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Meridian Energy Limited
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Upper Waiau Peg Line Survey 2026

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Upper Waiau Peg Line Survey 2026

Client: Meridian Energy Limited

Co No.: 9429037696863

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26-June-2026

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Executive Summary

AECOM was engaged by Meridian Energy Limited to assess riverbank erosion at two peg line monitoring sites on the Upper Waiau River (Rainbow Reach and Village Pond) following a flow event exceeding 800 m³/s that occurred between 23 October and 1 November 2025. This event-triggered survey was undertaken in accordance with the Manapōuri Power Scheme resource consent conditions. Survey data was collected by WSP Opus on 17–18 December 2025.

Bank retreat rates observed over the 2023–2025 monitoring period are within historic trends and do not represent a departure from long-term erosion patterns (1983–2025) at either site.

At Rainbow Reach, overall bank retreat since 2023 has been low, with a mean retreat rate of 0.11 m/yr, considerably below the long-term average of 0.58 m/yr. Retreat is concentrated in the upstream zone, where the mean rate was 0.27 m/yr, with pegs 305 and 306 recording the highest individual rates (1.33 and 0.40 m/yr respectively). The active upstream zone has extended downstream since the 2023 assessment, with the zone boundary migrating from between pegs 304–305 to peg 308, consistent with the downstream migration of active erosion on the outside of the riverbend associated with ongoing geomorphic adjustment following the Balloon Loop cutoff. Bank steepening in the upstream zone has been observed, and continued slope adjustment and top-of-bank retreat are expected as the profile progresses toward a stable gradient. The downstream zone remains stable, with a mean retreat rate of 0.0 m/yr since 2023.

At Village Pond, bank retreat has also been low, with an overall mean rate of 0.06 m/yr since 2023, less than half the long-term average of 0.24 m/yr. The upstream migration of the erosion zone boundary continues, with a step increase in retreat observed as the boundary passes individual pegs, a pattern consistent with historic trends at this site.

Migration of the active area of erosion on the outside of meander bends is a natural process and expected to change over time, in particular as this reach is currently adjusting to the Balloon loop cut off. This process was occuring prior to the operation of the Manapōuri Power Scheme.

Flows >800 m³/s trigger a survey to enable the magnitude of erosion to be monitored, implying that elevated erosion may result from flows of this disharge. No significant response in bank retreat was observed at Village Pond or Rainbow Reach during the 2023-2025 monitoring period despite the occurrence of flows exceeding this threshold. There is no geomorphic evidence to suggest that flow regimes since flow was regulated have changed erosional trends over and above those that were occurring prior to regulation. There is no visible response to changes to bank retreat related to >800 cumecs flow, which is consistent with historic trends.

1.0 Introduction

Meridian Energy Limited has engaged AECOM New Zealand Limited (AECOM) to analyse riverbank erosion as monitored from two peg line sites on the Upper Waiau River at Rainbow Reach and Village Pond (Figure 1). These were established in late 1983 when 14 pegs were placed behind the top of the riverbank at Rainbow Reach, and 22 pegs at Village Pond. Over the years the total number of pegs have changed as pegs have been lost and replaced, pegs have been added where bank retreat has extended along bank, and pegs have been lost and not replaced or no longer monitored in areas with no bank retreat. Currently there are 19 pegs at Rainbow Reach and 20 at Village Pond.

This assessment has been undertaken to comply with the Manapōuri Power Scheme resource consent conditions requiring a survey in response to a flow >800 cumecs in the Upper Waiau River at Queens Reach. Refer to Section 1.1 for consent monitoring conditions. The flow event of >800 cumecs that is the subject of this report occurred over 10 days from 23 October until 1 November 2025.

AECOM has previously completed assessments of bank erosion at Rainbow Reach and Village Pond sites for both scheduled surveys and > 800 cumec event surveys. The last assessment was a 7-year survey, undertaken on 15 March 2023. Refer to Appendix A for a full list of monitoring surveys and geomorphic assessments.

Data for this event-driven survey was collected by WSP Opus on 17th and 18th December 2025. The survey data includes the distance from the top of the riverbank to the pegs, the slope of the riverbank down to the water line and aerial imagery of the eroding riverbanks at Rainbow Reach and Village Pond.

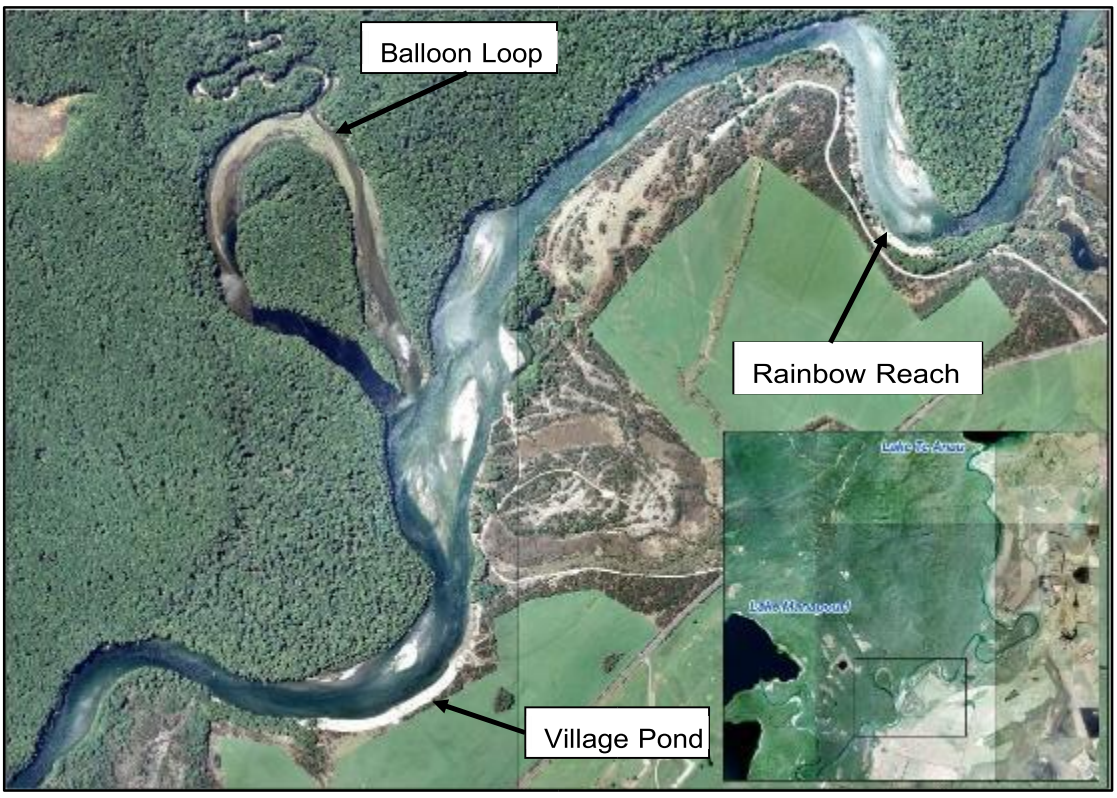


Figure 1 Project area including location of peg line survey area (LINZ Data Service)

1.1 Consent Monitoring Conditions

Appendix 1 to the Manapōuri Power Scheme 1996 consents sets out the peg line survey monitoring requirements as follows:

> *Objective: To continue to measure the amount of river bank erosion in the Upper Waiau River, after establishment of the refined flow regime.*
>
> *Methods: Two "peglines" were installed in the Upper Waiau River in 1983. These were at Rainbow Reach and "Village Pond". Offset measurements of the peglines will be reassessed every seven years with the next monitoring being undertaken in 2016; and after flows in excess of 800 cumecs (approximately 10-year return period) to enable the magnitude of erosion to be monitored. (The peglines were last surveyed in March 2003 (Opus 2003)).Reporting should give particular regard to the cliff aspect of any erosion occurring (fretting), relative to similar erosion in the general area so that the mechanisms of this type of erosion can be considered. Reporting should also identify events or trends of particular note and potential causes for these.*
>
> *Photo stations established by Opus in 2003 (refer Opus, April 2003) on the true right bank opposite both pegline sites shall be re-photographed concurrently with the pegline surveys every two years and after flows in excess of 800 cumecs.*
>
> *References:*
> *Opus International Consultants (November 2002). "Waiau River Monitoring Programme and Cross Section Survey Review."*
> *Opus International Consultants (April 2003). "Upper Waiau Peglines" (Letter, pegline surveys and photographs).*

As required by Appendix 1 of the Manapōuri Power Scheme 1996 consents, monitoring is undertaken to assess river bank erosion in the Upper Waiau River. The consent also requires triggered monitoring following flow events exceeding 800 cumecs (approximately a 10-year return period), to enable the magnitude of erosion to be monitored.

There have been 16 surveys completed since the peg lines were established in 1983. The surveys prior to 1999 were irregular and not required by resource consent conditions. The 1999 survey was undertaken shortly after a >800 m^3/s flow event. Subsequent surveys were at yearly intervals until 2002/3. The Te Anau Earthquake of August 2003 prompted a re-survey later that year, and thereafter surveys were at 2-yearly intervals until 2009, when the surveys changed to a 7-year monitoring interval, the first of which occurred in 2016 (due to a change in resource consent conditions). However, in April/May 2010 (26/4/10 – 6/5/10) and again in January 2013 (10/1/13 – 12/1/13) flow in the Upper Waiau River exceeded 800 m^3/s and post-flood surveys were therefore carried out in accordance with the resource consent conditions regarding a high flow event (over 800 cumecs). Surveys triggered by 800 cumec events do not reset the 7-year monitoring interval.

This report has been undertaken due to triggered monitoring by a flow event exceeding 800 cumecs.

A summary table of the historical monitoring regime of the peg lines is presented in Appendix A.

1.2 Scope of Work

The scope of works for this geomorphic assessment required under the Consent Monitoring (refer Section 1.1 above) is as follows:

- Analyse riverbank erosion survey data as monitored from two peg lines on the Upper Waiau River at Rainbow Reach and Village Pond to address the requirement for event-driven monitoring in the resource consent.
- Take regard to the "cliff aspect" of any erosion occurring relative to similar erosion in the general area so that the mechanisms of this type of erosion can be considered. It is noted that 'cliff aspect' is not a geomorphic term and is not defined in the consent conditions.
- Identify significant events and trends and discuss potential causes.

2.0 River Channel Geology and Morphology

The Upper Waiau River is 22.3 km long and drains southwards from Lake Te Anau into Lake Manapōuri. The geology along the Upper Waiau River is shown in Figure 2. There are several different types of loose, unconsolidated gravel and sand deposits that were formed in a complex of glacial, fluvial, and lacustrine environments between the terminal lobes of the Manapōuri and Te Anau glaciers between 30,000 and 14,000 years ago. This glacial till and outwash material (units mkt & mko on Figure 2) and recent fluvial terrace surfaces (unit fa) straddle the margins of the active river channel within the wider floodplain.

The Rainbow Reach site lies within the fluvioglacial gravels. These moraine materials have been transported from the glacier by meltwater and deposited as well packed sheets of alluvium.

Village Pond cuts into the Manapōuri Sand which is a slightly cemented, bedded coarse sand, interlayered with silts and gravels. The difference in riverbank materials may influence the style and rate of erosion at this site.

The Upper Waiau River can be roughly divided into two sub-reaches (upstream and downstream) which are controlled by the regional geology of the Upper Waiau valley:

- The upstream reach is confined by steep hillslopes on the western part of the river channel, extending 5 km downstream of the Lake Te Anau outlet and Lake Control Structure (TLC). This sub-reach is partially confined, and the channel alignment is stable, with a Sinuosity Index of 1.3. The degree of “windiness” of the river course is measured by the Sinuosity Index (SI) calculated as channel (or thalweg) length ÷ valley length
- The downstream reach extends from Horseshoe Bend to the mouth of Lake Manapōuri. In this reach, the river channel is bounded by glacial outwash materials or recent fluvial terraces (fa, gravels, sands and silts) and has an unconfined to partially confined valley setting. The reach has a SI of 2.4, including a number of active meanders. Where the channel is unconfined (located in the recent fluvial terraces fa), it has the ability to laterally migrate.

Sinuosity

The valley distance along the Upper Waiau River between Lakes Te Anau and Manapōuri is 14.3 km, however the winding river course covers some 22.3 km. For the Upper Waiau River, the overall SI = 1.56 (22.3 ÷ 14.3), which indicates it has a meandering character. However, this average SI measure obscures variability along the Upper Waiau River, where some sub-reaches are much more sinuous than others.

The upstream 5 km from TLC to Horseshoe Bend has SI = 1.3 (mildly sinuous), while the next 4 km to beyond Village Pond has SI = 2.0, which is strongly meandering. If the river still flowed around the Balloon Loop the SI of this sub-reach would be 2.3. The two peg line sites are in this strongly meandering sub-reach. Downstream there are two further sub-reaches of SI = 1.2 (mildly sinuous), and SI = 1.7 (meandering).

Channel slope

Data from which to estimate channel slope is taken from the topographic map, and lake level data. Analysis is necessarily limited as only two 20 m contour lines cross the river.

From lake level monitoring data, the river drops on average 24.6 m between the two lakes (202.38 m – 177.80 m, mean daily level 1975 – 2011). However, as the lake levels can be controlled independently of each other (and in accordance with the gazetted Lake Level guidelines), the fall can be as much as 25.9 m (when Lake Te Anau is high, and Lake Manapōuri is low), and as little as 22.9 m (when Lake Te Anau is low, and Lake Manapōuri is high). The river slope averages 0.0011 m/m (0.0012 m/m – 0.0010 m/m).

Again, this average slope conceals some likely variability, although this cannot be accurately documented given the limited data. The 200 m contour crosses the river at the end of Queens Reach and the slope of this 6.6 km sub-reach is gentle at just 0.0004 m/m (0.4 m/km). The 180 m contour crosses the river at the upstream end of sub-reach four, so the average slope of sub-reaches two and three (which includes Rainbow Reach and Village Pond peg lines) is 0.0015 m/m (1.5 m/km). This is nearly 4 times steeper than sub-reach one. Sub-reach four to Lake Manapōuri slopes at 0.0008 m/m (0.8 m/km).

From this it can be seen the eroding banks monitored by the peg line surveys occur in the most meandering and steepest part of the Upper Waiau River channel.

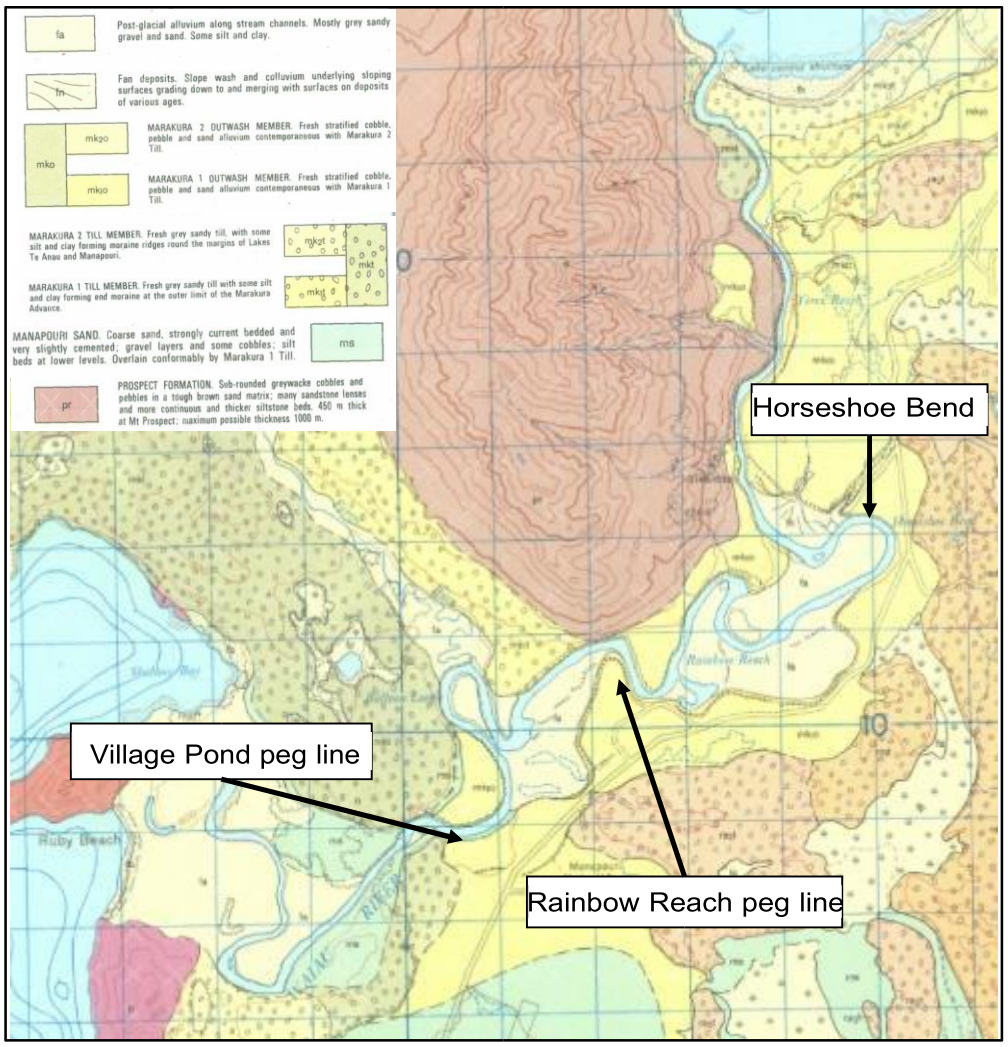


Figure 2 1:50,000 scale map geological map of the Te Anau-Manapōuri District (McKellar, 1973).

3.0 Upper Waiau River Flows

Erosion of the riverbanks at the Village Pond and Rainbow Reach bends has historically been driven and continues to be driven by flow in the Upper Waiau River. The expectation of the consent condition is that erosion is likely to be exacerbated by very high flows in excess of 800 cumecs. However, as noted by AECOM (2016, 2020, 2023) it is likely that other flow characteristics also play a role in erosion, therefore mean flow (calculated for each assessment based on flow data) and high flows (approximately 400 cumecs), are also reported on as distinct from very high flows, >800 cumecs (AECOM 2016).

There have been six[1] events which have exceeded flows of 800 cumecs at the Queens reach monitoring site on the Upper Waiau River since monitoring at this station began in 1976, two of which occurred since the last monitoring round, in September 2023 and October/November 2025. Flow duration, mean flow and peak flow for each of these events are listed in Table 1.

Table 1 Flow events that have exceeded 800 cumecs at Queens Reach - Upper Waiau River

Date	Number of Days >800 m^3/s	Mean Flow (m^3/s)	Peak Flow (m^3/s)
18 October 1988 – 12 November 1988	26	957	1081
18 November 1999 – 23 November 1999	6	859	901
26 April 2010 – 06 May 2010	10	880	968
10 January 2013 – 12 January 2013	2.3	815	827
4 December 2019 – 14 December 2019	10	885	975
22 September 2023 – 23 September 2023	2	802	804
23 October 2025 – 1 November 2025	10	877	920

Figure 3 shows the flow since the last monitoring round in 2023 to the 18th December 2025. Within this monitoring period (2023 – 2025) there were six > 400 cumec events that occurred on the Lower Waiau River.

[1] Event-driven monitoring was not undertaken in response to the September 2023 flow event because the exceedance was determined by Meridian to be within measurement accuracy of the 800 cumec trigger value.

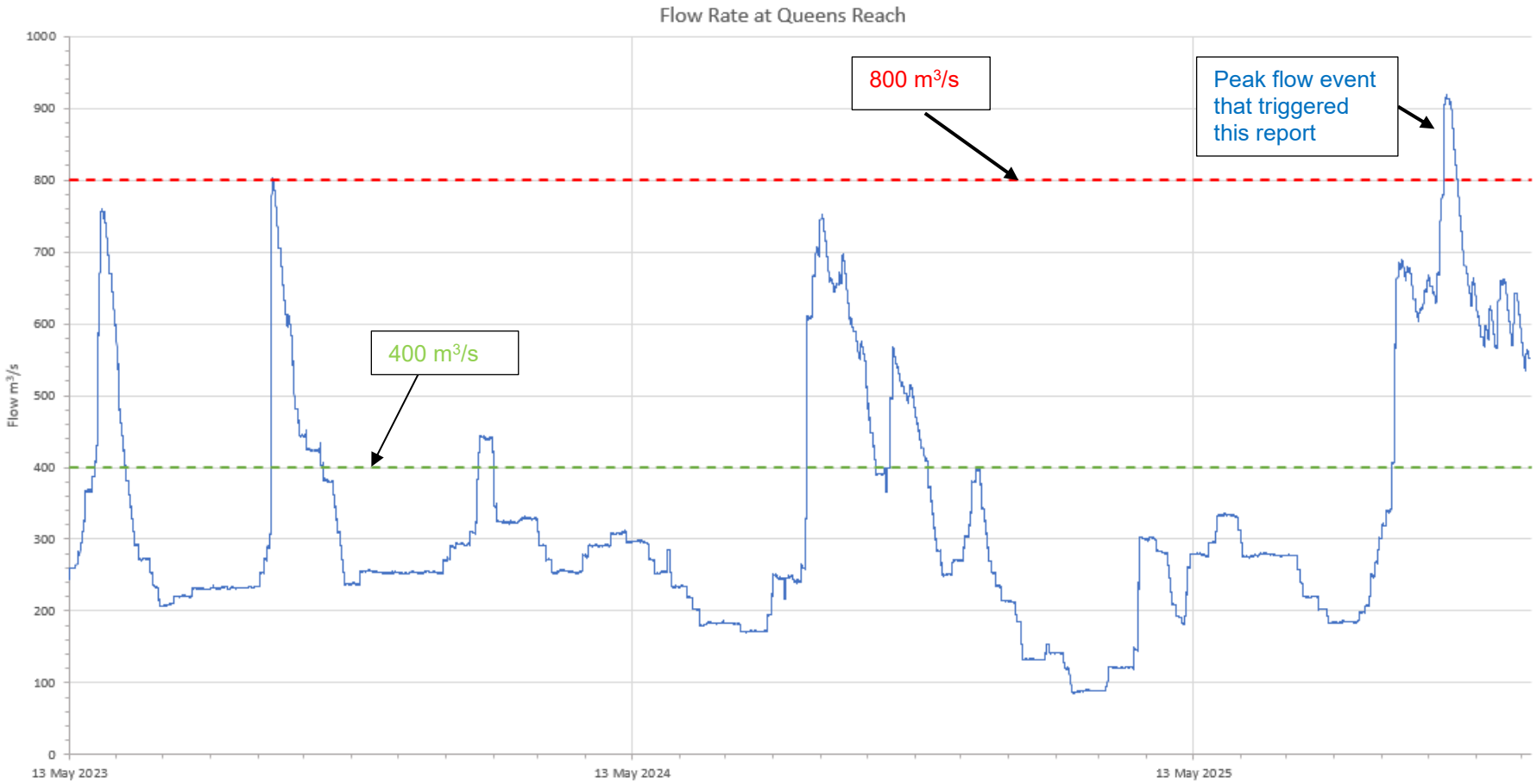


Figure 3 Hourly mean river flow for the Upper Waiau at Queens Reach (Site 79708) 13 May 2023 to 18 December 2025 (data provided by Eddie Stead, Meridian Energy Ltd).

Table 2 compares short term (since the last 7-year survey) and long term flow characteristics at Queens Reach. The mean flow rate for the monitoring period 2023 to 2025 was 330 m^3/s, which is 41 cumecs higher than the long-term average flow rate (289 cumecs) since monitoring at Queens Reach began in March 1976. A summary of high (>400 cumecs) and very high (>800 cumecs) flow events are also included in Table 2.

Table 2 Short and long-term flow characteristics at Queens Reach – Upper Waiau River

Period	Mean Flow (m^3/s)	% time >400 m^3/s	Number of events >400 m^3/s	% time >800 m^3/s	Number of events >800 m^3/s
1976 - 2025	289	14	98	0.4	7
2023 - 2025	330	24	7	1.0	1

4.0 Peg Line Survey Data - Monitoring Period 2023 to 2025

The locations of the peg line erosion monitoring sites, Rainbow Reach and Village Pond, are shown in Figure 1. The Survey data is included in Appendix B, with summary tables in Appendix C.

Both monitored sites of erosion occur on meander bends in the downstream sub-reach and are cutting into higher terraces formed in outwash gravels and the Manapōuri Sands.

Survey of both sites was undertaken using a combination of GPS and Unmanned Aerial Vehicle (UAV). The UAV was used to capture imagery and point cloud data of the surface of the banks. Panoramic images were taken from the established vantage point for reference to previous years' survey (WSP Opus 2025). Vegetation cover assessment has been undertaken on vertical imagery supplied with the Pegline survey, to allow for comparison with historic images.

The survey assessment focuses on data and photogrammetry comparisons from 2020, 2023, and 2025, providing a short-term evaluation of photogrammetry change across these survey periods within the broader long-term survey record.

The slope angle descriptions have been updated using 2025 WSP UAV data, which provides information on changes in slope angle from the water to the top of the bank. The survey data (refer Appendix B) includes only the overall slope angle.

4.1 Peg re-establishment

Peg loss due to bank retreat at the sites required re-establishment of 12 pegs in 2016. The replacement pegs were established approximately 15m behind the old pegs. The offset adjustment was not reported on in the 2016 report and was not taken forward for the 2020 and 2023 AECOM geomorphology assessments where bank retreat at the re-established pegs was assessed pre 2016 and post 2016. While some bank retreat occurred between 2013 and 2016 at the 12 pegs, the trends remain the same and the geomorphic assessment and conclusions remain valid. The geomorphology assessment on the 2025 monitoring has included the offset adjustment in the assessment. Refer to Appendix D for further details.

4.2 Rainbow Reach Peg Line Survey

The eroding bank at Rainbow Reach is approximately 540 m long and is located on the downstream limb of a tight meander bend upstream of the Balloon Loop cut-off (refer Figure 4 to Figure 6). Erosion is asymmetrically distributed from the bend apex downstream, resulting in a largely straight section of actively eroding bank. The average bank height is 26 m, with a slope distance of approximately 40 m from the top of bank to the river margin.

Vegetation cover across the eroding bank is estimated at ~40%, consisting mainly of scattered shrubs and grasses, representing a decrease of approximately 15% since 2023. Vegetation cover at the site has shown an increasing trend since 2002 when the bank was largely unvegetated through to 2023. A predominantly bare gravel bank persists at the upstream end of the reach, extending over approximately 190 m and accounting for ~38% of the total eroding bank length.

The eroding bank can be subdivided into two zones based on geomorphic characteristics:

1. Upstream Zone (~190 m; pegs 109–307):
   This zone is steeper, has less vegetation and high recent erosion rates. The zone has been extended downstream from the 2023 assessment extent (pegs 109–304) to reflect the downstream migration of active erosion (refer Figure 4 to Figure 6). The overall slope angle within this zone ranges from approximately 46° to 54°, an increase from 37° to 44° degrees in 2023, and vegetation cover is limited as shown in most recent aerial imagery (Figure 5).
2. Downstream Zone (~410 m; pegs 307–802):
   This zone has a gentler overall slope, with average slope angles of approximately 36° to 41°, and supports higher vegetation cover of approximately 65%. There has been little change in this zone since the last survey in 2023.

Migration of the active area of erosion on the outside of meander bends is a natural process and expected to change over time, in particular as this reach is currently adjusting to the Balloon loop cut off. This process was occurring prior to the operation of the Manapōuri Power Scheme. The historic changes are further discussed in Section 6.1.

Detailed survey data are presented in Appendix C: Table C1, shows the cumulative top-of-bank retreat recorded along the Rainbow Reach pegline since monitoring commenced in 1983 for both the upstream and downstream zones.

Recent top-of-bank retreat in the upstream zone is evident at pegs 110, 302, 305, and 306, refer to Figure 7. From 2023 to 2025 the mean retreat rate for the upstream zone is approximately 0.3 m/yr, whilst the long-term rate is approximately 0.6 m/yr at these pegs (Table C1). This bank retreat coincides with increased slope steepening in the upper bank. This slope adjustment and bank failure will continue to occur as the slope profile continues to adjust to a stable gradient, and will continue to occur in the future.

In contrast, the downstream zone, refer to Figure 8, has experienced minimal bank retreat in recent decades. Since 2023 the mean retreat rate for this zone has been 0.0 m/yr, well below the long-term (1983–2025) average of 0.6 m/yr, with little discernible bank retreat recorded since 2000.

Overall, Rainbow Reach has experienced a mean bank retreat rate of 0.11 m/yr since 2023, considerably lower than the long-term average rate of 0.58 m/yr recorded between 1983 and 2025 (Table C1).

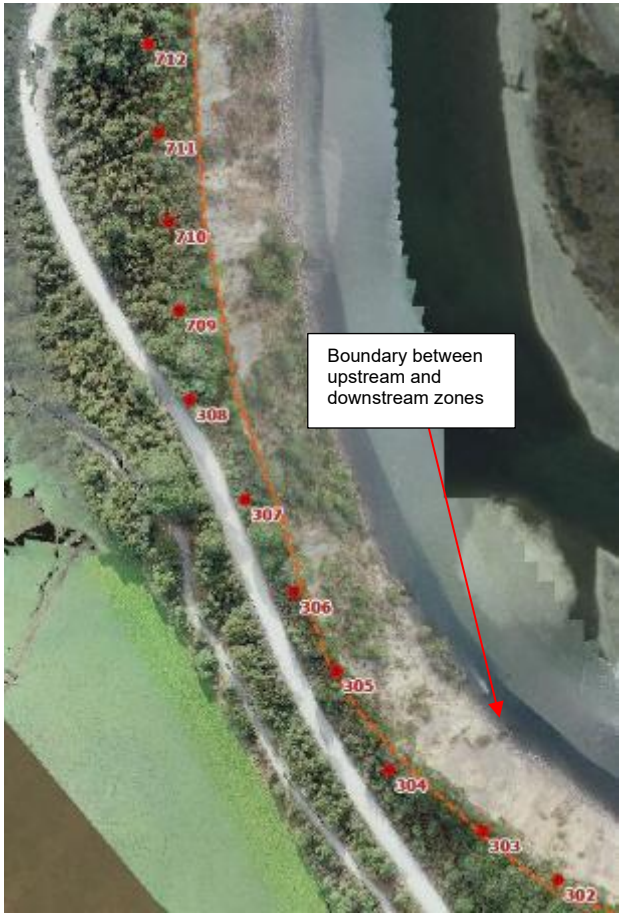


Figure 4 Rainbow Reach zone boundary 2020. Downstream towards top of page



Figure 5 Rainbow Reach zone boundary 15/3/2023. Downstream towards top of page



Figure 6 Rainbow Reach zone boundary 18/10/2025. Downstream towards top of page

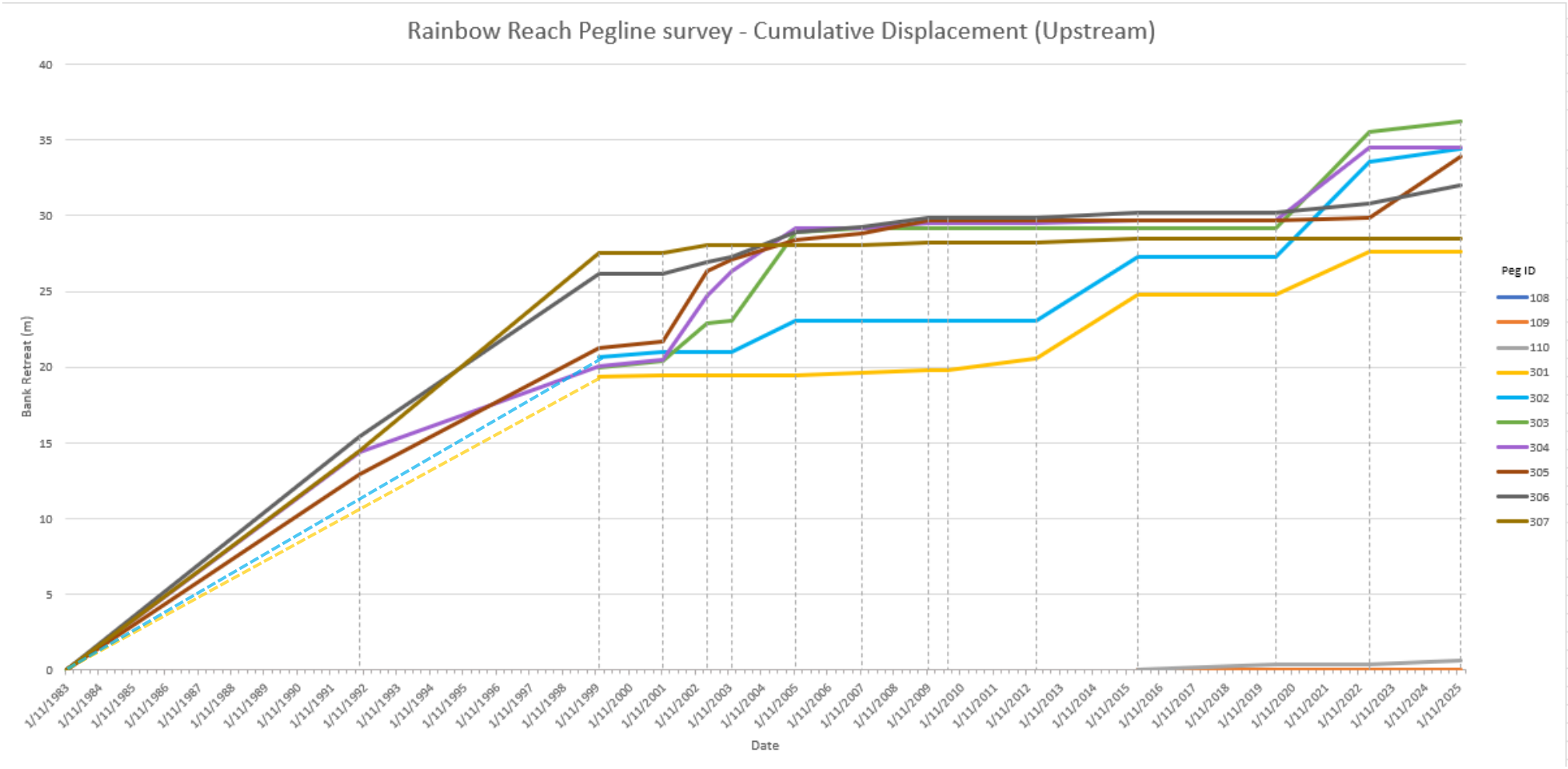


Figure 7 Cumulative displacement of pegs 108-307 (upstream) at Rainbow Reach peg line from 1983 to 2025

Note: Displacements are relative to previous survey peg positions. Rate of movement at pegs 301, 302 & 303 has been inferred between 1983 and 1999 as pegs were not surveyed in 1992. Pegs 109 & 110 were added during the 2016 survey. No measurements have been recorded at peg 108, it is very close to Peg 109, which has been used to monitor bank retreat. Peg locations are shown in Appendix B.

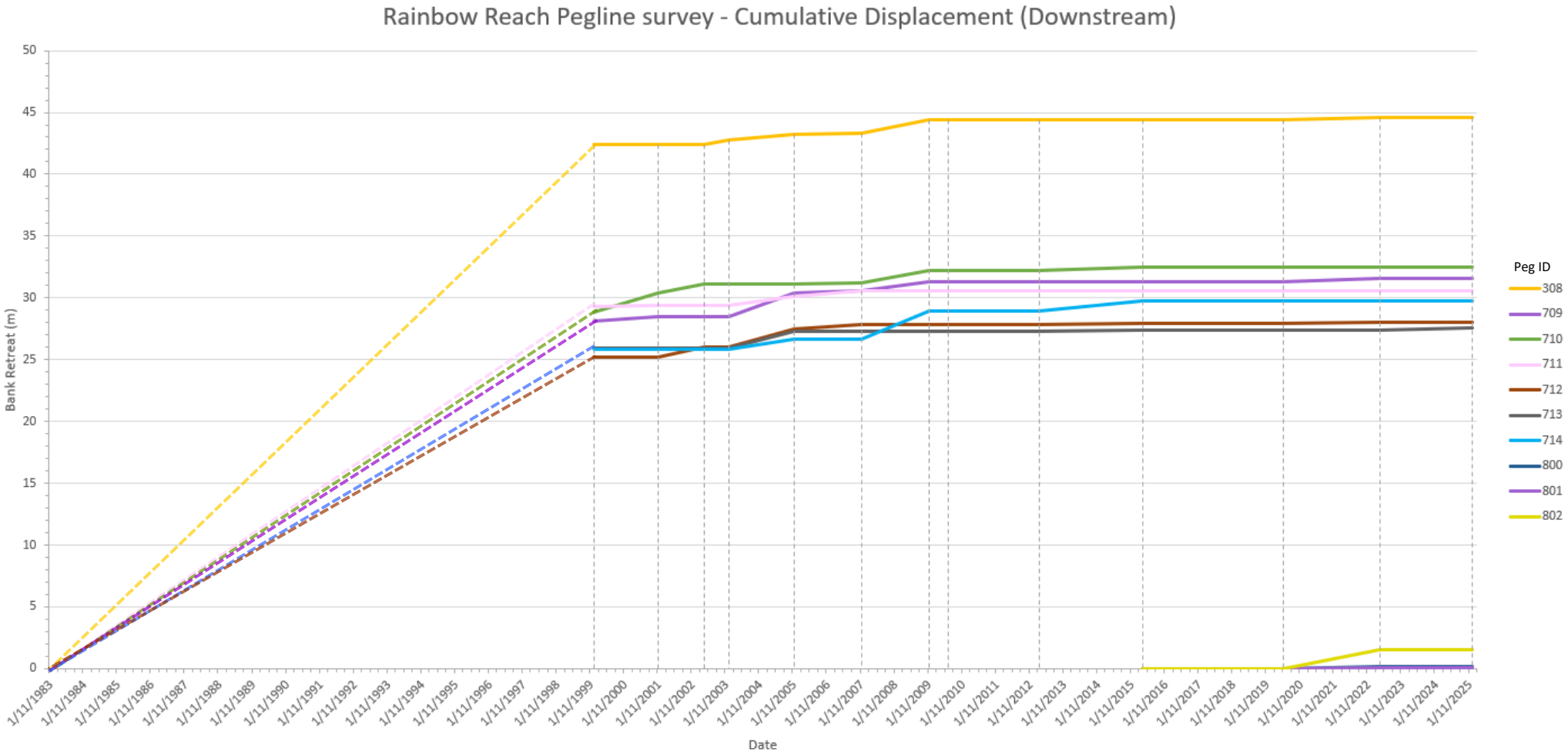


Figure 8 Cumulative displacement of pegs 308-802 (Downstream) at Rainbow Reach peg line from 1983 to 2025

Note: Displacements are relative to previous survey peg positions. Rate of movement at pegs 308-714 has been inferred between 1983 and 1999 as pegs were not surveyed in 1992. Pegs 800-802 were added during the 2016 survey. Peg locations are shown in Appendix B.

4.3 Village Pond Peg Line Survey

The eroding bank at Village Pond is 530 m long and is located on the outside of the bend downstream of the Balloon Loop in the Manapōuri Sands. About 40% of the site has some vegetation cover, although this is unevenly distributed in blocks of nearly continuous vegetation cover, completely bare areas, and areas with scattered clumps of vegetation. The erosion is symmetrically arranged upstream and downstream of the apex of the bend and so is in a slightly different arrangement than the Rainbow Reach site where the erosion is largely downstream of the bend apex. The bank height averages 26.5 m, and the slope distance from the top of the bank to the river edge is ~43 m.

The survey data for Rainbow Reach is included in Appendix B sheet C01 and C02 (WSP Opus, 2025), and summarised in Table C2 in Appendix C.

The eroding bank can be divided into two zones:

1. Upstream ~90 m (pegs 2100 – 1800) where the overall slope angle is ~35^{o} to 40^{o}, with little to no sub vertical component at the top. There is a near continuous vegetation cover of grass and low scrub, with very little erosion occurring at river level, and only slow retreat at the top of the bank
2. Downstream ~440 m (pegs 1700 – 100) where the overall slope angle is ~34 ^{o} to 43^{o}, with a 1 - 4m sub vertical component. There is little if any vegetation cover, and erosion is occurring both at river level and the top of the bank.

The boundary between these two zones is distinct and has been advancing upstream over the past 21 years (refer Figure 12, Figure 13, and Figure 14). Migration of the active area of erosion on the outside of meander bends is a natural process and expected to change over time, in particular as this reach is currently adjusting to the Balloon loop cut off. This process was occurring prior to the operation of the Manapōuri Power Scheme. The historic changes are further discussed in Section 6.1.

In 2002 aerial photographs (from Linz Data Service) it is 365 m from the upstream end of the erosion zone, and subsequent imagery show it at 310 m in 2007, 246 m in 2010, 180 m in 2014, 115m in 2023 and 90m in 2025. The upstream migration of the erosion zone boundary is likely linked to the ongoing rearrangement of the channel in this area due to the cut-off of Balloon loop.

The cumulative retreat since monitoring began in 1983 at pegs at the upstream and downstream zones of the Village Pond peg line are presented in Figure 9, Figure 10, and Figure 11. Note that due to the high number of pegs in the downstream zone, the data for this zone has been spread over two figures (Figure 10 and Figure 11).

Top of bank retreat has remained modest at most of the sites in the upstream zone where vegetation cover is good (pegs 2100 – 1800). The average retreat rate for these pegs from 2023 to 2025 was 0.26 m/yr, more than the long-term retreat rate at these pegs of 0.12 m/yr (Table C2). Pegs 2000 and 2100 have noticeable increases in cumulative displacement of 0.30 m/yr and 0.47 m/yr, as seen in Figure 10 from the 2023 to 2025 monitoring period.

Pegs in the downstream zone showed a mean top of bank retreat rate of 0.04 m/yr since 2023, lower than the long-term (1983-2025) mean of 0.27 m/yr. The slope has good vegetation cover, and the top of bank retreat may be due to local erosion at the top of the slope rather than erosion at the toe of the slope that has worked its way up.

As the boundary between the downstream and upstream erosion zones migrates past pegs, an increase in bank retreat has been observed in the data. This ‘step’ in bank retreat rate as the zone boundary passes can be seen in Pegs 1400 and 1300 between 2012 and 2016, in Pegs 1100 and 1000 between 2009 and 2010 and in Pegs 900 and 800 between 2003 and 2009 (Figure 11). Peg 1200 is located in a small gully, and therefore did not record the same step in bank retreat as adjacent pegs when the zone boundary passed it. The rates of bank retreat generally flatten over time after the zone boundary passes pegs.

Overall, Village Pond had a mean rate of bank retreat rate of 0.06 m/yr since 2023, lower that the long-term (1983-2025) rate of 0.24 m/yr (Table C2).



Figure 9 Village Point zone boundary 2020 (WSP 2025)

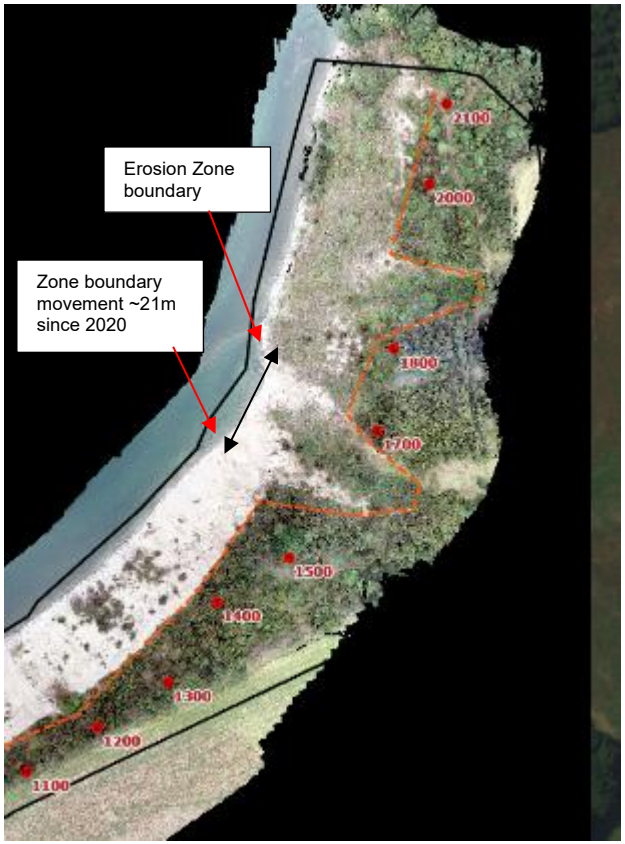


Figure 10 Village Point zone boundary 15/3/2023 (WSP 2023)

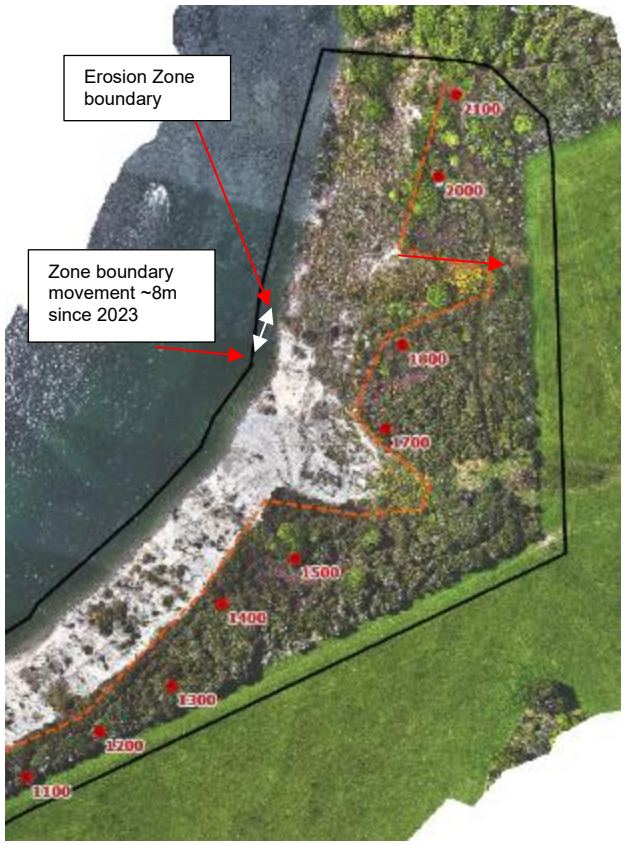


Figure 11 Village Pond zone boundary 18/10/2025 (WSP 2025)

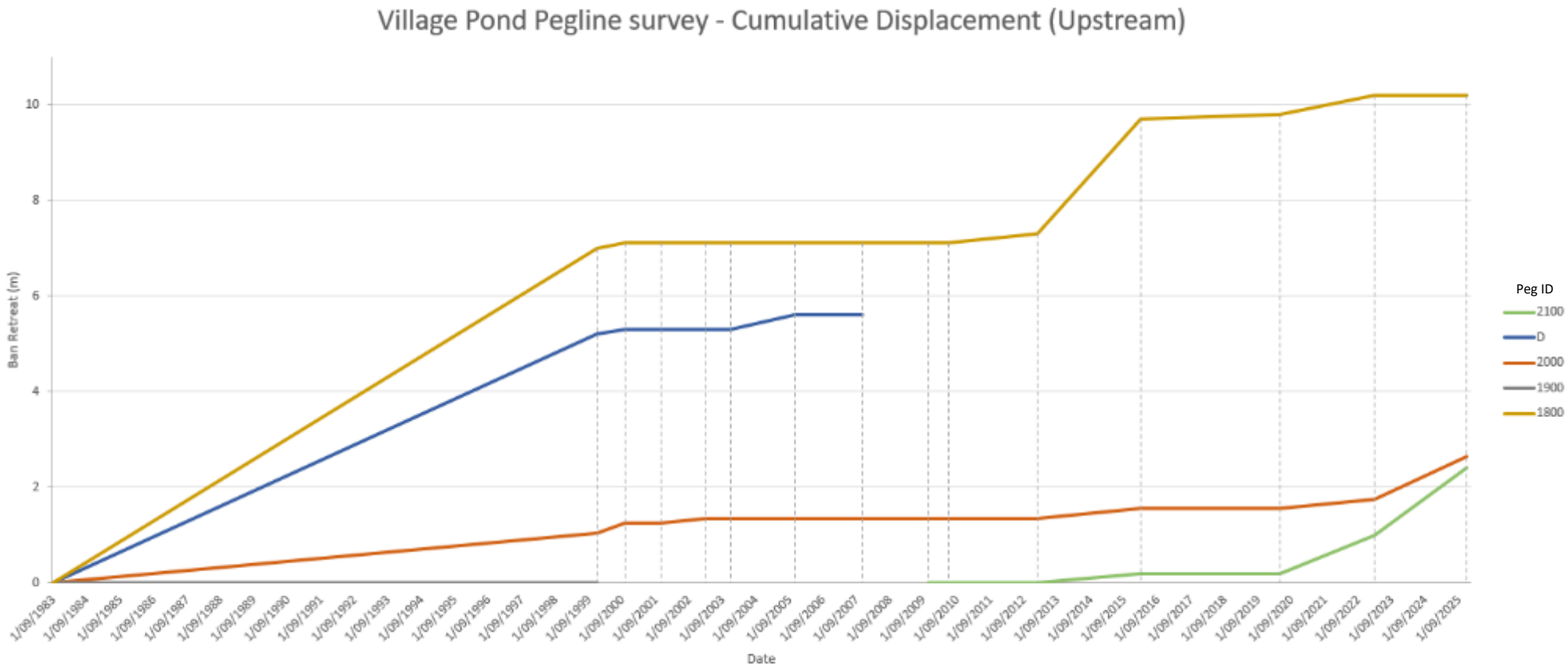


Figure 12 Cumulative displacement of pegs C – 2100 (Upstream) at Village Pond peg line from 1983 to 2025

Note: Displacements are relative to previous survey peg positions. Peg 1900 was missing during 1999 survey and was not replaced. Peg D has not been surveyed since 2007. Peg 2100 was installed in 2009. No measurements have been recorded at peg C. Peg locations are shown in Appendix B.

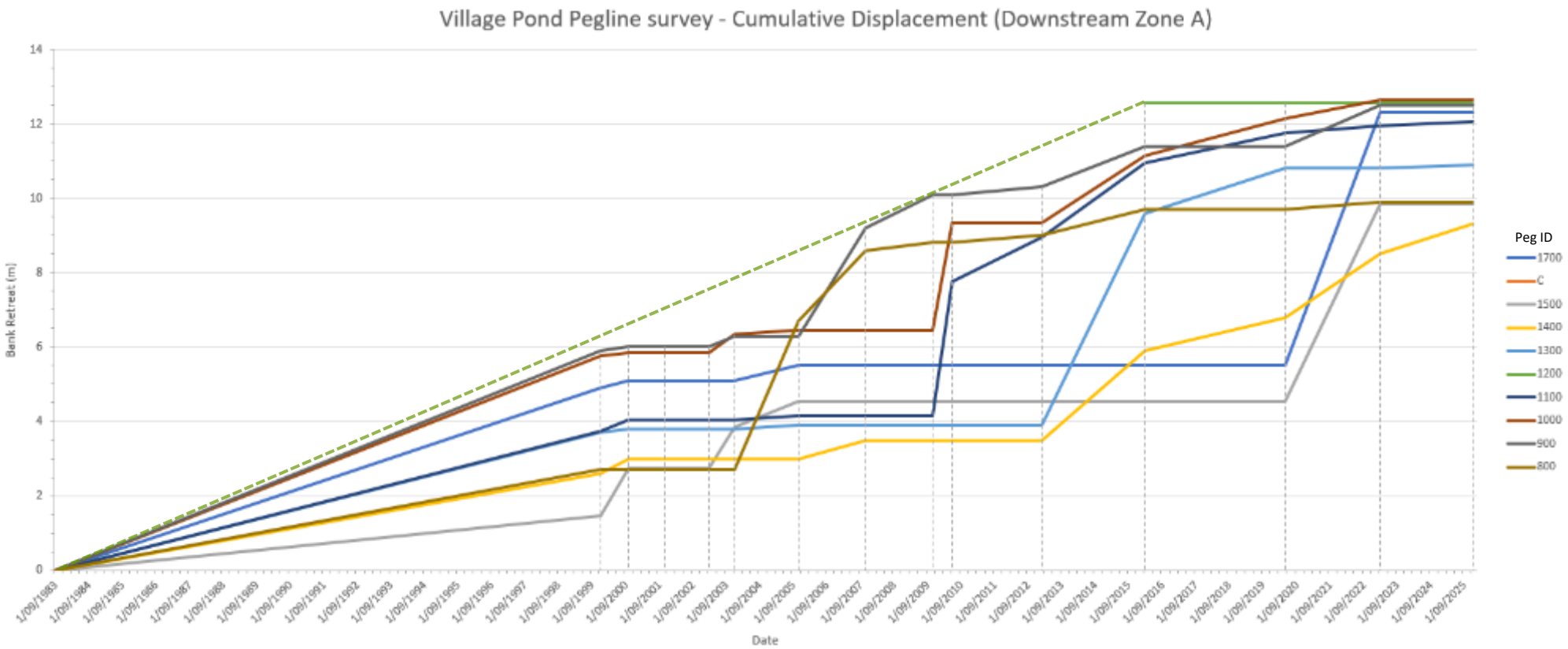


Figure 13 Cumulative displacement of pegs 800-1700 (Downstream Zone A) at Village Pond peg line from 1983 to 2025

Note: Displacements are relative to previous survey peg positions. Peg 1200 was missing during 1999 survey and was replaced in 2016. Peg locations are shown in Appendix B.

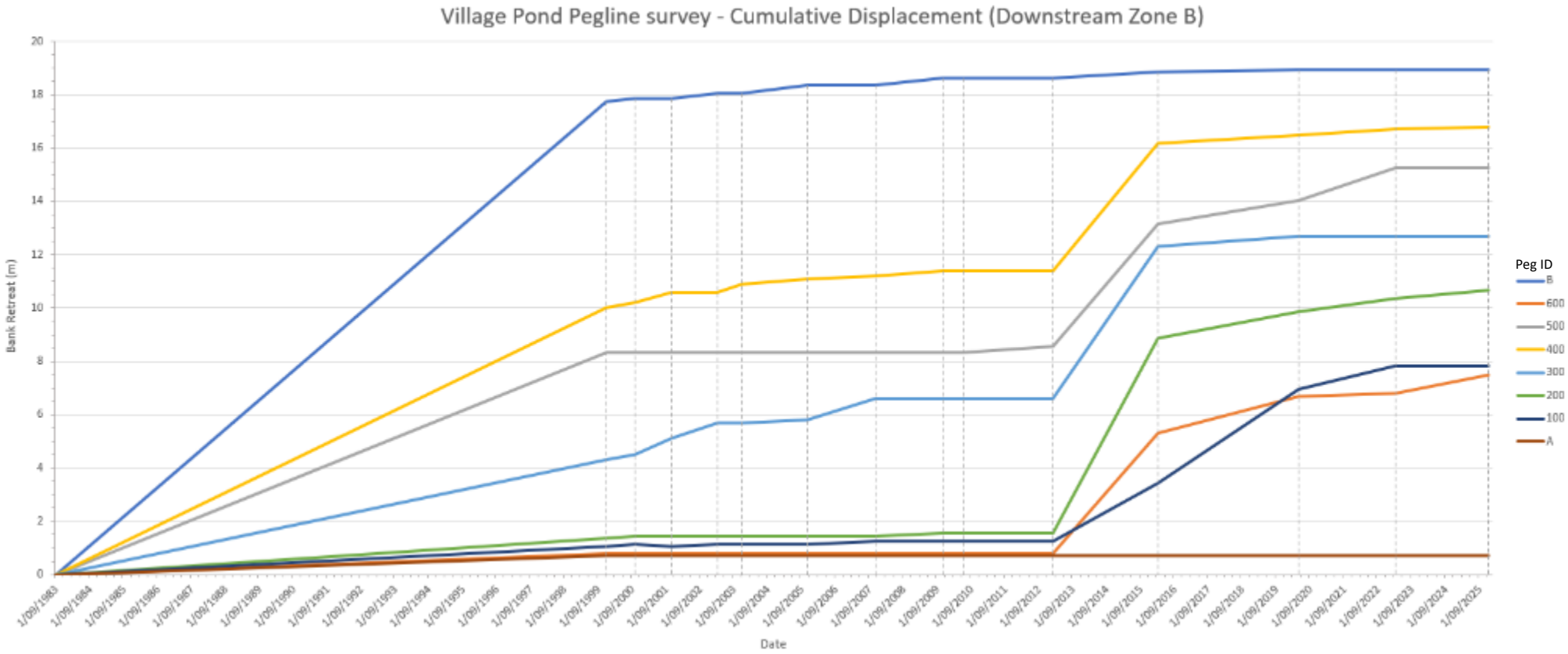


Figure 14 Cumulative displacement of pegs A - B (Downstream Zone B) at Village Pond peg line from 1983 to 2025

Note: Displacements are relative to previous survey peg positions. Peg locations are shown in Appendix B.

5.0 "Cliff Aspect" of Erosion

The Appendix 1 consent condition requires the assessment to have regard to the '*cliff aspect of any erosion occurring (fretting) relative to similar erosion in the general area, so that the mechanisms of this type of erosion can be considered'*.

This consent condition uses non-standard geomorphological terminology. Neither 'cliff aspect' or 'fretting' are geomorphological terms (as defined in geomorphology dictionaries) and they are not defined in the consent conditions. The word 'cliff' does not have a settled geomorphological definition, although generally speaking, a cliff is a landform comprising material that is strong enough to stand up in a very steep or near-vertical slope. 'Aspect' does have a commonly accepted meaning in geomorphology, referring to the (compass) direction the slope faces, but this is clearly not the intended meaning here. 'Fretting' is not a commonly used term to describe an erosion process in geomorphology, although regular English dictionaries do refer to fretting as gradually wearing away by rubbing or gnawing.

The professional opinion of AECOM authors (past and present) is that 'cliff aspect of erosion' refers to the landform forming processes that are causing the two slope complexes to erode, and requires the following to be addressed:

- Description of the geomorphic processes (mechanisms) which act on the landforms (slopes) at Rainbow Reach and Village Pond, and
- Identification of similar landforms in similar materials formed by similar geomorphic processes in the general area. This is to allow a comparison between Rainbow Reach and Village Pond, and other similar landforms.

The landforms at Rainbow Reach and Village Pond and the geomorphic processes acting on them are addressed and discussed in Sections 2.0, 4.5.0 and 6.0 of this report. These are consistent with descriptions of land forming processes in the 2023, 2020, 2016 and 2013 reports.

Rainbow Reach and Village Pond erosion slopes occur in fluvioglacial gravels that comprise slightly cemented sand/silt/gravel. Rainbow Reach and Village Pond are the only sites developed in these materials in the general area, so comparison with similar landforms cannot be undertaken. As noted in the 2020 report, erosion of younger and lower fluvial terraces (i.e., not fluvioglacial terraces) occurs in the general area (refer Figure 15). However, as the material in these younger terraces is looser and forms lower terraces, erosion can progress more quickly, and the resulting landform geometry and change over time is not comparable.

To determine if the land forming processes acting on Rainbow Reach and Village Pond are potentially affected by the operation of the MPS, AECOMs current and previous assessment approach has included the following:

- Historical review of these landforms. This has identified both Rainbow Reach and Village Pond slopes were eroding prior to the operation of the MPS and are continuing to develop in a similar way. Refer Section 6.1 this report.
- Assessment of landform change at these sites over time using the peg line monitoring data, with consideration of natural fluvial geomorphic process that occur on meandering rivers (erosion, sediment transport and deposition are all natural processes). Refer Section 4.0 and 6.2 of this report.
- Review of change in the Upper Waiau River over time, such as the Balloon Loop cut off, and potential associated changes in geomorphic processes at Rainbow Reach and Village Pond. Refer Section 2.0 and 6.0 of this report.
- Review of river flow data. Refer Section 3.0 this report.

The above approach to cliff aspect of erosion has been consistently applied to the analysis, assessment and reporting on the Upper Waiau River erosion by AECOM authors and previous reports.



Figure 15 Aerial Imagery Review of erosion occurring at sites downstream of Village Pond

6.0 Trends Over Time

6.1 Pre 1983 – Review of Historic Aerial Imagery

Rainbow Reach has dense forest cover up to at least 1965. Then by 1969 some erosion has started, and the road along the top has had to be moved back. By 1970 there is even more erosion. This all occurred before flow regulation began at TLC around 1974. It is not clear why erosion should suddenly start like this after many decades of stability (the dense forest cover suggests at least 50 years of stability). It is more than likely a natural process and not in any way out of the ordinary for a riverbank like this.

Village Pond is eroding in the earliest known aerial photographs (1949)[2], although there is a line of small trees along the base of the slope at the river edge. Review of recent aerial images shows that the upstream and downstream extents of the erosion have changed very little since 1949 and may have even reduced slightly. A large gully has expanded at the upstream end at the top of the eroding slope since 1949.

As the gullies at the crest of Village Pond continue to develop on the upstream portion of the riverbank, natural armouring may also be contributing to the slower rate of bank retreat observed, as it provides additional protection against undercutting at the base of the slope.

Figure16 shows the cut-off of Balloon Loop, directly upstream of Village Pond, which occurred between 1965 and 1979 (based on aerial imagery review). The narrowing of Balloon Loop 'goose neck' leading to its final cut off would have been ongoing for some time (in the order of hundreds of years) and predates the establishment of the regulated flow regime on the Upper Waiau River. The cut off is a natural and expected fluvial process.

Since Balloon Loop has been cut off, and as a direct result thereof, the river has been rearranging its channel and eroding a section of bank that will eventually develop into a new meander landform. This development of a new meander is a natural and expected fluvial process that has occurred due to on-going fluvial process (the narrowing of Balloon loop and eventual cut off) that predate the establishment of the regulated flow regime on the Upper Waiau River. These current processes are consistent with the long-term geomorphic process in this area, as evidenced by paleo features such as abandoned channels and meander cut-offs in the floodplain. The bank erosion has resulted in bank retreat of up to 105 m along 450 m of riverbank and is occurring in recent fluvial terrace materials on the bend directly upstream of Village Pond.

The cut-off of Balloon Loop has created a straighter section of channel upstream of Village Pond, reducing the channel length, and thus increasing flow velocity. This together with the associated bank erosion and development of the emerging meander has changed the flow characteristics at Village Pond by concentrating flows on the downstream section of the eroding bank, resulting in increased bank retreat in that area. This is due to the on-going natural geomorphic processes. These flow characteristics will continue to change in the future as the emerging meander continues to develop.

[2] Imagery publicly available on https://retrolens.co.nz

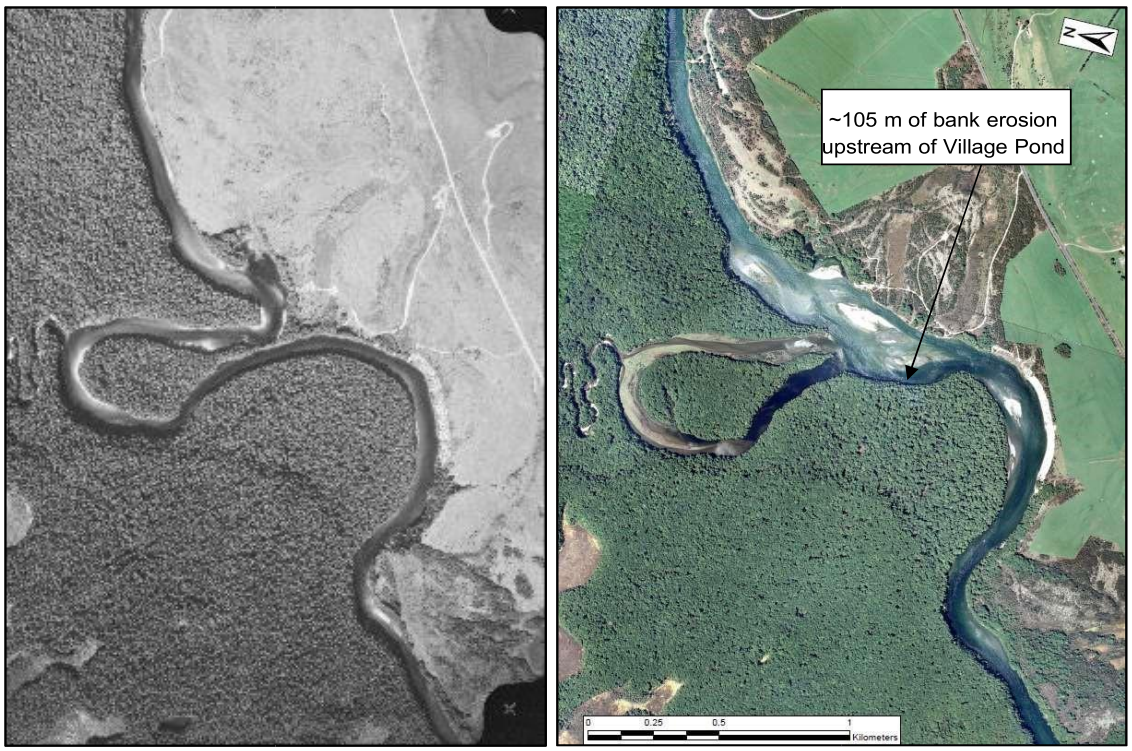


Figure 16 Aerial imagery comparison of the Balloon Loop cut-off from 1965 (pre-lake control works at the upstream outlet) to 2015

6.2 1983 until Present – Review of Peg Line Survey Data and Aerial Imagery

Rainbow Reach and Village Pond have an overall mean rate of retreat between 1983 to 2025 of 0.58 m/yr and 0.24 m/yr respectively. This represents a slight change from the previous assessment (1983-2023), during which Rainbow Reach exhibited 0.59 m/yr and Village Pond exhibited 0.21 m/yr, however rates are within historic variability. Longer-term erosion patterns observed between 1983 and 2023 show Rainbow Reach eroded at approximately three times the rate of Village Pond.

At Rainbow Reach, the overall trend from 2023 to 2025 includes minor bank retreat occurring within the downstream zone, averaging ~0.04 m/yr, consistent with the negligible retreat recorded between 2016 and 2023. Retreat within the upstream zone, which is more active, averages 0.27 m/yr between 2023 and 2025, lower than the long-term rates of 0.6 m/yr rates recorded. The more active upstream zone has extended downstream over the period 2023 to 2025, with the boundary between the upstream and downstream erosion zones migrating from between pegs 304 and 305 to now include pegs 304 to 308 see Figure 4 to 6. Pegs 305 and 306 recorded the highest retreat rates within the upstream zone during 2023 to 2025 (1.33 and 0.4 m/yr respectively), consistent with the erosion being concentrated in the downstream portion of the upstream zone. The upstream zone has also increased in steepness between 2023-2025, due to the higher flows experienced and associated erosion over this time. This steepening is consistent with geomorphological principles of bank instability, whereby continued slope adjustment and bank failure will drive further top of bank retreat as the profile progresses towards a stable gradient. Migration of the active area of erosion on the outside of meander bends is a natural process and expected to change over time, in particular as this reach is currently adjusting to the Balloon loop cut off.

Overall, Village Pond had a mean rate of bank retreat rate of 0.06 m/yr since 2023, less than half the long-term (1983-2025) rate of 0.19 m/yr. As the boundary between the downstream and upstream erosion zones migrates past pegs, an increase in bank retreat has been observed in the data for those pegs. These events are not a departure from long term patterns observed at the site.

The above average flow discharge and frequency of >400 and >800 m3/s flows between 2023 and 2025 appear to have had little influence on the erosion rate at Village Pond and Rainbow Reach over the same time period.

7.0 Conclusions

The bank retreat rates observed over the 2023-2025 monitoring period do not represent a departure from long-term erosion patterns (1983–2025) observed at either Rainbow Reach or Village Pond. This is within historic trends.

Rainbow Reach continues to exhibit lower rates of bank retreat compared to long-term patterns, consistent with trends observed since approximately 2000. Minimal retreat persists in the downstream zone, while higher rates in the upstream zone are consistent with previous assessments and episodic responses to closely spaced high and very high flow events. Notably, the upstream zone has extended downstream since the previous assessment. This extension reflects the ongoing downstream progression of active bank adjustment as pegs within the transitional reach are now subject to higher retreat rates characteristic of the upstream zone.

Bank retreat at Village Pond during the monitoring period is performing as expected under the current flow regime and is consistent with historic trends, with the upstream migration of the boundary between the upstream and downstream erosion zone resulting in a step increase in bank retreat as it passes pegs.

This assessment was triggered from a flow > 800 m^3/s. Flows >800 m^3/s trigger a survey to enable the magnitude of erosion to be monitored, implying that elevated erosion may result from flows of this discharge. No significant response in bank retreat was observed at Village Pond or Rainbow Reach during the 2023-2025 monitoring period despite the occurrence of flows exceeding this threshold. There is no geomorphic evidence to suggest that flow regimes since flow was regulated have changed erosional trends over and above those that were occurring prior to regulation. There is no visible response to changes to bank retreat related to >800 cumecs flow, which is consistent with historic trends.

8.0 References

AECOM 2016, Upper Waiau Pegline Survey 2016.

AECOM 2020, Upper Waiau Pegline Survey 2020.

AECOM 2023, Upper Waiau Pegline Survey 2023.

Linz Data Service LINZ Data Service

McKellar, 1973, 1:50,000 scale map geological map of the Te Anau-Manapōuri District

WSP Opus, 2023, Pegline Survey data

WSP, 2025, Pegline Survey data

Appendix A

Historical surveys and geomorphic assessments

Table A1 Historical surveys and triggering events

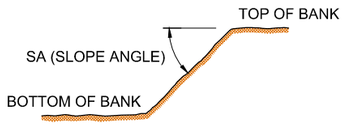
Survey Number	Survey Date	Number of pegs monitored	Reason for survey
1	**VP - 03 September 1983** **RR - 10 November 1983**	RR – 14 VP - 22	Peg lines installed at Rainbow Reach and Village Pond in the Upper Waiau to measure the rate of riverbank erosion. Surveys prior to 1999 were irregular and not required by resource consent conditions.
-	**1987**	Unknown	This survey was undertaken at both sites in 1987 by Duffill Watts and King. However, their methodology differed from other surveys and so has not been referred to in this assessment (OPUS, 2002)
2	**17 September 1992**	RR – 4	Survey undertaken as part of a suite of studies for the Waiau Working party. Village Pond not surveyed.
3	**23 December 1999**	RR – 14 VP - 19	1996 RMA consent conditions required a survey to be carried out where flow rate exceeded 800 m^3/s. This survey was triggered by a flow event of > 800 m^3/s, subsequent surveys were taken at yearly intervals until 2003.
4	**26 October 2000**	RR – 14 VP - 19	Annual (0.83 years) monitoring program.
5	**28 November 2001**	RR – 14 VP - 19	Annual (1.08 years) monitoring program.
6	**18 March 2003**	RR – 14 VP - 19	Annual (1.3 years) monitoring program.
7	**02 December 2003**	RR – 14 VP - 19	Te Anau Earthquake during August 2003 prompted a re-survey of the Upper Waiau riverbanks. Surveys thereafter completed at 2-yearly intervals until 2009.
8	**16 November 2005**	RR – 14 VP - 19	Biannual monitoring program following the Te Anau Earthquake.
9	**26 November 2007**	RR – 14 VP - 19	Biannual monitoring program following the Te Anau Earthquake.
10	**17 November 2009**	RR – 14 VP - 19	Change to resource consent conditions. Monitoring required every 7 years and after flow exceeding 800 m^3/s. Next 7 year survey scheduled for 2016.
11	**18 June 2010**	RR – 14 VP - 19	River flows in the Upper Waiau exceeded 800 m^3/s during April and May 2010.
12	**28 February 2013**	RR – 14 VP - 19	River flows in the Upper Waiau exceeded 800 m^3/s during January 2013.
13	**24 March 2016**	RR – 19 VP - 20	Surveyed for the 7-yearly monitoring program.
14	**13 May 2020**	RR – 19 VP - 20	River flows in the Upper Waiau exceeded 800m^3/s during December 2019
15	**15 March 2023**	RR – 19 VP - 20	Surveyed for the 7-yearly monitoring program.
16	**17-18 December 2025**	RR – 19 VP - 20	River flows in the Upper Waiau exceeded 800m^3/s during 27th October 2025

Appendix B

WSP Maps of Survey Pegline Data

LEGEND

- EDGE OF BANK 10/11/83
- EDGE OF BANK 15/03/23
- EXISTING EDGE OF BANK 2025
- EXISTING EDGE OF WATER 2025
- IT (IRON TUBE)
- PEG



WAIAU RIVER

EDGE OF BANK 15/03/2023

EDGE OF BANK 10/11/1983

EXISTING EDGE OF WATER

EDGE OF BANK 17-18/12/2025

IT XIX

IT XX SO 10978

IT XXI SO 10978

O PA 000

PEG C 1600 (Missing)

1900 (Missing)

TRAVERSE LINE

SA 55°35' SA 42°28' SA 42°11' SA 42°40' SA 41°34' SA 44°21' SA 40°41' SA 37°07' SA 44°18' SA 44°03' SA 43°47' SA 44°14' SA 40°54' SA 43°56' SA 47°04' SA 33°12' SA 34°40'

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1:1500@ A3
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New Zealand

CIVIL

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A.TENGU	Q.STEPHENS	C.FEELY
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
J.BOYDE	Q.STEPHENS	30/01/2026

INFORMATION

PROJECT
MERIDIAN ENERGY
UPPER WAIAU RIVER
LEFT BANK EROSION

TITLE
VILLAGE POND SLIP LINE

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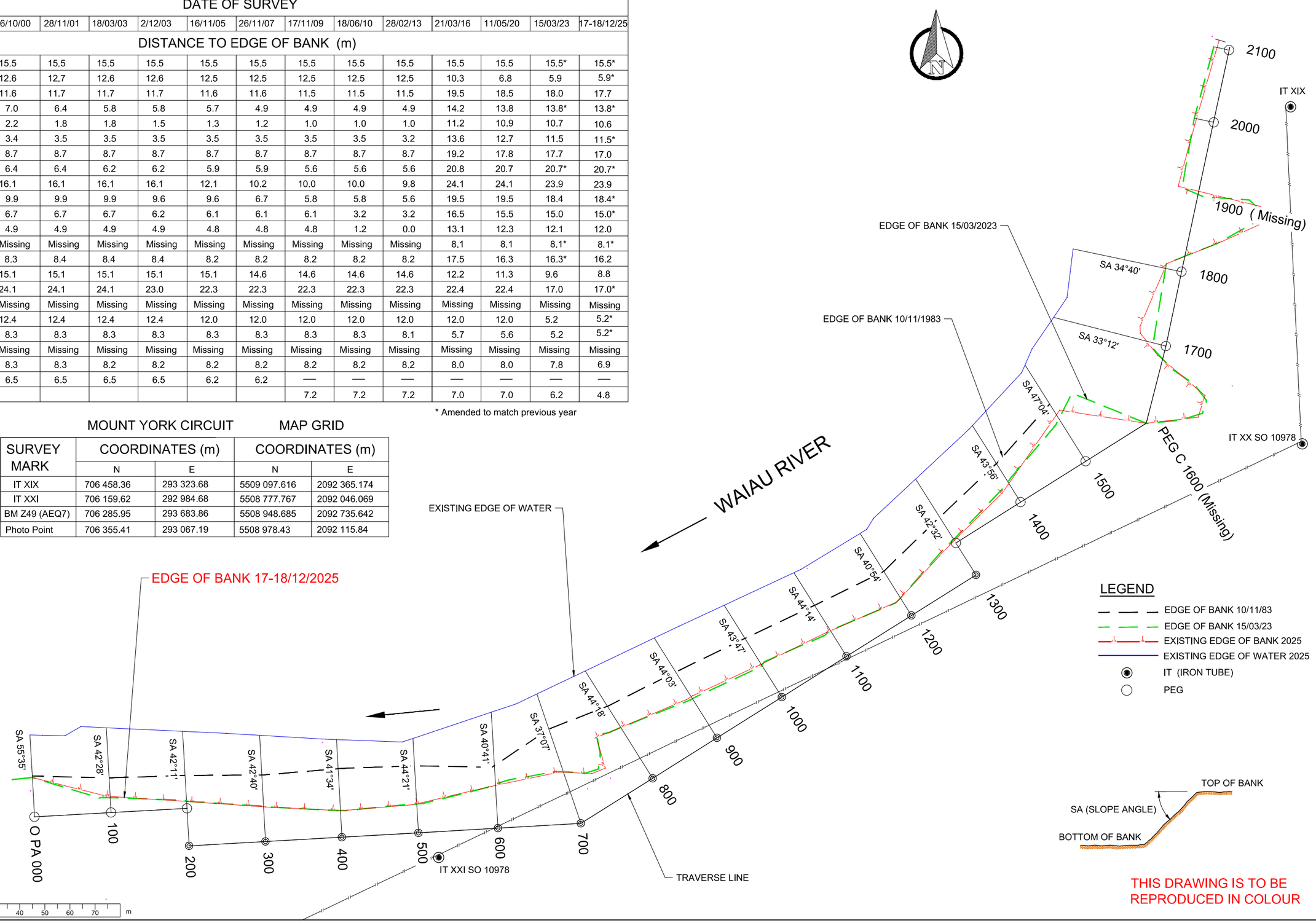
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100	13.75	12.7	12.6	12.7	12.6	12.6	12.5	12.5	12.5	12.5	12.5	10.3	6.8	5.9	5.9*
200	13.05	11.7	11.6	11.7	11.7	11.7	11.6	11.6	11.5	11.5	11.5	19.5	18.5	18.0	17.7
300	11.50	7.2	7.0	6.4	5.8	5.8	5.7	4.9	4.9	4.9	4.9	14.2	13.8	13.8*	13.8*
400	12.40	2.4	2.2	1.8	1.8	1.5	1.3	1.2	1.0	1.0	1.0	11.2	10.9	10.7	10.6
500	11.75	3.4	3.4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.2	13.6	12.7	11.5	11.5*
600	9.50	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	19.2	17.8	17.7	17.0
B	24.25	6.5	6.4	6.4	6.2	6.2	5.9	5.9	5.6	5.6	5.6	20.8	20.7	20.7*	20.7*
800	18.80	16.1	16.1	16.1	16.1	16.1	12.1	10.2	10.0	10.0	9.8	24.1	24.1	23.9	23.9
900	15.90	10.0	9.9	9.9	9.9	9.6	9.6	6.7	5.8	5.8	5.6	19.5	19.5	18.4	18.4*
1000	12.55	6.8	6.7	6.7	6.7	6.2	6.1	6.1	6.1	3.2	3.2	16.5	15.5	15.0	15.0*
1100	8.95	5.2	4.9	4.9	4.9	4.9	4.8	4.8	4.8	1.2	0.0	13.1	12.3	12.1	12.0
1200	5.65	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	8.1	8.1	8.1*	8.1*
1300	12.10	8.4	8.3	8.4	8.4	8.4	8.2	8.2	8.2	8.2	8.2	17.5	16.3	16.3*	16.2
1400	18.10	15.5	15.1	15.1	15.1	15.1	15.1	14.6	14.6	14.6	14.6	12.2	11.3	9.6	8.8
1500	26.85	25.4	24.1	24.1	24.1	23.0	22.3	22.3	22.3	22.3	22.3	22.4	22.4	17.0	17.0*
C	-	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
1700	17.50	12.6	12.4	12.4	12.4	12.4	12.0	12.0	12.0	12.0	12.0	12.0	12.0	5.2	5.2*
1800	15.40	8.4	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.1	5.7	5.6	5.2	5.2*
1900	10.85	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
2000	9.55	8.5	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.0	8.0	7.8	6.9
D	11.80	6.6	6.5	6.5	6.5	6.5	6.2	6.2	—	—	—	—	—	—	—
2100									7.2	7.2	7.2	7.0	7.0	6.2	4.8

* Amended to match previous year

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A.TENGU	Q.STEPHENS	C.FEELY
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
J.BOYDE	Q.STEPHENS	30/01/2026

INFORMATION

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MERIDIAN ENERGY
UPPER WAIAU RIVER
LEFT BANK EROSION

TITLE
VILLAGE POND SLIP LINE

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+64 3 211 3580
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Invercargill 9840
New Zealand

CIVIL

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A.TENGU	Q.STEPHENS	C.FEELY
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J.BOYDE	Q.STEPHENS	30/01/2026

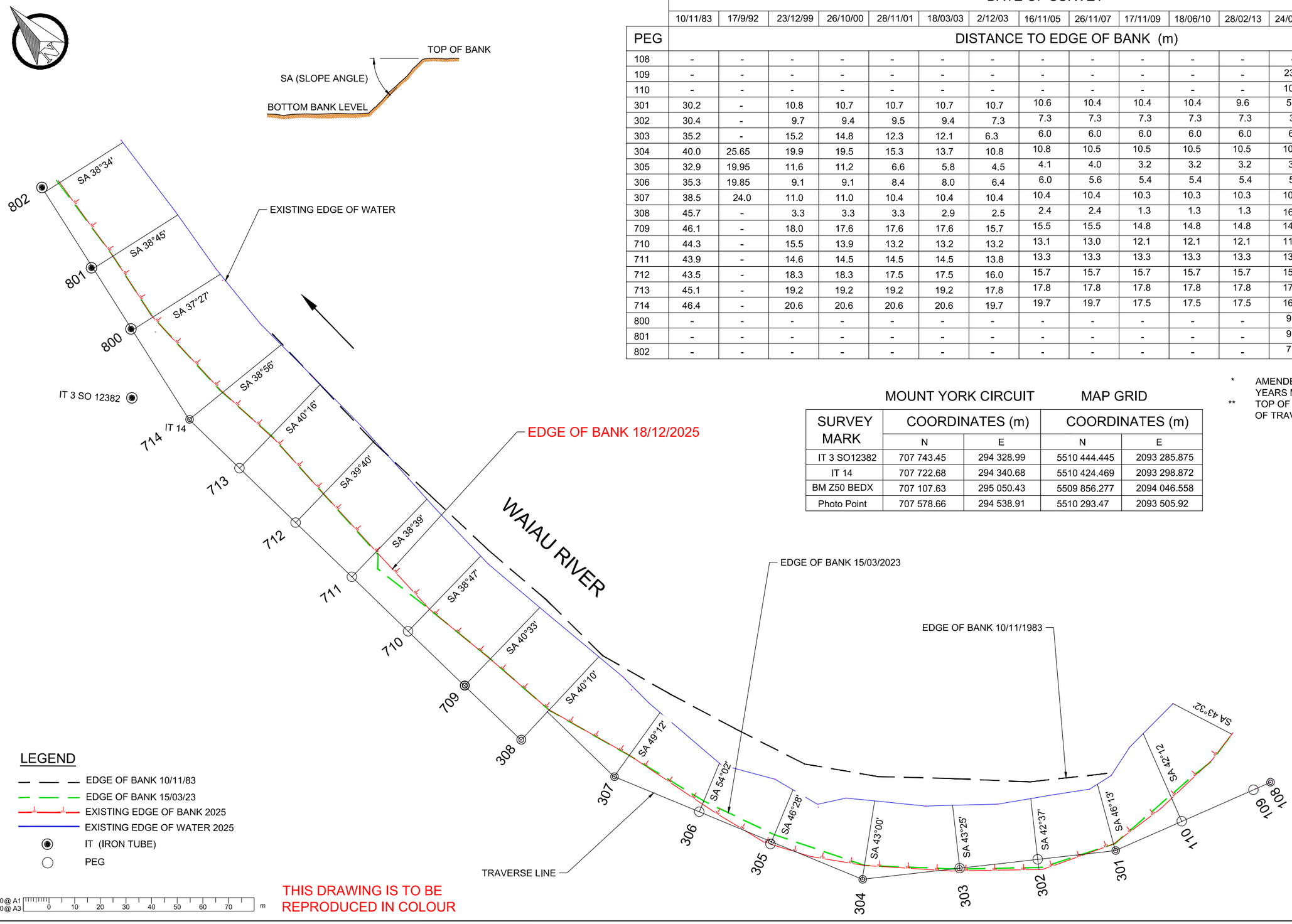
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MERIDIAN ENERGY MANAPOURI
UPPER WAIAU RIVER
LEFT BANK EROSION

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109	-	-	-	-	-	-	-	-	-	-	-	-	23.2	23.2	22.5	23.2
110	-	-	-	-	-	-	-	-	-	-	-	-	10.4	10.0	10.0*	9.8
301	30.2	-	10.8	10.7	10.7	10.7	10.7	10.6	10.4	10.4	10.4	9.6	5.4	5.4	2.6	2.6
302	30.4	-	9.7	9.4	9.5	9.4	7.3	7.3	7.3	7.3	7.3	7.3	3.1	3.1	-3.2**	-4.0**
303	35.2	-	15.2	14.8	12.3	12.1	6.3	6.0	6.0	6.0	6.0	6.0	6.0	6.0	-0.3**	-1.0**
304	40.0	25.65	19.9	19.5	15.3	13.7	10.8	10.8	10.5	10.5	10.5	10.5	10.3	10.3	5.5	5.5
305	32.9	19.95	11.6	11.2	6.6	5.8	4.5	4.1	4.0	3.2	3.2	3.2	3.2	3.2	3.0	-1.0**
306	35.3	19.85	9.1	9.1	8.4	8.0	6.4	6.0	5.6	5.4	5.4	5.4	5.1	5.1	4.5	3.3
307	38.5	24.0	11.0	11.0	10.4	10.4	10.4	10.4	10.4	10.3	10.3	10.3	10.0	10.0	10.0*	10.0*
308	45.7	-	3.3	3.3	3.3	2.9	2.5	2.4	2.4	1.3	1.3	1.3	16.1	16.1	15.9	15.9*
709	46.1	-	18.0	17.6	17.6	17.6	15.7	15.5	15.5	14.8	14.8	14.8	14.8	14.8	14.5	14.5
710	44.3	-	15.5	13.9	13.2	13.2	13.2	13.1	13.0	12.1	12.1	12.1	11.8	11.8	11.8*	11.8*
711	43.9	-	14.6	14.5	14.5	14.5	13.8	13.3	13.3	13.3	13.3	13.3	13.3	13.3*	13.3*	13.3*
712	43.5	-	18.3	18.3	17.5	17.5	16.0	15.7	15.7	15.7	15.7	15.7	15.6	15.6	15.5	15.5*
713	45.1	-	19.2	19.2	19.2	19.2	17.8	17.8	17.8	17.8	17.8	17.8	17.7	17.7	17.7	17.5
714	46.4	-	20.6	20.6	20.6	20.6	19.7	19.7	19.7	17.5	17.5	17.5	16.6	16.6	16.6	16.6*
800	-	-	-	-	-	-	-	-	-	-	-	-	9.7	9.7	9.5	9.5
801	-	-	-	-	-	-	-	-	-	-	-	-	9.1	9.1	9.0	9.0*
802	-	-	-	-	-	-	-	-	-	-	-	-	7.9	7.9	6.4	6.4*

MOUNT YORK CIRCUIT MAP GRID

SURVEY MARK	COORDINATES (m)		COORDINATES (m)	
	N	E	N	E
IT 3 SO12382	707 743.45	294 328.99	5510 444.445	2093 285.875
IT 14	707 722.68	294 340.68	5510 424.469	2093 298.872
BM Z50 BEDX	707 107.63	295 050.43	5509 856.277	2094 046.558
Photo Point	707 578.66	294 538.91	5510 293.47	2093 505.92

* AMENDED TO MATCH PREVIOUS YEARS MEASUREMENT
** TOP OF BANK NOW TO THE LHS OF TRAVERSE LINE

LEGEND

- EDGE OF BANK 10/11/83
- EDGE OF BANK 15/03/23
- EXISTING EDGE OF BANK 2025
- EXISTING EDGE OF WATER 2025
- IT (IRON TUBE)
- PEG

1:750 @ A1
1:1500 @ A3
0 10 20 30 40 50 60 70 m

THIS DRAWING IS TO BE REPRODUCED IN COLOUR

REVISION	AMENDMENT	APPROVED	DATE

Invercargill Office
+64 3 211 3580
PO Box 647
Invercargill 9840
New Zealand

CIVIL

SCALES: 1:750 @A1, 1:1500 @A3
ORIGINAL SIZE: A1

DRAWN	DESIGNED	APPROVED
A.TENGU	Q.STEPHENS	C.FEELY
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
J.BOYDE	Q.STEPHENS	30/01/2026

INFORMATION

PROJECT
MERIDIAN ENERGY MANAPOURI
UPPER WAIAU RIVER
LEFT BANK EROSION

TITLE
RAINBOW REACH SLIP LINE

WSP PROJECT NO. (SUB-PROJECT): 6-VX053.00
SHEET NO.: C04
REVISION: A

Appendix C

Summary of Survey data

Table C1 Rainbow Reach, summary of survey data

Some pegs have a shorter timeframe that the long-term rates were assessed over, see table notes for details.

Peg ID	Top of bank retreat		Rate of retreat	
	Long-term	Since Last monitoring period	Long-term	Since Last monitoring period
	1983 – 2025 (m)	2023 - 2025 (m)	1983 – 2025 (m/yr)	2023 - 2025 (m/yr)
108[1]	-	-	-	-
109[2]	0.0	0.0	0.00	0.00
110[2]	0.6	0.2	0.07	0.07
301	27.6	0	0.66	0.00
302	34.4	0.8	0.82	0.27
303	36.2	0.7	0.86	0.23
304	34.5	0	0.82	0.00
305	33.9	4	0.81	1.33
306	32	1.2	0.76	0.40
307	28.5	0	0.68	0.00
Upstream Mean	**25.3**	**0.8**	**0.61**	**0.26**
308	44.6	0	1.06	0.00
709	31.6	0	0.75	0.00
710	32.5	0	0.77	0.00
711	30.6	0	0.73	0.00
712	28	0	0.67	0.00
713	27.6	0.2	0.66	0.07
714	29.8	0	0.71	0.00
800[2]	0.2	0	0.02	0.00
801[2]	0.1	0	0.01	0.00
802[2]	1.5	0	0.17	0.00
Downstream Mean	**22.7**	**0.0**	**0.56**	**0.01**
Overall Mean	**22.7**	**0.3**	**0.58**	**0.11**

1 - No Survey Data, not included in calculation of bank retreat

2 - Peg established in 24/3/2016

Table C2 Village Pond, summary of survey data

Some pegs have a shorter timeframe that the long-term rates are assessed over, see table notes for details.

Peg ID	Top of bank retreat		Rate of retreat	
	Long-term	Since Last monitoring period	Long-term	Since Last monitoring period
	1983 – 2025 (m)	2023 - 2025 (m)	1983 – 2025 (m/yr)	2023 - 2025 (m/yr)
A	0.7	0.0	0.02	0.00
100	7.9	0.0	0.19	0.00
200	10.4	0.3	0.25	0.10
300	12.7	0.0	0.30	0.00
400	16.7	0.1	0.40	0.03
500	15.3	0.0	0.36	0.00
600	6.8	0.7	0.16	0.23
B	19.0	0.0	0.45	0.00
800	9.9	0.0	0.24	0.00
900	12.5	0.0	0.30	0.00
1000	12.7	0.0	0.30	0.00
1100	12.0	0.1	0.28	0.03
1200[1]	12.6	0.0	0.30	0.00
1300	10.8	0.1	0.26	0.03
1400	8.5	0.8	0.20	0.27
1500	9.9	0.0	0.23	0.00
1700	12.3	0.0	0.29	0.00
Downstream Mean	**11.2**	**0.1**	**0.27**	**0.04**
C[2]	-	-	-	-
1800	10.2	0.0	0.24	0.00
1900[3]	-	-	-	-
2000	1.8	0.9	0.04	0.30
D[4]	5.6	-	0.13	-
2100	1.0	1.4	0.06	0.47
Upstream Mean	**4.6**	**0.8**	**0.12**	**0.26**
Overall Mean	**9.9**	**0.2**	**0.24**	**0.06**

1 - Missing data between 1999 and 2013

2 - No Survey Data, not included in calculation of bank retreat

3 - Peg lost after 1983

4 - No data since 2007. Long term rates calculated using 1983-2007

Appendix D

2016 peg re-establishment

Peg loss due to bank retreat at the sites has required re-establishment of some pegs in 2016:

- Rainbow Reach: Peg 308 was re-established in 2016 15 m behind its 1999 location. The measurements to the top of bank were not adjusted in the survey data to reflect the new peg 308 location, thus the apparent growth between 2013 and 2016 is spurious and needs to be adjusted in the geomorphology assessment.
- Village Pond: 12 pegs were re-established approximately 15 m behind their 1976 positions. The measurements to the top of bank were not adjusted in the survey data to reflect these new peg locations, thus for these pegs the apparent growth between 2003 and 2016 is spurious and needs to be adjusted in the geomorphology assessment. The re-established pegs were: 200 – 600, B, and 800 – 1300. Peg 1200 that had been lost prior to 1999 was re-established as part of this process.

In order to calculate bank retreat rates in the Geomorphology assessment from the re-established peg locations, the offset to the new peg needs to be added to the distance to edge of bank survey measurements for previous surveys. This correction is shown on the survey plans for Rainbow reach for the 1983 peg re-establishment, but not for the peg re-establishment undertaken in 2016 at both Rainbow reach (one peg) and Village Pond (12 pegs), thus the apparent growth recorded in the survey data at these pegs between 2013 and 2016 is spurious.

The offset for the one re-established peg at Rainbow reach in 2016 (308) was calculated from the difference between the distance to edge of bank between the old and new pegs as surveyed on 24/03/2016 and shown on the Opus 2016 Survey plans.

The offsets for the pegs re-established in 2016 at Village Pond were calculated from the distance to edge of bank between the old and new pegs where this data was available as surveyed on 24/03/2016 and shown on the Opus 2016 Survey plans (pegs 200, 800, 900, 1100 and 1300), or as measured from plans georeferenced in GIS (Table 3)). As the calculated difference of the distance to edge of bank between the old and new peg location of peg 1100 was 13.1m, considerably less than the re-establishment distance of approximately 15m, the measured distance in GIS of 15.1m was taken.

The offset adjustment was not reported on in the 2016 report and was not taken forward for the 2020 (new author) and 2023 AECOM geomorphology assessments where bank retreat at the re-established pegs was assessed pre 2016 and post 2016. While some bank retreat occurred between 2013 and 2016 at the 12 pegs, the trends remain the same and the geomorphic assessment and conclusions remain valid. The geomorphology assessment on the 2025 monitoring (this report), has included the offset adjustment in the assessment.

Pegs lost to bank erosion since 2016 have not been re-established behind the lost peg, rather bank retreat at lost pegs is reported with negative numbers.

Table 3 Village Pond offset of pegs re-established in 2016

Peg	New peg offset from old peg (m) as reported on survey plan (Opus, 2016)	Measured from Opus 2016 plan via GIS	Offset used in 2016 AECOM report
200	15.3		15.3
300		15.0	15.0
400		15.0	15.0
500		15.0	15.0
600		15.0	15.0
B		15.4	15.4
800	15.0		15.0
900	15.0		15.0
1000		15.1	15.1
1100	13.1	15.1	15.1
1200		15.0	15.0
1300	15.0		15.0