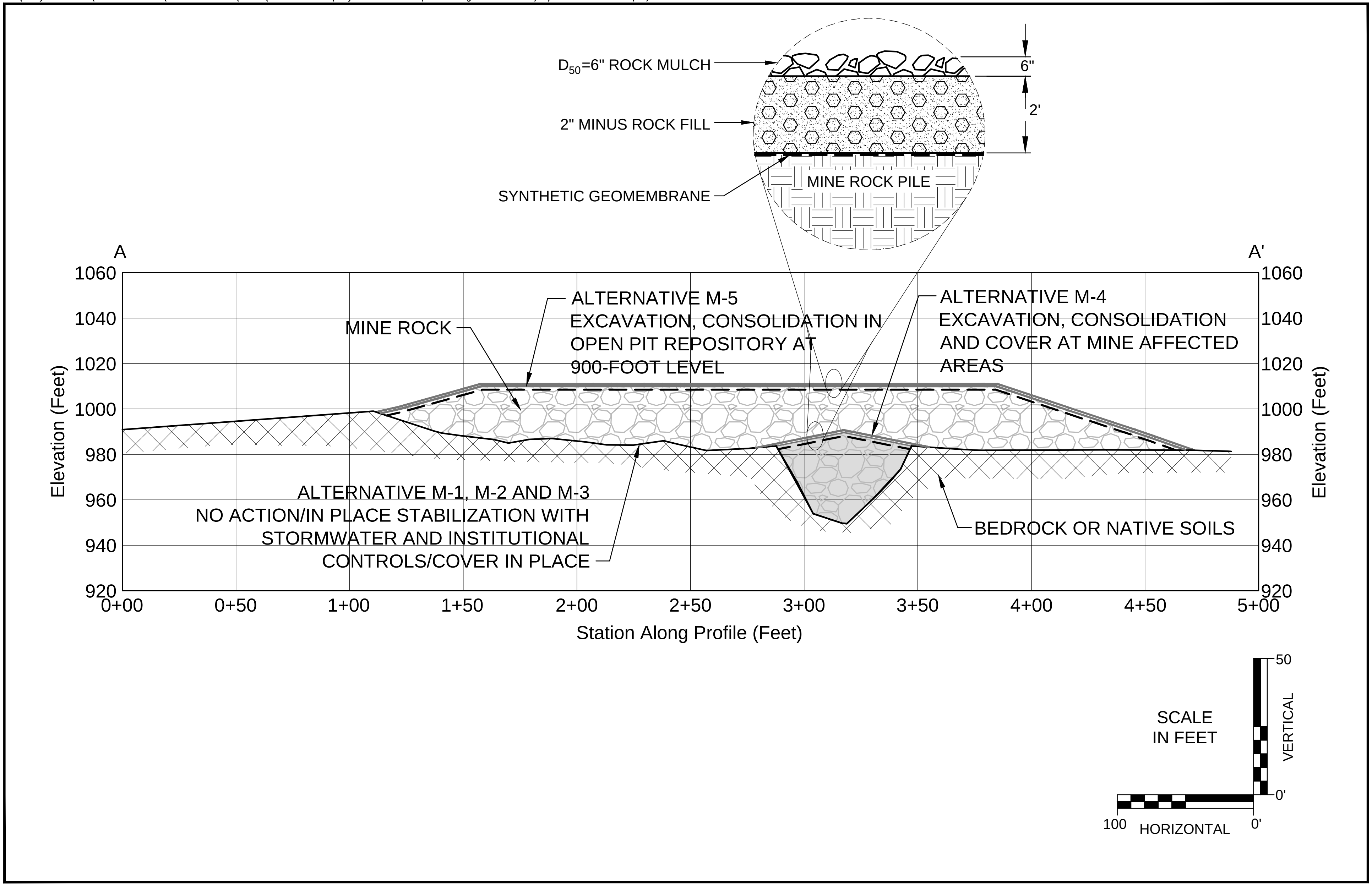

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Figure 6-25
Mine Rock Alternatives M-4 and M-5
Cross Section through Open Pit Repository at 900-Foot Level Repository

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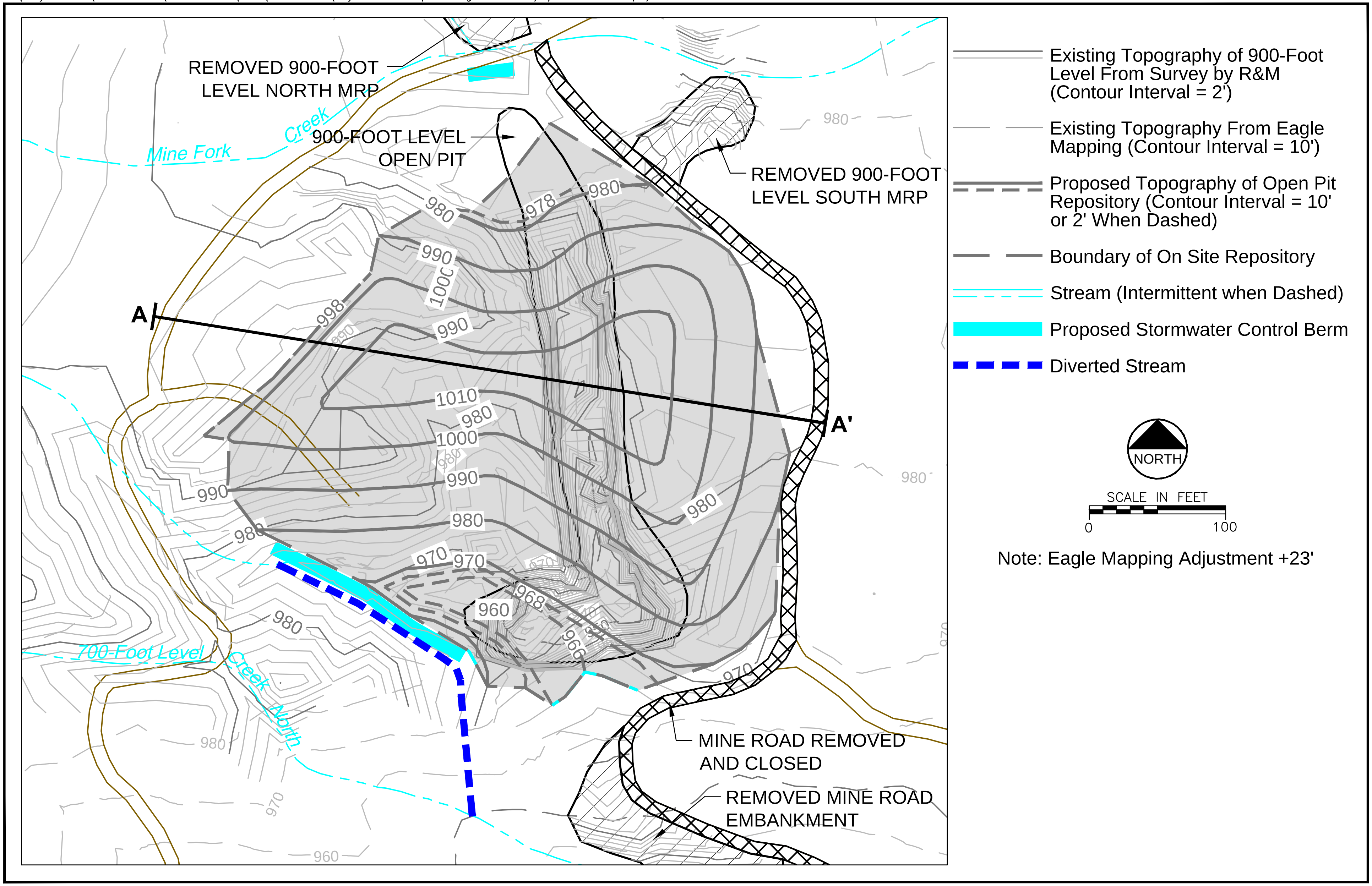

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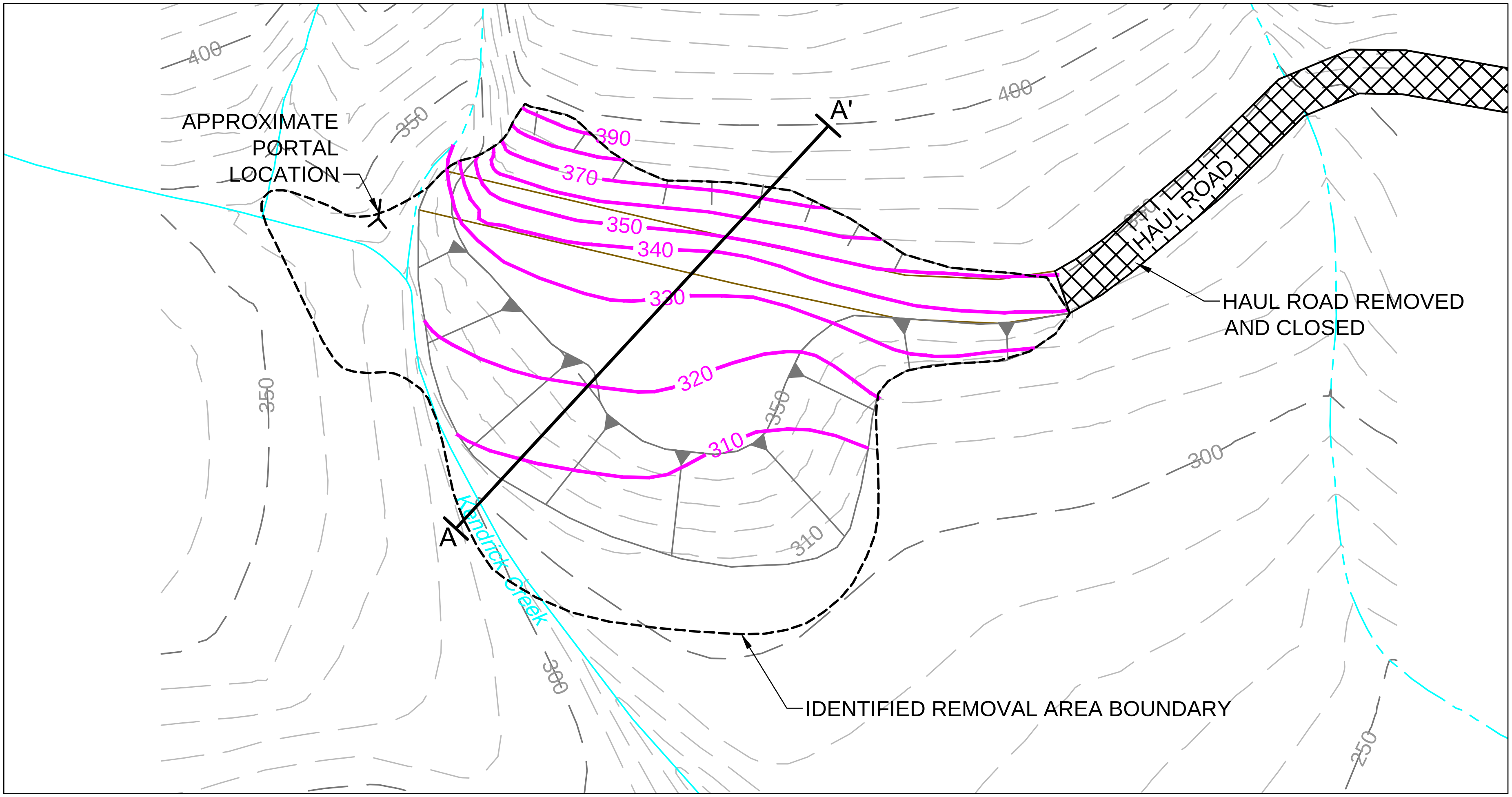
Figure 6-26
Mine Rock Alternative M-5
Excavation, Consolidation in Open Pit Repository at 900-Foot Level



Current Physical Boundary of 300-Foot Level MRP (Estimated by Tetra Tech, 2010)

Existing Topography From Eagle Mapping (Contour Interval = 10')

Post Removal Surface 300-Foot Level MRP (Contour Interval = 10')

Stream (Intermittent when Dashed)

SCALE IN FEET

0 100

NORTH

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Figure 6-27
Mine Rock Alternative M-5 - Removal
300-Foot Level

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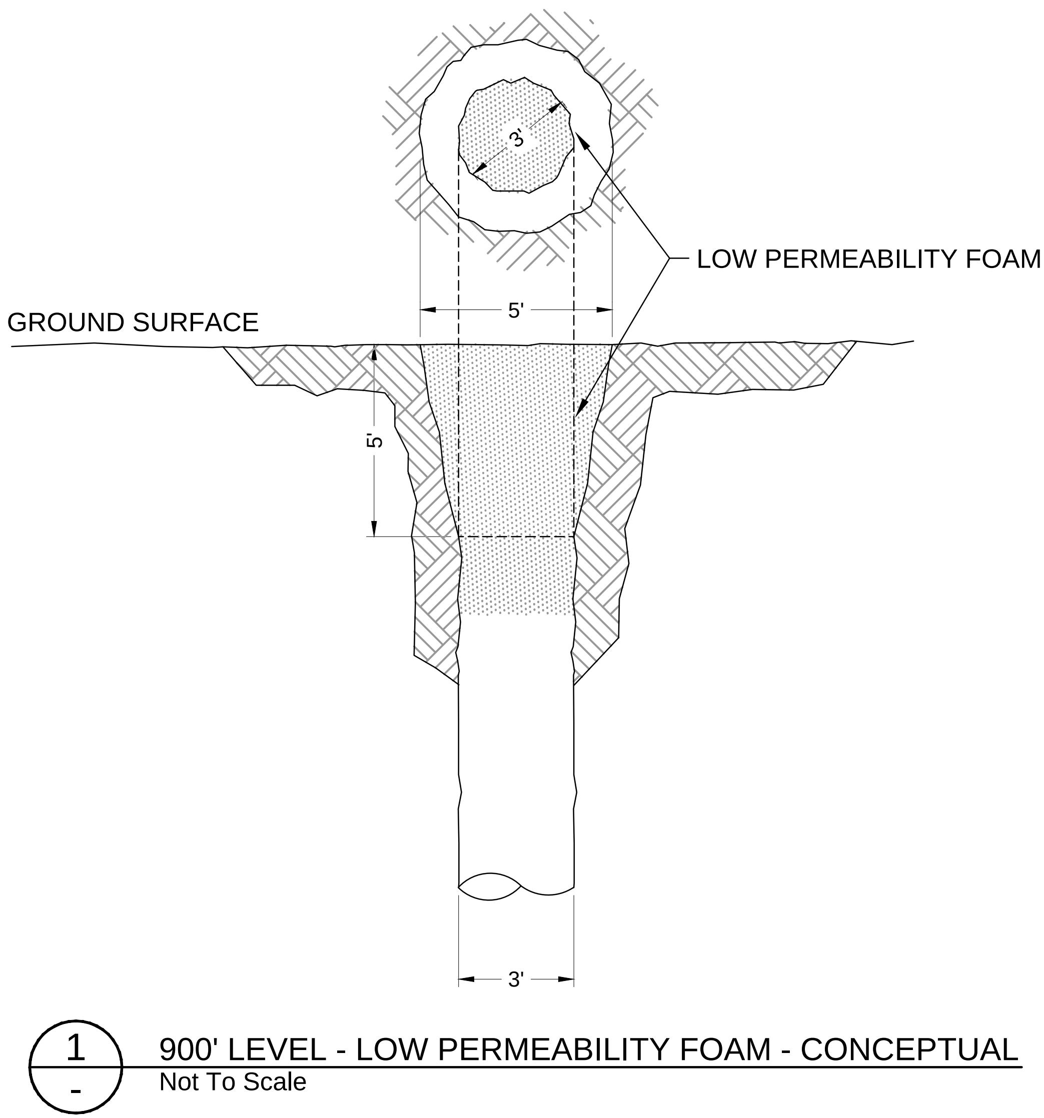

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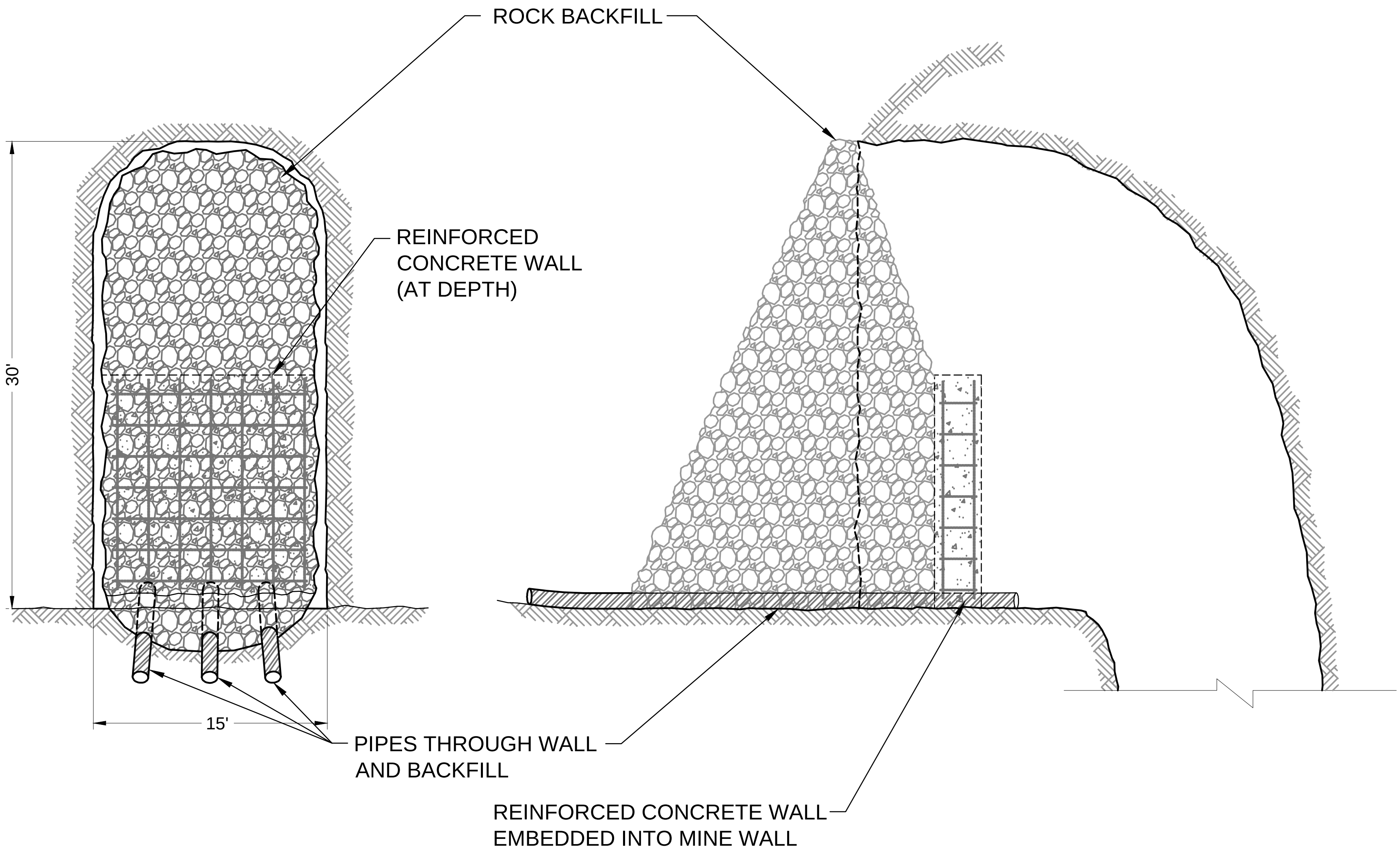
Figure 6-28
Common Element to Portal Alternatives
Closure of 900-Foot Level Vent Shaft



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HALF DAM WITH ROCK BACKFILL - CONCEPTUAL
Not To Scale

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Figure 6-29
Common Element to Portal Alternatives
Closure of 900-Foot Level Portal - Half Dam with Rock Backfill Option

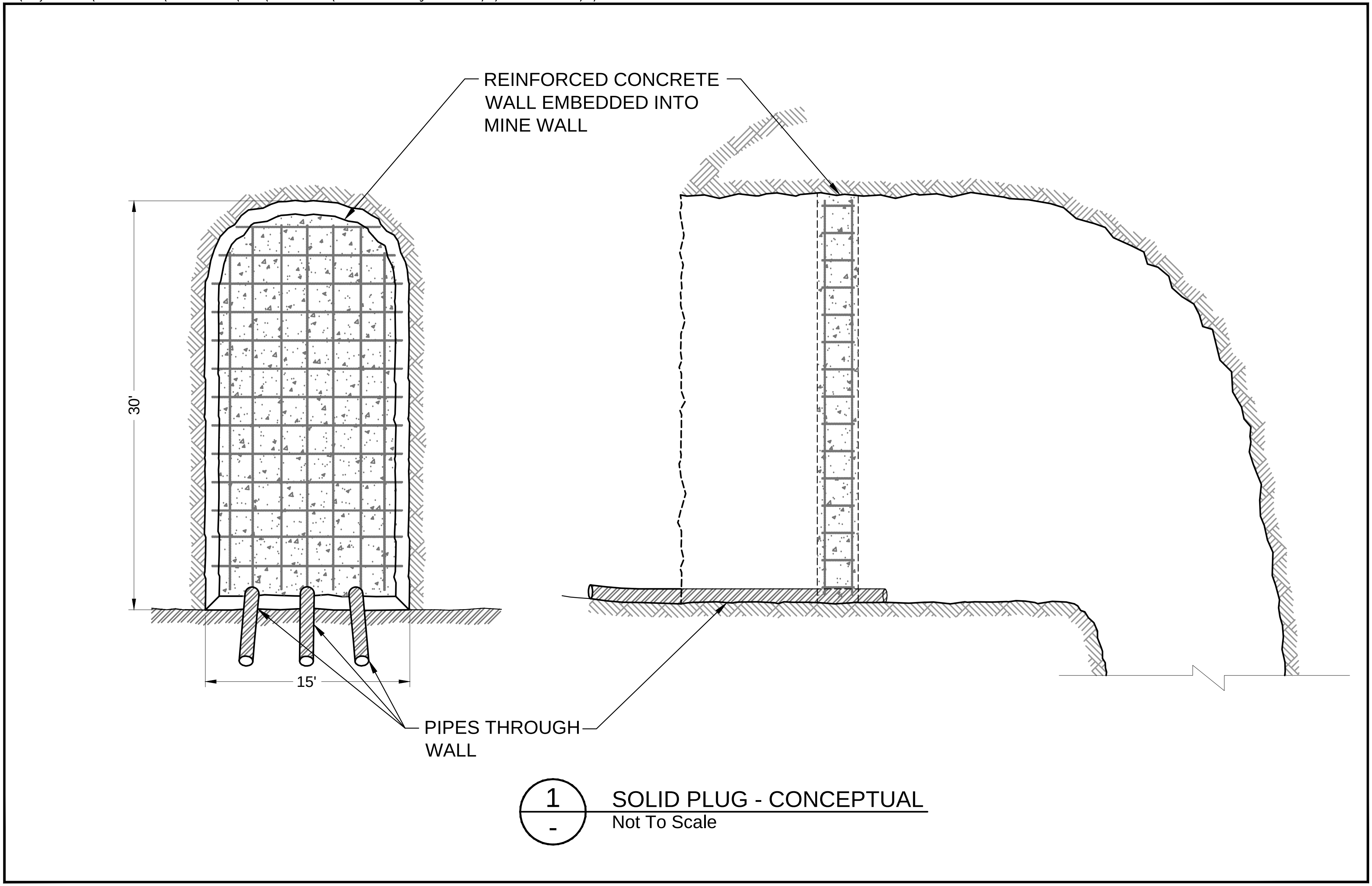

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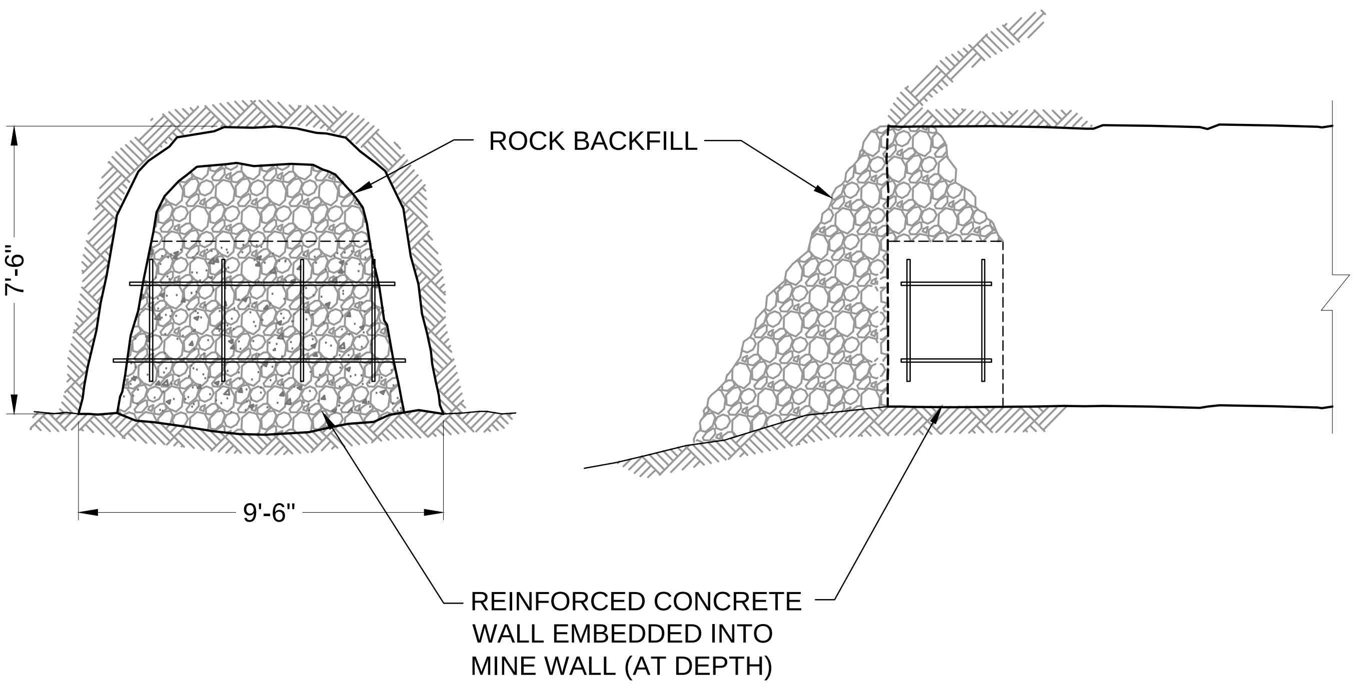
Figure 6-30
Common Element to Portal Alternatives
Closure of 900-Foot Level Portal - Solid Concrete Plug Option



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HALF DAM WITH ROCK BACKFILL - CONCEPTUAL
Not To Scale

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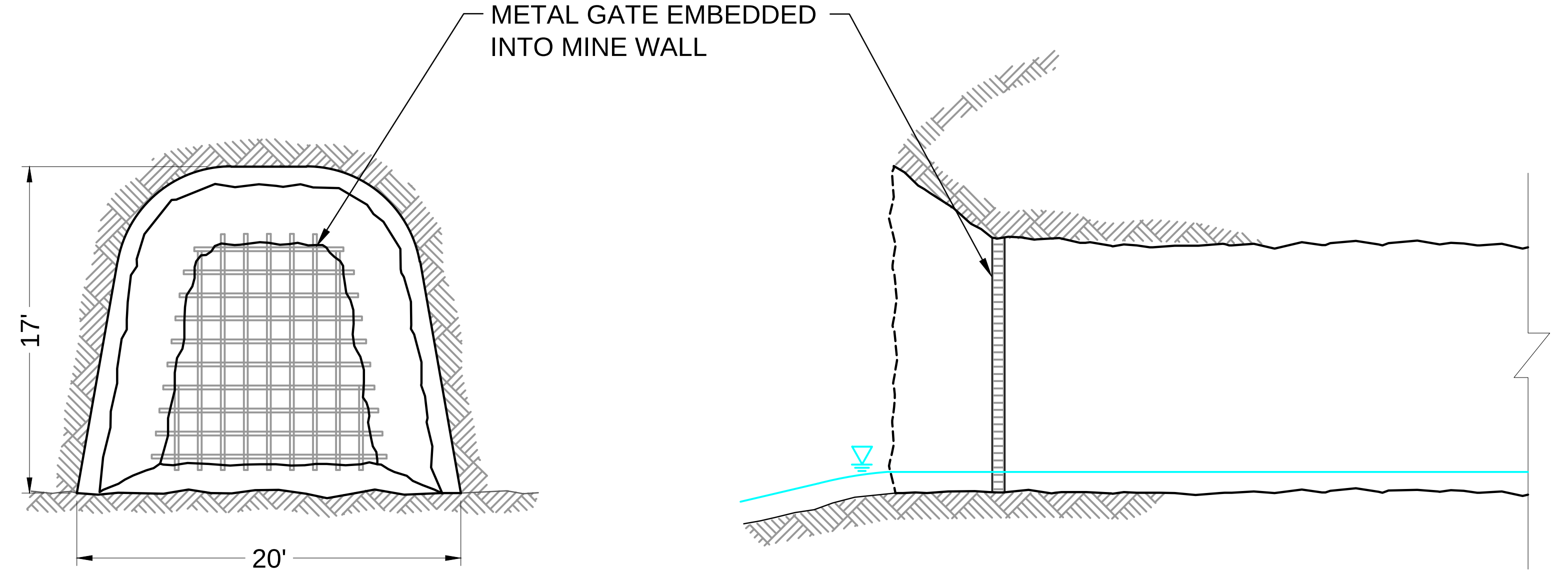
Figure 6-31
Common Element to Portal Alternatives
Closure of 700-Foot Level Portal



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ALTERNATIVE P-2 - METAL GATE CLOSURE AT 300-FOOT LEVEL PORTAL - CONCEPTUAL
Not To Scale

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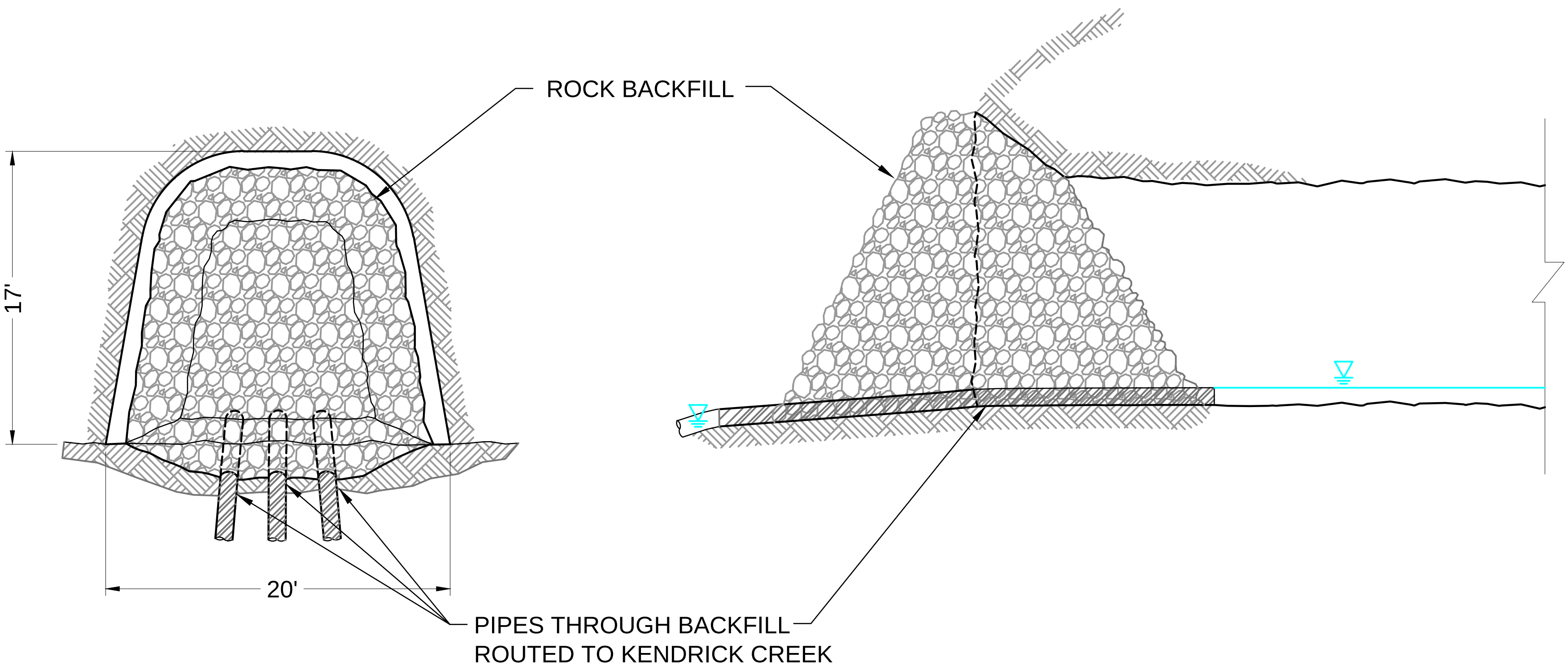
Figure 6-32
Portal Alternative P-2
Close Upper Mine Openings and Gate at 300-Foot Level Portal

Z:\Project Files\Ross Adams\AutoCADfiles\WME\EECA-2014\Ross Closure.dwg SAVED: 4/2/15 PRINTED: 4/2/15 BY: TOM



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ALTERNATIVE P-3 - ROCK BACKFILL AT 300-FOOT LEVEL PORTAL - CONCEPTUAL
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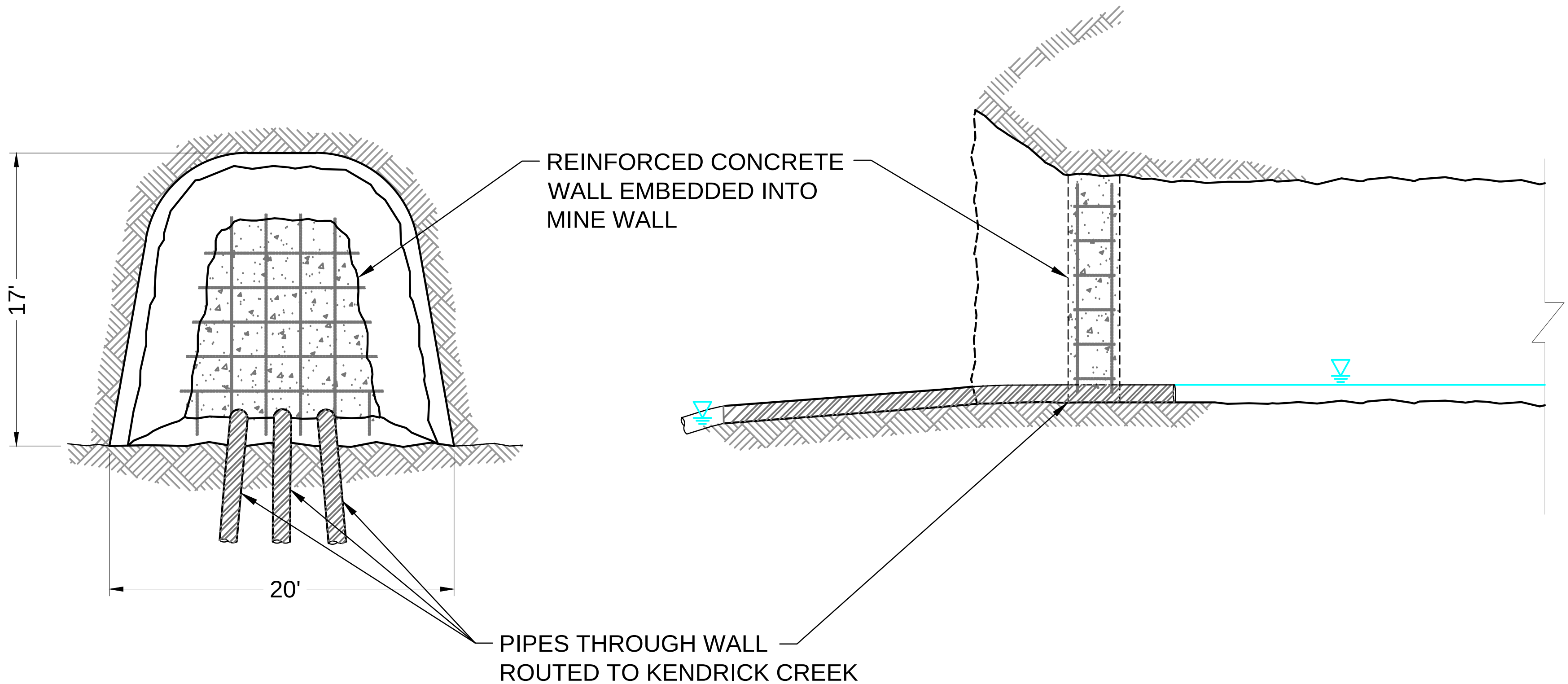
Figure 6-33
Portal Alternative P-3
Close Upper Mine Openings and Rock Backfill at 300-Foot Level Portal



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ALTERNATIVE P-4 - CONCRETE BULKHEAD AT 300-FOOT LEVEL PORTAL - CONCEPTUAL
Not To Scale

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Figure 6-34
Portal Alternative P-4
Close Upper Mine Openings and Concrete Bulkhead at 300-Foot Level Portal

7.0 Detailed Analysis of Removal Action Alternatives

Five removal action alternatives for mine rock areas and four removal actions for mine portals were retained for detailed analysis from the results of the screening of removal action technologies in Section 5.0. The Mine Rock Alternatives and Portal Alternatives are described in Section 6.0. These alternatives represent well established and proven technologies that have been implemented at similar uranium mine sites to address similar conditions. Each removal action alternative for the mine rock areas and mine portals are evaluated according to criteria established by EPA guidance (EPA, 1993a), and designated criteria for design and performance. The following sections provide a description of these criteria and analysis of the individual alternatives. Section 8.0 provides a comparative analysis of the removal action alternatives.

As described in Section 6.0, the removal action alternatives for mine rock include:

- Alternative M-1 – No Action
- Alternative M-2 – In-Place Stabilization with Stormwater and Institutional Controls
- Alternative M-3 – In-Place Covering of Mine Rock Piles
- Alternative M-4 – Excavation, Consolidation and Cover at Mine Affected Areas
- Alternative M-5 – Excavation, Consolidation and Cover at Open Pit Repository

The removal action alternatives for mine portals considered for detailed analysis include:

- Alternative P-1 – No Action
- Alternative P-2 – Close Upper Mine Openings with 300-Foot Level Portal Gate
- Alternative P-3 – Close Upper Mine Openings with 300-Foot Level Portal Rock Backfill Closure
- Alternative P-4 – Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead

7.1 Alternative Evaluation Criteria

EPA guidance (EPA 1993a) prescribes the evaluation of removal action alternatives according to three main criteria: effectiveness, implementability, and cost.

7.1.1 Effectiveness

The effectiveness of an alternative refers to its ability to achieve the identified RAOs. Effectiveness is assessed based on 1) overall protectiveness of human health and the environment; 2) ability to comply with potential ARARs; 3) short-term effectiveness including adverse impacts to the environment and protection of workers and public; 4) long-term effectiveness and permanence; and 5) reduction of toxicity, mobility, or volume. As described in

Section 4.2, the effectiveness of each alternative in achieving RAOs and RAGs for protection of human health and the environment was determined by evaluating whether the alternative would eliminate the exposure pathways for the constituents of concern identified in the HHRA and the SLERA to human and ecological receptors. Where the removal action alternative does not result in elimination of the exposure pathway to human receptors, an assessment was performed to predict the residual dose and/or risk attributable to the mine-affected areas.

For each alternative, the predicted annual radiation dose and lifetime risk to recreational users and occupational workers for exposure to the individual mine features was calculated, as described below and presented in Appendix F. The purpose of the dose/risk calculations is to allow the comparative effectiveness of the removal action alternatives to be evaluated with respect to the dose/risk criteria and does not necessarily represent the actual dose/risk that the recreational users and occupational workers might incur at the Site. The approach used for the effectiveness calculations for determining dose/risk for each alternative differs from the approach used in the HHRA; as the effectiveness calculations use slightly different exposure scenarios and dose rates. This was done to allow characterization of the discrete areas affected by the various removal action alternatives. Most notably calculated radon emanations from the discrete mine rock piles was used rather than the measured values which could not be applied to these discrete locations. The mine-affected areas attributable to former mining operations represent a fraction of the Site area. While institutional and access controls or land use restrictions will further reduce radiation exposure to human receptors for each alternative, the dose/risk calculations conservatively do not account for these controls.

For purposes of simplifying the predicted dose/risk for the alternatives, the calculations assume that removal of mine rock piles under Mine Rock Alternatives M-4 and M-5 or closure of all the mine openings under Portal Alternative P-4 will eliminate the radiation exposure at the locations of the removed mine rock piles or at the closed portals. Minimal residual dose/risk to human receptors may remain following removal of the mine rock piles at their current locations or at the portals following closure; however, the calculations assume that the residual dose/risk to these areas is zero for comparative purposes. Human health risks at the Site due to background radiation exposures in the mineralized area exceed the dose and risk criteria regardless of which removal action is implemented. This is an important distinction because the calculated incremental risk reductions for the alternatives provide relative comparisons. However, the effectiveness in reducing risk to human exposure pathways at the Site is constrained by the natural mineralization in the Bokan Mountain area.

The exposure pathways evaluated in the dose/risk calculations for each alternative included external exposure to direct gamma radiation from mine rock and inhalation of radon decay products generated from mine rock and mine openings. The residual radiation dose/risk to recreational users and occupational workers attributable to each mine feature for each removal action alternative were calculated based on the estimated exposure frequency and duration for human receptors to each mine-affected area, the measured and predicted gamma exposure rates, estimated radionuclide concentrations, and calculated radon flux from the mine rock piles and the measured and predicted radon concentrations at the mine openings. In the HHRA, the fraction of time that each human receptor would spend in certain areas of the Site was estimated in the SSRA in order to calculate the radiation dose/risk for existing conditions. In order to evaluate the dose/risk attributable to individual mine features for each alternative, the calculations require that the fraction of time spent by the receptors be further apportioned to the individual mine features and other areas of the Site. For the purpose of this radiation dose/risk estimation, the fraction of time that recreational users and occupational workers would spend at each mine feature was estimated based on a comparison of the area and a reasonable estimate of the area the receptor might access during the time at the Site. For the purpose of comparing the potential doses/risks for each removal action alternative, the individual was assumed to spend all of their apportioned time at or adjacent to each mine feature (i.e., the OSA, individual mine rock piles, or portals). This may be an overly conservative assumption but is applied only in order to compare the effectiveness of the removal action alternatives. Due to the relatively short period of travel time an individual would likely spend on the haul and mine roads, the roads are not considered as separate entities in this calculation.

The gamma exposure rates and radon flux resulting from cover placement on mine rock areas for each Mine Rock Alternative were calculated, as provided in Section 6.0. The reduction in radon exhalation for each Portal Alternative is also described in Section 6.0. For this comparative analysis of the alternatives, the results of the calculated gamma exposure rates and predicted radon emanation/exhalation for the individual mine features indicate that the cumulative direct gamma radiation from mine rock and radon exhalation from the mine openings contribute the majority of the potential annual dose and lifetime risk. The estimated potential risk/dose due to the predicted radon emanation from the mine rock piles was negligible compared to the direct gamma radiation from the mine rock piles and radon exhalation from the mine openings. The residual dose/risk for each alternative was compared to the excess dose criterion of 15 mrem/year and the lifetime risk criterion of 1E-5 above background specified as RAGs in Section 4.2 to define the effectiveness of each alternative.

The RAOs described in Section 4.2 include reducing the risk or eliminating the exposure pathways for terrestrial plants, invertebrates and wildlife from exposure to metals and radionuclides defined as constituents of concern in mine rock and soil in mine-affected areas via direct contact, ingestion and food-chain exposure. The RAOs also include reducing the risk or eliminating the exposure pathways for riparian animals from exposure to radium in surface water at the 700-Foot/900-Foot Levels and the drainage from the 300-Foot Level portal. The effectiveness of each alternative in achieving these RAOs was assessed by evaluating whether the alternative would reduce or eliminate the exposure pathways for these ecological receptors.

7.1.2 Implementability

Implementability of an alternative addresses its technical and administrative ability. Implementability is assessed based on 1) technical feasibility including ability to construct, reliability, demonstrated performance and life of technology, availability of services and materials, M&M considerations, and time required to implement; and 2) administrative feasibility including any permitting requirements, ability to implement institutional or access controls, and likelihood of USFS and community acceptance.

7.1.3 Cost

Total estimated cost of an alternative includes 1) direct capital cost consisting of the estimated costs of labor, equipment, and materials necessary to construct the removal action; 2) indirect capital cost consisting of estimated engineering, construction management, and project management costs; and 3) M&M cost for estimated long-term routine and periodic maintenance. Costs for the removal action alternatives were estimated in 2011. Costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014).

7.2 Analysis of Mine Rock Alternatives

An analysis of the effectiveness, implementability, and cost criteria for each mine rock removal action alternative is described in the following sections. The uncertainties and assumptions of the criteria are also presented. In addition, a summary description of each alternative is provided based on the detailed description of the alternatives provided in Section 6.0. Table 7-1 summarizes the results of the analysis for effectiveness and implementability and Table 7-2 summarizes the estimated total cost for each alternative that includes direct and indirect capital costs and M&M costs. Tables 7-3 through 7-7 summarize the calculated dose/risk values for the recreational users and occupational workers for each alternative.

7.2.1 Alternative M-1 - No Action Alternative

Effectiveness

The No Action alternative is included in the EE/CA as a baseline for comparison with other removal action alternatives. Under the No Action alternative, mine rock in all mine-affected areas would remain in its current condition, with no reduction in exposure pathways or reduction in existing risk to human or ecological receptors. Access by humans and wildlife would remain the same as currently exists. The alternative would not be effective in protecting human health and the environment, would not achieve RAOs and does not comply with chemical-specific ARARs defining acceptable risk for human and ecological receptors. The predicted dose and risk for this alternative are provided in Table 7-3. The total estimated pathway dose and lifetime risk for this alternative would exceed the excess dose criterion of 15 mrem/year and the lifetime risk criterion of 1E-5 above background for the site recreational visitor and the occupational workers. Background dose and lifetime risk also exceed the excess dose criterion of 15 mrem/year and the lifetime risk criterion of 1E-5.

No short-term effects are associated with implementation of this Alternative M-1 and it would not result in additional exposure to human health and ecological receptors compared to existing conditions. In the long-term, it is not expected that mine rock characteristics or Site conditions would change that would reduce or alter currently existing risks to human health and the environment.

Implementability

The No Action alternative is readily implementable and technically and administratively feasible, as no construction activities are associated with the alternative. The alternative is not dependent on the availability of equipment, personnel or services. This alternative is compatible with future mining scenarios for the Site. Under Alternative M-1, there would be no adverse impact to the historic features that make the site eligible to the NRHP.

Cost

There are no costs associated with this alternative.

7.2.2 Alternative M-2 – In-Place Stabilization, Stormwater and Institutional Controls

Alternative M-2 consists of stabilizing mine rock piles adjacent to stream channels, and constructing channels, diversions and berms to reduce stormwater run-on. Mine rock at the 300-Foot, 700-Foot and 900-Foot Levels would be stabilized by setting back the toe of the mine rock slopes a minimum of 10 feet from adjacent stream channels to minimize run-on and erosion. Rock protection would be placed at the regraded toe of the mine rock piles adjacent to the stream channels. As a common element to Alternatives M-2 through M-5, ore rock would be removed within the intertidal zone associated with former loading docks and ore loading operations and consolidated in the OSA or other mine rock piles. Miscellaneous solid waste and debris would be removed for off-site recycling and disposal, except for drill core that would be consolidated at the 300-Foot Level mine rock pile.

Effectiveness

Removing and stabilizing mine rock piles adjacent to stream channels and implementing stormwater controls would reduce the long-term potential for erosion and transport of mine rock. Stormwater controls would reduce run-on into the Open Pit reducing inflow into the underground mine via the 900-Foot Level portal; thereby, reducing flow from the 300-Foot Level portal. However, there would be no reduction in radon inhalation and external gamma radiation exposure pathways or reduction in existing risk for human receptors from mine rock at the OSA and the 300-Foot, 700-Foot, and 900-Foot Levels. Except for reducing the exposure pathway for riparian animals by removing and stabilizing mine rock piles adjacent to stream channels, current exposure pathways and risk for ecological receptors to mine rock in these mine-affected areas would also remain unchanged. Removal of the spilled ore rock would eliminate exposure pathways and existing risks to human receptors within the intertidal zone. Except for removal of ore rocks within the intertidal zone, the alternative would be only partially effective in reducing existing risk to human health and the environment, would not achieve RAOs and would not comply with chemical-specific ARARs defining acceptable risk for human and ecological receptors.

The predicted dose and risk for human receptors for this alternative are provided in Table 7-4. As discussed in Section 7.1.1, the results of the predicted dose/risk calculations are used for comparative evaluation of the incremental risk reduction for each alternative and do not include institutional and/or access controls or reflect actual Site risks due to radon and gamma radiation from naturally mineralized background. Without institutional and access controls, the total estimated pathway dose and lifetime risk attributable to the mine features for this alternative would exceed the excess dose criterion of 15 mrem/year and the lifetime risk criterion of 1E-5 above background for the Site recreational visitor and the occupational workers. As described below, implementation of institutional and access controls or land use restrictions would be required to reduce radiation exposures to the OSA and mine rock piles for protection of human health.

Institutional controls consisting of land use and access restrictions, including installation of signs and barriers on the existing haul and mine roads, would further reduce human access and potential exposure to external gamma radiation and radon associated with the mine-affected areas. Access restrictions would also protect the integrity of the implemented action. As depicted on Figure 7-1, a physical barrier (gate or boulders) and signage would be placed on the haul road to restrict access. Since land use restrictions may be difficult to enforce due to the remoteness of the Site, the controls may only be somewhat effective in reducing exposure pathways and risk to human receptors. Institutional controls would not be effective in reducing risk to ecological receptors from exposure to mine rock.

Short-term radiation exposure to external gamma radiation and radon for workers during mine rock grading and construction of stormwater controls near the mine rock piles would be managed by implementing standard worker health and safety practices. Regrading mine rock and placing rock protection adjacent to stream channels increases the potential for erosion during construction activities. This potential short-term risk would be mitigated by implementing appropriate stormwater and erosion control management plans. Regrading of the mine rock piles will likely expose fresh materials that by contact with precipitation and stormwater runoff may increase the potential for leaching of metal and radionuclide constituents from the mine rock in the short term during and following construction. In the short term, the regrading may also increase the potential for erosion and sediment transport. While the mine rock is not considered to generate ARD, regrading may increase the potential for short-term leaching of the mine rock and could increase the metal and radionuclide concentrations in stormwater runoff from the mine rock piles.

Removal of spilled ore rocks within the intertidal zone near the former loading docks would be permanently effective in eliminating the current risk to human receptors within the intertidal zone. Regrading of mine rock piles, including removal of mine rock adjacent to stream courses and stormwater controls would be effective in increasing the long-term stability of the mine rock piles and reducing the potential for erosion of mine rock. Through proper design of stormwater diversions and berms to reduce run-on into the Open Pit, the controls would be effective in reducing flow into the underground mine and flow from the 300-Foot Level portal.

Implementability

Alternative M-2 is both technically and administratively feasible, and could be implemented in one construction season. Construction of channels, diversions and berms, regrading of piles adjacent to drainages and placing rock erosion protection utilize conventional earth-moving equipment and construction practices. Stormwater controls have been proven reliable. Design methods and engineering requirements for stormwater controls are well documented and understood. The design of diversions, berms, and rock protection would be determined during design according to the criteria described in Section 6.1.1. Alternative M-2 does not include any removal action at the mine road, haul road or the I&L Spur road, as the road materials are presently stable. As such, Alternative M-2 is compatible with future mining at the Site, because it does not include road closure and preclusion of vehicle access.

The remote location requires that equipment be transported by barge to the Site requiring a temporary floating dock. A temporary on-Site camp or boat would be required to house Site workers. Depending on the size of rock protection for channel construction, it may be possible to source the necessary rock protection from on-Site areas including the Kendrick Creek Delta or the basalt rock outcrop along the north shore adjacent to the ore loading ramp that was the source of rock originally used to construct the ore loading ramp. Following removal of spilled ore rock from the ore loading ramp, the basalt rock used to construct the ore loading ramps could also be a source of rock protection.

Clearing of trees and vegetation would be necessary to regrade the pile toe and construct stormwater diversions. The logged trees and larger vegetation would be chipped, as necessary, for erosion protection and restoring areas disturbed during construction. Tree and vegetation removal increases the potential for erosion during and following construction, which would be mitigated by implementing appropriate stormwater and erosion control management plans. The top surface and sideslopes of the 300-Foot Level mine rock pile are densely vegetated. Clearing of trees and vegetation would be required in the western and southwestern areas of the 300-Foot Level mine rock pile adjacent to Mine Fork Creek and Kendrick Creek to regrade the sideslope of the pile and to place rock protection. The toe of the pile would be set-back from the creeks and the pile sideslope would be regraded to a 3H:1V slope in these areas. The metal culvert previously installed to convey Mine Fork Creek across the pile would also be removed.

Signs, physical barriers on the existing access roads, and land use restrictions are readily implementable to reduce human access and prevent future disturbance of the mine-affected areas. Periodic inspections and maintenance, as necessary, would be required to ensure the long-term integrity and effectiveness of the stormwater controls. There may be a potential for an adverse impact to the features that make the site eligible to the NRHP due to road improvements necessary for equipment access.

Cost

The total estimated cost for Alternative M-2 is $1,427,000 which includes estimated direct and indirect capital costs of $1,222,000 and estimated M&M net present value costs of $206,000. The direct capital cost estimate includes mobilization and de-mobilization of personnel and equipment, construction activities associated with set-back and grading of the pile sideslopes at the 300-Foot Level, 700-Foot Level, and 900-Foot Level North mine rock piles adjacent to the channels and placement of rock protection to armor the pile sideslopes adjacent to the channels. In addition, the costs include the common elements of removing spilled ore within the intertidal area associated with former ore loading operations and consolidation of the rock at the OSA, and off-site transport, recycling, and disposal of the miscellaneous solid wastes and debris. The estimated M&M costs include annual inspections for the first three years following implementation and then every five years and an allowance for maintenance during the 30-year M&M period. The estimated direct capital costs include a 20% contingency and the estimated M&M costs include a 25% contingency.

7.2.3 Alternative M-3 – In-Place Covering of Mine Rock Piles

As described in Section 6.0, Alternative M-3 consists of placing covers on the OSA and regraded mine rock piles at the 300-Foot Level, 700-Foot Level and 900-Foot Level (North and South mine rock piles). The I&L Spur road would be excavated and consolidated with the 900-Foot Level North mine rock pile prior to cover placement. The I&L Spur road would be closed as shown on Figure 7-1. In addition, one-foot of material would be excavated from the road surface of the identified mine road embankments and the identified haul road segments and replaced with one-foot of borrow material. The excavated material from the mine and haul roads would be consolidated at the pile nearest to the road areas. Similar to Alternative M-2, stormwater controls would be implemented at each mine rock pile area and to minimize run-on into the Open Pit. As a common element, ore rock would be removed within the intertidal zone associated with former loading docks and ore loading operations and consolidated in the OSA, and miscellaneous solid waste and debris would be removed and transported for off-site recycling and disposal.

Effectiveness

Alternative M-3 would provide protection of human health and the environment from exposure to the mine rock piles, would achieve RAOs for the mine rock piles, and would generally achieve ARARs. However, Alternative M-3 would not reduce the existing risk for human and ecological receptors from the Open Pit. The alternative would also not eliminate the human health risks associated with the natural radionuclide mineralization. By physically isolating the mine rock beneath a cover, radiation risk from mine rock to occupational and recreational users of the Site due to direct gamma radiation, inhalation of radon decay products, and incidental ingestion exposure pathways would be reduced. Exposure pathways associated with the mine rock piles to ecological receptors would also be substantially reduced. Covering the mine rock piles would eliminate or substantially reduce the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife. The covers would also eliminate or substantially reduce the potential for direct precipitation contact with mine rock; thereby reducing radium concentrations in surface water runoff from mine rock and potential exposure pathways for riparian animals. Human and ecological exposure pathways would be eliminated by removal of the I&L Spur road and would be reduced by excavating and replacing one-foot of material in the identified haul and mine roads. Removal of the spilled ore rock would reduce exposure pathways and existing risks to human receptors within the intertidal zone.

However, there would be no reduction in radon inhalation and external gamma radiation exposure pathways or reduction in existing risk for human receptors from the Open Pit. Implementation of institutional and access controls or land use restrictions would be required to protect human health from radiation risks at the Open Pit. Ecological exposure pathways and risks associated with the Open Pit would also remain unchanged from existing conditions.

The predicted dose and risk for human receptors for this alternative are provided in Table 7-5. The estimated dose and lifetime risk due to covering of the mine rock piles for this alternative would achieve the excess dose criterion of 15 mrem/year and the lifetime risk criterion of 1E-5 above background for the site recreational visitor and the occupational workers. Without institutional and access controls to restrict access to the vicinity of the Open Pit, the estimated dose and lifetime risk for radiation exposures from the Open Pit would exceed the excess dose criterion of 15 mrem/year for the mineral exploration worker and the lifetime risk criterion of 1E-5 above background for all human receptors.

Stormwater controls would reduce run-on into the Open Pit reducing inflow into the underground mine via the 900-Foot Level portal; thereby, reducing flow from the 300-Foot Level portal.

Institutional controls consisting of land use and access restrictions, including installation of signs and barriers on the existing haul and mine roads, would further reduce human access and potential exposure pathways associated with the mine-affected areas. Access restrictions would also protect the integrity of the implemented action.

The alternative involves extensive construction activities in all the mine rock affected areas of the Site. Short-term radiation exposure to external gamma radiation and radon for workers and Site users during mine rock grading and cover construction would be managed by implementing standard worker and public health and safety practices. Extensive regrading of the mine rock piles, except for the OSA, and transport and placement of cover materials increases the potential for erosion and dust generation during construction activities. Regrading of the mine rock piles will likely expose fresh materials that by contact with precipitation and stormwater runoff may increase the potential for leaching of metal and radionuclide constituents from the mine rock during construction prior to cover placement. In the short term, the regrading may also increase the potential for erosion and sediment transport during construction. While the mine rock is not considered to generate ARD, regrading may increase the potential for short-term leaching of the mine rock and could increase the metal and radionuclide concentrations in stormwater runoff from the mine rock piles prior to cover placement. Potential short-term risks would be mitigated by implementing appropriate stormwater, erosion and dust control management plans.

The alternative relies on the on-site excavation of material from the Kendrick Creek Delta within the intertidal zone as a source of borrow material for cover construction. While located within the Site boundary, the intertidal area is located on state-owned lands and would be subject to substantive requirements of ARARs of the State of Alaska, as described in Section 4.

Removal of spilled ore rocks within the intertidal zone near the former loading docks would be permanently effective in eliminating the current risk to human receptors within the intertidal zone. Regrading and covering of the mine rock piles would also provide long-term effectiveness depending on maintaining the integrity of the covers through the M&M plan. Through appropriate design criteria and maintenance, the life of the covers would be indefinite. Stormwater diversions and berms to reduce run-on into the Open Pit would also be effective over the long-term, using appropriate design criteria and maintenance, in reducing flow into the underground mine and flow from the 300-Foot Level portal.

Implementability

Alternative M-3 is technically and administratively feasible, and estimated to be implemented in one to two construction seasons. Conventional earth-moving equipment and construction practices would be involved. Earthen covers have been demonstrated to be effective and reliable in reducing gamma exposure rates and radon emanation from mine rock. Design methods and engineering requirements for covers are well documented and understood. The covers and stormwater controls would be designed according to the criteria described in Section 6.1.

The remote location requires that equipment be transported by barge to the Site requiring a temporary floating dock. A temporary on-Site camp or boat would be required to house Site workers.

Material would be excavated from the Kendrick Creek Delta within the intertidal zone as a source of borrow material for cover construction. No other suitable borrow areas have been identified at the Site. The proposed Kendrick Creek Delta borrow area would require additional investigation to confirm that physical and geotechnical properties of the available materials are suitable for cover construction, and to define the physical characteristics of the borrow area. Sorting or screening of materials from the proposed borrow area would be necessary to provide the necessary soil and rock geotechnical properties for cover construction. Rock for cover construction and pile toe protection could also be sourced on-site from the Kendrick Creek Delta or the basalt rock outcrop along the north shore adjacent to the ore loading ramp. Following removal of spilled ore rock from the ore loading ramp, the basalt rock used to construct the ore loading ramps could also be a source of rock protection.

The cover material would be transported by off-road haul trucks using the existing haul and mine roads following rehabilitation. One-foot of material would be excavated from the road surface of the identified mine road embankments and the identified haul road segments and replaced with one-foot of borrow material. Existing road rehabilitation and improvement would also include removal of trees which have invaded the road sides since mining ended, improving the roadbed in areas by placement of borrow material, and constructing pullouts at certain locations to allow multiple haul trucks to be used for cover transport. In the short-term, an increase in the potential for erosion and dust generation may occur during road rehabilitation and cover material transport, which would be mitigated by implementing erosion and sediment controls.

Clearing of trees and vegetation from the OSA and mine rock piles would be necessary to regrade the mine rock areas and to construct the covers. Most of the OSA is densely vegetated with trees and an organic mat covers the ground surface. The 300-Foot Level mine rock pile is also densely vegetated. Tree and vegetation removal increases the potential for erosion during and following construction, which would be mitigated by implementing appropriate stormwater and erosion control management plans. The logged trees and larger vegetation would be chipped, as necessary, for use as erosion protection during construction, for stabilizing and re-vegetating cover surfaces, and restoring areas disturbed during construction. To the extent practical, the organic mat from the OSA would also be salvaged and used for re-vegetation purposes.

Periodic inspections and maintenance, as necessary, would be required to ensure the long-term integrity and effectiveness of the covers, requiring inspections at multiple areas. The existing haul and mine roads would remain to provide access to the mine rock covered areas for inspection and maintenance requirements. Unrestricted road access would be prevented by placing physical barriers, such as rock barriers, at key access points.

Signs, physical barriers on the existing access roads, and land use restrictions are readily implementable and would be effective in reducing human access and prevent future disturbance of the covered mine rock areas. Land use restrictions would be required to prevent future disturbances that would jeopardize the integrity of the covers. Implementation of Alternative M-3 would reduce current access for potential future mining at the Site. Alternative M-3 actions would likely remove the Site from NRHP eligibility.

Cost

The total estimated cost for Alternative M-3 is $3,986,000, which includes estimated direct and indirect capital costs of $3,780,000 and estimated M&M net present value costs of $206,000. Major elements of the direct capital cost estimate includes mobilization and de-mobilization of personnel and equipment, regrading mine rock at the 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles, excavation of cover materials from the Kendrick Creek Delta, transport and placement of cover on the OSA and mine rock piles, and constructing stormwater controls in the covered mine rock areas and Open Pit. In addition, the costs include the common elements of removing spilled ore within the intertidal area associated with former ore loading operations and consolidation of the rock at the OSA, and off-site transport, recycling, and disposal of the miscellaneous solid wastes and debris. The estimated M&M costs include annual inspections for the first three years following implementation and then every five years and an allowance for maintenance during the 30-year M&M period. The estimated direct capital costs include a 20% contingency and the estimated M&M costs include a 25% contingency.

7.2.4 Alternative M-4 – Excavate, Consolidate and Cover at Mine Affected Areas

Alternative M-4 consists of consolidating all mine rock at the 300-Foot Level mine rock pile and into the Open Pit, and placing a cover over the two areas. The cover at the Open Pit would utilize a synthetic geomembrane barrier to minimize infiltration into the Open Pit. The mine-affected material at the OSA would be excavated and consolidated at the 300-Foot Level mine rock pile. The 700-Foot Level and 900-Foot Level (North and South) mine rock piles, the I&L Spur road, and the identified mine road (between the 700-Foot and 900-Foot Levels) embankments and scattered mine rock along the mine road would be excavated and placed into the Open Pit. The I&L Spur road and mine road would be closed, as shown on Figure 7-1. In addition, material would be excavated from the road surface of the identified haul road segments and replaced with one-foot of borrow material. The excavated material from the haul road segments would be excavated and replaced with borrow material, and the excavated material would be consolidated at the 300-Foot Level mine rock pile or in the Open Pit nearest to the haul road segments. Stormwater controls would be implemented at the 300-Foot Level mine rock pile and Open Pit to protect the covered areas. Ore rock would be removed within the intertidal zone associated with former loading docks and ore loading operations and consolidated in the Open Pit. Miscellaneous solid waste and debris would be removed and transported for off-site recycling and disposal.

Effectiveness

Alternative M-4 would provide protection of human health and the environment, would achieve RAOs, and would achieve ARARs. However, Alternative M-4 would not eliminate the human health risks associated with background radiation exposures in the mineralized area. Removing the OSA materials and the 700-Foot and 900-Foot Levels mine rock piles would substantially reduce exposure to human and ecological receptors from mine rock at their current locations. By consolidating the mine-affected materials at two areas and physically isolating the mine rock beneath a cover, radiation risk from mine rock to occupational and recreational users of the Site due to direct gamma radiation, inhalation of radon decay products, and incidental ingestion exposure pathways would be significantly reduced, including that presently occurring from the Open Pit. Radiation risks to human receptors from mine rock at the covered 300-Foot Level and Open Pit would be substantially reduced due to the reduction in external gamma exposure rates and radon emanation from mine rock by the cover over the two areas. The radiological characteristics of mine rock consolidated into the Open Pit are the same as the wall rock in the Open Pit and in the naturally mineralized area. Removing the mine-affected materials from the OSA and from the intertidal zone at and adjacent to the ore loading ramps significantly reduces the overall risk to Site visitors and recreational users, since it is assumed that these users spend most of their time on the shore of the West Arm of Kendrick Bay near the OSA.

The predicted dose and risk for human receptors for this alternative are provided in Table 7-6. The estimated dose and lifetime risk due to consolidation and covering of the mine rock piles would achieve the dose criterion of 15 mrem/year and the lifetime risk criterion of 1E-5 attributable to the mine rock above background for the recreational Site visitor and occupational workers. As described in Section 7.1.1, the predicted dose/risk calculations assume that removal of OSA and the 700-Foot Level and 900-Foot Level mine rock piles would eliminate the radiation exposure at the locations of the removed mine rock piles. However, minimal residual dose/risk to human receptors may remain following removal of the mine rock piles at their current locations.

Exposure pathways associated with the mine rock at the mine-affected areas to ecological receptors would also be significantly reduced. Consolidating and covering mine rock at the 300-Foot Level and the Open Pit would eliminate or substantially reduce the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife. The covers would also eliminate or substantially reduce the potential for direct precipitation contact with mine rock; thereby reducing radium concentrations in surface water runoff from mine rock and potential exposure pathways for riparian animals.

Cover placement and stormwater controls would reduce run-on into the Open Pit reducing inflow into the underground mine via the 900-Foot Level portal; thereby, reducing flow from the 300-Foot Level portal. The cover would be designed to promote positive surface drainage and minimize infiltration of direct precipitation. Existing pit wall seepage would still occur into the Open Pit. Closure of the 900-Foot Level portal would be required to backfill the Open Pit. As described in Section 6.2, the closure of the portal would allow water from the Open Pit to flow into the underground mine to prevent the pit from filling with water and saturating the consolidated mine rock. While cover placement and stormwater controls will reduce inflow and infiltration into the Open Pit and into the underground mine in the long term, backfilling the Open Pit with mine rock may increase the potential for leaching of metal and radionuclide constituents from the mine rock by pit wall seepage in the short term during and following construction. While the mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in the drainage from the 300-Foot Level portal for some time period. The synthetic geomembrane barrier reduces the potential for leaching of the mine rock backfill by minimizing infiltration of precipitation through the cover.

The alternative involves extensive construction activities in all the mine-affected areas of the Site. Short-term radiation exposure to external gamma radiation and radon for workers and Site users during mine rock excavation, transport and consolidation, and cover construction would be managed by implementing standard worker and public health and safety practices. Excavation and transport of materials from the OSA, mine rock from the 700-Foot and 900-Foot Level, and from the I&L Spur, mine, and haul roads, and the transport of cover materials increases the potential for erosion and dust generation during construction activities. The alternative increases the potential for a spill or release of mine rock to occur during transport. These potential short-term risks would be mitigated by implementing appropriate stormwater, erosion and dust control management plans, and appropriate practices during material transport.

Material for cover construction would be excavated from the on-site Kendrick Creek Delta borrow source within the intertidal zone. However, a smaller quantity of borrow material would be required for cover construction as compared to Alternative M-3. Excavation of materials from the Kendrick Creek Delta intertidal area would be subject to substantive requirements of ARARs of the State of Alaska, as described in Section 4.

Removal of OSA mine-affected material, mine rock from the 700-Foot and 900-Foot Levels, mine rock from the I&L Spur, haul, and mine roads, and spilled ore rocks within the intertidal zone near the former loading docks, would be permanently effective in eliminating the risk to human and ecological receptors from mine-affected materials in these areas. Consolidating and covering of the mine rock pile at the 300-Foot Level and Open Pit would also provide long-term effectiveness with properly designed covers and stormwater controls, periodic inspections and maintenance. The Open Pit cover and stormwater controls would also be effective over the long-term in reducing water inflow into the underground mine and flow from the 300-Foot Level portal.

No institutional and/or access controls would be required at the OSA and or to existing mine rock piles at 700-Foot and 900-Foot Levels, and to mine rock in identified haul road segments. The I&L Spur road and mine road between the 700-Foot and 900-Foot Levels would be permanently closed. Institutional and/or access controls would be required for covered areas at the 300-Foot Level and Open Pit. Institutional controls consisting of land use and access restrictions, including installation of signs and barriers on the existing haul road, would further reduce human access and residual risks associated with mine rock at the covered 300-Foot Level and Open Pit. Access restrictions would also protect the integrity of the implemented action.

Implementability

Alternative M-4 is technically and administratively feasible. While the alternative involves extensive construction activities in all mine-affected areas of the Site, the excavation and transport of mine rock and cover materials involves conventional earth-moving equipment and construction practices. Depending on the construction force and sequencing of construction activities, it is estimated that the work could be completed in two construction seasons.

Earthen covers have been demonstrated to be effective and reliable in reducing gamma exposure rates and radon emanation from mine rock. Design methods and engineering requirements for covers are well documented and understood. The covers and stormwater controls would be designed according to the criteria described in Section 6.1.

While equipment and personnel are readily available within the POW area, the remote location requires that equipment be transported by barge to the Site requiring a temporary floating dock. A temporary on-Site camp or boat would be required to house Site workers.

The available capacity for consolidating mine-affected materials from the OSA at the 300-Foot Level mine rock pile is limited without significantly increasing the footprint area of the 300-Foot Level mine rock pile. 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 (Tetra Tech, 2010). Based on topographic surveying, the total disturbed surface area of the OSA is approximately 1.4 acres. The estimated volume of material in the OSA is comprised of an approximately 18-inch thick surficial organic mat and two feet of affected soil, resulting in a total estimated material volume of 8,250 cubic yards. During design, the volume of material to be removed from the OSA will need to be verified. If the required volume of material to be excavated from the OSA exceeds the volume that can be consolidated at the 300-Foot Level, the excess material could be consolidated at the Open Pit.

Material would be excavated from the Kendrick Creek Delta within the intertidal zone as a source of borrow material for cover construction. No other suitable borrow areas have been identified at the Site. The proposed Kendrick Creek Delta borrow area would require additional investigation to confirm that physical and geotechnical properties of the available materials are suitable for cover construction, and to define the physical characteristics of the borrow area. Sorting or screening of materials from the proposed borrow area would be necessary to provide the necessary soil and rock geotechnical properties for cover construction. Rock for cover construction and pile toe protection could also be sourced on-site from the Kendrick Creek Delta or the basalt rock outcrop along the north shore adjacent to the ore loading ramp. Following removal of spilled ore rock from the ore loading ramp, the basalt rock used to construct the ore loading ramps could also be a source of rock protection.

The mine-affected materials from the OSA would be transported by off-road haul trucks using the existing haul road following removal of mine-affected from identified haul road segments and rehabilitation of the haul road surface. Mine rock from the 700-Foot Level would be transported by off-road haul trucks to the Open Pit prior to removal of mine rock from the mine road. Material for cover construction would be transported from the Kendrick Creek Delta borrow source to the 300-Foot Level and Open Pit by off-road haul trucks using the existing haul road following road rehabilitation. Mine-affected material from the haul road segments would be excavated to a depth of one foot and replaced with one-foot of borrow material. Existing road rehabilitation and improvement would also include removal of trees which have invaded the road sides since mining ended, improving the roadbed in areas by placement of borrow material, and constructing pullouts at periodic intervals to allow use of multiple haul trucks. In the short-term, an increase in the potential for erosion and dust generation may occur from the roads during road rehabilitation and material transport, which would be mitigated by implementing erosion and sediment controls.

Clearing of trees and vegetation from the OSA and mine rock piles at the 300-Foot, 700-Foot and 900-Foot Levels, and removal of brush along the floor of the Open Pit would be necessary. Most of the OSA is densely vegetated with trees and an organic mat covers the ground surface. The 300-Foot Level mine rock pile is also densely vegetated with trees and brush. Dense brush occurs over most of the Open Pit floor. Tree and vegetation removal increases the potential for erosion during and following construction, which would be mitigated by implementing appropriate stormwater and erosion control management plans. The logged trees and larger vegetation would be chipped, as necessary, and used for erosion protection during construction, for stabilizing and re-vegetating cover surfaces, and restoring areas disturbed during construction. The organic mat from the OSA would be removed to the extent possible and used for re-vegetation purposes.

The long-term performance of the covers over the 300-Foot Level and Open Pit is dependent on the type and properties material available from the on-site borrow source. With proper design, routine inspections and maintenance, the useful life of the covers is indefinite. Periodic inspections and maintenance, as necessary, would be required to ensure the long-term integrity and effectiveness of the covers. Maintenance activities would be expected to include repair of minor erosion of the cover following placement. The 300-Foot Level cover will be revegetated following the removal action, and may be more susceptible to future erosion than the Open Pit repository, which will be covered with rock mulch. The existing haul roads to the 300-Foot Level and Open Pit would remain to provide access to the covered areas for inspection and maintenance activities. Unrestricted road access would be prevented by placing physical barriers, such as rock barriers, at key access points.

Signs, physical barriers on the existing access roads, and land use restrictions are readily implementable and would be effective in reducing human access and prevent future disturbance of the covered mine rock areas. Land use restrictions would be required to prevent future disturbances that would jeopardize the integrity of the covers at the 300-Foot Level and Open Pit. Implementation of Alternative M-4 would preclude current access and close the Ross Adams Open Pit potentially eliminating future mining at the Site. Alternative M-4 actions will adversely impact the integrity of the historic site and remove the Site from NRHP eligibility.

Cost

The total estimated cost for Alternative M-4 is $3,592,000, which includes estimated direct and indirect capital costs of $3,441,000 and estimated M&M net present value costs of $152,000. Major elements of the direct capital cost estimate includes mobilization and de-mobilization of personnel and equipment, excavation, transport and consolidation of the OSA materials, the 700-Foot and 900-Foot Level mine rock piles, the I&L Spur road, the mine road and identified segments of the haul road, excavation of cover materials from the Kendrick Creek Delta, transport and placement of cover on the 300-Foot Level mine rock pile and Open Pit, and constructing stormwater controls. In addition, the costs include the common elements of removing spilled ore within the intertidal area associated with former ore loading operations and consolidation of the rock at the Open Pit, and off-site transport, recycling, and disposal of the miscellaneous solid wastes and debris. The estimated M&M costs include annual inspections for the first three years following implementation and then every five years and an allowance for maintenance during the 30-year M&M period. The estimated direct capital costs include a 20% contingency and the estimated M&M costs include a 25% contingency.

7.2.5 Alternative M-5 – Excavate, Consolidate and Cover in Open Pit Repository

Alternative M-5 consists of consolidating all mine rock from the Site at the Open Pit and placing a cover consisting of a synthetic geomembrane barrier and earthen materials over the repository area. Mine rock and mine-affected materials would be excavated from the following areas and transported to the Open Pit: mine rock piles at the 300-Foot, 700-Foot, and 900-Foot Levels; mine-affected materials and residual ore within the OSA, mine rock from the I&L Spur road; scattered mine rock along the mine road and the identified mine road embankments; mine rock in identified haul road segments; and ore rock within the intertidal zone associated with former loading ramps and ore loading operations. The I&L Spur road, mine road, and the haul road to the 300-Foot Level would be closed following mine rock removal, as shown on Figure 7-1. Stormwater controls would be implemented at the Open Pit repository to protect the cover. Common to all alternatives, miscellaneous solid waste and debris would be removed and transported for off-site recycling and disposal. Drill core would be consolidated at the Open Pit.

Effectiveness

Alternative M-5 would provide protection of human health and the environment, would achieve RAOs, and would achieve ARARs. The predicted dose and risk for human receptors for this alternative are provided in Table 7-7. The estimated dose and lifetime risk due to consolidation and covering of the mine rock piles at the Open Pit would achieve the dose criterion of 15 mrem/year and the lifetime risk criterion of 1E-5 attributable to the mine rock above background for the recreational visitor and occupational workers. As described in Section 7.1.1, the predicted dose/risk calculations assume that removal and consolidation of OSA, and the 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles would eliminate the radiation exposure at the locations of the removed mine rock piles. However, minimal residual dose/risk to human receptors may remain following removal of the mine rock piles at their current locations. Similar to the other alternatives, Alternative M-5 would not eliminate the human health risks associated with background radiation exposures in the mineralized area, which exceed the dose and risk criteria.

Removing the OSA mine-affected materials, spilled ore rocks within the intertidal area, and the 300-Foot Level, 700-Foot Level and 900-Foot Level mine rock piles would significantly reduce exposure to human and ecological receptors from mine rock at those current locations. By consolidating the mine-affected materials and physically isolating the mine rock beneath a cover at the Open Pit, radiation risk from mine rock to occupational and recreational users of the Site due to direct gamma radiation, inhalation of radon decay products, and incidental ingestion exposure pathways would be significantly reduced. Mine rock with the highest gamma activity would be placed at the bottom of the pit and covered with lower gamma activity mine rock; thereby further reducing the gamma exposure rate and radon emanation at the cover surface. Placement of the lower gamma activity material from the 300-Foot Level mine rock pile at the surface of the Open Pit repository will reduce the gamma and radon emanation at the cover surface. Radiation risks to human receptors from mine rock would be limited to the covered area of the Open Pit, where external gamma exposure rates and radon emanation from mine rock would be reduced by the cover. The radiological characteristics of mine rock consolidated into the Open Pit are the same as the wall rock in the Open Pit and in the naturally mineralized area. Isolating the mine rock at one location at the 900-Foot Level significantly reduces the overall Site risk to recreational and occupational users, since it is assumed that these users spend most of their time on the shore of the West Arm of Kendrick Bay near the OSA or in other areas of the Site.

Ecological exposure pathways and risk associated with exposure to mine rock would be eliminated or significantly reduced. Consolidating and covering all the mine rock at the Open Pit would eliminate or substantially reduce the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife. The cover would also eliminate or substantially reduce the potential for direct precipitation contact with mine rock; thereby reducing radium concentrations in surface water runoff from mine rock and potential exposure pathways for riparian animals.

Cover placement and stormwater controls would eliminate run-on into the Open Pit reducing inflow into the underground mine via the 900-Foot Level portal; thereby, reducing flow from the 300-Foot Level portal. The cover would be designed to promote positive surface drainage and minimize infiltration of direct precipitation on the cover. Existing pit wall seepage would still occur into the Open Pit. Closure of the 900-Foot Level portal would be required to backfill the Open Pit. As described in Section 6.2, the closure of the portal closure would allow water from the Open Pit to flow into the underground mine closure to prevent the pit from filling with water and saturating the consolidated mine rock. While cover placement and stormwater controls will reduce inflow into the Open Pit and into the underground mine in the long term, backfilling the Open Pit with mine rock may increase the potential for leaching of metal and radionuclide constituents from the mine rock by pit wall seepage in the short term during and following construction. While the mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in the drainage from the 300-Foot Level portal for some time period. The synthetic geomembrane barrier reduces the potential for leaching of the mine rock backfill by minimizing infiltration of precipitation through the cover.

The alternative involves extensive construction activities in all the mine-affected areas of the Site. Short-term radiation exposure to external gamma radiation and radon for workers and Site users during mine rock excavation, transport and consolidation, and cover construction would be managed by implementing standard worker and public health and safety practices. Excavation and transport of materials from the OSA, mine rock from the 300-Foot, 700-Foot and 900-Foot Levels, and from the I&L Spur, mine, and haul roads, and the transport of cover materials increases the potential for erosion and dust generation during construction activities. The potential for a spill or release of mine rock to occur during transport also increases. These potential short-term risks would be mitigated by implementing appropriate stormwater, erosion and dust control management plans, and appropriate practices during material transport.

Material for cover construction would be excavated from the on-site Kendrick Creek Delta borrow source within the intertidal zone. However, a smaller quantity of borrow material would be required for cover construction as compared to Alternatives M-3 and M-4. Excavation of materials from the Kendrick Creek Delta intertidal area would be subject to substantive requirements of ARARs of the State of Alaska, as described in Section 4.

Removal of OSA mine-affected material, mine rock from the 300-Foot, 700-Foot and 900-Foot Levels, mine rock from the I&L Spur, haul, and mine roads, and spilled ore rocks within the intertidal zone near the former loading docks, would be permanently effective in reducing the current risk to human and ecological receptors from mine rock in those areas. Consolidating and covering of the mine rock pile at the Open Pit would also provide long-term effectiveness with a properly designed cover and stormwater controls, and by periodic inspections and maintenance to ensure the integrity of the cover. The Open Pit cover and stormwater controls would also be effective over the long-term in reducing water inflow into the underground mine and flow from the 300-Foot Level portal.

No institutional and/or access controls would be required at the OSA and or to previously existing mine rock piles at the 300-Foot, 700-Foot and 900-Foot Levels, and in identified haul road segments where mine rock was removed. The I&L Spur road, the mine road between the 700-Foot and 900-Foot Levels, and the haul road to the 300-Foot Level would be permanently closed following mine rock removal. Institutional and/or access controls would be required for the covered area at the Open Pit. Institutional controls consisting of land use and access restrictions, including installation of signs and barriers on the existing haul road, would further reduce human access and residual risks associated with mine rock at the covered Open Pit. Access restrictions would also protect the integrity of the implemented action.

Implementability

Alternative M-5 is technically and administratively feasible. While the alternative involves extensive construction activities in all mine-affected areas of the Site, the excavation and transport of mine rock and cover materials involves conventional earth-moving equipment and construction practices. It is estimated that the work could be completed in two construction seasons depending on construction scheduling and sequencing.

Earthen covers have been demonstrated to be effective and reliable in reducing gamma exposure rates and radon emanation from mine rock. Design methods and engineering requirements for covers are well documented and understood. The Open Pit cover and stormwater controls would be designed according to the criteria described in Section 6.1. Rock mulch would be placed on the surface of the cover at the Open Pit, which would be less susceptible to future erosion than a revegetated cover.

While equipment and personnel are readily available within the POW area, the remote location requires that equipment be transported by barge to the Site requiring a temporary floating dock. A temporary on-Site camp or boat would be required to house Site workers.

The Open Pit repository has additional capacity to accommodate additional material by increasing the footprint or height of the consolidated materials. As such, this alternative is not as sensitive to uncertainties in the quantities of materials to be excavated from the mine feature areas as Alternative M-4, which has a limited area for the repository at the 300-Foot Level. Alternative M-5 results in a smaller mine rock footprint and requires less material to construct the cover, as compared to Alternatives M-3 and M-4.

The Open Pit repository cover requires a smaller quantity of material than Alternatives M-3 and M-4. Material would be excavated from the Kendrick Creek Delta within the intertidal zone as a source of borrow material for cover construction. No other suitable borrow areas have been identified at the Site. The proposed Kendrick Creek Delta borrow area would require additional investigation to confirm that physical and geotechnical properties of the available materials are suitable for cover construction, and to define the physical characteristics of the borrow area. Sorting or screening of materials from the proposed borrow area may be necessary to provide the necessary soil and rock geotechnical properties for cover construction. Rock for cover construction and stormwater diversions could also be sourced on-site from the Kendrick Creek

Delta or the basalt rock outcrop along the north shore adjacent to the ore loading ramp. Following removal of spilled ore rock from the ore loading ramp, the basalt rock used to construct the ore loading ramps could also be a source of rock protection.

The mine-affected materials from the OSA and the 300-Foot Level mine rock pile would be transported to the Open Pit by off-road haul trucks using the existing haul road following removal of mine-affected material from identified haul road segments and rehabilitation of the haul road surface. Mine rock from the 700-Foot Level would be transported by off-road haul trucks to the Open Pit prior to removal of mine rock from the mine road. Material for cover construction would be transported from the Kendrick Creek Delta borrow source to the Open Pit repository by off-road haul trucks using the existing haul road following road rehabilitation. Mine-affected material from the haul road segments would be excavated to a depth of one foot and replaced with one-foot of borrow material. Existing road rehabilitation and improvement would also include removal of trees which have invaded the road sides since mining ended, improving the roadbed in areas by placement of borrow material, and constructing pullouts at periodic intervals to allow use of multiple haul trucks. In the short-term, an increase in the potential for erosion and dust generation may occur from the roads during road rehabilitation and material transport, which would be mitigated by implementing erosion and sediment controls.

Clearing of trees and vegetation from the OSA and mine rock piles at the 300-Foot, 700-Foot and 900-Foot Levels, and removal of brush along the floor of the Open Pit would be necessary. Most of the OSA is densely vegetated with trees and an organic mat covers the ground surface. The 300-Foot Level mine rock pile is also densely vegetated with trees and brush. Dense brush occurs over most of the Open Pit floor. Tree and vegetation removal increases the potential for erosion during and following construction, which would be mitigated by implementing appropriate stormwater and erosion control management plans. The logged trees and larger vegetation would be chipped, as necessary, and used for erosion protection during construction, for stabilizing and re-vegetating cover surfaces, and restoring areas disturbed during construction. The organic mat from the OSA would be removed to the extent possible and used for re-vegetation purposes.

The long-term performance of the cover over the Open Pit repository is dependent on the type and properties material available from the on-Site borrow source. With proper design, routine inspections and maintenance, the useful life of the cover is indefinite. Maintenance activities would be expected to include repair of minor erosion of the cover following placement. However, the Open Pit repository cover will be constructed with rock mulch at the surface, which minimizes erosion of the cover and resulting long-term maintenance. Periodic inspections and maintenance, as necessary, would be required to ensure the long-term integrity and effectiveness of the cover. The existing haul road to the Open Pit would remain to provide access to the area for inspection and maintenance activities. Unrestricted road access would be prevented by placing physical barriers, such as rock barriers, at key access points.

Signs, physical barriers on the existing access roads, and land use restrictions are readily implementable and would be effective in reducing human access and prevent future disturbance of the covered mine rock area. Land use restrictions would be required to prevent future disturbances that would jeopardize the integrity of the cover at the Open Pit repository. Implementation of Alternative M-5 would preclude the current access and close the Ross-Adams Open Pit and reduce the potential for future mining at the Site. Alternative M-5 actions will adversely impact the integrity of the historic site and remove the Site from NRHP eligibility.

Cost

The total estimated cost for Alternative M-5 is $6,373,000, which includes estimated direct and indirect capital costs of $6,240,000 and estimated M&M net present value costs of $133,000. Major elements of the direct capital cost estimate includes mobilization and de-mobilization of personnel and equipment, excavation, transport and consolidation of the OSA materials, the 300-Foot, 700-Foot and 900-Foot Levels mine rock piles, the I&L Spur road, the mine road and identified segments of the haul road, excavation of cover materials from the Kendrick Creek Delta, transport and placement of cover on the Open Pit repository, and constructing stormwater controls. In addition, the costs include the common elements of removing spilled ore within the intertidal area associated with former ore loading operations and consolidation of the rock at the Open Pit, and off-site transport, recycling, and disposal of the miscellaneous solid wastes and debris. The estimated M&M costs include annual inspections for the first three years following implementation and then every five years and an allowance for maintenance during the 30-year M&M period. The estimated direct capital costs include a 20% contingency and the estimated M&M costs include a 25% contingency.

7.3 Analysis of Portal Alternatives

An analysis of the effectiveness, implementability, and cost criteria for each mine portal removal action alternative is described in the following sections. The uncertainties and assumptions of the criteria are also presented. Table 7-8 summarizes the results of the analysis for effectiveness and implementability and Table 7-9 summarizes the estimated total cost for each alternative that includes direct and indirect capital costs and M&M costs. The predicted dose and risk for human receptors for mine portal alternatives are provided in Table 7-10.

The mine portal removal actions address the 900-Foot Level portal, the Air Ventilation Shaft at the 900-Foot Level, the 700-Foot Level portal and the 300-Foot Level portal. As described in Section 2, the mine openings present avenues for radon emissions from the underground mine workings. Inhalation of radon decay products from radon emissions from the portals is an exposure pathway contributing risk to occupational and recreational users of the Site. The highest radon concentration measured at the Site was from the 300-Foot Level portal (Tetra Tech, 2010).

Based on available information, airflow enters the underground mine at the 900-Foot Level portal, the Air Vent Shaft and the 700-Foot Level portal, and exits the mine at the 300-Foot Level portal. Measures to restrict air flow into the underground mine at the upper mine openings would result in an equivalent reduction in air exhaust from the 300-Foot Level portal.

Radon exhalation from the 300-Foot Level is dependent on several factors, including air entry and ventilation rates through the mine workings, atmospheric air pressures and pressure gradients within the underground mine workings, and the emanation rate at which radon gas diffuses into the mine from the wall rock and broken rock. Reducing the airflow rate from the 300-Foot Level portal may reduce the radon exhalation rate from the portal but the reduction in radon exhalation may not be equivalent to the reduction in the airflow rate. The air radon concentration in the underground mine would likely increase in response to a decrease in the air ventilation rate.

The 900-Foot Level portal also represents an avenue for surface water intercepted by the Open Pit to enter the underground mine. The Open Pit serves as a catch basin for surface water, which can subsequently enter the mine workings via the 900-Foot Level portal. The water inflow entering the 900-Foot Level portal contributes to the drainage exiting the mine at the 300-Foot Level portal. Since rock obscures the bottom of the portal at the floor of the Open Pit, measurements to quantify the water flow entering the 900-Foot Level portal are not possible. Surface water was observed flowing into the Open Pit on several occasions during and following rain events during 2009 field investigations (Tetra Tech, 2010). Water was also observed flowing from the base of the rock pile into the 900-Foot Level portal from the Open Pit (Tetra Tech, 2010). It is expected that the flow rate of water intercepted by the Open Pit and entering the mine workings through the 900-Foot Level portal increases during periods of precipitation. Measures to reduce the water inflow into the mine from the Open Pit via the 900-Foot Level portal would result in an equivalent reduction in the drainage from 300-Foot Level portal.

As described in Section 2, mine water drainage occurs from the 300-Foot Level portal. The drainage from the 300-Foot Level has the highest radionuclide concentrations in surface water samples collected at the Site. Potential water ingestion of radionuclide concentrations in the drainage represents an exposure pathway evaluated for the Site Visitor in the HHRA. As evaluated in the SLERA, the risk due to radium concentrations in surface water represents the majority of the cumulative exposure to radium (Ra-226 and Ra-228) in combined surface water and stream sediments for riparian animals at the 300-Foot Level. The RAOs described in Section 4.2 include reducing the risk or eliminating the exposure pathways for Site visitors due to potential ingestion of water in the drainage from the 300-Foot Level portal and for riparian animals from potential exposure to radium in water in the drainage from the 300-Foot Level portal.

7.3.1 Alternative P-1 - No Action Alternative

Effectiveness

The No Action alternative is included in the EE/CA as a baseline for comparison with other removal action alternatives. Under the No Action alternative, the mine rock portals would remain in their current condition, with no reduction in exposure pathways or reduction in existing risk to human or ecological receptors. Access by humans and wildlife would remain the same as currently exists. The alternative would not be effective in protecting human health and the environment, would not achieve RAOs and does not comply with chemical-specific ARARs. The predicted dose and risk to human receptors for existing Site conditions for this alternative are provided in Table 7-10.

No short-term effects are associated with implementation of this Alternative P-1 and it would not result in additional exposure to human health and ecological receptors compared to existing conditions. In the long-term, it is not expected that radon exhalation from the mine portals or Site conditions would change that would reduce or alter currently existing risks to human health and the environment.

Implementability

The No Action alternative is readily implementable and technically and administratively feasible, as no construction activities are associated with the alternative. The alternative is not dependent on the availability of equipment, personnel or services.

Cost

There are no costs associated with this alternative.

7.3.2 Alternative P-2 – Close Upper Mine Openings with 300-Foot Level Portal Gate

As described in Section 6.0, as a common element to Alternatives P-2 through P-5, the upper mine openings consisting of the 900-Foot Level portal, Air Vent Shaft and 700-Foot Level portal would be closed. For this Alternative P-2, a gate would be installed at the 300-Foot Level portal. While not evaluated as part of this alternative, an optional component would be to install a water collection system at the portal to pipe the drainage from the 300-Foot Level portal directly to Kendrick Creek.

Effectiveness

Alternative P-2 would potentially provide protection of human health and the environment, and would potentially achieve RAOs and ARARs. Closure of the 900-Foot Level portal, Air Vent Shaft and 700-Foot Level portal would eliminate radon exhalation from these upper mine openings. Closure of the upper mine openings would significantly reduce air inflow into mine workings and air outflow from 300-Foot Level portal. The reduced airflow may reduce radon exhalation from the 300-Foot Level portal. However, due to the uncertain relationship between radon exhalation and airflow, the reduction in radon exhalation from 300-Foot Level portal is indeterminable. Therefore, reduction in radon exhalation from the 300-Foot Level portal was not included in the calculated residual dose and risk for human receptors for this alternative. Due to the uncertain reduction in radon exhalation, Alternative P-2 might not be protective of a Site Visitor, Mineral Exploration Worker, or a USFS Worker (as evaluated in the HHRA), and might not achieve RAOs and chemical-specific ARARs. Institutional controls, such as signage, and physical barriers that restrict access to the immediate area of the 300-Foot Level portal would further reduce human exposure to residual radon emissions from the portal. Alternative P-2 would not be effective in reducing risk or eliminating the exposure pathways associated with potential ingestion of the mine drainage water by a Site Visitor or the direct exposure pathways associated with radium concentrations in the water drainage to riparian animals, unless the drainage was piped directly to Kendrick Creek.

Closing the upper mine openings and installing a gate at 300-Foot Level portal would eliminate unrestricted human access to the underground mine workings. While it is not known if bats inhabit the mine workings, the gate at the 300-Foot Level portal would allow ingress/egress of bats into the mine workings.

The mine geometry and absence of flow observed during 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 (Tetra Tech, 2010). While drainage from the 700-Foot Level portal is uncommon and minimal, closure of the 700-Foot Level portal would eliminate the potential for water outflow. Implementation of Mine Rock Alternatives M-2 through M-5 would reduce the drainage from the 300-Foot Level portal by reducing the water intercepted by the Open Pit and flow into the underground mine via the 900-Foot Level portal.

Short term risks would include radiation and radon exposure to workers during construction of closures at the upper mine openings and during gate installation at the 300-Foot Level portal. Sediment disturbance during gate installation at 300-Foot Level portal could also occur. These potential short-term risks would be managed by implementing worker health and safety practices and sediment control measures. In the short term, bat habitat would be potentially reduced by closure of the upper mine openings.

Closure of the upper mine openings would be effective and permanent in eliminating radon exposure to human receptors at the upper mine openings. While closure of the upper mine workings would significantly reduce air outflow from the 300-Foot Level portal, the long-term effectiveness in reducing radon exhalation and human exposure to radon from the 300-Foot Level portal is uncertain. Implementing institutional or access controls to restrict access to the vicinity of the portal would reduce this uncertainty.

Implementability

Alternative P-2 for mine portals is both technically and administratively feasible, and could be readily implemented in one construction season. The 700-Foot Level and 900-Foot Level portals and the Air vent Shaft can be closed using conventional construction methods that have been proven to be reliable. Installation of a gate at the 300-Foot Level portal also involves conventional equipment and materials. Closure of the upper mine openings and gate installation at the 300-Foot Level portal would be compatible with all removal action alternatives for mine rock described in Section 7.2. Closure of the 900-Foot Level portal would be coordinated with mine rock consolidation in the Open Pit for mine rock Alternatives M-4 and M-5.

The remote location requires that equipment be transported by barge to the Site requiring a temporary floating dock. A temporary on-Site camp or boat would be required to house Site workers. Mine rock can be selectively used as fill to close the portals. On-site sources of rock backfill also include screening of rock from the Kendrick Creek Delta, the basalt rock outcrop adjacent to the ore loading ramp, or the basalt rock from the ore loading ramps following removal of the ore rocks spilled during former ore loading operations.

Routine inspections and any necessary maintenance of the closures at the upper mine workings and gate at 300-Foot Level portal would be readily implementable. Minimal maintenance would be required to ensure the integrity of the mine portal closures and gate. Mine rock consolidation in the Open Pit for mine rock Alternatives M-4 and M-5 would preclude direct inspection and maintenance of the 900-Foot Level portal closure. Closure of the mine openings would also prevent access to the underground mine for future mineral exploration. Signs, physical barriers on the existing access roads, and land use restrictions are readily implementable to prevent future disturbance of the mine portal closures.

Cost

The total estimated cost for Alternative P-2 is $724,000, which includes estimated direct and indirect capital costs of $694,000 and estimated M&M net present value costs of $30,000. The direct capital cost estimate includes mobilization and de-mobilization of personnel and equipment, construction activities associated with closure of the upper mine openings and gate installation at the 300-Foot Level portal. The estimated M&M costs include annual inspections for the first three years following implementation and then every five years and an allowance for maintenance during the 30-year M&M period. The estimated direst capital costs include a 20% contingency and the M&M costs include a 25% contingency.

7.3.3 Alternative P-3 – Close Upper Mine Openings with 300-Foot Level Portal Rock Backfill Closure

Similar to Alternative P-2, the upper mine openings consisting of the 900-Foot Level portal, Air Vent Shaft and 700-Foot Level portal would be closed. For this alternative, the 300-Foot Level portal would be closed with rock backfill. A water collection system would be installed through the rock backfill to pipe the existing drainage from the 300-Foot Level portal to Kendrick Creek. The rock backfill would also be designed to allow drainage through the backfill to prevent the backup of water in the underground mine if a significant increase in flow were to occur from the portal in the future.

Effectiveness

Alternative P-3 would potentially provide protection of human health and the environment, and would potentially achieve RAOs and ARARs. Similar to Alternative P-2, closure of the upper mine openings would eliminate radon exhalation at these upper mine openings and reduce air outflow from the 300-Foot Level portal. The reduced airflow may reduce radon exhalation from the 300-Foot Level portal. In addition to the effectiveness provided by Alternative P-2, the rock backfill at the 300-Foot Level portal would further reduce radon exhalation from the portal. However, diffusion of radon gas would still occur through the rock backfill. The reduction in radon exhalation from 300-Foot Level portal is indeterminable. As such, reduction in radon exhalation from the 300-Foot Level portal was not included in the calculated residual dose/risk for human receptors for this alternative. Due to the uncertain reduction in radon exhalation, Alternative P-3 might not be protective of a Site Visitor, Mineral Exploration Worker, or a USFS

Worker (as evaluated in the HHRA), and might not achieve RAOs and chemical-specific ARARs. Institutional controls, such as signage, and physical barriers that restrict access to the immediate area of the 300-Foot Level portal would further reduce human exposure to residual radon emissions from the portal.

Similar to Alternative P-2, even though drainage from the 700-Foot Level portal appears to seldom occur, closure of the 700-Foot Level portal would eliminate the potential for drainage from the portal. Implementation of Mine Rock Alternatives M-2 through M-5 would reduce drainage from the 300-Foot Level portal by reducing the water intercepted by the Open Pit and flow into the underground mine via the 900-Foot Level portal. Piping the drainage from the 300-Foot Level portal directly to Kendrick Creek would eliminate the direct exposure pathways for mine water to human and ecological receptors. Piping the drainage would eliminate the potential for ingestion of the open flowing water by Site visitors and would eliminate potential exposure to the water by riparian animals. Based on available data, uranium, radium (combined Ra-226 and Ra-228), manganese and zinc concentrations of the 300-Foot Level portal drainage have a reasonable potential to exceed certain standards for designated freshwater uses. Uranium, radium and manganese concentrations of water samples collected from the portal drainage were greater than Alaska water quality criteria for drinking water. Except for the zinc concentration in one sample (Tetra Tech, 2010), metal concentrations of the portal drainage were below Alaska chronic freshwater criteria for aquatic life and/or background surface water quality. Zinc concentrations of the portal drainage may slightly exceed the zinc freshwater chronic criterion at times of the year.

Water quality in Kendrick Creek below the confluence with Mine Fork Creek and the 300-Foot Level portal drainage, as documented in the SCR (Tetra Tech, 2010), meets Alaska water quality standards for all designated freshwater uses (except the chronic aluminum standard for freshwater aquatic life). While above the chronic standard for freshwater aquatic life, aluminum concentrations in Kendrick Creek were less than the range of background surface water concentrations and not attributable to the drainage from the 300-Foot Level portal. The existing water quality of Kendrick Creek would not be affected by piping the portal drainage to the creek, as the portal drainage currently flows to Mine Fork Creek, a short distance above the confluence with Kendrick Creek. The steep gradient of Kendrick Creek to below the 300-Foot Level is considered negligible spawning and rearing habitat for all salmonids (Tetra Tech, 2010).

Closing the upper mine openings and rock backfilling of the 300-Foot Level portal would eliminate human access to the underground mine workings. This alternative would also eliminate wildlife access into the underground mine and could have a negative impact on potential bat habitat.

Short term risks would include gamma radiation and radon exposure to workers during construction of closures at the upper mine openings and rock backfill at the 300-Foot Level portal. Sediment disturbance in the 300-Foot Level portal drainage during rock backfill and installation of the water collection system at the 300-Foot Level portal could also occur. These potential short-term risks would be managed by implementing worker health and safety practices and sediment control measures.

Closure of the upper mine openings would be effective and permanent in eliminating radon exposure to human receptors at the upper mine openings. While closure of the upper mine workings will significantly reduce air outflow from the 300-Foot Level portal, the long-term effectiveness in reducing radon exhalation and human exposure to radon from the 300-Foot Level portal is uncertain. Piping the 300-Foot Level portal drainage directly to Kendrick Creek would be effective in permanently eliminating the direct exposure pathways for mine water to human and ecological receptors.

Implementability

Alternative P-3 for mine portals is both technically and administratively feasible, and could be readily implemented in one construction season. The 700-Foot Level and 900-Foot Level portals and the Air Vent Shaft can be closed using conventional construction methods that have been proven to be reliable. Rock backfilling and installation of a water collection system at the 300-Foot Level portal also involves conventional equipment and materials. The flow rate of the drainage from the 300-Foot Level for design of the water collection and piping system would be determined during the design phase using available flow data.

Closure of the upper mine openings and rock backfilling of the 300-Foot Level portal would be compatible with all removal action alternatives for mine rock described in Section 7.2. Closure of the 900-Foot Level portal would be coordinated with mine rock consolidation in the Open Pit for mine rock Alternatives M-4 and M-5.

The remote location requires that equipment be transported by barge to the Site requiring a temporary floating dock. A temporary on-Site camp or boat would be required to house Site workers. Mine rock can be selectively screened and used as fill to close the portals. The mineralogy of the mine rock and Site water quality observations confirm that the mine rock is not acid producing. On-site sources of rock backfill also include screening of rock from the Kendrick Creek Delta, the basalt rock outcrop adjacent to the ore loading ramp, or the basalt rock from the ore loading ramps following removal of the ore rocks spilled during former ore loading operations.

Routine inspections and any necessary maintenance of the closures at the upper mine workings and the rock backfill at 300-Foot Level portal would be readily implementable. Minimal maintenance would be required to ensure the integrity of the mine portal closures. Backfilling of the 300-Foot Level portal would preclude direct inspection of the water collection system behind the backfill, but the backfill could be removed if inspections indicated that water was not flowing in the pipe. Mine rock consolidation in the Open Pit for mine rock Alternatives M-4 and M-5 would preclude direct inspection and maintenance of the 900-Foot Level portal closure. Closure of the mine openings would also prevent access to the underground mine for future mineral exploration. Signs, physical barriers on the existing access roads, and land use restrictions are readily implementable to prevent future disturbance of the mine portal closures.

Cost

The total estimated cost for Alternative P-3 is $813,000, which includes estimated direct and indirect capital costs of $719,000 and estimated M&M net present value costs of $94,000. Major components of the direct capital cost estimate include mobilization and de-mobilization of personnel and equipment, and construction activities associated with closure of the upper mine openings and backfilling of the 300-Foot Level portal. The estimated M&M costs include annual inspections for the first three years following implementation and then every five years and an allowance for maintenance during the 30-year M&M period. As described in Section 6.2.1, M&M costs include water quality monitoring in Kendrick Creek at a designated location downstream of the 300-Foot Level to confirm that applicable water quality standards or background (for aluminum) continue to be achieved in Kendrick Creek. The estimated direct capital costs include a 20% contingency and the M&M costs include a 25% contingency.

7.3.4 Alternative P-4 – Close Upper Mine Openings with 300-Foot Level Portal Bulkhead Closure

Similar to Alternatives P-2 and P-3, the upper mine openings consisting of the 900-Foot Level portal, Air Vent Shaft and 700-Foot Level portal would be closed. For Alternative P-4, the 300-Foot Level portal would be closed with a flow-through concrete bulkhead. A water collection system would be installed through the bulkhead to convey the existing drainage by pipe from the 300-Foot Level portal to Kendrick Creek. The water collection and piping would be designed to allow the free-flow of drainage through the bulkhead to prevent the backup of water in the underground mine.

Effectiveness

Alternative P-4 would provide protection of human health and the environment, and would achieve RAOs and ARARs. The predicted dose and risk for human receptors for this alternative are provided in Table 7-10. Closure of the 900-Foot Level portal, Air Vent Shaft, 700-Foot Level portal, and 300-Foot Level portal would eliminate the direct radon emissions from the underground mine through the mine openings. This alternative would eliminate risk to occupational and recreational users of the Site due to inhalation of radon decay products from the mine openings. Piping the drainage from the 300-Foot Level portal directly to Kendrick Creek would eliminate the potential for ingestion of the drainage water by a Site Visitor and eliminate the potential for direct exposure to radium concentrations in the drainage water by riparian animals.

Even though drainage from the 700-Foot Level portal appears to seldom occur, closure of 700-Level portal would eliminate the potential for drainage from the portal. Implementation of Mine Rock Alternatives M-2 through M-5 would reduce drainage from the 300-Foot Level portal by reducing the water intercepted by the Open Pit and flow into the underground mine via the 900-Foot Level portal. Similar to Portal Alternative P-3, piping the drainage from the 300-Foot Level portal directly to Kendrick Creek would eliminate the direct exposure pathways for mine water to human and ecological receptors. As previously described for Alternative P-3, it is not expected that the existing water quality of Kendrick Creek would be affected by piping the portal drainage to the creek, as the portal drainage currently flows to Mine Fork Creek, a short distance above the confluence with Kendrick Creek. In addition, the available data indicates that the metal concentrations of the drainage from the 300-Foot Level portal are below freshwater chronic criteria for aquatic life that have been established by the State of Alaska, except for zinc. Water quality in Kendrick Creek below the confluence with Mine Fork Creek and the 300-Foot Level portal drainage meets Alaska water quality standards for all designated freshwater uses (except for aluminum, which is below background surface water concentrations).

Closing the mine openings would eliminate human access to the underground mine workings. This alternative would also eliminate wildlife access into the underground mine and could have a negative impact on potential bat habitat.

Short term risks would include external gamma radiation and radon exposure to workers during construction of closures at the upper mine openings and the 300-Foot Level portal. Construction of the concrete bulkhead inside the 300-Foot Level portal would also pose short term physical risks to workers. Sediment disturbance in the 300-Foot Level portal drainage during bulkhead construction and installation of the water collection system at the 300-Foot Level portal could also occur. These potential short-term risks would be managed by implementing worker health and safety practices and sediment control measures.

Closure of the mine openings would be effective and permanent in eliminating radon exposure to human receptors from the mine openings. Piping the 300-Foot Level portal drainage directly to Kendrick Creek would be effective in permanently eliminating the direct exposure pathways for mine water to human and ecological receptors.

Implementability

Alternative P-4 for mine portals is both technically and administratively feasible, and could be readily implemented in one construction season. The 300-Foot Level, 700-Foot Level and 900-Foot Level portals and the Air Vent Shaft can be closed using conventional construction methods that have been proven to be reliable. Installation of a water collection system at the 300-Foot Level portal and piping the water to Kendrick Creek also involves conventional equipment and materials. The concrete bulkhead would be installed in competent rock inside the 300-Foot Level portal. Design methods and engineering requirements for concrete bulkheads and piping are well documented and understood. The location and design of the concrete bulkhead would be determined following inspection of rock integrity and strength within the adit during the design phase. Rehabilitation of the portal face would be required. In addition, the bulkhead would be designed to allow access and maintenance, if required, of the water collection system behind the bulkhead to ensure free flowing conditions. The flow rate of the drainage from the 300-Foot Level for design of the water collection and piping system would also be determined during the design phase using available flow data.

Closure of the upper mine openings and construction of a bulkhead at the 300-Foot Level portal would be compatible with all removal action alternatives for mine rock described in Section 7.2. Closure of the 900-Foot Level portal would be coordinated with mine rock consolidation in the Open Pit for mine rock Alternatives M-4 and M-5.

The remote location requires that equipment be transported by barge to the Site requiring a temporary floating dock. A temporary on-Site camp or boat would be required to house Site workers. Mine rock can be selectively screened and used as fill for closure of the upper mine openings. The mineralogy of the mine rock and Site water quality observations confirm that the mine rock is not acid producing. On-site sources of rock backfill also include screening of rock from the Kendrick Creek Delta, the basalt rock outcrop adjacent to the ore loading ramp, or the basalt rock from the ore loading ramps following removal of the ore rocks spilled during former ore loading operations.

Routine inspections and any necessary maintenance of the closures at the upper mine workings and the bulkhead and water collection system at 300-Foot Level portal would be readily implementable. Minimal maintenance would be required to ensure the integrity of the upper mine portal closures. The bulkhead would be designed to allow access and direct inspection of the water collection system. Mine rock consolidation in the Open Pit for mine rock Alternatives M-4 and M-5 would preclude direct inspection and maintenance of the 900-Foot Level portal closure. Closure of the mine openings would also prevent access to the underground mine for future mineral exploration. Signs and land use restrictions are readily implementable and would be effective in preventing future disturbance and protecting the integrity of the mine portal closures.

Cost

The total estimated cost for Alternative P-4 is $864,000, which includes estimated direct and indirect capital costs of $770,000 and estimated M&M net present value costs of $94,000. Major components of the direct capital cost estimate include mobilization and de-mobilization of personnel and equipment, and construction activities associated with closure of the upper mine openings and the 300-Foot Level portal, including construction of the concrete bulkhead and water collection system and piping the drainage to Kendrick Creek. The estimated M&M costs include annual inspections for the first three years following implementation and then every five years and an allowance for maintenance during the 30-year M&M period. As described in Section 6.2.1, M&M costs include water quality monitoring in Kendrick Creek at a designated location downstream of the 300-Foot Level to confirm that applicable water quality standards or background (for aluminum) continue to be achieved in Kendrick Creek. The estimated direct capital costs include a 20% contingency and M&M costs include a 25% contingency.

Table 7-1. Summary Evaluation of Removal Action Alternatives for Mine Rock

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
EFFECTIVENESS					
Protection of human health and the environment	Would not achieve RAOs. Not protective of human or ecological receptors. Institutional and/or access controls required for all mine-affected areas.	Would not achieve all RAOs. Not protective of human or ecological receptors, except within intertidal zone due to removal of spilled ore at former loading docks. Protection of human health is dependent on implementing institutional and/or access controls. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Reduces riparian animal exposure by removing and stabilizing mine rock piles adjacent to stream channels. Institutional and/or access controls required for all mine-affected areas.	Would achieve RAOs for mine rock piles and OSA, but not for Open Pit unless institutional and/or access controls are implemented. Protective; covering of mine rock piles at OSA, and 300-Foot, 700-Foot and 900-Foot Levels significantly reduces exposure pathways from surface mine rock materials and reduces exposure from radon emanation and external gamma radiation for human receptors. Significantly reduces ecological exposure pathways to mine rock piles. Covering mine rock piles eliminates or substantially reduces the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife, and reduces potential exposure pathway for riparian animals. Would not reduce radiation risks for human and ecological receptors associated with Open Pit. Institutional and/or access controls required for protection of human health. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Reduces human and ecological exposure pathways to haul roads and mine roads by excavating one-foot of mine rock and replacing with clean material in identified haul and mine road segments; thereby isolating remaining mine rock by covering. Institutional and/or access controls required for covered areas, including Open Pit.	Would achieve RAOs. Protective; mine rock removal significantly reduces human and ecological risk at OSA, mine road mine rock, and at 700-Foot Level and 900-Foot Level mine rock piles. Mine rock consolidation and cover placement at 300-Foot Level and Open Pit reduces exposure pathways from surface mine rock materials and reduces radon emanation and external gamma radiation for human receptors. Significantly reduces exposure pathways from mine rock piles to ecological receptors. Covering mine rock at 300-Foot Level and Open Pit eliminates or substantially reduces the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife, and reduces potential exposure pathway for riparian animals. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Significantly reduces human and ecological exposure pathways by removal of mine rock and closing of mine road from 700-Foot to 900-Foot Levels and I&L Spur road. Reduces human and ecological exposure pathways to haul roads by excavating one-foot of mine rock and replacing with clean material in identified haul road segments; thereby isolating remaining mine rock by covering. No institutional and/or access controls required at OSA and mine rock piles at 700-Foot and 900-Foot Levels. Institutional and/or access controls required for covered areas at 300-Foot Level and the Open Pit.	Would achieve RAOs. Protective; mine rock removal significantly reduces human and ecological risk at OSA and at 300-Foot Level, 700-Foot Level and 900-Foot Level mine rock piles. Mine rock consolidation and cover placement at Open Pit reduces exposure pathways from surface mine rock materials and reduces radon emanation and external gamma radiation for human receptors. Significantly reduces exposure pathways from mine rock to ecological receptors. Covering mine rock at Open Pit eliminates or substantially reduces the potential for direct contact, ingestion, and food-chain exposure pathways for terrestrial plants, invertebrates, and wildlife, and reduces potential exposure pathway for riparian animals. Significantly reduces human exposure pathways within intertidal zone due to removal of spilled ore at former loading docks. Significantly reduces human and ecological exposure pathways by removal of mine rock and closing of mine road from 700-Foot to 900-Foot Levels, I&L Spur road, and haul road from OSA to 300-Foot Level, and removal of mine rock from identified haul road segments from OSA to 900-Foot Level. No institutional and/or access controls required for mine rock at OSA, and at 300-Foot, 700-Foot, and 900-Foot Levels. Institutional and/or access controls required for covered area at the Open Pit.

Table 7-1. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
Ability to achieve ARARs	Would not comply with potential chemical-specific ARARs defining acceptable risk for human and ecological receptors. The alternative would not comply with Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would not comply with potential chemical-specific ARARs defining acceptable risk for human and ecological receptors. The alternative would not comply with chemical-specific ARARs, including Alaska regulations (18 AAC 75) which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is 1E-4 to 1E-6 for radionuclides.	Would comply with potential ARARs. On-site activities associated with removal of ore rocks from loadout ramps and on-site Kendrick Creek delta borrow source within intertidal zone may be subject to substantive requirements of the State of Alaska permitting programs.	Would comply with potential ARARs. On-site activities associated with removal of ore rocks from loadout ramps and on-site Kendrick Creek delta borrow source within intertidal zone may be subject to substantive requirements of the State of Alaska permitting programs.	Would comply with potential ARARs. On-site activities associated with removal of ore rocks from loadout ramps and on-site Kendrick Creek delta borrow source within intertidal zone may be subject to substantive requirements of the State of Alaska permitting programs.
Short-term effectiveness	No short-term impacts.	Short term impacts may include radiation exposure and erosion during grading operations. Regrading mine rock and placing rock protection adjacent to stream channels increases the potential for erosion during construction activities. Regrading of the mine rock piles may also increase the potential for leaching of metal and radionuclide constituents from the mine rock. While mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in stormwater runoff from the mine rock piles during and following construction. Potential risks could be managed by implementing worker safety measures and appropriate stormwater and erosion control measures.	Short term impacts may include radiation exposure, dust generation and erosion during grading operations. Removal of existing vegetation at 300-Foot Level and OSA mine rock piles required for regrading, which may increase short-term potential for erosion. Short-term impacts associated with on-site borrow material excavation, transport, and cover placement. Existing haul roads would require rehabilitation following mine rock removal in identified haul road segments for cover material transport, potentially resulting in short-term increase in erosion and dust generation during road rehabilitation and material transport. Regrading of the mine rock piles may increase the potential for leaching of metal and radionuclide constituents from the mine rock during construction prior to cover placement. Regrading may also increase the potential for erosion and sediment transport during construction. While mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in stormwater runoff from the mine rock piles prior to cover placement. Potential risks could be properly managed by implementing worker safety measures and appropriate dust and stormwater erosion control measures.	Short term impacts may include radiation exposure, dust generation and erosion during mine rock excavation, transport and consolidation. Also potential for spill or release during mine rock transport. Removal of existing vegetation at 300-Foot Level and OSA mine rock piles required, which would increase short-term potential for erosion. Short-term impacts associated with on-site borrow material excavation, transport, and cover placement. Existing haul roads would require rehabilitation following mine rock removal in identified haul road segments for transport of mine rock and cover material, potentially resulting in short-term increase in erosion and dust generation during road rehabilitation and material transport. Backfilling the Open Pit may increase the potential for leaching of metal and radionuclide constituents from the mine rock. While the mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in the drainage from the 300-Foot Level Portal for some time period. Potential risks could be properly managed by implementing worker safety measures and appropriate dust and stormwater erosion control measures.	Short term impacts may include radiation exposure, dust generation and erosion during mine rock excavation, transport and consolidation. Also potential for spill or release during mine rock transport. Removal of existing vegetation required at 300-Foot Level mine rock pile and at OSA, which would increase short-term potential for erosion. Short-term impacts associated with on-site borrow material excavation, transport, and cover placement. Existing haul roads would require rehabilitation following mine rock removal in identified haul road segments for cover material transport, potentially resulting in short-term increase in erosion and dust generation during material transport. Backfilling the Open Pit may increase the potential for leaching of metal and radionuclide constituents from the mine rock. While the mine rock is not considered to generate ARD, any leaching of the mine rock could increase the metal and radionuclide concentrations in the drainage from the 300-Foot Level Portal for some time period. Potential risks could be properly managed by implementing worker safety measures and appropriate dust and stormwater erosion control measures.

Table 7-1. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
Long-term effectiveness and permanence	Not effective and permanent. Risks to human and ecological receptors remain unchanged.	Somewhat effective and permanent, but would not reduce existing human or ecological exposure to surface mine rock materials, or radon emanation and external gamma radiation from mine rock piles and Open Pit. Would rely on institutional and/or access controls to reduce human exposures. Removal of spilled ore rocks from former loading docks eliminates risk to human receptors within the intertidal zone, and removing and stabilization of mine rock piles adjacent to stream channels reduces exposure to riparian animals. Regrading mine rock piles adjacent to stream channels and stormwater controls would increase pile stability and reduce potential for erosion of mine rock. Stormwater controls would reduce run-on into Open Pit; reducing inflow into underground mine, but stormwater intercepted by Open Pit would still be conveyed to underground mine.	Effective and permanent for reducing risks from mine rock to human and ecological receptors. Isolates mine rock with cover and reduces radon emanation and external gamma radiation. Radon and gamma radiation from Open Pit would remain unchanged. Would rely on institutional and/or access controls to reduce human exposures to radiation risks from Open Pit. Stormwater controls would reduce run-on into Open Pit; thereby reducing inflow into underground mine. Stormwater intercepted by Open Pit would still be conveyed to underground mine.	Effective and permanent for reducing risks from mine rock to human and ecological receptors. Isolates mine rock with covers at the 300-Foot Level and Open Pit, and reduces radon emanation and external gamma radiation from mine rock, including that occurring from the Open Pit. Human health and ecological risks due to mine rock piles at OSA, 700-Foot and 900-Foot Levels would be significantly reduced or eliminated. Cover on Open Pit reduces radon emanation and external gamma radiation from Open Pit. Reduces mine rock and cover footprint. Stormwater controls and cover, which includes synthetic geomembrane barrier, reduces water infiltration into Open Pit; thereby reducing potential for leaching of the mine rock, water inflow into underground mine, and drainage from the 300-Foot Level Portal.	Effective and permanent for reducing risks from mine rock to human and ecological receptors. Isolates mine rock with cover at the Open Pit, and reduces radon emanation and external gamma radiation from mine rock, including that occurring from the Open Pit. Human health and ecological risks due to mine rock piles at OSA, 300-Foot, 700-Foot and 900-Foot Levels would be significantly reduced or eliminated. Cover on Open Pit reduces radon emanation and external gamma radiation from Open Pit. Consolidates all mine rock in Open Pit area within naturally mineralized area and radiological characteristics of mine rock are consistent with naturally mineralized area. Minimizes mine rock and cover footprint. Stormwater controls and cover, which includes synthetic geomembrane barrier, reduces water infiltration into Open Pit; thereby reducing potential for leaching of the mine rock, water inflow into underground mine, and drainage from the 300-Foot Level Portal.
Reduction of toxicity, mobility, or volume through treatment	No reduction of toxicity, mobility, or volume would be achieved. No treatment provided.	No reduction of toxicity or volume would be achieved. Limited reduction in mobility due to stormwater controls and pile grading. No treatment provided.	No reduction of toxicity or volume would be achieved. Reduction in mobility due to physical isolation of mine rock and reduction in radon emanation and external gamma radiation by cover. No treatment provided.	No reduction of toxicity or volume would be achieved. Reduction in mobility due to physical isolation of mine rock and reduction in radon emanation and external gamma radiation by cover. No treatment provided.	No reduction of toxicity or volume would be achieved. Reduction in mobility due to physical isolation of mine rock and reduction in radon emanation and external gamma radiation by cover. No treatment provided.

Table 7-1. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
IMPLEMENTABILITY					
Technical feasibility/constructability	No construction required.	Removal action components are readily constructible. Enhanced erosion and sediment controls required to protect intertidal zone during removal of spilled ore rock at former ore loading ramps. Regrading of mine rock piles necessary in some locations to provide access for stormwater controls. Enhanced erosion and sediment controls also required during regrading of mine rock piles due to wet climate.	Removal action components are readily constructible. Requires regrading of piles to achieve acceptable geotechnical slope and surface stability for cover placement. Minimum 3H:1V sideslopes required for cover slope stability based on available information. Need to verify suitability of the type and properties of on-Site borrow material available within the intertidal zone of the Kendrick Creek delta for cover construction. Enhanced erosion and sediment controls required to protect intertidal zone during borrow material excavation and excavation would be sequenced with low tide. Improvements to existing haul roads for equipment access and cover material transport is feasible, but requires enhanced erosion and sediment controls. Enhanced erosion and sediment controls also required due to wet climate.	Removal action components are readily constructible. Requires regrading of piles to achieve acceptable geotechnical and surface stability for cover placement. Minimum 3H:1V sideslopes required for cover slope stability based on available information. Need to verify suitability of the type and properties of on-Site borrow material available within the intertidal zone of the Kendrick Creek delta for cover construction. Enhanced erosion and sediment controls required to protect intertidal zone during borrow material excavation and excavation would be sequenced with low tide. Need to verify volume of OSA materials to be excavated for consolidation, as capacity available at 300-Foot Level mine rock pile is limited. If additional volume of material excavation is required and exceeds volume that can be consolidated at 300-Foot Level, material could be consolidated at Open Pit. Improvements to existing haul roads for equipment and transport of mine rock and cover material is feasible, but requires enhanced erosion and sediment controls. Enhanced erosion and sediment controls also required due to wet climate.	Removal action components are readily constructible. Need to verify suitability of the type and properties of on-Site borrow material available within the intertidal zone of the Kendrick Creek delta for cover construction. Enhanced erosion and sediment controls required to protect intertidal zone during borrow material excavation and excavation would be sequenced with low tide. Need to verify volume of OSA materials to be excavated, but Open Pit consolidation not sensitive to uncertainty in OSA material quantity. Improvements to existing haul roads for equipment and transport of mine rock and cover material is feasible, but requires enhanced erosion and sediment controls. Enhanced erosion and sediment controls also required due to wet climate.
M&M requirements	No M&M required.	Inspections will be performed annually for the first three years and once every five years thereafter for 30 years to confirm stability of regraded mine rock piles and stormwater controls, and any necessary maintenance and are readily implementable.	Inspections of mine rock pile covers, stormwater controls, and any necessary maintenance will be performed annually for the first three years and once every five years thereafter for 30 years and are readily implementable. Inspections and any necessary maintenance would be required at multiple locations.	Inspections of mine rock pile covers, stormwater controls, and any necessary maintenance will be performed annually for the first three years and once every five years thereafter for 30 years and are readily implementable. Inspections and any necessary maintenance would be required at reduced number of locations.	Inspections of Open Pit cover, stormwater controls, and any necessary maintenance will be performed annually for the first three years and once every five years thereafter for 30 years and are readily implementable. Inspections and any necessary maintenance would be required at only one location.
Reliability and performance	Not applicable.	Stormwater controls are proven and reliable. Institutional controls may be effective in reducing human exposures, but will not protect ecological receptors.	Cover placement is a proven and reliable technology. Cover performance is dependent on the type and properties of available on-Site borrow material. Useful life of cover is indefinite with properly designed cover and stormwater controls, routine inspections and maintenance.	Cover placement is a proven and reliable technology. Cover performance is dependent on the type and properties of available on-Site borrow material. Useful life of cover is indefinite with properly designed cover and stormwater controls, routine inspections and maintenance.	Cover placement is a proven and reliable technology. Cover performance is dependent on the type and properties of available on-Site borrow material. Useful life of cover is indefinite with properly designed cover and stormwater controls, routine inspections and maintenance.

Table 7-1. Summary Evaluation of Removal Action Alternatives for Mine Rock (Continued)

Evaluation Criterion	Alternative M-1 No Action Alternative	Alternative M-2 In-Place Stabilization with Stormwater & Institutional Controls	Alternative M-3 Cover in Place	Alternative M-4 Excavation, Consolidation, and Cover at Mine Affected Areas	Alternative M-5 Excavation, Consolidation, and Cover in Open Pit
Time to Implement	Not applicable.	One construction season estimated.	One to two construction seasons estimated.	Two construction seasons likely.	Two construction seasons likely.
Availability of equipment, personnel and services	Not applicable.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house personnel during work.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house personnel during work.
Administrative feasibility	Requires institutional controls, access controls, and/or land use restrictions to reduce disturbance of mine rock and to reduce human exposures to mine-affected areas. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Compatible with future mining scenarios for the Site. No adverse impact to the historic features that make the Site eligible to the NRHP.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of re-graded mine rock piles and to reduce human exposures to mine-affected areas. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Removal action alternative most compatible with future mining at the Site. Potential for an adverse impact to the historic features that currently make the Site eligible to the NRHP.	Requires institutional controls, access controls, and/or land use restrictions to protect integrity of covers on mine rock piles. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Would reduce current access for potential future mining at the Site. Would likely remove the Site from NRHP eligibility.	Requires institutional controls, access controls, and/or land use restrictions to protect integrity of covers at 300-Foot Level and Open Pit. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Would preclude future access to the Open Pit. Will adversely impact the integrity of the historic site and remove the Site from NRHP eligibility.	Requires institutional controls, access controls, and/or land use restrictions to protect integrity of cover on Open Pit. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of mine rock locations from mineral entry. Institutional controls are readily implementable. Would preclude future access to the Open Pit. Will adversely impact the integrity of the historic site and remove the Site from NRHP eligibility.
			RELATIVE COST		
Capital – Direct & Indirect	None	$1,222,000	$3,780,000	$3,441,000	$6,240,000
M&M Cost	None	$206,000	$206,000	$152,000	$133,000
Total Project Cost	None	$1,427,000	$3,986,000	$3,592,000	$6,373,000

Table 7-2. Mine Rock Alternatives Cost Summary

Alternative Scenario	Total Direct Capital Costs	Total In-Direct Capital Costs	Total Capital Cost	Present Worth M&M Costs	Total Project Present Worth
Mine Rock Alternative M-2	$762,285	$459,502	$1,221,787	$205,690	**$1,427,477**
Mine Rock Alternative M-3	$2,270,192	$1,509,817	$3,780,009	$205,690	**$3,985,698**
Mine Rock Alternative M-4	$2,111,826	$1,328,741	$3,440,567	$151,523	**$3,592,090**
Mine Rock Alternative M-5	$3,894,864	$2,345,072	$6,239,936	$133,467	**$6,373,403**

Table 7-3. Summary of Estimated Dose/Risk for Mine Rock Alternative M-1[4]

Mine Rock Area	Gamma Exposure[1,2] Rate (uR/hr)	Exposure Time (hours/year)	Gamma Dose (mrem/yr)	Radon[1,3] Dose (mrem/yr)	Total Annual Dose (mrem/yr)	Lifetime Risk
		Dose to Site Visitor				(30 years)
OSA	1253	134.4	60.4	5.2E-02	60.5	1.0E-03
300-Foot Level Mine Rock Pile	341	9.6	1.0	2.7E-03	1.0	1.7E-05
700-Foot Level Mine Rock Pile	960	9.6	3.2	1.0E-02	3.2	5.3E-05
900-Foot Level North Pile	683	3.2	0.7	2.4E-03	0.7	1.2E-05
900-Foot Level South Pile	1020	3.2	1.1	9.0E-04	1.1	1.9E-05
Open Pit	960	3.2	1.1	3.3E-03	1.1	1.8E-05
Total Pathway Dose (mrem/yr) or Risk			67.5	7.1E-02	67.6	1.1E-03
		Dose to Mineral Exploration Worker				(3 years)
OSA	1253	144	64.7	5.5E-02	64.8	8.0E-05
300-Foot Level Mine Rock Pile	341	216	23.1	6.0E-02	23.2	2.9E-05
700-Foot Level Mine Rock Pile	960	216	71.5	2.3E-01	71.7	8.9E-05
900-Foot Level North Pile	683	72	16.3	5.5E-02	16.3	2.0E-05
900-Foot Level South Pile	1020	72	25.5	2.0E-02	25.5	3.1E-05
Open Pit	960	72	23.8	7.4E-02	24.0	2.9E-05
Total Pathway Dose (mrem/yr) or Risk			225.0	5.0E-01	225.5	2.8E-04
		Dose to USFS Worker				(25 years)
OSA	1253	12	5.4	4.6E-03	5.4	5.5E-05
300-Foot Level Mine Rock Pile	341	18	1.9	5.0E-03	1.9	2.0E-05
700-Foot Level Mine Rock Pile	960	18	6.0	1.9E-02	6.0	6.1E-05
900-Foot Level North Pile	683	6	1.4	4.6E-03	1.4	1.4E-05
900-Foot Level South Pile	1020	6	2.1	1.7E-03	2.1	2.2E-05
Open Pit	960	6	2.0	6.2E-03	2.0	2.0E-05
Total Pathway Dose (mrem/yr) or Risk			18.7	4.1E-02	18.8	1.9E-04

Footnotes:

1 Gamma exposure and radon flux the same as existing conditions

2 Mean measured gamma exposure rate (Table 2-2)

3 Dose from RADON code calculated flux at pile surface (Table 6-5)

4 Background risk/dose and reduced risk/dose due to institutional controls not included

Table 7-4. Summary of Estimated Dose/Risk for Mine Rock Alternative M-2[4]

Mine Rock Piles	Gamma Exposure[1,2] Rate (uR/hr)	Exposure Time (hours/year)	Annual gamma dose (mrem/y)	Radon[1,3] Dose (mrem/y)	Total Annual Dose (mrem/yr)	Lifetime Risk
		Dose to Site Visitor				(30 years)
OSA	1253	134.4	60.4	7.3E-02	60.4	1.0E-03
300-Foot Level Mine Rock Pile	341	9.6	1.0	4.6E-03	1.0	1.7E-05
700-Foot Level Mine Rock Pile	960	9.6	3.2	1.6E-02	3.2	5.3E-05
900-Foot Level North Pile	683	3.2	0.7	2.4E-03	0.7	1.2E-05
900-Foot Level South Pile	1020	3.2	1.1	9.0E-04	1.1	1.9E-05
900-Foot Level Open Pit	960	3.2	1.1	3.3E-03	1.1	1.8E-05
Total Pathway Dose (mrem/yr) or Risk			67.5	6.1E-02	67.6	1.1E-03
		Dose to Mineral Exploration Worker				(3 years)
OSA	1253	144	64.7	7.8E-02	64.8	8.0E-05
300-Foot Level Mine Rock Pile	341	216	23.1	1.0E-01	23.2	2.9E-05
700-Foot Level Mine Rock Pile	960	216	71.5	3.5E-01	71.7	8.9E-05
900-Foot Level North Pile	683	72	16.3	5.5E-02	16.3	2.0E-05
900-Foot Level South Pile	1020	72	25.5	2.0E-02	25.5	3.1E-05
900-Foot Level Open Pit	960	72	23.8	7.4E-02	24.0	2.9E-05
Total Pathway Dose (mrem/yr) or Risk			225.0	6.8E-01	225.6	2.8E-04
		Dose to USFS Worker				(25 years)
OSA	1253	12	5.4	6.5E-03	5.4	5.5E-05
300-Foot Level Mine Rock Pile	341	18	1.9	8.7E-03	1.9	2.0E-05
700-Foot Level Mine Rock Pile	960	18	6.0	2.9E-02	6.0	6.1E-05
900-Foot Level North Pile	683	6	1.4	4.6E-03	1.4	1.4E-05
900-Foot Level South Pile	1020	6	2.1	1.7E-03	2.1	2.2E-05
900-Foot Level Open Pit	960	6	2.0	6.2E-03	2.0	2.0E-05
Total Pathway Dose (mrem/yr) or Risk			18.7	5.8E-02	18.8	1.9E-04

Footnotes:

1 Gamma exposure and radon flux the same as existing conditions
2 Mean measured gamma exposure rate (Table 2-2)
3 Dose from RADON code calculated flux at pile surface (Table 6-5)
4 Background risk/dose and reduced risk/dose due to institutional controls not included

Table 7-5. Summary of Estimated Dose/Risk for Mine Rock Alternative M-3[3]

Mine Rock Piles	Gamma[1] Exposure Rate (uR/hr)	Exposure Time (hours/year)	Annual Gamma Dose (mrem/yr)	Radon[2] Dose (mrem/y)	Total Annual Dose (mrem/yr)	Lifetime Risk
		Dose to Site Visitor				(30 years)
OSA	5.9	134.4	0.56	2.9E-02	0.59	9.6E-06
300-Foot Level Mine Rock Pile	1.5	9.6	0.01	2.1E-03	0.01	1.9E-07
700-Foot Level Mine Rock Pile	3.6	9.6	0.02	7.0E-03	0.03	5.0E-07
900-Foot Level North Pile	3.2	3.2	0.01	1.7E-03	0.01	1.4E-07
900-Foot Level South Pile	4.2	3.2	0.01	6.1E-04	0.01	1.6E-07
Open Pit	960.4	3.2	1.06	3.3E-03	1.06	1.8E-05
Total Pathway Dose (mrem/yr) or Risk			1.67	4.4E-02	1.72	2.8E-05
		Dose to Mineral Exploration Worker				(3 years)
OSA	5.9	144	0.60	3.1E-02	0.63	7.8E-07
300-Foot Level Mine Rock Pile	1.5	216	0.22	4.7E-02	0.29	13.4E-07
700-Foot Level Mine Rock Pile	3.6	216	0.54	1.6E-01	0.78	9.0E-07
900-Foot Level North Pile	3.2	72	0.16	3.7E-02	0.20	2.6E-07
900-Foot Level South Pile	4.2	72	0.21	1.4E-02	0.22	2.8E-07
Open Pit	960.4	72	23.84	7.4E-02	23.91	2.9E-05
Total Pathway Dose (mrem/yr) or Risk			25.57	3.6E-01	26.03	3.2E-05
		Dose to USFS Worker				(25 years)
OSA	5.9	12	0.05	2.6E-03	0.1	5.4E-07
300-Foot Level Mine Rock Pile	1.5	18	0.02	3.9E-03	0.0	2.4E-07
700-Foot Level Mine Rock Pile	3.6	18	0.05	1.3E-02	0.1	6.3E-07
900-Foot Level North Pile	3.2	6	0.01	3.1E-03	0.0	1.8E-07
900-Foot Level South Pile	4.2	6	0.02	1.1E-03	0.0	1.9E-07
Open Pit	960.4	6	1.99	6.2E-03	2.0	2.0E-05
Total Pathway Dose (mrem/yr) or Risk			2.13	3.0E-02	2.2	2.2E-05

Footnotes:

1 MicroShield® calculated gamma exposure rate for 2-foot thick cover

2 Dose due to RADON code calculated flux for 2-foot thick on-site material cover (Table 6-5)

3 Background risk/dose and reduced risk/dose due to institutional controls not included

Table 7-6. Summary of Estimated Dose/Risk for Mine Rock Alternative M-4[5]

Mine Rock Piles	Gamma[1] Exposure Rate (uR/hr)	Exposure Time (hours/year)	Direct Gamma Dose (mrem/y)	Radon[2] Dose (mrem/y)	Total Annual Dose (mrem/yr)	Lifetime Risk
		Dose to Site Visitor				(30 years)
OSA	0	134.4	0	0	0	0
300-Foot Level Mine Rock Pile[3]	1.46	9.6	9.8E-03	2.5E-03	1.3E-02	2.0E-07
700-Foot Level Mine Rock Pile	0	9.6	0	0	0	0
900-Foot Level North Pile	0	3.2	0	0	0	0
900-Foot Level South Pile	0	3.2	0	0	0	0
Open Pit[4]	3.22	3.2	7.2E-03	1.8E-03	9.0E-03	1.5E-07
Total Pathway Dose (mrem/yr) or Risk			1.7E-02	4.3E-03	2.2E-02	3.5E-07
		Dose to Mineral Exploration Worker				(3 years)
OSA	0	144	0	0	0	0
300-Foot Level Mine Rock Pile[3]	1.46	216	2.2E-01	5.6E-02	2.8E-01	3.6E-07
700-Foot Level Mine Rock Pile	0	216	0	0	0	0
900-Foot Level North Pile	0	72	0	0	0	0
900-Foot Level South Pile	0	72	0	0	0	0
Open Pit[4]	3.22	72	1.6E-01	4.1E-02	2.0E-01	2.6E-07
Total Pathway Dose (mrem/yr) or Risk			3.8E-01	9.7E-02	4.9E-01	6.2E-07
		Dose to USFS Worker				(25 years)
OSA	0	12	0	0	0	0
300-Foot Level Mine Rock Pile[3]	1.46	18	1.8E-02	5.2E-03	2.4E-02	2.5E-07
700-Foot Level Mine Rock Pile	0	18	0	0	0	0
900-Foot Level North Pile	0	6	0	0	0	0
900-Foot Level South Pile	0	6	0	0	0	0
Open Pit[4]	3.22	6	1.4E-02	3.4E-03	1.7E-02	1.8E-07
Total Pathway Dose (mrem/yr) or Risk			3.2E-02	8.6E-03	4.1E-02	4.3E-07

Footnotes:

1 MicroShield® calculated gamma exposure rate for 2-foot thick cover

2 Dose due to RADON code calculated flux for 2-foot thick on-site material cover (Table 6-5)

3 Gamma exposure and radon flux due to OSA consolidation assumed to be represented by 300-Foot Level Pile

4 Lowest activity would be placed on top in Open Pit Repository; Assumed to be 900-Foot Level North Pile

5 Residual dose/risk assumed to be zero at removed mine rock piles; residual dose/risk would remain

Table 7-7. Summary of Estimated Dose/Risk for Mine Rock Alternative M-5[4]

Mine Rock Piles	Gamma Exposure[1] Rate (uR/hr)	Exposure Time (hours/year)	Direct Gamma Dose (mrem/y)	Radon[2] Dose (mrem/y)	Total Annual Dose (mrem/yr)	Lifetime Risk
		Dose to Site Visitor				(30 years)
OSA	0	134.4	0	0	0	0
300-Foot Level Mine Rock Pile	0	9.6	0	0	0	0
700-Foot Level Mine Rock Pile	0	9.6	0	0	0	0
900-Foot Level North Pile	0	3.2	0	0	0	0
900-Foot Level South Pile	0	3.2	0	0	0	0
Open Pit[3]	1.46	3.2	3.3E-03	8.8E-04	4.1E-03	6.7E-08
Total Pathway Dose (mrem/yr) or Risk			3.3E-03	8.8E-04	4.1E-03	6.7E-08
		Dose to Mineral Exploration Worker				(3 years)
OSA	0	144	0	0	0	0
300-Foot Level Mine Rock Pile	0	216	0	0	0	0
700-Foot Level Mine Rock Pile	0	216	0	0	0	0
900-Foot Level North Pile	0	72	0	0	0	0
900-Foot Level South Pile	0	72	0	0	0	0
Open Pit[3]	1.46	72	7.4E-02	2.0E-02	9.3E-02	1.2E-07
Total Pathway Dose (mrem/yr) or Risk			7.4E-02	2.0E-02	9.3E-02	1.2E-07
		Dose to USFS Worker				(25 years)
OSA	0	12	0	0	0	0
300-Foot Level Mine Rock Pile	0	18	0	0	0	0
700-Foot Level Mine Rock Pile	0	18	0	0	0	0
900-Foot Level North Pile	0	6	0	0	0	0
900-Foot Level South Pile	0	6	0	0	0	0
Open Pit[3]	1.46	6	6.1E-03	1.6E-03	7.8E-03	8.3E-08
Total Pathway Dose (mrem/yr) or Risk			6.1E-03	1.6E-03	7.8E-03	8.3E-08

Footnotes:

1 MicroShield® calculated gamma exposure rate for 2-foot thick cover
2 Dose due to RADON code calculated flux for 2-foot thick on-site material cover (Table 6-5)
3 Lowest activity would be placed on top in Open Pit Repository; Assumed to be 300-Foot Level Pile
4 Residual dose/risk assumed to be zero at removed mine rock piles; residual dose/risk would remain

Table 7-8. Summary Evaluation of Removal Action Alternatives for Portals

Evaluation Criterion	Alternative P-1 No Action Alternative	Alternative P-2 Close Upper Mine Openings and 300-Foot Level Portal Gate	Alternative P-3 Close Upper Mine Openings and 300-Foot Level Portal Rock Backfill	Alternative P-4 Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead
EFFECTIVENESS				
Protection of human health and the environment	Would not achieve RAOs. Not protective of human or ecological receptors. Radon exhalation would continue from mine openings. Water inflow to underground workings would continue at 900-Foot Level Portal. Unrestricted human access would continue. Institutional controls required for all mine openings.	Would not achieve RAOs. Potentially protective of human and ecological receptors. Eliminates radon exhalation from 900-Foot Air Shaft and Portal and 700-Foot Level Portal. Closure of upper mine openings significantly reduces air inflow into mine workings and air outflow from 300-Foot Level Portal, potentially reducing radon exhalation from 300-Foot Level Portal. However, the reduction in radon exhalation resulting from reduced air outflow from the 300-Foot Level Portal is indeterminable. Due to the uncertain reduction in radon exhalation, Alternative P-2 might not be protective of a Site Visitor, Mineral Exploration Worker, or an USFS Worker, and might not achieve RAOs. Does not eliminate human health and ecological exposure pathways to mine drainage water from 300-Foot Level Portal. Closure of 700-Foot Level Portal eliminates potential for drainage from portal. In conjunction with Mine Rock Alternatives M-4 and M-5, backfilling and covering of Open Pit reduces water inflow to underground mine reducing water flow from the 300-Foot Level Portal. Unrestricted human access eliminated by closure of upper mine openings and gate at 300-Foot Level. Institutional controls may be required to restrict access at 300-Foot Level Portal.	Would likely achieve RAOs. Protective; closure of upper mine openings eliminates radon exhalation and air inflow to underground mine. Backfilling of 300-Foot Level Portal further reduces radon exhalation from 300-Foot Level Portal. However, the reduction in radon exhalation resulting from reduced air outflow and backfilling of 300-Foot Level Portal is indeterminable. Due to the uncertain reduction in radon exhalation, Alternative P-3 might not be protective of a Site Visitor, Mineral Exploration Worker, or an USFS Worker, and might not achieve RAOs. Closure of 700-Foot Level Portal eliminates potential for drainage from portal. In conjunction with Mine Rock Alternatives M-4 and M-5, backfilling and covering of Open Pit reduces water inflow to underground mine reducing water flow from the 300-Foot Level Portal. Reduced water outflow from 300-Foot Level Portal piped to Kendrick Creek eliminates direct human (Site Visitor) and ecological (riparian animal) exposure pathways to mine drainage water. Unrestricted human access eliminated by closure of all mine openings. Institutional controls not required to restrict access to mine openings.	Would achieve RAOs. Protective; closure of upper mine openings eliminates radon exhalation and air inflow to underground mine. Concrete bulkhead in 300-Foot Level Portal eliminates radon exhalation from 300-Foot Level Portal. Closure of 700-Foot Level Portal eliminates potential for drainage from portal. In conjunction with Mine Rock Alternatives M-4 and M-5, backfilling and covering of Open Pit reduces water inflow to underground mine reducing water flow from the 300-Foot Level Portal. Reduced water outflow from 300-Foot Level Portal piped to Kendrick Creek eliminates direct human (Site Visitor) and ecological (riparian animal) exposure pathways to mine drainage water. Unrestricted human access eliminated by closure of all mine openings. Institutional controls not required to restrict access to mine openings.
Ability to achieve ARARs	Would not comply with potential chemical-specific ARARs defining acceptable human health risk. The alternative would not comply with Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would potentially comply with potential ARARs defining acceptable human health risk. Due to uncertainty in radon reduction, alternative may not comply with chemical-specific ARARs, including Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would potentially comply with potential ARARs. Due to uncertainty in radon reduction, alternative may not comply with chemical-specific ARARs, including Alaska regulations (18 AAC 75), which require site cleanup achieve a cumulative carcinogenic risk-based level of 1E-5 and a cumulative non-carcinogenic hazard index of one, and the To Be Considered guideline that the appropriate risk range is1E-4 to 1E-6 for radionuclides.	Would comply with potential ARARs.

Table 7-8. Summary Evaluation of Removal Action Alternatives for Portals (Continued)

Evaluation Criterion	Alternative P-1 No Action Alternative	Alternative P-2 Close Upper Mine Openings and 300-Foot Level Portal Gate	Alternative P-3 Close Upper Mine Openings and 300-Foot Level Portal Rock Backfill	Alternative P-4 Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead
Short-term effectiveness	No short-term impacts.	Short term impacts may include radiation and radon exposure during work activities at mine openings and sediment disturbance during gate installation at 300-Foot Level. Potential risks could be properly managed by implementing worker safety measures and sediment control measures. Potential bat habit will be reduced by closure of the upper mine openings.	Short term impacts may include radiation and radon exposure during work activities at mine openings and disturbance of water and sediment during backfilling at 300-Foot Level. Potential risks could be properly managed by implementing worker safety measures and sediment control measures. Potential bat habit will be eliminated by closure of the upper mine openings and backfilling of the 300-Foot Level portal.	Short term impacts may include radiation and radon exposure during work activities at mine openings and disturbance of water and sediment during bulkhead construction at 300-Foot Level. Potential safety hazards to workers during concrete bulkhead installation within 300-Foot Level Portal. Potential risks could be properly managed by implementing worker safety measures and sediment control measures. Potential bat habit will be eliminated by closure of the upper mine openings and closure of the 300-Foot Level portal.
Long-term effectiveness and permanence	Not effective and permanent. Risks to human and ecological receptors remain unchanged.	Effective and permanent for reducing radon risks to human receptors. While closure of the upper mine workings will significantly reduce air outflow from the 300-Foot Level Portal, the predicted reduction in radon exhalation from the 300-Foot Level Portal is uncertain.	Effective and permanent for reducing radon risks to human receptors. Closure will eliminate radon exhalation from the upper mine workings and significantly reduce air outflow from the 300-Foot Level Portal, but the predicted reduction in radon exhalation from the 300-Foot Level Portal is uncertain. Backfilling of 300-Foot Level Portal will further reduce radon exhalation from portal. Effective and permanent for reducing direct human and ecological pathways to mine water.	Effective and permanent for reducing radon risks to human receptors. Closure will eliminate radon exhalation from the upper mine workings. Bulkhead will eliminate radon exhalation from the 300-Foot Level Portal. Effective and permanent for reducing direct human and ecological pathways to mine water.
Reduction of toxicity, mobility, or volume through treatment	No reduction of toxicity, mobility, or volume would be achieved. No treatment provided.	No reduction of toxicity would be achieved. Reduction in water outflow from the 300-Foot Level Portal and possible reduction in mobility by reducing water inflow to underground mine. No treatment provided.	No reduction of toxicity would be achieved. Reduction in water outflow from the 300-Foot Level Portal and possible reduction in mobility by reducing water inflow to underground mine. No treatment provided.	No reduction of toxicity would be achieved. Reduction in water outflow from the 300-Foot Level Portal and possible reduction in mobility by reducing water inflow to underground mine. No treatment provided.
IMPLEMENTABILITY				
Technical feasibility/ constructability	No construction required.	Removal action components are readily constructible. Sediment controls required during gate installation at 300-Foot Level Portal. Closure of 900-Foot Level Portal will need to be coordinated if mine rock is consolidated in Open Pit.	Removal action components are readily constructible. Need to verify upper range of outflow from 300-Foot Level Portal for water collection system and pipe design. Sediment and water controls required during backfilling of 300-Foot Level Portal. Closure of 900-Foot Level Portal will need to be coordinated if mine rock is consolidated in Open Pit.	Removal action components are readily constructible. Need to verify upper range of outflow from 300-Foot Level Portal for water collection system and pipe design. Concrete bulkhead requires installation in competent rock inside portal, requiring rehabilitation of portal for worker safety. Sediment and water controls required during backfilling of 300-Foot Level Portal. Closure of 900-Foot Level Portal will need to be coordinated if mine rock is consolidated in Open Pit.

Table 7-8. Summary Evaluation of Removal Action Alternatives for Portals (Continued)

Evaluation Criterion	Alternative P-1 No Action Alternative	Alternative P-2 Close Upper Mine Openings and 300-Foot Level Portal Gate	Alternative P-3 Close Upper Mine Openings and 300-Foot Level Portal Rock Backfill	Alternative P-4 Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead
M&M requirements	No M&M required.	Inspections of closures at upper mine workings and gate at 300-Foot Level Portal will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Direct inspection and any maintenance of 900-Foot Level Portal closure not possible if mine rock is consolidated in Open Pit. Post-removal water quality monitoring will be performed in Kendrick Creek at a location downstream of the confluence with Mine Fork Creek and the drainage from the 300-Foot Level Portal to confirm that applicable water quality standards or background (for aluminum) continue to be achieved in Kendrick Creek. Water quality samples will be collected twice a year annually for the first five years and then once every five years thereafter, if determined necessary, from review of the resulting data.	Inspections of closures at upper mine workings and backfill at 300-Foot Level Portal will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Direct inspection and any maintenance of 900-Foot Level Portal closure not possible if mine rock is consolidated in Open Pit. Post-removal water quality monitoring will be performed in Kendrick Creek at a location downstream of the confluence with Mine Fork Creek and the drainage from the 300-Foot Level Portal to confirm that applicable water quality standards or background (for aluminum) continue to be achieved in Kendrick Creek. Water quality samples will be collected twice a year annually for the first five years and then once every five years thereafter, if determined necessary, from review of the resulting data.	Inspections of closures at upper mine workings and concrete bulkhead at 300-Foot Level Portal will be performed annually for the first three years and every five years thereafter for 30 years and are readily implementable. Direct inspection and any maintenance of 900-Foot Level Portal closure not possible if mine rock is consolidated in Open Pit. Post-removal water quality monitoring will be performed in Kendrick Creek at a location downstream of the confluence with Mine Fork Creek and the drainage from the 300-Foot Level Portal to confirm that applicable water quality standards or background (for aluminum) continue to be achieved in Kendrick Creek. Water quality samples will be collected twice a year annually for the first five years and then once every five years thereafter, if determined necessary, from review of the resulting data.
Reliability and performance	Not applicable.	Portal closure is a proven and reliable technology.	Portal closure is a proven and reliable technology.	Portal closure is a proven and reliable technology.
Time to Implement	Not applicable.	One construction season.	One construction season.	One construction season.
Availability of equipment, personnel and services	Not applicable.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house Site workers.	Readily available. Remote location requires that equipment be transported by barge to the Site requiring new floating dock. Temporary on-Site camp or boat required to house personnel during work.
Administrative feasibility	Requires institutional controls, access controls, and/or land use restrictions to preclude access to mine openings and to reduce human exposures to radon exhalation from mine openings. Controls could include signage, physical barriers, and inclusion in USFS land use management plans and land status records. Institutional controls are readily implementable. Compatible with potential future mining at Site.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of mine opening closures and to reduce residual radon from 300-Foot Level Portal to human receptors. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of locations from mineral entry. Institutional controls are readily implementable. Closure of the mine openings would reduce existing access to the underground mine for potential future mineral exploration or mining.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of mine opening closures. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of locations from mineral entry. Institutional controls are readily implementable. Closure of the mine openings would restrict existing access to the underground mine for potential future mineral exploration or mining.	Requires institutional controls, access controls, and/or land use restrictions to prevent disturbance of mine opening closures. Controls could include signage, physical barriers, inclusion in USFS land use management plans and land status records, and/or withdrawal of locations from mineral entry. Institutional controls are readily implementable. Closure of the mine openings would restrict existing access to the underground mine for potential future mineral exploration or mining.
RELATIVE COST				
Capital – Direct & Indirect	None	$694,000	$719,000	$770,000
M&M Cost	None	$30,000	$94,000	$94,000
Total Project Cost	None	$724,000	$813,000	$864,000

Table 7-9. Mine Portal Alternatives Cost Summary

Alternative Scenario	Total Capital Cost	Total M&M Present Worth	Total Project Present Worth
Portal Alternative P-2	$693,642	$30,093	**$723,735**
Portal Alternative P-3	$718,713	$94,040	**$812,753**
Portal Alternative P-4	$770,012	$94,040	**$864,052**

Table 7-10. Summary of Estimated Dose/Risk for Portal Alternatives

		300-Foot Level Portal	700-Foot Level Portal	900-Foot Level Portal	Air Ventilation Shaft	Open Pit		Radon Dose - Site Visitor				Radon Dose - Mineral Exploration Worker				Radon Dose - USFS Worker			
	Alternative	Estimated Radon Decay Product Concentration (WL)	Estimated Radon Decay Product Concentration (WL)	Estimated Radon Decay Product Concentration (WL)	Estimated Radon Decay Product Concentration (WL)	Estimated Radon Decay Product Concentration (WL)	Average Radon Decay Product Concentration (WL) Note 3	Exposure Time (h/y)	Radon Decay Product Exposure (WLM/y)	Radon Dose (mrem/y)	Lifetime Risk (30 Years)	Exposure Time (h/y)	Radon Decay Product Exposure (WLM/y)	Radon Dose (mrem/y)	Lifetime Risk (3 years)	Exposure Time (h/y)	Radon Decay Product Exposure (WLM/y)	Radon Dose (mrem/y)	Lifetime Risk (25 Years)
P-1	No Action	0.291	0.023	0.163	0.039	See Mine Rock	0.129	28.0	0.021	21.2	3.2E-04	648	0.492	492	7.4E-04	54	0.041	41.0	5.1E-04
P-2	300-Foot Level Portal Gate (Note 1)	0.291	0.000	0.000	0.000	See Mine Rock	0.073	28.0	0.012	12.0	1.8E-04	648	0.277	277	4.2E-04	54	0.023	23.1	2.9E-04
P-3	300-Foot Level Portal Backfill (Note 2)	0.291	0.000	0.000	0.000	See Mine Rock	0.073	28.0	0.012	12.0	1.8E-04	648	0.277	277	4.2E-04	54	0.023	23.1	2.9E-04
P-4	300-Foot Level Portal Bulkhead	0.000	0.000	0.000	0.000	See Mine Rock	0.000	28.0	0.000	0.0	0.0E+00	648	0.000	0	0.0E+00	54	0.000	0.0	0.0E+00

Alternative Descriptions:

P-1 No Action

P-2 Closure of 700-Foot Portal, 900-Foot Level Portal and Air Vent Shaft with 300-Foot Level Portal Gate

P-3 Closure of 700-Foot Portal, 900-Foot Level Portal and Air Vent Shaft with 300-Foot Level Portal Backfill

P-4 Closure of 300-Foot Portal, 700-Foot Portal, 900-Foot Level Portal and Air Vent Shaft

Footnotes:

1 Significant reduction in air flow, but reduction in radon exhalation indeterminable

2 Significant reduction in air flow and radon exhalation, but reduction in radon exhalation indeterminable

3 The site visitor, mineral exploration worker, and USFS worker were assumed to spend equal amounts of time per year at each location

Therefore, the average radon decay product concentration was multiplied by the total number of hours per year of exposure in the mined areas

The basis for the number of hours per year and the number of years on site is provided in the Risk Evaluation for Assessment of Alternatives (Appendix F).

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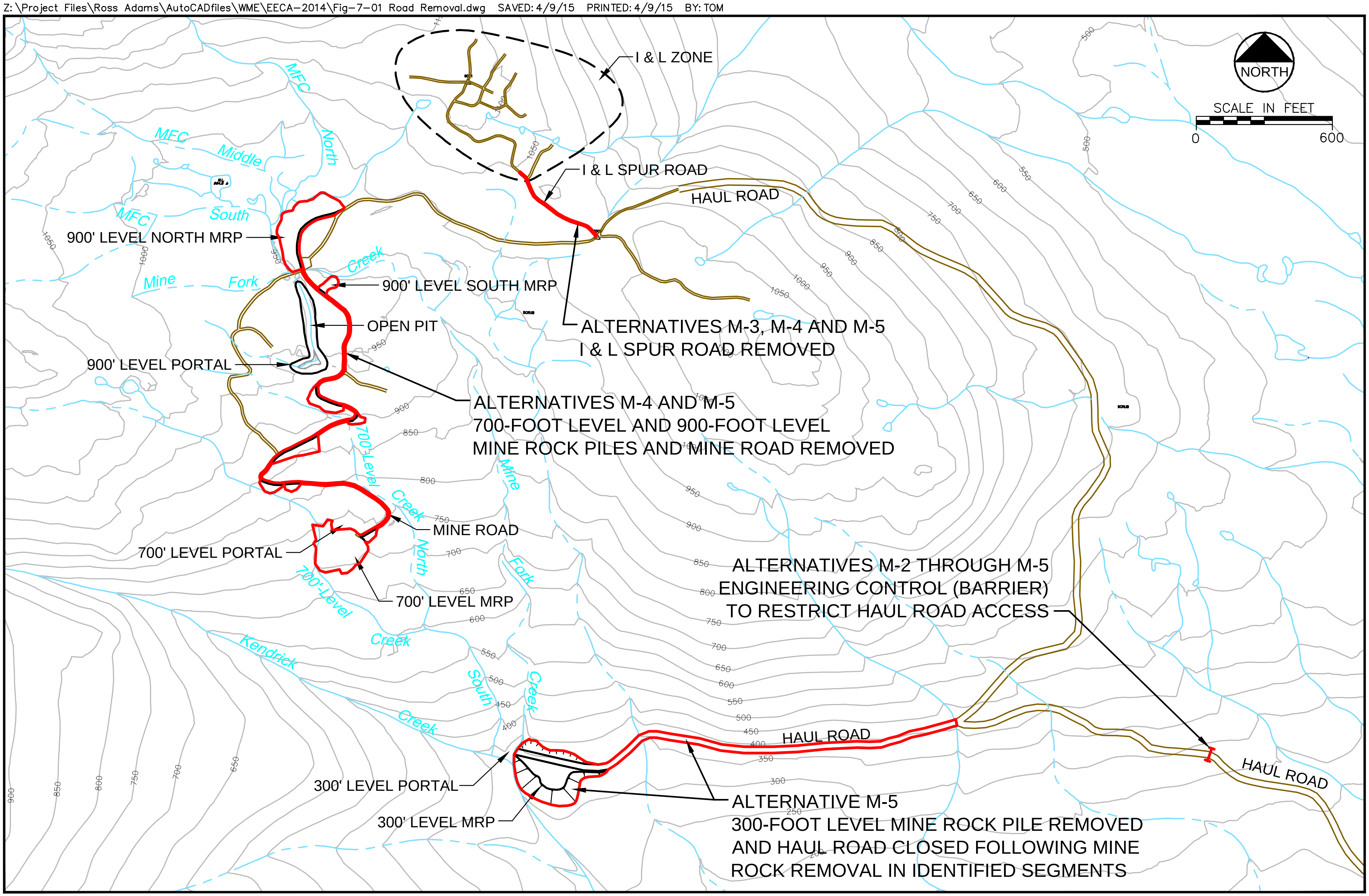

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Figure 7-1
Ross-Adams Site
Road and Mine Rock Pile Removal Areas

8.0 Comparative Analysis of Removal Action Alternatives

A comparative analysis was performed to evaluate the relative advantages and disadvantages of the five removal action alternatives for mine rock areas and the four removal action alternatives for the mine portals. According to EPA guidance (EPA, 1993a), the relative performance of each alternative is compared based on effectiveness, implementability and cost to identify key tradeoffs among alternatives. In addition, the key uncertainties that may affect the performance or implementability of the alternatives are evaluated. The results of the comparative analysis are used to identify the alternative that best satisfies the evaluation criteria. The comparative analysis for the mine rock and mine portal removal actions are provided separately in the following sections.

8.1 Comparative Analysis of Mine Rock Alternatives

The comparative analysis of the effectiveness, implementability, and cost criteria of the mine rock removal action alternatives is described in the following sections. The uncertainties associated with the performance of the alternatives are also presented. The comparative analysis of the alternatives is based on the evaluation presented previously in Tables 7-1 and 7-2.

8.1.1 Effectiveness

Alternative M-1 (No Action) is not effective in reducing the existing exposure pathways and potential risks to human and ecological receptors related to mine rock and the Open Pit at the Site. It is not expected that mine rock characteristics or Site conditions would change in the future that would reduce or alter currently existing risks to human health and the environment. While Alterative M-1 (No Action) does not satisfy the effectiveness criteria in protecting human health and the environment or achieving RAOs and ARARs, it is used as a baseline for comparison with other removal action alternatives. However, human health and ecological risks will remain due to the naturally mineralized background conditions at the Site even after selection and implementation of other alternatives that meet all the RAOs for mine rock. When comparing the effectiveness of Alternative M-1 to the other alternatives, it is important to consider whether the incremental risk reduction under Alternatives M-2 through M-5 provides significant risk reduction to warrant the costs and potential construction related impacts such as greenhouse gas emissions, health and safety risk, and short term environmental impacts. Additionally, it is important to consider future mining land use and what the impact to that use may be due to removal actions and road closures. Alternative M-1 with associated institutional controls may be a viable alternative to manage the human health and ecological risks in the near term.

Common elements for Alternatives M-2 through M-5 include removing scattered ore rock within the intertidal zone associated with former loading docks and ore loading operations for consolidation with other mine rock and removal of the miscellaneous solid waste and debris for off-site recycling and disposal, except for drill core that would be consolidated with the mine rock. Alternatives M-3 through M-5 also include the common element of complete removal of the I&L Spur road; however, the alternatives differ with respect to actions for the identified haul road segments and mine road embankments. The common elements for these alternatives would be similarly effective in eliminating human and ecological exposure pathways attributable to these mine-affected materials.

Alternative M-2 (In-Place Stabilization with Stormwater and Institutional Controls) would significantly reduce human exposure pathways to spilled ore rock within the intertidal zone and reduce stormwater contact and potential erosion of mine rock, but overall would not effectively reduce the existing risk associated with mine rock to human and ecological receptors. Alternative M-2 would not achieve the RAOs and would not comply with potential ARARs, and relies on institutional and access controls to reduce human exposure to mine rock. Beside Alternative M-1, Alternative M-2 would result in the least short-term construction risks of the alternatives.

Alternative M-3 (In-Place Covering), Alternative M-4 (Excavation, Consolidation and Cover at Mine Affected Areas) and Alternative M-5 (Excavation, Consolidation and Cover at Open Pit Repository) are protective of human health and the environment, achieve RAOs and comply with potential ARARs. These alternatives specifically address the existing exposure pathways and risks to human and ecological receptors associated with areas of mine rock materials that are attributable to former mining activities. While these alternatives eliminate or reduce exposure pathways and existing risk attributable to mine-related materials, human and ecological risks due to exposure from naturally occurring mineralized background conditions will still persist at the Site.

Alternative M-3 would reduce human and ecological risk by isolating mine rock with a cover at the OSA, 300-Foot, 700-Foot and 900-Foot Levels, eliminate risk associated with the I&L Spur road and reduce risk associated with haul and mine roads, but would not reduce the existing human risk due to external gamma radiation and radon emanation exposure pathways from the Open Pit. Exposure pathways from the haul and mine roads would be reduced by excavating and replacing one-foot of material in the identified haul road segments and mine road embankments. However, the haul and mine roads would require rehabilitation following removal of mine rock, including the assumed replacement of one-foot of material from the on-site borrow source in the excavated road areas, to allow transport of cover material to the individual mine levels.

Compared to Alternative M-3, Alternative M-4 provides an increased level of human health and environmental protection by removing the more easily accessible OSA materials near the shoreline and consolidating mine rock at the 300-Foot Level and Open Pit. Alternative M-4 is effective and permanent in reducing risks from mine rock to human and ecological receptors. In addition to Alternative M-3, Alternative M-4 includes the complete removal and consolidation of the mine road (900-Foot to 700-Foot Levels) surface and embankment materials, which would reduce existing exposure pathways attributable to mine materials along the mine road. Exposure to OSA materials and mine rock at the 700-Foot and 900-Foot Levels would also be significantly reduced. From the perspective of long-term effectiveness and permanence, Alternative M-4 reduces the footprint of mine rock and reduces the quantity of material required for cover construction compared to Alternative M-3. Consolidation of mine rock and placement of a cover on the Open Pit also reduces infiltration and the inflow of water into the underground mine via the 900-Foot Level portal; thereby reducing drainage from the 300-Foot Level portal. However, the short-term risks associated with excavation and transport of mine rock is greater for Alternative M-4. In addition to closure of the I&L Spur road, Alternative M-4 also allows the mine road (900-Foot to 700-Foot Levels) to be closed; thereby further reducing potential risks to human receptors by eliminating access.

Alternative M-5 is effective and permanent in reducing risks from mine rock and the Open Pit to human and ecological receptors. The characteristics of the consolidated mine rock are similar to that of the Open Pit and the naturally mineralized area. Consolidation of the mine rock at the Open Pit significantly reduces the existing human and ecological exposure pathways and risk to the OSA materials and mine rock at the 300-Foot, 700-Foot and 900-Foot Levels, and the I&L Spur, haul and mine roads. Placement of the lower gamma activity material from the 300-Foot Level mine rock pile over the higher gamma activity mine rock at the Open Pit for Alternative M-5 will reduce the gamma and radon emanation at the cover surface of the Open Pit repository compared to Alternative M-4. Similar to Alternative M-4, Alternative M-5 also reduces infiltration and the inflow of water into the underground mine via the 900-Foot Level portal. Compared to Alternatives M-3 and M-4, Alternative M-5 further reduces the footprint of mine rock and reduces the quantity of cover required for cover construction. In addition to closure of the I&L Spur road, Alternative M-5 allows the mine road (900-Foot to 700-Foot Levels) and the haul road to the 300-Foot Level to be closed; thereby further reducing potential risks to human receptors by eliminating access. While the short-term risks associated with cover material excavation and transport are reduced, the short-term risks associated with excavation and transport of mine rock are greatest for this alternative.

8.1.2 Implementability

Since no construction activities are associated with Alternative M-1, this alternative is readily implementable and technically and administratively feasible. Alternative M-1 is also administratively feasible with land use restrictions consisting of institutional, access and/or land use controls. Alternative M-1 is compatible with potential future mining at the Site and does not affect the Site eligibility for the NRHP.

The remaining Alternatives M-2 through M-5 involve progressing levels of construction activities; however, the removal action components of these alternatives are readily constructible and are proven and reliable technologies. Due to the remote Site location, implementation of each of these alternative involve technical challenges associated with transporting equipment and materials to the Site by barge and temporary installation of a new dock and unloading facilities. Transportation of workers to the Site also involves logistical challenges and a temporary on-Site camp or boat would be required to house Site workers. Any alternative or a component of an alternative that requires additional personnel, equipment or materials to be transported to the Site increases these technical challenges.

Depending on the construction force, including the availability of personnel and equipment, Alternatives M-2 through M-5 could potentially be completed in one construction season. However, due to logistical challenges associated with sequencing of multiple construction activities, including removing mine materials and rehabilitation of the existing haul and mine roads, excavating, transporting and consolidating mine rock, and transporting and placing cover materials at the same mine rock areas using the same roads, Alternatives M-4 and M-5 would likely require two construction seasons to complete.

Except for Alternative M-1, Alternative M-2 requires the least construction activities and construction methods would be easier to implement than the other alternatives. While regrading areas of each mine rock pile and constructing stormwater controls would be required, Alternative M-2 would not require the excavation, transport, or placement of mine rock and cover materials. Potential Site impacts due to implementation of this alternative would be significantly reduced compared to Alternatives M-3, M-4 and M-5. Alternative M-2 does not include implementation of any removal action at the mine road, haul road or the I&L Spur road. As such, Alternative M-2 is compatible with future mining at the Site, because it does not include road closure and preclusion of vehicle access. Alternative M-2 may potentially pose adverse impacts to the features that make the Site eligible to the NRHP due to road improvements necessary for equipment access.

The technical feasibility of implementing Alternatives M-3 through M-5 involve tradeoffs between the quantity of mine rock material to be excavated, transported and consolidated and the quantity of material to be excavated, transported and placed for cover construction. These three alternatives all involve removal of mine rock from the identified haul road segments and the mine road embankments, but to differing degrees. Alternative M-3 requires the least amount of mine rock material removal and consolidation, only that associated with removal of the I&L Spur, and removal of one-foot of material from the identified haul road segments and mine road embankments. Alternative M-4 requires additional quantities of mine rock to be excavated, transported and consolidated, with Alternative M-5 requiring the largest quantity of mine rock to be excavated, transported and consolidated. Potential Site impacts and necessary control measures associated with mine rock transport would increase proportionally to the quantity of mine rock to be consolidated.

For Alternative M-4, the available capacity for consolidating mine-affected materials from the OSA at the 300-Foot Level mine rock pile is limited without significantly increasing the footprint area of the 300-Foot Level mine rock pile. The quantity of OSA materials to be consolidated at the 300-Foot Level was based on the total estimated OSA soil and organic mat material quantity of 8,250 cubic yards. However, it is likely that the organic mat quantity would reduce in volume during excavation and a portion could be salvaged for revegetation and erosional controls. The footprint of the 300-Foot Level mine rock pile would increase due to placement of the OSA materials. During design, the volume of material to be removed from the OSA will need to be verified. If the required volume of material to be excavated from the OSA is significantly greater than currently estimated, the quantity could exceed the capacity at the 300-Foot Level without significantly increasing the footprint of the pile. In that case, excess material from the OSA could be transported and consolidated at the Open Pit. The covered area at the Open Pit could be expanded without a significant increase in the footprint.

Alternative M-4 would involve hauling the OSA materials to the 300-Foot Level using the existing haul road and hauling the 700-Foot Level mine rock using the existing mine road to the Open Pit. Given the locations of the 900-Foot Level mine rock piles adjacent to the Open Pit, minimal hauling would be required for consolidation of these piles. Mine rock removal from the identified haul road segments and rehabilitation of the haul road would occur prior to mine rock hauling. Improvements to the mine road would be required prior to hauling of the 700-Foot Level, but the mine road would not be removed until the mine rock is consolidated in the Open Pit. Alternative M-5 would involve the greatest quantity of mine rock to be hauled due to the longer haul distance and greater quantity associated with the OSA materials and 300-Foot Level mine rock.

On the other hand, Alternative M-3 would require the greatest quantity of cover material since the OSA and mine rock at the 300-Foot, 700-Foot and 900-Foot Levels would be covered in place. Alternative M-4 would reduce the footprint of mine rock and the total quantity of cover material required. Alternative M-5 would require the least amount of cover material, as the footprint of the mine rock would be reduced relative to Alternatives M-3 and M-4, and would be limited to the area of the Open Pit repository. While the total mine rock footprint would be reduced under Alternative M-5, a greater volume of cover material would need to be transported to the 900-Foot Level over the longer haul distance compared to the other alternatives. As with mine rock consolidation, potential Site impacts and necessary control measures associated with cover material transport increase proportionally to the quantity of cover material required. Alternative M-4 would reduce the total quantity of cover material required and Alternative M-5 would require the least total quantity of cover material.

The technical feasibility of implementing these alternatives is dependent on the source of borrow materials. On-site borrow sources are preferred over the importation of material from an off-site borrow source. The Kendrick Creek Delta within the intertidal zone is identified as an on-site source of borrow material for cover construction. No other borrow areas have been identified at the Site. Material would be excavated from the Kendrick Creek Delta within the intertidal zone, sorted or screened as necessary to provide the necessary soil and rock geotechnical properties for cover construction, and hauled to the respective areas. The Kendrick Creek Delta borrow source would be regraded following borrow material removal. Rock for channel construction could also potentially be sourced from the Kendrick Creek Delta. Material from Kendrick Creek Delta is expected to be coarse-grained, consisting of well graded silty-sand, gravels to cobble sized rock. The quantity of fines, such as clay and silt, from the borrow source are anticipated to be minimal. As compared to fine-grained materials, the coarse grained materials are marginal as a cover material in reducing radon emanation from mine rock, but are effective in gamma radiation shielding and provide surface erosional and geotechnical stability. During design, the proposed Kendrick Creek Delta borrow area would require additional investigation to confirm that physical and geotechnical properties of the available materials are suitable for cover construction, and to define the physical characteristics of the borrow area. While located on-site, the intertidal area is located on state-owned lands and would be subject to substantive requirements of ARARs of the State of Alaska. Therefore, the implementability of using on-site borrow material from the Kendrick Creek Delta for cover construction would be subject to ADNR applicable requirements and approval as a material development site in conformance with the POW Island Plan. ADNR would need to issue a final finding and decision prior to the area being developed as a borrow source (Johnson, 2012).

M&M requirements for Alternatives M-2 through M-5 would be similar. Routine inspections and maintenance would be required for each alternative. Similar maintenance activities are anticipated for in-place stabilization of mine rock under Alternative M-2 as for the covered mine rock areas under Alternatives M-3, M-4, and M-5. Maintenance of regraded mine rock and covers are expected to be highest during the first few years following construction and then reduced in following years. Additional maintenance may be required for covers over mine rock areas that are revegetated under Alternatives M-3 and M-4 since they may be more susceptible to future erosion than the Open Pit repository, which would be covered with rock mulch. Alternatives M-4 and M-5 would reduce the locations at which inspections and any maintenance would be necessary.

The administrative feasibility of implementing institutional and access controls, and/or land use restrictions are similar for Alternatives M-2 through M-5, except the degree of control varies for each alternative. Institutional controls, access controls, and/or land use restrictions would be required to protect the integrity of the removal action for each alternative, which would include the in-place stabilization of the mine areas for Alternative M-2 and the covers on mine rock piles for Alternatives M-3, M-4 and M-5. Alternative M-2 is the only removal alternative compatible with future mining at the Site, because it does not include road closure and preclusion of vehicle access. Alternatives M-4 and M-5 would preclude future access to the Open Pit for mineral exploration or development. Regardless of the alternative, controls or land use restrictions would be necessary for human exposure pathways within the naturally mineralized area. For Alternative M-2, a greater degree of controls would be necessary to reduce existing human risks resulting from the OSA materials, mine rock at the 300-Foot, 700-Foot, and 900-Foot Levels and the Open Pit. For Alternative M-3, controls would be necessary to reduce existing human risks resulting from the Open Pit and to protect the integrity of the covers at the OSA and at each mine level. Alternatives M-4 and M-5 would require a reduced area of control, with Alternative M-5 requiring the least area of control since materials would be contained at only one area. Alternatives M-3, M-4, and M-5 will likely adversely impact the integrity of the historic site and remove the Site from NRHP eligibility.

8.1.3 Cost

The cost of the removal action alternatives was presented in Sections 6 and 7. For each alternative, the total estimated cost includes estimated direct capital, indirect capital, and M&M costs. To the extent possible, current unit rates and costs from vendors were used in the cost estimates. The present worth of future M&M costs was calculated using a 3.9% discount rate for a 30-year period (Office of Management and Budget, 2014). The M&M costs for maintenance activities were estimated based on experience from similar projects. Typically, M&M inspection and maintenance costs were assumed to occur annually for the first three years following construction and then every five years thereafter for the 30-year period. A contingency of 20% was applied to the direct capital costs to reflect unlisted items and the uncertainty associated with the level of the cost estimates, which consistent with EPA guidance have an accuracy of plus 50% to minus 30%. A contingency of 25 percent was applied to the estimated M&M costs. Costs for the removal action alternatives were estimated in 2011. Costs have been adjusted to 2014 using historical cost indices (RSMeans, 2014). Comparative analysis of the costs for Mine Rock Alternatives M-2 through M-5 is summarized in Table 7-2. There are no costs associated with Alternative M-1, since no construction activities are required to implement the No Action Alternative. The assumptions and detailed cost calculations are provided in Appendix E.

The direct capital cost estimate for Alternatives M-2 through M-5 includes mobilization and de-mobilization of personnel and equipment and the common elements of removing spilled ore within the intertidal area associated with former ore loading operations and consolidation of the rock at the OSA, and off-site transport, recycling, and disposal of the miscellaneous solid wastes and debris. These alternatives also include M&M costs for periodic inspections and maintenance activities. The M&M costs are generally the same for Alternatives M-2 and M-3, but progressively decrease for Alternatives M-4 and M-5, as the number of mine rock consolidation areas decrease. Alternatives M-3 through M-5 also include the common element of completely removing the I&L Spur road and consolidating the material at the 900-Foot Level, either at the 900-Foot Level mine rock pile for Alternative M-3 or in the Open Pit for Alternatives M-4 and M-5.

As shown in Table 7-2, the total estimated cost for Alternative M-2 is approximately $1,427,000. The capital cost includes set-back and grading of the pile sideslopes adjacent to channels and placement of rock protection to armor the pile sideslopes adjacent to the channels. Alternative M-2 results in the lowest total estimated cost since mine rock would be stabilized in place without a cover.

The total estimated costs for Alternatives M-3, M-4 and M-5 are approximately $3,986,000, $3,592,000, and $6,373,000, respectively. The estimated capital costs for these alternatives assume that material for cover construction is obtained from the on-site borrow source. If off-site borrow is imported to the Site for cover construction, the capital cost significantly increases for these alternatives due to the significant increase in importing borrow material and reverses the relative ranking of the cost for each alternative, with Alternative M-3 being the most expensive and the cost of Alternatives M-4 and M-5 being similar.

The cost of Alternative M-3 is slightly greater than Alternative M-4, even though mine rock would not be consolidated due to the greater amount of cover material required. Major elements of the direct capital cost estimate for Alternative M-3 include regrading mine rock at the 300-Foot Level, 700-Foot Level, and 900-Foot Level mine rock piles, and excavation, transport and placement of cover materials on the OSA and mine rock piles at each mine level.

Major elements of the direct capital cost for Alternatives M-4 and M-5 include the excavation, transport and consolidation of mine rock and placement of a cover over the consolidated mine rock areas. Compared to Alternative M-4, Alternative M-5 represents the highest cost due to the quantity of mine rock being excavated and transported to the Open Pit, even though the total quantity of cover would be reduced. However, a greater volume of cover would be hauled a longer distance to the 900-Foot Level for Alternative M-5, as compared to Alternative M-4. The higher cost to consolidate mine rock is not offset by the lower total quantity of borrow material necessary to construct the cover over the Open Pit Repository for Alternative M-5. From a cost standpoint, Alternative M-4 provides a better balance of efficiencies between mine rock and cover material excavation, transport, and placement.

8.2 Comparative Analysis of Portal Alternatives

The comparative analysis of the effectiveness, implementability, and cost criteria of the mine portal removal action alternatives is described in the following sections. The uncertainties associated with the performance of the alternatives are also presented. The comparative analysis of the alternatives is summarized in Tables 7-8 and 7-9. While Alterative P-1 (No Action) does not satisfy the effectiveness criteria in protecting human health and the environment or achieving RAOs and ARARs, it is used as a baseline for comparison with the other removal action alternatives. All the mine portal alternatives are compatible with and could be implemented independently from the mine rock alternatives; except that mine rock consolidation in the Open Pit for mine rock Alternatives M-4 and M-5 would require closure of the 900-Foot Level portal. Implementation of Mine Rock Alternatives M-2 through M-5 would reduce the drainage from the 300-Foot Level portal by reducing the water intercepted by the Open Pit and inflow into the underground mine via the 900-Foot Level portal.

8.2.1 Effectiveness

Alternative P-1 (No Action) is not effective in reducing the existing exposure pathways and potential risks to human and ecological receptors at the Site, would not achieve RAOs and would not comply with ARARs. Alternative P-1 is not acceptable as it does not address the radiological or safety hazards associated with the mine openings. It is not expected that radon exhalation from the mine openings or the water quality of drainage from the 300-Foot Level would change in the future to reduce or alter currently existing risks to human health and the environment. Access by humans and wildlife would remain the same as currently exists. Since no construction activities would occur, no short-term impacts are associated with Alternative P-1 and it would not result in additional exposure to human health and ecological receptors compared to existing conditions. In the long-term, it is not expected that radon exhalation from the mine portals or Site conditions would change to reduce or alter currently existing risks to human health and the environment.

Common elements for Alternatives P-2 through P-4 include closing the upper mine openings consisting of the 900-Foot Level portal, Air Vent Shaft and 700-Foot Level portal. Closure of the upper mine openings would be effective and permanent in eliminating radon exposure to human receptors at the upper mine openings. Closing the upper mine openings would also significantly reduce air inflow into mine workings and air outflow from 300-Foot Level portal. The reduced airflow may reduce radon exhalation from the 300-Foot Level portal. However, due to the uncertain relationship between radon exhalation and airflow, the reduction in radon exhalation from 300-Foot Level portal caused by closing the upper mine openings is indeterminable. While drainage from the 700-Foot Level portal is uncommon and minimal, the closure of 700-Foot Level portal would eliminate the potential for water outflow.

Alternative P-2 (300-Foot Level Portal Gate) and Alternative P-3 (300-Foot Level Portal Backfill) would potentially provide protection of human health and the environment, and would potentially achieve RAOs and ARARs. As described above, closing the upper mine openings would significantly reduce air inflow into the mine workings and air outflow from 300-Foot Level portal, reducing the radon exhalation from the 300-Foot Level portal. However, the predicted reduction in radon exhalation from 300-Foot Level portal is indeterminable for both Alternatives P-2 and P-3. Due to the uncertainty in predicting the radon exhalation reduction from the portal, it is possible that both alternatives may not be effective and permanent as there would be residual risk to occupational and recreational users of the Site due to inhalation of radon at the 300-Foot Level portal. Qualitatively, Alternative P-3 would likely be more effective than Alternative P-2 in reducing the radon exhalation from the portal since radon gas would have to diffuse through the backfill at the portal resulting in lower radon concentrations near and downwind of the portal. Alternative P-3 would also provide additional protection by piping the 300-Foot Level portal drainage to Kendrick Creek eliminating direct human and ecological pathways to certain constituents in the open flowing water from the portal. Due to the uncertain reduction in radon exhalation, Alternatives P-2 and P-3 might not be protective of a Site Visitor, Mineral Exploration Worker, or an USFS Worker, as evaluated in the HHRA, and might not achieve RAOs and ARARs.

Alternative P-4 (300-Foot Level Portal Bulkhead) is the most effective and permanent in reducing existing risks to occupational and recreational users of the Site due to inhalation of radon decay products from the mine openings since radon exhalation from the upper mine openings and the 300-Foot Level portal would be eliminated. The alternative would achieve RAOs and would comply with ARARs. Of the alternatives considered, Alternative P-4 would provide the highest level of mine portal containment. Similar to Alternative P-3, Alternative P-4 would reduce human and ecological pathways associated with direct contact with the drainage water by collecting and piping the 300-Foot Level portal drainage to Kendrick Creek.

Alternatives P-2, P-3 and P-4 would eliminate unrestricted human access to the underground mine workings by closing the upper mine openings and installing a gate, backfilling or constructing a bulkhead at the 300-Foot Level portal. While it is not known if bats inhabit the mine workings, the gate at the 300-Foot Level portal for Alternative P-2 would allow ingress/egress of bats into the mine workings. For Alternatives P-3 or P-4, backfilling or constructing a bulkhead at the portal would preclude bat ingress/egress into the mine workings. Closure of the mine openings would also prevent access to the underground mine for future mineral exploration.

Except for Alternative P-1, short term risks would occur during construction activities. Worker exposure would result from gamma radiation and inhalation of radon decay products during construction of closures at the upper mine openings and during construction activities at the 300-Foot Level portal. Alternatives P-3 and P-4 would increase the potential for short term risks to workers during installation of the water collection system at the 300-Foot Level portal. Construction of the concrete bulkhead inside the 300-Foot Level portal under Alternative P-4 would increase worker exposures to gamma radiation and radon inhalation and also pose physical risks to workers. These potential short-term risks would be managed by implementing worker health and safety practices.

8.2.2 Implementability

Since no construction activities are associated with Alternative P-1, this alternative is readily implementable and technically and administratively feasible. Alternative P-1 is also administratively feasible with land use restrictions consisting of institutional, access and/or land use controls.

Alternatives P-2 through P-4 involve progressing levels of construction activities. The removal action components of these alternatives use conventional construction equipment, materials and methods and the technologies to close mine using portals are proven and reliable. Due to the remote Site location, implementation requires transporting equipment and materials to the Site by barge and temporary installation of a new dock and unloading facilities. Transportation of workers to the Site would also be necessary and a temporary on-Site camp or boat would be required to house Site workers. However, implementing these mine portal alternatives would not incrementally increase the technical challenges associated with the mine rock alternatives.

Alternatives P-2 through P-4 could all be completed in one construction season. If mine rock consolidation and covering of the Open Pit occurs under Mine Rock Alternatives M-4 or M-5, closing the 900-Foot Level portal would need to be performed prior to backfilling of the pit.

Installing a gate at the 300-Foot Level portal under Alternative P-2 requires the least construction activities and would be easier to implement than the other alternatives. Backfilling the portal for Alternative P-3 would not require considerably more construction effort than Alternative P-2. On-site sources of rock backfill are readily available given the relatively limited quantity of rock required to backfill the portal. While the construction activities for Alternative P-4 are technically feasible and readily implementable, the design methods, engineering requirements, and construction activities for the bulkhead are more complex. The concrete bulkhead would be installed in competent rock inside the 300-Foot Level portal. During the design phase, the location and design of the concrete bulkhead would be determined following inspection of rock integrity and strength within the adit. Rehabilitation of the portal face would be required to allow safe access for inspection and workers.

The 300-Foot Level portal closures for Alternatives P-3 and P-4 include construction of a water collection system and piping of the existing drainage to Kendrick Creek. The design of the water collection and piping system is dependent on the flow rate of the drainage from the

300-Foot Level portal. There are limited flow data currently available for the drainage. However, the water collection system and piping could be over-sized during the design phase to increase the reliability in conveying the peak drainage flow. In addition, the bulkhead for Alternative P-4 would be designed to allow access for inspection and maintenance, if required, of the water collection system behind the bulkhead to ensure free flowing conditions. The limited flow data would therefore not compromise the performance or permanence of Alternatives P-3 and P-4.

M&M requirements for Alternatives P-2 through P-4 would be similar. Periodic inspections and maintenance would be necessary for each alternative. It is anticipated that inspections would be performed annually during the first three years following construction and then at five year intervals thereafter. Given the permanence and the integrity of the removal actions, maintenance of the upper mine opening closures and at the 300-Foot Level portal are expected to be minimal. Mine rock consolidation in Open Pit for Mine Rock Alternatives M-4 and M-5 would preclude direct inspection and maintenance of the 900-Foot Level portal closure. Backfilling of the 300-Foot Level portal for Alternative P-3 would preclude direct inspection of the water collection system behind the backfill, but the backfill could be removed if inspections indicated that water was not flowing in the pipe. M&M requirements for Alternatives P-3 and P-4 would also include water quality monitoring in Kendrick Creek at a designated location downstream of Mine Fork Creek and the 300-Foot Level portal drainage. Water quality monitoring was assumed to occur twice a year for a five-year period following completion of the removal action and twice a year every five years thereafter, if determined necessary, from review of the resulting data.

The administrative feasibility of implementing institutional and access controls, and/or land use restrictions are similar for Alternatives P-2 through P-4, except the degree of control varies for each alternative. Institutional controls, access controls, and/or land use restrictions would be required to protect the integrity of the removal action for each alternative by preventing future disturbance of the mine portal closures. For Alternatives P-2 and P-3, a greater degree of controls would be necessary to reduce human risks due residual levels of radon from the 300-Foot Level portal. Alternative P-4 would require the least control since radon exhalation from all mine openings would be eliminated. Signage could be easily implemented and would be effective in reducing risks to human receptors.

8.2.3 Cost

The cost of the removal action alternatives for the mine portals was presented in Sections 6 and 7. For each alternative, the total estimated cost includes estimated direct capital, indirect capital, and M&M costs. To the extent possible, current unit rates and costs from vendors were used for the cost estimates. The present worth of future M&M costs was calculated using a 3.9% discount rate for a 30-year period. The M&M costs for maintenance activities were estimated based on experience from similar projects. Typically, M&M inspection and maintenance costs were assumed to occur annually for the first three years following construction and then every five years thereafter for the 30-year period. M&M water quality monitoring costs were assumed to occur twice a year for a five-year period following completion of the removal action and twice a year every five years thereafter. A contingency of 20% was applied to the estimated direct capital costs to reflect unlisted items and the uncertainty associated with the level of the cost estimates, which consistent with EPA guidance have an accuracy of plus 50% to minus 30%. A contingency of 25 percent was applied to the estimated M&M cost. The comparative analysis of the costs for Portal Alternatives P-2 through P-4 is summarized in Table 7-9. The assumptions and detailed cost calculations are provided in Appendix E.

There are no costs associated with Alternative P-1, since no construction activities are required to implement the No Action Alternative. The direct capital cost estimate for Alternatives P-2 through P-4 include mobilization and de-mobilization of personnel and equipment and the common elements of closing the upper mine openings. The M&M costs are the same for Alternatives P-3 and P-4.

The total estimated costs for Alternatives P-2, P-3 and P-4 are approximately $724,000, $813,000, and $864,000, respectively. The direct capital costs for these alternatives include closure of the upper mine openings. At the 300-Foot Level portal, Alternative P-2 includes the cost for installing a gate, Alternative P-3 includes the cost for backfilling and construction of a water collection system and piping the drainage to Kendrick Creek, and Alternative P-4 includes the cost for constructing a concrete bulkhead with a water collection system and piping the drainage to Kendrick Creek. While the three alternatives progressively reduce the human risk to radon exposure from the 300-Foot Level portal, there is not a significant difference in the total estimated costs between the alternatives. Alternative P-4 is the most cost-effective and permanent in reducing existing radon risks to occupational and recreational users of the Site.

9.0 Recommended Removal Action Alternatives

Based on the detailed and comparative analysis of the removal action alternatives presented in Sections 7 and 8 of this EE/CA, the combination of Mine Rock Alternative M-5 and Portal Alternate P-4 best satisfies the evaluation criteria. Both the mine rock and the mine portal alternatives are protective of human health and the environment in reducing or eliminating the exposure pathways and risks identified by the HHRA and the SLERA. Both alternatives are effective in reducing incremental radiation risks due to external gamma radiation and inhalation of radon decay products associated with mine rock and the inhalation of radon decay products associated with the mine openings. The alternatives achieve the RAOs and RAGs attributable to the mine-affected areas identified in Section 4, and comply with potential ARARs. However, the alternatives will not eliminate the Site-wide risk to human health, as radiation risks from background gamma radiation and radon in the naturally mineralized area exceed the acceptable human health risk and dose criteria.

Mine Rock Alternative M-5 includes the following components:

- Removal of ore rock within the intertidal zone associated with former loading ramps and ore loading operations and consolidation at the Open Pit Repository;
- Removal of the miscellaneous solid waste and debris and transport for off-site recycling and disposal, expect for drill core that would be consolidated at the Open Pit Repository;
- Excavating, transporting and consolidating the mine-affected material from the OSA, and the mine rock piles from the 300-Foot Level; 700-Foot Level, and 900-Foot Level (North and South) at the Open Pit Repository;
- Excavating and consolidating the I&L Spur road materials in the Open Pit and closing the road;
- Removing and consolidating the identified mine road (between the 700-Foot and 900-Foot Levels) surface and embankment material in the Open Pit and closing the mine road;
- Excavating the mine rock from the identified segments of the haul road and consolidating the material in the Open Pit;
- Placing a synthetic geomembrane barrier and 2-foot thick earthen cover on the mine rock materials consolidated at the Open Pit Repository from the on-site borrow source and constructing stormwater controls to protect the covered areas; and
- Implementing institutional controls, access controls, and/or land use restrictions to protect the integrity of the removal action.

Portal Alternative P-4 consists of the following components:

- Closure of the upper mine openings consisting of the 900-Foot Level portal, Air Vent Shaft and 700-Foot Level portal;
- Constructing a concrete bulkhead at the 300-Foot Level portal, with a water collection and piping system to convey the drainage from the portal directly to Kendrick Creek; and
- Implementing institutional controls, access controls, and/or land use restrictions to protect the integrity of the portal closures.

The primary factors that result in selection of Mine Rock Alternative M-5 as the recommended removal action include:

- Mine Rock Alternative M-5 will be effective in achieving the RAOs for the removal action areas, including reducing the predicted mine rock incremental dose to less than 15 mrem/year and the lifetime risk to less than 1E-5 above background for occupational workers and recreational users of the Site;
- Mine Rock Alternative M-5 will provide permanent containment of the mine-affected materials by consolidating mine rock and mine-affected materials in the Open Pit Repository, reducing the overall mine rock footprint and requiring less cover material;
- Mine Rock Alternative M-5 will remove the OSA materials near the shoreline of the West Arm of Kendrick Bay, significantly reducing human health exposures to gamma radiation and radon for Site visitors and occupational workers;
- Mine Rock Alternative M-5 will remove the 300-Foot Level mine rock pile located in the relatively steep area adjacent to Kendrick Creek, eliminating potential concerns with the long-term geotechnical and erosional stability and permanence of the 300-Foot Level mine rock pile;
- Mine Rock Alternative M-5 will return all mine rock and mine-affected materials to the Open Pit Repository where the characteristics of the materials are consistent with the naturally mineralized area and where the flatter topography is more suitable for long-term mine rock containment and cover stability;
- Mine Rock Alternative M-5 will reduce the gamma and radon emanation at the cover surface of the Open Pit Repository by placing the lower gamma activity material from the 300-Foot Level mine rock pile over the higher gamma activity mine rock;
- Mine Rock Alternative M-5 will require closure of the I&L Spur road, the haul road to the 300-Foot Level, and the mine road from the 700-Foot Level to the 900-Foot Level, reducing human access to the 300-Foot and 700-Foot Levels;
- Mine Rock Alternative M-5 will require that institutional and access controls and/or land use restrictions be implemented at only one isolated location, where access to the 900-Foot Level is already limited compared to other areas of the Site;
- Mine Rock Alternative M-5 will consolidate mine rock and place a cover on the Open Pit, reducing the inflow of water into the underground mine via the 900-Foot Level portal; thereby reducing drainage from the 300-Foot Level portal;

The primary factors that result in selection of Portal Alternative P-4 as the recommended removal action include:

- Portal Alternative P-4 will significantly reduce radon exhalation from the mine openings, significantly reducing the human health exposure pathway and risk due to inhalation of radon decay products from the mine openings;
- Portal Alternative P-4 has the least uncertainty of alternatives in achieving the RAOs for protection of human health and the environment by significantly reducing radon exhalation from the mine openings;
- Portal Alternative P-4 will reduce human and ecological pathways associated with direct contact with the drainage water by collecting and piping the 300-Foot Level portal drainage to Kendrick Creek;

- Portal Alternative P-4 will eliminate the potential for water drainage from the 700-Foot Level portal.

The total estimated cost of the recommended removal action consists of the combined cost of Mine Rock Alternative M-5 and Portal Alternative P-4 of approximately $7,237,000. Depending on the construction force, including the availability of personnel and equipment, the recommended removal action could potentially be completed in two construction season. Two construction seasons would likely be required to complete Mine Rock Alternative M-5 due to logistical challenges associated with sequencing of multiple construction activities, including removing mine materials and rehabilitation of the existing haul and mine roads, excavating, transporting and consolidating mine rock, and transporting and placing cover materials using the same roads.

10.0 Community Engagement Plan

The overall goal of the Community Engagement Program is to maintain and promote communication between citizens and the agencies involved in the project, and to provide opportunities for meaningful and active involvement by the community in the cleanup process. The USFS Alaska On-Scene Coordinator (OSC) will coordinate the activities described here. The Site OSC is designated as the USFS spokesperson for the Ross-Adams Site cleanup and other related issues regarding the Ross-Adams Site cleanup on National Forest Systems (USFS) land, and serves as the primary point of contact for community members, other regulatory agencies, and stakeholders relating to the USFS as it pertains to cleanup of the Site.

In addition to the USFS, other regulatory agencies involved in the Site cleanup process include ADEC and EPA. In addition to community members, interest groups, Organized Village of Kasaan (OVK), Village of Hydaburg, and UCore are also stakeholders in the cleanup process. ADEC, EPA, and OVK were involved in the planning for the ESI and review of the SCR and Draft EE/CA. The OSC serves as the liaison and point of contact with ADEC, EPA and other regulatory agencies and with OVK, UCore, and other stakeholders. The OSC will coordinate and schedule, prepare for, and attend all announced meetings to update the community on Site developments and address community questions, concerns, ideas and comments. The OSC will provide notice of scheduled meetings.

Citizens, participating agency staff, decision makers and other stakeholders will be provided with current, accurate, easy-to-read information throughout the project, with updates as appropriate, and distribution based upon the scope of the information. Information will be provided in the form of Fact Sheets, flyers, and posters at various meetings, forums and symposiums as well as emails from the OSC. An Administrative Record regarding the Site has been established and will be maintained by the OSC. The Administrative Record contains key information leading to the preferred cleanup alternative for the Site and is available to the public. It will be updated as necessary.

Various public meetings have been held to update stakeholders and other interested public on the status of the project. A public presentation was given at the POW Island Mining symposium in Craig, Alaska in May 2009 to provide information about the Site and ongoing data collection efforts for the ESI. A meeting to update the community was held in Hydaburg, Alaska in September 2009. A public open house event was held in Hydaburg in December 2010 to present the findings from the SCR and status of the project. The status of the Draft EE/CA was provided by the USFS on April 16, 2011 in two same-day public meetings in conjunction with UCore's public informational meeting regarding rare earth metals exploration activities at Bokan Mountain. A presentation was included during the POW Island-Wide mining symposium in Craig, Alaska on May 8-10, 2012 and on April 24-25, 2014 to update stakeholders and other interested public on the status of the project.

This EE/CA will be available to the public for a 30 day public comment review period to give community members an opportunity to review and comment on the documents, especially the preferred alternative proposed in the EE/CA for Site cleanup. During the comment review period, a public open house will be scheduled to present information contained in the EE/CA and to solicit questions and comments from the community. The OSC will coordinate scheduling and provide formal announcement of the comment review period and public open house. This process offers the community and other stakeholders the opportunity to provide input and comment for the OSC to take into consideration when making decisions about the Site cleanup.

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