Review of Coastal Erosion Setbacks: Whiritoa Beach

Prepared for Hauraki District Council

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Contents

1 Introduction

1.1 Purpose of this Report

The Hauraki District Council has recently reviewed its previous provisions relating to coastal erosion setbacks at Whiritoa Beach on the eastern Corormandel, adopting the setbacks recommended in a report prepared for Environment Waikato (Dahm and Munro, 2002).

Affected landowners have raised various concerns with the revised setbacks. Consequently, this report was commissioned by Council to review the proposed coastal erosion setbacks and recommend any appropriate changes.

1.2 Setbacks

Dahm and Munro (2002) defined two setbacks for developed areas on the eastern Coromandel:

- **A Primary Development Setback (PDS)** which identifies the area potentially vulnerable to extreme (100 year return period) erosion with existing sea level
- **A Secondary Development Setback (SDS)** which highlights the additional area that may become vulnerable to erosion with present best estimates of sea level rise over the next 100 years. The setbacks were calculated using a projected sea level rise of 0.5 m.

The new setbacks are spatially fixed with respect to a defined shore parallel baseline - which approximated the most seaward toe of dune. The earlier setbacks were not fixed and moved with the shoreline.

At the time of the analysis (1999), the available data was limited – with detailed information available at only a few sites. Beach profile data at many sites also did not include records of severe storm erosion. Consequently, generic setbacks were defined for the coast according to two beach types – coarse grained pocket beaches and finer-grained barrier beaches (such as Whangamata).

The setback recommendations relevant to Whiritoa were those developed for the pocket beaches – being a PDS of 35 m and an SDS of 50 m. The PDS was comprised of a 25 m estimate for erosion associated with dynamic shoreline fluctuations and a 10 m safety factor. The safety factor was included to allow for uncertainty (including data limitations) and ensure a precautionary approach.

A recent review of the recommendations for the Thames Coromandel District that based on a further 10 years data and new methodologies found that the generic setbacks were reasonable at many sites but overly precautionary at others (Dahm and Gibberd, 2009). The review also found that most sites now had sufficient data to enable site specific setbacks to be determined.

The present review for Whiritoa uses similar data and methodologies to that recently undertaken for the Thames Coromandel District to develop site specific recommendations for Whiritoa Beach.

1.3 Structure of this report

This review has the following structure:

Chapter 2: Brief outline of existing knowledge of Whiritoa Beach (more detailed information is provided in the 2002 report)

Chapter 3: Outline of the data used for this review

Chapter 4: Assessment/review of coastal erosion risk

Chapter 5: Recommendations

2 Whiritoa Beach

Whiritoa Beach is a pocket beach approximately 1400 m long, embayed between cliffed volcanic headlands. The beach is backed by a frontal dune along most of its length, the dune typically varying from 6-9 m in height, though isolated remnants of historic higher dunes also occur. The high tide beach fronting the dune varies in width over time but can on occasions be up to 60-80 metres wide.

The Ramarama and Whiritoa Streams discharge at the northern and southern ends of the beach, respectively. Local embayments are associated with both stream entrances. These streams are commonly impounded by the beach during low flows but break out to the sea during more significant flows. The Whiritoa Stream also has a man-made low-flow outlet through a natural blowhole in cliffs south of the beach.

The beach is composed of medium- coarse sands with typical mean grain sizes ranging from 0.35-0.5 mm (McLean, 1979). The beach system extends offshore to depths of approximately 8 m below mean sea level where it gives way to much finer sands with typical mean grain sizes of 0.14-0.20 mm (McLean, 1979).

The beach is now a closed sediment system with little to no net input of beach grade sand (i.e. the beach has essentially got all the sand it is ever going to get) (McLean 1979; Bradshaw, 1991; Dahm and Munro, 2002).

Historically, there has been some loss of sand from the beach system associated with both wind erosion and sand extraction (see Section 4.2 below for further discussion). The dunes along the beachfront have also been extensively modified by development.

Human impacts on the beach system were addressed by Environment Waikato and the Hauraki District Council in the early 1990's with joint development and implementation of a coastal hazard strategy in partnership with local iwi and the wider community. Under the agreed strategy, Maori landowners voluntarily agreed to close the sand extraction operations at considerable personal cost in the early 1990's to protect remaining beach reserves. In addition, a Beachcare group was established in the local community in January 1993 (the first such group in New Zealand) to restore and maintain a naturally functioning protective dune. Over the last 17 years the Beachcare group has enjoyed strong community support and undertaken extensive dune restoration and management. This work continues. Setbacks were also introduced to ensure nearshore development was not placed in areas potentially vulnerable to erosion.

3 Data used in this Review

The following data was used for this review:

3.1 Beach profile data

Environment Waikato and predecessor agencies have monitored beach profile sites at Whiritoa for up to 31 years. Beach profile monitoring consists of shore perpendicular transects which are resurveyed periodically to record changes in the beach and dune over time.

This review was primarily undertaken using beach profile data from the following sites:

- **Site CCS 59** located towards the northern end of the beach at the intersection of Kon Tiki Road and Fisherman's Bend. Data is available for this site from January 1979 to December 2009, a period of 31 years.
- **Site CCS** 61 located towards the centre of the beach, immediately north of the Surf Life Saving Club. Data is available for the site from December 1981 to the most recent survey of in December 2009, a period of 29 years.
- **Site CCS 63 located** towards the southern end of the beach adjacent to Moray Place. Data is available from February 1981 to December 2009 a period just under 29 years.

Broadly speaking, the sites provide a useful long term record for the northern, central and southern areas of the beach, respectively. Data from other beach profile sites at Whiritoa was also examined but the records were much shorter and not useful for the analysis.

3.2 Shoreline change mapping

Previous work at Whiritoa included mapping of shoreline changes from historic aerial photographs dating from 1948, 1963, 1978 (purpose flown photography after the major July 1978 storm) and 1987 (Dahm and Munro, 2002).

The shoreline mapping was conducted in the early 1990's using the following methods:

- Rectification of the 1987 imagery using ground survey control points
- Overlaying and matching the earlier historic photography using a zoom transfer scope and common points on the imagery
- Mapping various shoreline markers including the seaward toe of the dune

The work was conducted by experienced photogrammetrists from the then DSIR Land Resources Division at Aokautere in Palmerston North. Prior to the mapping, the author spent a day with DSIR staff examining each of the historic photographs with a scanning stereoscope and zoom transfer scope to identify the most appropriate shoreline markers and ensure consistency in the mapping of these features. Despite the considerable care taken with the analysis, the plotting of individual dunelines is likely to have an error of at least ±2.5 m giving a potential error in comparison of any two shorelines of at least ±5 m. Nonetheless, the data does provide useful indicative information on shoreline change back to 1948 – complementing the beach profile data.

Historic shoreline surveys were also examined in an attempt to extend the shoreline change data further back in time – though the usefulness of the data was limited as discussed in Section 4.2 below.

3.3 Other information on shoreline change

Investigations conducted at the beach in the early 1990's involved extensive discussions with community members, many of whom were able to provide useful information on the impact of past storms including the significant event of July 1978.

In addition, some useful information was obtained from earlier shoreline change investigations, management agency files and newspaper reports (see Dahm and Munro, 2002 for more detailed discussion of these data sources).

3.4 Drilling investigations

The previous work reported Dahm and Munro (2002) included ten sites drilled along the beach using both a trailer mounted hollow stem augur and a truck mounted rotary augur/flush system. All holes were drilled to the base of the Holocene sands (i.e. the base of the modern beach sands which have accumulated over the last 7000 years). This data provides useful information on areas where subsurface geology may limit the erosion which can occur. This is relevant to erosion setbacks as discussed further in Section 5.24.2.

4 Assessment of Coastal Erosion Risk

4.1 Methodology

Assessment of the hazard posed by coastal erosion at Whiritoa Beach requires consideration of:

- **Long term trends** – any existing long-term trends for permanent shoreline advance or retreat
- **Dynamic fluctuations -** the maximum likely erosion associated with dynamic shoreline fluctuations and associated dune instability (i.e. collapse of the over-steepened dune face formed by severe storm erosion)
- **Climate change** – the potential for aggravation of erosion by projected sea level rise over the next 100 years.

These are the major factors relevant to erosion hazard along most of Whiritoa Beach. The only exceptions are the areas in the vicinity of the Ramarama and Whiritoa Stream entrances where stream erosion also plays a role. The stream entrances are discussed separately in Section 5.2.

The dune height generally precludes any serious risk from coastal inundation (e.g. associated with storm surge and wave run-up).

Historically, severe wind erosion and migrating sand sheets have also been experienced at Whiritoa - as discussed briefly in Section 4.2. However, there is now a good vegetation cover on the dunes at Whiritoa and the local Beachcare group is progressively restoring appropriate native sand binding species. Wind erosion is therefore unlikely to pose a serious future hazard at Whiritoa. Nonetheless, the historic problems do illustrate the serious issues that can arise if appropriate vegetation cover is not maintained. A good cover of appropriate native dune species is also critical to maintenance of the finite sand reserves within the active beach system (i.e. minimizing permanent losses of sand to areas further landward) and to natural repair of the dune following storm erosion. It is therefore important that current Beachcare activities are maintained as the human pressure on the beach and dunes will otherwise result in steady degradation of the dunes and associated problems.

4.2 Long term shoreline trends

Shoreline advance

Previous work indicates that beach formation commenced about 7000 years ago, shortly after sea level reached present elevation following the most recent post-glacial rise in sea level (Dahm and Munro, 2002). The beach sands were derived from offshore sources and possibly also from erosion of remnant Pleistocene beach and dune deposits still present when sea level reached existing elevations. (These remnant deposits relate to the beach and dune system which formed at Whiritoa when sea level was last at or about present elevations – approximately 120,000 years ago).

These sediment sources no longer supply sand to the present beach as they are now buried. For instance the coarse sand on the continental shelf is now buried under a thick blanket of fine sands which lie beyond the seaward edge of the beach system (McLean, 1979; Bradshaw, 1991). Offshore sediment investigations reported by McLean (1979) indicated that the coarse sands from which much of Whiritoa Beach was derived are now typically only exposed in depths of about 30 m. More detailed work by Bradshaw (1991) confirmed that the coarse sands are generally only exposed 5-6 km offshore in depths greater than 30 m - though small exposures were noted at about 22-25 m depth.

These existing exposures of the source sediments are well beyond the seaward edge of the present beach system and no longer contribute significant volumes of sand to the beach. The beach is therefore now a closed sediment system with little to no net input of beach grade sand (i.e. the beach has essentially got all the sand it is ever going to get) (McLean 1979; Bradshaw, 1991; Dahm and Munro, 2002). Accordingly, there is no long term trend for beach advance. The only beach advance now occurring is that associated with dynamic shoreline fluctuations (i.e. periods of erosion and subsequent recovery) – discussed in Section 4.3 below.

Trends for long term erosion

Human activities have resulted in significant volumes of sand being lost from the beach and dune system over the last 150 years. In a beach system like Whiritoa with fixed sand volumes, such sand losses can result in trends for long term erosion.

The historic sand losses were particularly associated with both historic wind erosion and sand extraction. Coastal subdivision from the 1960's onwards also modified the protective dunes in places along the foreshore.

Serious wind erosion occurred in the late 1800's and early-mid 1900's associated with destruction of stabilising vegetation by human activities, including stock and fire. Photographs from the early to mid 1900s show landward migrating sand sheets extending up to 100-150 metres inland. This resulted in large volumes of finite beach and dune sand reserves being lost inland, now buried under coastal subdivision. Reports from an early settler indicate that the wind erosion lowered the high dunes which previously characterised the beach (see page 55 in Wheeler, 1970), though isolated remnants of the higher dunes remain.

Historic sand extraction also removed large volumes of the finite beach and dune sand reserves between 1947 and the early 1990's. The total removed was estimated in the early 1990's at about 160-180,000 cubic metres.

The sand extraction may have a direct impact of erosion – with storm erosion likely to extend further landward in response to loss of the beach sands. This impact may however be quite minimal as the volume removed, while significant, is small relative to the total volumes of sand in the beach system (estimated in the early 1990's as up to 5 million m^3, of which up to 4 million m^3 is in the active beach and the remainder in the dune).

The loss of dune sands through wind erosion is less likely to have directly impacted on erosion to date. However, the loss of finite sand reserves from the frontal dune and accompanying dune lowering will have reduced the long term resilience of the beach system (i.e. the ability of the beach to adjust to future change).

Analysis of the shoreline changes mapped from aerial photography (Section 3.2) indicated duneline retreat along most of the shoreline, though the extent varied along the beach (Dahm et al., 1994; Dahm and Munro, 2002). Transects at 50 m spacing were used to assess any overall trends for shoreline change. Offsets from a fixed baseline were measured at each transects and then averaged along the length of the main beach to provide an average offset for each date. This suggested there may have been a trend for net erosion in the period from 1948 to 1987 averaging just under 0.2 m/yr (Dahm et al., 1994). The assessed erosion in each period was generally well within the potential error of at least $\pm$5 m (see section 3.2) though the average erosion over the total 1948 to 1987 period (7.25 m) is probably significant. However, bias towards erosion may have occurred in the results given that a period of storm cut erosion occurred towards the end of the 1948 to 1987 period (particularly from about 1967/68 to 1978), with beach profile data indicating that full duneline recovery did not occur until the early 1990's. Therefore, it is difficult to reliably separate any trend for permanent erosion from the erosion associated with more significant dynamic shoreline fluctuations.

Examination of historic surveys is also inconclusive. The earliest survey dating from 1896 (ML 3836B) fixed only the landward edge of the frontal dune (the relevant field book for the survey was examined and included a sketch of the seaward shoreline but no fixes). The earliest shoreline survey dates from

June 1906 (SO 13784) and covered only a short area at the northern end of the beach. No details were able to be located on what shoreline feature (MHW, toe of dune, etc) was mapped precluding useful comparison with subsequent surveys. The other early shoreline survey located was conducted in 1918 and from examination of the relevant field book appears to have fixed the seaward toe of the dune. This data was able to be compared with a subsequent toe of dune survey conducted in 1975 (ML 20973) which extended from Moray Place south, providing some indication of overall change in this area. Comparison of these surveys indicates relative stability and probably even a small duneline advance at the southern end of the beach between 1918 and 1975. This is the area most likely to have responded with erosion in response to the sand extraction, given that most of the extraction occurred at the southern end of the beach.

Analysis of the beach profile data suggests most duneline changes over the period since records began are associated with dynamic shoreline fluctuations. No trend for long term erosion was able to reliably discerned. For instance:

- The most significant duneline change occurs towards either end of the beach (see discussion in Section 4.3 below), consistent with dynamic fluctuations.
- The site located closest to the centre of the beach (CCS 61) showed only minimal duneline erosion since measurements began in 1981, limited to minor storm cut at the toe of the dune with subsequent recovery (i.e. dynamic changes) (see further discussion in Section 4.3 below).

Overall, the data tends to suggest that most shoreline change over the last 50-90 years has been associated with dynamic shoreline fluctuations. There may have been some net erosion during the period from 1948 to 1987 in response to historic sand extraction though available evidence is ambiguous. There is no evident trend for permanent net erosion over the last 28-30 years suggesting any historic erosion trends that did occur have ceased.

Accordingly, no trend for permanent shoreline retreat has been assumed in the erosion hazard assessment. Any low trend that may exist will be more than adequately addressed by the precautionary approach adopted in the assessment of dynamic shoreline changes (see Section 4.3 below).

4.3 Erosion associated with dynamic shoreline fluctuations

Previous work has established that most shoreline change on eastern Coromandel ocean beaches is associated with dynamic shoreline fluctuations rather than long term trends for erosion or accretion (Dahm and Munro, 2002). Therefore, it is important to assess the maximum likely erosion associated with such changes.

Beach profile data for sites CCS59-61 at Whiritoa Beach (Figures 1-3) indicates that:

- The dune is typically fronted by a wide high tide beach, sometimes 50-60 m wide
- The high tide beach is very dynamic but the dune to landward is markedly less affected

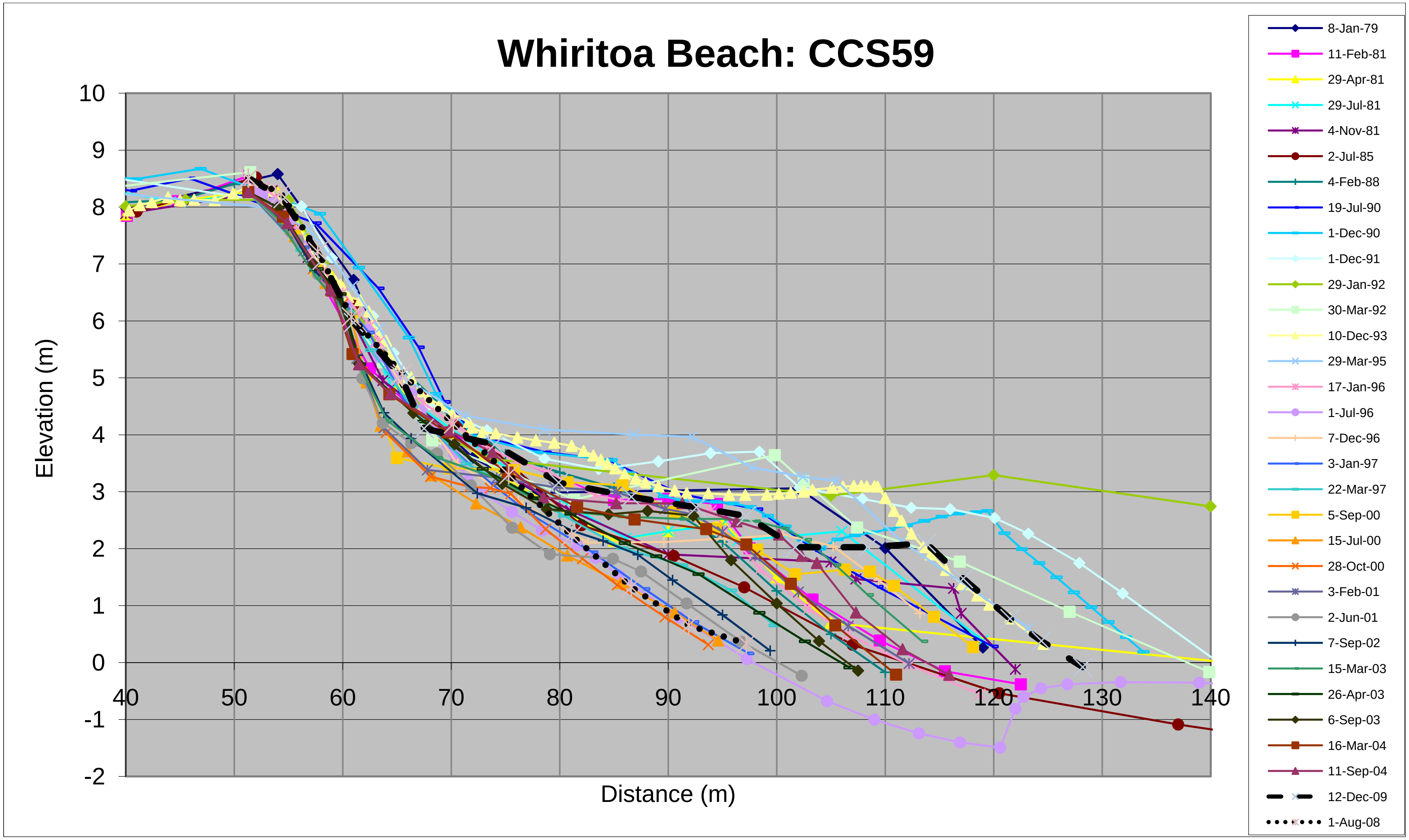

Figure 1: Beach and duneline changes recorded at CCS 59 towards the northern end of the beach

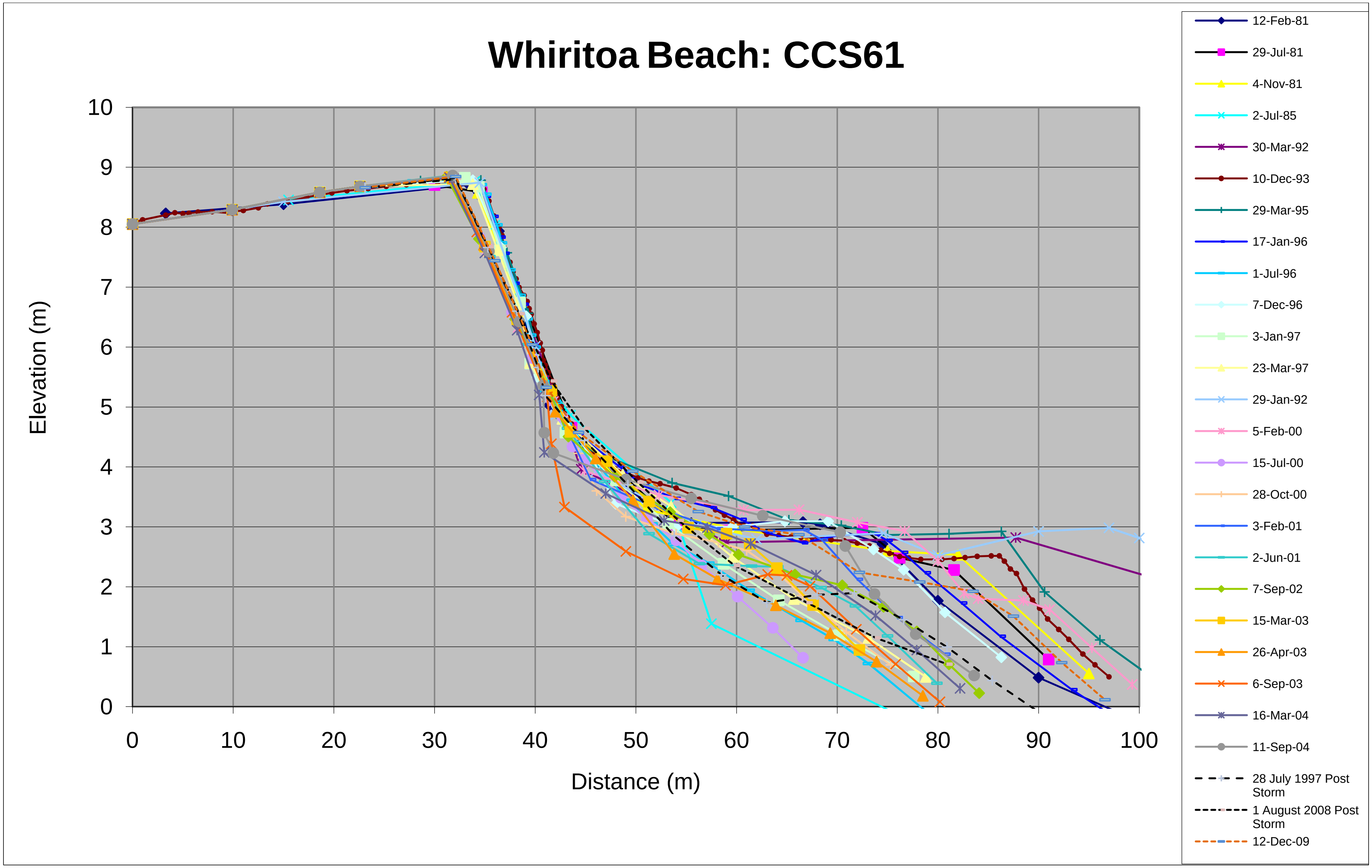

Figure 2: Beach and duneline changes recorded at CCS 61 near the centre of the beach. Note that the dune in this area was reshaped for planting in the early 2000's and this rather than erosion explains the upper duneline changes evident since this date.

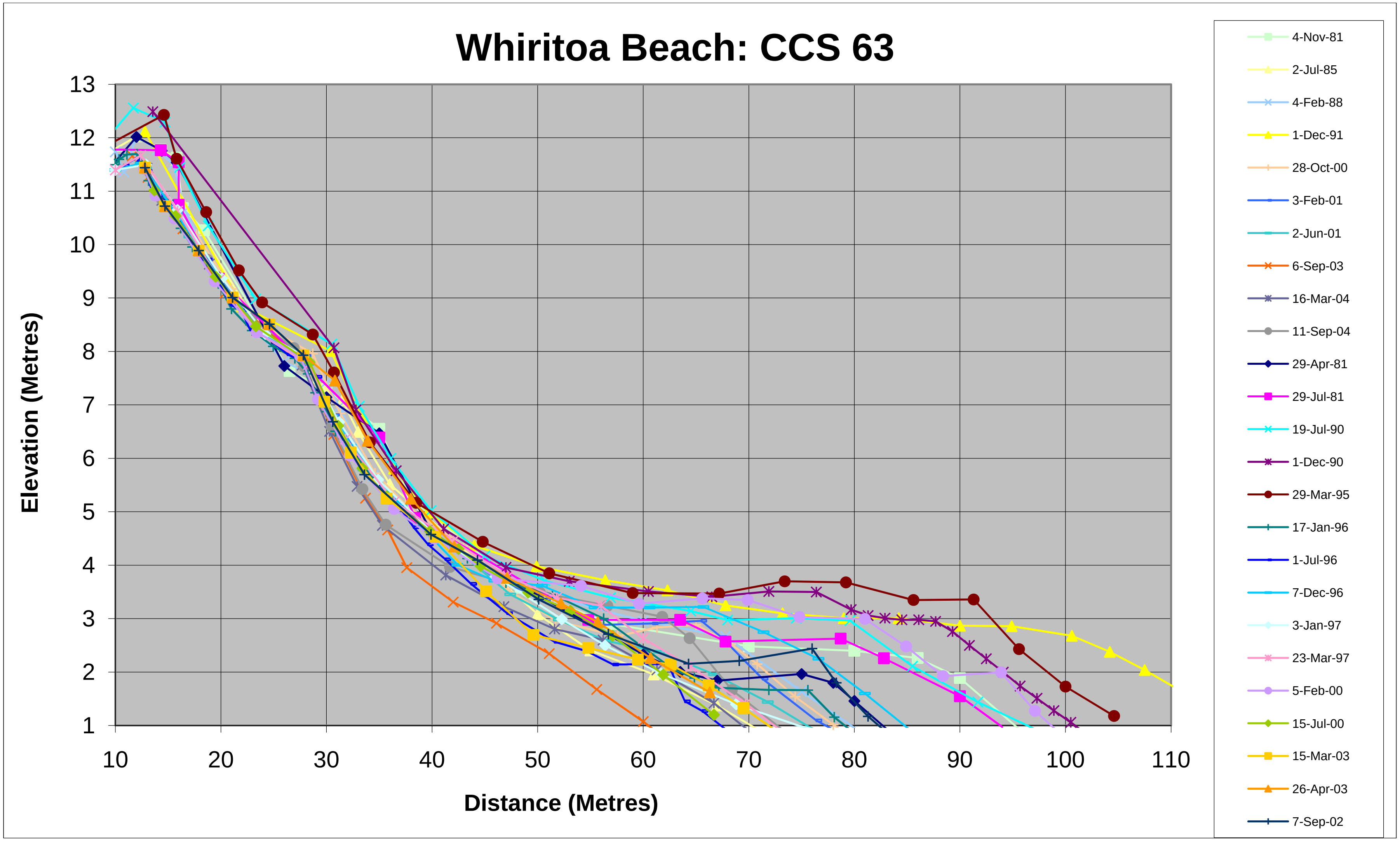

Figure 3: Maximum and minimum shoreline changes measured at beach profile site CCS 63 towards the southern end of the beach

This is further illustrated in Table 1 – which shows the maximum observed variation in high tide beach width (at elevation RL 2.5 m) and the maximum duneline variation for each of the 3 beach profile sites. Duneline variation was measured at the seaward toe of the dune which typically varies in elevation from RL 4 to 5 m, though can sometimes lower. It can be seen that the maximum measured variation in high tide beach width is typically 8-10 times the dynamic shoreline variation observed at the dune toe, typically just 1.5-2.5 m higher in elevation.

Beach Profile Site	**Variation in width of high tide beach (RL 2.5 m)**	**Variation in dune width at seaward toe**
CCS 59 (towards northern end of beach)	67	8.6
CCS 61 (near centre of beach)	55	5.1
CCS 60 (towards south end of beach)	55	8.7

Table 1: Dynamic variation in width of high tide beach and dune (measured dune toe) as measured at beach profile sites to December 2009

In addition, the duneline erosion primarily occurs near the dune toe with higher areas much less affected (see Figures 1-3).

Overall, it appears that the wide high tide beach tends to absorb most of the incoming wave energy so that the dune is less affected.

It can also be seen that the dune erosion towards the northern and southern ends of the beach is higher than that measured at the site nearest to the centre of the beach (Figures 1-3, Table 1). This is to be expected at a pocket beach such as Whiritoa due to beach rotation.

The beach profile records include up to 31 years data (Section 3.1) including a number of storm events. Therefore, the record should be sufficiently long for the measured beach and duneline changes to define typical shoreline variation. This is also supported by the beach profile data. For instance, the most significant post storm profiles measured at site CCS 59 (measured in July 1996, January 1997 (Cyclone Drena), June and October 2000, and August 2008) all closely overlie each other when plotted (Figure 4) despite many of these storm cut profiles being widely separated in time with periods of significant beach recovery having occurred between them. This tends to suggest the profiles are representative of the typical natural limit of storm cut depth at this site.

However, the full scale of the most serious duneline erosion is often only evident over periods of many decades or longer on eastern Coromandel beaches (Dahm and Gibberd, 2009). For example:

- The most serious duneline erosion at Hahei Beach in recent decades occurred during the storm of July 1978 – completely stripping beach and dune sands offshore to exposed older underlying materials over extensive areas. Advice from long term residents indicated that the previous time this had occurred had been over 60 years earlier in 1918.
- Recent severe erosion at the southern end of Whangapoua Beach in July-August 2008 was far more severe than any other erosion in the beach profile records in that area which extended back nearly

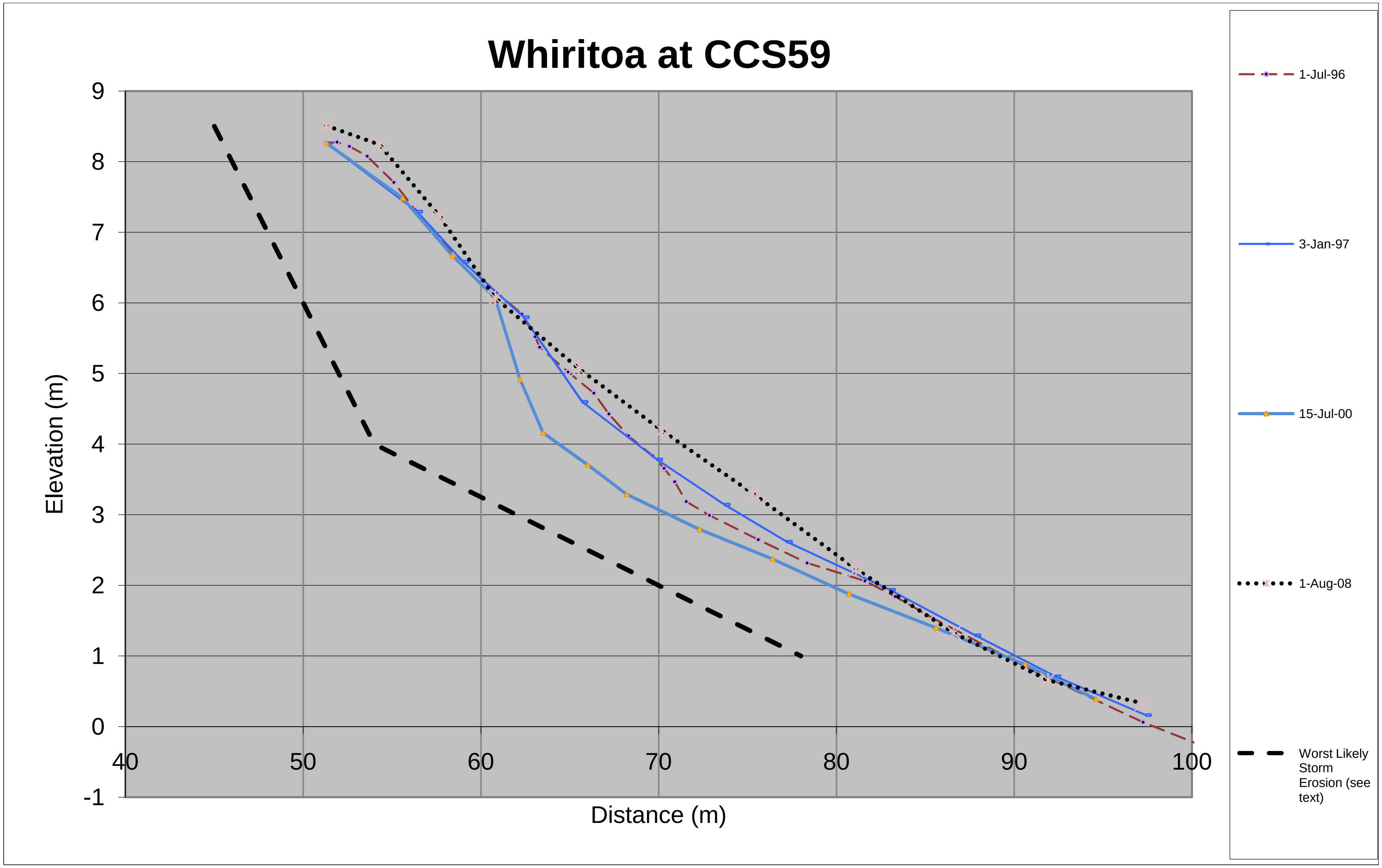

Figure 4: Worst storm cut profiles measured at site CCS 59 and compared to estimated worst likely erosion (see text for further discussion)

- 30 years. Use of the record that existed prior to that event would have under-estimated the erosion (Dahm and Gibberd, 2009).
- Erosion on Great Mercury Island during the July and August 2008 storm events exposed and damaged cultural deposits estimated to be around 500 years old (Furey, 2009).

Therefore, a precautionary approach has to be adopted in assessing the maximum likely erosion associated with dynamic fluctuations. The beach profile record at Whiritoa Beach though of a reasonable length is very unlikely to include the most serious erosion that can occur.

For instance, while the most serious storm cut profiles closely overlie each other, suggestive of a natural limit to the depth of storm cut (Figure 4), the distance to which these profiles extend landward will vary with storm duration, antecedent conditions, and other factors. Breaking waves at this site are quite capable of wave run-up to elevations of RL 4-5 m and higher – so that the storm cut profile could theoretically extend to these elevations given a storm of sufficient duration (or a number of relatively closely spaced storms). This would obviously result in far more significant duneline erosion.

Reliable estimation of the most serious erosion likely for return periods of up to 100 years is difficult. However, Dahm and Gibberd (2009) developed a methodology that can be used to estimate extreme events using beach profile data. Applied to Whiritoa, this method suggests the dune toe could erode up to 5 m further landward than measured - with the higher values towards the northern and southern ends of the beach. In order to be precautionary, a 50% safety factor was applied to the calculations yielding an upper limit value of 7.5 m. The maximum likely dune toe erosion in the centre of the beach may be less but for the sake of precaution the same value was adopted along the full length of the beach.

The top edge of the eroded dune face could undergo further retreat due to post-storm collapse of the unstable near-vertical erosion scarp formed by storms. Sand normally collapses to a stable angle of repose approximating 1V:2H and this has been assumed for the worst likely erosion profile. Collapse has been assumed to occur from the dune toe. This is a precautionary assessment as the top of the eroded face typically tends to collapse to the toe.

The estimated worst likely erosion profile so calculated is plotted in Figure 4 (CCS 59) by way of example. It can be seen that the estimated erosion considerably exceeds any dune erosion measured since beach profile monitoring commenced in 1979.

The estimated erosion was also checked against other available historic data (see Section 3) and against field observations. There was no evidence in either historic data or field observations that erosion of this magnitude has been exceeded. In all areas along the main beach the top edge of the estimated erosion lies comfortably landward of any measured or evident historic erosion.

A reality check of the erosion was also conducted by the plotting worst measured historic storm cut profiles and extrapolating these - to assess the wave run-up required to generate the erosion (Figure 4).

It can be seen that the estimated erosion would require a storm of sufficient duration to erode the toe of dune to elevations of approximately RL 5 m. The worst measured dune erosion on this extreme storm cut profile extends to about RL 4 m.

Wave run-up to RL 5 m is a realistic scenario at this beach though the required erosion would require a storm of significant duration or, more likely, two or more relatively closely spaced storms. However, the return period of such erosion is not easy to estimate. In my opinion, it is likely to be at least 100 years given the severity of the erosion relative to measured historic erosion (e.g. Figure 4).

Accordingly, the erosion is assessed as a reasonable but conservative (i.e. precautionary) assessment of the worst likely storm cut along the main ocean beach. This estimate can be further revised in the future as the length of the beach profile record extends.

The baseline for measuring the present setbacks is the most seaward toe of dune – a line fixed in the early 1990's when the beach was in an accreted state. At CCS 59, the landward edge of the estimated erosion lies about 24 m landward of the most seaward toe of dune (at RL 4 m) in the beach profile record. This figure has been rounded up to 25 m and adopted for the full length of the ocean beach.

Interestingly, the figure is identical to the generic 25 m figure recommended by Dahm and Munro (2002). However, given the precautionary approach adopted in this review (as outlined above) and the additional 10 years data now available, the 10 m safety factor applied in the 2002 report can now be safely eliminated. (i.e. There is sufficient precaution in the estimate).

4.4 Potential for aggravation of erosion by sea level rise

There is potential for predicted global warming to impact on a number of coastal processes that affect erosion at Whiritoa Beach including sea level; storm frequency, duration and severity; and wave climate (which can affect beach orientation, etc). Unfortunately, it is not presently practicable to define how climate change is likely to affect most of these factors along the eastern Coromandel coast, nor how these changes may impact Whiritoa Beach.

However, various projections are available for sea level rise and these can be used to estimate the potential impact on coastal erosion using the Bruun Rule. In essence, this rule is based on the assumption that the existing beach face slope out to the seaward edge of the beach system is in equilibrium with existing processes. The Bruun Rule predicts that maintenance of this equilibrium profile with sea level rise will result in a transfer of sand from upper areas of the beach system (e.g. visible areas of the beach above low tide) to parts of the beach system further offshore – with accompanying erosion of the beach and dune.

The potential for aggravation of erosion by sea level rise can be estimated using the Bruun Rule:

$X = al/h$

Where;

- X is the shoreline retreat in response to sea level rise

- a is the rise in mean sea level assumed
- l is the horizontal distance between the foredune crest and the seaward limit of profile adjustment (known as the closure depth)
- h is the elevation between these two points.

The Bruun Rule is generally accepted as a useful model in contexts such as Whiritoa Beach where the assumptions central to the method are likely to hold (as discussed by Dahm and Munro, 2002). Coastal hazard zones based on use of this method in similar settings have also been accepted by the Environment Court.

The Hauraki District Council has adopted a sea level rise of 0.5 m by 2100 for planning purposes. The 2008 MfE Guidance Manual recommends consideration of a base level of 0.5 m for the period to 2099 with 100 mm/yr thereafter – giving 0.6 m by 2110 (i.e. over the next 100 years). In addition to this base level, the manual recommends assessment of the potential consequences from a range of higher sea level rises - recommending that all assessments should consider the consequences of a mean sea level rise of at least 0.8 m by 2100 (or 0.9 m to 2110). Government is presently considering provision of a national standard for appropriate sea level rise projections.

The estimates in this report for the period to 2100 have adopted 0.5 m consistent with Council policy and the base level recommended in the MfE 2008 Guidance Manual. However, in line with the Guidance Manual, the effects of a sea level rise of 0.8 m by 2100 have also been assessed for comparison.

Calculations were conducted using parameters estimated from offshore profiles at CCS 59 (representative of northern areas of beach) and CCS 60 (representative of southern end of the beach).

Results of the calculations are presented in Table 2

Factor	0.5 m Sea Level Rise		0.8 m sea level Rise	
	CCS 59	CCS 60	CCS 59	CCS 60
L	278	360	278	360
H	12	12	12	12
X	12	15	19	24

Table 2: Estimates of additional erosion (X) that may accompany sea level rise of 0.5 m and 0.8 m at Whiritoa Beach (see text for more details)

It can be seen that erosion of 12-15 m may occur in response to sea level rise of 0.5 m, with 19-24 m erosion in response to sea level rise of 0.8 m. The higher values calculated for CCS 60 should be adopted for the sake of precaution (i.e. 15 m for a sea level rise of 0.5 m; 24 m, rounded up to 25 m, for a sea level rise of 0.8 m).

5 Recommended Setbacks

5.1 Ocean shoreline of beach excluding stream entrances

The calculations in Section 4 enable the PDS and SDS to be estimated for the main ocean beach and these setbacks are summarised in Table 3. The calculations have used the 0.5 m sea level rise consistent with present Council policy.

Factor	PDS	SDS
Long term erosion trend	0	0
Erosion associated with dynamic shoreline fluctuations	25	25
Potential aggravation of erosion by projected sea level rise	0	15
Total Setback Width (m)	25 m	40 m

Table 3: Revised setback widths estimated by review

The review suggests the PDS can be revised to 25 m width along the main ocean beach and the SDS to 40 m. This compares to the existing setbacks of 35 m and 50 m, respectively. The only change from the 2002 recommendations is the elimination of the 10 m safety factor from the PDS. The site specific assessment based on the better data and methodologies now available suggests there is sufficient precaution in the 25 m PDS estimate for this site without the need for the safety factor.

It should be noted that the SDS is sensitive to the sea level projection used and if national standards for this factor are promulgated by central government, the SDS will change accordingly. For instance, a national standard of 0.8 m would increase the SDS to 50 m (i.e. same as the existing SDS).

5.2 Other factors

In addition, there are four other factors relevant to coastal hazard setbacks at Whiritoa:

- The baseline from which the setbacks are measured
- Dune height
- The influence of erosion resistant materials
- Application of the setbacks around the stream entrances.

These factors are briefly discussed in turn below.

Baseline

Various submissions raised concerns about the baseline from which the setbacks are measured.

The baseline used for mapping of the setbacks by Council was the most seaward toe of dune as fixed in the early 1990's. The baseline from which the setbacks calculated in this review are measured is the most seaward toe of dune at RL 4 m elevation in the beach profile records at CCS 59.

Checks using CCS 59 data indicate that the most seaward duneline in the early 1990's is virtually identical to the most seaward duneline measured since. Therefore, the existing baseline should generally be sufficiently accurate for mapping the setbacks.

However, field examinations and other considerations suggest the following localised modifications should be made to the existing baseline to improve accuracy of the setbacks:

- **Ramarama Stream:** Some seaward movement of the baseline is justified along the ocean (i.e. not the lagoon) shoreline as follows:
    - Move the baseline 5 m seaward directly opposite the boundary line between 40 and 42 Fisherman's Bend
    - Extend this new line southwards to merge with the existing baseline directly seaward of the boundary between 32 and 34 Fisherman's Bend.
    - Extend this new line northwards to merge with the existing baseline around the lagoon on the northeast corner of 42 Fisherman's Bend.
- **5 to 7 Kon Tiki Road:** Extend the baseline seaward by eliminating the indentation presently occurring in this area. Extend this new straight line 10 m south of 7 Kon Tiki Road and then merge with existing baseline.

If desired, the setbacks can be plotted without using the existing baseline to further improve accuracy. However, this would require further work and for the reasons noted above is unlikely to result in any significant change in the setbacks along the ocean shoreline.

The concerns raised by landowners in respect to the lagoon areas have been dealt with separately below and the revised setbacks recommended for these areas are based on the existing baseline. The recommendations would need to be revised if the baseline was altered. The location of the setbacks relative to property boundaries would not change.

Dune height

The calculations in this review have assumed an average dune height of RL 8.5 m relative to mean sea level – this being adopted as representative value based on beach profile data. The setbacks are appropriate for areas of similar or lesser elevation which appear from field inspections to include most affected properties. However, in areas where higher dunes are encountered, some site specific adjustment is required. In any such areas, it is recommended that the setback be increased by 2 m for every 1 m increase in elevation above RL 8.5 m. This is unlikely to be relevant for applications involving the PDS.

Influence of erosion resistant materials

Critically, the setbacks assume the shoreline is free to erode – i.e. that loose erodible sands extend back to the setbacks.

This assumption does not always hold at Whiritoa Beach as available borehole data indicates that erosion resistant materials underlie the sands and extend above beach level in some areas (Dahm and

Munro, 2002). In such areas, these materials may restrict erosion and allow the setbacks to be appropriately reduced.

This is likely to allow some reduction of the setbacks in some areas – particularly the SDS. The limited available borehole data is not adequate to reliably identify such areas. However, it is recommended that the setbacks should allow for site specific investigation to assess this aspect. That will enable site specific reduction of the setbacks where erosion resistant materials are adequate to restrict erosion. Any setback adjustment should be based on investigations conducted by professionals experienced with coastal erosion.

Setbacks around the stream entrances

Definition of appropriate setbacks in the vicinity of the stream entrances is complex as these areas are subject to different processes from the main ocean beach, particularly erosion associated with the streams.

Past experience indicates that erosion in these areas can be severe. For instance:

- Alongshore migration of the Ramarama Stream in the 1980's severely eroded the dunes southwards almost to Pohutukawa Reserve. This reduced the width of the dune buffer in this area, increase the vulnerability of the properties to coastal erosion. Significant works were undertaken by the then Hauraki Catchment Board to address the issue.
- River bank erosion on the southern side of the Ramarama Stream severely threatened the adjacent beachfront property (42 Fisherman's Bend; Lot 1, DP 57291) in the mid to late 1990's.
- Severe erosion has occurred around the Whiritoa Stream entrance in the past allowing storm waves to wash onto the seaward end of Kon Tiki Road (e.g. July 1978 storm).

The existing setbacks assume that the dunelines around these areas will erode similarly to those along the beach. However, as the processes are different, this assumption does not apply and in some areas is too conservative. The cessation of sand extraction at the southern end of the beach in the early 1990's has markedly reduced hazard potential in this area. For instance, the dunes seaward of Kon Tiki Road have recovered significantly since this time.

Field inspection and information on historic changes allows some revision of the setbacks in the area of the stream entrances. The following recommendations for revision are made - with all distances relative to the existing baseline:

Ramarama Stream

- Lagoon margin from 42 Fisherman's Bend to the end of Fisherman's Bend, inclusive – a setback of 20 m from the baseline for the PDS and 30 m for the SDS
- Lagoon margin from 73 to 69 Fisherman's Bend, inclusive – a setback of 10 m from the baseline for the PDS and 20 m for the SDS.

Whiritoa Stream

- Lagoon margin from 128 Kon Tiki Road to 4 Swordfish Avenue, inclusive – a setback of 20 m from the baseline for the PDS and 30 m for the SDS

5.3 Summary of Setback Recommendations

It is recommended that setbacks along the ocean beach can be reduced as follows:

PDS – setback of 25 m

SDS – setback of 40 m

In addition, the setbacks in the vicinity of the Ramarama and Whiritoa Stream entrances can be reduced – as per the values outlined immediately above in Section 5.2.

All setback distances are relative to the existing baseline – with only minor and localised revision of this baseline presently recommended (as outlined in Section 5.2). Further refinement of the baseline would involve further work.

The reduced setbacks along the ocean beach reflect the elimination of the 10 m safety factor included in the 2002 report. The additional data and methodologies now available indicate that the 25 m estimate for the PDS is adequately precautionary and does not require the additional safety factor.

The reduced setbacks around the stream lagoon allow for the lesser wave effects that occur in these areas and the additional influence of stream erosion. The cessation of sand extraction at the southern end of the beach has also reduced hazards around the Whiritoa Stream entrance.

In some areas, additional reduction of the setbacks may be possible - based either on further refinement of the baseline (main beach only) or on further investigation of subsurface conditions which may reveal erosion resistant materials. In order to cover the uncertainties related to subsurface conditions, it is recommended that Council allow for revision of the setbacks based on site specific investigations – with such investigations to be conducted by professionals appropriately trained and experienced in the assessment of coastal erosion.

The recommended SDS is based on a sea level rise of 0.5 m consistent with existing Council policy. This setback will change as sea level rise projections are changed in the future and/or if central government promulgates a national environmental standard in regard to sea level rise that differs from present Council policy. It should be noted that the 0.5 m rise by 2100 provided for in present Council policy is the minimum standard recommended by present hazard management guidelines.

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