MINE DRAINAGE AERATION USING A TROMPE

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Aeration

- Most mine drainage treatment facilities require aeration for iron oxidation.
- \( \text{Fe}^{2+} + \frac{1}{4} \text{O}_2 + \text{H}^+ \rightarrow \text{Fe}^{3+} + \frac{1}{2} \text{H}_2\text{O} \)
- The time required for this reaction to occur is dependent on oxygen transfer to the water and the pH of the water.
Effect of pH

• The higher the pH the faster iron is oxidized.
• As iron is oxidized the pH is lowered lengthening the time required for oxidation.
• This increase in detention time requires a proportional increase in pond size.

After Dietz 2008
Effect of Carbon Dioxide

- Mine drainage from underground mines frequently contains excess carbon dioxide.
- The effect of this excess carbon dioxide is to lower the pH of the raw water.
- Aeration of mine water will remove the excess carbon dioxide and could increase pH (Kirby et al., 2009).
Aeration Removes CO$_2$ and Increases pH

\[ H^+ + HCO_3^- \leftrightarrow H_2O + CO_2 (g) \]

T & T Aeration Test
Aeration Removes CO$_2$ and Increases pH Continued

$H^+ + HCO_3^- \leftrightarrow H_2O + CO_2 (g)$
What is a TROMPE?

- It is a device that uses falling water to compress air.
- It has No moving parts.
- It does Not use electricity.
- It is Completely passive.
Principals of Operation

- Falling water in a pipe entrains air.
- The high velocity water carries the air down the pipe to an air separation chamber.
- Compressed air is separated from the water by gravity.
- The air is collected for use.
- The water is discharged.
Trompe History

- Discovered in 17th century Italy.
- Defining component of the Catalan Forge
- Developed 1 to 16 oz pressure
Trompe History Continued

- Rediscovered by Charles Taylor, Canada
- Ragged Chutes Compressor delivered 128 psi to the area mines
- Was in continuous operation for over 70 years with only two maintenance shutdowns.
Curley Site

North Fork Site
Curley Raw Water with Aeration
Curley Raw Water

Alkalinity 425 to 450 mg/l   Flow 31 to 100 gpm

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>EC</th>
<th>Al total</th>
<th>Ca total</th>
<th>Mg total</th>
<th>Fe total</th>
<th>Fe dissolved</th>
<th>Mn total</th>
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<tr>
<td>CURLEY RAW</td>
<td>1/18/2011</td>
<td>3399</td>
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<td>500.4</td>
<td>286.0</td>
<td>25.47</td>
<td>25.89</td>
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Feed Pipe & Overflow
TROMPE in Operation
Fine Bubble Aeration Discs
Air In

Curley DO
2-26-11

- Raw
- Plunge pool
- Bridge
- Pond 2 Inlet
- Pond 2 Outlet
- Base cascade
- Trompe in
- Trompe out
- Pond 4 out
Curley pH
2-26-11

- Raw
- Plunge pool
- Bridge
- Pond 2 Inlet
- Pond 2 Outlet
- Base cascade
- Trompe in
- Trompe out
- Pond 4 out

pH Rising
Curley Results

Percent Iron Oxidized

- Aerated 1-18
- Not Aerated 1-26
- Aerated 2-26

Graph showing the percent iron oxidized across different ponds and conditions.
Curley Results

Percent Iron Settled

- Aerated 1-18
- Not Aerated 1-26
- Aerated 2-26
Conclusions

- Multiple TROMPEs have been successfully designed and installed at both North Fork and Curley passive treatment systems.
- The TROMPE is providing aeration to the raw water and has increased the DO level at the bridge from 3.28 to 6.21 mg/l.
- There is an 11 to 16 percent increase in iron oxidation at the end of Pond 2.
- At the end of pond 3 iron oxidation has increased from 87.9% to between 97.3% and 97.5% as a result of TROMPE aeration.
Conclusions continued

- Sufficient oxygen is present in the water to fully oxidize the ferrous iron present. However, dissolved carbon dioxide is believed to be retarding the rate of iron oxidation by keeping the pH below the level it would achieve if the carbon dioxide were in equilibrium with the atmospheric carbon dioxide partial pressure.

- The amount of iron settled increased significantly as a result of aeration, particularly in pond 3.
Questions?