REPORT
Bay of Plenty Regional Council
Opureora Dredging Spoil Disposal Assessment

ENVIRONMENTAL AND ENGINEERING CONSULTANTS
# Table of contents

1. **Introduction**  
2. **Site inspection**  
3. **Sediment analysis**  
   - 3.1 Existing beaches  
   - 3.2 Opureora Channel  
   - 3.3 Sediment compatibility  
4. **Options assessment**  
   - 4.1 Descriptions  
   - 4.2 Rough order cost estimate  
   - 4.3 Summary  
5. **Conclusions**  
6. **Applicability**  

Appendix A: Location Plan  
Appendix B: Resource Consent  
Appendix C: Dredge Plan  
Appendix D: Sediment Samples  
Appendix E: Contamination Samples
Executive summary

Bay of Plenty Regional Council (Council) commissioned Tonkin & Taylor Ltd (T&T) to assess potential disposal sites for the Opureora Channel dredge spoil. The objective of the study is to assess potential disposal sites, taking into account indicative costs and the feasibility of the physical works. The physical dredging works have been assessed based on both the cutter suction dredge and barge mounted excavator method.

Council have resource consent to dredge the Opureora Channel. However, the consent does not provide for the disposal of dredged material. Based on previous work and consultation with the local community Council have identified 10 potential disposal sites (refer to Table below).

Potential Opureora Channel dredge spoil disposal option list identified by Council (cost estimates based on dredging 7,100 m³)

<table>
<thead>
<tr>
<th>Option</th>
<th>Disposal description</th>
<th>Feasible</th>
<th>Cost estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Port of Tauranga Main Ocean disposal site, Mt Maunganui</td>
<td>Yes</td>
<td>$533,000</td>
</tr>
<tr>
<td>2</td>
<td>J. Swap’s sand stockpile yard, Sulphur Point</td>
<td>Yes</td>
<td>$565,000</td>
</tr>
<tr>
<td>3</td>
<td>Sub-tidal location within the harbour for natural redistribution</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Land based disposal on the mainland (Ōmokoroa Peninsula)</td>
<td>Yes</td>
<td>$622,000</td>
</tr>
<tr>
<td>5</td>
<td>Land based disposal to Matakana Island</td>
<td>Yes</td>
<td>$565,000</td>
</tr>
<tr>
<td>6</td>
<td>Land based disposal or beach nourishment at Opureora sandspit</td>
<td>Yes – nourishment, No – land based</td>
<td>$380,000</td>
</tr>
<tr>
<td>7</td>
<td>Land based disposal on Motuhoa Island or Rangiwāea Island</td>
<td>Yes</td>
<td>$622,000</td>
</tr>
<tr>
<td>8</td>
<td>Beach renourishment or erosion protection backfill material at Opureora Marae</td>
<td>No - both</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Beach renourishment west of the Opureora Boat ramp</td>
<td>No - both</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Beach renourishment or erosion protection backfill material on Rangiwāea Island</td>
<td>No - both</td>
<td></td>
</tr>
</tbody>
</table>

The cost estimates have been provided in the above table for the options considered to be feasible. The estimates are for the total physical works costs of dredging based on the most economic method and also the professional fees for lodging a resource consent application.

We consider the four options to be unfeasible due to the following reasons:

- The sub-tidal deposition is a relatively uncontrolled method and there is a high risk of resource consent being declined for this activity (Option 3).
- Land based disposal is not considered feasible on Opureora Spit because it has been identified in the BOPRC Coastal Plan as a Coastal Habitat Preservation Zone (CHPZ19). The spit is listed as a significant marsh bird (New Zealand Fern Bird) habitat including searush and tussock land (Option 6 – land based).
Approximately 80% of the dredge spoil placed as beach nourishment in front of the three cliff locations is expected to be transported alongshore and offshore (winnowed) from the beach face to other parts of the beach profile below MSL. Therefore, we do not consider the dredged spoil to be suitable for beach nourishment at these locations (Option 8, 9 and 10 - nourishment).

Backfill behind an erosion protection structure would only account for a small proportion of the sediment requiring disposal and is not considered to be a feasible option on its own (Option 8 and 10 – erosion protection backfill).

The other six options identified in the above table are practically feasible and range in cost from $385,000 to $622,000 for the 7,100 m$^3$ volume scenario, including professional fees associated with lodging an application for resource consent. The land based disposal options have the highest cost due to the double handling of truck transfer. The beach nourishment of Opureora Spit has the lowest cost due to the close proximity to the site and the suitability of the cutter suction dredge method.

We recommend assessing the channel infilling rates based on the survey data undertaken on the second anniversary of completing the dredging, which is required under the existing consent. Maintenance dredging using the cutter suction dredge method is likely to be more economic over a longer time interval of 5 – 10 years, due to the high mobilisation costs.
1 Introduction

Bay of Plenty Regional Council (Council) commissioned Tonkin & Taylor Ltd (T&T) to assess potential disposal sites for the Opureora Channel dredge spoil. The objective of the study is to assess potential disposal sites, taking into account indicative costs and the feasibility of the physical works. The physical dredging works have been assessed based on both the cutter suction dredge and barge mounted excavator method.

The Opureora Channel is located within the Tauranga Harbour adjacent to Opureora, Matakana Island (refer to Appendix A for a site location plan). The Opureora Channel is approximately 1.8 km long and is the main access channel for the Omokoroa to Matakana Island vehicle ferry.

Council have an existing consent for the proposed dredging (Consent 63226 attached in Appendix B), which allows for up to 12,000 m$^3$ of material to be removed from the Opureora Channel over an area 20 m wide by 850 m long. The vehicle ferry requires a minimum water depth of 1.2 m below Chart Datum for all tide access when fully loaded. Council is also considering an overdredging buffer of 200 mm resulting in the following two dredging volume scenarios (refer to Appendix C for a Figure of the proposed dredging alignment):

- 10,500 m$^3$ based on a minimum cut depth of 1.4 m below Chart Datum
- 7,100 m$^3$ based on a minimum cut depth of 1.2 m below Chart Datum.

The consent does not provide for the disposal of dredged material and prohibits disposal in the coastal marine area (CMA). The consent is based on the assumption that the dredging will be undertaken by barge mounted excavator and limits the dredging activity to the outgoing tide. Based on previous work and consultation with the local community Council have identified 10 potential disposal sites (refer to Table 1). The 10 potential options can be categorised into the following three groups:

- offsite marine disposal location (Group A)
- land based disposal (Group B)
- foreshore based disposal for local erosion protection purposes (Group C).

Table 1 Potential Opureora Channel dredge spoil disposal option list identified by BOPRC

<table>
<thead>
<tr>
<th>Option</th>
<th>Disposal description</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Port of Tauranga Main Ocean disposal site, Mt Maunganui</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>J. Swap’s sand stockpile yard, Sulphur Point</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>Sub-tidal location within the harbour for natural redistribution</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>Land based disposal on the mainland (Ōmokoroa Peninsula)</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>Land based disposal to Matakana Island</td>
<td>B</td>
</tr>
<tr>
<td>6</td>
<td>Land based disposal or beach nourishment at Opureora sandspit</td>
<td>B/C</td>
</tr>
<tr>
<td>7</td>
<td>Land based disposal on Motuhoa Island or Rangiwāea Island</td>
<td>B</td>
</tr>
<tr>
<td>8</td>
<td>Beach renourishment or erosion protection backfill material at Opureora Marae</td>
<td>C</td>
</tr>
<tr>
<td>9</td>
<td>Beach renourishment west of the Opureora Boat ramp</td>
<td>C</td>
</tr>
<tr>
<td>10</td>
<td>Beach renourishment or erosion protection backfill material on Rangiwāea Island</td>
<td>C</td>
</tr>
</tbody>
</table>
2 Site inspection

A site inspection was undertaken by Mark Ivamy (T&T) and Bruce Gardner (Council) on 28 March 2014. The site inspection was based at Opureora, Matakana Island and covered inspecting the shoreline 400 m either side of the Opureora boat ramp including the basal end of the Opureora Spit. The primary purpose of the site inspections was to make visual observations and appraise the proposed beach nourishment disposal sites on Matakana Island. Surficial sediment samples from the proposed beach nourishment sites were also collected during the site visit.

The cliff system north of the boat ramp is actively eroding where the base of the cliff is undercut and the cliff face slumps onto the foreshore. A portion of the eroding cliff material is a source of sediment for the local beaches in this area. The direction of longshore transport is south toward the boat ramp, as evident from the sandy beach formed against the updrift side of the Opureora boat ramp. A rock seawall exists on the south eastern side of the boat ramp that is approximately 40 m long. There is currently no sandy beach east of the seawall along the south facing cliff section of shoreline fronting the Opureora Marae. There is sand build up on the western side of a private jetty located east of this cliff section at the basal end of the Opureora Spit. The build-up of sand on the western side of the jetty has formed a short beach, which is evidence of sand movement in an easterly direction. The Opureora Spit extends in a south east direction for approximately 800 m.

There were four existing sandy beaches identified during the site visit (refer to Figure 1 for site photographs):

- **Opureora Spit**
  - medium sand beach
  - 800 m long
  - minimal berm, erosion scarp evident
  - 12(Horizontal):1(Vertical) beach slope.

- **Opureora East** – located west of a private jetty adjacent to the basal end of the spit
  - coarse sand beach
  - 30 m long
  - 2 m wide berm
  - 10(Horizontal):1(Vertical) beach slope.

- **Opureora West** – located immediately north west of the Opureora boat ramp
  - coarse sand beach
  - 80 m long
  - 2 m wide berm
  - 10(Horizontal):1(Vertical) beach slope.

- **Opureora West Wharf** – located adjacent to the historic wharf some 300 m north west of the Opureora boat ramp
  - coarse sand beach
  - 40 m long
  - 2 m wide berm
  - 10(Horizontal):1(Vertical) beach slope.
3 Sediment analysis

3.1 Existing beaches

Surficial sediment samples were collected from each of the four existing beach locations (listed in the above section) to investigate the suitability of the dredge spoil for beach nourishment. Refer to the location plan attached in Appendix A for a location of the sediment sample points. The sediment samples were analysed for grain size at the University of Waikato using the Malvern Rapid Sediment Size Analyser.

Table 2 outlines the results of the beach sediment grain size analysis. Refer to Appendix D for a full set of the sediment analysis results.
Table 2 Beach sediment sample summary

<table>
<thead>
<tr>
<th>Sample</th>
<th>Location</th>
<th>D50 (mm)</th>
<th>Standard Deviation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opureora East</td>
<td>Beach Berm</td>
<td>0.517</td>
<td>0.208</td>
</tr>
<tr>
<td>Opureora West</td>
<td>Beach Berm</td>
<td>0.516</td>
<td>0.210</td>
</tr>
<tr>
<td>Opureora West Wharf</td>
<td>Beach Berm</td>
<td>0.516</td>
<td>0.208</td>
</tr>
<tr>
<td>Opureora Spit</td>
<td>Beach Slope 12(H):1(V)</td>
<td>0.359</td>
<td>0.207</td>
</tr>
<tr>
<td>Opureora East</td>
<td>Beach Slope 10(H):1(V)</td>
<td>0.610</td>
<td>0.365</td>
</tr>
<tr>
<td>Opureora West</td>
<td>Beach Slope 10(H):1(V)</td>
<td>0.670</td>
<td>0.334</td>
</tr>
<tr>
<td>Opureora West Wharf</td>
<td>Beach Slope 10(H):1(V)</td>
<td>0.750</td>
<td>0.380</td>
</tr>
<tr>
<td>Opureora East</td>
<td>Beach Toe</td>
<td>0.420</td>
<td>0.270</td>
</tr>
<tr>
<td>Opureora West</td>
<td>Beach Toe</td>
<td>0.345</td>
<td>0.178</td>
</tr>
<tr>
<td>Opureora West Wharf</td>
<td>Beach Toe</td>
<td>0.414</td>
<td>0.230</td>
</tr>
</tbody>
</table>

The beach slope sediment grain size appears to be greatest in the north west at the Opureora West Wharf beach and reduces further to the south east in the direction of longshore transport. The greatest beach sediment grain size is located on the active beach slope and then the berm area above high tide. The smallest beach sediment grain size is located below the mean sea level (MSL) elevation at the beach toe.

3.2 Opureora Channel

Subsurface sediment samples will be collected from 5 sites along the proposed dredged alignment to a depth of up to 1 m using the Ogeechee Sand Sampler. Refer to the location plan attached in Appendix A for a location of the sediment sample points. The sediment samples were analysed for grain size at the University of Waikato using the Malvern Rapid Sediment Size Analyser. Table 3 outlines the results of the beach sediment grain size analysis. Refer to Appendix D for a full set of the sediment analysis results.

Table 3 Opureora Channel sediment sample summary

<table>
<thead>
<tr>
<th>Sample (vertical distance below surface)</th>
<th>Location</th>
<th>D50 (mm)</th>
<th>Standard Deviation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH5A (0 – 150 mm)</td>
<td>Channel Sub-surface</td>
<td>0.308</td>
<td>0.227</td>
</tr>
<tr>
<td>BH5B (150 – 800 mm)</td>
<td>Channel Sub-surface</td>
<td>0.293</td>
<td>0.150</td>
</tr>
<tr>
<td>BH4 (0 – 800 mm)</td>
<td>Channel Sub-surface</td>
<td>0.356</td>
<td>0.196</td>
</tr>
<tr>
<td>BH3A (0 – 400 mm)</td>
<td>Channel Sub-surface</td>
<td>0.322</td>
<td>0.220</td>
</tr>
<tr>
<td>BH3B (400 – 800 mm)</td>
<td>Channel Sub-surface</td>
<td>0.298</td>
<td>0.220</td>
</tr>
<tr>
<td>BH2A (0 – 400 mm)</td>
<td>Channel Sub-surface</td>
<td>0.191</td>
<td>0.249</td>
</tr>
<tr>
<td>BH2B (400 – 800 mm)</td>
<td>Channel Sub-surface</td>
<td>0.82</td>
<td>0.190</td>
</tr>
<tr>
<td>BH1 (0 – 500 mm)</td>
<td>Channel Sub-surface</td>
<td>0.111</td>
<td>0.255</td>
</tr>
</tbody>
</table>

BH1 and BH2 comprised very fine sand and coarse silt. BH3, BH4 and BH5 comprise fine to medium sand sediment. Refer to Appendix D for a full set of the sediment analysis results.
The two samples located in close proximity to the ferry boat ramp, wharf and Opureora mainland (BH1 and BH2) where a higher risk of contamination could be expected were also analysed for both heavy metal and pesticide contamination. Both sites returned low values for all tests, which are below the NES Human Health Soil Guidelines for the Bay of Plenty Region. Refer to Appendix E for the contamination test results.

3.3 Sediment compatibility

The Opureora Channel dredge spoil is likely to be more prone to movement on the beach face than the in-situ material as the sediment is generally smaller and therefore more mobile and also will have a flatter stable angle than the existing beaches. The sediment sampled from BH1 is unsuitable for beach nourishment because of the very fine sand and silt material being too different to the in-situ material. The remaining Opureora Channel samples from BH2, BH3, BH4 and BH5 are fine to medium sand sediment and have some cross-over in grain size characteristics with the in-situ material. An estimate on the likely volume of dredged sediment required to replicate the natural shoreline has been assessed using a beach overfill ratio method (USACE, 1995).

The overfill ratio is used to estimate the volume of dredged material required to produce a stable unit of usable beach nourishment material with the same sediment characteristics as the in-situ material. Table 4 shows the estimated overfill ratios (Rₐ) for channel sediment samples based on an average of the four in-situ beach sediment samples taken from the beach slope.

Table 4 Estimates of the overfill ratio (Rₐ)

<table>
<thead>
<tr>
<th></th>
<th>BH5A</th>
<th>BH5B</th>
<th>BH4</th>
<th>BH3A</th>
<th>BH3B</th>
<th>BH2A</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rₐ</td>
<td>4.5</td>
<td>4.0</td>
<td>3.5</td>
<td>4.5</td>
<td>5.0</td>
<td>7.0</td>
<td>5</td>
</tr>
</tbody>
</table>

Based on the average overfill ratio (Rₐ) estimate of 5, 5 m$^3$ of dredged sediment is required to replicate placement of 1 m$^3$ of the in-situ material, but may be as high as 7 m$^3$. Therefore, on average approximately 20% of the dredged material is expected to remain on the beach if used as beach nourishment material. And 80% of the material is expected to be transported offshore (winnowed) from the beach face to other parts of the beach profile below MSL. Therefore, we do not consider the dredged spoil material to be suitable for beach nourishment at locations north of the boat ramp or in front of the Marae.

The sediment sampled from the Opureora Spit beach slope is much closer to the sediment characteristics of the sediment sampled from the Opureora Channel. The average overfill ratio for the Opureora Spit beach face only is 1.8 (Table 5). Therefore, on average approximately 60% of dredged sediment is expected to remain on the beach and approximately 40% of the material is expected to be transported offshore (winnowed) from the beach face to other parts of the beach profile seaward of the beach toe. Therefore, the dredged material from the Opureora Channel is considered to be suitable for placement along the shoreline of the Opureora Spit.

Table 5 Estimates of the overfill ratio for Opureora Spit only (Rₐ)

<table>
<thead>
<tr>
<th></th>
<th>BH5A</th>
<th>BH5B</th>
<th>BH4</th>
<th>BH3A</th>
<th>BH3B</th>
<th>BH2A</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rₐ</td>
<td>1.4</td>
<td>1.4</td>
<td>1.0</td>
<td>1.4</td>
<td>1.7</td>
<td>5</td>
<td>1.8</td>
</tr>
</tbody>
</table>
4 Options assessment

4.1 Descriptions

Port of Tauranga offshore disposal site (Option 1)

The Port of Tauranga (POT) have resource consent to dispose of dredged spoil material from Tauranga Harbour (sand sized sediment) in the nearshore zone located approximately 2 km offshore from Mt Maunganui main beach. This deposition ground is described as Area D (Main Ocean) under consent 40157, which has a maximum deposition allowance of 720,000 m³ per year. The largest volume of sediment deposited within Area D in any given year over the last 10 years is approximately 67,000 m³.

The dredge spoil from Opureora Channel could be disposed at this location assuming it meets the conditions of the consent and the POT agree to this activity. A new resource consent or consent variation would be required to undertake this disposal option. We consider this option to be a relatively low level consent risk.

Due to the distance from the site the only dredging method suitable for this option is a barge mounted excavator. The material would need to be transported by two split hopper barges operating in tandem to provide continuous transport and minimise down time.

Sulphur Point sand supply stock pile (Option 2)

Sand sized sediment from the POT dredging programme is stock piled at the Sulphur Point sand supply yard owned by J.Swap Ltd. The Opureora Channel dredge spoil could be deposited at this location assuming the yard has capacity and is willing to accept the material. The Opureora Channel dredging works would need to be scheduled to fit in with the POT dredging programme.

Due to the distance from the site the only dredging method suitable for this option is a barge mounted excavator. The material would need to be transported by two split hopper barges operating in tandem to provide continuous transport and minimise down time. The sediment could be unloaded at the Sulphur Point adjacent to the stock pile yard using a long reach excavator and transported using a front end loader. A land use resource consent would be required for this option because the temporary stockpile would be located within 50 m of mean high water springs. We consider this option to be a relatively low level consent risk.

There may be an opportunity to utilise the dredge spoil stockpiled at the Sulphur Point for nourishment of inner harbour city beaches, dependant on grain size compatibility analysis.

Sub-tidal site (Option 3)

The Opureora Channel dredge spoil could be deposited in an intertidal area close to the site for natural redistribution. This sub-tidal area should be located south of the Opureora Channel to minimise the risk of the material being transported back into the channel over time by longshore transport. There are large sand shoals currently located in the lee of Motuhoa Island. Due to the distance from the site the only dredging method suitable for this option is a barge mounted excavator. The sediment could then be transported and deposited by a single split hopper barge.

Resource consent would be required from BOPRC for this option to deposit material in the CMA. In our opinion, we consider this option unfeasible due to the relatively uncontrolled method of deposition and the high risk of resource consent being declined. We consider this option to be a relatively high level consent risk.
Land based disposal (Option 4, 5 and 7)

The Opureora Channel dredge spoil could be transported to temporary stockpile locations with good road access and used for land filling purposes. Council have identified the following four locations for land based disposal:

- Ōmokoroa
- Matakana Island
- Rangiwāea Island
- Motuhoa Island.

Matakana Island is the only location close enough to the site suitable for land based disposal using the cutter suction dredge method. Both Matakana Island and Ōmokoroa Island have suitable loading facilities for using the barge mounted excavator method. The Opureora Channel dredge spoil could be dredged and transported to the loading area using the barge mounted excavator. The dredge material would be transferred to a temporary stockpile where it could be loaded into trucks for transport. Two trucks operating in tandem and a 12T excavator would be required to shift the daily estimated dredge volume of two barge loads (180 m$^3$). A land use resource consent would be required for this option because the temporary stockpile would be located within 50 m of mean high water springs. We consider these options to be a relatively medium level consent risk.

There are limitations to the loading area at each site due to limited space and high vehicular usage. The ferry ramp car park area located along the landward edge of the seawall is the most suitable stockpile area at Matakana Island and would need to be temporarily closed for the duration of the works. There is also limited turning space for trucks at this location and temporary traffic controls may need to be implemented, particularly at the ferry loading and queuing area. The public boat ramp is the most suitable stockpile area at Ōmokoroa and it would need to be temporarily closed for the duration of the works and boat launching would be limited to the adjacent ferry ramp over this period. Truck transport in these two areas is also likely to involve the following disadvantages:

- Pressure on traffic at the ferry loading area and surrounding roads
- Maintenance work may be required on local roads and both the Omokoroa boat ramp and Matakana Island ferry car park due to the significant truck volumes.

Both Rangiwāea Island and Motuhoa Island could be used as locations for land based disposal using the barge mounted excavator method. However, the loading facilities are not ideal and the sediment would need to be temporarily stockpiled in the intertidal area at certain tides making the transfer to trucks more difficult. A front end loader would also be required in addition to an excavator to transfer the sediment into trucks. There is also likely to be some losses of sediment volume if it remains in the intertidal area over a tidal cycle. Resource consent would be required from BOPRC for this option to temporarily deposit material in the CMA. We consider these options to be a relatively medium level consent risk.

Opureora Spit (Option 6)

The Opureora Spit is located to the east of the site and is approximately 800 m long. Land based disposal is not considered feasible on Opureora Spit because it has been identified in the BOPRC Coastal Plan as a Coastal Habitat Preservation Zone (CHPZ19). The spit is listed as a significant marsh bird (New Zealand Fern Bird) habitat including sea-rush and tussock land.

The Opureora Channel dredge spoil could be deposited along the south west facing shoreline of the Opureora Spit as beach nourishment. The material could also act as a temporary stockpile if
the material was required for backfill behind a protection structure located in front of Opureora Marae at a later stage. Due to the predominant easterly sediment transport direction, the material is expected to move south east over time, in the direction of the natural spit extension. Resource consent would be required from BOPRC for this option to deposit material in the CMA. We consider this option to be a relatively medium level consent risk.

Only the cutter suction dredge method is suitable for this option due to the wide, shallow intertidal flat located between the spit and the channel, which significantly restricts the barge access.

**Beach protection (Option 8, 9, 10)**

The Opureora Channel dredge spoil could potentially be disposed at local locations near Opureora for the purpose of erosion protection in the form of either beach nourishment or backfill for a seawall structure. Council have identified the following three locations for erosion protection:

- Opureora Marae, Matakana Island
- North west of Opureora Boat Ramp, Matakana Island
- South west side of Rangiwāea Island.

The two locations on Matakana Island are the only locations close enough to the site suitable for disposal using the cutter suction dredge method for beach protection. Due to the predominant easterly sediment transport direction, the material is expected to move south east over time. Therefore, sand material placed in front of the Marae is expected to move east toward the Opureora Spit. Dredge spoil material placed north of the boat ramp is expected to move south toward the boat ramp and channel. Furthermore, approximately 80% of the placed material is expected to be transported offshore (winnowed) from the beach face to other parts of the beach profile below MSL (refer to Section 3.3). Therefore, we do not consider the dredged spoil to be suitable for beach nourishment at locations north of the boat ramp or in front of the Marae.

The dredge spoil could be transported to the south west side of Rangiwāea Island for beach nourishment using the barge mounted excavator method. The dredge spoil material can be dredged and transported to the location using the barge mounted excavator. The sediment will most likely need to be stockpiled in the intertidal area at certain tides. Some losses of sediment volume is likely if it remains in the intertidal area over a tidal cycle before placement. We would expect the dredge spoil placed as beach nourishment to behave in a similar way at Rangiwāea Island as at Opureora. Therefore, we do not consider the dredged spoil to be suitable for beach nourishment at Rangiwāea Island.

The dredge spoil could be transported to these locations for backfill material behind an erosion protection structure. A rock revetment is likely to be the most suitable erosion protection structure based on the wave climate and design life. A rock revetment design is likely to require a maximum backfill volume of 4 m$^3$ per linear meter. This equates to approximately 800 m$^3$ of required sediment over the 200 m shoreline section in front of the Opureora Marae. Therefore, this option would only account for a small proportion of the sediment requiring disposal and is not considered to be a feasible option on its own.

Resource consent would be required from BOPRC for this option to deposit material in the CMA. We consider these options to be a relatively medium level consent risk.

### 4.2 Rough order cost estimate

The scope of works for this report required the following two dredging methods to be considered for costing purposes:

- Cutter suction dredge (CSD)
• Barge mounted excavator (BME).

The majority of the options can be undertaken using the barge mounted excavator method, with the exception of Option 6 due to the depth limiting conditions of the wide intertidal flats restricting barge access. The cutter suction dredge method has only been considered for disposal options that are located close to the site where the slurry pipe does not interfere with marine navigation. Options 6, 8 and 9 can also be undertaken using the cutter suction dredge method. If the cutter suction dredge method is selected, then a variation to the existing dredging consent will most likely be required. Table 6 lists the plant required for the 10 options based on the relevant dredging method.

Table 6 Plant required to complete the dredging for each option

<table>
<thead>
<tr>
<th>Option</th>
<th>Disposal description</th>
<th>Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Port of Tauranga offshore disposal site, Mt Maunganui</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Two Split Hopper Barges (240 m³ per barge)</td>
</tr>
<tr>
<td>2</td>
<td>J. Swap’s sand stockpile yard, Sulphur Point</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Two Split Hopper Barges (240 m³ per barge)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and front end loader</td>
</tr>
<tr>
<td>3</td>
<td>Sub-tidal location within the harbour for natural redistribution</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One Split Hopper Barge (240 m³ per barge)</td>
</tr>
<tr>
<td>4</td>
<td>Land based disposal on the mainland (Ōmokoroa Peninsula)</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(90 m³ per barge)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and two trucks</td>
</tr>
<tr>
<td>5</td>
<td>Land based disposal to Matakana Island</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(90 m³ per barge)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and two trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or cutter suction dredge with slurry pipeline</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and two trucks</td>
</tr>
<tr>
<td>6</td>
<td>Land based disposal or beach nourishment at Opureora sandspit</td>
<td>Cutter suction dredge with slurry pipeline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front end loader</td>
</tr>
<tr>
<td>7</td>
<td>Land based disposal on Motuhoa Island or Rangiwāea Island</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(90 m³ per barge)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and two Trucks</td>
</tr>
<tr>
<td>8</td>
<td>Beach renourishment or erosion protection backfill material at Opureora Marae</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(90 m³ per barge)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and two trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front end loader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or cutter suction dredge with slurry pipeline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front end loader</td>
</tr>
<tr>
<td>9</td>
<td>Beach renourishment west of the Opureora Boat ramp and Jetty</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(90 m³ per barge)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and two trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front end loader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or cutter suction dredge with slurry pipeline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front end loader</td>
</tr>
<tr>
<td>10</td>
<td>Beach renourishment or erosion protection backfill material on Rangiwāea Island</td>
<td>Barge mounted excavator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(90 m³ per barge)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land based excavator and two trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front end loader</td>
</tr>
</tbody>
</table>
The existing consent for dredging allows material to be removed from the channel by a barge mounted excavator and is limited to the outgoing tide. This condition effectively sets a maximum allowable daily operation time of six hours between sunrise and sunset. However, six hours will not always be available on the outgoing tide between sunrise and sunset. Based on LINZ tide tables we estimate the available operational hours will be reduced by approximately 20%, due to the limitation of dredging on the outgoing tide. We have assumed a full eight hour day can be worked using the cutter suction dredge method regardless of tides. The effects of the slurry discharge associated with this method would need to be addressed at the resource consenting stage.

The rough order cost estimates are based on our understanding of industry rates and have been provided for comparison budget estimate purposes only. This cost does not include professional fees for detailed design and construction supervision or contract administration.

The rough order cost for an erosion protection structure is based on a rock revetment at $3,000 per linear meter.

The rough order cost estimates are presented in a $/m$^3$ rate based on dredging and disposing both 7,100 m$^3$ and 10,500 m$^3$ and includes a 20% contingency. The rough order cost estimate for dredging and disposing of the dredged spoil has been developed for the 10 options as outlined in Table 7.

**Table 7 Rough order cost estimate summary for dredging and disposal of spoil**

<table>
<thead>
<tr>
<th>Option</th>
<th>Dredging unit rate estimate ($/m^3$) (7,100 m$^3$ - 10,500 m$^3$)</th>
<th>Total dredging cost estimate based on the most economic method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BME</td>
<td>CSD</td>
</tr>
<tr>
<td>1</td>
<td>68 - 62</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>76 - 70</td>
<td>n/a</td>
</tr>
<tr>
<td>3</td>
<td>48 - 38</td>
<td>n/a</td>
</tr>
<tr>
<td>4</td>
<td>84 - 80</td>
<td>n/a</td>
</tr>
<tr>
<td>5</td>
<td>84 – 80</td>
<td>76 - 66</td>
</tr>
<tr>
<td>6</td>
<td>n/a</td>
<td>50 - 39</td>
</tr>
<tr>
<td>7</td>
<td>84 - 80</td>
<td>n/a</td>
</tr>
<tr>
<td>8</td>
<td>70 – 67</td>
<td>50 - 39</td>
</tr>
<tr>
<td>9</td>
<td>70 – 67</td>
<td>50 - 39</td>
</tr>
<tr>
<td>10</td>
<td>84 - 80</td>
<td>n/a</td>
</tr>
</tbody>
</table>

We recommend assessing the channel infilling rates based on the survey data undertaken on the second anniversary of completing the dredging, which is required under the existing consent. Maintenance dredging using the cutter suction dredge method is likely to be more economic over a longer time interval of 5 – 10 years, due to the high mobilisation costs.

The rough order costs for preparing and lodging a consent application for each option have been estimated including a 30% contingency. The costs are estimated up to the point of lodgement and do not include lodgement fees, responses to requests for further info, preparation of evidence or attendance at a hearing. The consenting cost estimates can be grouped into three costs based on the disposal activity:
• Option 1 - $50,000
• Option 3 - $125,000
• Option 2, 4, 5, 6, 7, 8, 9 and 10 - $25,000.
4.3 Summary

A summary of the 10 potential options identified by Council is presented in Table 8 listing the advantages and disadvantages and the rough order cost based estimate based on dredging and disposing the spoil.

Table 8 Summary of potential options

<table>
<thead>
<tr>
<th>Option</th>
<th>Method</th>
<th>Dredging cost estimate 10,500 m³ scenario (7,100 m³ scenario)</th>
<th>Lodging Consent cost estimate</th>
<th>Protection cost estimate</th>
<th>Total cost estimate 10,500 m³ scenario (7,100 m³ scenario)</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Consent risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BME only</td>
<td>$651,000 ($483,000)</td>
<td>$50,000</td>
<td>n/a</td>
<td>$701,000 ($533,000)</td>
<td>No effect on local road network and ferry operations.</td>
<td>No local use of sediment for erosion protection. Consent most likely required.</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>BME only</td>
<td>$735,000 ($540,000)</td>
<td>$25,000</td>
<td>n/a</td>
<td>$760,000 ($565,000)</td>
<td>No effect on local road network and ferry operations. Material could be used for inner city beach nourishment.</td>
<td>No local use of sediment for erosion protection. Consent most likely required.</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>BME only</td>
<td>$399,000 ($340,000)</td>
<td>$125,000</td>
<td>n/a</td>
<td>$524,000 ($465,000)</td>
<td>No effect on local road network and ferry operations.</td>
<td>No local use of sediment for erosion protection. Potentially high ecological effect of relatively uncontrolled disposal in the CMA.</td>
<td>High</td>
</tr>
<tr>
<td>Option</td>
<td>Method</td>
<td>Dredging cost estimate</td>
<td>Lodging Consent cost estimate</td>
<td>Protection cost estimate</td>
<td>Total cost estimate</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>10,500 m³ scenario</td>
<td></td>
<td>7,100 m³ scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>BME only</td>
<td>$840,000 ($597,000)</td>
<td>$25,000 n/a</td>
<td>$845,000 ($622,000)</td>
<td>Local land based use.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No local use of sediment for erosion protection.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High effect on local road network and ferry operations.</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Consent most likely required.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>BME</td>
<td>$840,000 ($597,000)</td>
<td>$25,000 n/a</td>
<td>$865,000 ($622,000)</td>
<td>Local land based use.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No local use of sediment for erosion protection.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High effect on local road network and ferry operations.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Consent most likely required.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CSD only</td>
<td>$410,000 ($355,000)</td>
<td>$25,000 n/a</td>
<td>$435,000 ($380,000)</td>
<td>Local use of sediment for erosion protection along Opureora Spit.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Consent most likely required.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No effect on local road network and ferry operations.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>BME only</td>
<td>$840,000 ($597,000)</td>
<td>$25,000 n/a</td>
<td>$865,000 ($622,000)</td>
<td>Local land based use.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No local use of sediment for erosion protection.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Advantages**

- Local land based use.

**Disadvantages**

- Not feasible due to the high risk of consent being declined.
- No local use of sediment for erosion protection.
- High effect on local road network and ferry operations.
- Consent most likely required.

**Consent risk**

- Medium
<table>
<thead>
<tr>
<th>Option</th>
<th>Method</th>
<th>Dredging cost estimate</th>
<th>Lodging Consent cost estimate</th>
<th>Protection cost estimate</th>
<th>Total cost estimate</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Consent risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>8, 9 Seawall backfill</td>
<td>BME</td>
<td>$704,000 ($497,000)</td>
<td>$25,000</td>
<td>$600,000</td>
<td>$1,329,000 ($1,122,000)</td>
<td>Local use of sediment for erosion protection.</td>
<td>Consent most likely required. High effect on local road network and ferry operations. Not feasible as backfill would only dispose of approximately 800 m$^3$.</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>CSD</td>
<td>$410,000 ($355,000)</td>
<td>$25,000</td>
<td>$600,000</td>
<td>$1,035,000 ($980,000)</td>
<td>Local use of sediment for erosion protection. No effect on local road network and ferry operations.</td>
<td>Consent most likely required. Not feasible as backfill would only dispose of approximately 800 m$^3$.</td>
<td>Medium</td>
</tr>
<tr>
<td>8,9 Beach Nourishment</td>
<td>BME</td>
<td>$704,000 ($497,000)</td>
<td>$25,000</td>
<td>n/a</td>
<td>$729,000 ($522,000)</td>
<td>Local use of sediment for erosion protection.</td>
<td>Consent most likely required. High effect on local road network and ferry operations. Not feasible as only 20% of material is expected to remain on the beach.</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>CSD</td>
<td>$410,000 ($360,000)</td>
<td>$25,000</td>
<td>n/a</td>
<td>$435,000 ($385,000)</td>
<td>Local use of sediment for erosion protection.</td>
<td>Consent most likely required.</td>
<td>Medium</td>
</tr>
<tr>
<td>Option</td>
<td>Method</td>
<td>Dredging cost estimate</td>
<td>Lodging Consent cost estimate</td>
<td>Protection cost estimate</td>
<td>Total cost estimate</td>
<td>Advantages</td>
<td>Disadvantages</td>
<td>Consent risk</td>
</tr>
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<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>10,500 m³ scenario</td>
<td>7,100 m³ scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Seawall backfill</td>
<td>BME</td>
<td>$840,000 ($597,000)</td>
<td>$25,000</td>
<td>$600,000</td>
<td>$1,465,000</td>
<td>Local use of sediment for erosion protection.</td>
<td>Not feasible as only 20% of material is expected to remain on the beach.</td>
<td>Medium</td>
</tr>
<tr>
<td>10 Beach Nourishment</td>
<td>BME</td>
<td>$840,000 ($597,000)</td>
<td>$25,000</td>
<td>n/a</td>
<td>$865,000</td>
<td>Local use of sediment for erosion protection.</td>
<td>Not feasible as backfill would only dispose of approximately 800 m³.</td>
<td>Medium</td>
</tr>
</tbody>
</table>

1 The seawall cost is based on a length of 200 m.
5 Conclusions

Council have resource consent to dredge the Opureora Channel. However, the consent does not provide for the disposal of dredged material. Based on previous work and consultation with the local community Council have identified 10 potential disposal sites (refer to Table below).

Potential Opureora Channel dredge spoil disposal option list identified by Council (cost estimates based on dredging 7,100 m$^3$)

<table>
<thead>
<tr>
<th>Option</th>
<th>Disposal description</th>
<th>Feasible</th>
<th>Cost estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Port of Tauranga Main Ocean disposal site, Mt Maunganui</td>
<td>Yes</td>
<td>$533,000</td>
</tr>
<tr>
<td>2</td>
<td>J. Swap’s sand stockpile yard, Sulphur Point</td>
<td>Yes</td>
<td>$565,000</td>
</tr>
<tr>
<td>3</td>
<td>Sub-tidal location within the harbour for natural redistribution</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Land based disposal on the mainland (Omokoroa Peninsula)</td>
<td>Yes</td>
<td>$622,000</td>
</tr>
<tr>
<td>5</td>
<td>Land based disposal to Matakana Island</td>
<td>Yes</td>
<td>$565,000</td>
</tr>
<tr>
<td>6</td>
<td>Land based disposal or beach nourishment at Opureora sandspit</td>
<td>Yes – nourishment No – land based</td>
<td>$380,000</td>
</tr>
<tr>
<td>7</td>
<td>Land based disposal on Motuhoa Island or Rangiwāea Island</td>
<td>Yes</td>
<td>$622,000</td>
</tr>
<tr>
<td>8</td>
<td>Beach renourishment or erosion protection backfill material at Opureora Marae</td>
<td>No - both</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Beach renourishment west of the Opureora Boatramp</td>
<td>No - both</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Beach renourishment or erosion protection backfill material on Rangiwāea Island</td>
<td>No - both</td>
<td></td>
</tr>
</tbody>
</table>

The cost estimates have been provided in the above table for the options considered to be feasible. The estimates are for the total physical works costs of dredging based on the most economic method and also the professional fees for lodging a resource consent application.

We consider the following four groups of options to be unfeasible due to the following reasons:

- The sub-tidal deposition is a relatively uncontrolled method and there is a high risk of resource consent being declined for this activity (Option 3).
- Land based disposal is not considered feasible on Opureora Spit because it has been identified in the BOPRC Coastal Plan as a Coastal Habitat Preservation Zone (CHPZ19). The spit is listed as a significant marsh bird (New Zealand Fern Bird) habitat including searush and tussock land (Option 6 – land based).
- Approximately 80% of the dredge spoil placed as beach nourishment in front of the three cliff locations is expected to be transported alongshore and offshore (winnowed) from the beach face to other parts of the beach profile below MSL. Therefore, we do not consider the dredged spoil to be suitable for beach nourishment at these locations (Option 8, 9 and 10 - nourishment).
• Backfill behind an erosion protection structure would only account for a small proportion of
the sediment requiring disposal and is not considered to be a feasible option on its own
(Option 8 and 10 – erosion protection backfill).

The other six options identified in the above table are practically feasible and range in cost from
$385,000 to $622,000 for the 7,100 m$^3$ volume scenario, including professional fees associated
with lodging an application for resource consent. The land based disposal options have the
highest cost due to the double handling of truck transfer. The beach nourishment of Opureora
Spit has the lowest cost due to the close proximity to the site and the suitability of the cutter
suction dredge method.

We recommend assessing the channel infilling rates based on the survey data undertaken on the
second anniversary of completing the dredging, which is required under the existing consent.
Maintenance dredging using the cutter suction dredge method is likely to be more economic over
a longer time interval of 5 – 10 years, due to the high mobilisation costs.
Applicability

This report has been prepared for the benefit of Bay of Plenty Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by: Mark Ivamy
Senior Coastal Scientist

Authorised for Tonkin & Taylor Ltd by: Richard Reinen-Hamill
Project Director
Appendix A: Location Plan
Appendix B: Resource Consent
Bay of Plenty Regional Council

Resource Consent

Pursuant to section 105 of the Resource Management Act 1991, the Bay of Plenty Regional Council, by a decision dated 8 September 2005, Hereby Grants to:

BAY OF PLENTY REGIONAL COUNCIL

P O Box 364
WHAKATANE

A coastal permit:

a) pursuant to section 12(1)(c) of the Resource Management Act 1991 and Rule 14.2.4(b) of the Bay of Plenty Regional Coastal Environment Plan to undertake a discretionary activity being to Disturb the Foreshore or Seabed of Tauranga Harbour; and

b) pursuant to section 12(1)(e) of the Resource Management Act 1991 and Rule 14.2.4(b) of the Bay of Plenty Regional Coastal Environment Plan to undertake a discretionary activity being to Destroy, Damage or Disturb the Foreshore or Seabed of Tauranga Harbour in a Manner That is Likely to Have an Adverse Effect on Plants, Animals or their Habitat; and

c) pursuant to section 12(2)(b) of the Resource Management Act 1991 and Rule 14.2.4(b) of the Bay of Plenty Regional Coastal Environment Plan to undertake a discretionary activity being to Remove Sand, Shingle, Shell or Other Natural Material from Crown Land in the Coastal Marine Area; and

d) pursuant to section 15(1)(a) of the Resource Management Act 1991 and Rule 9.2.4(b) of the Bay of Plenty Regional Coastal Environment Plan to undertake a discretionary activity being to Discharge Sediment-Laden Water to the Tauranga Harbour;

subject to the following conditions:

1 Purpose

For the purpose of excavating by dredging, material from the seabed of the Opureora Channel in the Tauranga Harbour to gain sufficient depth to restore navigability during most tidal conditions.

2 Quantity of Excavation

2.1 The quantity of material removed from the coastal marine area as capital dredging shall not exceed 12000 cubic metres.

2.2 The quantity of material removed from the coastal marine area as maintenance dredging shall not exceed 6000 cubic metres during any two-year period.
3 Location

At Opureora Channel, Tauranga Harbour as shown on BOPRC Plan Number RC 63226/1 submitted with the application for this consent.

4 Map Reference

Between or about map reference NZMS 260 U14: 8158 9300 and U14: 8275 9215.

5 Legal Description

Crown Land (Seabed), Tauranga Harbour (Western Bay of Plenty District).

6 Dredging Works

6.1 Works shall be located and carried out generally in accordance with “Opureora Channel Capital and Maintenance Dredging Assessment of Environmental Effects, June 2005”, and BOPRC Plan Number RC 63226/1, included in the application for this consent.

6.2 Capital dredging shall be completed within four months of the date of commencement.

6.3 Maintenance dredging shall be completed within four weeks of the date of commencement.

6.4 Dredging shall be carried out to provide a maximum water depth of 1.5 metres below chart datum and a maximum width of 20 metres including batters.

6.5 Dredging shall only be carried out on an ebb tide when the direction of flow is out to the main channel.

6.6 The consent holder shall ensure that no contaminants, including fuel oils, are permitted to enter the ocean waters as a result of these works.

6.7 No refuelling activities or fuel storage shall occur on the foreshore or seabed or within 20 metres of mean high water springs. The consent holder shall employ methods to avoid or minimise any fuel spillage, including the provision of appropriate security and containment measures, where necessary.

6.8 No dredging activities shall be undertaken on Saturdays, Sundays or public holidays.

7 Disposal of Dredged Material

No dredged material shall be disposed of within the coastal marine area.
8 **Discharge**

8.1 There shall be no discharge above mean low water springs and where practicable discharge shall be made via a weighted pipe to an adjacent channel.

8.2 The permit holder shall ensure that, after reasonable mixing, any discharge under this consent shall not result in any of the following:

- The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
- Any conspicuous change in colour or visual clarity;
- Any emission of objectionable odour; and/or
- Significant adverse effects on aquatic life.

9 **Notification of Intention to Dredge**

9.1 The consent holder shall advise the Regional Council Harbour Master, the Coastguard and Matakana Ferries Ltd in writing at least 10 working days prior to carrying out any dredging and shall provide details of the expected duration of the dredging and the name and contact details of the person supervising the works.

9.2 The consent holder shall place notices in the Bay of Plenty Times advising of the intention to dredge, the area which is to be dredged, the period over which dredging is expected to occur, and the restrictions to navigation that will apply, not less than seven days prior to, and on the day prior to commencement of dredging.

9.3 The consent holder shall place signage at the Omokoroa and Opureora Jetties at least 10 working days prior to carrying out any dredging and shall provide details of the expected duration of the dredging, and the name and contact details of the person supervising the works. Signage shall remain for the duration of any dredging.

9.4 The consent holder shall inform the Regional Council, in writing, within five working days following the completion of each dredging operation under this consent.

10 **Monitoring**

10.1 On each day that excavations occur within the coastal marine area the consent holder shall (during excavation operations), take water samples:

- From a site 200 metres up current of the excavation site; and
- From a point 350 metres down current of the site, in the direction of the plume.

10.2 From each sampling site one surface water sample shall be taken, in a minimum depth of 60 centimetres of water, and analysed as soon as practicable for suspended solids concentration.
10.3 All sampling and analyses required by condition 10.1 shall be carried out in accordance with the latest edition of: “Standard Methods for the Examination of Water and Wastewater APHA, AWWA, WEF” or such other method as may be agreed in writing by the Chief Executive of the Regional Council or delegate.

10.4 At the completion of works for each two-year period the consent holder shall undertake a harbour floor contour survey of the dredged area.

10.5 The consent holder shall make records of any analysis undertaken in accordance with 10.2 available to the Chief Executive of the Regional Council or delegate as required.

11 Reporting

11.1 The consent holder shall forward a report to the Regional Council within 20 working days of completion of the initial works and any subsequent maintenance works describing:

- The area excavated; and
- The quantity of sediment removed; and
- The quantity of sediment disposed of and the area/s to which the sediment has been disposed.

11.2 Within three months of the completion of the dredging operation the consent holder shall supply the results of the monitoring required by condition 10.1 to the Regional Council.

11.3 Within three months of the completion of the dredging operation the consent holder shall forward to the Regional Council results of the harbour floor contour survey as required by condition 10.4.

12 Term of Consent

This consent shall expire on 31 July 2015.

13 Resource Management Charges

The consent holder shall pay the Bay of Plenty Regional Council such administrative charges as are fixed from time to time by the Regional Council in accordance with section 36 of the Resource Management Act 1991.

14 The Permit hereby authorised is granted under the Resource Management Act 1991 and does not constitute an authority under any other Act, Regulation or Bylaw.
Advice Notes:

1. This permit does not authorise the holder to modify or disturb any archaeological or historic sites or deposits within the area affected by this consent. Should any artefacts, bones, shell midden or any other sites of archaeological or cultural significance be discovered within the area affected by this operation, written authorisation should be obtained from the Historic Places Trust before any damage, modification or destruction is undertaken.

2. This permit does not authorise the discharge of any contaminant to Tauranga Harbour.

3. Notification requirements pursuant to condition 8.2 of this permit should be made in writing (fax or letter) to the Bay of Plenty Regional Council, Environment Bay of Plenty, P O Box 364, Whakatane.

4. The permit holder is advised that non-compliance with permit conditions may result in enforcement action against the permit holder and/or their contractors.

5. The permit holder is responsible for ensuring that all contractors carrying out works under this permit are made aware of the relevant consent conditions, plans and associated documents.

6. This permit does not provide for disposal of any dredged material within the Coastal Marine Area.

7. This permit does not allow for the material attained through the dredging process to be on sold for profit.

DATED at Whakatane this 13th day of October 2005

For and on behalf of
The Bay of Plenty Regional Council

J A Jones
Chief Executive
Appendix C: Dredge Plan
Appendix D: Sediment Samples
**PROJECT:** Opureora Channel  
**LOCATION:** Opureora Channel, Tauranga Harbour  
**JOB No:** 851786

**CO-ORDINATES:**  
**R.L.:** -1.00 m  
**DATUM:** Chart Datum Level

**DRILL TYPE:** Ogeechee  
**DRILL METHOD:** Hand  
**DRILLED BY:** MCI

**HOLE STARTED:** 23/3/14  
**HOLE FINISHED:** 23/3/14  
**LOGGED BY:** MCI  
**CHECKED:** DEPP

**GEOMORPHOLOGICAL CORE RECOVERY (%):**

<table>
<thead>
<tr>
<th>GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.</th>
<th>ENGINEERING DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine sediment</td>
<td>Fine to medium SAND, dark grey. Saturated.</td>
</tr>
<tr>
<td></td>
<td>CLAY, white. Wet.</td>
</tr>
</tbody>
</table>

**SOIL DESCRIPTION**
- Soil type, minor components, plasticity or particle size, colour.
- Rock type, particle size, colour, minor components.
- Type, inclusion, thickness, roughness, filling.

**SHEAR STRENGTH (kPa):**

<table>
<thead>
<tr>
<th>Defect Spacing (mm)</th>
<th>1</th>
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<th>3</th>
<th>40</th>
<th>5</th>
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**COMPRESSIVE STRENGTH (MPa):**

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<th>Moisture Condition</th>
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<th>3</th>
<th>4</th>
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<tr>
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<td>2</td>
<td>3</td>
<td>4</td>
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**SHEAR STRENGTH (kPa):**

<table>
<thead>
<tr>
<th>Moisture Condition</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td>0</td>
</tr>
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</table>

**HOLE STARTED:** 23/3/14  
**HOLE FINISHED:** 23/3/14  
**DRILLED BY:** MCI

**LOGGED BY:** MCI  
**CHECKED:** DEPP

**SOIL DESCRIPTION**

- Soil type, minor components, plasticity or particle size, colour.
- Rock type, particle size, colour, minor components.
- Type, inclusion, thickness, roughness, filling.
Hand push tube

Fine to medium SAND with some shell fragments; dark grey. Saturated.

SILT; grey. Wet.

Fine to medium SAND with some silt; grey. Saturated.

SILT with minor sand; grey. Saturated; sand, fine.

0.8m END OF SAMPLE AT 0.8m BELOW HARBOUR BED LEVEL
### GEOLOGICAL

**Soil Type:** Marine sediment

**Soil Description:**
- **Hand push tube:** None
- **Description:**
  - Medium to coarse SAND with some shell fragments; dark grey. Saturated.
  - Medium to coarse SAND; brownish grey. Saturated.

**SOIL DESCRIPTION**
- Soil type, minor components, plasticity or particle size, colour.

**ROCK DESCRIPTION**
- Substance: Rock type, particle size, colour, minor components.
- Defects: Type, inclination, thickness, roughness, filling.

**MOISTURE CONDITION**

**COMPRESSIVE STRENGTH**

**DEFECT SPACING**

**SHEAR STRENGTH**

**ENGINEERING DESCRIPTION**

**FLUID LOSS METHOD**

**GEOLOGICAL CORE RECOVERY (%):**

**GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.**

**DEPTH (m):**

**MOISTURE CONDITION:**

**COMPRESSIVE STRENGTH (MPa):**

**DEFECT SPACING (mm):**

**SHEAR STRENGTH (kPa):**

**HOLE STARTED:** 23/3/14

**HOLE FINISHED:** 23/3/14

**DRILLED BY:** MCI

**LOGGED BY:** MCI

**CHECKED:** DEPP

---

**PROJECT:** Opureora Channel

**LOCATION:** Opureora Channel, Tauranga Harbour

**JOB No:** 851786

**CO-ORDINATES:**

**R.L.:** -0.50 m

**DATUM:** Chart Datum Level

**DRILL TYPE:** Ogeechee

**DRILL METHOD:** Hand

**DRILL FLUID:**

**LOGGED:**

**CHECKED:**

**HOle No:** BH3

---

**TIME:** DATETEMPLATE.GDT

**BORELLOG 851786 OPUREORA CHANNEL INFO.GPJ 15-May-2014**

**HOLE LOCATION:** Refer to location plan.

**TONKIN & TAYLOR LTD**
**Marine sediment**

- **Sample**: Hand push tube
- **Handing**: None
- **Soil Description**: Medium to coarse SAND with some shell fragments; grey. Saturated.
- **Depth**: 0.5m

**GEOMORPHOLOGICAL**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Soil Type</th>
<th>Minor Components</th>
<th>Plasticity</th>
<th>Particle Size</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>Marine sediment</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GEOLOGICAL TESTS**

- **DRILL TYPE**: Goochiee
- **DRILL METHOD**: Hand
- **DRILLED BY**: MCI
- **LOGGED BY**: MCI
- **CHECKED**: DEPP

**RESULTS**

- **Soil Condition**: Saturated

---

**WATER ENGINEERING DESCRIPTION**

- **FLUID LOSS METHOD**

---

**GEOLOGICAL LOG**

1.0m END OF SAMPLE AT 1.0m BELOW HARBOUR BED LEVEL
**Marine sediment**

- **Soil Type:** Fine to medium SAND, brownish grey.
- **Description:** Saturated.

- **Rock Description:**
  - **Substance:** Medium to coarse SAND with some shell fragments; dark grey. Saturated.
  - **Filling:**

**SOIL DESCRIPTION**
- Soil type, minor components, plasticity or particle size, colour.

**ROCK DESCRIPTION**
-岩性: 岩石类型，粒径，颜色，次要成分。
- **Defects:** Type, inclination, thickness, roughness, filling.

**WATER ENGINEERING DESCRIPTION**

**FLUID LOSS METHOD**

**GEOLOGICAL CORE RECOVERY (%)**
- **GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.**

**DEPTH (m)**

**MOISTURE CONDITION**

**COMPRESSIVE STRENGTH (MPa)**

**DEFECT SPACING (mm)**

**SHEAR STRENGTH (kPa)**

**HOLE STARTED:** 23/3/14

**HOLE FINISHED:** 23/3/14

**DRILLED BY:** MCI

**LOGGED BY:** MCI

**CHECKED:** DEPP

**PROJECT:** Opureora Channel

**LOCATION:** Opureora Channel, Tauranga Harbour.

**HOLE No:** BH5

**DRILL TYPE:** Ogeechee

**DRILL METHOD:** Hand

**DRILL FLUID:**

**CO-ORDINATES:**

**R.L.:** -0.50 m

**DATUM:** Chart Datum Level

**LOG SCALE:** 1:5

**HOLE LOCATION:** Refer to location plan.

**PRODUCER:** TONKIN & TAYLOR LTD
Result Analysis Report

Sample Name: 1 Operureora East, Spit
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/1
SOP Name: Marine Sediment
Measured by: rodgers
Result Source: Measurement
Measured: Thursday, 10 April 2014 1:56:08 p.m.
Analysed: Thursday, 10 April 2014 1:56:10 p.m.

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water
Dispersant RI: 1.330

Accessory Name: Hydro 2000G (A)
Absorption: 0.2

Analysis model: General purpose
Size range: 0.020 to 2000.000 µm

Specific Surface Area: 0.0266 m²/g
Surface Weighted Mean D[3,2]: 0.0266 µm

Volume Weighted Mean D[4,3]:

Concentration: 0.5946 %Vol
Span : 1.409
Uniformity: 0.441

Obscuration: 359.004
d(0.1): 184.422 µm
d(0.5): 359.004 µm
d(0.9): 690.420 µm

Volume Weighted Mean D[4,3]:

Standard Deviation: 207.893 µm

Operator notes:

Facility of Science and Engineering
The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Tel := +(0) 1684-892456 Fax +[44] (0) 1684-892799

Malvern Instruments Ltd.
Malvern, UK
Serial Number : MAL102144
Record Number: 84
15/04/2014 4:29:00 p.m.
Result Analysis Report

Sample Name: 2 Operureora East, Beach
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/2
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose

Concentration: 0.7335 % Vol
Specific Surface Area: 0.0149 m²/g
Concentration: 0.0149 m²/g

Dispersant Name: Water
Dispersant RI: 1.330
Absorption: 0.2
Vol. Weighted Mean D[4,3]: 684.444 um

Span : 1.498
Uniformity: 0.465
Volume (%)

0.050 0.00 0.980 0.00 37.000 0.75 105.000 1.39
0.060 0.00 2.000 0.00 44.000 0.85 125.000 1.44
0.120 0.00 3.900 0.00 53.000 0.99 149.000 1.69
0.240 0.00 7.800 0.02 63.000 1.13 177.000 2.36
0.480 0.00 15.600 0.35 74.000 1.26 210.000 3.83
0.700 0.00 31.000 0.66 88.000 1.36 250.000 6.59

Operator notes:

--- 

2 Operureora East, Beach, Thursday, 10 April 2014 2:02:39 p.m.
3 Opureora West, Ramp Beach, Friday, 11 April 2014 3:58:31 p.m.

---

**Result Analysis Report**

<table>
<thead>
<tr>
<th>Sample Name:</th>
<th>Marine Sediment</th>
<th>Measured:</th>
<th>Friday, 11 April 2014 3:58:31 p.m.</th>
</tr>
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<tbody>
<tr>
<td>Sample Source &amp; type:</td>
<td>Rodgers</td>
<td>Analysed:</td>
<td>Friday, 11 April 2014 3:58:33 p.m.</td>
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<tr>
<td>Sample bulk lot ref:</td>
<td>2014052/3</td>
<td>Result Source:</td>
<td>Measurement</td>
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</tbody>
</table>

**Particle Name:** Marine Sediment  
**Particle RI:** 1.500  
**Dispersant Name:** Water  
**Dispersant RI:** 1.330  
**Concentration:** 1.3999 % Vol  
**Specific Surface Area:** 0.00969 m²/g  
**Volume:** 619.032 um  
**Surface Weighted Mean D[3,2]:** 0.00969 745.812 um  
**Vol. Weighted Mean D[4,3]:** 2.891 um  
**Uniformity:** 0.385  
**Span:** 1.253  
**Obscuration:** 669.293 745.812 um  
**d(0.1):** 386.681 um  
**d(0.5):** 669.293 um  
**d(0.9):** 1225.032 um  
**SOP Name:** Hydro 2000G (A)  
**Accessory Name:** General purpose  
**Analysis model:** Off  
**Sensitivity:** Enhanced  
**Size range:** 0.020 to 2000.000 um  
**Result units:** Volume  
**Result Emulation:** General purpose  
**Concentration:** 1.3999 % Vol  
**Span:** 1.253  
**Uniformity:** 0.385  
**Specific Surface Area:** 0.00969 m²/g  
**Volume:** 619.032 um  
**Surface Weighted Mean D[3,2]:** 0.00969 745.812 um  
**Vol. Weighted Mean D[4,3]:** 2.891 um  
**Uniformity:** 0.385  
**Span:** 1.253  
**Obscuration:** 669.293 745.812 um  
**d(0.1):** 386.681 um  
**d(0.5):** 669.293 um  
**d(0.9):** 1225.032 um  
**SOP Name:** Hydro 2000G (A)  
**Accessory Name:** General purpose  
**Analysis model:** Off  
**Sensitivity:** Enhanced  
**Size range:** 0.020 to 2000.000 um  
**Result units:** Volume  
**Result Emulation:** General purpose  

---

**Particle Size Distribution**

---

**Operator notes:**

---

Malvern Instruments Ltd.  
Malvern, UK  
Tel: +44 (0) 1684-892456 Fax +44 (0) 1684-892789  
Facility of Science and Engineering  
The University of Waikato  
Private Bag 3105  
Hamilton, New Zealand  
Tel := +[44] (0) 1684-892456 Fax +[44] (0) 1684-892789  
File name: tonkin taylor  
Record Number: 86  
15/04/2014 4:29:00 p.m.  
Mastersizer 2000 Ver. 5.60  
Serial Number : MAL102144  
15/04/2014 4:29:00 p.m.
**Result Analysis Report**

**Sample Name:** 4 Opureora East sandbank  
**SOP Name:** Marine Sediment  
**Sample Source & type:**  
**Measured:** Friday, 11 April 2014 4:03:54 p.m.  
**Sample bulk lot ref:** 2014052/4  
**Measured by:** rodders  
**Result Source:** Measurement  
**Analysed:** Friday, 11 April 2014 4:03:56 p.m.

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<tr>
<td>Marine Sediment</td>
<td>Hydro 2000G (A)</td>
<td>General purpose</td>
<td>Enhanced</td>
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<table>
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<th>Particle RI:</th>
<th>Absorption:</th>
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<th>Obscuration:</th>
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<tr>
<td>1.500</td>
<td>0.2</td>
<td>0.020 to 2000.000 µm</td>
<td>18.90 %</td>
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<table>
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<th>Dispersant Name:</th>
<th>Dispersant RI:</th>
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<tr>
<td>Water</td>
<td>1.330</td>
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<th>Concentration:</th>
<th>Span:</th>
<th>Uniformity:</th>
<th>Result units:</th>
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<tr>
<td>0.5620 %Vol</td>
<td>1.468</td>
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<td>Volume</td>
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<th>Specific Surface Area:</th>
<th>Vol. Weighted Mean D[4,3]:</th>
<th>Standard Deviation</th>
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<tr>
<td>0.031 m²/g</td>
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<td>6</td>
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<td>Particle Size (µm)</td>
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<td>3.20</td>
<td>250.000</td>
<td>16.40</td>
</tr>
</tbody>
</table>

**Operator notes:**
Result Analysis Report

Sample Name: 5 Opureora West, old wharf beach
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/5

SOP Name: Marine Sediment
Measured by: rodgers
Result Source: Measurement

Measured: Friday, 11 April 2014 4:09:45 p.m.
Analysed: Friday, 11 April 2014 4:09:47 p.m.

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water

Accessibility Name: Hydro 2000G (A)
Absorption: 0.2
Dispersant RI: 1.330

Analysis model: General purpose
Sensitivity: Enhanced
Size range: 0.020 to 2000.000 µm
Weighted Residual: 2.852 %
Obscuration: 725.704
d(0.1): 0.980  um
Span : 1.367
Concentration: 1.3754  % Vol
Uniformity: 0.418

Specific Surface Area: 0.00934  m²/g
Surface Weighted Mean D[3,2]: 642.266  um
Vol. Weighted Mean D[4,3]: 806.385  um

D(0.5): 725.704  um
D(0.9): 1370.282  um

Operator notes:
Result Analysis Report

Sample Name: 6 BH5A 150 -500 mm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/6

SOP Name: Marine Sediment
Measured by: rodgers
Measured: Friday, 11 April 2014 4:14:58 p.m.
Analysed: Friday, 11 April 2014 4:14:59 p.m.
Result Source: Measurement

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water
Dispersant RI: 1.330
Accessory Name: Hydro 2000G (A)
Absorption: 0.2

Concentration: 0.4846 %Vol
Specific Surface Area: 0.0439 m²/g
Uniformity: 0.498
Span: 1.504

Size (µm) Vol Under %
0.050 0.00
0.060 0.00
0.120 0.00
0.240 0.00
0.490 0.00
0.700 0.00

Size (µm) Vol Under %
0.980 0.00
3.900 0.19
7.800 1.09
15.600 2.29
31.000 3.55

Size (µm) Vol Under %
37.000 3.91
44.000 4.19
63.000 4.33
74.000 4.33
88.000 4.33

Size (µm) Vol Under %
105.000 4.45
125.000 5.49
149.000 8.42
210.000 22.55
250.000 34.03

Size (µm) Vol Under %
300.000 47.79
350.000 59.52
420.000 72.03
590.000 93.30
710.000 99.86

Size (µm) Vol Under %
840.000 96.08
1000.000 97.82
1190.000 98.87
1410.000 99.49
1680.000 99.86

Size (µm) Vol Under %
15/04/2014 4:29:00 p.m.
File name: tonkin taylor
Record Number: 89

Operator notes:
Result Analysis Report

Sample Name: 7 BH5B 0 - 150 mm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/7
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
Sensitivity: Enhanced
Obscuration: 19.13 %
Concentration: 0.3979 %Vol
Span: 1.195
Specific Surface Area: 0.0443 m²/g
Surface Weighted Mean D[3,2]: 135.565 µm
Vol. Weighted Mean D[4,3]: 316.451 um
Standard Deviation: 150.387 µm

Measurement 2014052/7
Marine Sediment
Measured by: rodders
Result Source: Measurement
Analysed: Friday, 11 April 2014 4:21:08 p.m.
SOP Name: Marine Sediment
Sample Name & type: Marine Sediment
Size range: 0.020 to 2000.000 um
Water
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.000 um
Hydro 2000G (A)
Accessory Name: Hydro 2000G (A)
Absorption: 0.2
Volume (%)
Size (µm) Vol Under %
0.050 0.00 0.980 0.00 37.000 3.57 105.000 4.01
0.060 0.00 2.000 0.00 44.000 3.87 125.000 4.64
0.120 0.00 3.900 0.20 53.000 4.01 149.000 7.37
0.240 0.00 7.800 1.14 63.000 4.01 177.000 13.25
0.490 0.00 15.600 2.23 74.000 4.01 210.000 22.84
0.700 0.00 31.000 3.21 88.000 4.01 250.000 36.10
1.150 0.00 74.000 4.01 300.000 52.07 590.000 94.74
2.000 0.00 150.000 55.70 500.000 88.84 2000.000 100.00
3.000 0.00 243.000 72.00 350.000 65.48 1410.000 100.00
4.000 0.00 400.000 99.56 420.000 79.17 1190.000 100.00
5.000 0.00 800.000 150.387 590.000 94.74 1680.000 100.00
6.000 0.00 1200.000 199.43 710.000 98.24 2000.000 100.00

Operator notes:
### Result Analysis Report

**Sample Name:** 8 BH4 0-500 mm  
**Sample Source & type:** Marine Sediment  
**Sample bulk lot ref:** 2014052/8  
**SOP Name:** Marine Sediment  
**Measured by:** rodgers  
**Measured:** Tuesday, 15 April 2014 1:57:59 p.m.  
**Analyised:** Tuesday, 15 April 2014 1:58:01 p.m.  
**Result Source:** Measurement

<table>
<thead>
<tr>
<th>Particle Name:</th>
<th>Accessory Name:</th>
<th>Analysis model:</th>
<th>Sensitivity:</th>
<th>Size range:</th>
<th>Obscuration:</th>
<th>Result Emulation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Sediment</td>
<td>Hydro 2000G (A)</td>
<td>General purpose</td>
<td>Enhanced</td>
<td>0.020 to 2000.000 um</td>
<td>22.09 %</td>
<td>Off</td>
</tr>
</tbody>
</table>

**Concentration:** 0.4828 %Vol  
**Span:** 1.271  
**Specific Surface Area:** 0.0427 m²/g  
**Surface Weighted Mean D[3,2]:** 140.406 um  
**Vol. Weighted Mean D[4,3]:** 387.763 um

### Particle Size Distribution

- **d(0.1):** 189.435 um  
- **d(0.5):** 356.181 um  
- **d(0.9):** 642.051 um

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**Operator notes:**

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---
Result Analysis Report

Sample Name: 9 BH3A 0-400 mm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/9
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
Sensitivity: Enhanced
Size range: 0.020 to 200.000 um
Obscuration: 18.81 %
Weighted Residual: 0.573 %
Result Emulation: Off

Concentration: 0.4615 %Vol
Span: 1.590
Uniformity: 0.508
Result units: Volume

Specific Surface Area: 0.0376 m²/g
Surface Weighted Mean D[3,2]: 159.453 um
Vol. Weighted Mean D[4,3]: 370.071 um
Standard Deviation 221.944 um

<table>
<thead>
<tr>
<th>Size (µm)</th>
<th>Vol Under %</th>
<th>Size (µm)</th>
<th>Vol Under %</th>
<th>Size (µm)</th>
<th>Vol Under %</th>
<th>Size (µm)</th>
<th>Vol Under %</th>
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<th>Vol Under %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.050</td>
<td>0.00</td>
<td>0.980</td>
<td>0.00</td>
<td>37.000</td>
<td>2.92</td>
<td>105.000</td>
<td>4.48</td>
<td>300.000</td>
<td>45.08</td>
</tr>
<tr>
<td>0.060</td>
<td>0.00</td>
<td>2.000</td>
<td>0.00</td>
<td>44.000</td>
<td>3.17</td>
<td>125.000</td>
<td>6.47</td>
<td>350.000</td>
<td>55.57</td>
</tr>
<tr>
<td>0.120</td>
<td>0.00</td>
<td>3.900</td>
<td>0.13</td>
<td>53.000</td>
<td>3.33</td>
<td>149.000</td>
<td>10.14</td>
<td>420.000</td>
<td>67.61</td>
</tr>
<tr>
<td>0.240</td>
<td>0.00</td>
<td>7.800</td>
<td>0.75</td>
<td>63.000</td>
<td>3.33</td>
<td>177.000</td>
<td>15.76</td>
<td>500.000</td>
<td>77.82</td>
</tr>
<tr>
<td>0.490</td>
<td>0.00</td>
<td>15.600</td>
<td>1.58</td>
<td>74.000</td>
<td>3.35</td>
<td>210.000</td>
<td>23.46</td>
<td>590.000</td>
<td>85.73</td>
</tr>
<tr>
<td>0.700</td>
<td>0.00</td>
<td>31.000</td>
<td>2.61</td>
<td>88.000</td>
<td>3.60</td>
<td>250.000</td>
<td>33.28</td>
<td>710.000</td>
<td>92.21</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

--- 9 BH3A 0-400 mm, Tuesday, 15 April 2014 2:03:20 p.m.---

Operator notes:
Result Analysis Report

Sample Name: 10 BH3B 400-700 mm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/10
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
Dispersant Name: Water
Analysis model: General purpose
Concentration: 0.5707 % Vol
Span: 1.654
Specific Surface Area: 0.0378 m²/g
Surface Weighted Mean D[3,2]: 158.707 µm
Vol. Weighted Mean D[4,3]: 351.208 µm
Dispersant RI: 1.330
Sensitivitiy: Enhanced
Uniformity: 0.527
Result Source: Measurement
Result units: Volume
Size range: 0.020 to 2000.000 µm
Obscuration: 22.79 %
Weighted Residual: 0.657 %
Result Emulasion: Off
Standard Deviation: 220.78 µm

Operator notes:

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Malvern Instruments Ltd.
Malvern, UK
Tel: + (44) (0) 1684-892456 Fax + (44) (0) 1684-892789
Mastersizer 2000 Ver. 5.60
Serial Number: MAL102144
File name: tonkin taylor
Record Number: 93
15/04/2014 4:29:00 p.m.
Result Analysis Report

Sample Name: 11 BH2A 0-450 mm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/11
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
SOP Name: Marine Sediment
Measured by: rodders
Measured: Tuesday, 15 April 2014 2:20:36 p.m.
Analysed: Tuesday, 15 April 2014 2:20:38 p.m.
Result Source: Measurement

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water
Dispersant RI: 1.330
Concentration: 0.0291 %Vol
Specific Surface Area: 0.448 m²/g
Span: 2.837
Uniformity: 0.911

Size (µm) Vol Under %
0.050 0.00
0.060 0.00
0.120 0.00
0.240 0.00
0.490 0.31
0.700 0.94
0.980 1.73
2.000 3.91
3.900 7.24
7.800 11.81
15.600 16.80
31.000 22.36
Vol Under %
0.980
2.000
3.900
7.800
15.600
31.000
1.73
3.91
7.24
11.81
16.80
22.36

Volume (%)
11 BH2A 0-450 mm, Tuesday, 15 April 2014 2:20:36 p.m.

d(0.1): 5.992 µm
d(0.5): 191.343 µm
d(0.9): 548.890 µm

Surface Weighted Mean D[3,2]: 13.390 µm
Vol. Weighted Mean D[4,3]: 245.509 µm
Standard Deviation 249.445 µm

Absorption: 0.2
Dispersant Name:
Dispersant RI:
Concentration:
Specific Surface Area:
Span:
Uniformity:

Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
Sensitivity: Enhanced
Size range: 0.020 to 2000.000 µm
Obscuration: 13.23 %
Result Emulation: Off

Concentration:
Specific Surface Area:
Span:
Uniformity:

Volume:

Operator notes:

Facility of Science and Engineering
The University of Waikato
Private Bag 3105
Hamilton, New Zealand
Tel := +[44] (0) 1684-892456 Fax +[44] (0) 1684-892789
Malvern Instruments Ltd.
Malvern, UK
Mastersizer 2000 Ver. 5.60
Serial Number : MAL102144
File name: tonkin taylor
Record Number: 94
15/04/2014 4:29:00 p.m.
Result Analysis Report

Sample Name: 12 BH2B 400-750 mm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/12

SOP Name: Marine Sediment
Measured by: rodgers
Result Source: Measurement

Measured: Tuesday, 15 April 2014 2:26:43 p.m.
Analysed: Tuesday, 15 April 2014 2:26:45 p.m.

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water

Accessory Name: Hydro 2000G (A)
Absorption: 0.2
Dispersant RI: 1.330

Analysis model: General purpose
Sensitivity: Enhanced
Size range: 0.020 to 2000.000 um
Weighted Residual: 0.550 %
Obscuration: 18.43 %
Result Emulation: Off

Concentration: 0.0236 % Vol
Span : 4.738
Uniformity: 1.56

Specific Surface Area: 0.816 m²/g
Surface Weighted Mean D[3,2]: 7.356 um
Vol. Weighted Mean D[4,3]: 150.103 um

Size (µm) Vol Under %
0.000 0.00 0.000 0.00 0.000 0.00
0.050 0.00 0.980 3.39 37.000 38.46 105.000 54.87
0.060 0.00 2.000 7.55 44.000 40.68 125.000 59.03
0.080 0.00 3.900 13.43 53.000 43.15 149.000 63.73
0.120 0.00 7.800 20.69 63.000 45.61 177.000 68.70
0.240 0.00 15.600 28.14 74.000 48.14 210.000 73.79
0.480 0.73 31.000 36.25 88.000 51.22 250.000 78.88
0.700 1.94 62.500 66.67 100.000 81.92 300.000 87.53
1.000 4.01 125.000 125.00 150.000 100.00 350.000 100.00
2.000 15.00 250.000 250.00 300.000 100.00 700.000 100.00
4.000 30.00 500.000 500.00 500.000 100.00 1000.000 100.00
8.000 60.00 1000.000 1000.00 1000.000 100.00 2000.000 100.00

Operator notes:

Facility of Science and Engineering
The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Tel: +(44) (0) 1684-892456 Fax +(44) (0) 1684-892789
Malvern, UK
Malvern Instruments Ltd.
Serial Number : MAL102144
Mastersizer 2000 Ver. 5.60
Record Number: 95
File name: tonkin taylor
15/04/2014 4:29:00 p.m.
Result Analysis Report

Sample Name: 13 BH1
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014055/13

SOP Name: Marine Sediment
Measured by: rodders
Measured: Tuesday, 15 April 2014 2:46:23 p.m.
Analysed: Tuesday, 15 April 2014 2:46:25 p.m.

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water
Dispersant RI: 1.330
Concentration: 0.0482 %Vol
Specific Surface Area: 0.267 m²/g
Span: 4.417
Uniformity: 1.38

Accessory Name: Hydro 2000G (A)
Absorption: 0.2
Dispersant Name: Water
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.020 to 2000.000 um
Vol. Weighted Mean D[4,3]: 202.511 um
Surface Weighted Mean D[3,2]: 0.267 um
Vol. Weighted Mean D[4,3]: 202.511 um

Vol. % Under Size (µm)
0.050 0.00
0.060 0.00
0.120 0.00
0.240 0.00
0.480 0.10
0.700 0.41
5.000 1.74
3.900 3.38
7.800 6.45
15.600 10.88
31.000 17.73

Volume Under Size (µm)
0.980 0.77
4.000 2.73
53.000 27.89
63.000 32.35
74.000 36.96
88.000 42.32

Dispersant Name: Water
Dispersant RI: 1.500
Concentration: 0.0482 %Vol
Specific Surface Area: 0.267 m²/g
Span: 4.417
Uniformity: 1.38

Analysis model: General purpose
Size range: 0.020 to 2000.000 um
Vol. Weighted Mean D[4,3]: 202.511 um
Surface Weighted Mean D[3,2]: 0.267 um
Vol. Weighted Mean D[4,3]: 202.511 um

Vol. % Under Size (µm)
0.050 0.00
0.060 0.00
0.120 0.00
0.240 0.00
0.480 0.10
0.700 0.41
5.000 1.74
3.900 3.38
7.800 6.45
15.600 10.88
31.000 17.73

Volume Under Size (µm)
0.980 0.77
4.000 2.73
53.000 27.89
63.000 32.35
74.000 36.96
88.000 42.32

Operator notes:
Result Analysis Report

Sample Name: 14 Opureora East Beach Berm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/14

SOP Name: Marine Sediment Analysis
Measured: Tuesday, 15 April 2014 2:52:17 p.m.
Measured by: rodgers
Analysed: Tuesday, 15 April 2014 2:52:19 p.m.
Result Source: Measurement

<table>
<thead>
<tr>
<th>Particle Name</th>
<th>Accessory Name</th>
<th>Analysis model</th>
<th>Sensitivity</th>
<th>Size range</th>
<th>Obscuration</th>
<th>Weighted Residual</th>
<th>Result Emulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Sediment</td>
<td>Hydro 2000G (A)</td>
<td>General purpose</td>
<td>Enhanced</td>
<td>0.020 to 2000.000 um</td>
<td>14.63 %</td>
<td>1.177 %</td>
<td>Off</td>
</tr>
</tbody>
</table>

Concentration: 1.0990 % Vol
Specific Surface Area: 0.0123 m²/g

<table>
<thead>
<tr>
<th>Span</th>
<th>Accessory Name</th>
<th>Analysis model</th>
<th>Sensitivity</th>
<th>Size range</th>
<th>Obscuration</th>
<th>Weighted Residual</th>
<th>Result Emulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.978</td>
<td>Hydro 2000G (A)</td>
<td>General purpose</td>
<td>Enhanced</td>
<td>0.020 to 2000.000 um</td>
<td>14.63 %</td>
<td>1.177 %</td>
<td>Off</td>
</tr>
</tbody>
</table>

Hydro 2000G (A)

<table>
<thead>
<tr>
<th>Size (µm)</th>
<th>Vol Under %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.050</td>
<td>0.00</td>
</tr>
<tr>
<td>0.060</td>
<td>0.00</td>
</tr>
<tr>
<td>0.120</td>
<td>0.00</td>
</tr>
<tr>
<td>0.240</td>
<td>0.00</td>
</tr>
<tr>
<td>0.490</td>
<td>0.00</td>
</tr>
<tr>
<td>0.700</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (µm)</th>
<th>Vol Under %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.980</td>
<td>0.00</td>
</tr>
<tr>
<td>2.000</td>
<td>0.00</td>
</tr>
<tr>
<td>3.900</td>
<td>0.00</td>
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<tr>
<td>7.800</td>
<td>0.00</td>
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<tr>
<td>15.600</td>
<td>0.00</td>
</tr>
<tr>
<td>31.000</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Operator notes:
Result Analysis Report

Sample Name: 15 Opureora West Old Wharf Berm
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/15

SOP Name: Marine Sediment
Measured by: rodgers
Result Source: Measurement

Measured: Tuesday, 15 April 2014 4:07:07 p.m.
Analysed: Tuesday, 15 April 2014 4:07:09 p.m.

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water
Dispersant RI: 1.330

Accessory Name: Hydro 2000G (A)
Absorption: 0.2

Analysis model: General purpose
Size range: 0.020 to 2000.000 um
Weighted Residual: 1.119 %

Obscuration: 12.02 %
Result Emulation: Off

Concentration: 0.8879 %Vol
Specific Surface Area: 0.0123 m²/g

Span: 0.986
Uniformity: 0.312

Vol. Weighted Mean D[4,3]: 556.360 um
Surface Weighted Mean D[3,2]: 488.477 um

d(0.1): 327.163 um
d(0.5): 516.365 um
d(0.9): 836.144 um

Operator notes:
## Result Analysis Report

**Sample Name:** 17 Opureora West ramp toe  
**SOP Name:** Marine Sediment  
**Sample Source & type:**  
**Measured:** Tuesday, 15 April 2014 4:12:40 p.m.  
**Sample bulk lot ref:** 2014052/16  
**Measured by:** rodders  
**Result Source:** Measurement  
**Analysed:** Tuesday, 15 April 2014 4:12:42 p.m.

**Particle Name:** Marine Sediment  
**Accessory Name:** Hydro 2000G (A)  
**Analysis model:** General purpose  
**Analysis model:** Enhanced  
**Particle RI:** 1.500  
**Absorption:** 0.2  
**Dispersant Name:** Water  
**Dispersant RI:** 1.330  
**Span:** 1.237  
**Uniformity:** 0.389  
**Concentration:** 0.5301 % Vol  
**Specific Surface Area:** 0.0246 m²/g  
**Size range:** 0.020 to 2000.000 μm  
**Accuracy:** 14.34 %  
**Weighted Residual:** 0.561 %  
**Obscuration:** 345.700  
**Volume:** 620.057 μm  
**Result units:** Volume  
**Span:** 1.237  
**Result units:** Volume  
**Uniformity:** 0.389  
**Concentration:** 0.5301 % Vol  

### Particle Size Distribution

- 17 Opureora West ramp toe, Tuesday, 15 April 2014 4:12:40 p.m.

<table>
<thead>
<tr>
<th>Size (μm)</th>
<th>Vol Under %</th>
<th>Size (μm)</th>
<th>Vol Under %</th>
<th>Size (μm)</th>
<th>Vol Under %</th>
<th>Size (μm)</th>
<th>Vol Under %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.050</td>
<td>0.00</td>
<td>0.980</td>
<td>0.00</td>
<td>37.000</td>
<td>1.09</td>
<td>105.000</td>
<td>1.64</td>
</tr>
<tr>
<td>0.060</td>
<td>0.00</td>
<td>2.000</td>
<td>0.00</td>
<td>44.000</td>
<td>1.36</td>
<td>125.000</td>
<td>1.95</td>
</tr>
<tr>
<td>0.120</td>
<td>0.00</td>
<td>3.900</td>
<td>0.00</td>
<td>53.000</td>
<td>1.58</td>
<td>149.000</td>
<td>3.49</td>
</tr>
<tr>
<td>0.240</td>
<td>0.00</td>
<td>7.800</td>
<td>0.27</td>
<td>63.000</td>
<td>1.64</td>
<td>177.000</td>
<td>7.18</td>
</tr>
<tr>
<td>0.490</td>
<td>0.00</td>
<td>15.600</td>
<td>0.53</td>
<td>74.000</td>
<td>1.64</td>
<td>210.000</td>
<td>13.86</td>
</tr>
<tr>
<td>0.700</td>
<td>0.00</td>
<td>31.000</td>
<td>0.84</td>
<td>88.000</td>
<td>1.64</td>
<td>250.000</td>
<td>24.12</td>
</tr>
<tr>
<td>1.000</td>
<td>0.00</td>
<td>62.000</td>
<td>1.09</td>
<td>100.000</td>
<td>1.95</td>
<td>300.000</td>
<td>37.99</td>
</tr>
<tr>
<td>1.500</td>
<td>0.00</td>
<td>90.000</td>
<td>1.36</td>
<td>150.000</td>
<td>3.49</td>
<td>420.000</td>
<td>66.25</td>
</tr>
<tr>
<td>2.000</td>
<td>0.00</td>
<td>120.000</td>
<td>1.58</td>
<td>200.000</td>
<td>7.18</td>
<td>500.000</td>
<td>78.78</td>
</tr>
<tr>
<td>3.000</td>
<td>0.00</td>
<td>180.000</td>
<td>1.64</td>
<td>300.000</td>
<td>13.86</td>
<td>590.000</td>
<td>87.86</td>
</tr>
<tr>
<td>5.000</td>
<td>0.00</td>
<td>300.000</td>
<td>1.95</td>
<td>450.000</td>
<td>24.12</td>
<td>710.000</td>
<td>94.54</td>
</tr>
<tr>
<td>10.000</td>
<td>0.00</td>
<td>600.000</td>
<td>3.49</td>
<td>600.000</td>
<td>78.78</td>
<td>900.000</td>
<td>100.00</td>
</tr>
<tr>
<td>20.000</td>
<td>0.00</td>
<td>1200.000</td>
<td>66.25</td>
<td>1200.000</td>
<td>100.00</td>
<td>1800.000</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**Operator notes:**
Result Analysis Report

Sample Name: 18 Opureora Old Warf toe
Sample Source & type: Marine Sediment
Sample bulk lot ref: 2014052/17
Measured: Tuesday, 15 April 2014 4:18:02 p.m.
Measured by: rodders
Analysed: Tuesday, 15 April 2014 4:18:04 p.m.
Result Source: Measurement

Particle Name: Marine Sediment
Particle RI: 1.500
Dispersant Name: Water
Accessory Name: Hydro 2000G (A)
Absorption: 0.2
Dispersant RI: 1.330

Analysis model: General purpose
Sensitivity: Enhanced
Size range: 0.020 to 2000.000 um
Obscuration: 16.60 %
Weighted Residual: 0.909 %
Result Emulation: Off
Uniformity: 0.413
Concentration: 0.3893 %Vol
Span: 1.282

Specific Surface Area: 0.0385 m²/g
Surface Weighted Mean D[3,2]: 155.878 um
Vol. Weighted Mean D[4,3]: 453.061 um

Uniformity:
Concentration: 0.3893 %Vol
Span: 1.282

Standard Deviation: 230.221 um

Operator notes:
Appendix E: Contamination Samples
### Analysis Report

**Sample Type:** Soil

<table>
<thead>
<tr>
<th>Sample Name:</th>
<th>BH2 - Opureora 450-750 28-Mar-2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Number:</td>
<td>1258709.2</td>
</tr>
</tbody>
</table>

#### Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg

<table>
<thead>
<tr>
<th>Parameter</th>
<th>mg/kg dry wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Recoverable Arsenic</td>
<td>4</td>
</tr>
<tr>
<td>Total Recoverable Cadmium</td>
<td>0.17</td>
</tr>
<tr>
<td>Total Recoverable Chromium</td>
<td>11</td>
</tr>
<tr>
<td>Total Recoverable Copper</td>
<td>6</td>
</tr>
<tr>
<td>Total Recoverable Lead</td>
<td>14.8</td>
</tr>
<tr>
<td>Total Recoverable Mercury</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>Total Recoverable Nickel</td>
<td>5</td>
</tr>
<tr>
<td>Total Recoverable Zinc</td>
<td>44</td>
</tr>
</tbody>
</table>

#### Organochlorine Pesticides Screening in Soil

<table>
<thead>
<tr>
<th>Compound</th>
<th>mg/kg dry wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>alpha-BHC</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>beta-BHC</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>delta-BHC</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>gamma-BHC (Lindane)</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>cis-Chlordane</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>trans-Chlordane</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Total Chlordane [(cis+trans)* 100/42]</td>
<td>&lt; 0.04</td>
</tr>
<tr>
<td>2,4'-DDD</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>4,4'-DDD</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>2,4'-DDE</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>4,4'-DDE</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>2,4'-DDT</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>4,4'-DDT</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Endosulfan I</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Endosulfan II</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Endosulfan sulphate</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Endrin</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Endrin aldehyde</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Endrin ketone</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Heptachlor epoxide</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>&lt; 0.010</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>&lt; 0.010</td>
</tr>
</tbody>
</table>

**Sample Type:** Sediment

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.

The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.
### Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg

<table>
<thead>
<tr>
<th>Test</th>
<th>Method Description</th>
<th>Default Detection Limit</th>
<th>Sample No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Recoverable Arsenic mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable Cadmium mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable Chromium mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable Copper mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable Lead mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable Mercury mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable Nickel mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable Zinc mg/kg dry wt</td>
<td>&lt; 0.10 - 4 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
</tbody>
</table>

### Organochlorine Pesticides Screening in Soil

<table>
<thead>
<tr>
<th>Test</th>
<th>Method Description</th>
<th>Default Detection Limit</th>
<th>Sample No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>alpha-BHC mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>beta-BHC mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>delta-BHC mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>gamma-BHC (Lindane) mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>cis-Chlordane mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>trans-Chlordane mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Chlordane [(cis+trans)* 100/42] mg/kg dry wt</td>
<td>&lt; 0.04 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>2,4'-DDD mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>4,4'-DDD mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>2,4'-DDE mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>4,4'-DDE mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>2,4'-DDT mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>4,4'-DDT mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Dieldrin mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Endosulfan I mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Endosulfan II mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Endosulfan sulphate mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Endrin mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Endrin aldehyde mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Endrin ketone mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Heptachlor mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Heptachlor epoxide mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Hexachlorobenzene mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Methoxychlor mg/kg dry wt</td>
<td>&lt; 0.010 - 0.04 mg/kg dry wt</td>
<td>-</td>
<td>1-2</td>
</tr>
</tbody>
</table>

### SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

---

**Sample Type:** Sediment

<table>
<thead>
<tr>
<th>Test</th>
<th>Method Description</th>
<th>Default Detection Limit</th>
<th>Sample No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Solids Sample Preparation</td>
<td>Air dried at 35°C and sieved, &lt;2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td>Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg</td>
<td>Dried sample, &lt;2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.</td>
<td>0.10 - 4 mg/kg dry wt</td>
<td>1-2</td>
</tr>
<tr>
<td>Organochlorine Pesticides Screening in Soil</td>
<td>Sonication extraction, SPE cleanup, dual column GC-ECD analysis (modified US EPA 8082) . Tested on dried sample</td>
<td>0.010 - 0.04 mg/kg dry wt</td>
<td>1-2</td>
</tr>
<tr>
<td>Total Recoverable digestion</td>
<td>Nitric / hydrochloric acid digestion. US EPA 200.2.</td>
<td>-</td>
<td>1-2</td>
</tr>
</tbody>
</table>
These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Martin Cowell - BSc
Client Services Manager - Environmental Division