REPORT

Tonkin+Taylor

Waikawa Beach

Coastal Geomorphological Assessment and Management Options

Prepared for
Horizons Regional Council

Prepared by
Tonkin & Taylor Ltd

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Executive summary

The natural mobility of the Waikawa Inlet has led to the implementation of various management operations and structures since the mid-1900s. Shoreline erosion of some 25m over the past 10 years at the northern end of the inlet bay has resulted in Horizon Regional Council's (HRC) request for investigation into further management options to mitigate shoreline erosion.

Tonkin + Taylor was engaged by HRC to undertake the following scope of works, (refer T+T engagement letter dated 24 September 2018 for details):

- Site visit to develop an understanding of the site processes and current erosion extent along with the historical issues faced by the local residents through discussion with the local Ratepayers Association representatives (Stage 1),
- Undertake a coastal geomorphological assessment to understand the processes occurring and relationship to past development (Stage 2), and
- Undertake an options assessment to develop a range of solutions for managing the inlet to reduce erosion pressure on the shoreline (Stage 3).

The geomorphological assessment indicates that key contributing factors to the ongoing erosion south of the throat include decreased throat flushing efficiency resulting form:

- High angle groyne,
- Throat misalignment, and
- Ongoing accretion of the open coast shoreline north and south of the inlet

Six management options have been presented based on this assessment to mitigate erosion risk to the inlet shoreline:

1 Do nothing;

2 River training:

2a Minimum – on going manual cuttings,

2b Moderate – Removal of existing high-angle rock groyne and use rock to augment to 1991 alignment, or

2c Comprehensive – Removal of existing high-angle rock groyne and reconstruct as 1991 groyne alignment;

3 Bank protection:

3a Minimum – Dune construction along inlet shoreline,

3b Moderate – Additional groyne construction along inlet shoreline, or

3c Comprehensive – Rock protection along inlet shoreline

4 Combination of river training and bank protection

Advantages and disadvantages of each option were considered together with consenting implications and associated capital and annual costs (note these are an indicative cost for each concept to give an order of relative magnitude. This estimate should not be used for setting budgets at this early stage).

It is expected that options selection will be heavily dependent on available council funding and stakeholder preference. From an erosion and inlet management perspective, implementing a combination of the presented options is expected to be the most effective solution.

It is recommended that the following combination of options be considered in further detail:

1 Combination 1 (Limited scope):

Remove the current high-angle groyne to reduce its impediment on river flow, place rock along the 1991 alignment (optionally together with as much additional rock as budget allows). Undertake initial and ongoing channel cutting as required to prevent channel alignment running along the southern shoreline, place cutting material along shoreline and vegetate the dune line.

Potential to improve current situation but ongoing erosion and damage still likely to occur at times

Likely capital cost: $150K (+ additional rock as budget allows), likely annual cost $20-$40K

2 Combination 2 (Medium scope):

As per 1 above, along with extension and upgrade of the groyne to 1991 alignment and length. Dune re-establishment along the inlet shoreline to increase buffer from further storm events. Sand could be sourced from the northern side of the inlet.

Likely to improve current situation but ongoing erosion and damage could still potentially occur at times

Likely capital cost: $700-$900K; likely annual cost: $20-$40k

3 Combination 3 (Extensive scope):

As per 1 and 2 above along with installation of rock revetment along current shoreline to protect from further erosion.

Very likely to reduce ongoing erosion of land behind revetment. May be difficult to consent.

Likely Capital cost: $1M+

1 Introduction

Waikawa Beach is located on the west coast of the lower North Island, approximately 12km south west of Levin (refer Figure 1) within the South Taranaki Bight. The Waikawa inlet is located at the interface of the Waikawa River and the coastline where excess beach sediment causes the river to become partially blocked, impounding flow and causing the outlet channel to meander alongshore.

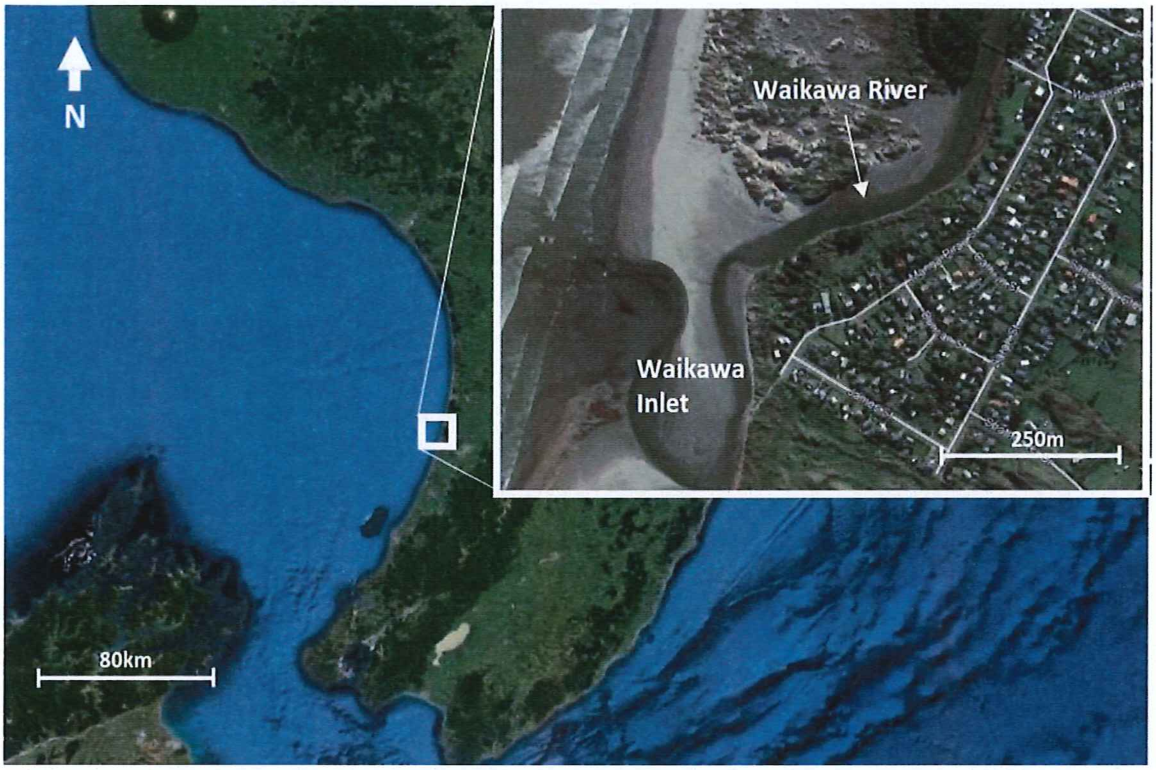


Figure 1: Waikawa Beach location map (aerial source: Google Earth)

The inlet is mobile, typical of outlets through the beach system. This mobility has historically caused concern and various interventions to control outlet alignment have been undertaken including manual excavator 'cutting' and groyne installations. Recently, erosion of the landward channel edge following ex-tropical cyclone Gita has cut off vehicle access to the beach from Manga-Pirau Street and the edge is now approaching adjacent private property, removing large parts of reserve land at this location (refer Figure 2 and Figure 3).

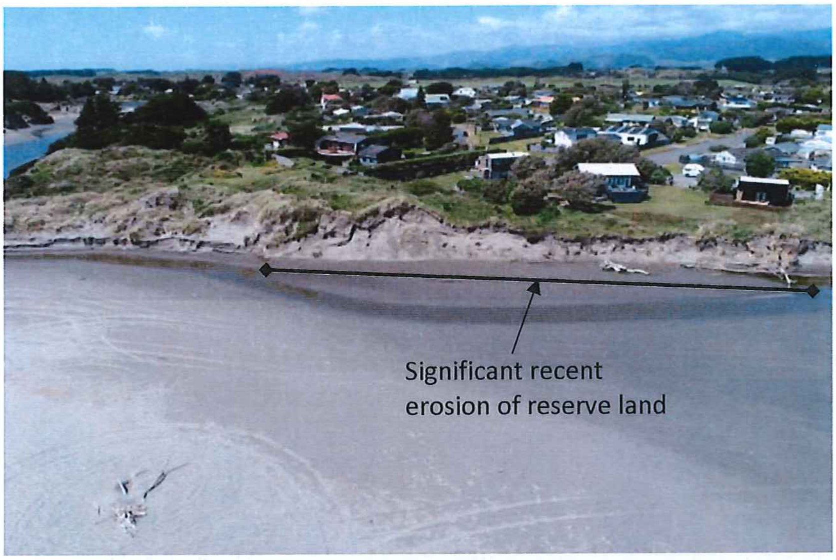


Figure 2: Dune erosion along shoreline at the back of the Waikawa Inlet

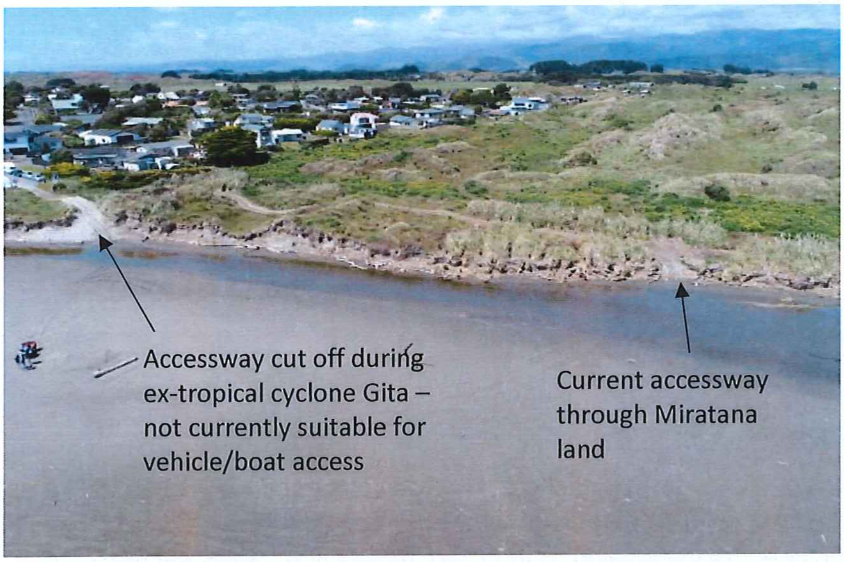


Figure 3: Current beach accessways at the southern end of Manga-Pirau Street

Horizons Regional Council (HRC) have engaged Tonkin & Taylor Ltd (T+T) to undertake the following scope of works:

- Site visit to develop an understanding of the site processes and current erosion extent along with the historical issues faced by the local residents through discussion with the local Ratepayers Association representatives (Stage 1),
- Undertake a coastal geomorphological assessment to understand the processes occurring and relationship to past development (Stage 2), and
- Undertake an options assessment to develop a range of solutions for managing the inlet to reduce erosion pressure on the shoreline (Stage 3).

This report, in accordance with our engagement letter dated 24 September 2018, presents the results of these assessments.

2 Background

2.1 Waikawa Beach residents meeting 18 August 2018

Key issues raised in the Waikawa Beach residents minutes of a meeting 18 Aug 2018 with councillors and officers were:

4 Groyne control not functioning/fit for purpose.

5 Erosion occurring along west side of Manga Pirau Street that is affecting four properties presently.

6 Access to beach, other than at the present Manga Pirau accessway which is across Miratana land (i.e. access to "southern" beach. At present vehicles also drive around the back of the inlet at lower tides).

2.2 Site meeting 2 November 2018

A summary of the meeting between T+T, local RA and Horowhenua District Council (HDC) is as follows:

Attendees

Alistair Holden – 16 year resident, produced a report for proposed erosion protection works in May 2018

Miraz Jordan – 3 year resident – writes local newsletter

Kevin Burns – 43 years on and off – Residents association secretary

John Hewitson – 20 year resident – Chair of Residents association

Shirley Cameron – 2.5 year resident – property owner of meeting location

Arthur Nelson – Horowhenua District Council – Property and Parks Manager

Dr Roger Shand – Coastal Systems – Coastal geomorphologist

Michael Paine – Tonkin + Taylor – Coastal Engineer

Information/documents discussed

- 'Bitter waters' – A book published in 1999 that covers the history of the town and river (including various river/dune configurations over the years). Book is sold out but John's copy was given to Roger for use in his assessment. Authors are Debbie and Laraine Shepherd. John will send through contact details to Roger to contact regarding permission to make a copy of the book.
- 1996 oblique aerial photo – two key features of note: a) groyne at river outlet is longer than current groyne, b) remnants of rock placed at the end of the current beach access to form a boat ramp (appears groyne-like in the aerial).
- Alistair produced options report for erosion protection in May 2018 – copy given to T+T for information.
- HRC profile monitoring programme (resource consent requirement but residents implied this was not carried out) – T+T will request available information from HRC.
- Arthur has a report on dune restoration/planting options historically investigated – includes aerial imagery showing dune alignment in 2010 before the latest groyne work. Arthur will send a copy to T+T.

Key issues raised by residents

- Approximately 20m dune erosion (setback) in front of 55-63 Manga-Pirau Street in the past 5-6 years (distance and date to be confirmed as part of Roger's work). This land was mostly reserve land but erosion has now begun along the seaward edge of property number 63 Manga Pirau Street (boundary peg in river). Residents voiced concern for these properties in future storm events.
- Beach access erosion making it difficult to drive on to beach.

Resident's opinions on causes/contributors to erosion

- High catchment rainfall combined with high tide leads to highest erosion rates with the river flow (when the alignment follows seaward toe of the dune) being the main contributor.
- During high river levels, water level overtops groyne – eddy effects along the southern side of the groyne contribute to erosion.
- The July 2016 storm event resulted in large amount of erosion.
- High tide now reaches bank along properties 55-63 Manga-Pirau Street as dunes are gone, increasing risk of erosion to properties from wave attack.
- Siltation of the river has led to higher river levels at outlet this causes river blockage and increased flood risk upstream, slower flow and poor water quality. Windblown sand bank build up at outlet contributes to this. Shirley said dredging river would lower river levels and reduce erosion risk.

Mitigation measures/works to date

- Groyne construction at river outlet. Historically this was longer and straighter than the current configuration, works undertaken on the groyne in 2010 included partial removal, digging toe in ~5m. John Foxell undertook this work.
- The most recent river cuts were undertaken by council in 2009 and July 2018. Excavator cut the channel in a straight line from outlet to ocean. 'Within weeks', river alignment changed.

2.3 Information base and approach

Searching early council files was beyond the scope of the present study as they are currently archived in various places. The morphological history was compiled from official survey plans and aerial/satellite images, the well-researched and published local history of Shepherd and Shepherd (1999), along with some more recent council reports and correspondences.

Unmanned Aerial Vehicle (UAV) survey and oblique imagery of the area around the Waikawa Inlet taken during the site visit on 2 November 2018.

Morphological process modelling which enables causal relationships to de defined between morphological behaviour and fluvial, marine and atmospheric drivers was beyond the scope of this study. Rather, morphological characteristics (channel and shoreline location) were measured over time as depicted in available survey plans, aerial and satellite photographs and compared with differing structures and morphological configurations to identify correlations or associations. While we speculate on possible causal relationships, this "black box" approach is considered suitable to identify management options.

3 Geomorphological assessment

3.1 Physical setting

The coastline at Waikawa has a shore-parallel orientation of 20 degrees. The present inlet (Figure 4) is some 700 m long by 300 m wide and has a vegetated perimeter of 1500 m. The inlet is backed by a sand plain and ground levels in the adjacent settlement are generally between 2 and 5 m above MSL (2005 LiDAR in T&T, 2013).

Sand dunes surround the inlet margin with those at either end slowly encroaching into the inlet. A well-developed foredune about 8 m high backs the open beach. The predominant wind is WNW, frequently reaches 19 to 28 km/hr and can increase to almost 55 km/hr during the most extreme conditions; this wind regime results in particularly high wind-drift potential using Freyberger's (1979) classification.

The open coast has a 200 m wide sandy dissipative beach with an average slope of 0.018 and the shoreline is undergoing long-term progradation at approximately 1.5 m/yr (T&T, 2013). At Otaki Beach, some 5 km to the south, the nearshore and off-shore slopes are 0.014 and 0.008 respectively, and the mean significant wave height is 0.93 m, the 1% exceedance wave height is 3.44 m and the peak wave period is 10 s (MetOcean, 2013).

The throat (where the inlet shoreline meets the river) is fixed at the northern end of the inlet. At the time of the site visit on 2 November (Figure 4), the low tide channel width upstream of the throat averaged about 25 m, reducing to about 20 m as it meandered across the inlet to enter the sea some 200 m to the south. Small "cut-off" lakes, remnants of an earlier channel (examples in Figure 4) were evident at the southern end of the inlet against the inlet-margin sand dune. Much of the dune along the landward side of the inlet (the inlet bay region is indicated by a dashed line in Figure 4) was severely scarped. This inlet morphology is evidence of a particularly dynamic system.

The Waikawa River has a mean flow of 50 m3/s and 1% AEP of 93 m3/s (Blackwood, 2012). The 400 meters of southern riverbank immediately upstream of the throat is rock lined and constrains the approach channel which enters the inlet with a southerly offset of some 50 degrees to the shoreline. A 30 m long rock entrance groyne set at 60 degrees to the current extends into the flow from the eastern bank at the throat (solid line next to the throat in Figure 5). There is minimal evidence of an earlier 120 m long rock entrance groyne that was parallel to the flow and of a shorter 45 m long rock groyne centrally located within the inlet bay (dotted lines in Figure 5).

Artificially excavating a channel directly between the throat and the sea, thus cutting out southward inlet meanders (a practice referred to as "mouth cutting"), is carried out from time to time to reduce both backwater flooding and bank (dune) erosion along the inlet bay. The most recent cut was made in July 2018. While the previously diverted (main) channel has migrated southward over the interceding months – likely in response to net longshore current, some evidence of this cut could still be seen at the time of the site visit with the cut-off channel remnants against the bank along the inlet bay.

Dredging at, and immediately upstream of, the throat was mentioned by residents at the November 2018 site meeting, and 2005 aerial imagery does indicate such activity (discussed further in Section 3.3). Shallowing in this area was evident at the time of the site visit (Figure 4).

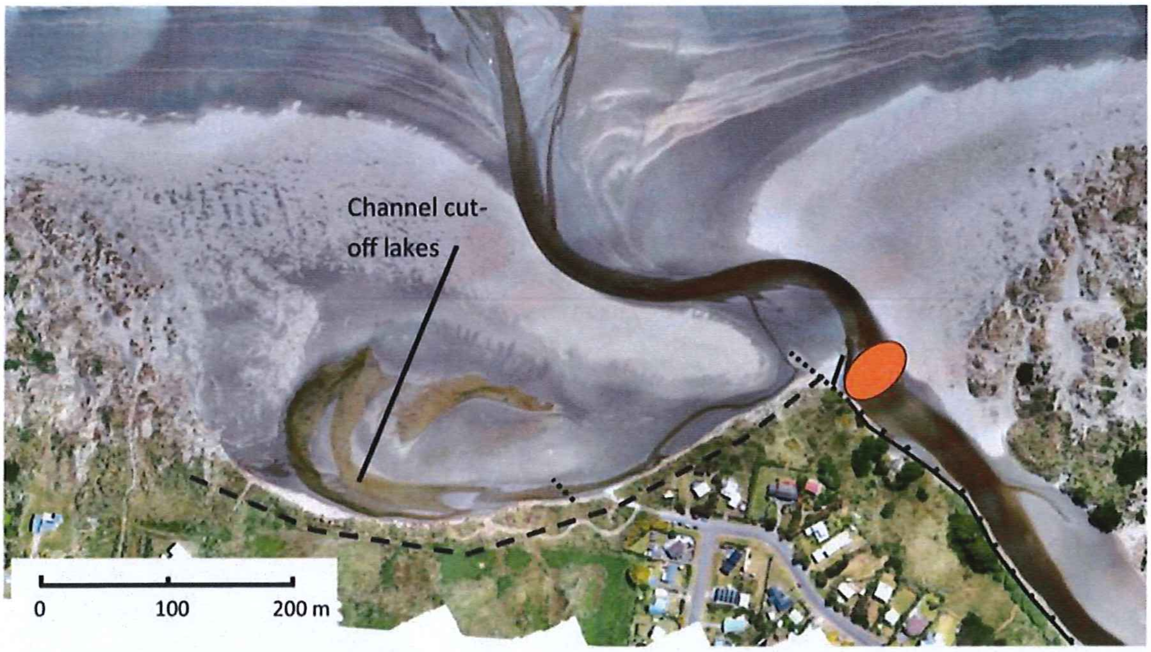


Figure 4: Waikawa inlet at the time of the site visit on 2nd November 2018. Bold black line is current rock groyne, dashed black lines are remnants of the 1991 rock groynes, raked black line is rock-lined river bank, and orange oval is throat as defined in this study. "Cut-off" lake examples are marked, and the "inlet bay" is located by the dashed black line.

3.2 Inlet behaviour

3.2.1 Data base

As noted in the introductory section, inlet behaviour (this section) and inlet processes (Section 3.3) were based on analysis of survey plans, aerial photographs and satellite images. These samples are detailed in Appendix A.

3.2.2 Ohau River connection

Shepherd and Shepherd (1999) p19 note that "In the 1850s the Ohau and Waikawa Rivers still merged half a mile from the coast and had a common mount". The earliest survey plan (1872) shows the Waikawa flowing into the sea via the Ohau River (see Appendix D) with their confluence being some 2 km north of the present Waikawa Inlet.

The 1878 survey plan (Appendix D) shows the Waikawa now having its own separate mouth, this being some 1.3 km north of the present inlet. This plan marks a 500 to 600 m wide "sand bank" (notation next to point E) which indicates the 1872 spit must have been a low and possibly intertidal feature which would facilitate frequent channel change. The Shepherd and Shepherd (1999) and 1872 and 1878 survey plan information suggests that this section of coast had recently received a very large input of sediment; with later data showing that no such input has occurred since that time. Such substantial episodic inputs can occur for a variety of reasons including volcanic eruptions, earthquakes or periods of intense rainfall and storms.

3.2.3 Southward migration

Successive survey plans and vertical aerial photographs show the Waikawa mouth migrating southward – constrained behind the emerging sand bar. The 1942 aerial photo shows the mouth some 1.5 km south of the present inlet throat (see Appendix E). The 1942 shoreline is marked purple in Figure 5. The river was diverted to the sea in 1945 (mapped on p36 Shepherd and Shepherd, 1999) some 250 m south of the pedestrian bridge/present car park on Waikawa Road (Figure 6). It is from this point that the present course heads toward the present throat.

3.2.4 Northward meander

However, the 1957 to 1972 aerial photos show the channel beyond the diversion point meandering northward (for example see the 1957 aerial in Appendix E and the 1968 aerial photo in Figure 5) for some 500 to 700 m before turning seaward. Shepherd and Shepherd (1999) also note that beginning in the 1970s rocks were dumped along the bank immediately east of the car park as erosion was getting to close houses on Manga Pirau Street.

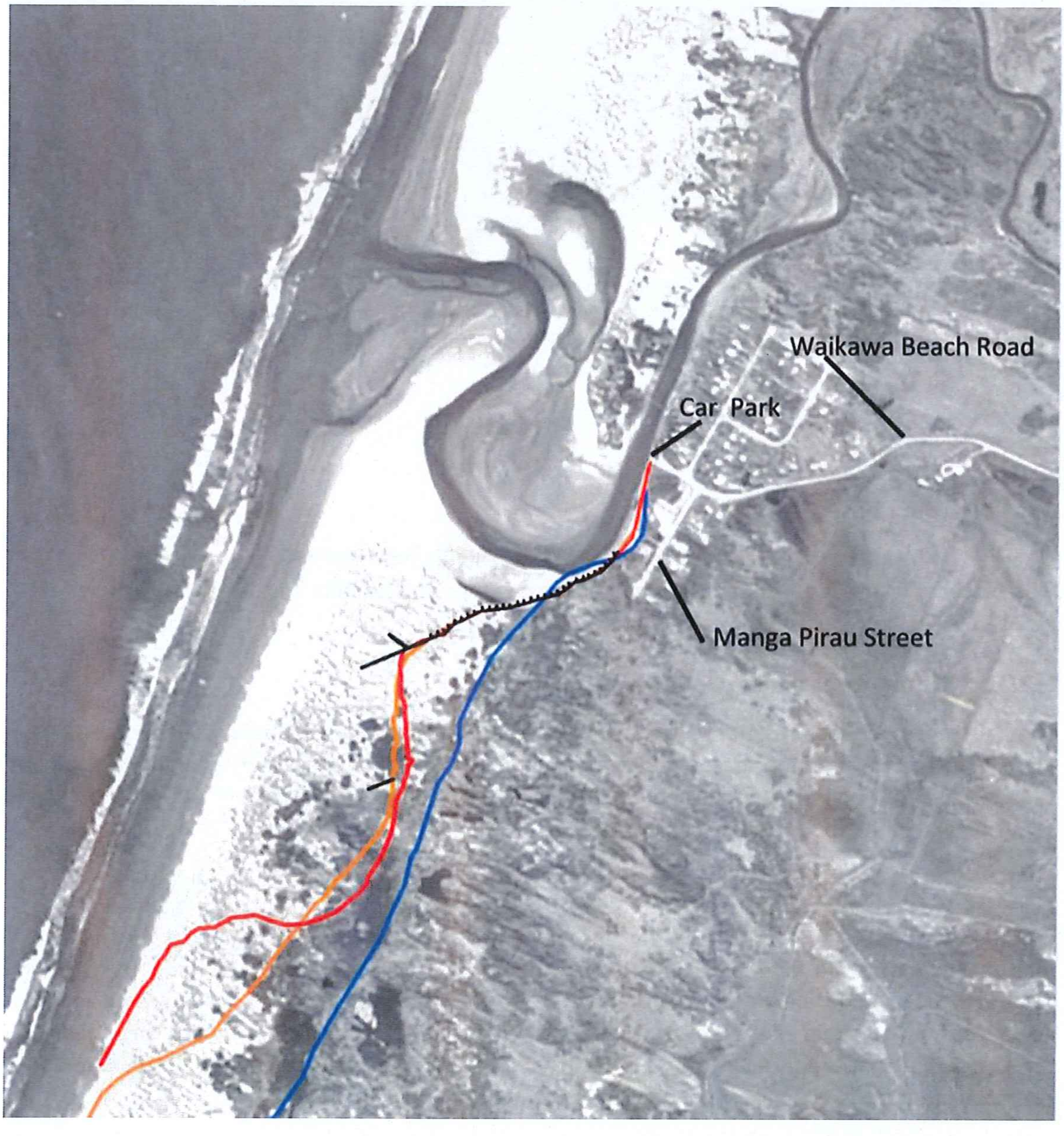


Figure 5: Typical post 1945-diversion response morphology on the 1968 aerial photo with the river meandering northward. The 1942 shoreline is marked purple, 1993 by orange and current 2018 by red. Structures are marked black as in Figure 4.

3.2.5 Southerly inlet approach

Analysis of historic aerial photographs show that the current southerly approach was artificially cut between 1972 and 1978 with rock lining fixing the southern bank in its present location (Figure 6).

The 1978 aerial photo shows construction of roading for the eastern subdivision (taking the settlement to its present eastern boundary). Ensuring a stable channel/mouth would have been desirable for the subdivision and this may well have been a consenting requirement.

During the 1980s, the foredune along the back of the inlet remained in a natural state and appears to have been subject to episodes of erosion. Mouth cutting was carried out when the southward meander (development of the north spit) became excessive. We have archive records of such a cut being carried out in May 1986. Obstructed inlets can naturally open under flood conditions. However, the only evidence we have seen of this occurring at the Waikawa is in 1989 (Central Districts Catchment Board letter from C. L. Darling, 3 June, 1989).

3.2.6 Rock groynes

"In 1991 the eastern rock wall was extended as a further measure against erosion" (Shepherd and Shepherd, 1999, p46). This appears to refer to the construction of a 120 m long rock groyne at the mouth with the same orientation as the adjacent approach channel (Figure 6). This orientation was presumably to reduce channel deflection to the south and consequential meandering against the back of the inlet which was in the vicinity of the new subdivision. The 1993 shoreline and groyne locations are marked in Figure 5.

Inspection of Figure 4 and Figure 6 show that while this groyne is an in-line continuation of the adjacent southern rock-lined riverbank, there is a misalignment about midway along the approach channel which could drive the flow line to the northern side of the throat; this is considered in greater detail in Section 3.3.3.

While the groyne may have reduced channel deflection to the south (the objective), mouth cutting was still occasionally carried out. The archive materials we have been provided with show the following cuts were carried between the early 1990s and 2010: 1994, 2000, 2004 and 2009. The 2004 cut may have been accompanied with possible dredging in the throat area and this is considered further in Section 3.3.3.

By 2000, the 120 m long throat (entrance or mouth) groyne had reduced in length by 25 m and the inlet bay shoreline had moved seaward some 40 m. By 2012 the height of remaining structure appears to have significantly reduced and width broadened (Blackwood 2012 photos).

Another rock groyne was constructed mid-way along the inlet bay in the early 1990s (Figure 7). This structure was some 45 m long with a downflow offset which gave it a similar orientation as the longer throat or mouth groyne. Presumably this structure was to provide additional shoreline/dune protection along the back of the inlet by deflecting the channel further seaward. This groyne had reduced in length some 25 m by 2000 and was often covered by sand thereafter. Its remnants are still evidence at times.

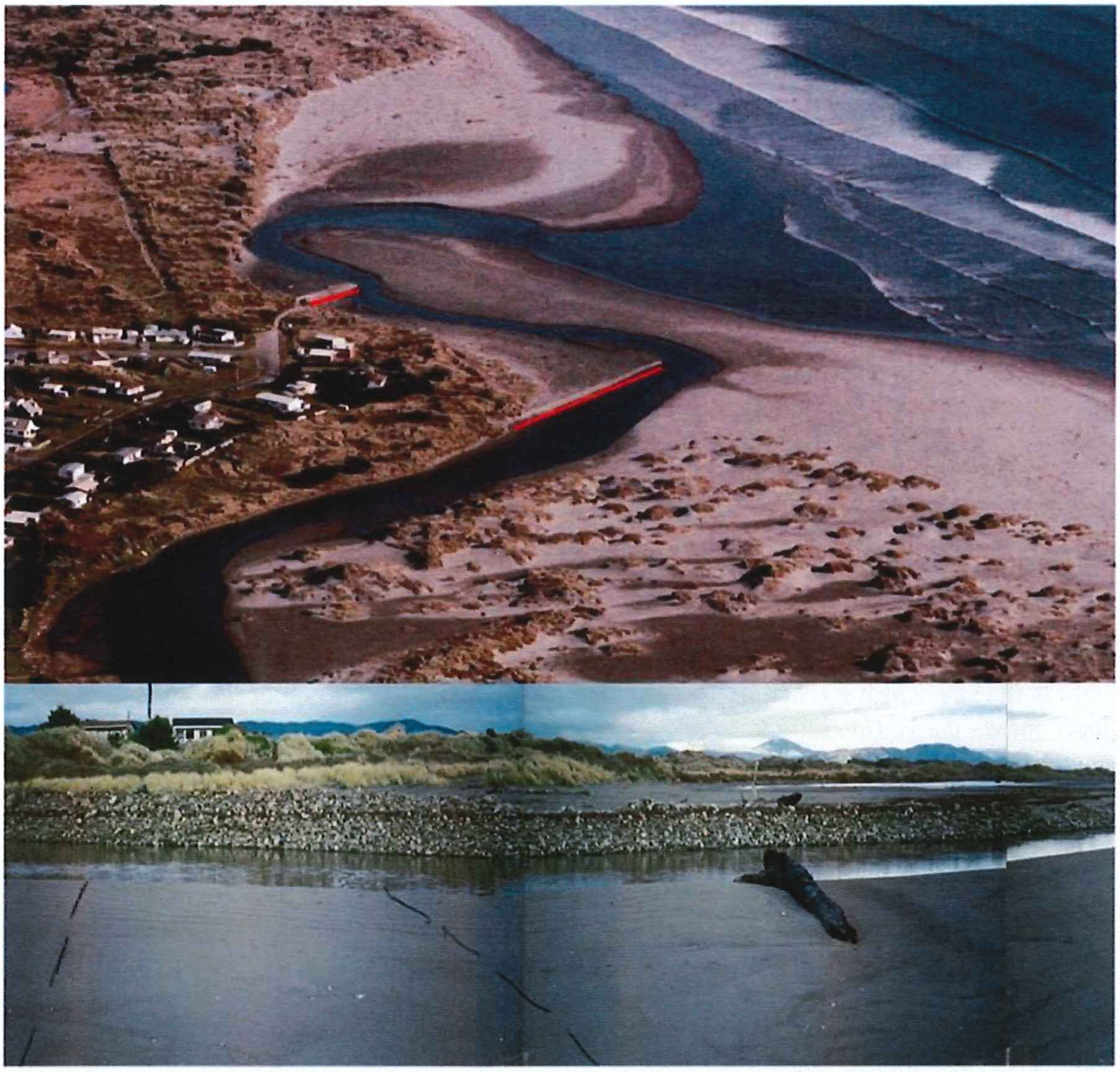


Figure 6: Upper photo (1996) shows the rock groynes (underlined red) that were constructed in 1991. Note the down-stream accretion behind each groyne. Lower photo shows the throat groyne in July 1994. Note the new dune development on accreting land on the far side of the groyne. (Source: kindly provided by Mr John Hewitson, Waikawa Beach).

3.2.7 Present high-angle groyne

The HRC internal report by engineer Mr Peter Blackwood (2012) quotes from a 2009 report by consultant engineer Mr John Philpott: "The existing (southern mouth) groyne does not provide an effective training of the flow towards the sea. Therefore, realignment of this groyne at a right angle to the stream flow is considered necessary and would increase the chances of the stream remaining on the cut alignment".

This groyne was designed to be at 60 degrees to the current and attached to the existing groyne at its intersection with the then dune line along the back of the inlet (Figure 8 lower photo). The high-angle groyne was designed to protrude into the throat channel some 25 m (as-built 30 m). A consent for the high-angle groyne was granted in 2010 and construction was carried out in April 2012. At this time, HRC photos show there was no threat to the central and northern inlet bay dune line (for example see Figure 7 upper photo).

Mouth cuts were subsequently carried out in July 2013 (Figure 8 left) and July 2018 (Figure 8right), each in response to the channel being in direct (or near) contact with the dune along the inlet bay. Note that the 2018 photo (Figure 8 right) shows the original groyne remnants still able to trap sediment on their downstream side.

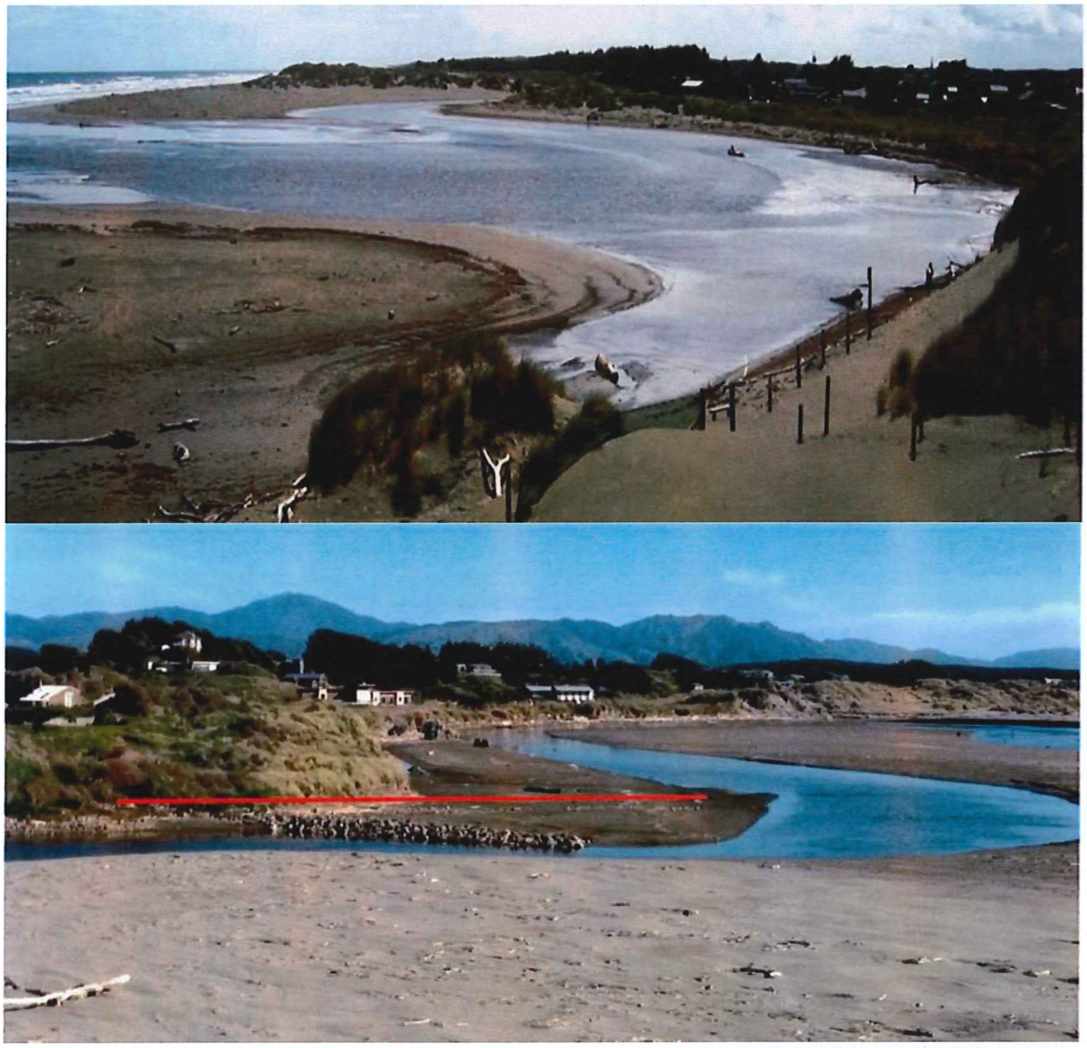


Figure 7: Upper photo (April 2012) shows the Waikawa Inlet at the time of the high-angle groyne construction. Lower photo shows the present high-angle groyne photographed in October 2016. Remnants of the original entrance groyne are just visible above the surface (below the red line). *(Source: CSL)*

Figure 8: The most recent mouth cuts. Left photo taken on 10 July 2013 (source HRC), and right photo taken on 31 July 2018 (source HDC) shortly after the mouth cutting operation. Note in both cases the pre-diversion channel was against/close to the dune line at the back of the inlet. Note we were unable to source the original HDC photo so included the one above with various annotations unrelated to this study.

3.3 Inlet processes

3.3.1 Channel analysis

Channel locations since the inlet approach was fixed by rock lining in the 1970s, were abstracted from historic aerial photographs and satellite images (Appendix A) and grouped into periods corresponding to differing control structures. The four groupings comprise the following:

- 1978 to 1990 eastern bank rock protection (number of samples (n=3);
- 1991 to 1999 full length inline rock groyne off southern end mouth and mid-bay rock groyne (n=4);
- 2000 to 2012 period of shortened rock groynes (n=8), and
- 2012 to 2018 high-angle groyne at mouth (n=8). Earlier groyne remnants still evident at times.

Sampling may not be fully representative of the configurations for all structure groups, so the results are considered to be indicative.

The channel envelopes for the different groupings are depicted in Figure 9 and suggest the following associations:

1. The longshore (southerly) extent of the channel maximised during the initial period with no groyne (1978 to 1990) and also during the shortened groyne period (2000 to 2012), while it reduced in extent during the long-groyne period (1991 to 1999) and minimised during the present period of the high angel groyne (2012 to 2018);
2. Along the northern inlet bay, there has been a systematic landward shift in channel location since construction of the long groyne in 1991;
3. Groyne length seems to correlate with downstream sediment entrapment/protection implying channel flow is effective, i.e. the structures are behaving as groynes subjected to alongshore flow. Photos in Figure 6, Figure 7 and Figure 8 demonstrate that the early groyne remnants still have some influence on adjacent downstream sedimentation despite being in a very degraded condition, and
4. The northern channel excursions are likely influenced by mouth cutting.

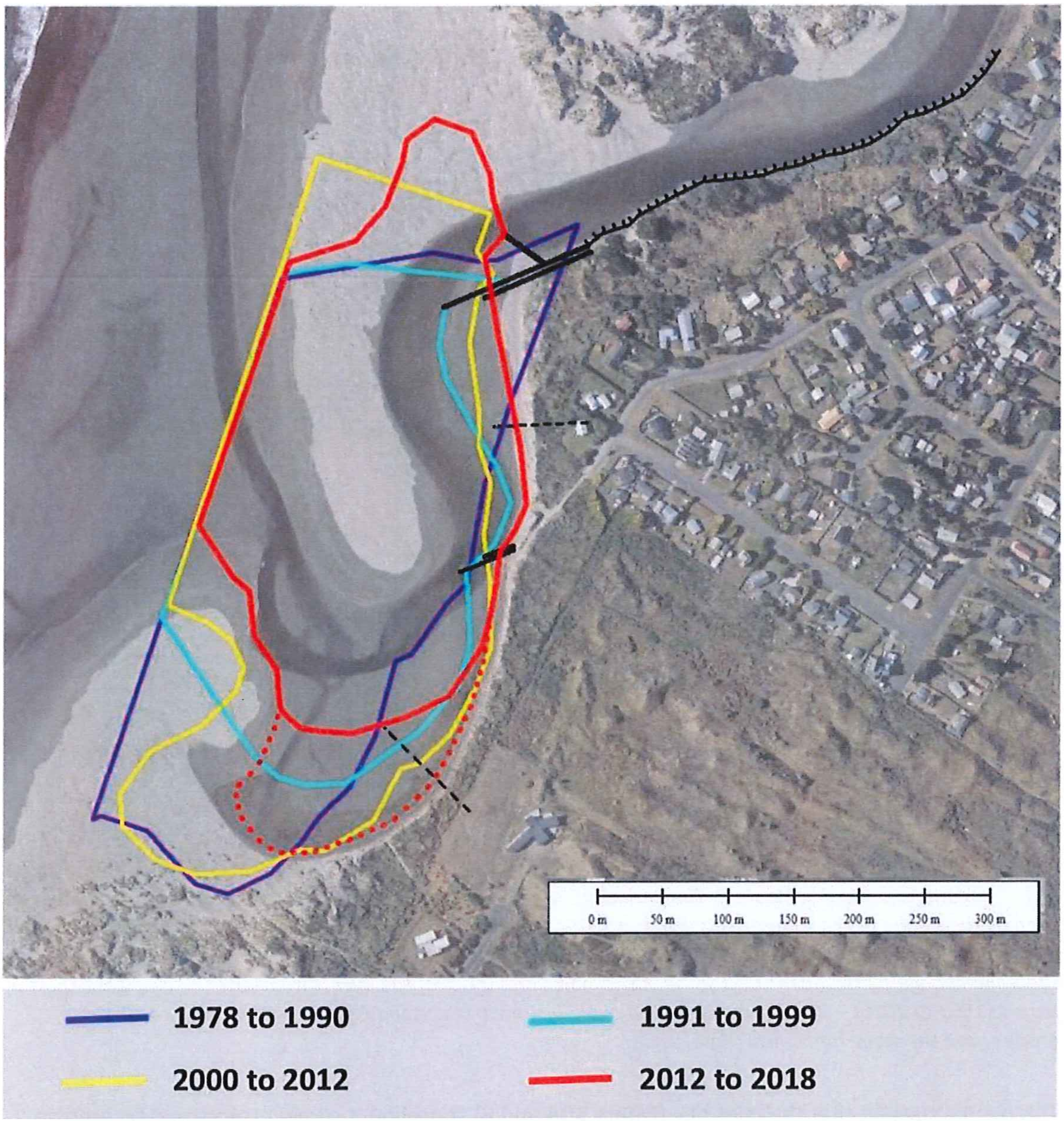


Figure 9: Envelopes of main channel location for colour-coded time periods—these corresponding to differing structural controls. Raked black line = rock protected river bank (from pre- 1978). Paired solid black lines are rock groynes, original long groyne from 1991 and shorter remnants from 2000. Single black line is 2013 high angle groyne. The dotted red line denotes a flooded secondary (c.f. main) channel during the final time period rather than a main channel. Dashed black lines are transects (upper North and lower South) used to sample shoreline change along the inlet bay (see Figures 11 A and B)

3.3.2 Shoreline analysis

The vegetation edge, an indicator typically used to define an inlet bank or foredune toe, have been plotted for a northern and southern transect within the inlet bay – see Figure 9 for locations. The same grouping and time periods (spanning 1978 to 2018) were used for the channel analysis but a lesser number of data points are required for vegetation-based shoreline analysis as this parameter changes more slowly than channel location. In addition, shoreline analysis was carried out for the open coast with transects located approximately 900 m in either direction alongshore from the throat - far enough to avoid contamination by historical inlet dynamics. Historical inlet effects also resulted in use of a shortened time span (1993 to 2016) for the open coast data set.

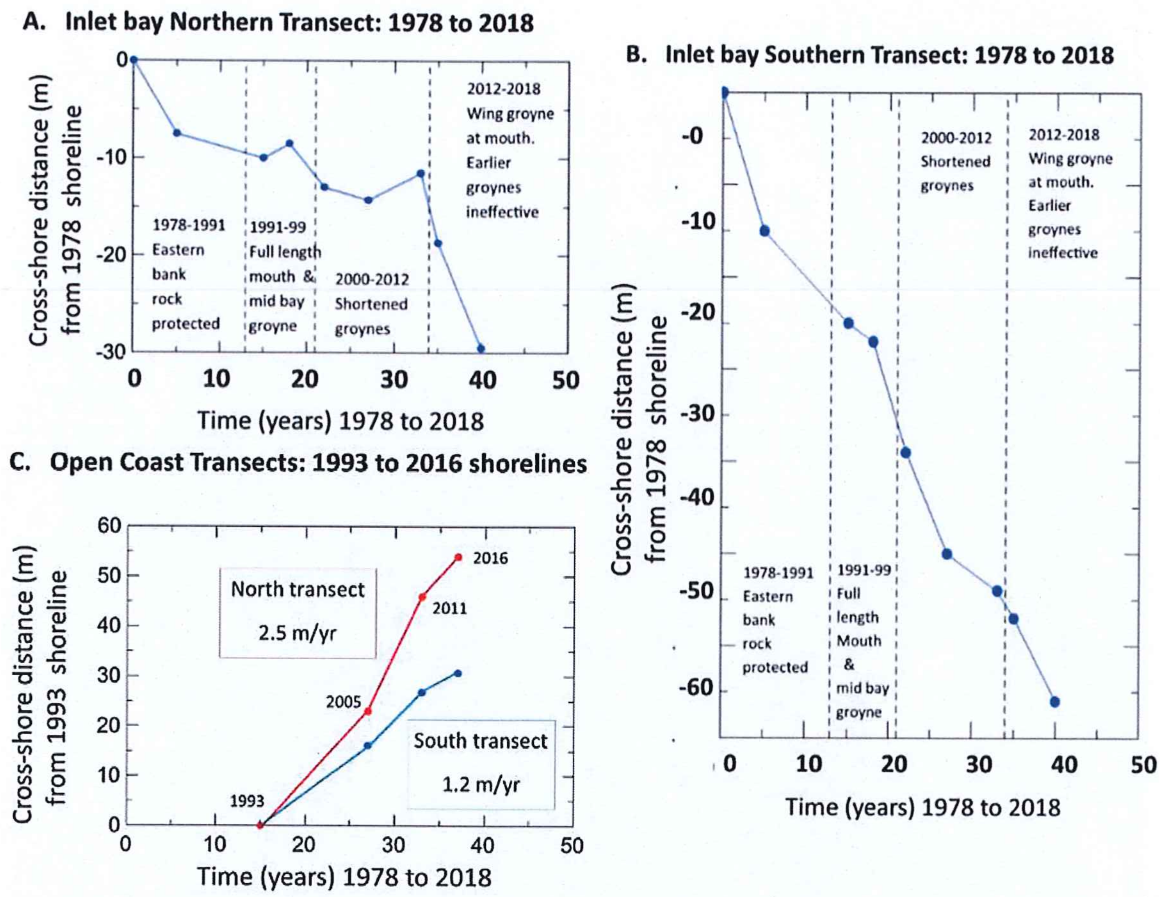


Figure 10: Shoreline change (based on vegetation-front) for the inlet transects (north Figure A and south Figure B) with locations marked in Figure 9. The period (1978 to 2018) covers the time since the inlet approach was fixed by rock lining of the southern bank in the 1970s. The periods of differing structural control are marked and annotated. Note graphs A and B have the same vertical scale to assist comparison. Figure C depicts shoreline-change on the open coast some 900 m north and south of the inlet (throat) over a somewhat shorter period (1993 to 2016) – this being required to avoid historical inlet behavioural response effects. All three graphs have the same horizontal (time) scale.

The results suggest that the inlet bay (Figure 10A and B) shoreline is subject to systematic erosion with the southern transect having undergone about twice the amount of retreat as the northern transect shoreline (60 m c.f. 30 m) during the 40 year sampling period. In addition, the northern transect data indicates an increased erosion rate during the final period under the high-angle groyne, while the southern transect shows more uniform retreat throughout the sampling period.

The channel and shoreline results suggest the channel proximity to the shoreline does influences erosion which could be by direct tractive force of the river flow or by river flow removing sediment eroded by storm wave processes during periods of inlet inundation.

The more recent erosion at the southern transect – during the period when the main channel has been in more northern locations, may be associated with ongoing slope adjustment processes following scarping during earlier episodes of toe erosion, or to the persistence of channel remnants (cut-off lakes in Figure 4) facilitating flows into this area during times of flooding (discussed further below).

The open coast graph (Figure 10C) shows the shoreline is advancing on each side of the inlet with the northern rate of 2.5 m/yr being almost double the southern rate of 1.4 m/yr. Their averaged rate of ~2 m/yr is greater than the long-term rate of 1.5 m/yr reported in T+T 2013, suggesting the accretional trend is increasing. This could be related to inlet configuration changes during the late 1940s to early 1970s when the inlet was located to the north, or to inlet changes associated with the Ohau River further north. None-the-less, while shoreline advance is likely to persist into the foreseeable future, general shoreline response models related to predicted sea-level rise infer that the net rate may slow somewhat.

3.3.3 Throat constrictions

As noted in Section 3.2.6, there is a misalignment about midway along the approach channel which could drive the flow line toward the northern side of the throat. The misalignment appears to widen the throat channel and this could be expected to reduce flow concentration and thus jetting momentum under high flows which in turn would decrease scour potential across the fronting sandbank – a situation made more critical by the prograding (seaward trending) coast which increases the volume of this feature. Widening of the throat could alse facilitate sedimentation within, and upstream of, the throat. The reduction in jetting and increase in sedimentation may also enable the channel to more easily meander toward the back of the inlet once past the groyne terminus. The current high-angle groyne may further exacerbate these situations as the flow is forced into an area of wind-blown sand accumulation (following paragraph), where it piles-up and has to redirect southward.

There is high potential for wind-blown sand to encroach upon the throat area from the northern beach as indicated by the bed forms in the vicinity of the dashed arrow in Figure 11A, and channel-margin bulge illustrated in Figure 11B. While it appears that flood-flows can clear the constriction in Figure 11C, significant shoaling within the throat can occur under more benign conditions (Figure 11D, and this could even necessitate dredging as appears to have occurred in Figure 11E (2005).

Littoral sand (i.e. beach sand) can reach the throat area under wave action along the channel margin during incoming tides (Figure 11F). However, this requires, the channel's sea-entry to be close to the throat rather than further southward along the inlet. It is noted that if the sea-entry is in the centre of the inlet, then littoral sediment can be transported landward at that location and potentially resupply the inlet bay. Furthermore, the recent lack of extreme southerly channel entry into the sea (indicated by the red envelope in Figure 9) prevents littoral sediment reaching this (southern) area; channel remnants (cut-off lakes) therefore persist and facilitate flood flow into this area as speculated earlier.

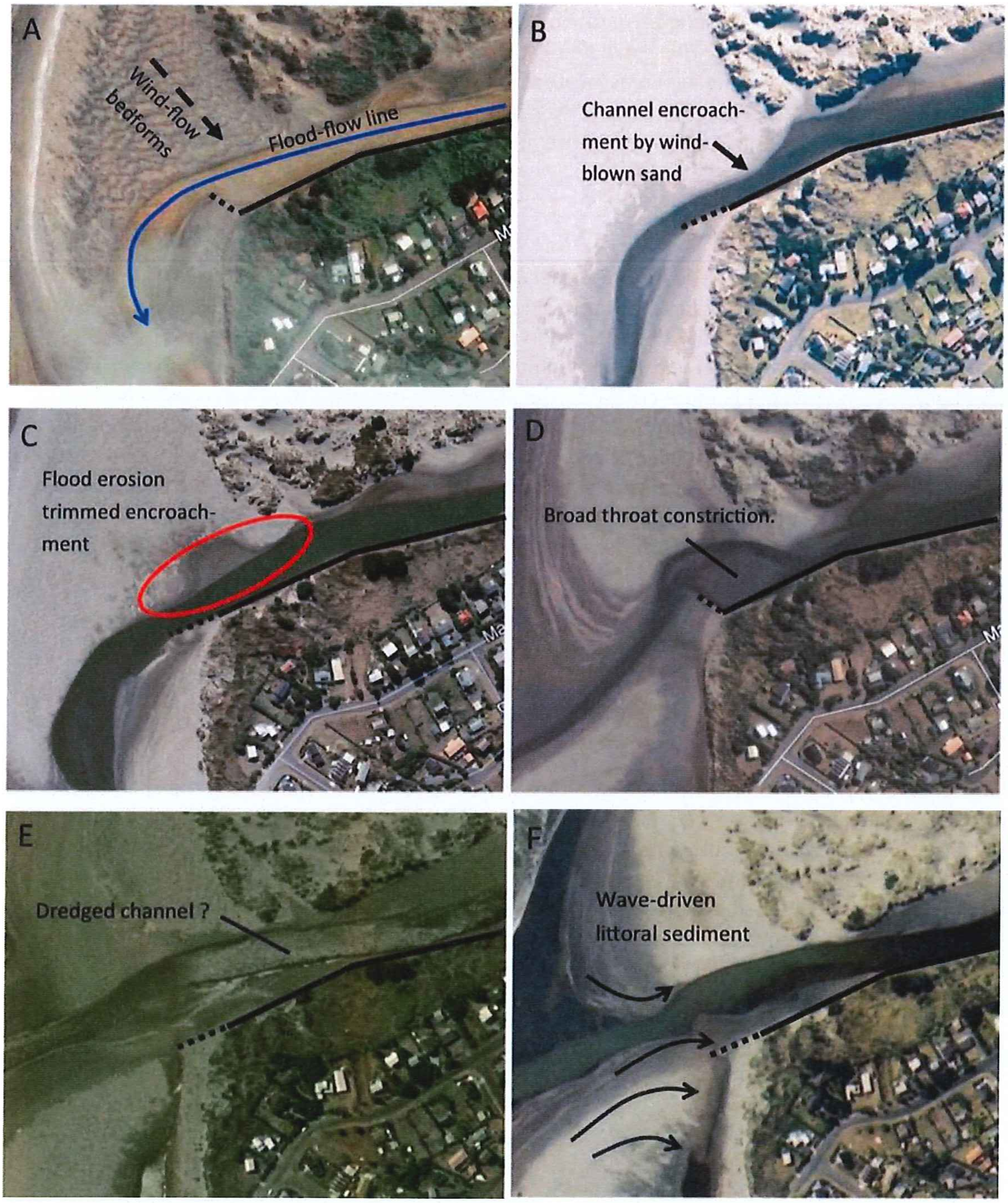


Figure 11: Configurations associated with throat constriction - see text for explanations. The black line defines the rock-lined southern embankment and the dashed black line marks the various entrance groyne. The bend mid-way along the southern embankment (black line) results in an approach channel misalignment with the original entrance groyne (dashed line in Figures B, C, E and F). Note the (apparently) dredged channel in E is more closely aligned with the upstream section of the marked southern embankment.

4 Summary of geomorphological characteristics and processes pertaining to inlet management

Based on the analysis above, geomorphological characteristics and processes at the Waikawa inlet of relevance to inlet management are summarised below:

a The present form of the Waikawa Inlet results from historical artificial diversions, rock control structures and to a lesser extent, mouth cutting. The inlet bay shoreline appears to still be responding to the rock controls and can be expected to do so for some time.

b Shoreline analysis within the Inlet (Figure 10 A and B) shows that the inlet bay is characterised by long-term erosion with an increased rate of erosion evident in more recent years at the northern end of the inlet.

c Analysis of the channel locations (Figure 9) compared with the various control structures suggests that the channel is more often located closer to the inlet bay shoreline/duneline since construction of the high-angle groyne, and this correlates with increased shoreline erosion in this area (Figure 10A).

d The present high-angle groyne, coupled with throat misalignment, may reduce jetting efficiency and hence facilitate sedimentation in the throat area and development of a sharp southward meander past the present groyne terminus with flow then moving towards the back of the inlet.

e Accretion is occurring along the open coast (Figure 10C) with the average rate during the 1993 to 2016 period being 1.4 and 2.5 m/year on the southern and northern coasts respectively. This ongoing natural accretion of the open coast is likely increasing the area of wind-blown sand accumulation and the volume of the fronting sand bar making breaching and discharge more difficult and promoting southward channel meander and ponding. This natural accretionary process can be expected to continue in the future, although the rate of accretion may adjust to ongoing sea level rise and other sediment supply controls.

f At some point in the future the present landward channel may become a relict (lake) feature as has occurred elsewhere along this coast and a new inlet meander will form seaward. However, the timing (and likelihood under predicted climate change/sea level rise) is impossible to determine.

5 Management options

Management options have been investigated for the Waikawa Inlet. The key consideration of this options assessment is to mitigate erosion along the shoreline of the inlet. The following management options have been assessed:

1 Do nothing;

2 River training:

   2a Minimum – on going manual cuttings,

   2b Moderate – Removal of existing high-angle rock groyne and use rock to augment to 1991 alignment, or

   2c Comprehensive – Removal of existing high-angle rock groyne and reconstruct as 1991 groyne alignment;

3 Bank protection:

   3a Minimum – Dune construction along inlet shoreline,

   3b Moderate – Additional groynes construction along inlet shoreline, or

   3c Comprehensive – Rock protection along inlet shoreline;

4 Combination of river training and bank protection.

A brief description of each option along with the advantages and disadvantages of each have been outlined in Table 1. Considerations in this assessment include:

- Effectiveness of protection measures in mitigating future shoreline retreat
- Ongoing works likely required following initial construction
- Construction difficulty/imported material requirement
- Aesthetics
- Cost estimate (see description below)
- Access implications

An indicative cost estimate has been provided for each of the options based on our experience with similar rates. This is an indicative cost for each concept to give an order of relative magnitude. This estimate should not be used for setting budgets at this early stage. Where ongoing costs are likely to be required these have been included as a separate figure (note that ongoing costs do not include for routine structural maintenance, only costs associated with the inlet management).

Key assumptions used in cost estimates:

Sand excavation and placement rate: $10/m3

Rock import and placement rate: $250/m3

P&G: 15%

Consenting fees: $5-10K

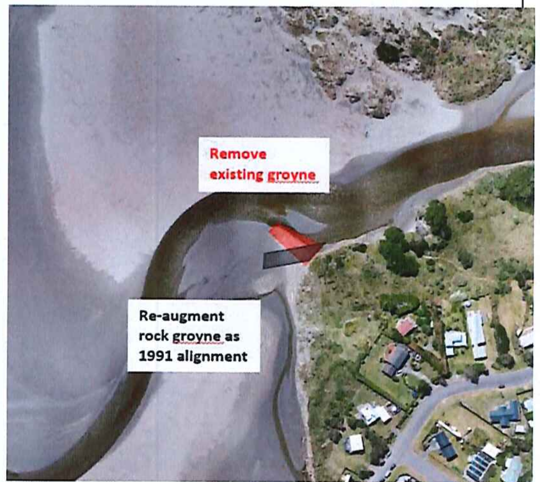
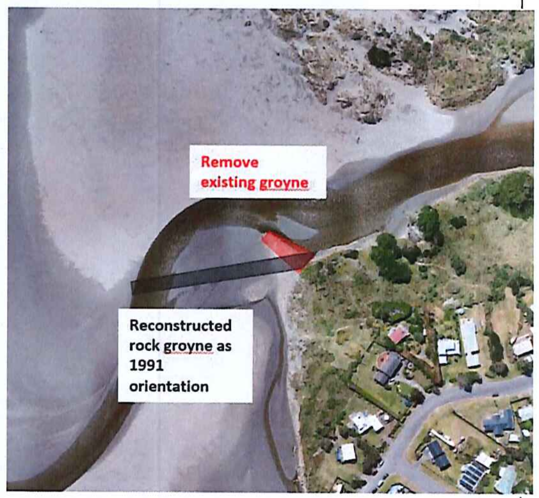
Professional fees (design & consent): 20% - 40% (depending on scale of works)

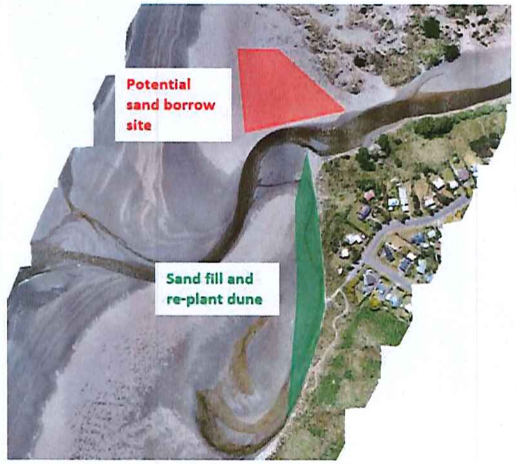
Contingency: 30%

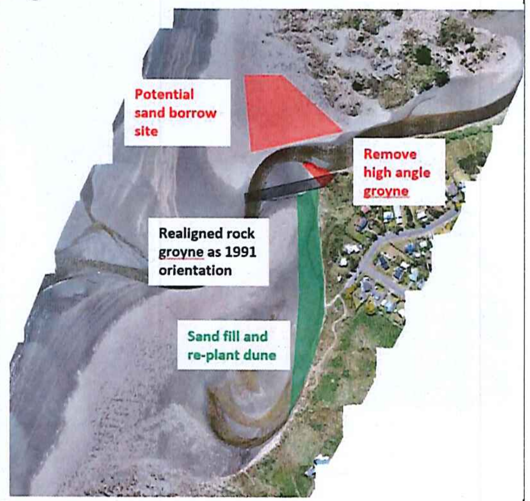
A detailed cost estimate will be provided for the preferred option during the detailed design phase.

Table 1: Waikawa inlet management options assessment

#	Description	Indicative Cost	Advantages	Disadvantages/Risks	Diagram
1	**Do nothing**	$0	-No cost.	-Ongoing erosion along shoreline in front of likely. At present rates of 2.5m/yr (northern transect refer Figure 10) the shoreline would reach the 63 Manga-Pirau Street in approximately 10 years. Refer adjacent diagram showing the approximate shoreline in 10 years based on current erosion rates (note this is not a hazard line, a hazard assessment would be required to define a new setback line). -Resident opposition likely. -Residents likely to implement (non-engineered) hard protection without council involvement.	
2	**River training**				
2a	<u>Minimum</u> - Manual cuttings. Implement a monitoring and trigger system and agreed mouth cutting method	$40k capital $10-20k annually subject to frequency of storms	-Low upfront capital cost. -Simple construction method -No imported materials required -No regrets solution (no rock placed on beach)	-History shows only effective for short period until channel re-aligns southward. -Relatively frequent (biannual) cuttings likely required to prevent channel alignment returning to along the southern shoreline. -No additional protection to properties from large future storm surge/flood events. -Resource consent expires in 2020, will require renewing.	

#	Description	Indicative Cost	Advantages	Disadvantages/Risks	Diagram
2b	Moderate - Remove existing high angle rock groyne and augment the remaining 1991 alignment groyne (although to a shorter length than previous). Initial stream cutting likely required.	$100k capital	-Moderate upfront cost. -Low ongoing costs -Improve stream alignment and may improve natural flushing at throat. -Likely some accretion south of new groyne orientation.	-May increase erosion pressure on existing rock groyne -No additional protection to properties from large future storm surge/flood events. -Short length of southerly protection, unlikely to encourage accretion at properties currently closest to shoreline (61, 63).	
2c	Comprehensive - Remove existing high angle rock groyne, augment and extend the existing rock groyne to similar length (90m) and orientation as 1991	$580k capital	-Inlet alignment forced further seaward at location of throat, possibly maintaining equilibrium with prograding open coast -Channel alignment less likely to retreat to southerly shoreline, reducing erosion risk to properties. -Decreased erosion rates evident historically with a groyne along this alignment. -Sand likely to build up in lee (south) of groyne providing some additional protection to properties.	-High upfront cost due to moderate volumes of rock required to form structure (~5m^3/li m) -Historical evidence shows unless construction is robust and structure is maintained, degradation and burial over time will reduce effectiveness. -No additional protection provided to shoreline from large future storm surge events.	

#	Description	Indicative Cost	Advantages	Disadvantages/Risks	Diagram
3	**Bank protection**				
3a	Minimum - Reconstruction of dunes along the current shoreline to mitigate erosion risk to properties 55-63 Manga-Pirau Street. Material would be taken from north of the outlet and moved to form dunes. Dunes would then be vegetated using native sand-binding grasses	$255k capital $10-20k annually subject to frequency of storms	-Reinstates buffer along current shoreline to increase protection to properties from storm surge events -Encourages seaward shift of southern channel -'Soft' engineering solution. - No regrets solution (no rock placed on beach) -No importation of material required. -Low-mod capital costs -Borrow site reduces southerly migration of sand encroaching into channel throat	-Dune still at risk of erosion – 'sacrificial nourishment'. -May be required in conjunction with another option to mitigate risk of channel alignment running along shoreline eroding dune. -Will likely require ongoing maintenance to re-build dune following storm surge/flood events. -Difficult to predict erosion rates of placed material -Likely have to accept risk and monitor performance.	
3b	Moderate - Installation of a series of smaller, additional rock groynes along the current inlet shoreline (similar orientation to the early 1990s groynes) to encourage seaward movement of southern channel and sediment deposition.	$430k capital	-Divert southerly channel away from bank -Provides more protection to properties than a single groyne at the throat. -Encourages reinstatement of sediment buffer between ocean and properties	-Moderate cost due to imported rock volumes. -Additional groyne installation requires imported material into beach environment – aesthetic and environmental considerations. -Ongoing maintenance likely required.	

#	Description	Indicative Cost	Advantages	Disadvantages/Risks	Diagram
3c	Comprehensive - Installation of rock revetment along current shoreline to protect properties 55-63 Manga-Pirau Street from further erosion.	$1,000k capital	-Provides greatest level of erosion protection to properties from both river flood flow and coastal storm (high wave/water level) events. -Minimal maintenance costs following initial capital expenditure.	-Highest capital cost due to large volumes of rock required to armour shoreline -Potential for end effects as southern termination of revetment - wall may have to be extended -Likely to encourage river outlet to form a more permanent channel alignment along seaward edge of revetment. -Increased difficulty for vehicle beach access, will require engineered access location through revetment. -Effect on beach aesthetics.	
4	Combination of any of river training and bank protection options listed above	Varies subject to combination, refer associated costs.	As options 2 and 3 as well as: -Mitigates erosion risk from both river flows and coastal storm events.	As options 2 and 3 as well as: -High capital cost	E.g. 

6 Resource consent considerations

6.1 Summary of consent requirements

The concept designs propose a works area that may include land that is located both inside and outside of the CMA. For those works located outside of the CMA, consideration of any relevant rules of the Horowhenua District Plan is required. Works located within the CMA require an assessment against the relevant rules of the Horizons One Plan.

At this preliminary stage, all of the potential options, with the exception of Option 1 (do nothing), are likely to require resource consents from Horizons Regional Council and / or Horowhenua District Council. A high-level summary of the likely consents and supporting information requirements for the consent applications and additional plan specific information can be found in Appendix C of this report.

6.2 Consenting challenges associated with the various options

The potential information requirements to inform the required consent applications have been identified in Appendix C, and can be confirmed with the respective councils prior to the preparation of the required resource consent applications.

In respect of the consenting challenges associated with the identified options, it should be noted that the New Zealand Coastal Policy Statement (NZCPS) identifies a clear preference for soft protection (as opposed to hard protection structures) in the coastal environment. We note that a range of 'soft' options have been identified, and any preference for the establishment of a hard structure would need to be carefully supported by evidence that that structure(s) is reasonably necessary to achieve the required project outcomes. Accordingly this may represent a more involved consenting process. It should also be noted that any group which has applied for Customary Marine Title over the area will be required to be notified of the proposal and their comments sought.

Option 3a proposes to take material from the existing beach in order to rebuild the dune system. Although this material remains part of the 'active beach system,' this may represent a more involved consenting process, and will require consideration of the effects of the sand take upon the beach processes, ecology and natural character of the environment.

6.3 Potential supporting information requirements

The information required to support the application for resource consent for all of these options is likely to include the following:

- Ecological assessment
- Hydraulic assessment
- Coastal geomorphological assessment (this report)
- Consent level design drawings and supporting information
- Engagement with tangata whenua
- Affected party approvals (for works extending into private property)

This will be confirmed with the respective councils prior to the preparation of a resource consent application.

7 Summary and recommendations

The natural mobility of the Waikawa Inlet forced by southerly and landward migration of the Waikawa River channel has led to the implementation of various management operations and structures since the mid-1900s. Shoreline erosion of some 25m over the past 10 years at the northern end of the inlet bay has led to HRC's request for investigation into further management options to mitigate further shoreline erosion.

The geomorphological assessment undertaken of the Waikawa Inlet indicates that key contributing factors to the ongoing erosion south of the river include:

- Southerly migration of the inlet since the late 1800s when the river used to join into the Ohau River some 2km north of its current location
- Decreased throat flushing efficiency resulting form:
  - High angle groyne impeding into river alignment
  - Throat misalignment
  - Ongoing accretion of the open coast shoreline north and south of the inlet

Six management options have been presented based on this assessment to mitigate the erosion risk to the inlet shoreline. Advantages and disadvantages of each are considered together with consenting implications and with associated capital and annual costs. It is expected that options selection will be heavily dependent on available council funding and stakeholder preference. From an erosion and inlet management perspective, implementing a combination of the above options is expected to be the most effective solution. It is recommended that the following combination of options be considered in further detail:

1 Combination 1 (Limited scope):

   Remove the current high-angle groyne to reduce its impediment on river flow, place rock along the 1991 alignment (optionally together with as much additional rock as budget allows). Undertake initial and ongoing channel cutting as required to prevent channel alignment running along the southern shoreline, place cutting material along shoreline and vegetate the dune line.

   Potential to improve current situation but ongoing erosion and damage still likely to occur at times

   Likely capital cost: $150K (+ additional rock as budget allows), likely annual cost $20-$40K

2 Combination 2 (Medium scope):

   As per 1 above, along with extension and upgrade of the groyne to 1991 alignment and length. Dune re-establishment along the inlet shoreline to increase buffer from further storm events. Sand could be sourced from the northern side of the inlet and vegetated.

   Likely to improve current situation but ongoing erosion and damage could still potentially occur at times

   Likely capital cost: $700-$900K; likely annual cost: $20-$40k

3 Combination 3 (Extensive scope):

   As per 1 and 2 above along with installation of rock revetment along current shoreline to protect from further erosion.

   Very likely to reduce ongoing erosion of land behind revetment. May be difficult to consent.

   Likely Capital cost: $1M+

8 Applicability

This report has been prepared for the exclusive use of our client Horizons 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.

Tonkin & Taylor Ltd

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Coast Geomorphologist

Alastair Meehan

Resource Management Planner

Reviewed by:

....

Dr Tom Shand

Technical Director

MAPP
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9 References

Blackwood, P., 2012. Waikawa Rivermouth Groyne Design for the Horowhenua District Council. Horizons Regional Council Memorandum, File PRD 521, PRD 807. 7p

Freyberger, S.G., 1979. Dune forms and wind regime. U.S. Geological Survey Professional Paper 1052, 137-170.

MetOcean Solutions Ltd., 2012. Kapiti Coast Wave Climate: Updated Statistics. A report prepared for the Kapiti Coast District Council, 12p.

Shepherd, D. and Shepherd, L., 1999. Bitter water: a story of Waikawa. 65p.

Tonkin and Taylor, 2013. Coastal Hazard Assessment: Waikawa to Waitarere. A report prepared for Horizons Regional Council. 25p.

Appendix A: Survey Plans, Aerial Photographs and Satellite Image Details

Date	Type	Reference No.	Source
1872	Survey plan	SO 11039-2	Land Information NZ
1877	Survey plan	ML 193	LINZ
1889	Survey plan	ML 914	LINZ
1893	Survey plan	ML 1215	LINZ
1894	Survey plan	ML 1254	LINZ
1923	Survey plan	SO 17046	LINZ
1942	Aerial photo vertical	SN 181-232	NZ Aerial Mapping
1957	Aerial photo vertical	SN 1005-C9	NZAM
1965	Aerial photo vertical	SN 3423-2	NZAM
1967	Aerial photo vertical	SN 1971 M10	NZAM
1972	Aerial photo vertical	SN 3540 A6	NZAM
1978	Aerial photo vertical	SN 5306 A5	NZAM
1983	Aerial photo vertical	SN 8171 A9	NZAM
1993	Aerial photo vertical	SN 234666	Aerial Surveys Ltd
1994-2	Aerial photo vertical	-	Lawrie Carins Ltd
1995-2-16	Aerial photo vertical	SN 249687	Aerial Surveys Ltd
1995-5-26	Aerial photo vertical	SN 12448A	Aerial Surveys Ltd
1996	Aerial photo oblique	-	Mr John Hewitson
1996	Survey plan	-	John Hurd Architect
2000-2	Aerial photo vertical	-	Lawrie Carins Ltd
2000-7	Aerial photo Vertical	-	Precision Aerial Surveys
2001	Aerial photo Vertical	-	from Horowhenua DC
2005-2	Satellite image vertical	-	from Horizons RC
2005-2	Aerial photo vertical	-	Lawrie Carins Ltd
2005-6-3	Satellite image vertical	-	Google Earth Pro
2005-9-2	Satellite image vertical	-	Google Earth Pro
2005-9-7	Satellite image vertical	-	Google Earth Pro
2005-9-20	Satellite image vertical	-	Google Earth Pro
2005-10-8	Satellite image vertical	-	Google Earth Pro

2005-11	Aerial photo vertical	-	Lawrie Carins Ltd
2006-2-6	Satellite image vertical	-	Google Earth Pro
2007-9	Aerial photo vertical	-	Lawrie Carins Ltd
2009-5	Aerial photo vertical	-	Lawrie Carins Ltd
2010-3-3	Satellite image vertical	-	Google Earth Pro
2010-3-31	Satellite image vertical	-	Google Earth Pro
2010-2011	Aerial photo vertical	BN33-0601	LINZ
2013-8-18	Satellite image vertical	-	Google Earth Pro
2013-9-17	Satellite image vertical	-	Google Earth Pro
2014-4-4	Satellite image vertical	-	Google Earth Pro
2015-1-25	Satellite image vertical	-	Google Earth Pro
2015-10-23	Satellite image vertical	-	Google Earth Pro
2015-11-5	Satellite image vertical	-	Google Earth Pro
2015-2016	Aerial photo vertical	BN33-0601	LINZ
2016-4-6	Satellite image vertical	-	Google Earth Pro
2016-2017	Aerial photo vertical	BN33-0601	LINZ
2017-10	Aerial photo oblique	-	Lawrie Carins Ltd
2018-7-31	Aerial photo vertical		from Horowhenua DC
2018-11-2	Aerial photo vertical and oblique		Tonkin and Taylor

Appendix B: UAV Orthomosaic and DSM

Figure 12: Waikawa inlet UAV aerial image - north

Figure 13: Waikawa inlet UAV aerial image - south

Figure 14: Waikawa inlet UAV oblique north to south - 1

Figure 15: Waikawa inlet UAV oblique north to south - 2

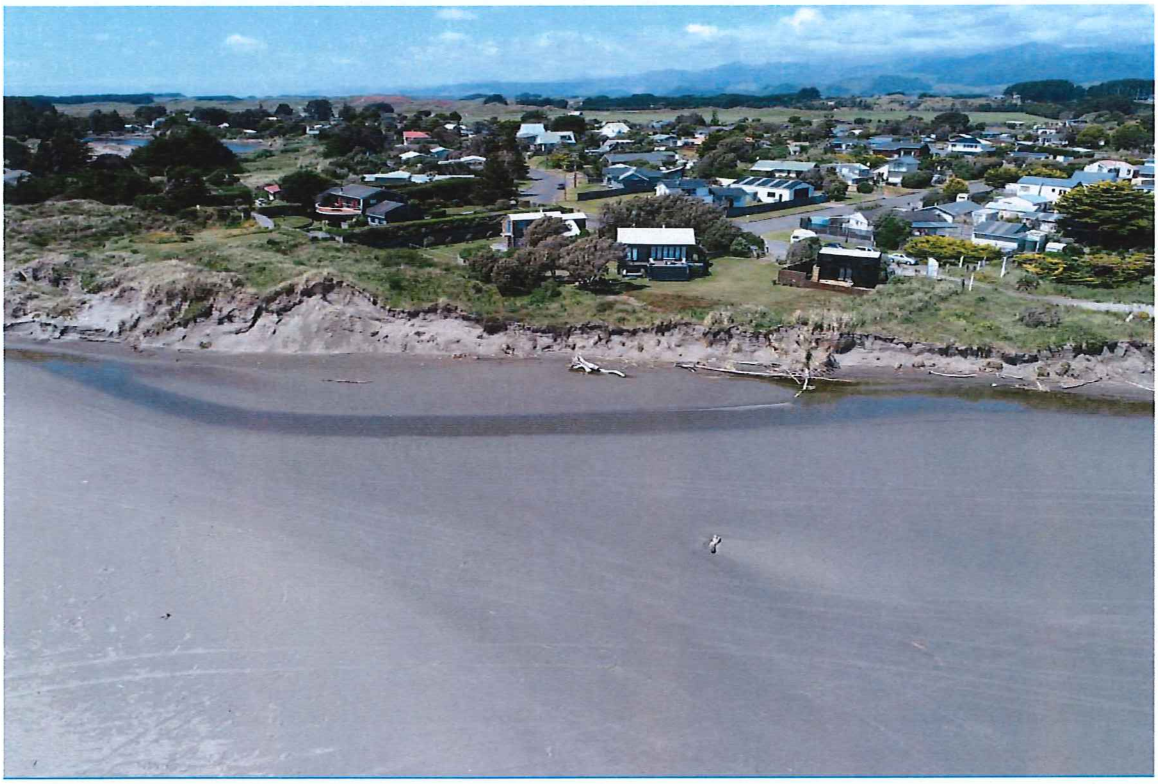


Figure 16: Waikawa inlet UAV oblique north to south - 3

Figure 17: Waikawa inlet UAV oblique north to south - 4

Figure 18: Waikawa inlet UAV oblique north to south - 5

Figure 19: Waikawa inlet UAV oblique north to south - 6

Figure 20: Waikawa inlet UAV oblique north to south - 7

Figure 21: Waikawa inlet UAV oblique north to south - 8

Appendix C: Resource consenting

The following section provides a preliminary assessment of the resource consent requirements in the Horowhenua District Plan and the Horizons One Plan for the options described in Section 5 above. The relevant zoning and overlays have been identified on Planning Map 36 of the Horowhenua District Plan and Planning Map I:7 of the One Plan. These are summarised in Table 2 below.

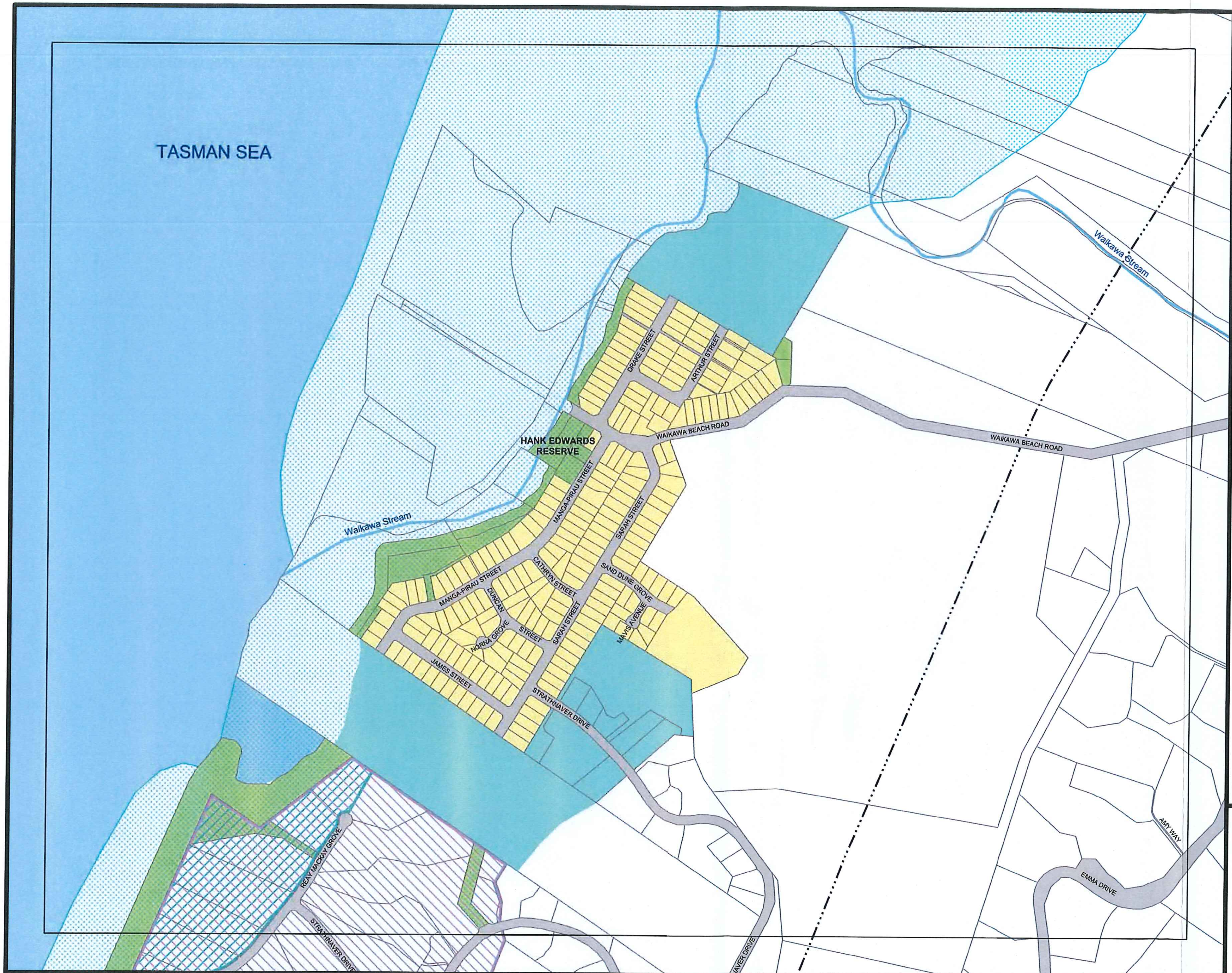
Table 2: Zoning and planning notations

Zoning/planning limitation	Location
Horowhenua District Plan: Map 36	
Coastal Natural Character and Hazard Area Overlay	Applies to the entire subject site, including the dune system to the north of the river mouth
Outstanding Natural Feature and Landscape – Coastal ONFL	Applies to the entire subject site, with the exception of the Residential Zone adjoining Manga Pirau Street
Landscape Domain – Coastal Environment Domain	Refers to the entire subject site.
Open Space Zone	Applies to the vegetated strip of land between the river bank and the residentially-zoned land adjacent to the existing rock groyne. None of the options appear to be located within this margin of land.
Residential Zone	Applies to the residential land adjacent to Manga Pirau Street. This is expected to remain clear of the works area.
Rural Zone	Applies to the dune system to the north of the subject site
Horizons One Plan: Map I:7	
Mean High Water Spring (MHWS) / Coastal Marine Area	The approximate CMA boundary can be found in Figure I:7 of the One Plan
Outstanding Natural Features or Landscapes	The Waikawa river estuary is identified as having particular ecological value for indigenous fauna in Schedule G
Water Management Zone – Waikawa (West_9)	Waikawa
Estuary Water Management Sub-Zone (Waikawa Estuary (West_9CMA)	Waikawa estuary

Table 3: Summary of the indicative consent requirements for those options identified in Table 1 above

Option #	Description	Potential Resource Consent triggers	Horowhenua District Plan requirements	Horizons District Plan requirements	Potential supporting information requirements
1	**Do nothing**	Nil	Nil	Nil	Nil
2	**River training**				
2a	<u>Minimum</u> - Manual cuttings. Implement a monitoring and trigger system and agreed mouth cutting method	River mouth cutting (within the CMA) Any ancillary earthworks, associated with the cutting, which fall outside of the CMA.	Earthworks within the coastal foredune are likely to be a **permitted activity** under Rule 19.1(v).	Minor cuttings (within the CMA) are likely to be **permitted activity** under Rule 18-24. Any land disturbance associated with the cuttings located outside of the CMA may require earthworks consent under Rule 13-7 as a **discretionary activity**.	The information required to support the application for resource consent for all of these options is likely to include the following: **1** Ecological assessment **2** Hydraulic assessment **3** Coastal geomorphological assessment (this report) **4** Consent level design drawings and supporting information **5** Engagement with tangata whenua **6** Affected party approvals (for works extending into private property) This will be confirmed with the respective councils prior to the preparation of a resource consent application.
2b	<u>Moderate</u> - Remove existing high angle rock groyne and augment the remaining 1991 alignment groyne (although to a shorter length than previous). Initial stream cutting likely required.	River mouth cutting (within the CMA) Removal of an existing structure.	Nil – works anticipated to be located wholly within the CMA	Minor cuttings (within the CMA) are expected to be **permitted** under Rule 18-24. Removal or demolition of the existing groyne structure is likely to be **permitted** under Rule 18-7. Establishment of a new structure within the CMA (in the form of a groyne) is likely to require resource consent under Rule18-44 as a **discretionary activity**.	
2c	<u>Comprehensive</u> - Remove existing high angle rock groyne, augment and extend the existing rock groyne to similar length (90m) and orientation as 1991	Removal of an existing structure. Establishing a new structure within the CMA.	Nil – works anticipated to be located wholly within the CMA	Removal or demolition of the existing groyne structure is likely to be **permitted** under Rule 18-7. Establishment of a new structure within the CMA (in the form of a groyne) is likely to require resource consent under Rule18-44 as a **discretionary activity**.	

Option #	Description	Potential Resource Consent triggers	Horowhenua District Plan requirements	Horizons District Plan requirements	Potential supporting information requirements
3	**Bank protection**				
3a	Minimum - Reconstruction of dunes along the current shoreline to mitigate erosion risk to properties 55-63 Manga-Pirau Street. Material would be taken from north of the outlet and moved to form dunes. Dunes would then be vegetated using native sand-binding grasses	Earthworks (associated with the borrow area) which fall outside of the CMA. Reclamation of / deposition within the historic river channel	Earthworks within the coastal foredune will be subject to consent from Horizons Regional Council, and will therefore be a **permitted activity** under Rule 19.1(v).	Any land disturbance associated with the cuttings located outside of the CMA may require earthworks consent under Rule 13-7 as a **discretionary activity**. The deposition of material / reclamation of the historic channel may require consent under Rule 18-18 as a **discretionary activity**.	
3b	Moderate - Installation of a series of smaller, additional rock groynes along the current inlet shoreline to encourage seaward movement of southern channel and sediment deposition.	Establishing a new structure within the CMA.	Nil – works anticipated to be located wholly within the CMA	Establishment of a new structure within the CMA (in the form of groynes) is likely to require resource consent under Rule18-44 as a **discretionary activity**.	
3c	Comprehensive - Installation of rock revetment along current shoreline to protect properties 55-63 Manga-Pirau Street from further erosion.	Establishing a new structure within the CMA.	Nil – works anticipated to be located wholly within the CMA	Establishment of a new structure within the CMA (in the form of a rock revetment) is likely to require resource consent under Rule18-44 as a **discretionary activity**.	
4	Combination of any of river training and bank protection options listed above	*As per those resource consent triggers identified for the respective options above*	*As per those resource consent triggers identified for the respective options above*	*As per those resource consent triggers identified for the respective options above*	



Horowhenua
DISTRICT COUNCIL

LEGEND

ZONES

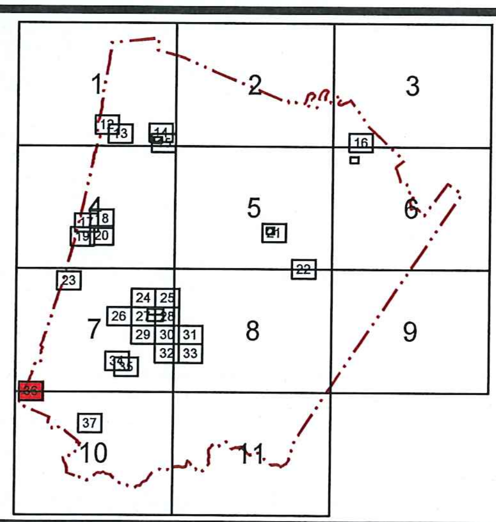
- Residential
- Residential Deferred
- Commercial
- Commercial Deferred
- Industrial
- Open Space
- Rural
- Greenbelt Residential
- Greenbelt Residential Deferred

OVERLAYS

- Greenbelt Residential Waitarere Rise
- Greenbelt Residential Foxton Beach North
- Strathnaver Coastal Natural Character Area
- Strathnaver Coastal Hazard Area
- Muhunoa West Forest Park
- Muhunoa West Forest Park Coastal Natural Character and Hazard Area
- Low Density Area
- Medium Density Area
- Large Format Retail Area
- Town Centre Heritage/Character Area
- Foxton Tourism Area
- Pedestrian Area
- Coastal Natural Character and Hazard Area
- Flood Hazard Area (1:50,000 Rural Maps Only)
- Moutoa Floodway (1:50,000 Rural Maps Only)
- Versatile Land (LUC Class I & II Soil)

FEATURES

- Notable Tree
- Historic Heritage Building, Structure or Site
- Gas Transmission Pipeline
- National Grid Corridor (High Voltage Transmission Line)
- Designation
- Road



N W E S

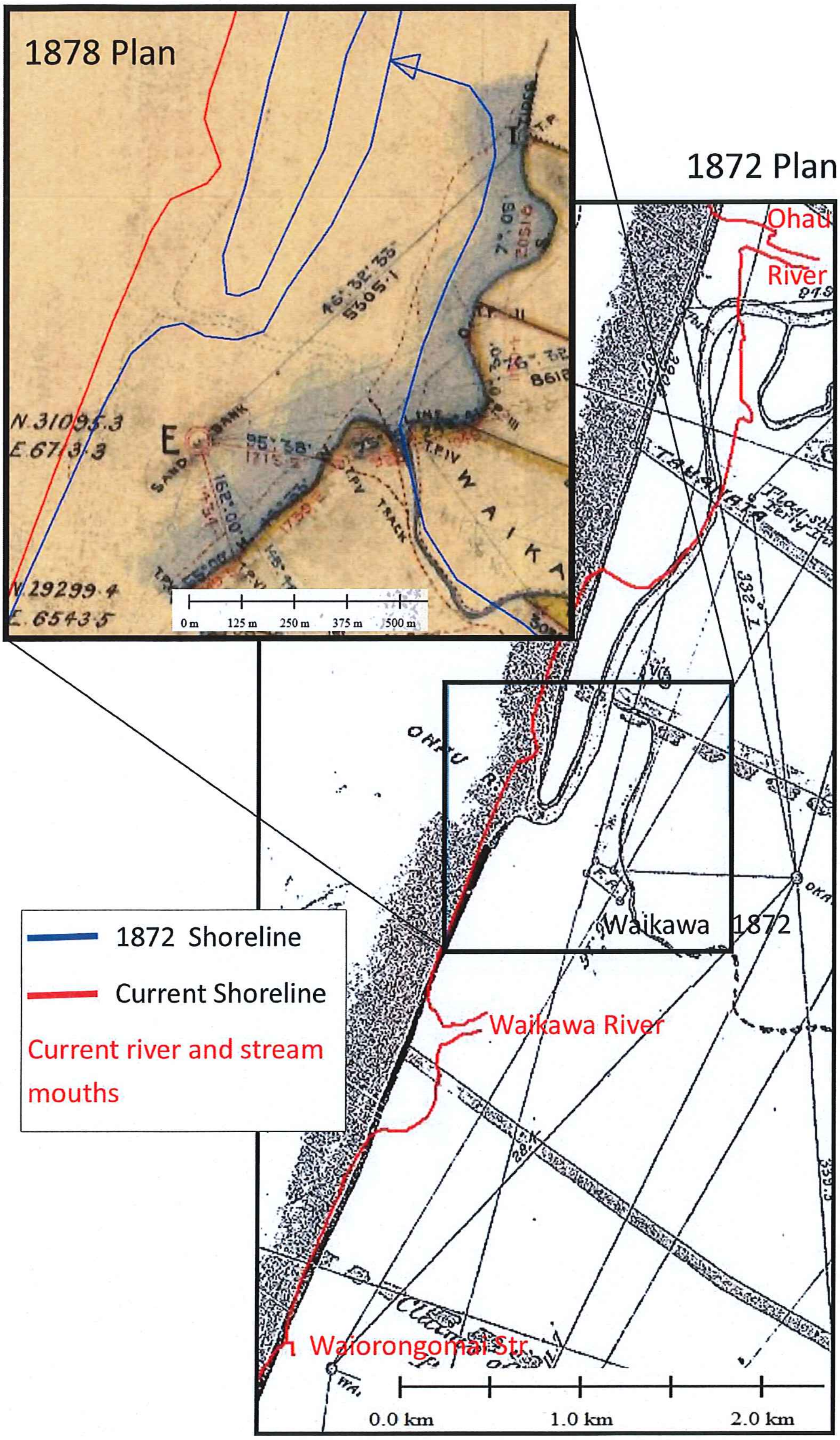
Scale 1 : 7,500

HOROWHENUA DISTRICT PLAN
WAIKAWA BEACH

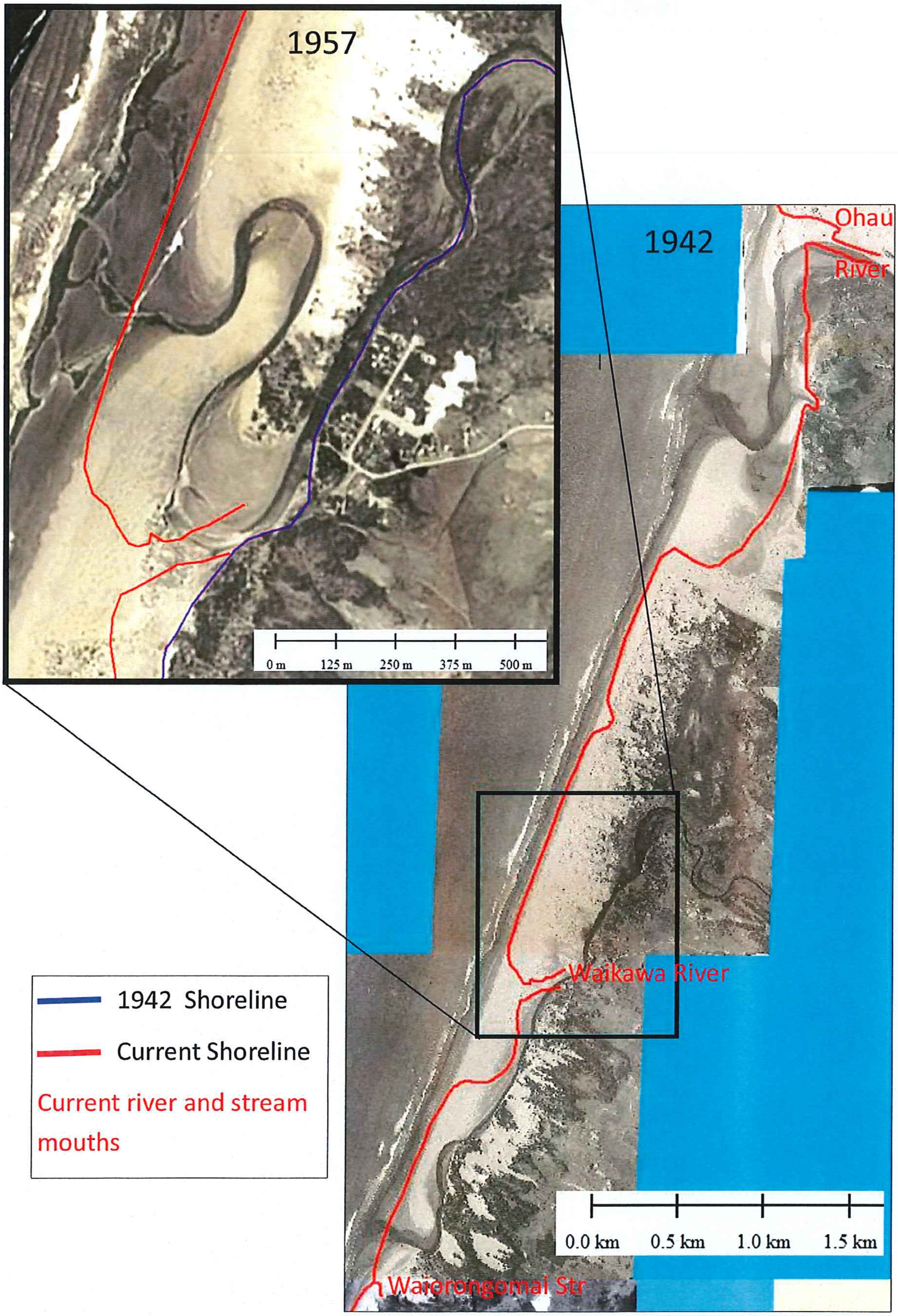
Planning Map 36

Date: 11/12/2015 Version: 2.1

Appendix D: Early plans and current features


1878 Plan
N.31095.3
E.6713.3
N.29299.4
E.6543.5
SAND BANK
46°32'33"
5305.1
7°09'
WAIKA
0 m
125 m
250 m
375 m
500 m
1872 Plan
Ohau
River
OHAU R.
TAUMATA
Waikawa 1872
Waikawa River
Waiorongomai Str
0.0 km
1.0 km
2.0 km
1872 Shoreline
Current Shoreline
Current river and stream mouths

Appendix E: Early aerial photos and current features



1957
0 m
125 m
250 m
375 m
500 m
1942
Ohau
River
Waikawa River
Waiorongomai Str
0.0 km
0.5 km
1.0 km
1.5 km
1942 Shoreline
Current Shoreline
Current river and stream mouths