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Catchment Environmental Monitoring Report 2013/14

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1 Introduction

1.1 Background

As part of Project Watershed and Peninsula Project implementation, the Catchment Environmental Monitoring (CEM) Programme was developed to demonstrate the long term benefits of soil conservation. To date, monitoring has been established in selected priority catchments for soil conservation in the Waipa, Lower Waikato, Upper Waikato and Coromandel management zones.

The CEM programme allows the Waikato Regional Council to:

- Demonstrate the long term benefits of soil conservation and river management work programmes.
- Better utilise resources and leverage opportunities to co-ordinate monitoring internally and externally (e.g. within the Waikato Regional Council, NIWA and Landcare Research).
- Integrate new monitoring requirements into existing regional monitoring networks.

Prior to the CEM programme soil conservation implementation relied on regional monitoring information being reinterpreted at a catchment scale. However, this information is often misleading because regional scale information is being applied at a finer scale (catchment scale).

This report provides CEM programme results for the 2013/2014 year. Copies of reports as described in the list of references can be obtained by contacting the Waikato Regional Council (the Library) on 0800 800 401, or in electronic format from the publications page of the Waikato Regional Council website http://www.waikatoregion.govt.nz/publications/ or email: inforeq@waikatoregion.govt.nz

1.2 Report content

This report provides information on the annual monitoring of the environmental effects of soil conservation and river management works implemented in soil conservation priority catchments across the Waikato region. It includes updated results from the 2013/14 monitoring period. Interpretations of the results, identification of trends (where applicable) and results from additional monitoring sites are also included. The report is structured so that each zone can be reviewed independently. This will be the final CEM report due to changes in the monitoring programme.

1.3 Monitoring approach

The aim of the CEM programme is to provide a representative (and where possible quantitative) indication of changes in various environmental parameters, resulting from soil conservation and river management work. Parameters include changes to hillslope erosion, stream bank erosion, riparian vegetation and fencing, sedimentation in surface water, water temperature and in-stream ecological habitat. Monitoring has been selected to measure changes on land and in surface water to provide some indication of the resulting on-site and off-site benefits. Details of the methods used are provided in the internal series report, Catchment Environmental Monitoring Methods (Grant et al., 2009a).

It is important to note that not all priority soil conservation catchments are monitored. However, the results for the monitored catchments should be applicable to other priority catchments in a given zone than monitoring results from elsewhere in the region. A standard monitoring approach is recommended for all monitored catchments but the specific suite of monitoring will differ from catchment to catchment. This is dependent on the type of soil conservation and river management issues within each catchment. There are several key outcomes of the CEM programme:

- An understanding of the long-term benefits of soil conservation, river management and catchment issues in the Waikato region.

- A long-term picture of the land and water quality benefits of soil conservation and river management initiatives provided by the Waikato Regional Council.

- A regional framework for obtaining, managing and implementing catchment scale monitoring information.

- Efficient integration of existing State of the Environment regional monitoring, Crown Research Institute catchment monitoring, the Waikato Regional Council implemented works consent monitoring, and the Waikato Regional Council initiatives specific catchment monitoring (e.g. Peninsula Project).

1.4 Management zone boundaries

The monitored catchments are positioned in four management zones, as described in Table 1. Zones which do not contain monitored catchments are Central Waikato (CWK), West Coast (WTC), Waihou-Piako (WPO) and Lake Taupo (TAU) zones. The priority catchments covered in this report are shown in Figure 1, in addition to the management zone boundaries.

Table 1: Location of the monitored catchments as at 2013/2014.

Monitored catchment	Management zone
Matahuru	Lower Waikato (LWK)
Mangare	Upper Waikato (UWK)
Pokaiwhenua	Upper Waikato (UWK)
Tahunaatara	Upper Waikato (UWK)
Mangatutu	Waipa (WPA)
Wharekawa	Coromandel (COR)

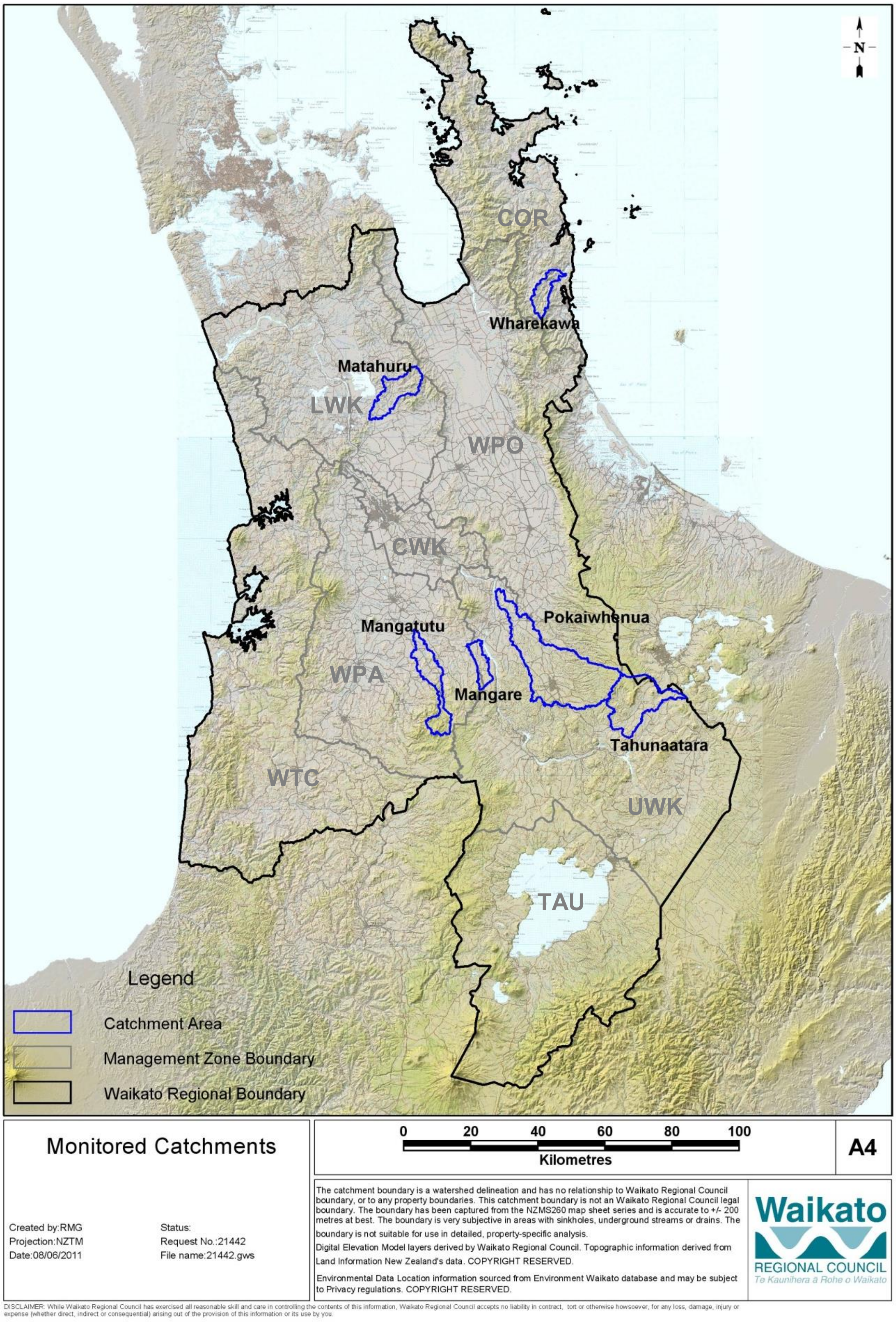

Figure 1: **Monitored priority catchment locations, with management zone boundaries (labels explained in Table 1).**

1.5 Monitoring information

The reported monitoring information is provided through specific catchment scale monitoring in selected soil conservation priority catchments. In addition, on-going regional monitoring information (Table 2) is utilised to increase our knowledge of the state and changes in soil erosion and sedimentation of water within the various management zones. The changes in soil stability in the Waikato Region from 2002 to 2007 are discussed in Thompson & Hicks (2009b). For the most recent results of the Regional Soil Stability assessment conducted in 2007 refer to Thompson & Hicks (2009a).

Table 2: Waikato Regional Council's land and water monitoring programmes.

Programme	Main measures	Last assessment/ frequency
Regional soil stability assessment	Soil stability and soil conservation	2007; assessment 5-10 yearly
Regional riparian characteristics assessment	Riparian fencing, vegetation and erosion	2012/13; assessment 5-10 yearly
Permanent suspended sediment sites	Water quality including sediment and peak flows	7 sites; reviewed annually
River ecological monitoring sites (REMS)	Stream biological and habitat condition	Ongoing (~10yrs data)
Regional rivers	Water quality including sediment	Ongoing (>10yrs data)

2 Lower Waikato zone

2.1 Introduction

Monitoring is present in one catchment in the Lower Waikato zone; Matahuru catchment.

2.2 Matahuru catchment

2.2.1 Monitoring progress

Monitoring is focused on the lower section of the Matahuru catchment on the Matahuru Stream; refer to Grant et al., (2009b) for survey locations. Table 3 presents monitoring completed by the end of the 2013/14 financial year.

Table 3: Matahuru catchment environmental monitoring completed between 2003/04 and 2013/14.

Monitoring	Activity	Completion	Included in this report (or year last reported)
Soil stability	Soil stability and soil conservation assessment	2005	2005/06
Riparian characteristics assessment	Complete assessment along the lower section of the Matahuru Stream	2003/04, 2005/06, 2007/08, 2009/10, 2011/12, 2013/14	✓
Photo points	Complete assessment along the lower section of the Matahuru Stream	2003/04, 2005/06, 2007/08 2009/10, 2011/12, 2013/14	✓
Permanent suspended sediment sampling site	Event driven sampling	Installed 2003 and ongoing	✓
Suspended sediment snapshots	• Low flow snapshot • Medium flow snapshot	2003 2008	2005/06 2007/08
Water temperature	Install loggers and record stream temperatures along the lower section of the Matahuru Stream	2003/04, 2004/05, 2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓

2.2.2 Soil stability

Refer to Hicks (2005a) for the most recent soil stability assessment report for this catchment.

2.2.3 Riparian characteristics

Introduction

Eleven 1 km samples were selected for assessment through the lower section of the Matahuru Stream. The assessments on the Matahuru Stream are at locations where Waikato Regional Council funded river management and soil conservation works are scheduled, where stream riparian margin access is possible and where landowner participation is forthcoming. The initial assessment was conducted during the 2003/04 summer with the most recent assessment completed in 2013/14.

The reported data for each parameter represents a percentage of the total assessed riparian margin in the catchment. Erosion, vegetation and fencing data summaries are presented in Figures 2, 3, 4 and 5. The riparian data used in each figure is tabulated in Appendix 1

Vegetation

Riparian vegetation contributes to stream bank stability and the shading of the stream. Effective shading can minimise instream temperature. Natural biodiversity along the riparian margin can be increased through the planting of native vegetation. Reported riparian vegetation was split into grass and woody vegetation (native + willow + exotic other). Figure 2 shows that during the 2013/14 reporting period 21% of the riparian margin was grass. The remaining 79% was woody vegetation, of which 46% of the total length was native, 12% was willow and 21% was other exotic species. The length of the riparian margin in grass has decreased from 51% to 21% between 2003/04 and 2013/14. The increase in woody vegetation between 2003/2004 is split between woody willow and woody exotic, with the majority of the increase being woody exotic vegetation (Figure 2).

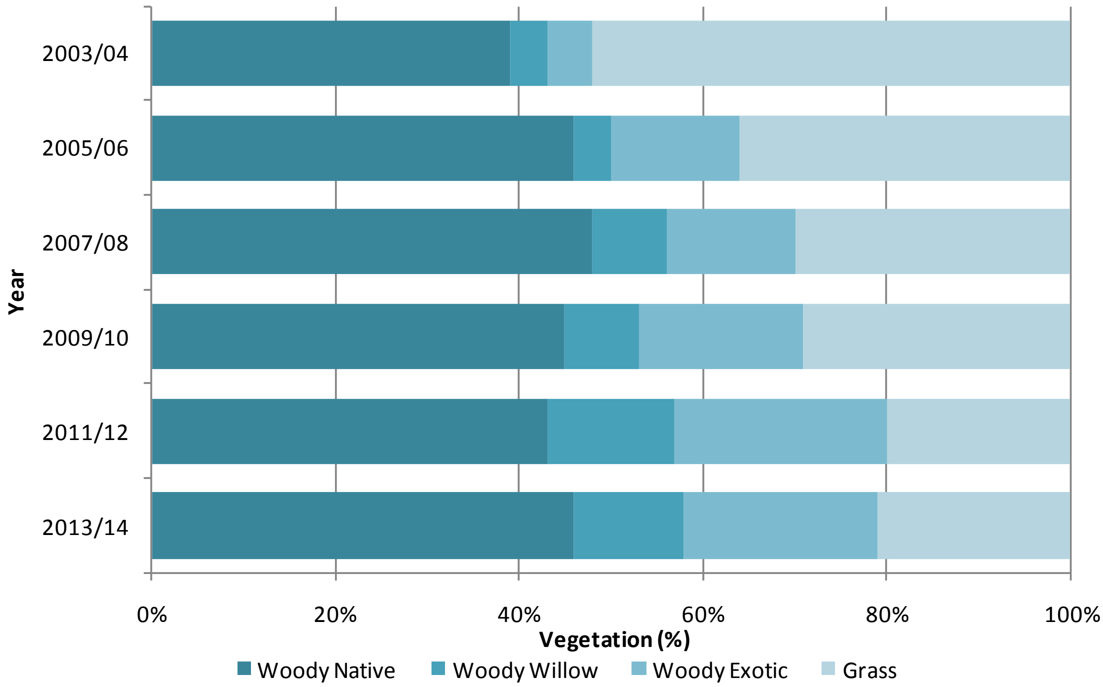

Figure 2: Matahuru catchment riparian vegetation by bank length (%).

Fencing

The amount of fencing on one side or both sides of the waterway is an indicator of likely stock exclusion. Stock exclusion reduces direct contamination of water by pathogens, direct damage to the stream ecology by trampling of the stream bed and indirectly reduces sediment load from stock trampling the banks.

The 2013/14 riparian survey indicates that stock was excluded from both sides for 98% of the waterway and from one side for 2% of the waterway (Figure 3). There has been an increase from 46 to 98% in the length of stream fenced on both sides since the 2003/04 assessment (Figure 3).

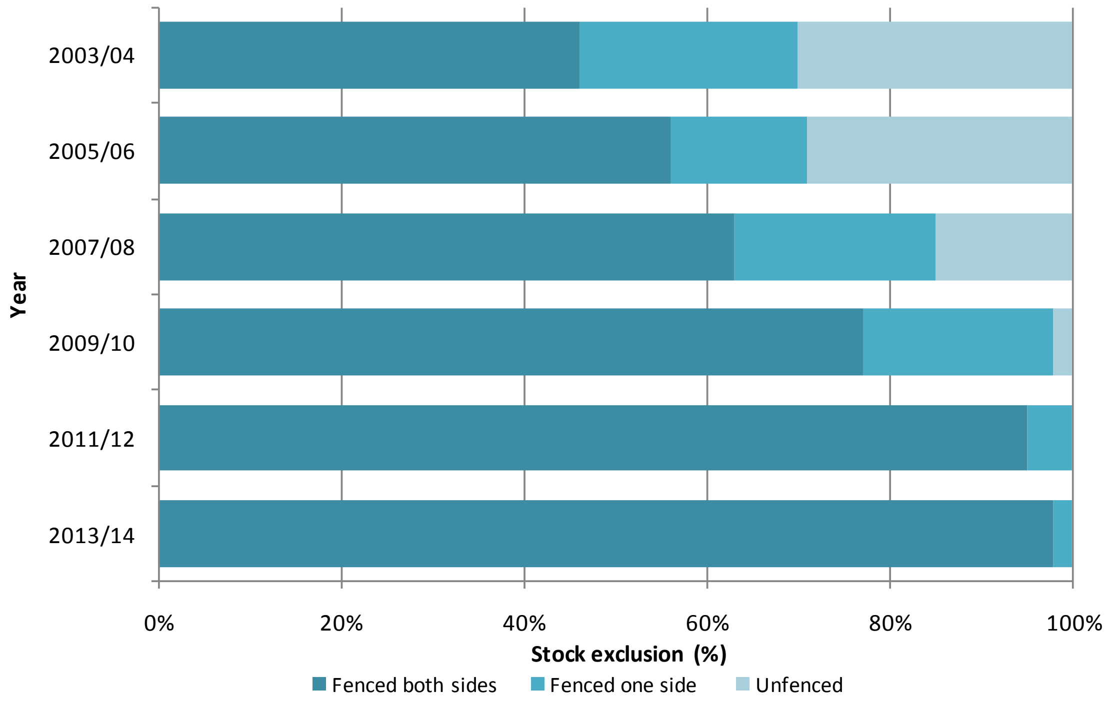

Figure 3: **Matahuru catchment stock exclusion by bank length (%).**

The proportion of stream bank that was fenced off and had woody vegetation increased from 40% to 79% of the total length of the Matahuru Stream between 2003/4 and 2013/14 (Figure 4). The 2013/14 assessment indicated that 79% and 20% of stream bank is fenced woody vegetation and grass respectively, leaving only 1% as unfenced grass (Figure 4).

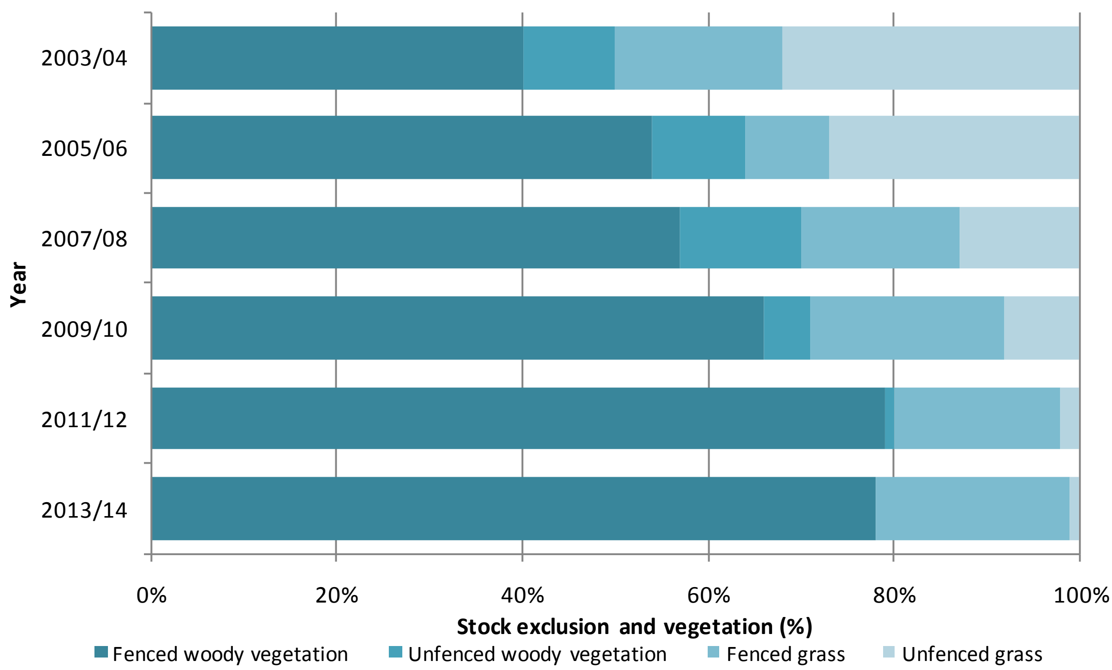

Figure 4: **Matahuru catchment bank length fencing and vegetation combinations (%).**

Stream bank stability

Stream bank stability can be improved through planting riparian vegetation, and fencing out stock. Stream bank erosion is perceived as being a significant contributor of suspended sediment especially in areas of pastoral land use (Hicks & Hill, 2010).

In 2013/14 an estimated 89% of the assessed riparian bank length was stable, up from 47% measured during the 2003/04 period. During 2013/14 11% of the total bank length was unstable this was represented by; fenced woody vegetation (8%), fenced grass (2%) and unfenced grass (1%). Unstable unfenced grass displayed the greatest decrease between 2003/04 and 2013/14, decreasing from 30% of total stream bank length to 1% (Figure 5).

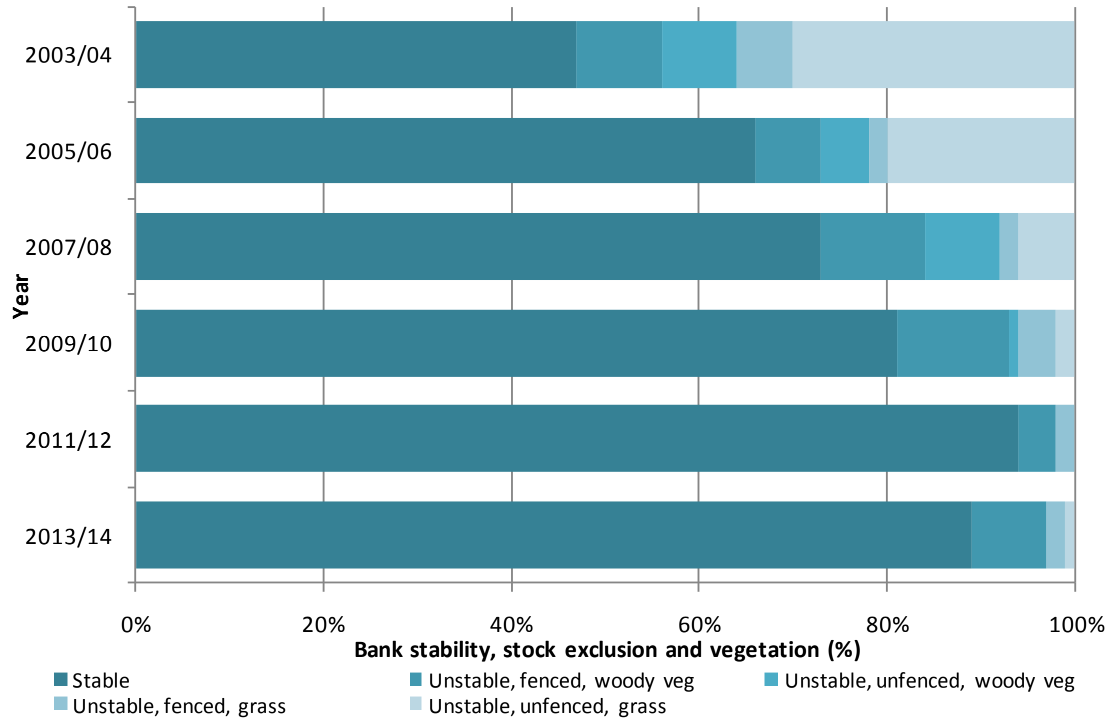

Figure 5: Matahuru catchment stream bank stability (%).

In summary, Figures 2 to 5 show that since reporting began in 2003/04 woody riparian vegetation increased, and fencing and stream bank erosion has improved.

2.2.4 Water temperature

Two water temperature loggers were deployed in the lower section of the Matahuru Stream; the upstream logger in the vicinity of the Mangapiko Valley Road Bridge and the downstream logger next to the Waikato Regional Council recorder station by Waiterimu Road. The distance between the two loggers is approximately 20 km. To date eleven deployments have been made with data collected for 10 weeks from 1 January during each summer between 2003/04 and 2013/14.

The average of the daily maximum water temperature is derived to produce a single temperature for each site. The upstream temperature is then subtracted from the downstream temperature to provide a temperature difference for the monitored section of the river.

The daily average upstream and downstream maximums for 2013/14 were 20.73°C and 21.31°C respectively. Refer to Table 21 in Appendix 2 for the annual upstream and downstream temperature measurements since 2003/04. Figure 6 indicates that the downstream temperature has been cooler than the upstream temperature for all years until 2013/14. Between 2003/04 and 2012/13, linear regression indicated that the difference between upstream and downstream temperatures had been decreasing, due to the downstream site becoming warmer (Littler & Berry, 2013). The summer of 2013/14 is the first year when the downstream site has been warmer than the upstream site and this difference appears to be a deviation from the trend observed between 2003/04 and 2012/13 (Figure 6). The reason for this deviation is unknown; however the downstream logger by Waiterimu Rd is close to the stream outlet and therefore may be influenced by temperature and water level changes in Lake Waikare.

Observations during field visits suggest that shading of the Matahuru Stream was sporadic between the two sites, with a variety of vegetation types present. However, generally the percentage of woody vegetation has increased over the assessment period (Figure 6). As existing vegetation combined with any new plantings established and grew, it was expected that shading would increase and result in a larger temperature difference between the upstream and downstream monitoring sites (i.e. a net decrease in water temperature downstream). To date this does not appear to have happened (Figure 6) and is perhaps related to the high stream order limiting the ability of riparian vegetation to effectively shade the stream.

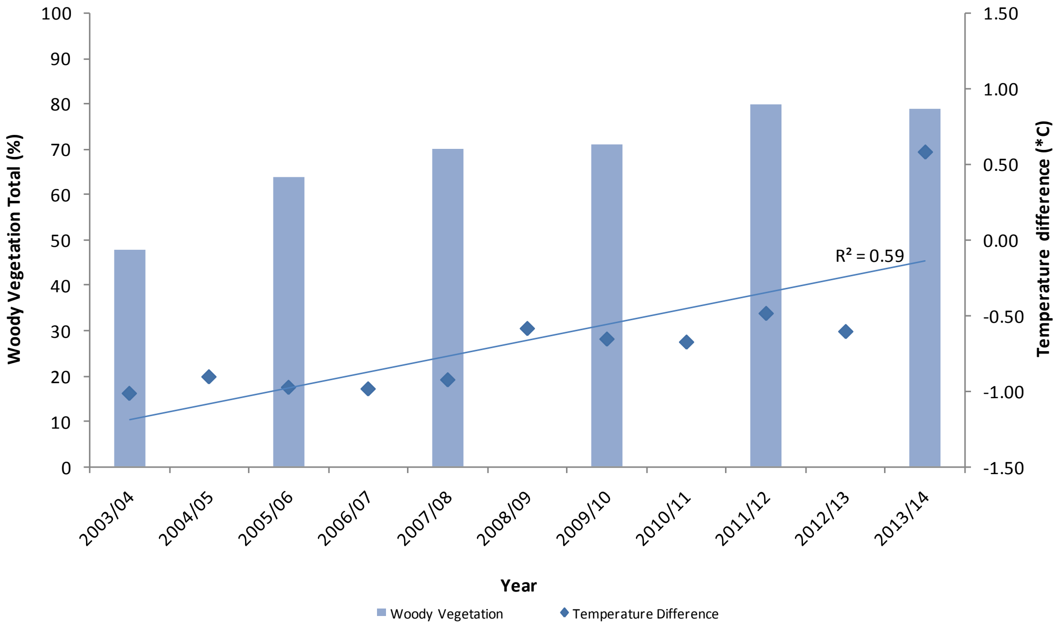

Figure 6: Annual changes in woody vegetation total (%) and temperature difference (ºC) for the Matahuru catchment.

2.2.5 Photo points

Photo assessments have been completed 6 times along the Matahuru Stream in 2003/04, 2005/06, 2007/08, 2009/10, 2011/12 and 2013/14. During the 2013/2014 assessment period eleven samples were taken along the stream totalling 55 photos over a total distance of 11000 m. Appendix 3 presents a comparison for each photo point for the 2003/04 and 2013/14 assessment years. Since measurements began large sections of the stream have been fenced, the presence of woody riparian vegetation has increased and stream bank erosion has decreased (Figures 2, 3, 4 and 5). Photo points have shown the effects of these changes through extensive growth of stream bank vegetation; in some cases this material completely covers the stream channel (Figure 7, C to F). Although, at some sites, where the stream channel is wide, changes in riparian characteristics since the commencement of the CEM programme were less obvious (Figure 7, A and B).

	2003/04	2013/14
Assesment 1 at 000 m		
Assessment 2 at 750 m		
Assesment 11 at 750 m		

Figure 7: Matahuru Stream photo point examples of visual change between 2003/04 and 2013/14 for assessment 1 at 000 m (A and B), assessment 2 at 750 m (C and D) and assessment 11 at 750 m (E and F).

2.2.6 Suspended sediment

A permanent suspended sediment sampling site has been in place at the Myjers farm bridge on the Matahuru Stream since July 2006. During this time 33 high flow events have been sampled using an automatic sediment sampler. The data set is analysed to estimate sediment variables and data includes all results up until 31/12/2013 (Table 4). A continuing focus, with all automated sediment sampling, is to carry out manual depth-integrated suspended sediment gauging while the automatic sampler is activated. The collection of these concurrent samples will allow the automatic series to be calibrated to the whole river cross-section. For more detailed information refer to Kotze et al., (2008) and Hoyle et al., (2012).

Table 4: Matahuru Stream, at Myjers farm bridge, permanent suspended sediment sampling site description and estimated sediment variables for data collection from July 2006 until December 2013.

Site name:	**Myjers**	**Map Ref (NZMS260):**	**S13:116-095**
River:	**Matahuru**		
		Start – End Date	**No of samples**
Flow Time Series		17/07/2006 – 31/12/2013	N/A
Sediment Samples		19/07/2006 – 6/12/2013	651
ISCO Period of Record		19/07/2006 – 6/12/2013	33 events
Specific yield ($t/km^2/yr$)	Average sediment yield (kt/yr)	% of sediment yield in gauged range of flow	% Error in Yield Estimate
184	15.2	65.4	5.1

The estimated specific sediment yield at the Matahuru Stream sampling site is 184 $t/km^2/yr$ and the average sediment yield is 15.2 kt/yr (Table 4). Relative to other sampling sites in the Waikato Region the Matahuru Stream has a high specific sediment yield (Figure 8). This high specific yield is likely a result of pastoral farming being the dominant land use and a catchment which is formed in erodible tertiary sediments (Hoyle et al., 2012).

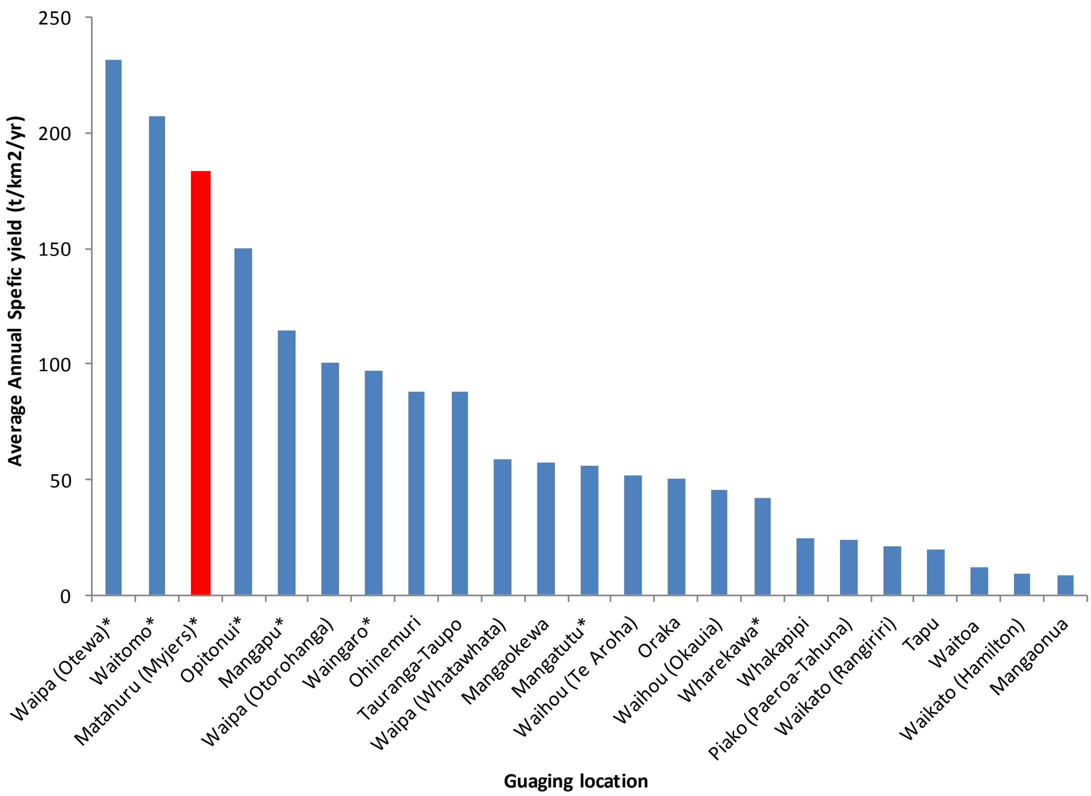

Figure 8: Average specific suspended sediment yield ($t/km^2/yr$) for monitored rivers in the Waikato Region (the Matahuru stream is highlighted in red). Sites with marked with an asterisk are monitored by automatic samplers.

2.2.7 Main Points

Soil Stability

- No soil stability assessment was completed this year.

Riparian Characteristics

- Riparian condition of the Matahuru Stream has improved since the commencement of monitoring.

- The proportion of grass to woody vegetation has declined from 52% to 21% between the 2003/04 and 2013/14 assessments. Woody vegetation covers 79% of the riparian margin, of which 46% of the total length is native, and 33% is exotic (including willows).

- There has been an increase in fencing over the total stream bank length from 46% in 2003/04 to 98% in the most recent survey (2013/14).

- The proportion of stream bank that was fenced off with woody vegetation has increased from 40% to 78% of the total stream bank length over the 10 years separating the assessments. The length of unfenced grass has decreased to 1% of the stream bank length.

- An estimated 89% of the assessed riparian bank length was considered stable in 2013/14, up from 47% in 2003/04.

Water Temperature

- The downstream temperature has been cooler on average than the upstream temperature and the temperature difference has become less for all monitored years until 2013/14. In 2013/2014 the downstream temperature was cooler than the downstream temperature. The reason for the sudden change in the pattern of temperature difference in 2013/14 is unknown.

- Since 2003/04 river management and soil conservation works have occurred, but in general, shading of the Matahuru Stream remains sporadic.

Suspended sediment monitoring

- A specific yield of 184 t/km^2/yr has been estimated based on results from the permanent suspended sediment monitoring site. This is high compared to other monitoring sites in the Waikato region and is a result of catchment land use and lithology.

3 Upper Waikato zone

3.1 Introduction

Monitoring is undertaken in three catchments in the Upper Waikato zone; the Pokaiwhenua, Mangare and Tahunaatara catchments. Monitoring progress and results are presented for each catchment individually.

3.2 Pokaiwhenua catchment

3.2.1 Monitoring progress

The monitoring locations in the Pokaiwhenua catchment are detailed in Grant et al., (2009b). Table 5 presents monitoring completed by the end of the 2013/14 financial year.

Table 5: Pokaiwhenua catchment monitoring completed between 2003/04 and 2013/14.

Monitoring	Activity	Completion	Included in this report (or year last reported)
Soil stability	Soil stability and soil conservation assessment	2005	2005/06
Riparian characteristic assessment	Complete assessment along the middle section of the Pokaiwhenua Stream	2003/04, 2005/06, 2007/08, 2009/10, 2011/12, 2013/14	✓
Photo points	Complete assessment along the mid section of the Pokaiwhenua Stream	2003/04, 2005/06, 2007/08, 2009/10, 2011/12, 2013/14	✓
Permanent suspended sediment sampling site	None planned	N/A	N/A
Suspended sediment snapshots	Low flow snapshot	2003	2005/06
Water temperature	Install loggers and record stream temperatures along the middle section of the Pokaiwhenua Stream	2003/04, 2004/05, 2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓
Stream ecological health	Assess stream ecological health along the middle section of the Pokaiwhenua Stream	2003/04, 2004/05, 2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓

N/A = not applicable

3.2.2 Soil stability

Refer to Hicks et al., (2005b) for the most recent soil stability assessment report for this catchment.

3.2.3 Riparian characteristics

Introduction

Six 1 km samples were selected for riparian assessment within the Pokaiwhenua catchment. Five of these assessments were through the middle section of the Pokaiwhenua Stream and one was on the Whakauru Stream. The assessments are at locations where Waikato Regional Council funded river management and soil conservation works are scheduled, where stream riparian margin access is possible, and where landowner participation is forthcoming. The initial assessment was conducted during the 2003/04 summer with the most recent assessment completed in 2013/14.

The reported data for each parameter represents a percentage of the total assessed riparian margin in the catchment. Erosion, vegetation and fencing data summaries are presented in Figures 9, 10, 11 and 12. The riparian data used in each figure is tabulated in Appendix 1

Vegetation

Riparian vegetation contributes to stream bank stability and can help regulate instream temperatures increases. Natural biodiversity along the riparian margin can be increased through the planting of native vegetation. Riparian vegetation is split into grass and woody vegetation (native + willow + exotic other). Figure 9 shows that during the most recent reporting period (2013/14) 23% of the total length of the riparian margin was grass. The remainder was woody vegetation, of which 18% was native, 14% was willow and 45% was other exotic species. The length of the riparian margin in grass has decreased from 55% to 23% between 2003/04 and 2013/14. During the same period both woody exotic and woody willow vegetation increased, however woody native vegetation decreased (Figure 9).

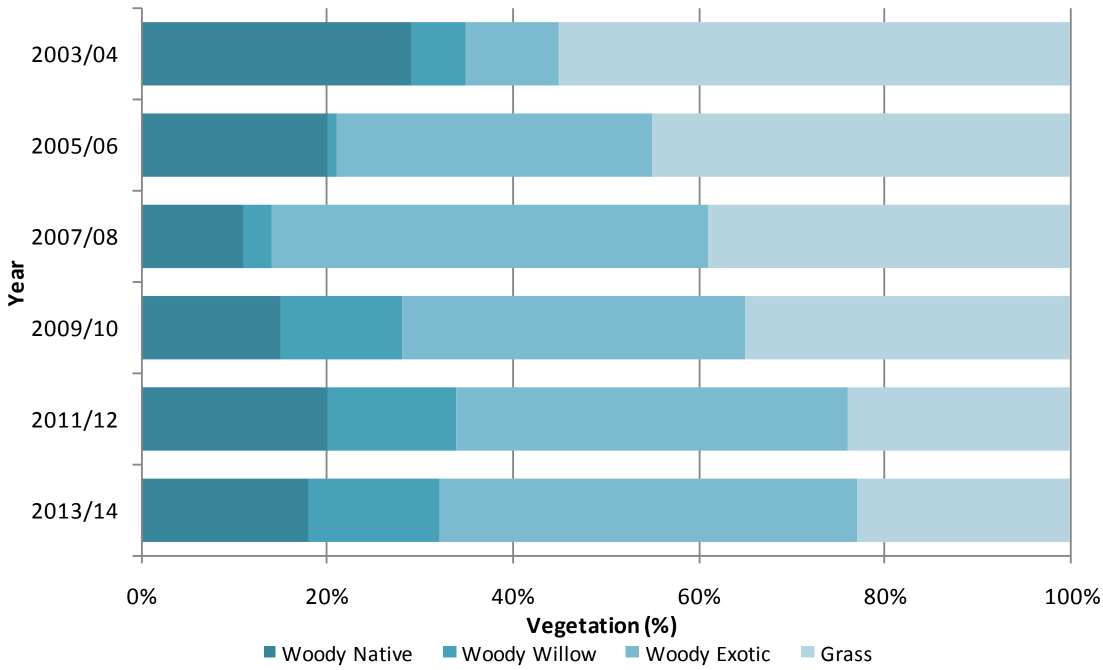

Figure 9: Pokaiwhenua catchment riparian vegetation by bank length (%).

Fencing

The amount of fencing on one side or both sides of the waterway is an indicator of likely stock exclusion. Stock exclusion reduces direct contamination of water by pathogens, direct damage to the stream ecology by trampling of the stream bed and indirectly reduces sediment load from stock trampling the banks.

Since the 2011/12 reporting period, stock have been excluded from both sides of the entire assessed length of the Pokaiwhenua stream. This represents an increase from 27% to 100% in the length of stream fenced, on both sides, since reporting began in 2003/04 (Figure 10).

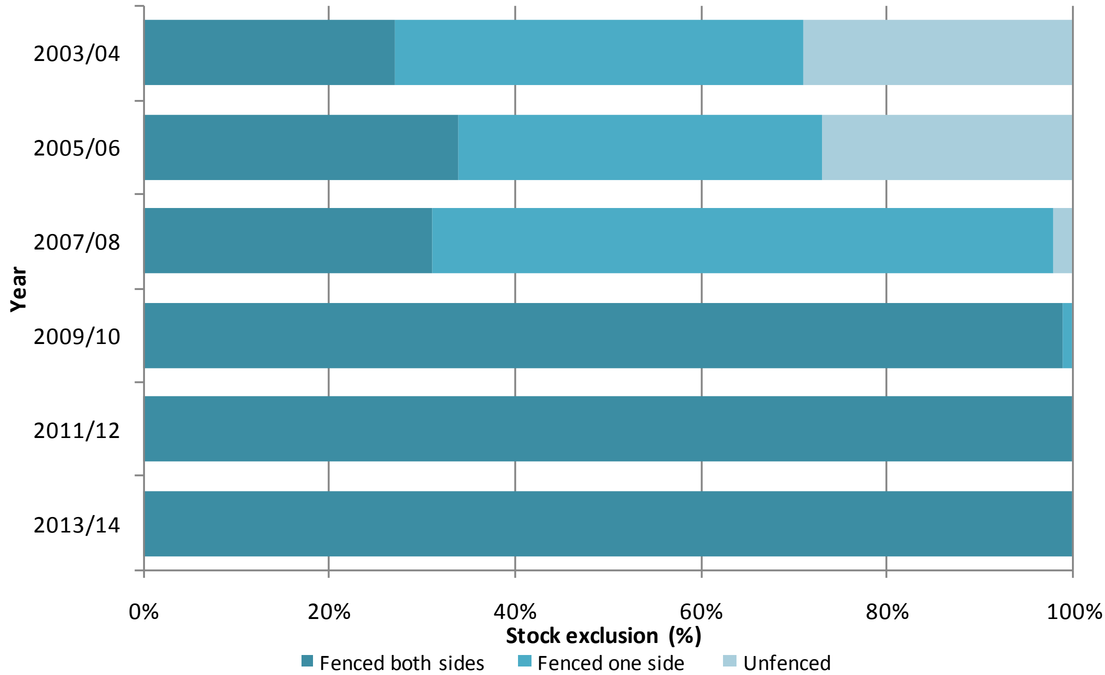

Figure 10: Pokaiwhenua catchment stock exclusion by bank length (%).

The proportion of stream bank that is fenced off and has woody vegetation has increased from 18% in 2003/04 to 77% in 2013/14. Since 2009/10 the majority of the fenced bank vegetation has been woody (Figure 11). This is due to a reduction in unfenced grass and an overall increase in fenced woody vegetation.

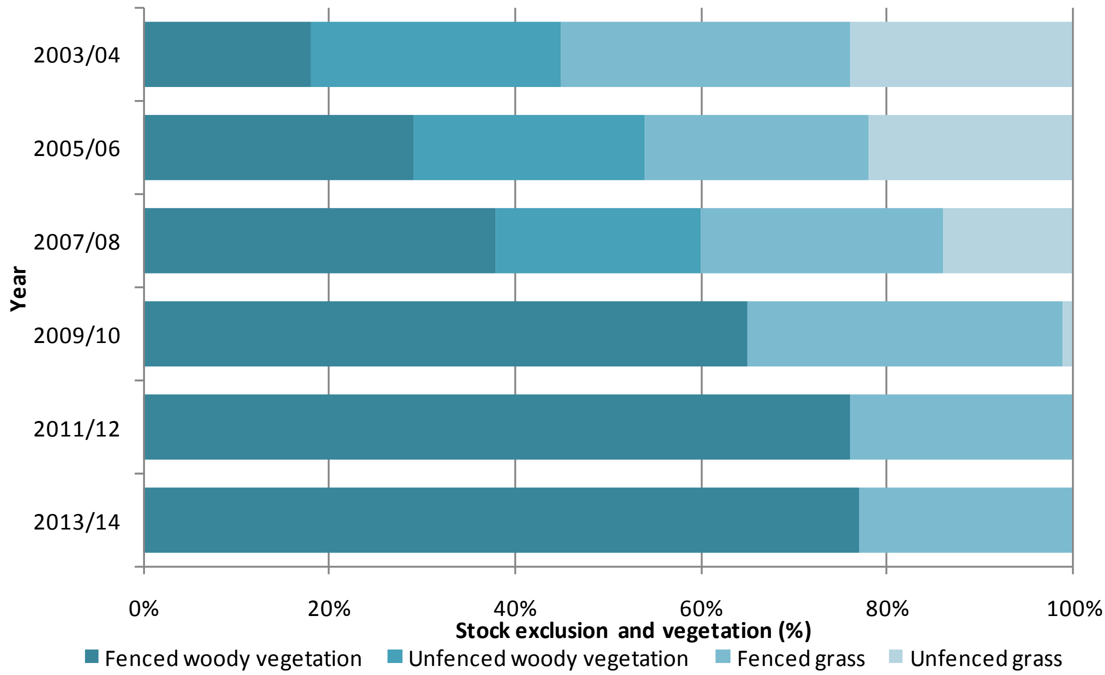

Figure 11: Pokaiwhenua catchment bank length fencing and vegetation combinations (%).

Stream bank stability

Stream bank stability can be improved through planting riparian vegetation and fencing out stock. Unstable stream banks are one of the main sources of sediment in waterways. During the current 2013/14 reporting period an estimated 98% of the assessed riparian bank length was stable, up from the 88% measured in the 2003/04 assessment (Figure 12).

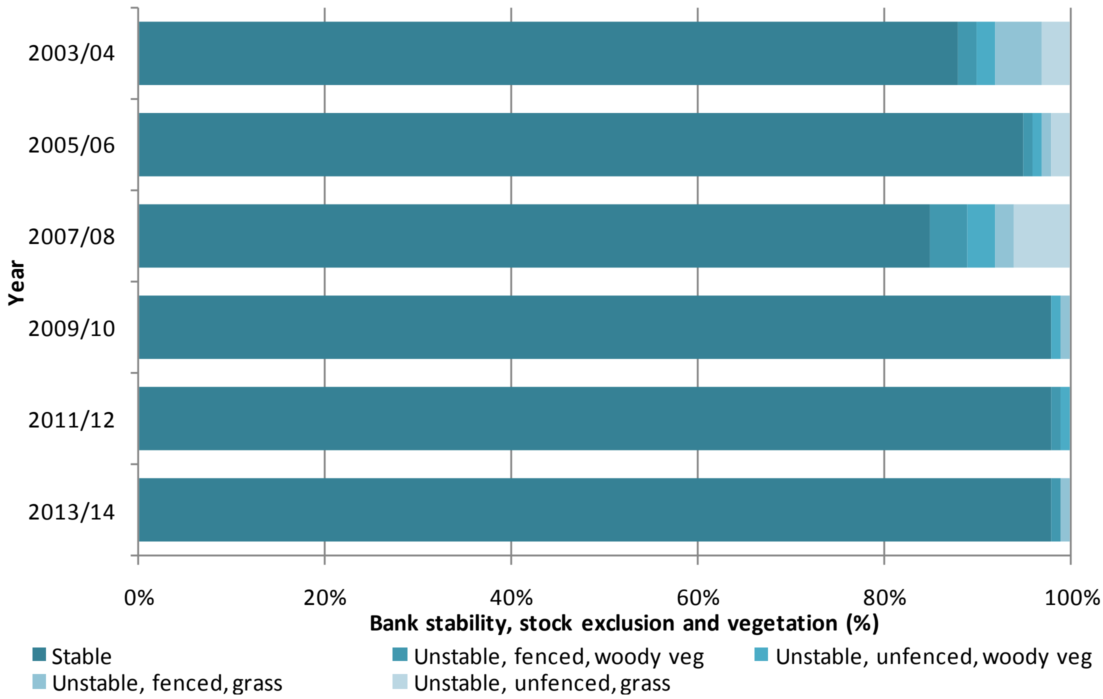

Figure 12: Pokaiwhenua catchment bank stability (%).

3.2.4 Water temperature

Two water temperature loggers were deployed in the middle section of the Pokaiwhenua Stream. The distance between the two loggers is approximately 1 km. To date eleven deployments have been made with data collected for 10 weeks from 1 January for each summer between 2003/2004 and 2013/2014 inclusive. The average of the daily maximum water temperature is derived to produce a single temperature for each site. The upstream temperature is then subtracted from the downstream temperature to provide a temperature difference for the monitored section of the river.

During the 2013/2014 reporting period the daily average upstream and downstream maximums were 17.81 and 17.41 °C respectively. Refer to Table 22 in Appendix 2 for annual upstream and downstream temperatures.

At the commencement of the reporting period in 2003/04 the downstream water temperature was about 0.2 °C lower than the upstream site. Between 2003/04 and 2009/10 the downstream site remained cooler and the temperature difference increased. However, from 2010/11 the temperature difference began reducing with downstream temperature becoming warmer than the upstream temperature in 2012/13. This was not sustained as the downstream temperature was once again cooler than the upstream temperature by 0.4 °C in 2013/14 (Figure 13).

Although sections of the stream have been fenced and planted, little shading occurs between the upstream and downstream monitoring sites. As can be seen in Figure 13 the temperature difference has been rather sporadic.

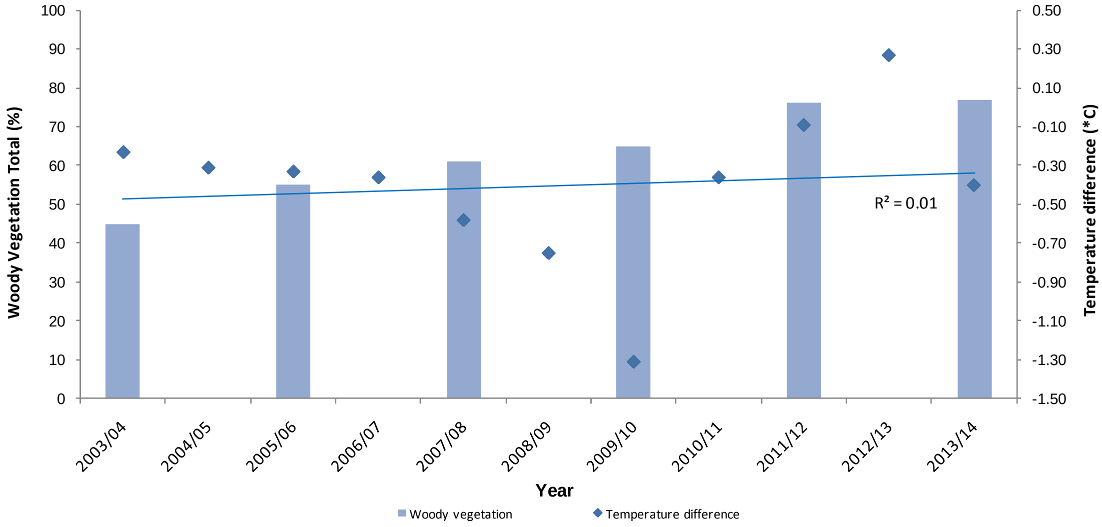

Figure 13: **Woody vegetation total (%) and temperature difference (ºC) in the Pokaiwhenua catchment.**

3.2.5 Photo points

The initial photo point assessment in the Pokaiwhenua catchment was during the summer of 2003/04 with subsequent assessments completed in 2005/06, 2007/08, 2009/10, 2011/12 and 2013/14. Appendix 3 presents a comparison for each photo point for the 2003/04 and 2013/14 assessment years. In 2013/14 Six 1 km stretches of stream bank were assessed at 250 m intervals, giving a total of 30 images for the Pokaiwhenua catchment. Considerable sections of the stream have been fenced (Figure 10), preventing stock access and allowing rank grass to grow (Figure 14, A and B). The percentage of riparian grass cover has also decreased since the project began and this has been replaced by woody vegetation (Figure 9) which is evident at some photo point sites (Figure 14, C and D).

	2003/04	2013/14
Assessment 3 at 500 m		
Assesment 6 at 250 m		

Figure 14: Pokaiwhenua Stream photo point examples of visual change, assessment 3 at 500 m (A and B) and assessment 6 at 250 m.

3.2.6 Stream ecological health

The dominant surrounding land use in the vicinity of both of the sampling sites in the Pokaiwhenua Stream is pastoral and horticultural. The stream ranges between 5 - 11.6 m in width with a substrate consisting of a combination of cobbles and large gravel. The canopy cover is open.

Invertebrate sampling is carried out in the same two locations where the water temperature probes are deployed in the middle section of the Pokaiwhenua Stream; from this invertebrate sampling macroinvertabrate community index (MCI) is calculated. The initial year of assessment was completed in 2003/04 with subsequent assessments completed annually between January and March. There have been occasions when the river has been too high to wade, which have restricted sampling.

In the vicinity of the two sampling sites, the presence and abundance of identified invertebrate species and the associated MCI scores indicate that the stream has had a moderate to mild degradation in ecological health (Wright-Stow & Winterbourn 2003) during the entire reporting period (Figure 15). From this limited time series there appears to be an upward trend in MCI values for the upstream section and a downward trend in the downstream section (Figure 15). The Mokaihaha stream (site number 555.2) has been included, in Figure 15, as a pristine reference site to compare the MCI values from the Pokaiwhenua Stream. However, this site displays a downward trend in MCI and the reason for this is unknown. For more information on the monitored streams see Appendix 4.

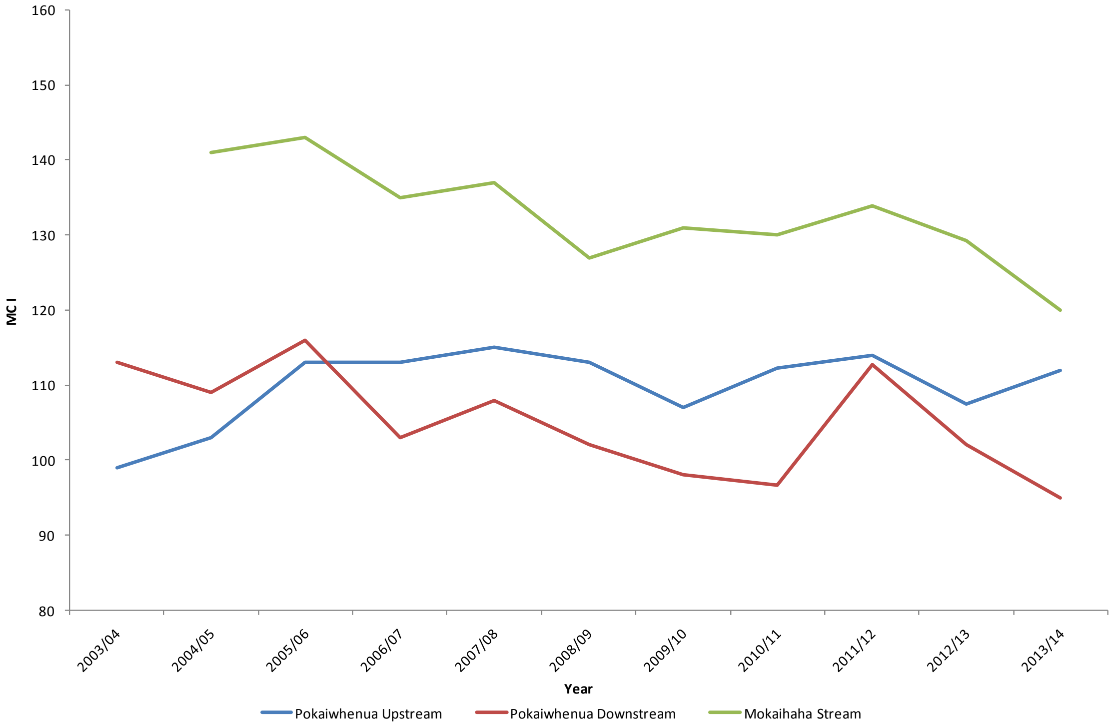

Figure 15: MCI values for the upstream and downstream sites in the Pokaiwhenua Stream and the nearby reference site in the Mokaihaha Stream.

3.2.7 Main points

Soil stability

- No soil stability assessment completed this year.

Riparian characteristics

- Riparian condition of the Pokaiwhenua Stream has improved since the commencement of monitoring.

- The proportion of grass to woody vegetation has declined from 55% to 23% between the 2003/04 and 2013/14 assessments. Woody vegetation covers 77% of the riparian margin, of which 18% is native, and 59% is exotic (including willows).

- There has been an increase in fencing over the total stream bank length from 27% in 2003/04 to 100% in the most recent survey (2013/14).

- The proportion of stream bank that is fenced off with woody vegetation has increased from 18% to 77% of the total stream bank length over the 10 year assessment period. The length of unfenced grass has decreased to 0% of the stream bank length.

- An estimated 98% of the assessed riparian bank length was considered stable, up from 88% in 2003/04. The unstable 2% of bank consists of woody vegetation and grass.

- Photo assessments have shown some changes where fencing has occurred and rank grass or woody vegetation has grown.

Water temperature

- The downstream temperature was typically cooler on average than the upstream temperature. However, trends over time are inconsistent.

- Soil conservation works have occurred along some stretches of bank, but due to the width of the river, the shading effect on the stream temperature may be limited.

Stream ecological health

- Assessments of the invertebrates in Pokaiwhenua Stream indicate that there was a moderate to mild degradation in ecological health. MCI results from the upstream site suggests an upward trend, whereas the downstream site suggest a downward trend.

3.3 Mangare catchment

3.3.1 Monitoring progress

For survey locations in the Mangare catchment, refer to Grant et al., (2009b). Table 6 contains monitoring completed by the end of the 2013/14 financial year.

Table 6: Mangare catchment monitoring completed between 2003/04 and 2013/14.

Monitoring	Planned activity	Completion	Included in this report (or year last reported)
Soil stability	Not planned	N/A	N/A
Riparian characteristic assessment	Complete assessment along the middle section of the Mangare Stream	2003/04, 2005/06, 2007/08, 2009/10, 2011/12, 2013/14	✓
Photo points	Complete assessment along the middle section of the Mangare Stream	2003/04, 2004/05, 2005/06, 2007/08, 2009/10, 2011/12, 2013/14	✓
Permanent suspended sediment sampling site	Not planned	N/A	N/A
Suspended sediment snapshot	Not planned	N/A	N/A
Water temperature	Install loggers and record stream temperatures along the middle section of the Mangare Stream	2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓
Stream ecological health	Assess stream ecological health along the mid section of the Mangare Stream	2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓

N/A = not applicable

3.3.2 Riparian characteristics

Introduction

Two 1 km samples were selected for assessment through the middle section of the Mangare Stream. The assessments on the Mangare Stream are at locations where Waikato Regional Council funded river management and soil conservation works are scheduled, where stream riparian margin access is possible, and where landowner participation is forthcoming. The initial assessment was conducted during summer 2003/04 with the most recent assessment completed in 2013/14.

The reported data for each parameter represents a percentage of the total assessed riparian margin in the catchment. Vegetation, fencing and erosion data summaries are presented in Figures 16, 17, 18 and 19. The riparian data used in each figure is tabulated in Appendix 1.

Vegetation

Riparian vegetation contributes to stream bank stability and the shading of the stream helps to regulate instream temperature. Natural biodiversity along the riparian margin can be increased through the planting of native vegetation. Riparian vegetation is split into grass and woody vegetation (native + willow + exotic other). For the 2013/14 reporting period Figure 16 shows that 41% of the riparian margin was grass. The remaining 59% was woody vegetation, of which 0% was native, 48% was willow and 11% was other exotic species. The length of riparian margin in grass has decreased from 94% to 41% between 2003/04 and 2013/14. Woody willow vegetation has displayed the greatest increase in riparian vegetation cover during the reporting period (Figure 16).

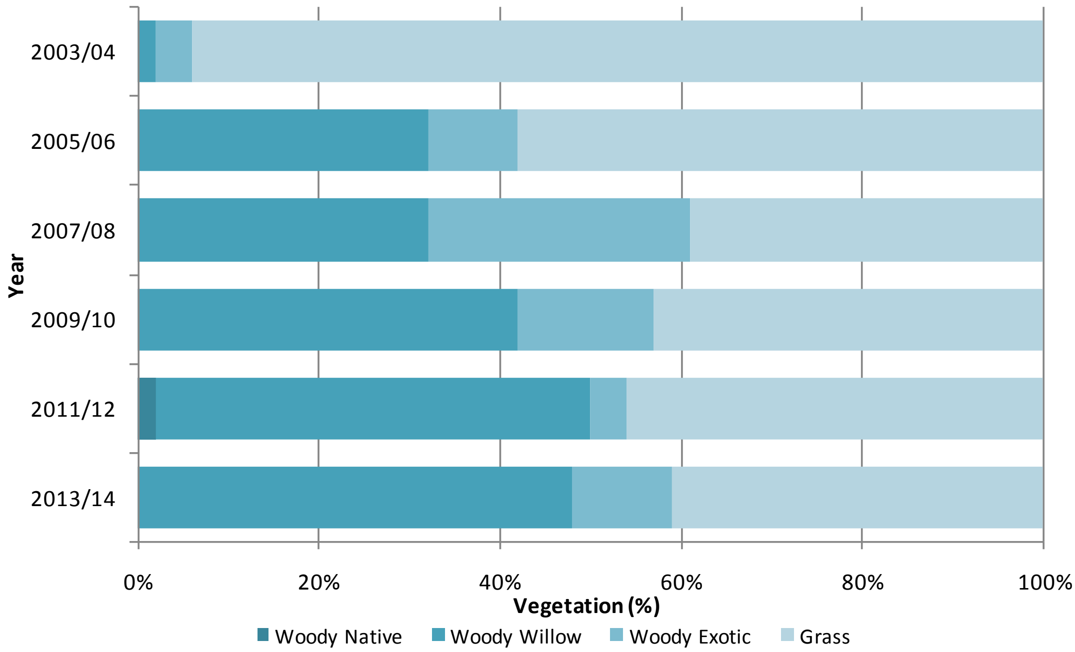

Figure 16: **Mangare catchment vegetation riparian vegetation cover (%).**

Fencing

The amount of fencing on one side or both sides of the waterway is an indicator of likely stock exclusion. Stock exclusion reduces direct contamination of water by pathogens, direct damage to the stream ecology by trampling of the stream bed and indirectly reduces sediment load from stock trampling the banks.

During the current reporting period the Mangare stream was fenced on both sides for 50% of the assessed length and on one side for a further 34%. There was no fencing on either side for 16% of the waterway (Figure 17). There has been an increase in the length of stream fenced on one and both sides since the 2003/04 assessment.

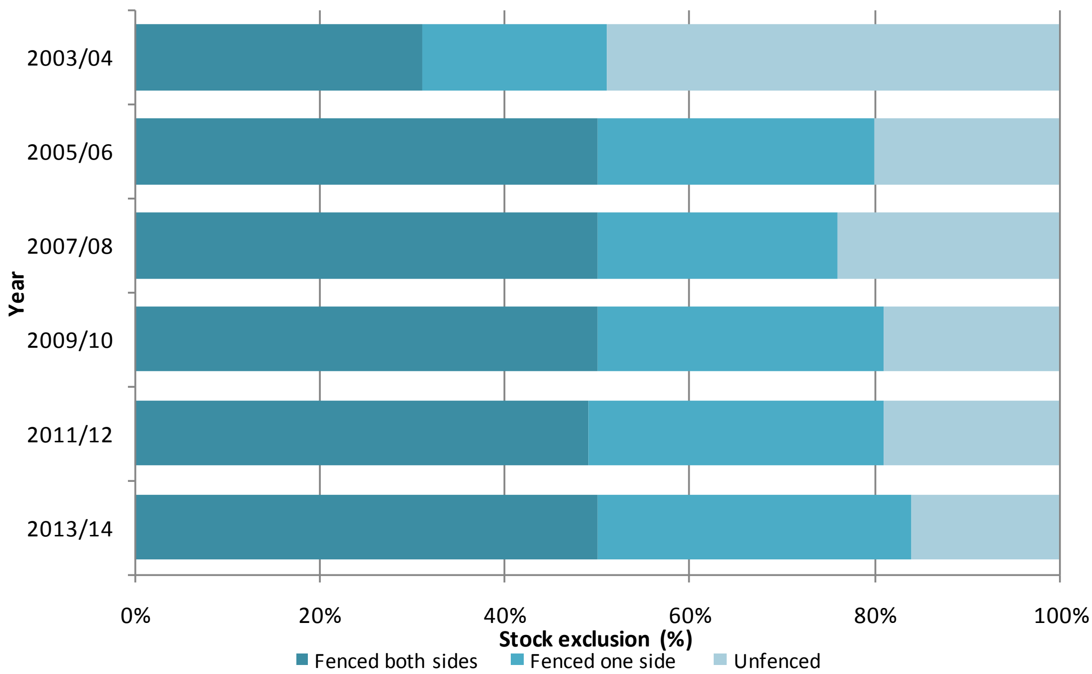

Figure 17: **Mangare catchment stock exclusion by bank length (%).**

There has been an increase in fencing from 41% to 67% over the total stream bank length since the baseline assessment (Figure 18). The majority of the fenced banks (85% of the total fenced bank length) have woody vegetation. The proportion of stream bank that is fenced off and has woody vegetation has increased from 3% to 57% of the total length. During the 2013/14 reporting period of the stream bank that was in grass, 31% and 10% was unfenced and fenced respectively (Figure 18).

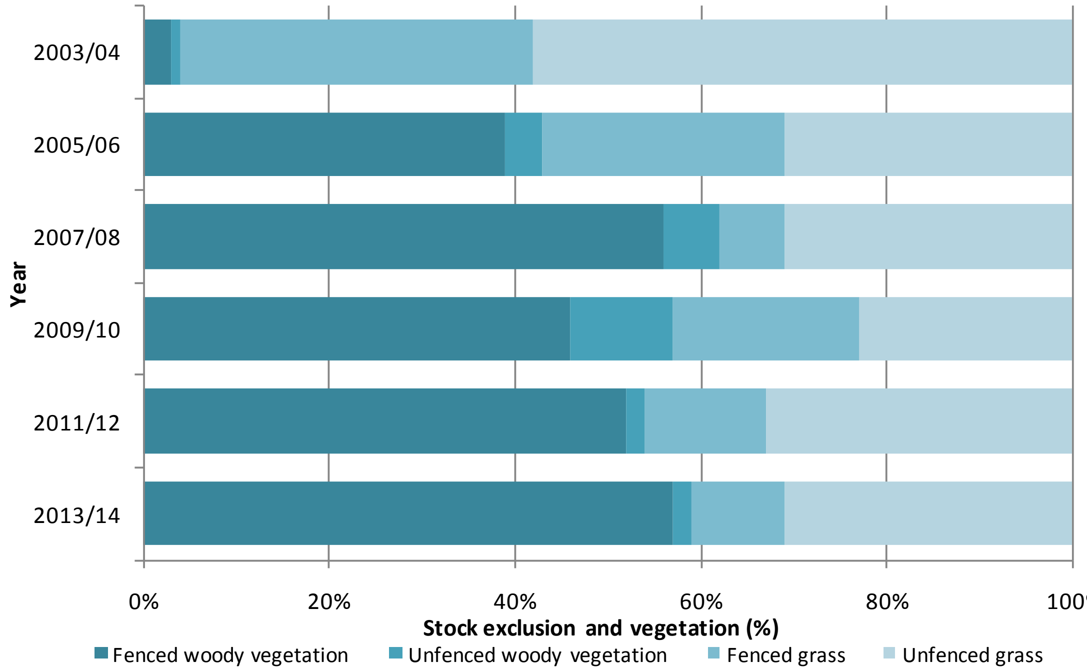

Figure 18: Mangare catchment bank length fencing and vegetation combinations (%).

Stream bank stability

Stream bank stability can be improved through planting riparian vegetation, and fencing out stock. Unstable stream banks are one of the main sources of sediment in waterways. An estimated 88% of the assessed riparian bank length is considered stable (Figure 19), up from the 39% measured in the 2003/04 assessment. The remaining 12% is unstable. Grass is present on 9% of the total unstable bank length.

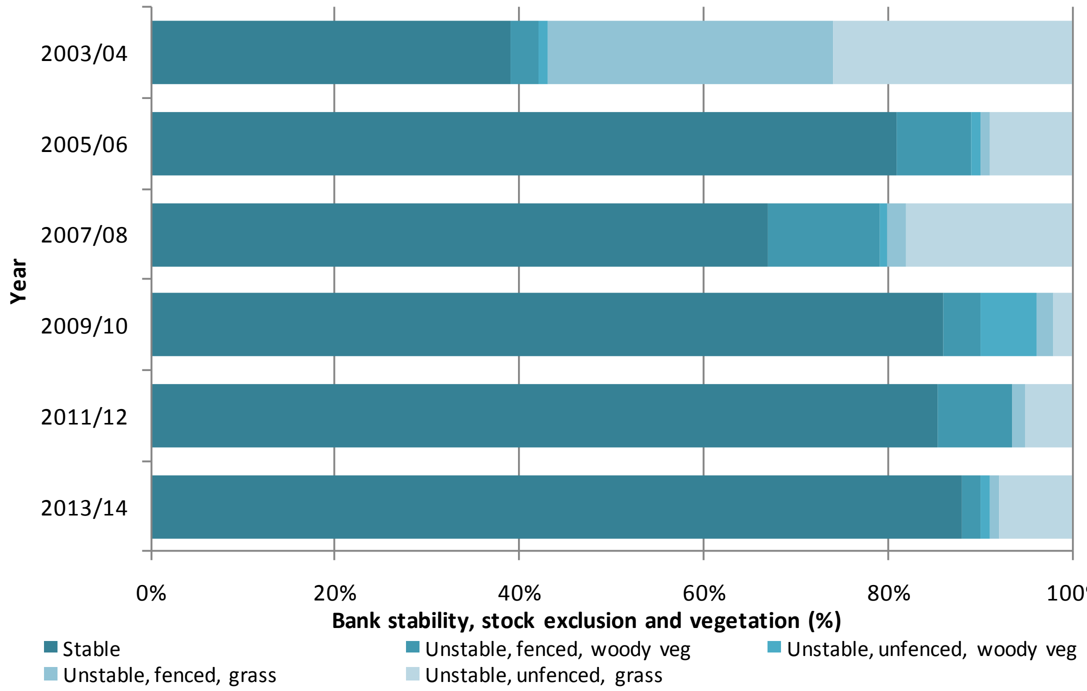

Figure 19: Mangare catchment stream bank stability (%).

3.3.3 Water temperature

Two water temperature loggers were deployed in the middle section of the Mangare Stream, with a distance between the two loggers of approximately 1km. The loggers have collected annual summer data for 10 weeks from 1 January between 2006/07 and 2012/13. Unfortunately, no data was collected during the 2013/14 period due to a technical issue.

The average of the daily maximum water temperature was derived to produce a single temperature for each site. The upstream temperature is then subtracted from the downstream temperature to provide a temperature difference for the monitored section of the river. Refer to Table 23 in Appendix 2 for annual upstream and downstream temperatures.

Figure 20 indicates that downstream temperature has been cooler than the upstream temperature for all years of assessment, because the temperature difference is always negative (Figure 20). In 2011/12 the temperature difference was small (Figure 20), this occurred during an exceptionally cool summer. It is anticipated that the low overall water temperature during 2011/12 resulted in less cooling from vegetative shading. The most recent results in 2012/13 display an alternate situation where the temperature difference has increased and downstream temperature is > 1°C cooler than upstream (Figure 20). The cause of this is unknown, for example the amount of woody vegetation has been stable since the 2007/08 reporting period (Figure 20).

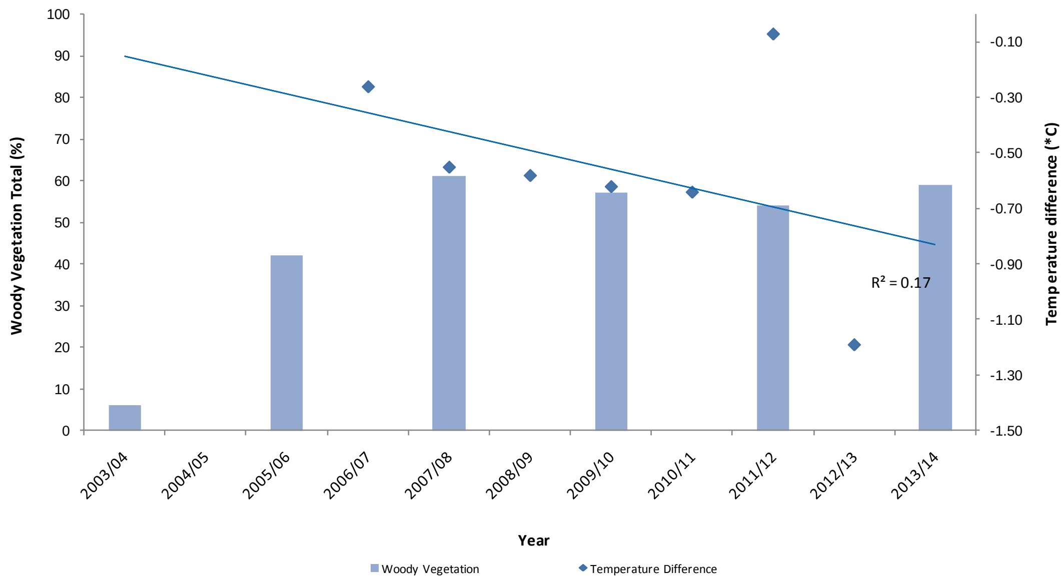

Figure 20: Woody vegetation total (%) and temperature difference (ºC) in the Mangare catchment. Temperature and woody vegetation data only begins from 2003/04 onwards.

3.3.4 Photo points

The initial year of assessment was 2003/04 with subsequent assessments completed in 2004/05, 2005/06, 2007/08, 2009/2010, 2011/12 and 2013/14. Appendix 3 presents a comparison for each photo point for the 2003/04 and 2013/14 assessment years.

Two 1 km stretches of stream bank were assessed at 250 m intervals giving a total of 10 photos for the Mangare Stream. Since the initial reporting period in 2003/04 the proportion of woody vegetation has increased (Figure 16) as has the amount of fencing (Figure 17), this is also evident in photo point samples (Figure 21, A and B). However, during the monitoring period little change in riparian characteristics has occurred along some sections of the stream (Figure 21, C and D). This is supported by Figure 18 which indicates that considerable sections of the Mangare Stream could still be fenced.

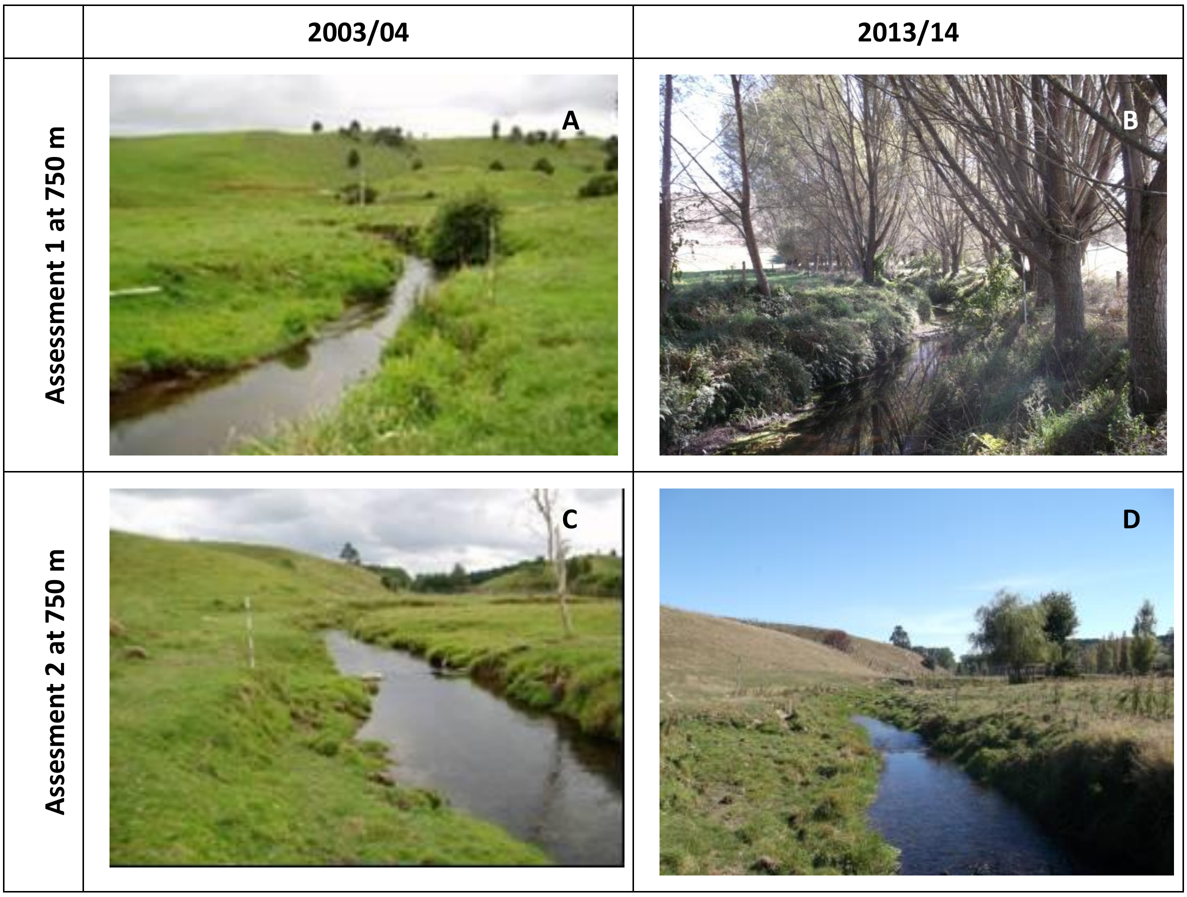

Figure 21: Mangare Stream photo point examples of visual change, assessment 1 at 750 m (A and B) and assessment 2 at 750 m (C and D) in 2003/04 and 2013/14.

3.3.5 Stream ecological health

The dominant surrounding land use in the vicinity of both of the sampling sites in the Mangare Stream is pastoral. The stream ranges between 1.5-5.3 m in width with the substrate predominantly consisting of large gravel. The stream between the upstream and downstream site is now significantly shaded by willows, however further upstream the canopy is still open.

MCI sampling is carried out in the same two locations where the water temperature probes are deployed in the middle section of the Mangare Stream. The initial year of assessment was completed in 2006, with subsequent assessments conducted annually. Figure 22 displays the MCI values as calculated for the upstream and downstream sampling sites in the Mangare Stream. Samples are taken between January and March every year. The upstream site is hard bottom and the downstream site is soft bottom. Refer to Table 33 in Appendix 4 for more detail.

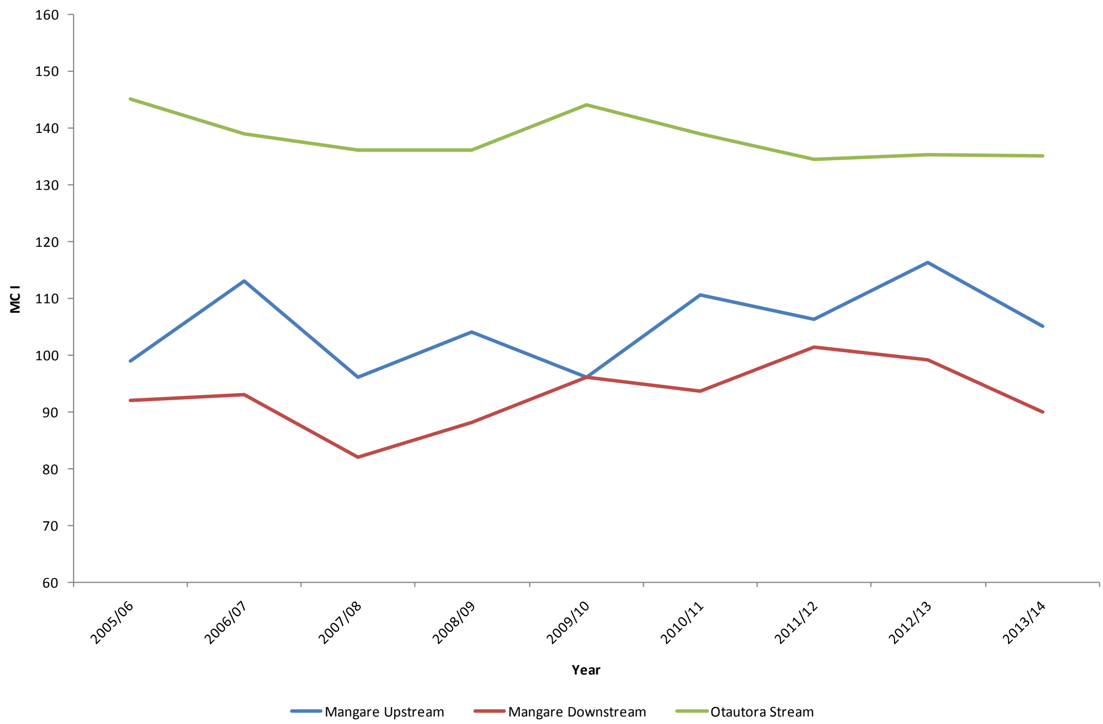

Figure 22: MCI values for the upstream and downstream sites on the Mangare Stream and nearby reference site on the Otautora Stream.

In the vicinity of the two sampling sites in the Mangare Stream, the presence and abundance of identified invertebrate species and associated MCI scores at the upstream site indicate that this stream has a moderate to mild degradation in ecological health (Wright-Stow & Winterbourn 2003). The Otautora Stream (site number 1888.4) has been included, in Figure 22, as a pristine reference site to compare the MCI values from the Mangare Stream.

3.3.6 Main points

Riparian characteristics

- Riparian condition of the Mangare Stream has improved since the commencement of monitoring.
- 59% cent of the riparian margin is woody vegetation.
- There has been an increase in fencing over the total stream bank length from 41% in 2003/04 to 67% in the most recent survey (2013/14).
- Of the entire length of stream bank, 67% was fenced, and 57% had both fencing and woody vegetation.
- An estimated 88% of the assessed riparian bank length was considered stable, up from 39% in 2003/04.

Water temperature

- No data was collected during this assessment period due to an equipment malfunction.
- Typically downstream temperature has been cooler on average than the upstream temperature.

Stream ecological health

- Assessments of the invertebrates in Mangare Stream, indicate that this stream has a moderate to mild degradation in overall ecological health.

3.4 Tahunaatara catchment

3.4.1 Monitoring progress

Monitoring focuses on the middle section of the Pokaitu Stream, a sub-catchment of the Tahunaatara Stream, which feeds into Lake Atiamuri. For survey locations in the Pokaitu catchment, refer to Grant et al. (2009b). Table 7 contains monitoring completed by the end of the 2013/14 financial year.

Table 7: Upper Waikato zone monitoring completed by 2013/14.

Monitoring	Planned activity	Completion	Included in this report (or year last reported)
Soil stability	Not planned	N/A	N/A
Riparian characteristic assessment	Not planned	N/A	N/A
Photo points	5km photo survey along the Pokaitu Stream	2003/04, 2008/09, 2013/14	✓
Permanent suspended sediment sampling site	Not planned	N/A	N/A
Suspended Sediment snapshot	Not planned	N/A	N/A
Water temperature	Install loggers and record stream temperatures along the middle section of the Pokaitu Stream	2003/04, 2004/05, 2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓
Stream ecological health	Assess stream ecological health along the middle section of the Pokaitu Stream	2003/04, 2004/05, 2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓

N/A = not applicable

3.4.2 Water temperature

Water temperature loggers are deployed in the middle section of the Pokaitu Stream, with a distance between them of approximately 5 km. To date, the temperature data for eleven summers, for 10 weeks from 1 January, have been recorded between 2003/2004 and 2013/14 inclusive. The average of the daily maximum water temperatures was derived to produce a single temperature for each site. The upstream temperature was then subtracted from the downstream temperature to provide a temperature difference for the monitored section of the river.

The daily average upstream and downstream maximums were 16.23°C and 16.43°C respectively. Refer to Table 24 in Appendix 2 for annual upstream and downstream temperatures.

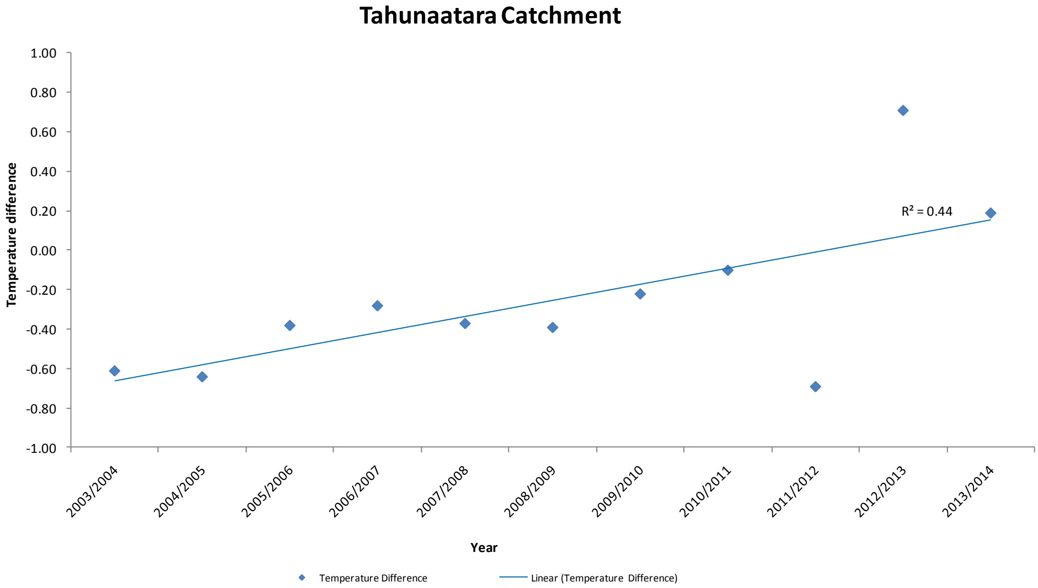

Figure 23: Temperature difference (downstream-upstream temperature) observed in the Tahunaatara catchment (2003-2014).

Figure 23 indicates that initially the downstream temperature was cooler than upstream however this difference was decreasing overtime. The temperature difference then departed from the observed trend for the 2011/12 and 2012/13 assessment years, returning to the observed trend for the 2013/14 assessment period. Although by 2013/14 the upstream temperature was cooler than the downstream temperature. Historically shading of the stream has been sparse and sporadic.

3.4.3 Photo points

Photo surveys have been undertaken along the Pokaitu Stream in 2003/04, 2008/09 and 2013/14. Appendix 3 presents a comparison for each photo point for the 2003/04 and 2013/14 assessment years. Photos are taken along the stream every 250 m for a distance of nearly five kilometres resulting in 20 images. During the initial assessment in 2003/04 about half of the photo points indicated that considerable stretches of the stream were fenced or difficult to access, this observation remained unchanged during the most recent assessment (Figure 24, A and B). Other sections displayed little change between 2003/04 and 2013/14 due to a lack of riparian enhancement during the reporting period (Figure 24, C and D). Those sections that were fenced displayed an improvement in riparian vegetation and shading (Figure 24, E and F). Although not shown, some areas of tree removal were observed during the riparian survey.

Figure 24: **Pokaitu Stream photo point examples of visual change at 750 m (A and B), 3250 m (C and D) and 4250 m (E and F) in 2003/04 and 20013/14.**

3.4.4 Stream ecological health

The dominant surrounding land use in the vicinity of the sampling site is pastoral. The stream is 3 - 6.6 m in width with the substrate predominantly consisting predominantly of large gravel. The canopy cover is open.

MCI sampling is conducted at one location in the Pokaitu Stream under the southern Apirana Road Bridge (where the downstream temperature probe is deployed). The initial year of assessment was in 2003/04, with subsequent assessments completed annually. Figure 25 illustrates the MCI values as calculated for the Pokaitu Stream sampling site. Samples are taken between January and March every year. Refer to Table 32 in Appendix 4 for more detail.

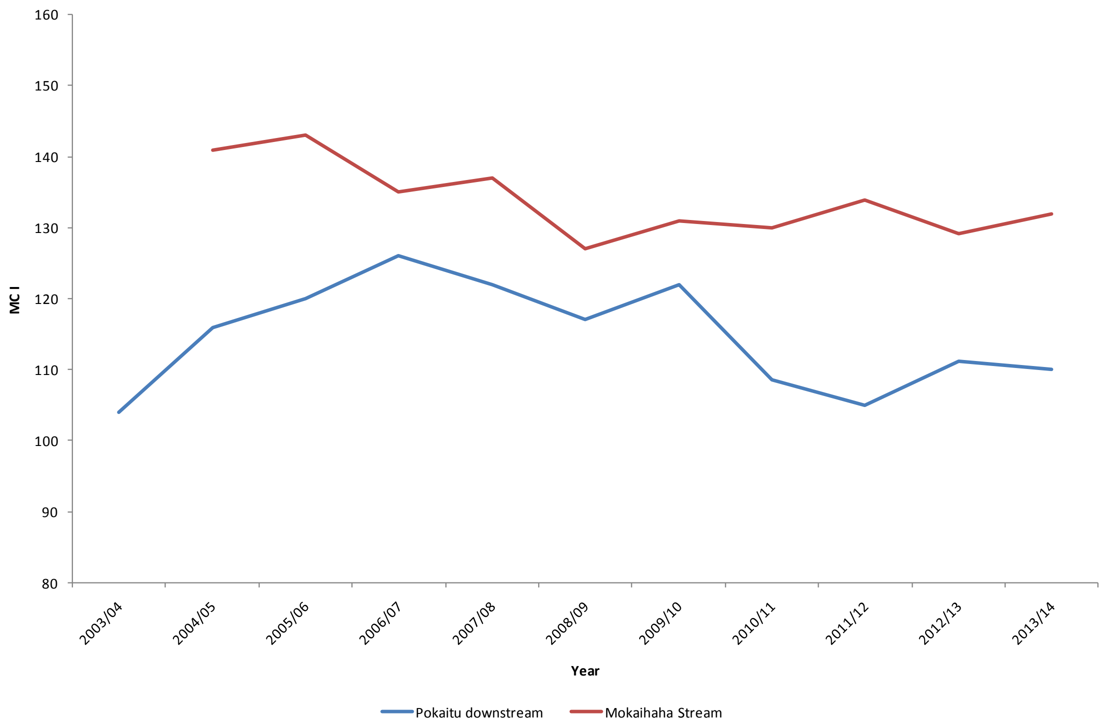

Figure 25: MCI values at the downstream site in the Pokaitu Stream (Tahunaatara catchment) and nearby reference site in the Mokaihaha Stream.

The presence and abundance of identified invertebrate species in the vicinity of the sampling site and associated MCI scores, indicate that the stream has mild degradation of ecological health (Wright-Stow & Winterbourn 2003). The Mokaihaha Stream (site number 555.2) has been included, in Figure 25, as a pristine reference site to compare the MCI values from the Pokaitu Stream. For more information on the monitored streams see Appendix 4.

3.4.5 Main points

Riparian characteristics

- No riparian survey has been undertaken on the Pokaitu stream.
- The photo survey showed that where fencing had occurred some improvement in riparian vegetation was observed and where fencing was absent no improvement was observed.
- Some removal of vegetation occurred during the study period.

Water temperature

- The downstream temperature was cooler on average than the upstream temperature for all assessed summers until 2010/11, this difference was decreasing over time. The temperature difference then departed from the observed trend for the 2011/12 and 2012/13 assessment years, returning to the observed trend for the 2013/14 assessment period.

Stream ecological health

- Assessments of the invertebrates in Pokaitu Stream indicate that the stream has mild degradation of ecological health.

4 Waipa zone

4.1 Introduction

Monitoring is present in one catchment in the Waipa zone; the Mangatutu catchment.

4.2 Mangatutu catchment

4.2.1 Monitoring progress

Monitoring focuses on the Mangatutu Stream catchment where river management and soil conservation initiatives are being implemented. For survey locations in the Mangatutu catchment, refer to Grant et al., (2009b). Table 8 contains monitoring completed by the end of the 2013/14 financial year.

Table 8: Waipa zone monitoring completed by 2013/14

Monitoring	Activity	Completion	Included in this report (or year last reported)
Soil stability	Not planned	N/A	N/A
Riparian characteristic assessment	Complete assessment along the lower section of the Mangatutu sub-catchment	2004/05, 2006/07, 2008/09, 2010/11, 2012/13	2012/13
Photo points	Complete assessment along the lower section of the Mangatutu sub-catchment	2004/05, 2006/07, 2008/09, 2010/11, 2012/13	2012/13
Permanent suspended sediment sampling site	Event driven sampling	Ongoing since June 2004	✓
Suspended sediment snapshots	Low flow snapshot	2004	2005/06
Water temperature	Install loggers and record stream temperatures along the lower section of the Mangatutu River	2003/04, 2004/05, 2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓
Stream ecological health	Assess stream ecological health along the middle and lower section of the Mangatutu River	2004/05, 2005/06, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓

N/A = not applicable

4.2.2 Riparian characteristics

No riparian characteristics data was collected in the 2013/14 monitoring period in the Mangatutu catchment. Refer to Littler & Berry, (2013) for the most recent results.

4.2.3 Water temperature

Three water temperature loggers are deployed along the monitored section of the Mangatutu Stream, due to its length (18km) and differences in character and management between the upper and lower sections of the stream. The downstream logger is under the Walker Road Bridge, the midstream logger is beneath the Lethbridge Road Bridge and the upstream logger is near the Wharepuhunga Road Bridge.

To date eleven deployments have been made with data collected, for 10 weeks from 1 January, for the summers between 2003/04 and 2013/14. The 2003/2004 temperature data collected was only for the period of February to March; therefore the daily maximum average for this summer is not representative and cannot be compared to the other summer's results.

The average of the daily maximum water temperature is derived to produce a single temperature for each site. The upstream temperature is then subtracted from the downstream temperature to provide a temperature difference for the monitored section of the river. The daily average upstream, midstream and downstream maximums were 20.01°C, 20.65°C, and 19.90°C respectively. Refer to Table 25 in Appendix 2 for more detail.

Figures 26, 27 and 28 show that shading of the Mangatutu Stream remains sporadic between the monitoring sites. There have been some trees planted in the catchment within the last couple of years; therefore the level of shading is expected to increase over the long term as the trees mature. For the entire reporting period the midstream sampling section has been warmer than the upstream section (Figure 26). However, with the exception of 2010/11 period the downstream section has always been cooler than the midstream section (Figure 27). Generally, in the monitored region of the stream there is a warming effect in the upper section compared with a cooling effect in the lower section. For the total monitored length (upstream versus downstream), stream temperature is typically lower upstream than downstream (Figure 28). Only the data from the 2007/08, 2012/13 and 2013/14 summers have shown the downstream temperature to be cooler than the upstream temperature.

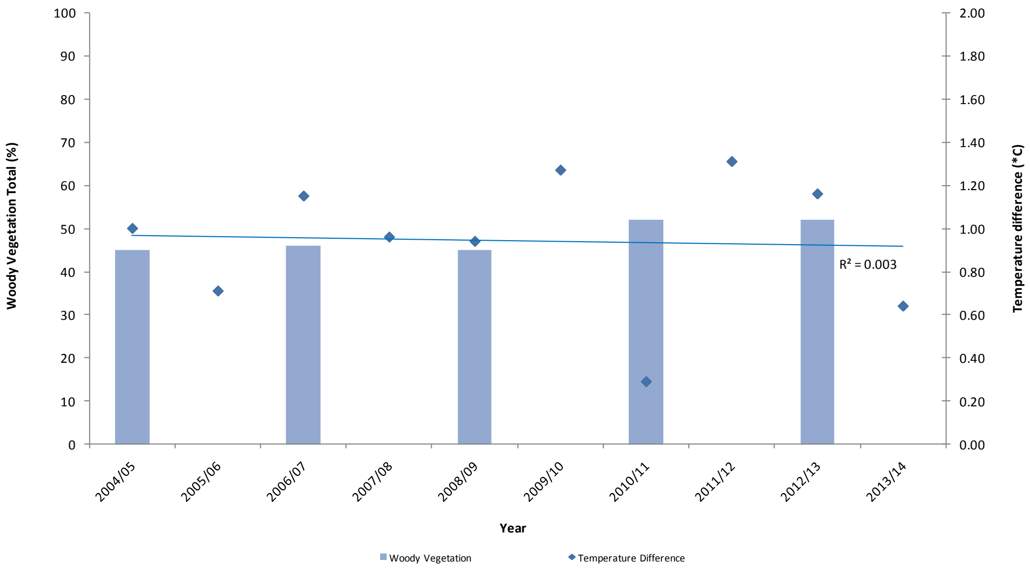

Figure 26: Woody vegetation total (%) and temperature difference (ºC) in the Mangatutu catchment midstream minus upstream temperature. Temperature and woody vegetation data only begins from 2004/05 onwards.

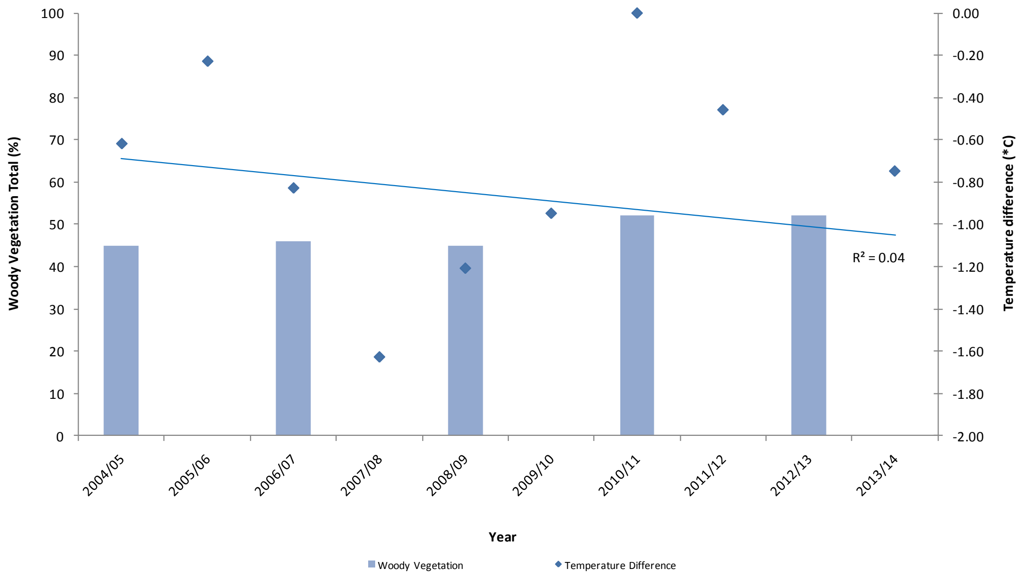

Figure 27: **Woody vegetation total (%) and temperature difference (ºC) in the Mangatutu catchment downstream minus midstream temperature. Temperature and woody vegetation data only begins from 2004/05 onwards.**

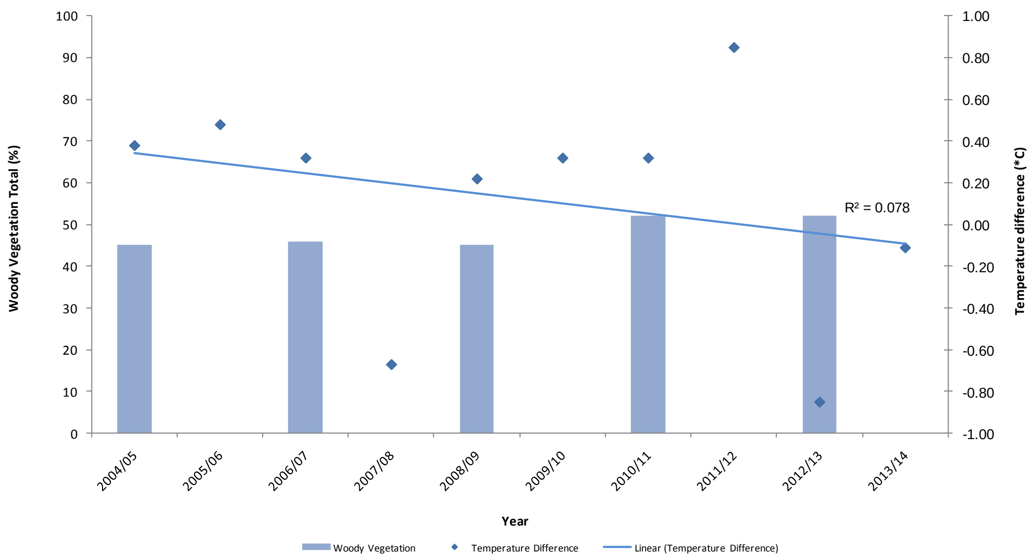

Figure 28: **Woody vegetation total (%) and temperature difference (ºC) in the Mangatutu catchment downstream minus upstream temperature. Temperature and woody vegetation data only begins from 2004/05 onwards.**

4.2.4 Photo points

No photos were collected in the 2013/14 monitoring period in the Mangatutu catchment. Refer to Littler & Berry (2013) for the most recent results and comparisons.

4.2.5 Suspended sediment

A permanent suspended sediment sampling site has been in place at Walker Road Bridge on the Mangatutu Stream since June 2004. During this time 54 events have been sampled using an automatic sediment sampler. The data set is analysed to estimate sediment variables. Data includes all results up until 31/12/2013 (Table 9). A continuing focus, with all automated sediment sampling, is to carry out manual depth-integrated suspended sediment gaugings while the automatic sampler is activated. The collection of these concurrent samples will allow for the automatic series to be calibrated to the whole river cross-section. For more detailed information refer to Kotze et al., (2008) and Hoyle et al., (2012).

Table 9: Mangatutu Stream permanent suspended sediment sampling site description and estimated sediment variables for data collected from June 2004 until December 2013.

Site name:	**Walker Road**	**Map Ref (NZMS260):**	**S15:203-423**
River:	**Mangatutu**		
		Start – End Date	**No of samples**
Flow Time Series		08/06/2004 – 31/12/2013	N/A
Sediment Samples		22/06/2004 – 10/12/2013	1110
ISCO Period of Record		22/06/2004 – 10/12/2013	54 events
Specific yield ($t/km^2/yr$)	Average sediment yield (kt/yr)	% of sediment yield in gauged range of flow	% Error in Yield Estimate
45	5.6	98.6	3

The Mangatutu Stream has an estimated specific yield of 45 $t/km^2/yr$ and an average sediment yield of 5.6 kt/yr (Table 9). The specific yield for the Mangatutu Stream can be considered moderate relative to many sites in the region. The dominant geology (comprising welded ignimbrite and overlying tephras) is the likely reason for this moderate specific sediment yield value (Figure 29).

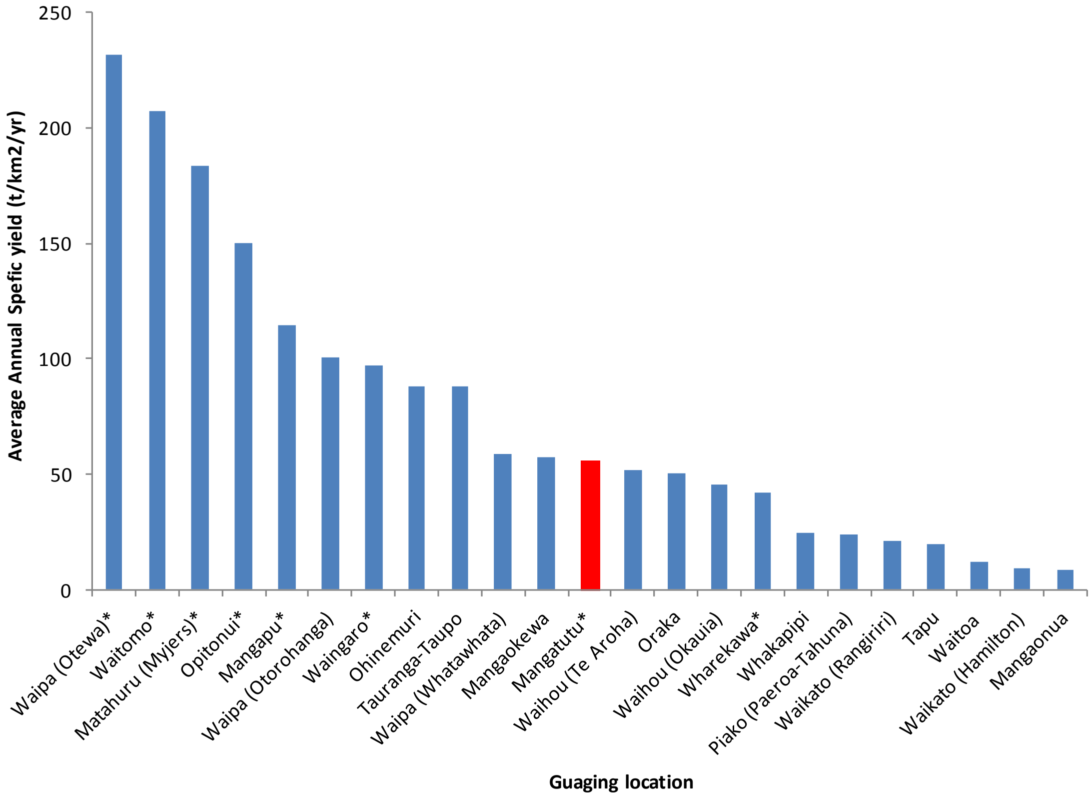

Figure 29: Average specific suspended sediment yield ($t/km^2/yr$) for monitored rivers in the Waikato Region, Mangatutu River is highlighted in red.

5.1.1 Stream ecological health

The dominant surrounding land use in the vicinity of the sampling site is pastoral. The stream is between 4 and 11.2 m wide with a substrate predominantly consisting of large to small gravel. The canopy cover is partly shaded although the removal of nuisance riparian willow will, in the short term, reduce canopy cover.

MCI sampling is conducted in the Mangatutu Stream immediately upstream of the Walker Road Bridge, near the downstream temperature logger. The initial year of assessment using these methods was in 2004/05 with subsequent assessments completed annually.

Figure 30 displays the MCI values as calculated for the Mangatutu Stream sampling site. Samples are taken between January and March every year. Refer to Table 31 in Appendix 4 for more detail.

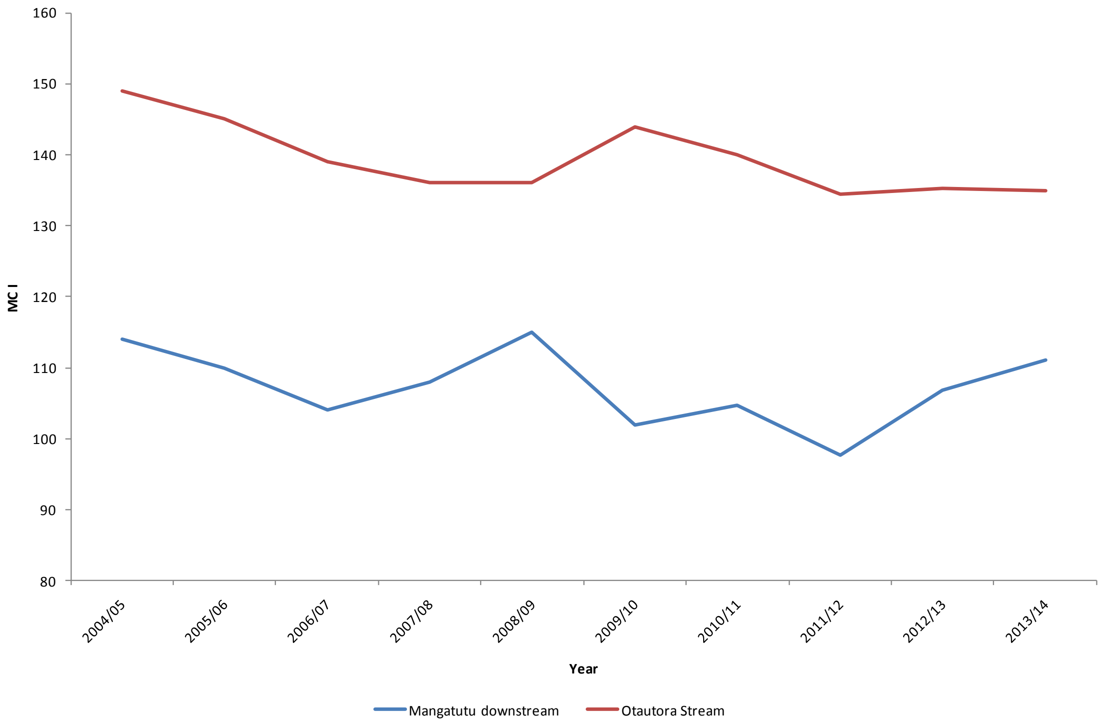

Figure 30: MCI values for the sampling site in the Mangatutu Stream and nearby reference site in the Otautora Stream.

The presence and abundance of identified invertebrate species in the vicinity of the sampling site in the Mangatutu Stream and associated MCI scores indicate that the ecological health of the stream is considered to be mildly degraded. (Wright-Stow & Winterbourn, 2003). The Otautora Stream (site number 1888.4) has been included, in Figure 30, as a pristine reference site to compare the MCI values from the Mangatutu Stream. For more information on the monitored streams see Appendix 4.

5.1.2 Main points

Riparian characteristics

- No riparian characteristics data was collected in the 2013/14 monitoring period in the Mangatutu catchment.

Suspended sediment monitoring

- The specific yield for the Mangatutu catchment above Walker Road Bridge is 45 t/km^2/yr.

- A low flow snapshot was taken in 2004, with results described in Hill et al., (2006).

Water temperature

- Water temperature has been monitored annually since 2004/05. With the exception of the 2007/08, 2012/13 and 2013/14 monitoring periods, the downstream site has recorded warmer temperatures than the upstream site. This is likely to improve as soil conservation plantings grow and shade the water. A longer monitoring period is required before a trend can be identified.

Stream ecological health

- Assessments of the invertebrates in Mangatutu Stream indicate that there is a mild degradation in ecological health.

5.1.3 Other monitoring

Automatic sediment samplers are installed on the Upper Waipa River (at Otewa) and the Waitomo Stream to monitor suspended sediment in the Waipa zone. The Mangapu Stream has had an automatic sampler in the past. For more detailed information refer to Kotze et al., (2008) and Hoyle et al., (2012). *Mangatutu Stream Ecological Monitoring Results – 2004 to 2007* has been completed by Gibbs (2008) as a Waikato Regional Council Internal Series report, and can be accessed internally on DOC #1212429 or by contacting Waikato Regional Council. Gibbs (2008) describes the changes in ecological health in the Mangatutu Stream resulting from the soil conservation work which has occurred since 2004.

6 Coromandel zone

6.1 Introduction

Monitoring is present in one catchment in the Coromandel zone; Wharekawa catchment.

6.2 Wharekawa catchment

6.2.1 Monitoring progress

Monitoring will focus on the Wharekawa River catchment where river management and soil conservation initiatives are being implemented. For survey locations in the Wharekawa catchment, refer to Grant et al. (2009b). Table 10 contains monitoring completed by the end of the 2013/14 financial year.

Table 10: Coromandel zone monitoring completed by 2013/14

Monitoring	Activity	Completion	Included in this report (or year last reported)
Soil stability	Not planned	N/A	N/A
Riparian characteristic assessment	Complete assessment along the monitored section of Wharekawa River	2006/07, 2008/09, 2010/11, 2012/13	2012/13
Photo points	Complete assessment along the monitored section of the Wharekawa River	2006/07, 2008/09, 2010/11, 2012/13	2012/13
Permanent suspended sediment sampling site	Event driven sampling, concluded in 2003. Site reinstalled	April 2000 until Feb 2003. Reinstalled Dec 2009	✓
Suspended sediment snapshots	Not planned	N/A	N/A
Water temperature	Install loggers and record stream temperatures along the Wharekawa River	2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓
Stream ecological health	Assess stream ecological health along the Wharekawa River	2004/05, 2006/07, 2007/08, 2008/09, 2009/10, 2010/11, 2011/12, 2012/13, 2013/14	✓

N/A = not applicable.

6.2.2 Riparian characteristics

No riparian characteristics data was collected during the 2013/14 monitoring period in the Wharekawa catchment. Refer to Littler & Berry, (2013) for the most recent results.

6.2.3 Water temperature

Three water temperature loggers are deployed in the lower section of the Wharekawa River. The downstream logger is near the SH25 Bridge, and the upstream logger is approximately 3.5km further upstream, near where the river emerges from the forest. The midstream logger is approximately 1km downstream of the upstream logger. Seven deployments have been made with data collected for 10 weeks from 1 January for all summers from 2006/07, until 2013/14 inclusive.

Over the summers of 2009/10 and 2011/12 the logger deployed at the upstream site was swept away, therefore there is no data during this period. The temperatures recorded at the Waikato Regional Council hydrology site (midstream logger) downstream from the upstream site have been used to compensate for this missing data. The average of the daily maximum water temperatures is derived to produce a single temperature for each site. The upstream temperature is then subtracted from the downstream temperature to provide a temperature difference for the monitored section of the river. The 2013/14 daily average upstream, midstream and downstream maximums were 21.30ºC, 22.30ºC and 21.07ºC respectively. Refer to Table 26 in Appendix 2 for more detail.

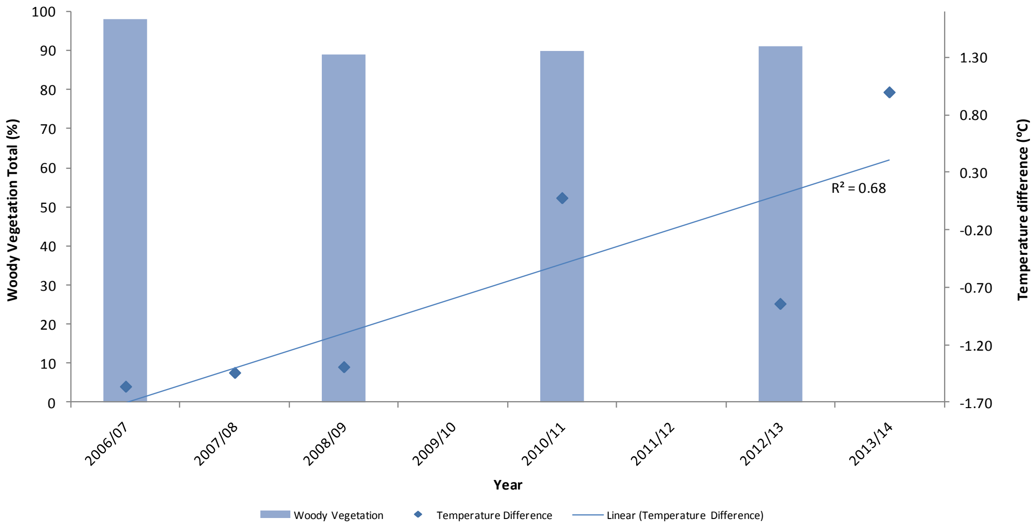

Figure 31: Woody vegetation total (%) and temperature difference (ºC) in the Wharekawa catchment midstream minus upstream temperature. Temperature and woody vegetation data only begins from 2006/2007 onwards.

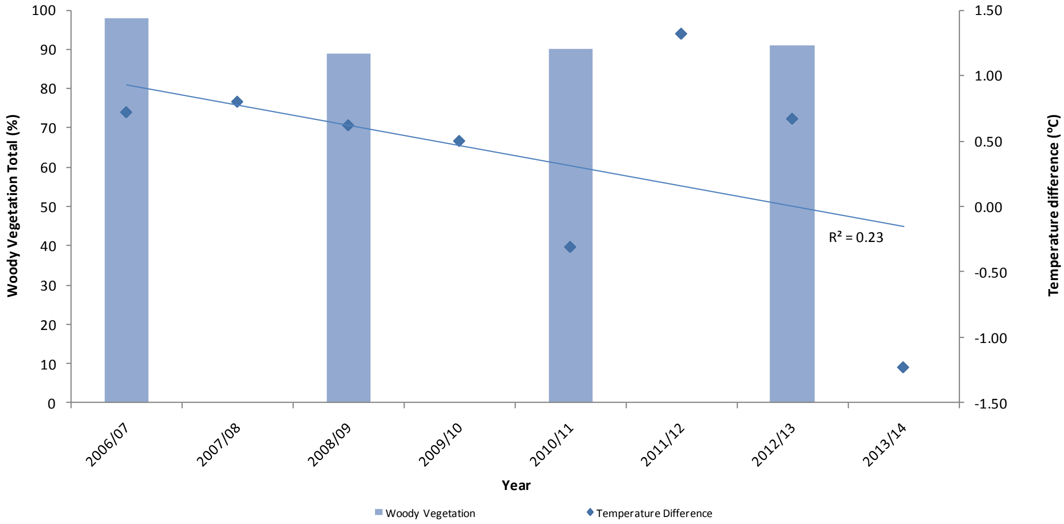

Figure 32: **Woody vegetation total (%) and temperature difference (ºC) in the Wharekawa catchment downstream minus midstream temperature. Temperature and woody vegetation data only begins from 2006/2007 onwards.**

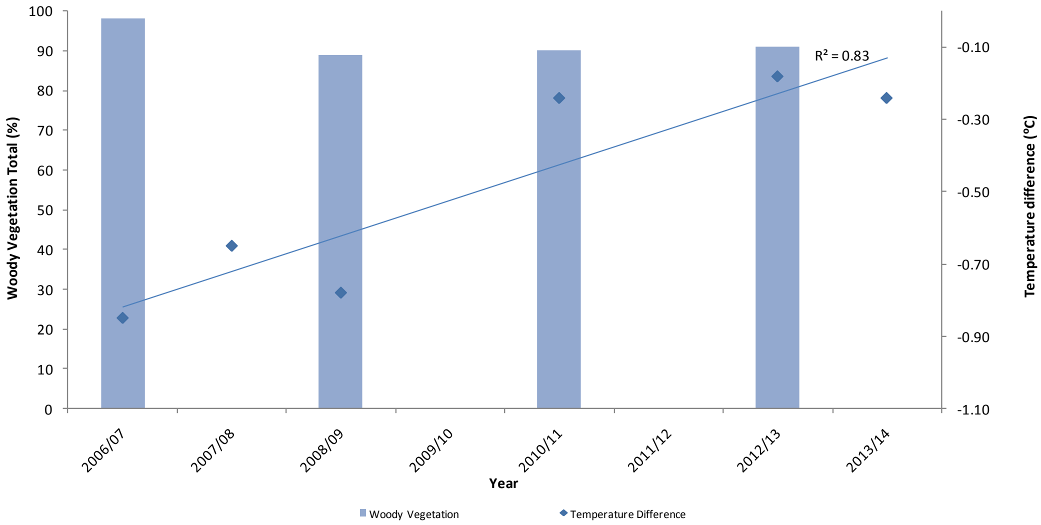

Figure 33: **Woody vegetation total (%) and temperature difference (ºC) in the Wharekawa catchment Downstream minus upstream temperature. Temperature and woody vegetation data only begins from 2006/2007 onwards.**

Figures 31 to 33 show the relationship between the temperature difference and the woody vegetation cover over the entire measurement period between the upstream to midstream, midstream to downstream and upstream to downstream temperature loggers. During the entire assessment period midstream is cooler than the upstream and downstream sites. However, the exception is the 2010/11 and 2013/14 assessment periods where the midstream site is warmer than upstream site and the downstream site is cooler than the midstream site (Figures 31 and 32). Figure 33 indicates that overall the water temperature for all assessment years is lower downstream than upstream. However, this difference is less during 2013/14 than it was during 2006/07.

6.2.4 Photo points

No photos were collected in the 2013/14 monitoring period in the Wharekawa catchment. Refer to Littler & Berry, (2013) for the most recent results and comparisons.

6.2.5 Suspended sediment

A permanent sediment sampling site has been in place at Adams Farm Bridge on the Wharekawa River since June 1991. During this time 33 events have been sampled using an automatic sediment sampler, which was on site between April 2000 and February 2003, and was redeployed in December 2009. The data set is analysed to estimate sediment variables. Data includes all results up until 31/12/2013 (Table 11). A continuing focus, with all automated sediment sampling, is to carry out manual depth-integrated suspended sediment gaugings while the automatic sampler is activated. The collection of these concurrent samples will allow for the automatic series to be calibrated to the whole river cross-section. For more detailed information refer to Kotze et al., (2008).

Table 11: Wharekawa River permanent suspended sediment sampling site description and estimated sediment variables for data collected from June 1991 until December 2013.

Site name:	**Adams Farm Bridge**	**Map Ref (NZMS260):**	**T12:623-468**
River:	**Wharekawa**		
		Start – End Date	**No of samples**
Flow Time Series		10/06/1991 – 31/12/2013	N/A
Sediment Samples		25/09/1991 – 06/12/2013	718
ISCO Period of Record		20/04/2000 – 06/12/2013	33 events
Specific yield ($t/km^2/yr$)	Average sediment yield (kt/yr)	% of sediment yield in gauged range of flow	% Error in Yield Estimate
57	2.69	87.3	4.7

The Wharekawa River has an estimated specific yield of 57 $t/km^2/yr$ and an average sediment yield of 2.69 kt/yr. The specific yield for the Wharekawa can be considered low relative to many sites in the region (Figure 34). The influencing factors are likely to be the dominance of woody vegetation cover and geology.

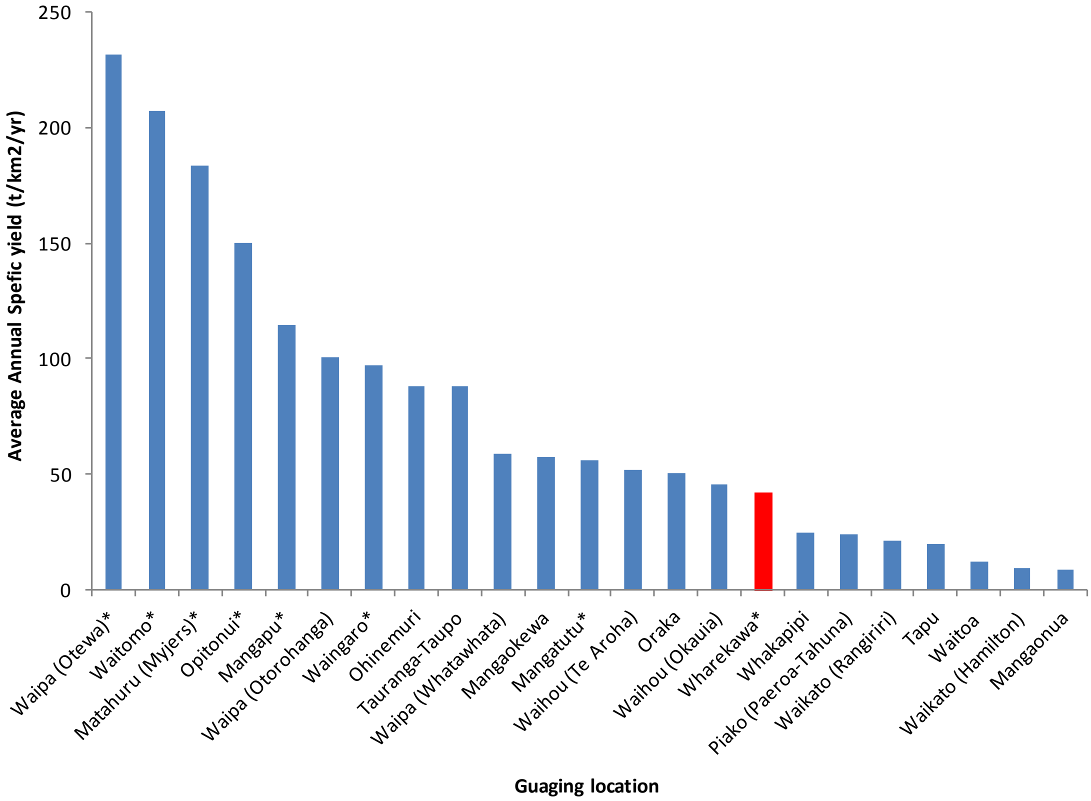

Figure 34: **Average specific suspended sediment yield (t/km^2/yr) for monitored rivers in the Waikato Region, the Wharekawa River is highlighted in red.**

7.1.1 Stream ecological health

The dominant surrounding land use in the vicinity of the sampling site is pastoral but the riparian zone is generally planted. The canopy cover is partly shaded. The stream is up to 14 m wide with the substrate predominantly consisting of large gravel and cobbles.

MCI sampling is conducted in the Wharekawa River in the vicinity of the Adam's Farm Bridge, midway between the upstream and downstream temperature loggers. The initial year of assessment using these methods was in 2004/05 with sampling undertaken annually since then, except for 2005/06 when no samples were taken. Figure 35 illustrates the MCI values as calculated for the Wharekawa River sampling site. Samples are taken between January and March every year. Refer to Table 34 in Appendix 4 for more detail.

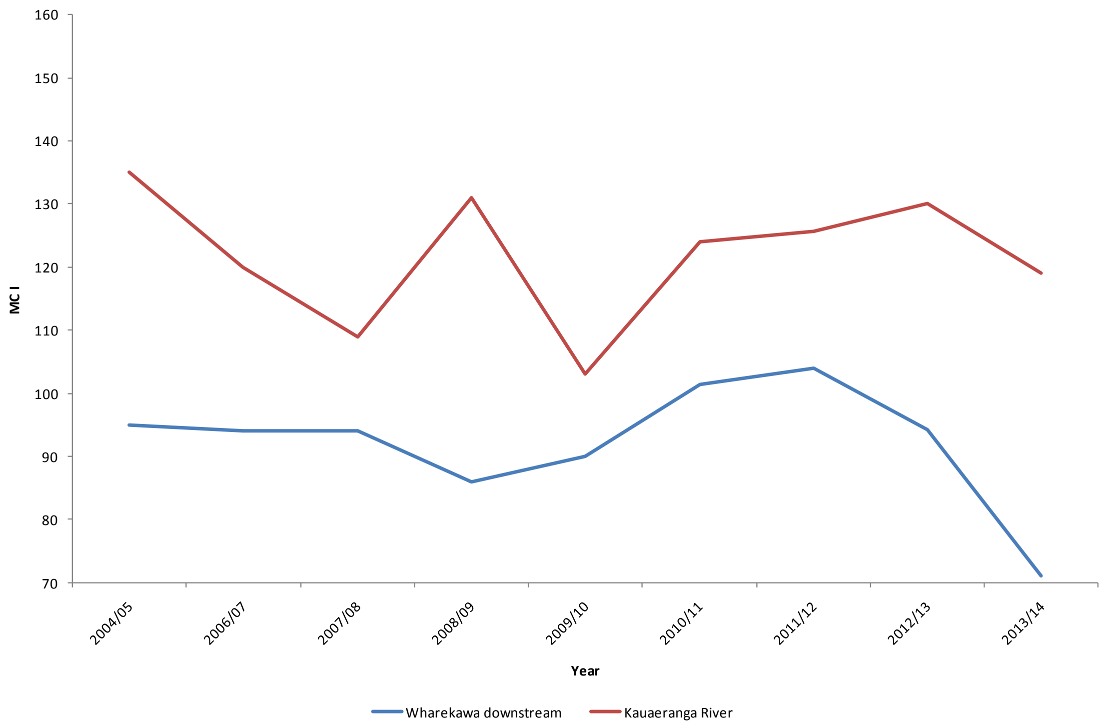

Figure 35: **MCI values for the sampling site in the Wharekawa River and nearby reference site in the Kauaeranga River.**

In the vicinity of the sampling site the presence and abundance of identified invertebrate species and the associated MCI scores indicate that there is a severe degradation in ecological health (Wright-Stow & Winterbourn 2003). The reason for the decline in the MCI score in 2013/14 is possibly due to three species of invertebrate being absent from samples. This absence is unusual and the reason for this occurrence is unknown. Continued monitoring would be required to see if this absence re-occurs in subsequent years. The Kauaeranga River (site number 234.28) has been included, in Figure 35, as a pristine reference site to compare the MCI values from the Wharekawa River.

7.1.2 Main points

Riparian characteristics

- No riparian characteristics data was collection in the 2013/14 monitoring period in the Wharekawa catchment.

Suspended sediment

- The specific yield for the Wharekawa catchment is estimated to be 57 t/km^2/yr, based on samples taken both manually and from an automatic sediment sampler since 1991.

- Continued manual and automatic sediment sampling will add to the existing dataset.

Temperature

- There are no upstream data for 2009/10 and 2011/12. In other years the downstream temperature has been cooler on average than the upstream logger.

Stream ecological health

- Assessments of the invertebrates in Wharekawa River indicate that there is a severe degradation in ecological health. This MCI score was lower than previous years and possibly due to the absence of three invertebrate species. The reason for this absence is unknown.

7.1.3 Other monitoring

An automatic sediment sampler is installed on the Opitonui River to monitor suspended sediment. For more detailed information refer to Kotze et al., (2008) and Hoyle et al., (2012).

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Appendix 1: Riparian characteristics summary

Matahuru catchment – Lower Waikato zone 2013/14

For each table the number in brackets is the percent change from the 2003/04 assessment, which was the first year the assessment was done.

Table 12: Matahuru erosion

Riparian **erosion** characteristics – Matahuru (% of total bank length)									
Erosion	stable 89(+42)	unstable 11(-42)							
Fencing	nd	fenced 10(-5)				unfenced 1(-37)			
Vegetation		grass 2(-4)	willow woody veg. 1(nc)	other exotic woody veg. 1(-2)	native woody veg. 6(+1)	grass 1(-29)	willow woody veg. 0(-1)	other exotic woody veg. 0(-2)	native woody veg. 0(-5)

nd = not detailed, nc = no change

Table 13: Matahuru vegetation

Riparian **vegetation** characteristics –Matahuru (% of total bank length)			
Grass 21(-31)	Woody vegetation 79(+31)		
	Exotic 33(+24)		Native 46(+7)
	Willow 12(+8)	Non-willow 21(+16)	

Table 14: Matahuru fencing

Riparian **fencing** characteristics - Matahuru								
Fencing: % of stream length	**no fence on both sides** 0(-30)				**fenced on one side** 2(-22)		**fenced on both sides** 98(+52)	
Fencing: % of total bank length	**not fenced** 1(-41)				**fenced** 99(+41)			
Breakdown by vegetation	grass 1(-31)	willow woody veg. 0(-2)	other exotic woody veg. 0(-2)	native woody veg 0(-6)	grass 21(+3)	willow woody veg. 11(+8)	other exotic woody veg. 21(+18)	native woody veg. 46(+12)

Pokaiwhenua catchment – Upper Waikato zone 2013/14

For each table the number in brackets is the percent change from the 2003/04 assessment, which was the first year the assessment was done.

Table 15: Pokaiwhenua erosion

<table>
<tr><td colspan="10">Riparian erosion characteristics – Pokaiwhenua (% of total bank length)</td></tr>
<tr><td>Erosion</td><td>stable
98(+10)</td><td colspan="8">unstable
2(-10)</td></tr>
<tr><td>Fencing</td><td rowspan="2">nd</td><td colspan="4">fenced
2(-5)</td><td colspan="4">unfenced
0(-5)</td></tr>
<tr><td>Vegetation</td><td>grass
1(-4)</td><td>willow woody veg.
0(nc)</td><td>other exotic woody veg.
0(nc)</td><td>native woody veg.
1(-1)</td><td>grass
0(-3)</td><td>willow woody veg.
0(nc)</td><td>other exotic woody veg.
0(-2)</td><td>native woody veg.
0(nc)</td></tr>
</table>

nd = not detailed, nc = no change

Table 16: Pokaiwhenua vegetation

<table>
<tr><td colspan="4">Riparian vegetation characteristics – Pokaiwhenua (% of total bank length)</td></tr>
<tr><td rowspan="3">Grass
23(-32)</td><td colspan="3">Woody vegetation
77(+32)</td></tr>
<tr><td colspan="2">Exotic
59(+43)</td><td rowspan="2">Native
18(-11)</td></tr>
<tr><td>Willow
14(+8)</td><td>Non-willow
45(+35)</td></tr>
</table>

Table 17: Pokaiwhenua fencing

<table>
<tr><td colspan="9">Riparian fencing characteristics - Pokaiwhenua</td></tr>
<tr><td>Fencing: % of stream length</td><td colspan="4">no fence on both sides
0(-29)</td><td colspan="2">fenced on one side
0(-44)</td><td colspan="2">fenced on both sides
100(+73)</td></tr>
<tr><td>Fencing: % of total bank length</td><td colspan="4">not fenced
0(-51)</td><td colspan="4">fenced
100(+51)</td></tr>
<tr><td>Breakdown by vegetation</td><td>grass
0(-24)</td><td>willow woody veg.
0(-3)</td><td>other exotic woody veg.
0(-8)</td><td>native woody veg
0(-16)</td><td>grass
23(-8)</td><td>willow woody veg.
14(+10)</td><td>other exotic woody veg.
45(+43)</td><td>native woody veg.
18(+6)</td></tr>
</table>

Mangare catchment – Upper Waikato Zone 2013/14

For each table the number in brackets is the percent change from the 2003/04 assessment, which was the first year the assessment was done.

Table 18: Mangare erosion

<table>
<tr><td colspan="10">Riparian **erosion** characteristics – Mangare (% of total bank length)</td></tr>
<tr><td>Erosion</td><td>stable
88(+49)</td><td colspan="8">unstable
12(-49)</td></tr>
<tr><td>Fencing</td><td rowspan="2">nd</td><td colspan="4">fenced
3(-31)</td><td colspan="4">unfenced
9(-18)</td></tr>
<tr><td>Vegetation</td><td>grass
1(-30)</td><td>willow woody veg.
2(+1)</td><td>other exotic woody veg.
0(-2)</td><td>native woody veg.
0(nc)</td><td>grass
8(-18)</td><td>willow woody veg.
0(-1)</td><td>other exotic woody veg.
0(+1)</td><td>native woody veg.
0(nc)</td></tr>
</table>

nd = not detailed, nc = no change

Table 19: Mangare vegetation

<table>
<tr><td colspan="4">Riparian **vegetation** characteristics – Mangare (% of total bank length)</td></tr>
<tr><td rowspan="3">Grass
41(-53)</td><td colspan="3">Woody vegetation
59(+53)</td></tr>
<tr><td colspan="2">Exotic
59(+53)</td><td rowspan="2">Native
0(nc)</td></tr>
<tr><td>Willow
48(+46)</td><td>Non-willow
11(+7)</td></tr>
</table>

nc = no change

Table 20: Mangare fencing

<table>
<tr><td colspan="9">Riparian **fencing** characteristics – Mangare</td></tr>
<tr><td>Fencing: % of stream length</td><td colspan="4">**no fence on both sides**
16(-33)</td><td colspan="2">**fenced on one side**
34(+14)</td><td colspan="2">**fenced on both sides**
50(+19)</td></tr>
<tr><td>Fencing: % of total bank length</td><td colspan="4">**not fenced**
33(-26)</td><td colspan="4">**fenced**
67(+26)</td></tr>
<tr><td>Breakdown by vegetation</td><td>grass
31(-27)</td><td>willow woody veg.
1(+nc)</td><td>other exotic woody veg.
1(+1)</td><td>native woody veg
0(nc)</td><td>grass
10(-28)</td><td>willow woody veg.
47(+46)</td><td>other exotic woody veg.
10(+8)</td><td>native woody veg.
0(nc)</td></tr>
</table>

nc = no change

Appendix 2: Temperature results

The downstream temperature is then subtracted from the upstream temperature to provide a single number for the monitored section of each river within a catchment (Table 1 to 6).

Matahuru catchment – Lower Waikato zone 2003-2014

Table 21: Matahuru Stream average daily maximum water temperatures for the 10 week period commencing 1st January

Year	Upstream average daily maximum (°C)	Downstream average daily maximum (°C)	Temperature difference between d/s and u/s locations (°C)
2003/04	21.86	20.84	-1.02
2004/05	22.78	21.87	-0.90
2005/06	22.20	21.22	-0.98
2006/07	22.61	21.62	-0.99
2007/08	23.34*	22.41	-0.93*
2008/09	22.34	21.76	-0.59
2009/10	22.62	21.96	-0.66
2010/11	22.93	22.25	-0.68
2011/12	20.77	20.28	-0.49
2012/13	22.19	21.58	-0.61
2013/14	20.73	21.31	0.58
*The upstream logger was out of the water during January 2008, so the daily maximum average temperature is unlikely to be representative.			

Pokaiwhenua catchment – Upper Waikato zone 2003-2014

Table 22: Pokaiwhenua Stream average daily maximum water temperatures for the 10 week period commencing 1st January

Year	Upstream average daily maximum (°C)	Downstream average daily maximum (°C)	Temperature difference between d/s and u/s locations (°C)
2003/04	18.44	18.21	-0.23
2004/05	18.78	18.47	-0.31
2005/06	18.32	17.98	-0.33
2006/07	18.51	18.15	-0.36
2007/08	19.21	18.63	-0.58
2008/09	19.07	18.32*	-0.75*
2009/10	18.75	17.45	-1.31
2010/11	18.69	18.33	-0.35
2011/12	17.11	17.01	-0.09
2012/13	17.71	17.97	0.27
2013/14	17.81	17.41	-0.40
*The downstream logger was out of the water during March 2009, so the daily maximum average temperature is unlikely to be representative.			

Mangare catchment – Upper Waikato zone 2006-2014

Table 23: Mangare Stream average daily maximum water temperatures for the 10 week period commencing 1st January

Year	Upstream average daily maximum (°C)	Downstream average daily maximum (°C)	Temperature difference between d/s and u/s locations (°C)
2006/07	21.53	21.27	-0.26
2007/08	22.82	22.28	-0.55
2008/09	21.85	21.27	-0.58
2009/10	21.45	20.82	-0.62
2010/11	21.64	21.00	-0.64
2011/12	18.54	18.47	-0.07
2012/13	21.07	19.88	-1.19
2013/14	19.99	*	*
*Due to technical issues there is no temperature data for Mangare downstream in 2013/14			

Tahunaatara catchment – Upper Waikato zone 2003-2014

Table 24: Pokaitu Stream average daily maximum water temperatures for the 10 week period commencing 1st January

Year	Upstream average daily maximum (°C)	Downstream average daily maximum (°C)	Temperature difference between d/s and u/s locations (°C)
2003/04	17.52	16.91	-0.61
2004/05	17.87	17.23	-0.64
2005/06	17.01	16.63	-0.38
2006/07	17.13	16.85	-0.28
2007/08	17.53	17.18	-0.35
2008/09	17.39	17.00	-0.39
2009/10	17.06	16.84	-0.22
2010/11	17.47	17.37	-0.10
2011/12	15.97	15.28	-0.69
2012/13	16.17	16.87	0.71
2013/14	16.23	16.43	0.19

Mangatutu catchment – Waipa zone 2004-2014

Table 25: Mangatutu Stream average daily maximum water temperatures for the 10 week period commencing 1st January.

Year	Upstream average daily max (°C)	Temp diff btwn m/s and u/s locations (°C)	Midstream average daily max (°C)	Temp diff btwn d/s and m/s locations (°C)	Downstream average daily maximum (°C)	Temp diff btwn d/s and u/s locations (°C)
2004/05	19.85	1.00	20.85	-0.62	20.22	+0.38
2005/06	19.41	0.71	20.12	-0.23	19.89	+0.48
2006/07	20.01	1.15	21.15	-0.83	20.33	+0.32
2007/08	21.74	0.96	22.70	-1.63	21.07	-0.67
2008/09	20.07	2.13	22.20*	-1.91	20.29	+0.22
2009/10	20.12	1.27	21.39	-0.95	20.44	+0.32
2010/11	19.43	0.29	19.73	0.02	19.75	+0.32
2011/12	17.24	+1.31	18.55	-0.46	18.09	+0.85
2012/13	20.51	+1.16	21.67	-2.01	19.66	-0.85
2013/14	20.01	0.64	20.65	-0.75	19.90	-0.11

*The midstream logger was out of the water during most of February and March 2009, so the daily maximum average temperature is unlikely to be representative.

Wharekawa catchment – Coromandel zone 2006-2014

Table 26: Wharekawa River average daily maximum water temperatures for the 10 week period commencing 1st January.

Year	Upstream average daily max (°C)	Temp diff btwn m/s and u/s locations (°C)	Midstream average daily max (°C)	Temp diff btwn d/s and m/s locations (°C)	Downstream average daily maximum (°C)	Temp diff btwn d/s and u/s locations (°C)
2006/07	22.06	-1.57	20.48	0.72	21.21	-0.85
2007/08	22.51	-1.45	21.06	0.80	21.86	-0.65
2008/09	22.62	-1.40	21.22	0.62	21.84	-0.78
2009/10	*	*	21.06	0.50	21.56	*
2010/11	21.65	+0.07	21.72	-0.31	21.41	-0.24
2011/12	*	*	19.75	1.32	21.07	*
2012/13	22.46	-0.85	21.61	0.67	22.27	-0.18
2013/14	21.30	0.99	22.30	-1.23	21.07	-0.24

*The upstream logger was lost for the period of 2009/10 and 2011/12 due to substantial flood events.

Appendix 3: Photo points

Matahuru Stream

2003/04	2013/14
	
Mhu01_03/04_0000m	Mhu01_13/14_0000m
	
Mhu01_03/04_0250m	Mhu01_13/14_0250m
	
Mhu01_03/04_0500m	Mhu01_13/14_0500m
	
Mhu01_03/04_0750m	Mhu01_13/14_0750m
	
Mhu01_03/04_1000m	Mhu01_13/14_1000m

	
Mhu02_03/04_0000m	Mhu02_13/14_0000m
	
Mhu02_03/04_0250m	Mhu02_13/14_0250m
	
Mhu02_03/04_0500m	Mhu02_13/14_0500m
	
Mhu02_03/04_0750m	Mhu02_13/14_0750m
	
Mhu02_03/04_1000m	Mhu02_11/12_1000m⁺

	
Mhu03_03/04_0000m	Mhu03_13/14_0000m
	
Mhu03_03/04_0250m	Mhu03_13/14_0250m
	
Mhu03_03/04_0500m	Mhu03_13/14_0500m
	
Mhu03_03/04_0750m	Mhu03_13/14_0750m
	
Mhu03_03/04_1000m	Mhu03_13/14_1000m

	
Mhu04_03/04_0000m	Mhu04_13/14_0000m
	
Mhu04_03/04_0250m	Mhu04_13/14_0250m
	
Mhu04_03/04_0500m	Mhu04_13/14_0500m
	
Mhu04_03/04_0750m	Mhu04_13/14_0750m
	
Mhu04_03/04_1000m	Mhu04_13/14_1000m

	
Mhu05_03/04_0000m	Mhu05_13/14_0000m
	
Mhu05_03/04_0250m	Mhu05_13/14_0250m
	
Mhu05_03/04_0500m	Mhu05_13/14_0500m
	
Mhu05_03/04_0750m	Mhu05_13/14_0750m
	
Mhu05_03/04_1000m	Mhu05_13/14_1000m

	
Mhu06_03/04_0000m	Mhu06_13/14_0000m
	
Mhu06_03/04_0250m	Mhu06_11/12_0250m+
	
Mhu06_03/04_0500m	Mhu06_13/14_0500m
	
Mhu06_03/04_0750m	Mhu06_13/14_0750m
	
Mhu06_03/04_1000m	Mhu06_11/12_1000m+


Mhu07_03/04_0000m


Mhu07_13/14_0000m


Mhu07_03/04_0250m


Mhu07_13/14_0250m


Mhu07_03/04_0500m


Mhu07_13/14_0500m


Mhu07_03/04_0750m


Mhu07_13/14_0750m


Mhu07_03/04_1000m


Mhu07_13/14_1000m

	
Mhu08_03/04_0000m	Mhu08_13/14_0000m
	
Mhu08_03/04_0250m	Mhu08_13/14_0250m
	
Mhu08_03/04_0500m	Mhu08_13/14_0500m
	
Mhu08_03/04_0750m	Mhu08_13/14_0750m
	
Mhu08_03/04_1000m	Mhu08_13/14_1000m

	
Mhu09_03/04_0000m	Mhu09_13/14_0000m
	
Mhu09_03/04_0250m	Mhu09_13/14_0250m
	
Mhu09_03/04_0500m	Mhu09_13/14_0500m
	
Mhu09_03/04_0750m	Mhu09_13/14_0750m
	
Mhu09_03/04_1000m	Mhu09_13/14_1000m

	
Mhu10_03/04_0000m	Mhu10_13/14_0000m
	
Mhu10_03/04_0250m	Mhu10_13/14_0250m
	
Mhu10_03/04_0500m	Mhu10_13/14_0500m
	
Mhu10_03/04_0750m	Mhu10_13/14_0750m
	
Mhu10_03/04_1000m	Mhu10_13/14_1000m

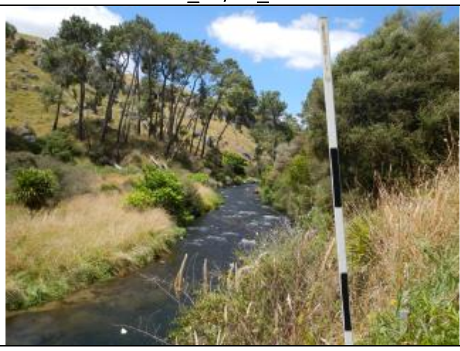
	
Mhu11_03/04_0000m	Mhu11_13/14_0000m
	
Mhu11_03/04_0250m	Mhu11_13/14_0250m
	
Mhu11_03/04_0500m	Mhu11_13/14_0500m
	
Mhu11_03/04_0750m	Mhu11_13/14_0750m
	
Mhu11_03/04_1000m	Mhu11_13/14_1000m

Pokaiwhenua Stream

2003/04	2013/14
	
Pok01_03/04_0000m	Pok01_13/14_0000m
	
Pok01_03/04_0250m	Pok01_13/14_0250m
	
Pok01_03/04_0500m	Pok01_13/14_0500m
	
Pok01_03/04_0750m	Pok01_13/14_0750m
	
Pok01_03/04_1000m	Pok01_13/14_1000m

	
Pok02_03/04_0000m	Pok02_13/14_0000m
	
Pok02_03/04_0250m	Pok02_13/14_0250m
	
Pok02_03/04_0500m	Pok02_13/14_0500m
	
Pok02_03/04_0750m	Pok02_13/14_0750m
	
Pok02_03/04_1000m	Pok02_13/14_1000m

	
Pok03_03/04_0000m	Pok03_13/14_0000m
	
Pok03_03/04_0250m	Pok03_13/14_0250m
	
Pok03_03/04_0500m	Pok03_13/14_0500m
	
Pok03_03/04_0750m	Pok03_13/14_0750m
	
Pok03_03/04_1000m	Pok03_11/12_1000m^{+}

	
Pok04_03/04_0000m	Pok04_13/14_0000m
	
Pok04_03/04_0250m	Pok04_13/14_0250m
	
Pok04_03/04_0500m	Pok04_13/14_0500m
	
Pok04_03/04_0900m	Pok04_07/08_0900m
	
Pok04_03/04_1000m	Pok04_13/14_1000m

	
Pok05_03/04_0000m	Pok05_13/14_0000m
	
Pok05_03/04_0250m	Pok05_13/14_0250m
	
Pok05_03/04_0500m	Pok05_13/14_0500m
	
Pok05_03/04_0750m	Pok05_13/14_0750m
	
Pok05_03/04_1000m	Pok05_13/14_1000m


Pok06_03/04_0000m


Pok06_13/14_0000m


Pok06_03/04_0250m


Pok06_13/14_0250m


Pok06_03/04_0500m


Pok06_13/14_0500m


Pok06_03/04_0750m


Pok06_13/14_0750m


Pok06_03/04_1000m


Pok06_13/14_1000m

Mangare Stream

2003/04	2013/14
	
Mge01_04_0000m	Mge01_13_0000m
	
Mge01_04_0250m	Mge01_13_0250m
	
Mge01_04_0500m	Mge01_13_0500m
	
Mge01_04_0750m	Mge01_13_0750m
	
Mge01_04_1000m	Mge01_13_1000m

Mge02_04_0000m

Mge02_13_0000m

Mge02_04_0250m

Mge02_13_0250m

Mge02_04_0500m

Mge02_13_0500m

Mge02_04_0750m

Mge02_13_0750m

Mge02_04_1000m

Mge02_13_1000m

Mangatutu Stream

2004/05	2012/13
	
Mtu01_04/05_0000m	Mtu01_12/13_0000m
	
Mtu01_04/05_0250m	Mtu01_12/13_0250m
	
Mtu01_04/05_0500m	Mtu01_12/13_0500m
	
Mtu01_04/05_0750m	Mtu01_12/13_0750m
	
Mtu01_04/05_1000m	Mtu01_12/13_1000m

	
Mtu02_04/05_0000m	Mtu02_12/13_0000m
	
Mtu02_04/05_0250m	Mtu02_12/13_0250m
	
Mtu02_04/05_0500m	Mtu02_12/13_0500m
	
Mtu02_04/05_0750m	Mtu02_12/13_0750m
	
Mtu02_04/05_1000m	Mtu02_12/13_1000m


Mtu03_04/05_0000m


Mtu03_12/13_0000m


Mtu03_04/05_0250m


Mtu03_12/13_0250m


Mtu03_04/05_0500m


Mtu03_12/13_0500m


Mtu03_04/05_0750m


Mtu03_12/13_0750m


Mtu03_04/05_1000m


Mtu03_12/13_1000m

	
Mtu04_04/05_0000m	Mtu04_12/13_0000m
	
Mtu04_04/05_0250m	Mtu04_12/13_0250m
	
Mtu04_04/05_0500m	Mtu04_12/13_0500m
	
Mtu04_04/05_0750m	Mtu04_12/13_0750m
	
Mtu04_04/05_1000m	Mtu04_12/13_1000m

	
Mtu05_04/05_0000m	Mtu05_12/13_0000m
	
Mtu05_04/05_0250m	Mtu05_12/13_0250m
	
Mtu05_04/05_0500m	Mtu05_12/13_0500m
	
Mtu05_04/05_0750m	Mtu05_12/13_0750m
	
Mtu05_04/05_1000m	Mtu05_12/13_1000m

	
Mtu06_04/05_0000m	Mtu06_12/13_0000m
	
Mtu06_04/05_0250m	Mtu06_12/13_0250m
	
Mtu06_04/05_0500m	Mtu06_12/13_0500m
	
Mtu06_04/05_0750m	Mtu06_12/13_0750m
	
Mtu06_04/05_1000m	Mtu06_12/13_1000m

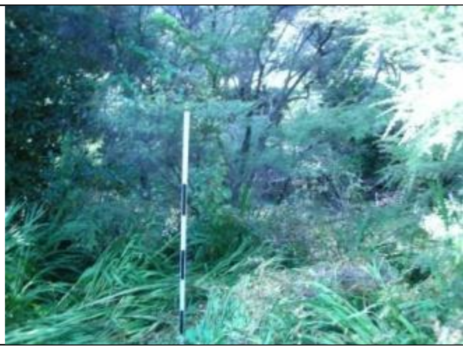
	
Mtu07_04/05_0000m	Mtu07_12/13_0000m
	
Mtu07_04/05_0250m	Mtu07_12/13_0250m
	
Mtu07_04/05_0500m	Mtu07_12/13_0500m
	
Mtu07_04/05_0750m	Mtu07_12/13_0750m
	
Mtu07_04/05_1000m	Mtu07_12/13_1000m

Wharekawa River

2006/2007	2012/2013
	
Wha01_06/07_0000m	Wha01_12/13_0000m
	
Wha01_06/07_0250m	Wha01_12/13_0250m
	
Wha01_06/07_0500m	Wha01_12/13_0500m
	
Wha01_06/07_0750m	Wha01_12/13_0750m
	
Wha01_06/07_1000m	Wha01_12/13_1000m

	
Wha02_06/07_0000m	Wha02_12/13_0000m
	
Wha02_06/07_0250m	Wha02_12/13_0250m
	
Wha02_06/07_0500m	Wha02_12/13_0500m
	
Wha02_06/07_0750m	Wha02_12/13_0750m
	
Wha02_06/07_1000m	Wha02_12/13_1000m

	
Wha03_06/07_0000m	Wha03_12/13_0000m
	
Wha03_06/07_0250m	Wha03_12/13_0250m
	
Wha03_06/07_0500m	Wha03_12/13_0500m
	
Wha03_06/07_0750m	Wha03_12/13_0750m
	
Wha03_06/07_1000m	Wha03_12/13_1000m

	
Wha04_06/07_0000m	Wha04_12/13_0000m
	
Wha04_06/07_0250m	Wha04_12/13_0250m
	
Wha04_06/07_0500m	Wha04_12/13_0500m
	
Wha04_06/07_0750m	Wha04_12/13_0750m
	
Wha04_06/07_1000m	Wha04_12/13_1000m

	
Wha05_06/07_0000m	Wha05_12/13_0000m
	
Wha05_06/07_0180m	Wha05_12/13_0180m
	
Wha05_06/07_0250m	Wha05_12/13_0250m
	
Wha05_06/07_0312m	Wha05_12/13_0312m
	
Wha05_06/07_0401m	Wha05_12/13_0401m

Wha05_06/07_0500m	Wha5_12/13_500m

Tahunaatara Stream

2003/04	2013/14
	
Tah_03_0000m	Tah_13_0000m
	
Tah_03_0250m	Tah_13_0250m
	
Tah_03_0500m	Tah_13_0500m
	
Tah_03_0750m	Tah_13_0750m
	
Tah_03_1000m	Tah_13_1000m

	
Tah_03_1250m	Tah_13_1250m
	
Tah_03_1500m	Tah_13_1500m
	
Tah_03_1750m	Tah_13_1750m
	
Tah_03_2000m	Tah_13_2000m
	
Tah_03_2250m	Tah_13_2250m

	
Tah_03_2500m	Tah_13_2500m
	
Tah_03_2750m	Tah_13_2750m
	
Tah_03_3000m	Tah_13_3000m
	
Tah_03_3250m	Tah_13_3250m
	
Tah_03_3500m	Tah_13_3500m

	
Tah_03_3750m	Tah_13_3750m
	
Tah_03_4000m	Tah_13_4000m
	
Tah_03_4250m	Tah_13_4250m
	
Tah_03_4500m	Tah_13_4500m
	
Tah_03_4750m	Tah_13_4750m

*Alternative view: Used when the original photo site and/or direction can no longer be accessed or has been overgrown to the point where no comparison can be made.

+Earlier years have been used on the rare occasion that none of the photos taken in the most recent assessment are clear enough for comparison, or have been taken in the wrong location.

Appendix 4: Macroinvertebrate Community Index (MCI)

Table 27: Macro invertebrate Community Index (MCI):

IBI Score range	Integrity Class	MCI Range	QMCI range	Degradation Category
58–60	Excellent	125-200	6.2-10	Clean
48-52	Good	105-115	5.2-5.7	Mild
40-44	Fair	85-95	4.2-4.7	Moderate
28-34	Poor	<75	0-3.7	Severe
12-22	Very poor	-	-	-

Appendix 2 Integrity Score (IBI), Integrity classes, Macroinvertebrate Community Index (MCI) and Quantitative Macroinvertebrate Community Index (QMCI) ranges defined for invertebrate communities (Wright-Stow and Winterbourn, 2003).

Table 28: Additional information on monitored streams:

Stream name	Stream Depth	Stream Width	Main Substrate Type	Distance between u/s and d/s loggers
Pokaiwhenua	0.6m	**11**.6m	Large Gravel/cobble	1.2km
Mangare	0.5m	5.3m	Large gravel	1.3km
Tahunaatara	0.5m	6.6m	Large gravel	4.5km
Mangatutu	0.5m	11.2m	Large/small gravel	18km
Wharekawa	0.3m	13.6m	Cobble/Large gravel	3.4km

Stream depth, width and substrate type are gathered while conducting REMS surveys and are only indicative of the 100m stretch that is sampled. It does however give an idea of the size and substrate type of the streams.

Table 29: Additional information on reference streams for REMS:

Stream name	Stream Depth	Stream Width	Main Substrate Type
Mokaihaha	0.2m	7.4m	Bedrock/Sand
Otautora	0.2m	3.6m	Cobble/Sand/Gravel
Kauaeranga	0.3m	20m	Boulder/Cobble
Pohomihi	0.3m	9.8m	Large Gravel

Stream depth, width and substrate type are gathered while conducting REMS surveys and are only indicative of the 100m stretch that is sampled. It does however give an idea of the size and substrate type of the streams.

Table 30: MCI values for the Pokaiwhenua Stream and nearby reference site (Mokaihaha Stream)

Site	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Pokaiwhenua upstream	99	103	113	113	115	113	107	112.2	114	107.5	112
Pokaiwhenua downstream	113	109	116	103	108	102	98	96.6	112.7	102.5	95
Reference site - Mokaihaha Stream	N/A	141	143	135	137	127	131	130	133.9	129.2	120

Table 31: MCI values for the sampling site in the Mangatutu River and nearby reference site (Otautora Stream)

Site	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Mangatutu downstream	114	110	104	108	115	102	104.7	97.6	106.9	111
Otautora Stream	149	145	139	136	136	144	140	134.4	135.3	135

Table 32: MCI values for the Pokaitu Stream and nearby reference site (Mokaihaha Stream)

Site	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Pokaitu downstream	104	116	120	126	122	117	122	108.6	105	111.2	129.2
Mokaihaha Stream	N/A	141	143	135	137	127	131	130	133.9	110	132

Table 33: MCI values for the Mangare Stream and nearby reference site (Otautora Stream)

Site	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Mangare upstream	99	113	96	104	96	110.5	106.3	116.2	105
Mangare downstream	92	93	82	88	96	93.7	101.3	99.1	90
Reference site – Otautora Stream	145	139	136	136	144	139	134.4	135.3	135

Table 34: MCI values for the sampling site in the Wharekawa River and nearby reference site (Kauaeranga River)

Site	2004/05	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Wharekawa	95	94	94	86	90	101.4	104	94.3	71
Kauaeranga River	135	120	109	131	103	124	125.6	130	119