Freshwater Periphyton
Monitoring Programme
(Periphyton monitoring in relation to amenity values)
State of Environment
Monitoring Report
2010-2012

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Executive summary

Section 35 of the Resource Management Act requires local authorities to undertake monitoring of the region's environment, including land, air, and fresh and marine water quality. The Taranaki Regional Council began monitoring for nuisance periphyton in the 2002-2003 monitoring year. This report summarises the results of the State of the Environment programme for the monitoring period 2010-2012.

The results for SEM periphyton programme during the 2010/2011 monitoring year showed that all 21 sites met the periphyton guidelines for thick mats and long filaments. For the 2011/2012 monitoring year, all sites met the guideline for thick mats and only one site, at Kapoaiaia Stream at Cape Egmont, breached the guideline limits for long filaments (Table 1).

For the TRC Periphyton Index, the median index value for 2010-2012 monitoring showed that 15 sites (71%) recorded 'Very good' and a further 6 sites (29%) recorded 'Good' TRC PI rating.

Long term periphyton trend analysis indicated that 11 sites showed indicative decreasing trends (ie the extent of periphyton was reducing) for thick mats and a further 19 sites showed indicative decreasing trends for long filaments (two of these sites are significant after FDR adjustment).

Table 1 Summary of SEM periphyton results for 2010-2012 monitoring year

Catch-ment	River/Stream	Site	Median TRC Periphyton Index	Indicative trend		Periphyton cover-compliance with national guideline	
				Thick mats	Long filaments	Thick mats	Long filaments
Upper	Patea	Barclay Road	Very good	Increasing	No trend	4/4	4/4
	Maketawa	Denby Road	Very good	Increasing	Increasing	4/4	4/4
Middle	Kapoaiaia	Wiremu Road	Very good	Decreasing	Decreasing*	4/4	4/4
	Kapoaiaia	Wataroa Road	Good	Decreasing	Decreasing	4/4	4/4
	Waingongoro	Opunake Road	Very good	Decreasing	Decreasing	4/4	4/4
	Waingongoro	Stuart Road	Very good	Decreasing	Decreasing	4/4	4/4
	Manganui	SH3	Very good	Decreasing	No trend	4/4	4/4
	Patea	Skinner Road	Good	Increasing	Decreasing	4/4	4/4
	Hangatahua (Stony)	Mangatete Road	Very good	Increasing	Decreasing	3/3	3/3
	Waiongana	SH3a	Very good	No trend	Decreasing	3/3	3/3
	Punehu	Wiremu Road	Very good	Increasing	Increasing	4/4	4/4
	Waiwhakaiho	SH3 (Egmont Village)	Very good	Increasing	Decreasing	3/3	3/3
	Maketawa	Tarata Road	Very good	Decreasing	Decreasing*	4/4	4/4
Lower	Kapoaiaia	Cape Egmont	Good	Decreasing	Decreasing	4/4	3/4
	Mangaehu	Ruapuha Road	Good	Increasing	Decreasing	3/3	3/3
	Manganui	Bristol Road	Good	Increasing	Decreasing	4/4	4/4
	Punehu	SH45	Very good	Decreasing	Decreasing	4/4	4/4
	Hangatahua (Stony)	SH45	Very good	Increasing	Decreasing	3/3	3/3
	Waiongana	Devon Road	Good	Increasing	Decreasing	3/3	3/3
	Waingongoro	Ohawe Beach	Very good	Increasing	Decreasing	4/4	4/4
	Waiwhakaiho	Constance Street, NP	Very good	Increasing	Decreasing	3/3	3/3

* Significant trend at $p<0.05$ after FDR adjustment

Periphyton is the algae or 'slime' that can be seen from time to time in rivers and streams, especially during extended periods of low flows and warm temperatures. It plays a fundamental role within the stream ecosystem by absorbing nutrients and converting them into biomass which is then used as a food source for invertebrates, and subsequently native fish and birds. Nuisance periphyton, in the form of either prolific thick mats or long filaments of algae can cause streams to become un-inviting for recreation and/or have adverse impacts on stream ecology.

This freshwater nuisance periphyton programme has been designed to monitor the presence and distribution of 'nuisance' algae in Taranaki streams and rivers which may affect the instream values of these streams i.e., aesthetic values (contact recreation and landscape values), biodiversity values, and those values linked to Maori culture and tradition.

The New Zealand Periphyton Guidelines, established by the Ministry for the Environment (Biggs, 200), provide a reference at which point growths of periphyton exceed the recreational guideline. This point is exceeded when at least 30% of the bed is covered by filamentous algae and/or at least 60% of the bed is covered by thick mats of algae.

Twenty-one sites are surveyed each year in 10 catchments around the Taranaki region. Sites were chosen to be representative of different catchment types such as high conservation, riparian and major abstraction. Each river or stream has one upper (mostly un-impacted) site, and one or two lower sites (with various degrees of impaction).

The Hangatahua (Stony) River was selected as a river with high conservation value and the Maketawa Stream was identified in the Regional Freshwater Plan for its regionally important recreational value. The Manganui, Patea and Waiwhakaiho Rivers, and the Mangaehu River were chosen as examples of waterways with large catchments and /or multiple human impacts. The Waingongoro River was included in the programme as a river under intensive usage and the Waiongana Stream as a stream from which there is a major water abstraction. The Punehu Stream was included as a stream within a primarily agricultural catchment and the Kapoaiaia Stream as a western Taranaki stream targeted for riparian planting initiatives.

Periphyton surveys were scheduled for two times per year, spring (15 September to 31 December) and summer (1 January to 15 April). Sampling was always carried out after an extended period of low flow (i.e. optimal conditions for establishing excessive growths). At each site, ten random assessments were made across the stream using a periphyton viewer. Types of periphyton cover on the stream bed within each square were estimated visually as a percentage coverage on the substrate; types being one of a range e.g. thin, medium and thick films of mats and short and long filaments. The colour of the growth (brown, black, or green) was also recorded, as this relates to the types of periphyton present.

The results were interpreted to provide a periphyton index score, and to record the number of times the site exceeded the recreational and aesthetic guidelines over the two year period.

This report was the first to incorporate long term periphyton trend analysis for each site. Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton for all sites and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis. Of the trends, ten were significant at the 5% level. Two remained significant after FDR application.

Most upstream sites, except for those in the Waiwhakaiho and Waiongana Streams, generally contained a low periphyton biomass throughout the year. Almost all downstream sites, except the Stony River and Maketawa Stream, exhibited some degree of periphyton proliferation with the progression of summer.

Overall, the following conclusions can be made:

1. All of the catchments monitored have improved in terms of compliance with the guidelines for nuisance growths since the 2006-2010 reporting period, except for the Stony and Manganui Rivers which have stayed the same.
2. True 'upstream sites' with little agriculture in their catchment have a low biomass and stable periphyton canopy throughout the year.
3. Periphyton communities at mid and low catchment sites are released from the growth inhibiting factors of spring as the water warms and flows become more stable in summer.
4. Nutrient inputs from municipal and industrial waste water discharges appear to cause greater periphyton proliferation than the cumulative nutrient input from diffuse and point source discharges from agricultural land (e.g. Patea River compared with Punehu River).
5. Catchments with a proportion of their catchment used for agriculture are more likely to have periphyton growths during an average summer (although not recently to a nuisance degree).
6. Flood flows can cause a dramatic reduction in periphyton growth, but the degree of this effect is not consistent within streams or seasons.
7. No didymo has been found.

From these conclusions, a number of recommendations are made in the report. Monitoring of the streams should continue as previously performed.

In response to the invasion of *Didymosphenia geminate* in the South Island, it is also recommended that samples continue to be taken by the Council at selected sites and microscopically scanned for *Didymosphenia geminata,* an invasive alga.

Table of contents

List of tables

List of figures

List of photographs

1. Introduction

The Resource Management Act 1991 ("the RMA") established new requirements for local authorities to undertake environmental monitoring. Section 35 of the RMA requires local authorities to monitor, among other things, the state of the environment of their region or district, to the extent that is appropriate to enable them to effectively carry out their functions under the Act.

To this effect, the Taranaki Regional Council ("the Council") has established a state of the environment monitoring ('SEM") programme for the region. This programme is outlined in the Council's "State of the Environment Monitoring Procedures Document", which was prepared in 1997. The monitoring programme is based on the significant resource management issues that were identified in the Council's Regional Policy Statement for Taranaki (2008) and also the Regional Freshwater Plan for Taranaki (2001).

The SEM programme is made up of a number of individual monitoring activities, many of which are undertaken and managed on an annual basis (from 1 July to 30 June). For these annual monitoring activities, summary reports are produced following the end of each monitoring year (i.e., after 30 June). Where possible, individual, consent monitoring programmes have been integrated within the SEM programme to save duplication of effort and minimize costs. The purpose of annual SEM reports is to summarise monitoring activity results for the year and provide a brief interpretation of these results.

This SEM Freshwater Nuisance Periphyton programme begun in the 2002-2003 monitoring year. Two previous reports have been written, summarising the 2002-2006 and 2006-2010 survey periods. The reporting period has since been changed to biennial, hence this report summarises the results for the 2010-2012 monitoring period. The freshwater nuisance periphyton programme has been designed to monitor the presence and distribution of 'nuisance' levels and types of algae in Taranaki streams and rivers which may affect the instream values of these streams i.e., aesthetic values (contact recreation and landscape values), biodiversity values and those values linked to Maori culture and tradition.

Responsibilities under the Resource Management Act

Water management in New Zealand is principally controlled by the RMA. Section 5 of the RMA describes its purpose:

1. The purpose of this Act is to promote the sustainable management of natural and physical resources.

2. In this Act, "sustainable management" means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while –

a. Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
b. Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
c. Avoiding, remedying or mitigating any adverse effects of activities on the environment.

Under section 30 of the RMA, functions and powers for water management lie with regional councils.

In certain circumstances periphyton can proliferate and become a nuisance and adversely affect water quality for a range of instream values. The RMA provides for waters to be classified in regional plans as an aid to the management of water quality. In recognition of the potential problems created by high-biomass biological growths in streams, the RMA specifies the following standard for waters being managed for aquatic ecosystem purposes, fish spawning, contact recreation, water supply, irrigation and industrial abstraction: “There shall be no undesirable biological growths as a result of any discharge of a contaminant into water” (schedule III).

1.1 Nuisance periphyton

What is periphyton?

Periphyton is the ‘slime’ and algae found on the beds of streams and rivers (Photo 1). It is essential for the function of healthy ecosystems, but when it proliferates it can become a nuisance by degrading swimming and fishing spots and clogging irrigation and water supply intakes. The periphyton community is composed predominantly of algae and cyanobacteria (blue-green algae).

Photo 1 Extensive filamentous algae growth in the Mangaehu River (MGH000950)

How is it important?
Periphyton is found in all aquatic habitats but is most conspicuous in streams and rivers. Periphyton communities contain the main primary producers of streams, being the transducers of light energy and mineral nutrients into food for most other stream life.

What factors contribute to periphyton growth?
The local factors controlling the biomass and type of periphyton existing at any given point in a stream, and at any given time, are a result of a hierarchy of environmental controllers. Large scale factors include catchment geology and climate (rainfall and temperature). More immediate reach scale factors that influence periphyton growth include:

- Light – the amount of sunlight can regulate periphyton communities; a lack of or the destruction of riparian margins can increase the potential for nuisance growths to occur, particularly in smaller streams where a vegetation canopy would normally provide significant shade to limit periphyton growth.
- Water quality, particularly nutrients - introduction of nutrients to streams can be increased due to damage to the riparian margin and increased input from agricultural fertilisers, particularly in intensively farmed areas. Further increased stocking densities of cows, dairy farm oxidation pond discharges and cows defecating directly in the stream can significantly contribute to nutrient levels in streams. Nitrogen and phosphorus are both key to periphyton growth. When just one of these two nutrients is limited, it can constrain periphyton proliferation.
- Water temperatures may influence the growth rates of periphyton (especially near the mouth of the stream), i.e., warmer temperatures (summer) allow periphyton to grow faster, whereas colder temperatures (winter) may limit growth. Water temperature regulation may be influenced by shading from riparian vegetation, directly in smaller streams or by cooling the water that flows into larger streams
- Stream flow regimes – the frequency of flood events are a particularly important controller of periphyton (repeated freshes will keep growth at bay); also the duration of stable low flows, particularly in summer may allow significant accrual of periphyton biomass.
- Invertebrate grazers or other biota that interact with periphyton may act to reduce periphyton growth. Many grazers are more prolific in cooler waters.

The interaction between all these factors must be considered when interpreting periphyton monitoring data. Both the extent and intensity of summer low flows and nutrient concentrations can be strongly influenced by human activity through changes in land use and hydrology, or by meteorological variations year by year.

It is important to note that high biomasses of periphyton can be a natural occurrence in some streams at certain times of the year - for example long, wide, shallow rivers will have large growths during late summer when temperatures are high and flows are low.

Values affected by nuisance periphyton growth
The waterways of New Zealand are valued for a wide range of reasons, all of which can be affected by the presence of nuisance periphyton growths.

Problems associated with excess bioaccumulation (nuisance growths) are most prominent during low flows and therefore may only occur at certain times of the year (Biggs, 2000). Common stream related values are listed in Table 1.

Table 1 Instream values affected by nuisance growths of algae (adapted from Biggs 2000)

Instream Value	Problem
Aesthetics	Degradation of scenery, odour problems
Biodiversity	Loss of sensitive invertebrate taxa through habitat alteration, possible reduction in benthic biodiversity
Contact recreation	Impairment of swimming, odour problems, dangerous for wading
Industrial use	Taste and odour problems, clogging intakes
Irrigation	Clogging intakes
Monitoring structures	Fouling of sensory surface, interferes with flow
Potable supply	Taste and odour problems, clogging intakes
Native fish conservation	Impairment of spawning and living habitat
Stock and domestic animal health	Toxic blooms of cyanobacteria
Trout habitats/angling	Reduction in fish activity/populations, fouling lines, dangerous for wading
Waste assimilation	Reduces stream flow, reduces ability to absorb ammonia, reduces ability to process organics without excessive DO depletion
Water quality	Increased suspended detritus, interstitial anoxia in stream bed, increased DO and pH fluctuations, increased ammonia toxicity, very high pH
Whitebait fishing	Clogging nets

1.1.1 Periphyton guidelines

New Zealand Periphyton Guidelines (Biggs, 2000) were released in June 2000 by Ministry for the Environment. The guidelines relevant to monitoring conducted in this programme are listed in Table 2.

Table 2 New Zealand periphyton guidelines

Instream value	Diatoms/cyanobacteria	Filamentous algae
Aesthetics/recreation (1 November to 30 April) Maximum cover of visible streambed	60% > 3mm thick	30% > 2cm long

Accompanying these guidelines, NIWA published a Stream Periphyton Monitoring Manual (Biggs and Kilroy, 2000) for Ministry for the Environment to assist monitoring agencies in the methods of periphyton monitoring. Several predominant periphyton community groups are specified in the manual and help to interpret what these periphyton communities indicate i.e., oligotrophic (high water quality), mesotrophic (moderately enriched), and enriched streams (Appendix 2 in Biggs and Kilroy, 2000).

1.1.2 Methodology

1.1.2.1 Periphyton surveys

Periphyton surveys were performed twice a year:

- spring (15th September –31st December) and
- summer (1st January – 15th April).

Prior to the 2010-2012 monitoring periods, surveys were performed three times a year:

- spring (September, October, November, early December)
- summer (late December to early February)
- late summer (late February- April).

At each site ten random assessments were made across the stream using a periphyton viewer (110 cm^2). Periphyton cover on the stream bed within each square was estimated visually as a percentage cover on the substrate, using the categories in Table 3.

Widespread coverage of thick mats (Photo 2) or long filaments on the streambed are often seen as nuisance growths, whereas thin films of algae act as an important food source for many of the ‘sensitive’ stream invertebrates.

Table 3 Periphyton categories used in visual estimates of cover

Type	Size		Colour	Periphyton Index Score
None			Clean stones, not slippery	No score
Mat/film	Thin	< 0.5 mm	Green	7
			Light brown	10
			Black, dark brown, very dark green	10
	Medium	0.5-3 mm	Green	5
			Light brown	7
			Black, dark brown, very dark green	9
	Thick	> 3 mm	Green	4
			Light brown	4
			Black, dark brown, very dark green	7
Filaments	Short	< 2 cm	Green	5
			Brown/reddish	5
	Long	> 2 cm	Green	1
			Brown/reddish	4
Other			Describe	N/A

Photo 2 Thick mat of cyanobacteria

Streams were sampled at least 10 days after the last fresh in excess of three times the median flow. This allows some time following a fresh for the periphyton community to recover and reflect actual water quality conditions rather than the effects of the most recent flood. Floods of this magnitude or greater are considered sufficient to move substrate and scour the bed of the stream, significantly reducing periphyton biomass.

Wherever possible all streams were sampled within a day or two of each other; sites within each individual stream catchment were sampled on the same day.

1.1.2.2 Periphyton index

Percentage cover data gathered is used to establish a periphyton index score. This index was introduced as part of the Stream Health Monitoring and Assessment Kit (SHMAK) produced by the Ministry for the Environment, and uses a scoring system, where each type of periphyton cover is assigned a score (Table 3). Scores have been assigned according to the conditions in which each category is usually found dominating the cover of stream beds (Biggs, Kilroy and Mulcock, 1998). The lower the score, the more eutrophic the conditions that type of cover is usually dominant in.

The periphyton index score (PI) is found using the following equation:

$$PI = \frac{\sum \text{(mean cover by periphyton category x rating of category)}}{\sum \text{(mean cover by all periphyton groups)}}$$

The resultant periphyton index score gives an indication of the periphyton community composition of the stream at that point in time, although it is based on the concept of a typical periphyton community i.e. one that has not been recently scoured away by floods, or proliferated in low flows. This is considered by Biggs *et al* (1998) to be after a period of six weeks since a three times median flood. In the case of Taranaki, it could be argued that sampling after a shorter period (as allowed by the protocols adopted by the Council) means that a community is being sampled that is still affected by a previous flood. However, due to the relatively high flood frequency in Taranaki, it is considered that a 'flood affected' community is relatively typical for this region. The only drawback of this policy is that late summer surveys that are less flood-affected will potentially record a lower PI, all other influences being equal. That said, this still reflects what is typical of a Taranaki stream at that time.

Biggs *et al* (1998) give the substrate area that is clear of algae a 'zero' score which strongly influences the periphyton index score of some sites in Taranaki, such as some higher up in catchments. For example, one site in the Stony River on 18 February 2003 recorded 96.5% of the bed to be clear of algae, with the remaining 3.5% made up of long (1%) and short (2.5%) filaments. This resulted in a PI score of 3.9, which is considered to be indicative of enriched conditions. Basically, when the SHMAK PI is used in flood affected communities, it could potentially return a result supposedly indicative of enriched conditions, implying a slimy, algae covered stream, when in fact the reverse is the case. It is precisely for this reason that the SHMAK PI should only be used in climax communities i.e. when the community has matured and is stable to the point of there being little further change in biomass.

Taking this into account, a 'TRC PI' value has been created, which gives an area clear of algae a score of 10. A drawback of this value is that the steeper, higher energy sites high on the mountain will have a raised TRC PI, compared to the lower sites, due to greater bed turnover during smaller floods. Any site with some substrate clear of algae will record a higher TRC PI than SHMAK PI. However, the TRC PI is useful when describing the degree of undesirable algal growths in a flood-prone stream.

It is not an absolute measure like the periphyton guidelines, which are either exceeded or not. In addition, it is not restricted to only long filaments and thick mats, including all types of cover, acknowledging the fact that undesirable growths may be present, even when the guidelines are not exceeded. However, there are some pitfalls to this type of interpretation, as shown by Table 4. It is possible that a site in breach of the recreational and aesthetic guidelines returns a very good PI. Therefore this type of interpretation should not be done in complete isolation from the percentage cover (guideline compliance) data.

Table 4 Range of Periphyton Scores when in exceedance of recreational and aesthetic guidelines

	Diatoms/cyanobacteria60% > 3mm thick			Filamentous algae30% > 2cm long		
Assuming remainder of bed is:	Clear of Algae[1]	Thin brown films[1]	Short filaments[1]	Clear of Algae[1]	Thin brown films[1]	Short Filaments[1]
SHMAK PI	4.0[2]-7.0[3]	6.4[2]-8.2[3]	4.0[2]-5.8[3]	1.0[4]-4.0[5]	7.3[4]-8.2[5]	3.1[4]-4.0[5]
TRC PI	6.4[2]-8.2[3]	6.4[2]-8.2[3]	4.0[2]-5.8[3]	7.3[4]-8.2[5]	7.3[4]-8.2[5]	3.1[4]-4.0[5]

1 Although a mixture of thin films, medium mats and short filaments is much more likely, and would result in a different PI value
2 60% Thick green mats
3 60% Thick black mats
4 30% Long green filaments
5 30% Long brown filaments

The lowest possible periphyton score for the SHMAK PI is 0 and for the TRC PI is 1 (100% long green filaments).

In short, while a high TRC PI may still be associated with a breach of the periphyton guidelines, a low TRC PI is almost certainly a reflection of undesirable algal growths. The TRC PI will be used in this report, as it is more reflective of the periphyton community in a flood-prone stream.

Below is a general explanation of the SHMAK periphyton index scores taken from Biggs, Kilroy and Mulcock (1998). These scores are also applicable to the TRC PI.

Score: 0 to 1.9
There are mainly long filamentous green algae at the site indicating that there is high to moderate enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond, or could occur naturally in streams that have a high proportion of mudstone/siltstone or recent volcanic rocks (central North Island) in their catchments.

Score: 2 to 3.9
These communities suggest a moderate level of enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond, or could occur naturally in streams that have a high proportion of mudstone/siltstone or recent volcanic rocks (central North Island) in their catchments.

Score: 4 to 5.9
These communities suggest slight enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond, or could occur naturally in streams that have a high proportion of mudstone/siltstone, recent volcanic rocks (central North Island), limestone or marble in their catchments. Clean stones can result from recent abrasion by flood flows or intense grazing by invertebrates/insects that live in the gravels.

Score: 6 to 7.9
These communities are generally composed of species that are able to grow under moderate to low nutrient conditions. These communities also usually grow back first after a flood has removed previous growths, but may be out-grown by filamentous algae if nutrient levels are sufficiently high.

Score: 8 to 10
These communities usually signify low concentrations of nutrients and/or intensive grazing by invertebrates/insects that live among the gravels.

Scores have been broken down further into category rating for descriptive purposes (Table 5).

Table 5 Category ratings for TRC PI scores

Rating	TRC PI score
Very good	8–10
Good	6–7.9
Moderate	4–5.9
Poor	2–3.9
Very poor	0–1.9

1.1.3 Site locations

Twenty one sites were chosen in ten catchments around the Taranaki Region (Table 6). Sites were chosen to be representative of different catchment types such as high conservation, riparian and major abstraction. Generally, each river/stream has one upper (mostly un-impacted) site and one or two lower sites (with various degrees of potential effects arising from land management activities).

Sites have been chosen within the existing hydrological flow monitoring network where possible, as hydrological information is helpful to the interpretation of results. Details of the catchments monitored are summarised in Figure 1.

Table 6 Summary of nuisance periphyton monitoring sites in the SEM programme

Feature	Sites			
	River/Stream	Location	Site Code	Distance from next site upstream (Km)
High conservation	Hangatahua (Stony)	Mangatete Road	STY000300	
		SH45	STY000400	5.2
	Maketawa	Denby Rd	MKW000200	
		Tarata Road	MKW000300	6.5
Large catchments/ Multiple impacts	Manganui	SH3	MGN000195	
		Bristol Road	MGN000427	29.1
	Patea R	Barclay Road	PAT000200	
		Skinner Road	PAT000360	17.2
	Waiwhakaiho	SH3 (Egmont Village)	WKH000500	
		Constance St, NP	WKH000920	15.9
Intensive usage	Waingongoro	Opunake Road	WGG000150	
		Stuart Road	WGG000665	22.4
		Ohawe Beach	WGG000995	37.1
Primary agricultural	Punehu	Wiremu Road	PNH000200	
		SH45	PNH000900	16.6
Riparian	Kapoaiaia	Wiremu Road	KPA000250	
		Wataroa Road	KPA000700	7.8
		Cape Egmont	KPA000950	11.8
Major abstraction	Waiongana	SH3a	WGA000260	
		Devon Road	WGA000450	15.1
Eastern hill country	Mangaehu	Raupuha Road	MGH000950	

Periphyton communities in the Kaupokonui River are also monitored monthly as part of the Riparian State of the Environment Monitoring Programme. Results relating to this catchment are summarised in other Council reports (TRC, 2004 and TRC draft 2010/11), and will not be presented in this report.

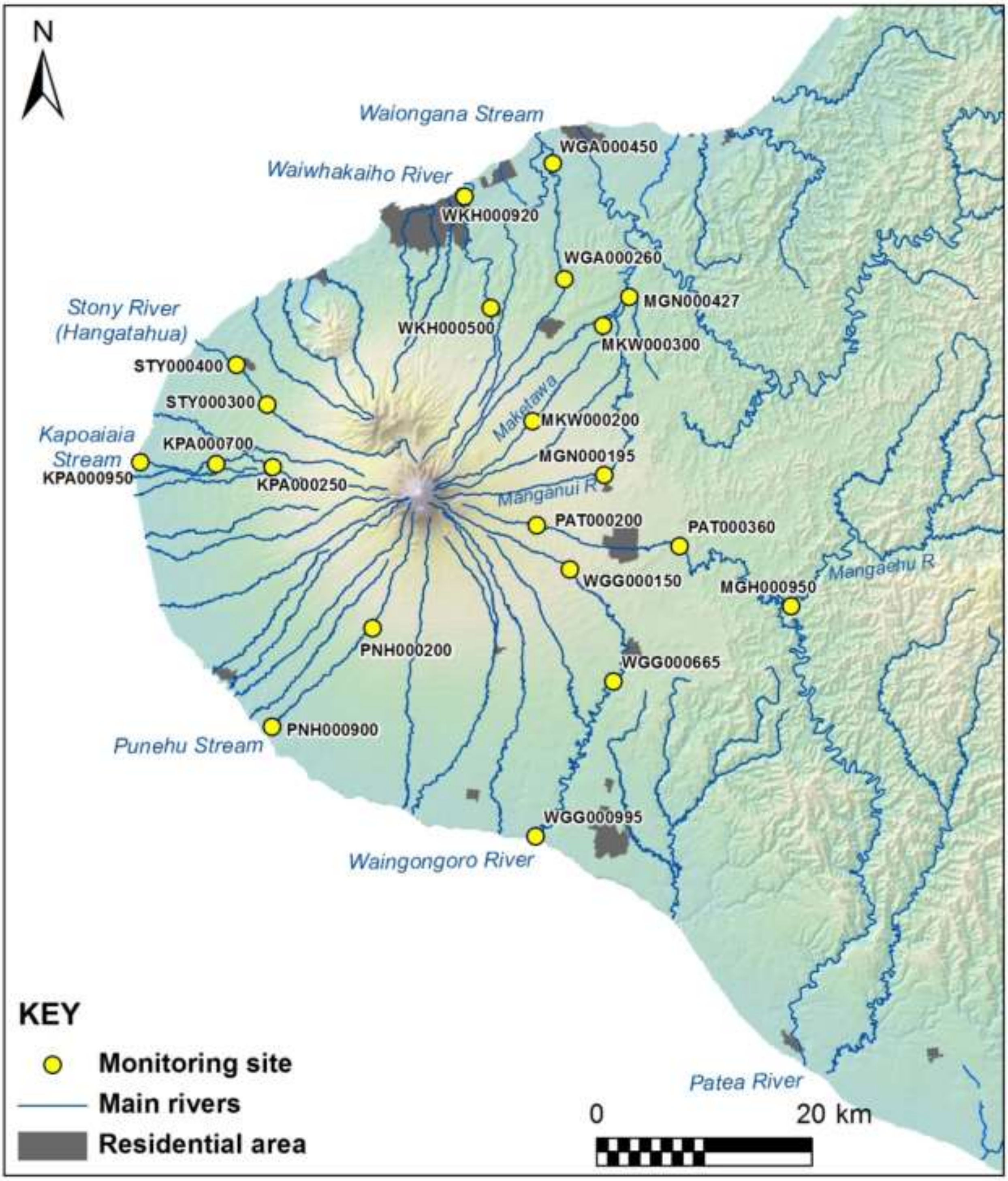


Figure 1 Sampling site locations

2. Results

2.1 Hangatahua (Stony) River

The Hangatahua (Stony) River rises within the National Park boundary, on the north-western side of Mount Taranaki. Upon leaving the National Park, it heads in a north-westerly direction for a distance of approximately 15 kilometres to the coast. The upper reaches of the catchment contain indigenous vegetation, the middle is mixed (including exotic trees and pasture), while the lower area is barren or comprises introduced grasses and weeds.

The Stony River is occasionally affected by significant natural erosion events in the headwaters, which can scour periphyton and limit proliferation and is a major source of sand for the Taranaki region.

This river is protected in its natural state by way of a Local Conservation Order. As such there are no abstractions from the river, and no direct discharges.

The top sampling site (Mangatete Rd, STY000300) is within 7 km of the park boundary (as close as feasible for regular access), while the downstream site (STY000400) is just above SH45 (12km downstream of the National Park boundary) (Figure 2). This is the final place at which the river is easily accessed before flowing through private land and out to sea. A hydrological flow recorder was installed in the Stony at Mangatete Road and flow data for this site is available from November 2004.

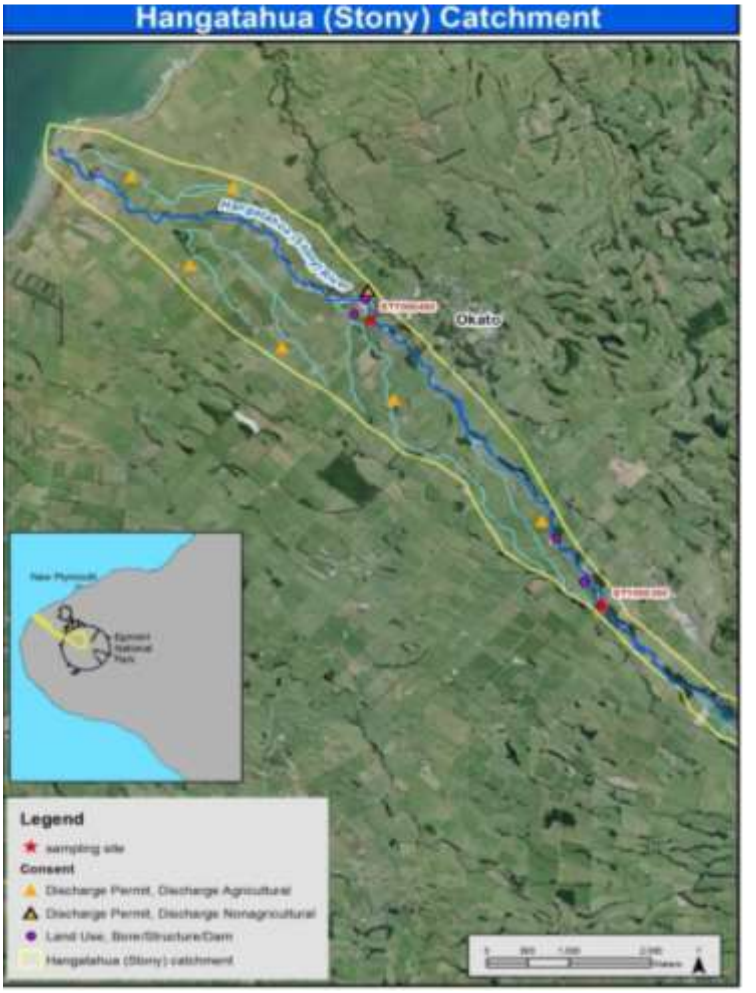


Figure 2 Monitoring site locations in relation to consents operating in the Stony River catchment

2.1.1 Flow data and survey dates

In the 2010-2011 monitoring period early spring was characterized by frequent floods in excess of 7x median flow (Appendix). This was followed by a flow recession from mid October to early November. A spring survey was carried out 03 November 2010 prior to a small fresh. The 2010-2011 summer period experienced a series of flood events throughout its duration which made it impossible to carry out any periphyton monitoring.

The 2011-2012 monitoring period experienced significant floods from September through to January. A small period of receding flow (interrupted only by one small fresh) occurred in the middle of November, allowing a spring survey to be carried out 21 November 2011, immediately prior to a large flood event. The summer of 2012 was relatively wet, with flood events occurring throughout January and March and towards the end of February. A period of flow recession beginning late March and ending in late April allowed a summer periphyton survey to be carried out 04April 2012 when levels were near mean annual low flow (MALF).

2.1.2 Periphyton cover

The Stony River is generally characterised by a low periphyton biomass throughout its catchment. The periphyton cover monitoring from 2010 to 2012 reflects this, with all of the sampling occasions recording no nuisance periphyton over a significant proportion of the streambed (Figure 3 and Figure 4).

In the 2010-2011 monitoring year no nuisance periphyton was found at either the upper survey site at Mangatete Rd or at the lower survey site at SH45. Mature periphyton communities are usually established by six weeks following a significant fresh. Regular flood events throughout the 2010-2011 period would have contributed to the maintenance of a low biomass of periphyton in the Stony catchment, through scouring and flushing of any significant growths.

Again, in the 2011-2012 monitoring year no nuisance periphyton was found at either the upper survey site at Mangatete Rd or at the lower survey site at SH45. Both the spring and summer surveys were conducted 10-11 days after a 7 x median flood, thus any growths were potentially reduced by these flood events.

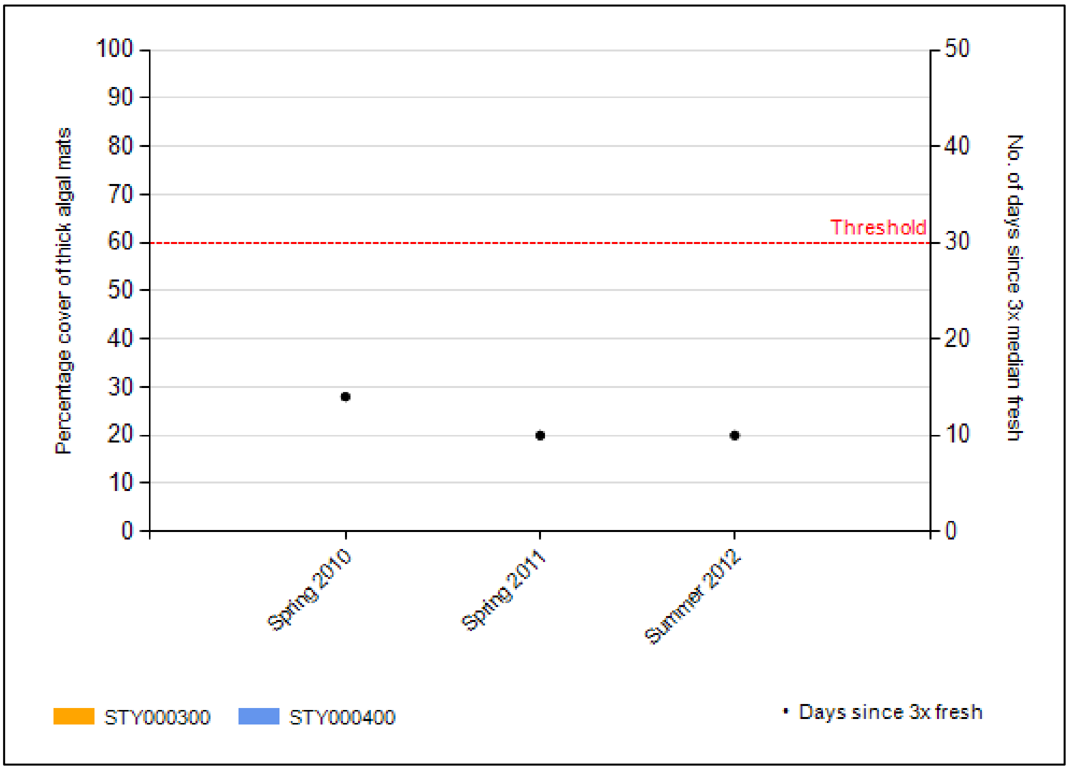


Figure 3 Percentage cover of thick mats of periphyton on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

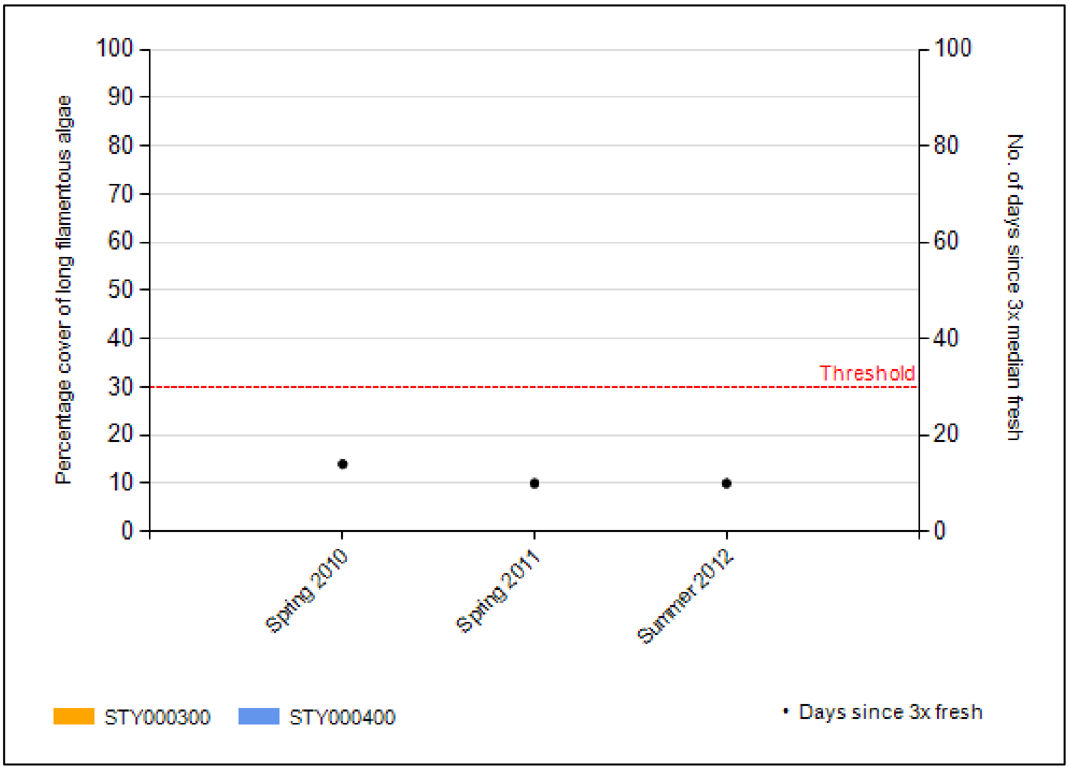


Figure 4 Percentage cover of long filamentous algae on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

Based on historical monitoring data, it appears unlikely that nuisance periphyton growths will develop in this catchment. Improved riparian planting in the years to come may also improve the already high water quality conditions in this catchment, by reducing the diffuse runoff which is generally a significant nutrient source in intensively farmed areas.

The Stony River runs through a protected reserve which is largely covered by native bush. The pristine nature of the river is evident in the low periphyton amounts recorded in the 2010-2012 monitoring periods.

2.1.3 Periphyton Index Score

Over the discussed period the Stony River largely had its bed clear of any nuisance periphyton. The TRC PI indicates that the upstream and downstream Stony River sites signify low concentrations of nutrients and/or intensive grazing by invertebrates/insects that live among the gravels. For the period under review the TRC PIs show no change across the upstream site and downstream site; consistently scoring maximum scores from spring to summer (Table 7). The current periphyton index scores indicate a healthy catchment with very limited nuisance periphyton growth. Unlike the current results, the historical medians suggest the downstream site generally has a lower TRC PI score than the upstream site, but this difference is only minor with the downstream site still scoring highly (Table 7).

Table 7 Seasonal periphyton index scores for the Stony River. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
STY000300	10.0	n/a	10.0	10.0	10.0	9.8
STY000400	10.0	n/a	10.0	10.0	9.9	9.1
Difference	0.0	n/a	0.0	0.0	0.1	0.7

2.1.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Stony catchment from 2002-2012. Over the 10 year period there has been very little periphyton proliferation at both sites monitored in the Stony catchment (Figure 5 and Figure 6).Periphyton has remained consistently low over the past 10 years. There have been occasional spikes but no record ever breached periphyton guidelines for mats or filaments at either of the Stony catchment sites monitored.

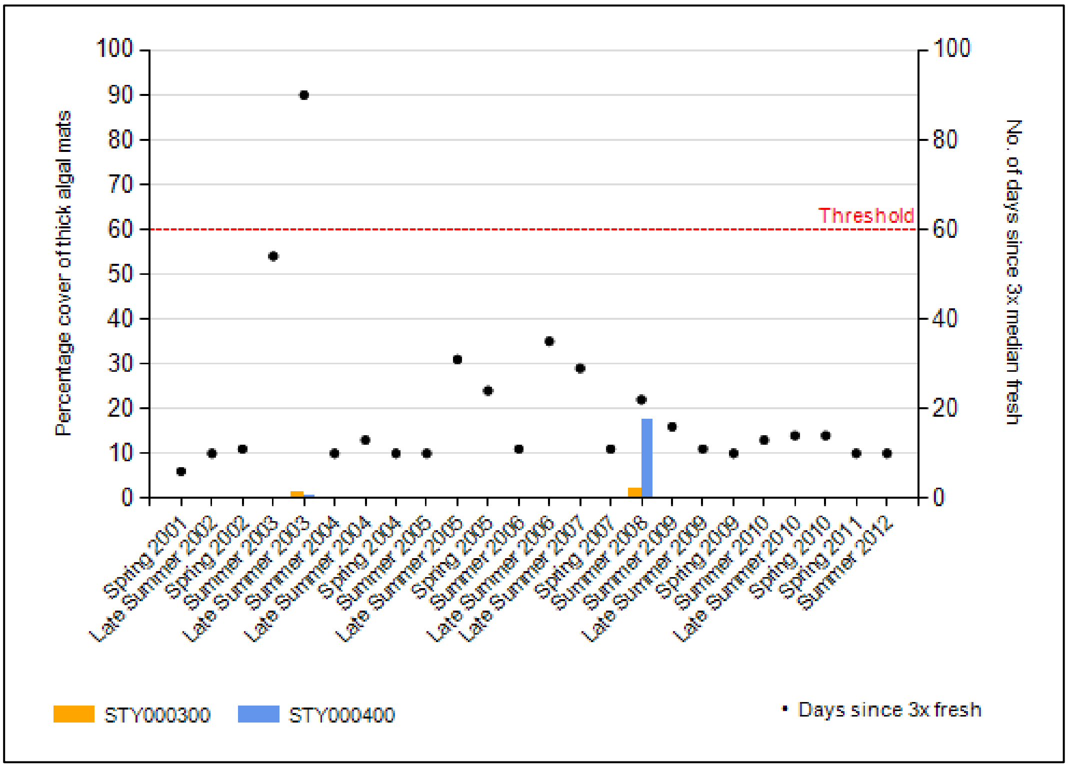


Figure 5 Percentage cover of thick mats of periphyton on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2002-2012 period

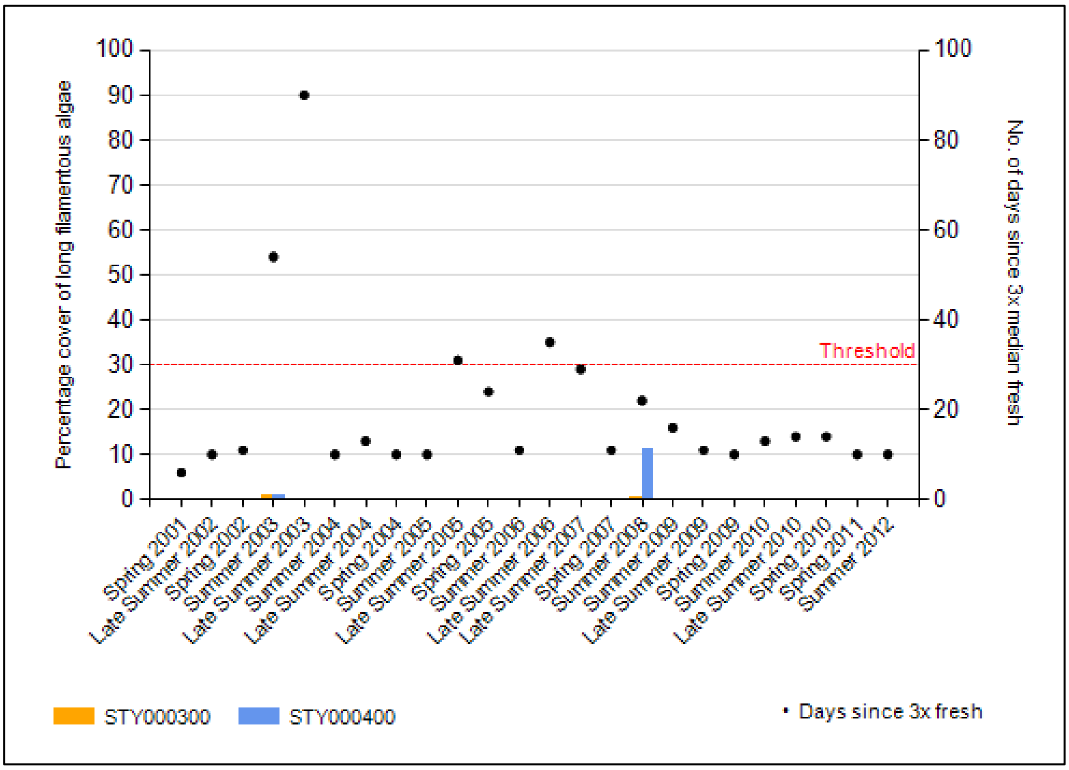
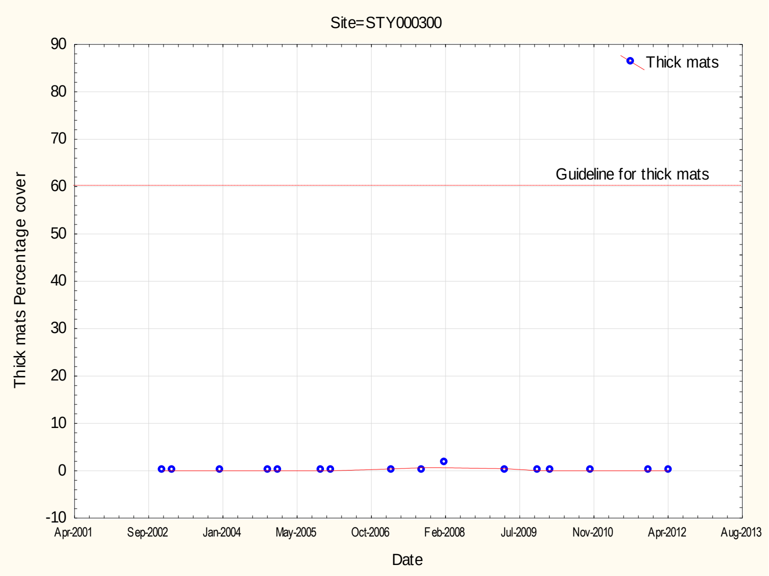


Figure 6 Percentage cover of long filamentous algae on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2002-2012 period

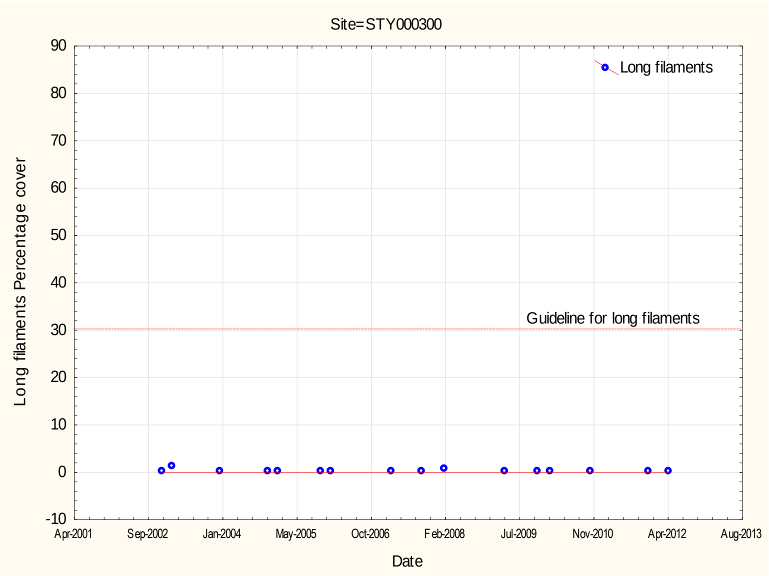
2.1.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Stony River, at Mangatete Road and SH45 over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 7 to Figure 10).



n = 16
Kendal tau = 0.070711
p-value = 0.702
FDR p-value = 0.956

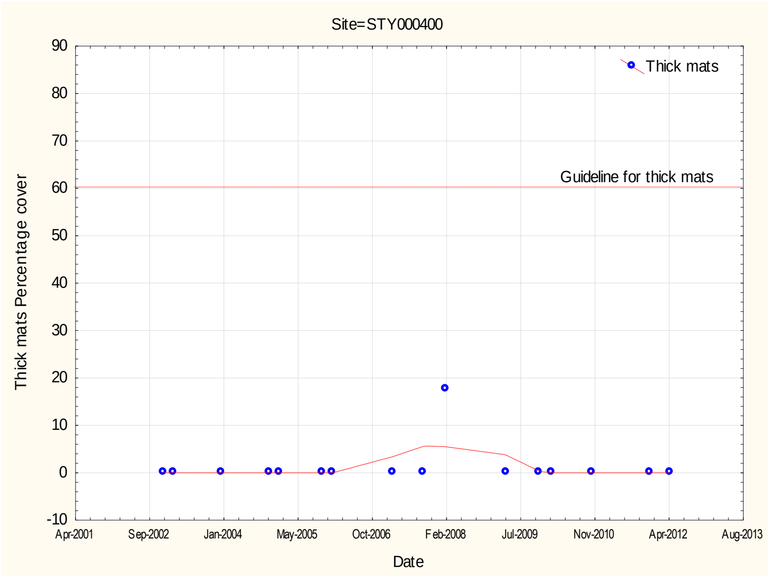
Figure 7 LOWESS trend analysis of percentage cover of thick mats at Stony River, Mangatete Road (STY000300)



n = 16
Kendal tau = -0.186467
p-value = 0.314
FDR p-value = 0.483

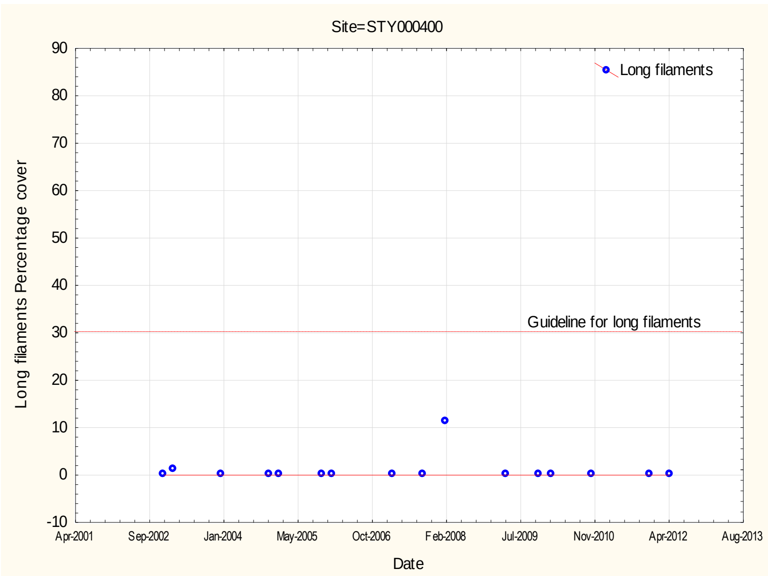
Figure 8 LOWESS trend analysis of percentage cover of long filaments at Stony River, Mangatete Road (STY000300)

At Mangatete Road (STY000300), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.070711) that was not significant at the 5% level (p =0.702). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.186467) that was not significant at the 5% level (p = 0.314).



n = 16
Kendal tau = 0.070711
p-value = 0.702
FDR p-value = 0.956

Figure 9 LOWESS trend analysis of percentage cover of thick mats at Stony River, SH45 (STY000400)



n = 16
Kendal tau = -0.152564
p-value = 0.410
FDR p-value = 0.585

Figure 10 LOWESS trend analysis of percentage cover of long filaments at Stony River, SH45 (STY000400)

At SH45 (STY000400), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.070711) that was not significant at the 5% level (p =0.702). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.152564) that was not significant at the 5% level (p = 0.410).

2.2 Maketawa Stream

The Maketawa Stream originates in the National Park, flowing approximately 25 kilometres north east before joining the Ngatoro Stream, shortly before this enters the Manganui River. Exotic trees, pasture and mixed vegetation are all present within the catchment.

The Maketawa stream contains good water quality throughout the whole catchment. This stream is subject to headwater erosion events which can lead to poorer water clarity and higher phosphorus values.

The Maketawa Stream has a catchment with high conservation status. Two sites have been located in this catchment to monitor periphyton communities (Figure 11). The top site (MKW000200) is 3.5km from the National Park boundary. Upstream of this site the stream has good riparian cover over most of this length. The bottom site (MKW000300) is in the lower reaches of a developed farmland catchment and is representative of a sub-catchment of the Manganui River and Waitara River catchments.

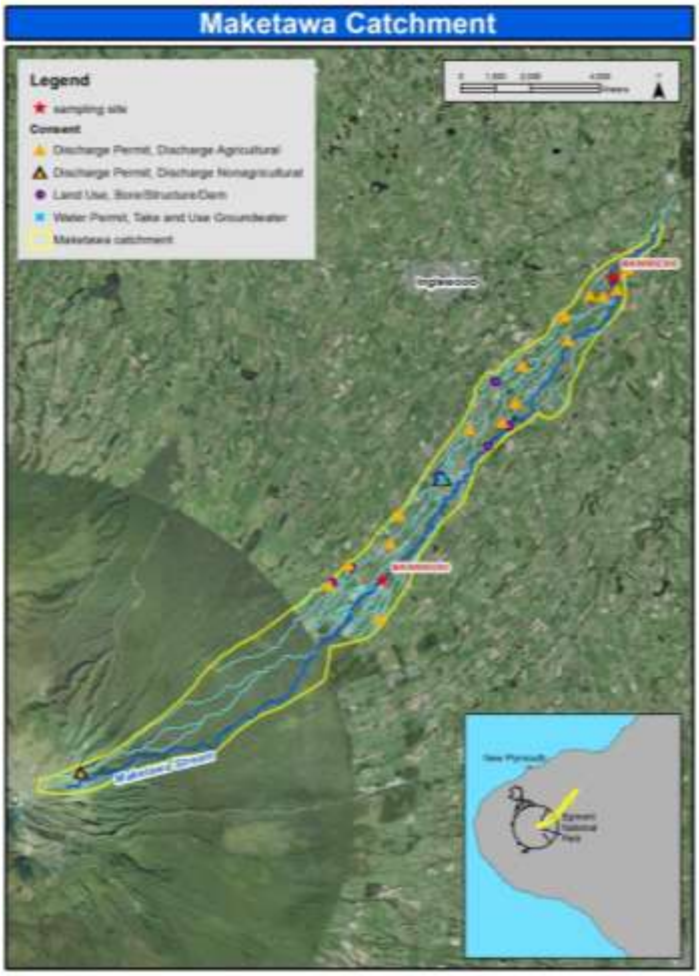


Figure 11 Monitoring site locations in relation to consents operating in the Maketawa Stream Catchment Manganui River

2.2.1 Flow data and survey dates

No continuous flow data is collected for the Maketawa Stream. The nearby Manganui River at SH3 has a telemetered hydrological monitoring station, and provides a general indication of the flow history in relation to sampling times in the Maketawa Stream catchment (Appendix).

In the 2010-2011 monitoring period, the beginning of spring was characterised by numerous floods, often exceeding 7x median flow. From mid October onwards flow receded and a long period of low flow was recorded up to mid December. A spring survey was undertaken 02-03 November 2010 when flow was close to MALF. Summer 2011 saw various floods intermittent with periods of receding and lower flows. Numerous floods in March and two small freshes in early April preceded the summer 2011 survey which was carried out on 08 April 2011.

Spring 2011 was relatively wet with frequent floods occurring throughout October and intermittently in November. A small period of lower flows in November allowed a spring survey to be carried out 21 November 2011. Summer also saw various flood events, particularly towards the end of February and throughout March. The summer periphyton survey was carried out 08 February 2012 during a small period of flow recession.

2.2.2 Periphyton cover

During the first four years that this programme had been operating (2002-2004), the upper catchment site was monitored at SH3 (MKW000250), after which time the site was moved upstream to Denby Road (MKW000200). This report looks at the Denby Road site and Tarata Road site from 2010-2012.

During the 2010-2011 monitoring period, nuisance periphyton was not present at either the mid-catchment site at Denby Road or at the lower catchment site at Tarata Road (Figure 12).

In the 2011-2012 monitoring period, nuisance periphyton was only recorded at the Denby Road site on one occasion. A small proliferation of long filamentous algae was recorded, well below the recommended guidelines (Figure 13). No nuisance periphyton was recorded at the Tarata Road site on any occasion.

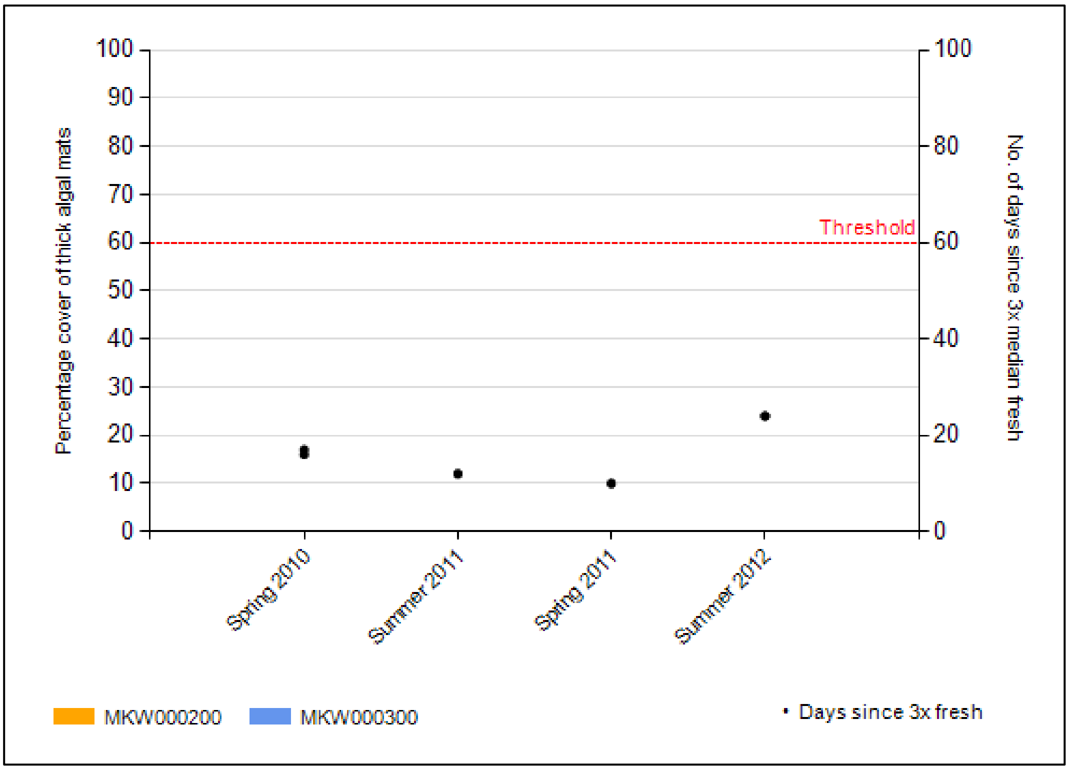


Figure 12 Percentage cover of thick mats of periphyton on the Maketawa streambed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

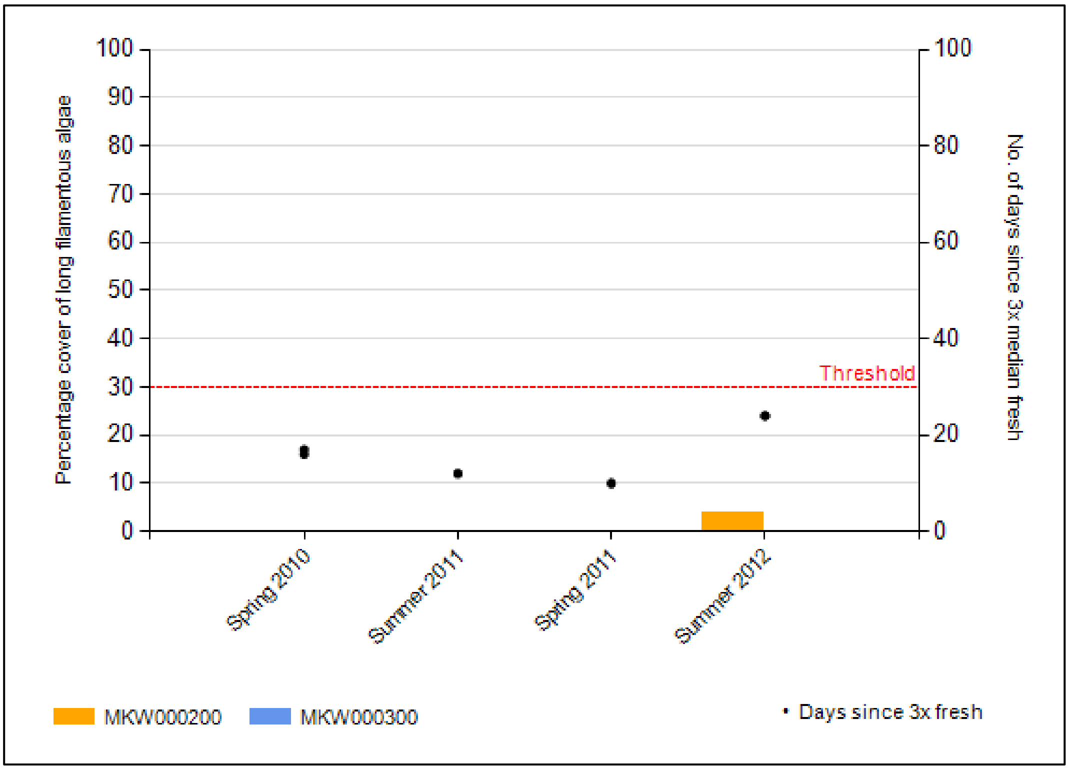


Figure 13 Percentage cover of long filamentous algae on the Maketawa streambed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

2.2.3 Periphyton Index Score

The Maketawa Stream had high TRC PI scores throughout the monitoring period (Table 8). On all but one occasion TRC PI scores exceeded historical medians. In summer 2012 the TRC PI at the upstream site (MKW000200) was 0.2 less than the historical median, but still had a high TRC PI rating. As reflected by both the current monitoring period results and the historical medians, the downstream site (MKW000300) consistently had a lower TRC PI rating. The difference in scores between the two sites is a likely reflection, in part of the agricultural land use between the sites and differences in nutrient inputs. For the period under review the drop in the overall TRC PI from upstream to downstream (a distance of approximately 13.3 km) was at a rate of 0.060 units per kilometre. This was similar to the 2006-2010 monitoring period but significantly less of a drop than the 2002-2006 monitoring period (TRC, 2008).

Table 8 shows how the TRC PI scores change from spring to summer at this site. There is occasionally a slight drop in TRC PI at each site from spring to summer, which could be expected through increased periphyton growth with warmer temperatures, and possibly less scouring events over the summer period. Compared with the historical TRC PI medians for summer, TRC PI scores at the downstream site for the current period have shown improvement from a moderate to a very good rating.

Table 8 Median seasonal periphyton index scores for Maketawa Stream. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
MKW000200	10.0	10.0	10.0	9.5	9.9	9.7
MKW000300	9.5	9.2	9.8	8.8	8.4	5.7
Difference	0.5	0.8	0.2	0.7	1.5	4.0

2.2.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Maketawa catchment from 2002-2012. Thick algal mats have never breached recreational guidelines at the two Maketawa Stream sites surveyed (Figure 14). Where thick mats have proliferated it has generally been at the downstream site. There have been odd occasions more so in the 2006-2010 monitoring period where thick algal mats upstream have proliferated to levels similar to the downstream site.

Long filamentous algae over the entire period has varied dramatically at both sites, with a higher cover present during summer periods during low flows, particularly at the downstream site (Figure 15). This has led to five breaches in the long filamentous guidelines at the downstream site, mostly within the summer seasons but with one event in spring 2005. These often, but not always coincided with longer periods of low flow. The upstream site occasionally recorded some nuisance growths of filamentous algae over the 2002-2010 monitoring period but not to the same extent as the downstream site. There were small proliferations of filamentous algae recorded at the upstream site over the more recent monitoring, well below guideline levels.

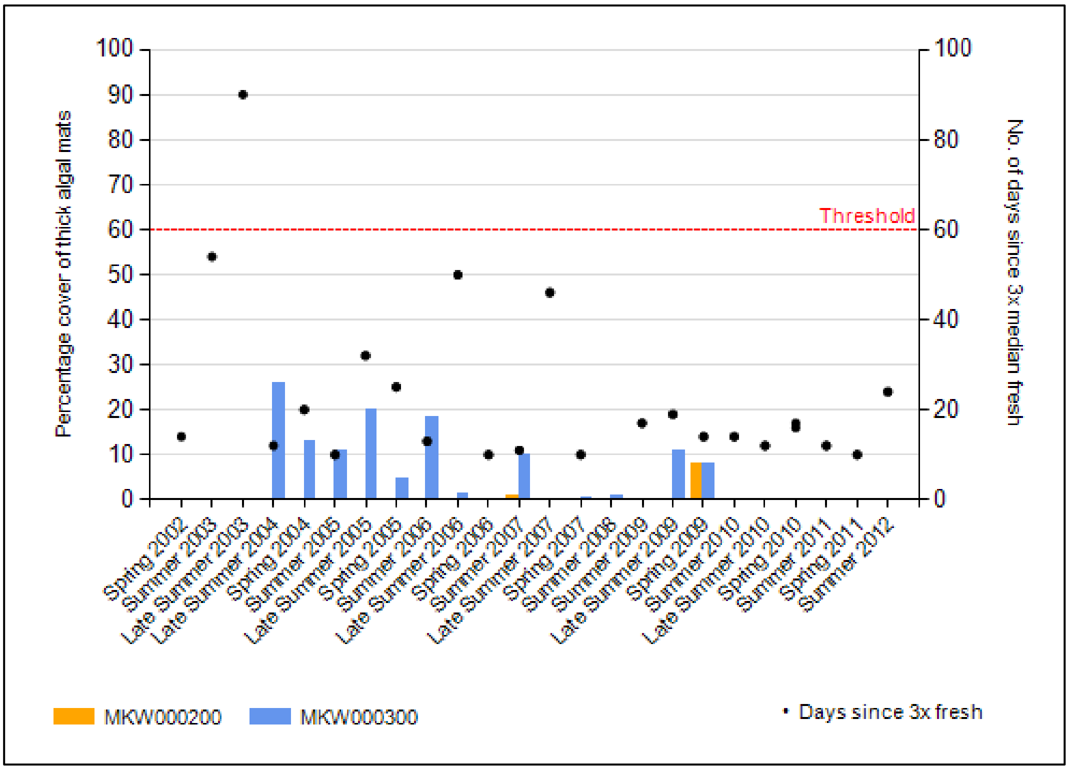


Figure 14 Percentage cover of thick mats of periphyton on the Maketawa streambed in relation to the guidelines for recreational values over the 2002-2012 period

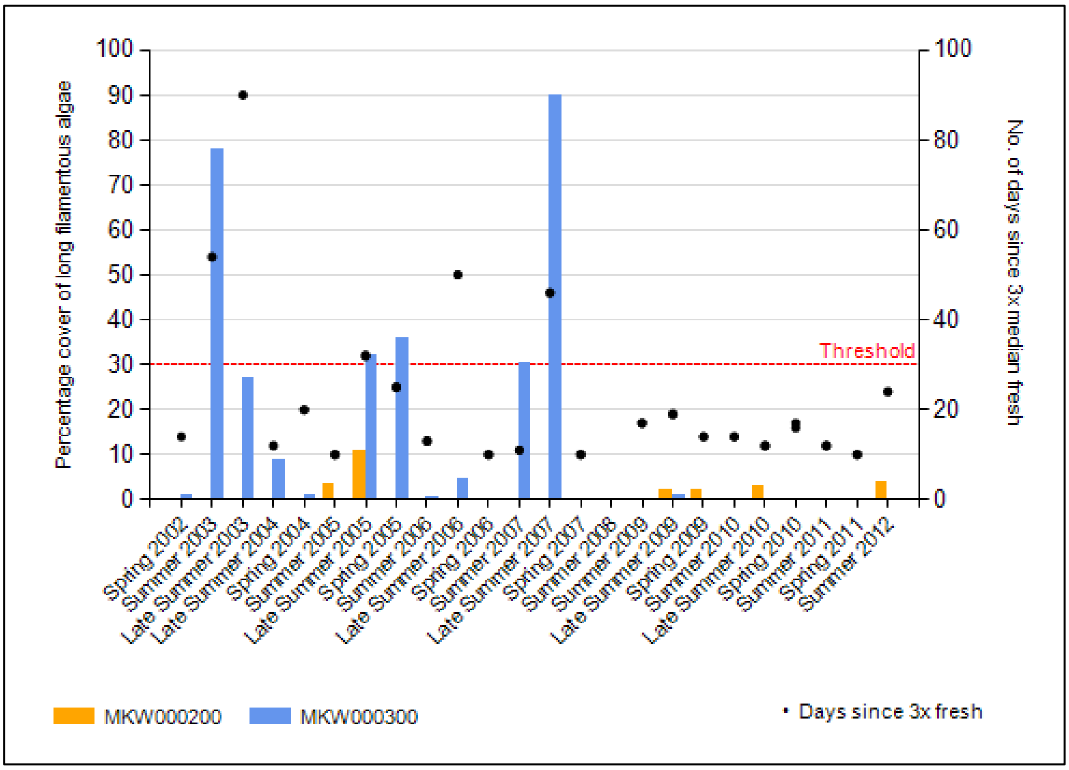
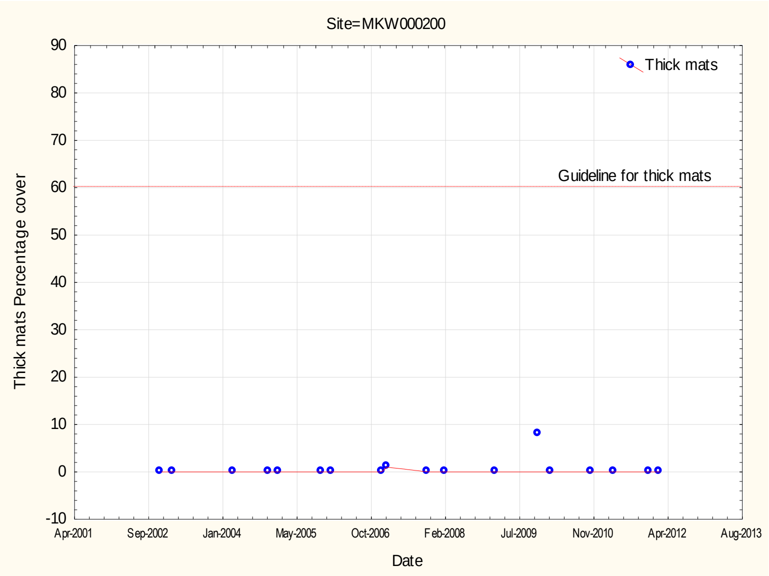


Figure 15 Percentage cover of long filamentous algae on the Maketawa streambed in relation to the guidelines for recreational values over the 2002-2012 period

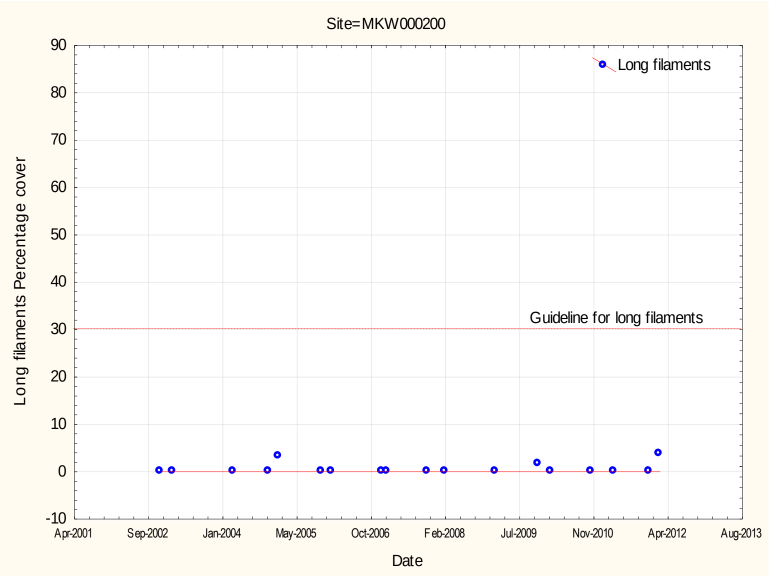
2.2.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Maketawa Stream, at Denby Road and Tarata Road over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 16 to Figure 19).



n = 18
Kendal tau = 0.098513
p-value = 0.568
FDR p-value = 0.956

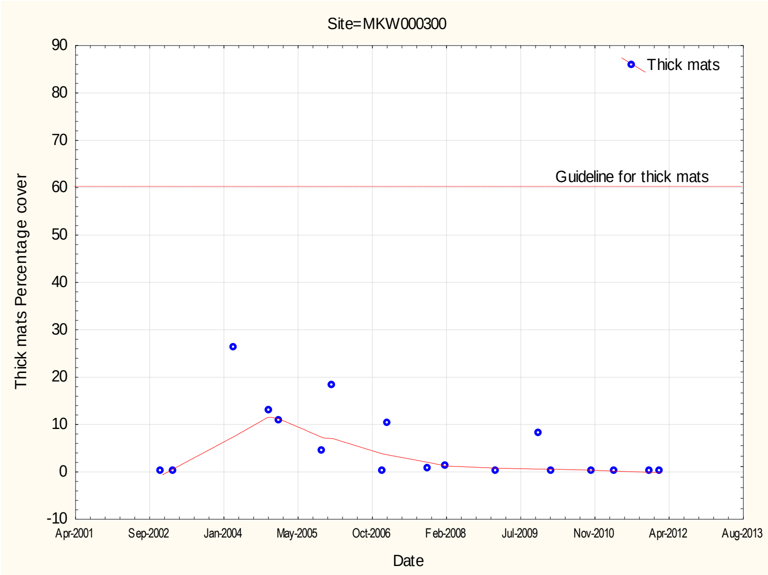
Figure 16 LOWESS trend analysis of percentage cover of thick mats at Maketawa Stream, Denby Road (MKW000200)



n = 18
Kendal tau = 0.186704
p-value = 0.279
FDR p-value = 0.465

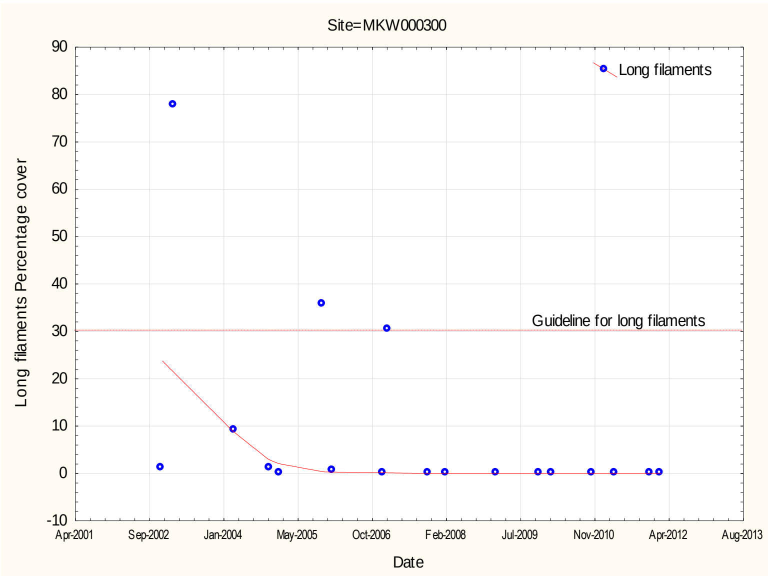
Figure 17 LOWESS trend analysis of percentage cover of long filaments at Maketawa Stream, Denby Road (MKW000200)

At Denby Road (MKW000200), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.098513) that was not significant at the 5% level (p =0.568). There was an increasing trend in percentage cover values of long filaments (Kendall tau =0.186704) that was not significant at the 5% level (p = 0.279).



n = 18
Kendal tau = -0.411078
p-value = 0.017
FDR p-value = 0.141

Figure 18 LOWESS trend analysis of percentage cover of thick mats at Maketawa Stream, Tarata Road (MKW000300)



n = 18
Kendal tau = -0.582810
p-value = 0.0007
FDR p-value = 0.011

Figure 19 LOWESS trend analysis of percentage cover of long filaments at Maketawa Stream, Tarata Road (MKW000300)

At Tarata Road (MKW000300), over the 10 year period monitored, there was decreasing trend in percentage cover values of thick mats (Kendall tau =-0.411078) that was significant using the Mann-Kendall test (p =0.017) but not significant after FDR application (p = 0.141).There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.582810) that was significant using the Mann-Kendall test (p =0.0007) and significant after FDR application (p = 0.011).

2.3 Manganui River

The Manganui River arises in the National Park and flows approximately 44 kilometres before joining the Waitara River; first heading east, then curving north near Midhirst through agricultural land.

The top site at SH3 (MGN000195) is located approximately 8 km downstream of the National Park boundary (Figure 20). The lower site is located at Bristol Rd (MGN000427), 38 km downstream of the National Park boundary, where the river is draining a largely agricultural catchment. The flow in this river is monitored continuously at both SH3 and at Everett Park (just downstream of the Bristol Road site).

There are two main abstractions from the Manganui River, with a significant consent relating to Trust Power Ltd, located at Tariki Road (downstream of the top site). Under this consent, much of the flow of the river is diverted through the Motukawa hydroelectric power scheme and then to the Waitara River. Therefore, except when the Tariki Rd weir is overtopping, most of the water in the Manganui River at Bristol Road (14 km downstream of this diversion) comes from tributaries such as the Mangamawhete, Waitepuke, Maketawa, and Ngatoro Streams.

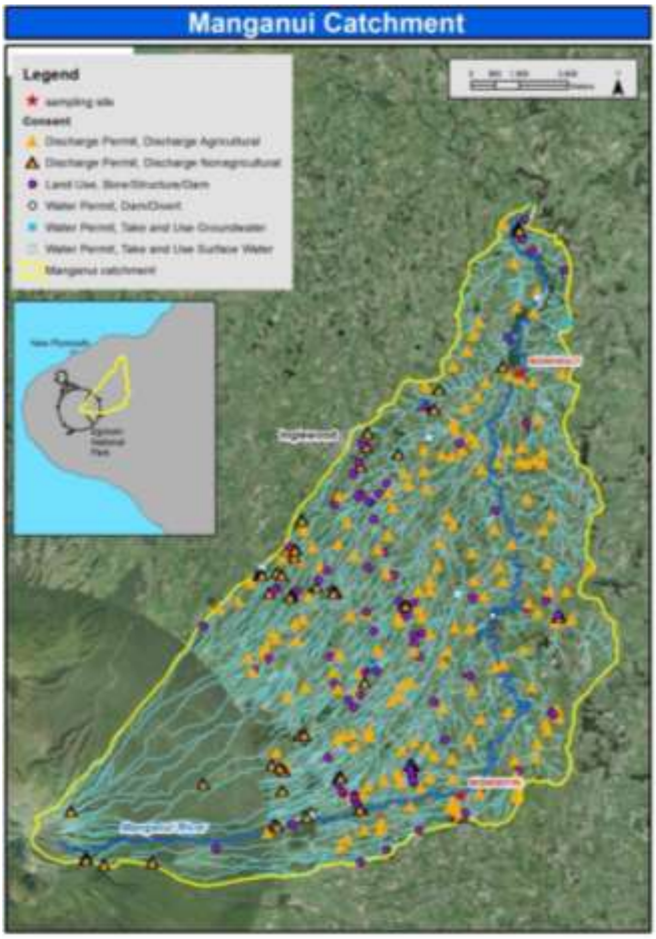


Figure 20 Monitoring site locations in relation to consents operating in the Manganui River catchment

2.3.1 Flow data and survey dates

In the 2010-2011 monitoring period, spring saw numerous floods in the Manganui River early in the season, with a flow recession and low flows recorded in the latter half of the season (Appendix). A spring survey was undertaken 02-03 November 2010 when flow was close to MALF. Numerous floods in March and two small freshes in early April preceded the summer 2011 survey which was carried out 08April 2011.

Spring 2011 experienced lower flows early on in the season, and higher than average flows with numerous flood events in the latter half of the season. A small period of lower lows in November allowed a spring survey to be carried out 21 November 2011. Summer also experienced numerous large flood events. March 2012, the month leading up to the summer survey, was particularly wet, with six flood events, (exceeding 7 x median) occurring over this period. The summer periphyton survey was carried out 05April 2012 during a period of relative flow recession.

2.3.2 Periphyton cover

The Manganui River was characterised by no nuisance periphyton in the upper catchment at SH3, with an increase in periphyton cover further down the catchment at Bristol Road, with filamentous algae generally dominating the community (Figure 21 and Figure 22). No breech of guidelines occurred at either the upstream or the downstream site for long filaments or thick mats over the 2010-2012 monitoring years.

In the 2010-2011 monitoring year, the upstream site at SH3 recorded no nuisance algal cover. At the upstream site the Manganui River is well shaded by riparian vegetation, with good riparian vegetation also present between the National Park and SH3 site. This shade, in conjunction with the high water quality, is likely to limit the growth of periphyton at this site. At the downstream site at Bristol Road a moderate percentage cover of long filamentous and thick mats of algae was recorded.

Again, in the 2011-2012 monitoring year, no nuisance periphyton was recorded at the upstream site at SH3. In spring 2011 long filamentous algae was recorded at the downstream site at Bristol Road at a low 6% coverage. In summer 2012, long filamentous algae continued to dominate the community with a 19% coverage compared to 3% coverage of thick mats. At the Bristol Road site, the bed is much wider and consequently less shaded, thus supporting greater proliferations of periphyton compared to the upstream site.

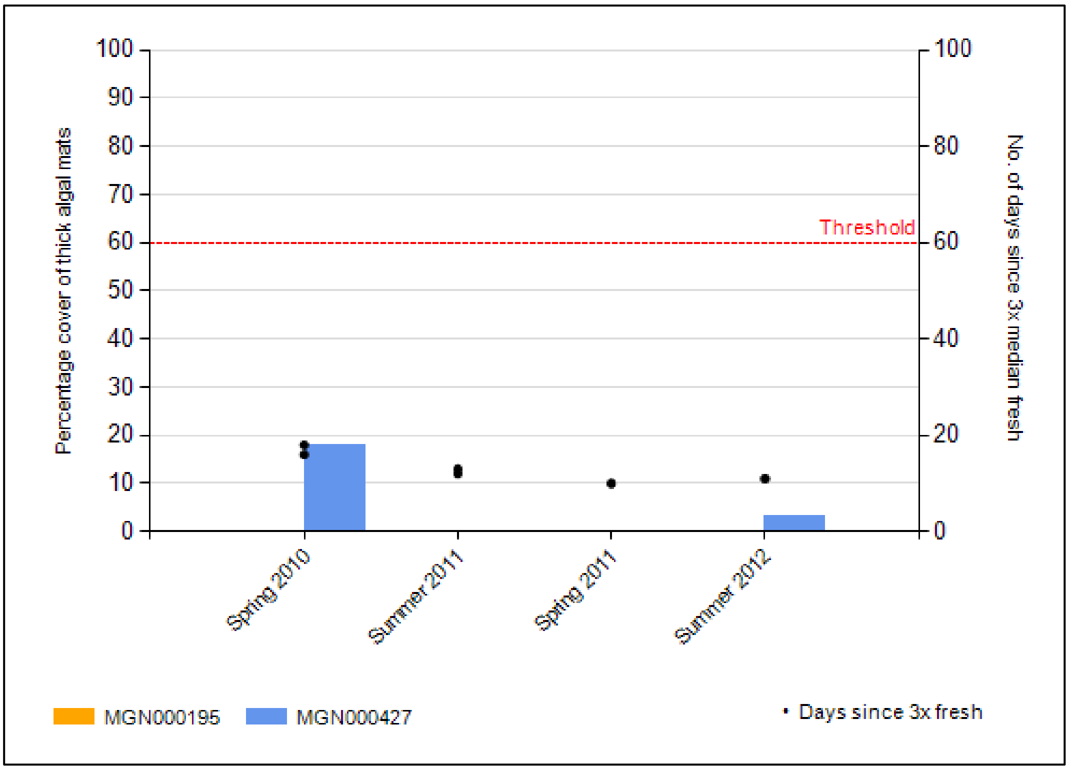


Figure 21 Percentage cover of thick mats of periphyton on the Manganui riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

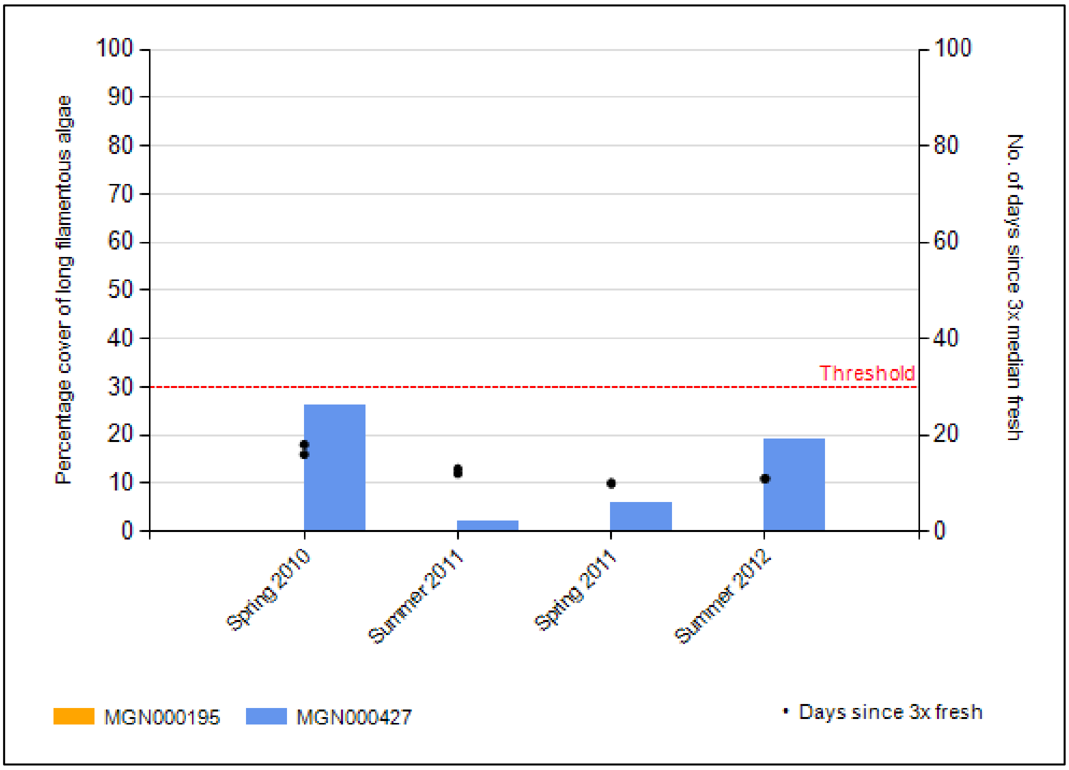


Figure 22 Percentage cover of long filamentous algae on the Manganui riverbed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

2.3.3 Periphyton Index Score

The Manganui River typically recorded moderate differences in TRC PI between upstream and downstream sites (Table 9). The upstream site consistently recorded a 'very good' TRC PI, reflective of its low nutrient input and good riparian shading. In contrast, the downstream site occasionally recorded a 'moderate' TRC PI, which reflects (amongst other factors) an increased nutrient input, but also the lack of shading at this site. This drop in TRC PI score occurred over a reach of approximately 29 kilometres, which is at a rate of 0.076 units per kilometre.

Table 9 Median seasonal periphyton index scores for Maketawa Stream. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
MGN000195	9.9	10	9.8	10.0	9.6	9.8
MGN000427	5.3	9.1	8.2	7.4	6.8	6.6
Difference	4.6	0.9	1.6	2.6	2.8	3.2

Table 9 shows that the TRC PI at the upstream site is relatively stable throughout spring and summer, consistently scoring a 'very good' rating. The periphyton community is likely to be controlled by nutrient supply, shading and also through invertebrate grazing at this site. The lower site had a much lower median TRC PI rating and scored a lower TRC PI on every sampling occasion, implying fewer limits on the periphyton community. Unlike the historical medians, it is interesting that both the upstream and downstream sites had a higher TRC PI score in summer rather than in spring. It is unclear why this is. In the previous (2006-2010) report periphyton communities showed a similar pattern, with the TRC PI increasing in the summer period. However the 2002-2006 results showed a decrease in periphyton score from spring to summer which is more typical of periphyton growth habits.

2.3.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Manganui catchment from 2002-2012. Overall at the downstream Bristol road site the periphyton community throughout the 10 year period of monitoring is substantially weighted to long filamentous algae growths rather than thick mats during periods of periphyton proliferation (Figure 23 and Figure 24). There were no breaches in guidelines for thick algal mats at either site over the entire 10 year period. The upper site at SH3 was generally more prone to thick algal mat than long filamentous algae growths particularly over the 2005-2007 monitoring years.

The lower catchment site breached long filamentous guidelines one three occasions over the 10 year period. These breaches were constrained to summer periods. The summer of 2004 recorded two breaches for long filamentous algae at the downstream site, while the highest breach was in summer 2006. During 2006-2010 and 2010-2012 there were no breaches of long filamentous guidelines. However there was generally always a slight proliferation of these nuisance growths in most surveys undertaken, more so than thick algal mats.

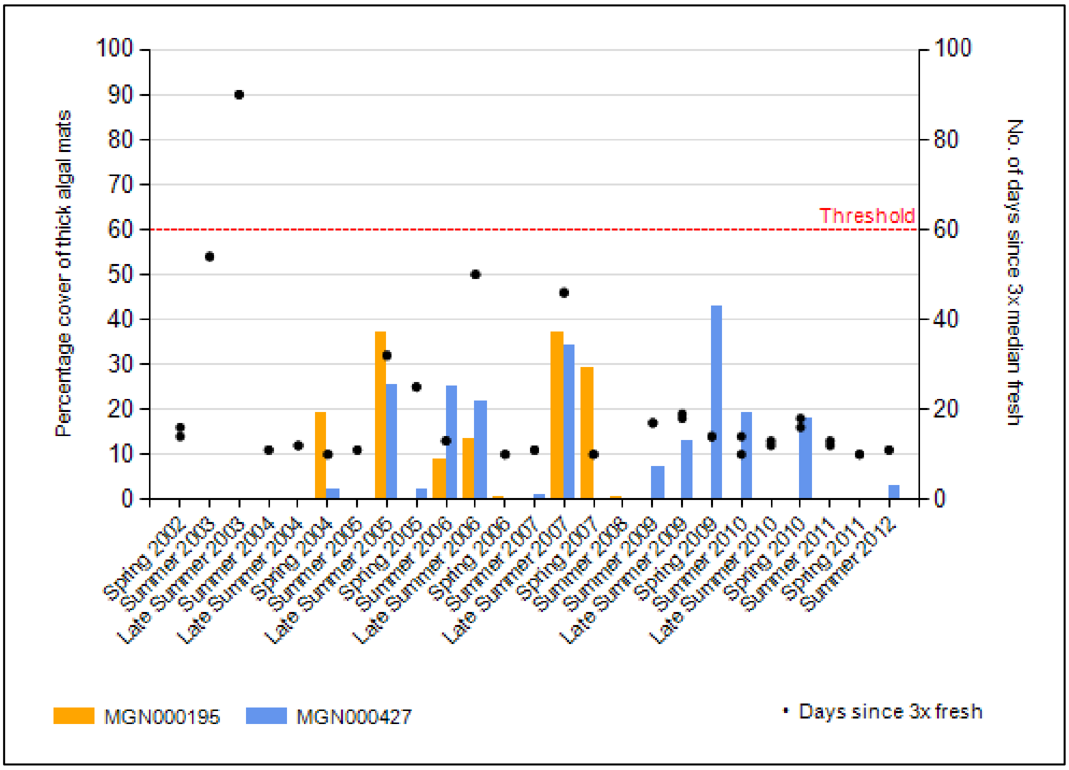


Figure 23 Percentage cover of thick mats of periphyton on the Manganui riverbed in relation to the guidelines for recreational values over the 2002-2012 period

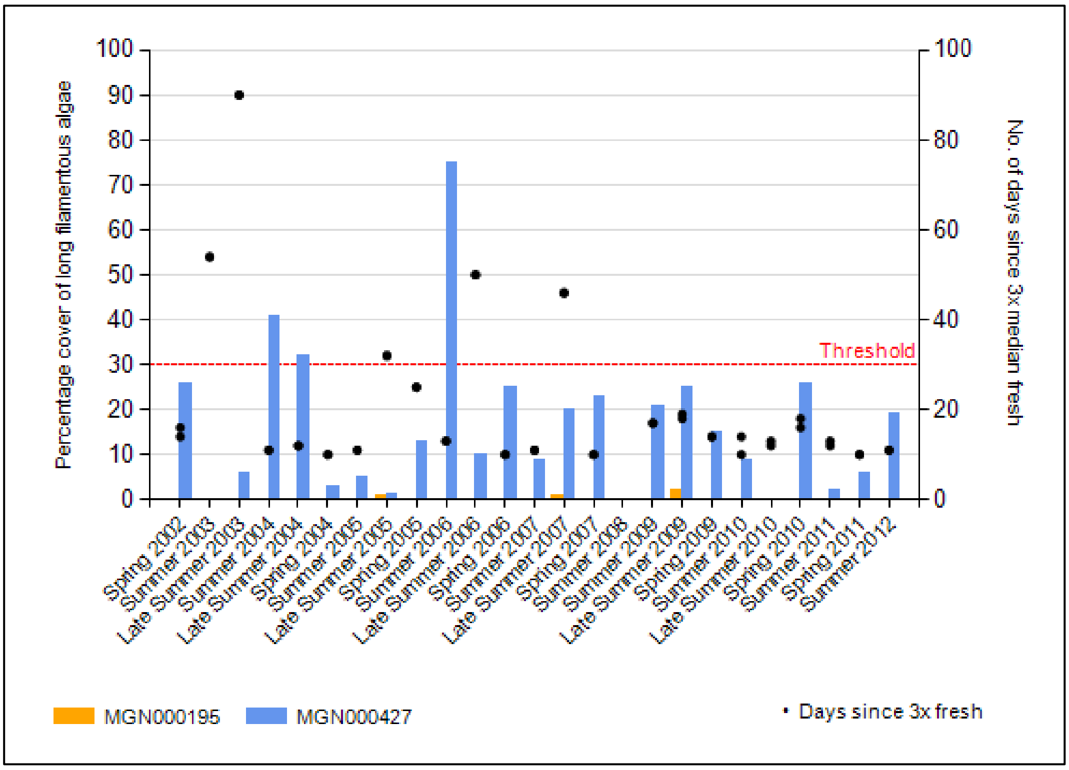
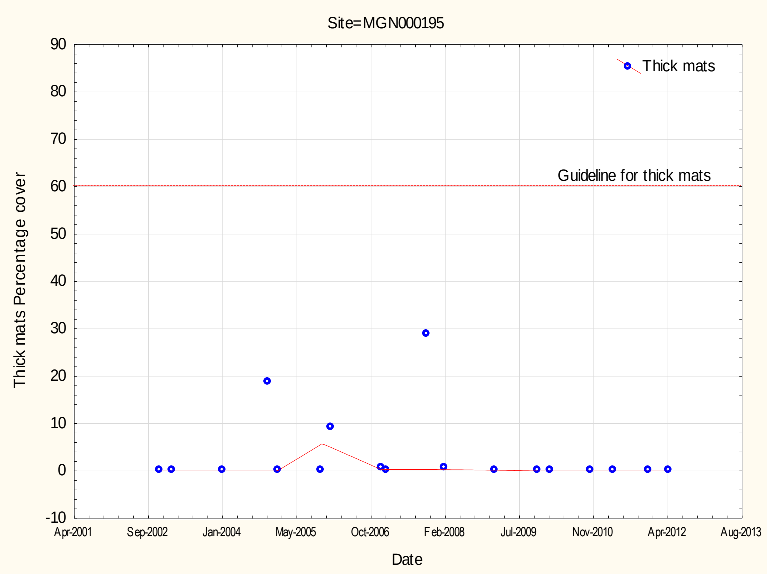


Figure 24 Percentage cover of long filamentous algae on the Manganui riverbed in relation to the guidelines for recreational values over the 2002-2012 period

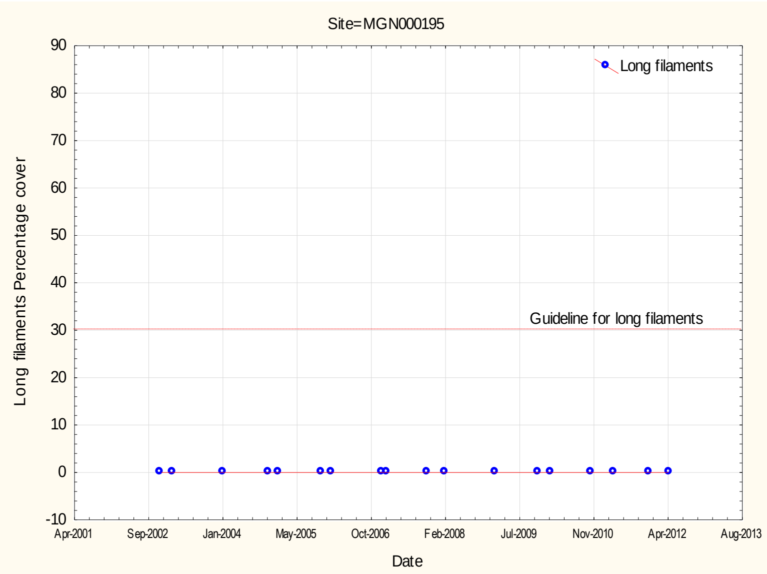
2.3.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Manganui River, at SH3 and at Bristol Road, over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 25 to Figure 28).



n = 18
Kendal tau = -0.169165
p-value = 0.327
FDR p-value = 0.763

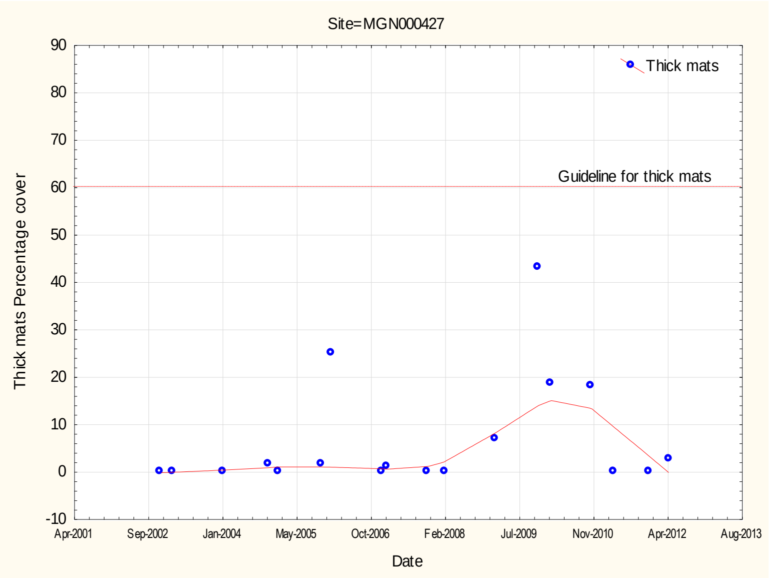
Figure 25 LOWESS trend analysis of percentage cover of thick mats at Manganui River, SH3 (MGN000195)



n = 18
Kendal tau = 0
p-value = 0
FDR p-value = 0

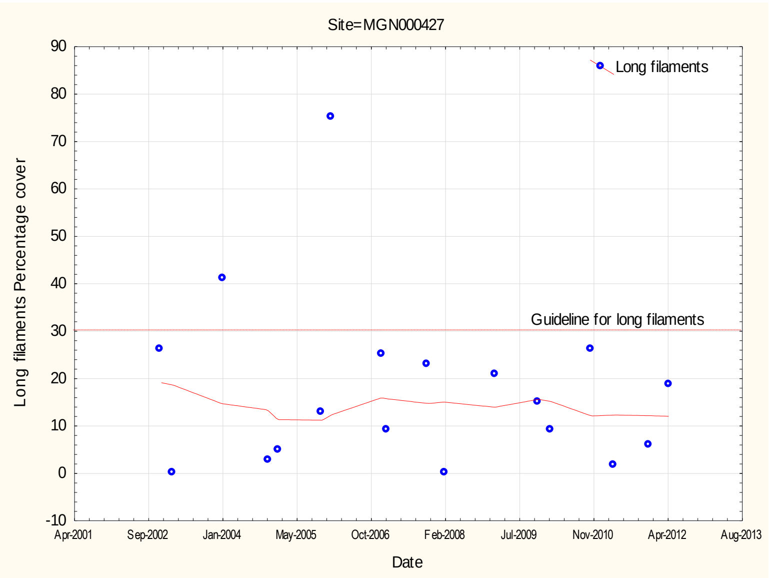
Figure 26 LOWESS trend analysis of percentage cover of long filaments atManganui River, SH3 (MGN000195)

At SH3 (MGN000195), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau =-0.169165) that was not significant at the 5% level (p = 0.327). There was no trend in percentage cover values of long filaments at SH3 (MGN000195).



n = 18
Kendal tau = 0.240201
p-value = 0.164
FDR p-value = 0.740

Figure 27 LOWESS trend analysis of percentage cover of thick mats at Manganui River, Bristol Road (MGN000427)



n = 18
Kendal tau = -0.066010
p-value = 0.702
FDR p-value = 0.780

Figure 28 LOWESS trend analysis of percentage cover of long filaments at Manganui River, Bristol Road (MGN000427)

At Bristol Road (MGN000427), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.240201) that was not significant at the 5% level (p = 0.164). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.066010) that was not significant at the 5% level (p = 0.702).

2.4 Patea River

The Patea River arises in the National Park, winding over 80 km in a curve; first heading east then south to the coast. Water quality is better in the upper reaches then deteriorates in the lower reaches as it travels through pasture and receives wastes such as treated dairy effluent and the discharge from the Stratford oxidation pond system, and is also joined by other rivers such as Mangaehu River (TRC, 1991).

The Patea has native forest in its headwaters, while the mid-low reaches comprise exotic forest and pasture. The top site (Barclay Road, PAT000200) is just below the boundary of National Park and as such the water quality here is very good (Figure 29). The lower site, at Skinner Road (PAT000360), is mid-catchment and below several discharges, including the Stratford municipal oxidation ponds, Stratford cycle power station discharge, and inputs from industrial discharge from the Kahouri Stream. The surrounding area is predominantly agricultural, and as such has a lesser water quality with a higher level of nutrients and lower clarity compared to the upper catchment site.

The lower catchment site at Skinner Road is monitored continuously for flow as part of the Council's hydrological telemetry system.

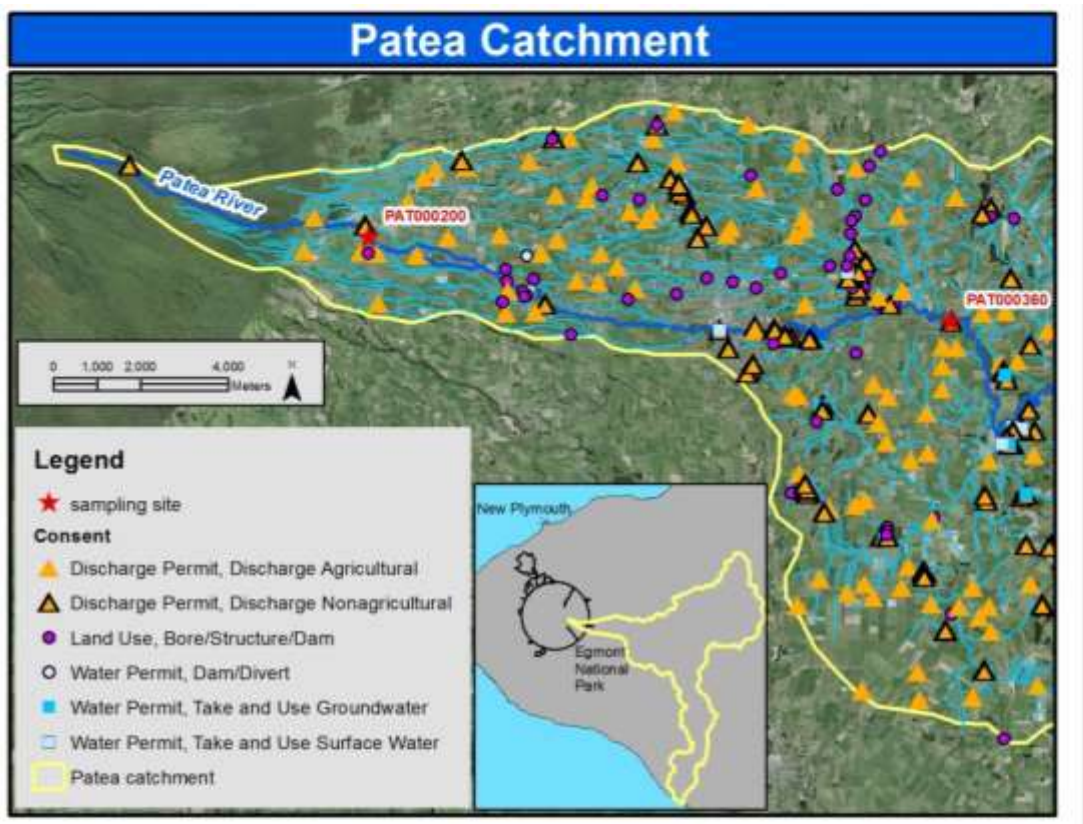


Figure 29 Monitoring site locations in relation to consents operating in the Patea River Catchment

2.4.1 Flow data and survey dates

The 2010-2011 monitoring year consisted of high spring flows throughout September and October, followed by a period of low flows in November and early December (Appendix). Spring sampling was carried out in 03 November 2010 during a period of recession when flows came close to MALF. The summer of 2011 was relatively wet with flood events occurring in late January and throughout March, April and May. The summer survey was completed after a series of small freshes, during a period of receding flows on 29 March 2011.

In spring 2011 flows remained relatively high throughout the month of October. A spring survey was carried out 17 November 2011 after a period of flow recession beginning early November, and ending early December. Summer 2012 saw a series of significant floods in the months of January and March. A summer periphyton survey was conducted in 01 February 2012 after a period of low flows that spanned from late January to mid February.

2.4.2 Periphyton cover

Nuisance periphyton at Barclay Road and at Skinner Road did not exceed guideline levels over the 2010-2012 monitoring periods. The amount of periphyton proliferation was comparatively much greater at the lower Skinner Road site, where long filaments dominated algal communities on all sampling occasions.

In the 2010-2011 monitoring year, no periphyton mats or filaments were recorded in the upper site at Barclay Road (Figure 30 and Figure 31). The complete shading by native riparian vegetation at this site, and for most of the upstream reach to the nearby National Park, is likely to limit periphyton growth to thin films.

At the mid catchment site at Skinner Road, proliferation of periphyton increased from spring to summer in the 2010-2011 monitoring year. Both mats and filaments of periphyton were visible during the summer 2011 survey, whereas in spring 2010 only filamentous algae were recorded. On both occasions the site did not exceed the guideline levels of coverage for recreational and aesthetic values.

Again, in the 2011-2012 monitoring year, no periphyton mats were recorded at Barclay Road, close to the National Park. Only a small amount of filamentous algae was visible in the summer of 2012, with levels well below the recommended guidelines.

In spring 2011 no periphyton mats were recorded at Skinner Road and only a small amount of long filamentous algae was recorded. In summer 2012, filamentous algae continued to dominate the periphyton community, increasing from spring to summer. A small proliferation of thick algal mats was also present with cover slightly higher than the previous year but still below the recommended guidelines.

Differences in algal cover may be explained by variations in nutrient levels between the two sites. The mid-catchment site at Skinner Road is situated below the Stratford Township and the discharge from the municipal wastewater treatment plant, thus nutrient levels are relatively high. Nutrient concentrations at the upper catchment

Barclay Road site are much lower, except occasionally for phosphorus, which is naturally high in many of the ring plain streams of Taranaki.

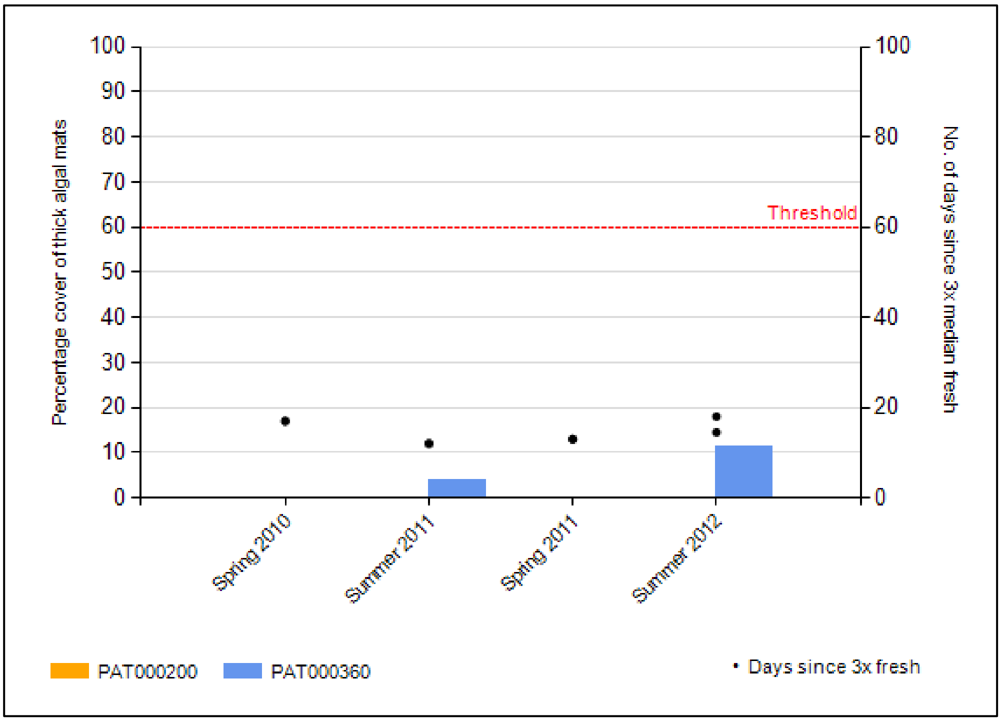


Figure 30 Percentage cover of thick mats of periphyton on the Patea riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

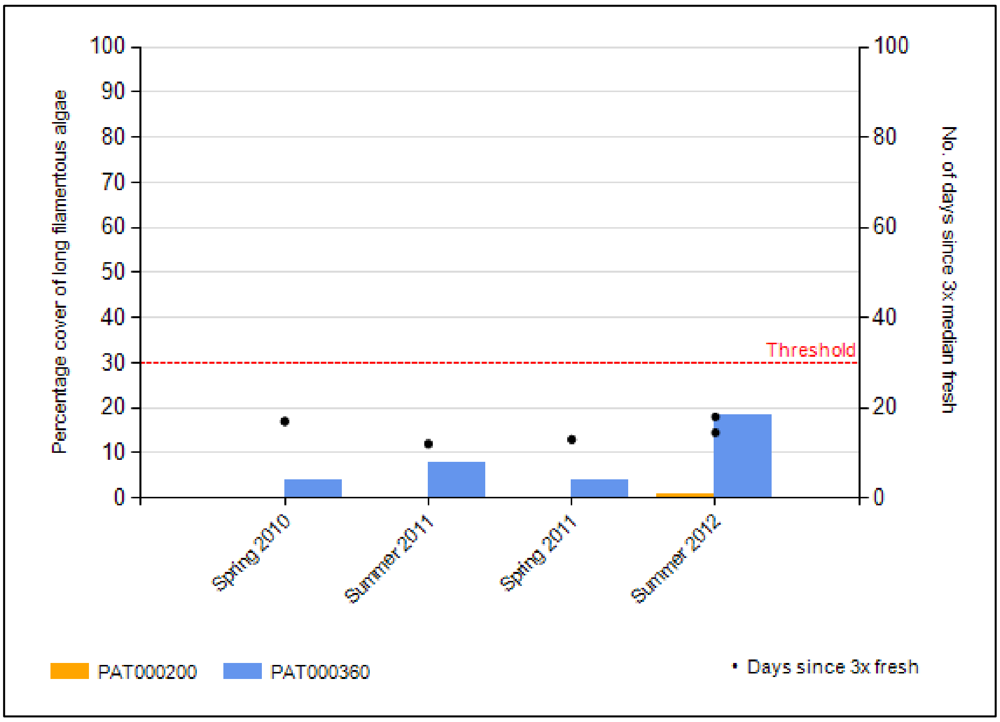


Figure 31 Percentage cover of long filamentous algae on the Patea riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

2.4.3 Periphyton Index Score

The upstream site on the Patea River (PAT000200) benefits from extensive riparian planting and low nutrient input, consequently it has a consistently ‘very good’ TRC PI value. In contrast, the downstream site (PAT000360) which receives a lot of runoff from agricultural pasture, and also receives the Stratford waste water discharge, generally has a ‘good’ to ’very good’ TRC PI value (Table 10). A drop in TRC PI score of 2 units over 17.2 kilometres, (a rate of 0.116 units per kilometre) was recorded; the highest rate of periphyton community degradation per distance downstream of all the rivers discussed.

Table 10 Median seasonal periphyton index scores for the Patea River. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
PAT000200	10.0	10.0	9.6	9.4	9.6	9.9
PAT000360	8.5	7.0	9.0	6.1	6.9	5.7
Difference	1.5	3.0	0.6	3.3	2.7	4.2

It is clear from the TRC PI results that the upstream site has a consistently high TRC PI, with no major change with season, while the downstream site sees a drop in TRC PI in summer from spring. However this mid-catchment stretch has an improved periphyton score in comparison to the historical summer medians, being greater by 1.3 units in 2011 and 0.4 units in 2012.

2.4.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Patea catchment from 2002-2012. Over the entire period, the Patea River has never breached thick algal mat periphyton guidelines (Figure 32). Proliferations of thick mats were usually more frequent and prolific at the lower site at Skinner Road. Thick algal mats were recorded at the upstream site at Barclay Road mostly during the 2006-2010 monitoring years, particularly over dry periods such as that of spring 2007. Over the 2010-2012 monitoring period, minor proliferations of thick mats only occurred at the lower site at Skinner Road.

At the downstream site at Skinner Road, large proliferations of long filamentous algae led to many breaches earlier in the 10 year period of monitoring (Figure 33). There were seven breaches in long filamentous guidelines from 2002-2006. In the 2006-2010 period there had been less frequent occurrences of long filamentous algae, but the two breaches recorded in summer 2007 and late summer 2009 were the highest percentages recorded over the 10 year period. These breaches do correspond to periods of low flow. There have been periods where flows have been much higher and periphyton proliferation has been lower (summer 2001 and summer 2003). No breaches for long filamentous periphyton occurred over the current period, with minor proliferations occurring mostly at the lower site at Skinner Road.

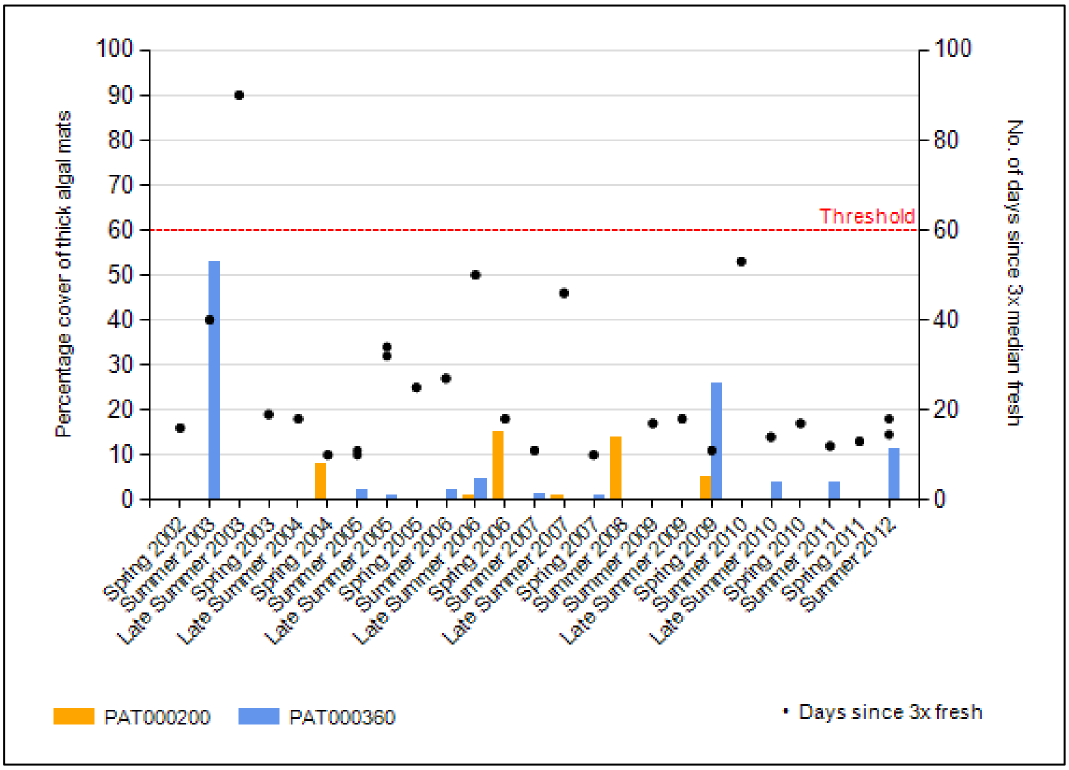


Figure 32 Percentage cover of thick mats of periphyton on the Patea riverbed in relation to the guidelines for recreational values over the 2002-2012 period

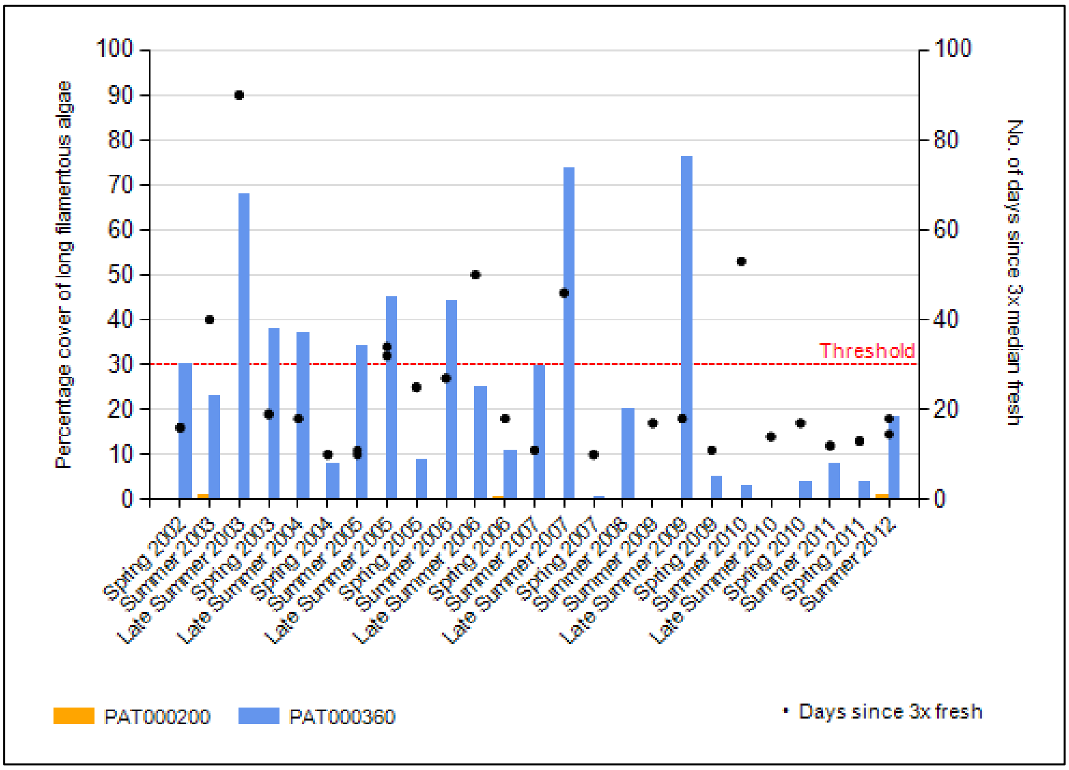
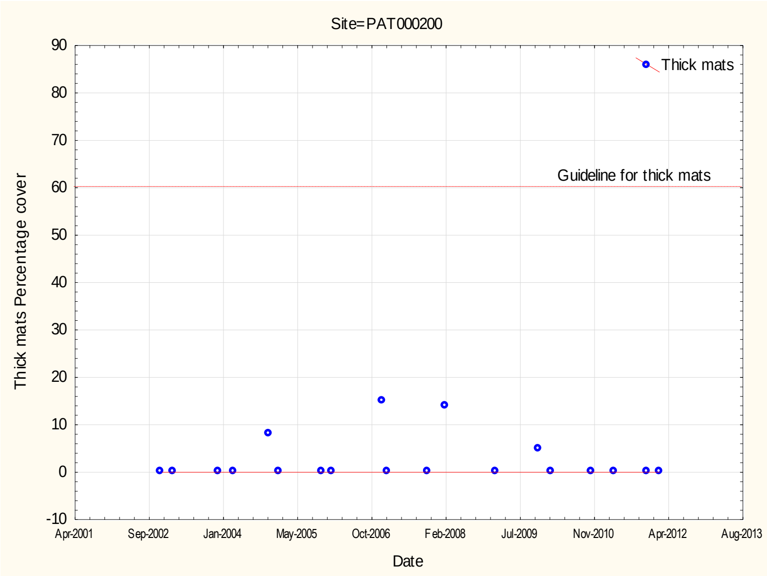


Figure 33 Percentage cover of long filamentous periphyton on the Patea River streambed in relation to the guideline for recreational values over the 2002-2012 period

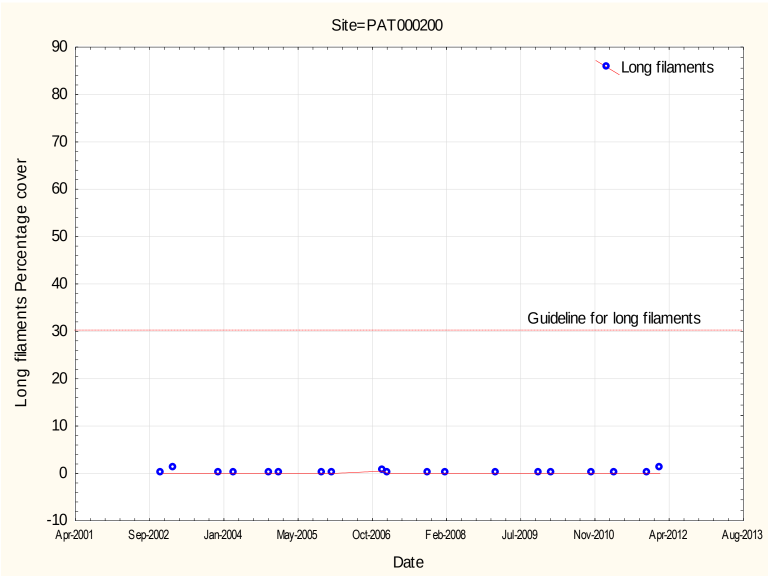
2.4.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Patea River, at Barclay Road, and Skinner Road over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 34 to Figure 37).



n = 19
Kendal tau = -0.018826
p-value = 0.910
FDR p-value = 0.956

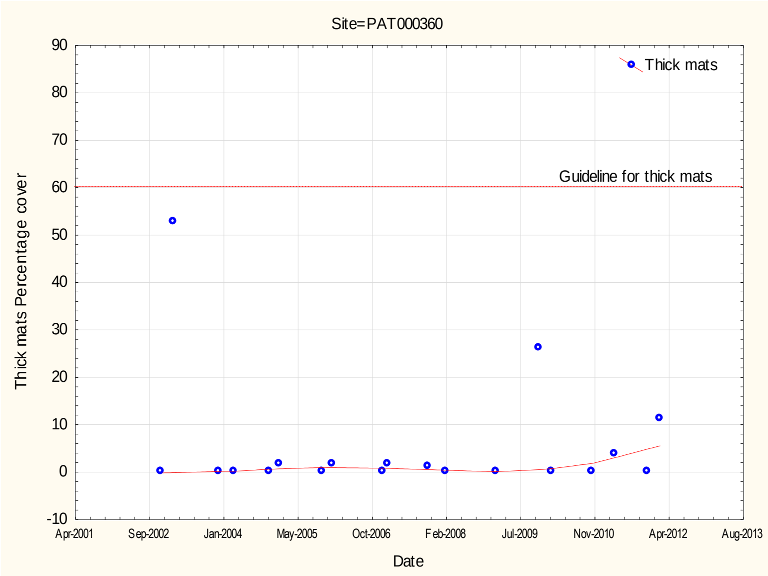
Figure 34 LOWESS trend analysis of percentage cover of thick mats at Patea River, Barclay Road (PAT000200)



n = 19
Kendal tau = 0.00
p-value = 1.00
FDR p-value = 1.00

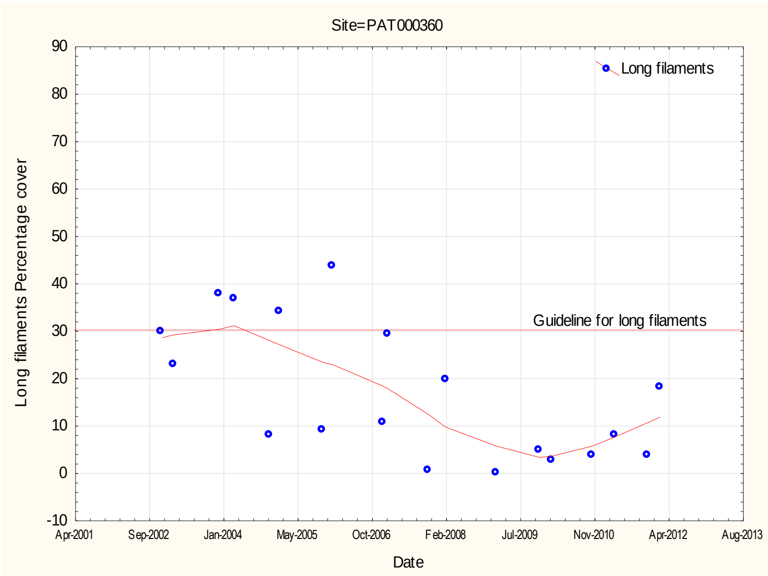
Figure 35 LOWESS trend analysis of percentage cover of long filaments at Patea River, Barclay Road (PAT000200)

At Barclay Road (PAT000200), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau =-0.018826) that was not significant at the 5% level (p = 0.910). There was no trend in percentage cover values of long filaments.



n = 19
Kendal tau = 0.092704
p-value = 0.579
FDR p-value = 0.956

Figure 36 LOWESS trend analysis of percentage cover of thick mats at Patea River, Skinner Road (PAT000360)



n = 19
Kendal tau = -0.405889
p-value = 0.015
FDR p-value = 0.076

Figure 37 LOWESS trend analysis of percentage cover of long filaments at Patea River, Skinner Road (PAT000360)

At Skinner Road (PAT000360), over the 14 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.092704) that was not significant at the 5% level (p = 0.579). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.405889) that was significant using the Mann-Kendall test (p =0.015) but not significant after FDR application (p = 0.076).

2.5 Waiwhakaiho River

The Waiwhakaiho River originates in the National Park, winding approximately 30 kilometres past Egmont Village in a north east direction to the coast, with the mouth of the river situated at the north end of New Plymouth. The river is representative of a large catchment with multiple impacts, with the upper catchment below the National Park boundary comprising primarily agriculture, and the lower catchment comprising urban and industrial areas.

The top sampling site (WKH000500) at SH3, Egmont Village is representative of the mid catchment (9km downstream of National Park boundary), draining developed farmland and is immediately upstream of the major diversion site for the New Plymouth water supply and the Mangorei HEP scheme (Figure 38). The bottom site (WKH000920) at Constance Street is approximately two kilometres from the mouth of the river and is markedly influenced by changes in flow due to hydroelectric generation releases from the HEP scheme and various municipal and industrial impacts in the lower catchment.

A telemetered river flow recording station is present at the site located at SH3, near Egmont Village.

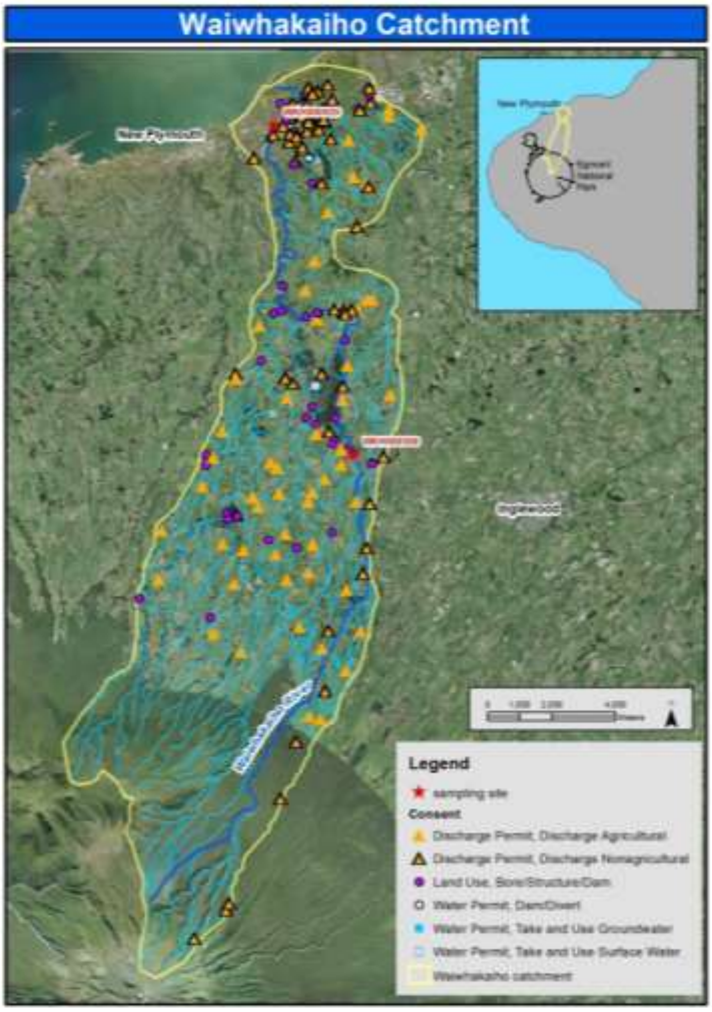


Figure 38 Monitoring site locations in relation to consents operating in the Waiwhakaiho River catchment

2.5.1 Flow data and survey dates

In the 2010-2011 monitoring year, floods were frequent throughout September and October (Appendix). A flood event in mid October was followed by a period of relative flow recession, lasting through to mid December. Spring sampling was carried out 02 November 2010 when flows came close to MALF for this site. The summer of 2011 saw several floods, with the highest flows recorded in early March. This was followed by a short period of recession, which allowed a summer periphyton survey to be carried out 16 March 2011 when flows were around MALF.

A spring survey was not carried out in the 2011-2012 monitoring year due to numerous flood events and subsequent high flows that occurred throughout the season. Flooding was also frequent in summer 2012, with significant flood events occurring in early January and throughout March. A summer survey was carried out 04 April 2012 after a period of flow recession that occurred between late March and late April.

2.5.2 Periphyton cover

In spring 2010 filamentous algae dominated the community at the middle catchment site at SH3; no thick periphyton mats were recorded (Figure 39 and Figure 40). A decrease (17%) in filamentous algae and an increase (5%) in algae mats was recorded from spring 2010 to summer 2011.

In the lower catchment at Constance Street, small proliferations mats and filaments were recorded in the spring survey 2010. A decrease in both mats and filaments was seen from spring to summer, with only a very small percentage of long filamentous algae recorded.

In the 2011-2012 monitoring year no spring survey was carried out due to weather constraints. In the summer survey of 2012 no mats or filaments were recorded at SH3. Unlike the previous summer, algal mats were present at the Constance Street site, but at levels well below the aesthetic and recreational guidelines. No long filamentous algae was recorded. A large number of scouring floods that occurred in the six weeks leading up to this survey may explain the overall low values for periphyton growths recorded during the 2011-2012 monitoring year.

The presence of filamentous algae, seen in greater amounts at the upper, mid-catchment site (at SH3, near Egmont Village) is not unexpected as the substrate between the two survey sites differs significantly. At SH3 the substrate is dominated by large boulders which provides a very stable substrate which is less susceptible to scouring during flood events. At Constance Street the substrate has a greater proportion of cobbles which are more likely to move during floods, regulating the amount of filamentous algae through scouring of the periphyton that could otherwise accumulate on more stable substrates.

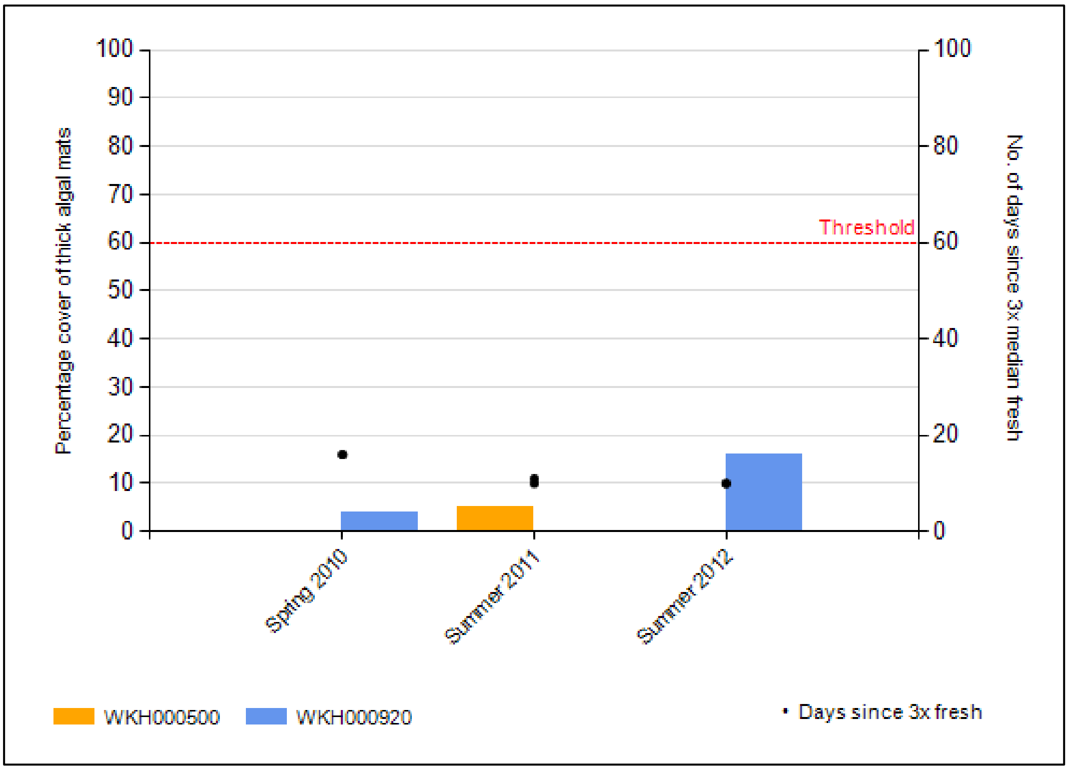


Figure 39 Percentage cover of thick mats of periphyton on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

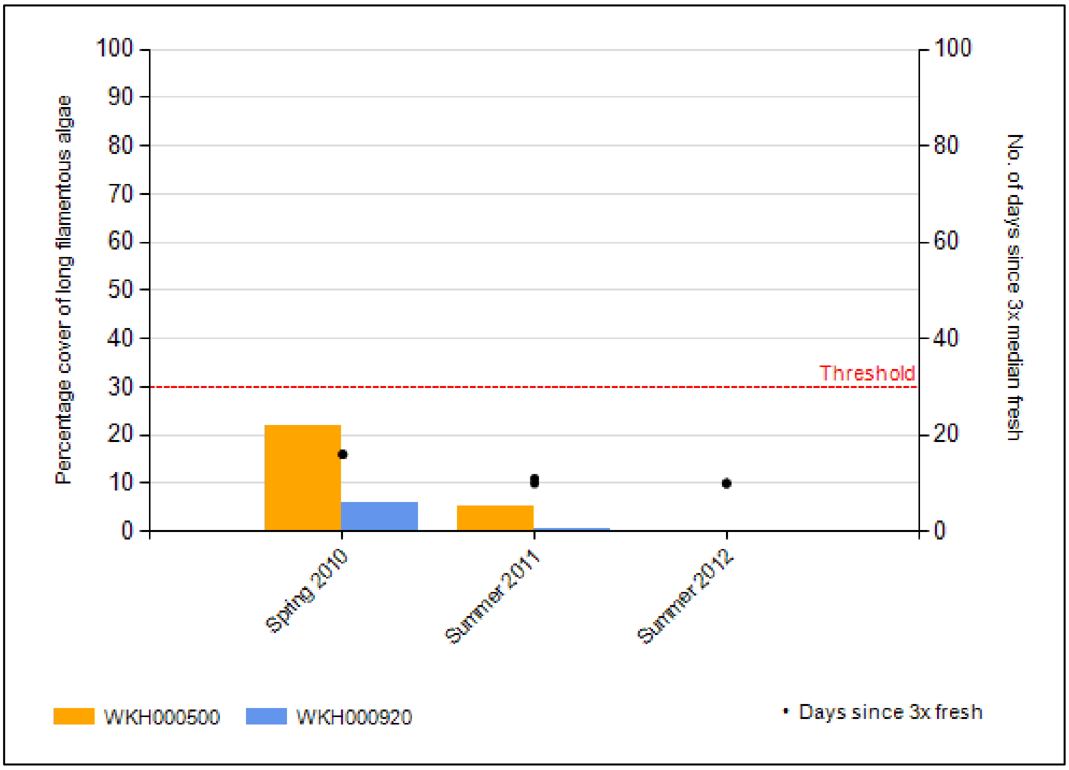


Figure 40 Percentage cover of long filamentous algae on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

2.5.3 Periphyton Index Score

The Waiwhakaiho River showed an improvement in TRC PI score in a downstream direction in spring 2010 with the upstream site receiving a 'good' TRC PI score and the downstream site a 'very good' TRC PI score (Table 11). In the 2006-2010 report identical median scores were recorded for upstream and downstream sites during summer surveys. For the current period a similar pattern was recorded for summer 2011 (8.2 and 8.1), but not in summer 2012 (9.5 and 6.7).

Both the upstream and downstream sites showed improvements in TRC PI scores from historical medians. However from spring 2010 to summer 2012 the upstream site showed an overall increase in TRC PI score, whereas the downstream site showed a clear decrease in TRC PI score.

The higher TRC PI results often recorded at the upstream site are most likely related to differences in substrate and nutrient inputs. The upstream site receives runoff from primarily agricultural land (other than that from the National Park), while land use downstream is less dominated by agriculture. This higher nutrient input upstream facilitates the higher biomass of periphyton. Riparian planting is negligible at both sites, and therefore there is little growth limitation by seasonal changes in light. Another factor in play is the difference in substrate between the two sites. Upstream, there is a greater dominance of large substrate, which is not turned over in large floods. Downstream the bed is more mobile, facilitating the scouring of periphyton during floods. This is likely to contribute to a higher periphyton biomass remaining at the upstream site compared to that at Constance Street.

Table 11 Median seasonal periphyton index scores for the Waiwhakaiho River. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
WHK000500	6.5	8.2	n/a	9.5	5.7	6.1
WHK000920	8.9	8.1	n/a	6.7	7.8	6.5
Difference	-2.4	0.1	n/a	2.8	-2.1	-0.4

2.5.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Waiwhakaiho catchment from 2002-2012 (Figure 41 and Figure 42). The upper site has been seen to be more prone to long filamentous nuisance periphyton communities which breached guidelines on eight occasions earlier in the monitoring period. In comparison, the lower site only breached guidelines on two occasions. The current period (2010-2012) recorded no breaches in long filamentous algae at either site.

Overall it appears that long filamentous algae are still prone to proliferate more so at the upstream site but not to the same extent or frequency as in previous monitoring years. This can only in part be attributed to more rainfall and scouring events, as in the most recent period there were long periods of low flow, comparable to previous years, and periphyton did not reach the same substrate dominance as in the 2002-2006 monitoring period.

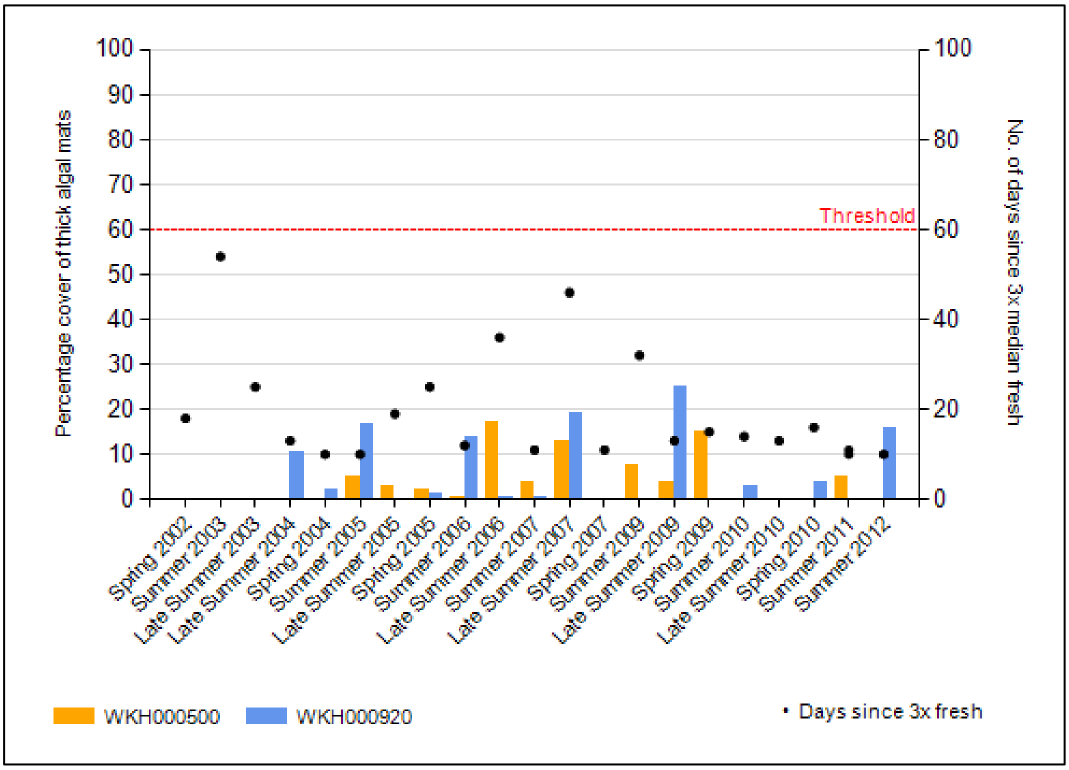


Figure 41 Percentage cover of thick mats of periphyton on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2002-2012 period

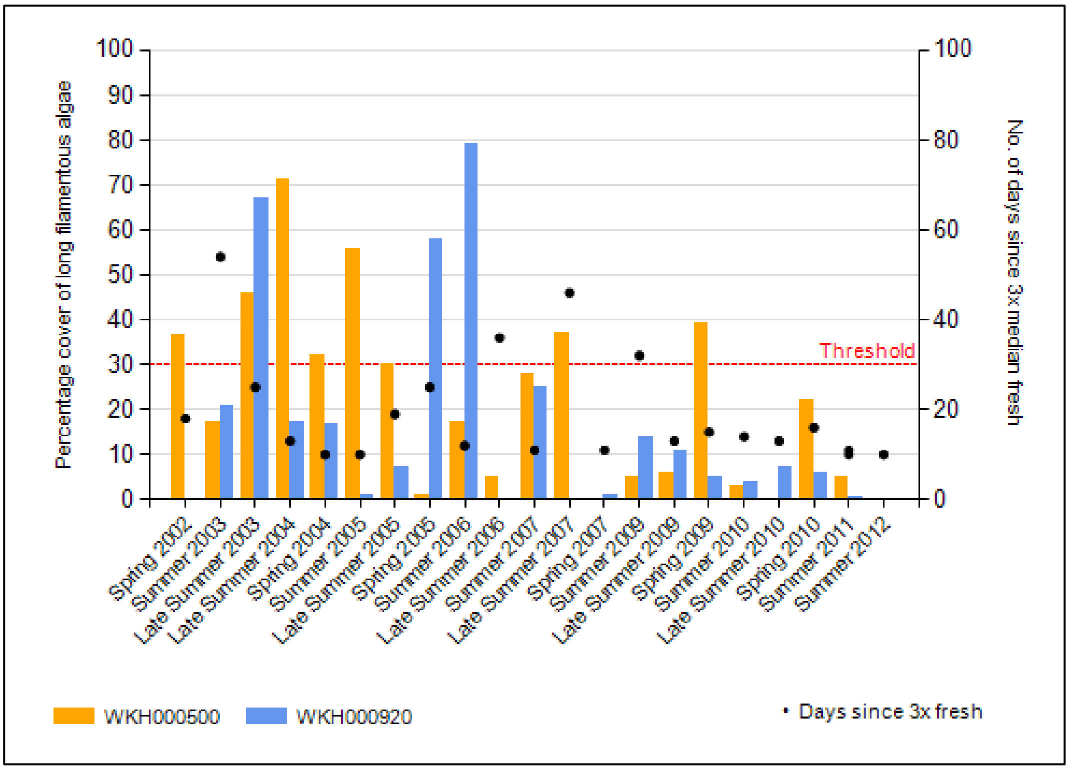
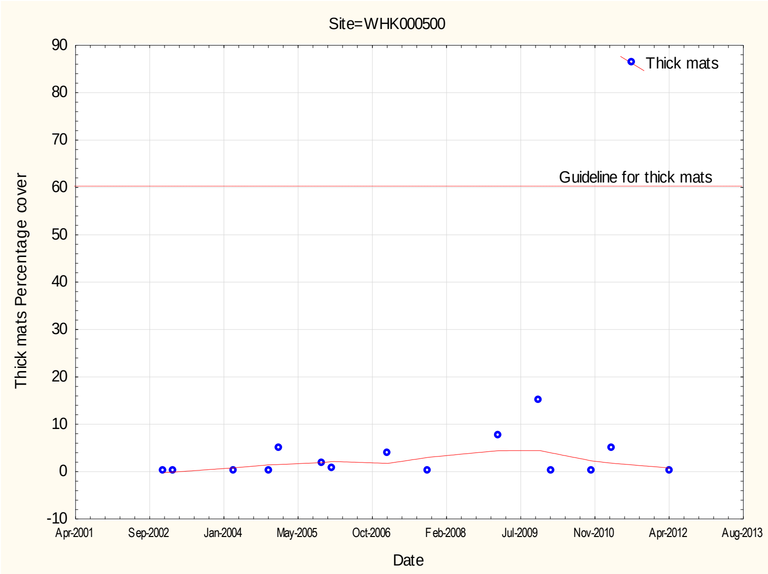


Figure 42 Percentage cover of long filamentous algae on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2002-2012 period

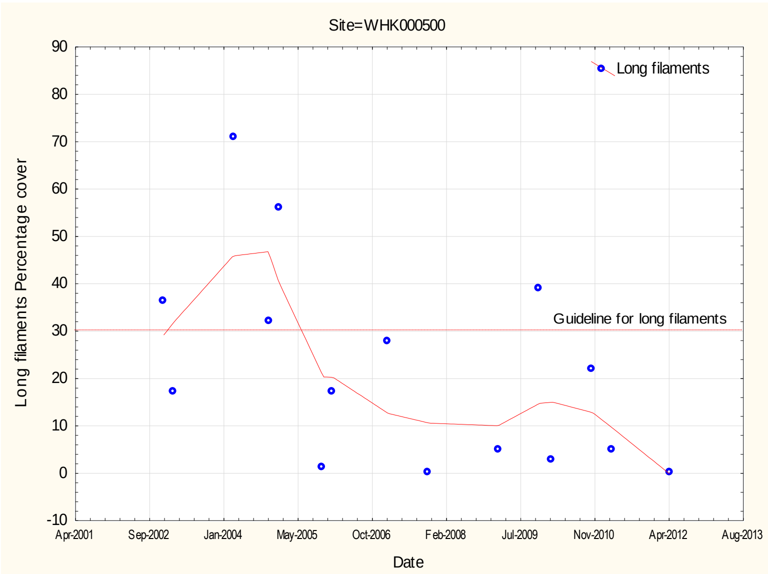
2.5.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Waiwhakaiho River, Constance Street and SH3 (Egmont Village), over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 43 to Figure 46).



n = 15
Kendal tau =0.201498
p-value = 0.295
FDR p-value = 0.763

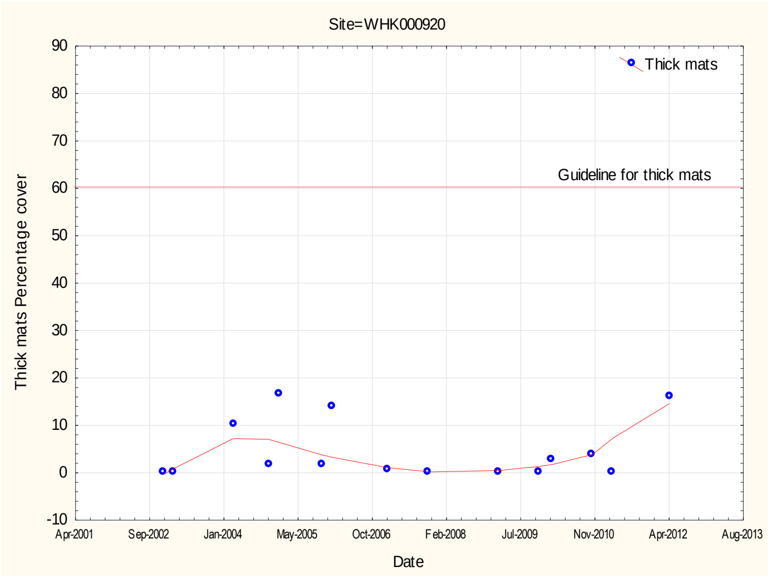
Figure 43 LOWESS trend analysis of percentage cover of thick mats at Waiwhakaiho River, SH3, Egmont Village (WKH000500)



n = 15
Kendal tau = -0.386514
p-value = 0.045
FDR p-value = 0.128

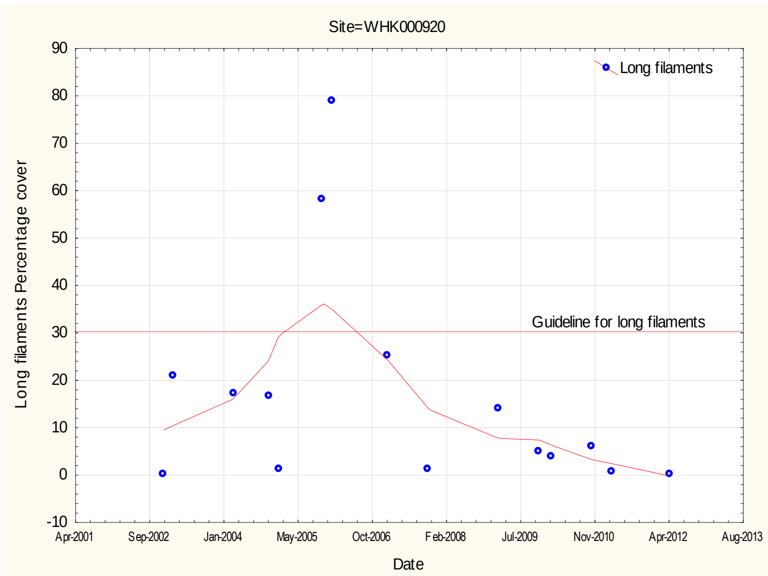
Figure 44 LOWESS trend analysis of percentage cover of long filaments at Waiwhakaiho River, SH3, Egmont Village (WKH000500)

At SH3 (Egmont Village), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.201498) that was not significant at the 5% level (p = 0.295). There was a decreasing trend in percentage cover values of long filaments (Kendall tau = -0.386514) that was significant at the 5% level (p = 0.357) but not significant after FDR application (0.128).



n = 15
Kendal tau = 0.041148
p-value = 0.831
FDR p-value = 0.956

Figure 45 LOWESS trend analysis of percentage cover of thick mats at Waiwhakaiho River, Constance Street, New Plymouth (WKH000920)



n = 15
Kendal tau = -0.298091
p-value = 0.121
FDR p-value = 0.304

Figure 46 LOWESS trend analysis of percentage cover of long filaments at Waiwhakaiho River, Constance Street, New Plymouth (WKH000920)

At the Constance Street site (WKH000920), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.041148) that was not significant at the 5% level (p = 0.831). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.298091) that was not significant at the 5% level (p =0.304).

2.6 Waingongoro River

The Waingongoro River originates in the National Park, heading south east towards Eltham where it turns south west before travelling to its mouth at Ohawe. With a total length of around 67 km (below the National Park boundary) the Waingongoro is the longest river confined to the ring plain.

Better water quality is found in the upper reaches, declining slightly in the middle and lower reaches. It is highly rated for recreational uses and values, and highly rated for aesthetic and scenic values.

The Waingongoro River is a catchment with intensive usage and as such, three sites have been located in this catchment to monitor periphyton communities (Figure 47). The top site at Opunake Road (WGG000150) is approximately six kilometres below the National Park and the catchment upstream has a very high level of riparian cover. The mid catchment site at Stuart Road (WGG000665) is located below several industrial discharges including a meatworks located at Eltham. Agricultural development is also intensified between these two sites and further downstream, which is encompassed by the lower catchment site located at Ohawe Beach (WGG000995), upstream of the river mouth.

River flow is recorded continuously at Eltham Road and SH45.

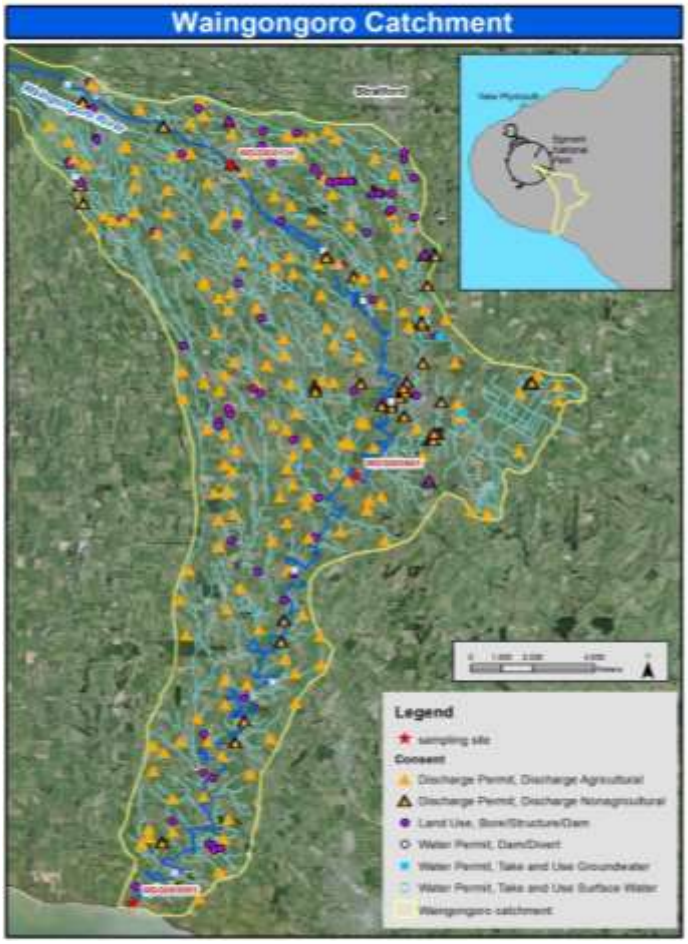


Figure 47 Monitoring site locations in relation to consents operating in the Waingongoro River catchment

2.6.1 Flow data and survey dates

The beginning of spring 2010 saw frequent floods, often exceeding 7x median flow (Appendix). From the end of October to early December a significant period of flow recession occurred. A spring survey was carried out during receding flows, on 03 November 2010. Summer 2011 saw a reasonable number of flood events throughout the period, with the longest flow recession occurring in the month of February. A summer survey was carried out 11th April 2011, during a short period of relatively low flow.

Over the 2011-2012 monitoring period, early spring was relatively dry. This was followed by a very wet October, with significant flood events and above average flows lasting through to early November. A period of flow recession continued throughout November, into early December which enabled a spring survey to be carried out 16 November 2011.A summer survey was carried out 02 February 2012 when flows were falling toward MALF.

2.6.2 Periphyton cover

In the 2010-2012 monitoring years, no thick algal mats or long filaments were recorded at the upper catchment site at Opunake Road on any sampling occasion (Figure 48 and Figure 49).

Further down the catchment at Stuart Road both filamentous algae and thick mats were recorded, each only on one occasion. In summer 2011 thick mats were recorded, and in summer 2012 long filaments were recorded. Proliferations on both occasions were well below the guideline limits.

The Ohawe beach survey site situated at the river mouth saw the most proliferation (comparatively) of nuisance periphyton of all three sites. Like previous years, algal mats tended to dominate the substrate over filamentous algae and similarly to the upstream sites proliferations remained very low. During the 2010-2012 monitoring period mat growths were recorded at around 7-8% coverage in three out of four surveys. No nuisance algal mats were recorded in spring 2010. Similarly to previous surveys filamentous algae was rarely seen, and was recorded only on one occasion (at 3%) during the summer 2012 survey.

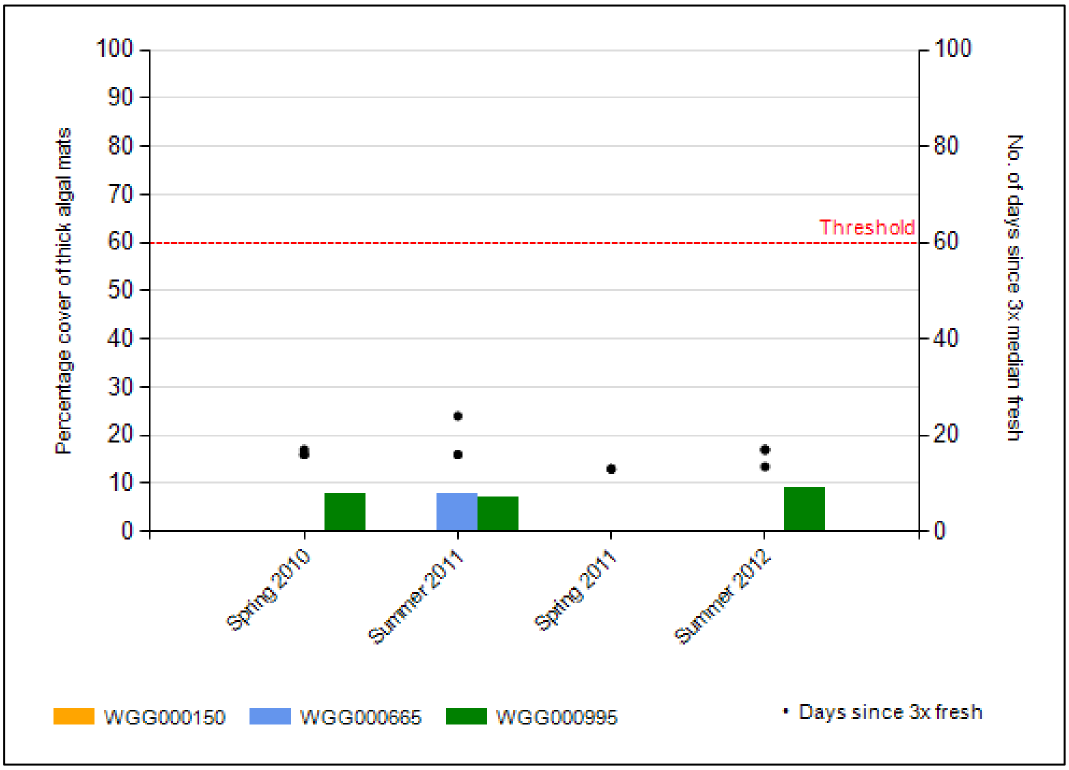


Figure 48 Percentage cover of thick mats of periphyton on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

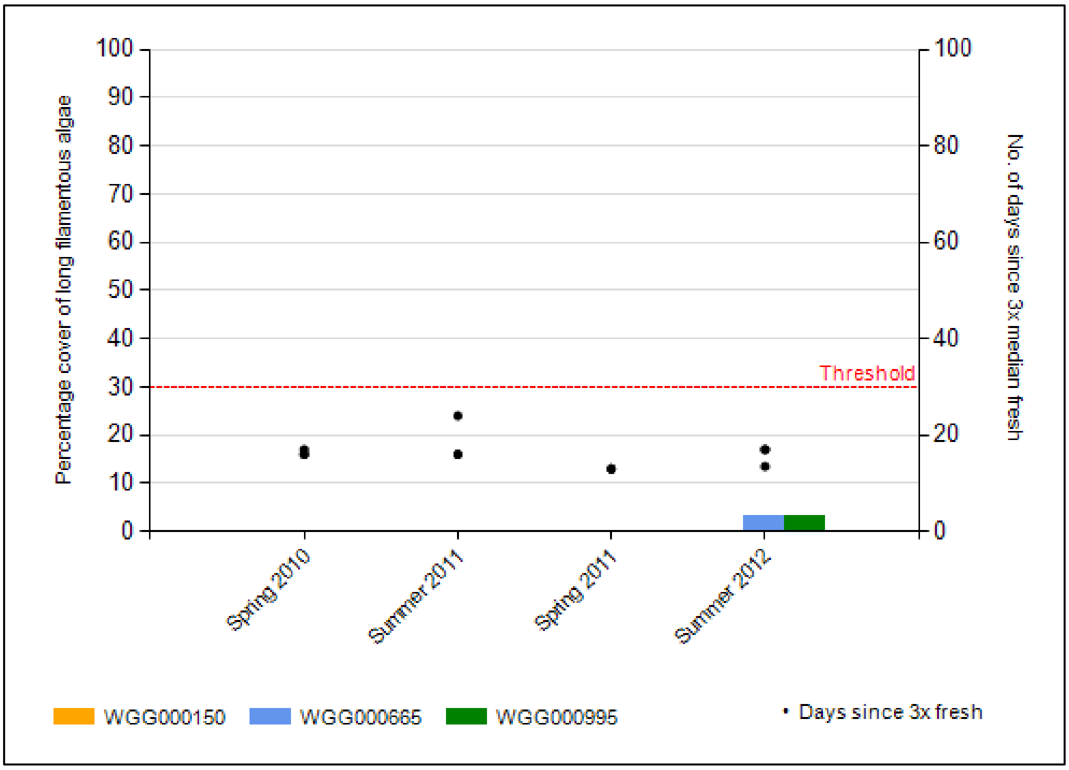


Figure 49 Percentage cover of long filamentous algae on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2010-2012 monitoring period and number of days since 3x median fresh

2.6.3 Periphyton Index Score

On all but one occasion the Waingongoro had 'very good' TRC PI scores throughout the period under review. As expected the upper site at Opunake Road generally had the highest TRC PI scores with little or no change occurring between seasons (Table 12). At the mid catchment site at Stuart Road TRC PI scores were generally slightly lower but still within the 'very good' range. A fluctuation in TRC PI score occurred between the seasons at this site, decreasing slightly in summer and increasing in spring. The lower catchment site at Ohawe Beach showed the biggest variations in TRC PI score between spring and summer. From spring 2010 to summer 2011 there was a drop of 1.2 units in TRC PI score. A similar result of 1.3 units was recorded between the spring 2011 and summer 2012 surveys.

As expected, median scores show a decrease in TRC PI scores in a downstream direction for the period under review (Table 12). A drop of 1.4 units over approximately 60 kilometres was recorded, a rate of 0.024 units per kilometre.

Table 12 Median seasonal periphyton index scores for Waingongoro River. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
WGG000150	10.0	10.0	9.8	9.9	8.8	9.3
WGG000665	9.6	9.0	10.0	9.6	8.4	7.4
WGG000995	9.2	8.0	9.3	8.0	9.0	7.1
Difference	0.8	2.0	0.5	1.9	-0.2	2.2

2.6.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Waingongoro catchment from 2002-2012. Nuisance periphyton appears to have formed more prolific growths during the period 2002-2008, with thick algal mats breaching guidelines five times and filamentous algae breaching guidelines twice (Figure 50 and Figure 51). Proliferation of thick mats and long filaments appeared to have diminished quite dramatically over more recent years (2008-2012) at all three sites, but in particular at the two downstream sites which previously had high levels.

More frequent flood flows may have led to the decrease in filamentous communities in the most recent monitoring period reported on. It is expected that the removal of major discharges to the Waingongoro has further decreased nutrient input into the catchment and helps limit the growth of nuisance periphyton proliferation.

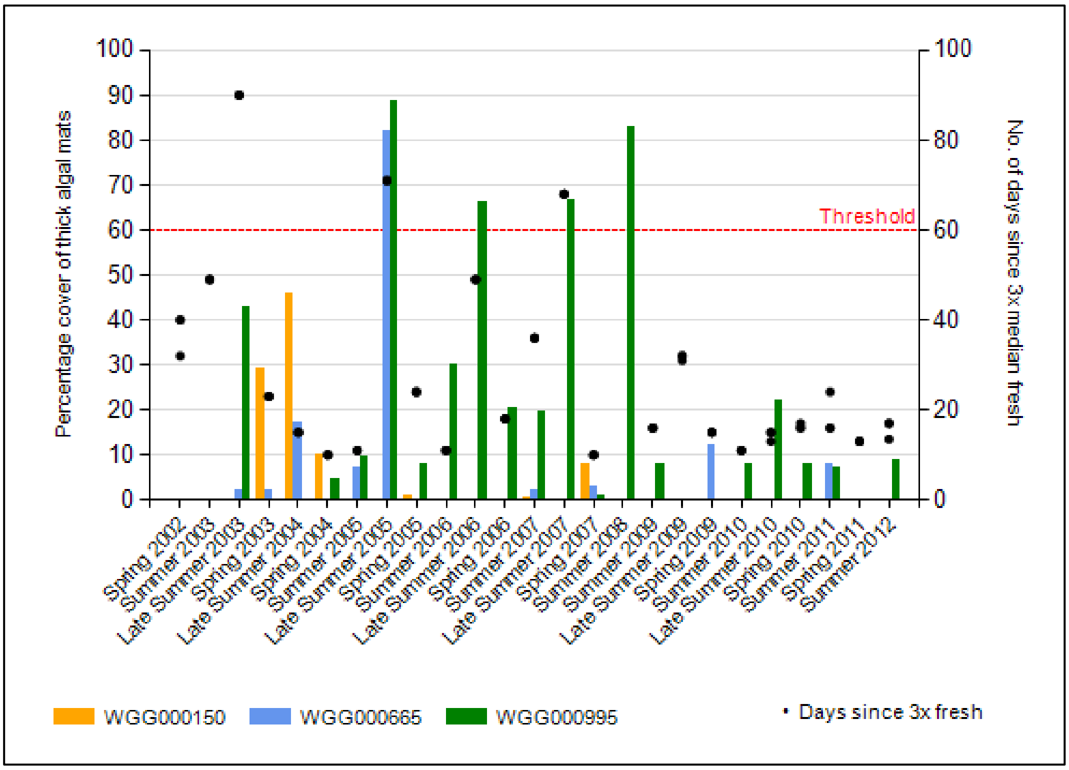


Figure 50 Percentage cover of thick mats of periphyton on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2002-2012 period

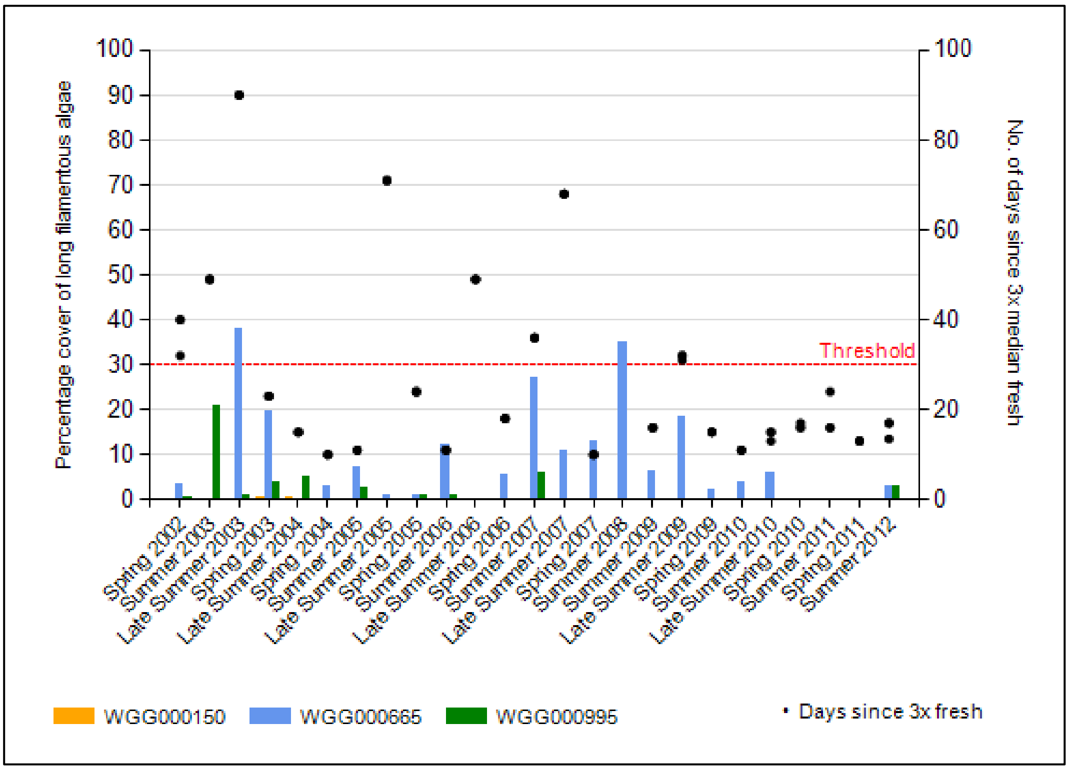
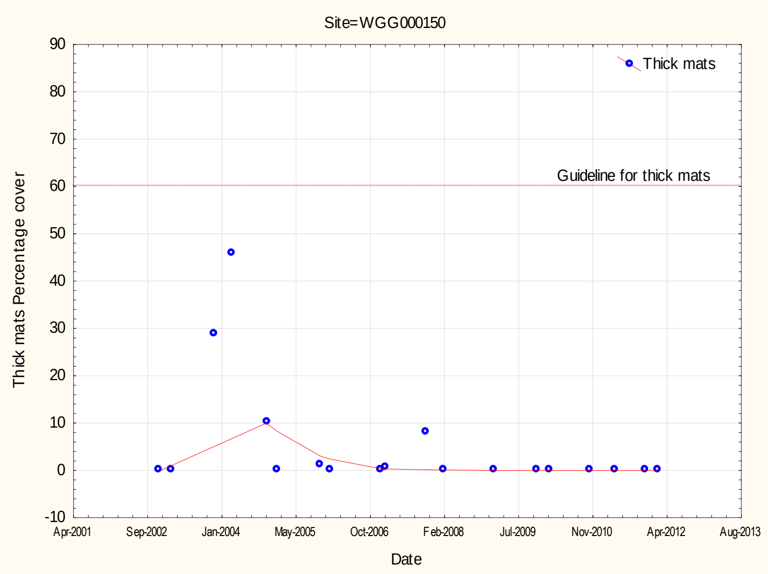


Figure 51 Percentage cover of long filamentous algae on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2002-2012 period

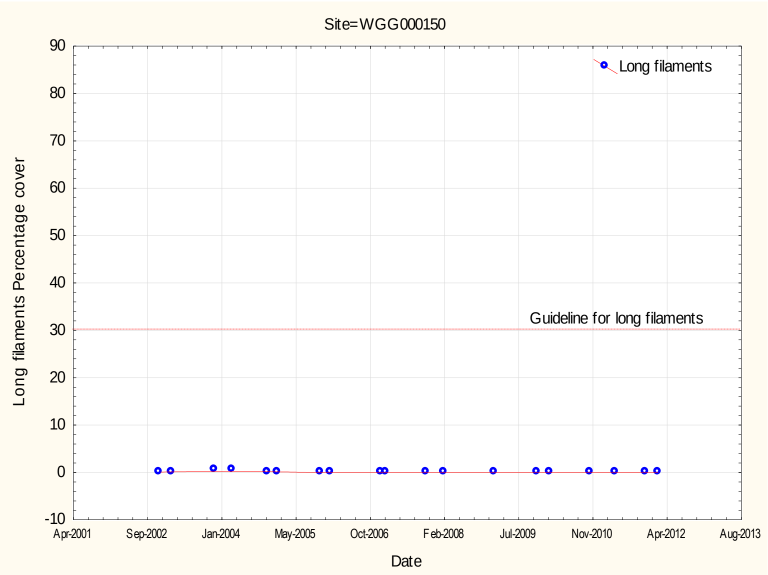
2.6.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Waingongoro River, at Opunake Road, Stuart Road and Ohawe Beach, over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 52 to Figure 57).



n = 19
Kendal tau = -0.388559
p-value = 0.020
FDR p-value = 0.141

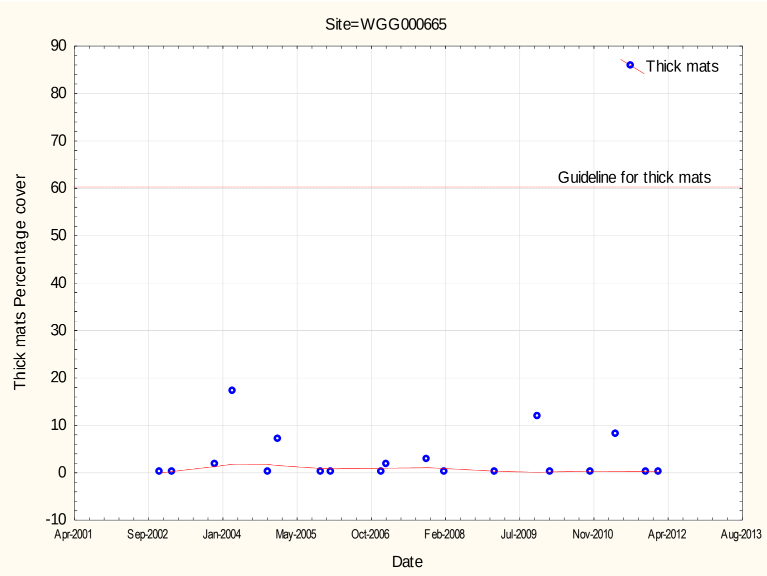
Figure 52 LOWESS trend analysis of percentage cover of thick mats at Waingongoro River, Opunake Road (WGG000150)



n = 19
Kendal tau = -0.340985
p-value = 0.041
FDR p-value = 0.128

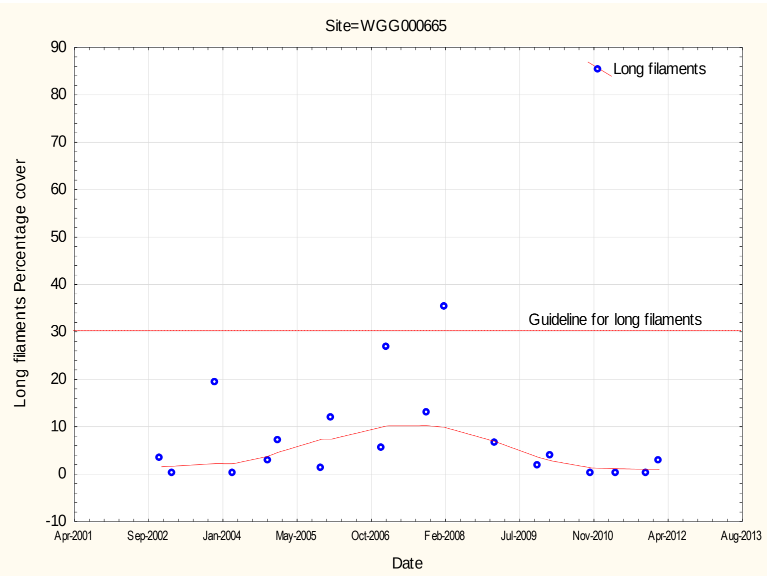
Figure 53 LOWESS trend analysis of percentage cover of long filaments at Waingongoro River, Opunake Road (WGG000150)

At Opunake Road (WGG000150), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau = -0.388559) that was significant using the Mann-Kendall test (p =0.020) but not significant after FDR application (p = 0.141).There was also a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.340985) that was significant using the Mann-Kendall test (p =0.041) but not significant after FDR application (p = 0.128).



n = 19
Kendal tau = -0.044992
p-value = 0.788
FDR p-value = 0.956

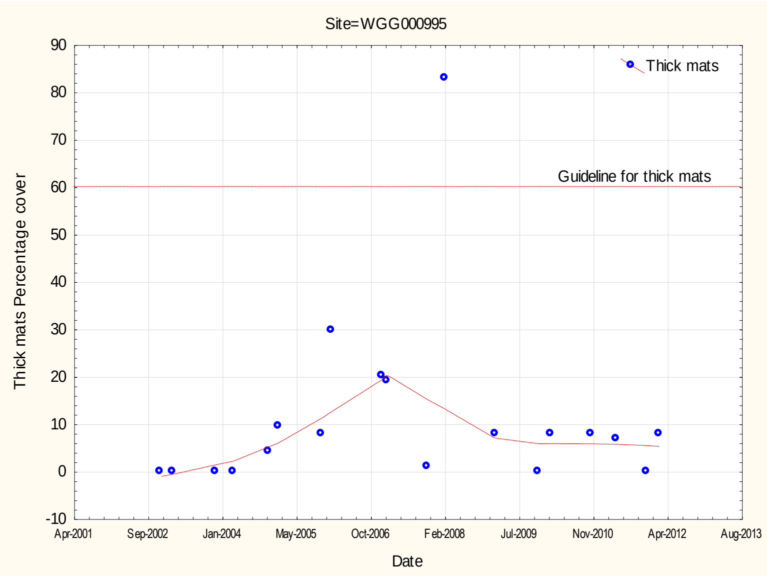
Figure 54 LOWESS trend analysis of percentage cover of thick mats at Waingongoro River, Stuart Road (WGG000665)



n = 19
Kendal tau = -0.108821
p-value = 0.515
FDR p-value = 0.644

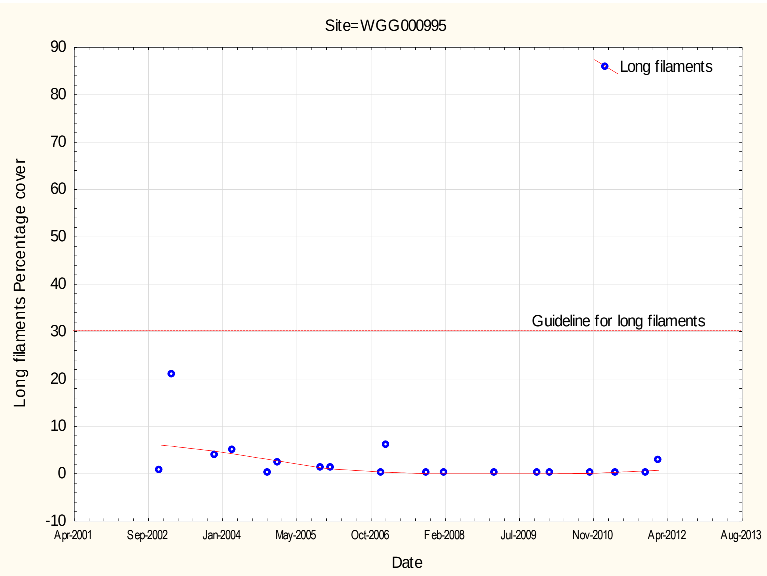
Figure 55 LOWESS trend analysis of percentage cover of long filaments at Waingongoro River, Stuart Road (WGG000665)

At Stuart Road (WGG000665), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau =-0.044992) that was not significant at the 5% level (p = 0.788). There was also a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.108821), that was not significant at the 5% level (p = 0.515).



n = 19
Kendal tau = 0.164550
p-value = 0.325
FDR p-value = 0.763

Figure 56 LOWESS trend analysis of percentage cover of thick mats at Waingongoro River, Ohawe Beach (WGG000995)



n = 19
Kendal tau = -0.417231
p-value = 0.013
FDR p-value = 0.076

Figure 57 LOWESS trend analysis of percentage cover of long filaments at Waingongoro River, Ohawe Beach (WGG000995)

At Ohawe Beach (WGG000995), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.164550) that was not significant at the 5% level (p = 0.325). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.417231) that was significant at the 5% level (p = 0.013) but not after FDR application (0.076).

2.7 Punehu Stream

The Punehu Stream arises in the National Park and heads approximately 25 kilometres in a south westerly direction to the coast; entering the sea just south of Opunake. The stream is representative of a south-western Taranaki catchment subjected primarily to intensive agricultural land use with water quality potentially affected by diffuse run-off and point source discharges from dairy shed treatment pond effluent.

The upper catchment site at Wiremu Road (PNH000200) lies approximately 2km below the National Park boundary and is representative of relatively un-impacted stream water quality (Figure 58). The lower catchment site near the coast at SH45 (PNH00090) is approximately 20km from the National Park. This site is also a NIWA hydrological recording station.

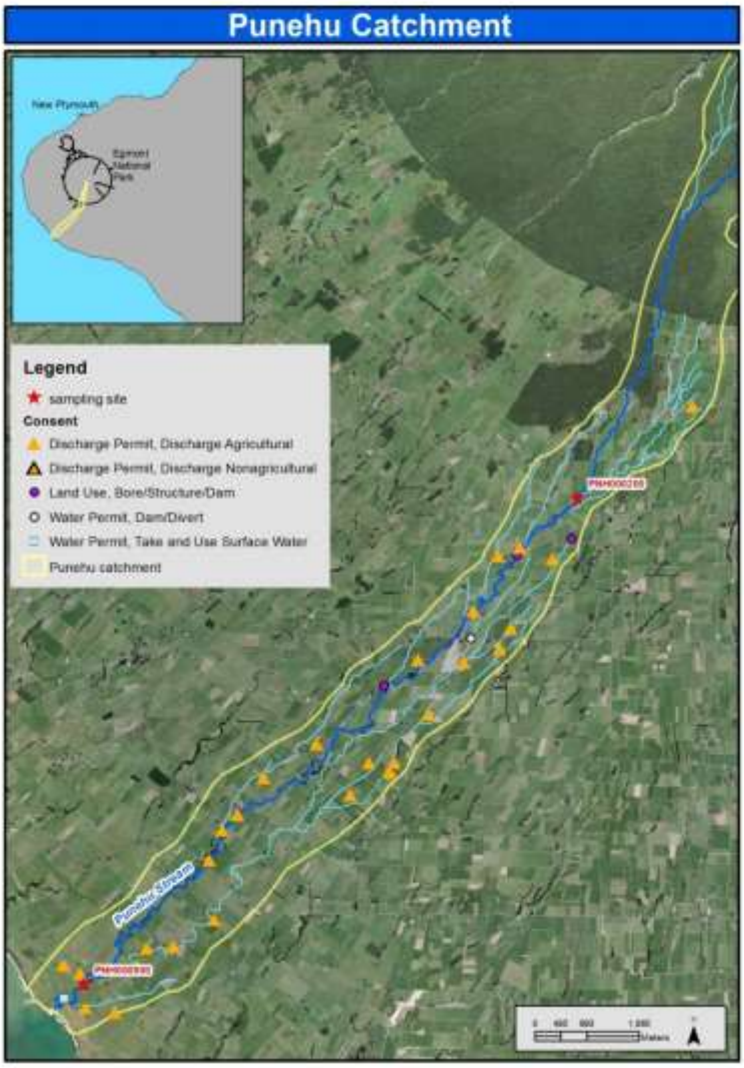


Figure 58 Monitoring site locations in relation to consents operating in the Punehu Stream catchment

2.7.1 Flow data and survey dates

Frequent high flows were recorded in the spring of 2010 with flood events occurring throughout September and early October and again in late December (Appendix). A spring survey was carried out 03 November 2010 following a period of relative flow recession that spanned from mid October to mid December. Regular floods were also frequent throughout summer 2011. Early March saw a series of flood events, many in excess of 7x median flow. This was then followed by a short period of flow recession which enabled a summer survey to be carried out 18 March 2011.
The following spring saw high flows with frequent flood events, predominantly through October and November. A spring survey was carried out 21 November 2011 during a short period of flow recession. Summer 2012 experienced intermittent flood events with periods of flow recession. A summer survey was carried out 02 February 2012 during a period of relative flow recession the occurred between mid January and mid February.

2.7.2 Periphyton cover

The periphyton cover recorded for both the upstream site at Wiremu Road and the downstream site at SH45 was relatively low; only small proliferations of nuisance algae were recorded (Figure 59 and Figure 60). Guideline levels of coverage for recreational and aesthetic values were not exceeded on any occasion throughout the 2010-2012 monitoring period.

In spring 2010, no nuisance periphyton was recorded at either of the two sites. High flows leading up to the spring survey may have contributed to this absence of nuisance periphyton. In summer 2011, there was very little growth with an absence of thick mats and only 4% coverage of long filamentous algae at both sites.

Similarly to the previous year, spring 2011 saw an absence of nuisance periphyton at both sites. In summer 2012, small proliferations of thick mats were noted, particularly at the upstream site. A small proliferation (1%) of long filamentous algae was recorded at the downstream site at SH45. Unlike previous years, periphyton coverage was not higher at the downstream site.

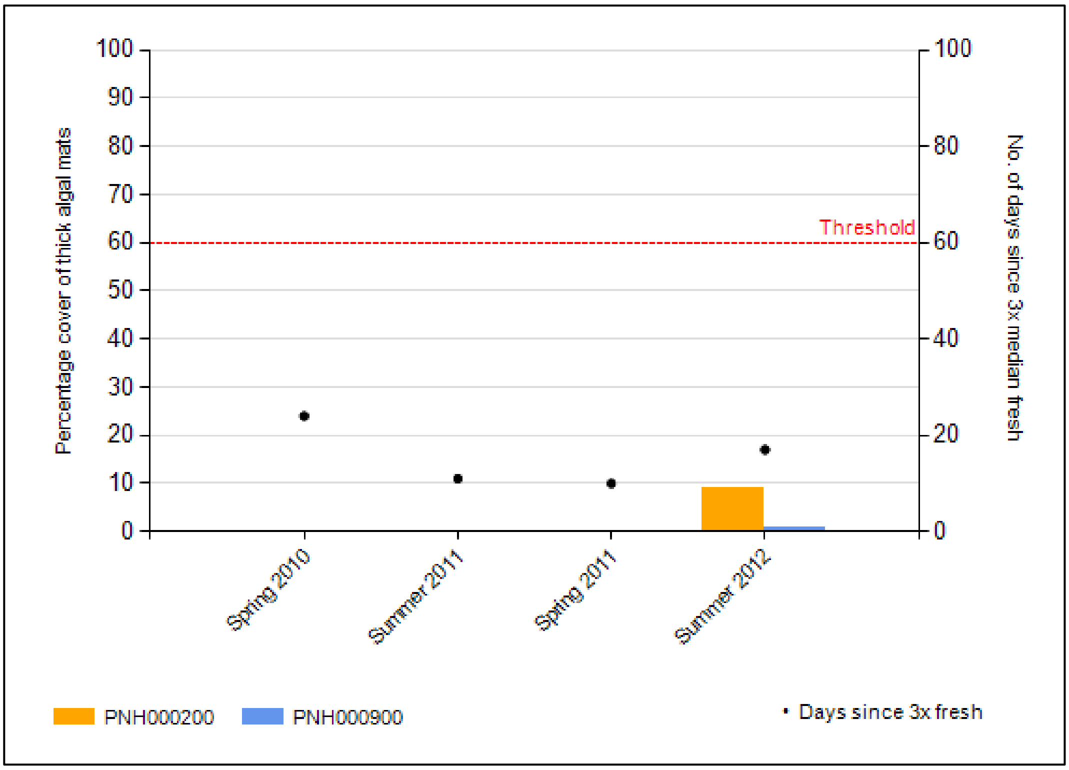


Figure 59 Percentage cover of thick mats of periphyton on the Punehu streambed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

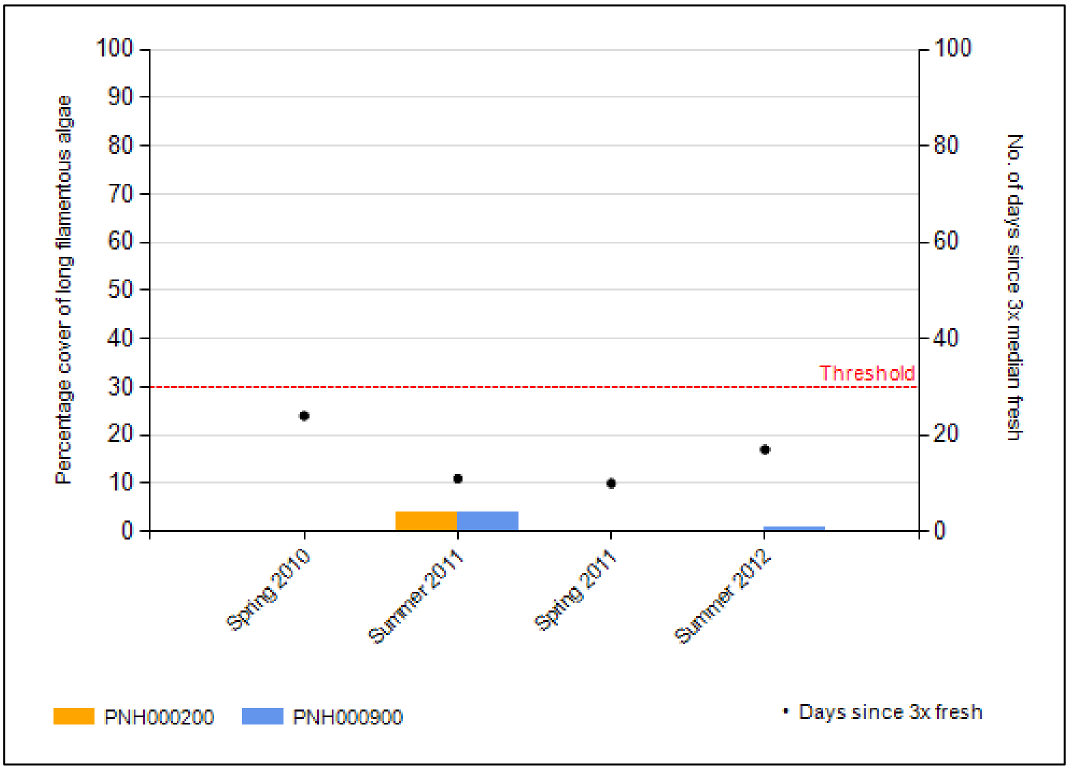


Figure 60 Percentage cover of long filamentous algae on the Punehu streambed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

2.7.3 Periphyton Index Score

The Punehu Stream has been included in this programme as its catchment is primarily used for dairying and therefore, there is the potential for an elevated nutrient input into the stream.

The upstream site at Wiremu Road (PNH000200) has no point source discharges in its headwaters, and consistently records a 'very good' TRC PI score (Table 13). This is a significant result, as this site has no riparian vegetation, and light conditions are consequently very good. In spring 2010 the upper site had a TRC PI score slightly lower than the historical median (by 0.2 unit), although for the rest of the reported period scores were above historical medians.

The downstream site (PNH000900), which has some riparian shading, had a lower TRC PI score than at Wiremu Road site on two occasions, the same TRC PI score in spring 2011 and a higher TRC PI score (by 0.7 unit) in summer 2012. These results differ from historical medians which show a clear reduction in TRC PI score between the upper and lower sites. In spring 2011 the downstream site also had a TRC PI score below the historical median (by 0.9 unit). The TRC PI score then increased well above the historical medians in the succeeding surveys. For the current period an overall decrease of 0.2 unit was recorded in a downstream direction over 16.6 kilometres, a drop of 0.012 unit per kilometre.

Table 13 Median seasonal periphyton index scores for the Punehu Stream. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
PNH000200	9.7	9.6	10.0	9.2	9.9	8.8
PNH000900	7.3	9.1	10.0	9.9	8.2	7.4
Difference	2.4	0.5	0.0	-0.7	1.7	1.4

2.7.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Punehu catchment from 2002-2012. No breaches in recreational guidelines for thick mats have been recorded at either site in the Punehu catchment over the past 10 year period (Figure 61). In the past there have been more frequent proliferations of thick mats at the downstream site although these have decreased in recent years (2006-2012). The upstream site has also recorded proliferations of thick algal mats on occasion and in the current period at levels greater than the downstream site.

The Punehu catchment has been subject to large proliferations of long filamentous algae over the 10 years of monitoring, especially at the downstream site (Figure 62). There have been a total of seven breaches of guidelines overall, none of which were recorded in the 2010-2012 period and only one of which was recorded in the 2006-2010 period. On this latter occasion, over 70% of the bed was covered in long filaments in summer 2008, the largest amount recorded for a nuisance growth over the entire monitoring history in this catchment. During the 2002-2006 period there were much more frequent breaches in long filamentous periphyton at the downstream site, with several of magnitude close to the summer 2008 event. There was also a breach at the upstream site after a long period of low flows in late summer 2005. These growths were not only restricted to summer months, and appeared throughout the 2002-2006 monitoring years, recording six breaches in total.

It appears that there has been a reduction in long filamentous communities in the catchment in comparison with the previous reported years. This cannot be explained by the amount of days preceding each survey since significant fresh events, as surveys taken in the 2010-2012 period were conducted after longer low flow periods than for the 2002-2006 surveys.

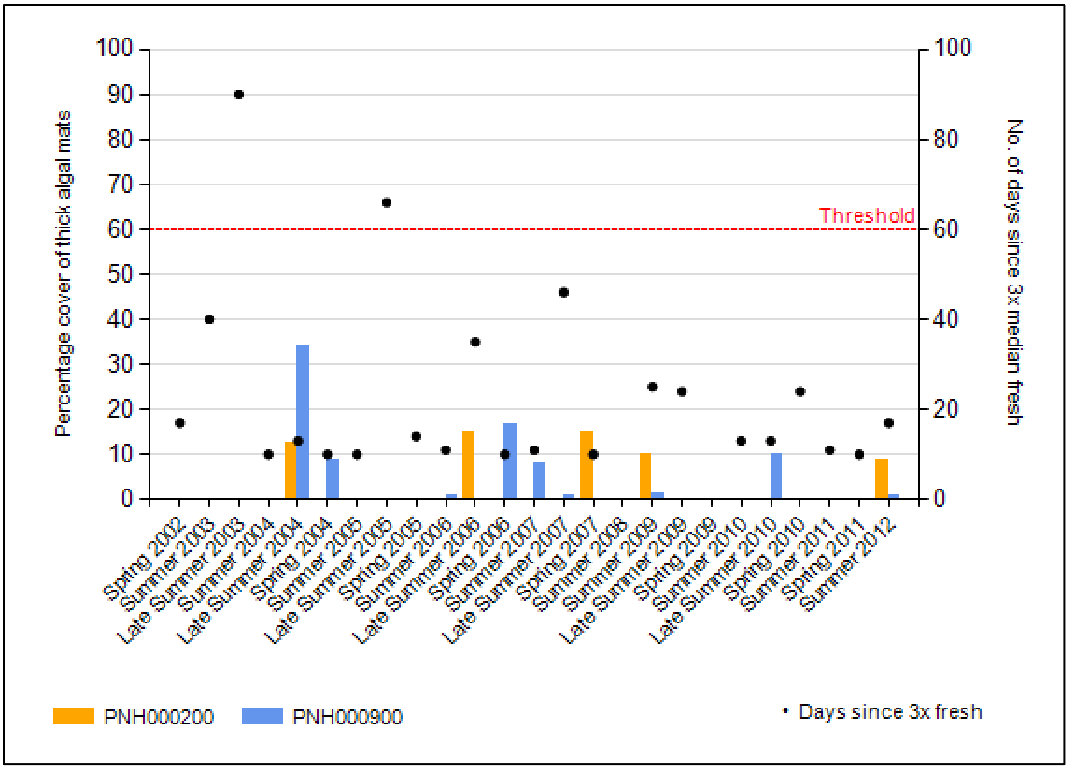


Figure 61 Percentage cover of thick mats of periphyton on the Punehu streambed in relation to the guidelines for recreational values over the 2002-2012 period

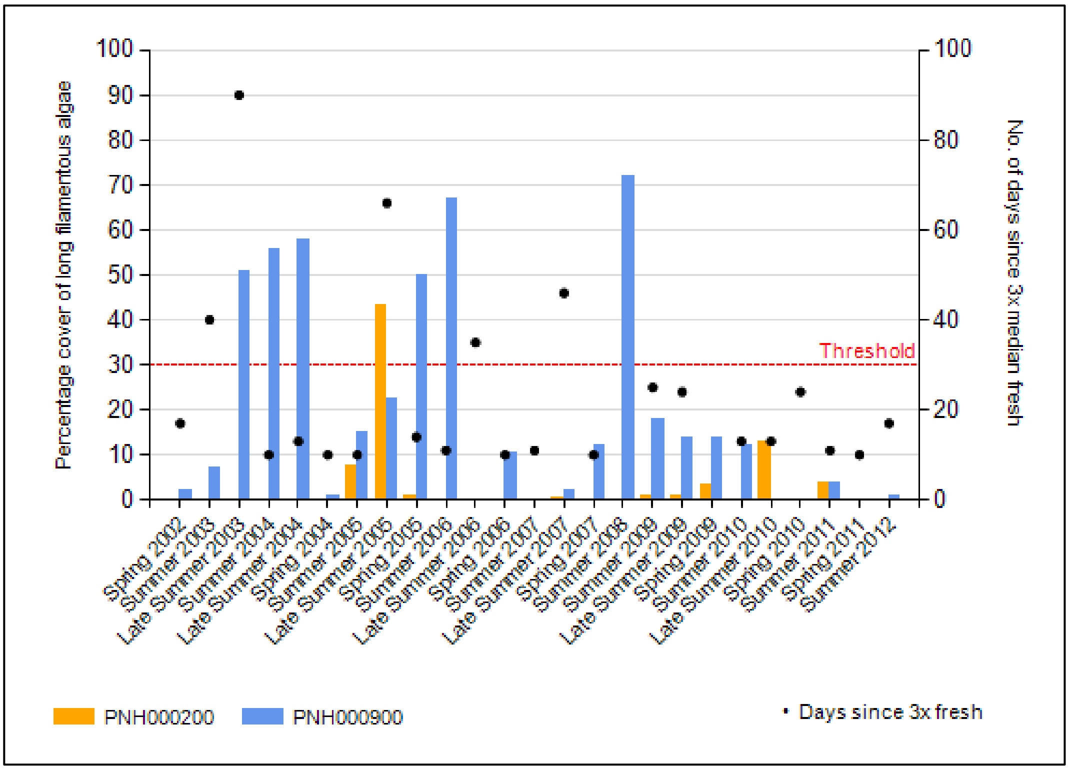
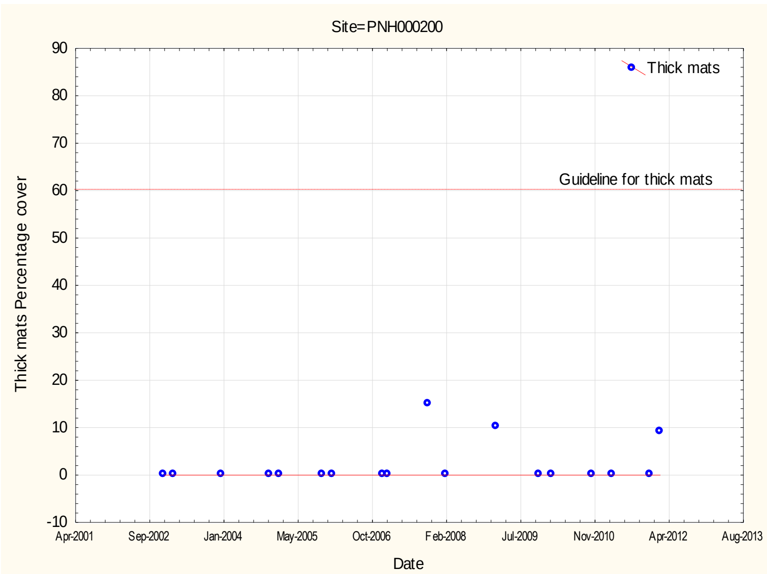


Figure 62 Percentage cover of long filamentous algae on the Punehu streambed in relation to the guidelines for recreational values over the 2002-2012 period

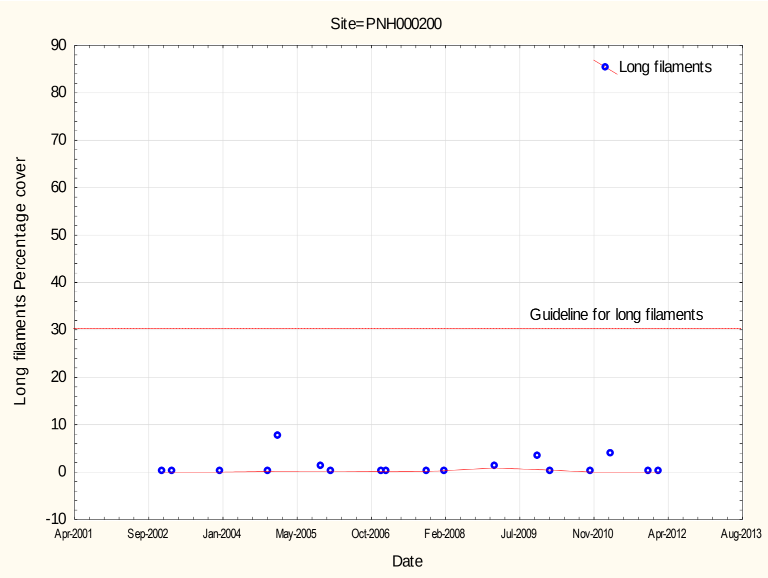
2.7.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Punehu Stream, at Wiremu Road, and SH45 over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 63 to Figure 66).



n = 18
Kendal tau = 0.233380
p-value = 0.176
FDR p-value = 0.740

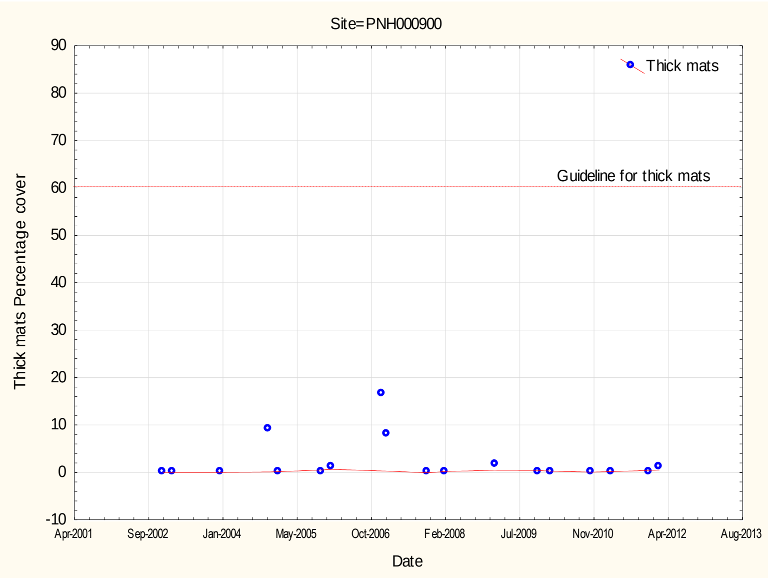
Figure 63 LOWESS trend analysis of percentage cover of thick mats at Punehu Stream, Wiremu Road (PNH000200)



n = 18
Kendal tau = 0.093981
p-value = 0.586
FDR p-value = 0.689

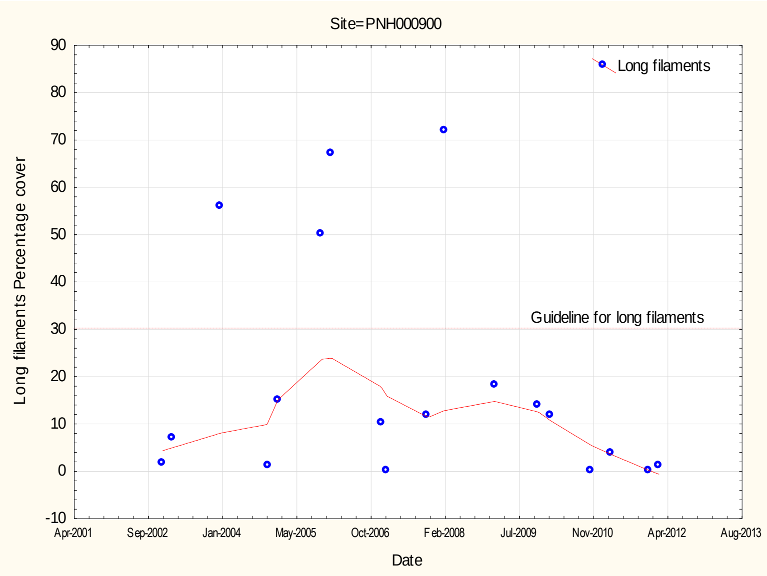
Figure 64 LOWESS trend analysis of percentage cover of long filaments at Punehu Stream, Wiremu Road (PNH000200)

At Wiremu Road (PNH000200), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.233380) that was not significant at the 5% level (p = 0.176). There was an increasing trend in percentage cover values of long filaments (Kendall tau =0.093981) that was not significant at the 5% level (p = 0.586).



n = 18
Kendal tau = -0.034871
p-value = 0.840
FDR p-value = 0.956

Figure 65 LOWESS trend analysis of percentage cover of thick mats at Punehu Stream, SH45 (PNH000900)



n = 18
Kendal tau = -0.199363
p-value = 0.248
FDR p-value = 0.451

Figure 66 LOWESS trend analysis of percentage cover of long filaments at Punehu Stream, SH45 (PNH000900)

At SH45 (PNH000900), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau =-0.034871) that was not significant at the 5% level (p = 0.840). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.199363) that was not significant at the 5% level (p = 0.248).

2.8 Kapoaiaia Stream

The Kapoaiaia Stream arises in the National Park, heading west approximately 25 km to the coast, entering the sea near Cape Egmont. The Kapoaiaia Stream has a narrow catchment area between the Waitotoroa Stream and the Warea River and is an example of a western catchment which has relatively poor riparian vegetation. This catchment drains agricultural land throughout its entire catchment below the National Park boundary, passing through Pungarehu Township at SH45.

Three sites have been monitored in this catchment (Figure 67). The upper site, located at Wiremu Road (KPA000250), is 5.5 km downstream of the National Park boundary. A second site is located in the mid-catchment at Wataroa Road (KPA000700). A third site (KPA000950) is located at Cape Egmont, 1km upstream from the Coast.

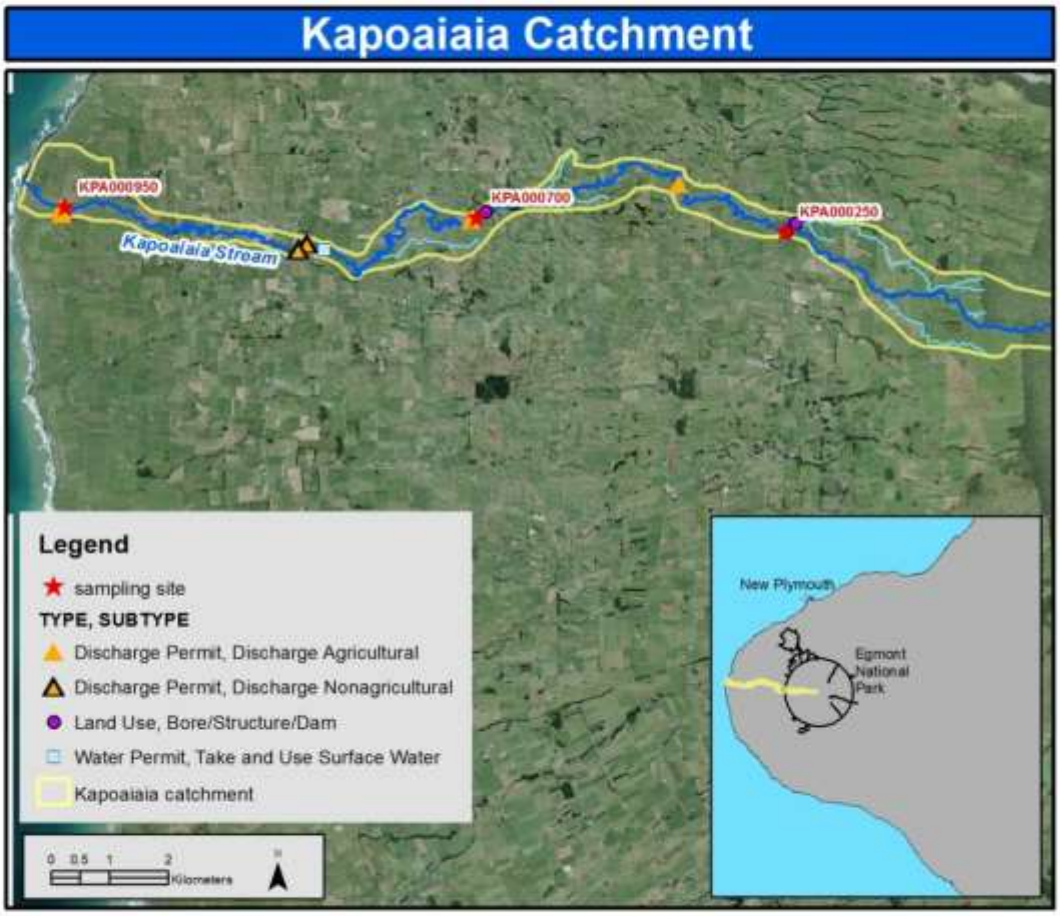


Figure 67 Monitoring site locations in relation to consents operating in the Kapoaiaia Stream catchment

2.8.1 Flow data and survey dates

Spring 2010 saw frequent floods early on in the period (September through to mid October) and again towards the end of December (Appendix). The spring periphyton survey was carried out 03 November 2010 after a period of receding flow that followed a flood in earlier October and a small fresh in mid October. Summer 2011 also experienced frequent floods. A periphyton survey was undertaken 20 March 2011 after a small fresh which preceded a settled period of low flows.

Spring 2011 was characterised by frequent floods throughout the season. The spring survey was undertaken 21 November 2011 during a small period of receding flows. In 2012, early January saw several flood events. This was followed by a period of recession and low flows that carried on through to late February. A summer survey was completed on 15 February 2012 when flows were close to MALF.

2.8.2 Periphyton cover

The Kapoaiaia Stream is known for a lack of riparian vegetation where it flows through farmland. This means it is provided with a lot of sunlight, and relatively warm ambient temperatures, which both can contribute to periphyton growth. Consequently, in the 2010-2012 monitoring period there was a long filamentous algae breach in summer 2012 at the most downstream site at Cape Egmont. Nuisance periphyton did not exceed guideline levels at the two upstream sites; Wiremu Road and Wataroa Road.

The section of the Kapoaiaia Stream above the upstream site at Wiremu Road, flows through open farmland and the bed is relatively wide, with a shallow flow, which provides sunlight and can support warmer stream temperatures and algal growth. Consequently in the past, filamentous algae have been present at this site and sometimes to levels of proliferation. However over the 2010-2012 monitoring period there were no filamentous or algal mats recorded at the Wiremu Road site (Figure 68 and Figure 69).

In spring 2010, both long filamentous and thick mats of algae were recorded at Wataroa Road. Proliferations of algae decreased at this site from spring 2010 to summer 2011; mats by 1% and filamentous algae, 3. In spring 2011, no thick mats or filamentous algae were recorded at Wataroa Road. An increase in both filamentous and thick mats of algae was recorded in summer 2012, however levels remained below the guideline limits.

In the spring of 2010 filamentous algae dominated the lower survey site at the downstream site at Cape Egmont. No thick mats were recorded. The reverse was observed in summer 2011, where small proliferations of thick mats were recorded with an absence of any long filamentous algae. The 2011-2012 monitoring year saw a definite increase in nuisance periphyton in the summer months. Thick mats increased from nil in spring 2011 to 40% coverage in summer 2012. Long filamentous algae had increased from 8.5% cover in spring to 45.5% cover in summer, which breached the guideline levels of coverage for recreational and aesthetic values.

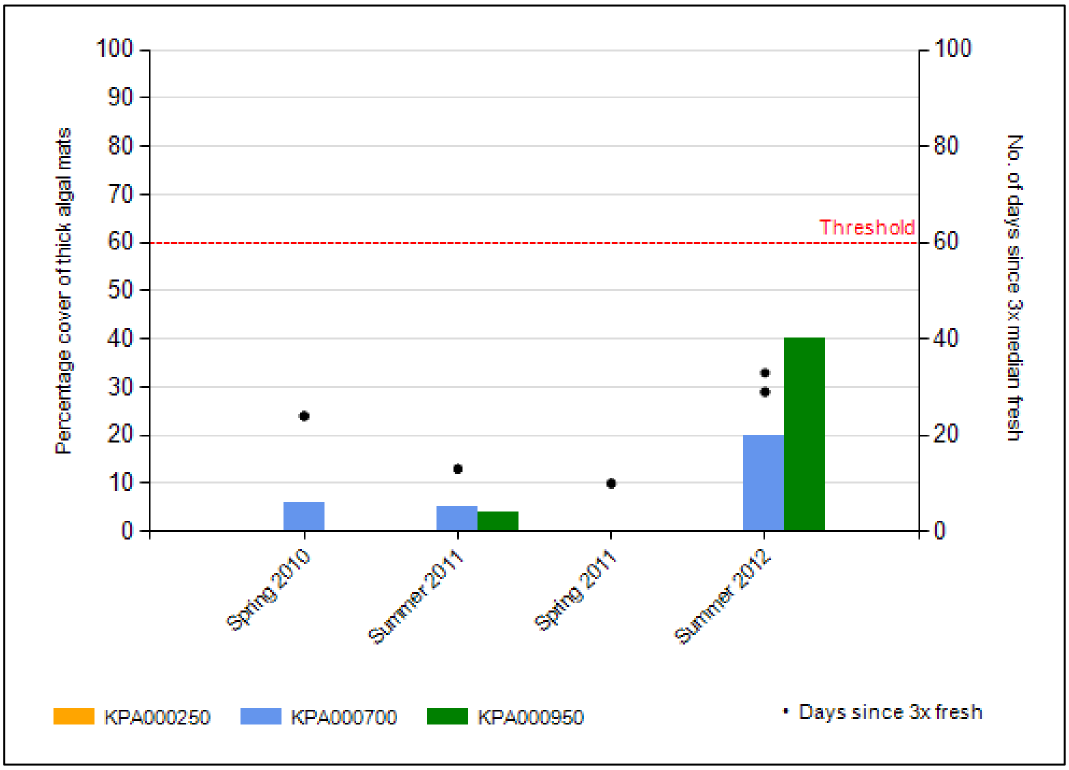


Figure 68 Percentage cover of thick mats of periphyton on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

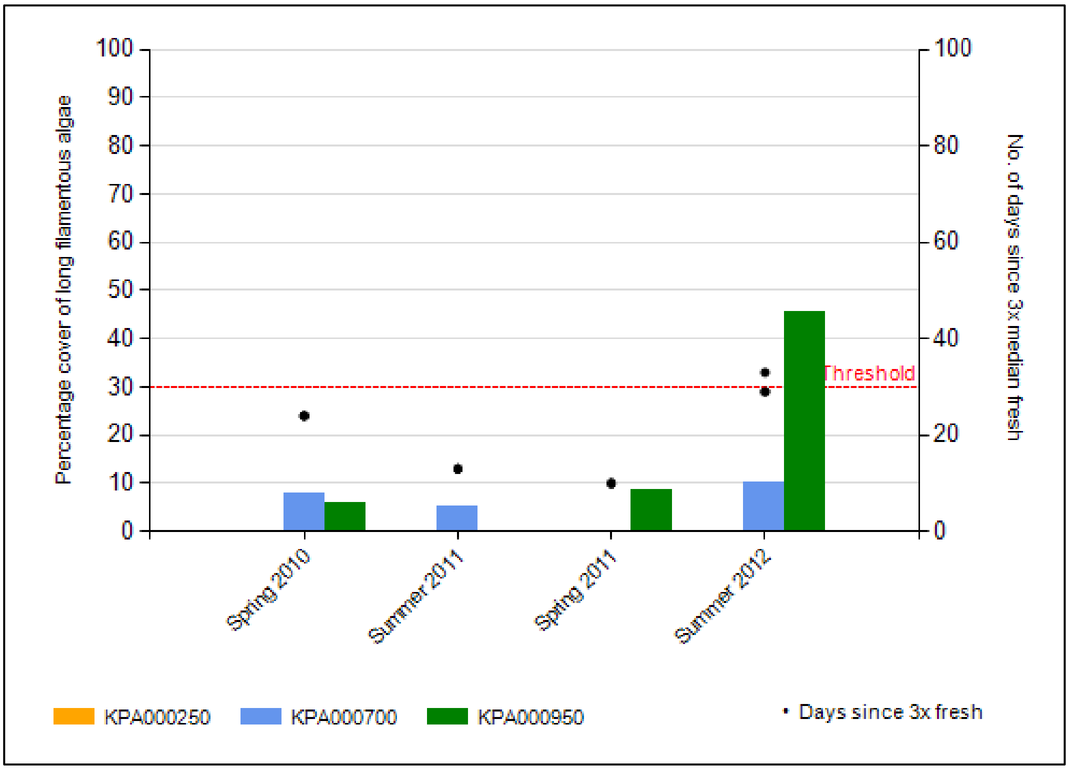


Figure 69 Percentage cover of long filamentous algae on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

2.8.3 Periphyton Index Score

The Kapoaiaia Stream showed a lot of variation in TRC PI scores, both between sites, and with season (Table 14). The upstream site (KPA000250) scored a maximum TRC PI value (10) throughout the reported period, across seasons. The mid-catchment site (KPA000700) showed a decrease in TRC PI score from the upstream site, varying between 'good' and 'very good'. Further decreases in TRC PI score were seen at the downstream site (KPA000950) on two occasions. However, in summer 2011 and spring 2011 the lower site scored a TRC PI higher than the mid-catchment site (by 0.9 unit and 0.3 unit respectively).

Similarly to the 2006-2010 results, the upstream site had improved dramatically from the previous 2002-2006 period from 'poor' to 'very good'. The two lower catchments also have overall improved TRC PI scores in comparison to the previous monitoring periods.

Table 14 Median seasonal periphyton index scores for the Kapoaiaia Stream. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
KPA000250	10.0	10.0	10.0	10.0	7.6	4.6
KPA000700	8.9	7.2	7.3	7.3	6.5	6.8
KPA000950	8.7	8.1	7.6	4.7	6.4	5.3
Difference	1.3	1.9	2.4	5.3	1.2	-0.7

The rate of change in overall TRC PI score from the top site to the most downstream site is a decrease of 0.082 units per kilometre. The rate of change in overall TRC PI score from the top site to the mid-catchment site is a decrease of 0.244 units per kilometre. This was a slight increase from the previous reports findings of a decrease of 0.205 units per kilometre and a complete change from the 2002-2006 report findings of an increase of 0.385 units per kilometre.

Table 14 shows the change in season at each site. The upstream site obtained consistently high scores throughout the monitoring period, whereas the lower site showed incremental decreases in TRC PI scores, with spring 2010 having a 'very good' score and summer 2012 only a 'moderate' TRC PI score. The mid catchment site showed a decrease in TRC PI score from spring 2010 to summer 2011, then only a slight increase from summer 2011 to spring 2011. The TRC PI score remained the same between spring 2011 and summer 2012. These results differed to the previous reports results where TRC PI scores for the upstream and downstream sites increased from spring to summer at every site, then decreased into late summer.

2.8.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Kapoaiaia catchment from 2002-2012. The Kapoaiaia catchment has been monitored over a 10 year period. There have been four breaches in the guidelines in respect of thick algal mats over the three sites, none of which occurred in the 2010-2012 monitoring period (Figure 70).

The mid catchment site and the downstream site breached thick mat guideline limits an equal number of times over the 2002-2012 period. There have also been some large proliferations of algal mats at the upstream site which have come close to breaching guidelines, particularly between the 2002- 2006 monitoring period. Over the most recent years of monitoring surveys (2010-2012) results have given way to very little thick algal mat proliferation (in comparison with previous years surveys).

There have been a significant number of breaches over the 10 year monitoring period for long filamentous nuisance growths (24 in total) (Figure 71). Overall there has been a significant decrease in long filamentous growths at the upper catchment site in recent years (2010-2012). In addition, there has been a decrease in long filamentous growth at the mid-catchment and downstream sites in comparison to previous years, with the exception of the breach that occurred at the Cape Egmont site. This breach was very significant, although it was at levels slightly lower to what has been seen in other breaches that have occurred over the past 6 years. This catchment has the highest amount of nuisance growths for long filaments within a catchment out of all the catchments monitored over the 10 year period in this report. There is still some work to be done in the Kapoaiaia catchment in keeping nutrient levels down and riparian cover increasing, to limit nuisance growths in the lower catchment sites.

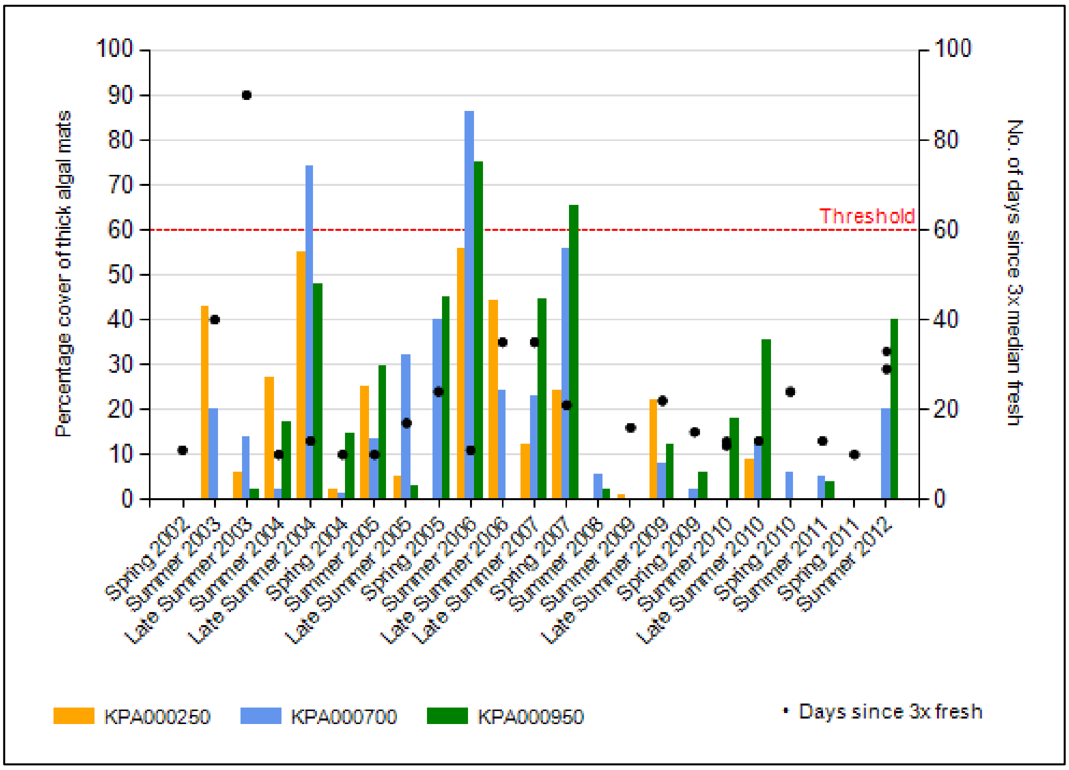


Figure 70 Percentage cover of thick mats of periphyton on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2002-2012 period

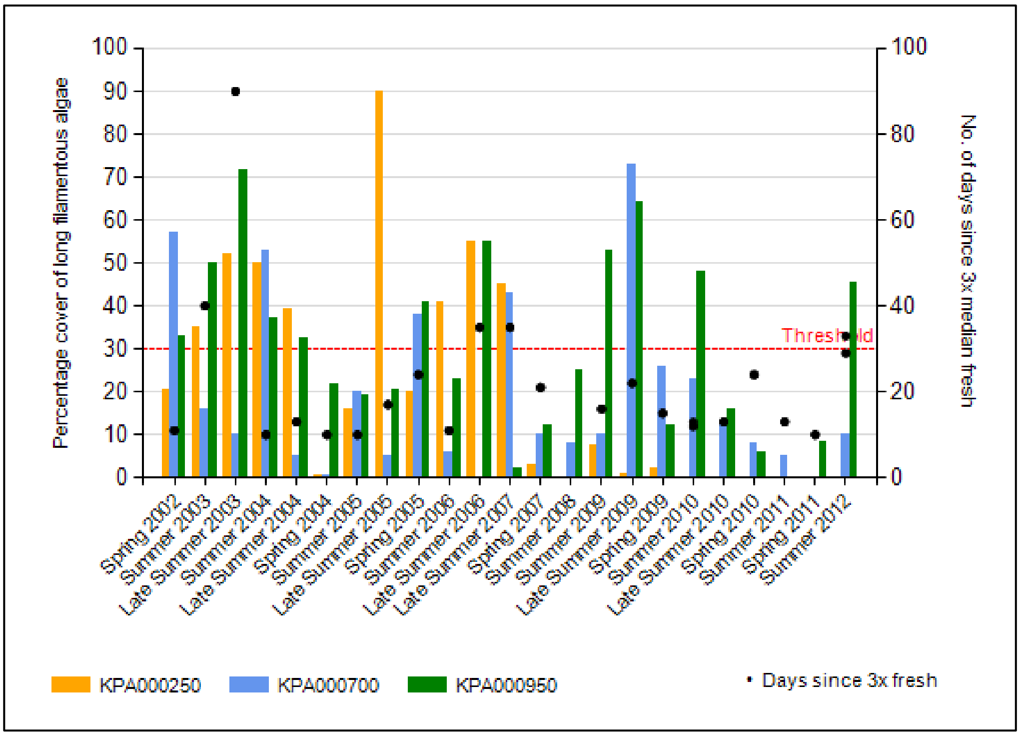
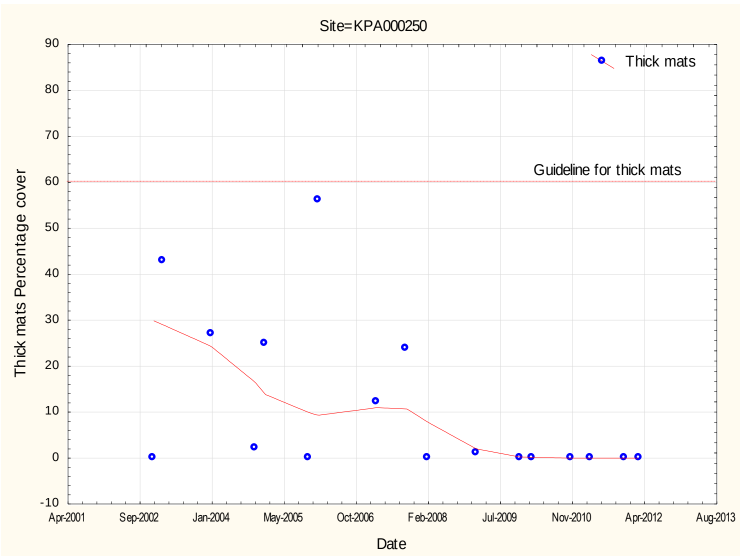


Figure 71 Percentage cover of long filamentous algae on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2002-2012 period

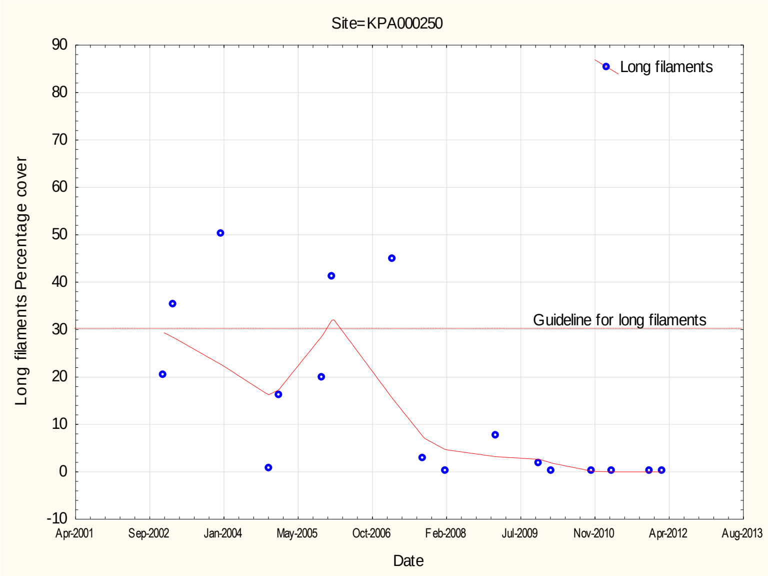
2.8.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at three sites on the Kapoaiaia Stream; Wiremu Road, Wataroa Road and at Cape Egmont. Monitoring was carried out over a 10 year period and trend analysis was carried out by testing the significance using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 72 to Figure 77).



n = 17
Kendal tau = -0.497346
p-value = 0.005
FDR p-value = 0.112

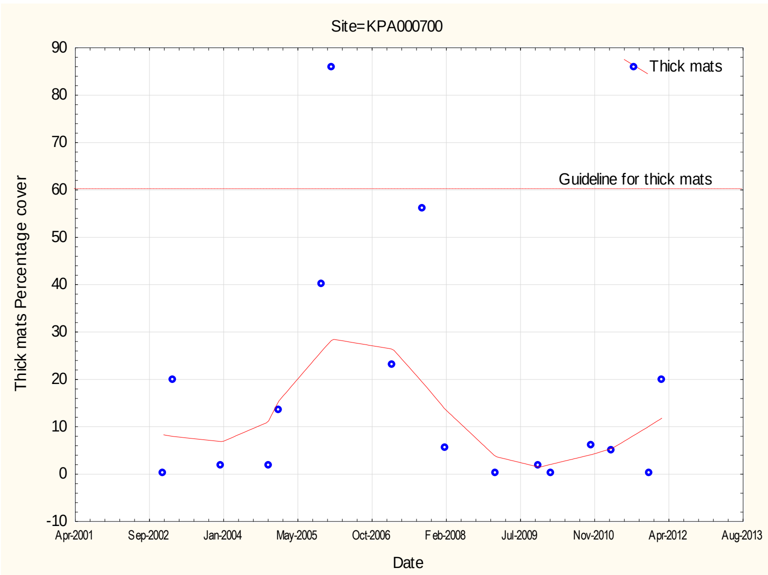
Figure 72 LOWESS trend analysis of percentage cover of thick mats at Kapoaiaia Stream, Wiremu Road (KPA000250)



n = 17
Kendal tau = -0.584654
p-value = 0.001
FDR p-value = 0.011

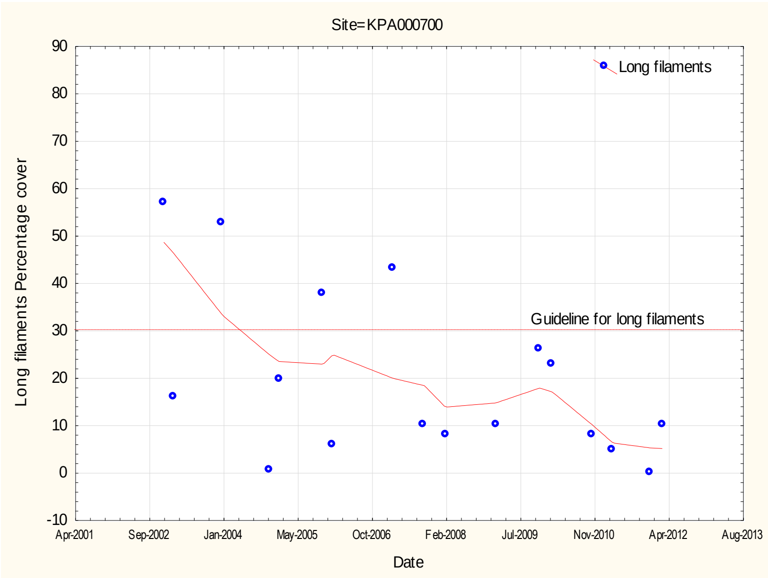
Figure 73 LOWESS trend analysis of percentage cover of long filaments at Kapoaiaia Stream, Wiremu Road (KPA000250)

At Wiremu Road (KPA000250), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau = -0.497346) that was significant using the Mann-Kendall test (p =0.005) but not significant after FDR application (p = 0.112). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.584654) that was significant using the Mann-Kendall test (p =0.001) and significant after FDR application (p = 0.011).



n = 17
Kendal tau = -0.075792
p-value = 0.671
FDR p-value = 0.956

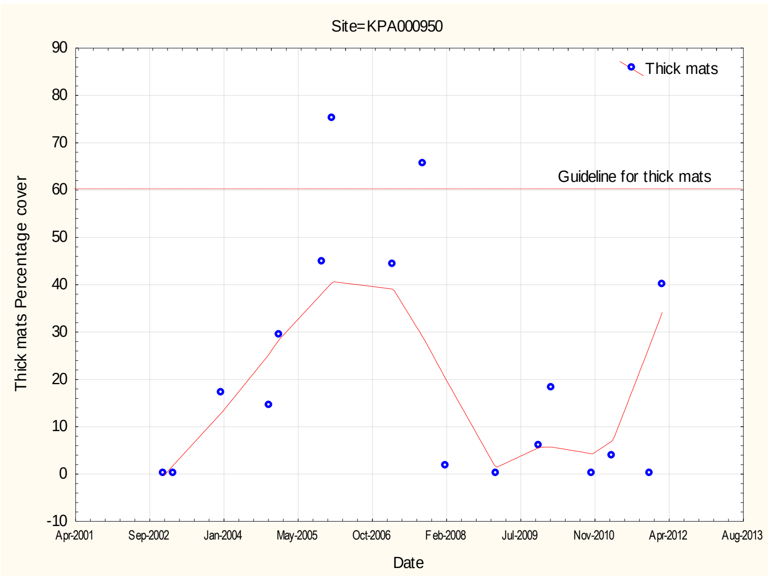
Figure 74 LOWESS trend analysis of percentage cover of thick mats at Kapoaiaia Stream, Wataroa Road (KPA000700)



n = 17
Kendal tau = -0.358249
p-value = 0.045
FDR p-value = 0.128

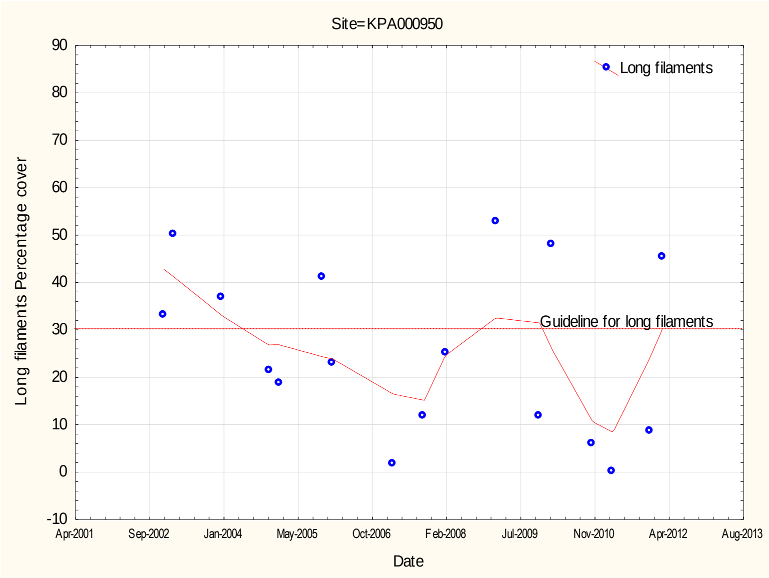
Figure 75 LOWESS trend analysis of percentage cover of long filaments at Kapoaiaia Stream, Wataroa Road (KPA000700)

At Wataroa Road (KPA000700), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau =-0.075792) that was not significant at the 5% level (p = 0.671). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.358249) that was significant using the Mann-Kendall test (p = 0.045) but not significant after FDR application (p = 0.128).



n = 17
Kendal tau = -0.030557
p-value = 0.864
FDR p-value = 0.956

Figure 76 LOWESS trend analysis of percentage cover of thick mats at Kapoaiaia Stream, Cape Egmont (KPA000950)



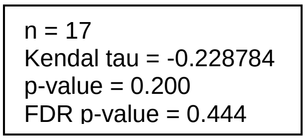


Figure 77 LOWESS trend analysis of percentage cover of long filaments at Kapoaiaia Stream, Cape Egmont (KPA000950)

At Cape Egmont (KPA000950), over the 10 year period monitored, there was a decreasing trend in percentage cover values of thick mats (Kendall tau =-0.030557) that was not significant at the 5% level (p = 0.864). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.228784) that was not significant at the 5% level (p = 0.200).

2.9 Waiongana River

The Waiongana Stream arises in the National Park tracking north east towards Inglewood then north to the coast; approximately 35 kilometres in total. The catchment covers a large area and includes numerous tributaries (Figure 78).

The top sampling site (WGA000260) at SH3a is located mid-catchment, situated just north of Inglewood. The second site (WGA000450), at Devon Road is located approximately 3 kilometres from the coastal mouth of the stream.

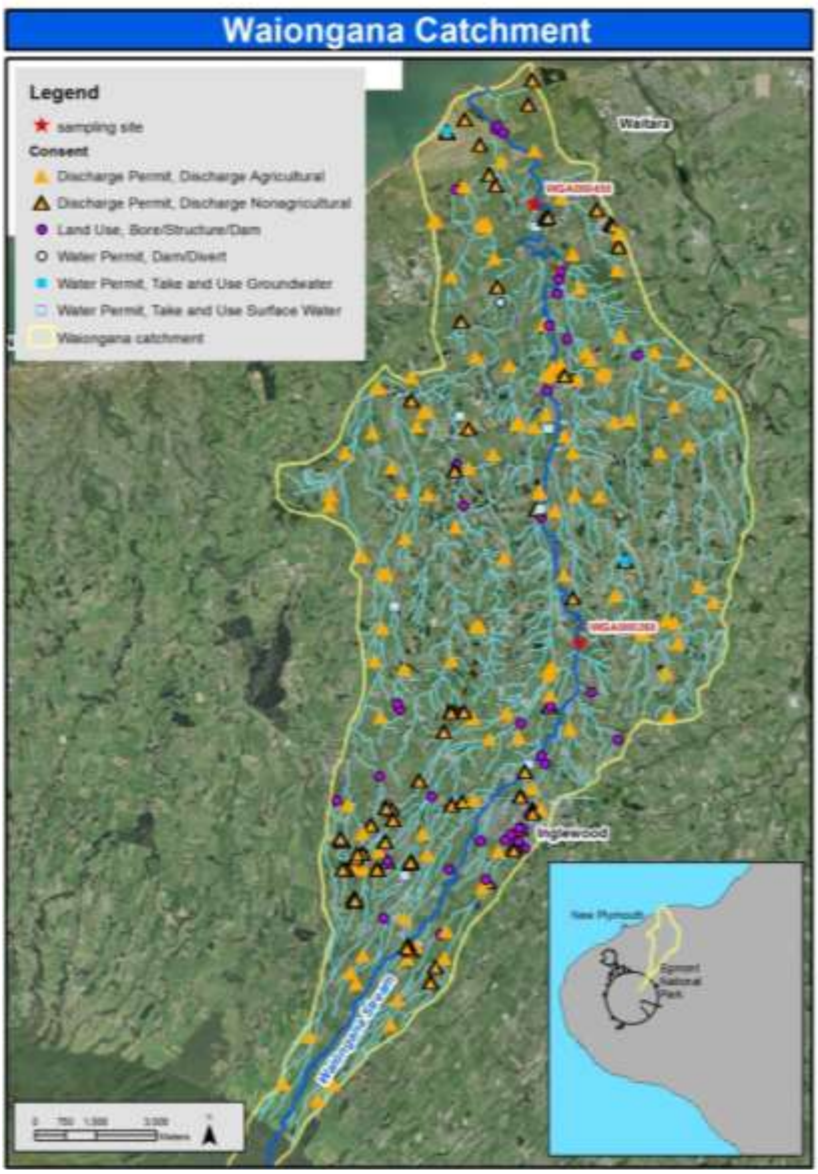


Figure 78 Monitoring site locations in relation to consents operating in the Waiongana Stream catchment

2.9.1 Flow data and survey dates

Early spring 2010 was characterised by frequent floods, regularly exceeding 7 x median flow (Appendix). A spring survey was undertaken 02 November 2010 following a period of receding flow that begun in mid October. The summer of 2011 experienced floods in late January, early March, late April and May. A summer periphyton survey was conducted after a small fresh, 31 March 2011 when levels were near MALF.

The 2011-2012 monitoring period was characterised by frequent floods. A very wet spring in 2011 meant a spring survey was not undertaken. Floods were frequent throughout early January and the whole of March. Towards the end of March flows began to recess and a summer survey was completed on 05 April 2012.

2.9.2 Periphyton cover

The two monitoring sites in the Waiongana River are situated mid-way down the catchment (SH3a), and near the lower end of the catchment (Devon Road). The river above these sites flows through predominantly through dairying country, and consequently there is likely to be a relatively high nutrient inflow, in the form of point source and diffuse runoff discharges. Both long filamentous and thick mats of algae were found on occasion in the surveys carried out in the 2010-2012 monitoring years (Figure 79 and Figure 80). No guidelines were breached over this two year period.

A spring survey was completed in early November 2010. In the mid-catchment site at SH3a filamentous algae dominated the community (26% coverage); no thick mats were recorded. Further downstream at Devon Road only thick mats were recorded, at a low 9% coverage. A decrease in periphyton occurred from spring to summer with no nuisance periphyton recorded at either site during the summer survey of 2011. A large flood event that occurred in early March and two small freshes that preceded the summer survey may have contributed to these low periphyton abundances.

In the 2011-2012 monitoring year only a summer survey was completed due to weather constraints. In this 2012 survey only a small proliferation of long filamentous algae was recorded at SH3a; no mats were visible. At the lower site at Devon Road, thick mats dominated the substrate, with only small proliferations of filamentous algae recorded.

In summary, SH3a (the mid catchment site) typically had a higher cover of long filamentous algae whereas Devon Road (the lower catchment site), had a higher cover of thick mats. Neither site breached the recreational guideline for nuisance periphyton in the two year period.

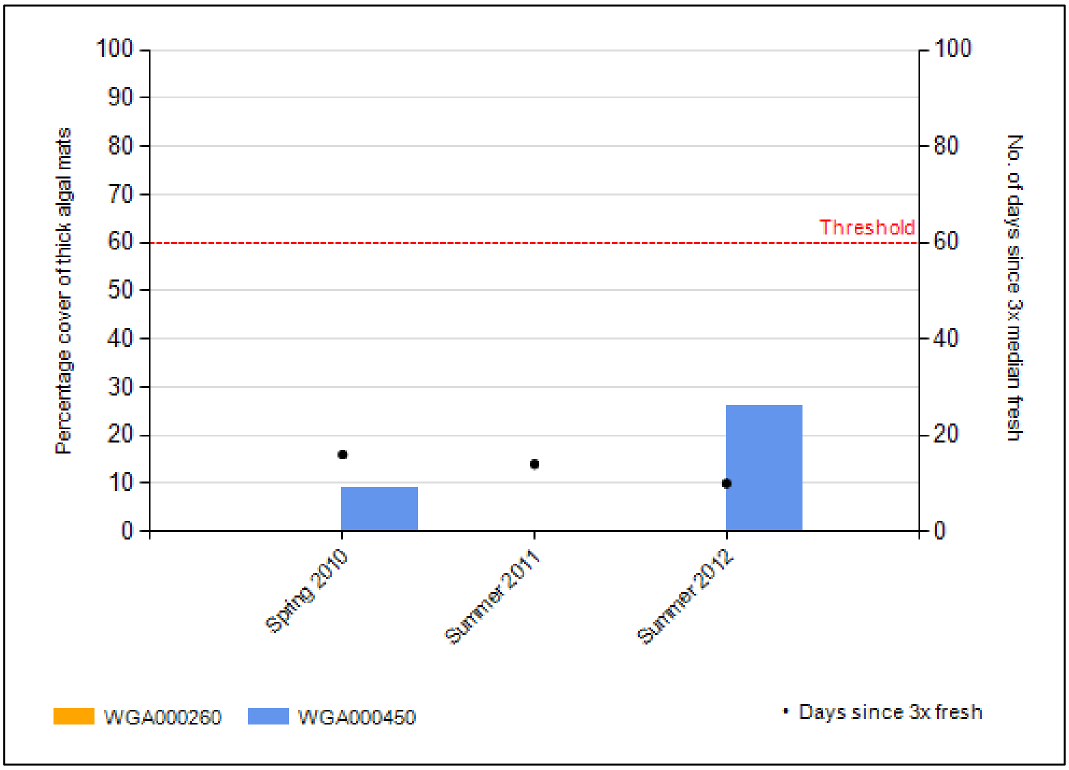


Figure 79 Percentage cover of thick mats of periphyton on the Waiongana riverbed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

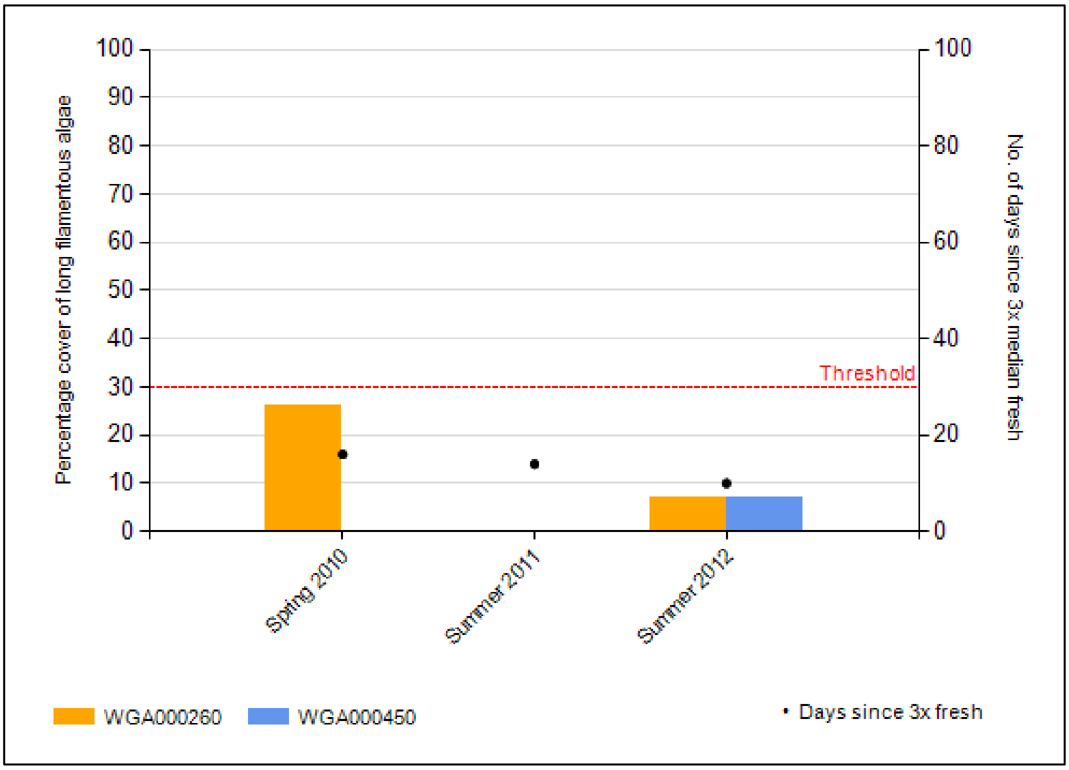


Figure 80 Percentage cover of long filamentous algae on the Waiongana riverbed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

2.9.3 Periphyton Index Score

The upstream site at the Waiongana River had a lower TRC PI score than the downstream site in spring 2010, but higher TRC PI in summer 2011 and summer 2012 (Table 15). This contrasts to previous monitoring years in which the upstream site consistently had a lower TRC PI score than the downstream site. This decrease in TRC PI score at the upstream site has, in the past, been attributed to a change from higher intensive land use in the upper catchment, to a less intensive land use in the lower catchment.

The upstream site showed an increase in TRC PI score from spring to summer, whereas the lower site showed an increase from spring 2010 to summer 2011 then a decrease of 2.4 units from summer 2011 to summer 2012. Reasons for the higher summer TRC PI scores are unclear, although it may be related to how nutrients enter the stream. If nutrients are primarily sourced through precipitation runoff, then in late summer, when there is less rain, there is less nutrient inflow and a consequent limitation on periphyton growth despite other conditions generally being more favourable at this time. This effect would be less noticeable in catchments where a significant nutrient inflow is through point source discharges, which are less affected by rainfall.

The rate of change in overall TRC PI score was a decrease of 0.046 units per kilometre, over approximately 15.1 kilometres. This is a complete change from the previous monitoring period in which an improvement occurred in a downstream direction at an average rate of 0.093 units per kilometre.

Table 15 Median seasonal periphyton index scores for the Waiongana River. The difference given is the TRC PI for the most upstream site minus the TRC PI for the most downstream site

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
WGA000260	6.5	9.7	n/a	8.4	7.1	5.8
WGA000450	7.7	8.9	n/a	6.5	7.7	7.0
Difference	-1.2	0.8	n/a	1.9	-0.6	1.2

2.9.4 Summary of 2002-2012 (10 year data set)

There is monitoring data for periphyton in the Waiongana catchment from 2002-2012. The Waiongana catchment over the 10 year data set has had no breaches in thick algal mats at either of the sites surveyed (Figure 81). There have been more significant growths of thick mats at the downstream site than the upstream site over more recent years (2010-2012). This contrasts to what was recorded in the 2006-2010 period, when greater proliferations were observed at the upstream site.

Long filamentous algae has intermittently breached guidelines throughout the entire record at both the upstream and downstream sites (Figure 82). The majority of these spikes in periphyton growths particularly at the upstream site tended to be after periods of significant low flows, such as late summer 2007 and summer 2008. There have not been as many breaches at the lower catchment site, however long filaments were generally present on most surveys undertaken. In the most recent period (2010-2012), proliferations were very low in comparison to what has been recorded historically.

The Waiongana catchment is the only catchment where breaches in periphyton guidelines increased between the 2002-2006 and 2006-2010 surveys. The last breaches occurred in summer 2010 at both sites, where proliferations only just exceeded guideline levels. In the most recent period there were no breaches in nuisance periphyton guidelines.

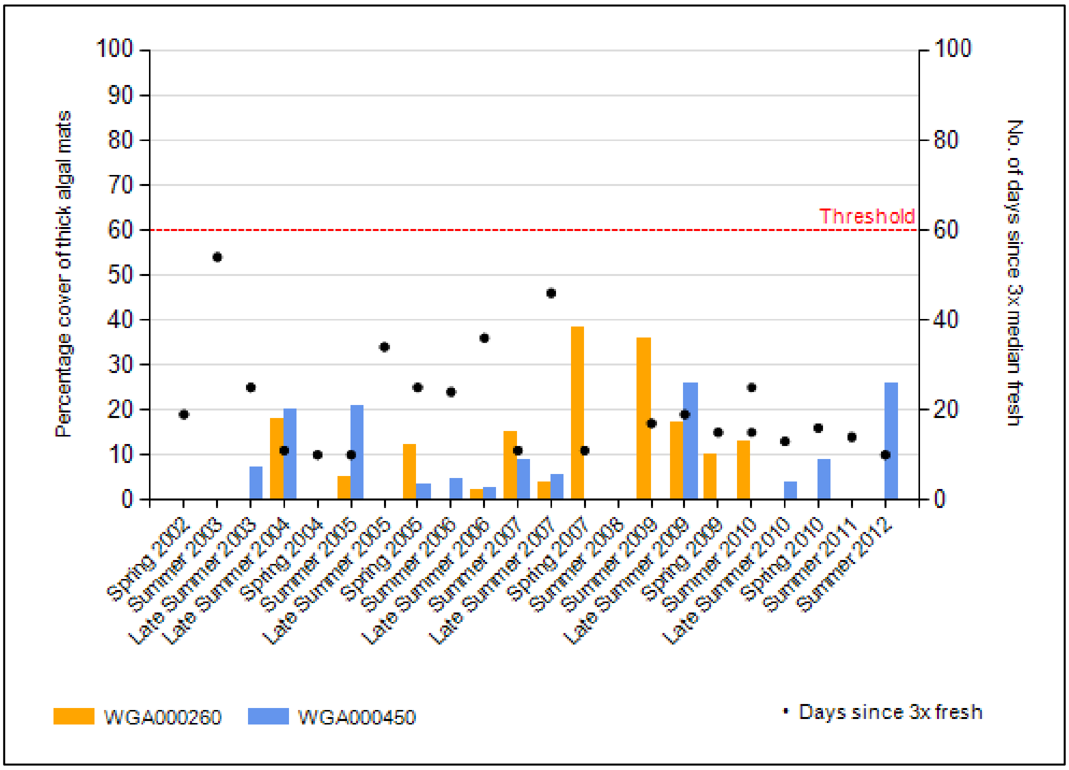


Figure 81 Percentage cover of thick mats of periphyton on the Waiongana riverbed in relation to the guidelines for recreational values over the 2002-2012 period

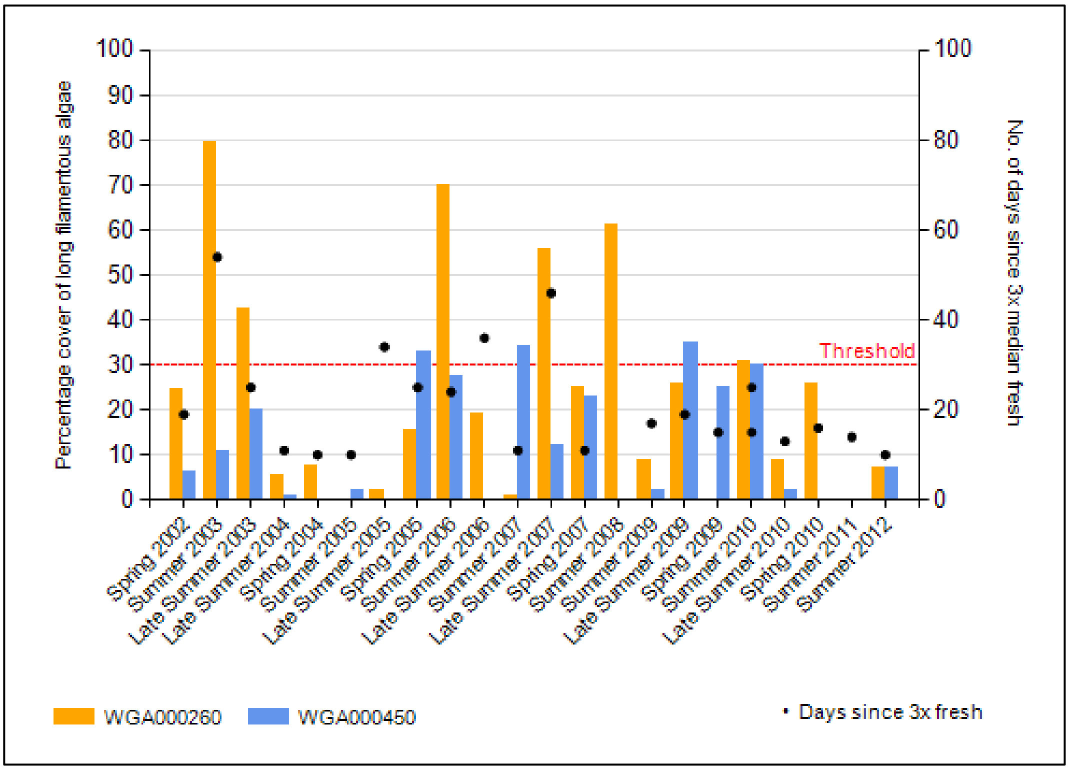
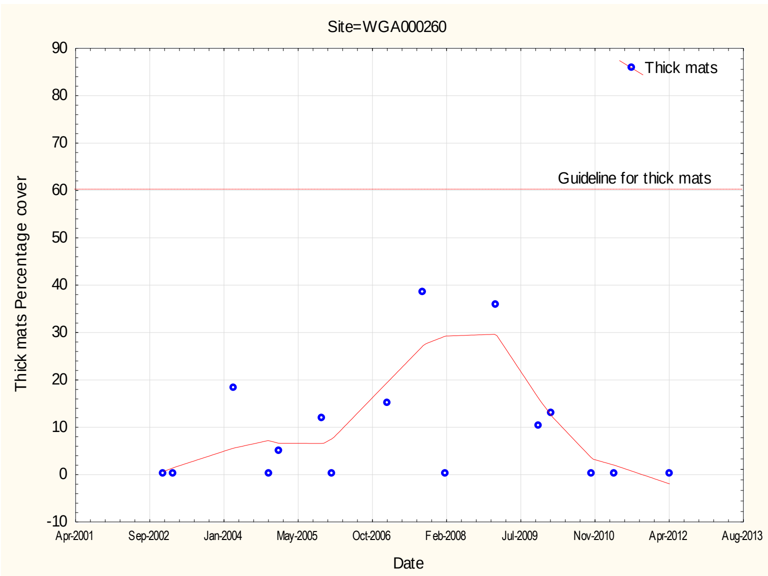


Figure 82 Percentage cover of long filamentous algae on the Waiongana riverbed in relation to the guidelines for recreational values over the 2002-2012 period

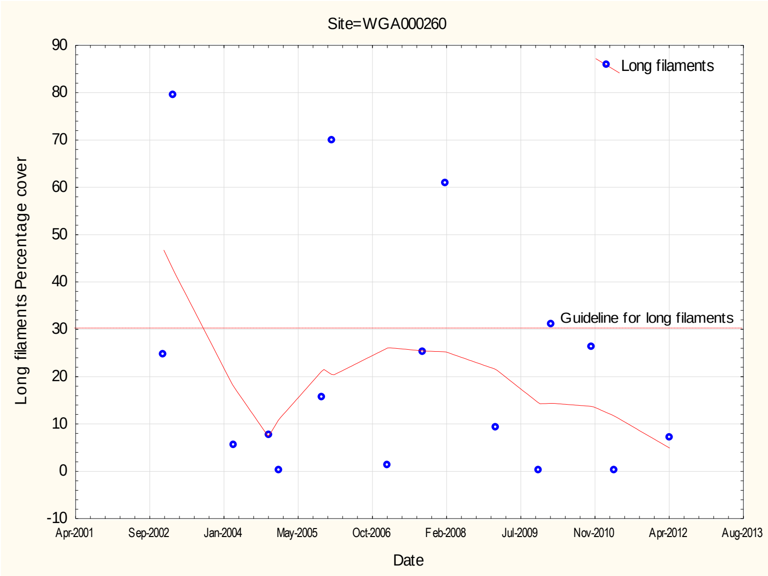
2.9.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Waiongana River, at SH3a and Devon Road, over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 83 to Figure 86).



n = 16
Kendal tau = 0.00
p-value = 1.00
FDR p-value = 1.00

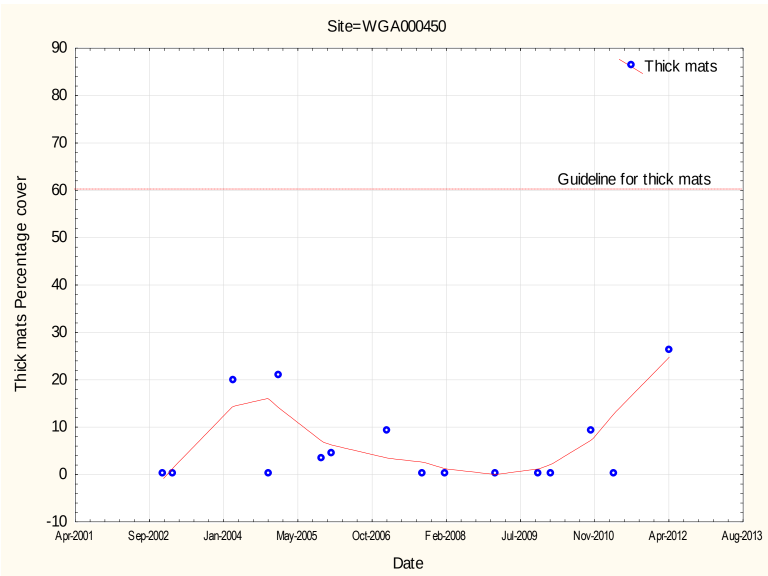
Figure 83 LOWESS trend analysis of percentage cover of thick mats at Waiongana River, SH3a (WGA000260)



n = 16
Kendal tau = -0.126592
p-value = 0.494
FDR p-value = 0.644

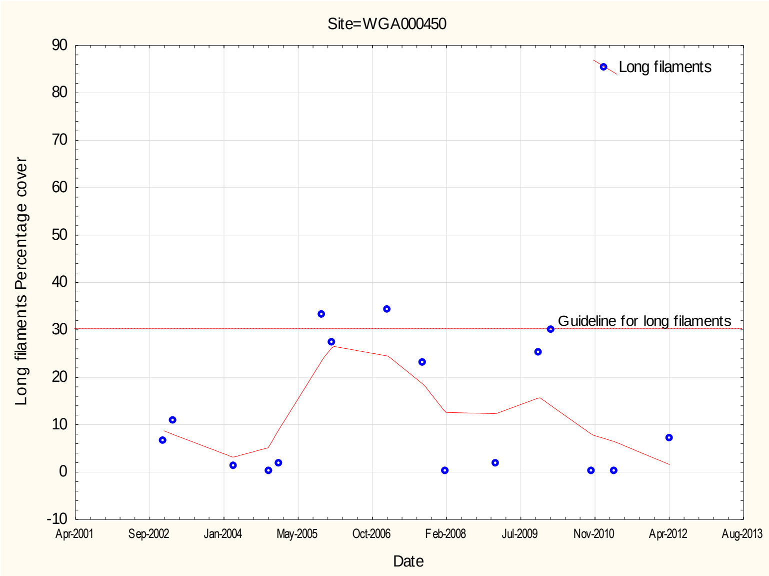
Figure 84 LOWESS trend analysis of percentage cover of long filaments at Waiongana River, SH3a (WGA000260)

At SH3a (WGA000260), over the 10 year period monitored, there was no trend for percentage cover values of thick mats. There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.126592) that was not significant at the 5% level (p = 0.494).



n = 16
Kendal tau = 0.030060
p-value = 0.871
FDR p-value = 0.956

Figure 85 LOWESS trend analysis of percentage cover of thick mats at Waiongana River, Devon Road (WGA000450)



n = 16 Kendal tau = -0.042938 p-value = 0.817 FDR p-value = 0.860

Figure 86 LOWESS trend analysis of percentage cover of long filaments at Waiongana River, Devon Road (WGA000450)

At Devon Road (WGA000450), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.030060) that was not significant at the 5% level (p = 0.871). There was a decreasing trend in percentage cover values of long filaments (Kendall tau = -0.042938) that was not significant at the 5% level (p = 0.817).

2.10 Mangaehu River

The Mangaehu River represents a typical eastern hill country river. Arising approximately 10 km south of Whangamomona it runs in a south-westerly direction for around 30 km through predominantly agricultural land before discharging into the Patea River.

The river typically has a relatively poor visual appearance, with low black disc clarity due to fine, colloidal suspended particles (TRC, 2012). This is due to the eastern hill country catchment geology that this river drains, which is very different from the stony ring plain streams around Mount Taranaki.

One monitoring site (MGH000950 at Raupuha Road) is monitored in this catchment, about 10 km upstream of the confluence of the Mangaehu River with the Patea River (Figure 87).

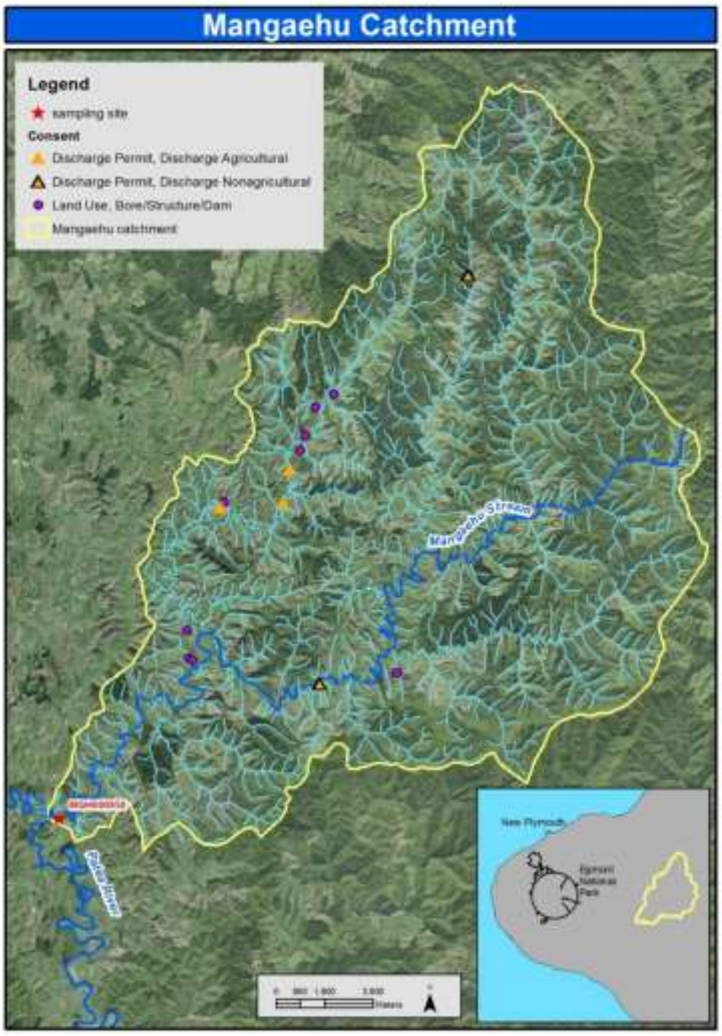


Figure 87 Monitoring site in the Mangaehu River

2.10.1 Flow data and survey dates

Early spring 2010 was characterised by numerous flood events, often exceeding 7x median flow (Appendix). A relatively long period of flow recession was recorded from early October through to mid December. A spring survey took place during this period of flow recession on 03 November 2010. The summer of 2011 was particularly wet, thus a summer periphyton survey was not carried out.

Spring 2011 experienced relatively lower flows in September, with only one flood event exceeding 3x median flow. October was particularly wet, with numerous flood events and high flows recorded throughout the month. A large flood event in early November was followed by a period of flow recession which allowed a spring survey to be carried out 17 November 2011. Summer 2012 saw intermittent flood events, together with reasonably long periods of flow recession. A summer periphyton survey was carried out 01 February 2012 during a period of relatively low flow that lasted from mid January to mid February.

2.10.2 Periphyton cover

Only one site was surveyed in the Mangaehu River. Located at the road bridge on Raupuha Road, it is situated near the lower end of the catchment just above the confluence with the Patea River. Thick mats dominated at this site and the total percentage cover of nuisance growths was relatively high (Figure 88 and Figure 89).

The streambed in spring 2010 had minor proliferations of thick mats and long filaments but not enough to breach recreational guidelines (14% and 6% respectively). The summer of 2011 was particularly wet which meant a periphyton survey was not carried out. In spring 2011 proliferations of algae were similar to the previous spring with minor proliferations of both thick mats (16% coverage) and long filaments (4.5% coverage). Summer 2012 saw a substantial increase in thick mats (by 37%), with the proliferation coming close to breaching guideline levels. Long filamentous algae also showed a 7.5% increase in coverage from spring to summer.

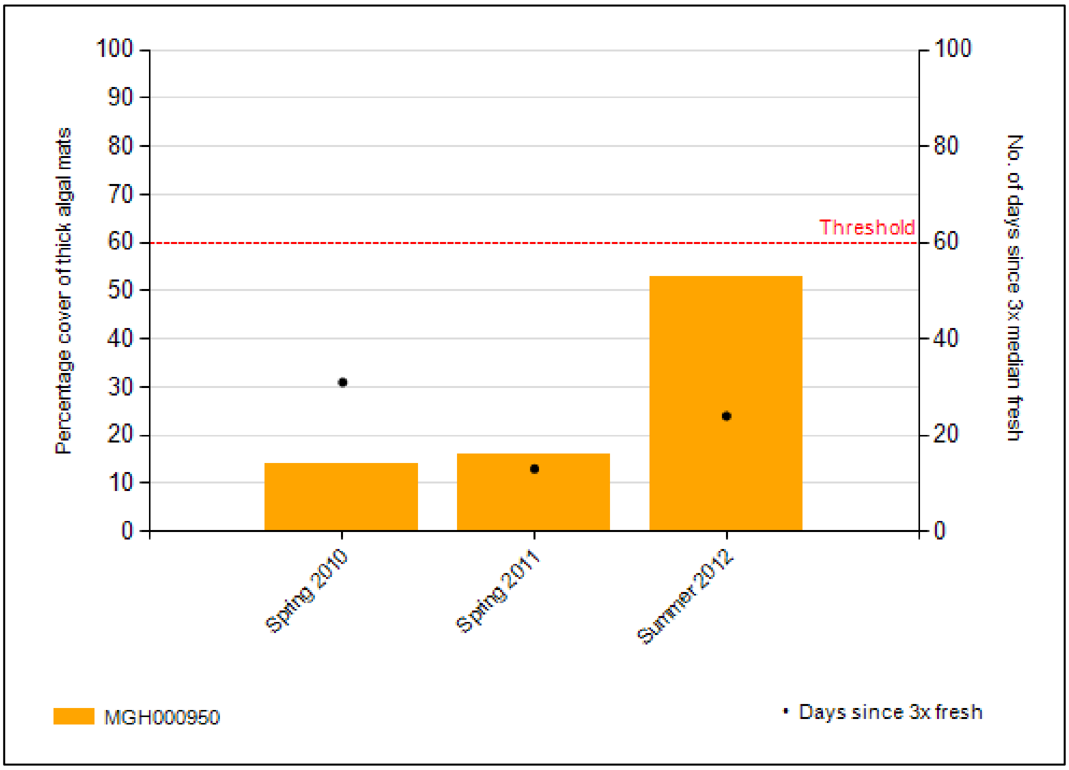


Figure 88 Percentage cover of thick mats of periphyton on the Mangaehu riverbed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

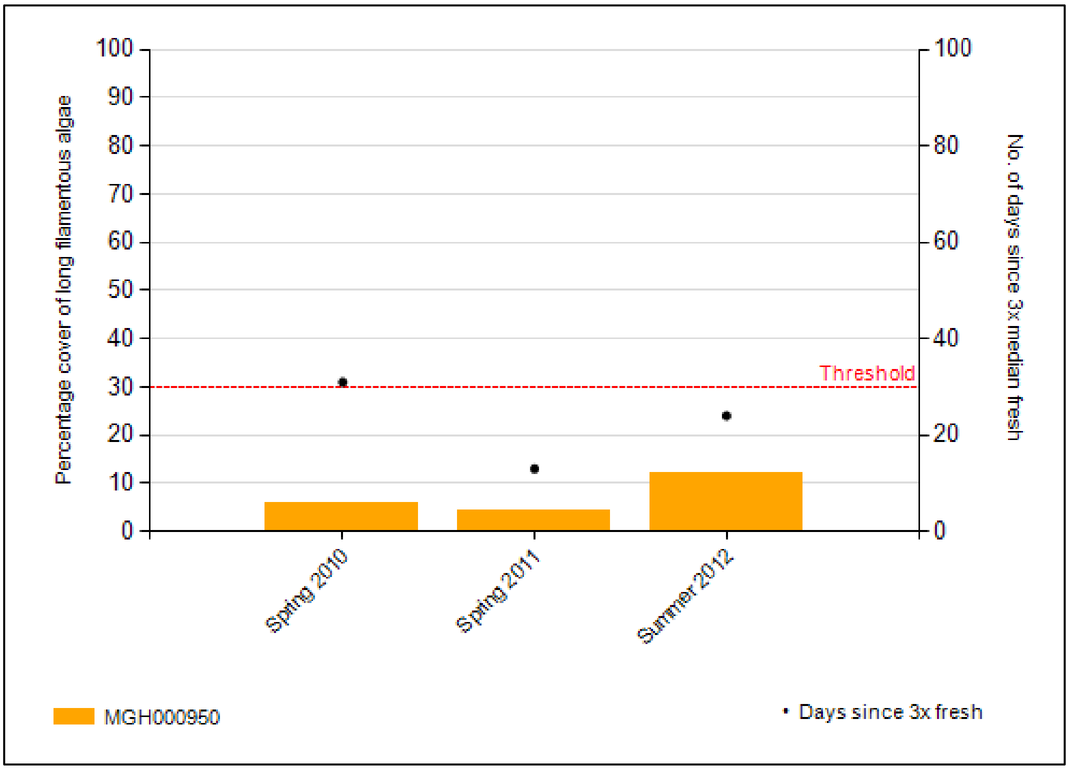


Figure 89 Percentage cover of long filamentous algae on the Mangaehu riverbed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

2.10.3 Periphyton Index Score

The Mangaehu River is subject to high sediment loads, as it drains the eastern hills of Taranaki. This is a factor not present for the other rivers in this programme, and it may have an influence on periphyton growth. Only one site is surveyed in this programme, so downstream changes cannot be discussed. There are some strong changes in median PI with season (Table 16).

In spring 2010 and 2011, a 'good' PI score was recorded. In spring 2010 the PI score was just below the historical median and in spring 2011 it was just over. Between spring 2011 and summer 2012 the PI score dropped by 2.4 units in summer, to a 'moderate' rating (this is similar to the median drop seen in the 2006-2010 monitoring period, however significantly smaller than the drop recorded in the 2002-2006 survey (5.2 units)). This decrease in PI score can be attributed to the proliferation of thick brown mats over the warmer summer period.

Table 16 Median seasonal periphyton index scores for the Mangaehu River

Site	TRC PI Spring 2010	TRC PI Summer 2011	TRC PI Spring 2011	TRC PI Summer 2012	TRC PI Historical spring median	TRC PI Historical summer median
MGH000950	6.8	n/a	8.0	5.6	7.7	4.4

2.10.4 Summary of 2002-2012 (10 year dataset)

There is monitoring data for periphyton in the Mangaehu catchment from 2002-2012. Overall percentage cover of growths in the form of long filaments and thick algal mats had increased over the 2002-2010 period of monitoring at the Mangaehu site (Figure 90 and Figure 91). Current results (2010-2012) show a potential reduction in nuisance growths, particularly thick mats. In this period there were no breaches of the nuisance periphyton guidelines for thick mats. Prior to this there has only been one breach and one close breach of thick mats and these were constrained to late summer 2004 and summer 2009 surveys. These two surveys followed longer intervals since significant freshes. The thick algal mats do tend to increase from spring to summer to late summer, which indicates that growths follow temperature increases and decreasing rainfall to some extent.

Long filamentous algae proliferate on a regular basis at this site, and have breached the recreational guidelines six times over the 10 year monitoring period. These occurrences are restricted to summer or late summer periods. During the 2002-2006 period there were four breaches in long filamentous algae compared to only two breaches in the 2006-2010 period in the same number of surveys. No breaches of long filamentous algae occurred in the current monitoring period.

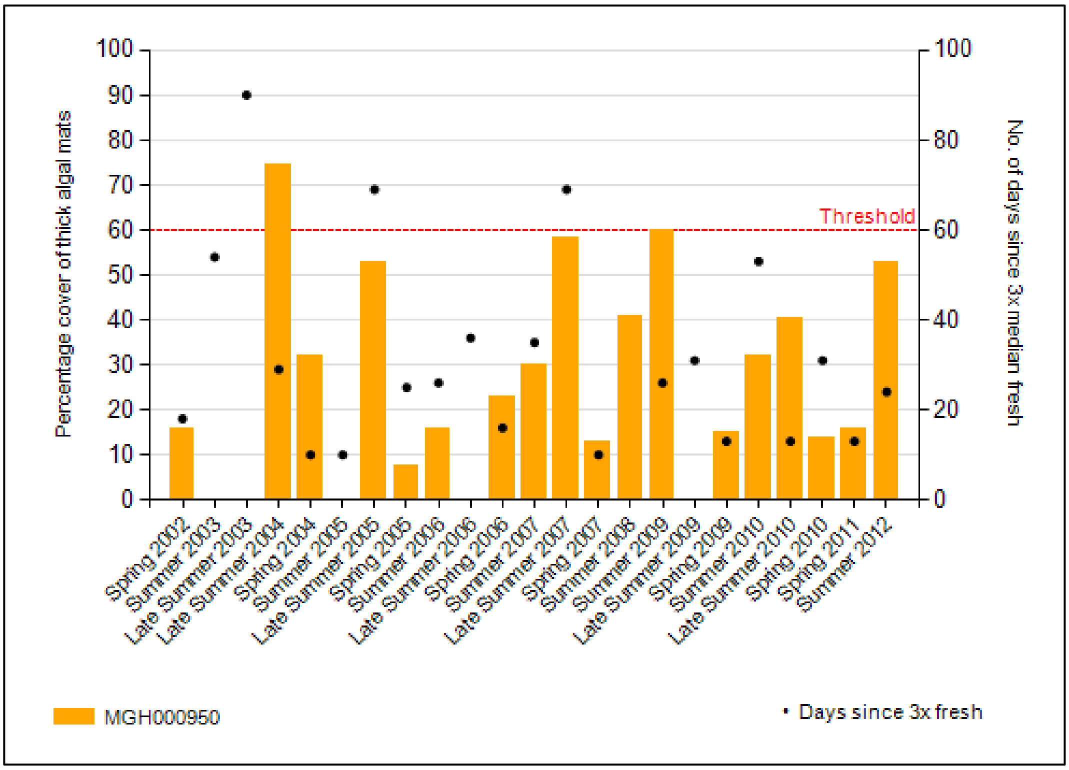


Figure 90 Percentage cover of thick mats of periphyton on the Mangaehu riverbed in relation to the guidelines for recreational values over the 2002-2012 period

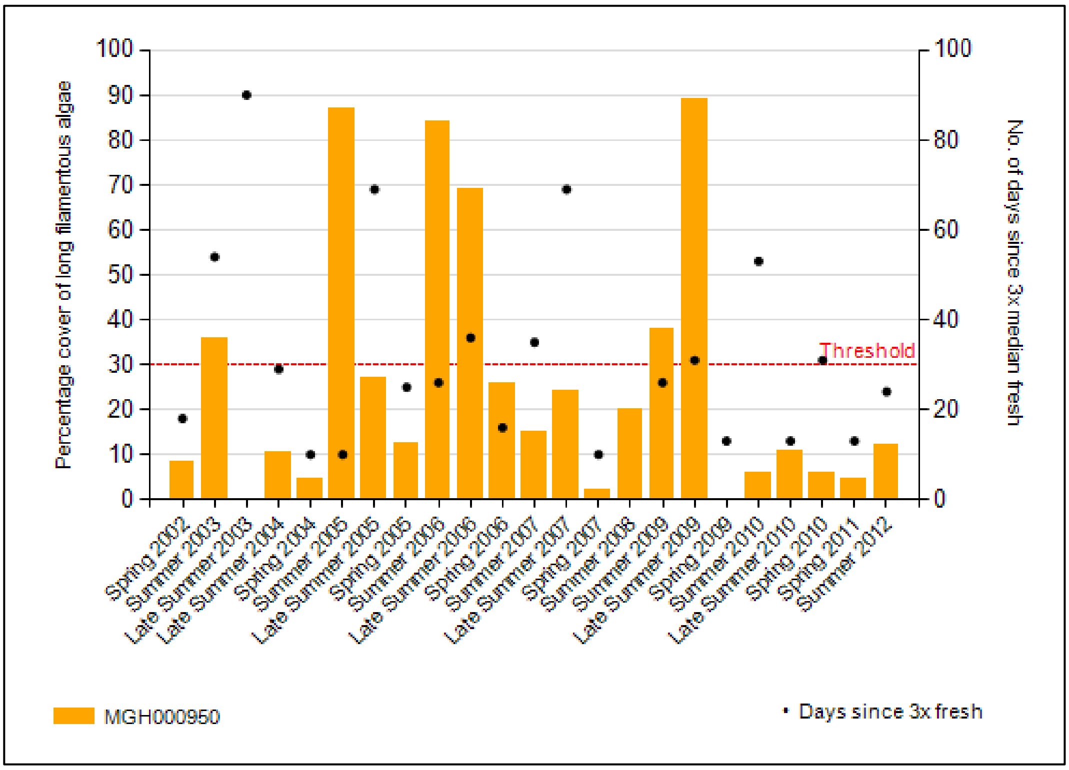
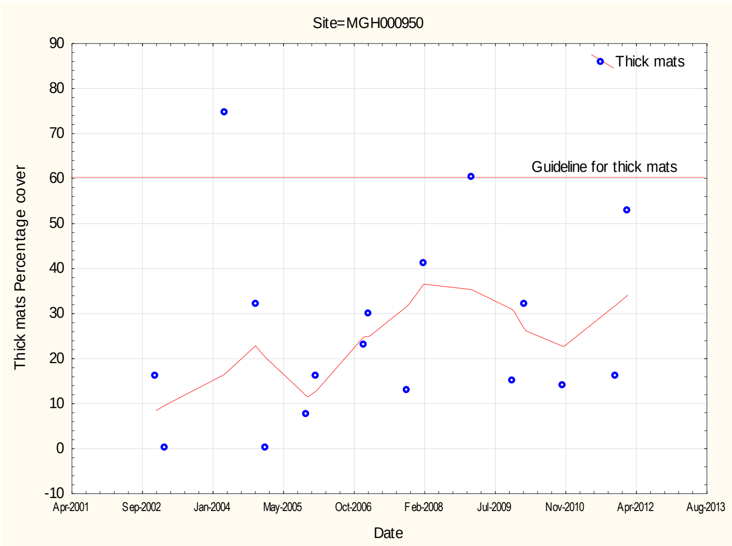


Figure 91 Percentage cover of long filamentous periphyton on the Mangaehu riverbed in relation to the recreational guideline over the 2002-2012 monitoring period

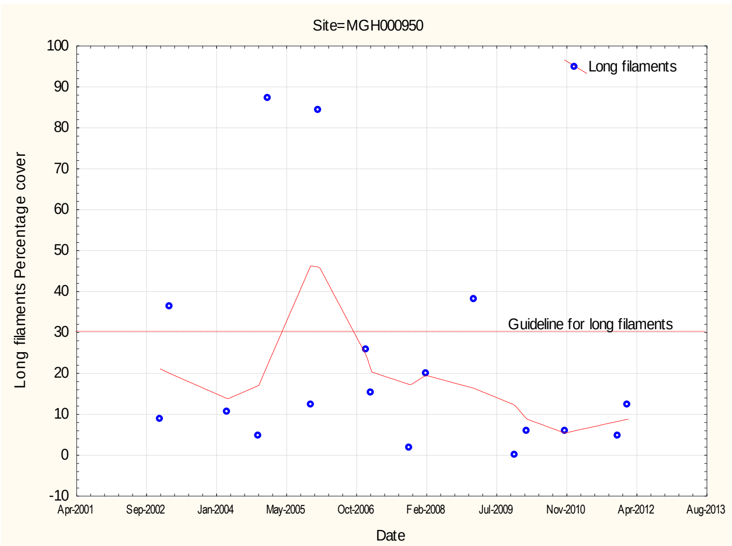
2.10.5 Long term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at the Mangaehu River, at Ruapuha Road over a 10 year period and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis (Figure 92 and Figure 93).



n = 17
Kendal tau = 0.202283
p-value = 0.257
FDR p-value = 0.763

Figure 92 LOWESS trend analysis of percentage cover of thick mats at Mangaehu River, Ruapuha Rd (MGH000950)



n = 17
Kendal tau = -0.20413
p-value = 0.245
FDR p-value = 0.451

Figure 93 LOWESS trend analysis of percentage cover of long filaments at Mangaehu River, Ruapuha Rd (MGH000950)

At Ruapuha Road (MGH000950), over the 10 year period monitored, there was an increasing trend in percentage cover values of thick mats (Kendall tau =0.202283) that was not significant using the Mann-Kendall test (p =0.257). There was a decreasing trend in percentage cover values of long filaments (Kendall tau =-0.20413) that was not significant at the 5% level (p = 0.245).

3. General summary

3.1 Periphyton cover

During the 2010-2012 monitoring period it was intended that 21 sites be monitored for periphyton on four occasions; spring 2010, summer 2011, spring 2011 and summer 2012. In spring 2010 all sites were monitored. In summer 2011, three sites were unable to be monitored due to poor weather conditions and high flows. In spring 2011 four sites were not monitored, however in summer 2012, all 21 sites were monitored (Table 17).

Table 17 Nuisance periphyton coverage at 21 sites over the 2010-2012 monitoring period

Catchment	River/Stream	Site	Nuisance periphyton percentage cover							
			Spring 2010		Summer 2011		Spring 2011		Summer 2012	
			Mats	Filaments	Mats	Filaments	Mats	Filaments	Mats	Filaments
Upper	Patea	Barclay Road	0	0	0	0	0	0	0	1
	Maketawa	Denby Road	0	0	0	0	0	0	0	4
Middle	Kapoaiaia	Wiremu Road	0	0	0	0	0	0	0	0
	Kapoaiaia	Wataroa Road	6	8	5	5	0	0	20	10
	Waingongoro	Opunake Road	0	0	0	0	0	0	0	0
	Waingongoro	Stuart Road	0	0	8	0	0	0	0	3
	Manganui	SH3	0	0	0	0	0	0	0	0
	Patea	Skinner Road	0	4	4	8	0	4	11.5	18.5
	Hangatahua (Stony)	Mangatete Road	0	0	n/a	n/a	0	0	0	0
	Waiongana	SH3a	0	26	0	0	n/a	n/a	0	7
	Punehu	Wiremu Road	0	0	0	4	0	0	9	0
	Waiwhakaiho	SH3 (Egmont Village)	0	22	5	5	n/a	n/a	0	0
	Maketawa	Tarata Road	0	0	0	0	0	0	0	0
Lower	Kapoaiaia	Cape Egmont	0	6	4	0	0	8.5	40	45.5**
	Mangaehu	Ruapuha Road	14	6	n/a	n/a	16	4.5	53	12
	Manganui	Bristol Road	0	0	0	2	0	6	3	19
	Punehu	SH45	0	0	0	4	0	0	1	1
	Hangatahua (Stony)	SH45	0	0	n/a	n/a	0	0	0	0
	Waiongana	Devon Road	9	0	0	0	n/a	n/a	26	7
	Waingongoro	Ohawe Beach	8	0	7	0	0	0	8	3
	Waiwhakaiho	Constance Street, NP	4	6	0	0.5	n/a	n/a	16	0

**Breach in guideline levels

High nuisance periphyton cover
Over the entire 2010-2012 monitoring period there were no breaches in thick mat guidelines and only one breach in long filamentous algae guidelines. The breach occurred at Cape Egmont, a lower catchment site on the Kapoaiaia Stream (Table 17). A high percentage of both mats cover and nuisance filaments were recorded at this site at the time this breach occurred (summer 2012). The Kapoaiaia Stream drains through agricultural land and has relatively poor riparian vegetation; meaning it is provided with a lot of sunlight, and nutrients, both of which can contribute to periphyton growth. Despite the breach in summer 2012, the prior three monitoring occasions recorded low periphyton cover for both mats and filaments.

Moderate nuisance Periphyton cover
Two sites which consistently recorded a low to moderate level of periphyton over the 2010-2012 monitoring period included the middle catchment site on the Patea River at Skinner Road and the lower catchment site on the Mangaehu River at Ruapuha Road (Table 17).

The proliferation of periphyton at the Patea River, Skinner Road is likely to be closely linked to the high nutrient inflows to the main stem between Barclay Road and Skinner Road, and in the tributaries that contribute to the Patea through this reach, such as the Kahouri Stream. Furthermore periphyton proliferation may be attributed to a lack of fencing and vegetation at this site. This site is subject to higher temperatures, and low amounts of shading, and has predominantly a boulder-cobble substrate, which all contribute to periphyton growth.

The Mangaehu River is at times subject to high sediment loadings, a factor not present in other rivers monitored. Sediment can transport attached nutrients, which may contribute to periphyton growth at this site. The greater proliferation of periphyton often recorded in summer at this site is primarily related to a reduction in turbidity in summer, due to a more stable flow, allowing more sunlight to reach the riverbed, and periphyton to flourish.

Seven sites from both middle and lower catchments, on occasion did not record any periphyton, while on other monitoring occasions recorded moderate to high (but not excessive) periphyton proliferation. These sites included the Kapoaiaia River at Wataroa Road, the Waiongana River at SH3a and Devon Road, the Waiwhakaiho River at SH3 and Constance, the Manganui River at Bristol Road and the Waingongoro River Ohawe Beach.

Typically an increase in periphyton proliferation was recorded from upstream to downstream, with summer 2012 generally recording the most periphyton proliferation over the reported period.

Low periphyton cover
The Maketawa Stream and Hangatahua (Stony) River recorded very little or no periphyton throughout the 2010-2012 monitoring period (Table 17). An upper catchment and middle catchment site were monitored on the Maketawa Stream and a middle and lower catchment site were monitored on the Stony River.

The very low periphyton biomass recorded at the Hangatahua (Stony) River can be attributed to two main factors; the low nutrient input into the river and also to the high sediment load during floods which can cause significant amounts of scouring to periphyton.

In the past, the Maketawa Stream exhibited some strong differences between the upstream and downstream sites as the lower site is situated in a predominantly dairying catchment. Agricultural activities provide nutrients in both point source, and diffuse runoff, and encourage periphyton proliferation when environmental conditions allow. Unlike the past, discharges appear to be to land rather than via oxidation ponds and into tributaries of the Maketawa. This change can perhaps explain the minimal periphyton growth over the 2010-2012 period.

The Punehu Stream also recorded very little periphyton biomass at both monitoring sites over the reported period (Table 17). The stream is representative of a south-western Taranaki catchment subjected primarily to intensive agricultural land use with water quality potentially affected by diffuse run-off and point source discharges from dairy shed treatment pond effluent. In the past the top site has been dominated by thin films of algae, with deterioration recorded at the lower site at SH45, where filamentous algae tended to dominate. However in the current reporting period periphyton biomass at both sites remained low.

Five upper monitoring sites including the Patea River at Barclay Road, the Kapoaiaia River at Wiremu Road, the Waingongoro River at Opunake Road and Stuart Road and the Manganui River at SH3 also recorded little or no periphyton over the 2010-2012 monitoring period (Table 17). The lower periphyton biomass at these sites can be attributed to either the riparian vegetation restricting high stream temperatures or to low upstream nutrient inputs.

3.2 TRC Periphyton index

TRC periphyton index scores ranged from 'moderate' to 'very good' over the reported period (Table 18). All upper catchment sites received 'very good' TRC PI scores. Of the 11 middle catchment sites, seven consistently scored 'very good' TRC PI scores, while the remaining four, varied between 'good' and 'very good'. The Hangatahua (Stony) River at SH45 was the only lower catchment site to have a consistently 'very good' TRC PI score. The lower catchment sites on the Punehu Stream and Waiongana, Waiwhakaiho and Waingongoro Rivers had TRC PI scores ranging from 'good' to 'very good', while the Kapoaiaia Stream at Cape Egmont and Manganui River at Bristol Road ranged between 'moderate', 'good' and 'very good'. The Mangaehu River at Ruapuha Road, a lower catchment site, was the only site to have a TRC PI score ranging from only 'moderate' to 'good'.

Table 18 TRC PI scores for 21 sites over the 2010-2012 monitoring period

Catchment	River/Stream	Site	TRC Periphyton Index Score								Median rating 2010-2012	
			Spring 2010		Summer 2011		Spring 2011		Summer 2012			
			TRC PI	Rating	TRC PI	Rating	TRC PI	Rating	TRC PI	Rating	TRC PI	Rating
Upper	Patea	Barclay Road	10.0	Very good	10.0	Very good	9.6	Very good	9.4	Very good	9.8	Very good
	Maketawa	Denby Road	10.0	Very good	10.0	Very good	10.0	Very good	9.5	Very good	10	Very good
Middle	Kapoaiaia	Wiremu Road	10.0	Very good	10.0	Very good	10.0	Very good	10.0	Very good	10	Very good
	Kapoaiaia	Wataroa Road	8.9	Very good	7.2	Good	7.3	Good	7.3	Good	7.3	Good
	Waingongoro	Opunake Road	10.0	Very good	10.0	Very good	9.8	Very good	9.9	Very good	9.95	Very good
	Waingongoro	Stuart Road	9.6	Very good	9.0	Very good	10.0	Very good	9.6	Very good	9.6	Very good
	Manganui	SH3	9.9	Very good	10.0	Very good	9.8	Very good	10.0	Very good	9.95	Very good
	Patea	Skinner Road	8.5	Very good	7.0	Good	9.0	Very good	6.1	Good	7.75	Good
	Hangatahua (Stony)	Mangatete Road	10.0	Very good	n/a	n/a	10.0	Very good	10.0	Very good	10	Very good
	Waiongana	SH3a	6.5	Good	9.7	Very good	n/a	n/a	8.4	Very good	8.4	Very good
	Punehu	Wiremu Road	9.7	Very good	9.6	Very good	10.0	Very good	9.2	Very good	9.65	Very good
	Waiwhakaiho	SH3 (Egmont Village)	6.5	Good	8.2	Very good	n/a	n/a	9.5	Very good	8.2	Very good
	Maketawa	Tarata Road	9.5	Very good	9.2	Very good	9.8	Very good	8.8	Very good	9.35	Very good
Lower	Kapoaiaia	Cape Egmont	8.7	Very good	8.1	Very good	7.6	Good	4.7	Moderate	7.85	Good
	Mangaehu	Ruapuha Road	6.8	Good	n/a	n/a	8.0	Good	5.6	Moderate	6.8	Good
	Manganui	Bristol Road	5.3	Moderate	9.1	Very good	8.2	Very good	7.4	Good	7.8	Good
	Punehu	SH45	7.3	Good	9.1	Very good	10.0	Very good	9.9	Very good	9.5	Very good
	Hangatahua (Stony)	SH45	10.0	Very good	n/a	n/a	10.0	Very good	10.0	Very good	10	Very good
	Waiongana	Devon Road	7.7	Good	8.9	Very good	n/a	n/a	6.5	Good	7.7	Good
	Waingongoro	Ohawe Beach	9.2	Very good	8.0	Good	9.3	Very good	8.0	Good	8.6	Very good
	Waiwhakaiho	Constance Street, NP	8.9	Very good	8.1	Very good	n/a	n/a	6.7	Good	8.1	Very good

3.3 Long term trends

This programme has been implemented to establish the state of certain selected rivers, with regard to their periphyton proliferation and any trends arising. It is designed to detect and record differences in periphyton proliferation within a river, changes in periphyton proliferation with season, and also to eventually see changes over time, as other activities begin to take effect, e.g. riparian planting. This is the third report to be written for this programme, and is the first to include analysis of trends. Trend analysis has been performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton and by testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis. Trend analysis was carried out for all streams, using a ten year data set.

Of the 21 sites monitored, where long term trend analysis was carried out for thick mats of periphyton, nine showed a decreasing trend for thick mat algal growth, while 11 showed an increasing trend (Table 19). The Waiongana River at SH3a showed no trend. Of these trends, only the Kapoaiaia Stream at Wiremu Road, Maketawa Stream at Tarata Road and Waingongoro River at Opunake Road showed a significant trend at the 5% level. These trends however, were not significant after FDR application.

Only one of the rivers monitored (Kapoaiaia Stream) showed decreasing trends for thick mat algal growth for all three of the sites monitored. Conversely, three rivers (Mangaehu River, Stony River and Waiwhakaiho River) showed increasing trends for thick algal mat growth for all of the sites monitored. The Manganui, Patea and Waingongoro Rivers showed decreasing trends at upstream sites, but increasing trends at the downstream sites. The Maketawa and Punehu Streams both showed increasing trends for thick mat algal growth at upstream sites and decreasing trends at the downstream sites.

Table 19 Kendall Tau Correlations for periphyton (thick mats) for data from 2002-2012 arranged in alphabetical order. A significant trend at p<0.05 is shown in green text, and at p<0.01 in red text

Site	Valid N	Kendall Tau	Z	p-value	p-exact	FDR adjustment
KPA000250	17	-0.497346	-2.78623	0.005333	----	0.111983
KPA000700	17	-0.075792	-0.424604	0.671125	----	0.955842
KPA000950	17	-0.030557	-0.171184	0.864079	----	0.955842
MGH000950	17	0.202283	1.133227	0.257119	----	0.762785
MGN000195	18	-0.169165	-0.980361	0.326908	----	0.762785
MGN000427	18	0.240201	1.392035	0.163912	----	0.740099
MKW000200	18	0.098513	0.570914	0.568058	----	0.955842
MKW000300	18	-0.411078	-2.38231	0.017204	----	0.140667
PAT000200	19	-0.018826	-0.112628	0.910326	----	0.955842
PAT000360	19	0.092704	0.554602	0.579167	----	0.955842
PNH000200	18	0.233380	1.352504	0.176214	----	0.740099
PNH000900	18	-0.034871	-0.202088	0.839848	----	0.955842
STY000300	16	0.070711	0.382029	0.702440	----	0.955842
STY000400	16	0.070711	0.382029	0.702440	----	0.955842
WGA000260	16	0.00	0.00	1.000000	----	1.000000
WGA000450	16	0.030060	0.162406	0.870986	----	0.955842
WGG000150	19	-0.388559	-2.32456	0.020095	----	0.140667
WGG000665	19	-0.044992	-0.269167	0.787801	----	0.955842
WGG000995	19	0.164550	0.984428	0.324905	----	0.762785
WKH000500	15	0.201498	1.047015	0.295093	----	0.762785
WKH000920	15	0.041148	0.213809	0.830696	----	0.955842

Of the 21 sites monitored, where long term trend analysis was carried out for long filamentous algal growth, 17 showed a decreasing trend for long filamentous algal growth, while two showed an increasing trend (Table 20). The Manganui River at SH3 and Patea River at Barclay Road showed no trends. Seven of these trends were significant at the 5% level; [Kapoaiaia Stream (Wiremu Road and Wataroa Road), Manganui River (SH3), Maketawa Stream (Tarata Road), Patea River (Barclay Road), Waingongoro River (Opunake Road and Ohawe Beach), and Waiwhakaiho River (SH3, Egmont Village).Only two of these trends were significant after FDR application; [Kapoaiaia Stream (Wiremu Road) and Maketawa Stream (Tarata Road)].

Six of the rivers monitored (Kapoaiaia Stream, Mangaehu River, Stony River, Waiongana River, Waingongoro River and Waiwhakaiho Rivers) showed decreasing trends for long filamentous algal growth for all of the sites monitored.

Table 20 Kendall Tau Correlations for periphyton (long filaments) for data from 2002-2012 arranged in alphabetical order. A significant trend at p<0.05 is shown in green text, and at p<0.01 in red text

Site	Valid N	Kendall Tau	Z	p-value	p-exact	FDR adjustment
KPA000250	17	-0.584654	-3.27535	0.001055	----	0.010553
KPA000700	17	-0.358249	-2.00698	0.044752	----	0.127862
KPA000950	17	-0.228784	-1.28169	0.199951	----	0.444335
MGH000950	17	-0.207413	-1.16197	0.245248	----	0.450801
MGN000195	18				----	
MGN000427	18	-0.066010	-0.382546	0.702056	----	0.780063
MKW000200	18	0.186704	1.082004	0.279251	----	0.465418
MKW000300	18	-0.582810	-3.37755	0.000731	----	0.010553
PAT000200	19	0.00	0.00	1.000000	----	1.000000
PAT000360	19	-0.405889	-2.42825	0.015172	----	0.075860
PNH000200	18	0.093981	0.544645	0.585998	----	0.689409
PNH000900	18	-0.199363	-1.15537	0.247940	----	0.450801
STY000300	16	-0.186467	-1.00743	0.313729	----	0.482660
STY000400	16	-0.152564	-0.824259	0.409792	----	0.585417
WGA000260	16	-0.126592	-0.683941	0.494012	----	0.643786
WGA000450	16	-0.042938	-0.231980	0.816553	----	0.859530
WGG000150	19	-0.340985	-2.03996	0.041355	----	0.127862
WGG000665	19	-0.108821	-0.651028	0.515029	----	0.643786
WGG000995	19	-0.417231	-2.49610	0.012557	----	0.075860
WKH000500	15	-0.386514	-2.00839	0.044602	----	0.127862
WKH000920	15	-0.298091	-1.54892	0.121400	----	0.303500

4. Conclusion

In general, the Taranaki streams surveyed for nuisance periphyton have displayed some key points.

- True upstream sites with little agriculture in their catchment have a low biomass and stable periphyton canopy throughout the year.
- Periphyton communities at mid and low catchment sites are typically released from the applicable growth inhibiting factors applying in spring, as the water warms and flows become more stable in summer.
- All catchments monitored have improved in terms of reductions in the numbers of breaches of guidelines for nuisance growths since the 2006-2010 reporting period. The Stony River and Manganui River have stayed the same (no guideline breaches).
- There has been a significant amount of riparian vegetation and fencing implemented throughout the Taranaki region since the last report was written. There has generally been an increase in all catchments, and this may have led to the reduction of nuisance growths at some of the downstream sites.
- Nutrient inputs from municipal and industrial waste water discharges appear to cause greater periphyton proliferation than the cumulative nutrient input from diffuse and point source discharges from agricultural land (e.g. Patea River compared with Punehu River).
- Catchments with a proportion of their catchment used for agriculture are likely to have nuisance growths (not necessarily above guidelines) during an average summer.
- Spring conditions are capable of significantly limiting periphyton growth, probably through cooler temperatures and frequent flooding.
- Flood flows can cause a dramatic reduction in periphyton growth, but the degree of this effect is not consistent within streams or seasons or type of periphyton.
- That said, given the right conditions, nuisance growths of algae can occur even in spring.
- Larger more stable substrates may require a flood of a higher magnitude (particularly greater than three times median flow) before scour is enough to significantly reduce periphyton biomass.
- Of the 21 sites monitored, where long term trend analysis was carried out for thick mats of periphyton, nine showed a decreasing trend for thick mat algal growth, while 11 showed an increasing trend (Table 19). The Waiongana River at SH3a showed no trend. Of these trends, only the Kapoaiaia Stream at Wiremu Road, Maketawa Stream at Tarata Road and Waingongoro River at Opunake Road showed a significant decreasing trend at the 5% level. These trends however, were not significant after FDR application.
- Of the 21 sites monitored, where long term trend analysis was carried out for long filamentous algal growth, 17 showed a decreasing trend for long filamentous algal growth, while two showed an increasing trend. The Manganui River at SH3 and Patea River at Barclay Road showed no trends. Seven of these trends were significant decreasing trend at the 5% level, and only two sites showed significant decreasing trends after FDR application; Kapoaiaia Stream at Wiremu Road and Maketawa Stream at Tarata Road.

5. Additional monitoring: *Didymosphenia geminata*.

In 2004, an issue regarding periphyton in New Zealand came to light: the invasion of *Didymosphenia geminata*.

Didymo (*Didymosphenia geminata*), is a freshwater diatom native to Northern Europe that was first found in New Zealand in October 2004 (Photo 3). It has spread to numerous rivers in the South Island but has not yet been detected in the North Island. Didymo is spread very easily. It attaches to the streambed by stalks and forms a thick brown layer which can smother substrate and submerged plants, which in turn affects native invertebrates, fish and birds.

Photo 3 A young colony of *Didymosphenia geminata*

The invasion of *Didymosphenia geminata* has led to the instigation of the Didymo monitoring programme undertaken by Council.

The sites in Table 21 and Figure 94 are popular freshwater recreational sites in Taranaki and are monitored during the spring/summer season on an annual basis. DNA is extracted from the algae samples collected during monitoring and is analysed to confirm there is no Didymo ('rock snot') present at the representative sites monitored. Since monitoring began to date there has been **no** evidence to suggest that Didymo is in the Taranaki region.

Table 21 Sites monitored for *Didymosphenia geminata*

River	Site Code	Site
Waiwhakaiho River	Constance Street	WKH000920
Manganui River	Bristol Road	MGN000427
Patea River	Skinner Road	PAT000360
Waingongoro River	Ohawe Beach	WGG000995
Kaupokonui River	Upper Glen Road	KPK000880
Kapuni Stream	SH45	KPN000450
Stony River	Mangatete Road	STY000300
Mangaoraka Stream	Corbett Road	MRK000420

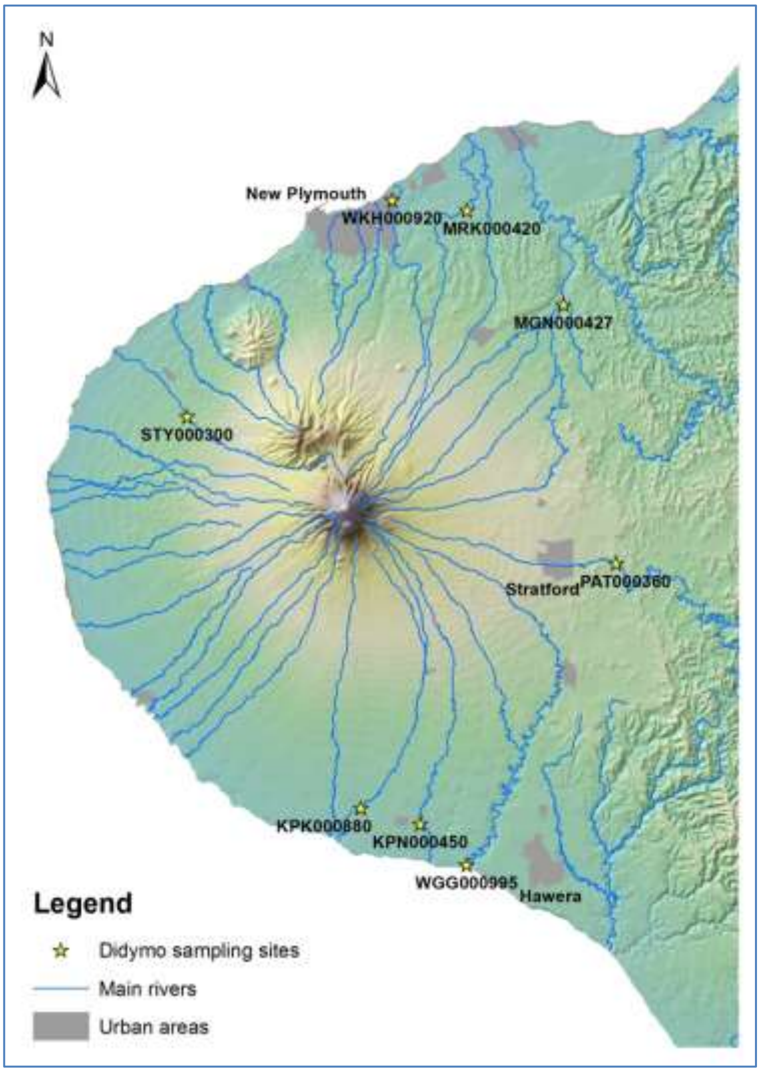


Figure 94 Sites to be monitored for *Didymosphenia geminata*

6. Recommendations

1. THAT monitoring of the periphyton communities in the Stony, Maketawa, Manganui, Patea, Waiwhakaiho, Waingongoro, Punehu, Kapoaiaia, and Mangaehu Rivers is continued for periphyton cover, using existing survey protocols.

2. THAT in the 2012-2014 monitoring period, the Waiwhakaiho, Manganui, Patea, Waingongoro, Stony and Kaupokonui Rivers and Kapuni and Mangaoraka Streams are monitored for the invasive alga *Didymosphenia geminata*.

3. THAT the periphyton survey results are included in the next SEM 5 yearly state of environment report.

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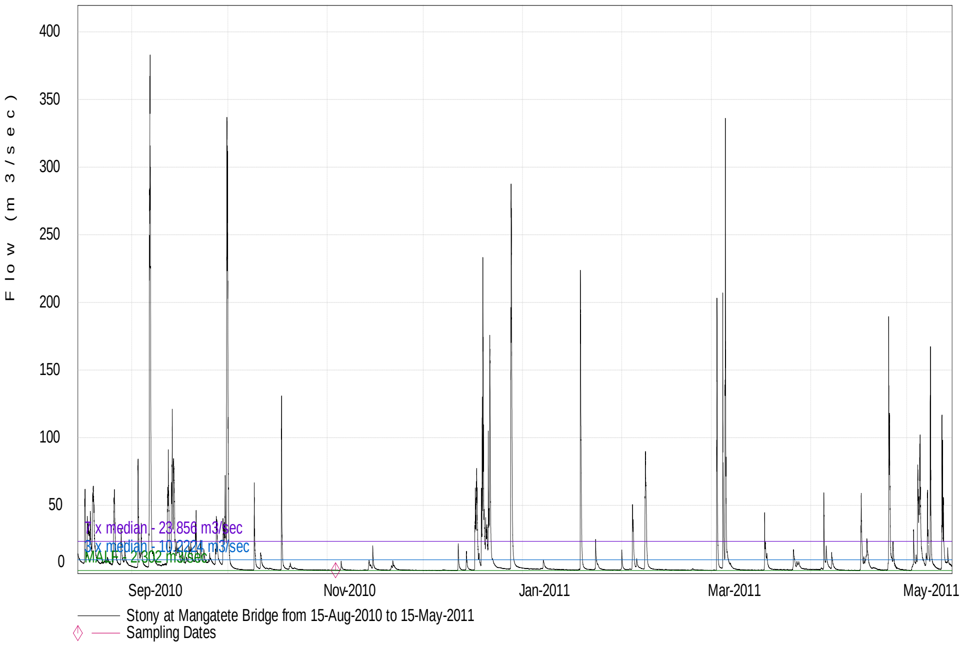
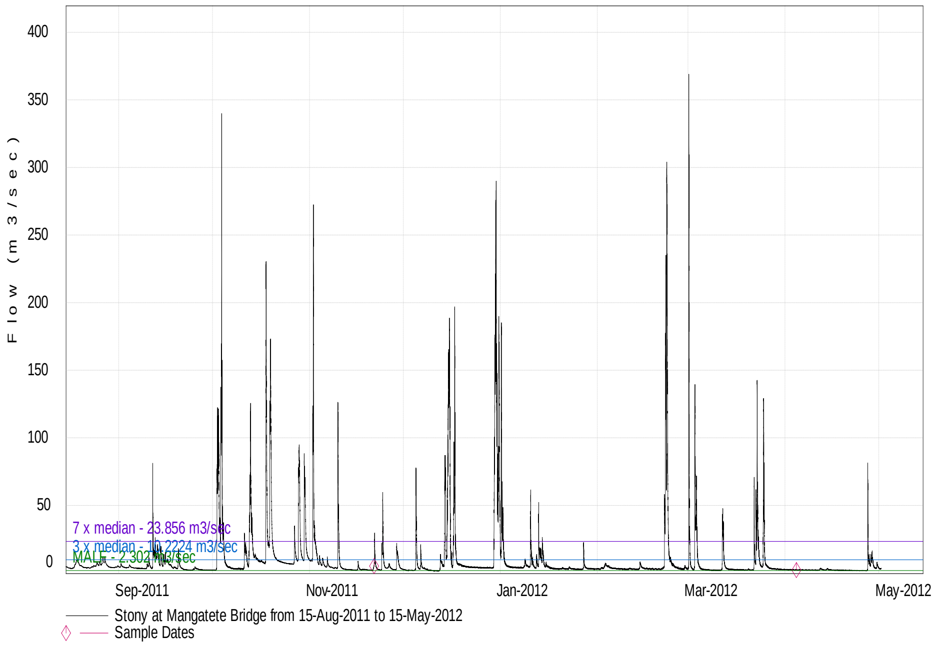
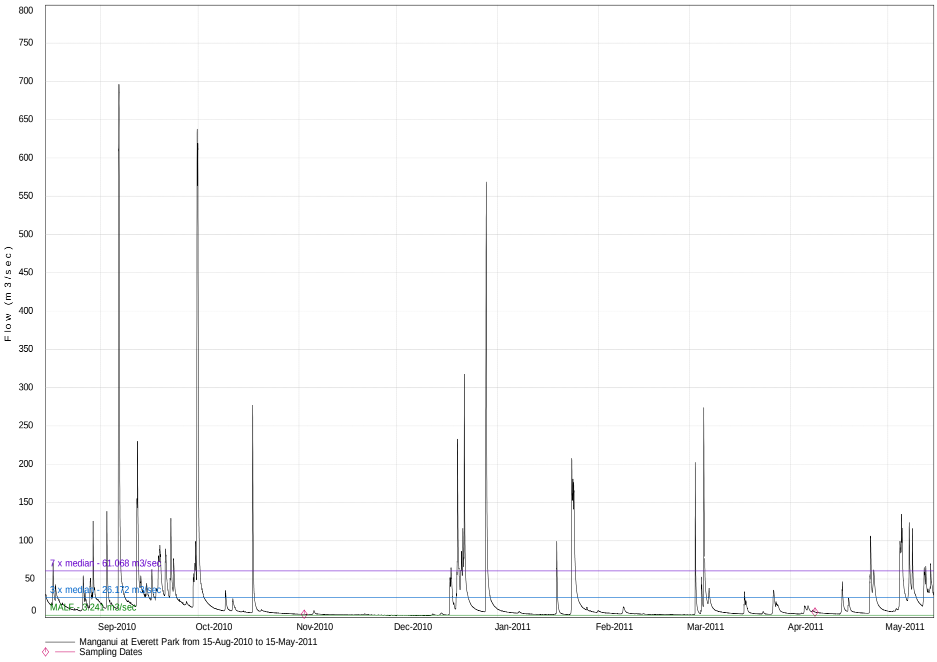
Appendix I
Flow data 2010-2012



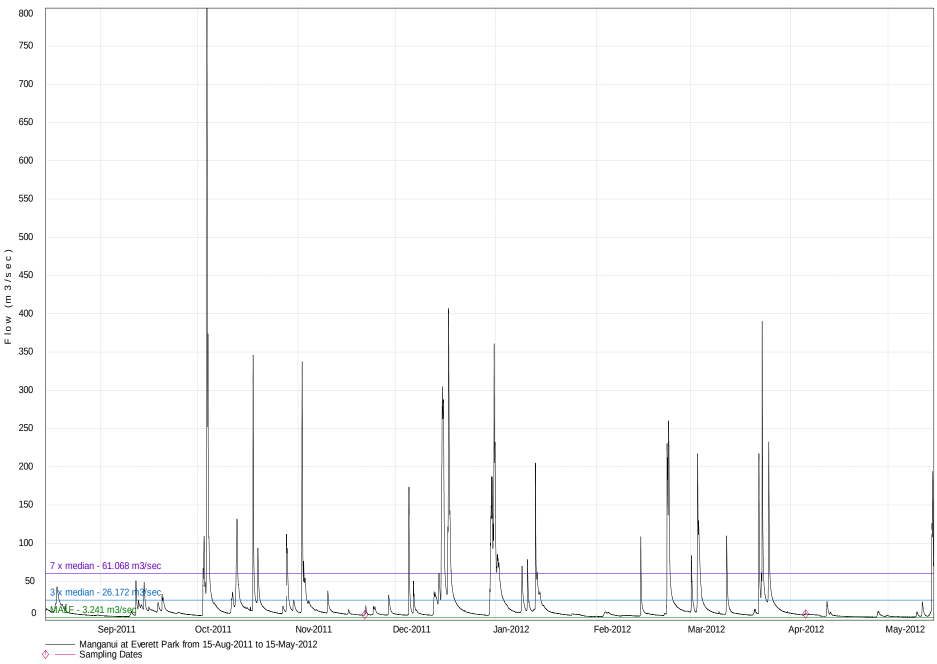
Flow in the Stony River over 2010-2011 sampling period



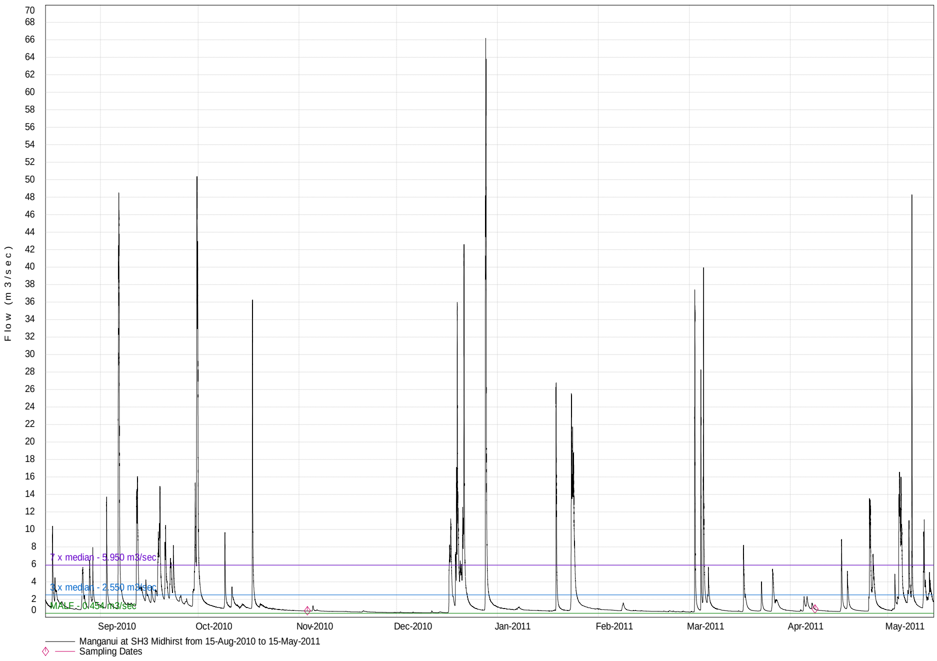
Flow in the Stony River over the 2011-2012 sampling period



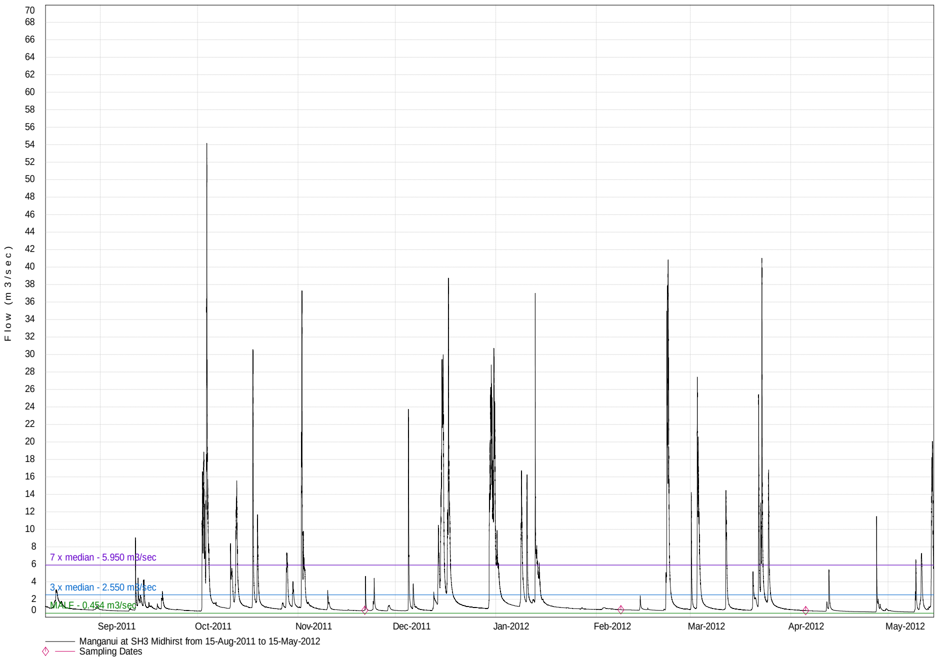
Flow in Manganui River at Everett Park over the 2010-2011 sampling period



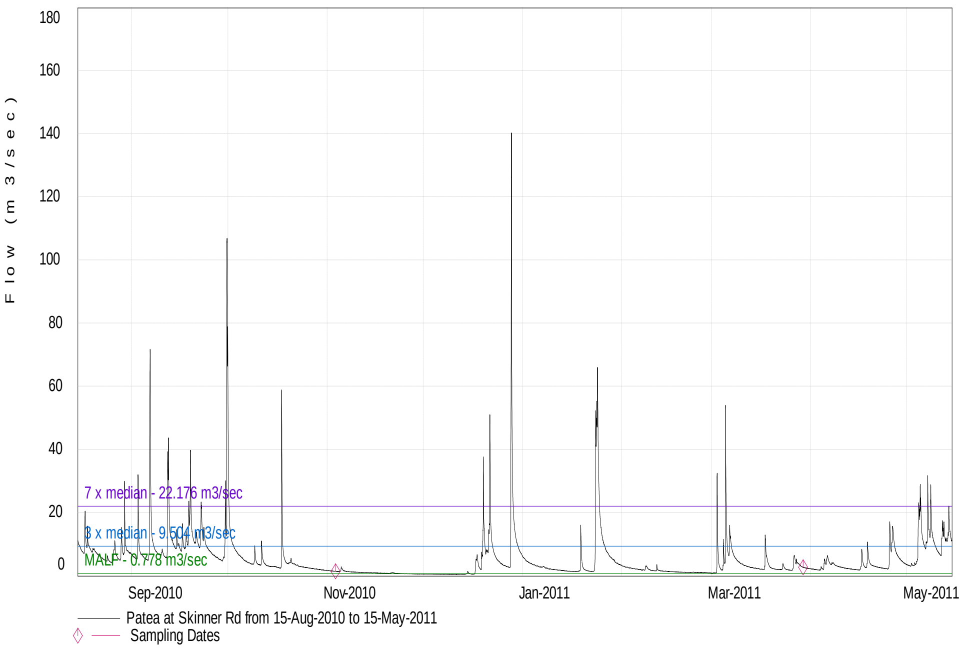
Flow in Manganui River at Everett Park over the 2011-2012 sampling period



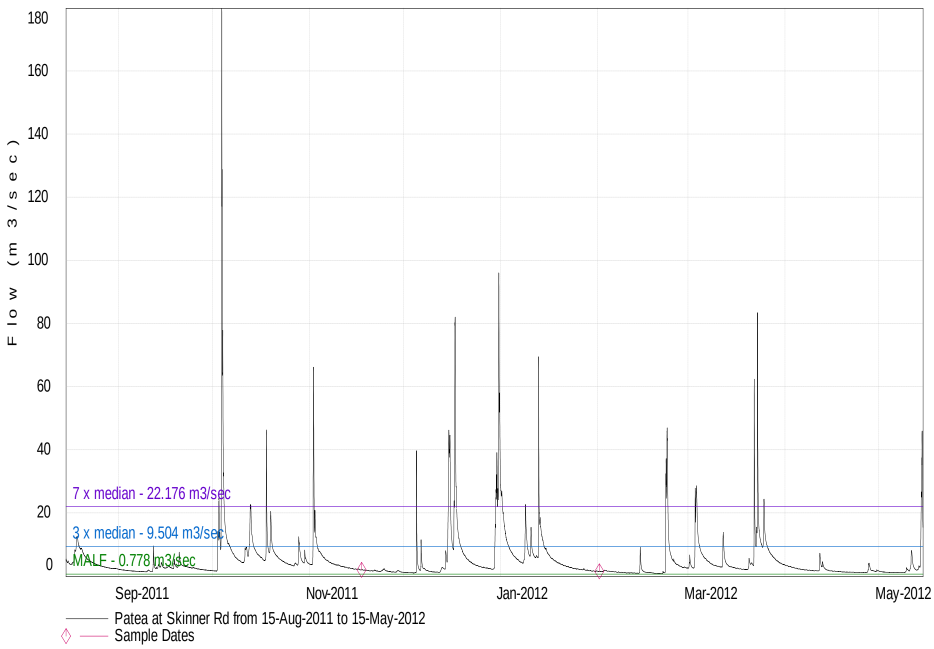
Flow in Manganui River at SH3 over the 2010-2011 sampling period



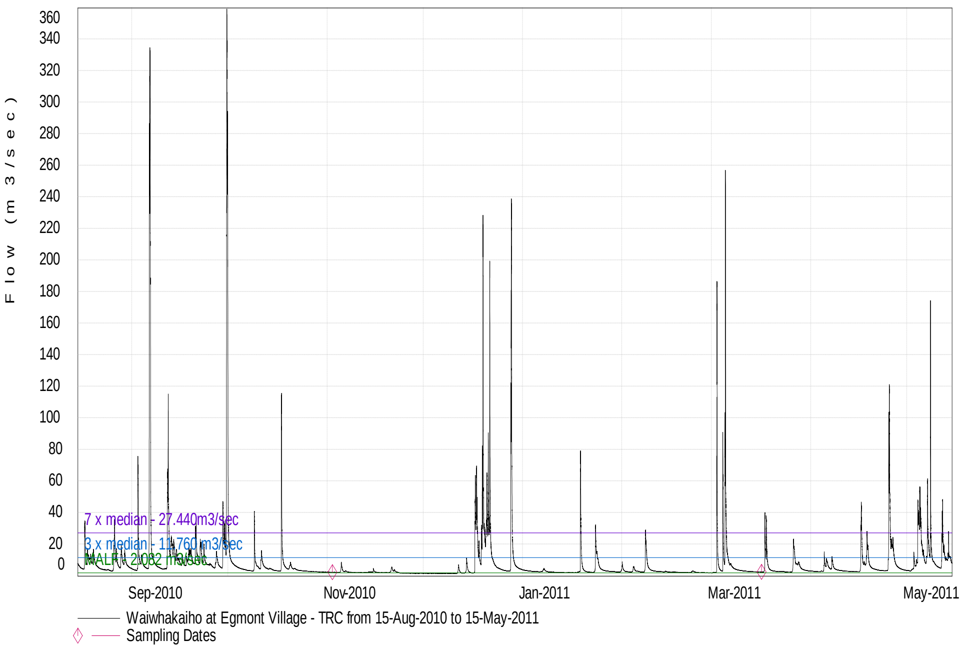
Flow in Manganui River at SH3 over the 2011-2012 sampling period



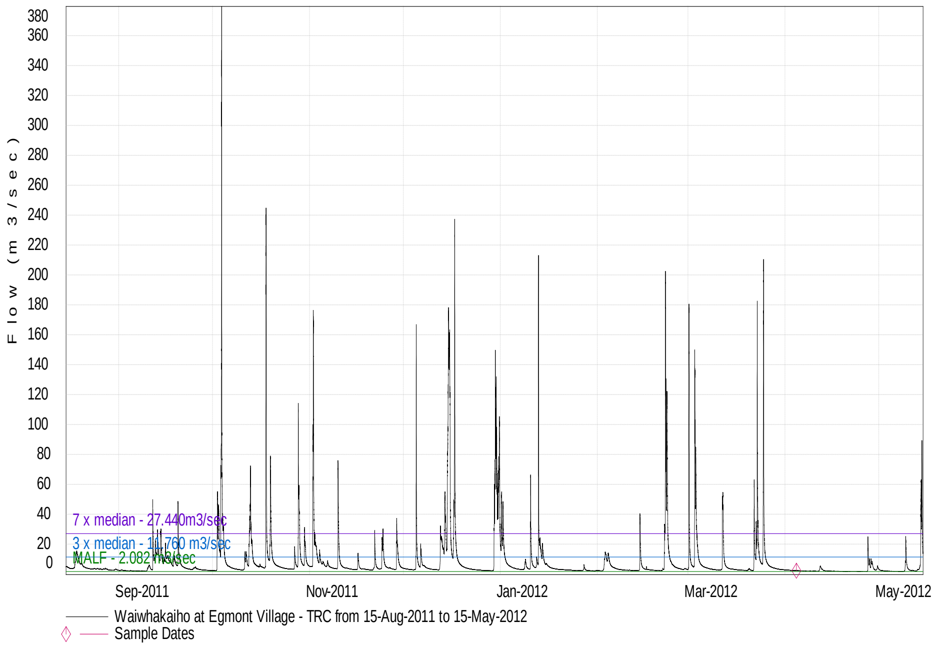
Flow in the Patea River over the 2010-2011 sampling period



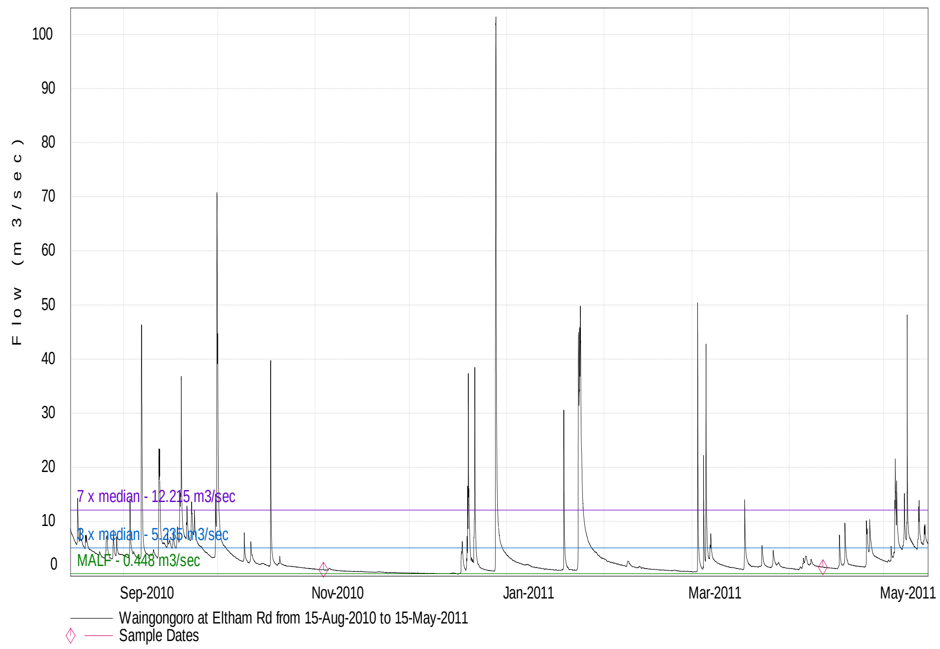
Flow in the Patea River over the 2011-2012 sampling period



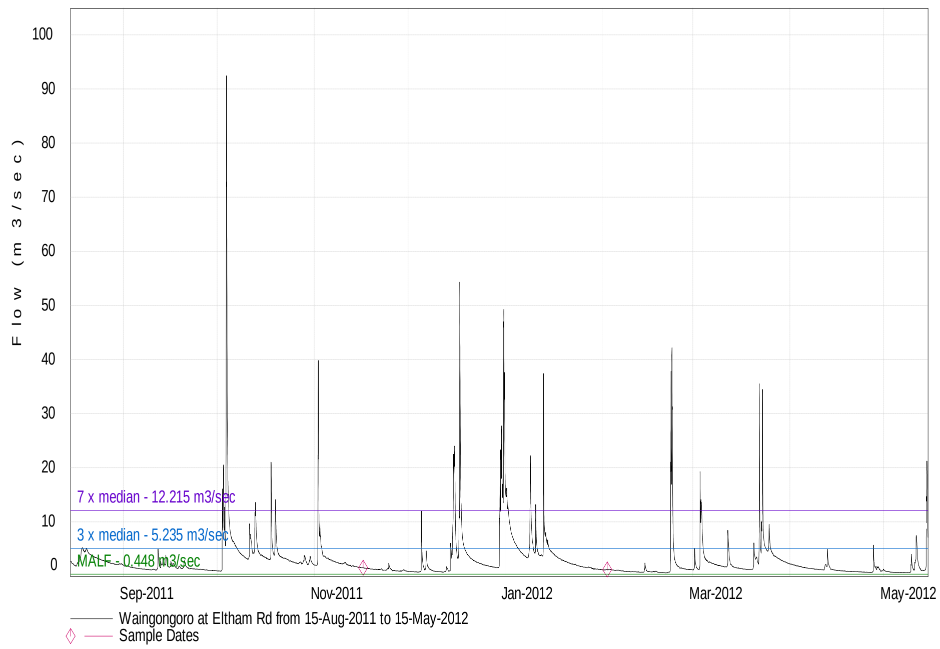
Flow in the Waiwhakaiho River during the 2010-2011 sampling period



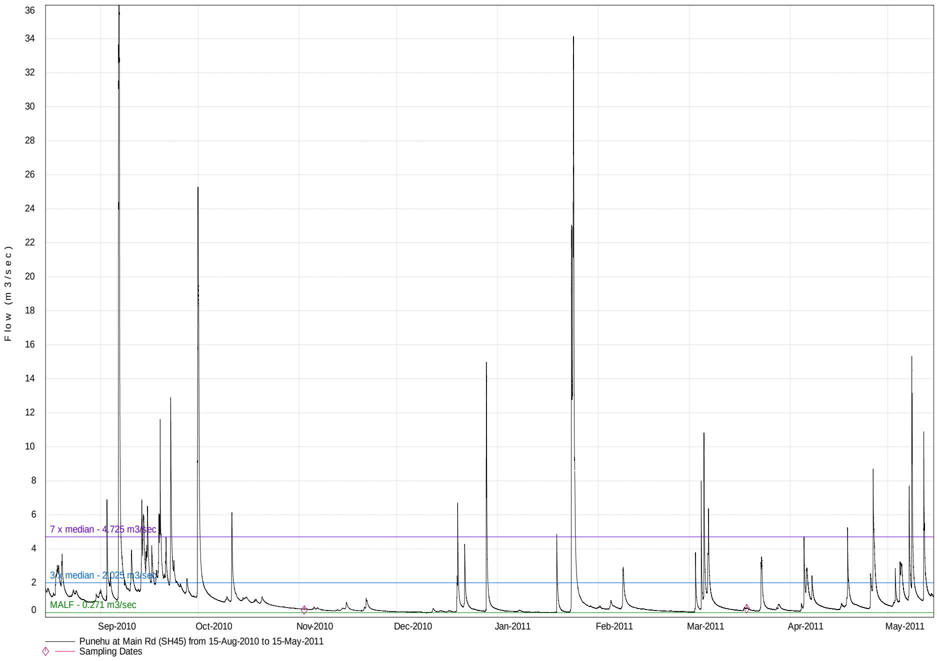
Flow in the Waiwhakaiho River during the 2011-2012 sampling period



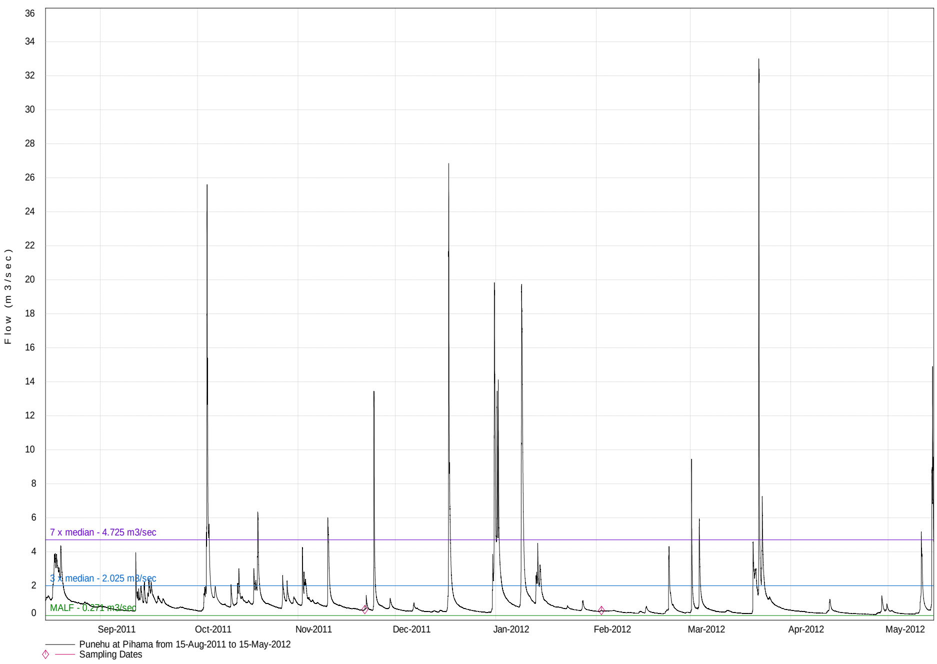
Flow in the Waingongoro River during the 2010-2011 sampling period



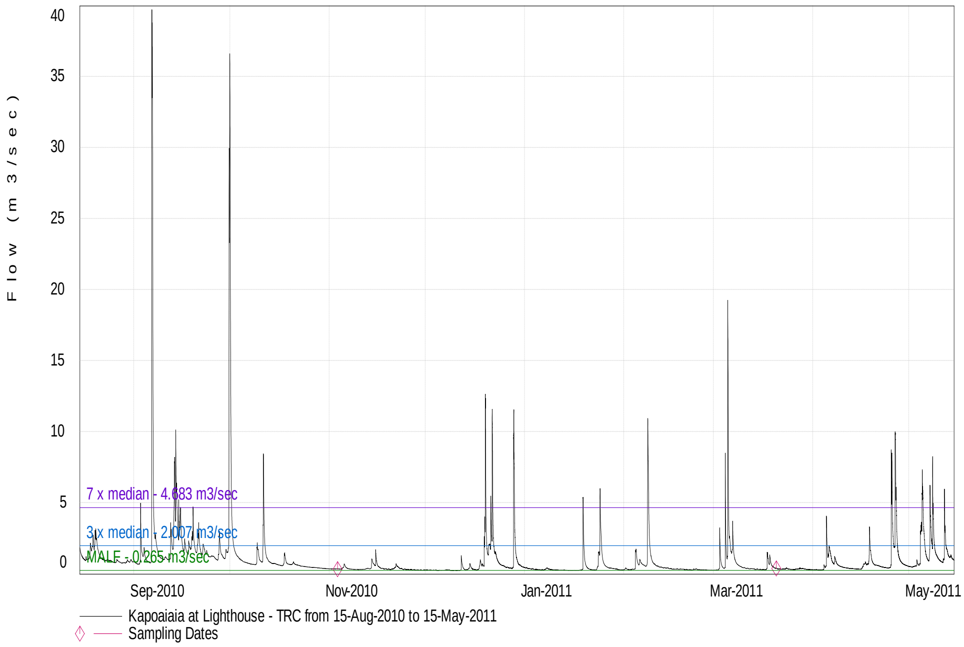
Flow in the Waingongoro River during the 2011-2012 sampling period



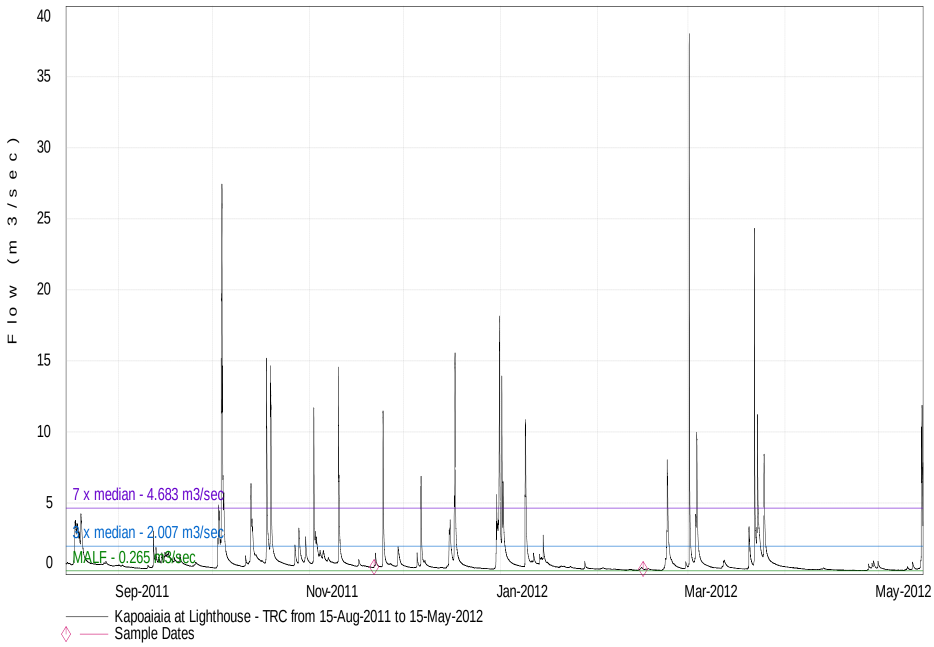
Flow in the Punehu Stream during the 2010-2011 sampling period



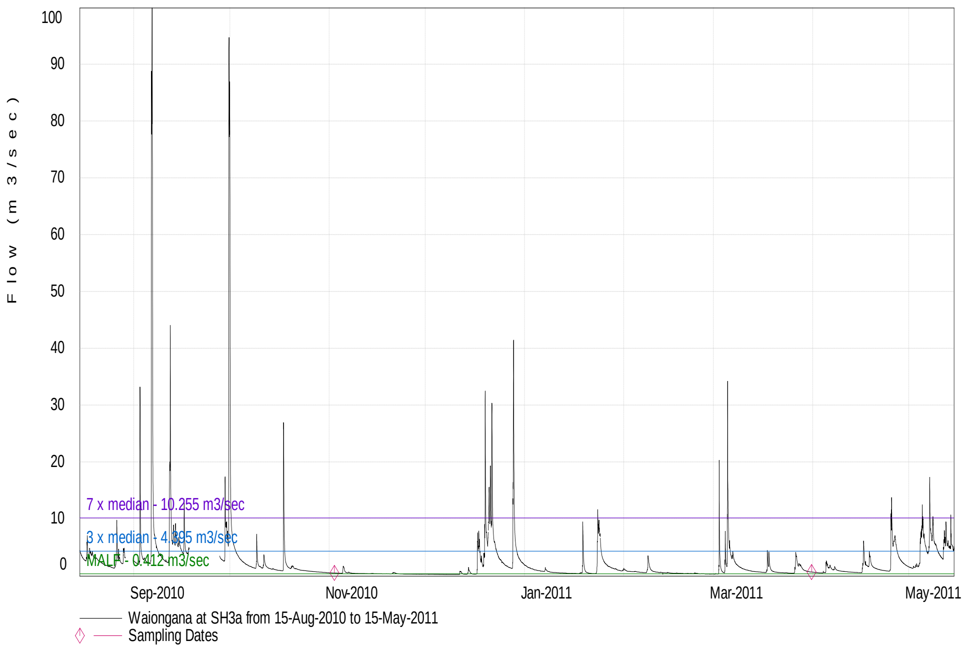
Flow in the Punehu Stream during the 2011-2012 sampling period



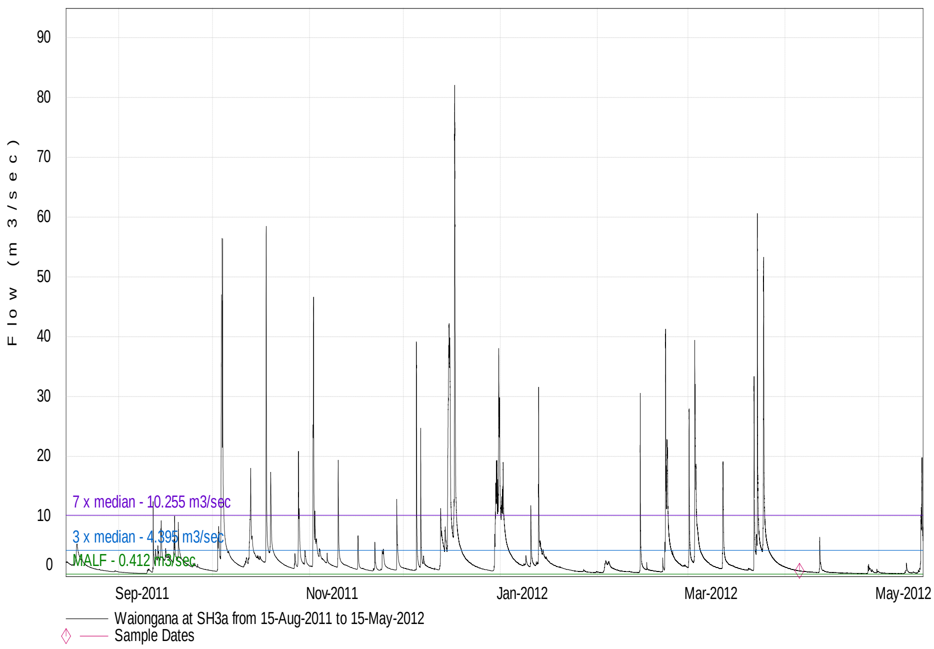
Flow in the Kapoaiaia Stream n the 2010-2011 monitoring period



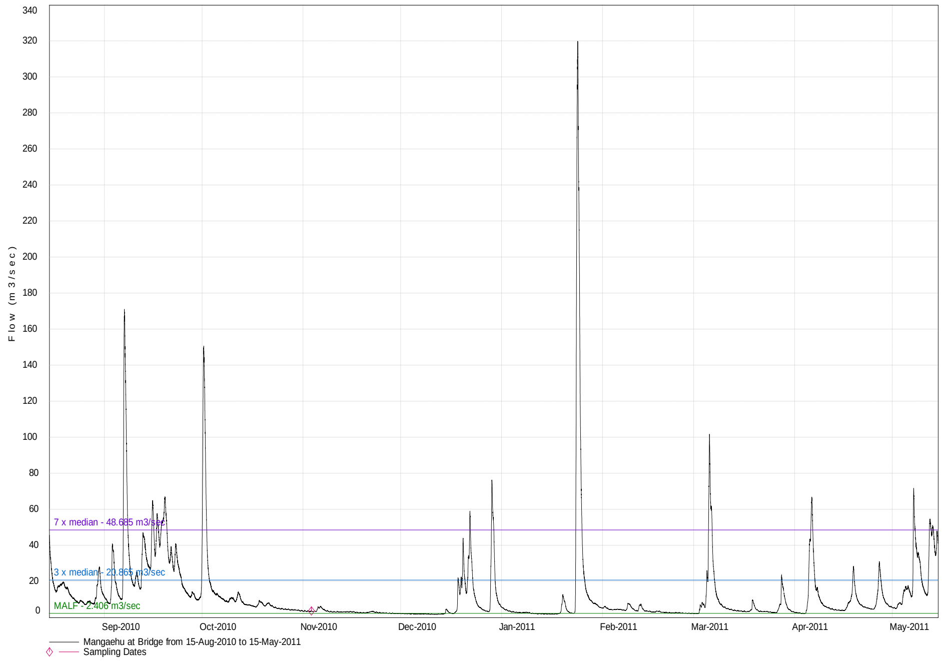
Flow in the Kapoaiaia Stream during the 2011-2012 monitoring period



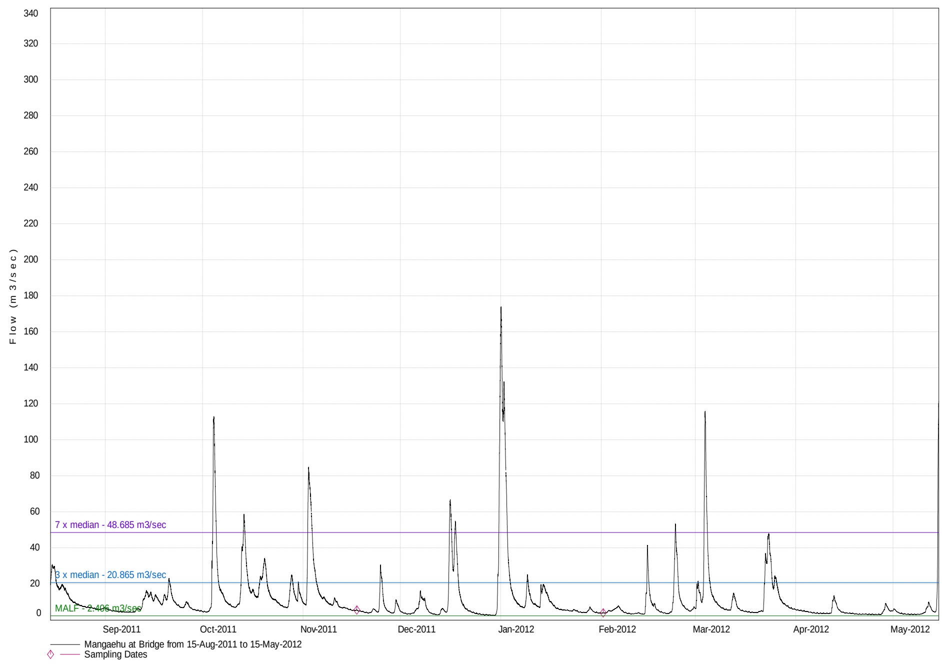
Flow in the Waiongana River during the 2010-2011 monitoring period



Flow in the Waiongana River during 2011-2012 monitoring period



Flow in the Mangaehu River during the 2010-2011 survey period



Flow in the Mangaehu River during the 2011-2012 survey period