Tonkin+Taylor

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Bay of Plenty Regional Council
5-11 Quay Street
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Attention: Mark Ivamy

Dear Mark

Ōpōtiki Harbour Development
Summary of predicted changes to coastal erosion hazard

1 Introduction

Tonkin & Taylor Ltd ("T+T") has been engaged by Bay of Plenty Regional Council ("BOPRC") to provide a summary of the coastal hazard erosion risk to the coastline adjacent to the existing Waioeka River mouth. This summary includes previous coastal hazard assessments based on the natural shoreline, work pertaining to how this is likely to change following construction of the Ōpōtiki Harbour Development ("OHD") (Figure 1.1), clarity on the consent conditions for the OHD and how they were derived, and the requirements for further work to establish revised coastal hazard erosion zones for subdivision and land use planning purposes. It is understood that Ōpōtiki District Council ("ODC") will use the contents of this summary, and referenced material, as a basis for decision making in relation to consent conditions for development within the area adjacent to the existing Waioeka River mouth. This summary has been prepared in accordance with the contract dated 11 May between the BOPRC and T+T.

Figure 1.1: Artist impression of Opotiki Harbour Development concept. (Source: ODC)

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2 Existing Hazard Assessments

2.1 Coastal erosion hazard

A number of coastal erosion hazard assessments have been undertaken for the Waiotahe shoreline (West of Waioeka river mouth), including Gibb (1974), Dahm and Kench (2007) and Eco Nomos Ltd (2016). T+T were engaged by BOPRC to undertake a detailed assessment of the coastal erosion hazard (T+T, 2019) to provide an updated assessment adopting a methodology consistent with that used on the rest of the Bay of Plenty coastline. All the assessments described above solely considered the natural coastline's susceptibility to erosion with no allowance made for the potential impact of the construction of the OHD on coastal erosion at Waiotahe.

Although these studies did not consider the influence of the OHD, they provide important context and a baseline for assessing any effects of the OHD and the consent conditions associated with the development (Table 2-1).

Table 2-1: Summary of previously defined erosion hazard zone widths

Previous study	Recommended erosion hazard zone width (100 year)
Gibb (1994)	100 to 130m
Dahm & Kench (2007)	70 m
Eco Nomos Ltd (2016)	50 to 65 m

Previous studies used a precautionary approach allowing for a sea level rise value at the upper end of predictions used by practitioners at the time. The recent update (T+T, 2019) used a probabilistic approach that gave a range of shoreline setback distances based on different sea level rise scenarios. Results from this 2019 assessment defined potential erosion setbacks ranging from 49 m (P50%) and 73 m (P5%) for a 100 year timeframe using a higher sea level rise scenario. These values are consistent with previous studies, all of which determine that the Waiotahe drifts sub-division ("The Drifts") could be at risk within 50-100 years based on evolution of the natural shoreline (no consideration given to OHD).

2.2 River migration hazard

Based on review of historic aerial imagery, the mouth of the Waioeka River has been migrating westwards since at least the 1940's. Analysis has concluded (Shand, 2019; T+T, 2019) that the migration process is related to changes in the upstream channel configuration, including changes from natural river processes and potentially river control structures, which are likely to continue to aggravate erosion of the westward shoreline.

Movement of the position river mouth 'throat' has been calculated to average 8 m/year, based on data from 1867 – 2015 (Shand, 2019), and has accelerated in recent years. While continued migration of the river mouth is possible, long term this is considered limited by the river's potential to breach through the spit. As a result, the river mouth would shift back eastward and the process of westward migration would repeat until the eastern spit breaches again. This process has been taken into consideration when developing the hazard mapping (T+T, 2019).

2.3 Summary

A summary of the erosion hazards, based on the natural coastline and coastal processes with no allowance for construction of the OHD, is illustrated in Figure 2.1. Construction of the OHD effectively fixes the position of the river and mitigates the river migration hazard. The development

will however influence the extent and timeline of coastal erosion, the potential for which is discussed in this report.

Figure 2.1: Areas considered susceptible to natural erosion hazards (T+T, 2019).

Although the shoreline to the east of the OHD is subject to the same consent conditions as the west, the area is largely undeveloped and as such this summary primarily considers the coastline to the west and proximity to The Drifts.

3 Anticipated changes to coastal morphology

3.1 Works summary

The consented OHD works comprise three main elements (Figure 3-1), the construction of two training walls 120 m apart extending c. 400 m from the shoreline. Dredging of a navigable channel between the training walls and into the estuary, and closure of the existing river mouth using available sediment.

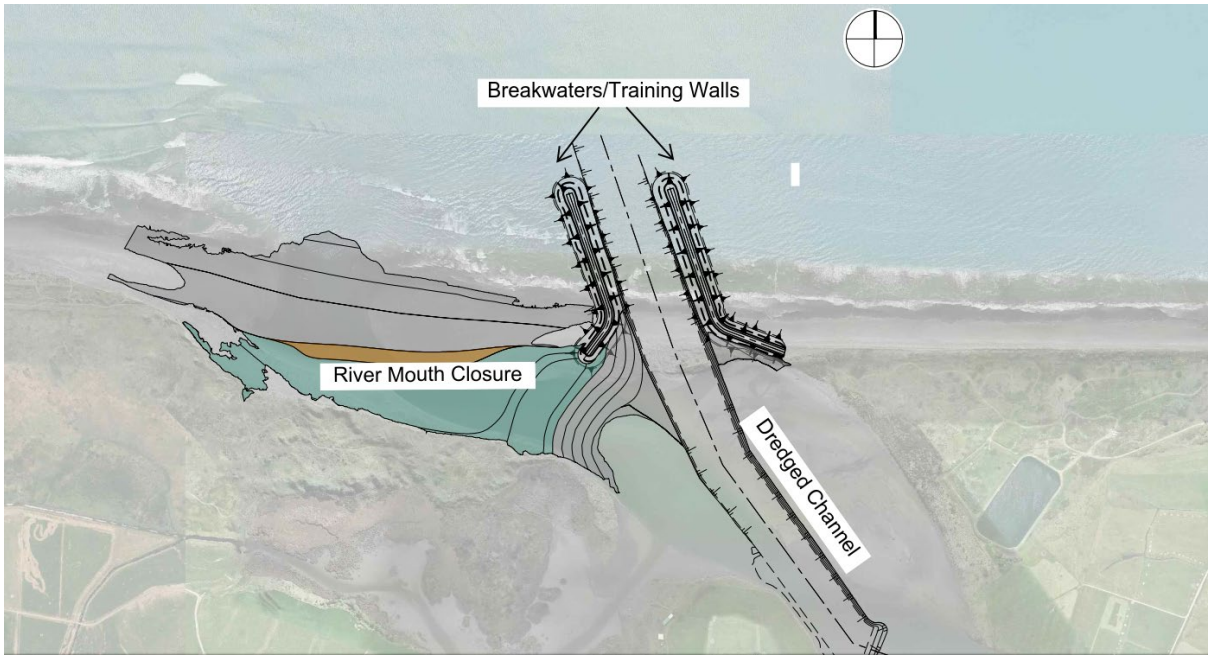

Figure 3-1: Key work components of the Opotiki Harbour Development.

3.2 Coastal process effects

Alongshore sediment transport is predominantly driven by the wave climate and orientation of the coastline. Construction of training walls will impede alongshore sediment transport, affecting the coastline morphology, and create new erosion and accretion trends. Conceptually the training walls will fix the position of the entrance and remove the potential for westward migration of the river mouth and hazard described in section 1.2.

The walls provide a barrier to sediment transport along the coast, the direction of which has been shown to vary both seasonally (within a year) and over longer timescales (years) (T+T, 2021). In simple terms a prolonged period of net sediment transport in either direction may lead to a build up of material against one wall with the potential for erosion of the coast on the downdrift side.

Other considerations for coastal erosion include the quantity of material used for the river closure and the anticipated breakdown of the ebb tide delta at the existing river mouth, and the sediment supply from the river.

There are known uncertainties relating to the OHD during both construction and operation and maintenance including the quantity of material to be used for the river closure, and the magnitude and frequency of beach renourishment and sediment bypassing that will be required. These uncertainties have implications for coastal erosion.

4 Consent conditions

Mitigation of any coastal setback is included in the consent conditions (Coastal permit 65563) granted in 2009. This is defined as a renourishment trigger in condition 12.29;

> *12.29 The renourishment trigger is set at 50m of landward retreat of the baseline toe of the foredune position. The distance should be measured from any of the datasets outlined in the Beach and Nearshore monitoring section.*

The basis for this trigger is understood to be a combination of preliminary modelling, the pre-existing erosion hazard susceptibility area (as defined by studies available at the time the consent

application was lodged and heard) and consideration of potential development landward of that point (the baseline toe of foredune). However, we have not been provided with any documentation that specifically presents a rationale for how the 50 m distance was derived. In 2009 a setback of 50m was considered possible with mitigation specified as a beach nourishment and dune planting programme once this trigger was hit.

> *12.30 The consent holder shall develop a beach nourishment and dune planting programme, to be implemented when the trigger identified in condition 12.29 is met.*

Although a mitigation requirement for potential erosion is specified in the OHD consent conditions, the mechanics of how this will be implemented are not. The speed at which the consent holder responds to the trigger being met, and the volume of material used for mitigation will have implications on the risk of the setback acceding this and by how much. Longer response times allow for continued erosion in the interim, while smaller renourishment volumes may result in a storm cutting the beach beyond the 50 m trigger.

5 Shoreline Modelling - Work completed to date

5.1 Pre-Consent (2008)

Modelling work used to inform the consent was primarily produced by the Danish Hydraulic Institute ("DHI") who released a series of reports and a summary of results (DHI,2008). The conclusion of the report in relation to erosion setback of the wider coast was;

"In the extreme case, average coastal setback of up to 100m could conceivably occur. Normal fluctuations are expected to be less, in the order of 40-60m, but the design would have to be able to accommodate some erosion and therefore a mitigation approach based on a combination of capital nourishment and regular monitoring is recommended."

This was based on information available at the time, a concept design, and ten-year wave dataset. It is our understanding that the consent condition, and requirement to mitigate coastal erosion, is based on this work completed by DHI.

5.2 Preliminary design (2017)

T+T were engaged in 2017 to produce the preliminary design and rough order cost estimates. As part of this process ODC engaged DHI to provide modelling data to T+T to support the design. The preliminary design defined the layout, angle and length of training wall structures which was not fundamentally different to the concept layout used for the pre-consent modelling and approved by the BOPRC.

For the shoreline modelling component new data was available to DHI including updated topographic and bathymetric surveys and a larger 40 year wave hindcast dataset. The results of the modelling showed that the 50m coastal setback trigger may be reached under certain conditions (Figure 5-1) but the potential was not greater than that defined in the original pre-consent modelling.

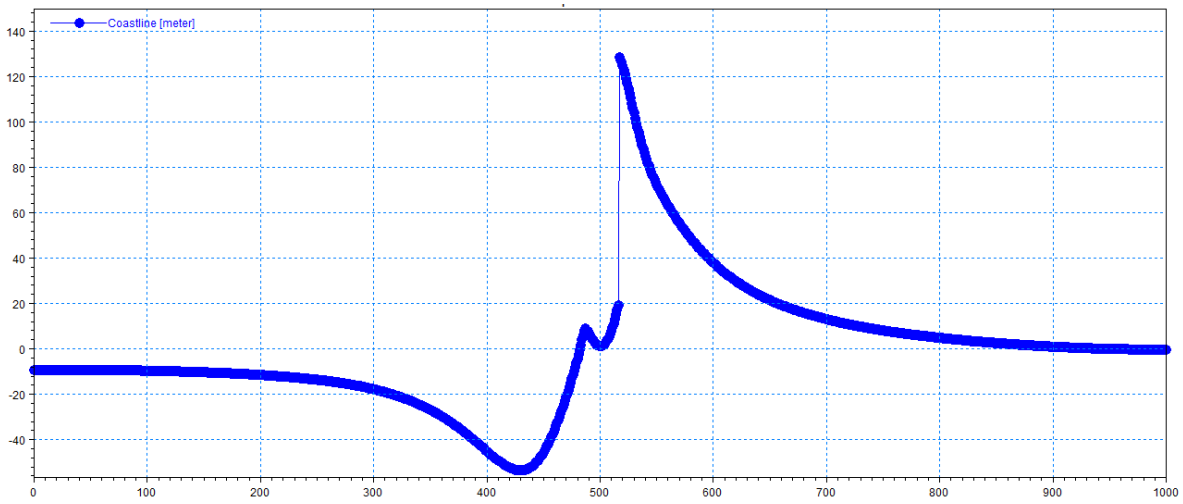

Figure 5-1: Example output of LITLINE model predicting an erosion setback of -55m on the western side during extreme conditions.

5.3 Detailed design (2021)

As part of the detailed design a substantial amount of additional data was collected and modelling undertaken. The relevant elements that were used to inform the shoreline evolution predictions used in the detailed design are outlined below:

- Collection of wave data from new offshore and nearshore wave buoys to validate model inputs.
- Collection of additional topographic and bathymetric survey data for the model baseline.
- Sediment sampling and analysis at several shoreline and nearshore locations.
- Production of revised longer term wave hindcast model (40+ years).
- Development of several wave numerical models (Figure 5-2).
- Physical modelling of the structure and effects on wave climate (Figure 5-3).
- Development of a morphological model to assess short term evolution of the coastline under different conditions (Figure 5-4).
- Modelling of the long-term fluctuations in shoreline position through a series of sensitivity tests.

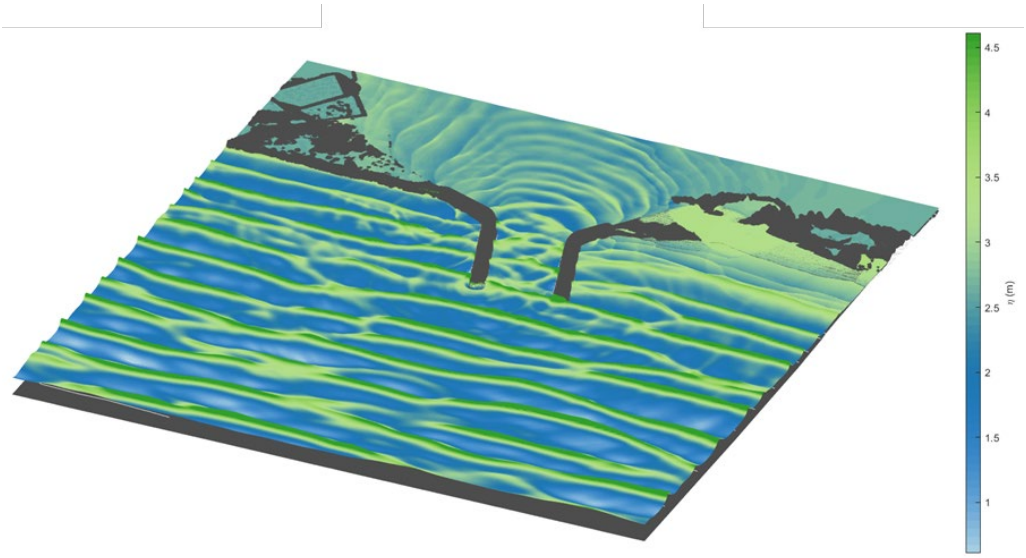

Figure 5-2: Example of wave model used to assess training wall structures' impact on wave climate.

Figure 5-3: Physical model constructed in a wave basin to validate nearshore wave heights and training wall structures' influence on wave climate.

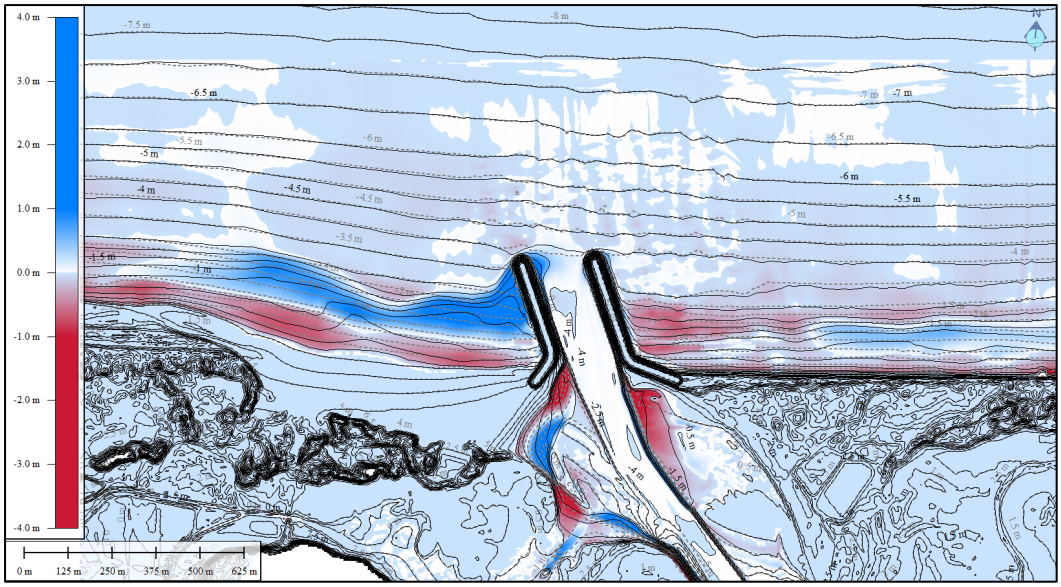

Figure 5-4: Example of a model result based on the response to a storm with waves from a NW direction resulting in accretion on the western side of the western training wall and erosion on the downdrift side (Eastern side of eastern training wall).

The model results reinforced the large natural variability in environmental conditions and enveloped the range of shoreline responses that could potentially occur. Outputs in terms of coastal setback were no worse than the original DHI 2008 study the consent condition was based on. The results of work completed as part of the detailed design predict slightly less potential for erosion and shoreline setback. However, these results will need to be calibrated during construction as detailed below.

5.4 Summary

A 50m setback distance is specified within the consent conditions and we are not aware of the rationale behind this value being used. An assumption is made that this was considered appropriate based on the existing coastal erosion hazard assessments available at the time, proximity of the proposed training walls to potential development areas, and the results of preliminary modelling carried out by DHI on shoreline evolution following construction. More detailed work undertaken by DHI as part of the preliminary design and T+T with the detailed design have confirmed the 50m setback is reasonable for the consent duration, but may be exceeded under certain conditions triggering the beach re-nourishment based consent condition.

6 Timeline for more detailed assessment

It is acknowledged that in order to perform its regulatory duties ODC would ultimately require a revised set of hazard zones that incorporate the potential influence of the OHD on coastal processes. Currently this is not recommended, with the range of uncertainties described above the confidence limits would be wide. A number of these uncertainties will be resolved, or allow for predictions with higher confidence, during and post construction and following the production of an Operation and Maintenance Manual and the implementation of the coastal monitoring programme specified by the consent conditions.

An indicative timeline for providing this information is provided below.

During Construction (2021-2023) – As part of the consent conditions detailed topographic surveys are being conducted every month and following large storm events. As the breakwater structures are built seawards (Figure 6-1) they will start to provide a barrier to sediment transport and effect

the natural coastal processes. The monitoring data will provide the basis for calibrating the shoreline evolution models based on observed changes to the beach topography and prevalent conditions. This will allow for predicting the potential changes to the coastline with a greater degree of certainty and will be used to inform the Operation and Maintenance Manual.

Figure 6-1: Construction progress of the eastern training wall May 2021 (Source: HEB Construction)

Following completion of the breakwater structures the existing river mouth will be closed, the volume of material used for this exercise is dependant on the quantity and suitability of material available on site. This will be stockpiled during construction, during excavation of the structures, with additional material sourced through dredging the new channel and breaching the existing spit. Although this volume can be estimated using existing survey data, the area is extremely dynamic and there is uncertainty on how much will be available at the time of the works. The more material that is available to be placed on the western side will have a significant effect on the formation and position of the coastline post development.

Completion (December 2023) – On completion of the works there is a requirement to provide ODC with an Operations and Maintenance Manual. This will set out ODCs responsibilities for maintaining the harbour entrance and meeting the consent conditions. This will include details on the dredging requirements for the channel, movement of material that has accumulated against either structure and remediation if the 50m coastline setback trigger is reached.

It is anticipated that works will be required on at least an annual basis and following storm induced extreme water levels and large wave events. However, the extent of works required and material availability is expected to fluctuate greatly depending on the wave climate and number of storms in any given year. Depending on prevalent conditions, placement of material may be required on either side of the training wall structures and sourced from the opposite side and maintenance dredging. There are practical and feasibility issues that need to be agreed with ODC around the frequency and extent of works. We also note that the frequency and magnitude of mitigation works will be dependent on sediment availability.

Production of the Operation and Maintenance Manual and establishment of triggers for works will allow for more accurate estimates of potential coastal setback on an actively managed coastline.

Post-Construction (2024+) – Following construction the ebb tide delta at the current river mouth position is expected to breakdown. This is likely to benefit the coastline to the west of the structures as wave action merges the material with the existing beach. Longer term additional data collected from shoreline monitoring and an increased understanding of actual and likely sea level rise will allow for more detailed coastal erosion susceptibility assessments.

This is considered no different to other areas of the Bay of Plenty coastline where hazard assessments are typically updated every ten years or when new information becomes available.

7 Summary/Conclusion

A consent for the OHD was granted in 2009. Since then, a great deal of work has been done as part of the preliminary and detailed design process leading up to construction. The following summarises the work to date, the current uncertainty and what is required to develop future erosion hazard areas:

- The latest coastal erosion hazard assessment, and previous hazard assessments, all show that an area +50m landward of the current shoreline position is potentially susceptible to erosion within 50-100 years (Assuming the training walls are not constructed).
- Land to the west of the river mouth has also been shown to be susceptible to erosion through river migration.
- Construction of the OHD will fix the river position and remove the river migration hazard. It will however interrupt sediment transport along the coast and result in greater fluctuations in shoreline position in a localised area of Waiotahe Beach depending on prevalent conditions.
- Analysis has shown that there is a great deal of natural variation in both the sediment transport direction and magnitude, both seasonally (within a year) and over larger time scales (years). This may result in a build up of material on either side of the training wall structures with erosion on the downdrift side.
- A consent condition requires that this downdrift erosion is mitigated if the coastline setback exceeds 50 m on either side of the structures and is based on modelling conducted by DHI in 2008.
- Modelling work conducted by DHI in 2017 to support the preliminary design, and a new numerical model developed by T+T for the detailed design predict that the potential coastal setback is no worse than the results of the original DHI assessment in 2008 that the consent condition was based on.
- There is uncertainty in predictions that will be partially resolved during construction and on completion of the works in terms of the amount of material that will be used for the river closure, calibration of the shoreline models based on observations during construction, the breakdown of the ebb tide delta, and the requirements for management to be set out in the Operations and Maintenance Manual. Resolution of the above uncertainties will allow for the production of revised coastal hazard lines at Waiotahe Beach with an increased level of confidence.

It is important to note that mitigation of erosion is based on redistribution of material within the local area i.e. no additional sediment is artificially added to the system. This redistribution will likely act to balance out short term fluctuations resulting from construction of the OHD, however long term with sea level rise the wider Bay of Plenty coastline is expected to retreat. A point will be reached where it is no longer possible to maintain the coastline using redistributed sediment, within a 50m setback of the baseline position, on both sides of the training wall structures due to insufficient material being available. This is similar to predictions of evolution and erosion of the natural coastline, without consideration of the OHD, whereby these areas were considered potentially susceptible to erosion.

We consider it likely that when an application is made to renew the OHD consent then the evolution of the wider coastline will be addressed in the assessment of effects and conditions, whereby the consent holder is only obliged to mitigate effects that are considered above those that would have occurred naturally. Based on this assumption, the area beyond the 50 m setback line would still be potentially susceptible to erosion within 100 years.

In conclusion, we recommend ODC consider the use of appropriate development controls that appropriately respond to this coastal hazard risk over the longer timeframe (50-100 years) when

assessing subdivision and land use consent resource consent applications for activities within The Drifts and along Waiotahe Beach in general.

8 References

DHI (2008). *Opotiki Harbour Access Modelling and Preliminary Design. Volume 1: Summary report*. Danish Hydraulic Institute (DHI): Project number 50073. Report prepared for Opotiki District Council.

T+T (2017). Contract 124 - *Design and Construction of the Opotiki Harbour Development Project: Concept Design Report*. Prepared for Opotiki District Council

T+T (2019). *Ōpōtiki Harbour Development: Updated Training Wall Concept Design Summary*. Prepared for HEB Construction Limited

T+T (2021). Detailed Design Report Design and Construction of the Ōpōtiki Harbour Development Project. Prepared for HEB Construction Limited.

9 Applicability

This report has been prepared for the exclusive use of our client 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, or by any person other than our client, without our prior written agreement.

We understand and agree that this report will be used by Ōpōtiki District Council in undertaking its regulatory functions in connection with the WH subdivision.

Tonkin & Taylor Ltd

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