MITIGATING MINING IMPACTS: PRINCIPLES AND PRACTICES
JAMES R. KUIPERS, P.E.
KUIPERS & ASSOCIATES, BUTTE, MONTANA

Lake Superior Binational Program
Mining in the Lake Superior Basin Webinar Series
Environmental Impacts of Mining
in the Lake Superior Basin
March 24, 2009
Mitigating Mining Impacts: Principles and Practices

- Mining Impacts 101
- Principle Mining Mitigation Approaches and Practices
  - Source Control
    - Covers
  - Management
    - Groundwater capture and treatment
  - Other practices
    - Liners (top and bottom)
    - Segregation, Commingling and Neutralization
    - Adaptive Management
- Prevention
Mining Impacts 101

Primary Sources at Mine Sites

- Underground workings
- Open pits
- Waste rock
- Tailings
- Leach pads, solution ponds
- Stock piles
- Smelter emissions
Source and Pathway Overview

- Floodplain Tailings
- Tailings Impoundment
- Tailing Pile Seep
- Adit Drainage
- Adit
- Underground Workings
- Waste Rock
- Mill
- Alluvial Aquifer
Pathways: Infiltration and Runoff

Infiltration and Runoff of Metals (and Water) from Contaminated Sediments
Pathways: Transport in Streams

Particulate, Dissolved, Suspended, and Bed Loads in River

- Some metals remain dissolved
- Some dissolved metals adsorb onto particles
- Some particles settle out (bedload)
- Some particles remain suspended
- High flows cause scouring and resuspension
Principle Mining Mitigation Approaches: Source Control

- **Primary objective**
  - Limit water infiltration and contaminant leaching

- **Secondary benefits**
  - Limit infiltration of oxygen and acid drainage
  - Often times supports post-mining land use (vegetation for grazing, wildlife, open space)

- Typically done by installing various covers
Source Control: Cover Types

- Typical – regrade with stormwater controls, apply topsoil, & revegetate
  - 20% to 90%+ reduction in groundwater infiltration
  - Post-mining land use (PMLU) primary goal
  - Operations and maintenance varies

- Engineered covers
  - Intended to reduce infiltration and other impacts
    - Cover depth
    - Water barriers (e.g. gcl)
    - Water balance, evapo-transpirative covers
Golden Sunlight Mine, Montana
Waste Rock Dump Regrading
Tyrone Mine, New Mexico Tailings Reclamation
Principle Mining Mitigation Approaches: Management

- Primary objective
  - Capture contaminants and treat as required
- Typically done by groundwater capture, water management and treatment
- Can result in overall cost increase ranging from 50% to 10,000% (100X) + initial reclamation cost estimate
- May be required for tens or hundreds of years or “in perpetuity”
Mining Mitigation Approaches: Other practices

- **Liners**
  - Clay and geocomposite over liners intended to prevent infiltration
    - Liners always leak
    - Require maintenance and periodic replacement
  - Under liners intended to capture leachate
    - Liners always leak, but can aid capture

- **Segregation, Commingling and Neutralization**
  - Segregation
    - Hide the waste, requires additional source controls, some applications
  - Commingling
    - Dilute the waste, requires coordination, limited applications
  - Neutralization
    - In-situ chemical treatment, requires mixing, questionable effectiveness

- **Adaptive Management**
  - Crisis management, over-relied upon, requires will and funds
Prevention

- Hydrologic and geochemical characterization failures are the most common root cause of mitigation not being identified, inadequate or not installed
  - Most common assumption is that “oxide” will not result in adverse impacts to water resources
  - Mitigations are often based on what is common practice rather than on site specific characterization
  - Mines in close proximity to groundwater and surface water resources are much more likely to result in water quality issues and result in water treatment requirements – additional care should be taken in these cases
Predicted vs. Actual Water Quality

- Geochemical Information
- Potential Water Quality
- Hydrologic/Climatic Information

Engineering Design
- Mitigation Measures
- Predicted Water Quality

Failure at 64% of sites

Actual Water Quality
Mine Mitigation -
Recommendations

- A more systematic and complete effort should be undertaken when collecting baseline and associated engineering data
- Recognize the importance of thorough hydrological and geochemical characterization
- Utilize information in a conservative manner to identify and utilize mitigation measures
- Consider the likelihood and consequences of mitigation failures