Channel morphology of the Rees River, Otago

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Otago Regional Council

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Cover image

Rees River in the vicinity of the Rees River Bridge, after a period of high flows, 11 January 2013

Executive summary

The Rees River is one of the main tributaries of Lake Wakatipu and drains a remote alpine catchment of 412 km^2. This report assesses recent changes to its channel morphology between Lovers Leap and Lake Wakatipu, using cross-section surveys and LiDAR. This assessment provides an update on changes that have occurred since the last catchment-wide analysis of long-term trends was completed (ORC, 2008). This report, therefore, not only focuses on recent changes in morphology, but also places them within the context of earlier changes. This information can be used to support the assessment of community vulnerability to flooding and to inform decisions relating to the management of the river, including gravel extraction, floodwater conveyance and asset management.

Large flood events are considered to be the primary means of transportation for redistributing sediments in the Rees River (Wild, 2012). Since the 2008 report was prepared, the highest flows observed occurred in April 2010, February 2011 and January 2013. This updated analysis is based on repeat cross-section surveys, collected in November 2011, and LiDAR data, collected in October 2011. This report compares these survey data with that collected in December 2006.

Between December 2006 and November 2011, a general trend of net aggradation of the river bed occurred near the Rees River Bridge, with a more defined main channel forming at the two sections immediately upstream. This is consistent with long-term trends in this reach, derived from both anecdotal evidence and survey data since the 1950s.

The updated analysis shows that there was very little net change in bed level and channel location in the lower Rees River, near Glenorchy, between the 2006 and 2011 surveys. Although a small amount of net aggradation was noted before 2006 (ORC, 2008), this latest analysis shows minimal net change since survey data was first collected in the 1990s.

The rapid changes in river morphology that occur in the Rees River are a common characteristic of rivers with a braided form. Braided rivers are also characterised by an extremely mobile bed. This report summarises recent trends and changes in river morphology.

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1. Introduction

1.1. Overview

This report provides an update on the morphology[1] of the Rees River channel between Lovers Leap and Lake Wakatipu, using cross-section survey data, collected in May, November, December 2010, November 2011, and LiDAR[2] information, collected in October 2011. The report is intended to inform decisions relating to the management of the river, including gravel extraction, floodwater conveyance and asset management, and to help understand any changes in flood risk for the local community. The extent of LiDAR coverage and cross-section locations are shown in Figure 1.

A description of the Rees catchment is provided below. A summary of the most recent changes in channel morphology is provided in Section 2, including visual observations following a high-flow event in January 2013. These most recent changes are also placed within the context of longer-term trends identified in ORC (2008). These changes are described for four reaches:

- the lowest part of the river, in the vicinity of Glenorchy (three cross-sections)
- approximately 4.4km upstream of the mouth (one cross-section)
- in the vicinity of the Rees River Bridge (three cross-sections)
- the upper part of the surveyed reach (five cross-sections).

The two reaches where changes in river morphology could have the greatest impact on people or assets are examined in greater detail. These are the areas next to and upstream of Glenorchy (cross-sections RR5, RR4A and RR3A), and the area immediately above and below the Rees River Bridge (cross-sections RR13, RR12 and RR11).

The cross-section data is presented in Appendix 1, and the methods used to collect and analyse morphological data are explained in Appendix 2.

[1] The form or structure of topographical features within the river channel

[2] **L**ight **D**etection **A**nd **R**anging (LiDAR) data is a mass of spot height information captured over a wide area, using an aircraft mounted laser. This data has a horizontal accuracy of ±0.2m and a vertical accuracy of ±0.15m, with a standard deviation of 0.026m.

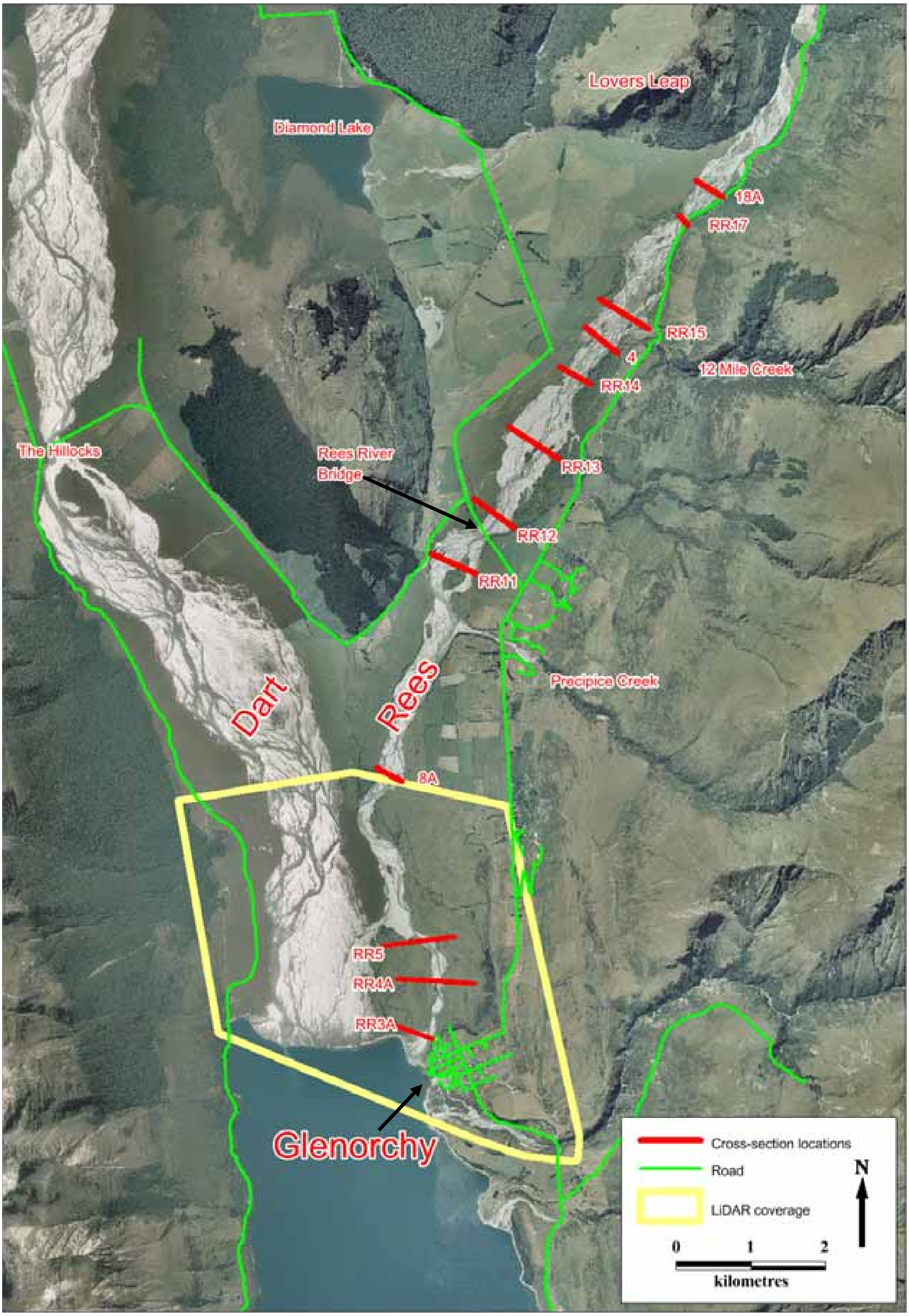

Figure 1 Extent of LiDAR coverage and cross-section locations on the lower Rees River

1.2. Catchment description

The lower Rees River valley is part of a large basin carved out by the Tyndall Glacier during the Pleistocene, about 12-15,000 years ago.[3] The river valley is typical of a previously glaciated u-shaped valley, with a flat valley floor and gentle lower slopes leading up to the near vertical peaks of the flanking mountain ranges. The Rees River catchment is bounded by the Richardson Mountains to the east and the Forbes Mountains to the west, which rise steeply to over 2,000m above mean sea level (msl) (Figure 3). Episodic debris flow and alluvial fan events can lead to sudden influxes of sediment into the Rees River system (Figure 2) and into the neighbouring Dart catchment.[4,5]

Figure 2 Sedimentation on the Earnslaw Burn alluvial fan following an extreme rainfall event in January 1994. Diamond Lake is at the top left of the image.

Figure 4 shows a longitudinal profile along the Rees River, from Rees Saddle to Lake Wakatipu. This graph shows the steep nature of the Rees River in its upper reaches and that it has a much shallower gradient in its mid- to lower reaches (Figure 5 to Figure 7). The main tributaries to the Rees River follow a similar profile, and include Precipice Creek, Invincible Creek, 12 Mile Creek[6] and 25 Mile Creek.

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[3] Williams, *et al.* (2011). (See Section 4 for full list of references.)
[4] McSaveny, *et al.* (2002)
[5] Thomas, and Cox. (2009)
[6] Also known as 'Ox Burn'

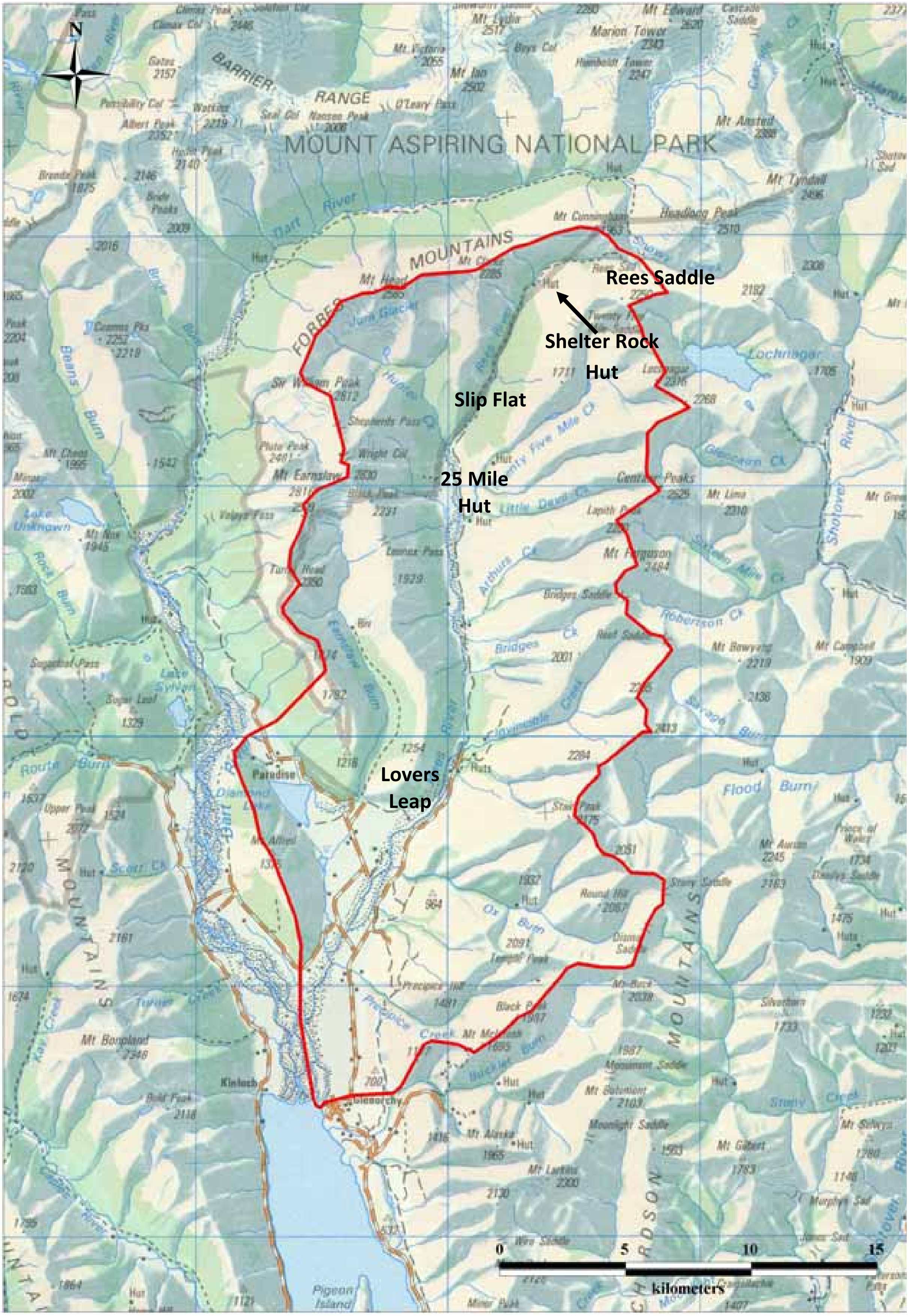

Figure 3 Rees River catchment

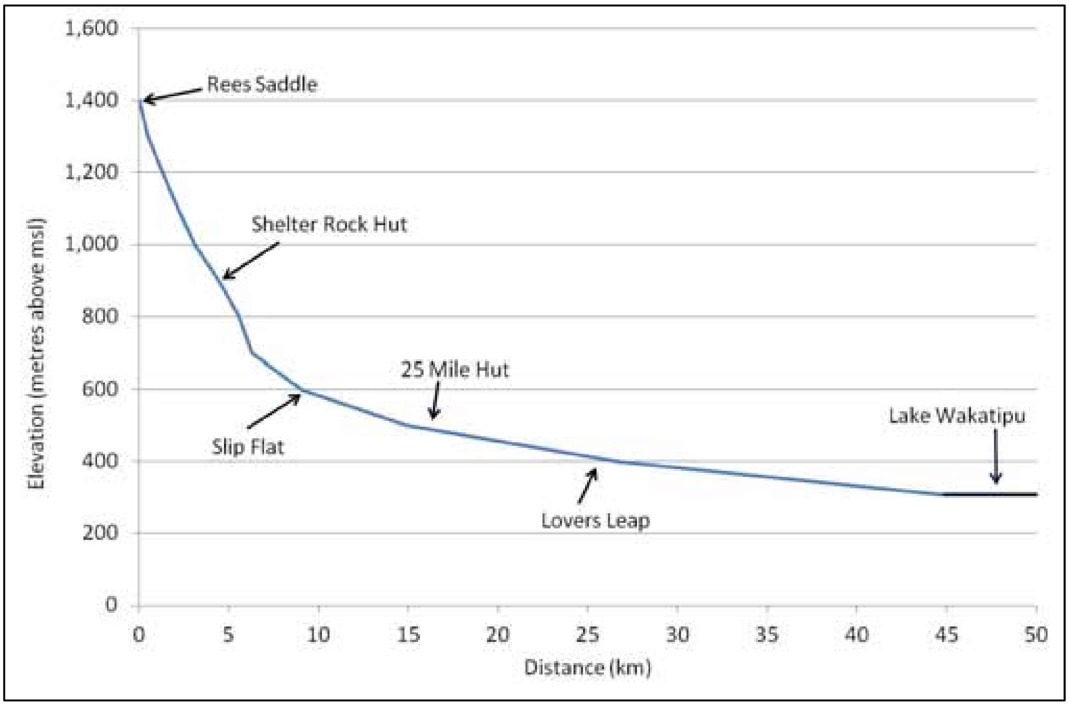

Figure 4 Longitudinal profile for the Rees River. Source: NZTM maps 1:50,000

Figure 5 View of the channel, floodplain and flanking mountains, looking downstream in the mid-reaches of the Rees River (above Lovers Leap)

The Rees and Dart rivers have together formed a 2.5km-wide delta where they discharge into Lake Wakatipu (Figure 6 and Figure 7). The townships of Glenorchy and Kinloch lie to the east and west, respectively, of this delta. ORC (2008) describes the channel morphology of the lower Rees River as consisting of a braided channel form with an extremely mobile bed load. The lateral migration of channel position within the active channel[7] margins occurs frequently,

[7] i.e. between the left bank (LB) and right bank (RB) of the river, as defined during the survey process. The plots of surveyed data in Appendix 1 show the LB and RB, as defined during the most recent survey in November 2011.

particularly during periods of higher flow. The multi-channel braided form of the lower Rees River is shown in Figure 7.

Figure 6 Lower Rees River catchment, looking towards Lake Wakatipu

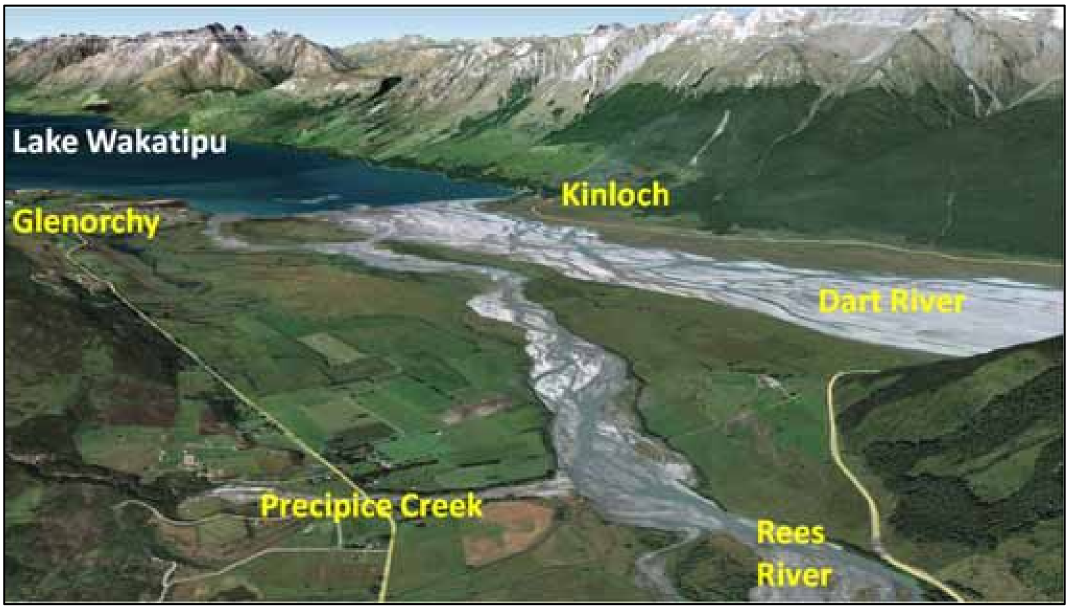

Figure 7 Oblique view of the lower Rees River valley. Source: Google Earth

1.3. Hydrology and gravel extraction

Changes in the morphology of the Rees River are mainly driven by the hydrological characteristics of the river, including the magnitude and frequency of flood events (Wild, 2012), and, at a more localised scale, by human activities such as gravel extraction. The characteristics of these two driving forces during the most recent survey period, and since records began, are summarised below.

There are no long-term flow records for the Rees River. However, records from the Dart River at Hillocks site can be used as a substitute, due to the similar topographic and climatic environments of the Rees and Dart catchments (Figure 1 and Figure 3).[8] High flow events occur reasonably frequently in both the Rees and Dart rivers, due to the steady progression of westerly fronts that typically move over the southern part of the South Island and bring heavy rainfall to these catchments.

Figure 8 shows that the frequency and magnitude of flood events in the Dart River at the Hillocks during the most recent survey period (December 2006 to November 2011) were similar to that observed during the full length of flow record at the site.

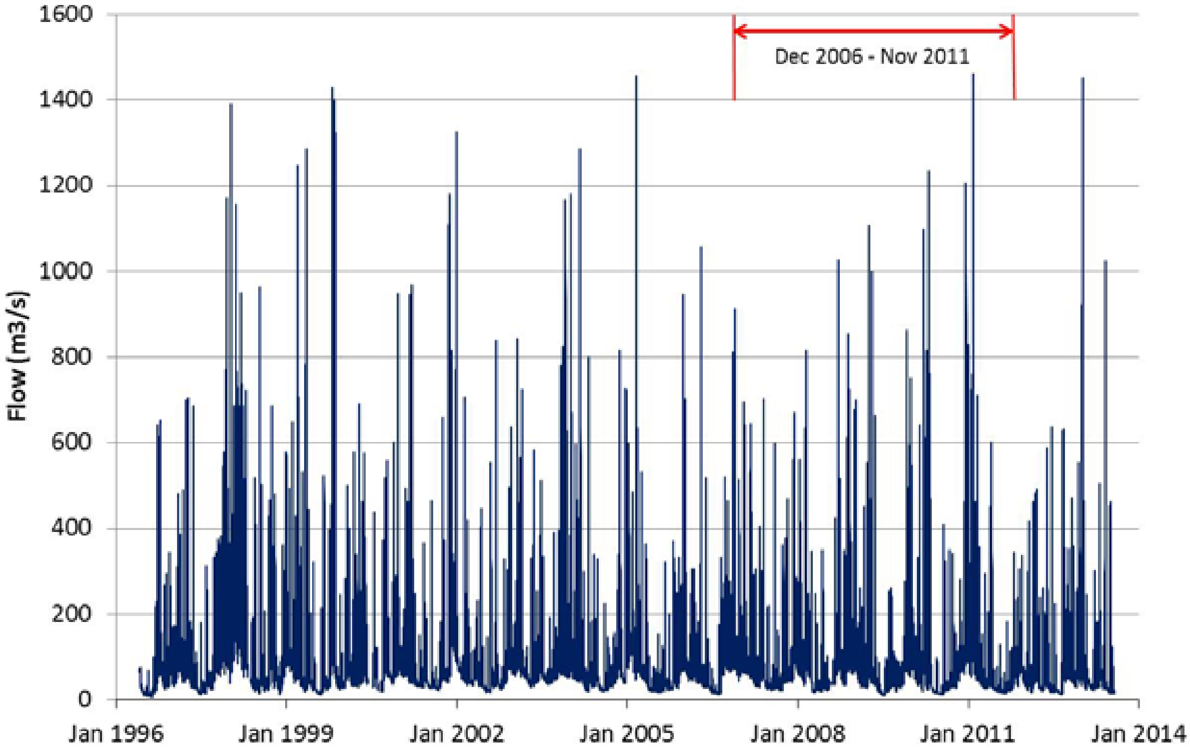

Figure 8 Flow in the Dart at the Hillocks for the complete record, June 1996-August 2013

[8] Average rainfall at Rees Valley Station near Precipice Creek is 1,457mm/yr (1988-2012), while average annual rainfall in the Dart catchment at the Hillocks is 1,686mm/yr (1998-2012). Average annual daily maximum rainfall at these two sites was 72mm and 89mm, respectively, during the same timeframes.

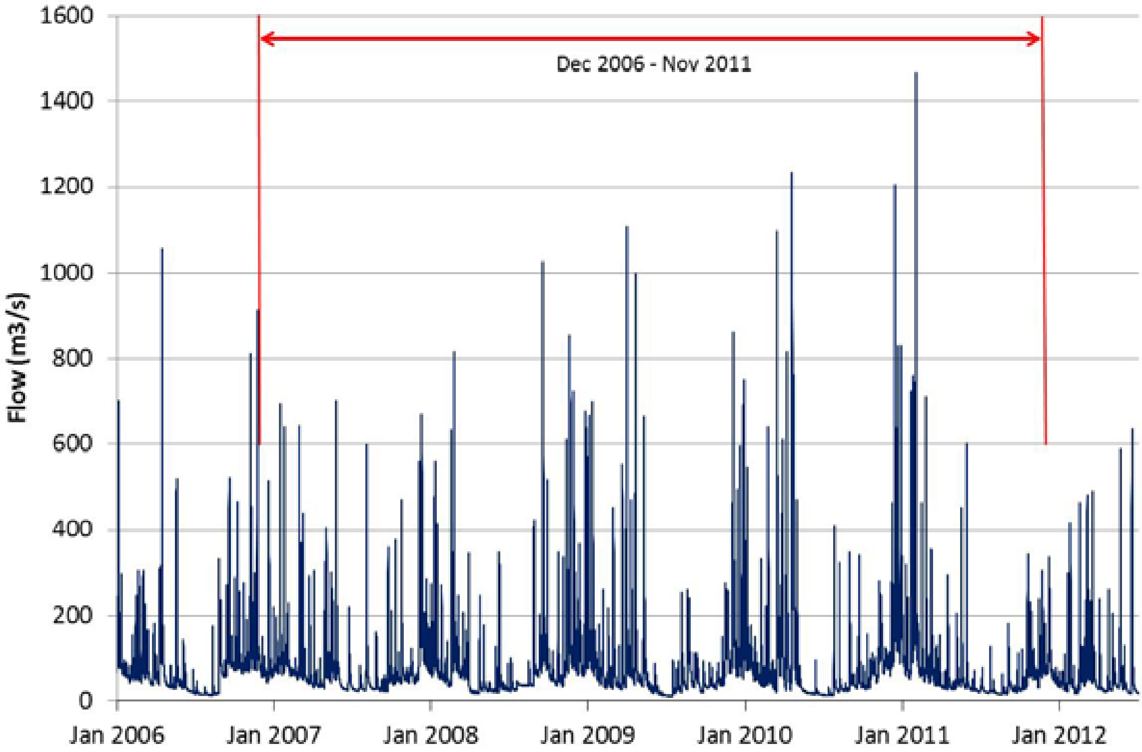

Figure 9 Flow in the Dart River at the Hillocks, with the most recent survey period marked in red

Figure 9 shows in more detail the flow in the Dart River at the Hillocks during the most recent survey period. A significant flood event occurred in February 2011, when the Dart River peaked at a flow of 1,469m^3/sec. Another large flood event occurred in January 2013 (after the latest set of cross-section data was collected), which peaked at 1,467m^3/sec. Figure 8 shows these two recent floods within the context of other observed flood peaks, and Figure 16, Figure 19 and 28 show high flows in the Rees River the day after the January 2013 event.

Otago Regional Council (ORC) records of gravel extraction in the Rees River begin in 2005, when gravel was extracted from five main localities. These locations, and the volume of sediment removed from each during the most recent survey period (December 2006 to November 2011), are shown in Figure 10. The total volume of gravel extracted during this period was 12,755m^3.

Before the most recent survey period, returns from gravel extractors show that 5,150m^3 of gravel was removed from above the Rees River Bridge in August 2006. Since November 2011, 8,000m^3 has been extracted from below the Rees River Bridge, and 1,100m^3 has been removed between cross-sections RR14 and RR13. Therefore, the total amount of gravel extracted from the Rees River between August 2006 and June 2013 is 27,005m^3. This total is minimal when compared to the total volume of sediment carried by the Rees River, and Wild (2012) estimates that the average total sediment supply rate of the river is 30,000 to 70,000m^3 per year. However, the effects of gravel extraction may still be quite noticeable at the actual extraction point and for some distance downstream of that point.

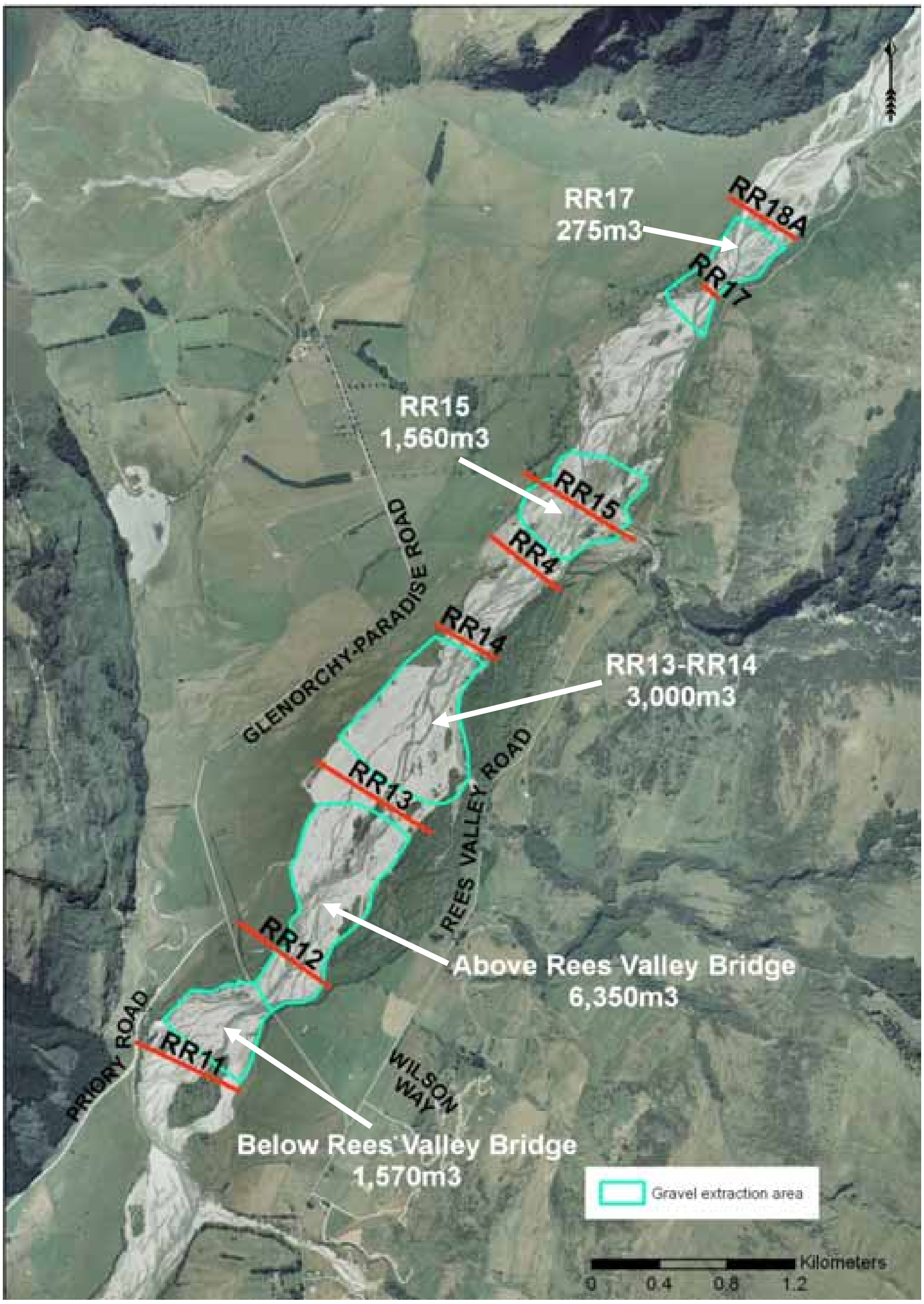

Figure 10 The location and volume of gravel extracted from five different localities on the Rees River between December 2006 and November 2011 (ORC records). Cross-section locations are shown in red.

2. Results

The active channel of the Rees River is a dynamic system where floods and sediment movement caused by high rainfall events regularly result in changes in channel morphology. These changes in the morphology of the river bed occur due to aggradation and degradation along the length of the channel, as well as lateral bank erosion and channel migration. This section summarises the changes that have occurred since the last survey in 2006 and places these changes within the context of trends identified in ORC (2008).

2.1. LiDAR

The topography of the lower Rees and Dart rivers is shown in Figure 11, as derived from LiDAR data obtained in October 2011. The braided nature of the active channel of both rivers, as well as a number of paleochannels on the wider floodplain, can be seen in the image. The colour-coded contour image shows that the centre of the floodplain, including the two main active channels, is more elevated than the lateral margins. This is particularly evident at the lower-lying wetland area on the true left of the Rees River, upstream of Glenorchy.

LiDAR can be used to create additional cross-sections on the Rees/Dart delta, or to extend existing surveyed sections. Figure 14 and Figure 15 show examples of this application. Note that LiDAR is not able to provide topographic information about areas that were covered by water at the time of collection.

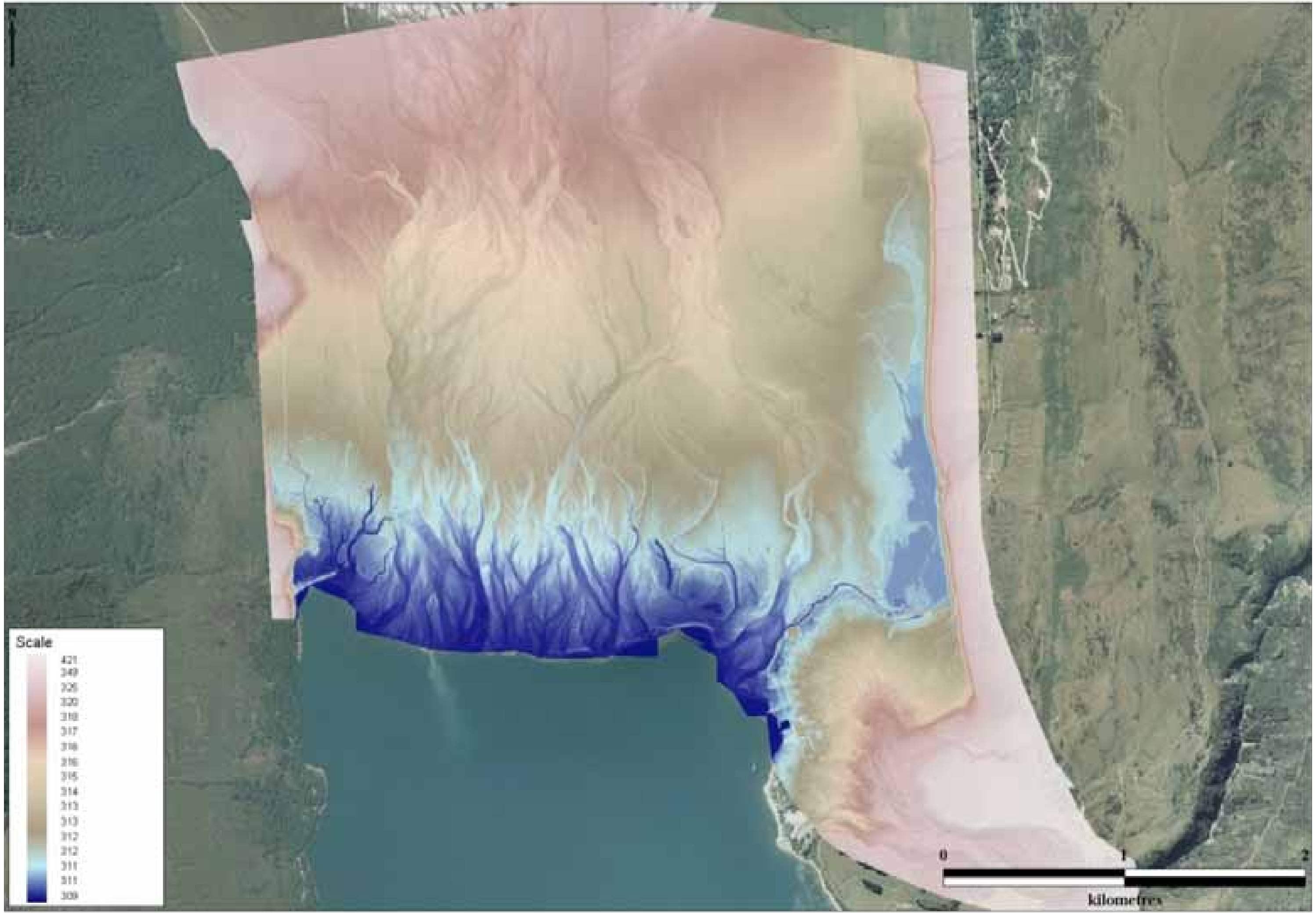

Figure 11 Topography of the lower Rees and Dart rivers. Elevations are in metres above msl (aerial photo underlying the LiDAR dated Feb 2006).

2.2. Lower Rees River (cross-sections RR3A-RR5)

Figure 12 shows the location of the three surveyed cross-sections next to, and upstream of, Glenorchy. Appendix 1 (Figure 29 to Figure 34) shows the survey data collected at these locations between 1990-2011 (RR5) and 1999-2011 (RR4A and RR3A).[9] Two graphs are provided for each location: one showing the entire cross-section, and one showing the active channel. ORC (2008) noted minor net aggradation of the channel in this lowest reach of the Rees River since records began until December 2006.

Figure 12 Location of cross-sections near Glenorchy, aerial photo dated February 2006

At cross-section RR3A, degradation of the bed occurred across much of the active channel between 2006 and 2011. Other parts of the bed aggraded during this period: in particular, a bank of sediment that lies 35-65m from the true-left bank, which built up by as much as 1m between 2006 and 2011. This feature was present during the cross-section surveys in May and December 2010 (Figure 30). Figure 30 also shows no net change in bed level between 1999 and 2011, with areas of degradation generally balanced by aggradation elsewhere in the channel. The active channel at RR3A is about 200m wide (Figure 13), and, for much of its width, it is 0.5 to 1m higher than the flood plain to the west (Figure 29).

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[9] i.e. since records began up until, and including, this most recent survey

Figure 13 View along cross-section RR3A, looking from the true-left (Glenorchy) side towards the true-right side (December 2010)

Figure 14 shows a cross-section derived from LiDAR, about 100m upstream of cross-section RR3A. The raised bund that separates the active channel from low-lying land between Butement and Oban streets in Glenorchy can be seen in the graph.

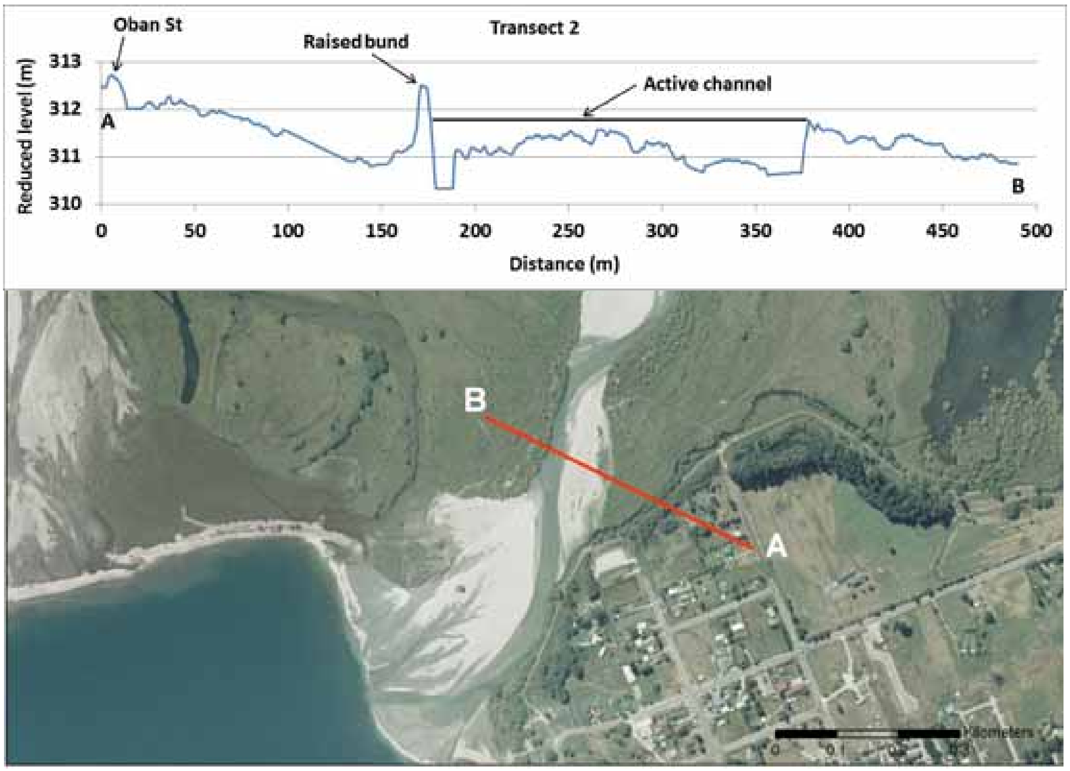

Figure 14 Transect 2 (looking downstream), created using LiDAR (top). Location of the transect (bottom)

Between 2006 and 2011, cross-sections RR4A and RR5 also experienced degradation of the river bed in some parts of the active channel and aggradation in others. As for cross-section RR3A, this latest analysis does not show any observable long-term trend at either of these sites. A deeper channel close to the true-left bank at RR4A in 2006 did continue to aggrade during this period (Figure 32), while a channel close to the true-right bank at RR5 became deeper and wider (Figure 34). At the time of the 2011 survey, the active channel was about 180m wide at both these locations (Figure 31 and Figure 33). The margins of the active channel appear to have remained stable at both cross-sections between 2006 and 2011.

This analysis of available survey data, therefore, does not show any clear aggradational or degradational trend at the three cross-sections closest to Glenorchy. Degradation of the river bed has occurred in some parts of the active channel, and aggradation has occurred in others, reflecting the dynamic nature of the Rees River.

To include the full width of the Rees/Dart floodplain (Figure 15), LiDAR data was used to extend cross-section RR5. The active channel of the Rees River is elevated between 2 and 2.5m above the adjacent wetland area to the east and 0.5 to 1m above the Dart River floodplain to the west. The Rees River generally alternates between three different flow paths in the lower reaches.[10] These are:

- a western flow path onto the Dart River floodplain
- an eastern flow path along the northern side of Glenorchy (the pre-dominant path in recent years)
- a relic central flow path in between the two.

These flow paths can be seen in Figure 15 and Figure 16. River management activity (control of crack willow) undertaken by the ORC along the Rees and Dart rivers has been (and continues to be) managed to preserve a linkage between the river fairways. That linkage permits a portion of the flood flow in the Rees River to join the Dart River, reducing the pressure on Glenorchy.

[10] Wild, 2012

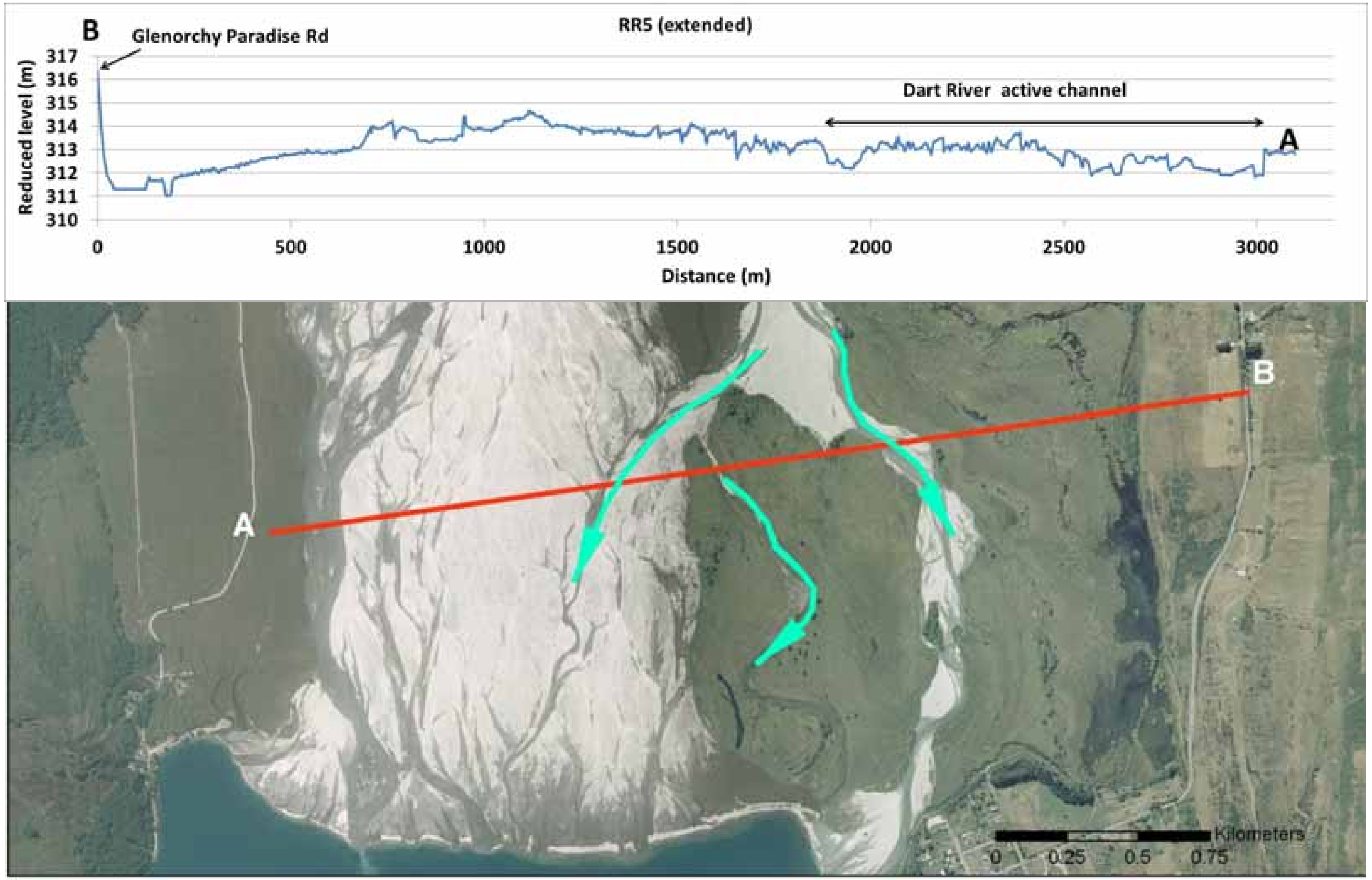

Figure 15 Extended cross-section RR5 (looking downstream), created using LiDAR (top). Location of the extended cross-section and Rees River flow paths (bottom)

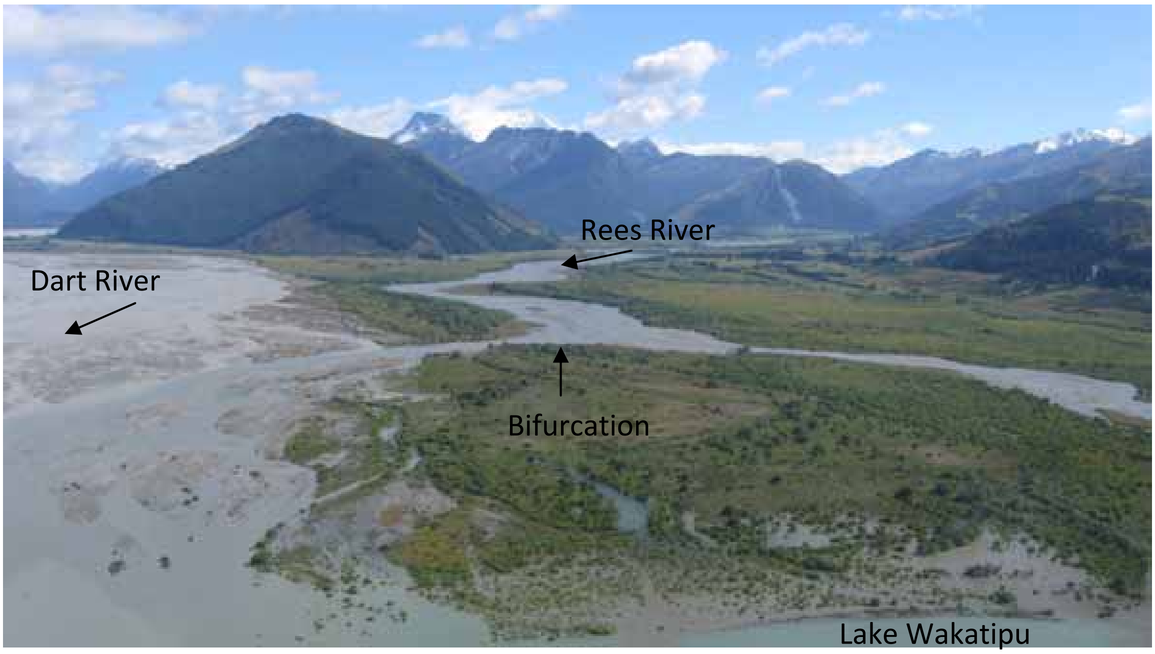

Figure 16 The lower Rees and Dart rivers about 10am on 11 January 2013, after a period of high flows. The image shows a bifurcation in the Rees River, with a portion of the flow entering the Dart River, and the remainder continuing on in the eastern channel. A flood peak of 1,467 cumecs occurred in the Dart River at the Hillocks on 10 January.

Changes in thalweg level in the active channel at cross-sections RR5 to RR3A are shown in Figure 17. Thalweg level at cross-section RR5 in 2011 was lower than all other surveys. Five hundred metres downstream at cross-section RR4A, thalweg level has increased steadily by about 1m between 1999 and 2011. Next to Glenorchy (cross-section RR3A), thalweg level also increased by 1m between 1999 and 2006, and then lowered by about 0.3m up to November 2011. These variations in thalweg level may be due to normal processes associated with a large braided river, such as migration of the main channel across the valley floor.

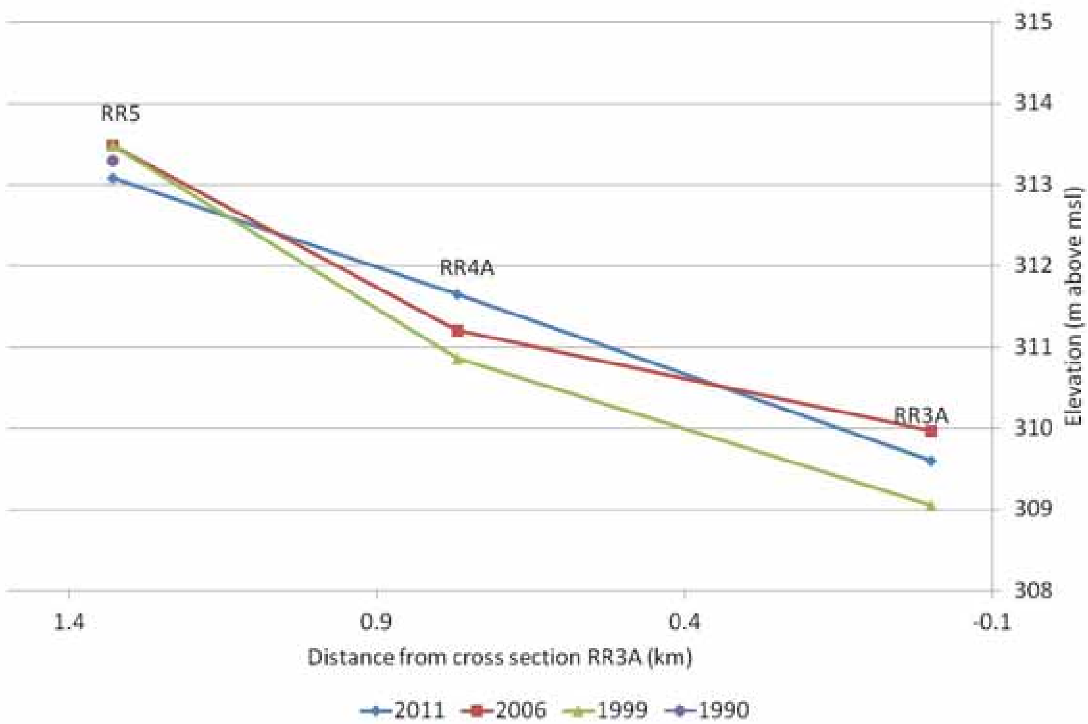

Figure 17 Thalweg values for cross-sections adjacent to, and upstream of, Glenorchy

2.3. Cross-section 8A

Cross-section 8A is located 4.4km upstream of the mouth, mid-way between the two reaches described in 3.2 and 3.4 (Figure 1). There has been on-going aggradation across much of the active channel and the adjacent floodplain at this location since the first comprehensive survey in 1999 (Figure 35). By 2011, the deepest part of the channel at the time of the 1999 survey had aggraded by more than 1m (at distance -50). However, minor degradation and incision of the main flow channel has occurred at other parts of this cross-section.

2.4. Rees River Bridge (cross-sections RR13-RR11)

Figure 18 shows the location of the two surveyed cross-sections immediately upstream of the Rees River Bridge and the section immediately downstream. Appendix 1 (Figure 36 to Figure 38) shows the survey data collected at these locations in 1999, 2006 and 2011.

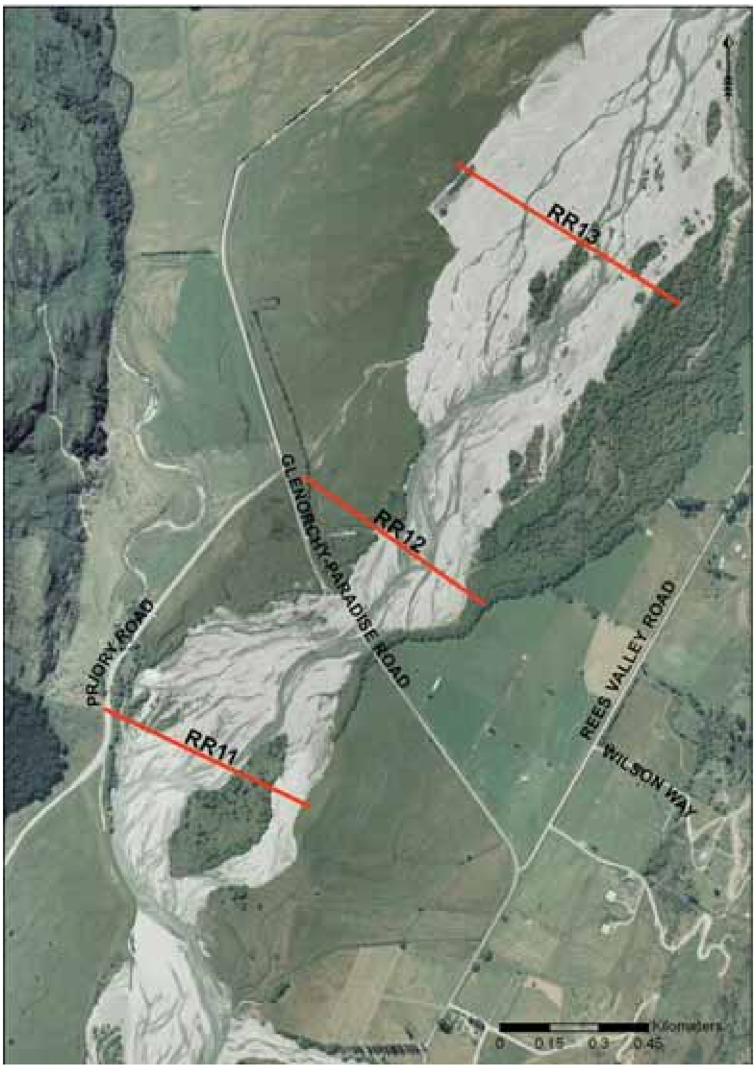

Figure 18 Location of cross-sections near the Rees River Bridge, overlying an aerial photo dated February 2006

At cross-section RR11, the primary Rees River channel currently flows to the true right of an island located in the mid-section of the active channel (Figure 18 and Figure 19). Aggradation of the bed occurred across much of this primary channel between 2006 and 2011 (Figure 36). The survey data shows that the aggradation was generally less than 0.5m, apart from at two locations, where deeper channels present in 2006 have been filled in by 1 to 1.5m. These deeper channels were located on either side of the primary flow path (i.e. one was located immediately to the true right of the island, and the other, deeper channel was located next to Priory Road). Where degradation did occur, it was generally less than 0.2m.

During periods of high flow, the Rees River also occupies the channel to the true left of the island (Figure 19). This channel did not change significantly between 2006 and 2011, with the exception of a deeper channel in its centre, which incised by about 0.5m.

Figure 19 Rees River Bridge, looking downstream, on 11 January 2013. The island located downstream of the bridge can be seen in the centre of the image.

Upstream of the Rees River Bridge, at cross-sections RR12 and RR13, a general pattern of aggradation across the active channel was also observed between 2006 and 2011, interspersed with small amounts of erosion and degradation. The main channel at RR12 (located at distance -390m) has continued to incise and widen since 2006 (Figure 37). It would therefore have the capacity to convey a greater flow during low- to medium-sized flood events. A similar channel has formed at RR13, at distance -450m (Figure 38).

Overall, the 2011 survey data shows that, since 2006, the river bed has aggraded slightly, near the Rees River Bridge. Other anecdotal evidence and photos confirm that this has been a trend for some time. Mabin (2007) reports that ‘local reminiscence suggests it was possible to drive a bulldozer under the bridge when it was first built.’ The images shown in Figure 20 to Figure 22 give an indication of the aggradation that has occurred since that time.[11] Figure 23 also shows the overall aggradation that has occurred at the closest cross-section to the bridge (RR12) between the first survey in 1984 and the most recent one in 2011.[12]

[11] The bridge was constructed in 1957.
[12] The density of data points for the survey in 1984 was considerably less than that of the 2011 survey.

Figure 20 Rees River Bridge, November 1973

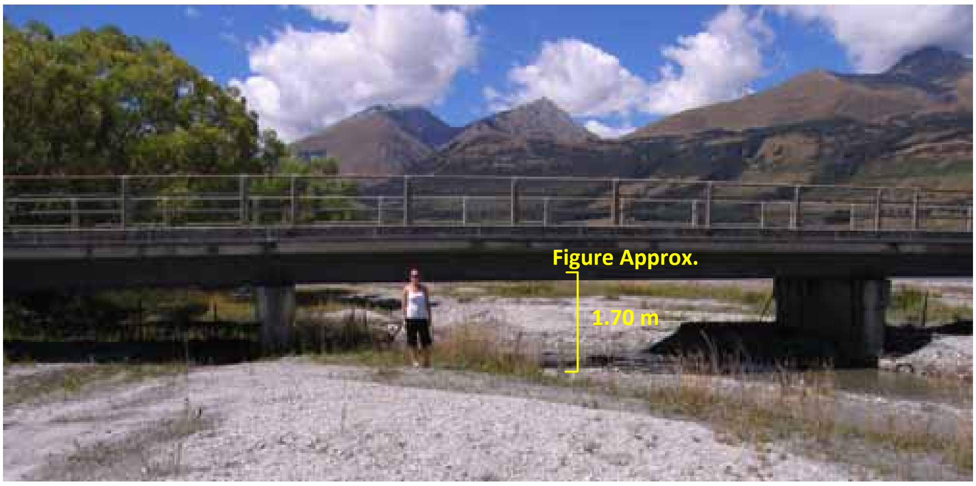

Figure 21 Rees River Bridge, on the true-right bank, looking upstream, February 2008

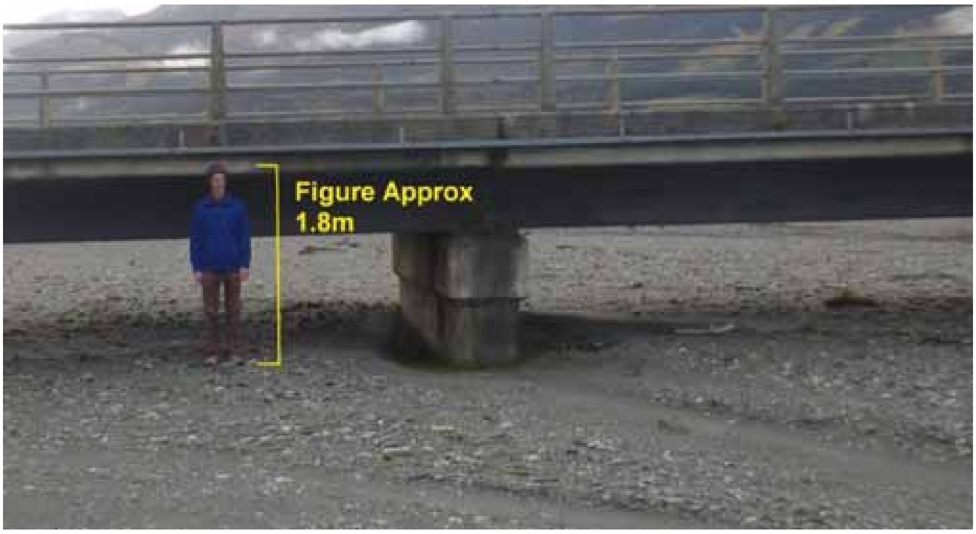

Figure 22 Rees River Bridge, on the true-right bank, looking upstream, May 2012

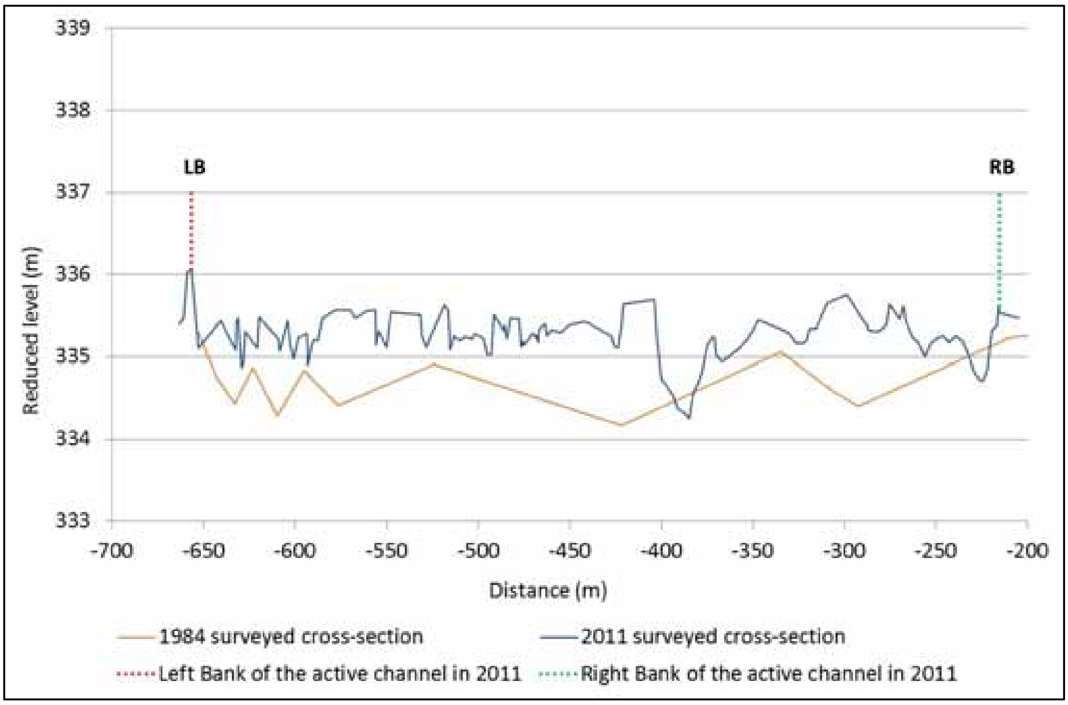

Figure 23 The earliest and most recent cross-section surveys at RR12, upstream of the Rees River Bridge

Changes in thalweg level at cross-sections RR11 to RR13 are shown in Figure 24. At the two cross-sections upstream of the Rees River Bridge, thalweg level did not change significantly between 2006 and 2011. Downstream of the bridge (cross-section RR11), thalweg level in November 2011 was similar to that in 1999, but 1m higher than in 2006.

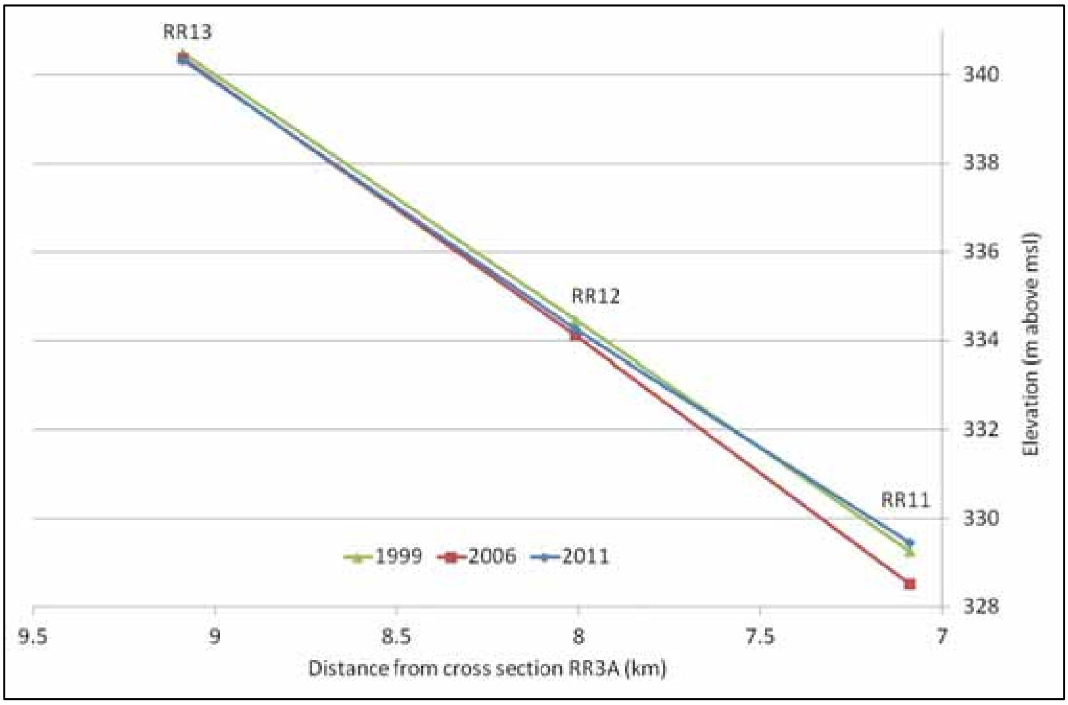

Figure 24 Thalweg values for cross-sections near the Rees River Bridge

Despite the net aggradation noted in this reach, the results of the 2011 survey suggest that the ability of the active channel to contain small to moderate flood events has improved slightly since 2006. The primary channel below the bridge now takes a more direct path, as it bypasses the island on the true right, with the active channel being wider on this side.[13] The deepest part of the channel upstream of the bridge has also become more incised and wider since 2006 (as noted above).

However, the overall net aggradation that continues to occur across the width of the active channel will have a detrimental effect on the capacity of the channel to contain larger flows. On-going aggradation will result in the Rees River Bridge being overtopped and the adjacent river terraces being inundated, at progressively lower flows. Observations after high flows in January 2013 suggest that flood water may have spilled out onto the true-right bank, upstream of the bridge (Figure 25), although neither the bridge nor the road was closed during this event.

Figure 25 Aerial view of the true right of the Rees River about 10am on 11 January 2013. Ponding on the lowest river terrace, between the active channel and Glenorchy-Paradise Road, is evident.

2.5. Upper part of the surveyed reach (cross-sections RR14 to 18A)

A summary of the changes observed at the cross-sections in the upper part of the surveyed reach of the Rees River between 2006 and 2011 is shown in Figure 26. Cross-section profiles from surveys conducted between 1999 and 2011 are shown in Figure 39 to Figure 43. These figures show that during this period, aggradation occurred in some parts of the active channel, while degradation was observed elsewhere. The largest change in the level of the river bed at any one point was about 2m, although generally the magnitude of change between survey periods is in the order of 0.2 to 0.5m.

Changes in thalweg level at cross-sections RR14 to 18A between 2003 and 2011 are shown in Figure 27. These changes suggest that the level of the lowest part of the river channel changed significantly between surveys.

[13] ORC (2008) states that the primary channel flowed to the true left of island at that time.

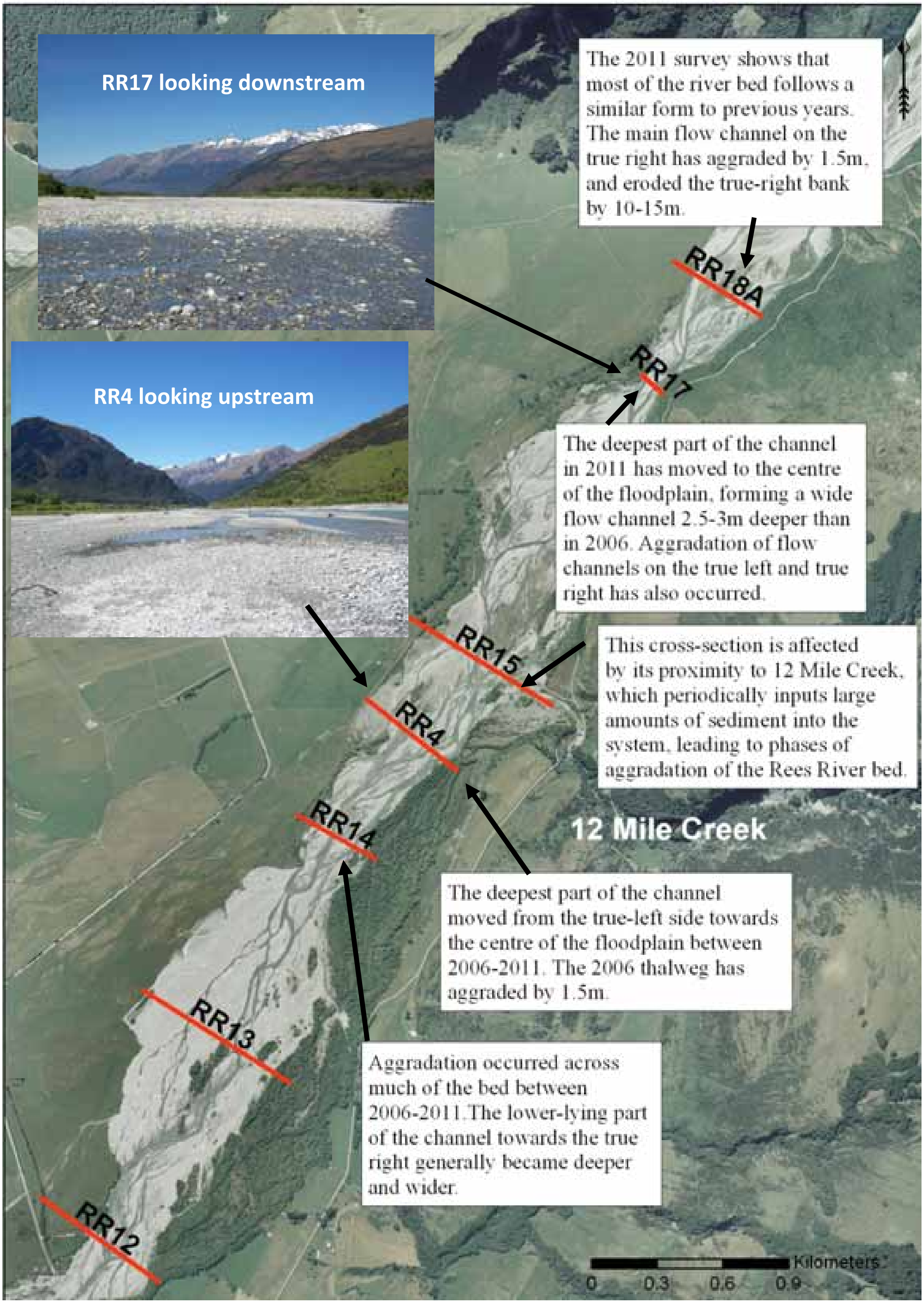

Figure 26 Summary of changes at cross-sections RR14 to RR18A between 2006 and 2011. Changes in RR12 and RR13 are described in Section 2.4. The aerial photo shows the state of the channel in February 2006.

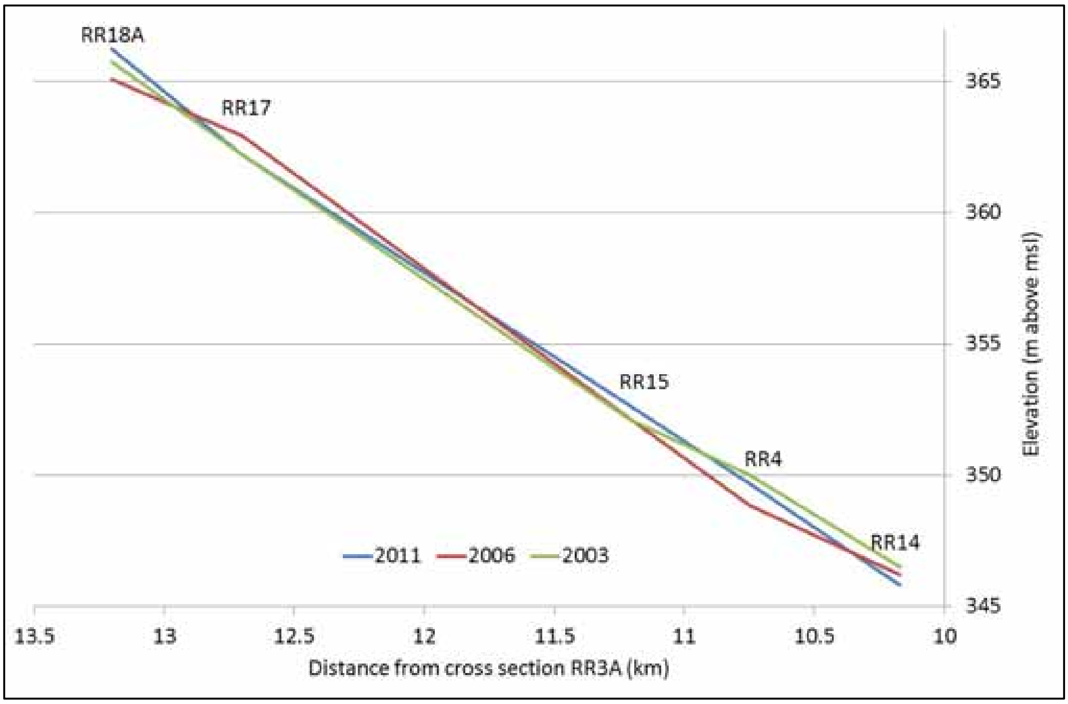

Figure 27 Thalweg values for cross-sections upstream of the Rees River Bridge

3. Conclusion

The active channel of the Rees River is a dynamic system that is constantly changing shape due to the natural processes associated with regular flood events and a high sediment load. Changes in the morphology of the active channel occurred between all survey periods, and included changes in thalweg level, location, shape and depth of the low-flow channel, and other changes across the active channel. These changes are probably due to the Rees River changing its primary flow path, additional channels (or braids) being created, or significant movement of sediment during flood events. Changes in morphology may also occur in response to sediment inputs from debris flows and alluvial fan activity. The surveyed cross-sections highlight the variability in the river bed between survey periods and show how the Rees River has been aggrading and degrading within the active channel between survey periods.

The constantly changing morphology of the channel and floodplain makes it difficult to determine any long-term trends (or lack thereof). However, the analysis undertaken for this report suggests that there has not been any obvious aggradational or degradational trend at the three cross-sections closest to Glenorchy since the first cross-section surveys were obtained in the 1990s. LiDAR information has helped to show that the lower part of the Rees River is perched (elevated above adjacent land) in its floodplain, suggesting that the Rees River has the ability to change its course towards the lateral margins of its floodplain, either west towards the Dart River, or further east, towards Glenorchy (Figure 28).

Figure 28 Aerial view towards Glenorchy and the lower Rees River about 10am on 11 January 2013

The findings of this report also suggest that the river channel has experienced an overall trend of aggradation in the vicinity of the Rees River Bridge. Survey data and historical photos indicate that the river bed has aggraded through this reach. As described above, localised erosion and degradation has occurred in some places, although the overall trend has been one of gradual aggradation.

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Appendix 1 Rees River cross-sections (left bank and right bank are based on November 2011 positions)

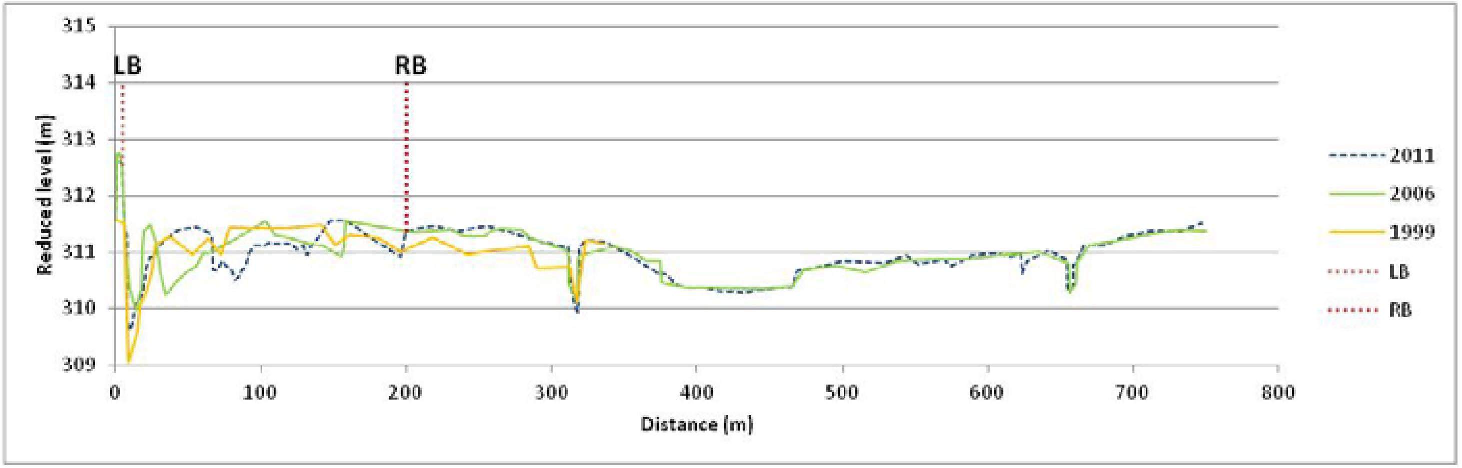

Figure 29 Cross-section RR3A – full width

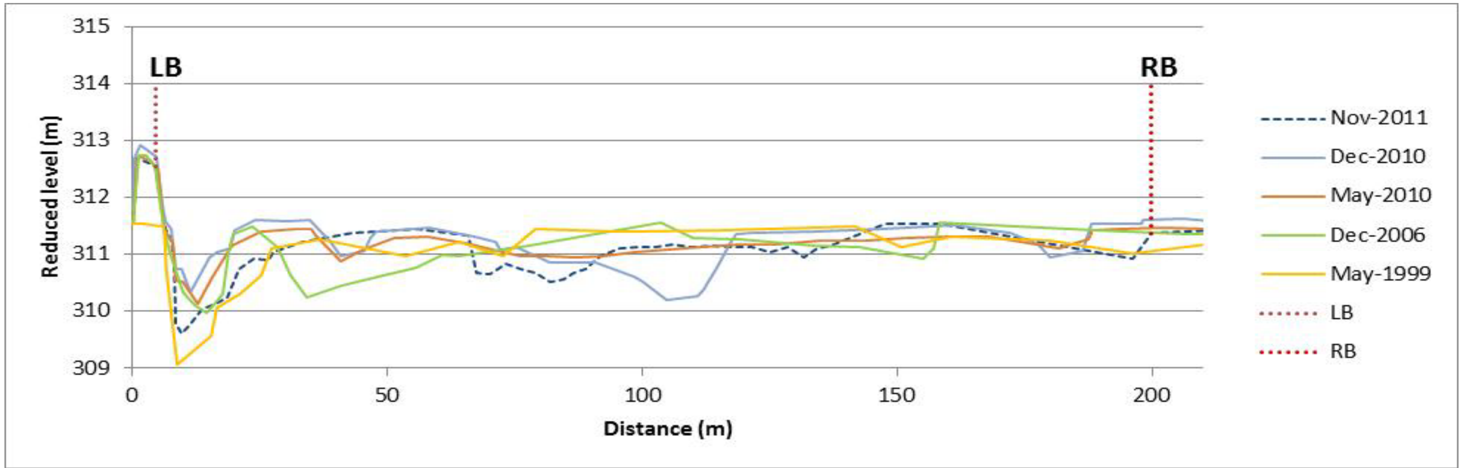

Figure 30 Cross-section RR3A – active channel

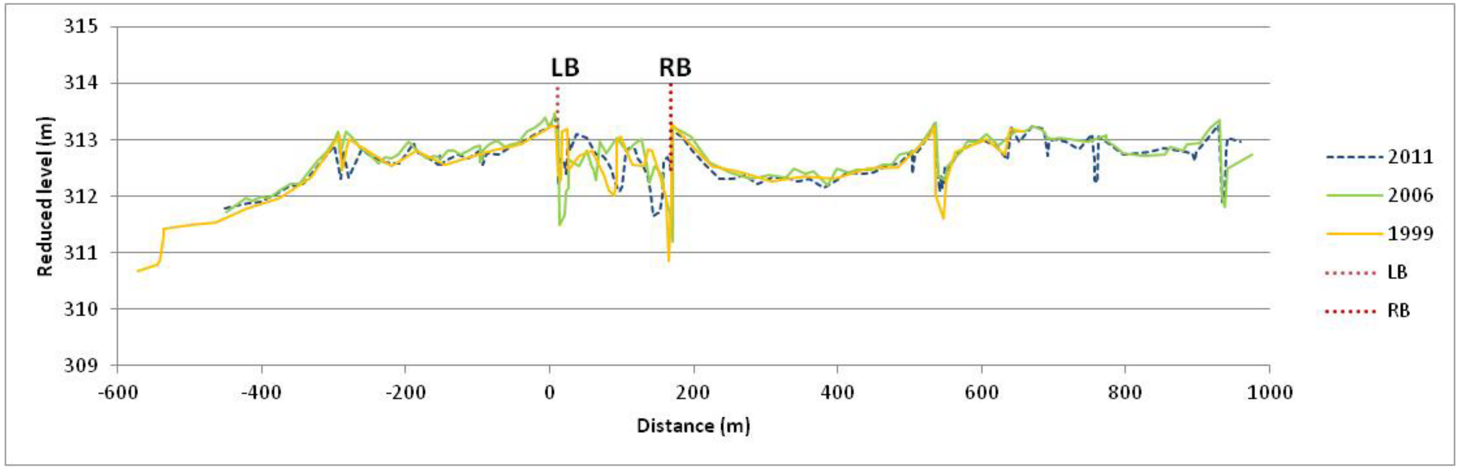

Figure 31 Cross-section RR4A – full width

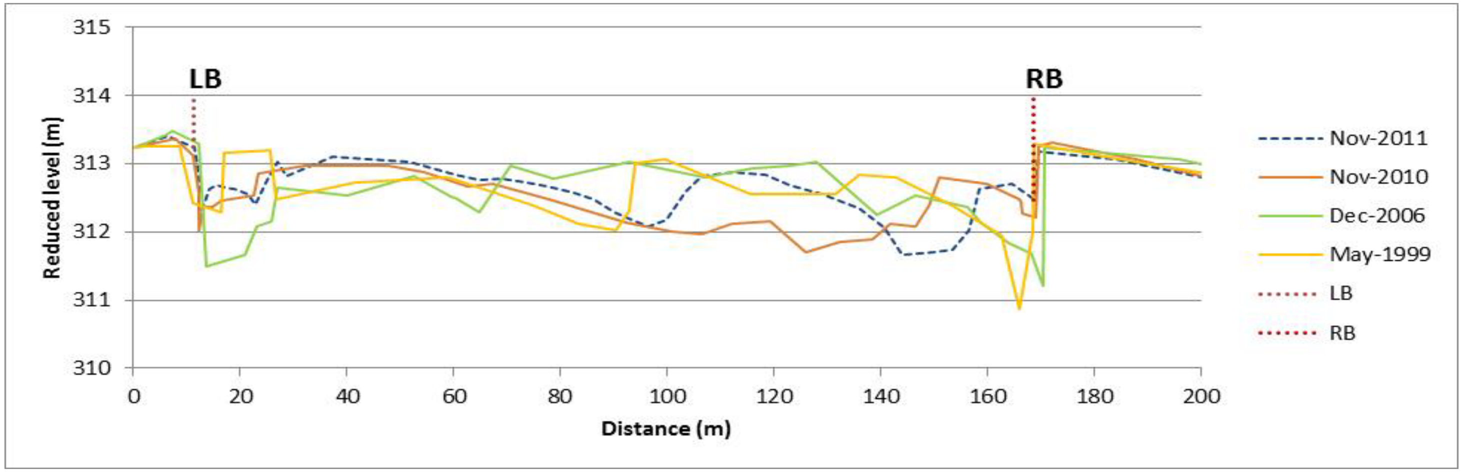

Figure 32 Cross-section RR4A – active channel

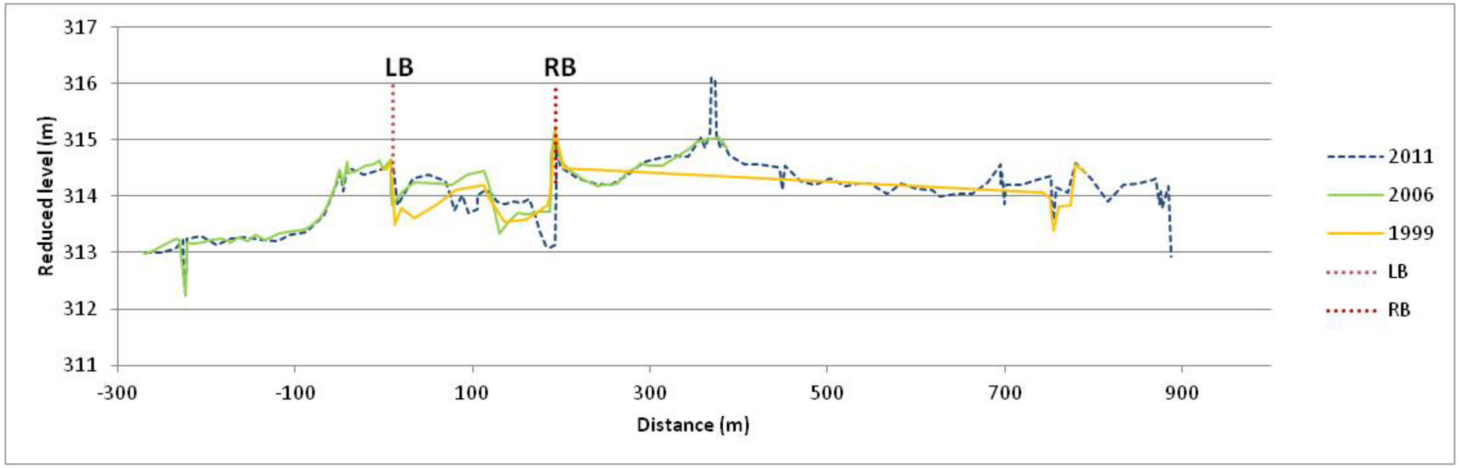

Figure 33 Cross-section RR5 – full width

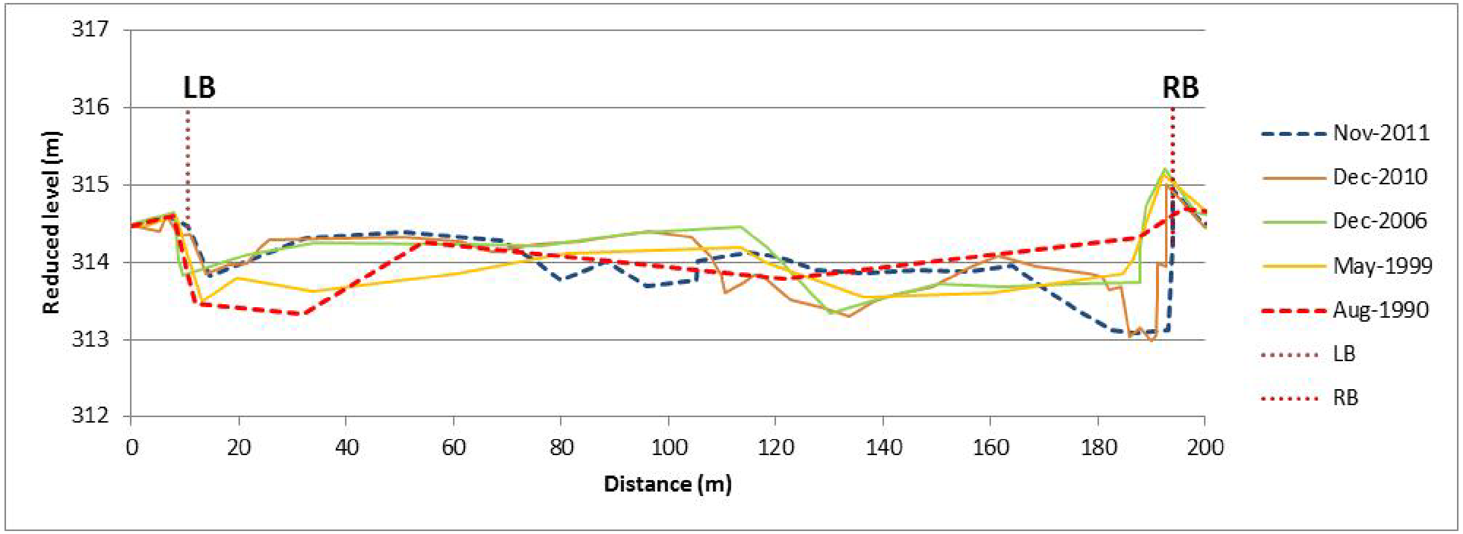

Figure 34 Cross-section RR5 – active channel only

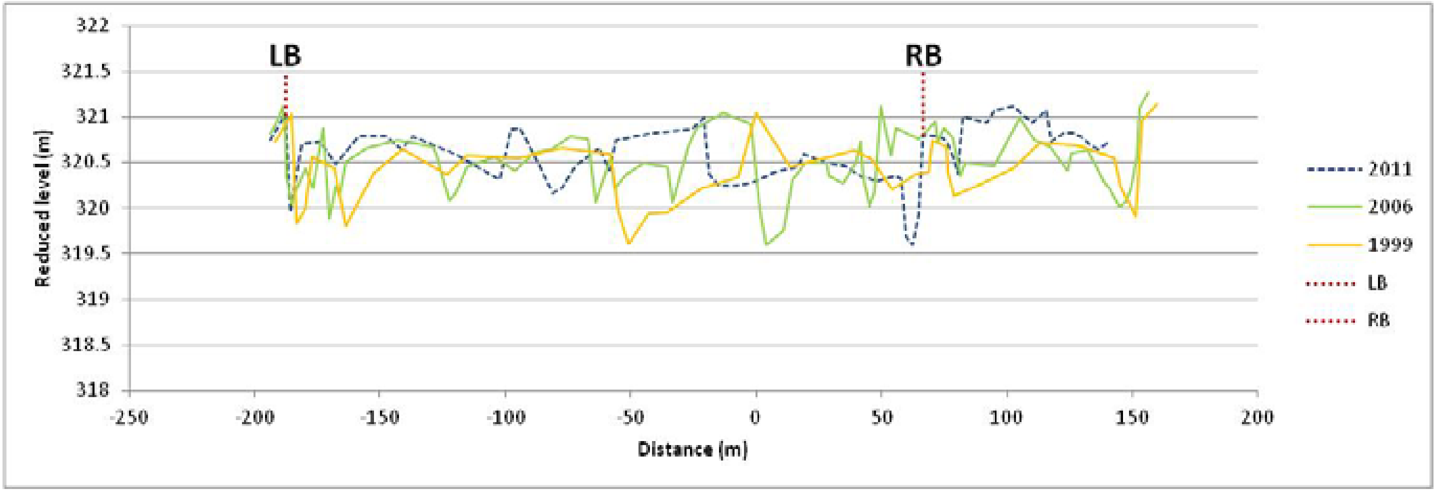

Figure 35 Cross-section RR8A

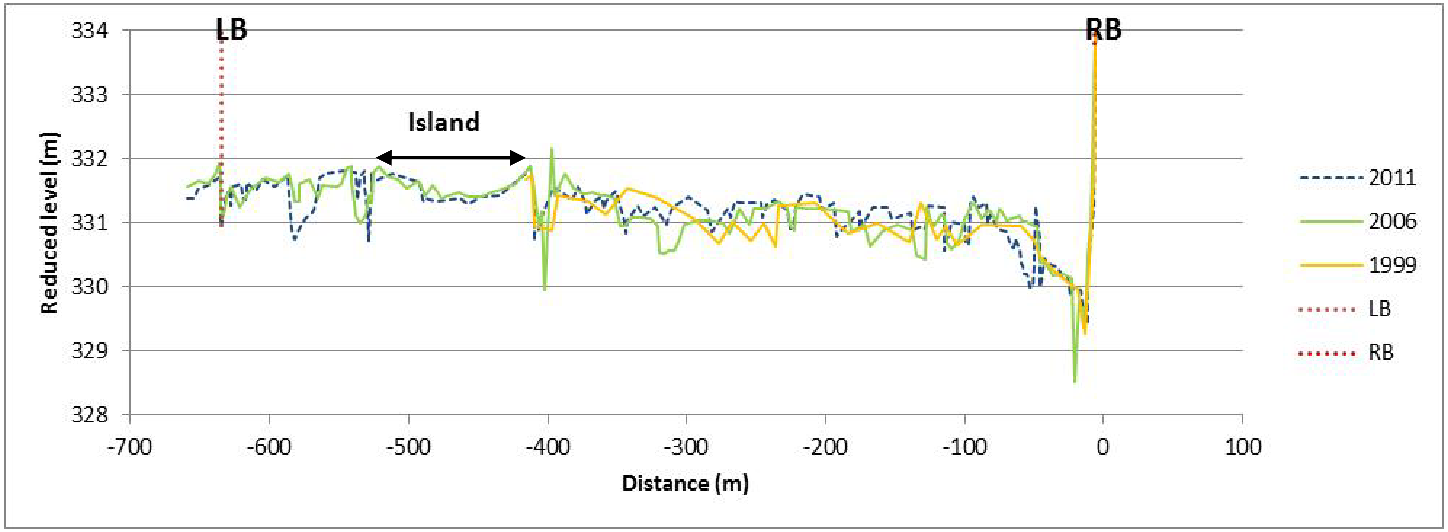

Figure 36 Cross-section RR11

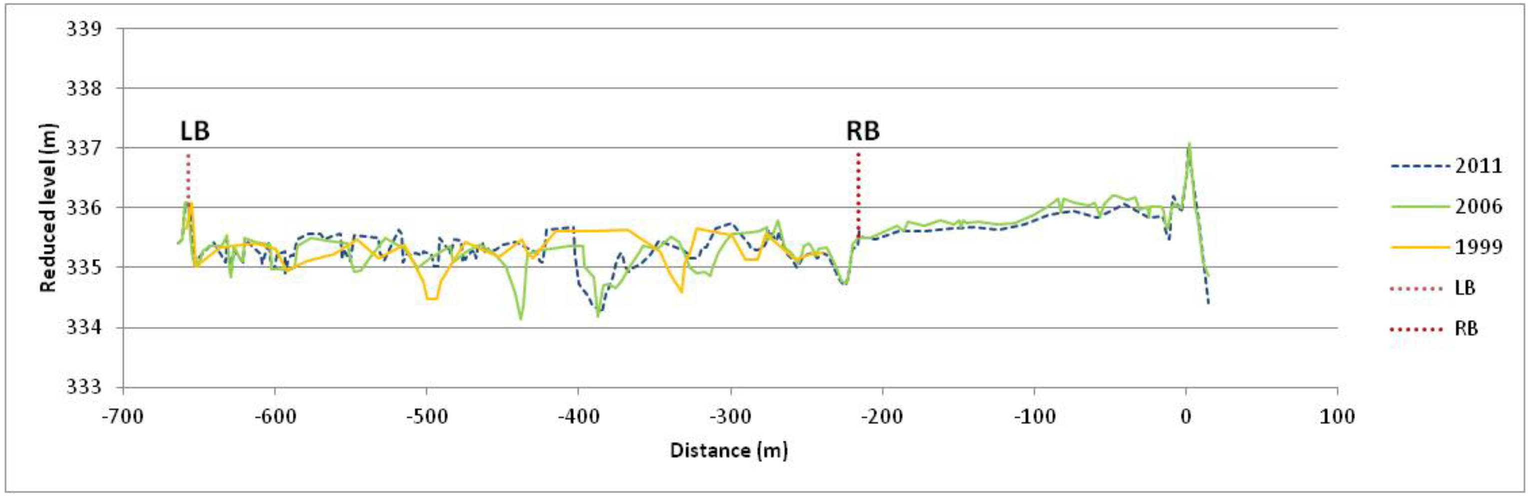

Figure 37 Cross-section RR12

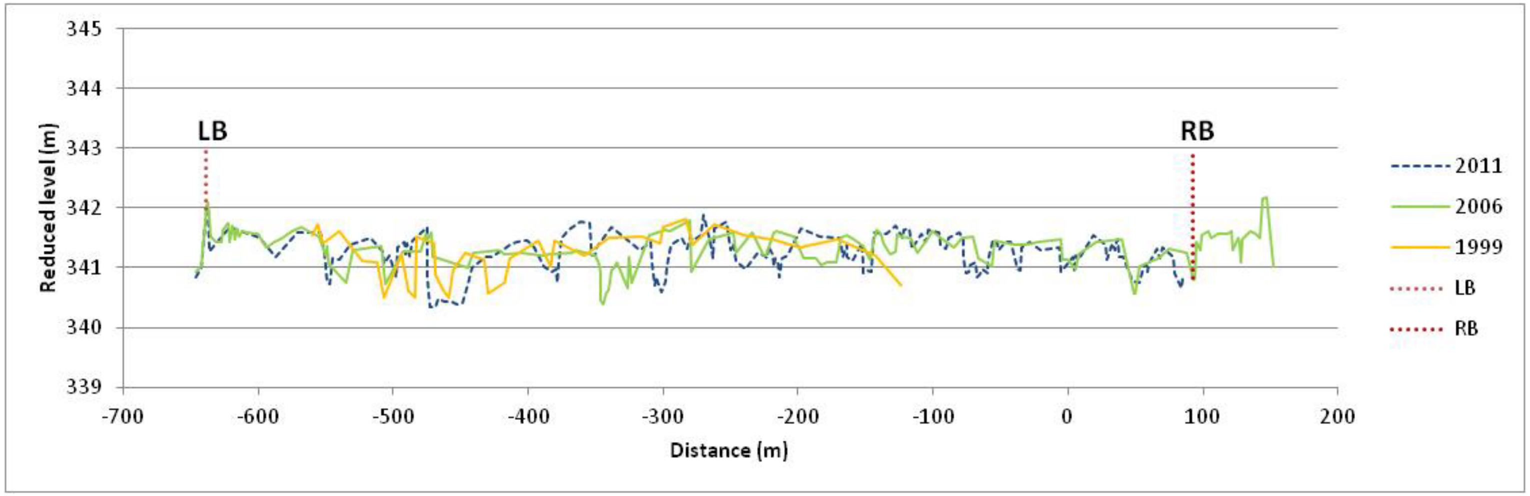

Figure 38 Cross-section RR13

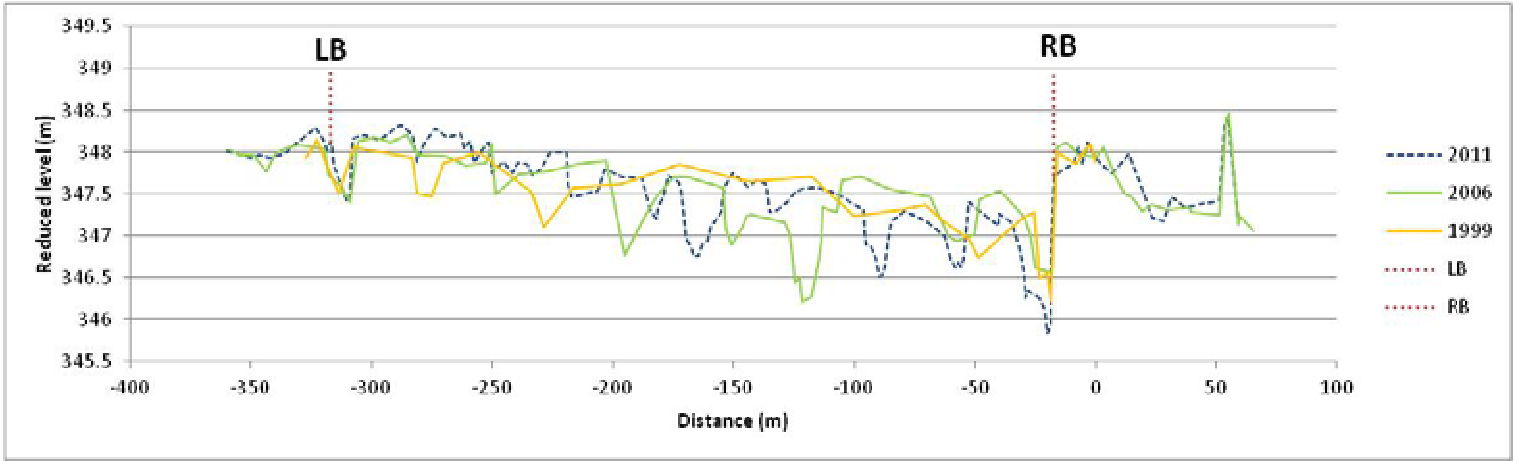

Figure 39 Cross-section RR14

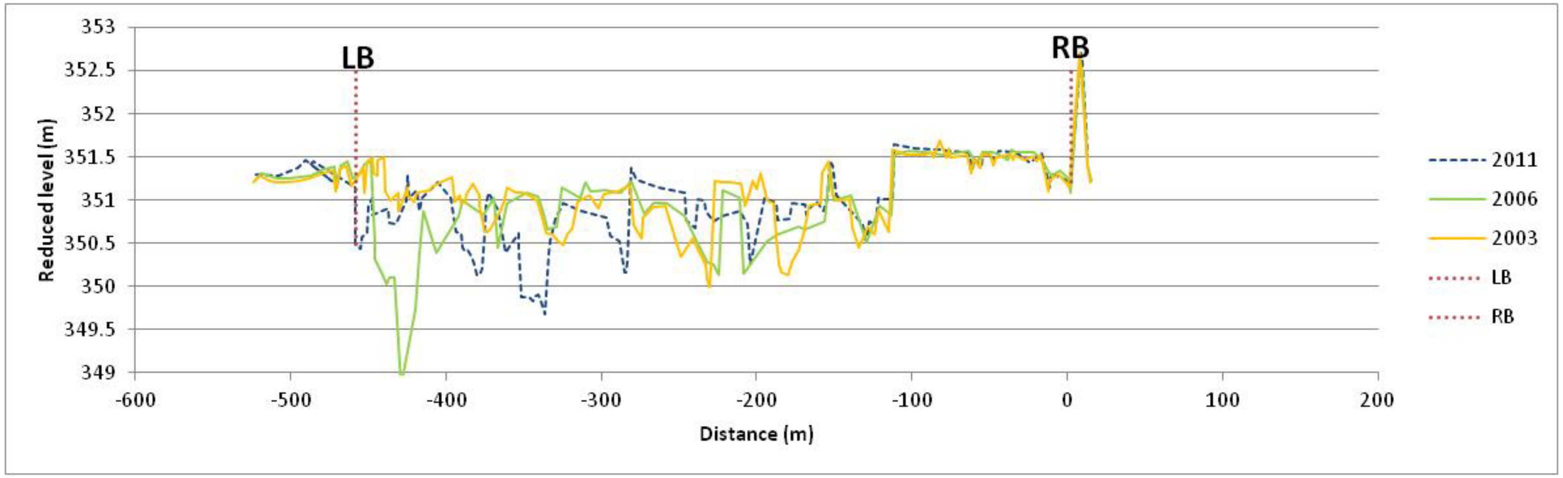

Figure 40 Cross-section 4

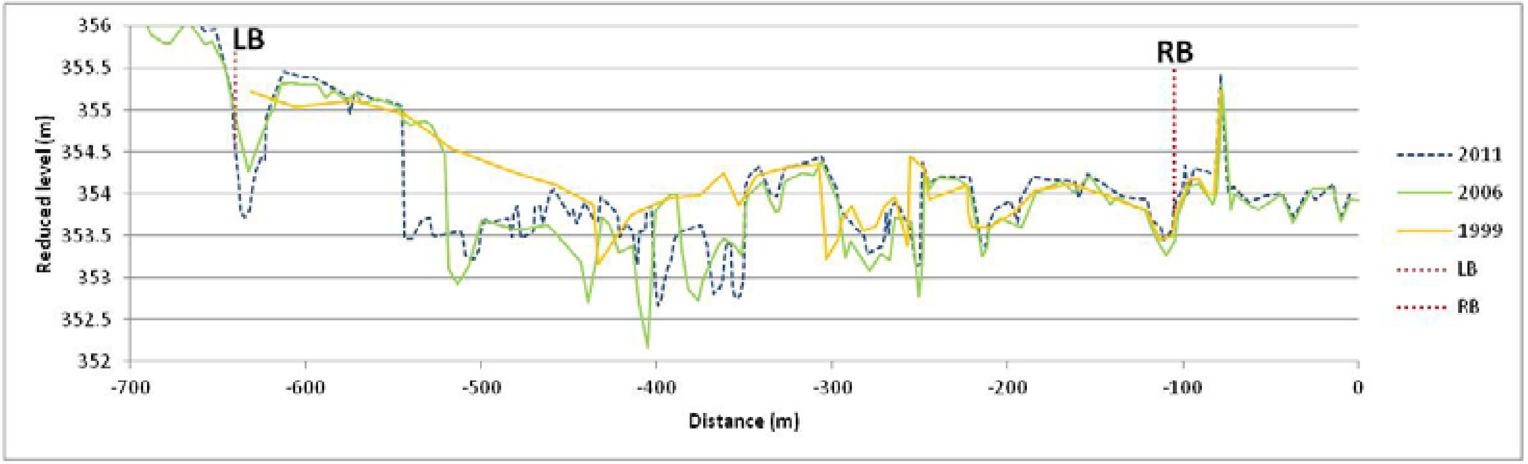

Figure 41 Cross-section RR15

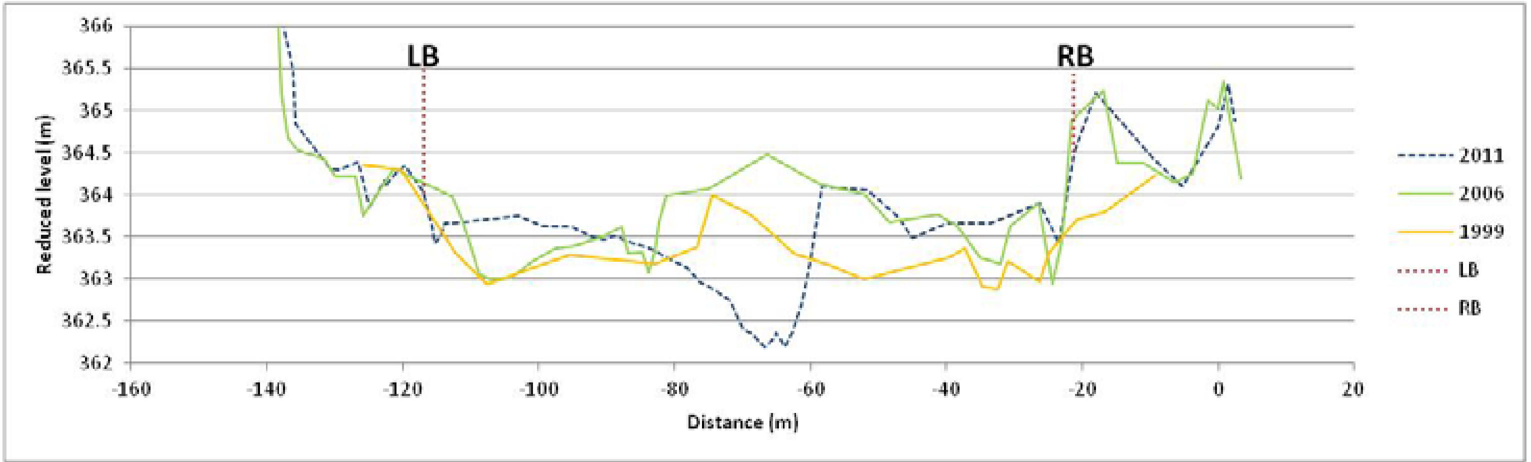

Figure 42 Cross-section RR17

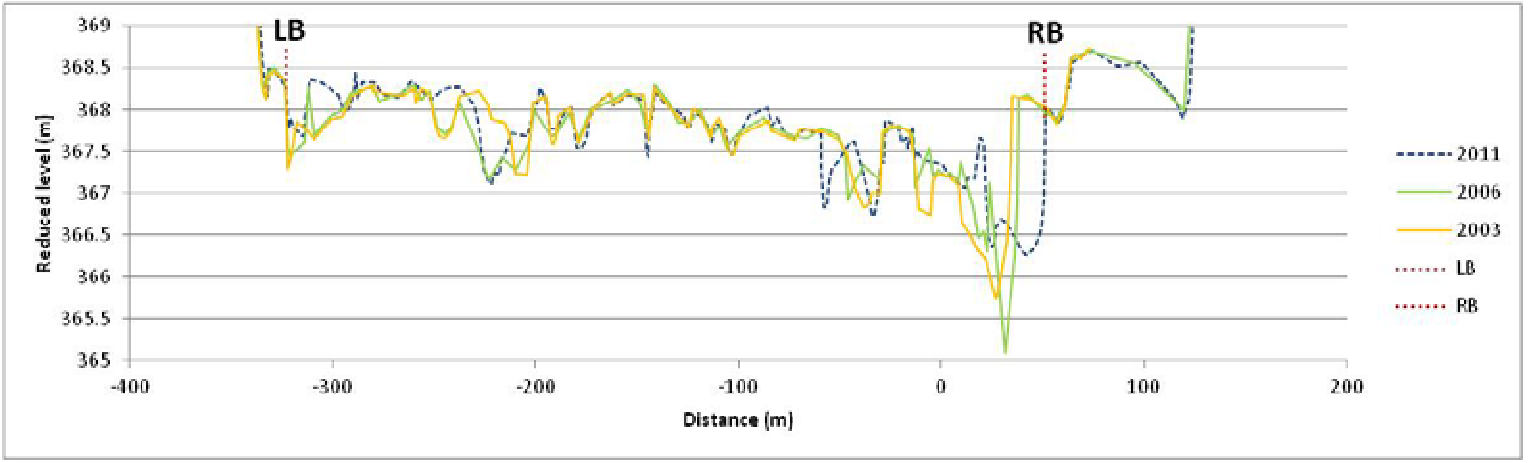

Figure 43 Cross-section 18A

Appendix 2 Methods

The ORC has collected cross-section survey information at 12 locations over a 13.2km stretch of the Rees River between Lovers Leap and Lake Wakatipu (Figure 1). Comprehensive surveys at all 12 locations were completed in 2003, 2006 and 2011, with partial surveys dating back to August 1978 (Table 1).

This report is intended to summarise any changes in morphology that have occurred since the last channel morphology report was published by ORC in 2008. The analysis therefore focuses on changes that occurred between the two full sets of data collected in December 2006 and November 2011. Other information is incorporated where appropriate, including earlier survey data, other observations and photos.

Table 1 Surveyed cross-sections for the Rees River. A blank space indicates that a cross-section was not surveyed that year.

Cross-section	Survey year											
	1978 Aug	**1984 June**	**1987 July**	**1990 Aug**	**1996 April**	**1999 May**	**2003 July**	**2006 Dec**	**May 2010**	**Nov 2010**	**Dec 2010**	**Nov 2011**
RR3A						X	X	X	X		X	X
RR4A			X			X	X	X		X		X
RR5				X		X	X	X			X	X
8A		X				X	X	X			X	X
RR11		X			X	X	X	X				X
RR12		X			X	X	X	X				X
RR13					X	X	X	X				X
RR14		X			X	X	X	X				X
4					X		X	X				X
RR15		X	X		X	X	X	X				X
RR17	X	X			X	X	X	X				X
18A	X	X					X	X				X

A limitation of the cross-section data is that it only shows a profile across the river at the time the survey was undertaken; therefore, it provides a snapshot view of the river morphology for that particular time and place. Furthermore, survey methods generally involve taking an elevation and distance measurement at every major break in slope. This method has limitations in terms of transect resolution. Earlier cross-sections (before 2006) generally contain fewer points than the later cross-sections. The interpretations made in this report, therefore, should be viewed within the context that the data was collected.

A decision was made not to compare mean bed levels at each cross-section for this report. The braided nature of the Rees River (with regular and significant changes in channel position and river bank location) means that the mean bed level at the time of one cross-section survey can often not be directly compared against that of a subsequent survey. An example is shown in Figure 44, where the location of the true-right bank (as defined during the survey process) in 2011 was 90m from its location in 2006.

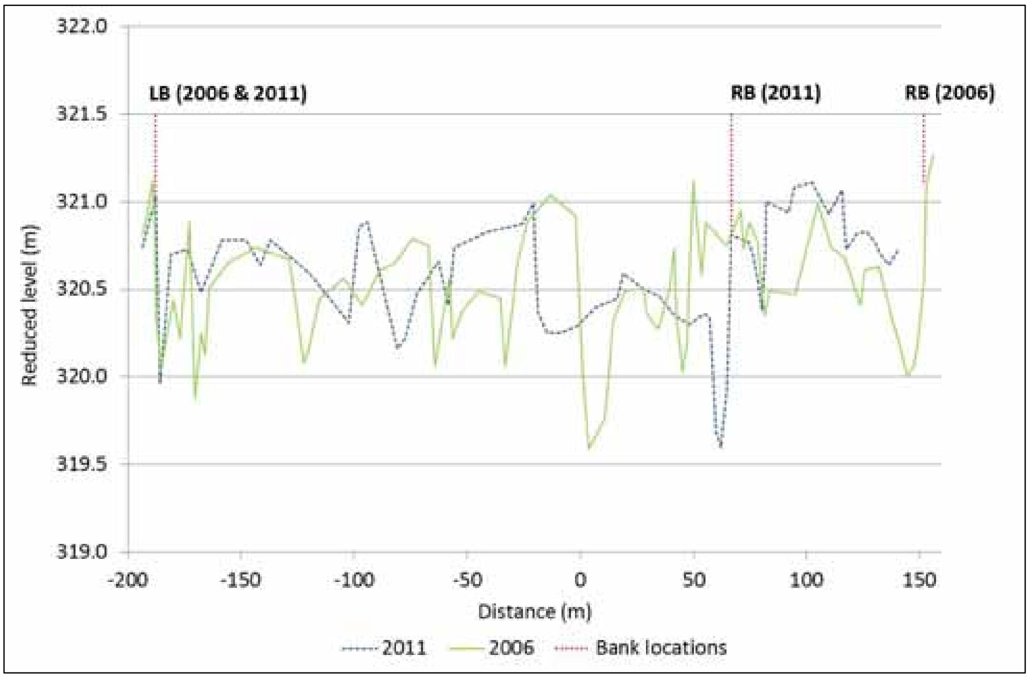

Figure 44 Cross-section data for RR8A in 2006 and 2011

Rather than calculating and comparing mean bed level, a general description of observed changes in morphology at each section has been provided (e.g. where the main channel has become more confined, or where significant aggradation/degradation is apparent).

Minimum (thalweg) values of each cross-section for each survey period were also determined. Analysis of thalweg values over different survey periods can indicate whether the gradient of the river has changed over time as a result of sediment movement (aggradation and/or degradation). Thalweg values were plotted against distance upstream from cross-section RR3A (the most downstream cross-section) for the 1999, 2006 and 2011 surveys. Changes in this profile over time can be used to indicate where the gradient of the river has changed due to the movement of sediment.

An analysis of thalweg values, and a more detailed description of changes in morphology, is provided for two reaches of the river (opposite Glenorchy and upstream/downstream of the Rees River Bridge) where community assets vulnerable to flood and erosion hazard exist. A brief description of recent changes at the cross-sections located outside these two reaches has also been completed.

LiDAR, obtained by the ORC and the Queenstown Lakes District Council in October 2011, was available for the lower reaches of the Rees and Dart rivers. LiDAR is useful in that it provides topographic data over a much wider extent than cross-section data (Figure 1 and Figure 11), and has a horizontal accuracy of ±0.2m and a vertical accuracy of ±0.15m. It was used to extend the length of existing surveyed cross-sections that cross the Rees River channel and to create new transects. Note that spot heights derived from LiDAR are not reliable for areas that were covered by water at the time of collection and are therefore unable to be used for thalweg determination.