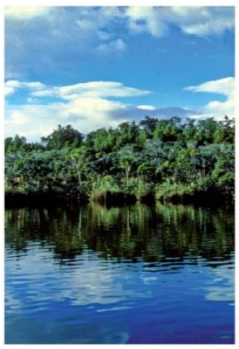

River planform and cross-section changes in the Whangamoa River near the Kokorua lowland forest remnant

Envirolink Advice Grant: 1407-NLCC74

Landcare Research
Manaaki Whenua

River planform and cross-section changes in the Whangamoa River near the Kokorua lowland forest remnant

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Contents

Summary

Project and Client

- Nelson City Council sought advice regarding river dynamics in the lower Whangamoa River where severe bank erosion has begun to remove parts of a regionally significant remnant of lowland coastal alluvial forest.
- The work, by Landcare Research, was carried out in September–November 2013.

Objectives

- Provide background understanding of river processes to underpin solutions to control bank erosion and prevent further loss of the remnant forest stand.

Methods

- Changes in river cross section were measured by annual cross-section surveys (2007 to 2012) with one cross section located on a meander bend adjacent to the forest remnant.
- River planform changes were mapped from orthophotographs taken in 1999 and 2009.

Results

- The cross-section data show very little change between 2007 and 2011, but between 2011 and 2012 the left bank retreated by c. 5 m and the channel deepened by >1.5–2 m.
- This change was probably associated with floods in December 2011 and January 2012.
- There does not appear to be any evidence of a build-up of gravel on the beach on the inside of the meander bend causing high shear stress on the outside of the bend.
- There has been little change at upstream and downstream cross sections.
- Mapping of channel planform change suggests that the straight reach of channel upstream of the meander bend realigned eastwards (in the order of 10 m) causing the downstream bend in the channel to become tighter, putting more stress on the true left bank, causing the bank to erode and the channel to deepen.
- The channel realignment occurred at least 2 years before bank erosion began and is part of the natural downstream migration of meander bends.

Conclusions

- Severe bank erosion at the Kokorua forest remnant occurred between the 2011 and 2012 cross-section surveys but was probably a response to earlier changes in channel planform upstream of the site. The channel meander bend is migrating downstream causing erosion on the outside of the bend and deposition of a point bar on the inside of the bend.
- The channel is likely to continue to migrate and erode the left bank in the absence of significant bank protection and/or realignment of the channel.

1 Introduction

Nelson City Council has sought advice regarding river dynamics in the lower Whangamoa River where severe bank erosion has begun to remove parts of a regionally significant remnant of lowland coastal alluvial forest on the inside of a large meander loop on the west (true left) bank of the river. It is intended that this advice provide background to determining solutions to control bank erosion and prevent further loss of the valuable forest stand. This short report summarises what annual survey of river cross sections and time-series planform mapping show about river behaviour over the last 10–15 years. This work by Landcare Research was completed between September and November 2013.

2 Methods

Changes in river cross sections were established from annual surveys of cross sections (described in Basher 2013), one of which (Cross Section 2) is located immediately adjacent to the forest stand (Figure 1). River planform changes were determined from two sets of orthophotographs taken in 1999 and 2009. A field visit to the site with a river engineer and scientist was undertaken to discuss bank erosion control options.

3 Results

3.1 River cross section trends

Cross Section 2 has been surveyed annually between 2007 and 2012 providing 6 years of record (Figure 2). These data are collected by tape-and-level survey and results are considered accurate to within ± 5 cm in the vertical and ± 20 cm in the horizontal. Wooden builders' pegs were placed in the ground as benchmarks at both ends of the surveyed cross section to ensure accurate re-location in subsequent surveys. The cross section was originally located at this point principally to characterise trends in bed level on the gravel beach (point bar) on the inside of the bend.

When it was first surveyed the section was characterised by a c. 2-m-high, near-vertical bank on the true left, a wetted channel about 5 m wide and 0.5 m deep, and a gently rising gravel beach on the true right c. 15 m wide. Total cross-sectional width between the benchmarks was 31.3 m. The true left bank downstream of the cross section was lined with standing and fallen shrubs and trees and my notes record rock protection and an eroding bank upstream of the section (but not shown on any of my photos).

The left benchmark, originally set nearly 2 m back from the eroding bank, was lost between the 2011 and 2012 surveys and replaced along what we believe to be close to the line of the original section. The left bank remains a vertical eroding bank but is now at least 3 m high, and the wetted channel is wider (c. 10 m) and deeper – in 2012 it was too deep to survey (>1.5 m deep). The difference in wetted channel width may be due to differences in flow between the survey dates.

Figure 1 Overview of lower reaches of Whangamoa River showing location of forest remnant within meander loop of the river and the location of river cross sections. Underlying image was taken in 2009.

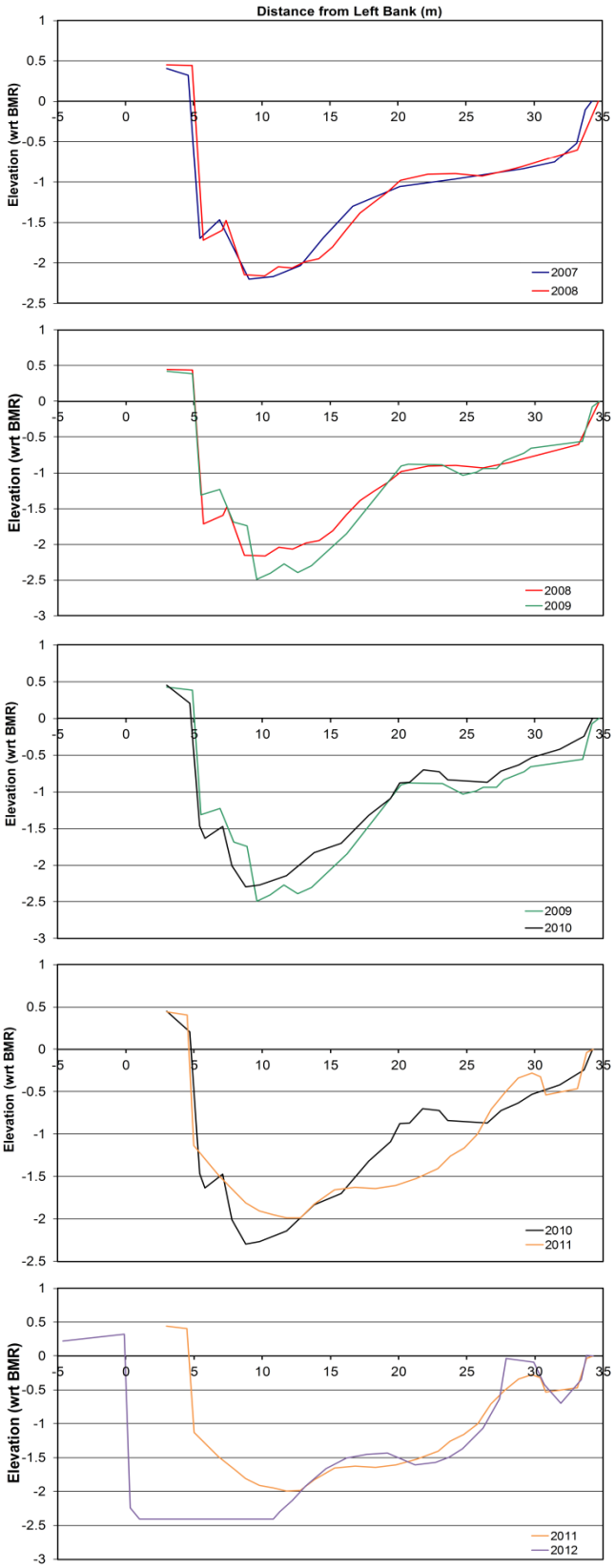

Figure 2 Comparison of annual plots of river-cross-section shape at Kokorua forest remnant, 2007–2012 (Cross Section 2).

The cross-section data show the following (Figure 2):

- 2007–08: very little change
- 2008–09: slight deepening of the channel in the centre of the river
- 2009–10: slight aggradation in the channel and the beach of the true right bank, slight deepening at the base of the true left bank
- 2010–11: slight aggradation in the channel and degradation of the river margin of the gravel beach on the true right
- 2011–12: the left bank retreated by c. 5 m and the channel deepened by at least 1.5–2 m.

In summary, only small changes to cross-section shape occurred from 2007 to 2011, with the major change occurring between the 2011 and 2012 surveys when there was massive bank erosion and channel deepening on the true left. This may have been associated with high flows during the December 2011 and subsequent storms, although there is no flow record for the Whangamoa and the storm did not appear to be as large in the Whangamoa area as in the lower Wakapuaka. A local resident suggests much of the erosion occurred in a series of floods in December and January (B Healy, pers. comm., October 2013).

These observations are supported by mean bed level (MBL) calculations that show between 2007 and 2011 MBL varied by ± 6.5 cm (essentially within measurement error) but between 2011 and 2012 fell by at least 25 cm (MBL cannot be accurately calculated for 2012 because the deep wetted channel was not entirely surveyed). There does not appear to be any evidence of a build-up of gravel on the beach on the inside of the bend (true right) putting stress on the outside (true left) of the bend.

The adjacent cross sections are situated a long way (>450 m) upstream and downstream of Cross Section 2 and are not especially helpful in understanding the changes that have occurred there. Cross Section 3 is on a meander bend similar to Cross Section 2, while Cross Section 1 is on a relatively straight reach of river. There has been little change at either of these cross sections between 2007 and 2012 (Figure 3). At these sites the banks have remained stable and there have been only minor fluctuations in MBL (± 2.3 cm at Cross Section 1, ± 12.3 cm at Cross Section 3). There is a tendency for slight erosion and channel deepening at the base of the true left bank at Cross Section 3, but not as severe as at Cross Section 2.

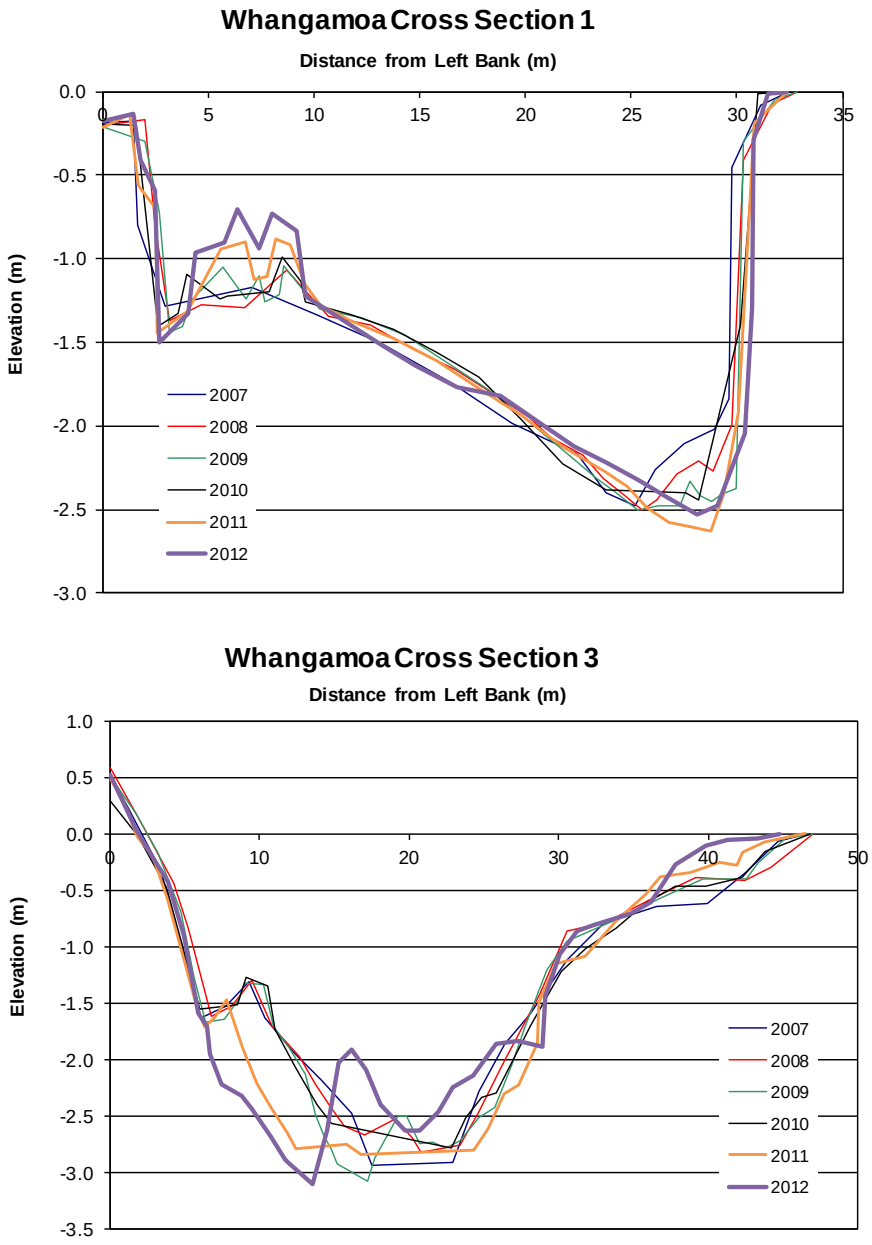

Figure 3 Changes in river-cross-section shape at upstream (Cross Section 3) and downstream cross sections, 2007–2012.

3.2 River planform changes

River planform changes help to provide a broader spatial context for the cross-section changes, although there is not a great match between the available orthophotographs (1999 and 2009) and the timespan of the cross-section surveys (2007–2012). Figures 4 and 5 show the position of the channel and the top of the channel banks[1] in 1999 and 2009 mapped on to the matching orthophotographs. Figure 6 shows the comparison between the two dates and

[1] The top of the channel bank is difficult to map in places with dense vegetation cover masking its true position

suggests substantial changes over the 10-year period. Part of the difference may be due to registration error, which can be up to 10 m on parts of the images; however, note the road adjacent to the site is well registered suggesting the differences are not likely to be due to registration error.

Figure 4 Mapping of channel planform in 1999 (RB = right bank, LB = left bank, TOB = top of bank, WE = water edge).

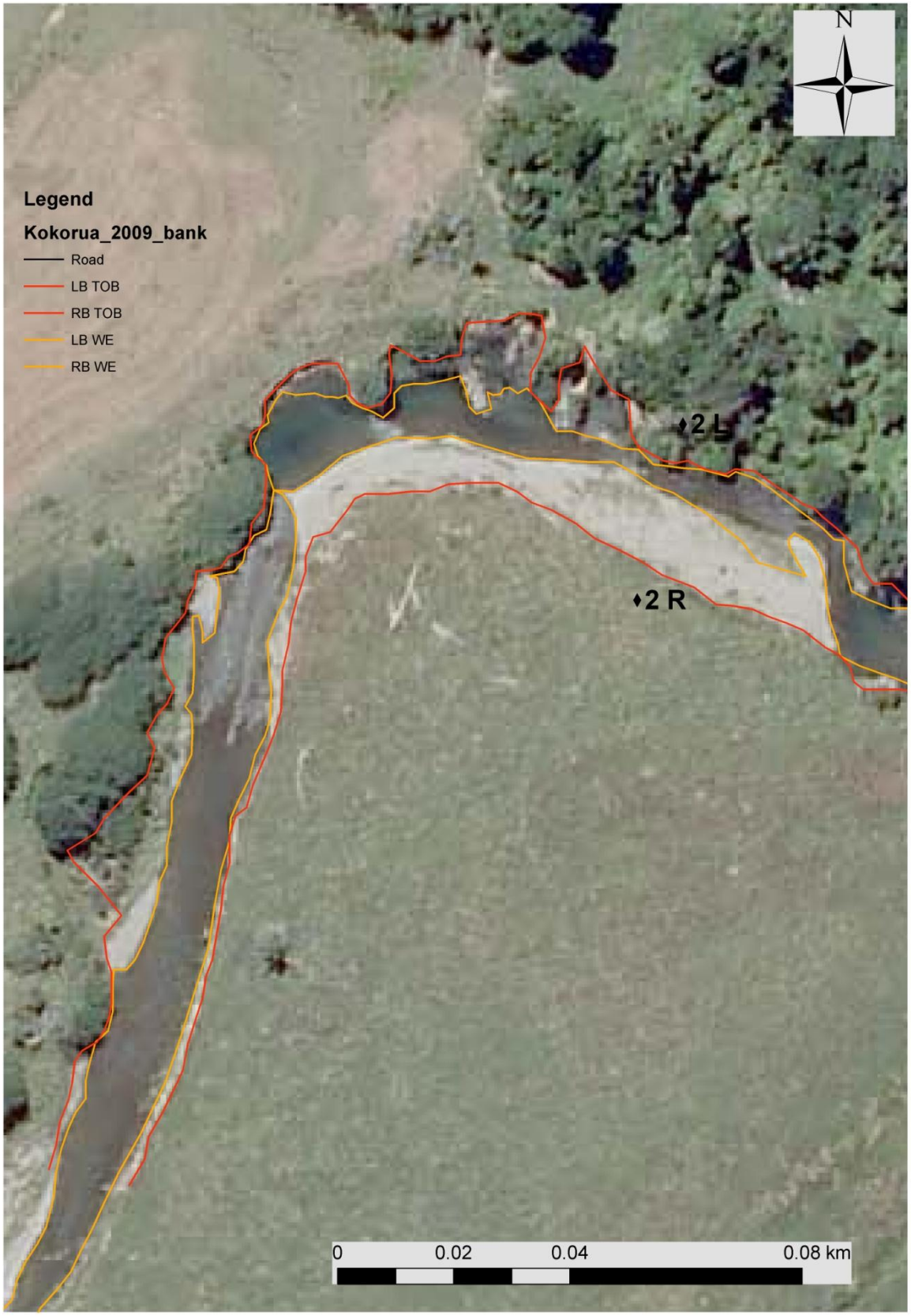

Figure 5 Mapping of channel planform in 2009.

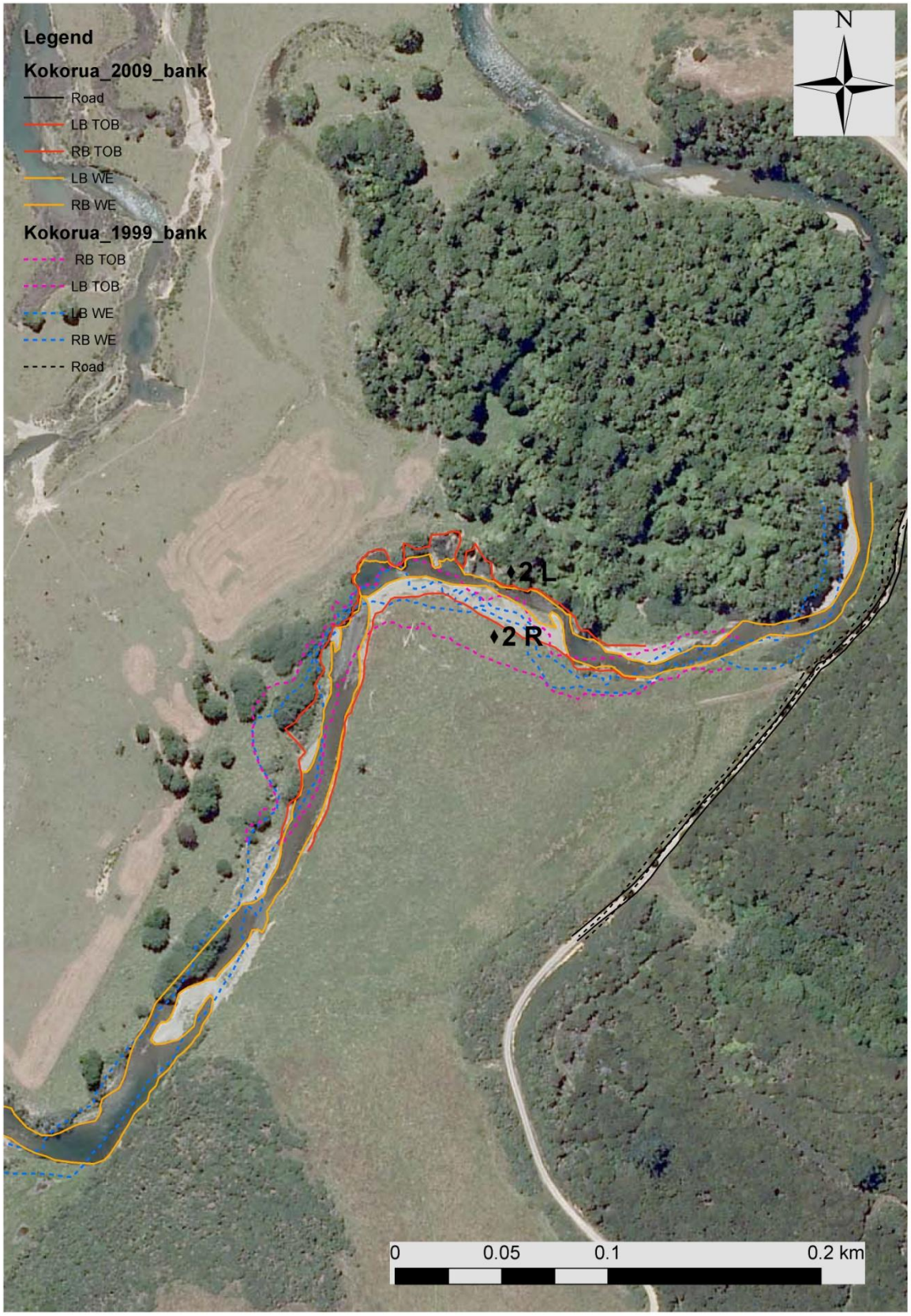

Figure 6 Comparison of channel planform in 1999 and 2009.

The mapping suggests that the straight reach of channel upstream of the bend on which Cross Section 2 is located has realigned eastwards (in the order of 10 m) causing the downstream bend in the channel to become tighter, putting more stress on the true left bank, causing the bank to erode and the channel to deepen. This has effectively resulted in the channel bend migrating and is part of the natural evolution of a meandering channel characterised by downstream migration of meander bends, which is associated with erosion on the outside of bends and deposition of point bars on the inside of bends (Figure 7). It is occurring at this point in the Whangamoa River because the sinuosity of the channel (ratio of channel length to down-valley length) between Cross Sections 1 and 3 is greater than anywhere else in the channel – it has a value of 1.6 compared with typical values of 1.1 to 1.2 between other cross sections.

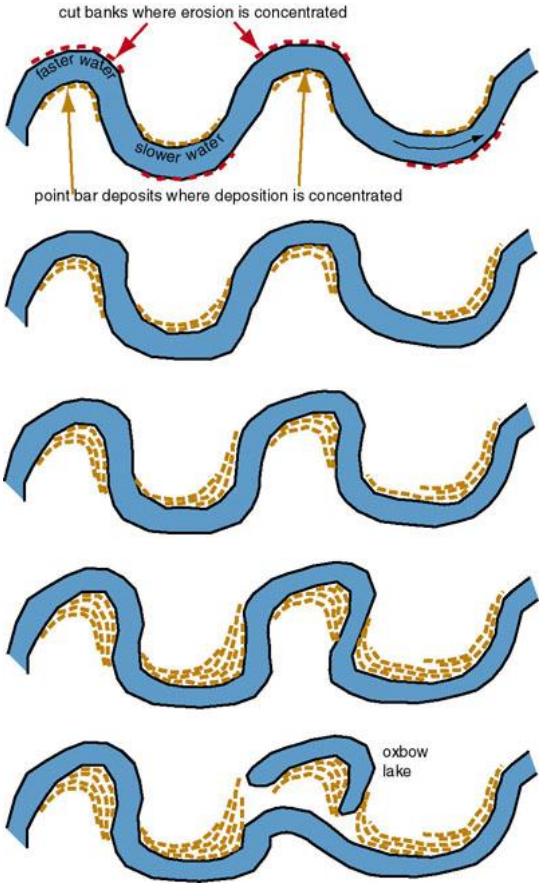

Figure 7 Diagrammatic illustration of the process of meander migration.

This apparent realignment of a straight reach of channel appears real since the channel mapping coincides upstream and downstream on the 1999 and 2009 mapping. It is not clear what has caused this channel realignment nor can the timing be established. It is possible the channel realignment may have occurred before the cross-section surveys began. It has occurred in an area with fairly dense willow cover, which may have caused deposition on the true-left berms. It does appear to confirm that the bank erosion is not a response to aggradation of the gravel beach on the inside of the bend – this is more likely to have been a consequence of sediment supplied by bank erosion from the upstream channel being deposited on the inside of the meander bend as a point bar. The channel is likely to continue to migrate and erode the left bank in the absence of significant bank protection or realignment of the channel.

4 Conclusions

Severe bank erosion at the Kokorua forest remnant occurred between the 2011 and 2012 cross-section surveys but was probably a response to earlier changes in channel planform upstream of the site. The channel meander bend is migrating downstream causing erosion on the outside of the bend and deposition of a point bar on the inside of the bend. The channel will continue to migrate and erode the left bank in the absence of significant bank protection and/or realignment of the channel.

5 Acknowledgements

Paul Fisher at Nelson City Council initiated the project and the Ministry of Business, Innovation and Employment provided funding under Envirolink Small Advice Grant 1407-NLCC74.

6 References

Basher LR 2013. River-cross-section data from the Wakapuaka and Whangamoa rivers: analysis of data 2007–2012 and implications for managing gravel extraction (Envirolink Medium Advice Grant 1272-NLCC-69). Landcare Research Contract Report LC1478 for Nelson City Council.