Challenges in Water Treatment

14th Annual BC MEND Workshop
Vancouver, BC. November 28, 2007
Past Disposal Practices

Current and Future Problems
AMEC Water Treatment Experience

• 16 WTPs constructed including 8 HDS plants in last 10 years

• Core process and study group in Vancouver dedicated to Water Treatment but supplied with the required disciplines to provide full engineering design and construction support to AMEC offices on a worldwide basis

• Full range of process technologies and experience in meeting low environmental limits

• Design and construction experience for harsh climates, remote locations and high elevation
Experience?

Study, design, construction, commissioning, start-up and trouble-shooting water treatment plants including:

- Cajamarquilla, Colquirica and Kingsmill in Peru
- Alumbrera, Aqua Rica and Profertil Bahia Blanc in Argentina
- Geco/Willroy, Montcalm and Totten in Ontario
- Equity, Britannia, Eskay Creek, Vancouver Wharves and Nickel Plate in British Columbia
- Gilt Edge in South Dakota
- Pogo, Pebble and Donlin in Alaska
- CEZinc Valleyfield and Norbec in Quebec
- Snap Lake and Gahcho Kue in the NWT
- Henderson/URAD in Colorado
- Confidential in California
What are the Challenges?

• Water Management
  – Collection and storage – handling peaks

• Remote Process Control
  – Design for unattended operation

• Mechanical Reliability
  – Equipment selection – proven in application
  – Backups and redundancy
  – Contingency plans for upset conditions

• Sludge Disposal
  – Forming stable precipitates – e.g. Mn and Fe co-precipitates
  – Complying with Regulations
  – Finding long-term storage locations
What are the Challenges?

- **Gypsum Scale**
  - Selecting optimum conditions – sludge density, pH, flocculants
  - Designing for scale removal
  - Limitations on Filtration

- **Effluent Criteria**
  - Lower standards moving towards Ambient at End-of-Pipe
  - Need for lower suspended solids levels
  - Sulfate and TDS removal
  - Demands for low Se levels
  - Disconnect between permitting and engineering
What are the Challenges?

• **Costs**
  - Low conceptual level capital and operating cost estimates
  - Clients cost expectations
  - CPI increased 30% between Jan 2002 and Jan 2007
  - Escalating costs for materials – steel, concrete
  - Availability of skilled labour
  - High labour rates

• **Operation**
  - Remote Sites
  - Lack of Trained Operators
  - Technical Supervision
What are the Challenges for Treatment Chemistry?

• Metals
  – Iron and Manganese
  – Copper, Zinc, Nickel
  – Lead, Cadmium, Silver, Mercury

• Non Metals
  – Arsenic, Antimony
  – Molybdenum
  – Selenium

• Major Anions
  – Sulphate
  – Chloride
  – Ammonia

• Suspended Solids
HDS - Process Flow Diagram

Recycle Water
Flocculant
Lime Paste
Acidic Feed Water

Sludge/Lime Mix Tank

Reactor Tank #1

Lime Tank

Reactor Tank #2

Clarifier

Effluent Overflow

Sludge Recycle

Sludge disposal
Geco-Willroy, Ontario

Project

- EPCM and commissioning of a large HDS water treatment plant
- Design flow - 930 m$^3$/h with 70m clarifier and three 9m x 13m reactor tanks

Challenges

- Design and construct plus Final commissioning and December Start-up
- Designed water diversion and collection structures and improvements, along with new pumping stations
- Design sludge disposal system - buried and above ground piping to tailings pond
## GECO Operating Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design</th>
<th>Permit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Feed Rate (m³/h)</td>
<td>930</td>
<td></td>
</tr>
<tr>
<td>Max. Hydraulic Load (m³/h)</td>
<td>1160</td>
<td></td>
</tr>
<tr>
<td>Max. Sludge Prod. (t/d d/w)</td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>Zinc (mg/L)</td>
<td>20</td>
<td>0.5</td>
</tr>
<tr>
<td>Sulphate (mg/L)</td>
<td>3300</td>
<td></td>
</tr>
<tr>
<td>Iron (mg/L)</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Copper (mg/L)</td>
<td>1.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Acidity (g/L as CaCO₃)</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>
Henderson/URAD, Colorado, USA

Project

• Treat mine water containing high concentrations of Mn and minor amounts of Zn at molybdenum mine and decommissioned uranium mine

Challenges

• Use HDS process to oxidize Mn using air
• Produce a dense sludge without a filter press that can be handled with mechanical equipment
• Comply with regulation for Mn and Zn
• Design for cold weather and long operating period
Henderson/URAD

Design Criteria

• Flows 3000 gpm
• HDS Process
  – Produces MnO₂ sludge 30-40 %
• Feed
  – Mn 200 mg/L
  – Zn 10 mg/L
• Effluent
  – Mn <1 mg/L
  – Zn <0.1 mg/L

Sludge

• Produced at over 45% solids due to presence of MnO₂
• Settles to over 65%
• Sludge removed from temporary pond on a campaign basis using mechanical equipment
Refinería de Cajamarquilla, Peru

- AMEC services - Design and construction of HDS plant to remove heavy metals from high strength refinery effluent
- High acid content (pH <2) and major concentrations of SO$_4$, Zn, Mn, Pb, Cd, Fe and As
- Treated water required to meet irrigation criteria
- Sludge disposal via pipeline over distance of 2 Km
Cajamarquilla
## Cajamarquilla Feed and Effluent

<table>
<thead>
<tr>
<th>Parameters (metals mg/L)</th>
<th>Feed</th>
<th>HDS Effluent</th>
<th>Final Effluent</th>
<th>Permit</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>1.5</td>
<td>&lt;9.5</td>
<td>7 to 8</td>
<td>&lt;9.0</td>
</tr>
<tr>
<td>Zn</td>
<td>1230</td>
<td>0.165</td>
<td>0.04</td>
<td>3.0</td>
</tr>
<tr>
<td>Fe</td>
<td>450</td>
<td>0.012</td>
<td>0.02</td>
<td>2.0</td>
</tr>
<tr>
<td>Mn</td>
<td>380</td>
<td>0.081</td>
<td>0.02</td>
<td>0.5</td>
</tr>
<tr>
<td>Cd</td>
<td>10.6</td>
<td>0.007</td>
<td>0.011</td>
<td>0.05</td>
</tr>
<tr>
<td>Cu</td>
<td>8.1</td>
<td>0.013</td>
<td>0.014</td>
<td>0.5</td>
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<tr>
<td>Ni</td>
<td>0.9</td>
<td>0.002</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>0.9</td>
<td>0.05</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Hg</td>
<td>0.25</td>
<td>0.002</td>
<td>0.001</td>
<td>0.01</td>
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Cajamarquilla Sludge Characteristics

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>–</td>
<td>47%</td>
<td>Magnesium</td>
<td>–</td>
</tr>
<tr>
<td>Calcium</td>
<td>–</td>
<td>21%</td>
<td>Arsenic</td>
<td>–</td>
</tr>
<tr>
<td>Carbonate</td>
<td>–</td>
<td>20%</td>
<td>Lead</td>
<td>–</td>
</tr>
<tr>
<td>Zinc</td>
<td>–</td>
<td>5.5%</td>
<td>Cadmium</td>
<td>–</td>
</tr>
<tr>
<td>Silica</td>
<td>–</td>
<td>2%</td>
<td>Copper</td>
<td>–</td>
</tr>
<tr>
<td>Manganese</td>
<td>–</td>
<td>1.8%</td>
<td>Selenium</td>
<td>–</td>
</tr>
<tr>
<td>Iron</td>
<td>–</td>
<td>0.8%</td>
<td>Mercury</td>
<td>–</td>
</tr>
</tbody>
</table>


CEZinc, Valleyfield, Quebec, Canada

Project

• Design HDS plant to replace LDS system at zinc refinery

• Reduce sludge storage requirements by producing coarse, self-draining, pumpable sludge at 40+% solids which will dewater to 55+% solids in existing pond

• Design process control system to handle highly variable flows and loadings
CEZinc

Challenges

• High strength variable feed containing major amounts of Mn, $\text{SO}_4$ and Zn

• Process required multi-stage lime addition points and “smart” pH control system
## CEZ Operating Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design</th>
<th>Permit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Feed Rate (m³/h)</td>
<td>290</td>
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</tr>
<tr>
<td>Max. Hydraulic Load (m³/h)</td>
<td>500</td>
<td></td>
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<tr>
<td>Max. Sludge Prod. (t/d d/w)</td>
<td>3.2</td>
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<tr>
<td>Zinc (mg/L)</td>
<td>475</td>
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</tr>
<tr>
<td>Manganese (mg/L)</td>
<td>142</td>
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<tr>
<td>Iron (mg/L)</td>
<td>28</td>
<td>0.5</td>
</tr>
<tr>
<td>Cadmium (mg/L)</td>
<td>6</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Equity Silver, BC, Canada Placer Dome

Challenges

- Replaced LDS plant
- EPCM services
- Complete site water management
- $10 M project
- 600 m$^3$/h (2600 gpm) water treatment plant – startup Dec 2004
- Pumping and placement of sludge in abandoned pit
- Designed for full automation and remote control
# Equity Design Feed and Effluent

<table>
<thead>
<tr>
<th>Parameters (mg/L)</th>
<th>Design Feed</th>
<th>Permit Limits (Diss)</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td>2.4</td>
<td>6.5 to 9.5</td>
</tr>
<tr>
<td>Acidity</td>
<td>13,500</td>
<td></td>
</tr>
<tr>
<td>Al</td>
<td>650</td>
<td>0.5</td>
</tr>
<tr>
<td>Cu</td>
<td>280</td>
<td>0.05</td>
</tr>
<tr>
<td>Fe</td>
<td>2000</td>
<td>0.3</td>
</tr>
<tr>
<td>Zn</td>
<td>350</td>
<td>0.2</td>
</tr>
<tr>
<td>SO4</td>
<td>12,500</td>
<td></td>
</tr>
<tr>
<td>TSS</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>Cd</td>
<td>1.2</td>
<td>0.01</td>
</tr>
<tr>
<td>As</td>
<td>2.5</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Pogo Mine Water Treatment Plant, Alaska

- Process development and EPCM services for a 23 m³/hr (100 gpm) exploration adit plant to remove heavy metals, primarily arsenic, from minewater
- EPCM of full-scale 90 m³/hr (400 gpm) plant to treat minewater and recycled tailings pond water
- Multi-media filters and sludge press
- Hydrogen peroxide and sodium hydrosulphide to reduce dissolved metals to low levels
- Final pH adjustment using carbon dioxide
Colquijirca, Peru

Project

• Design and build simple lime neutralization plant to treat acidic seepage and stormwater from coal refuse pile at lead-zinc mine

Challenges

• Highly variable storm flows
• Low-quality lime
• Need to mitigate current ARD problems in downstream area
Colquijirca, Peru

- Constructed ball mill to grind lime and generate slurry for neutralization
- Treatment in large aerated reactor
- Sludge deposited in ponds to cover acidic tailings
- Discharge mixed with other contaminated streams to meet final effluent criteria at compliance point
Alumbrera

• Concentrate and filter effluent thickener with aeration ponds for thiosalt (BOD) and copper removal in background
Minera Alumbrera
Tucuman Filter Plant, Argentina

Project

• Design and construction of system to re-thicken pipeline concentrate and treat all process.
• Overflow forwarded for treatment and concentrate sent to filter stock tanks
• Conversion of existing ponds to provide biological treatment system to remove particulate, soluble metal and thio-salts
Norbec, Quebec, Canada

Project:

• Design and build new HDS plant to treat ARD
• Plant designed for nominal flow of 1,000 gpm with maximum capacity 3,000 gpm
• Plant designed for remote operation without full-time operator
• Design makes maximum use of used equipment from on-site mill and other locations
<table>
<thead>
<tr>
<th>Parameters (Total metals mg/L)</th>
<th>Feed</th>
<th>HDS Effluent</th>
<th>Permit Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>2.7</td>
<td>9.2</td>
<td>6.5 to 9.5</td>
</tr>
<tr>
<td>Zn</td>
<td>15</td>
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<td>0.5</td>
</tr>
<tr>
<td>Fe</td>
<td>108</td>
<td>0.47</td>
<td>3</td>
</tr>
<tr>
<td>Mn</td>
<td>7.5</td>
<td>0.57</td>
<td>1</td>
</tr>
<tr>
<td>Cu</td>
<td>2.8</td>
<td>0.05</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Current Projects
Kingsmill WTP