Erosion Assessment & Management Options for Wilkinson Beach (West Rangiputa) Northland

A report prepared for the Department of Conservation

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EXECUTIVE SUMMARY

Section 5 (Summary) and Section 6 (Recommendations)

together serve as an Executive Summary

CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

In August 2018, Coastal Systems Ltd (CSL) was contacted by DOC Northland staff about erosion threatening the access road to popular Puwheke Beach in Northland (Figure 1). While erosion at this location had been noted for some time, the 3-5 January 2018 storm had had a significant impact (Figure 2) and staff now wanted to consider management options and environmental implications.

Figure 1 *Location diagram showing Rangiputa and Puwheke Beach on the eastern side of the Rangaunu Estuary's mouth*

Figure 2 *Post-storm erosion threatening DOC access road between Rangiputa settlement and Puwheke Beach, Northland Photos supplied by DOC staff*

The Department of Conservation (DOC) manages the natural area beyond Rangiputa settlement which is referred to as the Puwheke Marginal Strip (Figure 3). Features of intertest marked in Figure 3 include the following: Rangiputa Settlement and fronting seawall; the Wilkinson Reserve between the Settlement and the rocky headland of Kotiatia Point, the beach between the seawall and the headland, which for clarity we have named "Wilkinson Beach" in the present report; the access road across Wilkinson Reserve and around Kotiatia Point to the car park at Puwheke Beach – this being a popular recreation and freedom camping location.

While the area of interest to DOC is some 40 m long at the northern end of Wilkinson Beach, this beach remains in a natural state between two hard controls – the rocky headland and the revetment. Any management of the problem area will likely impact on the rest of Wilkinson beach, so the entire beach needs to be considered. In addition, this area is critically located between the enclosed Rangaunu Estuary and the exposed oceanic Rangaunu Bay, i.e. its on the eastern side of the throat section between these two features, so the wider morphological change and hydro/sediment dynamics need to be understood when identifying and assessing management options

Of particular relevance to the present study is the (approx) 560 m existing seawall which runs the entire length of Rangiputa settlement. The structure is some 2 to 3 metres in height above beach level and has a frontal slope of about 50 degrees in the north and 40 degrees in the south. Northland Regional Council granted a retrospective resource consent (No. 23858) for this structure in 2011 to enable maintenance works (the original structure dated from 1989) to specifications set out in NRC Plan 4377 (Appendix A). NRC staff have informed us that any extension to the present structure would require a consent under Rule 31.3.4 (l) of the Regional Coastal Plan for Northland and Rule C.1.1.17 of the Proposed Regional Plan for Northland. It is unclear whether the earlier structure had any district or county council permits.

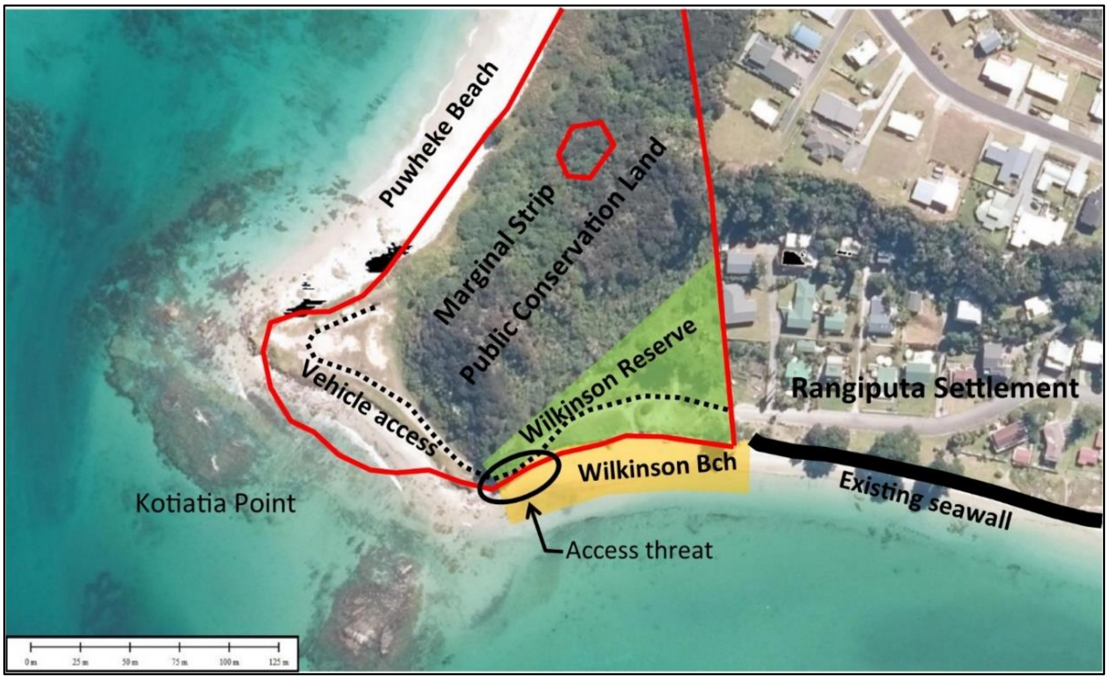


Figure 3 *Puwheke Marginal Strip and features pertinent to this report including the site of threatened vehicle access and "Wilkinson Beach", so named in this report to assist in clarification. Note the Marginal Strip boundary is defined by legal property lines not the current shoreline* *Aerial photo 2015 LINZ*

1.2 INSTRUCTIONS

CSL were engaged to carry out the following tasks:

1 A site inspection (this was completed on 30 August, 2018);

2. An information search;

3. An erosion assessment, and

4. Identify management options including environmental implications.

1.3 REPORT STRUCTURE

This report will first describe the present physical setting (Section 2) including the morphology of Rangaunu Bay and Estuary in general and Kohanga Bay/Rangiputa area in particular, as well as describing the driving forces (tides, waves, currents) and sediment characteristics. The 3-5 January 2018 storm event will also be considered. Section 3 describes physical behaviour (over time) in terms of historical shoreline change from Puwheke Bay to south of Rangiputa; this perspective enables an assessment of impacts of the existing seawall and assists is identifying environmental impacts from future management options described in Section 4. Section 5 summarises the report and Section 6 contains recommendations on how to proceed. In addition to some specific references provided within the text, a list of other relevant source materials used in preparing this report is included as a Bibliography.

2 PHYSICAL SETTING

2.1 GENERAL

The Rangaunu Estuary comprises some 97 km^2, 2/3 being intertidal flats (Figure 4). Three main channels about 9 m deep (below MSL) dissect the estuary with depths increasing to 15 m though the throat then decreasing to 7 to 9 m again across the extensive (ebb) delta and to 6 m along the delta front some 3 km seaward. The throat (mouth or neck) is some 1.5 m wide with the landward estuary bay increasing to about 11 km wide by 11 km long. The main outlet channel carrying flow across the ebb delta is offset to the north due to deflection by Kotiatia point and the Toby reef (so named for this study) which extend some 500 m across the neck from the eastern side. The main eastern inlet channel carrying flood flow into the estuary flows through Toby reef.

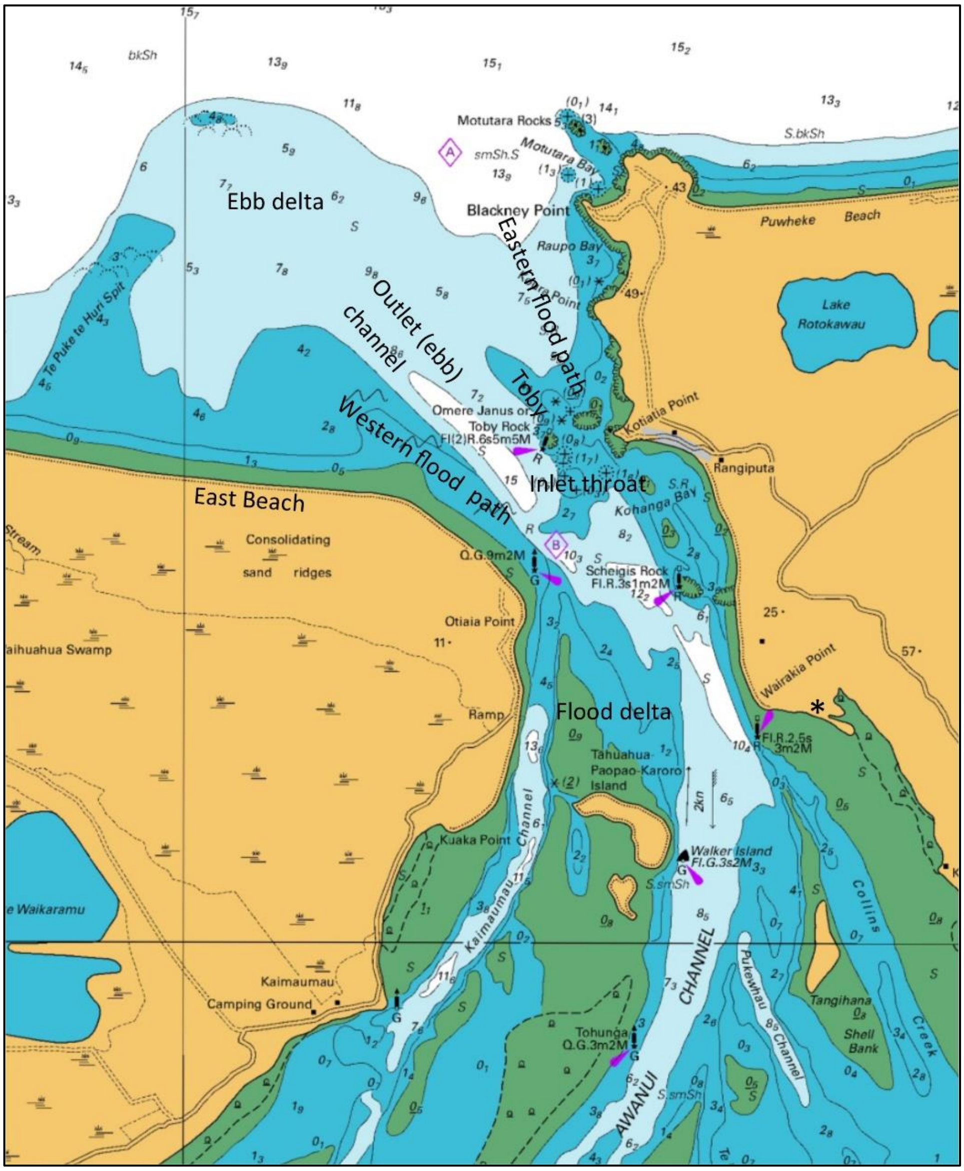


Figure 4 *Morphological and hydrological features of Rangaunu (landward) estuary and (seaward) bay. Depths are below chart datum which approximates the lowest tide level*

Chart NZ 5113 (LINZ)

2.2 SEDIMENT

Sediment along each side of the throat comprises fine sand with fine to very fine sand south of Rangiputa Settlement. Seaward of Puwheke Beach sea-bed sand coarsens to medium with coarse sand-gravels in the main (ebb) channel. The throat opposite Kotiatia Point has bare rock on the bottom indicating particularly strong incoming (flood) current.

2.3 ENERGY REGIME

Oceanic waves entering the estuary would be about half the deep water values (T&T 2017b) with a mean significant height[1] of about 1 m and storm significant value of about 2.5 m. Oceanic waves transform as they propagate into and through the estuary as illustrated by the wave crest patterns in Figure 5. The reefs offshore of Kotiatia Poiint dissipates wave energy as it enters Kohanga Bay and bend (refract) into Rangiputa and Wilkinson Beaches Nonetheless, a spring high tide (1.05 m above MSL) coupled with storm surge (water pileup from surface wind friction and low barometric pressure which can reach 0.5 m during storm conditions) would enable destructive storm waves to reach the Wilkinson shoreline as demonstrated by the January 2018 event.

Waves generated across Rangaunu Estuary by predominant S-SW winds can also reach the study area. Using Young and Verhagen's (1996) wave generation model and assuming a 3 to 10 km fetch, 2 to 6 m water depth and 10 to 25 m/s wind speed, significant wave heights range between of 0.2 m at a 1.9 second period, to 1.0 m at 4.1 seconds. If these waves co-incide with high water levels they may also have an erosive impact on the Wilkinson-Rangiputa shoreline.

Figure 5 *Wave transformation during propagation into the estuary. Note the dampening effect of the reefs off Kotiatia point and the particularly sheltered Rangiputa shoreline*
Image form Google Earth 2012

1. Significant wave height refers to the mean of the upper 1/3 of wave heights

2.4 CURRENTS and SEDIMENT TRANSPORT

A schematic representation of the circulation pattern and inferred sediment transport paths on the ebb delta and inlet neck are depicted in Figure 6. In conjunction with data interpretation from 1958 and 1979 bathymetric charts, it is evident that sediment (predominantly sand) is jetted seaward through the main ebb channel and across the delta front where is deposits. Sediment may then be transported laterally where, supplemented by additional littoral input from offshore, it is carried back through the throat via the margin channels. Of relevance for the present study is the main landward feed of sediment into and across the shallow (2 to 3 m deep) Kohanga Bay indicating potential for (re)supplying Rangiputa beach. Decreasing sediment size from offshore of Puwheke Beach, past Rangiputa and around Kohanga Bay is also consistent with a sediment pathway. Rangiputa thus appears to lie in the centre of a well-defined sediment transport system. Note that sediment transport within this area likely results from wave entrainment (lifting grains off the bed) then forward transport by tidally-driven currents.

Evidence of periodic sediment migration influxes (i.e. waves or slugs sediment), is burial of a sea grass meadow in the 1984 aerial photograph (Figure 7). Evidence of periodic sediment influx is also indicated by a series of wave-like seabed accumulations in the 1958/1979 bathymetric comparison and encircled red in Figure 8. And yet further evidence are the multiple terminal sand spits some 2 km south of Rangiputa and marked by the asterisk in Figure 4; these latter features indicating a marked reduction in wave/wind/tidal current.

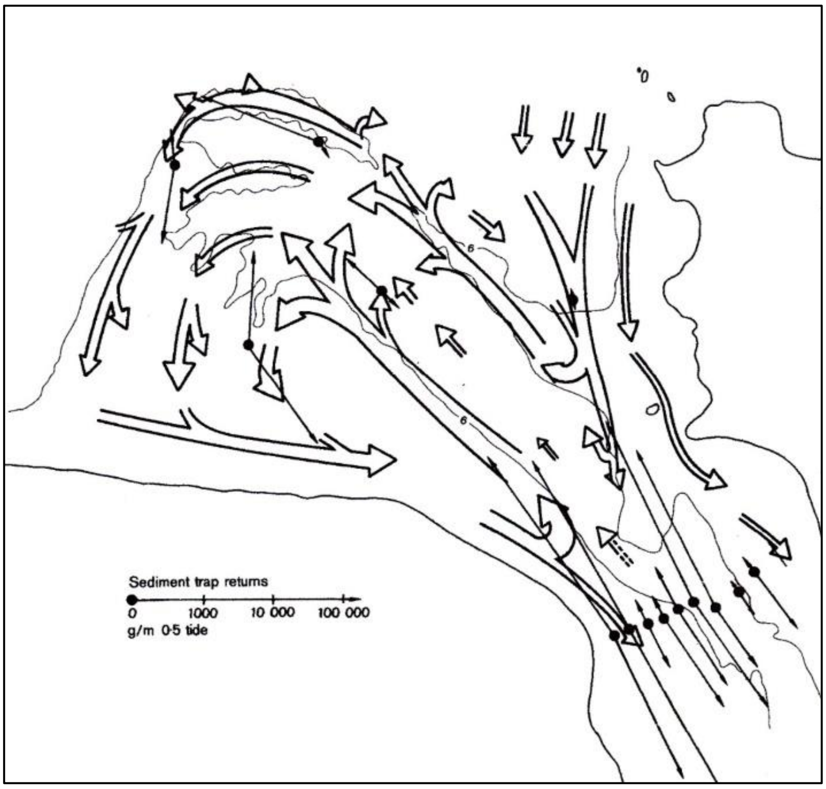


Figure 6 *Circulation currents and inferred sediment transport across the Ramgaunu ebb delta and through the estuary throat.* *Pickrill (1985)*

Figure 7 *Sediment wave (lighter area) migrating to the south east (arrowed) over (smothering) a sea grass meadow (dark area). 1984 aerial photo*

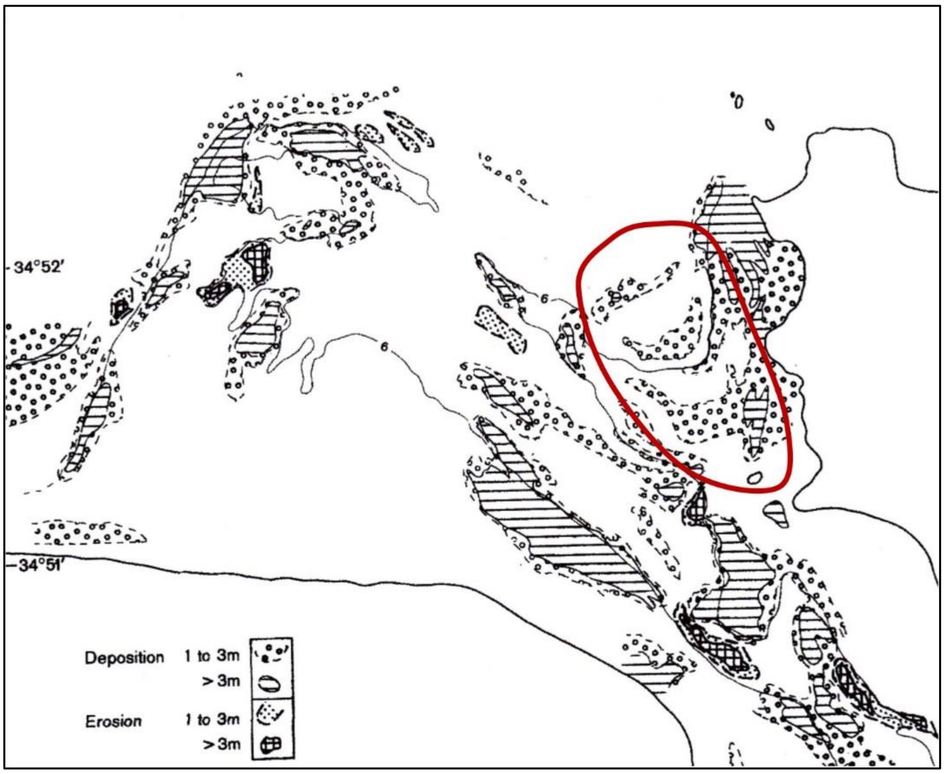


Figure 8 *Bathymetric changes (erosion/deposition) between 1958 and 1979. Red boundary locates sediment waves within the eastern flood channel with morphological form implying landward migration. Pickrill (1985)*

2.5 PROJECT AREA

Wilkinson Reserve and Beach are depicted in Figure 9 along with the section of threatened road accessway (bracketed in upper photo) and Rangipotu settlement and seawall (beyond arrow in lower photo). Wilkinson Beach stretches from the rocky headland (110 million year old Cretaceous sandstone with volcanic and metomorphic inclusions of the Mount Camel terrane) to the stone seawall. With hard controls at each end, this is essentially a 140 m long sandy "pocket beach". Based on measurement from the high resolution (0.1 m) LINZ 2015 aerial photo, the high tide beach can exceed 15 m in width. NRC surveys show the beach slope above MSL is 15 (horizontal) to 1 (vertical), while the adjacent offshore slope is relatively flat (200 to 1) and reaches 4 m below MSL some 700 m offshore. This beach is backed by a 1.5 to 3 m embankment that is freshly scarped in places. Three large makarakapa trees have been affecting the shoreline more recently, with the stump of one now on the beach, the stump of another embedded in the scarp and the third is still

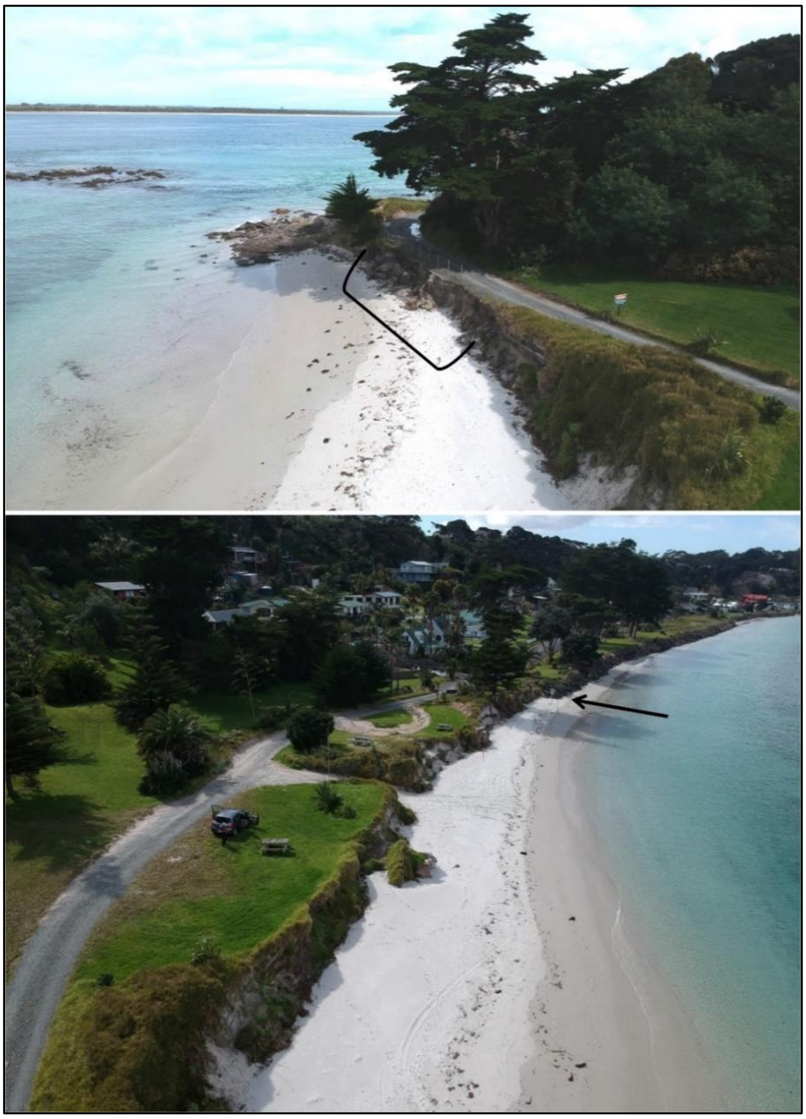


Figure 9 *Wilkinson Beach viewed to west (top photo) with the rocky headland (Kotiatia Point) in the distance and the section of threatened access road bracketed. Southern view (bottom photo) shows Wilkinson Reserve in the foreground and the Rangiputa settlement and seawall in the distance (beyond arrow). CSL 2018 aerial photos*

growing on the embankment nearer the seawall. These features are evident in the lower photo of Figure 9, and while they can provide some erosive resistance, once they project beyond the bank they may well exacerbate erosion by increasing local wave turbulence. The bank closer the revetment is given some protection by domestic rubble. Along the scarp can be seen ancient soil horizons interspersed with beach/dune sand and the area is capped by sand dune. Finally, a vehicle accessway for launching recreational boats has been cut through the embankment in the centre of Wilkinson Beach.

Regarding the 560 m long seawall: a boat accessway exists through the structure closer to its eastern terminus. A lower 25 m long seawall extension was added in 2011-2012. The high tide beach fronting the seawall is non-existent west of the boat accessway but is up to 5 m wide east of the access point.

South of the seawall the high tide beach widens to between 15 m to 20 m and is backed by low sand dune and swamp.

2.5 JANUARY 2018 STORM

Between 3rd and 5th January 2018, a subtropical depression moved southeast from the northern Tasman Sea to track just west of the upper North Island. Significant flooding was experienced along many northern-facing coastlines of the North Island.

As indicated in Section 2.2, for a storm system to result in significant coastal flooding and/or erosion, high waves must coincide with a high sea-level resulting from the tide level plus the storm surge level (onshore wind which piles water up against the coast and low pressure which allows the sea surface to lift). These exact conditions accompanied the January 2018 event.

North facing Tauranga Harbour experienced its highest inundation levels since at least 1960 (Coastal News Magazine, 2018) and the key storm parameters are graphed Figure 10. The combined tide and storm surge are shown in A with the predicted tide level shown by the red line. The curves are at least 0.5 m above the tide line – this being the storm surge. The underlying two graphs (B and C) show the storm surge components (wind and pressure) coinciding to maximise the storm surge. The bottom graph (D) shows the storm wave height reaching its maximum close to time of maximum water level. So the storm waves were superimposed upon an extremely high water level and this ensured high coastal impact. Probabilistically this has an exceptionally low likelihood of occurrence.

We have not sought out equivalent data for Rangaunu, but given that it was affected by the same system it likely responded in a similar manner. This being the case, the January 2018 event and shoreline impact at Rangiputa was highly unusual and, statistically speaking, is not expected to reoccur in the shorter-term at least.

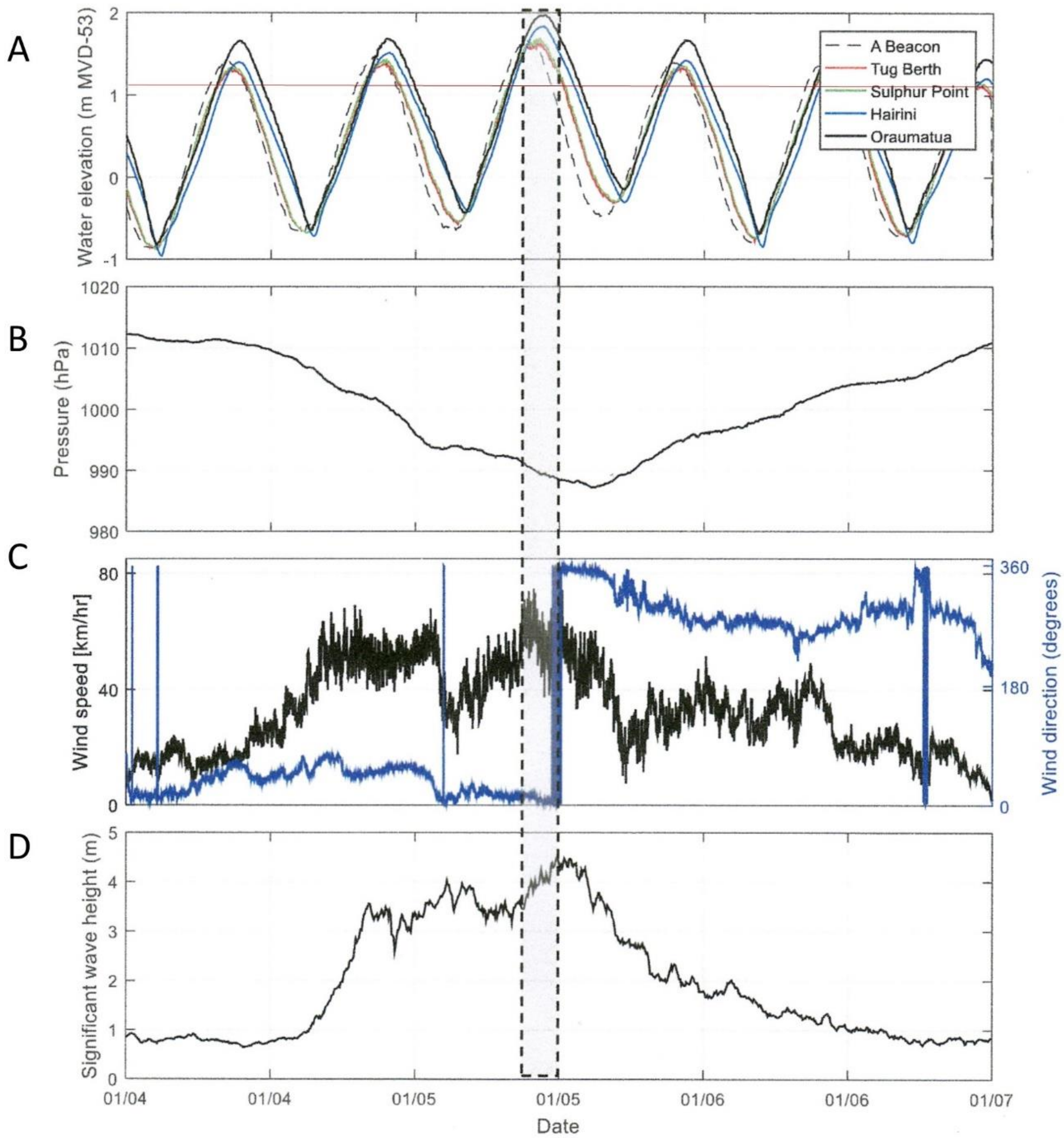


Figure 10 *Storm parameters for Tauranga Harbour for 4 to 6 January 2018. Graph A shows observed water level data from 6 tide gauges with the red horizontal line defining the predicted tide level. Graph B shows barometric pressure and graph C shows wind speed and direction – the combination of B and C define storm surge (the elevation above the red line in graph A). Graph D depicts the offshore significant wave height. The dashed rectangle brackets the time of maximum water level and state of the various contributary parameters.*

3 GEOMORPHOLOGICAL BEHAVIOUR

3.1 INTRODUCTION

The feature most often used to define historical morphological change in coastal environments is the shoreline which is mapped on 19th and 20th century survey plans and evident on aerial photography from the 1940s and satellite images from the 2000s.

The shoreline indicator for beaches is typically the foredune-toe/vegetation-sand boundary which is clearly evident in photo and satellite imagery. Survey plans may use a range of indicators and in our case (the 1897 survey plan) the shoreline is defined as a "sandy beach" which may or may not mean the foredune toe. So the 1897 shoreline is used with caution and the analysis uses the (first) 1944 aerial shoreline as the comparison datum, i.e. the cross-shore location zero and temporal zero are set at 1944.

Shoreline analysis allows for the identification of long-term/background change thus indicating erosion or accretion of a beach, dune, cliff or inlet. If the data set contains enough samples, then shorter-term fluctuations in cross-shore location can also be defined. The data set used in the present study has some large inter-survey periods thus limiting its use for studying shorter-term change.

For the present exercise, the shorelines from 10 samples (detailed in Table 1) were digitized, overlayed and then 8 representative cross-sections (transects) selected with their locations marked, numbered and named in Figure 11. A single transect (#1) in the middle of Puwheke Bay is the seawardmost sampling location. Two transects were selected in the main study area, Wilkinson Bay West (#2) and Wilkinson Bay East (#3), with the western site fronting the threatened accessway. Three transects front the seawall: the West Seawall transect (#4) representing a relatively straight section of wall with the residential boundary being about 20 m landward of the top of the structure; the Center Seawall transect (#5) lies within a slightly "embayed" section terminating at the vehicle accessway with adjacent properties lying 2 to 19 m to landward, and the Eastern Seawall transect (#6) lies between the accessway and the eastern end of the seawall with this section of wall being 5 to 26 m in front of the residential boundary. And two transects are used south of the seawall: 75_South (#7) lies 75 m beyond the structure and 285_South (#8) lies 285 m beyond the structure. These two locations were chosen soas to avoid existing accessways and drains, and more distant seawalls. Data points from these transects are shown as time-series graphs in Figure 12.

3.2 RESULTS

<u>Puwheke Beach</u>

Moving forward from the 1944 survey, the seaward facing Puwheka site (Transedt #1) is characterised by a sediment input to 1977 then loss of sediment thereafter, having now reached the 1944 state.

***Table 1** Shoreline source materials*

Year	Source	Accuracy (m)
1897	survey plan SO 11156	+/- 3
1944	aerial photograph SN 350 (1048-18)	+/- 2
1977	aerial photography SN 5006 E2	+/- 1.5
1984	aerial photography SN 8329 B5	+/- 1.5
1999	ground survey	+/- 0.5
2004	satellite (Google Earth Pro)	+/- 1.5
2007	ground survey	+/- 0.5
2012	satellite (Google Earth Pro)	+/- 1.5
2015	aerial photography LINZ, and	+/- 0.3
2018	aerial photography CSL (Wilkinson Beach only)	+/- 0.1
2018	satellite (Google Earth Pro)	+/- 1.5

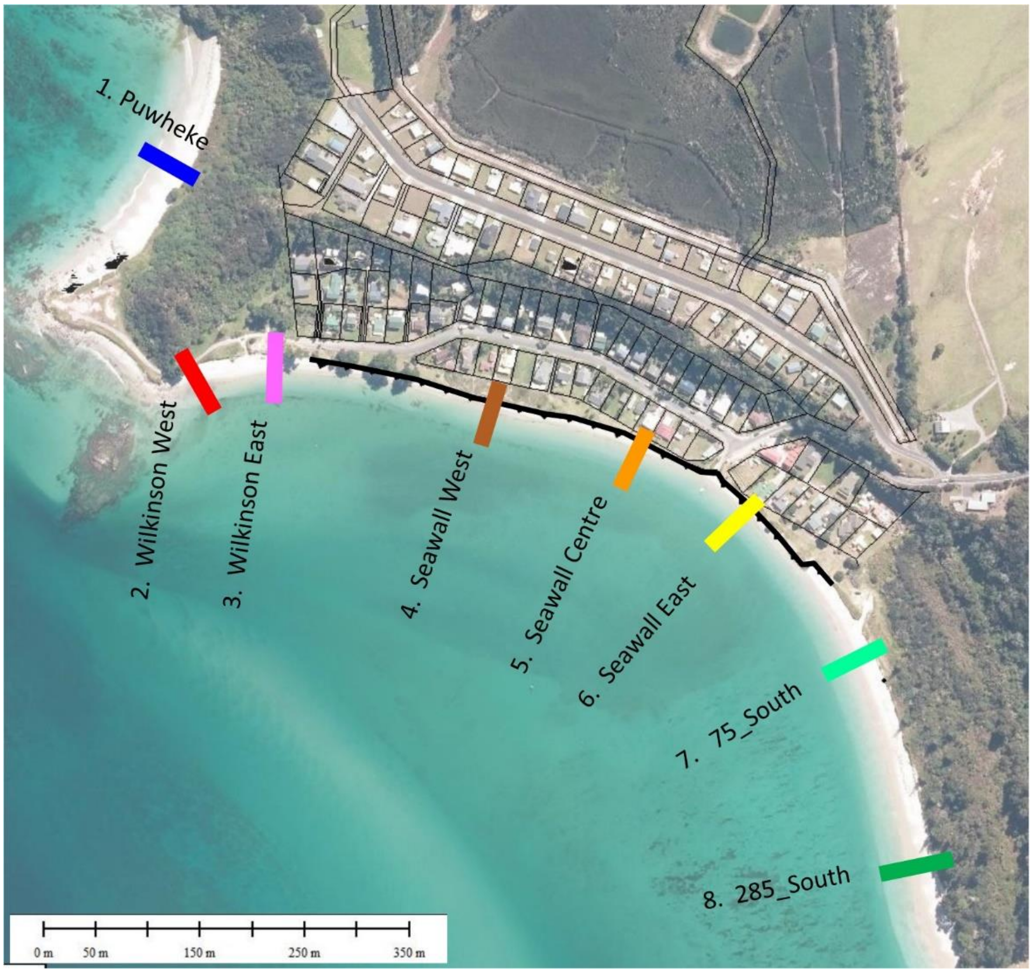
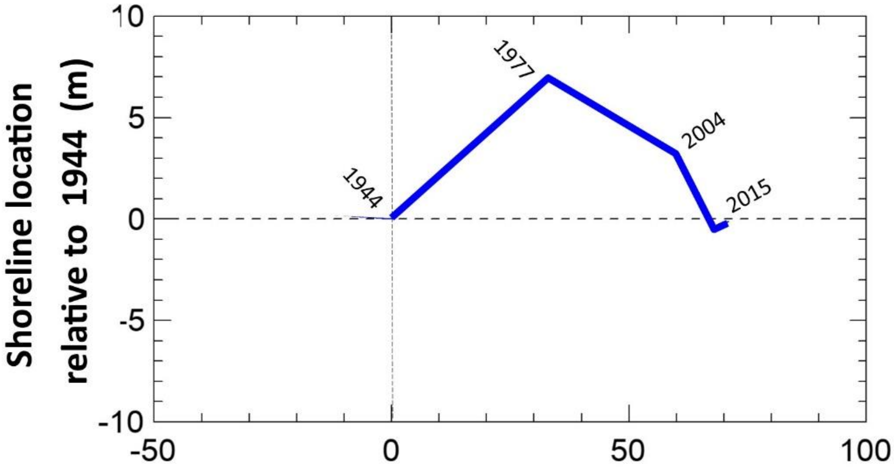
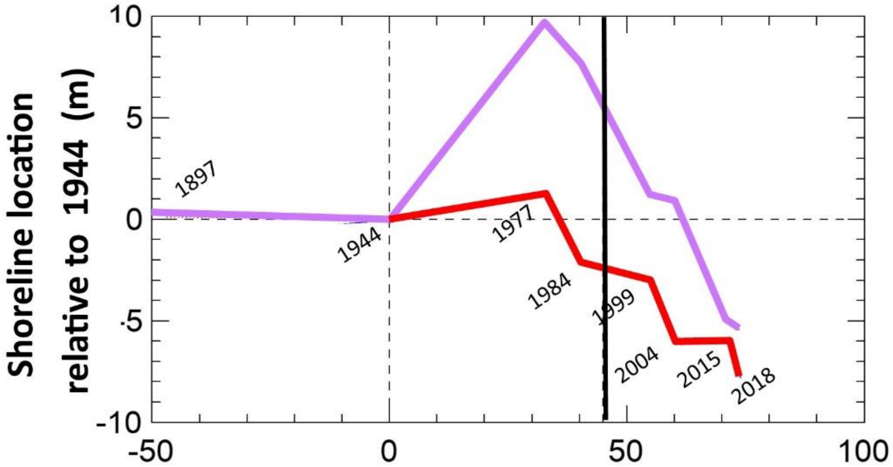


***Figure 11** Eight representative transect locations, named, numbered and colour coded to correspond with graphs in Figure 12 and 13. Bold black line represents the seawall and thin black lines locate property boundaries.*

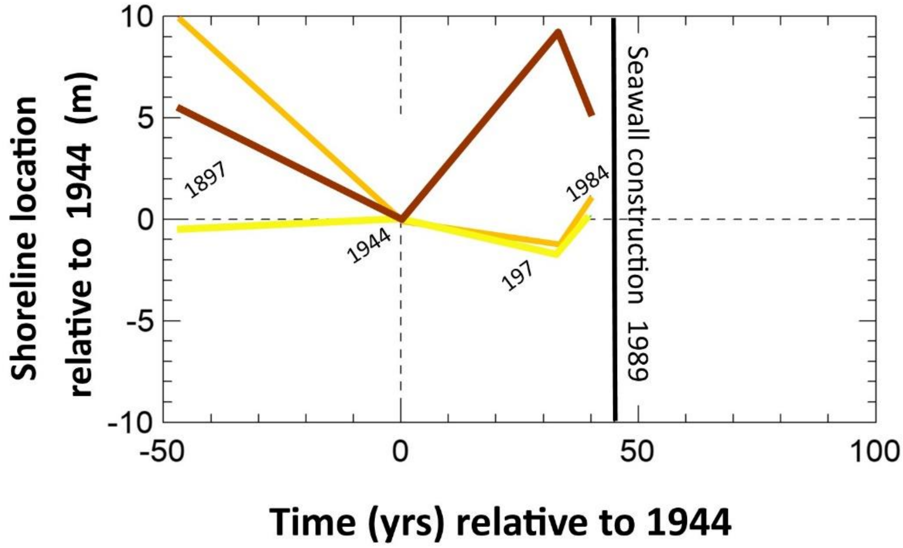
Transect 1 (Puwheke)



Transects 2 (Wilkinson West) and 3 (Winkinson East)



Transects 4 (Seawall West), 5 (Centre) and 6 (East)



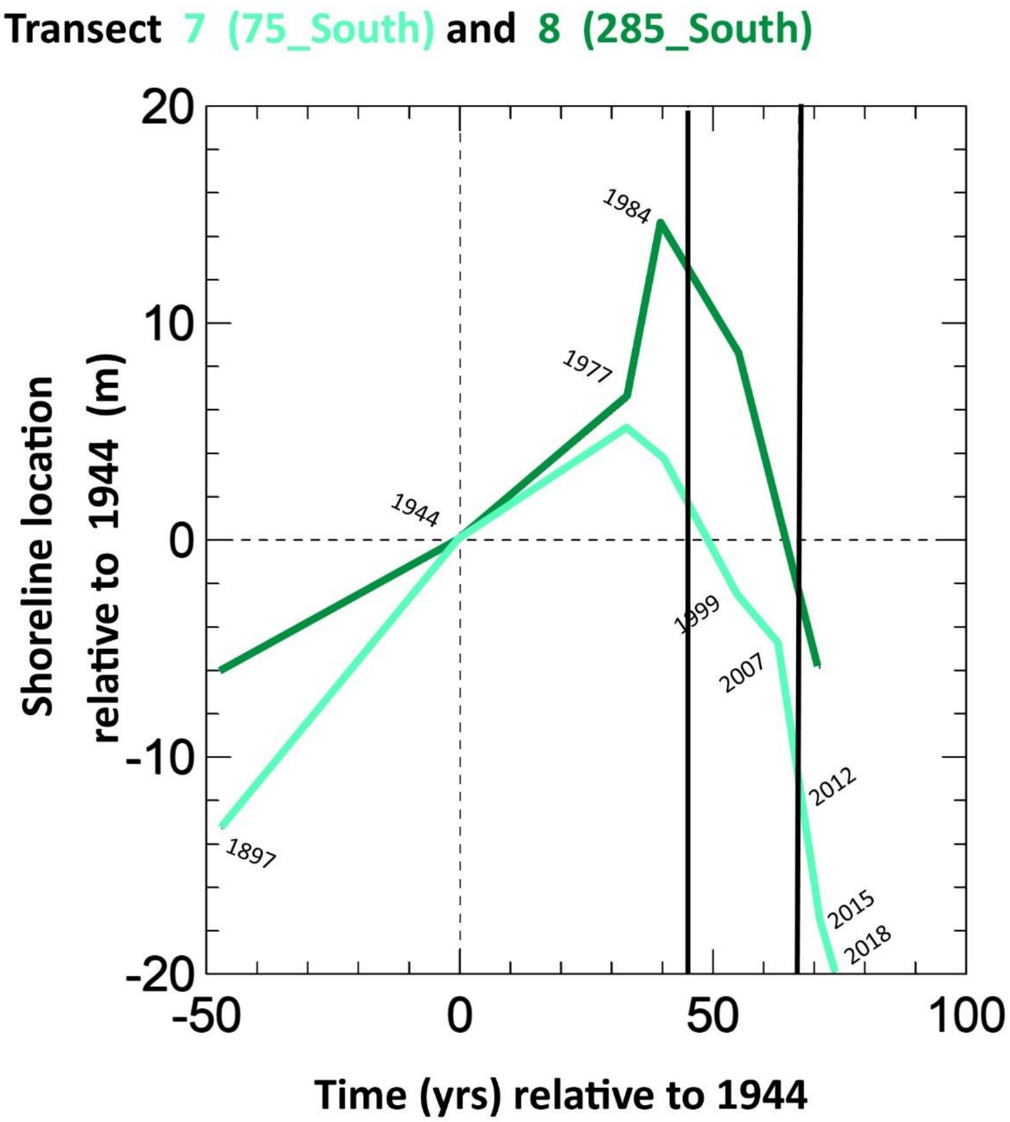


Figure 12 *Shoreline time-series graphs for Transects 1 to 8 (see Figure 11 for locations). Time and location datums have been zeroed at 1944 (see text). Note scales are the same on all graphs to assist visual comparison.*

Wilkinson Beach Transects

The Wilkinson West site (#2) fronting the threatened accessway at the western end of Wilkinson Beach had minimal sediment input 1944 to 1977 and episodically lost sediment thereafter such that the shoreline is now several metres landward of the 1944 position. The location near the headland rocks may experience turbulence which limits sediment accumulation in this area; however, the paleosols (ancient soils) horizons exposed in the escarpment (noted in Section 2.5), show erosion has not reached this far landward for several hundred years.

The eastern end of Wilkinson Beach (Transect #3) shows a particularly large sediment gain for the 1944 to 1977 period. The lack of intermediate samples prevents the identification of any lag between the seaward Puwheke Beach and these internal sites, but some delay would be expected. The eastern Wilkinson Beach site lost sediment after 1977 and, as with the western Wilkinson site, the shoreline is now several metres landward of its 1944 location. This loss of Wilkinson beach sand is in keeping with the sediment loss on seaward (Puwheke) beach; however, the loss is more extensive suggesting seawall – water current interactions may be also contributing. And as noted earlier, seawall effects may have been somewhat masked by the tree roots and bank rubble.

Seawall Transects

As with eastern Wilkinson Beach, the Western Seawall transect (#4) shows a large gain in sediment for 1944 to 1977. The Western Seawall site also lost sediment between 1977 and 1984 with the natural shoreline record ceasing thereafter due to construction of the seawall in 1989 (marked by a vertical dashed line in the Figure 12 graphs).

The graphs show that the Central Seawall transect (#5) and Eastern Seawall transects (#6) have similar pre-structure shoreline behaviours and in contrast to all other transect sites there was a slight loss of sediment between 1944 and 1977 followed by a gain between 1977 and 1984. Such alternating behaviour is a common characteristic along sediment pathways and this is discussed again below.

Southern Transects

The site closer to the seawall (75_South) consistently lost sediment after 1944 with the rate increasing after the seawall extension in 2011-2012 to reach 26 m of retreat; this compares with 15 m at Wilkinson Beach, i.e. beyond the northern end of the seawall. While the loss is consistent with the long-term loss being experience by the ocean beach and western internal sites, the greater magnitude indicating additional seawall effects. Indeed, the contrasting retreats at each end of this seawall is consistent with the expected difference between updrift and downdrift shorelines.

Shoreline behaviour at the more distant transect (285_South) has an interesting contrast to 75_South in that it contains a marked gain in sediment post 1977 with a loss commencing thereafter. This site is close to the migrating sediment wave depicted in Fig 7 and this would account for the rapid gain between 1977 and 1984, while the loss thereafter corresponds to both the general underlying erosional phase behaviour at other sites and also possible seawall effects. It is noted that empirical evidence for oceanic coasts suggests the effected shoreline can extend up to 0.7 @ the length of the seawall: in this case 0.7 * 560 = 392 m. However, this may be an over-estimate for Rangiputa due to the subdued wave climate.

1897 shoreline behaviour

Extending back in time from the 1944 data point provides an indication of earlier shoreline behaviour. These first data points have been plotted on transect graphs 3 to 8 in Figure 13 and indicate shoreline status before, and relative to, 1944. They could not be determined for Transects 1 and 2 as consulting the original surveyors field Book showed that north of the settlement the shoreline location was only estimated rather than directly measured. The result in Figure 13 indicates a positive sediment supply along the central seawall section and a substantial negative status along the southern transects. This supports the earlier comment that alternative erosional/depositional shoreline behaviour can occur along sediment pathways.

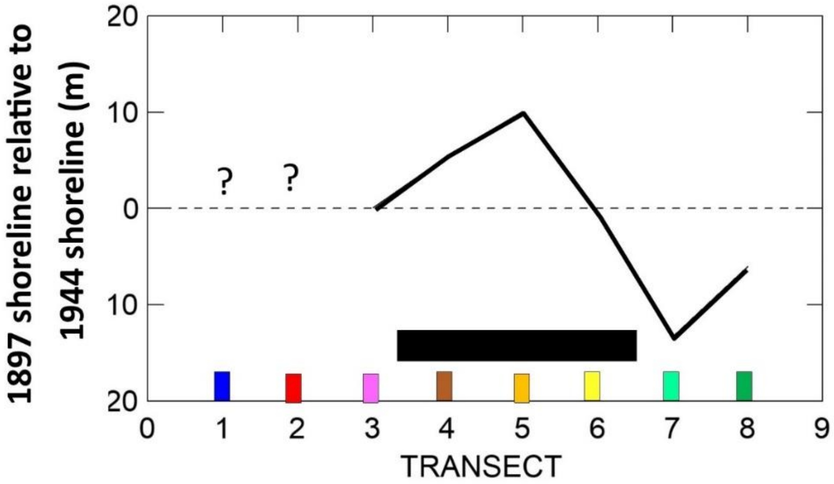


Figure 13 *1897 shoreline relative to the 1944 shoreline (datum), i.e. the 1897 data points in Figure 12. Horizontal black bar marks the present seawall reach.*

3.3 DISCUSSION

These results indicate shoreline advance and recession up to about +/- 10 m occurs at about 100 year intervals with smaller oscillations occurring over shorter time spans. Sites west and south of the central/eastern seawall experienced a major peak in the 1970s with minimum values occurring in the late 19th century and also more recently. By contrast, the central/eastern seawall area experienced a sediment supply minimum during the 1970s and maximum during the late 19th century. It appears to have been this episode of shoreline retreat during the 1970s that led residents to have the seawall subsequently constructed along the entire residential frontage.

Given the net sediment transport direction identified in Section 2.4, i.e. from offshore, around Kotiatia Point, and Rangiputa Beach to a sink some 2 km southward (* in Figure 4), this pattern of very slow shoreline advance and recession appears to tbe the result of migrating waves of sediment. However, lack of data points makes the model largely qualitative and of limited predictive capability other than to say processes have been identified that indicate the current erosion in Wilkinson Bay may switch to accretion sometime in the not too distant future.

As noted in the Results, as well as currently experiencing a natural erosive phase, the shoreline at each end of the seawall appears to also be affected by the structure interactioning with marine processes, i.e. seawall “end-effect erosion”. However, seawall end-effect erosion will only continue until a new hydraulic equilibrium is reached and this would be expected to have occurred at Wilkinson Beach, although the rubble and tree roots closer to the structure may prolong the response process.

A further influence on erosion are the effects of climate change. Changes to the wind/storm regime may alter the internal (estuary/basin) wave and current climate, and sea-level rise elevates the water level thereby increasing the erosive potential of storm waves. Present extreme water levels of tide and storm surge will occur more frequently. Erosion hazard models incorporate sea-level rise effects.

Historically, sea levels have been rising in Northland at 2.2 mm/yr = 0.11 m over the past 50 years and this will account for some erosion within the shoreline analysis and possibly also retard the natural sediment recovery process. Over the next 50 years, sea-level is predicted to rise a further 0.17 to 0.26 m thereby further affecting the expected recovery cycle at Wilkinson Beach. In addition, erosion facilitated by the higher water levels could reach 3.5 m although the response for inlets and enclosed water bodies is more complex than open coasts and models are not as well developed.

4 MANAGEMENT

4.1 INTRODUCTION

While this report has provided some evidence suggesting natural recovery may alleviate the present accessway threat along Wilkinson Beach, there are caveats. While the January 2018 extreme event, which caused erosion that led to the present investigation, appears to have a very low return period (recurrence likelihood) and should not (probabilistically) reoccur for decades, increased storm frequency predicted to occur under climate change could decrease this interval somewhat. Alternatively, while natural processes are expected to increase beach sediment supply via the ocean – Rangiputa sediment transport pathway, uncertainties exist in terms of timing and effectiveness under climate change. In conclusion, there is a case for considering management interventions and this section will describe some of the main options (listed in Table 2) along with indicative establishment cost ranges and expected operational duration.

4.2 MANAGEMENT OPTIONS

(i) Do nothing

The low probability of a recurrence of an erosive storm event coupled with the potential for future beach recovery, make the do-nothing approach somewhat viable. However, the uncertainties associated with this option and the associated risk tend to outweigh the cost advantage.

(ii) Widen access road

This would involve removal of a large Macrocarpa tree and excavation into the inland hillside which forms part of the headland. A retaining wall could be required to stabilize the cut if ground and vegetation disturbance was to be minimised. Horizontal excavation may enable the entire roadway to be situated on rock in which case no shoreline protection would be required and the coastal system could function naturally. However, if part of the access road remained on soft material (as at present) then some form of shoreline protection would still be necessary. This option would require a geotechnical investigation.

(iii) Beach Nourishment

Beach nourishment is a form of "soft protection" that involves importing and placing sand, ideally with similar characteristics as the native sand at the site, on the beach to compensate for an undersupply or to act as a sacrificial buffer against storm waves and currents. The required volume is approximately 10 cubic metres per linear metre. The entire 140 m long beach from the headland to the existing seawall would need to be nourished as movement of sand across the beach can be expected. The duration/effectiveness of the nourishment depends on the extent of the sand deficit and the subsequent storm sequence and the operation may need to be repeated accordingly, at least until natural beach recovery occurs. To increase the effectiveness of the nourishment, additional sand can be piled (pushed) up against the backing scarp and dune vegetation established. The vegetation increases resistance to wave and currents, facilitates dune grows by trapping wind-blow sand – thus increasing the buffer, and also assisting in recovery by trapping sand following a destructive event. A nourishment-based approach also offers environmental enhancement/landscaping opportunities

While beach nourishment provides shoreline/accessway protection while not negatively impacting on natural processes or recreational values, resource consents for abstraction and placement will still be required (see Appendix C).

<u>(iv) Hard Protection</u>

Shore protection has traditionally focused on engineering structures composed of rigid materials such as wood, concrete or rock - and hence their classification as “hard protection”. These structures typically consist either of groynes projecting into the adjacent water body which are designed to trap sediment thereby protecting the adjacent land, or shore-parallel structures designed to block/dissipate waves and current thereby directly protecting the land behind. Shore-parallel structures are envisaged as being the more appropriate for shore protection on Wilkinson Beach

Low angle structures are referred to as revetments, while higher angle structures as seawalls, although the term seawall is often applied to all shore-parallel structures.

While shore-parallel structures may be very effective at protecting land directly behind them (landward), in doing so interactions are introduced between waves, currents and sediment which include toe scour, profile steepening, reduced beach width, and delayed beach recovery following storms. The lower angle revetment induces less wave reflection compared with a higher angle seawall thereby reducing structure loading and supposedly causing less frontal scour and beach lowering.

Shore-parallel structures also induce additional lateral (alongshore) sediment responses referred to earlier as end-effect erosion which tapers in magnitude with increasing distance alongshore. Lateral effects are typically managed by tying the structure into an existing hard object (reef, rocky outcrop or structure) or increasing the structure length until the lateral erosion effects are of no consequence, i.e. the end effect erosion affects land of no or little value. When terminating in soft material, curving the ends landward (“returns”) prevents outflanking,

While a seawall across the entire Wilkinson Beach would eliminate end-effect erosion, environmental impacts would lower the fronting beach profile such that no high tide beach would exist. In addition, alongshore current may increase thereby threatening toe stability of the adjacent existing structure necessitating additional maintenance/strengthening.

The lifetime of such hard protection depends on the structure design, type of environment, construction materials and inspection/maintenance program and can typically vary up to from 20 to 30 years for timber 50 to 100 years for rock.

A succession of seawall types at a single site on the Raumati Coast are shown in Figure 14. The cantilevered wooden seawall in the foreground is a last remnant of a 1977 structure designed by coastal engineers, and in the distance is its replacement – a rock revetment that was also professionally designed. The iron protruding from the backfill are remnants of a cantilevered tram rail and brushwood wall established in the mid 1950s and designed by the Kapiti Borough Engineer; this structure appears to have been effective for some 10 years afterwhich maintenance ceased and it quickly became inoperative. These tram rails were later used as tie-backs for the 1977 structure. A more recent rock revetment protects the upper embankment against wave impact from overtopping.

Figure 14 *A succession of shore-parallel structures at Raumati on the southern Kapiti Coast . See text for description* *Photo CSL 2008*

A. Full length (140 m) hard protection options for Wilkinson Beach

i) A rock revetment using similar rock and geotextile filter fabric liner as used in the existing structure. Guidance manuals suggest a lesser frontal slope of 1.5 (horizontal):1 (vertical) for the available rock than the present structure (1:1). The revetment should be designed so the toe is not undermined by scour, and sufficiently high to reduce overtopping to a tolerable extent. This height could be up to 5 metres and approximately 8 cubic metres of rock per linear metre would be required for a 1 m thick layer at a 1.5:1 slope. Advantages of the rock revetment over other hard structures is progressive c.f. catastrophic, failure and its facilitation of maintenance and repair.

ii) A cantilevered pile structure (2/3 buried) consisting of vertical wooden or concrete piles tied together with horizontal rails backed by vertical lagging and tie-backs - such as the foreground seawall in Figure 14. While such vertical structures potentially have a higher failure rate that revetments, if designed, constructed and maintained correctly they can perform adequately in more sheltered environments such as Rangiputa. Added benefits include easily obtained materials, relatively straightforward construction and they provide for a more user-friendly environment. However, geotechnical investigation at the site would be required as penetration depth for pile driving at the western end, i.e. closer to the rocky headland may be limited by underlying rock, in which case stacked pre-caste (waste) concrete blocks, if available, may be a user-friendly and cost-effective alternative.

B. Partial Hard protection for Wilkinson Beach - restricted to the threatened accessway section (~40 m)

The reduced structure length will protect the threatened accessway while still leaving some natural beach. However, the shorter structure will still influence waves and currents and induce erosion on both the fronting beach and along the (adjacent) remaining natural beach which will retreat further landward and may outflank the structure unless adequate “returns” are included in the design and added to the existing revetment.

(v) Combined seawall and nourishment

In this option a seawall is constructed fronting a threatened section of accessway thereby preventing any further shoreline retreat, while end-effect erosion is managed by nourishment sand. Such “backstop” seawalls are typically used on beaches with fluctuating shorelines to prevent the erosive phase extending as far landward as it otherwise might (and destroy property/utilities etc) before the subsequent seaward fluctuation commences. During the accretional phase the structure may become buried. Dune planting can assist sand trapping in the accretion phase. This type of management option could suit the Wilkinson site where the shoreline may, in time, move seaward. It offers a cheaper option than full length seawall protection while preserving natural and recreational values.

4.3 INDICATIVE COSTS

Cost ranges are provided in Table 2. These estimates are based on generic designs from guidance documents (Herbst et al., 2003; PRIF, 2017) as well as experience-based comment from other engineers. They have been included to indicate option relativity and broad cost range. Design, supervision and consenting estimates are not included. When cost refinement is required, a qualified professional cognisant of design considerations, local materials and suppliers etc. should be engaged.

Table 2 *Indicative duration and costs[1] for protecting options for a low energy coastline such as Wilkinson Beach*

Option	Cost/unit	Total cost	Duration (yrs)[2]
Rock revetment (140 m)	$1000 to 1400/lin m	$140 to 196k	50+
Timber pile and lagging seawall (140 m)	$800 to 1200/lin m	$112 to 168k	25+
Nourishment including dune establishment (140 m)	$200 to 400/lin m	$28 to 56k	10+
Combined timber str(40 m) + nourishment/dune (140 m)	$800 to 1200/lin m $200 to 400/lin m	$60 to 104k	
Road widening earthworks[3]	$5 to $10,000 one off	Additional protection?	
Interim nourishment-pushups[4]	$40 to $80/lin m	$2k to $3k	yearly?

1 Excludes design (including specialist investigations such as geotechnical), supervision and consenting costs

2 Assumes regular inspection and maintenance

3 New access located on rock, otherwise additional protection required

4 Based on 50 linear meters, initial import of sand, with some recycling from the lower beach thereafter

4.4 ASSESSMENT CONSIDERATIONS

When the client and community assess these options, consideration should be given to, amongst other things, the following:

<u>Environmental impacts</u>: As described earlier, full width hard protection will eliminate the (high tide) beach and likely increase loadings on the existing seawall structure, while a short structure fronting just the threatened length of accessway will result in adjacent bank/shoreline (end-effect) erosion;

<u>Effective duration of the intervention</u>: Management options have finite lifespans which, to maximise, require ongoing monitoring and maintenance. Environmental change over time may require subsequent design modification and strengthening;

<u>Importance to the community</u>: For example, structural options will eliminate the high tide beach and it is existence of a high tide beach that to a large extent defines a recreational beach. Wilkinson Reserve has public vehicle access with public facilities. It is the only such beach that is sheltered in onshore winds;

Water access for boats: Parking of vehicle and trailers on the beach will not be possible with full protection (as the beach above high tide will disappear). This will place pressure in the Wilkinson Reserve parking spaces and also about the main boat access in the centre of Rangiputa. Future boat access is a matter that needs consideration. We noted that there appears to be no public vehicle access to the beach/reserve south of the seawall where suitable land for parking and a wide launching beach exist;

Cost: The costs in Table 2 are indicative and the ranges are included to assist in an initial screening of options;

Succession: A final solution may consist of option change over time to maximise use of the site while deferring high cost options as some uncertainties will reduce over time.

4.5 INTERIM PROTECTION

Arriving at a preferred option will require community consultation, geotechnical investigation, material sourcing, design, construction, securing funding and consenting. This process will take time and presents some risk that additional erosion may occur to the already vulnerable accessway before the final management solution is in place. Providing temporary protection against wayward storms, even though the chance of such an occurrence appear to be relatively low in the short-term, could be a means of managing that risk.

Sand "push-ups" have been successfully used elsewhere for this purpose with material being scraped off the inter-tidal beach and pushed into the scarp cavity (e.g. main photo in Figure 15). During extreme events it is this sacrificial sand that is eroded rather than the scarp retreating further (e.g. see inset Figure 15). If necessary, after the event, the sand can be artificially returned from the lower beach where it tends to deposit during storms. However, if the supply of sand on the fronting beach is considered too low for either initial scraping, or for restoration following an erosive event, then sand would need to be transported to the site. If sand were to be obtained from an active coastal site such as south of Rangiputa - as proposed for the full nourishment options, then consenting may well be required (see Appendix C). An alternative where consenting less restrictive, or even avoidable, would be to use a suitable terrestrial sand source and the scarp-cavity infilled from the access road so there would be no disturbance to the beach. At the present time, the required volume of sand to fill the (40 metre long) scarp cavity is approximately 2 cubic metres per linear metre.

5 SUMMARY

The vehicle accessway between Rangiputa Settlement and Puwheke Beach experienced severe erosion in January 2018 and the Department of Conservation requested CSL prepare a report that assesses this erosion and considers management options. The threatened accessway is at the western end of the Wilkinson Reserve which is fronted by a sandy beach (referred to as Wilkinson

Beach in this report) set between the existing 560 m long Rangiputa seawall and the rocky headland of Kotiatia Point at the mouth (throat) of Rangaunu Estuary.

The present study investigated the estuary and entrance dynamics and found that a major sediment transport pathway extends from the open coast/ebb delta well seaward of Puwheke Beach, around Kotiatia Point and along the Rangiputu shoreline to an intertidal depositional sink some 2 km to the south. Natural processes should therefore, periodically resupply Wilkinson Beach with sediment.

Figure 15 *Sand nourishment (push-up) filling the scarped back-shore at Oakura Beach, Taranaki, 2005. A sediment deficit was causing an erosive fluctuation and threatening the motor camp access road. Dune grass was subsequently planted on the push-up to trap wind-blown sand. This management action prevented a significant erosive episode in 2008 reaching the 2005 scarp line (inset).* *Photos CSL 2005*

A historical shoreline analysis (inferring spatial and temporal change in sediment availability) was carried out using data spanning 1897 to 2018 that was digitized from survey plans, vertical aerial photographs and satellite images. While the number of samples was somewhat sparse, the results are at least indicative and show shoreline advance and recession up to 10 m occurring at about 100 year intervals with smaller cross-shore oscillations at shorter time intervals. The fluctuations are not in phase alongshore and indicate waves of sediment migration. It was a deficit (between sediment slugs or waves) fronting the central/eastern seawall in the late 1970s that appears to have led to construction of the seawall in 1989. The shoreline analysis indicates that this seawall subsequently exacerbated an erosion phase that affected the adjacent natural Wilkinson Beach and the natural beach south of the structure. It is also noted that western Wilkinson Beach (fronting the threatened accessway), received less sediment than adjacent sites during the major influx between the 1940s and 1970s and may be more prone to erosion than the rest of Wilkinson Beach – possibly because of its proximity to the adjacent rocky headland.

While the investigation indicates the system has some capacity to recover from erosive episodes – and some such recovery could be expected in the not too distant future, there are other compounding factors such as the erosive effects of predicted climate change. In particular, modified wind, wave and current patterns can alter the erosion-deposition balance. In addition, present modelling suggests that predicted sea-level rise could claim another 3.5 m of Wilkinson shoreline over the next 50 years; however, there is high modelling uncertainty regarding SLR response within estuaries.

The following five management options have been described and broad cost ranges and estimated lifespan are also provided[1]:

- Do nothing and let natural processes control the shoreline. This no cost option carries the most risk. However, we note that the destructive January 2018 storm has, in the shorter term, a particularly low probability of recurrence;
- Widen the accessway. Natural beach processes can prevailing if the road is located entirely on rock ($10,000). However, additional protection work will be required if the accessway is still partially located on soft material;
- Beach nourishment. This could be coupled with sand dune development to increase effectiveness. This option is estimated at $28 to 56k. The beach would continue to exist and could be enhanced by landscaping. While nourishment is cheaper than the structural options, top ups must be carried out as required if the risk of road erosion is to remain tolerably low;
- Seawall construction using rock ($140 to 196k) or timber ($112 to 168k) stretching right across Wilkinson Beach from the existing seawall to the rocky headland (140 m). These options have the highest establishment costs and offer the highest level of asset protection, but also have a high environmental impact as Wilkinson beach would cease to exist;

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1. Cost ranges are provided in Table 2. These estimates are based on generic designs from guidance documents (Herbst et al., 2003; PRIF, 2017) as well as experience-based comment from other engineers. They have been included to indicate option relativity and broad cost range. Design, supervision and consenting estimates are not included. When cost refinement is required, a qualified professional cognisant of design considerations, local materials and suppliers etc. should be engaged.

- Seawall fronting the threatened accessway (40 m) coupled with full nourishment (140 m). Nourishment is used to mitigate the end effects from the short seawall. The establishment cost of $60 to 104k lies between the fully structural approach and the nourishment only approach. This option reduces the failure risk while maintaining environmental values, i.e. a functioning beach with potential landscaping potential would remain. It is also flexible in that if the system fails to deliver at some time in the future then the seawall can then be extended.

Because of the time required to consult, decide on a preferred option, design, acquire the necessary consents and effect/carry out the works, DOC may consider the risk of erosion occurring during the interim to be unacceptable. In this case temporary (soft) protection using sand “pushed up” into the scarp cavity may provide a suitable means of managing that risk while being relatively cheap and consenting relatively straightforward or even avoidable depending on the location of borrow sand.

Finally, a succession of options may be appropriate whereby a simple, environmentally friendly and more affordable nourishment-based approach could provide adequate protection for several years, or even for some decades, before more expensive hard protection with greater associated environmental impact becomes necessary.

6 RECOMMENDATIONS

- Assess the options set out in Section 4.2 having regards to, amongst other things, the following considerations (from Sections 4.3 and 4.4):

  - Environmental impacts;

  - Duration of the intervention;

  - Community values;

  -Water access for boats in the context of parking.

  -Cost.

- Screened option(s) be subject to further site investigation, design and costing;

- Design finalisation and acquire resource consents for preferred option;

- If desirable, undertake interim protection

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COASTAL SYSTEMS LTD

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Dr Roger Shand

Senior Coastal Scientist

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T&T, 2017b. Coastal flood hazard zones for selected Northland sites, 2017 Update. Prepared by Tonkin and Taylor Ltd for the Northland Regional Council. 39p plus appendices.

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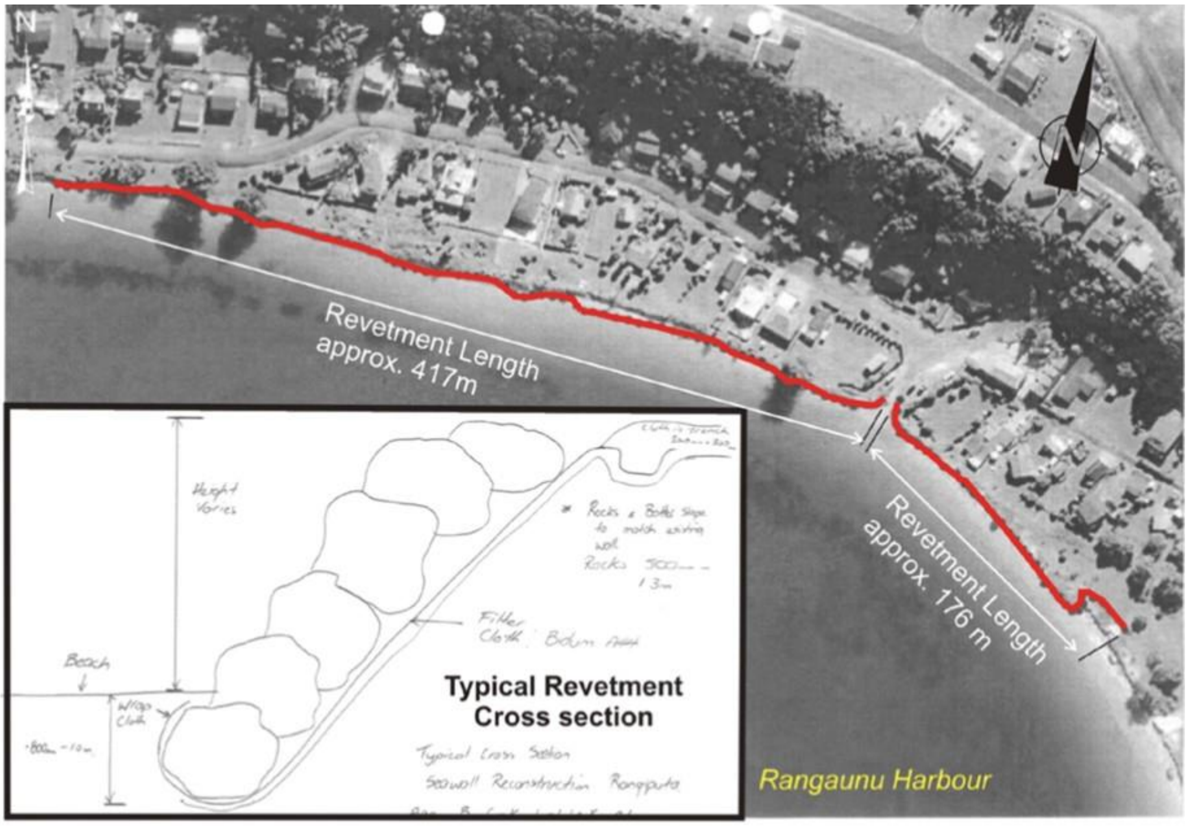
APPENDIX A Plan 4377 accompanying NRC resource consent 23858



NORTHLAND REGIONAL COUNCIL

RESOURCE CONSENT CON20092385801
for
Rangiputa Residents and Ratepayers Association
Rock Revetment
at Rangiputa, Rangaunu Harbour

Scale:	N.T.S.
Drawn:	JAG 03/11
App'd:	
Plan No.	4377

APPENDIX B Existing resource consent communications with NRC

From: Roger Shand [mailto:r.d.shand@gmail.com]
Sent: Tuesday, 2 October 2018 2:07 p.m.
To: Katie McGuire <katiemcguire@nrc.govt.nz>
Subject: Re: Rangiputa Seawall

Hi Katie
Does the current consent 23858 allow for construction of a 140 m seawall along the presently unprotected shoreline between the northern terminus of the existing seawall and the rocky headland?
Kind regards

Dr Roger D Shand
Coastal Systems Ltd

From: **Katie McGuire** <katiemcguire@nrc.govt.nz>
Date: Wed, Oct 3, 2018 at 4:02 PM
Subject: RE: Rangiputa Seawall
To: Roger Shand <r.d.shand@gmail.com>

Hi Roger,
The original application was for retrospective consent to authorise the existing wall and did not include any application to extend it beyond what was already there. Any extension to this structure would require a consent under Rule 31.3.4 (l) of the Regional Coastal Plan for Northland and Rule C.1.1.17 of the Proposed Regional Plan for Northland. Please let me know if you have any further questions.

Ngā mihi

Katie McGuire
Consents Officer - Generalist
Northland Regional Council » Te Kaunihera ā rohe o Te Taitokerau

APPENDIX C Nourishment resource consent communications with NRC

From: Roger Shand [mailto:r.d.shand@gmail.com]
Sent: Thursday, 1 November 2018 5:18 p.m.
To: Katie McGuire <katiemcguire@nrc.govt.nz>
Subject: Re: Rangiputa Seawall

Hi Katie
A possible source for nourishment sand to protect the erosion site would be from site a couple of kms south of Rangiputa (see aerial photo attached) and above MHWS. This is a natural deposition/sink area where sand from Rangiputa ends up. A very thin scraping is envisaged.

Could you please comment on resource consent requirements.
Kind regards

Dr Roger D Shand
Coastal Systems Ltd

From: **Katie McGuire** <katiemcguire@nrc.govt.nz>
Date: Mon, Nov 5, 2018 at 11:50 AM
Subject: RE: Rangiputa Seawall
To: Roger Shand <r.d.shand@gmail.com>

Hi Roger,
I had a quick look at your proposed source location and it appears a majority of this area is within an area of outstanding natural character (map attached identifying the area of ONC in orange). If you were to operate within the identified area you would need to demonstrate the works would have no adverse effects on the natural character values in this location. A natural character assessment by a landscape architect may by required. DOC should be able to provide advice on the ecological and habitat values of your chosen location.

Provided the works (including the use of heavy machinery) are above the line of mean high water springs, the activities would come under the rules for earthworks. If you are operating heavy machinery within the coastal marine area (for example if you are transporting sand up the beach from your source location to the area of deposition you would require a consent to disturb the foreshore also.

I have attached links to the relevant earthworks rules below. If your activities do not exceed the permitted activity thresholds for land disturbance in a riparian management zone you may not require consent. Please let me know if you have any further questions.

Regional Water and Soil Plan for Northland – Please see page 258 for Rule 34.1.3 (Permitted Activity) or 34.3.1 (Discretionary Activity) for earthworks in a riparian management zone
https://www.nrc.govt.nz/media/10761/consolidatedregionalwaterandsoilplanasat2014updated2016web.pdf

Proposed Regional Plan for Northland

Rule C.8.3.1 to Rule C.8.3.3 – includes thresholds for earthworks within the coastal hazard management area
http://consult-nrc.objective.com/portal/planning_and_policy/proposed_regional_plan/prp?pointId=s1475449427582#ID-1941896-POLICY-C.8.3.1

Ngā mihi

Katie McGuire
Consents Officer - Generalist
Northland Regional Council » Te Kaunihera ā rohe o Te Taitokerau