FLOODING AS A RECLAMATION SOLUTION TO AN ACIDIC TAILINGS POND AND OPEN PIT; MORE THAN 15 YEARS AFTER

18th BC/MEND Workshop

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Outline

• Location, Context and Historic data
• Flooding Experiments
• Reclamation Works for Tailings pond and Open pit
• Monitoring
• Results
• Conclusion
Historic Data

SOLBEC MINE (1962 - 1970)

- Massive sulfide deposit (chalcopyrite CuFeS$_2$, sphalerite ZnS, galena PbS, pyrite FeS$_2$).
- UG mine: 1,500,000 t
- OP mine: 414,000 t
- Total: 1,914,000 t grading 1.56 % Cu
  4.50 % Zn
  0.69 % Pb
  0.58 g/t Au
  52.1 g/t Ag

SOLBEC PLANT (1962 - 1977)

- Solbec: 1,914,000 t
- Cupra: 2,429,000 t
- Weedon: 427,000 t
- Clinton: 115,000 t
- Total: 4.9 Mt of sulfide ores
2.5 Mm$^3$ or 4.9 Mt of tailings

Surface oxidation (0 to 50 cm)

Solbec Tailings Pond 1987
Solbec Tailings Pond

- 66 hectares including 20 submerged hectares in the northern part.

**Acidic effluent in 1987:**

- pH : 3.0
- Cu : 1.0 mg/l
- Sulfates: 240 mg/l
- Zn : 3.0 mg/l
- Fe : 10 mg/l
Solbec complex natural drainage

- Solbec tailings pond drains into an unnamed creek that flows into a stream which empties into Lake Aylmer.

- The mine and mill sites also drain into an unnamed creek flowing into Bernier river and then into Lake Aylmer.
• 1985: Solbec mining complex was classified **Category 1** – a site presenting a **high risk** of contamination to the downstream environment.

<table>
<thead>
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<th>Category</th>
<th>Risk Potential</th>
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<td>Public Health</td>
<td>Environment</td>
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<td>Medium to High</td>
<td>High</td>
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<tr>
<td>2</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>None</td>
<td>Low</td>
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• In 1986, the Quebec Natural Resources Department sponsored a study to assess different rehabilitation methods. The report proposed flooding as the optimal solution to the problem.
Flooding Experiments (MEND program)

- **1989** CRM Laboratory columns and field basins
- **1990** CRM New field basin to simulate flow conditions
- **1991** Monentral Technical feasibility of flooding:
  - ensure a long term water cover
  - establish a potential water balance
  - test the bearing capacity of the ground under the dams
  - identify borrow pits
- **1992/93** Roche Tests to neutralize oxidation products in field basins
- **1993** McGill U. Depth of the water cover
- Laval U. Quantity and application mode for lime
- Laval U. Bacterial activity
Experiments Recommendations

• With the construction of **2 dams**, the water could accumulate into a 1.2 km² pond for 18 months before any overflow occurred.

• Depth of water required to inhibit acid generation: the study led to recommend a minimum water cover above the reactive tailings of **1.34 m or 0.74 m** if the tailings were to be covered with sand.

• As the tailings grain size was sand size, a **one meter water cover** was determined to be adequate.

• Quantity of **lime** to be used: the resulting recommendation was to apply 118 tons/ha on an average of a 15 cm layer.
Reclamation Works

1994: Clearing of **27 ha** of land (for access roads, dams site and some portion of the area to be flooded).

- **1994-95:** Construction of two dams:
  - **a main dam** 396 m long and 9 m high
  - **a second dam** 192 m long and 2.5 m high.
  - at the north end of the main dam, a 4 m wide concrete spillway was built to handle the flooding of the century.

- Before flooding, the whole surface of the tailings was limed. In the water-covered area (20 ha), hydrated lime (Ca(OH)$_2$) was dumped in the water. In the uncovered area, calcite dust and granules (CaCO$_3$) were incorporated into the tailings by plowing to a depth of 300 mm. An average of 230 tons per ha of material was applied.
Reclamation Work

• The surface of the watershed of the basin is 500 ha (5 km²) and total precipitation in the region ranged between 1.1 and 1.2 m per year with an average pH of 4.4.

• The tailings were completely flooded by the fall of 1995 and in February 1996, an effluent was reported at the spillway (1 m over the tailings).
Monitoring

• The environmental monitoring program following the flooding of the tailings pond was developed as part of the MEND program.

• Different aspects of the monitoring program included:
  • the quality of water cover, groundwater quality, effluent, quality receiving water down to Lake Aylmer,
  • the water balance,
  • the effect of waves and ice on sediments, bank erosion, and beach creation
  • the dam stability and integrity.

• The program which included more than 50 sampling stations analysed for more than 10 parameters was in place from 1996 to the end of 2002.

• In April 2003, MDDEP allowed water monitoring to be discontinued
• In 2002, The Dam Safety Act was introduced.

• The long dam was classified as a high-capacity and class C dam on the basis of the risks to persons and property.

• High capacity dams are subject to the preparation of an Emergency Response Plan and to regular inspection.

• Inspections have to be conducted by an engineer with relevant qualification and proposed remedial measures, if any, have to be implemented without delay.

• Today, the remaining dam stability and integrity follow up is performed by S.M. Group.
Tailings pond covering water - pH and Iron

The graph illustrates the pH and iron levels in the water covering the tailings pond over time. The x-axis represents different seasons (Fall, Spring, Summer) and years (1994 to 2011), while the y-axis shows the concentration in mg/l or ppm.

- **pH**: The pH values are represented by blue diamonds. The pH levels fluctuated significantly, with a noticeable decrease over time.
- **Directive 019 pH**: The Directive 019 pH levels are shown in purple squares. These levels remained relatively stable throughout the observation period.
- **Iron (mg/l)**: The iron concentrations are depicted in yellow diamonds. There was a noticeable decrease in iron levels over the years.
- **Directive 019 Fe**: The Directive 019 Fe levels are marked in green circles. These values also showed a steady decrease over time.
Tailings Pond Covering Water - Copper and Zinc

Graph showing the concentration of Zinc and Copper in mg/l or ppm over time from Sept 1994 to Aug 2011. The graph includes data points for each month and year, with Zinc and Copper concentrations indicated by different colored lines.

- Zinc (mg/l) is shown by a red line.
- Directive 019 Zn is shown by a pink line.
- Copper (mg/l) is shown by a blue line.
- Directive 019 Cu is shown by a green line.

The graph indicates that Zinc levels dropped significantly from Sept 1994 to Apr 1995, while Copper levels remained relatively stable throughout the period.
Results

• In 2009, a compilation study on the effectiveness of restoration was conducted at University Laval: the reclamation method had then been proved effective.

• In 2010, IAMGOLD had captured brown bullheads (Ameiurus nebulosus) from the lake developed on the former tailings pond and analysed mercury level: results were all way below the Canadian consumption guideline.

• Results from the various sampling campaigns showed that flooding of Solbec tailings pond is successful.
Lac de la Héronnière - 2011
Main Dam
Basin Spillway
OPEN PIT RECLAMATION
• Mining of the surface pillar had left an open trench (glory hole) where the accumulated waters had a pH below 5.

• 10 000 m³ of tailings had been disposed in the pit during the last few weeks of operation of the mill in 1977.

• In 1988: reactive rocks remaining on site were then transported to the trench and limed. The pit was then filled up to 2 m above the original water table elevation.

• Fortunately, a 1 m water cover could be maintained over the waste rocks by constructing a water retaining dyke across the south end of the pit.
Reclamation Work

- The overflow of the former glory hole drained by gravity into collection ponds, which drained through underground canalisation towards biofilters, before its discharge to the environment.

- Two collection ponds were constructed to accumulate water in order to equalize the input flow rate in the biofilters.
The biofilter known as Mediaflex technology was designed to reduce the metal concentrations. They are constituted of ashes and bacterial inoculums.

- Average capacity is 650 m$^3$/d
- Maximum capacity is 800 m$^3$/d
- Filters operate by ascending flow, system of pipes is not visible and no need for start-up procedure.
- As soon as the waters thaw in Spring, they are operative.
- Aquagenie monitors the efficiency of the Mediaflex filters.
Fall 1996
Overflow of the mediaflex filters: pH-Fe-Zn
Reclaimed pit
A successful story

The covering waters meet all requirements outlined in Guideline 019 as well as those of the Quebec drinkable water regulation
The pond site has returned to its natural state; the site had been recolonized by native fauna and flora.
Lots to sale

Domaine des Hauts-Cantons

Lac de la Héronnière

Secteur Ouest
Secteur Nord
Secteur Est
Secteur Sud-Est

Terrain à vendre
Terrain vendu
Bureau

Sur rendez-vous
(418) 332-9800

Entée

domainedeshautscantons.com
From Google Earth, 2009 aerial photo
Conclusion

• No one size fits all for reclamation
• Closure is a process not an event
• Deliver win-win outcomes
• What we leave behind after mining affects our reputation

• Thank you for your attention!