Randle Reef Sediment Remediation Project; Support Studies for Re-design

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Randle Reef – Project Development

- Cleaning up Randle Reef sediments will allow Hamilton Harbour to be removed from the list of Areas of Concern

- Extensive public consultation in 2003 resulted in selection of in-situ containment as preferred option for sediment management

- Environment and Climate Change Canada, Ontario Ministry of Environment and Climate Change, and Hamilton Port Authority have lead project design (completed spring 2012)

- Project design and cost estimates were developed by leading engineering firm and subjected to two peer reviews as well reviews by PWGSC and funding partners

- Cost: $138.9M inclusive of contingency. Funding announced December 2012;
  - GoC (ECCC) $46.3M
  - GoO (OMOECC) $46.3M
  - Local stakeholders $46.3M (Hamilton, Burlington, Halton, HPA, U.S. Steel)

- Project implementation agreements established with each funder in 2013. The project will be lead by ECCC.

- Project tendering and management is handled by PWGSC.
Randle Reef Project Components

- Construct a 6.2 hectare Engineered Containment Facility (ECF) over the most highly contaminated sediment (140,000 m$^3$ in-situ);
- Using a combination of hydraulic and mechanical dredging, remove 445,000 m$^3$ and place within ECF;
- Thin Layer Capping of 105,000 m$^3$ of marginally contaminated sediment
- Cap U.S. Steel Intake/Outfall Channel sediments 5,000 m$^3$
- Cap ECF and construct a port facility.
- Total sediment management of 695,000 m$^3$
Randle Reef Project Components

- **Stage 1;**
  - Installation of double steel sheetpile walls (ECF structure);
  - Mechanical dredging between ECF walls;

- **Stage 2;**
  - Production dredging and thin layer backfill;
  - Capping in U.S. Steel Channel; and
  - Thin layer capping of undredged areas

- **Stage 3;**
  - Installation of ECF cap, and
  - Consolidation and de-watering of dredged sediment
Stage 1: Installation of Double Steel Sheet pile Walls

Inner sheetpile walls have **sealed joints** and are driven into the underlying clay to contain contaminated sediment.

Dredge and backfill with rock fill between the walls
Stage 2: Dredging/Capping Sequence & Re-suspension Controls

Thin-layer cap on undredged sediment with tPAH >100 ppm
Stage 3; Installation of ECF cap

- The ECF capping system will consist of several layers:
  1. Foundation layer;
  2. Underliner drainage system;
  3. Hydraulic barrier layer;
  4. Overliner drainage system;
  5. Paved surface
  6. Stormwater management systems.
- Cap thickness ~3m
- Wick drains and a ‘preload’ of 500,000 tonnes will be used to increase the rate of sediment consolidation.
Stage 3: Randle Reef ECF Cap

Layers

[Diagram showing different layers with their respective elevations and materials]
Project Re-design

After an unsuccessful Stage 1 tender in 2014 ECCC and PWGSC worked to determine a new tendering strategy, including re-design, to ensure re-tendering would be successful. Major design changes included:

• Re-configuring and reducing the size of the ECF from 7.5 to 6.2 ha which resulted in;
  • Change in P1 dredge areas
  • Change in ECF wall configuration.

• Examining the vertical extent of the sheet pile wall and reducing where possible;

• Expanding the in-situ thin layer cap area.
ECF Design Changes 2006-2015

New dredge area

New wall alignment
Vertical ECF Wall Changes

From a structural and environmental standpoint what length reduction of the inner and outer wall is possible?
Changes to Thin Layer Sediment Capping

The reduction in the size of the ECF also means a greater portion of the Priority 3 sediment will now be managed using the thin layer capping approach.
Studies required for Re-design

• Geotechnical studies; to support ECF wall re-design.

• Sub-bottom Profiling; to support ECF wall re-design and dredge plan.

• Sediment Cores; to support ECF wall re-design and dredge plan.
Prior to the project re-design requirements a number of geotechnical studies were conducted focusing on the area of the ECF construction. These consisted of:

- Borehole sampling
- Laboratory testing of select borehole samples, and
- Cone penetration tests

The re-design required further geotechnical investigations, particularly in the footprint of the new ECF wall configuration. This consisted of:

- In-situ flat dilatometer testing
Geotechnical Investigations

2014 DMT locations
Geotechnical; In-situ Flat Dilatometer Testing

• The in-situ dilatometer testing confirmed the undrained shear strength and deformation properties of the silty clay material underneath the sediment layer.

• The testing procedures followed the ASTM D6635-01 (2007) “Standard Test Method for Performing Flat Plate Dilatometer”.

• A “blade” which gives pressure readings is pushed into the sediment/soil.

• The blade has a pressure plate and an internal diaphragm which is inflated once the blade has been advanced to the correct depth.
Geotechnical; In-situ Dilatometer Methods

• A truck mounted drill rig (on a barge) was used to drive the dilatometer blade into the undisturbed sediment and silty clay.

• The blade is attached via tubing to pressure gauges at the surface which give real time readings.
Geotechnical; In-situ Flat Dilatometer Testing Results

- Pressure readings are recorded for;
  - Lift-off
  - 1.1mm deformation, and
  - Deflation.
- Pressure readings are used to calculate;
  - Soil Index Number;
  - Horizontal Stress Index;
  - Dilatometer Modulus and Constrained Modulus
  - Pore Water Pressure
Geotechnical Conclusions

• The in-situ dilatometer testing results provided the geotechnical data necessary to;
  
  – Confirming the new wall locations were acceptable from a geotechnical standpoint, and
  
  – Optimizing the re-design of the walls in terms of the required depth of the sheet pile and distance between the outer wall and the inner wall (anchor wall).
Sub-bottom Profiling Study

- The contamination is generally in the surficial layer of soft saturated silt. Under the contaminated sediment is usually a firmer substrate, usually a silty clay. **Silty clay layer is uncontaminated.**
- This silty-clay layer was the target elevation for dredging for the majority of the site.
- A sub bottom profiler uses acoustic signals directed towards the harbour floor.
- Reflected acoustic readings help determine sediment layer thickness
- Refracted acoustic readings help determine sediment layer density
- Track-lines were set up with 50m spacing to cover the entire project area.
Sub-bottom Profiling – Methods

- The “towfish” emits and receives acoustic signals.
- Tow-fish was deployed off the survey vessel ~ 0.10 m below the water surface.
Sub-bottom Profiling – Methods

- Interpreted layers were visually identified and digitized onto the screen shots of transects. The digitized layers were compared to core data and existing bathymetry.
- Penetration of sub-bottom profiling is determined by the frequencies used and the acoustic qualities of the sediments being surveyed.
- The profiler penetration depth was ~3 m which was adequate for the majority of the Randle Reef site.
Sub-bottom Profiling – Results

Depthpic Image:
Sediment water interface determined by 200 kHz sounder
Upper to middle sediment transition determined by 12 kHz sounder
Middle to underlying sediment transition determined by 3.5 kHz sounder

3.5 kHz Sounder Image
Sediment Water interface was digitally added from the 200 kHz results
Yellow and Teal lines indicate transition zones between sediments
Green indicates maximum penetration
Sub-bottom Profiling Conclusions

• **Ground-truthing** was essential in order to properly interpret the results over a large site with 50 m spacing on survey lines.

• Confirmatory core locations indicated by green bars.

Conclusions:

• Resulted along with some other sources of data in a revised dredged plan with cost savings and reduced risk of claims related to second pass dredging.

• Sub-bottom profiling provided greater accuracy redefining the silty-clay target layer over a relatively large site.

Cores showed:

• Very light density sediment from **red** to **yellow**.

• Sandier sediments from **yellow** to **teal**.

• Silty clay from **teal** to **green**.
Core Studies

- The re-design required additional core collection to augment and corroborate the findings of the sub bottom profiler and confirm the environmental quality of the various sediment layers.
- Provided further sediment quality information in new dredge areas.
- Vibrocore was the most efficient method of collecting core samples from a time and cost perspective.
- **Deeper** (~4.5 m/15 ft) core samples were required in areas where the sub bottom profiler showed the underlying silty clay dipped to deeper elevations.
Deep Core Study Challenges

Collecting the deeper core samples faced the following challenges:

• Penetration into the deeper more consolidated layer is a challenge for conventional sediment sampling techniques;
• Techniques which utilize greater force would increase core compression of the unconsolidated surface sediment layers;
• Sample retention within the core barrel for longer heavier cores;
• Retrieval of the core after 4.5 m of penetration, and;
• Efficiency from a cost and timing perspective was key.
Deep Core Study

A number of techniques were considered;

• A continuous sectional vibracore was tested and resulted in considerable core compression.

• Drill Rig and barge would me delays and considerable additional cost.

• Vibracoring with conventional polyethylene tubes struggled to penetrate denser sediments and frequently had issues with core retention.
Deep Core Study

Vibracoring with 15 ft long thin walled aluminum pipes proved to be the best solution;

• The large opening of the 4” core tube vs. the thin wall helped with increasing penetration and minimizing core compression.
• Where required a collar outside the tube was used to measure core penetration vs. core sample length.
• Samples could be collected quickly (~4 per day)
• Thin flexible aluminum catchers where trimmed to minimize core compression while greatly increasing core retention.
Core Study Conclusions

The completion of the core studies;
• Corroborated the findings of the sub-bottom profiling;
• Established an environmental “clean-line” in area where the silty clay layer was deeper than previously completed samples.
• Assessed the environmental quality of the new dredge areas.

The core study results help in the optimize the dredge plan for the re-design and confirm the required depths of the inner ECF wall from an environmental perspective.
Re-design Success and Movement Forward into Implementation

The completion of these studies allowed ECCC, HPA and Riggs Engineering to complete the re-design of the project and resulted in a successful PWGSC re-tendering of Stage 1 of the project.

The first work was completed last fall with construction of the beginning this spring.

Stage 1; ECF Construction 2015 to 2017
Stage 2; Dredging 2018 to 2019
Stage 3; ECF Capping & Consolidation 2019 to 2022
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