Beach changes on Moturau and Te Ana-au (Lakes Manapōuri and Te Ana-au), January 2021 – January 2026



Prepared for

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March 2026

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Acknowledgements

Fieldwork was carried out with assistance of Nick Key from Wilderness Technical, Manapōuri, and research assistants from Shore Processes and Management. Nick was also responsible for the safety aspects of all the work on the water. Lake level and Manapōuri Airfield wind data was supplied by Meridian Energy Limited.

Executive Summary

This report presents the results of the January 2026 survey of beach changes on Lakes Manapōuri and Te Anau and is a continuation of the 5-yearly monitoring programme required by the conditions of consent to operate the Manapōuri Power Scheme in the 1996 resource consents and subsequent amendments as described in *Appendix 1: Manapouri Power Scheme Resource Consents - Monitoring & Management Responses Appendix*. The present work compares shoreline conditions as of January 2026 with those last surveyed in January 2021. In addition, an event-driven survey has also been prepared as a result of high lake levels through September to December 2025. The fieldwork for the event-driven monitoring was carried out as part of the 5-yearly monitoring and is reported on separately in an accompanying report *Manapōuri Power Scheme: October-November 2025 high lake levels on Lakes Manapōuri and Te Anau and effects on lakeshore geomorphology* (Single 2026).

Plotted beach profile surveys and photographs from the 2026 inspection are compared to data and observations collected from previous monitoring and used in assessing the change since 2021. The condition of the shore geomorphology was also considered in the context of the longer record of beach changes on the lakes and inspections undertaken since 1988.

The results for Lake Manapōuri show that:

- Inter-survey change over the last five years is overall of a similar magnitude and range to previous survey intervals.
- Between 2021 and 2026 there were eight sites that eroded and eight sites that accreted. Volume change was greatest at Fraser's Beach (M14) as a result of sediment loss across the mid-foreshore and the upper limit of wave run-up. The largest amounts of deposition occurred at Ruby Bay south (M12) and Bullins Beach (M3). Change at both sites was mainly due deposition across the upper foreshore.
- In the long term, the most dynamic beaches continue to be those exposed to the greatest wave energy (Frasers Beach and Ruby Bay), while beaches with nearby sources of sediment such as Calm Bay (M8), or have a nearshore source of sediment such as Bullins, George (M4) and Monument (M5) exhibit long-term accretion.
- For the 2021 to 2026 intersurvey period, there was no systemic pattern to the type of shore change with regard to sediment type or beach aspect to wave approach.

The results for Lake Te Anau show that:

- Inter-survey change over the last five years continues to be varied, with some sites showing very little change and some showing large increases in sediment volume.
- Over the long-term, most sites show accretion with sites close to or downdrift of the Upukerora River showing the greatest increase in beach volume. Shores exposed to high-energy waves have lost sediment.

- Sediment movement within pocket beach compartments continue to show large fluctuations in sediment volume across the monitored profiles or along the shore and don't necessarily indicate a change in beach character. However, the state of the overall beach area is sensitive to changes in sediment input from local streams due to steep offshore slopes preventing onshore sediment transport from deeper parts of the active profile.
- The beaches of Lake Te Anau are generally well-supplied by sediment and dynamically adjust to changes in the wave environment and lake level without exhibiting any adverse effects to the shore geomorphology at a systemic spatial or long-term temporal extent.

Changes along the southern shore of the Waiau River from Lake Manapōuri to Pearl Harbour appear to result from the recent high lake levels and subsequent higher velocity river flows, trees toppling from the top of the cliff face and erosion processes resulting from terrestrial slope processes such as water flows over and within the slope. Vegetation growth along the base of the cliff has resulted in stability at the water line for most of the shore.

The beaches of the two lakes remain dynamic and show responses consistent with those expected in the lacustrine process environment. The most noticeable changes between 2021 and 2026 are the effects of the high water level event of late 2025. However, there are no adverse changes in the lakeshore geomorphology that can be attributed to the Power Scheme operation as this event was exceptional in duration and coincided with high-energy wave events. As with changes observed after the 2019 high level event, the measured effects are not considered to be adverse in the long-term.

The operation of the Manapōuri Power Station in accordance with the operating guidelines continues to be effective in maintaining beach naturalness.

1. Introduction

This report presents the results of the 5-yearly monitoring of beach changes on Moturau and Te Ana-au, commonly known as Lake Manapōuri and Lake Te Anau. The January 2026 monitoring and surveys of beach form and appearance is compared to monitoring carried out in January 2021. The report is the latest in a series of studies of changes to the beaches of these lakes. The first was initiated in 1973 by Pickrill (1976), with subsequent monitoring and reporting in 1988, 1989, 1997, 2002, 2006, 2011, 2016 and 2021 carried out by Kirk and Single (Single and Coultas 2021, Single 2016, Single 2011, Single *et al.* 2006, Single *et al.* 2002, Kirk *et al.* 1997, Kirk *et al.* 1989, Kirk 1988a and Kirk 1988b).

The purpose of the monitoring is to assess the effects of the lake level management regime on the beach stability of Lakes Manapōuri and Te Anau. The previous studies provide a baseline and envelope of historical change against which, the present environment can be compared.

Shoreline conditions (from shoreline inspections and surveys of beach profiles) at the time of monitoring in January 2026 are compared with those as measured and documented in 2021. Previous findings (prior to 2021) have also been considered in assessing the changes between the 5-yearly beach profile surveys of 2021 and 2026. The January 2026 beach conditions are also assessed in the context of the longer record of beach changes measured on Lakes Manapōuri and Te Anau since 1973.

A high water level event occurred over late 2025 through to early January 2026. This necessitated additional event-driven assessment of the shore to identify specific changes resulting from the high lake levels. Although any changes to the shore geomorphology resulting from the event are included in the assessment of change between 2021 and 2026, specific effects of the high lake level event are addressed in a separate report (Single 2026, *Manapōuri Power Scheme: October-November 2025 high lake levels on Lakes Manapōuri and Te Anau and effects on lakeshore geomorphology*).

The methods employed for field measurements and observations for this report follow those of earlier studies.

2. Background

Background to the beach survey network and the conditions of consent of the Manapōuri Power Station hydropower generation at West Arm regarding beach sediment stability are presented in earlier reports. The brief of work for 2026 is similar to that of previous 5-yearly monitoring in that:

Meridian Energy (MEL) is required by its 1996 resource consents and subsequent amendments as described in *Appendix 1 (Amended July 2021): Manapouri Power Scheme Resource Consents - Monitoring & Management Responses Appendix* as below (NB: Reference to Single “2008” in the consents is corrected below):

2. Beach Sediments

Objective: To assess the effects of the lake level management regime on the beach stability of Lakes Manapōuri and Te Anau.

Methods: Monitoring will be undertaken using the sites and transects as set out in the most recent monitoring report for Lakes Te Anau and Manapōuri (Single, 2006). Methods of data collection and analysis are to be the same as set out in Single 2006, monitoring report so that the results are directly comparable. Any alterations to the sites or transects shall be discussed with the Guardians of Lakes Manapōuri, Te Anau and Monowai, and shall require approval from Environment Southland prior to implementation.

Re-inspection of the sites and re-measurement of the transects at Lakes Manapōuri and Te Anau undertaken by Single (2008) will occur at 5-yearly intervals, with the next monitoring being undertaken in 2016. Re-inspection of the sites and re-measurement of the transects may also occur if the lake operating guidelines have been breached ("event driven" monitoring).

For "event driven" monitoring surveys, the number of the shoreline monitoring sites and transects, and whether or not any of the transects are required to be re-measured, may vary from those required for the 5-yearly monitoring, depending on the nature and extent of the "event", as agreed with Environment Southland and following consultation by the consent holder with the Guardians of Lakes Manapōuri, Te Anau and Monowai.

Reference:

Single M. 2006. Beach changes on Lakes Manapōuri and Te Anau and cliff erosion at Pearl Harbour Manapōuri June 2002 – October 2006

The 2021 monitoring concluded:

There is no adverse effect of the Hydro-electric Power Scheme (HEPS) operation on the lakeshore geomorphology. As with previous surveys, the beaches of the two lakes remain dynamic, and show expected responses to changes in the process environment. Most noticeable are the effects of the high water level event of December 2019. However, this event was exceptional, and the measured effects are not considered to be adverse in the long-term. Changes to the mid- and lower foreshore are unlikely to persist in character, and many of the beaches had adjusted back to form and character consistent with the historical envelope of change between the 2020 (post-event inspection) and 2021 surveys.

The operation of the Manapōuri Power Station in accordance with the operating guidelines continues to be effective in maintaining beach naturalness.

3. Field Methods

The 2026 surveys were undertaken by a party of three working from the Manapōuri Water Taxi craft *Wilderness One* on Lake Te Anau and Pearl Harbour, and *Adventurer One* on Lake Manapōuri skippered by Nick Key of Wilderness Technical Limited. To extend the surveyed profile to as great a depth as possible, a member of the survey party wore a full wet suit, extending the profiles offshore to a depth of about 1.5 to 1.6 metres.

Shoreline inspections, photography and beach profile surveys were carried out on the sites around Lake Te Anau on January 6th and 8th 2026 with the level of the lake at dropping over that period from 202.44 m to 202.31 m (above MSL). The same tasks were undertaken for sites on Lake Manapōuri on January 7th and 9th with the lake level rising from about 178.20 m to about 178.36 m. These water levels were higher in comparison to those at the time of the 2021 (and 2016) monitoring, by about 0.5 m for Lake Te Anau and 0.7 m for Lake Manapōuri. Most beach profiles were surveyed to a depth below the limit of measurable profile change.

Winds from the northern quarter generated wave conditions that necessitated care in attaining safe landing and egress from the beaches on Lake Te Anau, while rain resulted in the level of Lake Manapōuri rising during the survey. All sites were surveyed with the exception of site M6 at Stockyard Cove on Lake Manapōuri where surveying was not able to be completed due to vegetation overhanging the shore and the high lake level which left only a steep upper beach face accessible.

Five profile sites located along the southern (True Right) bank of the lower Waiau River between Lake Manapōuri and Pearl Harbour were inspected and photographed on January 9th, with the water level at about 178.35 m (above MSL). The cliff edge, cliff face and the base of the cliff at the water level were surveyed, although vegetation growth on the shore and cliff face compromised some of the cliff face and water level position data.

3.1 Beach Profiles

Beach profiles are surveyed from fixed, relocatable markers located on the backshores of beaches landward of the reach of wave and current related effects on the shore within the operating ranges of the lakes. The elevations of the fixed markers are known, as is the lake level at the time of survey, so that two elevation control points are available for each profile site. Maps and location notes for the surveyed sites are presented in Appendices 1, 2 and 3 for Lake Manapōuri, Lake Te Anau and Pearl Harbour respectively. The survey data are plotted as overlays on previous survey lines. This allows direct, quantitative comparison of changes that may have occurred in the inter-survey period (e.g. changes to width, height, slope or shape of beach profiles). The procedure also facilitates the calculation of the volumes of sediment involved in any gains or losses from sites, as well as providing data for assessment of long-term trends of change in any and all of the beach form characteristics.

The surveying was carried out using a Sokkia Total Station Theodolite and single prism. The lines are measured at right angles to the shore with survey points located at all major breaks of slope. The profile line extends across all the various zones of the sub-aerial, visible parts of the beach, and across the nearshore to a water depth of about 1.6 m.

The outer parts of the profile were reached by wading (in a wet suit). The depth of the surveys for this study reached 200.6 to 201.3 m on Lake Te Anau and 176.5 to 176.8 m on Lake Manapōuri. Large waves at a small number of sites on Lake Te Anau limited the attainable depth for the surveys.

The waratah benchmark at Bullins Beach (site M3) on Lake Manapōuri was not present. A new benchmark was located in the backshore near to the location of the old benchmark, with the new profile running along the line of the old one. A description of the location of the new benchmark is given in Appendix 1.

3.2 Shore Inspections and Photography

Substantial lengths of shore are inspected during the monitoring surveys and field notes are made to supplement the beach profile surveys. Further, as part of the profile survey at each site photographic records are made. Photographs were taken from a point midway up the beach, approximately 20m along to the left and right of the survey line, looking towards the survey position. Additional photographs were taken looking lakeward and landward along the profile line. The photographs are compared to earlier photographs at the same sites.

4. Results Lake Manapōuri

Appendix 1 to this report shows a map of the survey sites and location notes for the benchmarks on Lake Manapōuri.

4.1 Lake Manapōuri general comments

Overall

The recent high lake level event resulted in geomorphological changes to the appearance, form and sediment distribution across the upper foreshore and backshore of the beaches of Lake Manapōuri. Beach sediment was deposited landward of the vegetation limit at sandy beach sites while erosion of the backshore occurred at sites exposed to waves generated by strong winds from the westerly quarter. Driftwood and in some cases, large logs had moved on the backshore and deposits of floated woody and leaf matter extended higher and more landward than seen during previous monitoring since the early 1990s.

Beach profile change was minor at most sites, although shore change along Fraser Beach was of an overall erosional character including erosion of the backshore scarp above the normal active beach zone. At sites with mobile beach sediments and exposure to moderate wave energy, sediment movement from the foreshore to the backshore was evident and likely a result of the recent high lake levels. However, there were also indications of sediment movement across the mid- to lower foreshore. Apart from the erosion along the backshore on Fraser Beach, the appearance of the beaches was not out of character to the long-term nature of the dynamic shores. Surveyed profiles are essentially within the long-term envelope of change, with the exception being the southern end of Fraser Beach (M15).

Changes to stream channels across the shore at Circle Cove (M2) and Monument Beach (M5) were noticeably of greater magnitude in extent along the shore and depth of incision on the upper foreshore than in recent years, but not uniquely so when considered over the longer term of monitoring since the 1980s.

Quantitative changes

Tables 4.1 and 4.2 and Appendix 4, Figures 1-8 set out measured beach change data for the monitoring sites on Lake Manapōuri. The tables and figures show summary information that is augmented by the written descriptions of change noted from the field examination, photograph comparisons and interpretation of the profile data in the following sections.

Table 4.1 gives a comparison of the exposed lengths of the profile marker waratahs. Note that while there are 16 profile sites, there are additional markers at Bullins (M3) and Fairy Beach (M7) that have been measured on occasion to indicate fluctuations of beach surface level at the position of the marker. Pickrill installed the original markers in 1972 (Pickrill 1976). Changes that are noted on markers that are sited within the commonly active beach processes will reflect beach response to the most recent processes at the elevation of the marker. Where the marker sited is landward of the normally active wave processes or lake level, change may result during high lake levels or from deposition of leaf matter or fallen foliage. A comparison of inter-survey change (Table 4.1) reflects more recent processes (i.e. over five year periods) and indicates the dynamic response of the beach over the inter-survey period rather than a long-term change to the profile (which is shown in Table 4.2).

As shown in Table 4.1, change of the beach surface level in the vicinity of the markers is generally small (≤ 0.04m). In most cases the marker is near the limit of wave run-up (at the top of the foreshore). However, even where the marker is situated within the active foreshore such as at Bullins and Fairy Beach, the change in beach surface elevation between 2021 and 2026 (0.34 m and -0.22 m respectively) is considered to be relatively small due to the exposure to high energy waves on these sandy beaches. The largest net change in beach surface lowering was at Fairy Beach (M7). This marker is within the active mid-foreshore area of the sandy beach and is relatively dynamic over the long-term. Bullins Beach (M3) is also situated within the mid-foreshore of a sandy beach. The central marker (3c) has been removed since 2021, but the markers at 3b and 3d show a slight lowering of the beach surface at the western end of the beach and raising of the surface at the eastern end of the beach. This a common occurrence for this type of dynamic pocket beach with a limited sediment supply constrained within rocky headlands. Sand movement along and across-shore is determined by wave energy but also by the direction of wave approach which can cause sand to move from one end of the beach to the other and back again with subsequent changes in wave direction.

Table 4.2 presents inter-survey beach volume changes for the last 5 years back to January 2021 and for earlier inter-survey periods back to 1973-1974 for most sites. General statements can be inferred from the data: -

- Inter-survey change over the last five years is overall of a similar magnitude and range to previous survey intervals;
- Between 2021 and 2026 there were eight sites that eroded and eight sites that accreted. Volume change was greatest at Fraser's Beach (M14) as a result of sediment loss across the mid-foreshore and the upper limit of wave run-up, especially when compared to the accumulation of sediment across the mid-foreshore between 2016 and 2021. The largest amounts of deposition occurred at Ruby Bay south (M12) and Bullins Beach (M3). Change at both sites was mainly due deposition across the upper foreshore.
- In the long term, the most dynamic beaches are those exposed to the greatest wave energy (Frasers Beach and Ruby Bay), while beaches with nearby sources of sediment such as Calm Bay (M8), or have a nearshore source of sediment to a pocket beach such as Bullins, George (M4) and Monument (M5) exhibit long-term accretion.
- For the 2021 to 2026 intersurvey period, there was no systemic pattern to the type of shore change with regard to sediment type or beach aspect to wave approach.

The remainder of this section of the report will describe beach changes noted in the assessment of the beach profile surveys, from comparison of photographs of each site from earlier surveys and from observations in the field.

Table 4.1 Lake Manapōuri. Exposed lengths of "Waratah" profile markers (metres) from 1997 to 2026.

Profile Name	Profile No.	Feb 97	Jun 02	Oct 06	Jan 11	Jan 16	Mar 20	Jan 21	Jan 26	Difference 89-97	97-02	02-06	06-11	11-16	16-21	21-26
Sandy Bay	M1	0.39	0.381	0.357	0.278	0.278	0.245	0.233	0.23	0.05	0.01	0.02	0.08	0.00	0.05	0.01
Circle Cove	M2	0.388	0.348	0.347	0.272	0.299	0.309	0.32	0.30	-0.01	0.04	0.00	0.08	-0.03	-0.02	0.02
	3a	1.526	1.53	1.46	1.46	-	-	-	-	-0.10	0.00	0.07	0.00	-	-	-
Bullins	3b	0.55	0.55	0.7	0.655	0.655	0.753	0.74	0.4 **	0.16	0.00	-0.15	0.04	0.00	-0.09	0.34
	M3c	0.52	0.58	0.689	0.68	0.77	0.725	0.705	!*	0.11	-0.06	-0.11	0.01	-0.09	0.07	-
	3d	0.578	0.59	0.587	0.58	0.58	-	-	0.59	0.02	-0.01	0.00	0.01	0.00	-	--0.01
George	M4	0.349	0.189	0.305	0.322	0.211	0.248	0.23	0.23	0.10	0.16	-0.12	-0.02	0.11	0.09	0.00
Monument	M5	0.304	0.227	0.225	0.2	0.171	0.198	0.13	0.16	0.02	0.08	0.00	0.03	0.03	0.07	-0.03
Stockyard	M6	0.879	0.845	0.87	0.87	0.94	0.953	0.945	0.95	-0.03	0.03	-0.03	0.00	-0.07	-0.01	0.00
	7a	0.68	0.77	0.77	na	-	-	-	-	0.03	-0.09	0.00	-	-	-	-
Fairy	M7b	0.805	0.656	0.768	0.749	-	0.772	0.686	.91 ***	-0.20	0.15	-0.11	0.02	-	0.06	-0.22
	7c	0.58	0.72	***	na	-	-	-	-	-0.01	-0.14	-		-	-	-
Calm Bay H	M8	0.223	0.247	0.227	0.245	0.245	0.207	0.22	0.23	0.05	-0.02	0.02	-0.02	0.00	0.03	-0.01
Calm Bay E	M9	0.795	0.89	0.89	0.95	1.00	1.04	1.02	1.04	-0.09	-0.10	0.00	-0.06	-0.05	-0.02	-0.02
Moturau Hut	M17				0.883	0.883	0.883	0.802	0.81				na	0.00	0.08	-0.01
Ruby Bay N	M10	0.45	0.459	0.479	0.477	0.479	0.481	0.481	0.48	-0.01	-0.01	-0.02	0.00	0.00	-0.00	0.00
Ruby Bay M	M11	0.475	0.476	0.491	0.472	0.471	0.438	0.45	0.49	0.01	0.00	-0.02	0.02	0.00	0.02	-0.04
Ruby Bay S	M12	0.837	0.636	0.615	0.651	0.643	0.761	0.76	0.75	-0.07	0.20	0.02	-0.04	0.01	-0.12	0.01
Frasers N	M16	Concrete pad under picnic table								na	-	-	-	-	-	-
Frasers M	M14a			0.678	0.678	0.678	0.59	0.59	0.62	-	-	-	0.00	0.00	0.09	-0.03
Frasers S	M15	0.359	0.359	0.359	0.359	0.77 *	0.77	0.82	0.81	na	-	-	0.00	0.00	-0.05	0.01

Note: Some markers are fixed backshore features such as fenceposts, large trees or constructed features. These are described in Appendix 1. Gaps in the table indicate where original markers have been replaced or new markers have been installed over the period since 1989. ** Waratah entangled in tree roots; !* Waratah washed out and new BM is rock above bush line; *** Waratah bent, fallen tree gone from beach. A positive difference indicates accretion or vegetation growth around the marker. A negative difference indicates lowering of the ground surface around the marker.

Table 4.2 Lake Manapōuri beach volume changes for the last inter-survey period (January 2021 to January 2026 – 5.00 years) in comparison to earlier periods and the longer period (initial survey to 2026). Units are in cubic metres per metre of shore ($m^3.m^{-1}$).

Profile Name	Profile No.	Change 73 to 88	Change 88 to 97	Change 97 to 02	Change 02 to 06	Change 06 to 11	Change 11 to 16	Change 16 to 20	Change 20 to21	Change 16 to 21	Change 21 to 26	Change Start to 26
Sandy Bay	M1	0.5	2.51	3.13	-1.25	1.53	0.53	-0.20	-0.39	-0.60	-1.06	4.79
Circle Cove	M2	-7.89	-1.77	-1.47	-0.96	0.93	-0.69	3.07	-3.17	-0.11	0.17	-3.89
Bullings	M3	-7.82	1.77	-2.16	-2.03	1.77	-0.99	1.07	-3.71	-2.64	7.25	2.97
George	M4	9.52	1.17	4.55	-4.35	1.37	0.52	4.20	-0.51	3.69	-0.51	6.45
Monument	M5	-44.3	6.89	4.39	-5.38	2.20	-1.32	1.47	-5.74	-4.27	0.52	3.03
Stockyard	M6	-0.81	1.54	-0.65	0.05	-	0.32	-0.08	0.96	0.88	-	2.25
Fairy	M7	-10.74	0.46	0.04	0.02	-2.62	-	1.90	0.59	2.49	0.96	1.35
Calm Bay H	M8	0.76	-1.75	1.89	-1.04	0.29	0.33	4.65	-1.33	3.33	1.53	4.58
Calm Bay E	M9	-3.59	1.65	-0.09	-	-	-3.23	0.54	0.30	0.85	-0.18	-1.00
Moturau Hut	M17						4.45	-3.61	2.59	-1.03	-0.73	2.69
Ruby Bay N	M10	9.55	-9.69	1.49	1.46	0.55	0.96	1.50	-0.18	1.32	2.62	-1.28
Ruby Bay M	M11	-4.03	2.35	-3.05	-0.52	1.24	2.89	1.75	-1.34	0.42	-0.75	2.58
Ruby Bay S	M12	1.87	-9.10	-2.42	-3.11	-3.26	-3.96	-8.76	-1.32	-10.07	5.64	-26.28
Frasers N	M13	-6.62	1.18	-	-	-	-	-	-	-	-	
Frasers N	M16	-			1.53	-5.40	4.36	-1.52	3.99	2.48	-1.85	1.12
Frasers M	M14	-3.06	-6.67	-	1.03	0.00	1.84	6.39	4.04	10.43	-13.36	-6.72
Frasers S	M15	-12.27	-1.26	-1.62	-0.90	0.34	0.55	-1.42	3.87	2.45	-5.87	-6.30

Note: Positive numbers denote accretion, negative numbers denote erosion.

4.2 Sandy Beach

Sandy Beach is a bayhead beach mantled in fine sand. Surveys of Profile M1 measured since February 1988 are shown on Appendix 4, Figure 1A. In conjunction with Table 4.2 the diagram shows that the beach accreted after 1974, that it experienced mild erosion through the earthquake and storm/flood episodes of 1988, and between 1989 and 2002 the middle to upper foreshore was strongly accretional. There have been only minor changes to the profile since 2002, with surveys between 2002 and 2016 showing landward sediment movement and accretion to the upper foreshore. Since 2021 the beach shows minor changes in the surface level across the upper foreshore. Sand has moved up the beach with the level of the surface lower across the lower foreshore and higher across the mid- and upper foreshore. There has been a small accretional berm constructed landward of the benchmark and movement of sand from the west to east along the shore. The main visual change is loss of woody debris from the upper foreshore and an increase in woody debris along the bush-line.

4.3 Circle Cove

Appendix 4, Figure 1B shows the beach profile M2 at Circle Cove. The beach is gently sloping and comprised of fine sand. The beach shows movement of sediment from the mid-foreshore to the upper foreshore since 2021. The main visual change is the removal of woody debris and sand covering an 8 m long log on the upper foreshore. The beach surface is relatively clear of large woody matter, but a recent ridge formed across the mid-foreshore includes sand - covered leaf and twig material. This beach continues to look healthy and is well-nourished with sediment.

4.4 Bullins Beach

Profile M3 shows a similar history to that at Circle Cove (see Appendix 4, Figure 2A and Table 4.2). Inter-survey periods show a mix of erosion and accretion at different times. There has been a large increase in sand onto this pocket beach since 2021. Boulders and pebbles visible on the shore in 2016 and 2021 have been covered by sand. The erosional scarp at the limit of wave run-up has retreated and nearly all of the woody debris and logs present in 2021 have gone from the upper foreshore. There has been an overall increase in sand content on the mid-to upper foreshore of the beach, but the character of this pocket beach is consistent with the long-term record.

4.5 George Bay Beach

Profile M4 is gently sloping and comprised of fine sand with underlying small pebbles. The beach profile surveys are plotted in Appendix 4, Figure 2B. This beach exhibits similar changes in movement of sand from the mid-foreshore to the upper foreshore as other sandy beaches on Lake Manapōuri. The profile lost a small volume of sand but overall, the beach appears well-nourished with sediment. The large amounts of floatable debris deposited in the backshore between 2020 and 2021 have either been removed from the beach or moved landward during high lake levels prior to the 2026 survey. Sand was also carried up to 10 m

landward of the normally active upper foreshore, leaving a deposit of sand about 0.1 m deep on the forest floor.

4.6 Monument Bay

Profile M5 (Appendix 4, Figure 3A) has an intermittent stream channel running through the centre of the embayment and across the line of the surveyed profile. This stream channel moves laterally along and across the shore, with varied depths of incising into the beach surface depending on the lake level at the time of stream flow. Apart from the position of the steam in 2026, the beach appearance was similar to that of 2021 and from previous monitoring. There has been an increase in the level of the mid- and upper foreshore surface and deposition of sand to the backshore onto the forest floor. There has been no change in character of the shore or the wider embayment beach.

4.7 Stockyard Cove

Profile M6 (Appendix 4, Figure 3B and Table 4.2) is a narrow, very steep, low energy gravel beach facing to the east. There is no visual change to the profile between 2021 and 2026.

4.8 Fairy Beach

Profile M7 (Appendix 4, Figure 4A) is a wide embayment with a source of sand sediment at the western end. Boulders underlie the beach sands in the area of the profile, near the centre of the embayment. A stepped profile is often present, indicative of periods of storm cutting and subsequent deposition of sand across the beach profile. The 2026 monitoring shows sand has been deposited to the upper foreshore, with the mid-foreshore surface level lowered and the lower foreshore level raised. Wave action during high water levels has resulted in removal of fallen tree trunks from the upper section of the beach, but no change to the general character of this dynamic foreshore.

4.9 Calm Bay Head

At the head of Calm Bay (M8 - see Appendix 4, Figure 4B and Table 4.2), the beach lies west of a large stream delta built out into the lake during river floods. The shore receives an ample supply of sediment and is subject to strong wave action in southerly or southeasterly winds. Between 2021 and 2026, sediment has moved onshore accumulating as a beach ridge under the juvenile manuka. This has led to continued sediment gains at this site while maintain the near-stream, low-lying barrier beach character of the shore.

4.10 Calm Bay Entrance

The basement of erodible, fine sediment has remained stable at this site (M9 – see Appendix 4, Figure 5A) since 2021.Small changes to the backshore scarp have occurred with winnowing of the clay (damsite sediment) through wetting and drying within the main operating range of the lake.

4.11 Moturau Hut

The profile at Moturau Hut (M17) is shown in Appendix 4, Figure 5B. This beach is long and sandy, and exposed to waves from the south and southwest. The sand beach is very dynamic and adjusts rapidly to changes in the process environment. For those reasons, it is a good indicator beach to illustrate potential systemic changes to the shore. Sediment has moved up the profile between 2021 and 2026, creating an accumulation of sand landward of the benchmark. Large pieces of driftwood, including long logs, have moved on the upper foreshore. There was a small volume loss from the profile but no visible erosion features or change in character of the beach.

4.12 Ruby Bay - Three Sites

Sites M10, M11 and M12 are situated respectively at the north, centre and south of Ruby Bay. The northern and central part of the bay has a very steep gravel beach ridge with numerous berms and older, fossil beach ridges to landward (resulting from past, natural, higher lake levels). This is a high-energy beach exposed to very strong wave action in westerly winds, and there is a net longshore transport of gravels from south to north. The southern end of the beach is historically erosional, the centre a transport zone, and the northern end a depositional area.

This medium to long-term pattern of change is seen in Table 4.2 and from Appendix 4, Figures 6A, 6B and 6C. The northern profile (M10) has accreted slightly since 1997 after significant erosion between 1988 and 1989. Since 2021, there has been accretion to the upper part of the profile and further landward movement of the gravel berm. There has also been deposition across the middle and upper foreshore of the profile accompanied by slight lowering of the lower-foreshore beach surface. There are generally only minor changes to the appearance of the beach since 2021 with the width of alternating gravel and sand beach parallel “lenses” indicative of active on- and offshore sediment movement.

At Profile M11 in the centre of Ruby Bay (the through transport area), the mobile nature of sediments is evident. In 2026, sand lenses are present lower on the profile than in 2021. However, there has been erosion of the backshore area where the beach gravels transition to the forest soil cover. This is a result of wave action and movement of woody debris and logs across the easily eroded soils. This has also resulted in areas of exposed roots of large beech trees at the forest edge along portions of this central section of Ruby Bay.

The beach in the vicinity of site M12 has consistently lost sediment until 2026. Profile M12 is at the updrift (feeder) southern end of Ruby Bay. It can be seen from Table 4.2 that significant erosion has occurred since 1988. However, the beach has gained sediment between 2021 and 2026. The loss of some forest edge vegetation has released sediment from the backshore to the beach, but gravel has also accumulated across the profile, with small ridges forming on the foreshore lakeward of the benchmark. The benchmark has been bent over while remaining in place, as a result of being struck by floating logs. These changes are discussed further in the high lake level event report (Single 2026, *Manapōuri Power Scheme: October-*

November 2025 high lake levels on Lakes Manapōuri and Te Anau and effects on lakeshore geomorphology).

4.13 Frasers Beach - Three Sites

Frasers Beach, the Township frontage at Lake Manapōuri is developed from the sediments of the moraine ridge that forms the natural dam at the outlet of Lake Manapōuri. Net longshore drift of sediments is from north to south (toward the outlet of the lake). The three sites along this stretch of shore exhibit different sediment characteristics and response to effectively the same wave environment from the north and north-westerly quarters. Recent erosion of the backshore of Frasers Beach was observed during the high lake level event of late 2025. These effects will be discussed in detail in the separate event report.

Profile (M16 Appendix 4, Figure 7B) was installed in 2002. The beach sediments are predominantly sand with some small pebbles. The backshore has been landscaped to provide a flat grassed area. An erosion scarp formed into the lakeward edge of the grassed area in December 2019 was further eroded between March 2020 and January 2021. Since 2021, the scarp has retreated approximately 4 m at the profile site. There has been deposition of sediment across the upper foreshore but lowering of the beach surface on the lower foreshore resulting in an overall loss of sediment from the beach. Previous losses of sediment at this site have been followed by recovery as there is sediment input from the north and from offshore. In the long-term this area of Frasers Beach is dynamic in response to changes in the wave environment but stable in form and appearance.

The benchmark at site M14 (Appendix 4, Figure 8A) was relocated in October 2006 along the same line as the old profile as the profile marker was damaged by rocks moving on the foreshore. The beach is sectioned into across-shore zones of fine sands and silts and areas of larger gravels. Large boulders are scattered at the water's edge. Prior to 2020 the site experienced very little change, but between 2020 and 2021, this site accreted along the vegetated and lower foreshore sections of the profile. Since 2021, there has been erosion and lowering of the beach surface across the whole foreshore, while wave run-up has reached to 10 m landward of the benchmark and modified the ridge of wrack (woody debris) and gravel. Gravel has also been deposited to the upper foreshore adjacent to the profile line. This is a dynamic high-energy foreshore that forms a slight promontory to the line of the longer Frasers Beach shore. Wave run-up is turbulent and able to readily move all sand and gravel sized sediment present across the shore due to the presence of large boulders and clumps of tussock grasses on the middle and upper foreshore. Although the volume change at the profile site is large, there is no change to the character of the shore, and it is likely that the loss of sediment is not permanent.

Profile M15 (Appendix 4, Figure 8B) has a similar open beach character to M16, but with coarser mix of sand and gravel/pebble sediment on the beach. There has been slight net erosion of sediment volume and lowering of the foreshore across the whole profile since 2021. Where grasses had started encroaching onto the beach from the backshore in 2021, these areas have undergone erosion, and small scarps have formed into the grassed surface and

into the steeper banks of the backshore to the north of the profile site. Sediment removed from the beach is present in the nearshore and the beach volume and sediment level on the upper foreshore is likely to return but at a slow rate.

5. Results Lake Te Anau

Appendix 2 to this Report shows a map of the survey sites on Lake Te Anau and presents a description of the Benchmark locations.

5.1 Lake Te Anau general comments

At a general level, the shore of Lake Te Anau appeared visually similar to the appearance during the monitoring in 2021. The amount and distribution of driftwood and lines of wrack were of a similar magnitude and position across the foreshore. However, there were specific differences at some sites that on closer examination showed the effects of the 2025 high lake levels. Erosion along the Te Anau township foreshore south of the Marina, north of and along Steamer Beach, and at the southern end of the lake east of the Te Anau Lake Control were limited in spatial extent but visually impactful. These effects are discussed in detail in the high lake level event report (Single 2026, *Manapōuri Power Scheme: October-November 2025 high lake levels on Lakes Manapōuri and Te Anau and effects on lakeshore geomorphology*).

Changes in the distribution of sediment sizes across the shore at sites with mixtures of sand and gravels were notable at high-energy sites along Patience Bay, and the distribution of the sand volume at Garden Point between the northern and southern aspects of the foreland was noticeably different from previous monitoring observations. However, the beaches of Lake Te Anau exhibited states consistent with the long-term range of dynamic character and variability reflecting the aspect to the wave environment and the sediment type.

Tables 5.1 and 5.2 set out the results of the beach change calculations since the last survey. For the most part, measured changes of beach level at the waratahs are very small (≤ .07 m), with the exception being at site T18 (0.32 m), South Patience Bay, where wave run-up has deposited sediment landward of the benchmark. The South Patience Bay site is subject to large waves from the north and comprises coarse mobile sediments that are deposited at the limit of wave run-up but are not transported down the beach by backwash. Run-up has also moved sediment (accretion and erosion) around the benchmarks at sandy beach sites (T13, T14, T15 and T16) relative to 2021, where the benchmark is sited landward of the vegetation limit but on gently sloping backshores, and at site T20 at the southern end of the lake.

Inter-survey beach sediment volumes for the last five years for the Lake Te Anau sites are set out in Table 5.2. Twelve of the sites show accretion since the 2021 survey, with twelve sites showing erosion. Of the sites showing accretion in volume, three have accretion greater than 5 $m^3.m^{-1}$ of shore (T23, T14 and T16). Sites T23 and T16 are exposed to waves from the north and are historically dynamic with active sources of “new” sediment. Sediment from a stream within the pocket beach at Deadmans Point (T16) supplies sand to the shore. There is a large reservoir of sand on the upper foreshore of Garden Point (T14 and T15). Sediment moves around the foreland from site T15 to T14 during northerly waves events and back again during

southerly conditions. This is reflected in the beach profile volume data for 2026 with a gain in volume at T14 and a loss of more than 5 $m^3.m^{-1}$ in volume at T15, indicative of north to south movement of sediment around the point. Site T23 is near the Upukerora River mouth and is supplied by sediment from both the river and from alongshore transport of sediment from the north.

As with the high lake level event in 2020, the coarse sediment beaches of Patience Bay to west and east of the Upukerora River mouth show evidence of waves from the north and west moving sediment upslope and alongshore to the south and away from the Upukerora River.

The two other sites of sediment loss greater than 5 $m^3.m^{-1}$ of shore are on the southern shore of the lake at sites T20 and T21. These shores have very shallow nearshore areas and small changes in the beach surface over the lower foreshore can add to a large loss for the profile. However, there has also been noticeable movement of sand sediment on the middle and upper foreshore at site T21, distributing sandy sediment among the manuka trees at the water's edge.

As with the measurement of Lake Manapōuri beach profiles, some broad summary points can be noted about the change to the Lake Te Anau beaches: -

- Inter-survey change over the last five years continues to be varied, with some sites showing very little change and some showing large increases in sediment volume compared to previous surveys.
- Over the long-term, most sites show accretion with sites close to or downdrift of the Upukerora River showing the greatest increase in beach volume. Shores exposed to high-energy waves have lost sediment.
- Sediment movement within pocket beach compartments (such as T13 and T16) and around Garden Point (T14 and T15) continue to show large fluctuations in sediment volume across the monitored profiles or along the shore and don't necessarily indicate a change in beach character. However, the state of the overall beach area is sensitive to changes in sediment input from local streams due to steep offshore slopes preventing onshore sediment transport from deeper parts of the active profile.
- The beaches of Lake Te Anau are generally well-supplied by sediment and dynamically adjust to changes in the wave environment and lake level without exhibiting any adverse effects to the shore geomorphology at a systemic spatial or long-term temporal extent.

Table 5.1 Lake Te Anau. Exposed lengths of "Waratah" profile markers (metres) from 1989 to 2026.

Profile Name	Profile No.	Feb-89	Feb-97	Jun-02	Oct-06	Jan-11	Jan-16	Mar-20	Jan-21	Jan-26	Difference 06-11	11-16	16-20	16-21	21-26
Upukerora Mouth	T23	-	-	-		fence	fence	fence	fence	-	-	na	na	na	na
West Upukerora	T24	-	-	-		fence	fence	fence	fence	-	-	na	na	na	na
Fence	T1	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.31	0.00	0.00	0.00	0.00	0.19
Rodeo	T2	0.30	0.30	0.41	fence	fence	fence	fence	fence	fence	na	na	na	na	na
Marina W	T3	0.30	0.53	0.53	0.52	0.52	0.48	fence	fence	fence	0.01	0.03	na	na	na
Marina S	T4	stump	stump	stump	stump	stump	stump	stump	stump	stump	na	na	na	na	na
Slipway	T5	fence	fence	fence	fence	kerb	kerb	kerb	kerb	kerb	na	na	na	na	na
Matai St	T19	-	-	concrete	concrete	concrete	concrete	concrete	concrete	concrete	na	na	na	na	na
Float Plane	T6	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	concrete	na	na	na	na	na
Steamer	T7	0.45	0.45	0.41	0.41	0.39	na	na	na	na	0.02	na	na	na	na
Picnic Area	T20	-	-	-	0.70	0.70	0.70	0.70	0.70	0.77	0.00	0.00	0.00	0.00	-0.07
West of Control	T21	-	-	-	0.90	0.87	0.79	0.87	0.78	0.80	0.03	0.08	-0.08	0.01	0.02
Dock Bay	T8	na	na	0.47	0.50	0.50	0.49	0.49	0.49	0.50	0.01	0.01	0.00	0.00	-0.01
Ski Lane	T9	0.40	0.40	0.36	0.36	0.38	0.38	0.38	0.38	0.38	-0.02	0.00	0.00	0.00	0.00
Brod Bay	T10	0.36	0.35	0.32	0.30	0.26	0.14	na[3]	concrete	concrete	0.04	0.13	na[3]	na	na
Garnet E	T11	1.28	1.28	1.28	1.36	1.36	1.36	1.36	1.34	1.34	0.00	0.00	0.00	0.02	0.00
Garnet W	T12	0.69	0.68	0.75	0.69	0.69	0.69	0.68	0.67	0.67	0.00	0.00	-0.01	0.02	0.01
Moonlight	T13	0.60	0.43	na[2]	na[2]	na[2]	na[2]	0.53	0.53	0.46	na	na	na	0.00	0.07
Garden Point S	T14	0.15	0.15	0.15	post	0.15	0.15	0.15	0.13	0.15	0.00	0.00	0.00	0.02	-0.02
Garden Point E	T15	0.52	0.52	0.47	0.47	0.35	0.35	0.31	0.31	0.24	0.12	0.00	-0.04	0.04	0.07
Deadmans	T16	0.48	0.48	0.49	0.50	0.64	0.50	0.50	0.50	0.53	-0.14	0.13	0.00	0.00	-0.03
N Patience	T17	0.58	0.58	0.57	0.56	0.73	0.73	0.73	0.73	0.39[1]	-0.16	0.00	0.00	0.00	na
S Patience	T18	0.44	na	0.82	0.82	0.82	0.82	0.82	0.82	0.50	0.00	0.00	0.00	0.00	0.32
East Upukerora	T22	-	-	-		0.79	0.42	0.45	0.45	0.45[1]	-	0.37	0.03	0.00	0.00

Some markers are fixed backshore features such as fenceposts, large trees or constructed features. These are described in Appendix 2.

Notes: [1] Waratah bent, exposed length measured. [2] Top of waratah reading obscured by bush and trees. [3] Waratah buried by sand.

A positive difference indicates accretion or vegetation growth around the marker (e.g. site T1). A negative difference indicates lowering of the ground surface around the marker.

Table 5.2 Lake Te Anau beach volume changes beach volume changes for the last inter-survey period (January 2021 to January 2026 – 5.00 years) in comparison to earlier periods and the longer period (initial survey to 2026). Units are in cubic metres per metre of shore ($m^3.m^{-1}$).

Profile Name	Profile No.	Change 73/74 to 88	Change 89 to 97	Change * 97 to 02	Change* 02-06	Change 06-11	Change 11- 16	Change 16-20	Change 20-21	Change 16-21	Change 21-26	Change start to 26
Upukerora Mouth	T23	-	-	1.49	6.88	-1.22	8.24	7.87	1.56	9.43	12.12	36.92
West Upukerora	T24	-	-	2.02	-2.57	5.23	-7.08	16.92	-4.72	12.20	3.99	13.78
Fence	T1	-	4.36	-2.34	2.15	0.25	-4.74	2.85	4.44	7.29	-3.03	3.94
Rodeo	T2	-	-2.59	2.48	4.23	-2.50	5.06	0.50	-5.90	-5.39	-1.20	0.10
Marina W	T3	-	-2.78	1.96	-2.41	-3.50	6.70	2.88	-1.91	0.97	2.78	3.71
Marina S	T4	-	0.52	-0.02	-0.95	-0.73	7.56	-2.37	-3.49	-5.87	0.11	0.62
Slipway	T5	-	4.58	-0.70	3.44	2.15	-1.79	-3.01	-3.39	-6.4	4.18	5.46
Matai St	T19	-	-	-	-1.45	2.95	8.57	0.18	1.75	1.93	0.94	12.94
Float Plane	T6	-	0.23	0.96	-0.02	1.09	-1.40	0.24	-0.82	-0.58	1.27	1.55
Steamer	T7	-	1.09	1.42	-0.33	1.60	5.39	-0.16	-0.18	-0.33	-0.49	8.34
Picnic Area	T20	-	-	-0.24	-1.07	4.89	-1.91	9.13	2.56	11.69	-7.63	5.72
East of Control	T21	-	-	1.58	-5.20	0.92	2.45	5.21	8.44	13.65	-21.08	-7.68
Dock Bay	T8	-	-7.23	1.68	6.61	-0.91	-0.73	0.16	-1.47	-1.31	-4.49	-6.38
Ski Lane	T9	-	5.18	0.15	0.69	0.62	0.66	-0.08	-2.17	-2.25	3.83	8.88
Brod Bay	T10	-	6.56	0.87	-0.26	2.28	-1.45	5.3	1.73	7.03	-3.32	11.71
Garnet E	T11	3.58	-4.22	4.64	-1.92	-3.08	10.93	-11.76	1.66	-10.09	-2.69	-5.60
Garnet W	T12	2.38	3.58	0.22	-3.22	-0.19	-0.5	1.02	1.16	2.17	4.12	2.14
Moonlight	T13	10.28	2.38	-1.48	-2.80	-1.50	7.77	-12.91	-0.18	-13.09	1.41	-9.16
Garden Point S	T14	33.67	5.03	-5.95	4.78	-1.45	4.48	8.39	-7.49	0.9	12.45	13.31
Garden Point E	T15	20.18	-4.48	0.89	3.65	-8.79	0.18	-8.19	9.50	1.31	-10.72	-28.85
Deadmans	T16	-17.38	4.79	-5.21	-1.52	4.85	-2.45	4.69	-0.85	3.84	7.57	8.88
N Patience	T17	-9.28	-0.32	-1.11	-3.06	1.77	-0.19	-2.17	0.75	-1.42	-3.32	-13.63
S Patience	T18	3.44	-	2.26	-3.57	-1.12	0.11	-5.10	1.21	-3.89	-1.11	-0.43
East Upukerora	T22	-	-	-0.65	0.79	8.77	3.12	12.32	3.18	15.50	-1.61	25.92

Note: Positive numbers denote accretion, negative numbers denote erosion.

- T20 to T24 start dates are 12/03, so changes are from 12/03 to 2/04, and 2/04 to 10/06

The following site discussions, based on survey data and photograph comparisons note changes since 2021 and over the longer monitoring program.

5.2 Upukerora River to Bluegum Point

Appendix 4, Figures 9, 10 and 11A show five profiles (T23, T24, T1, T2 and T3) located sequentially away from the sediment supply of the Upukerora River. The beaches at these sites are all coarse gravel with lenses of sand sized sediment spread through and across the profile. These shores have a greater exposure to storm wave energy than any others on Lake Te Anau.

T23, the profile nearest to the Upukerora River mouth, continues to show a significant increase in sediment volume and deposition to the top of the beach and backshore. The barrier height increased by about 0.4 m and prograded about 3 m since 2021.

The shore west of the Upukerora River mouth (sites T24 and T1) also shows sediment movement to the top of the active beach since 2021. Gravel has moved onshore, and areas of sand deposits along the upper foreshore in 2021 are again evident in 2026. Small berms and gravel beach ridges present on the mid-to upper foreshore in 2021 have been levelled out by wave action during recent high lake levels.

Changes to the mid-foreshore are also evident along the shoreline exposed to the west (T2 Rodeo and T3 Marina West). Although wave run-up has reached the base of the erosional scarp at T3, there has been no further retreat of the backshore at these sites. Gravel movement along the shore from the north is evident and the shore around the Te Anau Marina appears well-supplied with sediment.

5.3 Marina South and Public Slipway

Appendix 4, Figures 11B and 12A show the change to the profiles T4 (Marina South) and T5 (No entry Slipway) on either side of the entrance to the Te Anau Marina. There are very small changes to the profile form at these sites and evidence of sediment moving along the mid- to upper foreshore from west to east to south, bypassing the marina entrance. This takes the form of additional sand deposition on the upper foreshore just north of the slipway, while there appears to be a greater amount of large gravel sediment immediately adjacent to the boat ramp.

5.4 Te Anau Town Foreshore

Sites T19 (Matai St) and T6 (near the float plane wharf) are located along the township foreshore and are shown in Appendix 4, Figures 12B and 13A.

Although the surveyed profile shows only minor changes at T19, with a small increase in the beach volume, there was about 1 m retreat of the scarp between the active beach and the grassed backshore (see Appendix 5, Figure 1). There is also a visual change to the beach

sediment texture, with a greater sand content on the surface of the beach over the underlying gravel.

Change at site T6 is more visual than the plotted profile shows (see Appendix 5, Figure 2). There has been movement of gravel from the upper foreshore beach surface that has exposed the underlying boulders displaced from the rock revetment backshore. Some of these boulders have moved from the face of the revetment since 2021, and finer gravel sits on the beach surface compared to that present in 2021. It is likely that these changes are an effect of the high lake level event and are discussed further in the event report.

5.5 Steamer Beach

Site T7 is shown on Appendix 4, Figure 13B, and volume change is given in Table 5.2. There have been minor changes to the profile since 2021. There has been a small loss of sediment volume at the profile since 2021, but in the long-term this site has gained sediment. Movement of sediment from the mid-foreshore to the backshore and alongshore has resulted in distribution of the sediments of an old gravel beach ridge across the upper foreshore. An area where a grassed section of the backshore sits as a “promontory” in relation to the vegetation edge has had gravel removed from the beach to lakeward and eroding the lakeward edge of the feature. Erosion of the backshore has occurred to the west near the Marakura Wharf and Yacht Club and is discussed in the high lake level report.

5.6 Southern End of Lake Te Anau

There are three profiles along the southern end of the lake, two to the east (T20 Picnic Area and T21 East of Control) and one to the west of the control gates (T8 Dock Bay). The two easterly sites were installed in December 2003. The profiles are shown in Appendix 4, Figures 14A, 14B and 15A.

Changes at sites T20 and T21 include movement of sediment across the whole profile including the shallow muddy nearshore that extends for at least 250 m from the beach. Bands of gravel and sand lie across the beach at T20, and gravel sediment has moved onshore since 2021 while sand sized sediment is less visible on the beach surface. Small cusp ridges were present on the mid-foreshore, indicative of wave swash processes being dominant as the lake level has receded.

The small pocket beach at T21 has lost sand from within the beach sited between stands of manuka, but the sand has been redistributed sideways into the vegetated areas. The lower foreshore surface level has lowered but sediment is still present on the shallow nearshore and is likely to move onshore as has occurred in the past. The backshore has eroded along the shore to the east and west of the site and a number of mature manuka have fallen within the wooded area to the west.

The gravel beach at site T8 is shown on Appendix 4, Figure 15A. Gravel and woody debris have been moved landward to the grassy backshore during high lake levels and there is a greater presence of fine to coarse gravel on the surface of the upper foreshore. Small cobbles blanket

the mid- and lower foreshore. It is likely that the finer sediment has moved onshore from the lower foreshore and nearshore as this sediment has “cleaned” the cobble surface.

Overall, although there have been minor changes to these sites, mainly due to wave events during recent high lake levels, there character of the shore and beach sediments is consistent with the long-term observations.

5.7 Ski Lane Beach

Site T9 at Ski Lane Beach is a steeply sloping sandy foreshore on the south side of a prominent foreland. Profile changes since 1989 are shown on Appendix 4, Figure 15B and volume change is shown in Table 5.2. There has been an increase in sediment volume at this profile since 2021. This is illustrative of the dynamic nature of this site as although there is a steep nearshore shelf from which sediment can be lost to deeper water, as occurred between 2016 and 2021, there is a ready supply of sediment from alongshore transport from the north to this site. There has been sediment deposition across the majority of the profile at this site since 2021. This includes sediment on the lower foreshore, building out the steep shelf and offshore face of the slope. It is likely this sediment has been transported from the north and east, around the headland. The appearance of the beach retains the long-term character of a well-nourished sandy shore.

5.8 Brod Bay

Site T10 is at the centre of a long, broad sandy beach system in Brod Bay. The profile plots are shown in Appendix 4, Figure 16A. There has been gradual accretion to the beach since 1973 but no change in form and appearance. The beach character is unchanged, with coarse sand and lenses of gravel on the surface. Sediment has moved onshore and offshore from the mid-foreshore and there has been a loss of beach volume at the profile site. This site is exposed to waves from the north that can break against a nearshore step or shoal as they come inshore similar to an ocean beach. As a consequence, sediment can readily move on- and offshore in response to changes in the wave energy, exhibiting dynamic short to medium term changes in beach form without any long-term change to the beach character or backshore position.

5.9 Garnet Bay

Two profile sites are located in Garnet Bay, South Fiord, with the profiles shown in Appendix 4, Figure 17A and 17B. As can be seen from the variability in volume changes over the years in Table 5.2 and Appendix 4, Figure 17A, sediment fluctuation at Garnet East (T11) can be large due to the sediment laden stream entering the pocket beach. Underlying boulders are often covered then subsequently uncovered by gravel sourced from the stream and the nearshore. The beach is exposed to waves from the west and is a “sink” of logs and driftwood from further up South Fiord.

Garnet West (T12) is also underlain by large boulders and gravel but is covered by a layer of fine to medium sized sand. A number of small stream channels cross the beach and can modify the topography of the beach and the surveyed profile. Driftwood can also impact against the

soft backshore deposits on this beach resulting in erosion of the backshore and deposition onto the beach. This has occurred between 2021 and 2026 but without any change to the overall appearance or character of the beach.

5.10 Moonlight Beach

Profile T13 (Appendix 4, Figure 18A) is a sandy, pocket beach located on the northern, outer margins of South Fiord. The beach has a very narrow nearshore shelf and steep very deep-water close inshore. As can be seen from Table 5.2 this beach has experienced fluctuations in the volume of stored sand and has lost sediment volume since 1988.

The overall appearance of the beach has not changed since 2021 although there has been deposition of sand onto the backshore area under the tree canopy. A small increase in sediment volume at the position of the profile line is not indicative of any change to the character of the beach. The increase in volume is accretion and raising of the beach surface across the lower part of the foreshore (Appendix 4, Figure 18A). A stream to the west is a source of sediment, and the sand continues to move back and forth within the embayment.

5.11 The Garden Point Foreland

The beaches at Garden Point (T14 and T15, Appendix 4, Figures 19A and 19B respectively) are an accumulation feature called a “foreland”. The sediment source is from local streams with some new sediment transported south from the mouth of Point Burn, approximately 300 m to the north of T15. Past surveys of the profiles show numerous beach ridges and a large magnitude of intersurvey change (Appendix 4, Figures 19A and 19B). There is also a general tendency for sediment to be lost from T15 south to T14. This has been the case for garden Point between 2021 and 2026 with accumulation of sediment on the mid- and upper foreshore at T14, and with subsequent loss of sediment volume from similar elevations on T15.

The accretion of sediment to T14 is not noticeable in the appearance of the beach as the steep upper face of the whole foreshore and stepped nature of the mid-foreshore profile is unchanged, being a function of wave action, water level and the coarse sand sediment. The erosion of volume from T15 is noticeable in appearance as the upper foreshore is depleted of sand and there has been sediment transport towards the backshore landward of the bush line. An underlying layer of coarse sand and gravel is exposed across the mid-foreshore in a similar fashion to previous years, and the lower foreshore and nearshore shelf appears unchanged. It can be concluded on the basis of comparison to the history of monitoring records that although there is noticeable change in the beach appearance and the profile volumes, the character of the site has remained constant and shows no signs of detrimental effects over the long-term.

5.12 Deadman’s Point Beach

The steep, sandy beach at Site T16 (Appendix 4, Figure 20A and Table 5.2) shows a gain of sediment across the beach since 2021 across the upper and mid- foreshore, while the

nearshore has remained relatively stable. A thin veneer of sand has been transported to the backshore and there has been movement of the stream channel across the centre of the beach. The channel has recently incised into the loose sand deposited across the foreshore. From comparison of historical photographs, the level of the beach surface and the appearance of the beach at the eastern and western ends of the embayment is similar to previous years.

5.13 Patience Bay Sites

Appendix 4, Figures 20B, 21A and 21B show surveys for three sites in Patience Bay, north of the Upukerora River on the east shore of Lake Te Anau (T17, North Patience; T18 East Patience; T22, East Upukerora River). These shores are comprised of very long, continuous "linear" gravel beach ridges fed by streams and by erosion of the outwash terrace gravels and moraines of the lakeshore hinterland.

Since 2021, there has been erosion of sediment from the foreshore of both T17 and T18, deposition to the backshore at the monitoring sites and alongshore to the south of T17. It is evident that fresh sediment has been transported along the shore of Patience Bay and there is a greater presence of sand lenses at high elevations on the beach. Vegetation has been disturbed with removal of large driftwood accumulations and small bracken and weeds from the upper foreshore and backshore.

The profile at Site T22 has built up on the upper part of the beach with a loss of sediment volume from the lower part of the profile. As with sites T17 and T18, there is more sand on the surface of the beach, overlying gravels and cobbles. Three small willow trees, under 1 m high, present in 2021 have grown to over 3 m in height and each cover 4 m^2 of the upper beach. This green vegetation alters the appearance of the beach at T22 and obscures the change in the backshore that has occurred through deposition of sediment over previously present lines of driftwood and grasses at the limit of wave run-up. Although this site receives sediment from the Upukerora River Mouth, alongshore drift from the north is also a source of new sediment to this section of the shore.

6. Cliff Profiles at Pearl Harbour

A series of 5 cliff profiles were installed in 1994 to monitor erosion of the True Right (south) bank of the lower Waiau River at Pearl Harbour, Manapōuri. Erosion processes and possible control methods for this section of shore within the Waiau River are described in Kirk (1989). The establishment and other details of the monitoring network are presented in Kirk (1994). The location and comparison photographs of these sites are shown in Appendix 3.

Owing to the dense vegetation atop the cliffs, and the vertical cliff faces being unreachable safely with a surveying staff and prism, since 2016 the profiles were surveyed using a Total Station theodolite in reflector-less mode. The Benchmarks were located and the position relative to the cliff edge was either surveyed or measured by tape when vegetation obscured the line of sight from the Total Station. In 2026, vegetation compromised the distance reading for the cliff face and at the water line for all sites except PH1. The resulting survey plots of all

of the sites are comparable for the position of the cliff edge, but not adequate to calculate volume change or to accurately show the change in the cliff face over time. However, the general nature of change is evident from the survey plots and through comparison of the site to earlier photographs. Change in the survey method is possible through use of drone photography in addition to the benchmark survey. However, this would not meaningfully increase the appreciation of the type and magnitude of change or alter the interpretation of cause.

The surveyed data are shown in Appendix 4, Figures 22, 23 and 24. Sites number from PH1 near the inlet from the lake (opposite "The Glade"), downstream to PH5, just east of, and opposite the Real Journeys building. In addition, historical photographs of the sites were used to assess overall change of the cliff and southern shore of Pearl Harbour.

Profile **PH1** (The Glade, Appendix 4, Figure 22) was surveyed totally. A large tree has toppled from the top of the cliff and dislodged a large part of the cliff face resulting in retreat of the cliff along the surveyed profile. The sediment removed from the cliff is loose, fine lakebed deposits exposed by the incising Waiau River. This material does not provide beach sediments and is removed from the foreshore by the river at high lake levels. Visually the shore looks similar to the appearance in 2021, with the near-vertical cliff backing a lower sloped foreshore covered in large boulders, small trees and logs.

Profile **PH2** (Kiosk) is shown in Appendix 4, Figure 23A. The undercut cliff edge has remained stable since 2021, but the lower half of the slope has lost sediment and retreated due to removal of talus debris at the base of the slope. Pipe gullying (holes and/or small tunnels) is visible about 3 m above the upper limit of managed operation under the Guidelines for Lake Manapōuri. These features appear to have contributed to water flow down the cliff face, resulting in a combination of terrestrial slope erosive processes and water flow removing sediment from the base of the cliff.

Profile **PH3** (Boat Ramp) is shown in Appendix 4, Figure 23B. The cliff face is nearly totally vegetated with willow growing along the river edge across the profile line. There has been very little visual change at this site since 2006, and no change to the position of the top of the cliff. The survey indicates no change to the lower part of the cliff face.

The plotted profile at **PH4** (Kowhai) is shown in Appendix 4, Figure 24A. There has been no visual change at this site since the October 2006 survey, and no change to the position of cliff edge. The survey shows retreat of the base of the cliff from an elevation of about 182 m down to about 178.5 m (the water line at the time of the survey). It is likely that this erosion occurred during the high lake levels in late 2025.

The profile **PH5** (Real Journeys) is shown in Appendix 4, Figure 24B. There has been no change to the top of the cliff, and changes to the surveyed profile down the cliff and at the water line are likely due to the presence of vegetation. A bare area of cliff upstream of the profile shows similar erosion of the shore below 182 m elevation as at PH4. This type of erosion occurs where there is no vegetation protection on the cliff but will only occur as a fluvial process with

high lake levels. Slope erosion processes will also contribute to erosion of the unvegetated cliff face due to rainfall and groundwater flow within the sediment.

In general, the changes along the southern shore of the Waiau River from Lake Manapōuri to Pearl Harbour appear to result from the recent high lake levels and subsequent higher velocity river flows, trees toppling from the top of the cliff face and erosion processes resulting from water flows over and within the slope. Minor retreat of the cliff edge has occurred at some sites. However, vegetation growth along most of the base of the cliff has resulted in stability at the water line for most of the shore.

7. Water Level Record

Table 7.1 shows the gazetted operating water level ranges for each of the lakes.

Table 7.1 Gazetted Lake Manapōuri and Lake Te Anau operating levels

Range	Height above sea level	
	Lake Manapōuri	**Lake Te Anau**
High	178.6 m – 180.5 m	202.7 m – 204.3 m
Main	176.8 m – 178.6 m	201.5 m – 202.7 m
Low	175.86 m – 176.8 m	200.86 m – 201.5 m

Appendix 4, Figures 25 and 26 show the water level variations for Lakes Te Anau and Manapōuri for the period 1 January 2016 through to 16 January 2021, and 1 January 2021 to 12 January 2026 respectively. The lake level for uncontrolled Lake Hauroko is also shown for comparison over the 2021 to 2026 period in Appendix 4, Figure 26. These periods cover the inter-survey periods from 2016. Appendix 4, Figures 27 and 28 show the water levels for Lakes Manapōuri and Te Anau in more detail for the period 1 January 2021 to 12 January 2026 with the Operating Range band limits shown within the red and blue horizontal lines. Water levels have been provided by Meridian Energy Limited.

From Appendix 4, Figures 25 and 26 it can be seen that both Lakes Manapōuri and Te Anau follow a similar pattern of rising and falling related mainly to the inflow conditions. The pattern of change is similar to that of Lake Hauroko, indicating a consistent response to synoptic rainfall conditions for the Fiordland area.

The lake level on both lakes rose above the upper limit of managed operation under the Guidelines in October 2025 (Appendix 4, Figures 27 and 28). This episode is described in full by Single (2026) reporting on the event-driven assessment of the shoreline. There were no other occasions over the period January 2021 to January 2026 when the lake levels were

higher than the upper limit of managed operation under the Guidelines. The highest levels reached were on 25 October 2025 with Lake Ta Anau reaching 204.73 m and Lake Manapōuri reaching 180.81 m.

The Low Operating Range was entered on nine occasions for Lake Te Anau and on nine occasions for Lake Manapōuri during the inter-survey period. Between January and April 2022 Lakes Manapōuri and Te Anau were in the low operating range for a total of 48 and 66 days respectively (although not continuously). Between January and March 2025, the lakes were in the low operating range for 47 and 56 days respectively. The lowest level for Lake Te Anau in the intersurvey period was 201.075 m on 25 February 2025 and for Lake Manapōuri was 176.309 m on 4 April 2022.

Based on the 2026 shoreline examination and profile measurements, it is apparent that the high lake levels in 2025 had an effect on shore geomorphology at some sites that was outside of the range of changes seen since 1987. Locally adverse effects (backshore erosion) were limited to a small number of sites along the southern shore of Lake Te Anau and Frasers Beach on Lake Manapōuri. Most beach and nearshore sites exhibited change through movement of sediment across the profile, with much of this movement on the upper foreshore. Sediment was also deposited on the lower foreshore from offshore transport from higher on the beach but at some sites sediment had moved onshore from the nearshore shelf. There is no indication from the beach profile surveys and shore observations that the range of lake levels, including extended periods in the low operating range have had an adverse effect on the shore geomorphology except for those effects directly associated with high-energy waves during the high lake level event.

8. Discussion and Conclusions

Resurveying of beach profiles installed around Lakes Manapōuri and Te Anau has been carried out in accordance with consent conditions resulting from the use of these lakes for hydropower generation. Many of the profiles have data dating from 1973/74, while others were initiated in 1989 and 2003. For most sites there is a record of nearly 36 years of beach behaviour, with fifteen sites on Lake Manapōuri and eight sites on Lake Te Anau with a record of shore change dating back 53 years.

The 2026 monitoring shows minor to moderate changes in beach volume and geomorphological form on the surveyed beaches over the intersurvey period. The changes are generally limited to the mid- to upper foreshore and backshore and are a function of high-energy wave processes during the persistent high lake levels of late 2025. There are expected, albeit minor in magnitude, changes to the lower foreshore through deposition of sediment from alongshore, deeper on the nearshore shelf and from lakeward sediment transport from the mid-foreshore. This geomorphological work is related to inputs of sediment from streams and rivers and subsequent transport of sediment in the swash zone by wave and run-up processes, through onshore transport of sediment during periods when the lake was in the low operating range, and across-shore sorting of sediment sizes during the high lake level event.

The state of the lakeshore geomorphology at the time of the 2026 monitoring is consistent with changes that would occur with natural fluctuations of lake level and coincidence with changes in wave energy. The beaches of the two lakes remain dynamic and show expected responses to changes in the process environment and do not display any "signature" of effect of the controlled lake level range consequential to the Power Scheme operation.

The high water level event of late 2025 include some locally adverse effects, such as erosion of the backshore along Frasers Beach on Lake Manapōuri and adjacent to the Marakura Yacht Club on Lake Te Anau. These effects are to be expected during such an event and are not out of character with what would occur without the Power Scheme operation. This is discussed further in the high level event report. Changes that occurred to the upper and mid foreshore were similar to those observed and measured after the 2019 high level event and are likely to slowly adjust to a beach form and character consistent with the historical envelope of change.

Changes to the backshore will persist in the geomorphology until the next time that elevation of the shore is exposed to wave action. Similar event related effects are present in the backshore around the lakes, both predating and having occurred after the Power Scheme. Over time these effects become masked by vegetation growth, smaller natural events and human actions.

Minor changes were made to the benchmark positions at two sites in the survey network in 2026 to account for loss of the original (installed in 1973) benchmark waratah at site M3, and changes to the fenceline used as a benchmark at site T2. The new benchmark positions were reconciled with the old benchmark position through measurement to other unchanged features at the site and the level of the lake at the time of the survey. The network remains in a satisfactory state for long-term monitoring

Dr Single and Nick Key have carried out the shore monitoring of Lakes Te Anau and Manapōuri together since 2002. The experience on the lakes and familiarity with the sites leads to an efficient use of time in surveying and interpretation.

The monitoring methods used to date, accompanied by analysis of the historical data and photograph record provide for robust interpretation of inter-survey changes. However, this methodology also relies on the experience of the monitoring team in assessing the causes of measured and observed change. It is proposed that new surveying capabilities through drone based aerial imagery and Real-Time Kinematic positioning (RTK) or LiDAR are compared to the existing monitoring methodology to maintain the continuity going forward.

The next full survey is due to be undertaken in January 2031.

9. References

Kirk, R.M. 1988a *Beach Changes and Lake Level Operating Guidelines on Lakes Manapōuri and Te Anau, 1973-1988* Report to The Guardians of Lakes Manapōuri and Te Anau, and to Electricity Corporation of New Zealand Ltd., July 1988. 31pp

Kirk, R.M. 1988b *Lakes Manapōuri and Te Anau Beach Changes, February to August 1988 With Special Reference to Earthquake-Related Effects on and After June 4th* Report to The Guardians of Lakes Manapōuri and Te Anau and to Electricity Corporation of New Zealand Ltd., September 1988. 36pp

Kirk, R.M. 1989 *Shoreline erosion, Lower Waiau River (Pearl Harbour to Home Creek), Manapōuri* Report to the guardians of Lakes Manapōuri and Te Anau, and to Electricity Corporation of New Zealand Ltd., Dunedin, December 1989. 13 pp

Kirk, R.M. 1994 *Bank Erosion Monitoring Network, Pearl Harbour, Waiau River, Manapōuri* Report to The Guardians of Lakes Manapōuri, Monowai and Te Anau and to Electricity Corporation of New Zealand Ltd, Dunedin, and February 1994. 11pp

Kirk, R.M.; Single, M.B.; Allan, J.A.; Stephenson, W.; Smith, G.D. 1997 *Beach Changes on Lakes Manapōuri and Te Anau, and Cliff Erosion at Pearl Harbour, Manapōuri February 1989 – February 1997* Report to The Guardians of Lakes Manapōuri and Te Anau, and to Electricity Corporation of New Zealand Ltd., April 1997. 59 pp

Kirk, R.M.; Single, M.B.; Harrowfield, D.L.; McGown, A.C. 1989 *Beach Changes on Lakes Manapōuri and Te Anau, August 1988 To February 1989* Report to The Guardians of Lakes Manapōuri and Te Anau, and to Electricity Corporation of New Zealand Ltd., March 1989. 22 pp

Pickrill, R.A. 1976 T*he Lacustrine Geomorphology of Lakes Manapōuri and Te Anau* Unpublished Ph.D. Thesis, Department of Geography, University of Canterbury, Christchurch, New Zealand. 376pp

Single, M.B. 2010 *Manapōuri Tailrace Amended Discharge Project: Baseline assessment – Physical lakeshore and beach sediments* A report to Meridian Energy Ltd. June 2010. 9pp

Single, M.B.; Bunting, K.; Currie, J.; Key, N.; Kirk, R.M. 2002 *Beach Changes on Lakes Manapōuri and Te Anau, and Cliff Erosion at Pearl Harbour, Manapōuri February 1997 – June 2002* A report to Meridian Energy Ltd. and to The Guardians of Lakes Manapōuri and Te Anau. July 2002. 49 pp

Single, M.B.; Key, N.; Clay, T.; Kirk, R.M. 2006 *Beach Changes on Lakes Manapōuri and Te Anau, and Cliff Erosion at Pearl Harbour, Manapōuri, June 2002 – October 2006* A report to Meridian Energy Ltd. and to The Guardians of Lakes Manapōuri and Te Anau. December 2006. 25 pp

Single, M.B. 2011 *Beach Changes on Lakes Manapōuri and Te Anau October 2006 – January 2011* A report to Meridian Energy Ltd. and to The Guardians of Lakes Manapōuri and Te Anau. June 2011. 26 pp plus figures

Single, M.B. 2012 *Meridian Energy Limited Manapōuri HEP: Lakes Manapōuri and Te Anau shoreline inspection – December 2012* A report to Meridian Energy Ltd. December 2012. 12pp

Single, M.B. 2013 *Meridian Energy Limited Manapōuri HEP: Lakes Manapōuri and Te Anau low water level shoreline inspection – March 2013* A report to Meridian Energy Ltd. April 2013. 11pp

Single, M.B. 2014 *Meridian Energy Limited Manapōuri HEP: Lakes Manapōuri and Te Anau annual shoreline inspection – February 2014* A report to Meridian Energy Ltd. June 2014. 15pp

Single, M.B. 2015 *Meridian Energy Limited Manapōuri HEP: Lakes Manapōuri and Te Anau annual shoreline inspection – January 2015* A report to Meridian Energy Ltd. February 2015. 16pp

Single, M.B. 2016 *Meridian Energy Limited Manapōuri HEP: Lakes Manapōuri and Te Anau annual shoreline inspection – January 2016* A report to Meridian Energy Ltd. June 2016. 17pp

Single, M.B. 2016 *Beach Changes on Lakes Manapōuri and Te Anau January 2011 – January 2016* A report to Meridian Energy Ltd. and to The Guardians of Lakes Manapōuri and Te Anau. June 2016. 28 pp plus figures

Single, M.B. 2020 *Meridian Energy Limited Manapōuri HEP: Lakes Manapōuri and Te Anau high water level event shoreline inspection and survey – March 2020* A report to Meridian Energy Ltd. April 2020. 55pp

Single, M.B. 2021 *Beach Changes on Lakes Manapōuri and Te Anau January 2016 – January 2021* A report to Meridian Energy Ltd February 2021. 62 pp

Single, M.B. 2026 *Manapōuri Power Scheme: October-November 2025 high lake levels on Lakes Manapōuri and Te Anau and effects on lakeshore geomorphology* A report to Meridian Energy Ltd. (In Prep)

10. Appendix 1

Locations of beach profiles on Lake Manapouri



GPS locations of Lake Manapouri benchmarks

PROFILE	Latitude, Longitude	Northings & Eastings
M1	167°34’04”E 45°32’20”S	5504946.214 2085951.819
M2	167°34'27"E, 45°33'02"S,	5503678.950 2086533.788
M3	167°32'19"E, 45°32'35"S,	5504337.991 2083699.459
M4	167°33'32"E, 45°33'42"S,	5502364.232 2085408.607
M5	167°32'38"E, 45°34'25"S,	5500962.586 2084329.070
M6	167°29'34"E, 45°32'43"S,	5503863.033 2080149.984
M7	167°21'53"E, 45°30'30 "S	5507255.021 2069884.125
M8	167°30'30"E, 45°28'35"S,	5511580.659 2080843.742
M9	167°31'19"E, 45°28'55"S,	5511019.778 2081956.236
M17	167°36'34"E, 45°28'55"S,	
M10	167°36'15"E, 45°30'14"S,	5509014.119 2088529.061
M11	167°36'15"E, 45°30'28"S,	5508584.356 2088550.895
M12	167°36'06"E, 45°30'42"S,	5508152.480 2088385.983
M13	167°37'21"E, 45°33'21"S,	5503350.852 2090331.523
M16	167°37'14"E, 45°33'23"S,	
M14	167°37'02"E, 45°33'37"S,	5502821.904 2089953.104
M15	167°36'40"E, 45°33'53"S,	5502307.412 2089514.851

Profile location notes

M1 Sandy Beach: Profile is in centre of beach with waratah about 1m lakeward of large beech tree.

M2 Circle Cove: Profile is in centre of beach above vegetation line.

M3 Bullings Beach: Four waratahs are spaced along the edge of the vegetation. The southernmost is labelled 3a and is on the edge of a rocky outcrop. The profile runs in a line perpendicular to the line between waratahs 3b and 3d at a distance of 10.34 m from 3b and 10.1 m from 3d. Benchmark is top of rock (see photograph below, 2.5 m landward of 0.5 m high scarp.

M4 George Bay: Profile is in the centre of the western beach in George Bay, directly in front of a cluster of Manuka at the edge of the vegetation.

M5 Monument Bay: Profile is to the left of centre of the western beach in Monument Bay, near the highest storm berm.

M6 Stockyard Cove: Profile is approximately 50m south of picnic tables, south of a large tree trunk lying down the beach. Old waratah is adjacent to the trunk and amongst the vegetation. New waratah is 1.6m south of and 2m lakeward of the old one.

M7 Fairy Beach: Waratah for profile is labelled 7b and is 50m west of the westernmost boulder spur about 150m east of western end of beach. Waratah 7a is 45m east of easternmost boulder spur, 3m lakeward of beech trees beside mahoe. Waratah 7c is at western end of the beach where the vegetation curves back up a river valley. Waratah is next to a fallen tree, but only the trunk is left, so waratah is easily seen.

M8 Calm Bay Head: Waratah is towards the northern end of the beach about 25m south of stream mouth, and on the barrier beach about 1m lakeward of lagoon. Waratah sits lakeward of woody coprosma.

M9 Calm Bay Entrance: Waratah is at an elevation of about 178m and about 2 m lakeward of scarp at vegetation edge.

M17 Moturau Hut: Benchmark is wooden post west of the track down to beach from the hut.

M10 Ruby Bay North: Waratah is approximately 100m from the north end of the bay at the vegetation edge. New waratah is 2.5m shoreward of highest berm and old waratah.

M11 Ruby Bay Centre: Profile is approximately 500m south of M10, and 25m south of lone kowhai tree. Waratah is near vegetation edge.

M12 Ruby Bay South: Profile is approximately 470m south of M11 (further than you think). Waratah is amongst vegetation but on an erosion scarp, and on southern section of boulder fan.

M13 Fraser's Beach North: Profile is approximately 60m north of the end of vehicle track and picnic area, and north of small stream with large rocks in bed. Waratah is in centre of small stream (found in 2010 high water level inspection, but not since) amongst vegetation, turf and ground water springs and streams.

M16 Fraser's Beach Picnic Table: Benchmark is the northern lakeward corner of concrete base of northernmost picnic table.

M14a Fraser's Beach Centre: Profile is 40m south of track down to beach from road below Manapouri Motor Inn. Waratah is behind tussock and turf near large boulders. Profile runs perpendicular to lakeshore, and through remains of old waratah near reeds (edge of vegetation).

M15 Fraser's Beach South: Profile is at south end of beach below where the road turns and levels out behind the beach. Benchmark is waratah next to large rock in vegetation 1m landward of scarp amongst tree roots.



New Benchmark at Bullins Beach (M3)



Most of fallen tree has gone at Fairy Beach (M7)

11. Appendix 2

Locations of beach profiles on Lake Te Anau



GPS locations of Lake Te Anau benchmarks

PROFILE	Latitude, Longitude	Northings & Eastings
T23	167°44'27"E, 45°23'71"S,	5521579 2098917
T24	167°43'59"E, 45°23'42"S,	No new GPS reading
T1	167°43'12"E, 45°23'56"S,	5521265.905 2096811.719
T2	167°42'43"E, 45°24'14"S,	5520654.289 2096211.249
T3	167°42'17"E, 45°24'36"S,	5519955.535 2095695.729
T4	167°42'16"E, 45°24'43"S,	5519724.536 2095687.745
T5	167°42'24"E, 45°24'47"S,	5519618.317 2095870.290
T19	167°42'47"E, 45°24'86"S,	5519274 2095964
T6	167°42'50"E, 45°25'17"S,	5518729.000 2096487.113
T7	167°42'59"E, 45°25'40"S,	5518041.809 2096735.168
T20	167°42'40"E, 45°26'27"S,	5516697 2096049
T21	167°41'34"E, 45°26'51"S,	5516170 2094696
T8	167°41'03"E, 45°26'27"S,	5516434.616 2094303.211
T9	167°41'07"E, 45°25'41"S,	5517855.590 2094299.823
T10	167°40'17"E, 45°24'13"S,	5520469.873 2093048.299
T11	167°38'13"E, 45°21'53"S,	5524618.225 2090060.444
T12	167°37'55"E, 45°21'53"S,	5524587.534 2089675.379
T13	167°42'08"E, 45°20'07"S,	No GPS reading taken See notes
T14	167°43'25"E, 45°19'59"S,	5528571.013 2096607.944
T15	167°43'26"E, 45°19'58"S,	5528595.185 2096639.557
T16	167°43'48"E, 45°18'41"S,	5531012.282 2096955.393
T17	167°45'08"E, 45°21'04"S,	5526724.397 2098979.722
T18	167°45'16"E, 45°22'21"S,	5524340.159 2099306.625
T22	167°44'84"E, 45°23'74"S,	5521648 2099141

Profile location notes

T23 Upukerora River Mouth: Waratah is covered by gravel but east of the river mouth at end of track down from subdivision. New benchmark is corner top of fencepost of northernmost fence (about 112 m from top of beach). Has a plastic triangular tag with number 211932 on it.

T24 West Upukerora River: New benchmark is top of wooden fence post at lakeward end of 3rd fenceline west of Upukerora R mouth, by pond and east of walkway from end of Kaipo Drive. Old benchmark lost when track was remodelled.

T1 Fence and Gates: North of Rodeo marshalling yards, waratah (bent) is near two gates with fence separating two paddocks, about 60 m east of seating area at lakeward end of track from corner of South Arm Drive.

T2 Rodeo: Benchmark is centre of the top of strainer fence-post beside large willow tree between two gates.

T3 Marina West: Waratah was towards swamp grasses on Marina side of road opposite three poplar trees on the lakeward side of the road but was buried by marina landscaping. New benchmark installed in 2020 is base of fencepost at corner of fence north of enlarged marina. Now only two poplars on foreshore.

T4 Marina South: Benchmark is on the lakeward base of large tree-stump at the start of parking area. New benchmark is central crack in concrete marina edge (see photo below), with secondary survey point beside eyebolt in base of tree stump.

T5 No Entry Slipway: Benchmark was northern concrete gatepost of house #162. Profile runs to the north of Kowhai tree at beach scarp. Profile label was at base of post. Post removed in landscaping, so new benchmark is top of concrete kerb on lakeward side of road.

T19 South of Matai Street: Benchmark was a steel shackle on a concreted drain cover, about 40m lakeward of lamppost on western side of road. Drain cover removed when new footpath constructed. New benchmark is base of lamppost 40 m south of Matai St on landward side of road.

T6 Float Plane Landing: Benchmark is lakeward side of base of concrete marker with 'Live Cables Underground' on face, opposite Mokoroa Street just south of drainage water outlet.

T7 Steamer Beach: Waratah was in a group of poplar trees lakeward of single cabbage tree. Trees removed by 2015. New benchmark is "virtual" and in line with old BM. Position is 2.2 m west of stake landward of kowhai tree that is nearly in line with road sign on Motel side of main road at eastern end of new motel block. See photo below.

T20 Picnic Area: Waratah is at base of pair of large gum trees.

T21 East of Control Gates: Waratah is in grass landward of beach. A second waratah is located near the limit of wave run-up and about 9.6m from the first waratah.

T8 Dock Bay: Waratah is in grass approximately 30m west of track that runs down to the beach from the Kepler Track sign.

T9 Ski-lane Beach: Marker is a wooden pole lakeward of large double-trunk beech tree, that is the second large beech tree west of Ski-lane Point.

T10 Brod Bay: Profile is in the centre of the bay. New benchmark is northeast corner of concrete pad with concrete picnic table on it. Line runs approximately 2 m west of ski-lane poles. Second survey point taken in line with landward-most ski-lane pole.

T11 Garnet East: Waratah is amongst vegetation north of stream. A second waratah is sited 3m further into the bush up a steep slope.

T12 Garnet West: Waratah is 1m lakeward of tree fern in centre of the beach.

T13 Moonlight Beach Mark Point: Waratah is located east of stream, in vegetation near large beech trees approximately 25m west of easternmost bar-be-que area.

T14 Trig B South (Garden Point): Benchmark was top of western post of Department of Conservation sign. Sign now removed as no longer DoC serviced area. Old waratah (from 1973, with only 0.15m exposed) is located about 4 m into bush, east of old track to unused camping/toilet area.

T15 Trig B East (Garden Point): Waratah is at the base of a lancewood tree, 2m north of blank sign at limit of vegetation. Profile runs south of two manuka close together to the north.

T16 Deadman's Point: Waratah is 3m lakeward of old bent waratah 30m west of point.

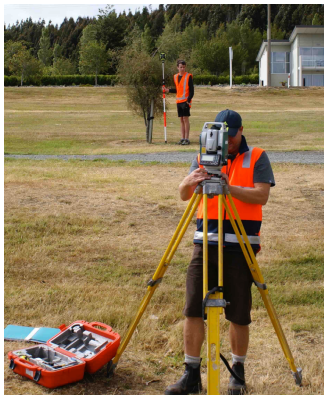
T17 North Patience Bay: Waratah is 50m south of eroded scarp of an exposed point opposite to South Arm and is on the lakeward edge of a low terrace. Waratah is bent at the base.

T18 East Patience Bay: Benchmark is southern, lakeward base of large rock with two long quartz veins showing as stripes, at the edge of the vegetation. A waratah is sitting at the back of the rock.

T22 East Upukerora River: Waratah is near the end of the gravel prograding beach, before the start of vegetation down to the lake edge. One waratah is near the crest of the beach berm, with second waratah about 8.5 m landward, and in overwash driftwood, near large rock. Lakeward waratah may be buried.

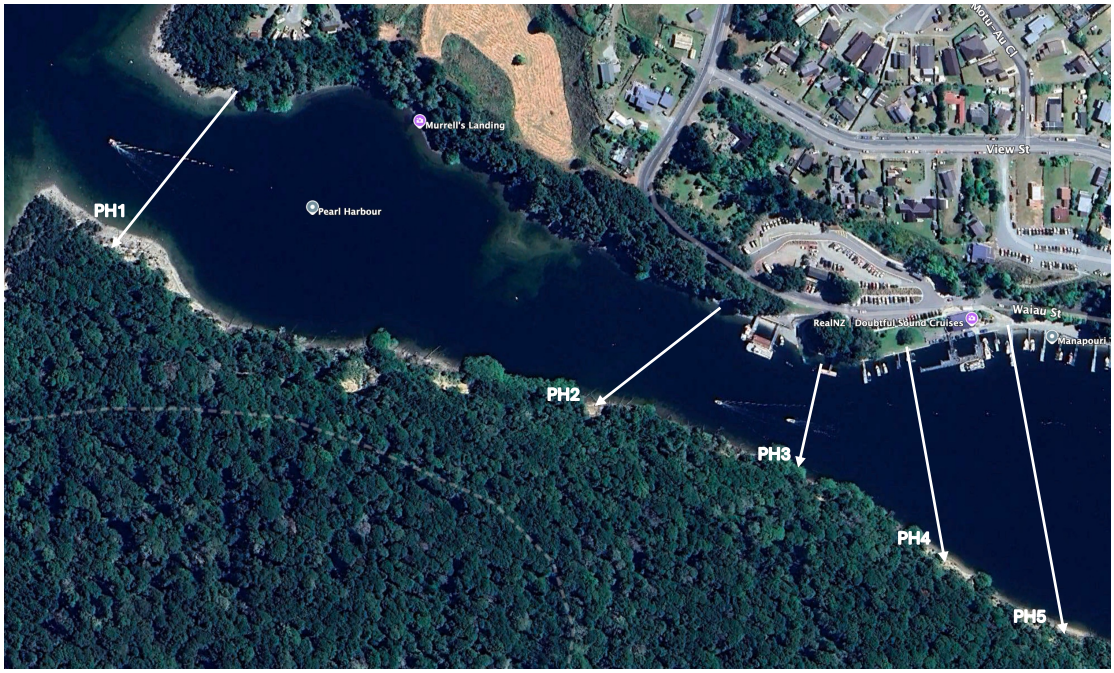


Marina (T4) Benchmark position



Steamer Beach (T7)

12. Appendix 3
Profile location notes for sites at Pearl Harbour



PH1 The Glade: Site is on the true right bank of the Waiau River near the outflow from Lake Manapouri, opposite "The Glade", a sign-posted area on the true left bank of the Waiau River. The marker is a steel waratah located in thick forest above a bare, overhanging cliff face in sands and coarse gravels, about 10 m inland from the cliff edge in 1994.

Total Station set up lakeward of high back-beach scarp and about 7.6 m from short wooden poles (the one without signage).

PH2 Kiosk: This site is opposite, but upstream of the small kiosk near the boat ramp and Meridian boat mooring. The marker is a steel waratah located about 8 m inland from the cliff edge in 1994.

Total Station is set up in line with upstream, lakeward corner of kiosk and about 1.9 to 2 m from building (and about 2 m from corner of wooden edge of retaining wall. Set up high enough to see over the fence constructed in 2020 (probably 0.2 to 0.3 m higher than in the past.

PH3 Boat Ramp: This site is opposite, but slightly downstream of the boat ramp (slipway). The marker is about 30 m downstream of a signpost for a walking track on the southern bank, and about 16 m from the cliff edge in 1994.

Total Station is set up on grass lakeward and in line with southern wall of toilet block, about 3.3 m landward of lakeward edge of gabion basket.

PH4 Kowhai: The site is opposite a kowhai tree that is sited about 20 m upstream of the Real Journeys terminal building and wharves. The marker is approximately 18 m inland from the cliff edge in 1994.

Total Station is set up on the line between the kowhai tree and the gabion wall, 6 m landward of lakeward edge of gabion basket.

PH5 Real Journeys: This site is opposite the downstream end of the Real Journeys terminal building and wharves. The marker is upstream of the track from the waters edge to the walking track, and about 12 m inland from the cliff edge in 1994.

Total Station is set up 1 m downstream of "Adventure Manapouri "sign and 3.3 m landward of wharf edge.

Sites in 2006 and 2026

Water level 178.66 m and 177.76 respectively. White dot is prism position above marker in 2006 photographs



PH1 2006 and 2026



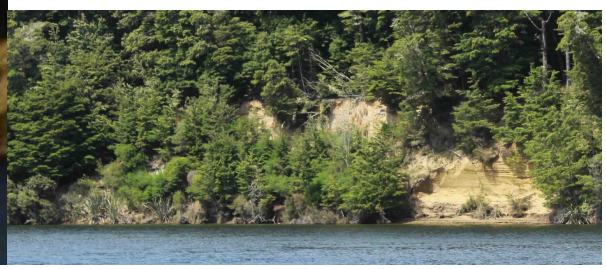
PH2 2006 and 2026



PH3 2006 and 2026




PH4 2006 and 2026

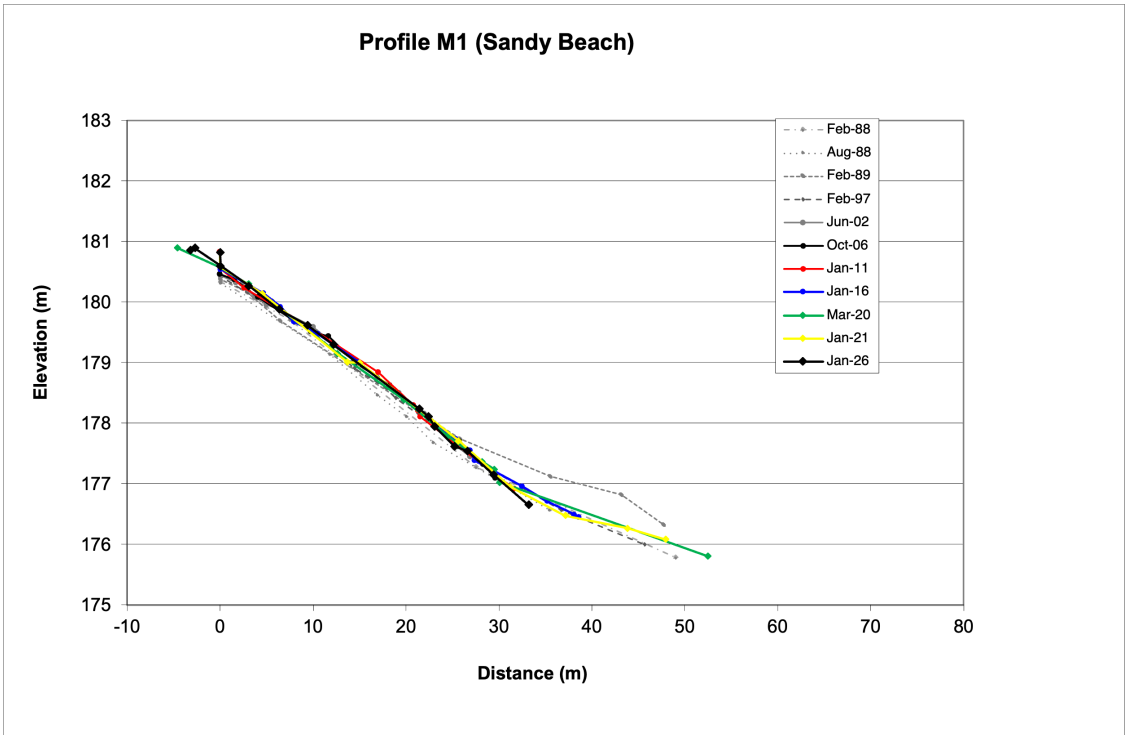



PH5 2006 and 2026

13. Appendix 4

Beach profile plots of shoreline monitoring sites

Note: Vertical lines on the plotted profile indicate the position and height of the site benchmark (often a steel waratah stake)



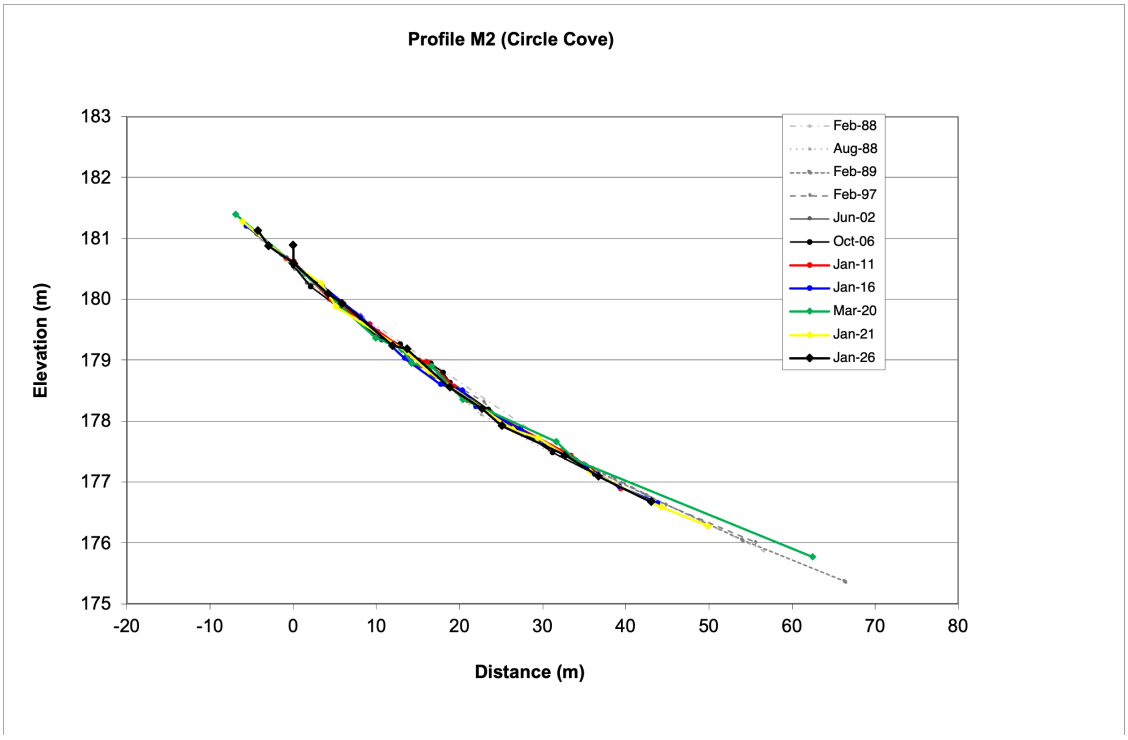
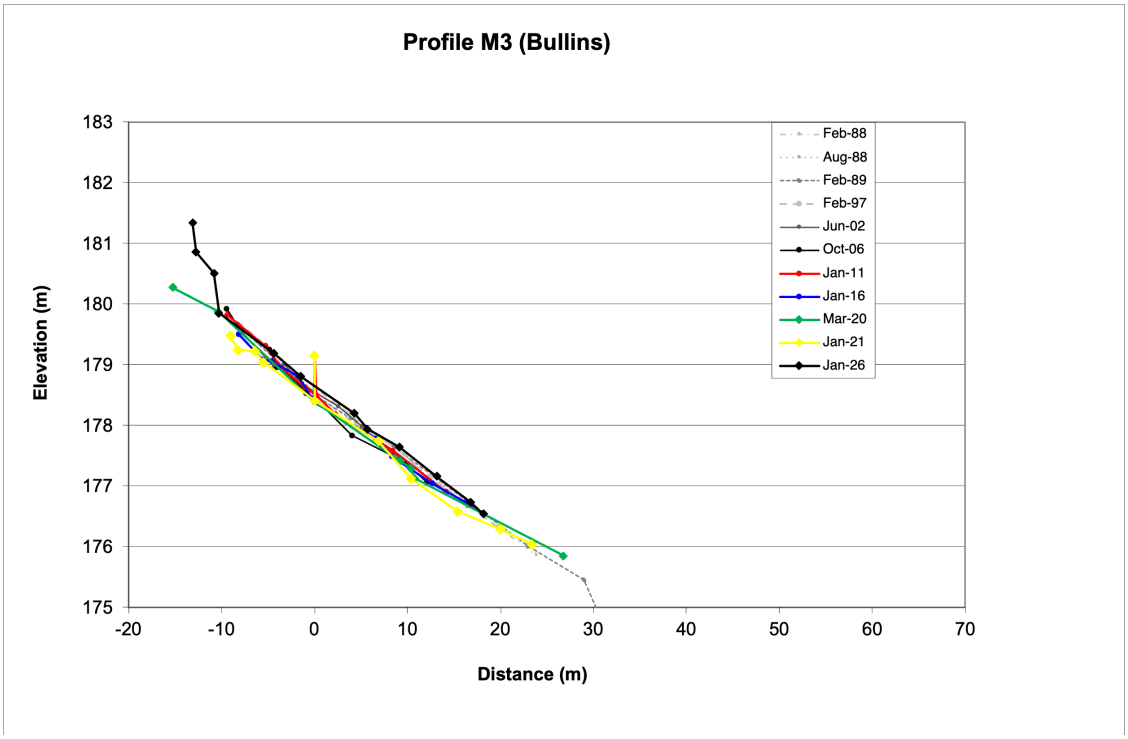


Figure 1.

A. Overlay plot of Beach profile surveys for M1, Sandy Beach, Lake Manapouri.

B. Overlay plot of Beach profile surveys for M2, Circle Cove, Lake Manapouri.



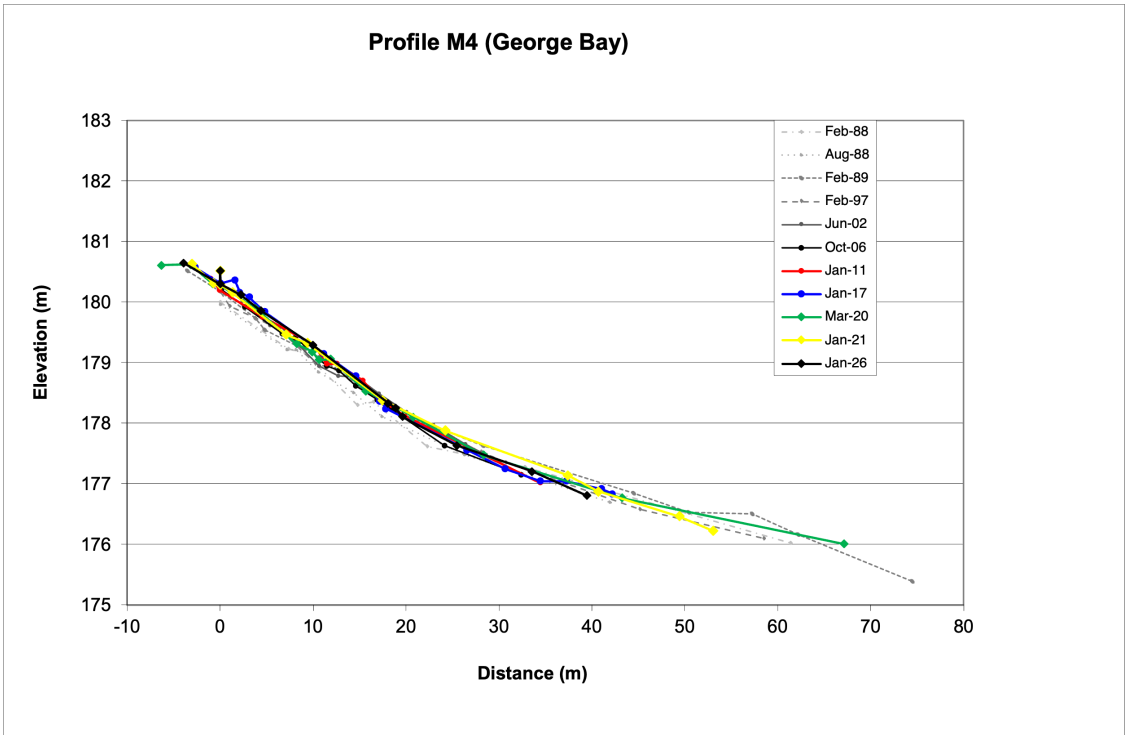
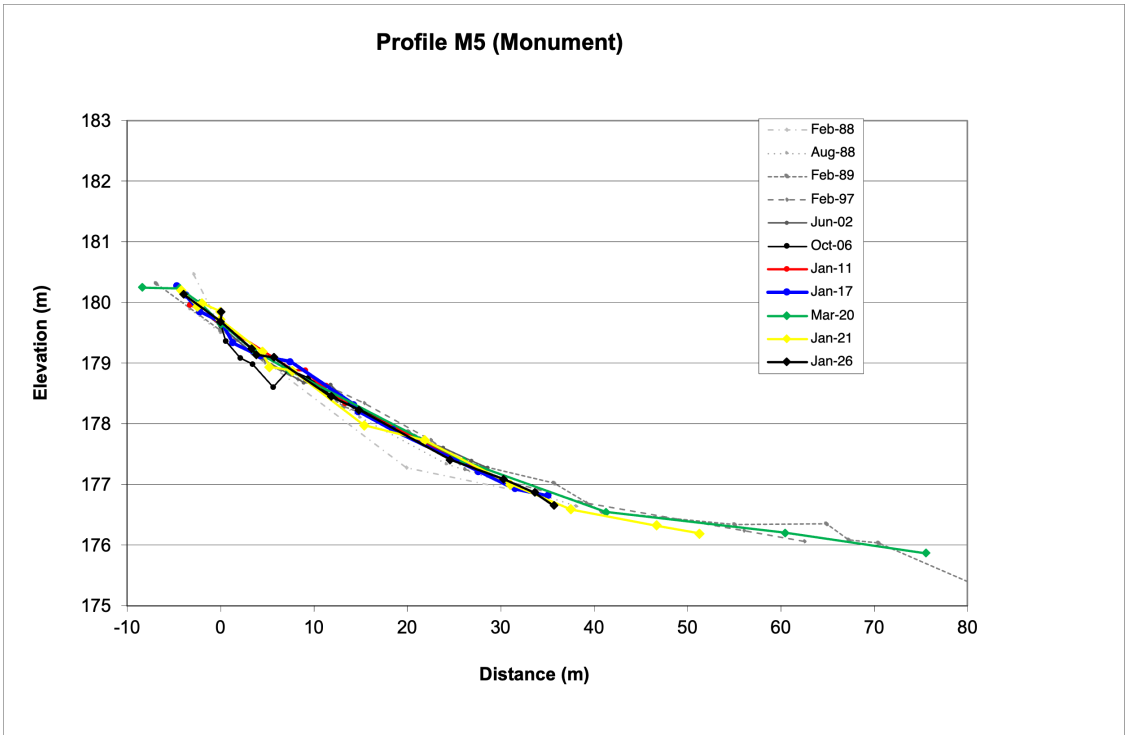


Figure 2. **A.** Overlay plot of Beach profile surveys for M3, Bullings Beach, Lake Manapouri.

B. Overlay plot of Beach profile surveys for M4, George Bay, Lake Manapouri.



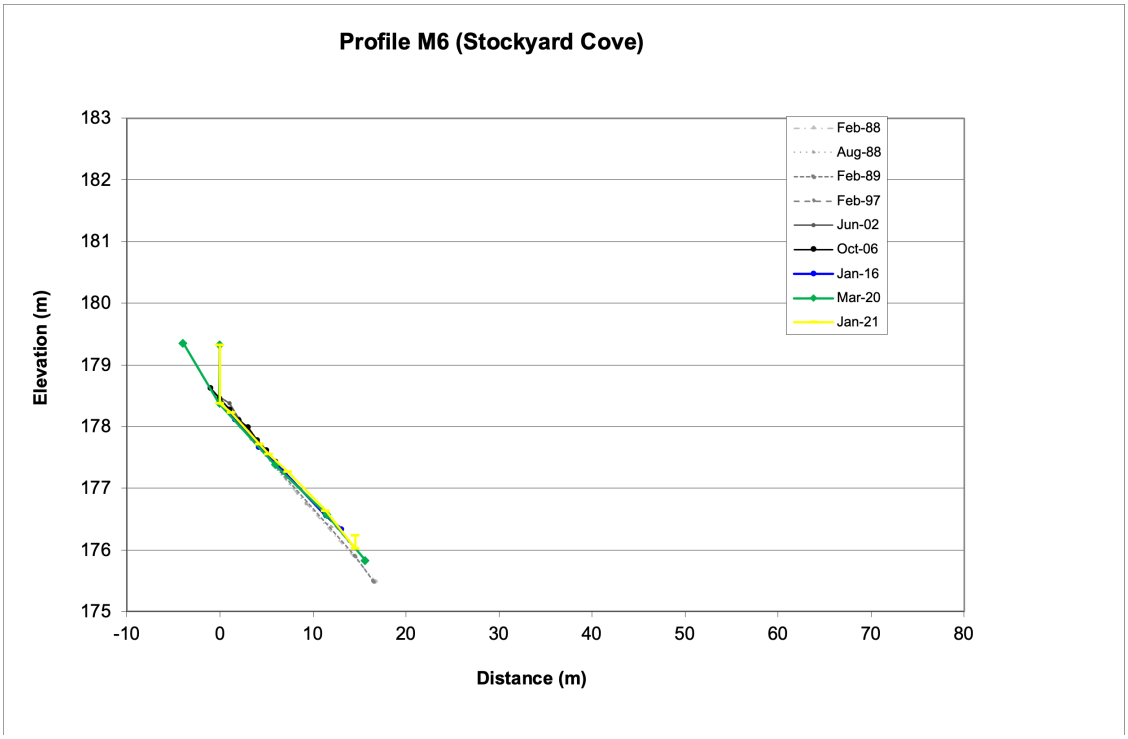
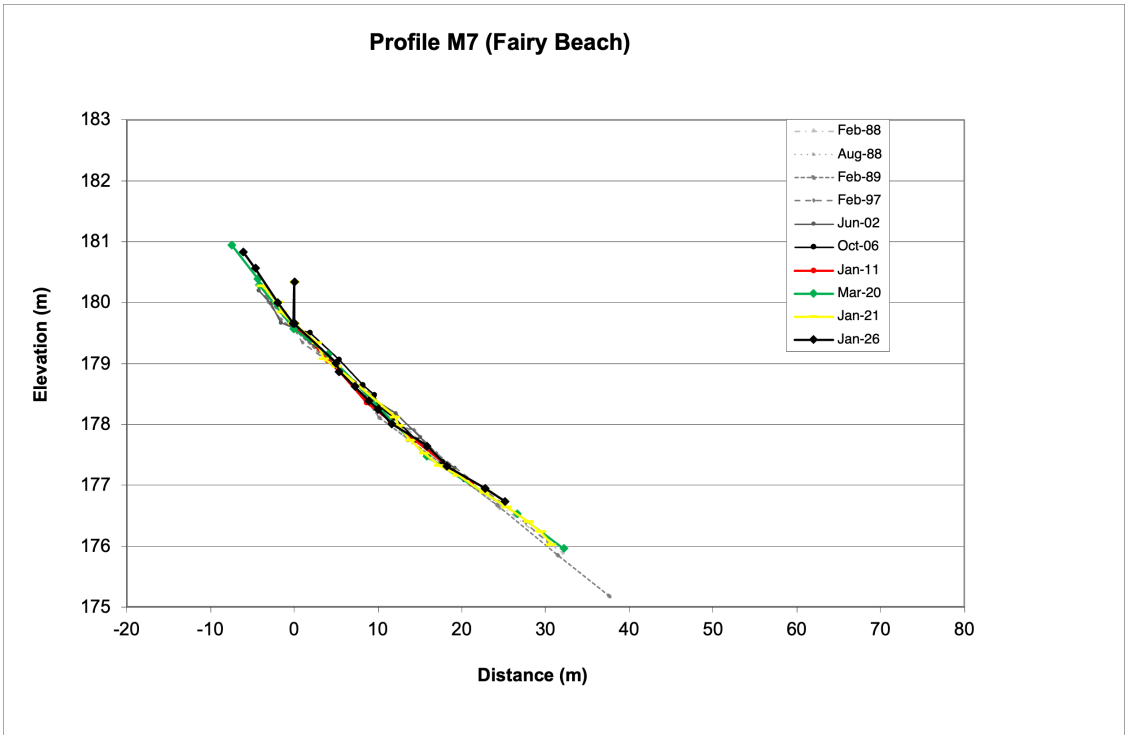


Figure 3. **A.** Overlay plot of Beach profile surveys for M5, Monument Beach, Lake Manapouri.

B. Overlay plot of Beach profile surveys for M6, Stockyard Cove, Lake Manapouri.



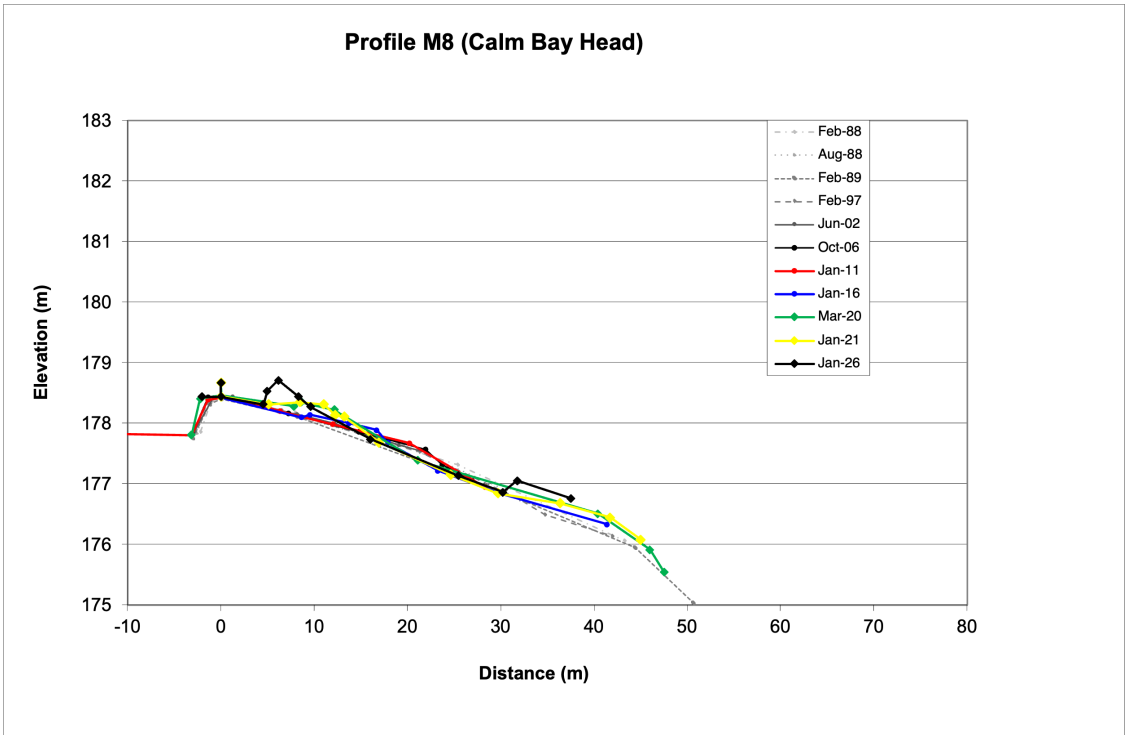
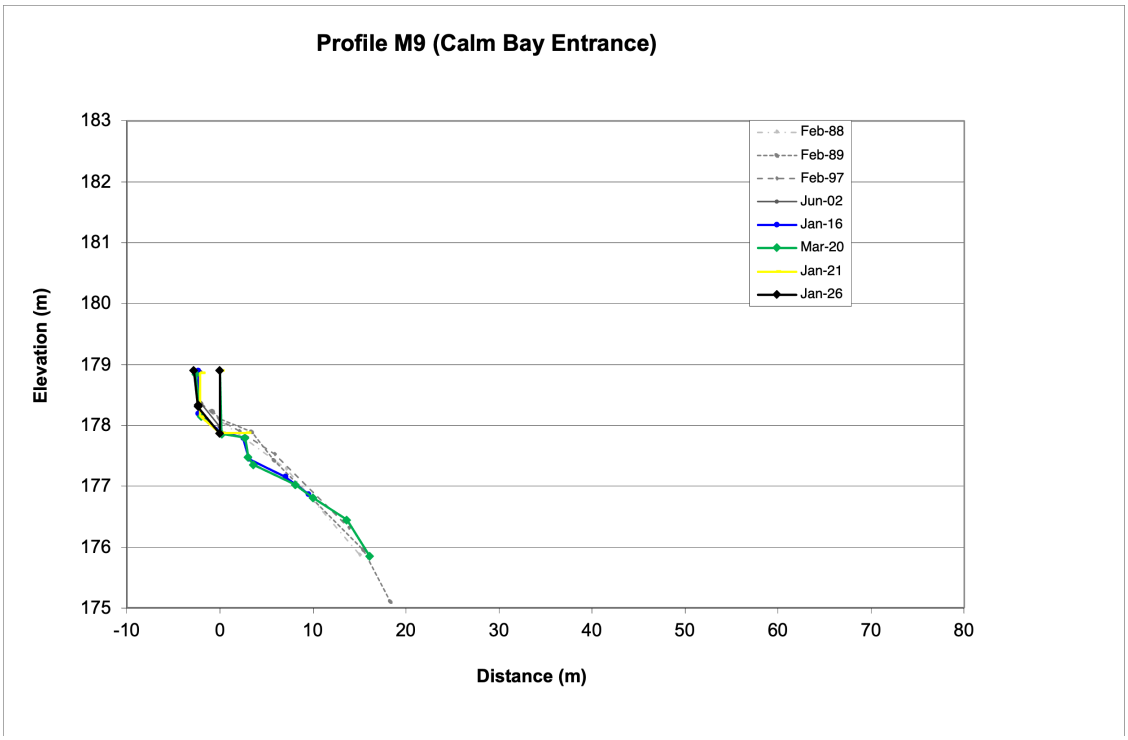


Figure 4. **A.** Overlay plot of Beach profile surveys for M7, Fairy Beach, Lake Manapouri.

B. Overlay plot of Beach profile surveys for M8, Calm Bay (head)Beach, Lake Manapouri.



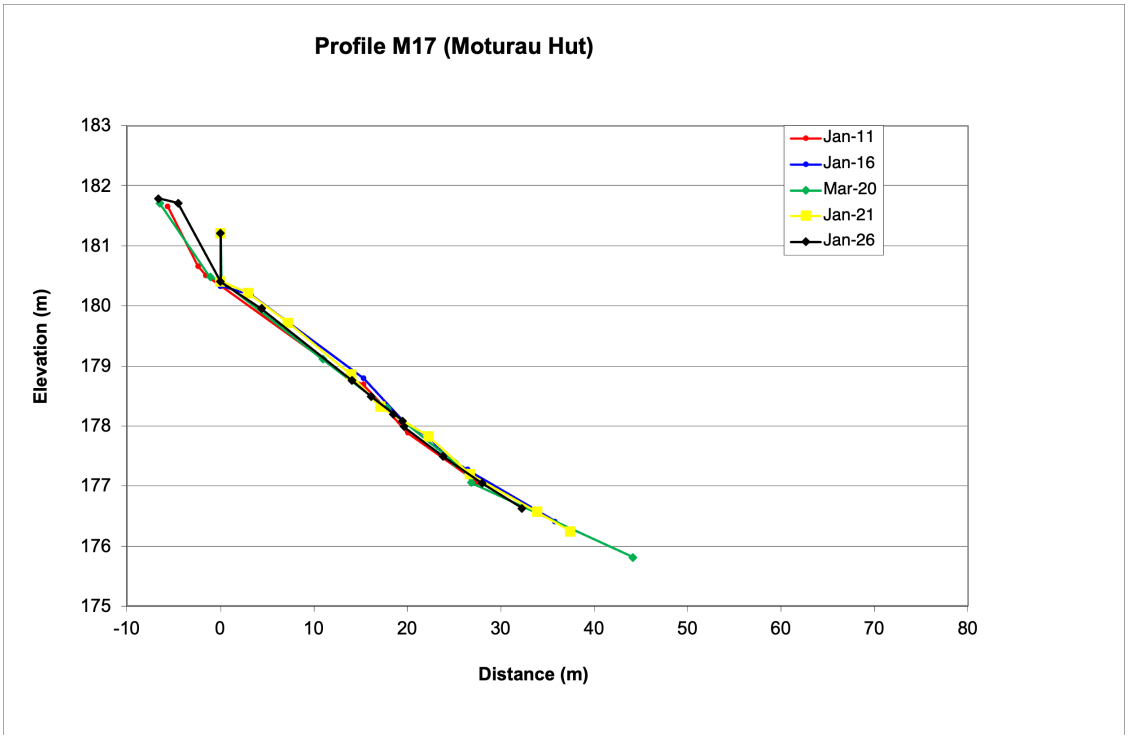
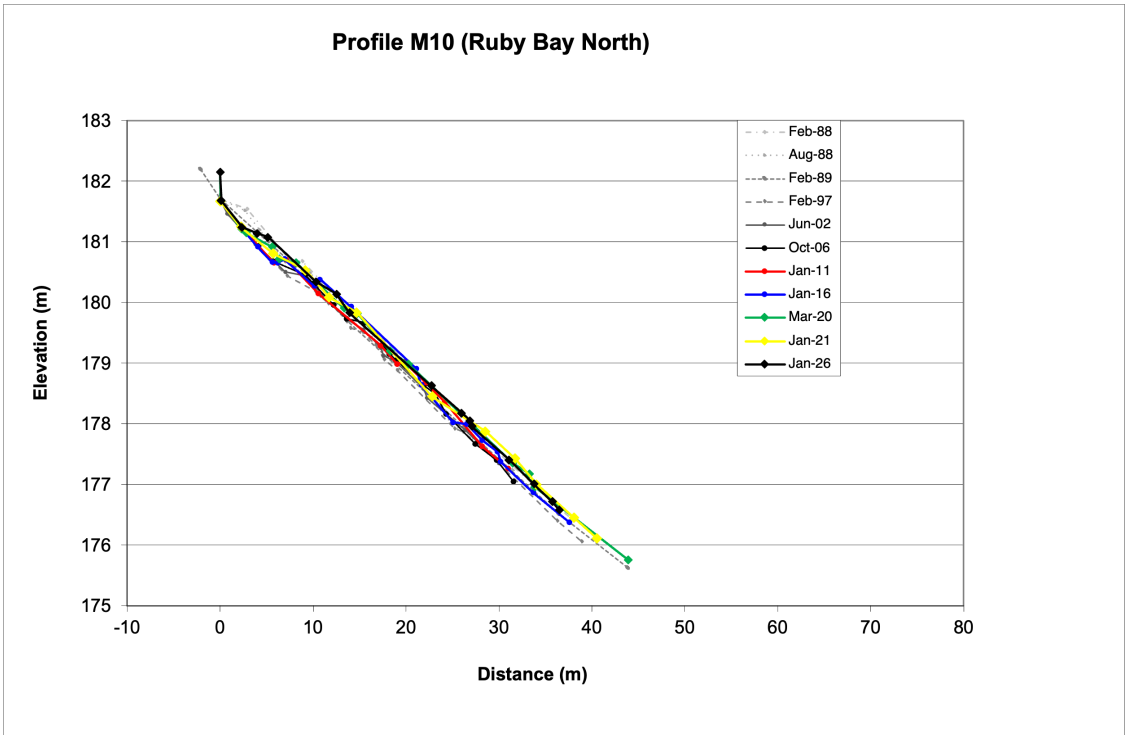


Figure 5. **A.** Overlay plot of Beach profile surveys for M9, Calm Bay (East Entrance) Beach, Lake Manapouri.

B. Overlay plot of Beach profile surveys for M17, Moturau Hut, Lake Manapouri.



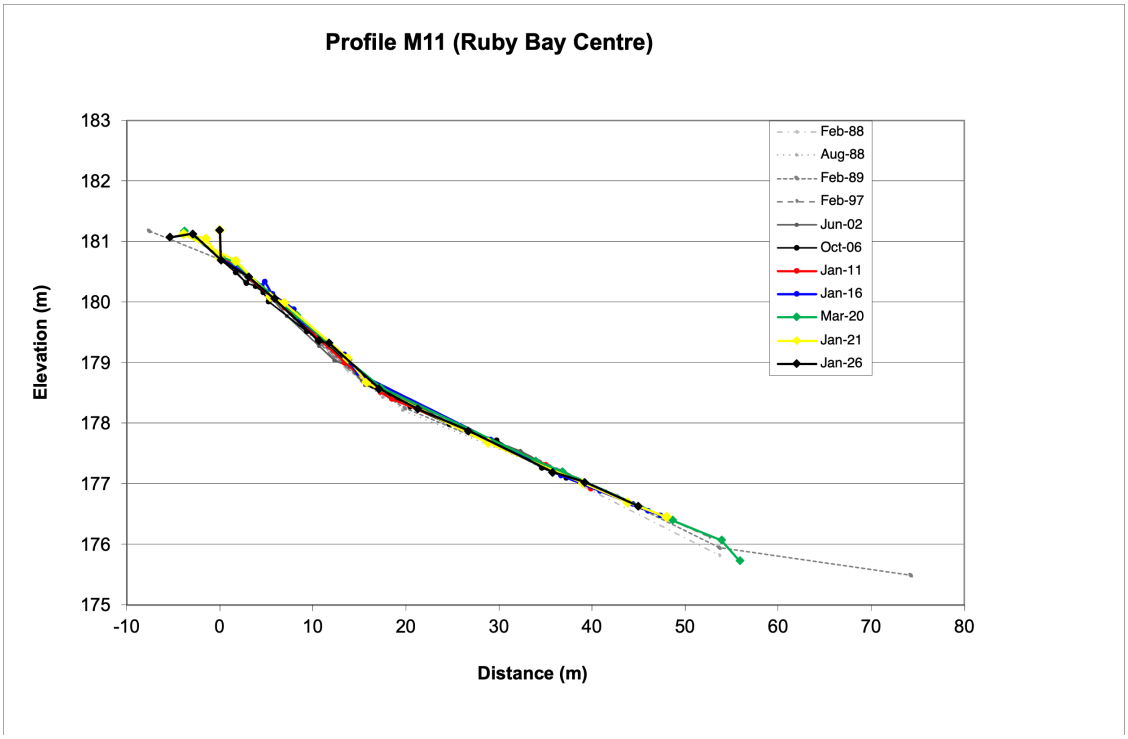


Figure 6. **A.** Overlay plot of Beach profile surveys for M10, Ruby Bay (north) Beach, Lake Manapouri.

B. Overlay plot of Beach profile surveys for M11, Ruby Bay (centre) Beach, Lake Manapouri.

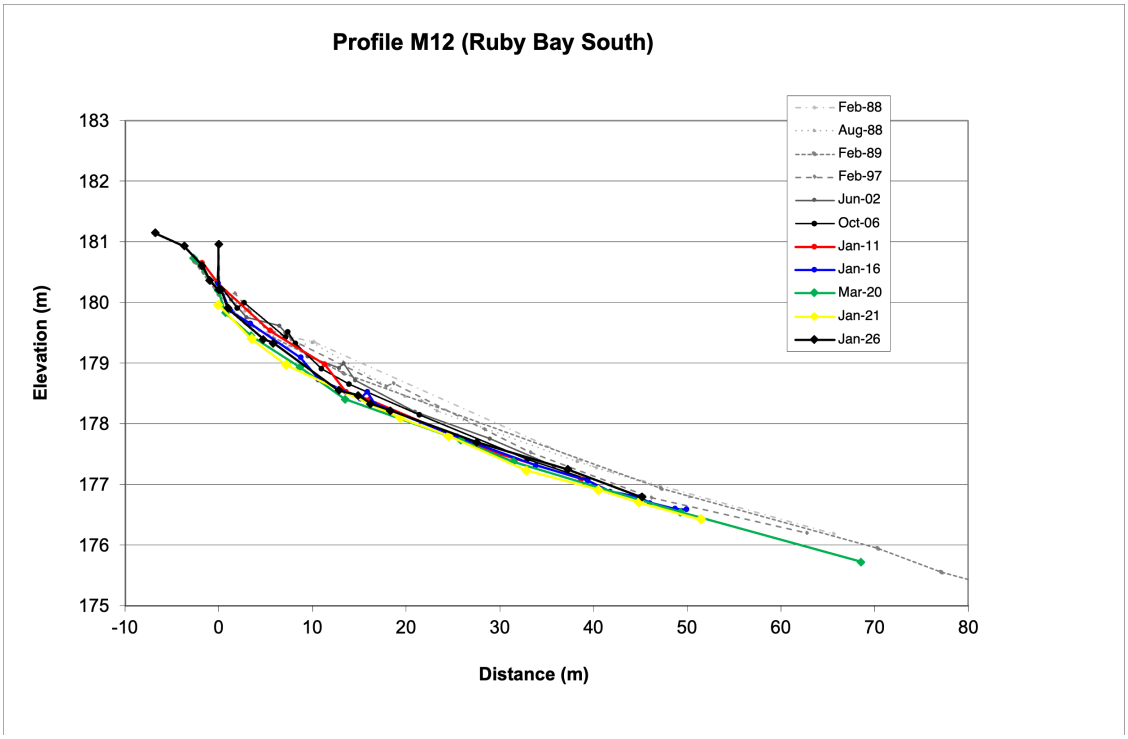
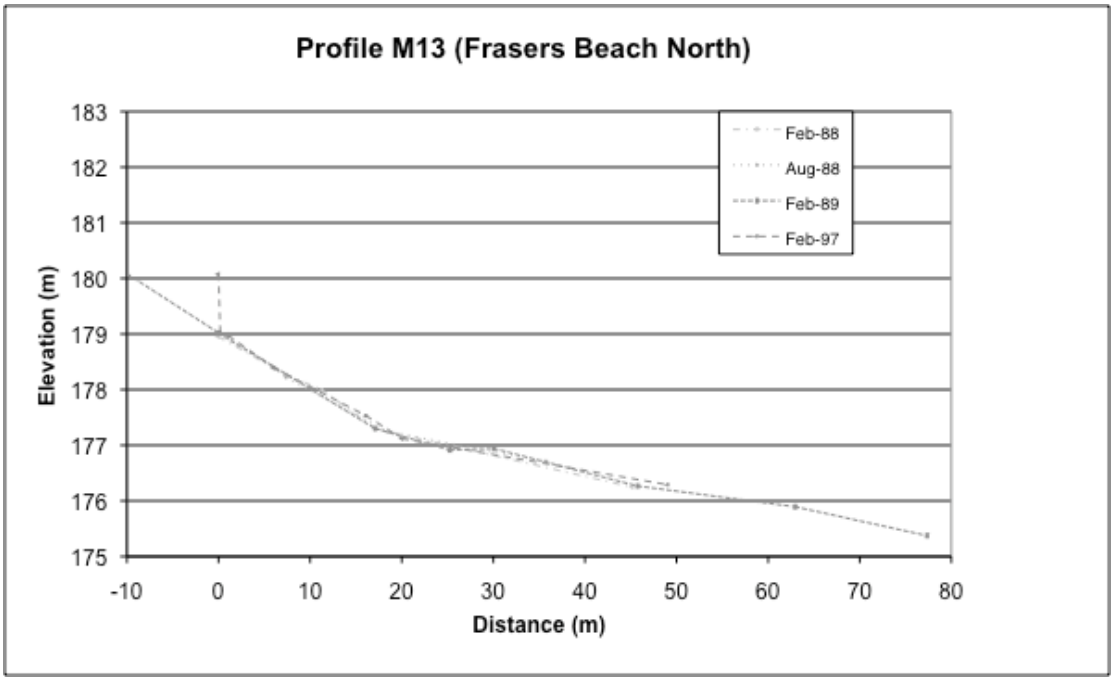


Figure 6. **C.** Overlay plot of Beach profile surveys for M12, Ruby Bay (South) Beach, Lake Manapouri.



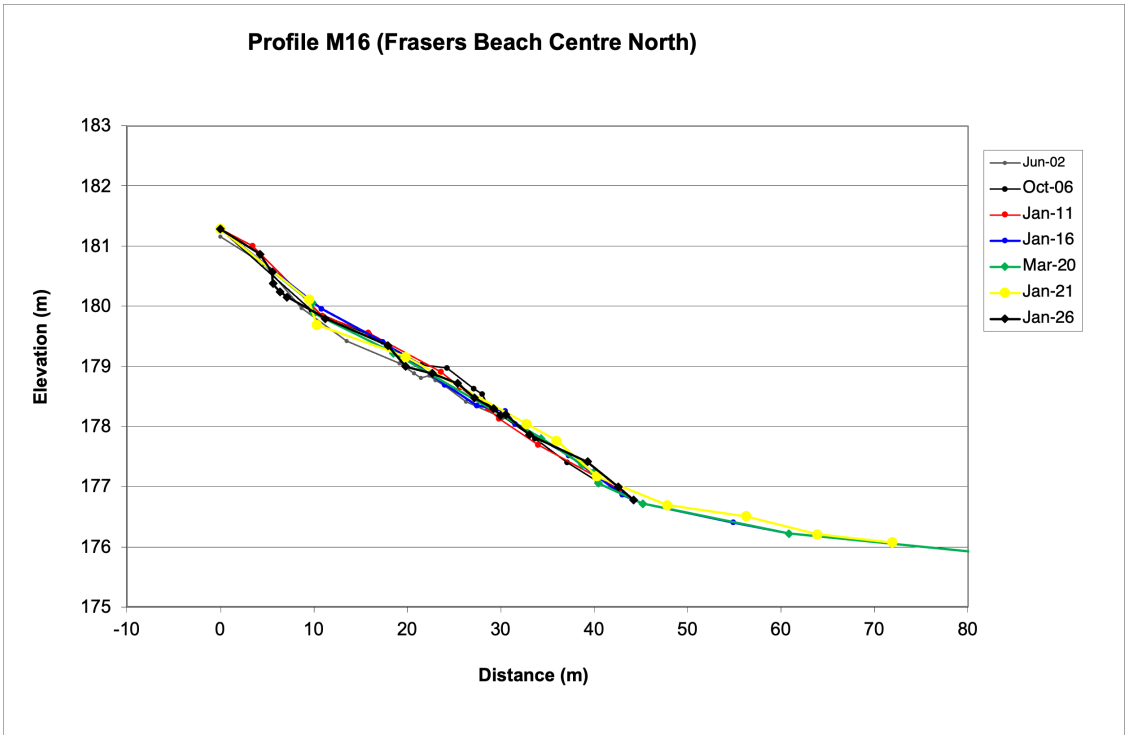
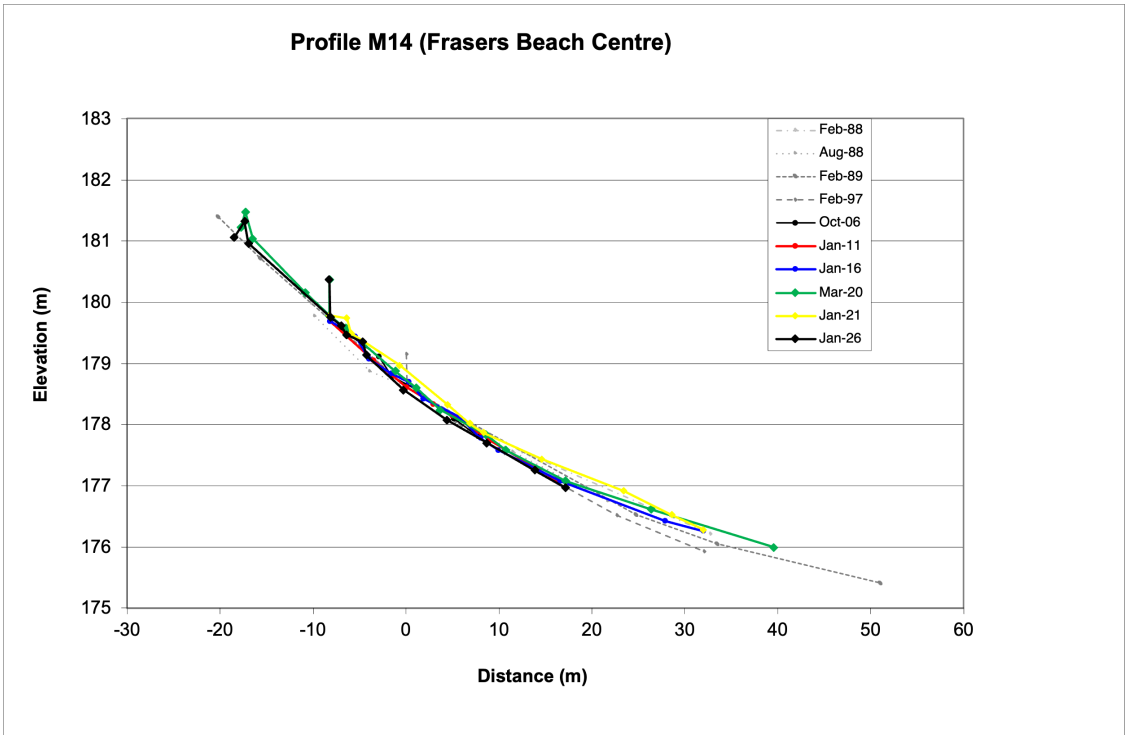


Figure 7. **A.** Overlay plot of Beach profile surveys for M13, Frasers Beach (north), Lake Manapouri.

B. Overlay plot of Beach profile surveys for M16, Frasers Beach (centre north), Lake Manapouri.



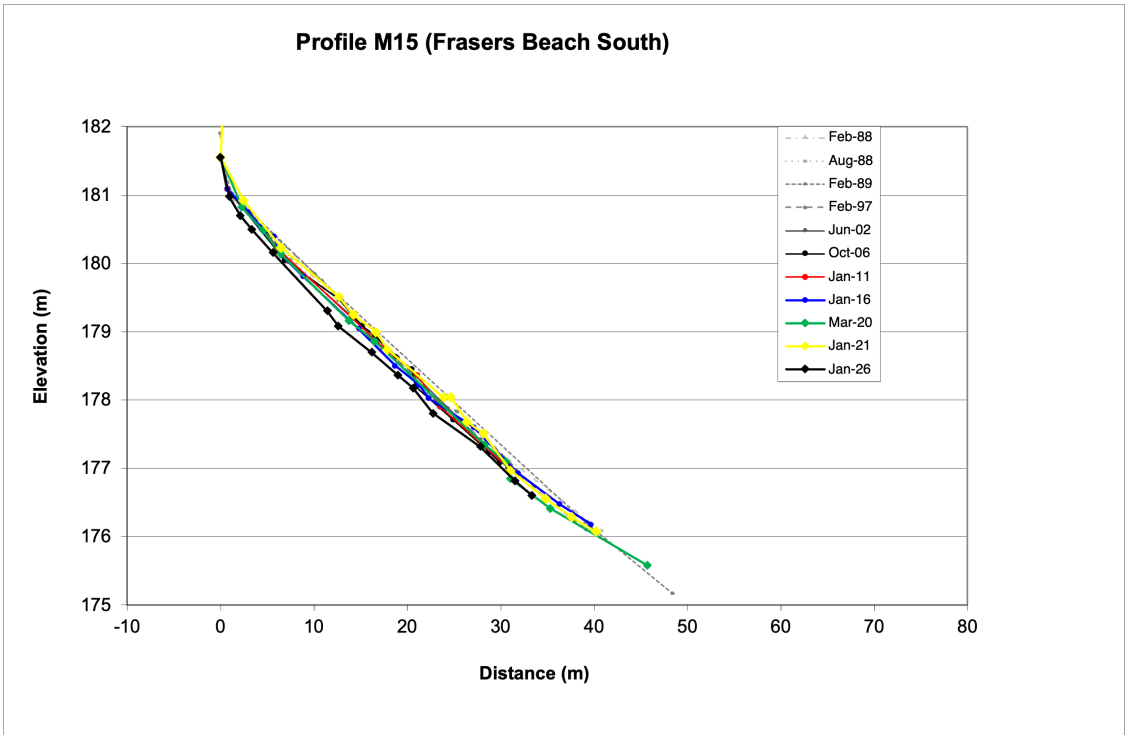
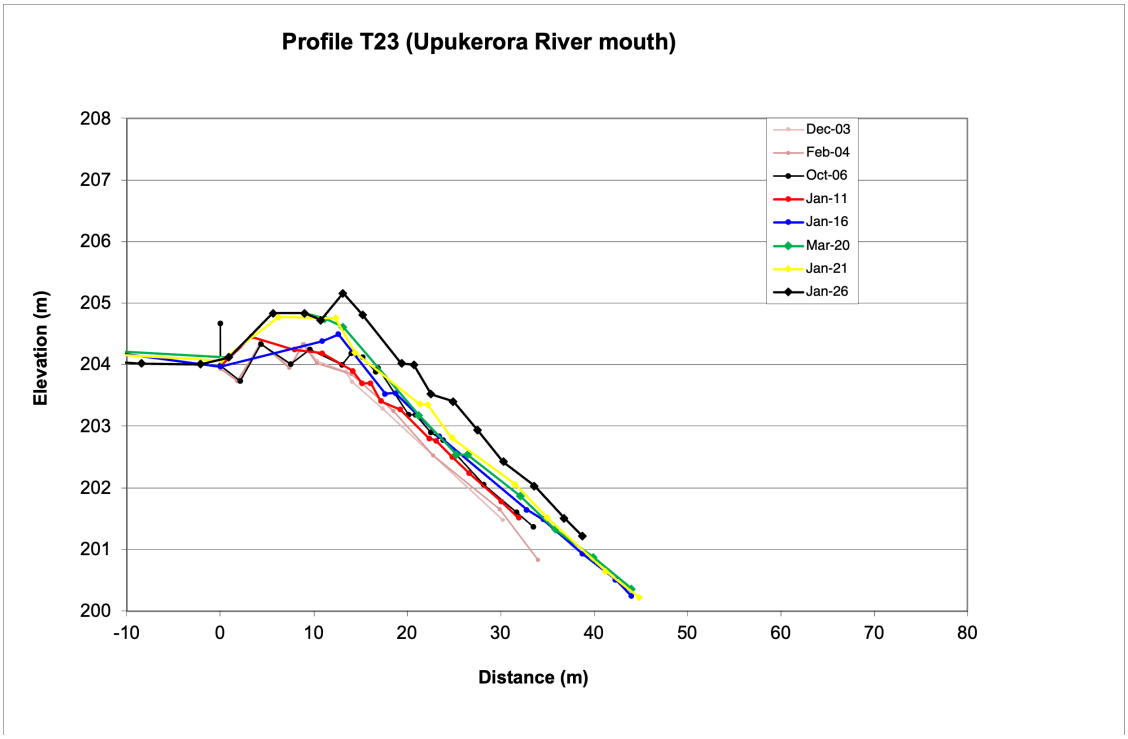


Figure 8. **A.** Overlay plot of Beach profile surveys for M14, Frasers Beach (centre), Lake Manapouri.

B. Overlay plot of Beach profile surveys for M15, Frasers Beach (south), Lake Manapouri.



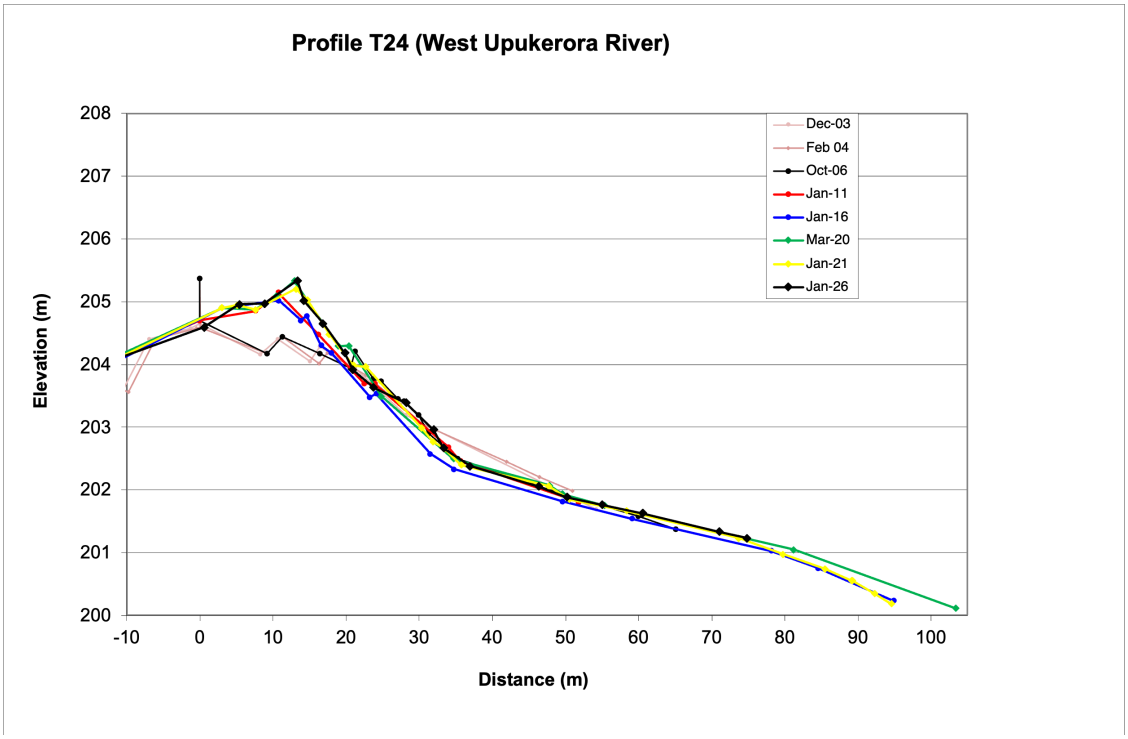
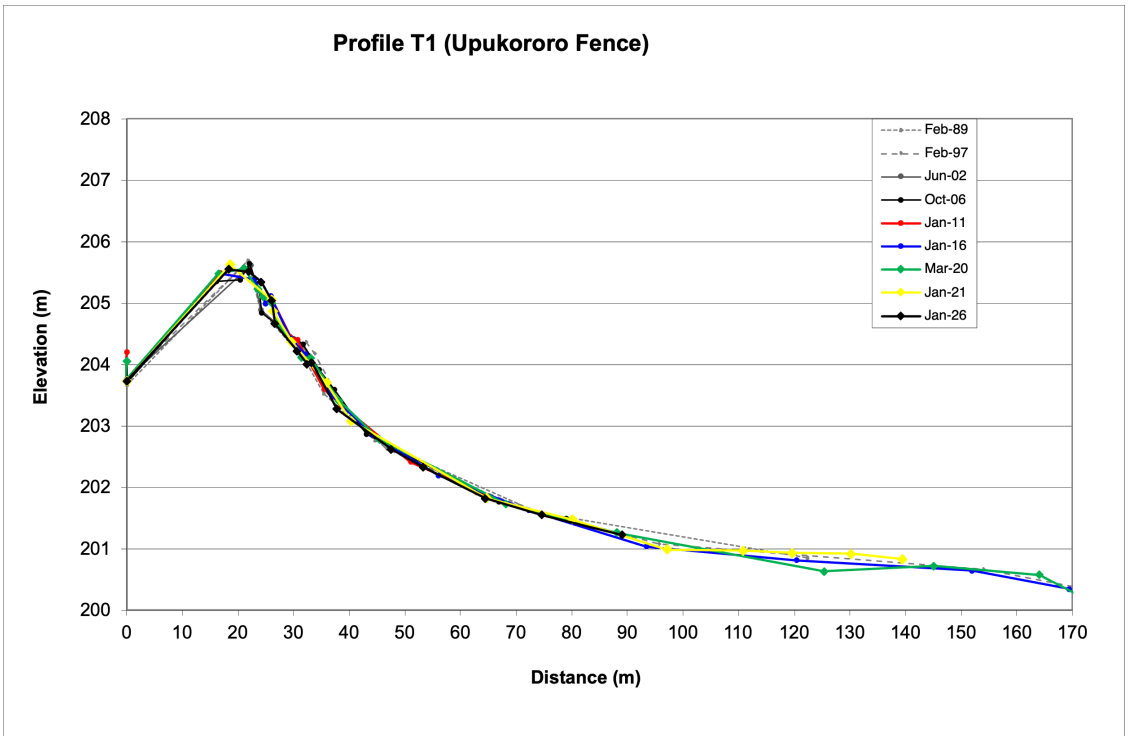


Figure 9. **A.** Overlay plot of Beach profile surveys for T23, Upukerora River Mouth, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T24, West Upukerora River.



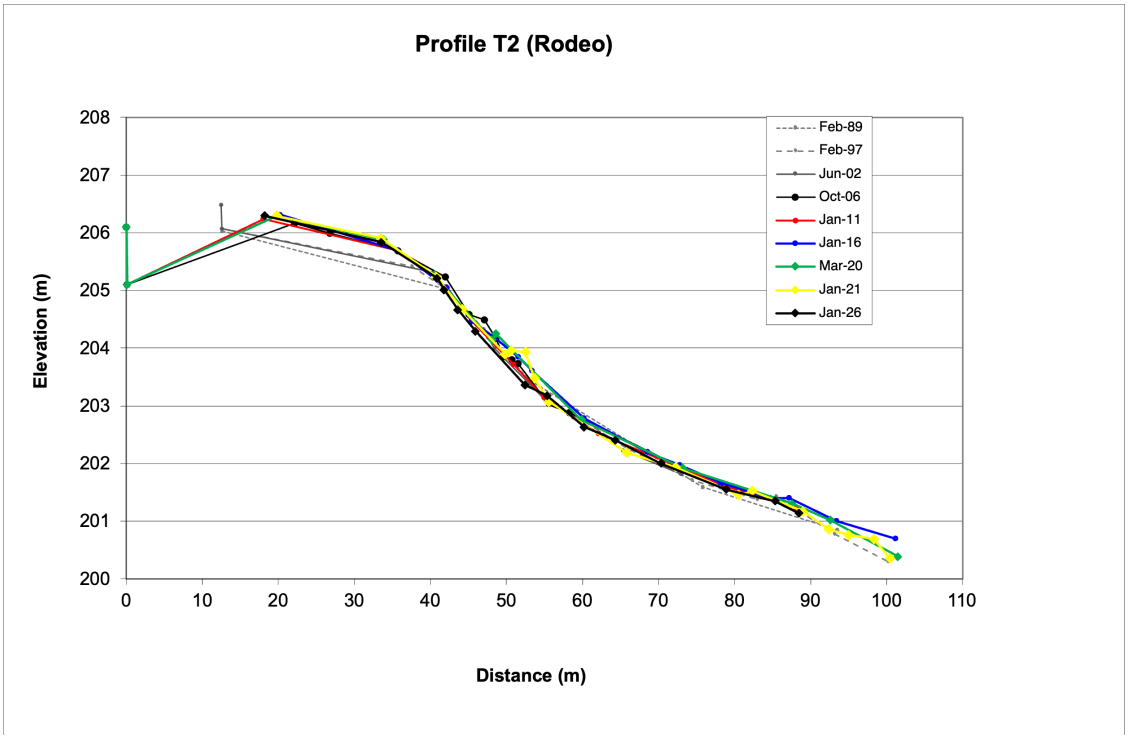
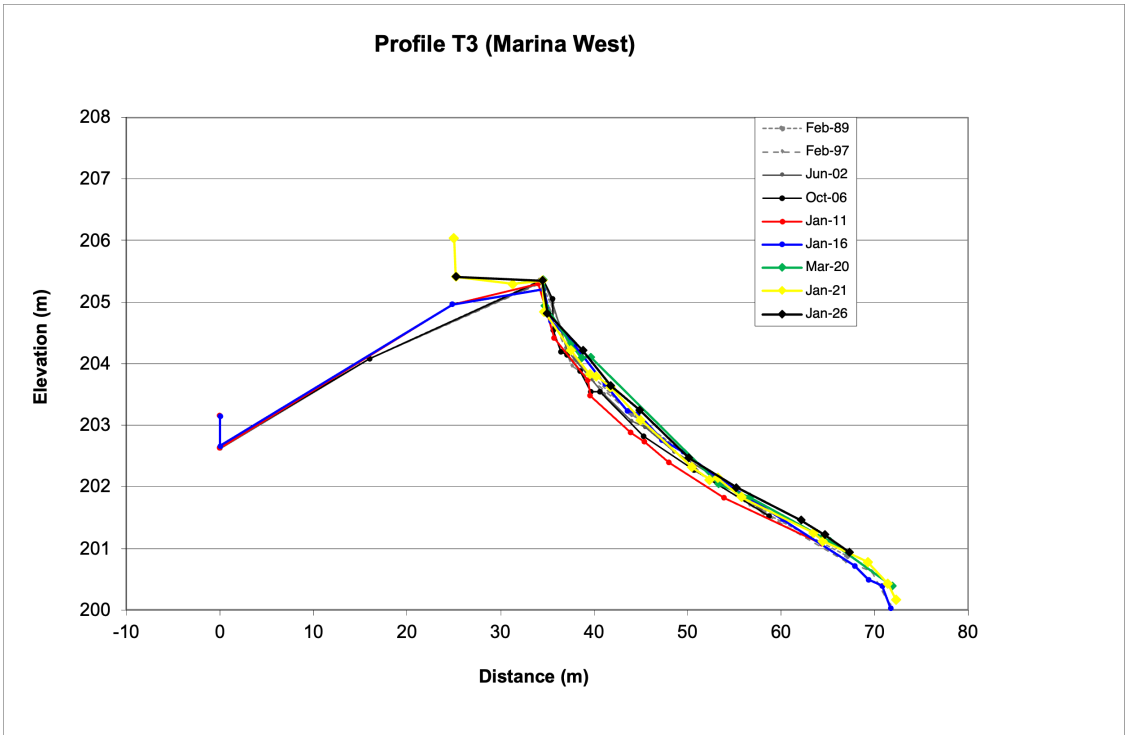


Figure 10. **A.** Overlay plot of Beach profile surveys for T1, North Rodeo Grounds, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T2, Rodeo Grounds, Lake Te Anau.



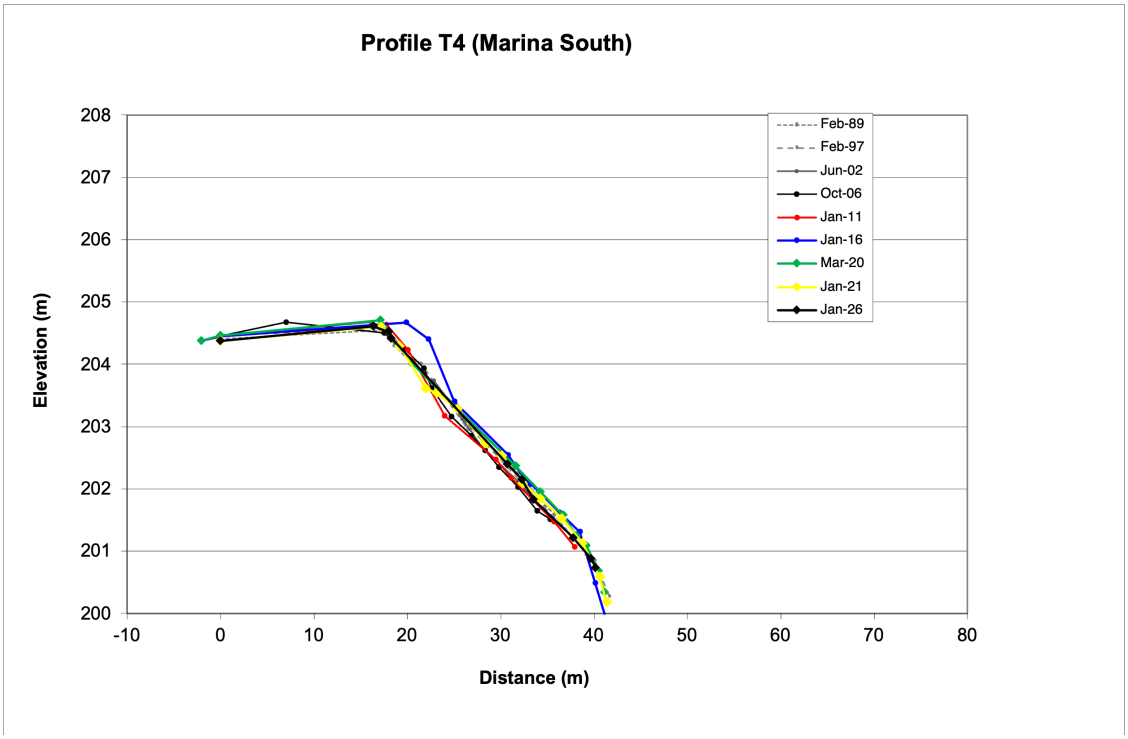
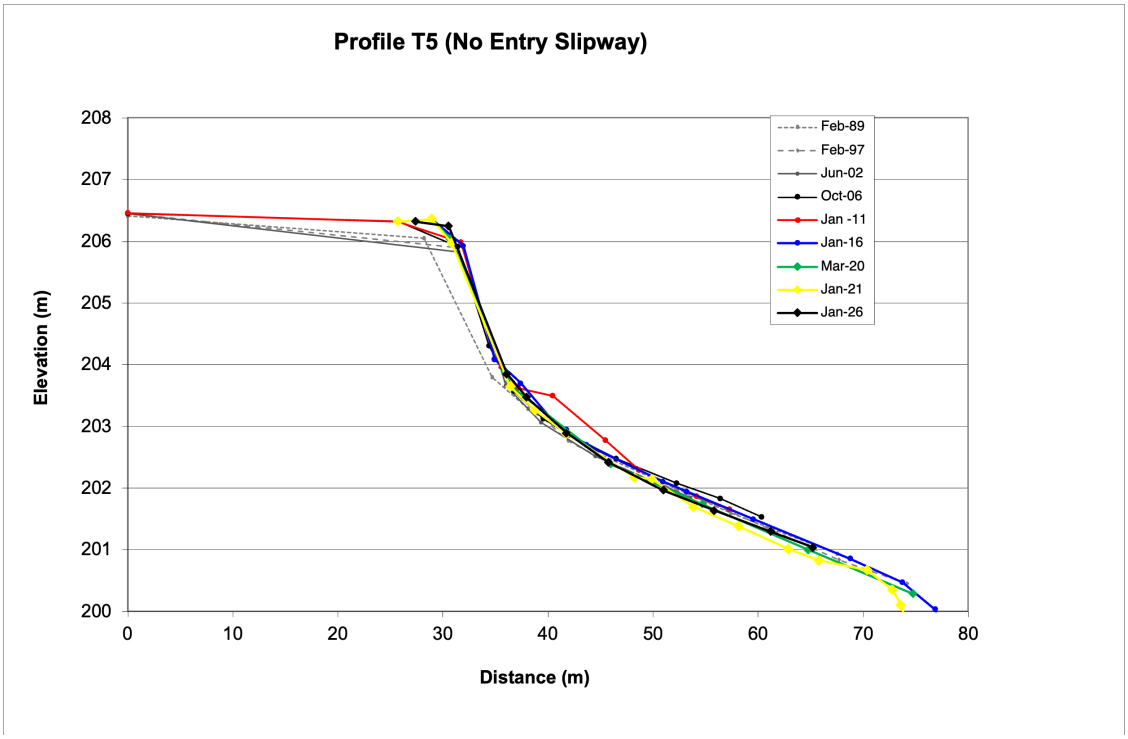


Figure 11. **A.** Overlay plot of Beach profile surveys for T3, Marina West, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T4, Marina South, Lake Te Anau.



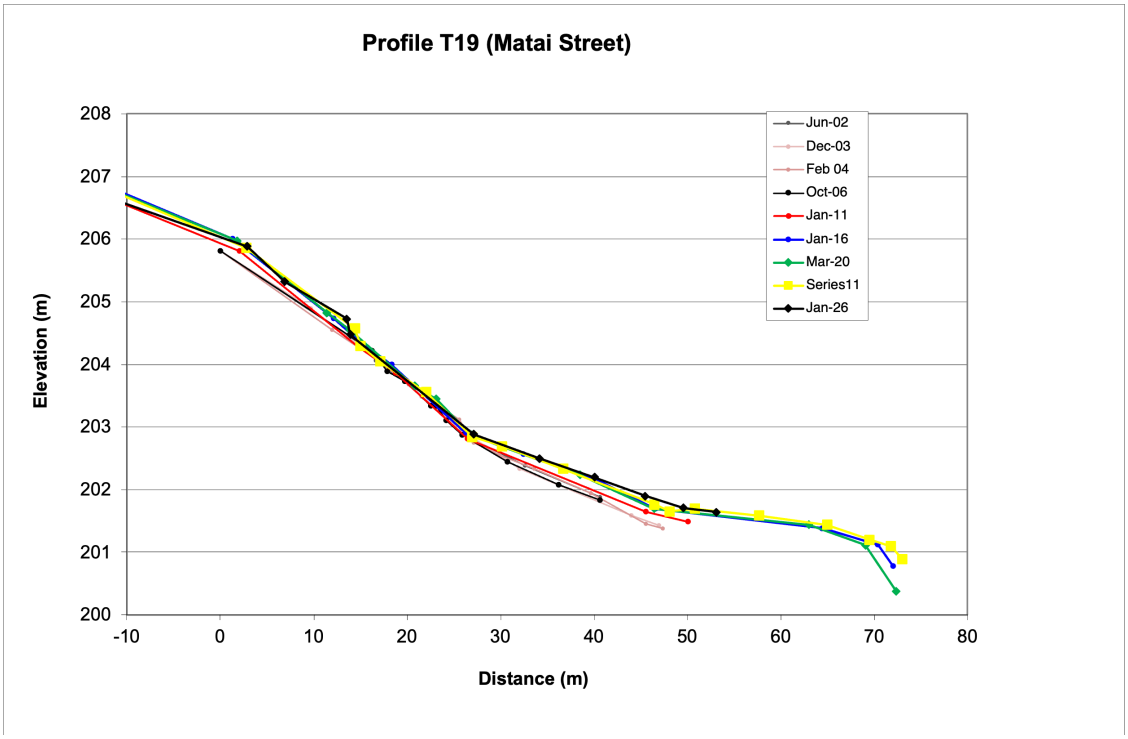
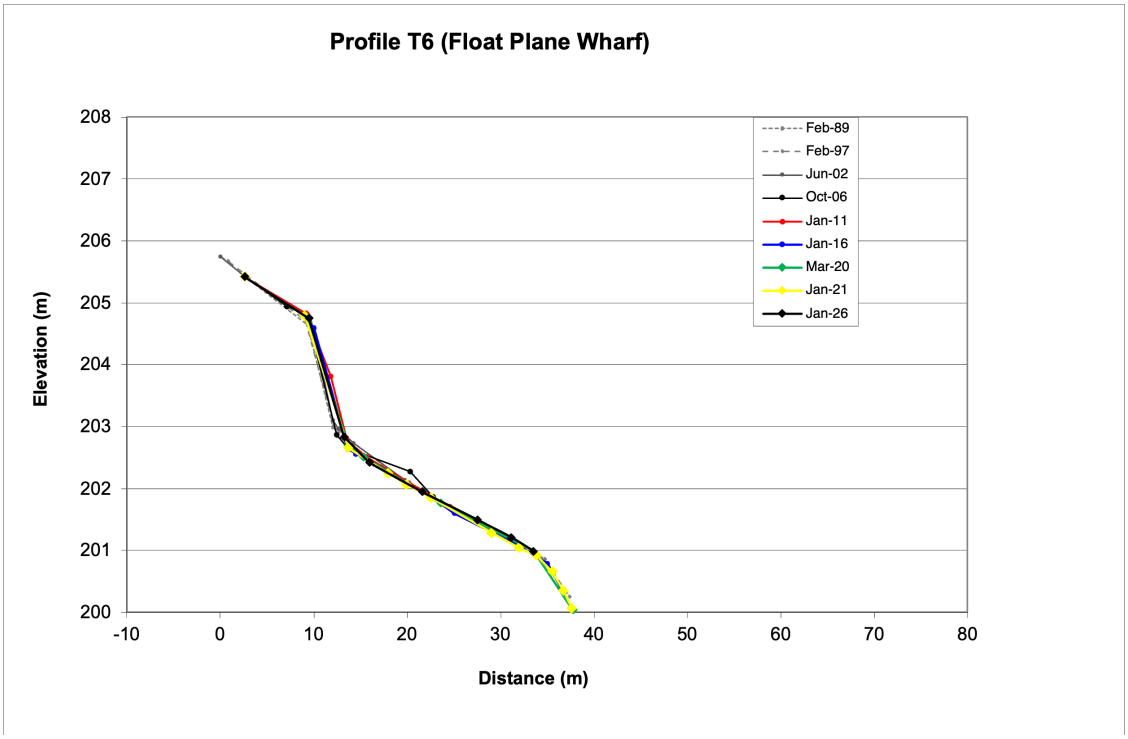


Figure 12. **A.** Overlay plot of Beach profile surveys for T5, No Entry Sign - Slipway Beach, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T19, Matai Street, Lake Te Anau.



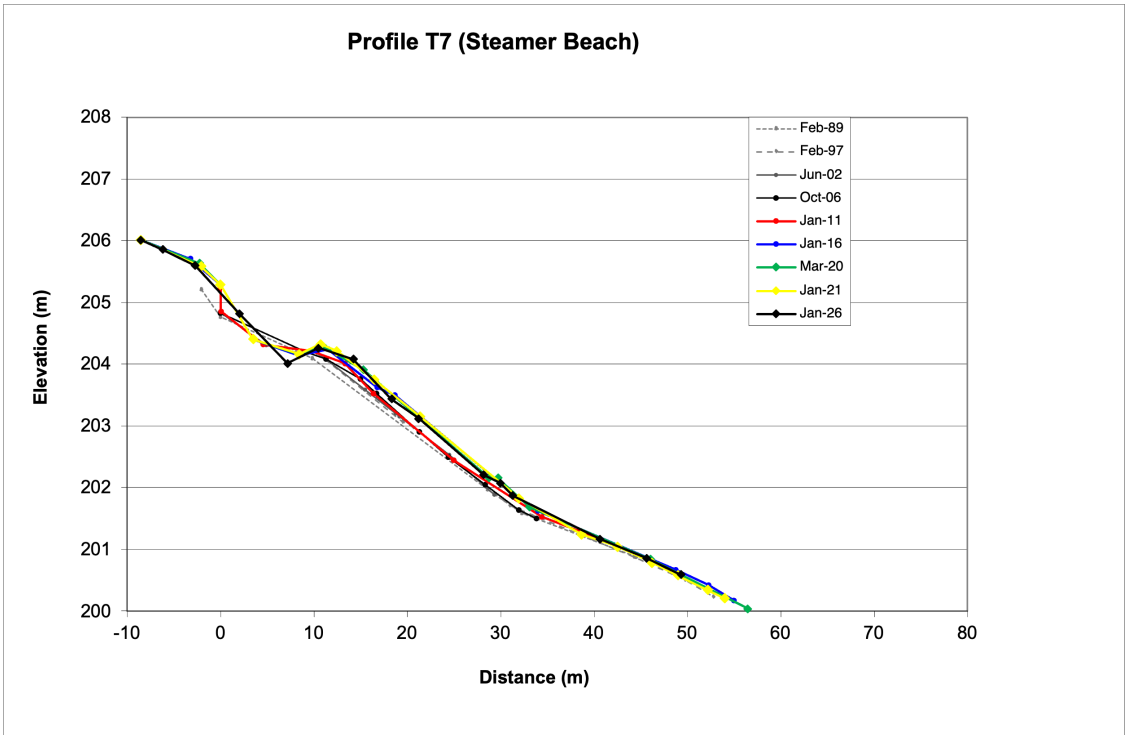
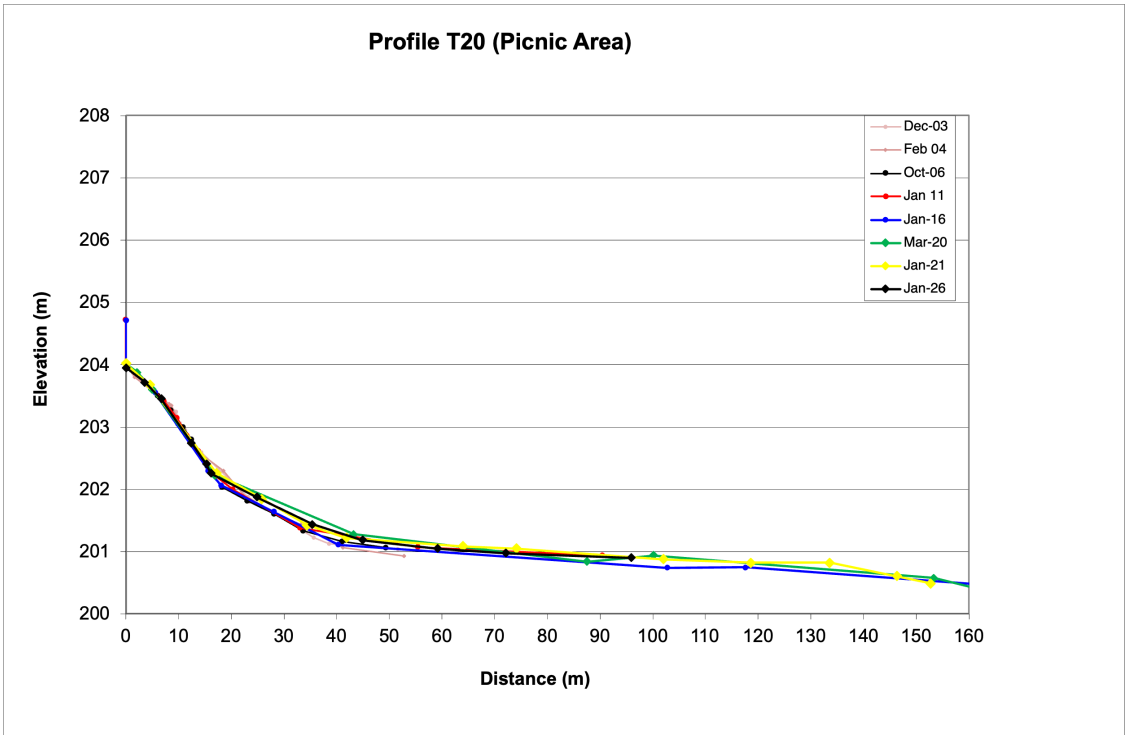


Figure 13. **A.** Overlay plot of Beach profile surveys for T6, Float Plane Landing Beach, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T7, Steamer Beach, Lake Te Anau.



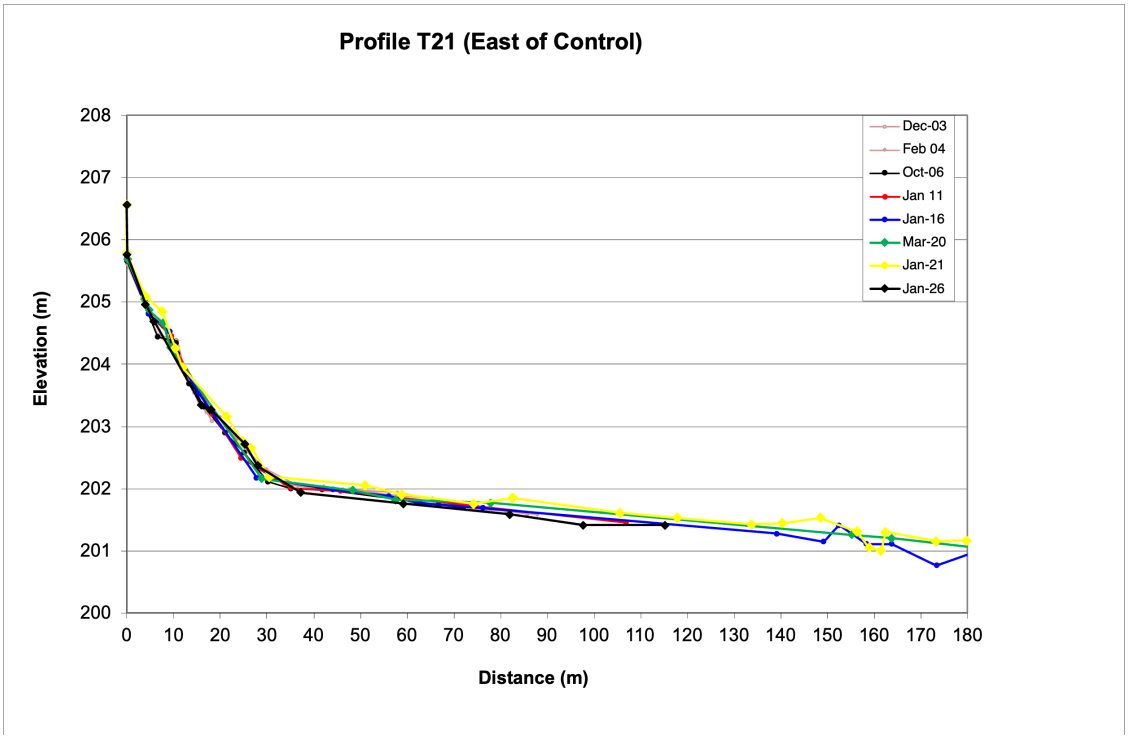
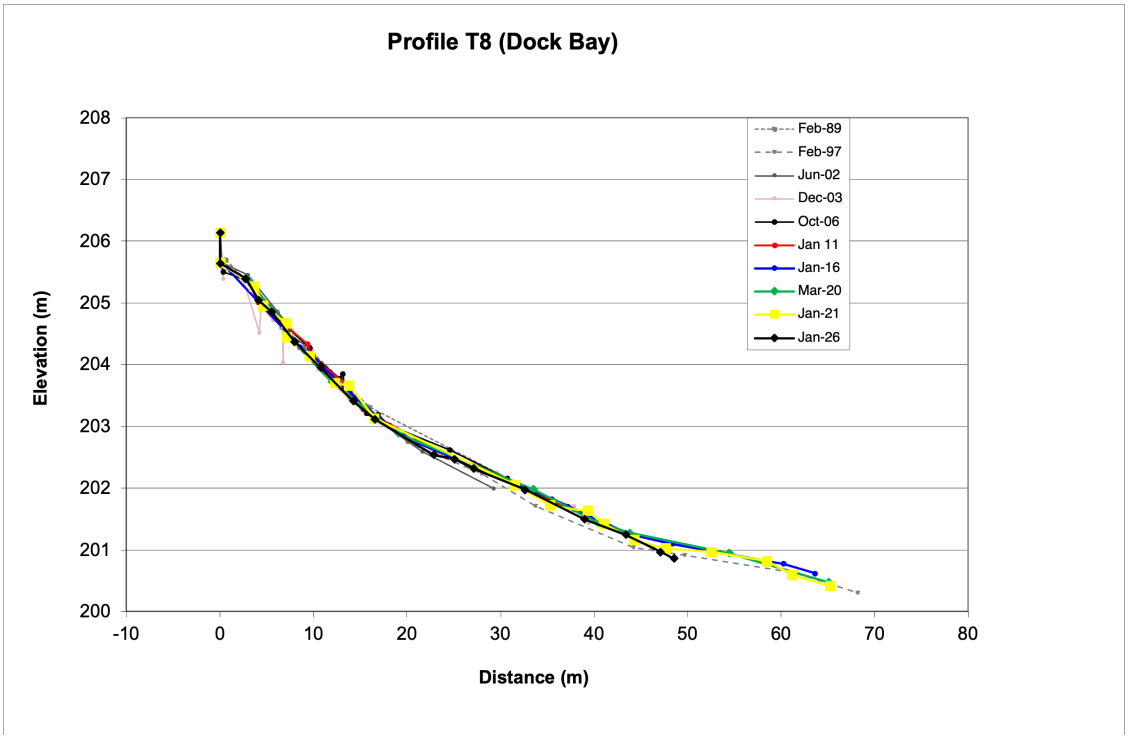


Figure 14. **A.** Overlay plot of Beach profile surveys for T20, Picnic Area, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T21, Sandfly Beach, West of Control, Lake Te Anau.



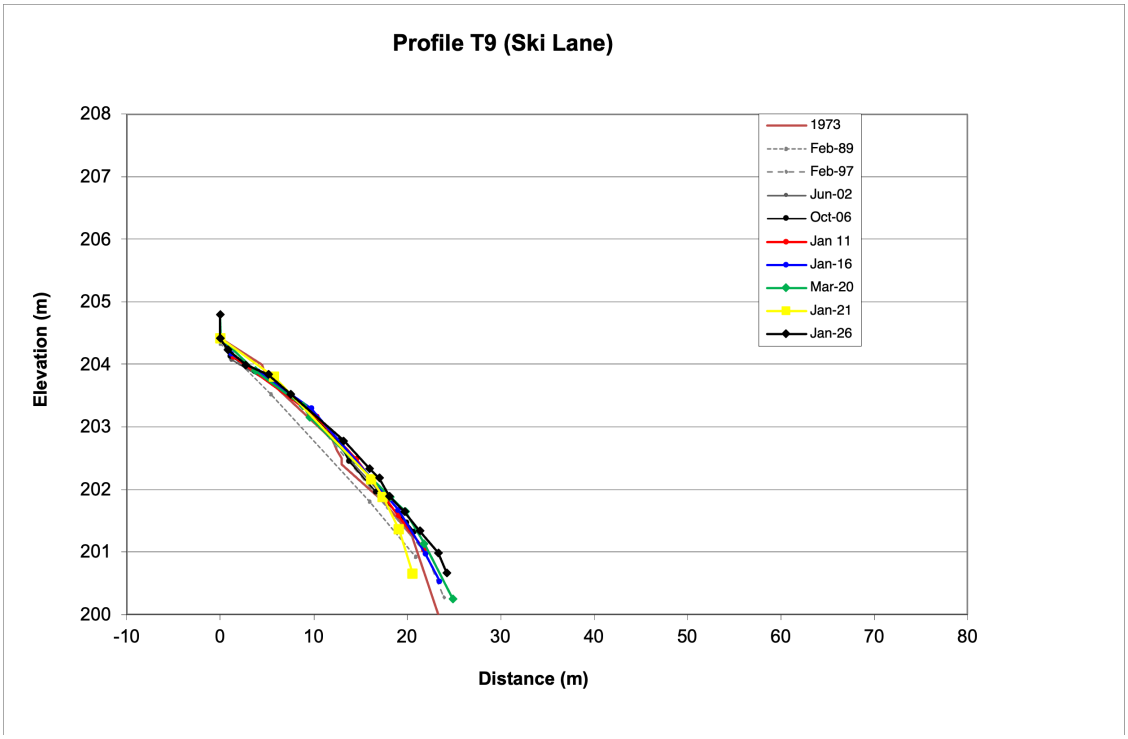


Figure 15. **A.** Overlay plot of Beach profile surveys for T8, Dock Bay Beach, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T9, Ski Lane Beach, Lake Te Anau.

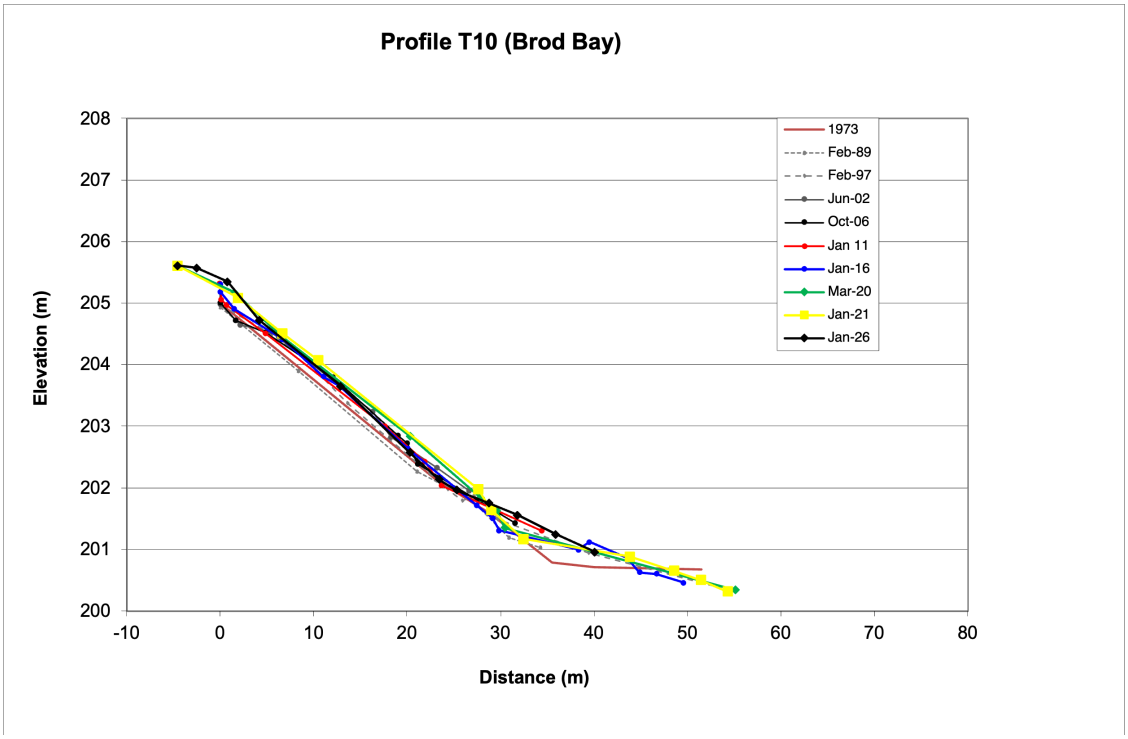
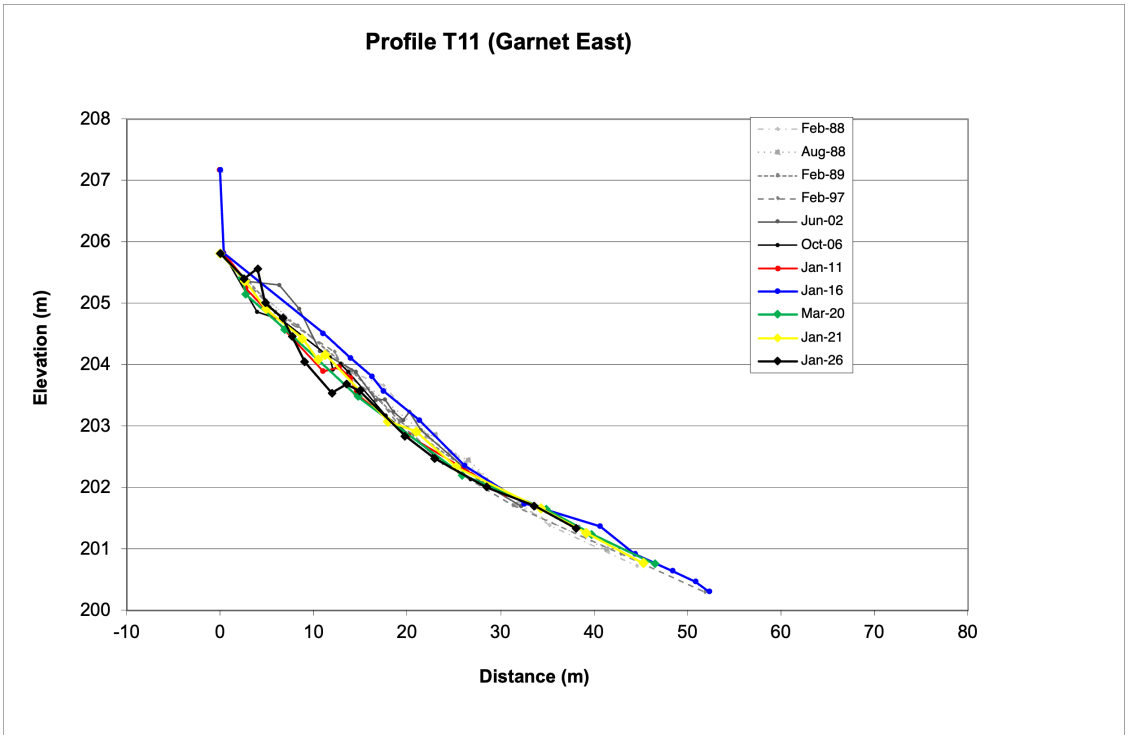


Figure 16. **A.** Overlay plot of Beach profile surveys for T10, Brod Bay Beach, Lake Te Anau.



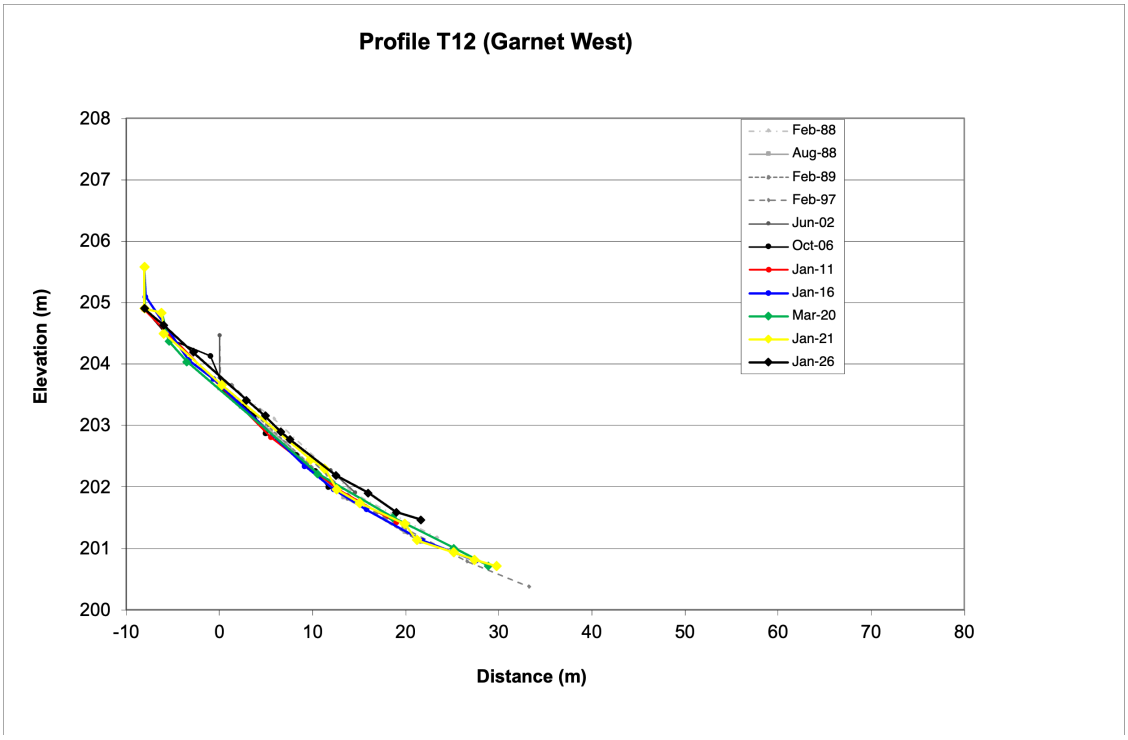


Figure 17. **A.** Overlay plot of Beach profile surveys for T11, Garnet Bay (East) Beach, South Fiord, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T12, Garnet Bay (west) Beach, South Fiord, Lake Te Anau.

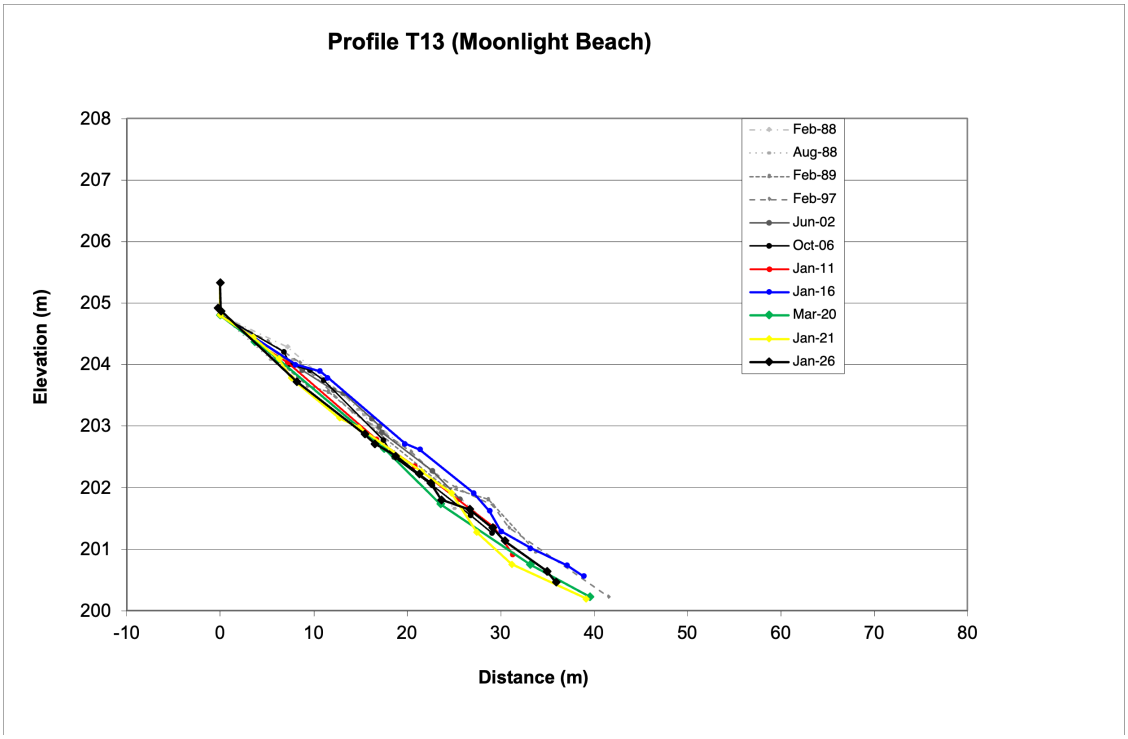
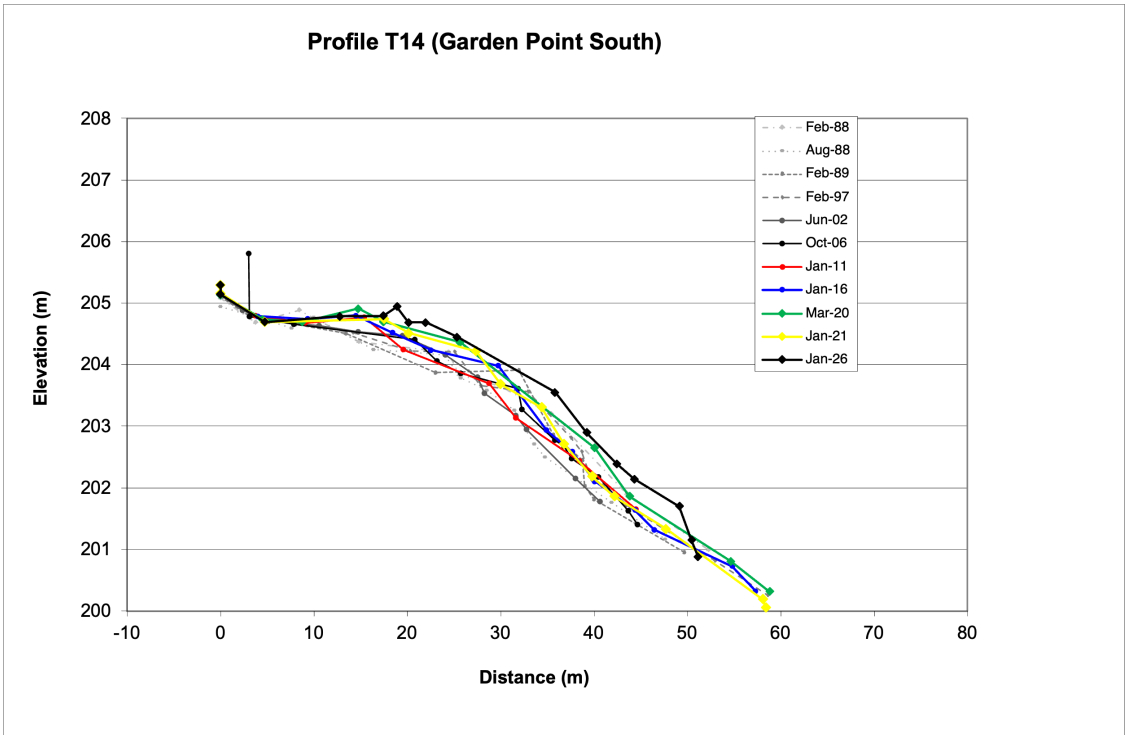


Figure 18. **A.** Overlay plot of Beach profile surveys for T13, Moonlight Beach, South Fiord, Lake Te Anau.



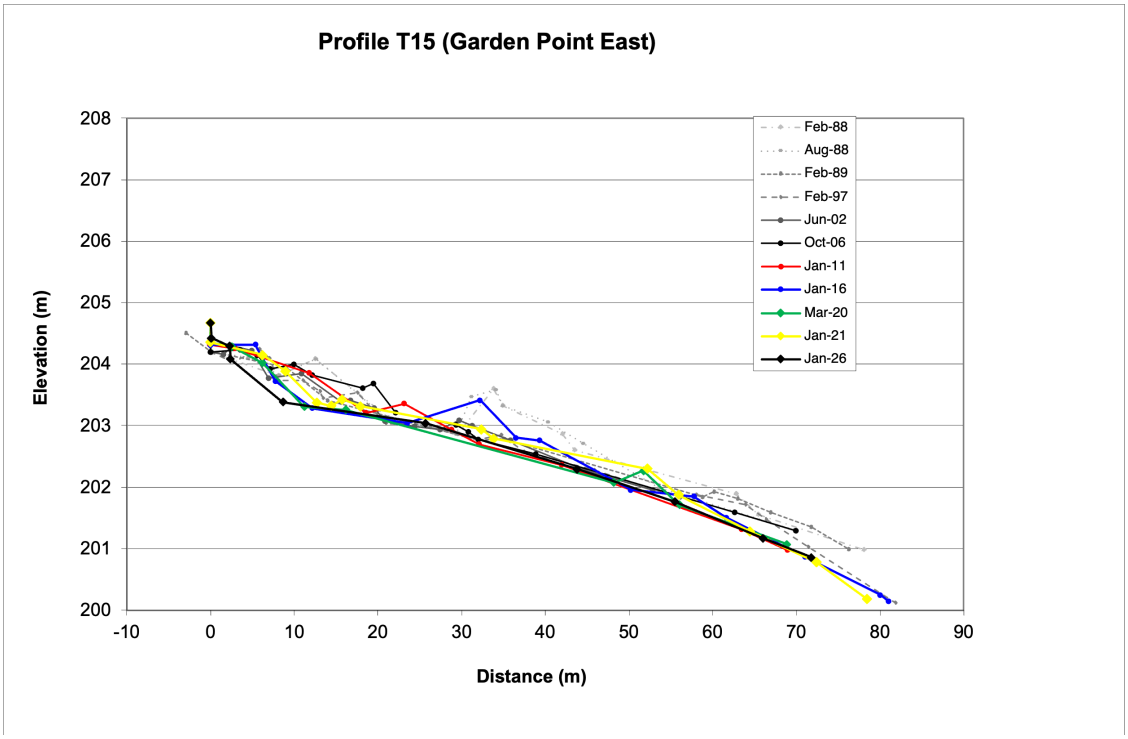
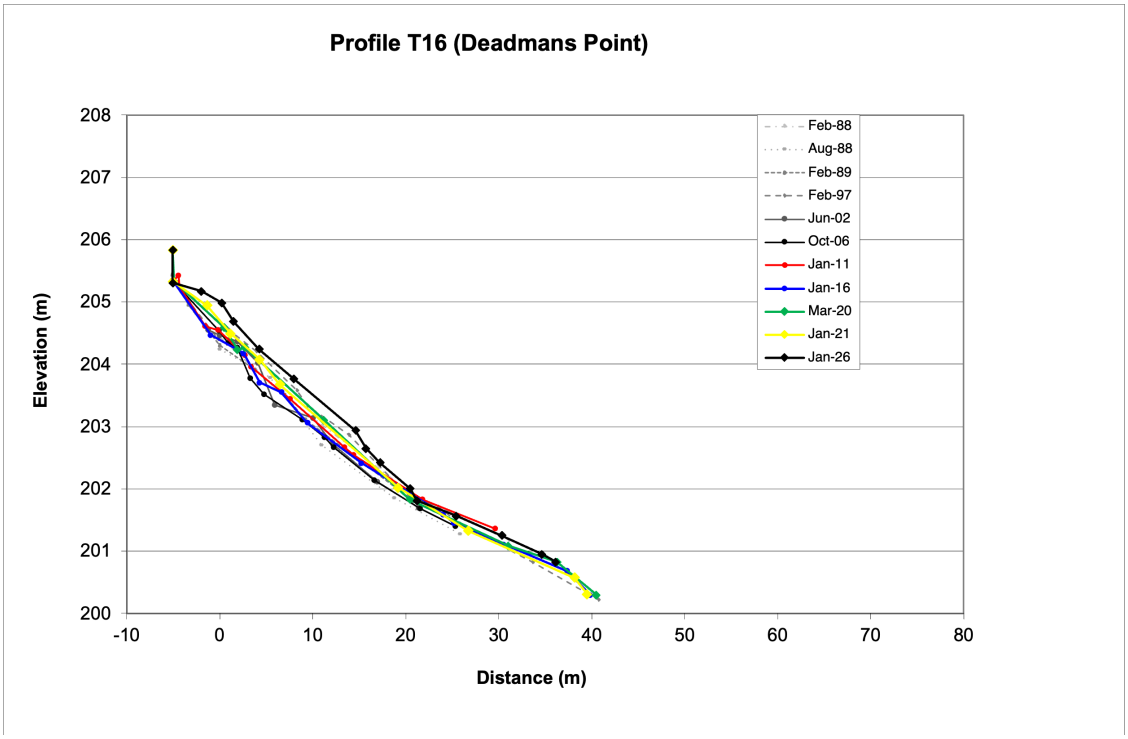


Figure 19. **A.** Overlay plot of Beach profile surveys for T14, Garden Point (also known as Trig- B south) Beach, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T15, Garden Point (also known as Trig- B east) Beach, Lake Te Anau.



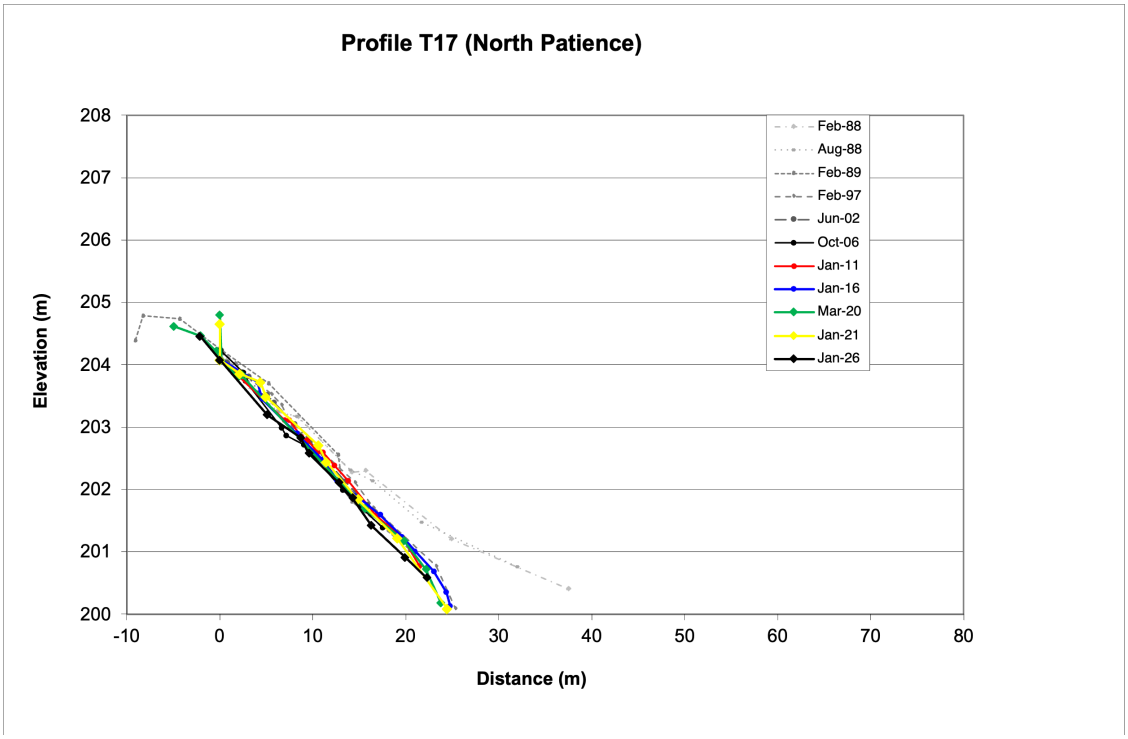
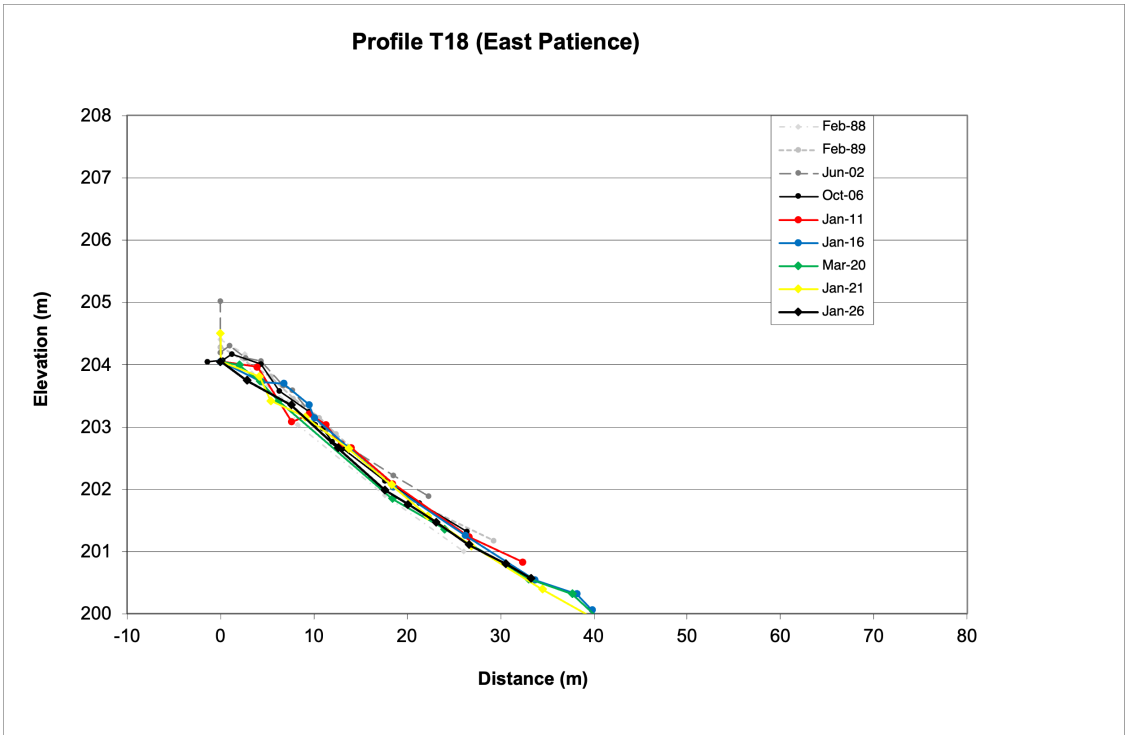


Figure 20. **A.** Overlay plot of Beach profile surveys for T16, Deadmans Point Beach, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T17, North Patience Bay Beach, Lake Te Anau.



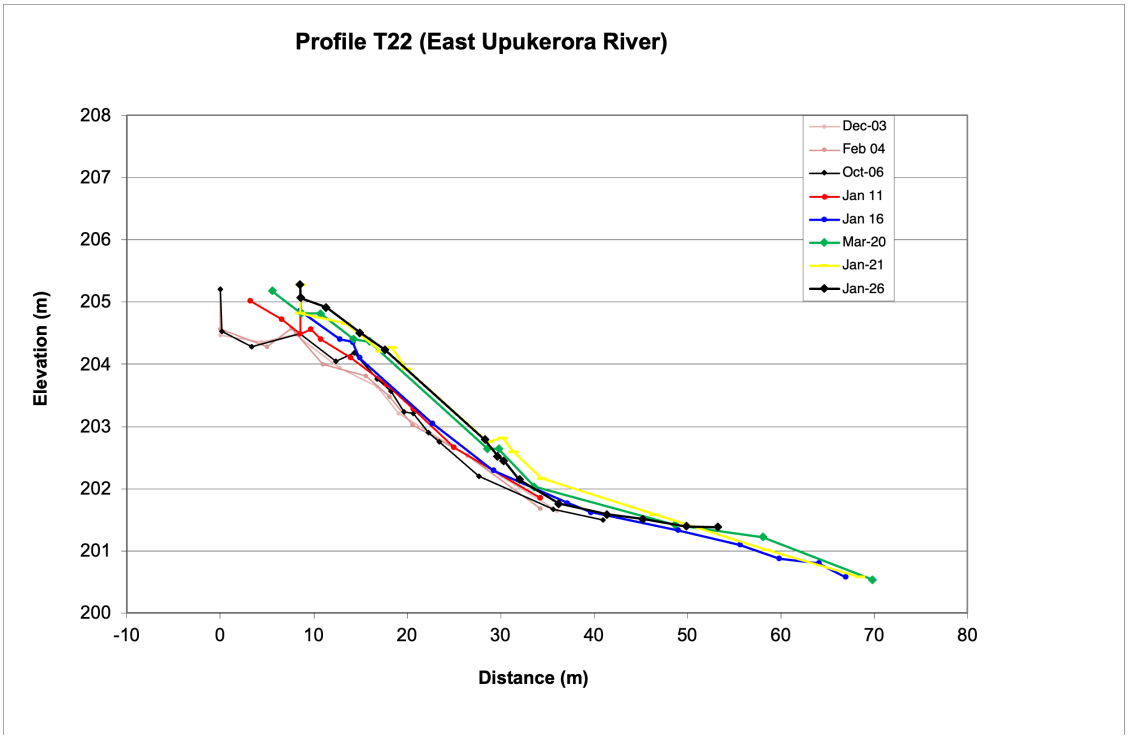


Figure 21. **A.** Overlay plot of Beach profile surveys for T18, East Patience Bay Beach, Lake Te Anau.

B. Overlay plot of Beach profile surveys for T22, East Upukerora River, Lake Te Anau.

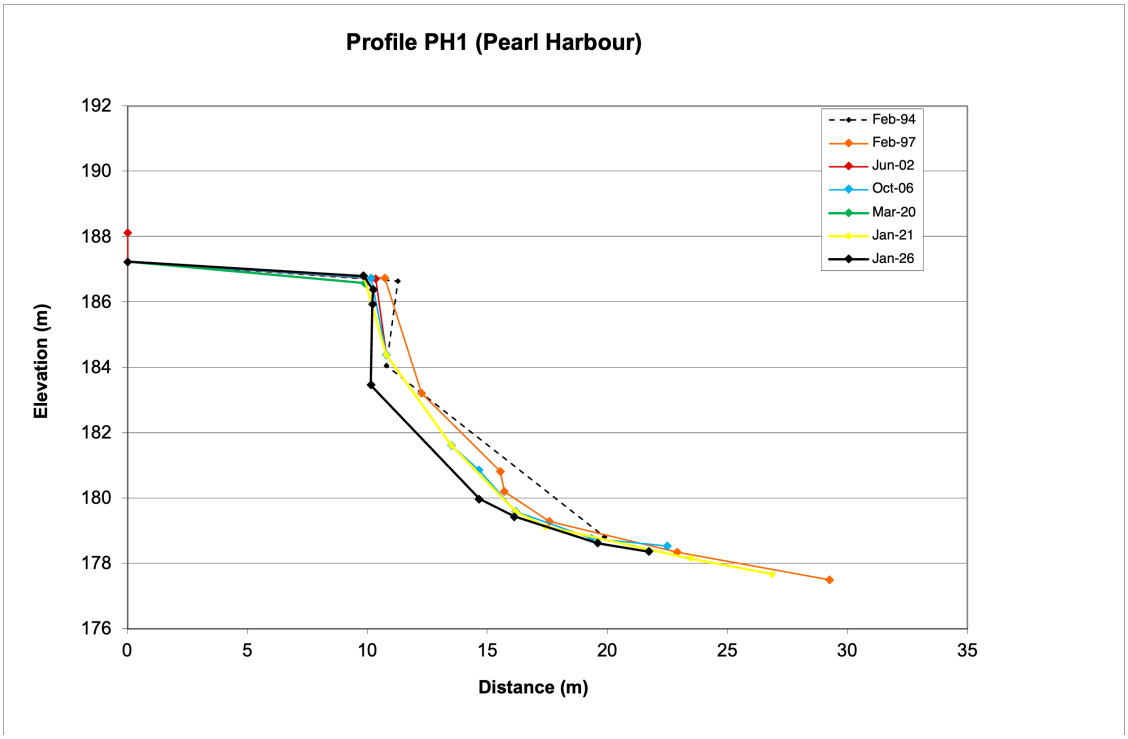
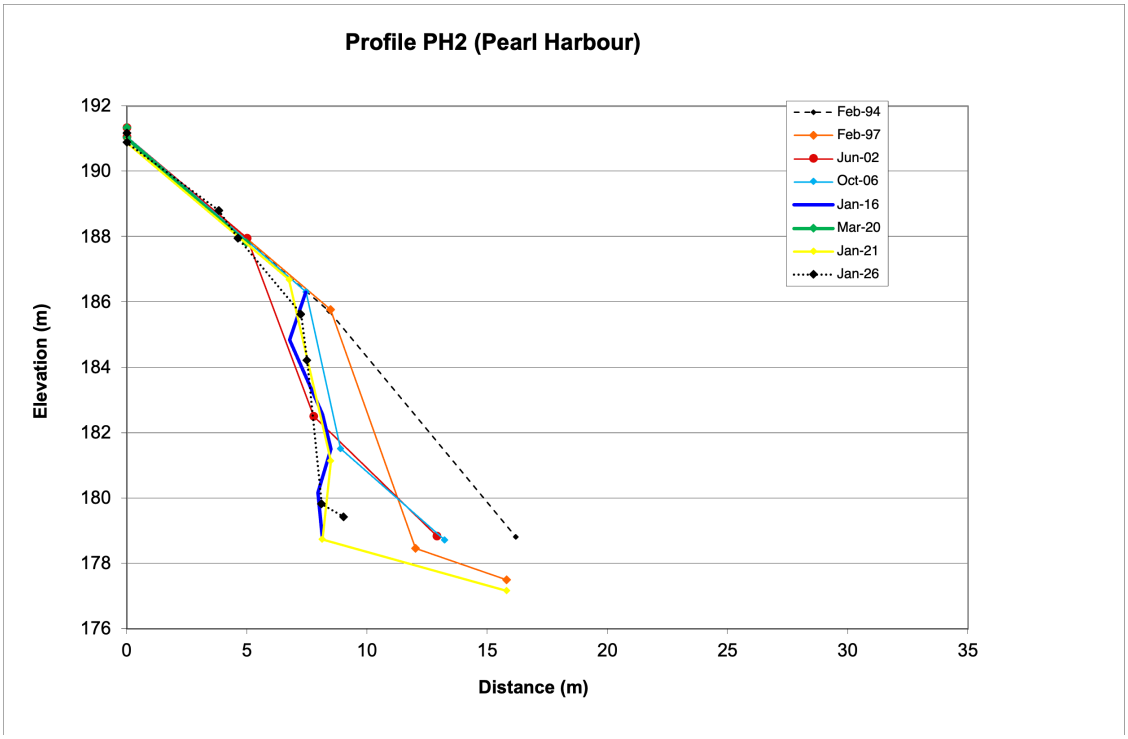


Figure 22. Overlay plot of cliff face profile surveys for PH1 The Glade, the lower Waiau River at Pearl Harbour, Manapouri.



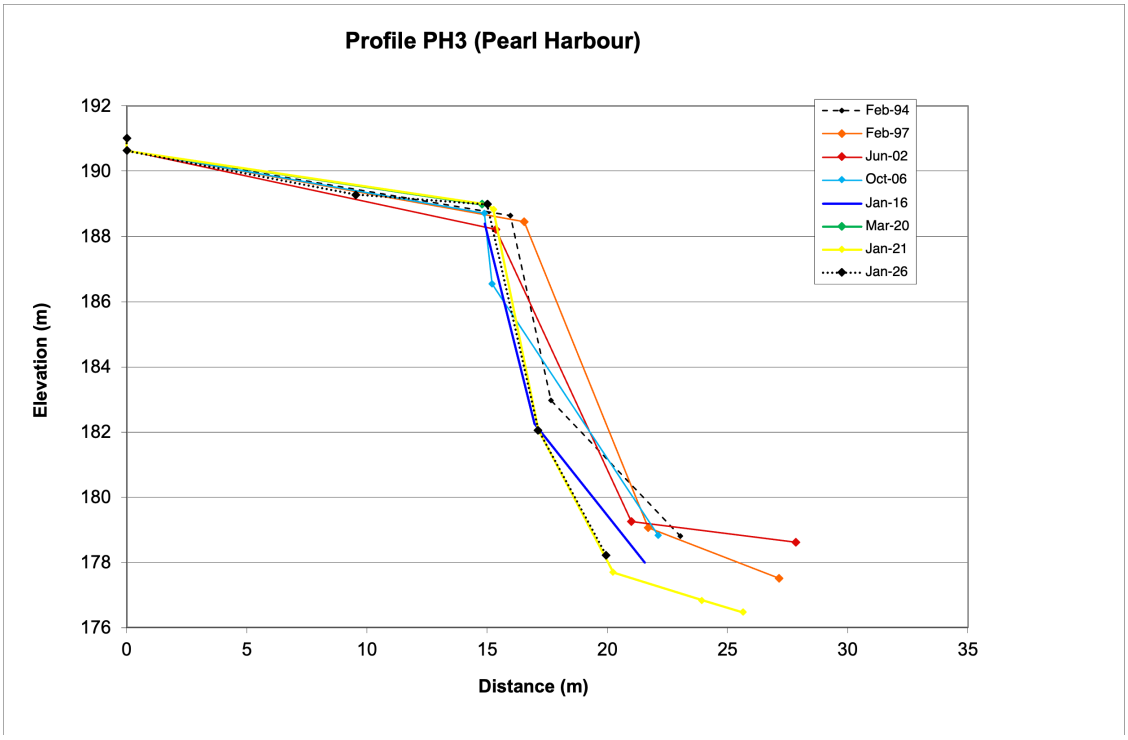
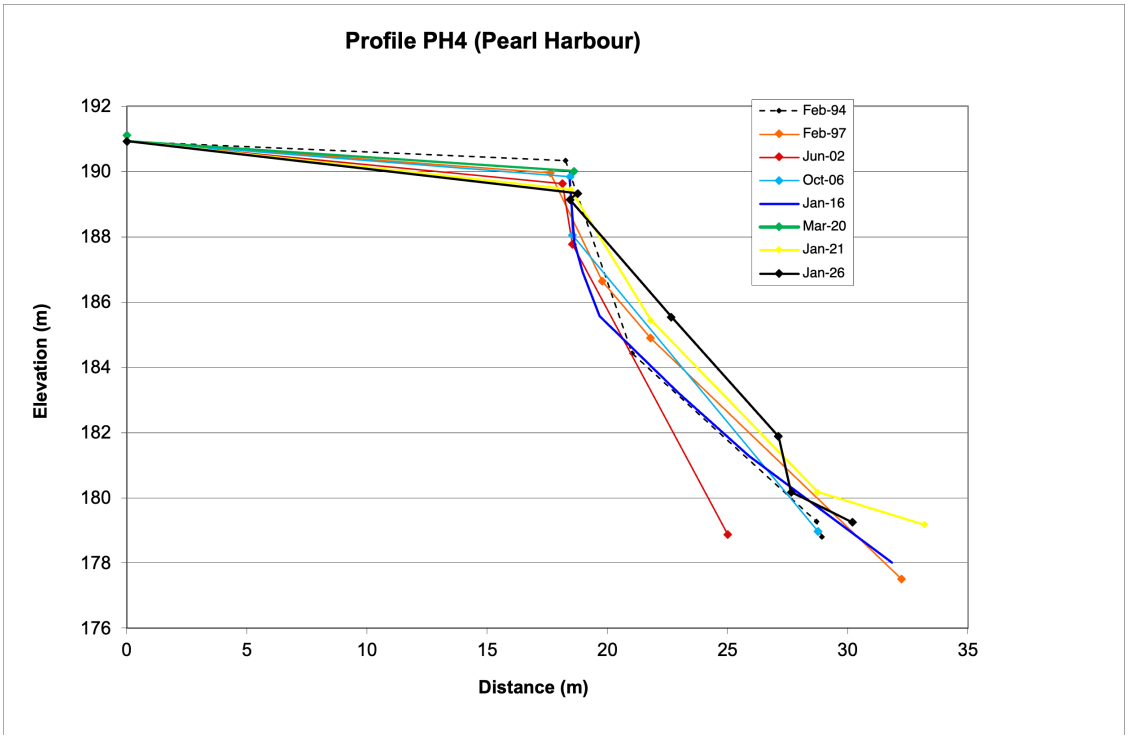


Figure 23. **A.** Overlay plot of cliff face profile surveys for PH2 Kiosk, lower Waiau River at Pearl Harbour, Manapouri.

B. Overlay plot of cliff face profile surveys for PH3 Boat Ramp, lower Waiau River at Pearl Harbour, Manapouri.

Dotted line type for Jan-26 indicates corrections made to the survey data due to "bad-conditions" in the electronic measurement.



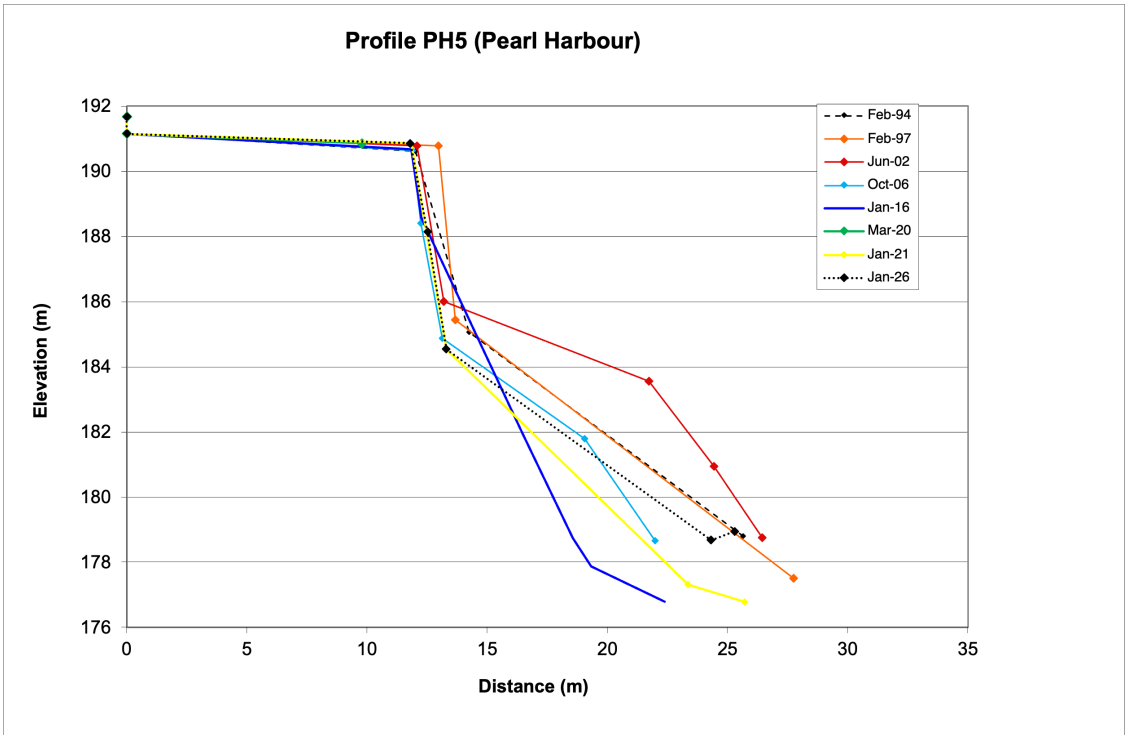


Figure 24. **A.** Overlay plot of cliff face profile surveys for PH3 Kowhai, lower Waiau River at Pearl Harbour, Manapouri.

B. Overlay plot of cliff face profile surveys for PH5 Real Journeys, lower Waiau River at Pearl Harbour, Manapouri.

Dotted line type for Jan-26 indicates corrections made to the survey data due to "bad-conditions" in the electronic measurement.

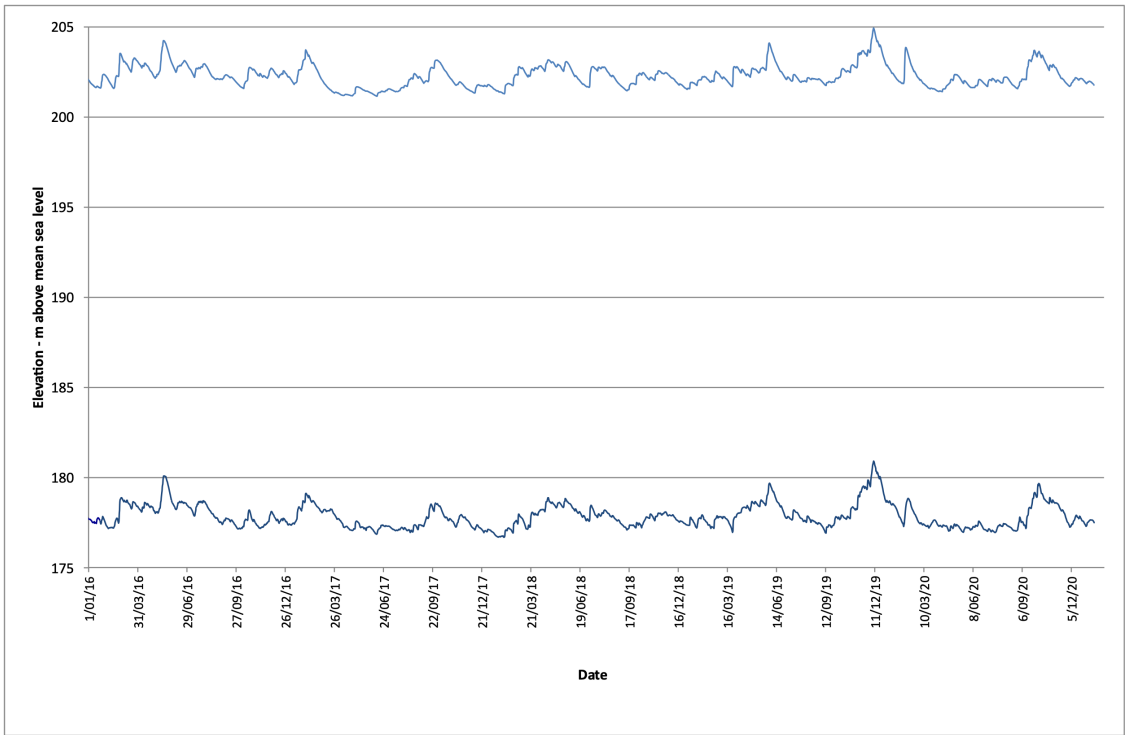


Figure 25 Water levels for Lakes Manapouri (lower line) and Te Anau (upper line) from 1 January 2016 to 16 January 2021

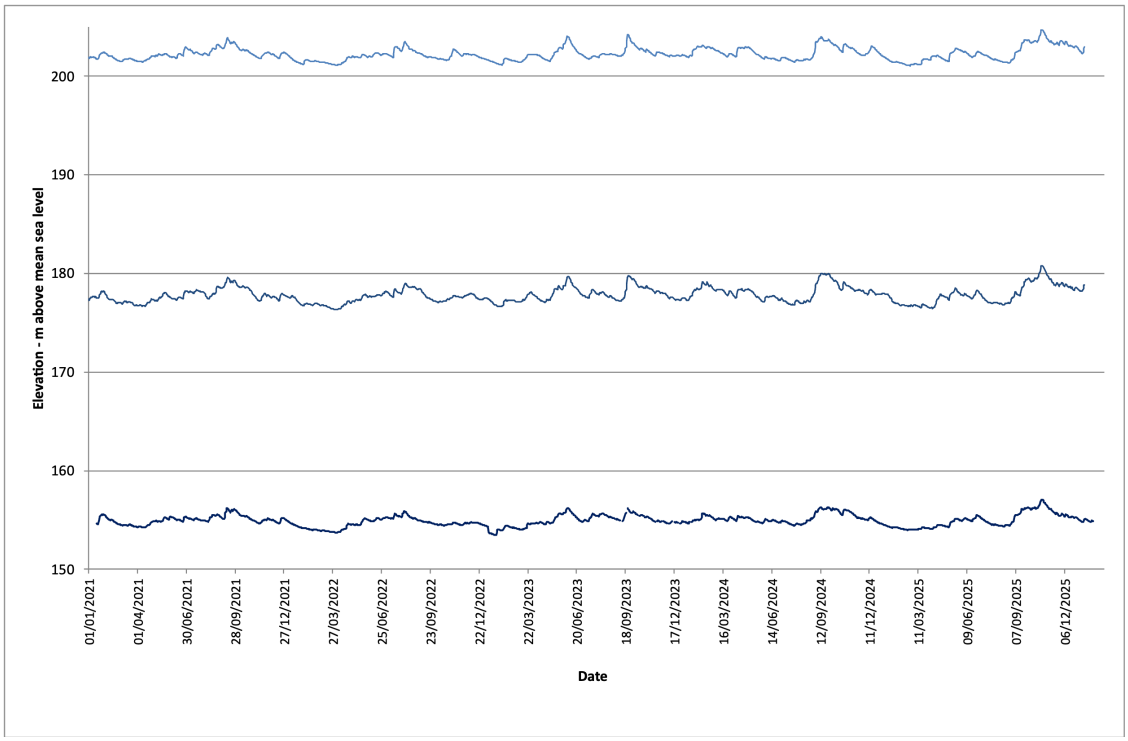


Figure 26 Water levels for Lakes Manapouri (middle line) and Te Anau (upper line) and Hauroko (lower line) from 1 January 2021 to 12 January 2026

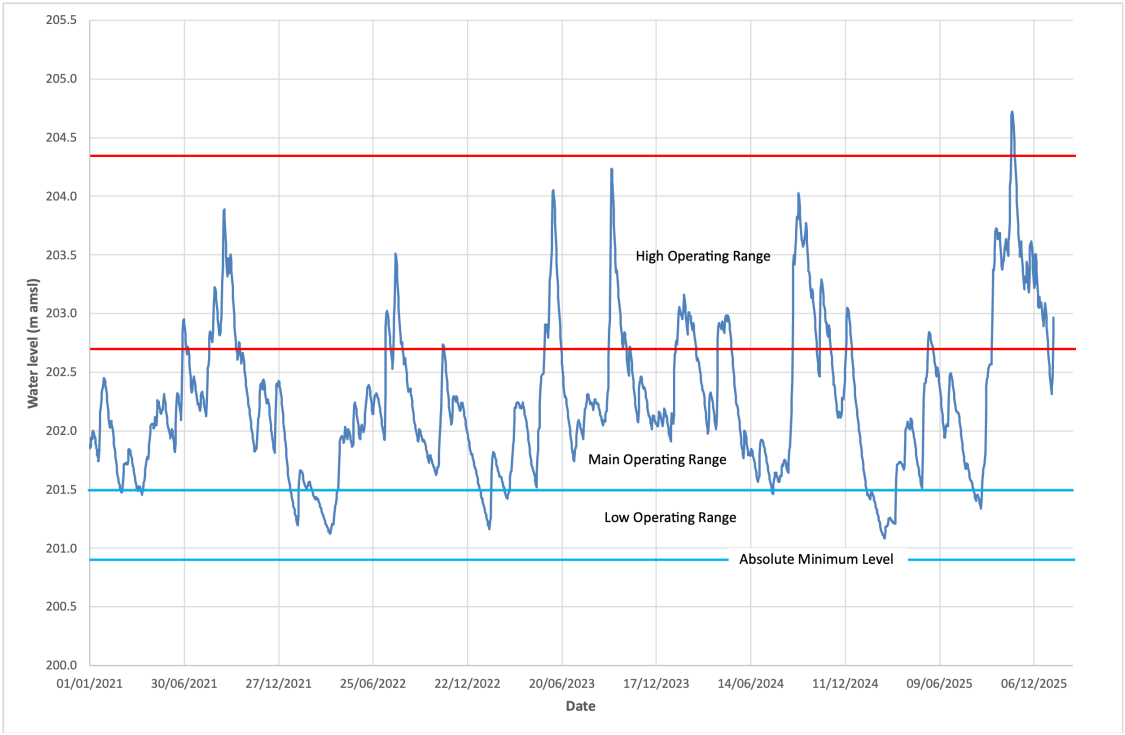


Figure 27 Water levels for Lake Te Anau 1 January 2021 to 12 January 2026 with the Operating Range limits shown

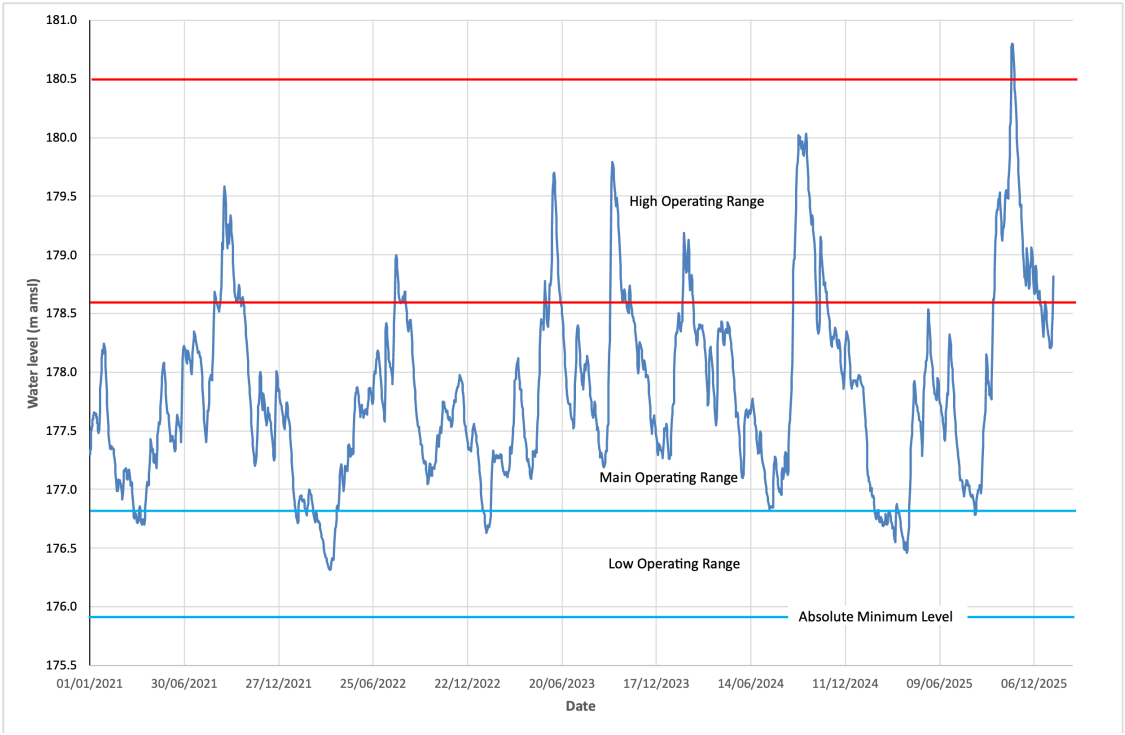


Figure 28 Water levels for Lake Manapouri 1 January 2021 to 12 January 2026 with the Operating Range limits shown

14. Appendix 5

Selection of photograph comparisons



Figure 1. Site T19 showing retreat of scarp in grassed turf and change in beach surface sediment texture. Top: January 2021; Bottom: January 2026



Figure 2. Site T6 showing displacement of rocks from the revetment and changes to the beach surface texture. Top: January 2021, lake level ~201.89 m; Bottom: January 2026, lake level ~202.44 m.