

Memorandum

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Long term SoE trends for periphyton for full record (1998-2013) and chlorophyll a analysis

Periphyton

Periphyton is the slime that can be seen from time to time coating stones, wood, weeds or any other stable surfaces in rivers and streams, especially during extended periods of low flows and warm temperatures. Periphyton community is fundamental for sustaining in-stream life, affecting natural character, and determining the intrinsic values of stream ecosystem. The community is composed predominantly of algae and cyanobacteria (also known as 'blue-green' algae). In the 'New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams' produced by MfE (2000), the focus is on periphyton communities living in relatively shallow streams/rivers (i.e. wadeable) which have beds predominantly composed of gravels and cobbles. These are the environments where periphyton impact most on human values and contribute to aquatic food chain.

The MfE guidelines specify that for aesthetic and ecological health reasons, long algae filaments should not exceed 30% coverage of the river bed, and thick algae mats should not exceed 60%.

To determine the state of the region's streams and rivers with regard to periphyton, the Council monitors periphyton twice a year, in 'worst case' conditions in spring and summer, at 21 sites in 10 catchments around the region. This programme is one component of the Council's on-going State of the Environment (SoE) monitoring regime.

Results from the 2010/11 to 2012/2013 monitoring years are presented in this memo. In addition, data from the SoE periphyton programme for the period ranging from summer 1998 to summer 2013 has been trended utilising the full historical record (15 years). It should be noted that this trend analysis is by its nature assessing trends in the percentage cover of periphyton when surveyed under conditions most conducive to the greatest proliferation, rather than in periphyton all year round.

Trend analyses for periphyton were performed by applying a LOWESS fit to a time scatterplot of the percentage cover for thick mats and long filaments of periphyton. Next, the Mann-Kendall analyses test followed by Benjamini-Hochberg False Discovery Rate (FDR) analyses were used to determine the significance of the trend analyses.

Chlorophyll *a*

Chlorophyll *a* is a photosynthetic pigment present in all algal species. As a consequence, measurements of the density of this pigment across a stream bed are commonly used as another means of estimating periphyton biomass, besides the percentage coverage methodology described above. Chlorophyll *a* ranges from 0.5% to 2% of total algal biomass,

with this ratio varying dependent on the species present in addition to nutrient and light availability. However, overall, measurements of chlorophyll *a* are considered to be an effective, rapid and cheap method of assessing periphyton biomass and can be easily related to existing guidelines. This Council has been undertaking measurements of chlorophyll *a* once a year, at the same sites as are used for periphyton coverage measurements.

The Government has just released the *National Policy Statement for Freshwater Management 2014* (NPS-FM). According to the National Objective Framework (NoF) contained within the NPS-FM, the extent of periphyton is to be assessed by measurements of chlorophyll *a*, undertaken on a regular monthly basis for at least 3 years before sites can be graded or banded into one of four attribute states (Table 1). Grading is on the basis of the number of samples each year that exceed a certain threshold (that is, grading is based on the worst case measurements rather than the average state). Of note, the NOF recognises that certain parts of the country are naturally more prone to excessive periphyton than others, due to warmer and drier conditions (hence extended periods of low, slow, and warm flows in streams) coupled with naturally originating phosphate due to underlying geology. The southern Taranaki ringplain is in this category. Whereas the default position for grading is that only one sample each year can exceed the relevant threshold, in the 'productive class' two samples can exceed the grading threshold without affecting the assigned attribute state.

The Council's existing monitoring programme only collects chlorophyll *a* once a year, during summer (worst case flow conditions). Therefore, a comparison against the new attribute's standards cannot be made. An analysis to compare with the new NoF guideline is presented below, for indicative purposes only. It should be noted that since the Council is sampling under worst-case conditions, then clearly if such a result falls into an A, B, or C category, then any other measurement made during the year would be at least as good. The situation is not so clear if a Council result lies within the D band, as it cannot be determined whether other results under less critical conditions would also lie in this band or one of the higher bands, and at least one exceedance is allowed in any case.

The Council's periphyton monitoring programme will need to be reviewed to provide for the new monitoring regime specified in the NoF and NPS-FW.

Results for chlorophyll-*a* for the 2012/2013 monitoring year are presented in this memo.

An overall summary of results for the nuisance periphyton programme together with each catchment summary is described further below.

Table 1: NoF Attribute table for periphyton

Attribute	Periphyton (trophic state)		
Attribute unit	mg chl-a/m ² (milligrams chlorophyll-a per square metre)		
Attribute State	Numeric Attribute State (default class)	Numeric Attribute State (Productive Class ¹)	Narrative Attribute State
	Exceeded no more than 8% of samples ²	Exceeded no more than 17% of samples ²	
A	≤50	≤50	Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat

B	>50 - ≤120	>50 - ≤120	Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat
C	>120-≤200	>120-≤200	Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat
National bottom line	200	200	
D	>200	>200	Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat

¹ Classes are streams and rivers defined according to types in the River Environment Classification (REC). The Productive periphyton class is defined by the combination of REC "Dry" Climate categories (i.e. Warm-Dry (WD) and Cool-Dry(CD)) and REC for Geology categories that have naturally high levels of nutrient enrichment due to their catchment geology (i.e. Soft-Sedimentary (SS), Volcanic Acidic (VA) and Volcanic Basic (VB)). Therefore the productive category is defined by the following REC defined types: WD/SS, WD/VB, WD/VA, CD/SS,CD/VB, SS/VA. The Default class includes all REC types not in the Productive class.

² Based on a monthly monitoring regime. The minimum record length for grading a site based on periphyton (chl-a) is three years.

Results

Long term trends in periphyton coverage

Trend analysis of the percentage cover of mats and long filaments for the full record (15 years) shows stable trends for thick mats for every site. Two sites (MKW000300 and KPA000250), one an upper catchment site and the other a lower catchment, show improvement (reduction) for long filamentous algae, and the remaining nineteen sites showed stable trends.

Table 2: Long term trends (15 years) for thick mats and long filaments at 21 monitoring sites

Catchment	Sites	Location	Thick mats	Long filaments
Upper	KPA000250	Wiremu Road	*	↑
	PAT000200	Barclay Road	*	*
	PNH000200	Wiremu Road	*	*
	WGG000150	Opunake Road	*	*
Middle	KPA000700	Wataroa Road	*	*
	MGN000195	SH3	*	*
	MKW000200	Opposite Denby Road	*	*
	PAT000360	Skinner Road	*	*
	STY000300	Mangatete Road	*	*
	WGA000260	SH3a	*	*
	WGG000665	Stuart Road	*	*
	WKH000500	SH3 (Egmont Village)	*	*
Lower	KPA000950	Cape Egmont	*	*
	MGH000950	Raupuha Road	*	*
	MGN000427	Bristol Road	*	*
	MKW000300	Tarata Road	*	↑
	PNH000900	SH45	*	*
	STY000400	SH45	*	*
	WGA000450	Devon Road	*	*
	WGG000995	Ohawe Beach	*	*
	WKH000920	Constance St, NP	*	*

Key:

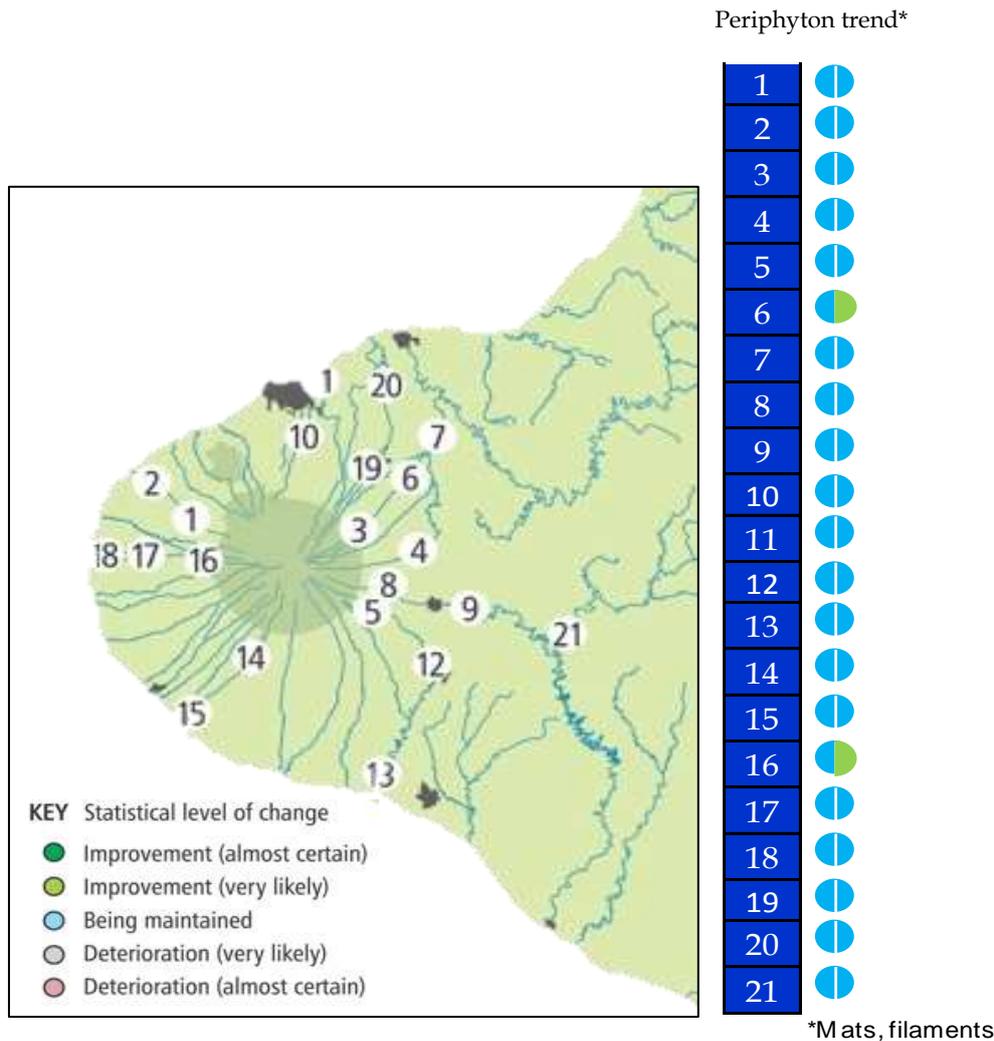
↑ statistically significant improvement p<0.01

*

↓ statistically significant deterioration p<0.05

↑ statistically significant improvement p<0.05

↓ statistically significant deterioration p<0.01



Periphyton- compliance with MfE guidelines

In summary, all sites except for one met the guidelines for thick mats and long filaments throughout the period 2010/2011 to 2012/2013 monitoring years (six survey occasions). The lower catchment site at KPA000950 exceeded the guideline for long filaments once, in 2011/2012. It met the guideline for mats on every occasion. Overall, the monitoring programme found a 99.2% compliance rate for the periphyton coverage surveys, even though they were surveyed under worst case conditions for periphyton proliferation.

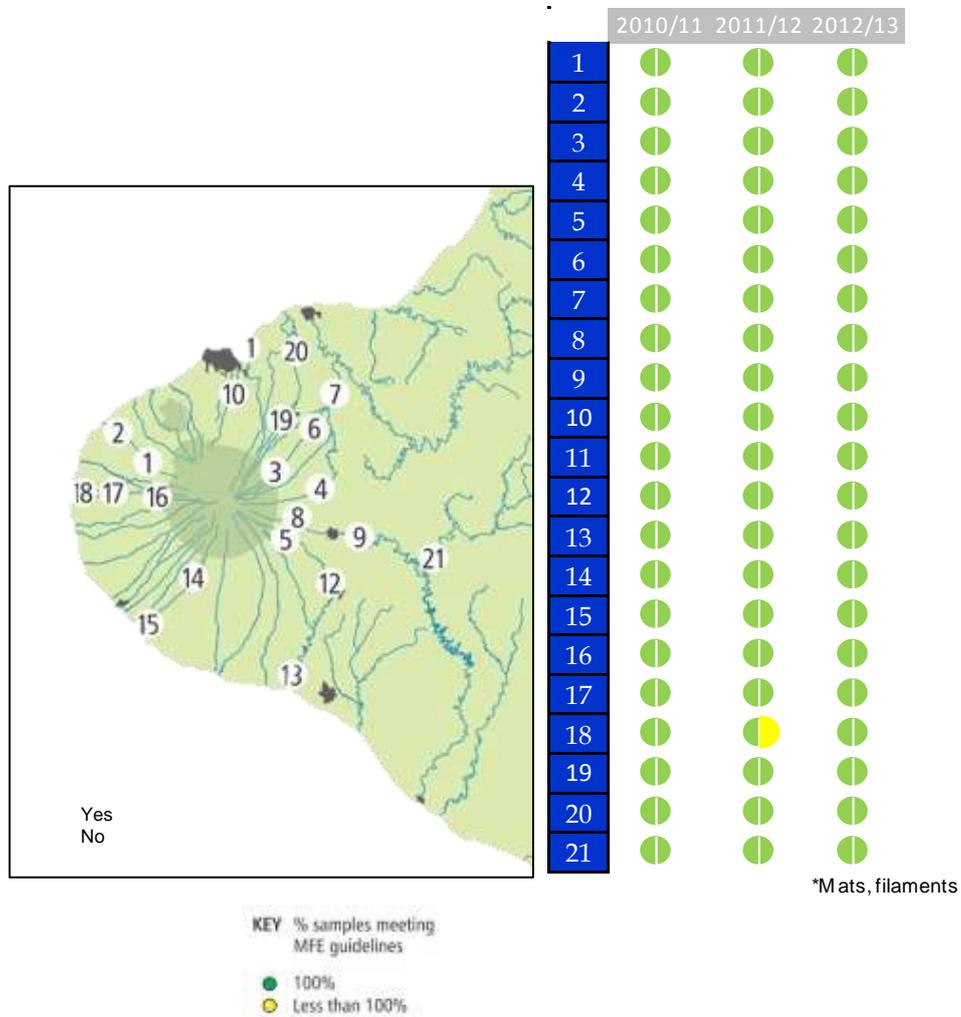
Table 3: Compliance with MfE periphyton coverage guidelines in Taranaki, 2010-2013

Catchment	Sites	Number of times (out of 6 surveys) exceeded the periphyton guidelines					
		2010/2011		2011/2012		2012/2013	
		Mats	Filaments	Mats	Filaments	Mats	Filaments
Upper	KPA000250	0	0	0	0	0	0
	PAT000200	0	0	0	0	0	0
	PNH000200	0	0	0	0	0	0
	WGG000150	0	0	0	0	0	0
Middle	KPA000700	0	0	0	0	0	0
	MGN000195	0	0	0	0	0	0
	MKW000200	0	0	0	0	0	0
	PAT000360	0	0	0	0	0	0

Middle (continued)	STY000300	0	0	0	0	0	0
	WGA000260	0	0	0	0	0	0
	WGG000665	0	0	0	0	0	0
	WKH000500	0	0	0	0	0	0
Lower	KPA000950	0	0	0	1	0	0
	MGH000950	0	0	0	0	0	0
	MGN000427	0	0	0	0	0	0
	MKW000300	0	0	0	0	0	0
	PNH000900	0	0	0	0	0	0
	STY000400	0	0	0	0	0	0
	WGA000450	0	0	0	0	0	0
	WGG000995	0	0	0	0	0	0
	WKH000920	0	0	0	0	0	0

Guideline for thick mats: less than 60% coverage of stream bed

Guideline for long filaments: less than 30% coverage of stream bed



Chlorophyll *a*

Based on the Council's existing periphyton monitoring regime (one sample of chlorophyll *a* per year, surveyed under worst case conditions for periphyton proliferation), then based on the results from the 2012/2013 monitoring year all sites could potentially satisfy the national bottom limit for periphyton. The results from fifteen sites met the attribute state A criterion, indicating low levels of chlorophyll *a* even under worst case environmental conditions.

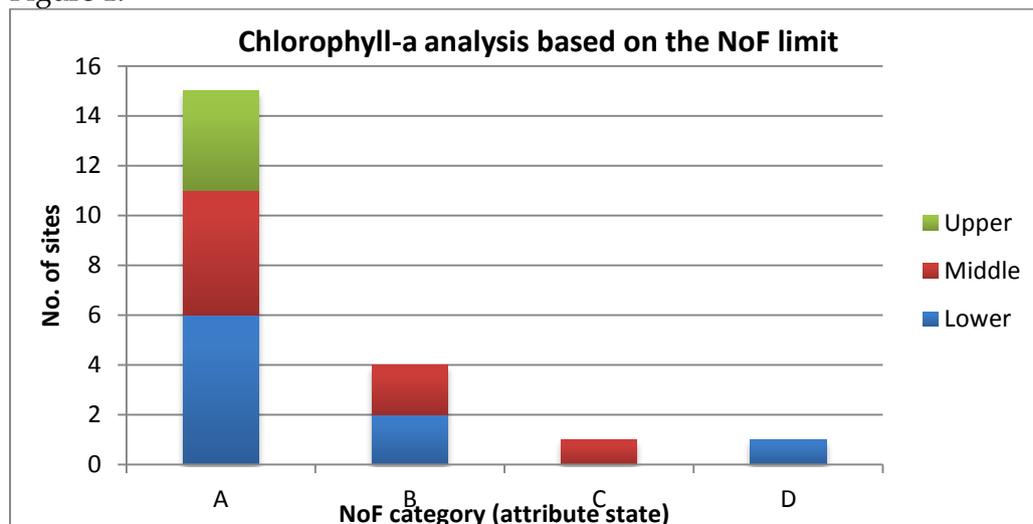
One site, WGG000995 at Ohawe Beach, had its result within the attribute state D range. Each result for this site over the three years of survey falls into the same category. In terms of the NOF, it should be noted this site is classified as a productive class. Sites identified as located within the 'productive periphyton' class can have no more than 17% of samples (or 2 samples per year, based on a strictly regular monthly monitoring regime) in the attribute D range of they are to be deemed to remain above the National Bottom Line. Given that the Council is currently surveying only once per year, but under conditions designed to detect the worst degree of proliferation, it is impossible to determine which attribute state this one site would fall into if surveyed under NOF protocols. Conservatively, for indicative comparative purposes it has been assigned to attribute state D in Table 4 below but this must not be taken as determinative, for the reasons just described.

Table 4: Chlorophyll *a* analyses for thick mats and long filaments at 21 monitoring sites

Catchment	Sites	Location	Attribute state
Upper	KPA000250	Wiremu Road	A
	PAT000200	Barclay Road	A
	PNH000200	Wiremu Road	A
	WGG000150	Opunake Road	A
Middle	KPA000700	Wataroa Road	A
	MGN000195	SH3	A
	MKW000200	Opposite Denby Road	A
	PAT000360	Skinner Road	C
	STY000300	Mangatete Road	A
	WGA000260	SH3a	B
	WGG000665	Stuart Road	B
	WKH000500	SH3 (Egmont Village)	A
Lower	KPA000950	Cape Egmont	A
	MGH000950	Raupuha Road	B
	MGN000427	Bristol Road	A
	MKW000300	Tarata Road	A
	PNH000900	SH45	A
	STY000400	SH45	A
	WGA000450	Devon Road	B
	WGG000995	Ohawe Beach	D?*
	WKH000920	Constance St, NP	A

*WGG000995 is classified under productive periphyton class. The productive periphyton class is defined by the combination of REC "Dry" Climate categories (i.e. warm-dry and cool-dry) and REC for Geology categories that have naturally high levels of nutrient enrichment due to their catchment geology (i.e. soft-sedimentary, volcanic acid and volcanic basic).

Figure 1:



Discussion - Catchment summary

a) Kapoiaia catchment

- There is an improving long term trend for long filaments (at $p < 0.05$, or 'highly likely' in statistical terms) at this upper catchment site.
- Long term trend analyses for KPA000700 and KPA000950 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed all three sites met the MfE periphyton guidelines for both thick mats and long filaments except once. The lower KPA000950 exceeded the long filaments once during the summer of 2012.
- The 2012/2013 measurement for chlorophyll *a* for both the upper and middle sites were within attribute state A of the NoF limit. The lower KPA000950 falls within attribute state B.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
KPA000250	Wiremu Road	*	↑	0	0	A
KPA000700	Wataroa Road	*	*	0	0	A
KPA000950	Cape Egmont	*	*	0	1	B

¹ Long term trend data from 2000-2013 (full data set)

² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only

³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

b) Mangaehu catchment

- Long term trend analysis for MGH000950 showed stable trend for both thick mats and long filaments.
- At Ruapuha Road (MGH000950), there was an increasing trend in percentage cover values of thick mats (Kendall tau = 0.318690) that was significant using the Mann-Kendall test ($p = 0.026$) but not significant after FDR application ($p = 0.363$).
- Three year analyses from 2010/2011 to 2012/2013 showed MGH000950 met the MfE periphyton guidelines for both thick mats and long filaments.

- The 2012/2013 measurement for chlorophyll *a* at site MGH000950 is within attribute state A of the NoF limit for chlorophyll *a*.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
MGH000950	Raupuha Road	*	*	0	0	B

¹ Long term trend data from 1998-2013 (full data set)

² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only

³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

c) Manganui catchment

- Long term trend analysis for MGN000195 showed a stable trend for thick mats. There is no trend for long filaments. Data collected for the last 15 years showed no coverage (zero) of long filaments have been recorded at this upstream site, indicating that although present only at low levels, the composition of the periphyton community is biased towards thick mats.
- Long term trend analyses for MGN000427 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed both sites met the MfE periphyton guidelines for both thick mats and long filaments.
- The 2012/2013 measurement for chlorophyll *a* at both sites were within attribute state A of the NoF limit for chlorophyll *a*.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
MGN000195	SH3	*	-	0	0	A
MGN000427	Bristol Road	*	*	0	0	A

¹ Long term trend data from 1998-2013 (full data set)

² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only

³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

d) Maketawa catchment

- There is an improving long term trend for long filaments (at $p < 0.05$) at the lower MKW000300 site.
- Long term trend analyses for MKW000200 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed both sites met the MfE periphyton guidelines for both thick mats and long filaments.
- The 2012/2013 measurement for chlorophyll *a* at both sites were within attribute state A of the NoF limit for chlorophyll *a*.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
MKW000200	Opp. Denby Rd	*	*	0	0	A
MKW000300	Tarata Road	*	↑	0	0	A

- ¹ Long term trend data from 2000-2013 (full data set)
² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only
³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

e) Patea catchment

- Long term trend analyses for PAT000200 and PAT000360 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed both sites met the MfE periphyton guidelines for both thick mats and long filaments.
- The 2012/2013 measurement for chlorophyll *a* showed that the lower site PAT00360 had higher level of chlorophyll *a* compared to PAT000200.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
PAT000200	Barclay Road	*	*	0	0	A
PAT000360	Skinner Road	*	*	0	0	C

- ¹ Long term trend data from 1998-2013 (full data set)
² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only
³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

f) Punehu catchment

- Long term trend analyses for PNH000200 and PNH000900 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed both sites met the MfE periphyton guidelines for both thick mats and long filaments.
- The 2012/2013 measurement for chlorophyll *a* at both sites were within attribute state A of the NoF limit for chlorophyll *a*.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
PNH000200	Wiremu Road	*	*	0	0	A
PNH000900	SH45	*	*	0	0	A

- ¹ Long term trend data from 1998-2013 (full data set)
² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only
³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

g) Stony catchment

- Long term trend analyses for STY000300 and STY000400 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed both sites met the MfE periphyton guidelines for both thick mats and long filaments.
- Overall periphyton has remained consistently low over the past 15 years at both sites in the Stony catchment.
- The 2012/2013 measurement for chlorophyll *a* at both sites were within attribute state A of the NoF limit for chlorophyll *a*.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
STY000300	Mangatete Road	*	*	0	0	A
STY000400	SH45	*	*	0	0	A

¹ Long term trend data from 1998-2013 (full data set)

² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only

³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

h) Waiongana catchment

- Long term trend analyses for WGA000260 and WGA000450 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed both sites met the MfE periphyton guidelines for both thick mats and long filaments.
- The 2012/2013 measurement for chlorophyll *a* at both sites were within attribute state B of the NoF limit for chlorophyll *a*.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
WGA000260	SH3a	*	*	0	0	B
WGA000450	Devon Road	*	*	0	0	B

¹ Long term trend data from 1998-2013 (full data set)

² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only

³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

i) Waingongoro catchment

- Long term trend analyses for WGG000150 and WGG000665 showed stable trend for both thick mats and long filaments.
- For WGG000995, there was a decreasing trend in percentage cover for long filaments that was significant using Mann-Kendall test (p-value =0.042) but not significant after FDR application (p=0.281). Trends for thick mats remained stable at this site.
- Three year analyses from 2010/2011 to 2012/2013 showed all three sites met the MfE periphyton guidelines for both thick mats and long filaments.
- The 2012/2013 measurement for chlorophyll *a* at the downstream site WGG000995 exceeded the NoF National Bottom Line (more than 200 mg ch-a/m²). This site however is classified as a production class under the NoF, and thus only if more than two samples each year (17% of the samples) breach the bottom limit will it be deemed to fall into attribute state D, below the National Bottom Line.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
WGG000150	Opunake Road	*	*	0	0	A
WGG000665	Stuart Road	*	*	0	0	B
WGG000995	Ohawe Beach	*	*	0	0	D

¹ Long term trend data from 1998-2013 (full data set)

² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only

³ Chlorophyll *a* analysis for 2012/2013 monitoring year only

j) Waiwhakaiho catchment

- Long term trend analyses for WKH000500 and WKH000920 showed stable trend for both thick mats and long filaments.
- Three year analyses from 2010/2011 to 2012/2013 showed both sites met the MfE periphyton guidelines for both thick mats and long filaments.
- The 2012/2013 measurement for chlorophyll *a* at both sites were within attribute state A of the NoF limit for chlorophyll *a*.

Site	Location	Long term trend ¹		No. of exceedances of MfE guidelines ²		Chlorophyll <i>a</i> ³
		Thick mats	Long filaments	Thick mats	Long filaments	Attribute state
WKH000500	SH3-Egmont Village	*	*	0	0	A
WKH000920	Constance Street	*	*	0	0	A

¹ Long term trend data from 1998-2013 (full data set)

² Analysis against MfE periphyton guidelines for 2010/2011-2012/2013 monitoring years only

³ Chlorophyll *a* analysis for 2012/2013 monitoring year only