Case Studies in ARD Management and Mine Closure

Rio Tinto US Sites

Rich Borden and Vicky Peacey

Rio Tinto

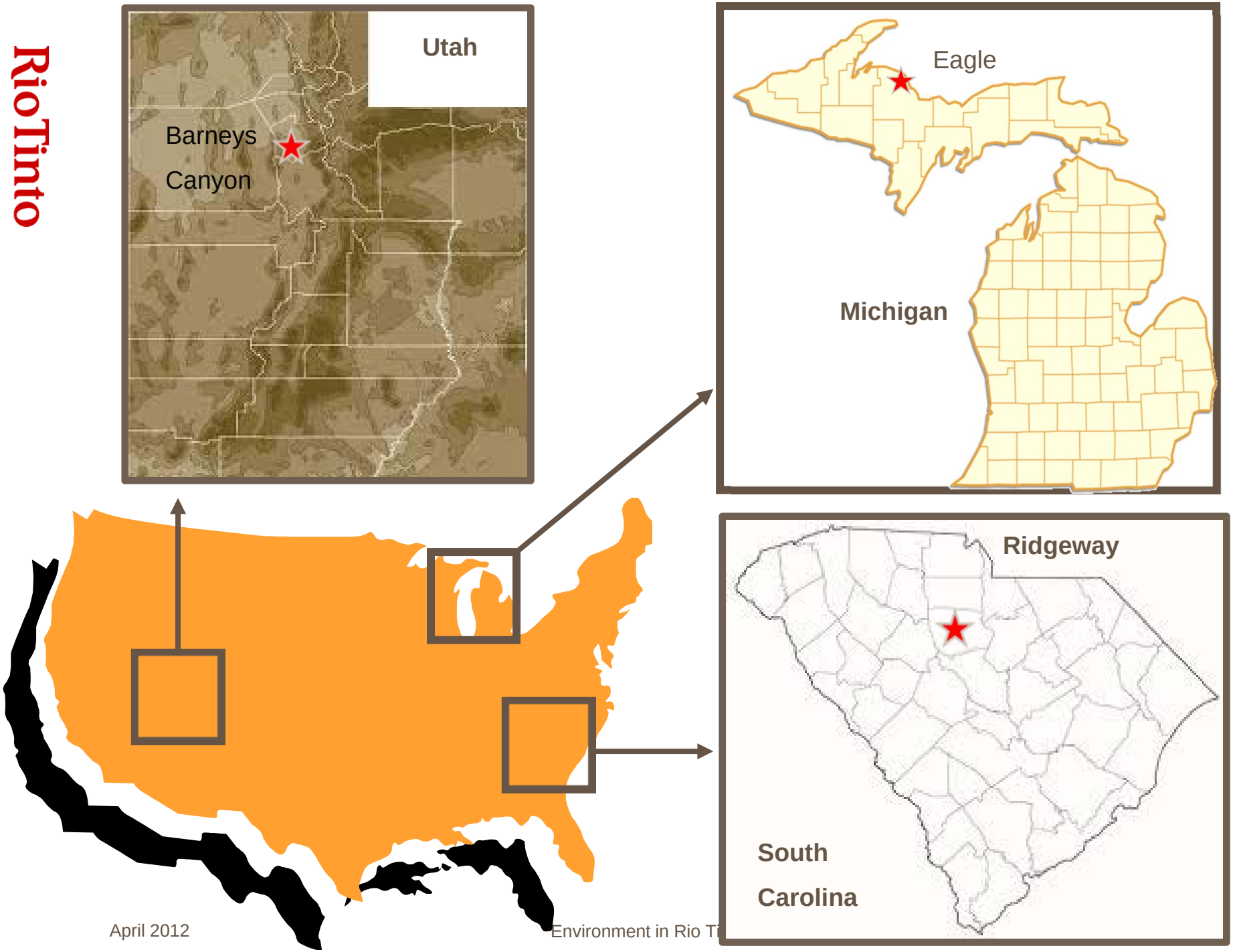
Proactive ARD Management for Mine Closure

- Proactive ARD management should seek to eliminate or a least reduce long term water treatment liabilities before they are created.

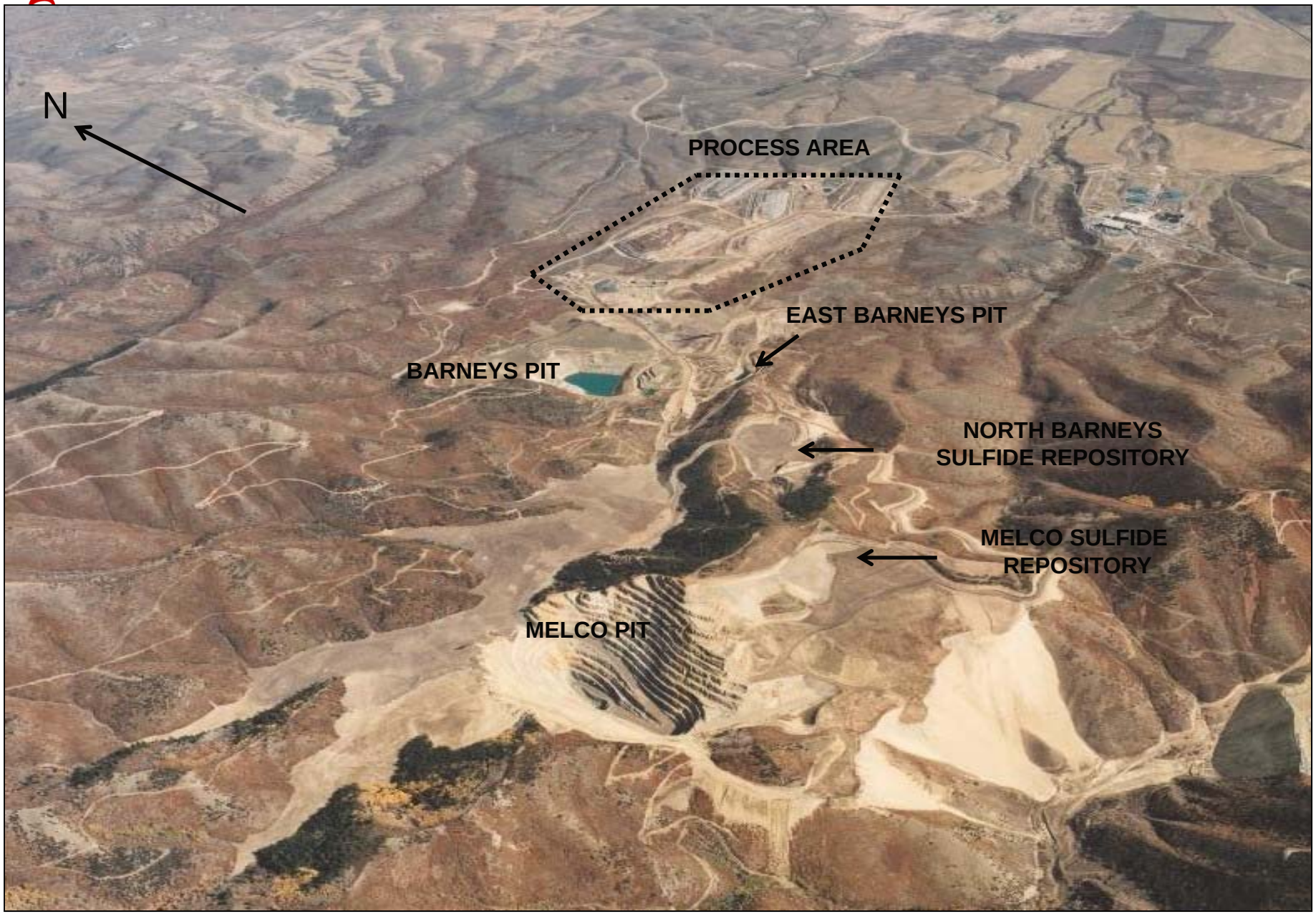
- Mine plans should focus on the strategic management of different mine materials to create sustainable landforms which are able to support beneficial post-mining uses

ARD Management Strategies used / considered at Rio Tinto Mines and Projects

PROACTIVE	REACTIVE
Mine Plan Optimization (selective mining)	Waste Removal and Consolidation
Selective Waste Placement and Salvage of Growth Media	Recontouring and Engineering to Promote non-Erosive Runoff
Up-Gradient Water Diversion	Direct Revegetation
Selective Handling and Encapsulation	General Purpose and Alkaline Covers
In Pit or Underground Disposal	Infiltration or Oxygen Limiting Covers (can be Proactive if placed on unoxidized material)
Subaqueous Disposal	Flooding post placement
Sulfide Flotation	Hydrogeologic containment
Liners	In-Pit Water Treatment
Temporary Synthetic Covers	Collection and Treatment of Contact Water (during operations and if needed after closure)


Utah
Barneys
Canyon
Eagle
Michigan
Ridgeway
South
Carolina

Barneys Canyon Gold Mine



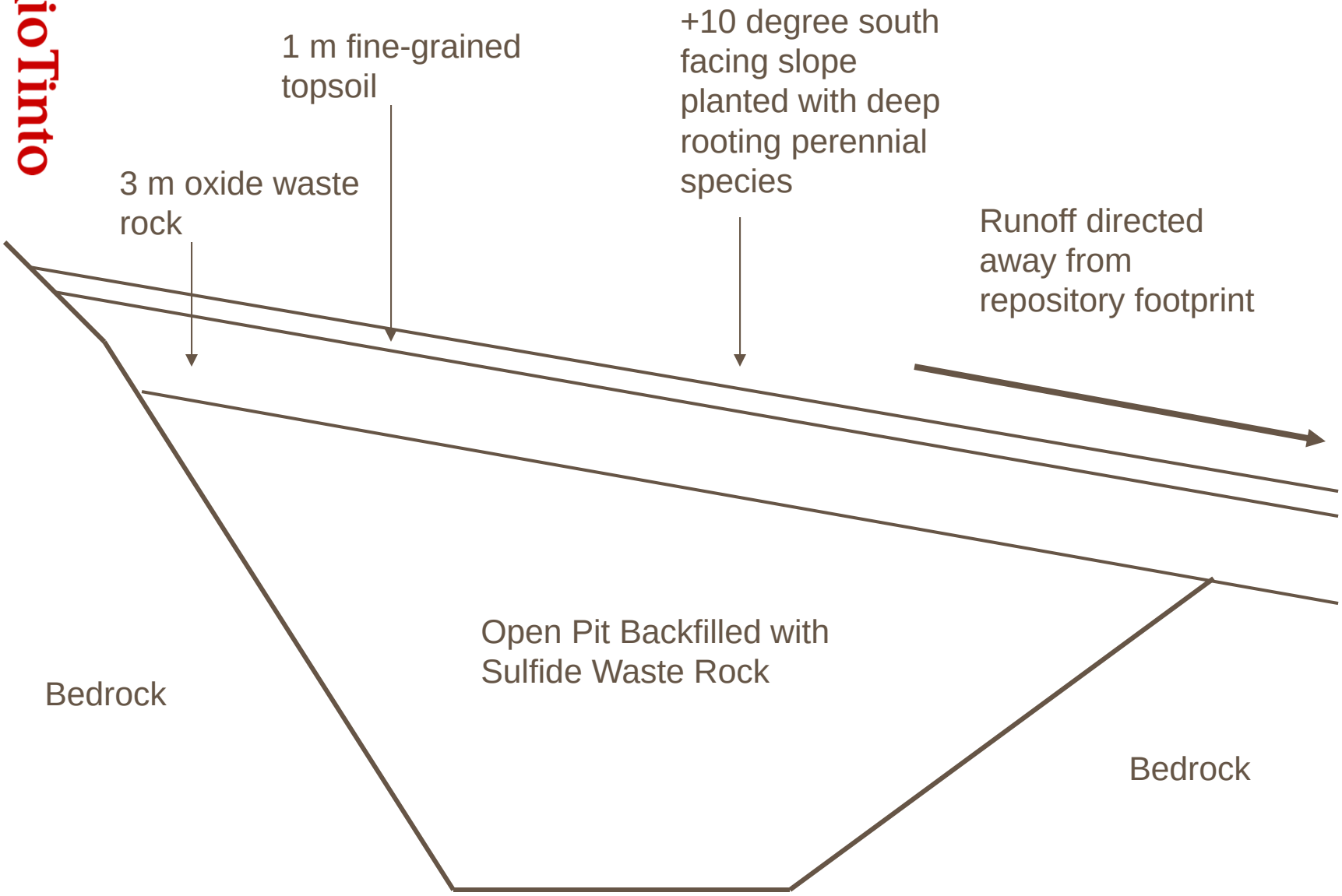
Waste Rock Segregation

- Visual classification of the waste
- Sampling confirmed that mean sulfur concentrations increased from 0.3% to 1.3% on average immediately across the color transition
- Designation was made by trained loader operators

Closure of Oxide Waste Rock Dumps

RioTinto

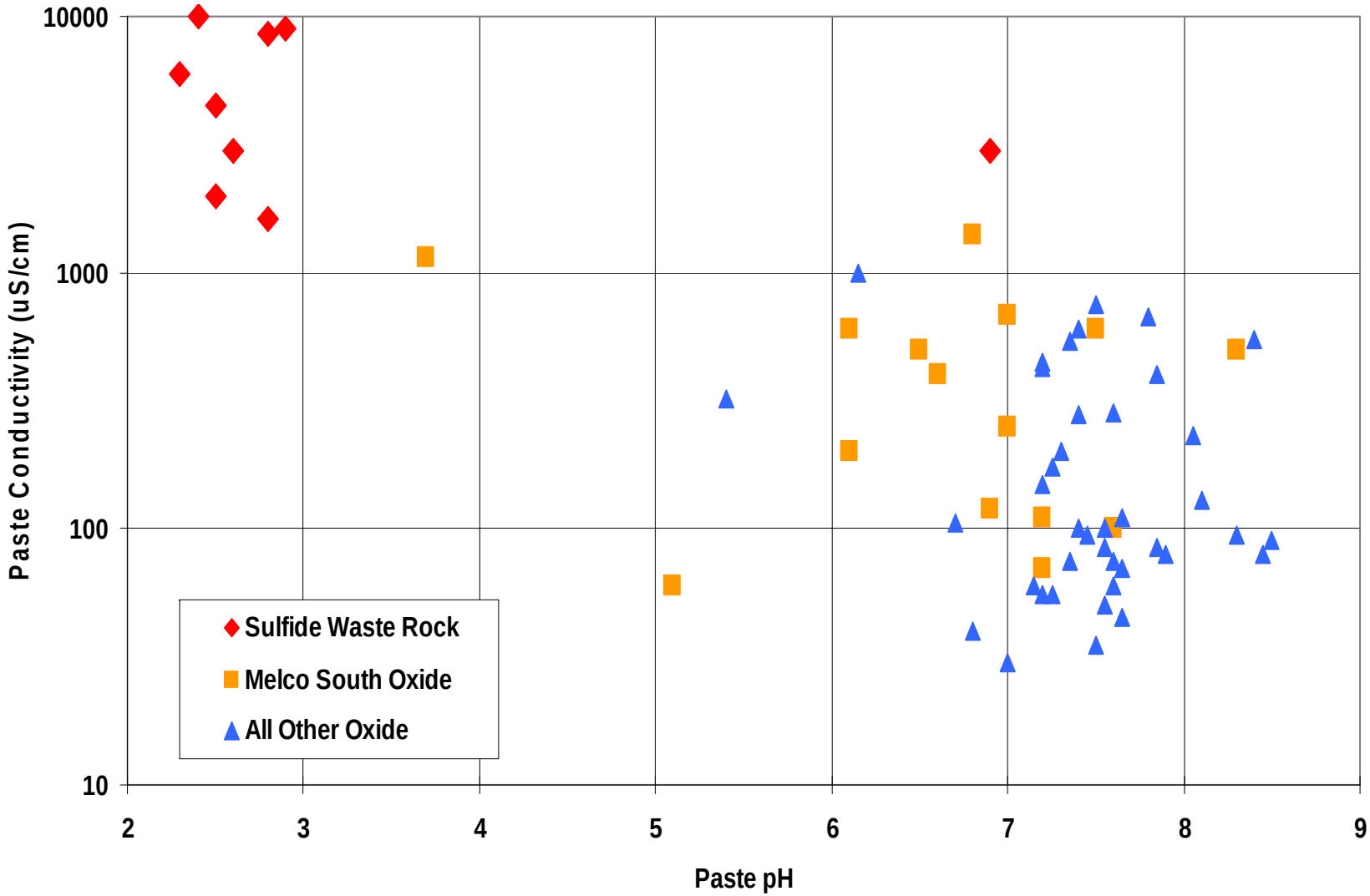
Barneys Canyon Sulfide Repository



NBCS Sulfide Repository (open pit)

Melco Sulfide Repository

Paste pH and Conductivity in 1999 (Before Dump Recontouring and Capping)



Alluvial Groundwater Down Gradient of Waste Rock and Repository (Since 2004)

- Mean pH – 7.4
- Mean Alkalinity – 320
- Mean TDS - 720
- Mean Sulfate – 140
- All Metals below USEPA water quality criteria for aquatic ecosystems and livestock guidelines

Closure of Barneys Open Pits

- **NBCS Pit** – Backfilled with sulfide waste rock and covered
- **SBCS Pit** – Backfilled with oxide waste rock
- **Melco Pit** – No water accumulation in pit
  - Above water table and no significant surface inflow into pit
- **East Barneys Pit (Flooding)**
  - Pit Lake pH = 7.9, alkalinity = 250 mg/L, TDS = 620 mg/L, sulfate = 130 mg/L, all metals below USEPA acute and chronic water quality for aquatic ecosystems and stockwater guidelines
- **Barneys Pit (Flooding)**
  - Pit Lake pH = 7.9, alkalinity = 190 mg/L, TDS = 410 mg/L, sulfate = 110 mg/L, all metals below USEPA acute and chronic water quality criteria for aquatic ecosystems and stockwater guidelines

Ridgeway Gold Mine

Ridgeway Gold Mine Mineral Waste Management

- Decision was made after several years of mining to segregate all waste rock with >0.5% sulfur
- Strategy to maintain acid generating tailings under saturation with an engineered cover using materials mined at LOM
- Used the Tailings and Open Pits to manage sulfide bearing waste rock
- Flooding and saturation of acid generating waste rock, tailings and sulfides on pit walls

Ridgeway Gold Mine Mineral Waste Management: Tailings

Ridgeway Gold Mine Mineral Waste Management: Open Pits

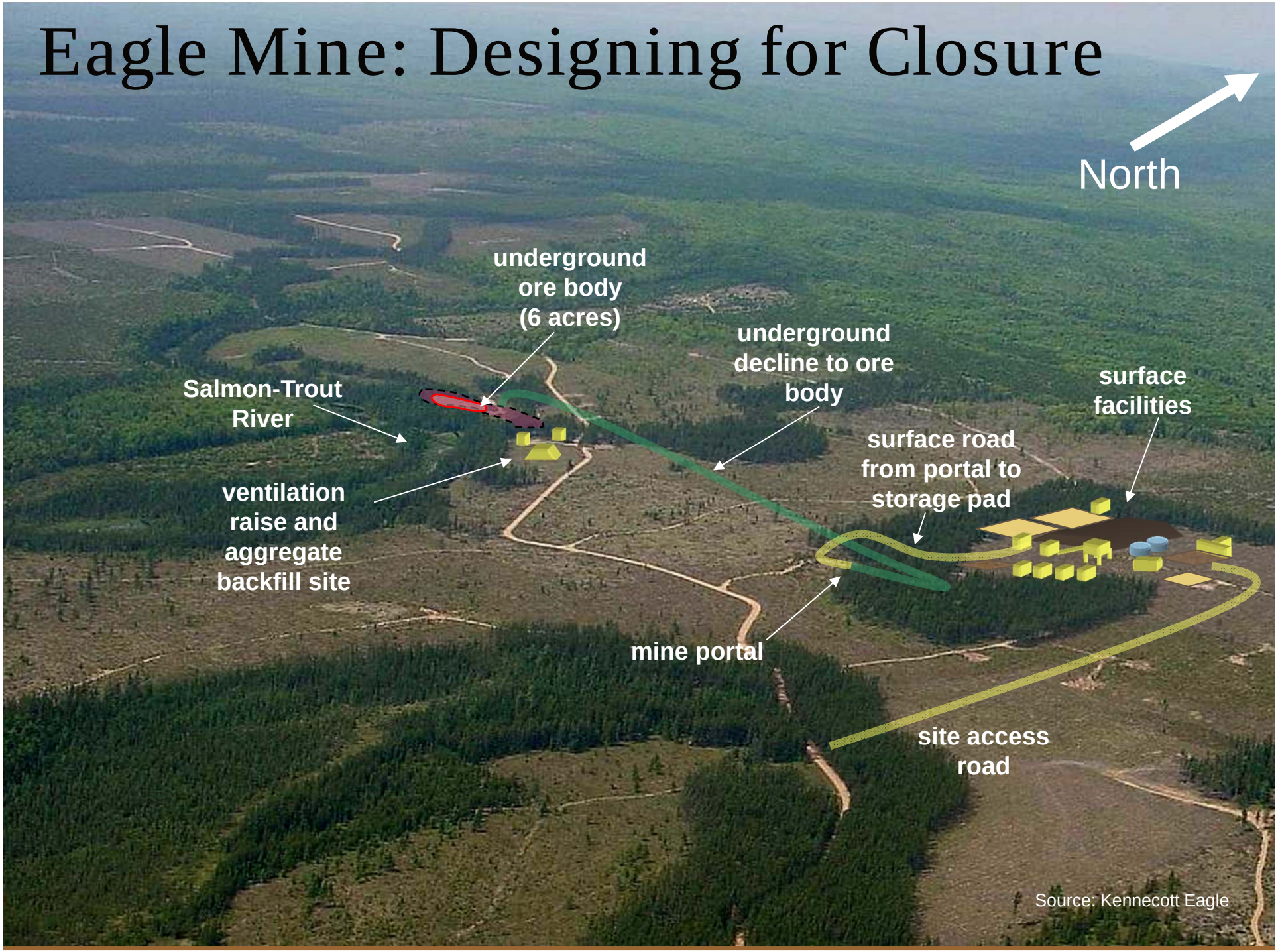
North pit

South pit

Ridgeway Results

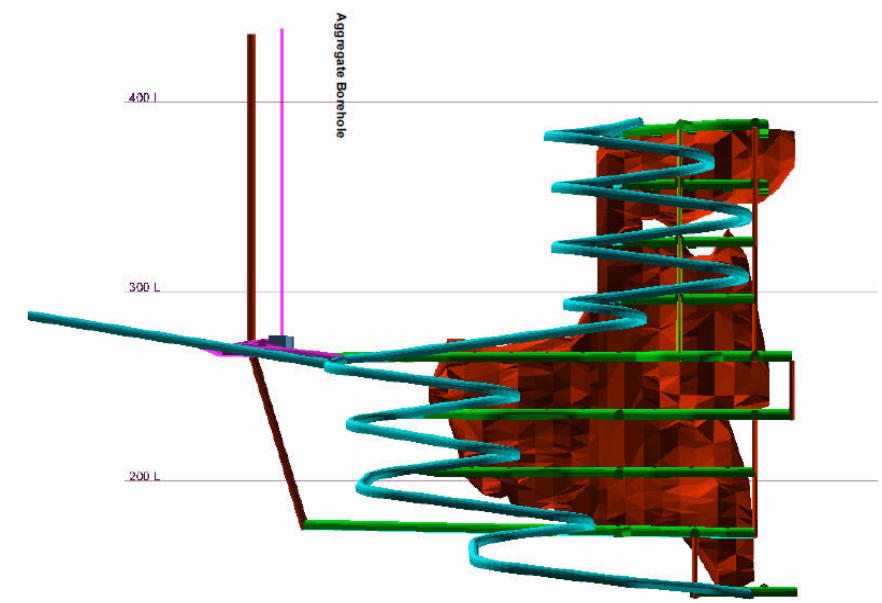
- Tailings cover is maintaining saturation and maintaining reducing conditions in tailings
  - Runoff does not need any treatment
- South Pit is almost completely flooded and is maintaining a neutral pH with low metals concentrations without lime addition
  - An aquatic ecosystem comparable to natural lakes in the region has been established
  - Water meets discharge criteria
- North Pit lake is currently being filled
  - Lime addition to maintain neutral conditions
- All site water is now being directed to the North Pit Lake to increase rate of flooding
- North Pit Lake on track to discharge water without water treatment when filled

Eagle Mine: Designing for Closure



Eagle Mine: Designing for Closure

Eagle Mine: Designing for Closure



UNDERGROUND MINE

•100% development rock backfilled into underground workings (secondary stopes)

• Closure involves rapid re-flooding, and submergence beneath water table

TAILINGS

•High acid generating potential

•Subaqueous in-pit disposal of fresh un-oxidized tailings

•Hydrogeologic containment

Successful Implementation of Proactive ARD Management Strategies for Closure

- Compatible with the chemical, physical, environmental and regulatory setting of the mine
- The strategy should be designed and implemented before a problem develops
- Strategies must be compatible with the life of mine plan and day to day operations
- ARD management costs should be fully integrated into economic models used by long-term mine planning
- Successful proactive ARD management requires buy-in from entire mine
- Monitoring and Feedback is required to ensure successful implementation and to ensure that the management strategy is leading to the intended results for optimal closure results