What Decades of Irregular Monitoring Can Show for Two Mines Sites: Iron Mountain, CA and Questa, NM

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Iron Mountain Mining History

- **Largest Cu mine in State of California; also produced Au, Ag, Zn, and S (for the production of $\text{H}_2\text{SO}_4$ from FeS$_2$)**
- In production from 1880’s to 1962
- **Brick Flat Open Pit and several underground mines**
- **Operated by Mountain Copper Co. (London) for 70 years**
Largest mine waste discharger in CA; 730 kg/day of Cu, Zn, Cd discharged and 4,700 tons/yr of pyrite weathered

Discharging metals into the Sacramento River, California’s single most important river, for > 100 yrs.

It would take > 2,500 years to complete the oxidation of the remaining pyrite

Caused bitter legal battles for decades
Environmental History

- 40 fish kills since 1940; as many as 100,000 anadromous fish killed in a single event
- Ranked 3rd worst Superfund site in the State of California since 1983
- Breaks all known records for low pH and highest metal and sulfate concentrations in the world
Environmental History

- 1901: Litigation against MCC by Forest Service
- 1901: USFWS notes loss of fish
- 1940: USFWS investigates fish losses from acid mine drainage; leads to 1955 study by PA Acad. Sci.
- 1973-76: USGS investigates acid mine drainage
- 1983-present: USEPA begins Superfund RI/FS
- 1986-97: Four RODs issued for remediation
- 1991: After numerous negotiations, USEPA files lawsuit for cost recovery
- Oct. 19, 2000: Out-of-court settlement reached for a grand total of $862 million and remediation completed by 2026
pH = 0.48
Fe = 18,600 mg/L
SO₄ = 110,000 mg/L
Sept. 1990
pH = -0.7
T = 38°C
Environmental History:

Four RODs issued for remediation (1986-97)
- Tailings removal
- Surface-water diversions
- Lime neutralization treatment

Overall Cu and Zn load reduction = 80-90%
Minnesota Flats Wastewater Treatment Plant
Total Copper Discharge
Spring Creek Debris Dam

Total Copper (μg/L)

Water Year

1999-2003: Copper Removed by Treatment Plant = 640,000 lb

Annual Copper Discharge (lb per year)

Copper Removed by Treatment Plant
SCDD Annual Copper Discharge
SCDD Cumulative Copper Discharge

Cumulative Copper Discharge (lb)

IMM COPPER DISCHARGE
IRON MOUNTAIN MINE
Present remediation phase:

Construction of Slickrock Creek dam to collect last major source of Cu and Zn loads for treatment

Total reduction of Cu and Zn expected to = 95%
Slickrock Creek Retention Dam
The Questa Baseline and Pre-Mining Ground-Water Quality Investigation

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Cheryl Naus (groundwater chief)
Geoff Plumlee (geology chief)
Briant Kimball (tracer chief)
Blaine McCleskey (chief chemist)
Ultimate driver for the study:

If it can be shown that the pre-mining ground-water quality was worse than the New Mexico standards, then those values can be adopted for the site-specific standards according to New Mexico law.
Molycorp formed in 1919 after the discovery of molybdenite

Underground and open pit mining

Permit for closure requires GW quality must meet NM stds

Natural weathering of mineralized and altered bedrock could result in concentrations of several water-quality constituents that may exceed water-quality standards

The State of New Mexico regulations provide for limited site-specific alternative standards
10-12 mile reach:
Town of Red River to gaging station
Figure 15. Variation of dissolved sulfate load with distance along study reach, Red River, New Mexico, August 2001
Scar Areas

ALTERATION SCARS

RED RIVER
Alteration & Scar Distribution

- Mine Pit
- Alteration Zones
- Old Underground Workings
- Mill Site
- Scar Areas
# Ground-water chemistry

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Main weathering processes that account for ground-water composition

Pyrite oxidation
  sulfate up to thousands of mg/L
Gypsum dissolution
  calcium up to 600 mg/L
Calcite dissolution
  bicarbonate up to 500 mg/L
Chlorite dissolution
  magnesium up to 400 mg/L
Fluorite dissolution
  fluoride up to 150 mg/L
40 years of irregular monitoring at the Red River gaging station, 1965–2003

- Downstream of the Questa mine
- Sulfate concentrations: 100–200 mg/L
- pH generally 6–7.5
- Water quality sensitive to any major changes caused by increased or decreased loading associated with mining contamination or remediation
Figure 12. Graph showing calcium concentrations in relation to sulfate concentrations in the Red River at Questa Ranger Station and the gypsum congruent dissolution line.
Figure 5. Graph showing sulfate concentrations in the Red River at the Questa Ranger Station from 1966 to 2001, and timing of mining history.
Figure 4. Graph showing sulfate concentrations and average daily discharge in the Red River at the Questa Ranger Station, from January 1977 to December 1979.
Figure 2. Graph showing average daily discharge and timing of surface water samples collected in the Red River at the Ranger Station in water years 1966 to 1982.
Figure 3. Graph showing average daily discharge and timing of surface water samples collected in the Red River at the Ranger Station in water years 1983 to 2001.
Figure 5. Graph showing sulfate concentrations in the Red River at the Questa Ranger Station from 1966 to 2001, and timing of mining history.
Figure 15. Graph showing specific conductance, pH, and average daily discharge in the Red River at Questa Ranger Station, from October 1978 to December 1986.
Remedial Activities:

• Stabilization of slumping waste piles
• Pumping out acid ground-water discharges into Red River along mine site
• Further site characterization
CONCLUSIONS:

- Continuous monitoring is necessary to show effectiveness of remediation and to quantify that effectiveness.
- For the IMM site, diversions, lime neutralization, and tailings removal has decreased Cu, Zn loads by 80-90%; further capture of SW flows could improve the reduction to 95%.
- At the Questa site, loads are much lower and remediation by pumping out contaminated ground water should be effective but it will be difficult to quantify against a high variability in background.