Appendix A: Site Summaries

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1 Ōhiwa Spit and Bryans Beach

1.1 Site description

Ōhiwa Spit and Bryans Beach is approximately 9 km west of Opotiki. The shoreline comprises 4.5 km of unconsolidated sandy shoreline (Figure 1.1). At the western end of the site is the Ōhiwa Harbour entrance and the Ōhiwa Spit where there are several residential properties. The central and eastern end of the site is referred to as Bryans Beach which also has several residential properties. The eastern extent of the site is bound by the Waiōtahe River mouth. The site has been split into six cells based on the morphology and coastal processes described below.

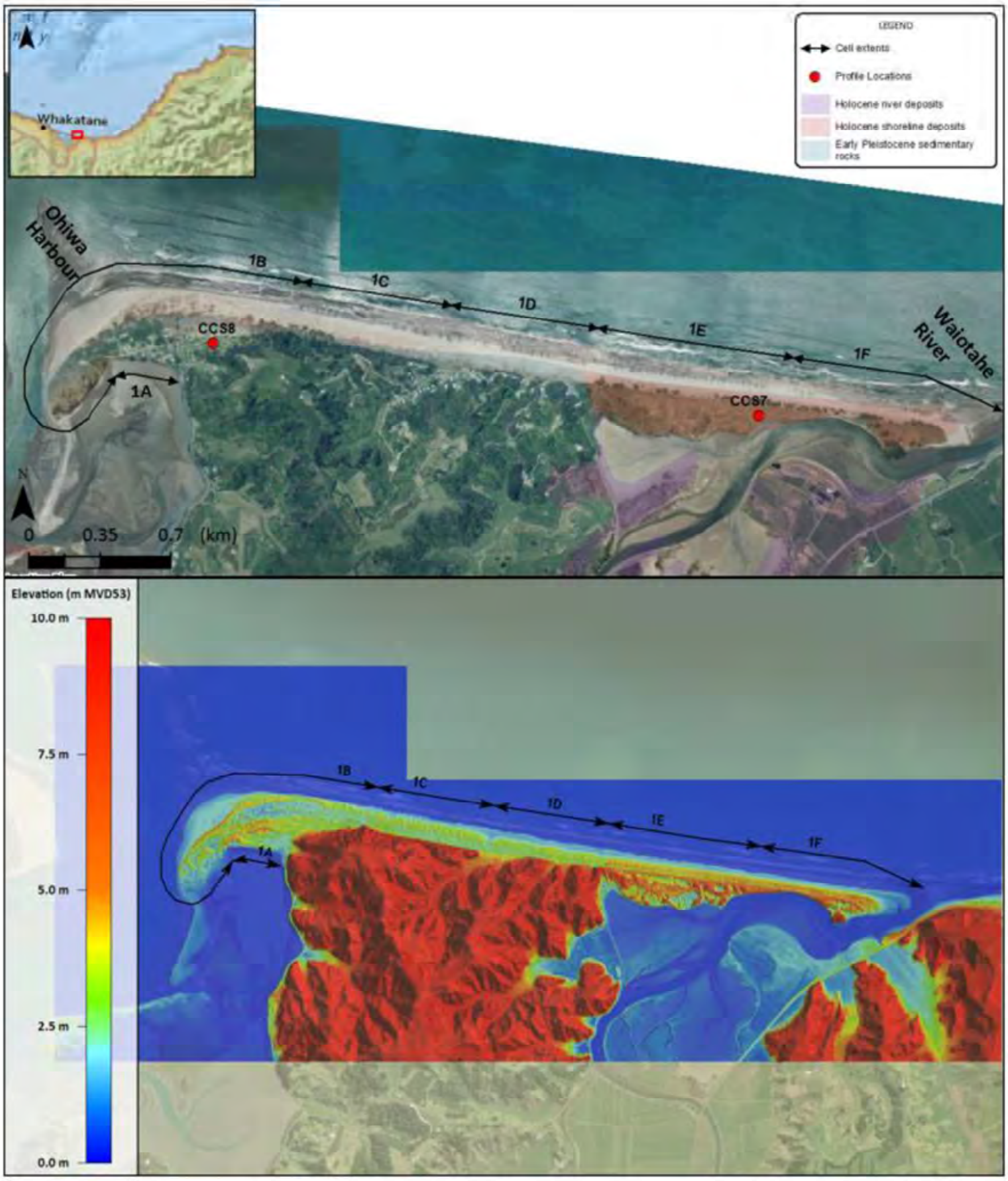


Figure 1.1: Site location and cell splits for Ōhiwa (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

1.2 Morphology

The underlying geology along the Ōhiwa shoreline comprises Holocene shoreline deposits backed by Early Pleistocene sedimentary rocks. Cell 1A is an unconsolidated harbour shoreline fronted by inter-tidal flats. Small sections of the harbour shoreline have a narrow band of salt marsh vegetation. Cell 1B (Figure 1.2, A, B) includes the Ōhiwa Spit which varies in width from 100 to 400 m (Figure 1.2, C). The seaward dune ridge along the spit ranges from 2 to 4 m high. Site observations in October 2019 showed a steep erosion scarp around the seaward edge of the spit (Figure 1.2, D and Figure 1.3). Within Cells 1C, 1D and 1E the dune complex is relatively wide and flat with lower dune heights, ranging from 1 to 2.5 m high (Figure 1.2, E, F, G). Cell 1F includes the Waiōtahe Spit which ranges from 50 to 300 m wide with several distinct dune ridges. Dune heights along the Waiōtahe Spit range from 2 to 3 m.

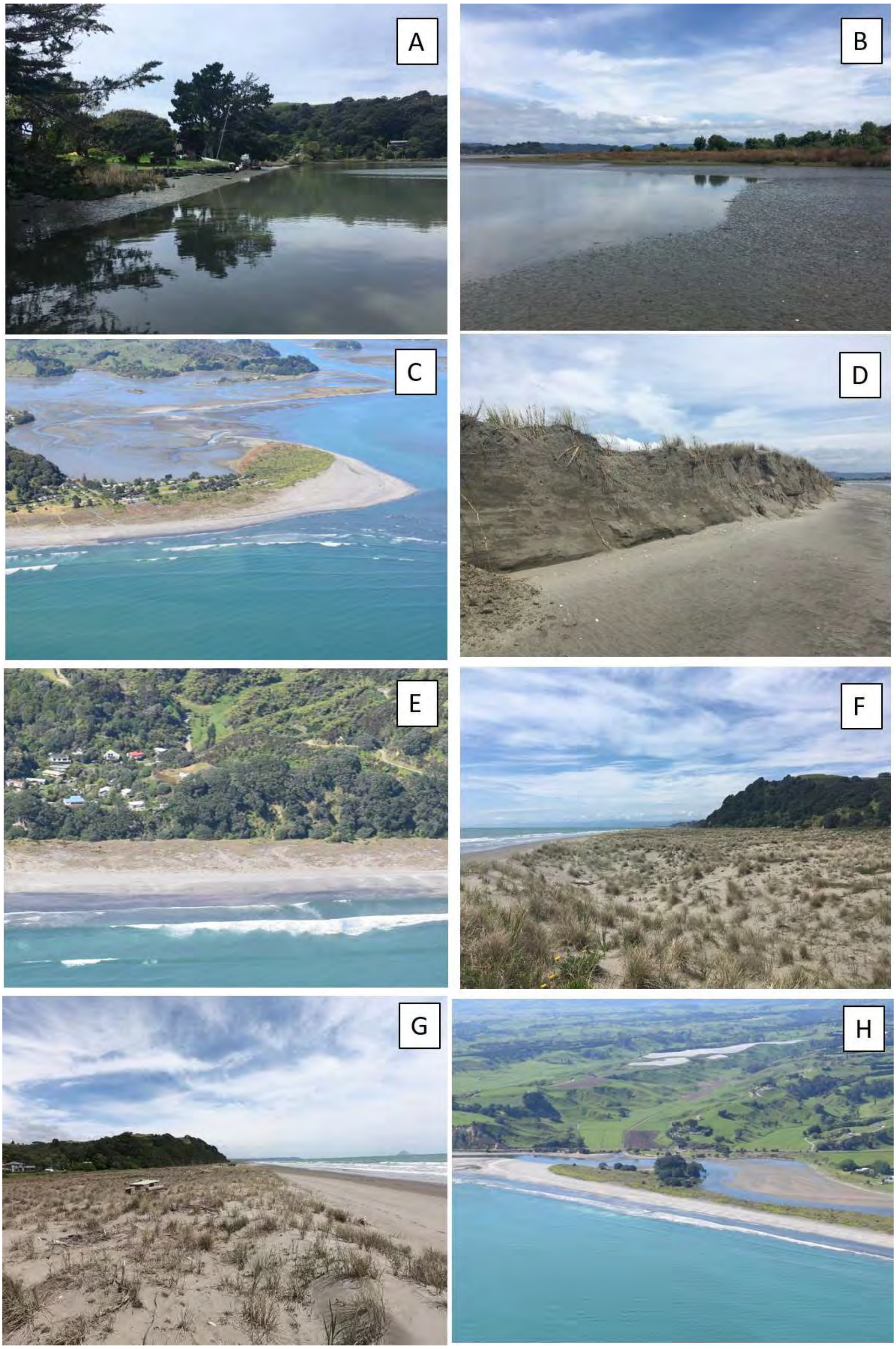


Figure 1.2: Site photos for Ōhiwa. (A) Harbour shoreline along Ōhiwa spit. (B) Salt marsh along the harbour shoreline at Ōhiwa spit. (C) Ōhiwa spit. (D) Erosion scarp at Ōhiwa spit (cell 1B). (E) Dunes within cell 1C. (F) Low vegetated dunes within cell 1C. (G) Low dunes within cell 1C. (H) Waiōtahe Spit (cell 1F)

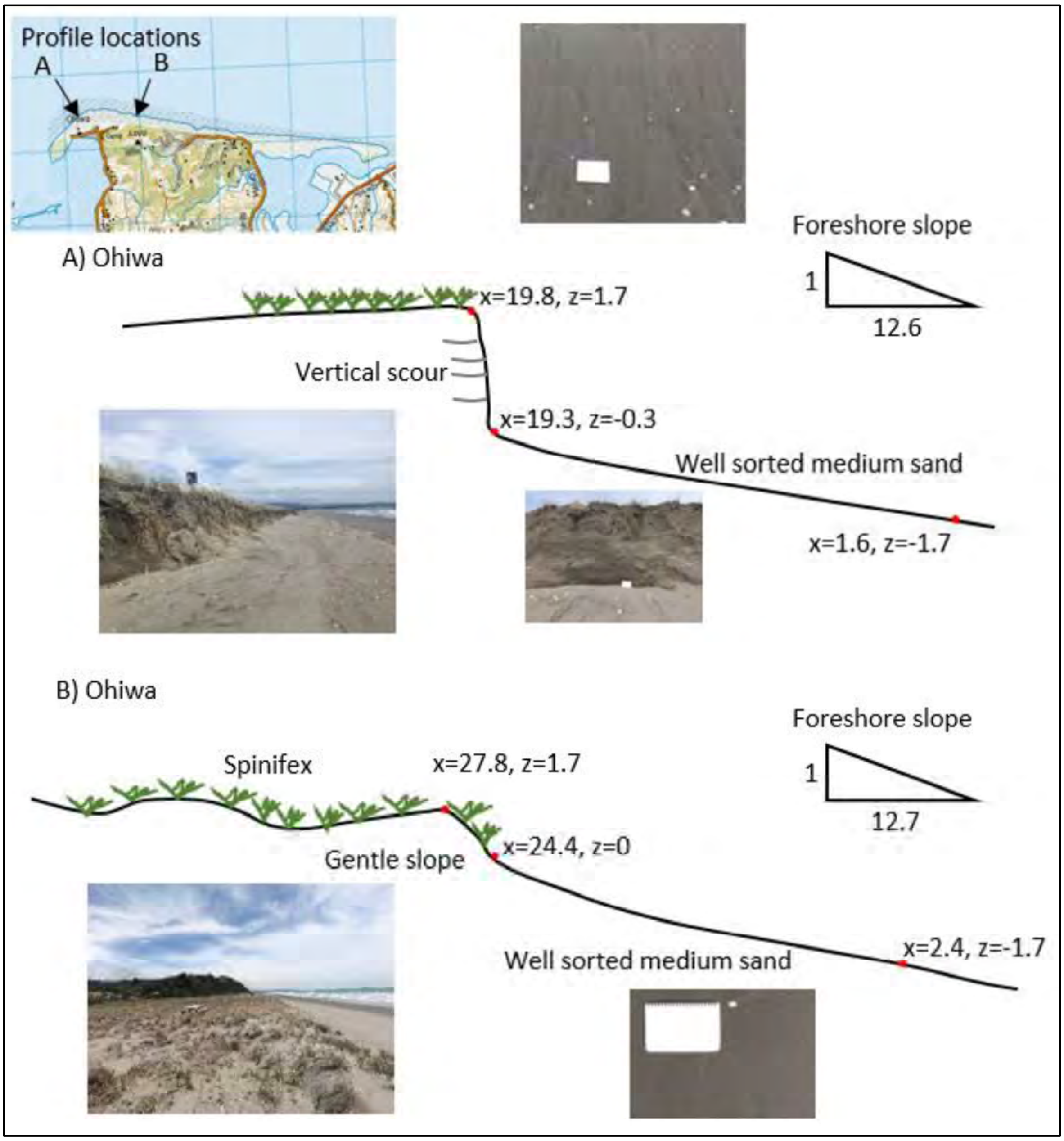


Figure 1.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cell 1B and 1C

1.3 Coastal processes

The open coast shoreline faces north and is exposed to waves from northwest through to northeast. Based on NIWA (2019) the 50 year ARI offshore wave height is 6.2 m and the 50 year ARI storm tide is 1.24 m MVD53. The western end of the shoreline is largely influenced by harbour entrance dynamics such as changes in the ebb tidal delta position under changing wave conditions. The eastern end of the shoreline is influenced by river mouth dynamics from the Waiōtahe River. The formation of the spits along this section of coast suggest that the littoral drift is oscillatory. The harbour shoreline faces south and its exposed to wind waves generated across the 2 km fetch. Due to the shallow tidal flats fronting the harbour shoreline, the wind waves are likely to be depth-limited.

1.3.1 Short-term

Beach profile data at CCS8 indicates large storm cut distances along the Ōhiwa Spit (cell 1B). For example between 2015 and 2016 surveys there was up to 118 m erosion of the dune toe (Figure 1.4). These large fluctuations are likely to be influenced by changes in the ebb tidal delta at the Ōhiwa Harbour entrance. Based on an extreme value analysis of the detrended residuals (erosion episodes) the adopted short term component ranges from 17 to 138 m within cell 1B. The short term shoreline fluctuations are significantly less at profile CC7 (cell 1E) (Figure 1.4). Extreme value analysis indicates short term erosion distances of 5 to 25 m for 5 year to 200 year ARI events. The profile plots and EVA distributions for each of the beach profiles is presented in Appendix C.

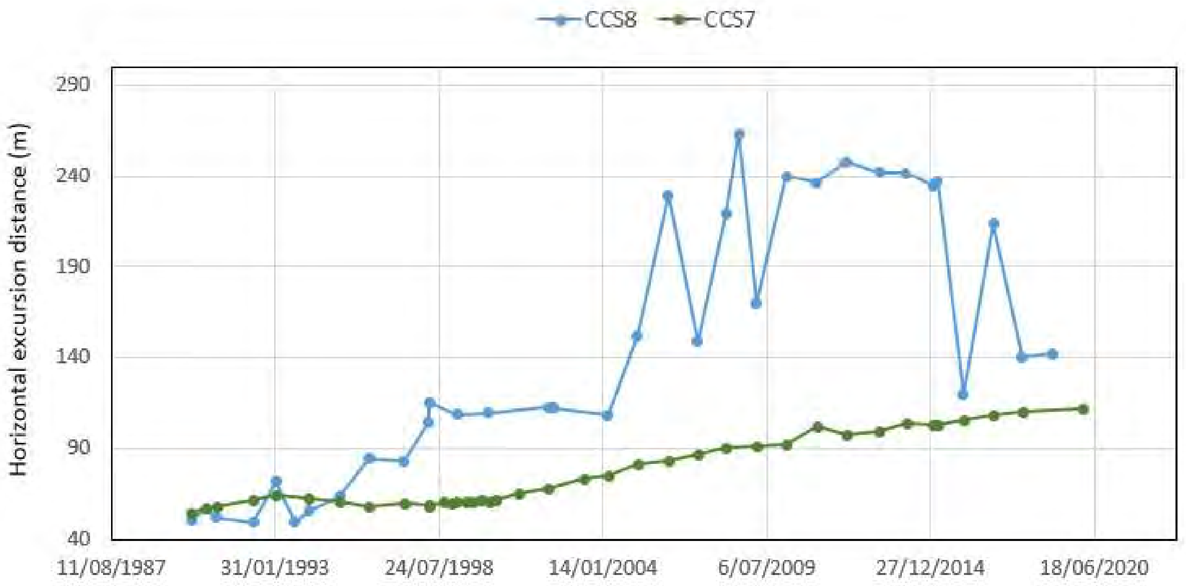


Figure 1.4: Horizontal excursion distances of the dune toe based on beach profile data along Ōhiwa Beach

There is limited beach profile data to infer the short-term storm cut along the harbour shoreline within cell 1A, however the SBEACH modelling (see main report, Section 5.4.1) indicates storm cut at the 2 m RL contour ranges from 1 to 6 m (Figure 1.5).

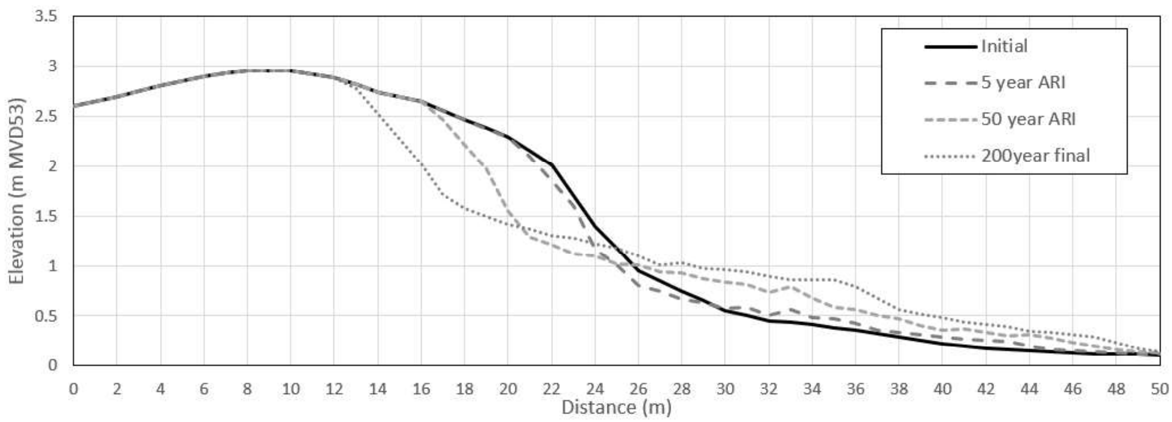
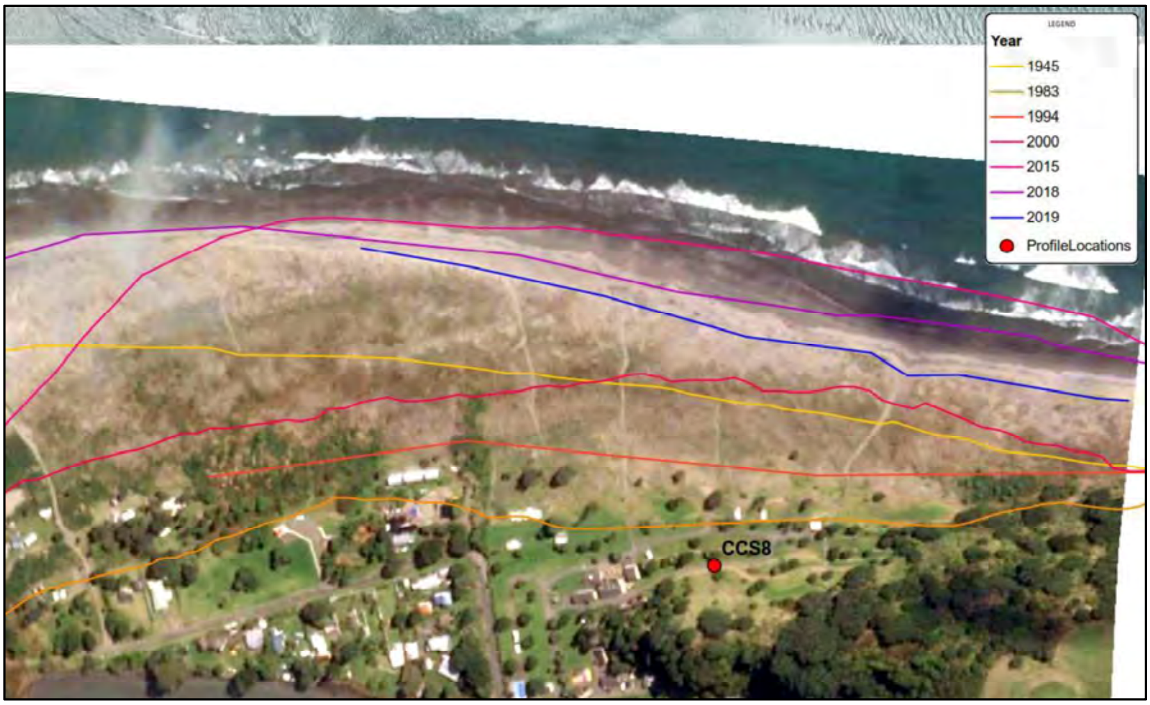


Figure 1.5: SBEACH results for the storm cut along the harbour shoreline (cell 1A). Storm cut at the 2 m RL contour ranges from 1 to 6 m.

1.3.2 Medium-term fluctuations

Decadal scale fluctuations are evident along the open coast Ōhiwa shoreline. Over the last 135 years there have been at least 3 periods of significant shoreline accretion and 2 periods of significant erosion along the Ōhiwa Spit. Figure 1.6 shows there was a period of up to 100 m erosion between 1940 and 1980, followed by a total of 300 m accretion between 1980 and 2008. Dahm and Kench (2007) report that during 1940 to 1980 there was up to 200 m erosion closer to the harbour entrance. Historic aerials show that in the 1970's the shoreline reached the residential properties with several houses being lost to sea (Figure 1.7) (Gibb, 1977).

Dahm and Kench (2007) suggest these fluctuations indicate a complete cycle of erosion and accretion occurring about once every 50 to 60 years, with periods of erosion and accretion typically lasting about 25 to 30 years long. These fluctuations are likely to be associated with the Interdecadal Pacific Oscillation (IPO) (50 to 70 year cycle) and possibly influenced by the ENSO (3 to 7 year cycle). Fluctuations are likely to be due to interactions between the adjacent ebb tide delta. Previous studies suggest rotating of the main ebb channel plays significant role in the erosion and accretion cycles (Dahm and Kench, 2007). Gibb (1977) notes that during 1865 to 1977 the Ōhiwa spit was eroding while the Ohope spit was accreting and the trend was reversed in 1982.



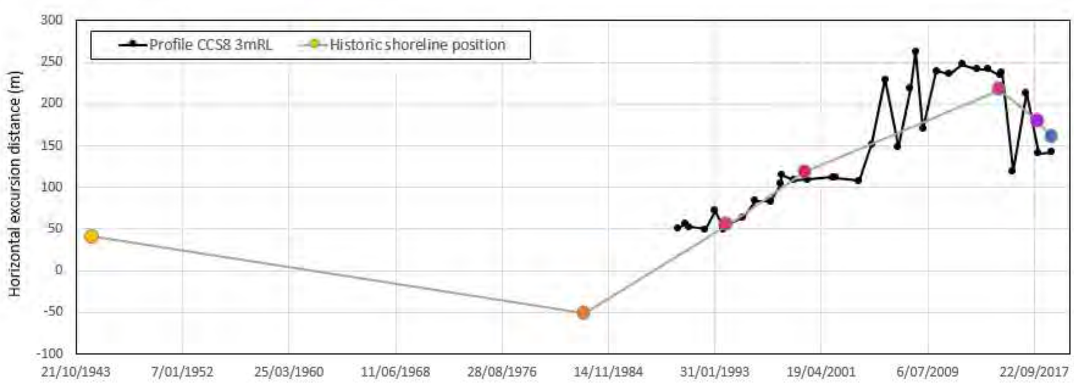


Figure 1.6: Historic dune toe and beach profile data showing medium term fluctuations along Ōhiwa Spit

Figure 1.7: Historic aerial showing the severe shoreline erosion along the Ōhiwa Spit during the 1970s (source: Richmond et al., 1984)

The historic shoreline data indicates that the medium term fluctuations along the eastern extent of the shoreline (cells 1D to 1F) are less compared to the western end (Figure 1.8). There appears to have been up to 30 m erosion between 1945 and 1990, followed by 55 m accretion from 1990 to present.

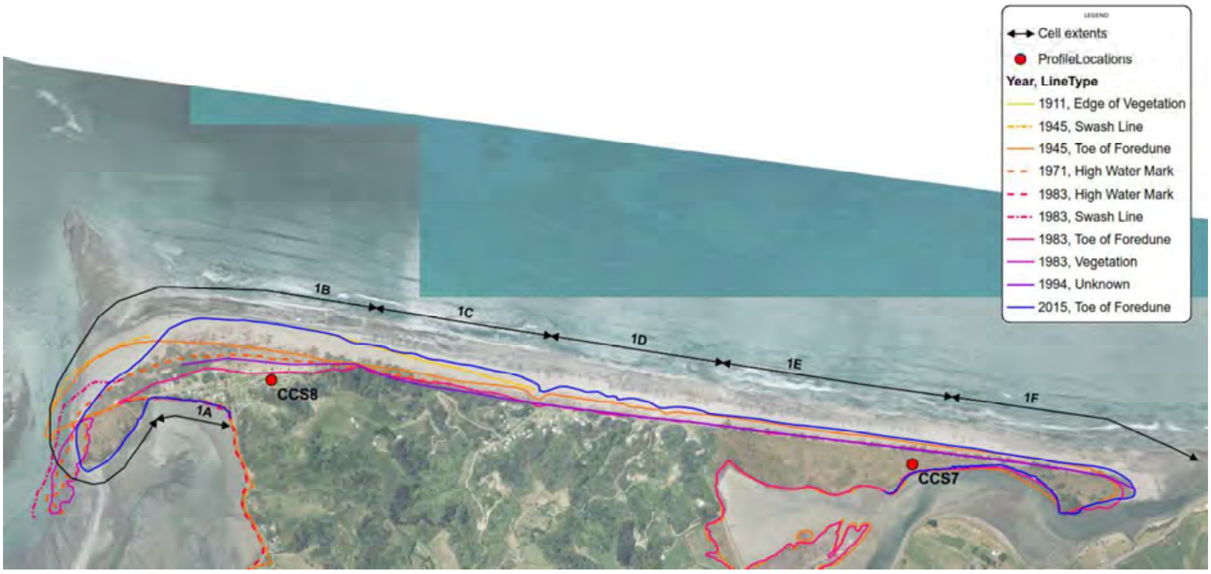


Figure 1.8: Historic shorelines for Ōhiwa

1.3.3 Long-term trends

The large medium-term fluctuations make it difficult to determine the long-term trends along the Ōhiwa shoreline. Some of the earliest studies (Healy 1977 and Gibb 1978) showed different long-term trends which could be influenced by the large seasonal variations. Based on the DSAS regression analysis of the historic shoreline data from 1945 to 2015 there appears to be a long-term erosion trend of up to -1 m/yr at the distal end of the spit (Figure 1.9). The shoreline east of the spit (cells 1B to 1D) appear to have long-term accretion, while the shoreline further east towards the Waiōtahe Spit shows long-term erosion rates ranging from 0 to -0.12 m/yr. However, the long-term rates identified through DSAS are most likely a function of the medium-term fluctuations and over the shoreline shows long-term stability. Subsequently, long-term rates of 0.1 to -0.1 m/yr have been adopted along the open coast shoreline. The DSAS results show a small erosion trend along the harbour shoreline within cell 1A, where rates of 0 to -0.08 m/yr have been adopted.

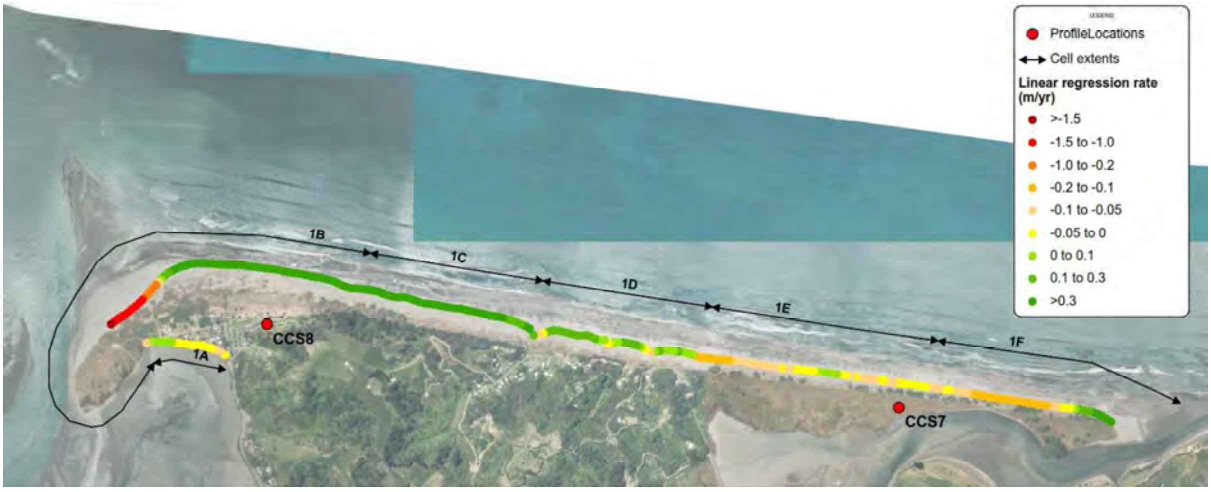


Figure 1.9: DSAS results for Ōhiwa. Results based on toe of foredune for 1945 to 2015

1.3.4 Sea level rise

Inner and outer closure depths along Ōhiwa and Bryans Beach are estimated to be 7.08 m and 10.6 m RL, respectively. Under high future SLR scenarios (i.e. 1.6 m) there is potential for the shoreline to erode between 50 to 123 m landward. There is uncertainty around how the harbour entrance dynamics will respond to SLR, however it is assumed that the shoreline response to SLR will be similar to the Bruun model (see main report Section 5.8.1).

1.4 Adopted component values

Adopted component values for Ōhiwa and Bryans Beach are presented within Table 1.1.

Table 1.1: Adopted component values for cells along Ōhiwa and Bryans Beach shoreline

Site		**Ōhiwa**					
Cell		**1A**	**1B**	**1C**	**1D**	**1E**	**1F**
Cell centre (NZTM)	**E**	1965292	1965280	1966372	1967094	1967922	1968820
	N	5787166	5787500	5787352	5787185	5787064	5786929
Chainage, m (from W)		0 to 360	360 to 2370	2370 to 3100	3100 to 3820	3820 to 4770	4770 to 5740
Morphology		Harbour beach	River/estuary mouth	Sand beach	Sand beach	Sand beach	River/estuary mouth
Baseline		2015 seaward edge of vegetation	2015 seaward edge of vegetation	2015 seaward edge of vegetation	2015 seaward edge of vegetation	2015 seaward edge of vegetation	2015 seaward edge of vegetation
Short-term (m)	**Min**	1	17	10	5	5	5
	Mode	3	86	20	15	15	15
	Max	6	138	25	25	25	25
	Min	0.5	1.5	1	1	2	2

Dune (m above toe)	**Mode**	1	2.0	1.5	1.5	2.5	2.5
	Max	1.5	4.0	2.5	2	3	3
Stable angle (deg)	**Min**	30	30	30	30	30	30
	Mode	32	32	32	32	32	32
	Max	34	34	34	34	34	34
Medium term (m)	**Min**	0	50	40	30	20	20
	Mode	0	100	80	50	30	30
	Max	0	150	100	80	50	50
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0	0.1	0.1	0.1	0.1	0.1
	Mode	-0.03	0	0	0	0	0
	Max	-0.08	-0.1	-0.1	-0.1	-0.1	-0.1
Closure slope (beaches)	**Min**	0.08	0.013	0.013	0.013	0.013	0.013
	Mode	0.09	0.019	0.019	0.019	0.019	0.019
	Max	0.1	0.03	0.03	0.03	0.03	0.03

1.5 Coastal erosion hazard

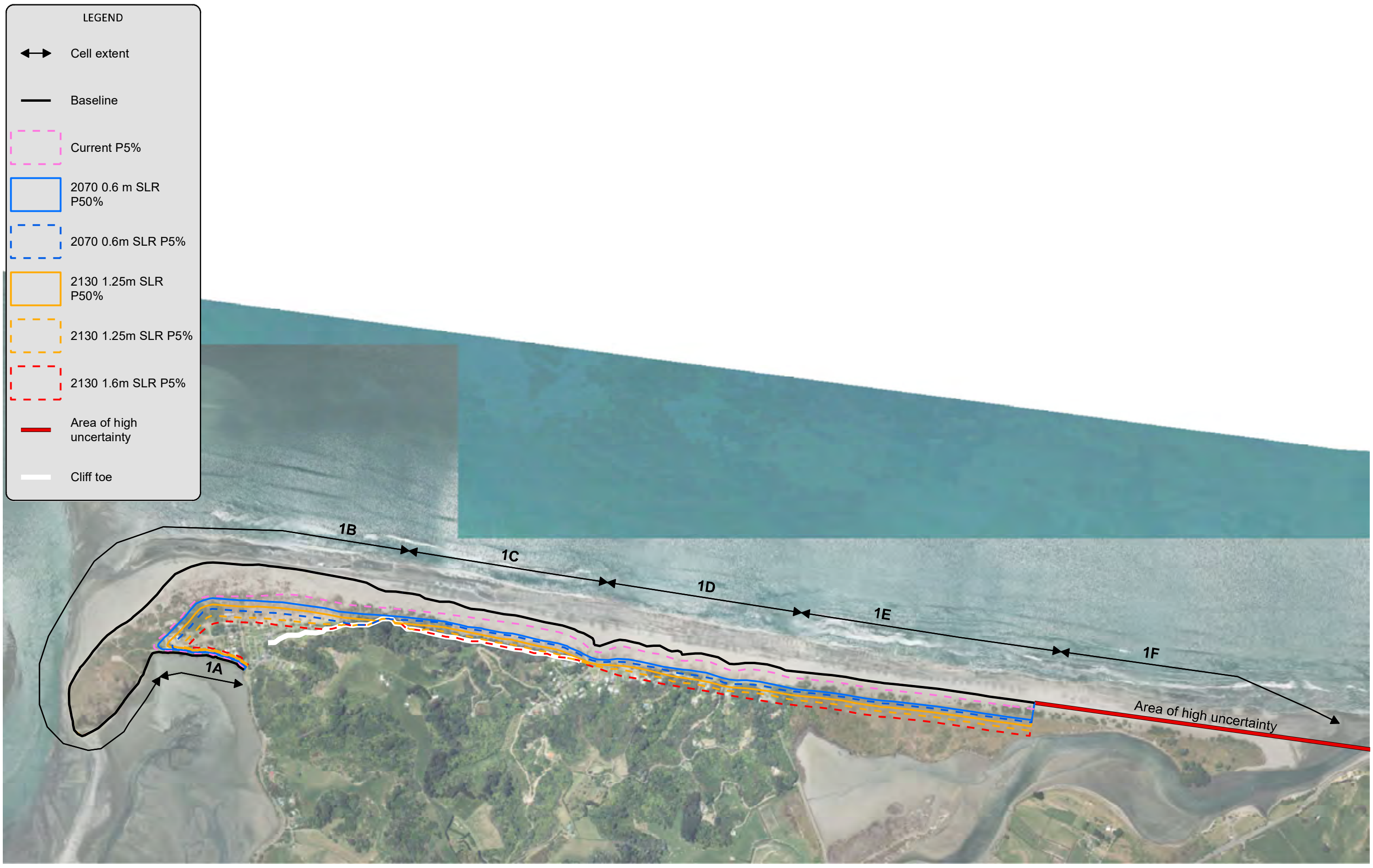
Coastal erosion hazard distances for Ōhiwa and Bryans Beach are presented in Table 1.2 and an overview map in Figure 1.10. Erosion hazard distances have been offset from the 2015 seaward edge of vegetation. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

P50% means there is a 50% chance of an erosion distance being exceeded within that timeframe. P66% can be considered a likely scenario and P5% can be considered a very unlikely scenario.

The current and future CEHA are largest within cell 1B where the shoreline is influenced by the large fluctuations associated with the Ōhiwa spit and harbour entrance. The assessment indicates that future erosion under a high-end sea level rise scenario may eventually reach the toe of the cliff landward of the Holocene coastal plain within cell 1B and 1C. However, potential instability of the cliff toe has not been accounted for within this assessment and subsequently, the mapped CEHA have been bound to the cliff toe. The future CEHA indicates the entire eastern extent of the Waiōtahe spit (cell 1F) may become at risk to coastal erosion by 2070. There is high uncertainty in how this section of the shoreline may respond as there is also potential for the spit to breach near the centre of cell 1F. Breaching could occur at any stage and if the Waiōtahe spit is breached the land on the southern side of the estuary may also become exposed to coastal erosion. Subsequently this area has been identified as an area of high uncertainty which would require a more detailed assessment with consideration of estuarine and riverine processes.

Table 1.2: Coastal erosion hazard widths (m) for Ōhiwa and Bryans Beach for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Ōhiwa	1A	Current (2020)	0.03	N/A	-2	-4	-4	-6	-7
		50yr (2070)	0.4	RCP4.5	-5	-9	-9	-12	-14
			0.6	RCP8.5	-6	-10	-11	-13	-16
		110yr (2130)	0.8	RCP4.5	-8	-13	-14	-18	-22
			1.25	RCP8.5	-12	-19	-20	-24	-30
			1.6	RCP8.5+	-16	-23	-24	-29	-35
	1B	Current (2020)	0.03	N/A	-19	-72	-84	-122	-139
		50yr (2070)	0.4	RCP4.5	-58	-114	-126	-165	-186
			0.6	RCP8.5	-62	-120	-132	-171	-194
		110yr (2130)	0.8	RCP4.5	-61	-123	-135	-174	-206
			1.25	RCP8.5	-80	-143	-155	-196	-234
			1.6	RCP8.5+	-92	-158	-170	-213	-254
	1C	Current (2020)	0.03	N/A	-11	-18	-20	-24	-27
		50yr (2070)	0.4	RCP4.5	-47	-60	-62	-69	-77
			0.6	RCP8.5	-51	-66	-68	-76	-86
		110yr (2130)	0.8	RCP4.5	-49	-68	-71	-82	-97
			1.25	RCP8.5	-64	-87	-91	-107	-126
			1.6	RCP8.5+	-75	-101	-106	-126	-148
	1D	Current (2020)	0.03	N/A	-6	-14	-16	-23	-26
		50yr (2070)	0.4	RCP4.5	-43	-56	-58	-66	-76
			0.6	RCP8.5	-47	-62	-64	-73	-84
		110yr (2130)	0.8	RCP4.5	-45	-65	-68	-80	-92
			1.25	RCP8.5	-59	-84	-88	-105	-122
			1.6	RCP8.5+	-69	-98	-103	-124	-144
	1E	Current (2020)	0.03	N/A	-7	-15	-17	-24	-27
		50yr (2070)	0.4	RCP4.5	-44	-57	-59	-67	-76
			0.6	RCP8.5	-48	-62	-65	-74	-85
		110yr (2130)	0.8	RCP4.5	-43	-65	-68	-81	-94
			1.25	RCP8.5	-58	-85	-88	-105	-123
			1.6	RCP8.5+	-68	-98	-103	-124	-144
	1F	Current (2020)	0.03	N/A	-7	-15	-17	-24	-27
		50yr (2070)	0.4	RCP4.5	-42	-57	-59	-67	-75
			0.6	RCP8.5	-46	-63	-65	-74	-83
		110yr (2130)	0.8	RCP4.5	-45	-65	-68	-80	-95
			1.25	RCP8.5	-60	-85	-88	-105	-125
			1.6	RCP8.5+	-70	-98	-103	-123	-147



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Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

A3 SCALE 1:13,000

0 0.15 0.3 0.45 0.6 0.75 (km)

Whakatane

Location Plan

Tonkin+Taylor

105 Carlton Gore Rd, Newmarket, Auckland
www.tonkintaylor.co.nz

DRAWN	RHAU	Sep.21
CHECKED		
APPROVED		
ARCFILE Ohiwa.mxd		
SCALE (AT A3 SIZE) 1:13,000		
PROJECT No. 1008669.2000		

Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 1: Ōhiwa

FIGURE No. Figure 1.10

Rev. 0

2 Hikuwai to Ōpape

2.1 Site description

The Hikuwai to Ōpape shoreline comprises 13.5 km of sand beach that extends east of the Waioeka River mouth (Figure 2.1). SH35 runs inland parallel along the coast and is closest to the shoreline at Hikuwai, where it is approximately 70 m landward from the beach. The Tirohanga settlement exists near the centre of the shoreline and includes residential property and the motor camp on the seaward side of SH35. Ōpape settlement is located at the eastern extent of the shoreline and includes several properties along the coastal edge. The Waiaua River discharges east of Tirohanga and there are several other smaller streams that discharge along the shoreline. The shoreline has been split into eight cells based on the morphology and coastal processes described below.

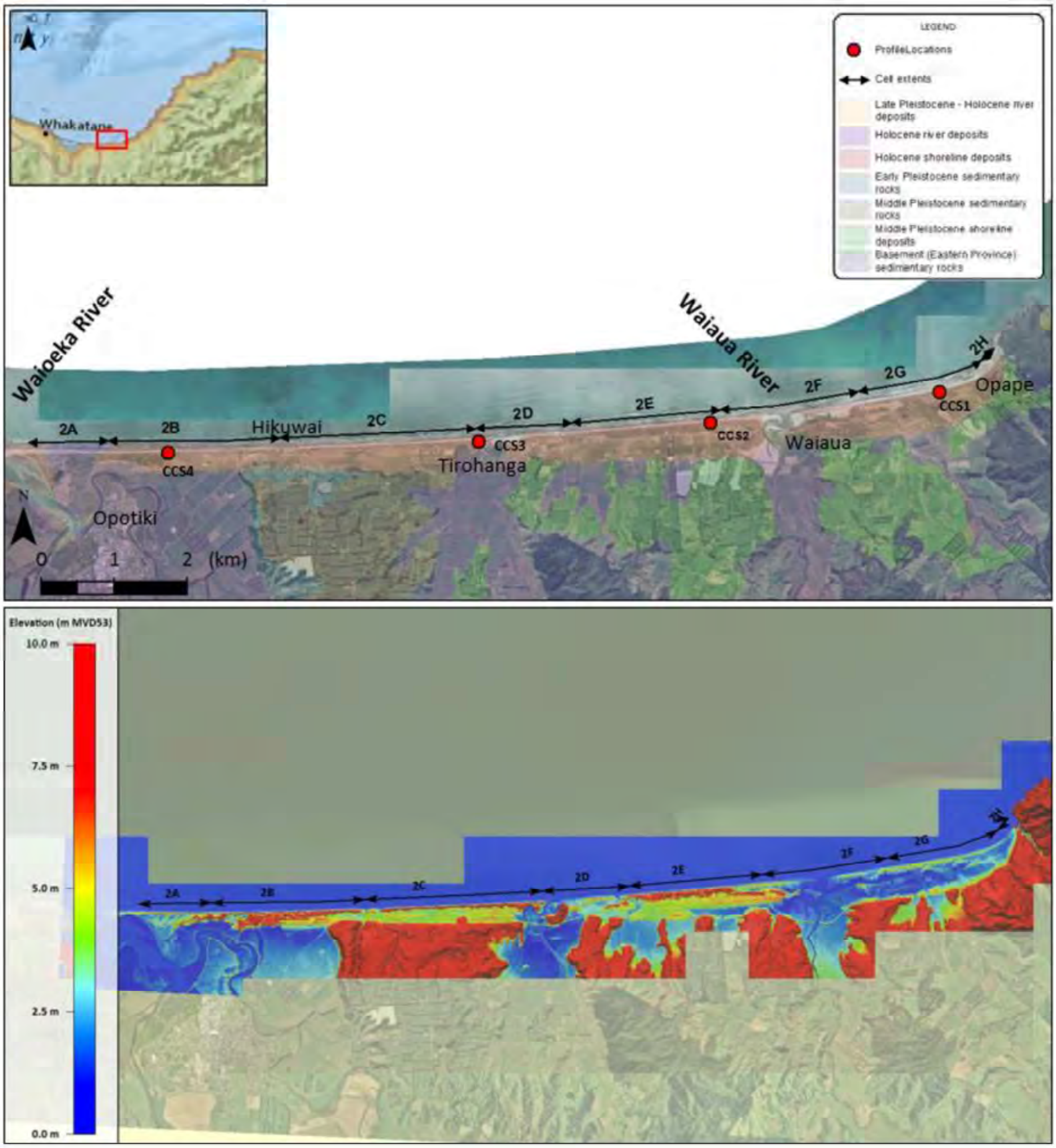


Figure 2.1: Site location and cell splits for Hikuwai (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

2.2 Morphology

The site is bound by the Waioeka River at western extent and Mount Tarakeha headland at the eastern end. The underlying geology along Hikuwai beach predominantly comprises low-lying Holocene shoreline and river deposits. The headland at the eastern extent comprises Eastern Province Basement sedimentary rocks (greywacke, argillite and conglomerate). Majority of the beach comprises find sand. The beach can broadly be described as four areas:

- Hikuwai (cells 2A, 2B, 2C)
- Tirohanga (cells 2D, 2E)
- Waiaua River (cell 2F)
- Ōpape (cells 2G, 2H)

Hikuwai beach is backed by a 60 to 200 m wide dune complex that forms the seaward boundary of the Waioeka fluvial plain (Figure 2.2, A). Site investigations indicate the dune is generally well-vegetated. Previous studies indicate westward migration of the Waioeka River mouth over the last century, resulting in growth of the spit at the western end of Hikuwai (Dahm and Kench, 2007; T+T, 2019). Further east along Hikuwai the dune is relatively high and steep with elevations up to 7 m high within cell 2B. Vegetation along the crest of the dune is typical of the back-dune environment which indicates there may be some long-term erosion (Figure 2.3). There are several small streams that discharge onto Hikuwai Beach near Beach Rd. These streams appear to cause localised instability of the shoreline position. Further east within cell 2C, there is a dune barrier protecting a narrow Holocene coastal plain. The dune heights increase up to 10 m high within cell 2C.

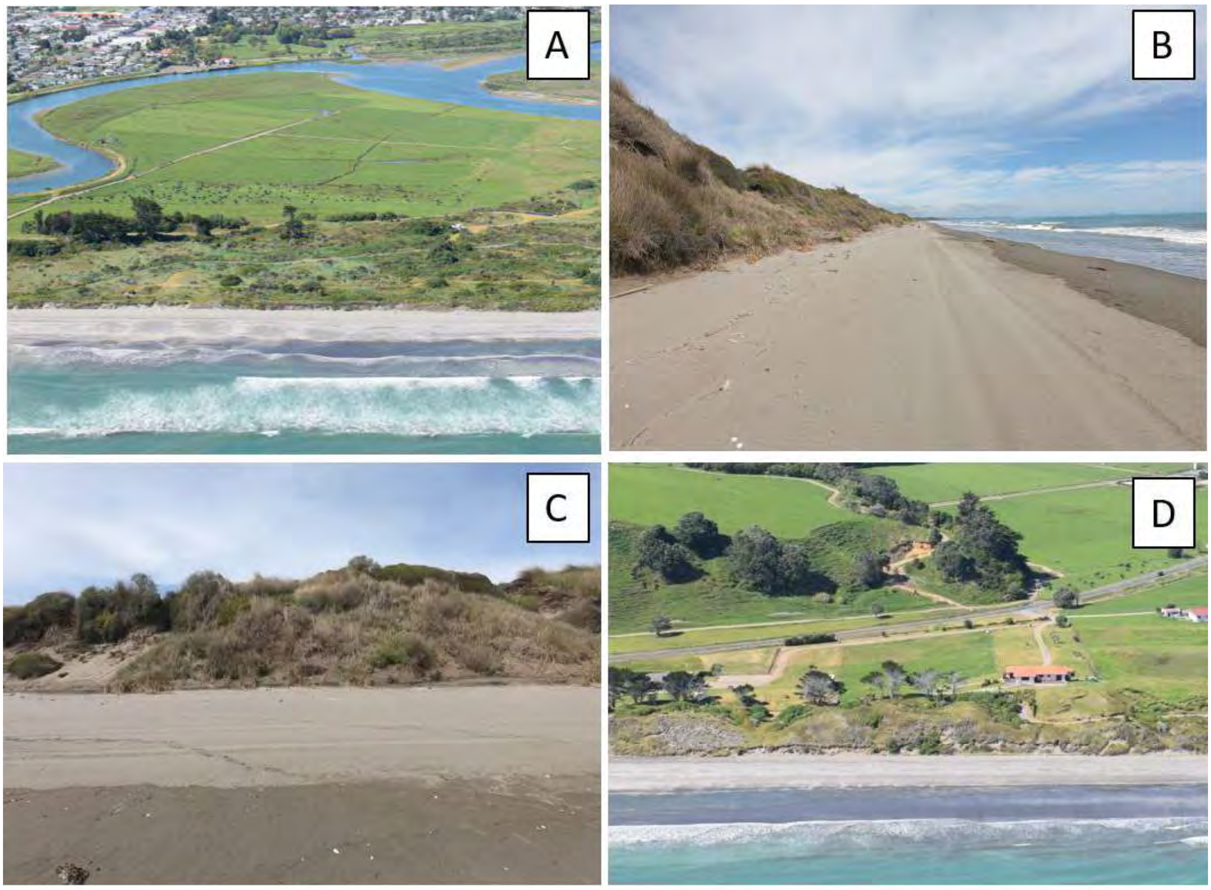


Figure 2.2: Site photos along Hikuwai beach (A) Cell 2A, (B), Vegetated dune within Cell 2A, (C) Vegetated dune within Cell 2B, (D) aerial view of Cell 2B

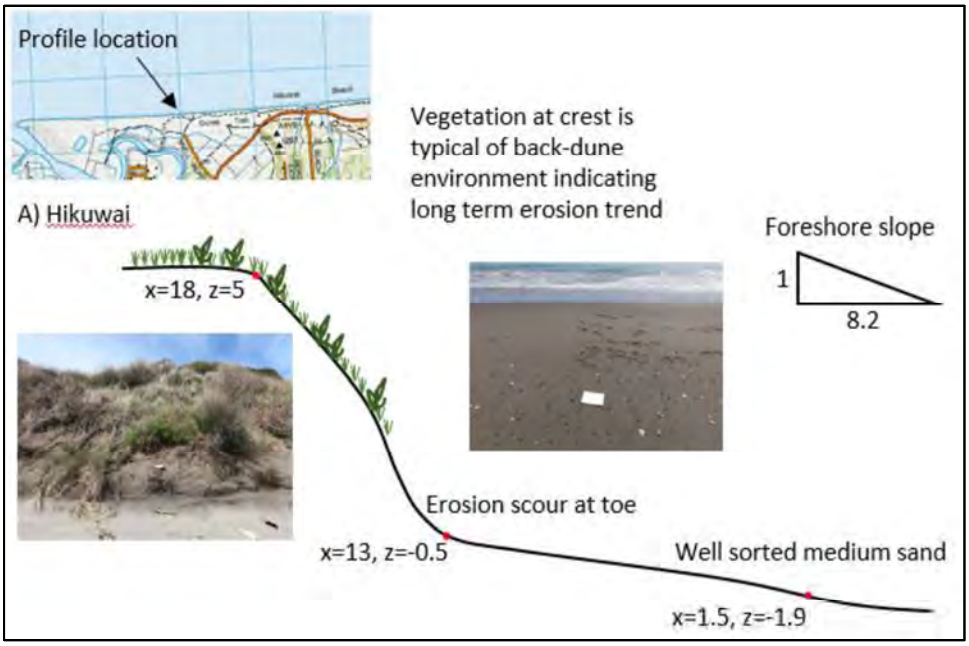


Figure 2.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cell 2B

Cell 2D is influenced by the Tirohanga Stream at the western end and the Waiorua Stream at the eastern end (Figure 2.4, B, D). The Waiorua Stream appears to be migrating west. Dune heights within cell 2D are less compared with the adjacent shoreline, ranging from 2 to 3.5 m high (Figure 2.4, C). Further east within cell 2E the dune heights increase up to 10 m.

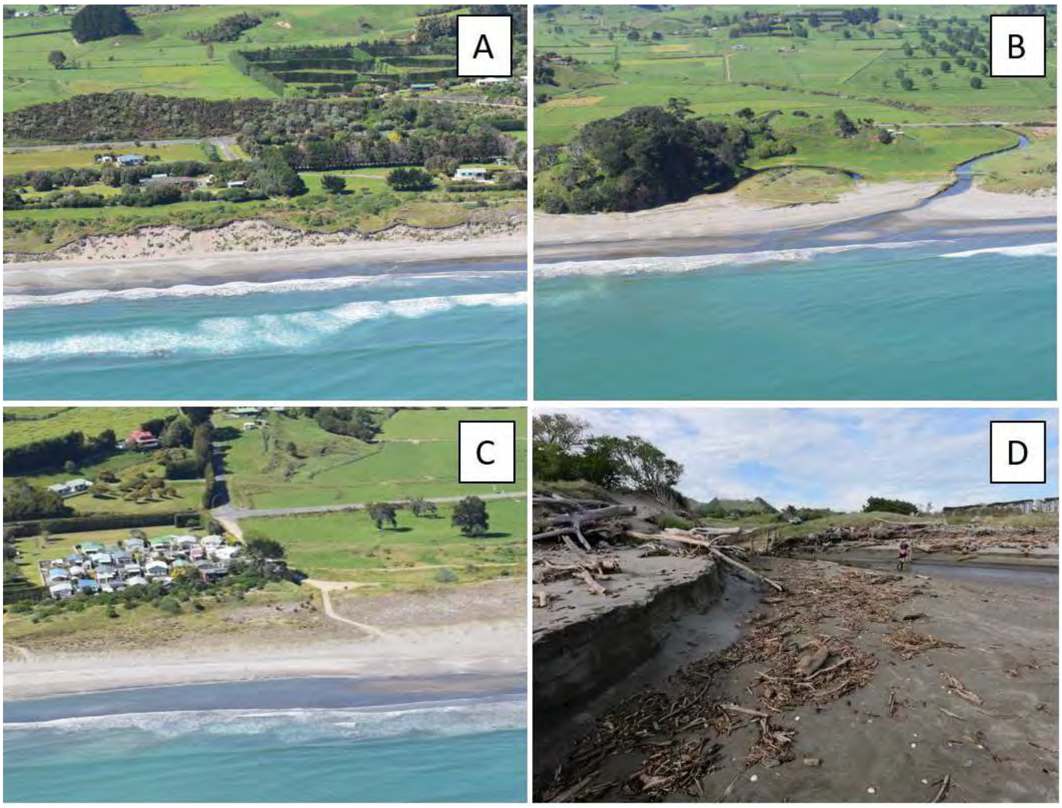


Figure 2.4: Site photos along Tirohanga (Hikuwai Beach). (A) Aerial view of cell 2C, (B) Tirohanga Stream mouth and small cliff section within cell 2D, (C) Tirohanga houses within cell 2D, (D), erosion scarp near the Waiorua Stream mouth at the eastern end of cell 2D

The shoreline within cell 2F is largely influenced by the Waiaua River mouth which is susceptible to movement within a broad 1400 m envelop (Figure 2.5, B). On the eastern side of the Waiaua River mouth the dune heights are significantly reduced, ranging from 1 to 2.5 m (Figure 2.5, C). The beach profile is also flatter compared to the beach near Tirohanga and Hikuwai. There is a narrow dune barrier which protects a swampy flood plain. At the eastern extent of the site (cell 2H) is the Ōpape settlement (Figure 2.1). There is a grass bank with minimal dunes along the seaward edge of the settlement (Figure 2.5, E and Figure 2.6).

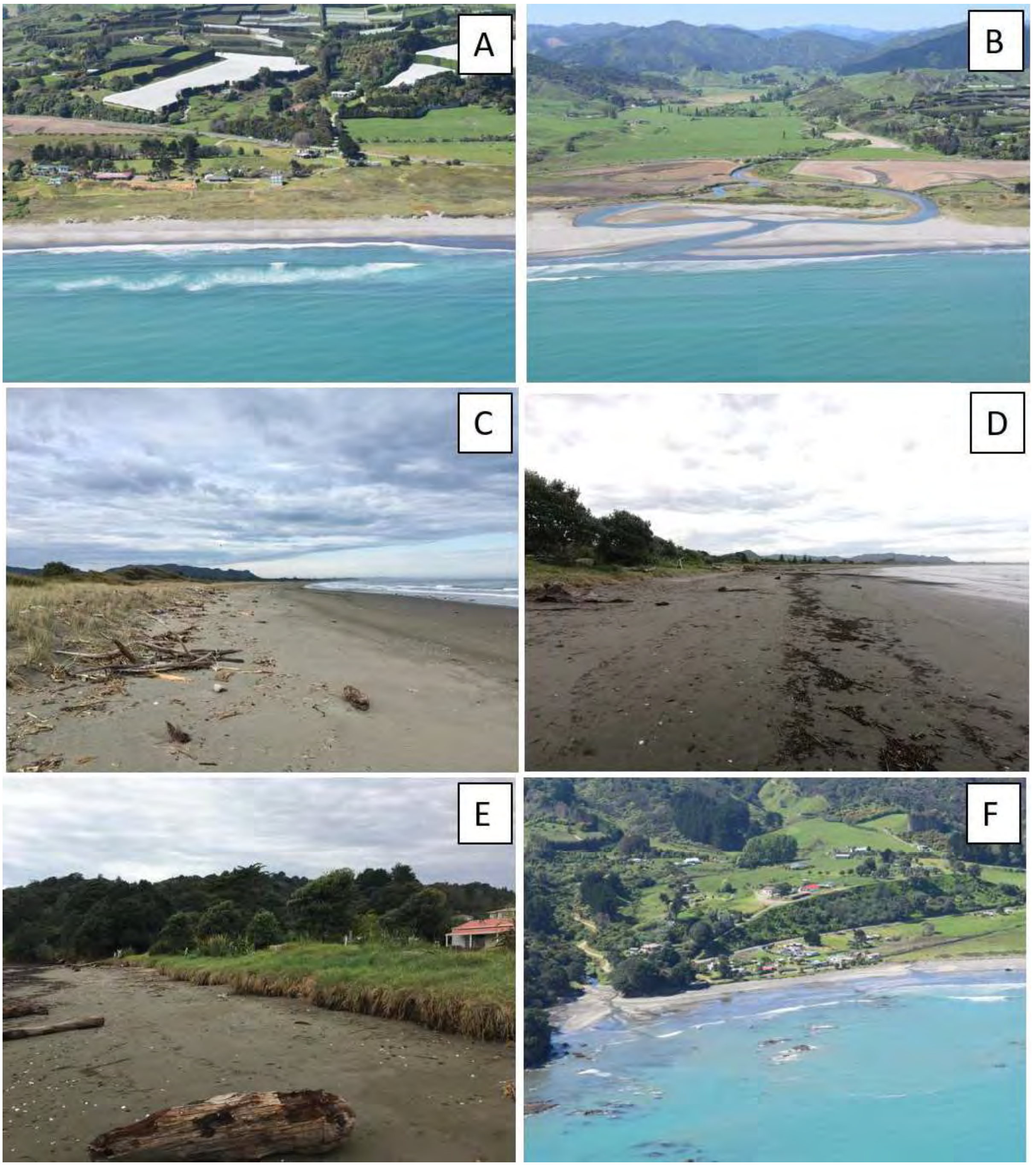


Figure 2.5: Site photos along Ōpape Beach (Hikuwai). (A) Shoreline directly west of the Waiaua River mouth, Cell 2F, (B) Waiaua River mouth, Cell 2F, (C) Low dune within Cell 2G, (D) flat beach within Cell 2G, near Ōpape,(E) Low grass bank along the shore within Cell 2H in Ōpape, (F) Aerial view of Ōpape settlement, with the Ōpape stream discharging at the eastern extent

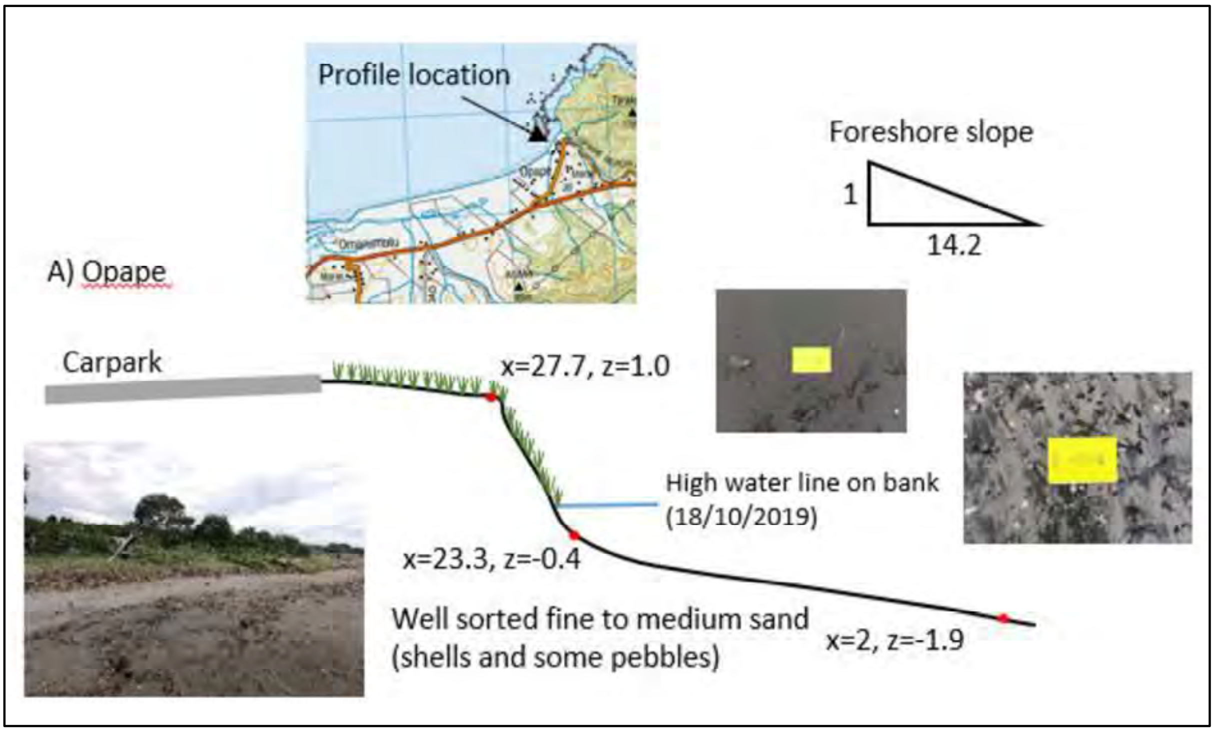


Figure 2.6: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cell 2H

2.3 Coastal processes

The Hikuwai to Ōpape shoreline is predominately north-facing and exposed to waves from the northwest to northeast. The headland at the eastern end provides partial sheltering from easterly wave directions for the shoreline along Ōpape (cell 2H). Based on NIWA (2019) the 50 year ARI offshore wave height is 5.97 m and the 50 year ARI storm tide is 1.26 m MVD53. Net sediment transport is westward, with sediment being sourced from the Motu River, Waiaua River and Waioeka River.

2.3.1 Short-term

As described in Section 5.4.1 of the main report, extreme value analysis (EVA) of the beach profile dataset was used to determine the storm cut distances. The profile plots and EVA distributions for each of the beach profiles is presented in Appendix C. Figure 2.7 shows the horizontal excursion distances of the dune toe (2 m RL) at each beach profile. The analyses of profile data shows slight variations between profiles, however in general the magnitude of storm cut potential is relatively consistent along the Hikuwai shoreline. Profile CCS3 is largely influenced by the Tirohanga stream position which shifted position between 2017 and 2019 (Figure 2.7). Adopted storm cut values range from 10 to 30 m along most of the Hikuwai to Ōpape shoreline. The profile data suggests storm cut is slightly larger within cell 2G where adopted values range from 10 to 40 m.

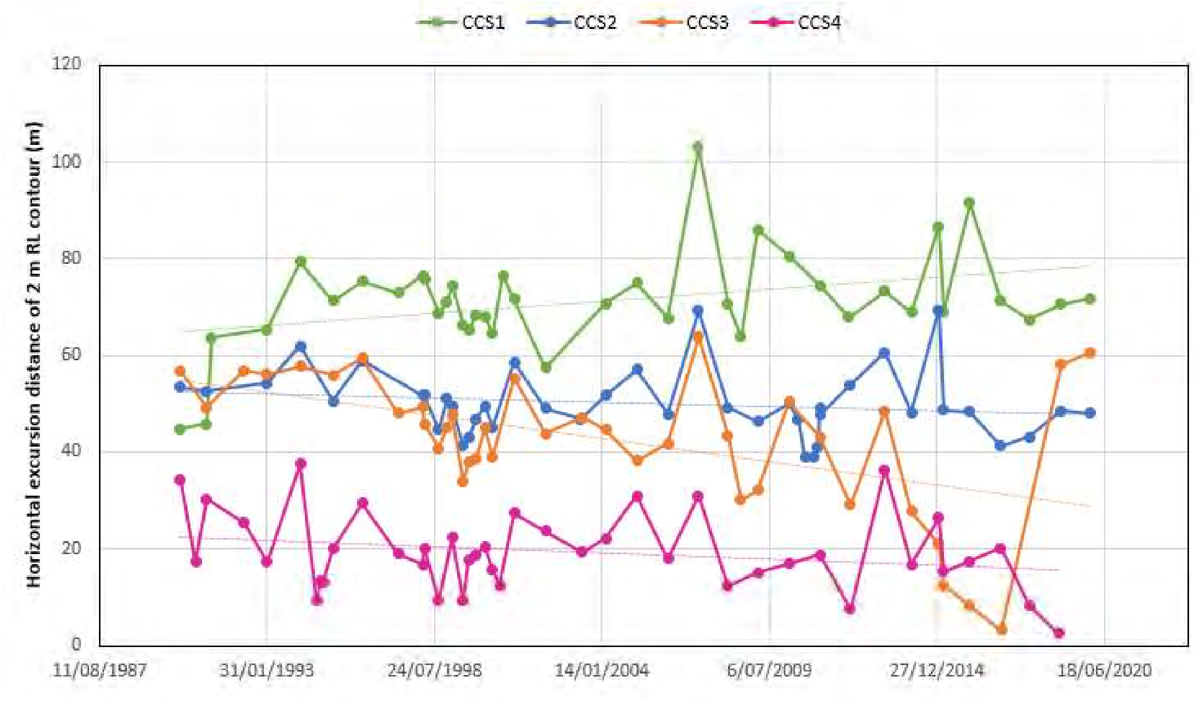


Figure 2.7: Horizontal excursion distances of the dune toe based on beach profile data along Hikuwai to Ōpape

2.3.2 Long-term trends

Historic shorelines for the Hikuwai to Ōpape shoreline include dune toe surveys from 1866 to 2015 (Figure 2.8). DSAS analysis of the historic shorelines indicate long-term erosion along most of the Hikuwai shoreline (Figure 2.9). Beach profile analysis also shows slight erosion trend at profiles CCS2, CCS3 and CCS4. Profile CCS1 near Ōpape shows an accretion rate of 0.44 m/yr. Long-term accretion within cell 2G is also apparent in the historic shoreline data (Figure 2.9). The shoreline between Tirohanga and Waiorua Stream (cell 2D) has undergone considerable shoreline movement with over all shoreline advancement (Figure 2.9).

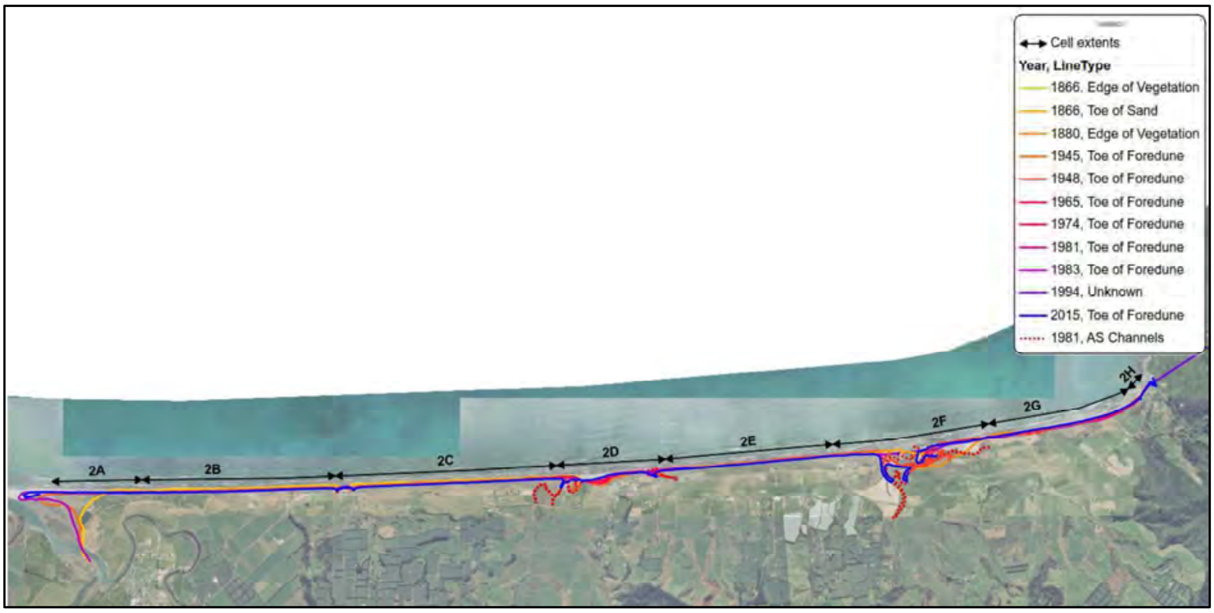


Figure 2.8: Historic shorelines for the Hikuwai to Ōpape shoreline

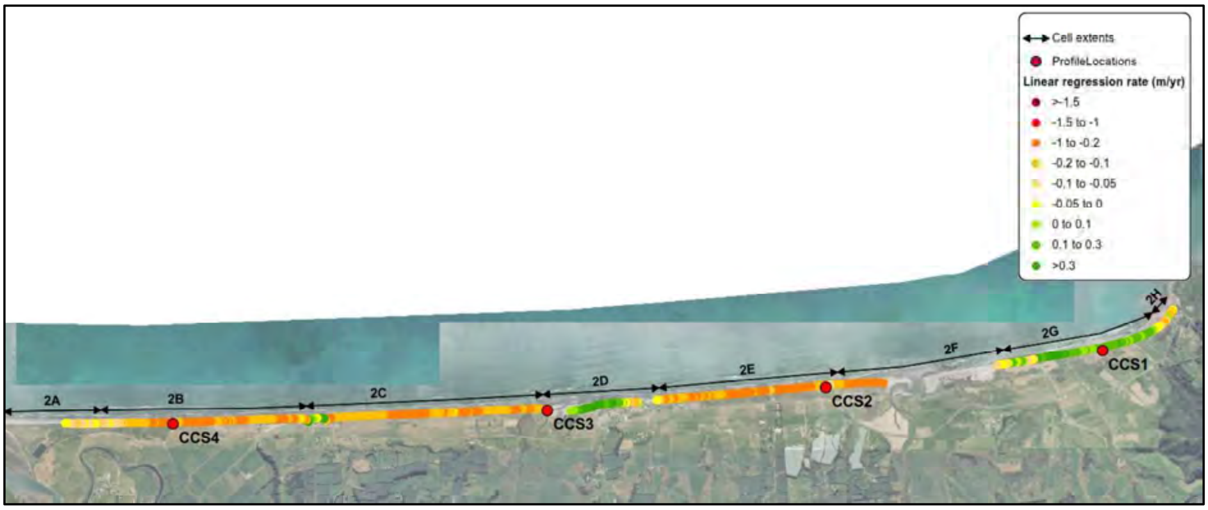


Figure 2.9: DSAS results for Hikuwai. DSAS analysis based on toe of foredune for 1945 to 2015

Medium-term fluctuations are not apparent along most of the shoreline. The shoreline generally showed overall retreat between 1866 and 1983. Between 1983 and 1994 the shoreline stabilised at the western end with advancement in the centre. Following 1994 most of the shoreline has continued to show gradual retreat. However, shoreline fluctuations within cell 2G suggest medium-term fluctuations of up to 10 m (profile CCS1).

2.3.3 Sea level rise

Inner and outer closure depths along Hikuwai Beach to Ōpape are estimated to range from 6 m RL to 12 m RL. Under high future SLR scenarios (i.e. 1.6 m) there is potential for the shoreline to erode up to 107 m at the western end (Hikuwai) and up to 160 m at the eastern end (Ōpape). The response to SLR is expected to be larger near Ōpape where the dune heights are low compared to Hikuwai where there are relatively high dunes. There is uncertainty around how the harbour entrance will respond to SLR, however it is assumed that for all of the site the SLR response will be similar to the Bruun model (see main report Section 5.8.1)

2.4 Adopted component values

Adopted component values are presented within Table 2.1.

Table 2.1: Adopted component values for cells along the Hikuwai shoreline

Site		Hikuwai	Hikuwai	Hikuwai	Tirohanga	Tirohanga	Waiua River	Ōpape	Ōpape
Cell		2A	2B	2C	2D	2E	2F	2G	2H
Profiles			CCS4		CCS3	CCS2		CCS1	
Cell centre (NZTM)	E	1975751	1977447	1980146	1981994	1983632	1985696	1987626	1988458
	N	5786427	5786452	5786548	5786662	5786783	5786967	5787278	5787678
Chainage, m (from W)		0 to 1100	1100 to 3430	3430 to 6090	6090 to 7430	7430 to 9450	9450 to 11400	11400 to 13180	13180 to 13460
Morphology		River mouth	Sand beach	Sand beach	Stream mouth	Sand beach	River mouth	Sand beach	Sand beach
Baseline		2015 seaward edge of vegetation	2015 seaward edge of vegetation	2015 seaward edge of vegetation	2015 seaward edge of vegetation	2015 seaward edge of vegetation		2015 seaward edge of vegetation	2015 seaward edge of vegetation
Short-term (m)	Min	10	10	10	10	10	River mouth – Area of high uncertainty (see main report Section 4.4.4)	10	10
	Mode	25	25	20	20	20		20	20
	Max	30	30	30	30	30		40	30
Dune (m above toe)	Min	3	5	5.5	2	4.5		1	0.4
	Mode	3.5	6	7.5	2.5	7.5		1.5	0.5
	Max	4.5	7	10	3.5	10		2.5	0.8
Stable angle (deg)	Min	30	30	30	30	30		30	30
	Mode	32	32	32	32	32		32	32
	Max	34	34	34	34	34		34	34
Medium term (m)	Min	0	0	0	0	0		0	0
	Mode	0	0	0	0	0		5	0
	Max	0	0	0	0	0		10	0
Long-term (m/yr) -ve erosion +ve accretion	Min	-0.1	-0.1	-0.1	0.1	-0.1		0.1	-0.05
	Mode	-0.2	-0.2	-0.2	0	-0.2		0	-0.1
	Max	-0.27	-0.27	-0.27	-0.15	-0.27		-0.1	-0.17
Closure slope (beaches)	Min	0.015	0.015	0.015	0.013	0.013		0.01	0.01
	Mode	0.023	0.023	0.023	0.02	0.02		0.016	0.016
	Max	0.043	0.043	0.043	0.047	0.042		0.026	0.026

2.5 Coastal erosion hazard

Coastal erosion hazard distances for Hikuwai are presented within Table 2.2 and an overview map in Figure 2.10. Erosion hazard distances have been offset from the 2015 seaward edge of vegetation. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

Note that this assessment does not consider the recent Ōpōtiki harbour development which may influence the CEHA within cells 2A and 2B. These cells may require reassessment at a later stage once the development is complete and there has been a sufficient period of monitoring.

The current and future CEHA are relatively consistent width along the Hikuwai to Ōpape shoreline, approximately -30 m for the current P5% CEHA and up to -110 m for the 2130 1.6m SLR P5% scenario.

Along Tirohanga (cell 2D) the current CEHA has been mapped along the landward extent of the meandering stream channels. There is a small section of cliff (~90 m length of shoreline) within cell 2D. However due to the scale of assessment, this small, consolidated section has not been directly assessed but rather interpolated from the adjacent beach cells.

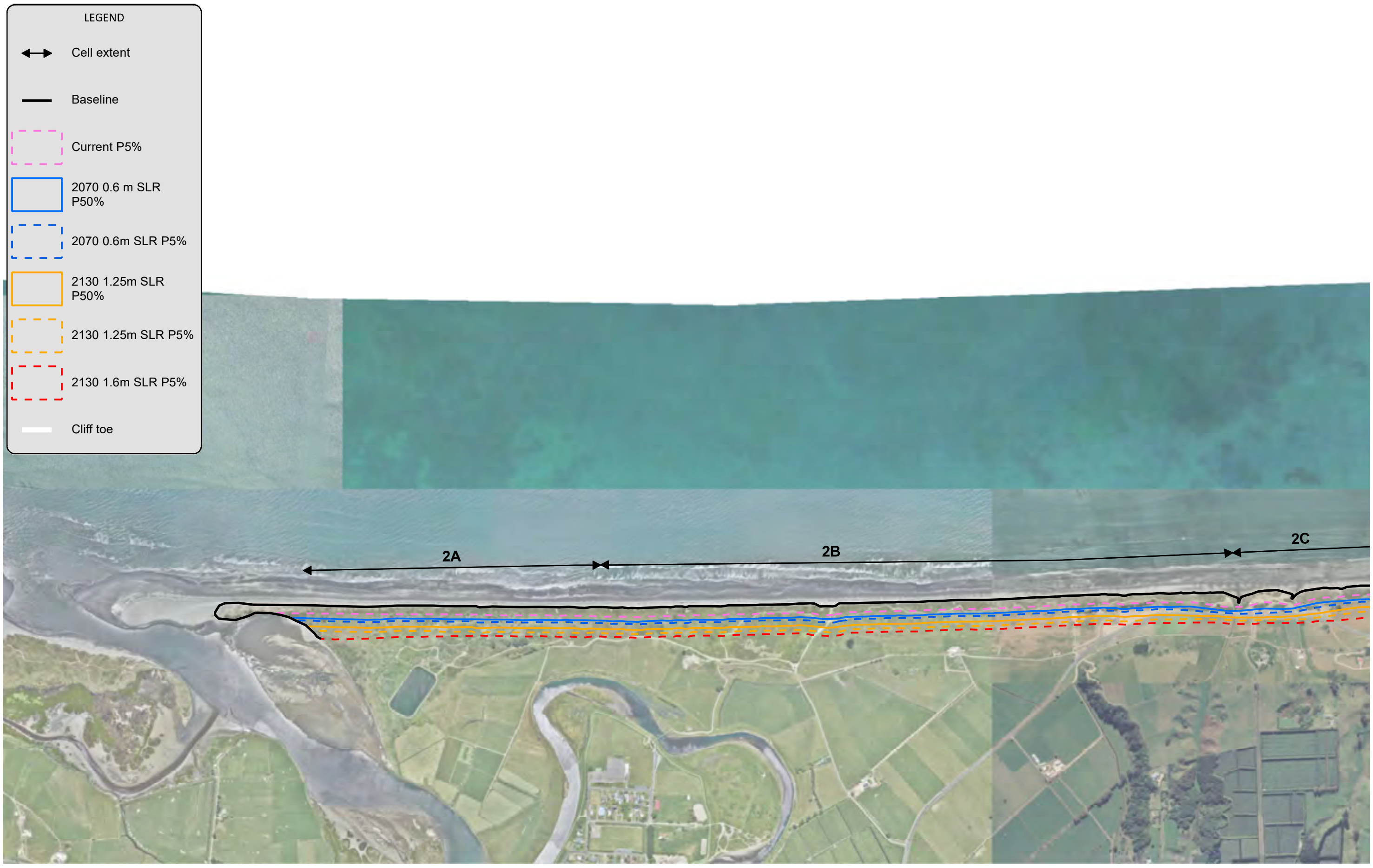
The CEHA have not been mapped around the Waiaua River mouth. This is because there is high uncertainty around the river mouth, with the hazard being a combination of riverine and coastal processes.

The future CEHA show that the cliff toe behind Ōpape settlement could potentially become at risk to erosion under high future SLR scenarios. Cliff toe instability has been accounted for within this assessment and therefore the mapped CEHA have been bound along the cliff toe.

Table 2.2: Coastal erosion hazard widths (m) for Hikuwai for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Hikuwai	2A	Current (2020)	0.03	N/A	-13	-23	-25	-31	-33
		50yr (2070)	0.4	RCP4.5	-26	-42	-44	-51	-59
			0.6	RCP8.5	-29	-46	-48	-57	-66
		110yr (2130)	0.8	RCP4.5	-38	-59	-62	-73	-88
			1.25	RCP8.5	-49	-74	-78	-94	-113
			1.6	RCP8.5+	-56	-84	-89	-109	-132
	2B	Current (2020)	0.03	N/A	-14	-25	-27	-33	-35
		50yr (2070)	0.4	RCP4.5	-28	-43	-46	-53	-61
			0.6	RCP8.5	-31	-48	-50	-59	-68
		110yr (2130)	0.8	RCP4.5	-42	-61	-64	-75	-85
			1.25	RCP8.5	-53	-76	-80	-96	-112
			1.6	RCP8.5+	-61	-86	-91	-111	-131
	2C	Current (2020)	0.03	N/A	-15	-24	-26	-33	-37
			0.4	RCP4.5	-29	-43	-45	-53	-61

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
		50yr (2070)	0.6	RCP8.5	-33	-47	-50	-59	-69
		110yr (2130)	0.8	RCP4.5	-40	-61	-64	-75	-90
			1.25	RCP8.5	-53	-75	-79	-96	-117
			1.6	RCP8.5+	-62	-86	-91	-111	-136
	2D	Current (2020)	0.03	N/A	-12	-20	-22	-29	-32
		50yr (2070)	0.4	RCP4.5	-15	-30	-33	-42	-52
			0.6	RCP8.5	-18	-35	-37	-48	-60
		110yr (2130)	0.8	RCP4.5	-16	-38	-41	-56	-72
			1.25	RCP8.5	-25	-52	-57	-78	-102
			1.6	RCP8.5+	-31	-63	-69	-95	-124
	2E	Current (2020)	0.03	N/A	-15	-24	-26	-33	-37
		50yr (2070)	0.4	RCP4.5	-28	-43	-46	-54	-63
			0.6	RCP8.5	-31	-48	-51	-61	-72
		110yr (2130)	0.8	RCP4.5	-40	-62	-65	-77	-93
			1.25	RCP8.5	-50	-77	-82	-101	-123
			1.6	RCP8.5+	-58	-89	-94	-119	-145
	2F	Current (2020)	0.03	N/A	River mouth – Area of high uncertainty (see main report Section 4.4.4)				
		50yr (2070)	0.4	RCP4.5					
			0.6	RCP8.5					
		110yr (2130)	0.8	RCP4.5					
			1.25	RCP8.5					
			1.6	RCP8.5+					
	2G	Current (2020)	0.03	N/A	-11	-21	-24	-36	-42
		50yr (2070)	0.4	RCP4.5	-20	-36	-39	-51	-64
			0.6	RCP8.5	-25	-43	-46	-60	-74
		110yr (2130)	0.8	RCP4.5	-22	-46	-50	-66	-83
			1.25	RCP8.5	-38	-69	-74	-97	-122
			1.6	RCP8.5+	-50	-85	-92	-121	-150
	2H	Current (2020)	0.03	N/A	-11	-19	-20	-27	-30
		50yr (2070)	0.4	RCP4.5	-26	-38	-40	-49	-59
			0.6	RCP8.5	-30	-45	-47	-58	-70
		110yr (2130)	0.8	RCP4.5	-37	-55	-58	-70	-83
			1.25	RCP8.5	-54	-77	-82	-102	-121
			1.6	RCP8.5+	-66	-93	-99	-126	-149



Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

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Whakatane

Location Plan

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SCALE (AT A3 SIZE) 1:13,000		
PROJECT No. 1008669.2000		

Ōpōtiki Coastal Erosion Hazard Assessment

Coastal Erosion Hazard Area (CEHA) Overview Map
Site 2: Hikuwai to Ōpape

FIGURE No. Figure 2.10a

Rev. 0

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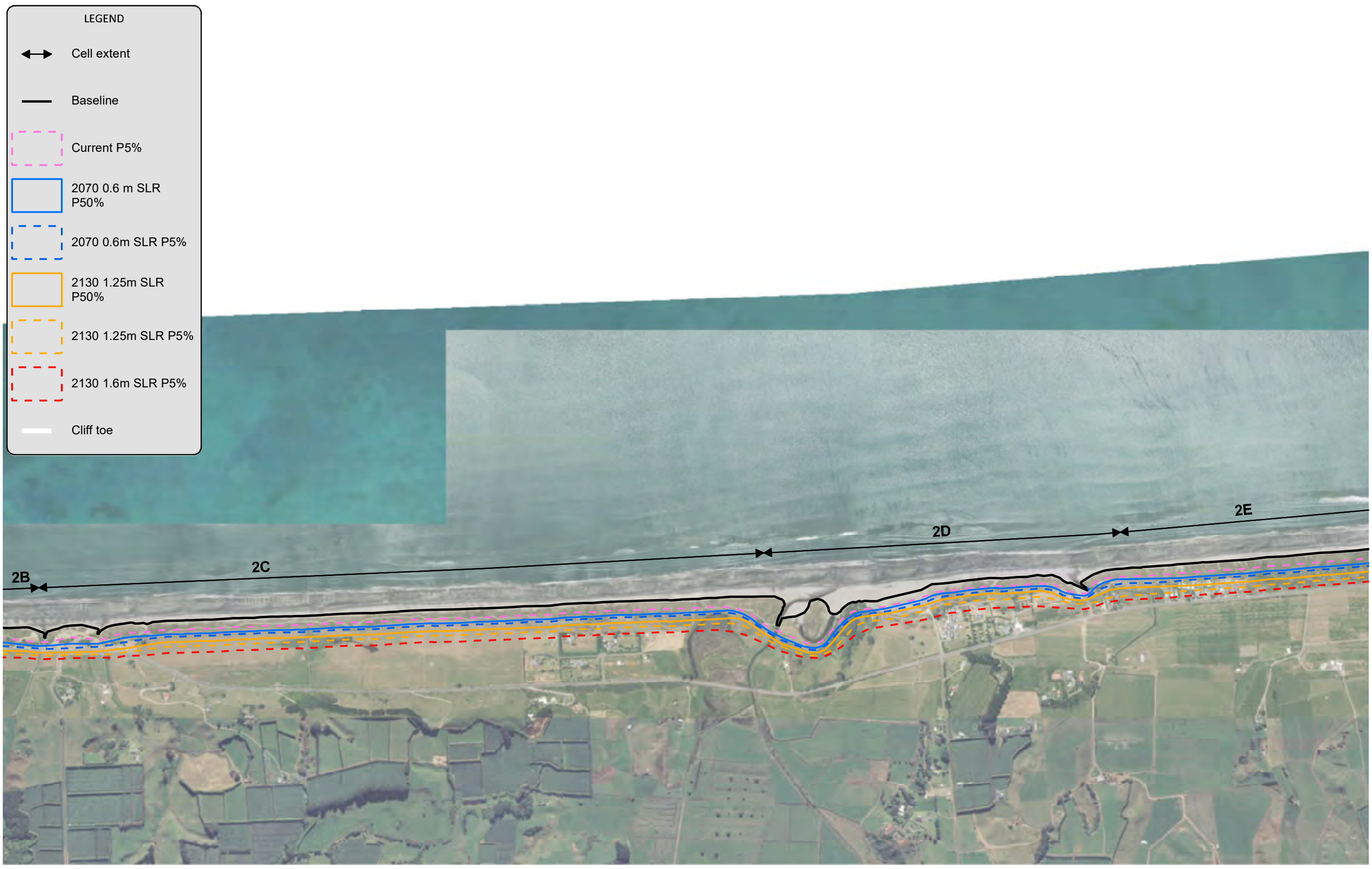

Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

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Ōpōtiki Coastal Erosion Hazard Assessment

Coastal Erosion Hazard Area (CEHA) Overview Map
Site 2: Hikuwai to Ōpape

FIGURE No. Figure 2.10b

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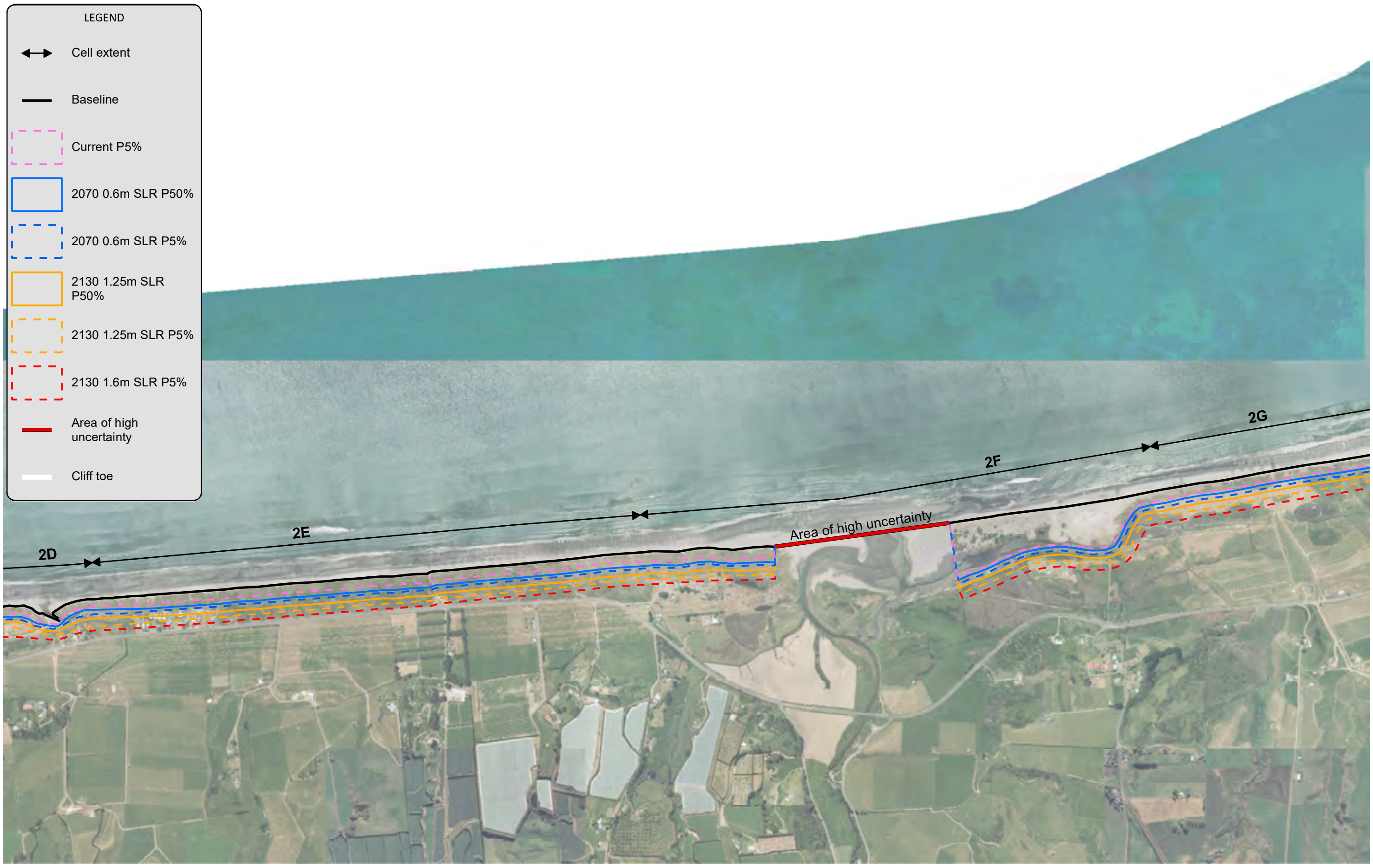

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Location Plan

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Ōpōtiki Coastal Erosion Hazard Assessment

Coastal Erosion Hazard Area (CEHA) Overview Map
Site 2: Hikuwai to Ōpape

FIGURE No. Figure 2.10c

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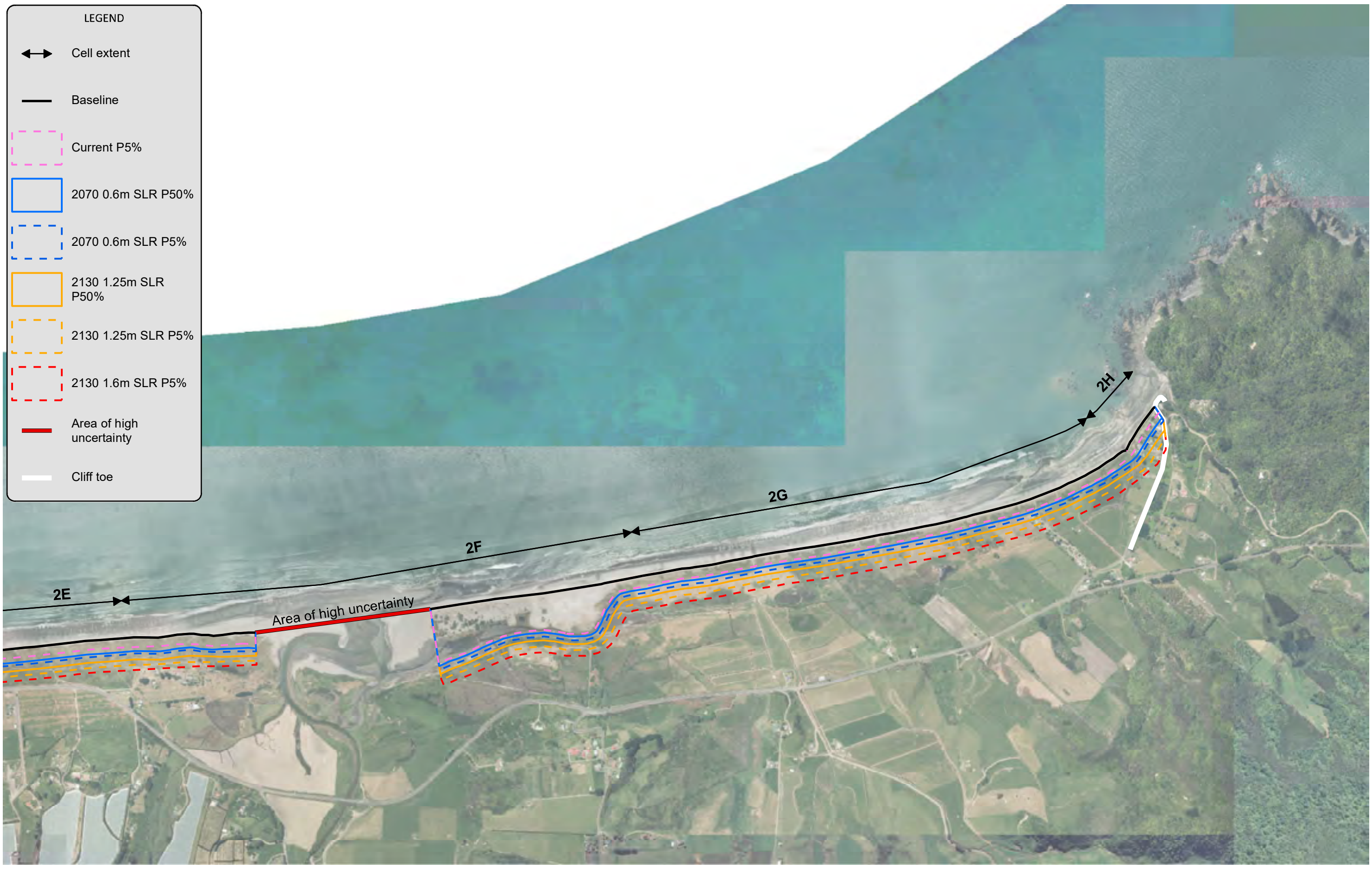

Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

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Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 2: Hikuwai to Ōpape

FIGURE No. Figure 2.10d

Rev. 0

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3 Tōrere

3.1 Site description

Tōrere is located approximately 15 km northeast of Ōpōtiki. The shoreline comprises a 5 km long sand and gravel beach located between Pehirairi Point to the northeast and Haurere Point to the east (Figure 3.1). The beach has been split into two cells that are divided by the Tōrere River mouth, the northern end that faces west to northwest and the western end that primarily faces north. SH35 runs parallel to the coast, approximately 150 to 200 m landward of the beach. The Tōrere settlement is located on the eastern side of the river.

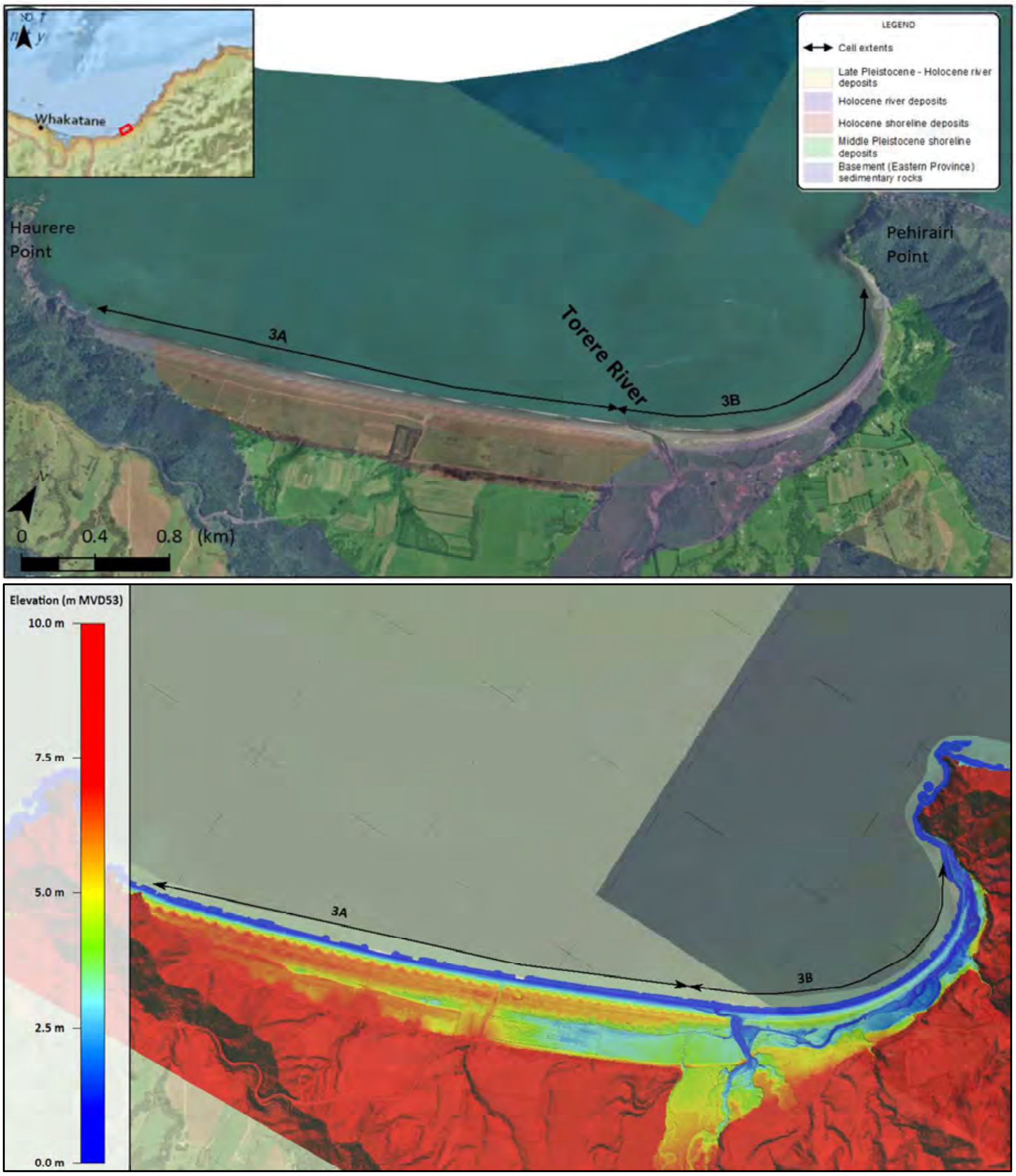

Figure 3.1: Site location and cell splits for Tōrere (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

3.2 Morphology

The underlying geology along Tōrere beach predominantly comprises low-lying Holocene shoreline deposits (Figure 3.1). The Holocene coastal plain extends for 300 m landward and is backed by Mid-Pleistocene marine terraces. The floodplain valley at the eastern end comprises Holocene river deposits. Headlands at either end of the beach are characterised by a mix of greywacke, argillite and conglomerate (Eastern Province Basement sedimentary rocks).

The far eastern end of the beach is backed by a narrow low-lying plain and a disconnected river channel that has become a lagoon. As the beach curves around to face northwest, the section of open coast west of the river mouth is characterised by a wider backshore environment that is backed by a grass covered coastal plain (4 to 6 m RL) with limited development. The vegetated backshore is characterised by a sequence of historic storm ridges built by gravel deposition. Ridge elevation is lower on the eastern side of Tōrere (3 to 3.5 m RL), and gradually increases at the central (5 to 5.5 m RL) and western sections (5.6 to 6.5 m RL) of the beach.

Figure 3.2: Site photos for Tōrere. (A) Western extent of Tōrere (cell 3A), (B) centre of Tōrere (cell 3A), (C), gravel barrier along Tōrere (cell 3A), (D) eastern extent of Tōrere cell 3B

Observations at the central beach on 17 October 2019 recorded a relatively steep foreshore at 8(H):1(V) that is comprised by a mixture of coarse sand and fine pebbles (Figure 3.3). A similar profile gradient with fine pebbles and limited topographic complexity extends landward to a berm crest covered in wave washed driftwood. A narrow (10 to 20 m wide) flat backshore extends to the vegetation line where a network of grass and shrubs covered deposits are intersected by four wheel drive tracks used for beach access.

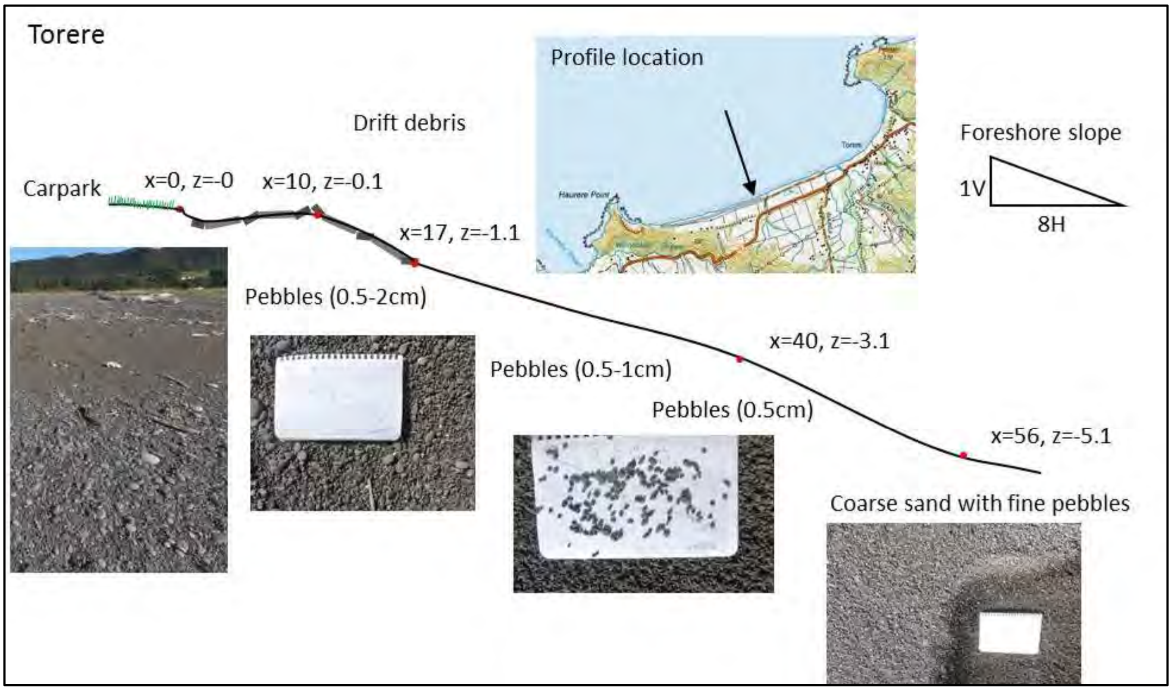

Figure 3.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cell 3A

3.3 Coastal processes

Majority of the beach faces north and is exposed to swell waves from the north and north east. The eastern section of coast is relatively sheltered from north and northeast swell; however it is exposed to locally generated waves from the west. Based on NIWA (2019) the 50 year ARI offshore wave height is 6.23 m and the 50 year ARI storm tide is 1.26 m MVD53.

The Tōrere River provides the most significant fluvial influence at the coast, with four smaller streams discharging along the western section and one stream discharging at the eastern end. The contemporary Tōrere River mouth is 100 m wide with a network of dynamic channels that flow into the sea. Historically the river mouth channel travelled to the north east along the historic barrier ridges and entered the beach near the headland. This channel appears to be closed off during low or moderate flow conditions and has resulted in disconnected channel and lagoon features in the backshore, to the east of the SH35 Bridge. At the river mouth, the section of shoreline influenced by river processes extends for up to 500 m alongshore, which is characterised by a channel migration east of the contemporary mouth. Previous hazard assessments treated all sections of beach east of the main channel as being influenced by dynamic river processes and indicate that high flow conditions can reconnect the historic channel that discharges at the eastern limit of the beach.

The Tōrere River provides a minor local source of sediment supply to the coast, with majority of the material likely delivered by southwest directed alongshore transport from the Motu River (13 km away).

3.3.1 Dynamic zone

The dynamic zone along Tōrere has been assessed based on XBeach-G modelling. Design storm conditions from NIWA (2019) are based on wave heights and storm tide levels offshore from Hāwai.

Model results indicate the dynamic zone ranges from 45 to 65 m from the MHWS position along the Tōrere shoreline (Figure 3.4). This zone extends to the current seaward edge of vegetation.

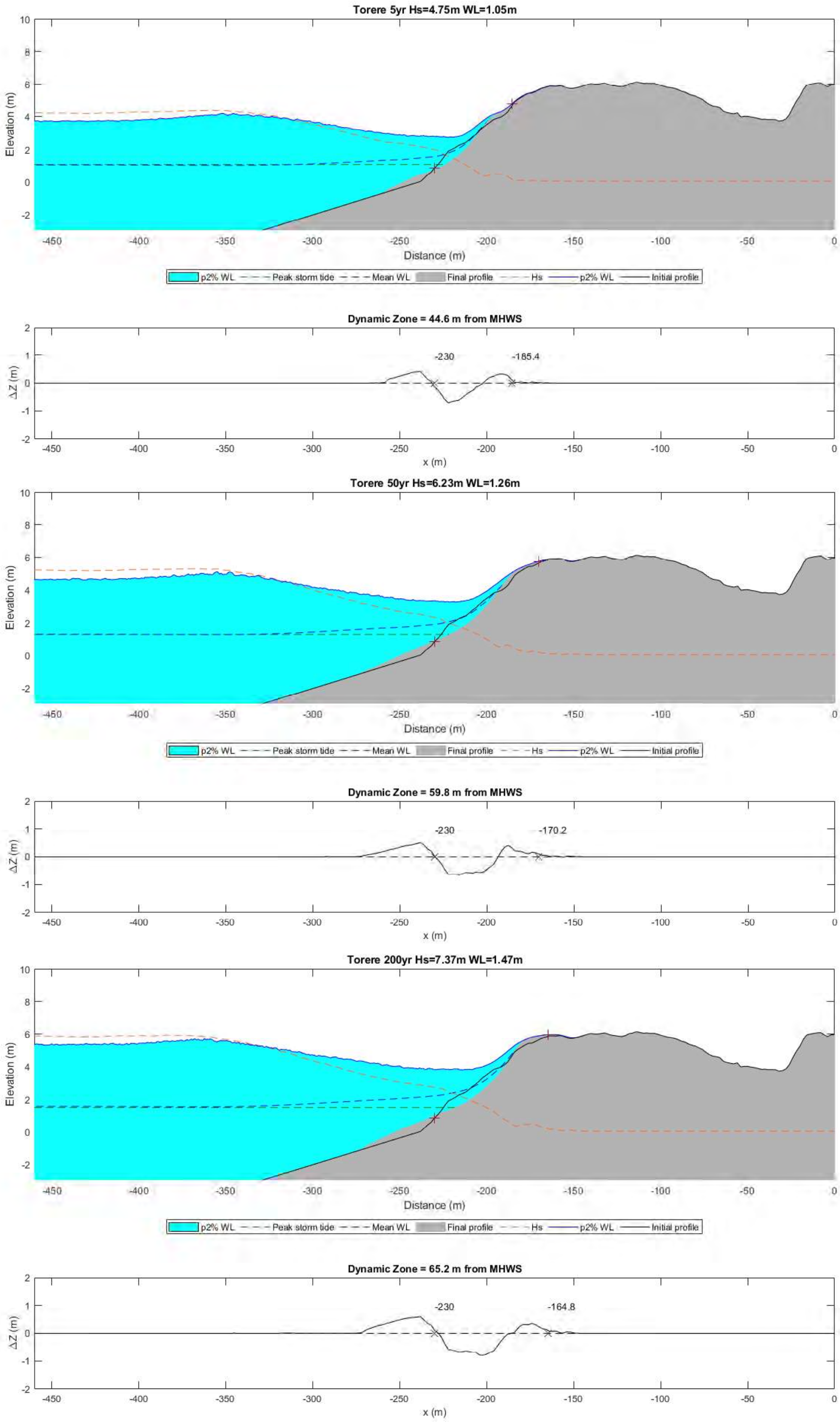

Figure 3.4: XBeach-G model results for Tōrere

3.3.2 Long-term trends and medium-term fluctuations

Long-term trends have been assessed using the high water surveys from 1916 to 2011 which exist in patches along the shoreline (Figure 3.5). Overall the DSAS analysis, based on the high water surveys shows long-term accretion for most of the shoreline with slight erosion at the very eastern extent (Figure 3.6).

The shoreline within cell 3A showed up to 35 m accretion between 1916 and 1971 followed by 25 m erosion between 1971 and 1981. Since 1981 to 2011 there has been overall accretion of 30 m. East of the river (cell 3B), the high water surveys between 1916 and 1981 indicates a seaward movement of 15 to 30 m over a period of 65 years. Between 1981 and 2011 the high water mark has shifted back to the 1916 position. A medium-term component of 10 to 20 m has been adopted to account for these shoreline fluctuations.

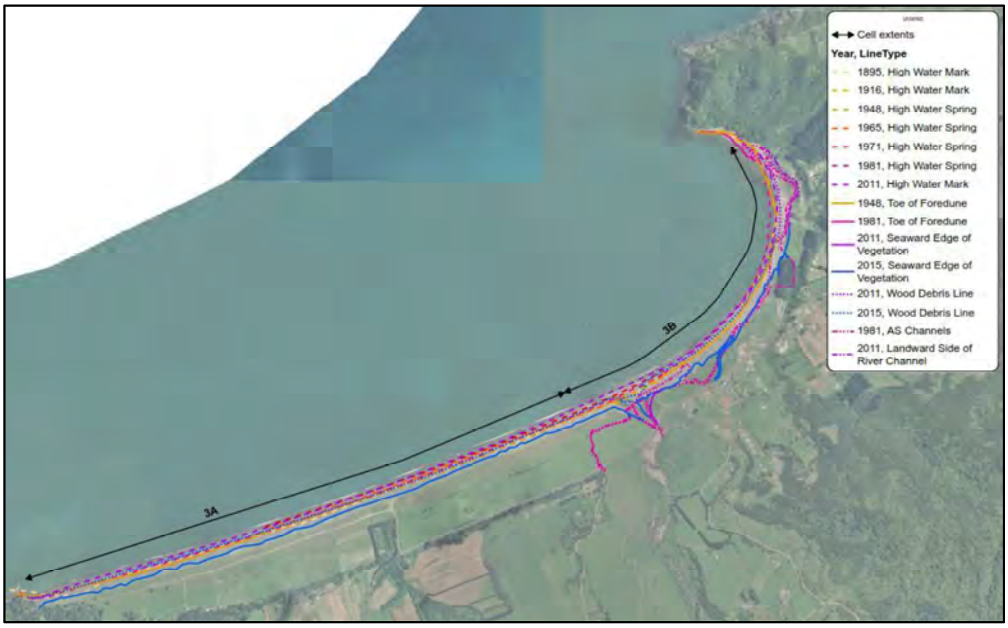

Figure 3.5: Historic shorelines for Tōrere

Figure 3.6: DSAS results for Tōrere

3.3.3 Sea level rise

SLR is expected to increase wave overtopping along Tōrere. Subsequently it is expected that the gravel berm will migrate landward and increase in elevation (barrier rollover). Berm elevation is slightly lower at the eastern extent of the beach (cell 3B) and therefore the landward migration is expected to be greater at the eastern end compared to the western end (cell 3A). Under high future SLR scenarios (i.e. 1.6 m) the berm may migrate up to 19 m landward within cell 3A and 35 m within cell 3B.

3.4 Adopted component values

Adopted component values for Tōrere are presented within Table 3.1.

Table 3.1: Adopted component values for the cells along Tōrere shoreline

Site		**Tōrere**	
Cell		**3A**	**3B**
Cell centre (NZTM)	**E**	1992514	1994558
	N	5789563	5790532
Chainage, m (from W)		0 to 2830	2830 to 4540
Morphology		Sand gravel beach	*Sand gravel beach
Baseline		2011 high water mark	2011 high water mark
Dynamic zone (m)	**Min**	45	45
	Mode	60	60
	Max	65	65
Medium term (m)	**Min**	10	10
	Mode	15	15
	Max	20	20
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0.6	0.2
	Mode	0.4	0
	Max	0.3	-0.1
Berm elevation (m)	**Min**	5.5	3
	Mode	6	3.5
	Max	6.5	4

*Also influenced by river mouth dynamic

3.5 Coastal erosion hazard

Coastal erosion hazard distances for Tōrere are presented within Table 3.2 and an overview map in Figure 3.7. Erosion hazard distances have been offset from the latest available high water survey (2015 high water mark). Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

The current P5% along the Tōrere coast is a -63 m offset from the 2015 high water mark, which is equivalent to the width of the existing gravel barrier for most of the shoreline. Within cell 3B where there are meandering disconnected river channels/lagoons, the current hazard area has been mapped along the landward extent of the stream channels.

The western end of the shoreline (cell 3A) is dominated by long-term accretion trends and subsequently majority of the future hazard scenarios are seaward of the current CEHA. Although the future CEHA also take into account SLR, the impact from long-term accretion is likely to counteract any potential recession due to SLR. For these future scenarios, the CEHA have been mapped equivalent to the current hazard. Cell 3B showed reduced accretion rates, with slight erosion and subsequently the future CEHA are further landward of the current hazard.

Table 3.2: Coastal erosion hazard widths (m) for Tōrere for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Tōrere	3A	Current (2020)	0.03	N/A	-45	-55	-57	-63	-65
		50yr (2070)	0.4	RCP4.5	-39	-59	-61	-71	-78
			0.6	RCP8.5	-40	-60	-63	-72	-79
		110yr (2130)	0.8	RCP4.5	-15	-40	-44	-56	-64
			1.25	RCP8.5	-19	-44	-47*	-60*	-68
			1.6	RCP8.5+	-21	-46	-50	-63	-72
	3B	Current (2020)	0.03	N/A	-45	-55	-57	-63	-65
		50yr (2070)	0.4	RCP4.5	-60	-80	-83	-92	-103
			0.6	RCP8.5	-62	-82	-85	-95	-105
		110yr (2130)	0.8	RCP4.5	-63	-86	-90	-103	-112
			1.25	RCP8.5	-68	-93	-97	-110	-119
			1.6	RCP8.5+	-72	-98	-102	-115	-125

*Mapped equivalent to current CEHA

Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

A3 SCALE 1:12,000
0 0.1 0.2 0.3 0.4 0.5 (km)

Whakatane
Location Plan

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PROJECT No. 1008669.2000		

Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 3: Tōrere

FIGURE No. Figure 3.7

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4 Hāwai

4.1 Site description

Hāwai is located approximately 22 km northeast of Ōpōtiki. The shoreline comprises a 4 km long sand and gravel beach with Haumiaroa Point located at the northeast end and Pehitairi headland at the southwest end (Figure 4.1). The Hāwai River mouth is located at the eastern end of the beach and there are four minor streams that discharge at various locations along the beach. SH35 runs parallel to the coast and is setback by a 30 to 50 m wide vegetated ridge system. A small settlement and holiday park is located landward of SH35 on at the eastern end, with land along the remaining coast used for agriculture. The site has been split into three cells based on the morphology and coastal processes described below.

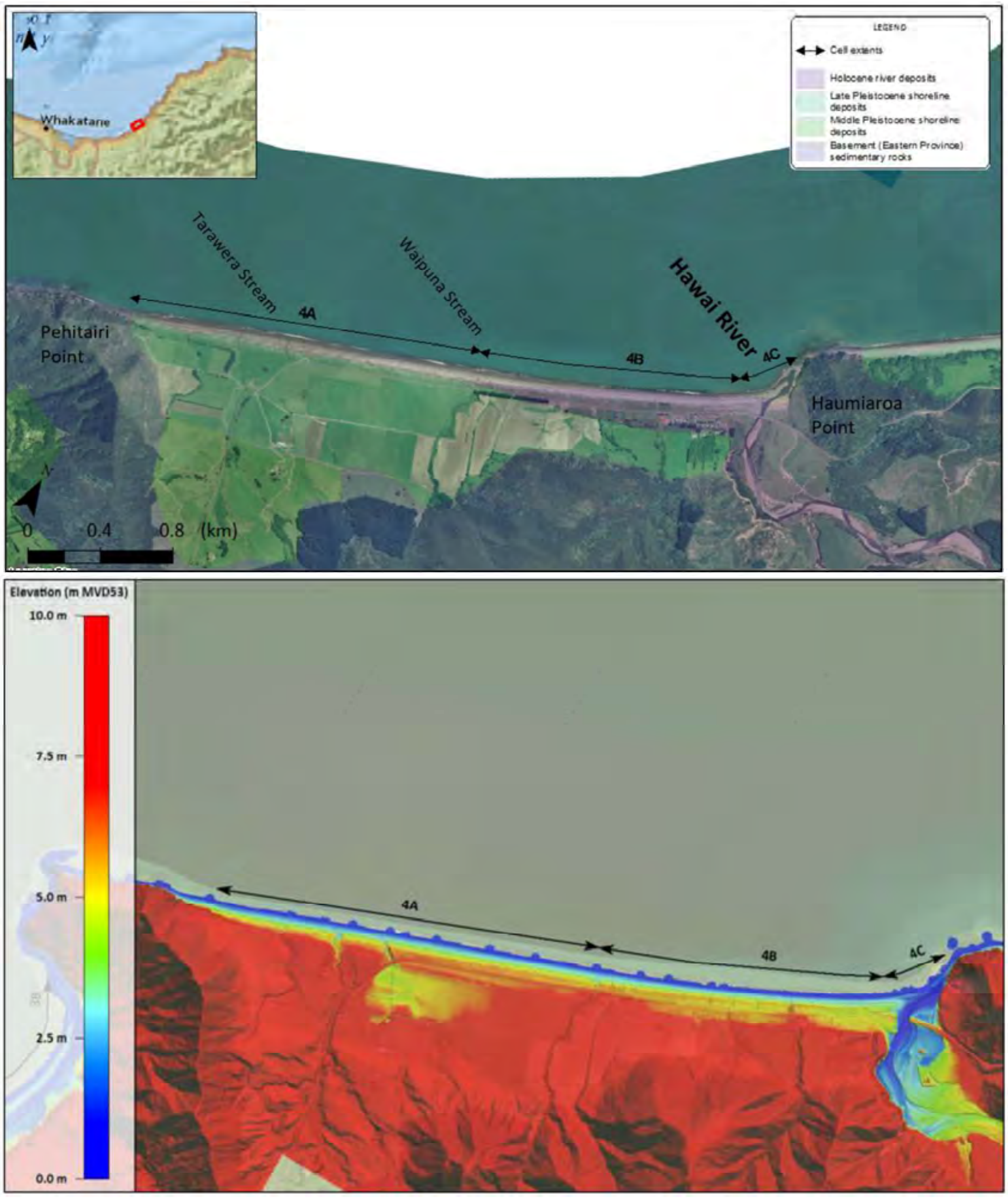


Figure 4.1: Site location and cell splits for Hāwai (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

4.2 Morphology

Sedimentary shoreline deposits from the Late Pleistocene and Holocene form a 300 to 500 m wide coastal plain behind majority of the beach (Figure 4.1). Alluvial deposits from the Hāwai River underlay the northeast section of Hāwai and extend for along a 500 m wide floodplain near the river mouth. The headlands at either end of the beach comprise Eastern Province Basement sedimentary rocks (greywacke, argillite and conglomerate).

At the northeast end, the beach morphology is directly influenced by discharge from the Hāwai River that flows close to the cliff and headland of Haumiaroa Point (Figure 4.2). The river is bound by relatively stable and vegetated banks until it flows below the SH35 Bridge. As the river flows seaward it is less restricted with a series of mobile channels and sand bar. The contemporary sand bar is welded to the headland and extends for 300 m before being intersected by the main channel that flows out to sea. Historic images suggest the bar and channel position migrate constantly in response to antecedent environmental conditions and fluctuate up to 200 m alongshore.

Open coast conditions prevail along the remaining shoreline with a small localised influence from the four small streams. Most of the beach is backed by a 30 to 50 m wide vegetated ridge system, with the seaward ridge crest ranging from 5.5 to 6 m RL. A network of access paths and channels punctuate the ridge systems and cause localised valleys. The western section of beach is backed by a narrow ridge that extends up to 12 m RL.

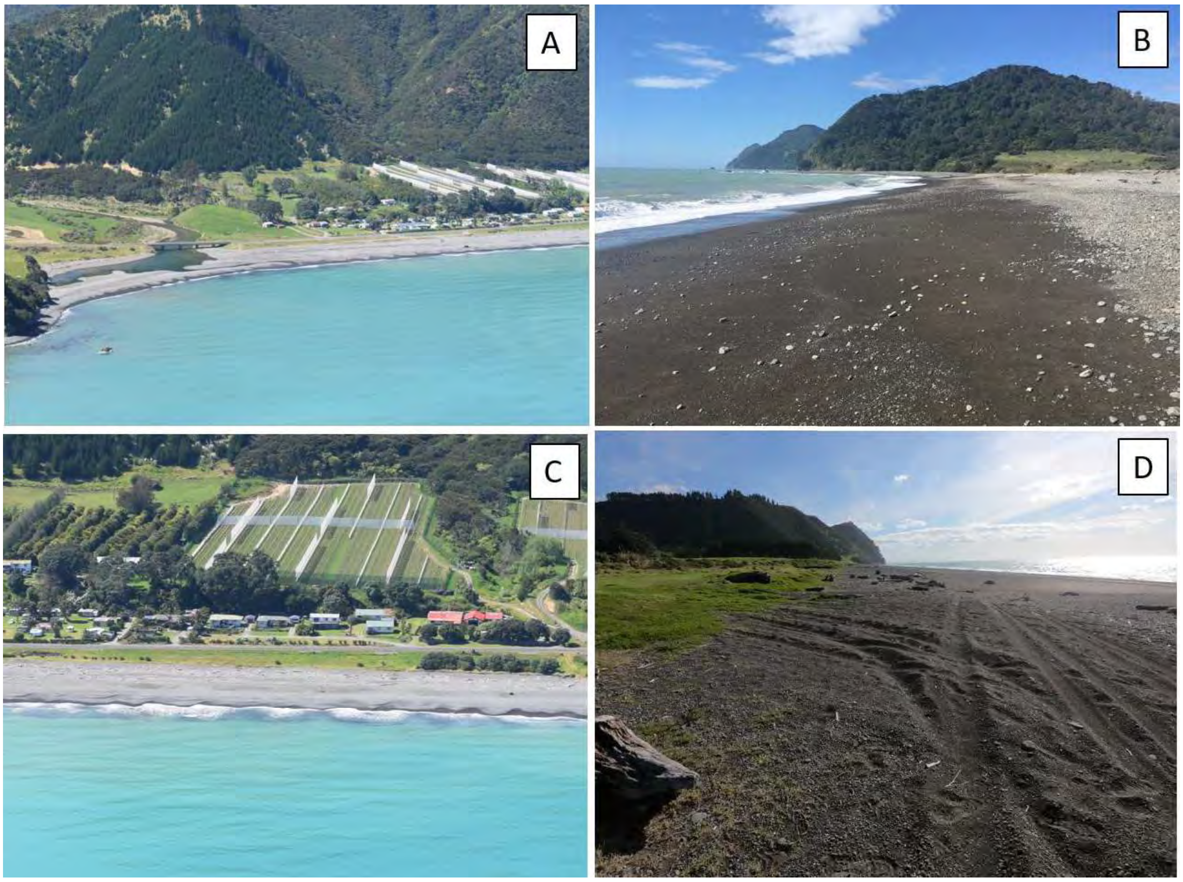


Figure 4.2: Site photos for Hāwai. (A) Hāwai River (cell 4C). (B) Gravel berm within cell 4B. (C) Hāwai settlement cell 4B. (D) Backshore within cell 4A

Site observation on 17 October measured a foreshore slope of 8.5(H):1(V) comprised by a surface layer of coarse sand and a subsurface layer of 4 cm diameter pebbles at the eastern section of open coast (away from the river influence) (Figure 4.3). Grain size increases landward, with a beach berm and backshore characterised by poorly sorted 1 to 10 cm diameter gravels. The backshore is undulating and scattered in driftwood debris, encroaching grass and four wheel drive tracks. The backshore extends for 5 to 15 m across shore and transitions into the vegetated ridge system with no evidence of recent erosion.

Observations at the central-western section of the beach indicate a similar morphology, with a mixture of coarse sand and pebbles on the foreshore with a slope of 15(H):1(V) (Figure 4.3). The central and upper beach extend on a similar gradient and are characterised by a mix of 1 to 6 cm diameter pebbles, indicating a decrease in grainsize along the south-westerly directed alongshore transport pathway. The backshore width also decreases towards the southwest but there is no evidence of erosion on the vegetated ridge system that backs the beach.

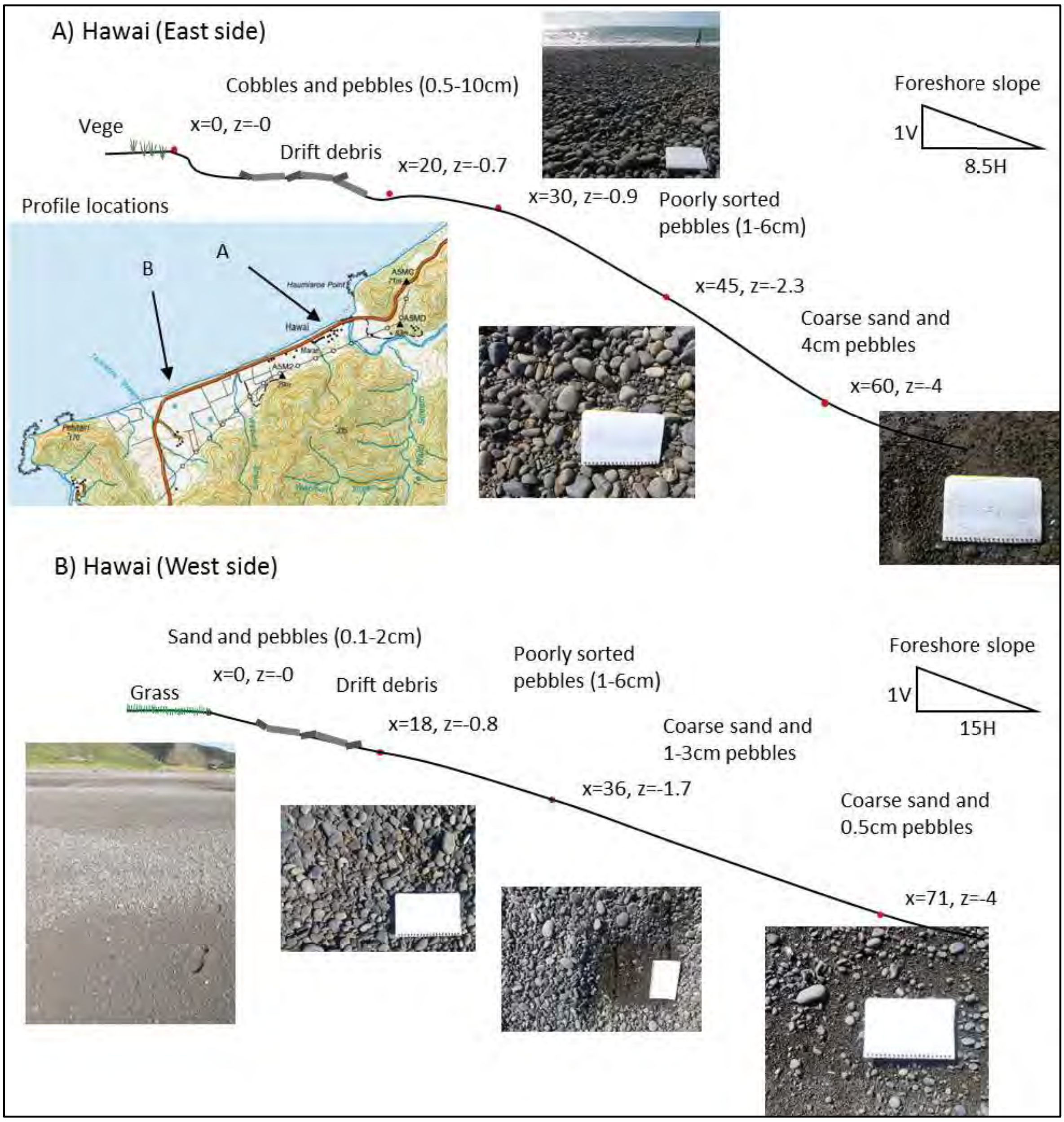


Figure 4.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cells 4A and 4C

4.3 Coastal processes

The Hāwai shoreline is predominately exposed to swell waves from the north and north east which is a key driver for the dominant southwest alongshore transport. Based on NIWA (2019) the 50 year ARI offshore wave height is 6.23 m and the 50 year ARI storm tide is 1.26 m MVD53.

The Motu River is located 8.5 km northeast of Hāwai beach and is likely a primarily source of sediment in addition to local discharge form the Hāwai River. A dominant southwest directed alongshore transport has resulted in a decreasing grain size and beach width towards the southwest end of Hāwai.

4.3.1 Dynamic zone

The dynamic zone along Hāwai has been assessed based on XBeach-G modelling. Model results indicate the dynamic zone ranges from 43 to 79 m from the MHWS position along the Hāwai shoreline (Figure 4.5). This zone extends approximately 20 to 30 m landward of the current edge of vegetation. For comparison, Medwin (2008) reports that during Cyclone Ivy in 2004 the water level along Hāwai peaked at 5.73 m RL and resulted in large debris being carried across State Highway 35. Photos indicate the debris was carried through the Motor Camp and Waipae Urupa which are approximately 100 m landward from the mean high water mark (Figure 4.4).

Figure 4.4: Extent of debris overwash during Cyclone Ivy in 2004. Sourced from Medwin (2008)

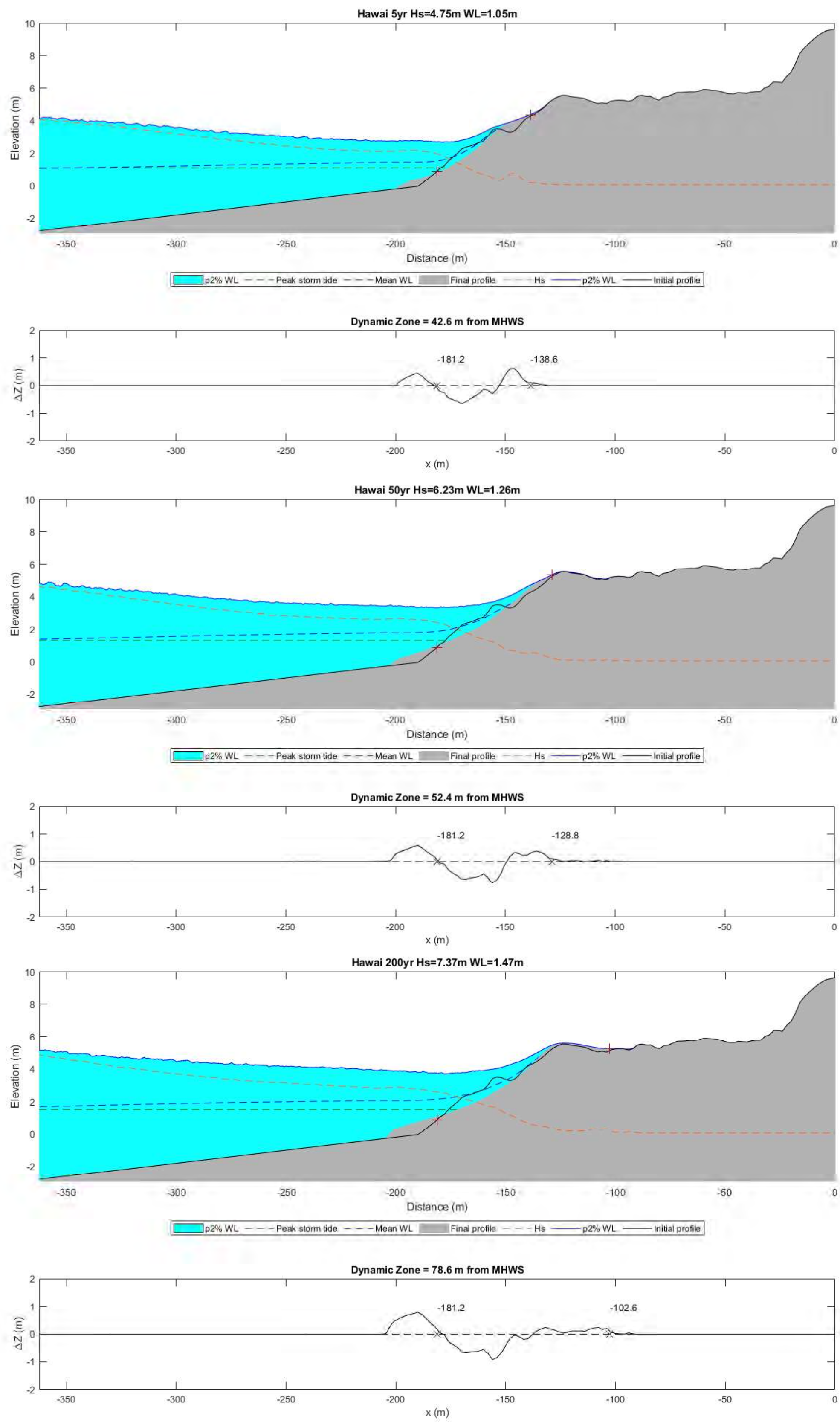


Figure 4.5: XBeach-G model results for Hāwai

4.3.2 Long-term trends and medium-term fluctuations

Long-term trends have been assessed using high water surveys from 1910 to 2011 (Figure 4.6). DSAS analysis was completed for most of the shoreline showing long-term accretion trends of 0.1 to 0.4 m/yr along the western end of the shoreline (cell 4A) (Figure 4.7). The edge of vegetation surveys within cell 4A also show a seaward shift of 20 to 30 m over the last 105 years.

There are limited high water surveys within cell 4B, however the 1910 and 2011 surveys are in approximately the same location. However, the edge of vegetation surveys show fluctuations, with the 2015 vegetation line approximately 5 to 15 m landward of the 1910 vegetation line. This data suggests the shoreline within cell 4B is either in dynamic equilibrium or has a slight erosional trend.

While majority of the shoreline has shown long-term accretion there has been medium-term fluctuations. On average the high water mark within cell 4A shifted seaward approximately 35 m between 1910 and 1965. This accretion was followed by approximately 20 m retreat between 1965 and 1971 and then approximately 25 m accretion from 1971 to 2011. Subsequently, medium-term fluctuations of 5 to 15 m have been accounted for.

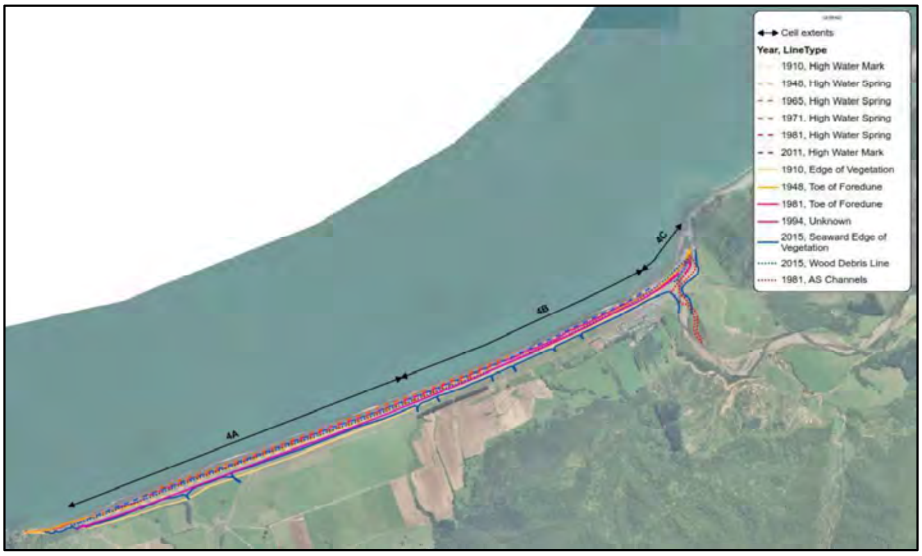


Figure 4.6: Historic shorelines along Hāwai

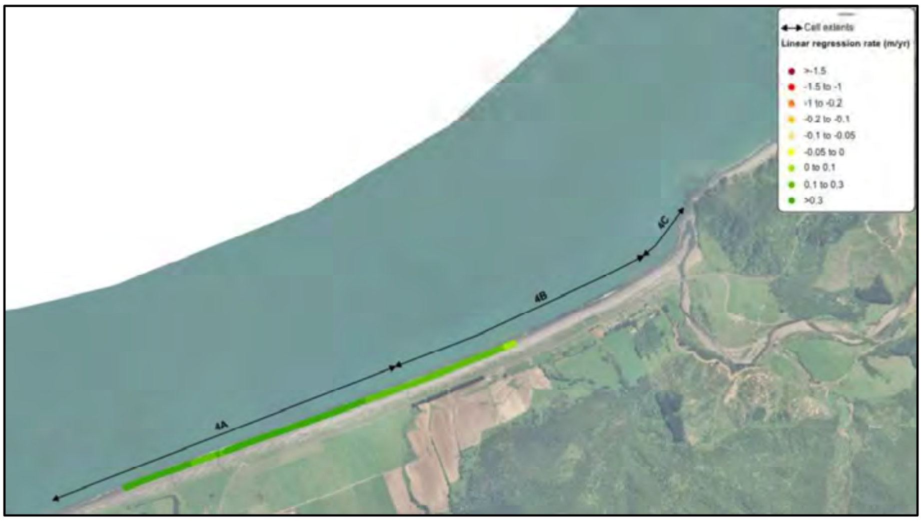


Figure 4.7: DSAS results for Hāwai (regression rates are absent for the eastern extent of 4B and 4C due to lack high water survey data)

4.3.3 Sea level rise

SLR is expected to increase wave overtopping along Hāwai. Subsequently it is expected that the gravel berm will migrate landward and increase in elevation (barrier rollover). Under high future SLR scenarios (i.e. 1.6 m) the berm may migrate up to 25 m landward.

4.4 Adopted component values

Adopted component values for Hāwai are presented in Table 4.1.

Table 4.1: Adopted component values for the cells along Hāwai shoreline

Site		**Hāwai**		
Cell		**4A**	**4B**	**4C**
Cell centre (NZTM)	**E**	1996098	1997503	1998380
	N	5792480	5793012	5793532
Chainage, m (from W)		0 to 1950	1950 to 3390	3390 to 3720
Morphology		Sand gravel beach	Sand gravel beach	River mouth
Baseline		2011 high water mark	2011 high water mark	River mouth – Area of high uncertainty (see main report Section 4.4.4)
Dynamic zone (m)	**Min**	43	43	
	Mode	52	52	
	Max	79	79	
Medium term (m)	**Min**	5	5	
	Mode	10	10	
	Max	15	15	
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0.4	0.1	
	Mode	0.3	0	
	Max	0.1	-0.05	
Berm elevation (m)	**Min**	5	5	
	Mode	5.5	5.5	
	Max	6	5.6	

4.5 Coastal erosion hazard

Coastal erosion hazard distances for Hāwai are presented within Table 4.2 and an overview map in Figure 4.8. Erosion hazard distances have been offset from the latest available high water survey (2015 high water mark). Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

P50% means there is a 50% chance of an erosion distance being exceeded within that timeframe. P66% can be considered a likely scenario and P5% can be considered a very unlikely scenario.

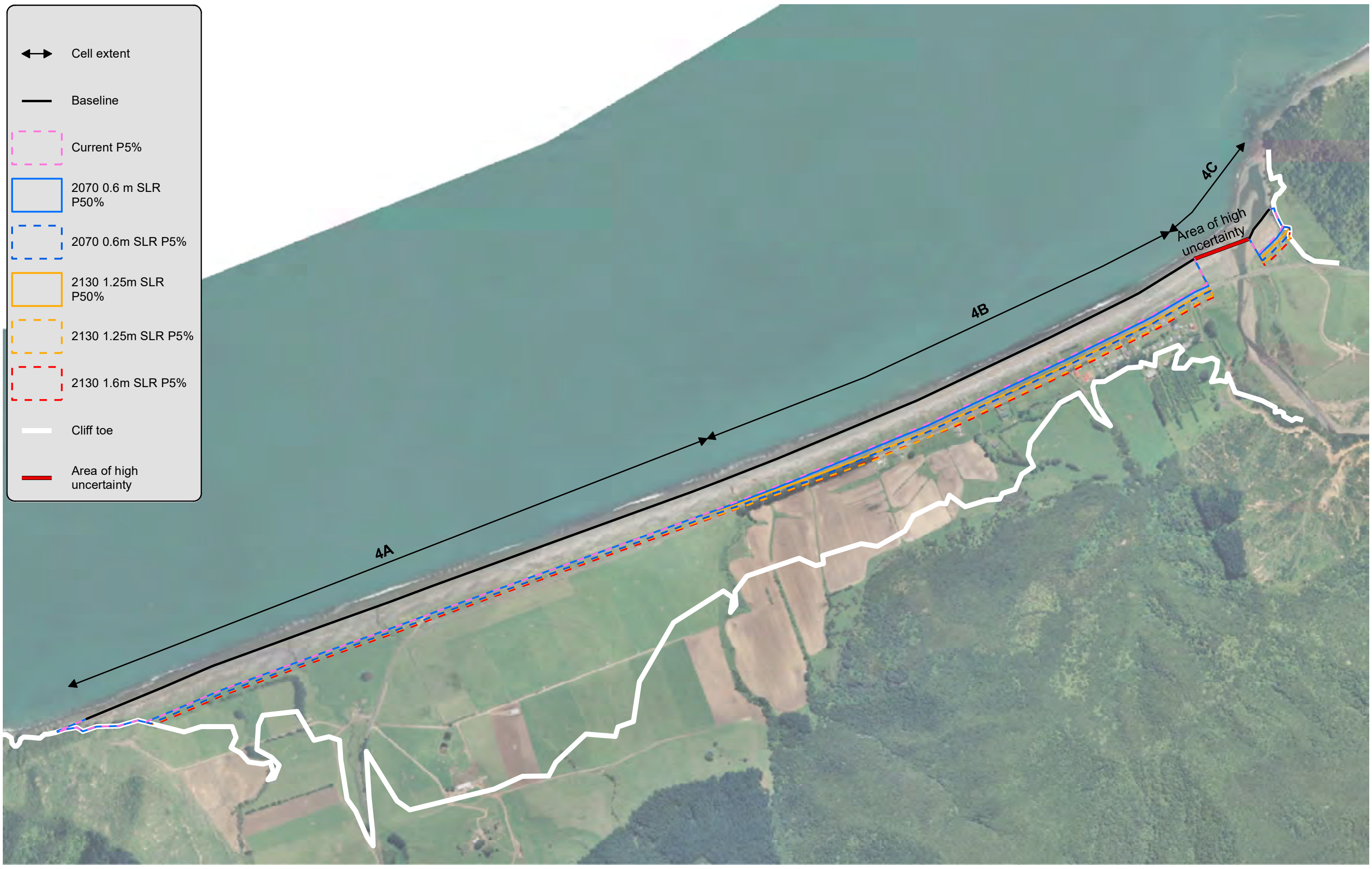
The current P5% is a -72 m offset from the 2015 high water mark along the Hawai coast. The future CEHA increases up to -88 m within cell 4A and 113 m within cell 4B for the 2130 1.6m SLR P5% scenario. Long-term accretion dominates the western end of the shoreline and subsequently the future CEHA are reduced compared to the eastern end. Within cell 4A, some of the future CEHA are seaward of the current CEHA. Although the future CEHA also take into account SLR, for the lower SLR scenarios, the impact from long-term accretion is likely to counteract any potential recession due to SLR. For these future scenarios, the CEHA have been mapped equivalent to the current hazard.

Alongshore movement of the Hawai River mouth is expected to be limited due to restriction from the SH35 bridge abutments. Historic shoreline data suggests that alongshore variation in the river mouth position has been limited to 200m section adjacent to the eastern headland. However, there is high uncertainty around the hazard in this area due to the combination of riverine and coastal processes.

Table 4.2: Coastal erosion hazard widths (m) for Hāwai for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Hawai	4A	Current (2020)	0.03	N/A	-43	-54	-57	-72	-79
		50yr (2070)	0.4	RCP4.5	-39	-59	-63	-80	-97
			0.6	RCP8.5	-40	-60	-65*	-82	-99
		110yr (2130)	0.8	RCP4.5	-25	-54	-59	-79	-98
			1.25	RCP8.5	-28	-58	-63*	-84	-104
			1.6	RCP8.5+	-30	-61	-66	-88	-109
	4B	Current (2020)	0.03	N/A	-43	-54	-57	-72	-79
		50yr (2070)	0.4	RCP4.5	-54	-72	-76	-92	-105
			0.6	RCP8.5	-55	-73	-77	-94	-106
		110yr (2130)	0.8	RCP4.5	-59	-83	-86	-104	-118
			1.25	RCP8.5	-63	-87	-91	-109	-124
			1.6	RCP8.5+	-66	-90	-94	-113	-129
	4C	Current (2020)	0.03	N/A	River mouth – Area of high uncertainty (see main report Section 4.4.4)				
		50yr (2070)	0.4	RCP4.5					
			0.6	RCP8.5					
		110yr (2130)	0.8	RCP4.5					
			1.25	RCP8.5					
			1.6	RCP8.5+					

*Mapped equivalent to current CEHA



Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

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Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 4: Hāwai

FIGURE No. Figure 4.8

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5 Houpoto

5.1 Site description

Houpoto is located approximately 28 km northeast of Ōpōtiki. The shoreline is a northwest-facing beach located in a 4.8 km long embayment between Tokata Point to the northeast and Parinui to the southwest. The Houpoto coast is heavily influenced by the Motu River which discharges at the north end of the bay (Figure 5.1). South of the river mouth an open coast sand gravel beach extends for approximately 2.9 km. The settlement of Houpoto includes several houses, a Marae and school that are located on a 500 m wide coastal plain between the beach and SH35. The site has been split into three cells based on the morphology and coastal exposure described below.

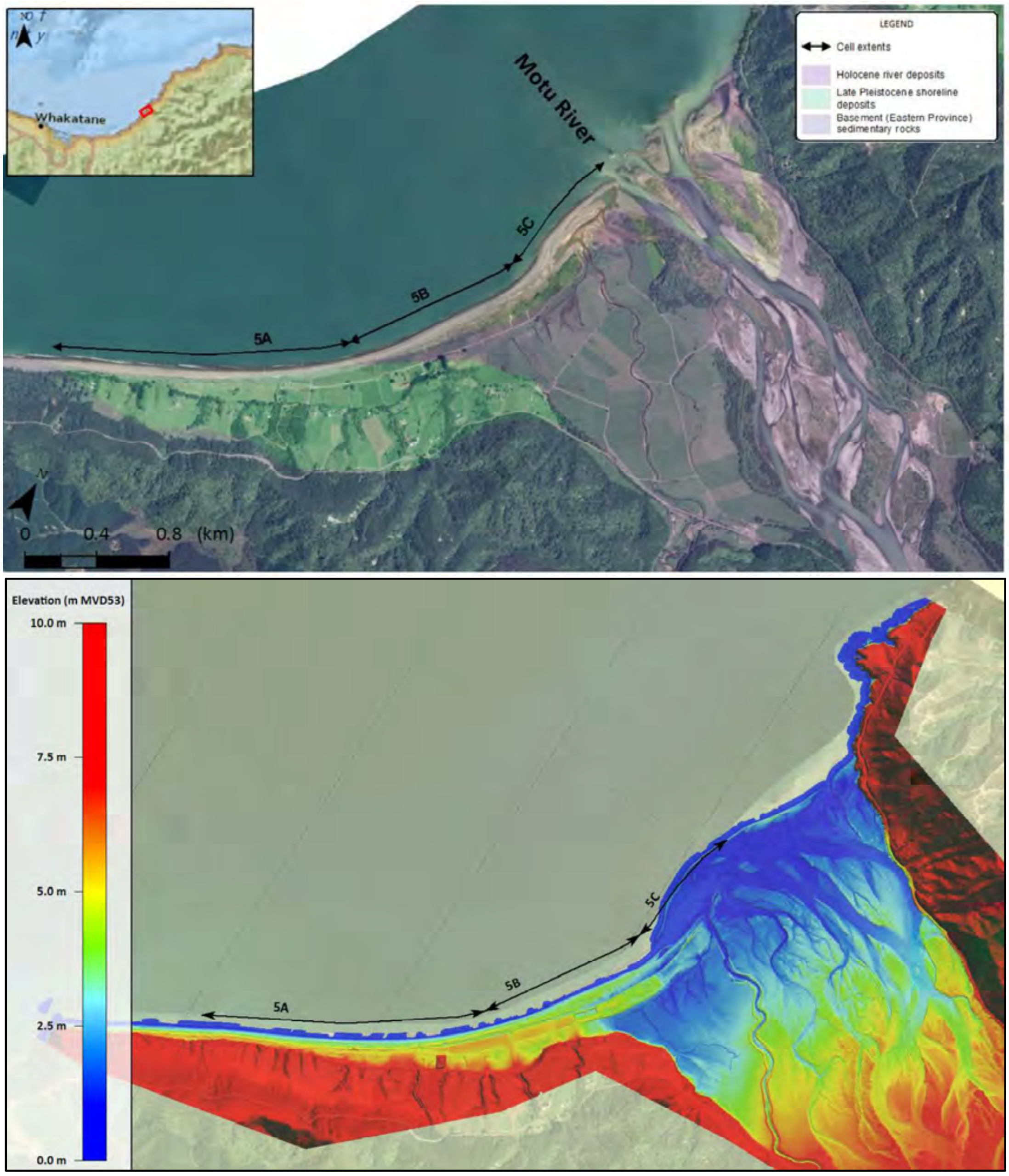


Figure 5.1: Site location and cell splits for Houpoto (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

5.2 Morphology

The western end of Houpoto comprises a 100 to 300 m wide Holocene coastal plain located between the marine terrace and active beach (cell 5A). The eastern end of the beach is characterised by a 2 km wide flood plain and river network at the Motu River mouth (cell 5C) (Figure 5.2). Late Pleistocene terraces bound the flood plain and extend along the coast to the west. The beach is a mix of sand and gravel with a steep foreshore and an undulating backshore washed in driftwood debris.

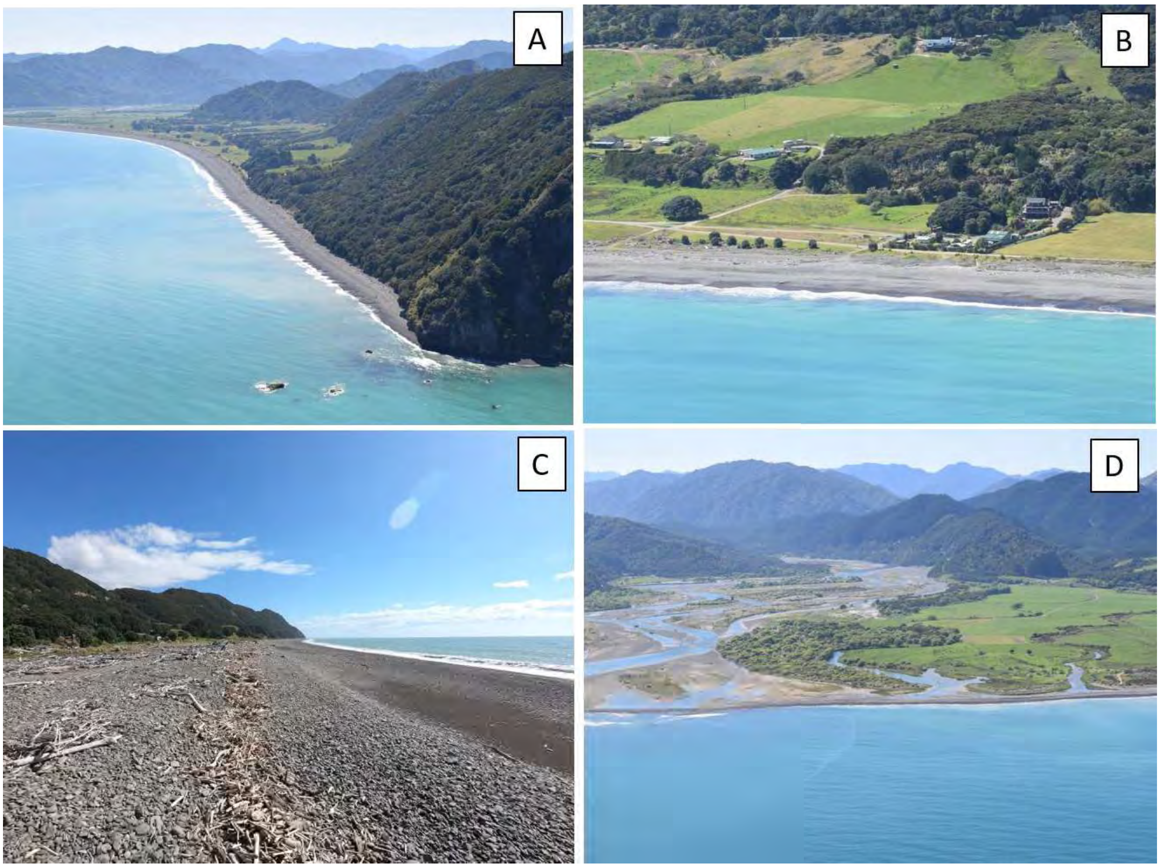


Figure 5.2: Site photos for Houpoto. (A) Parinui headland at the western end of Houpoto. (B) Gravel shoreline within cell 5A. (C) Gravel berm within cell 5A. (D) Motu River mouth (cell 5C)

Observations on 17 October 2019 measured a foreshore slope of 13(H):1(V) that was comprised of well sorted coarse sand (Figure 5.3). Sand in the foreshore was a surface veneer covering a deeper layer of pebbles with a mixed grain size. A sequence of ridges and swales built by pebble and cobble size clasts (2 to 10 cm in diameter) were present on the backshore. Wave washed driftwood was scattered along the undulating backshore but there was no evidence of erosion or undermining at the vegetation line (Figure 5.2).

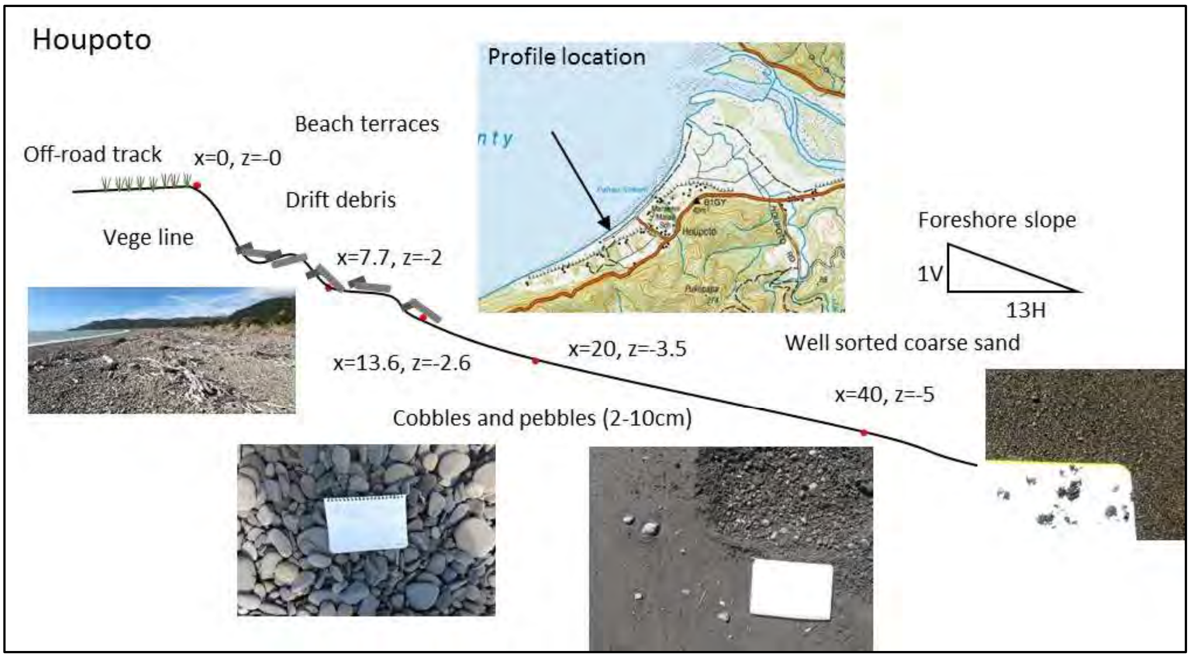


Figure 5.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at Cell 5A

5.3 Coastal processes

The Houpoto shoreline is predominately exposed to swell waves approaching from the north. Subsequently the dominant direction of alongshore sediment transport is southwest.

The Motu River has a significant influence on the coastal system at Houpoto and is likely the dominant source of sediment for the immediate beach and downstream locations such as Hāwai and Tōrere. The Motu River has a mean discharge of 91 m^3/s at Houpoto and suspended sediment yield of approximately 3.5 M t/y (Hicks et al. 2011).

5.3.1 Dynamic zone

The dynamic zone along Hāwai has been assessed based on XBeach-G modelling. Model results indicates the dynamic zone ranges from 32 to 67 m from the MHWS position along the Houpoto shoreline (Figure 5.4). This zone extends approximately 5 to 10 m landward of the current edge of vegetation.

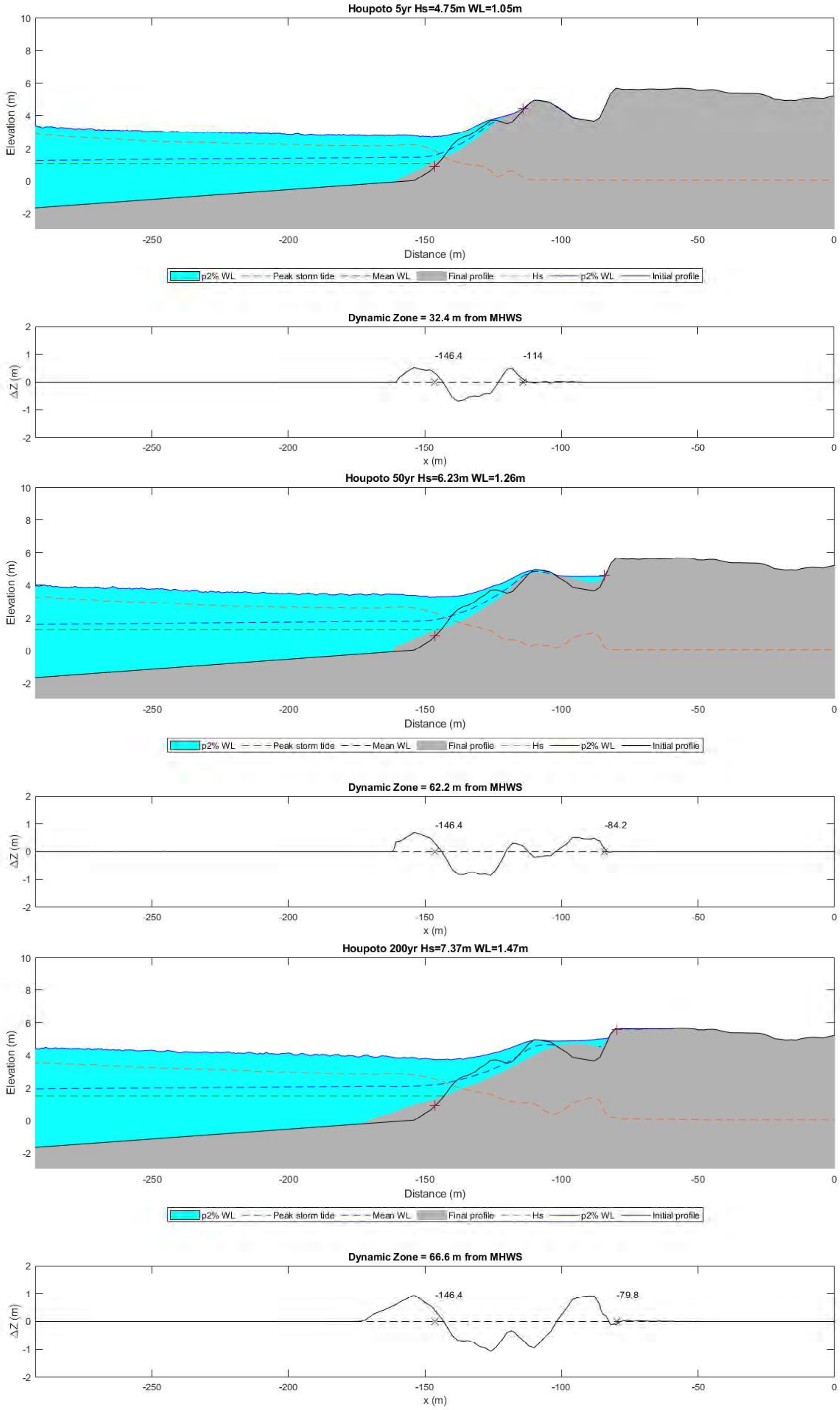


Figure 5.4: XBeach-G model results for Houpoto

5.3.2 Long-term trends and medium-term fluctuations

Historic shoreline data along Houpoto is limited to high water surveys from 1957, 1981 and 2011 (Figure 5.5). Along the majority of the site, the 1981 high water mark is landward of the 1957 high water mark by 2 to 20 m. However, the 2011 high water mark is now 30 to 60 m seaward from the 1981 survey within cell 5A and up to 120 m seaward within cell 5B. This data suggests significant accretion over the last 30 years with accretion rates decreasing with distance from the Motu River mouth. While a comparison between the high water surveys is insufficient for establishing a term trend, the location of these lines compared to the contemporary vegetation line also indicates a net trend of accretion along the coast, with highest accretion rates occurring within cell 5B (Figure 5.5). DSAS regression analysis suggests long-term accretion rates range from 0.4 to 0.8 m/yr within cell 5A and up to 2 m/yr within cell 5B (Figure 5.6). However, the high accretion over the last 30 years is potentially a function of medium-term fluctuations associated with the river sediment supply rather than a high long-term rate. Based on the limited shoreline data medium-term fluctuations of up to 20 m have been adopted with long-term accretion rates ranging from 0.4 to 0.8 m.

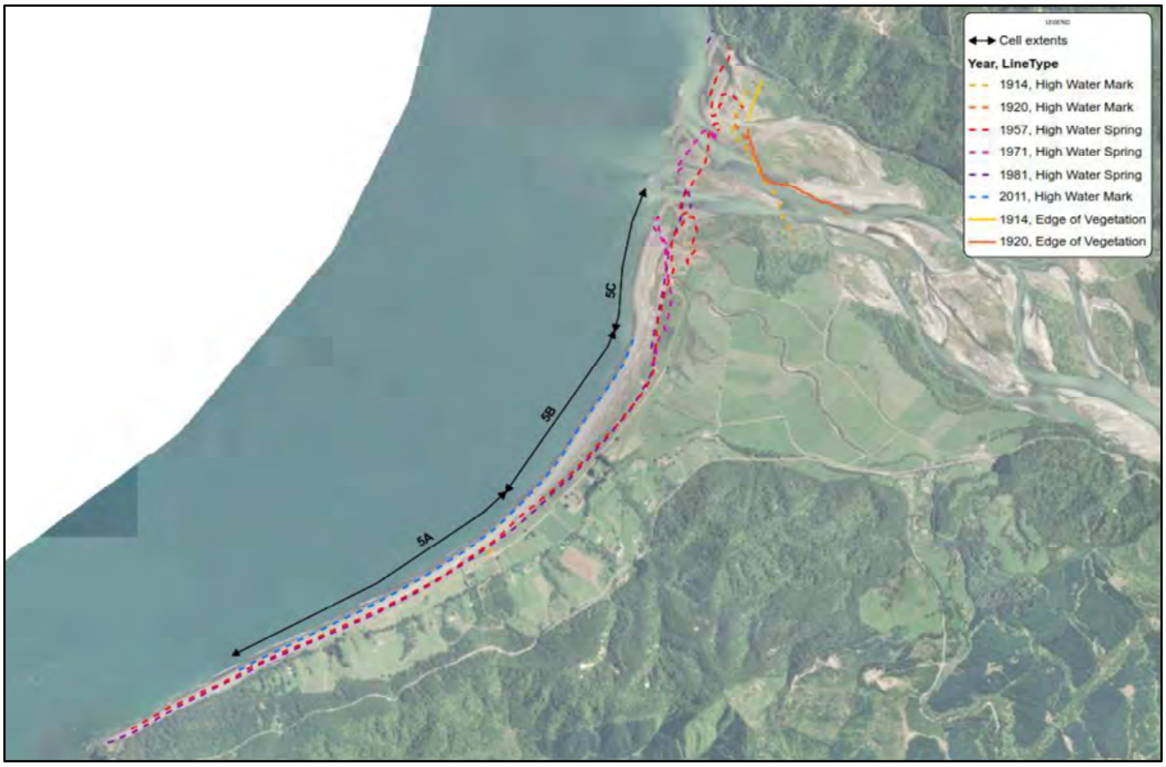


Figure 5.5: Historic shorelines along Houpoto

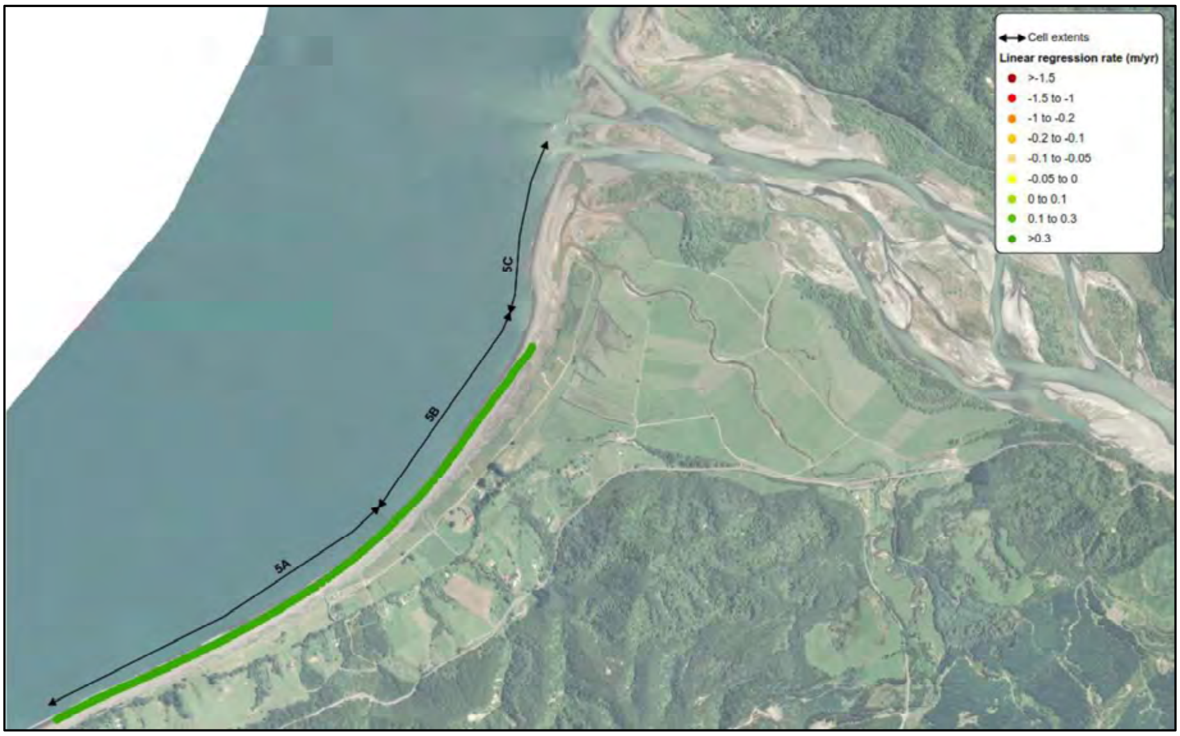


Figure 5.6: DSAS results for Houpoto

5.3.3 Sea level rise

SLR is expected to increase wave overtopping along Houpoto. Subsequently it is expected that the gravel berm will migrate landward and increase in elevation (barrier rollover). Under high future SLR scenarios (i.e. 1.6 m) the berm may migrate up to 35 m landward.

5.4 Adopted component values

Adopted component values are presented in Table 5.1.

Table 5.1: Adopted component values for the cells along Houpoto shoreline

Site		**Houpoto**		
Cell		**5A**	**5B**	**5C**
Cell centre (NZTM)	**E**	2002103	2003099	2003508
	N	5798080	5798949	5800172
Chainage, m (from W)		0 to 1650	1650 to 2640	2640 to 4170
Morphology		Sand gravel beach	Sand gravel beach	River mouth
Baseline		2011 high water mark	2011 high water mark	River mouth – Area of high uncertainty (see main report Section 4.4.4)
Dynamic zone (m)	**Min**	32	32	
	Mode	62	62	
	Max	67	67	
Medium term (m)	**Min**	5	5	
	Mode	10	10	
	Max	20	20	
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0.8	0.8	
	Mode	0.5	0.5	
	Max	0.4	0.4	
Berm elevation (m)	**Min**	3	3	
	Mode	3.5	3.5	
	Max	4	4	

5.5 Coastal erosion hazard

Coastal erosion hazard distances for Houpoto are presented within Table 5.2 and an overview map in Figure 5.7. Erosion hazard distances have been offset from the latest available high water survey (2015 high water mark). Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

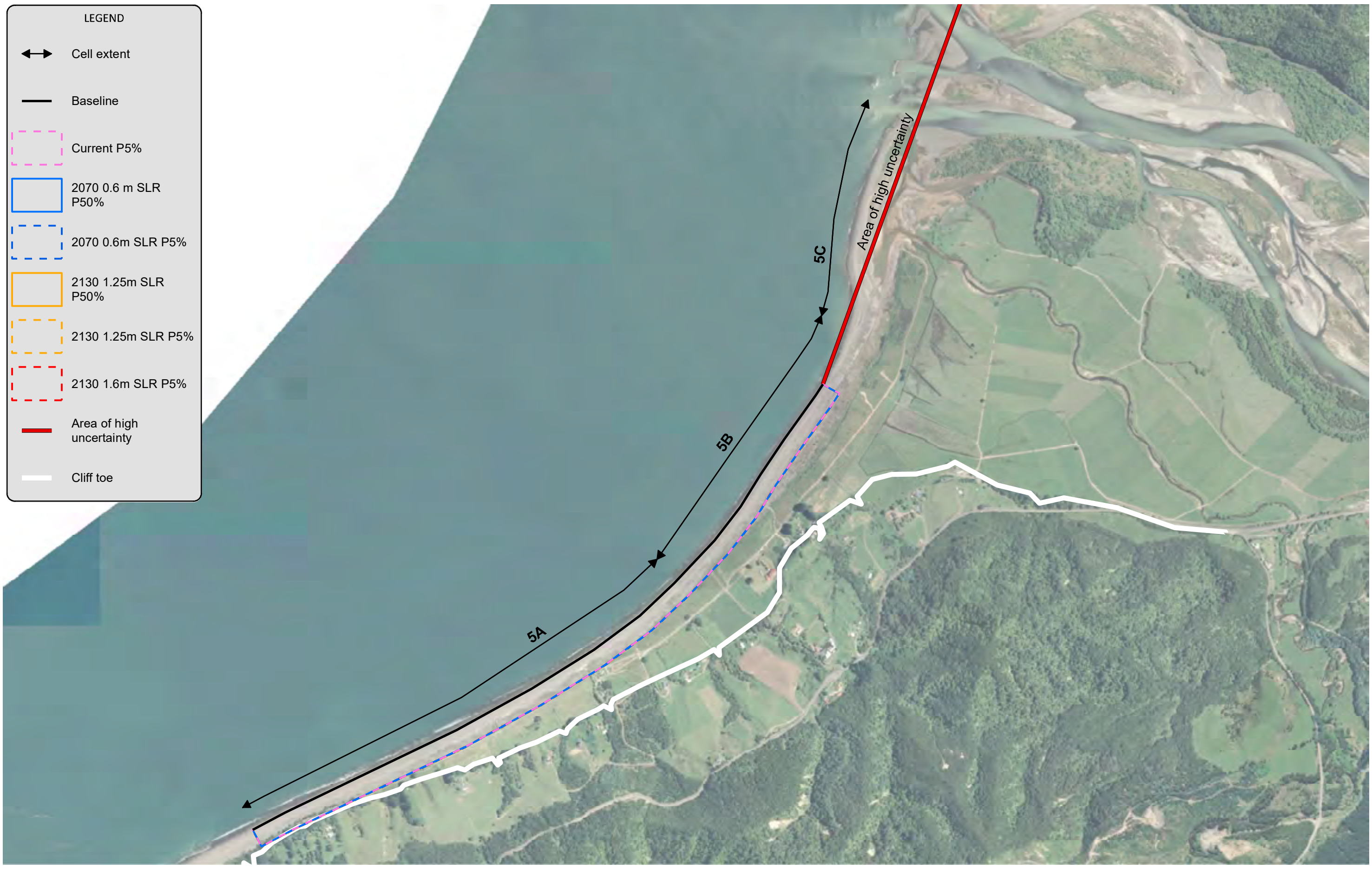
The current P5% hazard area along the Houpoto shoreline is approximately a -65 m offset from the high water mark which is equivalent to the existing gravel barrier width. Long-term accretion dominates the Houpoto shoreline and subsequently the future CEHA are seaward of the current CEHA. Although the future CEHA also take into account SLR, the impact from long-term accretion is likely to counteract any potential recession due to SLR. For these future scenarios, the CEHA have been mapped equivalent to the current hazard.

The CEHA have not been mapped at the Motu River mouth. This is because there is high uncertainty due to the hazard being dominated by river processes which have not been accounted for within this assessment.

Table 5.2: Coastal erosion hazard widths (m) for Houpoto for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Houpoto	5A	Current (2020)	0.03	N/A	-32	-51	-55	-64	-67
		50yr (2070)	0.4	RCP4.5	-12	-44	-48	-63	-76
			0.6	RCP8.5	-13	-45	-50*	-65	-78
		110yr (2130)	0.8	RCP4.5	22	-19	-25	-44	-58
			1.25	RCP8.5	17	-25	-32*	-51*	-66
			1.6	RCP8.5+	14	-30	-36	-57*	-71
	5B	Current (2020)	0.03	N/A	-32	-51	-55	-64	-67
		50yr (2070)	0.4	RCP4.5	-15	-43	-48	-63	-76
			0.6	RCP8.5	-16	-45	-50*	-65	-78
		110yr (2130)	0.8	RCP4.5	25	-19	-25	-44	-59
			1.25	RCP8.5	21	-25	-31*	-52*	-68
			1.6	RCP8.5+	19	-29	-36	-57*	-74
	5C	Current (2020)	0.03	N/A	River mouth – Area of high uncertainty (see main report Section 4.4.4)				
		50yr (2070)	0.4	RCP4.5					
			0.6	RCP8.5					
		110yr (2130)	0.8	RCP4.5					
			1.25	RCP8.5					
			1.6	RCP8.5+					

*Mapped equivalent to the current CEHA



Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

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Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 5: Houpoto

FIGURE No. Figure 5.7 Rev. 0

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6 Ōmaio Bay

6.1 Site description

Ōmaio Bay is approximately 35 km northeast of Ōpōtiki. The shoreline is a 4 km long sand and gravel beach that located between Pokohinu Point to the southwest and Okahau Point to the northeast (Figure 6.1). The Haparapara River mouth is located at the northeastern end of the shoreline and there are several small streams that discharge onto the beach at the southwestern end. Houses are scattered along the coast, with a concentration at Ōmaio to the southwest, Otuwhare at the centre and Pariokara to the north. Dwellings at Ōmaio and Otuwhare are located landward of SH35 or local roads but houses at Pariokara are located on the coastal plain seaward of the highway. The site has been split into five cells based on the morphology and coastal exposure described below.

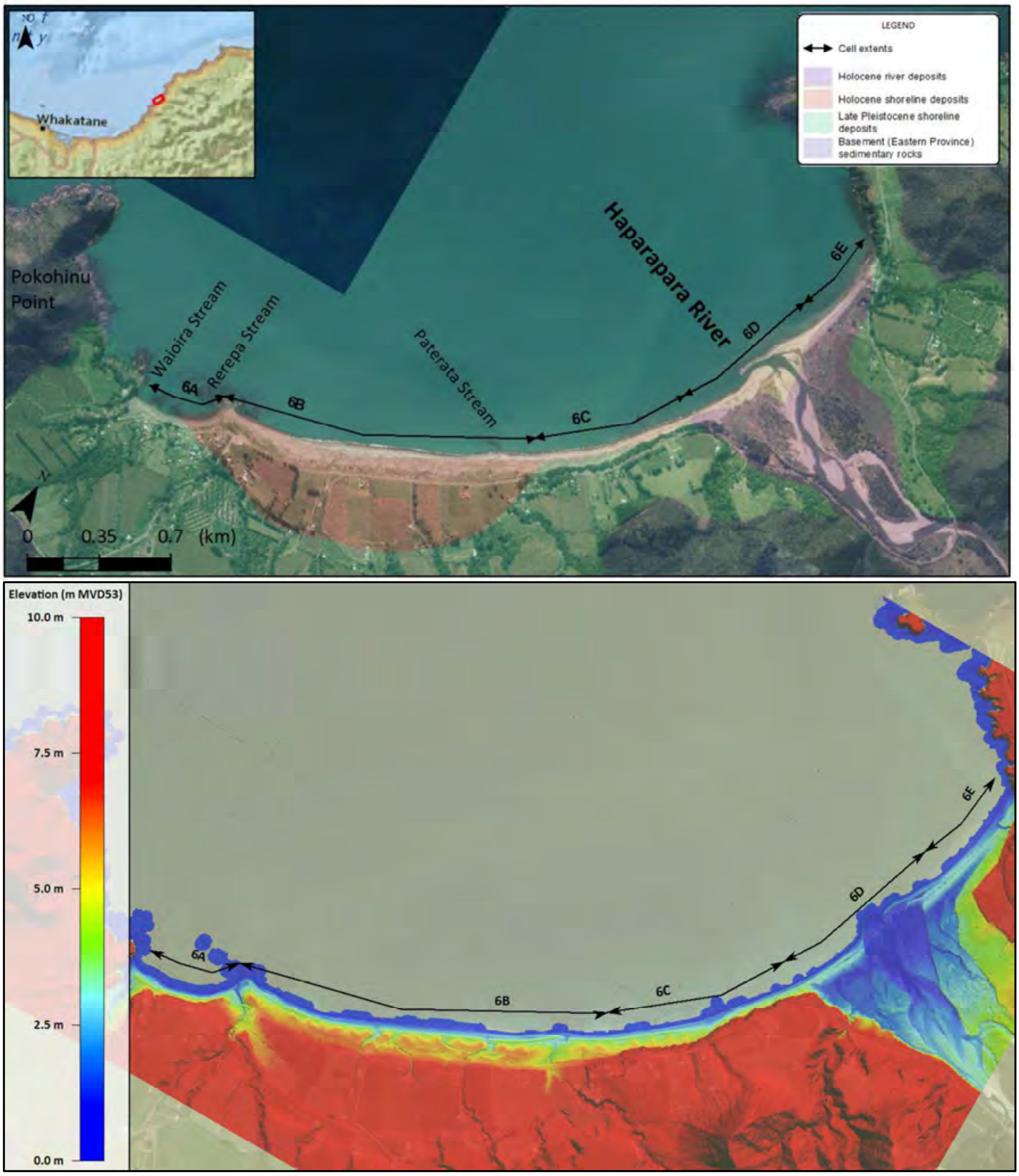

Figure 6.1: Site location and cell splits for Ōmaio Bay (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

6.2 Morphology

The southwestern section of Ōmaio Bay (cell 6A) is located at the seaward edge of a Holocene coastal plain that is elevated between 5 to 10 m RL and is comprised of alluvial sand and gravel deposits. The coastal plain extends 200 to 400 m landward of the beach and is backed by late Pleistocene Marine terrace formation (Figure 6.1). At the centre of the bay the Pleistocene marine terrace is located at the edge of the active beach (cell 6C). The northern section near Pariokara is characterised by Holocene river deposits within the floodplain that extends for 1 km alongshore (cell 6D and 6E) (Figure 6.1).

At the southwestern end of the beach there is a network of rock outcrops that provide shelter to the shoreline fronting Ōmaio settlement (cell 6A). Two small streams discharge on to the beach at either end of cell 6A. Cell 6A and 6B are separated by a tombolo that has formed connecting the beach with the rock outcrop (Figure 6.2, A).

Observations within cell 6A indicate the beach is comprised predominantly of fine pebbles (0.2 to 1 cm in diameter) with a band of cobbles near the swash line (Figure 6.3, Profile B). The grain size is smaller than the rest of the Ōmaio coast which is likely due to distance from the Haparapara River and a decrease in sediment transport around the rock outcrop and tombolo. The foreshore slope is relatively steep at 7.8(H):1(V) and extends to the vegetation line which is characterised by grass and shrubs lined by driftwood debris. There is no marked evidence of erosion at the vegetation line although it appears swash processes occasionally reach this location of the beach. An 8 to 25 m wide grass reserve is located between the beach and road with the Ōmaio settlement located on the landward side.

Cell 6B is characterised by sand gravel beach with backshore elevations between 5 to 6 m RL. There are also several small streams within cell 6B. Observations within cell 6B show the foreshore was comprised by poorly sorted pebbles with a diameter of 0.5 to 4 cm and had a slope of 9.5(H):1(V) (Figure 6.3, Profile A). A marked beach crest built from 3 to 8 cm cobble clasts was located approximately 40 m seaward of the vegetation line. The backshore environment between the crest and vegetation line was scattered with wave washed debris and dominated by cobble size material. The undulating backshore transitions into a grassed low lying plain with no evidence of erosion present during the visit.

The shoreline within cell 6C is located at the base of the Pleistocene marine terrane lined with Pohutukawa Trees for an alongshore distance of 800 m. Vegetation along the backshore of this section indicates that the beach is stable at present.

Cell 6D includes the Hapapara River mouth with a 700 m long section of coast with barrier spit features associated with the river dynamics (Figure 6.2, C). At the northern side of the Haparapara River mouth there is a 400 m section of west-facing, sand gravel beach (cell 6E). Access to this section of coast was limited due to private property but aerial inspection shows some scarping of the grass bank at the landward extent of the beach (Figure 6.2).

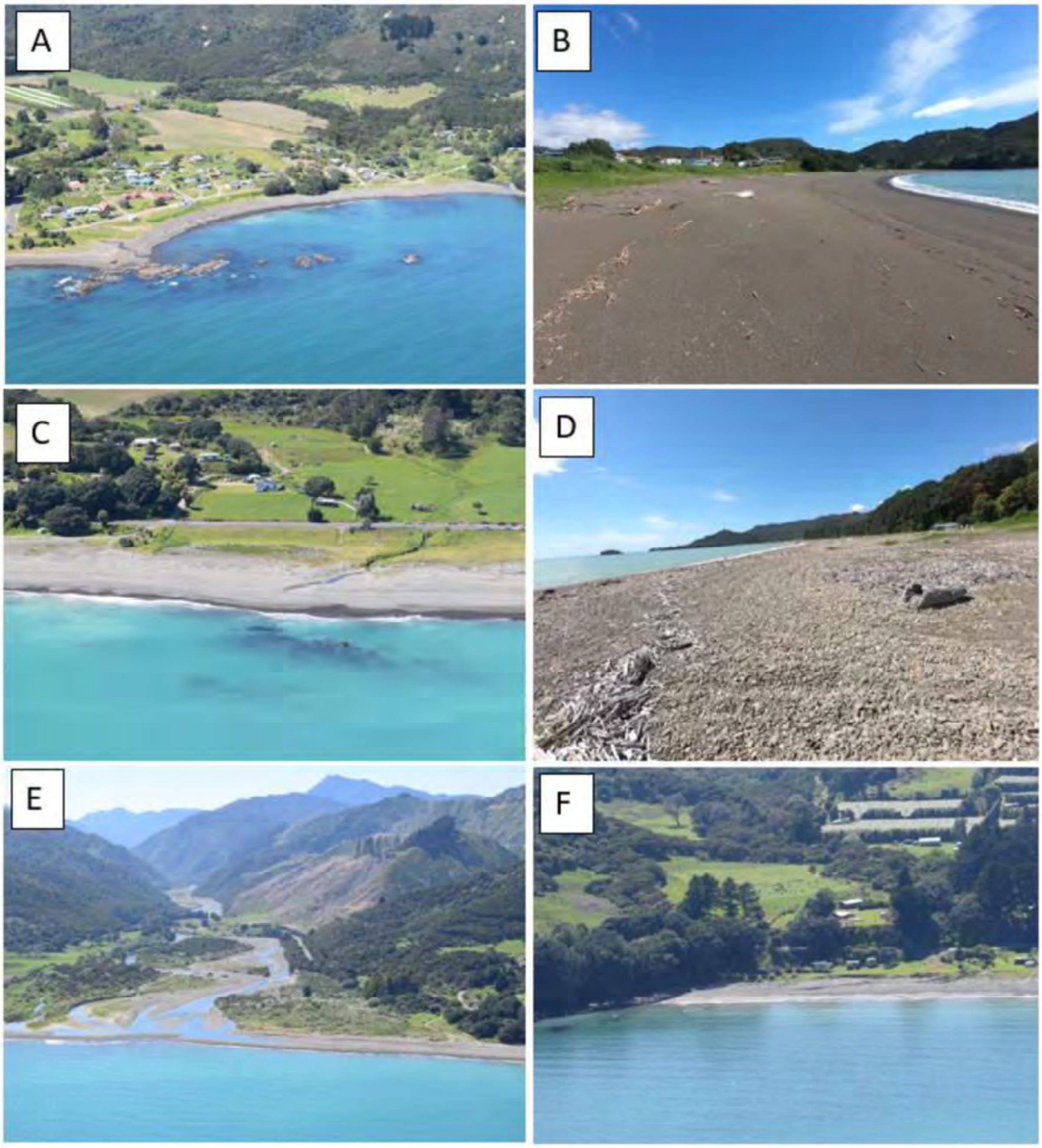

Figure 6.2: Site photos for Ōmaio Bay. (A) Ōmaio settlement (cell 6A). (B) Sand gravel beach fronting Ōmaio settlement (cell 6A). (C) Paterata Stream mouth (cell 6B). (D) Sand gravel beach within cell 6C. (E) Haparapara River mouth (cell 6D). (F) Eastern end of the shoreline (cell 6E).

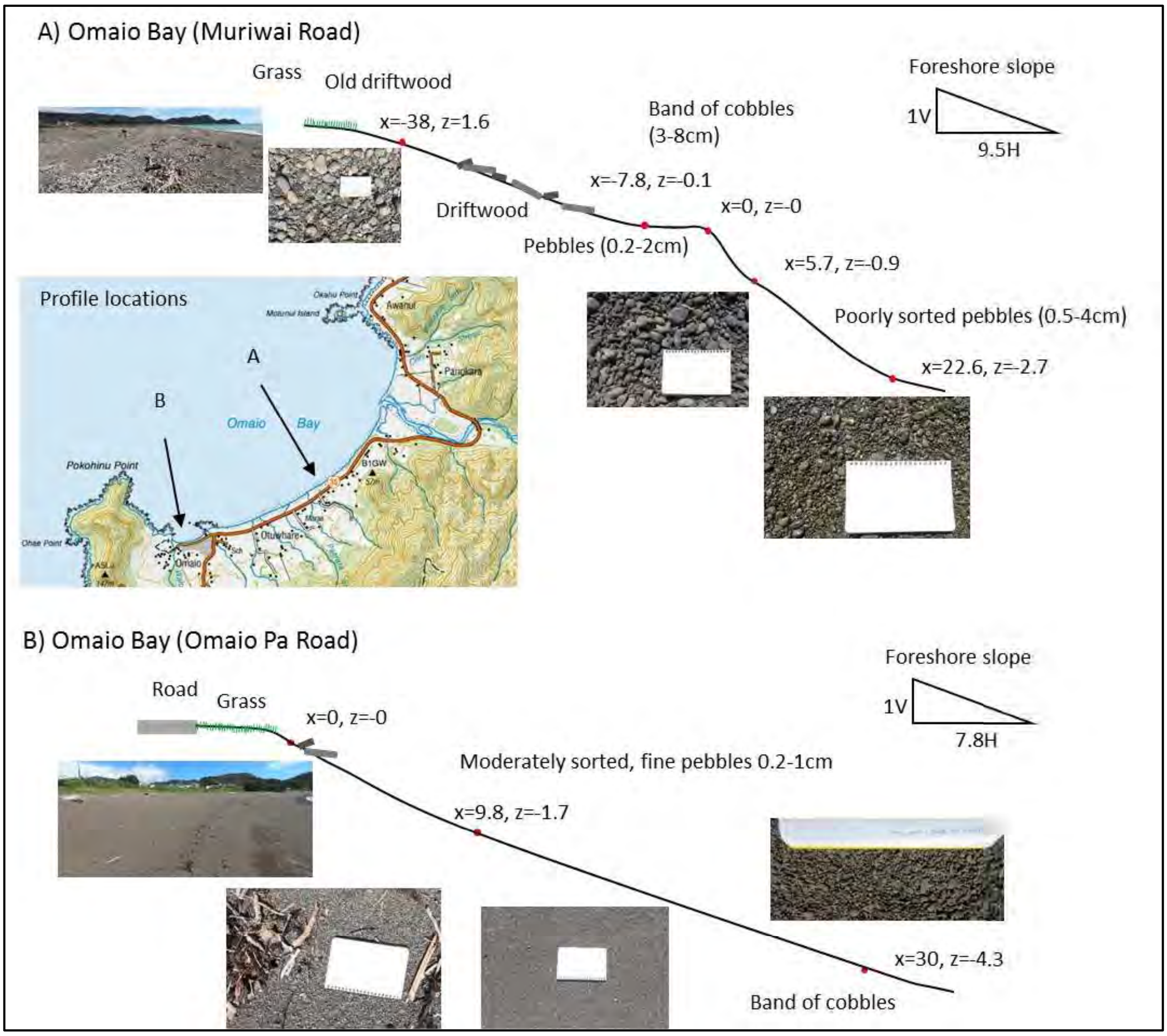

Figure 6.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cells 6B and 6A

6.3 Coastal processes

The Ōmaio shoreline is predominately exposed to swell waves from the north to northwest. The headlands at either end do provide some sheltering to the bay particularly at the southwestern end.

The Haparapara River has a significant influence on coastal processes at Ōmaio Bay and is likely the primary supply of sediment to the coast. It appears that material from the river is transported to the southwest by northerly approaching waves. Channel migration and river processes strongly influence a 700 m wide section of the beach at the north end of the bay. The small streams that discharge along the coast appear to have a minor influence on the adjacent shoreline.

6.3.1 Dynamic zone

The dynamic zone along Ōmaio Bay has been assessed based on XBeach-G modelling. Design storm conditions from NIWA (2019) are based on wave heights and storm tide levels offshore from Te Kaha which is approximately 8 km northeast of Ōmaio. Due to the more sheltered coastline within cell 6A, a 30% reduction in wave height has been assumed.

Model results indicate the dynamic zone ranges from 21 to 46 m from the MHWS position along Ōmaio west (Figure 6.5) and from 43 to 86 m along Ōmaio centre (Figure 6.6). This zone extends approximately 5 to 15 m landward of the present day vegetation edge. For comparison, Medwin (2008) reports that during Cyclone Ivy in 2004 the water level along Ōmaio peaked at 5.32 m RL which is approximately 1 to 2 m above the 2011 berm elevation. Site observations indicate storm debris approximately 50 m landward of high water mark (Figure 6.4).

The 2015 debris survey lines provided by BOPRC show the debris line approximately 25 m landward within cell 6A and 35 m landward within cell 6B which also demonstrates the dynamic zone on the western side of the cuspate headland (cell 6A) is smaller compared with the remainder of the shoreline.

Figure 6.4: Storm debris across foredune in front of Ōmaio store. Sourced from Medwin (2008)

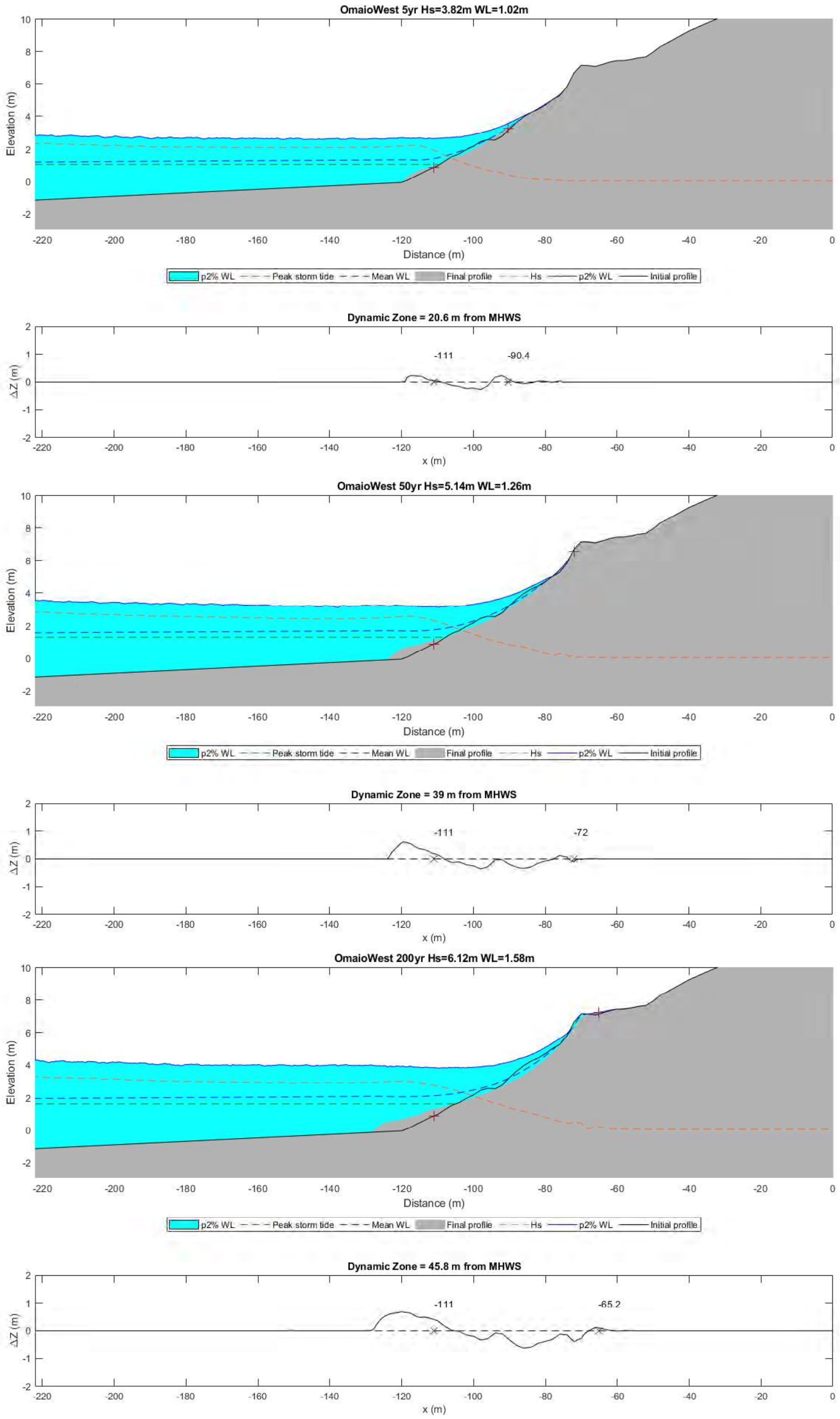

Figure 6.5: XBeach-G model results for Ōmaio west (cell 6A)

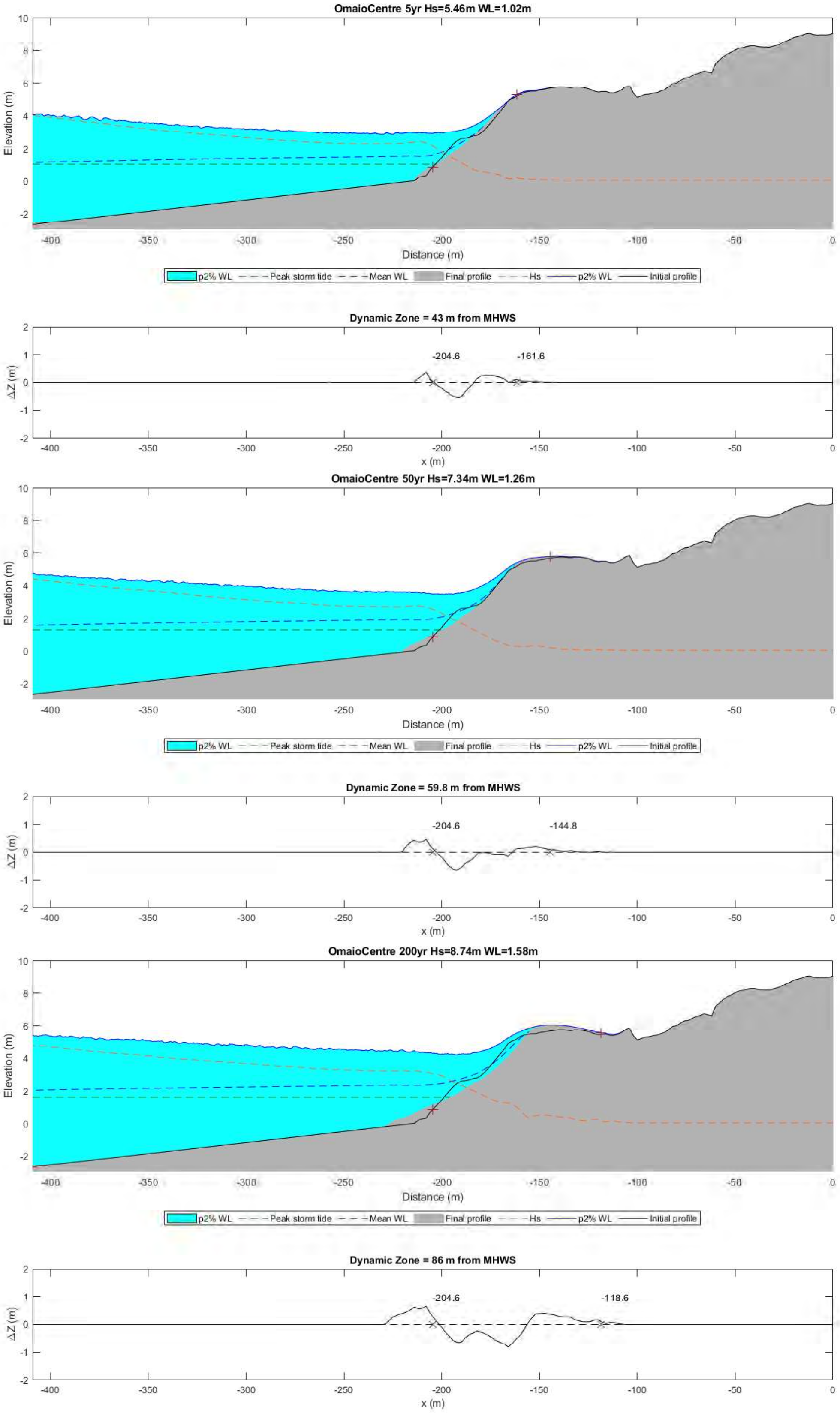

Figure 6.6: XBeach-G model results for Ōmaio centre (cell 6B to 6E)

6.3.2 Long-term trends and medium-term fluctuations

Shoreline data for Ōmaio includes high water surveys for 1916 to 2019 as well as a vegetation survey in 2015 (Figure 6.7). High water surveys within cell 6A show the shoreline has fluctuated within a 10 m envelope and is showing a slight accretional trend with the 2019 high water survey 10 to 15 m seaward of the 1916 survey.

The shorelines within cells 6B and 6C show a period of accretion between 1916 and 1957, followed by 10 to 20 m erosion between 1957 and 1981. Since 1981 the shoreline has advanced 10 to 30 m seaward. Based on the DSAS analysis, cells 6B and 6C show long-term accretion rates of 0.1 to 0.6 m/yr (Figure 6.8). Medium-term fluctuations of up to 15 m have been accounted for within cells 6B and 6C.

The Haparapara River mouth within cell 6D appears to be very dynamic and directly influences the adjacent shoreline within cell 6E. The high water surveys within cell 6E show up to 40 m erosion between 1962 and 1970. Reports from long-time residents described in Dahm and Kench (2007) also say the shoreline eroded landward by up to 80 m near the headland at the eastern extent. Based on the high water surveys, DSAS analysis indicates very high erosion rates (Figure 6.8). However, over recent years the shoreline appears relatively stable with the 2019 high water mark slightly seaward of the 1981 survey. It is likely that the shoreline within cell 6E experiences large medium-term fluctuations (40 m) associated with changes in the Haparapara River mouth instead of significant long-term erosion.

Figure 6.7: Historic shorelines along Ōmaio

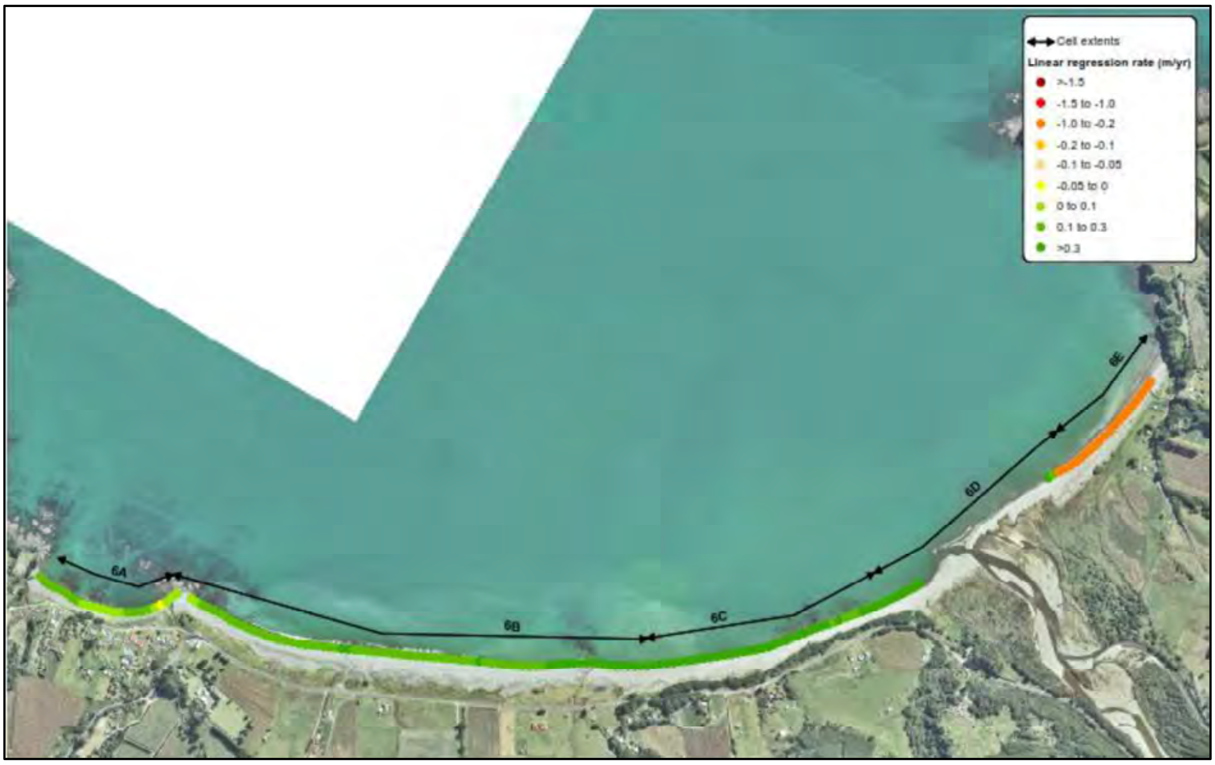

Figure 6.8: DSAS results for Ōmaio

6.3.3 Sea level rise

SLR is expected to increase wave overtopping along Ōmaio. Subsequently it is expected that the gravel berm will migrate landward and increase in elevation (barrier rollover). Berm elevation is slightly lower at the eastern extent of the beach (cells 6C to 6E) and therefore the landward migration is expected to be greater at the eastern end compared to the western end (cells 6A and 6B). Under high future SLR scenarios (i.e. 1.6 m) the berm may migrate between 25 to 70 m landward along the Ōmaio shoreline.

6.4 Adopted component values

Adopted component values are presented in Table 6.1.

Table 6.1: Adopted component values for the cells along Ōmaio shoreline

Site		Ōmaio				
Cell		6A	6B	6C	6D	6E
Cell centre (NZTM)	E	2007612	2008597	2009523	2009930	2010112
	N	5804683	5805063	5805652	5806313	5806845
Chainage, m (from W)		0 to 460	460 to 2000	2000 to 2800	2800 to 3540	3540 to 3990
Morphology		Sand gravel beach	Sand gravel beach	Sand gravel beach	River mouth	Sand gravel beach
Baseline		2019 high water mark	2019 high water mark	2019 high water mark	River mouth – Area of high uncertainty (see main report Section 4.4.4)	2019 high water mark
Dynamic zone (m)	Min	21	43	43		43
	Mode	39	60	60		60
	Max	46	86	86		86
Medium term (m)	Min	0	5	5		20
	Mode	5	10	10		30
	Max	10	15	15		40
Long-term (m/yr) -ve erosion +ve accretion	Min	0.1	0.3	0.6		0.05
	Mode	0.05	0.25	0.3		0
	Max	0	0.1	0.2		-0.05
Berm elevation (m)	Min	3	4	2.5		2
	Mode	4	4	3		2.5
	Max	6	4.5	3.5		3

6.5 Coastal erosion hazard

Coastal erosion hazard distances for Ōmaio Bay are presented within Table 6.2 and an overview map in Figure 6.9. Erosion hazard distances have been offset from the 2019 high water mark. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

The current P5% CEHA ranges from -43 m at the western end to -78 m at the eastern end. The future CEHA within cell 6A is up to -70 m for the 2130 1.6m SLR P5% scenario, however, there is a small bluff that runs along the landward extent of the existing beach. The assessment indicates that the toe of the bluff may become at risk to toe erosion under future SLR scenarios. However, instability of the cliff toe has not been accounted for within this assessment and subsequently, the mapped CEHA have been bound along the cliff toe. Similarly, along cell 6C the cliff toe is less than 40 m from the existing high water mark and the assessment shows that the cliff toe may become susceptible to future coastal erosion. The cliff toe within cell 6E is also at risk to erosion under future SLR rise scenarios.

The shoreline along cells 6B and 6C has shown long-term accretion and subsequently some of the low SLR scenarios (i.e. 2070 0.6m SLR P50%) are seaward of the current CEHA. Although the future CEHA also take into account SLR, for the low sea level rise scenarios, the impact from long-term accretion is likely to counteract any potential recession due to SLR. For these future scenarios, the CEHA have been mapped equivalent to the current hazard.

The CEHA within cell 6D (Haparapara River mouth) have not been mapped. This is because there is high uncertainty due to the hazard being dominated by river processes which have not been accounted for within this assessment.

Table 6.2: Coastal erosion hazard widths (m) for Ōmaio Bay for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Ōmaio	6A	Current (2020)	0.03	N/A	-21	-34	-36	-43	-46
		50yr (2070)	0.4	RCP4.5	-21	-41	-44	-53	-62
			0.6	RCP8.5	-22	-42	-45	-55	-63
		110yr (2130)	0.8	RCP4.5	-19	-46	-50	-63	-75
			1.25	RCP8.5	-21	-49	-53	-67	-80
			1.6	RCP8.5+	-22	-51	-56	-70	-83
	6B	Current (2020)	0.03	N/A	-43	-58	-62	-78	-86
		50yr (2070)	0.4	RCP4.5	-44	-68	-72	-90	-105
			0.6	RCP8.5	-45	-70	-74*	-93	-107
		110yr (2130)	0.8	RCP4.5	-39	-67	-72	-91	-107
			1.25	RCP8.5	-43	-73	-78	-99	-115
			1.6	RCP8.5+	-46	-77	-83	-105	-121
	6C	Current (2020)	0.03	N/A	-43	-58	-62	-78	-86
		50yr (2070)	0.4	RCP4.5	-33	-61	-66	-85	-100
			0.6	RCP8.5	-34	-64	-68*	-88	-103
		110yr (2130)	0.8	RCP4.5	-15	-52	-58	-81	-100
			1.25	RCP8.5	-21	-60	-66*	-91	-112
			1.6	RCP8.5+	-25	-66	-73	-99	-121
	6D	Current (2020)	0.03	N/A	River mouth – Area of high uncertainty (see main report Section 4.4.4)				
		50yr (2070)	0.4	RCP4.5					
			0.6	RCP8.5					
		110yr (2130)	0.8	RCP4.5					
			1.25	RCP8.5					
			1.6	RCP8.5+					
	6E	Current (2020)	0.03	N/A	-43	-58	-62	-78	-86
		50yr (2070)	0.4	RCP4.5	-77	-95	-99	-116	-126
			0.6	RCP8.5	-79	-97	-102	-120	-131
		110yr (2130)	0.8	RCP4.5	-78	-99	-103	-122	-134
			1.25	RCP8.5	-85	-109	-114	-135	-150
			1.6	RCP8.5+	-90	-116	-121	-145	-162

*Mapped equivalent to the current CEHA

Notes: Aerial photograph sourced from LINZ Data Service 2019

A3 SCALE 1:11,000

0 0.1 0.2 0.3 0.4 0.5 (km)

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Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 6: Ōmaio

FIGURE No. Figure 6.9 Rev. 0

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7 Maraetai Bay and Wharekura Bay

7.1 Site description

Maraetai Bay and Wharekura Bay are located approximately 45 km northeast of Ōpōtiki. Maraetai Bay is a 440 m long west-facing sand beach with rock reefs at either side (Figure 7.1). The southwestern end of the beach is bound by Kopuni Point and the northeastern end is bound by Wharekura Point which comprises a recreational reserve. There are two small streams which discharge near the beach. On the eastern side of Wharekura Point is Wharekura Bay which comprises a northwest-facing, sand gravel beach that is approximately 1.5 km long (Figure 7.1). The Pakaranui Stream discharges near the centre of the beach and at the northeastern end is the Mouriuri Stream. Settlements are scattered between the western end of Maraetai Bay and the eastern end of Wharekura Bay. SH35 follows most of the coast within a proximity of 10 to 50 m. The site has been split into four cells morphology and coastal exposure described below.

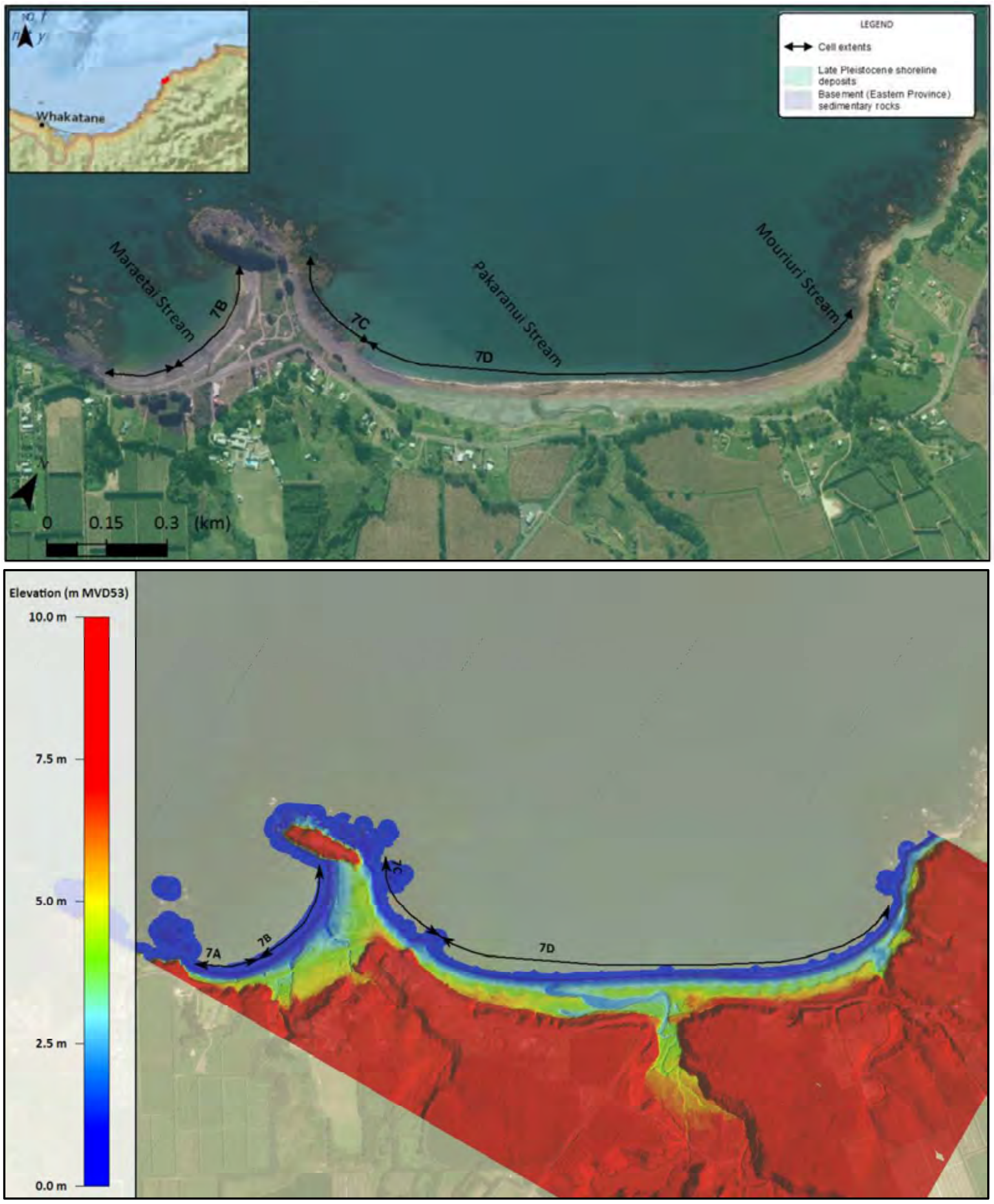

Figure 7.1: Site location and cell splits for Maraetai and Wharekura (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

7.2 Morphology

Maraetai Bay and Wharekura Bay are backed by a low-lying coastal plain that comprises Holocene shoreline deposits. Approximately 50 to 150 m landward from the contemporary beach is a Late Pleistocene marine terrace formation which has an elevation of 12 to 30 m RL (Figure 7.1).

Wharekura Beach comprises sands and gravels while Maraetai Beach is predominately sand. The source of sediment for both of the beaches is likely southwest alongshore transport form the Kereu River which discharges at the coast 1.5 km north of Wharekura. It appears that southwest transport of gravel materials have accumulated to form Wharekura Beach and subsequently the tombolo which joins Wharekura Point with the mainland. The presence of Whakerkura Point is likely to prevent gravel entering Maraetai Bay, although sand is still likely to be transported around the point.

Cell 7A comprises northwest-facing sand shoreline backed with vegetated banks ranging from 5 to 8 m RL. The toe of the grass embankment is located within 5 m of SH35. Cell 7B has a west-facing orientation and lower back shore elevations, ranging from 2 to 3 m RL.

Site observations at cell 7B indicate the foreshore was comprised of very well sorted fine sand with a slope of 10(H):1(V) (Figure 7.4). Irregular alongshore cusps comprised by a mix of pebbles and fine sand were present along the high water mark, 10 to 15 m seaward of the grass berm (Figure 7.2, C). Maraetai Stream outflows at the centre of the beach, resulting in erosion and undercutting of the adjacent bank (Figure 7.2, D). Scarping along the embankment indicates the beach may currently be in a state of erosion.

Figure 7.2: Site photos for Maraetai Bay. (A) Western end Maraetai Bay (cell 7A). (B) Wharekura Point at the eastern end of Maraetai Bay (cell 7B). (C) Flat sandy beach within cell 8A. (D) Undercutting of grass bank from the Maraetai Stream (cell 7B)

Cell 7C makes up the eastern side of the tombolo and is characterised by a northeast-facing sand gravel beach, fronted by rock outcrops (Figure 7.3, A). The Wharekura shoreline wraps around to a northwest-facing, sand gravel beach intersected by the Pakaranui Stream (cell 7D) (Figure 7.3, B).

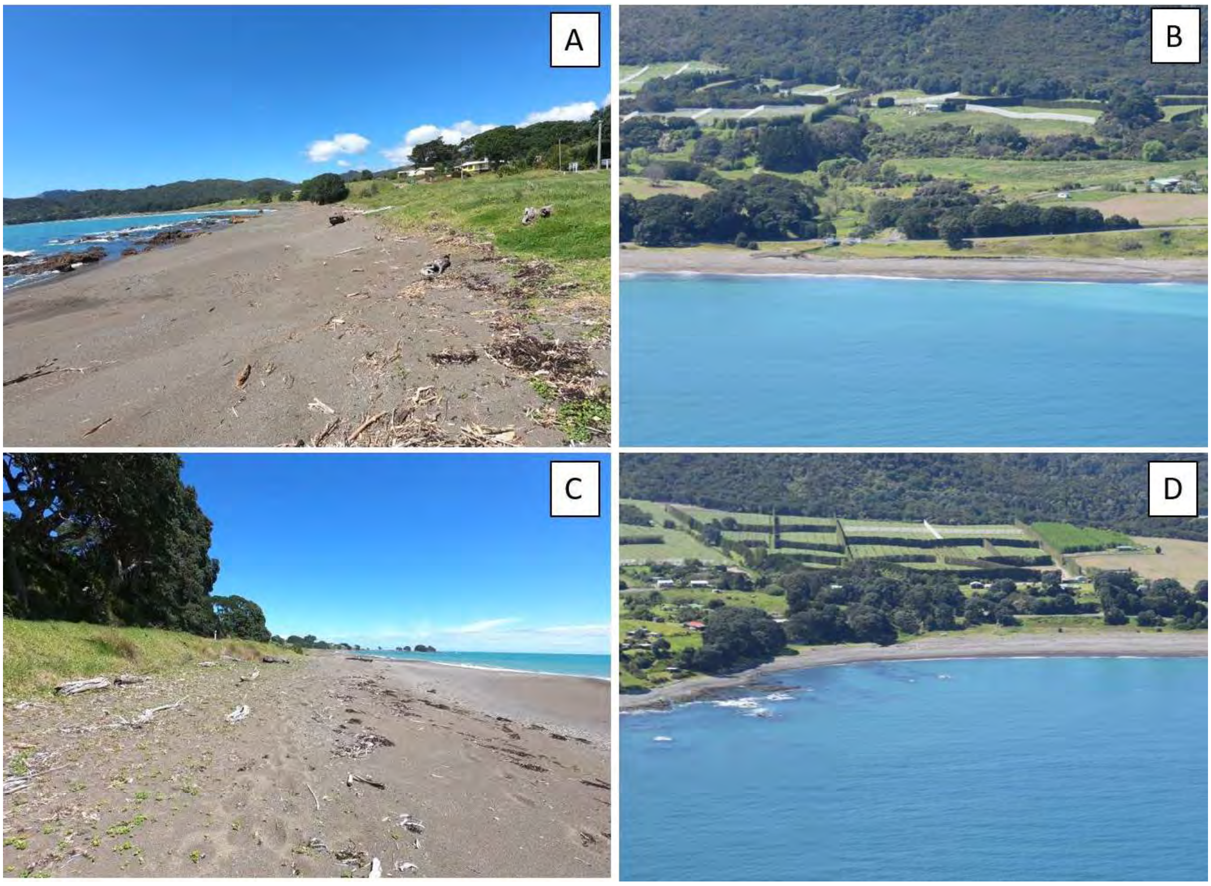

Figure 7.3: Site photos for Wharekura Beach. (A) Sand gravel beach within cell 7C. (B) Pakaranui Stream within cell 7D. (C) Stable grass bank within cell 7D. (D) Eastern extent of Wharekura Beach (cell 7D).

Site observations along Wharekura Beach show the lower beach was comprised of well sorted pebbles between 2 to 5 mm with a foreshore slope of 5.5(H):1(V) leading up to a beach step with alongshore irregular cusp features (Figure 7.4). The mid beach and backshore had a lower gradient and larger grain size with a mix of pebbles (0.5 to 5 cm diameter) and coarse sand. Driftwood debris was scattered across the backshore and wedged against the toe of a grass embankment (Figure 7.3, C). The 1.5 to 2 m high grass embankment defines the landward limit of the beach. There was no evidence of erosion or scarping along the embankment. The vegetation succession seaward of the embankment indicates the system is currently stable and potentially accreting.

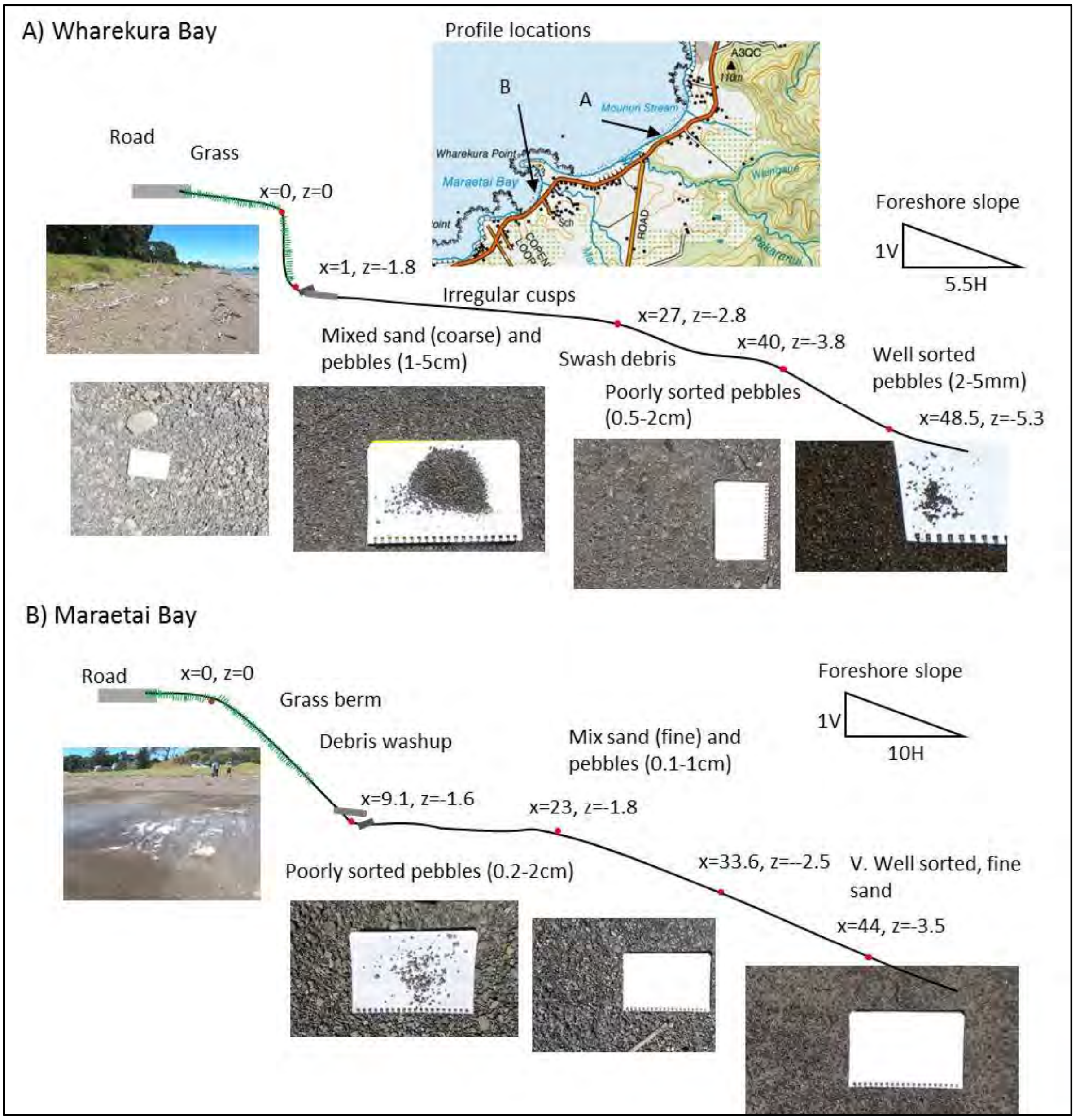

Figure 7.4: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at 7B and 7D

7.3 Coastal processes

Maraetai Bay faces west and is fully enclosed by rock reef and headlands which create a low energy lagoon environment 200 m offshore from the beach. Wharekura Beach faces northwest and is predominately exposed to open ocean swell waves from the north. As described in Section 7.2 the net sediment transport is southwest from the Kereru River.

7.3.1 Short-term and dynamic zone

Maraetai Bay is classified as a sandy beach and therefore the short-term fluctuations are defined by storm cut of the dune toe. In contrast, Wharekura Beach is classified as a mixed sand gravel beach where the short term component is defined by the dynamic zone (landward extent of gravel overwash from the high water mark).

Due to lack of profile data it is difficult to determine the short-term storm cut along Maraetai Bay. Based on a combination of field observations, judgement and previous studies, the storm cut potential along Maraetai Bay is assumed to be between 2 to 10 m.

The dynamic zone along Wharekura Beach has been assessed based on XBeach-G modelling. Model results indicate the dynamic zone ranges from 67 to 80 m along Wharekura beach (Figure 5.4). This zone extends approximately 10 to 20 m landward of the current edge of vegetation. As described in Dahm and Kench (2007) the low-lying backshore along Wharekura Beach is vulnerable to overwash during severe storms. Medwin (2008) reports that peak water levels along Wharekura Beach during Cyclone Ivy were 4.76 m RL which is 0.8 to 2 m above the 2011 berm elevation.

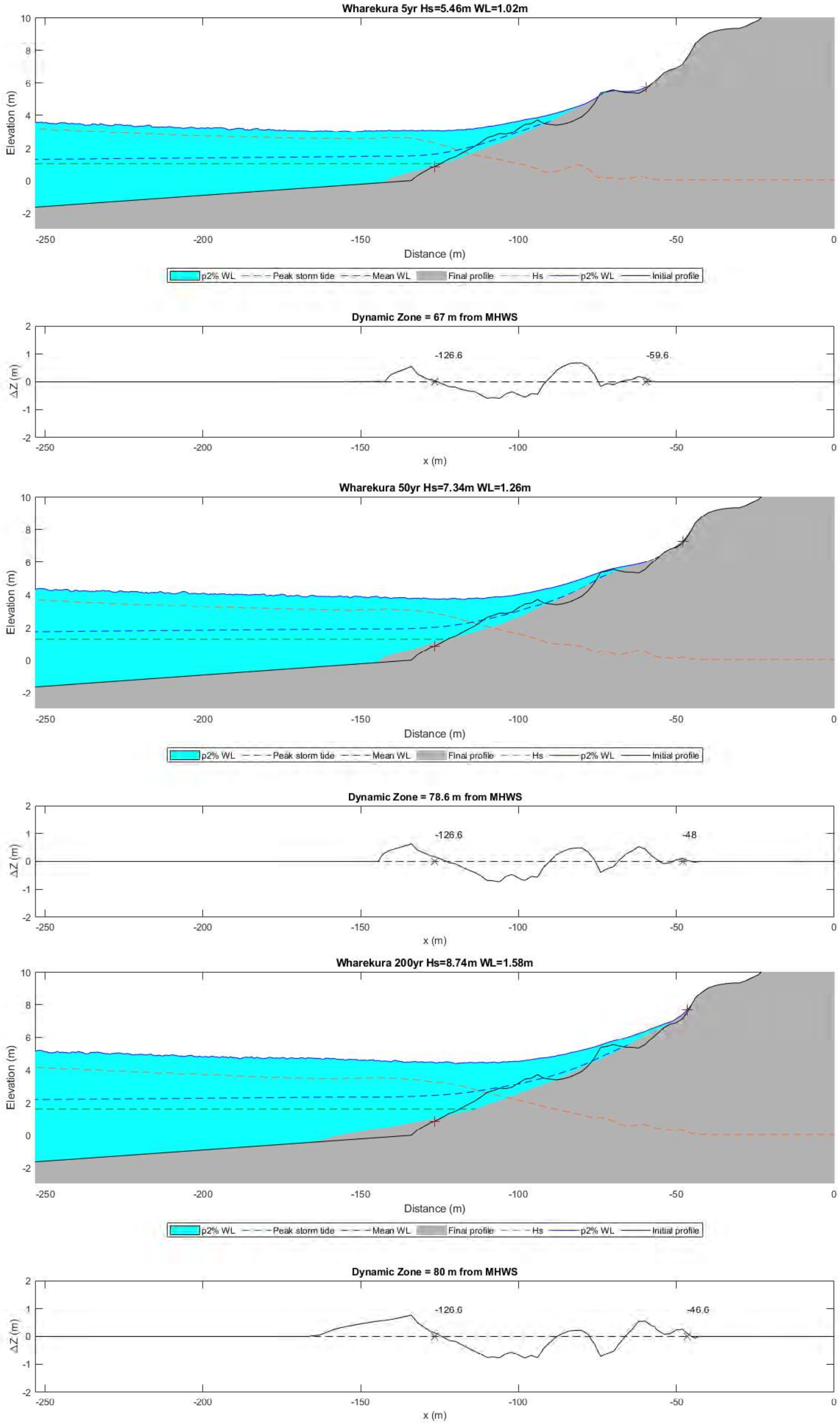

Figure 7.5: XBeach-G model results for Wharekura

7.3.2 Long-term trends and medium-term fluctuations

Shoreline data for Wharekura and Maraetai Bay is limited to edge of vegetation surveys for 1909, 2011 and 2019 and high water surveys between 1951, 1980 and 2019 (Figure 7.6). The edge of vegetation surveys along Maraetai Bay indicate relative stability at either end of the bay with up to 16 m accretion between 1909 and 2019 within the centre of the bay. Due to the limited dataset it is difficult to determine any long-term trends. Subsequently to account for this uncertainty, long-term trends of 0.05 to -0.05 m/yr have been adopted within cells 7A and 7B along Maraetai Bay.

The historic shoreline data indicates minimal change in the shoreline position within cell 7C on the eastern side of the tombolo. The DSAS analysis shows long-term rates ranging from 0.05 to -0.05 m/yr. The shoreline data within cell 7D shows accretion of the high water mark from 1980 to 2019. The edge of vegetation surveys also show accretion along majority of cell 7D, although there does appear to be localised erosion along the edge of vegetation near the Pakaranui Stream. The DSAS analysis shows long-term rates ranging from 0.1 to -0.1 m/yr (Figure 7.7). Based on the shoreline data there does not appear to be any medium-term fluctuations along the Wharekura shoreline.

Figure 7.6: Historic shorelines along Maraetai Bay and Wharekura Beach

Figure 7.7: DSAS results for Wharekura beach. Regression rates absent for Maraetai Bay due to limited comparable shoreline data

7.3.3 Sea level rise

The response to SLR along Maraetai Bay has been assessed using the beach face slope. Sediment availability and exchange is not expected to extend beyond the offshore rocky reef. Based on the modified Bruun Rule, high future SLR scenarios may result in erosion of 25 to 40 m.

SLR is expected to increase wave overtopping along Wharekura Beach. Subsequently it is expected that the gravel berm will migrate landward and increase in elevation (barrier rollover). The landward migration could be up to 40 m under high future SLR scenarios.

7.4 Adopted component values

Adopted component values for Maraetai Bay are presented in Table 7.1 and adopted component values for Wharekura Beach are presented in Table 7.2.

Table 7.1: Adopted component values along the Maraetai shoreline

Site		**Maraetai**	**Maraetai**
Cell		**7A**	**7B**
Cell centre (NZTM)	**E**	2013555	5813744
	N	2013681	5813956
Chainage, m (from W)		0 to 180	180 to 524
Morphology		Sand beach	Sand beach
Baseline		2019 seaward edge of vegetation	2019 seaward edge of vegetation
Short-term (m)	**Min**	2	2
	Mode	4	5
	Max	6	10
Dune (m above toe)	**Min**	1.5	0.5
	Mode	1.0	1
	Max	2.0	1.5
Stable angle (deg)	**Min**	30	30
	Mode	32	32
	Max	34	34
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0	0
	Mode	-0.01	-0.01
	Max	-0.05	-0.05
Beach face slope	**Min**	0.02	0.02
	Mode	0.05	0.05
	Max	0.06	0.06

Table 7.2: Adopted component values along Wharekura shoreline

Site		Wharekura	Wharekura
Cell		7C	7D
Cell centre (NZTM)	E	2013847	2014554
	N	5814102	5814297
Chainage, m (from W)		0 to 180	180 to 1335
Morphology		Sand gravel beach	Sand gravel beach
Baseline		2019 high water mark	2019 high water mark
Dynamic zone (m)	Min	67	67
	Mode	79	79
	Max	80	80
Medium term (m)	Min	0	0
	Mode	0	0
	Max	0	0
Long-term (m) -ve erosion +ve accretion	Min	0.05	0.1
	Mode	0	0
	Max	-0.05	-0.05
Berm elevation (m)	Min	3	3
	Mode	3.5	3.5
	Max	4	4

7.5 Coastal erosion hazard

Coastal erosion hazard distances for Maraetai and Wharekura Bay are presented in Table 7.3 and an overview map in Figure 7.8. Erosion hazard distances along Maraetai Bay have been offset from the 2019 seaward edge of vegetation and the hazard distances along Wharekura Beach have been offset from the 2019 high water mark. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

The CEHA along Maraetai Beach (cells 7A and 7B) ranges from -10m for the current P5% hazard and is up to -37m for the future CEHA. The assessment shows the cliff toe on the landward side of the road along cell 7A may become at risk to future coastal erosion. However, instability of the cliff toe has not been accounted for within this assessment and subsequently, the mapped CEHA have been bound along the cliff toe.

The current CEHA within cells 7C and 7D is approximately a -80 m offset from the 2019 high water mark which for most of the shoreline is equivalent to the width of existing gravel barrier. The full width of the Holocene beach and barrier is subject to future erosion. The toe of the cliff along cell 7D may also become at risk to future coastal erosion and subsequently the mapped CEHA have been bound along the cliff toe.

Table 7.3: Coastal erosion hazard widths (m) for Maraetai and Wharekura Bay for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Maraetai	7A	Current (2020)	0.03	N/A	-3	-6	-7	-10	-11
		50yr (2070)	0.4	RCP4.5	-8	-12	-13	-16	-19
			0.6	RCP8.5	-10	-14	-15	-18	-22
		110yr (2130)	0.8	RCP4.5	-12	-17	-18	-21	-25
			1.25	RCP8.5	-19	-25	-26	-30	-35
			1.6	RCP8.5+	-24	-31	-32	-37	-42
	7B	Current (2020)	0.03	N/A	-3	-6	-6	-9	-11
		50yr (2070)	0.4	RCP4.5	-7	-11	-12	-15	-18
			0.6	RCP8.5	-9	-14	-15	-18	-21
		110yr (2130)	0.8	RCP4.5	-11	-16	-17	-21	-25
			1.25	RCP8.5	-18	-24	-26	-30	-35
			1.6	RCP8.5+	-24	-30	-32	-36	-43
Wharekura	7C	Current (2020)	0.03	N/A	-67	-74	-76	-79	-80
		50yr (2070)	0.4	RCP4.5	-70	-79	-81	-85	-88
			0.6	RCP8.5	-72	-82	-84	-88	-91
		110yr (2130)	0.8	RCP4.5	-71	-83	-85	-91	-95
			1.25	RCP8.5	-78	-92	-94	-100	-105
			1.6	RCP8.5+	-83	-98	-100	-107	-113
	7D	Current (2020)	0.03	N/A	-67	-74	-76	-79	-80
		50yr (2070)	0.4	RCP4.5	-68	-78	-80	-85	-88
			0.6	RCP8.5	-70	-81	-83	-88	-91
		110yr (2130)	0.8	RCP4.5	-66	-81	-83	-90	-95
			1.25	RCP8.5	-73	-90	-92	-100	-105
			1.6	RCP8.5+	-78	-96	-98	-106	-112

Notes: Aerial photograph sourced from LINZ Data Service 2015-2019

A3 SCALE 1:5,000

0 0.055 0.11 0.165 0.22 0.275 (km)

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PROJECT No. 1008669.2000		

Ōpōtiki Coastal Erosion Hazard Assessment

Coastal Erosion Hazard Area (CEHA) Overview Map

Site 7: Maraetai Bay and Wharekura Bay

FIGURE No. Figure 7.8

Rev. 0

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8 Whanarua Bay

8.1 Site description

Whanarua Bay is approximately 56 km northeast of Ōpōtiki. The shoreline is a 900 m wide sand gravel embayment located between headlands extending for 700 m to the west and 400 m to the east (Figure 8.1). The settlement of Whanarua spans three small north facing embayment beaches that are backed by coastal cliffs. The western bay has a number of dwellings that are located on a slightly elevated reserve at the base of the cliff. The central bay has a few dwellings at the base of the cliff, situated on a narrow grass reserve between the beach and cliff. The eastern bay is accessible from private properties at the top of the cliff, however there no dwellings located along the cliff toe. The site has been split into two cells based on morphology and coastal processes described below.

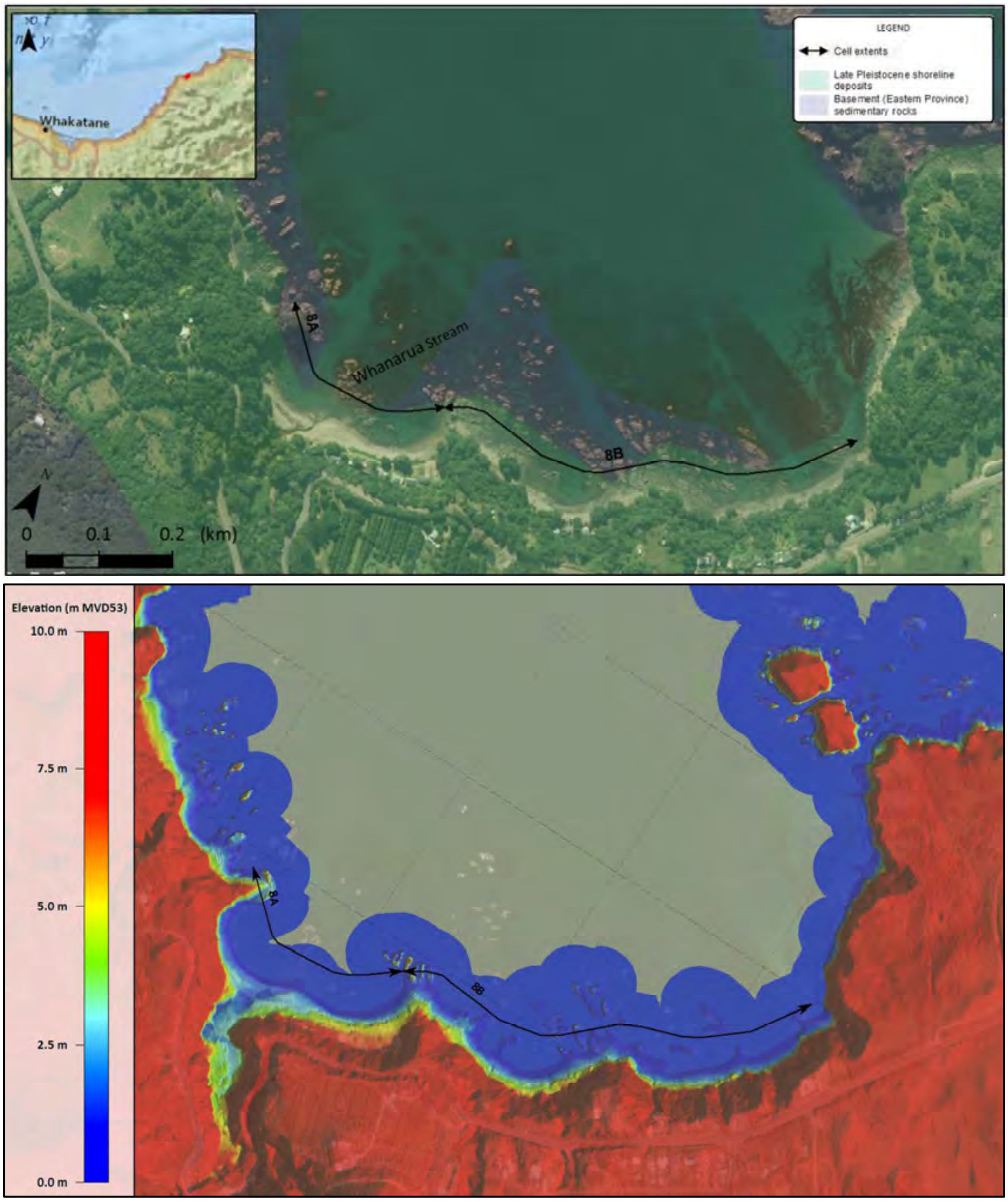

Figure 8.1: Site location and cell splits for Whanarua Bay (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

8.2 Morphology

The geomorphology of Whanarua Bay is strongly influenced by the coastal cliffs that surround the bay and rock shallow rocky reef outcrops that extend 200 to 300 m into the sea. The coastal morphology in each bay is characterised by a Late Pleistocene marine terrace cliff, a narrow of sand and gravel beach and rock outcrops in the nearshore zone (Figure 8.1).

The western bay (cell 8A) consists a low bank 2 to 5 m RL backed by cliffs 25 to 30 m high with a slope of 1(H):0.77(V) (Figure 8.2). Based on site observations the foreshore had a slope of 5.5(H):1(V) comprised of coarse sand with some pebbles (Figure 8.3). Grain size grades up moving landward, with the mid beach characterised by 1 to 4 cm diameter pebbles and larger pebble to cobble size gravels at the bank toe with a diameter of 1 to 15 cm. A 1 to 2 m high grass bank defines the landward beach limit. The driftwood debris line at the bank toe indicates that swash regularly washes up to the bank, however there was no evidence of recent erosion (Figure 8.2).

The central and western bays (cell 8B) have similar morphology. The cliffs landward of the foreshore range from 30 to 35 m high with a seaward facing slope of 1(H):0.8(V). Site observations showed the central bay foreshore was characterised by a 5(H):1(V) slope and comprised by predominantly by coarse sand with some pebbles (Figure 8.3, A). A pebble terrace was present on the mid beach with clasts between 1 to 3 cm in diameter and the back beach was characterised by a gravel terrace with clasts 1 to 12 cm in diameter. The landward limit of the beach is defined by the property boundary of different dwellings located at the cliff toe, with a mix of grass lawn and trees defining the coastal edge at an elevation of 3 to 5 m RL. Cuspate and terrace features on the sedimentary beach indicate active morphodynamic processes during normal energy conditions but there was no evidence of recent erosion of the vegetation line (Figure 8.2).

Figure 8.2: Site photos for Whanarua Bay. (A) Sand gravel foreshore within cell 8A. (B) Aerial view of cell 8A. (C) Rock outcrops within cell 8B. (D) Houses in proximity to shoreline (cell 8B)

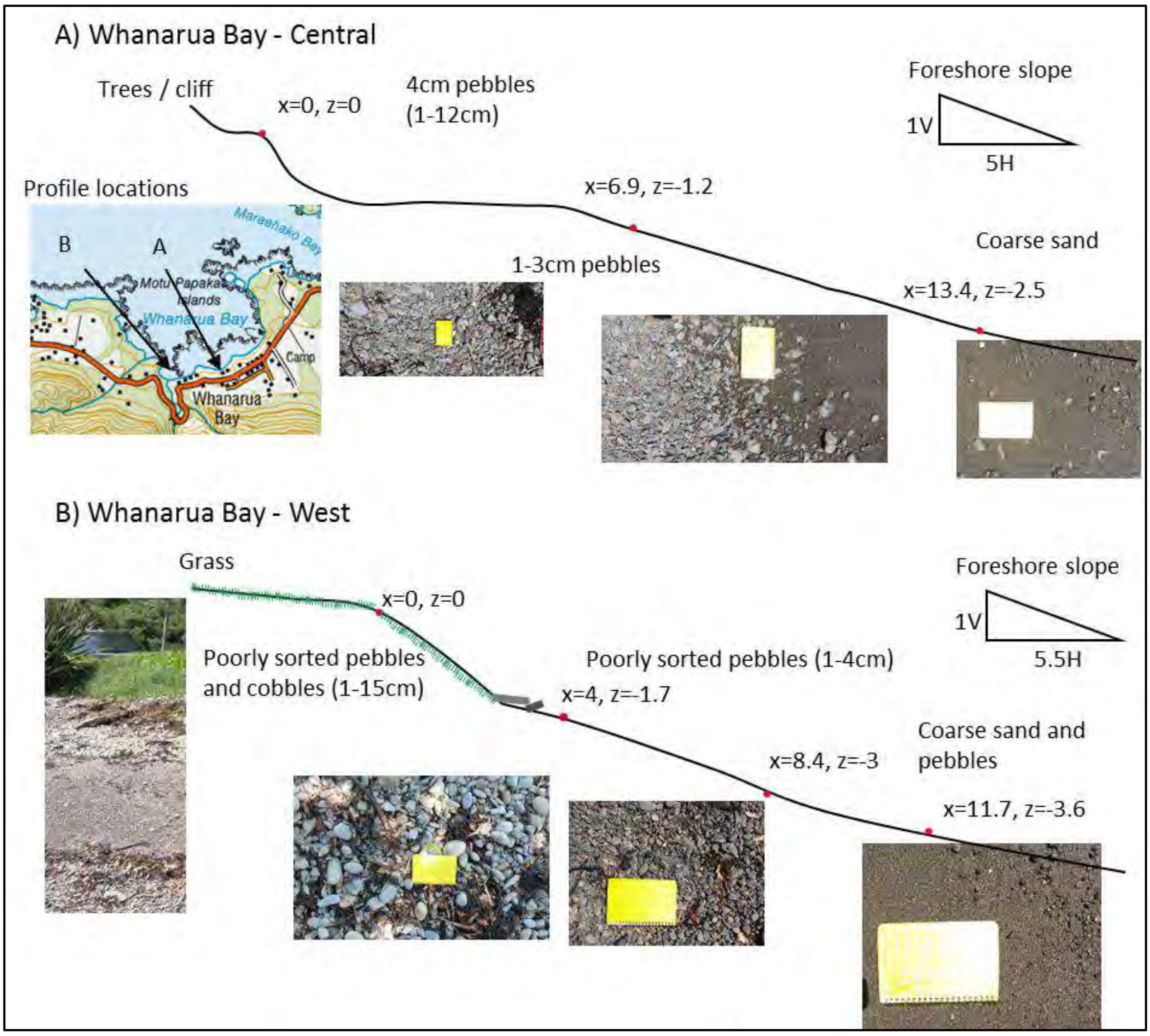

Figure 8.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at 8A and 8B

8.3 Coastal processes

The enclosed embayment and abundance of nearshore rock reefs provides an effective buffer to energetic ocean conditions. Entrance to the bay is through a 500 m wide passage that is located 700 m offshore of the shoreline. The majority of open ocean wave energy is likely dissipated in the nearshore environment. However, during storm events it is likely that some swell energy from the north and northwest will reach the shoreline.

Sediment supply to the nearshore is unknown but possibly a combination of material from Holocene shoreline deposition and erosion from nearshore reefs and cliffs. The Whanarua Stream discharges at the western beach and may deliver some sediment to the coast, as well as having a local influence on coastal processes and morphology. The channel migration is estimated to potentially have influence within a 150 m across-shore zone.

8.3.1 Short-term

Due to lack of profile data it is difficult to determine the short-term storm cut along Whanarua Bay. Geomorphic observations indicate that the beach morphology is dynamic and debris lines regularly reach the edge of vegetation. Therefore, there is potential for storm waves to cut into and erode the vegetation line or embankment even though there is limited evidence of vegetation scarping or erosion at present. Short-term storm cut of 2 to 6 m has been adopted for both cells 8A and 8B.

8.3.2 Long-term trends

There is limited shoreline data to assess trends at Whanarua Bay (Figure 8.4). At the western beach, the 2011 edge of vegetation line appears to follow the seaward edge of the grass reserve and is located landward of vegetation line survey in 1909, indicating erosion of the embankment. The 1909 vegetation is 5 to 15 m seaward of the 2011 survey at the western beach but it is unclear if this distance represents coastal erosion or other drives for changing vegetation cover. There is also uncertainty in the accuracy of the 1909 shoreline. Edge of vegetation surveys at the central beach from 1909, 2007 and 2011 are located in similar positions and are within 5 m of each other. This indicates a dynamic stability with a maximum erosion long term erosion of -0.05 m/yr. Comparable measurements are not available to specifically assess the eastern beach section at Whanarua.

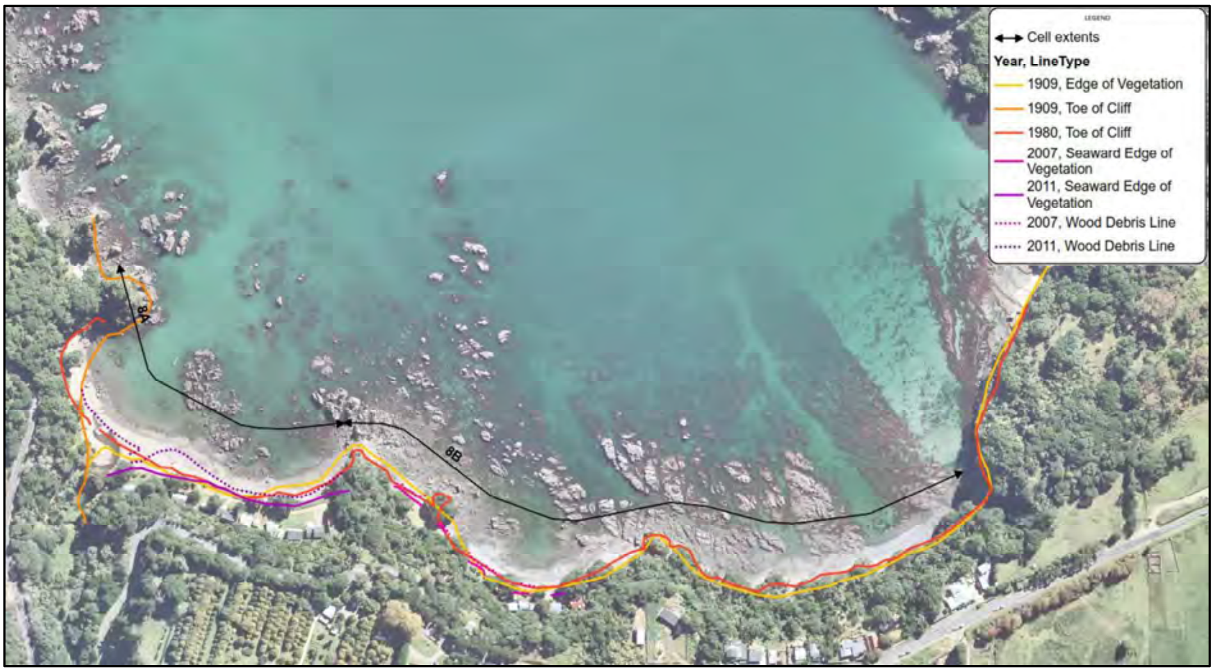

Figure 8.4: Historic shorelines along Whanarua Bay (note insufficient shoreline data was available to complete DSAS analysis

8.3.3 Sea level rise

The response to SLR along Whanarua Bay has been assessed using the beach face slope. Sediment availability and exchange is not expected to extend beyond the offshore rocky reef. Based on the modified Bruun Rule, high future SLR scenarios (i.e. 1.6 m) may result in erosion of 8 to 20 m.

8.4 Adopted component values

Adopted component values for Whanarua Bay are presented in Table 8.1.

Table 8.1: Adopted component values for the cells along the Whanarua Bay shoreline

Site		Whanarua	Whanarua
Cell		**8A**	**8B**
Cell centre (NZTM)	**E**	2022404	2022782
	N	5818796	5818943
Chainage, m (from W)		0 to 250	250 to 870
Morphology		Narrow gravel beach	Narrow gravel beach
Baseline		2019 seaward edge of vegetation	2019 seaward edge of vegetation
Short-term (m)	**Min**	2	2
	Mode	4	4
	Max	6	6
Bank height (m above toe)	**Min**	1.5	1
	Mode	2.0	2
	Max	3.5	3.5
Stable angle (deg)	**Min**	30	30
	Mode	32	32
	Max	34	34
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0	0
	Mode	-0.05	-0.05
	Max	-0.1	-0.1
Beach face slope	**Min**	0.1	0.1
	Mode	0.16	0.16
	Max	0.2	0.2

8.5 Coastal erosion hazard

Coastal erosion hazard distances for Whanarua Bay are presented in Table 8.2 and an overview map in Figure 8.5. Erosion hazard distances have been offset from the 2019 seaward edge of vegetation. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

The CEHA along Whanarua Bay range from -7 m for the current CEHA (P5%) to -24 m for the future CEHA (2130 1.6m SLR P5%). In several locations along the bay the future CEHA extends beyond the existing cliff toe which indicates the cliff may become subject to future toe erosion. Instability of the cliff toe has not been accounted for within this assessment and subsequently, the mapped CEHA have been bound along the cliff toe.

Table 8.2: Coastal erosion hazard widths (m) for Whanarua Bay for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Whanaru	8A	Current (2020)	0.03	N/A	-3	-5	-6	-7	-9
		50yr (2070)	0.4	RCP4.5	-6	-9	-10	-12	-15
			0.6	RCP8.5	-6	-10	-11	-13	-16
		110yr (2130)	0.8	RCP4.5	-7	-13	-14	-19	-22
			1.25	RCP8.5	-10	-16	-17	-22	-27
			1.6	RCP8.5+	-11	-18	-19	-24	-31
	8B	Current (2020)	0.03	N/A	-3	-5	-6	-7	-9
		50yr (2070)	0.4	RCP4.5	-5	-9	-10	-12	-15
			0.6	RCP8.5	-6	-10	-11	-13	-16
		110yr (2130)	0.8	RCP4.5	-7	-13	-14	-18	-22
			1.25	RCP8.5	-9	-16	-17	-22	-27
			1.6	RCP8.5+	-11	-18	-19	-24	-31

Notes: Aerial photograph sourced from LINZ Data Service 2019

A3 SCALE 1:2,500

0 0.025 0.05 0.075 0.1 0.125 (km)

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Coastal Erosion Hazard Area (CEHA) Overview Map
Site 8: Whanarua Bay

FIGURE No. Figure 8.5

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9 Papatea

9.1 Site description

Papatea Bay is located approximately 60 km northeast Ōpōtiki. The shoreline is a 4 km long sand and gravel beach that is heavily influenced by discharge from the Raukōkore River (Figure 9.1). Two small streams discharge onto the beach at either end of the shoreline. There is minimal development across the backshore. SH35 is approximately 200 m landward at the western end and approximately 50 m landward at the eastern end. The site has been split into four cells based on the morphology and exposure described below.

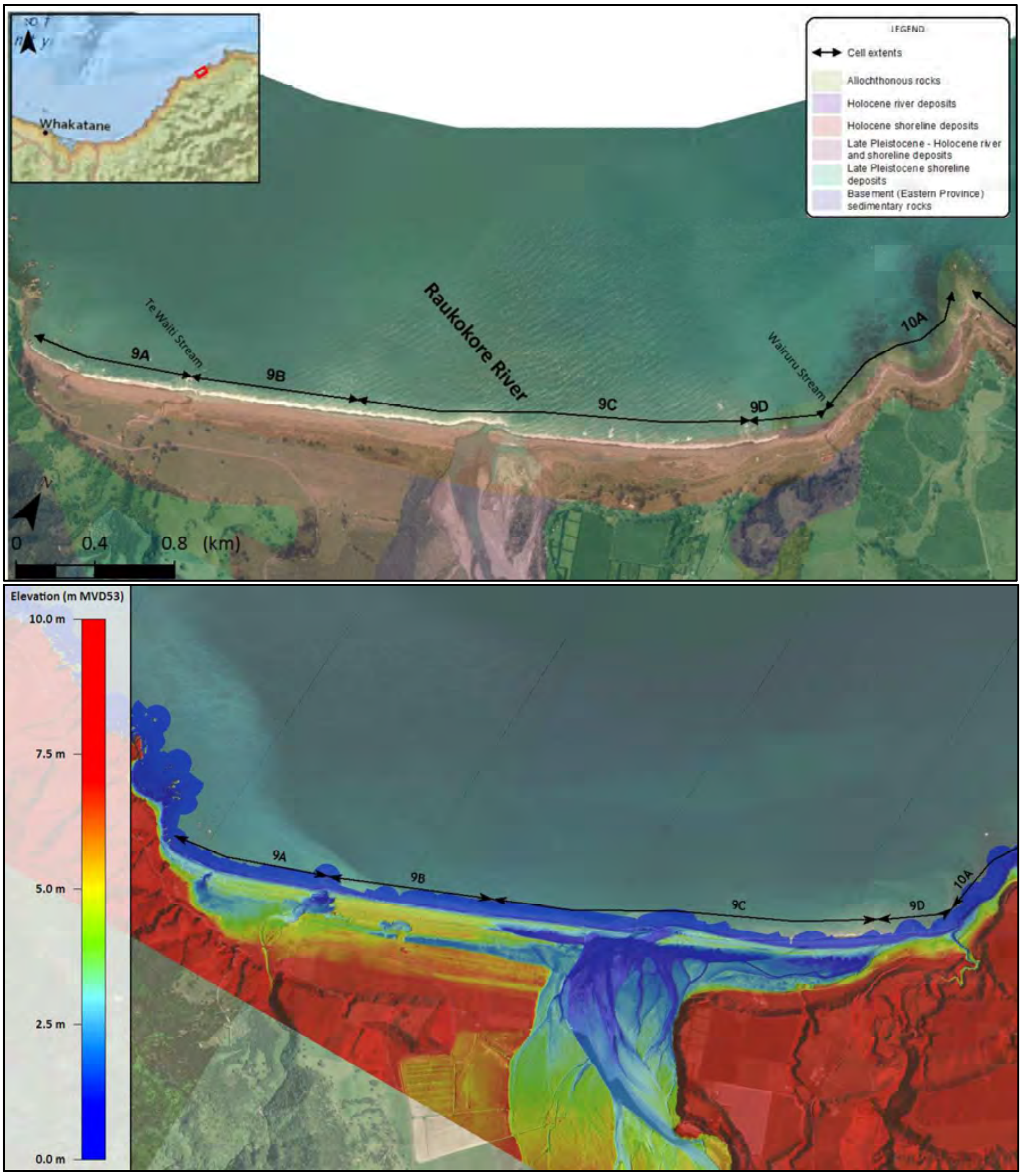

Figure 9.1: Site location and cell splits for Papatea (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

9.2 Morphology

The underlying geology along Papatea is predominately Holocene shoreline deposits. The Raukōkore River flows through a valley characterised by Eastern Provence Basement sedimentary rock. The valley opens up to a wide alluvial plain 2.5 m away from the coast that is comprised of Holocene river deposits. The contemporary river channel is confined to a 100 to 500 m wide area but may have migrated along the length of the contemporary beach over the Mid-Late Holocene. The contemporary coastal barrier is dominated by gravel sediment discharged by the Raukōkore River and forms a 40 to 100 m wide beach system.

The western end of the beach (cell 9A) is characterised by undulating backshore elevated approximately 3 to 4 m RL. On the eastern side of the Te Waiti Stream the backshore is slightly higher elevation (5 m RL) (cell 9B). Cell 9C represents the shoreline directly influenced by the Raukōkore River mouth dynamics. The river mouth is highly dynamic with spit and lagoon features along either side (Figure 9.2). Landward of the river mouth, a network of dynamic channels, islands and bars are present across an across shore plain of 400 to 1000 m.

The beach east of the river mouth (cell 9D) is characterised by a foreshore comprised of fine well sorted pebbles (1 cm diameter) and a slope of 4.6(H):1(V) (Figure 9.3). Pebble size increases up the beach face and a well-developed overwash berm was present on 17 October 2019 during site observations with poorly sorted pebbles and cobbles 1 to 12 cm in diameter. Large driftwood debris was scattered across a 20 to 40 m wide depression and an undulating backshore between the crest and edge of vegetation. LiDAR data from 2011 indicate the beach crest ranges in elevation between 2 to 3.5 m RL.

Figure 9.2: Site photos for Papatea. (A) Te Waiti Stream at western end of shoreline. (B) Raukōkore River mouth. (C) Shoreline west of the Wairuru Stream (cell 9D). (D) Sand gravel berm within cell 9D.

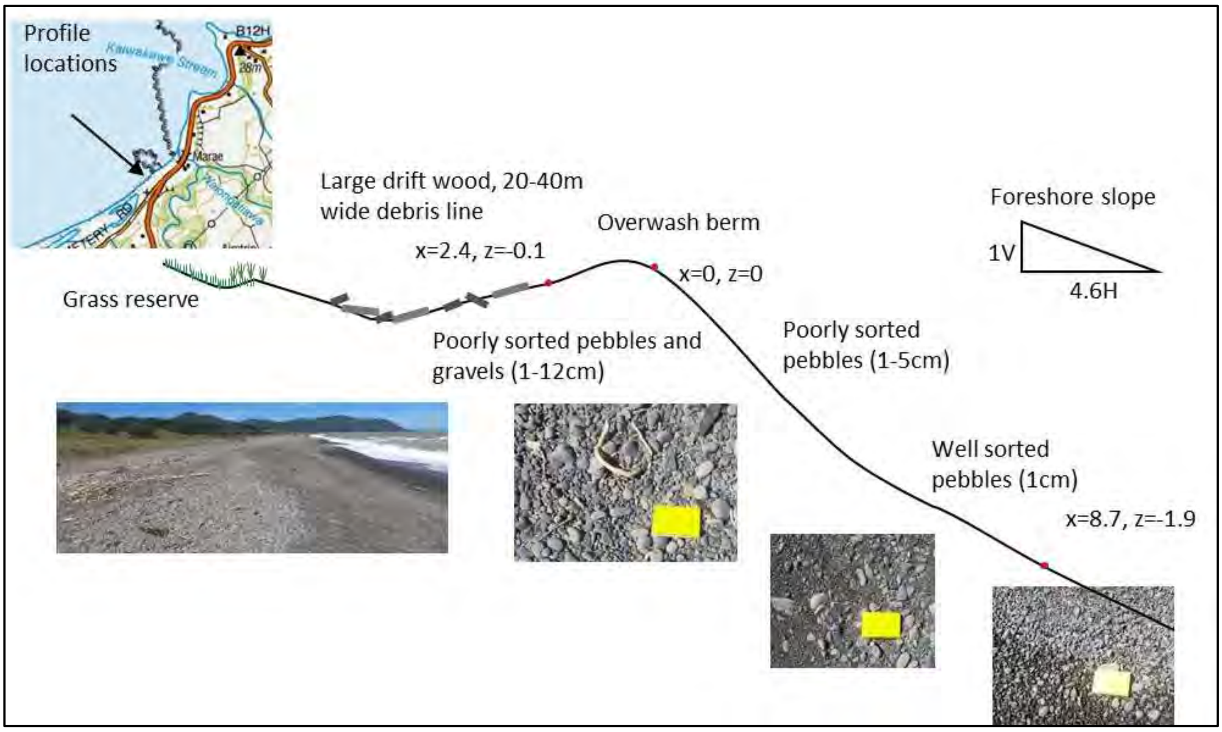

Figure 9.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cell 9C

9.3 Coastal processes

The Papatea shoreline is predominately exposed to swell waves from the north to northwest. Coastal processes at Papatea Bay are strongly influenced by river processes. According to Hicks et al (2011) the Raukōkore River discharges at a mean flow of 31 m^3/s at the SH35 bridge, with a suspended sediment yield of approximately 4.7M t/yr. The mouth of the Raukōkore River is dynamic and according to Gibb (1994) can migrate across a distance 1.9 km. The Wairuru Stream near the western end of Papatea Bay and locally influences the shoreline along a 200 m stretch where the mouth migrates.

9.3.1 Dynamic zone

The dynamic zone along Papatea has been assessed based on XBeach-G modelling. Model results suggest a dynamic zone width ranges from 44 to 123 m along Papatea (Figure 9.4). The relatively large dynamic zone along Papatea is due to the larger offshore wave heights and the low backshore environment. The minimum dynamic zone extends to the current seaward edge of vegetation while the maximum dynamic zone is approximately 80 m landward from the current edge of vegetation. The dynamic zone within cell 9D has been reduced to 30 to 70 m. Geomorphic evidence along this section of the shoreline suggests that the extent of overwash is less (existing barrier width is narrower) which is likely due to partial sheltering from the offshore reef.

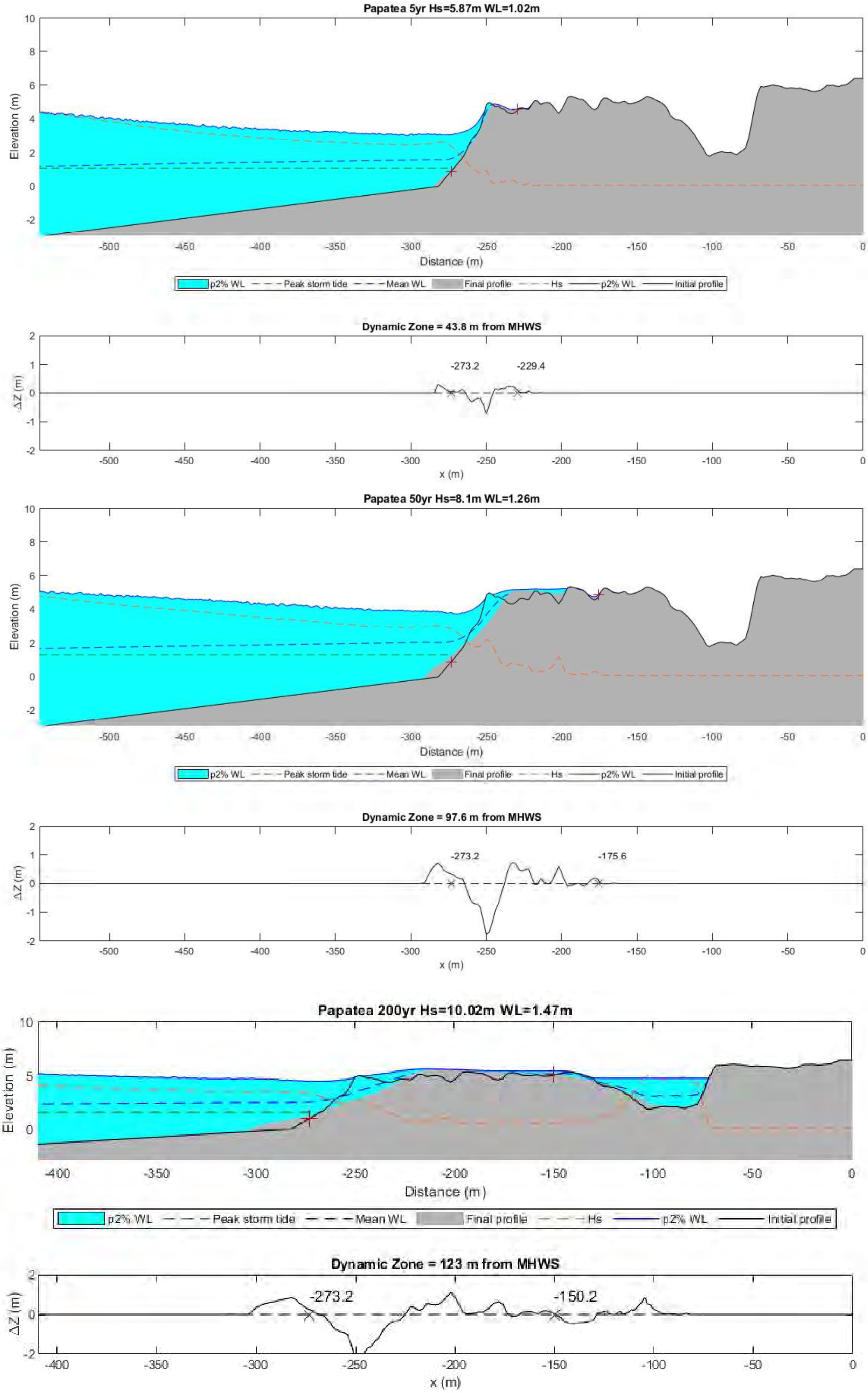

Figure 9.4: XBeach-G results for Papatea

9.3.2 Long-term trends and medium-term fluctuations

Historic shorelines for the Papatea shoreline include high water surveys from 1916 to 2019, as well as two edge of vegetation surveys (Figure 9.5). DSAS analysis of the high water surveys indicates high accretion rates ranging from 0.1 to 1 m/yr (Figure 9.6). The accretion rates are largest within cells 9A and 9B and are slightly less within cell 9D. Comparison of the 1918 and 2015 edge of vegetation surveys also show the shoreline has accreted 20 to 50 m over the last 100 years. The significant shoreline advancement is likely due to the proximity of the Raukōkore River and the continual sediment supply to the coast. While the shoreline has been accreting there was a period of erosion between 1951 and 1980 which suggests medium-term fluctuations of up to 15 m along the entire shoreline. Fluctuations are larger within cell 9C and therefore the 2 km stretch of coast around the Raukōkore River mouth has been treated as a river mouth cell.

Figure 9.5: Historic shorelines along Papatea

Figure 9.6: DSAS results for Papatea

9.3.3 Sea level rise

SLR is expected to increase wave overtopping along Papatea. Subsequently it is expected that the gravel berm will migrate landward and increase in elevation (barrier rollover). Under high future SLR scenarios (i.e. 1.6 m) the berm may migrate up to 80 m landward.

9.4 Adopted component values

Adopted component values for Papatea are presented in Table 9.1.

Table 9.1: Adopted component values for cells along the Papatea shoreline

Site		**Papatea**			
Cell		**9A**	**9B**	**9C**	**9D**
Cell centre (NZTM)	**E**	2026888	2027654	2028908	2030043
	N	5820551	5820849	5821389	5822020
Chainage, m (from W)		0 to 820	820 to 1670	1670 to 3620	3620 to 4050
Morphology		Sand gravel beach	Sand gravel beach	River mouth	Sand gravel beach
Baseline		2019 high water mark	2019 high water mark	River mouth – Area of high uncertainty (see main report Section 4.4.4)	2019 high water mark
Dynamic zone (m)	**Min**	44	44		30
	Mode	98	98		45
	Max	123	123		70
Medium term (m)	**Min**	5	5		5
	Mode	10	10		10
	Max	15	15		15
Long-term (m/yr) -ve erosion +ve accretion	**Min**	1.0	0.8		0.8
	Mode	0.8	0.7		0.7
	Max	0.6	0.6		0.6
Berm elevation (m)	**Min**	3.5	4		3.9
	Mode	4	4.5		4
	Max	4.5	5		4.1

9.5 Coastal erosion hazard

Coastal erosion hazard distances for Papatea are presented within Table 9.2 and an overview map in Figure 9.7. Erosion hazard distances have been offset from the 2019 high water mark. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

The current P5% CEHA ranges from -63 m on the eastern side of the river mouth (cell 9D) to -113 m on the western side (cells 9A and 9B). Long-term accretion dominates the western end of the shoreline and subsequently the future CEHA are seaward of the current CEHA. Although the future CEHA also take into account SLR, the impact from long-term accretion is likely to counteract any potential recession due to SLR. For these future scenarios, the CEHA have been mapped equivalent to the current hazard. Long-term accretion at the eastern end is reduced and subsequently the future high SLR scenarios are approximately 30 m landward of the current CEHA.

The hazard lines within the vicinity of the river mouth extend behind the existing lagoon system and terminate at the current river channel. Channel fluctuations further upstream are primarily driven by river processes and therefore have not been accounted for within this assessment.

The CEHA have not been mapped at the Raukōkore River mouth. This is because there is high uncertainty due to the hazard being dominated by river processes which have not been accounted for within this assessment.

Table 9.2: Coastal erosion hazard widths (m) for Papatea for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Papatea	9A	Current (2020)	0.03	N/A	-45	-82	-90	-113	-122
		50yr (2070)	0.4	RCP4.5	-15	-63	-72	-98	-119
			0.6	RCP8.5	-16	-66	-75*	-102*	-123
		110yr (2130)	0.8	RCP4.5	31	-28	-38	-68	-92
			1.25	RCP8.5	26	-37	-47*	-79*	-105
			1.6	RCP8.5+	22	-43	-54	-88*	-115
	9B	Current (2020)	0.03	N/A	-45	-82	-90	-113	-123
		50yr (2070)	0.4	RCP4.5	-19	-68	-76	-102	-119
			0.6	RCP8.5	-20	-70	-78*	-105*	-122
		110yr (2130)	0.8	RCP4.5	12	-38	-48	-75	-94
			1.25	RCP8.5	8	-46	-56*	-85*	-105
			1.6	RCP8.5+	4	-51	-62	-93*	-114
	9C	Current (2020)	0.03	N/A	River mouth – Area of high uncertainty (see main report Section 4.4.4)				
		50yr (2070)	0.4	RCP4.5					
			0.6	RCP8.5					
		110yr (2130)	0.8	RCP4.5					
			1.25	RCP8.5					
			1.6	RCP8.5+					
	9D	Current (2020)	0.03	N/A	-30	-44	-48	-63	-70
		50yr (2070)	0.4	RCP4.5	-32	-54	-58	-75	-87
			0.6	RCP8.5	-33	-56	-60*	-77	-89
		110yr (2130)	0.8	RCP4.5	-30	-55	-59	-77	-92
			1.25	RCP8.5	-34	-60	-64*	-83	-99
			1.6	RCP8.5+	-36	-63	-68	-88	-104

*Mapped equivalent to the current CEHA

Notes: Aerial photograph sourced from LINZ Data Service 2019

A3 SCALE 1:10,000

0 0.1 0.2 0.3 0.4 0.5 (km)

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Ōpōtiki Coastal Erosion Hazard Assessment

Coastal Erosion Hazard Area (CEHA) Overview Map
Site 9: Papatea

FIGURE No. Figure 9.7

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10 Raukōkore

10.1 Site description

Raukōkore is located approximately 65 km northeast of Ōpōtiki. The shoreline spans 3.7 km alongshore and is mostly characterised by small sand gravel beaches wedged between wide rock platforms that extend 100 to 200 m out into the sea (Figure 10.1). SH35 follows close to the coast and is protected by a rock revetment near the school and Marae at the northeast section where the road is within a few metres of the embankment toe. Other assets at Raukōkore include a church at the southwest section and a small settlement at the centre of the bay. Several small streams discharge along the shoreline including the Waiokaha and Tauranga streams. The site has been split into five cells based on the morphology and coastal exposure described below.

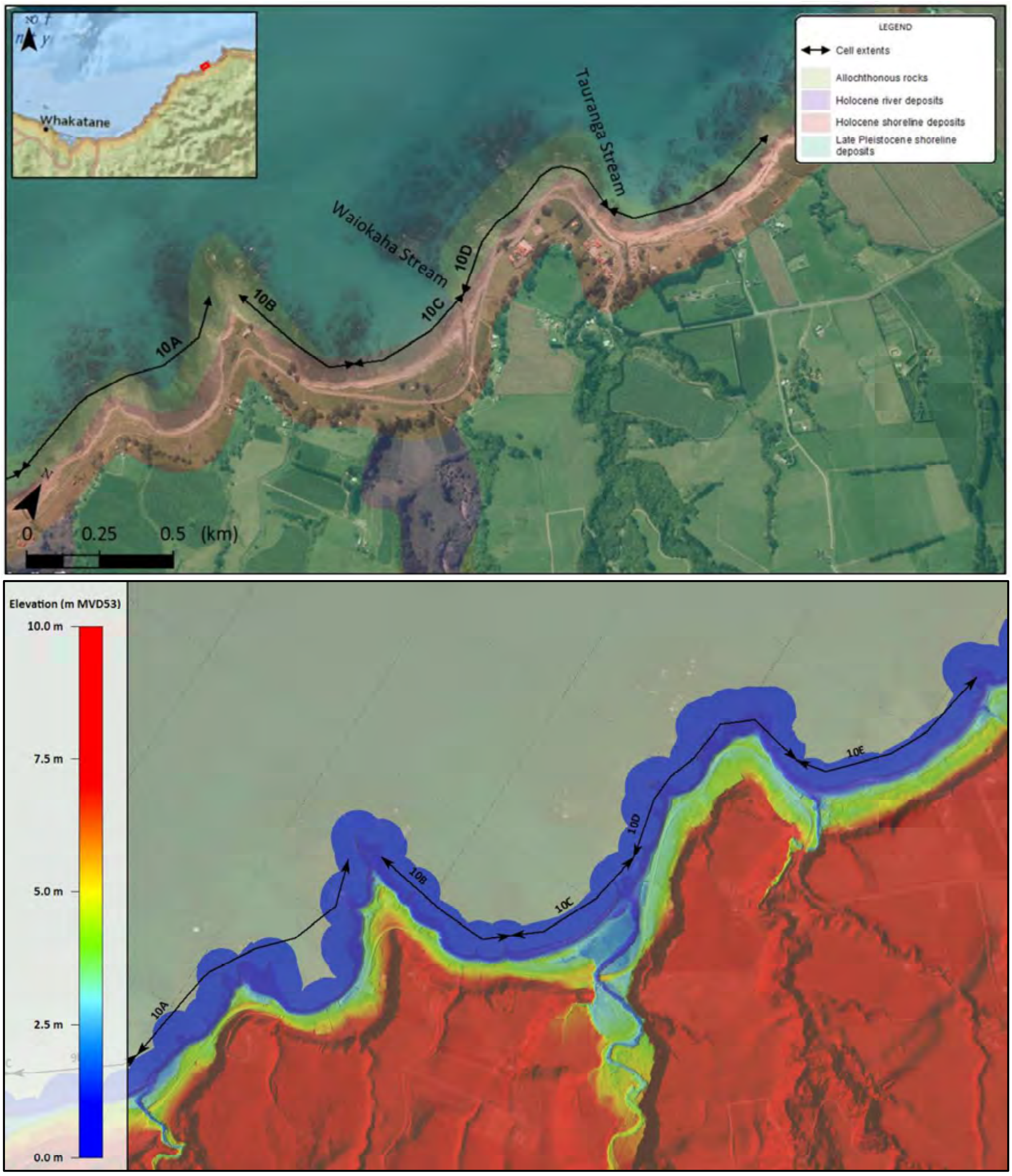

Figure 10.1: Site location and cell splits for Raukokere (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

10.2 Morphology

Most of the underlying geology along the Raukōkore shoreline comprises Holocene shoreline deposits. The Holocene coastal plain ranges in elevation from 3 to 5 m RL and extends 150 to 300 m inland before reaching Late Pleistocene marine terrace formations (Figure 10.1). The main source of local gravel sediment is likely exposure of Holocene marine sediment, with pebble and sand material potentially being delivered to the coast by the Waiokaha Stream.

The southwestern extent of the shoreline is characterised by a narrow sand gravel beach fronted with a rocky shore platform and backed by a grass bank (cells 10A and 10B) (Figure 10.2). Site observations found the grain size at bank toe to be 2 to 3 cm in diameter and a mix of coarse sand and fine pebbles at the foreshore with a slope of 12(H):1(V) (Figure 10.3, Profile B). Cell 10C comprises a low-lying sand beach with the Waiokaha Stream at the northern end (Figure 10.1).

The shoreline within cell 10D has a complex morphology influenced by rock reef outcrops in the nearshore. A narrow steep beach is comprised by pebble size gravels becoming larger and less stored moving in an onshore direction (Figure 10.3, Profile A). The foreshore is steep with a slope of 3.3(H):1(V) and beach cups were present on the day observations were made, resulting in small back shore terraces and channels that influence sediment transport and bank exposure. Erosion scarps are evident along sections of the coast. Cell 10E transitions to a low-lying sand beach with the Tauranga Stream discharging at the southern end (Figure 10.2).

Figure 10.2: Site photos for Raukōkore. (A) Grass bank and narrow gravel beach within cell 10B. (B) Gravel beach cusps within cell 10D. (C) Rocky shore platform fronting Raukōkore School. (D) Sandy beach (cell 10E)

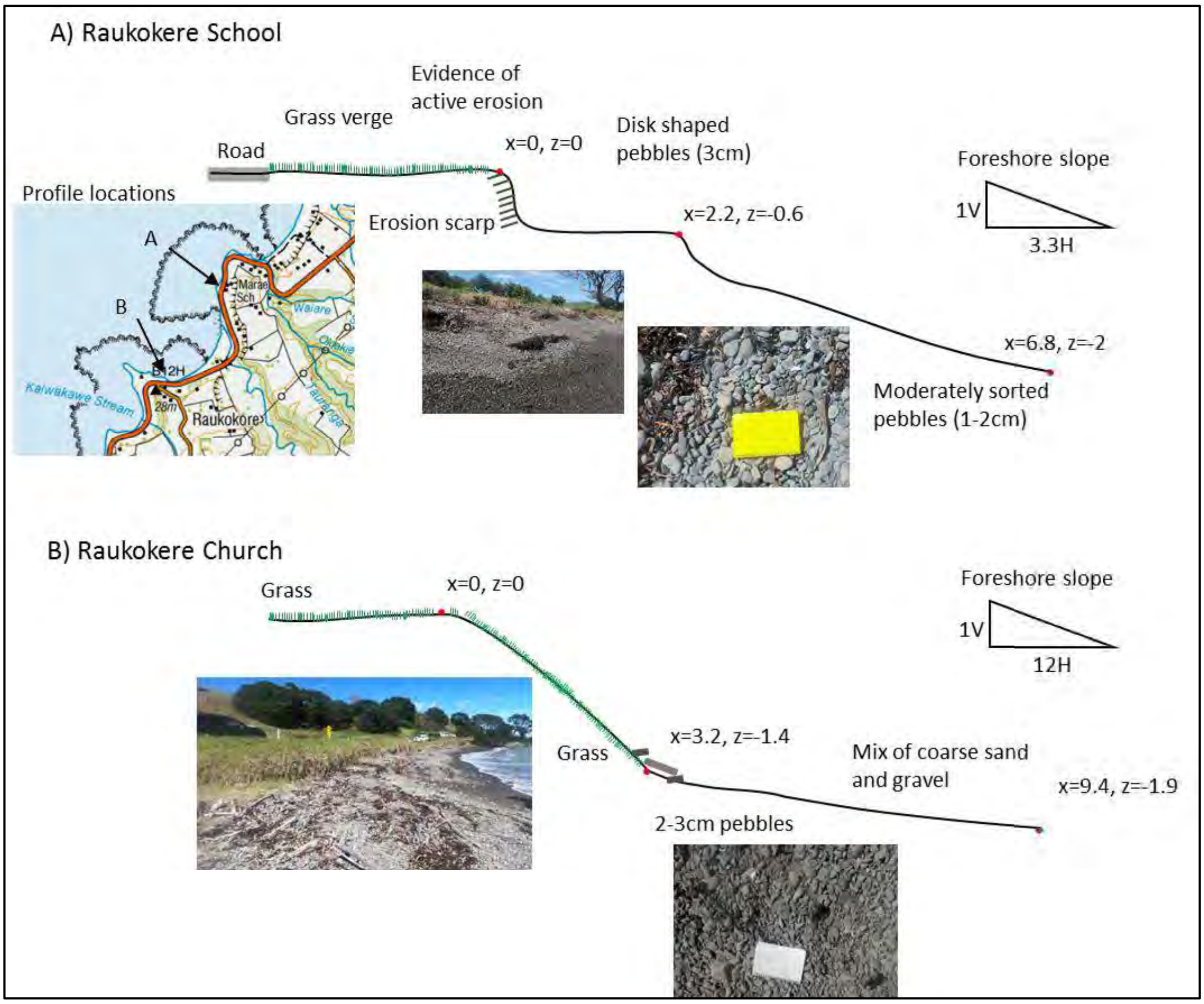

Figure 10.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cells 10B and 10D

10.3 Coastal processes

The shoreline orientation varies along the Raukōkore coast resulting in slightly different wave exposure. Majority of the coast is exposed to waves from the west although there are several north-facing sections which are directly exposed to northerly swell. The patches of rock platform outcrops are likely to dissipate wave energy and therefore provide some shelter to sections of the coast. As described in Medwin (2008), it was evident during Cyclone Ivy that the offshore reef absorbed wave energy and resulted in reduced wave runup around Raukōkore.

10.3.1 Short-term

Due to lack of profile data it is difficult to determine short-term storm cut along the Raukōkore shoreline. The two sections of sandy beach (cells 10C and 10E) are expected to have larger storm cuts compared to the areas of narrow gravel beach with embankments. The two sandy beaches are relatively exposed with a northwest orientation and have less rocky reef fronting the shoreline. Historic shorelines also indicate that the sandy shoreline is more dynamic compared with the gravel embankments. Storm cut for the sandy beaches is estimated to be 5 to 10 m while storm cut along the rest of the shoreline is estimated to be 2 to 6 m.

10.3.2 Long-term trends

Historic shoreline data along Raukōkore is limited to edge of vegetation surveys from 1914, 2011 and 2019 and high water surveys from 1914 to 1980 (Figure 10.4). The western extent of cell 10A shows some influence from the Raukōkore River mouth with up to 16 m accretion since 1914. Further north there appears to be up to 9 m erosion since 1914 and there is minimal land between the road and coast which indicates erosion has occurred. Cells 10B and 10D appear relatively stable, although there is evidence of historic erosion with the road now running very closely along the coastal edge. 10C includes the small sandy beach where there has been up to 25 m accretion since 1914. There is limited shoreline data for the sandy beach within cell 10E however there appears to be up to 4 m accretion along the edge of vegetation between 2011 and 2019.

Figure 10.4: Historic shorelines along the Raukōkore shoreline

Site observations indicate active erosion along sections of the coast, particularly within cells 10A, 10B and 10D where there is scarping and over-steepening of the grass embankment. Figure 10.5 shows that there is a current coastal erosion hazard with undermining of SH35.

Figure 10.5: Undermining of SH35 within cell 10A

10.3.3 Sea level rise

The response to SLR along Raukōkore has been assessed using the beach face slope. Sediment availability and exchange is not expected to extend beyond the offshore rocky reef. Based on the modified Bruun Rule, high future SLR scenarios (i.e. 1.6 m) may result in erosion 10 to 40 m.

10.4 Adopted component values

Adopted component values for Raukōkore are presented in Table 10.1.

Table 10.1: Adopted component values for cells along the Raukōkore shoreline

Site		**Raukōkore**				
Cell		**10A**	**10B**	**10C**	**10D**	**10E**
Cell centre (NZTM)	**E**	2030321	2030690	2031127	2031174	2031694
	N	5822587	5823016	5823270	5823861	5824155
Chainage, m (from W)		0 to 1190	1190 to 1700	1700 to 2250	2250 to 2960	2960 to 3700
Morphology		Narrow gravel	Narrow gravel	Sand beach	Narrow gravel	Sand beach
Baseline		2019 seaward edge of vegetation	2019 seaward edge of vegetation	2019 seaward edge of vegetation	2019 seaward edge of vegetation	2019 seaward edge of vegetation
Short-term (m)	**Min**	2	2	5	2	5
	Mode	4	4	8	4	8
	Max	6	6	10	6	10
Bank height (m above toe)	**Min**	1.2	2	1	1.5	1.8
	Mode	2.0	2.5	2	2	2
	Max	3.5	4	2.3	3	2.7
Stable angle (deg)	**Min**	30	30	30	30	30
	Mode	32	32	32	32	32
	Max	34	34	34	34	34
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0	0	0.1	0	0.1
	Mode	-0.05	-0.05	0	-0.05	0
	Max	-0.1	-0.1	-0.1	-0.1	-0.1
Beach face slope	**Min**	0.05	0.05	0.04	0.1	0.05
	Mode	0.08	0.08	0.05	0.08	0.1
	Max	0.1	0.1	0.07	0.15	0.12

10.5 Coastal erosion hazard

Coastal erosion hazard distances for Raukōkore are presented within Table 10.2 and an overview map in Figure 10.6. Erosion hazard distances have been offset from the 2019 seaward edge of vegetation. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

The erosion hazard along the Raukōkore shoreline is relatively consistent with a slightly larger hazard area along the sandy beach sections where the offshore reef is absent (i.e. cell 10C). The current P5% CEHA ranges from -7 m to -11 m while the future CEHA is up to -39 m for the 2130 1.6m SLR P5% scenario.

Table 10.2: Coastal erosion hazard widths (m) for Raukōkore for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Raukōkore	10A	Current (2020)	0.03	N/A	-3	-5	-6	-7	-8
		50yr (2070)	0.4	RCP4.5	-7	-11	-11	-14	-16
			0.6	RCP8.5	-8	-12	-13	-16	-19
		110yr (2130)	0.8	RCP4.5	-10	-16	-17	-21	-26
			1.25	RCP8.5	-14	-21	-22	-27	-33
			1.6	RCP8.5+	-17	-25	-26	-32	-39
	10B	Current (2020)	0.03	N/A	-4	-6	-6	-8	-9
		50yr (2070)	0.4	RCP4.5	-7	-11	-12	-14	-17
			0.6	RCP8.5	-9	-13	-14	-16	-19
		110yr (2130)	0.8	RCP4.5	-10	-16	-17	-22	-26
			1.25	RCP8.5	-14	-22	-23	-28	-33
			1.6	RCP8.5+	-18	-25	-27	-33	-38
	10C	Current (2020)	0.03	N/A	-6	-9	-9	-11	-12
		50yr (2070)	0.4	RCP4.5	-6	-13	-14	-18	-21
			0.6	RCP8.5	-8	-15	-16	-20	-24
		110yr (2130)	0.8	RCP4.5	-4	-15	-17	-25	-31
			1.25	RCP8.5	-10	-23	-25	-33	-40
			1.6	RCP8.5+	-14	-28	-31	-39	-47
	10D	Current (2020)	0.03	N/A	-3	-5	-6	-7	-8
		50yr (2070)	0.4	RCP4.5	-6	-10	-10	-13	-15
			0.6	RCP8.5	-7	-11	-12	-14	-17
		110yr (2130)	0.8	RCP4.5	-8	-14	-15	-19	-23
			1.25	RCP8.5	-11	-18	-19	-23	-28
			1.6	RCP8.5+	-13	-21	-22	-26	-32
	10E	Current (2020)	0.03	N/A	-7	-9	-9	-11	-12
		50yr (2070)	0.4	RCP4.5	-5	-11	-12	-16	-20
			0.6	RCP8.5	-6	-13	-14	-18	-22
		110yr (2130)	0.8	RCP4.5	-2	-12	-14	-22	-27
			1.25	RCP8.5	-5	-17	-19	-27	-35
			1.6	RCP8.5+	-8	-20	-22	-31	-40

Notes: Aerial photograph sourced from LINZ Data Service 2019

A3 SCALE 1:11,000

0 0.1 0.2 0.3 0.4 0.5 (km)

Location Plan

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Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 10: Raukōkore

FIGURE No. Figure 10.6

Rev. 0

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11 Waihau Bay

11.1 Site description

Waihau Bay is located approximately 70 km northeast of Ōpōtiki. The shoreline extends 4 km east from Orete point to Oruaiti Beach (Figure 11.1). Waihau Bay is characterised by an offshore rock reef and a narrow band of sand and gravel beach that is backed by a grass berm. SH35 follows the coast for most of Waihau Bay and is located between 5 and 100 m form the coastal edge at an elevation between 3 and 6 m RL. The eastern section of Waihau Bay faces north and the bay curves around to face east at the western section. The western end of Waihau Bay is accessed by Orete Point Road and has a small settlement with a wharf and natural boat harbour. There are several small streams which discharge onto the coast. The site has been split into two cells based on the morphology and coastal exposure described below.

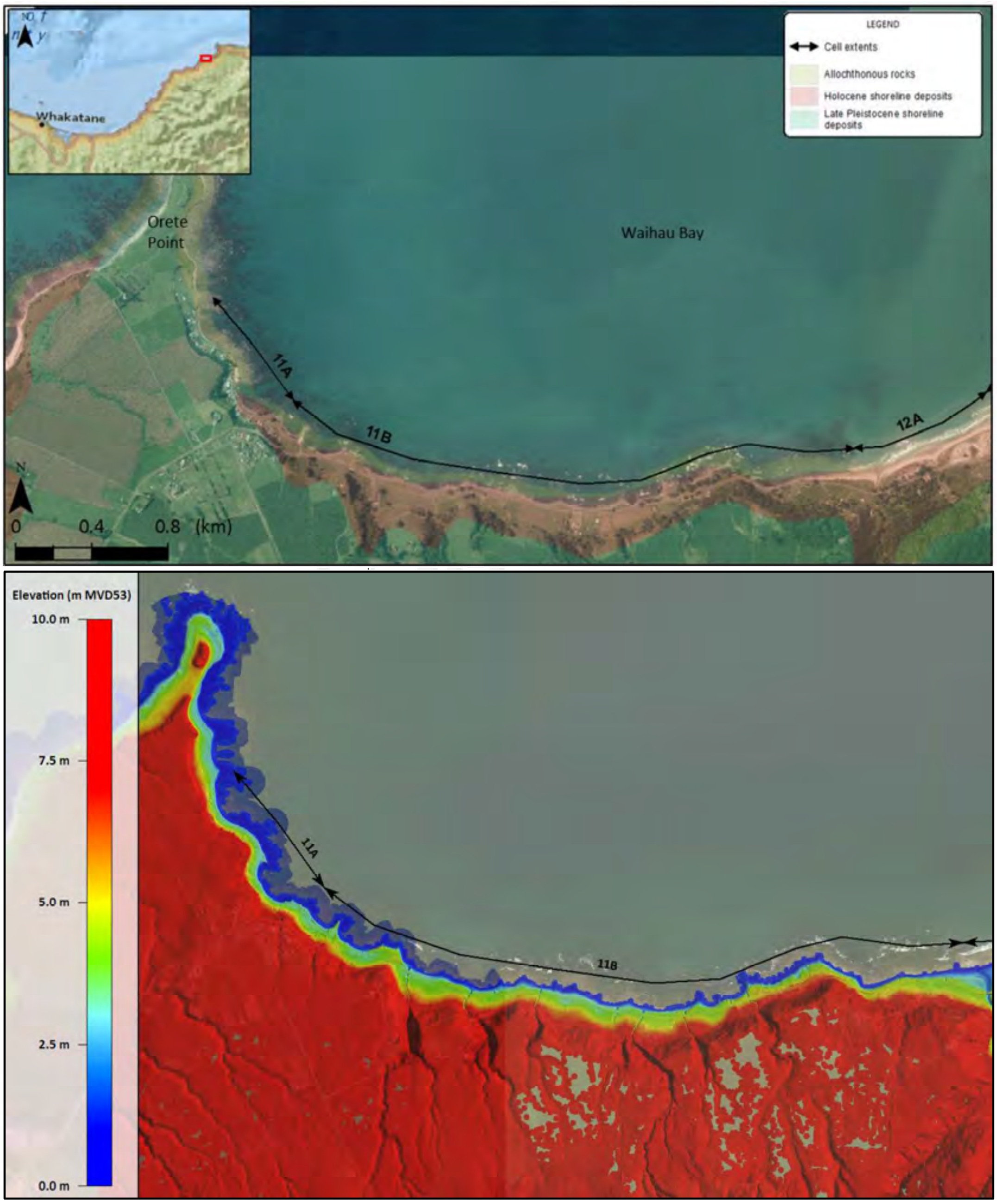

Figure 11.1: Site location and cell splits for Waihau Bay (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

11.2 Morphology

Waihau Bay is characterised by a narrow beach comprised by a mix of sand and gravel sediment with a steep grass embankment separating the coast from SH35 (Figure 11.1). Landward of the contemporary coastal embankment the underlying geology is a sand and gravel plain deposited in the Holocene for 200 m inland before an elevated Late Pleistocene marine terrace formation. A shallow and near continuous reef extends from Orete Point to Oruaiti Beach and extends for 100 m from the shoreline. Sediment sources for Waihau Bay are likely to be the small rivers to the east near Oruaiti Beach.

The grass embankment within cell 11A is elevated approximately 3.5 m RL. Site observations showed a representative profile at within cell 11A characterised by a mixed sand and pebble foreshore sloping at 5(H):1(V) and course pebbles and cobbles at the embankment toe (Figure 11.3, Profile B).

The grass embankment within cell 11B ranges in elevation from 3 to 4.5 m RL. Site observations showed a representative profile within cell 11B characterised by a 1(V):24(H) foreshore slope, with a mix of poorly sorted pebbles and sand at the seaward section and increasingly coarse gravels and pebbles moving landward (Figure 11.3, Profile A). Beach cusp features and gravel berms were present in some sections along the coast.

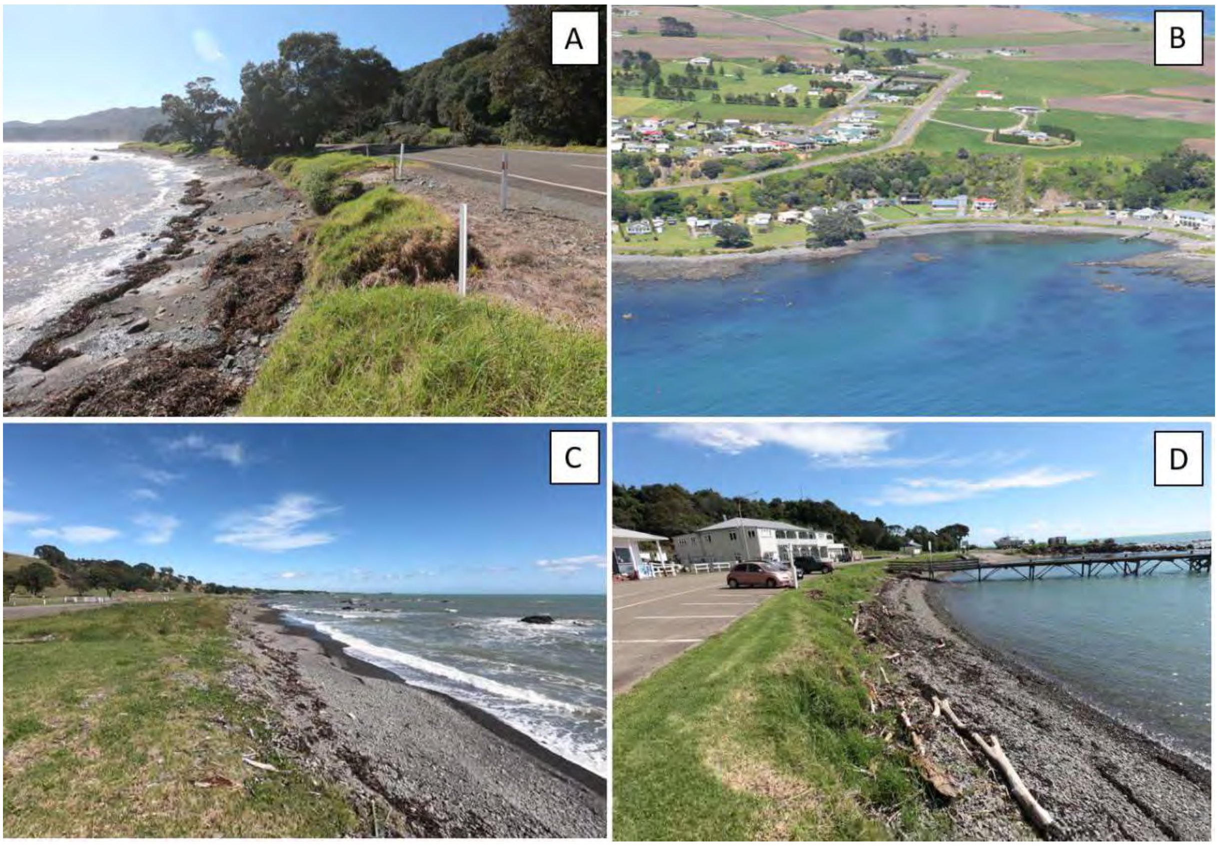

Figure 11.2: Site photos along the western end of Waihau Bay. (A) Grass bank along SH35 (cell 11B). (B) Aerial view of Waihau Bay township (cell 11A). (C) Narrow gravel beach with beach cusps near the centre of the bay (cell 11B). (D) Gravel beach and wharf near the Waihau Bay store (cell 11A)

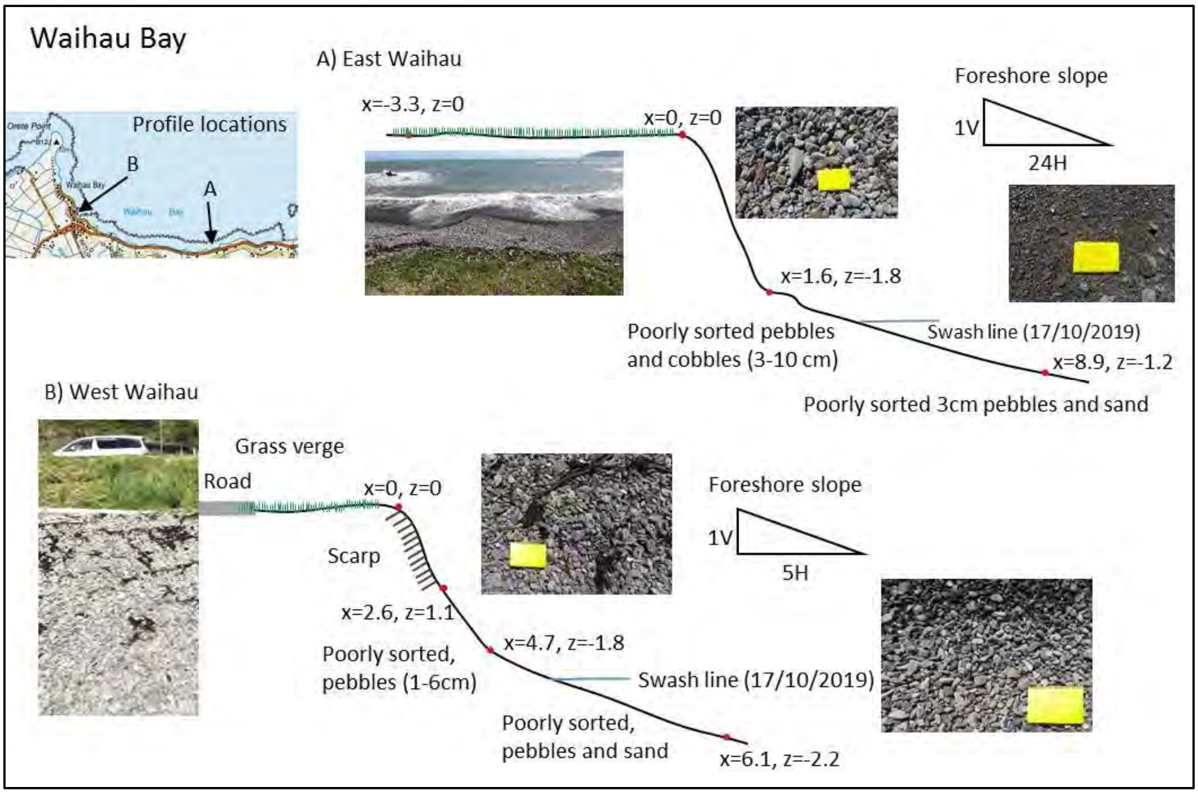

Figure 11.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at Cell 11A

11.3 Coastal processes

Waihau Bay is sheltered by Orete Point the west and is shadowed to a lesser extent by Te Ahikehe Point to the east. The bay is exposed directly to northerly swell waves. Cell 11A faces east and is likely to be slightly more sheltered compared to cell 11B. The small streams which discharge onto the coast within cell 11B appear to have minimal impact on the adjacent coast.

11.3.1 Short-term

Due to lack of profile data it is difficult to determine short-term storm cut distances for Waihau Bay. The embankment observed on 17 October 2019 indicated no evidence of active erosion but driftwood debris was present at the toe. Adopted short-term distances for Waihau Bay range from 2 to 6 m.

11.3.2 Long-term trends

Historic shoreline data available for Waihau Bay includes edge of vegetation surveys from 1905 to 2019 as well as high water surveys from 1914 to 1980. Previous assessments indicate no evidence of long term erosion at Waihau Bay, with Dahm and Kench (2007) identifying a coast that is potentially slowly accreting at a rate between 0.01 to 0.03 m/yr. Site observations indicate some minor undercutting and over steepening along the embankment however no significant erosion features were present. To account for long-term stability and potential erosion, long-term rates of 0 to -0.1m/yr have been adopted for Waihau Bay.

Figure 11.4: Historic shorelines for Waihau Bay

11.3.3 Sea level rise

The response to SLR along Waihau Bay has been assessed using the beach face slope. Sediment availability and exchange is not expected to extend beyond the offshore rocky reef. Based on the modified Bruun Rule, high future SLR scenarios (i.e. 1.6 m) may result in erosion 16 to 32 m.

11.4 Adopted component values

Adopted component values are presented in Table 11.1.

Table 11.1: Adopted component values for cells along the Waihau Bay shoreline

Site		Waihau Bay	
Cell		**11A**	**11B**
Cell centre (NZTM)	**E**	2033250	2034992
	N	5825556	5824857
Chainage, m (from W)		0 to 820	820 to 3800
Morphology		Narrow gravel beach	Narrow gravel beach
Baseline		2019 seaward edge of vegetation	2019 seaward edge of vegetation
Short-term (m)	**Min**	2	2
	Mode	4	4
	Max	6	6
Bank height (m above toe)	**Min**	2.5	2
	Mode	3	3
	Max	3.5	3.5
Stable angle (deg)	**Min**	30	30
	Mode	32	32
	Max	34	34
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0	0
	Mode	-0.05	-0.05
	Max	-0.1	-0.1
Beach face slope	**Min**	0.05	0.05
	Mode	0.08	0.08
	Max	0.1	0.1

11.5 Coastal erosion hazard

Coastal erosion hazard distances for Waihau Bay are presented within Table 11.2 and an overview map in Figure 11.5. Erosion hazard distances have been offset from the 2019 seaward edge of vegetation. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

The coastal erosion hazard is relatively consistent along the Waihau Bay shoreline. The current P5% is -8 m while the future CEHA (2130 1.6m SLR P5%) is up to -33 m.

Table 11.2: Coastal erosion hazard widths (m) for Waihau Bay for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Waihau Bay	11A	Current (2020)	0.03	N/A	-4	-6	-6	-8	-9
		50yr (2070)	0.4	RCP4.5	-8	-11	-12	-14	-17
			0.6	RCP8.5	-9	-13	-14	-16	-19
		110yr (2130)	0.8	RCP4.5	-10	-17	-18	-22	-26
			1.25	RCP8.5	-15	-22	-23	-28	-33
			1.6	RCP8.5+	-18	-26	-27	-33	-39
	11B	Current (2020)	0.03	N/A	-4	-6	-6	-8	-9
		50yr (2070)	0.4	RCP4.5	-7	-11	-12	-14	-17
			0.6	RCP8.5	-9	-13	-14	-16	-19
		110yr (2130)	0.8	RCP4.5	-10	-16	-17	-22	-25
			1.25	RCP8.5	-14	-22	-23	-28	-33
			1.6	RCP8.5+	-18	-25	-27	-33	-39

Notes: Aerial photograph sourced from LINZ Data Service 2019

A3 SCALE 1:10,000

0 0.1 0.2 0.3 0.4 0.5 (km)

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SCALE (AT A3 SIZE) 1:10,000		
PROJECT No. 1008669.2000		

Ōpōtiki Coastal Erosion Hazard Assessment

Coastal Erosion Hazard Area (CEHA) Overview Map

Site 11: Waihau Bay

FIGURE No. Figure 11.5

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12 Oruaiti Beach

12.1 Site description

Oruaiti Beach located approximately 73 km northeast of Ōpōtiki. The site is a 1.6 km long sandy beach within Te Rangiharu Bay, wedged between Te Ahikehe Point to the east and outcropping rock to the west at Waihau Bay (Figure 12.1). State Highway 35 is located 20 to 120 m landward from the current dune toe and several houses are in proximity to the shoreline at the eastern end. Three small streams including the Mangatoetoe, Wairuru and Waiotuma streams discharge on to the coast. The site has been split into two cells based on the morphology described below.

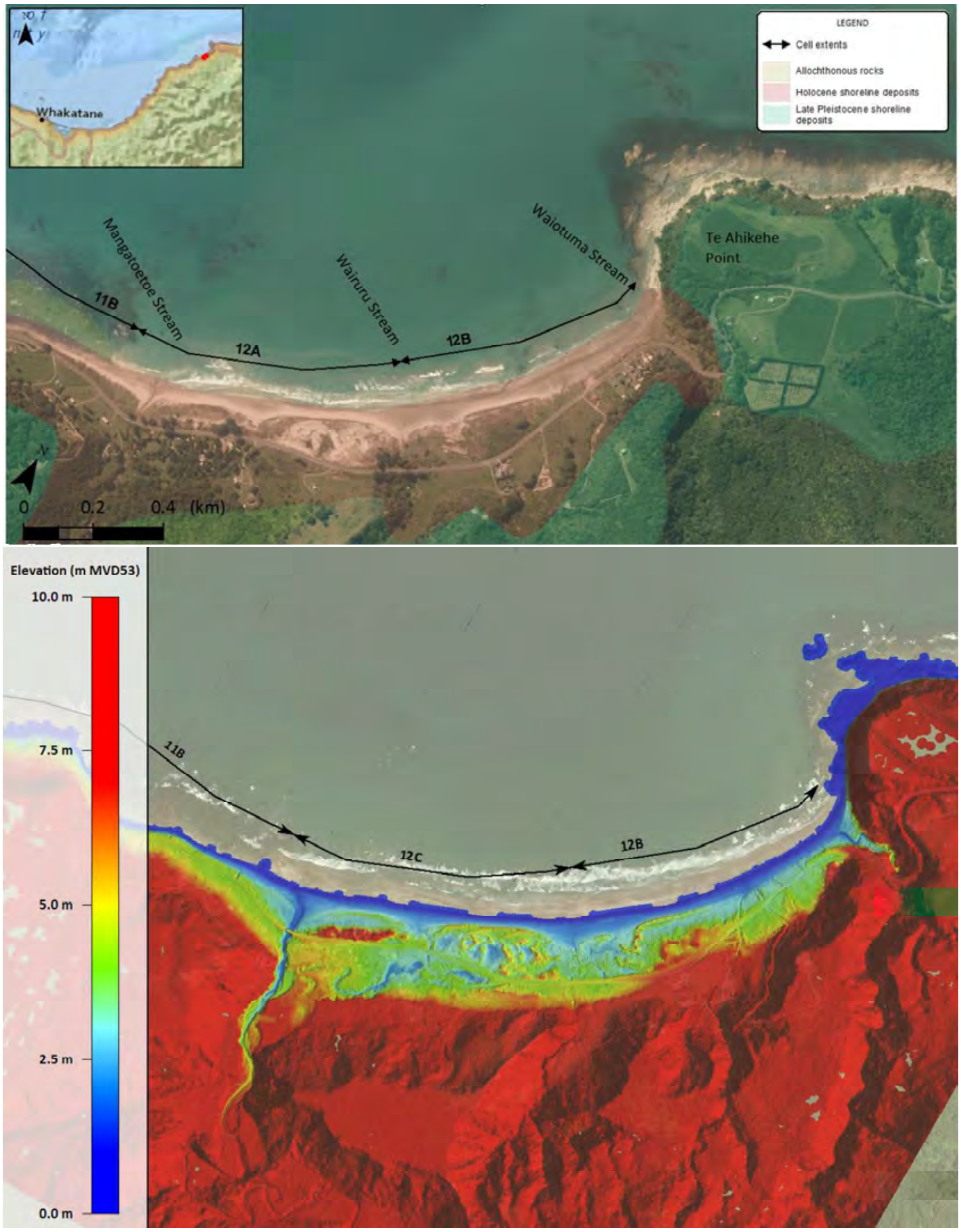

Figure 12.1: Site location and cell splits for Oruaiti Beach (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

12.2 Morphology

Oruaiti Beach is comprised of Holocene marine deposits in the form of a 150 to 300 m wide sedimentary barrier. The beach is comprised of medium to fine sand. Some of the sediment is likely to be supplied from local stream sources (Waiotuna, Wairuru and Mangtoetoe). However, Dahm and Kench (2007) suggest that the predominant that source of sediment for the beach is via headland bypassing from Whangaparaoa around Kopongatahi Point and Te Ahikehe Point.

The western section of the beach (cell 12A) is characterised by a well-established dune system with dune crest elevations ranging from 3 to 5 m RL. The foredune is vegetated from the toe with a mild foreshore slope (Figure 12.3, Profile B).

The eastern section (cell 12B) is characterised by a low embankment that was observed to be eroding, prone to wave impact, and overtopping, as indicated by washed vegetation, drift debris and scarping observed during site visits. The foreshore slope was very gentle with a gradient of 0.05 and with a 0.3 m high scarp in place of an established dune (Figure 12.2 and Figure 12.3, Profile A). The section of low embankment coast has a human modified grass reserve in the backshore and is in close proximity to a small coastal settlement.

Figure 12.2: Site photos for Oruaiti Beach. (A) Eastern end with Waiotuma Stream (cell 12C). (B) Eastern end with Mangatoetoe Stream. (C) Low embankment within cell 12C. (D) Established dunes within cell 12B

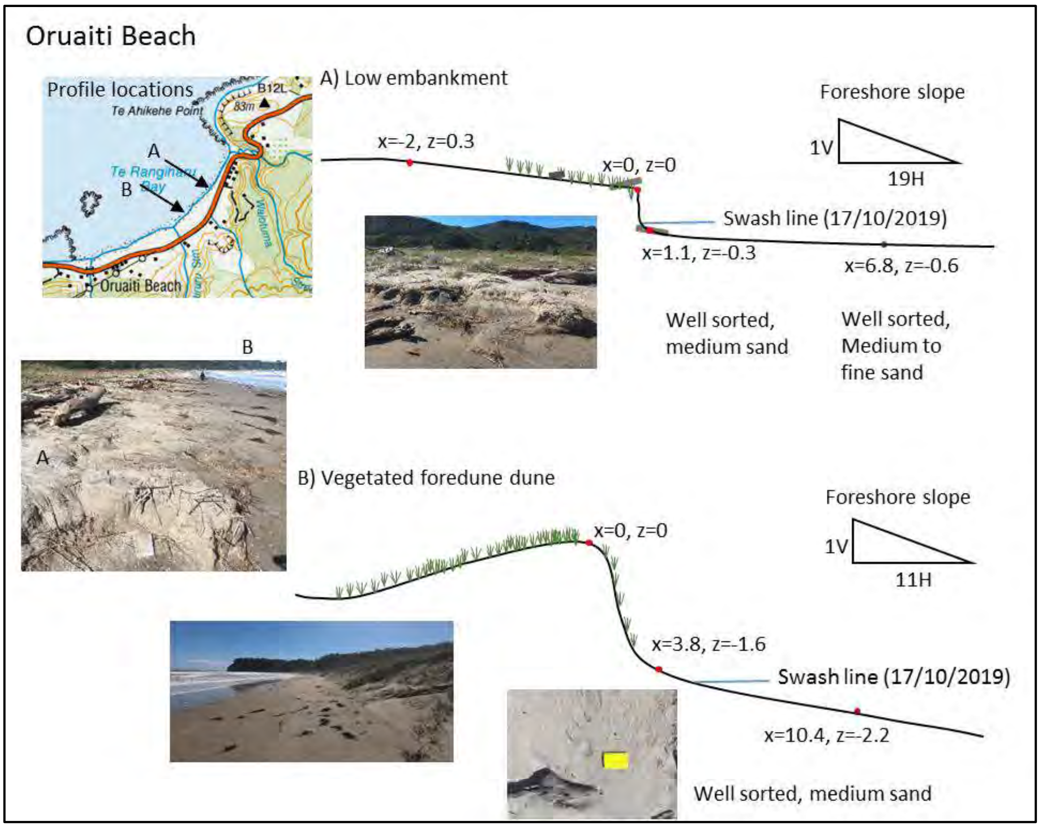

Figure 12.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at cells 12A and 12B

12.3 Coastal processes

Oruaiti Beach is a curved embayment that faces northwest but is relatively sheltered from waves approaching directly from the west by Orete Point, located 4.5 km away. The beach is also sheltered from waves approach form the east and north east, but is exposed to north and north-westerly swell. The streams which discharge onto the coast have a local influence on the beach morphology and prevent continuous dune development.

12.3.1 Short-term

Due to lack of profile data it is difficult to determine short-term storm cut along Orauiti Beach. Based on the shoreline exposure storm cut is estimated to range from 10 to 20 m.

12.3.2 Long-term trends

Historic shoreline data for Oruaiti Beach includes dune toe surveys from 1911 to 2019. This data indicates that the beach generally accreted seaward between 1951 and 1980, with continued minor accretion or dynamic stabilisation between 1980 and 2019 (Figure 12.4). The largest areas of historic accretion are in the two built up dune sections, between the streams within cell 12A. The shoreline within cell 12B shows a more stable shoreline position at the eastern section. DSAS analysis indicates long term accretion rates of 0 to 0.3 m/yr. There is no evidence of long term erosion and Dahm and Kench (2007) suggest that long-term accretion is in the order of less than 0.03 m/yr.

Figure 12.4: Historic shorelines along Oruaiti Beach

Figure 12.5: DSAS results along Oruaiti Beach

12.3.3 Sea level rise

Inner and outer closure depths for Oruaiti Beach are estimated to be 7 m and 10 m RL. Under high future SLR scenarios (i.e. 1.6 m) there is potential for the shoreline to retreat up to 80 m landward.

12.4 Adopted component values

Adopted component values are presented within Table 12.1.

Table 12.1: Adopted component values for cells along the Oruaiti Beach shoreline

Site		Oruaiti	
Cell		**12A**	**12B**
Cell centre (NZTM)	**E**	2036961	2037588
	N	5825107	5825548
Chainage, m (from W)		0 to 790	790 to 1600
Morphology		Sand beach	Sand beach
Baseline		2019 seaward edge of vegetation	2019 seaward edge of vegetation
Short-term (m)	**Min**	10	10
	Mode	15	15
	Max	20	20
Dune/Bank (m above toe)	**Min**	2	1
	Mode	3	1.5
	Max	4	3
Stable angle (deg)	**Min**	30	30
	Mode	32	32
	Max	34	34
Long-term (m/yr) -ve erosion +ve accretion	**Min**	0.15	0.1
	Mode	0.05	0.05
	Max	0	0
Closure slope (beaches)	**Min**	0.02	0.02
	Mode	0.03	0.03
	Max	0.058	0.058

12.5 Coastal erosion hazard

Coastal erosion hazard distances for Oruaiti Beach are presented within Table 12.2 and an overview map in Figure 12.6. Erosion hazard distances have been offset from the 2019 seaward edge of vegetation. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

P50% means there is a 50% chance of an erosion distance being exceeded within that timeframe. P66% can be considered a likely scenario and P5% can be considered a very unlikely scenario.

The CEHA along Orauiti beach ranges from -20 m for the current P5%, to -58 m for the future 2130 1.6m SLR P5%. While the beach shows a long-term accretion trend shoreline retreat due to future SLR is likely to outweigh the long-term accretion and subsequently the future CEHA are further landward of the current CEHA.

Table 12.2: Coastal erosion hazard widths (m) along Oruaiti for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Oruaiti Beach	12A	Current (2020)	0.03	N/A	-12	-16	-17	-20	-23
		50yr (2070)	0.4	RCP4.5	-11	-20	-21	-26	-32
			0.6	RCP8.5	-13	-23	-25	-31	-37
		110yr (2130)	0.8	RCP4.5	-7	-21	-23	-31	-40
			1.25	RCP8.5	-15	-32	-34	-46	-59
			1.6	RCP8.5+	-21	-39	-43	-58	-73
	12B	Current (2020)	0.03	N/A	-11	-16	-16	-20	-22
		50yr (2070)	0.4	RCP4.5	-13	-20	-21	-26	-31
			0.6	RCP8.5	-15	-23	-24	-30	-37
		110yr (2130)	0.8	RCP4.5	-11	-22	-23	-31	-37
			1.25	RCP8.5	-19	-33	-35	-47	-56
			1.6	RCP8.5+	-25	-40	-44	-58	-71

Notes: Aerial photograph sourced from LINZ Data Service 2019

A3 SCALE 1:6,000

0 0.065 0.13 0.195 0.26 0.325 (km)

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Coastal Erosion Hazard Area (CEHA) Overview Map
Site 12: Oruaiti Beach

FIGURE No. Figure 12.6

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13 Whangaparaoa Bay

13.1 Site description

Whangaparaoa Bay is located on the southwest side of Cape Runaway, approximately 75 km northeast from Ōpōtiki (Figure 13.1). The site is a 3 km stretch of mixed sand and gravel beach facing northwest that is bound by headlands to the east (Kopongatahi Point) and west (Te Ahikehe Point). Whangaparaoa River mouth is located at the eastern end of the beach and Waitawake stream discharges approximately 1 km from the western end of the beach. The site has been split into three cells based on the morphology and coastal processes described below.

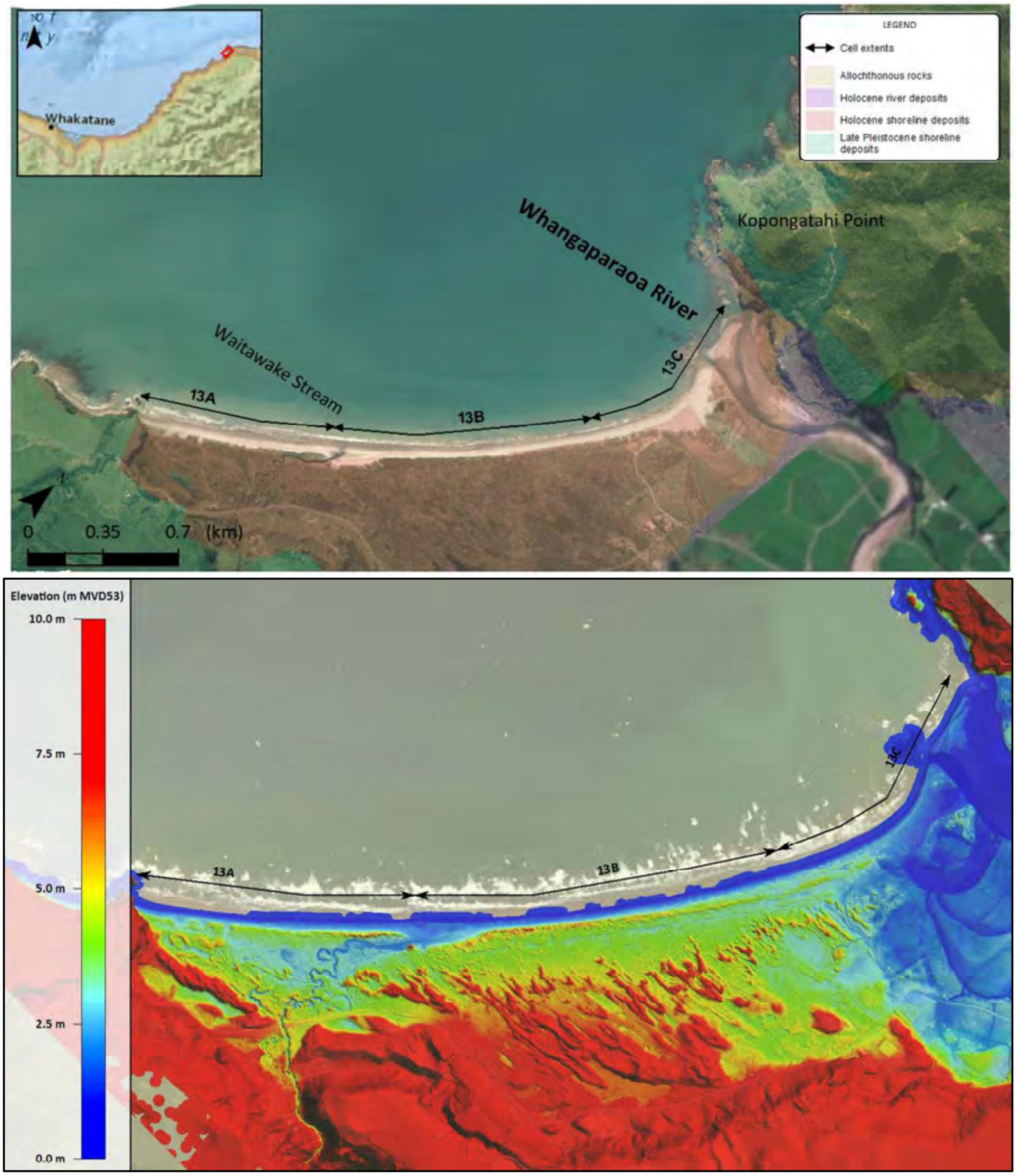

Figure 13.1: Site location and cell splits for Whangaparaoa (top). Elevation map based on 2011 LiDAR showing shoreline topography (bottom)

13.2 Morphology

The contemporary shoreline at Whangaparaoa Bay sits at the seaward edge of a wide barrier deposited from a mixture of coastal and fluvial sediments. Historic progradation of the coastal barrier, likely associated with sea level stabilising in the late Holocene, means the modern shoreline sits at the seaward extent of Kopongatahi Point. The mouth of the Whangaparaoa River has migrated over decadal and centennial time scales, creating a 1 km wide section of coast that is highly dynamic and susceptible to rapid dynamic change form fluvial influence.

Cell 13A defines the western section of the bay and consists of sandy foredune, with a dune crest of approximately 4 m RL. Cell 13B is located at the centre of the bay, where the sand is the dominant beach material and a dune crest ranges between 5 to 7 m RL. An erosion scarp is evident along sections of the well-developed dune system (Figure 13.2).

Cell 13C is located at the gravel dominant eastern margin of Whangaparaoa and includes the section of shoreline which is largely influenced by the dynamics of the Whangaparaoa River. Landward of the foredune crest, the Holocene deposited coastal barrier system extends for approximately 700 m, with an undulating elevation between 3 to 6 m RL.

Based on site observations a typical coastal profile sketch is provided for Cell 13C (Figure 13.3). The beach profile is characterised by a steep intertidal gravel foreshore with a slope of 1V:4.25H comprised of well-rounded but poorly sorted pebble size gravels ranging between 0.5 and 2 cm in diameter. A beach crest was present directly landward of the intertidal slope, characterised by larger pebbles (0.5 to 6 cm), which was elevated approximately 0.5 m above the backshore (Figure 13.3). The backshore environment was comprised of a similar pebble texture to the crest, with driftwood debris marking previous overwash events over a distance of 20 m landward.

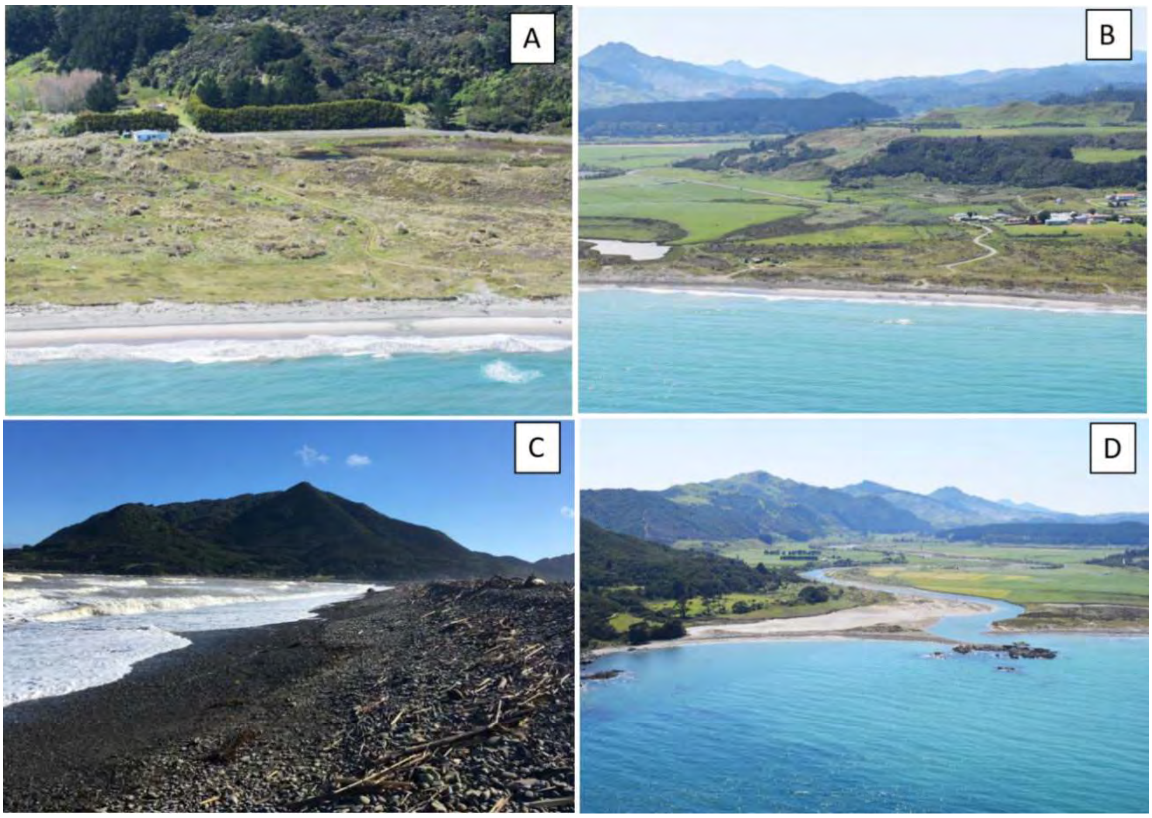

Figure 13.2: Site photos along the Whangaparaoa Bay shoreline. (A) Sandy foredune (cell 13A). (B) Whangaparaoa School and marae (cell 13B). (C) Gravel berm (cell 13C). (D) Whangaparaoa River mouth (cell 13C)

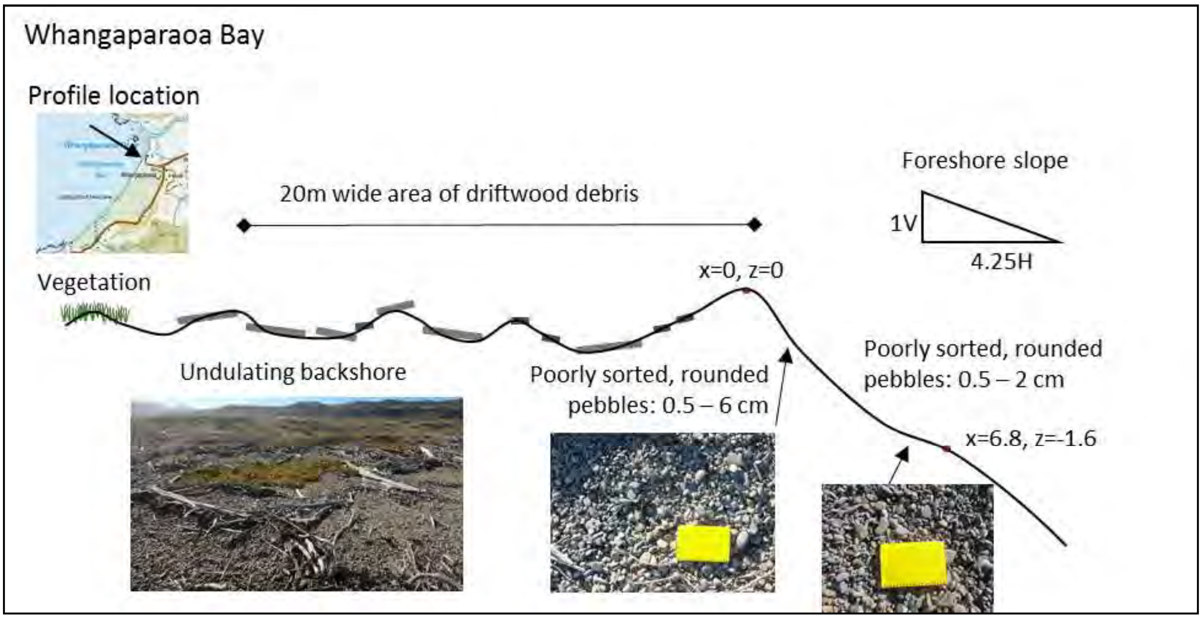

Figure 13.3: Typical beach profile and sediment characteristics based on site observation on 17 October 2019 at Cell 13C

13.3 Coastal processes

Whangaparaoa Bay faces northwest and is sheltered from waves approaching form the east and northeast by Cape Runaway. However the bay is exposed to northerly swell waves. The position at the northern tip of East Cape makes this location relatively exposed, with the 100 m depth contour located 6 km offshore. Based on NIWA (2019) the 50 year offshore wave height is 8.12 m with a storm tide level of 1.27 m RL.

The Whangaparaoa River has a significant influence on coastal processes and morphology at the coast, especially where the mouth is located at the eastern extent. The river supplies sand and gravel sediment to the coast but the rate of supply is unknown. The western and central section of beach is less influenced by the Whangaparaoa River and is more characteristic of an open coast system.

13.3.1 Dynamic zone

The dynamic zone along Whangaparaoa has been assessed based on XBeach-G modelling. Model results indicate the dynamic zone ranges from 110 to 190 m wide along Whangaparaoa (Figure 13.4). The relatively large dynamic zone along Whangaparaoa is due to the larger offshore wave heights and the low backshore environment. The debris survey lines provided by BOPRC suggest that the storm overwash is larger at Whangaparaoa compared with the other eastern Bay of Plenty beaches. For example the 2007 debris survey line is approximately 100 m landward from the high water mark (Figure 13.5).

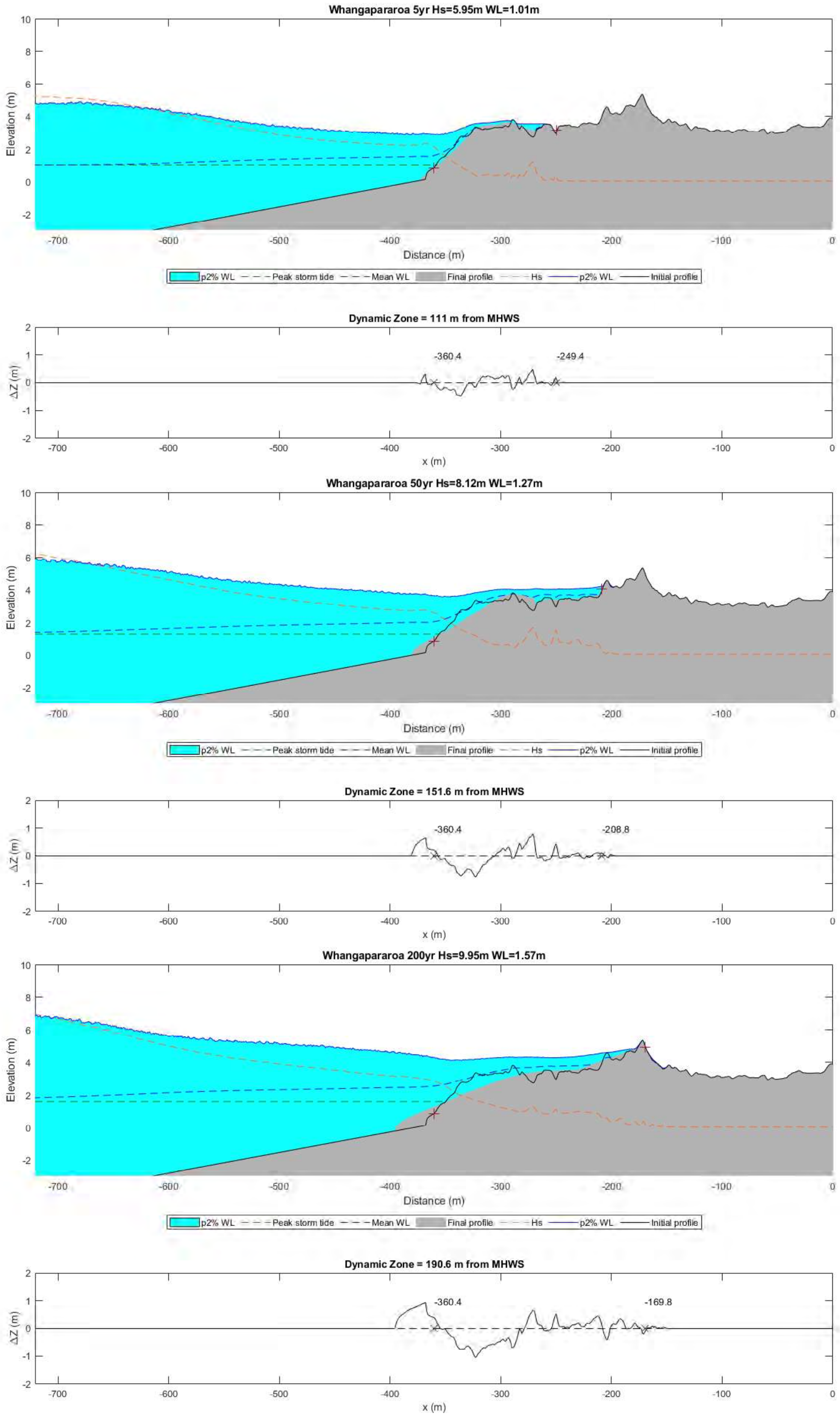

Figure 13.4: XBeach-G model results for Whangaparaoa

13.3.2 Long-term trends and medium-term fluctuations

Historic shoreline for Whangaparaoa includes high water surveys from 1914 to 2019 (Figure 13.5). The shorelines show most of Whangaparaoa is in dynamic equilibrium. Dahm and Kench (2007) conclude that the central and western sections of Whangaparaoa Bay are in dynamic equilibrium with sediment input from the river and loss to headland bypassing around Kopongatahi Point to Oruaiti Bay. The shoreline within cell 13C is significantly influenced by the dynamic fluctuations associated with the river mouth position and therefore has been assessed as a river mouth cell.

DSAS analysis indicates some long-term accretion within cell 13A with slight erosion in the centre of cell 13B (Figure 13.6). The shorelines show up to 30 m erosion between 1951 and 1970 followed by up to 40 m accretion from 1970 to 2019. There appears to be medium-term fluctuations of up to 15 m within cell 13A and 30 m within cell 13B. These fluctuations are likely in response to periodic storm events and variability in sediment supply.

Figure 13.5: Historic shorelines for Whangaparaoa

Figure 13.6: DSAS results for Whangaparaoa

13.3.3 Sea level rise

SLR is expected to increase wave overtopping along Papatea. Subsequently it is expected that the sand gravel berm will migrate landward and increase in elevation (barrier rollover). Under high future SLR scenarios (i.e. 1.6 m) the berm may migrate up to 76 m landward.

13.4 Adopted component values

Adopted component values are presented within Table 13.1.

Table 13.1: Adopted component values for cells along the Whangaparaoa shoreline

<table>
<tr><td colspan="2">Site</td><td colspan="3">Whangaparaoa</td></tr>
<tr><td colspan="2">Cell</td><td>13A</td><td>13B</td><td>13C</td></tr>
<tr><td rowspan="2">Cell centre (NZTM)</td><td>E</td><td>2039890</td><td>2040673</td><td>2041021</td></tr>
<tr><td>N</td><td>5828385</td><td>5829235</td><td>5830181</td></tr>
<tr><td colspan="2">Chainage, m (from W)</td><td>0 to 900</td><td>900 to 2120</td><td>2120 to 3000</td></tr>
<tr><td colspan="2">Morphology</td><td>Sand gravel beach</td><td>Sand gravel beach</td><td rowspan="14">River mouth – Area of high uncertainty (see main report Section 4.4.4)</td></tr>
<tr><td colspan="2">Baseline</td><td>2019 high water mark</td><td>2019 high water mark</td></tr>
<tr><td rowspan="3">Dynamic zone (m)</td><td>Min</td><td>111</td><td>111</td></tr>
<tr><td>Mode</td><td>152</td><td>152</td></tr>
<tr><td>Max</td><td>191</td><td>191</td></tr>
<tr><td rowspan="3">Medium term (m)</td><td>Min</td><td>5</td><td>10</td></tr>
<tr><td>Mode</td><td>10</td><td>20</td></tr>
<tr><td>Max</td><td>15</td><td>30</td></tr>
<tr><td rowspan="3">Long-term (m/yr)
-ve erosion
+ve accretion</td><td>Min</td><td>0.1</td><td>0.05</td></tr>
<tr><td>Mode</td><td>0.05</td><td>0</td></tr>
<tr><td>Max</td><td>0</td><td>-0.05</td></tr>
<tr><td rowspan="3">Berm elevation (m)</td><td>Min</td><td>4</td><td>4</td></tr>
<tr><td>Mode</td><td>5</td><td>5</td></tr>
<tr><td>Max</td><td>6</td><td>6</td></tr>
</table>

13.5 Coastal erosion hazard

Coastal erosion hazard distances for Whangaparaoa are presented within Table 13.2 and an overview map in Figure 13.7. Erosion hazard distances have been offset from the 2019 high water mark. Histograms of individual components and resultant erosion distances using a Monte Carlo technique are shown in Appendix G.

P50% means there is a 50% chance of an erosion distance being exceeded within that timeframe. P66% can be considered a likely scenario and P5% can be considered a very unlikely scenario.

The current P5% hazard area is a -178 m offset from the 2019 high water mark. This area represents the potential overwash extent from a large (i.e. 200 year ARI) storm event. The future CEHA is up to -250 m for the 2130 1.6m SLR P5% scenario.

The CEHA have not been mapped at the Whangaparaoa River mouth. This is because there is high uncertainty due to the hazard being dominated by river processes which have not been accounted for within this assessment.

Table 13.2: Coastal erosion hazard widths (m) along Whangaparaoa for current, 2070 and 2130 timeframes (shaded values indicate mapped scenarios)

Site	Cell	Timeframe	SLR (m)	Approximate RCP scenario	Probability of Exceedance				
					Min	P66%	P50%	P5%	Max
Whangaparaoa	13A	Current (2020)	0.03	N/A	-111	-144	-151	-178	-191
		50yr (2070)	0.4	RCP4.5	-125	-166	-173	-202	-221
			0.6	RCP8.5	-127	-169	-177*	-206	-226
		110yr (2130)	0.8	RCP4.5	-134	-178	-185	-215	-234
			1.25	RCP8.5	-143	-189	-198	-230	-251
			1.6	RCP8.5+	-149	-198	-207	-241	-264
	13B	Current (2020)	0.03	N/A	-111	-144	-151	-178	-191
		50yr (2070)	0.4	RCP4.5	-136	-177	-185	-214	-232
			0.6	RCP8.5	-139	-180	-188	-218	-237
		110yr (2130)	0.8	RCP4.5	-148	-187	-195	-225	-241
			1.25	RCP8.5	-158	-199	-207	-240	-258
			1.6	RCP8.5+	-164	-208	-216	-251	-271
	13C	Current (2020)	0.03	N/A	River mouth – Area of high uncertainty (see main report Section 4.4.4)				
		50yr (2070)	0.4	RCP4.5					
			0.6	RCP8.5					
		110yr (2130)	0.8	RCP4.5					
			1.25	RCP8.5					
			1.6	RCP8.5+					

*Mapped equivalent to the current CEHA

Notes: Aerial photograph sourced from LINZ Data Service 2019

A3 SCALE 1:11,000

0 0.1 0.2 0.3 0.4 0.5 (km)

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PROJECT No. 1008669.2000		

Ōpōtiki Coastal Erosion Hazard Assessment
Coastal Erosion Hazard Area (CEHA) Overview Map
Site 13: Whangaparoa

FIGURE No. Figure 13.7

Rev. 0

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