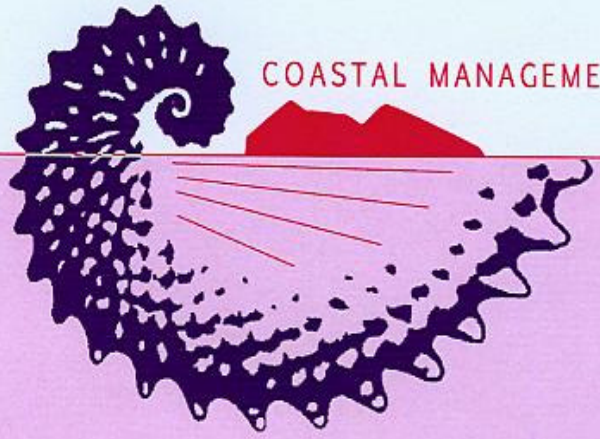

COASTAL MANAGEMENT CONSULTANCY LIMITED

INITIAL ASSESSMENT OF AREAS SENSITIVE TO COASTAL HAZARDS FOR SELECTED PARTS OF THE GISBORNE DISTRICT COAST

Report prepared for Gisborne District Council

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EXECUTIVE SUMMARY

Based on a comprehensive Coastal Hazards Database compiled in this study an initial assessment of Areas Sensitive to Coastal Hazards (ASCH) was made for 42 coastal areas between Mapere Point (south of Poverty Bay) and Potikirua Point (west of Hicks Bay). The major natural hazards identified were erosion, landslip and flooding.

Predominantly *erosion hazard areas* were mostly confined to coastal plains of Holocene aged unconsolidated sediments. Types of erosion identified included long-term retreat at rates from -0.02 to -1.24m/year, short-term shoreline fluctuations ranging from 2m to greater than 100m along both advancing and retreating coasts, river mouth migration, and wind erosion of sand dunes. ASCH widths ranged from 75m for an area of very slow retreat east of Te Araroa, up to 570m at Hautai Beach for an area of extreme wind erosion further east.

Predominantly *landslip hazard areas* are mostly confined to the retreating seacliffs cut into Late Cretaceous to Late Tertiary consolidated sedimentary rocks. Types of landslip identified included rockfalls, slumping and earthflows with the latter being associated with faulted and disrupted lithologies. ASCH widths ranged from 100m for the seacliffs flanking Tolaga Bay up to 1,070m for the deep seated earthflow prone slopes of Waipiro Bay.

Predominantly *flood hazard areas* were mostly low-lying land on the Holocene coastal plains especially near river mouths such as the Waipaoa, Waiapu and Wharekahika. Types of flooding identified included inundation from both storm wave and tsunami wave runup, and flooding from coastal rivers. ASCH widths ranged from 130 to 240m at Onepoto Bay from storm wave runup up to 700 to 2,500m at southern Poverty Bay from storm and tsunami wave runup coupled with peak flows in the Waipaoa River.

The most *stable coastal areas* were raised marine terraces formed from the Late Jurassic to Early Cretaceous very hard erosion resistent volcanic rocks between Hicks Bay and Cape Runaway. For these areas, including Lottin Point, a minimum ASCH width of 50m was adopted.

INITIAL ASSESSMENT OF AREAS SENSITIVE TO COASTAL HAZARDS FOR SELECTED PARTS OF THE GISBORNE DISTRICT COAST

by
Jeremy G Gibb

To be forewarned is to be forearmed

1.0 INTRODUCTION

For the Gisborne District coastline, coastal hazard mapping techniques were conceived developed, tested and standardised for New Zealand by the writer in the then Waiapu County between 1979 and 1980. For the 147km-long Waiapu coastline, coastal hazard maps were produced for 14 areas between Marau Point and Matakaoa Point (Gibb 1981a). In December 1980, the then Cook County Council commissioned the writer to assess a Coastal Hazard Zone (CHZ) for the 4.2km-long Wainui Beach. Using a comprehensive database, a 25 to 55m-wide CHZ was assessed consisting of a 15m-wide *"Zone of Immediate Risk"* and a 10 to 40m-wide *"Zone of Ultimate Risk"* (Gibb 1981b).

On 24 August 1994, Gisborne District Council commissioned the writer to provide an initial assessment of Areas Sensitive to Coastal Hazards (ASCH) for selected parts of the East coast listed in Appendix I. Many of the areas north of Marau Point were those previously studied by the writer (Gibb 1981a), providing an opportunity in the 14 years that have passed to review the original Coastal Hazard Zone assessments. In addition, ASCHs were assessed for new coastal areas thought to be at risk south of Marau Point.

In this report, the methods and criteria developed here for defining ASCHs along the Gisborne District Coast are described along with a brief summary of the characteristics of the identified coastal hazards. The ASCHs are then briefly described and widths tabulated for each coastal area. The ASCHs are delineated on 42 Photomaps at 1:5,000 Scale (Appendix I) supplied separately to Council. Finally, recommendations are given for future monitoring of selected coastal areas. This report is a revised version of an earlier report (Gibb 1994) to include the coastline from Anaura Bay to Mawhai Point.

2.0 METHODS

Areas Sensitive to Coastal Hazards (ASCH) were defined from the combination of field

work, studies of relevant literature, Infomaps with contours at 1.0m intervals of Poverty Bay, Onepoto and Hicks Bays, Coastal Resource maps showing historical patterns of coastal erosion or accretion during the last century from Tauporo Beach to Kaiaua and the Te Araroa and Hicks Bay areas, and Photomaps showing the geomorphology of the entire coast and historical patterns of erosion or accretion from Anaura Bay to Te Araroa.

2.1 Field Work

Between 5 and 17 September and 21 and 29 November 1994, 112 Stations were surveyed at approximately 1.0km intervals for selected parts of the Gisborne District coastline (Appendix I) between Tauporo Beach, south of Young Nicks Head, and Potikirua Point, west of Lottin Point. Most beaches were accessed at low tide by four-wheel drive vehicle and the rest by overland access across privately owned farmland with the owner's permission.

At each station, observations were made of particular elements contributing to the three principal coastal hazards of erosion, landslip and flooding. Following field investigations, field data and data on coastal erosion-accretion rates were entered into a computer database for each station to provide the basis for assessing a Coastal Sensitivity Index (CSI).

2.2 Coastal Sensitivity Index (CSI)

Gibb *et al.* (1992) developed and tested an initial framework to collect and store information about New Zealand coastal areas in a Coastal Hazards Database. The Coastal Hazards Database comprises 8 variables which include elevation, maximum storm wave runup level, gradient, maximum tsunami wave runup, lithology, coastal landform, long-term shoreline trend, and short-term shoreline fluctuations.

Each of the 8 variables is ranked into 5 sensitivity classes (1 to 5) in a matrix (Table 1) and a specific CSI is derived for each station by adding the class allocated to each of the 8 variables. CSI's potentially range from a minimum of 8 (Very Low Sensitivity) to a maximum of 40 (Very High Sensitivity), the classes ranging from Very Low (8-13), Low

(14-20), Medium (21-27), High (28-34), to Very High (35-40).

(i) Elevation

Elevation (Table 1) is the height of the immediate coastal landform (foredune, primary beach ridge, etc.), or first line of defence against the sea, in metres above Mean High Water Springs (MHWS), and expresses the sensitivity of the coastal hinterland to inundation. Elevation is an important variable because sections of coastline which are at relatively lower elevations, are more sensitive to overtopping and inundation from the sea compared to higher areas.

For each of the 112 Stations, elevation was determined in one of two ways. For those features under 15m above MHWS the height was levelled to the sea-horizon by eye to an accuracy of ±0.01m using a 3m graduated survey staff. MHWS was estimated on the day from the wetted line on the beach to an accuracy of ±0.5m. For those features over 15m above MHWS, elevation was determined from the NZMS 260 Topographic maps at 1:50,000 Scale to an estimated accuracy of ±5.0m.

(ii) Storm Wave Runup

During severe onshore storms, the combination of barometric set-up, wind set-up, wave set-up, predicted astronomical tide level, and wave runup contribute to a maximum level of storm wave runup (Table 1). For coasts with landforms at elevations less than storm wave runup levels, overtopping and inundation of low-lying areas of coastal hinterland will occur.

Maximum storm wave runup levels were estimated directly in the field from the highest flotsam and driftwood levels, anecdotal evidence and the elevations of storm berms on gravel beaches. On hard rocky coasts the runup level was estimated from the lowest line of terrestrial plants above MHWS. For sites with no evidence extrapolations were made from adjacent sites with reliable evidence.

Table 1: The combined matrix for the Coastal Hazards Database from which a Coastal Sensitivity Index can be derived. (adopted from Gibb *et al.* 1992, Table 4).

CLASS VARIABLE	**1 Very Low**	**2 Low**	**3 Medium**	**4 High**	**5 Very High**
Elevation above MHWS (m)	>20.0	20.0-10.1	10.0-5.1	5.0-2.0	<2.0
Max. Storm Wave Runup Level above MHWS (m)	<1.0	1.0-1.5	1.6-2.5	2.6-5.0	>5.0
Gradient (deg)	>20	20-11	10-6	5-2	<2
Max. Tsunami Wave Runup Level above MHWS (m)	<0.5	0.5-1.5	1.6-4.0	4.1-10.0	>10
Lithology					
Igneous	Plutonics. Intrusives.				
Metamorphic	Metamorphics (high to medium grade).	Low grade metamorphics.	Sheared metamorphics.		
Volcanic	Volcanics (lava, dikes).	Very densely & densely welded ignimbrites. Volcanic breccia.	Partially welded ignimbrite.	Non-welded ignimbrite. Consolidated volcanic ash. Lahars.	Unconsolidated volcanic ash.
Sedimentary		Densely indurated sedimentary rocks (greywacke, solid argillite). Well cemented, sedimentary rocks (limestones, quartzite).	Moderately indurated sedimentary rocks (sandstones argillite, conglomerate).	Weakly indurated sedimentary rocks (mudstones, weak argillite, weak conglomerates). Relict sands. Lignite. Loess.	Unconsolidated sediments (colluvium, alluvium, gravels, sands, silts, muds). Peat. Swelling bentonites.
Natural Landform	Very hard rock platforms & sea cliffs	hard rock platforms & sea cliffs	Moderately hard rock platforms & sea cliffs Moraines	Soft rock platforms & sea cliffs. Alluvial deltas. Saltmarsh/ mangroves.	Sand barriers, beaches, dunes & spits. Gravel barriers, beach ridges & spits. River mouths. Cuspate forelands.
Long-Term Trend (m/year)	>+0.50 Advance	+0.50 to -0.02	-0.03 to -0.49	-0.50 to -2.00	>-2.00 Retreat
Short-term Fluctuation (m)	<2	2-5	6-10	11-30	>30

(iii) Gradient

Gradient (Table 1) is the average slope of the coastal hinterland behind the initial elevation (coastal landform). A lower or negative gradient equates to a higher risk from inundation by the sea. Gradient was either estimated in the field by sighting from landward of the primary beach ridge or foredune, to the sea horizon, or from contour maps of the area.

(iv) Tsunamis

Tsunamis (Table 1) are long-period tide type waves (generally 20-30minutes) generated by large short duration disturbances of the sea-floor and may cause erosion of the coast and inundation of low-lying areas. For the Gisborne District coast maximum tsunami wave runup levels were adopted from Eiby (1982), de Lange and Healy (1986) and from local informants. For sites with no evidence extrapolations were made from adjacent sites with reliable evidence.

(v) Lithology

The type of bedrock lithology (Table 1) affects the erosional sensitivity of an area of coast to both shoreline retreat and landslip. Solid and massive rocks such as the Late Jurassic to Early Cretaceous volcanic rocks between Hicks Bay and Cape Runaway, including the Lottin Point area, are very resistant to wave attack. In contrast sandstones, siltstones and rocks with bedding planes, closely spaced joints or faults such as the Late Cretaceous to Late Tertiary rocks between Mapere Point and Te Araroa are more easily eroded, and loose, unconsolidated sands and gravels of Holocene age at selected areas along the entire coast sustain the most rapid erosion rates. Lithology was identified both in the field, from Gibb (1981a) and from the Geological Maps of New Zealand (Kingma 1965; 1966).

(vi) Landform

Coastal landforms (Table 1) result from the interaction of the ocean and atmospheric

forces with the land and have generally formed along the Gisborne District coast over the last 7,000 years. Landforms were identified both in the field and from the 1:5,000 Scale Photomaps.

(vii) Long-Term Trend

The long-term trend (Table 1) is the long-term (historic) rate of shoreline retreat, advance or dynamic equilibrium. Areas which are advancing from accretion of sediment have a relatively lower sensitivity than those which are retreating from erosion. For the study area the rate and direction of the long-term trend was determined by comparing historic surveys of shoreline positions over the last century at Scales of 1:2,500 and 1:5,000 on Coastal Resource Maps and Photomaps of the Gisborne District coast. These maps are essentially an update of analyses by Gibb (1981a) and Willard (1987). The survey procedures adopted for the analysis of historical cadastral plans are described in Willard (1987).

(viii) Short-term fluctuation

The short-term fluctuation (Table 1) is the maximum horizontal fluctuation of the duneline, toe of seacliff, or storm berm, irrespective of the long-term trend. A short-term retreat may occur during one or a cluster of severe onshore storms followed by short-term advance as a result of deposition during calmer sea conditions. Such fluctuations may also occur from alongshore fluxes of sediment and from coastal landslides temporarily advancing the shoreline. Short-term fluctuations were determined from the Coastal Resource Maps and Photomaps, from local informants and from geomorphic evidence in the field.

2.3 Photomaps

In May 1993 vertical black and white aerial photographs were taken of the entire Gisborne District coastline by Aerial Surveys Limited, Nelson. From the photographs, more than 60 Photomaps were produced at 1:5,000 Scale and A1 format of the coastline between

Mapere and Lottin Points. Although the photomaps are unrectified and therefore, limited from the viewpoint of determining accurate rates of shoreline advance or retreat, they provide important qualitative information on coastal hazards. Freshly cut erosion scarps along the coast were also easily identified as were sand dune complexes subject to wind erosion and past and present landslides and landslide types. Areas subject to past and present river mouth migration and associated erosion and flooding were also able to be identified.

3.0 CRITERIA FOR DEFINING ASCHs

The following criteria were developed to define ASCH widths for coastal areas dominated by one or the combination of the identified hazards of flooding, landslip and erosion.

3.1 General

For all ASCH assessments:

(i) The *precautionary principle* of *"erring on the side of caution"* was adopted.

(ii) A planning horizon up to the year 2100 A.D. was adopted.

(iii) The seaward toe of the foredune or seacliff, MHWS where defined by standard survey procedures, or top seaward edge of the storm berm on gravel beach ridges were adopted as the *reference shorelines* to determine ASCH widths.

(iv) The extent of historical coastal flooding and rates of erosion have a high probability of increasing next century from a *sea-level rise of 0.66m* above the present by 2100 A.D. as determined by the current Intergovernmental Panel on Climate Change (IPCC 1990) projections.

3.2 Flooding

(i) If the gradient of the coastal hinterland was less than 1^0 (1:60), or negative, a contour of 3m above MSL was adopted to define the potential inland limit of inundation by the sea based on historic storm wave and tsunami wave runup levels, projected sea-level rise and the area of land available to absorb catastrophic inundation.

(ii) If the gradient of the coastal hinterland was between 1^0 and 2^0 (1:30 to 1:60) a contour of 4m above MSL was adopted to define the potential inland limit of inundation by the sea based on the same criteria as (i) including the area of land available to absorb catastrophic inundation.

3.3 Landslip

(i) For sedimentary lithologies of Late Cretaceous to Late Tertiary age, a *minimum ASCH width of 100m* inland from the reference shoreline was adopted, or 50m inland from the top seaward edge of the landslide scarp, whichever distance is the greatest from the reference shoreline.

(ii) For volcanic lithologies of Late Jurassic to Early Cretaceous age, a *minimum ASCH width of 50m* inland from the reference shoreline was adopted, or 20m inland from the top seaward edge of the seacliff, whichever distance is the greatest from the reference shoreline.

3.4 Erosion

(i) Where the rate of long-term retreat is less than -0.01m/year and/or short-term shoreline fluctuations are less than 2m, a *minimum ASCH width of 50m* inland from the reference shoreline was adopted.

(ii) Where the rate of long-term retreat is between -0.01 and -0.10m/year and/or short-term shoreline fluctuations are between 2 and 5m, a *minimum ASCH width of 75m* inland from the reference shoreline was adopted.

(iii) Where the rate of long-term retreat is between -0.10 and -0.20m/year and/or short-term shoreline fluctuations are between 5 and 30m, a *minimum ASCH width of 100m* inland from the reference shoreline was adopted.

(iv) Where the rate of long-term retreat is between -0.20 and -0.40m/year and/or short-term shoreline fluctuations are between 30 and 60m, a *minimum ASCH width of 150m* inland from the reference shoreline was adopted.

(v) Where the rate of long-term retreat is between -0.40 and -0.80m/year and/or short-term shoreline fluctuations are between 60 and 100m, a *minimum ASCH width of 200m* inland from the reference shoreline was adopted.

4.0 COASTAL HAZARDS

The results of this study are summarised in the GDC Coastal Hazards Database (Appendix II), the summary of natural coastal hazards for each coastal area (Table 2) and the ASCHs delineated on the 42 Photomaps (Appendix I). In this section of the report, the major findings on coastal hazards along the Gisborne District coast are summarised.

4.1 Erosion Hazard

In Table 2, erosion has been subdivided into long-term retreat, short-term shoreline fluctuations, river mouth migration, and wind erosion. For each coastal area surveyed along the Gisborne District coast the presence or absence of the erosion type is noted in Table 2. The findings are:

(i) With the exception of the Late Jurassic to Early Cretaceous volcanic lithologies between Hicks Bay and Cape Runaway, all other lithologies forming the Gisborne District coast are subject to sea or wind erosion, or erosion from migrating river mouths to a greater or lesser degree.

(ii) The only unconsolidated sedimentary coastal areas without a history of long-term retreat from coastal erosion, are Poverty Bay including Muriwai, most of Anaura Bay, northern Nuhiti Beach, central Tokomaru Bay, central Tuparoa, Port Awanui to Rangitukia Beach, Hautai Beach, Orutua Beach, Karakatuwhero River to Punaruku, Onepoto Bay, and Hicks Bay. All these areas are either in dynamic equilibrium or have an historic long-term trend of shoreline advance from accretion ranging from 0.21 to 3.70m/year, from locally derived sediments.

(iii) The greatest rates of long-term retreat occur along the unconsolidated sand or gravel coastlines of Te Araroa (-0.43 to -1.24m/yr), Orongo and Tauporo Beaches (-0.43

to -0.51m/yr), Horoera (-0.48m/yr), southern Anaura Bay and Nuhiti Beach (-0.38m/yr), followed by erosion of weakly consolidated earthflow colluvium at Reporua (-0.75m/yr) and northern Waipiro Bay (-0.41m/yr).

(iv) Seacliffs cut into the Late Cretaceous to Late Tertiary sandstone-mudstone sedimentary lithologies are retreating everywhere at -0.10 to -0.29m/yr, averaging -0.17m/yr.

(v) Except for the Lottin Point area, all coastal areas examined are subject to short-term erosion-accretion cycles. The greatest fluctuations are located around river mouths such as the Wharekahika in Hicks Bay (200 to 250m) and the smallest (2 to 5m) along the raised beaches between East Cape and Te Araroa. Large landslides (slumps) are known to have caused temporary shoreline advances up to 120m between Tauporo and Orongo Beaches.

(vi) All sand dune complexes are subject to wind erosion once they lose their protective vegetation cover. The worst erosion encountered was at Hautai Beach where wind blown sand extends up to 570m inland from the beach and the entire dune complex constructed over approximately the last 4,000 years is currently destabilised.

4.2 Landslip Hazard

In Table 1, landslides have been broadly grouped into rockfalls, slumps and earthflows. The presence or absence of landslide types is noted in Table 2 for each coastal area. The findings are:

(i) Persistent coastal erosion is continually removing the lateral support of the sedimentary rocks so that old landslides are reactivated and new ones occur, the type and magnitude of landslide depending on the structure and composition of the lithology and elevation of the seacliffs.

Table 2: Occurrence of Natural Coastal Hazards for selected parts of the Gisborne District coastline including Coastal Sensitivity Index (CSI) ranking to coastal hazards and range in width of Areas Sensitive to Coastal Hazards (ASCH) in metres inland from either the seaward toe of the foredune or seacliff, or top seaward edge of the storm berm on gravel beach ridges.

GISBORNE DISTRICT COASTAL AREA	**NATURAL COASTAL HAZARDS**									**CSI** very low low medium high very high	**ASCH** (metres)
	EROSION				**LANDSLIP**			**FLOODING**			
	Long-term retreat	Short-term fluctuation	River mouth migration	Wind	Rockfall	Slump	Earthflow	Sea	River		
Tauporo Beach	*	*	*	*		*	*	*	*	medium to very high	150-950m
Tauporo to Orongo	*	*			*	*	*			medium	150-500m
Orongo Beach	*	*		*				*		very high	1500m
Young Nicks Head	*	*			*	*				medium	100-530m
Muriwai		*	*					*	*	high	150-200m
Poverty Bay (south)		*	*	*				*	*	high to very high	700-2500m

Whangara (south)	*	*		*	*		*			medium to high	100-650m
Whangara (north)	*	*		*				*		medium to high	100-170m
Waihau Beach	*	*		*	*	*		*		medium to high	100-350m
Tolaga Bay	*	*	*	*	*			*	*	high to very high	100-570m
Karaka Bay	*	*		*	*			*		high	75-180m
Kaiaua	*	*		*		*	*	*		medium to high	100-500m
Anaura Bay		*		*				*	*	high	100-150m
Nuhiti Beach	*	*		*	*	*		*		high	100-800m
Nuhiti to Mawhai Point	*	*			*	*	*	*		medium to high	100-450m
Tokomaru Bay (south)		*	*	*				*	*	medium to high	100-150m
Tokomaru Bay (north)	*	*			*		*	*		medium to high	75-230m
Waipiro Bay (south)	*	*					*	*		medium to high	75-580m

Waipiro Bay (north)	*	*					*	*		medium to high	75-1070m
Whareponga	*	*				*	*	*	*	high	100-520m
Tuparoa		*	*			*	*	*	*	high	100-420m
Reporua	*	*				*	*			high	200-520m
Port Awanui		*					*	*		high	100-150m
Te Wharau Beach		*	*					*	*	high	100m
Rangitukia Beach		*	*	*				*	*	high	150-550m
Rangitukia to Waikori Bluff	*	*			*					medium to high	120-240m
Waikori to Waikuta Stream	*	*		*	*					high	100-150m
East Cape area		*		*	*			*		high	100-220m
Hautai Beach		*		*				*		high	100-570m
Horoera	*	*		*						medium to high	150-200m

Orutua		*	*	*				*	*	high	100-210m
Orutua to Whararíki Point	*	*								medium	75-100m
Whararíki to Te Araroa		*			*					medium	75-250m
Te Araroa	*	*	*					*	*	high to very high	200m
Te Araroa to Karakatuwhero River	*	*	*					*	*	high	150-900m
Karakatuwhero to Punaruku		*	*	*				*	*	high	100-300m
Onepoto Bay		*						*		high	130-240m
Hicks Bay		*	*	*				*	*	high	350-1080m
Lottin Point area					*			*		very low to medium	50-140m

(ii) Rockfalls occur to a greater or lesser extent along steep seacliffs cut into both volcanic lithologies and alternating sequences of coherent sandstone-siltstone beds that generally dip landwards. They have a relatively high frequency of occurrence.

(iii) Slumps are generally large scale, deep seated and involve the collapse of entire hillsides and promontories temporarily advancing the coastline many tens of metres. They may be structurally controlled and are often triggered during significant earthquakes or prolonged heavy rainfall. They have a relatively low frequency of occurrence.

(iv) Earthflows may be either deep seated or shallow and vary enormously in size being associated with severely faulted and crushed rock. The deep seated flows tend to be moving seaward continuously, such as in Waipiro Bay, and are more active following saturation from prolonged rainfall. They have a relatively high frequency of occurrence.

4.3 Flood Hazard

In Table 2, flooding has been subdivided into that from the sea and that from coastal rivers. Flooding from the sea occurs from both storm wave and tsunami wave overtopping and inundation of low-lying coastal land. Flooding from coastal rivers generally occurs when flood waters back up owing to river mouths being partly blocked or when they are offset along the coast. The presence or absence of flooding types is noted for each coastal area in Table 2. The findings are:

(i) Tsunamis occur relatively frequently along the Gisborne District coast with 5 being recorded between 1840 and 1982. Two locally generated disruptions to the seabed created waves in March and May 1947 ranging from about 3m to over 10m between Tauporo Beach and Waipiro Bay. For the East Cape area a 3m tsunami was generated from a distant disturbance near Chile in August 1868. The 1947 events caused erosion of the foredune and flooding up to several kilometres inland in low-lying areas.

(ii) Storm wave runup levels typically between 3 and 5m above MHWS occur along much of the East Coast reducing to 2 to 3m at Hautai Beach and Orutua Beach between East Cape and Te Araroa.

(iii) Areas most susceptible to coastal inundation are those where the crest of the coastal landforms are generally less than 2.5m above MHWS such as Tauporo, and Orongo beaches, Muriwai to southern Poverty Bay, Tolaga Bay, Anaura Bay, Tokomaru Bay, Waipiro Bay, Whareponga, Tuparoa, Port Awanui to Te Wharau Beach, Hautai Beach, Orutua Beach, Te Araroa to Punaruku, Onepoto and Hicks Bays, and low-lying land adjacent to river mouths.

4.4 Coastal Sensitivity Index

CSIs are given for each of the 112 Stations in Appendix I and for each coastal area in Table 2. Findings are as follows:

(i) ***Very Low CSI's*** were identified for 1 of the 112 Stations (Appendix II) and were only found in the Lottin Point area. Such coastal areas were characterised by very hard erosion and landslip resistant volcanic rock and raised marine terraces with elevations generally above the effects of storm wave and tsunami wave runup.

(ii) ***Low CSI's*** were not identified for any of the coastal areas studied.

(iii) ***Medium CSI's*** were identified for 24 of the 112 Stations (Appendix II). Such coastal areas were characterised by retreating sandstone-mudstone seacliffs associated with active landslip, raised Holocene beaches and shore platforms or high sand barriers undergoing very slow retreat, active earthflows that were maintaining an equilibrium shoreline position in areas such as Waipiro Bay, and small stable bayhead gravel beaches in the Lottin Point area.

(iv) ***High CSI's*** were identified for 84 of the 112 Stations (Appendix II). Such coastal areas were characterised by retreating shorelines subject to significant short-term fluctuations, landforms composed of soft unconsolidated sediments ranging from sand to landslide colluvium, and landforms of low elevation with the coastal

hinterland subject to frequent flooding.

(v) ***Very High CSI's*** were identified for 5 of the 112 Stations (Appendix II) and were mostly associated with low lying, unconsolidated sedimentary shorelines with a history of significant coastal erosion and flooding from the sea and/or migrating river mouths. Notable examples are the areas around the river mouths at Tauporo Beach, central Poverty Bay, central Tolaga Bay, Te Araroa and the small barrier beach at Orongo south of Young Nicks Head.

5.0 AREAS SENSITIVE TO COASTAL HAZARDS

The ASCHs are defined on the 42 Photomaps listed in Appendix I, and accompany this report separately. They have been digitised by Gisborne District Council and incorporated into a Geographical Information System (GIS). ASCH widths measured from the Photomaps are given for each of the 112 Stations in Appendix II and for each coastal area in Table 2. The following is a summary of the ASCHs described under the principal identified hazards of flooding, landslip and erosion.

5.1 Predominantly Flood Hazard Areas

For coastal areas that have been, or are likely to be, subject to inundation from the sea and coastal rivers, ASCH widths are proportional to the amount of low-lying flood prone land in each area. It should be noted that although flooding may be the predominant coastal hazard, each area may be subject to the effects of other natural hazards (Table 2). From south to north flood hazard areas are:

(i) ***Tauporo Beach*** around the Maraetaha River where the ASCH extends up to 950m inland (Table 2) to include land subject to inundation from one or the combination of storm wave and tsunami wave runup and river flooding. The inland boundary of the ASCH is defined by the approximate position of the 3m contour on the basis of maximum storm wave and tsunami wave runup levels, flooding from the river, sea-level rise and a gradient of less than 1^0 of the hinterland.

(ii) ***Orongo Beach and southern Poverty Bay*** where the ASCH includes the low-lying land encircling Young Nicks Head and the Poverty Bay flats, up to 2,500m inland (Table 2). The land is undergoing tectonic downdrop and in some places is either at MSL or less than 2 metres above. The inland boundary of the ASCH is defined by the surveyed position of the 3m contour on the basis of maximum storm-wave and tsunami wave runup levels, sea-level rise, and a gradient of less than 1^0 of the hinterland. There is a high probability that the sea will breach Orongo Beach next century eventually isolating Young Nicks Head as an island which would have significant effects on the present orientation of the Poverty Bay shoreline.

(iii) ***Tolaga Bay*** around the Uawa River where the ASCH extends up to 570m inland (Table 2) to include historic meander areas which could be reactivated at any time should the river mouth become offset with the formation of sand bars across its mouth during prolonged low flows and persistent onshore swell conditions.

(iv) ***Anaura Bay*** where the ASCH extends up to 150m inland (Table 2) to include land subject to inundation from the Waipare Stream and an adjacent unnamed stream to the north, in the northern part of the bay.

(v) ***Waiapu River area*** where the ASCH extends up to 550m inland (Table 2) to include the historical low-lying meander areas which are extremely susceptible to flooding from the river when it changes course or when the mouth is reduced in size by offsetting from the growth of a gravel spit from south to north during low flow conditions.

(vi) ***Karakatuwhero River area*** where the ASCH extends up to 900m inland (Table 2) to include the wetlands sited in the historical meanders which are extremely susceptible to flooding from the river when the mouth is offset or blocked by the formation of a gravel barrier.

(vii) ***Onepoto Bay*** where the ASCH extends up to 240m inland (Table 2) to include land subject to inundation by the sea. The inland boundary of the ASCH is defined by the surveyed position of the 4m contour on the basis of maximum storm wave and

tsunami wave runup levels, sea-level rise and a gradient of 1 to 2^0 of the hinterland.

(viii) ***Hicks Bay*** where the ASCH extends up to 1080m inland (Table 2) to include land subject to inundation from one or the combination of the sea and the Wharekahika River. The inland boundary of the ASCH is defined by the surveyed position of the 3m contour on the basis of maximum storm wave and tsunami wave runup levels, flooding from the river, sea-level rise and a gradient of less than 1^0 of the hinterland.

5.2 Predominantly Landslip Hazard Areas

For coastal areas that have been, or are likely to be, subject to landslip, ASCH widths are proportionate to the area of land that has failed in the past. For the Gisborne District coast the predominantly landslip hazard areas are confined to all the Late Cretaceous to Late Tertiary sedimentary rocks which crop out on the coast in the study area between Tauporo Beach and Te Araroa. In addition to landslip these lithologies are also subject to retreat from coastal erosion discussed below. From south to north, landslip hazard areas are:

(i) ***Mapere Point to Young Nicks Head*** where the ASCH extends up to 530m inland to include land subject to rockfalls, slumping and earthflows (Table 2).

(ii) ***Pouawa to Whangara*** where the ASCH extends up to 650m inland to include land subject to rockfalls and earthflows (Table 2).

(iii) ***Waihau Beach*** where the ASCH extends up to 350m inland to include land subject to rockfalls and slumping at the north and south ends of the bay (Table 2).

(iv) ***Tolaga Bay*** where the ASCH extends up to 150m inland along the flanks of the bay to include land subject to rockfalls (Table 2).

(v) ***Karaka Bay*** where the ASCH extends up to 180m inland to include land subject to rockfalls at the north and south ends of the bay (Table 2).

(vi) ***Kaiaua*** where the ASCH extends up to 500m inland to include land subject to slumping and earthflows at the north and south ends of the bay (Table 2).

(vii) ***Nuhiti Beach*** where the ASCH extends up to 800m inland to include land subject to deep seated slumps at the south end of the beach (Table 2).

(viii) ***Nuhiti Beach to Mawhai Point*** where the ASCH extends up to 450m inland toward Mawhai Point to include deep seated slumps (Table 2).

(ix) ***Tokomaru Bay*** where the ASCH extends up to 230m inland to include land subject to earthflows at the north end of the bay (Table 2).

(x) ***Waipiro Bay*** where the ASCH extends up to 1,070m inland to include land subject to earthflows (Table 2).

(xi) ***Whareponga*** where the ASCH extends up to 520m inland to include land subject to slumping and earthflows at the north and south ends of the bay (Table 2).

(xii) ***Tuparoa*** where the ASCH extends up to 420m inland to include land subject to slumping and earthflows at the north and south ends of the bay (Table 2).

(xiii) ***Reporua*** where the ASCH extends up to 520m inland to include land subject to slumping and earthflows (Table 2).

(xiv) ***Port Awanui*** where the ASCH extends up to 150m inland to include land subject to earthflows (Table 2).

(xv) ***Rangitukia Beach to East Cape*** where the ASCH extends up to 240m inland to include land subject to rockfalls (Table 2).

(xvi) ***Whararikí to Te Araroa*** where the ASCH extends up to 250m inland to include land subject to rockfalls (Table 2).

(xvii) ***Lottin Point area*** where the ASCH extends up to 140m inland to include land subject to rockfalls (Table 2) for isolated pockets along an otherwise very stable coast.

5.3 Predominantly Erosion Hazard Areas

For coastal areas that have been, or are likely to be, subject to one or the combination of sea and wind erosion, ASCH widths are proportional to either the long-term rate of

erosion, the magnitude of short-term shoreline fluctuations, or the size of the area subject to wind erosion. Excluding the landslip prone retreating seacliffs, the predominantly erosion hazard areas are confined to the retreating Holocene sand dunes and gravel beach ridges that form many of the bayhead and open coast beaches along the Gisborne District coast. In addition to erosion many of these areas are also subject to flooding. From south to north, erosion hazard areas are:

(i) ***Tauporo Beach*** where the ASCH extends up to 200m inland to include dunes subject to retreat up to -0.43m/year with short-term shoreline fluctuations up to 80 to 100m around the Maraetaha River mouth (Appendix II).

(ii) ***Orongo Beach*** where the ASCH extends up to 1,500m inland to principally allow for inundation once the low dune barrier is permanently breached. The barrier is retreating at -0.51m/year with short-term shoreline fluctuations up to 20 to 30m (Appendix II).

(iii) ***Whangara*** where the ASCH extends up to 100m inland to include dune barriers subject to wind erosion, retreat up to -0.17m/year and short-term shoreline fluctuations up to 15 to 30m (Appendix II).

(iv) ***Waihau Beach*** where the ASCH extends up to 150m inland in the central area to include dune barriers subject to retreat up to -0.22m/year and short-term shoreline fluctuations up to 10 to 15m (Appendix II).

(v) ***Tolaga Bay*** where the ASCH extends up to 250m inland in the northern bay area to include dune complexes subject to retreat up to -0.15m/year and short-term shoreline fluctuations up to 80 to 100m associated with the behaviour of the Uawa River mouth (Appendix II).

(vi) ***Karaka Bay*** where the ASCH extends up to 100m inland to include dune complexes subject to wind erosion, retreat at -0.08m/year and short-term shoreline fluctuations up to 5 to 10m (Appendix II).

(vii) ***Kaiaua Bay*** where the ASCH extends up to 150m inland in the central bay to

include dune barriers subject to retreat up to -0.29m/year and short-term shoreline fluctuations up to 5 to 10m (Appendix II).

(viii) ***Anaura Bay and Nuhiti Beach*** where the ASCH extends up to 150m inland at the south ends of both beaches to include dunes and colluvium subject to retreat up to -0.38m/year and short-term shoreline fluctuations of 10-15m (Appendix II).

(ix) ***Whareponga Beach*** where the ASCH extends up to 100m inland in the central bay to include gravel beach ridges subject to retreat at -0.20m/year and short-term shoreline fluctuations of 2 to 5m (Appendix II).

(x) ***Hautai Beach*** where the ASCH extends up to 570m inland to include sand dune complexes subject to severe wind erosion in many places down to the ground water table, despite the fact that the beach is advancing between 0.50 and 1.67m/year (Appendix II).

(xi) ***Horoera*** where the ASCH extends up to 200m inland to include dunes overlying raised beaches subject to retreat up to -0.48m/year and short-term shoreline fluctuations up to 10 to 15m (Appendix II).

(xii) ***Waipohatuhatu Stream to Te Araroa*** where the ASCH extends to 75m inland to include dunes and beach gravels overlying raised shore platforms subject to retreat up to -0.02m/year and short-term shoreline fluctuations of 2 to 5m (Appendix II).

(xiv) ***Te Araroa*** area where the ASCH extends up to 200m inland to include gravel beach ridges subject to retreat up to -1.24m/year and short-term shoreline fluctuations up to 20 to 40m (Appendix II).

(xv) ***Hicks Bay*** where the ASCH extends up to 600m inland in the eastern part of the Bay to allow for short-term erosion-accretion up to 250m from migration of the Wharekahika River and associated flooding (Appendix II).

(xvi) ***Lottin Point*** area where the ASCH generally extends up to 50m inland to include seacliffs subject to retreat at less than -0.01m/year and to accommodate coastal Pohutukawas which play an important role in stabilising the seacliffs.

6.0 RECOMMENDED COASTAL MONITORING

(i) The 1:5,000 and 1:2,500 Scale Coastal Resources Planimetric maps from Mapere Point to Marau Point and from Te Araroa to Hicks Bay should provide the basis for updates to monitor the pattern, trend and rate of both long-term and short-term shoreline movements.

(ii) Coastal Resources maps showing historic shoreline positions should be prepared at 1:5,000 Scale for Anaura Bay to Nuhiti, Tokomaru Bay, Waipiro Bay, Whareponga, Tuparoa, Reporua, Port Awanui to Rangitukia Beach, Waikori Bluff to East Cape, and from East Cape to Te Araroa.

(iii) Excluding the eroding headlands, the position of the seaward toe of the foredune or top seaward edge of the storm berm for gravel beaches should be surveyed to an accuracy of ±2.0m every 5 years by ground or aerial survey and the new shoreline position plotted on the Coastal Resources Map Series.

(vi) Should a severe onshore storm or large tsunami occur then the landward limit and height of both storm wave and tsunami wave runup should be surveyed and recorded.

(vii) Significant migrations of the river mouths of the Waipaoa, Uawa, Mangahauini, Waiapu, Awatere, Karakatuwhero and Wharekahika should be recorded by vertical aerial photography and plotted on the Coastal Resources Maps.

7.0 CONCLUSIONS

(i) Areas Sensitive to Coastal Hazards (ASCH) delineated on 42 Photomaps accompanying this report should be regarded as early warning information of areas of land subject to, or likely to be subject to adverse effects from natural hazards. The ASCHs should be used with caution to control subdivision, use and development along selected coastal areas. For such areas, it is recommended that Coastal Hazard Zones are defined incorporating detailed risk assessments.

(ii) In terms of adverse effects from the identified coastal hazards of erosion, landslip

and flooding along the Gisborne District coast, the only relatively stable section of coastlines with minimal effects are the raised marine terraces cut into the Late Jurassic to Early Cretaceous volcanic lithologies between Hicks Bay and Cape Runaway, including the Lottin Point area.

(iii) With the exception of the coasts of volcanic lithologies, the entire Gisborne District coastline is subject to, and is likely to continue to be subject to, adverse effects from one or the combination of the natural hazards of sea and wind erosion, landslip and flooding from the sea and coastal rivers.

(iv) Areas subject to *predominantly flood hazard* include low-lying land around the mouths of the Maraetaha, Waipaoa, Uawa, Mangahauini, Waiapu, Awatere, Karakatuwhero and Wharekahika Rivers, and low-lying lands subject to storm wave and tsunami inundation at Tauporo and Orongo beaches, southern Poverty Bay, Onepoto Bay and Hicks Bay.

(v) ASCH widths for *predominantly flood hazard areas* range from 130 to 240 at Onepoto Bay up to 700 to 2,500m at southern Poverty Bay.

(vi) Areas subject to *predominantly landslip hazard* include all the retreating seacliffs cut into the Late Cretaceous to Late Tertiary sedimentary lithologies between Mapere Point and Te Araroa.

(vii) ASCH widths for *predominantly landslip hazard areas* range from 100 to 150m for the rockfall prone seacliffs along the flanks of Tolaga Bay up to 580 to 1,070m for the deep seated earthflow prone coastal slopes of Waipiro Bay.

(viii) Areas subject to *predominantly erosion hazard* include all the sand dunes and gravel beach ridges of Holocene age that form the bayhead and open coast beaches along the Gisborne District coast.

(ix) ASCH widths for *predominantly erosion hazard areas* range from 75m between the Waipohatuhatu Stream and Te Araroa, up to 570m at Hautai Beach for an area subject to severe wind erosion.

(ix) ASCH widths should be reviewed once every 5 years based on the results of a coastal monitoring programme to record the pattern and rate of erosion or accretion, extent of flooding from significant storm events or tsunami, and significant landslides.

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9.0 REFERENCES

de Lange, W.P. & Healy, T.R., 1986: New Zealand tsunamis 1840-1982. *New Zealand Journal of Geology and Geophysics*. 29: 115-134.

Eiby, G.A., 1982: Two New Zealand Tsunamis. *Journal of the Royal Society of New Zealand.* 12(4): 337-351.

Gibb, J.G., 1981a: Coastal Hazard mapping as a planning technique for Waiapu County, East Coast, North Island, New Zealand. *Water and Soil Technical Publication 21*. 63p.

Gibb, J.G., 1981b: *Assessment of a Coastal Hazard Zone for Wainui Beach, Gisborne*. Unpublished Water & Soil Directorate report to Cook County Council. 40p.

Gibb, J.G., Sheffield, A. & Foster, G., 1992: A standardised Coastal Sensitivity Index based on an initial framework for physical coastal hazards information. *Department of Conservation Science and Research Series*. No.55. 101p.

Gibb, J.G., 1994: *"Initial assessment of Areas Sensitive to Coastal Hazards for selected parts of the Gisborne District Coast"*. Consultancy report prepared for Gisborne District Council, October 1994. 26p.

IPCC, 1990: *"Climate Change. The IPCC Scientific Assessment"*. Houghton J.T., Jenkins G.J. and Ephraums J.J. (Eds). Cambridge University Press, Cambridge, Great Britain. 365p.

Kingma, J.T., 1965: Sheet 9-Gisborne. Geological Map of New Zealand. *1:250,000. N.Z. Geological Survey D.S.I.R.*

Kingma, J.T., 1966: Sheet 6-East Cape. Geological map of New Zealand. 1:250,000. *N.Z. Geological Survey. D.S.I.R.*

Willard, G.W., 1987: *Engineering Technical Report 1987/2. Coastal Resources - East Cape Region.* Unpublished report held by Gisborne District Council. 15p. + Appendices.

APPENDIX I

List of Photomaps

APPENDIX I: List of 42 Photomaps used to delineate Areas Sensitive to Coastal Hazards along the Gisborne District Coast.

GDC Sheet No.		Photomap Name	Scale 1:10,000	1:5,000	1:2,500
63	(i)	Mapere Point to Tauporo Beach (south)			*
62	(ii)	Tauporo Beach north			*
61	(iii)	Muriwai, Nicks Head, Orongo			*
Y18/2.3	(iv)	Wherowhero Lagoon	*		
Y18/2.2	(v)	Waipaoa River	*		
50	(i)	Whangara (south)			*
49	(ii)	Whangara (mid)			*
48	(iii)	Whangara (north			*
45	(i)	Waihau Bay (south)			*
44	(ii)	Waihau Bay (north)			*
41	(iii)	Tolaga Bay			*
40	(iv)	Karaka Bay			*
39	(v)	Kaiaua	*		
36	(i)	Anaura Bay			*
35	(ii)	Nuhiti (south)			*
34	(iii)	Nuhiti (north)			*
32	(iv)	Tokomaru Bay (south)			*
31	(v)	Tokomaru Bay (north)			*
28	(i)	Waipiro Bay (south)			*
27	(ii)	Waipiro Bay (mid)			*
26	(iii)	Waipiro Bay (north)			*
25	(iv)	Whareponga Beach			*
24	(v)	Tuparoa (south)			*
23	(vi)	Tuparoa Beach (north)			*
22	(vii)	Reporua			*
20	(i)	Port Awanui			*
19	(ii)	Te Wharau Beach			*
18	(iii)	Rangitukia Beach (south)			*
17	(iv)	Rangitukia Beach (north)			*
16	(i)	East Cape (south)			*
15	(ii)	East Cape Lighthouse			*
14	(iii)	Hautai Beach (east)			*
13	(iv)	Hautai Beach (west)			*
12	(v)	Horoera Point			*

11	(vi)	Orutua River	*	
10	(vii)	Orutua to Te Araroa	*	
9	(i)	Te Araroa to Karakatuwhero River	*	
8	(ii)	Karakatuwhero River to Punaruku	*	
2.2	(iii)	Onepoto & Hicks Bay (east)		*
1.2	(iv)	Hicks Bay (west)		*
2	(i)	Lottin Point (east)	*	
1	(ii)	Lottin Point (west)	*	

APPENDIX II

Gisborne District Council coastal Hazards Database

APPENDIX II: Gisborne District Council Coastal Hazards Database.

Station: There are 101 Stations numbered sequentially from Tauporo Beach northwards to Lottin Point Station names and grid references are taken from the NZMS 260, 1:50,000 Scale, NZ Topographic Map Series covering the GDC coastline

Elevation: Is metres above Mean High Water Springs (MHWS) of a landform adjacent to the foreshore.

Storm Wave Runup: Is metres above MHWS of the maximum observed level from past events.

Gradient: Is the approximate slope angle of the land in degrees inland from the crest of the coastal landform.

Tsunami: Is the maximum tsunami wave runup in metres above MHWS recorded in historical times by de Lange and Healy (1986) and Eiby (1982).

Lithology: Refers to the consolidated or unconsolidated rock type outcropping at each station.

Landform: Refers to the coastal landform.

Long-Term Trend: Is the rate of erosion (-ve) or accretion (+ve) over the survey period given, calculated from measurements made from Aerial Plan 1483, Coastal Resources Map Series at 1:5,000 & 1:2,500 Scales or comparisons at 1:5,000 Scale of shoreline positions from the earliest vertical aerial photography with that flown in 1993.

Short-Term Fluctuation: Is the distance in metres determined either in the field or from comparative shoreline positions shown on the Coastal Resources Map Series.

CSI: Is the Coastal Sensitivity Index (CSI) and description, derived by adding the indices (1 to 5) for each of the 8 variables and ranges from Very Low (8-13), Low (14-20), Medium (21-27), High (28-34) to Very High (35-40).

ASCH: Is the width of the Area Sensitive to Coastal Hazards (ASCH) derived for each Station from the Photomaps at Scales of 1:10,000, 1:5,000 and 1:2,500.

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
1: Tauporo Beach (south) Y18:373548	1 110m	4 c.3-4m	1 45^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.28m/yr 1905-1993	4 10-15m	25	medium	300m
2: Tauporo Beach (mid) Y18:377558	4 2.9m	4 3-4m	5 0^0	4 5-6m in 1947	5 sand	5 sand dunes	3 -0.43m/yr 1905-1993	4 15-25m	34	high	200m
3: Maraetaha River (south) Y18:381565	5 1m	4 2.6m driftwood	5 0^0	4 5-6m in 1947	5 sand	5 sand dunes	2 0.0m/yr 1905-1979	5 80-100m	35	very high	800m
4: Tauporo Beach (north) Y18:388571	1 172m	4 c.3-4m	1 45^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.10m/yr 1900-1979	5 80-120m	26	medium	280m
5: Potara Y18 393576	2 15m	4 c.3-4m	1 60^0	4 5-6m in 1947	5 sand	5 colluvium seacliff	3 -0.28m/yr 1900-1979	3 5-10m	27	medium	150m
6: Orongo Y18:401591	4 2m	4 c.3-4m	5 -5^0	4 5-6m in 1947	5 sand	5 sand barrier	4 -0.51m/yr 1900-1979	4 20-30m	35	very high	200m
7: Muriwai Y18:398603	5 1.3m	4 3-4m	5 0^0	4 5-6m in 1947	5 silt	5 raised beach	1 0.51m/yr 1886-1993	5 30-60m	34	high	180m
8: Wherowhero Barrier (south) Y18:393610	5 1.1m	4 3-4m	5 -2^0	4 5-6m in 1947	5 sand	5 sand spit	1 0.63m/yr 1914-1993	5 30-60m	34	high	1600m
9: Wherowhero Barrier (mid) Y18:392620	5 1.1m	4 3-4m	5 -2^0	4 5-6m in 1947	5 sand	5 sand spit	1 0.56m/yr 1913-1993	5 80-100m	34	high	1700m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
10: Wherowhero Barrier (mid) Y18:393630	5 1.3m	4 3-4m	5 -2^0	4 5-6m in 1947	5 sand	5 sand spit	1 0.76m/yr 1915-1993	5 50-60m	34	high	1700m
11: Beach Road Y18:395640	5 1.1m	4 3-4m	5 0^0	4 5-6m in 1947	5 sand	5 sand spit	1 2.12m/yr 1942-1993	5 30-50m	34	high	2400m
12: Waipaoa River (south) Y18:396648	5 0.7m	4 3-4m	5 0^0	4 c.5-6m in 1947	5 sand	5 river mouth	2 0.39m/yr 1942-1993	5 30-40m	35	very high	2500m
13: Pouawa Y18:620754	4 3m	4 3-4m	4 5^0	5 10.7m in 1947	5 sand	5 sand dunes	2 0.12m/yr 1895-1979	4 20-30m	34	high	100m
14: Pariokonohi Point Y18:628759	1 60m	4 2.5-3.5m	1 45^0	5 10.7m in 1947	4 mudstone	4 softrock seacliff	2 0.0m/yr 1895-1979	4 10-20m	25	medium	150m
15: Wharemapou Stream (south) Y18:629769	1 100m	4 2.5-3.5m	1 45^0	4 c.5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.12m/yr 1895-1979	4 20-30m	25	medium	400m
16: Whitiwhiti Stream (north) Y18:632776	3 8m	4 2.5-3.5m driftwood	4 5^0	4 c.5-6m in 1947	5 colluvium	5 raised beach	3 -0.14m/yr 1889-1979	2 2-5m	30	high	100m
17: Waiomoko River (south) Y18:644786	3 8-10m	4 2.5-3.5m	3 10^0	4 c.5-6m in 1947	5 sand	5 dune barrier	3 -0.17m/yr 1889-1979	4 10-15m	31	high	100m
18: Whangara (south) Y18:657794	4 4.5m	4 4-5m	4 2^0	4 c.5-6m in 1947	5 sand	5 sand dunes	3 -0.14m/yr 1885-1993	3 5-10m	32	high	100m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
19: Whangara Beach (mid) Y17:661803	2 12.8m	4 4-5m	1 30^0	4 c.5-6m in 1947	5 sand	5 dune barrier	3 -0.10m/yr 1889-1979	4 15-30m	27	medium	100m
20: Pakarae River (south) Y17:672807	4 3m	4 4-5m driftwood	4 5^0	4 5-6m in 1947	5 sand on mudstone	5 sand dunes	3 -0.17m/yr 1884-1993	5 20-40m	34	high	150m
21: Waihau Beach (south) Z17:721920	1 160m	4 4-5m	1 60^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.20m/yr 1877-1979	4 20-30m	25	medium	200m
22: Waihau Beach (south) Z17:724925	4 4.4m	4 4-5m	5 0^0	4 5-6m in 1947	5 sand	5 sand dunes	3 -0.22m/yr 1877-1993	4 10-15m	34	high	150m
23: Waihau Beach (mid) Z17:730933	2 20m	4 4-5m	1 45^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.10m/yr 1883-1979	2 2-5m	24	medium	100m
24: Waihau Beach (mid) Z17:736940	2 11.4m	4 4-5m	5 -2^0	4 5-6m in 1947	5 sand	5 dune barrier	3 -0.23m/yr 1883-1979	4 10-15m	32	high	150m
25: Waihau Beach (north) X17: 745947	4 4.4m	4 3-4m driftwood	4 5^0	4 5-6m in 1947	5 colluvium	5 raised beach	3 -0.27m/yr 1904-1979	4 15-20m	33	high	150m
26: Tolaga Bay (south) Z17:742000	4 3.5m	4 3-4m driftwood	4 2^0	3 3-4m in 1947	5 sand	5 sand spit	3 -0.05m/yr 1885-1993	4 15-25m	32	high	450m
27: Tolaga Bay (mid) Z17:735009	5 1.5m	4 3-4m	5 0^0	3 3-4m in 1947	5 sand	5 river mouth	2 0.34m/yr 1875-1993	5 80-100m	35	very high	250m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
28: Tolaga Bay (north) Z17:736019	4 2.1m	4 3-4m	5 -2^0	3 3-4m in 1947	5 sand	5 sand dunes	3 -0.15m/yr 1875-1993	4 20-30m	33	high	100m
29: Karaka Bay (south) Z17:757032	4 4m	4 3-4m	5 0^0	3 c.3m in 1947	5 gravel	5 raised beach	3 -0.07m/yr 1907-1979	2 2-5m	31	high	75m
30: Karaka Bay (mid) Z17:754041	4 2.5m	4 3-4m driftwood	5 -10^0	3 c.3m in 1947	5 sand	5 sand dunes	3 -0.08m/yr 1915-1979	3 5-10m	32	high	100m
31: Karaka Bay (north) Z17:755051	4 3m	4 3-4m driftwood	4 5^0	3 c.3m in 1947	4 mudstone	4 raised beach	3 -0.12m/yr 1913-1979	2 2-5m	28	high	100m
32: Kaiaua Bay (south) Z17:755067	1 140m	4 3-4m	1 50^0	3 3m in 1947	4 mudstone	4 softrock seacliff	3 -0.14m/yr 1943-1979	4 10-15m	24	medium	280m
33: Kaiaua Bay (mid) Z17:754074	4 4.4m	4 3-4m	5 0^0	3 3m in 1947	5 sand	5 sand dunes	3 -0.29m/yr 1908-1993	3 5-10m	32	high	150m
34: Kaiaua Bay (mid) Z17:758084	4 4.3m	4 3-4m	5 -10^0	3 3m in 1947	5 sand	5 sand dunes	3 -0.21m/yr 1908-1979	3 5-10m	32	high	150m
35: Kaiaua Bay (north) Z17:766089	4 3m	4 3-4m	1 50^0	3 3m in 1947	5 alluvium	4 raised beach	3 -0.21m/yr 1908-1979	2 2-5m	26	medium	150m
37: Tokomaru Bay (mid) Z16:760267	4 2.5m	4 3-4m	5 -5^0	3 c.3m in 1947	5 sand	5 sand dunes	1 1.04m/yr 1945-1993	4 15-30m	31	high	100m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
1: Tauporo Beach (south) Y18:373548	1 110m	4 c.3-4m	1 45^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.28m/yr 1905-1993	4 10-15m	25	medium	300m
2: Tauporo Beach (mid) Y18:377558	4 2.9m	4 3-4m	5 0^0	4 5-6m in 1947	5 sand	5 sand dunes	3 -0.43m/yr 1905-1993	4 15-25m	34	high	200m
3: Maraetaha River (south) Y18:381565	5 1m	4 2.6m driftwood	5 0^0	4 5-6m in 1947	5 sand	5 sand dunes	2 0.0m/yr 1905-1979	5 80-100m	35	very high	800m
4: Tauporo Beach (north) Y18:388571	1 172m	4 c.3-4m	1 45^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.10m/yr 1900-1979	5 80-120m	26	medium	280m
5: Potara Y18 393576	2 15m	4 c.3-4m	1 60^0	4 5-6m in 1947	5 sand	5 colluvium seacliff	3 -0.28m/yr 1900-1979	3 5-10m	27	medium	150m
6: Orongo Y18:401591	4 2m	4 c.3-4m	5 -5^0	4 5-6m in 1947	5 sand	5 sand barrier	4 -0.51m/yr 1900-1979	4 20-30m	35	very high	200m
7: Muriwai Y18:398603	5 1.3m	4 3-4m	5 0^0	4 5-6m in 1947	5 silt	5 raised beach	1 0.51m/yr 1886-1993	5 30-60m	34	high	180m
8: Wherowhero Barrier (south) Y18:393610	5 1.1m	4 3-4m	5 -2^0	4 5-6m in 1947	5 sand	5 sand spit	1 0.63m/yr 1914-1993	5 30-60m	34	high	1600m
9: Wherowhero Barrier (mid) Y18:392620	5 1.1m	4 3-4m	5 -2^0	4 5-6m in 1947	5 sand	5 sand spit	1 0.56m/yr 1913-1993	5 80-100m	34	high	1700m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
10: Wherowhero Barrier (mid) Y18:393630	5 1.3m	4 3-4m	5 -2^0	4 5-6m in 1947	5 sand	5 sand spit	1 0.76m/yr 1915-1993	5 50-60m	34	high	1700m
11: Beach Road Y18:395640	5 1.1m	4 3-4m	5 0^0	4 5-6m in 1947	5 sand	5 sand spit	1 2.12m/yr 1942-1993	5 30-50m	34	high	2400m
12: Waipaoa River (south) Y18:396648	5 0.7m	4 3-4m	5 0^0	4 c.5-6m in 1947	5 sand	5 river mouth	2 0.39m/yr 1942-1993	5 30-40m	35	very high	2500m
13: Pouawa Y18:620754	4 3m	4 3-4m	4 5^0	5 10.7m in 1947	5 sand	5 sand dunes	2 0.12m/yr 1895-1979	4 20-30m	34	high	100m
14: Pariokonohi Point Y18:628759	1 60m	4 2.5-3.5m	1 45^0	5 10.7m in 1947	4 mudstone	4 softrock seacliff	2 0.0m/yr 1895-1979	4 10-20m	25	medium	150m
15: Wharemapou Stream (south) Y18:629769	1 100m	4 2.5-3.5m	1 45^0	4 c.5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.12m/yr 1895-1979	4 20-30m	25	medium	400m
16: Whitiwhiti Stream (north) Y18:632776	3 8m	4 2.5-3.5m driftwood	4 5^0	4 c.5-6m in 1947	5 colluvium	5 raised beach	3 -0.14m/yr 1889-1979	2 2-5m	30	high	100m
17: Waiomoko River (south) Y18:644786	3 8-10m	4 2.5-3.5m	3 10^0	4 c.5-6m in 1947	5 sand	5 dune barrier	3 -0.17m/yr 1889-1979	4 10-15m	31	high	100m
18: Whangara (south) Y18:657794	4 4.5m	4 4-5m	4 2^0	4 c.5-6m in 1947	5 sand	5 sand dunes	3 -0.14m/yr 1885-1993	3 5-10m	32	high	100m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
19: Whangara Beach (mid) Y17:661803	2 12.8m	4 4-5m	1 30^0	4 c.5-6m in 1947	5 sand	5 dune barrier	3 -0.10m/yr 1889-1979	4 15-30m	27	medium	100m
20: Pakarae River (south) Y17:672807	4 3m	4 4-5m driftwood	4 5^0	4 5-6m in 1947	5 sand on mudstone	5 sand dunes	3 -0.17m/yr 1884-1993	5 20-40m	34	high	150m
21: Waihau Beach (south) Z17:721920	1 160m	4 4-5m	1 60^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.20m/yr 1877-1979	4 20-30m	25	medium	200m
22: Waihau Beach (south) Z17:724925	4 4.4m	4 4-5m	5 0^0	4 5-6m in 1947	5 sand	5 sand dunes	3 -0.22m/yr 1877-1993	4 10-15m	34	high	150m
23: Waihau Beach (mid) Z17:730933	2 20m	4 4-5m	1 45^0	4 5-6m in 1947	4 mudstone	4 softrock seacliff	3 -0.10m/yr 1883-1979	2 2-5m	24	medium	100m
24: Waihau Beach (mid) Z17:736940	2 11.4m	4 4-5m	5 -2^0	4 5-6m in 1947	5 sand	5 dune barrier	3 -0.23m/yr 1883-1979	4 10-15m	32	high	150m
25: Waihau Beach (north) X17: 745947	4 4.4m	4 3-4m driftwood	4 5^0	4 5-6m in 1947	5 colluvium	5 raised beach	3 -0.27m/yr 1904-1979	4 15-20m	33	high	150m
26: Tolaga Bay (south) Z17:742000	4 3.5m	4 3-4m driftwood	4 2^0	3 3-4m in 1947	5 sand	5 sand spit	3 -0.05m/yr 1885-1993	4 15-25m	32	high	450m
27: Tolaga Bay (mid) Z17:735009	5 1.5m	4 3-4m	5 0^0	3 3-4m in 1947	5 sand	5 river mouth	2 0.34m/yr 1875-1993	5 80-100m	35	very high	250m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
28: Tolaga Bay (north) Z17:736019	4 2.1m	4 3-4m	5 -2^0	3 3-4m in 1947	5 sand	5 sand dunes	3 -0.15m/yr 1875-1993	4 20-30m	33	high	100m
29: Karaka Bay (south) Z17:757032	4 4m	4 3-4m	5 0^0	3 c.3m in 1947	5 gravel	5 raised beach	3 -0.07m/yr 1907-1979	2 2-5m	31	high	75m
30: Karaka Bay (mid) Z17:754041	4 2.5m	4 3-4m driftwood	5 -10^0	3 c.3m in 1947	5 sand	5 sand dunes	3 -0.08m/yr 1915-1979	3 5-10m	32	high	100m
31: Karaka Bay (north) Z17:755051	4 3m	4 3-4m driftwood	4 5^0	3 c.3m in 1947	4 mudstone	4 raised beach	3 -0.12m/yr 1913-1979	2 2-5m	28	high	100m
32: Kaiaua Bay (south) Z17:755067	1 140m	4 3-4m	1 50^0	3 3m in 1947	4 mudstone	4 softrock seacliff	3 -0.14m/yr 1943-1979	4 10-15m	24	medium	280m
33: Kaiaua Bay (mid) Z17:754074	4 4.4m	4 3-4m	5 0^0	3 3m in 1947	5 sand	5 sand dunes	3 -0.29m/yr 1908-1993	3 5-10m	32	high	150m
34: Kaiaua Bay (mid) Z17:758084	4 4.3m	4 3-4m	5 -10^0	3 3m in 1947	5 sand	5 sand dunes	3 -0.21m/yr 1908-1979	3 5-10m	32	high	150m
35: Kaiaua Bay (north) Z17:766089	4 3m	4 3-4m	1 50^0	3 3m in 1947	5 alluvium	4 raised beach	3 -0.21m/yr 1908-1979	2 2-5m	26	medium	150m
37: Tokomaru Bay (mid) Z16:760267	4 2.5m	4 3-4m	5 -5^0	3 c.3m in 1947	5 sand	5 sand dunes	1 1.04m/yr 1945-1993	4 15-30m	31	high	100m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
38: Tokomaru Bay (mid) Z16:761276	4 3.4m	4 3-4m driftwood	5 -5^0	3 c.3m in 1947	5 sand	5 sand dunes	1 0.94m/yr 1945-1993	5 30-40m	32	high	150m
39: Tokomaru Bay (mid) Z16:765285	4 2.1m	4 3-4m	4 2^0	3 c.3m in 1947	5 sand	5 sand dunes	2 0.23m/yr 1886-1993	4 15-20m	31	high	100m
40: Te Puka Z16:774292	4 2.0m	4 3-4m	1 60^0	3 c.3m in 1947	4 mudstone	2 concrete seawall	2 0.0m/yr 1945-1993	1 <2m	21	medium	75m
41: Te Ariuru Z16:782296	4 2.1m	4 2-3m driftwood	5 0^0	3 c.3m in 1947	5 boulders	5 delta	2 0.0m/yr 1945-1993	2 2-5m	30	high	150m
42: Waima Wharf Z16:792302	3 10m	4 2-3m	1 60^0	3 c.3m in 1947	4 mudstone	4 softrock seacliff	3 -0.21m/yr 1945-1993	2 2-5m	24	medium	100m
43: Waikawa Stream (south) Z16:792374	4 3.2m	4 4-5m	5 0^0	3 c.3m in 1947	5 boulders	5 delta	1 0.68m/yr 1956-1993	2 2-5m	29	high	75m
44: Waipiro Bay (south) Z16:785377	4 2m	4 3.5m driftwood	5 0^0	3 c.3m in 1947	5 boulders	5 beach ridge	2 0.27m/yr 1956-1993	2 2-5m	30	high	75m
45: Waipiro Bay (mid) Z16:783387	2 20m	4 4-5m	1 30^0	3 c.3m in 1947	5 colluvium	5 earthflow	3 -0.22m/yr 1956-1993	3 5-10m	26	medium	580m
46: Waipiro Stream (south) Z16:873396	4 2.5m	4 4-5m	5 0^0	3 c.3m in 1947	5 gravel & sand	5 gravel beach ridge	3 -0.27m/yr 1956-1993	4 10-15m	33	high	150m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
38: Tokomaru Bay (mid) Z16:761276	4 3.4m	4 3-4m driftwood	5 -5^0	3 c.3m in 1947	5 sand	5 sand dunes	1 0.94m/yr 1945-1993	5 30-40m	32	high	150m
39: Tokomaru Bay (mid) Z16:765285	4 2.1m	4 3-4m	4 2^0	3 c.3m in 1947	5 sand	5 sand dunes	2 0.23m/yr 1886-1993	4 15-20m	31	high	100m
40: Te Puka Z16:774292	4 2.0m	4 3-4m	1 60^0	3 c.3m in 1947	4 mudstone	2 concrete seawall	2 0.0m/yr 1945-1993	1 <2m	21	medium	75m
41: Te Ariuru Z16:782296	4 2.1m	4 2-3m driftwood	5 0^0	3 c.3m in 1947	5 boulders	5 delta	2 0.0m/yr 1945-1993	2 2-5m	30	high	150m
42: Waima Wharf Z16:792302	3 10m	4 2-3m	1 60^0	3 c.3m in 1947	4 mudstone	4 softrock seacliff	3 -0.21m/yr 1945-1993	2 2-5m	24	medium	100m
43: Waikawa Stream (south) Z16:792374	4 3.2m	4 4-5m	5 0^0	3 c.3m in 1947	5 boulders	5 delta	1 0.68m/yr 1956-1993	2 2-5m	29	high	75m
44: Waipiro Bay (south) Z16:785377	4 2m	4 3.5m driftwood	5 0^0	3 c.3m in 1947	5 boulders	5 beach ridge	2 0.27m/yr 1956-1993	2 2-5m	30	high	75m
45: Waipiro Bay (mid) Z16:783387	2 20m	4 4-5m	1 30^0	3 c.3m in 1947	5 colluvium	5 earthflow	3 -0.22m/yr 1956-1993	3 5-10m	26	medium	580m
46: Waipiro Stream (south) Z16:873396	4 2.5m	4 4-5m	5 0^0	3 c.3m in 1947	5 gravel & sand	5 gravel beach ridge	3 -0.27m/yr 1956-1993	4 10-15m	33	high	150m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
47: Waipiro Bay (mid) Z15:785404	5 1.7m	4 4-5m	2 15^0	3 c.3m in 1947	5 colluvium	5 earthflow	2 0.0m/yr 1956-1993	3 5-10m	29	high	450m
48: Ohineakai Z15:788414	4 3m	4 4-5m	1 40^0	3 c.3m in 1947	5 sand	5 sand dune	3 -0.27m/yr 1956-1993	4 20-30m	29	high	300m
49: Waipiro Bay (north) Z15:794422	3 6m	4 4-5m	1 25^0	3 c.3m in 1947	5 colluvium	5 earthflow	3 -0.27m/yr 1956-1993	4 20-30m	28	high	970m
50: Otamarauiri Point (north) Z15:799428	1 260m	4 3-4m	1 35^0	3 c.3m in 1947	5 coluvium	5 earthflow	3 -0.41m/yr 1956-1993	4 10-20m	26	medium	500m
51: Te Maire Stream (south) Z15:807433	5 1.8m	4 3-4m driftwood	5 0^0	3 c.3m in 1947	5 boulder	5 delta	2 0.0m/yr 1956-1993	2 2-5m	31	high	75m
52: Whareponga Beach (mid) Z15:824454	5 1.8m	4 3-5m	5 0^0	3 c.3m in 1947	5 gravel	5 beach ridges	3 -0.20m/yr 1956-1993	2 2-5m	32	high	100m
53: Tuparoa (south) Z15:837495	4 3.5m	4 3-5m	5 -10^0	3 c.3m in 1947	5 coarse sand	5 sand dunes	2 0.41m/yr 1956-1993	4 10-15m	32	high	100m
54: Tuparoa (mid) Z15:838505	4 3m	4 3-5m	5 -5^0	3 c.3m in 1947	5 coarse sand	5 beach ridges	1 0.95m/yr 1922-1993	4 15-20m	31	high	100m
55: Tuparoa (north) Z15:844514	5 1.5m	4 3-5m	1 30^0	3 c.3m in 1947	5 coarse sand	5 debris slide	2 0.22m/yr 1956-1993	3 5-10m	28	high	100m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
56: Reporua Z15:855556	3 8m	4 3-5m	5 -10^0	3 c.3m in 1868	5 colluvium	5 earthflow	4 -0.75m/yr 1957-1993	3 5-10m	32	high	200m
57: Port Awanui (south) Z15:895606	5 1.4m	4 3-4m	5 0^0	3 c.3m in 1868	5 sand	5 sand plain	1 0.56m/yr 1957-1993	4 15-20m	32	high	100m
58: Port Awanui (north) Z15:896616	5 1.7m	4 3-4m	4 5^0	3 c.3m in 1868	5 sand	5 sand dunes	1 0.56m/yr 1957-1993	4 15-20m	31	high	100m
59: Te Wharau Beach (south) Z15:902624	5 1.5m	4 3-4m	5 -2^0	3 c.3m in 1868	5 sand & gravel	5 sand dunes	1 1.57m/yr 1939-1993	4 20-30m	32	high	100m
60: Te Wharau Beach (mid) Z15:907633	5 1.5m	4 3-4m	5 0^0	3 c.3m in 1868	5 coarse sand	5 beach ridges	1 1.85m/yr 1939-1993	4 20-30	32	high	100m
61: Te Wharau Beach (mid) Z15:914641	4 2.1m	4 3-5m	5 0^0	3 c.3m in 1868	5 coarse sand	5 beach ridges	1 2.96m/yr 1939-1993	4 20-30m	31	high	100m
62: Te Wharau Beach (north) Z15:921648	5 1.6m	4 3-5m	5 0^0	3 c.3m in 1868	5 sand & gravel	5 beach ridges	1 2.32m/yr 1939-1993	4 20-30m	32	high	100m
63: Waiapu River (south) Z15:928655	5 1.2m	4 3-5m	5 -5^0	3 c.3m in 1868	5 coarse sand & gravel	5 river mouth	1 2.0m/yr 1939-1993	5 50-100m	33	high	500m
64: Waiapu River (north) Z15:935665	4 2m	4 3-5m	5 0^0	3 c.3m in 1868	5 coarse sand & gravel	river mouth	1 3.70m/yr 1939-1993	5 100-150m	32	high	350m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
65: Rangitukia Beach (south) Z15:939673	4 3.7m	4 3-5m	5 -5^0	3 c.3m in 1868	5 coarse sand & gravel	5 sand dunes	1 1.39m/yr 1957-1993	5 30-60m	32	high	150m
66: Rangitukia Beach (mid) Z15:946682	4 3.3m	4 3-5m	5 -5^0	3 c.3m in 1868	5 coarse sand	5 sand dunes	1 1.25m/yr 1957-1993	5 40-80m	32	high	150m
66A: Rangitukia Beach (north) Z15:953689	4 3.8m	4 3-5m	5 -5^0	3 c.3m in 1868	5 coarse sand	5 sand dunes	1 0.69m/yr 1957-1993	5 30-60m	32	high	150m
67: Waikori Bluff (north) Z14:969719	5 1.7m	4 3m driftwood	2 15^0	3 c.3m in 1868	5 fine sand	5 sand dunes	3 c.-0.20m/yr	3 5-10m	30	high	100m
68: Maungaroa Stream Z14:975727	4 5m	4 3m	2 15^0	3 c.3m in 1868	5 fine sand	5 sand dunes	3 c.-0.20m/yr	4 15-20m	30	high	100m
69: Waikuta Stream Z14:981734	3 5.8m	4 3m	2 15^0	3 c.3m in 1868	4 mudstone	5 raised beach	3 c.-0.20m/yr	4 15-20m	28	high	100m
70: East Cape (south) Z14:989742	3 6.4m	4 4m driftwood	4 2^0	3 c.3m in 1868	5 gravel	5 raised beach	2 0.24m/yr 1952-1993	3 5-10m	29	high	100m
71: East Cape (north) Z14:991759	3 5.4m	4 3.7m driftwood	4 2^0	3 c.3m in 1868	5 fine sand	5 raised beach	2 0.20m/yr 1952-1993	4 10-15m	30	high	100m
72: Te Wharenaonao Point (west) Z14:980771	4 2.4m	4 2-3m	4 5^0	3 c.3m in 1868	5 fine sand	5 sand dunes	2 0.12m/yr 1951-1993	4 10-15m	31	high	100m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
73: Hautai Beach (east) Z14:970775	5 1.5m	4 2-3m	3 10^0	3 c.3m in 1868	5 fine sand	5 sand dunes	1 0.95m/yr 1951-1993	4 10-15m	30	high	150m
74: Hautai Beach (mid) Z14:962781	4 3.4m	4 2-3m	4 5^0	3 c.3m in 1868	5 fine sand	5 sand dunes	1 0.83m/yr 1951-1993	4 20-30m	30	high	570m
75: Hautai Beach (mid) Z14:955788	4 2.7m	4 2-3m	5 0^0	3 c.3m in 1868	5 fine sand	5 sand dunes	1 1.67m/yr 1951-1993	4 20-30m	31	high	220m
76: Hautai Beach (west) Z14:947796	5 <2m	4 3m driftwood	3 10^0	3 c.3m in 1868	5 fine sand	5 sand dunes	2 0.50m/yr 1912-1993	4 20-30m	31	high	200m
77: Hautai Beach (west) Z14:941803	5 <2m	4 2.6m driftwood	3 10^0	3 c.3m in 1868	5 fine sand	5 sand dunes	1 0.55m/yr 1951-1993	4 10-15m	30	high	100m
78: Horoera (east) Z14:934812	3 8m	4 2-3m	1 30^0	3 c.3m in 1868	5 fine sand	5 sand dunes	3 -0.48m/yr 1951-1993	4 10-15m	28	high	200m
79: Horoera (west) Z14:924813	4 3.5m	4 2-3m	2 15^0	3 c.3m in 1868	4 sandstone	4 raised shore platform	3 -0.29m/yr 1951-1993	2 2-5m	26	medium	150m
80: Orutua River (east) Z14:914812	5 1m	4 2.1m driftwood	4 2^0	3 c.3m in 1868	5 fine sand	5 sand dunes	1 0.71m/yr 1951-1993	4 15-20m	31	high	140m
81: Orutua River (west) Z14:904814	5 1.7m	4 2-3m	4 2^0	3 c.3m in 1868	5 medium sand	5 sand dunes	1 0.95m/yr 1951-1993	4 20-30m	31	high	100m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
82: Waipohatuhatu Stream (east) Z14:895819	4 3.8m	4 3-4m	2 20^0	3 c.3m in 1868	4 mudstone	4 raised shore platform	2 -0.02m/yr 1951-1993	2 2-5m	25	medium	75m
83: Whahariki Point (east) Z14:886823	3 5.7m	4 3-4m	2 20^0	3 c.3m in 1868	4 mudstone	4 raised shore platform	2 -0.02m/yr 1951-1993	2 2-5m	24	medium	75m
84: Whahariki Point (west) Z14:876825	3 6m	4 2-3m	1 25^0	3 c.3m in 1868	4 mudstone	4 raised shore platform	2 -0.02m/yr 1951-1993	2 2-5m	23	medium	75m
85: Marihou Point Z14:866826	4 4.6m	4 2-3m	2 12^0	3 c.3m in 1868	5 sand on platform	4 raised shore platform	2 0.14m/yr 1951-1993	2 2-5m	26	medium	75m
86: Te Hekawa Point Z14:858829	4 2m	4 2-3m driftwood	3 8^0	3 c.3m in 1868	5 sand on platform	4 raised shore platform	2 0.12m/yr 1951-1993	2 2-5m	27	medium	75m
87: Awatere River (west) Z14:843825	4 2.6m	4 3-4m	5 -2^0	3 c.3m in 1868	5 gravel	5 beach ridges	4 -1.24m/yr 1951-1993	5 20-40m	35	very high	200m
88: Te Araroa (mid) Z14:834828	4 2.7m	4 3.5m driftwood	5 0^0	3 c.3m in 1868	5 gravel	5 beach ridges	4 -0.57m/yr 1951-1993	4 15-25m	34	high	200m
89: Te Araroa (west) Z14:825833	4 2.1m	4 3-4m	5 0^0	3 c.3m in 1868	5 coarse sand & gravel	5 beach ridges	3 -0.43m/yr 1951-1993	4 15-25m	33	high	200m
90: Karakatuwhero River (east)	5 1.7m	4 3-4m	5 0^0	3 c.3m in 1868	5 coarse sand &	5 beach ridges	2 0.49m/yr	5 30-50m	34	high	900m

VARIABLES STATION	Elevation	Storm Wave Runup	Gradient	Tsunami	Lithology	Landform	Long-Term Trend	Short-Term Fluctuation	CSI		ASCH (metres)
Z14:818839					gravel		1921-1993				
91: Karakatuwhero River (west) Z14:813843	5 1.9m	4 3-4m	5 -5^0	3 c.3m in 1868	5 sand & gravel	5 River mouth barrier	1 1.02m/yr 1893-1983	5 50-80m	33	high	900m
92: Hine Tokata Rock (west) Z14:806850	4 2.4m	4 3-4m	5 -5^0	3 c.3m in 1868	5 sand & gravel	5 beach ridges	1 1.22m/yr 1893-1983	4 20-30m	31	high	250m
93: Punaruku (east) Z14:800857	4 2.1m	4 3m driftwood	5 0^0	3 c.3m in 1868	5 sand & gravel	5 beach ridges	1 0.77m/yr 1893-1983	4 20-30m	31	high	100m
94: Punaruku (west) Z14:796862	4 3m	4 3-4m	5 0^0	3 c.3m in 1868	5 fine sand	5 sand dunes	2 0.39m/yr 1893-1983	4 20-30m	32	high	100m
95: Onepoto Bay Z14:781871	5 1.5m	4 3-4m	5 <2^0	3 c.3m in 1868	5 fine sand	5 sand plain	2 0.0m/yr 1915-1993	4 10-20m	33	high	210m
96: Hicks Bay (east) Z14:778876	5 1.1m	4 3-4m	5 -5^0	3 c.3m in 1868	5 sand & gravel	5 river barrier	1 0.65m/yr 1915-1983	5 150-200m	33	high	600m
97: Hicks Bay (mid) Z14:775886	4 2.2m	4 3.9m driftwood	5 -5^0	3 c.3m in 1868	5 sand & gravel	5 river barrier	2 0.44m/yr 1915-1983	5 200-250m	33	high	430m
98: Hicks Bay (west) Z14:776896	4 2.6m	4 3-4m	5 -2^0	3 c.3m in 1868	5 sand & gravel	5 sand dunes	1 0.71m/yr 1915-1983	5 200-250m	32	high	510m
99: Lottin Point (east) Y14: 866926	4 3m	4 3-4m	2 15^0	3 c.3m in 1868	5 gravel on	5 beach ridges	2 c.0.1m/yr	1 <2m	26	medium	50m

VARIABLES **STATION**	**Elevation**	**Storm Wave Runup**	**Gradient**	**Tsunami**	**Lithology**	**Landform**	**Long-Term Trend**	**Short-Term Fluctuation**	**CSI**		**ASCH** (metres)
					platform						
100: Lottin Point (west) Y14: 634929	1 25m	3 3-4m	1 25^0	3 3m in 1868	1 basalts	1 very hard rock platform	2 0.0m/yr	1 0m	13	very low	50m