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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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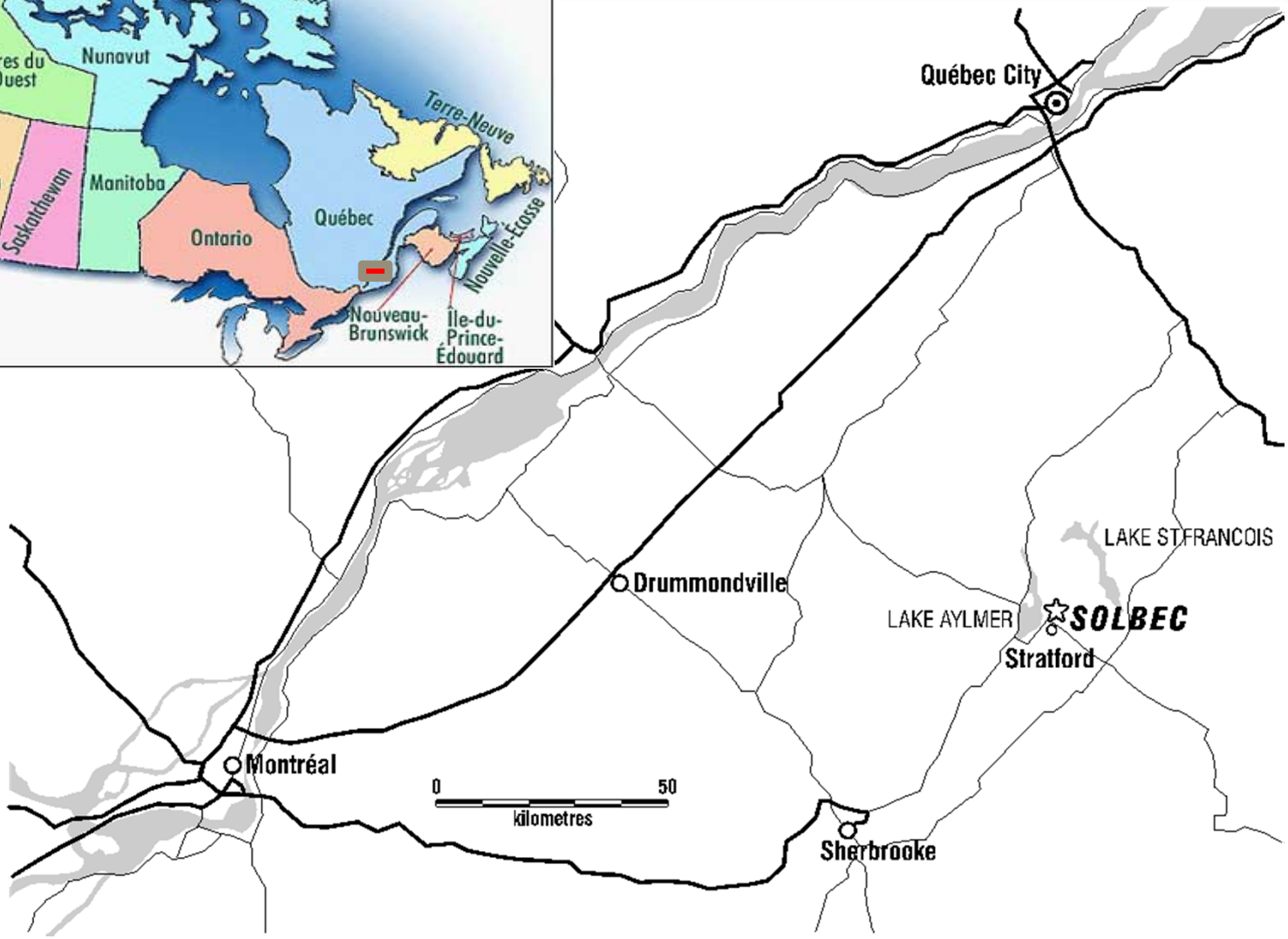
Outline

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

LOCATION



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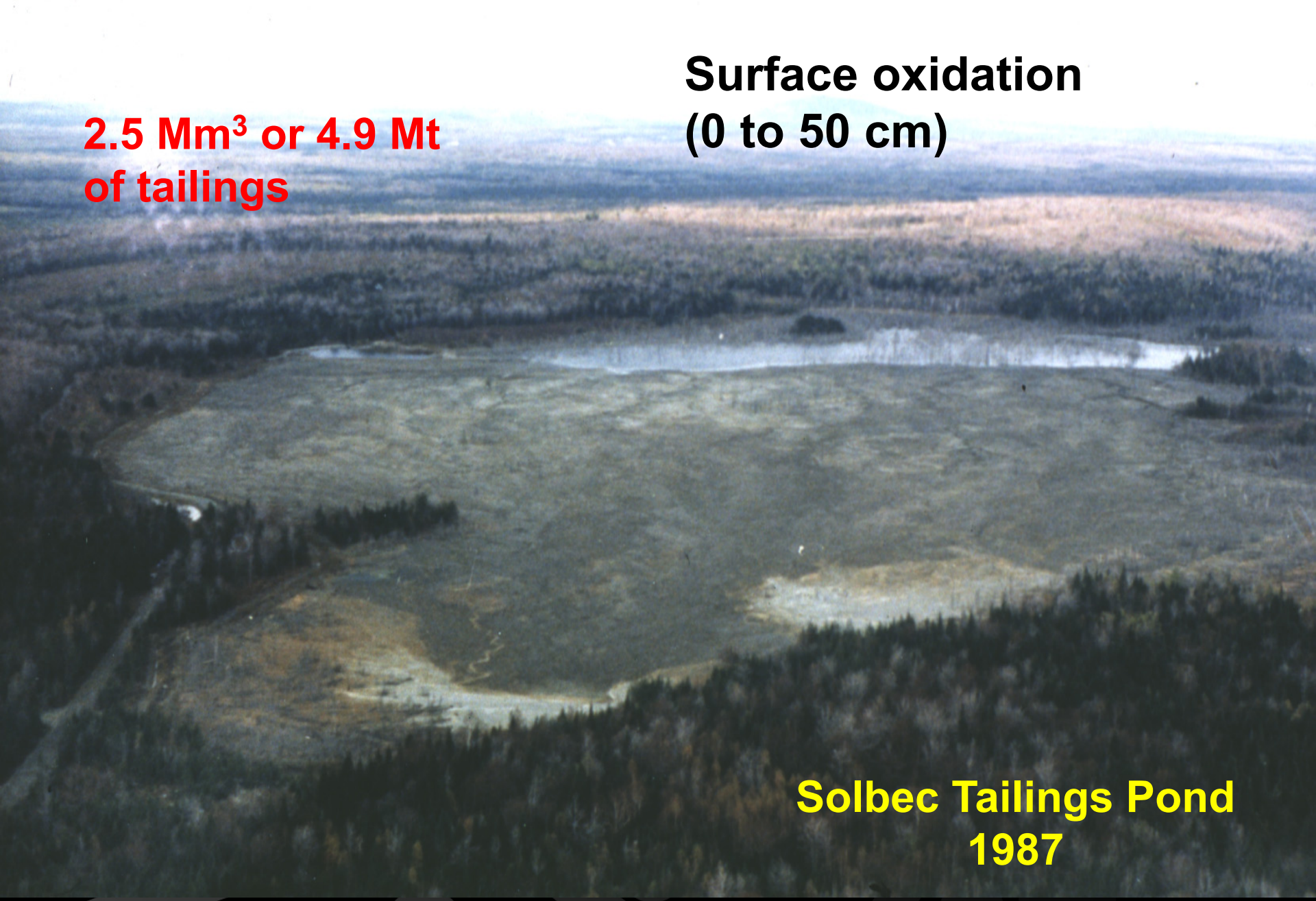
Historic Data

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 Mm3 or 4.9 Mt
of tailings
Surface oxidation
(0 to 50 cm)
Solbec Tailings Pond
1987

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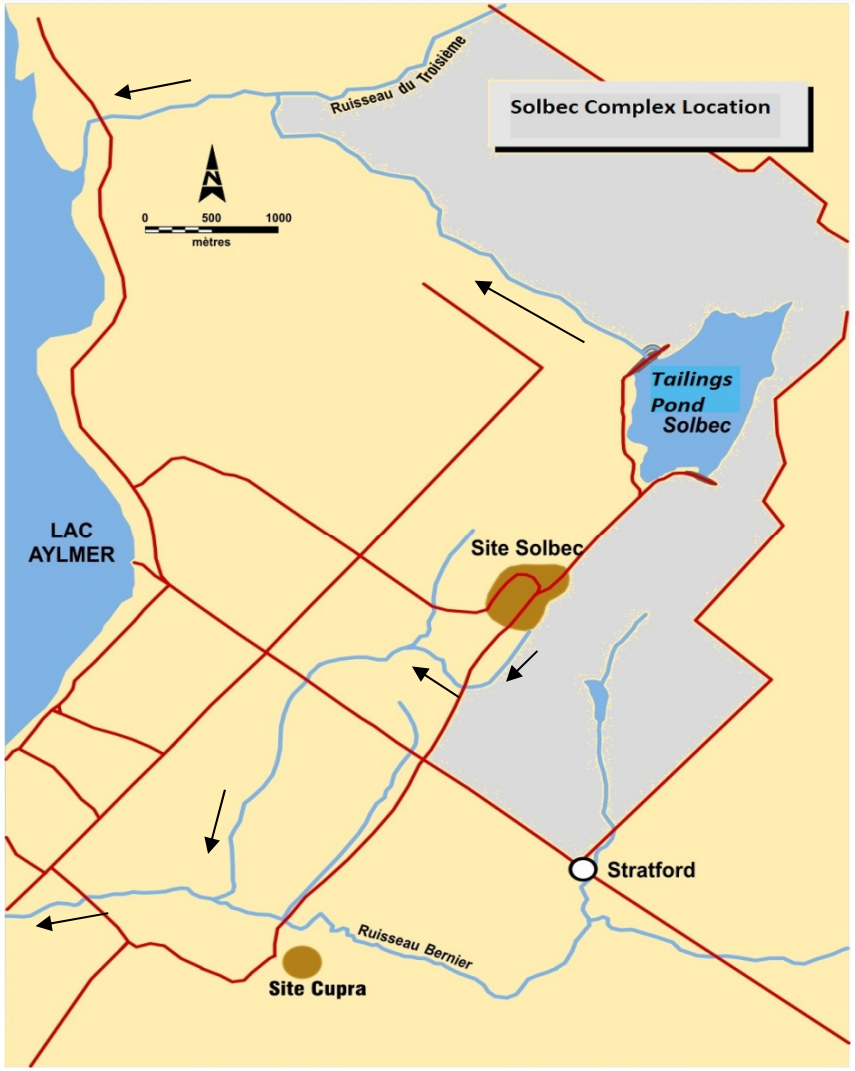
Solbec Tailings Pond

- 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**

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Post Decommissioning Regulators' Initiative

•1985 : Solbec mining complex was classified **Category 1** – a site presenting a **high risk** of contamination to the downstream environment.

Category	Risk Potential	
	Public Health	**Environment**
1	Medium to High	High
2	Low	Medium
3	None	Low

•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** Monterval 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 km^2 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 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).

•The surface of the watershed of the basin is 500 ha (5 km^2) and total precipitation in the region ranged between 1.1 and 1.2 m per year with an average pH of 4.4.

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.

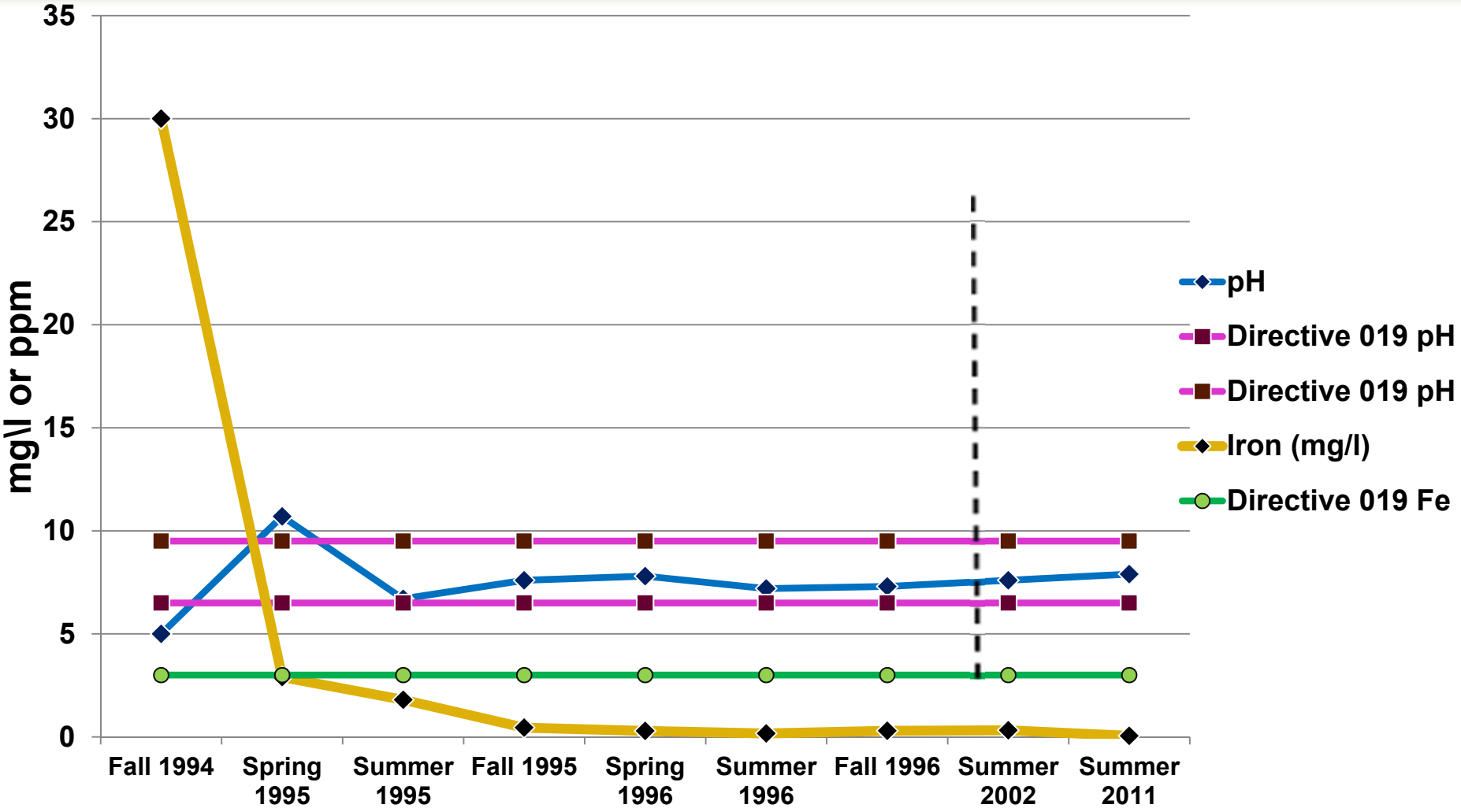
- The program which included more than 50 sampling stations analysed for more than 10 parameters was in place from 1996 to the end of 2002.

- In April 2003, MDDEP allowed water monitoring to be discontinued

Monitoring

- 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



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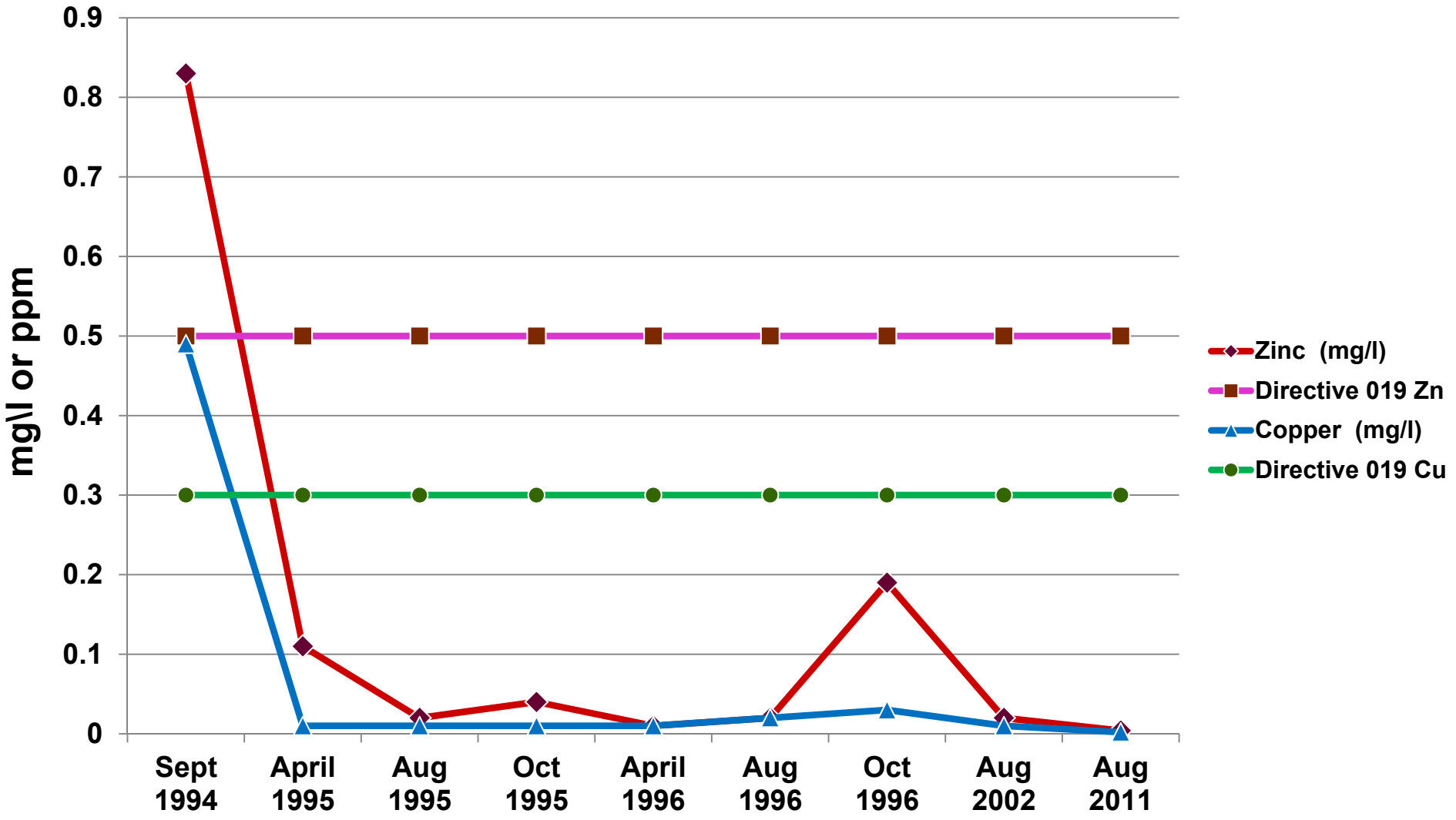
Tailings Pond Covering Water - Copper and Zinc



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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

Reclamation Work

•Mining of the surface pillar had left an open trench (glory hole) where the accumulated waters had a pH below 5.

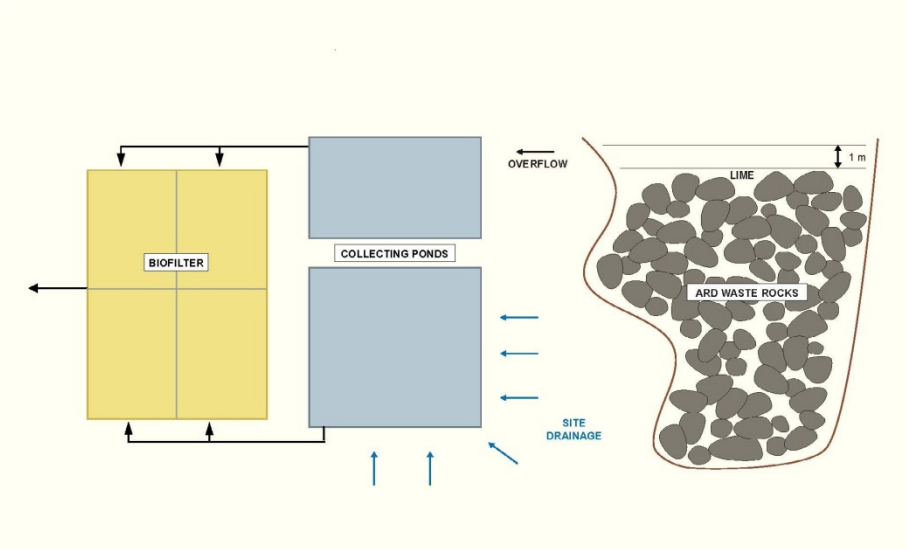
•10 000 m3 of tailings had been disposed in the pit during the last few weeks of operation of the mill in 1977.

•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.



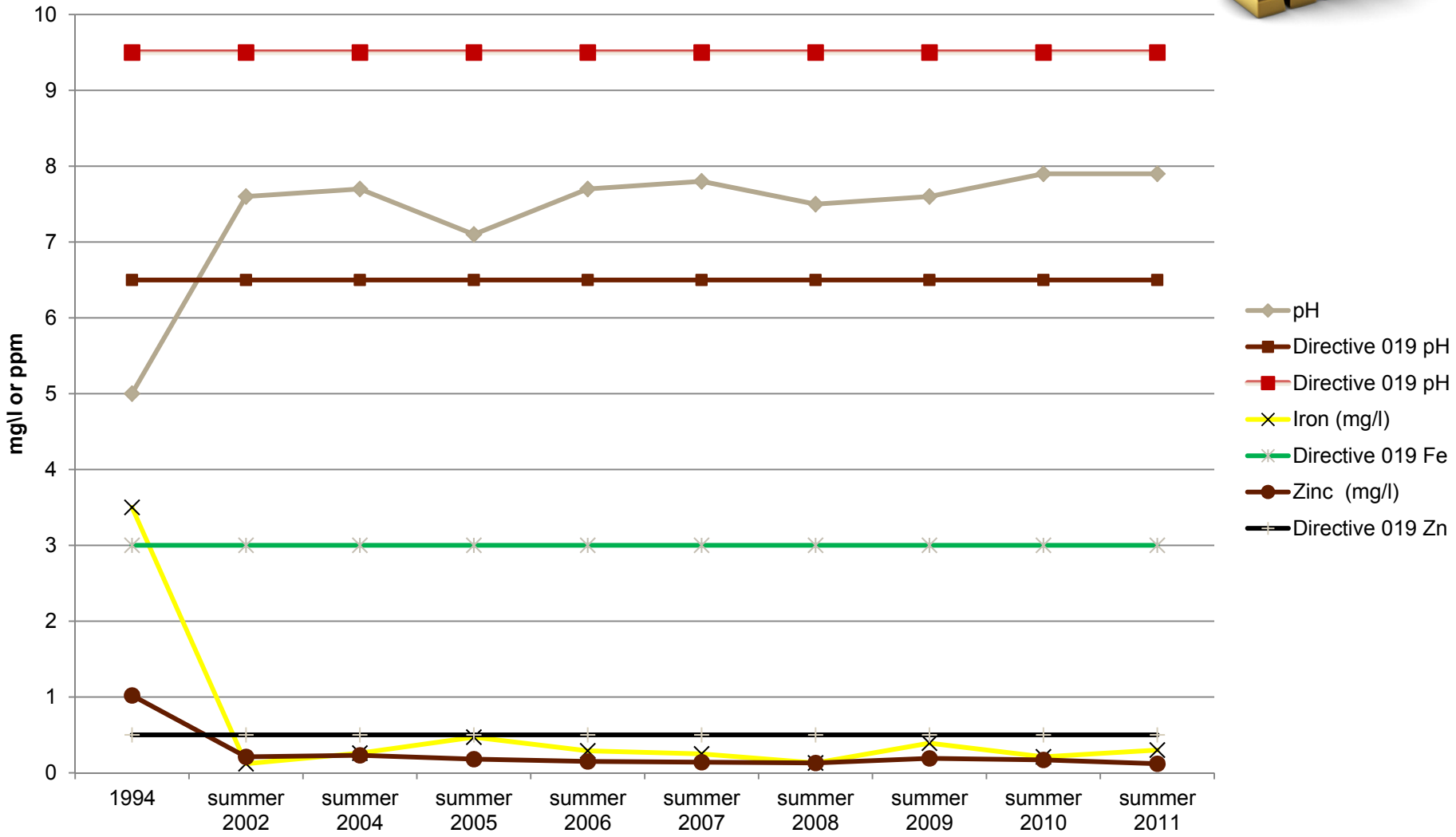
•Two collection ponds were constructed to accumulate water in order to equalize the input flow rate in the biofilters

Reclamation Work

- 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



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Biofilters - 2011

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

Regular visitors

The pond site has returned to its natural state; the site had been recolonized by native fauna and flora

Lots to sale

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From Google Earth, 2009 aerial photo

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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!