Upper Whanganui
Gravel Resource Study

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Executive Summary

This study examines the gravel resources in the Upper Whanganui River based on the analysis of river cross section survey data.

The main findings to emerge from this gravel resource study of the Upper Whanganui River are:

Between 1979 and 1991 the gravel volume was degraded significantly; 69,000 cubic metres from the active channel at a rate of 5,750 cubic metres per annum. However, between 2000 and 2015 the gravel volume has aggraded 128,000 cubic metres at a rate of 8,500 cubic metres per annum. The gravel degraded in 1979-1991 has been recovering well in recent years (since 2000).

Whilst the mean bed level dropped significantly between 1979 and 1991, it has remained fairly stable in recent years.

The mean invert elevation is declining all along the study reach; though the changes fluctuate significantly at the downstream reach in the most recent time period. The mean invert level change may be due to flood events concentrating flow and causing erosion and also avulsing channels with different depths at their inverts.

Erosion protection works post-2000 may have had an effect on gravel volume as the energy is no longer being used on eroding the bank and can be concentrated elsewhere (such as lateral bars, beaches etc.)

Gravel extraction has played a significant role in the depletion of gravels. This is proven by the heavy degradation of gravel between 1979 and 1991 whilst 433,000 cubic metres of gravel were extracted. Restoration of gravel volume between 1991 and 2000 occurs as the extraction load is reduced to 20,000 cubic metres (see Appendix B).

From aerial photographs of the study area it is evident that two spots have eroded the river bed and there is now exposed papa base rock. This may affect the gravel surveys in future as the mean bed elevation will remain constant.

It is evident from this analysis the current river management techniques are successful and these should be continued to ensure a sufficient gravel volume is maintained.

CONTENTS

Upper Whanganui River Gravel Study

1 Introduction

This study examines the gravel resources in the Upper Whanganui River based on the analysis of river cross section survey data. It covers a 14 km reach of the river from the 241 km benchmark to Piriaka at approximately the 255 km benchmark, centred on Taumarunui. The location of the study reach is shown in Figure 1.1.

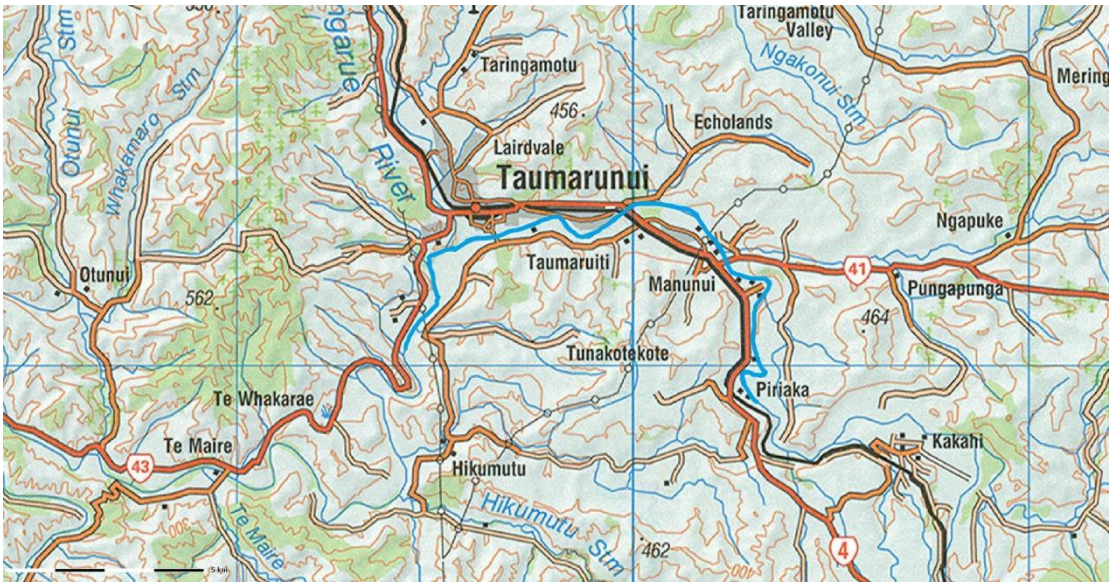


Figure 1.1 – Location of Study Reach of the Upper Whanganui River shown with a bold blue line.

The cross section surveys used in this study have been carried out during 1979, 1991, 2000 and 2015. This study has focused on information from these river cross section surveys, as they provide the most complete record of the river.

2 Background

Upstream of Taumarunui the river is steep, and has a bed grading from fine gravel to large boulders. Downstream of Taumarunui the river bed is papa mudstone and flows through a gorge which is discontinuous through to Whanganui.

Viable gravel deposits are centred on the Taumarunui to Manunui reach, between 1950 and 1980 the bed lowered 1 m through this reach from over extraction of gravel.

Hard greywacke is the base rock material through Taumarunui and is exposed near Porou Street and upstream of Victory Bridge, this presents distinct bed level controls (Horizons, 2003). The exposure of the base rock affects the alignment and form of the river as there is no consistent pattern of meander amplitude and wavelength.

3 Cross Section Survey Data

The study reach was surveyed along its entire length in 1979, 2000 and 2015, and majority of its length was surveyed in 1991 apart from seven cross sections. The average river distance between cross sections from 1979 to 2015 was 288 m.

4 Analysis of Cross Section Survey Data

To determine the change in gravel resources of the Upper Whanganui River the change in volume of gravel beneath the river bed and the active channel has been calculated.

For the purpose of this study the river bed has been defined as the channel bottom of the river that contains the normal water flow (including the gravel bars). The active channel is defined as the area that includes the river bed and the gravel beaches located above the normal water level. Also assessed in this study is the change in the mean bed elevation and river invert elevation at each cross section. Figure 3.1, below, shows a typical cross section of the river on which the extents of the river bed and active channel have been marked.

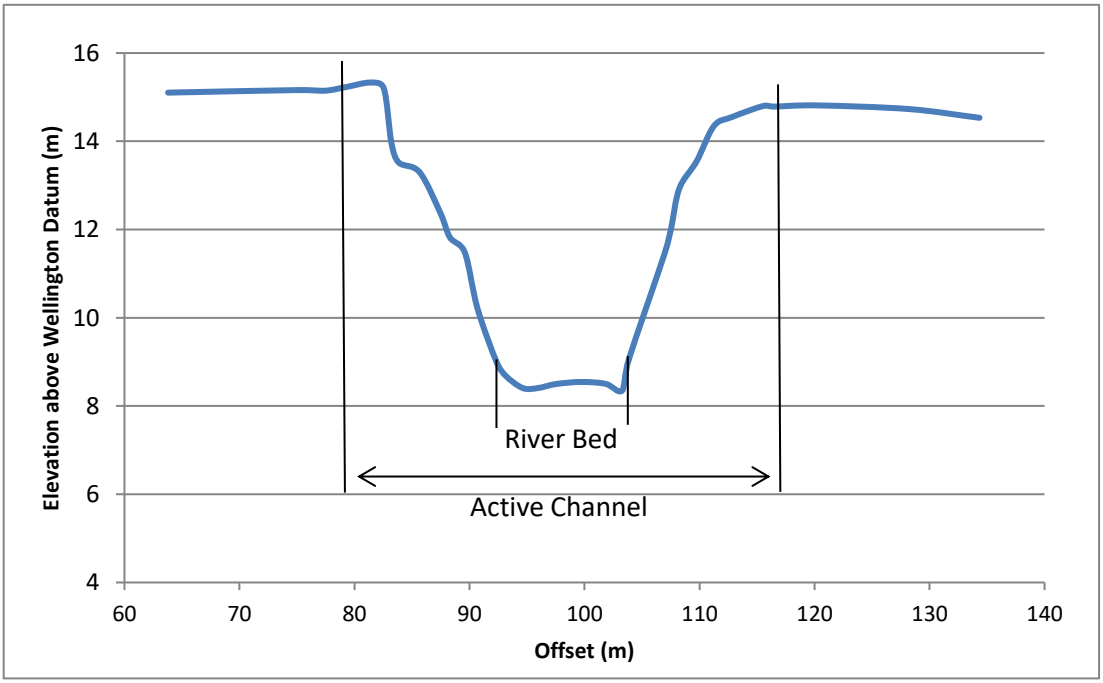


Figure 3.1 – Typical Channel Cross Section showing River Bed and Active Channel

Analysis of the change in gravel volume beneath the river bed and the active channel as well as the change in mean bed elevation will identify trends in aggradation or degradation that may be occurring to the gravel resource of the Upper Whanganui River.

4.1 Analysis of the Gravel Resource beneath the Bed of the Upper Whanganui River

To calculate the volume of gravel beneath the bed of the river, an individual analysis of each cross section was carried out. HILLTOP software was used to calculate the area beneath the bed at each cross section. These cross sectional areas were then

integrated over half the distance to the adjacent up and downstream cross section to obtain a volume.

While this volume would include all material, and not just gravel, between the river bed and the assumed datum level, it is reasonable to assume that any change between surveys will be due to the movement of gravel on the bed of the river and any gravel extraction.

4.2 Analysis of the Gravel Resource beneath the Active Channel of the Upper Whanganui River

To calculate the volume of gravel beneath the active channel of the river an individual analysis of each cross section was carried out. HILLTOP software was used to calculate the area beneath the active channel at each cross section. These cross sectional areas were then integrated over half the distance to the adjacent up and downstream cross section to obtain a volume.

While this volume would include all material, and not just gravel, between the river bed and the assumed datum level, it is reasonable to assume that any change between surveys will be due to the movement of gravel on the bed of the river and any gravel extraction.

4.3 Analysis of the Mean Bed Elevation and Bed Invert Elevation of the Upper Whanganui River

The surveyed river cross section profiles were plotted using the over plot function on Manager. HILLTOP software was used to calculate the mean river bed elevation and the bed invert elevation for each cross section survey date.

5 Results

5.1 Analysis of gravel beneath the river bed of the Upper Whanganui River

Figure 5.1, below, shows the change in gravel volume beneath the river bed from 1979-2015. This figure shows how the volume beneath the river bed has fluctuated over time.

This figure shows, between 1979 and 1991; the overall trend was one of degradation beneath the river bed meaning the gravel volume decreases are greater than the increases.

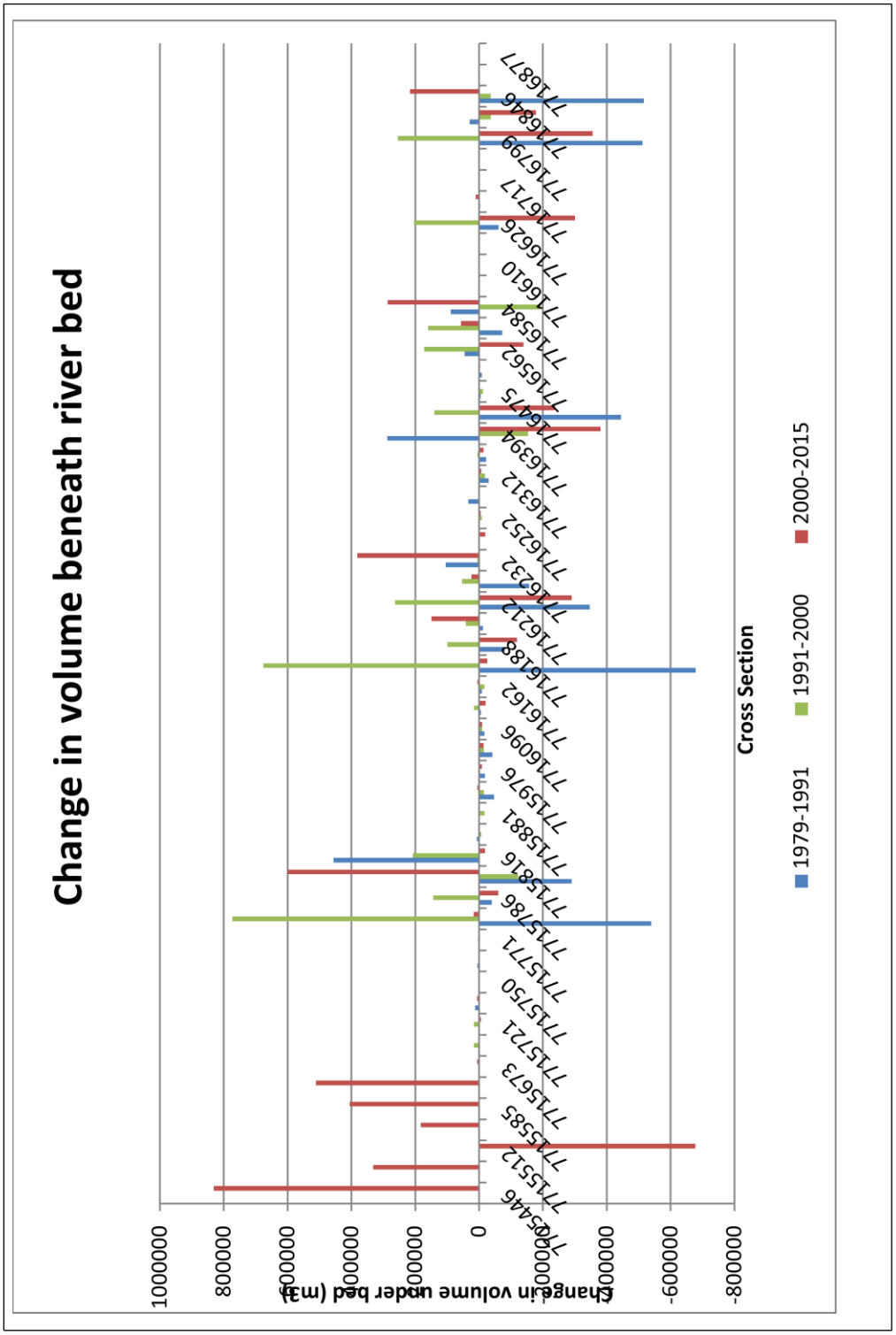
Between 1979 and 1991 a net loss 2,889,930 m^3 of gravel occurred.

The overall trend between 1991 and 2000 is aggradation, a net gain of 2,577,672 m^3 of gravel occurred in this time period.

From 2000-2015 the overall trend is aggradation beneath the river bed. A net gain of 1,138,170 m^3 of gravel occurred in this time period for this study reach. A large portion of this aggradation is concentrated in the downstream reach of the river.

This analysis has produced some surprisingly large fluctuations in gravel volume beneath the bed of the river (in the range of hundreds of thousands of cubic metres). Considering the relatively short distances between cross sections these results are considered anomalous and are the result of a change in width of the river bed.

Figure 5.1 – Change in volume beneath the river bed for the Upper Whanganui River, from downstream cross-sections to upstream cross sections.



5.2 Analysis of Gravel beneath the active channel of the Upper Whanganui River

Figure 5.2, below, shows the change in gravel volume beneath the active channel from 1979-2015. This figure shows the volume beneath the active channel has fluctuated over time.

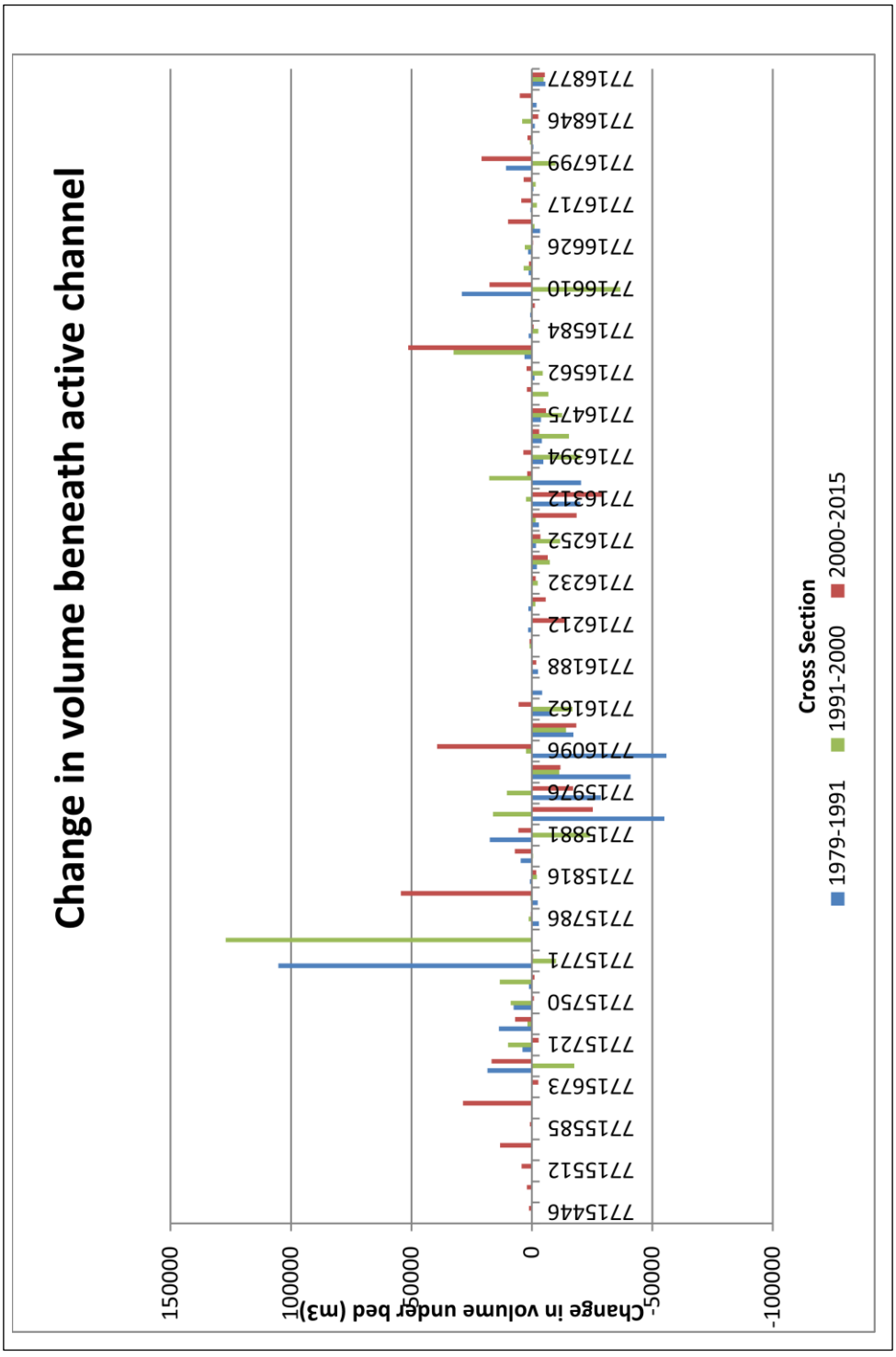
From 1979-1991; the active channel is degrading, with little to no instances of increasing volumes. A net loss of 69,500 m^3 of gravel occurred from beneath the active channel.

The overall trend from 1991 to 2000 is aggradation with relatively few cross sections experiencing a decrease in gravel volume. A net gain of 16,000 m^3 of gravel occurred in the active channel between 1991 and 2000 throughout this study reach.

Between 2000 and 2015 overall aggradation of the active channel is occurring, a net gain of 128,200 m^3 of gravel occurred from beneath the active channel.

The active channel has undergone significant degradation between 1979 and 1991 but this has improved and the gravel resource has begun to replenish its stock between 1991 and 2015, the total volume change between 1979 and 2015 is a gain of 74,700 m^3.

Figure 5.2 – Change in volume beneath the active channel for the Upper Whanganui River from downstream cross-sections to upstream cross sections.



5.3 Analysis of the Mean Bed Elevation and Mean Bed Invert of the Upper Whanganui River

Figures 5.3 and 5.4, below, show the change in mean bed elevation and invert for the Upper Whanganui River from 1979-2015.

Figure 5.3 shows an overall decline in mean bed elevation; more so between 1979 and 1991 than from 1991 to 2015. From 1991-2000 fewer cross sections are experiencing declines in mean bed elevation than the other two study periods, which is consistent with the gravel volume change. The bed level becomes more stable between 2000 and 2015, which could also be related to the level which papa bed becomes exposed, it is evident in aerial photos the areas with exposed papa bed.

Figure 5.4, below, shows the change in invert elevation from 1979-2015. This figure indicates from 1979-1991 the invert elevation is decreasing across the study reach. From 1991-2000 the invert elevation is also decreasing, more so than the previous time period. From 2000-2015 the invert elevation has improved, but there is still an overall decline in invert elevation. Invert change could be due to avulsing channels following periods of large flood events.

Figure 5.3 – Change in mean bed elevation for the Upper Whanganui River from downstream cross sections to upstream cross sections.

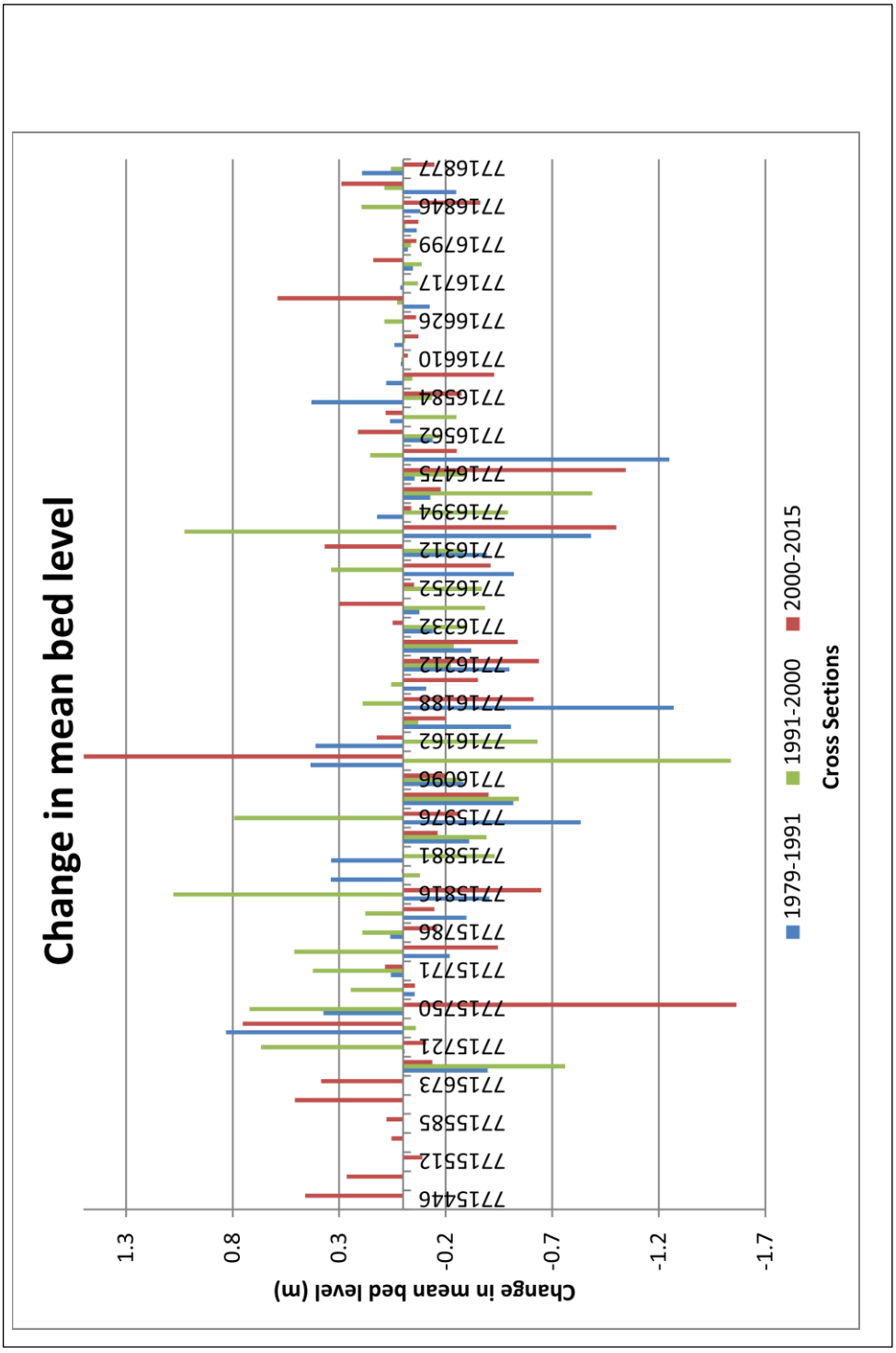
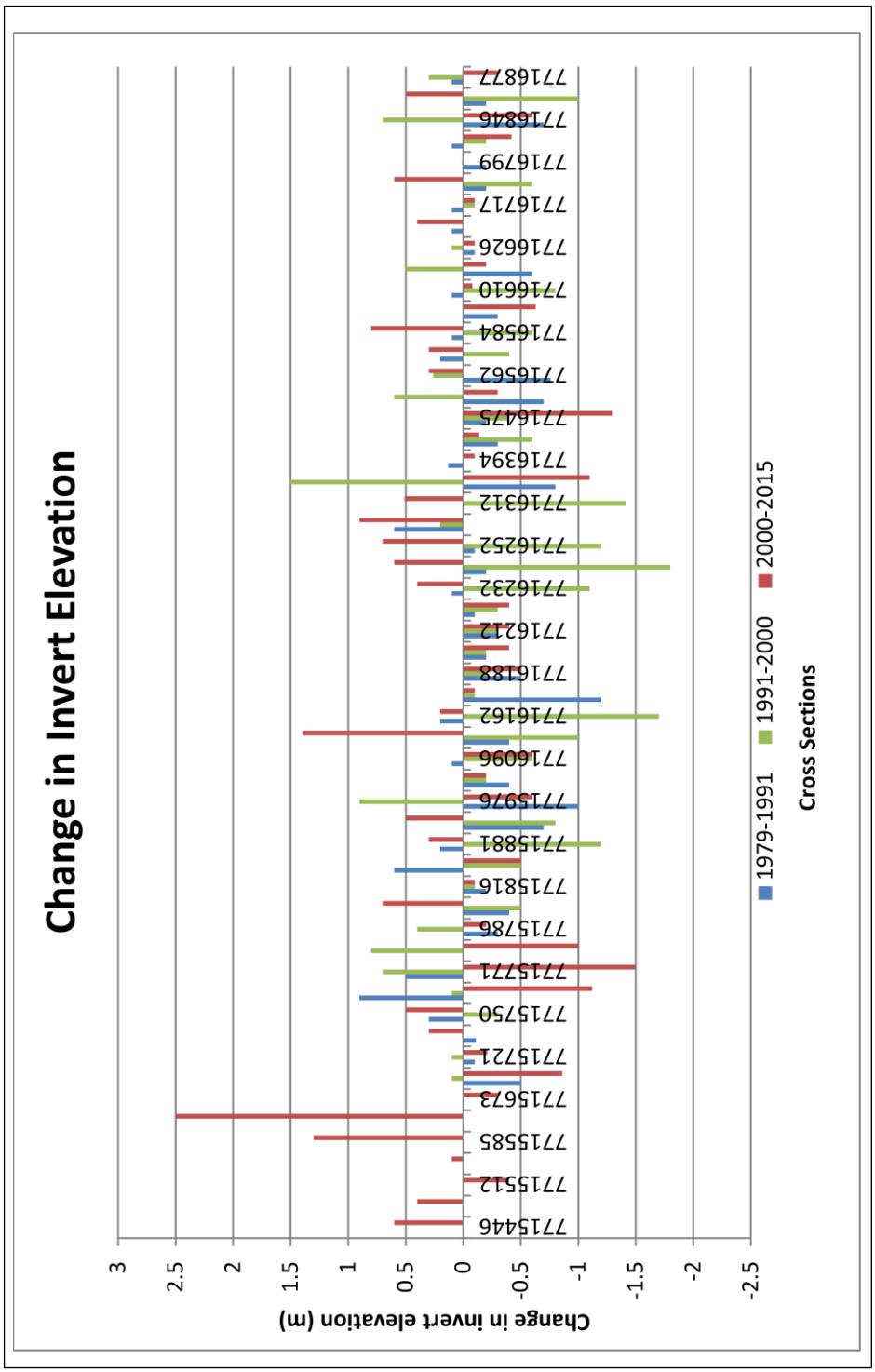


Figure 5.4 – Change in invert elevation for the Upper Whanganui River from downstream cross sections to upstream cross sections.



5.4 Analysis of Cumulative Change of Gravel Volume

As discussed in Section 5.1, the analysis of the changes in the volume of gravel beneath the river bed produced a number of anomalous results. As such, the cumulative volume change beneath the bed has not been calculated as it would compound the errors associated with the changing width of the river bed.

Figure 5.5, below, shows the cumulative change in gravel beneath the active channel of the Upper Whanganui River. This figure shows a similar pattern to Figure 5.6; depletion in gravel from 1979-1991, accumulation from 1991-2000 and 2000-2015.

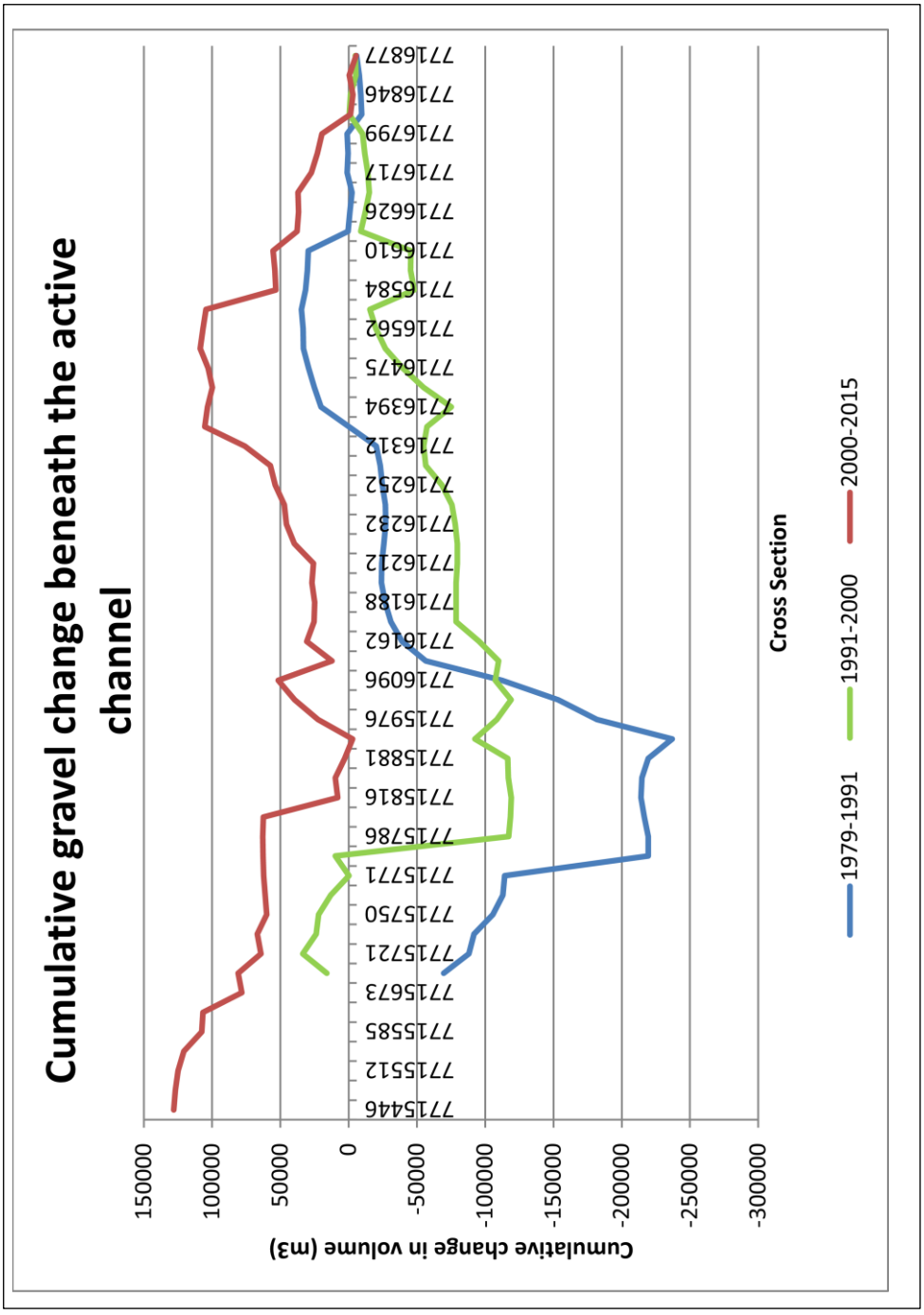
The 13 km reach between cross sections 7716877 and 7715700 was surveyed four times between 1979 and 2015. The surveys conducted in 2000 and 2015 also covered an additional 2.2 km at the downstream end of the survey reach.

Between 1979 and 1991 the depletion of gravel was significant; a total of 69,500 m^3 of gravel was degraded. However, in the period between 1991 and 2000 the gravel volume began to recover and accumulated an additional 16,000 m^3 in the active channel. Between 2000 and 2015 this reach of the river saw an aggradation of 80,000 m^3 of gravel.

When the whole survey reach is considered, the Upper Whanganui River saw a total aggradation of 128,000 m^3 of gravel between 2000 and 2015.

These values show the gravel degraded between 1979 and 1991 is being recovered.

Figure 5.5 – Cumulative change of gravel beneath the active channel for the years 1979-1991, 1991-2000, 2000-2015, ranging from downstream cross sections on the left of the x-axis to upstream cross sections on the right.



6 Gravel Extraction

Gravel has been extracted from beaches in the Upper Whanganui River over a considerable period of time. In the 1940s there were quantities large enough to cause some degradation, and from the 1950s to the early 1980s there was large scale extraction occurring.

Appendix B contains the data of gravel extraction for this study reach from 1978-2016. A total of 498,599.5 m^3 of gravel has been extracted from this study reach between 1979 and 2015 (Horizons, 2003). The majority of this volume was taken between 1979 and 1991 which indicates the gravel extraction was causing the decline in gravel volume. Between 1991 and 2000 the gravel volume begins to replenish as gravel extraction is reduced.

7 Gravel Resource

The gravel transport rate of the Upper Whanganui River is low, meaning gravel extraction can have significant effects on the gravel resource and can cause channel degradation if extraction is concentrated at specific sites rather than over this entire study reach (Horizons, 2002).

The Upper Whanganui River has a scarce resource of large, easily erodible gravel deposits upstream as well as a low gradient which explains its lack of gravel waves and pulses, which is expected in this study reach due to its proximity to its headwaters and the size of the river.

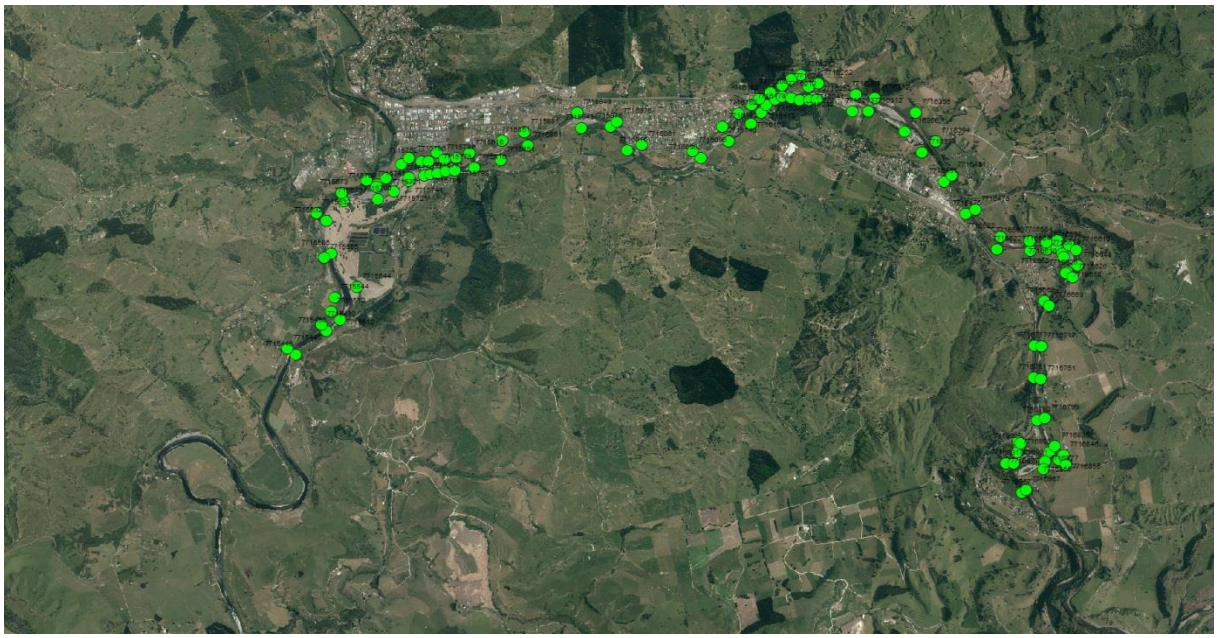
8 Conclusions

The main findings to emerge from this gravel resource study of the Upper Whanganui River are:

- Between 1979 and 1991 the gravel volume has degraded significantly; 69,000 m^3 from the active channel at a rate of 5,750 m^3 per annum. However, between 2000 and 2015 the gravel volume has aggraded 128,000 m^3 at a rate of 8,500 m^3 per annum. The gravel degraded in 1979-1991 has been recovering well in recent years (since 2000).
- Whilst the mean bed level dropped significantly between 1979 and 1991, it has remained fairly stable in recent years (since 2000).
- The mean invert elevation is declining all along the study reach; though the changes fluctuate significantly at the downstream reach in the most recent time period. As mentioned earlier, the mean invert level change may be due to flood events concentrating flow causing erosion and also avulsing channels with different depths at their inverts.
- Erosion protection works post-2000 may have had an effect on gravel volume as the energy is no longer being used on eroding the bank and can be concentrated elsewhere (such as lateral bars, beaches etc.)
- Gravel extraction has played a significant role in the depletion of gravels. This is proven by the heavy degradation of gravel between 1979 and 1991 whilst 433,000 m^3 of gravel was extracted. Restoration of gravel volume between 1991 and 2000 occurs as the extraction load is reduced to 20,000 m^3.
- From aerial photographs of the study area it is evident that two spots have eroded the river bed and there is now exposed papa base rock. This may affect the gravel surveys in future as the mean bed elevation will remain constant.
- It is evident from this analysis current river management techniques are successful and these should be continued to ensure a sufficient gravel volume is maintained.

9 Appendix

9.1 Appendix A



9.2 Appendix B

Year	Total Extraction
1978	45825
1979	214608
1980	44246
1981	25972
1982	18729
1983	13892
1984	5000
1985	106000
1986	0
1987	0
1988	0
1989	0
1990	0
1991	5355
1992	3200
1993	4800
1994	2000
1995	2000
1996	1665
1997	610
1998	150
1999	8
2000	48
2001	0
2002	0
2003	0
2004	0
2005	0
2006	8
2007	25228
2008	7044
2009	17976
2010	0
2011	0
2012	0
2013	7.5
2014	24
2015	29
2016	0
TOTAL:	**544424.5**
TOTAL 1979-2015:	**498599.5**

9.3 Appendix C

NIWA and Genesis are acknowledged for the use of this data.

YEAR	PEAK	NUMBER 2 years or greater	DURATION (hrs) above 2 year
1947	110		
1948	70		
1949	240		
1950	140		
1951	570	2 year	
1952	140		
1953	140		
1954	340		
1955	290		
1956	680	2-5 year	
1957	795	Double peak 5 year	
1958	1,820	100+ year, 2 year, double peak 10-20 year	
1959	410		
1960	375		
1961	315		
1962			
1963			
1964			
1965	660	2 year & 2-5 year	
1966	505		
1967	520		
1968	420		
1969	245		
1970	370		
1971	625	2-5 year & 2-5 year	3.5
1972	625	2-5 year	1
1973	495		
1974	385		
1975	370		
1976	460		
1977	515		
1978	895	5-10 year	7
1979	570	2 year	1
1980	585	2 year & 2 year	2
1981	545		
1982	430		
1983	410		
1984	525		
1985	415		
1986	670	2 year & 2-5 year	5
1987	325		
1988	550		
1989	470		
1990	770	5 year & 5 year	17
1991	670	Double peak 2-5 year	6
1992	485		
1993	895	5 year & 5-10 year	14
1994	645	2-5 year & 2-5 year close together	5
1995	625	2-5 year	4.5
1996	875	5 year & 5-10 year	12
1997	935	10 year	5
1998	1,055	2-5 year triple peak, 2 year, 10-20 year triple peak	33.5
1999			
2000	865	5-10 year	7
2001	715	5 year	5

FLOOD PEAK

>2 year

>10 year

10 References

Horizons Regional Council. (2000). *Channel Change and Gravel Resource Report for the Upper Whanganui River at Taumarunui.* Palmerston North, N.Z: Horizons Regional Council.

Horizons Regional Council. (2003). *Upper Whanganui River Management Scheme.* Palmerston North, N.Z: Horizons Regional Council.