.

Waikawa Beach

geomorphological assessment

A report prepared for Tonkin and Taylor Ltd on behalf of Horizons Regional Council

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Reference	2019-02 CRep
Version	2
Status	Open
Date	March, 2019

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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.

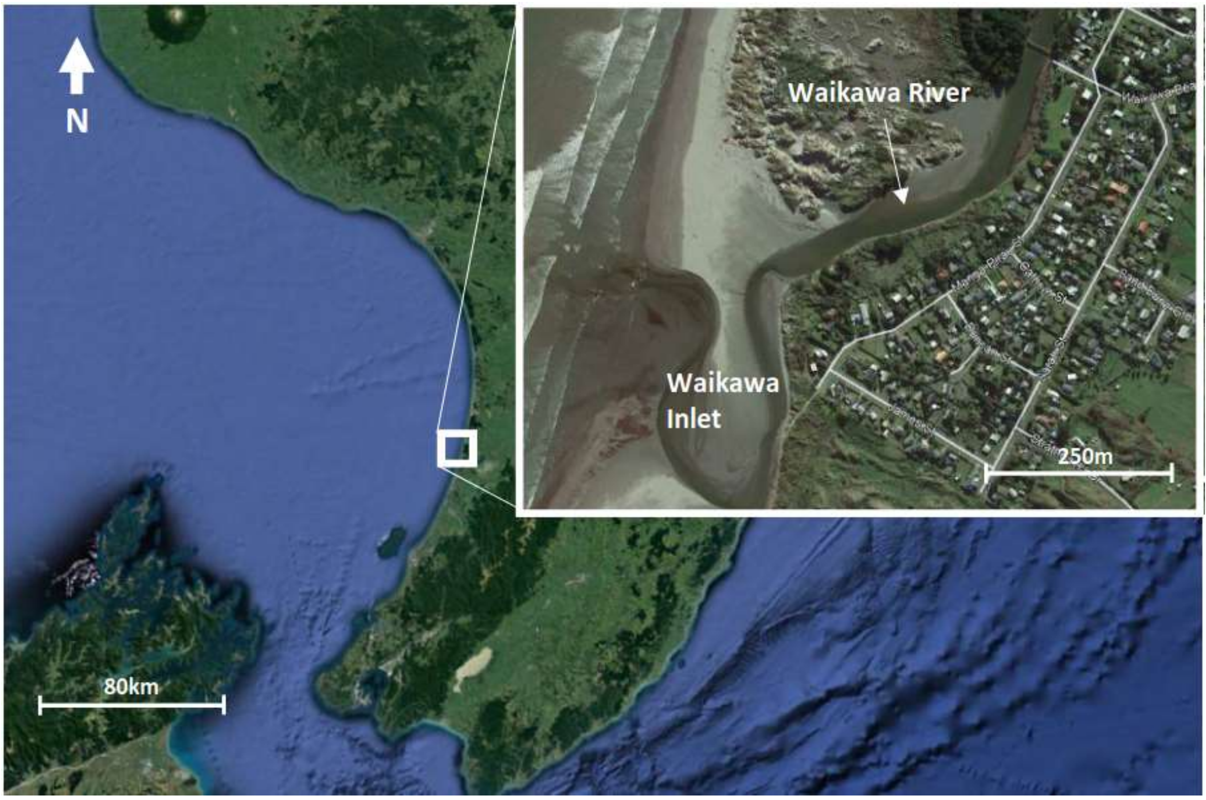

Figure 1: Waikawa Beach location map (aerial source: Google Earth)

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).

Coastal Systems Ltd (CSL) were subcontracted to carry out the coastal geomorphological assessment and this is reported below in Section 3. Section 1 (this section and Section 2 (background) were written by T&T and are included in this CSL report to provide context, and a summary in Section 4.

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:

1. Groyne control not functioning/fit for purpose.
2. Erosion occurring along west side of Manga Pirau Street that is affecting four properties presently.
3. 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).

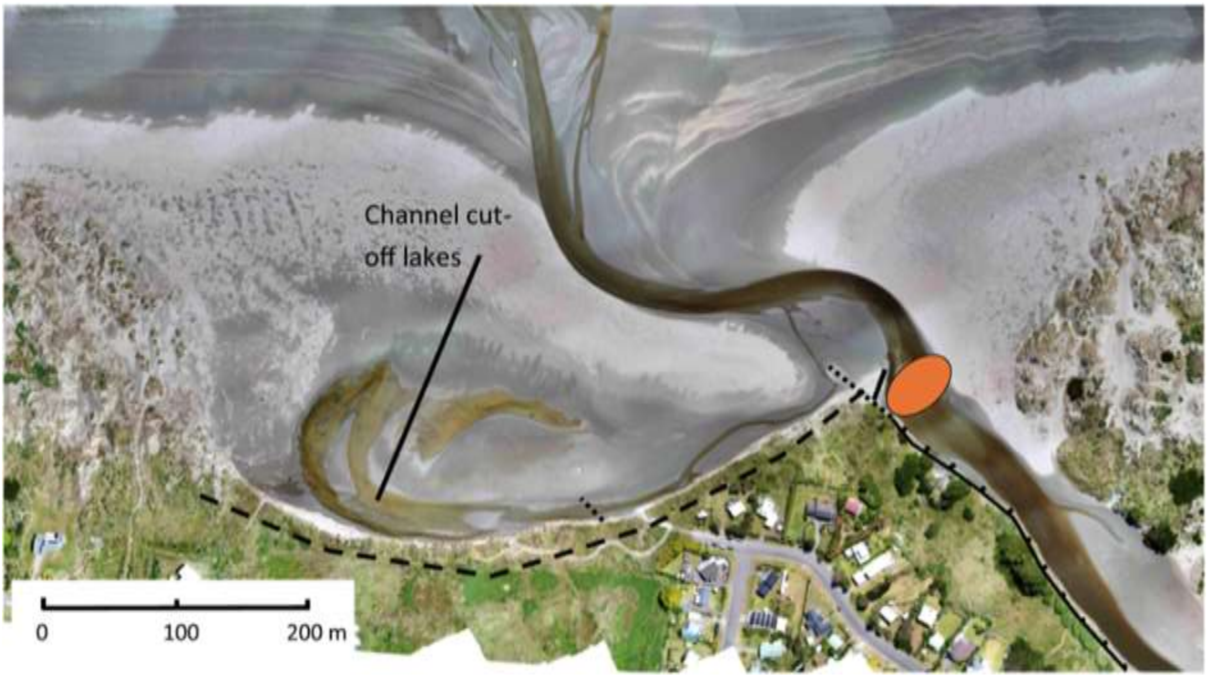

Figure 4: Waikawa inlet at the time of the site visit on 2nd November 2018. Bold black line is current rock groyne, dashed black lines are remnants of the 1991 rock groynes, raked black line is rock-lined river bank, and orange oval is throat as defined in this study. "Cut-off" lake examples are marked,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

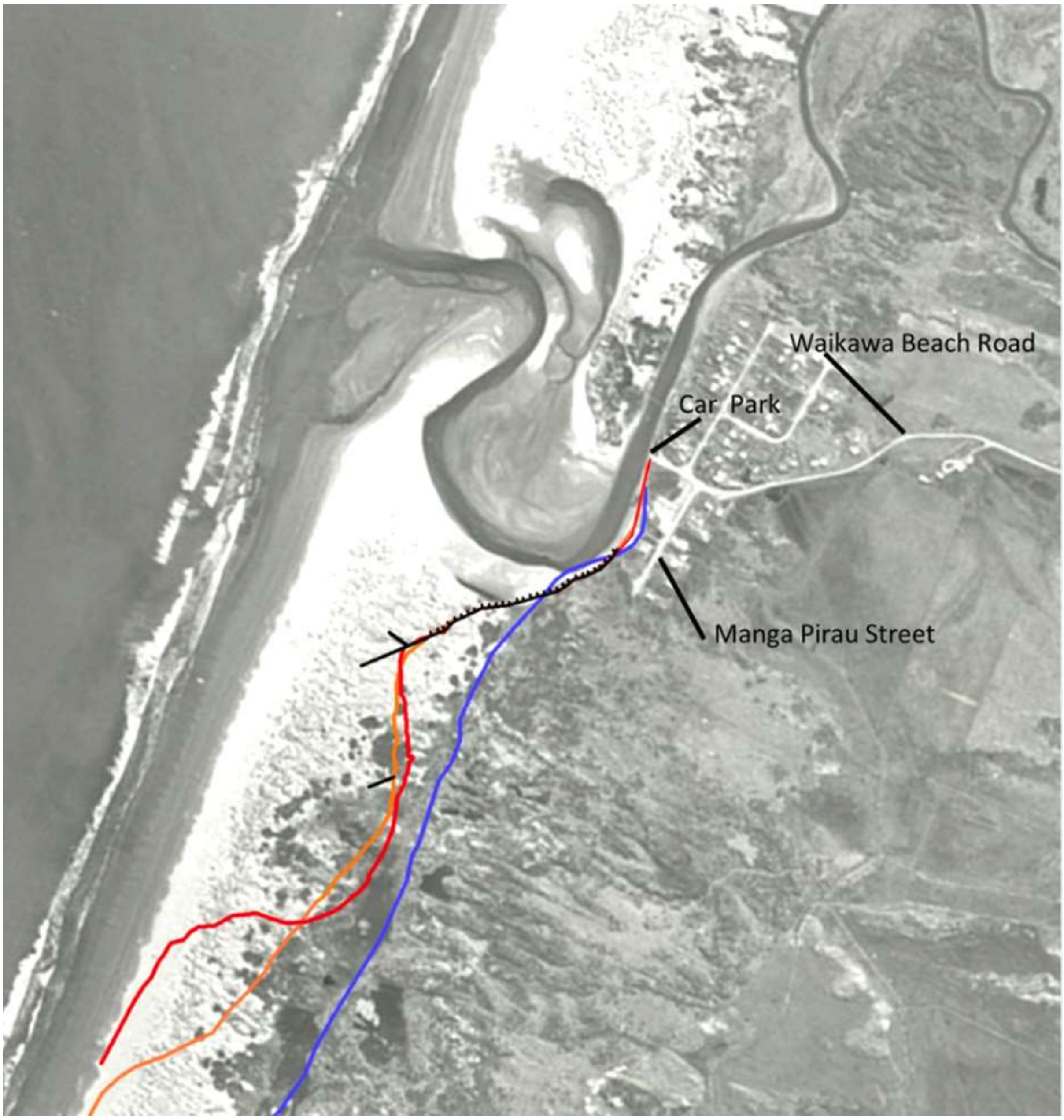

Figure 5: Typical post 1945-diversion response morphology on the 1968 aerial photo with the river meandering northward. The 1942 shoreline is marked purple, 1993 by orange and current 2018 by red. Structures are marked black as in Figure 4.

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.

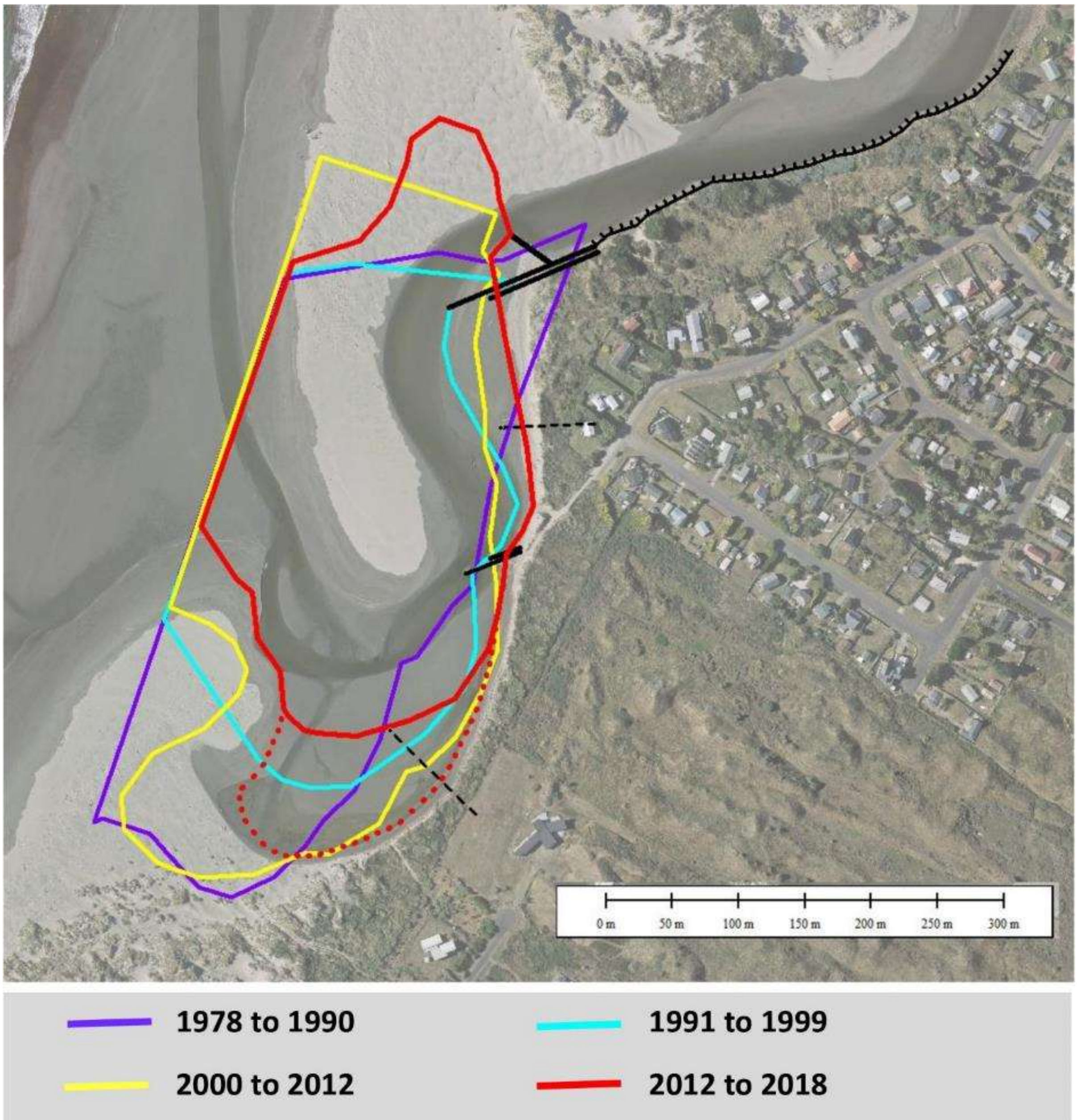

Figure 9: Envelopes of main channel location for colour-coded time periods—these corresponding to differing structural controls. Raked black line = rock protected river bank (from pre- 1978). Paired solid black lines are rock groynes, original long groyne from 1991 and shorter remnants from 2000. Single 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.

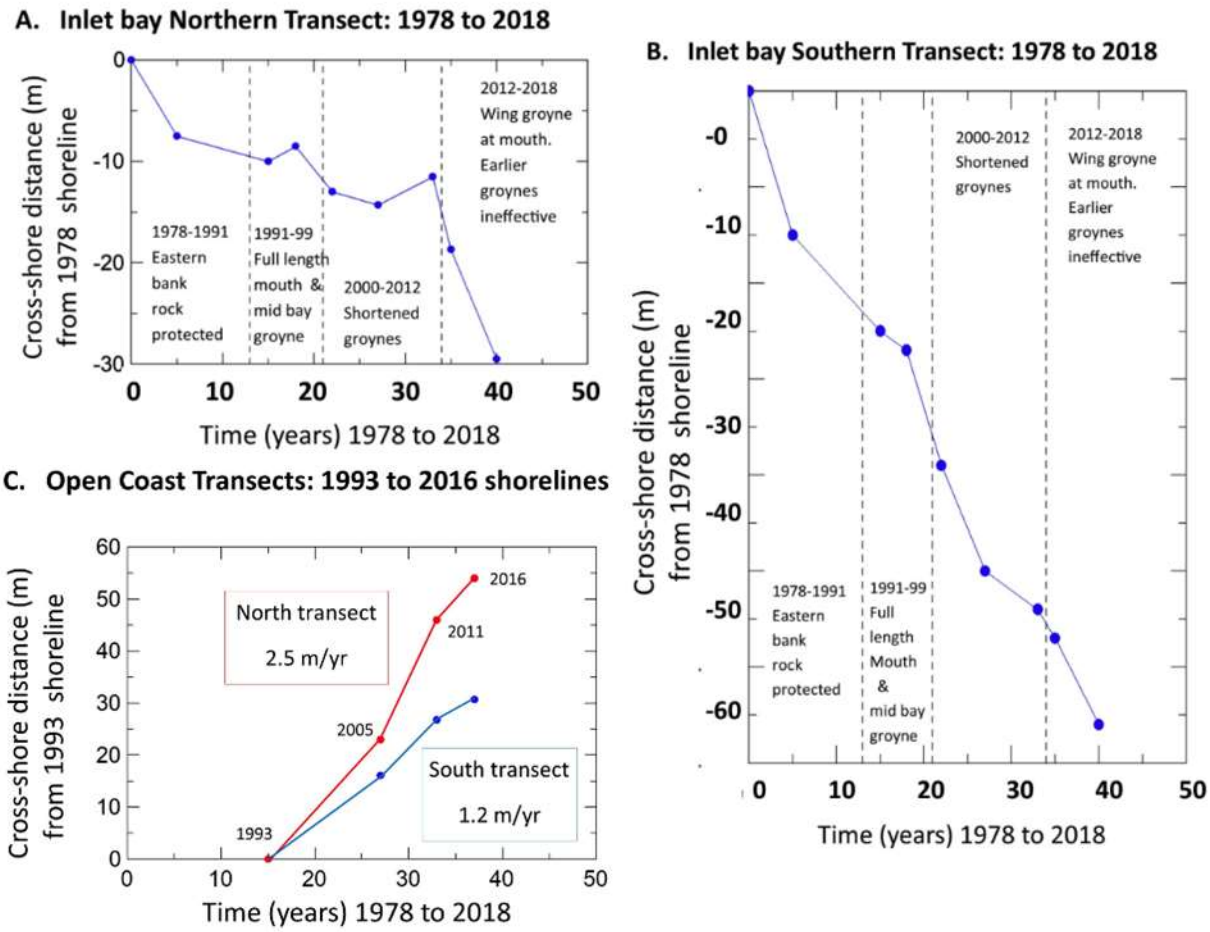

Figure 10: Shoreline change (based on vegetation-front) for the inlet transects (north Figure A and south Figure B) with locations marked in Figure 9. The period (1978 to 2018) covers the time since the inlet approach was fixed by rock lining of the southern bank in the 1970s. The periods of differing 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.

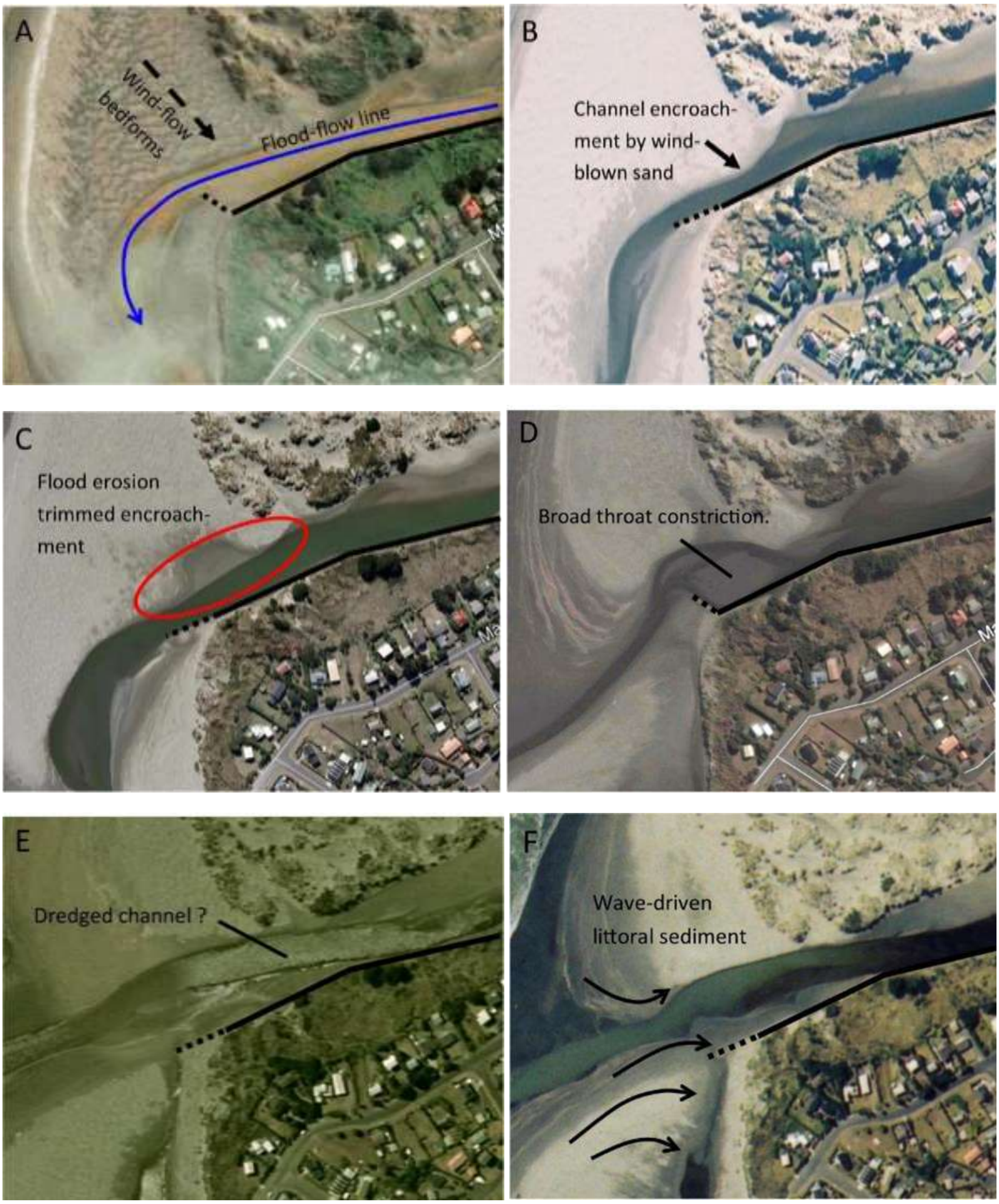

Figure 11: Configurations associated with throat constriction - see text for explanations. The black line defines the rock-lined southern embankment and the dashed black line marks the various entrance groyne. The bend mid-way along the southern embankment (black line) results in an approach channel 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.

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