Use of Solubility and Leach Tests in the Prediction of Drainage Chemistry from Weathered Tailings and Waste Rock - Examples from Gold and Uranium Mines

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Introduction

- Leach tests can be applied to a variety of waste to define source chemistry in;
  - Porewater
  - Flooded waste
  - Drainage
- Standardized test procedures may be useful (ie. BC MEM leach test) but modifications may be appropriate for others – depends on geochemical characteristics

The Basics of Leach Tests

- Add water to Solids – Shake (Don't Stir) – analyse water
- Water to solids ratios depend on application
  - 20:1 Common (ie. TCLP)
  - 3:1 recommended in BC guidelines for ARD-ML
- Chemistry modifications to leach water depend on application
  - Mild acid to enhance metal removal
  - Dilute phosphate to enhance arsenic removal
  - Etc….

Outline

- Examples at two mines
- 1 – Weathered Gold Tailings:
  - Mitigate high-sulphide / Acidic tailings by encapsulation in low-sulphide acid-consuming tailings
- 2 – Weathered uranium waste rock
  - Define source chemistry to assess long-term releases to the environment

Gold Mine Tailings – Timmins, ON PJV (Placer Dome / Kinross Gold)

- Typically low-sulphide ores
- Historic milling practice resulted in two tailings streams;
  - High sulphide concentrate / low carbonate
  - Low sulphide / high carbonate
- When recombined in mill, net-acid consuming tailings produced
- When kept separate, high sulphide tailings are acid generating
- Historic acidic tailings require reclamation

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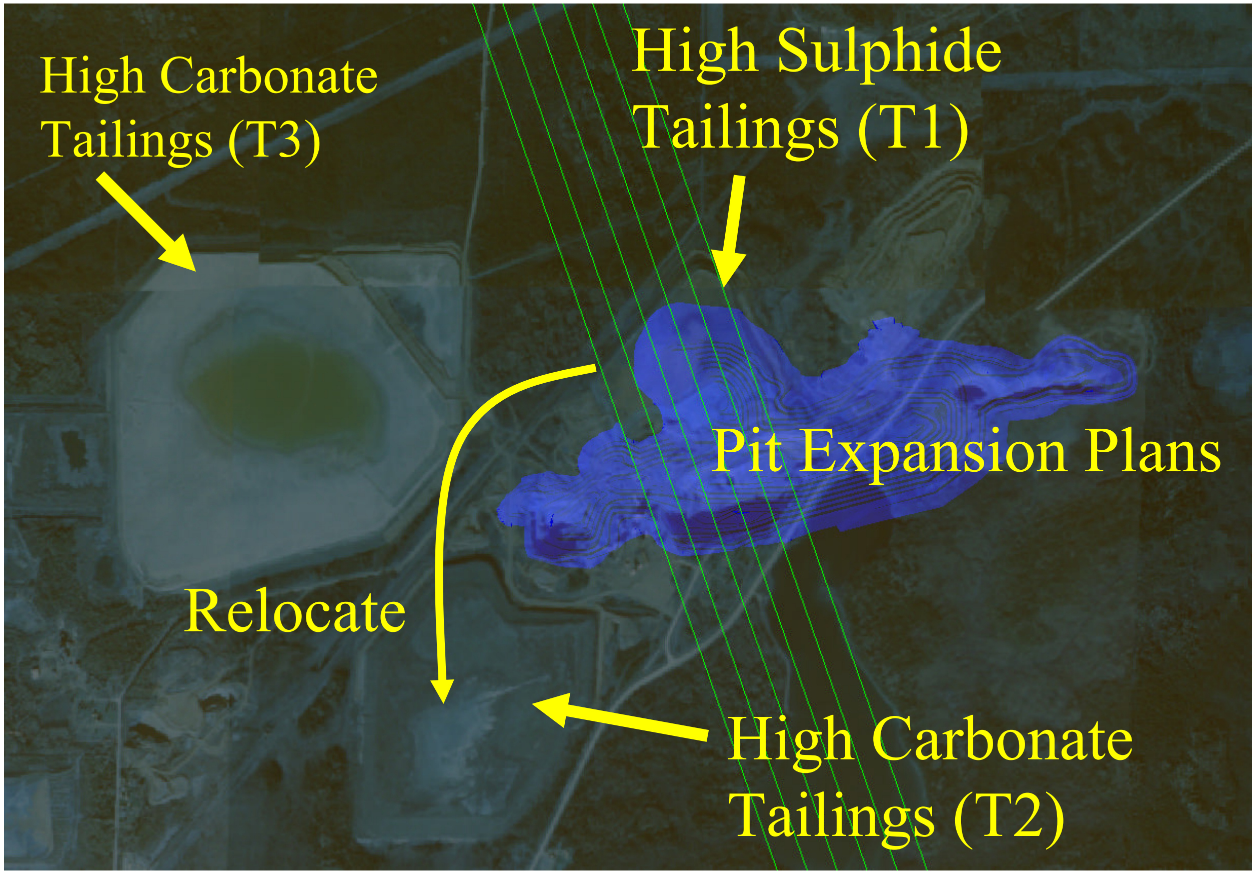
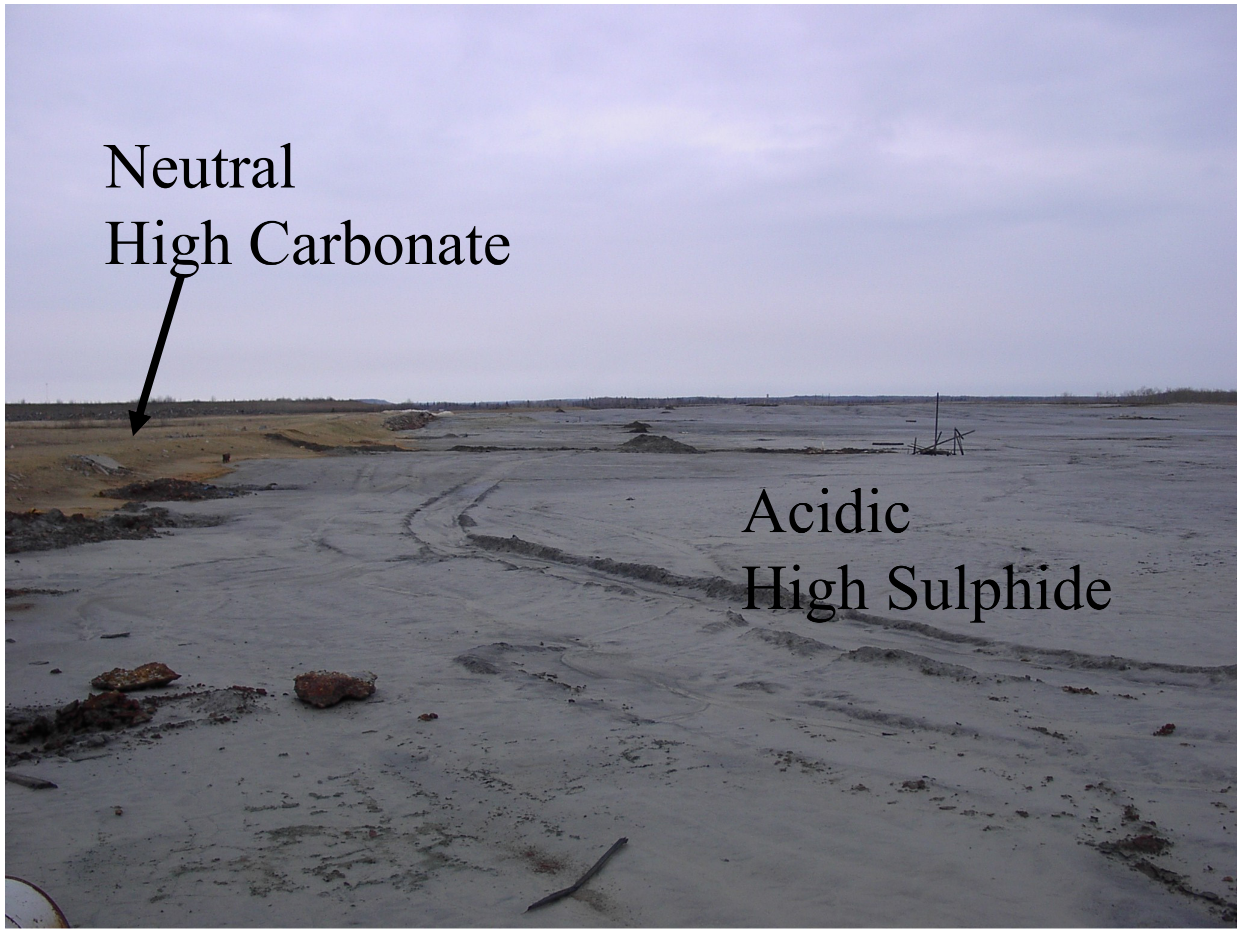
Gold Tailings

- Planned expansion of Pamour pit
- Need to relocate tailings impoundment containing acidic high sulphide material
- Plan to relocate acid generating (high sulphide) tailings (T1) onto acid consuming (high carbonate) tailings (T2)

Pamour Pit Expansion

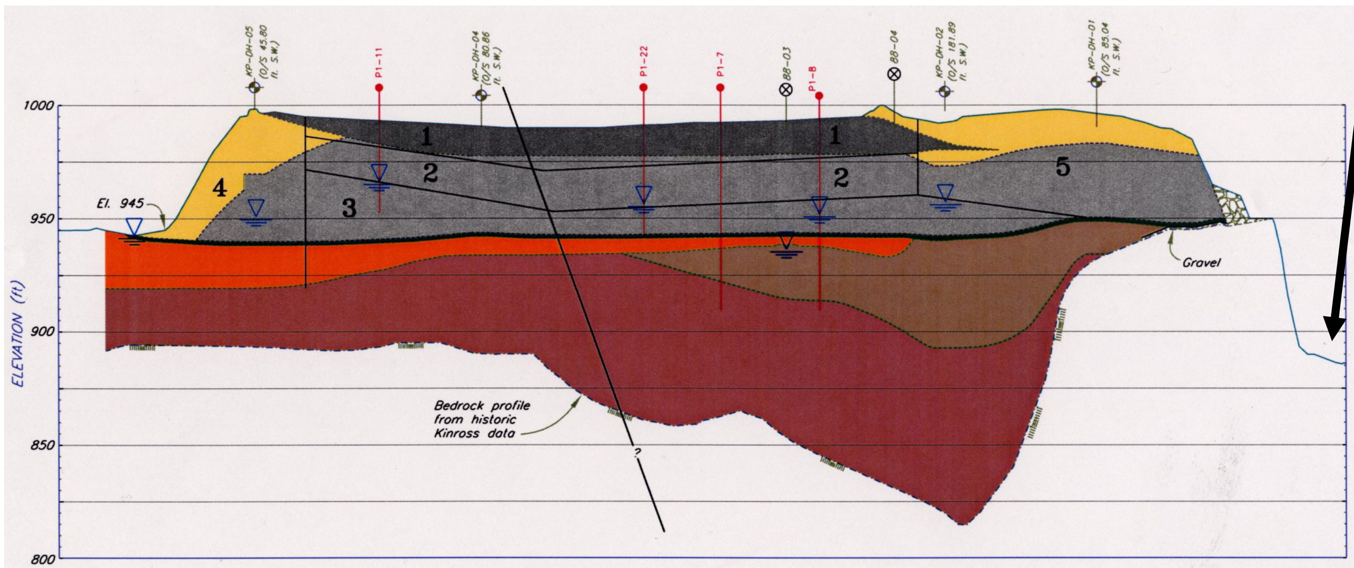


T1 Tailings to be relocated

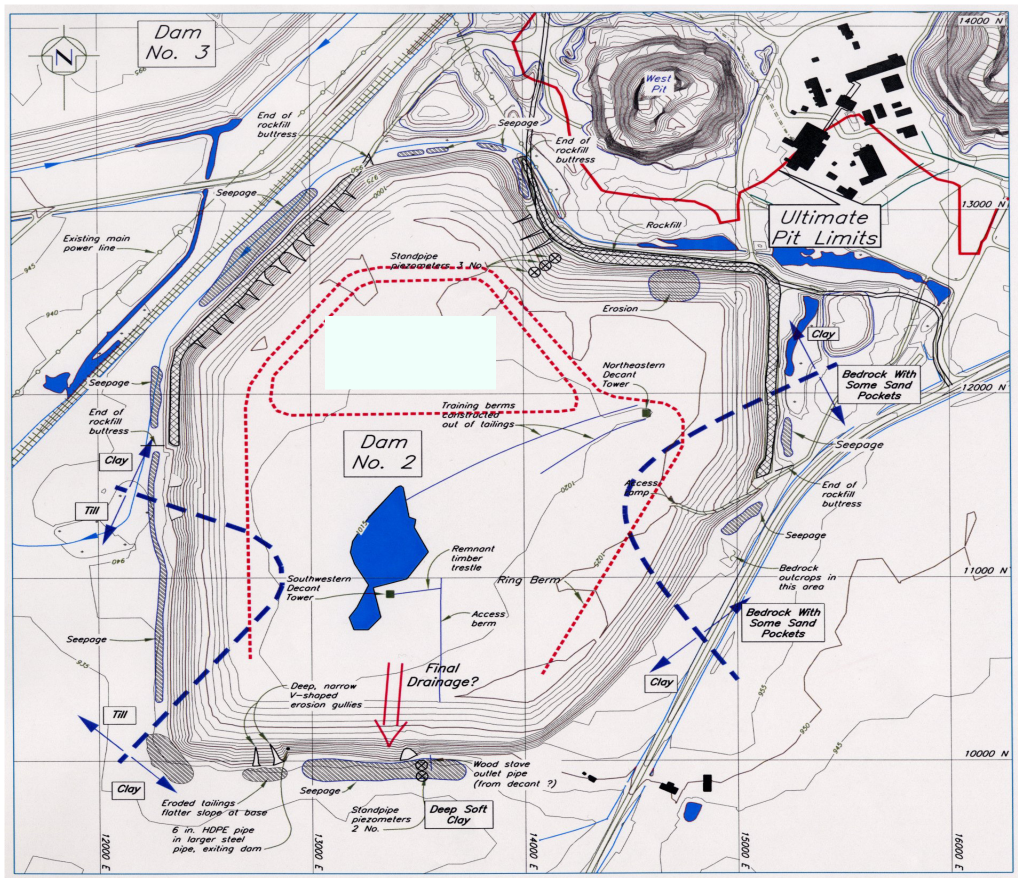


Cross-section – with high sulphide tailings (#1)

Existing Pit



Relocation to Tailings Dam T2



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Design Features for Relocation

- High carbonate tailings to consume/neutralize existing soluble acidity in sulphide tailings
- High carbonate tailings to consume acid produced in future if remaining sulphide oxidizes
- Prevent additional degradation of water quality within high carbonate tailings

Encapsulation Concept for High Sulphide Tailings

	Carbonate tailings Oxygen Barrier	pH > 7
	Oxidized Sulphide tailings	pH 3-7
	Oxidized Carbonate tailings (optional)	pH < 7
	Existing Carbonate tailings	pH 8 - 9

Acid-Base Characteristics

	T1 Sulphide	T1 Carbonate	T2 Carbonate	T3 Carbonate
S (%)	20.4	0.80	0.32	0.21
AP*	491	8.5	4.9	1.2
Carbonate NP*	16.7	148	112	108
NP/AP ratio	0.03	13.9	24	104

Shake Flask Rinse Water Results -pH and Soluble Acidity

Sample Description	pH	Soluble Acidity (mg/L)	Soluble Acidity ($kg\text{-}CaCO_3/t$)
T1 – Oxidized Sulphide Tailing	3.10	6390	17
T2 - Oxidized Carbonate Tailings	6.96	12	0.02

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Soluble Constituents in Tailings

Parameter	Units	Oxidized Sulphide Tailings in T1	Oxidized Carbonate Tailings in T2
pH		3.16	7.86
Acidity	(mg-$CaCO_3$/L)	6015	12
Sulphate	(mg/L)	8655	338
Arsenic	(mg/L)	0.36	0.039
Iron	(mg/L)	280	0.019
Nickel	(mg/L)	114	0.065
Zinc	(mg/L)	117	0.054

Mixing Tests

- Screening tests developed to assess potential benefits of reacting high carbonate tailings with acidic water from high sulphide tailings
- 1:1 mixtures of tailings
- 3:1 water to solids / 24 hour agitation

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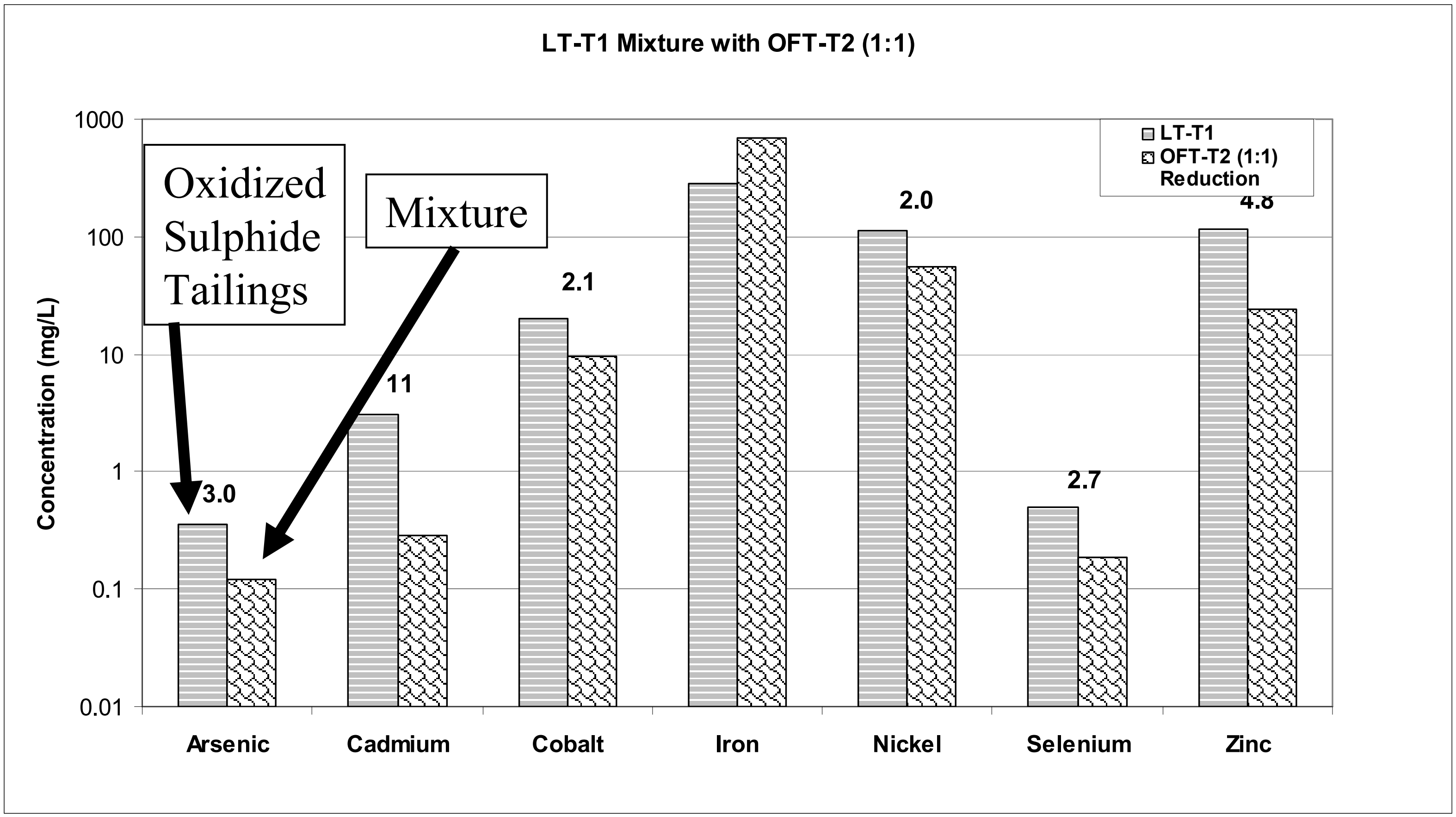
Results of Mixing Tests



Follow-Up

- Additional percolation tests through carbonate tailings showed excellent attenuation and reduction of metal concentrations
- Modelling of concept verified appropriateness of cover layer thickness
- Additional laboratory tests proposed to verify water quality effects
- Field monitoring planned in 2006 after relocation

Uranium Mine Waste Rock McLean Lake and Cluff Lake AREVA (Cogema Resources)

Waste Rock

- Waste rock from two sites considered
  - Weathered acidic low-sulphide rock that has leached Nickel and Uranium
  - Fresh rock destined for underwater disposal (in-pit) – high in Arsenic and Nickel
- Objectives:
  - Determine leachable mass from rock
  - Develop source functions to assess release from pit containment facility

Final Disposal in Backfilled Pit

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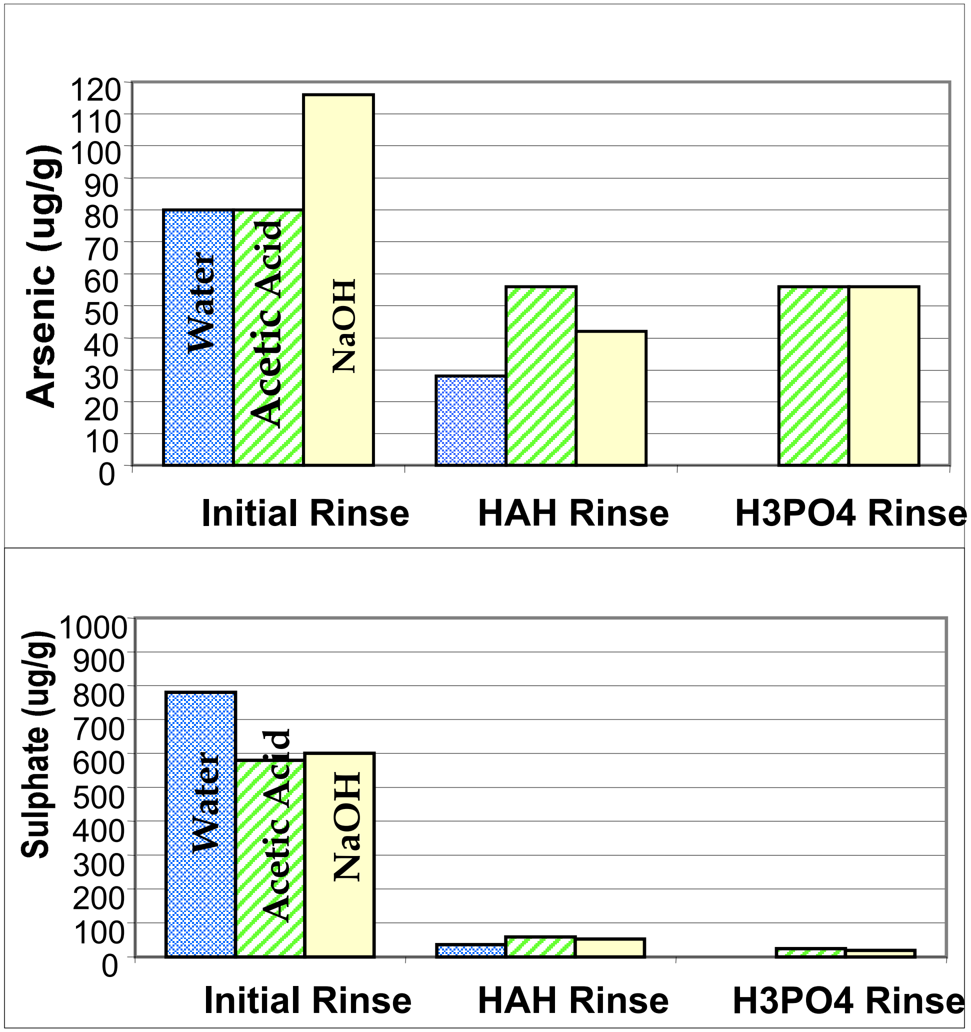
Example Results of Sequential Leaching for Arsenic from Fresh Waste Rock

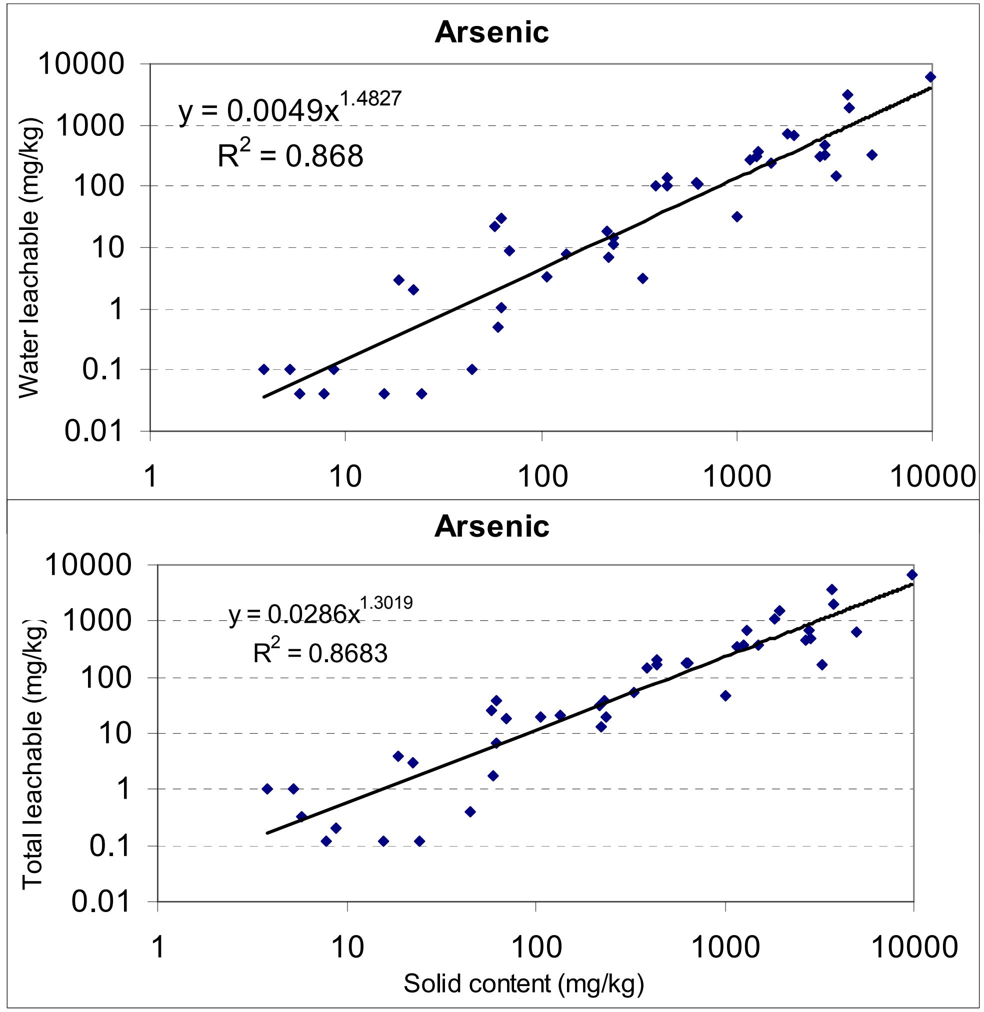


1st Rinse 2nd Rinse 3rd Rinse

Water and Total Leachable Arsenic

Final Leach Protocol

-2 Water Rinses
-2 Phosphate Rinses



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Underwater Tests

- Estimate porewater concentrations

- Test changes in concentration with flushing (simulate porewater replacement in pit)

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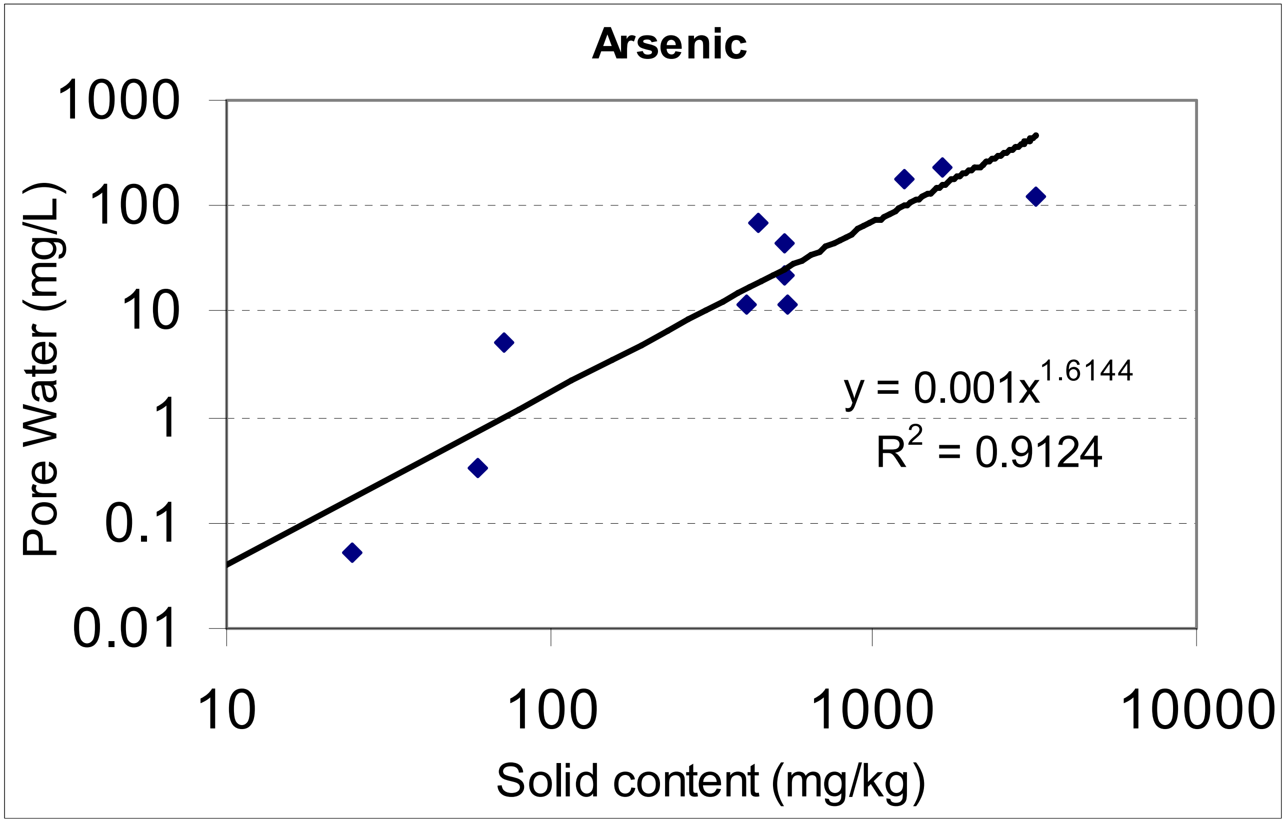
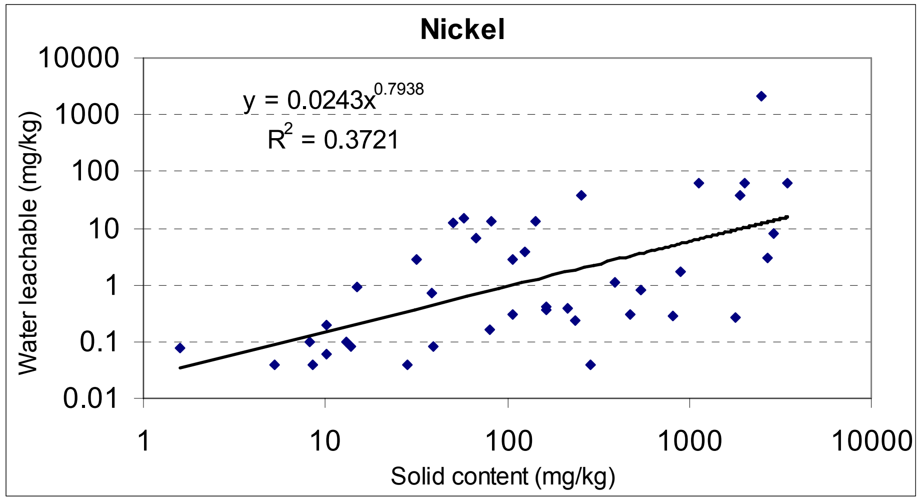
Initial Porewater Concentrations for Arsenic in Flooded Rock

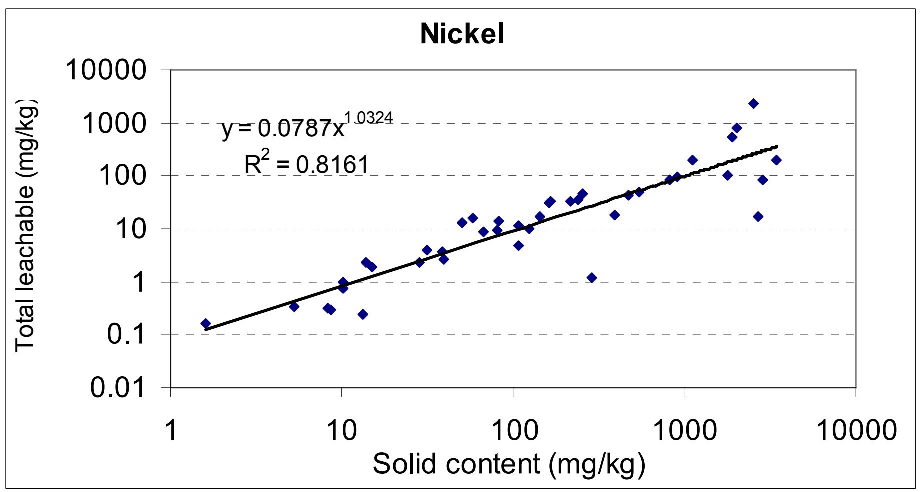


Weathered Rock – Nickel / Uranium

Sample	Water:Solids	pH	Nickel Water Leachable (mg/kg)	Nickel Total Leachable (mg/kg)	Uranium Water Leachable (mg/kg)	Uranium Total Leachable (mg/kg)
CWR - T1	20:1	3.18 - 4.75	18.5	23.6	35.3	49.2
CWR – T1	3:1	3.71 - 4.19	19.5	21.8	35.7	38.2
CWR - T3	20:1	3.06 - 4.67	4.4	5.8	33.2	48.8
CWR - T3	3:1	3.70 - 4.39	4.3	4.5	35.3	36.2

Water and Total Leachable Nickel





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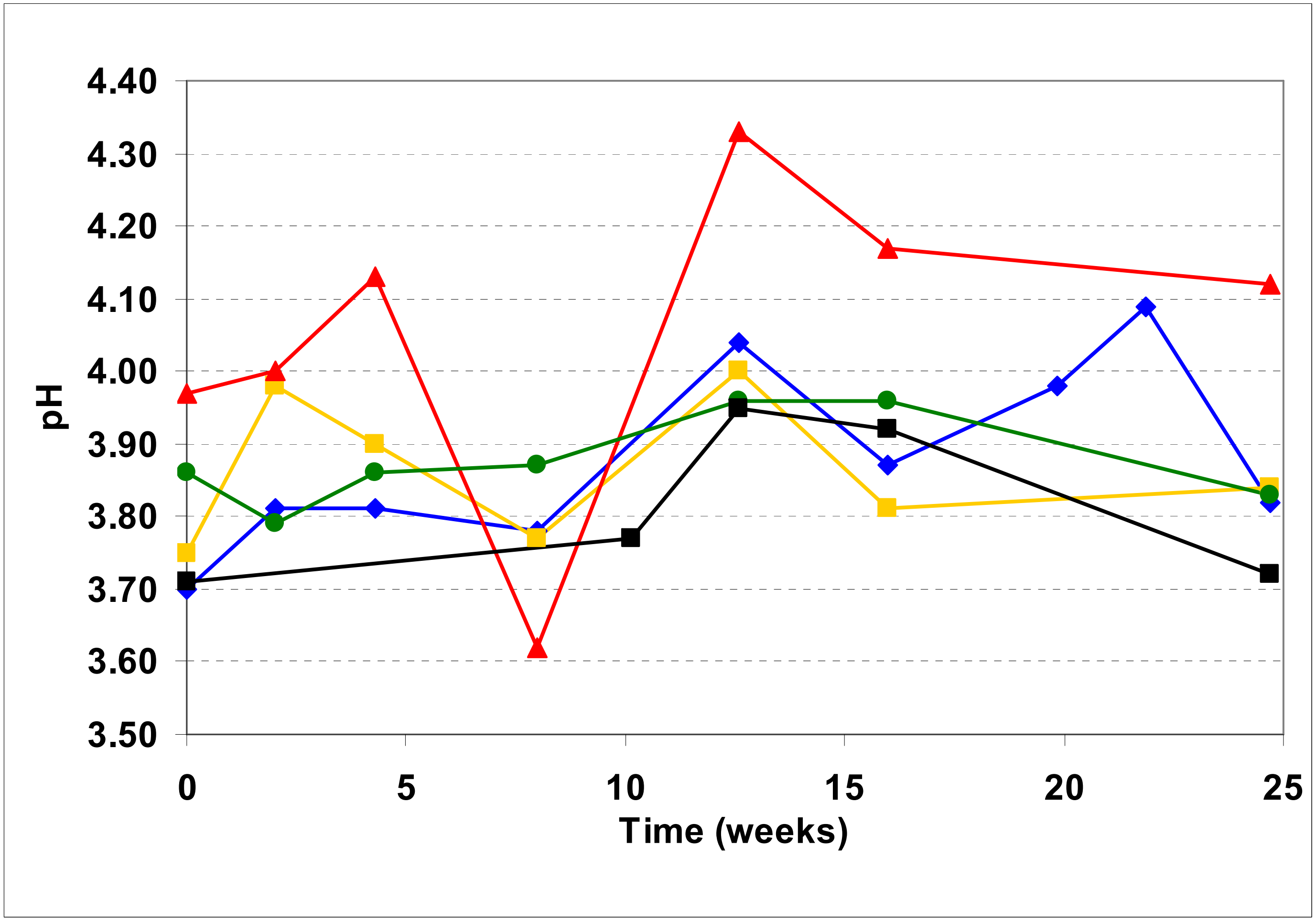
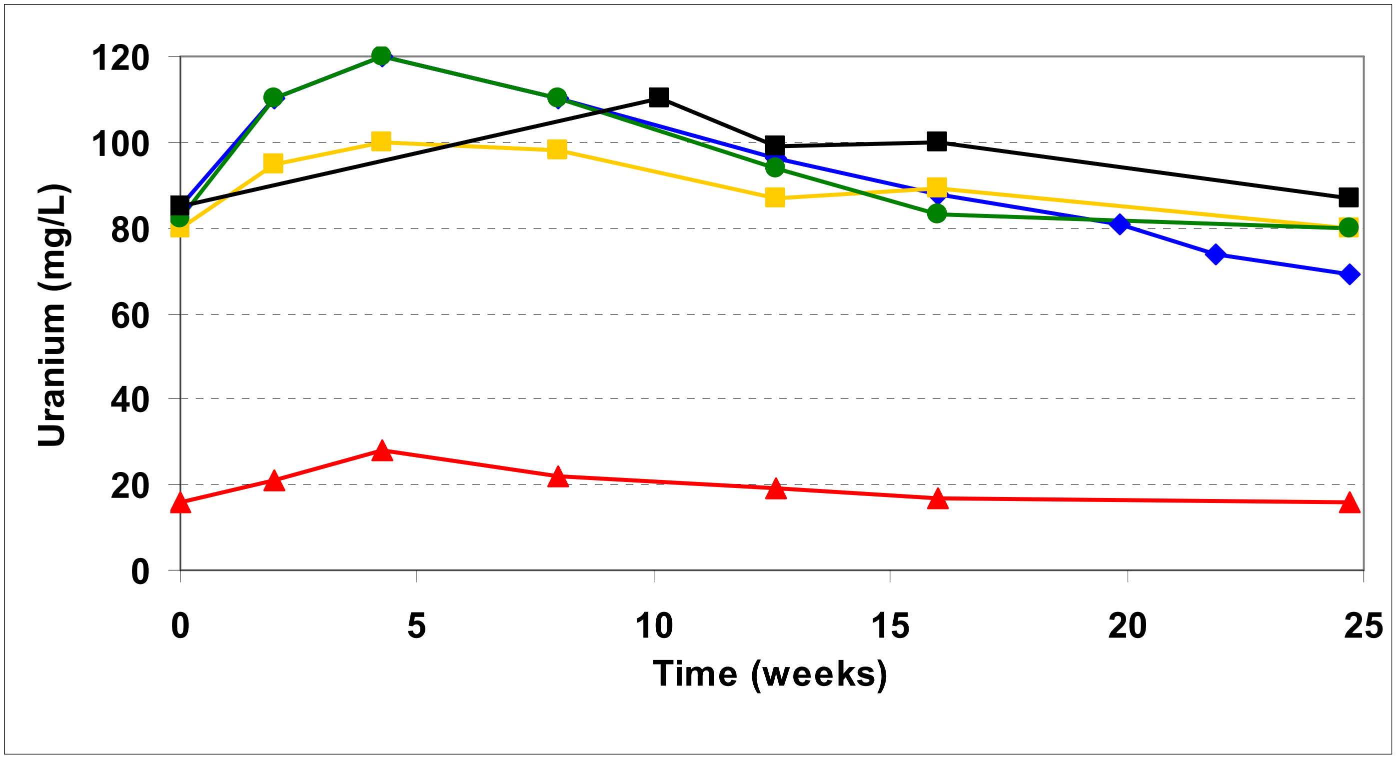
Column Tests
pH of Porewater in Flooded Rock



Column Tests
Uranium Concentrations in Porewater of Flooded Rock



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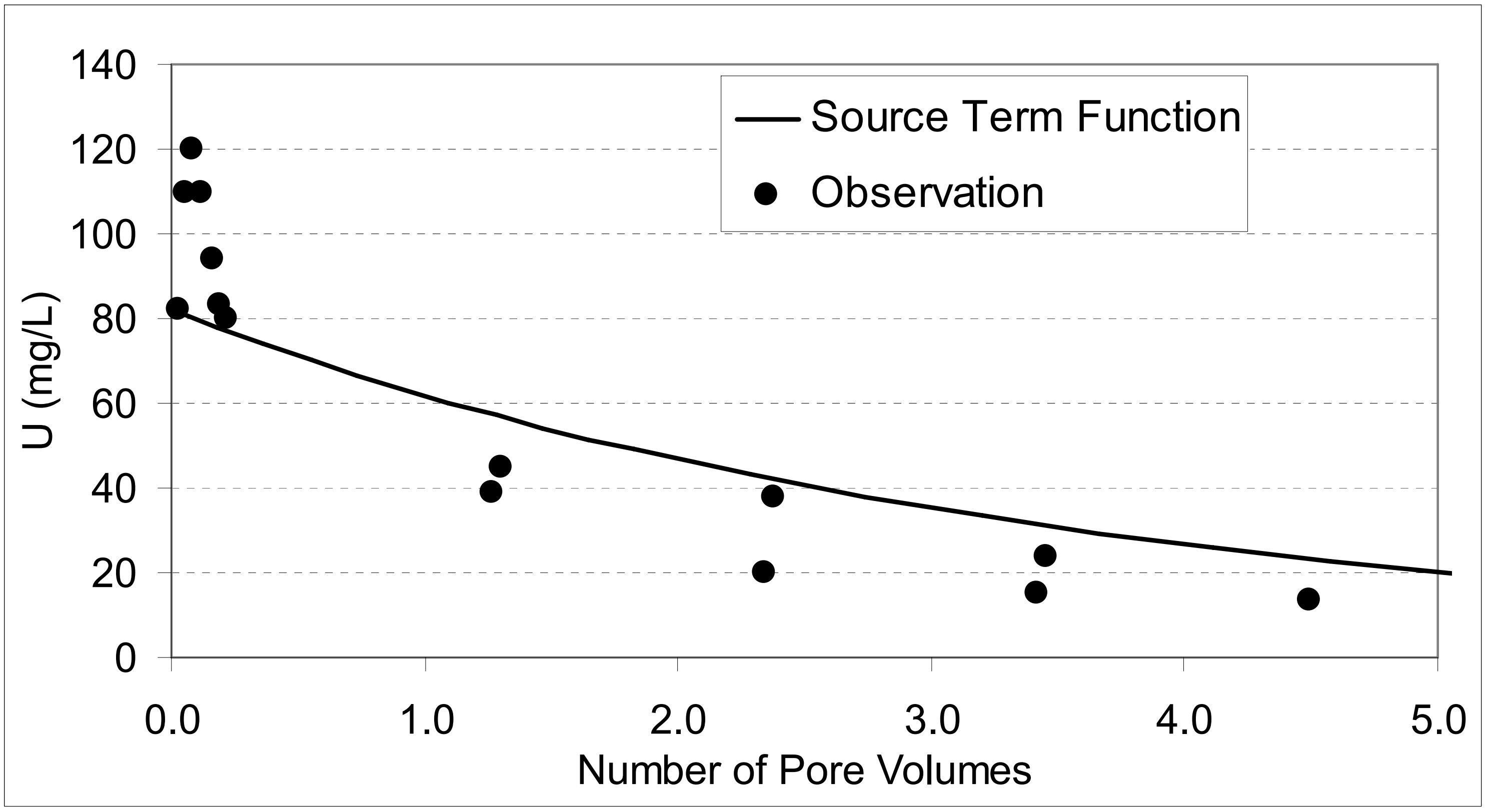
Uranium Concentrations in Porewater as Pore Volumes Replaced – Data and Model



Concluding Remarks

- Leach tests can be applied for a variety of needs related to mine waste management and options assessments
- Most applications pertain to weathered materials but may be appropriate for non-weathered as well
- Useful for mass balance and when complemented with other tests provides source term functions to assess releases to receiving environment – predict impacts
- Simple tests – useful and practical information