Water Quality Expectations for Thickened Tailings and Lessons Learned at the Kidd Metsite TMA, Timmins, Ontario

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Kidd Metallurgical Site

- Processed Ore from three mines:
  - Kidd Upper Mine & Kidd Mine D (Zn, Cu)
  - Montcalm Mine (Ni)
- Produces 2 – 3 Mt tailings per year
- Currently contains >100Mt tailings
- Thickened tailings (65% solid) are mixed and deposited with other effluent streams in the tailings management area (TMA)
- Original TMA occupied about 1,200 ha
- Tailings contain Pyrite / Pyrrhotite (6% S)
- NP/AP < 1 – Therefore acid generator when disposed on land

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THICKENED TAILINGS

- What is “THICKENED” tailings?
  - Higher Density / % Solids
    - produced in Thickener
  - Greater viscosity
  - Faster Settling
  - No or Little Segregation of Grain Sizes in Impoundment when Discharged

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WHY THICKENED TAILINGS ??

- No requirement for Large Dams
  - only berms needed to contain solids
  - reduced cost because no need to import large amounts of material to build dams
- No classic "Beaches" and "Slimes"
- Thought that could reduce potential for Acid Generation
  - Tailings would be wet
    - Non-segregated therefore higher air entry pressure; wicking of moisture upward

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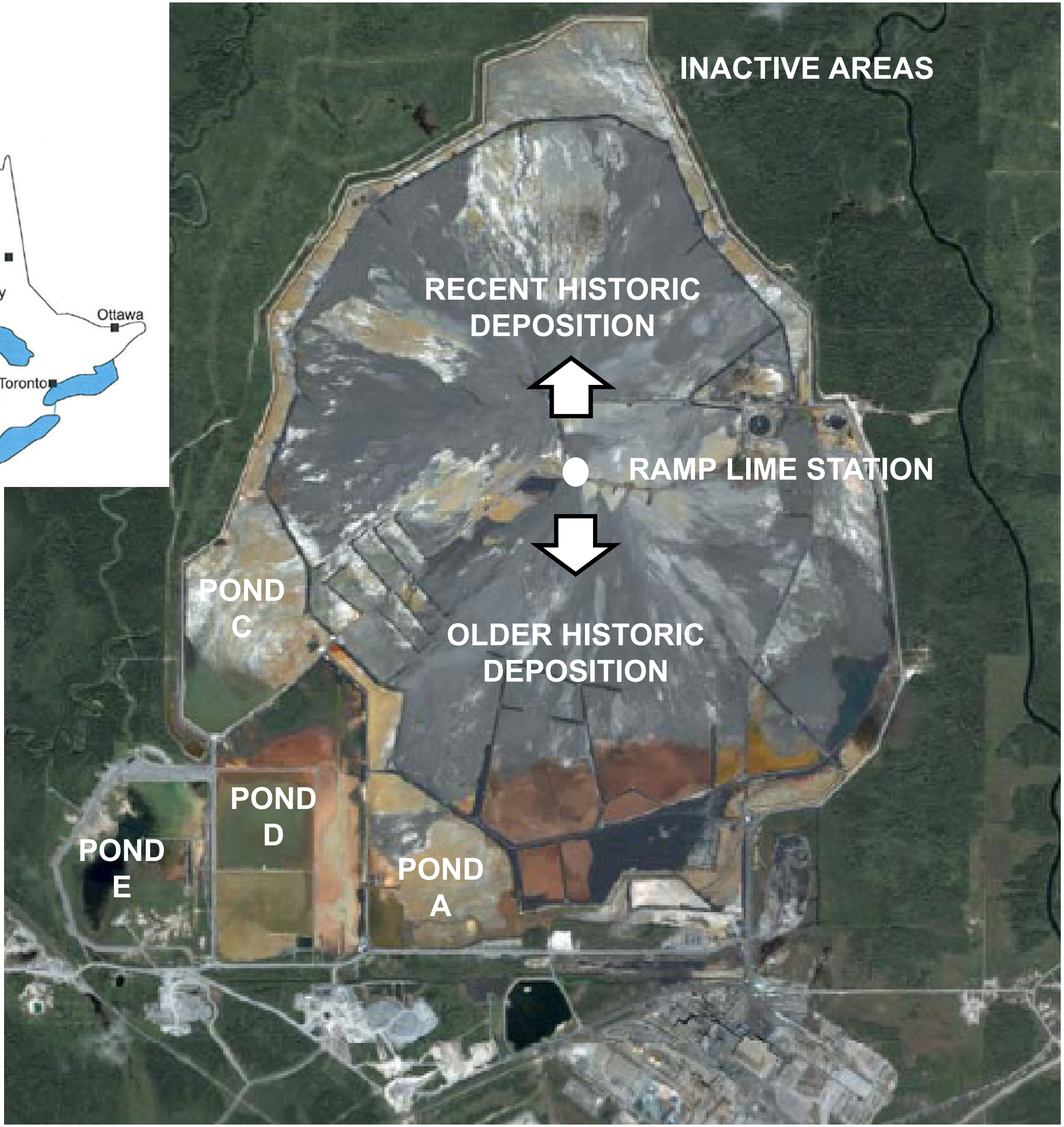

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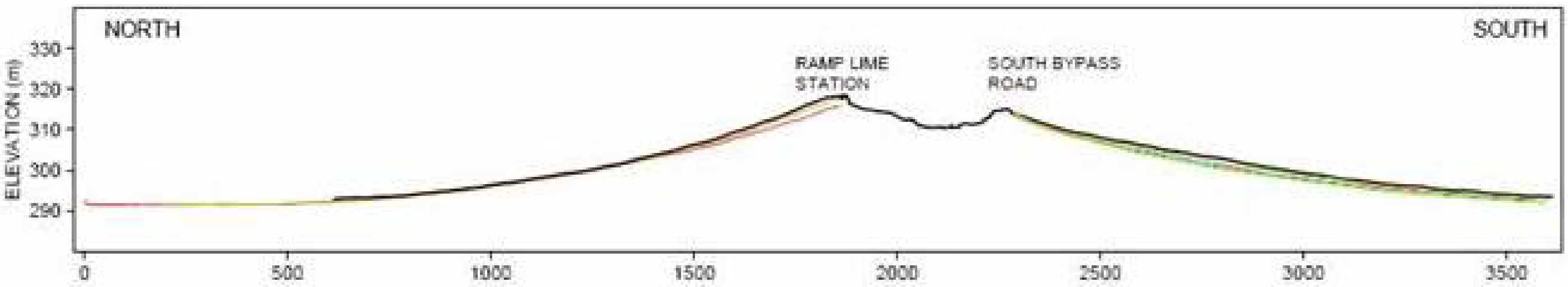
Tailings Profile



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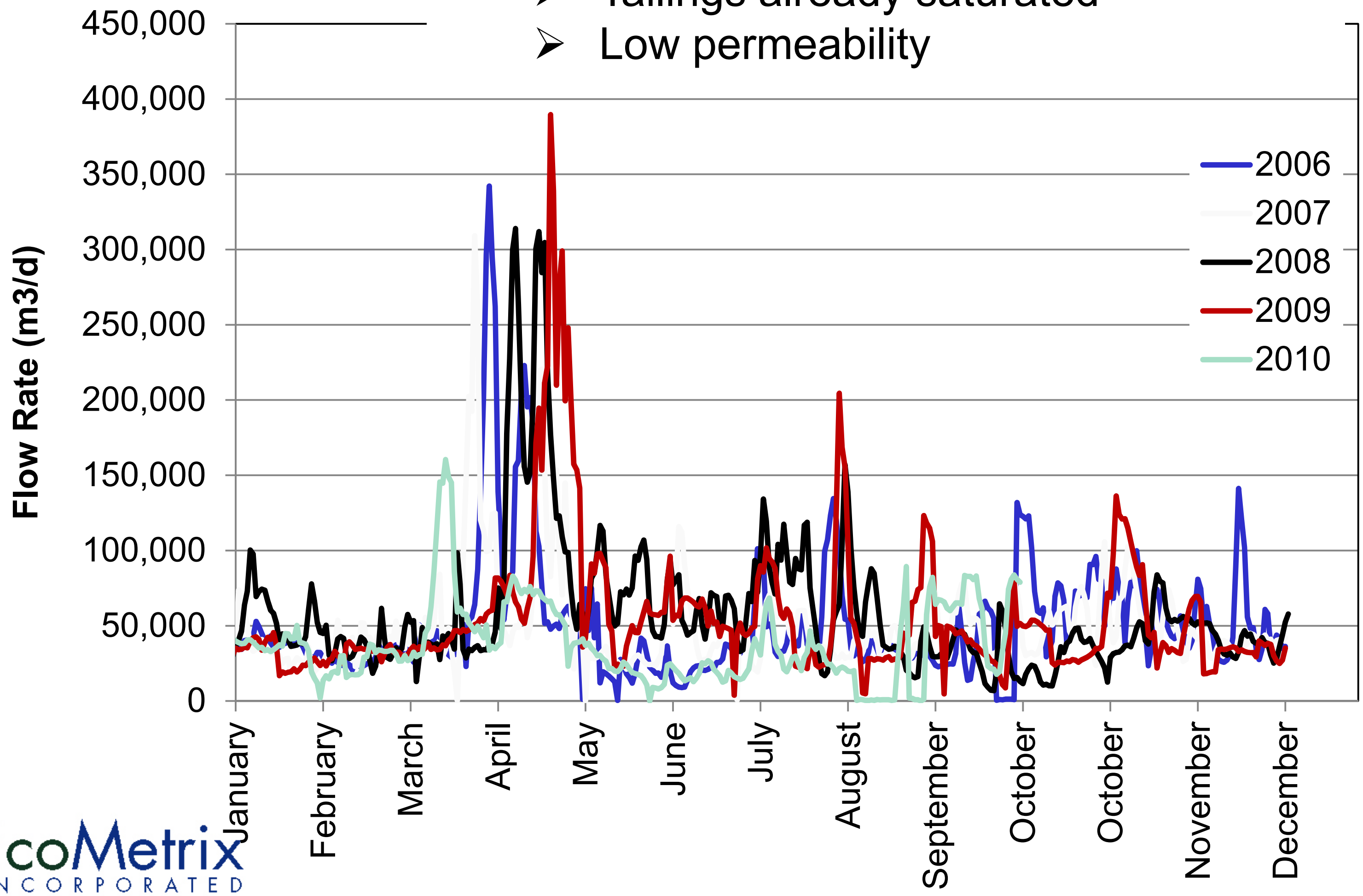
Lesson 1

Efficient at Shedding Water – Results in High Runoff

- Flash flow during precipitation events
  - Tailings already saturated
  - Low permeability



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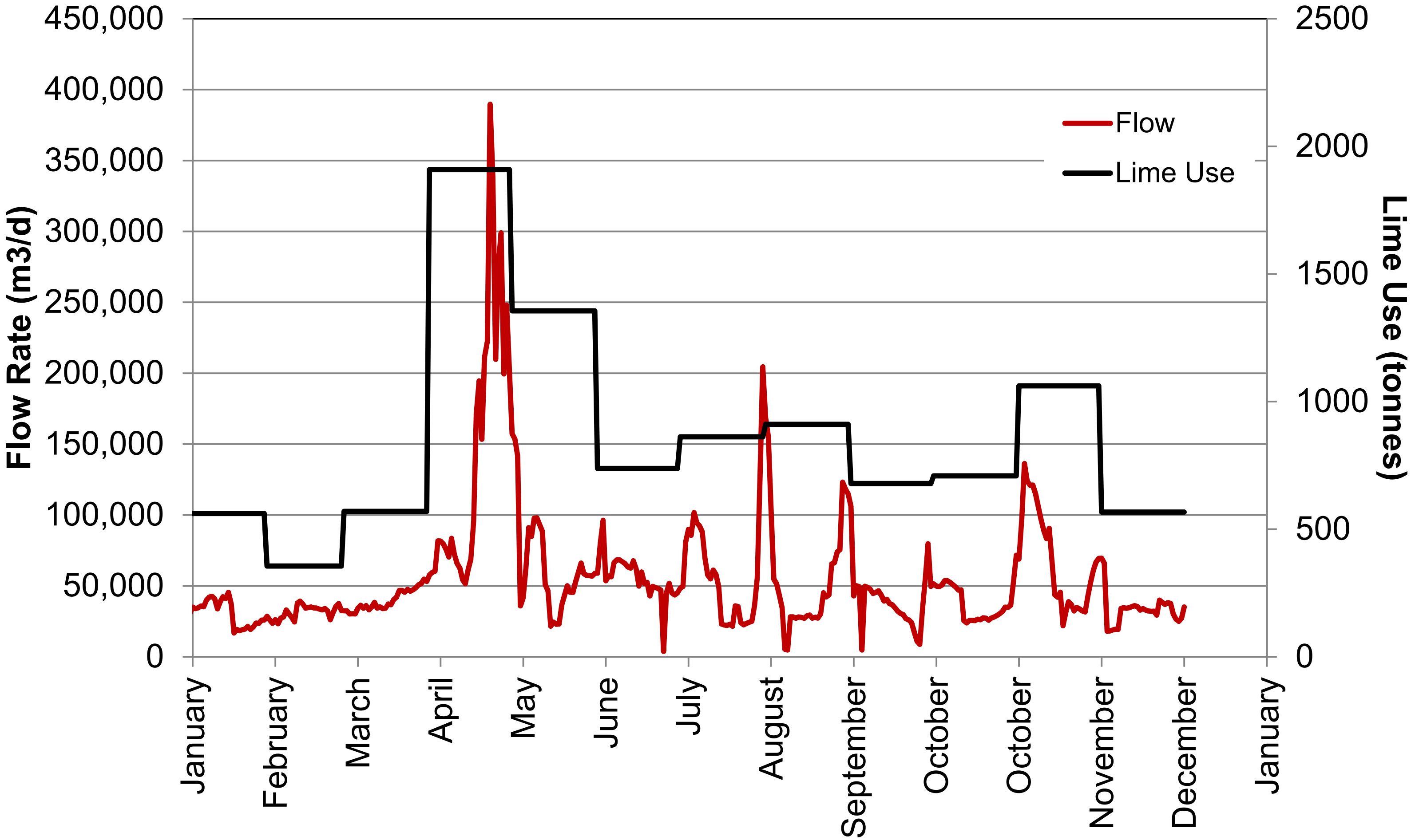

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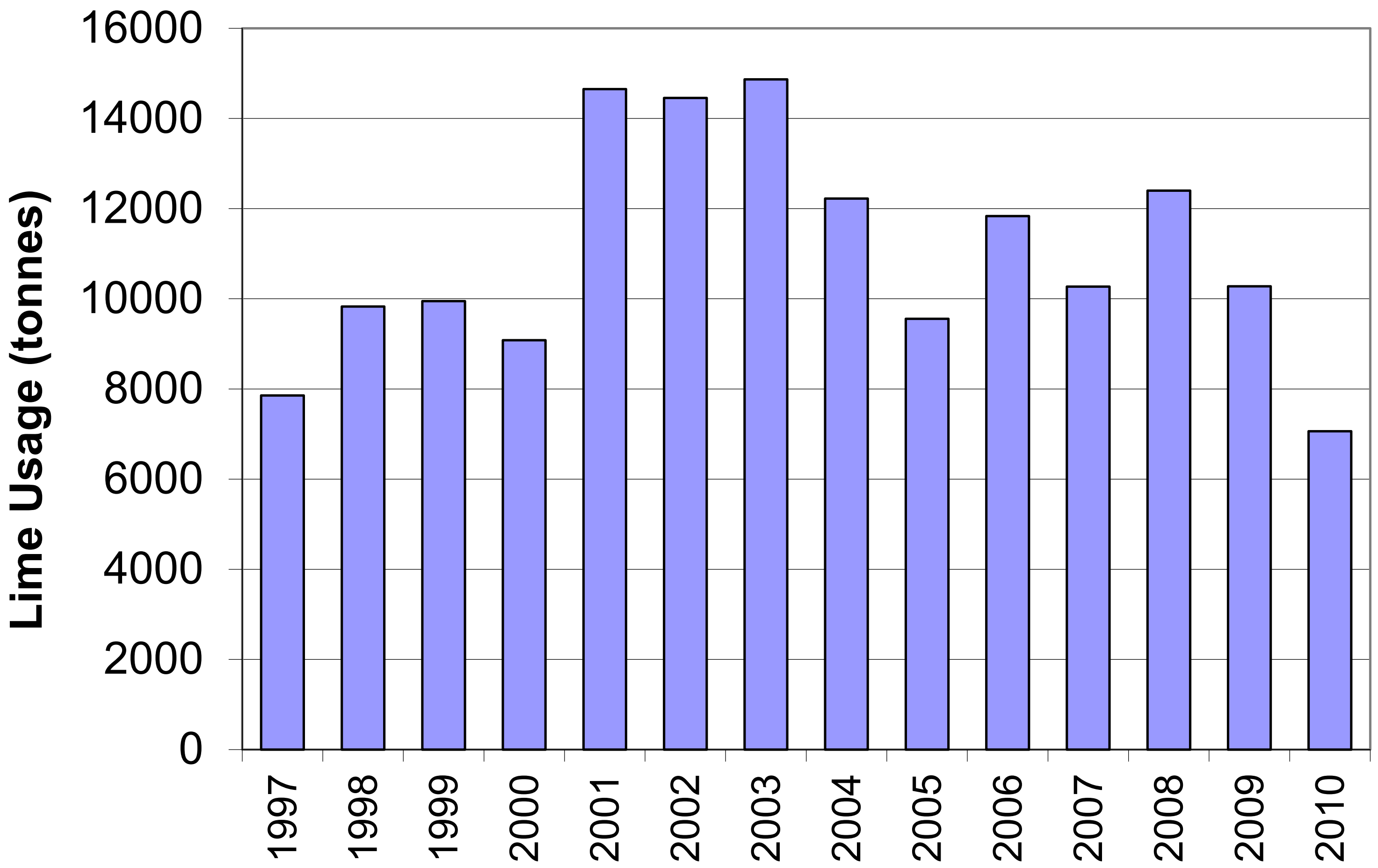
Annual Lime Use



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Lesson 2
Efficient Acid Generator with High Lime Demand

Acid Generation Studies

- Early 1990's –
  - David Blowes and Tom Al (U of Waterloo)
    - Pore waters / above and below water table
  - Noranda Technology Centre (NTC) – Surface Hydrology / Cover test plots
- Mid 1990's – 2000's
  - Beak International
    - Modelling
    - oxygen consumption measurements
    - soluble extractions for regular monitoring

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Lesson 2
Efficient Acid Generator with High Lime Demand

Acid Generation Studies

- Mid 2000's – 2010
  - EcoMetrix
    - Jarosite studies – NP Consumption
    - Lime demand modelling / optimization

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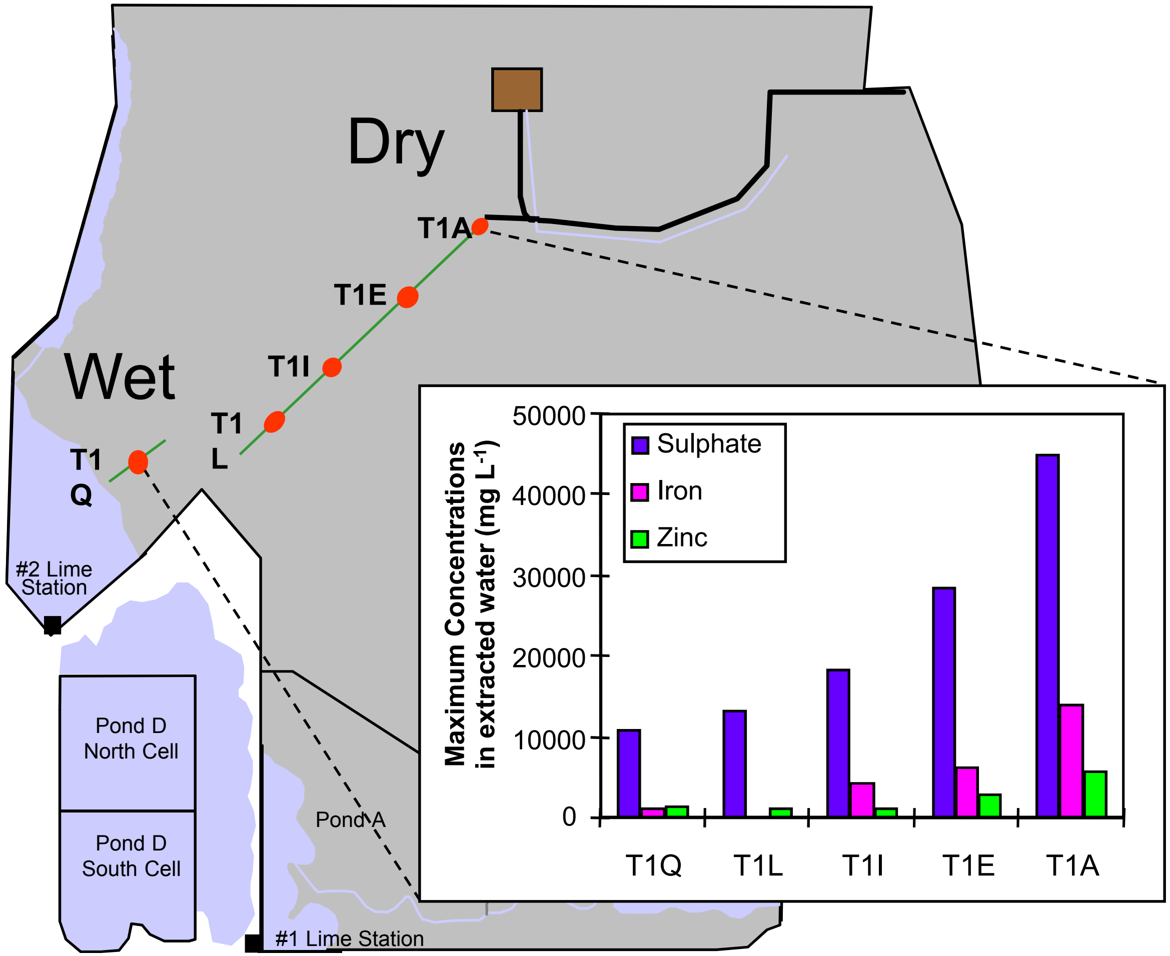
Spatial Trends of Dissolved Sulphate, Iron and Zinc in Pore Water



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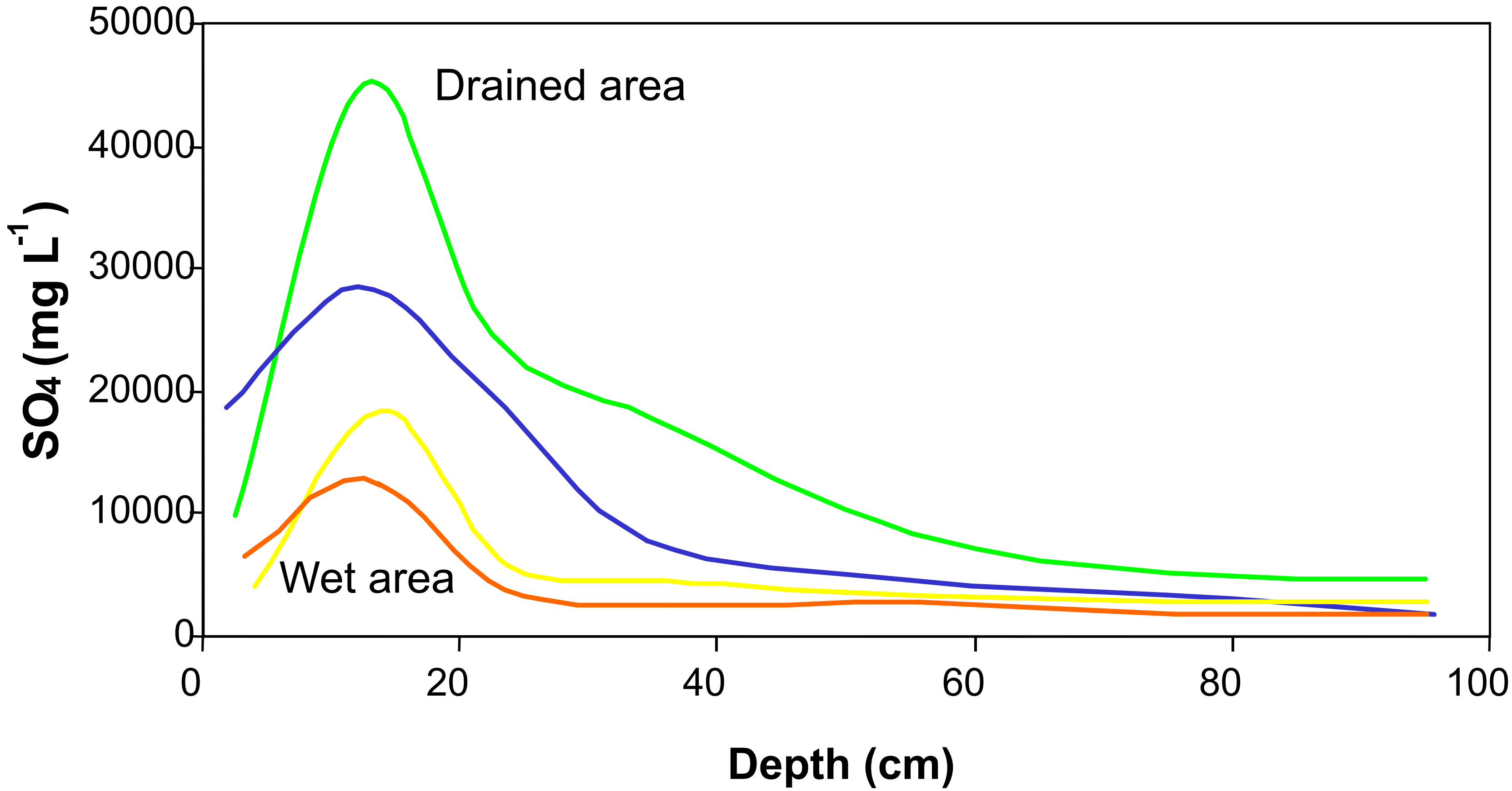
Tailings Pore Water Variation from Drained to Wet Areas



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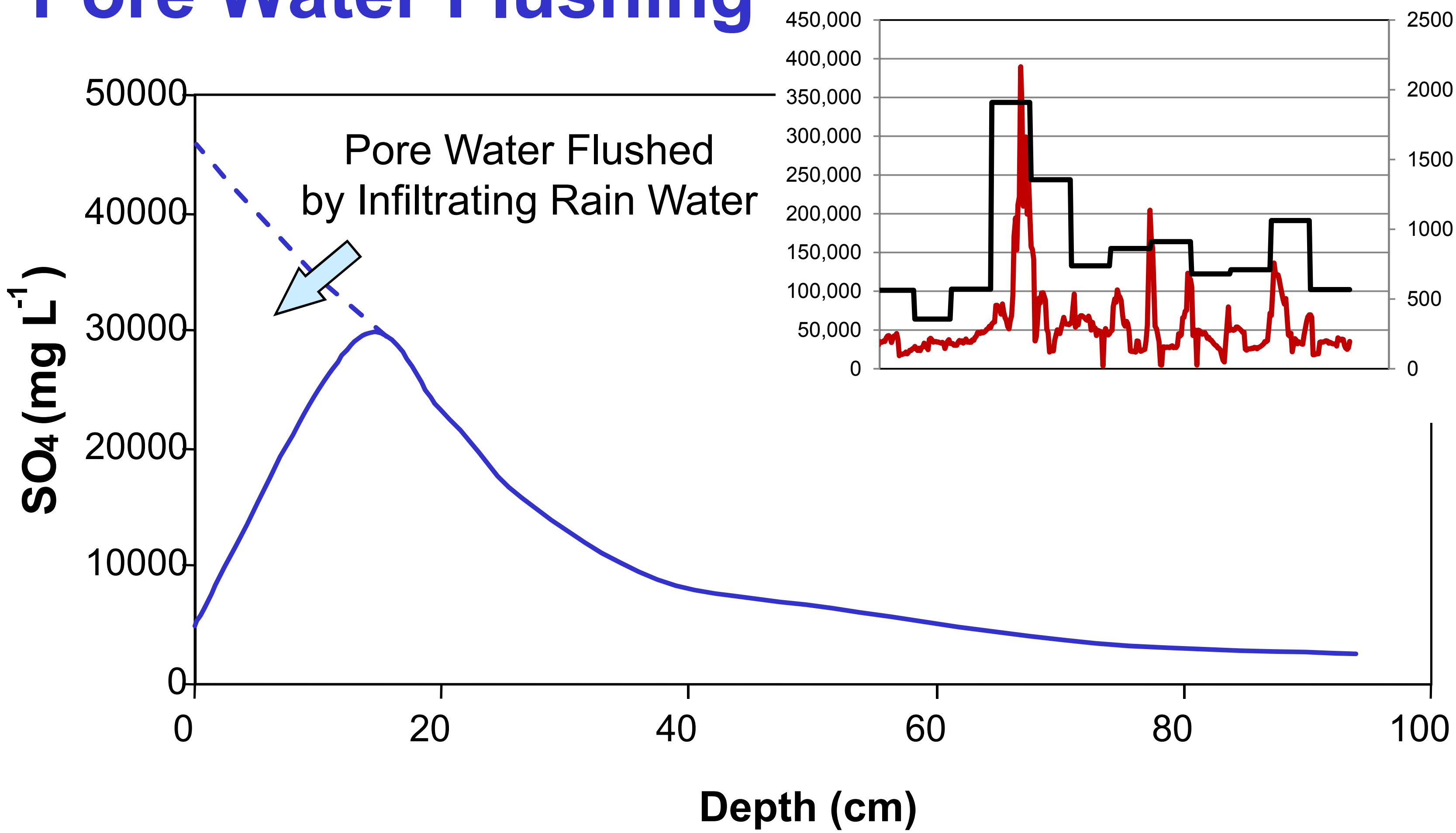
Acidity and Metal Loads from Shallow Pore Water Flushing



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Lesson 3 – Lime Demand Increases after NP at Surface is Depleted

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Lag Time for Acid Generation

- Fresh tailings are neutral with reasonable Neutralization Potential (NP) values
- Sulphide Oxidation generates acid and consumes NP
- High acidity and metal loads only after NP depleted
- Lag time between start of oxidation and NP depletion is critical and depends on:
    - Oxidation rates
    - Available NP

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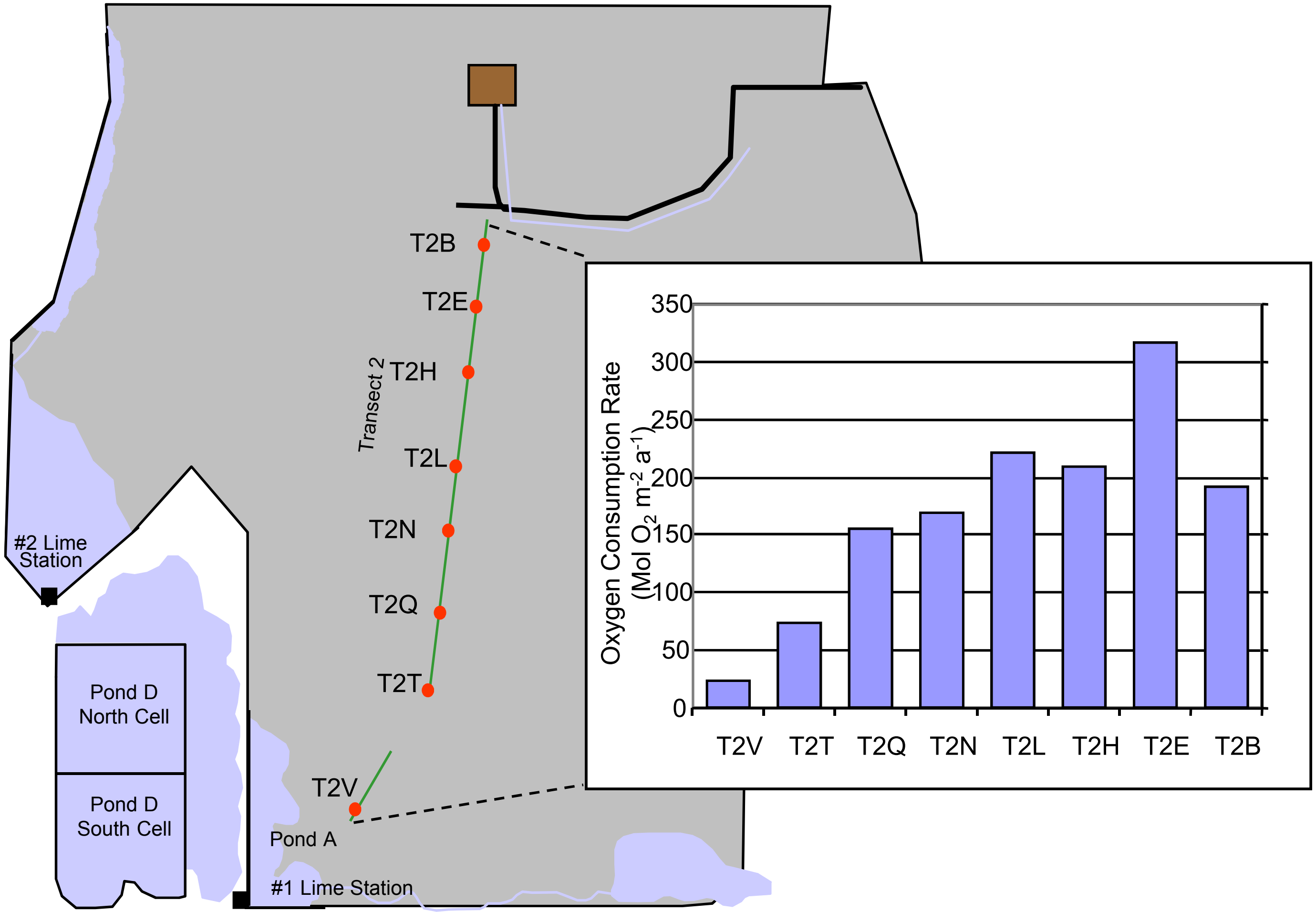
Spatial Trends of Oxygen Consumption Rates



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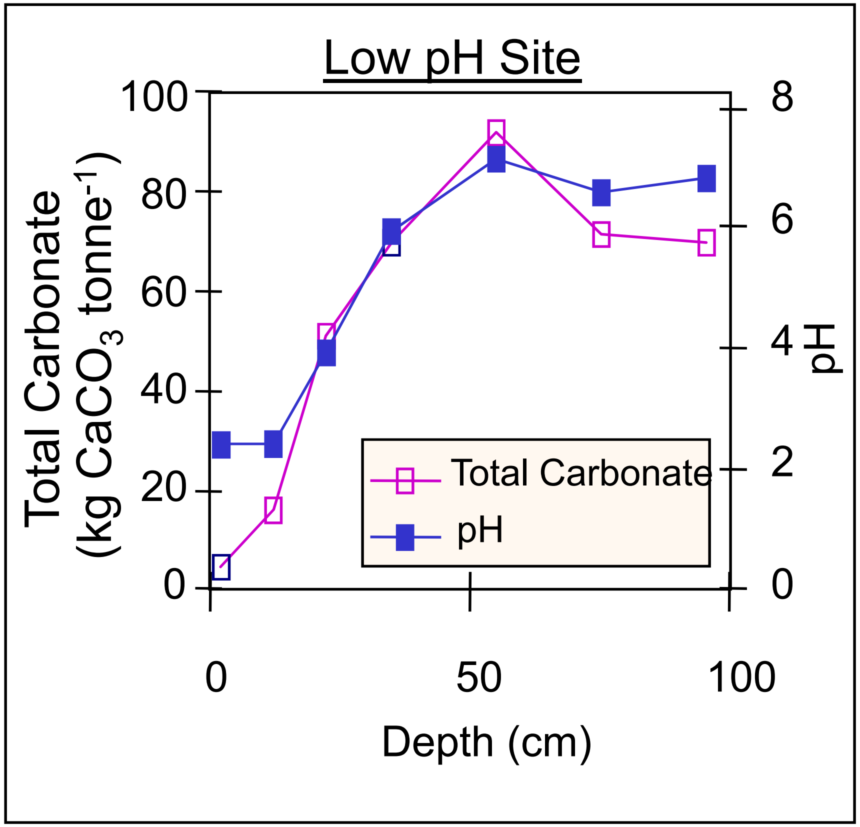
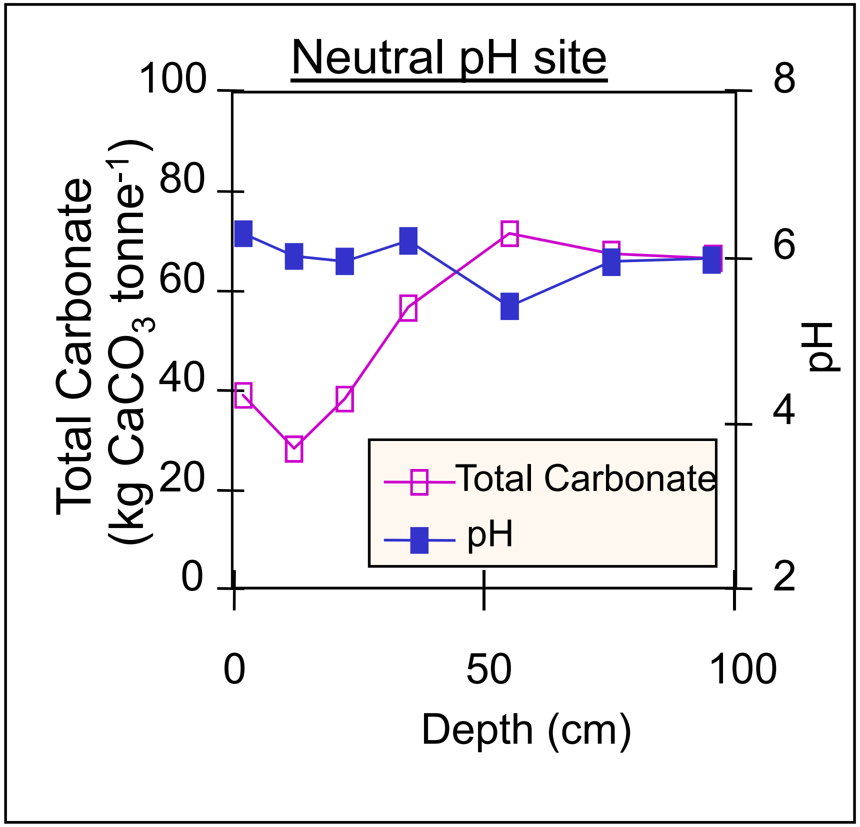
Carbonate Content (NP) and Pore Water pH As a Function of Depth





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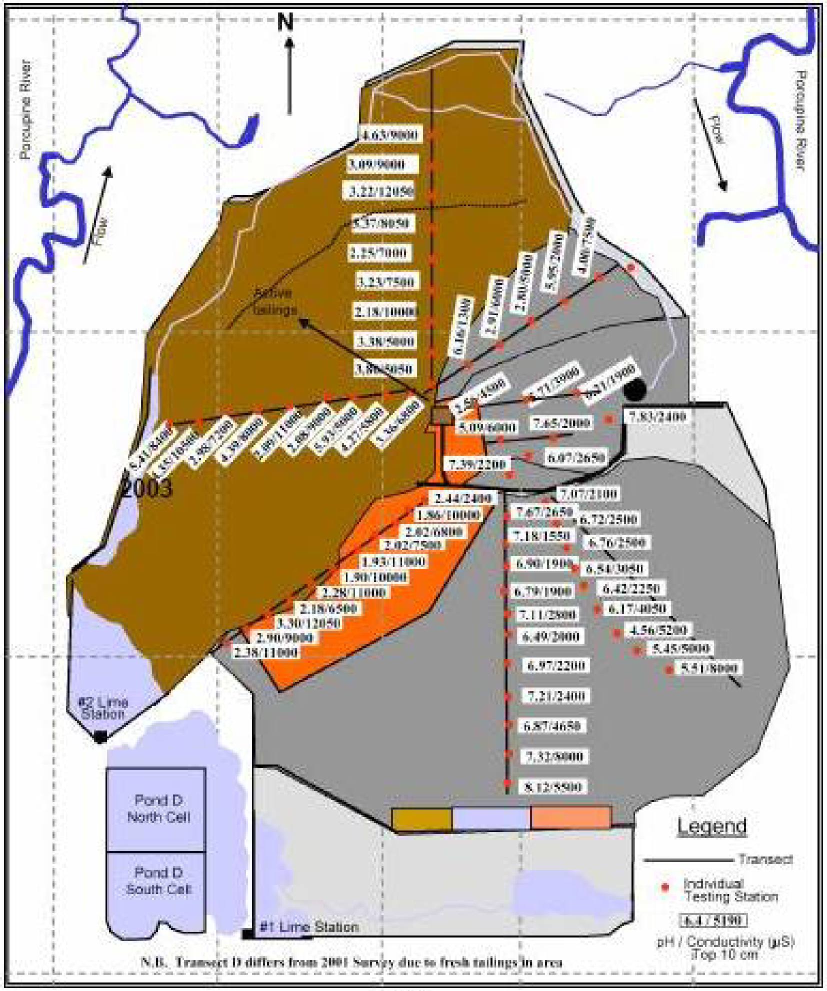
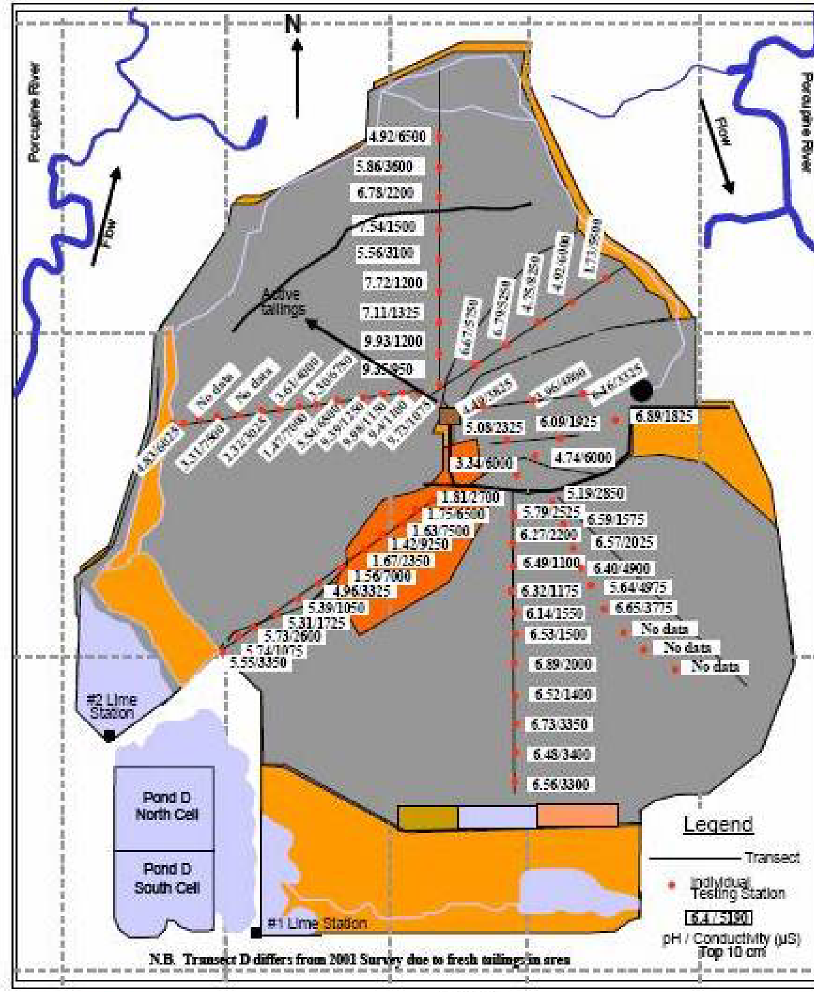
Annual pH / Conductivity Surveys



2003



2004

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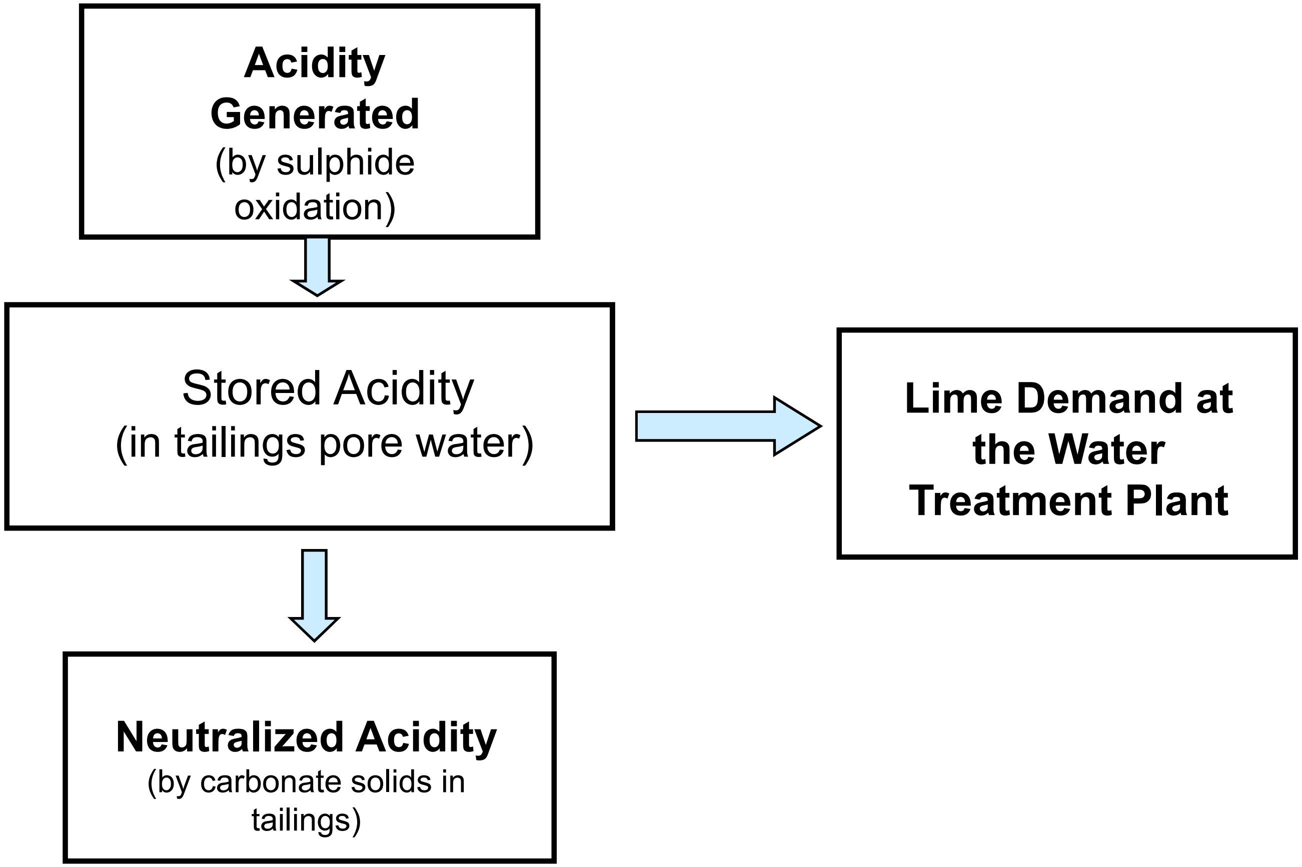
Acidity Mass Balance



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Lime Demand Model

- Tailings Management Tool
- Developed to forecast future annual and maximum potential daily lime demands

- **Evaluated variables affecting lime demand:**
  - ➢ acid generating factors (above)
  - ➢ tailings Neutralizing Potential (NP)
  - ➢ deposition cycling period (and LAG time)

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Lime Demand Model

- **Sources of acidity:**
  - oxidation of the sulphides near surface prior to covering with fresh material
  - acid released from the aged acidic tailings
  - jarosite dissolution (iron sulphate bi-product of zinc process that dissolves and releases acid)
  - oxidation of thiosalts in mill process water

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Lime Demand Model

Past Studies

- **Field study:**
  - ➢ The inactive area (base load) was estimated by pore water measurements to be 2,600 t-CaO/a.
  - ➢ NP depletion rate from sulphide oxidation is 4 kg-$CaCO_3$/t/a.
- **Laboratory testing:**
  - ➢ Mixture of jarosite in tailings showed that the half-life of jarosite is between 1 and 3 years.
  - ➢ Pilot studies showed that the NP of mine D tailings (uncertain among the three) ranges from 5 to 23 kg-$CaCO_3$/t.

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Sensitivity Analysis

- Sensitivity analysis was performed to address uncertainty
  - Tailings deposition time: 1.5 – **3** years
  - Jarosite disposal: separate disposal – **codisposal with tailings**
  - Tailings NP content: 5 – 10 – **14** – 23 kg $CaCO_3$/t
  - Jarosite dissolution half-life: 1 – **1.5** – 2 years
  - Sulphide oxidation rate: 2 – **4** – 6 kg $CaCO_3$/t/a

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Lessons Learned
Refinements to TMA Management

- Stop depositing in small areas for long periods – reducing exposure times in older areas
  - 1year cycle with 15-20cm layer
- Reconfiguration of deposition areas

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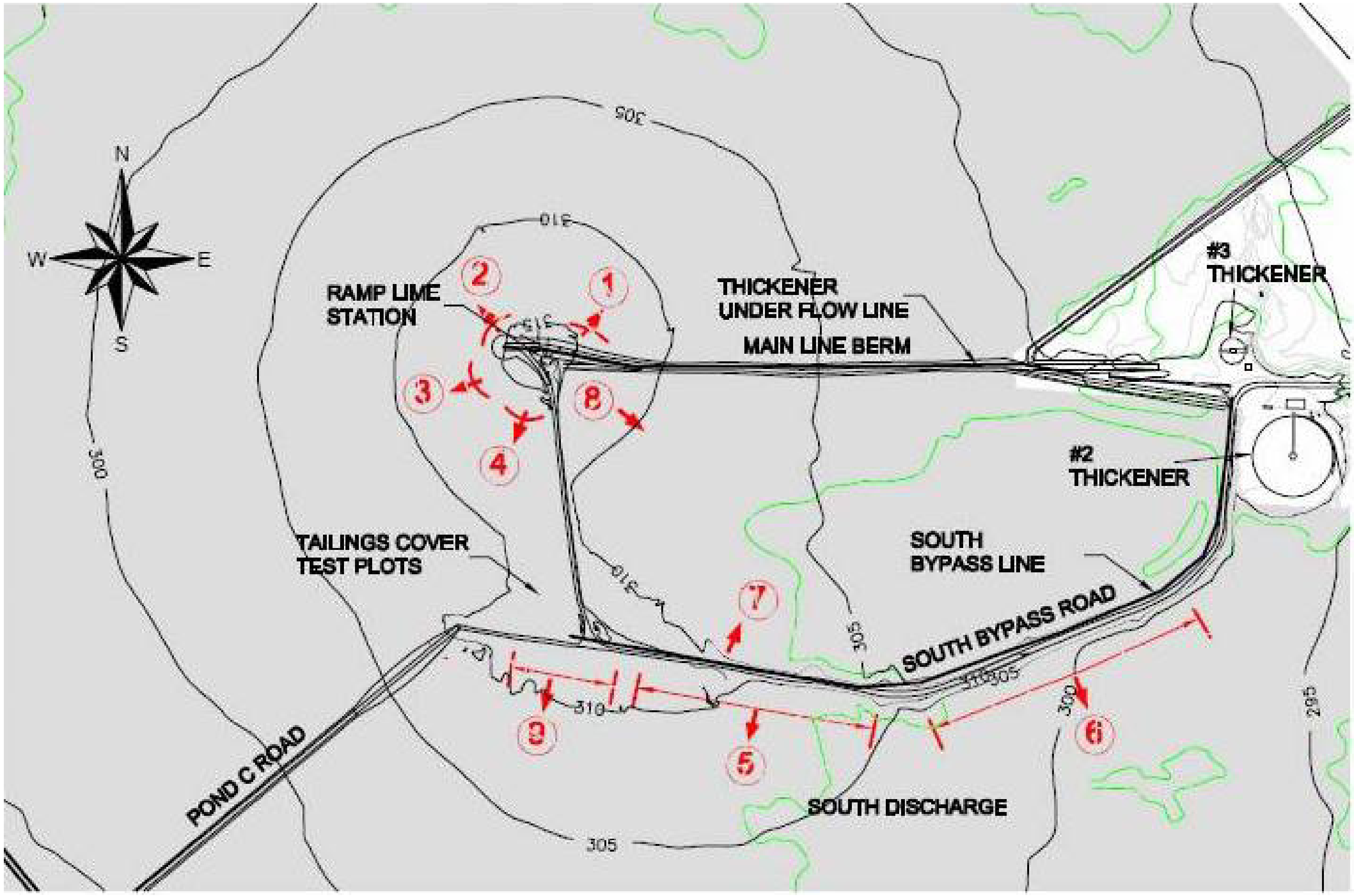
Multiple Discharge Points



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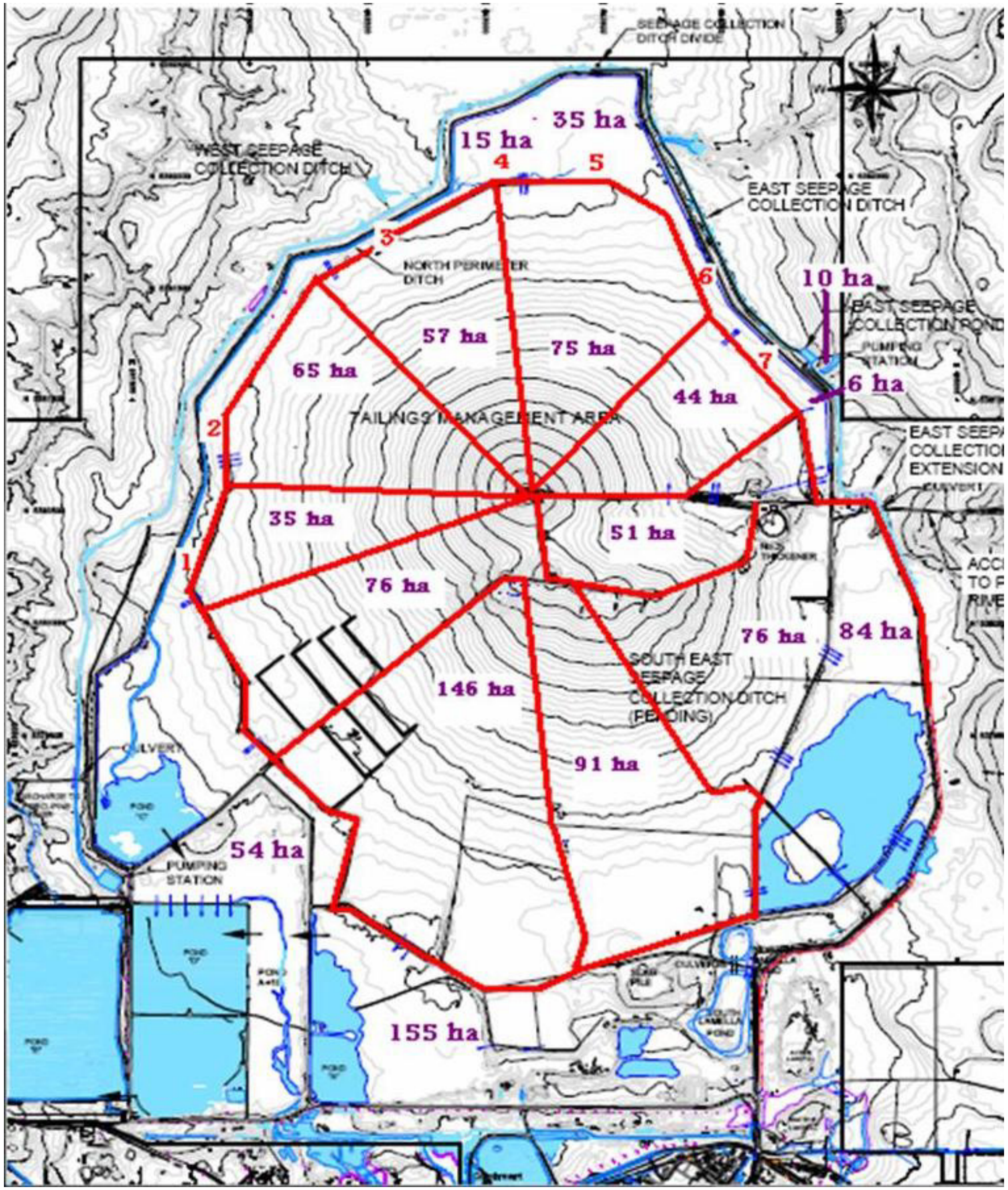
New Deposition Cycle and Internal Berms



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Lessons Learned
Refinements to TMA Management

- Removal of Jarosite from tailings
  - Separate disposal area
- Continued Evaluation of Lime Demand
- Upgrading Lime System
  - Distribution and Slaker
- Currently amending Closure Plan (anticipate end of 2012)
  - Closure at 2018

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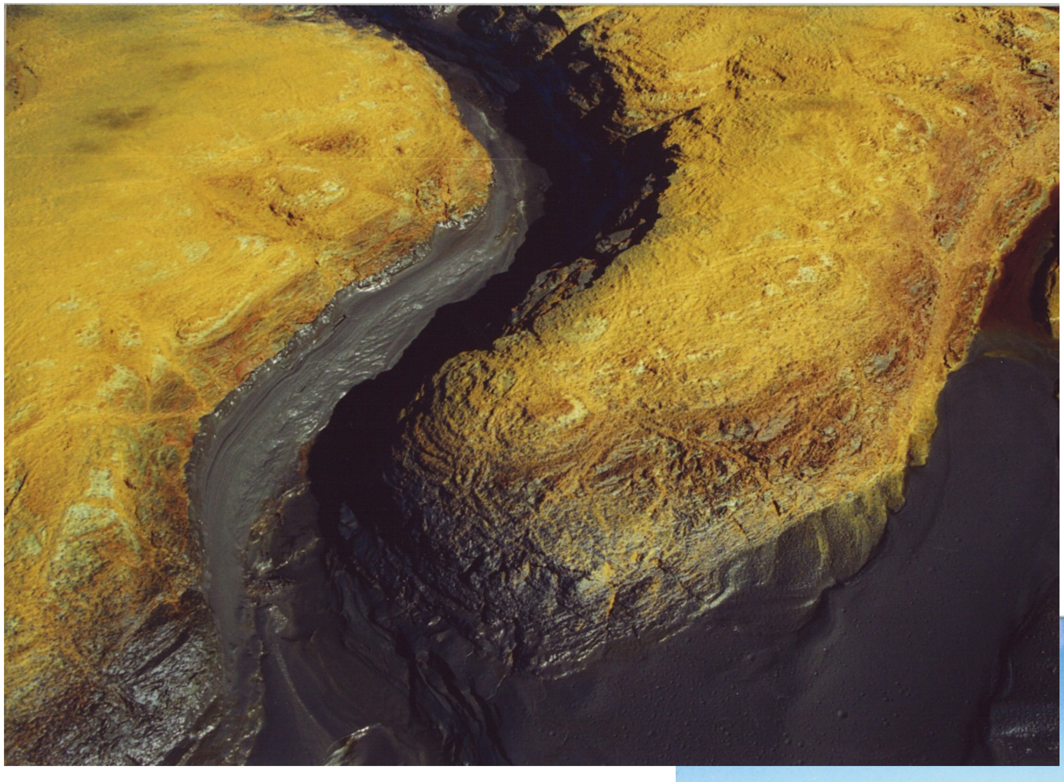
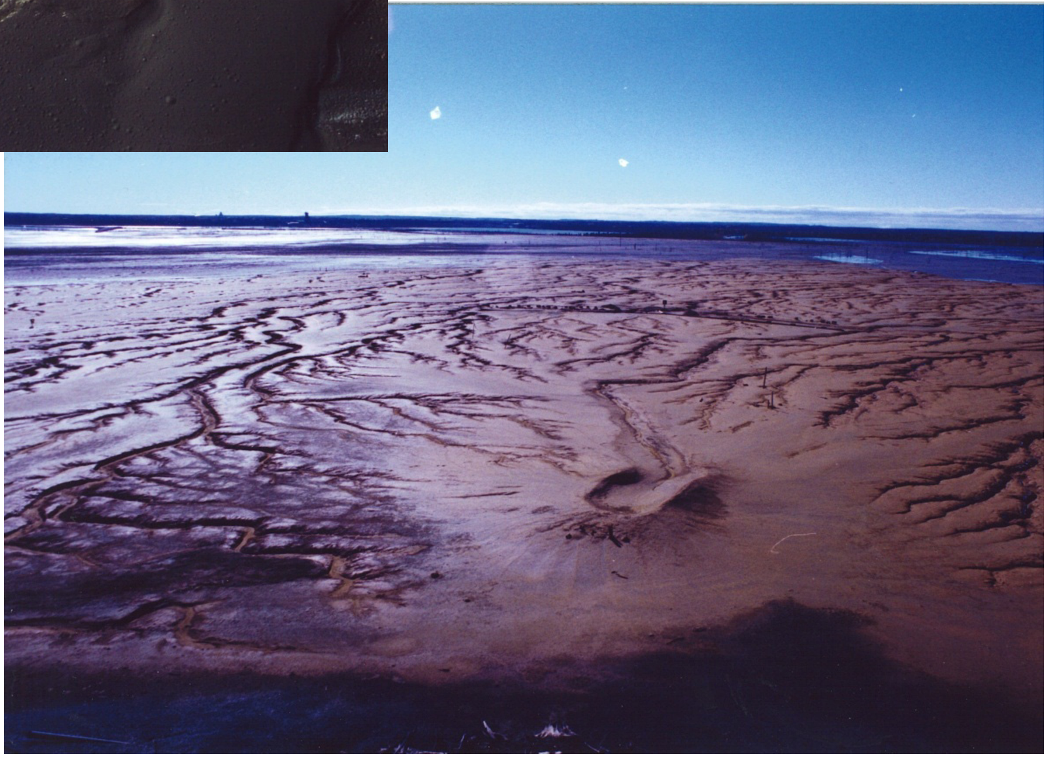


Questions?



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