Table C-2: Photogrammetry Accuracy, Where No Specific Analysis of Accuracy is Available (Source: Evans and Hanslow, 1996)

Year	Vertical Accuracy (m)	Horizontal Accuracy (m)
Pre-1960	±0.7	±1
Post-1960	±0.2	±0.5

C.2.1   Locations of Photogrammetry

At each beach, the processed photogrammetry data has been provided at discrete profiles along the beach. Profile spacing varies between 20 m – 50 m, depending on the location. Figures C-1 to C-10 show the profile locations at each of the beaches where erosion modelling was undertaken. Each profile is identified by a block name (letter or number) and profile number (e.g. BEP19 – Block E, Profile 19).
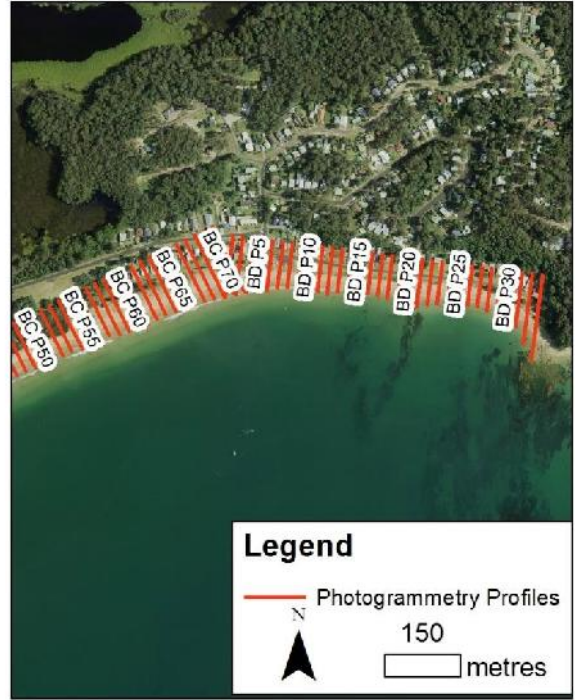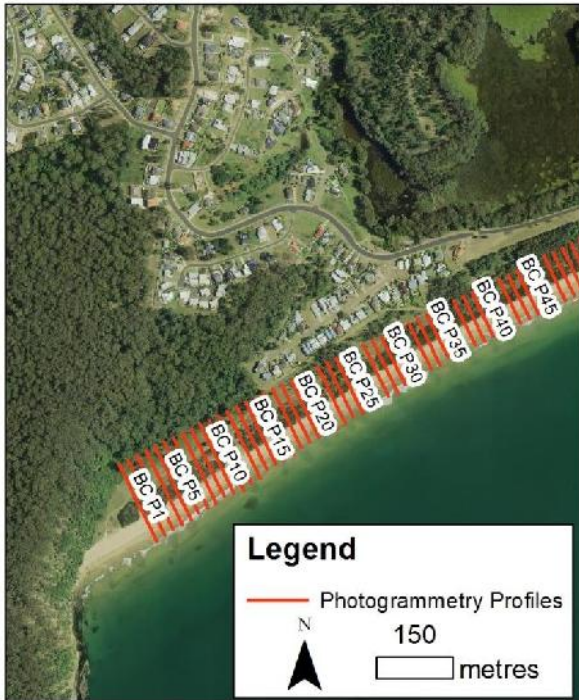

Figure C-1: Maloneys Beach profile locations

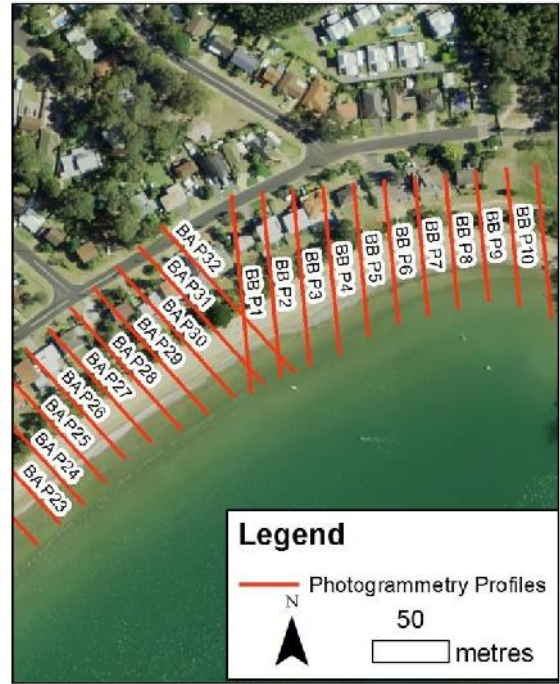**Figure C-2: Long Beach profile locations (not all profiles are labelled)**

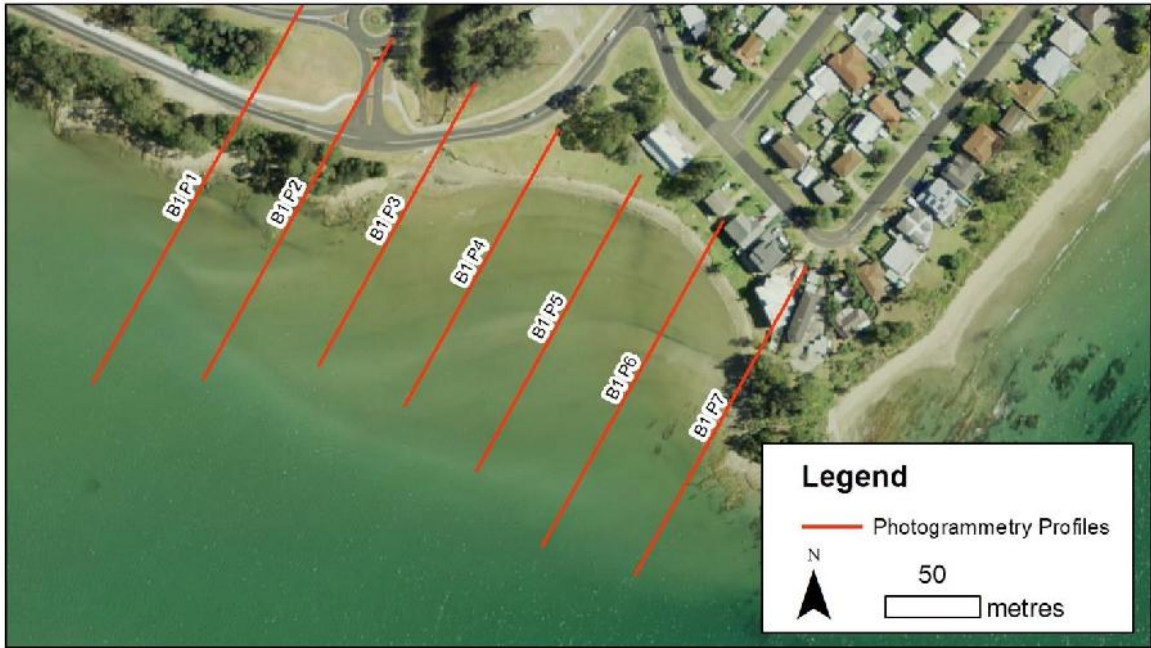**Figure C-3: Surfside Beach (east) profile locations**

Figure C-4: Surfside Beach (west) profile locations
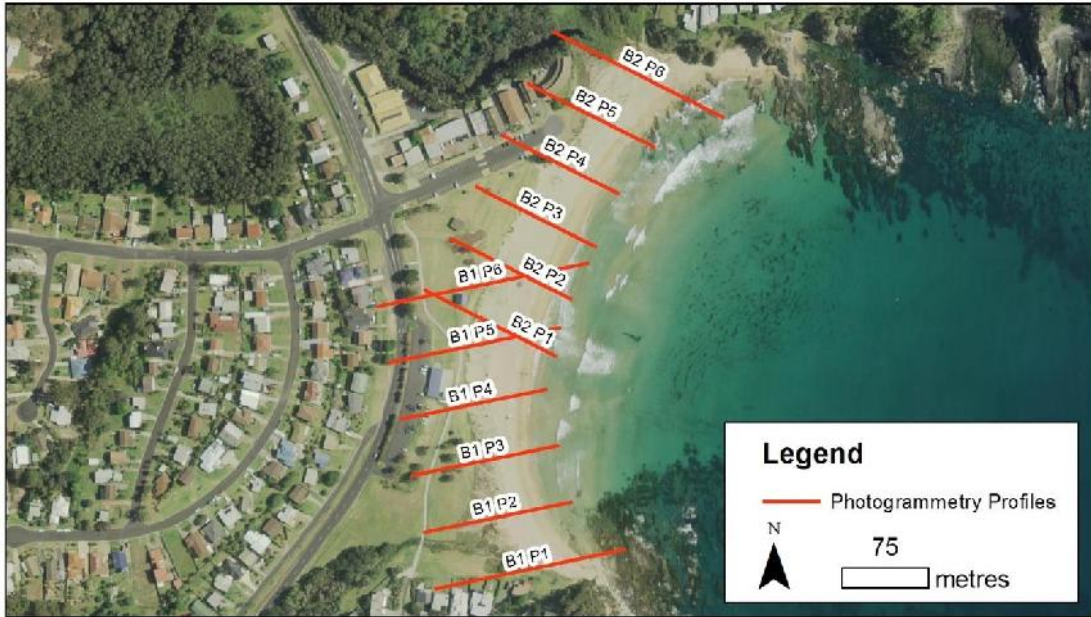

Figure C-5: Sunshine Bay profile locations

Figure C-6: Malua Bay profile locations
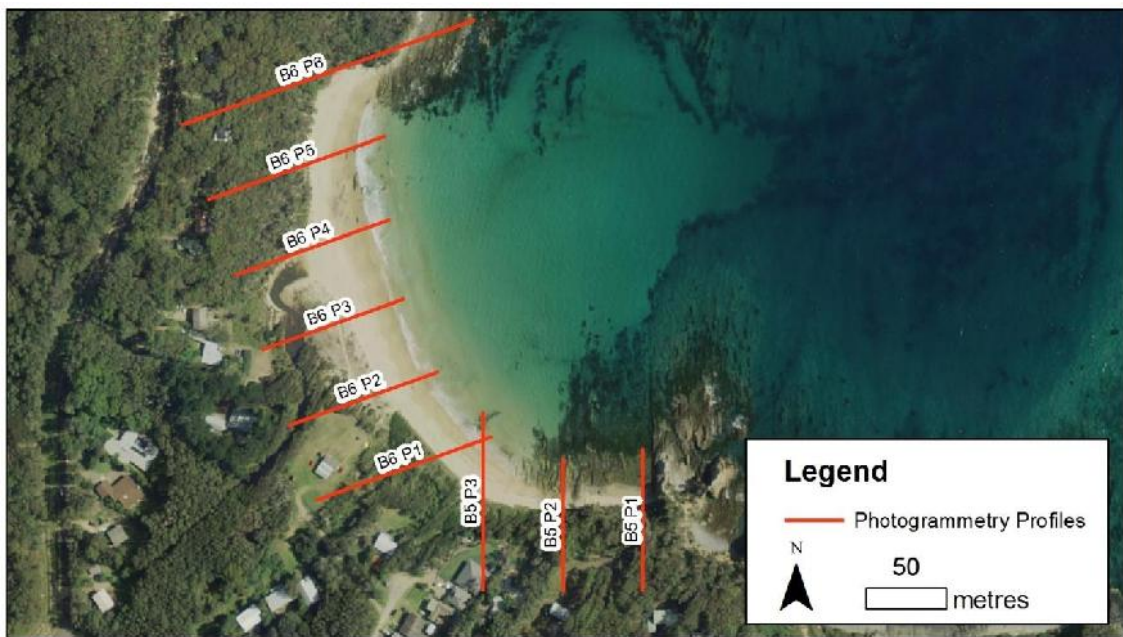

Figure C-7: Guerilla Bay profile locations
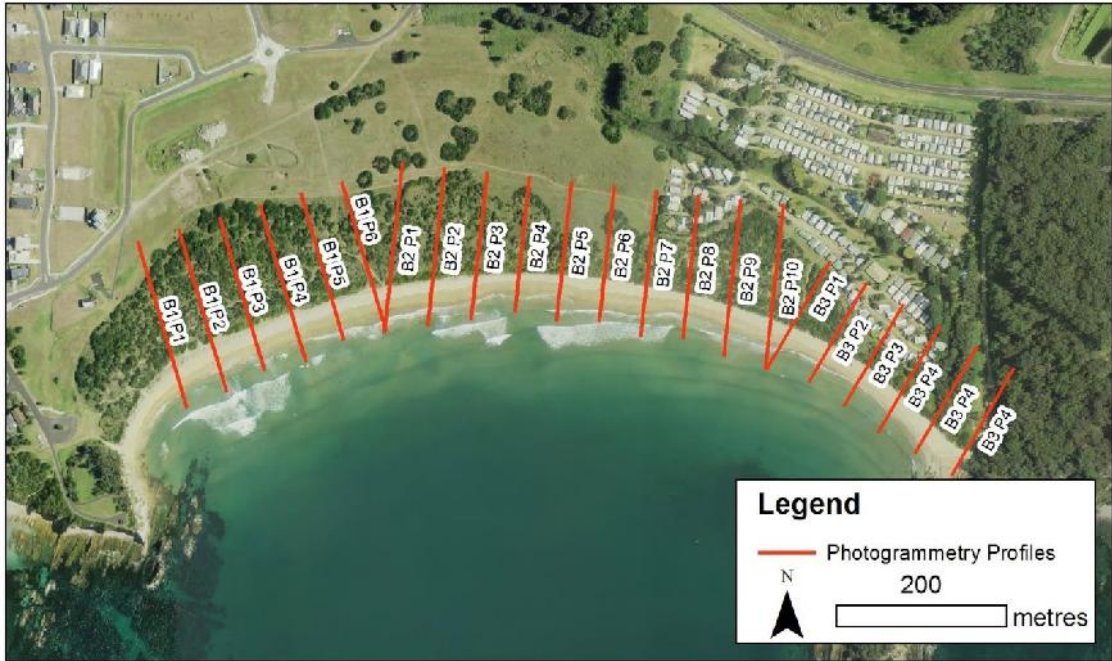
Figure C-8: Barlings Beach profile locations
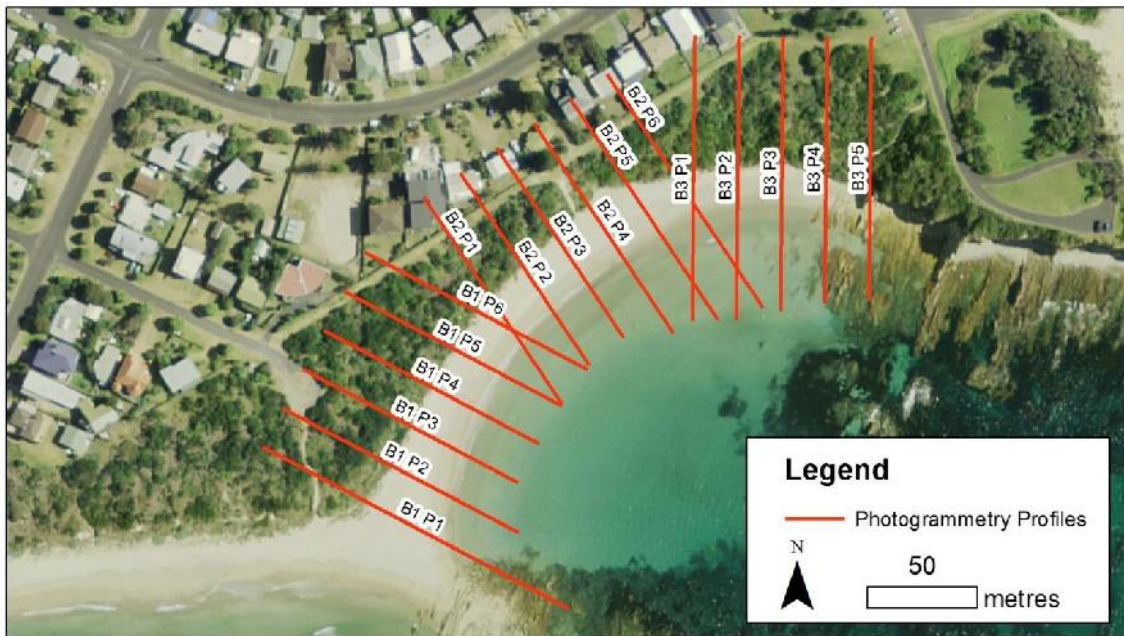
Figure C-9: Tomakin Cove profile locations
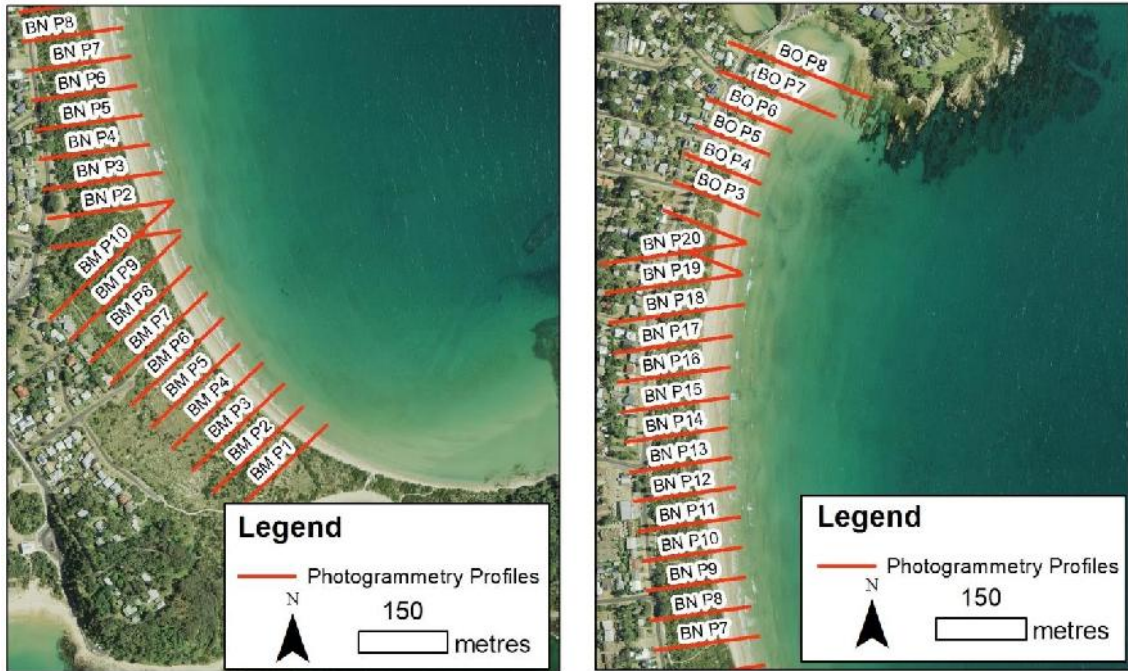
Figure C-10: Broulee Beach profile locations

C.2.2 Photogrammetry Cross Sections

Example photogrammetry cross sections for each beach section where erosion modelling was undertaken are shown in Figures C-11 to C-27.

Figure C-11: Example photogrammetry cross sections at Maloneys Beach East (Block E, Profile 28)

Figure C-12: Example photogrammetry cross sections at Maloneys Beach West (Block E, Profile 1)

Figure C-13: Example photogrammetry cross sections at Long Beach East (Block D, Profile 19)

Figure C-14: Example photogrammetry cross sections at Long Beach Central (Block C, Profile 68)

Figure C-15: Example photogrammetry cross sections at Long Beach Central (Block C, Profile 1)

Figure C-16: Example photogrammetry cross sections at Surfside Beach (east) North (Block A, Profile 28)

Figure C-17: Example photogrammetry cross sections at Surfside Beach (east) South (Block A, Profile 14)

Figure C-18: Example photogrammetry cross sections at Surfside Beach (west) (Block 1, Profile 5)
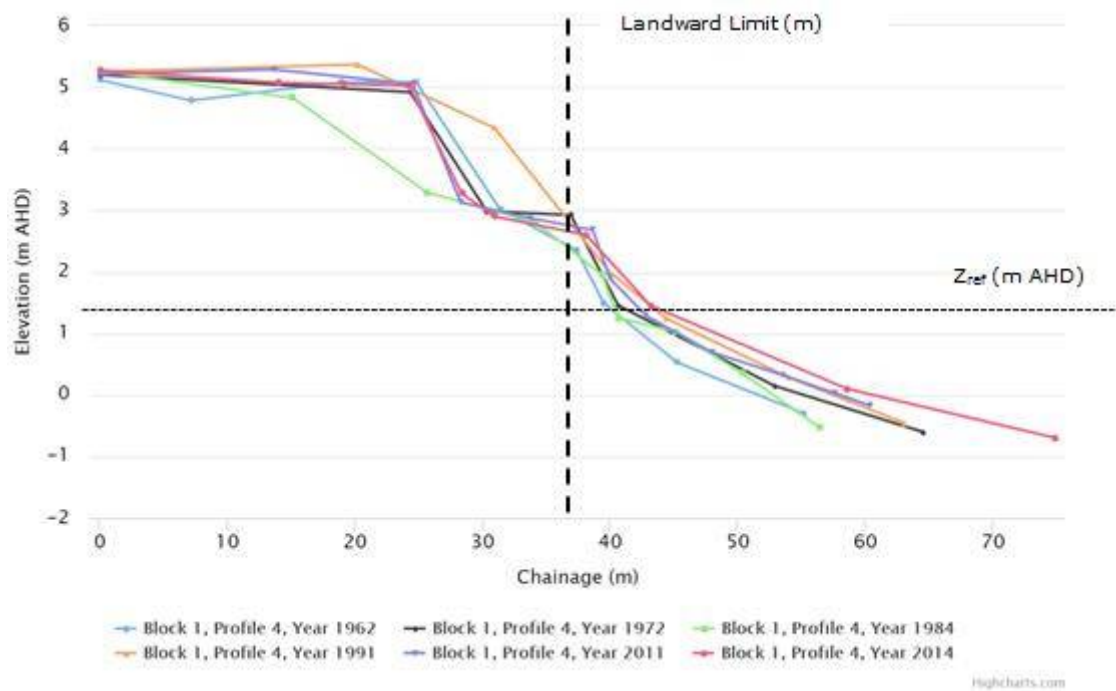
Figure C-19: Example photogrammetry cross sections at Sunshine Bay (Block 1, Profile 4)

Figure C-20: Example photogrammetry cross sections at Malua Bay (Block 2, Profile 2)
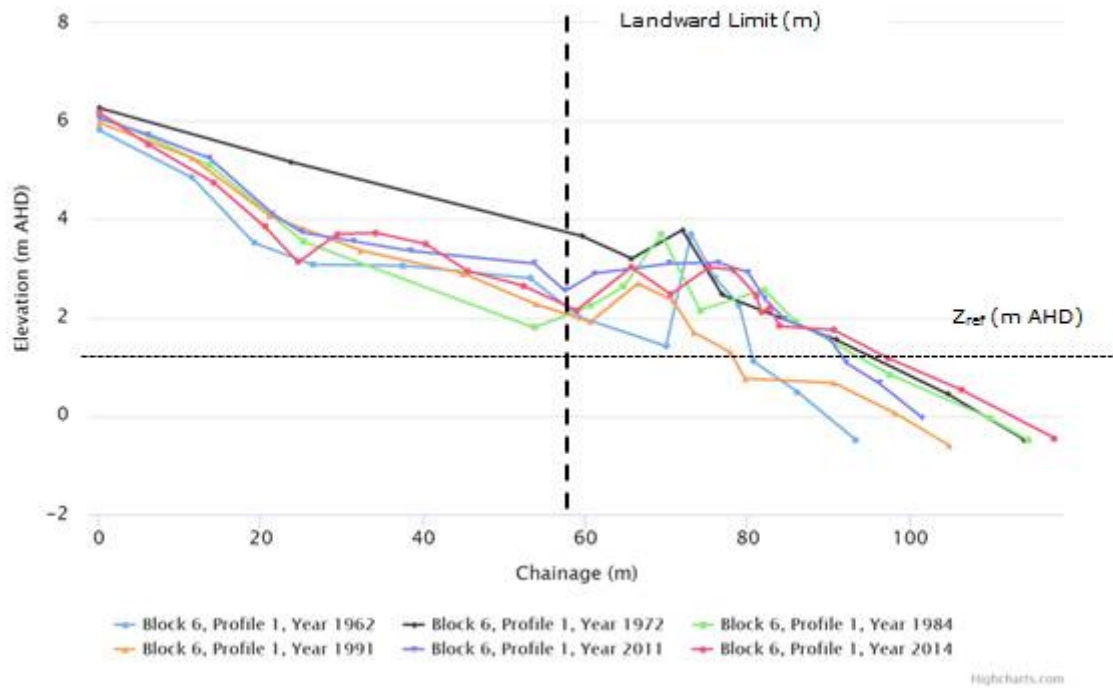
Figure C-21: Example photogrammetry cross sections at Guerilla Bay (Block 6, Profile 1)
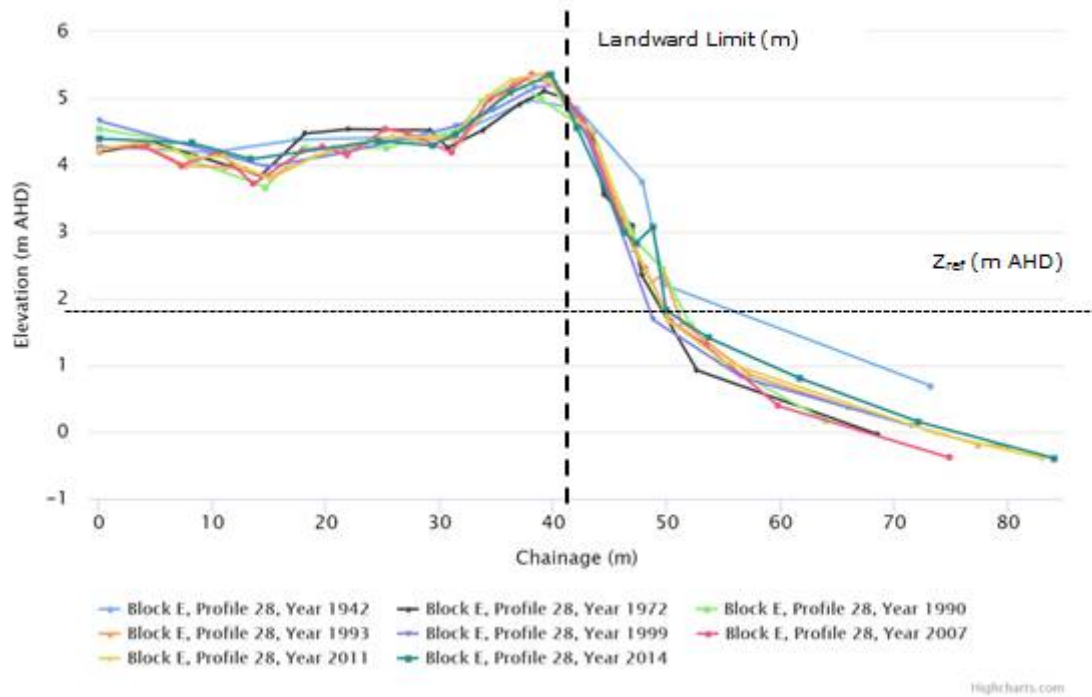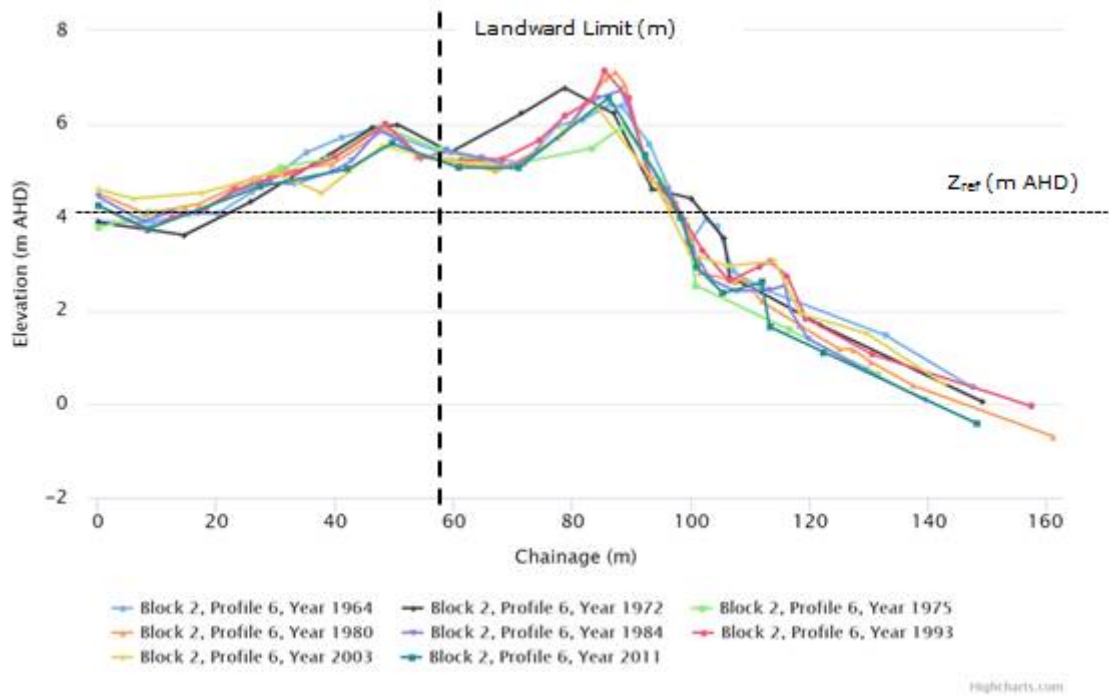

Figure C-22: Example photogrammetry cross sections at Barlings Beach East (Block 2, Profile 6)
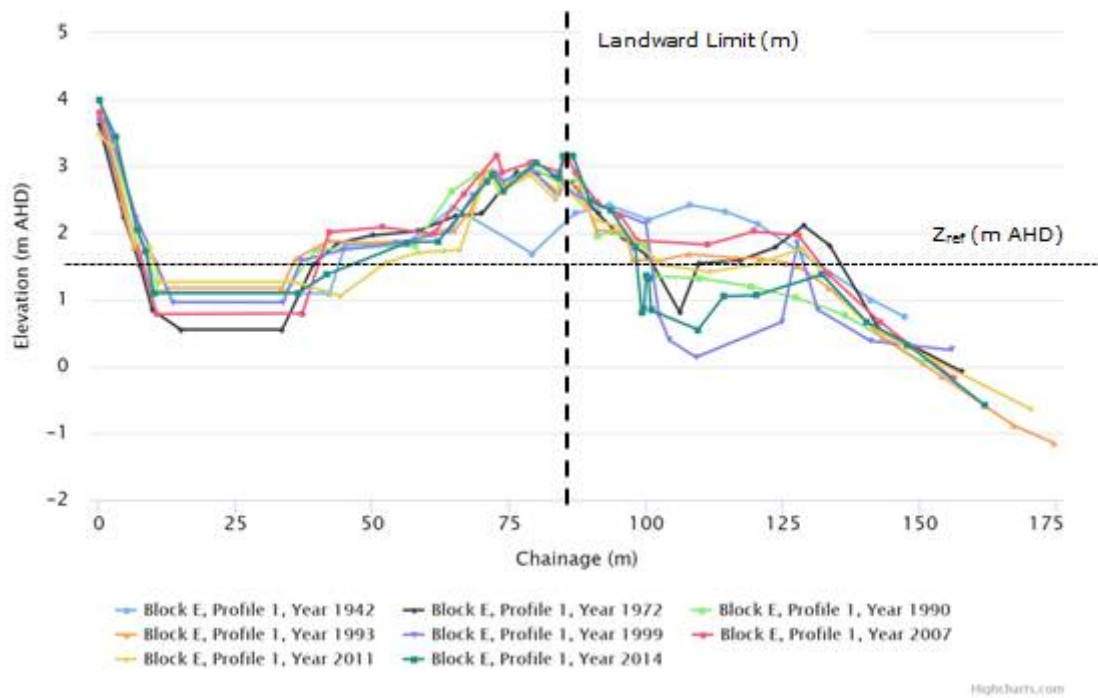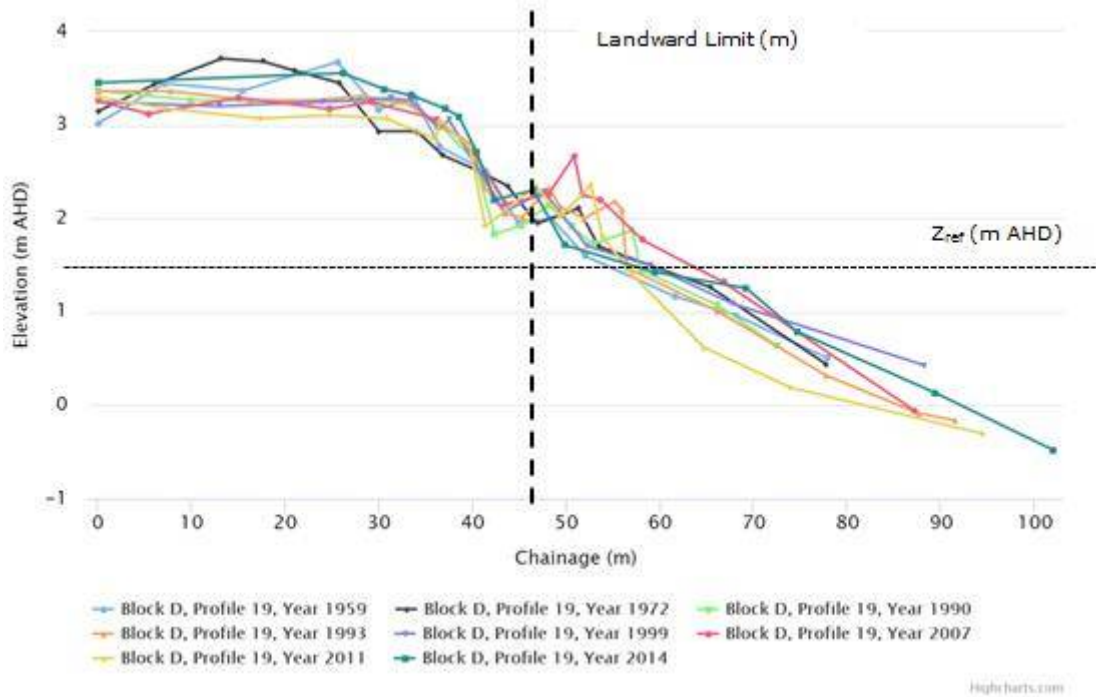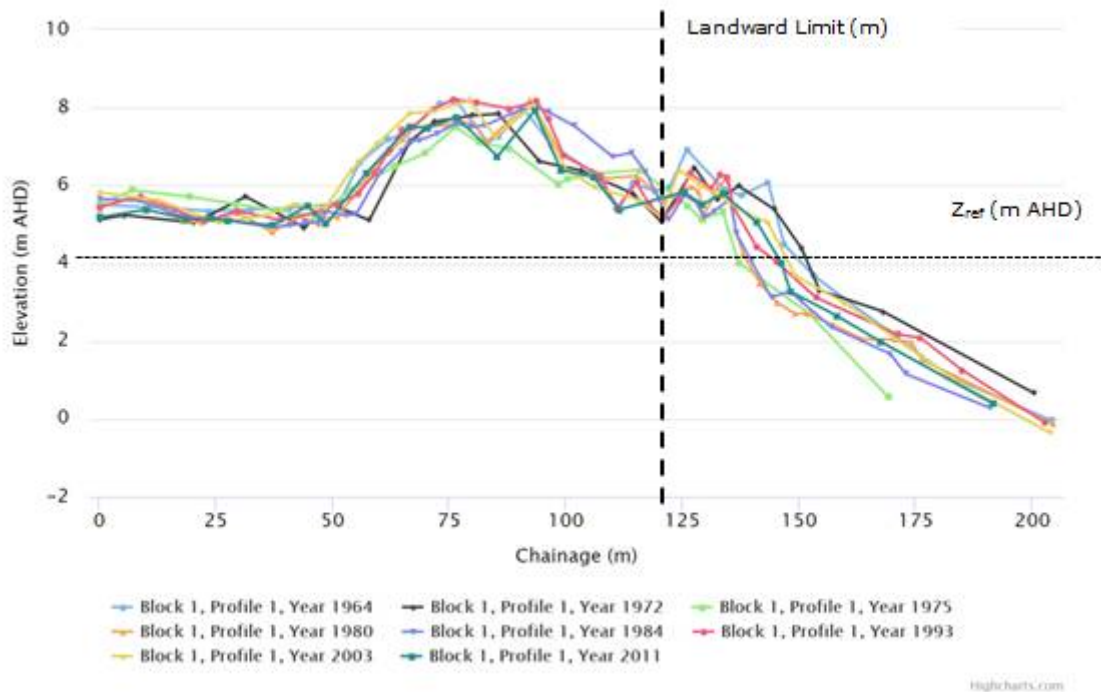
Figure C-23: Example photogrammetry cross sections at Barlings Beach West (Block 1, Profile 1)
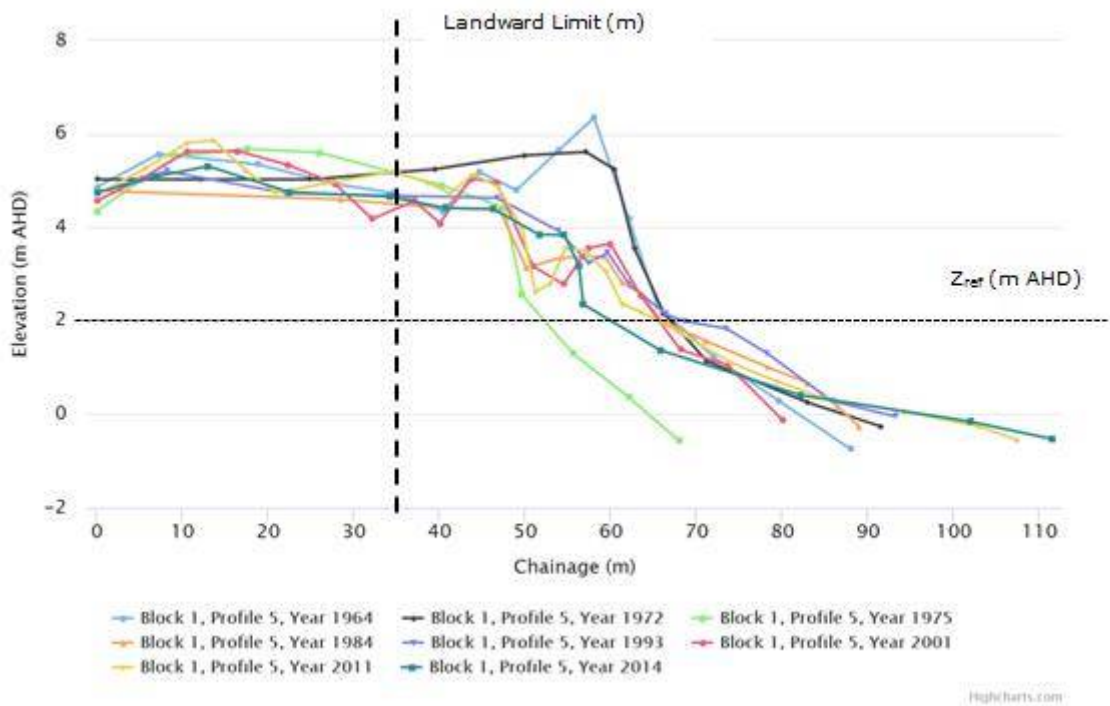
Figure C-24: Example photogrammetry cross sections at Tomakin Cove (Block 1, Profile 5)
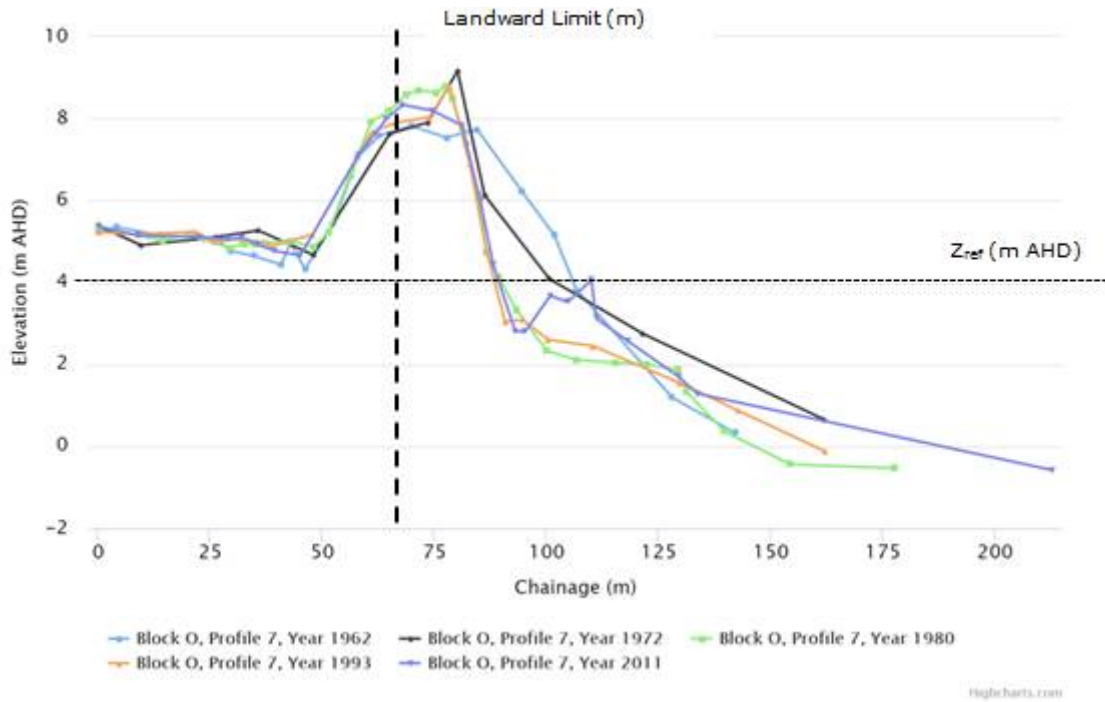
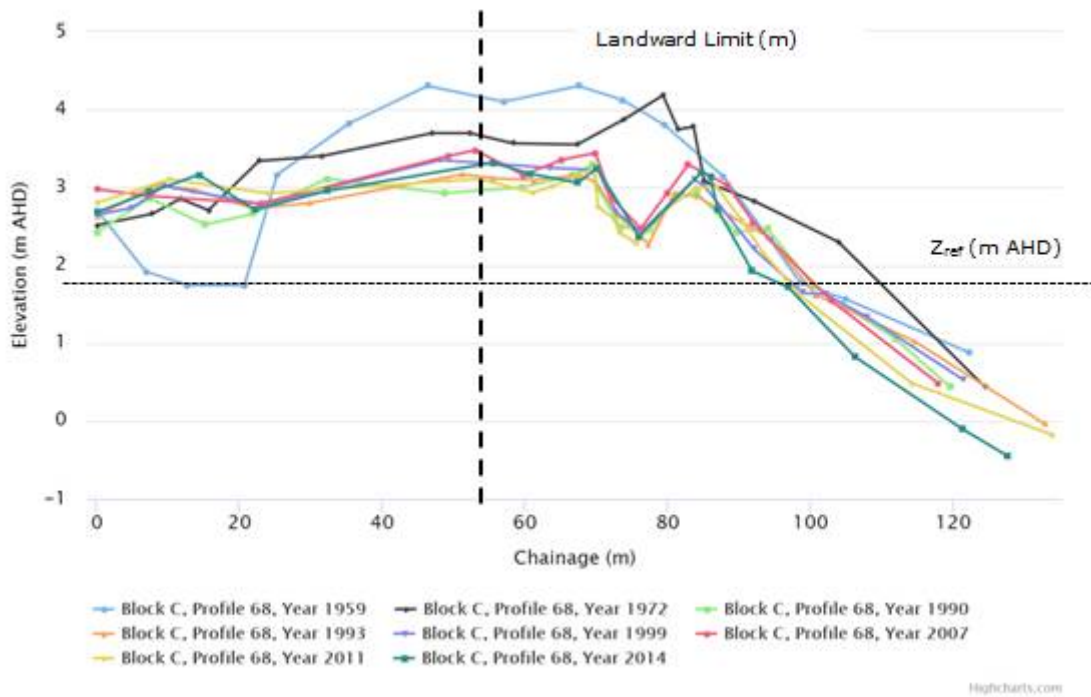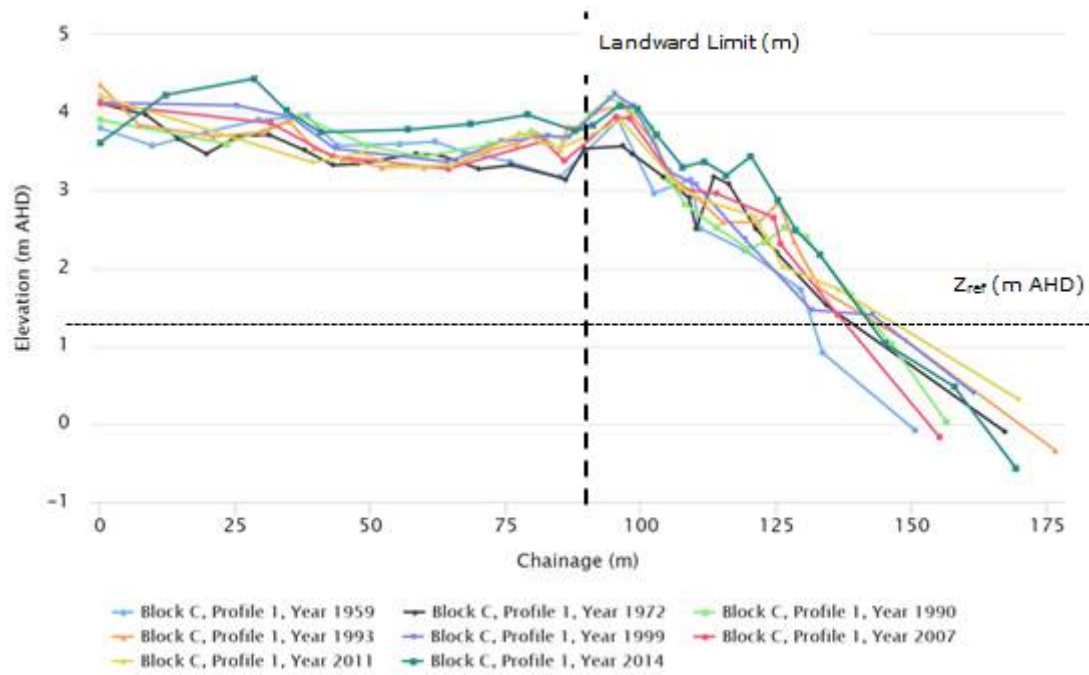**Figure C-25: Example photogrammetry cross sections at Broulee Beach North (Block O, Profile 7)**

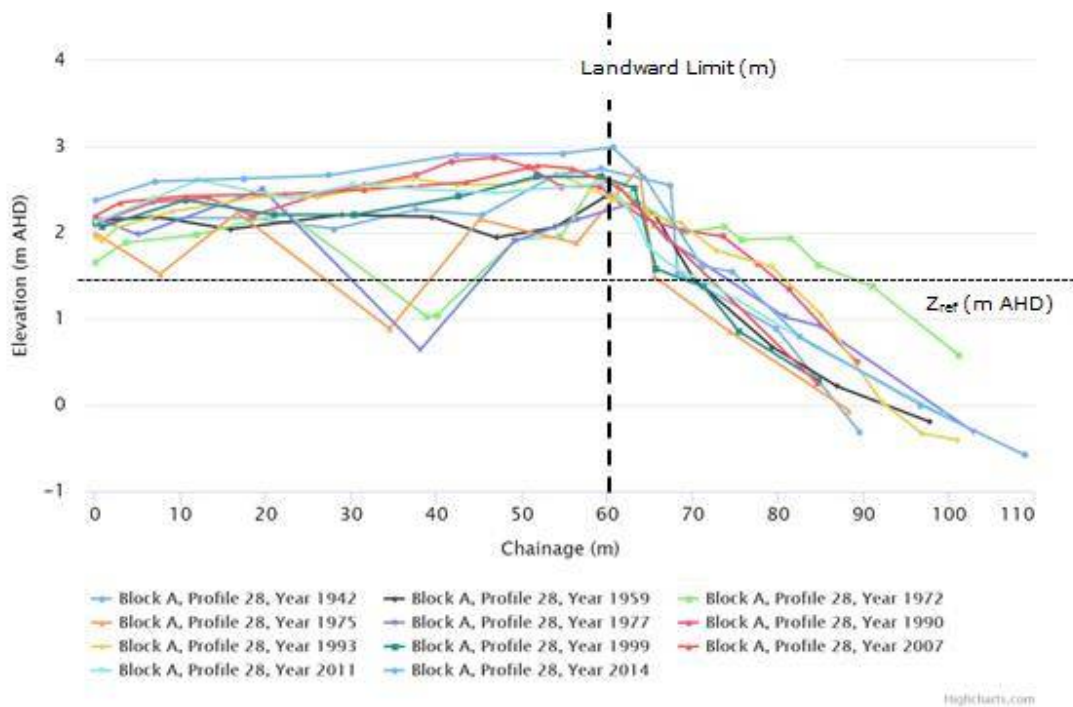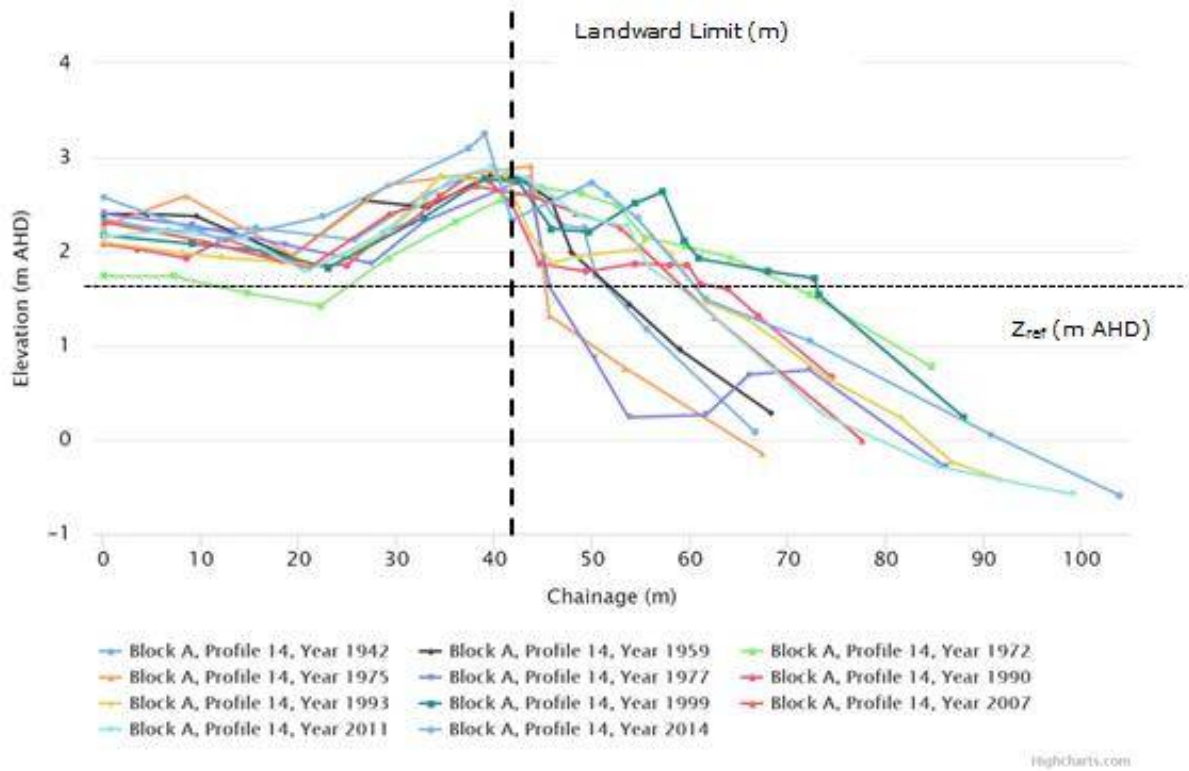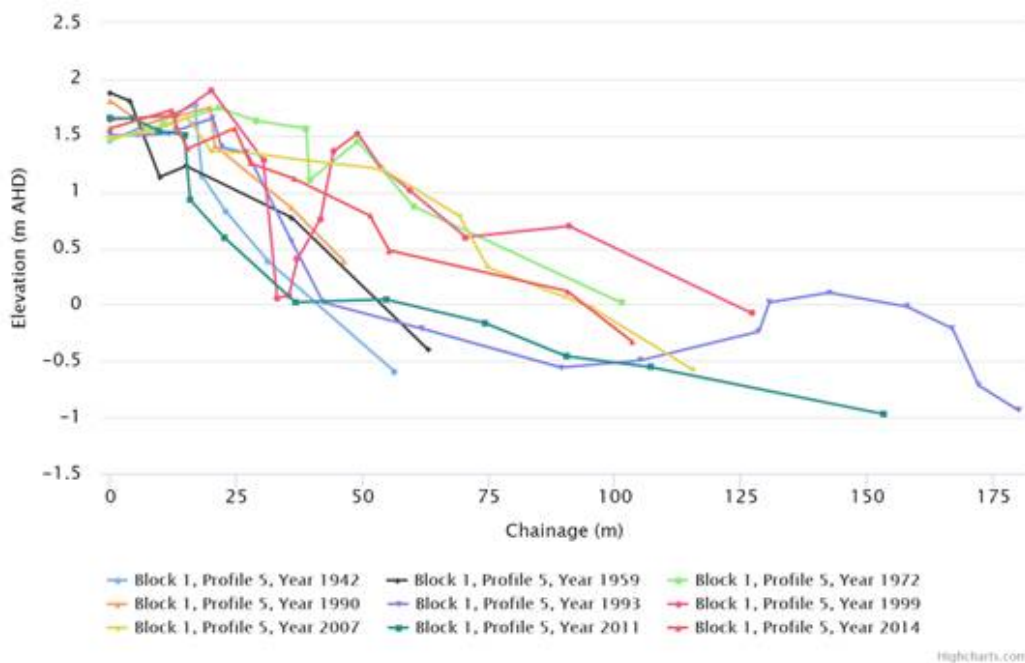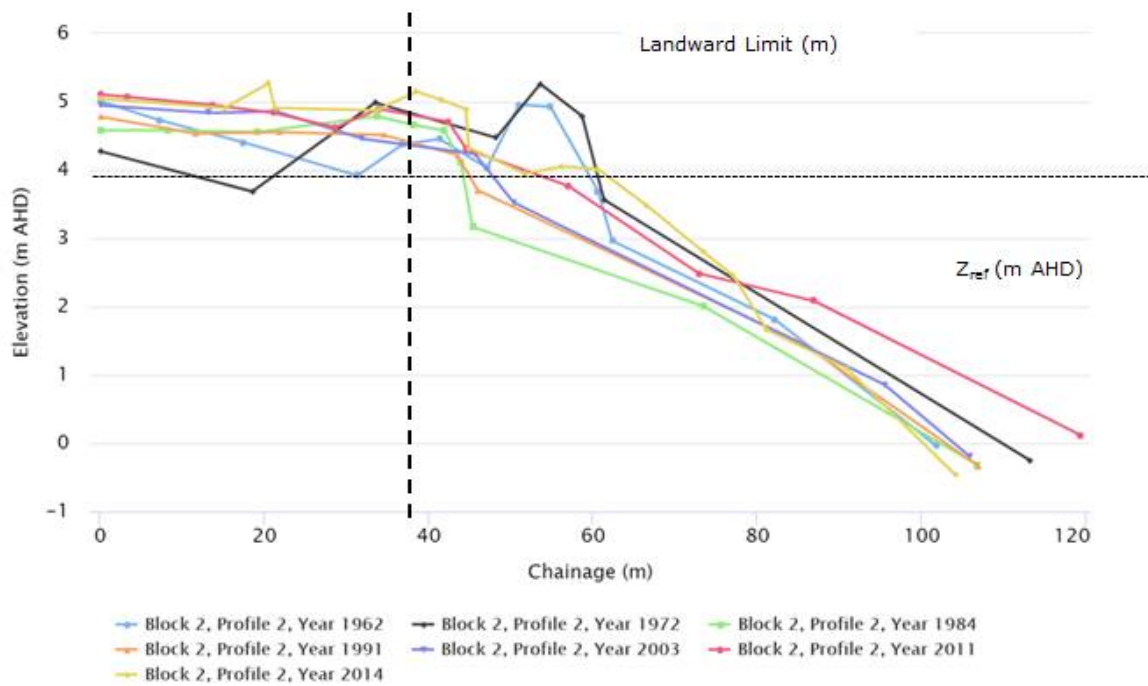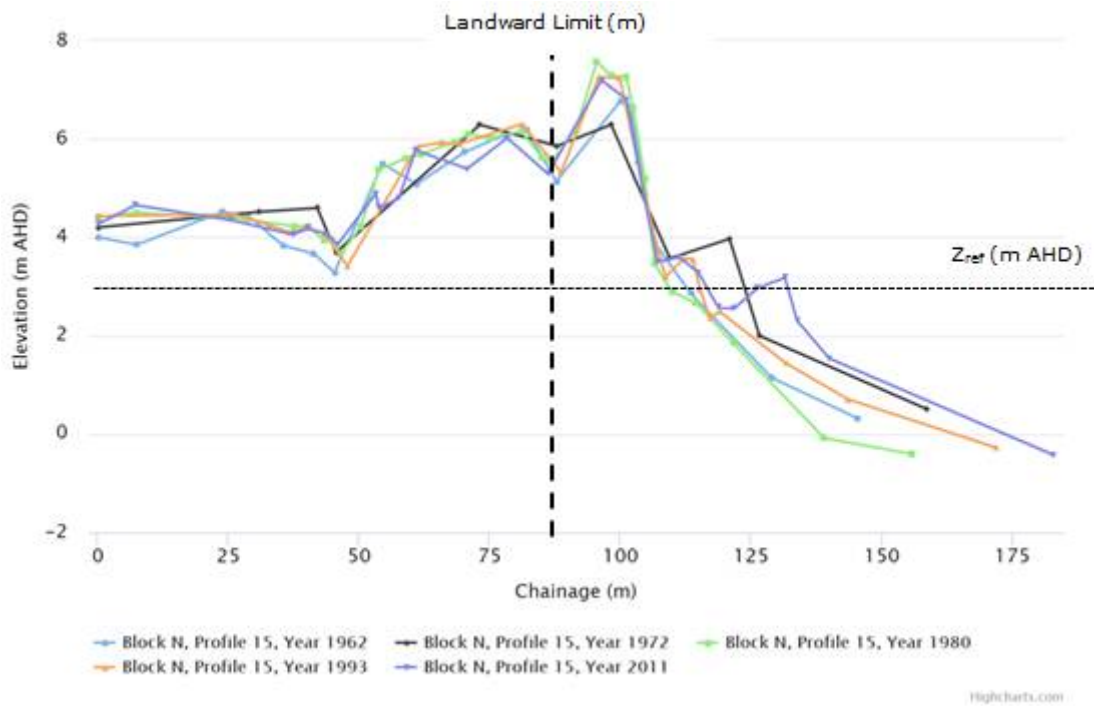**Figure C-26: Example photogrammetry cross sections at Broulee Beach Central (Block N, Profile 15)**
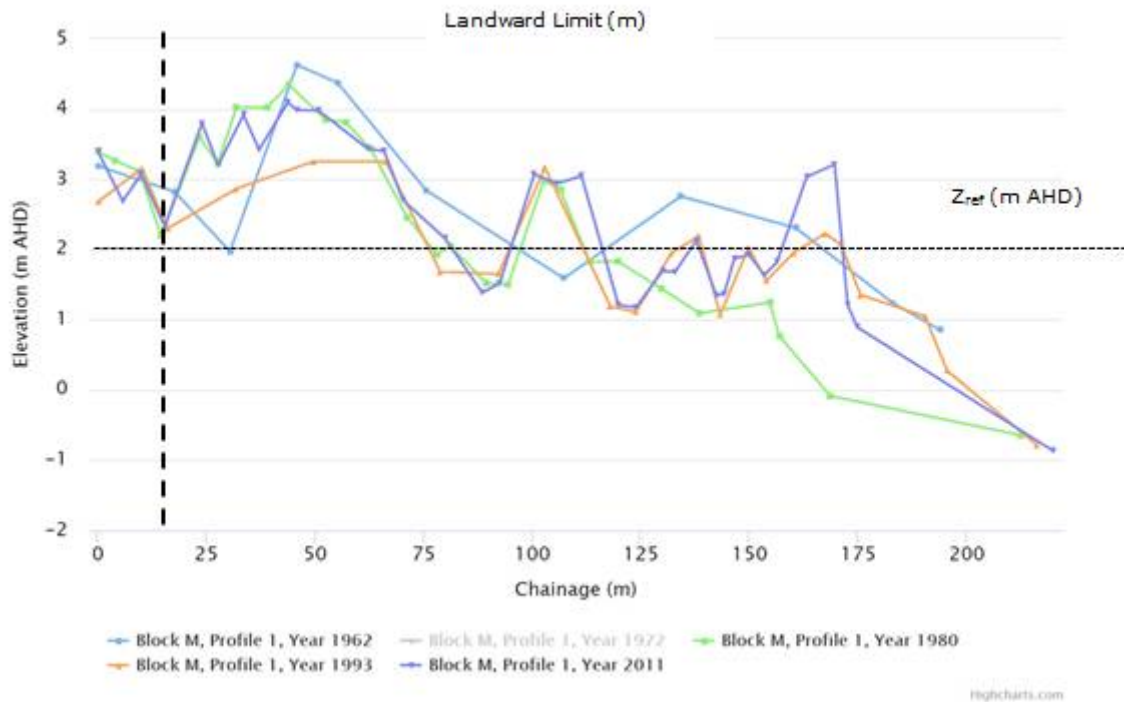
Figure C-27: Example photogrammetry cross sections at Broulee Beach South (Block M, Profile 1)

C.3 Analysis of Photogrammetry

The photogrammetry records have been used to quantify both long term historical changes (underlying recession) and short term storm erosion at each of the beaches. This section summarises the methodology used to undertake these analyses, and the corresponding results.

C.3.1 Underlying Recession

Underlying recession defines the natural recessionary (or accretionary) trends of a beach, and is typically measured in horizontal lineal metres per year. Unless otherwise stated, recession is indicated as a negative value and accretion as a positive value. As beaches are dynamic environments, the long term recessionary trends can be difficult to separate from short term fluctuations in the beach state. In order to deal with this uncertainty, two methods have been used to measure the underlying recession:

1. Movement of a representative contour (Z_{ref}) (m/year); and
2. Rate of volumetric change (m^3/m/year), converted to a linear trend (m/year) by dividing by the average dune height at each profile.

Where a dune exists, the representative contour has been chosen on the lower dune face, such that is not typically influenced by daily wave action, but will move on a long term scale. Volumetric analysis is defined as the sub aerial beach volume seaward of a defined landward limit (landward of which profile changes are not associated with coastal processes). Where necessary, profiles have been extrapolated seaward to 0 m AHD using a 1V:10H slope. Table C-3 summarises the representative contour and the landward limits used at each profile.

Examples of analysis for underlying shoreline movement using the two methods are presented in Figure C-28 (Z_{ref} trend) and Figure C-29 (volumetric trend) for Surfside Beach (east) (Block B, Profile 2).

The results of the analysis on underlying movement (accretion – positive, recession – negative) are provided in Figure C-30 to Figure C-38. Note that some profiles have been excluded from the analysis due to the presence of rocky cliffs that are considered non erodible or creek mouth where sediment transport is not primarily driven by wave action. No results have been provided for Surfside Beach (west) as the photogrammetry showed no discernible trend. This is likely to be due to the tide-dominated nature of Surfside Beach (west).

Table C-3: Summary of Landward Limits and Representative Contours

Beach	Block	Profile	Landward Limit	Zref (m AHD)
Maloneys Beach	E	1	85	1.5
	E	2	80	1.9
	E	3	85	1.5
	E	4	83	1.5
	E	5	77	1.8
	E	6	75	2
	E	7	65	1.9
	E	8	63	2
	E	9	61	1.9
	E	10	50	1.5
	E	11	50	2
	E	12	45	2
	E	13	44	1.9
	E	14	41	2
	E	15	37	2
	E	16	35	2
	E	17	32	2
	E	18	35	1.9
	E	19	33	2
	E	20	26	2
	E	21	23	2
	E	22	30	1.8
	E	23	32	1.8
	E	24	32.5	1.8
	E	25	32.5	2
	E	26	35	2
	E	27	39	1.5
	E	28	41	1.9
	E	29	41	2
	E	30	52	1.6
	E	31	55	1.5
	E	32	60	1.5
	E	33	65	1.9
	E	34	75	1.5
	E	35	83	1.2
	E	36	96	1.5
	E	37	110	1.2
	E	38	105	1.2

Table C-3: Summary of Landward Limits and Representative Contours (cont...)

Beach	Block	Profile	Landward Limit	Zref (m AHD)
	C	1	89	1.25
	C	2	85	1.9
	C	3	84	1.8
	C	4	80	2
	C	5	70	1.8
	C	6	66	2
	C	7	72	2
	C	8	63	2
	C	9	66	2
	C	10	60	1.8
	C	11	59	1.9
	C	12	51	1.8
	C	13	54	1.5
	C	14	48	1.8
	C	15	52	1.7
	C	16	45	1.6
	C	17	48	1.7
	C	18	43	2
	C	19	36	1.5
	C	20	36	1.5
	C	21	40	1.8
	C	22	41	1.7
	C	23	41	2
	C	24	42	1.8
	C	25	32	1.8
	C	26	27	1.5
Long Beach	C	27	24	1.8
	C	28	38	1.9
	C	29	35	1.7
	C	30	33	1.8
	C	31	15	1.9
	C	32	23	2
	C	33	30	1.7
	C	34	30	1.7
	C	35	29	2
	C	36	29	1.8
	C	37	34	1.8
	C	38	34	1.75
	C	39	35	1.7
	C	40	30	1.9
	C	41	28	2
	C	42	15	1.7
	C	43	15	2
	C	44	17	2
	C	45	27	1.8
	C	46	14	2
	C	47	9	1.6
	C	48	30	1.5
	C	49	36	1.9
	C	50	35	2
	C	51	31	1.5
	C	52	31	1.7
	C	53	18	1.5

Table C-3: Summary of Landward Limits and Representative Contours (cont...)

Beach	Block	Profile	Landward Limit	Zref (m AHD)
Long Beach (cont...)	C	54	18	1.6
	C	55	17	1.7
	C	56	21	1.6
	C	57	22	2
	C	58	33	1.8
	C	59	35	1
	C	60	30	1.5
	C	61	48	2
	C	62	46	1.7
	C	63	37	1.6
	C	64	42	1.7
	C	65	46	1.9
	C	66	60	2
	C	67	52	2
	C	68	54	1.9
	C	69	65	1.6
	C	70	70	1.9
	C	71	86	1.5
	C	72	80	1.8
	D	1	55	1.5
	D	2	48	1.8
	D	3	50	2
	D	4	45	1.9
	D	5	42	1.5
	D	6	48	1.8
	D	7	46	1.5
	D	8	36	1.5
	D	9	34	1.5
	D	10	37	1.5
	D	11	36	1.5
	D	12	37	1.4
	D	13	39	1.5
	D	14	40	1.4
	D	15	50	1.4
	D	16	47	1.5
	D	17	45	1.5
	D	18	46	1.5
	D	19	46	1.5
	D	20	47	0.7
	D	21	43	0.5
	D	22	41	0.6
	D	23	40	0.8
	D	24	40	1.2
	D	25	40	1.3
	D	26	40	1.3
	D	27	40	1
	D	28	41	1.1
	D	29	50	1.2
	D	30	64	1
	D	31	70	1
	D	32	90	1

Table C-3: Summary of Landward Limits and Representative Contours (cont...)

Beach	Block	Profile	Landward Limit	Zref (m AHD)
Surfside Beach (east)	A	1	67	1.4
	A	2	67	1
	A	3	66	1
	A	4	70	1.3
	A	5	65	1.5
	A	6	62	1.5
	A	7	52	1.5
	A	8	58	1.5
	A	9	56	1.6
	A	10	54	1.5
	A	11	45	1.5
	A	12	44	1.6
	A	13	49	1.5
	A	14	42	1.6
	A	15	44	1.5
	A	16	42	1.7
	A	17	41	2.1
	A	18	40	1.6
	A	19	40	1.8
	A	20	42	1.9
	A	21	40	1.75
	A	22	47	1.6
	A	23	44	1.8
	A	24	43	1.5
	A	25	53	1.6
	A	26	55	1.5
	A	27	58	1.6
	A	28	60	1.5
	A	29	55	1.5
	A	30	60	1.4
	A	31	64	1.5
	A	32	67	1.5
	B	1	73	1.3
	B	2	52	1.3
	B	3	47	1.5
	B	4	45	1.1
	B	5	30	1.7
	B	6	28	1.6
	B	7	34	1.55
	B	8	23	0.7
	B	9	22	1
	B	10	19	0.8
	B	11	26	0.7
	B	12	35	1.1
Surfside Beach (west)	1	1	74	1.5
	1	2	84	1.5
	1	3	40	0
	1	4	30	0.5
	1	5	18	0.5
	1	6	20	0.5
	1	7	50	0.6

Table C-3: Summary of Landward Limits and Representative Contours (cont...)

Beach	Block	Profile	Landward Limit	Zref (m AHD)
Sunshine Bay	1	1	51	1
	1	2	22	1.5
	1	3	29	1
	1	4	37	1.5
	2	1	58	1.5
	2	2	32	1.5
	2	3	27	1.5
	2	4	30	1
	2	5	28	1.5
	3	1	37	1.4
	3	2	29	1.5
	3	3	39	0.8
Malua Bay	1	1	75	1
	1	2	25	1.3
	1	3	53	2.5
	1	4	55	3
	1	5	56	3.3
	1	6	61	3.5
	2	1	35	3.5
	2	2	37	4
	2	3	28	4
	2	4	36	4.6
	2	5	49	3.5
	2	6	20	1
Guerilla Bay	5	1	51.75	1.3
	5	2	51.25	1.1
	5	3	44	1.7
	6	1	58	1.3
	6	2	27	1.3
	6	3	42	1.3
	6	4	35	1.5
	6	5	66	1.7
	6	6	148.5	1.1

Table C-3: Summary of Landward Limits and Representative Contours (cont...)

Beach	Block	Profile	Landward Limit	Zref (m AHD)
Barlings Beach	1	1	120	4
	1	2	108	4
	1	3	100	4
	1	4	95	4
	1	5	95	4
	1	6	95	4.5
	2	1	101	4.5
	2	2	65	4.5
	2	3	61	4
	2	4	55	4
	2	5	60	4
	2	6	59	4
	2	7	60	4
	2	8	70	4
	2	9	72	3
	2	10	68	4
	3	1	76	3.5
	3	2	41	4
	3	3	53	4
	3	4	72	3.5
Tomakin Cove	1	1	10	1.2
	1	2	26	1.9
	1	3	32	2
	1	4	35	1.9
	1	5	36	2
	1	6	39	2
	2	1	46	2
	2	2	39	2
	2	3	40	1.7
	2	4	38	2
	2	5	42	1.8
	2	6	40	1.6
	3	1	55	1.7
	3	2	52	1.9
	3	3	42	2
	3	4	42	1.6
	3	5	74	1.8

Table C-3: Summary of Landward Limits and Representative Contours (cont...)

Beach	Block	Profile	Landward Limit	Zref (m AHD)
Broulee Beach	M	1	14	2
	M	2	72	2
	M	3	63	2.5
	M	4	101	2.5
	M	5	106	2.5
	M	6	44	2.5
	M	7	74	2.5
	M	8	111	2.8
	M	9	115	2.5
	M	10	122	2.5
	N	1	94	2.5
	N	2	87	3
	N	3	70	3
	N	4	76	3
	N	5	75	3
	N	6	83	3
	N	7	60	3
	N	8	81	3
	N	9	73	3
	N	10	70	3
	N	11	60	2.8
	N	12	80	2.8
	N	13	81	3
	N	14	88	3
	N	15	86	3
	N	16	95	3
	N	17	108	3
	N	18	93	3
	N	19	126	3
	N	20	149	3
	O	1	65	4
	O	2	63	4
	O	3	61	4.5
	O	4	47	4.5
	O	5	59	5.2
	O	6	72	4.5
	O	7	65	4
	O	8	58	2.5
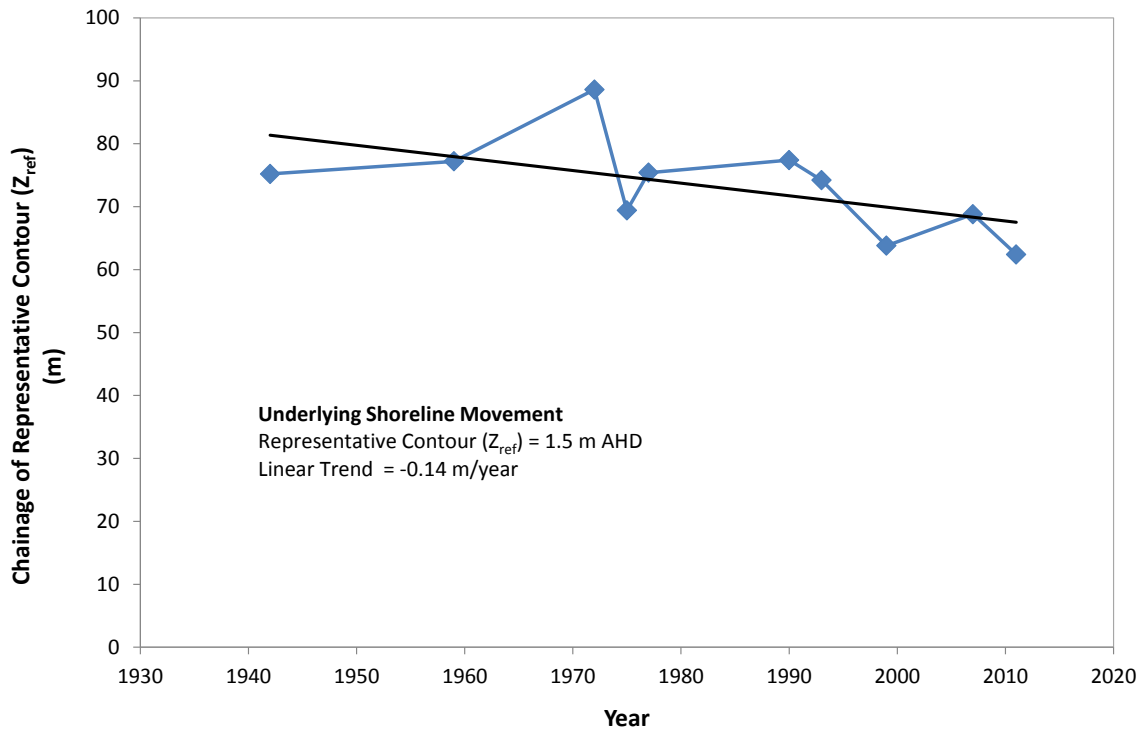
Figure C-28: Example Underlying Shoreline Movement Analysis from Photogrammetry Data - Movement of Representative Contour, Surfside Beach (east), Block B, Profile 3
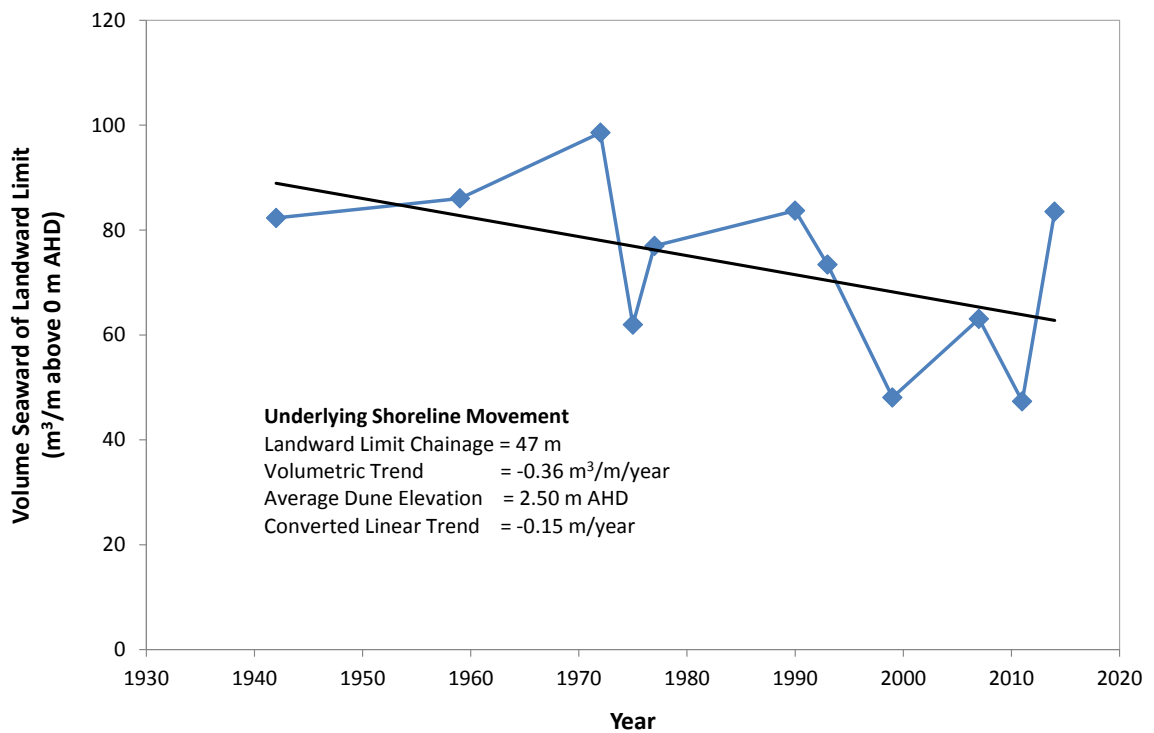
Figure C-29: Example Underlying Shoreline Movement Analysis from Photogrammetry Data - Rate of Volumetric Change, Surfside Beach (east), Block B, Profile 3
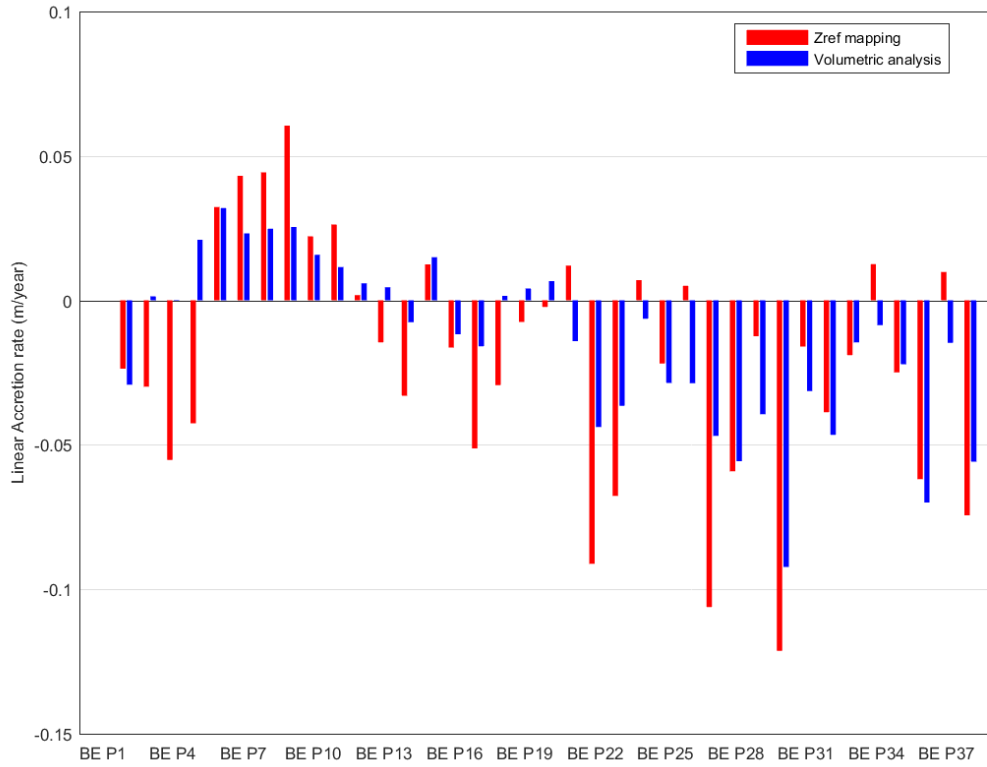
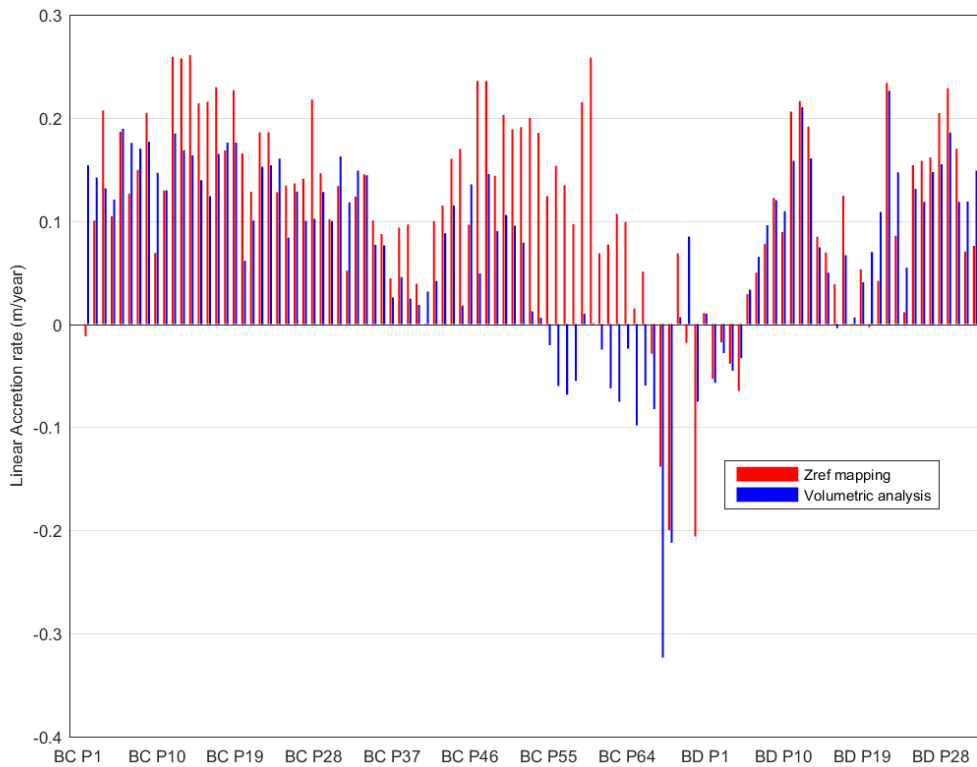**Figure C-30: Maloneys Beach Underlying Movement**

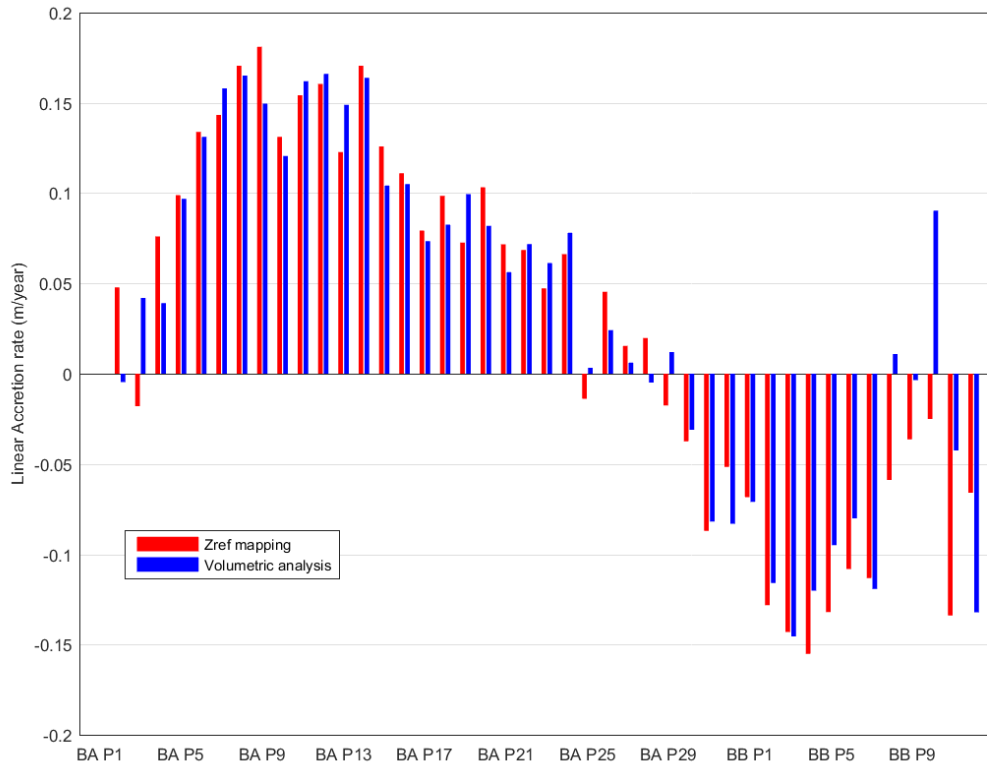**Figure C-31: Long Beach Underlying Movement**
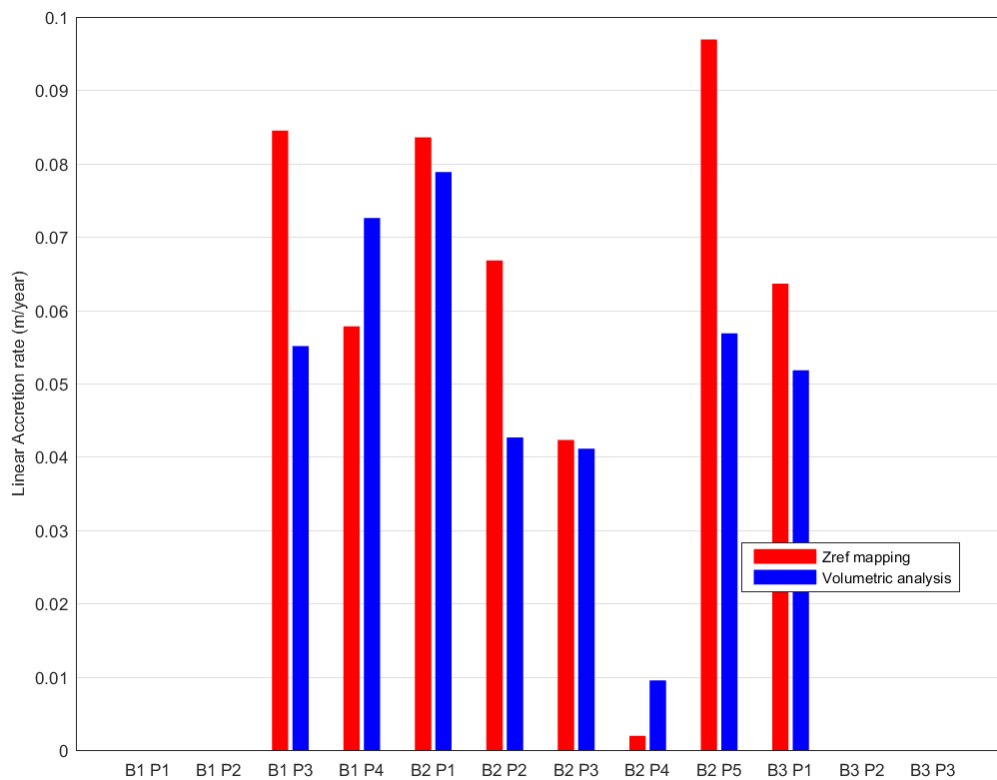
Figure C-32: Surfside Beach (east) Underlying Movement

Figure C-33: Sunshine Bay Underlying Movement
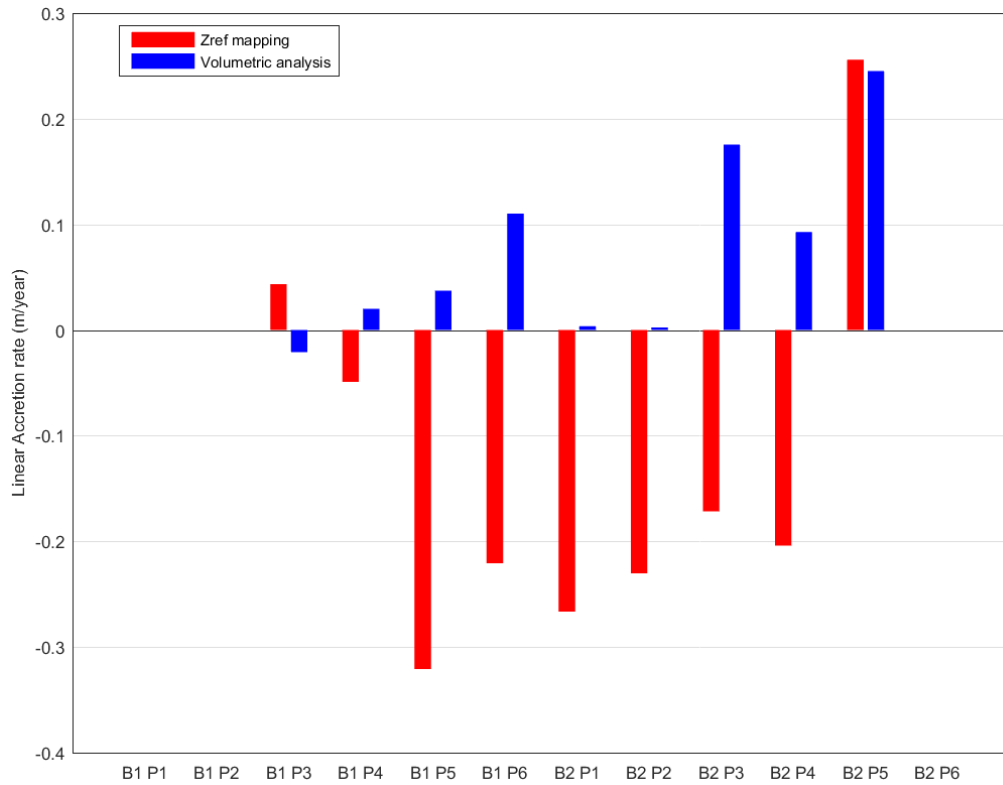
Figure C-34: Malua Bay Underlying Movement
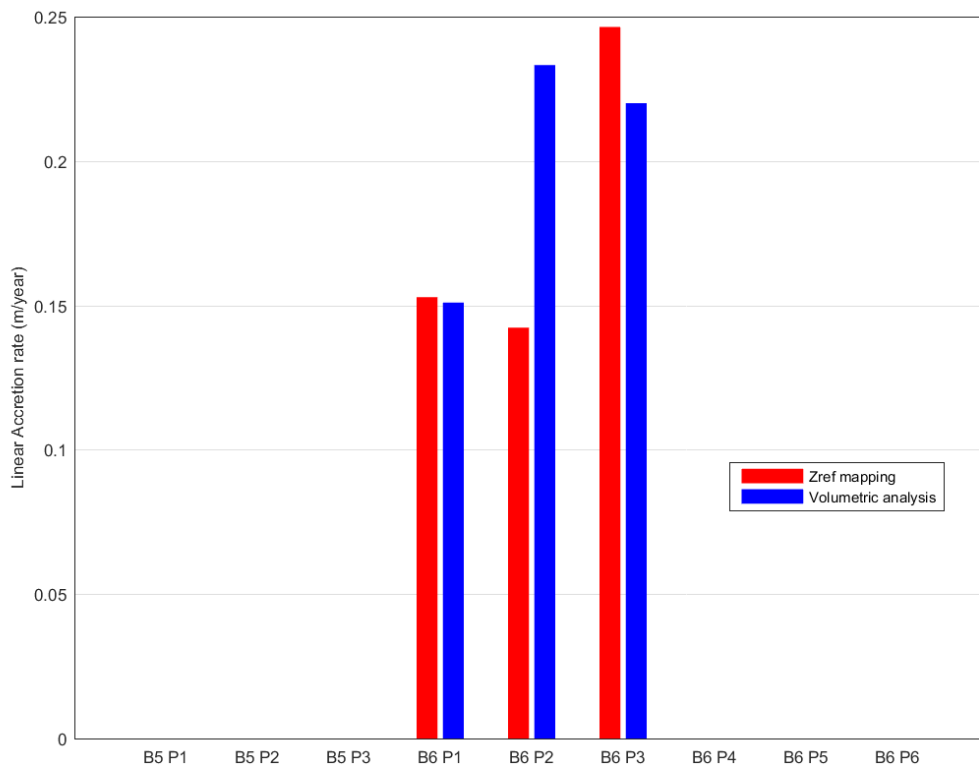
Figure C-35: Guerilla Bay Underlying Movement

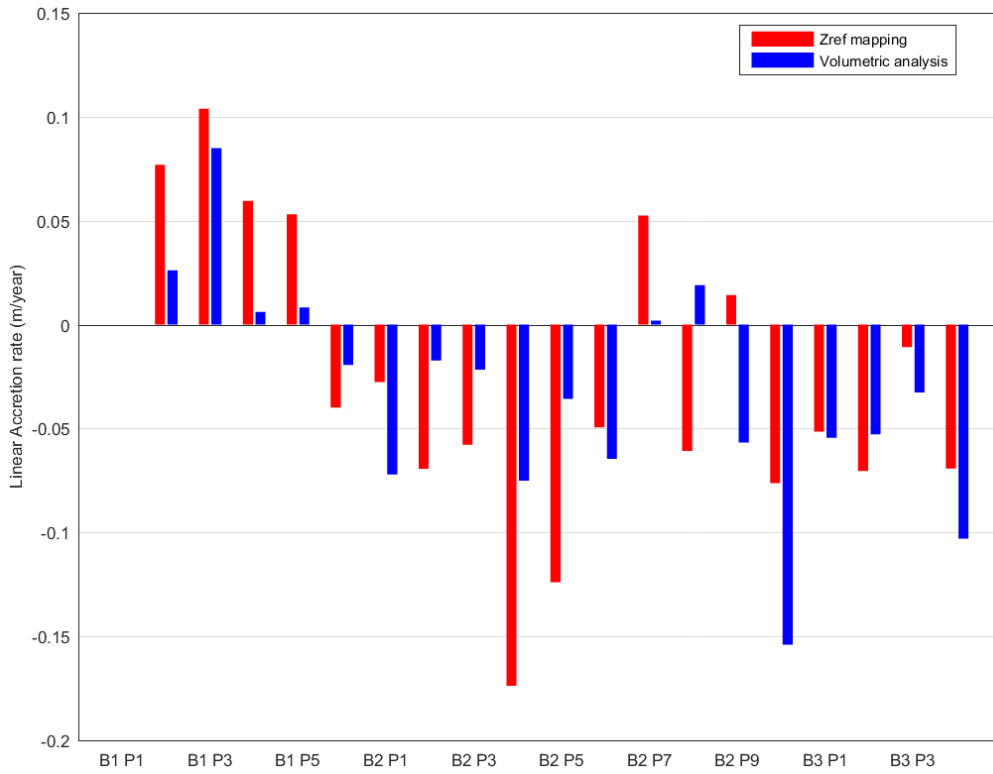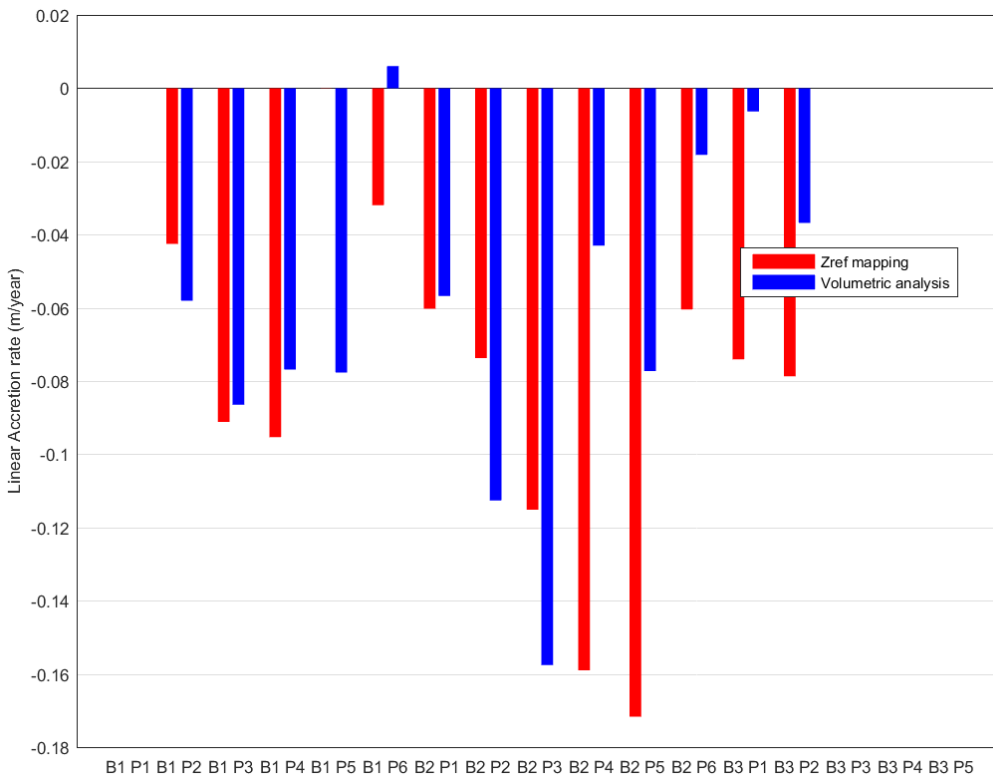**Figure C-36: Barlings Beach Underlying Movement**

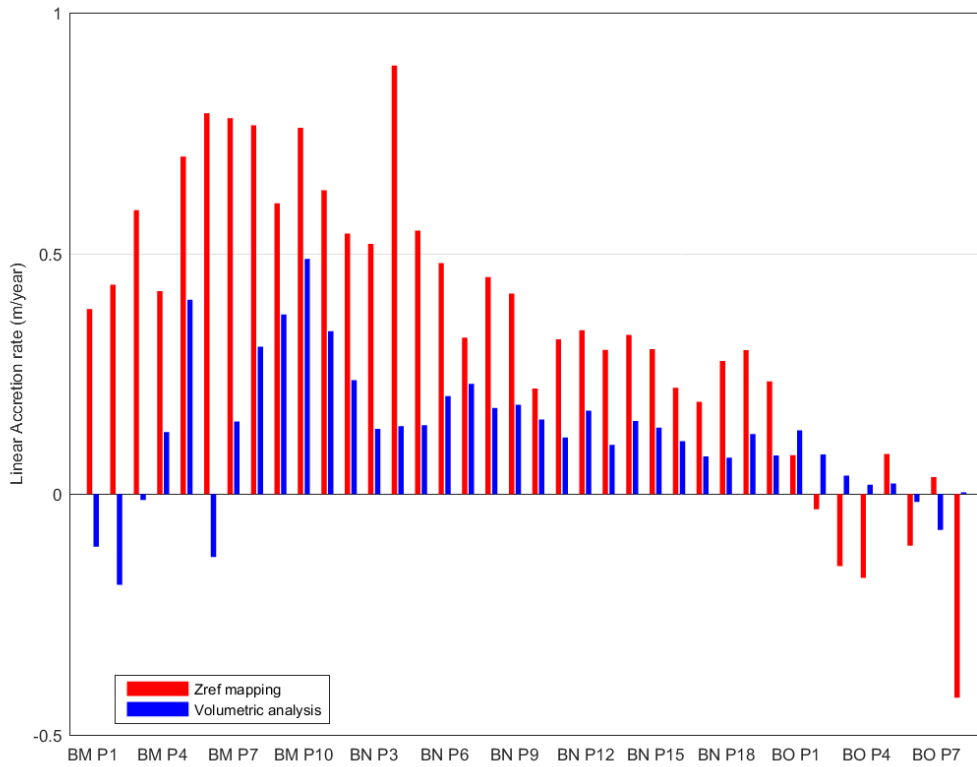**Figure C-37: Tomakin Cove Underlying Movement**

Figure C-38: Broulee Beach Underlying Movement

C.3.2   Maximum Historical Storm Erosion

The maximum historical storm erosion is defined here as the maximum negative change in sub aerial beach volume between two consecutive photogrammetry years at each profile location. Similar to the volumetric analysis, profiles have been extrapolated to 0 m AHD (as necessary) at a slope of 1V:10H and volume was only calculated seaward of the landward limit described in Table C-3.

The results of the maximum historical storm erosion are provided in Figure C-39 to Figure C-47 and summarised in Table C-5. As per Section C.3.1, no results are provided at profiles backed by a rocky cliff or a creek mouth, nor are any results presented for Surfside Beach (west).
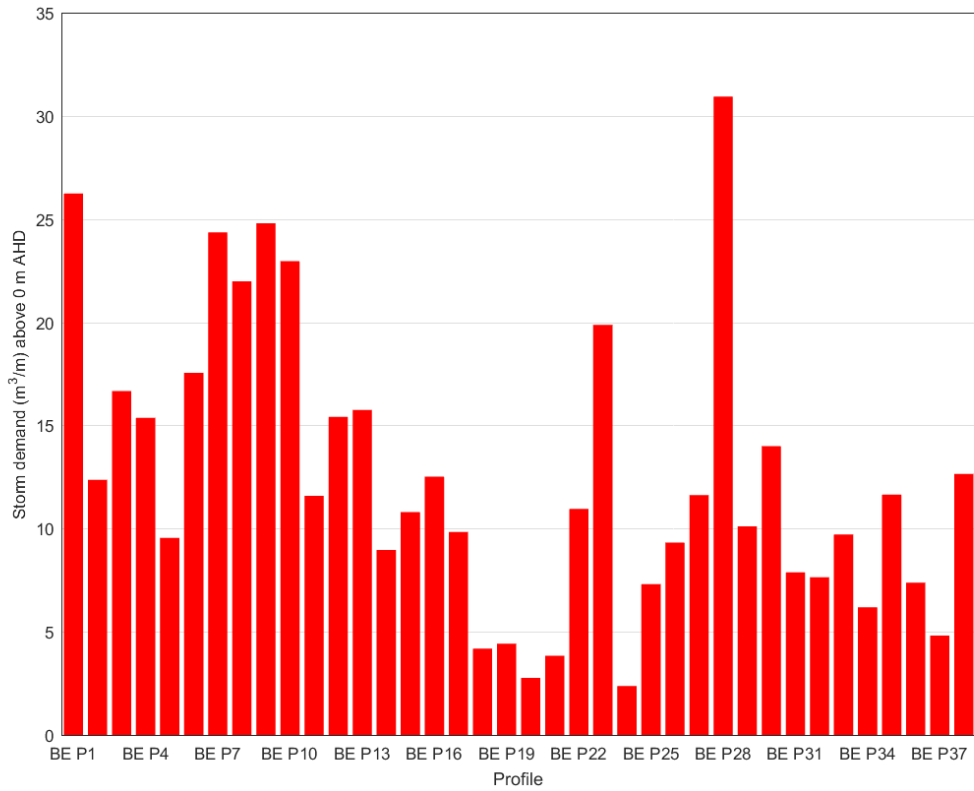
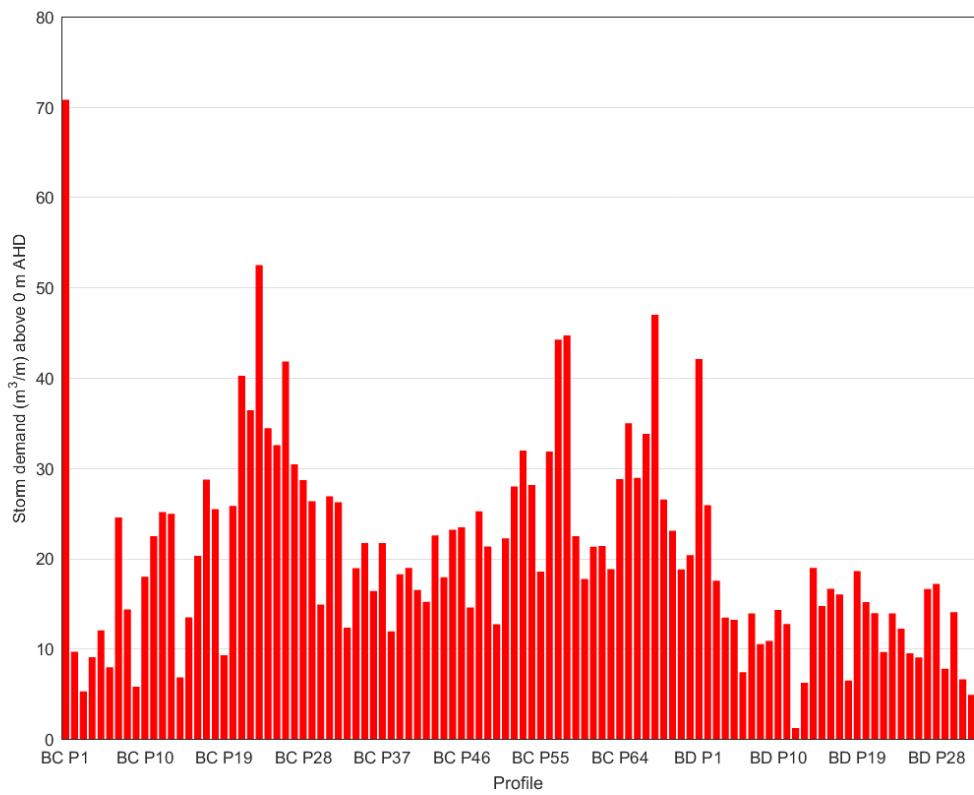**Figure C-39: Maloneys Beach Maximum Storm Demand**
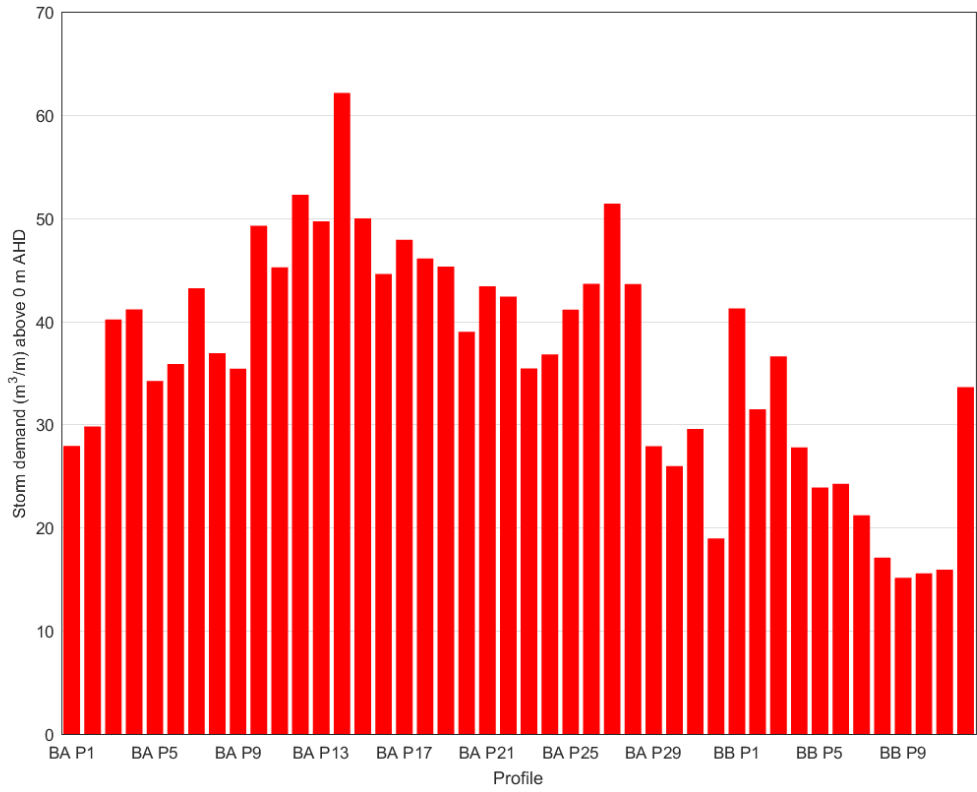

Figure C-40: Long Beach Maximum Storm Demand

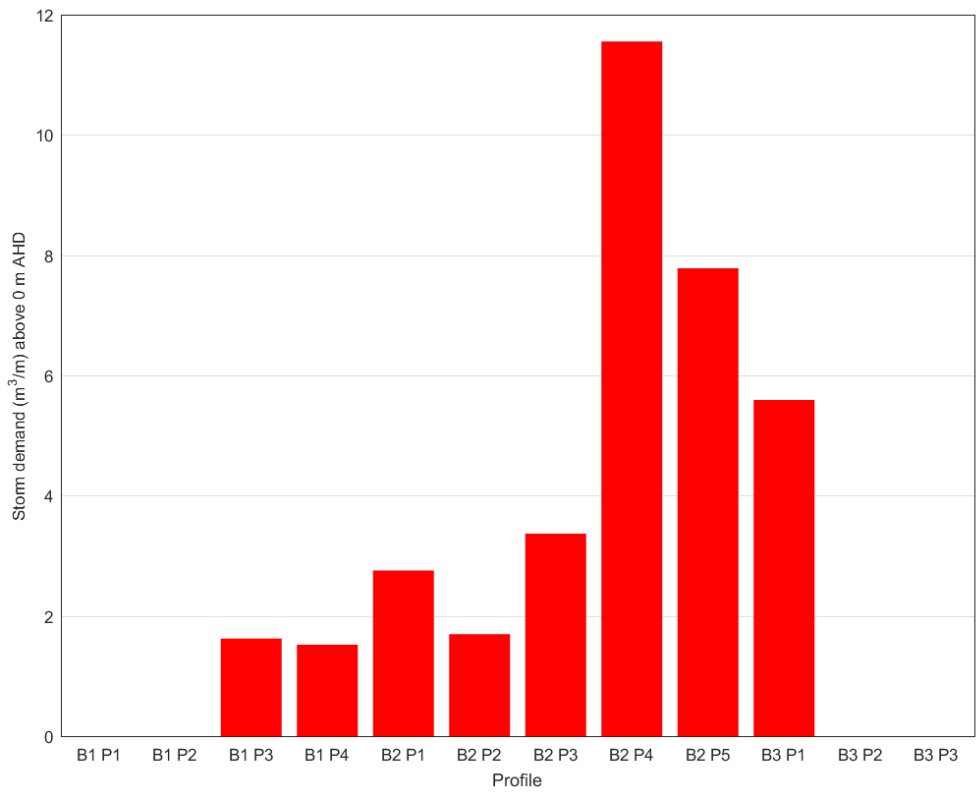**Figure C-41: Surfside Beach (east) Maximum Storm Demand**

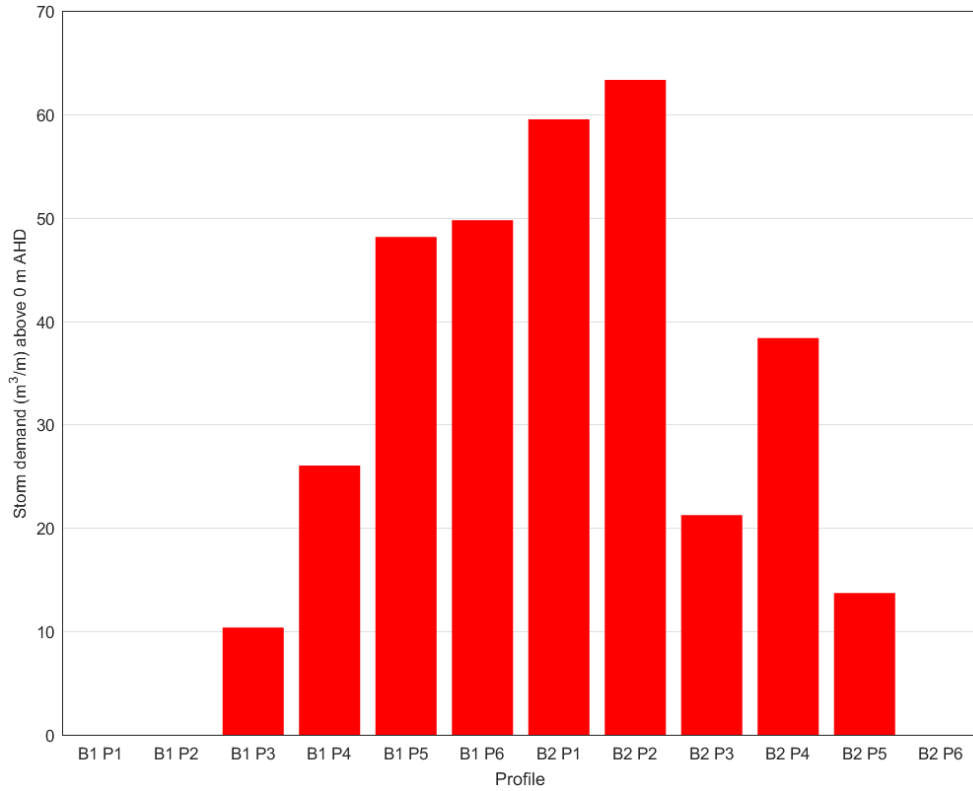**Figure C-42: Sunshine Bay Maximum Storm Demand**
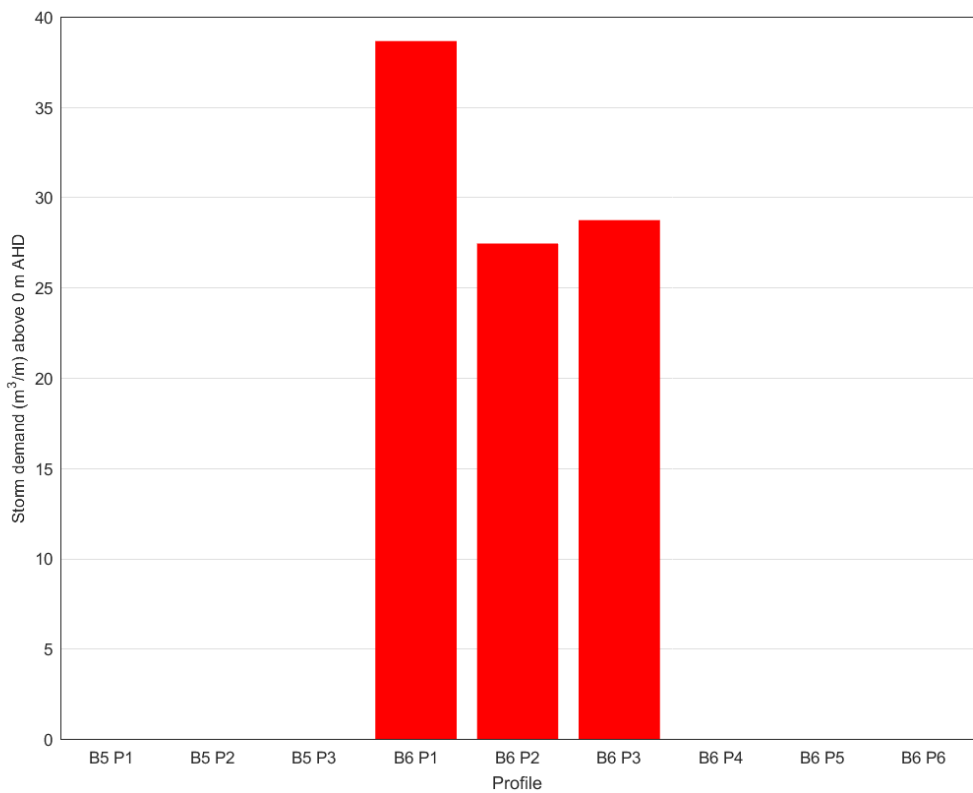
Figure C-43: Malua Bay Maximum Storm Demand

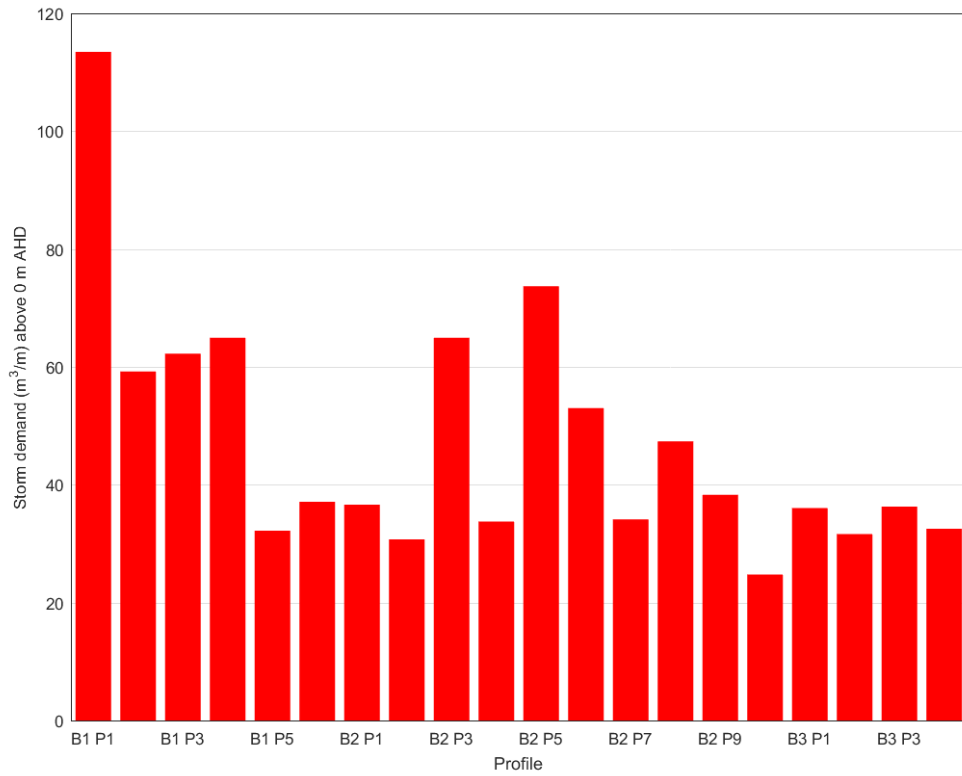**Figure C-44: Guerilla Bay Maximum Storm Demand**

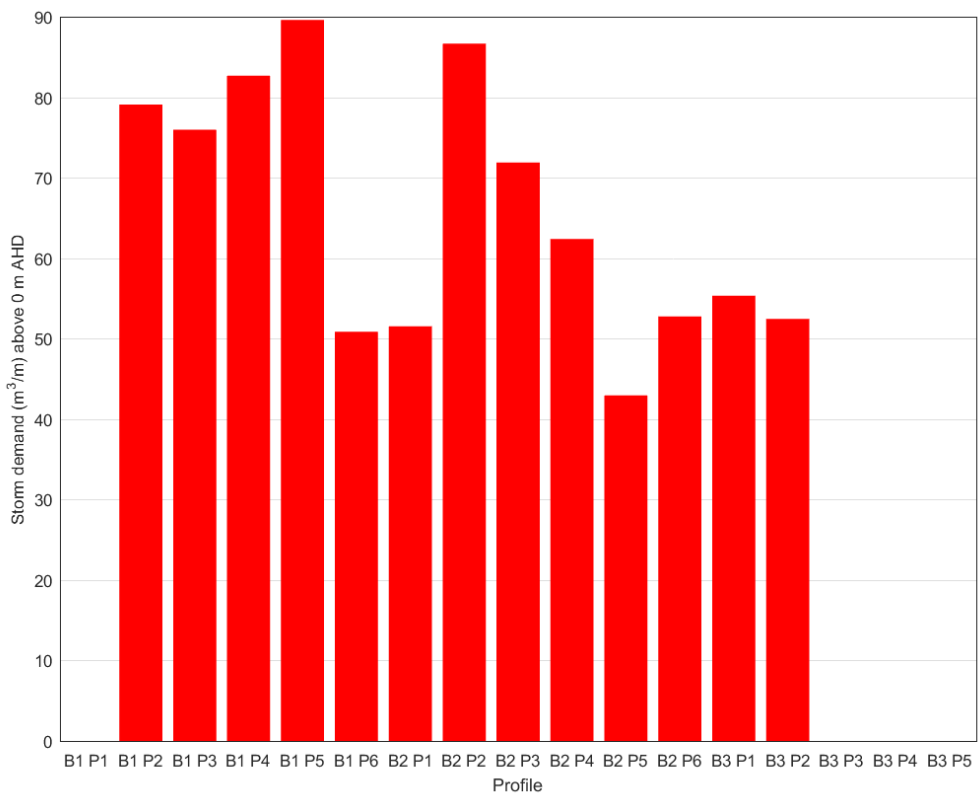**Figure C-45: Barlings Beach Maximum Storm Demand**

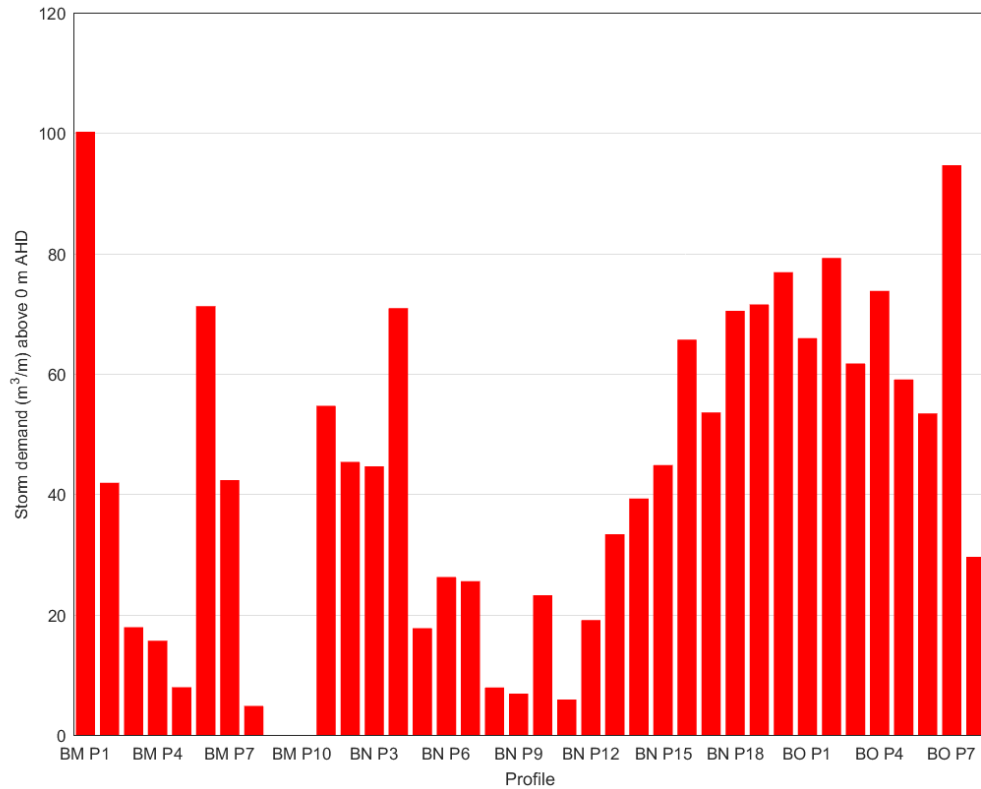**Figure C-46: Tomakin Cove Maximum Storm Demand**

Figure C-47: Broulee Beach Maximum Storm Demand

C.4 Summary

Some of the beaches were treated as separate sections, when the underlying shoreline movement or storm demand varied along the length of the beach (Table C-4). The erosion hazard lines for the two profiles on either side of the intersection points were blended to give a smooth transition between the beach sections.

A summary of maximum storm demand volumes derived from photogrammetry records is provided in Table C-5.

Based on measurements commencing in 1972 at nearby Bengello Beach, the study area's most erosive period in the last 45 years occurred due to a sequence of storm events in May-June 1974. Photogrammetry was recorded at all beaches in 1972, providing an indicative "pre-storm-sequence" condition. For beaches where "post-storm-sequence" photogrammetry was available for 1975 (Surfside Beach (east), Barlings Beach and Tomakin Cove), the maximum storm demand estimated from photogrammetry is considered a reasonable representation of the erosion that occurred due to this erosive period. Indeed, the consensus values for 100 year ARI storm demand adopted by the expert panel at these beaches are similar to the values calculated from the photogrammetry. However, for beaches where photogrammetry was not available for a significant period of time following May-June 1974 and beach recovery had occurred over a number of years (particularly Maloneys Beach, Long Beach and Sunshine Bay where at least 16 years elapsed), the maximum storm demand estimated from photogrammetry is considered an underestimate of the erosion attributable to this storm sequence and alternative methods were used to estimate storm demand.

Table C-4: Extents of Different Beach Sections

Beach	Section	Section Start		Section End	
		Block	Profile	Block	Profile
Maloneys Beach	West	E	1	E	17
	East	E	17	E	38
Long Beach	West	C	1	C	55
	Central	C	55	D	7
	East	D	7	D	32
Surfside Beach (East)	South	A	0	A	28
	North	A	28	B	12
Barlings Beach	West	1	1	2	4
	East	2	4	3	4
Broulee Beach	South	M	1	N	5
	Central	N	5	N	15
	North	N	15	O	8

Table C-5: Summary of Maximum Storm Demand Volumes Derived from Photogrammetry

Beach	Section	Maximum Storm Demand (m³/m above 0 m AHD)	Comment
Maloneys Beach	Eastern End	31	Block E, Profile 28: 1942 - 1972
	Western End	26	Block E, Profile 1: 1993 - 1999
Long Beach	Eastern End	19	Block D, Profile 19: 2007 - 2011
	Central	47	Block C, Profile 68: 1972 - 1990
	Western End	71	Block C, Profile 1: 1993 - 1999
Surfside Beach (East)	Northern End	44	Block A, Profile 28: 1972 - 1975
	Southern End	62	Block A, Profile 14: 1972 - 1975
Surfside Beach (West)	Central	-	-
Sunshine Bay	Central	12	Block 1, Profile 4: 1962 - 1972
Malua Bay	Central	63	Block 2, Profile 2: 1972 - 1984
Guerilla Bay (South)	Central	39	Block 6, Profile 1: 1984 - 1991
Barlings Beach	Eastern End	53	Block 2, Profile 6: 1972 - 1975
	Western End	113	Block 1, Profile 1: 1972 - 1975
Tomakin Cove	Central	90	Block 1, Profile 5: 1972 - 1975
Broulee Beach	Northern End	95	Block O, Profile 7: 1972 - 1980
	Central	45	Block N, Profile 15: 1972 - 1980
	Southern End	71-100 (spit influenced)	Block M, Profile 1: 1962 - 1980