Controlling Recontamination During Phase 2 Sediment Remediation Dredging at the Esquimalt Graving Dock

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Outline
1. Background
2. Containment Objectives & Design
3. Water Quality Monitoring
4. Sediment Assessment
5. Discussion

Background – Esquimalt Graving Dock Waterlot Remediation Project

Site Description and Background

EGD Waterlot Remediation Objectives
1. Remove maximum contamination practicable
   • Reduce Government of Canada financial liability
   • Establish baseline conditions for future operations
   • Meet federal and provincial standards
   • Reduce risks to human health and environment
   • Achieve Federal Contaminated Sites Action Plan objectives
2. Minimize disturbance to operations
3. Ensure high level of certainty in Project outcome

Active Shipyard/Graving Dock Facility

Phase 1A – Under-Pier Erosion Protection System

Phase 1B – Open-Water Dredging
### Phase 2 - Jetty Demolition

- Timber jetty (demolished)
- Steel pile supported jetty (retained)

### Phase 2 Under-Pier Remediation

- Construction October 2015 to December 2016
- 36,500 m$^3$ of contaminated sediment removed
- Required removal volume (with overdredge): 34,400 m$^3$
- Hazardous waste removal volume: 200 m$^3$
- Missed inventory (contingency): 2,100 m$^3$

### Phase 2 Remediation (cont.)

- Maximum Contaminant Concentrations
- *Contaminants include PAHs, metals, PCBs, and TBT*

### Sediment Containment Objectives

**Temporary Resuspension Barriers (TRBs)***
- Exterior Containment
  - Prevent recontamination of previously remediated sediments (Phase 1B area)
- Interior Containment
  - Contain hazardous waste level sediments (Zone 1)
  - Allow for separate activities to occur concurrently (dredging and capping)

### TRB Construction

- Plan view
- Side view

### TRB East End Construction

- Plan view
- Side view

### Water Quality Monitoring

- Norm Healey
### Water Quality Monitoring Locations

### Phase 2 Water Quality Performance Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Early Warning</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>2.5 (induced)</td>
<td>100</td>
</tr>
<tr>
<td>DO</td>
<td>mg/L</td>
<td>5 max; 8 mean</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>7.0 to 8.5</td>
<td></td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>5 (induced)</td>
<td></td>
</tr>
<tr>
<td>Total As</td>
<td>µg/L</td>
<td>125</td>
<td>12.5</td>
</tr>
<tr>
<td>Total Cu</td>
<td>µg/L</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>Total Zn</td>
<td>µg/L</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>PAHs</td>
<td>µg/L</td>
<td>1-510</td>
<td>0.1-51</td>
</tr>
</tbody>
</table>

### Phase 2 Water Quality Criteria for TSS

![Graph showing TSS vs. Time (days) with units and values](image)

### Water Quality Monitoring Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Exceedances</th>
<th>Max</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>93 (0.4%)</td>
<td>24 NTU</td>
<td>2.5 NTU</td>
</tr>
<tr>
<td>TSS</td>
<td>13 (2%)</td>
<td>16 mg/L</td>
<td>5 mg/L</td>
</tr>
<tr>
<td>Cu</td>
<td>3 (0.5%)</td>
<td>4.3 µg/L</td>
<td>3 µg/L</td>
</tr>
</tbody>
</table>

### Turbidity Spatial Variation

![Map showing turbidity spatial variation](image)

### Water Quality Monitoring Visual Observations

![Photo of water quality monitoring](image)

### Water Quality Monitoring Summary

- Relatively low Project Water Quality Performance Criteria
- Intensive spatial and temporal monitoring
- Overall
  - Low frequency and magnitude of exceedances of water quality criteria
  - Zones 2 & 3
  - More frequent and greater magnitude exceedances of water quality criteria
  - Visual evidence of particulate release and compromised TRB integrity

### Baseline and Recontamination Sediment Assessment

David McKeown
Baseline Sediment Assessment

- Surface sediment samples collected around perimeter of Phase 2 area prior to construction activities.
- Results compared to Numeric Remedial Action Objectives (NRAOs) established during Phase 1B and catalogued for comparison to post-construction re-sampling.
- Diver inspections of armoured slope areas outside of TRB also conducted to establish pre-construction conditions.

Baseline Sediment Sample Results

- Re-sampling conducted at all locations following substantial completion (Nov 2016).
- Results compared to NRAOs and baseline results to determine changes in sediment chemistry during Phase 2 works.
- Diver inspections also completed along armoured slope.
- Observations of sediment deposited/spilled outside of the Phase 2 boundary.

Sediment Re-Assessment Results

- Baseline results below NRAOs with three exceptions.
- Interim resampling indicated elevated levels of select parameters (metals, PAH, PCB) in some locations.
- Prompted additional core-out samples for delineation purposes.
- Final post-construction sampling confirmed elevated levels of select parameters in localized area.
- Additional remedial action deemed necessary in other locations.
- Post-construction diver inspections did not reveal any significant deposits of material along the adjacent armoured slope.

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Corrective Actions

- RMC Placement
  - 0.3 m thick RMC layer placed in localized area where elevated surface concentrations noted.
  - Based on exceedance of 4 x NRAO.
  - Provides clean surface at end of construction.
  - Anticipated to mix with underlying sediments over time to achieve remedial targets.
  - Long-term monitoring of sediment quality planned.

- Sheet pile wall extraction
  - Extraction of SPW created exposed sediment noted during final diver inspections.
  - Additional armour rock placed to isolate sediments and provide seamless transition between Phase 1B and Phase 2 armour covering.

Discussion

- Challenging project objectives.
- TRB design, construction and operation generally successful at containing contaminated sediments.
- WQ and Sediment monitoring used to assess TRB performance.
- Exceedances of WQ thresholds were infrequent and low magnitude.
- Sediment chemistry indicated localized areas of resettled sediment exceeding remedial targets.
- Source uncertain, but evidence suggests release of suspended sediment from eastern Phase 2 area.
  - WQ stations with higher incidence of exceedances were coincident with identified sediment chemistry results.
  - Elevated chemistry results not consistent with other areas in harbour.
  - Visual evidence of lighter material deposits similar to Phase 2 sediments.
Discussion (Cont’d)

• Lessons Learned:
  - Importance of multiple lines of evidence within monitoring program (water and sediment monitoring).
  - More frequent sediment testing may be beneficial.
  - WQ monitoring may not be sensitive enough on its own or may be limited temporally and spatially to detect impacts associated with potential misrouting.
  - Overall, post-construction conditions met remedial objectives of the project (with some minor additional remedial actions).
  - TRB was generally successful in controlling off-site migration of contaminants during a long and complex project.
  - Monitoring components were intensive and provided data to demonstrate effectiveness of mitigation measures and TRB performance.

Thank You!