Hydro Flex Water Treatment

*Utilizing the Value Extraction Process*

*R3 Conference Philadelphia, PA– January 29, 2014*
Hydro Flex Technology

• **Key differentiators from conventional wastewater treatment technologies include**
  – Eliminates sludge—reduces disposal costs
  – Can meet low discharge requirements (e.g., <50 ppm sulfate, <1 ppm metals and nutrients)
  – Uses standard off-the-shelf process equipment
  – Ease of control—can handle feed variability
  – Easily optimized for multiple applications
Technology Demonstrations

- Processes have been developed and demonstrated for
  - Acid mine drainage
  - Industrial process waters
  - Agricultural wastewaters

- Possibility to be extended to treatment of saline and brackish waters
St Michael AMD project
Platform for Metal Recovery

**Metal Finishing Waste**

- Purified Water
- Metal Sulfate Concentrate

**Acid Mine Drainage**

- Water Purification Stages
- Loaded Extractant
- Metal Recovery Stages
- Sulfate Recovery Stages

- Extractant
- AMD Feed
- Sulfuric Acid
- Potassium or Sodium Sulfate Concentrate
- Potassium or Sodium Carbonate

Extractant

Sulfate Loaded Extractant

Extractant
St. Michael AMD Hydro Flex Plant
# Product Water Characteristics – Results

<table>
<thead>
<tr>
<th>Component</th>
<th>Target</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO$_4$</td>
<td>250-500 mg/L</td>
<td>&lt;100 mg/L</td>
</tr>
<tr>
<td>Fe</td>
<td>&lt;3 mg/L</td>
<td>0.1 to 1 mg/L</td>
</tr>
<tr>
<td>Al</td>
<td>&lt;1 mg/L</td>
<td>&lt;0.2 mg/L</td>
</tr>
<tr>
<td>pH</td>
<td>6.5 to 8.5</td>
<td>7 to 8</td>
</tr>
<tr>
<td>O&amp;G</td>
<td>&lt;100 mg/L</td>
<td>&lt;10 mg/L</td>
</tr>
</tbody>
</table>

- Reduced sulfate (1,050 mg/L to < 100 mg/L)
- Reduced iron from (120 mg/L to < 1 mg/L)
- Findings are all under fresh secondary drinking water standards
Potassium Sulfate

- Liquid Concentrate: 10% $\text{K}_2\text{SO}_4$
- Filter Cake: >90% Solids
- Crystals: >98% pure (see XRD spectrum)
### (In solution) Co-Product Characteristics

<table>
<thead>
<tr>
<th>Product Stream</th>
<th>Product Concentration (wt% wet basis)</th>
<th>Impurity (ppm)</th>
<th>Phase 4 Projected Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>K$_2$SO$_4$</td>
<td>11%-13%</td>
<td>Mg = 12, Si = 27, Ca = 16, Fe (total) = 14, Mn = 4, Zn = 2, Al, Co, Ni &lt; 1</td>
<td>~30 gal. / 1000 gal. AMD feed</td>
</tr>
<tr>
<td>FeSO$_4$</td>
<td>3%-10%</td>
<td>Mg = 70, Al = 230, Si = 60, Ca = 220, Mn = 460, Zn = 70, Ni, Co &lt; 30</td>
<td>~6 gal. / 1000 gal. AMD feed</td>
</tr>
</tbody>
</table>
Current Hydro Flex Efforts

- Installing 100gpm plant in Butler County, PA
  - System to go online near end of February
  - Modular – moveable systems
  - Provide water to shale gas companies active in the region
AMD for Hydraulic Fracturing

Hydro Flex treated AMD meets fresh water storage and use standards!

2 Million Gallons of H₂O

Post-Treatment

Clean H₂O

Waste

5 Million Gallons of H₂O

Well

F-LLX

AMD H₂O
Benefits / Advantages

GO GREEN!

- Proactive approach to addressing one of the biggest environmental concerns within OH, PA, and WV (Acid Mine Drainage)
- Improved public perception - positive environmental message to community
- Utilization of cleaned/treated AMD reducing the impact of contaminated AMD finding its way into fresh water sources!

- Operating Cost - utilize prepared/operational WWS Site in close proximity to Natural Gas Infrastructure
- Opportunities to reduce transportation cost

1. Multiple withdrawal points
2. Proximity to highway infrastructure
3. Improved efficiency, quick turnaround time
Advantages of **Hydro Flex** Technology Comparison to conventional processes

<table>
<thead>
<tr>
<th>Feature</th>
<th>Hydro Flex</th>
<th>Biological Processes</th>
<th>Membrane Filtration</th>
<th>Lime Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate Removal to below 100 mg/L</td>
<td>Yes</td>
<td>Yes</td>
<td>Possible</td>
<td>No, limited to &gt;1000 mg/L</td>
</tr>
<tr>
<td>Process Footprint</td>
<td>Small</td>
<td>Large</td>
<td>Small</td>
<td>Medium to Large</td>
</tr>
<tr>
<td>Product Streams</td>
<td>Water Treatment Chemicals</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Waste Streams</td>
<td>None</td>
<td>Sludge Generation</td>
<td>Large Brine Streams</td>
<td>Sludge Generation</td>
</tr>
<tr>
<td>Energy Requirements</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Low to Medium</td>
</tr>
</tbody>
</table>
Hydro Flex Technology Differentiation

- Key differentiators from conventional waste water treatment technologies include
  - Simultaneous removal *and recovery* of contaminants for value
    - Conversion of contaminants to products avoids waste sludge production
    - Process chemistry allows for selective separation of contaminants
  - Contaminant removal to very low discharge requirements (e.g., <50 ppm sulfate, <1 ppm metals, <1 ppm)
    - Potential to achieve lower concentrations (ppb levels) through use of columns and increased process control
  - Highly tunable to feed variability (adjust ratio of extractant to aqueous feed)

*The process chemistry and operation can be tailored to meet application requirements and minimize costs*
Thank you for your time and consideration!

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