Overview of U.S. EPA’s ORD Technical Outreach and Support Activities on Sustainable Mining Applications

Denver, CO
The Westin Tabor Center
Can we efficiently?

- Extract and utilize resources (including by-products)
- Manage wastes
- Reclamation/restoration
- Produce socio-economic advantages
Magnitude of Ore Mine Waste Problem
Number Indicates Number of Mines
ORD’s Mining Efforts

• Mine Waste Technology Program (MWTP)

• Engineering Technical Support Center

• Technology Transfer Program
Collaboration

- EPA Region 8
- EPA Region 10
- Technology Transfer Program
- EPA Region 7
- Industry Partners
- Academia
- Western Governors Association
- BLM
- Forest Service
- DOE
MWTP Overview

- **EPA-NRMRL**
  - Technical Direction/Oversight
  - Quality Assurance Oversight
- **DOE**
  - Administrative Oversight
- **MSE**
  - Applied Research
  - Field Demonstrations
  - Technology Implementation
- **Montana Tech**
  - Basic Research
MWTP Projects

- Post-Mining Development Using Resources from Flooded Underground Mine Workings
- Cyanide Heap Biological Detoxification Phase II
- Design and Installation of a Modular SRB Bioreactor for Acid Rock Drainage Treatment
- Pulsed Limestone Bed Treatment of Metal Mine Drainage at the Argo Tunnel in Idaho Springs
Engineering Technical Support
Center Innovative Bioreactor Studies

- Constructed Wetlands with Bioreactors
- Sulfate Reducing Bioreactors
- Biochemical Reactors
ORD Technology Transfer and Outreach

1998 Heavy Metals Contamination Workshop - 150 attendees - Carol Browner gave keynote, Sen. Baucus and Sen. Burns spoke interactively
1998 Mining Workshop - 300 attendees
1999 Heavy Metals Contamination Workshop - 180 Attendees
1999 Pit Lakes Workshop - 240 attendees
2000 Mercury Workshop – 275 attendees
2001 Arsenic Workshop – 70 attendees
2002 Hard Rock Mining Conference – 375 attendees
2003 Workshop on Mining Impacted Native American Lands – 275 attendees
2004 Pit Lakes – 250 attendees
2005 Abandoned Mine Lands Workshop – 100 attendees
2006 Hard Rock Mining Conference – 350 attendees
2007 Abandoned Mine Lands Workshop – Coeur d’Alene, Idaho;
1993-2006 Mine Operations, Design, and Closure Conferences;
Sponsors include: USFS, BLM, MT DEQ, MWTP
ORD Websites

U.S. EPA/U.S. DOE Mine Waste Technology Program web site:
http://www.epa.gov/minewastetechnology

EPA’s Abandoned Mine Lands Program web site:
http://www.epa.gov/superfund/programs/aml
Case Study on the Belmont Mine Resource Recovery
Butte, MT

Suzzann Nordwick – MSE
Keri Petritz – MSE/Montana Tech
Norma Lewis – EPA
Diana Bless – EPA
Butte, Montana
Project Purpose

• Explore feasibility of recovering additional resources for beneficial use from underground mine workings

• Characterize underground mine waters at the Belmont Mine (long-term pumping test)

• Determine feasibility of upgrading water for use as irrigation water (treatability tests)

• Determine feasibility of using naturally elevated temperature water as a heat source for nearby buildings
Belmont Mine Site

Berkeley Pit

Amphitheater

Football Field
Pumping Tests

1. Step-Drawdown Test
2. Long-Term Pumping Test
3. Recovery Test
4. Test Data Analysis
Pumping Tests

Analyses for primary sampling events:

- Field parameters: pH, specific conductivity (SC), temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP)
- Major cations and anions (Ca, Mg, Na, K, SO$_4^{2-}$, NO$_3^-$, HCO$_3^-$, and Cl$^-$)
- Total recoverable metals (Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, V, U, and Zn);
- Dissolved metals (same list as above)
- Alkalinity and hardness
- Total suspended solids (TSS)
- Speciation of Fe
- Speciation of As
- Stable isotopic analysis (dD of water, d18O of water, d18O of sulfate, d32S of sulfate, d13C of dissolved inorganic carbon)
- Radionuclide analysis (dissolved radon, radium, uranium)
# Pump Test Water Quality Data

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Gallons Pumped</td>
<td>N/A</td>
<td>5000</td>
<td>1,800,000</td>
<td>2,700,000</td>
<td>4,960,000</td>
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<tr>
<td>pH (SU)</td>
<td>N/A</td>
<td>6.1</td>
<td>5.8</td>
<td>5.7</td>
<td>5.6</td>
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<tr>
<td>Temp (° C)</td>
<td>N/A</td>
<td>16.5</td>
<td>19.5</td>
<td>19.5</td>
<td>19.0</td>
</tr>
<tr>
<td>As (ug/L)</td>
<td>100</td>
<td>1190</td>
<td>1320</td>
<td>1340</td>
<td>1390</td>
</tr>
<tr>
<td>Cd (ug/L)</td>
<td>10</td>
<td>ND</td>
<td>0.3</td>
<td>0.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Fe (ug/L)</td>
<td>20,000</td>
<td>28,600</td>
<td>182,000</td>
<td>188,000</td>
<td>160,000</td>
</tr>
<tr>
<td>Mn (ug/L)</td>
<td>10,000</td>
<td>4420</td>
<td>21,800</td>
<td>21,900</td>
<td>17,500</td>
</tr>
<tr>
<td>Pb (ug/L)</td>
<td>5000</td>
<td>0.8</td>
<td>1.7</td>
<td>Not analyzed</td>
<td>1.6</td>
</tr>
<tr>
<td>Zn (ug/L)</td>
<td>10,000</td>
<td>1990</td>
<td>20,900</td>
<td>19,300</td>
<td>10,100</td>
</tr>
</tbody>
</table>
Belmont Mine Water

• Technical Challenges:
  – Large batch flows, limited space, changing chemistry, etc.
  – Arsenic (As), iron (Fe), manganese (Mn), and zinc (Zn) concentrations exceed the guidelines for water reuse
• Oxidation/pH adjustment with solid/liquid separation is a straightforward option
• Innovative technologies were also evaluated during the treatability study
Belmont Treatability Studies

• 100 gallons of Belmont Water collected during pumping test for treatability testing stored under continuous nitrogen

• Two Phases of Testing
  – Phase 1 treatment tests were designed to incorporate oxidation and pH adjustment
    • Oxidation was accomplished using 30% H₂O₂ or air
    • 50% solution of NaOH was used for pH adjustment
  – Phase 2 tests optimized the most favorable treatment path identified in Phase 1
    • Hydrated lime (Ca(OH)₂) instead of NaOH was used for the pH adjustment
    • H₂O₂ was used to oxidize the water
Treatability Test Results

• Comparing the results of test runs—H₂O₂ has better contaminant removal with Fe, As, and Mn
• Oxidation first requires less pH-adjustment reagent to achieve the target pH
• Lime addition to pH 9.5 followed by H₂O₂ oxidation is the most effective treatment for removing all of the contaminants
• Settling tests were performed and flocculent was needed to settle sludge in a reasonable time
## Belmont Water Quality Data

<table>
<thead>
<tr>
<th>Water Needs</th>
<th>Cost to irrigate with groundwater from Belmont well ($/1000 gals)</th>
<th>Cost to irrigate with municipal water ($/1000 gals)</th>
<th>Cost difference that can be used for treatment of mine water for Irrigation ($/1000 gals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-inch/month per 10 acres for 5 months/year</td>
<td>$0.17</td>
<td>$1.72</td>
<td>$1.55</td>
</tr>
<tr>
<td>Treatment Technology</td>
<td>Cost ($/1000 gallons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated Dollar Available for Treatment of Mine Water</td>
<td>&lt; $1.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMD Treat (DOI’s Office of Surface Mining)</td>
<td>$0.92—1.69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

http://amd.osmre.gov/amdtreat.asp
Conclusions/Recommendations

- Belmont water is moderately contaminated
- Water can be upgraded to meet irrigation standards and be utilized in a beneficial way, reducing stress on municipal water supply
- Additional feasibility/treatability testing on a larger scale is warranted
- Site owner is pursuing funding for eventual implementation of a treatment system
- MSE is finalizing conceptual design for a treatment system
- High temperature water should be investigated as potential heat source for nearby buildings
Acknowledgements

- Montana Economic Redevelopment Development Institute (MERDI)
- Butte Silver Bow Government/Planning Department
- Montana Resources
- BP-ARCO
- Montana Bureau of Mines and Geology
- EPA (Local and Regional)
- DOE
- Dr. Chris Gammons, Montana Tech
- Dr. Paul Miranda, Center for Advanced Mineral Processing
- Mine Waste Technology Program – EPA, ORD, NRMRL
- MSE Applications Inc.
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