Combining In Situ Treatment and Active Water Treatment: Case Study at Schwartzwalder Uranium Mine

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Talk Overview

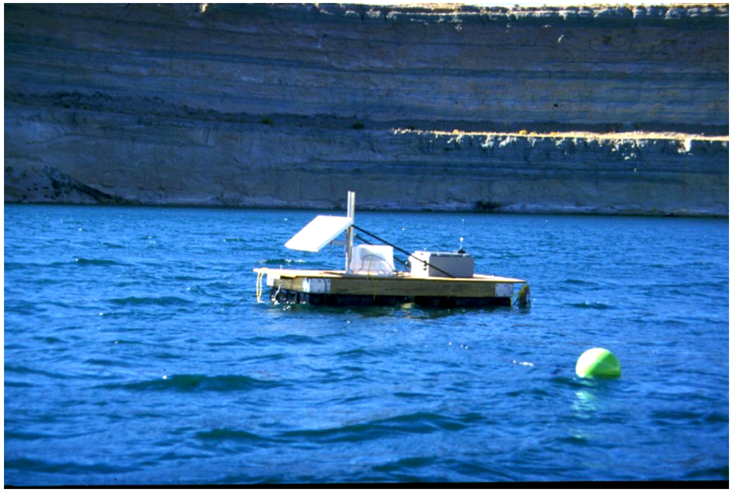
- In Situ Treatment: methods and applications for mines
- Schwartzwalder Mine history and water treatment process considerations
- In Situ Pretreatment at Schwartzwalder
- Active Water Treatment Process at Schwartzwalder
- Reverse Osmosis combined with In Situ Treatment
- Discussion

In Situ Treatment Applications

- **Primary water treatment**
  - To achieve a licence/permit discharge standard
- **Pretreatment**
  - To reduce constituent concentrations, reduce reagent requirements, or improve constituent ratios, or reduce the number of constituents requiring active treatment
- **Treatment waste product disposal**
  - To increase permanence of disposal, reduce costs of disposal, allow waste to be stabilized on site

In Situ Treatment Settings

- Open pit lakes
- Pond settings (tailings, seepage toes)
- Underground mine workings
- Groundwater affected by mine sources (wherever there is a hydraulic driver)



In Situ Treatment Examples

- **Primary water treatment**
  - Sweetwater Mine (Se, U), Silver King Mine (Zn, Cd), Cr plumes
- **Pretreatment**
  - Platoro Mine (As, Zn), 15 in-heap leach facilities (CN, N species, metals), Schwartzwalder Mine (U, Se, Mo)
- **Treatment waste product disposal**
  - Platoro Mine (Fe coagulation (As), lime precipitation (Zn, Mn, Fe) sludge), Schwartzwalder Mine (U, Se, Mo in RO concentrates)

Why In Situ Treatment?

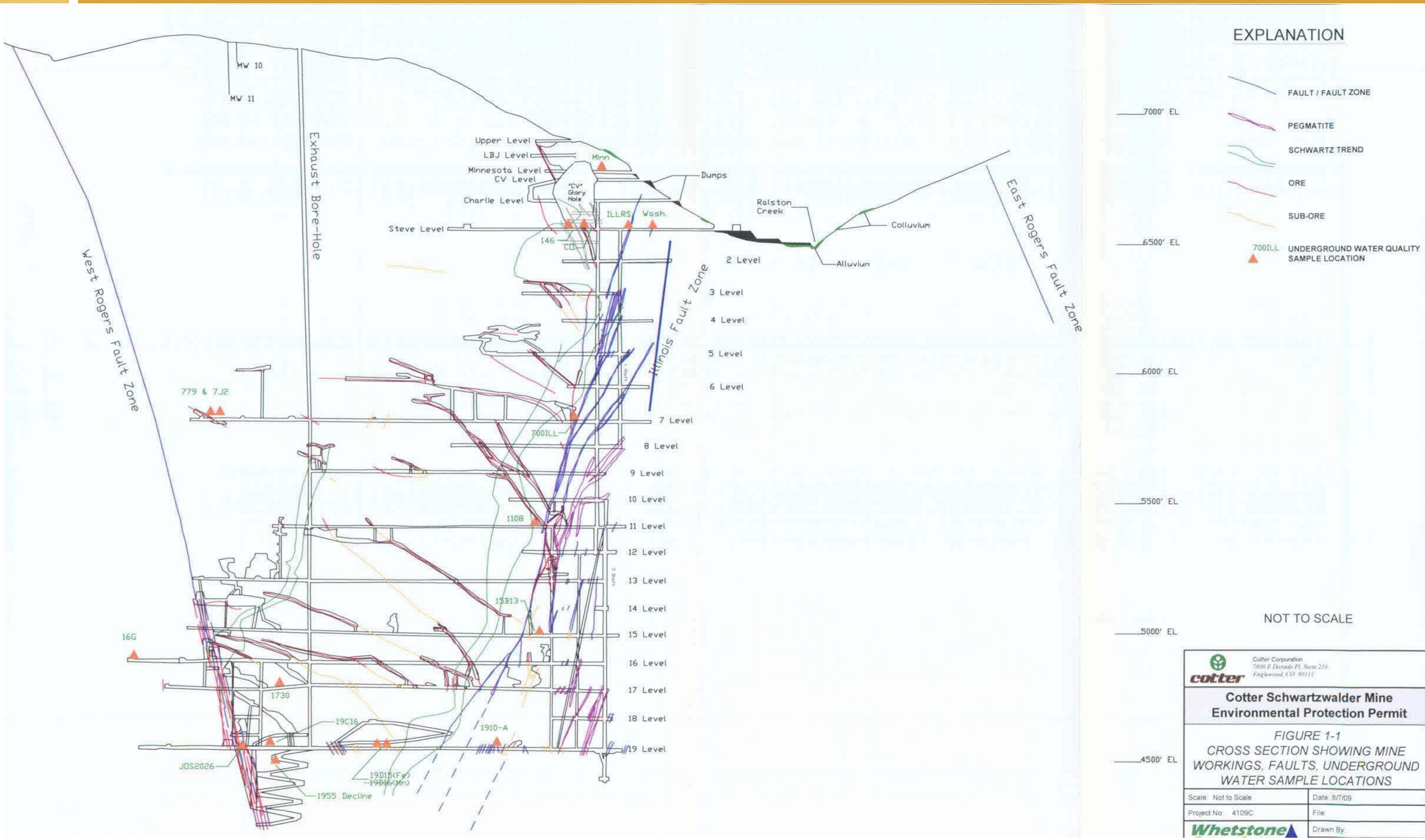
- Typically lower capital costs than active water treatment because mine infrastructure (pit, u/g workings) is reused as the treatment vessel
- Anaerobic conditions can be created at source:
  - Benefit of preventing oxidative leaching
  - At site of in situ treatment: elevated Fe^{2+}, alkalinity, DOC, sulphide, and some reductively dissolved trace metals
  - Trace metals precipitated as metal sulphides
- Treat source rather than wait till contaminant is collected
- Geochemical gradients (compare to stirred reactors)
  - Fe^{2+} to Fe^{3+}, Mn^{2+} to $Mn^{3+/4+}$, pH and alkalinity gradients (CO_2 off-gassing)
- Enhances engineered controls (covers, water diversions, backfill, etc.)
- Enhances active treatment performance (if still required) because reduced sludge production, better Fe/trace metal ratio

Schwartzwalder Mine History

- Discovered by janitor Fred Schwartzwalder in 1949 near start of cold war; vein deposit
- Pitchblend mineral (UO_2/U_3O_8) hosted in gneiss, schist, quartzite
- Drove first adit 1953, produced 1955, and by 1957 was largest U mine in US
- 99% of Colorado U production came from Schwartzwalder U Mine
- 17 million lbs. U produced; 16 million lbs. U reserves
- Closed down in 2000
- Dewatering stopped in early 2000's

Schwartzwalder Mine, Colorado

Schwartzwalder Mine



Headlines You Don't Want

OPINION > EDITORIALS

Cotter, clean up your mine

By **THE DENVER POST** | newsroom@denverpost.com

September 24, 2010 at 11:38 am

NEWS

Colorado regulators order Cotter to do more to stop uranium contamination of water

By **KAREN CRUMMY**

PUBLISHED: September 28, 2011 at 4:25 pm | UPDATED: May 2, 2016 at 8:07 am

Water Treatment Selection Process at Schwartzwalder Mine

- During operations, water treatment of dewatering water was part of U recovery process (IX resin)
- Upon receipt of order to start treatment, IX was installed for alluvial groundwater (mixed stream, waste rock, and mine water influence)
- IX resin fouling from Ca/Mg hardness, high Fe/Mn with alluvial water
- IX resin fouling much worse with mine water (3x higher hardness)
- RO with in situ pre-treatment was authorized as remedy to provide hydraulic control of the mine

Reverse Osmosis Objectives

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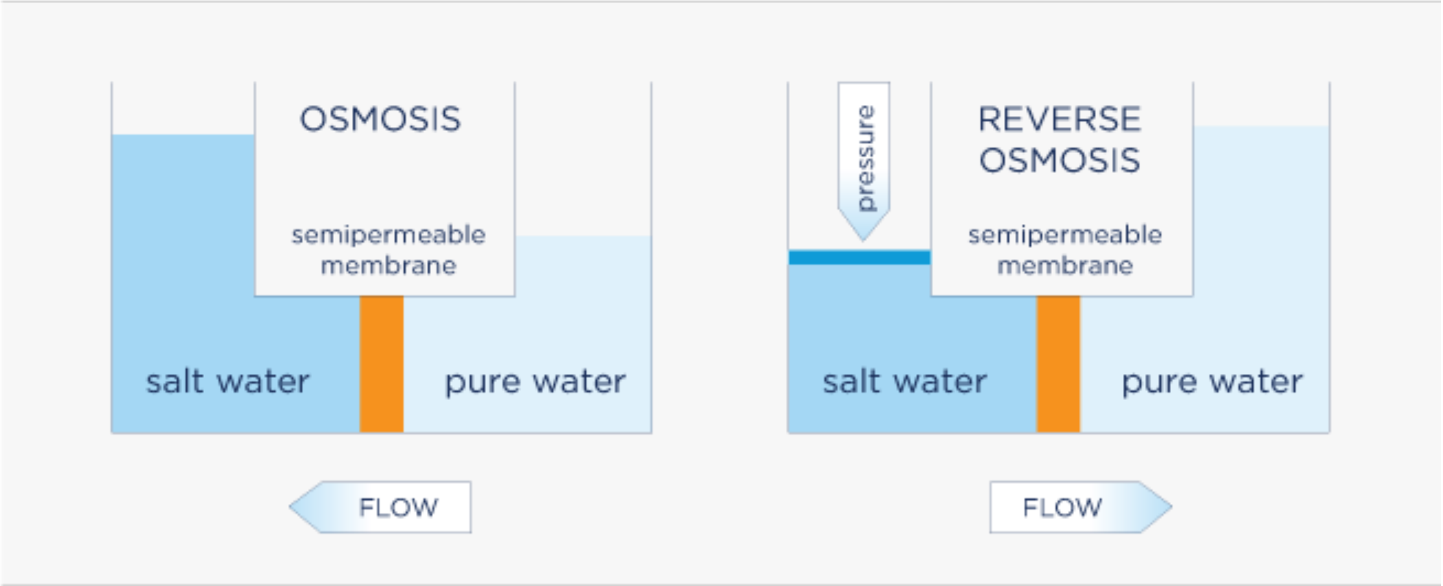
- Dewater mine to at least 150’ below Steve level; discharge at less than 30 µg/L U (i.e., 99.9% reduction)
- Maintain hydraulic control over the mine as alluvial fill is cleaned up
- Maintain hydraulic control until final remedy is implemented



RO Concentrate Disposal Options

- Surface water discharge
- Land Application (e.g., irrigation, road de-icing, dust control)
- Public works (sewer, etc.)
- Further concentration (evaporation, dryer/ concentrator/filter, secondary membrane treatment, VSEP, etc.)
- Deep well injection

Why In Situ Treatment

Before Treatment Average (8 samples 2011-2013)

- Uranium 25.75 mg/L
- Molybdenum 1.30 mg/L
- Selenium 0.118 mg/L

Benefits Summary: Pretreatment and Brine Disposal

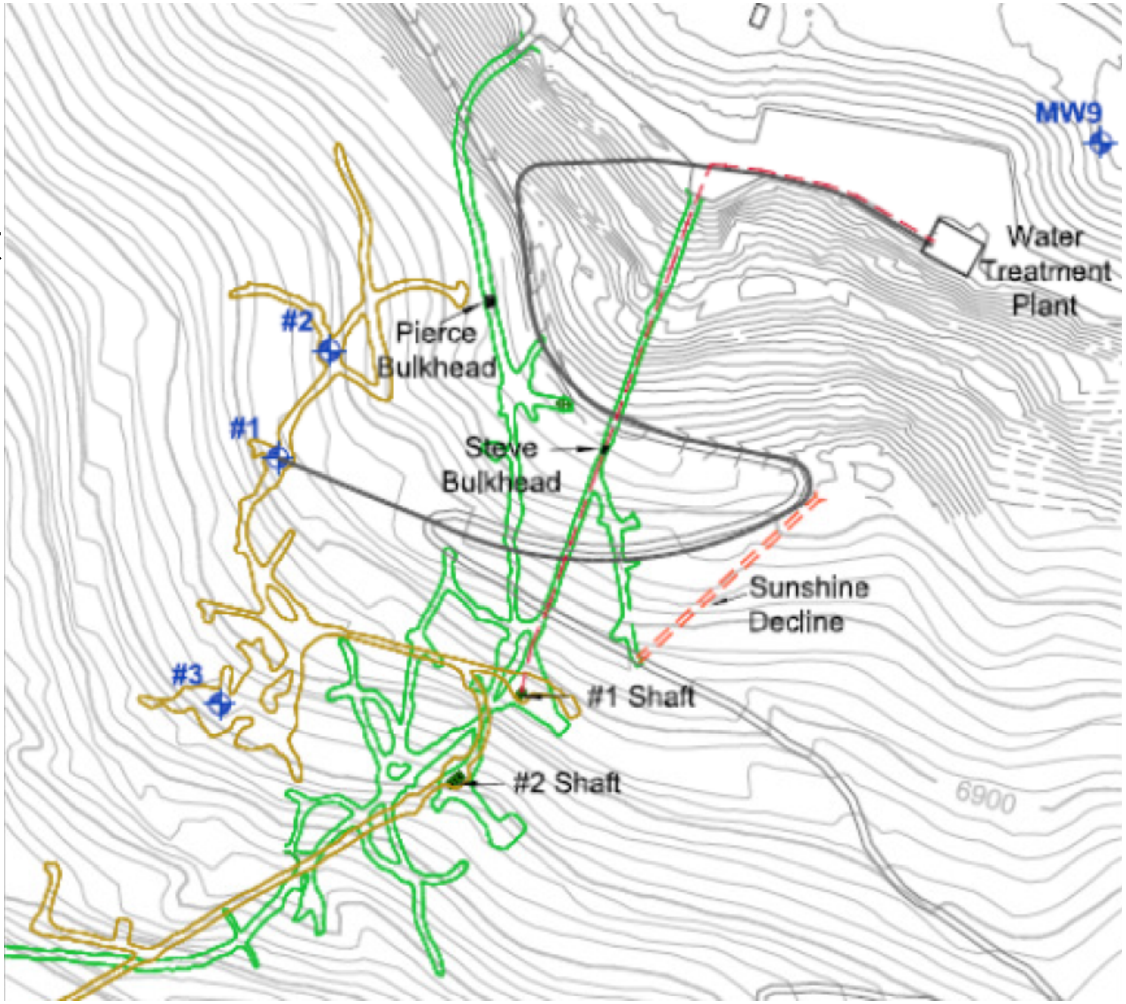
- Provides lower starting point for RO
- Increases certainty achieving discharge criteria
- Allows for on-site RO concentrate management
- Prevents buildup of constituents of concern in mine pool

In Situ Pre-Treatment of Schwartzwalder Mine

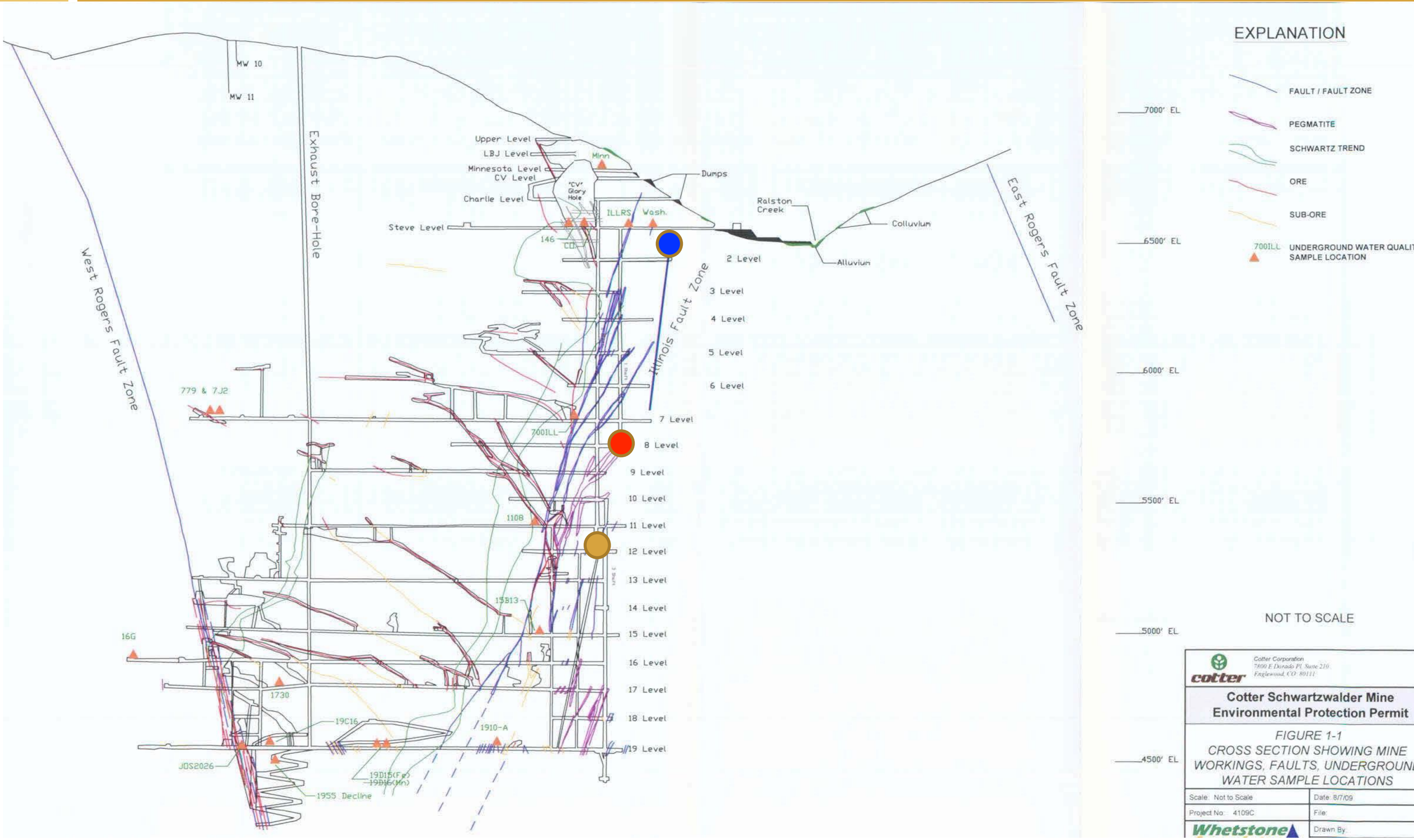
- Objectives:
  - Reduce RO feed concentration of U, Se, Mo
  - RO reject averages 99.4-99.7% of constituents
  - Initial concentration: 25 mg/L U, 1.3 mg/L Mo, 0.12 mg/L Se
  - Interim goals of in situ treatment: 3 mg/L U, 0.2 mg/L Mo, 0.05 mg/L Se
  - Goal was expressed in terms of dissolved constituents since any discharge would involve filtering process

In Situ Layout

- Pumped from #2 Shaft (~300' bgs)
- Reinject in #1 shaft (800'deep), #2 shaft (1160') or open stope behind bulkhead



Schwartzwalder Mine



Pretreatment Target Locations

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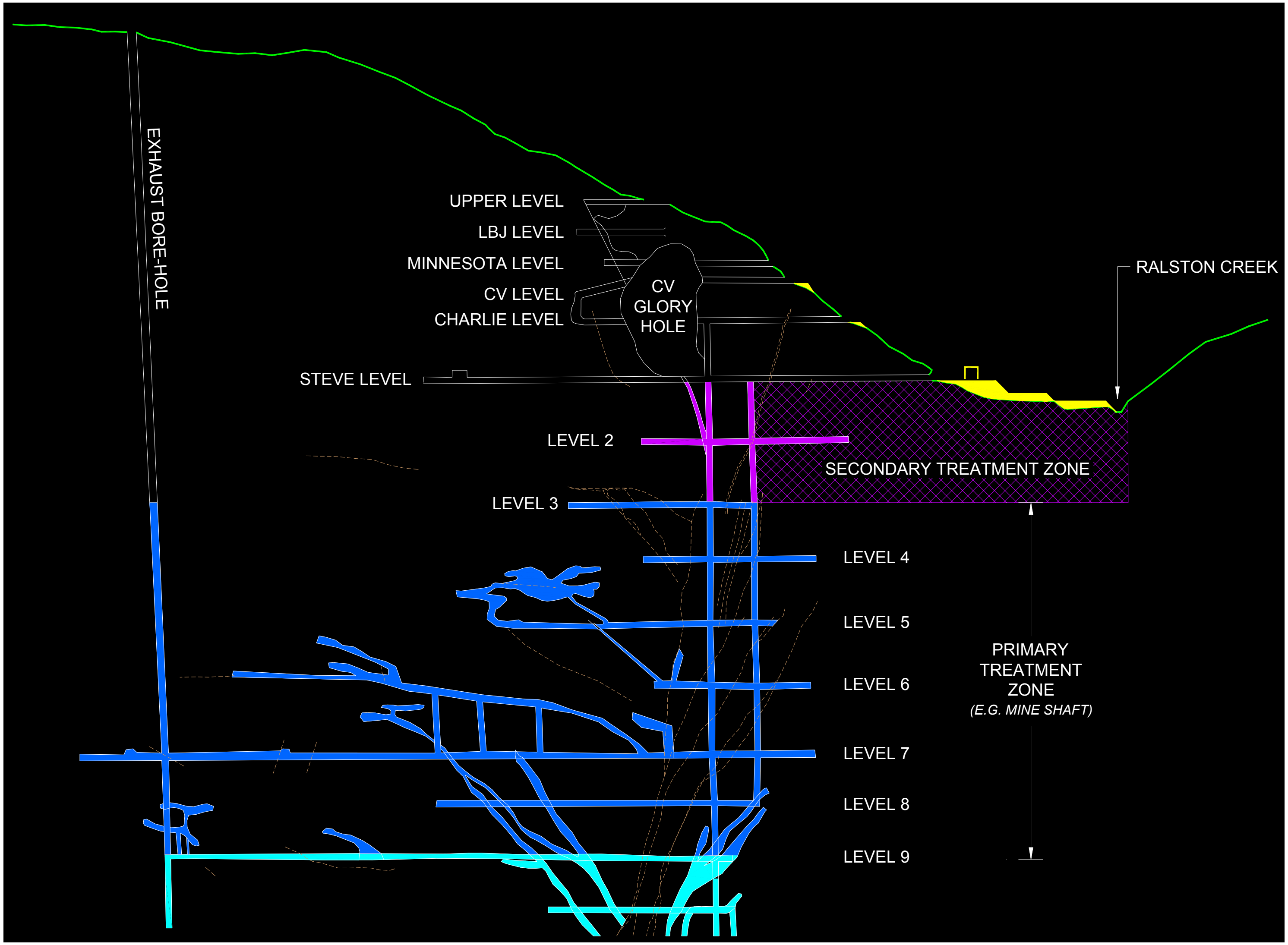


Pretreatment Results: First 4 Months

Before Treatment Average
(8 samples 2011-2013)

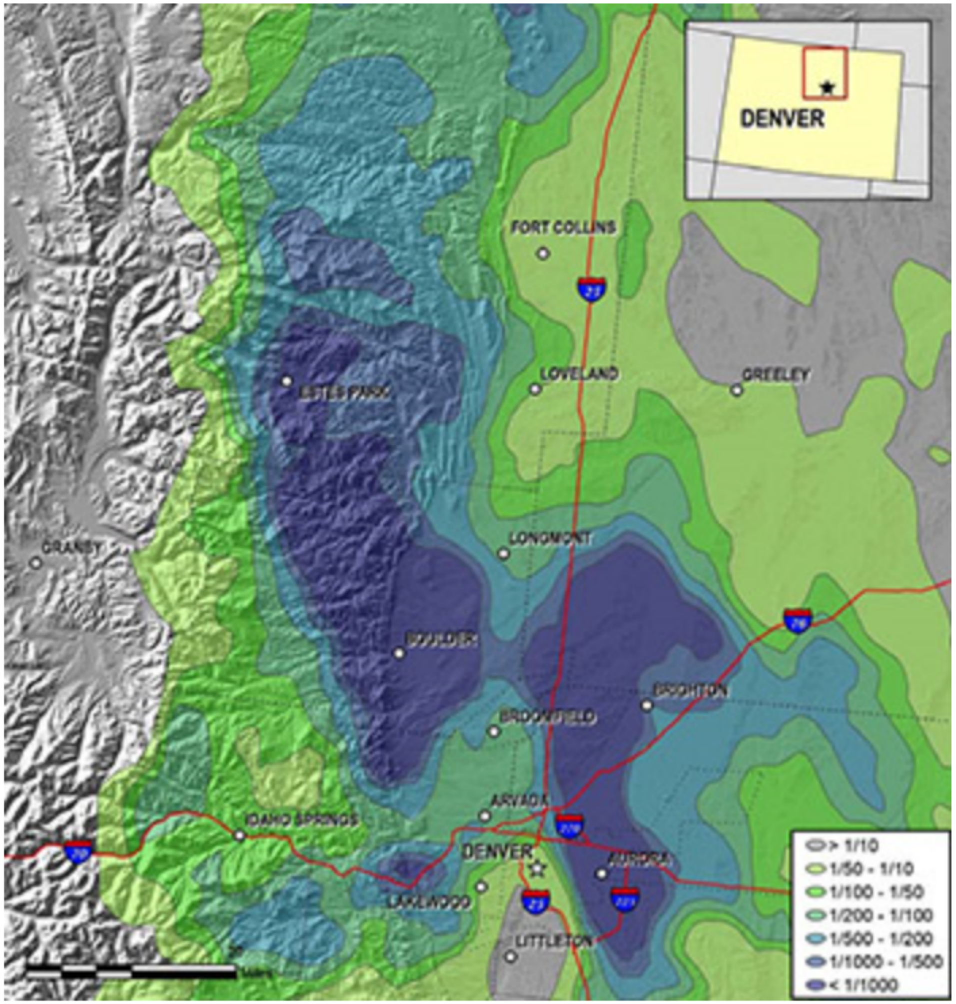
- Uranium 25.75 mg/L
- Molybdenum 1.30 mg/L
- Selenium 0.118 mg/L

After Treatment Average
(8 samples August-December 2013)

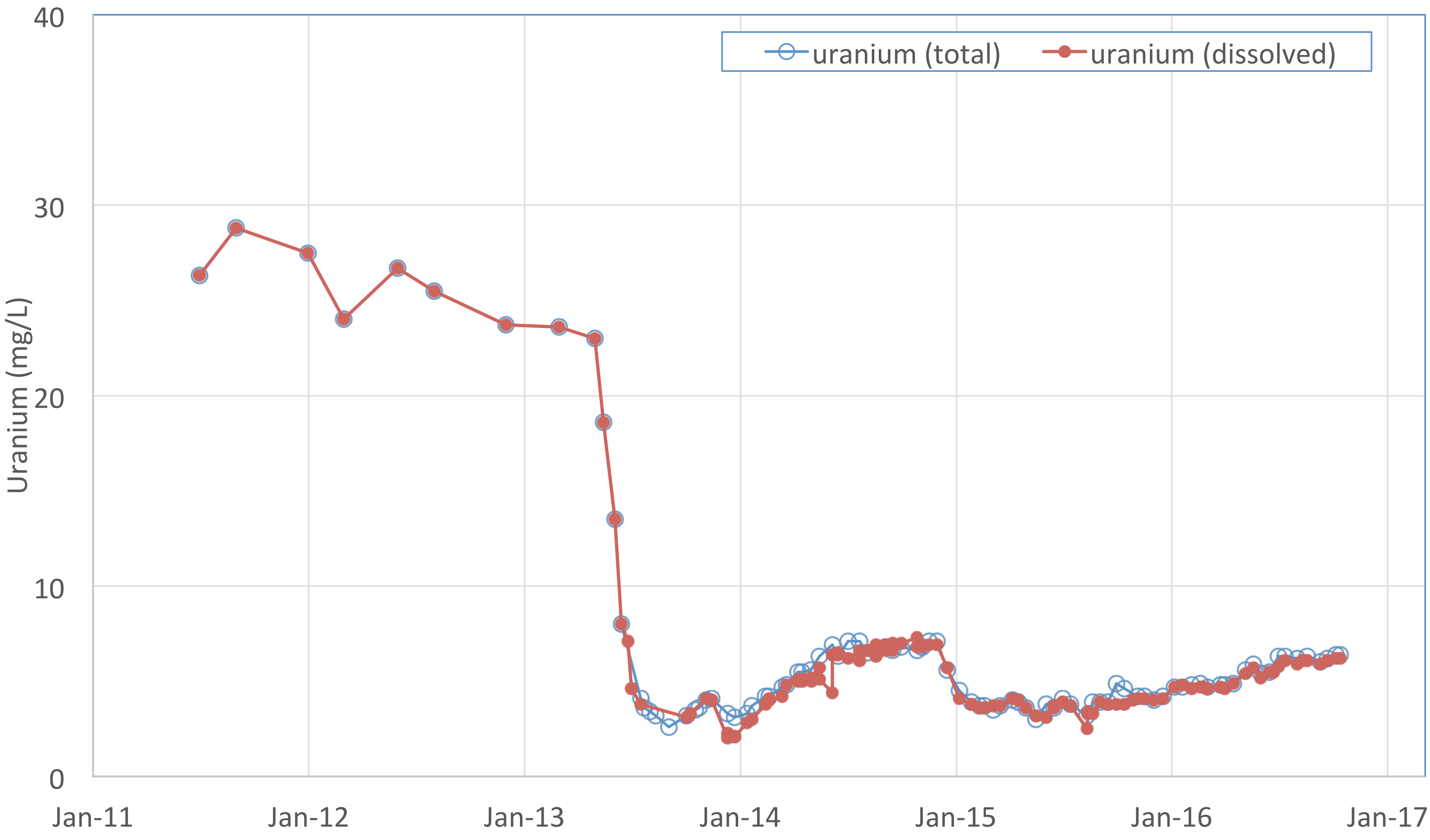
- Uranium 3.4 mg/L = 87% reduction
- Molybdenum 0.081 mg/L = 94% reduction
- Selenium <0.018 mg/L = >98.5% reduction

1:1,000+ year flood

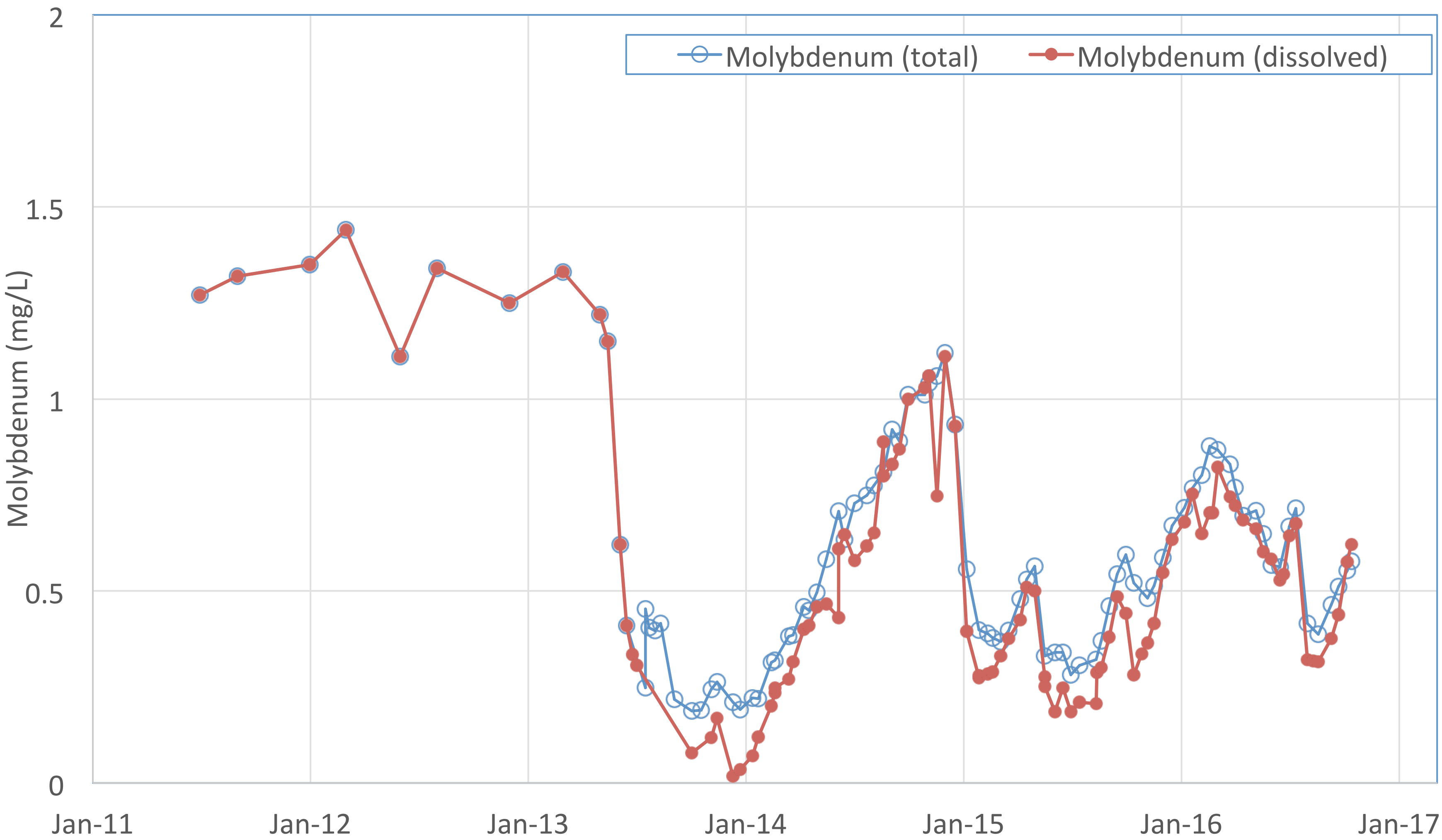
- 5.5 day storm
- 14-19 inches
- Access to site was lost after September 2013 until summer 2015



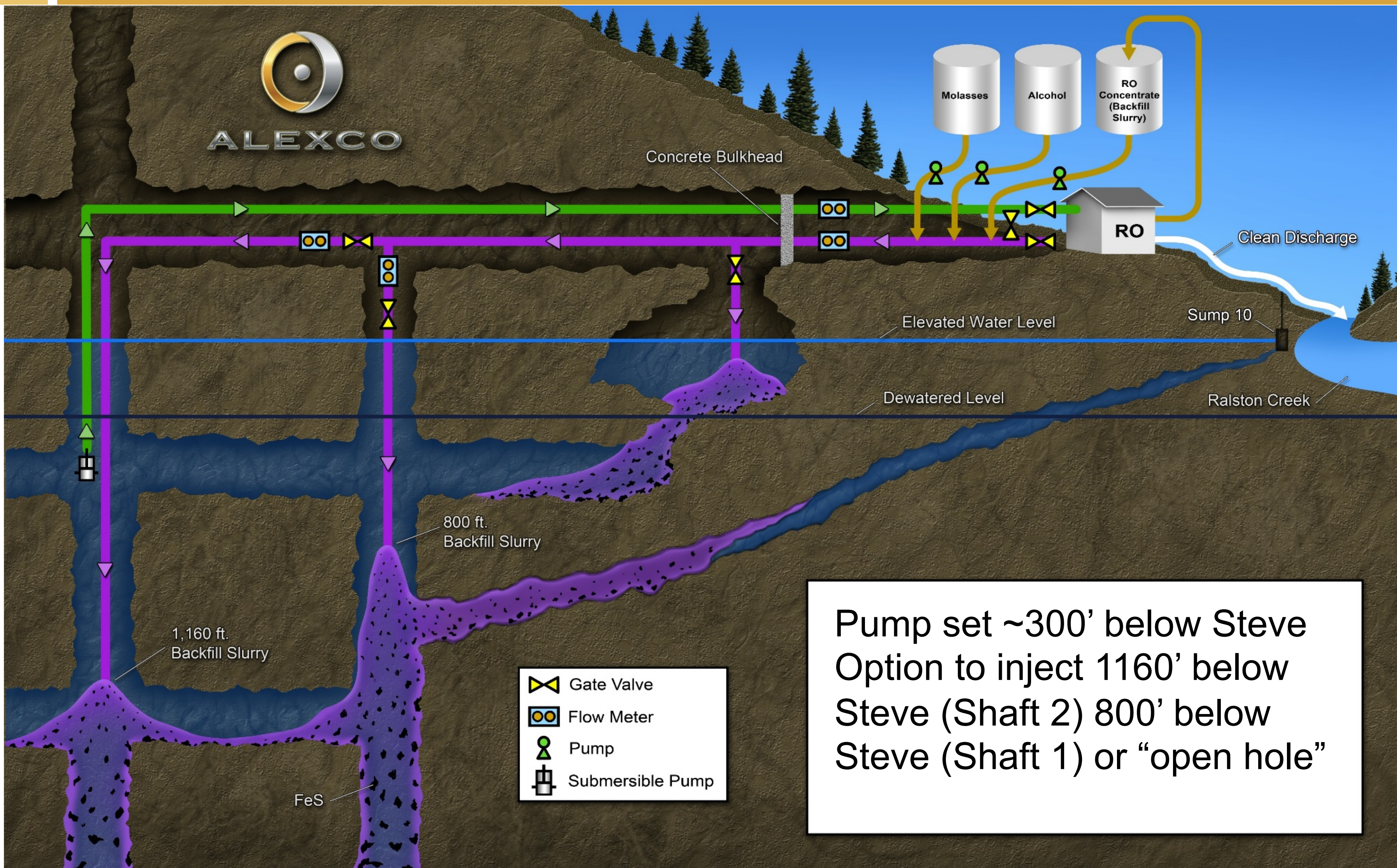
Uranium Pretreatment Results



Molybdenum Pretreatment Results



RO Concentrate In Situ Treatment

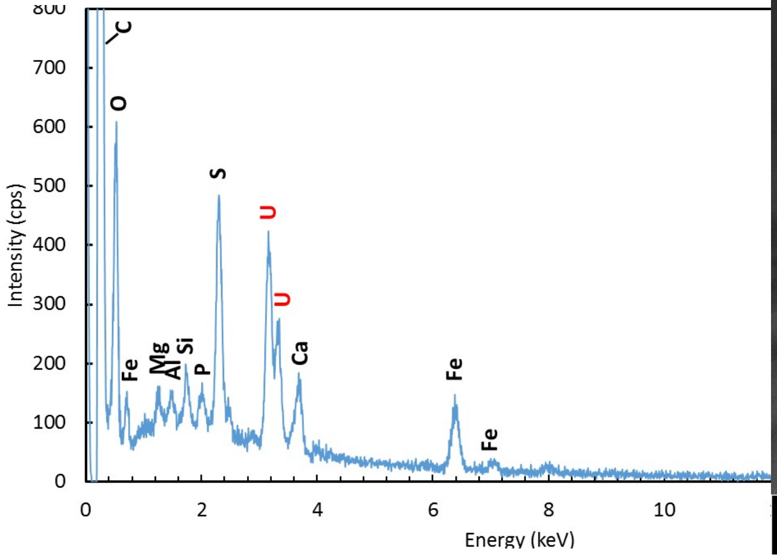


Pump set ~300’ below Steve
Option to inject 1160’ below Steve (Shaft 2) 800’ below Steve (Shaft 1) or “open hole”

Next Steps

- "Permanent" treatment facility constructed
  - Pumping from mine and alluvial sumps
  - Separate trains for mine water and alluvial water
  - Mine: pre-filter, RO: permeate conditioned and discharged, concentrate amended and reinjected
  - Alluvial: chemical precipitation (sludge amended and injected into mine), filtration, RO with permeated and concentrate comingled with mine waters
  - In situ pre-treatment campaign winter 2016-7
  - Alluvium removal 2017-2018
  - Negotiate stable discharge scenario with State of CO

Questions?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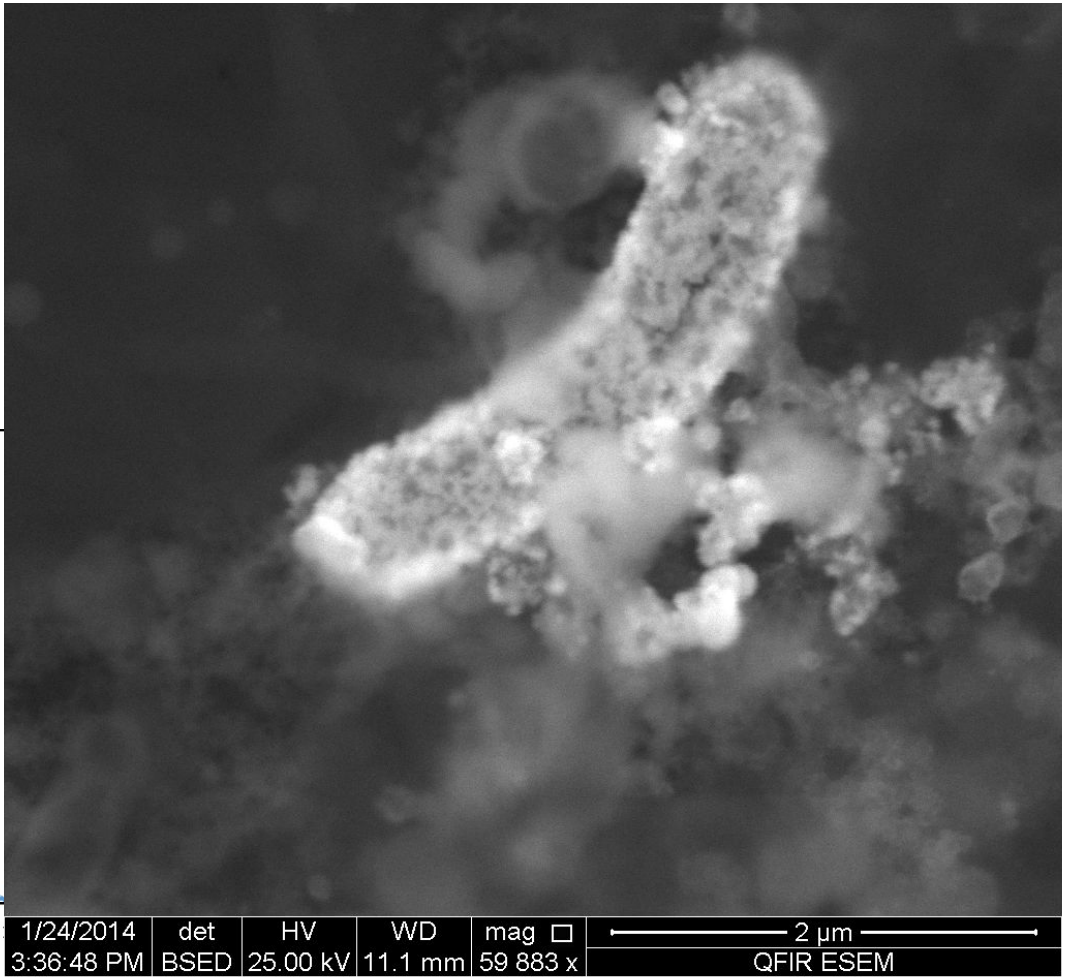
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