Implementation of a Thin Layer Cap on Lake Superior in Marathon, Ontario

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History

• Marathon renaissance in 1946 with construction of Marathon Pulp and Paper - Town motto: “Built on paper, laced with gold”

• Bleached kraft pulp mill which operated on the shores of Jellicoe Cove from 1946 until 2009

• Principal discharges resulted from untreated pulp mill effluent and treated effluent from a chlor-alkali plant which operated from 1977 to 1984

• Marathon Pulp and Paper filed for bankruptcy in 2009 and ceased operation

• Investigations dating back to 1980 have measured elevated mercury and PCBs in Cove sediments
Extent of Contamination & Regulatory Action

- Identified as an Area of Concern (AOC) in 1985 by the Water Quality Board of the International Joint Commission


- Hg in sediment in Jellicoe Cove is elevated with higher concentrations at depth.

- Erosion possible during storm events, but under most scenarios sediments are stable.

- Net accumulation of sediments in Jellicoe Cove is low.

- Sediments not toxic to benthic organisms, but affect upper trophic community including reproductive success of bottom feeding fish.

Figure 7-1 Conceptual Plan for Remedial Alternative 1 (Thin Layer Capping) Marathon Canada Sediment Remediation
Sediment Management Options – Selected Alternative

• Options considered included dredging and capping alternatives

• Presence of higher levels of contamination at depth and risk of resuspension were concerns with dredge options

• ERA/SMO predicted natural recovery of site in ~ 70 yrs

• Thin layer sand cap provided ability to achieve adequate risk reduction and to provide enhanced natural recovery of the site

• Prescribed remedy is placement of 15 - 20 cm layer of clean sand over defined contaminated “hot spots”
Geotechnical Assessment

Marathon Canada Sediment Remediation

Note: Locations of geotechnical borings is approximate.

Geotechnical Borings (Actual Locations)

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>X</th>
<th>Y</th>
<th>Water Depth (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO-1</td>
<td>544403.8</td>
<td>3396742.8</td>
<td>12.5</td>
</tr>
<tr>
<td>GEO-2</td>
<td>544487.4</td>
<td>3396322.8</td>
<td>4.6</td>
</tr>
<tr>
<td>GEO-3</td>
<td>544434.4</td>
<td>3396474.8</td>
<td>2.3</td>
</tr>
<tr>
<td>GEO-4</td>
<td>544437.6</td>
<td>3396740.8</td>
<td>19.9</td>
</tr>
<tr>
<td>GEO-5</td>
<td>544391.5</td>
<td>3396467.8</td>
<td>19.9</td>
</tr>
<tr>
<td>GEO-6A</td>
<td>544308.0</td>
<td>3396984.0</td>
<td>15.2</td>
</tr>
<tr>
<td>GEO-6</td>
<td>544276.5</td>
<td>3396874.6</td>
<td>6.1</td>
</tr>
<tr>
<td>GEO-7</td>
<td>544257.3</td>
<td>3396791.8</td>
<td>15.3</td>
</tr>
<tr>
<td>GEO-8</td>
<td>544577.0</td>
<td>3396956.0</td>
<td>10.7</td>
</tr>
<tr>
<td>GEO-9</td>
<td>544616.5</td>
<td>3396968.4</td>
<td>20.0</td>
</tr>
<tr>
<td>GEO-10</td>
<td>544453.0</td>
<td>3396508.8</td>
<td>6.3</td>
</tr>
</tbody>
</table>

NAD_1988_UTM_ZONE_10N

- Actual Geotech Boring Locations
- Proposed Geotech Boring Locations
- Historical Core Sample Locations
  (ENVIRON, May 2008)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Characteristic Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Content, w</td>
<td>40%</td>
<td>Average</td>
</tr>
<tr>
<td>Liquid Limit, LL</td>
<td>24%</td>
<td>Average</td>
</tr>
<tr>
<td>Plasticity Index, PI</td>
<td>0 (non-plastic)</td>
<td>≤ 10%, but generally zero</td>
</tr>
<tr>
<td>Specific Gravity, G</td>
<td>2.69</td>
<td>Average</td>
</tr>
<tr>
<td>Void Ratio, e₀</td>
<td>1.1</td>
<td>Average</td>
</tr>
<tr>
<td>Organic Content</td>
<td>4.7%</td>
<td>Surficial sediments only; deeper sediments are inorganic.</td>
</tr>
<tr>
<td>Percent Silt Sized Particles</td>
<td>55%</td>
<td>Average (&lt; 0.075 mm; &gt; 0.005 mm)</td>
</tr>
<tr>
<td>Percent Clay Sized Particles</td>
<td>12%</td>
<td>Average (&lt; 0.005 mm)</td>
</tr>
<tr>
<td>D₈₅ Size</td>
<td>0.12 mm</td>
<td>Average</td>
</tr>
<tr>
<td>Unit Weight (Saturated)</td>
<td>17.8 kN/m³ (113 pcf)</td>
<td>Average. Assumes G = 2.69</td>
</tr>
<tr>
<td>Pre-consolidation Stress</td>
<td>N/A</td>
<td>Assume normally consolidated</td>
</tr>
<tr>
<td>Compression Index, Cc</td>
<td>0.40</td>
<td>Correlation with water content (Holtz &amp; Kovacs 1981)</td>
</tr>
<tr>
<td>Coefficient of Consolidation, cv</td>
<td>18.9 m²/year (203 ft²/year)</td>
<td>Correlation with Liquid Limit (Holtz &amp; Kovacs 1981)</td>
</tr>
<tr>
<td>Drained Friction Angle, φ</td>
<td>27 degrees</td>
<td>Correlation with PI and USC system (Holtz &amp; Kovacs 1981)</td>
</tr>
<tr>
<td>Undrained Shear Strength, c</td>
<td>c/p = 0.22</td>
<td>Correlation with effective overburden pressure, p (Holtz &amp; Kovacs, 1981)</td>
</tr>
</tbody>
</table>

- Soft native sediments support the cap.
- Compression of sediments from cap's weight will be ~25% to 33% of cap thickness.
- Cap settlement estimated to be substantially complete in 13 months.
- Transition zones provided near the edges of the cap for stability.
Cap Coverage, Stability, and Gradation Requirements

- 15-20 cm of medium to coarse sand able to withstand storm events and prevailing currents

- Flow velocities at the lake bottom due to storm waves estimated at 0.44 m/s at the western side of the cap area, 0.22 at the center of the cap area, and 0.09 at the eastern side of the cap area.

<table>
<thead>
<tr>
<th>Size</th>
<th>% passing</th>
<th>% passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 mm</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>12 mm</td>
<td>100</td>
<td>90-100</td>
</tr>
<tr>
<td>#10 sieve</td>
<td>50-80</td>
<td>20-45</td>
</tr>
<tr>
<td>#40 sieve</td>
<td>10-40</td>
<td>0-10</td>
</tr>
<tr>
<td>#100 sieve</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>#200 sieve</td>
<td>&lt;6</td>
<td>&lt;6</td>
</tr>
<tr>
<td>Uniformity coefficient</td>
<td>&lt;8</td>
<td>&lt;8</td>
</tr>
<tr>
<td>Plasticity (fine fraction)</td>
<td>non-plastic</td>
<td>non-plastic</td>
</tr>
<tr>
<td>D50 mm</td>
<td>0.5</td>
<td>2.25</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>&lt;2.64</td>
<td>&lt;2.64</td>
</tr>
</tbody>
</table>
Design & Specification Considerations – Cap Thickness

• Test plots constructed at operations start-up to monitor effectiveness of placement operations across range of site conditions

• Core samples extracted to measure cap thickness, sediment/cap material mixing

• Secondary cap thickness verification through use of volumetric placement data

• Resultant data used to confirm effectiveness of placement methodologies and performance criteria
Design & Specification Considerations – Key Issues

- Schedule: Defined work window limited to May – August due to fisheries restrictions
- Sourcing of two grades of sand – variable sources
- Placement sequencing adaptation to progress, weather, mechanical issues
- Space limited and third party controlled staging area
- Water quality controls vs. sand placement productivity in defined schedule window
Design Considerations - Construction Monitoring Plan

- Measurements performed using boat-based nephelometer with direct turbidity readout (also monitor temperature, specific conductance and DO with depth) – Turbidity an analogue for TSS

- Measurements made at baseline, initial intensive, standard conditions and any change therein

- During intensive conditions water sample collection and analysis for SS, total Hg and PCBs conducted

- Monitoring control limit set at 100m from point of operation

- Preliminary actionable level is set at 25 NTU above baseline or background condition with 50 NTU as hard limit

- Selected near shore areas prescribed for additional protection (silt curtains)
Construction Schedule and Approach

- Construction Tender by PWGSC: March 2012
- Construction Award: May 2012 to Milestone
- Mobilization and site prep: May 2012
- Construction Start: June 2012 – test cell first week of June; Construction Completion: August 5, 2012
- Medium Sand sourced locally – Coarse sand shipped from remote
- Mechanical Placement:
  - Long reach excavator (Sennebogen) with $2 \text{ m}^3$ bucket on spudded capping barge
  - Supported by material barge
  - Tug supported navigation and landing craft for personnel transport
  - RTK GPS and DREDGEPAK Electronic positioning
Implementation – Key Issues

- Water Quality Monitoring/Control
- Cap Thickness Verification
- Production Rate within schedule, mechanical, weather and water quality constraints
Water Quality Control During Sand Placement

- No water quality related work stoppages
- Turbidity to TSS relationship adequate for construction water quality control
- Effective sand placement approach and cell sequencing derived from test phase
Cap Thickness Verification – Piston Coring
Sand Cap Thickness Verification

- 5 cores per hectare
- Average thickness per cell (15 cm / 20 cm medium / coarse)
- Individual core max and min (30 cm / 10 cm)
- Secondary verification using ullages from barges
Capping Production

- Average Production Rate: \( \sim 4,600 \text{ m}^2/\text{day}; \sim 930 \text{ m}^3/\text{day} \) over 48 production days @ 12 hours/day
- Capping completed 25 days ahead of schedule;
- Additional capping area completed within existing project budgets/timeframes;
- No weather or water quality control related work stoppages;
Record of Cap Progress and Completion

- Sequencing of cells by sand grade and water column depth
- Completion of additional ~ 30,000 m²
- Adaptability to weather, water quality, mechanical factors
- Strong Owner, Resident Engineer, Contractor relationship and cooperation
Post - Construction Monitoring Plan – Long Term

- Assess the physical stability of the placed thin layer cap
- Compare fish tissue concentrations of mercury and PCBs from the Peninsula Harbour AOC with those of suitable reference areas
- Compare sediment concentrations of mercury and PCBs in the thin cap and natural recovery areas within the AOC with suitable reference areas
- Compare the benthic community structure in the thin cap and natural recovery areas within the AOC with suitable reference areas
- Compare benthic macroinvertebrate tissue concentrations of mercury and PCBs from the AOC with those of suitable reference areas
- Evaluate temporal trends in sediment concentrations and fish and benthic macroinvertebrate tissue concentrations of mercury and PCBs in the thin cap and natural recovery areas of the AOC