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Report

Annual Waikanae River and River Recharge Report 2013/14 (Consents WGN130103 [31993] and [31994])

Prepared for Greater Wellington Regional Council

On behalf of Kāpiti Coast District Council

Prepared by CH2M Beca Ltd

26 August 2014

Revision History

Revision Nº	Prepared By	Description	Date
1	**Kirsten Fraser**	Draft for Council review	11 July 2014
2	Kirsten Fraser	For Adaptive Management Group	29 July 2014
3	Kirsten Fraser	Final for submission to GWRC	26 August 2014
4			
5			

Document Acceptance

Action			
Prepared by	**Kirsten Fraser**		
Reviewed by	**Andrew Watson** **Malory Osmond**		
Approved by	**Andrew Watson**	**Signed:**	**Date:** **26 August 2014**
on behalf of	CH2M Beca Ltd		

Executive Summary

This annual report for the Waikanae River take and river recharge has been prepared on behalf of Kāpiti Coast District Council (Council) in accordance with Condition 24 of consent WGN130103 [31993] and Condition 26 of consent WGN130103 [31994]. This is the first annual Waikanae River and River Recharge report, and covers the period from commencement of the consent (7 October 2013) through to 30 June 2014.

In accordance with Conditions 4 and 18 of consent WGN130103 [31994] river recharge did not occur during the 2013/14 reporting period. Construction of the required infrastructure for river recharge is currently underway and, subject to the necessary approvals, Council expects to be able to commence river recharge from April 2015.

The maximum daily abstraction from the Waikanae River was 21,779 m^3/day on 21 December 2013, while the average daily abstraction volume was 13,734 m^3/day. The maximum instantaneous abstraction rate was 348 L/s (on 28 December 2013 for no more than 15 minutes). This short duration high flow was likely due to a maintenance flush of the wet well of the water treatment plant intake. Typically the instantaneous abstraction rate was less than 250 L/s.

Council reduced abstraction during the months of February to April due to low river flows, which necessitated the use of the Waikanae Borefield to supplement the public water supply for three periods during this time. The downstream low flow requirements of the consent were complied with.

Other than using the Waikanae Borefield for three periods during February to April, no other unusual events were noted by Council in relation to their river take.

Baseline monitoring of the Waikanae River was carried out in March and April 2014 in accordance with the certified Waikanae River Baseline Monitoring Plan (River BMP). There was insufficient periphyton cover variation and associated aquatic macroinvertebrate data collection to establish any strong relationships at this stage.

Looking ahead to the coming year (2014/15), there is no additional mitigation or adaptive management that is anticipated at this stage.

Further river baseline monitoring will be carried out over the 2014/15 summer in accordance with the River BMP.

The Waikanae Borefield will be used for supplementary supply during 2014/15 if abstraction is restricted by low river flows, until such time as river recharge is permitted.

Contents

Appendices

1 Introduction

The Kāpiti Coast District Council (Council) holds resource consents WGN130103 [31993] and [31994] to take water from the Waikanae River for public water supply and to discharge groundwater to the Waikanae River for the purpose of river recharge.

This is the first annual Waikanae River and River Recharge report, and covers the period from commencement of the consent (7 October 2013) through to 30 June 2014. This report is required by Condition 24 of consent WGN130103 [31993] and Condition 26 of consent WGN130103 [31994]. The requirements of these conditions are listed in the tables below (Table 1 and Table 2) with cross-references to the relevant section in this report.

In accordance with Conditions 4 and 18 of consent WGN130103 [31994] river recharge did not occur during the 2013/14 reporting period. Construction of the required infrastructure for river recharge is currently underway and, subject to the necessary approvals, Council expects to be able to commence river recharge from April 2015.

Table 1: Requirements for Annual Waikanae River report

Condition 24 of consent WGN130103 [31993]		Section in this annual report
The consent holder shall, by 30th August each year, submit an Annual Waikanae River report to the Manager. The annual Waikanae River report shall report on the year 1 July to 30 June inclusive, and include the following information:		
a)	Records of the instantaneous rate of take (L/s), and total daily volumes (m^3);	Section 2.1.2
b)	Flow and river recharge information to demonstrate compliance with Condition 6 (Waikanae River low flow);	Section 2.1
c)	Provide information to demonstrate compliance with Condition 18 of this consent	Sections 2.1 and 2.2
d)	Results of all monitoring undertaken that year required by Conditions 19, 20 and 21 of this consent (if applicable), including a comprehensive analysis of the monitoring results, assessment against any relevant guidelines and comparison with previous years' results (i.e. trend analysis);	Section 3
e)	Details of any trigger levels or compliance limits that were reached (if occurred that year);	Section 3
f)	Details of any actions and/or mitigation/adaptive management taken in response to trigger levels or compliance limits being reached, including an assessment of the effectiveness of these actions and/or mitigation/adaptive management;	Section 3
g)	Any recommendations for changes to the Waikanae River Baseline Monitoring Plan or the On-going Mitigation Plan (as relevant), including triggers, compliance limits or actions and/or mitigation measures or changes to the operations and maintenance manual, including recommendations of the Adaptive Management Group (referred to in Condition 26 of this consent);	Section 3.3 and Section 2.3
h)	A discussion on any mitigation/adaptive management that may be required in the coming year;	Section 4

Condition 24 of consent WGN130103 [31993]	Section in this annual report
i) Summary of any maintenance undertaken	Section 2.2
The annual Waikanae River report can be combined with the annual River Recharge report required by the conditions of discharge permit WGN130103 [31994]. The annual Waikanae River report shall be made available to the public on the Kāpiti Coast District Council website no later than 30th August each year. *Note: The consent holder is only required to report on the listed requirements of this condition if they have occurred during that compliance year (1 July to 30 June inclusive).*	Refer www.kapiticoast.govt.nz

Table 2: Requirements for Annual River Recharge report

Condition 26 of consent WGN130103 [31994]	Section in this annual report
The consent holder shall, no later than 30th August each year that a discharge to the River occurs, submit an annual River Recharge report to the Manager. The annual River Recharge report shall report on the year 1 July to 30 June inclusive, and include the following information:	
a) Records of the instantaneous rate of discharge (L/s), and total daily volumes (m^3) of discharge	Section 2.1.3 Not applicable 2013/14
b) Dates, times and duration of discharge	Section 2.1.3 Not applicable for 2013/14
c) Information to demonstrate compliance with the rate of discharge specified in Condition 5	Section 2.1.3 Not applicable for 2013/14
d) Flow and river recharge information to demonstrate compliance with the Waikanae River low flow specified in Condition 12 of this consent	Section 2.1.3 Not applicable for 2013/14
e) Results of all monitoring undertaken that year required by Conditions 22 or 23 of this consent (if applicable), including a comprehensive analysis of the monitoring results, assessment against any relevant guidelines and comparison with previous years' results (i.e. trend analysis)	Section 3
f) Details of any trigger levels or compliance limits that were reached (if occurred that year)	Section 3
g) Details of any actions and/or mitigation/adaptive management taken in response to trigger levels or compliance limits being reached, including an assessment of the effectiveness of these actions and/or mitigation/adaptive management	Section 3
h) Any recommendations for changes to the Waikanae River Baseline Monitoring Plan or the On-going Mitigation Plan as relevant), including triggers, compliance limits or actions and/or mitigation measures or changes to the operations and maintenance manual, required by Condition 17 to be discussed with the Adaptive Management Group (as required by Condition 27 of this consent)	Section 3.3 and Section 2.3
i) A discussion on any mitigation/adaptive management that may be required in the coming year	Section 4
j) Summary of any maintenance undertaken	Section 2.2

Condition 26 of consent WGN130103 [31994]	Section in this annual report
The annual River Recharge report may be combined with the annual Waikanae River report required by consent WGN130103 [31993]. The annual River Recharge River report shall be made available to the public on the Kāpiti Coast District Council website by 30 August each year.	Refer www.kapiticoast.govt.nz

2 Operation of River Take and River Recharge

2.1 River Flows, Abstraction and Recharge

2.1.1 Waikanae River Flows

The Waikanae River flow is monitored by Greater Wellington Regional Council (GWRC) at a gauging station approximately 200 m upstream of the Waikanae Water Treatment Plant (WTP) intake. Flow data, recorded at 15 minute intervals, that has been supplied by GWRC for the reporting period is summarised in Figure 1 together with weekly rainfall depths. The river flow data was extracted from GWRC's system on 2 July 2014 and had been quality checked by GWRC up to 4 April 2014 at 1400h.

Rainfall through October kept river flows above 3,000 L/s until mid-November. Drier weather during November and December resulted in flows receding down to 1,100 L/s by 24 December. Heavy rain in late December and early January restored flows, with a peak flow of 124,633 L/s recorded on 5 January.

Rainfall was generally low from mid-January to mid-April, with flows dropping steadily to lows of 809 L/s on 16 March and 764 L/s on 7 April. From mid-April onwards, heavy rainfall raised flows above threshold levels.

Further commentary is included in Section 2.1.4 in relation to the low flows in the river from February to April 2014.

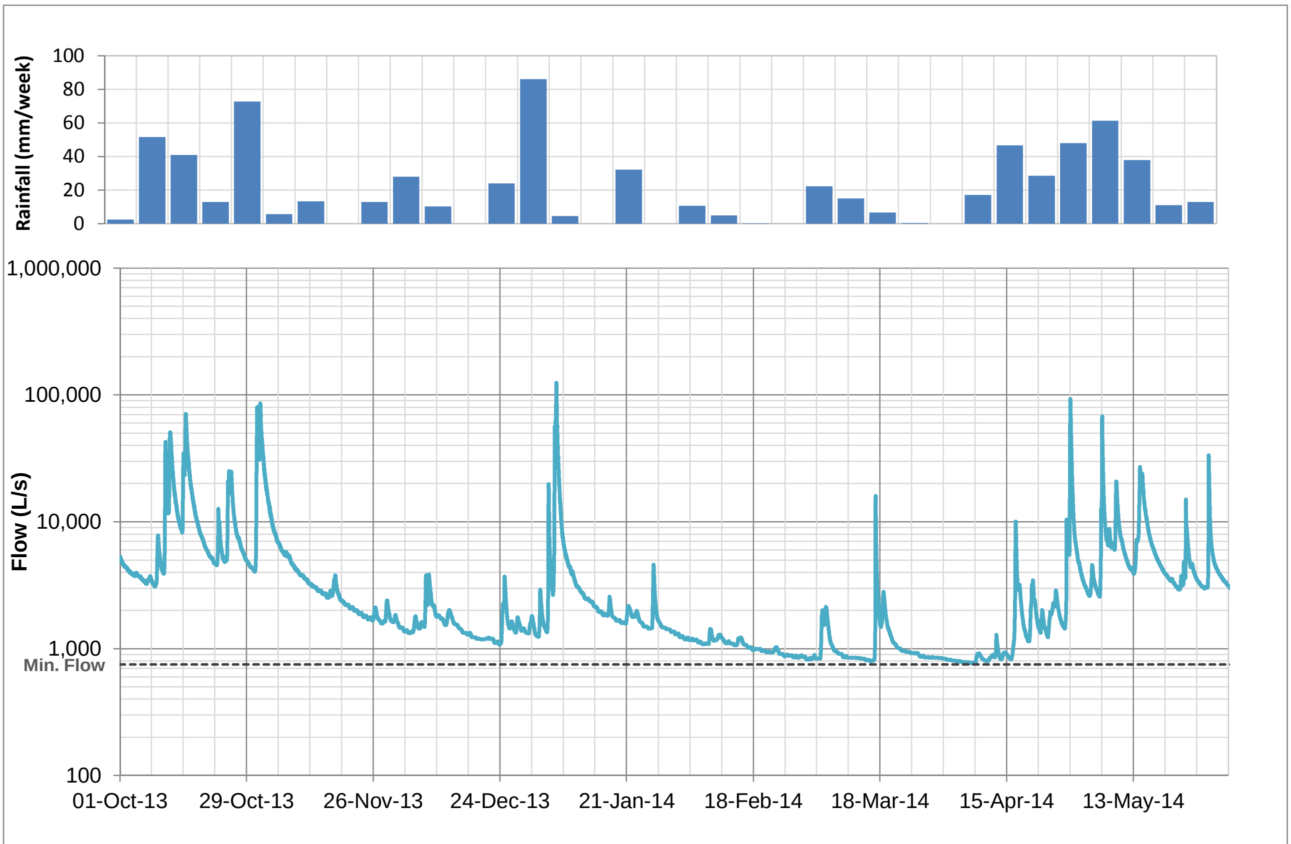

Figure 1: Waikanae River Flow at Water Treatment Plant (October 2013 – June 2014)

2.1.2 River Abstraction

Council measures and records the rates and volumes of water abstracted from the Waikanae River by way of a flow meter at the WTP intake. Council regularly submits its abstraction records to GWRC as per Condition 13 of consent WGN130103 [31993]. A summary of this data is provided below.

The daily abstraction volumes for the reporting period are summarised in Figure 2. The maximum daily abstraction was 21,779 m^3/day on 21 December 2013. This is less than the maximum allowable daily volume of 30,700 m^3/day specified by Condition 5 of consent WGN130103 [31993]. The total volume abstracted in the period 1 October 2013 to 30 June 2014 was 3,749,503 m^3.

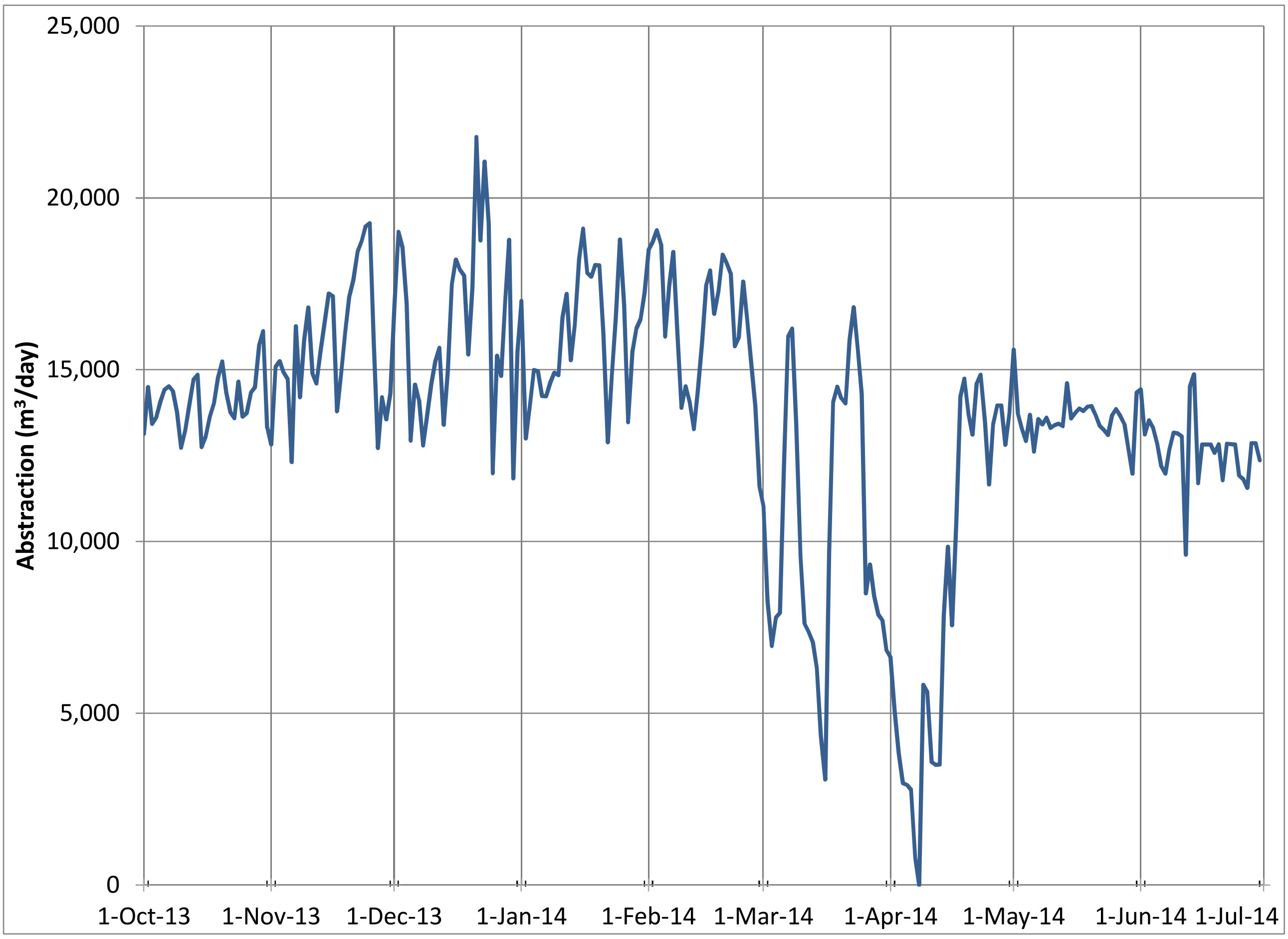

Figure 2: Waikanae WTP River Abstraction Volumes (m^3/day)

The instantaneous rates of abstraction (recorded at 15 minute intervals) for the reporting period are shown in Figure 3. The maximum abstraction rate was 348 L/s on 28 December 2013, which is less than the maximum pumping rate given by Condition 5 of consent WGN130103 [31993]. This peak rate was for no more than 15 minutes duration and Council has suggested that this was due to a maintenance flush of the intake wet well. The average instantaneous abstraction rate over the reporting period was 163 L/s.

The reduced rates of abstraction by Council during the months of February to April are due to the low river flows that occurred at this time which necessitated the use of the Waikanae Borefield for supplementary supply. Refer to section 2.1.4 for further analysis of this period.

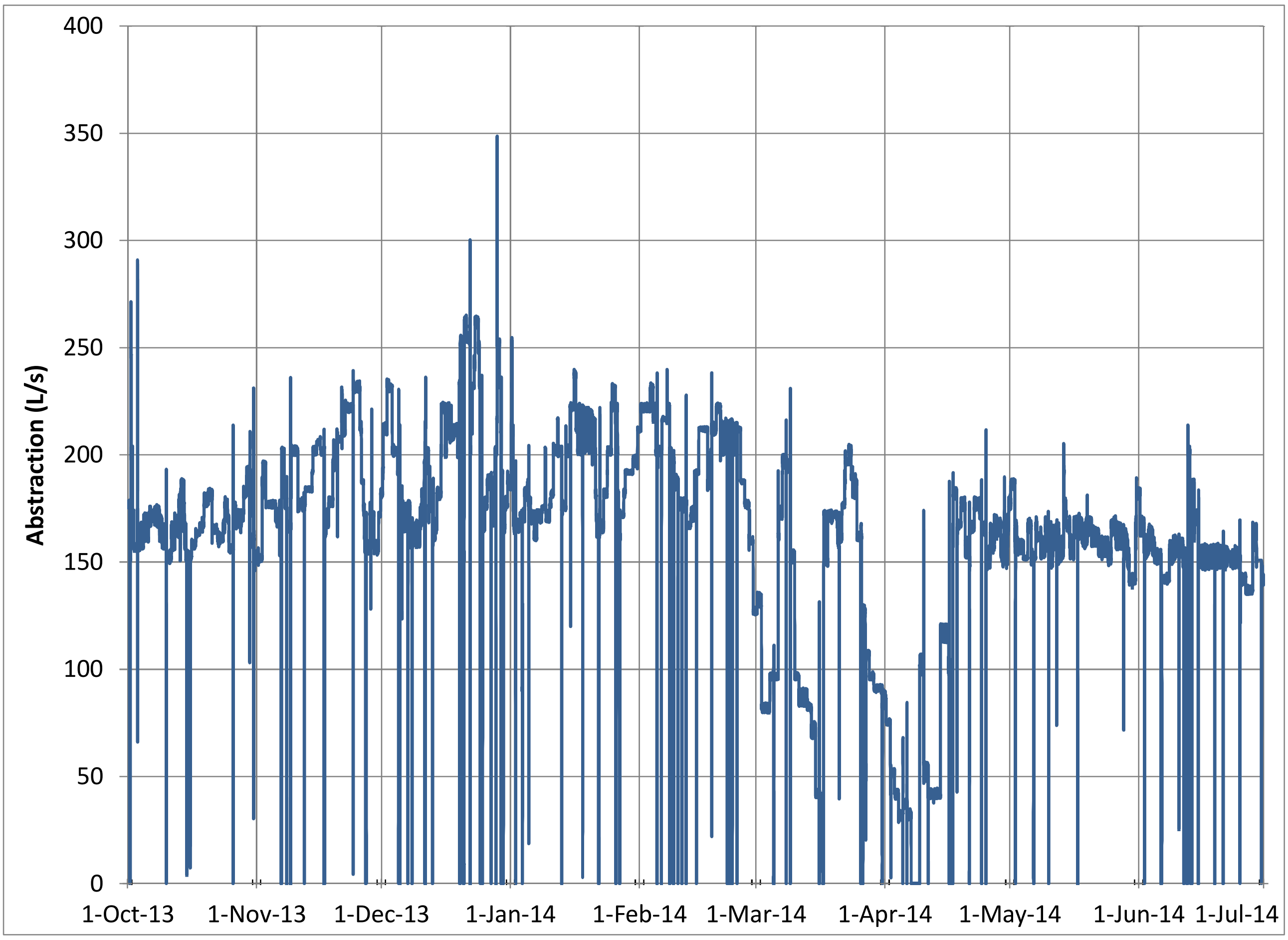

Figure 3: Waikanae WTP River Abstraction Rates (L/s)

2.1.3 River Recharge

There was no discharge of groundwater to the Waikanae River for the purpose of river recharge during the reporting period.

2.1.4 River Low Flow Periods

The flow of the Waikanae River was low enough during the months of February to April 2014 that Council had to reduce abstraction from the Waikanae River and use the Waikanae Borefield as a supplementary source for water supply. The Borefield was used for supplementary supply for a total of 43 days. Abstraction from the river ceased on 7 April 2014 at 0700h due to low river flows and the Borefield provided all water for public supply until the river abstraction was re-started on 9 April 2014 at 0800h.

Figure 4 shows the river flow at the GWRC gauging site upstream of the WTP, the WTP abstraction and the calculated flow immediately downstream of the WTP during this period of low river flow. The turquoise line is the river flow data extracted from GWRC's SCADA system on 2 July 2014, while the turquoise circles are the river flows taken from GWRC's website each day that Council's WTP Operators used to set the abstraction rate from the river. GWRC re-gauged the river and adjusted the rating curve on 28 February 2014, resulting in an adjusted flow record for the preceding months, which is why there is a difference between these two data sets. Using the river flows recorded from GWRC's website with Council's abstraction records, the calculated downstream flow is illustrated by the purple circles. The calculated downstream flow is above or at 750 L/s. This demonstrates compliance with Condition 12 of consent WGN130103 [31993].

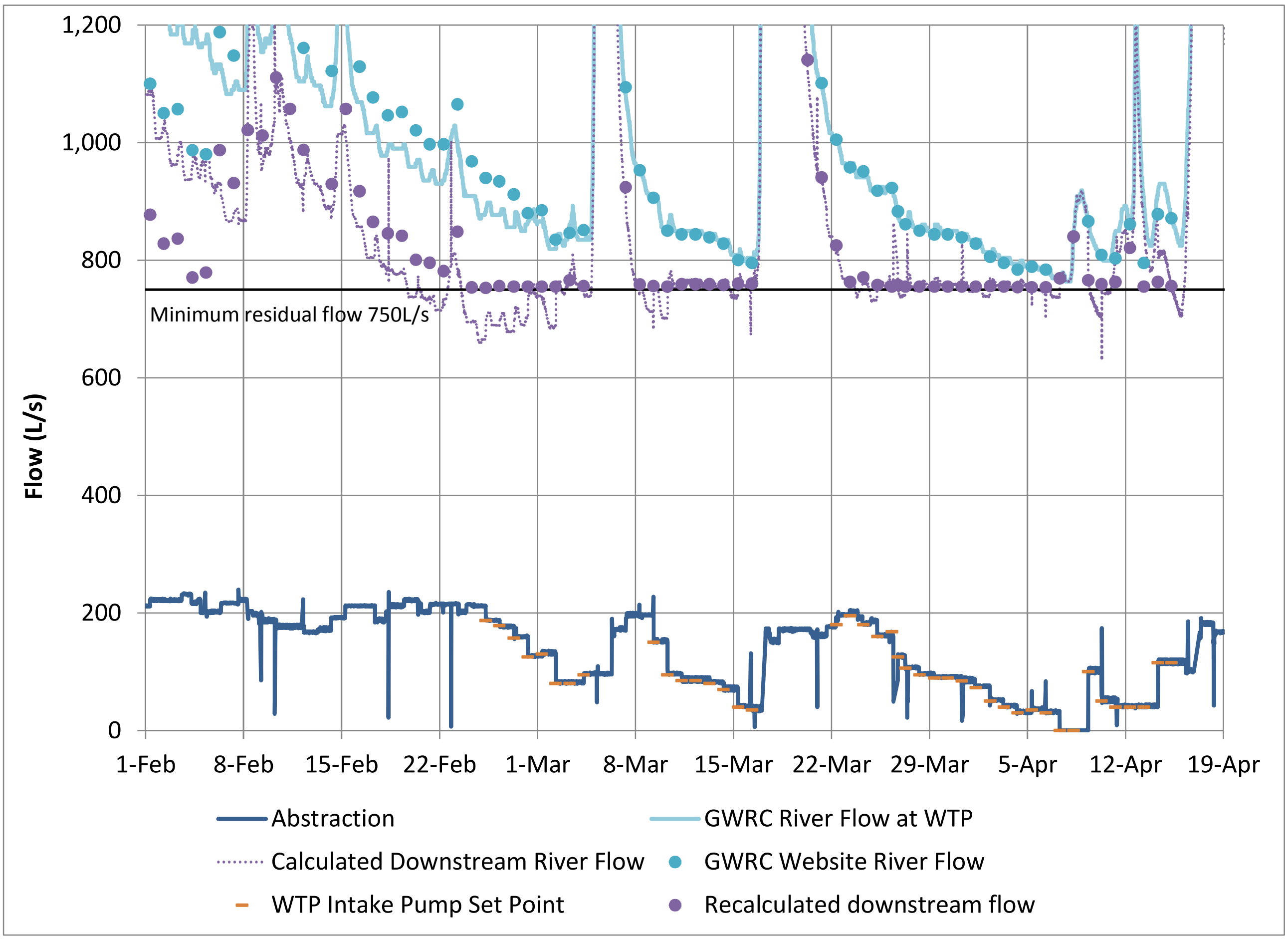

Figure 4: River flow upstream and downstream of WTP during low flow periods

A minimum flow of 200 L/s was maintained over the weir downstream of the abstraction point at all times in accordance with Condition 16 of consent WGN130103 [31993].

2.2 Operations Log and Maintenance Undertaken

Council has confirmed that its existing SCADA system together with the NCS system are an 'electronic data management system' which records and stores the information required by Condition 18 of consent WGN130103 [31993]. Council are working with the GWRC to enable river abstraction records to be submitted in a format compatible with GWRC's systems.

Council are currently implementing a new system (WaterOutlook) that will be used to store and report data and operational information relating to the Waikanae River take and recharge. This is expected to be in place by December 2014.

Pages from the Council's WTP operations log that relate to maintenance of the intake are included in Appendix A. Council has a separate consent relating to the removal of river gravels near the WTP intake (WGN100252). Contractors carried out this maintenance work on 6 November and 19 December 2013 in accordance with the conditions of the consent, and the WTP was shut down while the work took place.

Modification of the intake structure for the new screens is underway as part of the upgrade of the Waikanae WTP in accordance with the conditions of consent WGN130103 [31995].

Other than using the Waikanae Borefield for three periods in during February to April, no other unusual events were noted by Council.

2.3 Operations and Maintenance Manual

The Waikanae River Take Operations and Maintenance Manual (ROMM) is being prepared for Council by Cardno. The ROMM is due for completion by 7 April 2015 in accordance with Condition 17 of consent WGN130103 [31993]. In the interim period Council is continuing to use the operations and maintenance manual from the previous water permit WGN050024 [31767].

There are no recommended changes to the ROMM at this time.

3 River Monitoring

3.1 Aquatic Monitoring

Baseline monitoring of the Waikanae River was carried out in March and April 2014 in accordance with the River BMP. The results of this monitoring are documented in the report "Waikanae River Aquatic Baseline Monitoring Data" by Boffa Miskell, which is included as Appendix B.

The hydrological conditions in 2013/14 are considered to be not atypical. The river flow was consistently low, with no freshes or floods over 10 m^3/s, for the period 17 March to 16 April 2004 (30 days).

As there was no river recharge during the 2013/14, none of the interim trigger levels for the Waikanae River applied.

3.2 Bore Water Quality Monitoring

Water samples are collected from the production bores in the Waikanae Borefield by Council on a monthly basis to characterise the water quality of the bores. This data will be used to prepare the Bore Preference Hierarchy Plan which must be approved before river recharge occurs. A summary of the bore water quality sampling results obtained through to June 2014 is included in Appendix C. Fewer samples have been collected from bores K10 and K4; this is because bore K10 was undergoing redevelopment during March and April 2014, and the pump in bore K4 was not operable until February 2014 due to an electrical fault.

As required by the River BMP, a summary of the river water quality results from the baseline monitoring is included in Appendix C for comparison with the bore water quality.

The full water quality sampling results will be submitted with the Bore Preference Hierarchy Plan required by Condition 16 of consent WGN130103 [31994].

There has been no monitoring of blended bore water. Blended bore water quality monitoring will commence following characterisation of the bore water quality for the Bore Preference Hierarchy Plan and when river recharge commences.

3.3 Changes to River Baseline Monitoring Plan

No changes to the Waikanae River BMP are proposed at this stage.

4 Mitigation/Adaptive Management in the Coming Year

Looking ahead to the coming year (2014/15), there is no additional mitigation or adaptive management that is anticipated at this stage.

Further river baseline monitoring will be carried out over the 2014/15 summer in accordance with the River BMP.

The Waikanae Borefield will be used for supplementary supply during 2014/15 if abstraction is restricted by low river flows, until such time as river recharge is permitted.

5 Adaptive Management Group

The Adaptive Management Group (AMG) for the RRwGW scheme comprises three members who are representatives of GWRC, Council and Te Āti Awa ki Whakarongotai. The AMG met on 12 August 2014 to discuss this annual report, as well as the annual Waikanae Borefield report and procedural matters. Representatives of The Kapiti Fly Fishing Club, Regional Public Health and Friends of the Waikanae River also attended this meeting.

A recommendation of the AMG was that the due date for submitting the annual reports to GWRC (30 August each year) be extended. As the annual reports are required to report on the period 1 July to 30 June, it was discussed that the two month period from 1 July to 30 August was a tight timeframe to enable sufficient time for preparation of the report, consideration of the report by the AMG and stakeholders, hold an AMG meeting, and include the recommendations of the AMG in the final reports submitted to GWRC.

GWRC confirmed that there may be cases whereby an extension of this due date would be acceptable. However, it was noted that the conditions currently do not provide this flexibility. The AMG acknowledged that there may be times where the 30 August due date will be met. However, additional time would be required if there were more than minor compliance or monitoring matters to resolve or recommended changes to operations, monitoring and adaptive management. The members of the AMG agreed that the best approach would be to include flexibility in the consent whereby an extension to the due date could be agreed with GWRC. As such an application to change consent conditions 42 of consent [31992], 24 of consent [31993] and 26 of consent [31994] has been lodged with GWRC to action this recommendation.

Appendix A

Operations Log

Waikanae WTP Operations Log

Date	Action
29/10/2013	Cleared leaf rack
	Cleared intake
	Flushed scan
	5 bags of carbon
	Put pallet of carbon in carbon room
	Flushed low range NTU
	Flushed scan NTU
	Flushed probes and tank
	Flushed recirc pump and cyclone
	Flushed lime back from clearwell
	Washed down clarifier
	Put pallets of fluoride into room
	Removed branch from intake
	Cleaned out filter channels
	Flow 180l/s
	Flow increased to 190l/s @1405
6/11/2013	Clean/clear leaf rack
	Check intake - flush scan
	flush W/R NTU filter
	2 bags of carbon into hopper
	Flush/clean W/R NTU meter
	Flush/clean scan W/R NTU meter bowl
	Lime Room:
	Change manifold over
	Back flush from clearwell
	Flush post lime through pump and hardware
	Remove clearwell injector lime dosing and clean
	Clean level sensor probes/tank/sides/bucket
	Hose walls, floors and drains
	Flush cyclone of sand, flush circ pump
	Make a batch of poly
	2005hrs: Shutdown plant - river modifications
	2340hrs: Remove gravels from intake, restart plant
	2350hrs: Set pumps 200l/s
	Carry out UV verification Waikanae plant (BO & TA)
	Clean and calibrate deplox CL2 Re-gis
	Full contractor induction WAL (Lyn) Cooper (Goodman)
	Fluoride sample 0.54 fluoride retec
	Flow 170 l/s
	Flow 200 l/s @ 2350hrs
7/11/2013	Clear leaf rack
	check intake
	clear 5 Scan cyclone
	Lime Room:
	Flush cyclone

	Check recirculation pump head
	Flush lime pump and hose
	Backflush lime bosing and probes
	Maintenance:
	Remove sticks and small branches from intake
	Clean W/R NTU Meter bowl.
	Danny, Mark, Stewart (Goodmans) - site clear back area with digger
	Flow 180l/s from 1356hrs.
19/12/2013	Cleaned leaf rack
	Flushed scan
	Cleared intake
	Hosed down backwash tanks
	flushed and cleaned low range NTU
	Cleaned scan NTU and bowl
	4 bags of carbon
	Adjusted carbon feed to maximum 999
	Adjusted blow down from 120-60, 15-60
	Make batch of Poly
	NTU verifications
	Flush cyclone
	check recirc pipe
	Flush lime to pump
	Flush pump
	Flush lime back from clearwell
	Wash tank and probes
	Wash walls and floors
	Calibrate chlorine/Deplox
	River maintenance:
	1800hrs: contractor in river at Deoils Elbow
	200l/s
	1600: 230 l/s
	2230:250 l/s
	Shut down plant 1830hrs
	Start up 2215hrs
	Bypass 86 C3 0400hrs
19/02/2014	Clear/clean leaf rack
	Hose down mono pump area, run mono's on MA
	Hose sludge tank two
	Clean W/R NTU meter/scan W/R NTU bosing and probes
	Back flush and scan W/R NTU filter @ rapid mix
	Clean intake screen of leaf material
	Flush scan cyclone
	Flush recirc pump and cyclone
	Cleared recirc pump inlet box
	cleared tank outlets
	Washed probes and tank
	Washed walls and floor

	Flushed lime back from clearwell
	5 bags of carbon
	Turned down feeder to 270
	Intake Maintenance:
	Cutoff jaggered steel from intake weir
	Flow 220l/s
29/04/2014	2 bags of carbon
	cleaned leaf rack, checked monos
	Filled fluoride
	Clean NTU meter, turn off backflush
	Clear the top of the intake
	flush the 5 Scan probe and bowl
	Wash down lime tank
	Flush lime cyclone
	Clean leaf mud rack, run mono's again @1500
	Clean lime tank probes, finish cyclone
	1645hrs: Raw water intake blocked 9Alram)
	Stopper R/W pump, unblocked screen - intake.
	1656hrs: restart pump, push reset button (blue) on consol
	Flow 150l/s
	1630: Flow 155l/s

Appendix B

Aquatic Monitoring Report

Waikanae River Aquatic Baseline Monitoring Data:

A report on 2013/2014 aquatic data collection for water permits WGN130103 [31993] & [31994]

Prepared for Kapiti Coast District Council

Document Quality Assurance

Bibliographic reference for citation: Boffa Miskell Limited 2014. *Waikanae River Aquatic Baseline Monitoring Data: A report on 2013/2014 aquatic data collection for water permits WGN130103 [31993] & [31994]*. Report prepared by Boffa Miskell Limited for Kapiti Coast District Council.		
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Status: Final	Revision / version: 6	Issue date: 25 August 2014

Template revision: 20140327 0000

File ref:W14012_05_annual_Waikanae_data_report_final_20140729

Cover photograph: Cobble & periphyton of the Waikanae River © B. Risi 2014

1.0 Introduction

Resource consent conditions 19 (Consent WGN130103 [31993]) and 21 (Consent WGN130103 [31994]) for Kapiti Coast District Council's River Recharge with Groundwater Project (RRwGW Project) requires the preparation of a 'Waikanae River Baseline Monitoring Plan' (Waikanae River BMP). That plan (as prepared by BML (2014) and certified by GWRC) requires collection of: periphyton data (including visual cover and community composition assessments, algal biomass (AFDM) and chlorophyll-a) over summer periods at frequencies that depend on the river's flow; macroinvertebrate samples that are dependent on periphyton levels (i.e. two sets of samples are collected in each of a low, medium and high periphyton period); water quality samples for a base set of water quality per week; and a set of velocity measures at each visual cover estimation plot. Manual water flow measures are also required on a small number of occasions. These data are collected from 2 upstream "control" and 3 downstream "affected" monitoring sites on the Waikanae River during the months of December to April.

Full details of the consent conditions and the parameters and requirements for monitoring can be found in the BML report "Waikanae River Baseline Aquatic Monitoring Plan" dated 23 February 2014 (prepared for KCDC).

2.0 Scope

This report:

- Presents the findings of the first two months of data collection, March and April 2014, as part of the first year of baseline sampling, prior to introduction of any bore water recharge to the Waikanae River;
- Presents the data and basic analyses of the metrics that may be used in the future to track potential effects of the groundwater discharge to the Waikanae River; and
- Concludes with any lessons learnt on collection of the data and observations as to the usefulness of the data to predict responses to the potential effects of bore water addition.

This report presents only the first two sampling periods (i.e. two months) of the minimum one year of baseline monitoring required prior to any bore water recharge. After one year of monitoring, and subject to the approval of GWRC, bore water recharge may comprise up to 20% of the river flow downstream of the Waikanae water treatment plant. The baseline monitoring will then continue for a further two years to complete the three year baseline monitoring period required by the consents for the RRwGW project. The baseline monitoring data will inform the development of ongoing trigger levels once the three year baseline monitoring period is complete.

3.0 Report structure

This report presents the findings of the first two months of baseline sampling, before the introduction of bore water to the Waikanae River. It is part of a 3 year baseline monitoring programme, as described in the Waikanae River BMP (BML 2014).

This report presents a methods section which does not detail the methods of collection of the data, that detail is produced in the baseline monitoring plan (BML 2014). The methods section of this report illustrates the monitoring sites and details the methods of data analysis undertaken.

Section 5 then presents background data such as river flows and rainfall, and Section 6 presents some information on the monitoring sites that has contextual value, but is not directly relevant to the monitoring purpose.

Section 7 (Results) is the presentation of the monitoring results, examining the metrics of water quality measured over time for each site. Sub-section 7.1 is concluded with a brief summary where river flow and the changing water quality metrics are examined.

Sub-section 7.2 looks at periphyton in the river, both from visual cover estimates and broad community composition, as well as the quantitative data from samples.

This sub-section is followed by an analysis of correlations between the different periphyton and water quality parameters. This section, with the limited current data set, is as yet not sufficient to develop macroinvertebrate community – periphyton correlations or flow relationships, but is sufficient to show correlations between the different measures of periphyton. Wider and different periphyton conditions are required before better correlation analysis can be undertaken which may provide better resolution on existing relationships.

Sub-section 7.4 examines the aquatic macroinvertebrate assemblies but has only two sample collections which both relate to medium and medium-high levels of periphyton. A wider range of periphyton levels and related macroinvertebrate sampling is required before periphyton-macroinvertebrate relationships can be made.

Section 8 (Fish Population Summary) covers the results of the search and sampling of upper river tributaries in the Waikanae River and Otaki River (the control). These data are to establish a baseline population of migratory fish in an effort to produce a measurable trigger to the persistence of upward migrating fish. The Otaki River control site is established but further work is required to find a suitable Waikanae River site.

The report then briefly examines the flow gauging results for the lower Waikanae River (Section 9).

Lastly the report examines the resultant averaged condition of the water quality from monitoring and compares these to national guidelines and then discusses the monitoring to date, the parameters measured and makes recommendations as to the value of the information collected and if any changes to the monitoring regime are recommended.

4.0 Methods

4.1 Monitoring sites

The monitoring locations have been determined in the Waikanae River BMP, and in summary consist of:

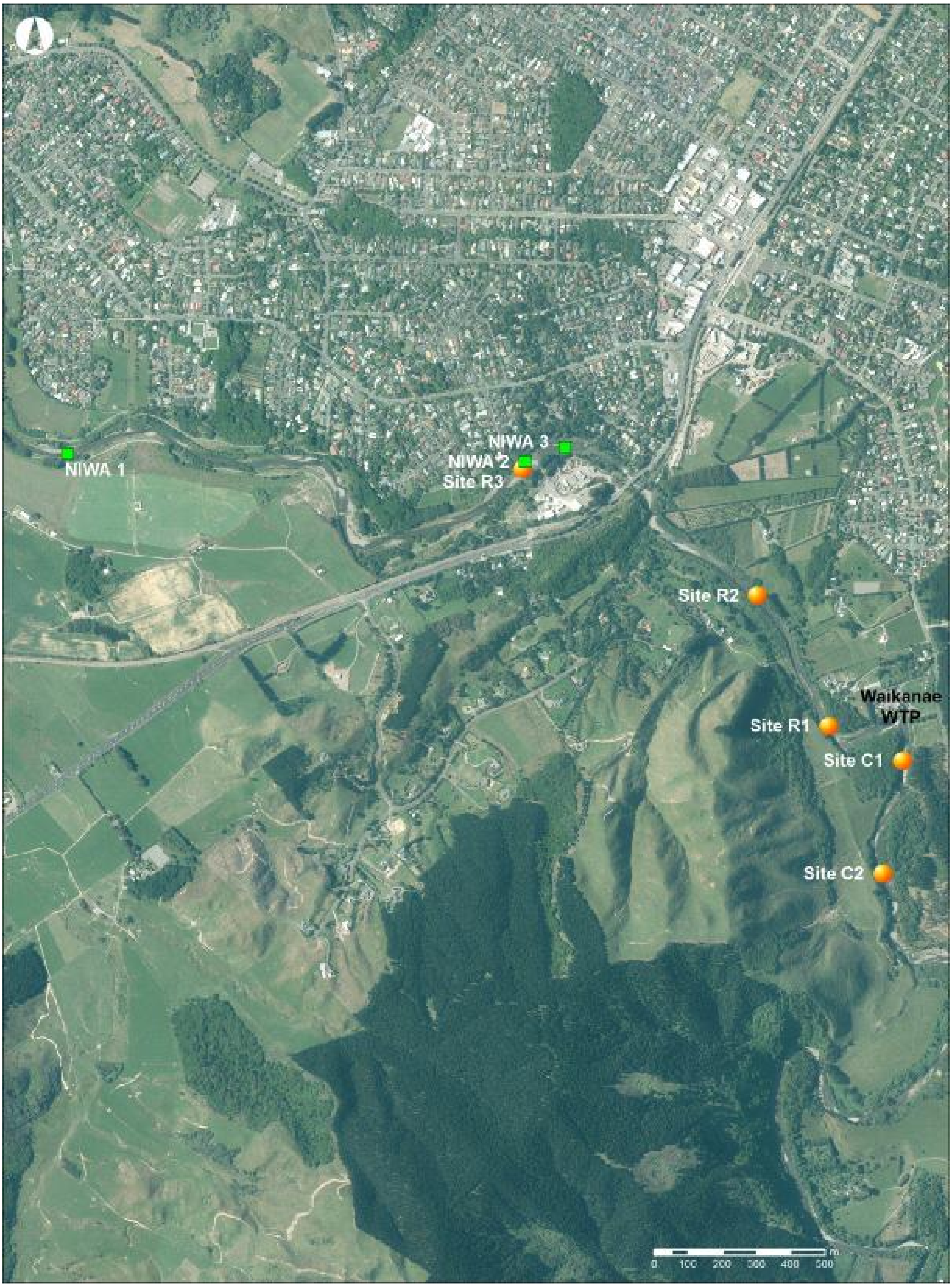
- Two 'control' sites, located upstream of the Waikanae Water Treatment Plant (WTP); and
- Three 'receiving' sites, located at predetermined intervals downstream of the Waikanae WTP.

The locations of these sites are described in full in the Waikanae River BMP (BML 2014) and shown in Map 1 below. At each site, a wooden stake has been driven into the bank so that the exact site location can be resampled over time. Down from these stakes are measured the transect positions and off those are defined the sampling locations for water quality, periphyton and macroinvertebrates.

The 'control' sites and 'receiving' sites are simply replicate data sites until such time as bore water is introduced. Following that time the upper sites (C1 and C2) become control sites to examine the effects of bore water on the parameters measured at the downstream receiving sites (R1, R2 and R3).

Part of the initial monitoring results and analysis is to determine if Sites C1 and C2 (the control sites) are sufficiently similar in the monitored metrics as to be good control sites.

Map 1 – Waikanae River Monitoring locations (note that the NIWA sites are those at which river gauging was undertaken – refer section 4.2, item 6).



The following photographs give a general indication of the conditions at each site.

Figure 1: 'Receiving' Site R1: looking upstream from and showing the location of the first transect

Figure 2: 'Receiving' Site R2: under pylon, looking downstream

Figure 3: ‘Receiving’ Site R3: below SH1 looking downstream from riffle to run

Figure 4: ‘Control’ Site C1: looking upstream

Figure 5: ‘Control’ Site C2: looking downstream from upper transect

4.2 Monitoring methods

At each of the 2 'control' and 3 'receiving' sites, the following was measured during fine weather and low-flow conditions (i.e. no raised or flushing flow events prior to sampling).

Full methods for this sampling programme are provided in Waikanae River BMP (BML 2014), but in summary, the following parameters were required to be measured at each site in March 2014 and again in April 2014.

1. Water chemistry and temperature:
    - pH;
    - Temperature (˚C);
    - Conductivity (µS/cm);
    - Dissolved reactive phosphorus (DRP, mg/L);
    - Total phosphorus (TP, mg/L);
    - Soluble inorganic nitrogen (SIN, mg/L);
    - Total nitrogen (TN, mg/L);
    - Total ammonia (NH_4, mg/L); and
    - Dissolved calcium (mg/L).
2. Periphyton:
    - Visual observations of percent cover of periphyton at each site according to the RAM 1 & 2 methods of Biggs and Kilroy (2000); and
    - Periphyton biomass, based on both chlorophyll-a and ash-free dry mass (AFDM) measurements (Biggs and Kilroy (2000)), from multiple rock scrapings collected from each site.
3. Velocity:
    - At each periphyton quadrat the water velocity was measured by "the ruler method" (Harding et al 2009, Drost 1963[1]).
4. Benthic macroinvertebrates:
    - The macroinvertebrate community was sampled at each site following the Ministry for the Environment sampling 'Protocol C3 – Hard-bottomed, Quantitative', where five replicate Surber samples were collected from riffle habitat at each site; and
    - Six biotic metrics (total abundance, taxonomic richness, Ephemeroptera, Plecoptera, Trichoptera [ETP] richness, EPT abundance, Macroinvertebrate Community Index [MCI], and the Quantitative Macroinvertebrate Community Index [QMCI]) were calculated for each Surber sample.
5. Freshwater fish:
    - The freshwater fish community was sampled at each site using a Kainga EFM 300 backpack mounted electro-fishing machine (NIWA Instrument Systems, Christchurch); and

[1] Drost, H., 1963. Velocity head rod for measuring stream flow. J. Hydrol. (New Zealand) 2: 7–11.

- A 150 m reach was fished, using a single pass, at each site.

6. Flow gauging

   - Standard river gauging (following the BMP methodology) undertaken just below SH1 (site NIWA 2 (March 2014) & NIWA 3 (April 2014) on Map 1) and at the start of Jim Cooke Park (site NIWA 1 on Map 1).

In addition some basic substrate data, in terms of hard bottom cover available for periphyton was assessed as was the proportion of river shaded to assist in understanding the periphyton results.

4.3 Data analyses

Tables and charts (graphic plots) were prepared to examine the differences in water quality, periphyton and macroinvertebrate results between sites and over time[2]. Two factor ANOVA (Excel 2013) **without** replication (where no replication in measure exists other than over time) was performed (with an Alpha level of 0.05) on the water chemistry, water velocity, periphyton cover, chlorophyll, AFDM data collected over 5 sites and through 2 months (8 collection times) to recognise statistically significant differences across monitoring sites and through time.

A T-test was used, on occasion, to ascertain similarities in sets of data between only two sites.

Pearson Correlation (Excel 2013) was undertaken on all river data including velocity measurements to ascertain significant (alpha 0.05) positive and negative correlations. Reporting focused on chlorophyll as a significance focus of the river response is in regard to periphyton responses.

A non-metric multidimensional scaling (or NMDS) ordination[3], with 1000 random permutations, using abundance data, was used to determine if the macroinvertebrate community found was similar among the 5 sites surveyed, and particularly between the March and April sampling periods (medium-high and high periphyton periods, respectively).

NMDS ordinations rank sites such that distance in ordination space represents community dissimilarity (in this case using the Bray-Curtis metric). Therefore, an ordination score (i.e. an x and a y value) for the entire macroinvertebrate community found at any site can be presented on an x-y scatterplot to graphically show how similar (or dissimilar) the community at a site is from that found at another site. Ordination scores that are closest together are more similar in macroinvertebrate community composition, than those further apart (Quinn and Keough 2002[4]).

An analysis of similarities (ANOSIM), with 100 permutations, was then used to test for significant differences in macroinvertebrate community composition between the March and April sampling. It is helpful to view ANOSIM results when interpreting an NMDS ordination. An NMDS ordination may show that communities appear to be quite distinct (i.e. when shown graphically, sites could be quite distinct from one another in ordination space), but ANOSIM results show whether these differences are in fact statistically significantly different[5].

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[2] Note that the data in the plots are point location and single time data, not continuous data, and therefore should not technically be represented in the plots with lines connecting the point data. However, for ease of establishing trends and to assist the eye in following the sites through time these data have been linked by a smoothed line.

[3] Goodness-of-fit of the NMDS ordination was assessed by the magnitude of the associated 'stress' value. A stress value of 0 indicates perfect fit (i.e. the configuration of points on the ordination diagram is a good representation of actual community dissimilarities). It is acceptable to have a stress value of up to 0.2, indicating an ordination with a stress value of <0.2 corresponds to a good ordination with no real prospect of misleading interpretation (Quinn & Keough 2002).

4 Quinn GP, Keough MJ (2002) *Experimental design and data analysis for biologists*. Cambridge University Press, Cambridge

[5] ANOSIM is a non-parametric permutation procedure applied to the rank similarity matrix underlying the NMDS ordination and compares the degree of separation among and within groups (i.e. sites or years) using the test statistic, R. When R equals 0 there is no distinguishable difference in community composition, whereas an R-value of 1 indicates completely distinct communities (Quinn & Keough 2002).

If ANOSIM revealed significant differences in macroinvertebrate community composition (i.e. $R \neq 0$ and $P \leq 0.05$) between the two baseline sampling occasions, similarity percentages (SIMPER) were calculated[6] to show which macroinvertebrate taxa were driving these differences.

NMDS, ANOSIM and SIMPER analyses were performed in PRIMER version 6.1.13 (Clarke and Warwick 2001; Clarke and Gorley 2006).

There are a range of guide or standard thresholds values for many of the water quality and periphyton metrics monitored in this programme. Table 1 presents those metrics with published standards.

Table 1: NZ Standards, guides and comparative measurement thresholds

Metric	Accepted range or upper limit	Reference
pH	7.2-7.8. 6.5-8.0	ANZECC 2000, ECAN 2012
DRP	0.003 g/m^3	Biggs 2000
DRP	0. 006 g/m^3	ECAN 2012
SIN/DIN	0.034 g/m^3	Biggs 2000
SIN/DIN	0.47 g/m^3	ECAN 2012
Ammonia	0.021 g/m^3 (at pH 8)	ANZECC 2000
Turbidity	4.1	ANZECC 2000
Periphyton cover (LGF %), biodiversity	30%	Biggs 2000
Periphyton thick matts (%), biodiversity	60%	Biggs 2000
TP	0.009 – 0.033g/m^3	ECAN 2012, ANZECC 2000
TN	0.016 -0.614 g/m^3	ECAN 2012, ANZECC 2000
NO_x	0.444	ANZECC 2000
DO% saturation	98-105	ANZECC 2000

Several sources are used and the measures are not the same. ECAN has set limits and guidance values to suit its regional issues, especially farming intensification as that relates to nutrients leached into waterways. ANZEEC provides a wider view set against national statistics. These are guidance values, not absolute adverse effects bottom line limits.

Sources:

ANZEEC (2000). Australian and New Zealand guidelines for fresh and marine Water quality. National water quality management strategy, Paper No/ 4 October 2000. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Biggs B. (2000). New Zealand Periphyton Guidelines: Detecting, Monitoring and Managing Enrichment of Streams. Prepared for the Ministry for the Environment by the National Institute for Water and Atmospheric Research (NIWA).

ECAN 2012: Proposed Canterbury Land and Water Regional Plan, Vol 1.

[6] The SIMPER routine computes the percentage contribution of each macroinvertebrate taxon to the dissimilarities between all pairs of sites among groups.

5.0 Water quantity through monitoring period

The Waikanae River BMP specifies the frequency of summer sampling relative to the 7-day average flow for the Waikanae River. Fortnightly sampling is undertaken when the 7-day average flow is above 1100 L/s. Weekly sampling is required when the 7-day average flow is below 1100 L/s.

5.1 Rainfall and river flow

Weekly rainfall depths and average flow data during the summer of 2013-2014, which includes the monitoring period of March and April 2014, is summarised in Table 2 and Figure 6.

Table 2: Background Waikanae Rainfall and River flow records (data from GWRC) 1st October 2013 to 2 June 2014

Week ending	7-day Rainfall (mm)	7-day average flow (L/s)	Week ending	7-day Rainfall (mm)	7-day average flow (L/s)
7/10/2013	2.5	3992	**10/02/2014**	10.6	1167
14/10/2013	51.5	12013	**17/02/2014**	5.0	1135
21/10/2013	40.9	15539	**24/02/2014**	0.1	972
28/10/2013	13.0	8889	**3/03/2014**	0.0	866
4/11/2013	72.7	18403	**10/03/2014**	22.3	1135
11/11/2013	5.6	5272	**17/03/2014**	15.0	848
18/11/2013	13.4	2991	**24/03/2014**	6.7	1730
25/11/2013	0.0	2103	**31/03/2014**	0.3	883
2/12/2013	13.0	1750	**7/04/2014**	0.0	807
9/12/2013	27.9	1771	**14/04/2014**	17.2	858
16/12/2013	10.3	1703	**21/04/2014**	46.6	1889
23/12/2013	0.0	1227	**28/04/2014**	28.5	1797
30/12/2013	24.0	1563	**5/05/2014**	48.0	8232
6/01/2014	86.0	9802	**12/05/2014**	61.2	9068
13/01/2014	4.6	4875	**19/05/2014**	38.0	8635
20/01/2014	0.0	1932	**26/05/2014**	11.0	4156
27/01/2014	32.1	1747	**2/06/2014**	13.0	4858
3/02/2014	0.0	1511			

Rainfall through October kept river flows above 3,000 L/s until mid-November. Drier weather during November and December resulted flows recessing down to 1,100 L/s by 24 December. Heavy rain in late December and early January restored flows, with a peak flow of 124,633 L/s recorded on 5 January.

Rainfall was generally low from mid-January to mid-April, with flows dropping steadily to lows of 809 L/s on 16 March and 764 L/s on 7 April. From mid-April onwards, heavy rainfall raised flows above threshold levels.

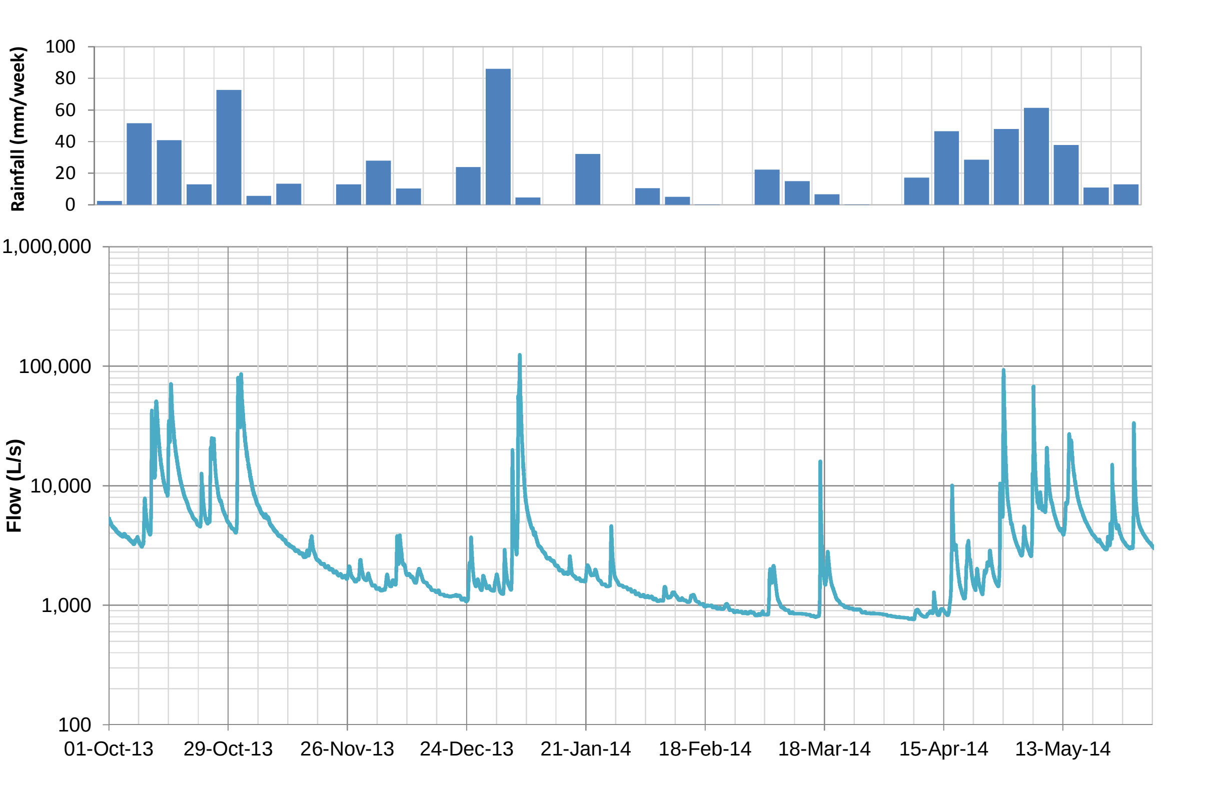

Figure 6: Weekly rainfall depths and recorded flow at the Waikanae WTP

Flow gaugings were carried out by NIWA at two locations downstream of the water treatment plant on 11 March and 10 April. These are reported in Section 9.0.

5.1.1 Effect on baseline monitoring

As flows rise, the ability to visually monitor periphyton reduces, so that only scrape samples and water quality data may be collected. Furthermore, where flows increase such that sampler safety is placed at risk sampling at that time is abandoned. The flow of 100,000 L/s on 28-29 April was high enough to preclude the final baseline monitoring survey scheduled for the end of April.

5.2 Abstraction

Figure 7 shows daily average abstraction from the beginning of October 2013 to the end of June 2014. During this period, the average abstraction was 13,734 m^3/day (159 L/s daily average), with a peak of 21,779 m^3/day (252 L/s). The peak abstraction occurred on 21 December. Abstraction from the river was reduced during the periods of: 25 February to 6 March 2014, 9 to 17 March 2014, and 25 March to 17 April 2014 due to low river flows. GWRC re-gauged the river and adjusted the rating curve in late February. This resulted in the river flow data through February retrospectively being adjusted downwards by about 50-60 L/s compared with the river flows that were used in real-time for operation of the water treatment plant abstraction. The water treatment plant abstraction was operated such that the downstream flow was above or at 750 L/s based on the flow rating in use at the time. However, the river flow data presented in Figure 7is the updated data from GWRC following re-gauging of the river.

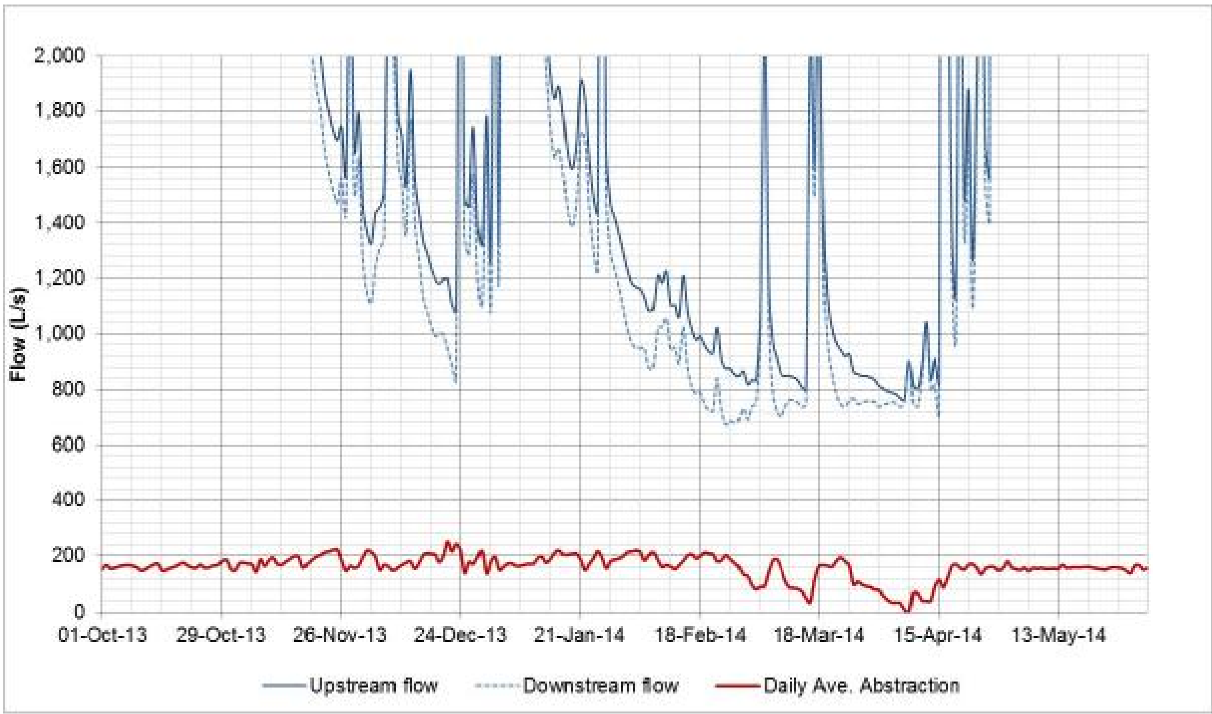

Figure 7: Waikanae River daily abstraction and calculated downstream flow

5.3 Water temperature

The water temperature of the Waikanae River is recorded by GWRC at its recording station upstream of the water treatment plant, as shown in Figure 8. Until the end of October, the maximum temperature was 14^{o}C. As river flows dropped through November and December, maximum daytime temperatures were about 19^{o}C. As flows increased due to the heavy rain in early January, maximum temperatures fell back to about 14^{o}C, before rising steadily to peak at just over 20^{o}C in late February. Through March, maximum temperatures were about 16^{o}C, before dropping back to about 10^{o}C during April.

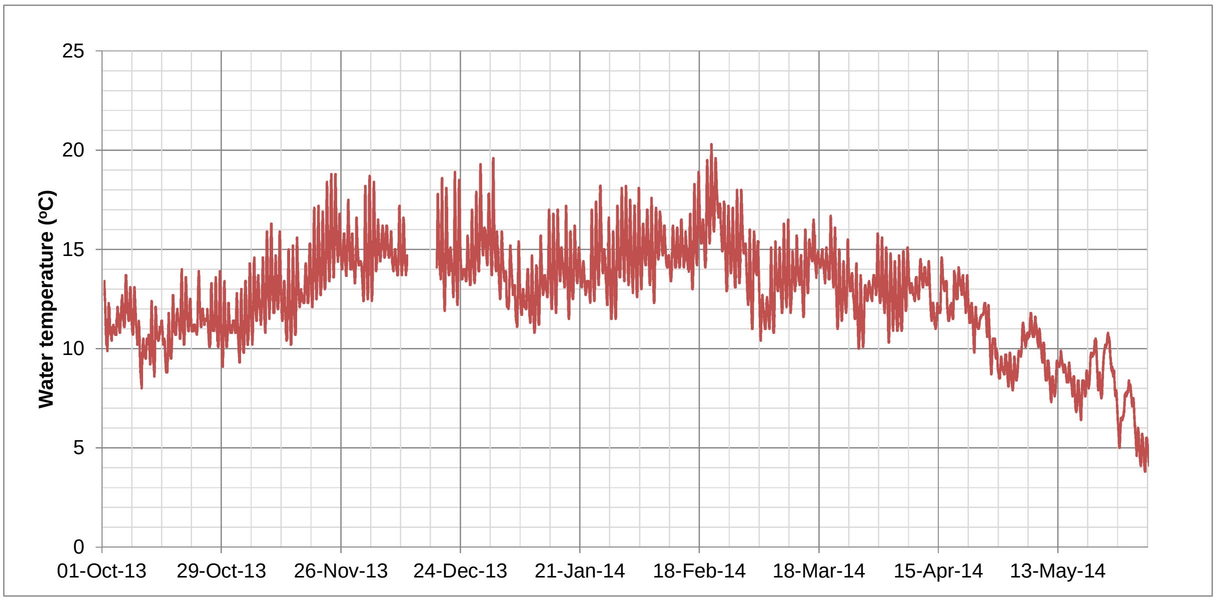

Figure 8: Waikanae River recorded water temperature

6.0 Monitoring sites' shade and substrate quantity for periphyton attachment

Around 80% of $1m^2$ quadrats along each of the 5 site transects were of sufficient size and hardness to support attaching periphyton (Figure 9). The other 20% of the substrate was generally sands.

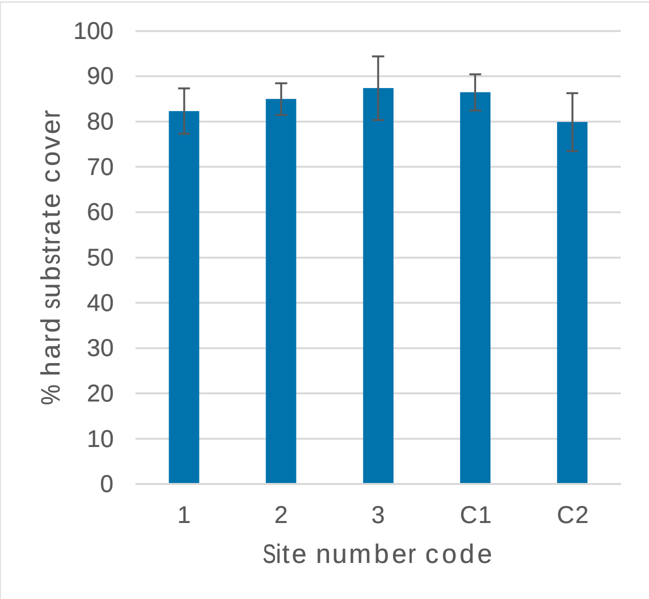

Figure 9: Average (n=20) hard substrate available at each monitoring site

Shading is largely absent at all monitoring sites and despite there being native (and exotic) shrub and forest generally near the river, most tall vegetation is set back from the active water channel sufficiently so that no actual direct shade is provided except in early morning and late evening (Table 3).

Table 3: Shade estimates

Transects	Shading (%)	Wetted width (m)
Control 1 (C1)		
Riffle 1	10	10.5
Riffle 2	12.5	12.6
Run 1	10	13.1
Run 2	10	12.7
Control 2 (C2)		
Riffle 1	0	10.2
Riffle 2	0	10.6
Run 1	0	13.1
Run 2	0	12.6
Site R1		
Run 1	0	15
Run 2	0	17.5
Riffle 1	0	23.2
Riffle 2	0	21
Site R2		
Riffle 1	0	11
Riffle 2	5	12.5
Run 1	0	10.2
Run 2	0	11.6
Site R3		
Riffle 1	0	10
Riffle 2	0	10
Run 1	0	20.3
Run 2	0	18.5

7.0 Results

7.1 Water chemistry and temperature

Condition 19 requires the collection of a prescribed set of water quality parameters as listed in the Methods section (section 4.0) and detailed in the Waikanae River BMP (BML 2014).

The raw tabulated data are presented in Appendix 1, with summary plots of that data for March and April 2014 in the following sub-sections. Note the data are not continuous, they are one point in time measures, and therefore plots should not be connected by a line – however, to ease the reader's viewing through time and potentially mimic the likely trend, a line connecting each sites data has been included.

7.1.1 pH

There was no discernible weekly pattern in pH across the sites although there was one period (11 April 2014) at Site R2 where pH rose atypically (Figure 10). The average pH across the sites was around 7.7, which is generally considered circum-neutral and a normal or "healthy" state. There was a statistically significant difference in pH among sites (Two factor ANOVA, df=5, F=5.3, P=0.002), but not through time (Two factor ANOVA, df=5, F=1.3, P=0.29). This difference, it appears, may be due to the differences between Site R2 and Site C2 (T-test, paired two sample for means, two-tailed, tstat=3.06, df=6, p=0.022) and especially the anomalies at Site R2 on 7 March and at Site C2 on 1 April.

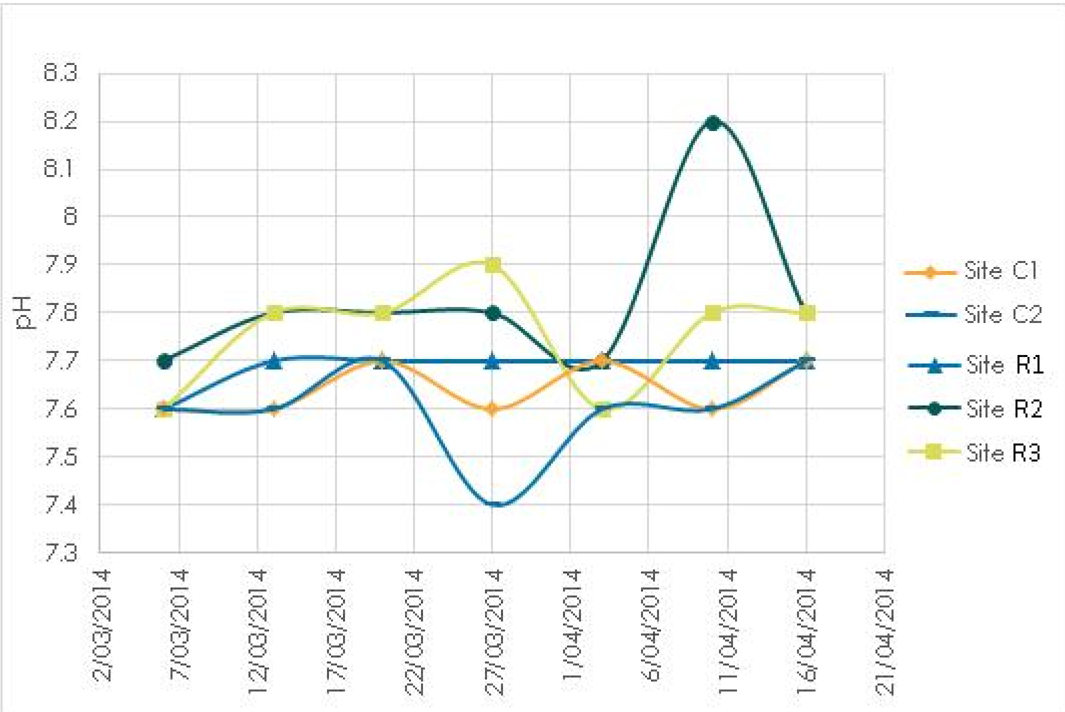

Figure 10: pH measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.2 Temperature

While there was no significant difference between temperatures at each site (Two Factor ANOVA, df=4, f=0.16, P=0.96), there was a statistically significant difference in temperature at different monitoring dates (Two Factor ANOVA, df=5, f=0.69, P=0.0007). As the graph (Figure 11) below shows, early March had cooler water.

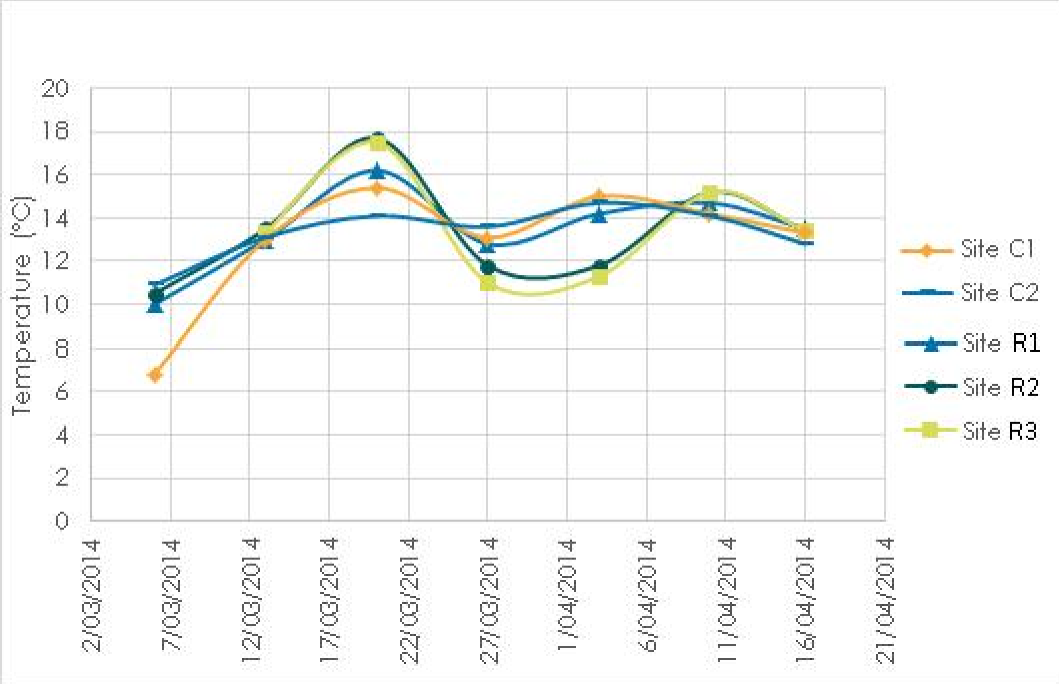

Figure 11: Temperature measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.3 Conductivity

Conductivity (often a proxy for nutrient contaminants), was no different in each site (Two factor ANOVA, df=4, F=0.8, P=0.52) despite the fall in measure at Sites R3 and C1 in the last sampling period. There was however a difference over time (Two Factor ANOVA, df=5, F=5.3, P=0.002). That difference, as can be seen in Figure 12, may relate to a sudden decline in conductivity at Site C1 and Site R3 in late April, otherwise the measures through time are relatively stable.

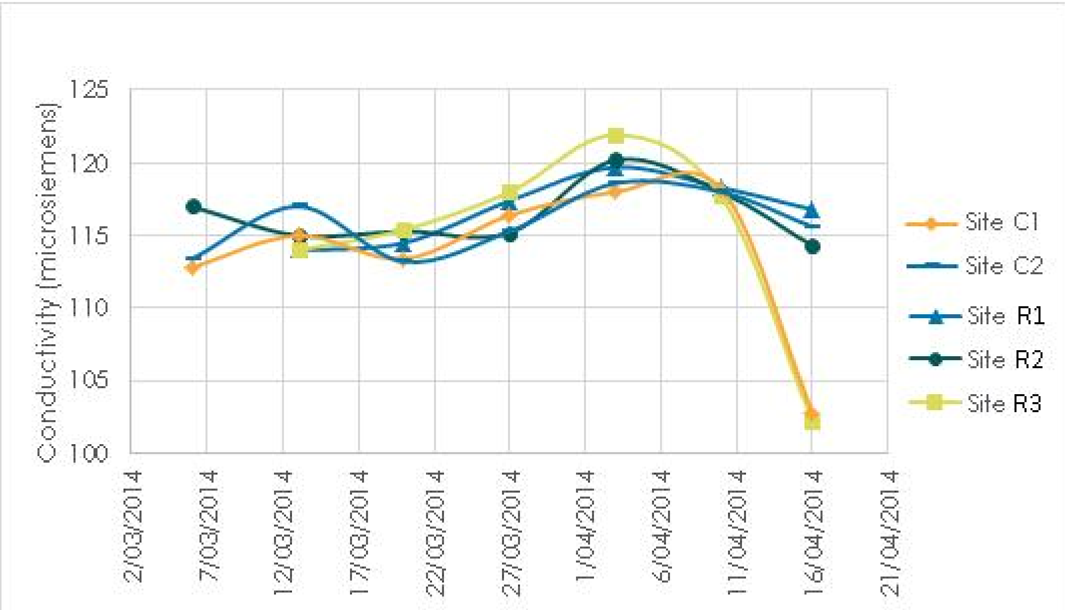

Figure 12: Conductivity measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.4 Total phosphorus

Total phosphorus measures, Figure 13, show small and non-significant variation between sites (Two Factor ANOVA, df=5, F=1.06, P=0.4). This is despite one measure at Site C2 on the 27 March 2014 being atypically raised. The reason for this is unknown and short of a collection/lab error (which is unlikely) the only reason that suggests itself is a chance sample grab of a small slug of enriched water or material. Otherwise levels are around 0.01 g/m^3. There is a statistical difference in measure across time (Two Factor ANOVA, df=6, F=13.2, P<0.00001).

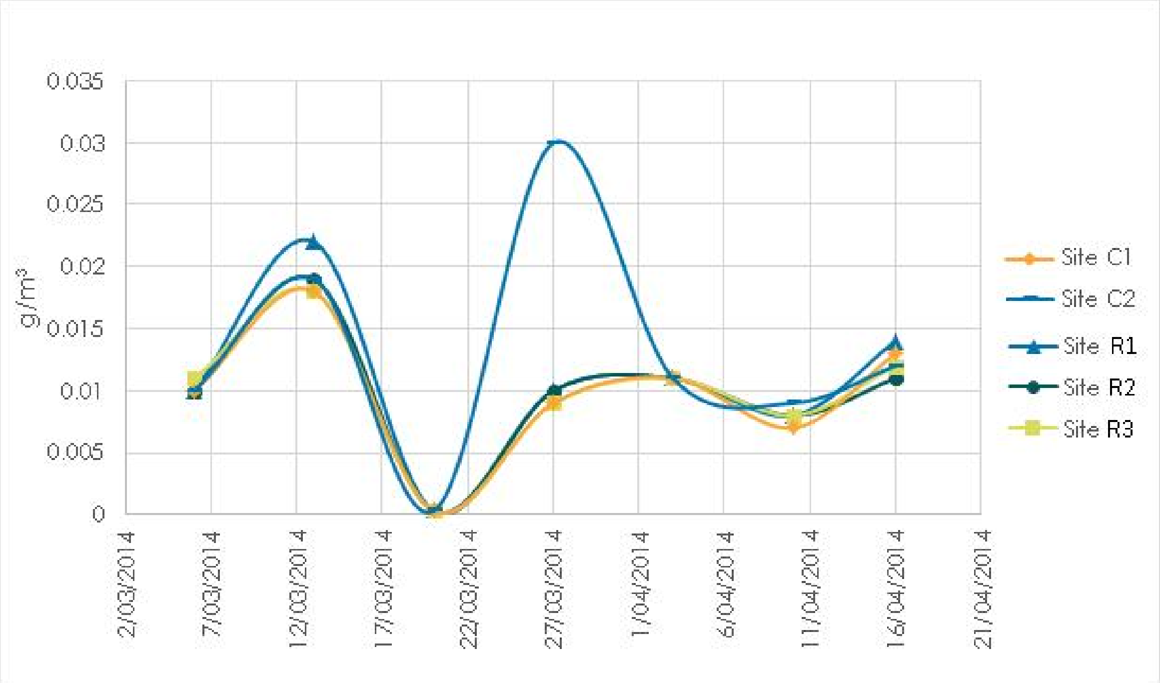

Figure 13: Total Phosphorus measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.5 Dissolved reactive phosphorus (DRP)

DRP, Figure 14, across the sites was the same (Two Factor ANOVA, df=4, F=1.8, P=0.16). Measures fell through April but returned to around the initial measure in March (averaging 0.009 g/m^3) and, over the monitoring time, DRP was significantly different (Two Factor ANOVA, df=6, F=170, P< 0.00001).

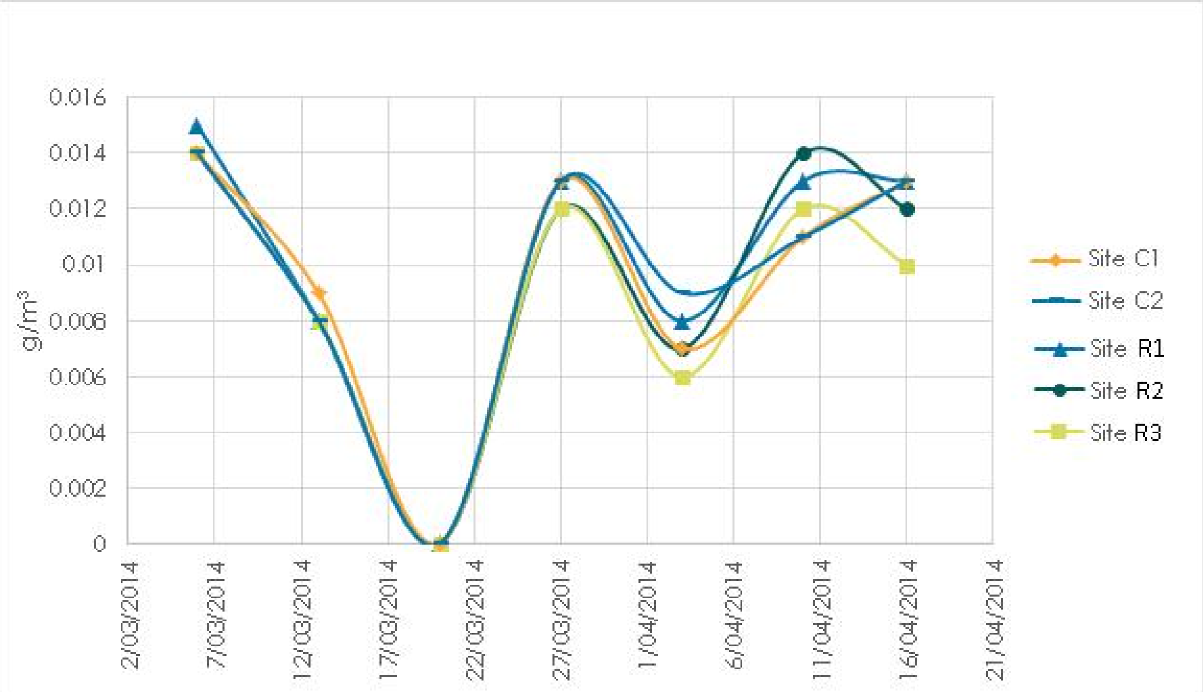

Figure 14: Dissolved Reactive Phosphorus measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.6 Total nitrogen

Total nitrogen levels are statistically no different across the sites and through time (Two Factor ANOVA, (site, time) df=4, 6; F=1, 1.3; P=0.48, 0.28). There was however one atypical measure at Site C2 on the 27 March 2014 (Figure 15). That measure (at 1.52 g/m^3) was 100 times the "normal" level recorded at other sites and at Site C2 in other weeks. This atypical measure coincided with an atypical total phosphorus level at Site C2 (Figure 13). As with the total phosphorus the reason for this is unknown and again it may be a chance sample grab of a small slug of enriched water or material.

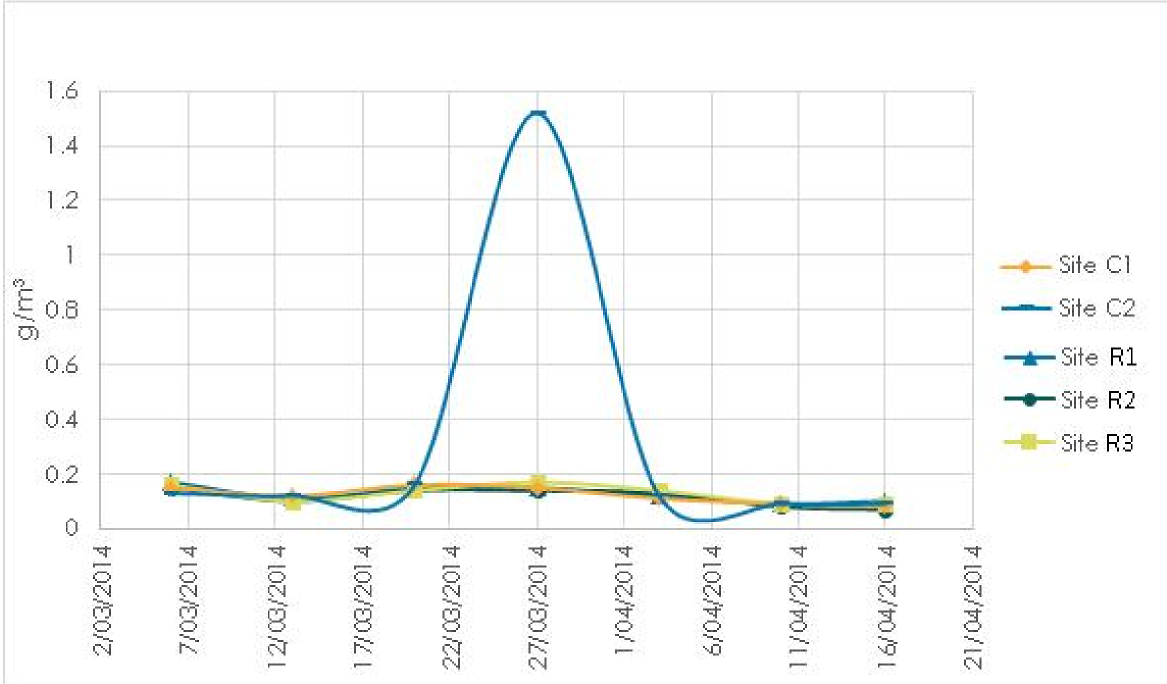

Figure 15: Total Nitrogen measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.7 Dissolved calcium

Dissolved calcium was statistically different between sites and across dates (Two Factor ANOVA, (site, date), df=4, 6; F=2.9, 8.1; P=0.04, 0.0007). There is a general trend of increasing calcium recorded from middle March to late April (Figure 16), but the "trend" is not a strong linear one (regression analysis R^2 = 0.19). The spread of measures was substantial in the first early March period and is believed to be the driver of the statistical difference between sites, which otherwise have very similar measures.

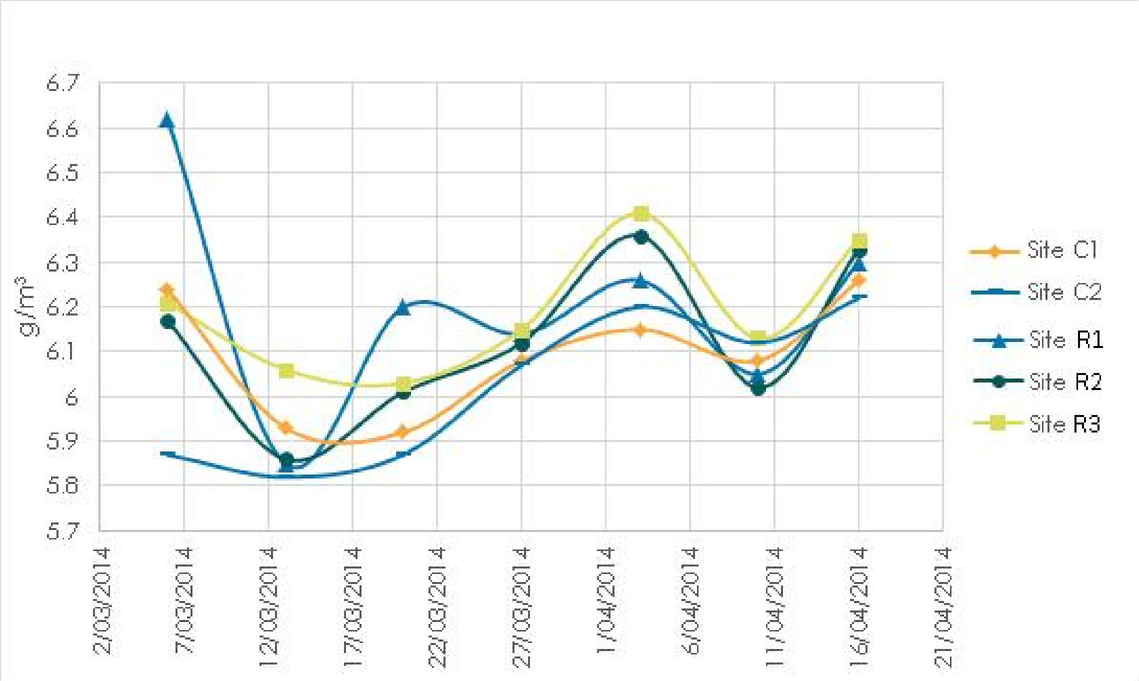

Figure 16: Dissolved calcium measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.8 Ammonia-Nitrogen

All measures, for all sites and sampling dates, were below the level of detection for ammonia-nitrogen (0.01 g/m^3).

7.1.9 Nitrite/Nitrate Nitrogen

Site measures for nitrite/nitrate nitrogen, aside from one measure at Site C2 on 7 March 2014 (Figure 17), are very similar and are not statistically different (Two factor ANOVA, df=4, F=0.46, P=0.046). There is an apparent, almost cyclic, swing in this parameter from the start of measures to the end and it may be that there will be found a continuing natural variation in time between a low concentration (between 0 and 0.02 g/m^3) and an upper concentration of around 0.12 g/m^3, perhaps dependent on upper catchment stock activity. The difference in measures over time were statistically significantly different (Two factor ANOVA, df=6, F=20.2, P<0.0002).

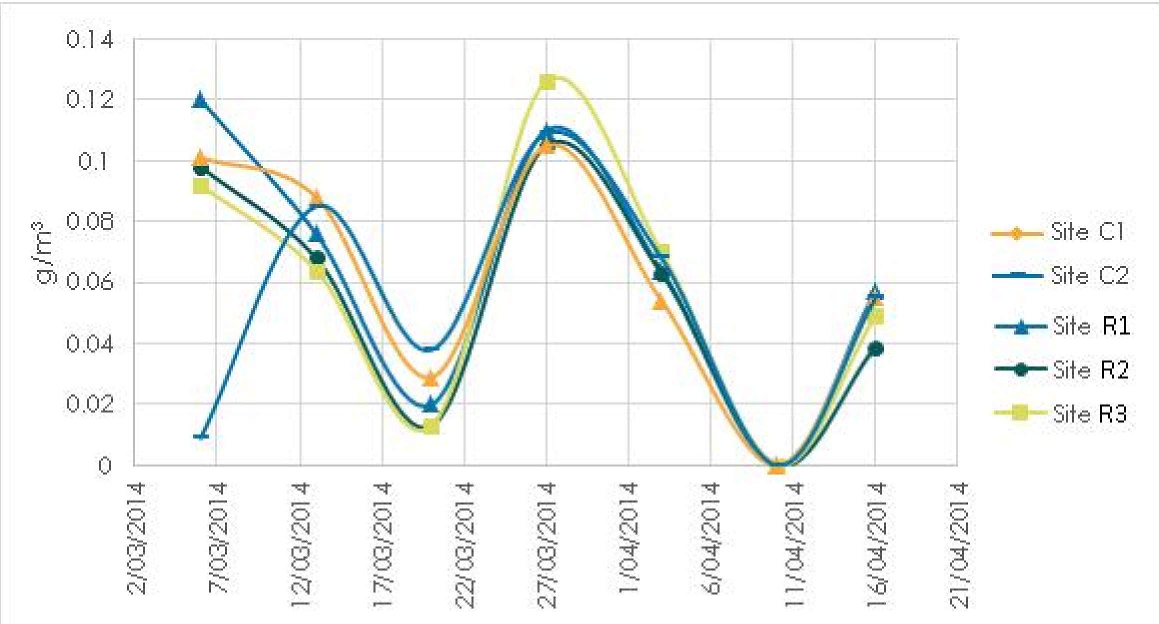

Figure 17: Nitrite/Nitrate Nitrogen measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.10 Soluble inorganic nitrogen

As with Nitrite/Nitrate-Nitrogen, soluble inorganic nitrogen oscillated through the measurement period between 0.02 and 0.12 g/m^3 (again noting that the lower figure is somewhere between 0 and 0.02 g/m^3) and is naturally a similar measure as Nitrite/Nitrate-Nitrogen (Figure 18). The differences between sites are not statistically different (Two factor ANOVA, df=4, F=1.7, P=0.18), but were over time (Two factor ANOVA, df=6, F=91.8, P<0.0002).

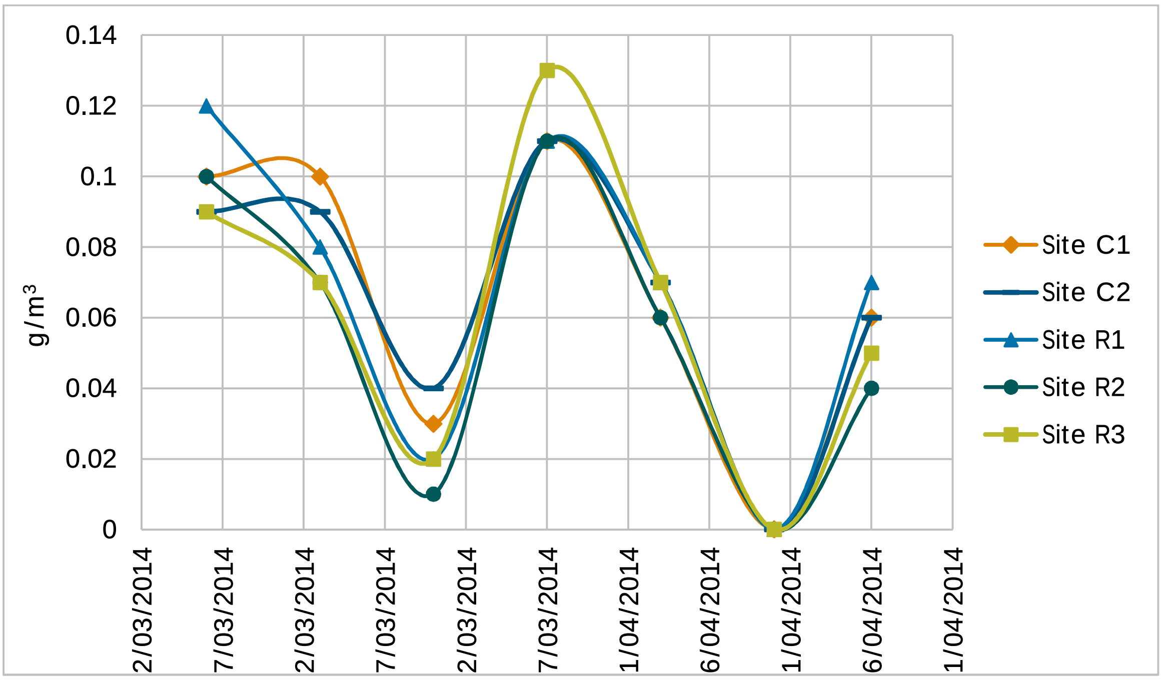

Figure 18: Soluble inorganic nitrogen measures across monitoring sites at successive dates through March, April 2014 in the Waikanae River

7.1.11 Summary

Water chemistry across the sites is remarkably similar and follows small but visible oscillations across the 2 months of monitoring. There is generally little difference and infrequently any statistically significant difference between sites implying the control sites will be suitable for their monitoring purpose. There is more often temporal differences which are statistically significant.

Figure 19 and Figure 20 show a summary of averages of water chemistry (noting across site value similarities allow averaging), against a GWRC measured flow (from the GWRC flow monitoring site upstream of the water treatment plant) for each measurement period. By visual observation of the plots, there is no apparent trend or pattern associated with river flow.

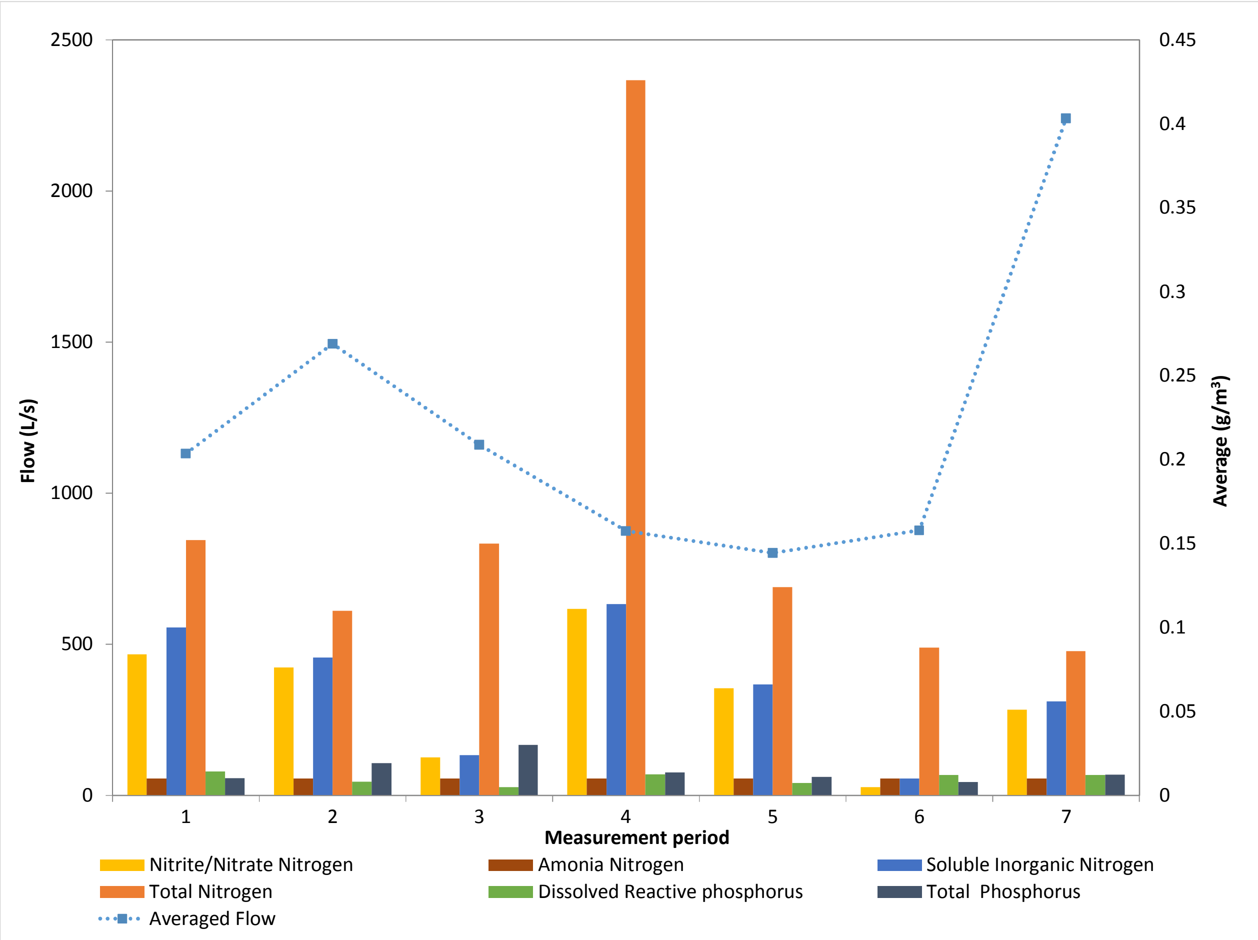

Figure 19: Comparison of river flow (averaged 3 day flow either side of sample date) against the water nutrient chemistry measures through March-April 2014

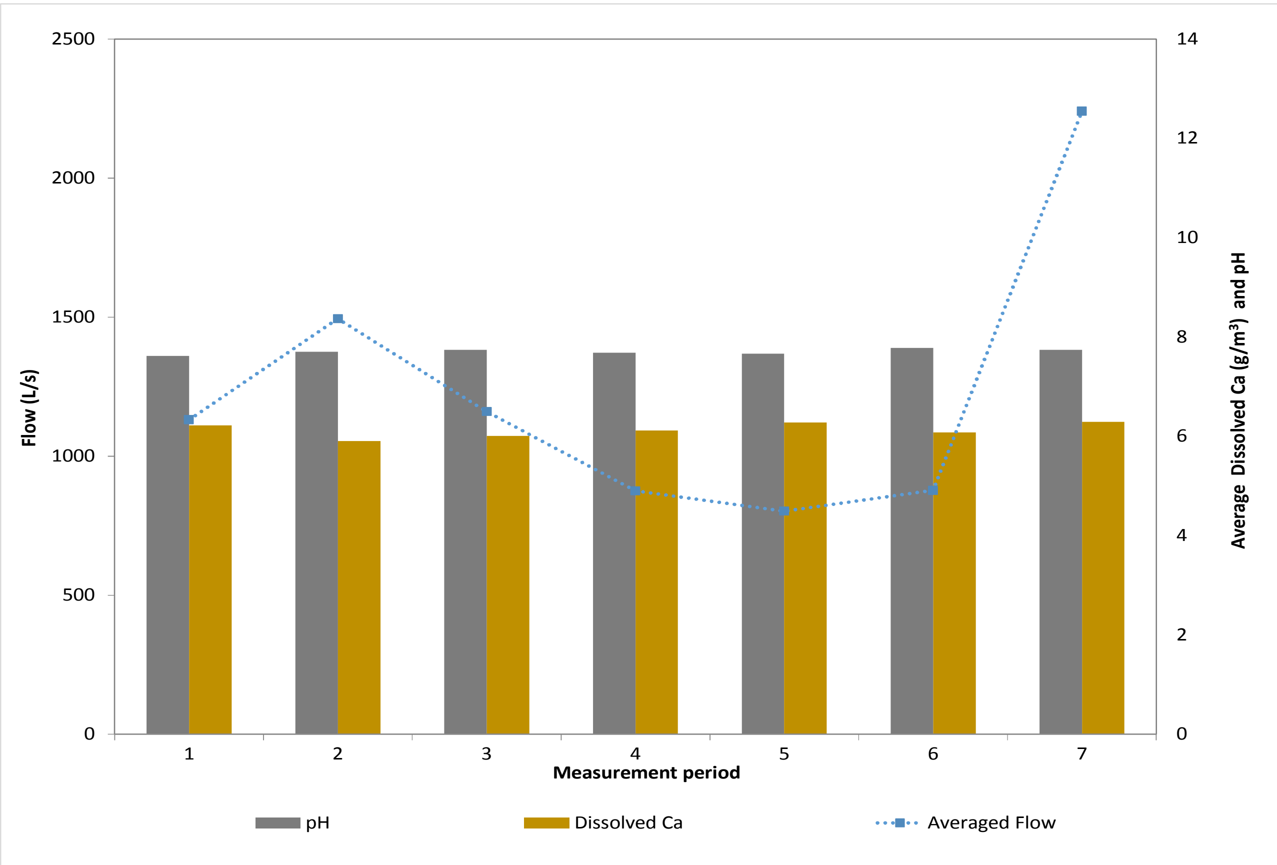

Figure 20: Comparison of river flow (averaged 3 day flow either side of sample date) against pH and dissolved calcium measures through March-April 2014

7.2 Periphyton

7.2.1 Visual assessments of fixed plots

Visual periphyton cover measures were taken from 4 across river transects and 5 quadrats per transect illustrated (Figure 21) of the hard cover available to periphyton (c.f. Figure 9). The cover averaged around 95% and changed only marginally. Mean cover at sites and through time was not statistically different (Two-factor ANOVA (site, time), df=4, 6; F=0.63, 2.06; P=0.64, 0.096), although there was a greater variation between times than within sites.

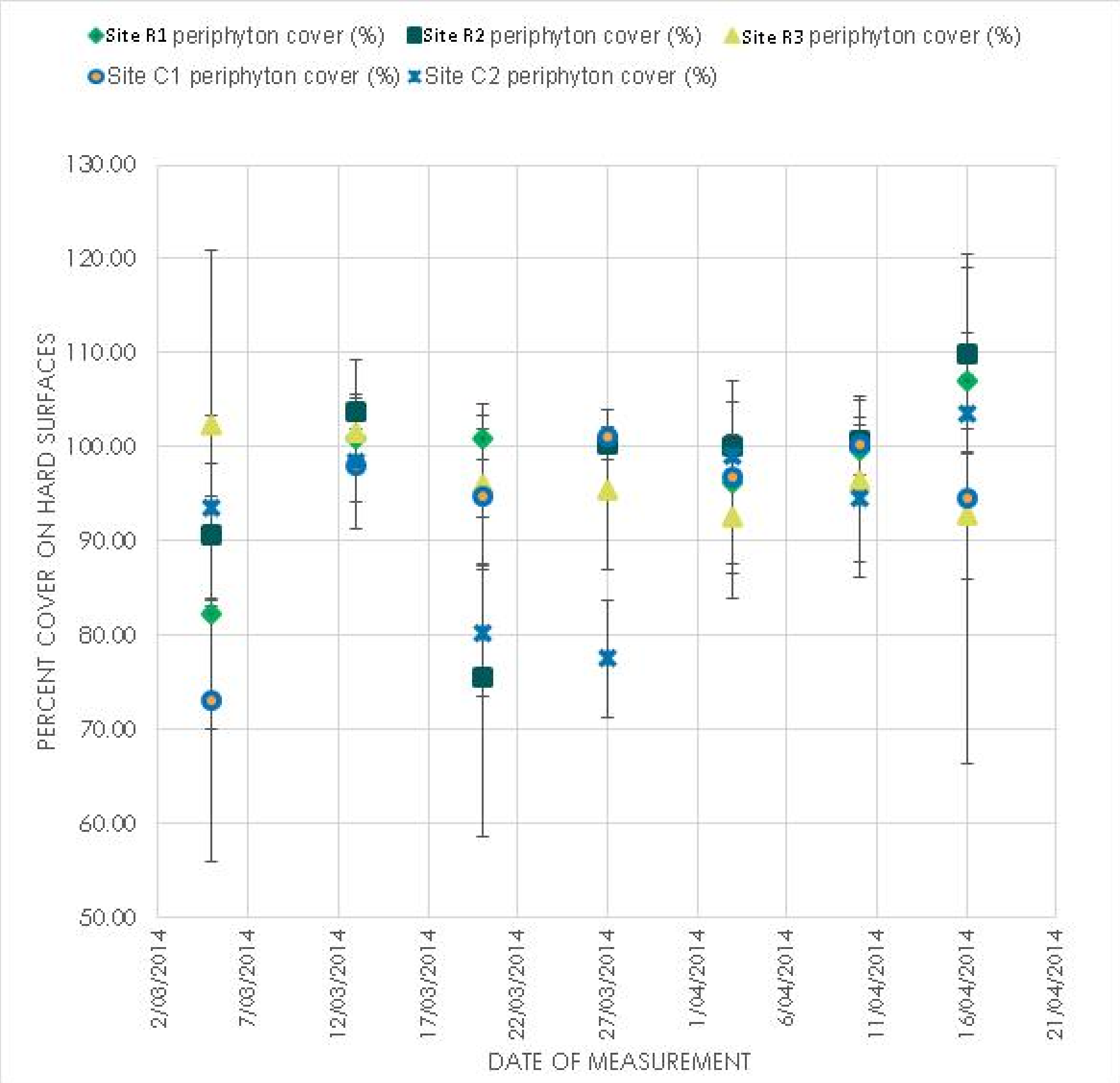

Figure 21: Average (n=20) periphyton cover across monitoring sites on the Waikanae River (2014 season). Error bars are standard error of the mean

7.2.2 Velocity at measurement plots

Velocities at each quadrat (Figure 22) indicate a “typical” range from 0.5 to 0.7 m/s with occasionally high velocities up to 1 m/s. Water speed across the sites was statistically different (Two factor ANOVA, df= 4, F = 3.5, P = 0.02), and velocities did also change (statistically significantly) through time (Two factor ANOVA, df = 6, F =3.0, P = 0.02). Those differences, although subtle, relate to a flow variation recorded towards the end of March.

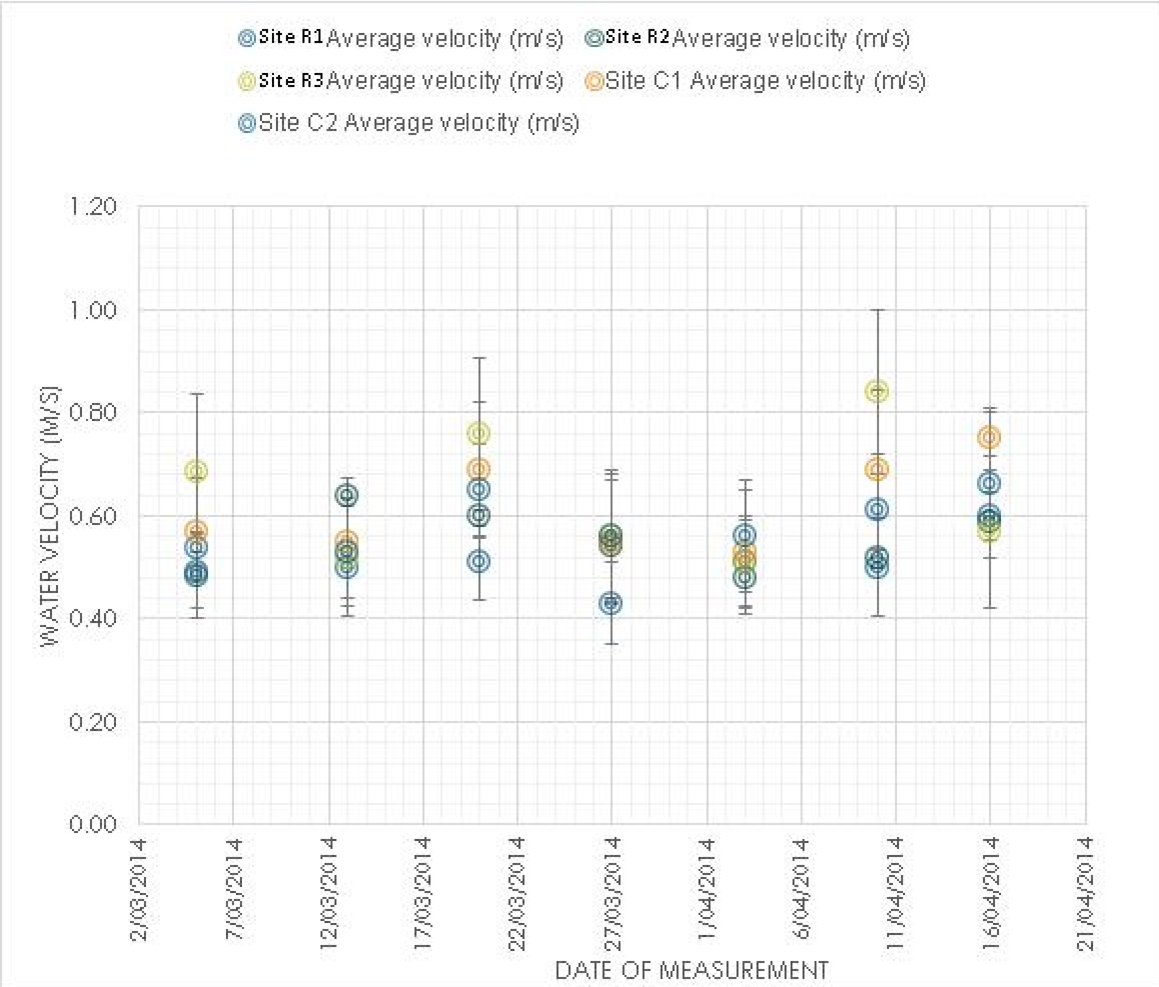

Figure 22: Average (n= 20) water velocity across periphyton monitoring locations at each site over the monitoring period on the Waikanae River. Error bars are standard errors of the mean

There was no discernible velocity by periphyton cover pattern. Site velocities follow river flow increases slightly (there was a small flow increase to 16 m^3/s at around 16 March), but there were no "flushing" flow periods through the monitoring period until late April. A flushing flow was seen in late April (90 m^3/s) which precluded the last monitoring run (23 April) due to poor visibility and high river height.

7.2.3 Qualitative Periphyton community measures through time

The following plots (Figure 23 to Figure 27) present the cover percentages of the 8 broad periphyton assemblage types. They also show that there was a preponderance of thin light brown matting periphyton with occasional coverage of a few other sporadic types. Long filamentous and short filamentous algae were infrequently seen and in minor abundances. There are no clear temporal patterns in the periphyton community types present.

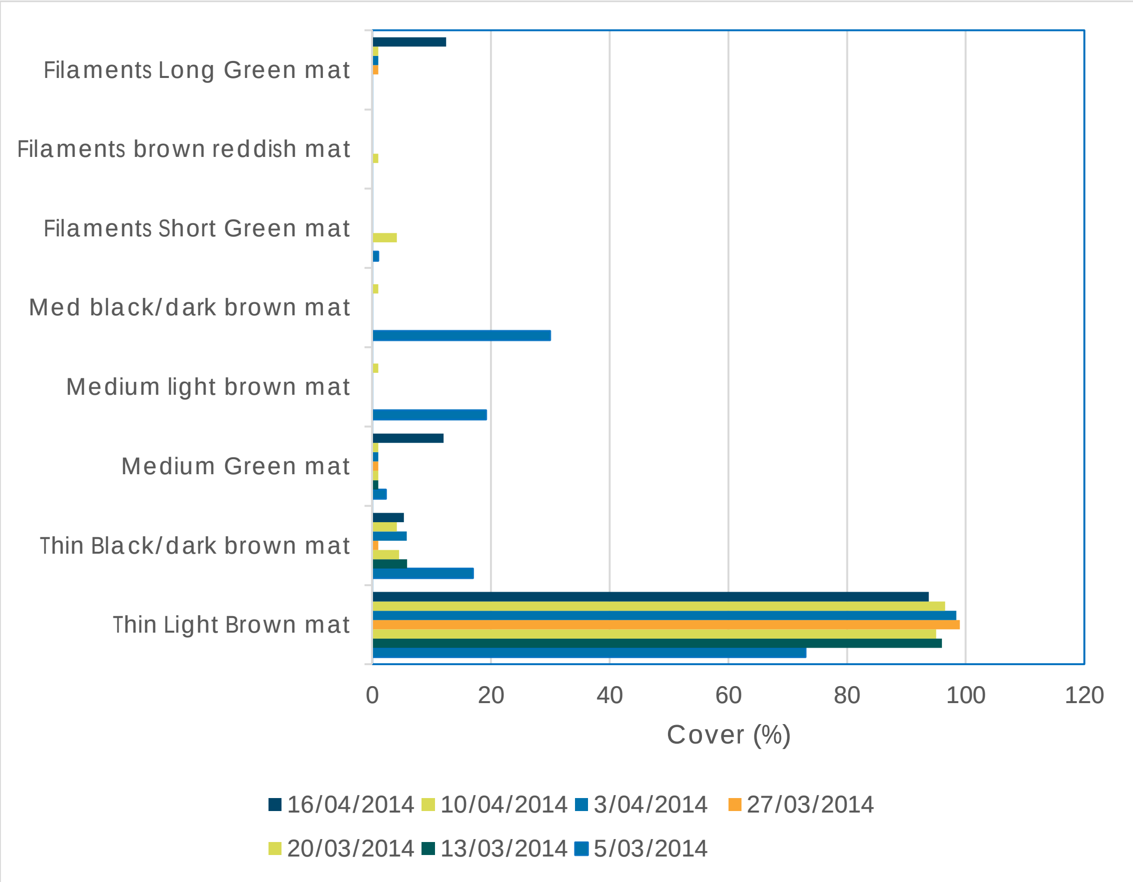

Figure 23: Site R1 % periphyton classes by visual estimation over time, Waikanae River

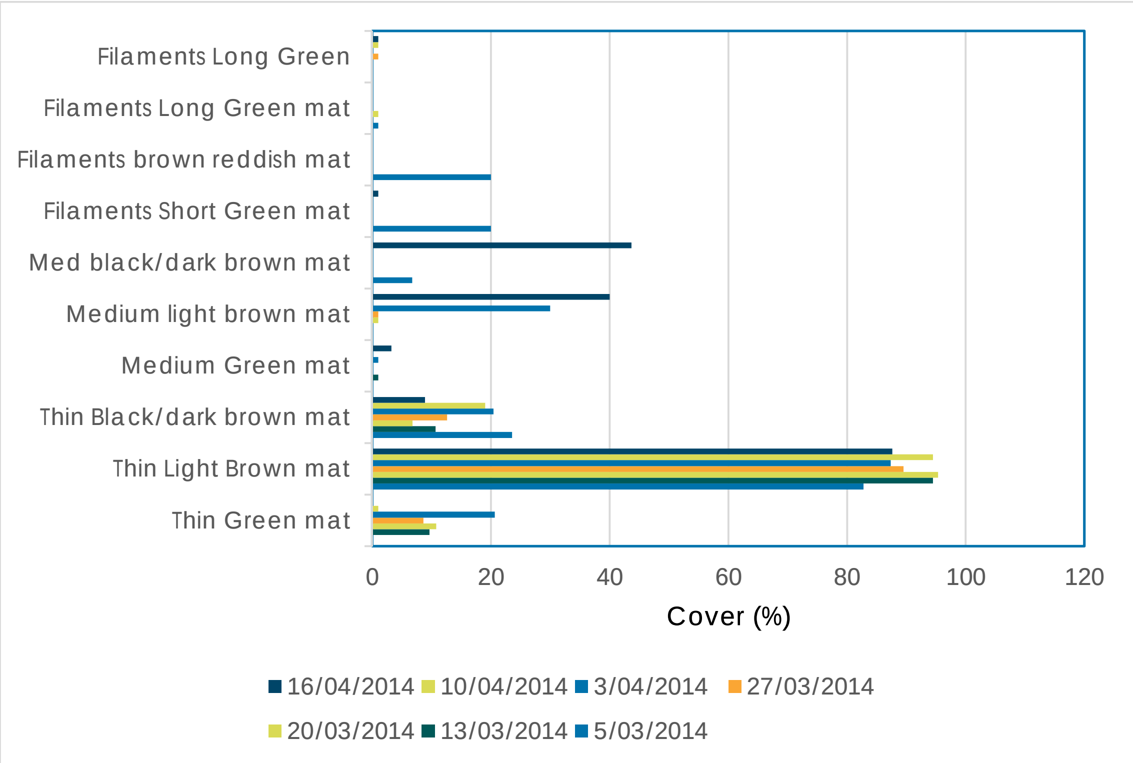

Figure 24: Site R2 % periphyton classes by visual estimation over time, Waikanae River

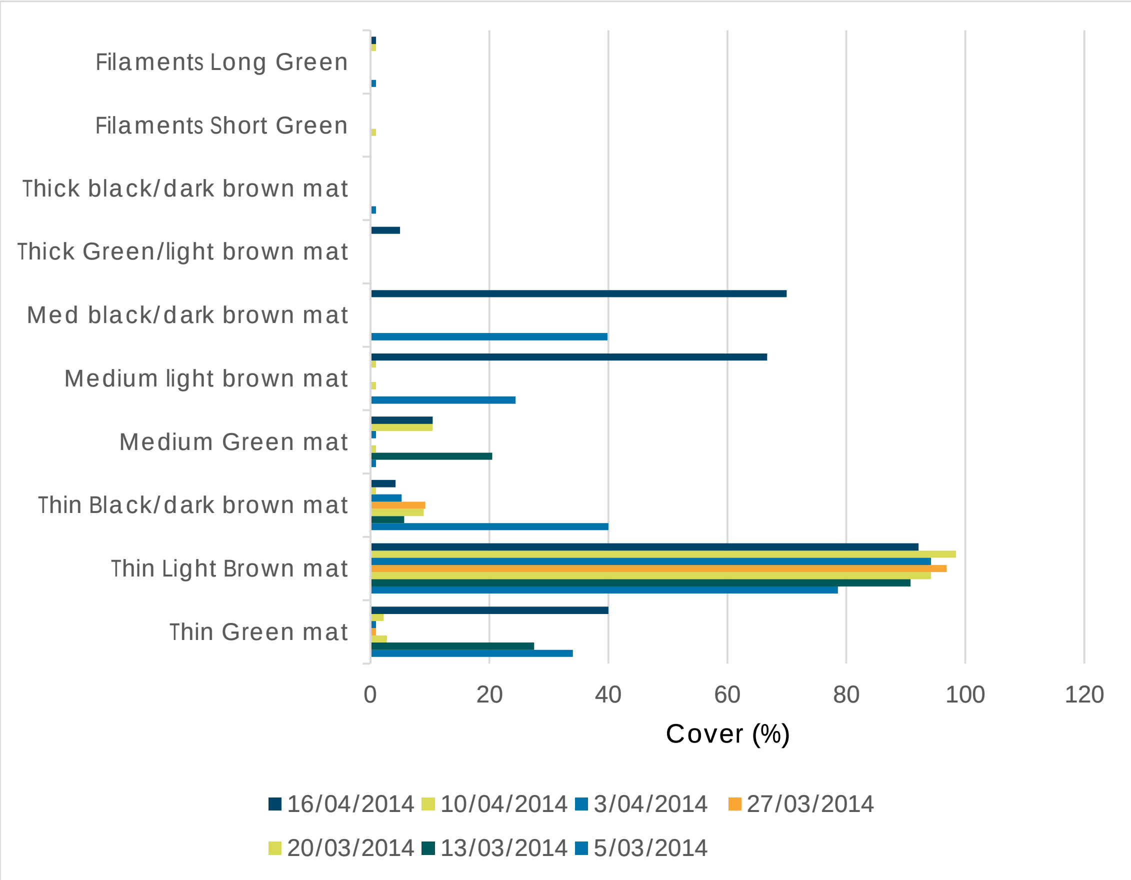

Figure 25: Site R3 % periphyton classes by visual estimation over time, Waikanae River

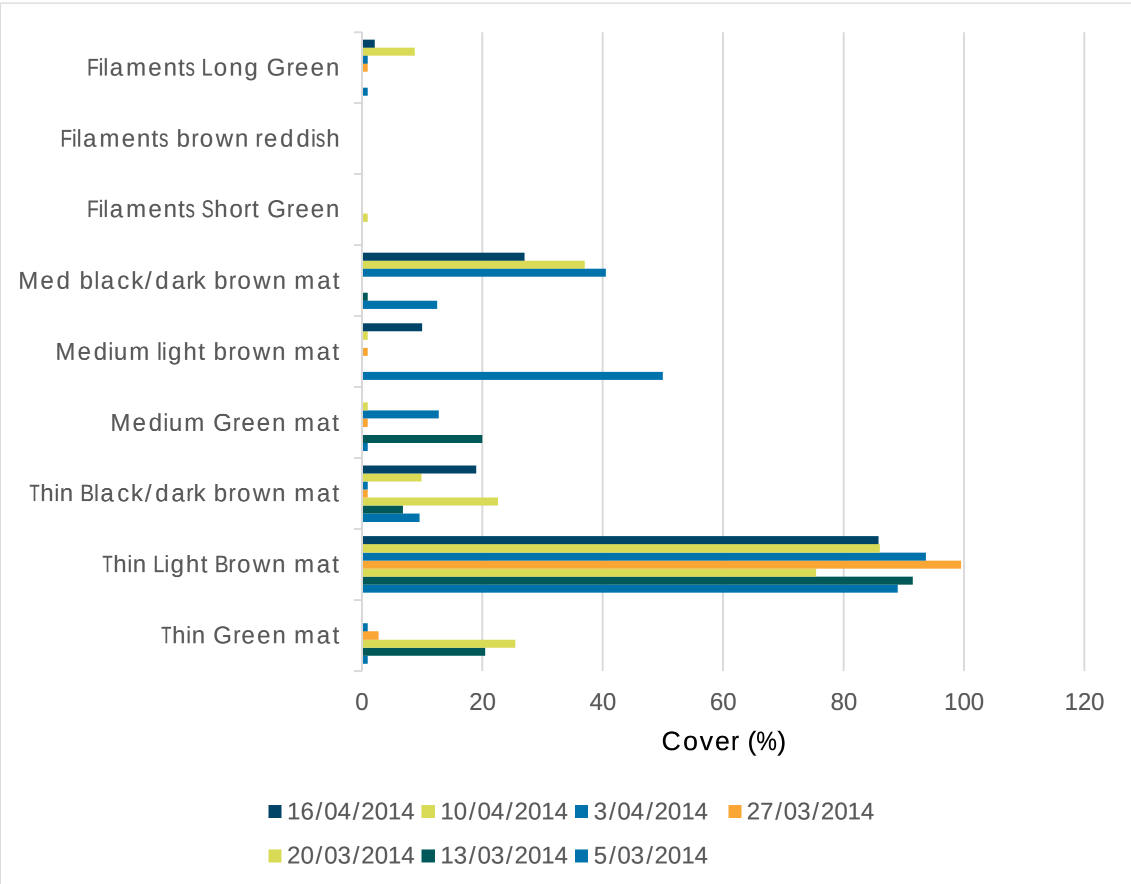

Figure 26: Site C1 % periphyton classes by visual estimation over time, Waikanae River

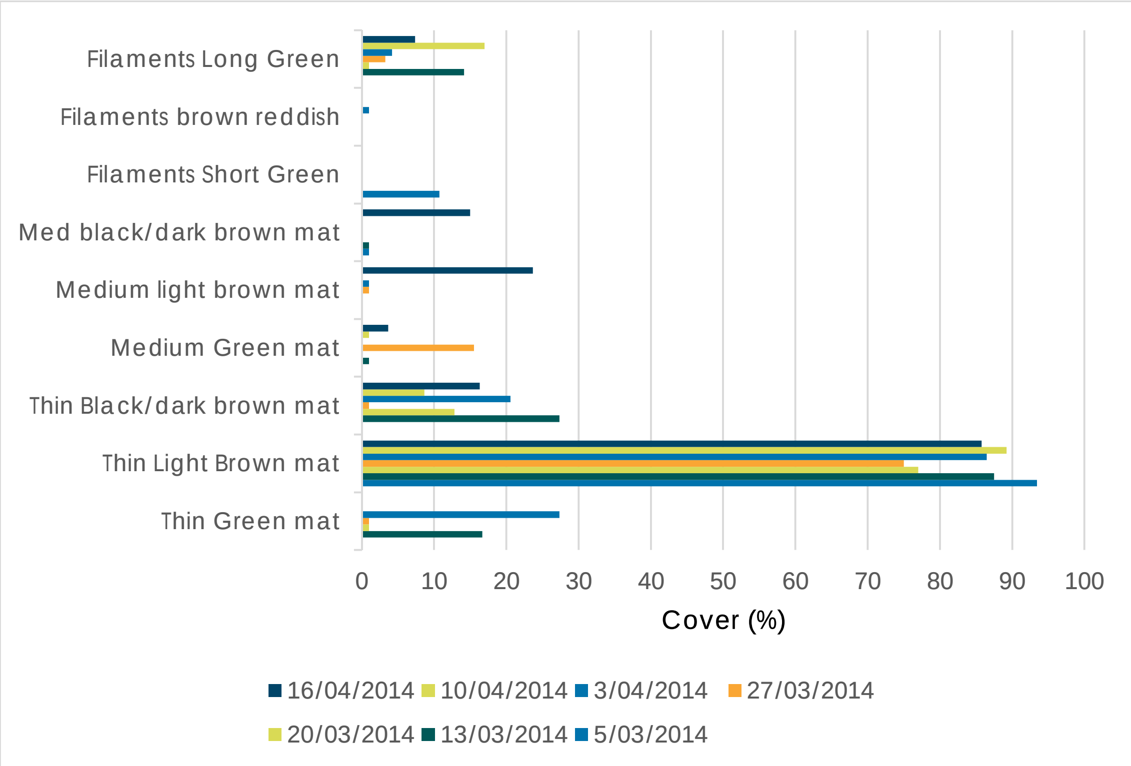

Figure 27: Site C2 % periphyton classes by visual estimation over time, Waikanae River

7.2.4 Quantitative periphyton measures

Chlorophyll-a measures between sites and time where not statistically different (Two factor ANOVA, (site, time), df=4, 4; F=1.33, 3.4; P=0.31, 0.0537). However, there was a noticeable increase in chlorophyll-a at Site R2 in early April (3/04/2014) (Figure 28).

The measures attained suggest that the Waikanae River, at these points of measure, is between oligotrophic and mesotrophic in terms of Biggs 2000 guide (chlorophyll-a bounds of 60 mg/m^2 and 200 mg/m^2 to delimit oligotrophic, mesotrophic and eutrophic streams (after Dodds et al. 1998, referenced in Biggs 2000[8])). The values attained in the Waikanae River over the late 2013/2014 summer generally fall below national guideline chlorophyll-a levels for benthic biodiversity in early March but fail to do so in the early April (especially Site R2). After March the sampled chlorophyll-a generally breach the recommended 50 mg/m^2 maximum level for benthic biodiversity (this was evidenced in the visual assessments as a thickening of the mats constantly recorded and not an increase in area covered).

[7] Note different time measures almost have sufficient variance to be statistically significantly different.

[8] Biggs, B. 2000. NZ periphyton guideline: Detecting, Monitoring and managing enrichment of streams. NZ Ministry of the Environment, NIWA.

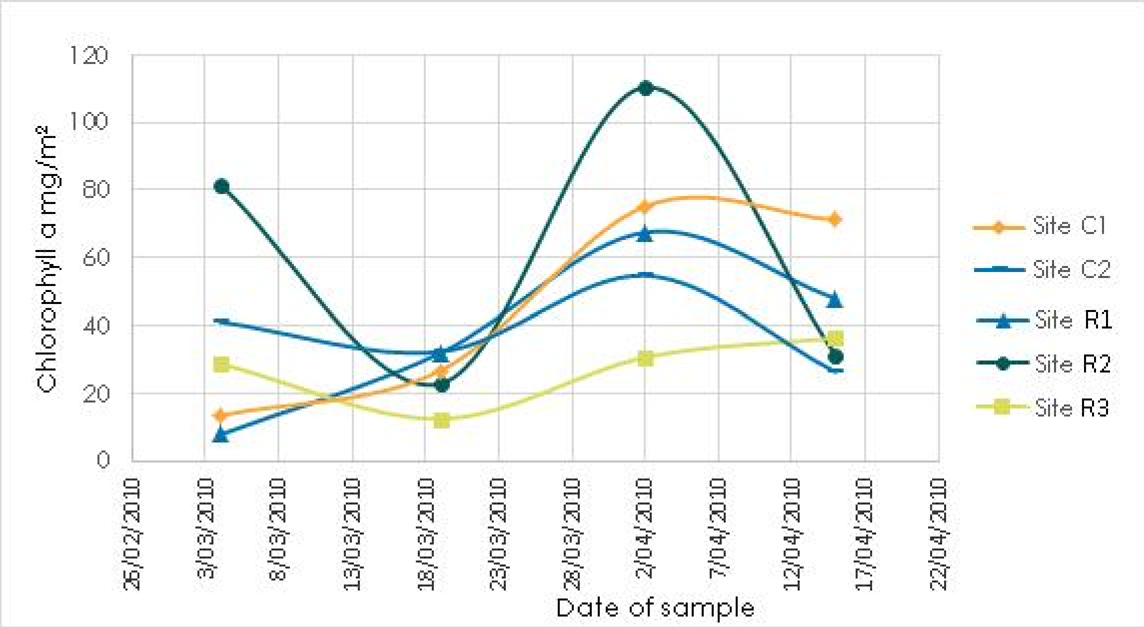

Figure 28: Average Chlorophyll-a (mg/m^2) monitored from each Waikanae River site

Average Ash Free Dry Matter follows the same pattern as chlorophyll-a (Figure 29), and its values between sites and across time are also not statistically significantly different (Two factor ANOVA (site, time), df=2, 4; F=0.33, 3.4; P=0.85, 0.054). Again there is a peak in values around early April[9].

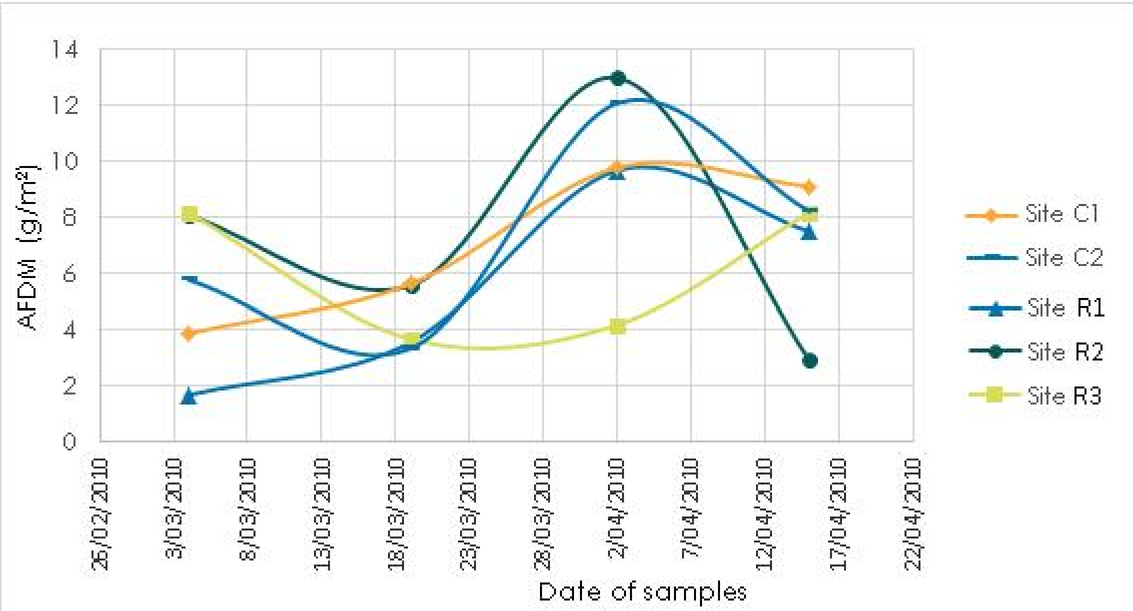

Figure 29: Average Ash free dry matter (g/m2) monitored from each Waikanae River site

Although there was between site variation and a general trend of decreasing indices value (Figure 30) those differences in the autotrophic indices (the ratio of AFDM to live algae (represented by chlorophyll-a) are not statistically significant variation (Two factor ANOVA (site, time), df=2, 4; F=0.75, 0.19; P=0.58, 0.82).

[9] This almost, but not quite, produces sufficient variation to cause a statistically significant difference.

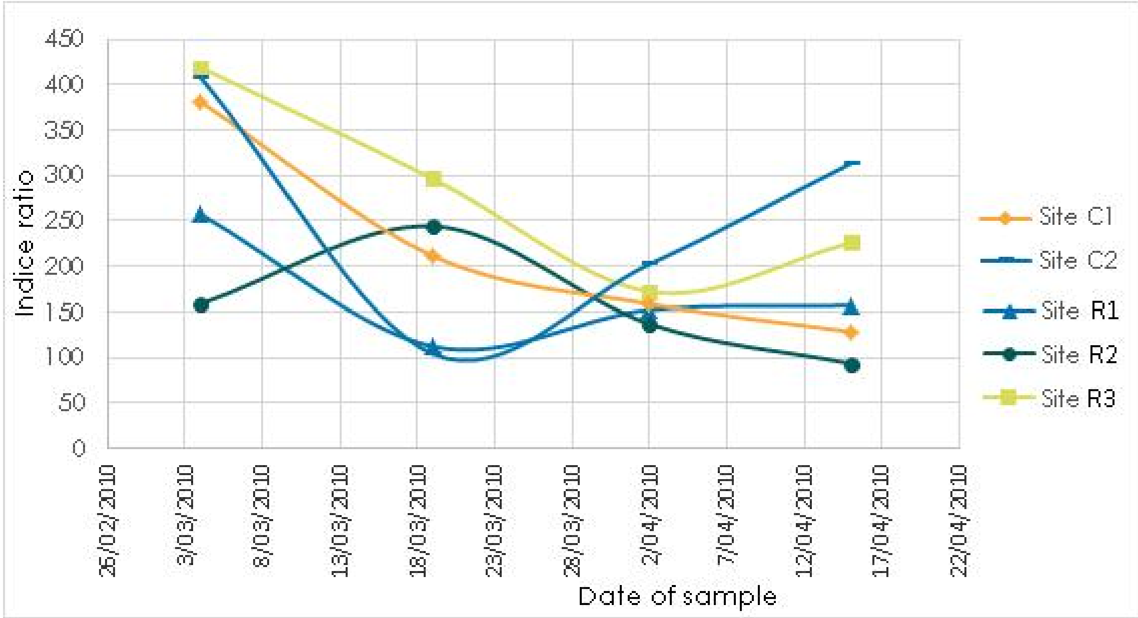

Figure 30: Autotrophic Indices for each monitored Waikanae River site

7.2.5 Periphyton species richness and community composition

The number of taxa making up the periphyton community was the same across the sites in early March (around 8 species) and increased to around 15 species at all sites in April (Figure 31).

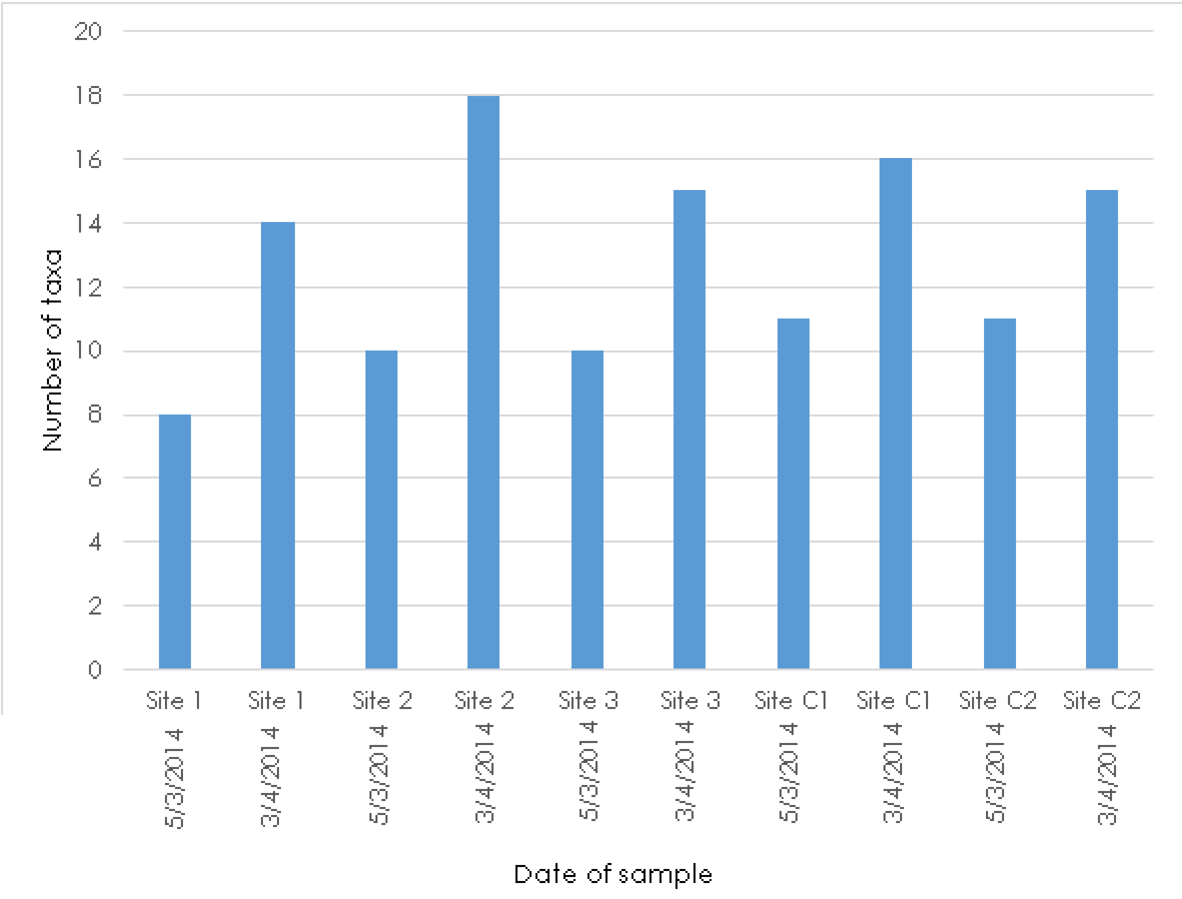

Figure 31: Number of periphyton taxa at two times in the Waikanae River late summer 2014

This increase in taxa richness and chlorophyll-a generally reflects the long period of stable low flow in the Waikanae River over the March and early April period (refer to Section 5 above).

Figure 32 below shows the proportions of taxa at sites from the April and March samples. These data show that across the sites the composition change in terms of species represented and as proportions of the assemblage change. For example at Site R1, as well as increasing by 87% the number of species, previously dominant taxa (*Oscillatoria / Phormidium* and *Melosira*) are no longer prominent in the community and there is a more even distribution of proportions of taxa present.

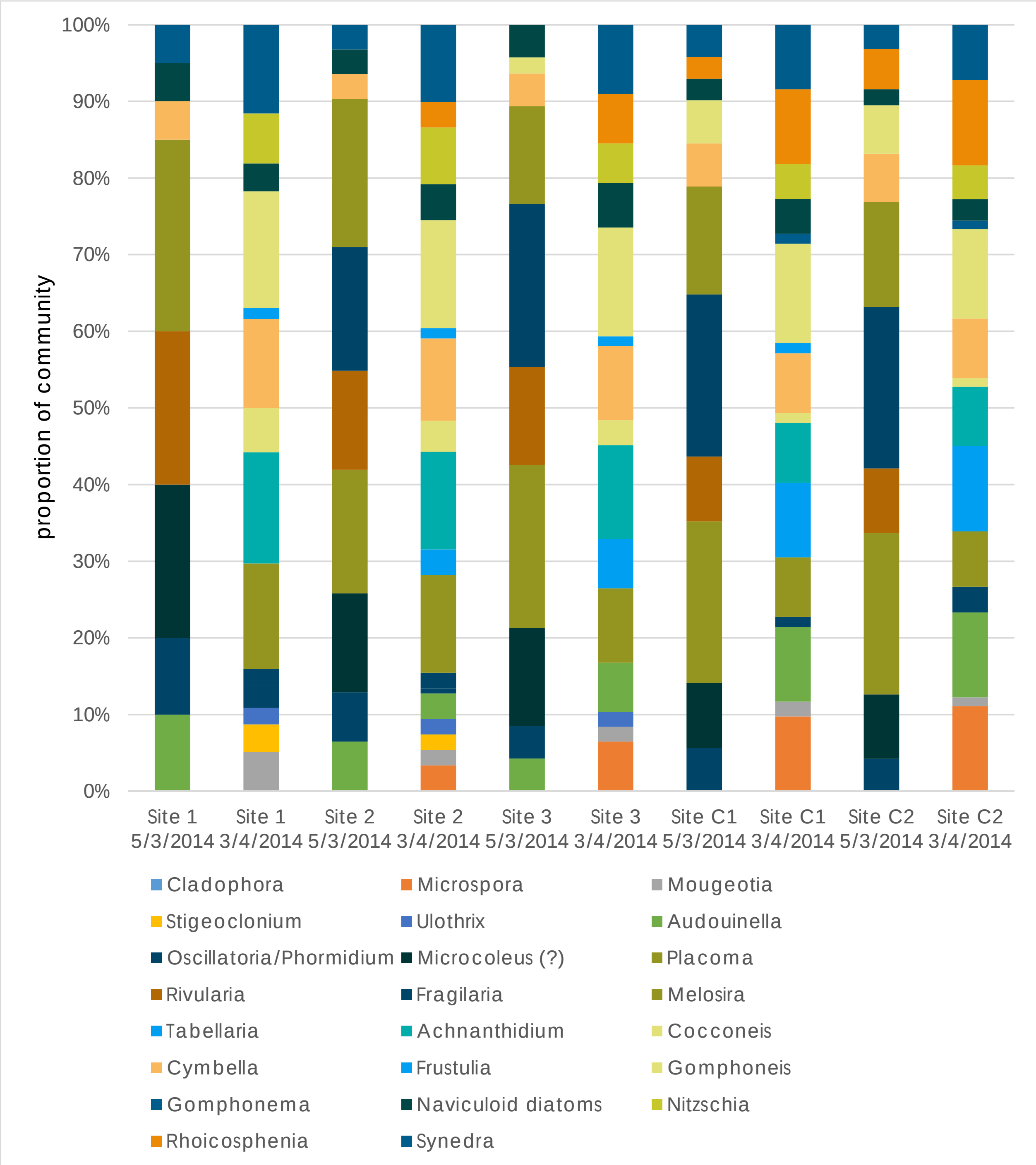

Figure 32: Periphyton community compositions in Waikanae River in March and April 2014

7.3 Correlations

The Excel(©) analysis function “correlation” was used to examine the correlation between water quality parameters, periphyton parameters, and water velocity at each site over time.

The PEARSON correlation calculates the correlation coefficient between measurement variables and provides an output table. These tables are presented in Appendix 6 and show the correlation coefficient for each possible pair of measurement variables.

The correlation coefficient is a measure of the extent to which two measurement variables "vary together".

Of particular importance/value for this monitoring programme is the determination of correlations between chlorophyll-a and biomass and with visual cover estimation (Table 4: Correlation coefficients for chosen metrics related to chlorophyll-a). A correlation coefficient of 0.5 or greater, suggests a significant positive correlation or a negative correlation if the coefficient is lower than -0.5.

Table 4: Correlation coefficients for chosen metrics related to chlorophyll-a

	Correlation between Chlorophyll-a & visual cover	Correlation between Chlorophyll-a & AFDM	Correlation between TP & Chlorophyll-a
Site R1	0.62	0.97	0.29
Site R2	-0.79	0.92	0.65
Site R3	-0.23	0.68	0.97
Site C1	0.73	0.99	0.56
Site C2	0.13	0.62	0.26

The absence of strong time trends of measured variables (in large part due to the stability over the monitoring period) or between-site trends (given the similarity between sites) makes seeking mathematical correlations of dubious value to biologically significant correlations. Some of the positive correlations observed are due (we currently believe) to chance.

Not unexpected (but now confirmed) chlorophyll-a and AFDM are strongly correlated. Of some surprise is the absence of strong correlation between chlorophyll-a and periphyton cover. Only sites R1 and C1 showed positive correlations. Site R2 showed a strong negative correlation (which is entirely unexpected) and sites R3 and C2 showed no correlation.

The matrices in Appendix 6 show varied correlations across the variables and sites, but with no lasting patterns.

AFDM and chlorophyll-a are often correlated with dissolved calcium, nitrite/nitrate nitrogen and inorganic nitrogen over the sites, but at each site which periphyton variable that is correlated with these nutrient parameters often changes. DRP did not feature as often as we assumed, which a positive correlation with either chlorophyll-a, or Autotrophic indices at sites R1, R2, and C2, but not at sites R3 or C1. Total phosphorus however, was positively correlated at all sites with either chlorophyll-a or Autotrophic indices except at Site R1.

There were no notable correlations with water velocity.

7.4 Macroinvertebrates

The object of this monitoring was to sample benthic macroinvertebrates at times and in locations with increasing benthic periphyton. The Waikanae River BMP proposes either (a) in a sequence after a flushing flood, or (b) throughout the summer-autumn period at three difference stages (levels of development) of periphyton (low, moderate and high).

No flood flows were experienced (highest flow a 16 m^3/s event which caused no periphyton flushing). Therefore a sample was undertaken in March (5 March 2014) during a period deemed to represent a medium density/coverage of periphyton (see periphyton results above (4 March, Chlorophyll a results)) and a sample in April (12 April 2014) also representing a medium, (although increasing) periphyton level (see Figure 28, Chlorophyll a results).

7.4.1 March Sample results – Medium periphyton level

Five samples across the river, each of area 0.12 m^2 (sum area sampled of 0.6 m^2) on 5 March at a time of medium periphyton density/cover, returned results which are summarised in Table 5 below.

The results indicate that sites R1, R2, C1 and C2 are most similar and Site R3 poorer and more different. MCI and QMCI scores indicate good quality water and habitat communities. Sites R2, C1 and C2 rank as "excellent" (Stark & Maxted 2007[10]) in terms of MCI and QMCI, Site R1 ranks as "Good" in terms of MCI and "excellent" in terms of QMCI, while Site R3 ranks as "Good" in terms of MCI and "fair" in terms of QMCI (noting that accounting for the variability could just place the site in the "good" category). In other words, all sites have a relatively natural hard bottom assemblage with a fair representation of EPT taxa (around 50-60% of total taxa).

Table 5: Average (n=5) biometric indices and scores for the 5 monitoring sites on the Waikanae River sampled in March. Standard error of the means are supplied for a measure of the variance about each mean value (errors are standard error of the mean).

Average Biometric	Site R1	SEM	Site R2	SEM	Site R3	SEM	Site C1	SEM	Site C2	SEM
Abundance	241.2	84.2	333.6	113.0	245.2	164.0	274.4	79.5	341.8	131.0
Number of taxa	16.6	2.3	17.4	3.6	15.6	7.4	18	1.2	18	5.8
Number of EPT taxa	9.6	1.8	10.2	1.6	8.4	4.5	10.8	1.3	10.6	3.8
MCI score	117.58	6.4	119.98	5.3	113.36	17.3	124.24	6.8	131.08	7.1
QMCI	6.38	0.5	6.46	0.9	4.96	0.4	6.4	0.2	7	0.3

Six taxa were generally numerically dominate (>2% of the total abundance) in the assemblages at each site. Figure 33 illustrates the abundances of those taxa across the monitoring sites. One mayfly, four caddisfly, 2 true fly, one snail and one beetle larvae characterise the fauna. Deleatidium is the most numerically dominant taxa, followed by Elmidae. Elmidae are likely to be a good indicator of periphyton development as elmids often become numerically dominant with increasing algae cover.

[10] Stark JD, Maxted JR 2007. A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No.1166. 58 p.

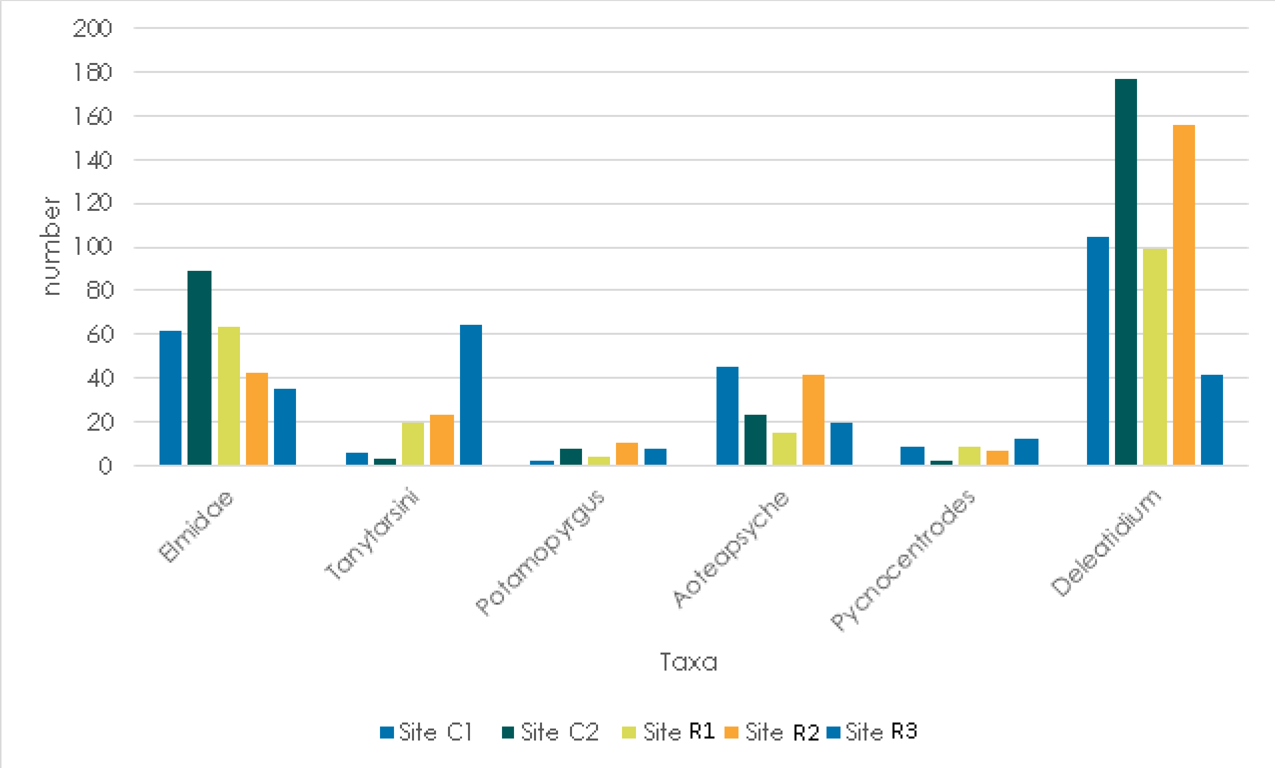

Figure 33: Numerically dominant taxa in March samples (medium periphyton levels) across all sampling sites

In terms of the dominant taxa there is no difference in averaged abundance of invertebrates across sites in March (Two factor ANOVA[11], df = 24, F = 1.4, P=0.13) but (as to be expected) there is a significant difference in the abundances of specific invertebrates between sites (Two factor ANOVA, df = 8, F = 38.2, P<<0.0007). Figure 33 illustrates that result, with Site R3 having notably raised numbers of *Tanytarsini* and much lower numbers of *Deleatidium* (both responsible for the lower QMCI score). But the lower *Elmidae* abundance suggests that this result is not one to be associated only with raised periphyton levels.

7.4.2 April Sample results - Medium periphyton level

The following results (Table 6) relate to the aquatic macrophyte sample of 12 April at which point periphyton abundances and cover had marginally increased from that of March.

Table 6: Average (n=5) biometric indices and scores for the 5 monitoring sites on the Waikanae River sampled in April. Standard error of the means are supplied for a measure of the variance about each mean value (errors are standard error of the mean).

Average Biometric	Site R1	SEM	Site R2	SEM	Site R3	SEM	Site C1	SEM	Site C2	SEM
Abundance	472.6	105.7	288.4	92.7	416.8	141.3	361.4	138.1	334.2	203.5
Number of taxa	21	1.7	17.8	2.6	22	2.6	21.6	1.1	17.8	3.6
Number of EPT taxa	12.2	1.8	9.8	2.4	12.2	2.0	12.6	1.1	10	2.0
MCI score	122.88	3.8	111.38	9.0	113.98	8.8	121.7	3.1	116.68	3.7

[11] Note this Two factor ANOVA is **with** replication

QMCI	5.24	0.3	5.78	0.5	4.74	0.2	5.66	0.5	5.46	0.5

As in March, there are a small number of taxa (9) that were numerically dominant (>2% of the total abundance) in April. Their abundances are shown below in Figure 34.

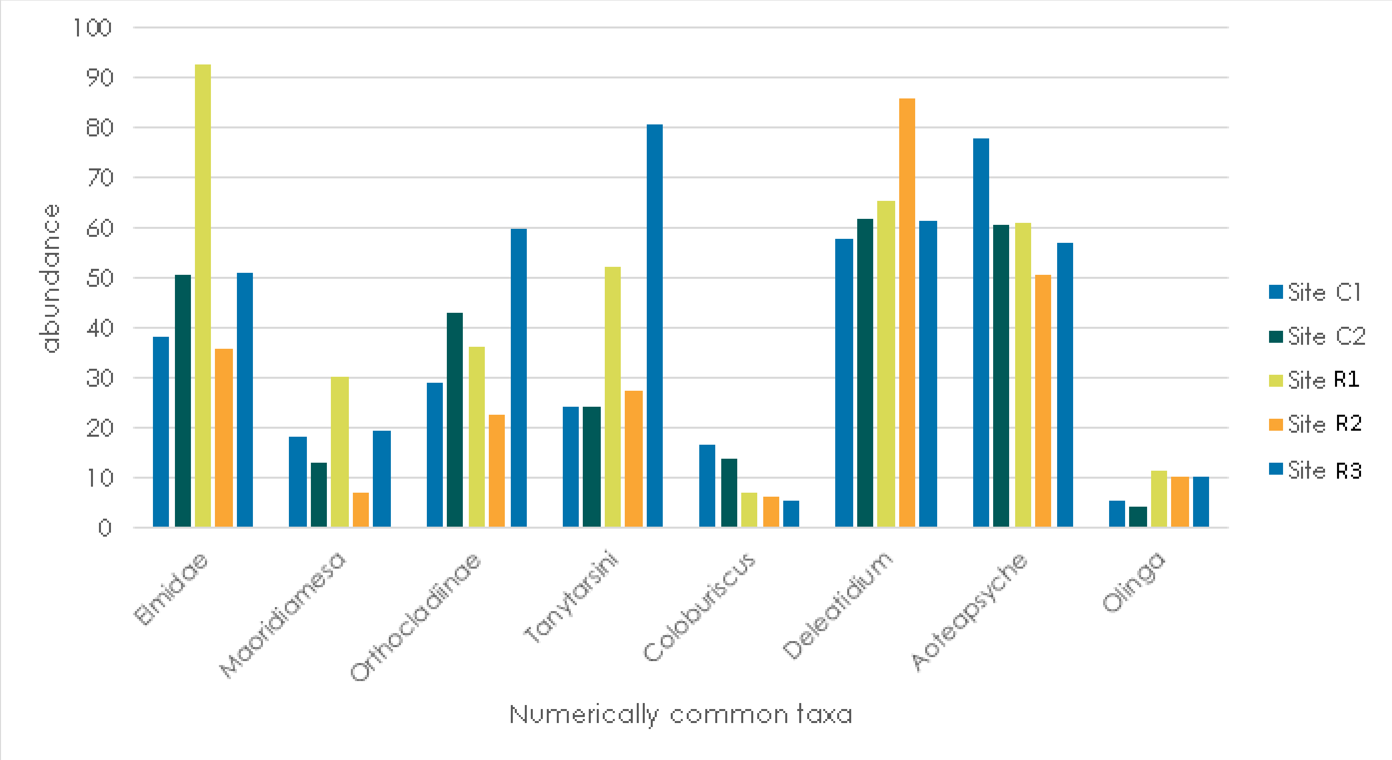

Figure 34: Numerically dominant taxa in April samples (medium-High periphyton levels) across all sampling sites

Table 7 below illustrates by comparison the numerically dominant taxa and their percentage as a total of the pooled samples across all sites. In March 7,181 individuals were caught over the 5 sites, in April this number rose to 9,367. April has three taxa that increase in numerical dominance and in part account for this increase.

Table 7: Numerically dominant (>2% of total abundance of all samples) taxa as a proportion of the total abundance from all samples at all sites in March and in April.

Numerically dominant taxa	March	April
Elmidae	20.30%	14.3%
Maoridiamesa		4.7%
Orthocladiinae		10.2%
Tanytarsini	8.10%	11.2%
Coloburiscus		2.6%
Deleatidium	40.20%	17.8%
Aoteapsyche	10.10%	16.4%
Olinga		2.2%
Pycnocentrodes	2.60%	6.2%
Potamopyrgus	2.30%	

7.4.3 Macroinvertebrate Community Composition

The NMDS ordination and ANOSIM indicated that the macroinvertebrate community composition was generally similar between 'control' and 'receiving' sites (ANOSIM: $R = 0.108$; $P = 0.010$). There were, however, weak, yet statistically significant differences in macroinvertebrate community composition between March (low-medium periphyton) and April (medium periphyton) sampling (ANOSIM: $R = 0.317$; $P = 0.001$) (Figure 35).

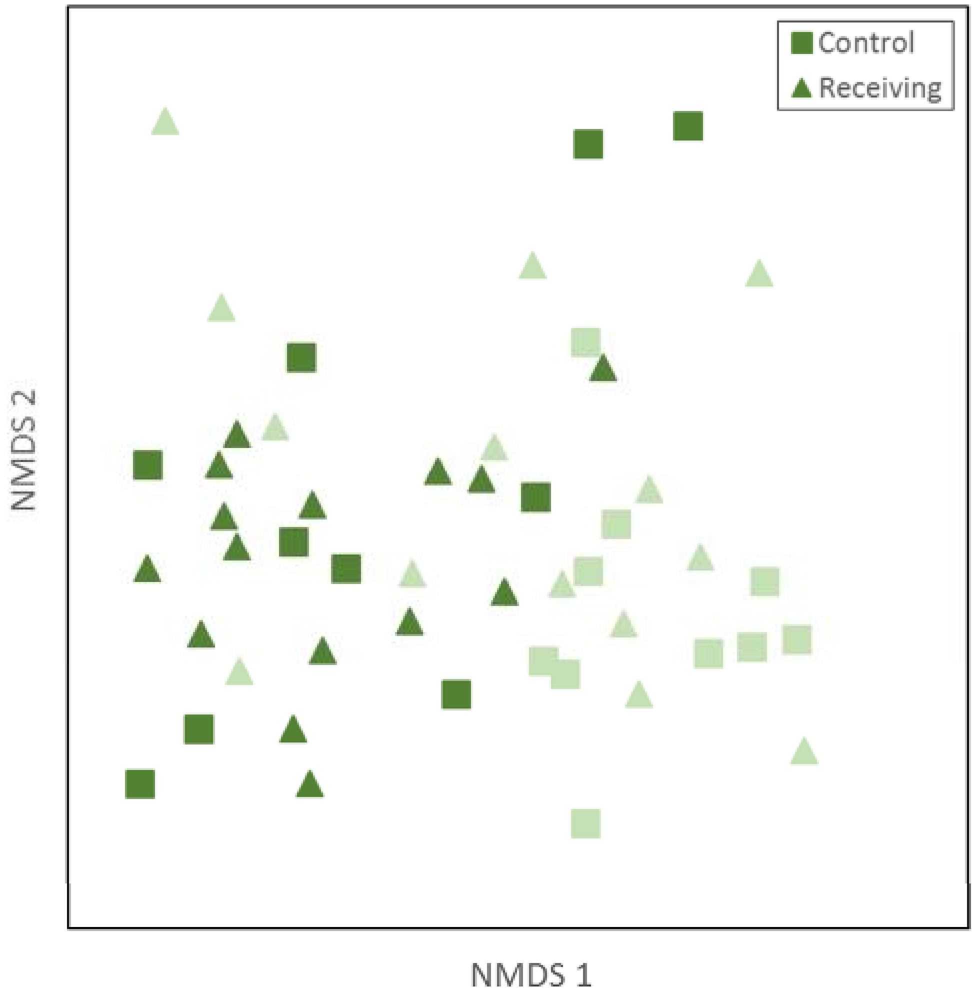

Figure 35: Ordination plot

Figure 35**:** Non-metric multidimensional scaling (NMDS) ordination based on a Bray-Curtis matrix of dissimilarities calculated from macroinvertebrate abundance data collected in a kick net at each of two 'control' and three 'receiving' sites prior to bore water discharges (i.e. baseline conditions). 'Control' sites are shown as squares, 'receiving' sites are triangles; low-medium periphyton conditions sampled in March 2014 are light green, while medium periphyton conditions sampled in April 2014 are dark green. Note, the NMDS gave a good representation of the actual community dissimilarities between sites and sampling occasions (two-dimensional stress = 0.18). Axes are identically scaled so that the sites closest together are more similar in macroinvertebrate community composition than those further apart.

SIMPER indicated that these significant (albeit weak) differences were largely due to differences in abundances of the macroinvertebrates detected in March and April, rather than a shift in community composition (i.e. none of the taxa strongly driving the differences detected by NMDS and ANOSIM were absent from March or April) (Table 8). For example, the mayfly *Deleatidium* was more abundant in March (low-medium periphyton conditions) than in April (medium periphyton conditions). The net-spinning caddisfly *Aoteapsyche* showed the opposite trend, being more abundant in April (medium periphyton) than in March (low-medium periphyton conditions).

Table 8: Similarity Percentages (SIMPER) results showing macroinvertebrate taxa that were the greatest drivers of the weak, but statistically significant, differences in macroinvertebrate community composition between low-medium (March 2014) and medium (April 2014) periphyton sampling occasions in the 'control' and 'receiving' sites during baseline conditions (i.e. prior to bore water discharge commencing).

Low-medium vs medium periphyton	Average abundance		Average dissimilarity = 48.35
Taxon	low-medium periphyton	Medium periphyton	% Contribution to dissimilarity
Deleatidium	120.3	66.6	21.8
Aoteapsyche	30.0	61.5	13.7
Tanytarsini	24.3	41.9	12.2
Elmidae	60.5	53.7	11.5
Orthocladiinae	8.6	38.2	9.0
Pycnocentrodes	7.8	23.1	5.6
Maoridiamesa	2.8	17.6	4.9
Coloburiscus	3.8	9.9	2.7
Potamopyrgus	6.8	6.9	2.7
Beraeoptera	2.5	8.0	2.4
Olinga	4.8	8.4	2.0
Aphrophila	5.0	6.7	1.7
Hydrobiosis	5.7	6.9	1.6

8.0 Fish population surveys

8.1 Purpose

The purpose of the EFM survey is to attempt to attain a repeatable estimation of a local migrant fish population and specifically the density and age structure of that population over time. This may be through measurement of one or several species, typically of *galaxiid*.

8.1.1 Location of monitoring

The location had to be one in which there was a high probability of resident galaxiids of various ages; a stable habitat in terms of physical environment (bank, bed and riparian condition), accessible (to both upward migrating fish and research) and fishable.

A control site was required in the Otaki River, a comparable sized river near the Waikanae River on the same coast. There a similarly sized, stable, inland distance tributary was to serve as a control for galaxiid migration evidence.

Two sites were located with suitable aquatic and riparian features matching the above criteria and are:

1. An un-named Waikanae River tributary at around altitude 140m above sea level, above farmland near the end of the formed Mangaone South Road; and
2. The Pukeatua Stream at around 110-120m above sea level, off the Otaki Gorge Road in the upper Otaki River catchment.

Both survey locations have been selected on the basis of having a number of historic survey data periods and presence of migrant fish populations.

Figure 36: Waikanae River tributary, 100 m downstream of DOC visitor entrance, (4052385S, 1750751E)

Figure 37: Otaki River Tributary (Pukeatua Stream) (405045S, 1754008E)

8.2 Results

8.2.1 Waikanae River tributary

100 m of the tributary was laid out and EFM fished. The results are presented in Table 9. The conditions of substrate, riparian vegetation, upper catchment land use, etc appear conducive to native fish populations. The reach surveyed was on average 50 cm wide, 10 cm deep, had pools averaging 30-40 cm in length and 30 cm deep. The reach surveyed contained 50 m of run habitat, 30 m of riffle habitat, 5 m of pool habitat and 15 m of cascade habitat.

Table 9: Fish records from the 100m reach survey of the chosen Waikanae River tributary

Fish species	Length (cm)	Section & Habitat
Korao	100	10th section, cascade
Common bully	60	9th section, run
Long fin eel	270	17th section, riffle
Long fin eel	270	18th section, riffle
Korao	120	20th section, riffle

8.2.2 Otaki (Pukeatua Stream)

This is a boulder stream with cascades and rock chutes. The average width was 1.5 m and average depth ranging from 30-40 cm. The sampled reach was composed of: 30 m of run, 45 m of riffle, 10 m of pool, and 15 m of cascade and chute habitat. The results are presented in Table 10.

Table 10: Fish records from the 100m reach survey of the chosen Otaki River tributary

Fish species	Length (cm)	Section & Habitat
Common bully	26	1stth section, run
Torrent fish	120	6th section, cascade
Koaro	80	7th section, riffle
Banded kokopu	50	8th section, riffle
Common bully	60	9th section, deep run
Koaro	90	9th section, deep run
Torrent fish	70	10th section, riffle
Red fin bully	80	13th section, run
Common bully	30	14th section, pool
Common bully	40	16th section pool
Common bully	50	16th section pool
Red fin bully	50	17th section, run
Brown trout	90	17th section, run
Koaro	180	20th section, run

8.2.3 Fish monitoring conclusion

The data for the Waikanae River system and the site surveyed is deemed as yet unsatisfactory as a representative site to measure long term upstream successful migrants. Further survey work will be required to find a better location with a larger population of galaxiid, common bully, torrent fish and eel.

The Otaki River site is sufficient in fish abundance to potentially represent a site that will receive upstream migrants and have sufficient taxa richness and abundance to follow migrant establishment, or population permanence through time.

9.0 Flow gauging

The aims of the hydrological monitoring are to:

- Identify/confirm and monitor the relationship between river flows, river abstraction rates and groundwater pumping in the river downstream of the water treatment plant. This is to identify whether additional groundwater pumping reduces flows in the Waikanae River downstream of the treatment plant due to increased losses through the bed of the river as a result of lowered groundwater levels.

- Confirm river flows at the periphyton and water quality monitoring locations to allow correlation of monitoring and effects.

Two sets of flow gauging were conducted by NIWA at the locations specified in River BMP; just downstream of SH1 and alongside Jim Cooke Park (see also Map 1). The results are summarised in Table 11.

The two gaugings undertaken by NIWA indicate:

- Net gain of 87 L/s and net loss of 28 L/s between the water treatment plant and the gauging location just downstream of SH1. The gain occurred when upstream river flows were higher.
- Net losses of 286 L/s and 183 L/s between SH1 and Jim Cooke Park, with the greater loss occurring when river flows (as recorded at GWRC's flow monitoring station upstream of the water treatment plant) were slightly higher.

Table 11: Gauging on the Waikanae River

Date	Water treatment plant			Site	Flow (L/s)	Area (m^2)	Velocity (m/s)	Time (NZST)
	Upstream flow (L/s)	Abstraction (L/s)	Calculated downstream flow (L/s)					
11 March	850	87	763	Below SH1 (NIWA 2)	850	3.18	0.268	13:45
				Jim Cooke Park (NIWA 1)	564	2.49	0.227	15:08
10 April	799	52	747	Below SH1 (NIWA 3)	719	2.62	0.275	11:10
				Jim Cooke Park (NIWA 1)	536	2.55	0.210	12:30

10.0 Summary and Recommendations

10.1 Summary

This report, while presenting an abundance of data, only represents 2 months of the required one year (5 months) of pre-recharge baseline monitoring in the Waikanae River.

Table 12 is a summary of water quality results set against New Zealand freshwater standards and guidelines. The summary of the data shows that while pH, nitrate/nitrite, ammonia-nitrogen (NH4), and algae are generally lower than the guidance values, other nutrient measures are not. Calcium is low and only above that which is considered to mark an oligotrophic system (calcium being important in many of the invertebrate requirements).

Table 12: Average values from all sites and all monitoring periods on the Waikanae River, March-April 2014.

	pH	Soluble Inorganic Nitrogen	Nitrite/ Nitrate Nitrogen	NH_4-N	Calcium Dissolved	TP	DRP	TN	LGF (%)	Algae thick matts	DO (%)
Average of all data	7.7	0.063	0.0584	0.0001	6.127	0.011	0.0096	0.162	5.8%	8%	3.5
Guide values (refer to Table 1)	6.5 to 8	0.034 to 0.47	0.444	0.021	5mg/L to 50mg/L	0.009 to 0.033	0.003 to 0.006	0.016 to 0.614	30%	60%	9.8 to 10.5

Units are mg/L where not otherwise stated. LGF = long green filamentous algae cover.

The nutrients TP, DRP, soluble inorganic nitrogen and TN are above or between the two guidance figures and suggest on the whole that the Waikanae River at the monitoring points has a raised level of these particular nutrients.

Of greatest interest is the very low average dissolved oxygen measures, and while the data represents late summer low stable flows, expectations are for higher DO than was consistently measured. It would appear that the Waikanae River in late summer is not well oxygenated and the increasing algae growths may be a factor in that low measure.

10.2 Recommendations

The monitoring programme requires analysis focused on establishing correlations between water chemistry and periphyton, as well as between aquatic macroinvertebrates and periphyton. As yet, and while correlation analyses have been undertaken, there is insufficient periphyton cover variation and associated aquatic macroinvertebrate data collection to establish any strong relationships.

In that vein, and of note, is that the chlorophyll-a data is correlated with the AFDM and that the chlorophyll-a data appears a more responsive measure than the periphyton cover. This may be an artefact of starting the measures in later summer where cover, although thin, was around 95%. December, January, February measures may be far more variable and provide the growth cycle evidence we expect, as well as a stronger macroinvertebrate community response.

For these reasons we see that the visual cover measures, while appearing less useful than the chlorophyll-a measures should continue through the next December-February 2014/15 summer monitoring. However, we suspect that these visual cover measures will eventually prove less indicative and informative than the replicated and pooled periphyton sampling for chlorophyll-a and AFDM. We anticipate that the best correlations and most useful data will come from those measures and that the visual cover assessments will be able to be abandoned following the 2014/15 sampling period.

To date, the water flow data relative to the ecological monitoring sites is sufficiently served by GWRC's Waikanae WTP gauging site.

Two sets of flow gauging undertaken downstream of the WTP have begun to show the relationship between upstream river flows and losses further downstream. More gaugings are required to develop this relationship and to assist the borefield and ecological monitoring.

No ongoing triggers or limits can yet be established for water quality, periphyton or aquatic macroinvertebrates. That said, there are signs that evidence of increasing periphyton cover with an invertebrate response may be measureable, which is the increase in abundance of Orthoclad flys, and a reduction in Deleatidium. However, the expected increase in Elmidae was not seen.

Appendices

1 Water quality data

2 Visual cover periphyton data

3 Velocity data

4 Periphyton laboratory sample data – chlorophyll-a, AFDM and taxa data

5 Macroinvertebrate survey data

6 Measurement correlations

Appendix 1: Water quality data

Date	Site	Time	pH	Inorganic Nitrogen	Nitrate Nitrite Nitrogen	Ammonia Nitrogen	Calcium Dissolved	Total Phosphorus
6/03/2014	Control 2	15:30	7.6	0.09	0.009	<0.01	5.87	0.01
6/03/2014	Control 1	11:15	7.6	0.1	0.101	<0.01	6.24	0.01
5/03/2014	Site R1	10:50	7.6	0.12	0.12	<0.01	6.62	0.01
5/03/2014	Site R2	13:50	7.7	0.1	0.098	<0.01	6.17	0.01
5/03/2014	Site R3	15:40	7.6	0.09	0.092	<0.01	6.21	0.011
13/03/2014	Control 2	12:00	7.6	0.09	0.085	<0.01	5.82	0.019
13/03/2014	Control 1	11:10	7.6	0.1	0.088	<0.01	5.93	0.018
13/03/2014	Site R1	14:15	7.7	0.08	0.076	<0.01	5.85	0.022
13/03/2014	Site R2	13:20	7.8	0.07	0.068	<0.01	5.86	0.019
13/03/2014	Site R3	15:55	7.8	0.07	0.064	<0.01	6.06	0.018
20/03/2014	Control 2	10:35	7.7	0.04	0.038	<0.01	5.87	<0.03
20/03/2014	Control 1	12:42	7.7	0.03	0.029	<0.01	5.92	<0.03
20/03/2014	Site R1	13:40	7.7	0.02	0.02	<0.01	6.2	<0.03
20/03/2014	Site R2	15:30	7.8	0.01	0.013	<0.01	6.01	<0.03
20/03/2014	Site R3	16:45	7.8	0.02	0.013	<0.01	6.03	<0.03
27/03/2014	Control 2	14:15	7.4	0.11	0.109	<0.01	6.07	0.03
27/03/2014	Control 1	13:30	7.6	0.11	0.105	<0.01	6.08	0.009
27/03/2014	Site R1	12:40	7.7	0.11	0.11	<0.01	6.14	0.01
27/03/2014	Site R2	10:30	7.8	0.11	0.105	<0.01	6.12	0.01
27/03/2014	Site R3	9:30	7.9	0.13	0.126	<0.01	6.15	0.009
3/04/2014	Control 2	14:30	7.6	0.07	0.068	<0.01	6.2	0.011
3/04/2014	Control 1	15:50	7.7	0.06	0.054	<0.01	6.15	0.011
3/04/2014	Site R1	13:45	7.7	0.07	0.064	<0.01	6.26	0.011
3/04/2014	Site R2	10:35	7.7	0.06	0.063	<0.01	6.36	0.011
3/04/2014	Site R3	8:50	7.6	0.07	0.07	<0.01	6.41	0.011
10/04/2014	Control 2	12:15	7.6	<0.01	<0.005	<0.01	6.12	0.009
10/04/2014	Control 1	13:15	7.6	<0.01	<0.005	<0.01	6.08	0.007
10/04/2014	Site R1	13:55	7.7	<0.01	<0.005	<0.01	6.05	0.008
10/04/2014	Site R2	15:25	8.2	<0.01	<0.005	<0.01	6.02	0.008
10/04/2014	Site R3	16:35	7.8	<0.01	<0.005	<0.01	6.13	0.008
16/04/2014	Control 2	14:30:00	7.7	0.06	0.055	<0.01	6.22	0.012
16/04/2014	Control 1	13:10:00	7.7	0.06	0.055	<0.01	6.26	0.013
16/04/2014	Site R1	15:45:00	7.7	0.07	0.057	<0.01	6.3	0.014
16/04/2014	Site R2	12:00:00	7.8	0.04	0.039	<0.01	6.33	0.011
16/04/2014	Site R3	10:00:00	7.8	0.05	0.049	<0.01	6.35	0.012

Date	Site	Time	Dissolved Reactive phosphorus	Total Nitrogen	Temp	Conductivity	Oxygen %	pH (meter)
6/03/2014	Control 2	15:30	0.014	0.13	10.9	113.4	2.9	8.17
6/03/2014	Control 1	11:15	0.014	0.15	6.8	112.8	2.5	8.35
5/03/2014	Site R1	10:50	0.015	0.17	10		3.2	8.44
5/03/2014	Site R2	13:50	0.014	0.15	10.5	117	8.0	8.22
5/03/2014	Site R3	15:40	0.014	0.16				
13/03/2014	Control 2	12:00	0.008	0.12	13.1	117	3.5	7.8
13/03/2014	Control 1	11:10	0.009	0.12	13	115	3.9	7.7
13/03/2014	Site R1	14:15	0.008	0.11	13	114	3.6	7.7
13/03/2014	Site R2	13:20	0.008	0.1	13.5	115	3.2	7.8
13/03/2014	Site R3	15:55	0.008	0.1	13.3	114	2.8	7.8
20/03/2014	Control 2	10:35	<0.005	0.16	14.1	113.2	3.2	7.3
20/03/2014	Control 1	12:42	<0.005	0.16	15.4	113.4	3.9	7.3
20/03/2014	Site R1	13:40	<0.005	0.15	16.2	114.5	1.9	7.5
20/03/2014	Site R2	15:30	<0.005	0.14	17.7	115.3	4.3 - 7.1	7.25
20/03/2014	Site R3	16:45	<0.005	0.14	17.5	115.4		7.45
27/03/2014	Control 2	14:15	0.013	1.52	13.6	115.3	6.5	7.6
27/03/2014	Control 1	13:30	0.013	0.15	13.1	116.4	2.9	7.54
27/03/2014	Site R1	12:40	0.013	0.15	12.8	117.4	1.2	7.41
27/03/2014	Site R2	10:30	0.012	0.14	11.8	115.2	2.0	7.86
27/03/2014	Site R3	9:30	0.012	0.17	11	118	2.0	7.81
3/04/2014	Control 2	14:30	0.009	0.12	14.7	118.6	7.4	7.45
3/04/2014	Control 1	15:50	0.007	0.11	15	118	6.9	7.13
3/04/2014	Site R1	13:45	0.008	0.12	14.2	119.7	2.5	7.6
3/04/2014	Site R2	10:35	0.007	0.13	11.8	120.2	1.9	7.67
3/04/2014	Site R3	8:50	0.006	0.14	11.3	121.9	0.2	7.8
10/04/2014	Control 2	12:15	0.011	0.09	14.1	118	2.2	7.56
10/04/2014	Control 1	13:15	0.011	0.09	14.2	118.2	2.0	7.41
10/04/2014	Site R1	13:55	0.013	0.09	14.7	118.3	3.7	7.4
10/04/2014	Site R2	15:25	0.014	0.08	15.2	118	6.5	7.73
10/04/2014	Site R3	16:35	0.012	0.09	15.2	117.7	6.4	7.71
16/04/2014	Control 2	14:30:00	0.013	0.09	12.8	115.6	2.5	7.7
16/04/2014	Control 1	13:10:00	0.013	0.08	13.3	102.8	2.9	7.75
16/04/2014	Site R1	15:45:00	0.013	0.1	13.5	116.8	4.2	7.74
16/04/2014	Site R2	12:00:00	0.012	0.07	13.4	114.3	3.8	7.76
16/04/2014	Site R3	10:00:00	0.01	0.09	13.4	102.2	1.2	7.74

Appendix 2: Periphyton visual cover data

Date	Site	Transect		Quadrat	Total cover (%)
5/03/2014	R2	1	Riffle 1	1	
5/03/2014	R2	1	Riffle 1	2	62
5/03/2014	R2	1	Riffle 1	3	100
5/03/2014	R2	1	Riffle 1	4	100
5/03/2014	R2	1	Riffle 1	5	90
5/03/2014	R2	2	Riffle 2	1	101
5/03/2014	R2	2	Riffle 2	2	101
5/03/2014	R2	2	Riffle 2	3	102
5/03/2014	R2	2	Riffle 2	4	101
5/03/2014	R2	2	Riffle 2	5	70
5/03/2014	R2	3	Run 1	1	100
5/03/2014	R2	3	Run 1	2	100
5/03/2014	R2	3	Run 1	3	100
5/03/2014	R2	3	Run 1	4	100
5/03/2014	R2	3	Run 1	5	40
5/03/2014	R2	4	Run 2	1	100
5/03/2014	R2	4	Run 2	2	101
5/03/2014	R2	4	Run 2	3	115
5/03/2014	R2	4	Run 2	4	90
5/03/2014	R2	4	Run 2	5	50
March 1st Sampling	Average				90.68
Site R2	STdev				20.04
6/03/2014	C2	3	Riffle 1	1	70
6/03/2014	C2	3	Riffle 1	2	80
6/03/2014	C2	3	Riffle 1	3	100
6/03/2014	C2	3	Riffle 1	4	100
6/03/2014	C2	3	Riffle 1	5	
6/03/2014	C2	4	Riffle 2	1	100
6/03/2014	C2	4	Riffle 2	2	81
6/03/2014	C2	4	Riffle 2	3	100
6/03/2014	C2	4	Riffle 2	4	101
6/03/2014	C2	4	Riffle 2	5	95
6/03/2014	C2	1	Run 1	1	101
6/03/2014	C2	1	Run 1	2	100
6/03/2014	C2	1	Run 1	3	101
6/03/2014	C2	1	Run 1	4	100
6/03/2014	C2	1	Run 1	5	101
6/03/2014	C2	2	Run 2	1	101
6/03/2014	C2	2	Run 2	2	101
6/03/2014	C2	2	Run 2	3	140
6/03/2014	C2	2	Run 2	4	100
6/03/2014	C2	2	Run 2	5	100
March 1st Sampling	Average				98.53

Date	Site	Transect		Quadrat	Total cover (%)
Site C2	STdev				13.44
5/03/2014	R1	1	Run 1	1	100
5/03/2014	R1	1	Run 1	2	100
5/03/2014	R1	1	Run 1	3	50
5/03/2014	R1	1	Run 1	4	67
5/03/2014	R1	1	Run 1	5	10
5/03/2014	R1	2	Run 2	1	100
5/03/2014	R1	2	Run 2	2	100
5/03/2014	R1	2	Run 2	3	100
5/03/2014	R1	2	Run 2	4	100
5/03/2014	R1	2	Run 2	5	102
5/03/2014	R1	3	Riffle 1	1	85
5/03/2014	R1	3	Riffle 1	2	100
5/03/2014	R1	3	Riffle 1	3	100
5/03/2014	R1	3	Riffle 1	4	101
5/03/2014	R1	3	Riffle 1	5	10
5/03/2014	R1	4	Riffle 2	1	20
5/03/2014	R1	4	Riffle 2	2	101
5/03/2014	R1	4	Riffle 2	3	101
5/03/2014	R1	4	Riffle 2	4	100
5/03/2014	R1	4	Riffle 2	5	100
March 1st Sampling	Average				82.35
Site R1	STdev				32.60
5/03/2014	R3	1	Riffle 1	1	51
5/03/2014	R3	1	Riffle 1	2	100
5/03/2014	R3	1	Riffle 1	3	150
5/03/2014	R3	1	Riffle 1	4	111
5/03/2014	R3	1	Riffle 1	5	0
5/03/2014	R3	2	Riffle 2	1	100
5/03/2014	R3	2	Riffle 2	2	102
5/03/2014	R3	2	Riffle 2	3	100
5/03/2014	R3	2	Riffle 2	4	82
5/03/2014	R3	2	Riffle 2	5	80
5/03/2014	R3	3	Run 1	1	
5/03/2014	R3	3	Run 1	2	191.5
5/03/2014	R3	3	Run 1	3	180
5/03/2014	R3	3	Run 1	4	171
5/03/2014	R3	3	Run 1	5	122.5
5/03/2014	R3	4	Run 2	1	100
5/03/2014	R3	4	Run 2	2	101
5/03/2014	R3	4	Run 2	3	101
5/03/2014	R3	4	Run 2	4	101
5/03/2014	R3	4	Run 2	5	102
March 1st Sampling	Average				107.68
Site R3	STdev				44.07
6/03/2014	C1	3	Riffle 1	1	0
6/03/2014	C1	3	Riffle 1	2	0

Date	Site	Transect		Quadrat	Total cover (%)
6/03/2014	C1	3	Riffle 1	3	0
6/03/2014	C1	3	Riffle 1	4	0
6/03/2014	C1	3	Riffle 1	5	0
6/03/2014	C1	4	Riffle 2	1	50
6/03/2014	C1	4	Riffle 2	2	105
6/03/2014	C1	4	Riffle 2	3	120
6/03/2014	C1	4	Riffle 2	4	101
6/03/2014	C1	4	Riffle 2	5	103
6/03/2014	C1	1	Run 1	1	80
6/03/2014	C1	1	Run 1	2	100
6/03/2014	C1	1	Run 1	3	100
6/03/2014	C1	1	Run 1	4	100
6/03/2014	C1	1	Run 1	5	100
6/03/2014	C1	2	Run 2	1	100
6/03/2014	C1	2	Run 2	2	100
6/03/2014	C1	2	Run 2	3	101
6/03/2014	C1	2	Run 2	4	101
6/03/2014	C1	2	Run 2	5	101
March 1st Sampling	Average				73.10
Site C1	STdev				45.23
13/03/2014	C2	1	Run 1	1	101
13/03/2014	C2	1	Run 1	2	113
13/03/2014	C2	1	Run 1	3	100
13/03/2014	C2	1	Run 1	4	101
13/03/2014	C2	1	Run 1	5	100
13/03/2014	C2	2	Run 2	1	102
13/03/2014	C2	2	Run 2	2	100
13/03/2014	C2	2	Run 2	3	100
13/03/2014	C2	2	Run 2	4	100
13/03/2014	C2	2	Run 2	5	100
13/03/2014	C2	3	Riffle 1	1	80
13/03/2014	C2	3	Riffle 1	2	100
13/03/2014	C2	3	Riffle 1	3	101
13/03/2014	C2	3	Riffle 1	4	60
13/03/2014	C2	3	Riffle 1	5	90
13/03/2014	C2	4	Riffle 2	1	101
13/03/2014	C2	4	Riffle 2	2	80
13/03/2014	C2	4	Riffle 2	3	80
13/03/2014	C2	4	Riffle 2	4	100
13/03/2014	C2	4	Riffle 2	5	161
March 2nd Sampling	Average				98.50
Site C2	STdev				18.85
13/03/2014	C1	1	Run 1	1	100
13/03/2014	C1	1	Run 1	2	100
13/03/2014	C1	1	Run 1	3	80
13/03/2014	C1	1	Run 1	4	80
13/03/2014	C1	1	Run 1	5	100

Date	Site	Transect		Quadrat	Total cover (%)
13/03/2014	C1	2	Run 2	1	90
13/03/2014	C1	2	Run 2	2	90
13/03/2014	C1	2	Run 2	3	90
13/03/2014	C1	2	Run 2	4	101
13/03/2014	C1	2	Run 2	5	90
13/03/2014	C1	3	Riffle 1	1	102
13/03/2014	C1	3	Riffle 1	2	120
13/03/2014	C1	3	Riffle 1	3	101
13/03/2014	C1	3	Riffle 1	4	101
13/03/2014	C1	3	Riffle 1	5	91
13/03/2014	C1	4	Riffle 2	1	101
13/03/2014	C1	4	Riffle 2	2	100
13/03/2014	C1	4	Riffle 2	3	120
13/03/2014	C1	4	Riffle 2	4	101
13/03/2014	C1	4	Riffle 2	5	102
March 2nd Sampling	Average				98.00
Site C1	STdev				10.30
13/03/2014	R3	1	Riffle 1	1	101
13/03/2014	R3	1	Riffle 1	2	100
13/03/2014	R3	1	Riffle 1	3	101
13/03/2014	R3	1	Riffle 1	4	102
13/03/2014	R3	1	Riffle 1	5	101
13/03/2014	R3	2	Riffle 2	1	101
13/03/2014	R3	2	Riffle 2	2	103
13/03/2014	R3	2	Riffle 2	3	101
13/03/2014	R3	2	Riffle 2	4	101
13/03/2014	R3	2	Riffle 2	5	101
13/03/2014	R3	3	Run 1	1	100
13/03/2014	R3	3	Run 1	2	100
13/03/2014	R3	3	Run 1	3	101
13/03/2014	R3	3	Run 1	4	102
13/03/2014	R3	3	Run 1	5	100
13/03/2014	R3	4	Run 2	1	140
13/03/2014	R3	4	Run 2	2	91
13/03/2014	R3	4	Run 2	3	90
13/03/2014	R3	4	Run 2	4	102
13/03/2014	R3	4	Run 2	5	90
March 2nd Sampling	Average				101.40
Site R3	STdev				9.92
13/03/2014	R1	1	Run 1	1	100
13/03/2014	R1	1	Run 1	2	101
13/03/2014	R1	1	Run 1	3	100
13/03/2014	R1	1	Run 1	4	100
13/03/2014	R1	1	Run 1	5	100
13/03/2014	R1	2	Run 2	1	100
13/03/2014	R1	2	Run 2	2	102
13/03/2014	R1	2	Run 2	3	103
13/03/2014	R1	2	Run 2	4	102

Date	Site	Transect		Quadrat	Total cover (%)
13/03/2014	R1	2	Run 2	5	100
13/03/2014	R1	3	Riffle 1	1	101
13/03/2014	R1	3	Riffle 1	2	102
13/03/2014	R1	3	Riffle 1	3	102
13/03/2014	R1	3	Riffle 1	4	101
13/03/2014	R1	3	Riffle 1	5	100
13/03/2014	R1	4	Riffle 2	1	100
13/03/2014	R1	4	Riffle 2	2	103
13/03/2014	R1	4	Riffle 2	3	101
13/03/2014	R1	4	Riffle 2	4	100
13/03/2014	R1	4	Riffle 2	5	101
March 2nd Sampling	Average				100.95
Site R1	STdev				1.05
13/03/2014	R2	1	Riffle 1	1	101
13/03/2014	R2	1	Riffle 1	2	103
13/03/2014	R2	1	Riffle 1	3	100
13/03/2014	R2	1	Riffle 1	4	100
13/03/2014	R2	1	Riffle 1	5	101
13/03/2014	R2	2	Riffle 2	1	101
13/03/2014	R2	2	Riffle 2	2	120
13/03/2014	R2	2	Riffle 2	3	102
13/03/2014	R2	2	Riffle 2	4	160
13/03/2014	R2	2	Riffle 2	5	101
13/03/2014	R2	3	Run 1	1	100
13/03/2014	R2	3	Run 1	2	101
13/03/2014	R2	3	Run 1	3	102
13/03/2014	R2	3	Run 1	4	100
13/03/2014	R2	3	Run 1	5	100
13/03/2014	R2	4	Run 2	1	100
13/03/2014	R2	4	Run 2	2	101
13/03/2014	R2	4	Run 2	3	102
13/03/2014	R2	4	Run 2	4	100
13/03/2014	R2	4	Run 2	5	81
March 2nd Sampling	Average				103.80
Site R2	STdev				14.69
20/03/2014	C2	1	Run 1	1	0
20/03/2014	C2	1	Run 1	2	80
20/03/2014	C2	1	Run 1	3	80
20/03/2014	C2	1	Run 1	4	90
20/03/2014	C2	1	Run 1	5	80
20/03/2014	C2	2	Run 2	1	100
20/03/2014	C2	2	Run 2	2	80
20/03/2014	C2	2	Run 2	3	30
20/03/2014	C2	2	Run 2	4	60
20/03/2014	C2	2	Run 2	5	92
20/03/2014	C2	3	Riffle 1	1	70
20/03/2014	C2	3	Riffle 1	2	101

Date	Site	Transect		Quadrat	Total cover (%)
20/03/2014	C2	3	Riffle 1	3	91
20/03/2014	C2	3	Riffle 1	4	90
20/03/2014	C2	3	Riffle 1	5	101
20/03/2014	C2	4	Riffle 2	1	50
20/03/2014	C2	4	Riffle 2	2	70
20/03/2014	C2	4	Riffle 2	3	90
20/03/2014	C2	4	Riffle 2	4	80
20/03/2014	C2	4	Riffle 2	5	91
20/03/2014	C2	4	Riffle 2	1	80
March 3rd Sampling	Average				80.30
Site C2	STdev				17.72
20/03/2014	C1	4	Riffle 2	2	100
20/03/2014	C1	4	Riffle 2	3	100
20/03/2014	C1	4	Riffle 2	4	100
20/03/2014	C1	4	Riffle 2	5	101
20/03/2014	C1	3	Riffle 1	1	100
20/03/2014	C1	3	Riffle 1	2	100
20/03/2014	C1	3	Riffle 1	3	100
20/03/2014	C1	3	Riffle 1	4	100
20/03/2014	C1	3	Riffle 1	5	90
20/03/2014	C1	2	Run 2	1	80
20/03/2014	C1	2	Run 2	2	100
20/03/2014	C1	2	Run 2	3	101
20/03/2014	C1	2	Run 2	4	100
20/03/2014	C1	2	Run 2	5	101
20/03/2014	C1	1	Run 1	1	100
20/03/2014	C1	1	Run 1	2	101
20/03/2014	C1	1	Run 1	3	101
20/03/2014	C1	1	Run 1	4	101
20/03/2014	C1	1	Run 1	5	101
March 3rd Sampling	Average				94.74
Site C1	STdev				18.81
20/03/2014	R1	4	Riffle 2	1	102
20/03/2014	R1	4	Riffle 2	2	82
20/03/2014	R1	4	Riffle 2	3	121
20/03/2014	R1	4	Riffle 2	4	102
20/03/2014	R1	4	Riffle 2	5	100
20/03/2014	R1	3	Riffle 1	1	102
20/03/2014	R1	3	Riffle 1	2	101
20/03/2014	R1	3	Riffle 1	3	102
20/03/2014	R1	3	Riffle 1	4	101
20/03/2014	R1	3	Riffle 1	5	100
20/03/2014	R1	2	Run 2	1	100
20/03/2014	R1	2	Run 2	2	100
20/03/2014	R1	2	Run 2	3	101
20/03/2014	R1	2	Run 2	4	100
20/03/2014	R1	2	Run 2	5	100
20/03/2014	R1	1	Run 1	1	101

Date	Site	Transect		Quadrat	Total cover (%)
20/03/2014	R1	1	Run 1	2	101
20/03/2014	R1	1	Run 1	3	101
20/03/2014	R1	1	Run 1	4	100
20/03/2014	R1	1	Run 1	5	102
March 3rd Sampling	Average				100.95
Site R1	STdev				6.38
20/03/2014	R2	4	Riffle 2	1	100
20/03/2014	R2	4	Riffle 2	2	100
20/03/2014	R2	4	Riffle 2	3	101
20/03/2014	R2	4	Riffle 2	4	100
20/03/2014	R2	4	Riffle 2	5	100
20/03/2014	R2	2	Run 2	1	103
20/03/2014	R2	2	Run 2	2	102
20/03/2014	R2	2	Run 2	3	102
20/03/2014	R2	2	Run 2	4	100
20/03/2014	R2	2	Run 2	5	101
20/03/2014	R2	1	Run 1	1	100
20/03/2014	R2	1	Run 1	2	101
20/03/2014	R2	1	Run 1	3	100
20/03/2014	R2	1	Run 1	4	100
20/03/2014	R2	1	Run 1	5	100
20/03/2014	R2	3	Riffle 1	1	101
20/03/2014	R2	3	Riffle 1	2	100
20/03/2014	R2	3	Riffle 1	3	101
20/03/2014	R2	3	Riffle 1	4	100
20/03/2014	R2	3	Riffle 1	5	100
March 3rd Sampling	Average				100.60
Site R2	STdev				0.88
20/03/2014	R3	4	Run 2	1	101
20/03/2014	R3	4	Run 2	2	100
20/03/2014	R3	4	Run 2	3	101
20/03/2014	R3	4	Run 2	4	102
20/03/2014	R3	4	Run 2	5	101
20/03/2014	R3	3	Run 1	1	0
20/03/2014	R3	3	Run 1	2	100
20/03/2014	R3	3	Run 1	3	101
20/03/2014	R3	3	Run 1	4	101
20/03/2014	R3	3	Run 1	5	103
20/03/2014	R3	1	Riffle 1	1	102
20/03/2014	R3	1	Riffle 1	2	101
20/03/2014	R3	1	Riffle 1	3	101
20/03/2014	R3	1	Riffle 1	4	100
20/03/2014	R3	1	Riffle 1	5	103
20/03/2014	R3	2	Riffle 2	1	100
20/03/2014	R3	2	Riffle 2	2	101
20/03/2014	R3	2	Riffle 2	3	101
20/03/2014	R3	2	Riffle 2	4	102

Date	Site	Transect		Quadrat	Total cover (%)
20/03/2014	R3	2	Riffle 2	5	100
March 3rd Sampling	Average				96.05
Site R3	STdev				22.63
27/03/2014	R3	1	Riffle 1	1	100
27/03/2014	R3	1	Riffle 1	2	100
27/03/2014	R3	1	Riffle 1	3	101
27/03/2014	R3	1	Riffle 1	4	101
27/03/2014	R3	1	Riffle 1	5	100
27/03/2014	R3	2	Riffle 2	1	100
27/03/2014	R3	2	Riffle 2	2	102
27/03/2014	R3	2	Riffle 2	3	100
27/03/2014	R3	2	Riffle 2	4	100
27/03/2014	R3	2	Riffle 2	5	102
27/03/2014	R3	3	Run 1	1	0
27/03/2014	R3	3	Run 1	2	100
27/03/2014	R3	3	Run 1	3	102
27/03/2014	R3	3	Run 1	4	100
27/03/2014	R3	3	Run 1	5	100
27/03/2014	R3	4	Run 2	1	100
27/03/2014	R3	4	Run 2	2	100
27/03/2014	R3	4	Run 2	3	100
27/03/2014	R3	4	Run 2	4	100
27/03/2014	R3	4	Run 2	5	101
March 4th Sampling	Average				95.45
Site R3	STdev				22.48
27/03/2014	R2	2	Run 2	1	101
27/03/2014	R2	2	Run 2	2	101
27/03/2014	R2	2	Run 2	3	102
27/03/2014	R2	2	Run 2	4	100
27/03/2014	R2	2	Run 2	5	100
27/03/2014	R2	1	Run 1	1	100
27/03/2014	R2	1	Run 1	2	101
27/03/2014	R2	1	Run 1	3	101
27/03/2014	R2	1	Run 1	4	100
27/03/2014	R2	1	Run 1	5	90
27/03/2014	R2	3	Riffle 1	1	100
27/03/2014	R2	3	Riffle 1	2	100
27/03/2014	R2	3	Riffle 1	3	100
27/03/2014	R2	3	Riffle 1	4	100
27/03/2014	R2	3	Riffle 1	5	100
27/03/2014	R2	4	Riffle 2	1	101
27/03/2014	R2	4	Riffle 2	2	104
27/03/2014	R2	4	Riffle 2	3	101
27/03/2014	R2	4	Riffle 2	4	101
27/03/2014	R2	4	Riffle 2	5	101
March 4th Sampling	Average				100.20
Site R2	STdev				2.59

Date	Site	Transect		Quadrat	Total cover (%)
27/03/2014	R1	4	Riffle 2	1	102
27/03/2014	R1	4	Riffle 2	2	101
27/03/2014	R1	4	Riffle 2	3	103
27/03/2014	R1	4	Riffle 2	4	102
27/03/2014	R1	4	Riffle 2	5	102
27/03/2014	R1	3	Riffle 1	1	102
27/03/2014	R1	3	Riffle 1	2	102
27/03/2014	R1	3	Riffle 1	3	102
27/03/2014	R1	3	Riffle 1	4	102
27/03/2014	R1	3	Riffle 1	5	100
27/03/2014	R1	2	Run 2	1	100
27/03/2014	R1	2	Run 2	2	101
27/03/2014	R1	2	Run 2	3	101
27/03/2014	R1	2	Run 2	4	100
27/03/2014	R1	2	Run 2	5	100
27/03/2014	R1	1	Run 1	1	102
27/03/2014	R1	1	Run 1	2	101
27/03/2014	R1	1	Run 1	3	100
27/03/2014	R1	1	Run 1	4	81
27/03/2014	R1	1	Run 1	5	102
March 4th Sampling	Average				100.30
Site R1	STdev				4.64
27/03/2014	C1	2	Run 2	1	102
27/03/2014	C1	2	Run 2	2	100
27/03/2014	C1	2	Run 2	3	102
27/03/2014	C1	2	Run 2	4	101
27/03/2014	C1	2	Run 2	5	101
27/03/2014	C1	1	Run 1	1	100
27/03/2014	C1	1	Run 1	2	100
27/03/2014	C1	1	Run 1	3	100
27/03/2014	C1	1	Run 1	4	102
27/03/2014	C1	1	Run 1	5	101
27/03/2014	C1	3	Riffle 1	1	101
27/03/2014	C1	3	Riffle 1	2	102
27/03/2014	C1	3	Riffle 1	3	103
27/03/2014	C1	3	Riffle 1	4	100
27/03/2014	C1	3	Riffle 1	5	101
27/03/2014	C1	4	Riffle 2	1	101
27/03/2014	C1	4	Riffle 2	2	100
27/03/2014	C1	4	Riffle 2	3	104
27/03/2014	C1	4	Riffle 2	4	101
27/03/2014	C1	4	Riffle 2	5	101
March 4th Sampling	Average				101.15
Site C1	STdev				1.09
27/03/2014	C2	1	Run 1	1	101
27/03/2014	C2	1	Run 1	2	102
27/03/2014	C2	1	Run 1	3	60

Date	Site	Transect		Quadrat	Total cover (%)
27/03/2014	C2	1	Run 1	4	51
27/03/2014	C2	1	Run 1	5	100
27/03/2014	C2	2	Run 2	1	81
27/03/2014	C2	2	Run 2	2	90
27/03/2014	C2	2	Run 2	3	70
27/03/2014	C2	2	Run 2	4	61
27/03/2014	C2	2	Run 2	5	72
27/03/2014	C2	3	Riffle 1	1	70
27/03/2014	C2	3	Riffle 1	2	61
27/03/2014	C2	3	Riffle 1	3	70
27/03/2014	C2	3	Riffle 1	4	70
27/03/2014	C2	3	Riffle 1	5	80
27/03/2014	C2	4	Riffle 2	1	80
27/03/2014	C2	4	Riffle 2	2	60
27/03/2014	C2	4	Riffle 2	3	71
27/03/2014	C2	4	Riffle 2	4	100
27/03/2014	C2	4	Riffle 2	5	100
March 4th Sampling	Average				77.50
Site C2	STdev				16.24
3/04/2014	R3	1	Riffle 1	1	101
3/04/2014	R3	1	Riffle 1	2	100
3/04/2014	R3	1	Riffle 1	3	100
3/04/2014	R3	1	Riffle 1	4	100
3/04/2014	R3	1	Riffle 1	5	101
3/04/2014	R3	2	Riffle 2	1	100
3/04/2014	R3	2	Riffle 2	2	100
3/04/2014	R3	2	Riffle 2	3	100
3/04/2014	R3	2	Riffle 2	4	101
3/04/2014	R3	1	Riffle 2	5	101
3/04/2014	R3	1	Run 1	1	0
3/04/2014	R3	1	Run 1	2	102
3/04/2014	R3	1	Run 1	3	102
3/04/2014	R3	1	Run 1	4	101
3/04/2014	R3	1	Run 1	5	100
3/04/2014	R3	2	Run 2	1	80
3/04/2014	R3	2	Run 2	2	80
3/04/2014	R3	2	Run 2	3	92
3/04/2014	R3	2	Run 2	4	91
3/04/2014	R3	2	Run 2	5	100
April 1st Sampling	Average				92.60
Site R3	STdev				22.78
3/04/2014	R2	3	Riffle 1	1	102
3/04/2014	R2	3	Riffle 1	2	101
3/04/2014	R2	3	Riffle 1	3	101
3/04/2014	R2	3	Riffle 1	4	102
3/04/2014	R2	3	Riffle 1	5	103
3/04/2014	R2	4	Riffle 2	1	100

Date	Site	Transect		Quadrat	Total cover (%)
3/04/2014	R2	4	Riffle 2	2	100
3/04/2014	R2	4	Riffle 2	3	101
3/04/2014	R2	4	Riffle 2	4	101
3/04/2014	R2	4	Riffle 2	5	101
3/04/2014	R2	1	Run 1	1	100
3/04/2014	R2	1	Run 1	2	100
3/04/2014	R2	1	Run 1	3	100
3/04/2014	R2	1	Run 1	4	100
3/04/2014	R2	1	Run 1	5	100
3/04/2014	R2	2	Run 2	1	101
3/04/2014	R2	2	Run 2	2	100
3/04/2014	R2	2	Run 2	3	100
3/04/2014	R2	2	Run 2	4	90
3/04/2014	R2	2	Run 2	5	100
April 1st Sampling	Average				100.15
Site R2	STdev				2.54
3/04/2014	R1	2	Run 2	1	101
3/04/2014	R1	2	Run 2	2	101
3/04/2014	R1	2	Run 2	3	101
3/04/2014	R1	2	Run 2	4	101
3/04/2014	R1	2	Run 2	5	101
3/04/2014	R1	1	Run 1	1	0
3/04/2014	R1	1	Run 1	2	103
3/04/2014	R1	1	Run 1	3	100
3/04/2014	R1	1	Run 1	4	100
3/04/2014	R1	1	Run 1	5	101
3/04/2014	R1	3	Riffle 1	1	102
3/04/2014	R1	3	Riffle 1	2	101
3/04/2014	R1	3	Riffle 1	3	101
3/04/2014	R1	3	Riffle 1	4	104
3/04/2014	R1	3	Riffle 1	5	102
3/04/2014	R1	4	Riffle 2	1	100
3/04/2014	R1	4	Riffle 2	2	101
3/04/2014	R1	4	Riffle 2	3	102
3/04/2014	R1	4	Riffle 2	4	101
3/04/2014	R1	4	Riffle 2	5	100
April 1st Sampling	Average				96.15
Site R1	STdev				22.65
3/04/2014	C2	4	Riffle 2	1	100
3/04/2014	C2	4	Riffle 2	2	100
3/04/2014	C2	4	Riffle 2	3	101
3/04/2014	C2	4	Riffle 2	4	100
3/04/2014	C2	4	Riffle 2	5	101
3/04/2014	C2	3	Riffle 1	1	101
3/04/2014	C2	3	Riffle 1	2	101
3/04/2014	C2	3	Riffle 1	3	101
3/04/2014	C2	3	Riffle 1	4	90

Date	Site	Transect		Quadrat	Total cover (%)
3/04/2014	C2	3	Riffle 1	5	100
3/04/2014	C2	2	Run 2	1	102
3/04/2014	C2	2	Run 2	2	100
3/04/2014	C2	2	Run 2	3	101
3/04/2014	C2	2	Run 2	4	90
3/04/2014	C2	2	Run 2	5	101
3/04/2014	C2	1	Run 1	1	101
3/04/2014	C2	1	Run 1	2	100
3/04/2014	C2	1	Run 1	3	91
3/04/2014	C2	1	Run 1	4	102
3/04/2014	C2	1	Run 1	5	100
April 1st Sampling	Average				99.15
Site C2	STdev				3.86
3/04/2014	C1	1	Run 1	1	90
3/04/2014	C1	1	Run 1	2	0
3/04/2014	C1	1	Run 1	3	90
3/04/2014	C1	1	Run 1	4	100
3/04/2014	C1	1	Run 1	5	101
3/04/2014	C1	2	Run 2	1	100
3/04/2014	C1	2	Run 2	2	101
3/04/2014	C1	2	Run 2	3	102
3/04/2014	C1	2	Run 2	4	102
3/04/2014	C1	2	Run 2	5	100
3/04/2014	C1	3	Riffle 1	1	92
3/04/2014	C1	3	Riffle 1	2	90
3/04/2014	C1	3	Riffle 1	3	102
3/04/2014	C1	3	Riffle 1	4	161
3/04/2014	C1	3	Riffle 1	5	100
3/04/2014	C1	4	Riffle 2	1	101
3/04/2014	C1	4	Riffle 2	2	102
3/04/2014	C1	4	Riffle 2	3	102
3/04/2014	C1	4	Riffle 2	4	100
3/04/2014	C1	4	Riffle 2	5	100
April 1st Sampling	Average				96.80
Site C1	STdev				27.05
10/04/2014	C2	2	Run 2	1	100
10/04/2014	C2	2	Run 2	2	102
10/04/2014	C2	2	Run 2	3	101
10/04/2014	C2	2	Run 2	4	101
10/04/2014	C2	2	Run 2	5	100
10/04/2014	C2	1	Run 1	1	106
10/04/2014	C2	1	Run 1	2	102
10/04/2014	C2	1	Run 1	3	91
10/04/2014	C2	1	Run 1	4	100
10/04/2014	C2	1	Run 1	5	100
10/04/2014	C2		Riffle 1	1	100
10/04/2014	C2		Riffle 1	2	100
10/04/2014	C2		Riffle 1	3	100

Date	Site	Transect		Quadrat	Total cover (%)
10/04/2014	C2		Riffle 1	4	100
10/04/2014	C2		Riffle 1	5	100
10/04/2014	C2		Riffle 2	1	0
10/04/2014	C2		Riffle 2	2	90
10/04/2014	C2		Riffle 2	3	100
10/04/2014	C2		Riffle 2	4	100
10/04/2014	C2		Riffle 2	5	100
April 2nd Sampling	Average				94.65
Site C2	STdev				22.54
10/04/2014	C1	1	Run 1	1	100
10/04/2014	C1	1	Run 1	2	102
10/04/2014	C1	1	Run 1	3	100
10/04/2014	C1	1	Run 1	4	62
10/04/2014	C1	1	Run 1	5	100
10/04/2014	C1	2	Run 2	1	80
10/04/2014	C1	2	Run 2	2	102
10/04/2014	C1	2	Run 2	3	102
10/04/2014	C1	2	Run 2	4	103
10/04/2014	C1	2	Run 2	5	100
10/04/2014	C1	3	Riffle 1	1	103
10/04/2014	C1	3	Riffle 1	2	100
10/04/2014	C1	3	Riffle 1	3	103
10/04/2014	C1	3	Riffle 1	4	101
10/04/2014	C1	3	Riffle 1	5	102
10/04/2014	C1	4	Riffle 2	1	100
10/04/2014	C1	4	Riffle 2	2	141
10/04/2014	C1	4	Riffle 2	3	101
10/04/2014	C1	4	Riffle 2	4	102
10/04/2014	C1	4	Riffle 2	5	100
April 2nd Sampling	Average				100.20
Site C1	STdev				13.71
10/04/2014	R1	1	Run 1	1	101
10/04/2014	R1	1	Run 1	2	102
10/04/2014	R1	1	Run 1	3	100
10/04/2014	R1	1	Run 1	4	70
10/04/2014	R1	1	Run 1	5	103
10/04/2014	R1	2	Run 2	1	101
10/04/2014	R1	2	Run 2	2	101
10/04/2014	R1	2	Run 2	3	101
10/04/2014	R1	2	Run 2	4	101
10/04/2014	R1	2	Run 2	5	101
10/04/2014	R1	4	Riffle 2	1	102
10/04/2014	R1	4	Riffle 2	2	102
10/04/2014	R1	4	Riffle 2	3	101
10/04/2014	R1	4	Riffle 2	4	102
10/04/2014	R1	4	Riffle 2	5	100
10/04/2014	R1	3	Riffle 1	1	101

Date	Site	Transect		Quadrat	Total cover (%)
10/04/2014	R1	3	Riffle 1	2	102
10/04/2014	R1	3	Riffle 1	3	101
10/04/2014	R1	3	Riffle 1	4	102
10/04/2014	R1	3	Riffle 1	5	100
April 2nd Sampling	Average				99.70
Site R1	STdev				7.03
10/04/2014	R2	2	Riffle 2	1	101
10/04/2014	R2	2	Riffle 2	2	101
10/04/2014	R2	2	Riffle 2	3	102
10/04/2014	R2	2	Riffle 2	4	101
10/04/2014	R2	2	Riffle 2	5	101
10/04/2014	R2	1	Riffle 1	1	100
10/04/2014	R2	1	Riffle 1	2	101
10/04/2014	R2	1	Riffle 1	3	100
10/04/2014	R2	1	Riffle 1	4	100
10/04/2014	R2	1	Riffle 1	5	100
10/04/2014	R2	3	Run 1	1	100
10/04/2014	R2	3	Run 1	2	101
10/04/2014	R2	3	Run 1	3	100
10/04/2014	R2	3	Run 1	4	100
10/04/2014	R2	3	Run 1	5	100
10/04/2014	R2	4	Run 2	1	101
10/04/2014	R2	4	Run 2	2	101
10/04/2014	R2	4	Run 2	3	102
10/04/2014	R2	4	Run 2	4	101
10/04/2014	R2	4	Run 2	5	100
April 2nd Sampling	Average				100.65
Site R2	STdev				0.67
10/04/2014	R3	2	Riffle 2	1	102
10/04/2014	R3	2	Riffle 2	2	101
10/04/2014	R3	2	Riffle 2	3	101
10/04/2014	R3	2	Riffle 2	4	102
10/04/2014	R3	2	Riffle 2	5	101
10/04/2014	R3	1	Riffle 1	1	100
10/04/2014	R3	1	Riffle 1	2	102
10/04/2014	R3	1	Riffle 1	3	101
10/04/2014	R3	1	Riffle 1	4	102
10/04/2014	R3	1	Riffle 1	5	101
10/04/2014	R3	4	Run 2	1	101
10/04/2014	R3	4	Run 2	2	101
10/04/2014	R3	4	Run 2	3	101
10/04/2014	R3	4	Run 2	4	101
10/04/2014	R3	4	Run 2	5	100
10/04/2014	R3	3	Run 1	1	0
10/04/2014	R3	3	Run 1	2	100
10/04/2014	R3	3	Run 1	3	103
10/04/2014	R3	3	Run 1	4	103
10/04/2014	R3	3	Run 1	5	103

Date	Site	Transect		Quadrat	Total cover (%)
April 2nd Sampling	Average				96.30
Site R3	STdev				22.69
16/04/2014	R3	4	Run 2	1	102
16/04/2014	R3	4	Run 2	2	105
16/04/2014	R3	4	Run 2	3	175
16/04/2014	R3	4	Run 2	4	165
16/04/2014	R3	4	Run 2	5	185
16/04/2014	R3	3	Run 1	1	0
16/04/2014	R3	3	Run 1	2	100
16/04/2014	R3	3	Run 1	3	181
16/04/2014	R3	3	Run 1	4	100
16/04/2014	R3	3	Run 1	5	101
16/04/2014	R3	2	Riffle 2	1	100
16/04/2014	R3	2	Riffle2	2	160
16/04/2014	R3	2	Riffle 2	3	180
16/04/2014	R3	2	Riffle 2	4	100
16/04/2014	R3	2	Riffle 2	5	101
16/04/2014	R3	1	Riffle 1	1	0
16/04/2014	R3	1	Riffle1	2	0
16/04/2014	R3	1	Riffle 1	3	0
16/04/2014	R3	1	Riffle 1	4	0
16/04/2014	R3	1	Riffle 1	5	0
April 3rd Sampling	Average				92.75
Site R3	STdev				69.82
16/04/2014	R2	2	Riffle 2	1	140
16/04/2014	R2	2	Riffl2	2	92
16/04/2014	R2	2	Riffle 2	3	181
16/04/2014	R2	2	Riffle 2	4	181
16/04/2014	R2	2	Riffle 2	5	61
16/04/2014	R2	1	Riffle 1	1	101
16/04/2014	R2	1	Riffle 1	2	101
16/04/2014	R2	1	Riffle 1	3	102
16/04/2014	R2	1	Riffle 1	4	100
16/04/2014	R2	1	Riffle 1	5	100
16/04/2014	R2	3	Run 1	1	122
16/04/2014	R2	3	Run 1	2	101
16/04/2014	R2	3	Run 1	3	101
16/04/2014	R2	3	Run 1	4	100
16/04/2014	R2	3	Run 1	5	100
16/04/2014	R2	4	Run 2	1	101
16/04/2014	R2	4	Run 2	2	101
16/04/2014	R2	4	Run 2	3	101
16/04/2014	R2	4	Run 2	4	101
16/04/2014	R2	4	Run 2	5	111
April 3rd Sampling	Average				109.90
Site R2	STdev				28.06
16/04/2014	C2	1	Run 1	1	102

Date	Site	Transect		Quadrat	Total cover (%)
16/04/2014	C2	1	Run 1	2	101
16/04/2014	C2	1	Run 1	3	100
16/04/2014	C2	1	Run 1	4	150
16/04/2014	C2	1	Run 1	5	101
16/04/2014	C2	2	Run 2	1	101
16/04/2014	C2	2	Run 2	2	101
16/04/2014	C2	2	Run 2	3	101
16/04/2014	C2	2	Run 2	4	102
16/04/2014	C2	2	Run 2	5	101
16/04/2014	C2	3	Riffle 1	1	102
16/04/2014	C2	3	Riffle 1	2	100
16/04/2014	C2	3	Riffle 1	3	101
16/04/2014	C2	3	Riffle 1	4	100
16/04/2014	C2	3	Riffle 1	5	101
16/04/2014	C2	4	Riffle 2	1	101
16/04/2014	C2	4	Riffle 2	2	105
16/04/2014	C2	4	Riffle 2	3	100
16/04/2014	C2	4	Riffle 2	4	101
16/04/2014	C2	4	Riffle 2	5	100
April 3rd Sampling	Average				103.55
Site C2	STdev				10.99
16/04/2014	C1	4	Riffle 2	1	101
16/04/2014	C1	4	Riffle 2	2	100
16/04/2014	C1	4	Riffle 2	3	102
16/04/2014	C1	4	Riffle 2	4	101
16/04/2014	C1	4	Riffle 2	5	101
16/04/2014	C1	3	Riffle 1	1	100
16/04/2014	C1	3	Riffle 1	2	100
16/04/2014	C1	3	Riffle 1	3	100
16/04/2014	C1	3	Riffle 1	4	101
16/04/2014	C1	3	Riffle 1	5	1
16/04/2014	C1	2	Run 2	1	80
16/04/2014	C1	2	Run 2	2	101
16/04/2014	C1	2	Run 2	3	101
16/04/2014	C1	2	Run 2	4	101
16/04/2014	C1	2	Run 2	5	100
16/04/2014	C1	1	Run 1	1	100
16/04/2014	C1	1	Run 1	2	100
16/04/2014	C1	1	Run 1	3	100
16/04/2014	C1	1	Run 1	4	100
16/04/2014	C1	1	Run 1	5	100
April 3rd Sampling	Average				94.50
Site C1	STdev				22.49
16/04/2014	R1	1	Run 1	1	101
16/04/2014	R1	1	Run 1	2	105
16/04/2014	R1	1	Run 1	3	105
16/04/2014	R1	1	Run 1	4	100
16/04/2014	R1	1	Run 1	5	101

Date	Site	Transect		Quadrat	Total cover (%)
16/04/2014	R1	2	Run 2	1	105
16/04/2014	R1	2	Run 2	2	102
16/04/2014	R1	2	Run 2	3	120
16/04/2014	R1	2	Run 2	4	110
16/04/2014	R1	2	Run 2	5	106
16/04/2014	R1	4	Riffle 2	1	100
16/04/2014	R1	4	Riffle 2	2	105
16/04/2014	R1	4	Riffle 2	3	110
16/04/2014	R1	4	Riffle 2	4	105
16/04/2014	R1	4	Riffle 2	5	100
16/04/2014	R1	3	Riffle 1	1	100
16/04/2014	R1	3	Riffle 1	2	100
16/04/2014	R1	3	Riffle 1	3	160
16/04/2014	R1	3	Riffle 1	4	101
16/04/2014	R1	3	Riffle 1	5	105
April 3rd Sampling	Average				107.05
	STdev				13.38

Visual assessment cover values by periphyton classes

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
5/03/2014	R2	1	1												
5/03/2014	R2	1	2		60				1			1			
5/03/2014	R2	1	3		80						20				
5/03/2014	R2	1	4		100										
5/03/2014	R2	1	5		30	60									
5/03/2014	R2	2	1		100	1									
5/03/2014	R2	2	2		100	1									
5/03/2014	R2	2	3		100	1			1						
5/03/2014	R2	2	4		100	1									
5/03/2014	R2	2	5		70										
5/03/2014	R2	3	1		100										
5/03/2014	R2	3	2			100									
5/03/2014	R2	3	3		100										
5/03/2014	R2	3	4		80					20					
5/03/2014	R2	3	5		40										
5/03/2014	R2	4	1		100										
5/03/2014	R2	4	2		90	1			10						
5/03/2014	R2	4	3		100				15						
5/03/2014	R2	4	4		90										
5/03/2014	R2	4	5		50										
March 1st Sampling	R2	Mean			82.78	23.57			6.75	20.00	20.00	1.00			
		STEDev			23.21	40.24			6.95						
6/03/2014	C2	3	1		70										
6/03/2014	C2	3	2		80										
6/03/2014	C2	3	3		100										
6/03/2014	C2	3	4		100										
6/03/2014	C2	3	5												
6/03/2014	C2	4	1		100										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
6/03/2014	C2	4	2		80							1			
6/03/2014	C2	4	3		100										
6/03/2014	C2	4	4		100									1	
6/03/2014	C2	4	5		95										
6/03/2014	C2	1	1		100							1			
6/03/2014	C2	1	2		100										
6/03/2014	C2	1	3		100							1			
6/03/2014	C2	1	4		100										
6/03/2014	C2	1	5		100									1	
6/03/2014	C2	2	1		100									1	
6/03/2014	C2	2	2		100				1						
6/03/2014	C2	2	3		100							40			
6/03/2014	C2	2	4		50									50	
6/03/2014	C2	2	5		100										
March 1st Sampling	C2	Mean			93.42				1.00			10.75			
		STEDev			13.75										
5/03/2014	R1	1	1		100										
5/03/2014	R1	1	2		100										
5/03/2014	R1	1	3		50										
5/03/2014	R1	1	4		65	1						1			
5/03/2014	R1	1	5		10										
5/03/2014	R1	2	1		100										
5/03/2014	R1	2	2		100										
5/03/2014	R1	2	3		100										
5/03/2014	R1	2	4		100										
5/03/2014	R1	2	5		100		1	1							
5/03/2014	R1	3	1		80			5							
5/03/2014	R1	3	2		95		5								
5/03/2014	R1	3	3		100										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
5/03/2014	R1	3	4		70	30	1								
5/03/2014	R1	3	5		10										
5/03/2014	R1	4	1		20										
5/03/2014	R1	4	2		70			30				1			
5/03/2014	R1	4	3		40			30	30			1			
5/03/2014	R1	4	4		50	20		30							
5/03/2014	R1	4	5		100										
March 1st Sampling	R1	Mean			73.00	17.00	2.33	19.20	30.00			1.00			
		STEDev			32.50	14.73	2.31	14.86				0.00			
5/03/2014	R3	1	1	50			1								
5/03/2014	R3	1	2	100											
5/03/2014	R3	1	3	50	100										
5/03/2014	R3	1	4		70	40			1						
5/03/2014	R3	1	5												
5/03/2014	R3	2	1		100										
5/03/2014	R3	2	2		100			1	1						
5/03/2014	R3	2	3		100										
5/03/2014	R3	2	4		80			1	1						
5/03/2014	R3	2	5		80										
5/03/2014	R3	3	1												
5/03/2014	R3	3	2	45.5	46			20	80						
5/03/2014	R3	3	3	38	40			50	50		1			1	
5/03/2014	R3	3	4	33	38			50	50						
5/03/2014	R3	3	5	12	13.5				96					1	
5/03/2014	R3	4	1		100										
5/03/2014	R3	4	2		100		1								
5/03/2014	R3	4	3	1	100										
5/03/2014	R3	4	4	10	90						1				
5/03/2014	R3	4	5	1	100						1				

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
March 1st Sampling	R3	Mean		34.05	78.59	40.00	1.00	24.40	39.86		1.00			1.00	
		STEDev		30.29	28.65		0.00	24.62						0.00	
6/03/2014	C1	3	1												
6/03/2014	C1	3	2												
6/03/2014	C1	3	3												
6/03/2014	C1	3	4												
6/03/2014	C1	3	5												
6/03/2014	C1	4	1		50										
6/03/2014	C1	4	2		100				5						
6/03/2014	C1	4	3		100				20						
6/03/2014	C1	4	4		100	1									
6/03/2014	C1	4	5	1	100	1	1								
6/03/2014	C1	1	1		80										
6/03/2014	C1	1	2		100										
6/03/2014	C1	1	3		85	15									
6/03/2014	C1	1	4		20	30		50							
6/03/2014	C1	1	5		100										
6/03/2014	C1	2	1		100										
6/03/2014	C1	2	2		100										
6/03/2014	C1	2	3		100	1									
6/03/2014	C1	2	4		100									1	
6/03/2014	C1	2	5		100		1								
March 1st Sampling	C1	Mean		1.00	89.00	9.60	1.00	50.00	12.50					1.00	
		STEDev			23.47		0.00								
13/03/2014	C2	1	1	20	80		1								
13/03/2014	C2	1	2	10	100		1		1					1	
13/03/2014	C2	1	3		100										
13/03/2014	C2	1	4		100									1	
13/03/2014	C2	1	5		100										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
13/03/2014	C2	2	1		100	1								1	
13/03/2014	C2	2	2		20	80									
13/03/2014	C2	2	3		100										
13/03/2014	C2	2	4		100										
13/03/2014	C2	2	5		100										
13/03/2014	C2	3	1	20	60										
13/03/2014	C2	3	2		100										
13/03/2014	C2	3	3		100									1	
13/03/2014	C2	3	4		60										
13/03/2014	C2	3	5		90										
13/03/2014	C2	4	1		100									1	
13/03/2014	C2	4	2		80										
13/03/2014	C2	4	3		80										
13/03/2014	C2	4	4		100										
13/03/2014	C2	4	5		80	1								80	
March 2nd Sampling	C2	Mean		16.67	87.50	27.33	1.00		1.00					14.17	
		STEDev		5.77	20.74	45.61	0.00							32.25	
13/03/2014	C1	1	1		100										
13/03/2014	C1	1	2		100										
13/03/2014	C1	1	3		80										
13/03/2014	C1	1	4		80										
13/03/2014	C1	1	5		100										
13/03/2014	C1	2	1		90										
13/03/2014	C1	2	2		90										
13/03/2014	C1	2	3		90										
13/03/2014	C1	2	4		100	1									
13/03/2014	C1	2	5		90										
13/03/2014	C1	3	1	1	100	1									
13/03/2014	C1	3	2		100	20									

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
13/03/2014	C1	3	3		100	1									
13/03/2014	C1	3	4		100	1									
13/03/2014	C1	3	5		90	1									
13/03/2014	C1	4	1		100	1									
13/03/2014	C1	4	2	40	60										
13/03/2014	C1	4	3		60	40	20								
13/03/2014	C1	4	4		100	1									
13/03/2014	C1	4	5		100	1			1						
March 2nd Sampling	C1	Mean		20.50	91.50	6.80	20.00		1.00						
		STEDev		27.58	12.68	13.10	#DIV/0!								
13/03/2014	R3	1	1	20	80					1					
13/03/2014	R3	1	2		50	30				20					
13/03/2014	R3	1	3	10	90	1									
13/03/2014	R3	1	4		100	1				1					
13/03/2014	R3	1	5		100					1					
13/03/2014	R3	2	1		100									1	
13/03/2014	R3	2	2	1	100	1								1	
13/03/2014	R3	2	3		60		40			1					
13/03/2014	R3	2	4	100			1								
13/03/2014	R3	2	5	1	100										
13/03/2014	R3	3	1		100										
13/03/2014	R3	3	2		100										
13/03/2014	R3	3	3	1	95	5									
13/03/2014	R3	3	4		100					1				1	
13/03/2014	R3	3	5		100										
13/03/2014	R3	4	1	60	80										
13/03/2014	R3	4	2		90	1									
13/03/2014	R3	4	3		90										
13/03/2014	R3	4	4		100	1								1	

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
13/03/2014	R3	4	5		90										
March 2nd Sampling	R3	Mean		27.57	90.79	5.71	20.50								
		STEDev		38.26	14.36	10.81	27.58								
13/03/2014	R1	1	1		100										
13/03/2014	R1	1	2		100	1									
13/03/2014	R1	1	3		100										
13/03/2014	R1	1	4		100										
13/03/2014	R1	1	5		100										
13/03/2014	R1	2	1		100										
13/03/2014	R1	2	2	1	100		1								
13/03/2014	R1	2	3	1	100	1	1								
13/03/2014	R1	2	4	20	80	1	1								
13/03/2014	R1	2	5		100										
13/03/2014	R1	3	1	20	80		1								
13/03/2014	R1	3	2	1	100		1								
13/03/2014	R1	3	3	1	100		1								
13/03/2014	R1	3	4		100	1									
13/03/2014	R1	3	5		100										
13/03/2014	R1	4	1		100										
13/03/2014	R1	4	2	1	100	1	1								
13/03/2014	R1	4	3		100	1									
13/03/2014	R1	4	4		60	40									
13/03/2014	R1	4	5		100	1									
March 2nd Sampling	R1	Mean		6.43	96.00	5.88	1.00								
		STEDev		9.27	10.46	13.79	0.00								
13/03/2014	R2	1	1		100		1								
13/03/2014	R2	1	2	1	100	1	1								
13/03/2014	R2	1	3	20	60	20									
13/03/2014	R2	1	4		50	50									

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
13/03/2014	R2	1	5		100	1									
13/03/2014	R2	2	1	1	100										
13/03/2014	R2	2	2		100	20									
13/03/2014	R2	2	3	1	100	1									
13/03/2014	R2	2	4	60	100										
13/03/2014	R2	2	5		100	1									
13/03/2014	R2	3	1		100										
13/03/2014	R2	3	2		100	1									
13/03/2014	R2	3	3	1	100	1									
13/03/2014	R2	3	4		100										
13/03/2014	R2	3	5		100										
13/03/2014	R2	4	1		100										
13/03/2014	R2	4	2	1	100										
13/03/2014	R2	4	3	1	100		1								
13/03/2014	R2	4	4		100										
13/03/2014	R2	4	5	1	80										
March 2nd Sampling	R2	Mean		9.67	94.50	10.67	1.00								
		STEDev		19.89	14.32	16.89	0.00								
20/03/2014	C2	1	1		0										
20/03/2014	C2	1	2		80										
20/03/2014	C2	1	3		80										
20/03/2014	C2	1	4		90										
20/03/2014	C2	1	5		80										
20/03/2014	C2	2	1		40	60									
20/03/2014	C2	2	2		80										
20/03/2014	C2	2	3		30										
20/03/2014	C2	2	4		60										
20/03/2014	C2	2	5	1	90									1	
20/03/2014	C2	3	1		70										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
20/03/2014	C2	3	2		100	1									
20/03/2014	C2	3	3		90	1									
20/03/2014	C2	3	4		90										
20/03/2014	C2	3	5		100	1									
20/03/2014	C2	4	1		50										
20/03/2014	C2	4	2		70										
20/03/2014	C2	4	3		90										
20/03/2014	C2	4	4		80										
20/03/2014	C2	4	5		90	1									
20/03/2014	C2	4	1		80										
March 3rd Sampling	C2	Mean		1.00	77.00	12.80								1.00	
		STEDev			18.95	26.39									
20/03/2014	C1	4	2		50	50									
20/03/2014	C1	4	3		80	20									
20/03/2014	C1	4	4		50	50									
20/03/2014	C1	4	5	1	80	20									
20/03/2014	C1	3	1		90	10									
20/03/2014	C1	3	2		60	40									
20/03/2014	C1	3	3		60	40									
20/03/2014	C1	3	4		50	50									
20/03/2014	C1	3	5	50	40										
20/03/2014	C1	2	1		80										
20/03/2014	C1	2	2		70	30									
20/03/2014	C1	2	3		100	1									
20/03/2014	C1	2	4		80	20									
20/03/2014	C1	2	5		100	1									
20/03/2014	C1	1	1		100										
20/03/2014	C1	1	2		100	1									
20/03/2014	C1	1	3		100							1			

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
20/03/2014	C1	1	4		100	1									
20/03/2014	C1	1	5		100	1									
March 3rd Sampling	C1	Mean		25.50	75.45	22.59						1.00			
		STEDev		34.65	24.51	19.04									
20/03/2014	R1	4	1		100	1						1			
20/03/2014	R1	4	2		80	1						1			
20/03/2014	R1	4	3		100	1						20			
20/03/2014	R1	4	4		100	1						1			
20/03/2014	R1	4	5		60	40									
20/03/2014	R1	3	1	1	100							1			
20/03/2014	R1	3	2	20	80	1									
20/03/2014	R1	3	3		100	1	1								
20/03/2014	R1	3	4		100	1									
20/03/2014	R1	3	5		100										
20/03/2014	R1	2	1		100										
20/03/2014	R1	2	2		100										
20/03/2014	R1	2	3	20	80		1								
20/03/2014	R1	2	4		100										
20/03/2014	R1	2	5		100										
20/03/2014	R1	1	1		100							1			
20/03/2014	R1	1	2		100	1									
20/03/2014	R1	1	3		100	1									
20/03/2014	R1	1	4		100										
20/03/2014	R1	1	5		100	1							1		
March 3rd Sampling	R1	Mean		13.67	95.00	4.55	1.00					4.17	1.00		
		STEDev		10.97	11.00	11.76	0.00					7.76			
20/03/2014	R2	4	1		100										
20/03/2014	R2	4	2		70	30									
20/03/2014	R2	4	3	40	60	1									

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
20/03/2014	R2	4	4		100										
20/03/2014	R2	4	5		100										
20/03/2014	R2	2	1		100	1		1				1			
20/03/2014	R2	2	2	1	100							1			
20/03/2014	R2	2	3	1	100							1			
20/03/2014	R2	2	4		100										
20/03/2014	R2	2	5	1	100										
20/03/2014	R2	1	1		100										
20/03/2014	R2	1	2		100	1									
20/03/2014	R2	1	3		100										
20/03/2014	R2	1	4		100										
20/03/2014	R2	1	5		100										
20/03/2014	R2	3	1		100	1									
20/03/2014	R2	3	2		70	30									
20/03/2014	R2	3	3	40	60	1									
20/03/2014	R2	3	4		100										
20/03/2014	R2	3	5		100										
March 3rd Sampling	R2	Mean		16.60	93.00	9.29		1.00				1.00			
		STEDev		21.36	14.55	14.15						0.00			
20/03/2014	R3	4	1		100	1									
20/03/2014	R3	4	2		100										
20/03/2014	R3	4	3		100	1									
20/03/2014	R3	4	4	1	100							1			
20/03/2014	R3	4	5		100	1									
20/03/2014	R3	3	1												
20/03/2014	R3	3	2		100										
20/03/2014	R3	3	3		100	1									
20/03/2014	R3	3	4	10	90	1									
20/03/2014	R3	3	5		80	20	1	1				1			

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
20/03/2014	R3	1	1	1	100		1								
20/03/2014	R3	1	2		100	1									
20/03/2014	R3	1	3		60	40						1			
20/03/2014	R3	1	4		80	20									
20/03/2014	R3	1	5		100	1	1	1							
20/03/2014	R3	2	1		80	20									
20/03/2014	R3	2	2	1	100										
20/03/2014	R3	2	3		100	1									
20/03/2014	R3	2	4	1	100							1			
20/03/2014	R3	2	5		100										
March 3rd Sampling	R3	Mean		2.80	94.21	9.00	1.00	1.00				1.00			
		STEDev		4.02	11.21	12.92	0.00					0.00			
27/03/2014	R3	1	1		100										
27/03/2014	R3	1	2		100										
27/03/2014	R3	1	3		100	1									
27/03/2014	R3	1	4		100	1									
27/03/2014	R3	1	5		50	50									
27/03/2014	R3	2	1		100										
27/03/2014	R3	2	2	1	100	1									
27/03/2014	R3	2	3		100										
27/03/2014	R3	2	4		100										
27/03/2014	R3	2	5	1	100	1									
27/03/2014	R3	3	1												
27/03/2014	R3	3	2		100										
27/03/2014	R3	3	3	1	100	1									
27/03/2014	R3	3	4		100										
27/03/2014	R3	3	5		100										
27/03/2014	R3	4	1		100										
27/03/2014	R3	4	2		100										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
27/03/2014	R3	4	3		90	10									
27/03/2014	R3	4	4		100										
27/03/2014	R3	4	5	1	100										
March 4th Sampling	R3	Mean		1.00	96.84	9.29									
		STEDev		0.00	11.57	18.26									
27/03/2014	R2	2	1	1	100										
27/03/2014	R2	2	2	1	100										
27/03/2014	R2	2	3	1	100	1									
27/03/2014	R2	2	4		100										
27/03/2014	R2	2	5		100										
27/03/2014	R2	1	1	10	90										
27/03/2014	R2	1	2		100	1									
27/03/2014	R2	1	3		100	1									
27/03/2014	R2	1	4		100										
27/03/2014	R2	1	5		90										
27/03/2014	R2	3	1		100										
27/03/2014	R2	3	2		60	40									
27/03/2014	R2	3	3	30	40	30									
27/03/2014	R2	3	4	30	40	30									
27/03/2014	R2	3	5		100										
27/03/2014	R2	4	1	1	100										
27/03/2014	R2	4	2	1	100	1		1						1	
27/03/2014	R2	4	3	10	90	1									
27/03/2014	R2	4	4	1	80	20									
27/03/2014	R2	4	5		100	1									
March 4th Sampling	R2	Mean		8.60	89.50	12.60		1.00						1.00	
		STEDev		11.86	19.59	15.70									
27/03/2014	R1	4	1		100	1	1								
27/03/2014	R1	4	2	1	100										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
27/03/2014	R1	4	3	1	100	1	1								
27/03/2014	R1	4	4	1	100	1									
27/03/2014	R1	4	5	1	100		1								
27/03/2014	R1	3	1		100	1	1								
27/03/2014	R1	3	2	1	100		1								
27/03/2014	R1	3	3		100	1	1								
27/03/2014	R1	3	4		100		1							1	
27/03/2014	R1	3	5		100										
27/03/2014	R1	2	1		100										
27/03/2014	R1	2	2		100		1								
27/03/2014	R1	2	3		100		1								
27/03/2014	R1	2	4		100										
27/03/2014	R1	2	5		100										
27/03/2014	R1	1	1	1	100		1								
27/03/2014	R1	1	2	1	100										
27/03/2014	R1	1	3		100										
27/03/2014	R1	1	4	1	80										
27/03/2014	R1	1	5	1	100	1									
March 4th Sampling	R1	Mean		1.00	99.00	1.00	1.00							1.00	
		STEDev		0.00	4.47	0.00	0.00								
27/03/2014	C1	2	1	1	100									1	
27/03/2014	C1	2	2	10	90										
27/03/2014	C1	2	3	1	100	1									
27/03/2014	C1	2	4		100	1									
27/03/2014	C1	2	5		100	1									
27/03/2014	C1	1	1		100										
27/03/2014	C1	1	2		100										
27/03/2014	C1	1	3		100										
27/03/2014	C1	1	4		100	1	1								

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
27/03/2014	C1	1	5		100	1									
27/03/2014	C1	3	1		100	1									
27/03/2014	C1	3	2	1	100	1									
27/03/2014	C1	3	3		100	1	1	1							
27/03/2014	C1	3	4		100										
27/03/2014	C1	3	5		100									1	
27/03/2014	C1	4	1		100	1									
27/03/2014	C1	4	2		100										
27/03/2014	C1	4	3	1	100	1	1	1							
27/03/2014	C1	4	4		100	1									
27/03/2014	C1	4	5		100	1									
March 4th Sampling	C1	Mean		2.80	99.50	1.00	1.00	1.00						1.00	
		STEDev		4.02	2.24	0.00	0.00	0.00						0.00	
27/03/2014	C2	1	1	1	90									10	
27/03/2014	C2	1	2	1	100		1								
27/03/2014	C2	1	3		60										
27/03/2014	C2	1	4		50									1	
27/03/2014	C2	1	5		100										
27/03/2014	C2	2	1		80									1	
27/03/2014	C2	2	2		90										
27/03/2014	C2	2	3		70										
27/03/2014	C2	2	4		60	1									
27/03/2014	C2	2	5	1	70			1							
27/03/2014	C2	3	1		70										
27/03/2014	C2	3	2		60									1	
27/03/2014	C2	3	3		70										
27/03/2014	C2	3	4		70										
27/03/2014	C2	3	5		80										
27/03/2014	C2	4	1		80										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
27/03/2014	C2	4	2		60										
27/03/2014	C2	4	3		70	1									
27/03/2014	C2	4	4		100										
27/03/2014	C2	4	5		70		30								
March 4th Sampling	C2	Mean		1.00	75.00	1.00	15.50	1.00						3.25	
		STEDev		0.00	14.69	0.00	20.51							4.50	
3/04/2014	R3	1	1	1	100										
3/04/2014	R3	1	2		100										
3/04/2014	R3	1	3		90	10									
3/04/2014	R3	1	4		80	20									
3/04/2014	R3	1	5		100	1									
3/04/2014	R3	2	1		100										
3/04/2014	R3	2	2		100										
3/04/2014	R3	2	3		100										
3/04/2014	R3	2	4		100	1									
3/04/2014	R3	1	5		100	1									
3/04/2014	R3	1	1												
3/04/2014	R3	1	2		100	1	1								
3/04/2014	R3	1	3		100	1	1								
3/04/2014	R3	1	4		100	1									
3/04/2014	R3	1	5		100										
3/04/2014	R3	2	1		80										
3/04/2014	R3	2	2		80										
3/04/2014	R3	2	3		90	1	1								
3/04/2014	R3	2	4		90	1									
3/04/2014	R3	2	5		80	20									
April 1st Sampling	R3	Mean		1.00	94.21	5.27	1.00								
		STEDev			8.38	7.76	0.00								
3/04/2014	R2	3	1	1	100	1									

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
3/04/2014	R2	3	2		60	40	1								
3/04/2014	R2	3	3		50	50	1								
3/04/2014	R2	3	4	1	60	40	1								
3/04/2014	R2	3	5		70	1	1	30						1	
3/04/2014	R2	4	1	100											
3/04/2014	R2	4	2	20	80										
3/04/2014	R2	4	3		100	1									
3/04/2014	R2	4	4	1	70	30									
3/04/2014	R2	4	5	1	100										
3/04/2014	R2	1	1		100										
3/04/2014	R2	1	2		80	20									
3/04/2014	R2	1	3		100										
3/04/2014	R2	1	4		100										
3/04/2014	R2	1	5		100										
3/04/2014	R2	2	1		100	1									
3/04/2014	R2	2	2		100										
3/04/2014	R2	2	3		100										
3/04/2014	R2	2	4		90										
3/04/2014	R2	2	5		100										
April 1st Sampling	R2	Mean		20.67	87.37	20.44	1.00	30.00							
		STEDev		39.60	17.27	20.13	0.00								
3/04/2014	R1	2	1		100									1	
3/04/2014	R1	2	2		100									1	
3/04/2014	R1	2	3		100									1	
3/04/2014	R1	2	4	1	100										
3/04/2014	R1	2	5		100									1	
3/04/2014	R1	1	1												
3/04/2014	R1	1	2		100	1	1							1	
3/04/2014	R1	1	3		100										

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
3/04/2014	R1	1	4		100										
3/04/2014	R1	1	5		100	1									
3/04/2014	R1	3	1		100		1							1	
3/04/2014	R1	3	2		100									1	
3/04/2014	R1	3	3		100	1									
3/04/2014	R1	3	4	1	100	1	1							1	
3/04/2014	R1	3	5		100		1							1	
3/04/2014	R1	4	1		100										
3/04/2014	R1	4	2		100									1	
3/04/2014	R1	4	3		100	1								1	
3/04/2014	R1	4	4		70	30								1	
3/04/2014	R1	4	5		100										
April 1st Sampling	R1	Mean		1.00	98.42	5.83	1.00							1.00	
		STEDev		0.00	6.88	11.84	0.00							0.00	
3/04/2014	C2	4	1		100										
3/04/2014	C2	4	2		100										
3/04/2014	C2	4	3		100	1									
3/04/2014	C2	4	4		100										
3/04/2014	C2	4	5		100	1									
3/04/2014	C2	3	1	1	80	20									
3/04/2014	C2	3	2		100	1									
3/04/2014	C2	3	3		100	1									
3/04/2014	C2	3	4		90										
3/04/2014	C2	3	5		100										
3/04/2014	C2	2	1		100			1						1	
3/04/2014	C2	2	2		30	70									
3/04/2014	C2	2	3		100									1	
3/04/2014	C2	2	4		90										
3/04/2014	C2	2	5		100									1	

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
3/04/2014	C2	1	1		50	50								1	
3/04/2014	C2	1	2		80									20	
3/04/2014	C2	1	3	1	90										
3/04/2014	C2	1	4		100								1	1	
3/04/2014	C2	1	5	80	20										
April 1st Sampling	C2	Mean		27.33	86.50	20.57		1.00					1.00	4.17	
		STEDev		45.61	24.34	28.41								7.76	
3/04/2014	C1	1	1		90										
3/04/2014	C1	1	2												
3/04/2014	C1	1	3		90										
3/04/2014	C1	1	4		100										
3/04/2014	C1	1	5		100	1									
3/04/2014	C1	2	1		100										
3/04/2014	C1	2	2		100	1									
3/04/2014	C1	2	3		100	1	1								
3/04/2014	C1	2	4		100		1							1	
3/04/2014	C1	2	5		100										
3/04/2014	C1	3	1		90	1			1						
3/04/2014	C1	3	2		90										
3/04/2014	C1	3	3	1	100	1									
3/04/2014	C1	3	4		100	1	60								
3/04/2014	C1	3	5		100										
3/04/2014	C1	4	1		100	1									
3/04/2014	C1	4	2		100		1							1	
3/04/2014	C1	4	3	1	100		1								
3/04/2014	C1	4	4		100										
3/04/2014	C1	4	5		20				80						
April 1st Sampling	C1	Mean		1.00	93.68	1.00	12.80		40.50					1.00	
		STEDev		0.00	18.32	0.00	26.39		55.86					0.00	

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
10/04/2014	C2	2	1		90									10	
10/04/2014	C2	2	2		100	1								1	
10/04/2014	C2	2	3		100									1	
10/04/2014	C2	2	4		100									1	
10/04/2014	C2	2	5		90									10	
10/04/2014	C2	1	1		80	20	1							5	
10/04/2014	C2	1	2		100		1							1	
10/04/2014	C2	1	3		90									1	
10/04/2014	C2	1	4		40									60	
10/04/2014	C2	1	5		100										
10/04/2014	C2		1		100										
10/04/2014	C2		2		100										
10/04/2014	C2		3		100										
10/04/2014	C2		4		95	5									
10/04/2014	C2		5		100										
10/04/2014	C2		1												
10/04/2014	C2		2		90										
10/04/2014	C2		3		100										
10/04/2014	C2		4		100										
10/04/2014	C2		5		20									80	
April 2nd Sampling	C2	Mean			89.21	8.67	1.00							17.00	
		STEDev			21.87	10.02	0.00							28.56	
10/04/2014	C1	1	1		100										
10/04/2014	C1	1	2		100			1						1	
10/04/2014	C1	1	3		100										
10/04/2014	C1	1	4		60	1		1							
10/04/2014	C1	1	5		100										
10/04/2014	C1	2	1		80										
10/04/2014	C1	2	2		100	1		1							

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
10/04/2014	C1	2	3		100	1		1							
10/04/2014	C1	2	4		100	1		1						1	
10/04/2014	C1	2	5		50	50									
10/04/2014	C1	3	1		100	1	1	1							
10/04/2014	C1	3	2		80	20									
10/04/2014	C1	3	3		100	1		1						1	
10/04/2014	C1	3	4		100									1	
10/04/2014	C1	3	5		100	1		1							
10/04/2014	C1	4	1		60	40									
10/04/2014	C1	4	2		100	1								40	
10/04/2014	C1	4	3		70		1		30						
10/04/2014	C1	4	4		100	1			1						
10/04/2014	C1	4	5		20				80						
April 2nd Sampling	C1	Mean			86.00	9.92	1.00	1.00	37.00					8.80	
		STEDev			22.80	17.40	0.00	0.00	39.96					17.44	
10/04/2014	R1	1	1		100									1	
10/04/2014	R1	1	2		100	1								1	
10/04/2014	R1	1	3		100										
10/04/2014	R1	1	4		70										
10/04/2014	R1	1	5		100	1	1							1	
10/04/2014	R1	2	1		100									1	
10/04/2014	R1	2	2		100									1	
10/04/2014	R1	2	3		80	20								1	
10/04/2014	R1	2	4		100									1	
10/04/2014	R1	2	5		100									1	
10/04/2014	R1	4	1		100	1			1						
10/04/2014	R1	4	2		100	1								1	
10/04/2014	R1	4	3		100									1	
10/04/2014	R1	4	4		100				1					1	

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
10/04/2014	R1	4	5		100										
10/04/2014	R1	3	1	20	80									1	
10/04/2014	R1	3	2		100			1						1	
10/04/2014	R1	3	3		100									1	
10/04/2014	R1	3	4		100	1								1	
10/04/2014	R1	3	5		100										
April 2nd Sampling	R1	Mean		20.00	96.50	4.17	1.00	1.00	1.00					1.00	
		STEDev			8.75	7.76			0.00					0.00	
10/04/2014	R2	2	1		100									1	
10/04/2014	R2	2	2		100	1									
10/04/2014	R2	2	3		100	1								1	
10/04/2014	R2	2	4		100	1									
10/04/2014	R2	2	5		100									1	
10/04/2014	R2	1	1		100										
10/04/2014	R2	1	2		100	1									
10/04/2014	R2	1	3		50	50									
10/04/2014	R2	1	4		40	60									
10/04/2014	R2	1	5		100										
10/04/2014	R2	3	1		100										
10/04/2014	R2	3	2		100									1	
10/04/2014	R2	3	3		100										
10/04/2014	R2	3	4		100										
10/04/2014	R2	3	5		100										
10/04/2014	R2	4	1		100									1	
10/04/2014	R2	4	2		100									1	
10/04/2014	R2	4	3	1	100									1	
10/04/2014	R2	4	4		100									1	
10/04/2014	R2	4	5		100										
April 2nd Sampling	R2	Mean		1.00	94.50	19.00								1.00	

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
		STEDev			17.01	28.06								0.00	
10/04/2014	R3	2	1	1	100									1	
10/04/2014	R3	2	2		100									1	
10/04/2014	R3	2	3	1	100										
10/04/2014	R3	2	4	1	100	1									
10/04/2014	R3	2	5		100									1	
10/04/2014	R3	1	1		80		20								
10/04/2014	R3	1	2		100	1								1	
10/04/2014	R3	1	3	10	90									1	
10/04/2014	R3	1	4		100		1							1	
10/04/2014	R3	1	5		100									1	
10/04/2014	R3	4	1		100									1	
10/04/2014	R3	4	2		100			1							
10/04/2014	R3	4	3		100									1	
10/04/2014	R3	4	4		100	1									
10/04/2014	R3	4	5		100										
10/04/2014	R3	3	1												
10/04/2014	R3	3	2		100										
10/04/2014	R3	3	3	1	100	1								1	
10/04/2014	R3	3	4	1	100	1								1	
10/04/2014	R3	3	5	1	100	1								1	
April 2nd Sampling	R3	Mean		2.29	98.42	1.00	10.50	1.00						1.00	
		STEDev			5.01	0.00	13.44							0.00	
16/04/2014	R3	4	1		100	1								1	
16/04/2014	R3	4	2		100	5									
16/04/2014	R3	4	3		100				70	5					
16/04/2014	R3	4	4		100				60	5					
16/04/2014	R3	4	5		100				80	5					
16/04/2014	R3	3	1												

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
16/04/2014	R3	3	2		100										
16/04/2014	R3	3	3		100	1	20	60							
16/04/2014	R3	3	4	40	60										
16/04/2014	R3	3	5		100		1								
16/04/2014	R3	2	1		90	10									
16/04/2014	R3	2	2		100			60							
16/04/2014	R3	2	3		100			80							
16/04/2014	R3	2	4		80		20								
16/04/2014	R3	2	5	40	60		1								
16/04/2014	R3	1	1												
16/04/2014	R3	1	2												
16/04/2014	R3	1	3												
16/04/2014	R3	1	4												
16/04/2014	R3	1	5												
April 3rd Sampling	R3	Mean		40.00	92.14	4.25	10.50	66.67	70.00	5.00				1.00	
		STEDev		0.00	14.77	4.27	10.97	11.55	10.00	0.00					
16/04/2014	R2	2	1		95	5			40						
16/04/2014	R2	2	2		90	1			1						
16/04/2014	R2	2	3		100	1			80						
16/04/2014	R2	2	4		100				80					1	
16/04/2014	R2	2	5						60					1	
16/04/2014	R2	1	1		90	10	1								
16/04/2014	R2	1	2		30	10	1	60							
16/04/2014	R2	1	3		60	1	1	40							
16/04/2014	R2	1	4		70	30									
16/04/2014	R2	1	5		90	10									
16/04/2014	R2	3	1		100	20			1	1					
16/04/2014	R2	3	2		100									1	
16/04/2014	R2	3	3		60			40						1	

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
16/04/2014	R2	3	4		80			20							
16/04/2014	R2	3	5		100										
16/04/2014	R2	4	1		100									1	
16/04/2014	R2	4	2		100									1	
16/04/2014	R2	4	3		100	1									
16/04/2014	R2	4	4		100									1	
16/04/2014	R2	4	5		100		10							1	
April 3rd Sampling	R2	Mean			87.63	8.90	3.25	40.00	43.67	1.00				1.00	
		STEDev			19.46	9.64	4.50	16.33	36.23					0.00	
16/04/2014	C2	1	1		100	1								1	
16/04/2014	C2	1	2		100									1	
16/04/2014	C2	1	3		80	20									
16/04/2014	C2	1	4		100			50							
16/04/2014	C2	1	5		80				20					1	
16/04/2014	C2	2	1		40	60	1								
16/04/2014	C2	2	2		95		5							1	
16/04/2014	C2	2	3		70	15	5		10					1	
16/04/2014	C2	2	4		100	1								1	
16/04/2014	C2	2	5		90	10								1	
16/04/2014	C2	3	1		100			1						1	
16/04/2014	C2	3	2		80	20									
16/04/2014	C2	3	3		100									1	
16/04/2014	C2	3	4		90	10									
16/04/2014	C2	3	5		100									1	
16/04/2014	C2	4	1	1	100										
16/04/2014	C2	4	2		100									5	
16/04/2014	C2	4	3		80			20							
16/04/2014	C2	4	4		100									1	
16/04/2014	C2	4	5		10	10								80	

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
April 3rd Sampling	C2	Mean			85.75	16.33	3.67	23.67	15.00					7.38	
		STEDev			23.36	17.77	2.31	24.70	7.07					21.85	
16/04/2014	C1	4	1		100									1	
16/04/2014	C1	4	2		40				60						
16/04/2014	C1	4	3		100	1								1	
16/04/2014	C1	4	4		40	60								1	
16/04/2014	C1	4	5		80	20			1						
16/04/2014	C1	3	1		100										
16/04/2014	C1	3	2		80	10								10	
16/04/2014	C1	3	3		80	20									
16/04/2014	C1	3	4		100									1	
16/04/2014	C1	3	5			1									
16/04/2014	C1	2	1		80										
16/04/2014	C1	2	2		100									1	
16/04/2014	C1	2	3		70	20		10						1	
16/04/2014	C1	2	4		80	20								1	
16/04/2014	C1	2	5		80				20						
16/04/2014	C1	1	1		100										
16/04/2014	C1	1	2		100										
16/04/2014	C1	1	3		100										
16/04/2014	C1	1	4		100										
16/04/2014	C1	1	5		100										
April 3rd Sampling	C1	Mean			85.79	19.00		10.00	27.00					2.13	
		STEDev			19.24	18.57			30.12					3.18	
16/04/2014	R1	1	1		100		1								
16/04/2014	R1	1	2		100		5								
16/04/2014	R1	1	3		95	5	5								
16/04/2014	R1	1	4		100										
16/04/2014	R1	1	5		100		1								

Date	Site	Transect	Quadrat	Thin Green mat	Thin Light Brown	Thin Black/dark brown	Medium Green	Medium light brown	Med black/dark brown	Thick Green/light brown	Thick black/dark brown	Filaments Short Green	Filaments brown reddish	Filaments Long Green	Filaments Long brown reddish
16/04/2014	R1	2	1		100									5	
16/04/2014	R1	2	2		100	1								1	
16/04/2014	R1	2	3		100									20	
16/04/2014	R1	2	4		100									10	
16/04/2014	R1	2	5		100	1								5	
16/04/2014	R1	4	1		90	10									
16/04/2014	R1	4	2		100									5	
16/04/2014	R1	4	3		100									10	
16/04/2014	R1	4	4		80		20							5	
16/04/2014	R1	4	5		60		40								
16/04/2014	R1	3	1		70	10								20	
16/04/2014	R1	3	2		80	5								15	
16/04/2014	R1	3	3		100									60	
16/04/2014	R1	3	4		100									1	
16/04/2014	R1	3	5		100									5	
April 3rd Sampling	R1	Mean			93.75	5.33	12.00							12.46	
		STEDev			11.80	4.03	15.41							15.63	

Appendix 3: Velocity data

Individual, visual plot velocity measurement data at each sampling date.

Date	Site R1	Site R2	Site R3	Site C1	Site C2
5/03/2014	0.99	0.77	0.31	0.94	0.14
5/03/2014	0.31	0.99	1.94	1.36	0.37
5/03/2014	0.48	1.08	1.04	0.70	0.56
5/03/2014	0.28	0.40	0.44	1.36	0.73
5/03/2014	0.44	0.00	0.00	0.20	0.87
5/03/2014	0.20	0.20	0.54	0.00	0.24
5/03/2014	0.31	0.77	1.17	0.56	0.50
5/03/2014	0.77	0.73	0.89	0.77	0.61
5/03/2014	0.31	0.52	0.63	0.83	0.56
5/03/2014	0.00	0.14	0.31	0.44	0.58
5/03/2014	0.40	0.31	0.00	0.20	0.54
5/03/2014	0.74	0.70	0.31	0.42	0.66
5/03/2014	0.69	0.31	0.63	0.42	0.56
5/03/2014	0.96	0.40	0.99	0.59	0.48
5/03/2014	0.28	0.20	0.54	0.31	0.40
5/03/2014	0.77	0.44	0.54	0.31	0.52
5/03/2014	0.00	0.63	0.37	0.31	0.64
5/03/2014	1.04	0.44	0.70	0.20	0.48
5/03/2014	1.25	0.31	0.54	0.52	0.24
5/03/2014	0.00	0.31	0.40	0.34	0.14
13/03/2014	0.20	0.67	0.00	0.00	0.31
13/03/2014	0.28	0.89	0.94	0.14	0.44
13/03/2014	0.44	1.43	1.25	0.20	0.31
13/03/2014	0.31	0.70	0.77	0.42	0.24
13/03/2014	0.14	0.28	0.31	0.24	0.14
13/03/2014	0.46	0.31	0.31	0.28	0.28
13/03/2014	0.40	1.40	0.59	0.20	0.42
13/03/2014	0.31	0.89	0.77	0.24	0.24
13/03/2014	0.31	0.70	0.59	0.56	0.31
13/03/2014	0.14	0.00	0.31	0.31	0.54
13/03/2014	0.44	0.31	0.31	0.14	0.44
13/03/2014	0.54	0.44	0.20	0.56	0.77
13/03/2014	0.63	0.31	0.31	0.77	0.77
13/03/2014	0.63	0.31	0.34	0.54	0.20
13/03/2014	0.31	0.20	0.20	0.28	1.08
13/03/2014	0.20	0.40	0.37	0.48	0.54
13/03/2014	0.40	0.31	0.31	0.84	0.70
13/03/2014	0.89	0.31	0.24	1.04	0.54
13/03/2014	1.17	0.20	0.40	1.33	0.59

Date	Site R1	Site R2	Site R3	Site C1	Site C2
13/03/2014	0.70	0.20	0.14	0.31	0.70
20/03/2014	0.54	0.99	0.44	0.99	0.00
20/03/2014	0.54	1.17	0.44	0.99	0.20
20/03/2014	0.44	0.99	0.44	1.17	0.54
20/03/2014	0.63	0.31	0.63	0.77	0.63
20/03/2014	0.77	0.31	0.20	0.77	0.44
20/03/2014	0.31	0.44	0.00	0.99	0.58
20/03/2014	0.31	0.77	0.31	0.99	0.83
20/03/2014	0.70	0.31	0.44	0.89	0.54
20/03/2014	0.89	0.31	0.44	0.77	0.70
20/03/2014	0.44	0.20	0.44	0.00	0.37
20/03/2014	0.31	0.44	0.44	0.31	1.08
20/03/2014	0.44	0.54	0.44	0.63	0.70
20/03/2014	0.77	0.44	1.47	0.44	0.89
20/03/2014	0.31	0.44	1.33	0.63	0.83
20/03/2014	0.24	0.00	0.63	0.20	0.44
20/03/2014	0.54	0.99	1.25	0.31	0.31
20/03/2014	0.44	1.17	1.17	0.44	0.44
20/03/2014	0.31	0.99	0.89	0.44	0.89
20/03/2014	0.20	0.31	0.77	0.00	0.63
20/03/2014	0.44	0.31	0.44	0.69	0.89
20/03/2014	0.51	0.67	0.76	0.35	0.31
27/03/2014	0.20	0.31	1.17	0.20	0.44
27/03/2014	0.77	0.37	0.77	0.44	0.54
27/03/2014	0.63	0.44	0.83	0.59	0.44
27/03/2014	0.63	0.24	0.31	0.54	0.00
27/03/2014	0.44	0.20	0.00	0.20	0.00
27/03/2014	0.44	0.31	0.44	0.14	0.31
27/03/2014	0.31	0.31	0.99	0.31	0.00
27/03/2014	0.63	0.44	0.77	0.31	0.31
27/03/2014	0.44	0.20	0.44	0.31	0.63
27/03/2014	0.20	0.31	0.44	0.00	0.31
27/03/2014	0.14	0.24	0.00	0.00	0.31
27/03/2014	0.63	0.89	0.00	0.44	0.70
27/03/2014	0.20	0.63	0.63	0.89	0.70
27/03/2014	0.14	0.31	0.44	0.54	0.44
27/03/2014	0.20	0.20	0.20	0.31	1.40
27/03/2014	0.44	0.31	0.31	0.44	0.44
27/03/2014	0.46	1.08	0.63	0.54	0.54
27/03/2014	0.48	1.17	0.31	1.25	0.44
27/03/2014	0.00	0.77	0.31	0.99	0.54
27/03/2014	0.24	0.44	0.00	0.63	0.89
3/04/2014	0.31	0.63	0.31	0.00	0.31
3/04/2014	0.44	0.44	0.89	0.14	0.44
3/04/2014	0.44	1.08	0.77	0.31	0.63
3/04/2014	0.31	0.63	0.63	0.31	0.63
3/04/2014	0.31	0.31	0.20	0.14	0.77

Date	Site R1	Site R2	Site R3	Site C1	Site C2
3/04/2014	0.44	0.54	0.44	0.00	0.31
3/04/2014	0.44	0.63	0.89	0.31	0.99
3/04/2014	0.31	0.77	0.63	0.54	0.70
3/04/2014	0.20	0.63	0.63	0.44	0.44
3/04/2014	0.44	0.00	0.31	0.31	1.17
3/04/2014	0.31	0.31	0.00	0.00	0.40
3/04/2014	0.44	0.31	0.31	0.54	0.63
3/04/2014	0.44	0.31	0.63	0.89	0.44
3/04/2014	0.63	0.20	0.44	0.63	0.20
3/04/2014	0.63	0.00	0.20	0.20	0.44
3/04/2014	0.20	0.31	0.31	0.44	0.31
3/04/2014	0.20	0.31	0.44	0.63	0.44
3/04/2014	0.77	0.00	0.31	0.89	0.31
3/04/2014	0.89	0.44	0.44	1.08	0.00
3/04/2014	0.99	0.00	0.24	0.77	0.00
10/04/2014	0.31	0.44	1.25	0.31	0.44
10/04/2014	0.44	1.17	1.17	0.20	0.77
10/04/2014	0.31	1.08	0.77	0.44	0.44
10/04/2014	0.00	0.44	0.77	0.31	0.24
10/04/2014	0.44	0.31	0.44	0.00	0.44
10/04/2014	0.31	0.20	0.63	0.00	0.31
10/04/2014	0.31	0.54	1.33	0.44	0.44
10/04/2014	0.63	0.99	1.53	0.44	0.44
10/04/2014	0.00	0.31	1.33	0.54	0.31
10/04/2014	0.00	0.20	0.63	0.44	0.44
10/04/2014	0.54	0.00	0.31	0.31	0.31
10/04/2014	0.31	0.24	0.44	0.77	0.63
10/04/2014	0.63	0.44	0.44	1.08	0.99
10/04/2014	0.77	0.00	0.63	0.77	0.44
10/04/2014	0.77	0.00	0.99	0.00	1.08
10/04/2014	0.63	0.44	0.00	0.63	0.00
10/04/2014	0.44	0.44	0.44	0.77	0.31
10/04/2014	0.63	0.44	0.44	1.40	0.94
10/04/2014	0.89	0.31	0.44	1.17	0.77
10/04/2014	0.44	0.00	0.00	1.17	0.99
16/04/2014	0.00	0.44	0.31	0.00	0.44
16/04/2014	0.44	1.08	0.44	1.08	0.63
16/04/2014	0.44	1.08	0.44	0.89	0.63
16/04/2014	0.44	0.63	0.44	1.33	0.63
16/04/2014	0.20	0.00	0.00	0.99	0.44
16/04/2014	0.44	0.31	0.00	0.31	0.63
16/04/2014	0.44	0.63	0.44	0.89	0.44
16/04/2014	0.77	0.99	0.54	1.08	0.44
16/04/2014	0.44	0.44	0.31	1.47	0.00
16/04/2014	0.54	0.44	0.00	0.44	0.00
16/04/2014	0.44	0.00	0.00	0.00	0.44
16/04/2014	0.63	0.44	0.00	0.44	0.63

Date	Site R1	Site R2	Site R3	Site C1	Site C2
16/04/2014	0.99	0.63	1.40	0.63	0.99
16/04/2014	0.99	0.44	0.99	0.77	0.63
16/04/2014	1.08	0.44	0.20	0.63	1.17
16/04/2014	0.31	0.44	0.00	0.20	0.63
16/04/2014	0.44	0.63	0.00	0.44	0.63
16/04/2014	0.77	0.00	0.00	0.44	0.89
16/04/2014	0.63	0.63	0.00	0.44	0.63
16/04/2014	0.31	0.31	0.00	0.00	0.99

Appendix 4: Periphyton laboratory sample data – chlorophyll-a, AFDM and taxa data

Date	Site	Sample	Chlorophyll *a* (mg per m^2)	AFDM (g per m^2)	Autotrophic Index (AFDM in mg/m^2 : chlorophyll *a* in mg/m^2)
5 March 2014	**Site R1**	**a**	14.8	4.1	278.2
		b	11.6	2.3	197.7
		c	8.4	1.1	128.3
		d	2.6	0.6	232.6
		e	1.4	0.6	448.6
	Site R2	**a**	6.4	1.2	190.3
		b	75.7	9.7	128.5
		c	284.8	21.7	76.1
		d	37.1	6.9	185.4
		e	3.8	0.8	214.7
	Site R3	**a**	7.6	8.8	1157.2
		b	24.5	4.9	198.6
		c	19.1	5.6	294.0
		d	78.6	18.5	235.8
		e	14.2	3.0	208.9
	Control 1	**a**	1.3	0.9	697.8
		b	8.8	3.2	360.4
		c	10.1	2.9	288.5
		d	35.8	9.2	256.5
		e	11.4	3.4	301.6
	Control 2	**a**	5.3	1.9	355.3
		b	187.7	22.1	117.6
		c	4.6	1.1	247.2
		d	5.7	1.8	307.5
		e	1.9	2.0	1011.9

Date	Site	Sample	Chlorophyll *a* (mg per m^2)	AFDM (g per m^2)	Autotrophic Index (AFDM in mg/m^2 : chlorophyll *a* in mg/m^2)
20 March 2014	**Site R1**	**Pooled x10**	31.9	3.6	112.2
	Site R2	**Pooled x10**	22.9	5.6	244.1
	Site R3	**Pooled x10**	12.5	3.7	296.4
	Control 1	**Pooled x10**	26.7	5.7	211.4
	Control 2	**Pooled x10**	32.3	3.4	103.9

Date	Site	Sample	Chlorophyll *a* (mg per m^2)	AFDM (g per m^2)	Autotrophic Index (AFDM in mg/m^2 : chlorophyll *a* in mg/m^2)
3 April 2014	Site R1	a	45.9	6.8	147.2
		b	40.8	7.0	170.3
		c	73.6	13.3	180.7
		d	18.1	2.6	145.5
		e	159.0	18.8	118.0
	Site R2	a	83.0	12.6	152.1
		b	72.7	10.3	141.0
		c	161.4	12.7	78.7
		d	164.6	12.6	76.6
		e	70.4	16.6	235.8
	Site R3	a	33.9	3.2	94.7
		b	7.7	1.4	174.5
		c	70.0	7.7	109.9
		d	9.8	3.0	310.9
		e	31.9	5.5	171.3
	Control 1	a	50.9	7.7	151.2
		b	42.7	13.8	324.0
		c	136.6	11.1	81.5
		d	133.1	14.6	110.1
		e	12.7	1.6	127.8
	Control 2	a	67.3	29.0	431.1
		b	41.0	4.9	120.1
		c	90.9	16.2	178.2
		d	38.3	5.9	155.1
		e	35.9	4.6	126.9

Date	Site	Sample	Chlorophyll *a* (mg per m^2)	AFDM (g per m^2)	Autotrophic Index (AFDM in mg/m^2 : chlorophyll *a* in mg/m^2)
16 April 2014	Site R1	Pooled x10	47.9	7.5	157.0
	Site R2	Pooled x10	31.3	2.9	93.5
	Site R3	Pooled x10	36.3	8.2	225.8
	Control 1	Pooled x10	71.1	9.1	128.3
	Control 2	Pooled x10	26.3	8.2	313.0

	Site R1					Site R2					Site R3					Control 1					Control 2				
5-Mar-14	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**
Filamentous green algae																									
Microspora						1							2						1						
Mougeotia						2					3				1			2							
Stigeoclonium								5	2			2	1	2	2						2			1	
Filamentous red algae																									
Audouinella			2																						
Cyanobacteria																									
Microcoleus (?)								6																	
Oscillatoria/Phormidium		1	1				1	3			1	2				1	4					2			
Rivularia			2	1	1		2	2	3													4	2		
Filamentous diatoms																									
Melosira	2	3				3	3	4	3	2	3	3	4	6	4			3	3	3	2				
Tabellaria																	2								
Diatoms																									
Achnanthidium								4	2	1			2	5	2				3	5		1			
Cocconeis																			1						
Cymbella			1				1	3	2	1	2			2	1		1	1	5	2	1				2
Frustulia											1														1
Gomphoneis							1	3	2			1		3	1	1									
Gomphonema														2								2			
Naviculoid diatoms	1					1	1					1					1	1							
Nitzschia											1														
Rhoicosphenia								2	3																
Synedra		1						3			1		1	3	3	1		1	3	2					

	Site R1					Site R2					Site R3					Control 1					Control 2				
3-Apr-14	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**
Filamentous green algae																									
Cladophora																							5		
Mougeotia	4			3					2	2															
Stigeoclonium	2	3																				3			5
Ulothrix			3								2														
Cyanobacteria																									
Oscillatoria/Phormidium	3	1						2	4				3					5	4			1			
Placoma																					2	4	3	2	
Rivularia						4	5																		
Filamentous diatoms																									
Fragilaria		3																			2				
Melosira	4	4	5	3	3	4		2	4	3	4	3	3	1	3	5	3	3	5		5		3		
Diatoms																									
Achnanthidium	4	3	7		6	3	3		2	2				3		4	3		3		2		3		
Cocconeis	2	1	3		2						1		1			2	1							1	
Cymbella	3	3	3		7	3	2		2	2	1		2	2		4	4	4	2	2	3		2	1	
Frustulia				2								1				2									
Gomphoneis	5	5	4	3	4	5	6	2	4	3	2	2	3		2	6	7	4	6	1	7	3	3		1
Gomphonema								2																	
Naviculoid diatoms			2	2	1	2	2									1	1		3				1	1	
Nitzschia		3	3	1	2	2		2	2		1		1			2	1	1	2		2		2		
Synedra	4	3	3	3	3	3	2	2	3	3	2	1	1	1	1	4	3	3	5	2	4		3		2

Appendix 5: Aquatic macroinvertebrate data

March (05/03/2014) Sample event data

05/03/2014 Macroinvertebrate samples	Site C1	Site C1	Site C1	Site C1	Site C1	Site C2	Site C2	Site C2	Site C2	Site C2
Replicate	a	b	C	d	e	a	b	c	d	e
OLIGOCHAETA					1			1	3	
Elmidae	95	68	54	62	27	133	128	36	75	72
Hydraenidae								2	1	
Ostracoda	2		1				1			
Paracalliope									2	
Aphrophila	15	12	8	8	3	5	6	3	9	2
Austrosimulium						1		1	1	
Chironomus	1									
Eriopterini	2					3			1	1
Maoridiamesa						1		1		
Orthocladiinae	2	12	7	3	9	1		1	11	
Podonominae										
Tabanidae					1					
Tanypodinae										
Tanytarsini	2	6	2	11	6				15	
Acanthophlebia									2	
Ameletopsis					1					
Austroclima										
Coloburiscus	7	8	3	3	1	1	2	11	11	1
Deleatidium	96	148	99	118	62	121	135	158	303	165
Ichthybotus										
Nesameletus					2	1	1	1	1	
Archicauliodes	6	7	7	4	1	2	2	1	17	5
Potamopyrgus	1	8	2	1	1		1	2	25	11
Austroperla		1						1		

05/03/2014 Macroinvertebrate samples	Site C1	Site C1	Site C1	Site C1	Site C1	Site C2	Site C2	Site C2	Site C2	Site C2
Stenoperla										1
Zelandoperla	1	6		3	1	7	3	2	7	6
Aoteapsyche	68	73	27	34	23	20	6	13	57	20
Beraeoptera	5	3	5	14	2	1		1	4	
Costachorema	2	1	2	1						
Helicopsyche	2			1	1			2	3	1
Hudsonema										
Hydrobiosis	3	4	7	5			2	1	7	3
Neurochorema								1	3	3
Olinga	4	6		1	7			4	3	4
Oxyethira										
Plectrocnemia								1		
Psilochorema		1	1	1	1		2	2	2	2
Pycnocentria		2	1	3					2	3
Pycnocentrodes	8	2	5	14	14			2	8	2

05/03/2014 Macroinvertebrate samples	Site R1	Site R1	Site R1	Site R1	Site R1	Site R2	Site R2	Site R2	Site R2	Site R2
Replicate	a	b	c	d	e	a	b	c	d	e
OLIGOCHAETA										3
Elmidae	97	76	65	43	35	61	55	35	19	42
Hydraenidae	1				1		1			
Ostracoda										1
Paracalliope										
Aphrophila	2	2	4	1	2	5	4	2		1
Austrosimulium							1			3
Chironomus										
Eriopterini	1		1	1		4	1			
Maoridiamesa	5	1	7	1					2	

05/03/2014 Macroinvertebrate samples	Site R1	Site R1	Site R1	Site R1	Site R1	Site R2	Site R2	Site R2	Site R2	Site R2
Orthocladiinae	15	19	9		1	4	9	11	21	12
Podonominae										
Tabanidae										
Tanypodinae						1	3	1		5
Tanytarsini	14	77	7	1	1	1	12	10	18	76
Acanthophlebia										
Ameletopsis										
Austroclima								1		3
Coloburiscus					1		2	12		8
Deleatidium	113	100	98	50	133	261	212	166	72	68
Ichthybotus						1				
Nesameletus		1	1							2
Archicauliodes	5		1	1	4		4	3		13
Potamopyrgus	16	3			2	2				48
Austroperla						1				
Stenoperla										
Zelandoperla		1						3	2	1
Aoteapsyche	34	3	12	7	20	8	39	42	1	116
Beraeoptera	3	2	3		10	1		1		
Costachorema	2	3		1						
Helicopsyche					2		4			2
Hudsonema						2				
Hydrobiosis	1	6	5	2	1	1	10	4	6	7
Neurochorema	1	2	1	2	1	1			1	9
Olinga	3	2			1	14	13	9	4	14
Oxyethira		1		1				1		1
Plectrocnemia	1									
Psilochorema	3	3	1			7	3	1	2	
Pycnocentria			3		1		3			

05/03/2014 Macroinvertebrate samples	Site R1	Site R1	Site R1	Site R1	Site R1	Site R2	Site R2	Site R2	Site R2	Site R2
Pycnocentrodes	6	10	2	3	21	5	6	5	4	12

05/03/2014 Macroinvertebrate samples	Site R3	Site R3	Site R3	Site R3	Site R3
Replicate	a	b	c	d	e
OLIGOCHAETA					1
Elmidae	46	102	2	15	12
Hydraenidae				1	
Ostracoda					
Paracalliope					
Aphrophila	3	12		8	2
Austrosimulium				2	
Chironomus					
Eriopterini	1	1			
Maoridiamesa		8	1	36	4
Orthocladiinae	7	16		26	10
Podonominae				1	
Tabanidae	3				
Tanypodinae	1				1
Tanytarsini	116	75		45	88
Acanthophlebia					
Ameletopsis					
Austroclima					
Coloburiscus	5			13	1
Deleatidium	29	90		64	25
Ichthybotus					
Nesameletus	2	1			
Archicauliodes	3	4		1	
Potamopyrgus	9	20		10	

05/03/2014 Macroinvertebrate samples	Site R3	Site R3	Site R3	Site R3	Site R3
Austroperla					
Stenoperla					
Zelandoperla		1		4	
Aoteapsyche	26	30	1	41	1
Beraeoptera	3	1		1	1
Costachorema	1	2		6	
Helicopsyche	8	4			
Hudsonema					
Hydrobiosis	10	34		11	7
Neurochorema	3	8		4	2
Olinga	13	9		1	4
Oxyethira					
Plectrocnemia					
Psilochorema	3	4			
Pycnocentria					
Pycnocentrodes	32	13			14

April (12/04/2014) Sample event data

Site	Site C1	Site C1	Site C1	Site C1	Site C1	Site C2	Site C2	Site C2	Site C2	Site C2
Replication	a	b	c	d	e	a	b	c	d	e
OLIGOCHAETA		2	2			1	1			
Hydra										
Elmidae	15	34	16	79	47	34	45	46	82	46
Hydraenidae	2									
Ptilodactylidae										
COLLEMBOLA		1								
Aphrophila	3	9	12	8	5	24	17	11	5	2
Austrosimulium	1	1	1	1	1	1	3	1		
Chironomus										
Empididae			1					1		
Eriopterini			2		2					
Maoridiamesa	8	53	15	15		7	5	44	5	5
Mischoderus										1
Orthocladiinae	44	34	23	24	21	95	13	81	19	8
Pelecorhyncidae										
Tanypodinae					1					
Tanytarsini	37	24	29	19	13	57	5	51	9	
Ameletopsis										
Austroclima		2	3	1		2	5	1		
Coloburiscus	10	30	18	23	2	21	31	14	3	
Deleatidium	57	68	37	33	95	83	106	88	14	19
Neozephlebia								1		
Nesameletus	1									
Archicauliodes	7	9	6	8	7	22	11	7	4	5
Physa										
Potamopyrgus	1	3			1	10	11	1		
NEMERTEA										
Austroperla										

Site	Site C1	Site C1	Site C1	Site C1	Site C1	Site C2	Site C2	Site C2	Site C2	Site C2
Spaniocerca	1									
Zelandiobius										
Zelandoperla	4	10	17	9		4	5		4	1
Aoteapsyche	17	245	59	51	17	154	97	39	4	9
Beraeoptera	19	28	29	30	23	10	3		1	
Costachorema			3	1		2	1	7		2
Helicopsyche	1	2	1		1	20				
Hydrobiosis	6	8	6	6	2	11	6	5	3	3
Neurochorema	2	1	1	1	3	1	1	2		
Olinga	5	6	4	4	9	10	5	3	2	1
Oxyethira				1						
Psilochorema				1	4		1			1
Pycnocentria	2	1	1	1	2					
Pycnocentrodes	27	34	20	17	37	34	23	8	1	3

Site	Site R1	Site R1	Site R1	Site R1	Site R2	Site R2	Site R2	Site R2	Site R2
Replication	a	b	c	d	a	b	c	d	e
OLIGOCHAETA	1			1	3	1			
Hydra					1	1			
Elmidae	70	51	76	139	36	23	42	18	60
Hydraenidae	1						2		
Ptilodactylidae									
COLLEMBOLA				1					
Aphrophila	11	2	11	9	1		2	2	3
Austrosimulium		3	1		1				2
Chironomus									
Empididae									
Eriopterini	4								
Maoridiamesa	15	16	19	21	2	9	10	2	12
Mischoderus									

Site	Site R1	Site R1	Site R1	Site R1	Site R2	Site R2	Site R2	Site R2	Site R2
Orthocladiinae	21	36	37	36	14	23	22	17	38
Pelecorhyncidae									
Tanypodinae						1			
Tanytarsini	45	60	82	40	19	48	17	20	34
Ameletopsis				1					
Austroclima									
Coloburiscus		11	14	3	13	1	1	3	14
Deleatidium	4	131	36	69	124	103	78	88	37
Neozephlebia									
Nesameletus									
Archicauliodes	5	3	4	11	13	3	4	3	8
Physa									
Potamopyrgus	14	15	19	31			4	1	19
NEMERTEA									
Austroperla		1		1					
Spaniocerca									
Zelandiobius								1	1
Zelandoperla			1	1			1		5
Aoteapsyche	59	36	46	41	51	30	37	5	130
Beraeoptera	9	5	12	7			3		1
Costachorema	1	2	2	5		1	2		5
Helicopsyche	2	1	3	12					1
Hydrobiosis	11	8	9	6	10	7	2	1	13
Neurochorema	3	3	8	9	4	3	2		6
Olinga	23	14	5	10	4	10	11	5	22
Oxyethira						1			
Psilochorema	3	5	3	7	3	1			1
Pycnocentria				1		2			
Pycnocentrodes	36	74	34	39	23	15	1	8	10

Site	Site R3	Site R3	Site R3	Site R3	Site R3
Replication	a	b	c	d	E
OLIGOCHAETA	1			2	
Hydra					
Elmidae	30	43	21	85	76
Hydraenidae					
Ptilodactylidae				1	
COLLEMBOLA					
Aphrophila		2	1	9	2
Austrosimulium	1	4		4	2
Chironomus			1	4	
Empididae				3	
Eriopterini			1	1	
Maoridiamesa	29	27	10	26	5
Mischoderus					
Orthocladiinae	77	42	45	109	26
Pelecorhyncidae		1			
Tanypodinae					
Tanytarsini	77	53	40	131	103
Ameletopsis					
Austroclima	4	1	2		2
Coloburiscus	8	1	6	3	9
Deleatidium	60	41	47	102	58
Neozephlebia					
Nesameletus					
Archicauliodes		2	3	4	4
Physa				1	
Potamopyrgus	7	11	4	6	9
NEMERTEA				1	
Austroperla	1				
Spaniocerca					

Site	Site R3	Site R3	Site R3	Site R3	Site R3
Zelandiobius					
Zelandoperla	1	4			1
Aoteapsyche	48	55	73	58	52
Beraeoptera	1	8	1	6	2
Costachorema	3	4	3	1	5
Helicopsyche		2			
Hydrobiosis	10	8	6	11	6
Neurochorema	2	7	1	11	13
Olinga	5	7	3	24	13
Oxyethira	1	3		1	7
Psilochorema	2				3
Pycnocentria		2			
Pycnocentrodes	5	39	7	47	19

Appendix 6: Factor correlations for each monitoring site

Site R1														
	Velocity	Periphyton cover	Temperature	conductivity	pH	TP	DRP	TN	Diss Ca	N/N	IN	Autotrophic	Chloro a	AFDM
5/03/2014	0.54	82.35	10		7.6	0.01	0.015	0.17	6.62	0.12	0.12	257.1	7.8	1.7
13/03/2014	0.5	100.95	13	114	7.7	0.022	0.008	0.11	5.85	0.076	0.08			
20/03/2014	0.51	100.95	16.2	114.5	7.7	0.0003	0.00005	0.15	6.2	0.02	0.02	112.2	31.9	3.6
27/03/2014	0.43	100.30	12.8	117.4	7.7	0.01	0.013	0.15	6.14	0.11	0.11			
3/04/2014	0.51	96.15	14.2	119.7	7.7	0.011	0.008	0.12	6.26	0.064	0.07	152.3	67.5	9.7
10/04/2014	0.50	99.70	14.7	118.3	7.7	0.008	0.013	0.09	6.05	0.00005	0.0001			
16/04/2014	0.60	107.05	13.5	116.8	7.7	0.014	0.013	0.1	6.3	0.057	0.07	157.0	47.9	7.5
	Velocity	*Periphyton cover*	*Temperature*	*conductivity*	*pH*	*TP*	*DRP*	*TN*	*Diss Ca*	*N/N*	*IN*	*Autotrophic*	*Chloro a*	*AFDM*
Velocity	1													
Periphyton cover	0.060892	1												
Temperature	-0.08303	0.679964295	1											
conductivity	-0.05906	-0.417954951	-0.09645	1										
pH	-0.2208	0.908361876	0.798923	#DIV/0!	1									
TP	0.124176	0.121659602	-0.44927	-0.14419	0.051205	1								
DRP	0.101932	-0.297201002	-0.72806	0.516007	-0.42768	0.379747	1							
TN	-0.27861	-0.650724345	-0.42177	-0.24462	-0.6333	-0.40162	-0.09641	1						
DC	0.421826	-0.657063355	-0.50719	0.489926	-0.77438	-0.37181	0.320282	0.589166	1					
N/N	-0.167	-0.513444436	-0.85147	-0.00386	-0.56614	0.392525	0.458319	0.613821	0.408488	1				
IN	-0.08634	-0.455990719	-0.84417	0.011154	-0.53156	0.443096	0.471168	0.552857	0.41043	0.993694	1			
Autotrophic	0.166524	-0.833348549	-0.99022	0.773791	-0.94538	0.445858	0.816071	0.504507	0.990329	0.983564	0.959234	1		
Chloro a	-0.0142	0.619871552	0.561487	0.99997	0.817271	0.29325	-0.23095	-0.82201	-0.72842	-0.47798	-0.38943	-0.62636	1	
AFDM	0.131106	0.565940108	0.391912	0.973439	0.718371	0.486078	-0.02376	-0.8699	-0.5915	-0.31697	-0.21053	-0.47544	0.978037	1

Site R2														
	Velocity	Periphyton cover	Temperature	conductivity	pH	TP	DRP	TN	Diss Ca	N/N	IN	Autotrophic	Chloro a	AFDM
5/03/2014	0.48	0.49	10.5	117	7.7	0.01	0.014	0.15	6.17	0.098	0.1	159	81.6	8.1
13/03/2014	0.64	0.53	13.5	115	7.8	0.019	0.008	0.1	5.86	0.068	0.07			
20/03/2014	0.60	0.65	17.7	115.3	7.8	0.0003	0.00005	0.14	6.01	0.013	0.01	244.1	22.9	5.6
27/03/2014	0.54	0.56	11.8	115.2	7.8	0.01	0.012	0.14	6.12	0.105	0.11			
3/04/2014	0.48	0.56	11.8	120.2	7.7	0.011	0.007	0.13	6.36	0.063	0.06	136.8	110.4	13
10/04/2014	0.52	0.61	15.2	118	8.2	0.008	0.014	0.08	6.02	0.00005	0.0001			
16/04/2014	0.59	0.66	13.4	114.3	7.8	0.011	0.012	0.07	6.33	0.039	0.04	93.5	31.3	2.9
	Velocity	*Periphyton cover*	*Temperature*	*conductivity*	*pH*	*TP*	*DRP*	*TN*	*DC*	*N/N*	*IN*	*Autotrophic*	*Chloro a*	*AFDM*
Velocity	1													
Periphyton cover	0.385095	1												
Temperature	0.552249	0.739091579	1											
conductivity	-0.78608	-0.296120383	-0.25879	1										
pH	0.026617	0.357338937	0.47076	0.090619	1									
TP	0.175451	-0.550263876	-0.57571	-0.04935	-0.15667	1								
DRP	-0.4309	-0.346002834	-0.62732	0.073414	0.309073	0.419012	1							
TN	-0.38169	-0.503609395	-0.26273	0.197939	-0.58369	-0.31884	-0.31272	1						
Diss Ca	-0.56883	0.147363528	-0.46226	0.365001	-0.38013	-0.10468	0.208541	0.015285	1					
N/N	-0.26299	-0.766517713	-0.851	-0.05985	-0.66203	0.474651	0.322611	0.554461	0.172321	1				
IN	-0.24507	-0.76009291	-0.84779	-0.09093	-0.63182	0.485898	0.352916	0.528663	0.150724	0.998621	1			
Autotrophic	0.252964	0.078816971	0.674583	-0.08093	0.190834	-0.92895	-0.77564	0.697417	-0.91897	-0.39464	-0.41367	1		
Chloro a	-0.96333	-0.79152354	-0.77328	0.940546	-0.95571	0.605615	0.332127	0.407527	0.526943	0.744411	0.708504	-0.303	1	
AFDM	-0.83724	-0.643073587	-0.46596	0.994693	-0.84732	0.27977	-0.06128	0.571894	0.306866	0.478625	0.428645	0.017589	0.920721	1

Site R3														
	Velocity	Periphyton cover	Temperature	conductivity	pH	TP	DRP	TN	Diss Ca	N/N	IN	Autotrophic	Chloro a	AFDM
5/03/2014	0.68	102.30	10.5		7.6	0.011	0.014	0.16	6.21	0.092	0.09	418.9	28.8	8.2
13/03/2014	0.52	101.40	13.5	114	7.8	0.018	0.008	0.1	6.06	0.064	0.07			
20/03/2014	0.76	96.05	17.7	115.4	7.8	0.0003	0.00005	0.14	6.03	0.013	0.02	296.4	12.5	3.7
27/03/2014	0.56	95.45	11.8	118	7.9	0.009	0.012	0.17	6.15	0.126	0.13			
3/04/2014	0.51	92.60	11.8	121.9	7.6	0.011	0.006	0.14	6.41	0.07	0.07	172.3	30.7	4.2
10/04/2014	0.84	96.30	15.2	117.7	7.8	0.008	0.012	0.09	6.13	0.00005	0.0001			
16/04/2014	0.57	92.75	13.4	102.2	7.8	0.012	0.01	0.09	6.35	0.049	0.05	225.8	36.3	8.2
	Velocity	*Periphyton cover*	*Temperature*	*conductivity*	*pH*	*TP*	*DRP*	*TN*	*Diss Ca*	*N/N*	*IN*	*Autotrophic*	*Chloro a*	*AFDM*
Velocity	1													
Periphyton cover	0.1458	1												
Temperature	0.57622	-0.192493239	1											
conductivity	0.097404	0.108213042	-0.11763	1										
pH	0.089037	-0.163932978	0.45123	-0.32878	1									
TP	-0.65484	0.324278741	-0.61393	-0.20021	-0.14678	1								
DRP	-0.0172	0.299404265	-0.69351	-0.12868	-0.04377	0.489899	1							
TN	-0.14368	0.134171278	-0.40749	0.553836	-0.21297	-0.31755	0.018713	1						
Diss Ca	-0.46721	-0.565894933	-0.55668	-0.14164	-0.53141	0.271432	0.213476	-0.01643	1					
N/N	-0.67235	0.17204254	-0.82573	0.143062	-0.06925	0.404032	0.44717	0.676035	0.242305	1				
IN	-0.68443	0.176727788	-0.78338	0.140957	-0.01923	0.390336	0.398443	0.67956	0.19083	0.996969	1			
Autotrophic	0.716884	0.97687234	-0.16014	-0.24759	-0.18703	-0.13864	0.424025	0.569615	-0.58888	0.294746	0.31008	1		
Chloro a	-0.81106	-0.231800301	-0.76343	-0.40997	-0.30037	0.972161	0.75238	-0.46741	0.895163	0.653408	0.630605	-0.27242	1	
AFDM	-0.11966	0.378750167	-0.57831	-0.90794	-0.05867	0.674167	0.90162	-0.28993	0.281787	0.553927	0.538517	0.434339	0.677788	1

Site C1														
	Velocity	Periphyton cover	Temperature	conductivity	pH	TP	DRP	TN	Diss Ca	N/N	IN	Autotrophic	Chloro a	AFDM
5/03/2014	0.57	73.10	6.8	112.8	7.6	0.01	0.014	0.15	6.24	0.101	0.1	381	13.5	3.9
13/03/2014	0.55	98.00	13	115	7.6	0.018	0.009	0.12	5.93	0.088	0.1			
20/03/2014	0.69	94.74	15.4	113.4	7.7	0.0003	0.00005	0.16	5.92	0.029	0.03	211.4	26.7	5.7
27/03/2014	0.55	101.15	13.1	116.4	7.6	0.009	0.013	0.15	6.08	0.105	0.11			
3/04/2014	0.53	96.80	15	118	7.7	0.011	0.007	0.11	6.15	0.054	0.06	158.9	75.2	9.8
10/04/2014	0.69	100.20	14.2	118.2	7.6	0.007	0.011	0.09	6.08	0.00005	0.0001			
16/04/2014	0.75	94.50	13.3	102.8	7.7	0.013	0.013	0.08	6.26	0.055	0.06	128.3	71.1	9.1

	Velocity	*Periphyton cover*	*Temperature*	*conductivity*	*pH*	*TP*	*DRP*	*TN*	*Diss Ca*	*N/N*	*IN*	*Autotrophic*	*Chloro a*	*AFDM*
Velocity	1													
Periphyton cover	0.122809	1												
Temperature	0.281717	0.877545938	1											
conductivity	-0.61819	0.255335451	0.174059	1										
pH	0.405544	0.124547454	0.518295	-0.42507	1									
TP	-0.37294	0.011277964	-0.25668	-0.18047	-0.28485	1								
DRP	-0.12463	-0.263742884	-0.62145	-0.22397	-0.55522	0.551277	1							
TN	-0.43226	-0.341775821	-0.28405	0.298808	-0.184	-0.44098	-0.32524	1						
Diss Ca	0.1124	-0.486843912	-0.50511	-0.45817	0.108774	0.223531	0.696363	-0.38348	1					
N/N	-0.66213	-0.374458756	-0.60874	-0.09081	-0.37792	0.504889	0.463251	0.457824	0.18471	1				
IN	-0.67392	-0.305136598	-0.54811	-0.08796	-0.36114	0.564166	0.440735	0.413684	0.140079	0.994765	1			
Autotrophic	-0.44615	-0.950050131	-0.86618	0.274294	-0.95252	-0.13251	0.292706	0.701191	0.120876	0.757644	0.689467	1		
Chloro a	0.101304	0.737612333	0.595726	-0.18119	0.709053	0.55889	0.089168	-0.88481	0.295053	-0.36876	-0.27095	-0.86884	1	
AFDM	0.100291	0.792650014	0.665591	-0.1293	0.76302	0.480652	-0.00552	-0.84097	0.204179	-0.44456	-0.34957	-0.89703	0.995466	1

Site C2													
	Velocity	Periphyton cover	Temperature	conductivity	pH	TP	DRP	TN	Diss Ca	N/N	IN	Autotrophic	Chloro a	AFDM
5/03/2014	0.49	93.60	10.9	113.4	7.6	0.01	0.014	0.13	5.87	0.009	0.09	407.9	41.1	5.8
13/03/2014	0.53	98.50	13.1	117	7.6	0.019	0.008	0.12	5.82	0.085	0.09			
20/03/2014	0.65	80.30	14.1	113.2	7.7	0.0003	0.00005	0.16	5.87	0.038	0.04	103.9	32.3	3.4
27/03/2014	0.56	77.50	13.6	115.3	7.4	0.03	0.013	1.52	6.07	0.109	0.11			
3/04/2014	0.56	99.15	14.7	118.6	7.6	0.011	0.009	0.12	6.2	0.068	0.07	202.3	54.7	12.1
10/04/2014	0.61	94.65	14.1	118	7.6	0.009	0.011	0.09	6.12	0.00005	0.0001			
16/04/2014	0.66	103.56	12.8	115.6	7.7	0.012	0.013	0.09	6.22	0.055	0.06	313.0	26.3	8.2

	Velocity	*Periphyton cover*	*Temperature*	*conductivity*	*pH*	*TP*	*DRP*	*TN*	*Diss Ca*	*N/N*	*IN*	*Autotrophic*	*Chloro a*	*AFDM*
Velocity	1													
Periphyton cover	-0.03655	1												
Temperature	0.486677	-0.170461014	1											
conductivity	-0.03401	0.51893125	0.570327	1										
pH	0.508738	0.488293263	-0.04	-0.1417	1									
TP	-0.41134	-0.182962285	-0.06567	0.209604	-0.85704	1								
DRP	-0.40022	0.343061481	-0.50807	0.185329	-0.4493	0.555231	1							
TN	-0.15032	-0.69631704	0.095362	-0.14655	-0.87682	0.791171	0.26883	1						
Diss Ca	0.431287	0.335952526	0.417064	0.546079	-0.04954	0.111483	0.406501	0.088825	1					
N/N	-0.11015	-0.216742878	0.276476	0.160771	-0.52784	0.749574	0.011747	0.639137	0.077439	1				
IN	-0.62077	-0.162387785	-0.41246	-0.24688	-0.54238	0.68795	0.329567	0.539783	-0.25155	0.698726	1			
Autotrophic	-0.58388	0.572713097	-0.88431	-0.12955	-0.42244	0.718484	0.932919	-0.54989	0.021814	-0.50114	0.854251	1		
Chloro a	-0.66775	0.135968624	0.283606	0.622907	-0.87061	0.263057	0.083996	0.132523	0.139047	0.213797	0.470029	-0.04647	1	
AFDM	-0.1889	0.781691777	0.358759	0.970297	-0.48837	0.750273	0.443753	-0.62653	0.847345	0.708965	0.345322	0.113177	0.629936	1

Appendix C

Bore Water Quality Summary

Table C.1: Summary of Bore Water Quality Sampling Results (October – June 2014) and River Water Quality Sampling Results (March & April 2014)

Bore		Temperature (field) (°C)	pH (field) -	pH (lab) -	Conductivity (field) mS/m	Conductivity (lab, @25°C) mS/m	Dissolved Oxygen (field) mg/L	Dissolved Oxygen (lab) g O_2/m^3	Total (NP) Organic Carbon g/m^3	Alkalinity - Total g $CaCO_3$/m^3	Total Dissolved Solids g/m^3	Bicarbonate g $CaCO_3$/m^3	Free CO2 g CO_2/m^3	Anion Sum meq/L	Cation Sum meq/L	Ion Balance %	Fluoride g/m^3
KB4	Maximum	16.2	7.8	7.7	100.5	125	0.40	2.2	0.8	270	688	268	10	11.4	11.4	7.02	0.05
	Minimum	13.9	7.5	7.6	68.3	106	0.09	0.5	<0.3	195	582	194	8	9.6	9.8	0.49	0.03
	Average	14.7	7.6	7.7	80.4	116	0.19	0.9	0.3	211	637	209	8	10.3	10.7	1.97	0.04
	Number of Samples	9	4	8	4	9	4	9	9	9	9	9	9	9	9	9	9
K4	Maximum	15.2	7.6	7.5	53.9	53.1	0.40	0.8	1.1	117	292	117	9	4.7	4.9	2.83	0.21
	Minimum	14.3	7.3	7.4	43.4	50	0.10	<0.5	<0.5	111	275	111	7	4.4	4.5	0.14	0.20
	Average	14.7	7.5	7.4	48.6	52.1	0.19	0.5	0.8	114	286	114	8	4.5	4.7	1.48	0.21
	Number of Samples	5	4	5	4	5	4	5	5	5	5	5	5	5	5	5	5
K5	Maximum	16	7.9	8	89.8	110	0.40	0.9	0.9	255	604	253	5	10.1	10.5	7.14	0.06
	Minimum	15.1	7.6	8	60.7	97	0.06	<0.5	<0.5	217	535	215	4	8.7	8.9	0.06	0.05
	Average	15.5	7.8	8.0	73.5	105	0.19	0.6	0.5	240	579	238	5	9.4	10.0	3.20	0.06
	Number of Samples	9	4	9	4	9	4	9	9	9	9	9	9	9	9	9	9
K6	Maximum	16.2	7.7	7.7	96.2	113	0.49	2.1	0.9	289	622	288	14	10.4	11.4	7.77	0.05
	Minimum	15	7.5	7.6	73.7	109	0.12	<0.5	<0.3	205	598	204	8	9.2	10.0	1.29	0.04
	Average	15.4	7.6	7.7	84.0	111	0.34	1.0	0.4	271	609	270	11	9.9	10.6	3.56	0.04
	Number of Samples	9	4	9	4	9	4	9	9	9	9	9	9	9	9	9	9
K10	Maximum	15.5	7.4	7.6	46.3	80.4	0.40	0.7	1	227	442	226	14	7.3	7.7	6.37	0.04
	Minimum	15	7.4	7.5	46.3	78.9	0.40	0.6	<0.3	219	434	218	11	6.5	7.4	1.88	0.03
	Average	15.2	7.4	7.5	46.3	79.4	0.40	0.7	0.5	223	437	222	13	7.0	7.5	3.53	0.04
	Number of Samples	5	1	5	1	5	1	5	5	5	5	5	5	5	5	5	5
River Sampling March & April 2014 (5 sites)	Maximum	17.7	8.44	8.2	12.2		8.0										
	Minimum	6.8	7.13	7.4	10.2		0.2										
	Average	13.4	7.68	7.7	11.6		3.5										
	Number of Samples	34	34	35	33		33										

Bore		Chloride g/m³	Nitrite - Nitrogen g/m³	Bromide g/m³	Nitrate - Nitrogen g/m³	Sulphate g/m³	Ammonia Nitrogen g/m³	Total Hardness g $CaCO_3/m^3$	Boron - Dissolved g/m³	Calcium - Dissolved g/m³	Iron - Dissolved g/m³	Magnesium - Dissolved g/m³	Manganese - Dissolved g/m³	Potassium - Dissolved g/m³	Sodium - Dissolved g/m³	Total Phosphorus g/m³	Dissolved Reactive Phosphorus g/m³
KB4	Maximum	288	0.02	1.05	<0.01	2.07	0.38	152	0.616	39.5	<0.003	14.5	0.072	8.78	192	0.063	0.072
	Minimum	194	<0.01	0.73	<0.01	0.77	0.04	128	0.226	32.9	<0.003	11.1	0.021	5.98	117	0.027	0.028
	Average	243	0.01	0.90	<0.01	1.55	0.10	140	0.282	35.6	<0.003	12.4	0.032	7.07	170	0.034	0.040
	Number of Samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
K4	Maximum	89	<0.01	0.30	<0.01	13.90	0.04	28	0.098	4.0	0.007	4.4	0.149	1.78	98.8	0.098	0.099
	Minimum	80	<0.01	0.27	<0.01	12.40	<0.01	25	0.086	3.6	<0.003	3.9	0.127	1.61	90.5	0.090	0.090
	Average	85	<0.01	0.29	<0.01	13.36	0.02	27	0.094	3.8	0.004	4.2	0.139	1.73	94.4	0.095	0.097
	Number of Samples	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
K5	Maximum	211	0.02	0.78	<0.01	0.58	0.34	141	0.484	31.2	0.027	16.0	0.062	9.58	178	0.124	0.129
	Minimum	168	<0.01	0.66	<0.01	0.43	0.25	105	0.379	24.3	<0.003	10.8	0.056	6.69	149	0.084	0.075
	Average	192	0.01	0.72	<0.01	0.51	0.30	124	0.435	28.3	0.011	13.0	0.058	7.78	167	0.101	0.104
	Number of Samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
K6	Maximum	225	0.02	0.86	<0.01	1.50	0.44	151	0.674	35.1	<0.003	17.3	0.084	11.30	195	0.078	0.077
	Minimum	160	<0.01	0.70	<0.01	0.27	0.07	133	0.269	30.9	<0.003	12.1	0.024	6.43	160	0.028	0.038
	Average	192	0.01	0.74	<0.01	0.64	0.35	140	0.586	32.6	<0.003	14.3	0.072	9.16	174	0.067	0.065
	Number of Samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
K10	Maximum	131	<0.01	0.51	<0.01	<0.02	0.25	173	0.170	48.3	<0.003	14.1	0.165	8.50	92.9	0.068	0.062
	Minimum	100	<0.01	0.49	<0.01	<0.02	0.22	164	0.155	45.8	<0.003	11.9	0.158	7.47	88.2	0.061	0.041
	Average	119	<0.01	0.50	<0.01	<0.02	0.23	170	0.162	47.0	<0.003	12.7	0.162	7.86	89.7	0.064	0.055
	Number of Samples	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

River Sampling March & April 2014 (5 sites)	Maximum						<0.01			6.62						0.030	0.015
	Minimum						<0.01			5.82						0.007	<0.005
	Average						<0.01			6.13						0.013	0.010
	Number of Samples						35			35						35	35

Bore		Total Nitrogen g/m3	Arsenic - Dissolved g/m3	Cadmium - Dissolved g/m3	Chromium - Dissolved g/m3	Copper - Dissolved g/m3	Lead - Dissolved g/m3	Nickel - Dissolved g/m3	Zinc - Dissolved g/m3
KB4	Maximum	0.35	0.001	0.0003	<0.001	0.0036	<0.001	0.0009	0.014
	Minimum	<0.05	<0.001	<0.0002	<0.001	0.0009	<0.0005	<0.0005	0.005
	Average	0.09	0.001	<0.0002	<0.001	0.0020	<0.0005	0.0004	0.008
	Number of Samples	9	9	9	9	9	9	9	9
K4	Maximum	0.06	<0.001	<0.0002	<0.001	0.0015	<0.0005	0.0005	0.009
	Minimum	<0.05	<0.001	<0.0002	<0.001	0.0007	<0.0005	<0.0005	0.004
	Average	<0.05	<0.001	<0.0002	<0.001	0.0011	<0.0005	0.0003	0.007
	Number of Samples	5	5	5	5	5	5	5	5
K5	Maximum	0.32	0.001	0.0003	<0.001	0.0093	0.0038	0.0007	0.019
	Minimum	0.29	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	<0.002
	Average	0.31	0.001	<0.0002	<0.001	0.0013	0.0007	0.00030	0.003
	Number of Samples	9	9	9	9	9	9	9	9
K6	Maximum	0.42	0.001	0.0003	<0.001	0.0063	<0.001	0.0025	0.013
	Minimum	<0.05	<0.001	<0.0002	<0.001	0.0010	<0.0005	<0.0005	<0.002
	Average	0.35	0.001	<0.0002	<0.001	0.0023	<0.0005	0.0008	0.008
	Number of Samples	9	9	9	9	9	9	9	9
K10	Maximum	0.26	0.001	0.0002	<0.001	0.0012	<0.001	0.0006	0.008
	Minimum	0.20	<0.001	<0.0002	<0.001	0.0005	<0.0005	<0.0005	0.005
	Average	0.24	0.001	<0.0002	<0.001	0.0009	<0.0005	<0.0005	0.006
	Number of Samples	5	5	5	5	5	5	5	5

River Sampling March & April 2014 (5 sites)	Maximum	1.52							
	Minimum	0.07							
	Average	0.16							
	Number of Samples	35							