37 Paihia

37.1 Description and geomorphology

The site spans a length of 1 km alongshore and includes the main resort town of Paihia. Figure 37.1 shows the site and its division into six coastal cells for the purpose of assessing coastal erosion hazards. Site photos showing each cell are presented in Figure 37.2.

Coastal processes and morphology are strongly influenced by Waipapa greywacke rock headlands at the north, south and centre of the bay. Coastal and alluvial sediments filled in space between the headlands during the Holocene, creating a sedimentary low-lying plain at an elevation of 3-5 m above mean sea level that extends 300-400 m inland. The natural coastal edge is therefore a mixture of cliff headland and beach. Paihia is a popular resort town and the coast has been significantly developed to accommodate a wharf and main road that fringes the shoreline. A significant proportion of the coast at Paihia is engineered, including the reclaimed wharf, armoured terrace to the north and a rock revetment to the south.

The section of beach at Cells E and F are characterised by moderately sorted sand of medium grain size at the backshore, which becomes increasingly fine in a seaward direction.

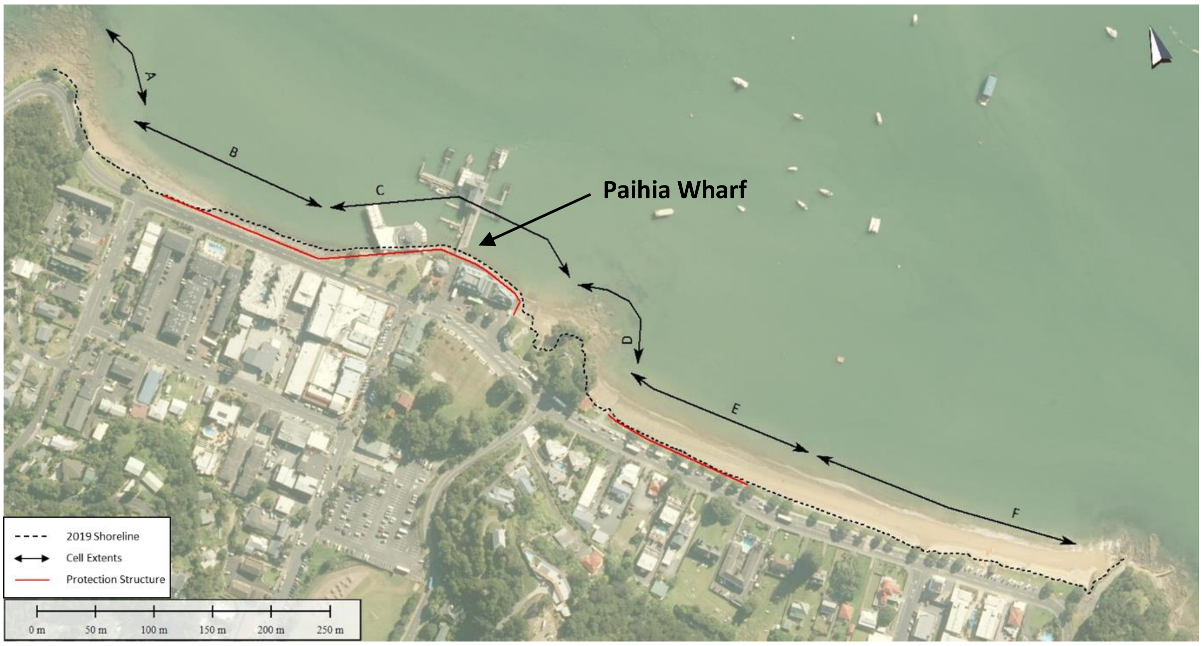


Figure 37.1: Map showing 2019 shoreline position and cell extents with background aerial imagery from 2014.

Figure 37.2: Photos from Paihia site visit on 22/01/2020.

37.2 Local considerations

The shoreline north of the wharf is 200 m long, with 150 m armoured with a mix of sloping seawall, rock revetment and Gobi® Block. A 50 m long section at the northern end has a natural grass terrace, with toe armour on select trees and outflow pipes. No intertidal beach is present north of the wharf, apart from a small section at the northern end where the large protection structures end. The wharf area is reclaimed and protected with a mix of hard structures. A small beach with a helicopter pad has a failed Gobi® Block boat ramp and is flanked by unstable cliff with visible signs of erosion.

The northern part of the southern beach section is armoured with an engineered rock revetment, with the beach submerged at high tide. Midway along the beach the protection stops and gives way to a natural grass terrace. As the beach transitions from armoured to natural, the bed level of the backshore and foreshore increase in elevation and a dry high tide beach is present.

37.3 Component values

The site is split into six cells based on coastal geomorphology and human modification. Cliff cells (A and D) are located at the northern and central sections of the site and have a consistent underlying geology of Waipapa greywacke, resulting in the same stable angle (26 – 34 degrees) and sea level rise response factor, as informed by a senior geotechnical engineer. A road traverses the crest of the cliff at Cell A and the cliff face is protected in some places for stability. No protection is present at the headland at Cell D and natural erosion and instability was observed during the site visit. Cliff heights are similar at both cells, with an average height of 8-10 m based on analysis of LiDAR data. Similar long-term erosion rates were adopted for the two cliff sites (Cell A and D) based analysis of historic short-term shoreline rates, with average rates of -0.08 and -0.1 m/yr.

Historic and modern coastal protection structure have a significant impact on the coast at Paihia. Where coastal protection structures are maintained at Cells B and C, CEHZ0 should be adopted. However, if structures should fail or be removed then hazard zones could be extended to CEHZ1-3 depending on timeframe and SLR scenario. Component values for the reclaimed site at Cell C are based on neighbouring values from neighbouring Cell B, which is likely representative of the shoreline prior to reclamation.

Coastal erosion along the armoured terrace at Cell B was assessed using the consolidated cliff method, because no dynamic beach is present. At this location, the stable angle and sea level rise response factor are based on sedimentary material that is partly cemented and topped by vegetation. Analysis of historic shoreline position at Cell B indicates a trend of erosion at an average rate of -0.1m/yr. The majority of this section is now protected using a range of different structural methods to protect the road and walkway and construction of different structures overtime has an influence on long-term rates.

Susceptibility to coastal erosion at southern coastal terrace sites Cell E and F were assessed using the unconsolidated beach method. The short-term component was adopted from Table 4.6 from T+T (2020) and dune / bank stability was determined by the toe to crest elevation with a stable angle based on unconsolidated sand. The closure slope used to assess beach response to sea level rise is based on the methodology from Section 4.6 of T+T (2020), with the dune crest replaced by the landward limit of unconsolidated beach. A representative closure slope was taken from Cell F and applied to Cell E. Both unconsolidated beach cells appear to have a historically stable shoreline position with an average rate of change of 0 ± 0.1m/yr.

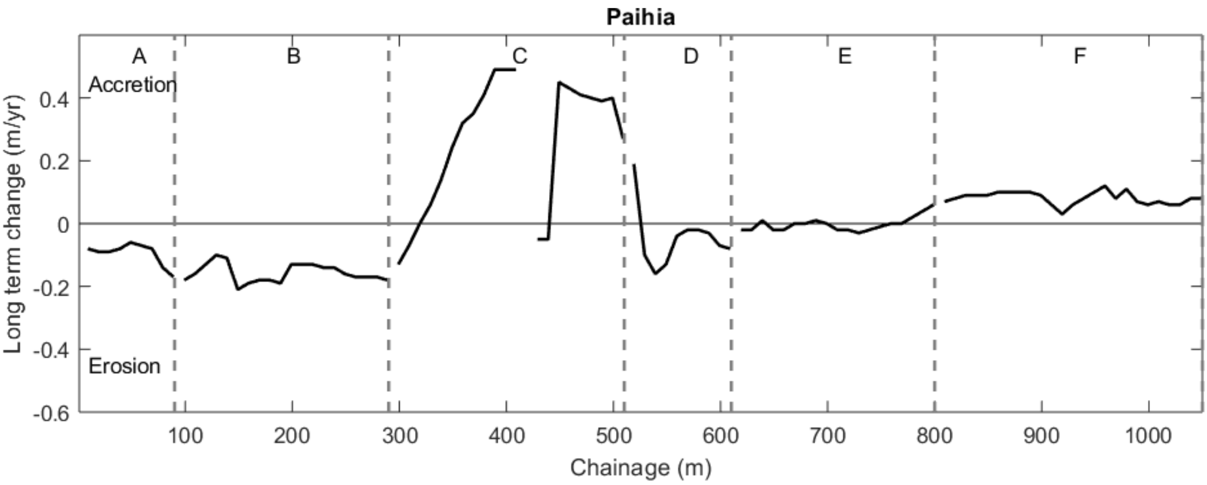


Figure 37.3: Rate of long-term shoreline change along the site showing each cell.

Table 37.1: Component values for Erosion Hazard Assessment

Site		37. Paihia					
Cell		**37A**	**37B[1]**	**37C[1]**	**37D**	**37E[1]**	**37F**
Cell centre (NZTM)	E	1699158	1699208	1699400	1699486	1699527	1699670
	N	6095480	6095367	6095255	6095136	6095022	6094895
Chainage, m (from N)		1-80	80-280	280-500	500-600	600-800	800-1040
Morphology		Waipapa greywacke cliff	Consolidated terrace[+]	Seawall / reclaimed[+]	Waipapa greywacke cliff	Coastal terrace	
Short-term (m)	Min	-	-	-	-	2	2
	Mode	-	-	-	-	4	4
	Max	-	-	-	-	6	6
Dune/Cliff elevation (m above toe or scarp)	Min	6	2.5	2.0	7	1.0	0.8
	Mode	8	3.0	2.5	10	1.5	1.4
	Max	10	3.2	3.0	12	2.0	1.9
Stable angle (deg)	Min	26.6	30	30	26.6	30	30
	Mode	30.15	32	32	30.15	32	32
	Max	33.7	34	34	33.7	34	34
Long-term (m) -ve erosion +ve accretion	Min	-0.17	*-0.20*	*-0.2*	-0.15	*-0.10*	-0.10
	Mode	-0.10	*-0.15*	*-0.15*	-0.08	*0.00*	0.00
	Max	-0.06	*-0.10*	*-0.1*	0.00	*0.10*	0.10
Closure slope (beaches) / Cliff response factor	Min	0.1	0.2	0.2	0.1	0.018	0.018
	Mode	0.2	0.3	0.3	0.2	0.03	0.03
	Max	0.3	0.4	0.4	0.3	0.089	0.089

[+]Shoreline armoured with engineered coastal protection structure

[1]CHEZ0 method applied

Table 37.2: Adopted sea level rise values (m) based on four scenarios included in MfE (2017) adjusted to 2019 baseline

Coastal type	Year	RCP2.6M	RCP4.5M	RCP8.5M	RCP8.5+
Consolidated cliff	2080	0.29	0.34	0.46	0.64
	2130	0.52	0.66	1.09	1.41
Unconsolidated beach[1]	2080	0.16	0.21	0.33	0.51
	2130	0.28	0.42	0.85	1.17

[1]Adjusted to remove the influence of historic SLR (2.2 mm/year) on long-term rates of shoreline change

37.4 Coastal erosion hazard assessment

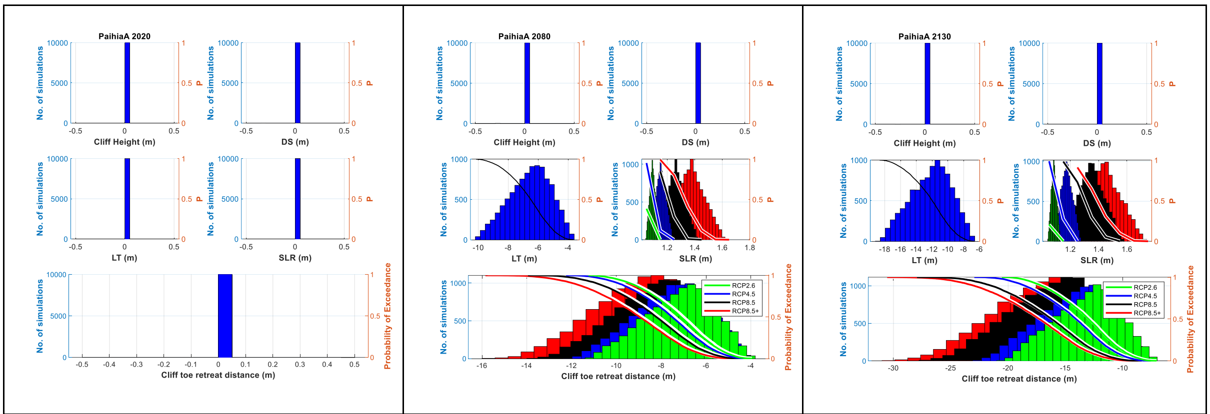
Histograms of individual components and resultant CEHZ distances computed using a Monte Carlo technique are shown in Figure 37.4 to Figure 37.9. Coastal Erosion Hazard Zone widths and future shoreline distances are presented within Table 37.3 to Table 37.5 and mapped in Figure 37.10.

For beach dune and coastal terrace cells, CEHZ1 distance range from 11 to 15 m with Cells E and F rounded up to the minimum value of 15 m for dunes. CEHZ2 values range from 25 to 42 m, with Cell C rounded up to the minimum value of 25 m for terraces. CEHZ3 values range from 25 to 54 m.

For cliff Cells A, B and D, the cliff projection method was adopted and the result figures and tables below show the toe recession distance instead of CEHZ distances. Projected distances to 2080 distances from 5 to 14 m for RCP8.5 distances to 2130 range from 19 to 28 m for RCP8.5 and 20 to 44 m for RCP8.5+.

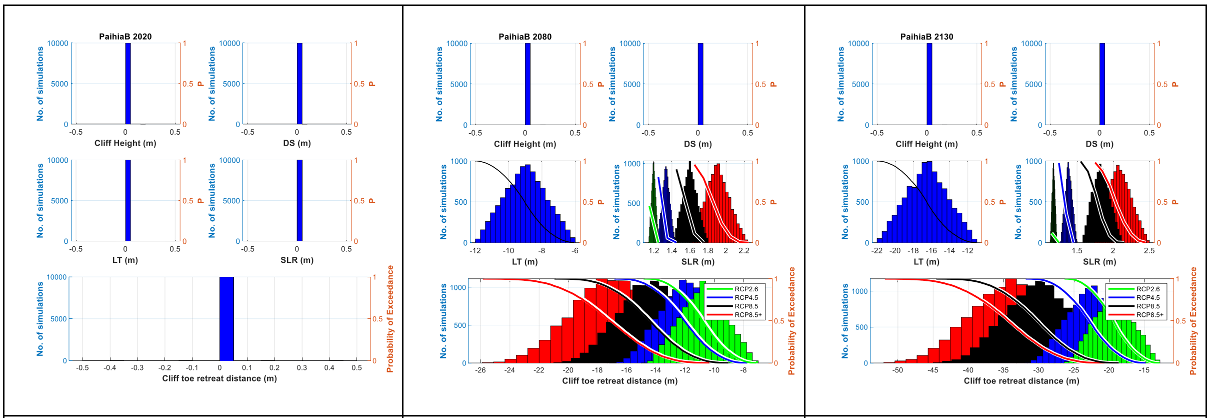
Total erosion distances for the three cliff cells was assessed using the cliff projection method, where the toe recession distance and stable angle were used to identify the stability zone using LiDAR extracted across-shore profiles extracted in 10 m intervals. A summary of total ASCE distances for cliff cells is presented in Table 37.6.

Figure 37.11 shows the available historic shorelines for Paihia.



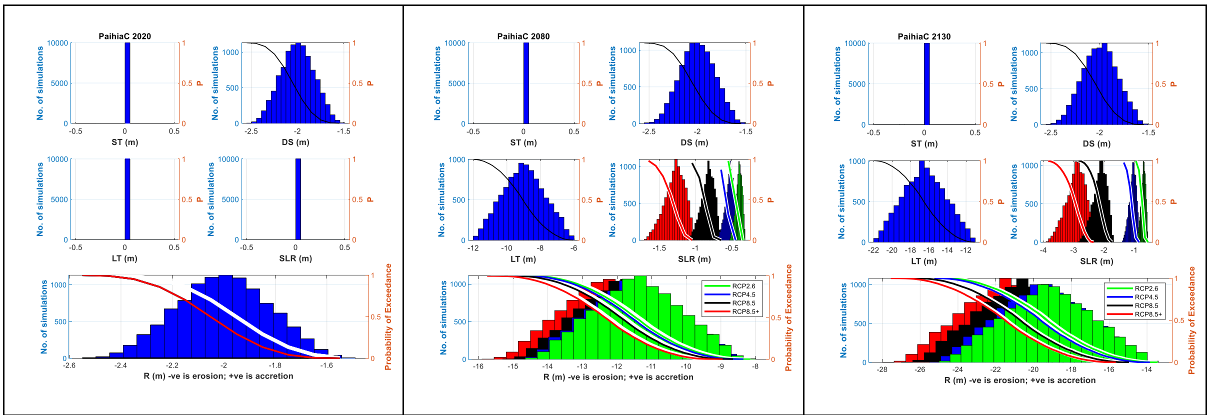
2020	2080	2130

Figure 37.4: Histograms of parameter samples and the resultant shoreline distances for 2020, 2080 and 2130 timeframes for cell 37A



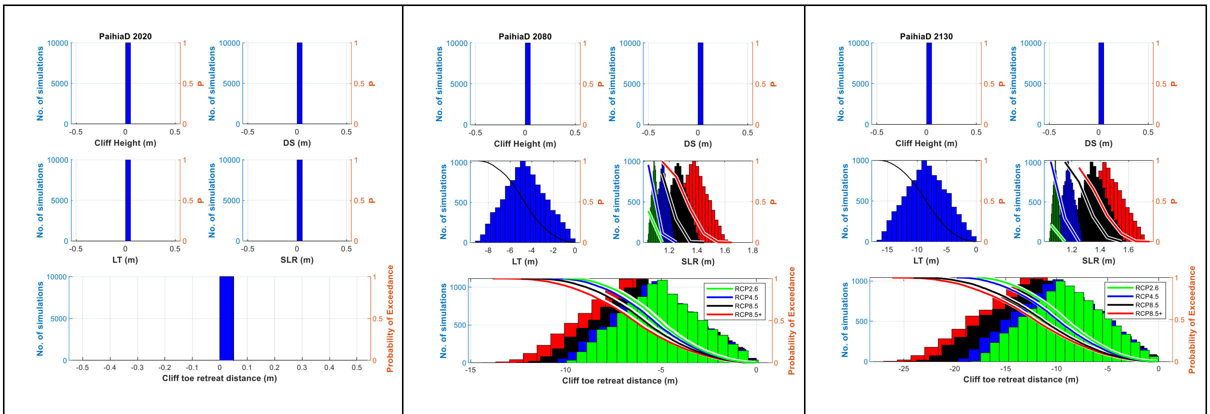
2020	2080	2130

Figure 37.5: Histograms of parameter samples and the resultant shoreline distances for 2020, 2080 and 2130 timeframes for cell 37B



2020	2080	2130

Figure 37.6: Histograms of parameter samples and the resultant shoreline distances for 2020, 2080 and 2130 timeframes for cell 37C



2020	2080	2130

Figure 37.7: Histograms of parameter samples and the resultant shoreline distances for 2020, 2080 and 2130 timeframes for cell 37D

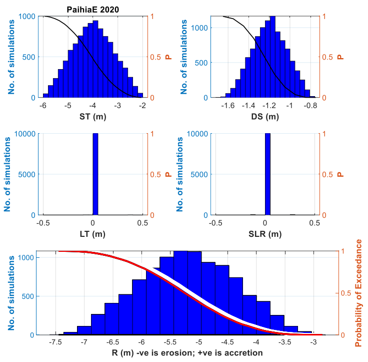
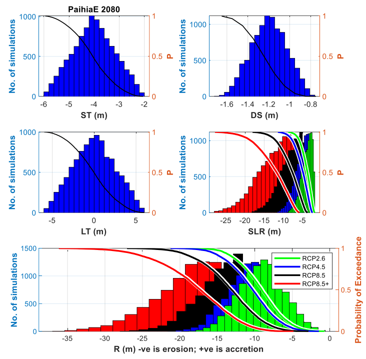
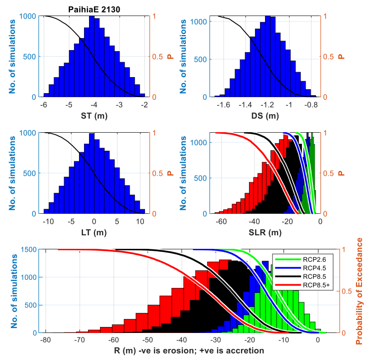
		
2020	*2080*	*2130*

Figure 37.8: Histograms of parameter samples and the resultant shoreline distances for 2020, 2080 and 2130 timeframes for cell 37E

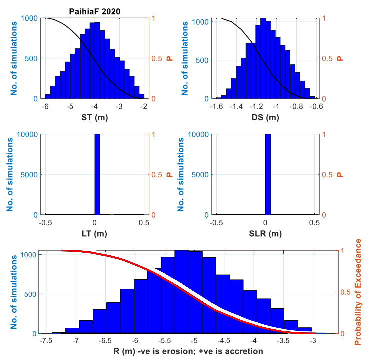
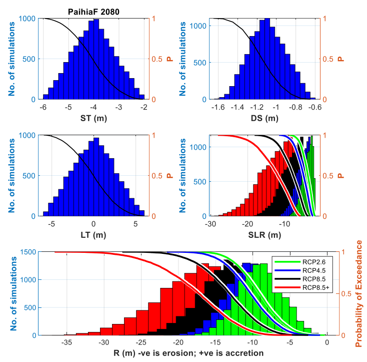
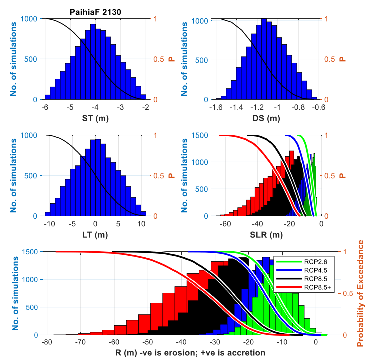
		
2020	*2080*	*2130*

Figure 37.9: Histograms of parameter samples and the resultant shoreline distances for 2020, 2080 and 2130 timeframes for cell 37F

Table 37.3: Coastal Erosion Hazard Zone Widths (m) Projected for 2020

Site		37. Paihia					
	Cell	37A*	37B*	37C	37D*	37E	37F
Probability of CEHZ (m) Exceedance	Min	0	0	-2	0	-3	-3
	99%	0	0	-2	0	-3	-3
	95%	0	0	-2	0	-4	-4
	90%	0	0	-2	0	-4	-4
	80%	0	0	-2	0	-4	-4
	70%	0	0	-2	0	-5	-5
	66%	0	0	-2	0	-5	-5
	60%	0	0	-2	0	-5	-5
	50%	0	0	-2	0	-5	-5
	40%	0	0	-2	0	-5	-5
	33%	0	0	-2	0	-6	-5
	30%	0	0	-2	0	-6	-6
	20%	0	0	-2	0	-6	-6
	10%	0	0	-2	0	-6	-6
	5%	0	0	-2	0	-7	-7
	1%	0	0	-2	0	-7	-7
	Max	0	0	-3	0	-7	-7

*Cliff projection method has been used, so cliff toe position has been tabulated, which has been assumed to be unchanged from the adopted 2019 baseline. Actual CEHZ width will be greater depending on cliff height and stable slope angle.

Table 37.4: Coastal Erosion Hazard Zone Widths (m) Projected for 2080

Site		37. Paihia																							
Cell		37A				37B				37C				37D				37E				37F			
RCP scenario		2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+
Probability of CEHZ (m) Exceedance	Min	-4	-4	-4	-5	-7	-8	-9	-10	-8	-8	-9	-9	0	0	0	0	-1	-1	-3	-5	0	-1	-3	-5
	99%	-4	-5	-5	-5	-8	-8	-10	-12	-9	-9	-9	-10	-1	-1	-1	-1	-3	-3	-5	-8	-3	-4	-5	-8
	95%	-5	-5	-6	-6	-8	-9	-11	-13	-9	-9	-10	-10	-2	-2	-2	-2	-4	-5	-7	-10	-4	-5	-7	-10
	90%	-5	-6	-6	-7	-9	-10	-12	-14	-10	-10	-10	-11	-2	-2	-3	-3	-5	-6	-8	-12	-5	-6	-8	-11
	80%	-6	-6	-7	-7	-9	-11	-13	-15	-10	-10	-11	-11	-3	-3	-4	-4	-7	-8	-10	-13	-6	-8	-10	-13
	70%	-6	-7	-7	-8	-10	-11	-13	-16	-11	-11	-11	-12	-4	-4	-5	-5	-8	-9	-11	-15	-7	-9	-11	-15
	66%	-6	-7	-7	-8	-10	-11	-14	-16	-11	-11	-11	-12	-4	-4	-5	-5	-8	-9	-12	-15	-8	-9	-11	-15
	60%	-7	-7	-8	-8	-10	-12	-14	-16	-11	-11	-12	-12	-5	-5	-5	-6	-8	-9	-12	-16	-8	-9	-12	-16
	50%	-7	-7	-8	-9	-11	-12	-14	-17	-11	-12	-12	-12	-5	-5	-6	-6	-9	-10	-13	-17	-9	-10	-13	-17
	40%	-8	-8	-9	-10	-11	-12	-15	-18	-12	-12	-12	-13	-6	-6	-6	-7	-10	-11	-14	-19	-10	-11	-14	-19
	33%	-8	-8	-9	-10	-11	-13	-15	-18	-12	-12	-12	-13	-6	-6	-7	-8	-10	-12	-15	-20	-10	-12	-15	-20
	30%	-8	-8	-9	-10	-12	-13	-16	-19	-12	-12	-13	-13	-6	-6	-7	-8	-11	-12	-15	-20	-11	-12	-15	-20
	20%	-9	-9	-10	-11	-12	-14	-16	-19	-13	-13	-13	-13	-7	-7	-8	-9	-12	-13	-16	-22	-12	-13	-16	-22
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	5%	-10	-10	-12	-13	-13	-15	-18	-22	-13	-14	-14	-14	-8	-9	-10	-11	-14	-16	-20	-27	-14	-16	-20	-27
	1%	-11	-11	-12	-14	-14	-16	-19	-23	-14	-14	-14	-15	-9	-10	-11	-12	-16	-18	-23	-31	-16	-18	-23	-31
	Max	-11	-12	-14	-16	-15	-17	-21	-26	-15	-15	-15	-16	-10	-11	-12	-14	-19	-21	-27	-36	-19	-22	-28	-37
	CEHZ1	-7*				-14*				-11				-5*				-15				-15			

*Cliff projection methodology used, so distance to future cliff toe position has been tabulated. Actual CEHZ width will be greater depending on cliff height and stable slope angle.

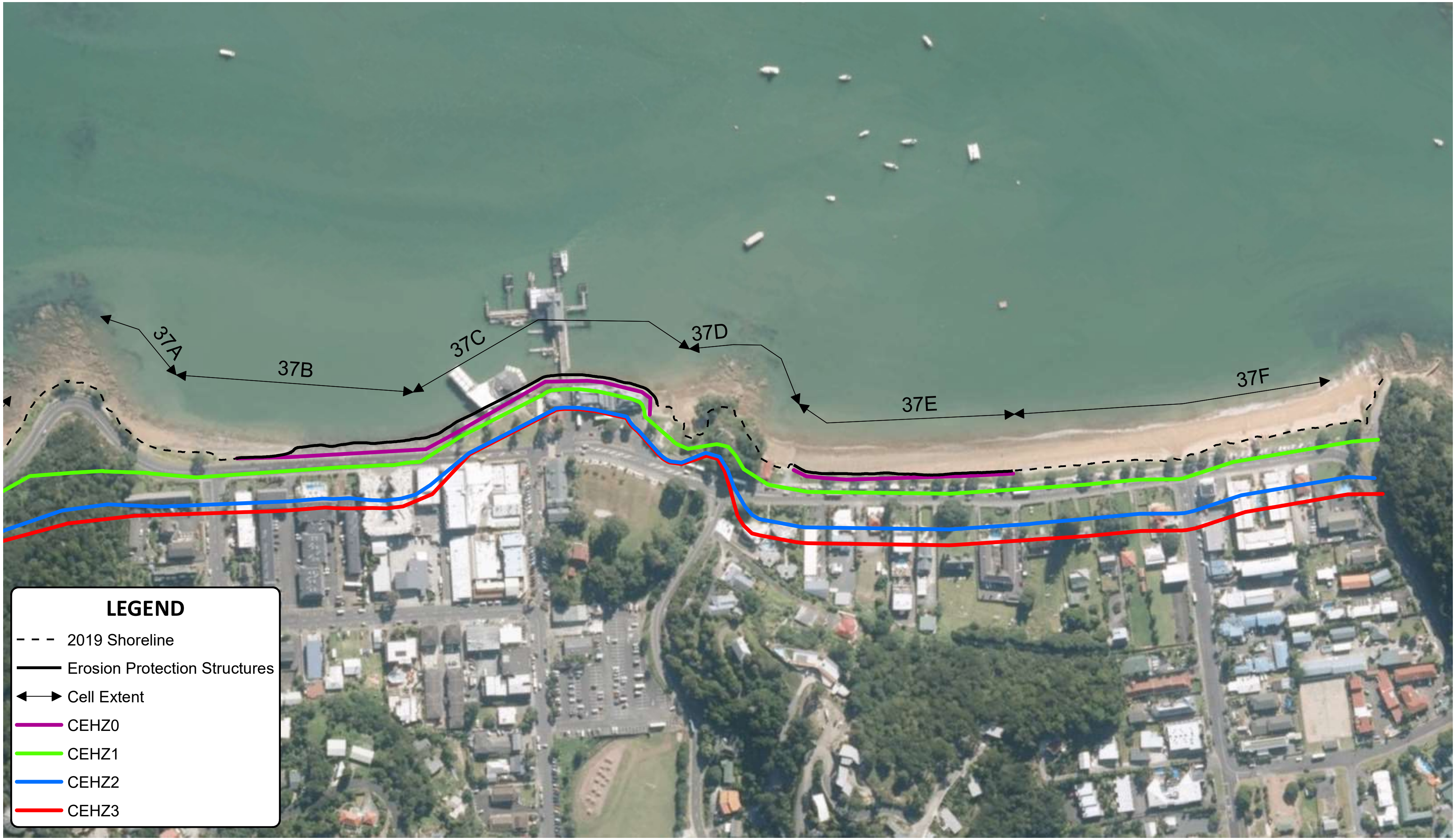
Table 37.5: Coastal Erosion Hazard Zone Widths (m) Projected for 2130

Site		37. Paihia																							
Cell		37A				37B				37C				37D				37E				37F			
RCP scenario		2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+	2.6	4.6	8.5	8.5+
Probability of CEHZ (m) Exceedance	Min	-7	-7	-8	-8	-13	-14	-18	-20	-13	-14	-15	-16	0	0	0	0	2	0	-5	-9	3	1	-4	-8
	99%	-8	-9	-10	-10	-14	-16	-21	-23	-14	-15	-16	-17	-1	-1	-2	-2	-1	-3	-10	-14	-1	-3	-10	-14
	95%	-9	-10	-11	-12	-15	-18	-23	-26	-15	-16	-17	-18	-3	-3	-4	-4	-4	-6	-13	-18	-4	-6	-13	-18
	90%	-10	-10	-12	-13	-16	-19	-24	-27	-16	-16	-18	-18	-4	-5	-5	-6	-5	-8	-16	-21	-5	-8	-16	-21
	80%	-11	-12	-13	-14	-17	-20	-26	-30	-17	-18	-19	-19	-6	-6	-7	-8	-8	-10	-19	-24	-7	-10	-19	-24
	70%	-11	-12	-14	-15	-18	-21	-28	-31	-18	-18	-19	-20	-7	-8	-9	-9	-9	-12	-21	-27	-9	-12	-21	-27
	66%	-12	-13	-15	-16	-18	-21	-28	-32	-18	-19	-20	-20	-8	-8	-9	-10	-10	-13	-22	-28	-10	-13	-22	-28
	60%	-12	-13	-15	-16	-19	-22	-29	-33	-19	-19	-20	-21	-8	-9	-10	-11	-11	-14	-23	-30	-11	-14	-23	-30
	50%	-13	-14	-16	-17	-19	-23	-30	-34	-19	-20	-21	-21	-9	-10	-11	-12	-12	-15	-25	-33	-12	-15	-25	-33
	40%	-14	-15	-17	-18	-20	-24	-31	-36	-20	-20	-21	-22	-10	-11	-13	-13	-13	-17	-28	-36	-13	-17	-27	-36
	33%	-14	-15	-18	-19	-21	-24	-32	-37	-20	-21	-22	-23	-11	-12	-14	-14	-14	-18	-29	-38	-14	-18	-29	-38
	30%	-15	-16	-18	-19	-21	-24	-33	-37	-20	-21	-22	-23	-11	-12	-14	-15	-15	-19	-30	-39	-15	-18	-30	-39
	20%	-16	-17	-20	-21	-22	-26	-34	-39	-21	-22	-23	-24	-12	-13	-16	-17	-17	-20	-33	-43	-16	-20	-33	-43
	10%	-17	-18	-21	-23	-23	-27	-36	-41	-22	-23	-24	-25	-14	-15	-18	-19	-19	-23	-38	-49	-19	-23	-38	-49
	5%	-18	-19	-23	-24	-24	-28	-38	-44	-23	-23	-24	-25	-15	-16	-19	-20	-21	-25	-42	-54	-21	-25	-41	-54
	1%	-19	-21	-25	-27	-25	-30	-41	-47	-24	-24	-25	-26	-17	-18	-21	-23	-24	-30	-48	-63	-24	-29	-49	-63
	Max	-21	-23	-29	-32	-26	-32	-45	-52	-25	-25	-27	-28	-18	-20	-25	-27	-30	-37	-60	-76	-31	-38	-61	-77
	CEHZ2	-23*				-38				-25				-19*				-42				-41			
	CEHZ3	-24*				-44				-25				-20*				-54				-54			

*Cliff projection methodology used, so distance to future cliff toe position has been tabulated. Actual CEHZ width will be greater depending on cliff height and stable slope angle.

Table 37.6: Summary of CEHZ distances for cliff cells mapped using cliff projection method

	CEHZ1			CEHZ2			CEHZ3		
Cell	**Min (m)**	**Average (m)**	**Max (m)**	**Min (m)**	**Average (m)**	**Max (m)**	**Min (m)**	**Average (m)**	**Max (m)**
36A	-14	-31	-53	-48	-68	-87	-49	-69	-89
36B	-18	-19	-20	-42	-44	-51	-48	-50	-57
36D	-15	-20	-23	-25	-31	-34	-25	-31	-35



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Notes: Dashed CEHZ indicates greater uncertainty around stream mouths and backshore topography.
Northland 0.4m Rural Aerial Photos (2014-2016).

A4 SCALE 1:4,000

0 0.1 0.2 (km)

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

DRAWN	JJOU	May.20
CHECKED		
APPROVED		

ARCFILE 1012360_CEHZ001_v2.mxd

SCALE (AT A4 SIZE) 1:4,000

PROJECT No. 1012360

NORTHLAND REGIONAL COUNCIL
Coastal Erosion Hazard Assessment
Paihia
Site: 37

FIGURE No. Figure 37-10

Rev. 1

Path: P:\1012360\WorkingMaterial\GIS\CEHZ maps\1012360_Historicv2.mxd Date: 9/06/2020 Time: 9:24:37 AM

Notes: Dashed CEHZ indicates greater uncertainty around stream mouths and backshore topography.
Northland 0.4m Rural Aerial Photos (2014-2016).

A4 SCALE 1:4,000

0 0.1 0.2 (km)

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

DRAWN	JJOU	Jun.20
CHECKED		
APPROVED		

ARCFILE 1012360_Historicv2.mxd
SCALE (AT A4 SIZE) 1:4,000
PROJECT No. 1012360

NORTHLAND REGIONAL COUNCIL
Historic Shorelines
Paihia
Site: 37

FIGURE No. Figure 37-11
Rev. 1