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Plate 21 Photo taken 4 April 1992, of Site 70, Lottin Point, East Cape, rated 13. This site is composed of very hard basalts, has a steep cliff and rock platform and is not susceptible to inundation by storm wave run- up or short term fluctuations despite having full exposure to very heavy seas at times from the northerly quadrant.

4.3.3 Sea-level rise

Depending on it's magnitude and rate sea-level rise can be a major contributing facto to accelerated shoreline retreat (Gibb 1988; 1991). Sea-level can also influence the type and magnitude of such processes as tidal range, breaker type, longshore current velocities, and sedimentation rates (Pethick 1984). A change in sea-level will modify coastal processes, affecting the relative magnitude or causing a complete change in processes which operate on a particular landform. Carter (1988) noted that a gradual rise in sea-level would enhance the landward penetration of surges and storm waves, and would lead to shoreline erosion.

Greenhouse affected weather patterns couls alter the amount of sediment supplied to the coast, altering sediment transport rates. Storm frequency, intensity and predominant wave direction may also be affected, causing significant reversals in longshore drift directions. In some cases, the enhanced greenhouse effect may cause a coast to react 'favourably' (e.g., by accreting).

Historic rates of sea-level rise for New Zealand have been calculated by Hannah (1990) who analysed mean sea-level data obtained from tide gauges at the ports of Auckland, Wellington, Lyttelton, and Dunedin over the period 1899 to 1988. hannah's results indicated rising trends in sea-level on 1.3, 1.7, 2.3 and 1.4 mm/yr for Auckland, Wellington, Lyttelton and Dunedin,

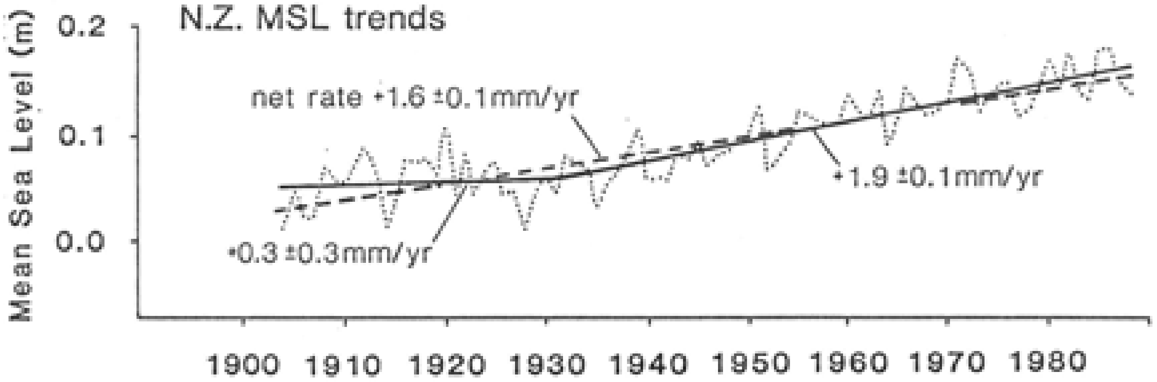

Figure 20 sea-level trend for New Zealand (1904-1988) adapted from Gibb (1991).

respectively which together gave a mean trend of 1.7 mm/yr for the east coast of New Zealand as a whole. From the same datasets Gibb (1991) derived an historical sea-level curve for New Zealand for the period 1904 to 1988 (Figure 20), and a mean trend of 1.6 ± 0.1 which agreed favourably with Hannah (1990).

Projections made by the Intergovernmental Panel on Climate Change (IPCC 1990) based on an assessment of climate change and the enhanced greenhouse effect suggest that under the IPCC Business-as-Usual scenario global mean temperatures are predicted to rise to about 1°C above the present value by 2025 A.D. and 3°C before 2100. Based on these projections, sea-level rise around New Zealand may increase 2-6 times above the present rate of ~1.7 mm/yr, within a range of 3-12 mm/yr by 2100 A.D. (Figure 21).

Local relative sea-level on a global scale differs from place to place however, and measurements have been recorded over a variety of time spans. Changes in local relative sea-level are regional; therefore it is advisable to use local trends such as those published by Hannah (1990) and Gibb (1991) for New Zealand when assessing the likely impacts of sea-level changes on the coast.

Average sea-level rise of 2.4 mm/yr at Lyttelton has culminated in a 20 cm elevation of the sea surface since the 1900s, yet Christchurch beaches have maintained a dynamic equilibrium and have actually risen vertically rather than been eroded landwards (R. Kirk, pers. comm., June 1992). The tidal prism of the Avon-Heathcote estuary has doubled with about half of this expansion attributed to sea-level rise, although this has not markedly affected the estuary (Findlay and Kirk 1988). An increase in rainfall may in fact have a greater effect on the coast than a rise in sea-level owing to raised water table effects causing increased beach scour.

Using Hannah (1990) and Gibb (1991) sea-level rise values for New Zealand and the projections made by IPCC an attempt was made to assess the change that would occur to the CSI, in order to identify areas of the coast which may be most susceptible to an increase in sea-level rise. The following case study illustrates an example to incorporate sea-level rise into the CSI, with limited success.

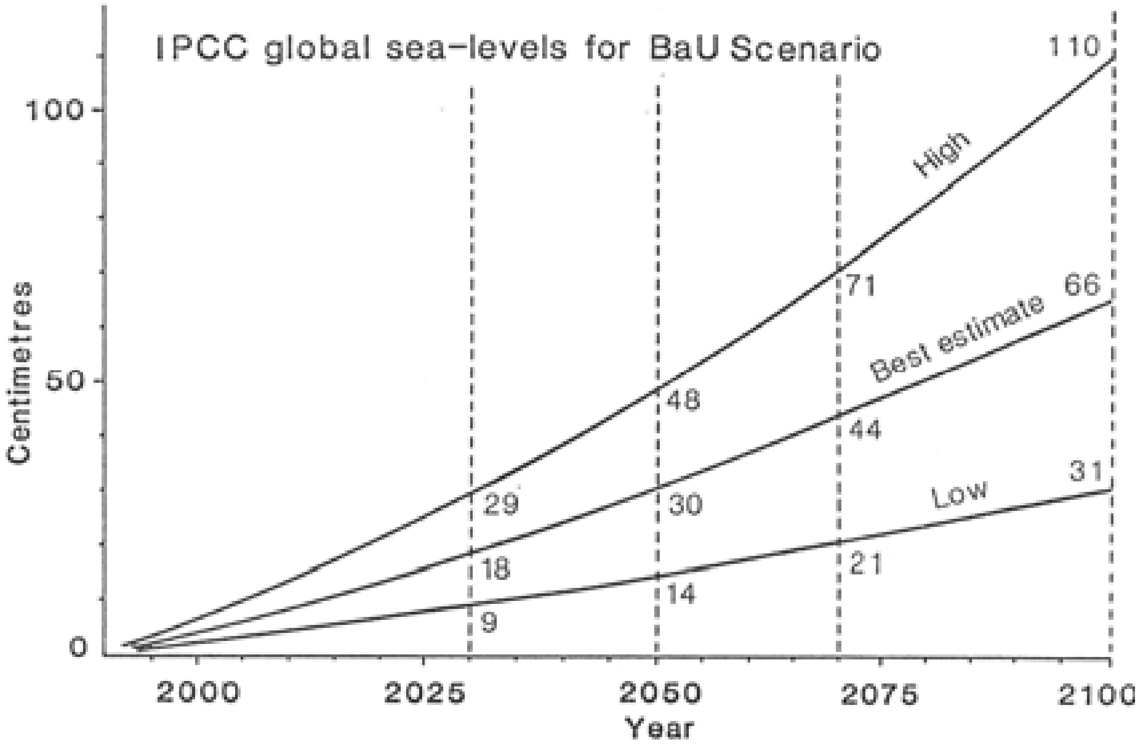

Figure 21 Graphs showing low, best estimate and high projections of global sea-level rise for the period 1990-2100 adapted from Gibb (1991).

Methods and results
A number of tests were conducted for the following scenarios:

1. Sea-level continues to rise at the historic rate of 1.7 mm/yr, (Figure 20) and with local rates as follows: Auckland 1.2 mm/yr, Wellington 1.7 mm/yr, Lyttelton 2.4 mm/yr and Dunedin 1.4 mm/yr (after Gibb 1991). Where a site was located near any of the major recording sites the local rate was used for accuracy, otherwise the national average rate was used.

2. Based on the IPCC projections the historical rate of sea-level rise (Figure 21) accelerates 2 to 6 times (i.e., from 3.4 to 10.2 mm/yr) during the next century.

To conduct the tests the following criteria were also applied:
1 That a rise in sea-level equates to a corresponding relative fall in elevation. This assumes that beaches or ridges will not have the time or sediment supply to prograde in response to an accelerating rise in sea-level.

2 That storm wave run-up levels will remain of the same magnitude. Low-lying areas that had previously not been flooded may become more susceptible to the effects of inundation.

3 That no appreciable changes in horizontal trend occur. Erosion or accretion may increase or abate with increasing sea-level. However, it is not possible to predict what changes to horizontal trend may occur with any confidence at this stage.

As a first step the rise in sea-level that may occur by the year 2050 **A.D.** and 2100 **A.D.** was calculated using the 1.7 mm/yr average for New Zealand, and the IPCC scenarios of 2 and 6 times the present rates (3.4 and 10.2 mm/yr). Assuming sea-level rise from present (1992) the rise in mm by 2050 A.D. (58 years) and 2100 A.D. (108 years) was calculated (Table 7).

Table 7 Total rise in sea-level (in cm) to 2050 A.D. and 2100 A.D. using the average rate of sea-level rise for New Zealand and the IPCC scenarios of 2 and 6 times the present rate.

Year	**Average New Zealand rise in sea-level** Rate= 1.7 mm/yr	**Rise in sea-level** (IPCC accelerated rates)	
		2 times (3.4 mm/yr)	6 times (10.2 mm/yr)
2050	9.9cm	19.7 cm	59.2 cm
2100	18.4 cm	36.7 cm	110.2 cm

As a second step the changes to CSI between present and future were assessed, for selected test areas which may illustrate increasing sensitivity to sea-level rise (i.e., low-lying beaches and ridges). This assumed that criteria 2 and 3 above are met and that only elevation will decrease relative to the rise in sea-level.

Detailed results are given in Appendix 10. In general, the results from these tests did not significantly change the CSI values or classes. The main changes however, occurred with the largest IPCC projections for sea-level rise. Significant change in the CSI occurred only where sea-level rise caused increased overtopping, and therefore a change in the position where gradient is measured. Generally however, the change was not great enough to alter the rating, from high to very high sensitivity, or medium to high sensitivity.

The greatest unknown in this assessment however, is whether the coast will advance or retreat in response to sea-level rise. Much of this unknown centres on a lack of knowledge of coastal sediment budgets and their response to sea-level changes. Geologic evidence from New Zealand and Australia revealed that during the postglacial marine transgression from about 18,000 years B.P. to about 6,500 years B.P. there was widespread retreat of coastlines everywhere. During this 11,500 year period sea-level rose at 10-15 mm/yr, a rate projected to occur with the worst case greenhouse scenarios. Should that rate occur again then it is highly likely that coastlines will once again retreat everywhere, overwhelming positive sediment budgets and tectonic uplift. Under this scenario most if not all sand and gravel coasts would increase to a very high CSI rating.

5. CONCLUSIONS

1. The Resource Management Act 1991 establishes a partnership for coastal management between the Minister of Conservation as the Crown's representative and regional and district councils. Under the Act, regional councils shall control the use of land for the purpose of the avoidance or mitigation of natural hazards. For the area seaward of MHWS that function is shared with the Minister of Conservation with respect to controlling any actual or potential effects of the use, development, or protection of the land including the avoidance or mitigation of natural hazards.
2. The Coastal Sensitivity Index (CSI) developed here satisfies the requirements of the Resource Management Act by providing a standardised method for assessing the relative sensitivity of areas of the New Zealand coastline to existing physical processes, which may become hazardous to human property and values. The major hazards considered were flooding from tsunami, storm wave run-up and sea-level rise, and erosion from shoreline retreat and landslip. Natural hazards not considered included earthquake, volcanic and geothermal activity, subsidence, wind, drought and fire. Human induced hazards not considered included pollution and the adverse effects of coastal protection works.

3. The CSI and initial framework for physical coastal hazards information were developed through a process of rigorous field testing at 113 sites, representing different types along both the open-exposed and sheltered coasts of New Zealand. Test sites included the coastlines of Wairarapa, Wellington's south and west coasts, Pauatahanui Inlet, Manukau Harbour, Hawkes Bay, East Cape, Bay of Plenty, and Canterbury regions. The development process was followed by extensive consultation and feedback from coastal practitioners and specialists.

4. The CSI matrix evolved from an initial 13 variables to 8, each representing the end effect of many interacting processes. The 8 variables adopted were; elevation, maximum storm wave run-up level, gradient, maximum tsunami wave height, lithology, natural landform, horizontal shoreline trend, and short-term shoreline fluctuation.

5. Each of the 8 variables requires reliable, professionally defensible data which is subdivided into 5 classes. The CSI for a section of coast is derived by adding the specific class (1-5) allocated to each of the 8 variables. Coastal Sensitivity Indices potentially range from a minimum of 8 to a maximum of 40 for a specified site, the numerical class boundaries being 8-13 (very low), 14-20 (low), 21-27 (medium), 28-34 (high), and 35-40 (very high).

6. For the 113 coastal sites tested, CSI's covered the full spectrum ranging from very low to high (30) for sheltered coasts, and from very low (13) to very high (36) for open exposed coasts. Coastlines with very high CSIs (35-40) were typically low-lying coastal landforms of unconsolidated sediments with a history of shoreline retreat, high to very high shoreline fluctuations, and inundation from storm wave run-up and tsunami. Coastlines with very low CSI's (8-13) were typically hard rock landforms of steep elevation, with a history of low to very low shoreline movements and inundation from the sea.

7. The CSI assessment technique is rapid and easily applied if good quality data are available. Sites take about 15-30 minutes to assess. Depending on travel time and coastal access it is possible to assess about 10 sites per day over 30 km of coast.

8. The identification of very low to very high sensitivity areas of coast on a local, regional or national scale provides a useful basis for both more detailed monitoring of specific areas and basic information to assist with the development of regional and district plans by local authorities. Because the CSI technique has been tested and standardised it will be possible to compare high to very high sensitivity areas nationally, including measures taken by regional councils to avoid or mitigate the adverse effects of natural hazards in such areas.

9. The coastal hazards database underpinning the CSI provides an essential framework to assess the potentially adverse effects of accelerated sea-level rise next century in response to enhanced greenhouse warming. Further work is required in this area however, because of the uncertainty of how coastlines with different sediment budgets and physical characteristics will respond to rises in local relative sea-level.

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APPENDIX 1
Hazards assessment terminology

Coastal hazard: a natural phenomenon that exposes the littoral zone to risk of damage or other adverse effects (Gomitz 1991). [This definition is not used in this study.]

Coastal hazards database: a database containing information on the 8 variables used to define a CSI, with the capacity to incorporate information on other variables.

Coastal Sensitivity Index (CSI): an estimation of the relative sensitivity of the natural coast to natural hazards.

Coastal vulnerability: the liability of the shore to respond adversely to a hazard (Gomitz 1991) -this definition is not used in this study.

Sensitivity: readily responding to or recording slight changes of condition; being affected by external stimuli (Concise Oxford Dictionary).

Natural hazard (Resource Management Act 1991): any atmospheric or earth or water related occurrence including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding), the action of which adversely affects or may adversely affect human life, property or other aspects of the environment.

Hazard agent: a (damaging) physical process. [Same definition by the UN and engineers.]

Natural hazard: the probability of occurrence within a specified period of time and within a given area of a potentially damaging phenomenon. [Defined as risk by engineers (IPENZ)].

Vulnerability: the degree of loss to a given element or set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude. It is expressed on a scale from 0 to 1. [Defined as by engineers (IPENZ)].

Specific risk: the expected degree of loss due to a particular natural phenomenon.

Elements at risk: the population, properties, economic activities, including public services etc, at risk in a given area [Defined as hazards by engineers (IPENZ)]

Total risk: the number of lives lost, persons injured, damage to property, or disruption of economic activity due to a particular natural phenomenon. [Defined as risk of hazard by engineers (IPENZ)].

> *'The main difference between the two terminologies is that the UN term hazard is equivalent to the IPENZ term risk, with reference to the physical process. Whereas IPENZ use of the term hazeard refers to the damaging impacts of that process. The ultimate gain of any hazard assessment is to make a statement on the probability of specified impacts occurring in a given place.'*
>
> Crozier (1992)

The CSI does not attempt to do that, but an indication of the relative sensitivity of the natural coast to physical processes that may, or may not pose hazards to human assets and values.

APPENDIX 2
Abbreviations, Definitions and Terminology

Bentonite: a clay derived from the weathering and decomposition of volcanic ash material and composed of smectite. It has a great ability to absorb water and to swell accordingly (Moore 1976).

Coastal erosion: the process of episodic removal of material at the shoreline leading to a loss of land as the shoreline retreats landward (Gibb 1984).

Coastal accretion: the product of deposition of material at the shoreline, leading to a gain of land as the shoreline advances seaward (Gibb 1979, 1981).

Coastal hazard: a natural phenomenon that exposes the coastal environment to risk of damage or other adverse effects.

Coastal hazard zone: the land adjacent to the coast being highly vulnerable to hazards (Gibb 1981).

Erosion: ... "the group of processes whereby earthy rock material is loosened or dissolved and removed from any part of the earth's surface"...(American Geological Institute 1962).

Elevation: height (metres) above mean sea level of the land immediately adjacent to the coast.

IPENZ: Institution of Professional Engineers, New Zealand.

Maximum significant wave height: the maximum significant wave height for more than one wave record. This is dependent on the length of record, and how frequently the measurement is made (W. de Lange, pers. Comm., February 1992).

Mean high water spring (MHWS): the average of the levels of each pair of successive high waters during that period of about 24 hours in each semi-lunation (which is approximately every 14 days) when the range of the tide is greatest.

Mean sea level (MSL): the average level of the sea, as calculated from a large number of observations at equal intervals of time.

NZLRI: New Zealand Land Resource Inventory (developed by DSIR, now Land Resources New Zealand).

R: the net long-term rate of accretion or erosion (m/yr) (Gibb 1983).

S: the maximum range of short-term fluctuations (m) as a result of one or a cluster of onshore storms (Gibb 1983).

Shoreline displacement: horizontal advance or retreat of the shoreline (m/yr) (Gornitz 1991).

Static shorelines: those where net erosion was <0.02 m/yr over approximately the last 100 years (Gibb 1984).

Tsunami: long-period waves generated by large short-duration disturbances of the sea-floor (Hume *et al.* 1992).

APPENDIX 3
Composite matrix of all variables tested during development

CLASS *VARIABLE*	*1* *VERY LOW*	*2* *LOW*	*3* *MEDIUM*	*4* *HIGH*	*5* *VERY HIGH*
Elevation above MHWS (m)	>30.0	30.0-10.1	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 (degrees)	>20	20-11	10-5	5-2	<2 (including <0)
Max. tsunami wave height (m)	<0.5	0.5-1.5	1.6-4.0	4.1-10.0	>10
Lithology	Plutonics. Intrusives. Metamorphics (high to medium grade). Volcanics (lava, dikes).	Low grade metamorphics. Dense indurated sedimentary rocks (greywacke, solid argillite, conglomerate). Very densely and densely welded ignimbrites. Volcanic breccia.	Moderately indurated sed. Rocks (sandstones, argillite, conglomerate). Partially welded ignimbrite. Sheared metamorphics.	Weakly indurated sed. Rocks (mudstones, argillite, weak conglomerates). Non-welded ignimbrite. Lahars. Lignite. Relict snads. Consolidated volcanic ash. Loess.	Unconsolidated sediments (alluvium, gravels, sands, silts, muds). Swelling bentonites. Unconsolidated volcanic ash. Peat.
Natural landform	Very hard rock platforms and sea cliffs.	Hard rock platforms and seal cliffs.	Moderately hard rock platforms and sea cliffs. Moraines.	Soft rock platforms and sea cliffs. Alluvial deltas. Saltmarsh/ mangroves.	Sand barriers, beaches, dunes, and spits. Gravel barriers, beach ridges and spits. River mouths. Cuspate forelands.
Horizontal trend (m/yr)	> + 0.50	+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
Mean spring tidal range (m)	0.00-0.69	0.70-1.09	1.10-2.09	2.10-4.00	>4.00
Overtopping height (m)	0	0.1-0.2	0.3-0.5	0.6-1.0	>1.0
Vertical trend (mm/yr)	> + 2.0	2.0 to -0.1	-0.2 to -0.9	-1.0 to -3.0	>-3.0 Submergence
Max wave height (m)	0.1-1.5	1.6-3.0	3.1-6.0	3.0-10.0	>10.0
Max. storm surge level (m)	<0.1	0.1-0.3	0.4-0.8	0.9-1.5	>1.5

APPENDIX 4
Quotes for horizontal trend information (1992)

The following are quotes for the collection of horizontal trend data as at July 1992.

As an estimate, DOSLI normally allows $500 per kilometre per photographic survey for coastal erosion mapping, e.g., where a 1958 and 1969 survey was overlain on 1985 imagery, this would equate to three photo surveys at a scale of 1:5000. For mapping at larger scales, e.g., 1:1000, allow for additional material costs. Conversely for a 1:10 000 a cheaper rate would be envisaged. It would be impracticable to use a scale of 1:50 000 as this would not show any detail. It will be up to the user to discuss with DOSLI that they require maximum coverage incorporating a minimum error, of as many different records of coastline position that exist.

APPENDIX 5
Data entry procedure

To store the information collected during this study the Coastal Hazards Database using dBase IV V1.1 was developed. The procedures for using the database are given below.

Minimum computer requirements
To run the database an IBM compatible computer (and printer) with at least a 2 Mb hard drive with access to run-time dBASE IV or full dBASE IV package is required. If dBASE IV or "run-time" is already installed then the program will run from a floppy disk.

Familiarity with dBASE IV would also be a minimum requirement for using the database.

Data input
After loading the program, at the control screen run then the following commands can be used within the program.

1 When the program begins, the last record entered is automatically shown. Pressing the page down [PgDn] key displays a prompt asking for new records to be added.

2 To SAVE information after adding or amending records, hold down the control [Crtl] and press the End key [End].

3 To move from one record to another the following keys can be used:
  [PgUp] Page Up moves to the previous record.
  [PgDn] Page Down moves to the next record.

4 To move quickly from one record to another, a browse mode can be used. By pressing the [F2] key a spreadsheet/list mode appears. To move up or down this list use the Up or Down arrows until the required record is reached. Pressing [F2]again returns to the highlighted record.

Data entry screen format

1 Location: contains the site name and number.

2 Grid Reference: includes the sheet number (from NZMS 260 sheets), northing (3 digits) and easting (3 digits).

3 Date: date that the field survey was conducted.

4. Variable and sensitivity class: class values 1-5 are input first depending on the relevant site information for each of the eight variables. Notes up to 60 characters can be written on each of the variables, with final
  followed by summary notes and sources of information.

5 Notes: any supplementary notes (up to 254 characters or 5 lines long) about the site, section profile number.

6 The CSI is calculated and displayed on the screen when viewing a record with a qualifier as to which hazard the area is most sensitive to. The calculation is not saved directly to disk or updated in the database until a listing of high-low CSI values is run (see below).

Data output
A data output form has been created for filing and reference purposes. This sheet contains all the information that has been entered into the input data screen and also contains space for a site photograph to enable easy comparison and site recognition. Each site record can be printed out by pressing the
key while in the database. To do this use the program "DRIVE" which will create and print while in the database.

Lists of sites and CSIs (in descending order) can also be obtained for comparison by pressing the F5 key while in the database (Appendix 7). The database is updated and the CSI stored within the database after this procedure has been undertaken. Completed site forms can be generated for files.

APPENDIX 6
Database information collection sheet

LOCATION:
Grid Reference: Sheet: East: North: Date: / /

VARIABLE	VALUE	DATA
Elevation above MHWS (m)	0	
Storm wave run-up (m)	0	
Gradient	0	
Max tsunami wave height (m)	0	
Lithology	0	
Landform	0	
Horizontal trend (m/yr)	0	
Short-term fluctuation (m)	0	

CSI = 0 Rating:

Notes:

APPENDIX 7
Complete summary data for each test area

The following tables summarise the information collected for each field area visited during testing and list the CSIs derived from the Coastal Hazards Database in order from highest to lowest CSI. The complete set of information is stored on the database held by the Science and Research Division, Department of Conservation, Wellington, and is in dBase IV format.

APPENDIX 7
Complete summary data for each test area

Variable	Elevation	Storm Wave Run-up	Gradient	Tsunami*	Lithology	Landform	Horiz. Trend‡	Short term Fluctn‡	CSI
Wairarapa Kaiwhata Rivermouth (Site 15)	5 0.7 m	4 3 m	5 <2 degree	3 1.8 m	5 alluvial sands	5 rivermouth	4 –0.87 m/yr	5 >100 m	36
Riversdale Beach (Site 11)	5 1.6 m	4 3 m	5 <2 swale	3 1.8 m	5 sands	5 sand beach/dunes	4 –0.5 m/y	4 11–30 m range	35
Flat Point (Site 17)	4 3 m	4 3 m	5 0.95 deg	3 1.8 m	5 sands	5 cuspate foreland	4 –1.29 m/yr	5 >30 m	35
Orui Station (Site 18)	5 1.5 m	4 3 m	5 1.1 degree	3 1.8 m	5 sands	5 sand beach/dunes	2 +0.5 m/yr	5 >30 m	34
Uruti Beach Nth (Site 10)	5 1.7 m	4 3 m	5 1.7 degree	3 1.8 m	5 sands	5 sand barrier	3 –0.29 m/yr	3 6–10 m	33
Sandy Beach (Site 7)	4 2.5 m	4 3 m	5 <1 degree	3 1.8 m	5 sands	5 sand beach/barrier	3 –0.3 m/yr	4 11–30 m	33
Whareama River (Site 1)	4 3.3 m	4 3 m	5 <2 degree	3 1.8 m	5 sands	5 rivermouth/beach	2 static	5 >30 m flucts.	33
Boat Ramp Beach (Site 8)	5 1.8 m	4 3 m	5 swale	3 1.8 m	5 peat/gravel	5 gravel barrier	4 –1.14 m/yr	1 <2 m	32
Sunset Rd, Riversdale (Site 19)	4 2.4 m	4 3 m	5 swale	3 1.8 m	5 sands	5 sand dunes/beach	2 ~static	4 11–30 m	32
Gravel Beach (Site 4)	4 2.5 m	4 3 m	4 3.8 degrees	3 1.8 m	5 gravel colluv.	5 gravel beach	3 –0.2 m/yr	1 <2 m	29

Variable	Elevation	Storm Wave Run-up	Gradient	Tsunami*	Lithology	Landform	Horiz. Trend‡	Short term Fluctn‡	CSI
Low Cliff, Kaiwhata (Site 14)	4 4 m	4 3 m	1 60 degrees	3 1.8 m	5 alluvium	4 softrock cliffs	4 –0.87 m/yr	4 11–30 m	29
Faceted dunes (Site 3)	4 4.5 m	4 3 m	2 14 degrees	3 1.8 m	5 sand	5 sand dunes/beach	2 ~static	3 5–10 m	28
Uruti Beach (Site 9)	3 6 m	4 3 m	2 17 degrees	3 1.8 m	5 sand	5 sand dunes/beach	2 ~static	4 11–30 m	28
Riversdale Beach (Site 20)	3 5.6 m	4 3 m	2 14 degrees	3 1.8 m	5 sand	5 sand dunes/beach	1 +1.2 m/yr	4 11–30 m	27
Fail slope, Flat Pt (Site 16)	3 5–10 m	4 3 m	1 40 degrees	3 1.8 m	5 sand	4 softrock cliff/platf.	1 +1.2 m/yr	4 20 m slump	27
Low cliffs, Homewood (Site 12)	4 2.5 m	4 3 m	1 60 degrees	3 1.8 m	5 mudst. colluv.	4 softrock cliff	3 –0.25 m/yr	4 15 m slump	27
Platform with fence (Site 5)	3 5–6 m	4 3 m	1 60 degrees	3 1.8 m	5 colluvium	4 softrock platf./cliff	4 –0.5 m/yr	3 10 m slump	27
Whareama Homestead (Site 2)	4 3.1 m	4 3 m	2 15 degrees	3 1.8 m	5 gravels	5 gravel ridge	2 ~static	2 2–5 m	27
Highcliffs, Kaiwhata (Site 13)	1 ~100 m	4 3 m	1 60 degrees	3 1.8 m	4 mudstones	4 softrock cliffs	4 –1.3 m/yr	5 30 m slumps	26
''Lazy surveyor rock'' (Site 6)	3 6 m	4 3 m	1 27 degrees	3 1.8 m	2 greywacke	2 hardrock platform	2 static	1 static	18

* Tsunami recorded on 13 August 1960 at Castlepoint.

‡ Horizontal trend and short term fluctuation data courtesy of Wellington Regional Council.

Variable	Elevation	Storm Wave Run-up*	Gradient	Tsunami†	Lithology	Landform	Horiz. Trend‡	Short term Fluctn‡	CSI
Kapiti Coast Otaki Rivermouth (Site 21)	4 2.5 m	4 2.6 m	5 0.5 degrees	2 <1 m	5 gravels	5 river mouth	4 –0.8 m/yr	5 >100 m	34
Raumati South (Site 30)	5 1.6 m	4 2.6 m	5 1.4 degrees	2 <1 m	5 sand	5 beach/dunes	5 –2.5 m/yr	4 20 m	35
Sims Road, Te Horo (Site 22)	4 3 m	4 2.6 m	5 swale	2 <1 m	5 gravels	5 gravel/beach	2 0.5 m/yr	4 20	31
Raumati South (Site 29)	3 7–8 m	4 2.6 m	1 28 degrees	2 <1 m	5 sand	5 beach/dunes	5 –2.5 m/yr	4 20	29
Pekapeka Beach (Site 24)	4 3.6 m	4 2.6 m	3 8.2 degrees	2 <1 m	5 sands	5 sand beach	2 0.4 m/yr	11–30 m	29
Waikanae Rivermouth (Site 25)	4 4.5 m	4 2.6 m	2 12 degrees	2 <1 m	5 sands	5 rivermouth	1 1.14 m/yr	5 >100 m	28
Rua Rd South (Site 27)	4 5 m	4 2.6 m	1 42 degrees	2 <1 m	5 sands	5 sand beach	2 0.16 m/yr	5 >30 m	28
Paekakariki (Site 31)	3 6 m	4 2.6 m	2 13 degrees	2 <1 m	5 sands	5 sand dunes	3 –0.4 m/yr	4 11–30 m	28
Paraparaumu (Site 26)	4 4 m	4 2.6 m	1 22 degrees	2 <1 m	5 sands	5 cusp.foreland	1 0.92 m/yr	5 >30 m	27
Te Horo beach (Site 23)	4 5 m	4 2.6 m	2 14 degrees	2 <1 m	5 sands	5 sand beach	1 1.25 m/yr	4 11–30 m	27

* Storm wave run-up recorded by Gibb (1978).

† All recorded tsunami on the West Coast have been <1 m (tidal bores, e.g., Wanganui, Manawatu rivers).

‡ Horizontal trend and short term fluctuation data courtesy of Wellington Regional Council.

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