

# Ross-Adams Mine Site, Tongass National Forest, Alaska

## Administrative Settlement Agreement and Order on Consent For Engineering Evaluation/Cost Analysis

The Ross-Adams Mine Site is a former uranium mine located in the Tongass National Forest near the southern end of Prince of Wales Island, Alaska. The Ross-Adams Mine was mined by open pit and then later by underground operations intermittently between 1957 and 1971 by several different mining companies.

In April 2009, Newmont USA Limited and Dawn Mining Company LLC voluntarily entered into an Administrative Settlement Agreement and Order on Consent (ASAOC) with the USDA Forest Service (USFS) to perform an Engineering Evaluation/Cost Analysis (EE/CA) for the Site.

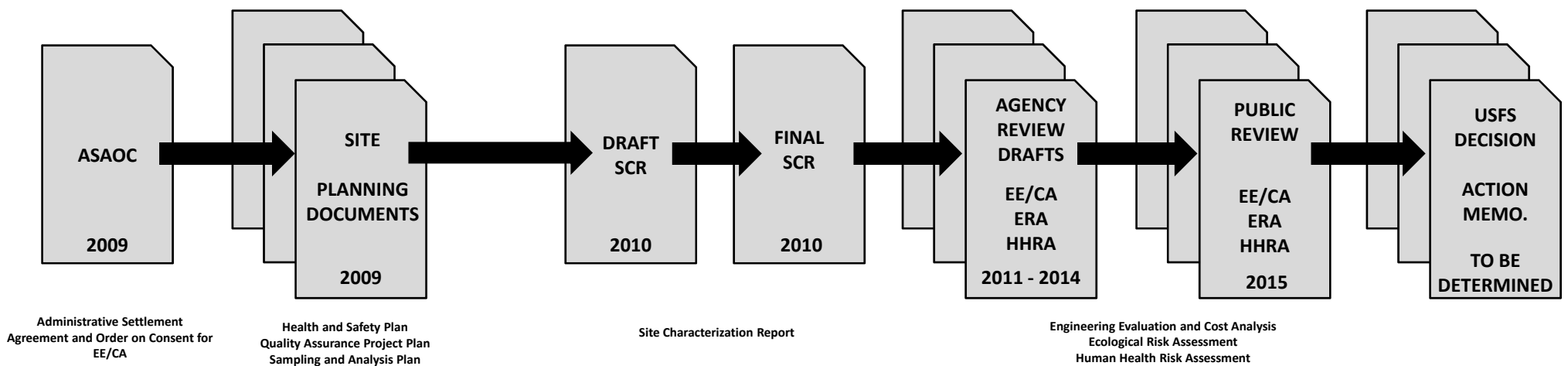
**The ASAOC is a legally binding agreement that prescribes completion of the following major tasks and deliverables:**

- **Site Planning Documents** – Sampling and Analysis Plan (SAP), Work Plans for Human Health and Ecological Risk Assessments, Quality Assurance Project Plan (QAPP) and Health and Safety Plan (HASP) – approved by USDA Forest Service in mid-2009.
- **Expanded Site Investigation (ESI)** – Undertaken in 2009 in accordance with the ASAOC Statement of Work to address data gaps identified by previous investigations by collecting additional data and information to characterize the

physical, chemical and radiological conditions of the Site. Gamma radiation surveys and soil, surface water, stream sediment, marine sediment, and ambient air sampling were performed. The ESI also included a biological assessment, an engineering assessment, and an assessment of land use conditions of the Site and subsistence resource use in the regional area.

- **Site Characterization Report (SCR)** – Describes the work conducted and presents the results and conclusions of the 2009 ESI. A Draft SCR was submitted in March 2010 for review by the Forest Service, Organized Village of Kasaan, Alaska Department of Environmental Conservation and EPA. The Final SCR, which incorporates agency comments, was approved by the Forest Service in December 2010.
- **Engineering Evaluation/Cost Analysis (EE/CA)** – Defines and evaluates the range of removal action (cleanup) alternatives to mitigate potential risk from historic mining activities by addressing the mine rock materials, adjacent mine-affected areas, and affected media defined by the SCR. Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) were conducted as part of the EE/CA to evaluate existing risks to human health and the environment associated with historic mining operations and to assess the effectiveness of cleanup alternatives.

### ASAOC DELIVERABLES



#### EE/CA Process

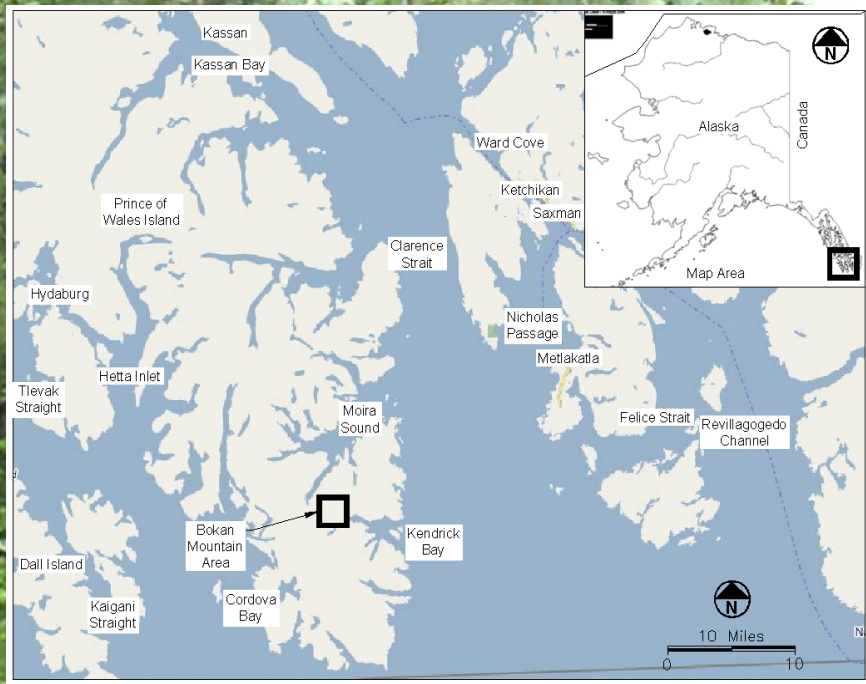
- Site Characterization Results
- Human Health and Ecological Risk Assessments
  - Risk assessments evaluate risks to human health and ecological receptors considering site-specific land uses, exposure units, exposure pathways and receptors defined by Conceptual Site Model (CSM)
  - CSM defines potentially complete exposure pathways for risk assessment based on sources, release mechanisms, constituents of concern, exposure routes and receptors developed from results of site investigations
- Identification of Removal Action Objectives
- Identification of Applicable or Relevant and Appropriate Requirements
- Identification of Removal Action Alternatives
- Analysis of Removal Action Alternatives
  - Effectiveness
  - Implementability
  - Cost
- Comparative Analysis of Removal Action Alternatives
- Recommended Removal Action Alternatives



- **Overall objective of EE/CA process is to work with the agencies to define the appropriate removal (cleanup) action for the Site that is protective of human health and the environment considering site-specific data and information provided by previous investigations and the ESI**
- **ASAOC is a legally binding agreement that defines the scope of work and activities to be completed**
- **ASAOC defines the timeline and schedules for tasks and deliverables**

- **Process involves and provides opportunities for Tribal, community and stakeholder input, public review and comment on EE/CA**
- **U.S. Forest Service will select the cleanup action, in collaboration with the State and EPA, after public review and input**
- **Responsibility for implementation of the preferred cleanup action will be defined at a later time**

# Site Location and Ross-Adams Mine Features



## Site Location

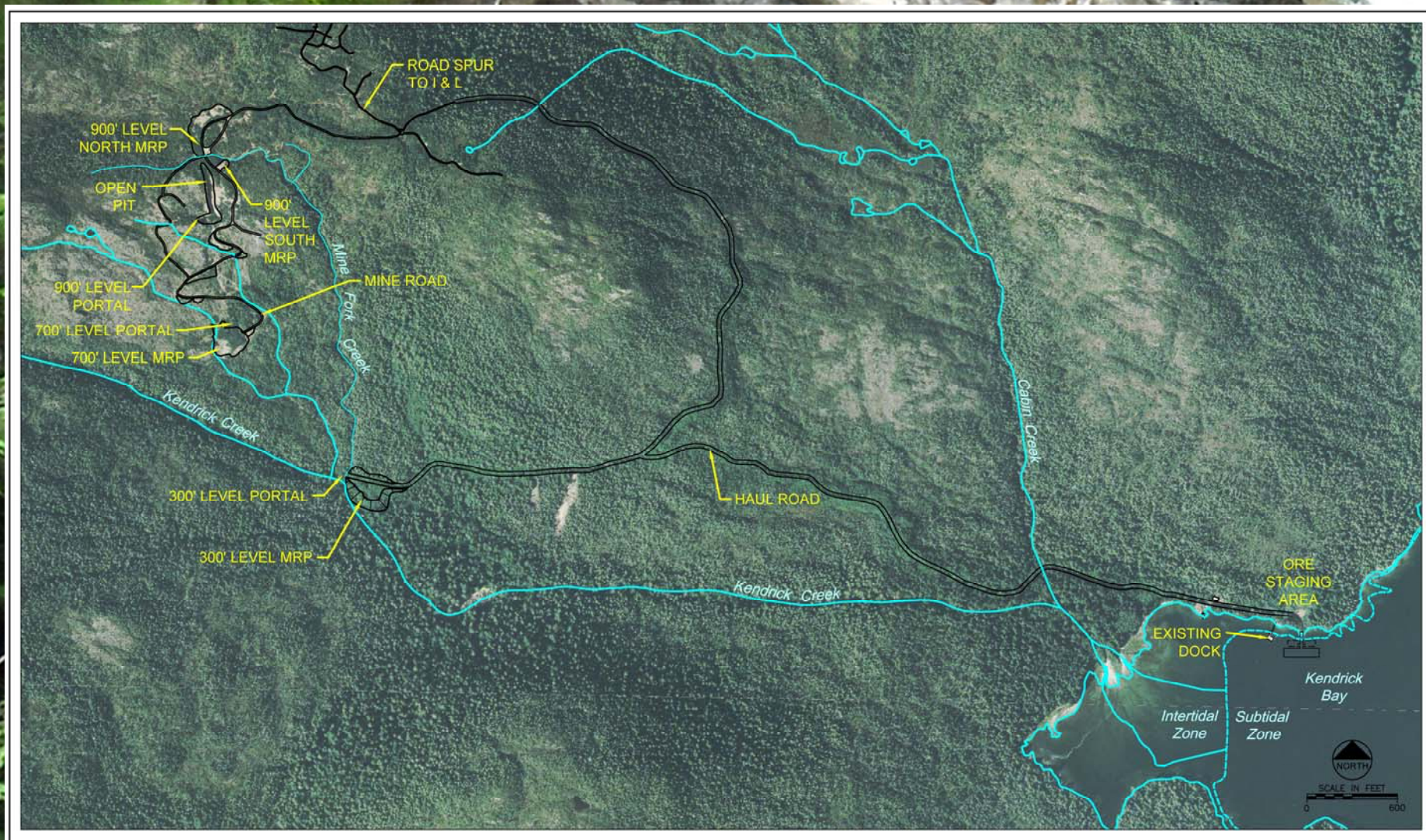
- Southern end of Prince of Wales Island in the Tongass National Forest, approx. 38 air miles southwest of Ketchikan and 33 air miles southeast of Hydaburg, Alaska
- Located on the southeastern slopes of Bokan Mountain within the Kendrick Creek watershed, which drains to the West Arm of Kendrick Bay
- Remote - accessible only by float plane or boat, or over land by hiking through trail-less rugged terrain

## Ross-Adams Mine History

- Ore deposit identified in 1955
- Mining started in 1957 and was conducted intermittently through 1971 by various mining companies
- Mineral exploration has continued to date by various companies

## Ross-Adams Mine Operations

- Mine initially developed by open-pit mining and later by underground operations from three portals at different elevations: "900-Foot Level"; "700-Foot Level"; and "300-Foot Level"
- Mine rock placed near the open-pit and portals at the three levels
- Mine road constructed between the 900-Foot and 700-Foot Levels and haul roads constructed from the 900-Foot Level and 300-Foot Level to the ore storage area
- Ore produced from all levels hauled by truck to former ore staging area and barge loading docks on the north shore of the West Arm of Kendrick Bay
- All ore was shipped offsite for processing outside of Alaska; no onsite mill nor tailing generated or stored onsite
- All environmental requirements at the end of mining in 1971 by Dawn Mining Company were met



## 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 (MRP), and mine rock embankments along the access road to the 700-Foot Level
- **700-Foot Level** - mine portal and mine rock pile
- **300-Foot Level** - mine portal with mine water drainage and mine rock pile
- **Former Ore Staging Area (OSA)** – at northern shore of the West Arm of Kendrick Bay, with residual ore materials
- **Former Ore Loading Docks** – Two remnant rock ramps extend from the OSA area into the West Arm of Kendrick Bay and the remnants of a third and older ramp are located west of the existing floating dock
- **Mine and Haul Roads** (including I&L spur road) - primary roads constructed for exploration and mine access which served as haul roads connecting the 700-Foot, 900-Foot and 300-Foot Levels to the OSA and loading docks/ramps

Mine affected area is 17.2 acres within the 1,400 acre Kendrick Creek watershed

Approximately 65,800 cubic yards of mine rock are located onsite



# Site Characterization Overview

## Previous Investigations

- Mineral resource and economic geology studies:
  - MacKevett (1963), Eakins (1970), Staatz (1978), Warner & Barker (1989)
  - Define mineralogy and geology conditions of Bokan Mountain uranium and rare earth deposits, including Ross-Adams and nearby ore deposits
  - Provide characterization of mineralization and geology of Ross-Adams deposit
- Environmental investigations:
  - 1998 BLM Removal Preliminary Assessment
  - 2004 Forest Service Preliminary Assessment/Site Inspection – conducted by Kent & Sullivan, Inc.
  - Evaluated nature and extent of mine materials and migration/exposure pathways in media to potential receptors
  - ASAOC Statement of Work designed to address gaps identified by previous investigations

## Expanded Site Investigation (ESI)

- Purpose – address data gaps identified by previous investigations by collecting additional data and information to characterize physical, chemical and radiological conditions of Site
- Data collected to further characterize mine features and environmental media consisting of soil, surface water, stream sediment, marine sediment, and air (radon)
- Data and information will be used to support EE/CA and human health and ecological risk assessments

## Gamma Exposure Rate Surveys

- Gamma surveys measure gamma-emitting exposure rates of surface materials to define the spatial extent of the mine feature areas and to define local background gamma exposure rates
- Gamma exposure rate surveys conducted of mine features, adjacent areas, and background mineralized and non-mineralized areas, including the mine rock piles at the 900-Foot, 700-Foot and 300-Foot Levels, mine and haul roads, ore storage area, and loading dock areas
- Gamma exposure rate surveys also conducted along the Kendrick Creek channel, within the Kendrick Creek Bay delta intertidal area, and a limited area of the naturally mineralized and un-mined I&L zone
- Over 182,000 data points representing approximately 185 acres were measured

## Soil Sampling

- Total of 86 soil samples collected to characterize metal and radionuclide concentrations of mine rock piles, adjacent areas, and natural mineralized and non-mineralized areas
- Soil radionuclide concentrations were correlated with gamma exposure rate measurements
- Higher soil metal concentrations coincident with mine features

## Surface Water Sampling

- Total of 45 surface water samples collected at 18 locations in Kendrick Creek and tributaries (700-Foot Level Creek, Mine Fork Creek, and Cabin Creek) in June, July and September 2009 to characterize background and assess effects of mine features
- Field measurements performed and samples analyzed by laboratory for metals and radionuclides in the natural uranium (U) and thorium (Th) decay series
- Sampling events capture the range of flow conditions, dry to wet season, typical for the Site

## Stream Sediment Sampling

- Total of 12 stream sediment samples collected in July 2009 at locations in Kendrick Creek and tributaries to characterize background and assess effects of mine features
- Samples analyzed by laboratory for metals and radionuclides in the natural uranium (U) and thorium (Th) decay series

## Marine Sediment Sampling

- Total of 22 intertidal and 8 subtidal marine sediment samples collected from the West Arm of Kendrick Bay in July 2009 to assess effects of historic mining operations, including ore loading operations at the former ore storage area and loading docks/ramps
- Samples analyzed by laboratory for metals and radionuclides in the natural uranium (U) and thorium (Th) decay series

## Air Radon Measurements

- Short-term and long-term radon monitoring performed at 34 locations to assess radon concentrations at mine features (mine rock and portals), adjacent areas, and mineralized and non-mineralized areas

## Background Evaluation

- Soil, radon, surface water, stream sediment and marine sediment samples collected at locations upstream and/or distant from the mine features to assess background for mineralized and non-mineralized areas
- Limited gamma radiation survey performed in the I&L Zone to evaluate background gamma exposure rates in an un-mined, mineralized area
- Background reference data compared to media data collected to evaluate the extent of mine-related impacts and to support human health and ecological risk assessments

## Engineering Assessment

- Documents physical/engineering aspects of both mine-related and natural features to refine material quantities, define engineering constraints and identify constructability conditions in support of the EE/CA
- Visual inspection, mapping, surveying, and description of the physical dimensions, locations, conditions and stability of mine-related features (mine rock piles, water diversion structures, roads, and mine openings) and natural features (landslides)

## Biological Assessment

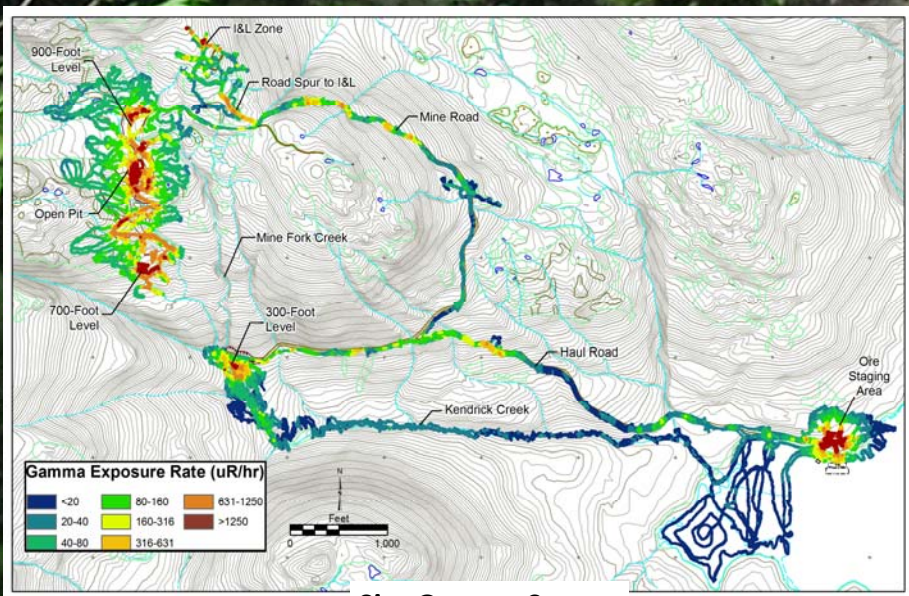
- Biologic assessment of Site conducted in July 2009 to identify the main habitat types and associated aquatic and terrestrial species for use in the exposure pathways analyses of the ecological and human health risk assessments
- Additional literature-based research was performed to augment the field survey data and to assess Site land use conditions and subsistence resource use in the regional area

## Miscellaneous Solid Waste Inventory

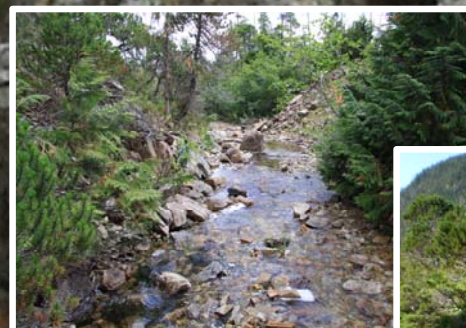
- Inventory conducted to catalogue the types, locations and quantities of remaining miscellaneous solid wastes, petroleum products, abandoned vehicles and other materials associated with several exploration camps after 1971
- Soil samples were collected at four of the waste locations and analyzed for gasoline range organics (GROs) and diesel range organics (DROs), with one sample analyzed for polychlorinated biphenyls (PCBs)

## Site Characterization Report (SCR)

- Comprehensive Final Site Characterization Report presents results and conclusions of the ESI. SCR provides the necessary data and information to support the EE/CA and associated human health and ecological risk assessments



Site Gamma Survey



Soil Sample Collection



Soil Sample Preparation



Former Ore Loading Ramp



Aerial View of West Arm Kendrick Bay at Low Tide

# Human Health Risk Assessment

**A human health risk assessment (HHRA) was performed to evaluate pathways of potential human exposure to site-related chemicals based on current and future uses of the Site. The HHRA was divided into a screening-level risk assessment and a site-specific risk assessment.**

## Screening Level Risk Assessment

The screening level risk assessment compared maximum concentrations of chemicals and radionuclides found in soil, surface water, stream sediment and marine sediment at the site with conservative screening levels representing potential human exposure via ingestion, dermal contact, inhalation, and external exposures for each of these media as appropriate. The screening level risk assessment eliminated many substances with no substantive risk and identified other constituents of potential concern that were evaluated in detail in the site-specific risk assessment.

Constituents of potential concern selected for evaluation in the site-specific risk assessment are:

- Trace metals - Arsenic, uranium, manganese
- Naturally occurring radionuclides of uranium, thorium, radium, lead, and polonium
- Radon - A radioactive, colorless, odorless, tasteless, noble gas that occurs naturally as a decay product of uranium or thorium
- Gamma Radiation – Electromagnetic emissions produced by radioactive decay of naturally occurring radionuclides like radium-226
- Gross alpha and Gross beta - Particle emissions produced by radioactive decay of heavy radionuclides like radium, radon, uranium, and thorium

## Site-Specific Risk Assessment Approach

Because residential use of the Site is not allowed by the Tongass National Forest Land and Resource Management Plan, the site-specific risk assessment is based on other current and future uses of the Site:

- Occupational Visitors - Exposures 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
  - A mineral exploration worker at the site for 120 days/year for 3 years
  - A USDA FS worker at the site 10 days/year for 25 years
- Child and Adult Recreational Visitors - Exposure 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 at the site for 14 days per year for 30 years.
- Subsistence Hunter-Gatherers – Based on annual rates of harvest and consumption for Prince of Wales Island residents for:
  - Deer and local berries from upland habitat at the site
  - Seaweed, sea cucumbers and flounder from the west Arm of Kendrick Bay.

## Site-Specific Risk Assessment Results

Estimated risks were compared to regulatory levels of concern for non-cancer and cancer risks. Risk were below levels of concern for:

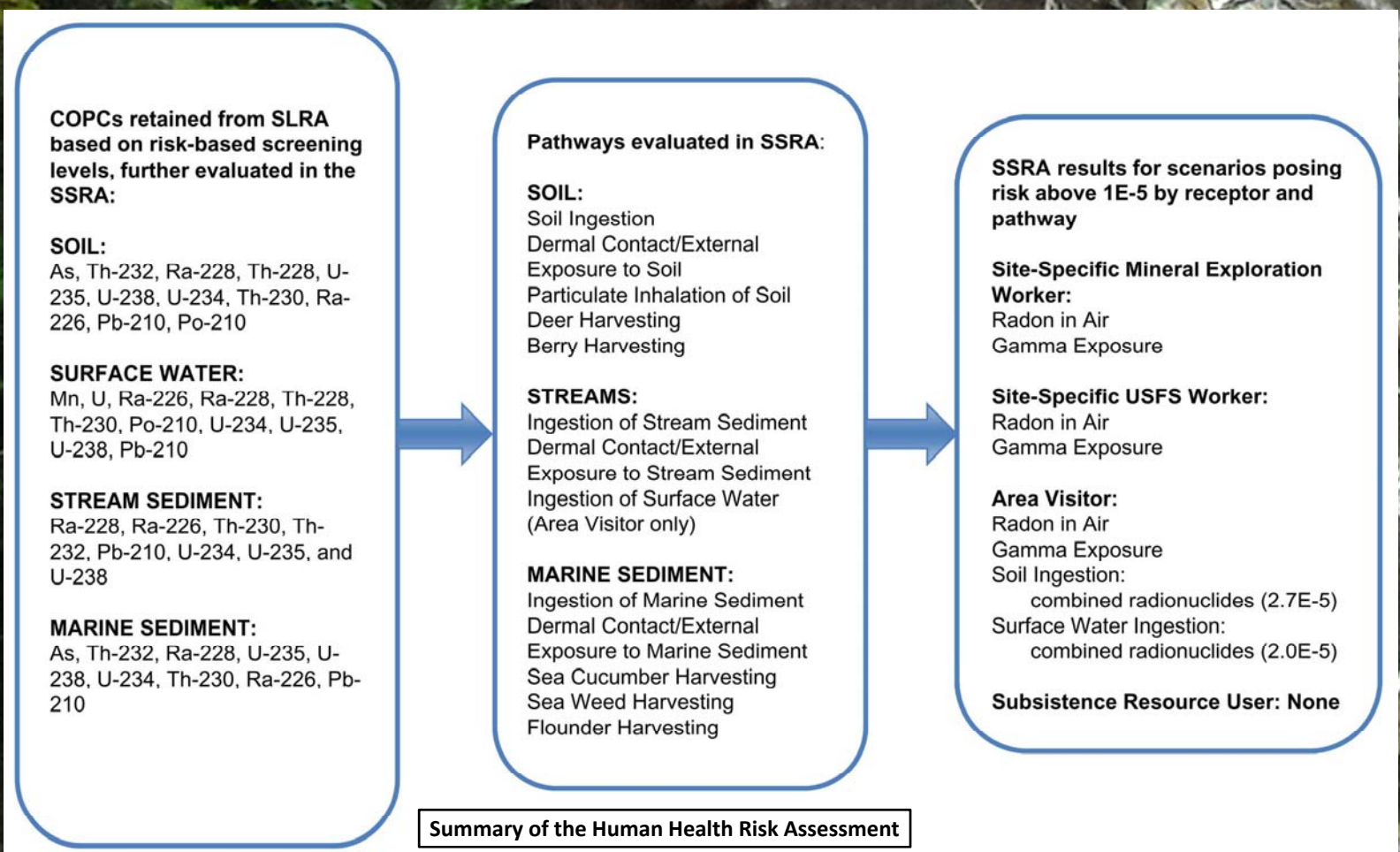
- Trace metals (As, U, Mn) in all media and exposure scenarios.
- Subsistence consumption of food gathered in upland and marine habitats

### Site-use scenarios that exceed regulatory levels of concern are:

- Mineral Exploration Worker – Radon in air and gamma exposure
- Forest Service Worker – Radon in air and gamma exposure
- Site Visitors – Radon in air, gamma exposure, and combined radionuclides in soil and water

Although radionuclides that exceed risk levels of concern contribute to risk for site visitors, the vast majority of risk is from 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.

Because background risks for radon and gamma exposure also exceed regulatory levels of concern, Removal Action Objectives and cleanup decisions for protection of human health will be based on achieving background levels of radon and gamma radiation.



Summary of the Human Health Risk Assessment

# Ecological Risk Assessment

**A Screening Level Ecological Risk Assessment (SLERA) was performed to evaluate potential risks for exposure pathways to ecological receptors in terrestrial and aquatic environments, including freshwater and marine environments, based on existing site conditions. Major components of the SLERA included:**

- Problem formulation – Identification of chemicals of potential ecological concern and sensitive communities and wildlife
- Characterization of exposure and effects of chemicals of potential ecological concern
- Characterization of risk to valued communities and selected wildlife species

## **Problem Formulation**

Chemicals of potential ecological concern included over 20 metals and two radionuclides (Ra-226, Ra-228).

Community-level receptors that were evaluated consisted of terrestrial plants, terrestrial soil invertebrates, stream surface water invertebrates and fish, stream benthic invertebrates, and marine benthic invertebrates.

Individual wildlife indicator species were selected for evaluation of risk to eight functional avian and mammalian wildlife groups in the region:

- Upland terrestrial and wildlife habitat – Dark-eyed junco, American robin, masked shrew, long-tailed vole, belted kingfisher
- Marine habitat – Belted kingfisher, mew gull, sea otter, harbor seal

## **Characterization of Exposure and Effects**

Potential risks to community receptors and wildlife indicator species are based on comparison of receptor exposure to toxicity reference values. Exposure levels that are greater than their toxicity reference value indicate a level of concern that needs to be addressed in context of 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.

## **Risk Characterization**

Ecological exposure to six metals (cobalt, manganese, cadmium, lead, uranium and zinc) exceeds toxicity reference levels for terrestrial plants, soil invertebrates and terrestrial wildlife. However, the risk levels for these chemicals are often in the low range and dominated by a few samples in localized areas. These localized occurrences are generally within the mine rock affected areas.

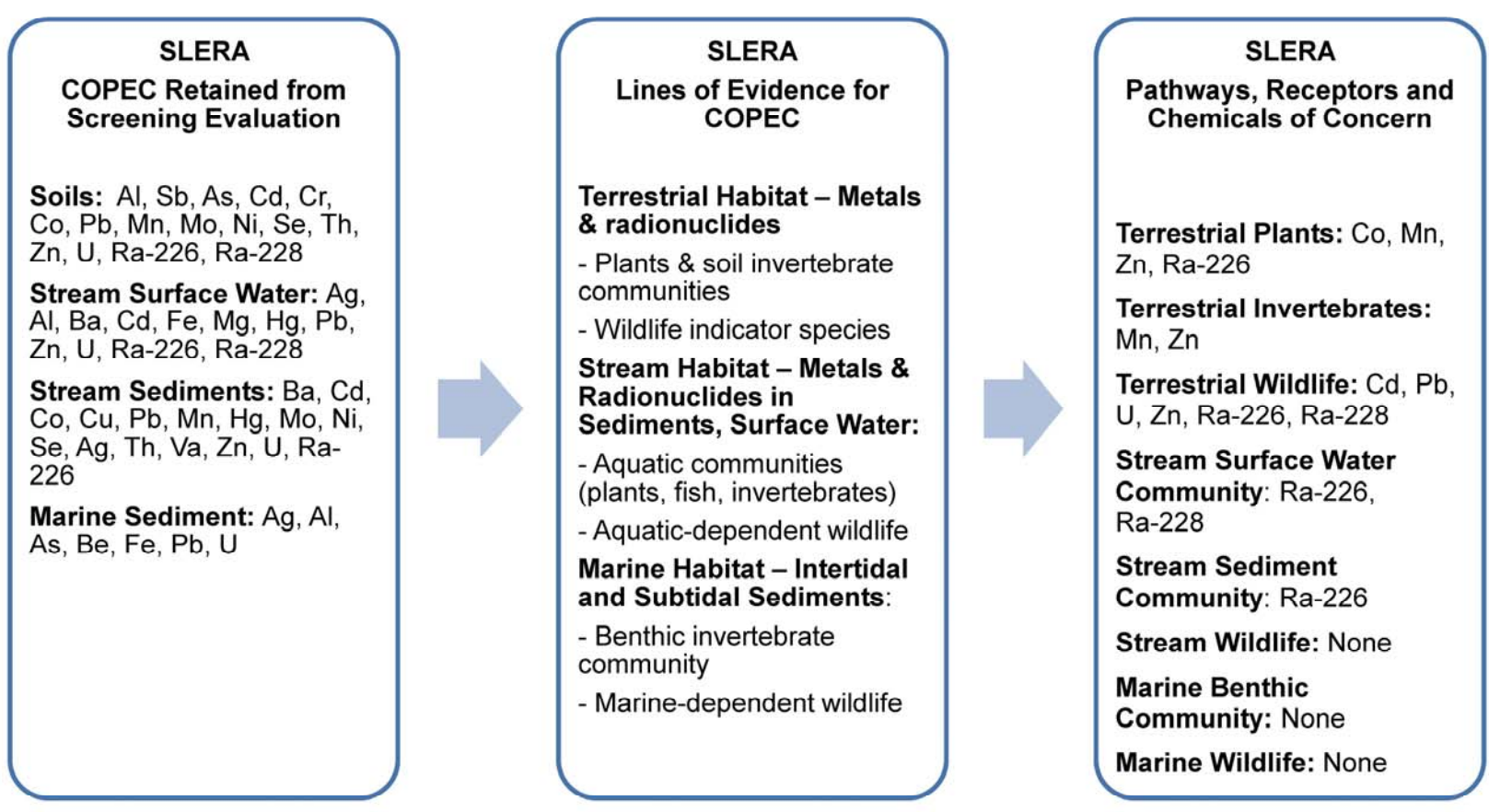
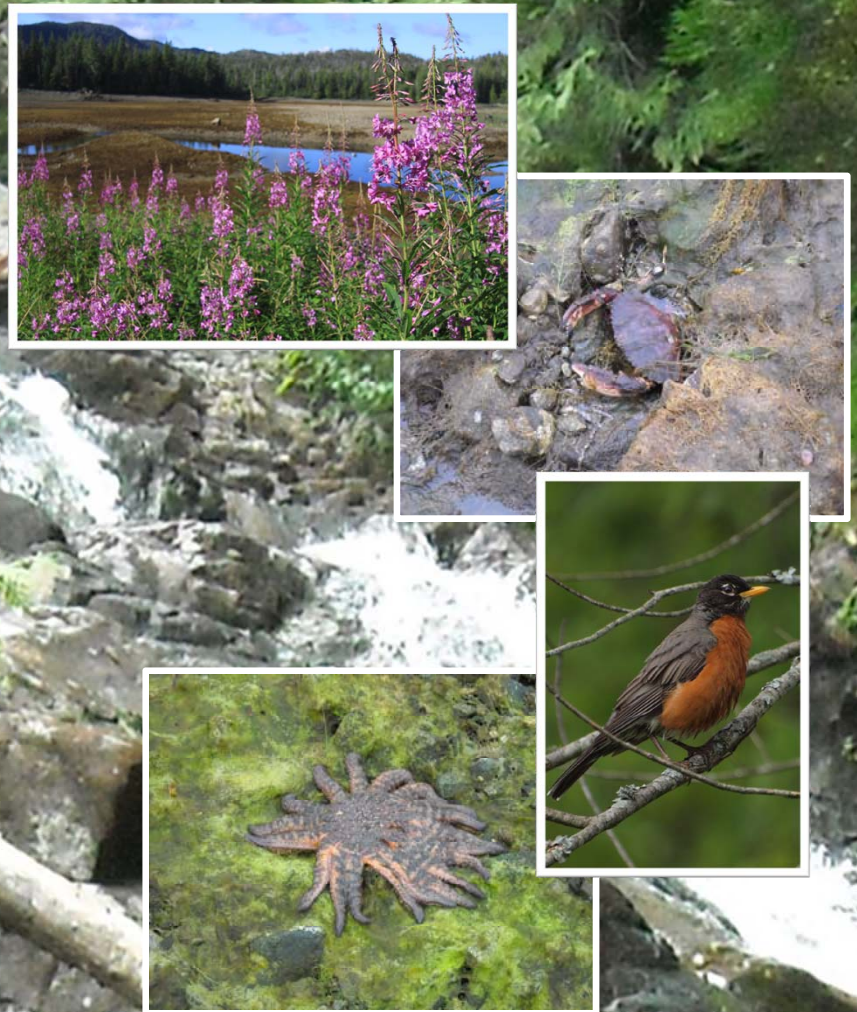
Risk levels for trace metals in stream surface water, stream sediment, and marine sediment were not significantly elevated for either the community receptors or indicator wildlife species in these habitats.

Risk levels for radionuclides (Ra-226, Ra-228) were elevated for terrestrial plants and for stream-dependent riparian wildlife. For terrestrial receptors, risks are highest at the upper elevations within the mineralized area, decreasing to lower values at lower elevations within the non-mineralized area. For riparian wildlife, radionuclide risks appear to be localized to elevated concentrations in a few sample locations 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 were developed for four trace metal-receptor pairs:

- Cadmium – Small mammals (masked shrew)
- Cobalt – Plants
- Lead – Birds (American robin)
- Zinc – Plants or soil invertebrates.

Ecological PRGs were not developed for radionuclides (Ra-226, Ra-228) because activity levels of these substances are highly correlated with gamma emissions and background gamma levels have been selected as the cleanup goal for non-mineralized areas.



# EE/CA Removal Action Alternatives

**Removal action alternatives for mine rock and mine portals were identified separately to allow flexibility in analyzing and recommending a combined removal action that best satisfies the removal action objectives. A number of technical options were infeasible and were not further considered.**

## Mine Rock Alternatives

### Common elements to all mine rock alternatives:

- Remove scattered ore rock from the loadout ramps within the intertidal zone and consolidation with other mine rock
- Off-site disposal and recycling of miscellaneous debris present at the Site (drums, vehicles, batteries, and metal and plastic debris)
- Develop access and staging areas, with removal of trees and vegetation within construction areas
- Establish stormwater and sediment/erosion control measures during construction activities
- Materials for cover construction and rock protection sourced on-site from Kendrick Creek delta, or other suitable borrow source
- Procedures to delineate, control and confirm excavation of mine rock and mine-affected materials
- Revegetate areas disturbed by construction
- Monitoring and maintenance (M&M) of the completed removal action.

**Alternative M-1 – No Action** – 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. The No Action alternative represents a baseline condition against which other removal action alternatives are compared.

**Alternative M-2 – In-Place Stabilization with Stormwater and Institutional Controls** – Regrade mine rock piles (300-Foot, 700-Foot and 900-Foot Levels) to stable slopes, stabilize mine rock adjacent to stream channels, and implement stormwater controls to minimize run-on to mine-affected areas. Establish institutional controls (land use and access restrictions) to reduce human exposure to mine-affected areas. Revegetate disturbed areas following construction. Estimated total cost: \$1.4 million.

**Alternative M-3 – In-Place Covering of Mine Rock Piles** – Regrade OSA and mine rock piles (300-Foot, 700-Foot and 900-Foot Levels) and place a two-foot thick cover. Excavate and cover select portions of the Haul Road and Mine Road, and remove the I&L Spur Road. Approximately 20,978 cubic yards of cover material required. Estimated total cost: \$4 million.



**900-Foot Level Mine Rock**

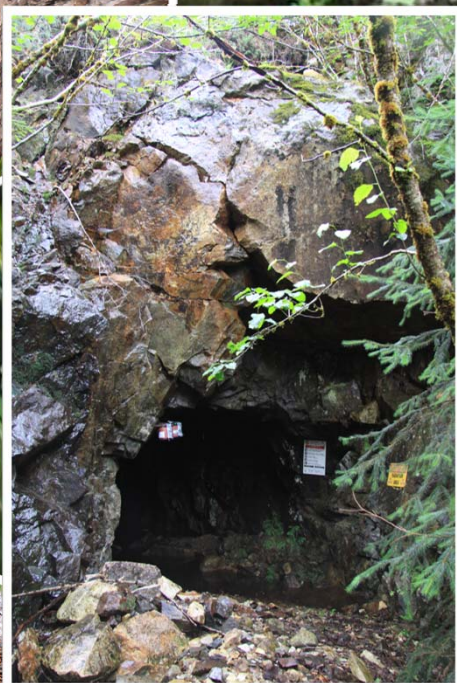
## Mine Rock Alternatives (continued)

**Alternative M-4 – Excavation, Consolidation and Cover at Mine Affected Areas** – Excavate OSA material and consolidate in the 300-Foot Level mine rock pile and place a two-foot cover. Excavate and consolidate the 700-Foot Level and 900-Foot Level mine rock piles into the Open Pit and place a two-foot thick cover over a synthetic geomembrane. Excavate the Mine Road, I&L Spur Road and identified sections of the Haul Road, and place in repositories. Close the Mine Road and the I&L Spur Road, and place fill in identified sections of the Haul Road. Approximately 12,531 cubic yards of cover material required. Estimated total cost: \$3.6 million.

**Alternative M-5 – Excavation, Consolidation and Cover at Open Pit Repository** – Excavate OSA material, all mine rock piles (300-Foot, 700-Foot and 900-Foot Levels), Mine Road, I&L Spur Road and identified sections of the Haul Road and consolidate into the Open Pit repository. Place a two-foot thick cover over a synthetic geomembrane over the consolidated materials in the Open Pit repository. Remove and close the Mine Road, I&L Spur Road and the Haul Road to the 300-Foot Level. Approximately 11,615 cubic yards of cover material required. Estimated total cost: \$6.4 million



**900-Foot Level Portal**



**700-Foot Level Portal**



**900-Foot Level Vent Shaft**



**Open Pit**

## Mine Portal Alternatives

### Common elements to all mine portal alternatives:

- Close the 900-Foot Level vent shaft to prevent air and water entry
- Close the 900-Foot Level portal to prevent air entry but allow water entry
- Close the 700-Foot Level portal to prevent air entry but allow water entry
- Develop access and staging areas
- Revegetate areas disturbed by construction

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.

**Alternative P-1 – No Action** – Portals would remain in their present condition, with no measures taken to reduce or monitor existing conditions. This No Action Alternative represents a baseline condition against which other portal removal actions are compared.

**Alternative P-2 – Close Upper Mine Openings with 300-Foot Level Portal Gate** – Install gate at the 300-Foot Level portal to prevent human access but allow animal access and water outflow from the mine workings. Implement institutional controls to restrict physical access, such as signage and physical barriers. Estimated total cost: \$724,000.

**Alternative P-3 – Close Upper Mine Openings with 300-Foot Level Portal Rock Backfill Closure** – Backfill 300-Foot Level portal with rock to prevent human and animal access but allow water outflow from the mine workings. Construct outflow structure to pipe drainage to Kendrick Creek. Establish institutional controls to restrict physical access, such as signage and physical barriers. Estimated total cost: \$813,000.

**Alternative P-4 – Close Upper Mine Openings and 300-Foot Level Portal Concrete Bulkhead** – Install concrete bulkhead at 300-Foot Level portal to eliminate air outflow and radon exhalation, and to prevent human and animal access. Construct outflow structure to pipe water drainage to Kendrick Creek. Establish institutional controls to restrict physical access, such as signage and physical barriers. Estimated total cost: \$864,000.

# Mine Rock Alternative M-5 and Mine Portal Alternate P-4 Recommended as Preferred Removal Action in EE/CA

Forest Service will select the Removal Action, in collaboration with the State and EPA, after considering community input

## EE/CA evaluates removal action alternatives against three main criteria:

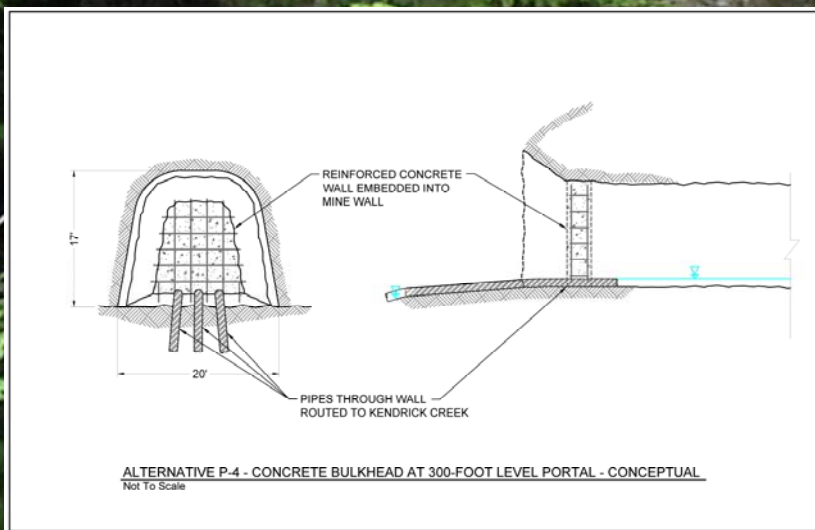
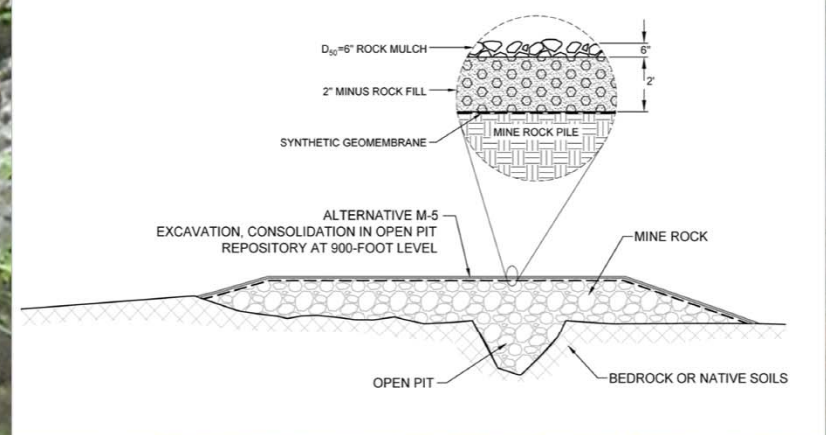
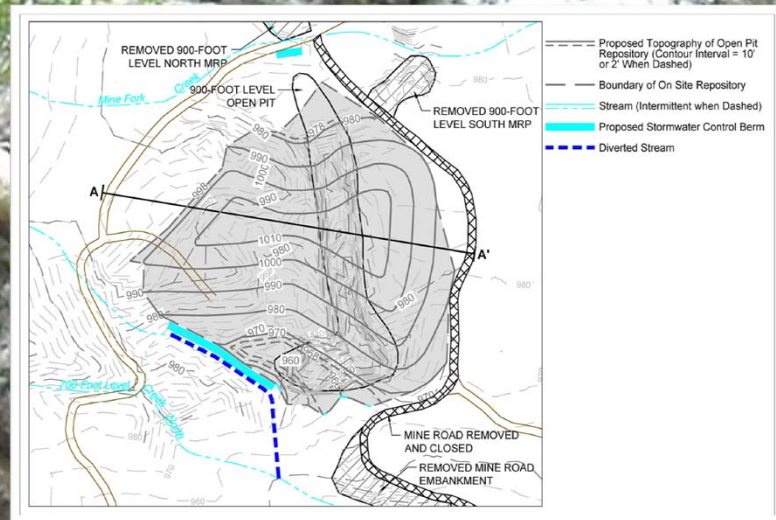
- Effectiveness
- Implementability
- Cost

EE/CA provides comparative analysis using the three evaluation criteria to assess the relative advantages and disadvantages of the removal action alternatives.

Mine Rock Alternative M-5 and Mine Portal Alternate P-4 best satisfies the evaluation criteria.

## Mine Rock Alternative M-5 is the recommended removal action:

- Effective in 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;
- 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;
- Removing the more easily accessible OSA materials near the shoreline of the West Arm of Kendrick Bay will significantly reduce human health exposures to gamma radiation and radon for site visitors and occupational workers;
- Eliminates potential concerns with the long-term geotechnical and erosional stability and permanence of the 300-Foot Level mine rock pile;
- Returns 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 longterm mine rock containment and cover stability;
- Reduces 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;
- 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 reduces human access to the 300-Foot and 700-Foot Levels;
- Requires 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;
- Reduces the inflow of water into the underground mine via the 900-Foot Level portal; thereby reducing drainage from the 300-Foot Level portal.



## Mine Portal Alternative P-4 is the recommended removal action:

- Significantly reduces 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;
- 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;
- Reduces 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;
- Eliminates the potential for water drainage from the 700-Foot Level portal.

Total estimated combined cost of Mine Rock Alternative M-5 and Portal Alternative P-4 is \$7,237,000. Costs are based upon conceptual level design of alternatives for comparative purposes.

## Two construction seasons likely required to complete removal action:

- Depending on the construction force, availability of personnel and equipment;
- Logistical challenges associated with Site access and sequencing of multiple construction activities;
- Removing mine materials and rehabilitation of the existing haul and mine roads;
- Excavating, transporting and consolidating mine rock;
- Transporting and placing cover materials;
- Closing haul and mine roads.