Review of Nelson City Council's river-cross-section network for managing gravel extraction

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Landcare Research
Manaaki Whenua

Review of Nelson City Council's river-cross-section network for managing gravel extraction

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Summary

Project and Client

- Nelson City Council asked Landcare Research (Envirolink grant NLCC64) in September 2012 to review the cross-section network being used to monitor bed-level trends in the Wakapuaka and Whangamoa rivers.

Objective

- Review the operation of the river-cross-section monitoring network and provide advice to Nelson City Council on its use for guiding allowable levels of gravel extraction.

Method

- Nelson City Council provided a copy of the data collected over the last five years and some summary analysis from Hilltop Software. The 32 cross sections were resurveyed and briefly compared with previous results.

Results

- The tape-and-level survey method is a practical, low-cost approach for characterising morphological change in the Wakapuaka and Whangamoa rivers.
- The builders' pegs used to mark the start and end of each cross section have not provided a durable or easily locatable set of benchmarks.
- A quality assurance procedure should be implemented to ensure all data entered into Hilltop Software has been carefully checked for accuracy and consistency and better use should be made of comments to complement the topographic survey data.
- Analysis of the data should report changes in both mean bed level and gravel volume.
- The available orthophotos should be used to map the location of all gravel beaches and to characterise variation in the river planform.

Recommendations

- Replace the builders' pegs being used as benchmarks with something more durable and more easily locatable.
- Complement the cross-section network with river planform mapping using the available orthophotos.
- Complete an analysis of 2012 survey data and review results of all previous surveys for errors, to underpin decisions about the need for gravel extraction.

1 Introduction

In 2007 Nelson City Council requested Landcare Research to design a practical, low-cost method for monitoring bed-level trends in Nelson rivers. Results were reported by Basher (2007).

Cross sections were established in the two major rivers in Nelson Region and a tape-and-level survey method used to characterise river morphology. In the Wakapuaka River 22 cross sections were established between the coast and Hira, and in the Whangamoa River 10 cross sections were established between the coast and State Highway 6. The positions of each end of the cross sections were marked with builders' pegs and their locations recorded by GPS. Data were compiled into a Microsoft Excel spreadsheet and used to calculate mean bed level at each of the cross sections. The cross sections have been surveyed annually since 2007 by council staff, and data are now compiled into Hilltop Software for archiving and analysis.

In December 2011 a severe storm affected parts of the Nelson Region, causing large floods in the Wakapuaka and Whangamoa rivers. At the Wakapuaka-at-Hira gauging site the flood recurrence interval was <10 years; however, much of the rain was concentrated near the coast and in the lower reaches of the river the flood was probably much larger – 370 mm of rain was recorded in 2 days at Hira. Other effects included localised extensive landsliding, flooding, gravel movement and changes in river morphology.

Nelson City Council have sought advice on the operation of the river-cross-section network to provide guidance for future gravel extraction, river control and flood control measures to protect infrastructure. The 32 cross sections were re-located and resurveyed with council staff. Discussions were held with council staff over the methodology and results of previous surveys.

2 Objective

- Review operation of the river-cross-section monitoring network and provide advice to Nelson City Council on its use for guiding allowable levels of gravel extraction.

3 Method

- Nelson City Council provided a copy of the data collected over the last five years and some summary analysis from Hilltop Software. The 32 cross sections were resurveyed and briefly compared with previous results.

4 Results

The methodology implemented by Basher (2007) has proved a practical, low-cost approach for developing an understanding of morphological dynamics in the Wakapuaka and Whangamoa rivers. The 32 cross sections can be surveyed by two staff in 3 days. The data are beginning to provide a picture of relative stability and instability in different parts of the two rivers.

Builders' pegs, extending only 20 cm above the ground surface, were used for the benchmarks marking the start and end of each cross section. With the growth of grass, gorse and willows, along with changes in river course, deposition of silt and sand burying pegs, and rotting of pegs, it has become difficult to find some benchmark pegs and many have been replaced. These changes have not always been recorded. This is not ideal as it may change the location of cross sections slightly, which can influence results. It would be worth considering replacing the builders' pegs with something more permanent and taller (e.g. steel waratah posts) so they are more durable and easier to locate in tall vegetation. This would increase the efficiency of survey and decrease the likelihood of further loss of benchmarks.

An additional issue is that some cross sections have changed substantially, through bank erosion (Whangamoa Cross Section 2, Wakapuaka Cross Sections 2, 3, 5) or river avulsion[1] (Wakapuaka Cross Section 17). Bank erosion should be predictable from the trends of past surveys and from field evidence, but river avulsion is likely to be unpredictable. Bank erosion will continue to affect many cross sections and at these sites it would be worth establishing auxiliary benchmarks as back sights to ensure the cross-section positions can continue to be accurately located. All information on loss of benchmarks and channel changes should be archived in Hilltop Software so any analysis can incorporate consideration of their effect on the results. Some sections are not surveyed full width because they are too deep (Wakapuaka Cross Section 5, Whangamoa Cross Section 2) and these results should not be used for analysis – this should also be clearly recorded in Hilltop Software.

The cross-section data can be used to calculate mean bed level (MBL) at each cross section, and to calculate change in gravel volumes between cross sections and overall. MBL can be calculated accurately so long as the cross section is surveyed full width and should always be reported as a reliable indicator of change in bed level at a cross section. Calculations of gravel volume changes are less reliable because of the generally large distance between cross sections (typically several hundred metres) compared to the widths of the cross sections (mostly <50 m), and because of the meandering planform of both rivers. Work in the Motueka River comparing detailed planform mapping from GPS surveys with cross-section data has shown that the cross-section approach typically underestimates changes in gravel volume (Fuller & Basher 2010).

The cross-section method relies on the cross-section locations accurately representing overall river morphology. This was not rigorously assessed by Basher (2007) as the emphasis in that study was on establishing a practical survey methodology. There are clear examples where the location of cross sections does not adequately characterise river behaviour. For example Whangamoa Cross Section 9 is a very stable cross section where little has changed in 5 years.

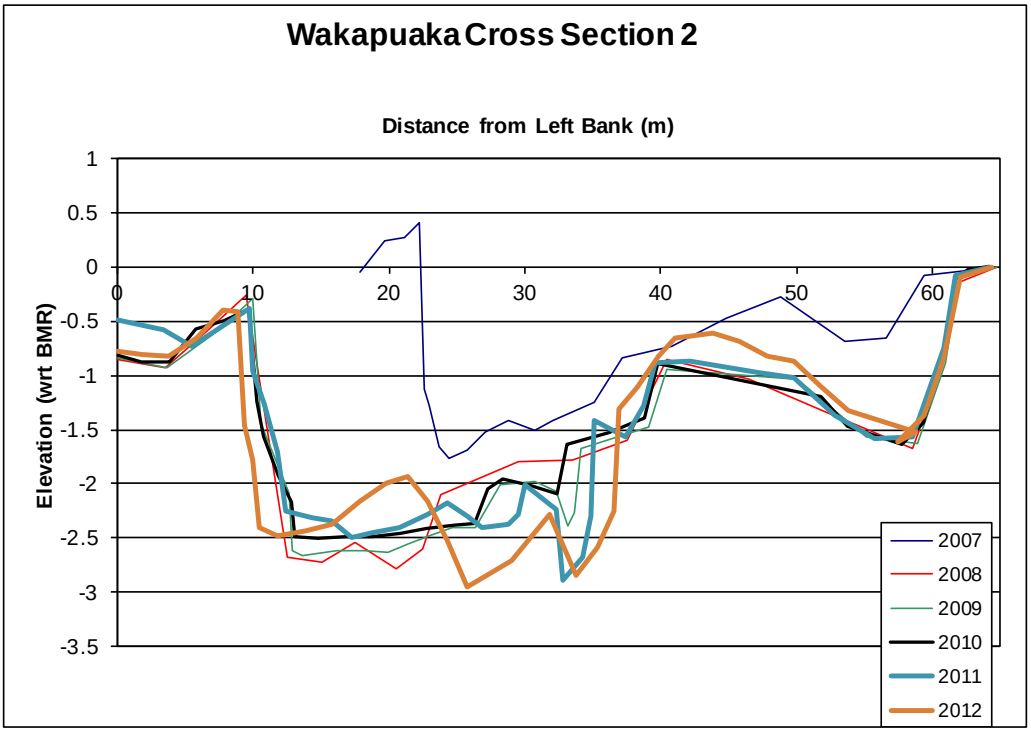
[1] Abandonment of existing river channel into a new channel

However, upstream of the cross section there is evidence of substantial gravel deposition on the true left of the channel and several metres of bank erosion of the true right bank – none of this is evident from the cross-section plot. Similarly Wakapuaka Cross Section 12 is towards the upstream end of a large gravel beach that has aggraded substantially over the last two years – while the cross section records some aggradation it appears lower than the beach as a whole.

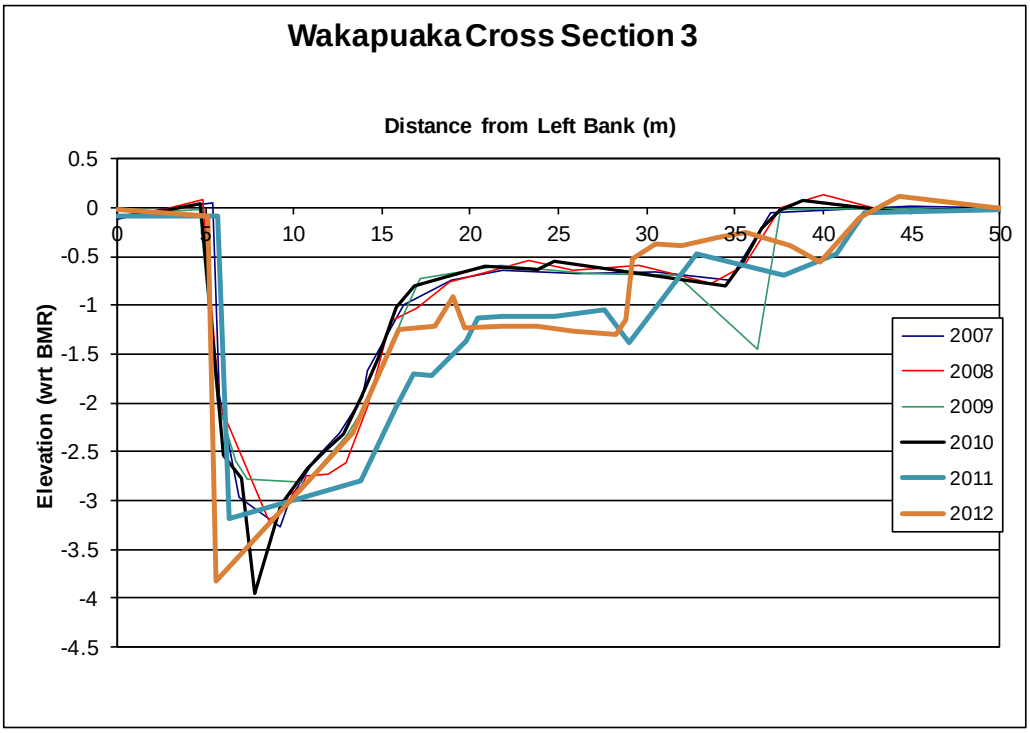
The major driver for establishing the cross-section network was to help manage gravel extraction. This requires knowledge of (a) the location of beaches where gravel is being deposited and (b) the rate at which gravel is accumulating or eroding. The latter can be established from cross sections while the former needs the location of beaches to be mapped. Nelson City Council now has multiple sets of orthophotos of the Wakapuaka (1999, 2009, 2012) and Whangamoa (1999, 2009) rivers and a useful complement to the present cross-section network would be to use these orthophotos to map the location of all gravel beaches and to characterise variation in river planform. This could be used to establish whether the present network of cross sections adequately characterises the rivers, and especially whether enough of the gravel beaches that are under pressure for gravel extraction are currently being monitored. All beaches could be accurately identified and their extent mapped.

No comprehensive analysis of the data has been completed, nor have the results been compared with the hydrological record over the last five years. This should be completed along with analysis of the 2012 survey data. This will allow the effect of the large floods in December 2011 to be evaluated and decisions made about the need for gravel extraction in both rivers. However, before this analysis is completed there needs to be a substantial review and quality assurance check completed on the data. Problems already identified with the data, from a preliminary analysis, include:

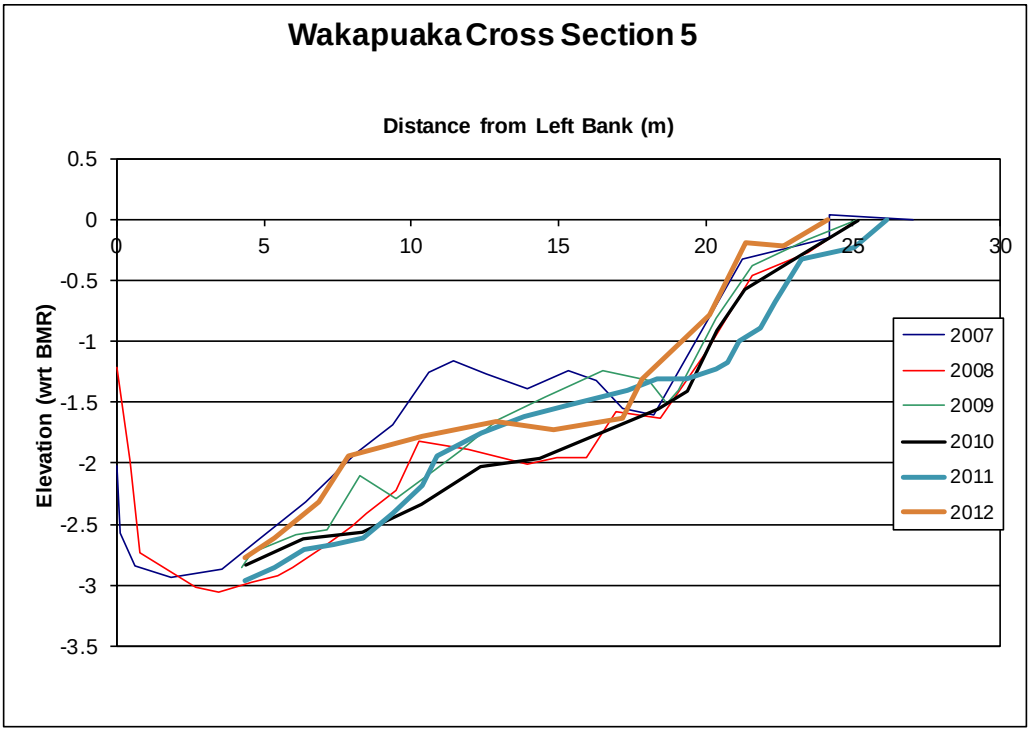
- Wakapuaka Cross Section 2. A completely different surveying set-up was used in 2007 compared with all later data. The 2007 data may be usable but the distances would need to be corrected.



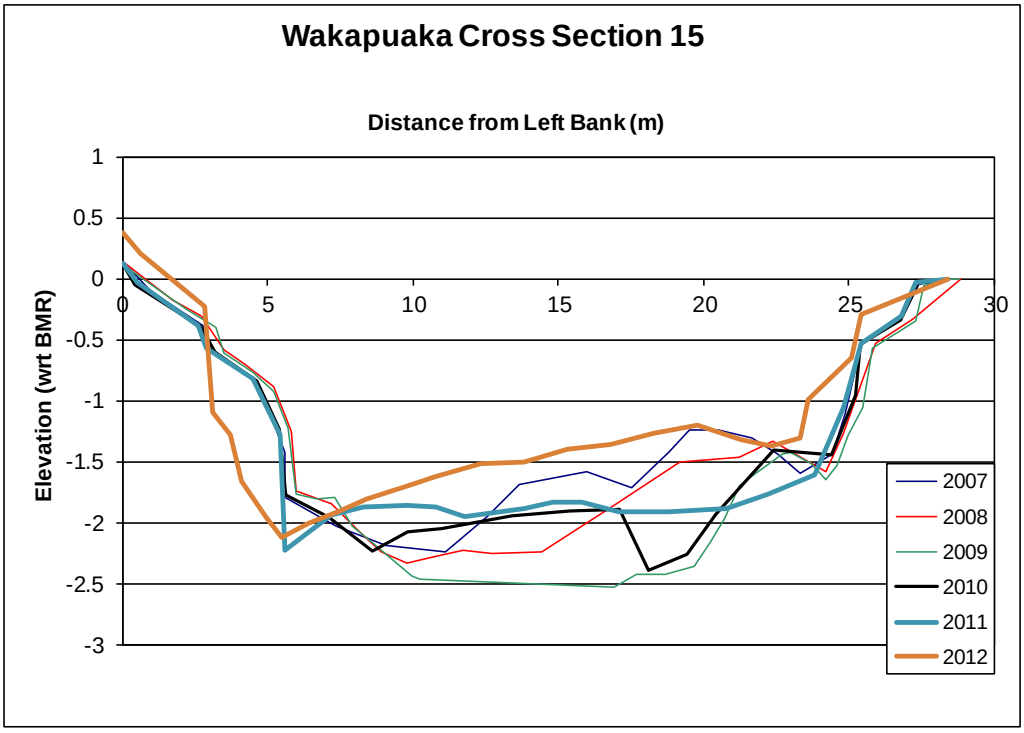
- Wakapuaka Cross Section 3. The surveyed distance along this cross section is much greater in 2011 and 2012 (c. 55 m) than earlier surveys (c. 49 m). The data state the true left bank had eroded and a new true-left benchmark was established. This suggests the 2011 and 2012 data should be plotted to the true right benchmark instead of extending the plot on the true right bank.



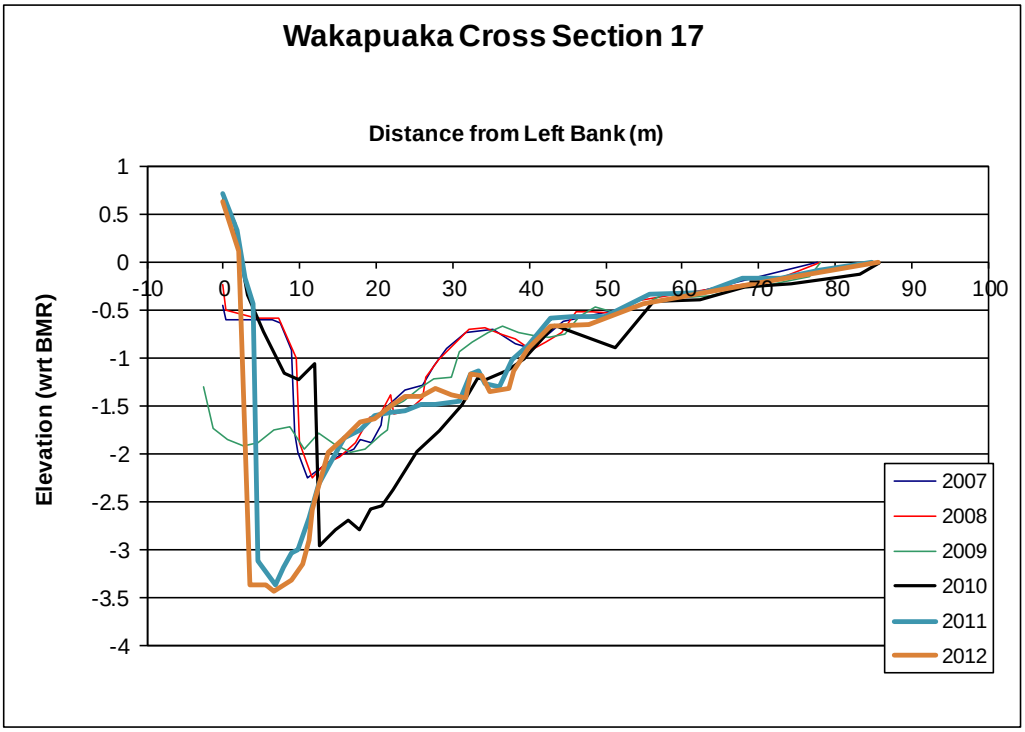
- Wakapuaka Cross Section 5 has not been surveyed full width since 2009 and cannot be used for calculating mean bed level or gravel volume. It should be relocated to somewhere it can be surveyed full width.



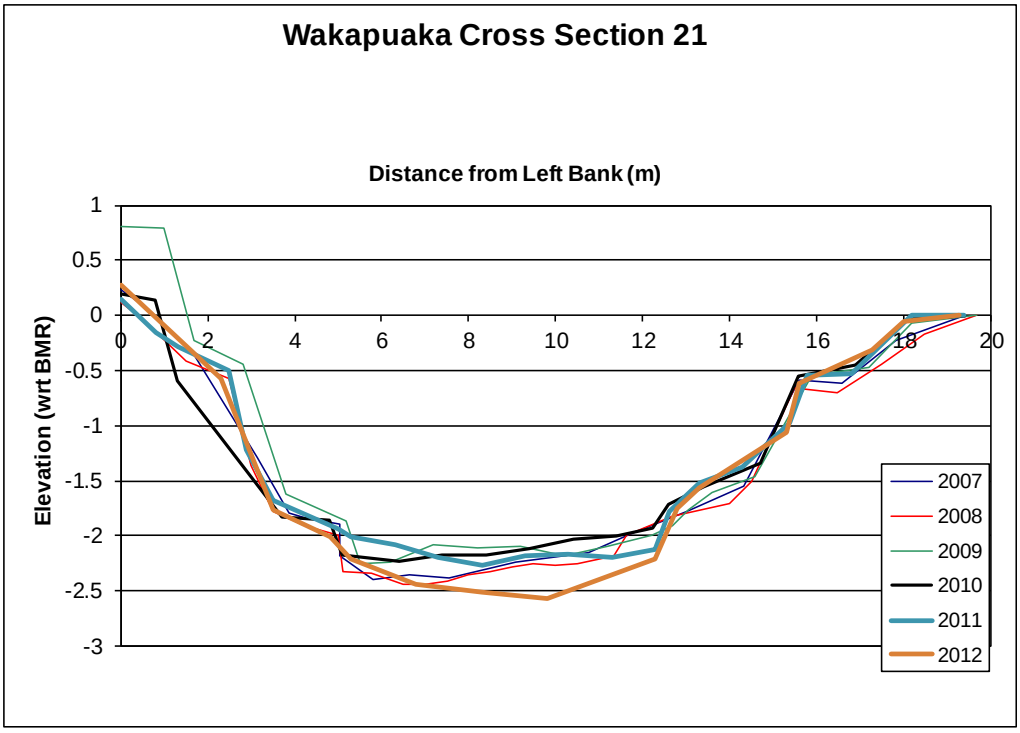
- Wakapuaka Cross Section 15. The survey data for 2009 looks odd compared with all other years and the straight line suggests the water was too deep to survey from 10 to 17 m.



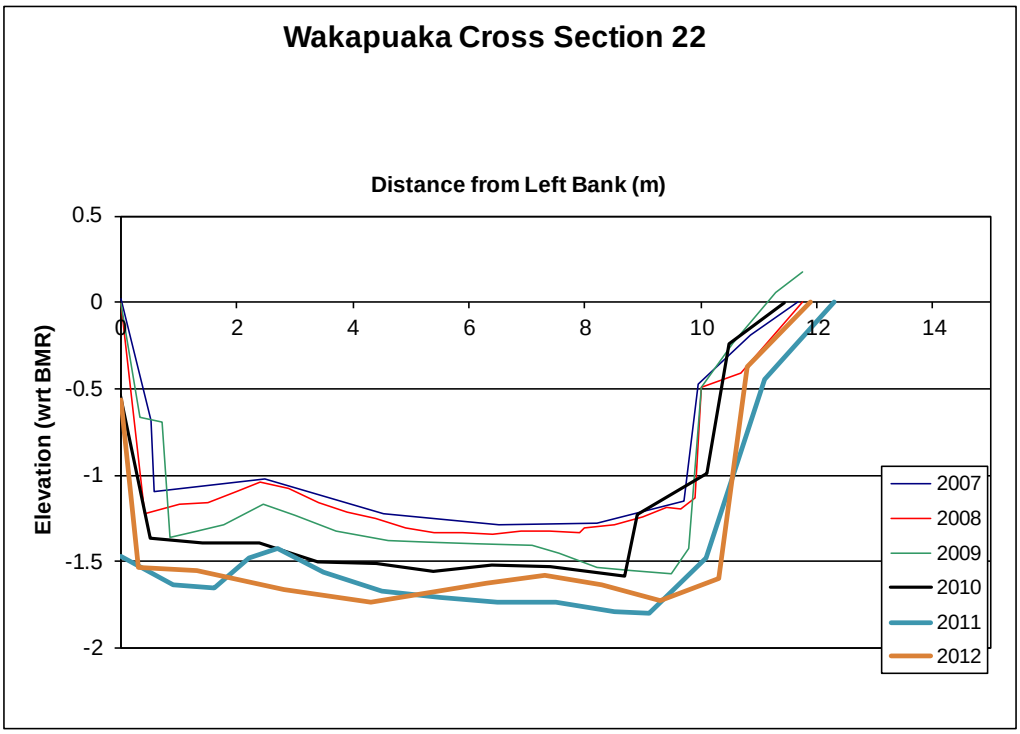
- Wakapuaka Cross Section 17. There was a major river avulsion here beginning in 2009 and there was considerable bank erosion on the true left bank. All data should be plotted relative to the true-right benchmark and their suitability for analysis considered.



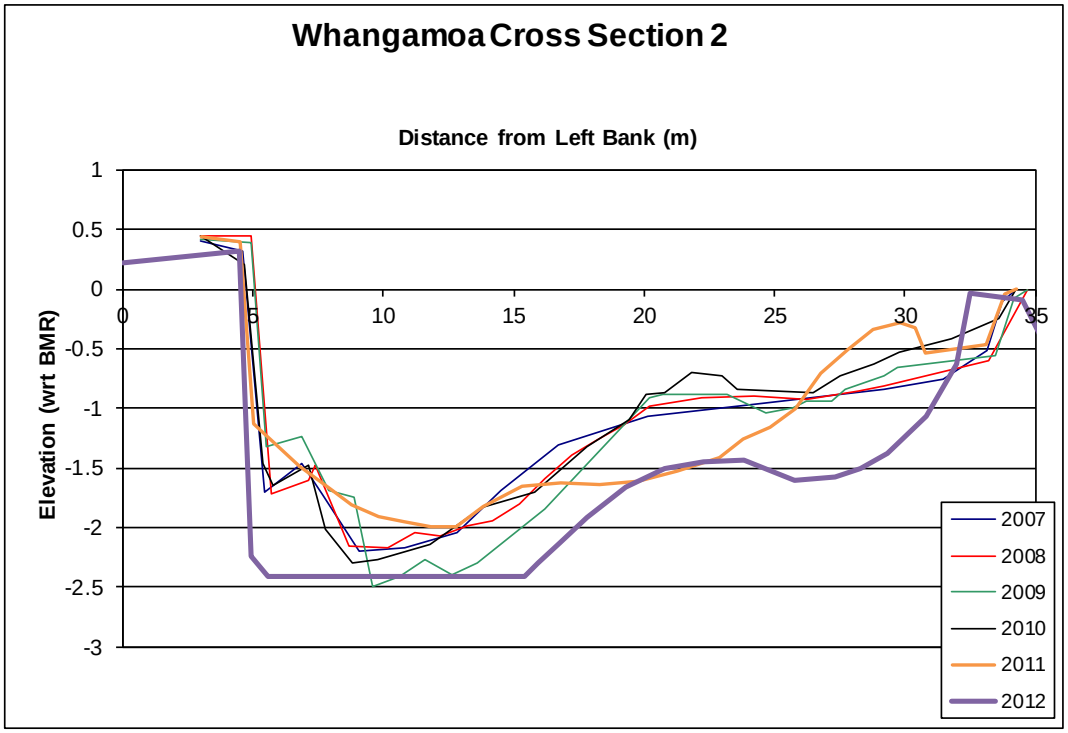
- Wakapuaka Cross Section 21. The plot of the 2009 data looks odd with a much higher left-bank origin than in all other surveys. It is not clear if it was surveyed to an existing benchmark.



- Wakapuaka Cross Section 22. This cross section has always been surveyed to the existing staff gauge on the true left bank. All plots should converge on the same elevation on the true left bank. This section looks very stable but the plot suggests considerable change of bed level (by 0.5 m).



- Whangamoa Cross Section 2. There has been massive bank erosion on the true left bank yet the cross-section plot does not show this. Part of the section is now too deep to survey (between 6 and 15 m) and it may be necessary to relocate the section.



In the field surveyors should always record presence, or absence, of benchmarks – it is likely this has always been done on the field sheets (Paul Fisher, pers. comm.) but it is not clear whether this information has been transferred to the results spreadsheets and Hilltop Software. It would be useful to record more comments; for example, identifying the water's edge and the margins of gravel beaches is helpful in interpreting the cross-section changes. Similarly comments about observable changes along cross sections (such as bank erosion or gravel deposition) are also helpful, as are observations of observable features upstream and downstream of the cross sections. This information all helps to interpret measured changes at cross sections.

The cross-section-based data provide a good indication of changes in mean bed level in the two rivers. If combined with data on gravel beach locations and sizes from planform mapping, the cross-section data would provide a sound basis for decisions about gravel extraction.

5 Conclusions

The tape-and-level survey method is a practical, low-cost approach for characterising morphological change at cross sections in the Wakapuaka and Whangamoa rivers. A useful complement to the present cross-section network would be to use the available orthophotos to map the location of all gravel beaches, to characterise variation in river planform, and to assess whether all the main gravel deposition sites are adequately characterised by the existing cross-section network. Before any further analysis is completed, the data need to be carefully checked for errors.

6 Recommendations

- Replace the builders' pegs being used as benchmarks with something more durable and more easily locatable.
- Complement the cross-section network with river planform mapping using the available orthophotos.
- Complete an analysis of 2012 survey data and review results of all previous surveys for errors, to underpin decisions made about the need for gravel extraction.

7 Acknowledgements

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8 References

Basher LR 2007. Design of a cross-section network for low-cost monitoring of the impact of gravel extraction. Landcare Research Contract Report LC0607/150.

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