MARLBOROUGH DISTRICT COUNCIL

Omaka River Pilot Study for Periphyton Monitoring in Marlborough

Technical Report No: 19-001
January 2019

Omaka River Pilot Study for Periphyton Monitoring in Marlborough

MDC Technical Report No: 19-001

File Reference/Record No:
E375-001-003-02/18281034

January 2019

Report Prepared by:
Steffi Henkel
Environmental Scientist - Water Quality
Environmental Science & Monitoring Group

Marlborough District Council
Seymour Square
PO Box 443
Blenheim 7240
Phone: 520 7400
Website: www.marlborough.govt.nz

Executive Summary

The community of algae and bacteria growing on stream and river beds is referred to as periphyton. The National Policy Statement for Freshwater Management (NPS-FM) contains a periphyton attribute requiring councils to monitor periphyton chlorophyll-a on a monthly basis. The monitoring results are then compared to chlorophyll-a limits in the NPS-FM allowing the assignment of attribute states.

There are a number of factors influencing periphyton growth that need to be considered before 'representative' monitoring sites can be chosen. The influence of two of these factors, stream bed shading and meso habitat, were assessed in a one-year trial within a short reach of the Omaka River. Periphyton chlorophyll-a was monitored monthly at five sites with varying degree of shading by riparian vegetation within riffle and run habitats. Visual bank-side assessment of percentage periphyton cover was also carried out.

Periphyton growth was higher in riffles and unshaded sites. The difference was sufficient to result in different attribute states. Recent draft monitoring standards suggest sampling of run habitats. Based on the results of this trial, it is suggested to sample run habitats at unshaded sites for the regular monitoring required under the NPS-FM. This allows management of periphyton based on the worst case scenario. Periphyton sampling could therefore be carried out at the bottom of catchments, where most State of the Environment monitoring sites are currently located.

Visual estimation of periphyton cover did not correlate well with chlorophyll-a. Nevertheless, on occasions when periphyton cover mainly consists of thin algae mats, the comparatively time-consuming sampling for chlorophyll-a could be omitted with the assumption that chlorophyll-a will be within the A-band limits. However, more data is needed before this can be implemented.

Table of Contents

1. Introduction

Periphyton is a term for the algae and bacteria growing on the beds of rivers and streams. The thickness of periphyton cover ranges from very thin mats that are difficult to remove to thick mats and long filamentous algae. Periphyton plays an important role in the aquatic ecosystem. Together with plant material from the surrounding terrestrial vegetation, periphyton is at the basis of the aquatic food web. Many aquatic insects graze on periphyton, preventing periphyton mats from forming thick layers. High nutrient concentrations and limited shading of the stream bed by riparian vegetation lead to an increase in the growth of periphyton. When large areas of the river or stream bed become covered with filamentous algae or thick algae mats, ecological and aesthetic values are significantly affected. The types of aquatic insects present, become dominated by more tolerant species, such as snails and worms. Excessive periphyton growth also reduces suitable fish spawning habitat and significant amounts of filamentous algae are considered aesthetically unpleasant.

"Periphyton is the slime and algae found on the bed of streams and rivers. It is essential for the function of healthy ecosystems, but when it proliferates it can become a nuisance, degrading swimming spots, clogging irrigation and water supply intakes.**"**

Biggs (2000) New Zealand Periphyton Guidelines

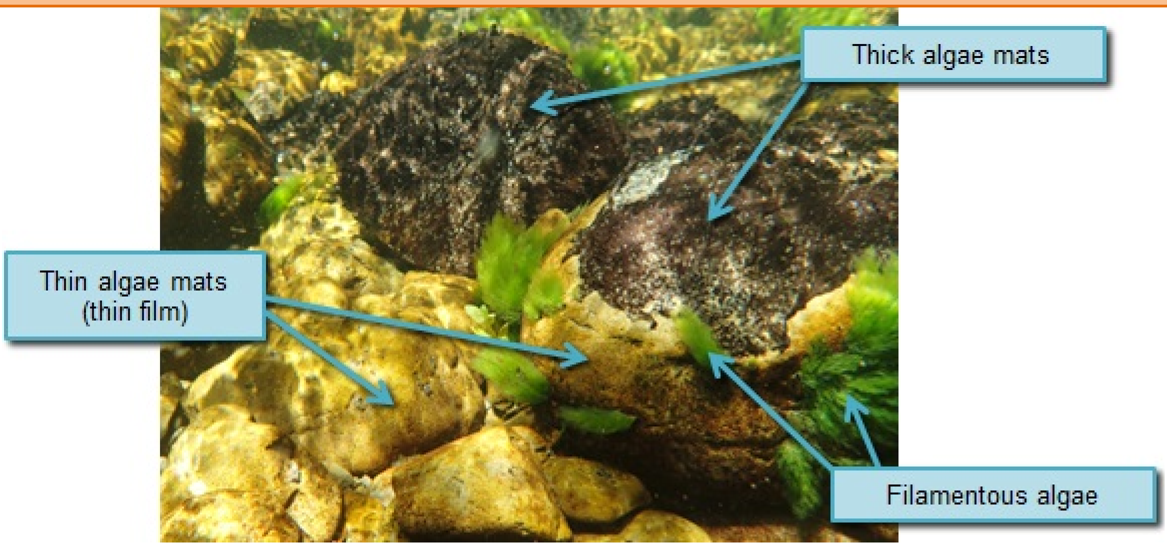

Figure 1: Definition and photo of Periphyton, showing the algae categories generally used for visual periphyton cover assessments.

Apart from grazing by aquatic insects, periphyton is removed during high flow events with sufficient water velocities that cause destabilisation of the stream bed (ie; freshes and floods). The movement of stream bed material during these events causes abrasive removal of the periphyton. For rivers with excessive periphyton growth, flood flows are the main form of periphyton removal. The frequency of sufficiently large flood events depends on rainfall patterns and the size of the stream bed substrate. In the Te Hoiere/Pelorus catchment, flood events are relatively frequent while in the South of Marlborough the time for periphyton to accumulate is significantly longer. As a result, South Marlborough streams and rivers tend to have more periphyton compared to waterways in North Marlborough.

The National Policy Statement for Freshwater Management 2014 (NPS-FM) introduced a compulsory periphyton attribute. The document provides limits for periphyton cover, which is measured as the amount of Chlorophyll-a[1] per square meter of stream bed. As for other attributes, the limits are used to define four bands, which express the state of a waterway in regard to that attribute (Table 1).

[1] Chlorophyll-a is the green pigment in plants that enables photosynthesis (the conversion of sunlight and carbon dioxide to sugar and oxygen).

Generally the limits will naturally be exceeded on average at least once a year during longer periods of fine weather (8% of samples). In dryer regions with a geology that naturally results in higher nutrient concentrations, the limits are allowed to be exceeded twice yearly (17% of samples). In Marlborough, only the Waima (Ure) catchment falls into this category.

Because the number and size of flood flows varies from year to year, a large data set is required to determine which attribute band a waterway generally falls into. The NPS-FM requires monthly sampling over a period of three years. The Marlborough District Council has historically not measured periphyton Chlorophyll-a, but regular monitoring at selected State of the Environment sampling sites commenced at the beginning of 2017.

Table 1: Periphyton attribute limit table in the National Policy Statement for Freshwater Management (NPS-FM).

Value	Ecosystem health		
Freshwater Body Type	Rivers		
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 and ≤120	>50 and ≤120	Occasional blooms reflecting low nutrient enrichment and/ or alteration of the natural flow regime or habitat.
C	>120 and ≤200	>120 and ≤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**	

In the NPS-FM, periphyton cover is used as measure for nutrient enrichment. Subsequently, councils are required to set nutrient limits for the management of periphyton.

However, the supporting documentation for the NPS-FM acknowledges that nutrient concentrations are not the only factor determining periphyton growth. Site-to-site variation in periphyton cover is also influenced by light intensity (shading of the waterway) and substrate stability.

According to the recommended sampling procedure [7], periphyton cover is measured across a transect of stable stream bed substrate in the most common meso-habitat. Field observations indicate that the larger, more stable substrate is generally found in riffles, which also tends to be the dominant habitat in a large number of waterways in the region. Therefore, during the first year of periphyton sampling in Marlborough, samples were taken from riffle habitats. However, most councils monitor periphyton in runs. This has a historical reason in the simultaneous acquisition of visual substrate cover using underwater viewers, which is generally not possible in riffle habitats. This historical development is likely the reason that the national sampling standard for periphyton that is currently under development, will suggest the sampling of runs, rather than riffles.

Visual observations indicate that shading of waterways by riparian vegetation and substrate stability appear to be major controlling factors for periphyton growth for some of the waterways in Marlborough. In order to determine the impact of these two factors on the periphyton state of a water way, a short section of the Omaka River was sampled at several sites, which are shaded by riparian vegetation to different degrees.

2. Methodology

Five sites along the Omaka River, upstream of the Hawkesbury Bridge were sampled monthly over the cause of one year. The sites are located within a 500 meter reach with varying amount of shading and substrate sizes (Figure 2). Because the reach does not receive inflow from tributaries or groundwater and livestock do not have access, nutrient concentrations are assumed to be similar at all sites.

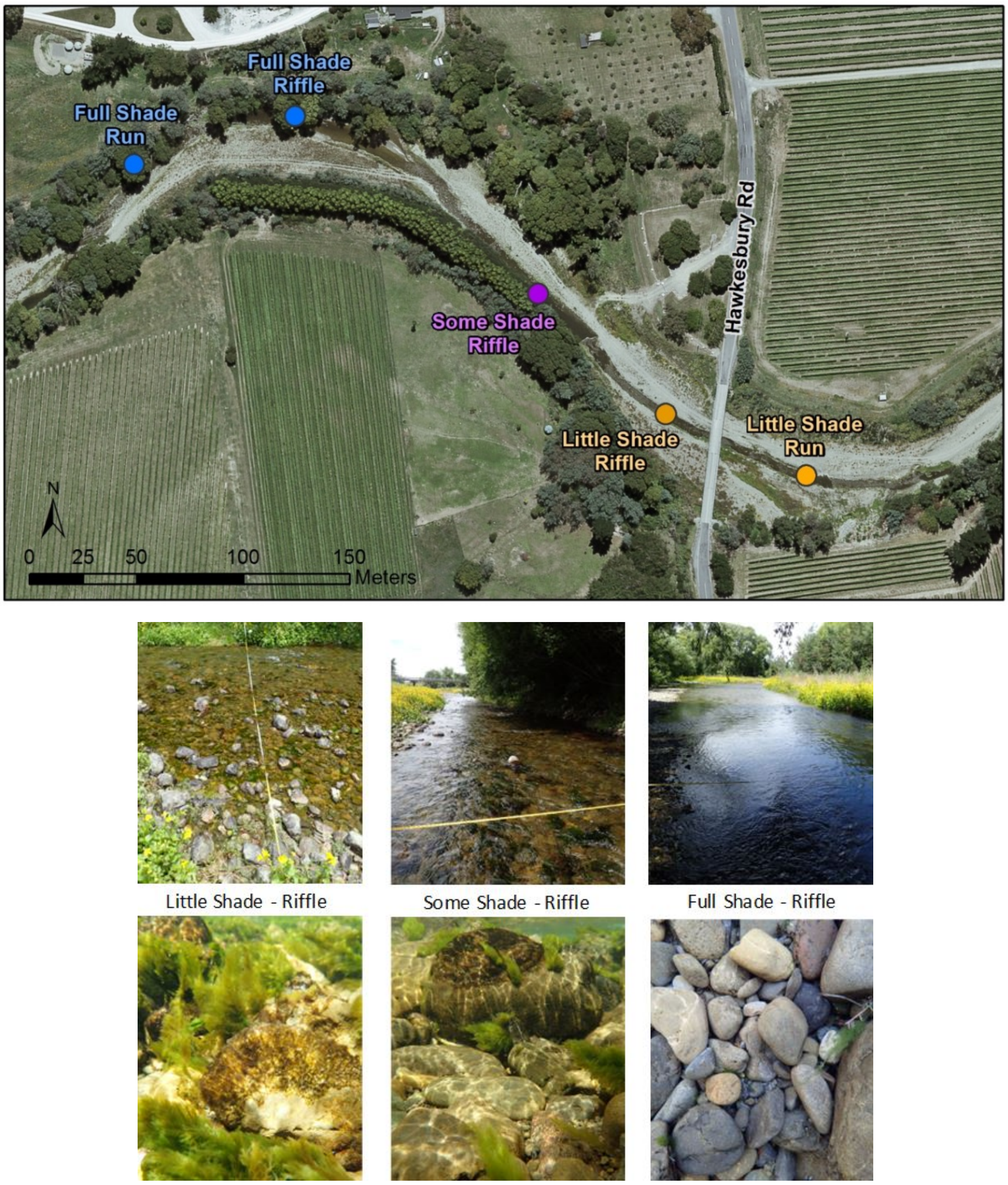

Figure 2: The map shows the location of the five sampling sites; the photos below the riffle-habitat sites on the same day in January 2017.

At each site 10 stones were removed across a transect at equally spaced points. The stones were chosen by moving along a measuring tape that had been put across the river and at the sampling point bending down to touch the river bed without looking. The stone that was touched was sampled unless it was too small, then the closest stone large enough was chosen.

A modified bottle cap was used to cover an area of 0.00018 m^2 on the top surface of the stone. Using a brush, all periphyton surrounding the bottle cap was removed. The area covered by the bottle cap was then marked using a scalpel before removing the bottle cap. All periphyton in the marked area was then removed using scalpel and brush and washed into a sample bottle. All ten stones were sampled this way and the periphyton collected in one combined sample bottle. The sample was then put on ice and frozen. The frozen samples were sent to Cawthron Laboratories for measurement of the total Chlorophyll-a in the samples. The Chlorophyll-a measure required by the NPS-FM was then calculated based on the laboratory result and the total area of stone-surface sampled.

$$\text{Periphyton (NPS-FM)} = \text{Total Chlorophyll-a [in mg]}/\ (10 * 0.00018\ m^2)$$

In addition to the actual sampling of periphyton, periphyton cover was estimated as percentage cover with thin algae mats, thick algae mats or filamentous algae using a simple bankside assessment.

3. Results and Discussion

3.1. Influence of Shading and Meso-Habitat on Periphyton Chlorophyll-a

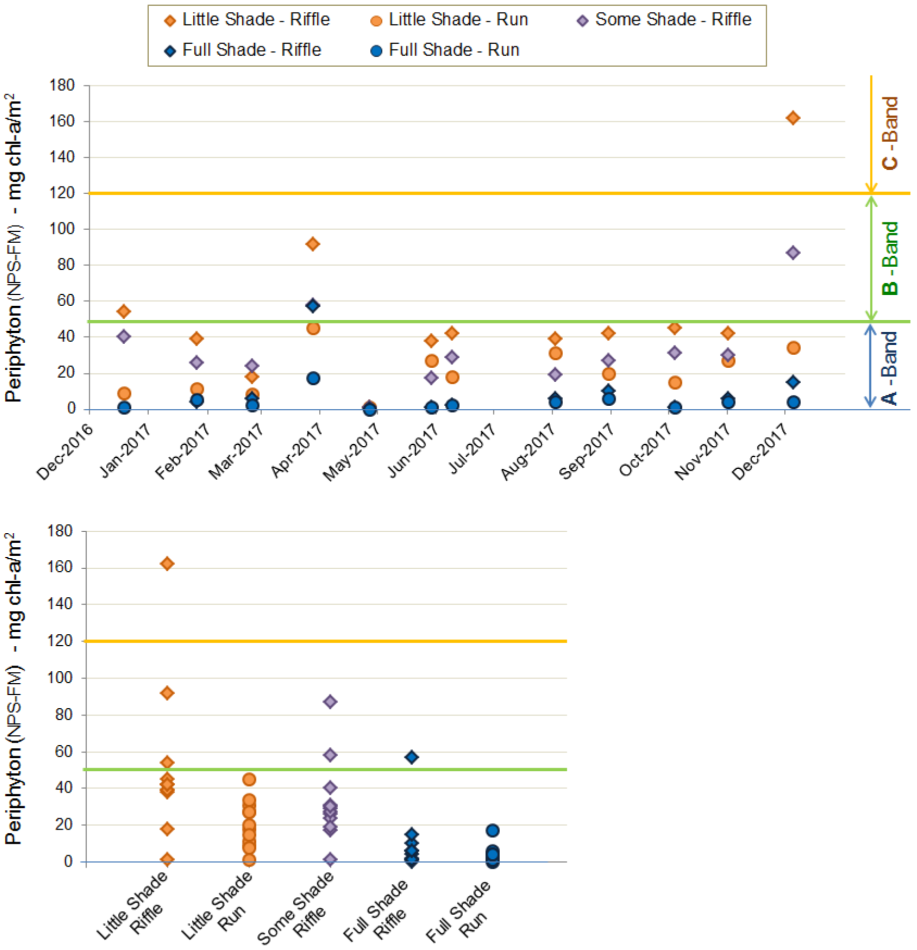

Figure 3: Periphyton Chlorophyll-a at the five trial sites.

Figure 3 shows the Chlorophyll-a concentrations of the periphyton sampled at the five sites in the Omaka River during the trial. It can be seen that Periphyton Chlorophyll-a is generally higher in the riffle meso-habitats compared to the run-habitats. Although substrate size was not measured as part of this study, the substrate in the riffle habitats was comprised of visibly larger rocks and stones compared to the runs. Following freshes or flood flows, periphyton was more likely to persist on this larger substrate. The main reason is that smaller rocks and stones are more easily moved by the force of the water, causing abrasive removal of the periphyton. Additionally the generally faster flow in riffles results in a greater nutrient supply during lower flows when periphyton is growing [11].

Because prolonged dry weather periods can result in excessive periphyton growth even in relatively low-nutrient waters, the NPS-FM allows approximately one exceedance of band limits per year (8%). Determining the periphyton state in accordance with the NPS-FM requires monthly data over a period of three years. Although, the trial concluded after one year, the results can be used as an indication for the periphyton state.

The NPS-FM states that water quality needs to be maintained or enhanced, but does not specify what that means. A report by the Land and Water Forum in 2012 [1] defined maintaining water quality as staying within a band specified in the NPS-FM attribute tables. This was indorsed by the Commissioner for the Environment in a 2015 report [9].

Because nutrients are one of the main drivers for periphyton growth, the NPS-FM requires that periphyton is managed via the setting of catchment limits for dissolve nutrient concentrations, in particular Dissolved Inorganic Nitrogen and Dissolved Reactive Phosphorus. Based on the results of this trial, the choice of sampling site has implications in regard to the limit-setting process.

If the attribute state of the Omaka River is based on samples taken in run-habitats with little shading, nutrient concentrations within the Omaka catchment need to be managed quite well if water quality is to be maintained. In contrast, if periphyton measurements in shaded reaches are used to calculate the state, management in the catchment can allow significant land-use intensification before the water quality in the Omaka River is considered to be degrading. However, this would risk severe degradation in unshaded parts of the stream.

The trial clearly shows that even within a relatively short section of a stream, it is impossible to select a single “representative” site. A possible solution to this is the monitoring of periphyton at a number of different locations most representatives of the most common meso-habitats within a catchment or Freshwater Management Unit (FMU). However, this would be extremely costly in regard to analysis cost and staff time.

A small number of councils use a network design based on randomised site selection. Monitoring sites are chosen so that the major stream categories (i.e. geology, landuse, source of flow etc.) are represented. This is again a costly approach, but it provides good data for the creation of region-wide water quality models. A drawback is that modelled data is not always representative of real water quality, particularly if poor management practices on individual land parcels have disproportionate impacts on water quality in the catchment. This has been observed in some of the catchment studies carried out in Marlborough [3, 4].

Another possible monitoring approach is to sample the worst case scenario. It can be assumed that the ecological impact of periphyton growth varies on a scale. Periphyton growth in the unmodified headwaters of tributaries is usually minor, while in the highly modified lowland areas, periphyton growth is at maximum (Figure 4). Lowland areas with little riparian shading of the waterway represent the worst case scenario for a catchment. Periphyton monitoring in these areas would provide the lower end of the scale for the periphyton attribute.

The data from this trial shows that with sufficient riparian shading, periphyton cover will be within the A-band even in waterways with elevated nutrient concentrations. It can therefore be assumed that some tributaries within a catchment, such as unmodified headwaters or well-shaded stream sections have Periphyton cover at the opposite end of the scale (within the A-Band).

In Marlborough, State of the Environment sampling for freshwater quality is usually carried out at the bottom of catchments. The reason is a management based approach to monitoring. Any changes within a catchment are likely to result in changes of the water quality measured at the bottom of the catchment.

Because sites at the bottom of catchments are usually also those most impacted by human activity, (eg; channel straightening and riparian vegetation removal) they are also the sites with greatest potential for periphyton cover. Therefore, periphyton monitoring at unshaded State of the Environment sites would most likely provide the lowest attribute state within a catchment. Catchment management can then be based on maintaining or improving the periphyton state at the monitoring sites, because periphyton cover of streams within the rest of the catchment is likely within the same or a better attribute band.

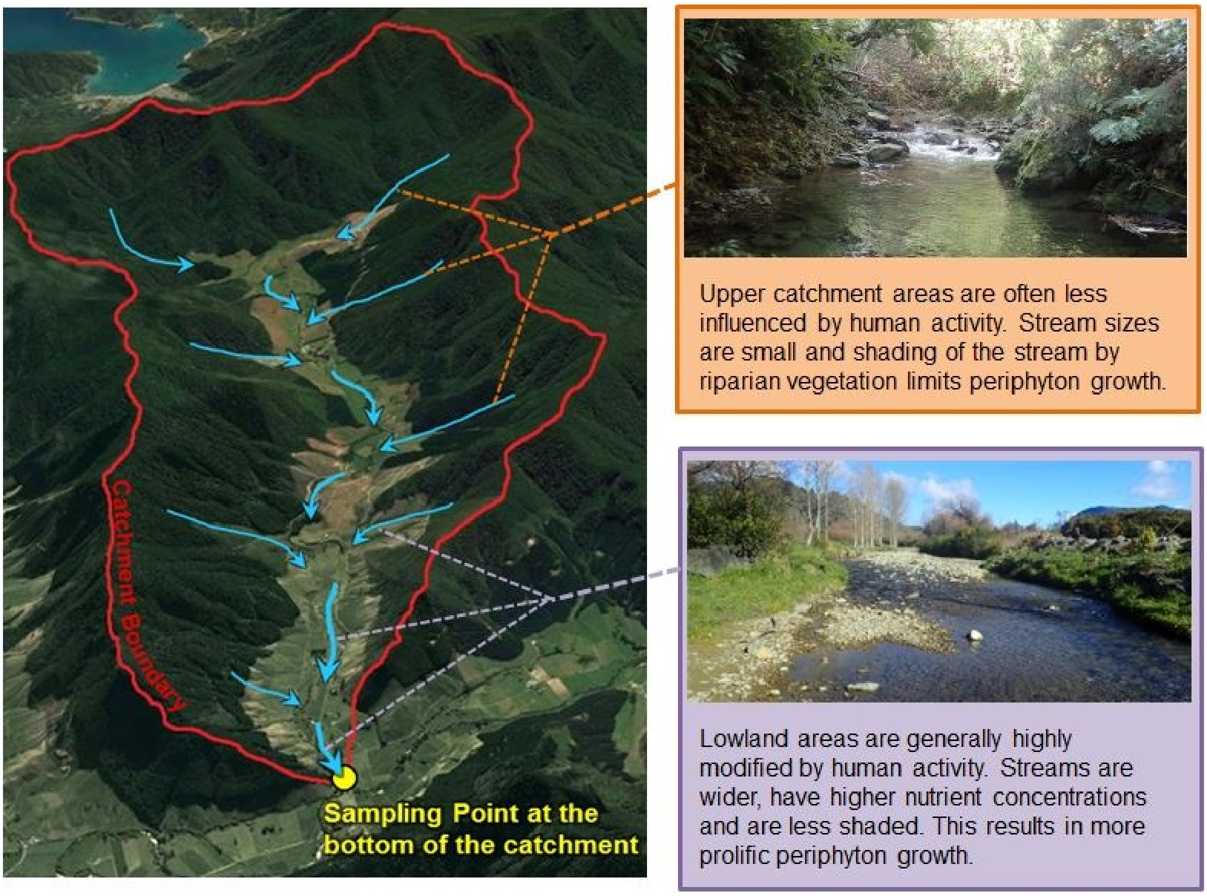

Figure 4: Principal flow of water within a catchment with differences in stream characteristics relating to periphyton growth for the upper and lower catchment areas.

3.2. Visual Periphyton Assessment

Because periphyton sampling is very time consuming, visual assessment of periphyton cover could potentially be used as a substitute for sampling, particularly when there is very little filamentous algae present and algae mats are thin.

Figure 5 shows results of the visual periphyton cover assessments and periphyton chlorophyll-a in the meso-habitat that is most likely to exceed periphyton limits, the riffles. There is only a weak correlation between the visual periphyton cover and periphyton Chlorophyll-a. On some occasions, Chlorophyll-a stayed within the A-band when more than half the stream bed was covered in filamentous algae, while the highest chlorophyll-a values were observed when filamentous and thick algae mats covered a much smaller area. The reason is the ever-changing composition of algae species that make up the periphyton mats. The amount of Chlorophyll-a in the cells of algae differs from species to species, but also changes depending on the environmental conditions.

The results show that visual assessment of periphyton cover cannot be used to estimate periphyton Chlorophyll-a.

Nonetheless, based on the results, it could be assumed that Chlorophyll-a value are within the A-band when filamentous and thick algae mats cover less than 20% of the streambed independent of riparian shading. Since the NPS-FM limits are exceedance-based, periphyton sampling could therefore be omitted on occasions when there is little filamentous algae and thick algae mats present. However, further monitoring is required to provide sufficient certainty before this approach could be implemented. It is also important to note that the percentage cover of filamentous algae and thick algae mats for which Chlorophyll-a is still within the A-band, is likely to be different for other waterways. It is therefore suggested that visual assessment of periphyton cover is carried as part of the periphyton sampling programme.

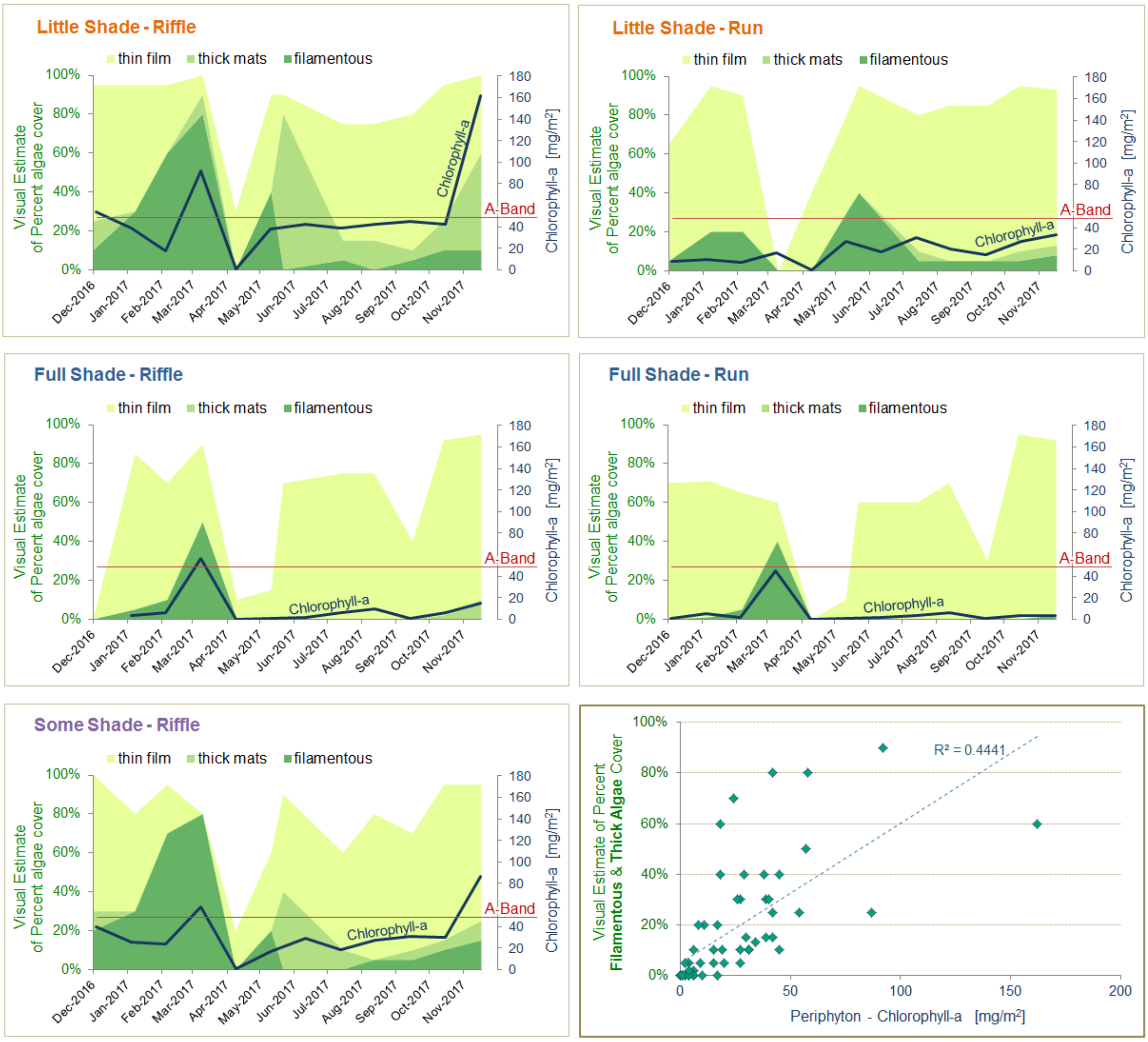

Figure 5: Comparison of visual periphyton cover and Chlorophyll-a at the trial sites.

3.3. Riparian planting

The results of this trial clearly show that planting of riparian vegetation that grows to sufficient height to shade waterways, is an effective way of controlling the growth of periphyton. Riparian vegetation has many other positive effects on water quality [9] and provides significant ecological values. However, it is important to note that the ability of riparian vegetation to provide sufficient shading decreases with increasing stream width. Even mature trees will not provide sufficient shading for rivers that are wider than eight to ten meters [1]. Therefore, for large rivers and streams, management of nutrient inputs into waterways is the main tool for the control of periphyton growth. This is reflected in the NPS-FM, which requires the setting of phosphorus and nitrogen limits to achieve the planned periphyton state.

4. References

1. Davies-Colley RH and Quinn JM (1998) Stream lighting in five regions of North Island, New Zealand: control by channel size and riparian vegetation. New Zealand Journal of Marine and Freshwater Research Vol.32:591-605

2. Land and Water Forum (2012) Second Report of the Land and Water Forum: Setting Limits for Water Quality and Quantity, and Freshwater Policy- and Plan-Making through Collaboration.

3. Marlborough District Council (2015a) Taylor River Catchment Characterisation – Doctors Creek. MDC Technical Report No: 15-001.

4. Marlborough District Council (2015b) Water Quality in the Are Are Creek Catchment. MDC Technical Report No: 15-004.

5. Marlborough District Council (2016) State of the Environment Surface Water Quality Monitoring Report 2016. MDC Technical Report No: 16-006.

6. Biggs BJF (2000) New Zealand Periphyton Guidelines: Detecting, Monitoring and Managing Enrichment of Streams. Published by NIWA https://www.mfe.govt.nz/sites/default/files/nz-periphyton-guide-jun00.pdf

7. Biggs BJF, Kilroy C (2000)Stream Periphyton Monitoring Manual. Published by NIWA https://www.niwa.co.nz/sites/niwa.co.nz/files/import/attachments/peri_complete.pdf

8. New Zealand Government (2014) National Policy Statement for Freshwater Management 2014 http://www.mfe.govt.nz/fresh-water/acts-and-regulations/national-policy-statement-freshwater-management

9. Parkyn S (2004) Review of Riparian Buffer Zone Effectiveness. MAF Technical Paper No: 2004/05

10. Parliamentary Commissioner for the Environment (2015) Managing water quality: Examining the 2014 National Policy Statement. https://www.pce.parliament.nz/publications/managing-water-quality-examining-the-2014-national-policy-statement

11. Wilcock B, Biggs B, Death R, Hickey C, Larned S and Quinn J (2007) Limiting nutrients for controlling undesirable periphyton growth. NIWA Client Report No: HAM2007-006 for Horizons Regional Council