Prepared for Environment Southland

Waituna Creek Rebattering

A review of water quality monitoring

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Prepared for Environment Southland
By Ryder Consulting Ltd

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A review of water quality monitoring

prepared by

Ruth Goldsmith, PhD.
Greg Ryder, PhD.

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Ryder Consulting Limited
195 Rattray Street
PO Box 1023
DUNEDIN, 9054
New Zealand

Phone: 03 477 2119

www.ryderconsulting.co.nz

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1. Background

During February to April 2013 contractors undertook erosion control works along an approximately 1 km long reach of Waituna Creek within Stevenson Farm. The works included the rebattering of the channel banks to create a 2:1 slope and installation of rock edge protection on eroding bends. Rebattering required the removal of approximately 7,300-9,180 cubic metres of material from the banks using an excavator, and armouring the installation of approximately 960 tonnes of rock.

The works form part of the Waituna Stream Erosion Control Project, which came about in response to community concern regarding the continuing loss of soil from stream bank erosion on the section of the Waituna Stream (Environment Southland consent application). The project is not a flood protection scheme, but rather a method of erosion control to maintain stability of Waituna Stream and to minimize the loss of land through erosion. The project is also expected to reduce the amount of sediment entering Waituna Lagoon from bank erosion (Environment Southland consent application).

To determine if the works associated with the rebattering had any effect on the water quality of Waituna Creek, Environment Southland measured water quality at several sites in the creek prior to and throughout the works period.

Environment Southland engaged Ryder Consulting to analyse the Waituna Creek water quality monitoring data and to prepare a report summarizing and interpreting the results.

2. Methods

2.1 Survey site and monitoring period

Water quality was monitored at four sites in Waituna Creek (Figure 1). Two control sites were located upstream of the rebattering works, 50 and 100 m upstream of the Stevenson Farm bridge. One site was located within the rebattering works area, and the fourth site was located approximately 4 km downstream of the works at Marshall Road.

The rebattering works commenced on the 26th February 2013 and were completed on the 22nd of April 2013. Water quality was measured regularly (every one to 9 days) on at least 12 occasions at the two control sites and the rebattering site during (28th of February to 15th of April) and once immediately following works completion (on the 30th of April) (Table 1).

The Marshall Road site is an Environment Southland State of the Environment Monitoring site and has been monitored regularly since 1995. Water quality monitoring data from this site during the works period, and also for the two years prior, was included in the analysis. Marshall Road data from the 23rd of January 2011 to the 11th of February 2013 provided an indication of typical water quality in Waituna Creek prior to the works. It should be noted however that several small tributaries enter the creek within the 4 km reach between the works site and Marshall Road and these will also influence water quality at Marshall Road.

Frequent water quality measurements were made at Marshall Road as flows increased during a fresh in May 2011. Measurements were made approximately every two to six hours as flows increased from 6.32 m^3/s on the 16th of May to 22.18 m^3/s on the 17th of May, and then as flows decreased again to 5.32 m^3/s on the 21st of May. As measurements were made more frequently throughout the fresh and therefore could skew results, this data was not included in the analysis of typical water quality in Waituna Creek, however the data is shown in graphs.

Table 1 *Waituna Creek rebattering works water quality monitoring site locations and monitoring period.*

Site	Grid reference	Monitoring period
100 m upstream of bridge at Stevenson Farm	E2169011 N5404394	04 Mar – 30 Apr 2013
50 m upstream of bridge at Stevenson Farm	E2168900 N5404290	28 Feb – 30 Apr 2013
Rebattering site at Stevenson Farm	E2168444 N5403424	04 Mar – 30 Apr 2013
Marshall Road	E2167900 N5400500	23 Jan 2011 – 30 Apr 2013

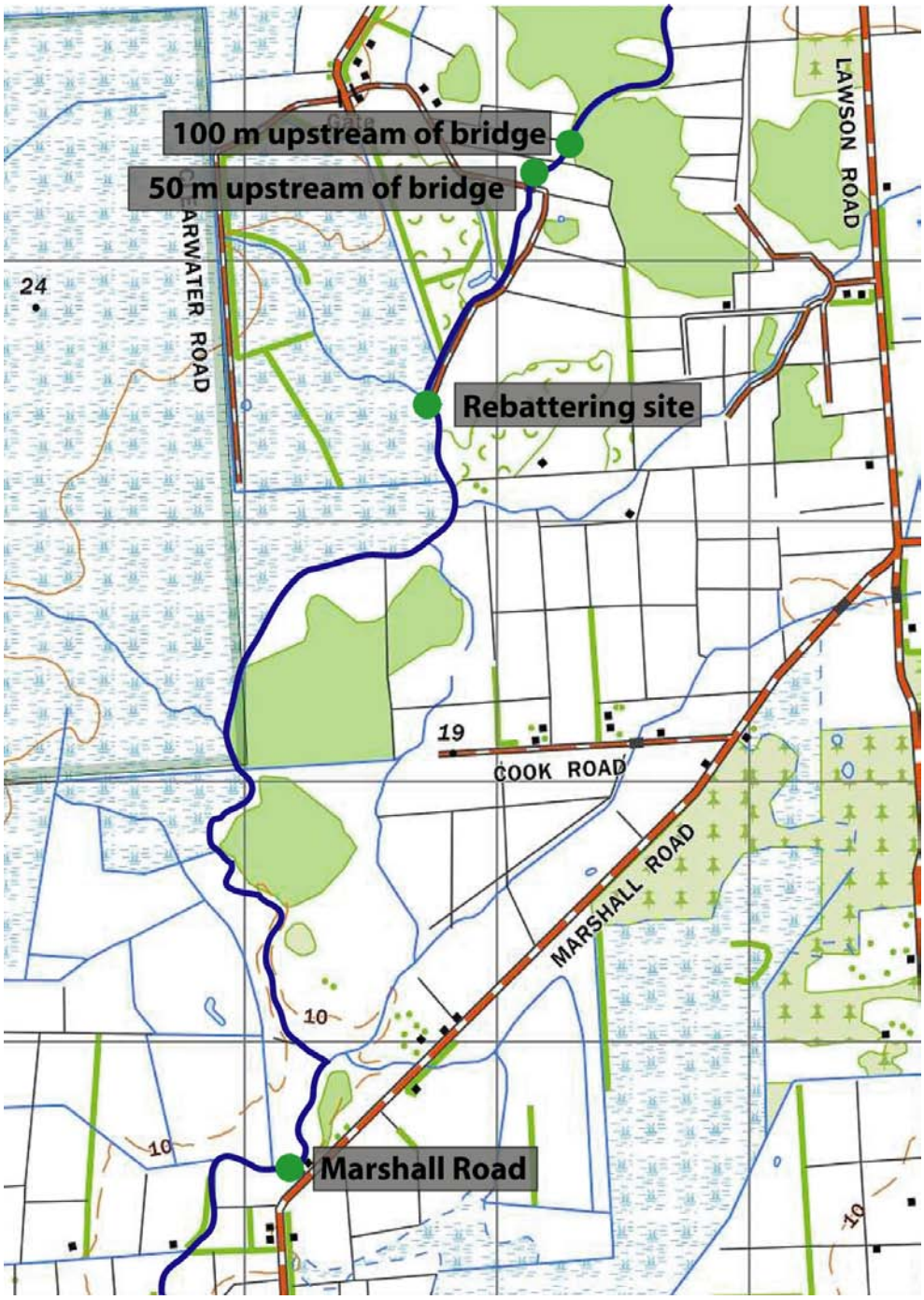

Figure 1 *Waituna Creek rebattering works water quality monitoring sites.*

2.2 Water quality and flow measurement

Ten water quality parameters were measured at the four sites in Waituna Creek:

- Water temperature (°C)
- Dissolved oxygen (%)
- Dissolved oxygen (mg/L)
- Turbidity (NTU)
- Total suspended solids (mg/L)
- Conductivity (µS/cm)
- Total nitrogen (mg/L)
- Nitrate-nitrite nitrogen (mg/L)
- Total kjeldahl nitrogen (mg/L)
- Total phosphorus (mg/L)

Measurements of conductivity, dissolved oxygen (saturation and concentration) and water temperature were made using field meters, and the remaining parameters were measured in the laboratory.

Flow data (m^3/s) was also available for the Marshall Road site prior to and throughout the works period (provided by Environment Southland). Flow at the site is simulated based on a relationship with flow in the nearby Waihopai River and has been checked against a flow rating developed at the Marshall Road site (flow relationship supplied by Environment Southland). Flow at the rebattering site at Stevenson Farm was calculated from that at Marshall Road using the difference in catchment area (95.7 km^2 and 108 km^2, respectively).

Catchment yields of total suspended solids, total nitrogen and total phosphorus were calculated for the rebattering and Marshall Road sites by dividing the daily load (concentration multiplied by flow at the site) by the catchment area above the site.

3. Results and Discussion

Flows were low throughout the works period, with the median flow at the Marshall Road site 0.10 m^3/s and the maximum flow 0.21 m^3/s (Table 2).

Median water temperature and dissolved oxygen levels were similar among the sites (Table 2 and Figure 2). Dissolved oxygen levels were slightly lower at the Marshall Road site than the other sites, however they were well within the range observed at this site prior to the works (Table 2).

Median turbidity and total suspended solids levels were only slightly higher at the rebattering and Marshall Road sites than at the upstream control sites during the works (Table 2 and Figure 3). Maximum values of these parameters (32 NTU and 33 mg/L, respectively) were observed at the rebattering site on the 12th of March 2013, however they were much lower than those observed at the Marshall Road site prior to the works (135 NTU and 240 mg/L, respectively) (Figure 3).

A similar range of conductivity values was observed among sites during the works, and median values were lower than those observed at the Marshall Road site prior to the works (Table 2 and Figure 3).

Median values for nutrients (total nitrogen, nitrate nitrite nitrogen, total kjeldahl nitrogen and total phosphorus) were similar among the control and rebattering sites (Table 2 and Figures 4 and 5). Total nitrogen and nitrate-nitrite nitrogen median values were slightly lower at the Marshall Road site but this is unlikely to be related to the works (Table 2 and Figure 4).

Increases in turbidity and suspended solids were expected at the rebattering site relative to the control sites as a result of the works, however the low flows during the works are likely to have helped reduce the amount of disturbed sediment entering the creek and being transported downstream. Additional water quality measurements were made at each site on the 30th of April 2013 following completion of the works and at a significantly higher flow of 2.77 m^3/s (i.e., a fresh). On this occasion, turbidity and total suspended solid levels at the rebattering site were 50 NTU and 159 mg/L respectively, and the highest of all four sites (Table 3). It is likely that, at the higher flow, exposed sediment on the

banks of the creek entered in water and fine sediment deposited on bed was re-suspended by the higher velocities. All other water quality parameters were similar among the sites at this time (Table 3), however it is important to note that suspended sediment levels were elevated at all sites relative to normal flow conditions. For example, suspended sediment levels at the two upstream control sites were 84 and 95 mg/L whereas the previous maximum levels recorded at these sites during the rebattering period (when low flows prevailed) were 7.0 and 6.0 mg/L. Consequently, it seems that the 30th April fresh carried elevated sediment levels from throughout the catchment.

Table 2 *Waituna Creek water quality monitoring at four sites during the works, 4th of March to 15th of April 2013, and at the Marshall Road site prior to the works, 23rd of January 2011 to 11th of February 2013 (excluding the 16th of May to the 21st of May 2011). Median with range in brackets.*

Parameter	100 m upstream of bridge	50 m upstream of bridge	Rebattering site	Marshall Road	Marshall Road prior to works
Flow (m^3/s)				0.10 (0.08 – 0.21)	1.31 (0.06 – 17.79)
Water temperature (°C)	11.3 (6.2 – 14.1)	11.5 (6.3 – 14.6)	11.3 (5.9 – 15.4)	12.1 (7.7 – 14.8)	9.6 (4.1 – 20.7)
Dissolved oxygen (%)	106.0 (83.6 – 134.0)	105.0 (83.6 – 136.0)	104.0 (81.0 – 138.0)	101.0 (62.0 – 126.0)	103.0 (68.2 – 143.0)
Dissolved oxygen (mg/L)	12.0 (8.8 – 14.1)	11.5 (9.0 – 14.1)	11.8 (9.0 – 14.0)	11.3 (6.4 – 13.0)	11.7 (6.9 – 14.8)
Turbidity (NTU)	4.9 (3.3 – 9.2)	4.8 (3.6 – 8.2)	6.7 (5.4 – 32.0)	8.6 (2.6 – 14.4)	9.2 (3.2 – 135.0)
Total suspended solids (mg/L)	4.0 (1.5 – 7.0)	4.0 (1.5 – 6.0)	7.0 (3.0 – 33.0)	5.0 (4.0 – 13.0)	9.0 (1.5 – 240.0)
Conductivity (µS/cm)	206.4 (201.1 – 228.8)	206.3 (201.0 – 260.0)	209.3 (202.0 – 239.2)	211.4 (204.9 – 252.0)	223.5 (173.0 – 264.7)
Total nitrogen (mg/L)	1.49 (0.95 – 2.10)	1.48 (1.38 – 2.1)	1.42 (1.02 – 2.30)	1.10 (0.92 – 3.50)	2.50 (0.76 – 5.70)
Nitrate nitrite nitrogen (mg/L)	1.12 (0.93 – 1.27)	1.09 (0.92 – 1.25)	1.01 (0.82 – 1.37)	0.65 (0.56 – 1.16)	1.54 (0.17 – 4.60)
Total kjeldahl nitrogen (mg/L)	0.37 (0.10 – 0.79)	0.42 (0.30 – 0.84)	0.40 (0.20 – 0.94)	0.43 (0.06 – 2.30)	0.74 (0.27 – 2.70)
Total phosphorus (mg/L)	0.02 (0.02 – 0.04)	0.03 (0.02 – 0.04)	0.04 (0.02 – 0.07)	0.04 (0.02 – 0.06)	0.06 (0.03 – 0.58)

Table 3 *Waituna Creek water quality monitoring at four sites following completion of the works, 30th of April 2013, and at the Marshall Road site prior to the works, 23rd of January 2011 to 11th of February 2013 (excluding the 16th of May to the 21st of May 2011). Median with range in brackets.*

Parameter	100 m upstream of bridge	50 m upstream of bridge	Rebattering site	Marshall Road	Marshall Road prior to works
Flow (m^3/s)			2.45 (estimated)	2.77	1.31 (0.06 – 17.79)
Water temperature (°C)	10.3	10.3	10.2	10.5	9.6 (4.1 – 20.7)
Dissolved oxygen (%)	118.0	119.0	126.0	108.0	103.0 (68.2 – 143.0)
Dissolved oxygen (mg/L)	13.2	13.3	14.3	12.0	11.7 (6.9 – 14.8)
Turbidity (NTU)	36.0	42.0	50.0	29.0	9.2 (3.2 – 135.0)
Total suspended solids (mg/L)	84.0	95.0	159.0	47.0	9.0 (1.5 – 240.0)
Conductivity (µS/cm)	290.8	291.5	289.3	266.7	223.5 (173.0 – 264.7)
Total nitrogen (mg/L)	5.2	5.0	5.3	4.6	2.50 (0.76 – 5.70)
Nitrate nitrite nitrogen (mg/L)	3.5	3.6	3.4	2.7	1.54 (0.17 – 4.60)
Total kjeldahl nitrogen (mg/L)	1.67	1.43	1.91	1.89	0.74 (0.27 – 2.70)
Total phosphorus (mg/L)	0.15	0.18	0.22	0.20	0.06 (0.03 – 0.58)

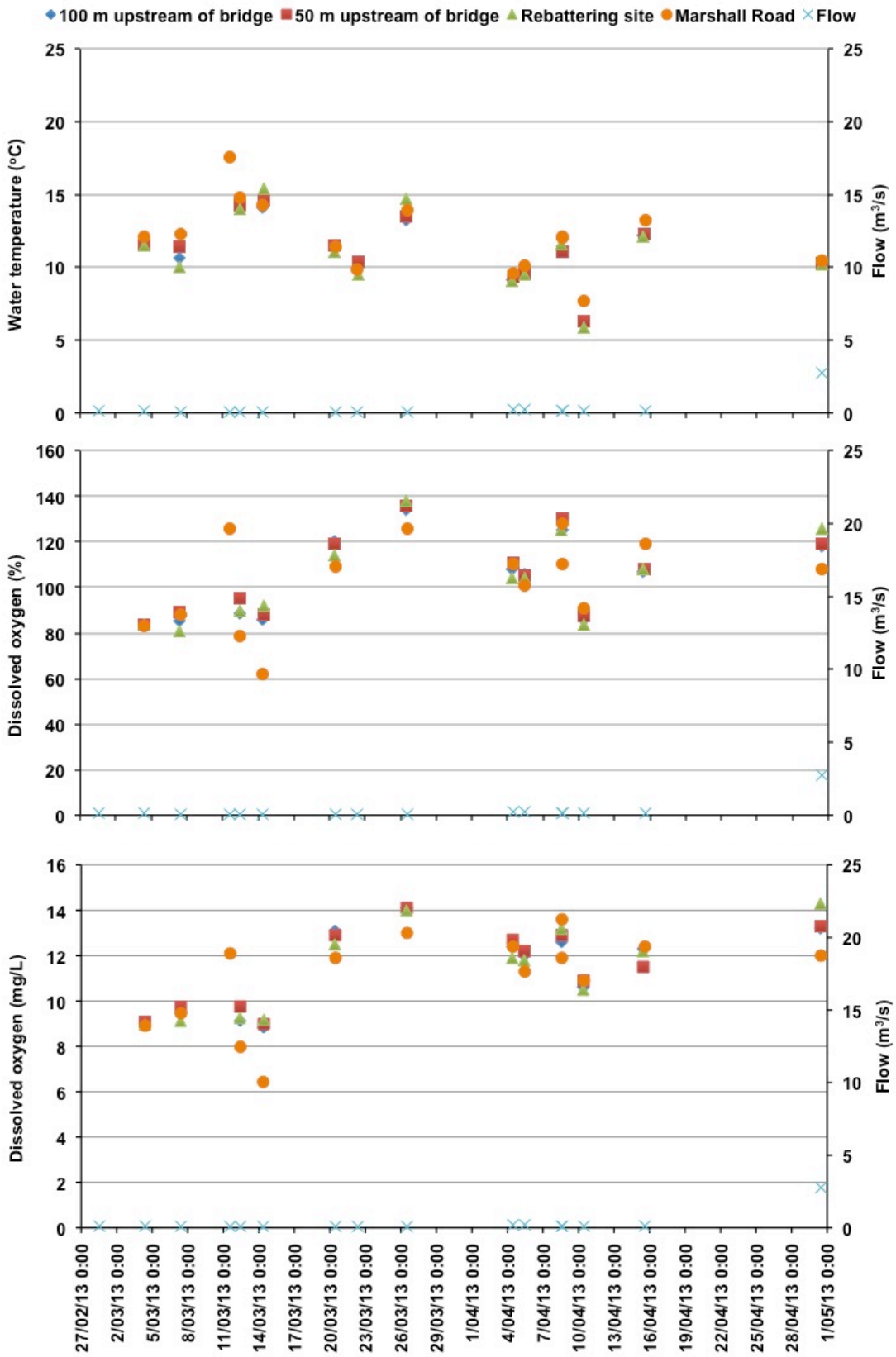

Figure 2 *Top to bottom: water temperature, dissolved oxygen (%), dissolved oxygen (mg/L) and flow at four monitoring sites in Waituna Creek, 28th of February 2013 to 30th of April 2013.*

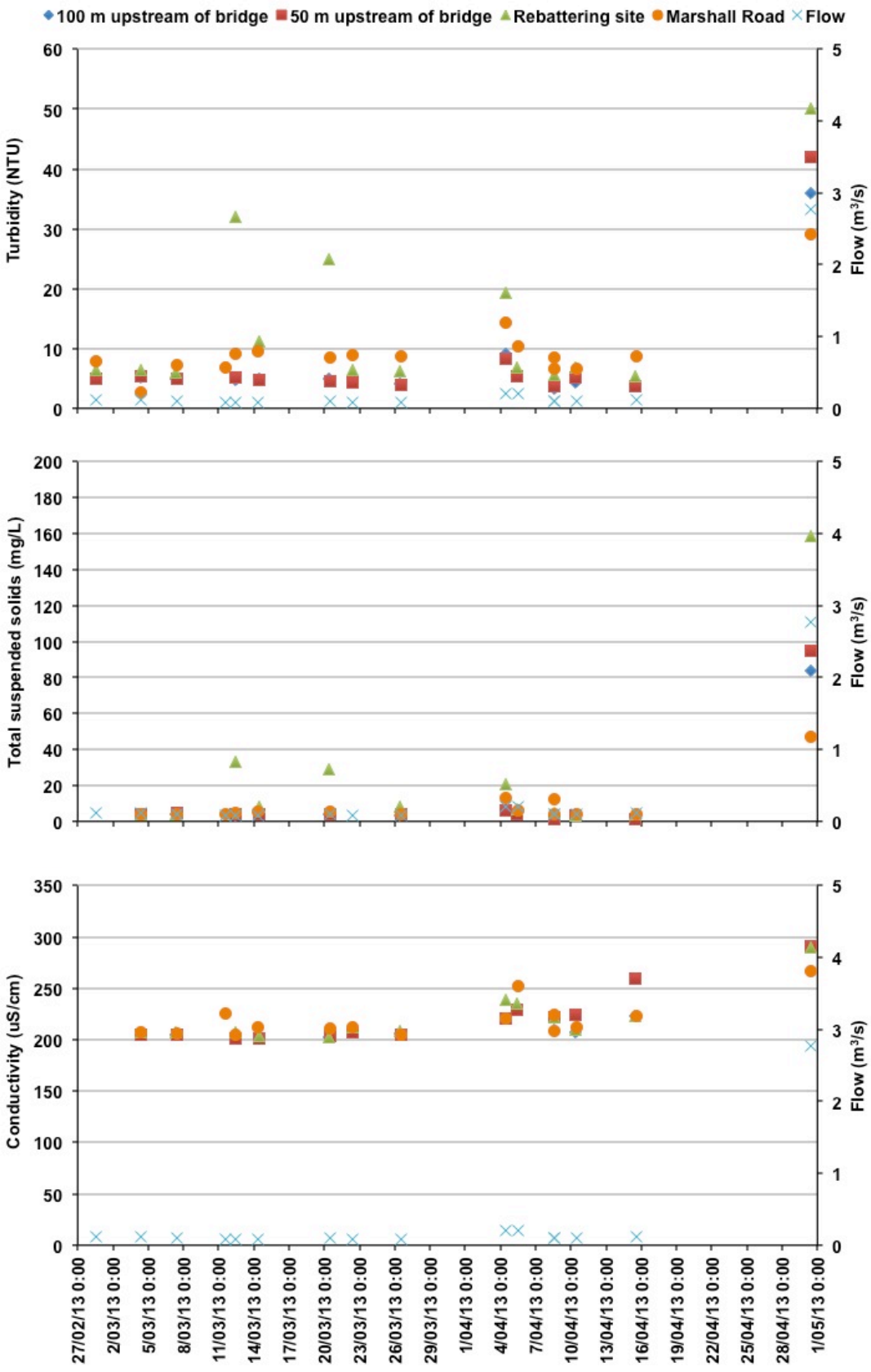

Figure 3 Top to bottom: turbidity, total suspended solids, conductivity and flow at four monitoring sites in Waituna Creek 28th of February 2013 to 30th of April 2013.

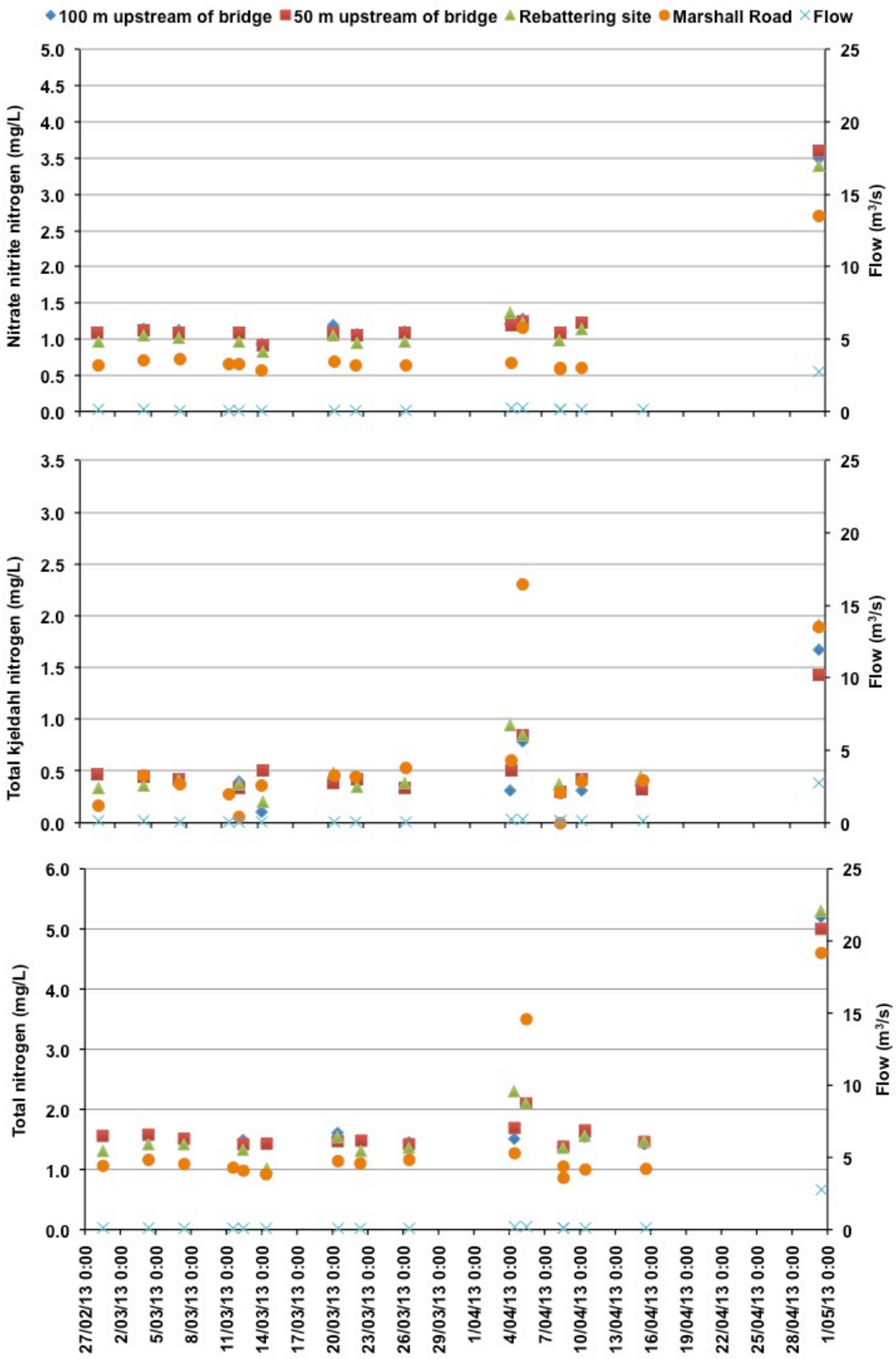

Figure 4 *Top to bottom: total nitrogen, nitrate nitrite nitrogen, total kjeldahl nitrogen and flow at four monitoring sites in Waituna Creek, 28th of February 2013 to 30th of April 2013.*

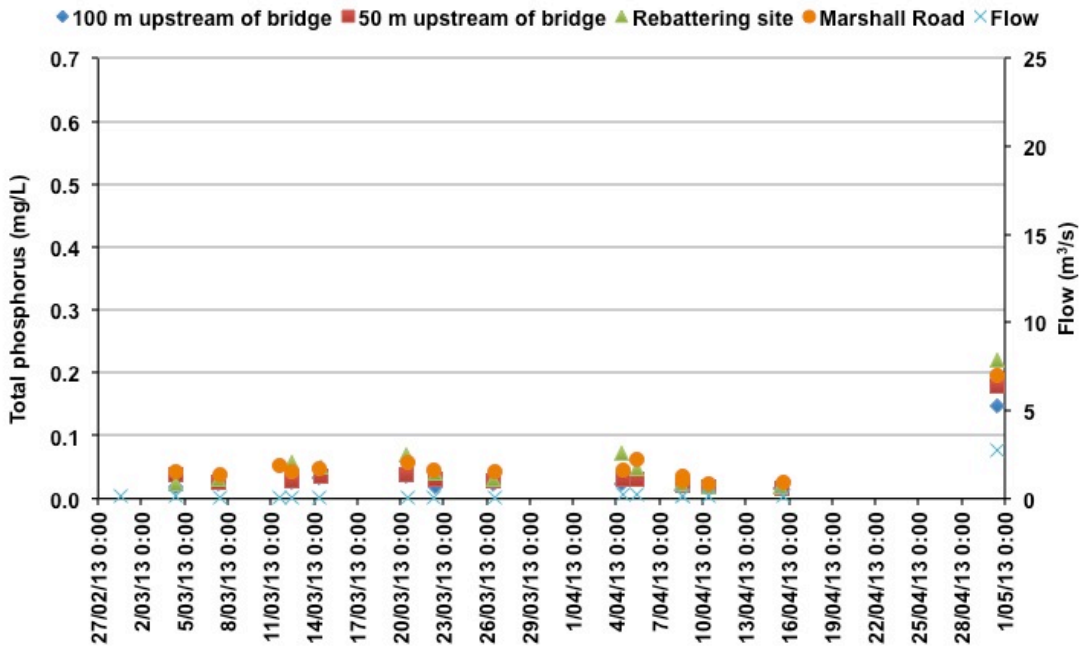

Figure 5 *Total phosphorus and flow at four monitoring sites in Waituna Creek, 28th of February 2013 to 30th of April 2013.*

Figures 6 to 9 show relationships between flow and contaminants for the Waituna Creek at Marshall Road site prior to rebattering (May 2011 to January 2013), during rebattering (11 February to 15 April 2013) and immediately following the rebattering works (30 April 2013). It is apparent from these relationships that concentrations of total suspended solids, total phosphorus, nitrate-nitrite nitrogen and total nitrogen during and immediately after the rebattering works were similar, for a given flow, to that observed prior to rebattering. We note, however, that Marshall Road is a considerable distance downstream of the rebattering site and it is likely the creek attenuates the peak concentrations of contaminants before they reach this downstream site.

Ballantine and Hughes (2012) undertook a similar analysis to determine the effect of drain clearing in Waituna Creek in 2012. They observed that concentrations of total suspended solids and total phosphorus, but not nitrate-nitrite nitrogen and total nitrogen, were higher during drain clearing than for the long term record.

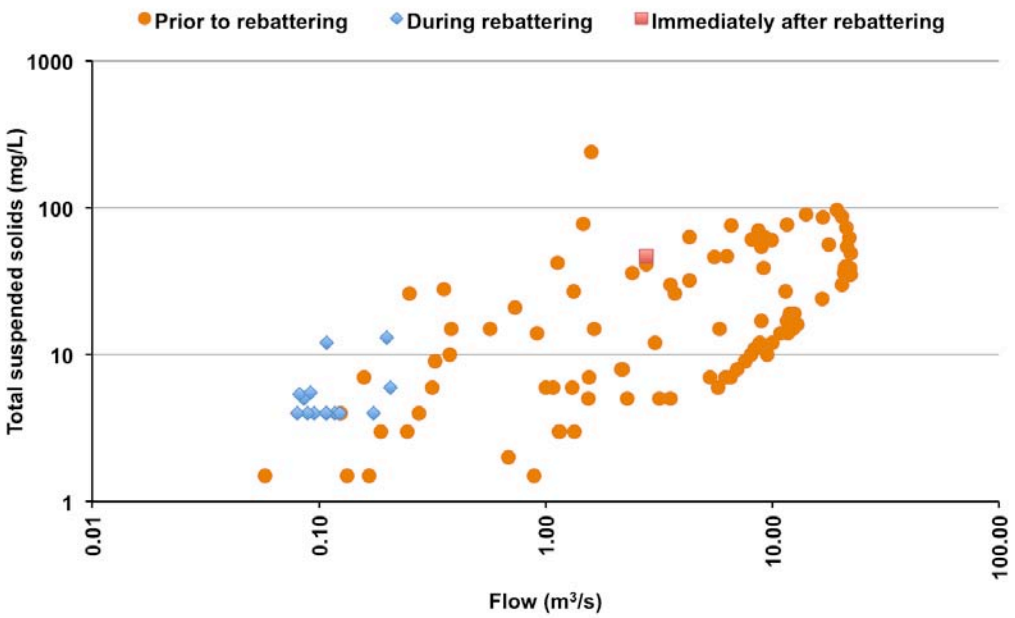

Figure 6 *Total suspended sediment (mg/L) and flow (m^3/s) relationship for the Waituna Creek at Marshall Road site, prior to the rebattering works (May 2011 – January 2013), during rebattering (11 February to 15 April 2013), and immediately after rebattering (30 April 2013). Note both the x and y axes are on a logarithmic scale.*

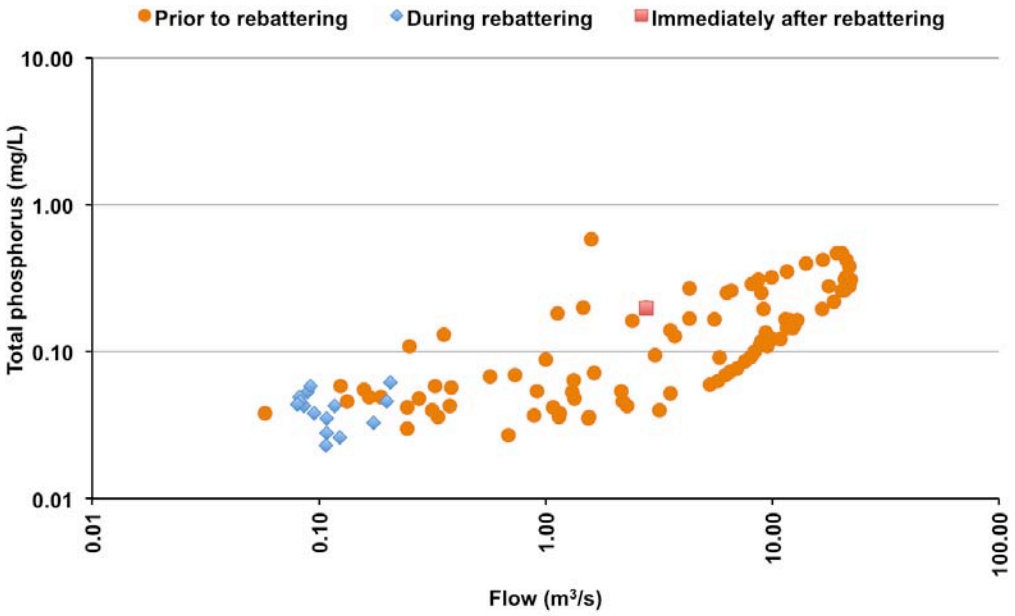

Figure 7 *Total phosphorus (mg/L) and flow (m^3/s) relationship for the Waituna Creek at Marshall Road site, prior to the rebattering works (May 2011 – January 2013), during rebattering (11 February to 15 April 2013), and immediately after rebattering (30 April 2013). Note both the x and y axes are on a logarithmic scale.*

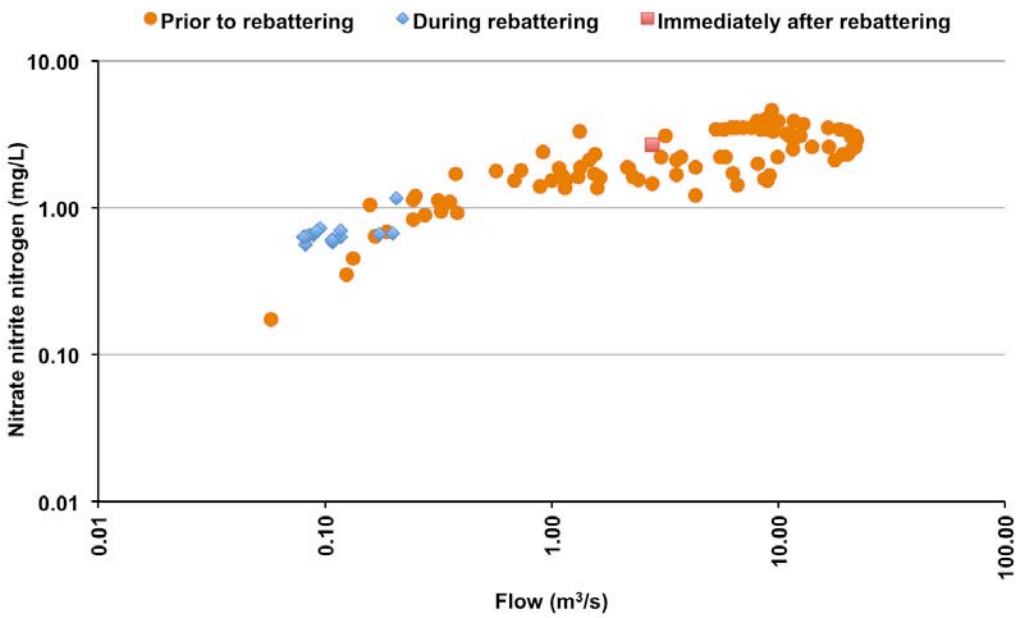

Figure 8 *Nitrate nitrite nitrogen (mg/L) and flow (m^3/s) relationship for the Waituna Creek at Marshall Road site, prior to the rebattering works (May 2011 – January 2013), during rebattering (11 February to 15 April 2013), and immediately after rebattering (30 April 2013). Note both the x and y axes are on a logarithmic scale.*

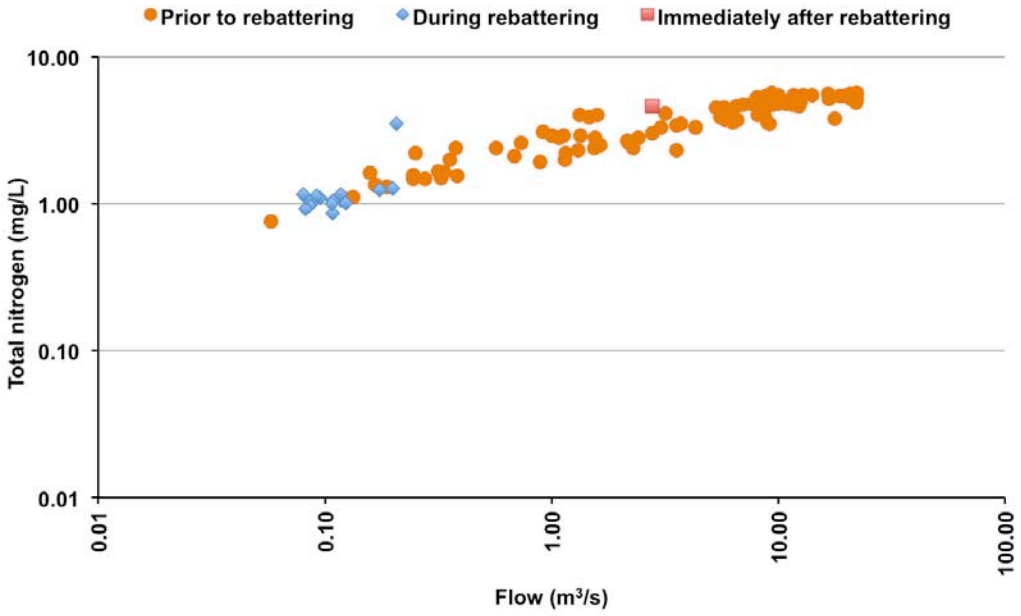

Figure 9 *Total nitrogen (mg/L) and flow (m^3/s) relationship for the Waituna Creek at Marshall Road site, prior to the rebattering works (May 2011 – January 2013), during rebattering (11 February to 15 April 2013), and immediately after rebattering (30 April 2013). Note both the x and y axes are on a logarithmic scale.*

Catchment yields of total suspended solids, total nitrogen and total phosphorus were calculated and compared between upstream control sites, the rebattering and Marshall Road sites over the study period (Figure 10). Values for all sites were similar throughout the works period, with the only major difference observed after the works were completed during the fresh that occurred on the 30th of April 2013. Nutrient yields were similar for all sites at this time but sediment yield was higher at the rebattering site relative to upstream sites indicating a higher localised contribution from this section of the creek (Figure 10).

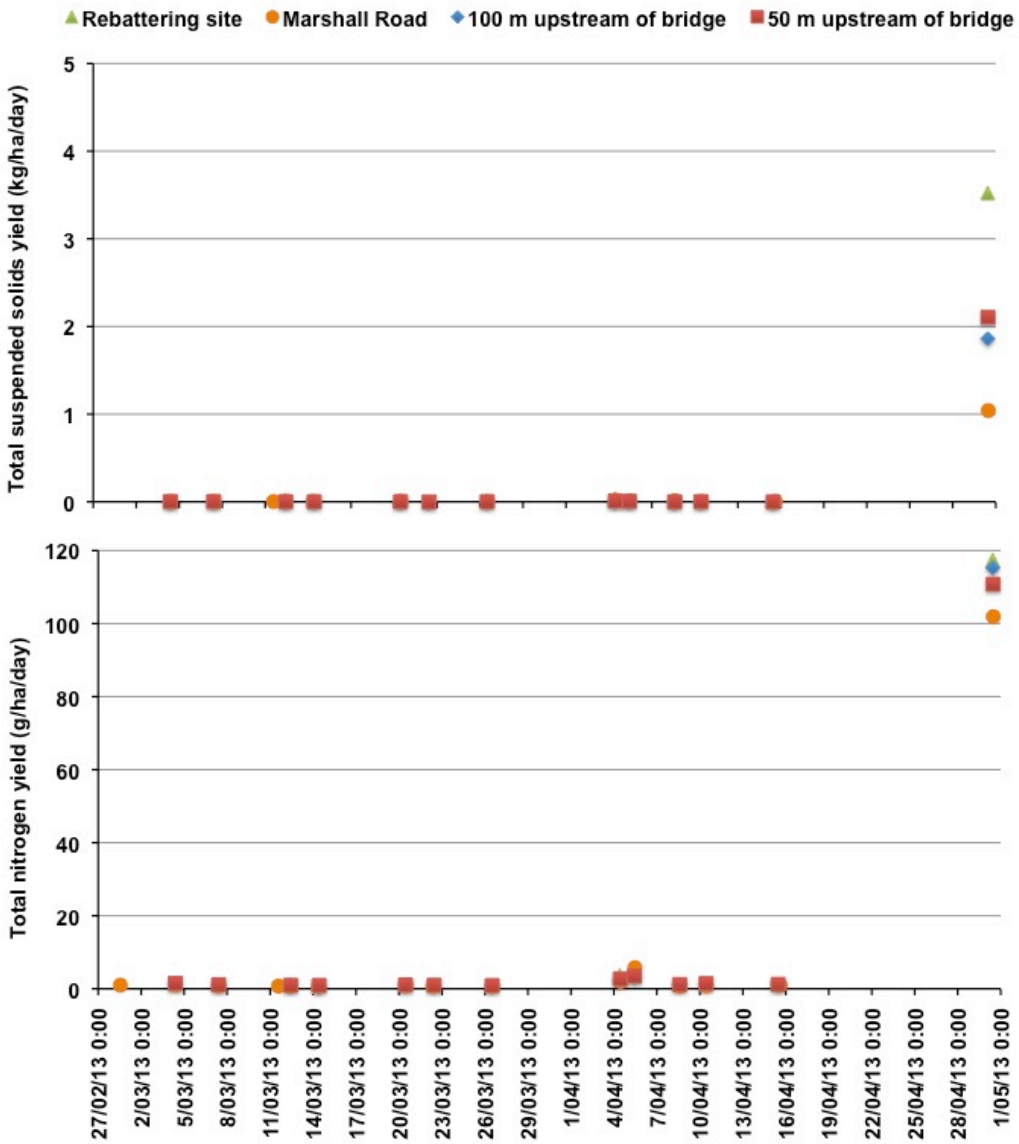

Figure 10 Top to bottom: Calculated total suspended sediment (kg/ha/day) and total nitrogen (g/ha/day) yields at upstream sites, the rebattering site and Marshall Road site in Waituna Creek, 23rd of January 2011 to 30th of April 2013.

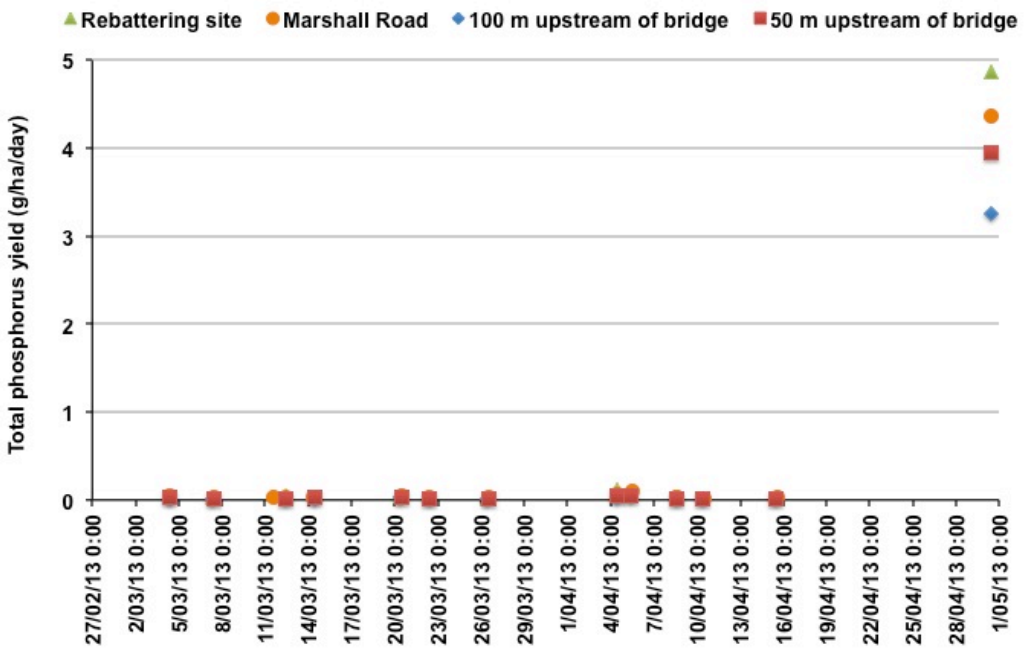

Figure 10 (cont'd) Calculated total phosphorus yield (g/ha/day) at upstream sites, the rebattering site and Marshall Road site in Waituna Creek, 23rd of January 2011 to 30th of April 2013.

4. Conclusion

Environment Southland monitored 10 water quality parameters at four sites in Waituna Creek during rebattering works between February and April 2013. The four monitoring sites included two control sites located immediately upstream of the works, one site within the works area, and a site at Marshall Road approximately 4 km downstream of the works. Water quality monitoring data from the Marshall Road site prior to the works provided an indication of typical water quality in Waituna Creek, and flow data was also obtained from this site. Flows were very low throughout the works period. A fresh occurred not long after rebattering work was completed and water quality was sampled on this occasion also.

Values of most water quality parameters were similar among sites during the works. Median turbidity and total suspended solid levels were only slightly higher at the rebattering and Marshall Road sites than at the upstream control sites during the works. Larger increases in these parameters were expected at the rebattering site as a result of the works, however the low flows during the works are likely to have reduced the

amount of disturbed sediment entering the creek and moving downstream. Higher turbidity and suspended sediment levels were observed at the rebattering site following the works when a fresh occurred, however observed levels were still lower than maximum values observed at the Marshall Road site prior to the works.