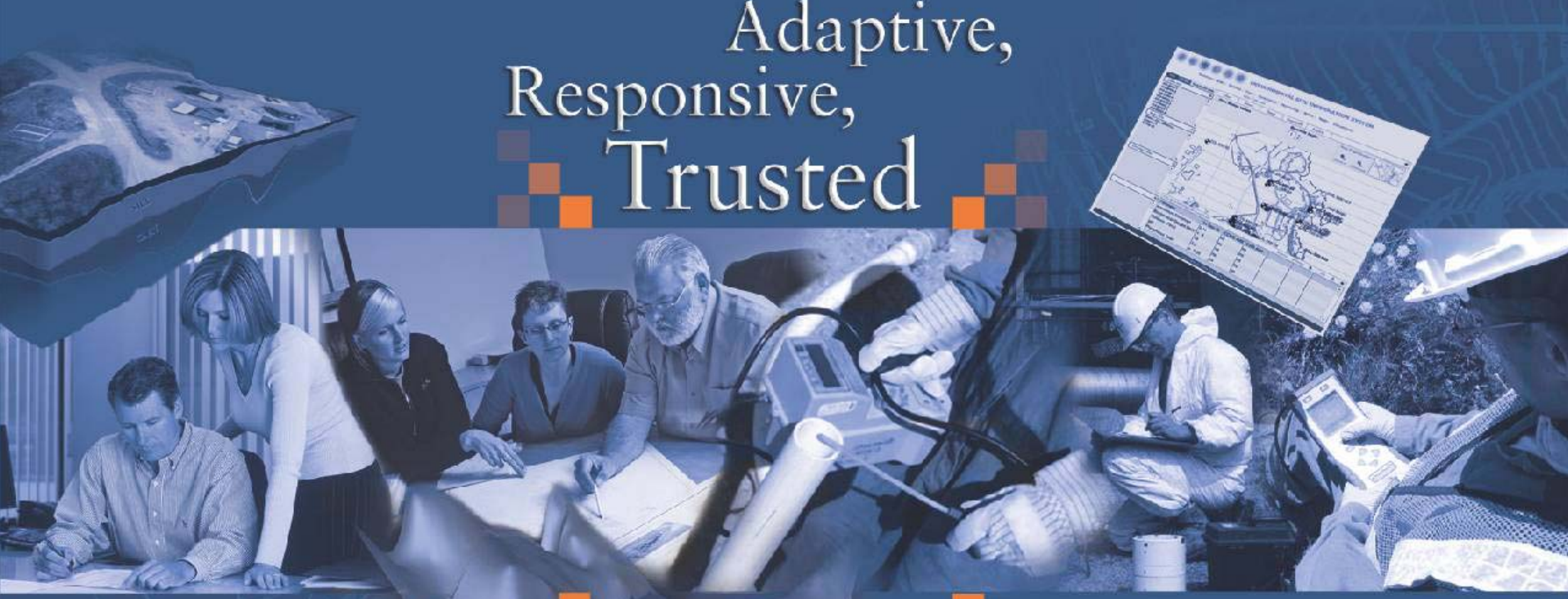

Remediation of a Coal Waste Pile in Union Bay, BC

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Remediation of a Coal Waste Pile in Union Bay, BC

Tara Siemens, MET and Ian Mitchell, MSc, PGeo

SEACOR Environmental Inc.

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Outline

- Site Description and History
- Environmental Investigations
- Problem Formulation/Screening RA
- Remedial Plan

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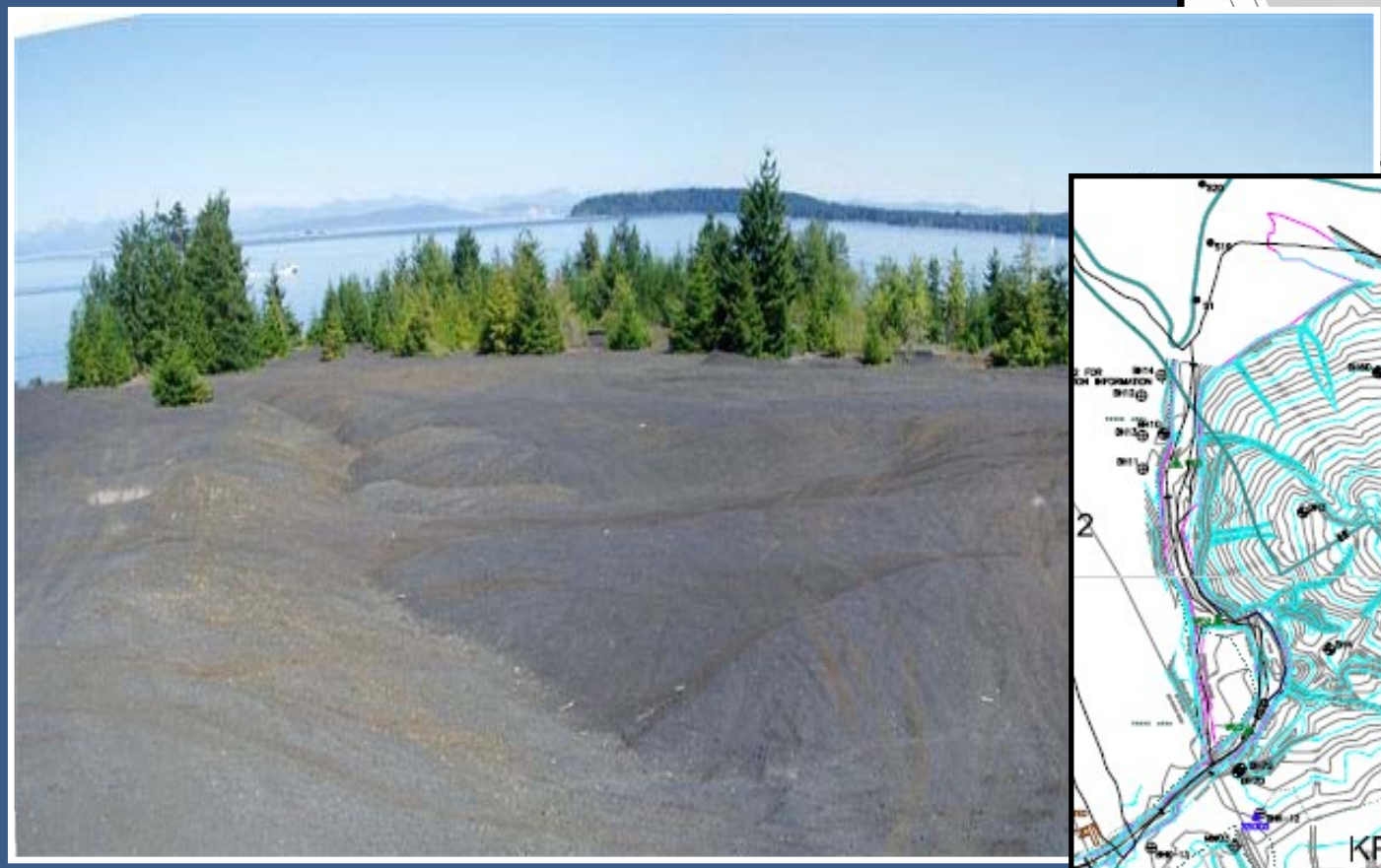
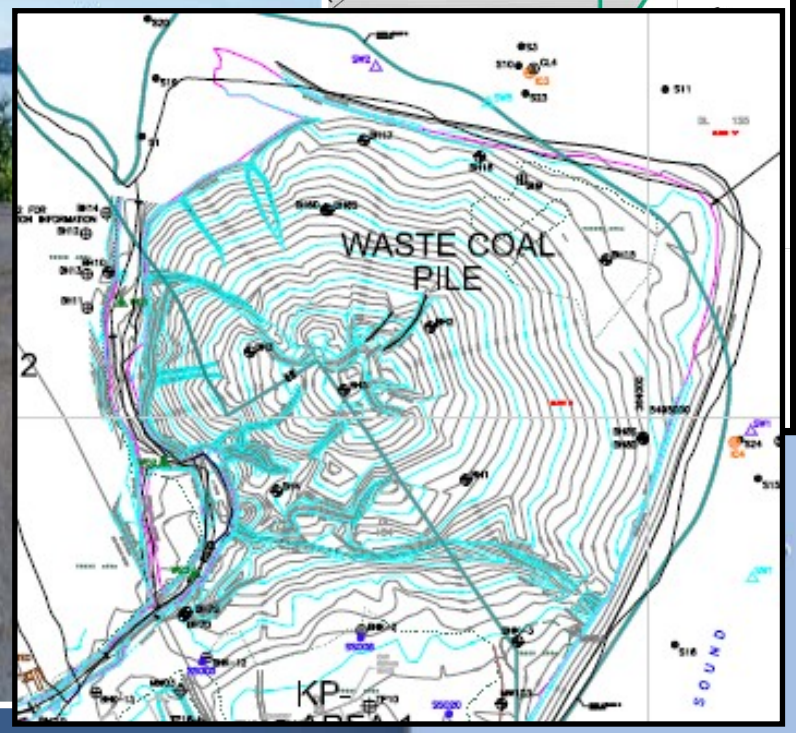
Site Description

- 13 ha waste coal pile in Union Bay, BC





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Site Description

- 13 ha waste coal pile in Union Bay, BC
- Bounded to north and east by Pacific Ocean

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Site Description

- 13 ha waste coal pile in Union Bay, BC
- Bounded to north and east by Pacific Ocean
- Bounded to west by Hart Creek

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Site Description

- 13 ha waste coal pile in Union Bay, BC
- Bounded to north and east by Pacific Ocean
- Bounded to west by Hart Creek
- Future land use: residential/parkland

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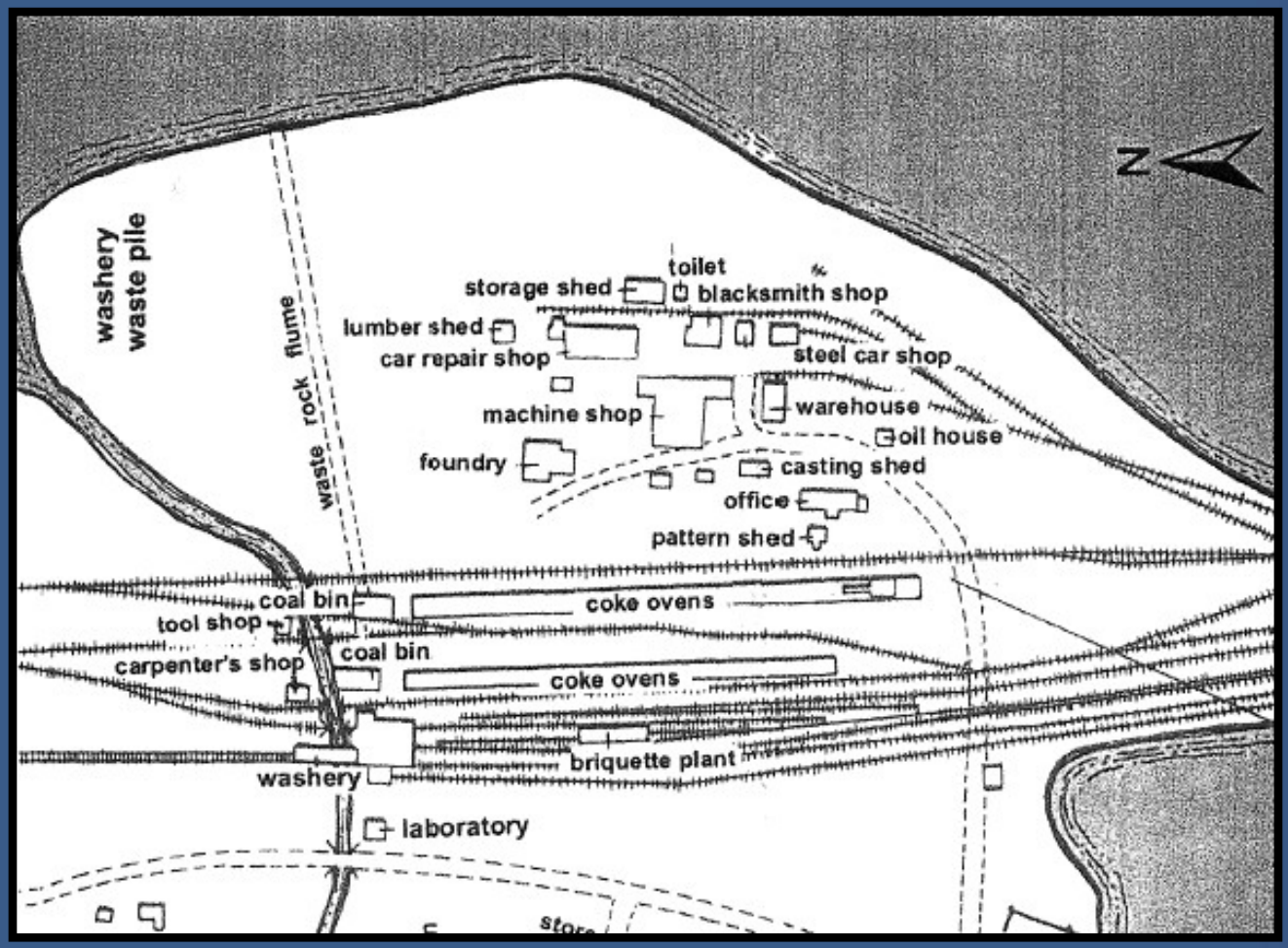
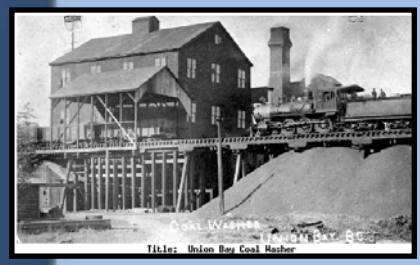
Site History

- Coal Processing Facility
- 1888 to ~ 1960





Historical photographs from BC Archive at www.bcarchives.gov.bc.ca.

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Site History

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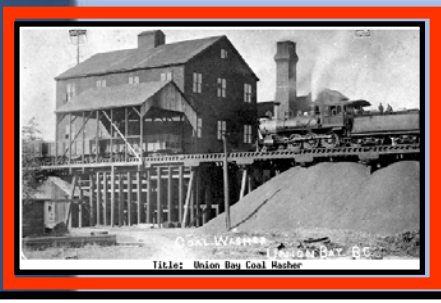

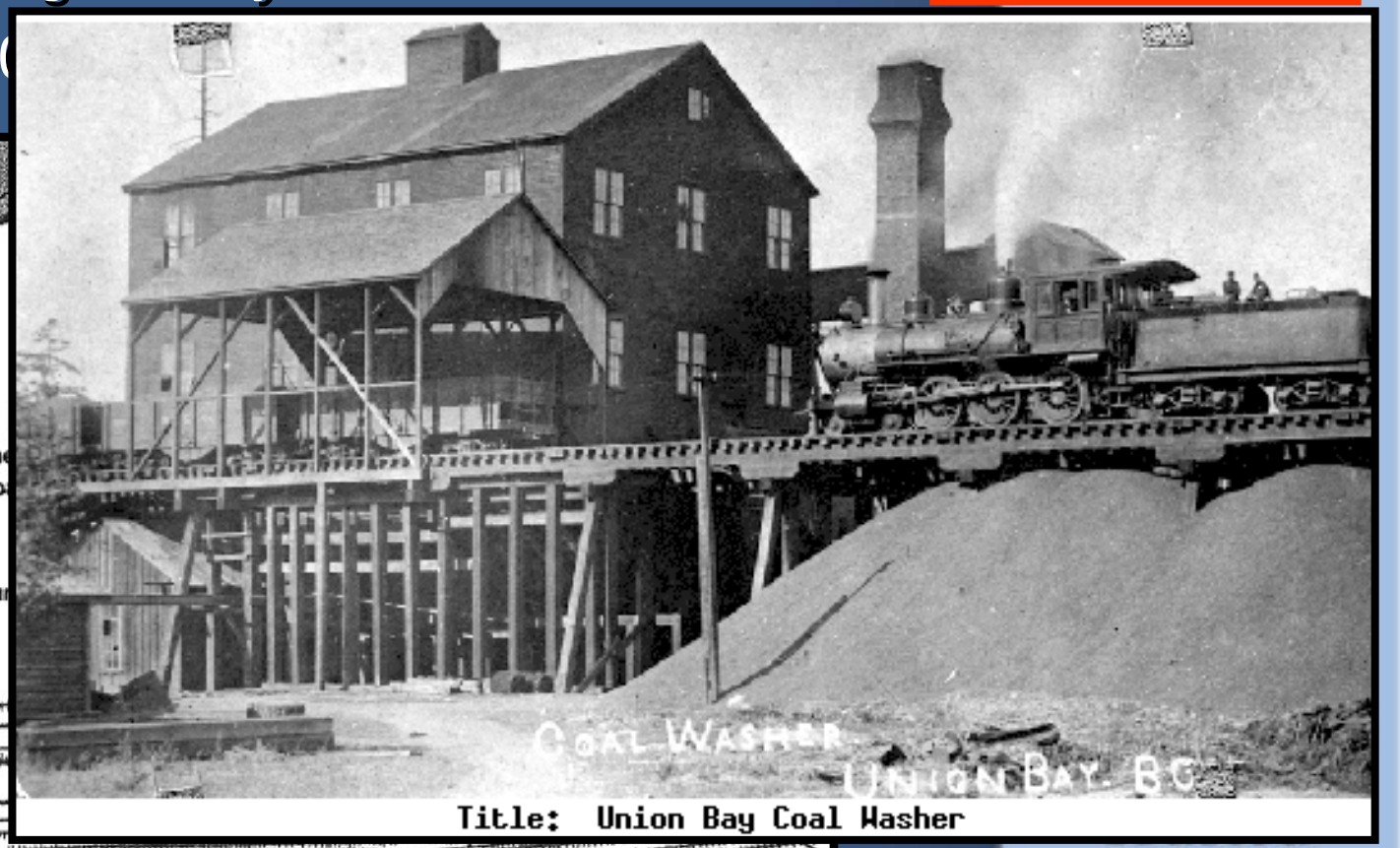

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Site History

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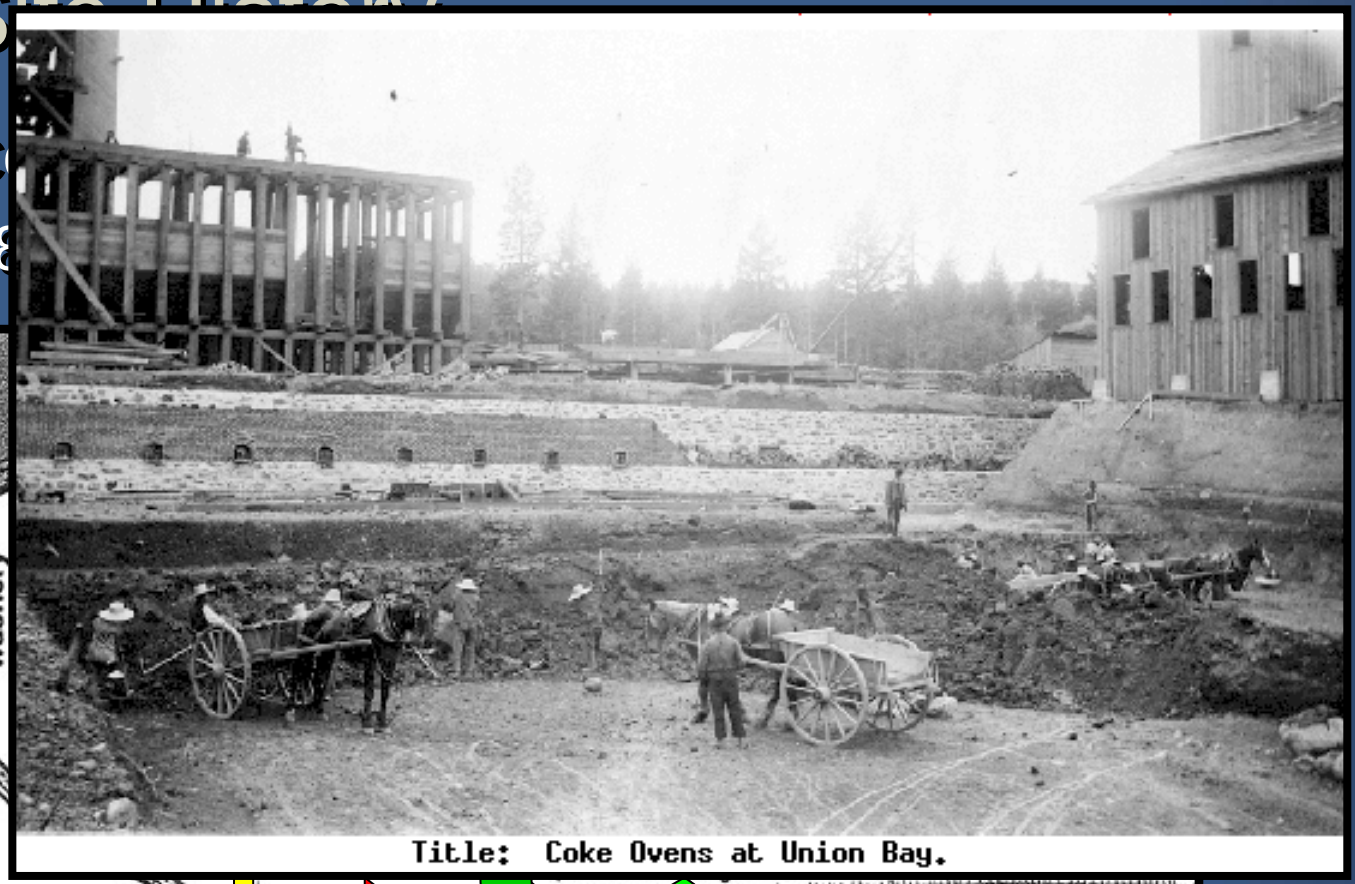
- 18



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Site History

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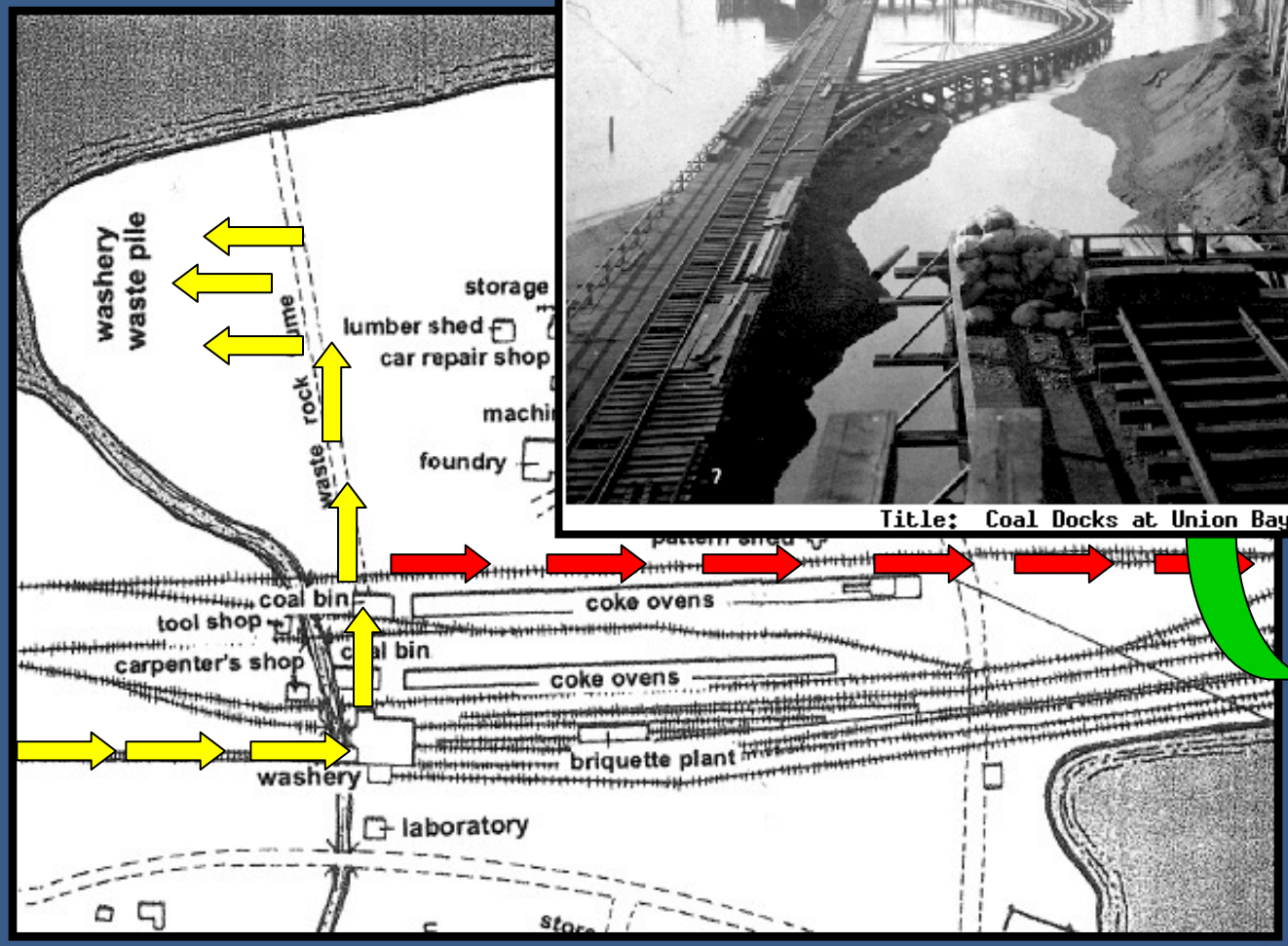
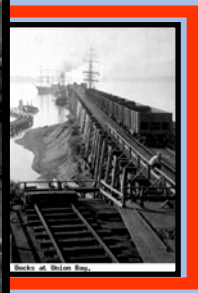
- 1888 to ~ 1960




Title: Coal Docks at Union Bay.



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Environmental Investigations

- Waste Coal Pile and adjacent properties, Baynes Sound and Hart Creek
- Samples of waste coal, native soil, groundwater, sediment and surface water analysed for PCOCs
- PCOCs include metals, PAHs, sulphate
- ABA, kinetic testing and other geochemical parameters

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Waste Coal Pile - Results

- Waste Coal: arsenic, copper, naphthalene and phenanthrene > standards
- Native soils < standards
- Groundwater: cadmium,cobalt, copper, nickel, zinc and sulphate > standards for aquatic life; PAHs < standards

Hart Creek - Results

- Surface Water < criteria
- Sediment: PAHs and metals > criteria in 1 sample

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Baynes Sound - Results

- Waste coal present to > 30 m offshore
- Iron staining present in sediments north and east of coal pile in areas of groundwater discharge
- Sediment: PAHs and metals > criteria
  - 9 PAHs
  - Arsenic, copper and mercury
- Seep water: Metals > criteria
  - Aluminum, cadmium, cobalt, iron, manganese, nickel and zinc
  - ~ 10x's dilution of groundwater occurring during discharge to environment

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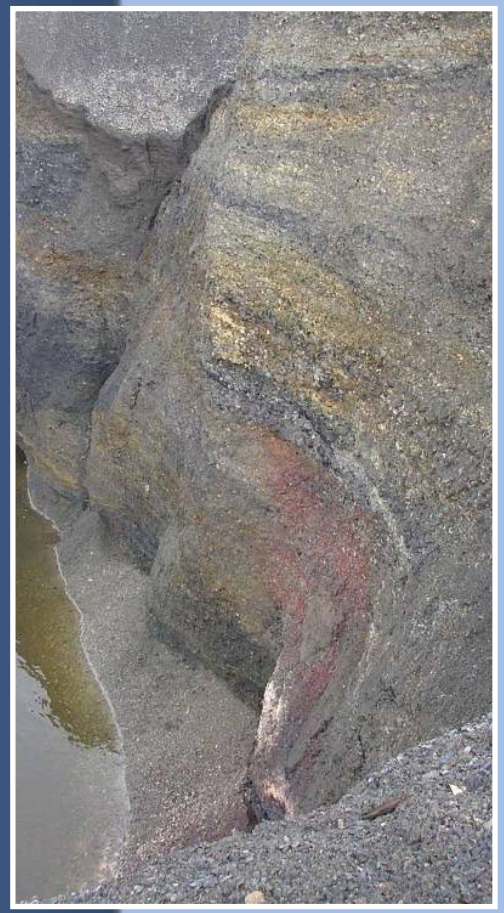
Geochemistry



- Geochemical characterization conducted by SRK Consulting (Canada) Inc.
- Static and kinetic testing conducted
- Testing indicated that all material is potentially acid generating or is already acidic
- Geochemical Profile
  - Sulphide sulphur present throughout
  - Accumulation of sulphate within top 2 m
  - Increasing pH and NP with depth
- Under existing conditions, acidification expected to continue for decades to a century

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Detailed Hydrogeology Assessment

- Review of climate data
- Infiltration tests at pile surface
- Hydraulic conductivity tests at base of pile
- Analysis of tidal effects
- Physicochemical groundwater monitoring
- Assessment of groundwater flow
- Evaluation of pile water balance

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Infiltration Test Results

- Infiltration rate at 20cm depth is 5x greater than infiltration rate at typical surface locations
- Infiltration rate at typical surface locations is 10x greater than highly compacted surface areas

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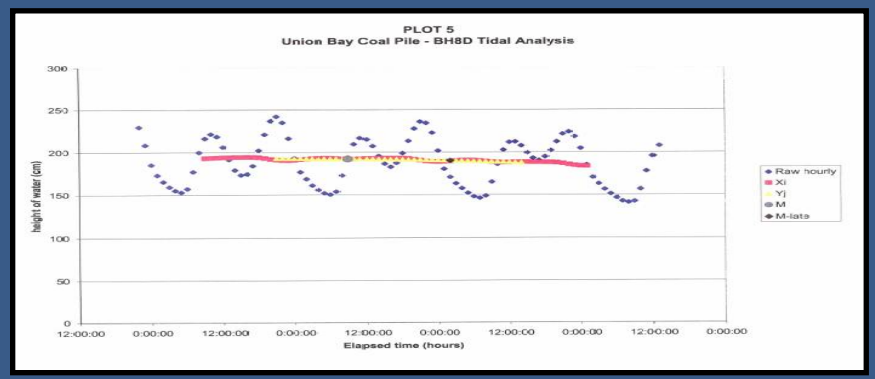
Tidal Analysis

- Tidally induced groundwater fluctuations 1.5m adjacent to foreshore; absent 400 metres inland
- Intrusion of saline groundwater observed to 75m inland
- Upgradient third of pile not exposed to tidal flushing



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Summary of Groundwater Flow

- Estimated groundwater velocity in coal waste is 100-150 m/yr
- Estimated groundwater velocity in underlying native soil is 15-25 m/yr
- Net groundwater flow direction is towards the ocean

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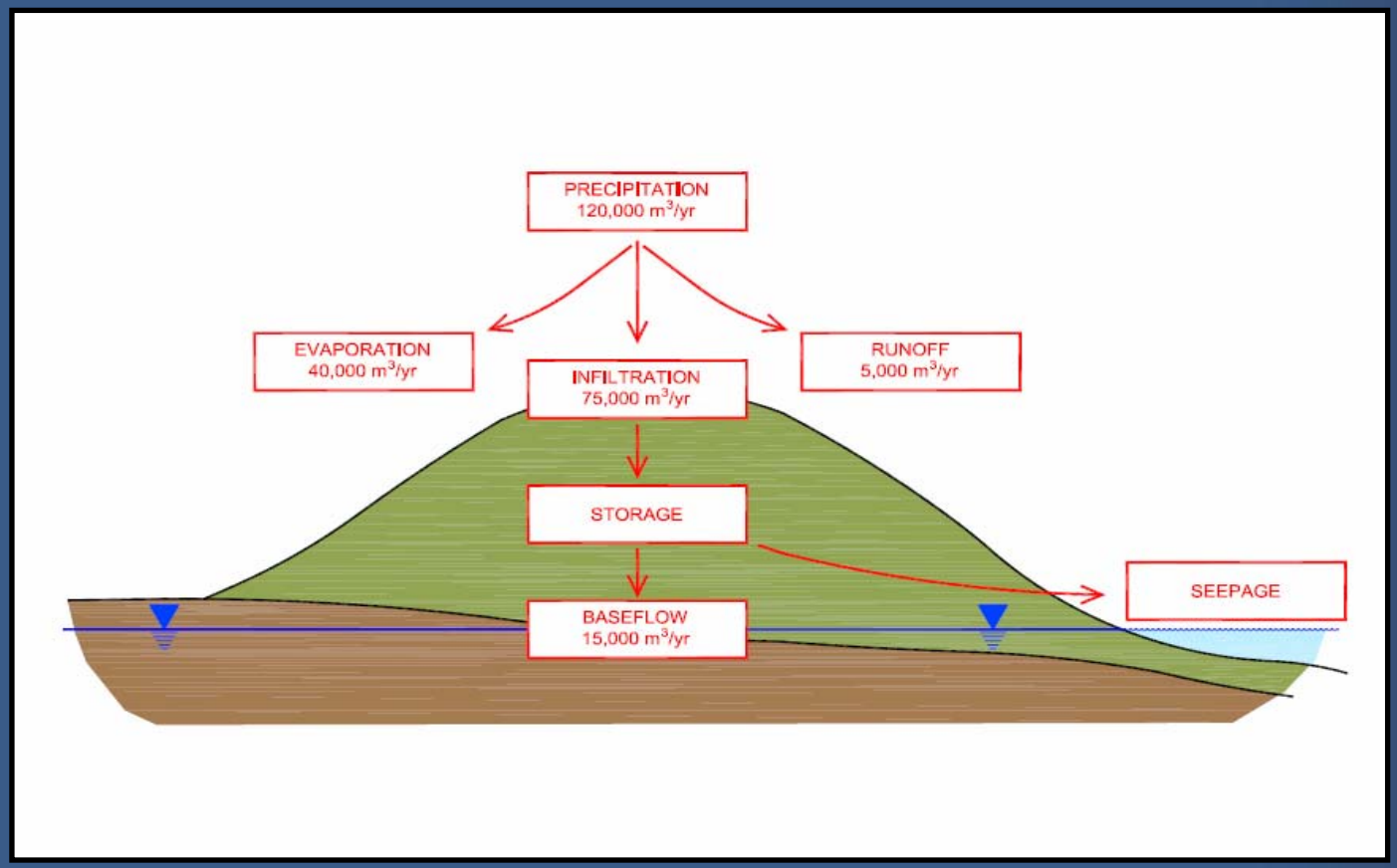
Water Balance



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Important Conclusions

- Upgradient third of pile unsaturated at the base
- Upgradient side of pile not recharged by Hart Creek
- Contrast in conductivity promotes seepage along interface at base of pile
- Baseflow flushing through pile is relatively small component of overall discharge

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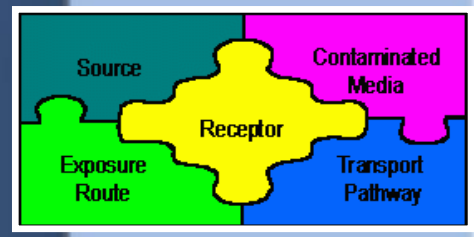
Problem Formulation/SLRA



- Based on pre-remediation conditions; comprehensive RA to be conducted post remediation
- Chemicals of Potential Concern for RA = parameters in different media > applicable standards/criteria

Human Health SLRA

- Non-cancer and cancer risks to Site users < 1E+00 and 1E-05
- Risks to seafood consumers <1E+00 and 1E-05

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Problem Formulation/SLRA

Ecological RA

- Marine species identified as primary receptors of concern
- Primary assessment endpoints for Eco RA:
  - Bioassays for benthic and pelagic species
  - Species composition and habitat quality
- Preliminary evaluation of endpoints conducted

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Problem Formulation/SLRA

Ecological RA (cont.)

- Sediment bioassays:
  - for amphipod (*E. estuarius)* and polycheate (*N. arenaceodentata)*
  - one sample of six toxic to polychaete
- Groundwater and seep water bioassays:
  - for topsmelt (*A. affinis*), sand dollar gametes (*D. excentricus*) and oyster spat (*C. gigas*)
  - Preliminary results indicate lethality at 6%
- Abundant flora and fauna present in intertidal and subtidal, including extensive eel grass bed

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Risk-Based Groundwater Remedial Targets

- Site-specific groundwater remedial targets currently being derived
  - Based on results of toxicity testing and literature review
  - Final remedial design will be based on groundwater remedial targets

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Remediation Plan

- Waste coal subdivided into 4 different zones:
  - Main pile (focus of presentation)
  - Hart Creek deposit
  - Tidal Zone deposit
  - Submarine deposit

Distinct characteristics indicate that different remedial strategies required for each zone

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Remediation of Main Pile Primary Considerations

- Technical feasibility
- Cost and associated risks
- Potential for economic benefits
- Preference given to alternatives that provide a more permanent solution

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Remediation of Main Pile Important Factors

- Pile forms a distinctly convex dome
- Coarse waste material results in a net downward flux of water
- Steep side slopes may destabilize over time as pile acidifies and cementation degrades
- Data indicates that direct revegetation is unlikely sustainable

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Contaminant Release Mechanisms

- Wind Dispersion of the waste coal solids
- Leaching of metals by infiltrating water and runoff
- Leaching of metals by tidal effects
- Shore erosion by wave action in tidal and subtidal zone
- Erosion by stream flow in Hart Creek

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Potential Control Measures to Reduce Metal Loadings

- Alkaline amendment to offset excess acid potential
- Measures to control oxygen ingress to the pile
- Reduction or elimination of infiltration of water

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Primary Remedial Objectives

- Minimize potential release of contaminants by wind blown dust
- Minimize release of soluble oxidation products to groundwater
- Restore coal pile to land use suitable for residential/urban park

Based on the above, the selected remedial alternative is a physical cover/cap

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Cover Design Considerations

- Climatic water balance for the pile is net positive
- Main risk to low permeability cover is dessication due to wet/dry cycles
- Regrading of steep slopes required
- Special design considerations for contact areas with roadways, foundations

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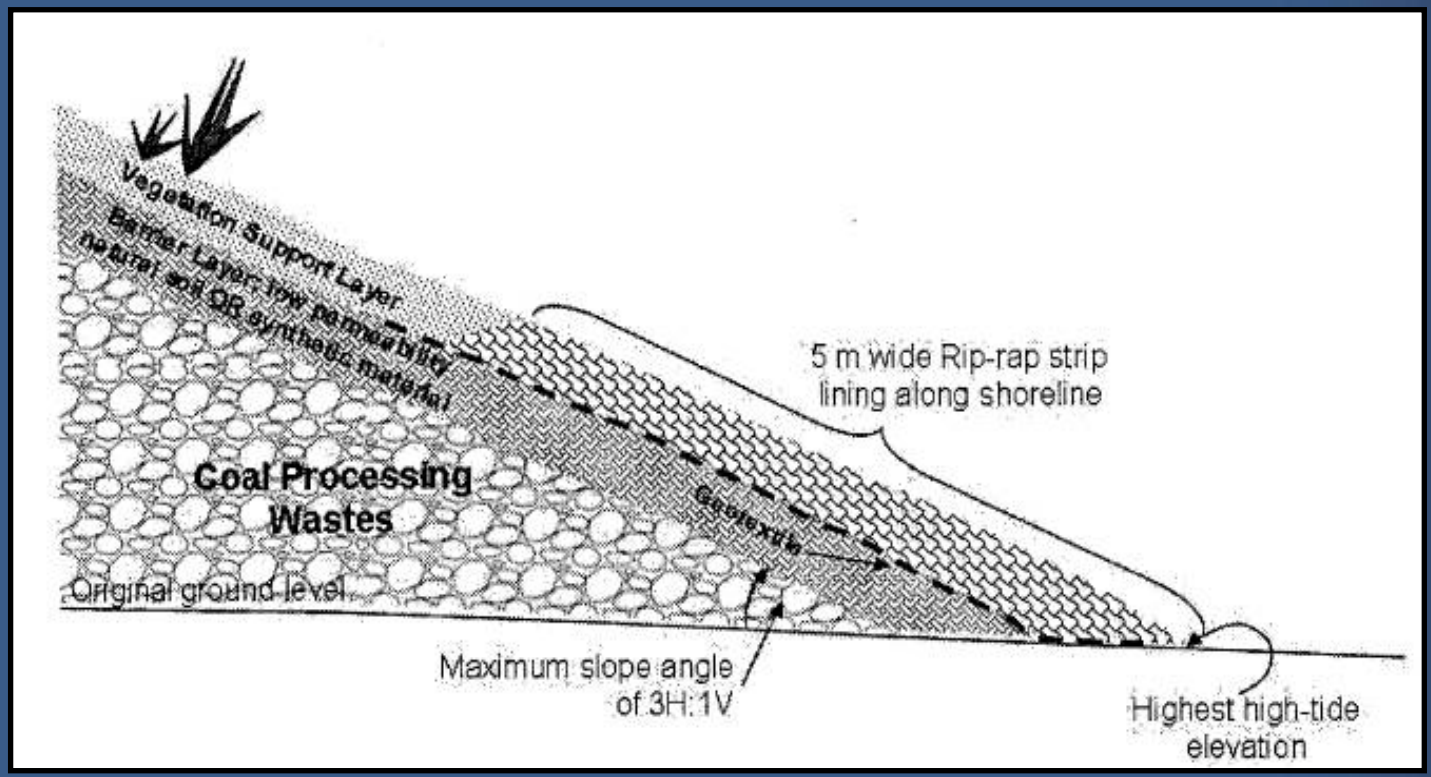
Cover Design Considerations

- Management of runoff to control erosion
- Shoreline protection measures



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Preferred Cover Design Alternatives

- Natural soil low permeability barrier cover
- Synthetic barrier cover using HDPE/Bituminous liner
- Synthetic barrier cover using GCL
- Store and release cover

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Cover Design Uncertainties

- Availability of suitable low permeability soil
- Availability of vegetation substrate
- Final adopted remediation design life
- Final adopted land use
- Overall cost effectiveness
- Risk based groundwater remedial target

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Path Forward

- Upper reaches of Hart Creek rechannelled in Sept 2005
- Risk based targets for groundwater currently being derived
- Slope regrading and capping of pile slated for summer 2006

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