Freshwater Periphyton
Monitoring Programme
(Periphyton monitoring in relation to amenity values)
State of Environment
Monitoring Report
2012-2014

Technical Report 2015-99

ISSN: 1178-1467 (Online)
Document: 1558975 (Word)
Document: 1654541 (Pdf)

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March 2016

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 2012-2014. Periphyton biomass (as measured by the surface area concentration of chlorophyll *a*, a pigment in algae) is included in this SEM periphyton reporting for the first time and covers the monitoring period 2010-2014.

The results for SEM periphyton programme during the 2012/2013 monitoring year showed that all 21 sites met the periphyton guidelines for thick mats and long filaments. For the 2013/2014 monitoring year, all sites met the guidelines for thick mats and 19 of 21 sites met the guidelines for filaments. Kapoaiaia Stream at Cape Egmont and Waiongana Stream at Devon Road breached the guideline limits for long filaments (refer Table 1 for all results).

For the TRC Periphyton Index, the median index value for 2012-2014 monitoring showed that 13 sites (62%) recorded 'Very good' rating, 7 sites (33%) recorded 'Good' rating, and one site (5%) recorded 'moderate' rating. None were in a 'poor' or 'very poor' condition of periphyton proliferation.

Table 1: Summary of SEM periphyton results for 2012-2014 monitoring year

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

* Significant trend at p<0.05 after FDR adjustment

Long term periphyton trend analysis indicated that 13 sites showed indicative decreasing trends (ie reductions in the average extent of periphyton) for thick mats (2 sites remain statistically significant after FDR adjustment) and 18 sites showed indicative decreasing trends for long filaments (3 sites are significant after FDR adjustment).

Periphyton is a mixture of algae and cyanobacteria that naturally occurs in rivers and streams. It plays a fundamental role in stream ecosystem functioning by utilising sunlight via photosynthesis and providing a food source for invertebrates which in turn provide food for other organisms such as fish and birds. Nuisance periphyton in the form of either prolific thick mats, pervasive long filaments or cyanobacteria can cause a range of issues such as streams becoming un-inviting for recreational users, anglers having difficulty fishing, streams closures due to cyanobacteria toxins and/or have adverse impacts on stream ecology.

This freshwater periphyton programme has been designed to monitor for the presence and biomass of 'nuisance' algae in Taranaki streams and rivers at levels 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.

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. Most rivers or streams had one upper (mostly un-impacted) site, and one or two lower sites (with various degrees of land use impact).

The Hangatahua (Stony) River was selected as a river with high conservation value and the Maketawa Stream was identified for its 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 of at least 10 days since a fresh of 3x median base flow (i.e. during 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 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. Additionally, during the summer period periphyton samples were collected from ten rocks randomly selected at each site and levels of chlorophyll *a* pigment analysed in a laboratory to determine periphyton biomass.

The New Zealand Periphyton Guidelines, established by the Ministry for the Environment (Biggs, 2000), 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. A TRC specific periphyton index score derived from the standard periphyton index score (Biggs et al., 1998) was also calculated from the periphyton cover data and scores converted into one of five grades.

This report is the first to incorporate periphyton biomass. Chlorophyll *a* was used to estimate the amount of live periphyton biomass over four summers (2011-2014). Guidelines for chlorophyll *a* were established by the Ministry for the Environment (Biggs, 2000). The National Objectives Framework (NOF) (MfE, 2014) also uses chlorophyll *a* to assign bands to rivers and streams. There will be a requirement to ensure streams and rivers are above the D band (chlorophyll *a* 200 mg/m^2) from 2025 onwards. The Council's established chlorophyll *a* sampling protocols differ from those established more recently in the NOF, and results cannot be directly translated to NOF bands.

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.

Generally, the rivers and streams monitored were in reasonable condition. No sites failed for thick algal mats and only the Kapoaiaia and Waiongana Rivers failed for long filamentous algae for the 2014 survey only. All rivers received a rating of at least 'moderate' for the TRC periphyton index score in all individual surveys except for the Mangaehu River for the 2014 survey only, which received a 'poor' rating. No sites had cyanobacteria mats above 50% streambed coverage that would place a site in the 'Action' category.

Periphyton biomass results were generally poorer. There were five sites with one or more chlorophyll *a* levels in exceedance of the NOF bottom line criterion, but of these, four of the five sites had exceedances for only one of the four surveys reported on. The Waingongoro River at Ohawe Beach had consistency high chlorophyll *a* levels and was the only site with an average chlorophyll *a* level in exceedance of the NOF bottom line. As noted above, even this result does not mean that a 'D' NOF classification can be applied to this (or any other) site.

The data used for nuisance periphyton guidelines (thick algal mats and long filaments) overlaps slightly with the periphyton index score but was potentially completely different from the periphyton biomass data as rocks viewed for periphyton cover are not necessarily, and probably unlikely, to be the same ones used to collect periphyton biomass. Therefore, even though ten replicates were used, results can potentially differ significantly between the two methods. Furthermore, periphyton coverage examines both live and dead periphyton while periphyton biomass uses chlorophyll *a* which is contained within live material only.

Most upstream sites, except for those in the Waiwhakaiho and Waiongana Streams, contained very low levels of periphyton. Except for the Waiwhakaiho, all rivers and streams had greater levels of periphyton at the downstream sites. Almost all downstream sites, except the Stony River had some level of periphyton.

Unlike other reported results the difference between spring and summer surveys was less substantial in the period being reported. Summer surveys usually have higher periphyton levels than spring surveys (e.g. TRC, 2014) but the spring 2013 survey had slightly higher levels of periphyton than the summer 2013 survey. The spring 2012 survey had the overall best results, followed by summer 2013, spring 2013 and lastly summer 2014 though for some sites the spring 2013 survey had lower periphyton than the summer 2013 survey. A long period of no flood flows probably contributed to the higher periphyton levels in the summer 2014 survey. If the spring and summer surveys were averaged then overall the summer season would still have had higher periphyton levels than the spring season.

Time trends for the full data set (2002-2014) reveal that for the majority of sites there was no statistically significant trend. There was a significant trend at four sites which all showed long term decreasing levels of nuisance periphyton with the upper Kapoaiaia and Waingongoro sites having decreasing levels of thick algal mats and the upper Kapoaiaia, Patea River at Skinner Road and Maketawa at Tarata Road sites having decreasing levels of long filamentous algae.

No *Didymosphenia geminate* was found for the current monitoring period.

Overall, the following conclusions can be made:

1. Generally, the monitored sites were in reasonable condition with 100% and 98% complying with the periphyton guideline for thick mats long filaments respectively.
2. 'Upstream sites' with little agriculture in their catchment had low levels of periphyton.
3. Middle and lower catchment sites had higher levels of periphyton which occasionally breached guidelines.
4. Due to the number of variables involved (e.g. nutrients, sunlight, temperature, substrate type, time since last fresh or flood, water clarity, level of invertebrate grazing etc) only broad generalisations can be made as different sites behave differently due to site specific situations.
5. The cumulative affects of agricultural discharges via point source or diffuse pollution was likely to be a leading cause of algae proliferation in middle and lower catchment sites.
6. 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 never had any guideline breaches in any case.
7. Flood flows can cause a reduction in periphyton growth but the degree of this effect is not consistent within streams or seasons. A long period of no flood flows probably contributed to the higher periphyton levels in the summer 2014 survey.

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 sent away for analysis.

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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.

The SEM Freshwater Nuisance Periphyton programme began in the 2002-2003 monitoring year. Three previous reports have been written, summarising the 2002-2006, 2006-2010 and 2010-2012 survey periods. The reporting period was changed to biennial for the 2010-2012 reporting period and this report continues with the biennial report format, hence this report summarises the results for the 2012-2014 monitoring period. The freshwater nuisance periphyton programme has been designed to monitor the coverage and biomass 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.

This report is the first to examine periphyton biomass as estimated by chlorophyll *a* and incorporates four years of data for the reporting periods 2010-2011, 2011-2012, 2012-2013 and 2013-2014 and. For periphyton biomass it is recommended that at least three years of data been analysed which is why the previous 2010-2012 report did not include the chlorophyll *a* data collected during that time period.

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 functioning 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 Kapoaiaia Stream (KPA000700)

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 ultimate providers of food to stream and river foodwebs.

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 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. Shading from stream banks and turbid water will also limit light levels.
- 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 importaant 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 limit growth); also the duration of stable low flows, particularly in summer may allow significant accrual of periphyton biomass.
- Invertebrate grazers or other biota that consume periphyton may act to reduce periphyton growth. Many grazers are more prolific in cooler waters.
- Substrate type - periphyton generally occurs on hard surfaces such as boulders and cobbles and is less unlikely to form on soft sediment unless flows are very slow and stable.

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 periphyton is a normal phenomenon and in some streams at certain times of the year thick algal mats and long filamentous algae will naturally occur. For example, long, wide, shallow rivers may have some 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.

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
Human and 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 from (Biggs, 2000)

Instream value	Diatoms/cyanobacteria	Filamentous algae
Aesthetics/recreation (1 November to 30 April)		
Maximum cover of visible streambed	60% > 3mm thick	30% > 2cm long
Maximum chlorophyll *a* (mg/m^2)	n/a	120
Benthic biodiversity		
Monthly mean chlorophyll *a* (mg/m^2)	15	15
Maximum chlorophyll *a* (mg/m^2)	50	50
Trout habitat and angling		
Maximum chlorophyll *a* (mg/m^2)	200	120

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 Cyanobacteria

Periphyton in the form of benthic cyanobacteria in streams and rivers can affect amenity values by causing health problems to humans, domestic animals and livestock. In 2009, the Ministry for the Environment released an interim guidance document entitled "*New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters*" (MfE and MoH, 2009). These guidelines provide a national alert–level framework for assessing the public health risk from cyanobacteria associated with contact recreation in lakes and rivers.

Table 3 below shows the alert-level framework for benthic cyanobacteria.

Table 3 Alert level framework for benthic cyanobacteria

Alert level[a]	Actions
Surveillance (green mode) Up to 20% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Undertake fortnightly surveys between spring and autumn at representative locations in the water body where known mat proliferations occur and where there is recreational use. • Take scrapings every second survey for microscopic identification, to compare with visual assessments in order to ensure cyanobacteria is being recorded accurately, and to provide an indication of the species present.
Alert (amber mode) 20−50% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Notify the public health unit. • Increase sampling to weekly. • Recommend erecting an information sign that provides the public with information on the appearance of mats and the potential risks. • Consider increasing the number of survey sites to enable risks to recreational users to be more accurately assessed. • If toxigenic cyanobacteria dominate the samples, testing for cyanotoxins is advised. If cyanotoxins are detected in mats or water samples, consult the testing laboratory to determine if levels are hazardous.
Action (red mode) *Situation 1:* Greater than 50% coverage of potentially toxigenic cyanobacteria attached to substrate; or *Situation 2:* up to 50% where potentially toxigenic cyanobacteria are visibly **detaching** from the substrate, accumulating as scums along the river's edge or becoming **exposed** on the river's edge as the river level drops.	• Immediately notify the public health unit. • If potentially toxic taxa are present then consider testing samples for cyanotoxins. • Notify the public of the potential risk to health.

a The alert-level framework is based on an assessment of the percentage of river bed that a cyanobacterial mat covers at each site. However, local knowledge of other factors that indicate an increased risk of toxic cyanobacteria (e.g., human health effects, animal illnesses, prolonged low flows) should be taken into account when assessing a site status and may, in some cases, lead to an elevation of site status (e.g., from surveillance to action), irrespective of mat coverage.

Photo 2 Thick mat of cyanobacteria.

1.1.3 Methodology

1.1.3.1 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 4.

Widespread coverage of thick mats 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 4 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

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.

1.1.3.2 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 was assigned a score (Table 4). 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 was 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.

The indicator scores were preliminary and are derived from Biggs et al. 1998 and unpublished data of the authors. It was anticipated that scores would be updated as new information was collected (Biggs and Kilroy, 2000) but this has not yet occurred. Currently, the index scores give significantly different weightings based on differences in colour which corresponds to different taxonomic groups. For example, light brown thick mats (diatoms) have a score of 4 while dark brown or black thick mats (cyanobacteria) have a score of 7. A streambed completely covered in thick black mats of the toxin producing cyanobacteria *Phormidium*, would produce a periphyton index rating of 'good' even though a river in that condition should be closed for recreational use. Therefore scores reflect stream health more than aesthetes or recreation.

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. 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.

The periphyton index 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 5. 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 5 Range of Periphyton Scores when in exceedance of recreational and aesthetic guidelines

	Diatoms/cyanobacteria 60% > 3mm thick			**Filamentous algae 30% > 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).

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 6).

Table 6 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	1-1.9

1.1.3.3 Periphyton biomass

Chlorophyll *a* gives an indication of the total amount of live biomass in a periphyton sample. Chlorophyll *a* is considered to be the most widely recognised method for estimating periphyton biomass (Kilroy, 2013) and is the method used to estimate periphyton in the National Objectives Framework (NOF) that will create national standards for certain water quality parameters (Snelder et al., 2013).

Periphyton biomass surveys were started in the 2010-2011 monitoring year for the summer 2011 survey at the same 21 sites that periphyton cover was surveyed and was always done in conjunction with periphyton cover surveys. Periphyton biomass surveys were only undertaken during summer (January 1st- April 15th) as the time and cost involved in collecting and analysing the samples was significantly higher than surveying for periphyton cover. This report examines chlorophyll *a* data for four summers (2011-2014).

The method for collecting periphyton biomass was adapted from Biggs and Kilroy (2000). Ten randomly selected rocks and a known area of periphyton (0.0196m^2) was scrapped off each rock. TRC employs a slightly different process to sample the periphyton as suggested by Biggs and Kilroy (2000). A device was constructed that allows periphyton from a fixed area to be sucked up via a tube connected to a pump. This has the advantage that periphyton does not need to be first removed from the surrounding area as it does with the methodology suggested by Biggs and Kilroy (2000).

The ten periphyton samples were combined to form a single sample for a site and the sample was brought back to a laboratory where chlorophyll *a* was extracted and analysed. Periphyton guidelines for chlorophyll *a* (Biggs, 2000) suggest a range of maximum chlorophyll *a* limits to protect benthic biodiversity, aesthetics and trout habitat/angling depending on whether they algal type is diatoms/cyanobacteria or long filaments (Table 2). In practice, composite samples will likely contain a mixture of both diatoms/cyanobacteria and long filaments. The National Objective Framework (NOF) proposes four bands (Table 7) which are maximum limits based on a monthly monitoring regime. The minimum record length for grading a site based on periphyton biomass is three years. The bottom line that must be met is 200 mg/m^2 of chlorophyll *a*.

Table 7 National Objective Framework standards for periphyton using chlorophyll a for rivers in the default class (all current monitored sites)

Band	Chlorophyll *a*
	Exceeded no more than 8% of samples
A	0-50
B	>50-120
C	>120-200
National Bottom Line	**200**
D	>200

Photo 3 Device used to extract periphyton for chlorophyll *a* analysis. Periphyton was scrapped off the rock using a stiff paint brush. The tube at the side is used to suck up fine particles of periphyton

Photo 4 Periphyton covered rock with clear area where all the periphyton has been extracted for chlorophyll *a* analysis

1.1.4 Site locations

Twenty-one sites were chosen in ten catchments around the Taranaki Region (Table 8). 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 8 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	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 (e.g. TRC, 2004) and will not be presented in this report.

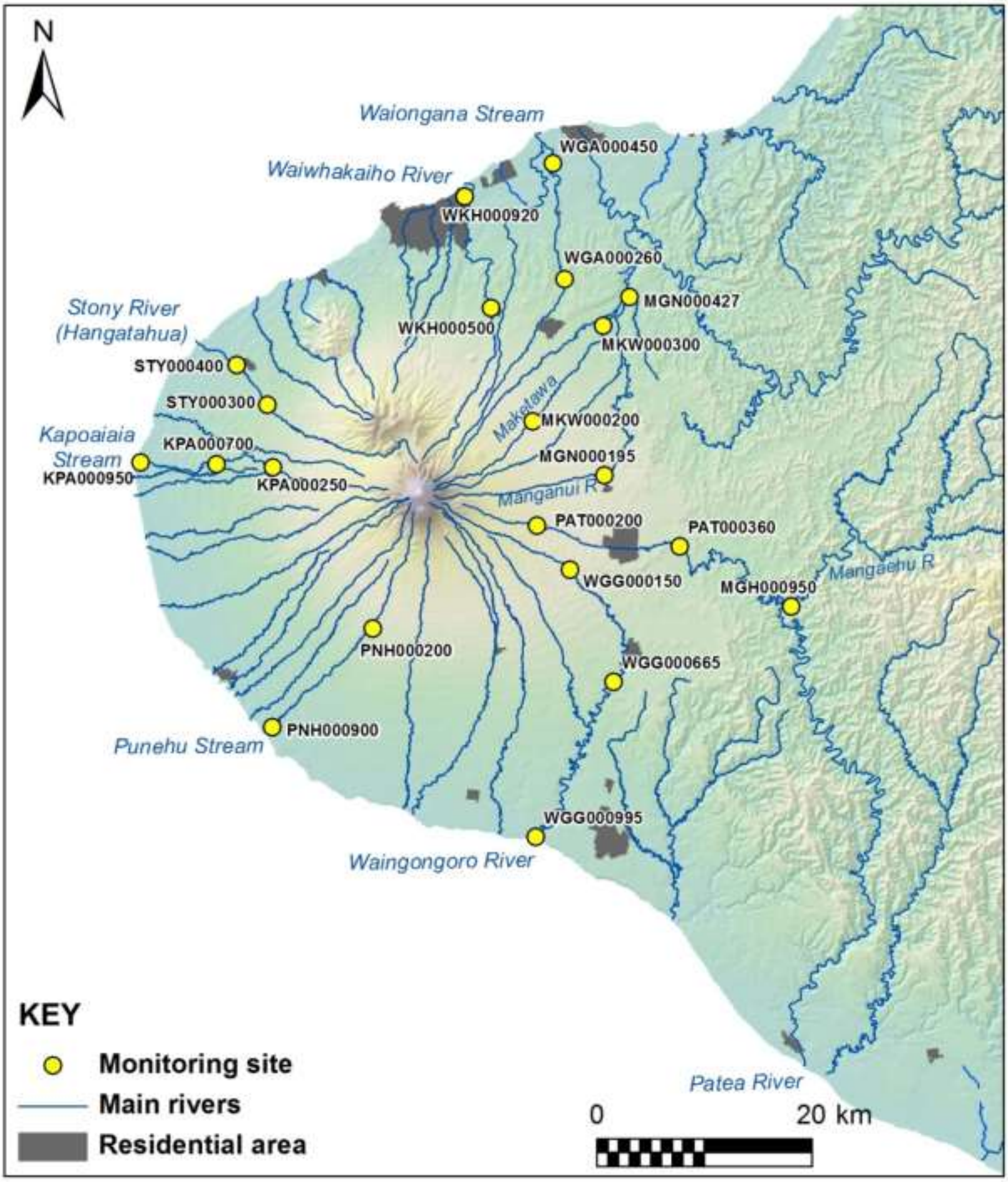


Figure 1 Sampling site locations

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 river has also been designated as one of only two river catchments in the draft Freshwater and Land Management Plan for Taranaki (2015) to be in the Freshwater Management Unit A: outstanding freshwater bodies.

The top sampling site (Mangatete Rd, STY000300) is within seven 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 Monitoring site locations in relation to consents operating in the Stony River catchment). This is the final place at which the river is easily accessed before flowing through private land and out to sea.

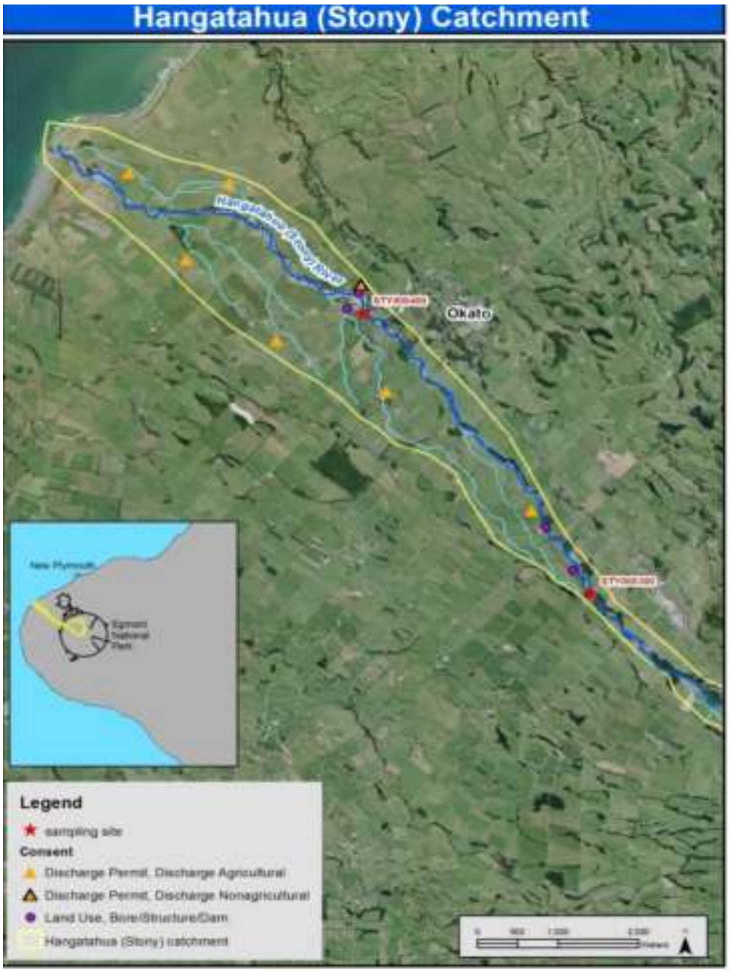


Figure 2 Monitoring site locations in relation to consents operating in the Stony River catchment

2.1.1 Flow data and survey dates

A hydrological flow recorder was installed in the Stony at Mangatete Road and flow data for this site was available from 2004-2011 but no continuous flow gauging data has been collected since 2011. The nearby Kapoaiaia River has a telemetered hydrological monitoring station and provides a general indication of the flow history in relation to sampling times in the Stony River catchment (Appendix).

The spring 2012 survey was conducted on 14 November 2012 13 days after a fresh in excess of both 3x and 7x median flow. The summer 2013 survey was carried out on 20 February 2013 15 days after a fresh in excess of both 3x and 7x median flow.

The spring 2013 survey was conducted on 15 November 2013 13 days after a fresh in excess of 3x median flow and 14 days after a fresh in excess of 7x median flow. The summer 2014 survey was carried out on 2 March 2014 35 days after a fresh in excess of both 3x and 7x median flow. No significant freshes occurred after the fresh prior to sampling and the river was experiencing a low flow period at the time of sampling.

2.1.2 Periphyton cover

The Stony River is generally characterised by a low periphyton biomass throughout its catchment. The periphyton cover monitoring from 2012 to 2014 reflects this, with all of the sampling occasions recording no nuisance periphyton (Figure 3 and Figure 4).

In the 2012-2013 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 six weeks following a significant fresh (Biggs and Kilroy, 2000). Sampling for the spring and summer surveys was conducted after only 13 and 15 days respectively from a large fresh which would have significantly reduced any periphyton present at the site.

In the 2013-2014 monitoring year no nuisance periphyton was found at either the upper survey site at Mangatete Rd or at the lower survey site at SH45. The summer survey was conducted after a relatively long period of 35 days since a fresh of 3x median flow which would have allowed periphyton levels to reach close to a maximum potential biomass. The lack of nuisance periphyton found was therefore more a reflection of the low nutrient status of the river than scouring events.

The majority of the Stony River catchment runs through national park with only a very limited area in the mid and lower part of catchment in agricultural use. Nutrient inputs into the river would therefore be expected to be very low and the periphyton results for the 2012-2014 monitoring period support this.

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

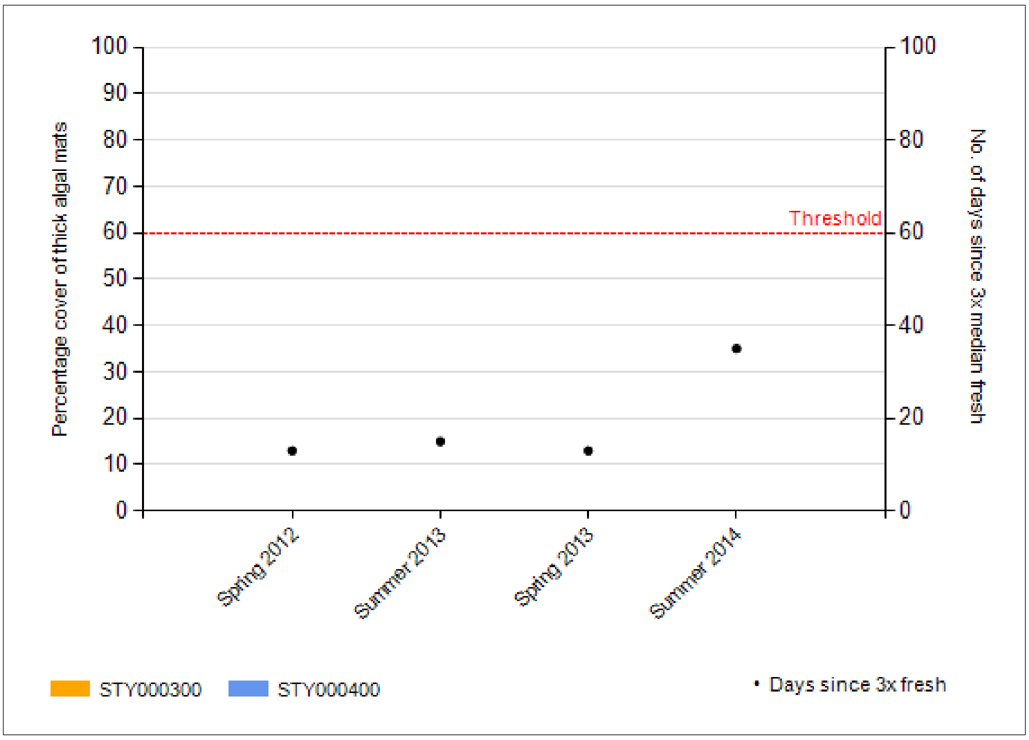


Figure 3 Percentage cover of thick mats of periphyton on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

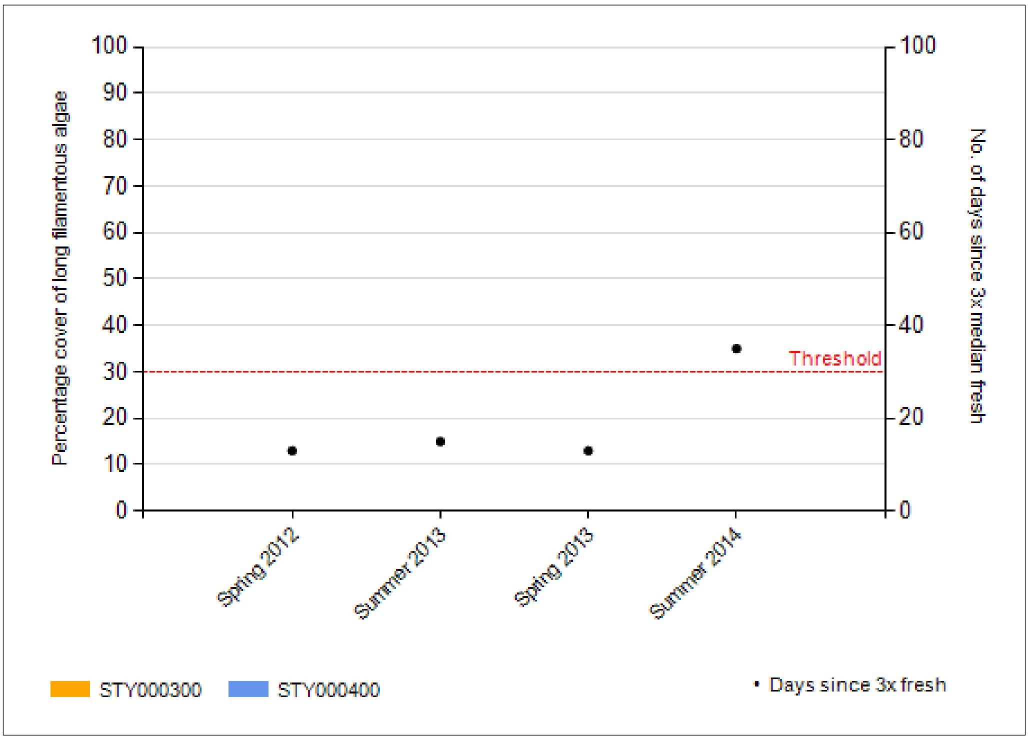


Figure 4 Percentage cover of long filamentous algae on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

2.1.3 Periphyton Index Score

Over the 2012-2014 monitoring period the Stony River largely had its bed clear of any nuisance periphyton with both sites within the monitoring period having a 'very good' TRC PI. For the 2012-2013 monitoring period there was no change across the upstream site and downstream site; scoring maximum scores for both spring and summer (Table 9). For the 2013-2014 monitoring period there was a very minor decrease in TRC PI at the upstream but not the downstream site for the spring period. There was a larger difference in the summer survey with the downstream site scoring 9.0 compared with the upstream site which scored the maximum score of 10.0 indicating a small deterioration in periphyton condition. The historical median for the upstream and downstream site indicates that the downstream site generally has a lower TRC PI score than the upstream site, but this difference is only minor with the downstream site in the 'very good' category (Table 9).

Table 9 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
STY000300	10.0	10.0	9.8	10.0	10.0	10.0
STY000400	10.0	10.0	10.0	9.0	9.9	9.4
Difference	0.0	0.0	-0.2	1.0	0.1	0.6

2.1.4 Periphyton biomass

Due to frequent fresh and flood events monitoring could not be carried out in the summer of 2011. The results for the summer of 2012, 2013 and 2014 for both sites showed extremely low chlorophyll *a* levels with both sites averaging only 3 mg/m^2 with a maximum chlorophyll *a* of 4 mg/m^2 recorded at both sites (Figure 5). These values are well within guidelines to protect biodiversity, aesthetic and trout habitat/angling values (Table 2) and NOF guidelines (Snelder et al., 2013). The low chlorophyll *a* levels are congruent with the periphyton cover results and reinforces the findings that the Stony River has outstanding water quality.

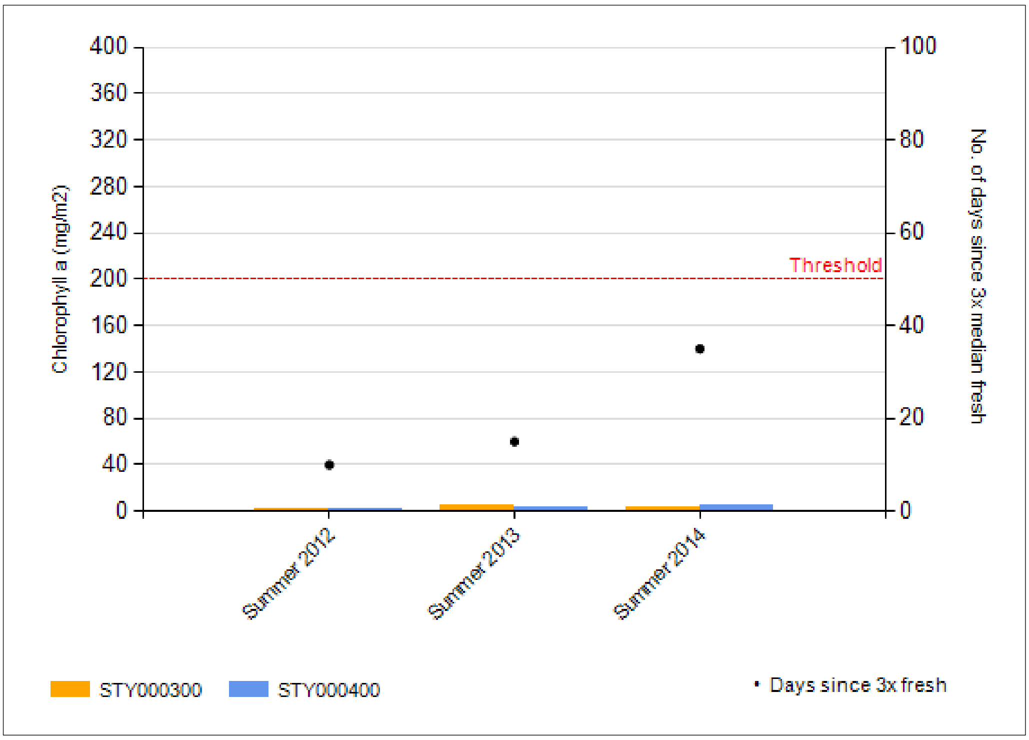


Figure 5 Periphyton biomass (chlorophyll a) on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.1.5 Summary of 2002-2014 (12 year data set)

Over the 12 year period there has been very little periphyton proliferation at both sites monitored in the Stony catchment (Figure 6 and Figure 7). Periphyton has remained consistently low over the past 12 years. There have been occasional spikes but no record ever came close to a breach in periphyton guidelines for mats or filaments at either of the Stony catchment sites.

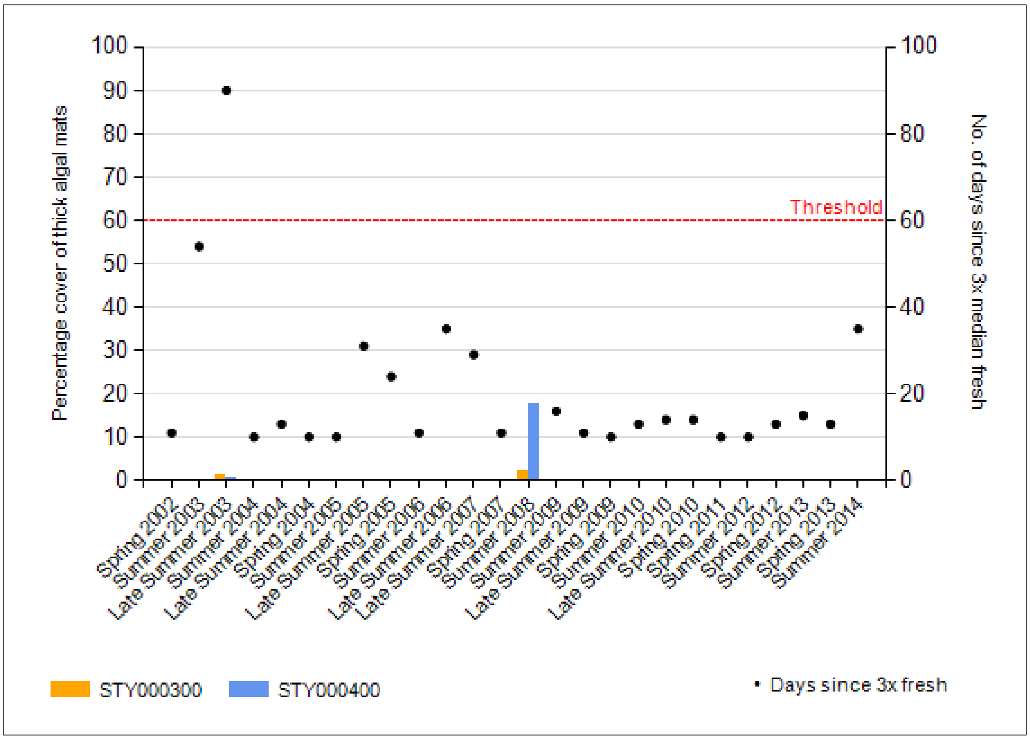


Figure 6 Percentage cover of thick mats of periphyton on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2002-2014 period

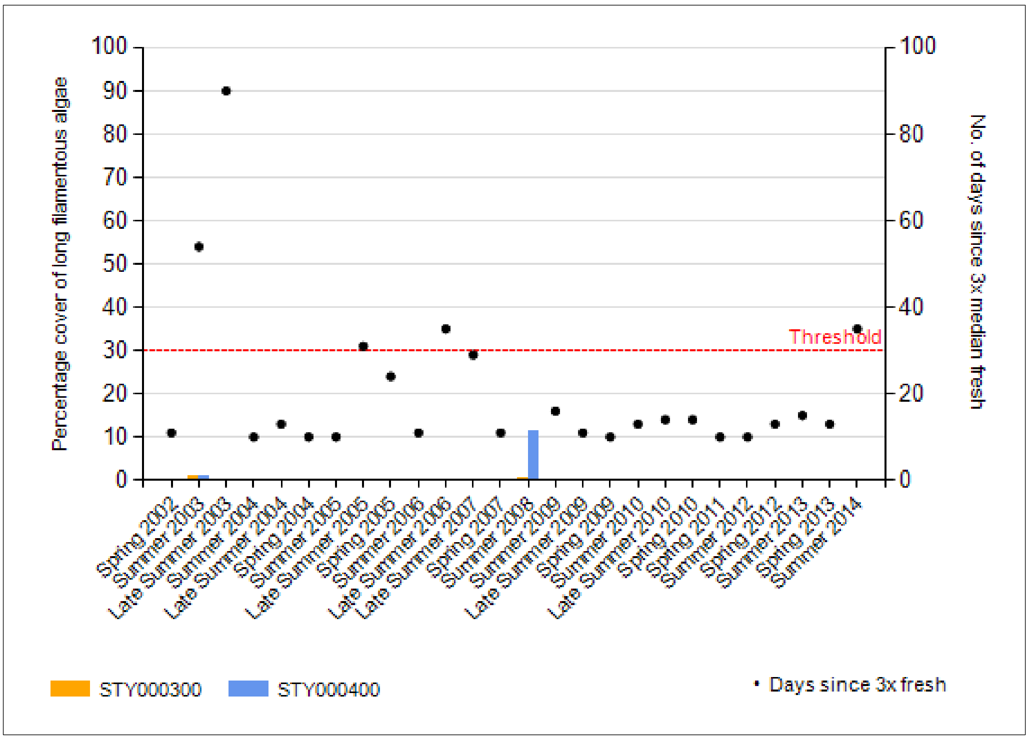
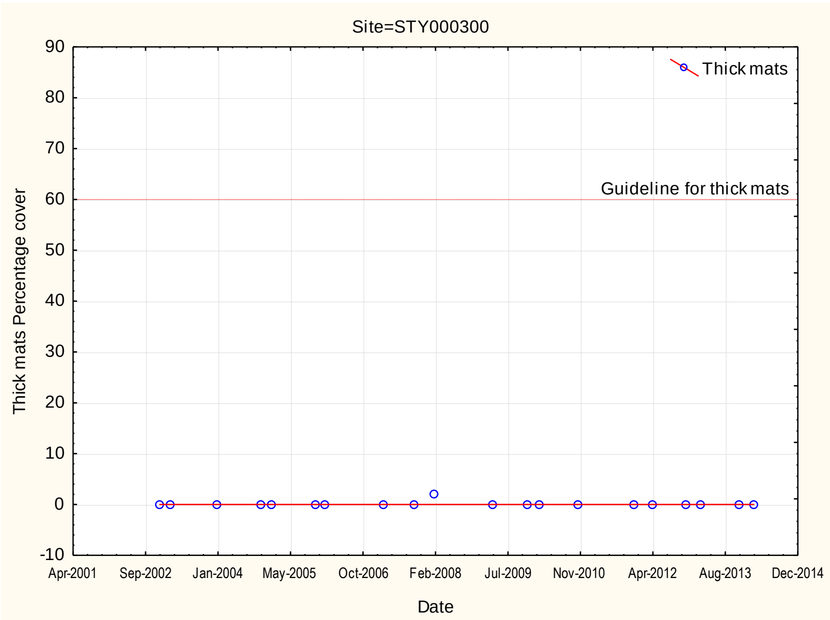


Figure 7 Percentage cover of long filamentous algae on the Hangatahua (Stony) riverbed in relation to the guidelines for recreational values over the 2002-2014 period

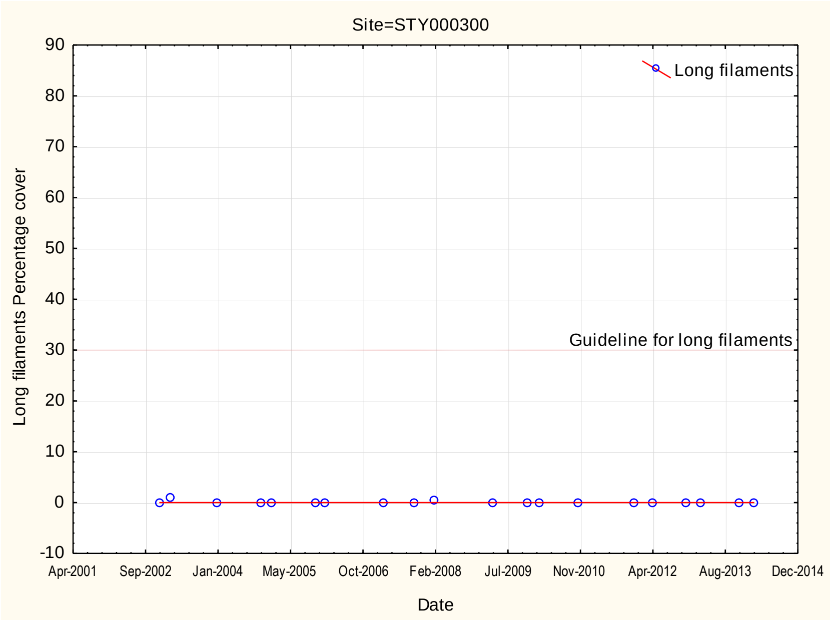
2.1.6 Long term trend analysis

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 12 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 8 to Figure 11).



n = 20
Kendal tau = -0.017
p-value = 0.918
FDR p-value = 0.947

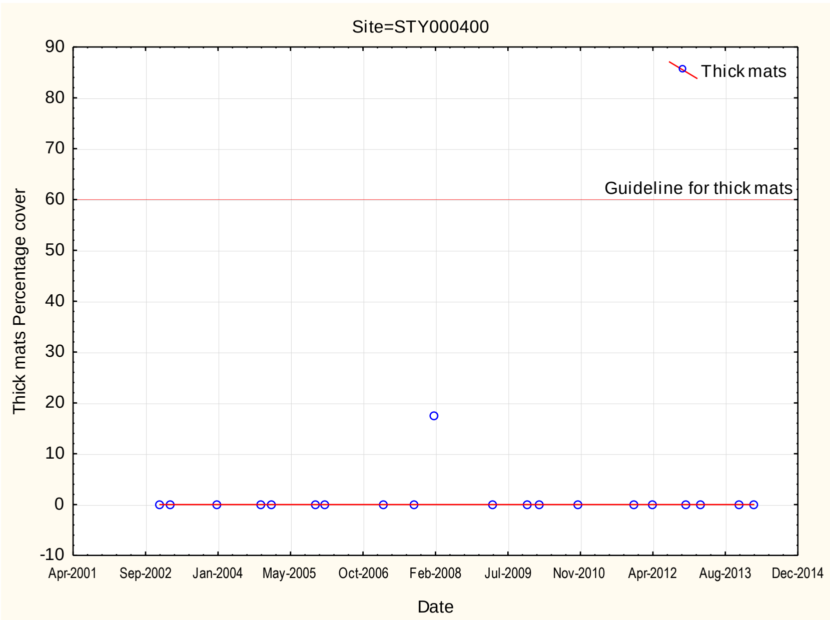
Figure 8 LOWESS trend analysis of percentage cover of thick mats at Stony River, Mangatete Road (STY000300)



n = 20
Kendal tau = -0.227
p-value = 0.162
FDR p-value = 0.295

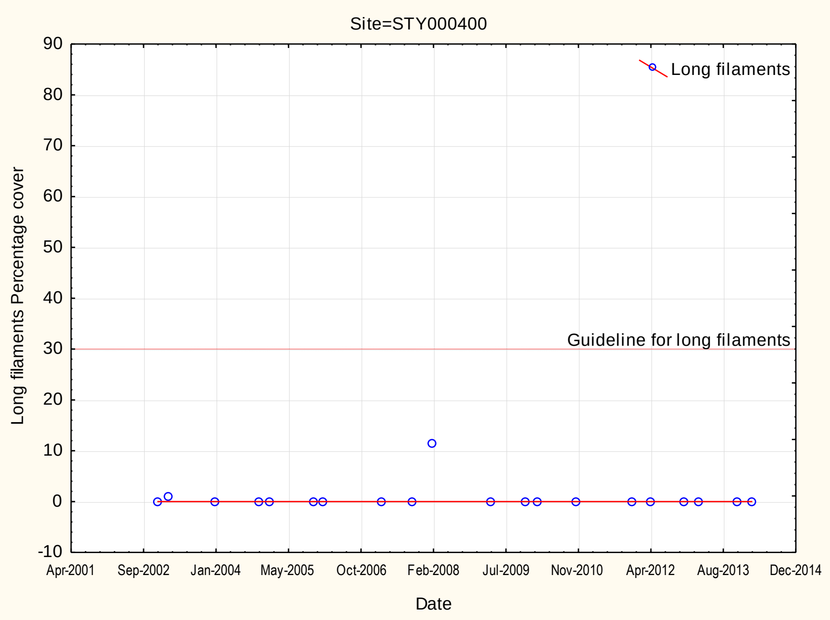
Figure 9 LOWESS trend analysis of percentage cover of long filaments at Stony River, Mangatete Road (STY000300)

At Mangatete Road (STY000300) over the 12 year monitored period there were no significant trends for thick mats (p=0.947) or long filaments (p=0.295) at the 5% level of significance.



n = 20
Kendal tau = -0.017
p-value = 0.918
FDR p-value = 0.947

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



n = 20
Kendal tau = -0.203
p-value = 0.211
FDR p-value = 0.352

Figure 11 LOWESS trend analysis of percentage cover of long filaments at Stony River, SH45 (STY000400)

At SH45 (STY000400) over the 12 year monitored period there were no significant trends for thick mats (p=0.947) or long filaments (p=0.352) at the 5% level of significance.

2.2 Maketawa Stream

The Maketawa Stream originates in Egmont 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 generally 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 (Appendix 2).

The Maketawa Stream has a catchment with high conservation status and has been designated as one of only two river catchments in the draft Freshwater and Land Management Plan for Taranaki (2015) to be in the Freshwater Management Unit A: outstanding freshwater bodies. Two sites have been located in this catchment to monitor periphyton communities (Figure 12). 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.

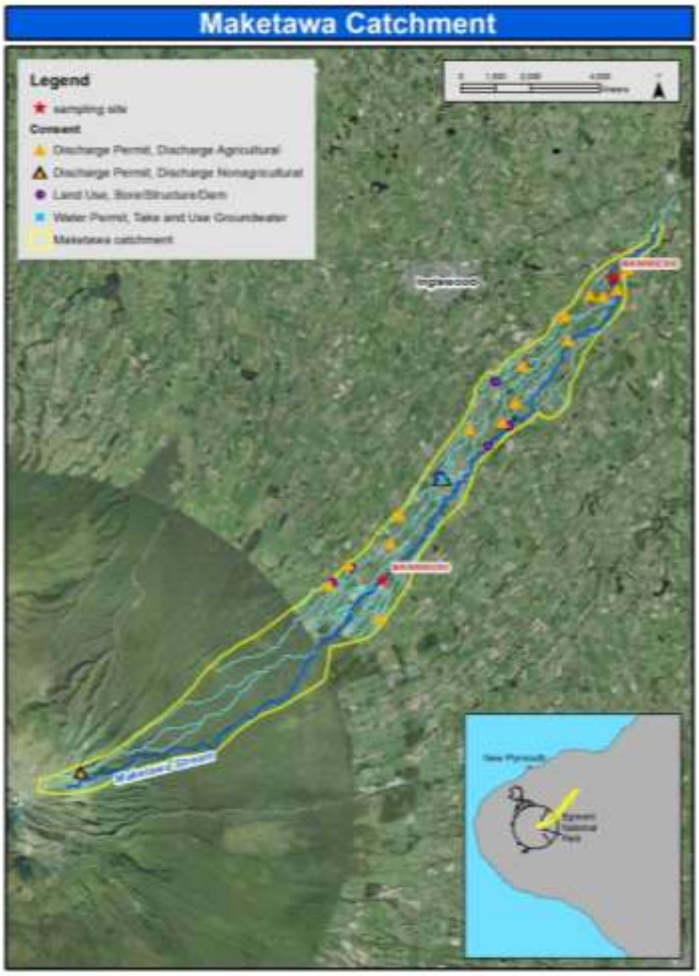


Figure 12 Monitoring site locations in relation to consents operating in the Maketawa Stream catchment Manganui River

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).

The spring 2012 survey was conducted on 3 November 2012 13 days after a fresh in excess of both 3x and 7x median flow. The summer 2013 survey was carried out on 25 February 2013 19 days after a fresh in excess of both 3x median flow and 20 days in excess of 7x median flow. No significant freshes occurred after the 3x median fresh and the river was experiencing a low flow period at the time of sampling (Appendix).

The spring 2013 survey was conducted on 22 November 2013 15 days after a fresh in excess of 3x median flow and 21 days after a fresh in excess of 7x median flow. The summer 2014 survey was carried out on 25 February 2014 27 days after a fresh in excess of 3x median flow and 30 days after a 7x median flow. No significant freshes occurred after the 3x median fresh and the river was experiencing a low flow period at the time of sampling (Appendix).

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 2012-2014.

During the 2012-2013 monitoring period, very low levels of nuisance periphyton was detected at the lower catchment site at Tarata Road during the summer survey. A very small level of long filamentous algae was recorded, well below the recommended guidelines (Figure 14).

In the 2013-2014 monitoring period nuisance periphyton was recorded at both sites. Denby Road had very low levels of filamentous algae and the Tarata Road site had moderately low levels of thick algal mats recorded during the spring survey. However, the thick algal mats consisted of thick black mats likely to be the cyanobacteria *Phormidium* which would trigger the 'Alert' level for breaching 20% bed coverage.

No nuisance periphyton was recorded during the summer 2014 survey at both sites even though it was a summer survey carried out after an extensive period of no freshes or floods (Figure 13 and Figure 14).

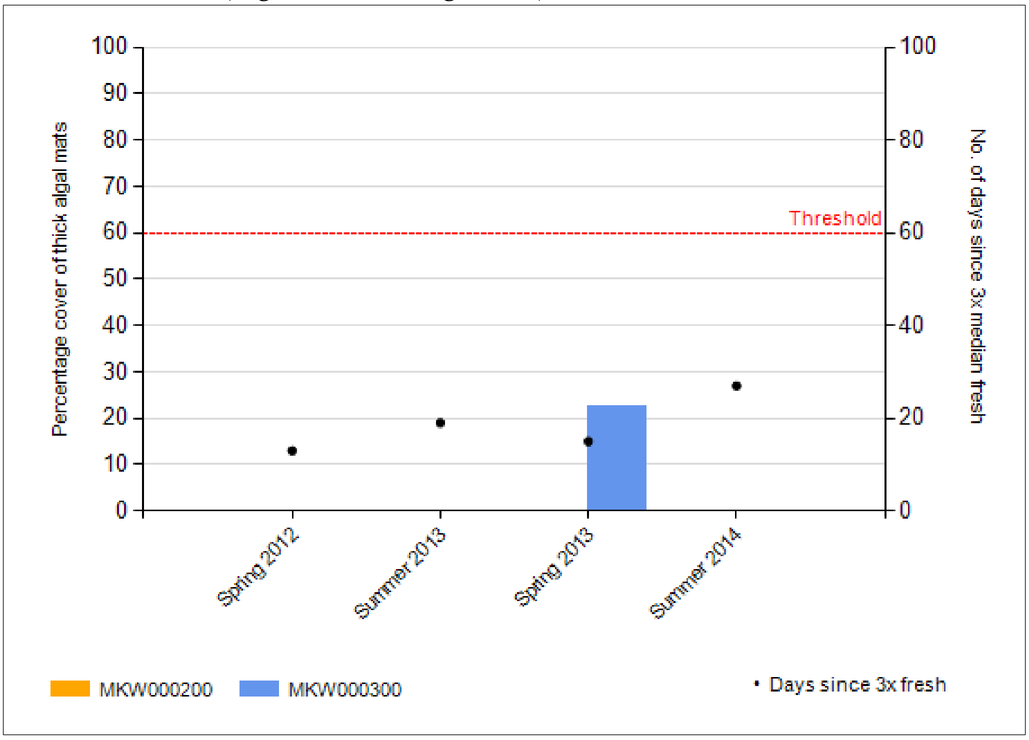


Figure 13 Percentage cover of thick mats of periphyton on the Maketawa streambed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

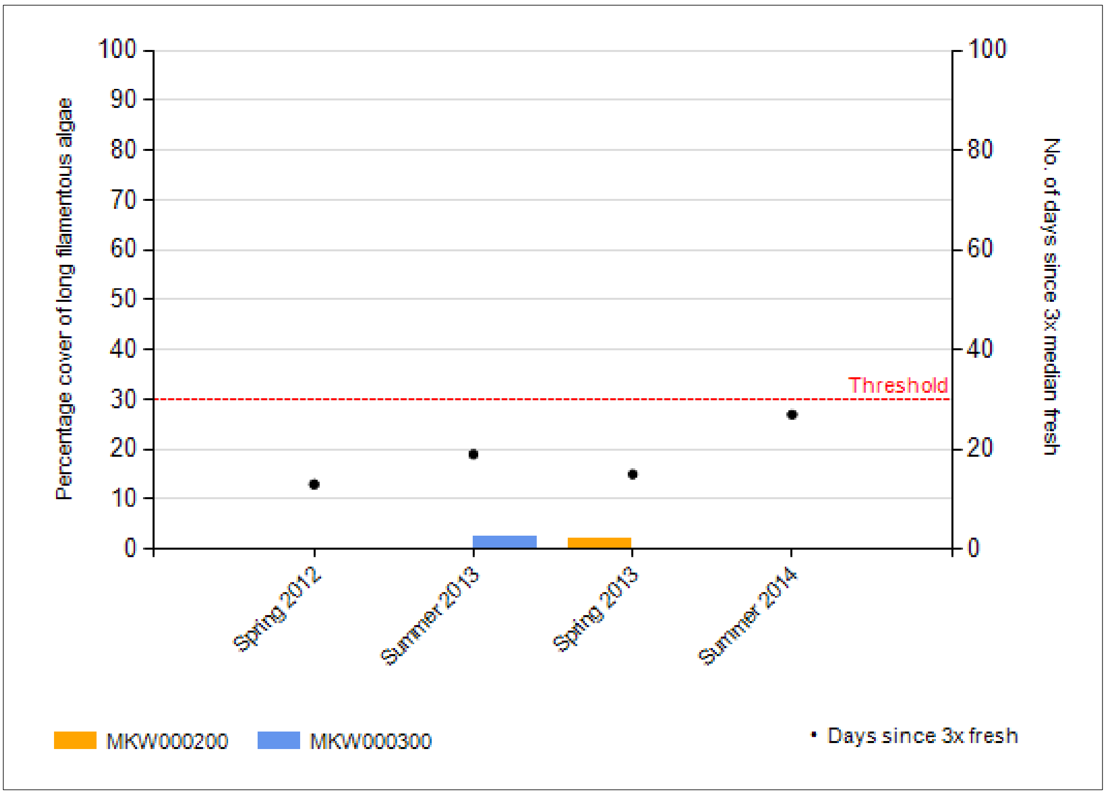


Figure 14 Percentage cover of long filamentous algae on the Maketawa streambed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

2.2.3 Periphyton Index Score

The Maketawa Stream at the upstream site (MKW000200) and downstream site (MKW000300) had 'very good' TRC PI scores during both spring and summer surveys (

Table 10). On all occasions TRC PI scores exceeded historical medians. 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 was likely a reflection of the increased nutrient inputs from agricultural land between the sites. 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 0.056 units per kilometre. This was relatively similar number to the 2010-2012 monitoring period of 0.060 units per kilometre (TRC, 2014).

Table 10 10 shows how the TRC PI scores change from spring to summer at this site. There is a drop in TRC PI at each site from spring to summer, which could be expected through increased periphyton growth with longer sunlight hours, warmer temperatures, and 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 'good' or 'very good' rating.

Table 10 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
MKW000200	9.9	9.6	9.8	9.6	10.0	9.5
MKW000300	9.4	9.1	8.2	9.2	9.1	6.4
Difference	0.5	0.5	1.6	0.4	0.9	3.1

2.2.4 Periphyton biomass

The results for the 2011- 2014 monitoring period found extremely low levels of chlorophyll *a* at the upstream site and low to moderately low levels at the downstream site (Figure 15). Though the results are congruent with TRC PI scores indicating that the Maketawa Stream did not have high levels of periphyton there was more variation in the chlorophyll *a* scores (17-66 chlorophyll *a* mg/m^2) than the TRC PI scores (8.8-9.2).

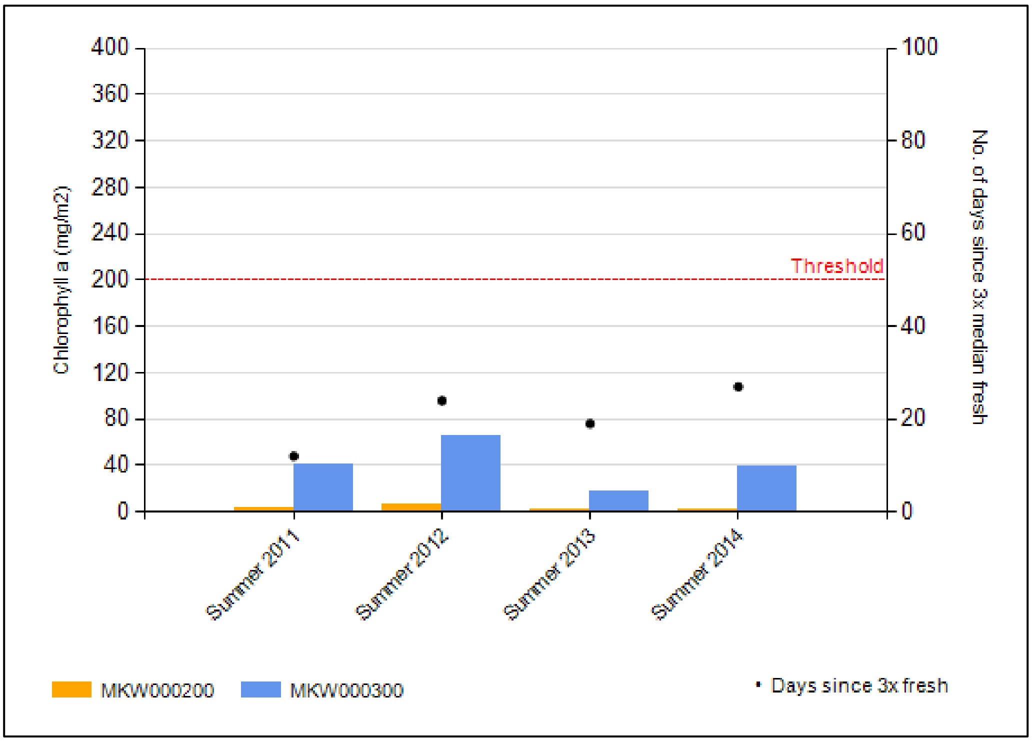


Figure 15 Periphyton biomass (chlorophyll *a*) on the Maketawa riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.2.5 Summary of 2002-2014 (12 year data set)

Thick algal mats have never breached recreational guidelines at the two Maketawa Stream sites surveyed (Figure 16). Where thick algal mats have proliferated it was typically at the downstream site with only one occasion where thick mats at the upstream site have proliferated which was in the spring 2009 survey.

Long filamentous algae has varied dramatically at both sites, with a higher cover present during summer periods during low flows, particularly at the downstream site (Figure 17). 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. The breaches usually coincided with longer periods of low flow. The upstream site occasionally recorded some nuisance growths of filamentous algae from 2002-2010 but not to the same extent as the downstream site. There were small proliferations of thick algal mats recorded at the downstream site during spring 2013 but this was well below guideline levels.

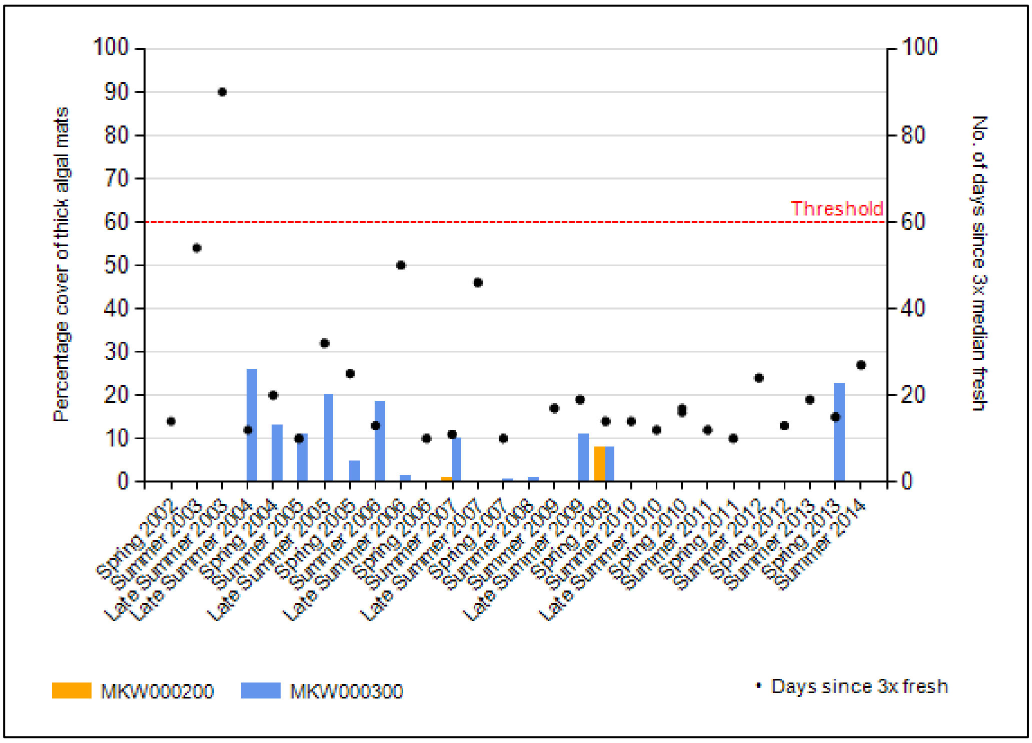


Figure 16 Percentage cover of thick mats of periphyton on the Maketawa streambed in relation to the guidelines for recreational values over the 2002-2012 period

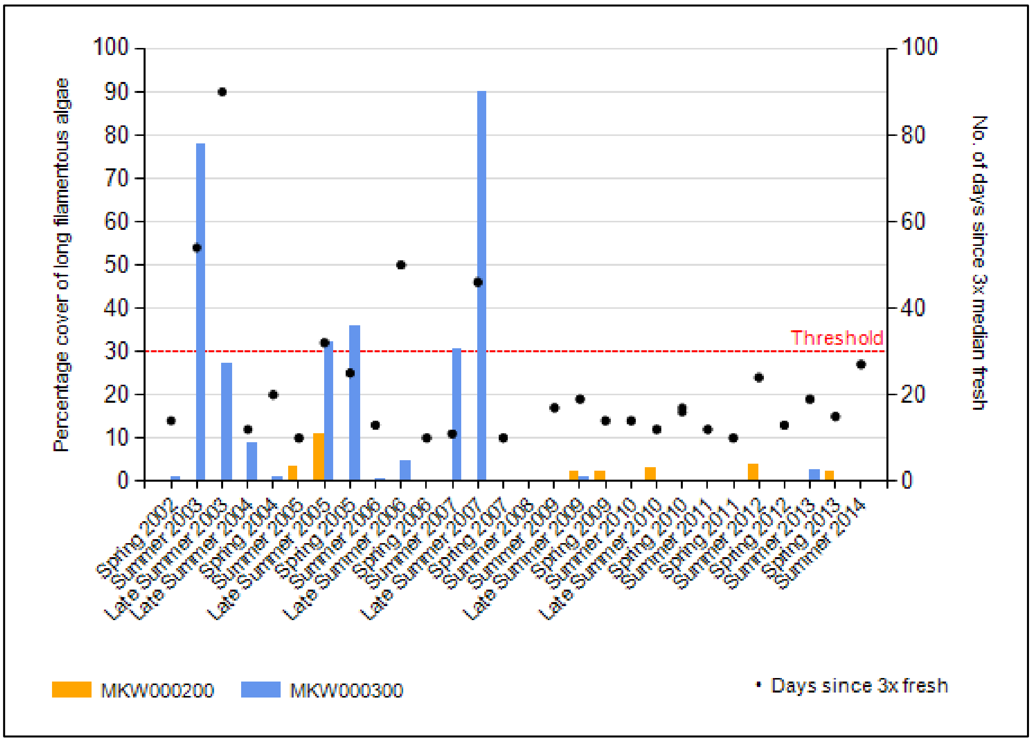
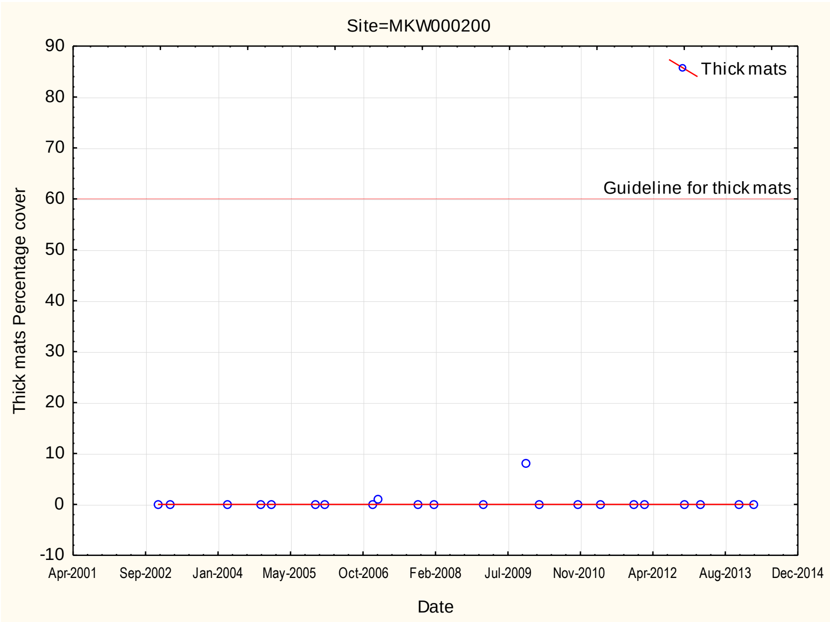


Figure 17 Percentage cover of long filamentous algae on the Maketawa streambed in relation to the guidelines for recreational values over the 2002-2012 period

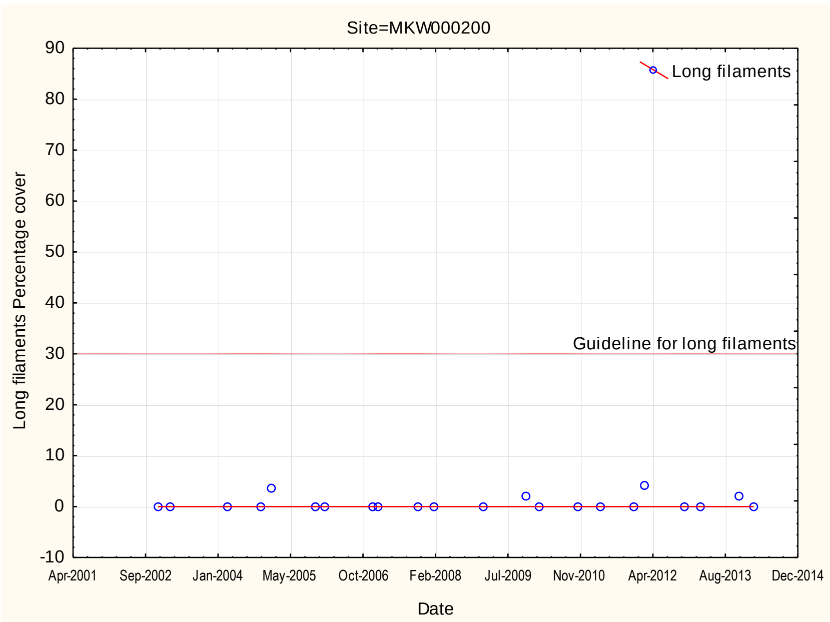
2.2.6 Long term trend analysis

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 12 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 17 to Figure 21).



n = 22
Kendal tau = -0.010
p-value = 0.947
FDR p-value = 0.947

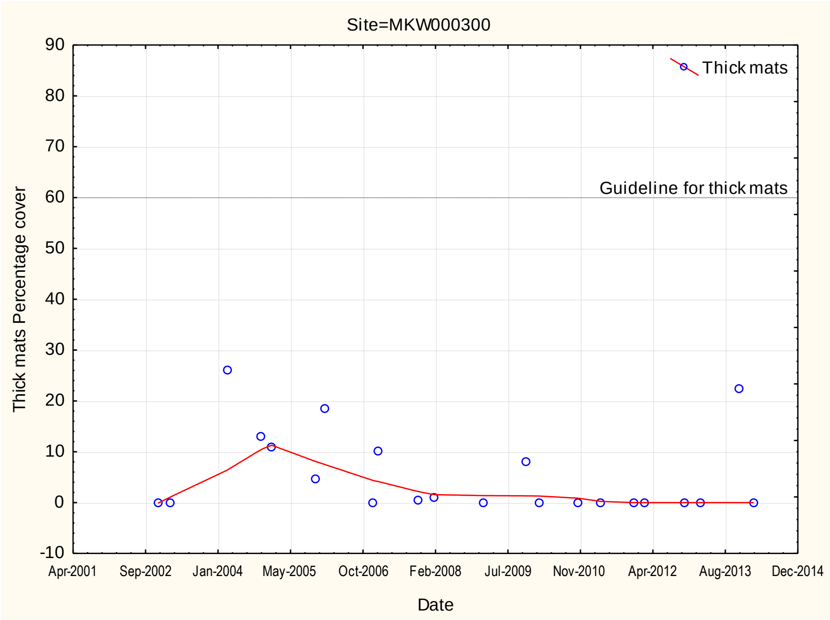
Figure 18 LOWESS trend analysis of percentage cover of thick mats at Maketawa Stream, Denby Road (MKW000200)



n = 22
Kendal tau = 0.157
p-value = 0.305
FDR p-value = 0.436

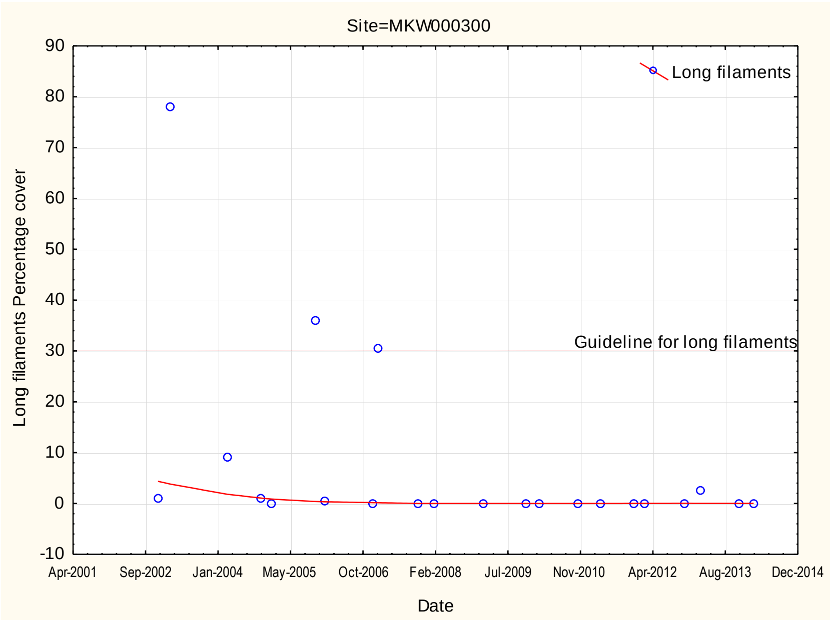
Figure 19 LOWESS trend analysis of percentage cover of long filaments at Maketawa Stream, Denby Road (MKW000200)

At Denby Road (MKW000200) over the 12 year monitored period there were no significant trends for thick mats (p=0.947) or long filaments (p=0.436) at the 5% level of significance.



n = 22
Kendal tau = -0.333
p-value = 0.030
FDR p-value = 0.168

Figure 20 LOWESS trend analysis of percentage cover of thick mats at Maketawa Stream, Tarata Road (MKW000300)



n = 22
Kendal tau = -0.463
p-value = 0.003
FDR p-value = 0.017

Figure 21 LOWESS trend analysis of percentage cover of long filaments at Maketawa Stream, Tarata Road (MKW000300)

At Tarata Road (MKW000300) over the 12 year monitored period there was no significant trend for thick mats (p=0.168). However, there was a significant negative trend (tau = -0.463 for long filaments (p=0.017) at the 5% level of significance indicating that long filamentous algae had decreased during the monitored period.

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 22). 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.

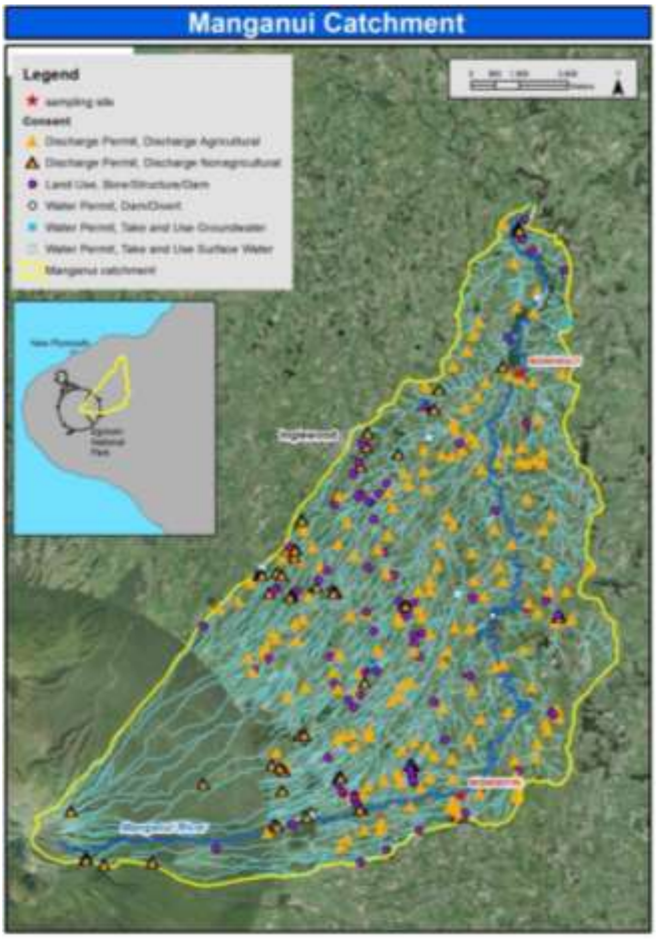


Figure 22 Monitoring site locations in relation to consents operating in the Manganui River catchment.

2.3.1 Flow data and survey dates

The spring 2012 survey was conducted on 16 November 2012 13 days after a fresh in excess of both 3x and 7x median flow for the SH3 site while the fresh took longer to reach the downstream site at Bristol Road resulting in a 3x median flow fresh 12 days prior to surveying. The summer 2013 survey was carried out on 25 February 2013 19 days after a fresh in excess of 3x median flow and 20 days in excess of 7x median flow for both sites. No significant freshes occurred after the 3x median fresh and the river was experiencing a low flow period at the time of sampling (Appendix).

The spring 2013 survey was conducted on 18 December 2013 11 days after a fresh in excess of both 3x and 7x median flow for the SH3 site and 10 days after a fresh in excess of 3x median flow and 21 days after a fresh in excess of 7x median flow for the Bristol Road. The summer 2014 survey was carried out on 25 February 2014 27 days after a fresh in excess of 3x median flow and 30 days after a 7x median flow for the SH3 site and 38 days after a fresh in excess of 3x median flow and 51 days after a 7x median flow for the Bristol road site. A minor (<3x median flow) fresh occurred halfway between sampling and the 3x median fresh but the site was experiencing a low flow period at the time of sampling (Appendix).

2.3.2 Periphyton cover

The Manganui River was characterised by no nuisance periphyton in the upper catchment at SH3 and only a moderately low level of thick algal mats at Bristol Road (Figure 23 and Figure 24). No breech of guidelines occurred at either the upstream or the downstream site for long filaments or thick mats over the 2012-2014 monitoring years.

In the 2012-2013 monitoring year, both the upstream site at SH3 and the downstream site at Bristol Road recorded no nuisance algal cover. At the upstream site the Manganui River was well shaded by riparian vegetation. This shade, in conjunction with low nutrient levels was likely to limit the growth of periphyton at this site. The Bristol Road site had a much wider bed and was consequently less shaded suggesting a lack of nutrients only may have limited periphyton growth.

In the 2013-2014 monitoring year no nuisance periphyton was recorded at the upstream site at SH3. In the summer period thick algal mats comprised of diatoms were recorded at the downstream site at Bristol Road. This result was well below guideline limits and probably reflects the long period with no flushing flows prior to sampling occurring and the site having no shade.

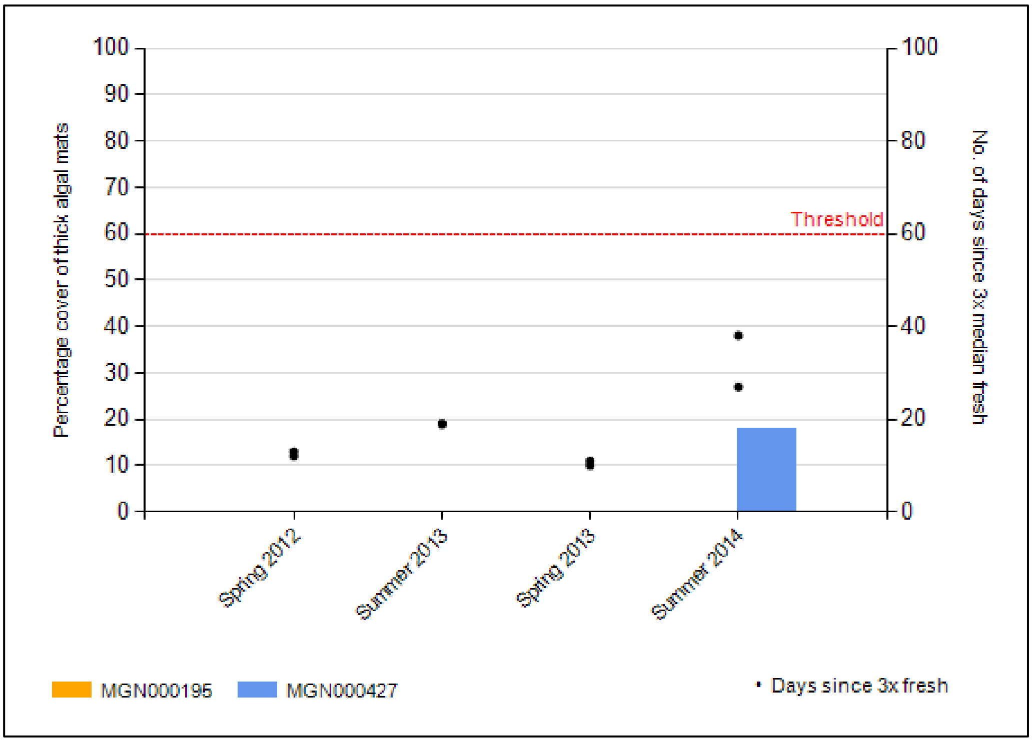


Figure 23 Percentage cover of thick mats of periphyton on the Manganui riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

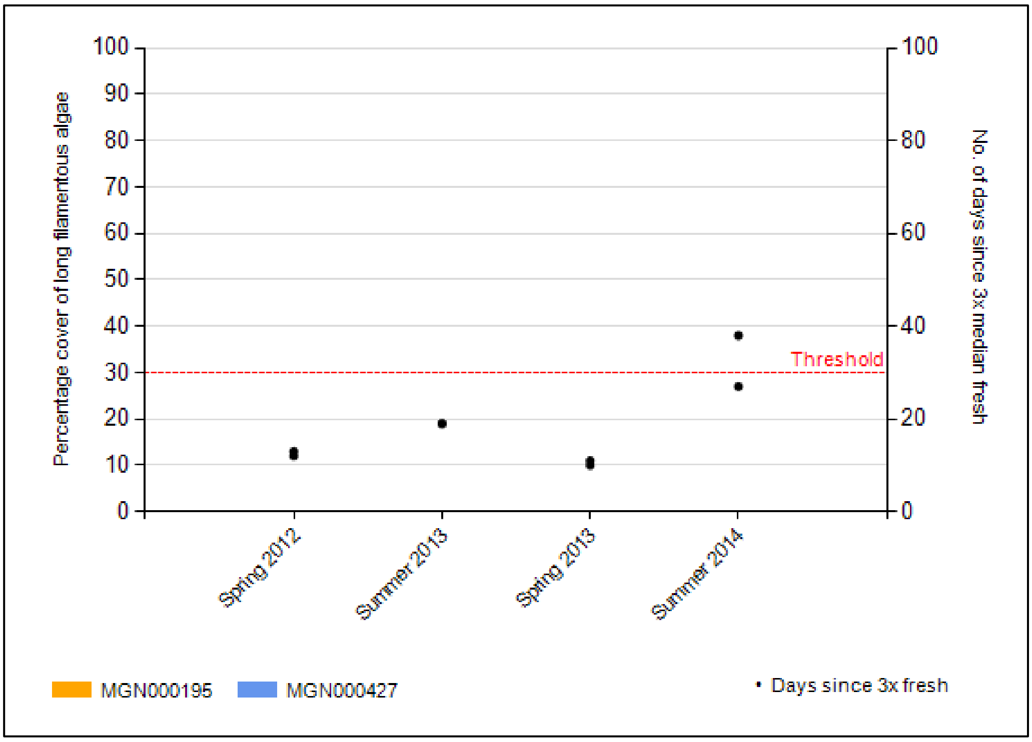


Figure 24 Percentage cover of long filamentous algae on the Manganui riverbed in relation to the guidelines for recreational values over the 2010-20112 monitoring period and number of days since 3x median fresh

2.3.3 Periphyton Index Score

The Manganui River typically recorded moderate differences in TRC PI between upstream and downstream sites (Table 11). 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 'good' 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 0.008 units per kilometre which was similar to the rate found previously in 2010-2012 period of 0.076 units per kilometre (TRC, 2014).

Table 11 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
MGN000195	10.0	9.8	10.0	9.8	9.6	9.8
MGN000427	9.2	8.6	6.3	6.2	5.9	5.9
Difference	0.8	1.2	3.7	3.6	3.7	3.9

Table 11 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 and shading. The lower site had a lower median TRC PI rating and scored a lower TRC PI on every sampling occasion, particularly in the 2013-2014 monitoring period where values were significantly lower. Unlike other sites, little difference occurred between spring and summer surveys. Previous surveys have found a higher TRC PI score in summer rather than in spring (TRC, 2014). Normally there is a marked increase in periphyton score from spring to summer.

2.3.4 Periphyton biomass

The results for the 2010-2014 monitoring period found extremely low levels of chlorophyll *a* at the upstream site and low to moderately low levels at the downstream site (Figure 25). The results were congruent with the findings from the periphyton index scores (9.1, 7.4, 8.6, and 6.2) from the four summers where chlorophyll *a* was collected that showed TRC PI was inversely correlated with chlorophyll *a* mg/m^2 (the lower the TRC PI score the higher the chlorophyll *a* mg/m$^{2)}$.

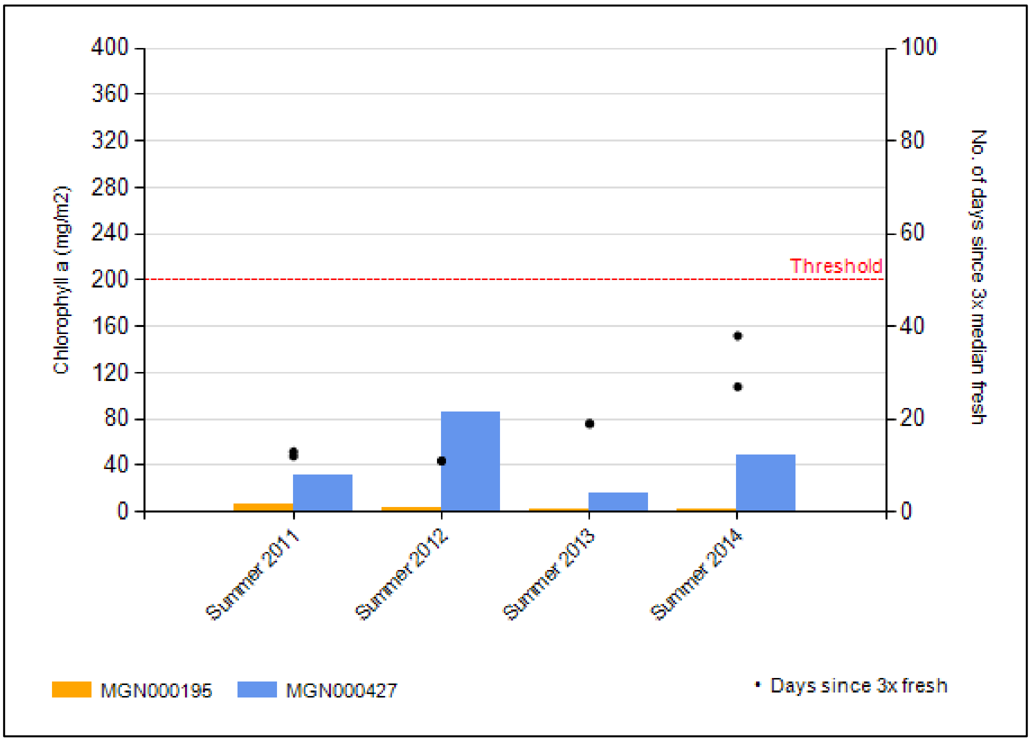


Figure 25 Periphyton biomass (chlorophyll *a*) on the Manganui riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.3.5 Summary of 2002-2014 (12 year data set)

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 (Figure 26 and Figure 27). At the downstream Bristol road site the periphyton community had greater levels of long filamentous algae and than thick algal mats. There were no breaches in guidelines for thick algal mats at either site over the entire 12 year period.

The upper site had no filamentous algae present. However, the lower catchment site breached long filamentous guidelines on three occasions over the 12 year period. These breaches occurred solely in 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 and the current reported period from 2012-2014 found no long filamentous algae.

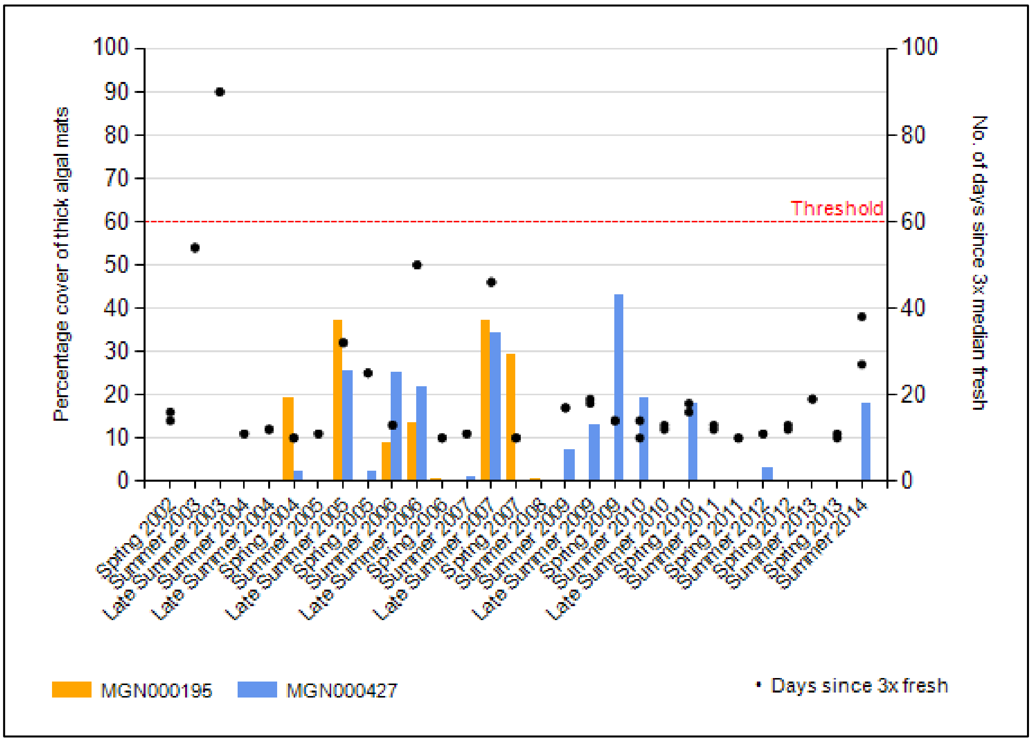


Figure 26 Percentage cover of thick mats of periphyton on the Manganui riverbed in relation to the guidelines for recreational values over the 2002-2012 period

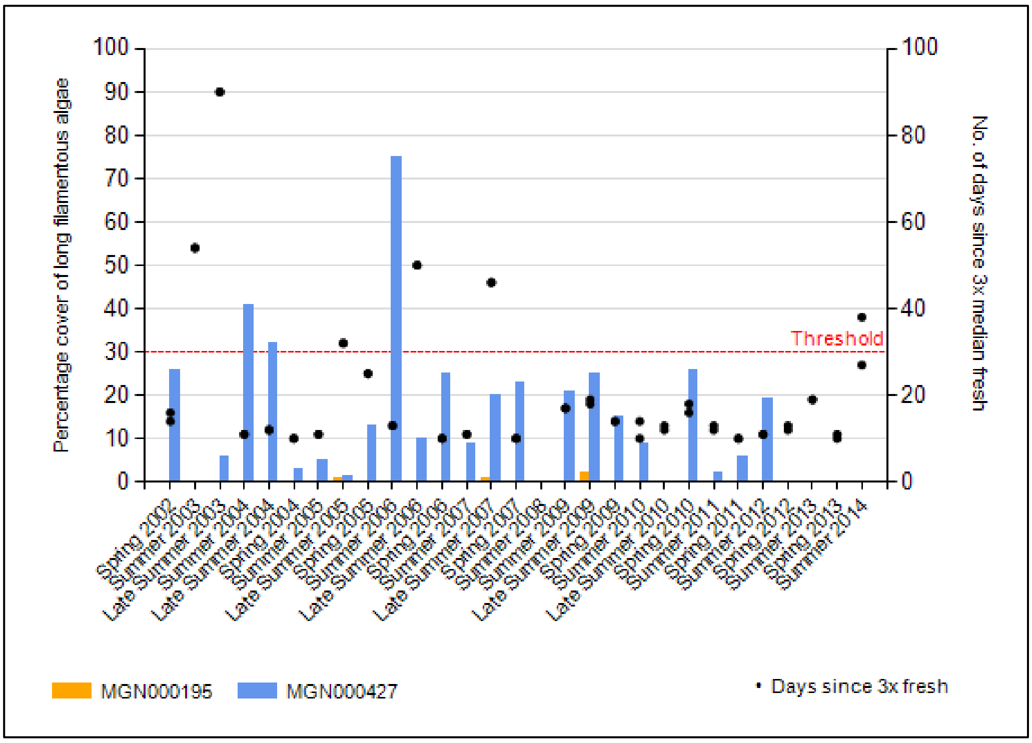
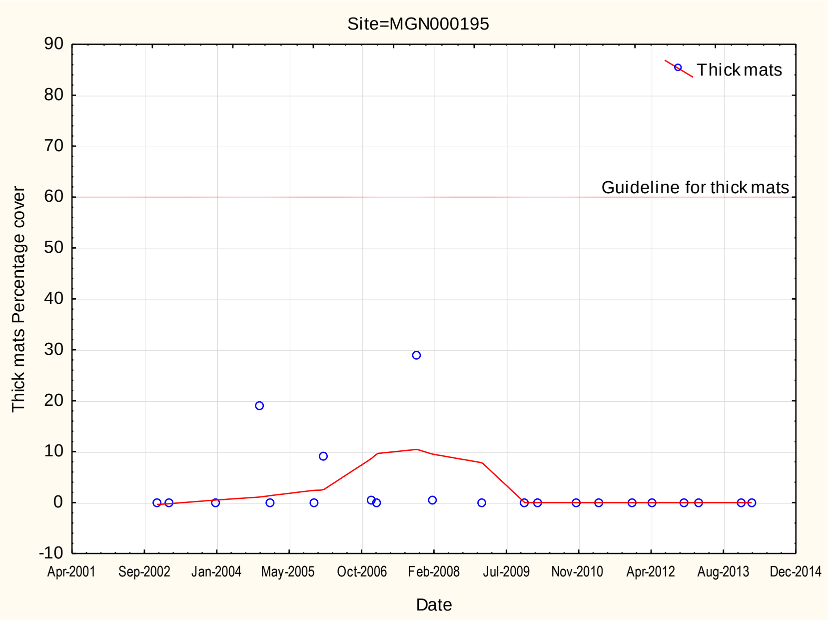


Figure 27 Percentage cover of long filamentous algae on the Manganui riverbed in relation to the guidelines for recreational values over the 2002-2012 period

2.3.6 Long term trend analysis

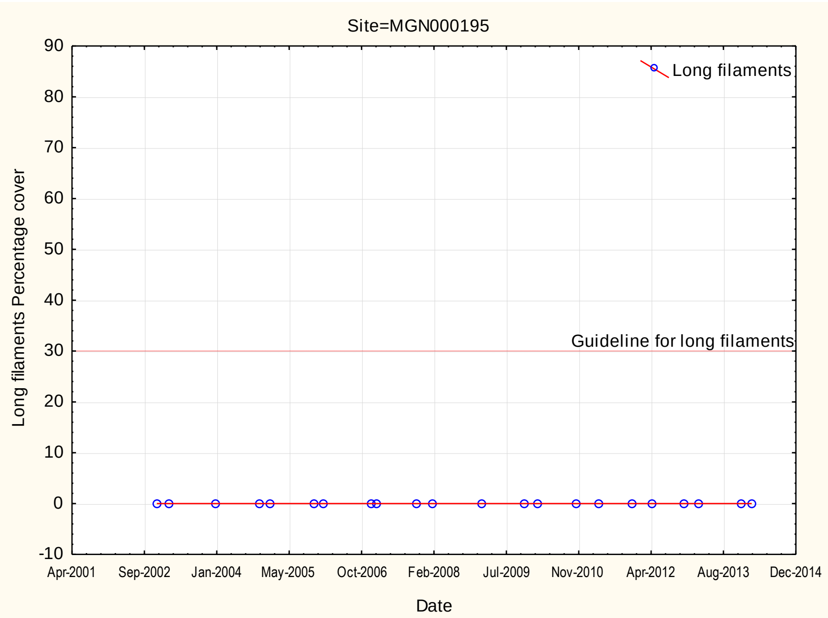
Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at

the Manganui River, at SH3 and at Bristol Road, over a 12 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 28 to Figure 31).



n = 22
Kendal tau = -0.258
p-value = 0.093
FDR p-value = 0.326

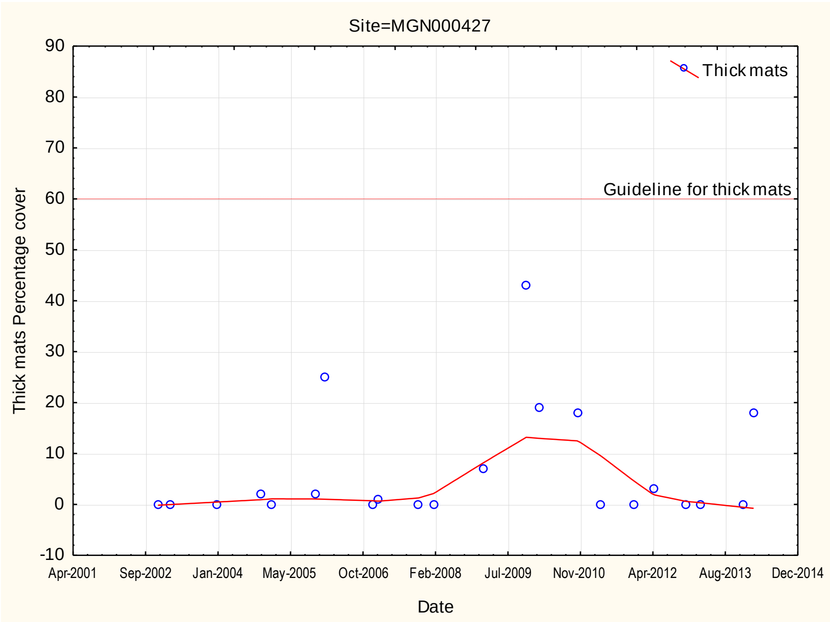
Figure 28 LOWESS trend analysis of percentage cover of thick mats at Manganui River, SH3 (MGN000195)



n = 22
Kendal tau = 0
p-value = 0
FDR p-value = 0

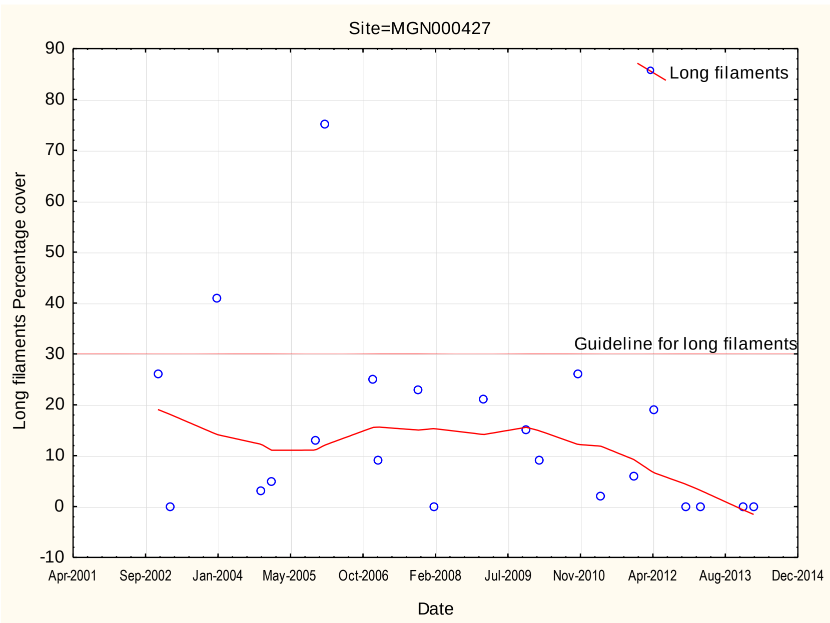
Figure 29 LOWESS trend analysis of percentage cover of long filaments at Manganui River, SH3 (MGN000195)

At SH3 (MGN000195) over the 12 year monitored period there was no significant trend for thick mats (p=0.326) at the 5% level of significance and no long filaments were recorded.



n = 22
Kendal tau = 0.098
p-value = 0.524
FDR p-value = 0.822

Figure 30 LOWESS trend analysis of percentage cover of thick mats at Manganui River, Bristol Road (MGN000427)



n = 22
Kendal tau = -0.333
p-value = 0.030
FDR p-value = 0.076

Figure 31 LOWESS trend analysis of percentage cover of long filaments at Manganui River, Bristol Road (MGN000427)

At Bristol Road (MGN000427) over the 12 year monitored period there were no significant trends for thick mats (p=0.822) or long filaments (p=0.076) at the 5% level of significance. However, the result for long filaments was close to being significant suggesting that long filaments may be decreasing (tau = -0.333).

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 32). 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.

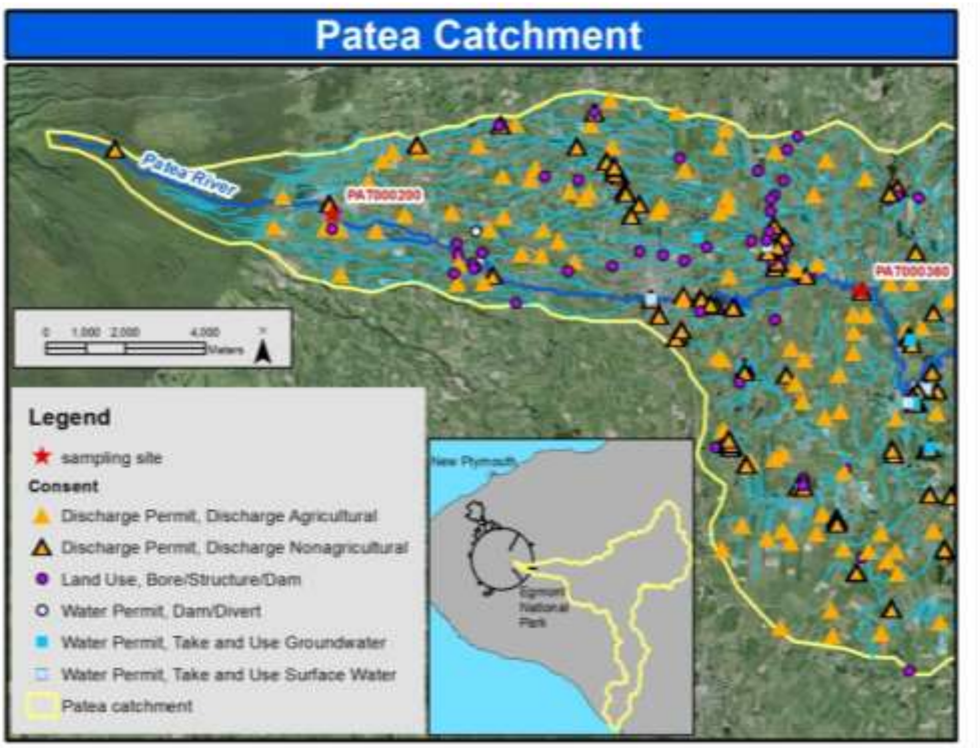


Figure 32 Monitoring site locations in relation to consents operating in the Patea River catchment

2.4.1 Flow data and survey dates

The spring 2012 survey was conducted on 2 November 2012 13 days after a fresh in excess of 3x median flow and 20 days after a 7x median flow. The summer 2013 survey was carried out on 1 February 2013 17 days after a fresh in excess of 3x median flow and 57 days in excess of 7x median flow. No significant freshes occurred after the 3x median fresh (Appendix).

The spring 2013 survey was conducted on 12 November 2013 11 days after a fresh in excess of both 3x and 7x median flow. The summer 2014 survey was carried out on 7 April 2014 72 days after a fresh in excess of 3x median flow and 92 days after a 7x median flow. A minor fresh occurred shortly after the 3x median fresh but the site was experiencing a low flow period at the time of sampling (Appendix).

2.4.2 Periphyton cover

Nuisance periphyton at Barclay Road and at Skinner Road did not exceed guideline levels over the 2012-2013 monitoring period but Skinner Road did exceed periphyton guidelines for filamentous green algae for the summer period in the 2013-2014 monitoring period. The amount of thick algal mats was also much greater at the lower Skinner Road site.

In the 2012-2013 monitoring year no nuisance periphyton mats or filaments were recorded in the upper site at Barclay Road (Figure 33 and Figure 34). 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 thick algal mats were visible during the summer 2013 survey, whereas in spring 2012 no periphyton was recorded. However, the site did not exceed the guideline levels of coverage for recreational and aesthetic values.

In the 2013-2014 monitoring year only a small amount of thick algal mats were recorded at Barclay Road during the summer of 2012, with levels well below the recommended guidelines.

In spring 2013, no periphyton mats were recorded at Skinner Road. In summer 2014, periphyton levels significantly increased. Filamentous algae dominated the periphyton community with 40% bed coverage which exceeded recommended guidelines. Thick algae mats comprised of diatoms comprised another 20% of the streambed making total coverage of nuisance periphyton at 60%.

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. The large difference between the two monitoring years is probably attributed to the substantially longer time since a fresh occurred for the summer of 2014 compared with the summer of 2013.

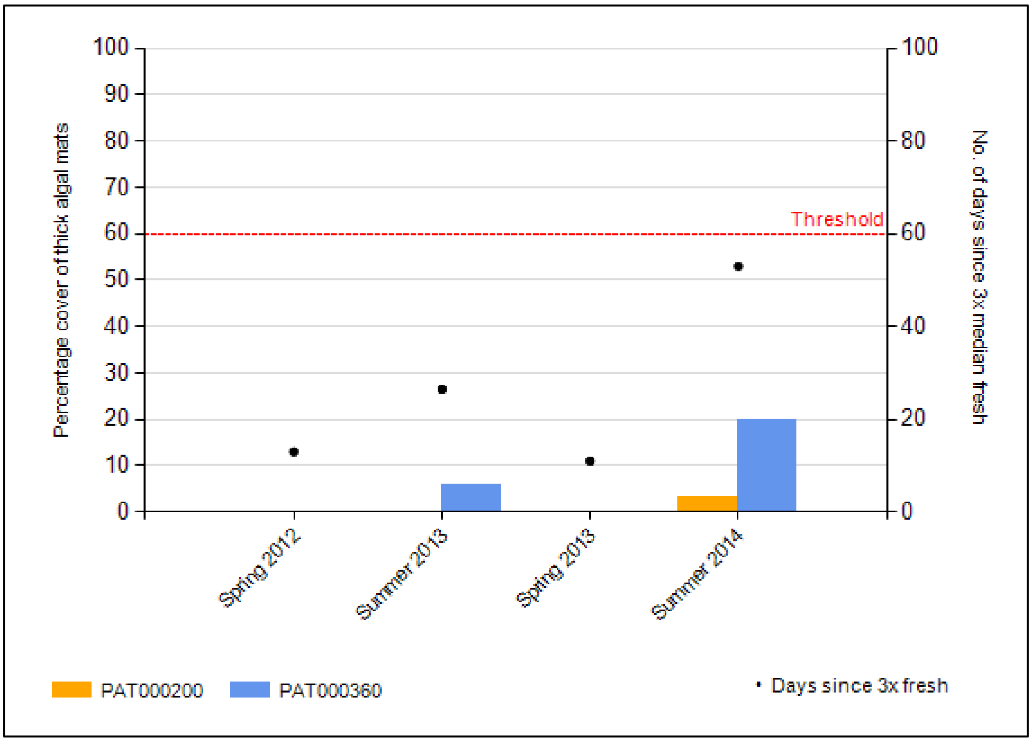


Figure 33 Percentage cover of thick mats of periphyton on the Patea riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

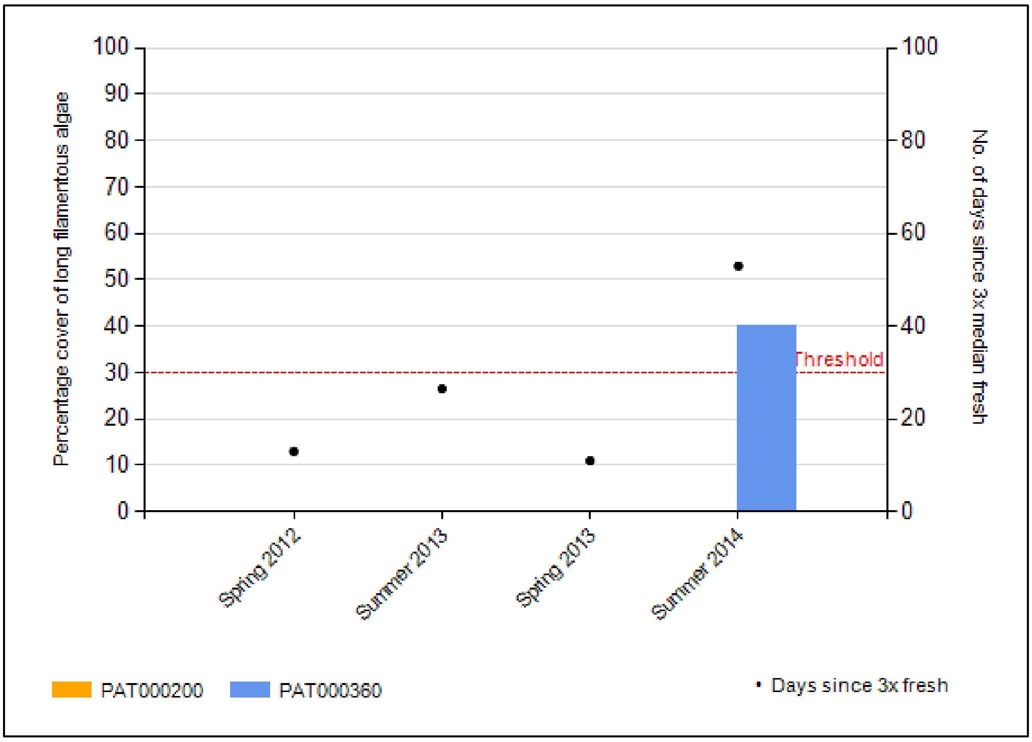


Figure 34 Percentage cover of long filamentous algae on the Patea riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

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 runoff from agricultural pasture, and also receives the Stratford waste water discharge, generally has a 'moderate' to 'very good' TRC PI value (Table 12). A drop in TRC PI score of 0.134 units per kilometre was recorded which was larger than what was previously found (0.116 units per kilometre was recorded; TRC, 2014) and is the highest rate of periphyton community degradation per distance downstream of all the rivers where at least two sites are monitored. A very significant difference between spring and summer surveys was evident with the summer 2014 survey having a particularly low score.

Table 12 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
PAT000200	9.7	10.0	9.9	9.8	9.5	9.8
PAT000360	9.2	7.2	9.3	4.5	7.2	5.2
Difference	0.5	2.8	0.6	5.3	2.3	4.6

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 catchment has an improved periphyton score in comparison to the historical summer medians, being greater by 1.0 unit in 2013 and 0.7 units in 2014.

2.4.4 Periphyton biomass

The results for the 2010- 2014 monitoring period found extremely low levels of chlorophyll *a* at the upstream site and moderately low to high levels at the downstream site. In particular, for the summer 2012 survey (220 chlorophyll *a* mg/m^2) chlorophyll *a* exceeded recommended guidelines for trout angling (Table 2) and the proposed bottom line for NOF standards (Snelder et al., 2013). Moderately high levels were also found for the summer 2013 survey and all surveys exceeded the guideline for benthic biodiversity (Table 2).

Interestingly, the TRC PI score was 4.5 for the summer 2014 survey and the periphyton cover score breached guidelines during that same survey for filamentous algae but the chlorophyll *a* levels were not particular high and were lower than both the 2012 and 2013 surveys which had higher TRC PI scores recorded (6.1 and 7.2 respectively). Furthermore, for the 2012 survey (TRC, 2014) the TRC PI was 'good' (6.1) but chlorophyll *a* breached standards. Some variability within a site will always exist and it was important to note that areas that were viewed for periphyton cover and TRC periphyton index were not necessarily the same place rocks were taken for chlorophyll *a* analysis.

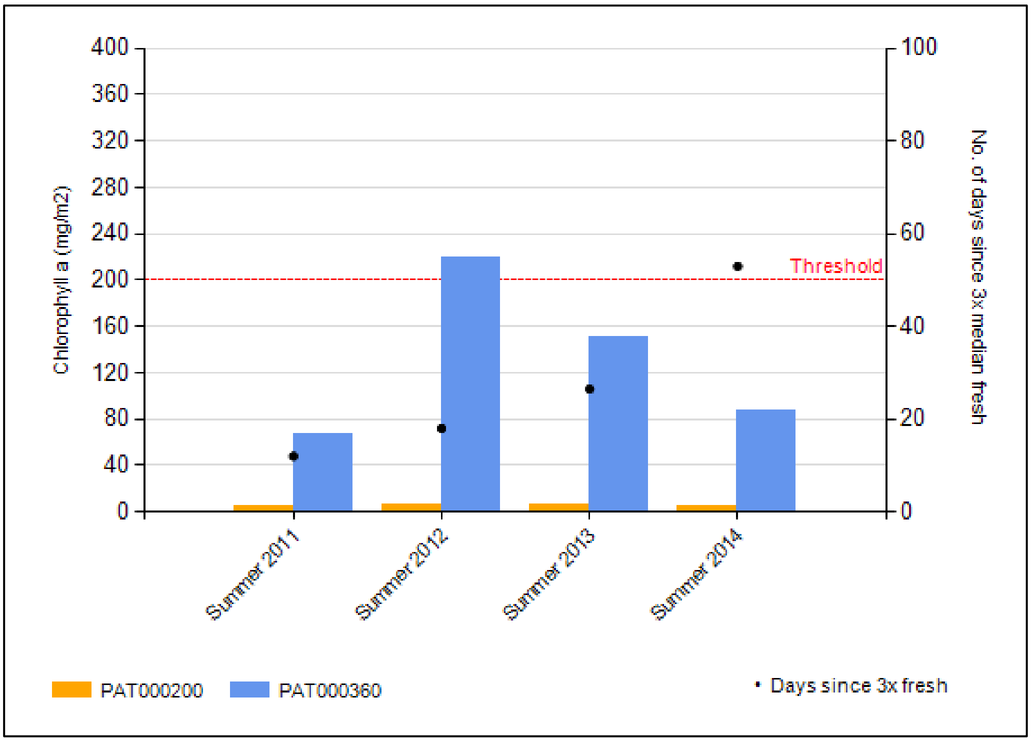


Figure 35 Periphyton biomass (chlorophyll *a*) on the Patea riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.4.5 Summary of 2002-2014 (12 year data set)

Over the entire period the Patea River had never breached thick algal mat periphyton guidelines (Figure 36). 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, proliferations of thick mats only occurred at the lower site at Skinner Road but for the current reporting period thick algal mats occurred at both sites, though with much higher levels at Skinner Road.

At the downstream site at Skinner Road, large proliferations of long filamentous algae led to many breaches throughout the 12 year period of monitoring (particularly during the earlier monitoring years) (Figure 37). There were seven breaches in long filamentous guidelines from 2002-2006. In the 2006-2010 period there was 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 12 year period. The majority of the breaches corresponded 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). After five years without a breach the last survey at the Skinner Road site in summer 2014 recorded a breach which corresponded with a long period without flushing flows.

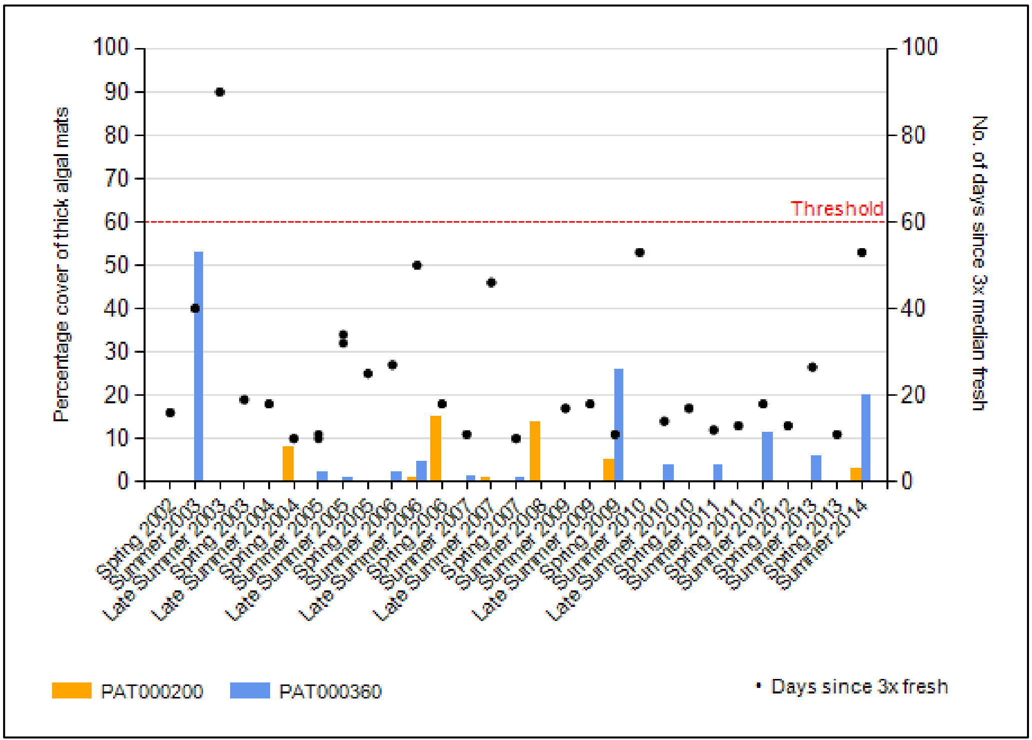


Figure 36 Percentage cover of thick mats of periphyton on the Patea riverbed in relation to the guidelines for recreational values over the 2002-2012 period

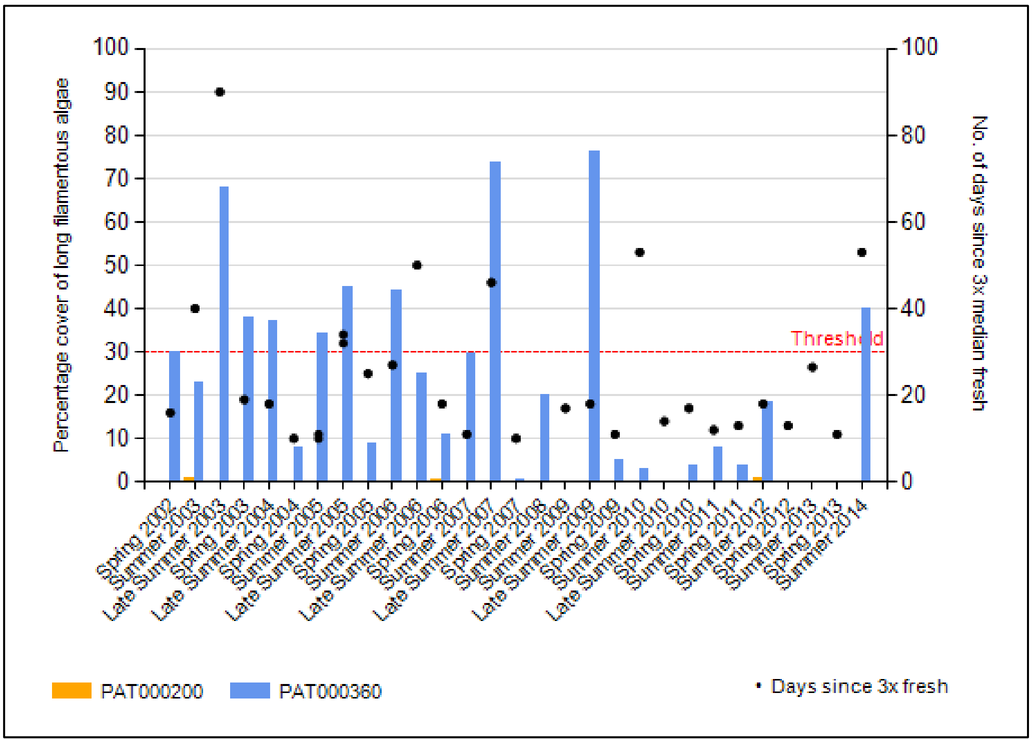
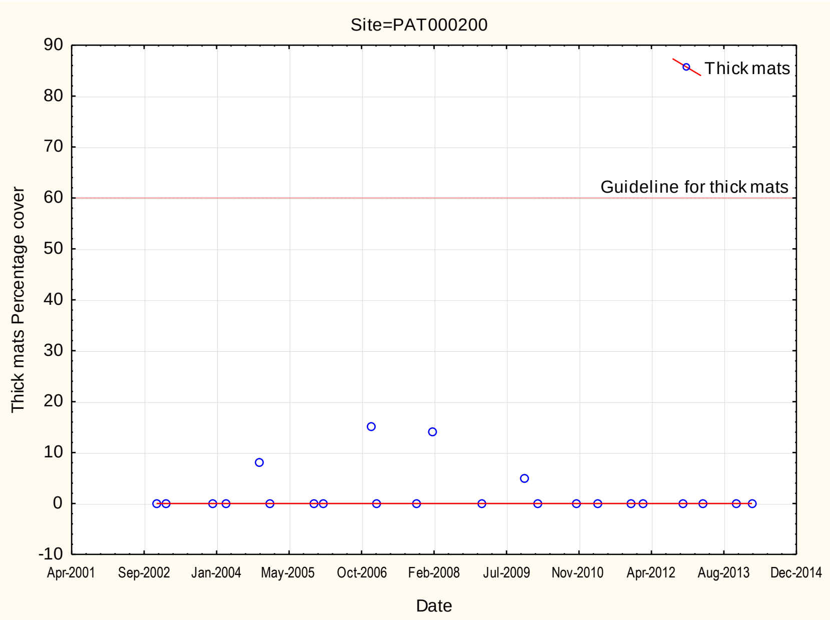


Figure 37 Percentage cover of long filamentous periphyton on the Patea River streambed in relation to the guideline for recreational values over the 2002-2012 period

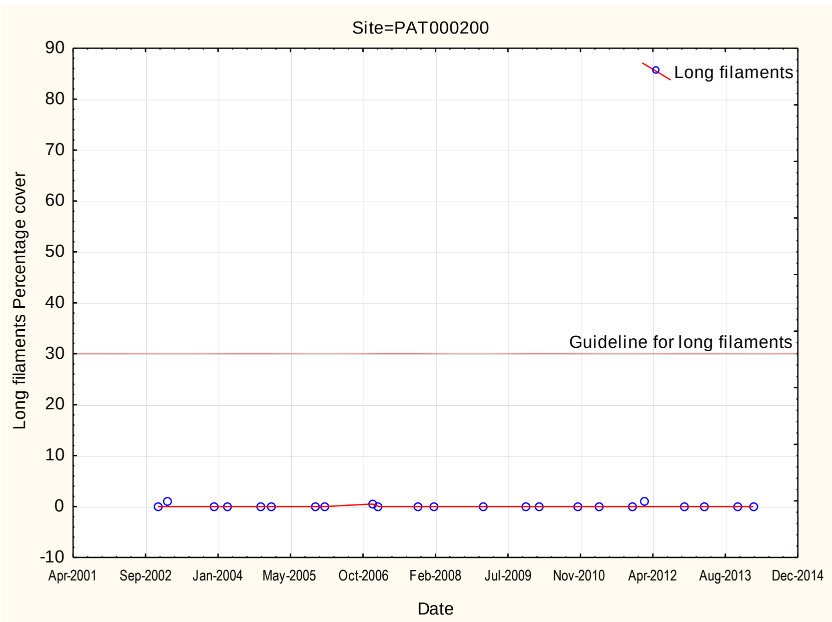
2.4.6 Long term trend analysis

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 12 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 38 to Figure 41).



n = 23
Kendal tau = -0.125
p-value = 0.404
FDR p-value = 0.822

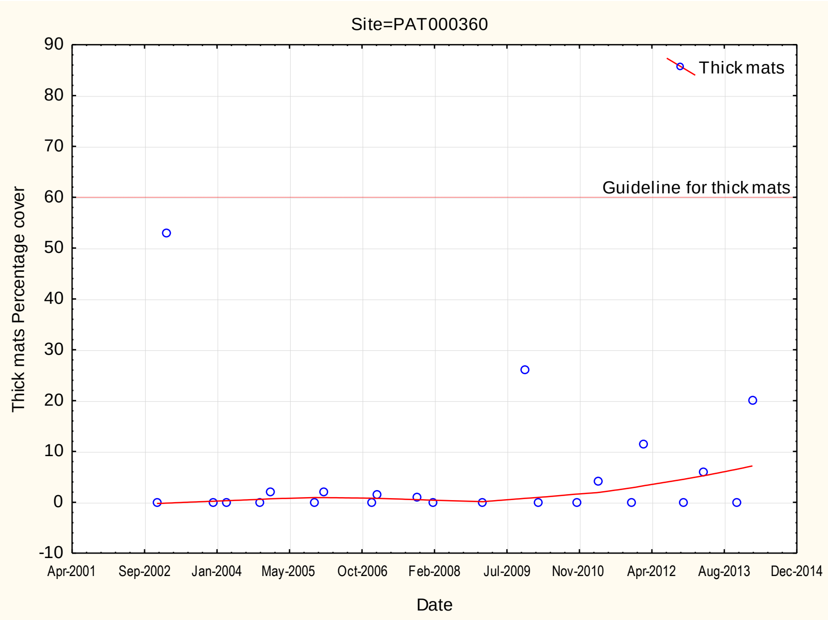
Figure 38 LOWESS trend analysis of percentage cover of thick mats at Patea River, Barclay Road (PAT000200)



n = 23
Kendal tau = -0.096
p-value = 0.522
FDR p-value = 0.580

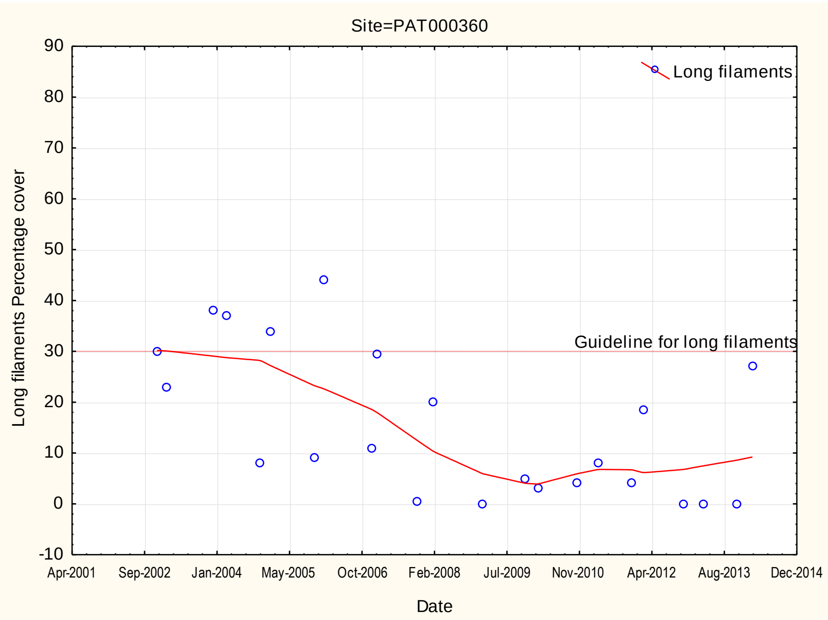
Figure 39 LOWESS trend analysis of percentage cover of long filaments at Patea River, Barclay Road (PAT000200)

At Barclay Road (PAT000200) over the 12 year monitored period there were no significant trends for thick mats (p=0.822) or long filaments (p=0.580) at the 5% level of significance.



n = 23
Kendal tau = 0.133
p-value = 0.373
FDR p-value = 0.822

Figure 40 LOWESS trend analysis of percentage cover of thick mats at Patea River, Skinner Road (PAT000360)



n = 23
Kendal tau = -0.454
p-value = 0.002
FDR p-value = 0.017

Figure 41 LOWESS trend analysis of percentage cover of long filaments at Patea River, Skinner Road (PAT000360)

At Skinner Road (PAT000360) over the 12 year monitored period there was no significant trend for thick mats (p=0.822). However, there was a significant (p=0.017) negative (tau=-454) trend for long filaments at the 5% level of significance indicating that long filamentous algae had decreased at the site during the monitored period, possibly as a result of improvements to the Stratford oxidation pond discharges.

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. 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.

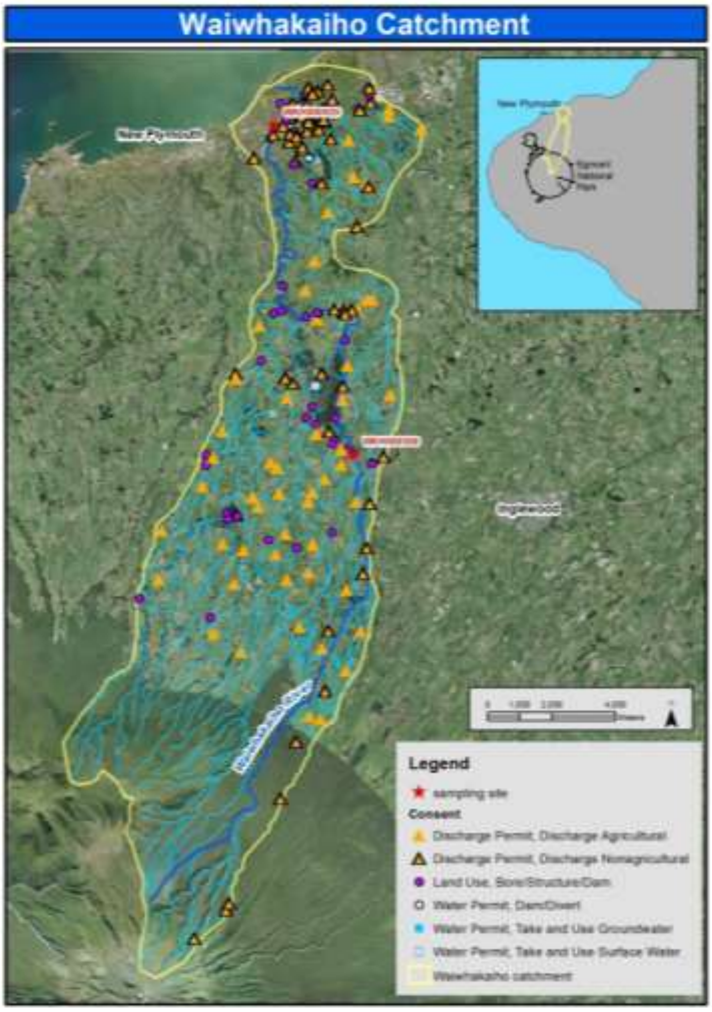


Figure 42 Monitoring site locations in relation to consents operating in the Waiwhakaiho River catchment

2.5.1 Flow data and survey dates

The spring 2012 survey was conducted on 14 November 2012 13 days after a fresh in excess of 3x and 7x median flow. The summer 2013 survey was carried out on 19 February 2013 17 days after a fresh in excess of 3x median flow and 57 days in excess of 7x median flow. No significant freshes occurred after the 3x median fresh (Appendix).

The spring 2013 survey was conducted on 12 November 2013 11 days after a fresh in excess of both 3x and 7x median flow. The summer 2014 survey was carried out on 7 April 2014 72 days after a fresh in excess of 3x median flow and 92 days after a 7x median flow. A minor fresh occurred shortly after the 3x median fresh but the site was experiencing a low flow period at the time of sampling (Appendix).

2.5.2 Periphyton cover

In the 2012-2013 monitoring year only very minor levels of nuisance periphyton occurred at the Waiwhakaiho River sites at SH3 and Constance Street. The 2013-2014 monitoring year saw a large increase of nuisance algae at both sites but levels were still below guidelines standards.

No nuisance periphyton was recorded for spring 2012 at the SH3 site and only very low levels of thick algal mats were recorded at the lower Waiwhakaiho River site at Constance Street. Filamentous algae were recorded at both sites in summer 2013 but these were at levels well below recommended guideline values (Figure 43 and Figure 45).

In the lower catchment at Constance Street, low levels of 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 2013-2014 monitoring year the middle catchment site at SH3 saw moderate levels of nuisance periphyton. Individually, thick algal mats and long filaments did not exceed the recommended guidelines and currently there is no guideline limit for a combination of the two periphyton types. However, there was no logical reason to consider each in isolation and they would have cumulative impacts on aesthetic and recreational values. Therefore, the nuisance periphyton was likely to have reached a level to significantly impact recreational values for spring 2013 survey. The Constance Street site had low levels of nuisance periphyton. The presence of filamentous algae, seen in greater amounts at the upper, mid-catchment site (at SH3, near Egmont Village) was not unexpected as the substrate between the two survey sites differs significantly. At SH3 the substrate was dominated by large boulders which provide a very stable substrate which was less susceptible to scouring during flood events. At Constance Street the substrate had 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.

For the summer 2014 survey, a reversal of the results found in the previous survey occurred. The SH3 site had low levels of nuisance periphyton while the Constance

Street site had moderate levels of periphyton. Again, thick algal mats and long filaments (27%) did not exceed individual guidelines but if combined were likely to be at an undesirable level. Long filaments were only just below recommended guidelines of 30%. This result further reinforces the previous observation that both sites behave differently. The summer 2014 survey was undertaken after a long period without flushing flows and therefore substrate type would not be as an important factor affecting periphyton levels.

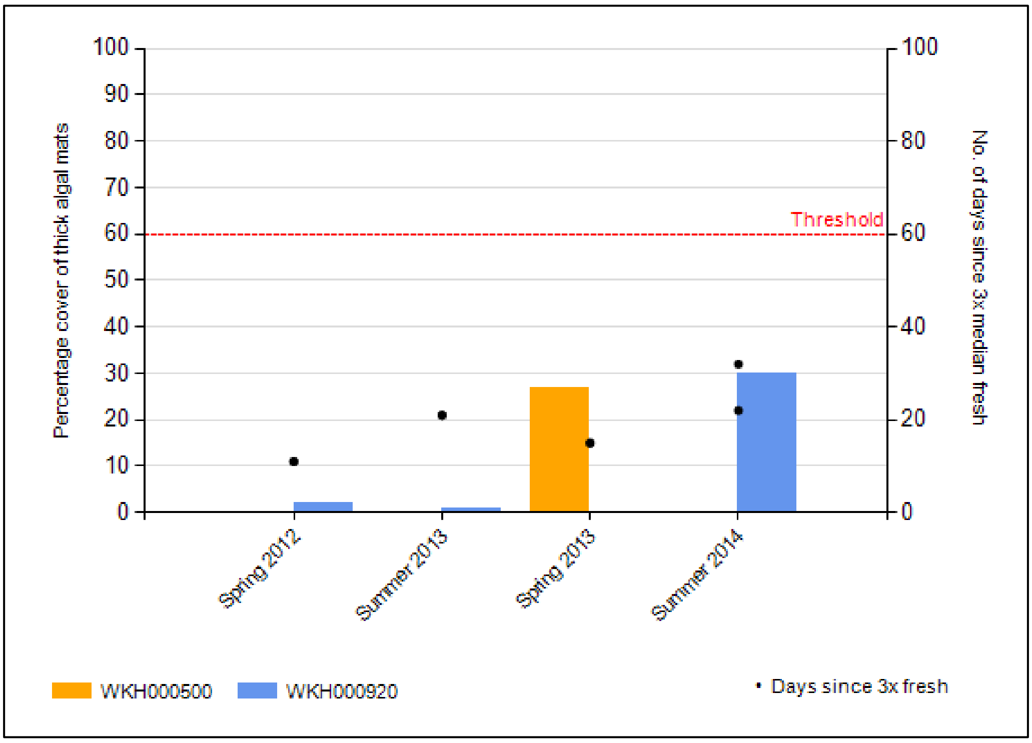


Figure 43 Percentage cover of thick mats of periphyton on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

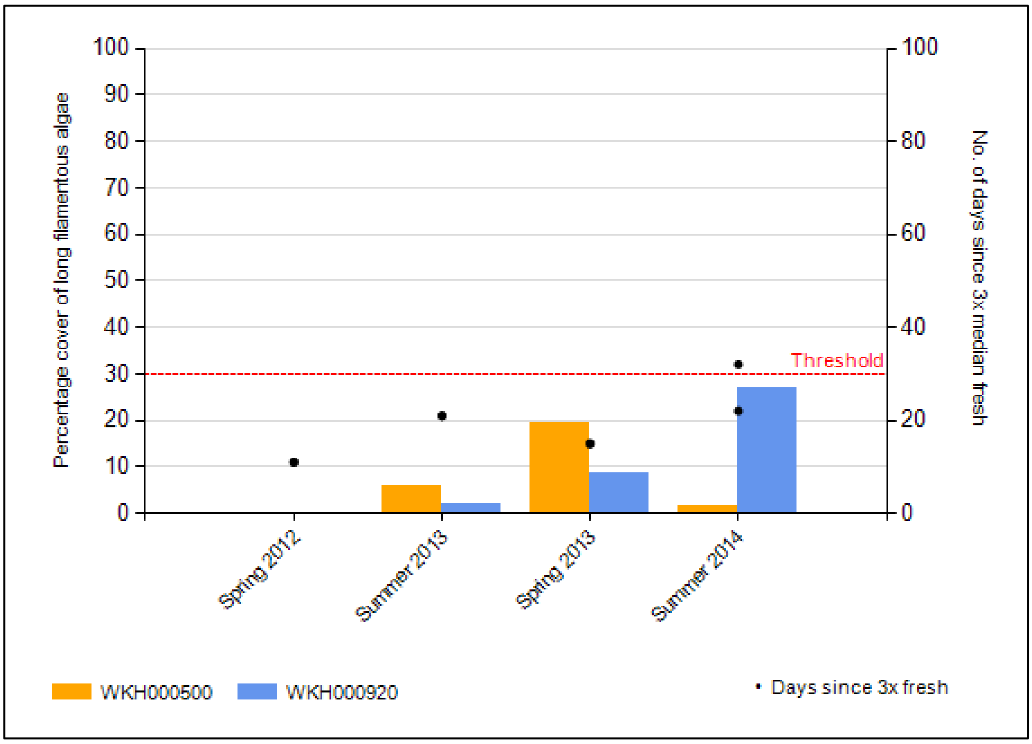


Figure 44 Percentage cover of long filamentous algae on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

2.5.3 Periphyton Index Score

The Waiwhakaiho River, unlike other monitored rivers in Taranaki, normally shows an improvement in TRC PI score at the downstream site compared with the upstream site but this only occurred once for the spring 2013 survey for the two years examined in this report. The 2012-2013 year surveys were mostly ‘very good’ with one ‘good’ survey which was close to the boundary of being ‘very good’ for the summer 2013 survey at the downstream site (Table 13).

For the 2013-2014 year there was a deterioration in the condition of the periphyton communities that followed a similar pattern to the previous year. All surveys were ‘good’ except for the summer 2014 survey at the downstream site which was ‘moderate’.

Both the upstream and downstream sites showed improvements in TRC PI scores from historical medians for the 2012-2013 year. However, the 2013-2014 year had scores lower than historical medians except for the summer 2014 survey at the SH3 site.

The lower 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 was less dominated by agriculture. This nutrient input upstream facilitates periphyton growth. If nutrients were 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 were less affected by rainfall. The lower site was in a more urban area which had bird colonies at various points along its length which would supply nutrients. Riparian planting was negligible at both sites and therefore there was little growth limitation by seasonal changes in light.

The upstream had a greater dominance of large substrate, which was not turned over in large floods. Downstream the bed is more mobile, facilitating the scouring of periphyton during floods. The interaction between nutrients, season and flow was likely to contribute to a higher periphyton biomass remaining at the upstream site during spring and the downstream site during summer.

Table 13 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
WKH000500	9.0	8.4	6.1	7.4	6.7	6.2
WKH000920	9.0	7.8	6.6	4.6	8.0	6.7
Difference	0.0	0.6	-0.5	2.8	-2.3	-0.5

2.5.4 Periphyton biomass

The results for the period 2010- 2014 showed both sites in the Waiwhakaiho River had mostly low or moderately low levels of chlorophyll *a* (Figure 48). Unlike other monitored rivers where upstream sites usually had a markedly lower periphyton biomass than downstream sites there was less differentiation between the two sites in the Waiwhakaiho River. The upstream site for the 2013 and 2014 surveys had higher periphyton biomass and TRC PI results have also found the downstream site to be in better condition than the upstream site (TRC, 2014).

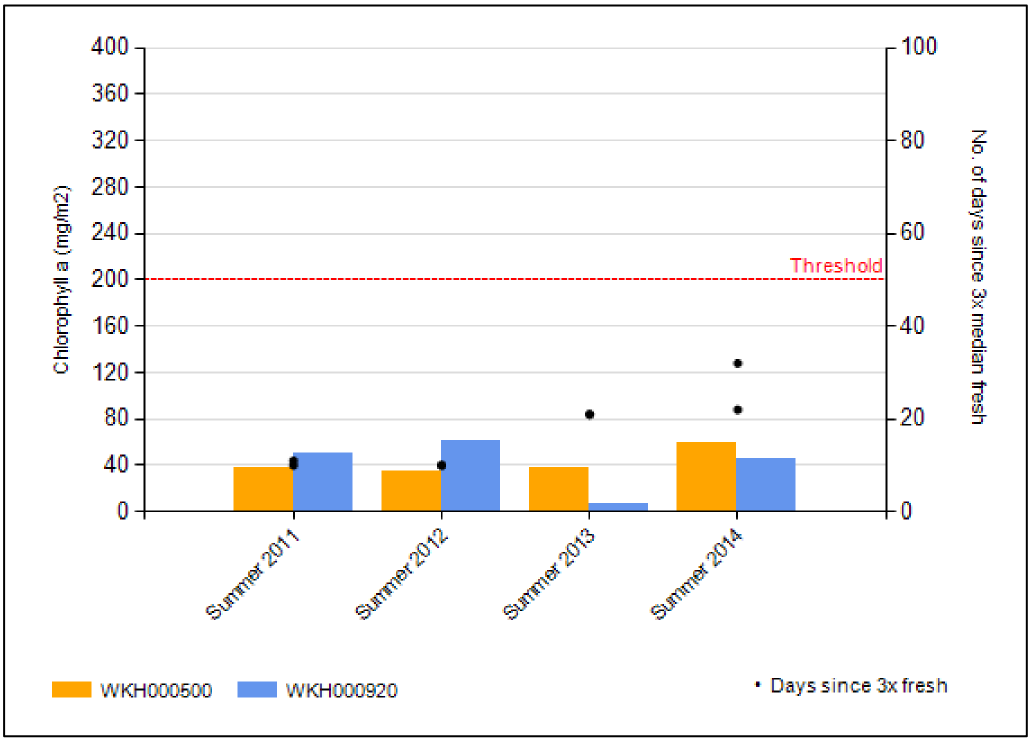


Figure 45 Periphyton biomass (chlorophyll *a*) on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2010-2014 period.

2.5.5 Summary of 2002-2014 (12 year data set)

Both sites never came close to having a breach in the guideline for thick algal mats. The upper site was more prone to long filamentous nuisance periphyton communities which breached guidelines on eight occasions throughout the monitoring period. In comparison, the lower site only breached guidelines on two occasions. The current period (2012-2014) recorded no breaches in long filamentous algae at either site (Figure 46 and Figure 47).

Overall, long filamentous algae were prone to proliferate more at the upstream site but not to the same extent or frequency as earlier 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 though the bottom site nearly breached guideline limits for the summer 2014 survey which corresponded with a long period without flushing flows.

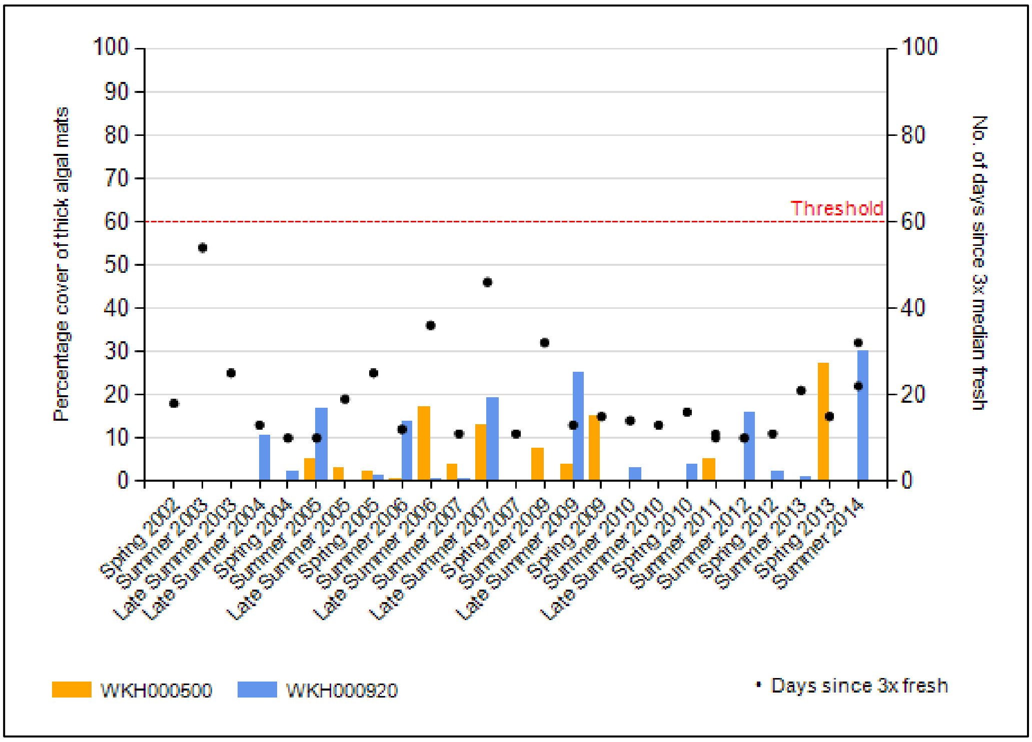


Figure 46 Percentage cover of thick mats of periphyton on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2002-2012 period

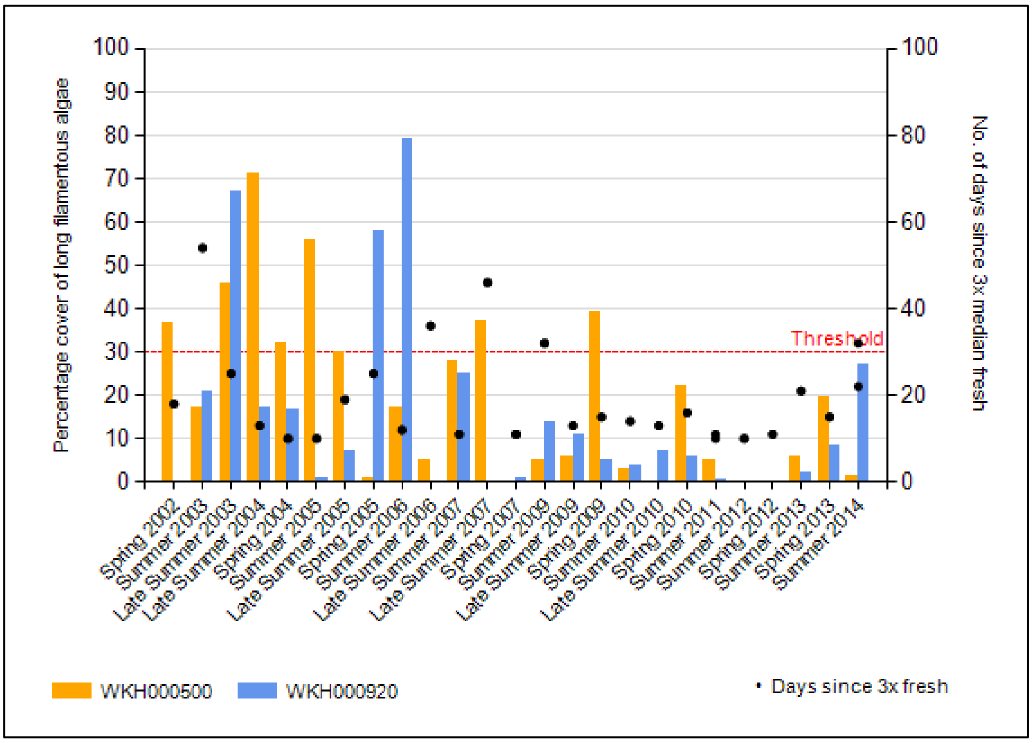
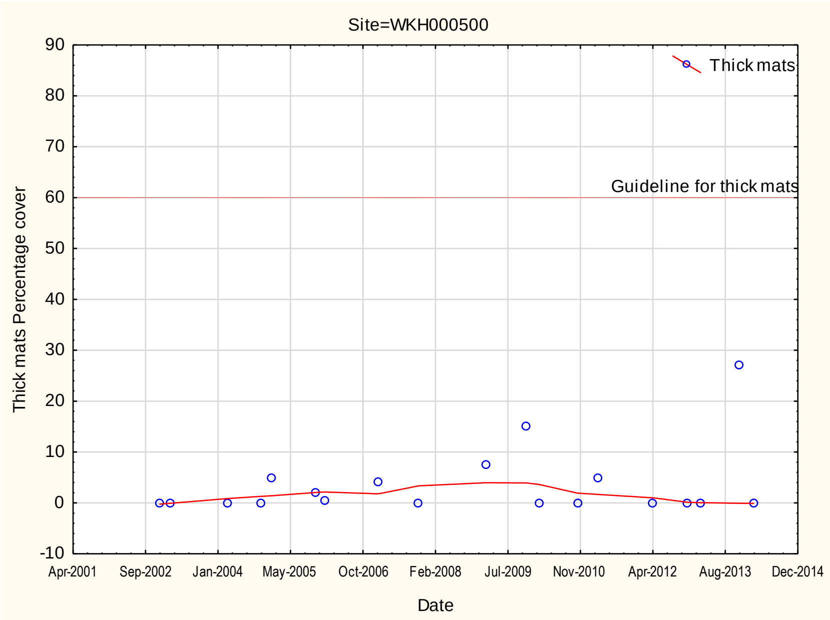


Figure 47 Percentage cover of long filamentous algae on the Waiwhakaiho riverbed in relation to the guidelines for recreational values over the 2002-2012 period

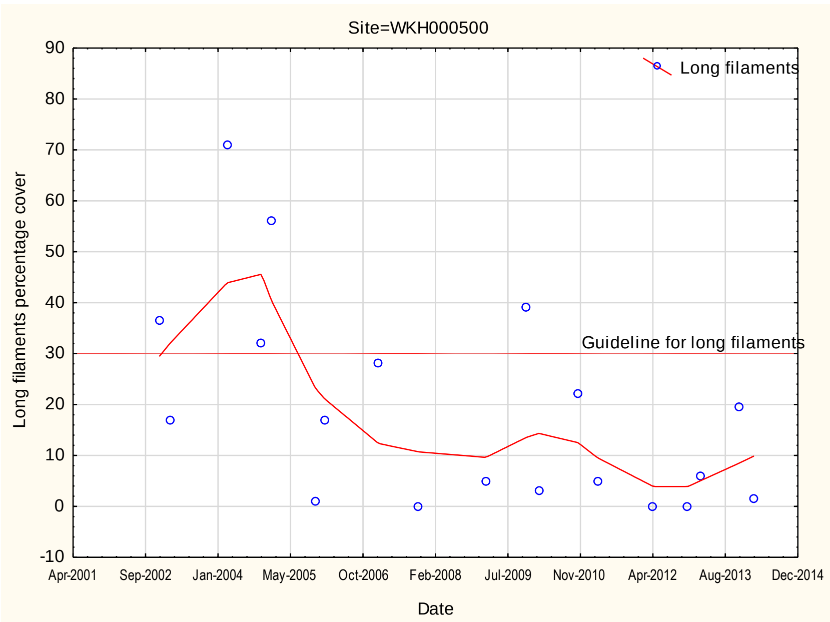
2.5.6 Long term trend analysis

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 12 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 48 to Figure 51).



n = 19
Kendal tau =0.093
p-value = 0.579
FDR p-value = 0.822

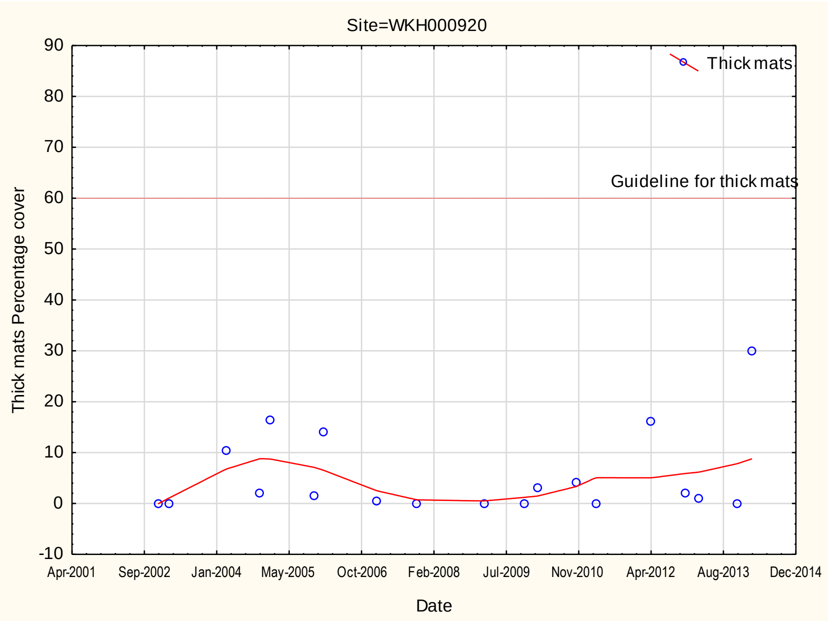
Figure 48 LOWESS trend analysis of percentage cover of thick mats at Waiwhakaiho River, SH3, Egmont Village (WKH000500)



n = 19
Kendal tau = -0.368
p-value = 0.028
FDR p-value = 0.076

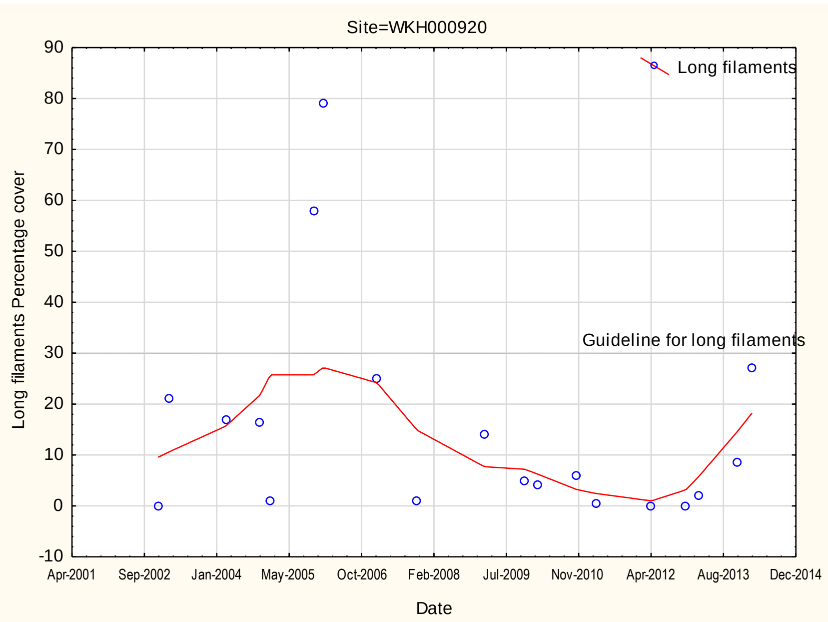
Figure 49 LOWESS trend analysis of percentage cover of long filaments at Waiwhakaiho River, SH3, Egmont Village (WKH000500)

At SH3 (Egmont Village) over the 12 year monitored period there were no significant trend for thick mats (p=0.822) or long filaments (p=0.076) at the 5% level of significance. However, the result for long filaments was close to being significant suggesting that long filaments may be decreasing (tau = -0.368).



n = 19
Kendal tau = 0.069
p-value = 0.680
FDR p-value = 0.840

Figure 50 LOWESS trend analysis of percentage cover of thick mats at Waiwhakaiho River, Constance Street, New Plymouth (WKH000920)



n = 19
Kendal tau = -0.183
p-value = 0.272
FDR p-value = 0.419

Figure 51 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 12 year monitored period there were no significant trends for thick mats (p=0.840) or long filaments (p=0.419) at the 5% level of significance.

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 was 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 52). 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.

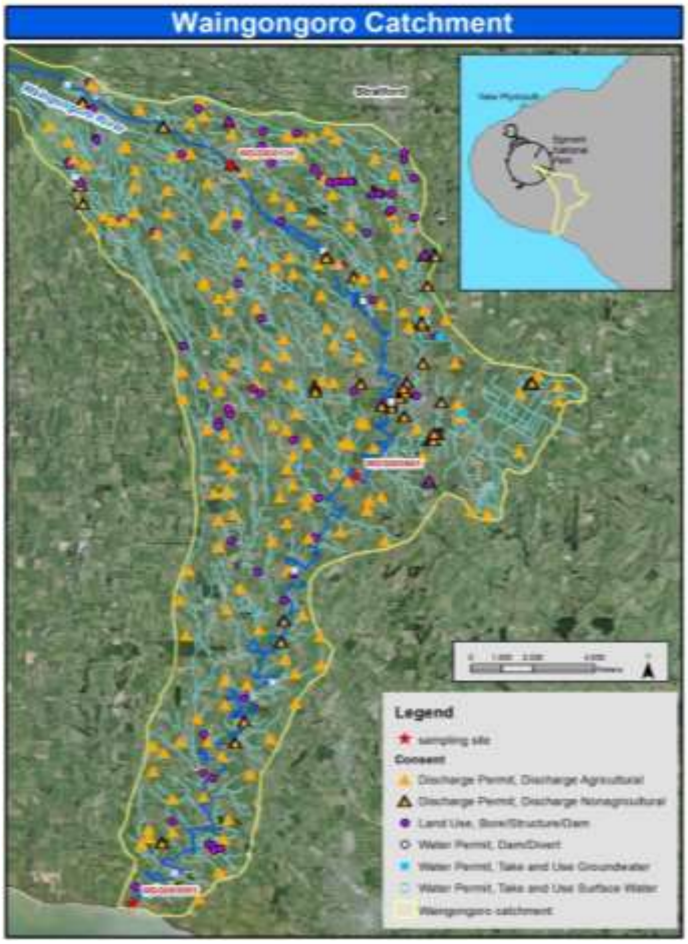


Figure 52 Monitoring site locations in relation to consents operating in the Waingongoro River catchment

2.6.1 Flow data and survey dates

The spring 2012 survey was conducted on 14 November 2012 13 days after a fresh in excess of 3x and 7x median flow and flows were close to median flow. The summer 2013 survey was carried out on 19 February 2013 14 days after a fresh in excess of 3x and 7x median flow. A fresh close to 3x median flow occurred shortly before sampling (Appendix).

The spring 2013 survey was conducted on 11 November 2013 10 days after a fresh in excess of both 3x and 7x median flow. The flow was still receding at the time of the survey from the large fresh and the flow was at approximately median flow at the time of the survey. The summer 2014 survey was carried out on 28 February 2014 38 days after a fresh in excess of 3x median flow and 54 days after a 7x median flow at the Opunake and Stuart Road sites and 53 days after a fresh in excess of both 3x and 7x median flow at the Ohawe Beach site. All three sites were experiencing a sustained low flow period at the time of sampling (Appendix).

2.6.2 Periphyton cover

In the 2012-2013 monitoring year, no thick algal mats or long filaments were recorded at the upper catchment site at Opunake Road or the middle catchment site at Stuart Road on both sampling occasions (Figure 53 and Figure 54). The lower site had very low levels of thick algal mats and moderate levels of filamentous algae which were well below guideline limits.

In the 2013-2014 monitoring year the upper site did not have any nuisance periphyton, the middle site at Stuart Road had very low levels of thick algal mats and the lower site at Ohawe Beach had moderate levels of both thick algal mats and filamentous algae.

The Ohawe Beach survey site situated at the river mouth typically had the most nuisance periphyton of all three sites. Like previous years, algal mats (mostly comprised of diatoms) dominated the substrate. If thick algal mats and filamentous algae were examined together then levels of nuisance periphyton would likely be at an undesirable level for the summer 2014 survey. One contributing factor for the periphyton levels recorded at Ohawe Beach during summer 2014 was the long period without significant freshes to scour the streambed. Also, as Ohawe Beach is the furthest site downstream in an agricultural catchment the cumulative effects of diffuse pollution from farms would likely provide sufficient nutrients for excessive periphyton growth.

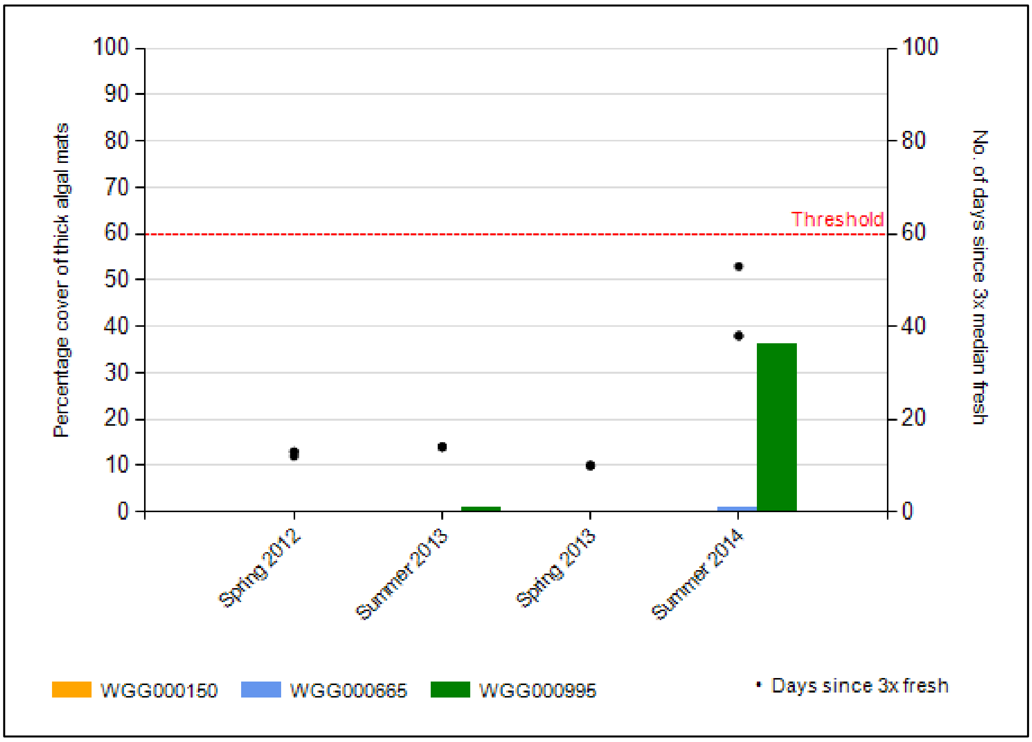


Figure 53 Percentage cover of thick mats of periphyton on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

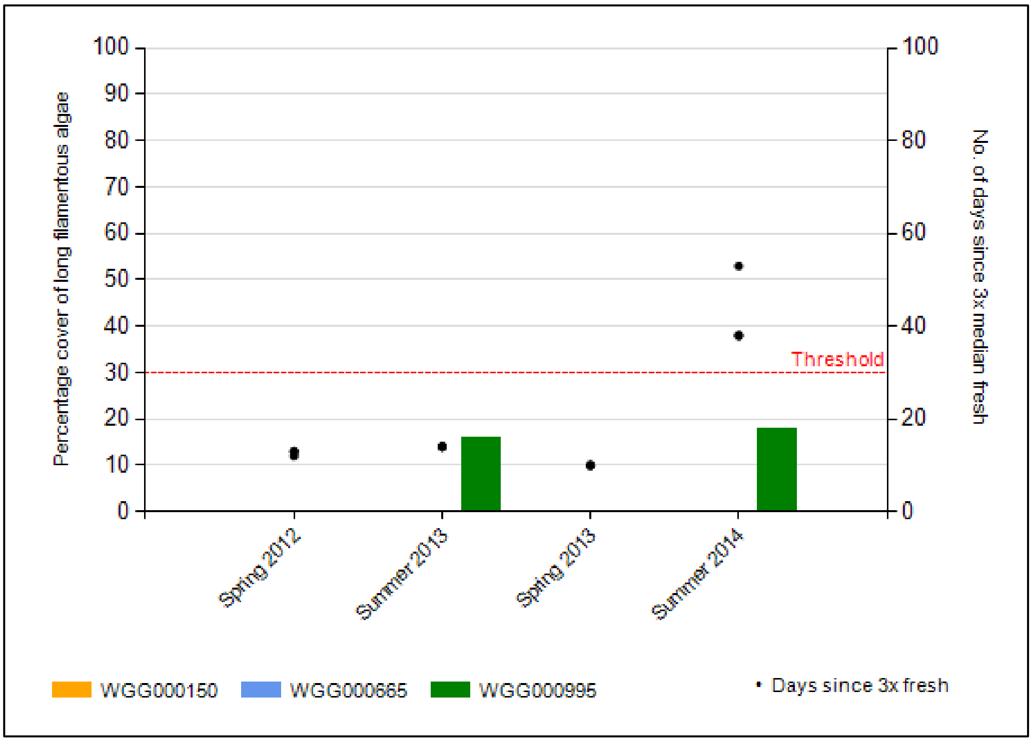


Figure 54 Percentage cover of long filamentous algae on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

2.6.3 Periphyton Index Score

On all but two occasions 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 14). At the mid catchment site at Stuart Road TRC PI scores were generally slightly lower but still within the 'very good' range.. The lower catchment site at Ohawe Beach showed significant variations in TRC PI score between spring and summer going from 'very good' to 'moderate' for both monitoring years. From spring 2012 to summer 2013 there was a drop of 3.0 units in TRC PI score. A similar result of 3.5 units was recorded between the spring 2013 and summer 2014 surveys. This result was similar to what was seen for 2010-2012 period but the result was less pronounced (TRC, 2014).

As expected, median scores show a decrease in TRC PI scores in a downstream direction for the period under review (Table 14). A drop of 2.1 units over approximately 60 kilometres was recorded, a rate of 0.034 units per kilometre.

Table 14 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
WGG000150	10.0	10.0	9.6	9.7	8.8	9.1
WGG000665	9.7	9.3	10.0	9.4	8.4	7.4
WGG000995	9.8	6.8	9.0	5.5	9.2	7.2
Difference	0.2	3.2	0.6	4.2	-0.4	1.9

2.6.4 Periphyton biomass

The results for the period 2010- 2014 indicate that the upstream site had very low levels of periphyton biomass, the mid catchment site had low to moderately low levels and the downstream site at Ohawe Beach had moderately high to high levels (Figure 55). The summer 2012 and 2013 breached the guideline thresholds for trout habitat/angling values (Table 2) and NOF standards (Snelder, et al. 2013). This deviated substantially from the TRC PI for the four relevant summer surveys 2011-2014 (8.0, 8.0, 6.8, and 5.5) in that the summer of 2012 had a TRC PI of 'very good' and the summer 2013 survey had a TRC PI of 'good'. This suggests that there was too much variability between periphyton cover and biomass as estimated by chlorophyll *a* to use periphyton cover as a surrogate for chlorophyll *a*.

The pattern exhibited suggested that nutrients were driving periphyton biomass in the Waingongoro River as the river runs through predominately agricultural land and nutrient levels would increase towards the lower reaches of the river due to the cumulative affects of point source and diffuse pollution.

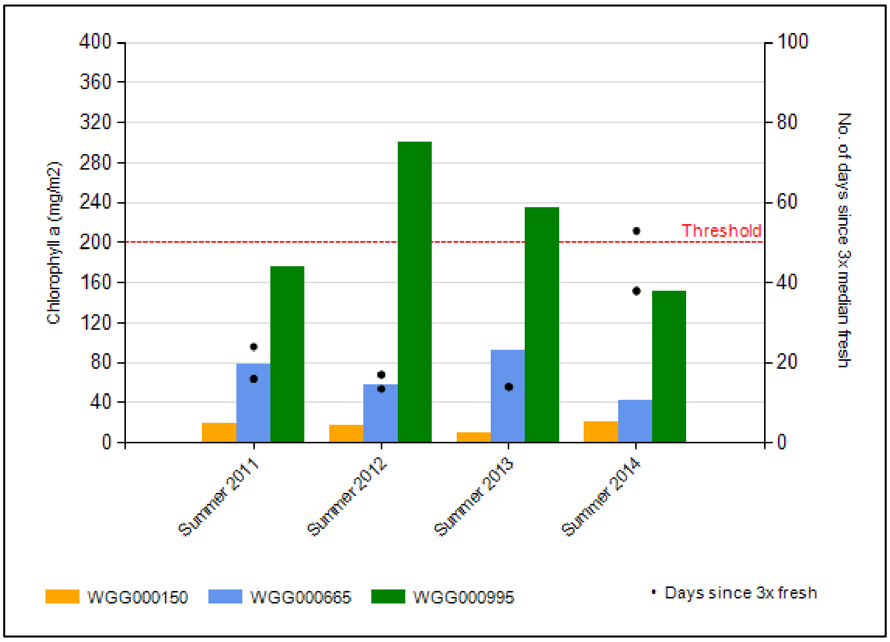


Figure 55 Periphyton biomass (chlorophyll *a*) on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.6.5 Summary of 2002-2014 (12 year data set)

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 56 and figure 57). Proliferation of thick mats and long filaments appeared to have decreased since 2008, particular at the two downstream sites which previously had high levels. The most downstream site at Ohawe Beach had higher than normal abundances of filamentous mats for the two most recent summer surveys and thick algal mats for the summer 2014 survey was also at its highest level since 2008.

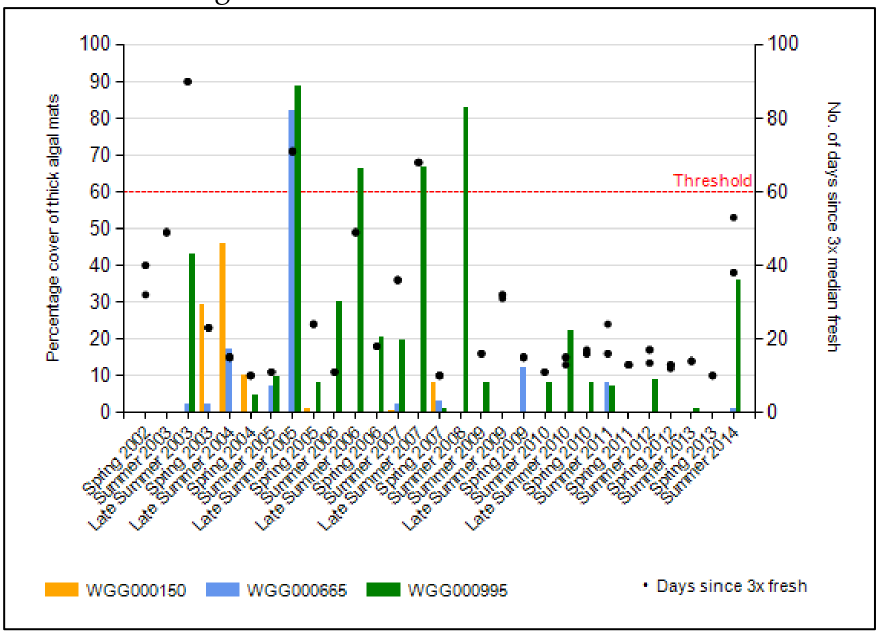


Figure 56 Percentage cover of thick mats of periphyton on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2002-2012 period

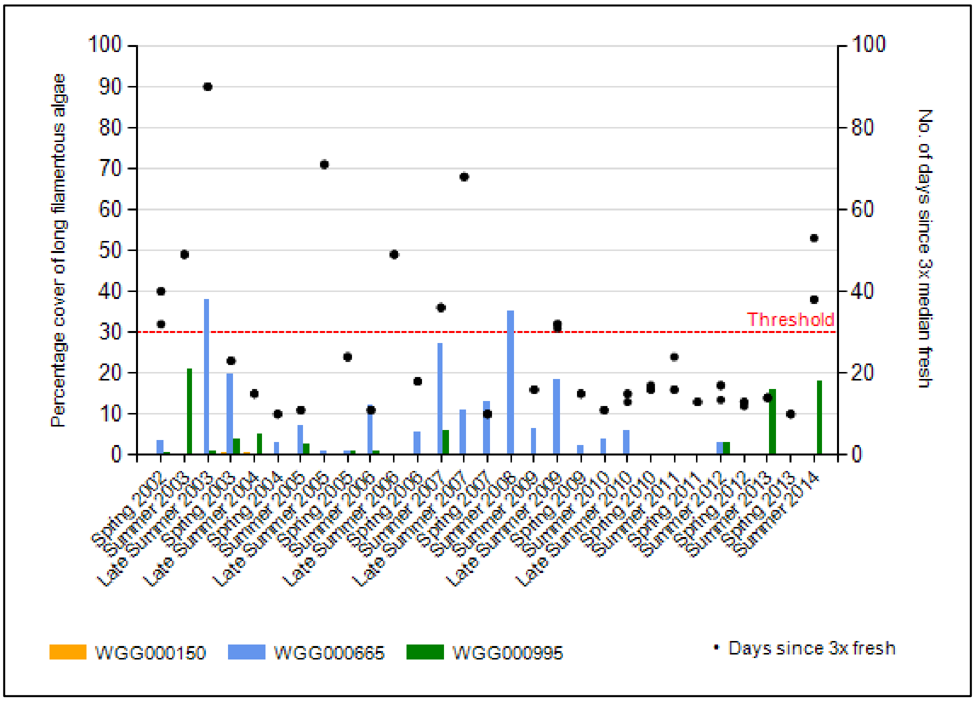
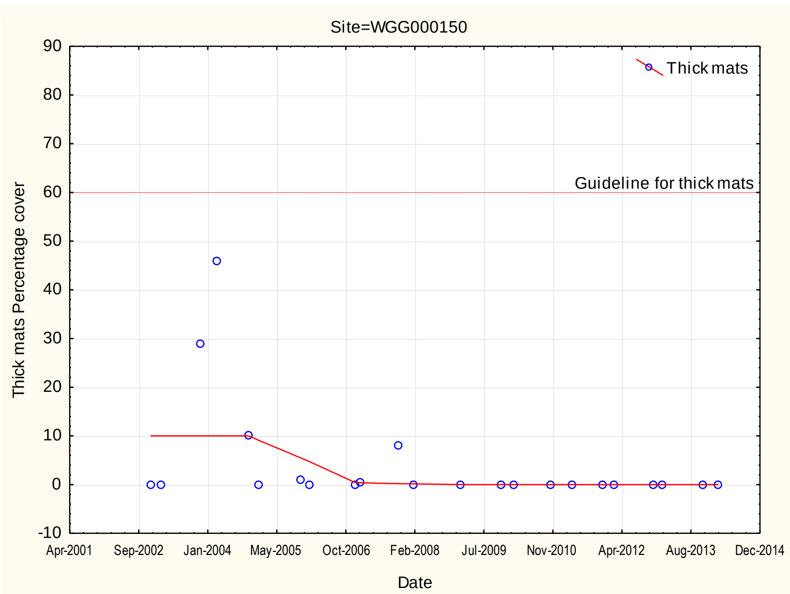


Figure 57 Percentage cover of long filamentous algae on the Waingongoro riverbed in relation to the guidelines for recreational values over the 2002-2012 period.

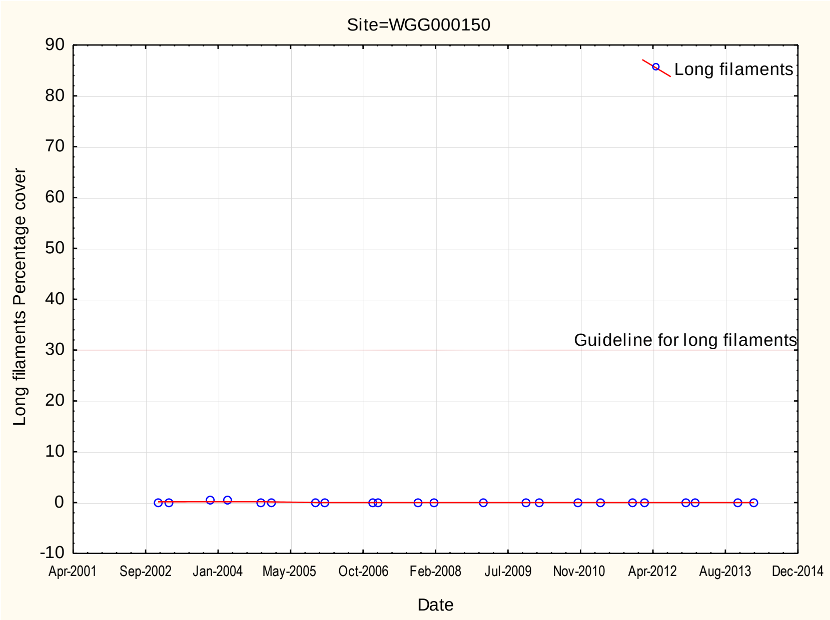
2.6.6 Long term trend analysis

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 12 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 58 to Figure 63).



n = 23
Kendal tau = -0.424
p-value = 0.005
FDR p-value = 0.048

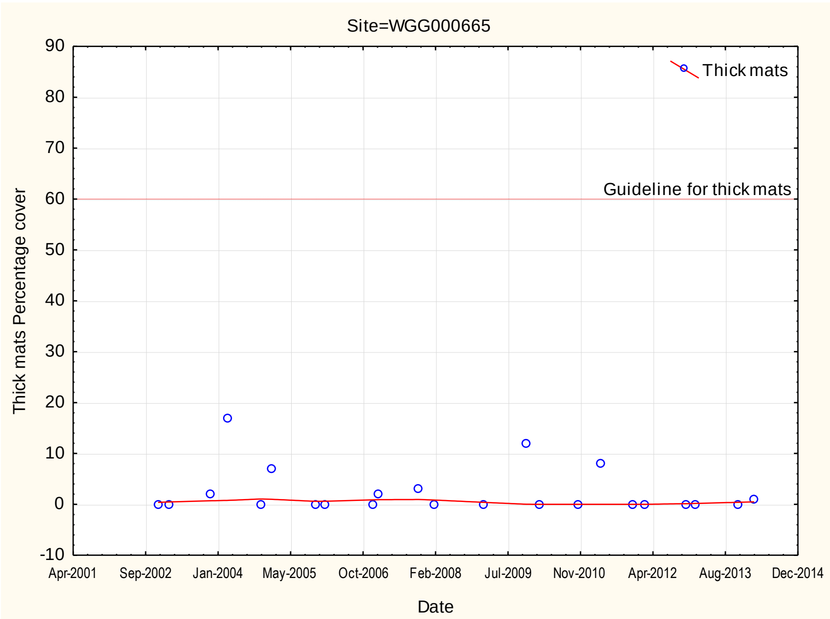
Figure 58 LOWESS trend analysis of percentage cover of thick mats at Waingongoro River, Opunake Road (WGG000150)



n = 23
Kendal tau = -0.330
p-value = 0.028
FDR p-value = 0.076

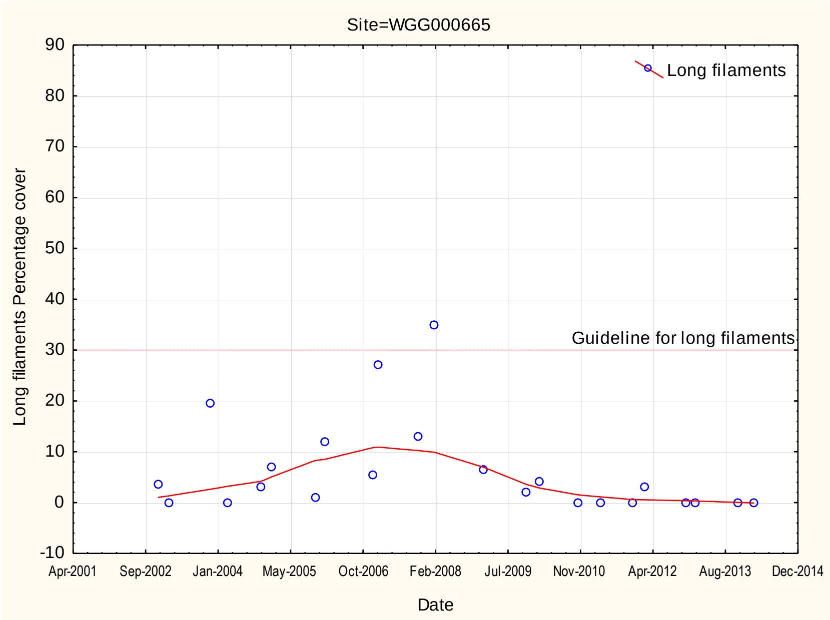
Figure 59 LOWESS trend analysis of percentage cover of long filaments at Waingongoro River, Opunake Road (WGG000150)

At Opunake Road (WGG000150) over the 12 year monitored period there was a significant (p=0.048) negative (tau=-0.424) trend for thick mats at the 5% level of significance indicating that thick periphyton mats had decreased over the monitored period. Long filaments were not significant (p=0.076) at the 5% level of significance. However, the result for long filaments was close to being significant suggesting that long filaments may be decreasing (tau = -0.330).



n = 23
Kendal tau = -0.099
p-value = 0.510
FDR p-value = 0.822

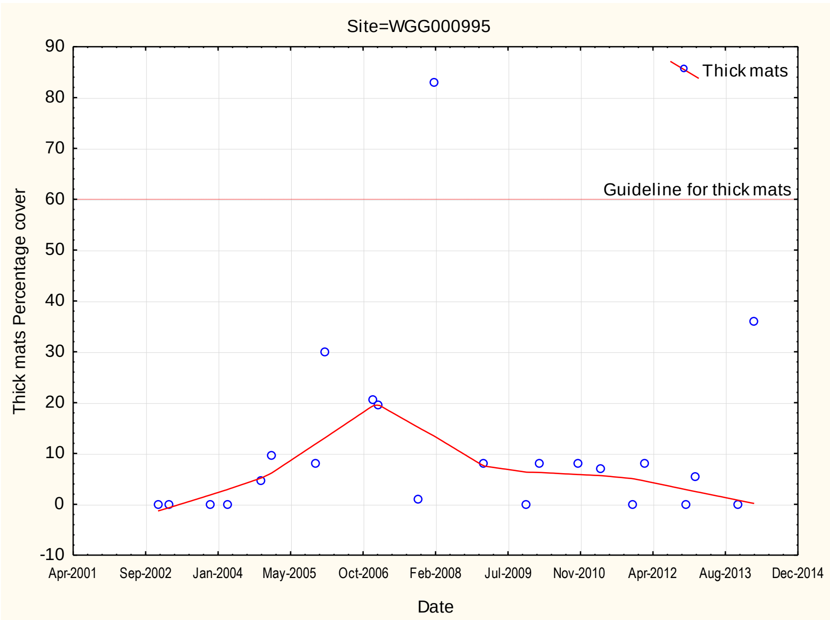
Figure 60 LOWESS trend analysis of percentage cover of thick mats at Waingongoro River, Stuart Road (WGG000665)



n = 23
Kendal tau = -0.317
p-value = 0.034
FDR p-value = 0.076

Figure 61 LOWESS trend analysis of percentage cover of long filaments at Waingongoro River, Stuart Road (WGG000665)

At Stuart Road (WGG000665) over the 12 year monitored period there were no significant trends for thick mats (p=0.822) or long filaments (p=0.076) at the 5% level of significance. However, the result for long filaments was close to being significant suggesting that long filaments may be decreasing (tau=-0.317).



n = 23
Kendal tau = 0.073
p-value = 0.626
FDR p-value = 0.822

Figure 62 LOWESS trend analysis of percentage cover of thick mats at Waingongoro River, Ohawe Beach (WGG000995)

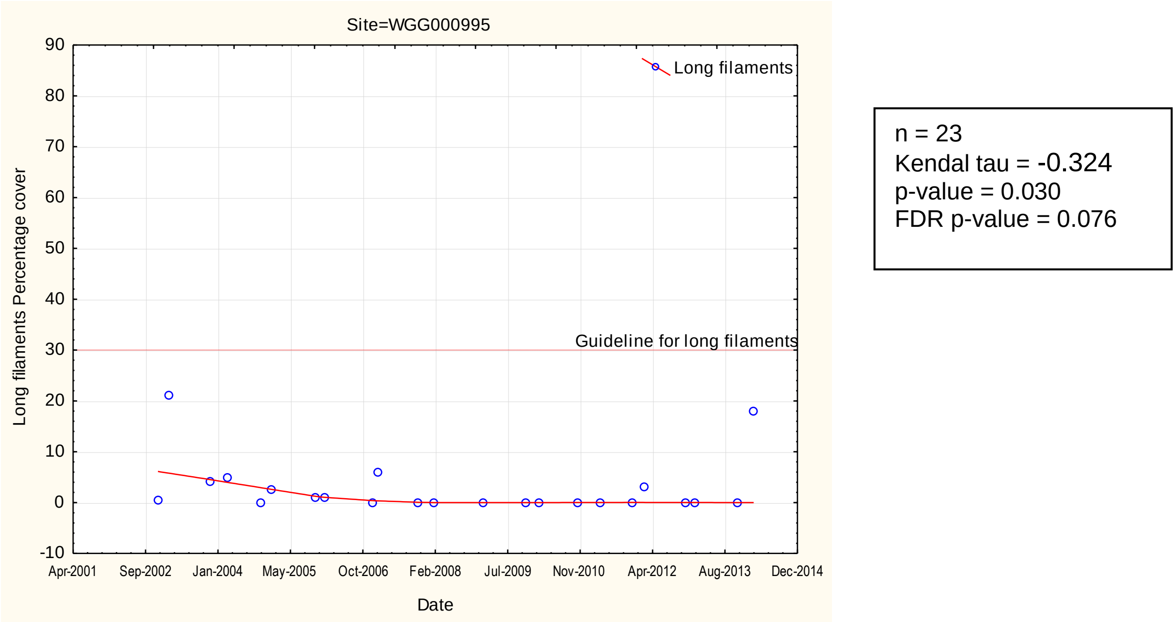


Figure 63 LOWESS trend analysis of percentage cover of long filaments at Waingongoro River, Ohawe Beach (WGG000995)

At Ohawe Beach (WGG000995) over the 12 year monitored period there were no significant trends for thick mats (p=0.822) or long filaments (p=0.076) at the 5% level of significance. However, the result for long filaments was close to being significant suggesting that long filaments may be decreasing (tau=-0.324).

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 64). 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.

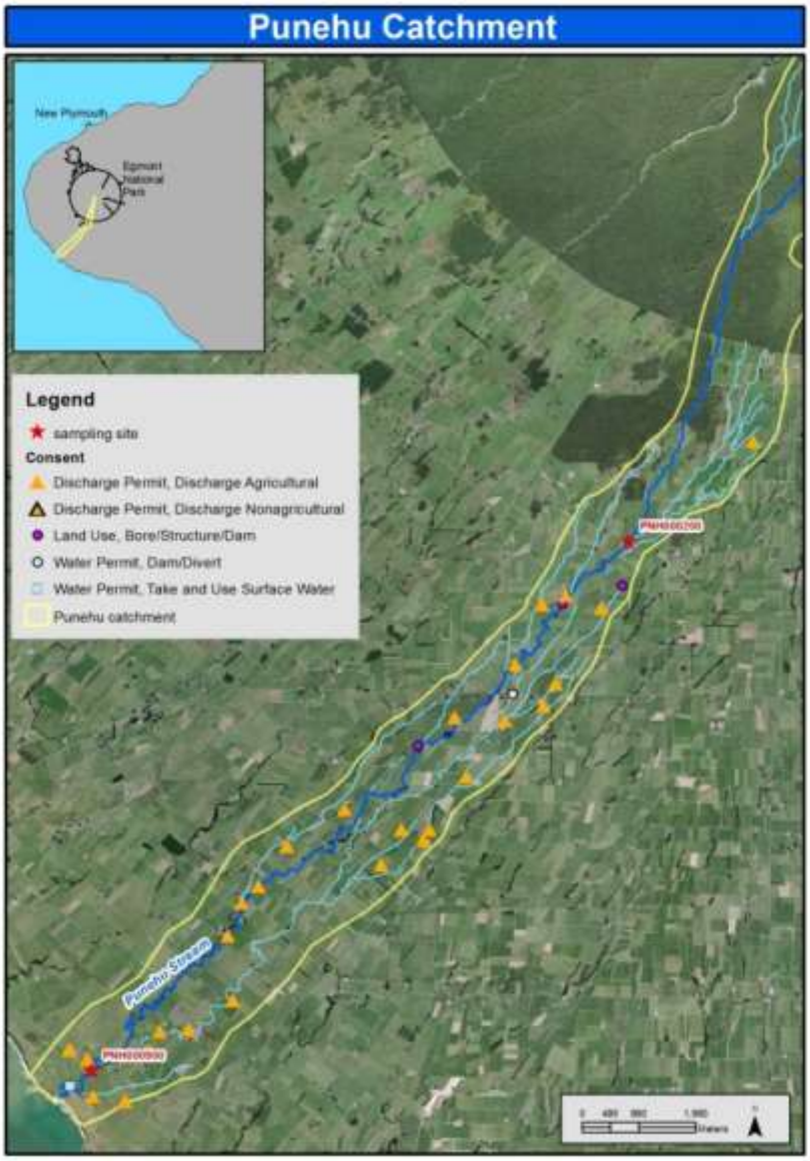


Figure 64 Monitoring site locations in relation to consents operating in the Punehu Stream

2.7.1 Flow data and survey dates

The spring 2012 survey was conducted on 26 November 2012 13 days after a fresh in excess of 3x median flow and 39 days after a fresh in excess of 7x median flow. The summer 2013 survey was carried out on 19 February 2013 14 days after a fresh in excess of 3x and 7x median flows (Appendix).

The spring 2013 survey was conducted on 21 November 2013 13 days after a fresh in excess of 3x median flow and 20 days after a fresh in excess of 7x median flow. The summer 2014 survey was carried out on 3 March 2014 35 days after a fresh in excess of 3x median flow 36 days after a fresh in excess of 7x median flow (Appendix).

2.7.2 Periphyton cover

For the 2012-2013 monitoring period only very low levels of nuisance periphyton was recorded for both the upstream site at Wiremu Road and the downstream site at SH45 (Figure 65 and Figure 66). Surveys occurred after relatively short periods of flushing flows which probably contributed to the low nuisance periphyton levels.

For the 2013-2014 monitoring period the Wiremu Road site recorded no nuisance periphyton for both sampling occasions. The downstream site at SH45 recorded moderate levels of nuisance periphyton which did not exceed guideline values. The spring 2013 survey was again undertaken not long after flushing flows but did not result in the very low levels of periphyton observed in the previous monitoring year. The summer 2014 survey was undertaken during low flows which would have contributed to the moderate levels of filamentous algae found. Typically for the Punehu River, nuisance periphyton levels are usually higher at the downstream site.

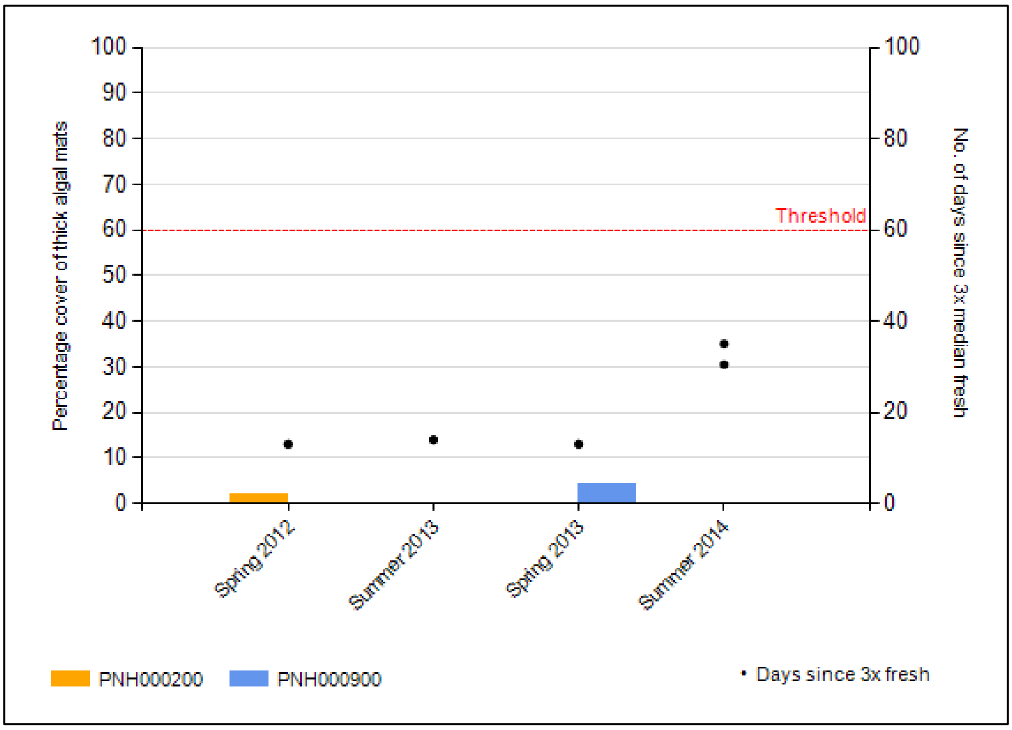


Figure 65 Percentage cover of thick mats of periphyton on the Punehu streambed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

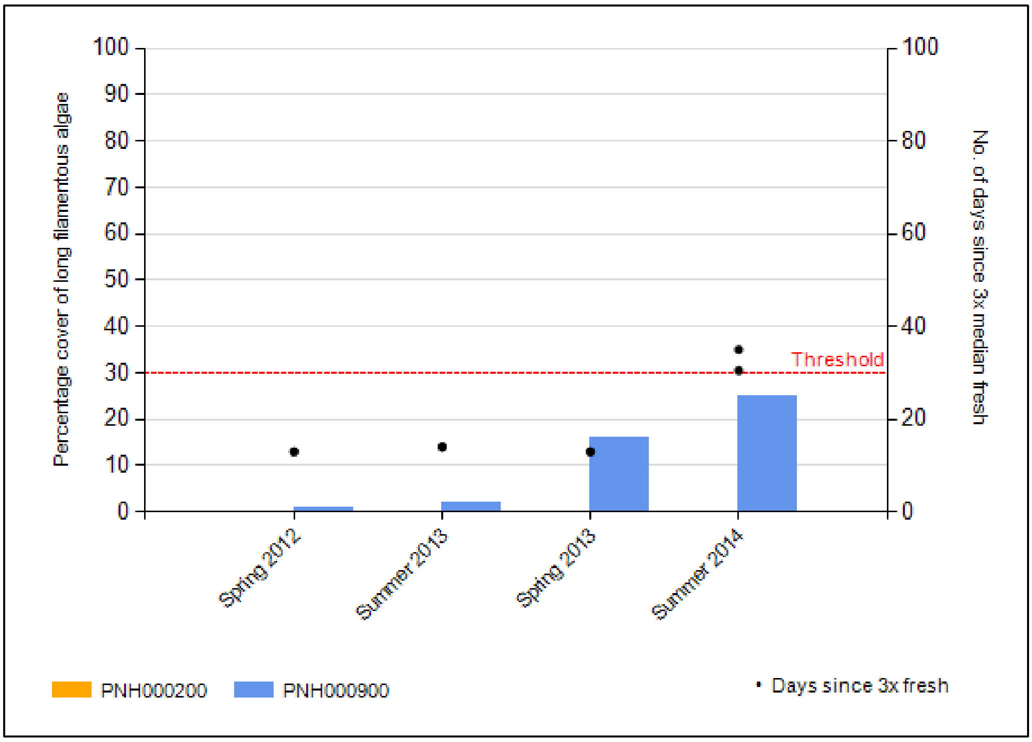


Figure 66 Percentage cover of long filamentous algae on the Punehu streambed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

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 15). This is a significant result, as the site had no riparian vegetation, and light conditions were consequently very good. During the reported period scores were equal to or above historical medians.

The downstream site (PNH000900) had some riparian shading, had a lower TRC PI score than at Wiremu Road site on all occasions though the differences for the 2012-2013 year were significantly less than the 2013-2014 year. Furthermore, the 2012-2013 year had scores higher than the historical median but the 2013-2014 year had scores slightly lower than the historical median.

For the current period an overall decrease of 1.45 unit was recorded in a downstream direction over 16.6 kilometres, a drop of 0.087 unit per kilometre which was greater than the previous period from 2010-2012 of 0.012 unit per kilometres (TRC, 2014).

Table 15 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
PNH000200	9.9	9.2	10.0	10.0	9.9	9.0
PNH000900	9.3	9.1	7.8	7.1	7.9	7.9
Difference	0.6	0.1	2.2	2.9	2.0	1.1

2.7.4 Periphyton biomass

The results for the 2010- 2014 survey period for the upstream site showed that it had extremely low chlorophyll *a* levels with the downstream site also having low chlorophyll *a* levels (Figure 67). These values were within guidelines to protect biodiversity, aesthetic and trout habitat/angling values (Table 2).

The chlorophyll *a* levels were largely congruent with the results using TRC PI that showed the Punehu Stream had good periphyton communities though between summer 2013 and summer 2014 for TRC PI there was a large increase in the difference between upstream and downstream sites. The chlorophyll *a* levels for the same period were similar and only showed a small deterioration between upstream and downstream sites.

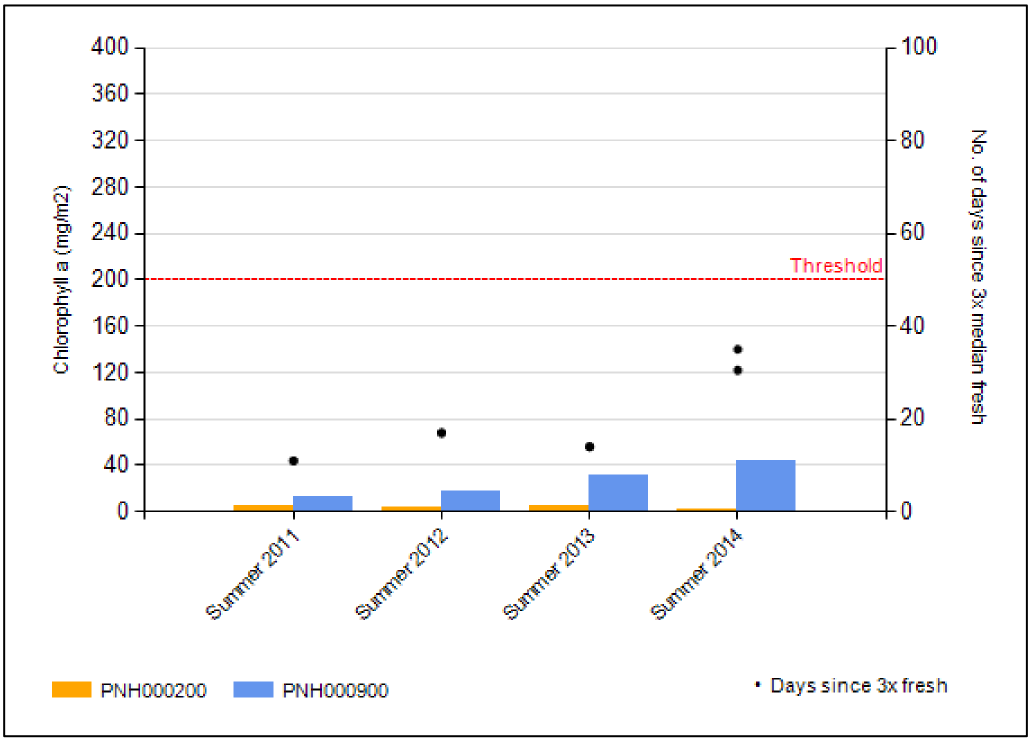


Figure 67 Periphyton biomass (chlorophyll *a*) on the Punehu riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.7.5 Summary of 2002-2014 (12 year data set)

No breaches in recreational guidelines for thick mats have been recorded at either site in the Punehu catchment over the past 12 year period (Figure 68). In the past there have been more frequent proliferations of thick mats at the downstream site although these have decreased in recent years (2006-2014).

The Punehu catchment has been subject to large proliferations of long filamentous algae over the 12 years of monitoring, especially at the downstream site (Figure 69). There have been a total of seven breaches of guidelines overall, none of which were recorded in the 2012-2014 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.

The summer 2014 survey had higher filamentous algae levels compared with the preceding three years which nearly exceeded the guideline level. The summer 2014 survey corresponded with a long period without flushes which may partially explain the elevated level but the proceeding spring 2013 survey was undertaken only a few days after the minimum 10 day limit after a 3x median base flow and therefore an increase in nutrients may have caused the increase.

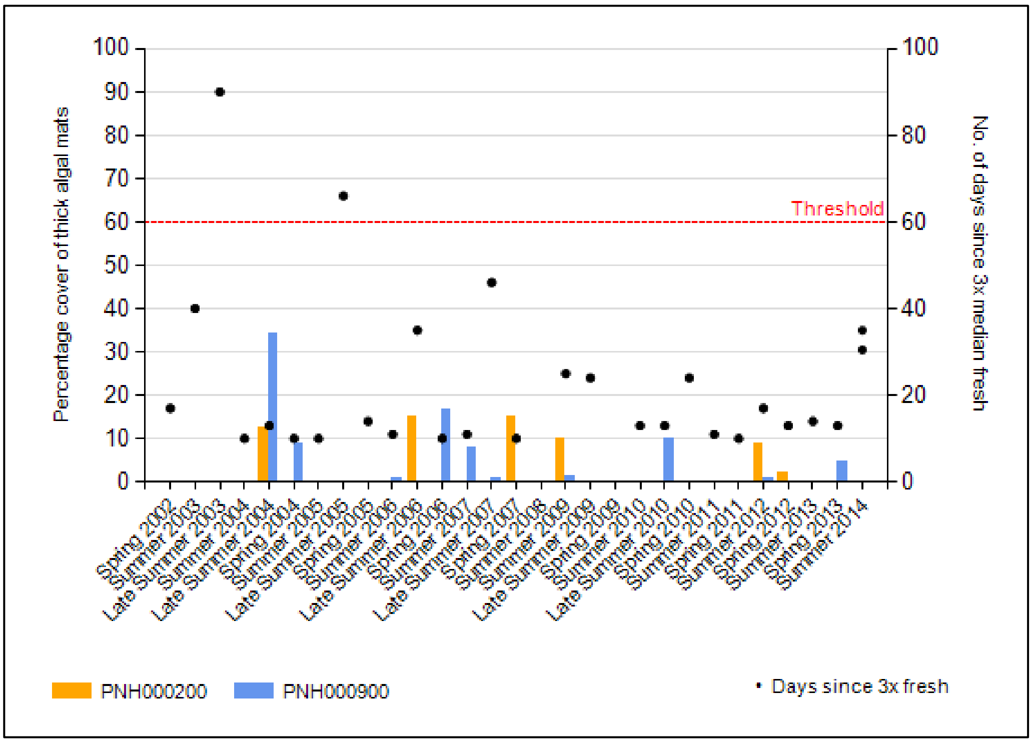


Figure 68 Percentage cover of thick mats of periphyton on the Punehu streambed in relation to the guidelines for recreational values over the 2002-2012 period

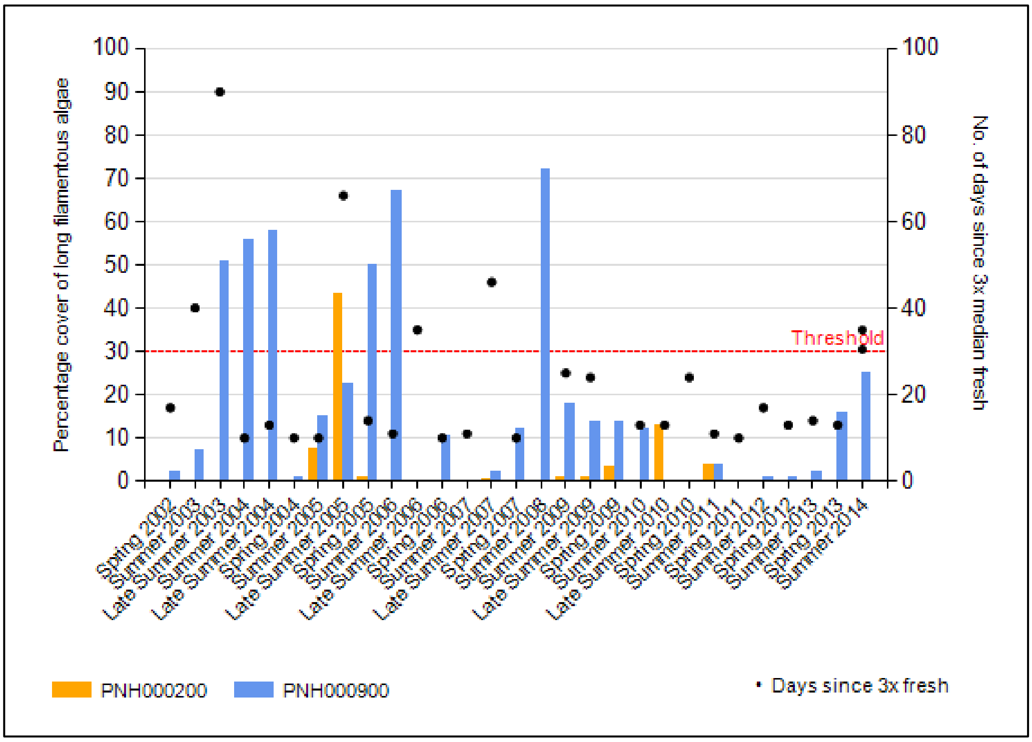
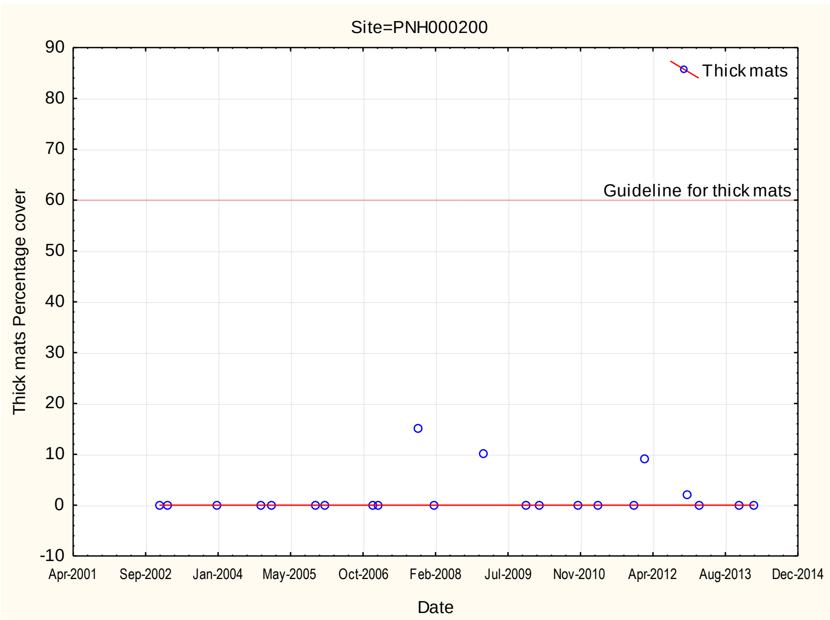


Figure 69 Percentage cover of long filamentous algae on the Punehu streambed in relation to the guidelines for recreational values over the 2002-2012 period

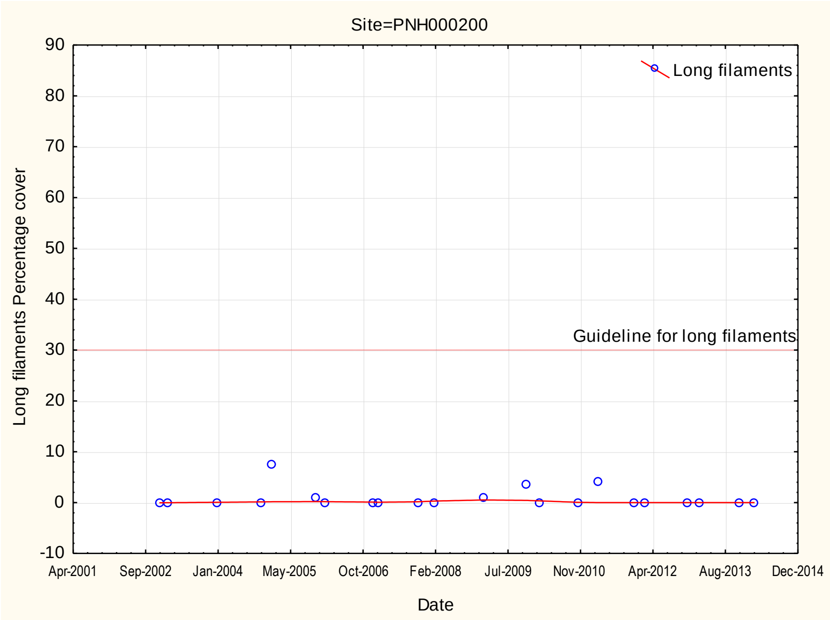
2.7.6 Long term trend analysis

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 12 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 70 to Figure 73).



n = 22
Kendal tau = 0.149
p-value = 0.332
FDR p-value = 0.822

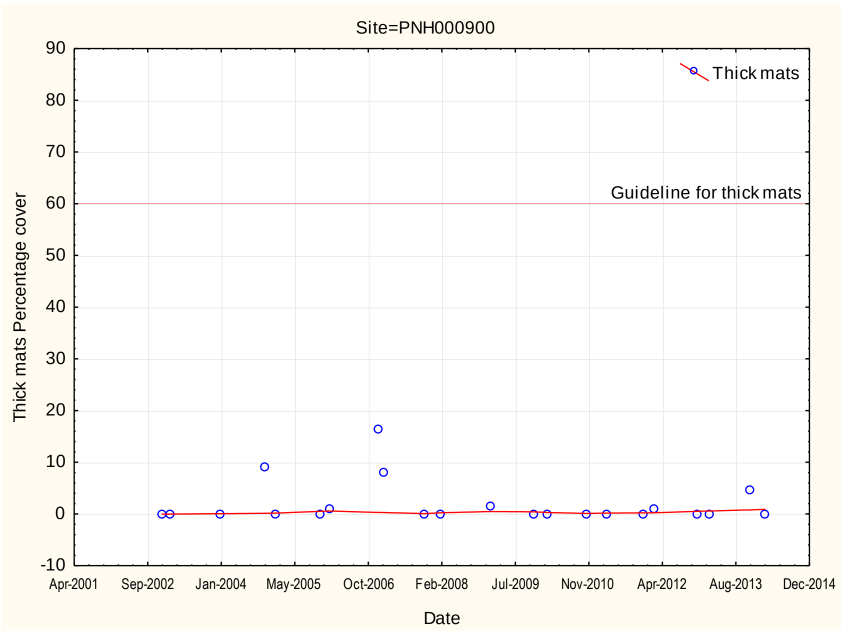
Figure 70 LOWESS trend analysis of percentage cover of thick mats at Punehu Stream, Wiremu Road (PNH000200).



n = 22
Kendal tau = -0.068
p-value = 0.658
FDR p-value = 0.693

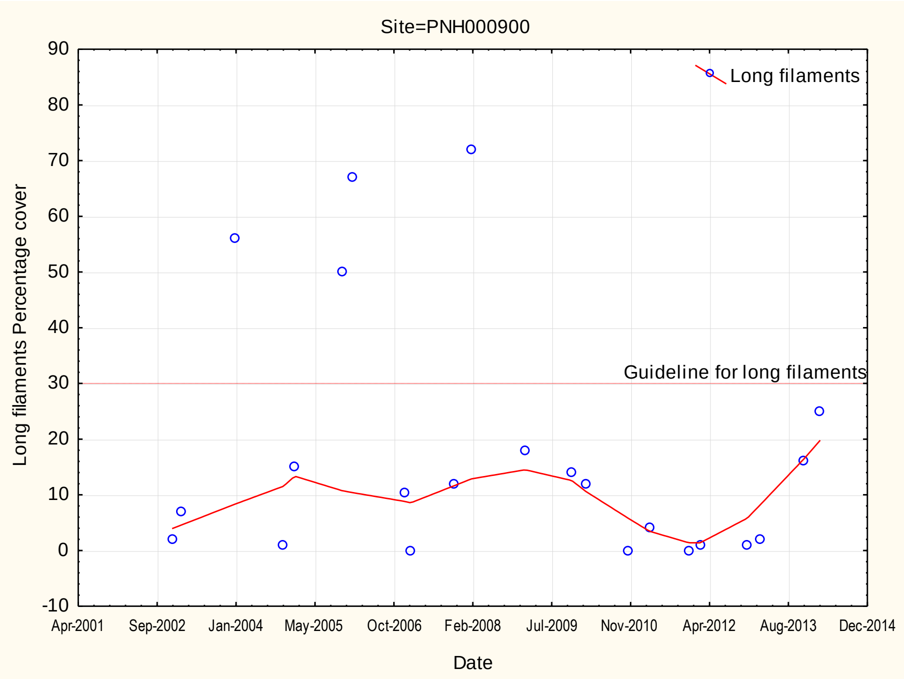
Figure 71 LOWESS trend analysis of percentage cover of long filaments at Punehu Stream, Wiremu Road (PNH000200)

At Wiremu Road (PNH000200) over the 12 year monitored period there were no significant trends for thick mats (p=0.822) or long filaments (p=0.693) at the 5% level of significance.



n = 22
Kendal tau = -0.052964
p-value = 0.730
FDR p-value = 0.852

Figure 72 LOWESS trend analysis of percentage cover of thick mats at Punehu Stream, SH45 (PNH000900)



n = 22
Kendal tau = -0.101
p-value = 0.509
FDR p-value = 0.580

Figure 73 LOWESS trend analysis of percentage cover of long filaments at Punehu Stream, SH45 (PNH000900)

At SH45 (PNH000900) over the 12 year monitored period there were no significant trends for thick mats (p=0.852) or long filaments (p=0.451) at the 5% level of significance.

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 74). 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.

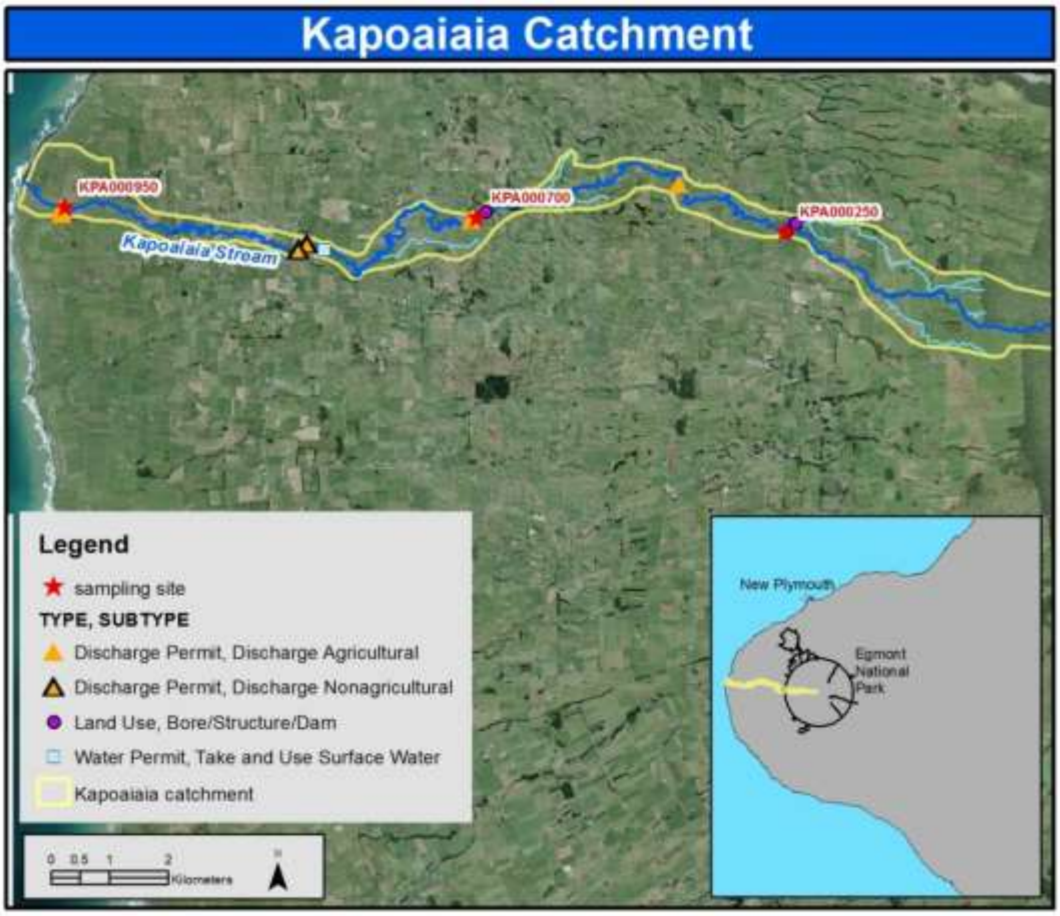


Figure 74 Monitoring site locations in relation to consents operating in the Kapoaiaia Stream catchment.

2.8.1 Flow data and survey dates

The spring 2012 survey was conducted on 14 November 2012 12 days after a fresh in excess of 3x median flow and 13 days after a fresh in excess of 7x median flow. The summer 2013 survey was carried out on 20 February 2013 15 days after a fresh in excess of 3x and 7x median flows (Appendix).

The spring 2013 survey was conducted on 11 November 2013 10 days after a fresh in excess of both 3x and 7x median flow. The summer 2014 survey was carried out on 3 March 2014, 37 days after a fresh in excess of 3x median flow 38 days after a fresh in excess of 7x median flow (Appendix).

2.8.2 Periphyton cover

For the 2012-2013 monitoring period no nuisance periphyton was recorded at the upper site at Wiremu Road. The middle site at Wataroa Road had long filaments which were at half the guideline value (15%) for spring 2012 while the downstream site at Cape Egmont had long filaments approaching the guideline limit and low levels of thick algal mats for spring 2012 while for summer 2013 moderate levels of thick algal mats occurred with low levels of long filaments (Figure 75 and figure 76).

For the 2013-2014 monitoring period no nuisance periphyton was recorded at the upper site at Wiremu Road. The middle site at Wataroa Road had very low levels of long filaments for spring 2013 and no nuisance periphyton for summer 2014. The downstream site at SH45 had long filamentous algae at levels just below recommended guidelines for spring 2013 and above guideline limits for summer 2014.

The Wiremu Road site had no nuisance periphyton for the 2012-2014 monitoring period and no nuisance periphyton was also recorded for the 2010-2012 monitoring period. The site was near a bridge and this provides full shading at times. It has been noted that the periphyton cover upstream of the site for a considerable distance was substantially greater than at the survey site and this would be likely due to the shading.

The Kapoaiaia Stream only had minor levels of riparian vegetation where it flows through farmland. The streambed was open with high sunlight levels and relatively warm water temperatures. Furthermore, there was little buffering for nutrient inputs. These factors can contribute to periphyton growth. Consequently, nuisance periphyton at the bottom site was often high and there was also a long filamentous algae breach in summer 2012 at the most downstream site at Cape Egmont. The summer 2014 survey had higher levels of long filamentous algae at Cape Egmont than the summer 2013 and this may be due to having a longer period of no flushing flows before sampling occurred in the summer 2014 survey.

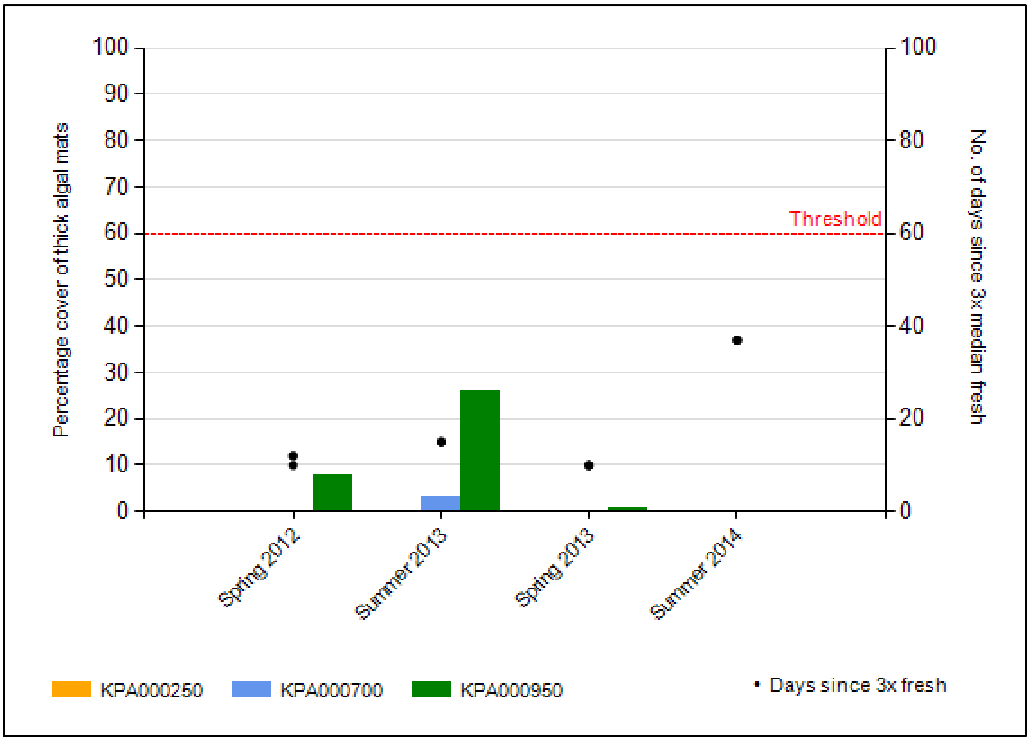


Figure 75 Percentage cover of thick mats of periphyton on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

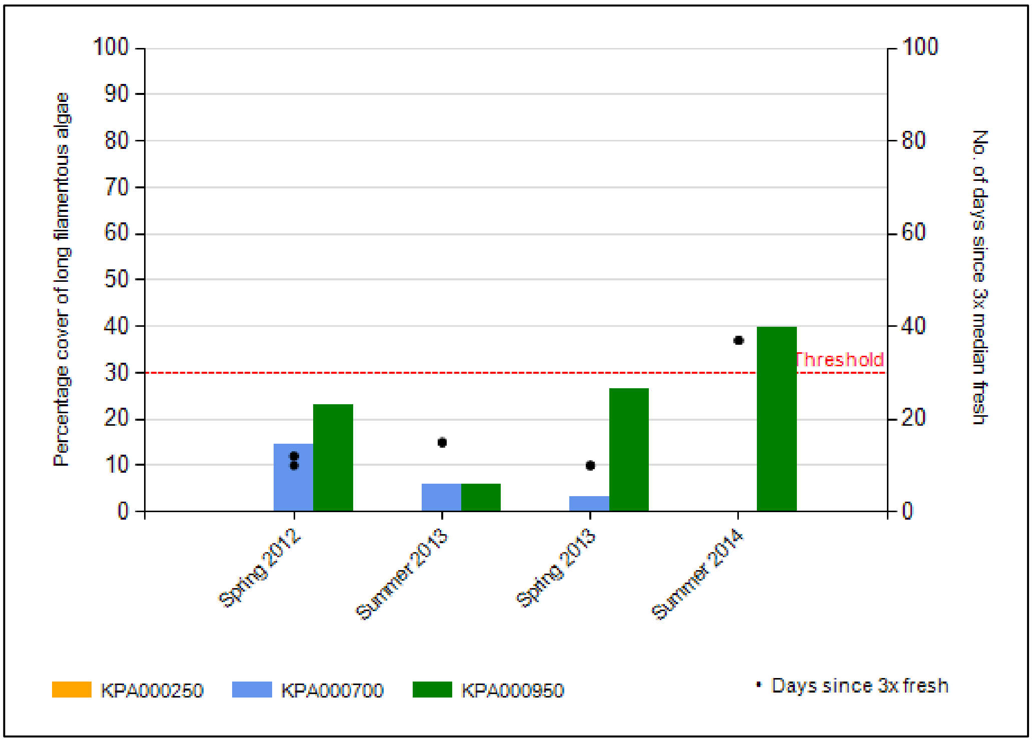


Figure 76 Percentage cover of long filamentous algae on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

2.8.3 Periphyton Index Score

The Kapoaiaia Stream showed a lot of variation in TRC PI scores among sites (Table 16). The upstream site (KPA000250) scored a maximum TRC PI value (10) for three surveys. The mid-catchment site (KPA000700) showed a decrease in TRC PI score from the upstream site, varying between 'good' and 'very good'. In particular, the scores had decreased from the 2012-2013 year to the 2013-2014 year. Further decreases in TRC PI score were seen at the downstream site (KPA000950) on all survey occasions with the site showing little fluctuation between spring and summer with all survey results 'good'.

Similarly to the 2010-2012 and 2006-2010 results, the upstream site had improved dramatically from the 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 16 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
KPA000250	10.0	9.2	10.0	10.0	8.6	5.2
KPA000700	9.3	9.1	7.8	7.1	7.1	6.8
KPA000950	6.8	6.7	6.8	6.8	6.4	5.0
Difference	3.2	2.5	3.2	3.2	2.2	0.2

The rate of change in overall TRC PI score from the top site to the most downstream site is a decrease of 0.256 units per kilometre which was an increase from the previous reported period from 2010-2012 of 0.082 units per kilometre (TRC, 2014).

2.8.4 Periphyton biomass

The results for the 2010- 2014 survey period for the upstream site showed that it had extremely low chlorophyll *a* levels with the mid catchment site having low to moderately high chlorophyll *a* levels and the downstream site having moderately low to very high chlorophyll *a* levels (Figure 77).

The summer 2012 survey at the most downstream site breached guidelines to protect trout habitat/angling values (Table 2) and NOF standards (MfE, 2014) by a considerable amount and was the highest chlorophyll *a* level recorded at any site for the 2011-2014 survey period. The high chlorophyll *a* level for the summer 2012 survey also corresponded with the lowest TRC PI score (4.7) recorded for the Kapoaiaia Stream for the period 2011-2014 though the score still placed the site within the 'moderate' category. The mid catchment site during the summer 2012 also had a moderately high level chlorophyll *a* level suggesting the period was particularly bad for the majority of the Kapoaiaia Stream though the upper site appears to have been unaffected, probably as a result of shading from the bridge.

The results suggest that nutrients were driving periphyton biomass in the Kapoaiaia Stream as the stream runs through predominately agricultural land and nutrient levels would increase towards the lower reaches of the river due to the cumulative affects of point source and diffuse pollution.

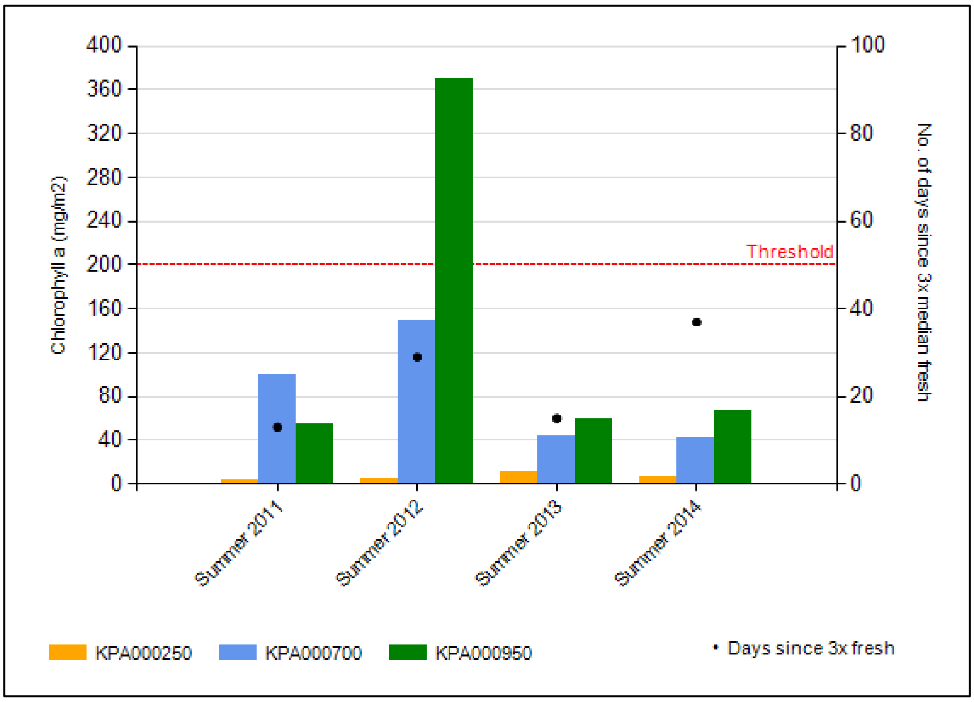


Figure 77 Periphyton biomass (chlorophyll *a*) on the Kapoaiaia riverbed in relation to the guidelines for recreational values over the 2010-2014 period.

2.8.5 Summary of 2002-2014 (12 year data set)

The Kapoaiaia catchment has been monitored over a 12 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 2012-2014 monitoring period (Figure 78).

The mid catchment and downstream sites breached thick mat guideline limits twice each over the 2002-2014 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. During the current reporting period (2012-2014) only the downstream site during the summer 2013 survey had significant levels of thick algal mats.

There have been a significant number of breaches over the 12 year monitoring period for long filamentous nuisance growths (25 in total) (Figure 79). Overall there has been a significant decrease in long filamentous growths at the upper and mid catchment sites in recent years; 2008-2014. The lower catchment site still had high levels of long filamentous growth with a breach in guidelines recorded for the summer 2014 survey at the site and the spring 2013 survey was close to being breaching the guideline level.

This catchment has the highest amount of nuisance growths for long filaments within a catchment out of all the catchments monitored over the 12 year period. 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.

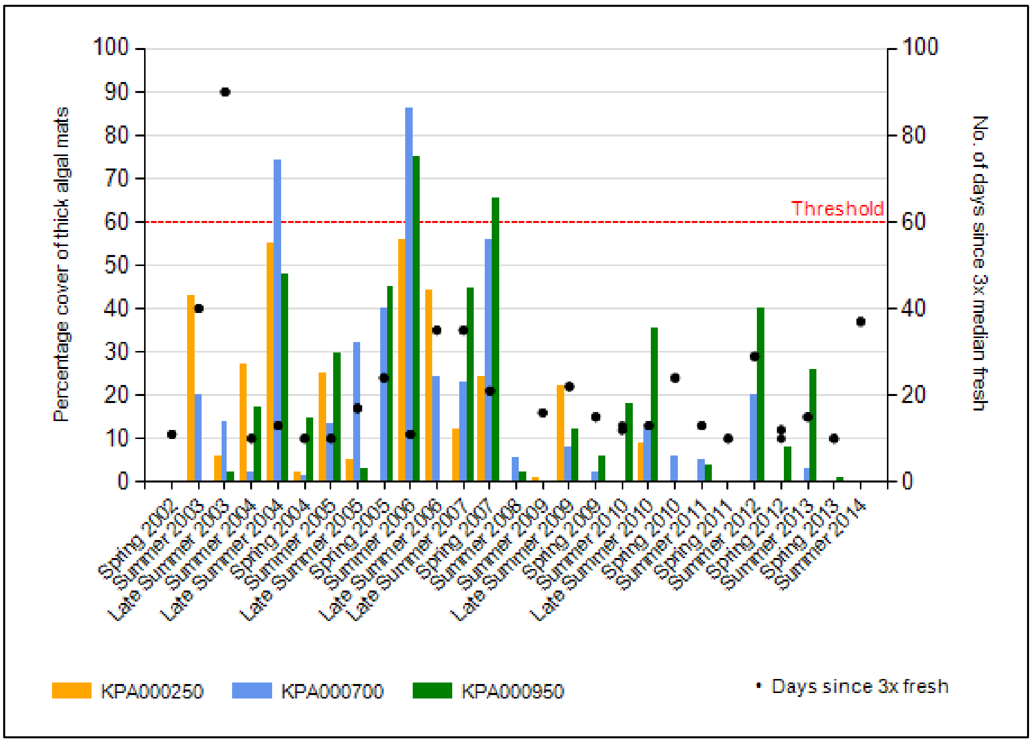


Figure 78 Percentage cover of thick mats of periphyton on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2002-2012 period

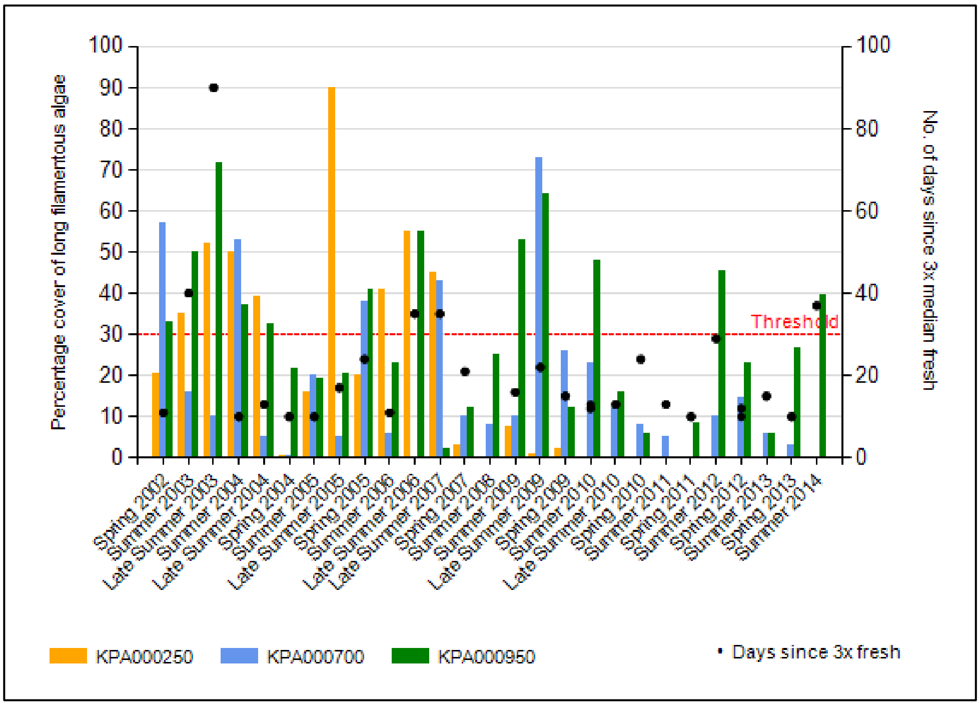
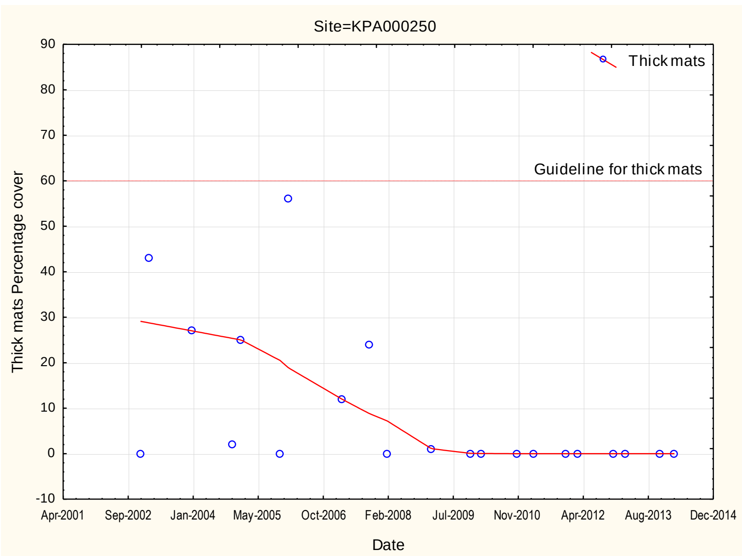


Figure 79 Percentage cover of long filamentous algae on the Kapoaiaia streambed in relation to the guidelines for recreational values over the 2002-2012 period

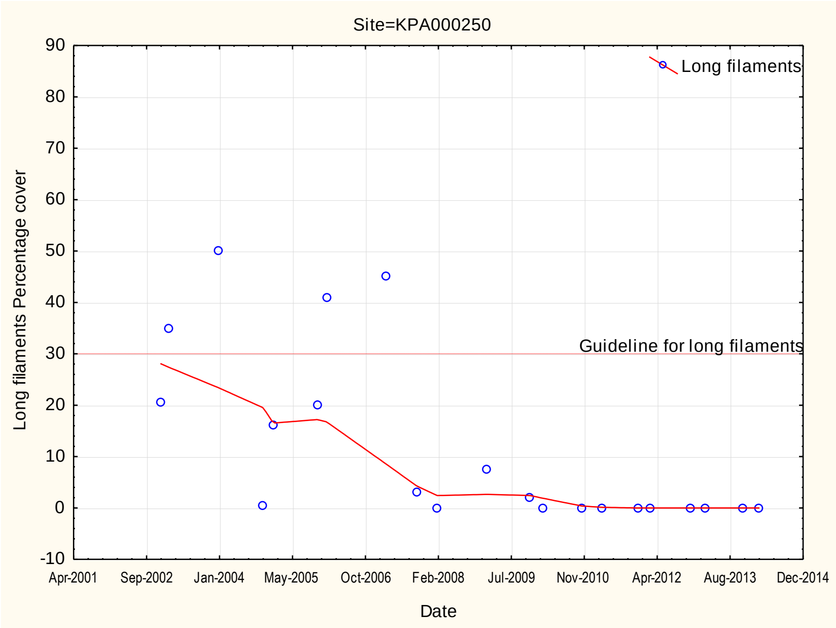
2.8.6 Long term trend analysis

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 12 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 80 to Figure 85).



n = 21
Kendal tau = -0.541
p-value < 0.001
FDR p-value = 0.013

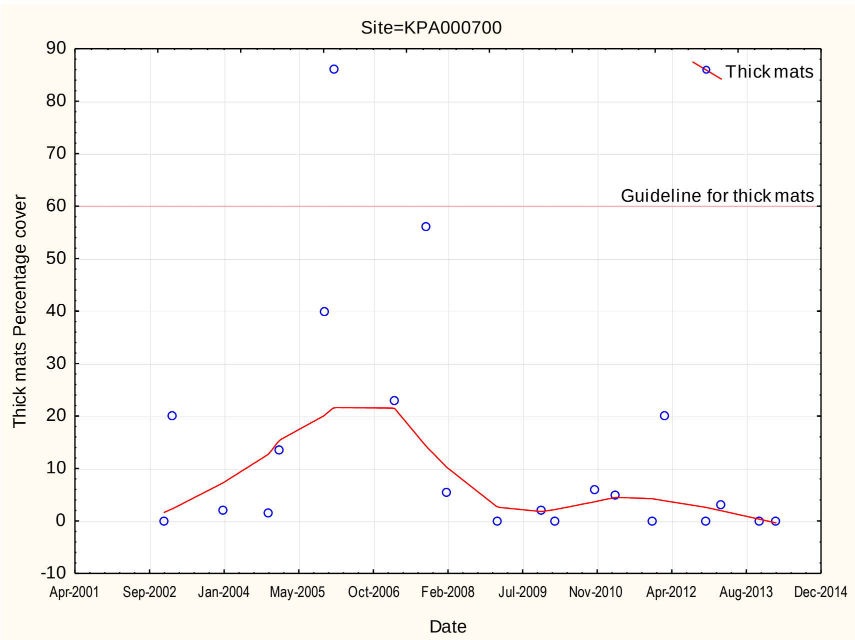
Figure 80 LOWESS trend analysis of percentage cover of thick mats at Kapoaiaia Stream, Wiremu Road (KPA000250)



n = 21
Kendal tau = -0.639
p-value < 0.001
FDR p-value = 0.001

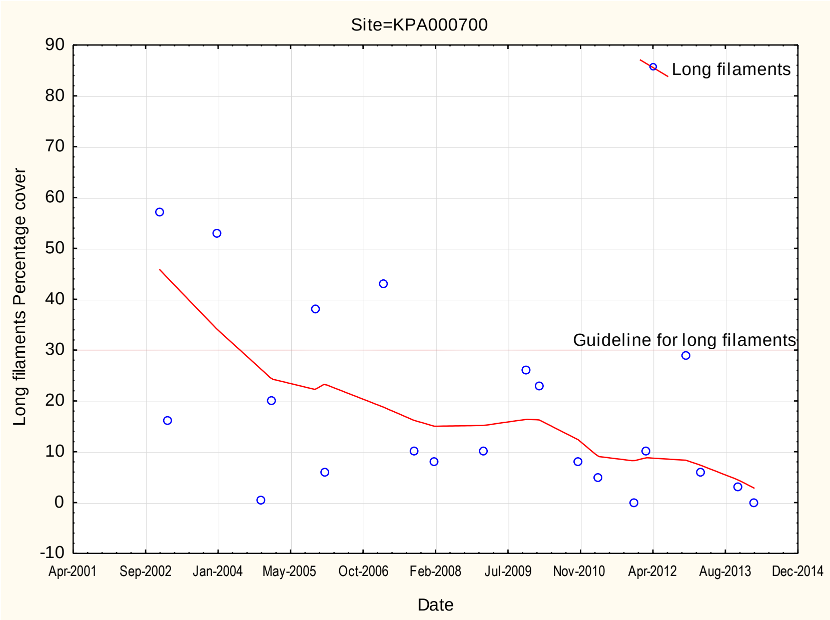
Figure 81 LOWESS trend analysis of percentage cover of long filaments at Kapoaiaia Stream, Wiremu Road (KPA000250)

At Wiremu Road (KPA000250) over the 12 year monitored period there was a significant (p=0.013) negative (tau=-0.541) trend for thick mats and a significant (< 0.001) negative (tau=-0.639) trend for long filaments at the 5% level of significance indicating that both had decreased over the monitored period.



n = 21
Kendal tau = -0.267
p-value = 0.090
FDR p-value = 0.326

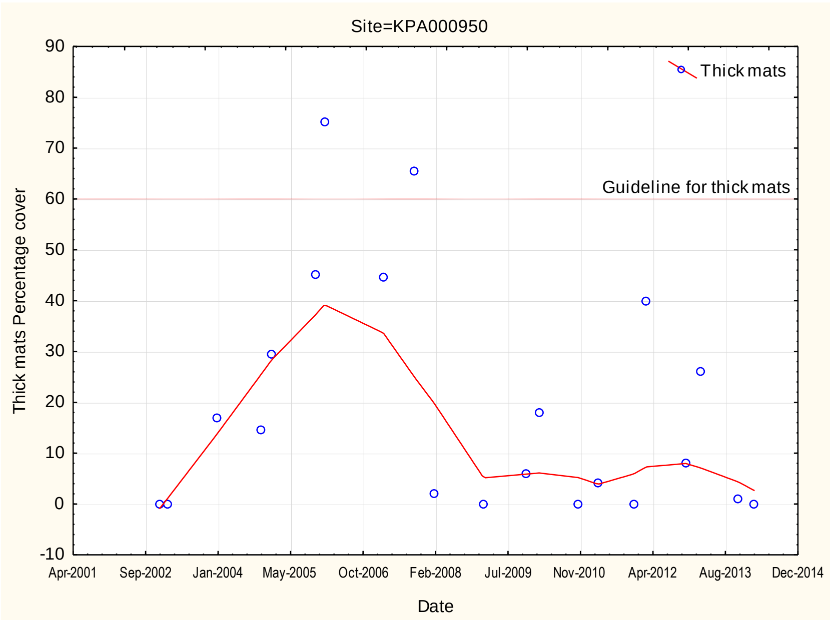
Figure 82 LOWESS trend analysis of percentage cover of thick mats at Kapoaiaia Stream, Wataroa Road (KPA000700)



n = 21
Kendal tau = -0.406
p-value = 0.010
FDR p-value = 0.050

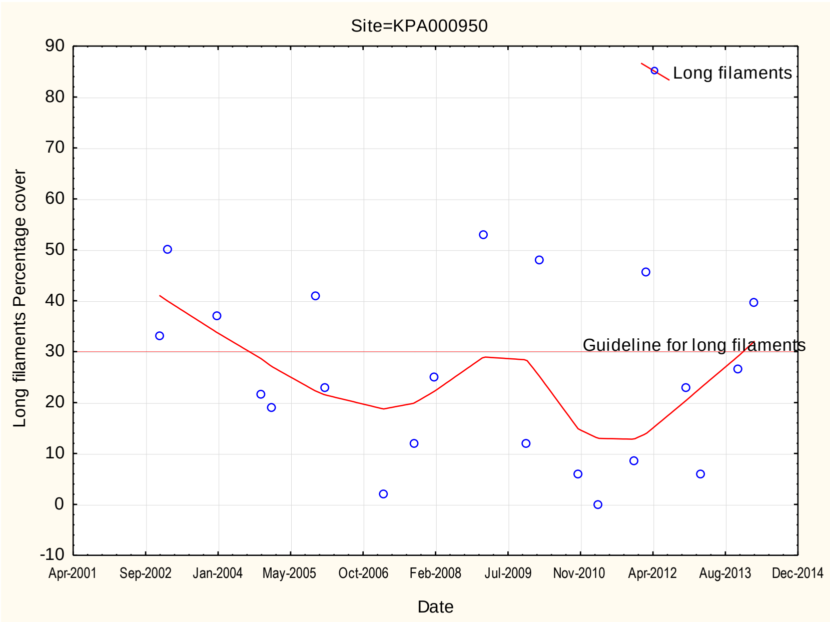
Figure 83 LOWESS trend analysis of percentage cover of long filaments at Kapoaiaia Stream, Wataroa Road (KPA000700)

At Wataroa Road (KPA000700) over the 12 year monitored period there was no significant trend for thick mats (p=0.326) but there was a significant (p=0.050) negative (tau=-0.406) trend for thick mats at the 5% level of significance indicating that long filamentous algae had decreased over the monitored period.



n = 21
Kendal tau = -0.114
p-value = 0.471
FDR p-value = 0.822

Figure 84 LOWESS trend analysis of percentage cover of thick mats at Kapoaiaia Stream, Cape Egmont (KPA000950)



n = 21
Kendal tau = -0.139
p-value = 0.378
FDR p-value = 0.472

Figure 85 LOWESS trend analysis of percentage cover of long filaments at Kapoaiaia Stream, Cape Egmont (KPA000950)

At Cape Egmont (KPA000950) over the 12 year monitored period there were no significant trends for thick mats (p=0.822) or long filaments (p=0.472) at the 5% level of significance.

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 86).

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.

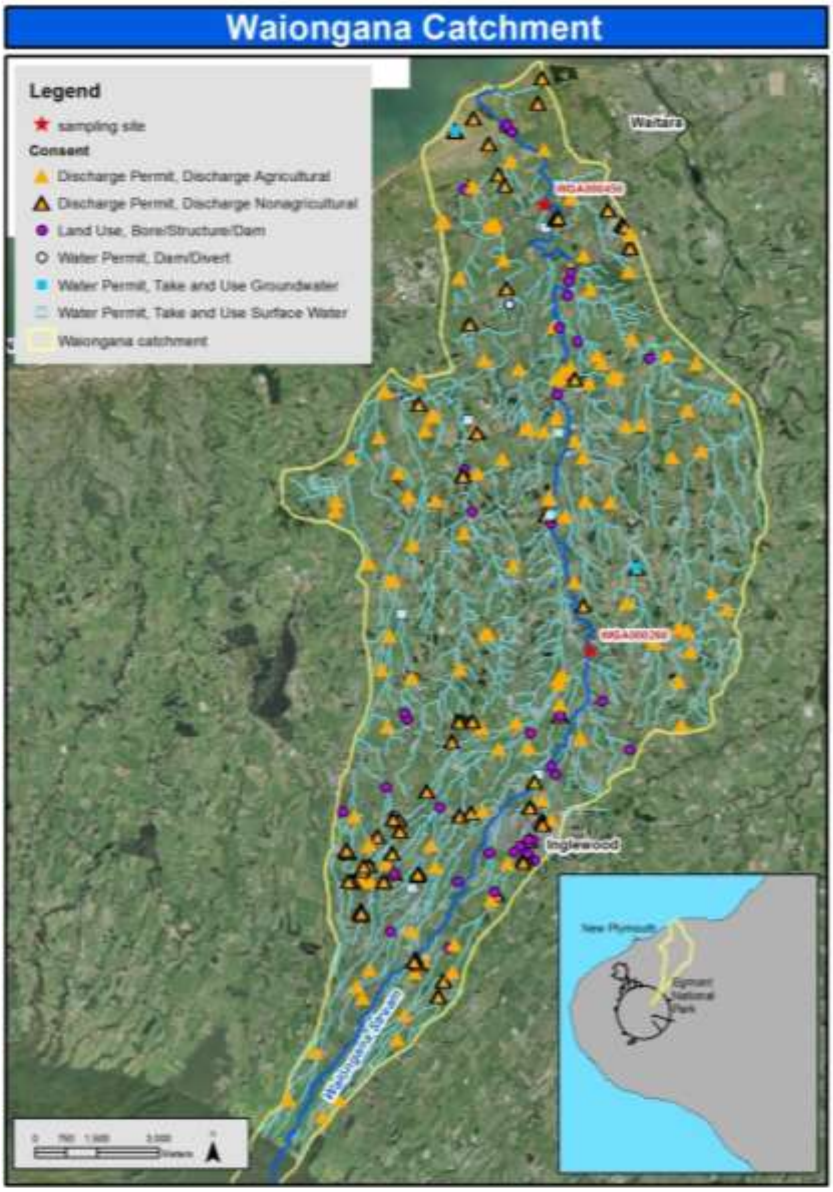


Figure 86 Monitoring site locations in relation to consents operating in the Waiongana Stream catchment

2.9.1 Flow data and survey dates

The spring 2012 survey was conducted on 16 November 2012 13 days after a fresh in excess of 3x and 7x median flow. There was a small fresh immediately prior to sampling. The summer 2013 survey was carried out on 26 February 2013 21 days after a fresh in excess of 3x and 7x median flows during a low flow period (Appendix).

The spring 2013 survey was conducted on 22 November 2013 15 days after a fresh in excess of both 3x and 7x median flow. The summer 2014 survey was carried out on 27 February 2014 50 days after a fresh in excess of 3x median flow and 53 days after a fresh in excess of 7x median flow during a low flow period (Appendix).

2.9.2 Periphyton cover

For the 2012-2013 monitoring period there were low levels of long filaments at the two monitoring sites in the Waiongana River. The two sites are situated mid-way down the catchment (SH3a) and near the lower end of the catchment (Devon Road). For the 2013-2014 monitoring period the upstream site at SH3a had very low levels of long filaments during spring 2013. The downstream site at Devon Road saw a significant increase in nuisance periphyton and the long filament guideline level of 30% was exceeded for the summer 2014 survey at the site (Figure 87 and Figure 88).

In the mid-catchment site at SH3a long filamentous algae was recorded at low levels and thick algal mats were absent for the spring 2012 survey and the downstream site at Devon road had no nuisance periphyton recorded for the spring 2012 survey. No nuisance periphyton was recorded for the summer 2013 survey at the SH3a site and very low levels of long filaments was recorded at the Devon Road site.

There were moderately high levels of nuisance periphyton recorded at the Devon Road site for the 2013-2014 monitoring year. The combined level of thick algal mats and long filamentous algae for the spring 2013 survey was at an undesirable level and the guideline was breached for long filaments for the summer 2014 survey. The Waiongana River flows predominantly through dairy farms and consequently there is likely to be a relatively high nutrient input into the river in the form of both point source discharges and diffuse runoff. Both long filamentous algae and thick mats of nuisance algae were found on occasion in the surveys carried out in the 2010-2012 monitoring years. However, no guidelines were breached over that two year period.

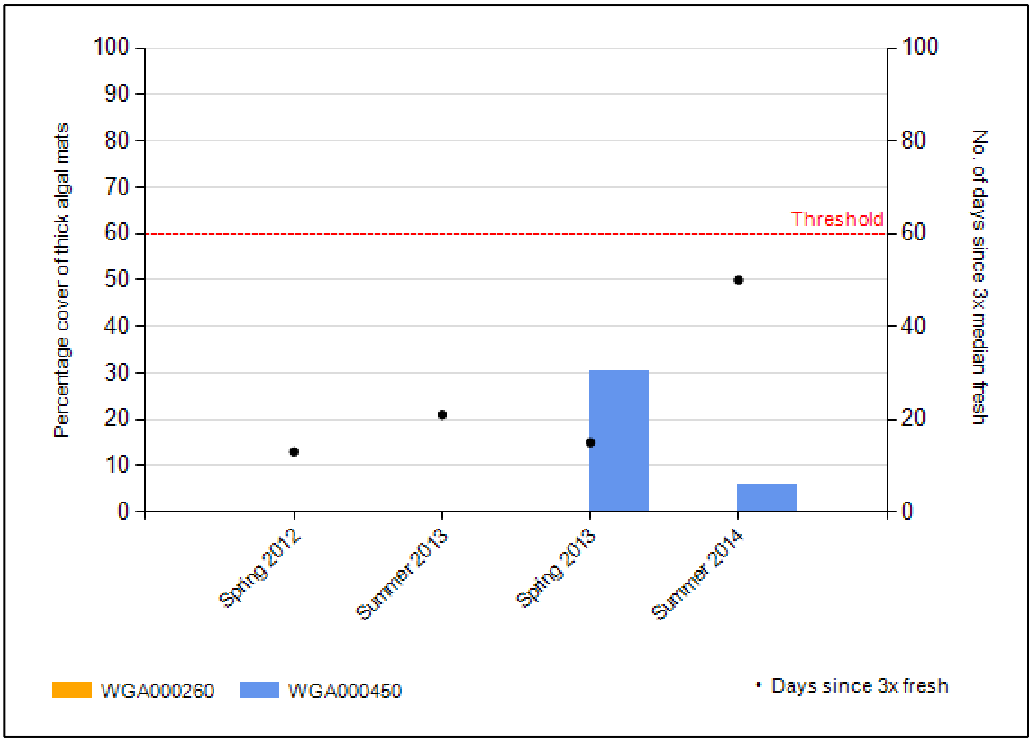


Figure 87 Percentage cover of thick mats of periphyton on the Waiongana riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

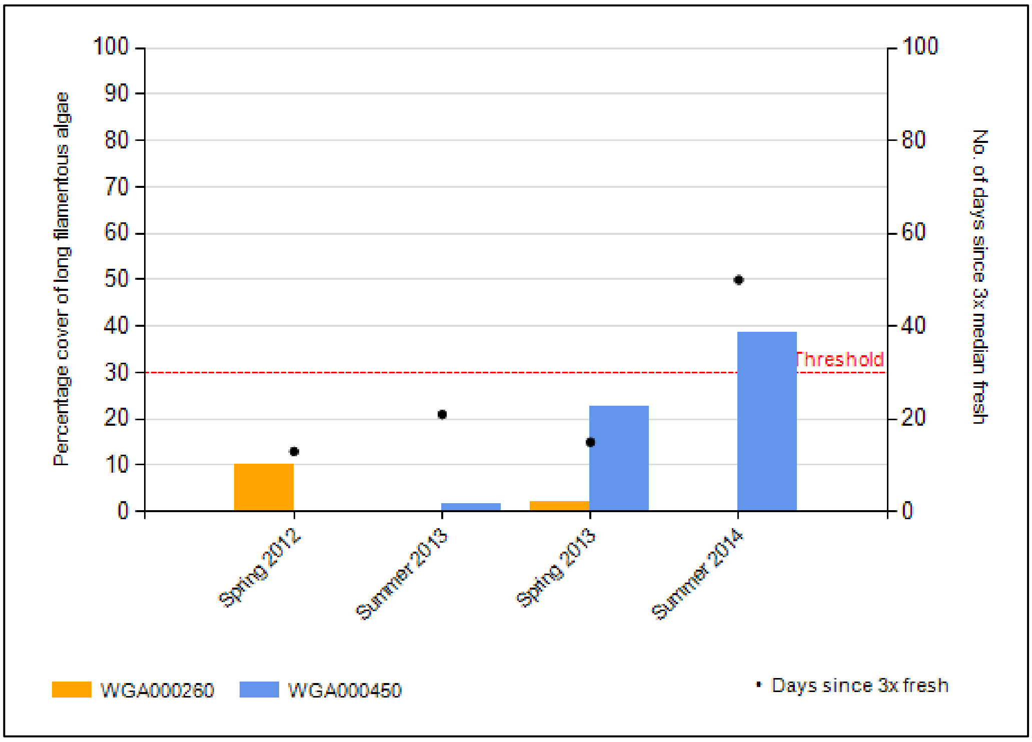


Figure 88 Percentage cover of long filamentous algae on the Waiongana riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

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 scores in the rest of the surveys (Table 17). In the last reported monitoring period (2010-2012) an increase in TRC PI was also found in the single spring survey undertaken (TRC, 2014).

The 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 which is consistent with the previous reported monitoring period from 2010-2012 (TRC. 2014), whereas the lower site showed either no change or a decrease from spring to summer. Reasons for the higher summer TRC PI scores at the upstream site were unclear, although it may be related to how nutrients enter the stream. If nutrients were 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 were less affected by rainfall.

The rate of change in overall TRC PI score was a decrease of 0.026 units per kilometre over approximately 15.1 kilometres. This was similar to the previous monitoring period of 0.046 units per kilometre but different from older monitoring periods which saw an improvement in downstream condition, which is evident in the historical medians which show a negative difference between upstream and downstream (Table 17).

Table 17 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 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
WGA000260	8.7	9.1	7.0	7.3	6.3	5.6
WGA000450	9.6	9.6	6.1	5.2	7.2	7.1
Difference	-0.9	-0.5	0.9	2.1	-0.9	-1.5

2.9.4 Periphyton biomass

The results for the 2011- 2014 survey period for the mid catchment upstream site showed that it had moderately low chlorophyll *a* levels with the mid catchment site having low to moderately high chlorophyll *a* levels and the downstream site having moderately low to high chlorophyll *a* levels (Figure 89).

The summer 2014 survey at the downstream site breached guidelines to protect trout habitat/angling values (Table 2) and NOF standards (MfE, 2014). The high chlorophyll *a* level for the summer 2014 survey also corresponded with the lowest TRC PI score (5.2) recorded for the Waiongana River for the period 2011-2014 (8.9, 6.5, 9.6, and 5.2) though the score still placed the site within the 'moderate' category. The chlorophyll *a* level for the 2014 survey was significantly higher than other values recorded for the site which may be related to the relatively long period without flushing flows.

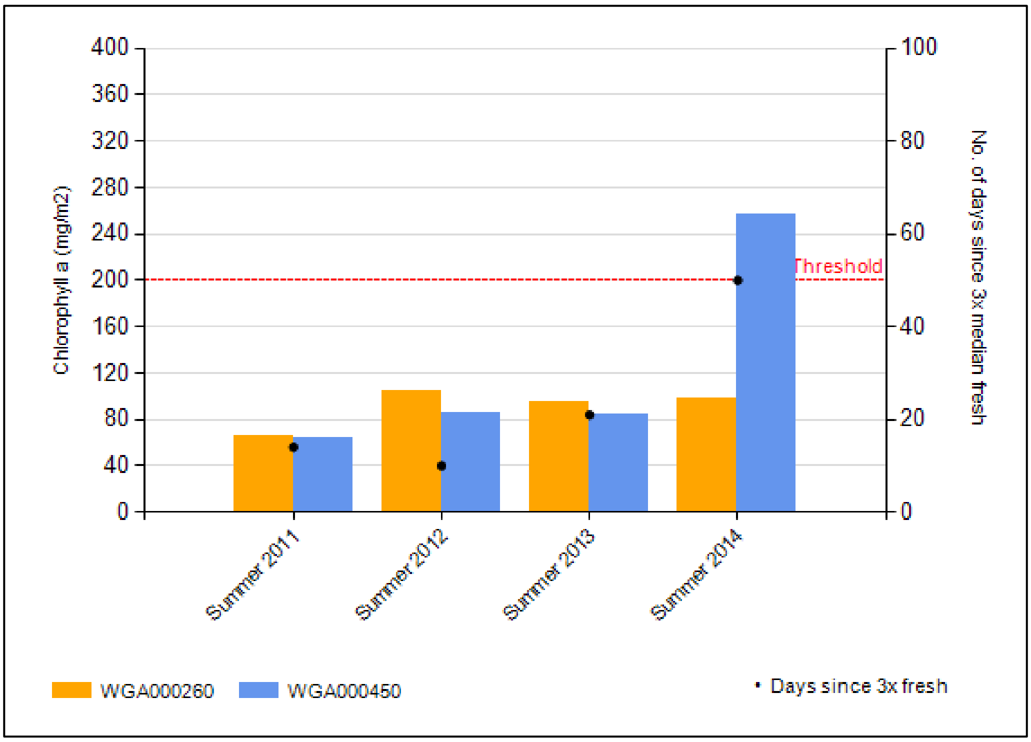


Figure 89 Periphyton biomass (chlorophyll *a*) on the Waiongana riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.9.5 Summary of 2002-2014 (12 year data set)

The Waiongana catchment over the 12 year data set has had no breaches in thick algal mats at either of the sites surveyed (Figure 90). There have been more significant growths of thick mats at the downstream site than the upstream site over more recent years (2010-2014). This contrasts to what was recorded in the 2006-2010 period, when greater proliferations were observed at the upstream site.

Long filamentous algae had intermittently breached guidelines throughout the entire record at both the upstream and downstream sites (Figure 91). The majority of the breaches at the upstream site tended to be after long periods without flushing flows, such as late summer 2007, summer 2008 and summer 2014. There have not been as many breaches at the lower catchment site compared with the upper catchment site but since 2008 three of the last four breaches were at the downstream site. This was largely due to improvements at the upstream site rather than the downstream site having more breaches.

The Waiongana catchment was the only catchment where breaches in periphyton guidelines increased between the 2002-2006 and 2006-2010 surveys. In the most recent period there was one breach in nuisance periphyton guidelines at the downstream site for the 2014 survey.

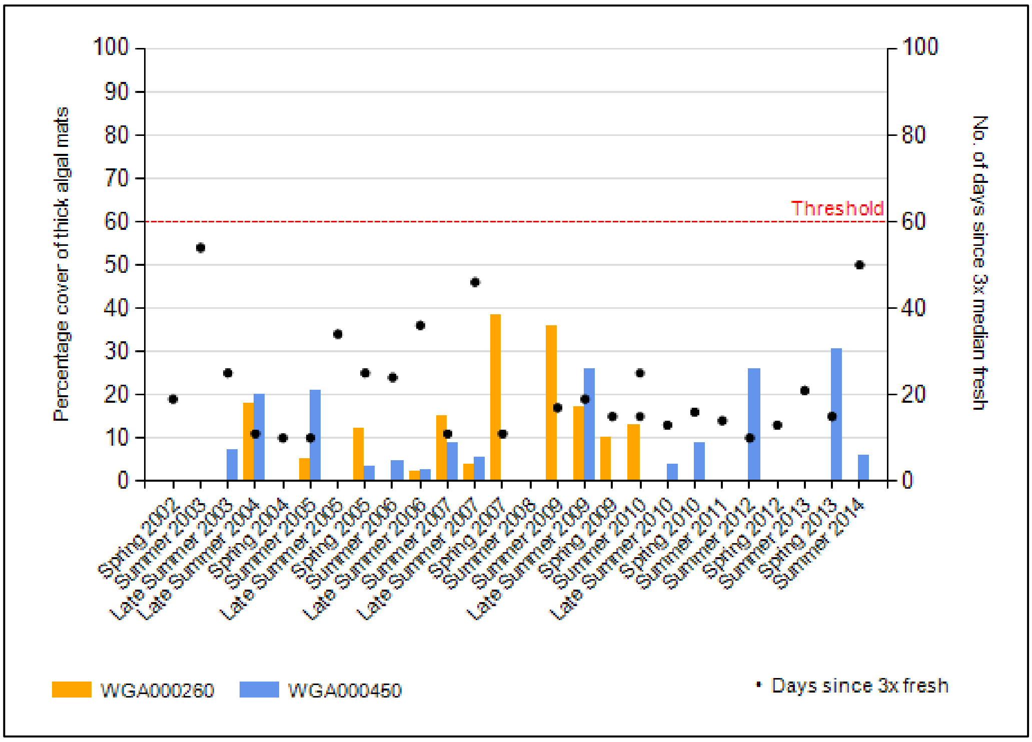


Figure 90 Percentage cover of thick mats of periphyton on the Waiongana riverbed in relation to the guidelines for recreational values over the 2002-2014 period

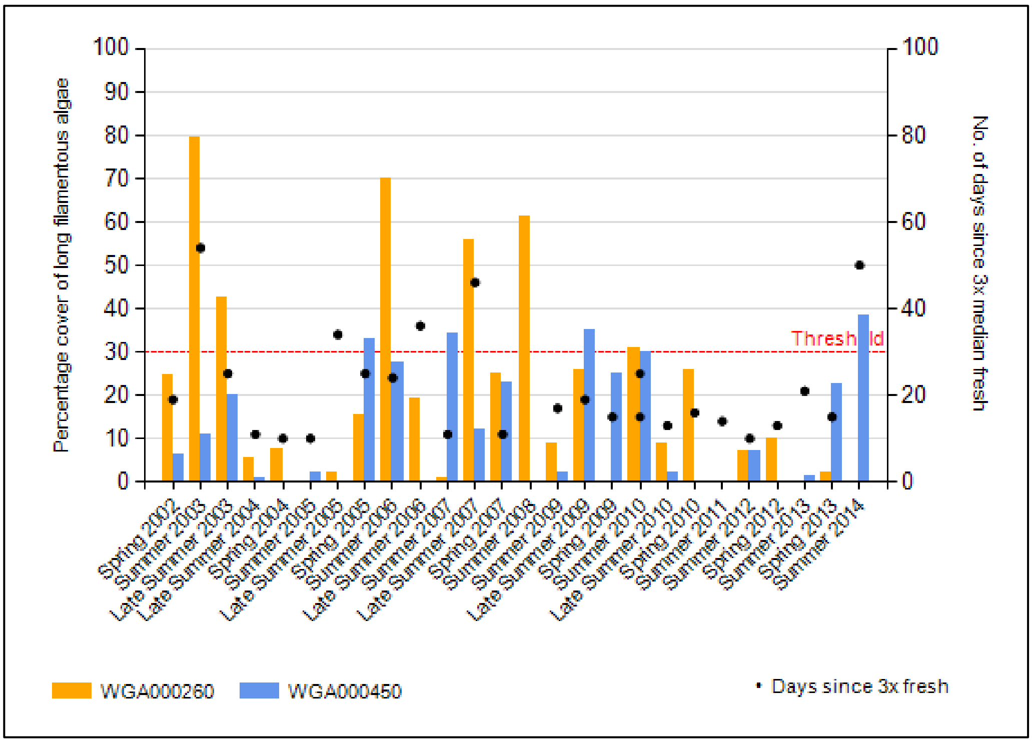
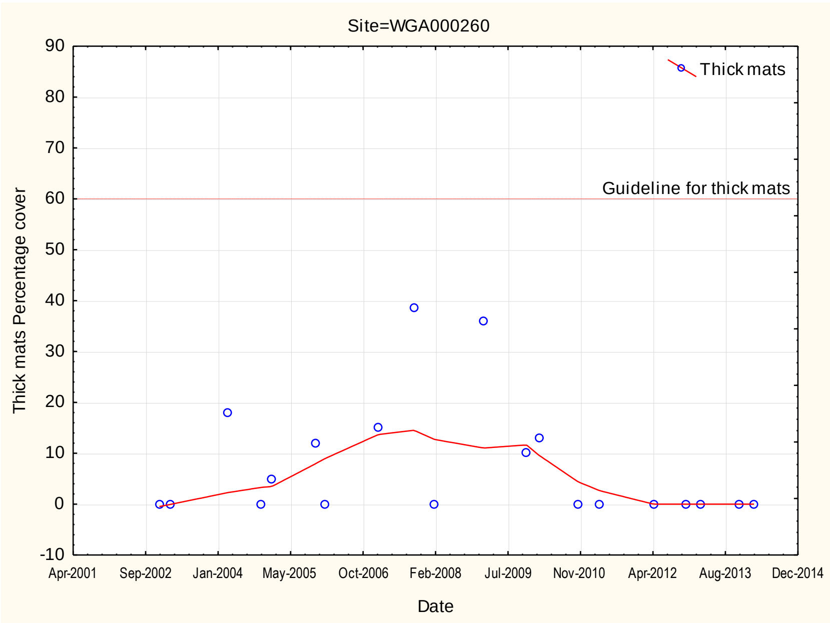


Figure 91 Percentage cover of long filamentous algae on the Waiongana riverbed in relation to the guidelines for recreational values over the 2002-2014 period

2.9.6 Long term trend analysis

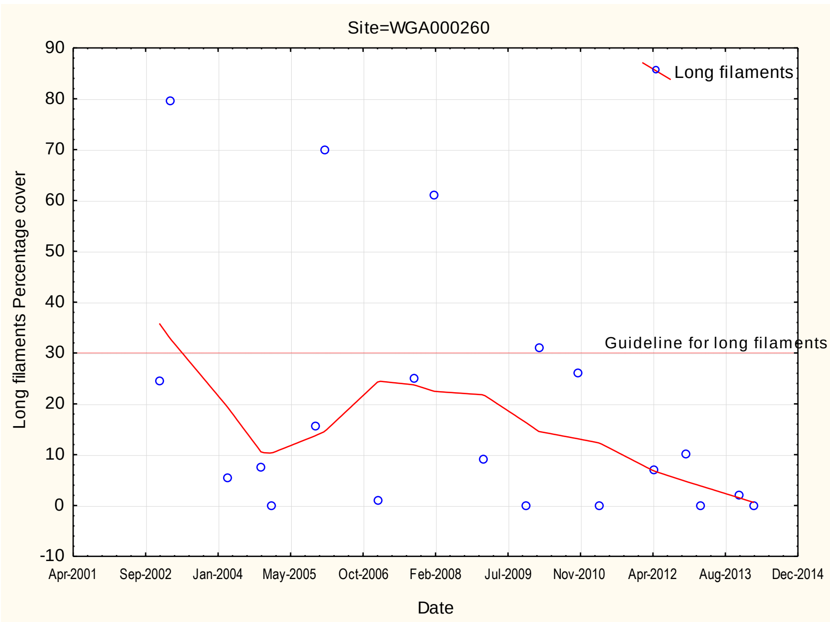
Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at

the Waiongana River, at SH3a and Devon Road, over a 12 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 to Figure 95).



n = 20
Kendal tau = -0.208
p-value = 0.199
FDR p-value = 0.596

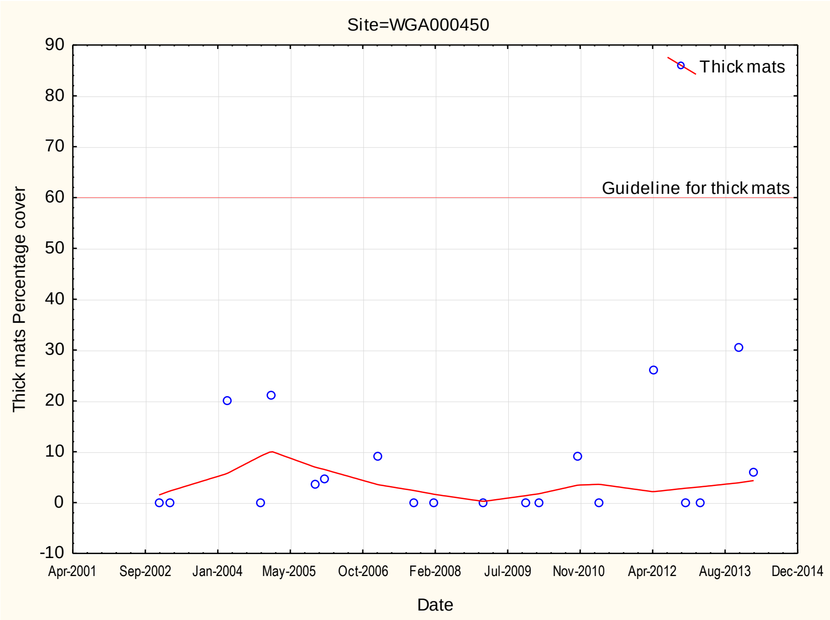
Figure 92 LOWESS trend analysis of percentage cover of thick mats at Waiongana River, SH3a (WGA000260)



n = 20
Kendal tau = -0.281
p-value = 0.083
FDR p-value = 0.166

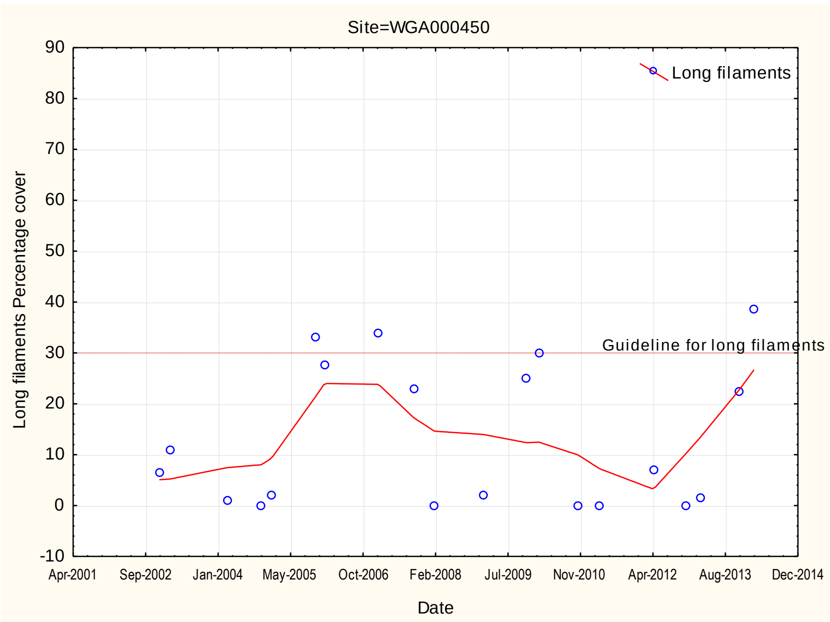
Figure 93 LOWESS trend analysis of percentage cover of long filaments at Waiongana River, SH3a (WGA000260).

At SH3a (WGA000260) over the 12 year monitored period there were no significant trends for thick mats (p=0.596) or long filaments (p=0.166) at the 5% level of significance.



n = 20
Kendal tau = 0.088
p-value = 0.589
FDR p-value = 0.822

Figure 94 LOWESS trend analysis of percentage cover of thick mats at Waiongana River, Devon Road (WGA000450)



n = 20
Kendal tau = 0.016
p-value = 0.920
FDR p-value = 0.920

Figure 95 LOWESS trend analysis of percentage cover of long filaments at Waiongana River, Devon Road (WGA000450)

At Devon Road (WGA000450) over the 12 year monitored period there were no significant trends for thick mats (p=0.822) or long filaments (p=0.920) at the 5% level of significance.

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 96).

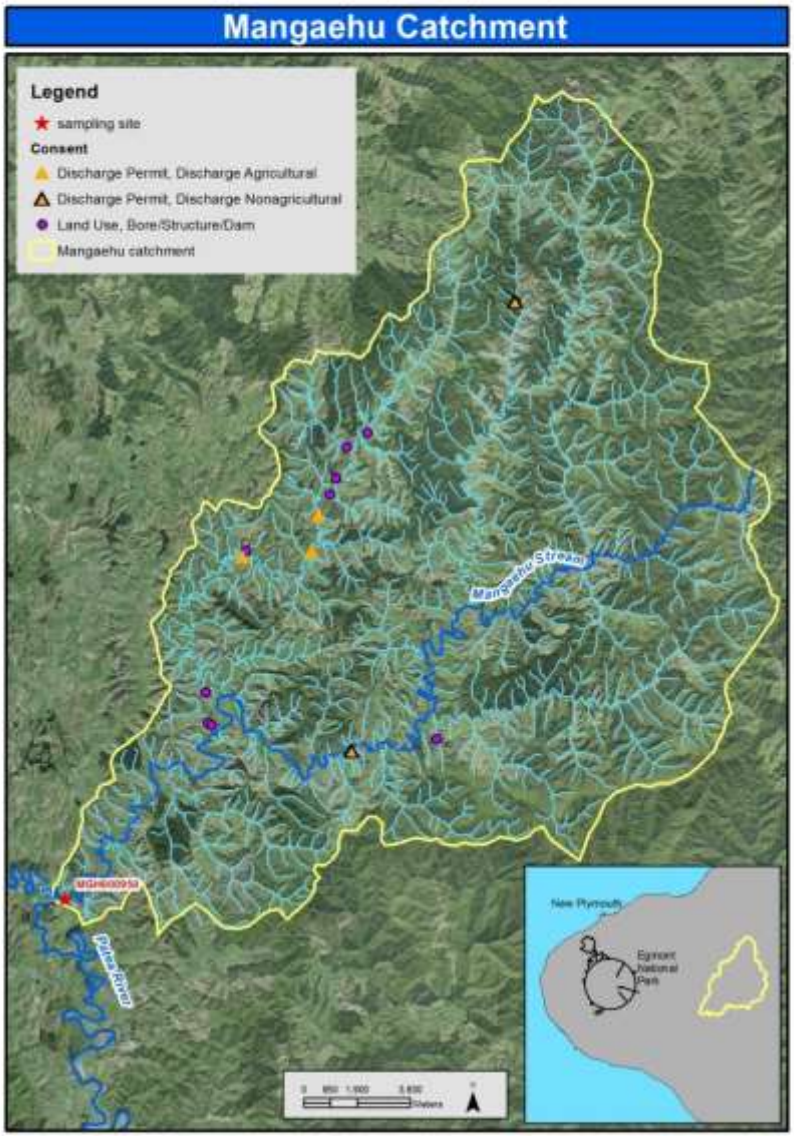


Figure 96 Monitoring site in the Mangaehu River catchment

2.10.1 Flow data and survey dates

The spring 2012 survey was conducted on 2 November 2012 12 days after a fresh in excess of 3x median flow and 15 days after a fresh in excess of 7x median flow. There was a small fresh immediately prior to sampling. The summer 2013 survey was carried out on 25 February 2013 20 days after a fresh in excess of 3x median flow and 110 days after a fresh in excess of 7x median flow during a low flow period (Appendix).

The spring 2013 survey was conducted on 15 November 2013 12 days after a fresh in excess of 3x median flow and 13 days after a fresh of 7x median flow. The summer 2014 survey was carried out on 25 February 2014 50 days after a fresh in excess of both 3x and 7x median flow during a low flow period (Appendix).

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. Nuisance periphyton was at high levels for all four surveys (Figure 97 and Figure 98).

For the 2012-2013 monitoring period thick algal mats comprising diatoms approached the guideline limits on both sampling occasions (53%) and (57%). Furthermore, long filaments were also present and for the summer 2013 survey (22%) approached guideline limits and in total 79% of the streambed was covered in nuisance periphyton for the summer 2013 survey which would be at an undesirable level.

For the 2013-2014 monitoring period nuisance periphyton had decreased for the spring 2013 survey. This result was due to large spring flows scouring the streambed and removing algal growth. The summer 2014 survey was conducted after a lengthy period without a significant fresh and by this time nuisance periphyton had substantially increased to undesirable levels. Both long filaments (27.5%) and thick algal mats comprising diatoms (54.5%) approached the guideline limits and combined made up 82% of the streambed.

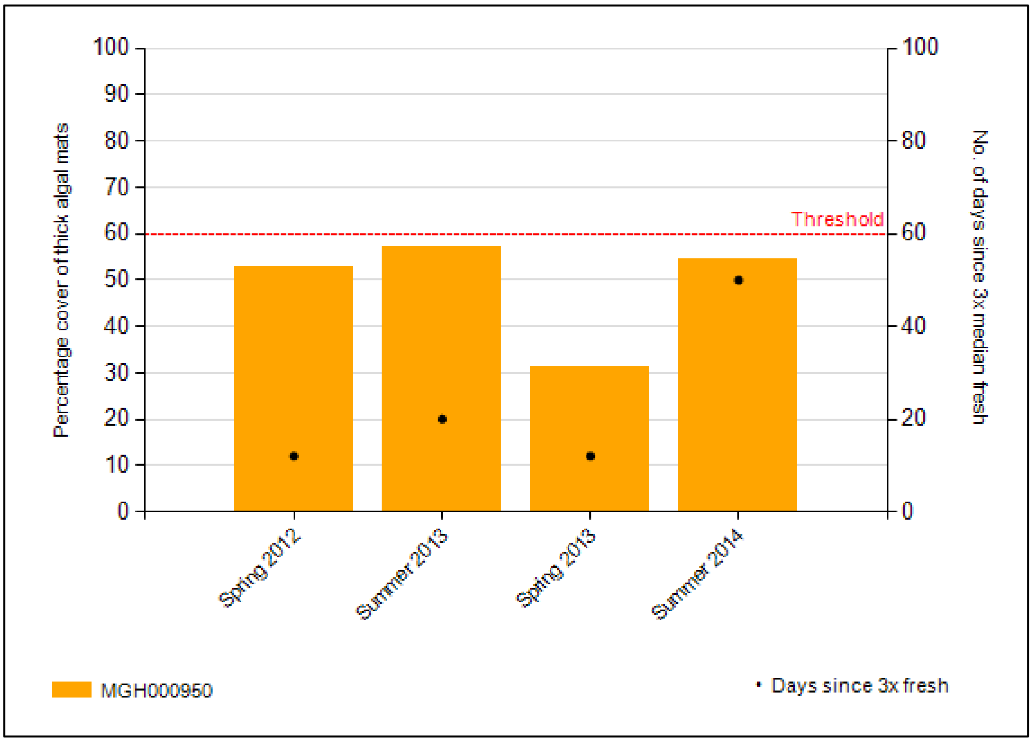


Figure 97 Percentage cover of thick mats of periphyton on the Mangaehu riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

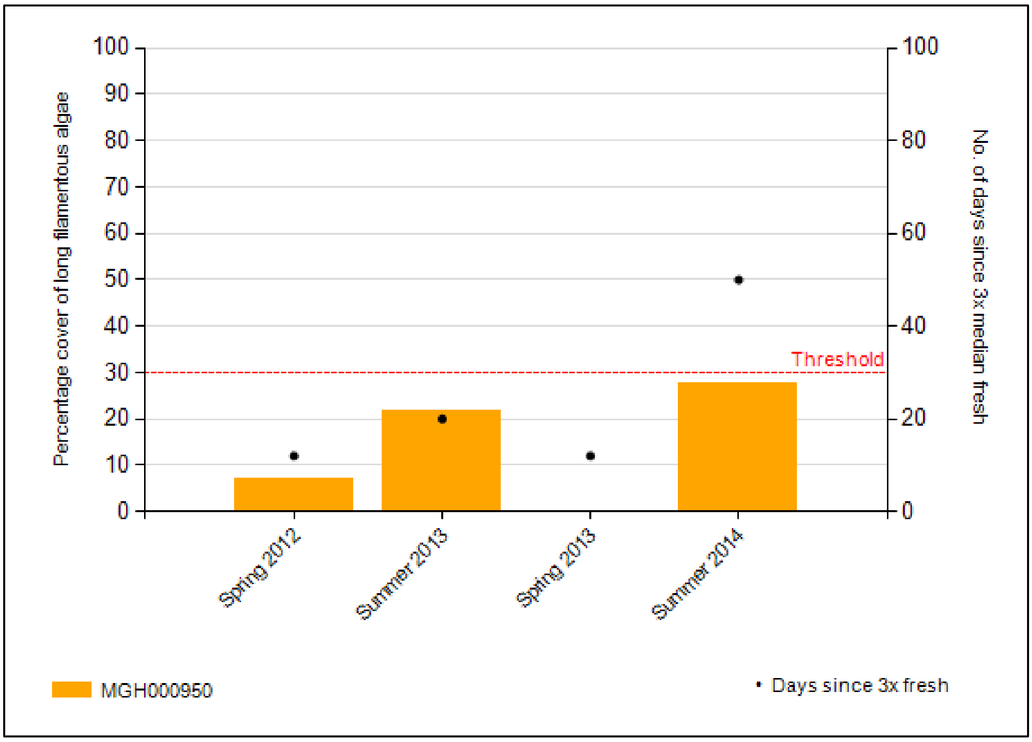


Figure 98 Percentage cover of long filamentous algae on the Mangaehu riverbed in relation to the guidelines for recreational values over the 2012-2014 monitoring period and number of days since 3x median fresh

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 was some variability with season, with spring surveys having higher TRC PI scores than summer surveys (Table 18).

In spring 2012 a 'moderate' TRC PI score was recorded which was well below the historical median and in spring 2013 it had a 'good' score that was just below the historical median. Between spring 2013 and summer 2014 the PI score dropped by 0.7 units but stayed within the 'moderate' rating and the summer 2013 score was exactly the same as the historical median.

The large decrease from spring 2013 to summer 2014 was typical for the site but the summer 2014 score was below the historical mean and was rated 'poor'. This was the worst rating for all sites surveyed in the two years examined in this report. This decrease in PI score can be attributed to the proliferation of long green filamentous algae over the warmer summer period coupled with a long period without a flushing flow.

Table 18 Median seasonal periphyton index scores for the Mangaehu River

Site	TRC PI Spring 2012	TRC PI Summer 2013	TRC PI Spring 2013	TRC PI Summer 2014	TRC PI Historical spring median	TRC PI Historical summer median
MGH000950	5.2	4.5	7.0	3.7	7.4	4.5

2.10.4 Periphyton biomass

No summer 2011 sample was taken due to adverse weather conditions. The results for the 2012- 2014 period showed moderately low to moderate chlorophyll *a* levels (Figure 99). These values were within guidelines to protect trout habitat/angling values (Table 2) and the NOF bottom line (MfE, 2014).

The chlorophyll *a* levels were not congruent with the TRC PI values (5.6, 4.5 and 3.7) for the same respective surveys. The lowest TRC PI recorded for the monitoring period 2012-2014 did not correspond with a particularly high chlorophyll *a* and there was an inverse relationship between TRC PI and chlorophyll *a*. Possible reasons for the lack of a relationship include large amounts of dead periphyton present at the site that would not contain chlorophyll *a* but would still count for periphyton cover or a substrate bias where high levels of periphyton occurred on larger rocks that were not easily sampled for chlorophyll *a* due to lifting constraints. Smaller rocks could be more easily turned over from smaller freshes and hence have lower periphyton cover. A substrate size class has been noted in the past when large boulders were found to have high levels of periphyton but were not able to be sampled for chlorophyll *a* at another site (Scott Cowperthwaite pers. comm.).

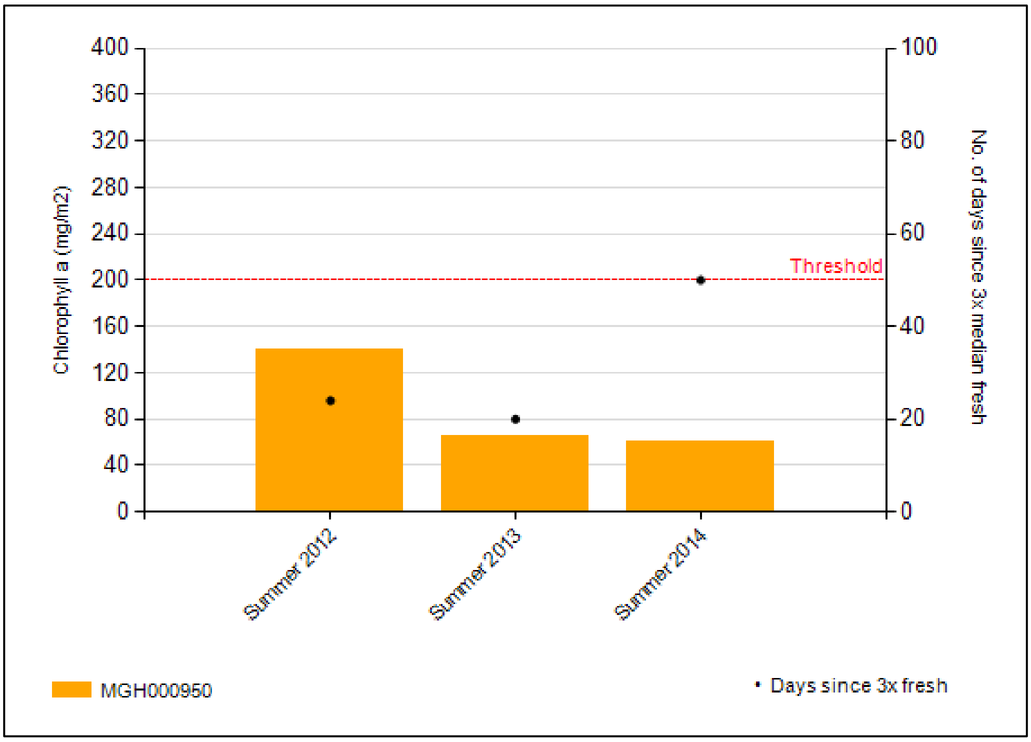


Figure 99 Periphyton biomass (chlorophyll *a*) on the Mangaehu riverbed in relation to the guidelines for recreational values over the 2010-2014 period

2.10.5 Summary of 2002-2014 (12 year dataset)

The Mangaehu River has usually had high levels of nuisance periphyton in the form of both thick algal mats and filamentous algae (Figure 100 and Figure 101). There had been only one breach of thick mats at the site though several survey results came close to breaching the guideline. Though no breaches occurred thick algal mat coverage was slightly higher than normal for the current period (2012-2014) with three out of the four surveys recording thick algal mats at above 50% of total streambed cover. The thick algal mats tended to increase from spring to 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 12 year monitoring period but the last breach was several years ago in the summer 2009 survey. These occurrences were restricted to 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 though the summer 2014 survey came close to breaching guidelines.

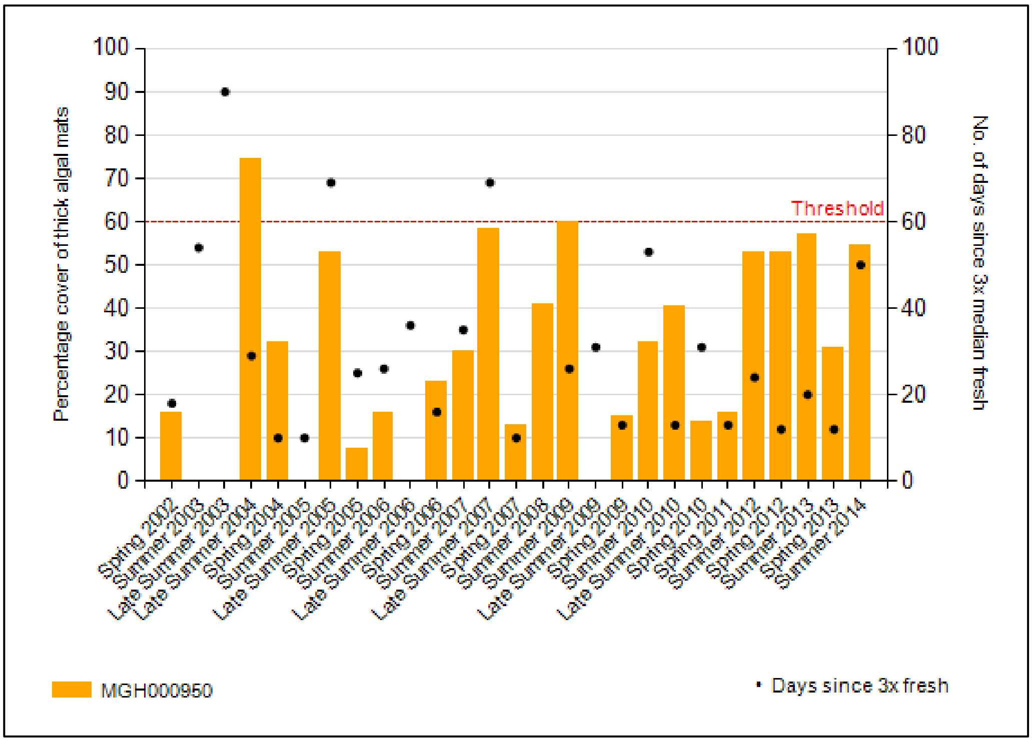


Figure 100 Percentage cover of thick mats of periphyton on the Mangaehu riverbed in relation to the guidelines for recreational values over the 2002-2014 period

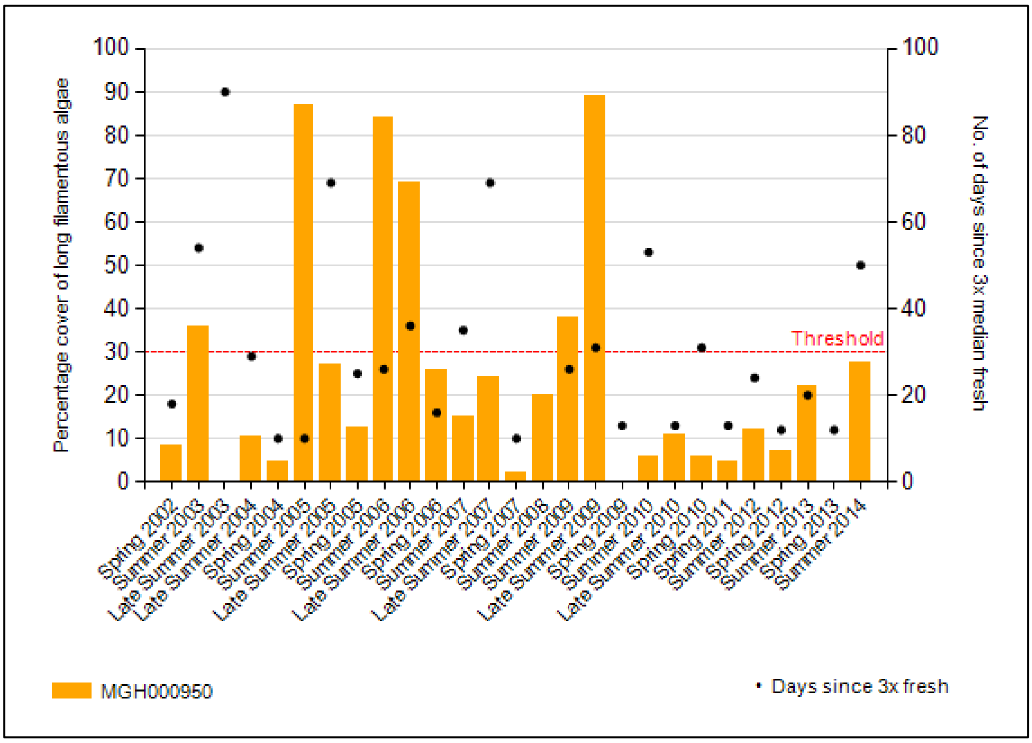
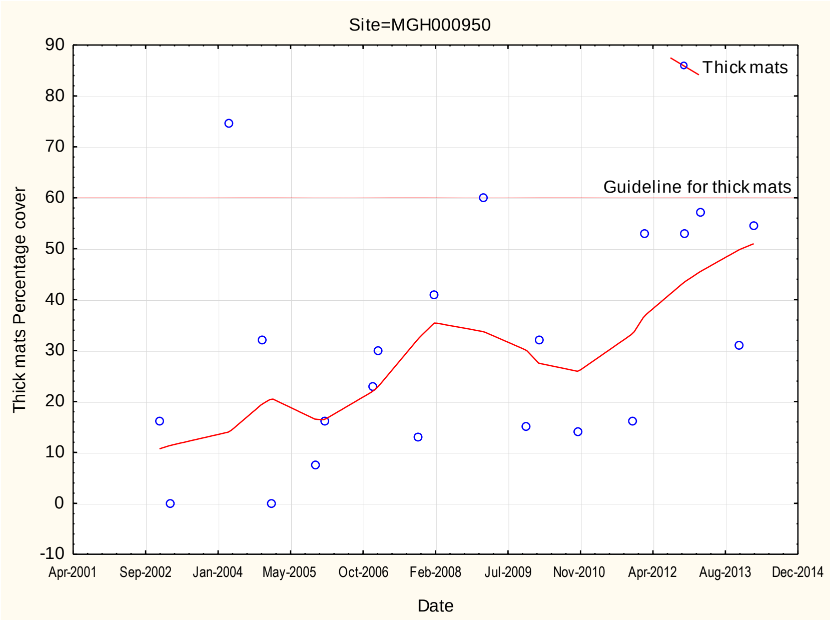


Figure 101 Percentage cover of long filamentous periphyton on the Mangaehu riverbed in relation to the recreational guideline over the 2002-2014 monitoring period

2.10.6 Long term trend analysis

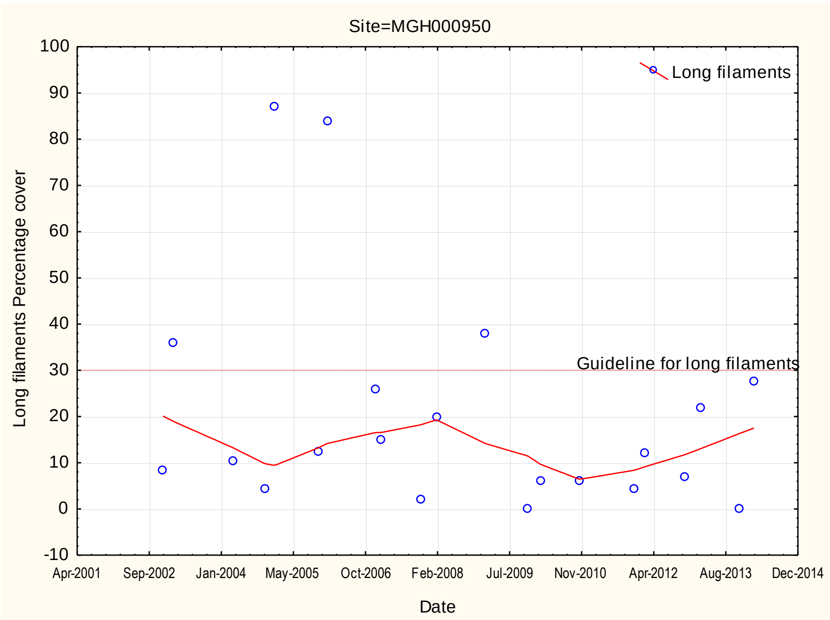
Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the percentage cover of thick mats, and long filaments of periphyton at

the Mangaehu River, at Raupuha Road over a 12 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 102 and Figure 103).



n = 21
Kendal tau = 0.338
p-value = 0.032
FDR p-value = 0.168

Figure 102 LOWESS trend analysis of percentage cover of thick mats at Mangaehu River, Raupuha Rd (MGH000950)



n = 21
Kendal tau = -0.149
p-value = 0.346
FDR p-value = 0.461

Figure 103 LOWESS trend analysis of percentage cover of long filaments at Mangaehu River, Raupuha Rd (MGH000950).

At Raupuha Road (MGH000950) over the 12 year monitored period there were no significant trends for thick mats (p=0.168) or long filaments (p=0.461) at the 5% level of significance.

3. General summary

3.1 Periphyton cover

During the 2012-2014 monitoring period 21 sites were monitored for periphyton on four occasions; spring 2012, summer 2013, spring 2013 and summer 2014 (Table 19).

Table 19 Nuisance periphyton coverage at 21 sites over the 2012-2014 monitoring period

Catchment	River/Stream	Site	Nuisance periphyton percentage cover							
			Spring 2012		Summer 2013		Spring 2013		Summer 2014	
			Mats	Filaments	Mats	Filaments	Mats	Filaments	Mats	Filaments
Upper	Patea	Barclay Road	0	0	0	0	0	0	0	0
	Maketawa	Denby Road	0	0	0	0	0	2	0	0
Middle	Kapoaiaia	Wiremu Road	0	0	0	0	0	0	0	0
	Kapoaiaia	Wataroa Road	0	14.5	3	6	0	3	0	0
	Waingongoro	Opunake Road	0	0	0	0	0	0	0	0
	Waingongoro	Stuart Road	0	0	0	0	0	0	1	0
	Manganui	SH3	0	0	0	0	0	0	0	0
	Patea	Skinner Road	0	0	6	0	0	0	20	27
	Hangatahua (Stony)	Mangatete Road	0	0	0	0	0	0	0	0
	Waiongana	SH3a	0	10	0	0	0	2	0	0
	Punehu	Wiremu Road	2	0	0	0	0	0	0	0
	Waiwhakaiho	SH3 (Egmont Village)	0	0	0	6	27	19.5	0	1.5
	Maketawa	Tarata Road	0	0	0	2.5	22.5	0	0	0
Lower	Kapoaiaia	Cape Egmont	8	23	26	6	1	26.5	0	39.5*
	Mangaehu	Raupuha Road	53	7	57	22	31	0	54.5	27.5
	Manganui	Bristol Road	0	0	0	0	0	0	18	0
	Punehu	SH45	1	0	0	2	4.5	16	0	25
	Hangatahua (Stony)	SH45	0	0	0	0	0	0	0	0
	Waiongana	Devon Road	0	0	0	1.5	30.5	22.5	6	38.5*
	Waingongoro	Ohawe Beach	0	0	1	16	0	0	36	18
	Waiwhakaiho	Constance Street, NP	2	0	1	2	0	8.5	30	27
Average			3.1	2.6	4.5	3.0	5.5	4.8	7.9	9.7

*Breach in guideline levels (MfE, 2000)

Over the 2012-2014 monitoring period there were no breaches in the thick algal mat guideline (>60% coverage) and only two breaches in the long filamentous algae guideline (>30% coverage). The breaches occurred at two lower catchment sites during the summer 2014 survey at Cape Egmont on the Kapoaiaia Stream and at Devon Road on the Waiongana River (Table 19).

If the thick algal mat and filamentous algae guidelines were combined so that a composite guideline for nuisance periphyton was created (e.g. > 60% streambed cover for %thick algal mats +%long filamentous algae x 2) then a number of additional sites would also have nuisance levels of periphyton: the Mangaehu River for both summer surveys and the spring 2012, the Waiwhakaiho River at SH3 during the summer 2013 survey, the Waiongana River at Devon Road for the spring 2013 survey, the Patea River at the Skinner Road site, Waingongoro at Ohawe Beach and the Waiwhakaiho River at Constance Street.

In general, sites with higher levels of nuisance periphyton were located at the lower end of the catchment with levels of both algae types (thick mats and long filaments) for all surveys being consistently higher at the lower catchment sites and lowest at the upper catchment sites. The most likely explanation for the higher algal levels at the lower catchment sites would be intensive agriculture that provides nutrients which encourages periphyton proliferation. Other factors that may also cause increased levels of nuisance periphyton at lower catchment sites would include a lack of shading due to either limited riparian vegetation (more common at lowland sites in the Taranaki ringplain) and/or a wider, more open bed where shading from bankside vegetation does not reach (river are often wider at lower elevations). Higher altitude rivers and streams are also more likely to have high flood peaks when heavy rainfall occurs. Further downstream floods peaks are somewhat attenuated. High flood peaks will promote scouring of the streambed.

The Mangaehu River was at times subject to high sediment loadings, a factor not present in other rivers monitored. 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.

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 the high levels of material washed down during a flood which causes significant amounts of scouring to periphyton.

There was significant seasonal variation. Usually summer surveys would typically have higher levels of nuisance periphyton due to higher water temperatures which enables faster periphyton growth, longer daylight hours which promotes photosynthesis and longer periods without freshes or floods to scour away periphyton. The summer of 2014 had the highest levels of nuisance periphyton for both categories but the spring 2013 survey had higher levels than the summer 2013. In part this was because the summer 2013 surveys generally occurred after only a short period after a fresh unlike the summer 2014 surveys.

3.2 TRC Periphyton index

TRC periphyton index scores ranged from ‘poor’ to ‘very good’ over the reported period (Table 20). For the spring 2012 survey 90% of sites were ‘very good’, 5% were ‘good’ and 5% ‘moderate’ rating. For the summer 2013 survey 76% of sites were ‘very good’, 19% were ‘good’ and 5% ‘moderate rating. For the spring 2013 survey 52% of sites were ‘very good’ and 48% were ‘good’. For the summer 2014 survey 38% of sites were ‘very good’, 33% were ‘good’, 23% ‘moderate’ and 5% ‘poor’ rating.

Table 20 TRC PI scores for 21 sites over the 2012-2014 monitoring period

Catchment	River/Stream	Site	TRC Periphyton Index Score								Median rating 2012-2014	
			Spring 2012		Summer 2013		Spring 2013		Summer 2014			
			TRC PI	Rating	TRC PI	Rating	TRC PI	Rating	TRC PI	Rating	TRC PI	Rating
Upper	Patea	Barclay Road	9.7	Very good	10.0	Very good	9.9	Very good	9.8	Very good	9.85	Very good
	Maketawa	Denby Road	9.9	Very good	10.0	Very good	9.7	Very good	10.0	Very good	9.95	Very good
Middle	Kapoaiaia	Wiremu Road	10.0	Very good	9.8	Very good	10.0	Very good	10.0	Very good	10	Very good
	Kapoaiaia	Wataroa Road	8.5	Very good	8.0	Very good	9.3	Very good	8.6	Very good	8.55	Very good
	Waingongoro	Opunake Road	8.7	Very good	9.1	Very good	7.0	Good	7.3	Good	8	Very good
	Waingongoro	Stuart Road	9.6	Very good	9.6	Very good	6.1	Good	5.2	Moderate	7.85	Good
	Manganui	SH3	10.0	Very good	9.8	Very good	10.0	Very good	9.8	Very good	9.9	Very good
	Patea	Skinner Road	9.2	Very good	7.2	Good	9.3	Very good	4.5	Moderate	8.2	Very good
	Hangatahua (Stony)	Mangatete Road	10.0	Very good	10.0	Very good	9.8	Very good	6.4	Good	9.9	Very good
	Waiongana	SH3a	8.7	Very good	9.1	Very good	7.0	Good	7.3	Good	8	Very good
	Punehu	Wiremu Road	9.9	Very good	9.2	Very good	10.0	Very good	10.0	Very good	9.95	Very good
	Waiwhakaiho	SH3 (Egmont Village)	9.0	Very good	8.4	Very good	6.1	Good	7.4	Good	7.9	Good
	Maketawa	Tarata Road	9.4	Very good	9.1	Very good	8.2	Very good	9.2	Very good	9.15	Very good
Lower	Kapoaiaia	Cape Egmont	6.8	Good	6.7	Good	6.8	Good	6.8	Good	6.8	Good
	Mangaehu	Raupuha Road	5.2	Moderate	4.5	Moderate	7.0	Good	3.7	Poor	4.85	Moderate
	Manganui	Bristol Road	9.2	Very good	8.6	Very good	6.3	Good	6.2	Good	7.45	Good
	Punehu	SH45	9.3	Very good	9.1	Very good	7.8	Good	7.1	Good	8.45	Very good
	Hangatahua (Stony)	SH45	10.0	Very good	10.0	Very good	10.0	Very good	9.0	Very good	10	Very good
	Waiongana	Devon Road	9.6	Very good	9.6	Very good	6.1	Good	5.2	Moderate	7.85	Good
	Waingongoro	Ohawe Beach	9.8	Very good	6.8	Good	9.0	Very good	5.5	Moderate	7.9	Good
	Waiwhakaiho	Constance Street, NP	9.0	Very good	7.8	Good	6.6	Good	4.6	Moderate	7.2	Good

3.3 Periphyton biomass (chlorophyll *a*)

Periphyton biomass levels as estimated by chlorophyll *a* ranged from 1 to 370 mg/m² with average levels at sites ranging from 2 to 216 mg/m² over the reported period (Table 21). There was significant variation among years for the average for all sites. However, most sites were consistent among years, especially sites with low chlorophyll *a* levels that tended to have very low levels of fluctuation. Some sites with more moderate levels of chlorophyll *a* such as the Kapoaiaia Stream at Cape Egmont had significant variation. With only four years data it was not possible to determine whether large spikes in chlorophyll were relatively normal or were in fact outliers.

Table 21 Periphyton biomass as estimated by chlorophyll *a* (mg/m^2) for 21 sites over the 2010-2014 monitoring period

Catchment	River/Stream	Site name	Periphyton biomass (chlorophyll *a* mg/m²)				
			Summer 2011	Summer 2012	Summer 2013	Summer 2014	Average
Upper	Patea	Barclay Road	5	6	6	5	6
	Maketawa	Denby Road	4	6	1	2	3
Middle	Kapoaiaia	Wiremu Road	3	5	11	7	7
	Kapoaiaia	Wataroa Road	99	150	44	42	84
	Waingongoro	Opunake Road	19	17	10	21	17
	Waingongoro	Stuart Road	78	58	92	42	68
	Manganui	SH3	7	3	2	2	4
	Patea	Skinner Road	67	220*	151	88	132
	Hangatahua (Stony)	Mangatete Road	n/a	2	4	3	3
	Waiongana	SH3a	65	104	95	98	91
	Punehu	Wiremu Road	4	4	6	2	4
	Waiwhakaiho	SH3 (Egmont Village)	37	34	38	212*	80
	Maketawa	Tarata Road	6	66	17	39	32
Lower	Kapoaiaia	Cape Egmont	55	370*	59	67	138
	Mangaehu	Raupuha Road	n/a	140	65	61	89
	Manganui	Bristol Road	31	85	16	48	45
	Punehu	SH45	12	17	31	44	26
	Hangatahua (Stony)	SH45	n/a	1	3	4	3
	Waiongana	Devon Road	64	86	84	257*	123
	Waingongoro	Ohawe Beach	176	300*	235*	151	216*
	Waiwhakaiho	Constance Street, NP	50	61	6	70	47
Average			43	83	46	66	

*Breach in NOF bottom line (D band)

Though chlorophyll *a* levels followed other periphyton indices with the trend of upper catchment<middle catchment<lower catchment there was not a substantial difference between middle catchment sites and lower catchment sites. Both upper catchment sites had very low levels of chlorophyll *a*. Of the 11 middle catchment sites, six had average scores below 50 mg/mg² indicating low levels of periphyton biomass. Four of the remaining five mid catchment sites had chlorophyll *a* levels between 50-120 mg/mg² while the Patea River at Skinner Rd had an average chlorophyll *a* level of 132 mg/mg². The Hangatahua (Stony) River at SH45 and Punehu Stream at SH45 were the only lower catchment sites to be below 50 mg/m². The lower catchment sites on the Manganui, Mangaehu and Waiwhakaiho Rivers were between 50-120 mg/m², the Kapoaiaia Stream at Cape Egmont, Waiongana had average chlorophyll *a* levels between 120-200 mg/m² and the Waingongoro River had an average level above 200 mg/m².

3.4 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 forth report to be written for this programme, and is the second 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 12 year data set.

Table 22 Kendall Tau correlations for periphyton (thick mats) for data from 2002-2014. A significant trend at $p<0.05$ is shown in orange text, and $p<0.01$ in red text

Site	Valid N	Kendall Tau	Z	p-value	FDR adjustment
KPA000250	21	-0.540562	-3.42790	0.000608	0.012774
KPA000700	21	-0.267452	-1.69601	0.089885	0.325526
KPA000950	21	-0.113658	-0.72075	0.471065	0.821926
MGH000950	21	0.338200	2.14464	0.031981	0.167902
MGN000195	22	-0.257878	-1.67974	0.093007	0.325526
MGN000427	22	0.097916	0.63780	0.523605	0.821926
MKW000200	22	-0.010275	-0.06693	0.946636	0.946636
MKW000300	22	-0.332940	-2.16868	0.030107	0.167902
PAT000200	23	-0.124970	-0.83503	0.403701	0.821926
PAT000360	23	0.133451	0.89170	0.372553	0.821926
PNH000200	22	0.148997	0.97052	0.331786	0.821926
PNH000900	22	-0.052964	-0.34499	0.730099	0.851783
STY000300	20	-0.016644	-0.10260	0.918282	0.946636
STY000400	20	-0.016644	-0.10260	0.918282	0.946636
WGA000260	20	-0.208479	-1.28515	0.198740	0.596219
WGA000450	20	0.087740	0.54087	0.588599	0.821926
WGG000150	23	-0.424297	-2.83509	0.004581	0.048104
WGG000665	23	-0.098522	-0.65831	0.510338	0.821926
WGG000995	23	0.072890	0.48704	0.626229	0.821926
WKH000500	19	0.092704	0.55460	0.579167	0.821926
WKH000920	19	0.068913	0.41227	0.680138	0.840171

Long term trend analysis of the 21 sites monitored for thick periphyton mats found only two sites with significant trends at the 5% level once p values had the FDR adjustment applied to them. The upper Kapoaiaia Stream site at Wiremu Road and the upper Waingongoro River site at Opunake Road had a decline in thick mats during the monitored period. No significant reduction in mats occurred for the other downstream sites for both waterways (Table 22). In total eight sites had a positive trend for thick periphyton mats but these were all not significant indicating that there was no actual trend. The Mangaehu River had a significant p value before FDR adjustment though this was non-significant at the 5% level once the p value had the FDR adjustment applied.

Long term trend analysis of the 21 sites monitored for long filamentous algal found three sites with significant trends at the 5% level once p values had the FDR adjustment applied to them. A further six sites were very close to being significant (Table 23). All significant and close to significant sites had a negative trend indicating that long filamentous algae were declining over the monitored period.

Table 23 Kendall Tau correlations for periphyton (long filaments) for data from 2002-2014. A significant trend at $p<0.05$ is shown in orange text, and $p<0.01$ in red text.

Site	Valid N	Kendall Tau	Z	p-value	FDR adjustment
KPA000250	21	-0.639286	-4.05394	0.000050	0.001007
KPA000700	21	-0.405840	-2.57357	0.010065	0.050327
KPA000950	21	-0.139092	-0.88203	0.377759	0.472198
MGH000950	21	-0.148685	-0.94286	0.345751	0.461001
MGN000195	22	--	--	--	--
MGN000427	22	-0.332827	-2.16794	0.030163	0.075862
MKW000200	22	0.157459	1.02565	0.305059	0.435798
MKW000300	22	-0.463196	-3.01713	0.002552	0.017012
PAT000200	23	-0.095813	-0.64021	0.522037	0.580041
PAT000360	23	-0.453874	-3.03271	0.002424	0.017012
PNH000200	22	-0.067863	-0.44204	0.658462	0.693118
PNH000900	22	-0.101337	-0.66008	0.509200	0.580041
STY000300	20	-0.226608	-1.39691	0.162441	0.295348
STY000400	20	-0.202755	-1.24986	0.211349	0.352248
WGA000260	20	-0.281184	-1.73333	0.083036	0.166073
WGA000450	20	0.016267	0.10028	0.920123	0.920123
WGG000150	23	-0.329833	-2.20389	0.027532	0.075862
WGG000665	23	-0.316552	-2.11515	0.034417	0.076483
WGG000995	23	-0.324096	-2.16556	0.030345	0.075862
WKH000500	19	-0.367993	-2.20153	0.027699	0.075862
WKH000920	19	-0.183445	-1.09746	0.272438	0.419136

The three sites with significant trends were all in separate catchments: Kapoaiaia Stream at Wiremu Road, the Patea River at Skinner Road and the Maketawa Stream at Tarata Road. All three Waingongoro River sites were close to having a significant decline in filamentous algae as was another site on the Kapoaiaia Stream at Wataroa Road, the Manganui River at Bristol Road and the Waiwhakaiho River at SH3 (Egmont Village). In total only two sites had a positive trend for filamentous algae which were both not significant.

There has been a significant amount of riparian vegetation and fencing implemented throughout the Taranaki region since periphyton monitoring began. There has generally been an increase in all catchments, and this may have led to the reduction of nuisance growths at the sites where negative trends for periphyton were detected.

4. Conclusions

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

- The rivers and streams monitored were in reasonable condition. No sites failed for thick algal mats and only the Kapoaiaia and Waiongana Rivers failed for long filamentous algae for the 2014 survey only. All rivers received a rating of at least 'moderate' for the TRC periphyton index score except for the Mangaehu River for the 2014 survey only which had a 'poor' rating.
- Periphyton biomass results were generally poorer. There were five sites with chlorophyll *a* levels in exceedance of the NOF bottom line but of these, four of the five sites had exceedances for only one of the four surveys reported on. The Waingongoro River at Ohawe Beach had consistency high chlorophyll *a* levels and was the only site with an average chlorophyll *a* level in exceedance of the NOF bottom line.
- The data used for nuisance periphyton guidelines (thick algal mats and long filaments) overlaps slightly with the periphyton index score but was potentially completely different from the periphyton biomass data as rocks viewed for periphyton cover are not necessarily, and probably unlikely, to be the same ones used to collect periphyton biomass. Therefore, even though ten replicates were used, results can potentially differ significantly between the two methods. Furthermore, periphyton coverage examines both live and dead periphyton while periphyton biomass uses chlorophyll *a* which is contained within live material only.
- True 'upstream sites' with little agriculture in their catchment had low levels of periphyton.
- Middle and lower catchment sites had higher levels of periphyton which occasionally breached guidelines.
- Due to the high number of variables involved (nutrients, sunlight, temperature, substrate type, time since last fresh, water clarity, level of invertebrate grazing etc) only broad generalisations can be made as different sites behave differently due to site specific situations.
- The cumulative affects of agricultural discharges via point source or diffuse pollution is likely to be a leading cause of algae proliferation in middle and lower catchment sites.
- 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 never had any guideline breaches.
- The time trend analyses reveal that for the majority of sites there was no statistically significant trend. There was a significant trend at four sites which all showed long term decreasing levels of nuisance periphyton with the upper Kapoaiaia and Waingongoro sites having decreasing levels of thick algal mats and the upper Kapoaiaia, Patea River at Skinner Road and Maketawa at Tarata Road sites having decreasing levels of long filamentous algae.
- There has been a significant amount of riparian vegetation and fencing implemented throughout the Taranaki region since periphyton monitoring began. There has generally been an increase in all catchments, and this may have led to the reduction of nuisance growths at some sites.
- Flood flows can cause a reduction in periphyton growth but the degree of this effect is not consistent within streams or seasons. The generally longer period of

low flows without a significant fresh probably contributed to the higher periphyton levels in the summer 2014 survey.

5. Additional monitoring: *Didymosphenia geminata*

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

Didymo (*Didymosphenia geminata*), is a freshwater diatom native to Northern Europe that was first found in New Zealand in October 2004 (Photo 5). 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 5 A *Didymosphenia geminate* covered rock

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

The sites in Table 24 and Figure 104 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 24 Sites monitored for *Didymosphenia geminate*

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

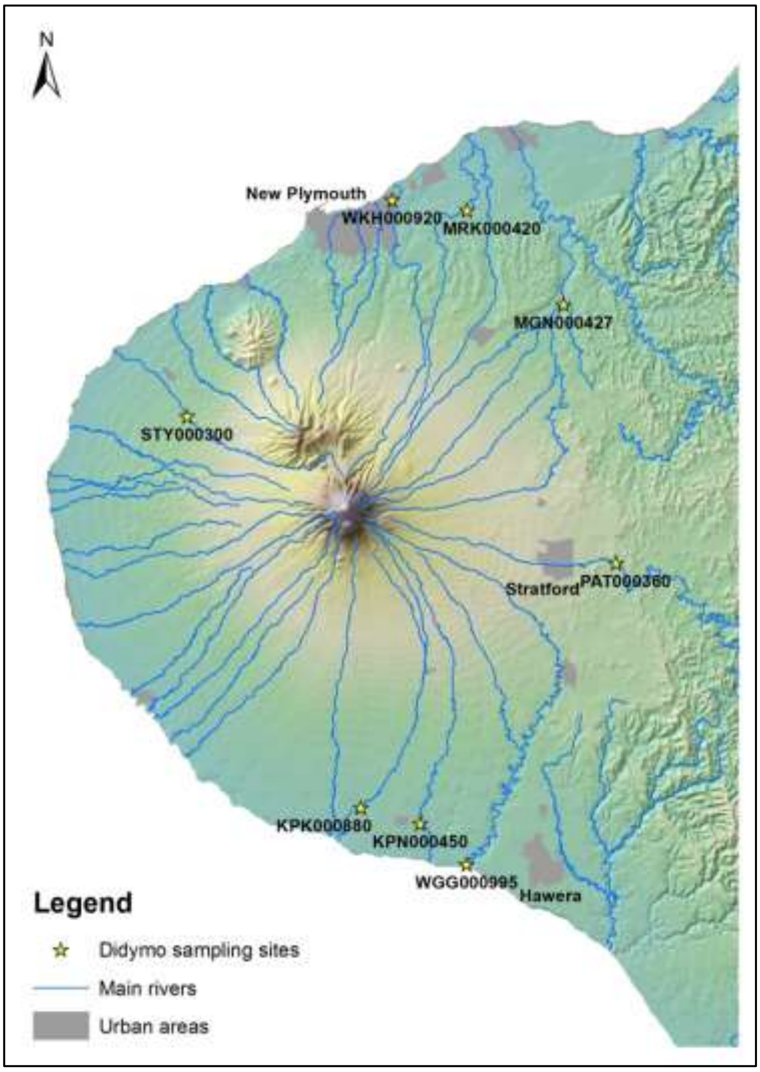


Figure 104 Sites to be monitored for *Didymosphenia geminate*

6. Recommendations

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

2. THAT in the 2014-2016 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.

4. THAT programmes designed to limit nutrient input into Taranaki streams and rivers continue to be implemented such as riparian planting/fencing and disposal of diary shed effluent to land in order to reduce periphyton levels in lowland streams and rivers in agriculturally dominated catchments.

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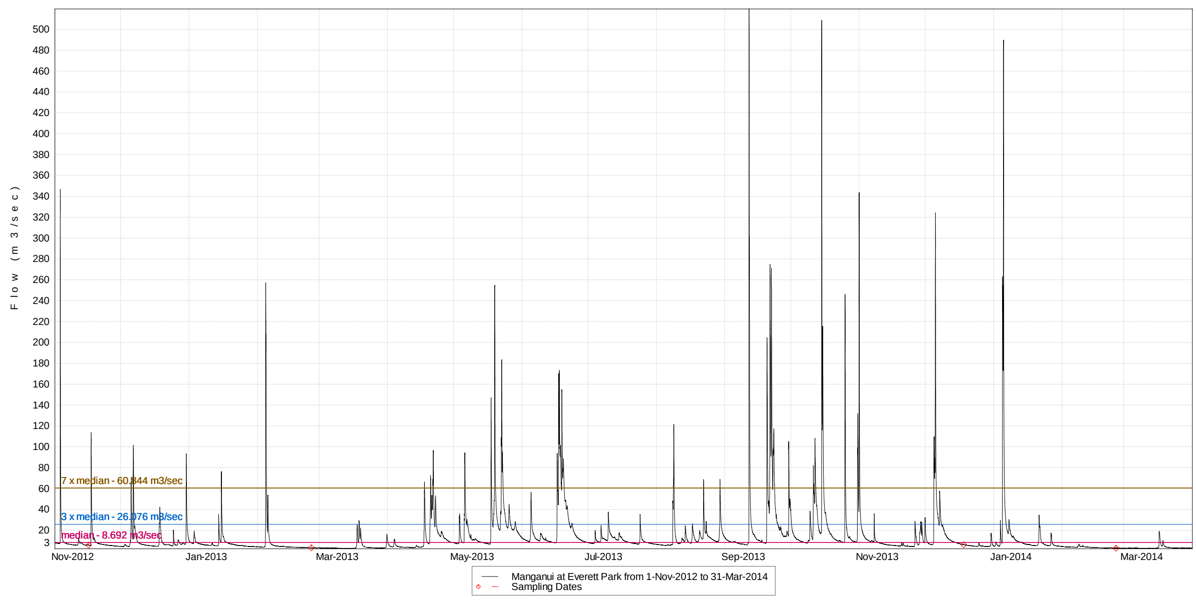
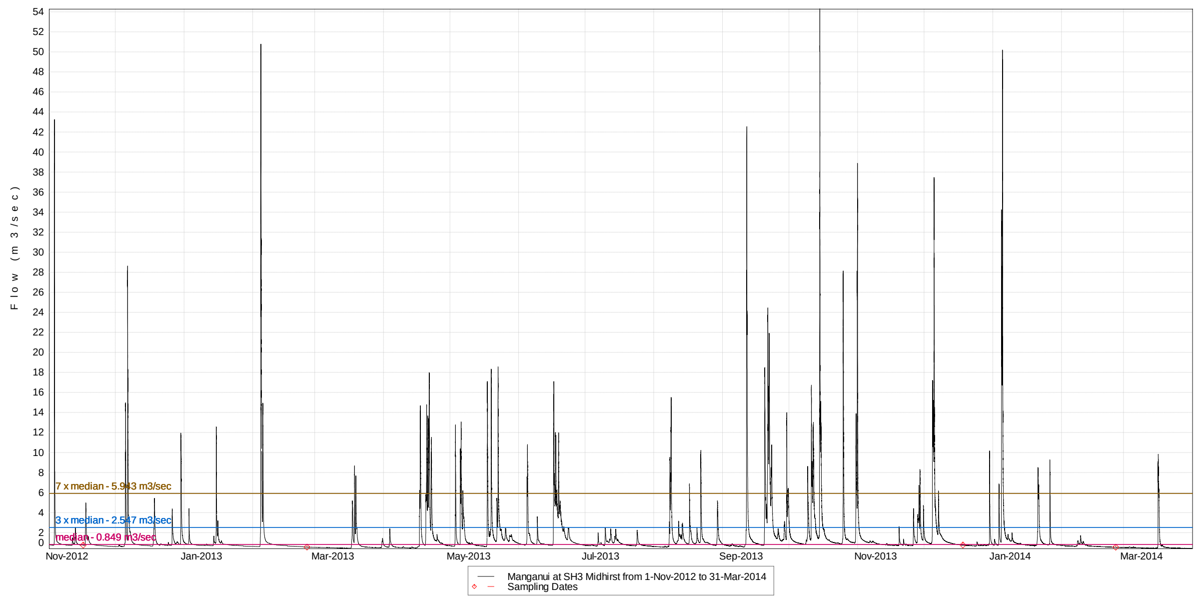
Appendix I

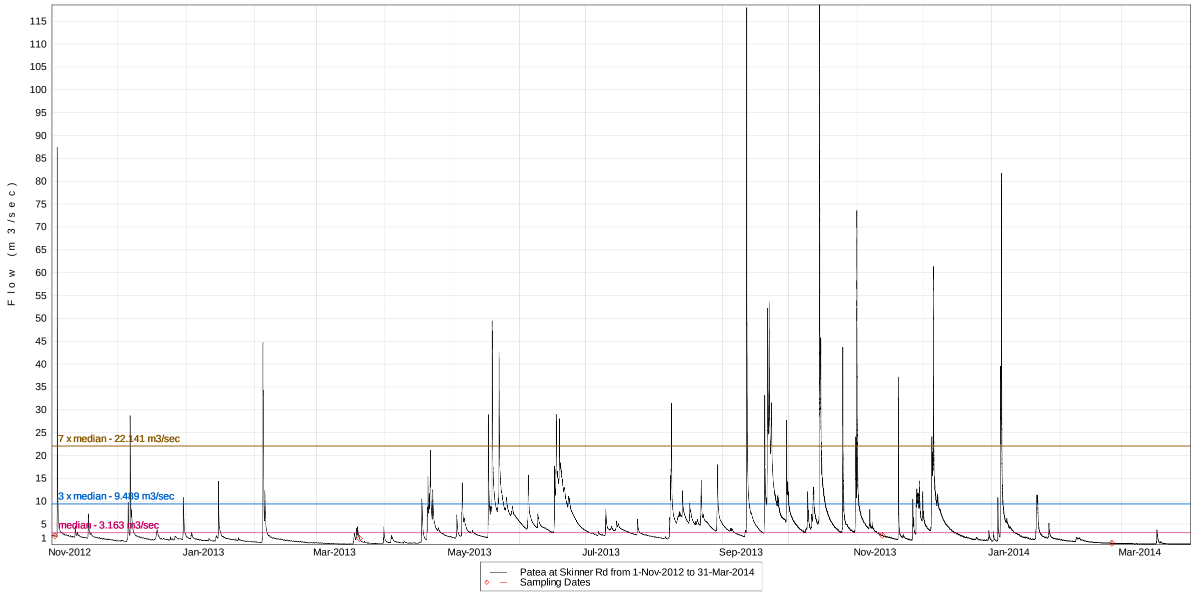
Flow data 2012-2014



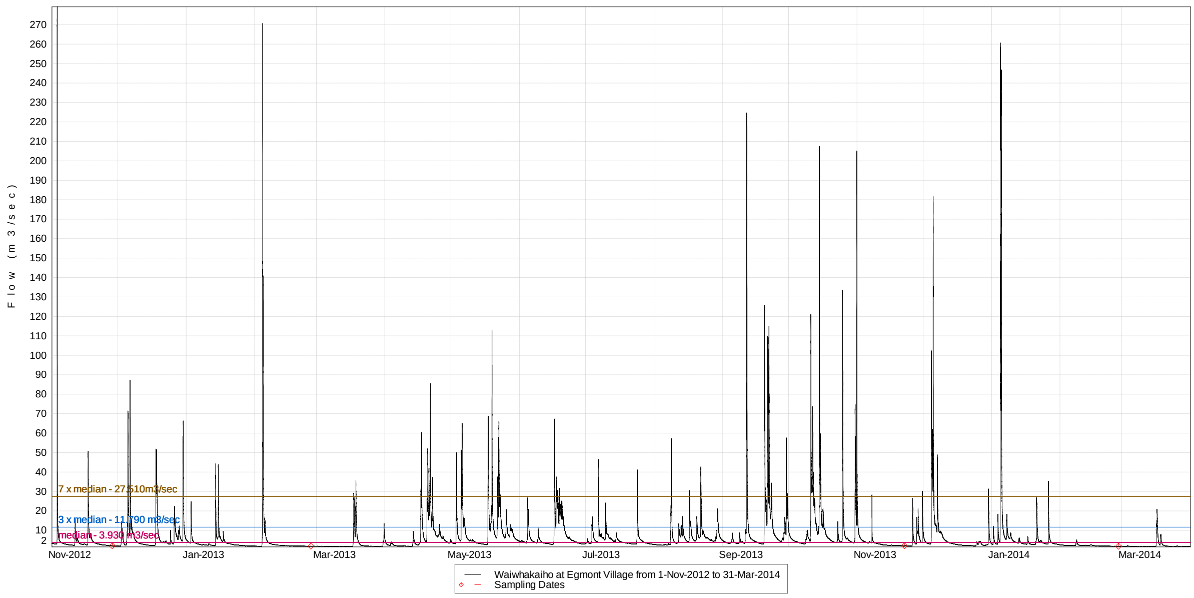
Flow in Manganui River at Everett Park over the 2012-2014 sampling period



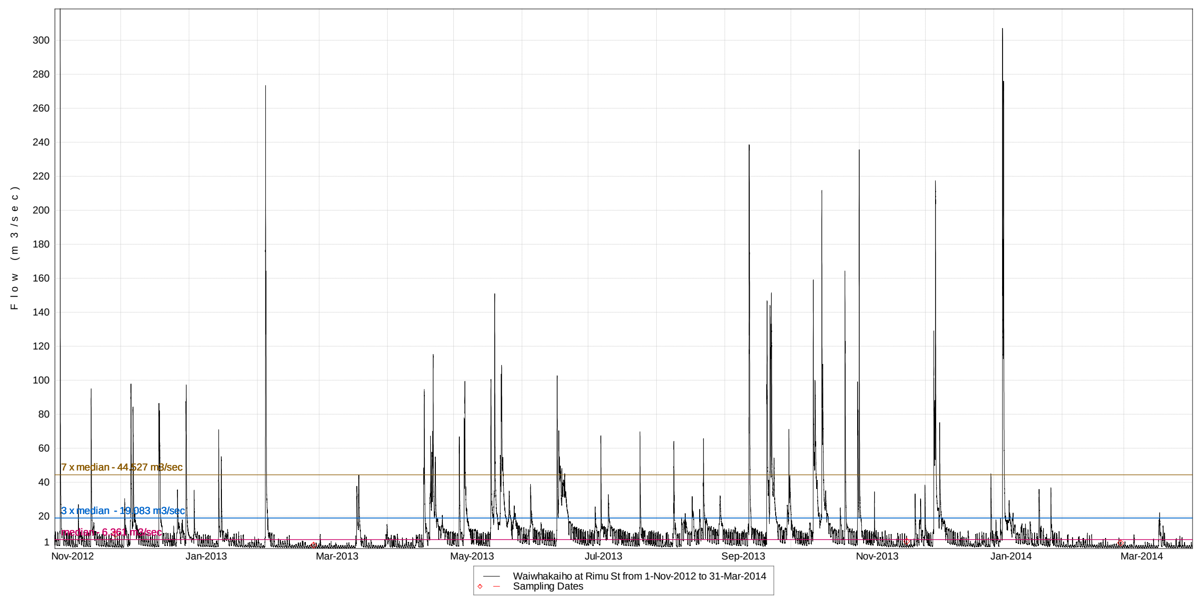
Flow in Manganui River at SH3 over the 2012-2014 sampling period



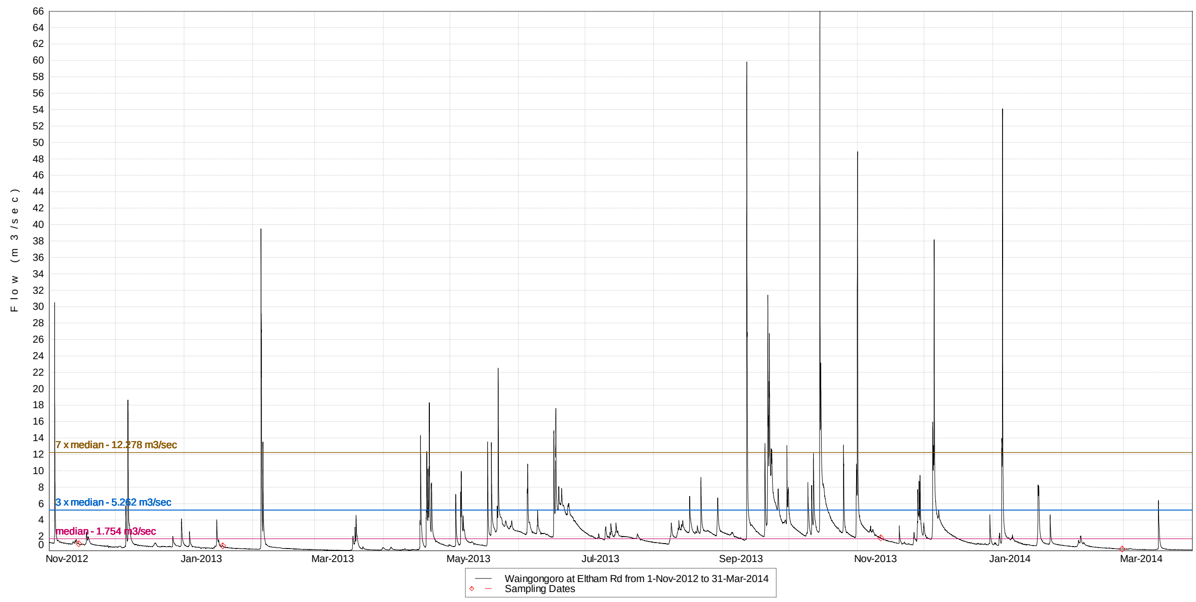
Flow in the Patea River over the 2012-2014 sampling period



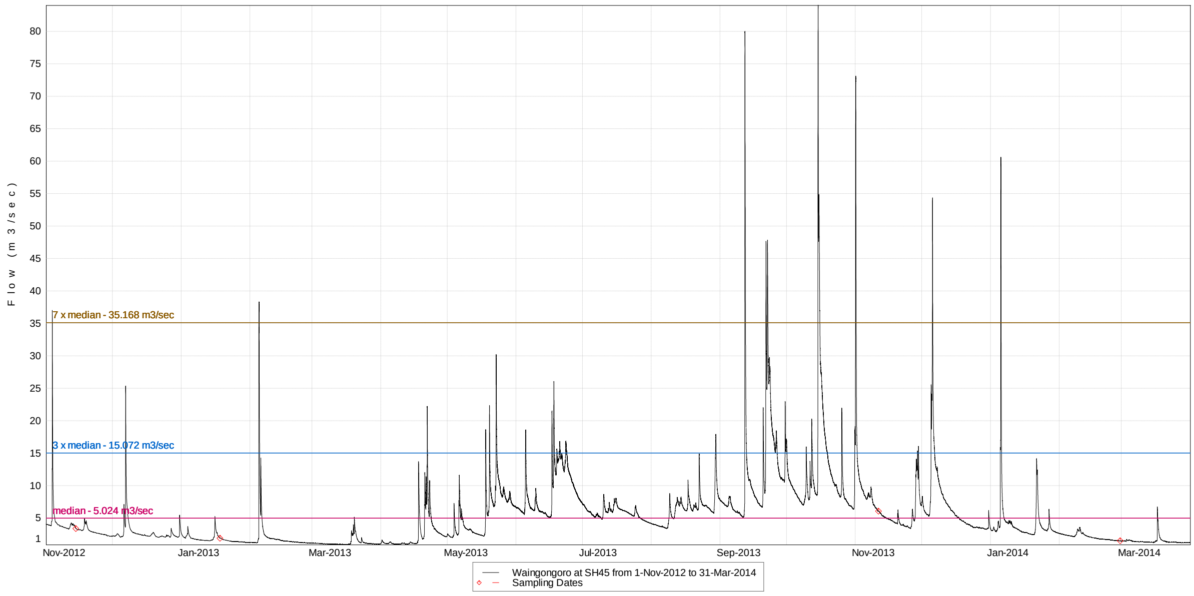
Flow in the Waiwhakaiho River at Egmont Village during the 2012-2014 sampling period



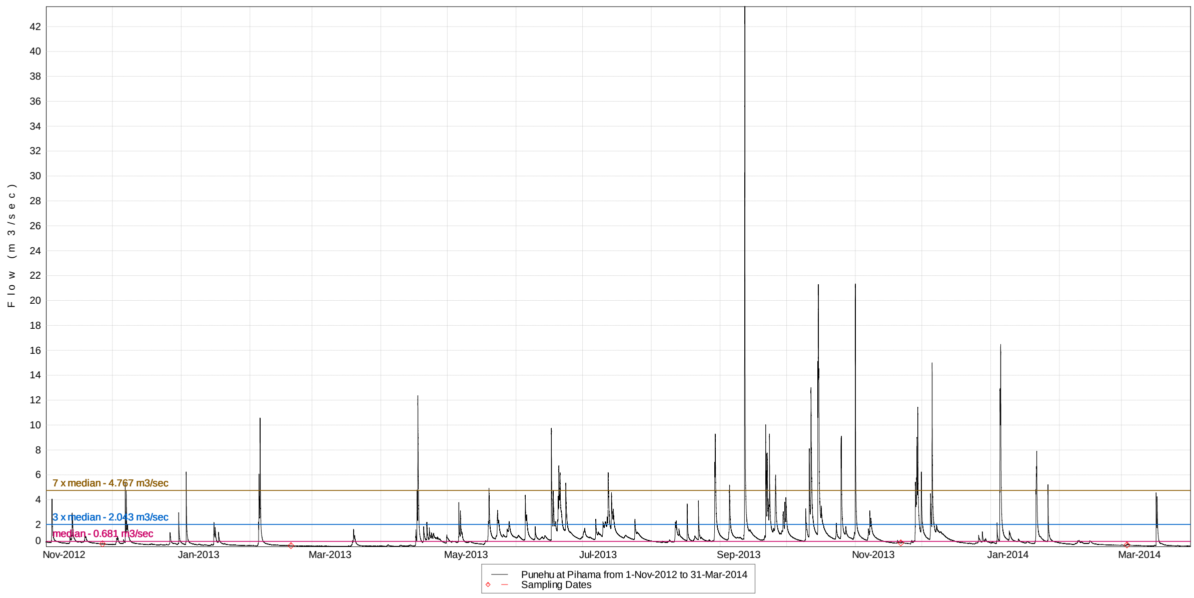
Flow in the Waiwhakaiho River at Rimu Street during the 2012-2014 sampling period



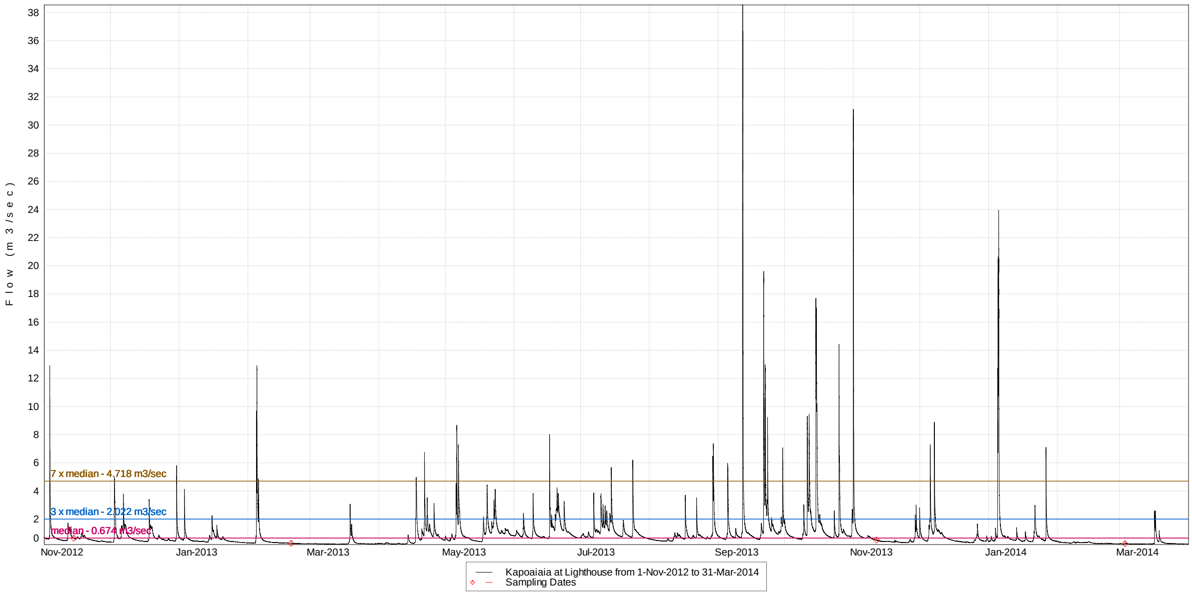
Flow in the Waingongoro River at Eltham Road during the 2012-2014 sampling period



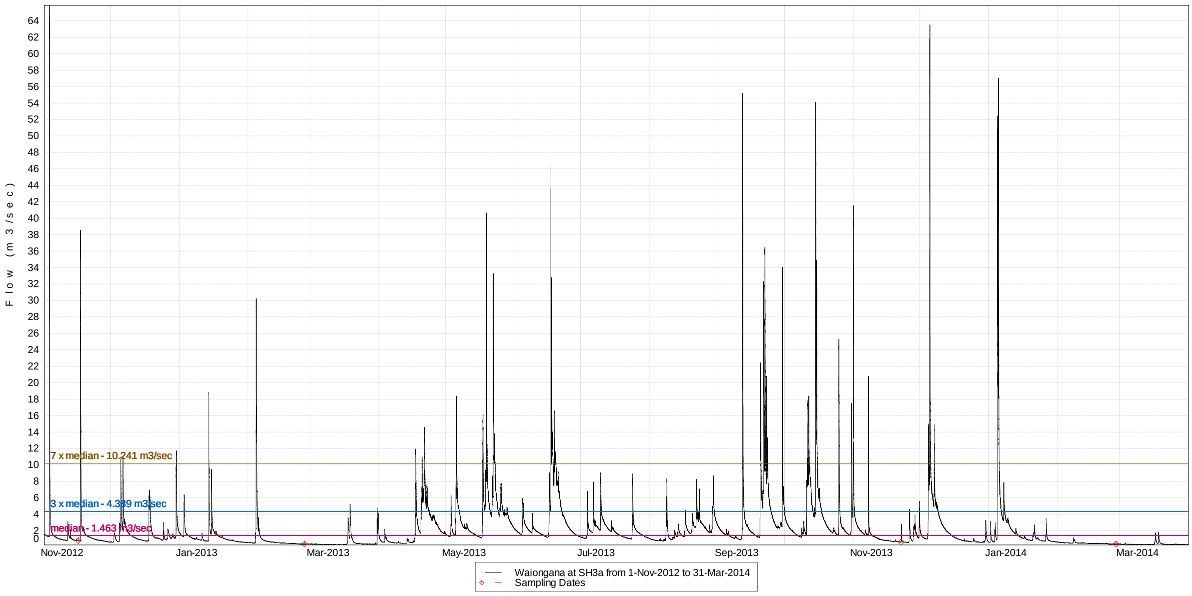
Flow in the Waingongoro River at SH45 during the 2012-2014 sampling period



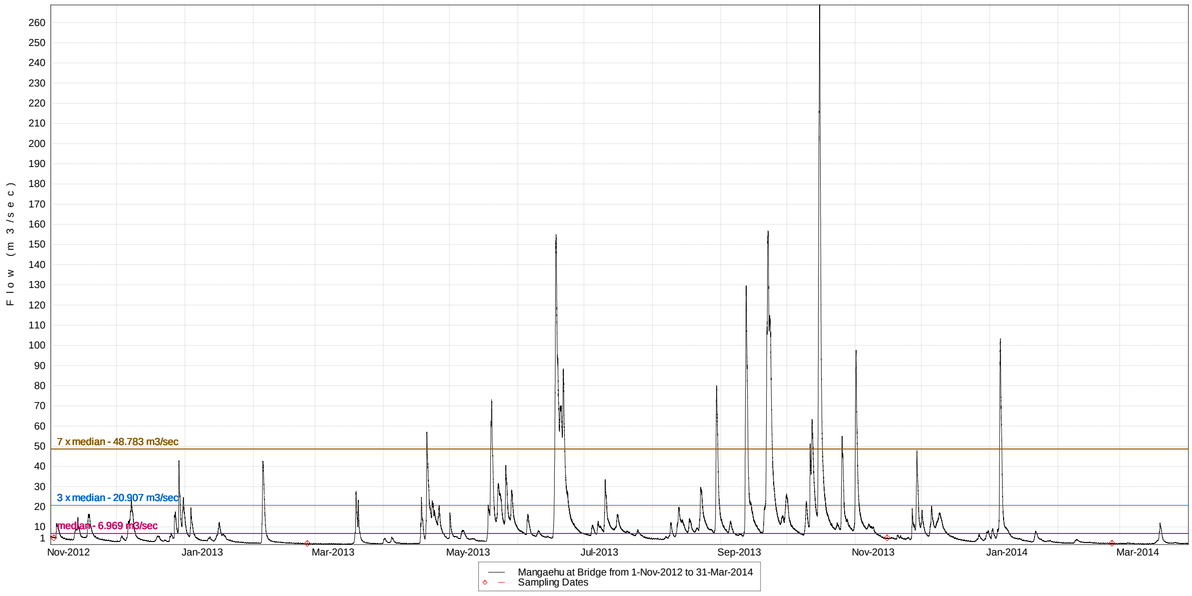
Flow in the Punehu Stream during the 2012-2014 sampling period



Flow in the Kapoaiaia Stream during the 2012-2014 monitoring period



Flow in the Waiongana River at SH3a during the 2012-2014 monitoring period



Flow in the Mangaehu River during the 2012-2014 survey period

Appendix II

Nutrient data 2012-2014

Nutrient data showing the median value for a sampling year (July-June) for dissolved reactive phosphorus and dissolved inorganic nitrogen (ammonia, nitrate and nitrite). Prevention of undesirable growths DRP <0.03 mg/L and total nitrogen <0.6 mg/L (ANZEEC, 2000), and prevention of excessive *Phormidium* growths DIN <0.1 mg/L (NZSSC, 2015)

Catchment	River/Stream	Site	2012-2013			2013-2014		
			DRP-1	DIN	TN	DRP-1	DIN	TN
Upper	Patea	Barclay Road	0.021	0.029	0.070	0.017	0.023	0.080
	Maketawa	Denby Road	n/a	n/a	n/a	n/a	n/a	n/a
Middle	Kapoaiaia	Wiremu Road	n/a	n/a	n/a	n/a	n/a	n/a
	Kapoaiaia	Wataroa Road	n/a	n/a	n/a	n/a	n/a	n/a
	Waingongoro	Opunake Road	n/a	n/a	n/a	n/a	n/a	n/a
	Waingongoro	Eltham Rd*	0.037	1.178	1.380	0.03	1.186	1.530
	Manganui	SH3	n/a	n/a	n/a	n/a	n/a	n/a
	Patea	Skinner Road	0.037	0.893	1.005	0.036	0.987	1.250
	Hangatahua (Stony)	Mangatete Road	0.019	0.022	0.033	0.016	0.012	0.040
	Waiongana	SH3a	n/a	n/a	n/a	n/a	n/a	n/a
	Punehu	Wiremu Road	0.023	0.021	0.125	0.019	0.066	0.160
	Waiwhakaiho	SH3 (Egmont Village)	0.029	0.110	0.150	0.025	0.135	0.165
	Maketawa	Tarata Road	0.026	0.184	0.280	0.030	0.305	0.410
Lower	Kapoaiaia	Cape Egmont	n/a	n/a	n/a	n/a	n/a	n/a
	Mangaehu	Raupuha Road	0.007	0.079	0.220	0.006	0.103	0.245
	Manganui	Bristol Road	n/a	n/a	n/a	n/a	n/a	n/a
	Punehu	SH45	0.058	0.769	0.965	0.0505	1.417	1.900
	Hangatahua (Stony)	SH45	n/a	n/a	n/a	n/a	n/a	n/a
	Waiongana	Devon Road	n/a	n/a	n/a	n/a	n/a	n/a
	Waingongoro	SH45*	0.052	1.635	2.100	0.052	1.525	2.180
	Waiwhakaiho	Constance Street, NP	n/a	n/a	n/a	n/a	n/a	n/a

* No nutrient data was available for the Waingongoro sites but sites close to the periphyton sites did have nutrient data and are therefore displayed.