Whangaumu Bay

Coastal Erosion Hazard and Management Recommendations

Prepared for: Northland Regional Council

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Executive Summary

The report reviews coastal erosion hazard at Whangaumu Bay and develops management recommendations for the short and longer term. The issues at this site are typical of many developed beaches along the eastern coast of Northland.

The review of coastal erosion indicates that the beach is currently in dynamic equilibrium, with the duneline simply fluctuating backwards and forwards over time in response to storm erosion and subsequent dune recovery. This pattern of erosion and subsequent recovery appears to have a broad relationship with climatic cycles, particularly IPO; with a general tendency for the dune to undergo net erosion during negative phases of the IPO and net dune recovery during positive IPO phases.

This coastal erosion does not pose a threat to any existing houses. Similarly, most private properties are not threatened except for the western end of the beach (particularly 6 to 18 Whangaumu Road) where (in the absence of existing rock protection) severe storm erosion can extend inside the front property boundaries. The 20 m reserve set off at the time of subdivision was insufficient to protect these latter properties, due to the higher elevation of the dunes in this area and greater exposure to wave attack.

In the medium-longer term future, there is potential for the beach to develop a trend for progressive and permanent long term shoreline retreat in response to projected sea level rise. For instance, with projected sea level rise of 0.9 m over the next century there is potential for erosion to extend up to 15 m further landward into private properties - unless restricted by erosion resistant geology underlying the Holocene dunes. Such erosion would require landward relocation of many existing dwellings over time. If however dune erosion is restricted by erosion resistant geology, the main effect of projected sea level rise will be severe narrowing of the beach. Sub-surface investigations would be required to assess the degree to which erosion may be restricted.

The review of erosion hazard in this report has revised earlier calculations, particularly in respect to long term trends, dune slope collapse at the western end, and the potential impact of sea level rise (the latter changes due to revised sea level rise projections). However, overall, the changes balance and the revised setbacks are very similar to those developed in the previous review by Gibb (1998). Accordingly, no changes to the existing setbacks are recommended.

It is recommended that the existing and potential longer term erosion hazard is most appropriately managed using a combination of the following approaches:

- **Use of development setbacks and associated controls to avoid and reduce risks** – with recommended action discussed in Section 4.1. Many of these measures are already in place and reducing risk at Whangaumu. Additional measures are included in the recommendations (e.g. to ensure setbacks cannot be circumvented by existing use rights and to ensure new dwellings are practicably relocatable). The recommended development controls are also relevant in identified coastal hazard areas at most east coast Northland sites.

- **Dune restoration to enhance the natural hazard protection provided by these features** through restoration of dune function, particularly natural dune repair processes. The existing dunes are in a severely degraded condition and this restoration is a high priority. Detailed guidelines for this work are provided in Section 4.2, along with examples of similar work elsewhere. In the area from 30 to 70 Whangaumu Road, the reserve seaward of existing properties is of sufficient width to restore a sustainable dune for existing sea level and coastal processes and it is recommended that initial work focus on this area. The area from 24 to 28 Whangaumu Road is also a priority but will require additional action to address end effects erosion from the sea wall at the western end of the beach. In addition to improving the protective function of the dunes, the restoration work will significantly enhance natural values and natural character as well as visual beach amenity.

- **Management of the sea wall at the western end of the beach.** This sea wall provides protection to the front edge of adjacent private properties and to beach access from these properties. However, the structure has some adverse environmental effects, which are likely to become more severe in the longer term. In the short-medium term, focus should be given to mitigation of end effects from the sea wall, which aggravate erosion on immediately adjacent unprotected properties. Recommendations are outlined in Section 4.3.3. In the longer term (probably decades), complete removal of the sea wall may be required – particularly if projected sea level rise results in a trend for permanent long term shoreline retreat.

Beach nourishment, a soft engineering option, is also briefly discussed in the report. While this option could be used to offset any long term erosion associated with projected sea level rise, it has serious difficulties as discussed in Section 4.4. In particular, the option is likely to be very expensive and will require identification of an appropriate source of sand. The option is not likely to be practicable in the near future.

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1 Introduction

1.1 Purpose of Report

Whangaumu Bay is a developed pocket sand beach south of Tutukaka and east of Ngunguru Spit (Figure 1).

The original subdivision placed properties close to the sea leaving only a relatively narrow dune buffer to seaward. The close proximity of the development to the sea and the limited width of the dune buffer seaward of the properties has led to a range of issues being experienced over time, including erosion hazard, placement of shoreline armouring works and degradation of the natural dune system.

This report was commissioned by Northland Regional Council to report on these issues and possible solutions, both in the short- and longer-term. The issues at the site are not unique and typical of much early post-war subdivision along the east coast of Northland and many other areas of the North Island. Accordingly, it is hoped that the report addressing the issues at Whangaumu will also help clarify management directions for similar sites along the Northland coast

1.2 Methodology and Data

The preparation of the report has involved the following work:

- Review of previous investigations and reports relevant to beach development and coastal hazards at this site and the east coast of the Northland Region.
- Collation and analysis of available data – including:
  - Historic photographs provided by Northland Regional Council (Table 1), including photographs taken after severe erosion in the late 1970's
  - Various historic vertical and oblique photography (Table 1)
  - Historic shoreline change data provided by Northland Regional Council (NRC Plan No. 2163/26) and contained in Gibb (1998) (Table 1)
  - Beach profile data (Table 1)

  This various data together with the field inspections conducted during this investigation provide 'snapshots' of the beach and shoreline change from 1942 through to the present, a period of just over 70 years (Table 1).
- Field investigations conducted in June 2012 - including detailed examination of dune morphology and vegetation over the full length of the bay and survey of cross sections over the dune and beach at various points. Useful discussions were also held with various landowners along the beach who happened to be present during the fieldwork.

Figure 1: Location of study site (arrowed)

Table 1: Data used in study

Year	Description of Data	Source or Plan/Photo Number
1942	Vertical aerial photograph entire beach flown 30 April 1942	NZ Aerial Mapping SN209 405/25
1942	Mapped shoreline (toe of dune) from aerial photo	NRC Plan No. 2163/26 & Gibb 1998
1959	Mapped shoreline (toe of dune) from aerial photo	NRC Plan No. 2163/26 & Gibb 1998
1961	Mapped shoreline (toe of dune) from aerial photo	NRC Plan No. 2163/26 & Gibb 1998
1963	Vertical aerial photo (entire beach) flown 11 Oct 1963	NZ Aerial Mapping SN1561 B/1&2
1976	Oblique aerial photograph (entire beach) flown 2 April 1976	Whites Aviation WA7236F
1979	Vertical aerial photograph (entire beach) flown 10 Jan 1979	NZ Aerial mapping SN 5091 F/38
1979	June 1979 photos of severe erosion (July 1978 storm event)	Northland Regional Council
1983	Oblique aerial photographs entire beach flown 24 May 1983	Whites Aviation WA76918&38
1985	Oblique aerial photographs entire beach flown 7 Jan 1985	Whites Aviation WA78042,43 & 44
1985	Mapped shoreline (toe of dune) from aerial photo	NRC Plan No. 2163/26
1989	Photograph western end of beach "circa 1989"	Northland Regional Council
1998	Vertical aerial photograph entire beach flown 4 March 1983	NZ Aerial mapping SN 9772 C/7
1998	Mapped shoreline (toe of dune) from aerial photo	Gibb 1998
1998	Beach profile survey 10 March 1998	Northland Regional Council
2003	Beach profile survey 13 August 2003	Northland Regional Council
2005	Beach profile survey 8 March 2005	Northland Regional Council
2007	Beach profile surveys 27 February and 26 July	Northland Regional Council
2008	Beach profile surveys 7 and 29 January	Northland Regional Council
2009	August 2009 photographs (western and central beach areas)	Northland Regional Council
2010	Beach profile survey 11 August	Northland Regional Council
2012	Beach profile survey, filed inspections and photos June 2012	This study

Unless otherwise indicated, all levels referred to in the report are in terms of the LINZ MSL Datum 1964 (One Tree Point) – based on the benchmark at the single Northland Regional Council beach profile monitoring site located near the centre of the beach.

2 Site Description and Coastal Processes

2.1 Coastal Morphology

Whangaumu bay is a pocket beach of about 750 m length embayed between headlands at the eastern and western ends. The beach is backed by coastal development in western and central areas and by a public reserve at the eastern end (Figure 2) – with only narrow dunes seaward of the properties (Figure 3).

The beach, oriented approximately east-west, is exposed to the south but sheltered from waves to the east and the north. A rock reef extends partly across the bay from the headland at the eastern end (Figure 2 and Figure 3), providing increased shelter to eastern and (to a lesser extent) central areas of the beach. The headland at the western end separates the beach from the entrance to Ngunguru Harbour and associated ebb tide delta (Figure 1). It is not currently known if sediment exchanges between Whangaumu Bay beach and the ebb tide delta off the Ngunguru entrance.

The geology of the area surrounding Whangaumu Bay is primarily greywacke and argillite (NRC, 1988), exposed in the headlands at both ends of the beach.

A small stream draining the catchment behind the beach discharges towards the sheltered east of the beach (Figure 2).

The westernmost end of the beach is backed by rock revetments, which extend over a length of approximately 175 m. The rock revetments front elevated areas which decrease in height eastward from about 15 m to 7 m (Figure 5). The remainder of the beach eastwards to the stream entrance is backed by dunes typically 3-5 m high (Figure 5).

The reserve east of the stream entrance is a low grassed area with trees. The beach in this area is periodically reworked by alongshore migration of the stream entrance and channel, but the grassed reserve to landward is protected by shoreline armouring works (discussed further in Section 514.3).

2.2 Beach Sediments and Sediment Supply

The beach and nearshore sands of Ngunguru Bay (including Whangaumu) are generally fine grained and composed predominantly of feldspar (45-55%), rock fragments (20-25%) and shell (13-27%) (Central Laboratories, 1986 – referenced from NRC, 1988).

The quartzo-feldspathic sands were primarily derived from onshore movement following the most recent post-glacial rise in sea level (Schofield, 1965, 1975 & 1979; NRC, 1988; Gibb, 1998). These sands were deposited offshore during periods of lower sea level, primarily derived from the ancestral Waikato River which discharged into the Hauraki Gulf though the Firth of Thames up until about 20,000 years ago (Schofield, 1965, 1970). Investigations of Holocene beach development along the east coast of the North Island indicate that most net onshore movement to beaches from the inner shelf has now ceased (Gillie, 1979; Hilton, 1995; Hesp and Hilton, 1996; Dahm and Munro, 2002).

Figure 2: Recent aerial photograph of Whangaumu Bay (from Google Earth)

Figure 3: Whangaumu Bay showing property boundaries (from Whangarei District Council GIS maps). Note the narrow vegetated dune buffer seaward of the properties

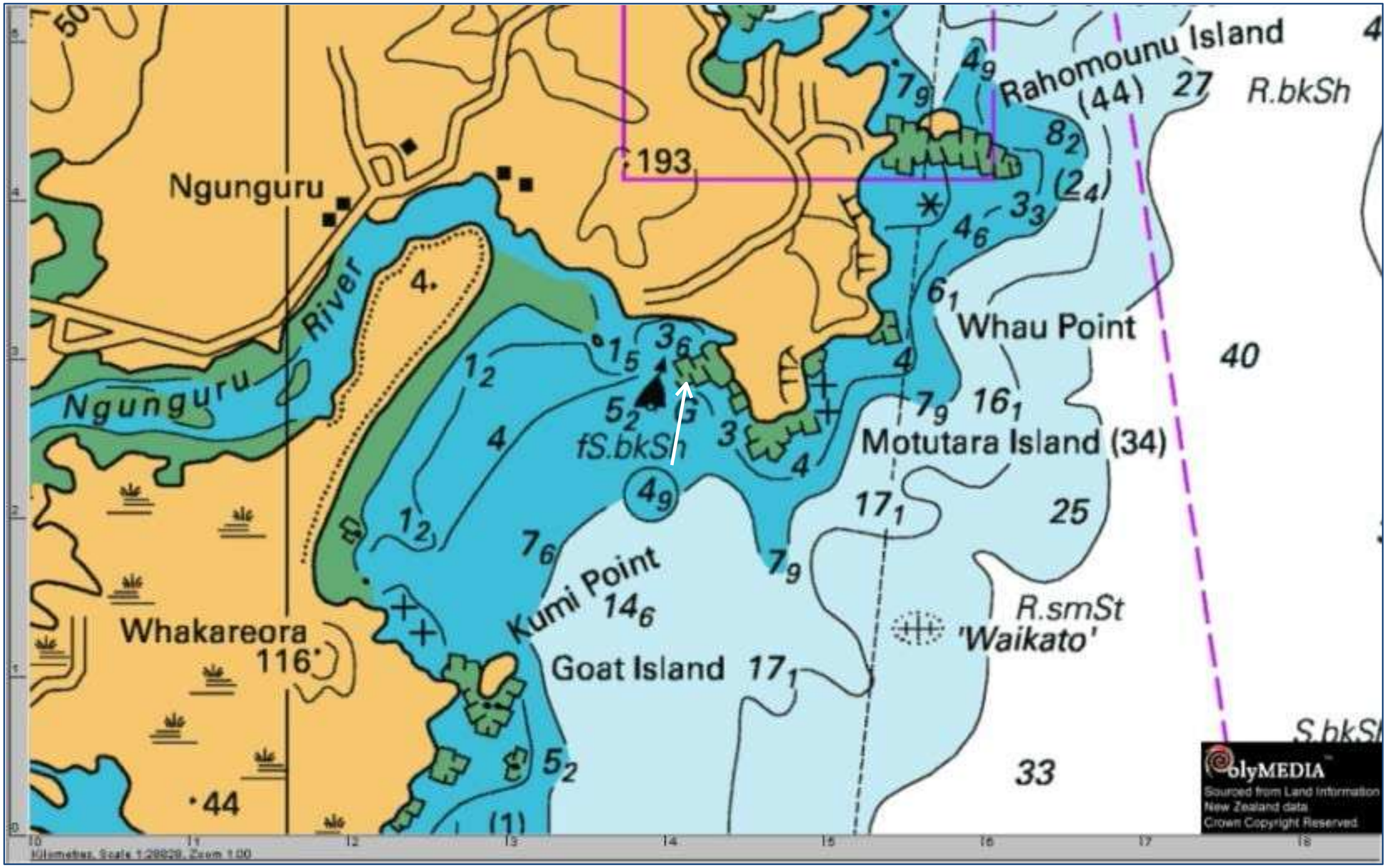

Figure 4: Bathymetry in vicinity of Ngunguru and Whangaumu. Reef off the eastern end of Whangaumu is arrowed.

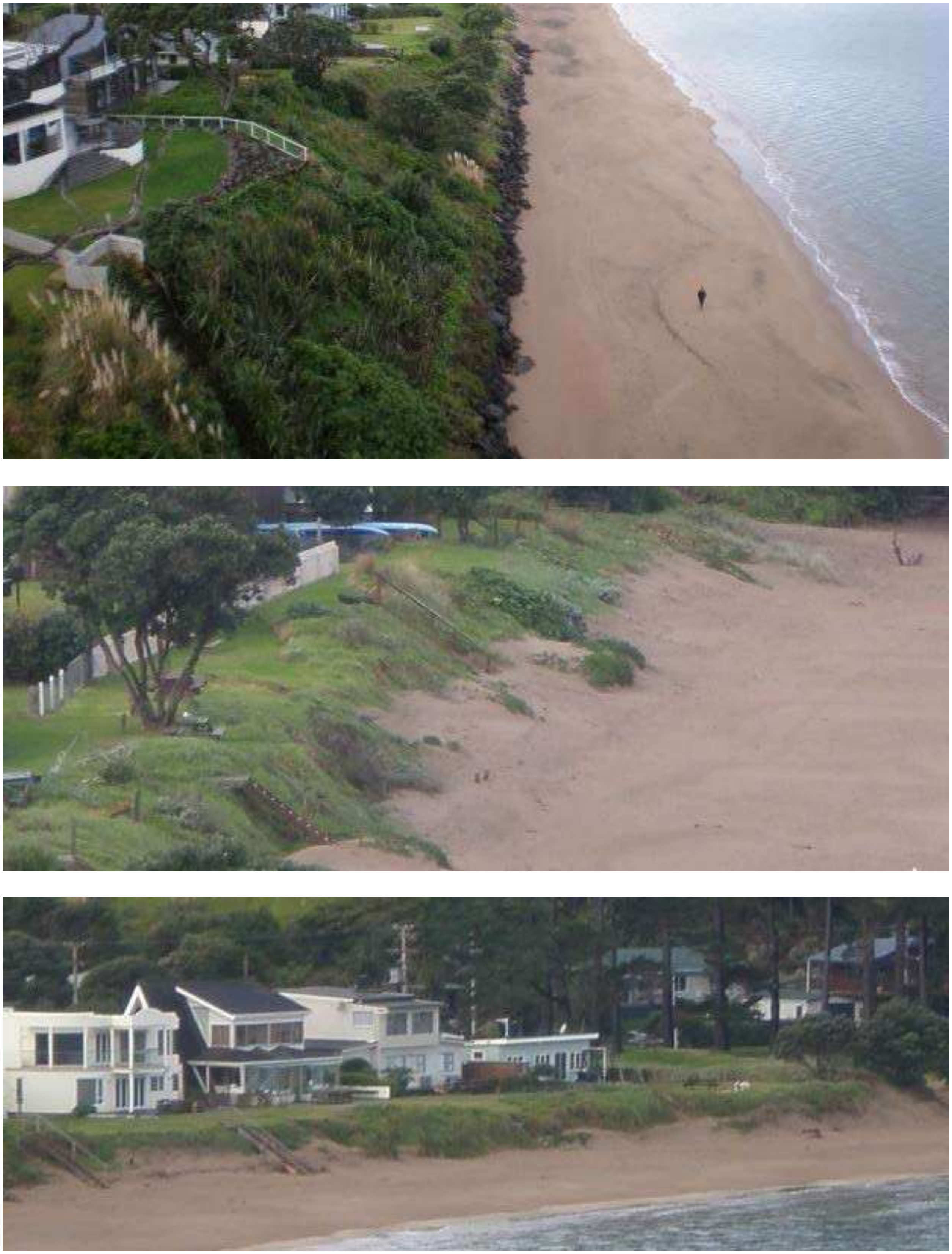

Figure 5: View of high dunes and rock revetment at western end of the beach (top) and dunes in central (middle photo) and eastern (bottom photo) ends of the beach

The rock and shell fragments indicate a significant component of locally derived sediment, but any ongoing sand supply from these sources is believed to be slow (NRC, 1988).

It is not presently known if the beach exchanges sand with the ebb tide delta offshore from the Ngunguru Harbour entrance – though it is not likely that there is a net sand supply from this source.

Accordingly, the sands of Whangaumu Beach are finite and for practical management purposes the beach essentially has all of the sand it is ever going to get (NRC, 1988).

2.3 Astronomical Tides and Storm Surge

Marsden Point is the nearest tide gauge to this site. Tidal parameters for that site are summarised in Table 2 relative to Chart Datum – based on data from the LINZ web site[1]. The tidal elevations have also been converted to the One Tree Point (OTP) mean sea level datum using the correction of -1.677 given by Howse (2005).

It can be seen that Marsden Point has an average spring and neap tide ranges of 2.3 m and 1.43 m, respectively. The highest astronomical tide (HAT) is just over 1.3 m above mean sea level.

The Secondary Ports table[2] suggests that tidal elevations vary slightly at Tutukaka Harbour – the nearest site to Whangaumu Bay – with spring and neap ranges of 2 m and 1.1 m, respectively.

Table 2: tidal parameters for Marsden Point in terms of Chart Datum and the One Tree Point (OTP) mean sea level datum

Site	Datum	HAT	MHWS	MHWN	MSL	MLWN	MLWS
Marsden Point	Chart Datum	2.99	2.72	2.29	1.56	0.86	0.42
	MSL (OTP)	1.31	1.04	0.61	-0.117	-0.82	-1.27
Tutukaka Harbour	Chart Datum		2.3	1.9	1.4	0.8	0.3
	MSL (OTP)		0.62	0.223	-0.277	-0.877	-1.38

Storm surge, caused by meteorological conditions such as a drop in atmospheric pressure (the inverted barometric pressure response) and wind stress, can elevate sea levels well above predicted tides. For instance, Bell *et al*. (2000) report that:

- Storm surge during Cyclone Bola (6-9 March, 1988), associated with strong southeast winds and low atmospheric pressure, resulted in extreme sea levels about 0.63 m above predicted tides at Marsden Point

[1] http://legacy.linz.govt.nz/geodetic/datums-projections-heights/vertical-datums/tidal-level-information-for-surveyors/index.aspx : This site presents the average predicted values for MHWS, MHWN, MLWN and MLWS over the 18.6 year tidal cycle. The value of MSL is based on 19 years of tidal observations (1991-2009). The value of HAT is the highest tide level predicted to occur under average meteorological conditions during the period 1 January 2000 to 31 December 2018.
[2] http://legacy.linz.govt.nz/docs/hydro/tidal-info/tide-tables/sec-ports/marsden-point.pdf

- Cyclone Giselle (the Wahine storm) on 9-10 April 1968 resulted in a maximum storm surge of at least 0.88 m at the Port of Tauranga.

They note that the maximum possible storm surge on the New Zealand coast is probably in the order of about 1 m – with extreme storm surge heights being around double the inverted barometer effect for Northern New Zealand.

Extreme sea levels arising from the combination of astronomical tides and storm surge have not yet been estimated for this area of the Northland coast.

2.4 Waves, Wave Setup and Runup

The east coast of Northland is sheltered from prevailing southwest and westerly winds and is a low energy lee shore with average wave heights of 1-2 m and average wave periods of about 7 seconds (MfE, 2004).

The storm wave climate primarily relates to mid-latitude weather systems and infrequent tropical cyclones (NIWA, 2003). Storms associated with these events result in wave energy arriving from a range of directions but predominantly from the north through to the east and more particularly the east through to northeast (see wave rose in Figure C.10 on p18 of NIWA, 2003).

Whangaumu Bay is sheltered from these more common storm wave directions and only directly exposed to waves from the southeast and south-southeast (Figure 1). The eastern headland and the rock reef which extends seaward from this feature (Figure 4) act to further reduce wave exposure towards the eastern end of the beach.

Storm waves from southeasterly directions are far less frequent than waves from the east and northeast (see wave rose in Figure C.10 on p18 of NIWA, 2003) but do occur. For instance, in July and August 2000 sustained southeast winds caused significant erosion on many east coast beaches of Northland (NIWA, 2003).

Therefore, severe beach erosion and (in lower areas such as the reserve at the eastern end) coastal inundation are likely to occur primarily during south-easterly storm wave events. However, while the beach is not directly exposed to the east, easterly storm waves probably do refract around the headland seaward of the bay and impact the beach, particularly towards the more exposed western end.

In any given year, severe storm waves are most likely to be experienced during the period from February-July, inclusive. Waves along the northeast coast of New Zealand also tend to be about 50% higher in the winter than during summer (MfE, 2004).

During major coastal storms on the Northland coast, storm wave runup can commonly reach elevations of 3.5-4 m and during extreme events may reach higher elevations depending on factors such as wave and beach conditions and exposure (Howse, 2005). Therefore, during storm wave conditions with elevated sea levels wave runup can result in severe dune erosion. In low-lying areas such as the eastern end of Whangaumu Beach, there is also potential for wave inundation and overtopping.

2.5 ENSO and IPO

The El Nino-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) have a significant influence on sea levels and the frequency of coastal storms along the eastern coast of New Zealand.

ENSO is a quasi-periodic climate system characterized by a cycle of alternate El Nino and La Nina episodes that influences climate and sea level variations around the Pacific, with cycles of 2 to 5 years (NIWA, 2003). ENSO variability dominates the climate of the Pacific on interannual time scales (Calvo et al., 2007). For instance, sea levels on the Northland east coast are depressed below normal levels by up to 0.12 m during El Nino episodes (negative SOI) and can be elevated by a similar amount during La Nina episodes (NIWA, 2003). There is also a higher frequency of extra-tropical cyclones affecting New Zealand during La Nina conditions and larger, steeper waves (i.e. more likely to cause erosion) are more frequent (de Lange, 2007). Therefore, there is a higher probability of dune erosion during La Nina events.

The IPO involves 20-30 year oscillations of alternate positive (warm) and negative (cool) phases that affect the Pacific area (NIWA, 2003; MfE, 2008). The IPO is presently in a negative phase which commenced in 1998 and which may last until sometime between 2020 and 2030 (NIWA, 2003). The previous negative phase of the IPO occurred in the period between 1947 and 1976/77, with a positive phase from 1978-1998.

The IPO has been shown to modulate the strength and frequency of ENSO events and the impact of individual ENSO events (Calvo et al., 2007). Of relevance to Whangaumu Bay, negative phases of the IPO are characterised by more La Nina events, more easterlies and northeasterlies over northern New Zealand and a tendency for beaches on the northeast coastline of New Zealand to erode (de Lange, 2001; MfE, 2008). Sea levels also tend to be elevated (by up to 0.05 m) during negative IPO phases (NIWA, 2003). Accordingly, during the present negative phase of the IPO there is a higher than average probability of dune erosion.

2.6 Coastal Storms

Coastal storms lead to two main hazard drivers:

- Storm surge which elevates ocean and nearshore levels well above predicted tides, leading to increased beach and dune erosion and (in low lying areas) coastal inundation;
- Storm waves and swell which can severely erode beaches and dunes and cause coastal inundation (NIWA, 2003).

A combination of storm waves and storm surge with spring tides can result in substantial beach erosion - as for instance observed along the Northland coast following the July 1978 storm when a 0.5 m storm surge coincided with spring tides (NIWA, 2003).

Overall, the present negative phase of the IPO (predicted by NIWA to persist until sometime between 2020-2030) is likely to contribute to a higher incidence La Nina events, higher sea levels and more frequent beach and dune erosion along the east coast of Northland.

2.7 Sea Level Rise

Sea-level has been rising around New Zealand at a time-averaged rate of about 0.16 m per century since the early-mid 1800's (NIWA, 2003).

In the future, projected climate change is likely to result in an increased rate of sea level rise – probably persisting for some centuries.

To provide some guidance on this assessment process, the present Coastal Hazards and Climate Change Guidance Manual recommends the following sea level rise considerations for planning and decision timeframes out to the 2090s (2090–2099):

1. *a base value sea-level rise of 0.5 m relative to the 1980–1999 average should be used,* ***along with***
2. *an assessment of the potential consequences from a range of possible higher sea-level rises (particularly where impacts are likely to have high consequence or where additional future adaptation options are limited). At the very least, all assessments should consider the consequences of a mean sea-level rise of at least 0.8 m relative to the 1980–1999 average.*

For longer planning and decision timeframes where, as a result of the particular decision, future adaptation options will be limited, an allowance for sea-level rise of 10 mm per year beyond 2100 is recommended (in addition to the above recommendation) (MfE, 2008, p20).

In terms of the period to 2050-2059, the Guidance Manual recommends a base sea level rise of 0.25 m and consideration of the consequences of sea level rise of at least 0.36 m (MfE, 2008, Table 2.3, p21).

This guidance was based on the IPCC Fourth Assessment Report and the science available to 2008.

It is important to appreciate that these are not upper level projections and that sea level rise is also projected to continue for several centuries. In a more recent paper produced by the Royal Society of New Zealand to inform the public on emerging issues (RSNZ, 2010) it was noted that *climate change may cause several metres of sea level rise over the next thousand years (p3)*. They also noted:

> *For the decades and centuries that are important for planning purposes, we cannot yet state the likelihood of a given rate of sea level rise. However, our uncertainty is mostly one-sided, with more possible effects that might hasten sea level rise than might slow it.*

In this regard, the paper notes that recent research has suggested upper limit sea level rise estimates of 1-2.2 m by 2100 with lower limits ranging from 0.3-0.75 m (see Table 2 of RSNZ, 2008 and discussion of this table on their p3).

Accordingly, sea level rise is likely to be a significant factor at Whangaumu Beach in the medium to longer term.

3 Coastal Erosion Hazard at Whangaumu Bay

The shoreline width vulnerable to coastal erosion with both present and projected future sea level change is a critical consideration in the management of nearshore areas. This section reviews and updates previous work on coastal erosion at Whangaumu Bay based on available information on historic shoreline change and present sea level rise projections.

3.1 Previous Work

Previous assessments of coastal erosion hazard at Whangaumu Bay were conducted by NRC (1988) and subsequently reviewed and updated by Gibb (1998).

NRC (1988) assessed erosion hazard based on field inspections and shoreline (toe of dune) changes mapped from aerial photography dating from 1942, 1959, 1961 and 1985. The review by Gibb (1998) considered this data (except for the 1961 photography) and a further toe of dune survey conducted in 1998 (Figure 6).

NRC (1988) assessed coastal erosion, coastal inundation and coastal landslide hazards and delineated two coastal hazard zone (CHZ) setbacks; CHZ1 and CHZ2 (Figure 6). The CHZ1 setback identified the area vulnerable to coastal hazards (i.e. coastal erosion and/or coastal inundation) over 50 years with existing sea level and coastal processes. The CHZ2 setback identified the additional width of land likely to be subject to coastal hazards with a 0.5 m sea-level rise over a 50-year period.

Gibb (1998) re-defined the CHZ1 and CHZ2 setbacks to cover coastal erosion hazard for 50 and 100 year planning periods, respectively. A sea level rise of 0.2 m was assumed for the 50 years and 0.49 m for 100 years – based on the most recent IPCC assessment available at that time.

The following factors were assessed by NRC (1988) and Gibb (1998) in defining coastal erosion hazard at Whangaumu:

- Any long-term trends for net shoreline (toe of dune) advance or retreat (R)
- Maximum likely erosion associated with dynamic shoreline fluctuations (S)
- Collapse of over-steepened dune erosion scarps to a more stable slope (D)
- Stream erosion (relevant only at the eastern end of Whangaumu Bay)
- Potential impact of projected sea level rise (X).
- Factor of safety (F) – Gibb (1998) only.

These various factors are reviewed in the following sections of this chapter.

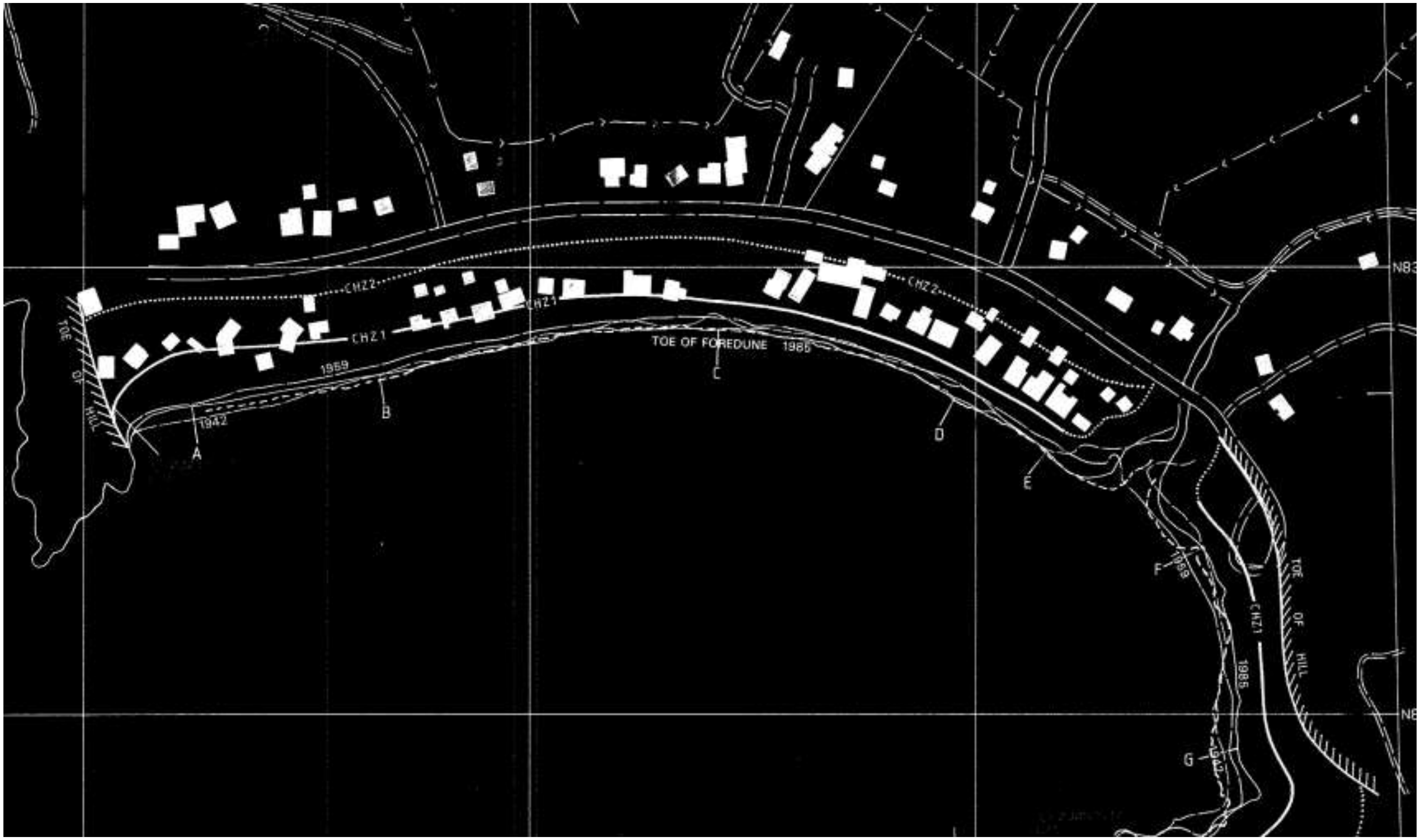

Figure 6: Shoreline changes mapped by (NRC 1988). The analysis by Gibb (1998) presented additional data based on a toe of dune survey from 1998 - analysing shoreline change between 1942 and 1998 at Sections A-G shown on the above figure.

3.2 Long-Term Shoreline Trends

NRC (1988) and Gibb (1998) both assessed long-term trends by comparing the net seaward advance or retreat between the 1942 photography and the latest shoreline fix available to them – a technique known as end-point analysis. Long-term trends were assessed at transects A-G shown in Figure 6.

The analysis by NRC (1988) only included assessed trends for long-term erosion in their setback calculations - but both erosion and accretion trends were included by Gibb (1998)

The long-term trends assessed by the previous workers are summarised in Table 3.

Table 3: Long-term rates of shoreline retreat assessed along Whangaumu Beach by previous work (see Figure 6 for location of transects A-G).

Author	Rate of long-term shoreline change assessed (m/yr)						
	A	B	C	D	E	F	G
NRC 1988	-0.17	0.06	0.14	0.16	0.00	0.00	-0.20
Gibb 1998	-0.09	-0.04	0.11	0.14	0.02	0.07	0.11

It can be seen that both studies assessed a long-term erosion trend at the extreme western end of the beach (Transects A and B) with accretion trends or dynamic equilibrium (i.e. no net change) assessed for most (though not all) other areas.

However, the assessed trends appear unrealistic – with significant differences in long term trends alongshore. For instance, the long-term trends assessed by Gibb (1998) would result in some areas of the beach being offset relative to each other by up to 23 m over the next century. It is difficult to envisage what mechanisms operating at this site could produce such contrasting trends for permanent shoreline advance and retreat along the beach. The trends, if real, would also significantly change the plan shape of the beach over time and this is unlikely – given that the existing plan shape has evolved over a long period of time. (Most studies that have dated beach development along the east coast of the North Island indicate that beach development typically commenced at least 6-7,000 years ago, shortly after sea level reached present elevation following the most recent post glacial sea level rise).

In my opinion, the assessed trends are an artefact of either errors in mapping the historic shorelines and/or the technique used to assess the long term trends. For instance, the use of end-point analysis to assess long term trends can result in significant anomalies on shorelines where (like Whangaumu Bay) dynamic fluctuations are significant relative to long-term trends.

An alternative approach to assessing long-term trends is shown in Figure 7.

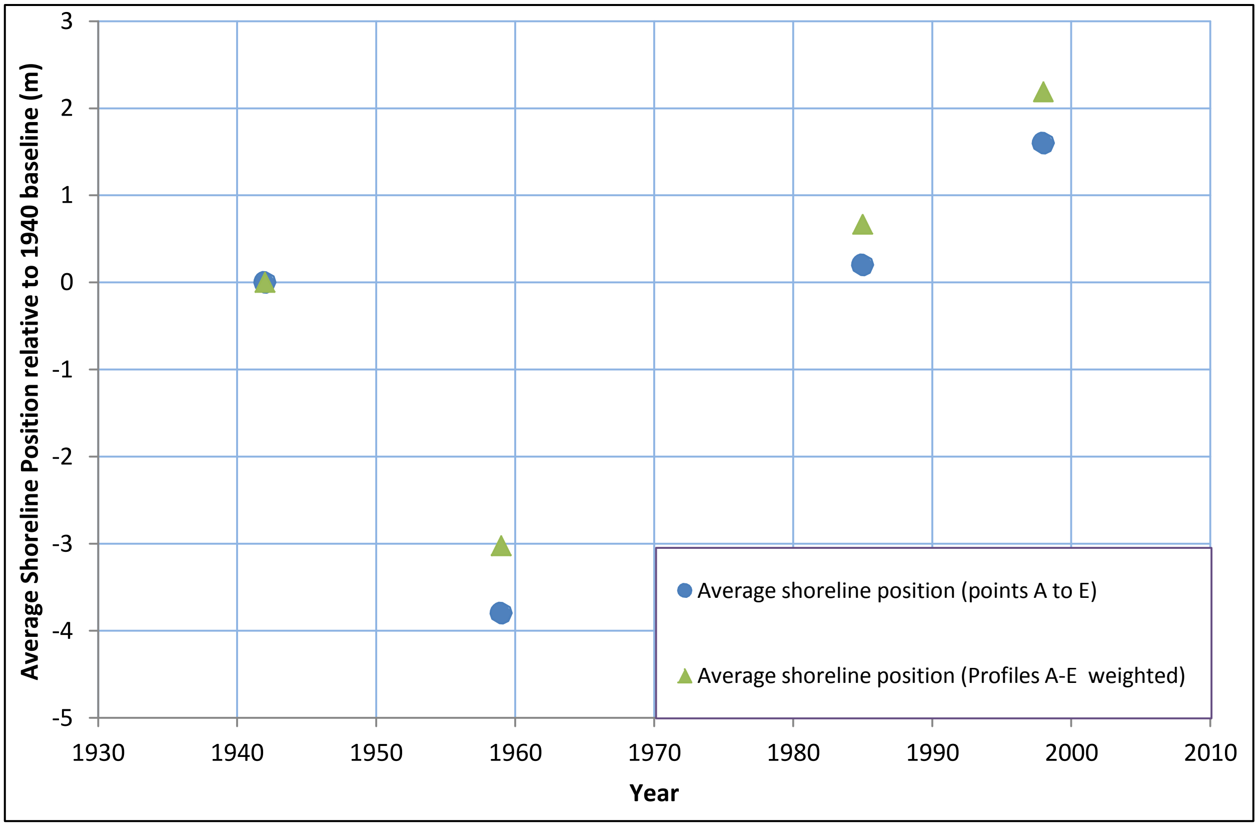

Figure 7: Average shoreline position in 1942, 1959, 1985 and 1998 relative to 1942 shoreline (see text for discussion)

This figure shows the average shoreline position along the main beach (i.e. Profiles A-E inclusive) relative to the 1942 shoreline – using data from Gibb (1998).[3] It can be seen that the average shoreline position retreated significantly between 1942 and 1959 but by 1985 had recovered to a similar position to 1942 and by 1998 was seaward of the 1942 position.

This pattern suggests a shoreline in equilibrium subject to dynamic fluctuations (i.e. periods of shoreline erosion and recovery) - with little to no present trend for permanent shoreline advance or retreat.

A similar conclusion is suggested by various other lines of evidence. For instance:

- In 1942 the shoreline was in an accreted position (Figure 7) with a low frontal dune seaward of the higher bank behind (Figure 8). However, there is also clear evidence of an historic storm erosion scarp on the high bank behind the lower frontal dune (Figure 8).

[3] Profiles F and G were excluded from the calculations as duneline positions in this area are affected by stream erosion as well as storm wave erosion. However, analysis using this data also showed similar trends to Figure 7. The "weighted" averages in the figure were calculated by weighting shoreline position at each of Profiles A-E according to the proportion of the total shoreline length represented by each profile – whereas the other average is simply the arithmetic average of the 5 values. Both values show similar trends.

Figure 8: 1942 aerial photograph showing dune in accreted position. For instance, note the wide (8-10 m) dune seaward of the elevated land at the western end of the beach. The elevated area immediately landward of this dune also shows an old erosion scarp (tip of black arrow) indicating previous periods of storm erosion similar to that shown in

- The shoreline subsequently underwent significant erosion by 1959 (Figure 6 and Figure 7), with photos indicating that the low frontal dune evident at the western end of the beach was largely removed. The relatively rapid erosion is consistent with storm erosion rather than progressive shoreline retreat.
- Photographs from the 1970's indicate further storm erosion, culminating in the erosion of July 1978 (Figure 9) - the most serious erosion evident in photographs in the period 1963-1978. The top edge of the erosion scarp at the southern end of the beach after the 1978 event was similar to the historic erosion scarp evident in the 1942 aerial photograph.
- The shoreline then showed an overall trend for shoreline recovery in the period to 1998 (Figure 7), evident also in aerial photos taken during the period (e.g. Figure 11) even though photographs indicate occasional storm events in this period. This recovery occurred in the period after 1978.

Interestingly, the pattern of erosion and accretion noted demonstrates a fairly close relationship to IPO phases over the period – also consistent with storm cut and recovery rather than any trends for progressive shoreline change. For instance:

- The accreted dune condition evident in the 1942 aerial photograph occurred towards the end of a lengthy positive phase of the IPO extending from 1925-1946.

- The period of erosion between 1942 and 1959 (Figure 7) coincided with change to a negative phase of the IPO (which commenced in 1947).

- The most severe erosion evident in the 70 year record occurred during the July 1978 storm event (Figure 9) which followed a lengthy (1947-1977) negative phase of the IPO, the impact of this event probably reflecting in part the cumulative dune erosion in preceding years.

- The overall trend for dune recovery evident in the period to 1998 (Figure 7) coincided with the change back to a positive phase of the IPO. The fact that this duneline recovery occurred after the July 1978 event further suggests a fairly strong relationship to the IPO – as the positive phase of the IPO commenced about 1977. The overall trend for dune recovery is also evident in photographs from the 1980's (e.g. Figure 11).

Overall, the data suggests there may be a broad relationship between IPO phase and the pattern of storm erosion and recovery at Whangaumu Bay – suggesting a higher probability of overall dune erosion during negative IPO phases and overall dune recovery during positive IPO phases.[4]

This apparent broad relationship with IPO has implications for management of the site as discussed later in the report.

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[4] This does not mean that periods of storm erosion do not occur in positive IPO phases or that periods of dune recovery do not occur in negative IPO phases – but it does suggest there is more likely to be a general overall trend for erosion during negative IPO phases and for dune recovery during positive IPO phases.

Figure 9: Severe dune erosion caused by storm of July 1978. The fencing (top photo), vegetation recovery on dune face (bottom photo) and the build-up around the brush dune fence (bottom photo) indicate the erosion occurred sometime before these photos were taken (Northland Regional Council photographs – believed to date from June 1979).

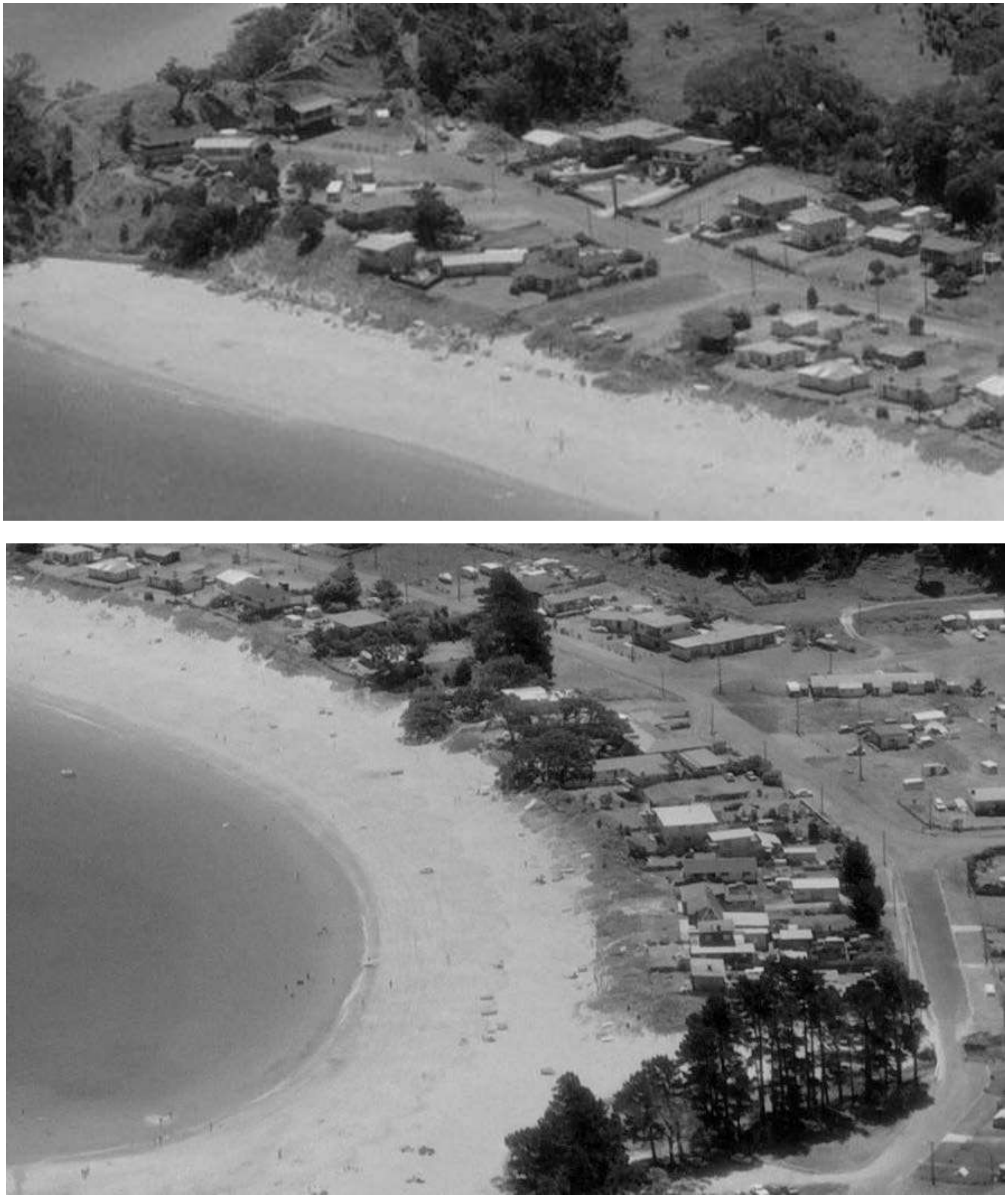

Figure 10: Aerial photographs from 7 January 1985 showing vegetated frontal dunes recovering from erosion in 1970's (Photo: Whites Aviation - WA78042F, Alexander Turnbull Library).

3.3 Dynamic Shoreline Fluctuations

The considerations in the previous section suggest that dynamic shoreline fluctuations associated with periods of dune erosion and recovery are the primary present day cause of coastal erosion at Whangaumu Bay. There is no evidence that the site is yet experiencing any measurable trend for net shoreline retreat.

In other words, calculating the maximum likely erosion associated with dynamic shoreline fluctuations will essentially define the present day coastal erosion hazard. This calculation requires assessment of two separate factors:

- Dune toe erosion by storm waves (factor S discussed in Section 3.1)
- Collapse of the eroded dune face to a more stable slope (factor D discussed in Section 3.1)

3.3.1 Dune toe erosion

NRC (1988) and Gibb (1998) assessed the maximum likely magnitude of dynamic shoreline fluctuations using historic mapped shorelines, field inspections (e.g. noting the position of historic erosion scarps) and other information (e.g. historic photos, newspaper articles and previous reports) where available.

Both studies assessed the maximum likely dune toe erosion at Whangaumu Bay to be 10 m, relative to their respective reference shorelines – though Gibb (1998) also applied a multiplier of 1.3 (factor of safety) to this and the other components in his erosion assessment.

Examination of the various historic mapped shorelines and historic imagery available to this study (Table 1) and field examinations support the findings of the earlier work that 10 m is a reasonable estimate of the maximum likely dune toe erosion at Whangaumu Bay – relative to the most seaward vegetated dune toe. The estimate is more precautionary in central and eastern areas than at the western end.

3.3.2 Collapse of eroded dune face to more stable slope

A common approach to this factor is to assume that the dune face will collapse to the angle of repose of dry sand, with this slope formed by the top half of the eroded scarp collapsing to the base. This was the approach adopted by Gibb (1998) and is in my opinion adequately precautionary.

However, the assessment by Gibb (1998) did not allow for the fact that storm erosion at the western end of the beach cuts back into much higher dunes (e.g. see Figure 9), with field survey indicating these dunes vary from 7-15 m in height (decreasing in height with distance east). Gibb (1998) adopted much lower dune heights for this area in his calculations (see values of h1 on page 5 of Appendix II of Gibb, 1998). Accordingly, his calculated values of D under-estimate this factor for the western end of Whangaumu Bay – even considering the factor of safety of 1.3 applied to the estimates.

3.3.3 Most severe historic dune erosion at Whangaumu

The most severe dune erosion evident in historic photographs is the erosion that occurred following the major storm of July 1978 (Figure 9). As noted earlier, this storm followed a prolonged period of negative IPO in which there was a reasonably high incidence of coastal storms and coastal erosion along the east coast of the North Island.

Severe erosion also occurred between 1942 and 1959 (Figure 6 and Figure 7). Examination of photographic evidence from the 1960's and 1970's suggest this erosion was less severe than that in July 1978 (e.g. Figure 11). However, as some of the properties in this area were levelled seaward during or shortly after subdivision in the early 1960's, it is also possible that the top edge of the 1950's erosion scarp was modified (i.e. moved seaward).

The 1942 aerial photograph shows an historic erosion scarp landward of the (then) accreted shoreline (Figure 8), in very similar location to the erosion scarp evident after the 1978 erosion. The date of this earlier erosion is unknown. It may have occurred during the severe coastal storms of 1936 (two separate events - 1-2 February and 25-26 March, 1936) which caused severe coastal erosion at many east coast sites - but this is uncertain.

Overall, it appears that the July 1978 erosion event and the above-noted historic event prior to 1942 are the two most serious coastal erosion events over at least the last 70-80 years – with these events of similar severity.

Observation of historic erosion scarps using field examinations and the available photographic record also provide a useful indication of the worst likely storm erosion – certainly for return periods of at least 50-60 years. These observations indicate that historic erosion scarps associated with rare and severe erosion events (e.g. July 1978):

- Extend up to and often within private properties at the western end of the beach (particularly 8-18 Whangaumu Road)
- Extend up to or close to front property boundaries in the area immediately east of the seawall (22-28 Whangaumu Road)
- Lie well seaward (typically by at least 3-5 m) of private property boundaries in other beach areas.

Overall, it appears that from 30 Whangaumu Road eastwards, the reserve seaward of the properties is generally adequate to protect against the worst likely storm erosion with existing sea level. In areas further west, the reserve width set aside at the time of the original subdivision is less adequate and (in the absence of protection works) the seaward edge of private properties could be impacted by rare and severe erosion (e.g. July 1978 event). However, there are no existing houses that would be at risk from severe storm erosion alone.

Figure 11: Photograph of south end of beach taken in April 1976. Note evidence of recent dune face erosion (arrowed). The subsequent July 1978 event extended erosion within some of the property boundaries in this area and also partly undermined the house nearest the bank (see Figure 9). The properties in the area of the arrow (14-18 Whangaumu Road) were levelled at or shortly after subdivision in the early 1960's, extending the flat grassed areas seaward over an earlier erosion scarp. So there were earlier erosion events that extended further landward than shown. The vegetated dune face (i.e. absence of recent erosion) at the extreme western end (bottom left of photo) reflects protection then provided by a wooden sea wall. (Whites Aviation photo WA72365F, Alexander Turnbull Library).

3.4 Potential Impact of Projected Sea level Rise

In the longer term, the existing risk from coastal erosion may be aggravated by projected sea level rise and possibly other changes accompanying predicted global warming. This section provides a brief assessment of this potential longer term risk based on the present sea level rise projections recommended for planning purposes (outlined in MfE, 2008).

3.4.1 Best present sea level rise projections

Sea-level has been rising around New Zealand at a time-averaged rate of about 0.16 m per century since the early-mid 1800's (NIWA, 2003). In the future, projected climate change is likely to result in an increased rate of sea level rise – probably persisting for some centuries (MfE, 2008; RSNZ, 2010).

The present Coastal Hazards and Climate Change Guidance Manual (MfE, 2008) recommends the following sea level rise considerations for planning and decision timeframes out to the 2090s (2090–2099):

1. *a base value sea-level rise of 0.5 m relative to the 1980–1999 average should be used, along with*
2. *an assessment of the potential consequences from a range of possible higher sea-level rises (particularly where impacts are likely to have high consequence or where additional future adaptation options are limited). At the very least, all assessments should consider the consequences of a mean sea-level rise of at least 0.8 m relative to the 1980–1999 average.*

For longer planning and decision timeframes where, as a result of the particular decision, future adaptation options will be limited, an allowance for sea-level rise of 10 mm per year beyond 2100 is recommended (in addition to the above recommendation) (MfE, 2008, p20).

In terms of the period to 2050-2059, the Guidance Manual recommends a base sea level rise of 0.25 m and consideration of the consequences of sea level rise of at least 0.36 m (MfE, 2008, Table 2.3, p21).

This guidance is based on the IPCC Fourth Assessment Report and the science available to 2008.

It is important to appreciate that these are not upper level projections and that sea level rise is also projected to continue for several centuries. In a more recent paper produced by the Royal Society of New Zealand to inform the public on emerging issues (RSNZ, 2010) it was noted that climate change may cause several metres of sea level rise over the next thousand years (p3). They also noted:

> *For the decades and centuries that are important for planning purposes, we cannot yet state the likelihood of a given rate of sea level rise. However, our uncertainty is mostly one-sided, with more possible effects that might hasten sea level rise than might slow it.*

In this regard, the paper notes that recent research has suggested upper limit sea level rise estimates of 1-2.2 m by 2100 with lower limits ranging from 0.3-0.75 m (see Table 2 of RSNZ, 2008 and discussion of this table on their p3).

In addition, sea level is projected to continue to rise for several centuries.

Accordingly, sea level rise is likely to be a significant factor at beaches along the Northland coast in the medium and longer term.

3.4.2 Potential impact of sea level rise on coastal erosion

On the embayed beach systems of the eastern coast of Northland, such as Whangaumu Bay, it is very likely that projected sea level rise will cause net erosion.

In general, an indicative assessment of the impact of sea level rise on sandy beaches in these settings can be provided by the simple Bruun Rule (Bruun, 1962, 1983). This rule predicts that as sea level rises against a shore profile in equilibrium, beach erosion takes place to provide sediments to the nearshore so that the seabed can elevate in direct proportion to the rate of sea level rise.

Bruun proposed the following simple equation to estimate the extent of shoreline retreat:

$X = al/h$

Where

> X = shoreline retreat due to sea level rise,
>
> a = the rise in mean sea level,
>
> l = the horizontal distance between the foredune crest and the seaward limit of profile adjustment (a depth known as the closure depth), and
>
> h is the elevation between these two points.

The various assumptions underlying application of the Bruun Rule generally apply to the embayed beaches of the Northland east coast and therefore this approach has been adopted by previous workers (NRC, 1988; Gibb, 1998) to estimate the potential impact of projected sea level rise on coastal erosion. The method is simple and crude but is the best approach presently available to provide an *indicative* assessment of the potential impact of projected sea level rise.

The work by Gibb (1998) used “mid-range projections” of sea level rise from the most recent IPCC assessment then available (IPCC, 1996) - being 0.2m and 0.49m for the years 2050 and 2100, respectively. He estimated that these projected sea level rises could result in net retreat of 3-4 m over the next 50 years and 7-10 m over the next 100 years (see Appendix II of Gibb, 1998).

In this study, the sea level rise projections have been altered to 0.36 m by the 2050’s and 0.9 m over the next 100 years - to reflect the updated projections recommended for planning purposes as discussed further above. The calculations (using the same Bruun Rule parameters as Gibb, 1998), indicate that:

- Projected sea level rise of 0.36 m could result in net erosion of about 6 m over the next 50 years
- Projected sea level rise of 0.9m could result in net erosion of 15 m over the next 100 years.

It is important to note that these are *projection*s and not *prediction*s as the scale and rate of sea level rise are matters of uncertainty, as is the scale of erosion that may accompany any given sea level rise. Moreover, there are other potential effects of climate change that the Bruun Rule does not take into account – such as any change in the frequency, duration and/or severity of coastal storms and the potential for changes in beach plan shape that may accompany any change in wave climate. There is presently insufficient information to make any useful assessment of the likelihood or impact of such changes. There may also be erosion resistant geology under the Holocene dunes which will limit any erosion that can occur – sub-surface investigations would be required to investigate this aspect.

Nonetheless, the indicative Bruun Rule calculations do indicate the potentially serious impact of projected sea level rise. In simple terms, projected sea level rise has the potential to fundamentally change the coastal dynamics of Whangaumu Bay – from a shoreline which simply fluctuates backwards and forwards over time to one which also shows a trend for significant permanent shoreline retreat

The potential impact of projected sea level rise will depend on whether or not there are older and more erosion resistant geology underlying the Holocene dunes that may limit the erosion – which would require subsurface investigations to assess.

If the width of Holocene dune sands exceeds the assessed erosion, then any progressive erosion accompanying future sea level rise will erode deeply into adjacent properties.

Conversely, if erosion resistant materials become exposed along the back of the beach, the response to any ongoing erosion will change - progressively narrowing the beach to seaward rather than impacting property to landward. In this case, the ongoing progressive erosion could eventually eliminate a high tide dry beach with Whangaumu Bay becoming an intertidal beach backed by low, slowly eroding banks or cliffs cut in the erosion resistant materials.

Similarly, in any area of the beach backed by a rock sea wall, the response to progressive erosion accompanying sea level rise would be progressive narrowing of the beach – eventually eliminating the high tide beach seaward of the rock wall.

It is clear from the above considerations that projected sea level rise has the potential to seriously impact on private properties to landward and/or the beach itself.

Sea level rise would also increase the potential for inundation from storm surge and storm waves – particularly the low-lying areas at the eastern end of the beach.

3.5 Stream Erosion

The stream at the eastern end of the beach has a significant influence on beach and dune erosion in this area, particularly the area to the east of the stream entrance. Field inspections and historic photographs indicate that this area has historically been eroded by eastward alongshore migration of the stream channel and entrance.

Erosion protection structures have since been placed to limit the landward extent of erosion accompanying such stream channel movements (Figure 12).

3.6 Safety Factor

In my opinion, the safety factor of 1.3 applied by Gibb (1998) in estimate of development setbacks is adequate and not excessively precautionary.

Figure 12: View of reserve frontage at eastern end of the beach showing rock protection placed to limit landward extent of stream and storm erosion. Note the low dune seaward of the rock wall.

3.7 Summary of Erosion Hazard

This section briefly summarises the results of the review of erosion hazard – in regard to both the existing situation and to the medium and longer term future. Implications for the existing setbacks are then discussed.

3.7.1 Existing situation

At present, the beach appears to be in dynamic equilibrium – the duneline simply fluctuating backwards and forwards over time. There is no conclusive evidence in available data of any significant trend for permanent net shoreline advance or retreat.

The most significant shoreline fluctuations occur over periods of decades in association with storm erosion and recovery.

This pattern of erosion and subsequent recovery appears to have a broad relationship with climatic cycles, particularly IPO; with a general tendency for the dune to undergo net erosion during negative phases of the IPO and net dune recovery during positive IPO phases.

In general, the most severe erosion accompanying dynamic fluctuations does not extend back to property boundaries – except towards the western end of the beach (from about 28 Whangaumu Road westwards and particularly between 4 to 18 Whangaumu Road).

At present, natural dune recovery is severely limited by inappropriate dune vegetation and the absence of the native species (spinifex and pingao) critical to natural dune building and repair (see Section 4.2).

3.7.2 Medium and longer term future

The review suggests there is potential for projected sea level rise to fundamentally change the behavior of Whangaumu Beach over the next 50-100 years – by introducing a trend for progressive shoreline retreat on top of the existing dynamic shoreline fluctuations.

There is considerable uncertainty as to the scale and timing of this potential erosion, as the effects are critically dependent on the rate and scale of future sea level rise and on the impact of this sea level rise on erosion. These matters cannot be presently quantified with any certainty.

Nonetheless, broadly indicative estimates based on sea level rise projections currently recommended for planning purposes and use of the Bruun Rule suggest potential for net shoreline retreat of about 6 m and 15 m over the next 50 and 100 years, respectively. This erosion will be in addition to that associated with dynamic shoreline fluctuations.

Erosion of this scale would lead to serious erosion damage of properties and/or significant beach narrowing and loss – these effects depending on the width of the Holocene sands backing the beach. Sub-surface investigations would be required to assess the width of Holocene dune sands and thereby better assess the potential impact of projected sea level rise on the beach and adjacent properties. In the interim, a precautionary approach is appropriate – i.e. assume erodible sands over the full width of the assessed erosion. The setbacks can be modified if future investigations indicate this is not the case.

In the longer term (i.e. beyond the next 100 years), best present information suggests that sea level will continue to rise and probably for centuries (MfE, 2008; RSNZ, 2010). Accordingly, there is potential for serious erosion damage at Whangaumu Bay over the next few centuries.

3.8 Recommendations for Setback Revision

The review of coastal erosion has changed some factors involved in the calculation of the existing coastal hazard setbacks by the last review (Gibb, 1998), namely:

- Removal of existing long term trends for net shoreline advance and retreat – as available evidence suggests these trends are not real.
- Increase in the allowance for erosion accompanying dune face collapse at the western end of the beach (i.e. properties from about 18 Whangaumu Road westwards) – as the dune height in this area was under-estimated in the original calculations.
- Revision of sea level rise calculations - to incorporate changes in national guidance on future sea level projections since the last review of coastal erosion.

The influence of these changes on setback calculations are shown in Appendix II and summarized below in Table 4. It is important to note that the setbacks assume that there are no erosion resistant materials that would limit erosion – which would require subsurface investigations to confirm.

Table 4: Setback estimates using revised factors suggested by this review compared to existing setbacks from Gibb (1998)

	Transect A	Transect B	Transect C	Transect D	Transect E
CHZ 1 Review	**30**	**25**	**20**	**20**	**20**
CHZ 1 Existing	30	25	20	20	20
CHZ 2 Review	**45**	**40**	**20**	**20**	**25**
CHZ 2 Existing	40	40	20	20	25

While there is a small difference between the setbacks calculated by this review relative to the existing setbacks (see Appendix II), when rounded up the recommended setbacks are virtually identical (Table 4). Accordingly, no changes to the existing setbacks are recommended.

However, as plotted on Council GIS maps, the existing setbacks are often quite close to the top landward edge of existing erosion scarps – particularly in the area immediately east of the rock wall. The reasons for this are not clear. It may reflect end effects erosion from the sea wall (see discussion in Section 4.3.2)

– as any such effects not presently accounted for in the setbacks. Alternatively, it may reflect issues with the baseline used to plot the setbacks.

In some places, the CHZ 1 and CHZ2 setbacks plotted on Council maps are also the same. The reasons for this are not clear.

Field checks of the plotted setback suggest they are more than adequate to protect against the worst likely storm erosion with existing sea level (certainly for events with return periods up to 100 years) but in places may not provide the full additional width of protection suggested by the calculations in Table 4.

The close proximity of the setback to historic erosion scraps (though generally >5m landward) also emphasizes the need for complementary measures such as dune restoration.

Management recommendations are discussed in the next chapter.

4 Adaptation Options and Recommendations

This section evaluates the various adaptation options for managing the assessed coastal erosion hazard in Whangaumu Bay and develops recommendations for management of coastal erosion hazard.

The management options assessed include:

- Avoid and reduce risk to development using setbacks and development controls
- Restore natural dune defences
- Existing hard engineering options
- Soft engineering options (beach nourishment being the only relevant option at this site)

4.1 Avoid and Reduce Risk using Setbacks and Development Controls

This option involves the use of coastal setbacks and associated development controls to avoid and reduce the risk of adverse effects and of social, environmental and economic harm from coastal erosion.

Elements of this option are already in place with the existing setbacks and District Plan provisions.

4.1.1 Purpose and description

The purpose of this option is to manage development and infrastructure so that the risk of adverse effects and harm is progressively reduced over time – ideally, eventually enabling natural coastal movements to be lived with.

With existing subdivision such as Whangaumu Bay, the measures required typically include:

- **Controls which ensure that new development is located landward of the high risk coastal erosion zone** (CHZ1 in at Whangaumu Bay). Significant renovation of existing houses within the high risk area should also not be permitted.

  Ideally, existing use rights should also be extinguished in regional planning documents (typically the Regional Policy Statement) to preclude use of these provisions to upgrade or replace existing dwellings within the high risk area. Otherwise, experience indicates that some owners will utilise these rights to upgrade or replace existing dwellings within their existing footprint – even in high risk locations. This undermines the effectiveness of the setbacks in risk reduction. The impacts of such actions on lateral views from adjacent properties can lead to these owners also taking similar action - as well as other issues.

- **Requirement for new development landward of the CHZ1 but seaward of CHZ2 to be practicably relocatable.**

  This measure enables new dwellings to be protected in the longer term by landward relocation should this be necessary (i.e. should erosion be aggravated by projected sea level rise).

This requirement recognises that there is considerable uncertainty about the future scale and rate of shoreline change in response to projected sea level rise (e.g. it may occur more quickly) and enables this uncertainty to be provided for without unnecessarily restraining development. It also recognises that new dwellings may ultimately have a design life longer than the 50 years provided for by the CHZ1.

Ideally, relocatability requirements should provide for landward relocation on the existing property. In addition, where there is any doubt that the house can be reasonably and practicably relocated, the applicant should be required to specify the steps that could be undertaken to relocate the dwelling to ensure that the requirement has been reasonably provided for in the design. If relocation is likely to involve significant difficulty, this should be clear in reports accompanying the consent application. If approved, the relevant reports should be attached to the property file so the issues can be noted in any LIM reports (ensuring future owners are adequately informed).

- **Register notice against the property under section 73 of the Building Act 2004** when building consents are granted for dwellings within areas subject to natural hazards (e.g. areas seaward of CHZ1 or CHZ 2 at Whangaumu Bay).

  This is a legislative requirement that protects the Council from civil liability when a property owner exercises their right to build on land subject to a natural hazard and Council grants a building consent pursuant to section 72 of the Building Act. In addition, it ensures that present and future owners are aware of the potential risk.

  It also serves as a flag for Council when considering future consent applications relating to the property – enabling Council to check that the further activities for which consent is sought will not preclude risk avoidance (e.g. prevent a dwelling from being relocated landward of CHZ2 should this be required in the longer term).

  The notice can be removed at a future date if a specialist report is accepted by Council which demonstrates that the natural hazard is no longer present. At Whangaumu Bay, such a report might include an assessment of subsurface geology which demonstrates a geological limit on future erosion.

- **Precluding further subdivision of beachfront sections affected by the defined hazard areas** – so that hazard vulnerability is not increased.

  This is sometimes seen as unnecessary by Councils because lack of services (e.g. reticulated sewers) precludes such subdivision. However, this can result in Councils being “caught out” at a later date when such services are provided and opportunities for subdivision are taken advantage of before Councils can get suitable controls through the planning process.

  The absence of such provisions can also be unfair for future owners – who may buy the property with a view to undertaking subdivision. For instance, when a sewage scheme is proposed for a particular area it quite often attracts buyers wishing to take advantages of the opportunities such services provide. This can also result in serious landowner opposition and significant legal costs associated with attempts by Council to "plug the gap" at a later stage. It is best to signal clearly and early that such activities are not appropriate.

If future work indicates that the risk is less than anticipated and further subdivision is appropriate, regulations can always be changed at that time. (This might occur for instance if future subsurface investigations at Whangaumu were to find that erosion potential is limited – e.g. erosion resistant geology close to the shore). A precautionary approach is required in the interim.

4.1.2 Assessment of option

The identification of areas potentially affected by coastal hazards over at least the next 100 years and the management of these areas to avoid increasing and encourage risk reduction is a requirement of the NZCPS 2010. For instance, in areas potentially affected by coastal hazards over at least the next 100 years, the NZCPS 2010 requires Councils to:

- Avoid increasing the risk of harm and any redevelopment or change in land use that would increase the risk of adverse effects (Policy 25a, b)
- Encourage redevelopment where that would reduce the risk of adverse effects
- Promote and identify long term sustainable risk reduction approaches (Policy 27(1)(a))
- Focus on approaches to risk management that reduce the need for hard protection structures (Policy 27(2)(a)).

Accordingly, this option is central to effective management of coastal hazards at Whangaumu Bay.

Existing setbacks and many of the above development controls are already in place at Whangaumu Bay. Most existing houses are now landward of the CHZ1 and so these existing measures have already been relatively effective in reducing risk.

4.1.3 Recommendation

It is recommended that existing hazard management provisions be expanded as required to ensure that any increase in the risk of harm and adverse effects from coastal hazards is avoided and existing risk is progressively decreased over time.

4.2 Natural Defences against Coastal Hazards

At Whangaumu Bay, the natural defences against coastal hazards are the beach and, more particularly, the coastal dune between the beach and development to landward. This option involves protection and, where required, restoration or enhancement of this natural protection.

4.2.1 Dunes as natural defences against erosion

Figure 13 provides a schematic overview of the role of dunes in natural protection from storm erosion:

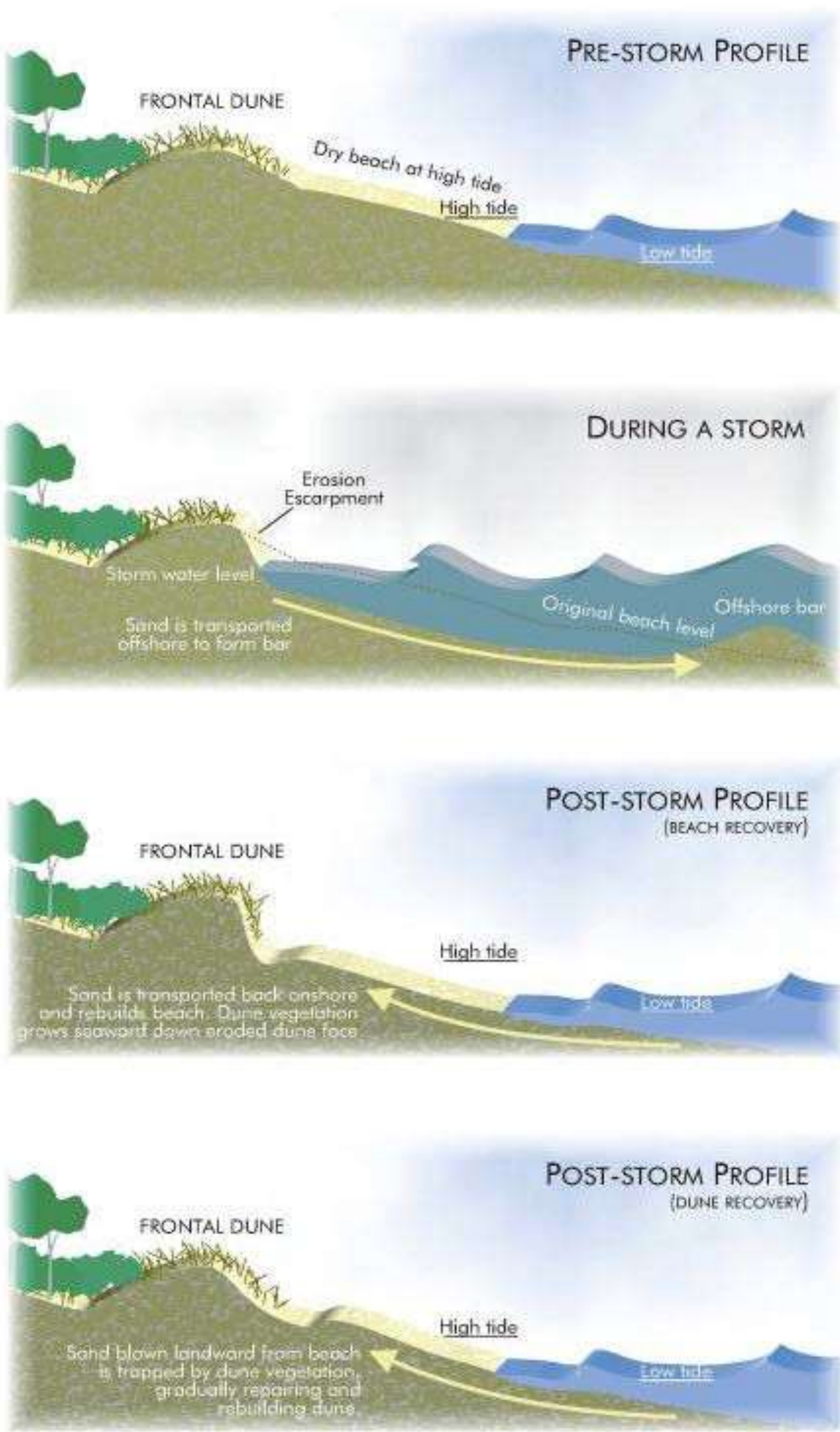

Figure 13: Schematic illustration of storm erosion and recovery - illustrating storm erosion and the process of natural beach and dune repair. Dune repair is critically dependent on appropriate sand trapping vegetation. See text for discussion.

- During normal beach conditions, sand blowing landward from the beach is trapped by sand trapping dune vegetation and dunes typically build such periods (i.e. sand is transferred from the beach to the dune) (top diagram in Figure 13).
- During storm wave events with elevated sea levels and high wave energy, the dune and the visible areas of the beach are typically eroded, with sand transported offshore to form a wide shallow bar in subtidal areas of the beach system. This shallowing of offshore areas helps to dissipate (by wave breaking) the increased energy associated with storm wave events (second diagram from top in Figure 13).
- In subsequent periods, constructive waves gradually return the sand to the beach – restoring the beach, though the dune remains eroded (third diagram in Figure 13).
- Dune repair is effected by sand trapping vegetation that extends down the eroded dune face, trapping windblown sand and gradually repairing the dune (bottom diagram in Figure 13).

The figure is schematic and idealized and at any given site the process of storm erosion and dune repair are much more complex. For instance, a full cycle of serious dune erosion and subsequently dune recovery may occur over a number of storm events and an extended time rather than individual events. For instance, as discussed in Section 2.5 climatic phases can result in quite extended periods characterized by either dune erosion or dune recovery.

Nonetheless, Figure 13 summarises the essence of the process.

The NZCPS 2010 places considerable emphasis on protection and restoration of dunes as natural ecosystems and as natural defences (e.g. Objectives 1 and 5; Policies 11, 14, 25e, and 26).

4.2.2 Practicality of dune protection at Whangaumu

The two central environmental requirements for effective natural dune protection are:

i. Adequate width of natural dune to absorb the worst likely storm erosion **– i.e.** sufficient space between the beach and nearshore development such as houses or infrastructure.

ii. Presence of an adequate width of natural sand trapping vegetation to ensure natural dune repair following erosion.

Community understanding of the role of natural dunes and the requirements for effective dune protection is also a critical requirement at developed sites like Whangaumu – as otherwise it is difficult to get community support for dune restoration.

Width available for dune protection

The review of coastal erosion hazard in Section 3 indicates that no existing dwellings are presently at risk from coastal erosion, even in the absence of existing protection works. Moreover, most existing dwellings are also now landward of the high risk CHZ1 zone – so that most houses are unlikely to be affected by coastal erosion over the next 50 years even with the additional erosion that may accompany projected sea level rise over that period.

Accordingly, there is sufficient width fronting coastal development for effective dune protection.

Restoration of a sustainable natural dune buffer at the western end of the beach would however need to extend into private properties and would require removal of the existing rock wall. Moreover, during severe storms dune erosion would impact on the seaward areas of the properties and would disrupt beach access from these properties (e.g. see Figure 9).Therefore, while theoretically practical, there are significant complications that would need to be addressed in the transition back to natural defences at the western end of the beach.

Similarly, while there is potential to do useful dune restoration between the northern end of the sea wall and 28 Whangaumu Road, the space available seaward of private properties is marginal. There is also some evidence that end effects erosion from the existing sea wall may affect this area (see discussion in Section 4.3.2). Dune restoration in this limited area is therefore also slightly more complicated. It would require either retreat of the seawall further westwards to reduce end effects (see discussion in Section 4.3.3) and/or extending the restored dune slightly into adjacent private property to ensure it is sustainable in the face of storm erosion.

Accordingly, in the immediate future, dune restoration is most readily undertaken in areas to the east of 28 Whangaumu Road - where there is sufficient width for this work seaward of private properties. This simplifies the potential for dune restoration as private landowners often prefer to maintain lawn to their boundaries (though the significant advantages associated with a naturally vegetated dune can result in some landowners accepting minimal intrusion to enhance overall property protection).

The area to the east of the stream entrance is a complicated area for dune restoration as it is periodically severely eroded by alongshore stream migration. There is presently sufficient space to restore a dune seaward of the road rock protection works (Figure 12) but it is doubtful this dune would be sustainable. The dune is likely to be severely eroded by periodic (albeit rare) alongshore stream migration.

A dune could in theory be restored landward of the protection works in this area- but would not be a natural or sustainable dune. In particular, the protection works would prevent periodic erosion of the dune – which is central to free exchange of sand between the dune and beach (Figure 13) and to natural dune character. Over long periods of time, the dune would become progressively larger as any sand trapped in the feature would not be able to return to the beach. The lack of periodic erosion would also ultimately impact on the natural dune vegetation. In addition, the dune would have limited hazard protection value; while it would reduce storm wave inundation of the reserve, this inundation is rare and does not present significant management issues.

Accordingly, restoration of a sustainable natural dune east of the stream entrance would require removal of existing protection works and some landward retreat of the existing grassed reserve to create space for the dune. These various complications can be worked through in the longer term if desired – but the area is not as high a priority for dune restoration as the areas seaward of beachfront private properties.

Accordingly, in the immediate future, dune restoration should focus on the area fronting private properties between 28 Whangaumu Road and the stream entrance. Dune restoration in other areas is also possible but as discussed above is more complicated and, in most areas, of lesser priority.

Nonetheless, planning for Whangaumu Bay should develop transition mechanisms and timeframes to gradually move back towards natural defences in other areas. Consultation with key parties (e.g. landowners, tangata whenua, beach users and the local community) will be required.

Sand trapping vegetation for dune repair

The process of natural dune repair is critical to effective natural dune protection – as it rebuilds and repairs the dune following storm erosion (see bottom diagram in Figure 13).

The native species that are critical to natural dune repair along the coast of the Northland region are spinifex (*Spinifex sericeus*) and pingao (*Ficinia spiralis*). However, these species are almost completely absent from the frontal dune at Whangaumu. Instead, dune vegetation is presently dominated by a wide range of exotic weed species, including exotic perennial grasses (e.g. kikuyu and Buffalo grass), a wide range of garden plants/escapees (e.g. agapanthus, South African ice plant, arctotis, etc) and succulents (including yucca, agaves and even cacti) (see Figure 14 and Figure 15). These exotic species are largely ineffective at sand trapping and natural dune repair.

The absence of spinifex and pingao from the seaward dune face means that the natural process of dune repair at Whangaumu Bay is severely constrained. In fact, the lower dune face along much of the beach is often largely unvegetated with the only sand accumulation and dune repair occurring being the limited piling of windblown sand against the base of the old erosion scarp (e.g. Figure 15).

Accordingly, only limited natural dune repair presently occurs between periods of storm wave dune erosion. The absence of this natural dune repair process significantly reduces the width of dune that would otherwise be available to mitigate erosion. For instance, at the time of the May 2012 inspection, the width of protective dune available was typically about 5 m less than would have been expected had the dunes been vegetated in spinifex and pingao.

Restoration of the native vegetation critical to natural sand trapping and dune repair restoration is therefore central to effective dune protection at Whangaumu Bay. This will maximise natural dune repair between periods of erosion. This is particularly critical given the enhanced potential for storm erosion during the present negative phase of the IPO.

Restoration of natural dune vegetation will also enhance the natural and amenity values of the dune.

4.2.2 Work required for dune restoration at Whangaumu

This section outlines the work required for dune restoration at Whangaumu Bay to restore sand trapping and natural dune repair processes and to enhance natural dune values.

Figure 14: Views of dunes in eastern and central areas of the beach showing dominance of exotic vegetation including exotic perennial grasses and a wide range of garden plants and garden escapees (e.g. succulents, agapanthus, arctotis, and South African ice plant.

Figure 15: Various views of dunes towards western end of beach immediately east of seawall. As with other areas of the beach, the dune face is totally dominated by exotic species that are largely ineffective in natural dune repair. Note sand piled against base of dune by wind (bottom photo) indicating potential for active dune building and repair with more effective native trapping vegetation such as spinifex and pingao.

The immediate priority for dune restoration is the area between 28 Whangaumu Road and the stream entrance – where there is sufficient width for the dune restoration to be undertaken seaward of private properties. The area between the eastern end of the sea wall and 28 Whangaumu Road is also a priority area but is more complicated as it will require action to reduce end effects and/or will require the dune to extend back into private property (see discussion in Sections 4.2.2 and 4.3.2).

It is recommended that the dune be restored over the full width of the reserve to maximise the width of dune protection and create a more sustainable dune.

The following sequential steps are recommended for dune restoration in this area:

Clear exotic vegetation from the width over which restoration is to occur.

This work requires spraying of the vegetation, followed (once the exotic vegetation has died) by earthworks using an excavator to remove the vegetation back to clean loose sand. The vegetation removed can simply be buried in a hole on the beach (or dune) and covered over.

The dune surface must be restored back to clean loose sands and all exotic vegetation removed – otherwise ongoing problems with maintenance can be serious – as many of the exotic species are very aggressive and any stolons left in the ground can result in the weeds coming away again. This is the reason it is also important to spray the weeds prior to earthworks – to minimise weed recovery from any underground growth left after the earthworks.

Existing areas of existing native vegetation can be avoided where this is practical but these areas are very limited in extent at Whangaumu Bay. It is more critical to ensure the exotic vegetation is completely removed. Leaving extensive patches of weeds because they also contain some native vegetation is not good practice and will only complicate subsequent maintenance. If planting instructions below are followed, a good cover of native vegetation will be quickly restored even if the entire area is cleared back to bare sand.

Ideally, the earthworks should be conducted only 1-2 days before the planting to avoid issues with windblown sand. Problems with windblown sand only occur with rare and very strong winds, particularly strong winds not accompanied by rain. Nonetheless, the risk is best avoided.

Planting of the dune with appropriate native dune vegetation.

The seaward dune face and the area to at least 1-2 m landward of the dune crest should be planted with spinifex, with a small (say 10%) component of pingao. Plant spacing of 0.3-0.5 m spacing is adequate, with a fertilizer tablet included at time of planting to boost plant establishment.

Given the current climate phase, there is a higher than average probability of dune erosion over the next few years. Accordingly, it is not advisable to plant the dune face right down to the dune toe – as the more seaward plants will be too susceptible to storm erosion. Spinifex stolons will rapidly spread down the dune face once the plants are established and so the planting need only extend part way down the dune face.

In more landward areas (e.g. the area 1-3 m seaward of property boundaries), planting should emphasize knobby clubrush (*Ficinia nodosa*) – planted quite densely (ideally 0.3-0.4 m plant spacing). Pohuehue (*Muehlenbeckia complexa*) and/or native spinach (*Tetragonia* sp.) should then be planted in the small gaps between the clubrush. These clambering species appreciate the shelter and architecture provided by the clubrush and will eventually form a dense community.

This knobby clubrush backdune zone is critical to effective restoration of the frontal dune as it will minimise re-invasion of exotic species and facilitate control of exotic grasses invading from lawn areas to landward. It will also enhance the natural values of the restored dune.

Management of beach access across the restored dune using defined accessways.

This is required to protect the restored dune vegetation from trampling.

In dunes areas fronting reserves and subject to extensive pedestrian traffic, a board and chain accessway may be required. Simple board and chain structures are simpler to maintain and are less seriously damaged than fixed steps. In a post-store situation where a steep vertical scarp can interrupt beach access, the simplest approach is generally to regrade the slope in the area of the accessway (manually or with machines) and lay the sand ladder back down on the restored slope. Avoid extending the toe of the dune too far seaward of the eroded dune toe to minimise maintenance. A limited number of signs requesting beach access via defined public accessways are also useful to encourage community and beach user awareness.

In the case of private properties, beach access structures are often not required and a narrow sandy path can be adequate to provide for beach access while protecting vegetation. A number of existing properties have constructed steps down the dune face to facilitate access. It is desirable to manage such structures to protect visual amenity and natural character. In practice, consent is also required for such private structures on public land. Over time, Council should work with landowners to develop appropriate guidelines for such works. For instance, to work towards a situation where adjacent neighbours share any such structures to minimise the numbers required. Structures of this nature are also best kept small and simple as they are likely to require significant maintenance or even total replacement after rare and severe storm erosion.

Maintenance

Ongoing maintenance of the restoration work will be required but should be minimal if the work is undertaken well initially. The main areas of required maintenance are likely to be:

- **Control of exotic species to prevent re-invasion**. It is particularly important to control any reappearance of more aggressive invasives such as agapanthus, arctotis and gazanias, ice plant and yucca/agave species - though any common garden plants should ideally be removed as soon as practicable. The required maintenance is usually most significant in the first 1-2 years after restoration, often requiring checks and control 2-3 times per year (e.g. October/November and February/March). Maintenance requirements usually decrease thereafter.

- **Control of exotic grasses** invading the restored dunes from lawn areas to landward as these can significantly reduce and even eliminate the spinifex zone, especially at lower energy sites like

Whangaumu. This is an ongoing maintenance requirement as the stoloniferous exotic grasses used in coastal lawns (e.g. kikuyu, buffalo grass) tend to readily expand seaward. Control is most simply undertaken by using a grass-specific herbicide along the landward edge of the restored dune in spring and autumn. The knobby clubrush community along the landward margin of the restored dune will be unaffected by a grass-specific herbicide. The exotic grasses should never be allowed to invade seaward into the spinifex zone as control then becomes much more difficult. Use of general purpose sprays such as Roundup would be avoided to minimise risk to the native plantings.

- **Repair of any ongoing human damage to dune vegetation** arising from failure to use defined accessways.

It is not necessary and not advisable to plant up dune faces following storm erosion and this practice should be avoided. The width of planting recommended above will ensure there are remaining areas of spinifex landward of even the worst likely storm erosion, ensuring a self-sustaining dune. The remaining plants to landward will send stolons seaward down the eroded dune face and will repair the eroded dune once natural processes allow. This process will re-vegetate the eroded dune face faster and more effectively than planting. Moreover, in the current negative IPO climatic phase, any planting on eroded dune faces has a higher than normal probability of being lost to erosion.

It is recommended that the dune restoration be undertaken progressively over a number of years – working on lengths of about 50-100 m each year as resources permit. The cost of the restoration work (spraying, earthworks and plants) at Whangaumu will depend on various factors (particularly planting density and area). However, based on similar work elsewhere, the cost of restoring the dune back to property boundaries is likely to be about $15,000 per 100 m using a community-based approach. The vast majority of this cost (about $12000) is plants.

The advantages of progressive implementation over time include:

- Enables the work to proceed with limited resources in any given year – often within the scope of existing reserve management budgets
- Reduces plant losses that can occur if rare and extreme storm events occur in the months immediately after restoration
- Enables the work to be conducted using community-based approaches – typically limited to 1-2 short (say 1.5-2 hour) working bees each year. Dune restoration that does not involve the local community and beach users is often quickly degraded as the behaviors that caused the dune damage are not changed.
- Enables progressive learning from experience. While dune restoration practices are now well established for work of this nature, each site is unique. Accordingly, improved outcomes can often be achieved by progressive implementation over time with monitoring of results and subtle adjustment of practice in response.

Examples of similar dune restoration work elsewhere using the above approach are shown in Figure 16 to 18. It is important that the work is undertaken using a community-based approach (such as the NRC Coastcare programme) to encourage community ownership and learning.

Figure 16: Dune restoration at Tairua Ocean Beach, eastern Coromandel showing exotic dominated dune (top photo), planting of natives following clearance (mid photo) and restored 1 year later (bottom photo).

Figure 17: Restoration at Cooks Beach showing exotic dominated dune before (top), following excavation and prior to planting (middle) and restored dune (bottom).

Figure 18: Restoration of Cooks Beach backdune - showing dune dominated by exotics (top), following excavation and planting (middle) and restore dune 1 year after planting (bottom).

It is important to ensure the earthworks do not disturb any cultural sites on the dunes (e.g. NRC staff advise that there is a recorded midden deposit in the centre of the beach). In general, the risk is low as any required earthworks typically only disturb surficial sands – as the primary intent of the earthworks is simply to remove exotic vegetation and any placed fill to restore clean loose sands for planting. Cultural deposits are generally deeply buried but can be exposed on or close to the surface where historic or ongoing dune degradation has resulted in wind erosion reducing sand cover. Therefore, careful site inspection and consultation with relevant local iwi is important prior to any works. Works in the vicinity of any cultural deposits may also require NZHPT approval. Once natural sand trapping and dune building processes have been restored with appropriate planting, the works will enhance the protection of cultural deposits.

4.3 Hard Engineering

Whangaumu Beach presently contains two separate lengths of rock seawall – approximately 165 m at the western end of the beach (Figure 5) and fronting the reserve at the eastern end (Figure 12).

4.3.1 Purpose of the structures

The rock sea wall at the western end of the beach protects the seaward edge of adjacent private properties from storm wave erosion. The seaward edge of the properties were affected by storm erosion in the July 1978 storm, with the high, sloping storm scarp formed during that event extending inside the seaward property boundaries and back to the seaward edge of the house then then located on the property at 14 Whangaumu Road (Figure 9).

Examination of earlier photographs indicate evidence of similar erosion in the past prior to subdivision of the properties (e.g. see discussion in Section 3.3.3 and the historic erosion scarp arrowed in Figure 8).

It appears that the reserve set off along the front of the properties at the time of subdivision was not sufficient to protect the seaward edge of the properties. i.e. The front property boundaries lie within the dynamic envelope – the shoreline width affected by dynamic shoreline changes.

The greater erosion at the western end of the beach probably reflects a number of factors, including:

- Greater exposure to wave action (see discussion in Section 2.4)
- Potential for the headland at the western end of the beach to encourage rip formation, allowing higher storm waves nearer the shore in this area
- The greater height of the dunes in this area – which results in post-storm collapse of dune erosion scarps extending further landward than in areas of lower dunes)
- Possible current and other effects arising from proximity to the ebb tide delta off the Ngunguru entrance

The existing coastal setbacks ensure houses are set well back from the top edge of the historic erosion scarp and no existing dwellings would presently be under threat if the rock protection were not in place. Accordingly, at present, the primary role of the protection is to protect the seaward edges of the adjacent private properties and to prevent beach access from these properties from being periodically disrupted by severe storm erosion.

The rock structure at the eastern end protects the adjacent grassed reserve from erosion associated with occasional alongshore migration of the stream entrance and channel.

4.3.2 Environmental effects of the sea walls

The primary effects of the sea walls are:

- Beneficial effects in terms of protection provided to private and public assets
- Adverse effects on the environment

These effects are briefly discussed below.

Protection to private and public property

The sea wall at the western end of the beach prevents occasional storm erosion of the dunes in this area and thereby protects the front edge of the adjacent private properties and prevents periodic disturbance of beach access from these properties.

The dwellings on the properties are protected by the coastal setbacks and so the sea wall is not presently critical to protection of these assets. In the longer term these houses could however come under threat if erosion were exacerbated by projected sea level rise (Section 3.4) - unless erosion is limited by erosion resistant geology underlying the Holocene sands.

The rock wall fronting the reserve at the eastern end of the beach protects the seaward edge of the grassed reserve and associated shade trees in this area. If the sea wall were not present, rare and severe erosion associated with alongshore migration of the stream entrance could affect these areas and possibly the gravel access road further landward.

Adverse environmental effects

The primary adverse environmental effects of the sea walls relate to:

- **Separation of the beach from adjacent dune reserves** – preventing return of dune sands to the beach during periodic storm erosion.

  This adverse effect is most significant for the sea wall at the western end of the beach where the rock sea wall is located too far seaward to allow a natural dune to form seaward of the wall. For instance, at the time of the May 2012 field inspection and survey the eastern end of this wall extended well seaward of the natural dune profile to the immediate east (fig – photo and survey).

  These effects are less significant at the eastern end as the rock wall is set well back from the beach enabling a low vegetated dune is able to form between the beach and the rock protection (fig). Sands are able to be recycled between this low dune and the beach.

- **Narrowing of the beach** resulting from placement loss (i.e. burial of beach width under the sea wall) and from passive erosion (fixing of the landward boundary of the beach system). Passive erosion losses are a common effect of sea walls and occur due to the fact that the beach seaward of the protection is able to erode while the protection works provide a fixed landward edge. Accordingly, the beach between the protection works and the sea narrows during periods of erosion.

If a beach is simply fluctuating backwards and forwards (as is presently the case at Whangaumu) the degree of adverse effect depends on how far seaward the wall is located.- with beach narrowing only a temporary effect if the sea wall is not located too far seaward.

The sea wall at the western end of Whangaumu is located well seaward, with the front edge of the sea wall generally forward of where a natural duneline would be located. Therefore, in this area, beach narrowing occurs due to both placement losses and passive erosion. In addition, the seaward encroachment increases towards the western end of the sea wall – where the beach is also naturally narrower. However, in spite of the beach narrowing that occurs in front of this sea wall, a high tide beach is typically present on most occasions - any loss of a high tide beach that does occur is presently only temporary. Moreover, given the tendency for east coast beaches to be more accreted during summer months, beach loss is likely to be less frequent during this peak use period.

The adverse effects will however become more serious in front of this sea wall if Whangaumu Beach ever develops a trend for permanent shoreline retreat – as may occur with projected sea level rise. If this occurs, beach loss in front of the sea walls would become progressively more serious over time and eventually a high tide beach may be permanently lost. This would have serious effects on beach amenity and on public access along the beach.

Beach narrowing is not presently an issue for the rock wall at the eastern end of the beach as this structure is set well back from the shoreline and does not currently affect beach width.

- **Aggravation of erosion on adjacent unprotected lengths of shoreline due to "end effects".** This effect can occur during coastal storms at sites when there is often significant wave interaction with sea walls. Aggravated erosion of adjacent unprotected shoreline is typically worst in the areas closest to the seawall and diminishes with distance. The severity of the effect also increases where sea walls are well seaward on beaches.

  There is some geomorphic evidence of this effect in unprotected areas immediately adjacent to the seawall at the western end of the beach. For instance, at the time of the beach surveys in May 2012, the beach width between high tide and the toe of the dune was typically 3-4 m wider than in other unprotected areas further east. This is a concern as the width of the dune seaward of adjacent private properties is relatively narrow in this area - aggravated erosion could generate pressure to extend the sea wall further eastwards. However, there are practical solutions for this issue as discussed in Section 4.3.3 below.

  There is no evidence of any end effects with the sea wall at the eastern end of the beach – reflecting the fact that this sea wall is set well back from the beach and has a low dune to seaward.

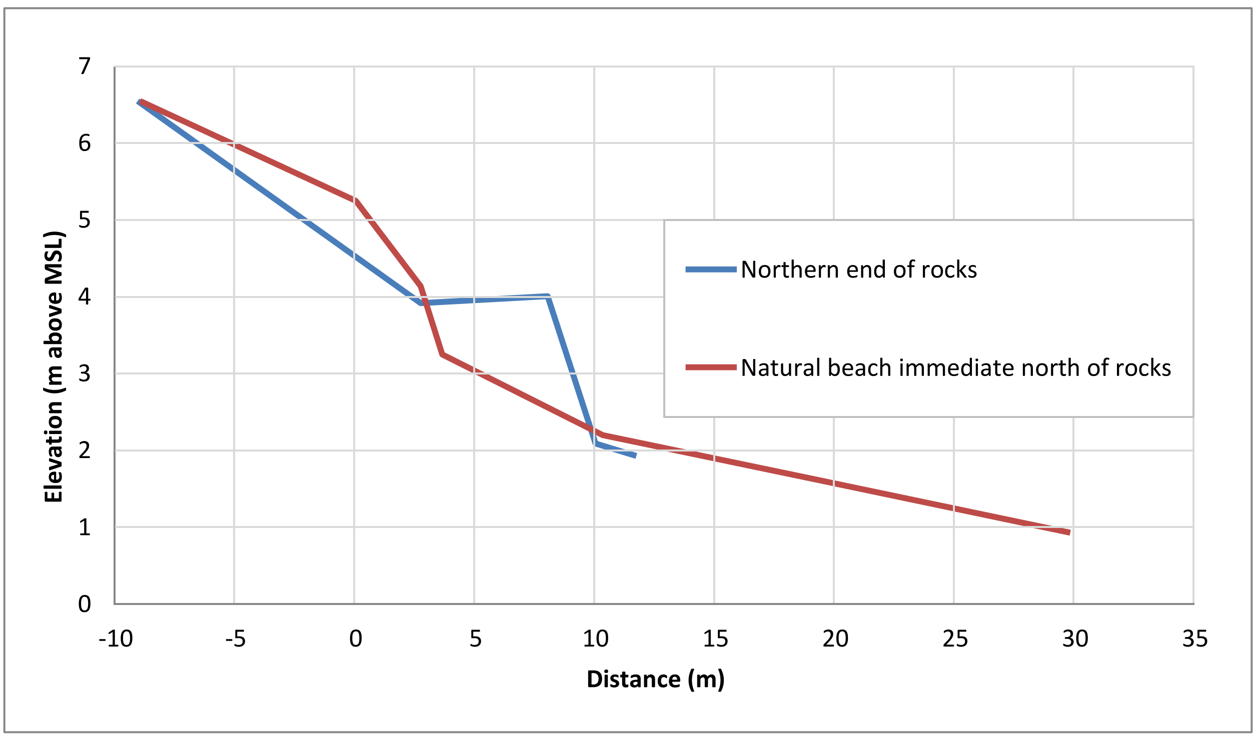

Figure 19: View of sea wall at western end of beach (top) looking westwards alongshore from adjacent unprotected shoreline. Note how rock wall extends seaward of the natural duneline. The bottom graph shows cross sections surveyed in the same area showing profile over the rocks compared to the natural shoreline.

- **Loss of natural character and impacts on visual amenity.** The rock sea wall at the eastern end of the beach is a prominent and permanently exposed feature (Figure 5), imparting a human-built and engineered character to this section of the beach and reducing the natural character and visual amenity of the beach. This reflects the fact that the structure is located well seaward on the beach profile.

  The vegetation that presently occurs on the dune behind the protection due is also significantly different in character from that which would occur in the absence of the sea wall.

  The wall at the eastern end of the beach is less prominent as it is set further back from the coast and is partly obscured by the low dune to seaward (Figure 12).

In summary, the sea wall at the western end of the beach has a range of adverse effects on the environment. These effects will increase in severity in the future if projected sea level rise results in a trend for permanent shoreline retreat.

In contrast, the sea wall at the eastern end has only relatively minor adverse effects.

The contrast in effects between the sea walls at the eastern and western ends of the beach illustrates a basic principle central to location of sea walls – namely, that where these structures are required they should be located as far landward as possible as this can significantly reduce adverse effects.

4.3.3 Recommendations for management of sea walls

Western end sea wall

It is clear from Sections 4.3.1 and 4.3.2 that this structure presently has a relatively limited protection role, as the setbacks and development controls have now resulted in coastal development (i.e. dwellings) being located landward of the high risk erosion area. Nonetheless, it is likely that landowners in this area appreciate the protection the seawall provides to the seaward edge of their properties and to beach access from their properties.

The sea wall, located largely on public land, is having adverse effects on the environment including some beach loss and narrowing, aggravated erosion of the adjacent unprotected land at the eastern end of the wall during coastal storms, and impacts on natural character and visual amenity.

In the longer term, were the beach to develop a trend for permanent shoreline retreat, the adverse effects of the sea wall would become very serious.

These various adverse effects are not consistent with present national policy. Accordingly, the sea wall is unlikely to be consented as a long term solution to coastal erosion and is best regarded as an interim measure.

It would be readily possible to remove the existing seawall and reinstate a natural dune in this area. However, property owners are not likely to favour this action in the near future and the present adverse effects on public values are not sufficiently serious to warrant removal of the structure as a priority.

In the immediate future, the key requirement is probably to mitigate any end effects erosion on adjacent unprotected properties – particularly to avoid further eastwards extension of the rock wall after future storm erosion.

In the short term, this can be most simply achieved by beach scraping – i.e. pushing up sand from the beach to reinstate the dune after severe erosion. This technique has been successfully used for this purpose at similar sites and, if well designed and undertaken appropriately, would work well at this site. The work would need to be delayed for a period of some weeks after the storm to allow the high tide beach to recover sufficiently before the sand scraping was undertaken. Given the relative rarity of extreme storm erosion, this option will provide adequate mitigation in the short term. Resource consent could be obtained in the interim to enable the work to progress rapidly when required. Given the usefulness of the technique of beach scraping, NRC might even wish to consider seeking region-wide consent for the approach along the east coast of Northland subject to appropriate guidelines – as has been done in at least one other district of New Zealand (Thames Coromandel District).

In the medium term, consideration should be given to a more permanent solution. The cheapest option would be to remove the remove the easternmost 50 m of the wall – so that the wall terminates on the reserve immediately east of 18 Whangaumu Road. This would move the focus of any end effects away from private property frontages (i.e. 26 and 28 Whangaumu Road) to the frontage of the reserve (i.e. 20 and 22 Whangaumu Road). The rocks removed could be partly used to recurve the new eastern end of the seawall landward to protect the remaining structure from out flanking (i.e. ensuring the 18 Whangaumu Road property remains protected). Once the seawall is removed from the frontage of the reserve, the dune in this area could also be reshaped and restored to enhance natural and amenity values, and to restore natural dune vegetation and processes. This restoration will need to be designed to accommodate occasional end effects erosion during major coastal storms.

In the longer term (probably >20 years), consideration should be given to total removal of the sea wall and restoration of natural shoreline conditions. The timeline or trigger for this work can probably be tied to adverse effects of the sea wall. For instance, removal of the structure will need to be considered as a priority if permanent loss of a high tide beach occurs for sustained periods of time over peak use summer periods. Design of this work will need to address restoration of beach access for adjacent properties after rare periods of severe storm erosion (e.g. May 1978 event – see Figure 9) as well as landscaping of the seaward edges of the properties to accommodate such periodic severe storm erosion.

Eastern end sea wall

This structure is essentially a "backstop" sea wall being set back well landward of the normal high tide beach – with a low vegetated dune between the seawall and the beach. At present, adverse effects of the structure are minimal (Section 4.3.2). In the longer term, it would be possible to remove the rock wall and restore a wider, naturally-vegetated dune – though this would require some retreat of the adjacent grassed reserve.

4.4 Beach Nourishment

This option essentially involves adding sand to the beach system to counter-balance erosion. It is has been extensively used around the world on open coast and estuarine beaches.

A major issue with this approach would be finding a source of suitable sand – as the sand needs to be the same or a coarser grade than the existing beach. In order to maintain existing beach character, it would also be necessary to use similar quartzo-feldspathic sands. It is probable that the only suitable source would be another similar beach system judged to have surplus sand. The nearest existing sand extraction operation with suitable grade sand would probably be Pakiri Beach but transport costs from this site would be very high. There may also be suitable coarse sand in continental shelf sediments closer to Whangaumu Bay – as existing information on these sediments off the Northland and Auckland east coast suggests that areas of coarse sediment occur (Gillie, 1977; Hilton. 1995; NIWA, 2000). However, available information suggests these coarse sands are likely to be much shelly, to include much coarser grades of sand and to be much more poorly sorted than beach sands. Extraction would also be expensive.

The volumes of sand required would also be very large. For instance, assuming a suitable source of similar fine grade beach sand could be found, indicative calculations suggest a volume of 60-100,000 cubic metres of sand would be required to counterbalance the 15 m net erosion that might accompany a sea level rise of 0.9 m over the next century. The cost of this volume of nourishment would be very dependent on extraction and transport charges but with a distant source could easily be $50-100 per cubic metre – suggesting a total cost of around $4-8 million.

The volume and cost could be reduced by using slightly coarser sand. For instance, indicative calculations suggest that use of medium grade beach sand would reduce the volume required to about 15-20,000 cubic metres, with costs commensurably reduced (assuming a similar distance of transport). The use of this coarser sand would however steepen the beach face and change beach characteristics.

A major unknown and often a significant cost factor with beach nourishment is the volume of ongoing maintenance placement required. This requires complex investigations to assess. However, at Whangaumu, it is possible that maintenance would be minimal given the minimal losses likely from this embayed beach system – provided beach width was maintained at or less than present dimensions).

Overall, the option requires significant volumes of suitable beach sand and is likely to be quite expensive. Accordingly, while it might be an option to mitigate the effects of climate change in the longer term if a suitable source of sand were identified, it seems unlikely to be relevant or affordable in the short-medium term.

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