AREVA

Optimizing In-Pit Disposal of Problematic Waste Rock using Leaching Tests, Portable XRF, Block and Mass Transport Models

Frederic Guerin and Steve Wilson
AREVA Resources Canada Inc.

Ronald Nicholson
Ecometrix Inc.

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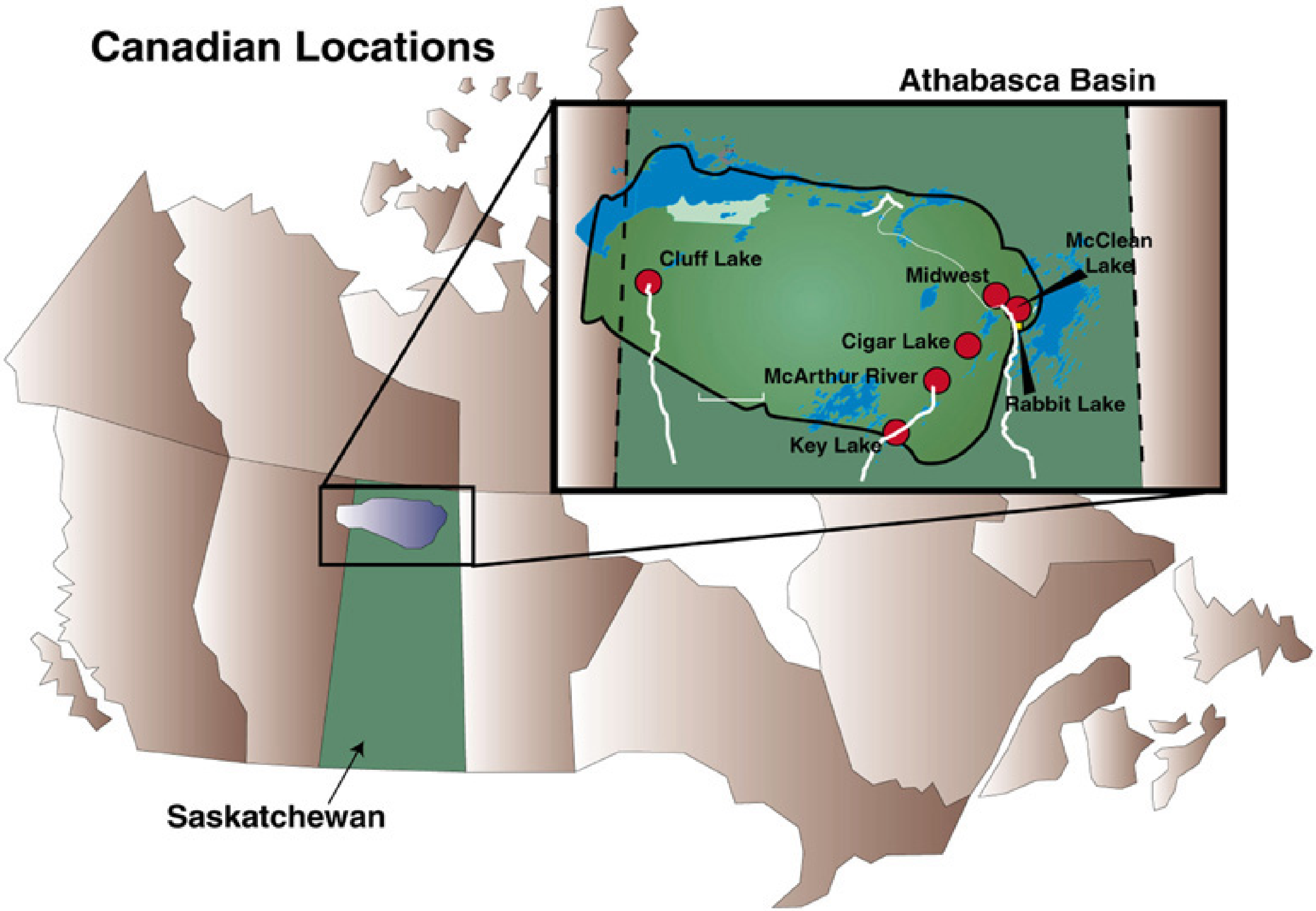
OUTLINE

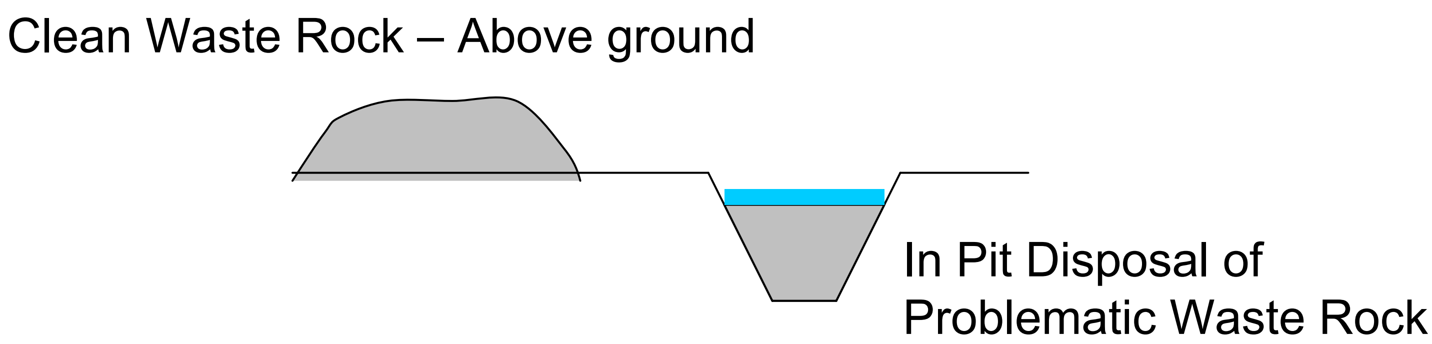
- CONTEXT
  - Open Pit Mining of Uranium Deposits
  - Decommissioning Strategy
- WASTE ROCK CHARACTERIZATION
  - Arsenic : Laboratory testing
  - Volumes : Block Models
- POST-DECOMMISSIONING
  - Groundwater Flow and Mass Transport Conditions
- WASTE ROCK SEGREGATION DURING MINING
  - Portable XRF
- CONCLUSION

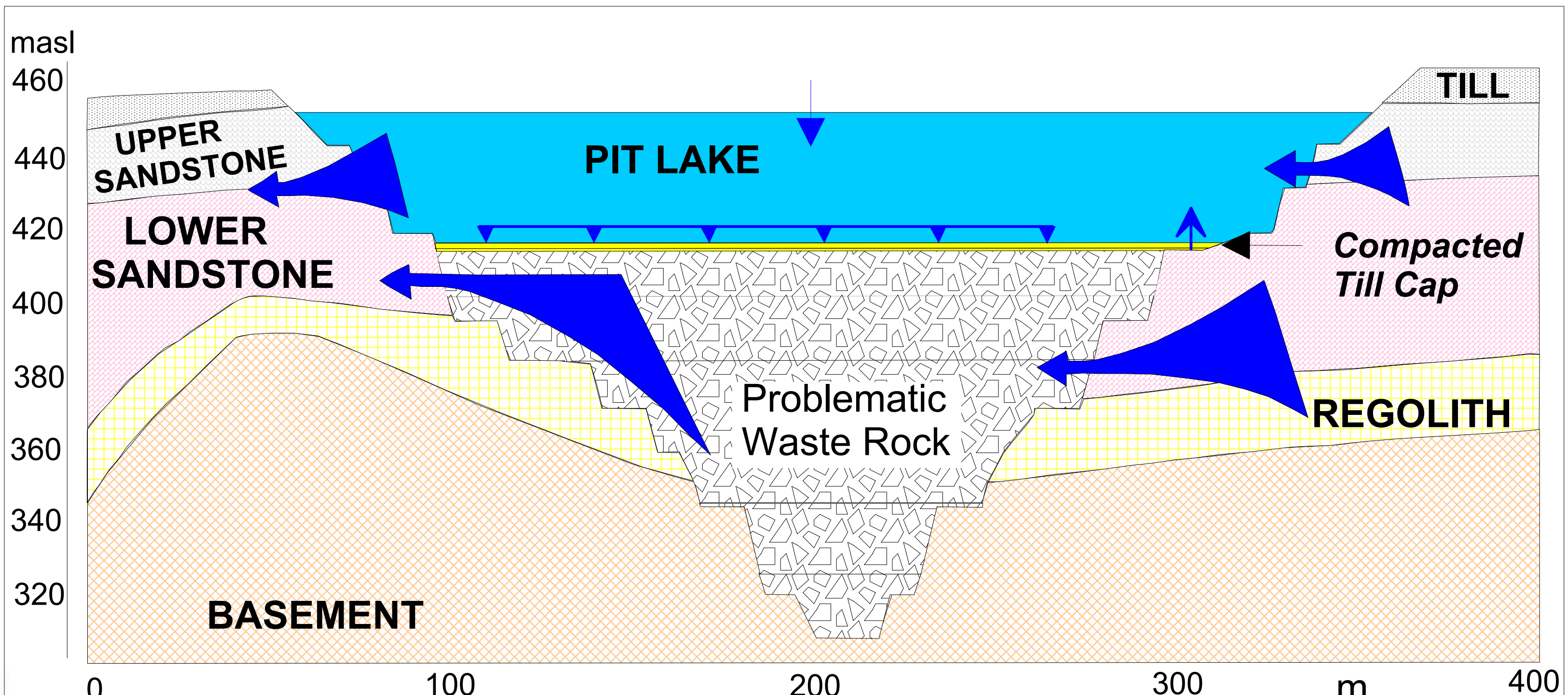
Uranium Mine Locations in Saskatchewan, Canada



Sue Mining Area – McClean Lake Operation

Decommissioning Strategy



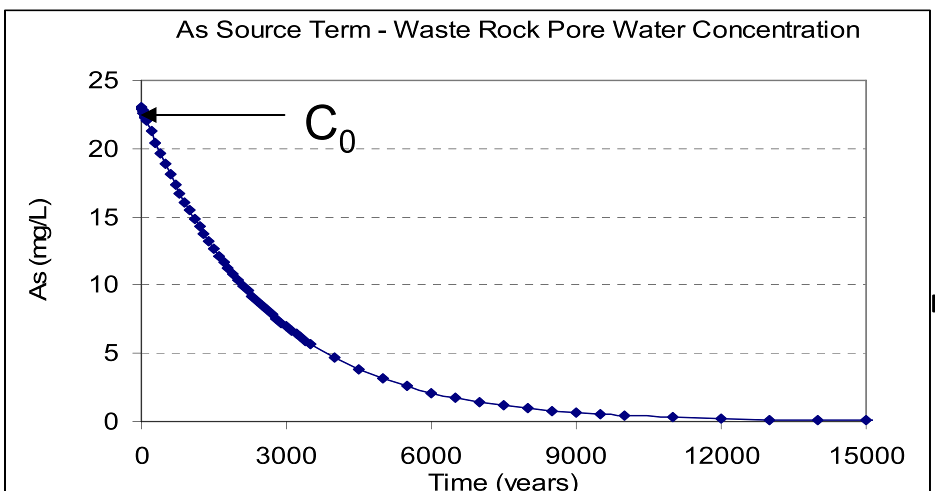


Problematic Waste Rock vs Clean Waste Rock

- **Mineralogical Context**
  - **Uranium: oxide, silicate**
  - **Arsenic, Nickel: variations within the system Ni-As-S-Fe ($NiAs$, $NiAs_2$, $NiAsS$,...)**
- **Definition**
  - **Problematic Waste Rock: material that contains between 250 mg/kg and ~ 850 mg/kg U, or has been identified as having acid generating potential, or contains greater than (75 to 250) mg/kg Arsenic**
  - **Clean Waste Rock**
    = Total Rock – Ore – Problematic Waste Rock

Waste Rock Characterization

- ***Objectives***
  - ***Source term definition for impact (mass transport) assessment models***
- ***Methods***
  - ***Sequential leach tests => Leachable mass***
  - ***Column tests => Initial concentration (C0)***
  - ***Flow model => Flow through placed waste rock***
  - ***Assumption => Shape of source term function***



Mass released

$$\blacksquare = \int_0^{Tmax} Flow \cdot C0 \cdot \exp(-\beta \cdot t)\, dt$$

Waste Rock Characterization - Sequential Leach tests

- ***Leachable Mass***

→ ***Short Term = Water leachable mass***

→ ***Longer Term= Water + acid leach steps***

→ Water to Solid ratio of 20:1 (50 g / 1 L)

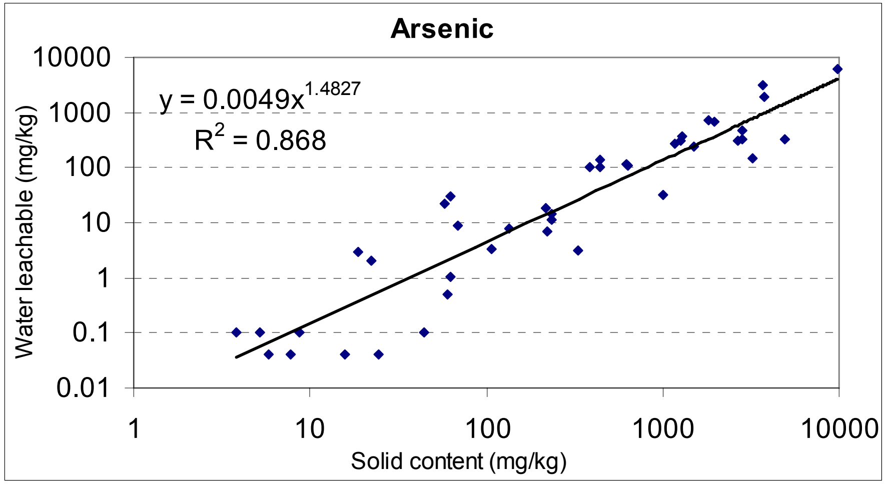
→ Agitation

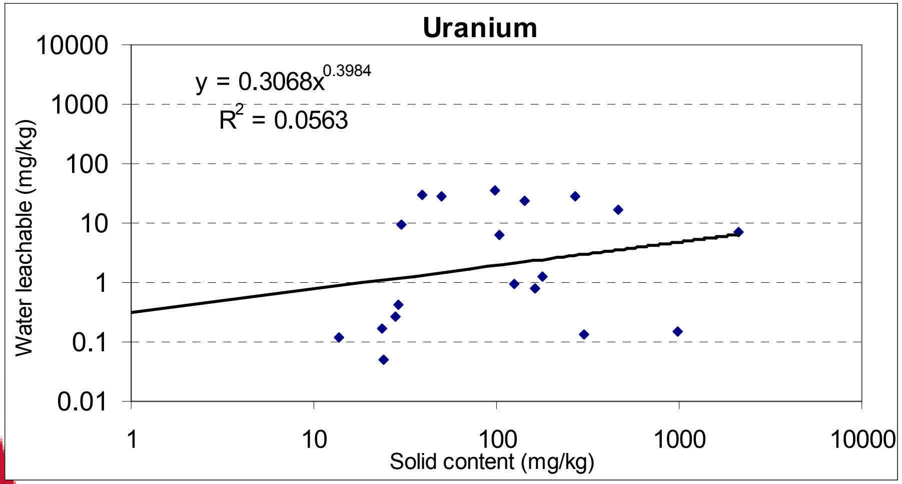
→ Leach 1: de-ionized water for 48 hrs

→ Leach 2: de-ionized water for 48 hrs

→ Leach 3: weak Hydrochloric or Phosphoric acids for 72 hrs

Water Leachable Concentrations vs Metal Content in the Waste Rock





- As - Independent of age and degree of oxidation
- U, Ni - Highest water leachable concentrations associated with aged samples

Saturated Column Tests

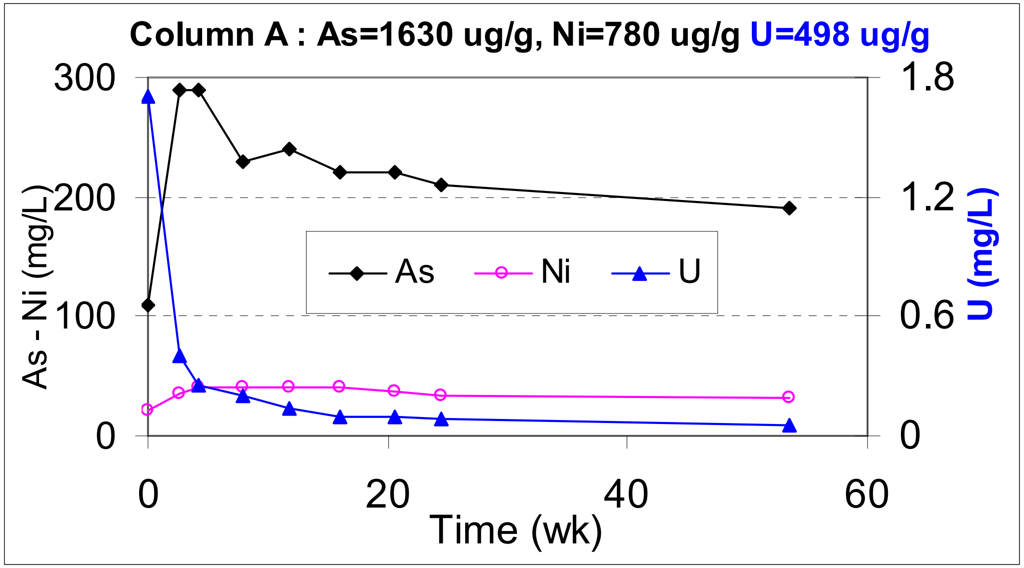
Minimum volume (0.15 litres) sampled bi-weekly and submitted for chemical analysis

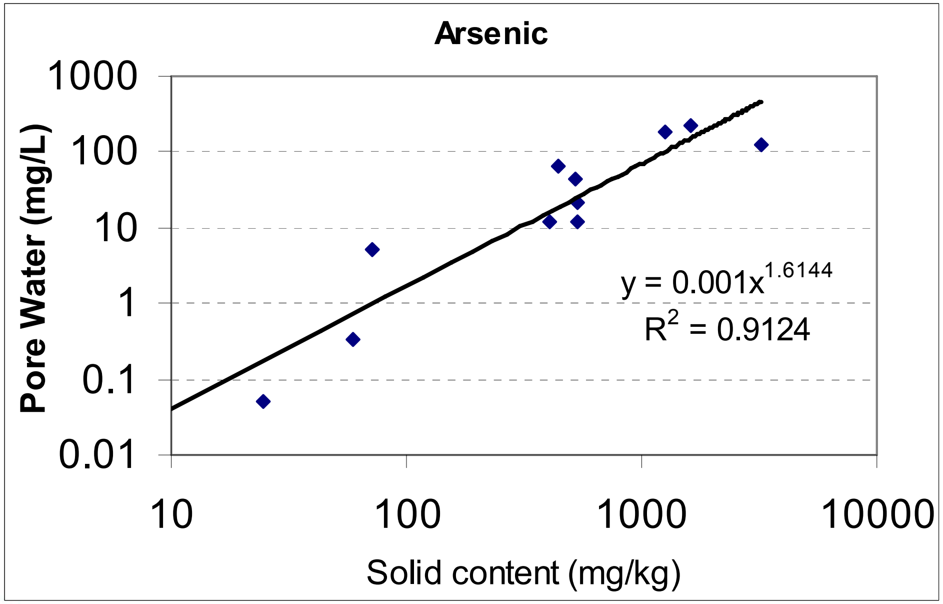
Sample volume replaced

N_2 Conditions

0.75m

Initial Pore Water Concentrations vs Solid Content

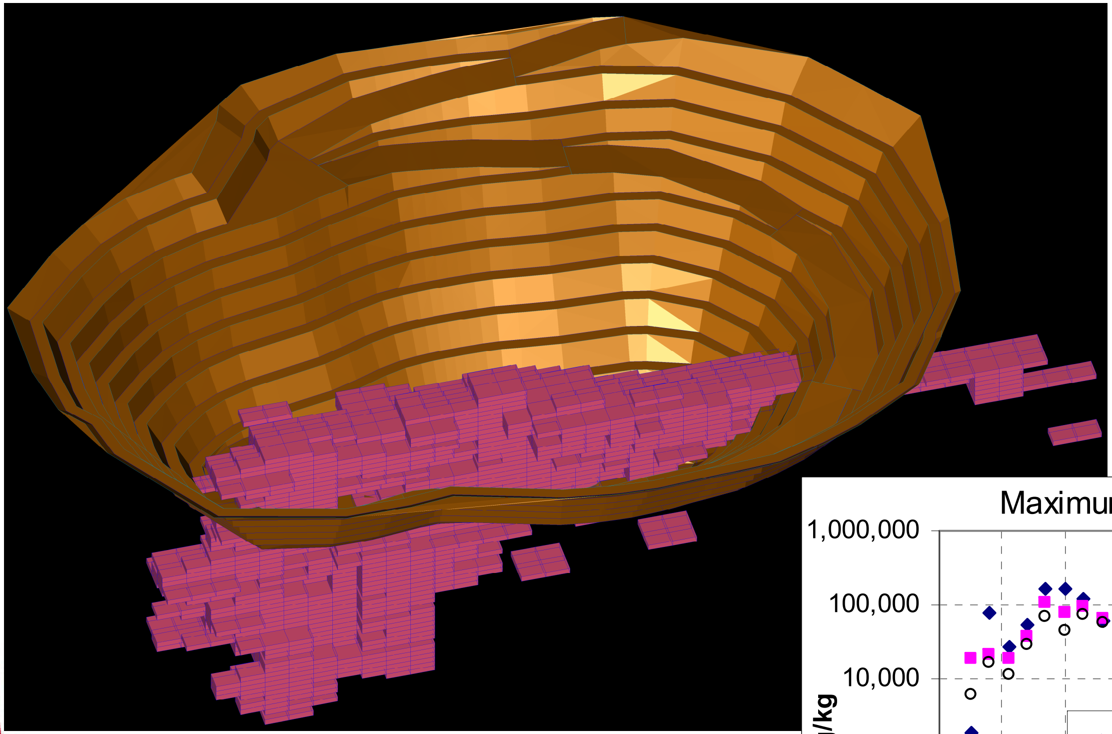


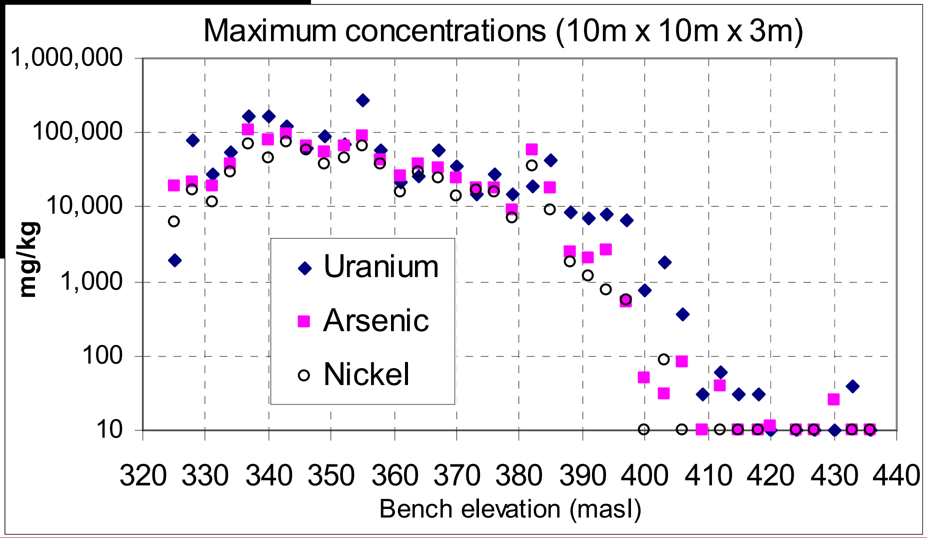


- Correlation independent of age of rock samples

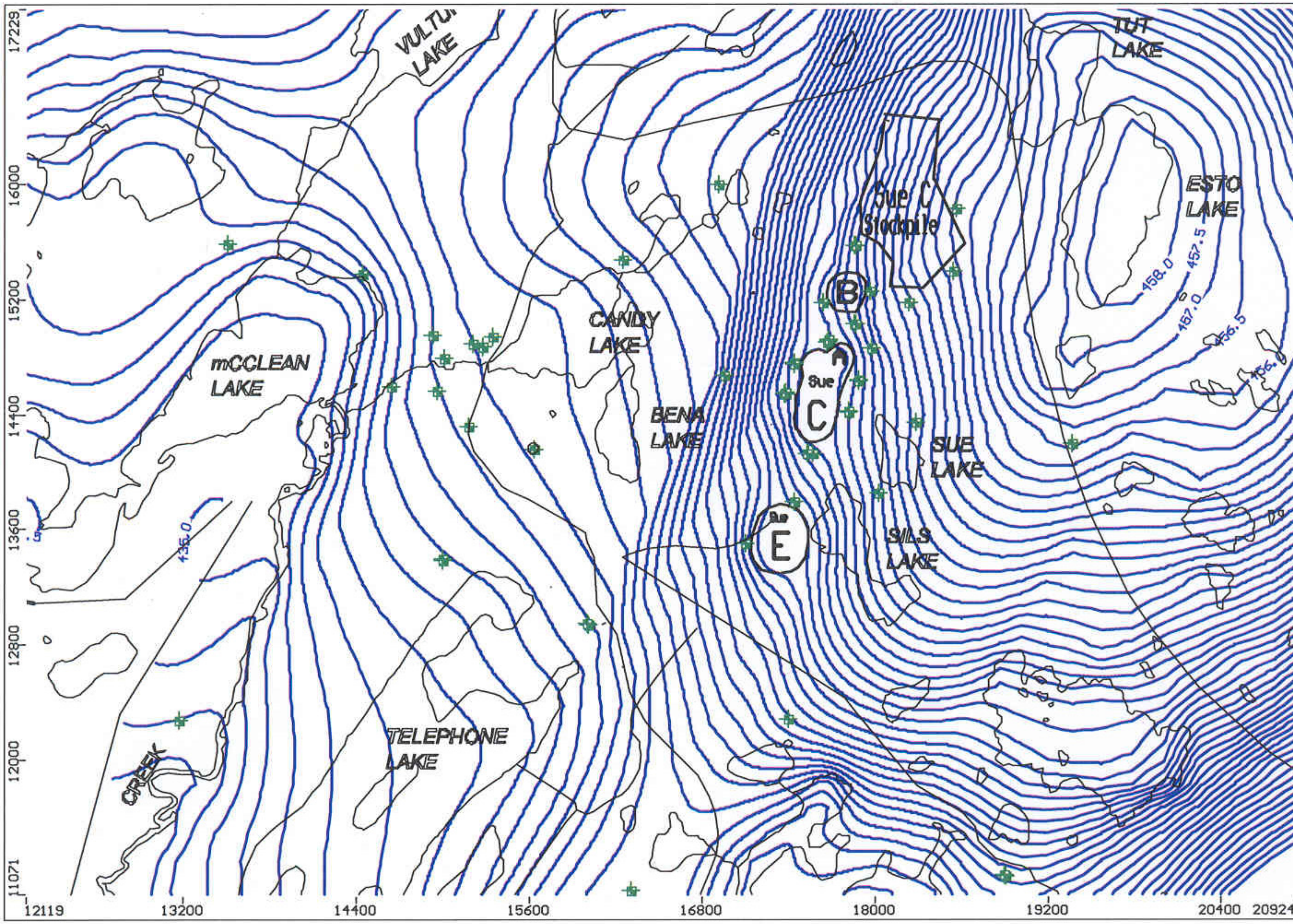
Problematic Waste Rock – Bloc Modelling

- ***Conservative Approach: Assumptions that tend to maximize the amount of problematic waste rock***

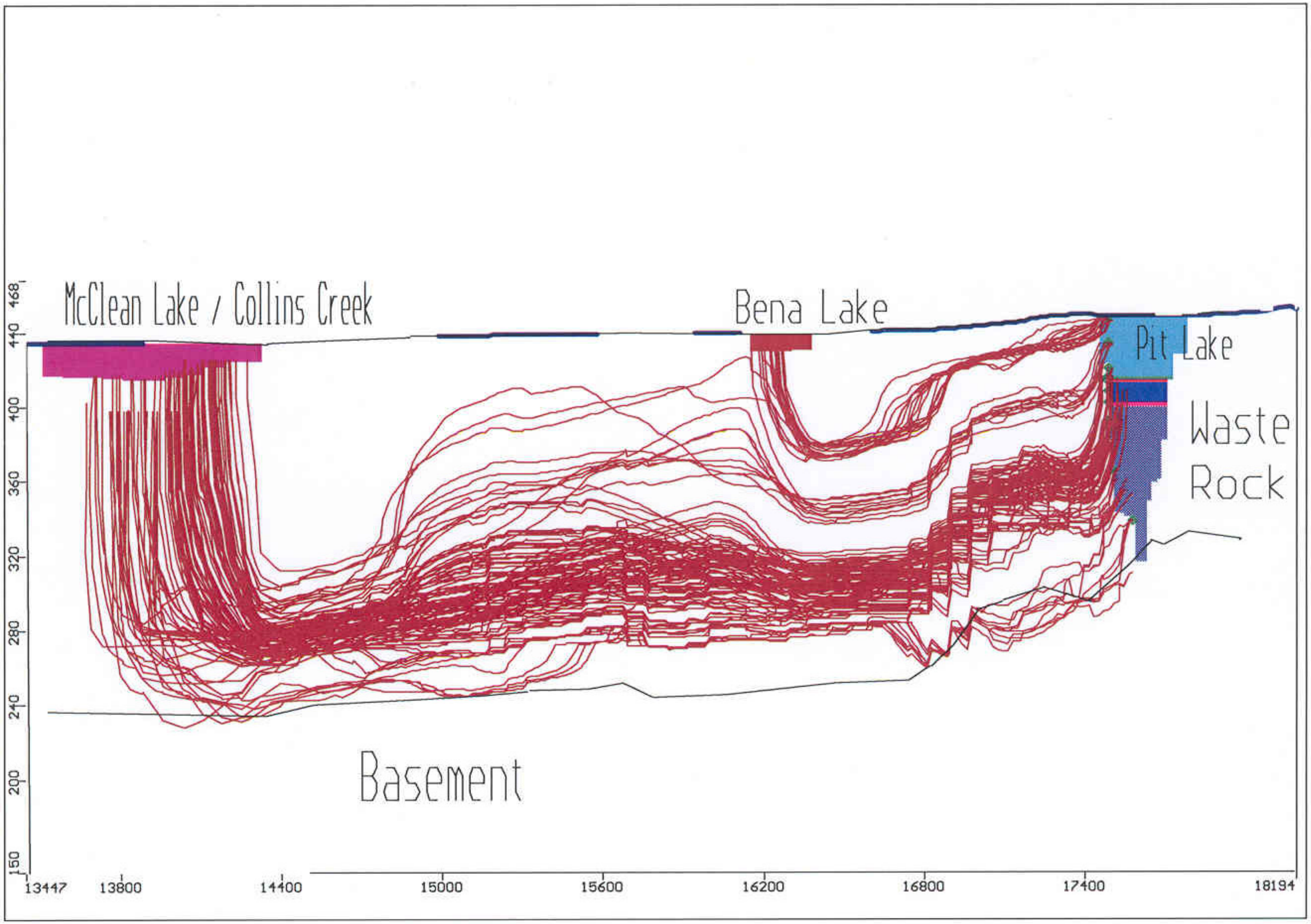




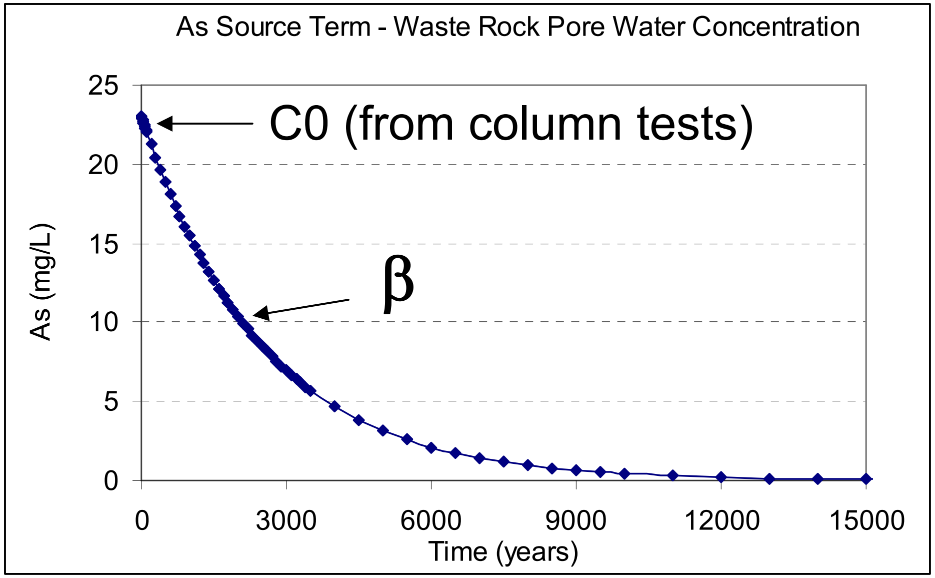
Post Decommissioning – Ground Water Flow Conditions



Post Decommissioning - Particle Path Analysis



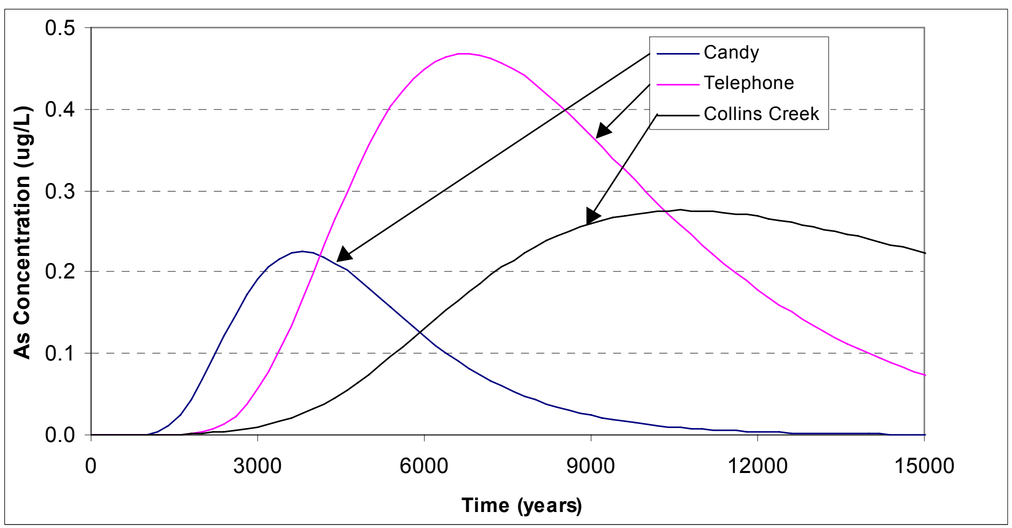
Post Decommissioning – Mass Transport



Typical Source Term Function

Mass released

$$\blacksquare = \int_0^{Tmax} Flow \cdot C0 \cdot \exp(-\beta \cdot t)\, dt$$



Typical Breakthrough Curve

Waste Rock Segregation

- **OBJECTIVES**
  - ***To Minimize the Volume of Problematic Waste Rock to be disposed in pit***
  - ***To ensure that the Clean Waste Rock is Clean***
- **CONSTRAINTS**
  - ***Field Conditions***
  - ***Results in ~ 24 hours***
- **SELECTED APPROACH**
  - ***Sampling of Blast Hole Cuttings***
  - ***Traditional Approach – Radiometric Scanning for U***
  - ***New Development - XRF technology for As detection***

Waste Rock Segregation - Blast Pattern

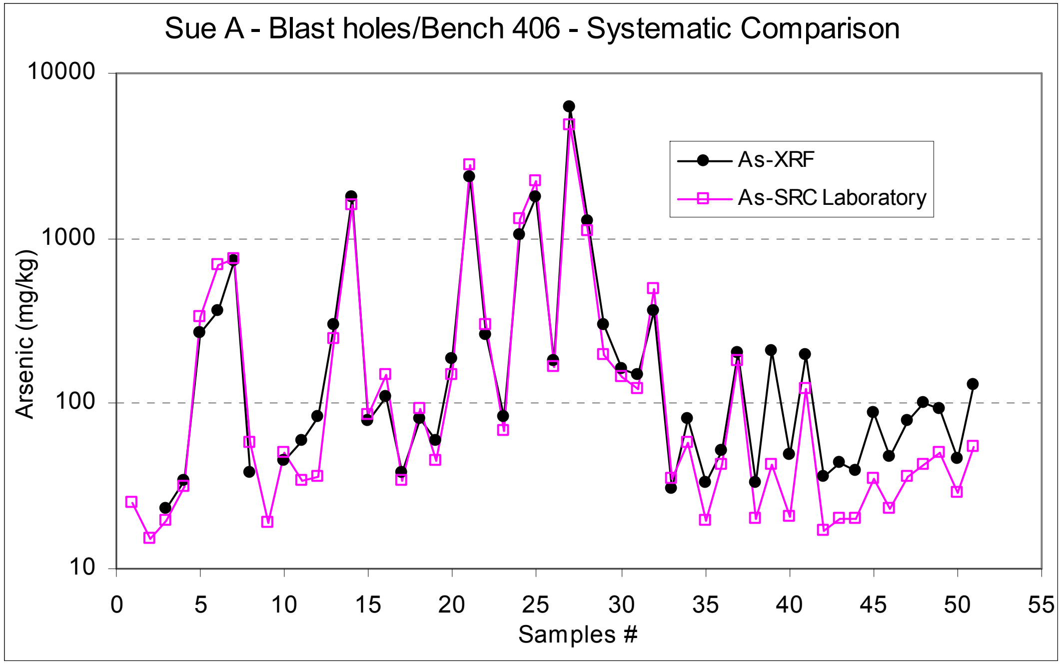
Waste Rock Segregation - Sampling

Field Radiometric Scanning

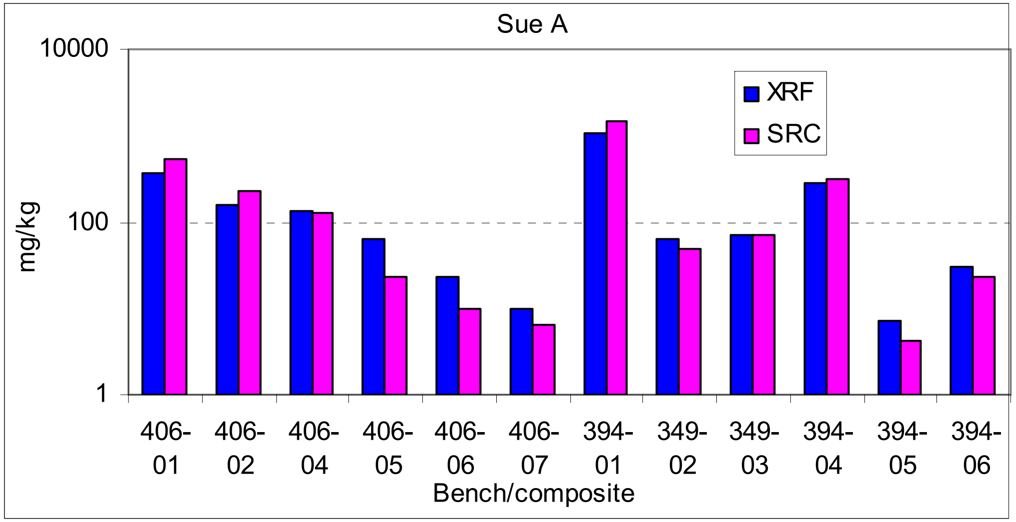
Sampling for XRF Analysis

Waste Rock Segregation - XRF Analyser

Correlation Portable XRF - Laboratory



Arsenic – Sue A Pit



CONCLUSION 1/2

- ***In-pit disposal of uranium mine rock in northern Saskatchewan is the primary strategy for mitigation of acid drainage from potentially reactive mine rock***
- ***However: Arsenic can be leached and subsequently transported in the groundwater flow system when the rock is submerged in water***

CONCLUSION 2/2

- ***Assessment Stage: Conservative Approach to Develop Source Term, Flow and Mass Transport Scenarios***

- ***During Mining: Waste Rock Segregation based on XRF and Radiometric Scanning is a promising approach to optimize waste rock management***