Report

Annual Waikanae River and River Recharge Report 2015/16 (Consents WGN130103 [33760] and [33761])

Prepared for Greater Wellington Regional Council

On behalf of Kāpiti Coast District Council

Prepared by CH2M Beca Ltd

22 September 2016

Revision History

Revision Nº	Prepared By	Description	Date
1	Simon Newton, Tracy Clode	Draft for Council review	18 July 2016
2	Tracy Clode	Draft for Adaptive Management Group	1 August 2016
3	Simon Newton	Final for Council approval	15 September 2016
4	Tracy Clode	Final for Submission to Greater Wellington Regional Council	22 September 2016

Document Acceptance

Action			
Prepared by	**Simon Newton & Tracy Clode**		
Reviewed by	**Malory Osmond** **Tracy Clode** **Andrew Watson**		
Approved by	**Andrew Watson**	**Signed:**	**Date:** 22 September 2016
on behalf of	CH2M Beca Ltd		

Highlights

This 2015/16 annual report has been prepared for Kāpiti Coast District Council as part of the consenting requirements for the River Recharge with Groundwater scheme. It reports on operational aspects and monitoring undertaken in relation to the Council's water take from, and discharge of groundwater to, the Waikanae River during the year 1 July 2015 to 30 June 2016. In line with the conditions of the resource consents, the discharge of groundwater to the Waikanae River for river recharge occurred five times in this year.

The flow in the Waikanae River reached low levels in October 2015 and March/ April 2016, and the Waikanae Borefield was used to recharge the Waikanae River. The Council's take from the Waikanae River during these times of low flow, as well as throughout the rest of the year, was in general accordance with the requirements of the consent. There were some technical nuances with the automated interface between river recharge and river water abstraction which for short periods left slightly less than 750 L/s in the river (for an average of 30 minutes) when the upstream river levels dropped below 920 L/s. This was a result of the time it takes for the river flow information to get from the Greater Wellington Regional Council's flow gauge through to the Kāpiti Coast District Council's control system and to the river intake and production bore pumps. Along with the ramp up and ramp down of the abstraction pumps. During one river recharge event the 20% maximum recharge was exceeded for a short period. This instance was investigated and reviewed by Greater Wellington Regional Council who then advised that there was no adverse effects on river ecology as a result.

There was a comprehensive programme of monitoring in the Waikanae River during the months of December to April at sites upstream and downstream of the water treatment plant. The monitoring involved regular water quality measurements and assessments of the numbers and types of algae and macroinvertebrates in the river. There were two algae triggers exceeded in this period however neither are considered to be a result of river recharge.

This monitoring will continue for a further summer and the data collected over the three years will be used to develop a longer term monitoring programme and triggers with a series of actions in case of potential adverse effects from the groundwater discharge to the river. Fish surveys were not required this year as the information from last year's fish survey provided enough baseline data and alternative methods are being investigated with GWRC for monitoring migrating fish.

Some changes to the current monitoring programme have been recommended based on the observations to date. These recommended changes are generally to improve the reliability of data collected, or in some cases it has been recognised that sufficient data has been gathered and further data collection is not necessary.

The Adaptive Management Group which comprised representatives of the Council, Greater Wellington Regional Council and Te Ati Awa ki Whakarongotai met in August 2016 to discuss the report, alongside representatives of key stakeholder groups. Recommendations from the Adaptive Management Group included:

- Removal of chlorophyll-a interim triggers from consent conditions due to the time delay in receiving results making these ineffective triggers
- Continue visual periphyton sampling every two weeks for remaining 3 months of baseline monitoring.
- Removal of further fish monitoring during baseline monitoring along the river and upper tributaries to "tidy up" the consents while an alternative is agreed (if required)
- Removal of further macroinvertebrate sampling except if very high PeriWCC levels are encountered then sampling still required.

The Adaptive Management Group asks that GRWC consider the merits of the following:

- Removal of chlorophyll-a sampling for the remaining three months. And if not, that chlorophyll-a sampling be taken as a pool sample at each of the five sites at a frequency of once per month.
- Removal of further community periphyton measures in the remaining three months, noting there is one sample remaining for baseline monitoring.

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 [33760] and Condition 26 of consent WGN130103 [33761]. This is the third annual Waikanae River and River Recharge report, and covers the period from 1 July 2015 to 30 June 2016.

The maximum daily abstraction was 16,644 m^3/day on 16 December 2015. The average daily abstraction of 12,249 m^3/day for 2015/16 is slightly higher than in last year's (2014/15) annual report. This can be attributed to the continuous abstraction of water for supply from the river in the 2015/16 year while in the 2014/15 year river abstraction was not used for 29 days and water from the production bores was used solely for supply. The maximum instantaneous rate was 252 L/s on 23 March 2016.

The condition to maintain a minimum of 750 L/s in the Waikanae River, downstream of the discharge point, was generally met by Council. There were some technical nuances with the automated interface between river recharge and river water abstraction which for short periods left slightly less than 750 L/s in the river (for an average of 30 minutes) when the upstream river level dropped below 920 L/s. This is related to the time it takes for the river flow information to get from the Greater Wellington Regional Councils flow gauge through to the Council's 's control system and to the river intake and production bore pumps which can be up to 40 minutes. It is also related to the river intake and production bores pump ramp up and ramp down, which has a knock on effect on the downstream flow levels for short periods. This occurred during 6 periods of lower upstream flow.

River recharge of no more than 20% of the downstream river flow was approved by GWRC on 16 October 2015 and discharges for recharge occurred five times in 2015/16 on 14 days for a total of 226 hours. The river recharge exceeded the 20% threshold on one occasion on 20 March 2016. This occurred for a total of 51 minutes with an average exceedance of 14.7 L/s and a maximum exceedance of 21.7 L/s. GWRC investigated the exceedances and considered the effects were less than minor due to a number of factors. Although these are strictly exceedances (against the daily measured flow from GWRC), the actual flow within the river would have been compliant during the 20 March event

Baseline monitoring of the Waikanae River was carried out during the period December 2015 to April 2016 in in accordance with the certified Waikanae River Baseline Monitoring Plan (River BMP) and agreement with GWRC that fish surveys were not required in this period. The results of this monitoring are documented in Appendix B.

The baseline monitoring data collected during 2015/16 is part of a three-year programme of monitoring and adds to the data collected in March and April 2014, and the data collected in the 2014/15 monitoring period. This data includes water quality, periphyton measurements and macroinvertebrate samples.

Moderate to high algae growths were seen this year above the low-medium bed cover observed last year. This year an observable change to the calcium and therefore electrical conductivity was noted after river recharge activities. No other water quality or biotic parameter changed in an observable way as a result of recharge this year. There were two periphyton interim trigger exceedances during the monitoring period, and the Chlorophyll-a trigger was exceeded 3 times. The timing of these exceedances does not indicate a relationship with river recharge. The Weighted Composite Cover (WCC) trigger was exceeded once. The WCC sample taken following this exceedance indicates that the growth is not a direct result of river recharge.

Further river baseline monitoring will be carried out over December 2016 to February 2017 in accordance with the River BMP, following which the river baseline monitoring will be complete. Boffa Miskell has

recommended some changes for next year's river baseline monitoring programme and the AMG has evaluated and added to these recommendations. These changes are:

- Alignment of Waikanae River Lower Flow conditions with Rate of Take conditions.
- Remove chlorophyll-a triggers from Appendix 2a of consent WGN130103 [33761], as is ineffective due to reporting timeframes.
- The AMG asked that GWRC consider the merits of removing chlorophyll-a sampling for the remaining three months. And if not, that chlorophyll-a sampling be taken as pool sample at each of the five sites at a frequency of once per month.
- AMG asked that GWRC consider the merits of no further community periphyton measures in the remaining three months. There is one sample remaining for baseline monitoring.
- Remove requirement for further fish monitoring during baseline monitoring along the river and upper tributaries to "tidy up" the consents while an alternative was agreed.
- Confirm way forward to survey migratory fish (Alternative fish survey method).
- Removal of the macroinvertibrate sampling at low and medium PeriWCC levels as sufficient data has been collected to understand the communities prior to full recharge. The AMG recommended that macroinvertebrate sampling is still taken if very high PeriWCC levels are encountered (e.g. at 70%. percentage cover)

Looking ahead to the coming year (2016/17), there is no additional mitigation or adaptive management that is anticipated at this stage, other than the proposed changes to the River BMP.

As the conditions to allow 20% recharge have been approved by GWRC, river recharge may be used again next summer (2016/17) if required due to low flows in the Waikanae River. The recharge will be undertaken in accordance with the approved Bore Preference Hierarchy Plan.

Contents

1	**Introduction**	**1**
2	**Operation of River Take and River Recharge**	**5**
2.1	River Flows, Abstraction and Recharge	5
2.2	Operations Log and Maintenance Undertaken	14
2.3	Operations and Maintenance Manual	15
3	**River Monitoring**	**15**
3.1	Aquatic Monitoring	15
3.2	Bore Water Quality Monitoring	16
3.3	Changes to River Baseline Monitoring Plan	17
4	**Mitigation/Adaptive Management in the Coming Year**	**17**
5	**Recommendations of the Adaptive Management Group**	**18**

Appendices

Appendix A

Operations Log

Appendix B

Waikanae River Aquatic Baseline Monitoring Report

Appendix C

Bore and River Water Quality Summary

1 Introduction

The Kāpiti Coast District Council (Council) holds resource consents WGN130103 [33760] and [33761] 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 third annual Waikanae River and River Recharge report to Greater Wellington Regional Council (GWRC), and covers the period from 1 July 2015 through to 30 June 2016. This report is required by Condition 24 of consent WGN130103 [33760] and Condition 26 of consent WGN130103 [33761]. 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 Condition 4 of consent WGN1303103 [33761] discharge of groundwater to the Waikanae River occurred following approval by GWRC of the Bore Preference Hierarchy Plan as required by condition 16 of consent WGN130103 [33761]. In accordance with Condition 18 of consent WGN130103 [33761] river recharge of no more than 20% of the downstream river flow was approved by GWRC on 16 October 2015. River recharge will continue to be limited to 20% for the 2016/17 year.

Table 1: Requirements for Annual Waikanae River report

Condition 24 of consent WGN130103 [33760]	Section in this annual report
The consent holder shall, by 30th September each year, submit an Annual Waikanae River report to the Manager, or by another date as agreed with 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 3.1
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, Section 2.3, Section 4 and Section 5,

Condition 24 of consent WGN130103 [33760]		Section in this annual report
h)	A discussion on any mitigation/adaptive management that may be required in the coming year;	Section 4
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 [33761]. The annual Waikanae River report shall be made available to the public on the Kāpiti Coast District Council website no later than 30th September each year, or by another date as agreed with the Manager. *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).* *Note: The consent holder may request, with the Manager's approval, an extension of time to submit the annual report to the Manager and make it available to the public on the website, if the Adaptive Management Group requires more time to consider the draft annual report and provide their recommendations as required by part (g) of this condition.*		Refer www.kapiticoast.govt.nz

Table 2: Requirements for Annual River Recharge report

Condition 26 of consent WGN130103 [33761]		Section in this annual report
The consent holder shall, no later than 30th September each year that a discharge to the River occurs, submit an annual River Recharge report to the Manager, or by another date as agreed with 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
b)	Dates, times and duration of discharge	Section 2.1.3
c)	Information to demonstrate compliance with the rate of discharge specified in Condition 5	Section 2.1.3
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
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 3.1
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	Section 3.3, Section 2.3, Section 4 and Section 5

Condition 26 of consent WGN130103 [33761]		Section in this annual report
	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)	
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
The annual River Recharge report may be combined with the annual Waikanae River report required by consent WGN130103 [33760]. The annual River Recharge River report shall be made available to the public on the Kāpiti Coast District Council website by 30 September each year, or by another date as agreed with the Manager. *Note: The consent holder may request, with the Manager's approval, an extension of time to submit the annual report to the Manager and make it available to the public on the website, if the Adaptive Management Group requires more time to consider the draft annual report and provide their recommendations as required by part (g) of this condition.*		Refer www.kapiticoast.govt.nz

There are a number of plans and manuals required by the River Recharge with Groundwater (RRwGW) suite of consents and various reports have been produced from the 2015/16 monitoring. These documents are set out in the following figure (Figure 1).

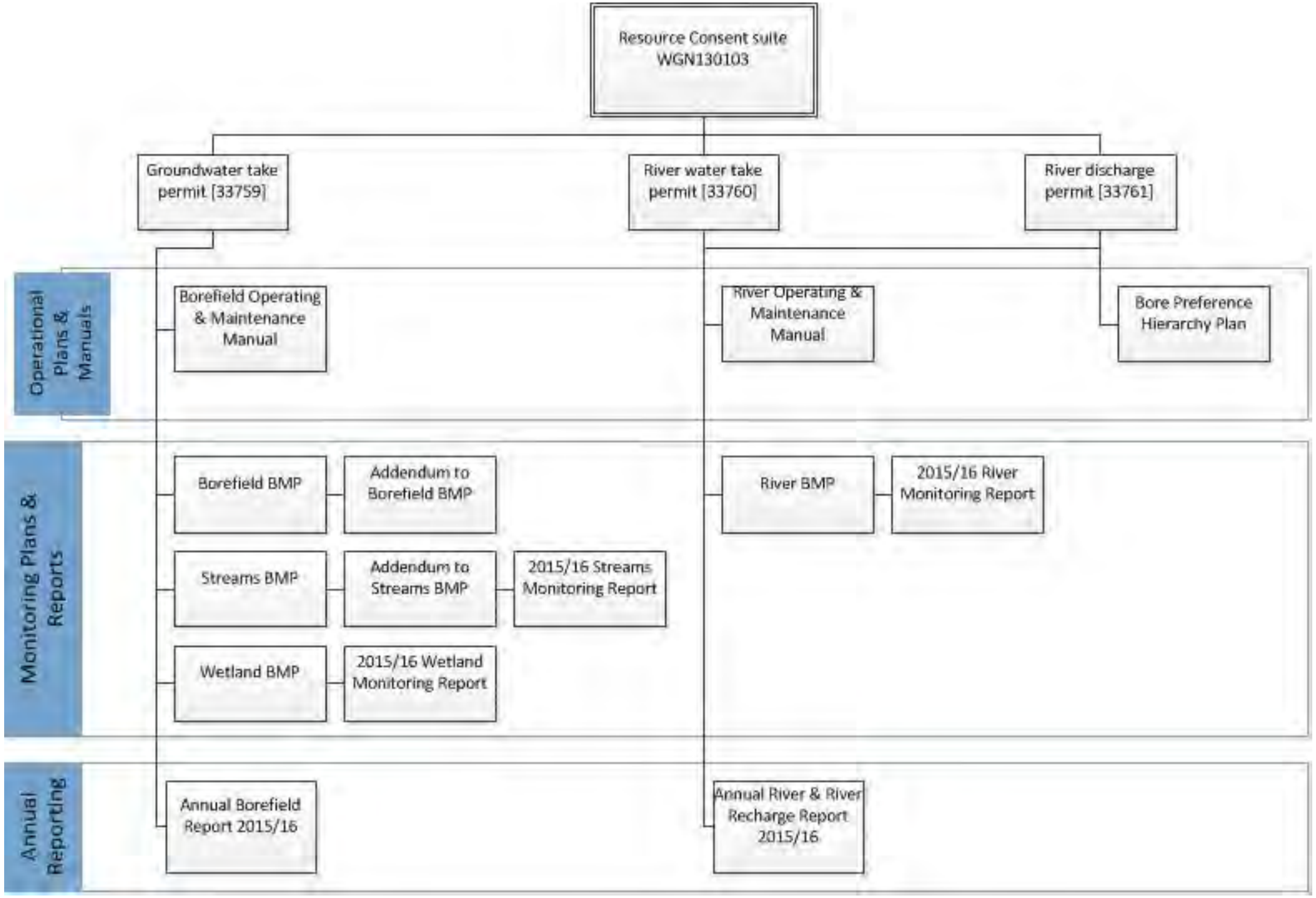


Figure 1: Key documents for RRwGW consents and 2015/16 monitoring

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 GWRC at a gauging station approximately 200 m upstream of the Waikanae Water Treatment Plant (WTP) intake. Rainfall is also measured by GWRC at this site. River flow data, recorded at 15 minute intervals, for the reporting period is presented in Figure 2 together with weekly rainfall totals.

Council's SCADA system receives river flow data from GWRC's SCADA system on an approximately 15 minute basis. The river flow data received and stored by Council is used for managing the water supply abstraction and, unlike GWRC's river flow database, this data is not back-corrected if GWRC subsequently updates the rating curve for the gauging station. GWRC gauged the river 5 times during the 2015/16 monitoring period. The gaugings occurred consistently near the end of each month from December 2015 through to April 2016. GWRC uses these gauged flows to create an updated rating curve, which can be seen as a sudden drop in the river flow as shown on Figure 2. Daily Rainfall data for the whole 2015/16 year was sourced from GWRC's Environmental Monitoring and Research website[1] .

Low rainfall through October kept river flows below 2,000 L/s until late in October. Rainfall through November and December raised flows to a peak flow of more than 100,000 L/s on 10 December. The start of the summer flow recession commenced in the first week of December and continued until a major rainfall event at the end of February. After this February rainfall event, the river's recession continued and the river's lowest level for the 2015/16 period was recorded on the 23 March 2016 with a flow of 750 L/s. 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 in October 2015 and March/ April 2016.

[1] http://graphs.gw.govt.nz/?siteName=Waikanae River at Water Treatment Plant&dataSource=Rainfall&interval=1%20Hour, sourced 1 July 2016

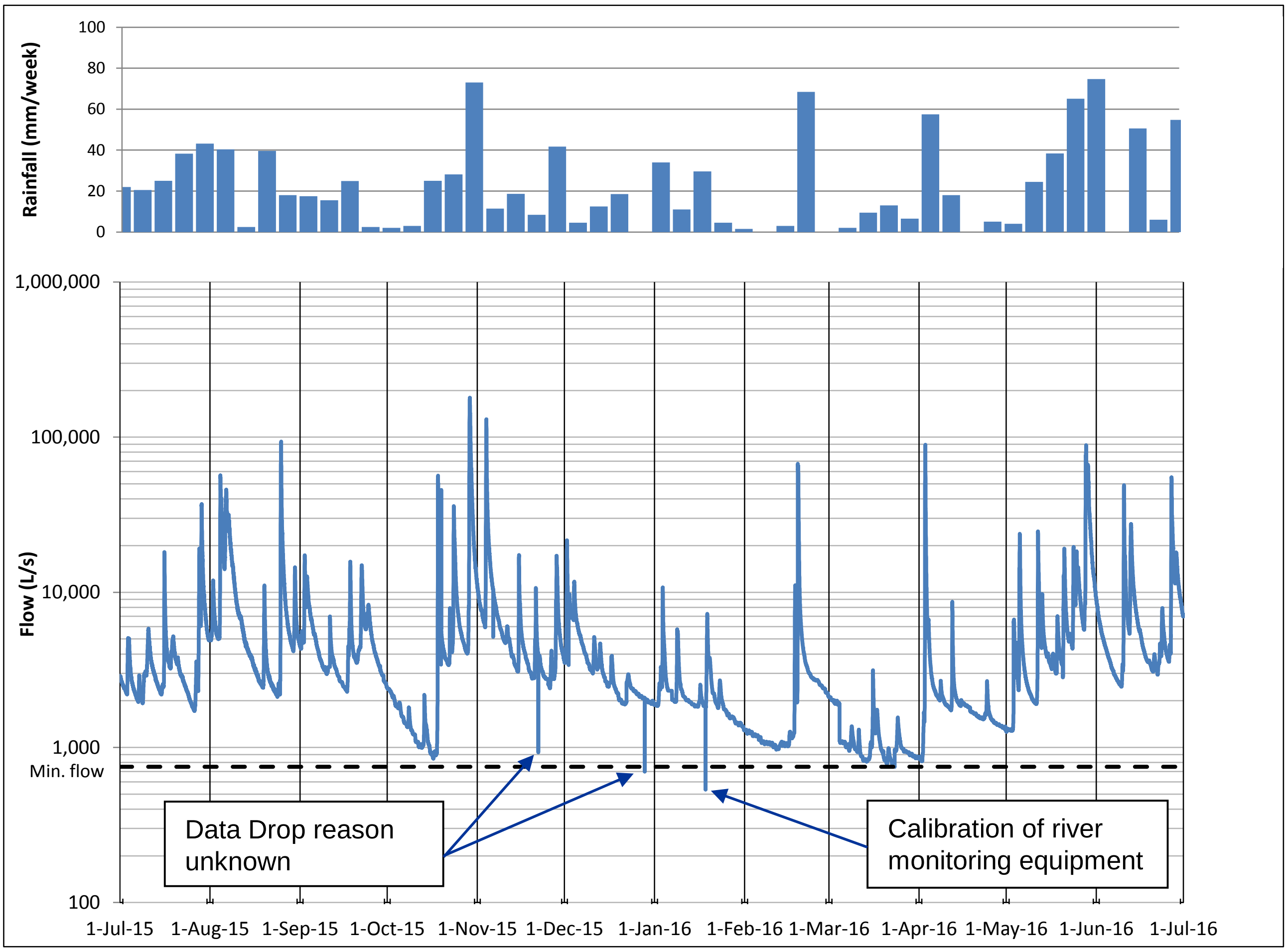


Figure 2: Waikanae River Flow and Rainfall at Water Treatment Plant (July 2015 – June 2016)

2.1.2 River Abstraction

Council measures and records the flow rates and volumes of water abstracted from the Waikanae River by way of a flow meter at the WTP intake. Council regularly submits its river abstraction records to GWRC, as per Condition 13 of consent WGN130103 [33760], automatically from Council's SCADA to GWRC's Water Use Data Management System (Hydrotel). A summary of the abstraction data is provided below.

The daily abstraction volumes for the reporting period are summarised in Figure 3. The maximum daily abstraction was 16,644 m^3/day on 16 December 2015. This is less than the maximum allowable daily volume of 30,700 m^3/day specified by Condition 5 of consent WGN130103 [33760]. The maximum daily abstraction volume for 2015/16 is less than the volume reported in last year's (2014/15) annual report.

The total volume abstracted in the period 1 July 2015 to 30 June 2016 was 4,459,341 m^3. This is equivalent to an average daily abstraction of 12,249 m^3/day. The average daily abstraction volume for 2015/16 is slightly higher than in last years (2014/15) annual report. This can be attributed to the continuous abstraction of water for supply from the river in the 2015/16 year while in the 2014/15 year river abstraction was not used for 29 days and water from the production bores was used solely for supply.

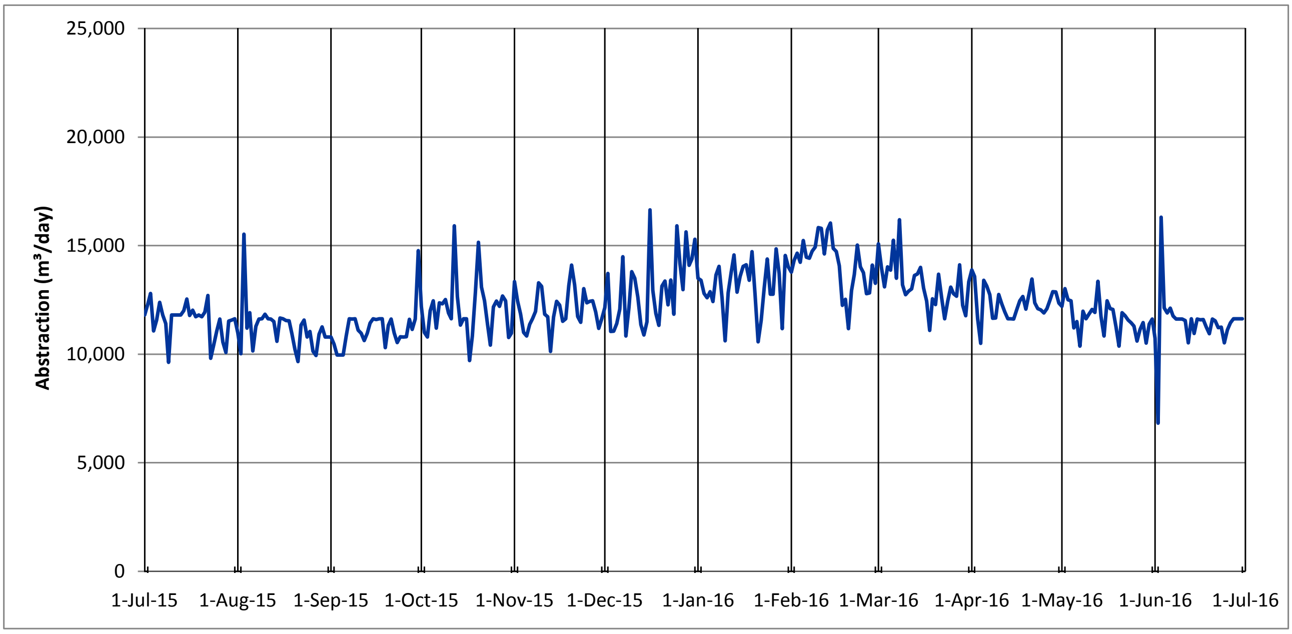


Figure 3: Waikanae WTP River Abstraction Volumes (m^3/day)

The instantaneous rates of abstraction (recorded at 15 minute intervals) for the reporting period are shown in Figure 4. The maximum abstraction rate was 258 L/s on 2 April 2016. Condition 5 of consent WGN130103 [33760] sets the maximum instantaneous abstraction rate of 355 L/s (when the flows in the river are below 1,400 L/s). The instantaneous abstraction rate was less than 310 L/s at all times during 2015/16.

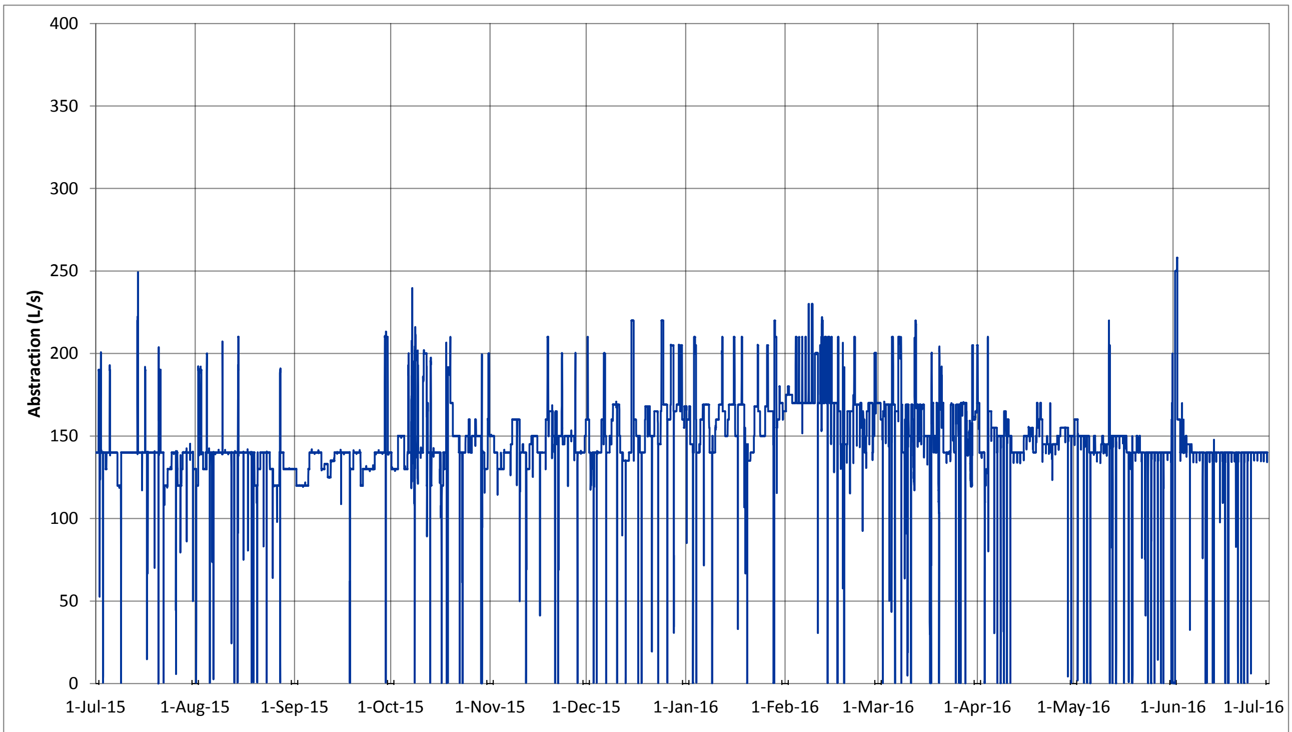


Figure 4: Waikanae WTP River Abstraction Rates (L/s)

2.1.3 River Recharge

River recharge was used for 14 days during the 2015/16 period. The first recharge was undertaken on 16 October 2015 and the last was on 2 April 2016. As per Condition 26b of WGN130103 [33761] the recharge details are listed in Table 3 and Table 5. Short Duration Discharges of groundwater associated with routine bore testing & maintenance to the Waikanae River also occurred during the 2015/16 period and these are shown with the discharges for river recharges on the figures below. The Short Duration Discharges are shown separately from the river recharge in Table 5.The maximum recharge rate was 175 L/s and an overview of the recharge is detailed on Figure 6. The daily recharge is detailed in Figure 5, and a maximum daily recharge of 8,118 m³ was achieved on 13 March 2016.

On 23 March 2016 testing and maintenance (short duration discharge) of the bores coincided with river recharge activities. This is shown by the small blue peak within the red discharge on Figure 5. The river recharge was set to discharge 135 L/s to the river during this period and is shown by the red line in Figure 6.

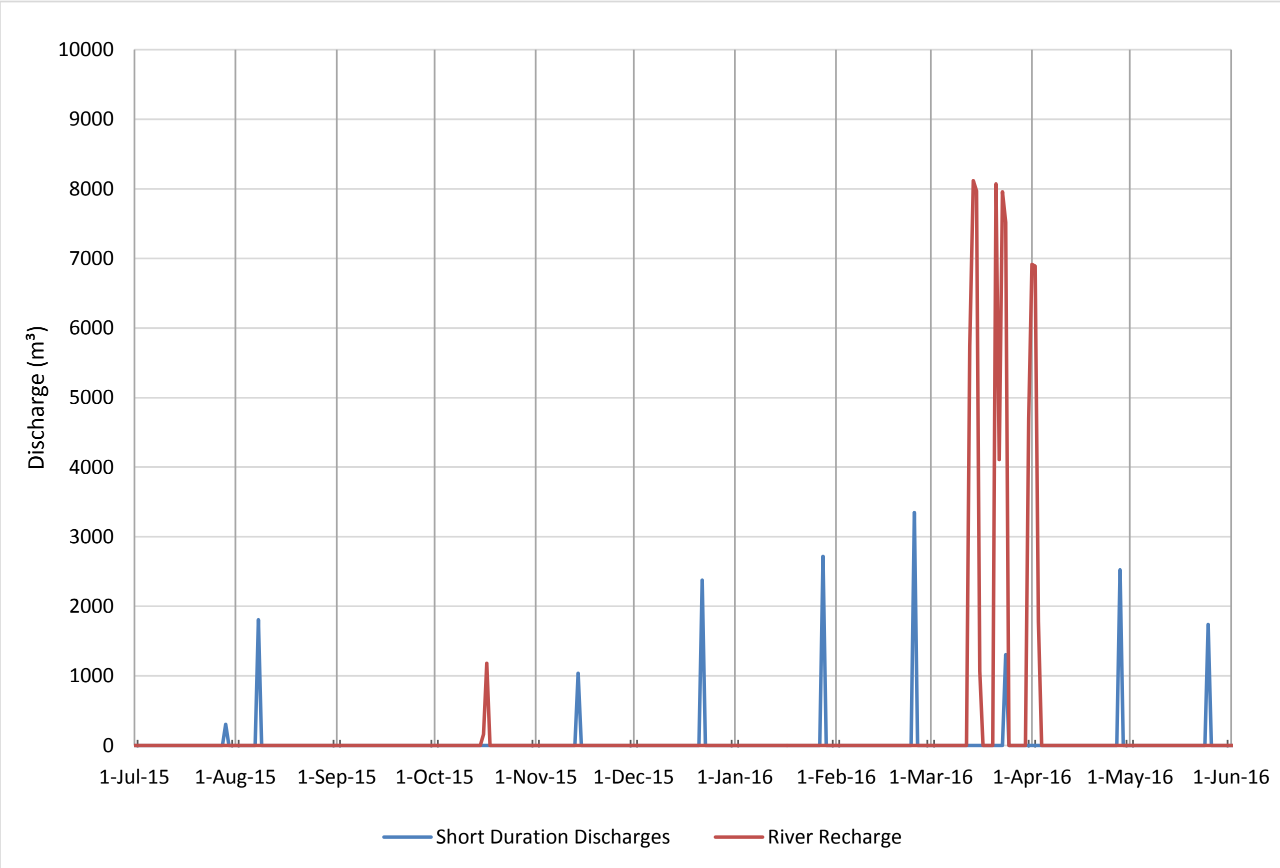


Figure 5: Daily Waikanae River Recharge (and Short Duration Discharges) for 2015/16 (m³)

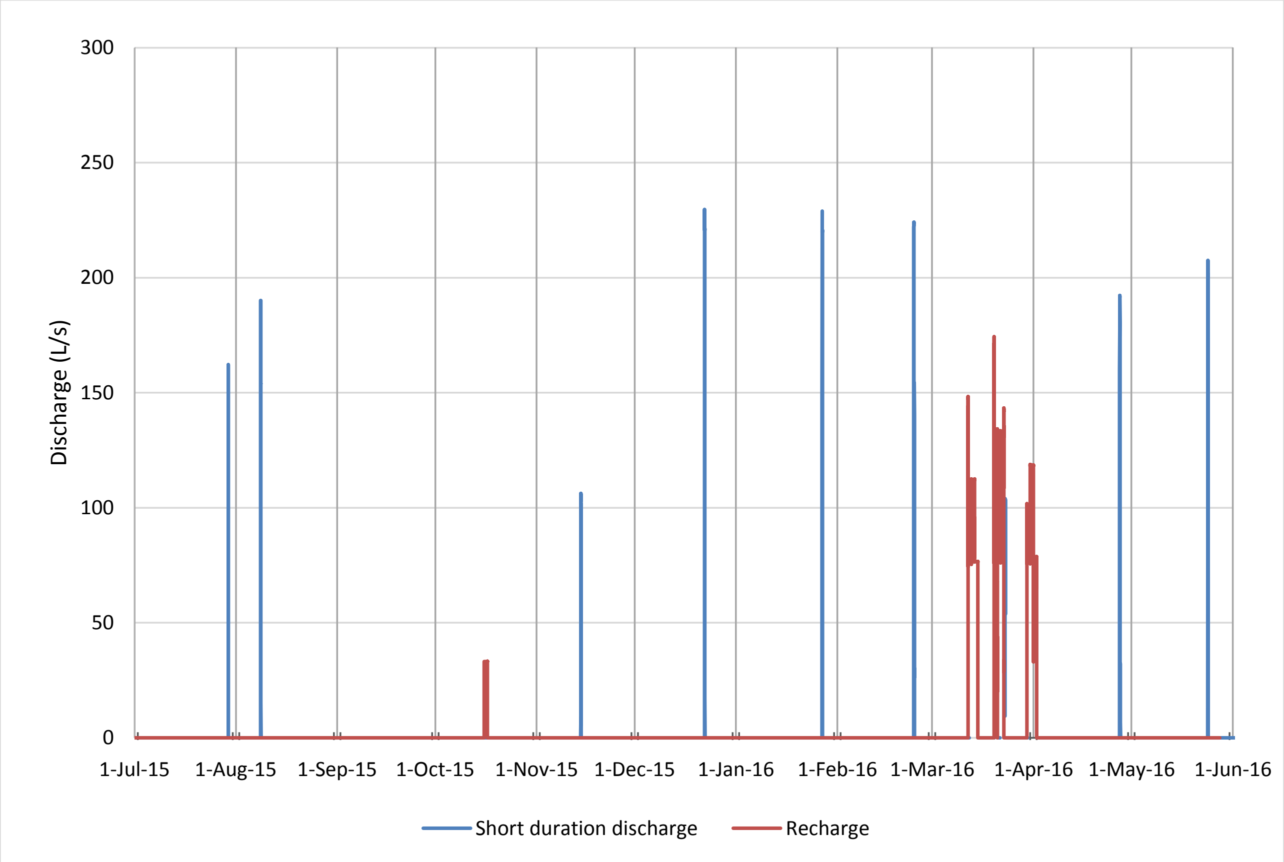


Figure 6: Instantaneous Waikanae River Recharge (and Short Duration Discharges) 2015/16 (L/s)

Table 3: Waikanae River Recharge for 2015/16 (Daily Totals)

Date	Recharge volume (m³)	Max Instantaneous Recharge (L/s)
October 16, 2015	163	34.65
October 17, 2015	1182	71.52
March 12, 2016	5740	149.72
March 13, 2016	8118	113.17
March 14, 2016	7970	128.27
March 15, 2016	1068	78.61
March 20, 2016	8073	175.14
March 21, 2016	4110	135.27
March 22, 2016	7959	135.37
March 23, 2016	7520	143.43
March 30, 2016	4699	112.52
March 31, 2016	6914	119.66
April 01, 2016	6889	119.55
April 02, 2016	1780	81.78

Table 4: Waikanae River Recharge for 2015/16 (Start, Finish and Duration)

Discharge Start Date and Time	Discharge Finish Date and Time	Duration (minutes)
October 16, 2015 22:37	October 17, 2015 9:54	677
March 12, 2016 9:45	March 15, 2016 4:55	4030
March 20, 2016 1:57	March 21, 2016 10:13	1936
March 21, 2016 19:57	March 23, 2016 16:00	2643
March 30, 2016 7:58	April 2, 2016 7:24	4276

Short duration discharges (of a few hours) of groundwater to the Waikanae River via the swale have taken place ten times in the 2015/16 monitoring period. The discharges were all in relation to testing and maintenance of the bores (and hence the approximate monthly periods between discharges). All but one of the discharges fell within the constraints for Short Duration Discharges as outlined by Consent WGN130103 [33761].

One discharge on 27 April 2016 lasted for 7 hrs and 15 minutes and exceeded the constraints of Short Duration Discharges, which states a Short Duration Discharge can last up 6 hours. The Short Duration Discharges in April 2016 total 7 hours and 15 minutes which is within the maximum cumulative duration of Short Duration Discharges of 24hrs over a 30 day period as defined by Consent WGN130103 [33761]. The discharge coincided with sampling of the bores and testing and maintenance operations. The exceedance occurred at a time where the flow in river was 1350 L/s and therefore any potential effects of the discharge on the river are considered to be *de minimis*.

Table 5: Waikanae River Recharge – Short Duration Discharges (Daily Totals)

Date	Recharge volume (m^3)	Max Instantaneous Recharge (L/s)
July 28, 2015	305	163.21
August 08, 2015	1806	190.61
November 14, 2015	1041	11.62
December 22, 2015	2375	230.62
January 27, 2016	2720	229.17
February 24, 2016	3348	224.77
April 26, 2016	2525	192.7
March 23, 2016	1304	116.4
May 24, 2016	1741	208.00
June 27, 2016	1601	212.41

Table 6: Waikanae River Recharge – Short Duration Discharges (Start, Finish and Duration)

Discharge Start Date and Time	Discharge Finish Date and Time	Duration (minutes)
July 29, 2015 16:27	July 29, 2015 17:18	51
August 8, 2015 13:09	August 8, 2015 16:21	192
November 14, 2015 12:27	November 14, 2015 15:30	183
December 22, 2015 09:03	December 22, 2015 12:27	204
January 27, 2016 08:18	January 27, 2016 12:06	228

Discharge Start Date and Time	Discharge Finish Date and Time	Duration (minutes)
February 24, 2016 09:15	February 24, 2016 15:09	356
March 23, 2016 08:28	March 23, 2016 11:46	97
April 27, 2016 08:42	April 27, 2016 15:54	432
May 24, 2016 08:42	May 24, 2016 11:36	174
June 28, 2016 08:30	June 28, 2016 11:06	156

GWRC advised Council on 7 October 2015 that the hydrological conditions for the first year of monitoring river conditions were not atypical and so a recharge of up to 20% of downstream flow is acceptable as per Condition 18(c) of consent WGN130103 [33761]. Figure 7 details the recharge percentage of downstream flow.

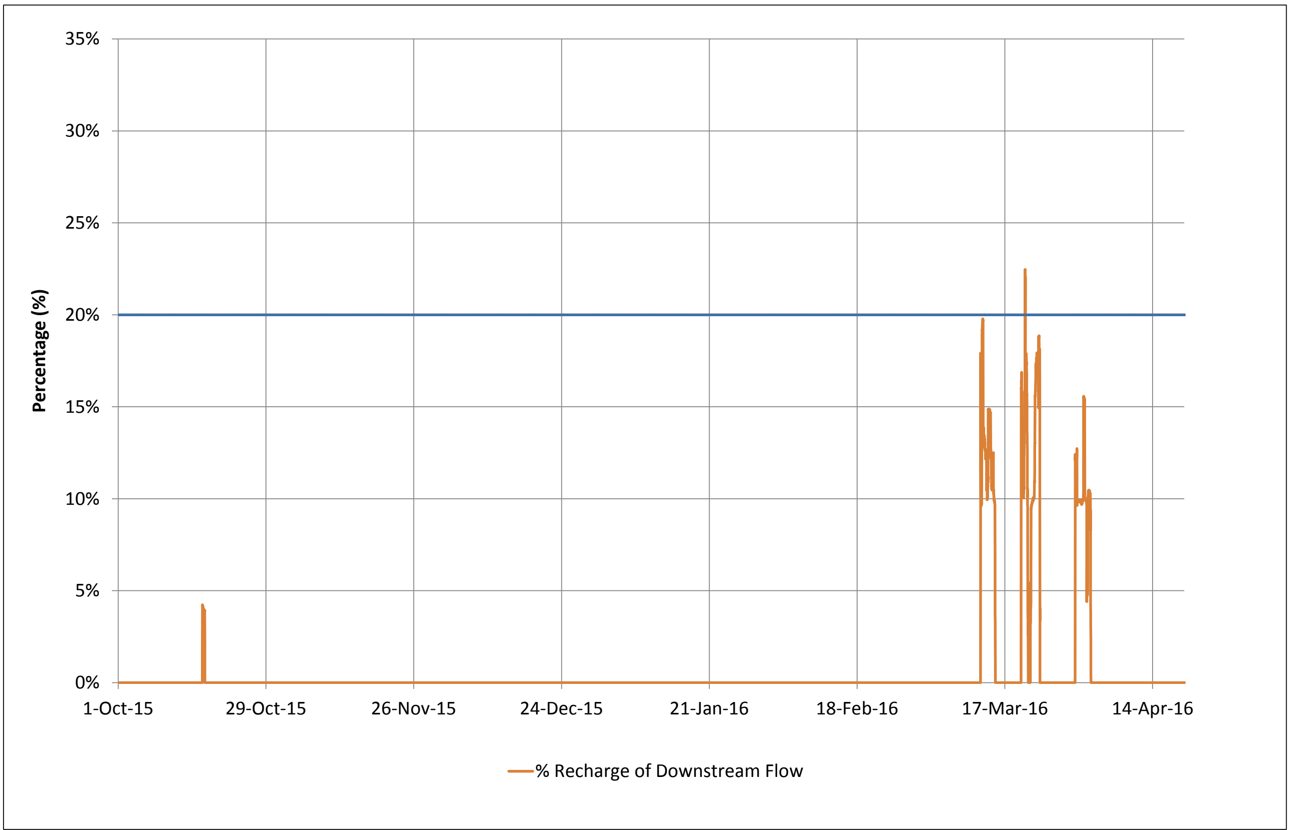


Figure 7: Waikanae River Recharge as a Percentage of Downstream Flow

The recharge exceeded the 20% threshold on one occasion of recharging. The recharge exceeded 20% for a total of 51 minutes with an average exceedance of 14.7 L/s and a maximum exceedance of 21.7 L/s. This was a result of the bores have minimum pump rates combined with the requirements of the approved Bore Preference Hierarchy Plan (Bore PHP). Now that monthly sampling for K10, KB7, K12 and N2 is complete the Bore PHP will be resubmitted for approval and incorporate operational changes which will allow pump trimming/balancing as more or less groundwater is required to maintain downstream flow limits. GWRC was notified on 23 March 2016 and Council received comments back on the 21 April 2016. GWRC noted that the "*GWRC gauge was under-recording by a significant amount at the time of the breach".* Although this was registered as a technical non-compliance (against the daily measures from GWRC), the actual flow within the river would most likely have made these discharges compliant.

2.1.4 River Low Flow Periods

The flow in the Waikanae River was low enough during October 2015 and March to April 2016 that Council had to use the Waikanae Borefield for river recharge. There were some technical nuances during river recharge which were discussed with GWRC immediately following their discovery in March. GWRC was informed by phone on 21 March 2016 which was followed up in writing with full details of the instance on 23 March 2016. A number of mitigation strategies where also put in place at that time including:

- River recharge to be put on standby (discharge 35 L/s from bores) when potentially required overnight so auto start of recharge can occur.
- Additional recharge buffer flow of 5 L/s applied.

Following a review of the information provided by Council, GWRC responded on 21 April 2016, and stated they had *"reviewed the information you have sent through regarding the exceedances and considers that the non-compliances would have had less than minor instream effects".* As the exceedances were temporary, of short duration and GWRC has concluded had a less than minor instream effect, we consider that no further action is required following implementation of the mitigation measures discussed above.

Subsequent to that event and following a full detailed review of the data for the preparation of this Annual Report it was found that the 750 L/s downstream flow requirement was not maintained on a number of occasion when the river flow up stream was 920 l/s or less. These instance are as follows:

- 16 October 2015
  - Below 750 L/s for 120 minutes over a 345 minute period
  - Average downstream flow over period 758 L/s
  - Minimum downstream flow 742 L/s
- 8 March 2016
  - Below 750 L/s for 15 minutes
  - Minimum downstream flow 746 L/s
- 11 to 14 March 2016
  - Below 750 L/s for 705 minutes over a 4200 minute period
  - Average downstream flow over period 756 L/s
  - Minimum downstream flow 744 L/s
- 19 to 23 March 2016
  - Below 750 L/s for 975 minutes over a 5820 minute period
  - Average downstream flow over period 765 L/s
  - Minimum downstream flow 725 L/s
- 28 to 30 March 2016
  - Below 750 L/s for 450 minutes over a 2325 minute period
  - Average downstream flow over period 752 L/s
  - Minimum downstream flow 736 L/s
- 1 April 2016
  - Below 750 L/s for 45 minutes over a 60 minute period
  - Average downstream flow over period 749 L/s
  - Minimum downstream flow 745 L/s

During the above periods the average period that the flow was less than 750l/s was 30 minutes.

These instances have been investigated and are considered to be largely attributed to the time it takes for the data from the GWRC river flow gauge to reach and be actioned by the KCDC production bore and intake pumps. This process can take up to 40 minutes. In that time the river may have dropped further which has resulted in a number of instances where the downstream river flow has dropped below 750 L/s. In addition to this pump ramp up and ramp down also affected the downstream flow levels.

WGN 130103 [33759] Condition 8 and WGN 130103 [33760] Condition 5 Rate of Take allows for the maximum instantaneous pumping rates to be exceed by up to 15% for a maximum duration of 15 minutes for the purposes of pump ramp-up and ramp down upon start-up, set point change and shut down of the pumps. Although allowed for in the rate of take the effect of this is not currently allowed for in the Waikanae River Lower Flow Conditions. A number of the exceedance noted above can be attributed to this discrepancy. It is proposed that this is resolved via a change to consent applications if appropriate following discussion with GWRC.

Given the scale of the instances are all similar to that investigated on March 2016 by GWRC, and the level of accuracy of both the river gauging and measurement equipment, it is concluded that any instream effects would have been less than minor.

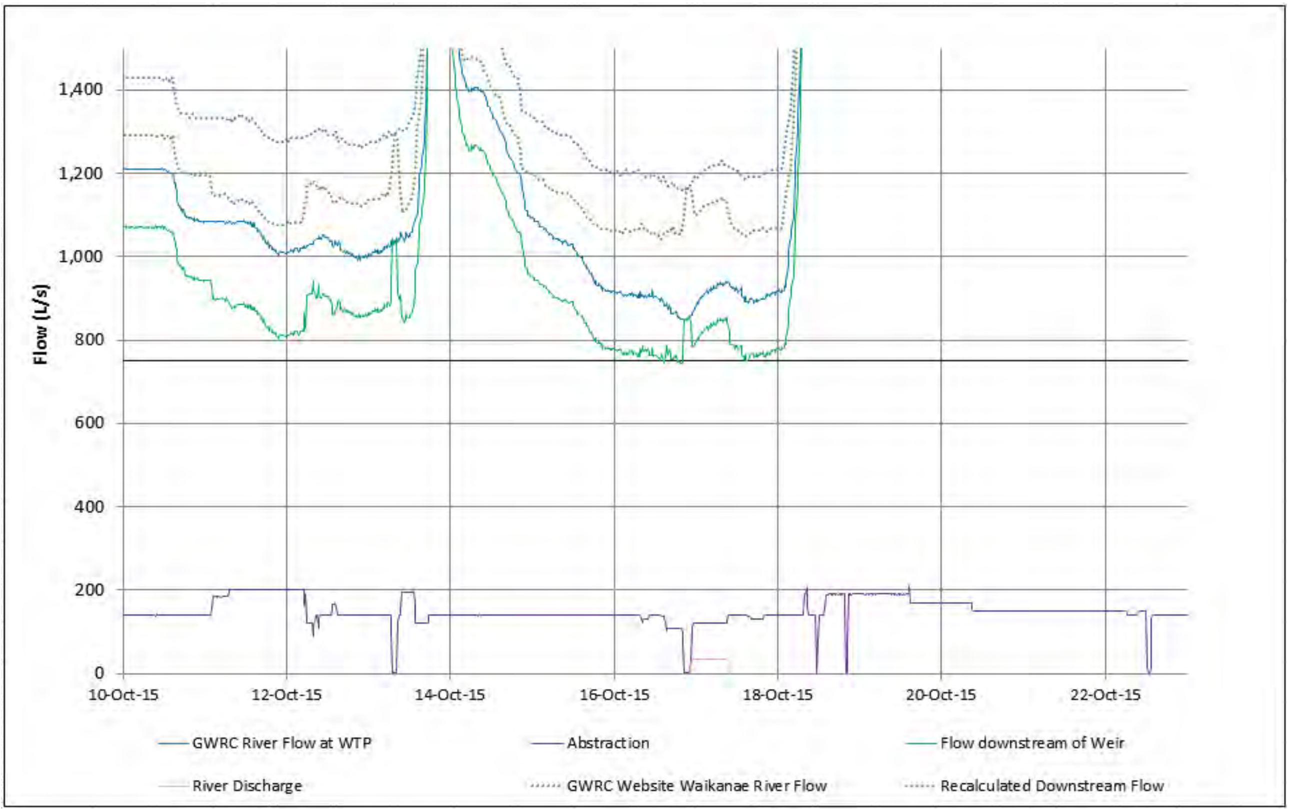


Figure 8: River flow upstream and downstream of WTP during the October low flow period

Figure 8 and Figure 9 show the river flow at the GWRC gauging site upstream of the WTP (blue line), the WTP abstraction (purple line), and the Waikanae River recharge (orange line); these are 15-minute readings taken from Council's SCADA, and the resulting calculated flow immediately downstream of the recharge point (green line) during the period of low river flows in summer and autumn 2015/16. The blue dotted line is the re-rated flow the GWRC website following application of the rating curve and the green dotted line is the related downstream flow. The blue and green lines demonstrate general compliance with Condition 6 of consent WGN130103 [33760] and condition 12 of WGN130103 [33761].

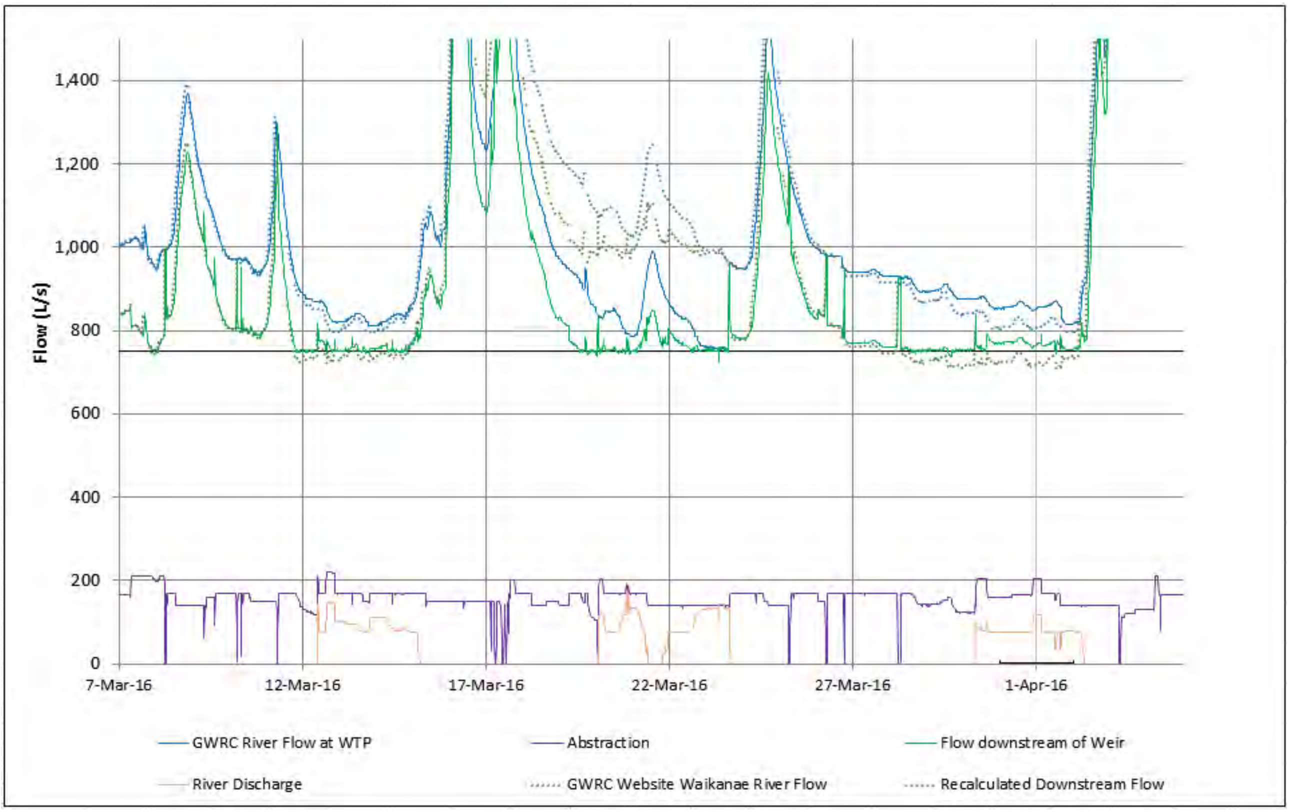


Figure 9: River flow upstream and downstream of WTP during the February to April low flow period

Analysis of the flow data shows that 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 [33760].

2.2 Operations Log and Maintenance Undertaken

Council has confirmed that its upgraded 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 [33760]. Council is also currently implementing WaterOutlook to store and report data and operational information relating to the Waikanae River take and recharge.

Excerpts from the Council's WTP operations log that relate to maintenance of the intake are included in Appendix A. Additionally the WTP operators carry out an inspection of the intake every day and clear accumulated debris from the intake screens, such as leaves and twigs, as required. The following key events are noted:

- Open day for swale and Water Treatment Plant on 8 August 2015
- Trial of the raw water pumps on 7 October 2015 and trials of the VSD (variable speed drive) pumps occurred on the 8 October 2015.
- The borefield compliance alarms were reset on 8 August 2015. Noted that Bore N2 communication was down.
- Various river recharge activities during the 4 periods of recharge
- On 24 February 2016 AFI carried out manipulations of the river flow to force river recharge. To check bore hierarchy and to allow fine tuning. The bores were running for sampling concurrently to AFI tests.

No unusual events occurred, in addition to the above, in relation to water quality, quantity and infrastructure apart from the unusually fast drop off of river flows around the 16 October 2015 which resulted in the activation of river recharge. GWRC re-gauged the river following this event and actual river flow at this time was found to be higher than that recorded on the day.

2.3 Operations and Maintenance Manual

The Waikanae River Take Operations and Maintenance Manual (ROMM) was approved by GWRC on 25 August 2015, in accordance with Condition 17 of consent WGN130103 [33760].

There are no recommended changes to the ROMM at this time. Once the final Waikanae Water Treatment Plant Operating and Maintenance Manual is issued along with the updated Waikanae Water Treatment Plant Stage 1 Functional Design Specification, the ROMM will be updated and resubmitted for GWRC approval.

3 River Monitoring

3.1 Aquatic Monitoring

Baseline monitoring of the Waikanae River was carried out during the period December 2015 to April 2016 in accordance with the certified Waikanae River Baseline Monitoring Plan (River BMP) and as agreed with GWRC. 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 river baseline monitoring generally involved collection of periphyton data, macroinvertebrate samples, and water quality measurements at two sites upstream of the Waikanae WTP and three downstream sites. Fish surveys at these same sites as well as in upper tributaries of the Otaki and Waikanae Rivers were completed in 2014/15 but not required this year as agreed with GWRC. Algae growth was seen at a moderate to high bed cover this year and corresponding macroinvertebrate communities were collected.

The first observable environmental change related to the introduction of groundwater for the purpose of river recharge was an increase in conductivity, potentially, by the increase in calcium. There were no other water quality biotic parameter changes observes as a result of river recharge

The 2015/16 summer saw increased quantities of filamentous and thicker matting algae, including blue-green algae, though the averaged measure was not considered to be high or very high. The averaged maximum was less than 30% and while this year’s results were the highest measured to date, a 30% average cover is still only moderate cover. There were two floods in the measuring period which reduced the cover appreciably.

Two interim trigger levels for monitoring the Waikanae River, as per Condition 19 of consent WGN130103 [33761], were exceeded. The interim trigger relating to Condition 19b (chlorophyll-a) was exceeded 3 times and interim trigger relating to Condition 19(c) periphyton weighted composite cover (periWCC) was exceeded once.

Condition 19(b) requires investigation into the volume of chlorophyll upstream and downstream of the recharge activities, and comparing the upstream and downstream sites to see if there are any effects on the river’s ecology. One of the exceedances was attributed to an erroneous data point (8 March). Of the remaining two; one occurred on 21 March 2016) while river recharge was taking place and the other occurred a month after the last river recharge for 2015/16 occurred on 2 May 2016. Appendix 2A of consent

WGN130103 [33761], requires that groundwater discharge to the river is ceased immediately when a Chlorophyll biomass exceeds 120mg/m³ (and not exceeded at any upstream monitoring site) as per the two instances above. Due to the laboratory processing time the samples taken on 21 March results were not available till after recharge had already ceased on the 23 March. The second exceedance on 2 May 2015 was the last sample from the monitoring period and the most recent river recharge occurred a month prior. No river recharge has occurred since.

On average, this year, it has taken 20 days to receive chlorophyll-a results back from the laboratory. The interim trigger actions associated with chlorophyll-a biomass as defined by Appendix 2A of consent WGN130103 [33761] are not practicable as the results from the laboratory typically take 20 days for results to be returned. Within this time frame the river will have gone through changes and may make the actions required inappropriate for the current state of the river.

Condition 19(c) requires investigation into the composite cover level of periphyton upstream and downstream of the recharge activities, and comparing the upstream and downstream sites to see if there are any effects on the river's ecology that could be used to set on going triggers. The one exceedance that occurred on 18 April 2016 where all three downstream sites exceeded 30% PeriWCC cover and both upstream sites did not, is actually a cease trigger under Appendix 2A of consent WGN130103 [33761]. The cease trigger actions requires groundwater discharge to the river to stop immediately until the biomass reduces. There had been no river recharge for the 2 weeks prior to this exceedance. The PeriWCC sample taken following this instance indicates that the growth is not a direct result of river recharge as all site have a similar high level of growth.

From monitoring undertaken to date the timing of these triggers exceedances is not indicating a relationship with river recharge.

The baseline monitoring data collected during the 2015/16 summer/autumn adds to the data collected in March and April 2014 and between December 2014 and April 2015. The data collected over the 3-year baseline monitoring period will be used to develop an on-going monitoring regime for the Waikanae River and inform the development of management trigger levels and cease abstraction compliance limits as part of the On-going Mitigation Plan for the Waikanae River.

3.2 Bore Water Quality Monitoring

The Bore Preference Hierarchy Plan, which is required by Condition 16 of consent WGN130103 [33761], was approved by GWRC on 13 October 2015. This plan included full water quality results for the production bores Kb4, K4, K5 and K6 from monthly sampling carried out between October 2013 and January 2015.

Sampling for the remaining production bores, K10, Kb7, K12 and N2, commenced in May 2015 following the installation of bore pumps and headworks piping. A year of sampling for these bores was completed in April 2016. The next revision of the Bore Preference Hierarchy Plan will be submitted to GWRC shortly. This will include full water quality results for all production bores. This means that, subject to GWRC's approval, all eight production bores can be used for recharge in the 2016/17 year.

Ongoing testing of bore water quality was taken from production bores approved for use as required by Condition 15 of consent WGN130103 [33761] and subsequently aligns with condition 27 (j) of consent [33759]. This requires testing if a bore has been used for more than one day, and prior to turning off if a bore has been used for three days or more. K4 and Kb4 were the only bores that were required to be sampled due to pumping for a period of 3 days.

Blended bore water was sampled as per the minimum requirements under [33760] condition 19(j) of consent [33760] at the same frequency as is required by condition 27(j) of consent [33759]. This will allow for comparison of the individual bore water quality sampling with the blended bore water sampled if necessary. GWRC has yet to confirm the clarification of blended bore water sampling (refer email sent on 15 December 2015).

As required by the River BMP, a summary of the river water quality results from the 2015/16 baseline monitoring is included in Appendix C for comparison with the bore water quality.

3.3 Changes to River Baseline Monitoring Plan

The Waikanae River monitoring report for 2015/16 (Appendix B) includes recommendations relating to changes to the baseline monitoring programme. These are summarised below; refer to Appendix B for further detail.

- Discontinuation of the macroinvertebrate measures as sufficient baseline data has been collected for this parameter
- An alternative migratory fish sampling method is proposed, i.e. whitebait trapping, as near as possible to the migratory period of the fish but still within the monitoring period. It is recommended that discharge of groundwater to the river is undertaken at the time of the survey to see if this impacts the movement of the fish to above the weir on the Waikanae River.
- Periphyton measures:

  - Discontinue twice annual community measure as sufficient baseline information has been collected as to the species composition of the periphyton, and there are only 3 months of river baseline monitoring remaining
  - Removal of chlorophyll-a sampling for the last three months of baseline monitoring -The AMG has asked GWRC to assess the merits of discontinuing the sampling – or that one pooled sample per site for chlorophyll-a is taken monthly i.e. not 5 separate samples per site every second week (or weekly if flow drops below <1100 L/s). Sufficient baseline monitoring information has been collected to understand the relationship across the width of the river and a pooled sample is sufficient going forward. This sample will still provide a biomass measure which can be related to the visual measurements.

Going forward, visual periphyton measure to remain with one pooled sample per site per month. Following the AMG meeting on 31 August this recommendation was updated and visual periphyton measure will remain at the current frequency for the remainder of baseline monitoring. i.e. once every 2 weeks.

4 Mitigation/Adaptive Management in the Coming Year

Looking ahead to the coming year (2016/17) the following mitigation and/or adaptive management is proposed:

- Removal of the chlorophyll-a parameter from the interim trigger in Appendix A 2A - Waikanae River Periphyton. On average, lab results for chlorophyll-a take 20 days to arrive and by the time the result is received a number of changes could have taken place on the river rendering the actions required by the interim trigger ineffective.
- Removal of the last three months of baseline monitoring for chlorophyll-a and macroinvertebrates. The AMG was split as to a decision on whether or not these measures should be removed. They have indicated that they will happy with the decision that the GWRC determines through its internal investigations.

There is no additional mitigation or adaptive management that is anticipated at this stage, other than the proposed changes to the River BMP as outlined in Section 3.3 above.

Further river baseline monitoring will be carried out over the 2016/17 summer in accordance with the certified River BMP.

5 Recommendations of the 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. Figure 10 shows the stages of AMG and key stakeholder involvement in the lead up to the submission of this annual report to GWRC.

Council held a briefing session with the AMG and key stakeholders on 26 May 2016. Representatives of Wellington Fish and Game Council, The Kapiti Fly Fishing Club and Regional Public Health were present at the briefing. The purpose of this briefing session was to discuss the observations from the baseline monitoring undertaken to date, as well as any observations of the AMG and key stakeholders during the 2015/16 period. The briefing was also to make an early start in the process of considering the potential for adaptive management in regards to these observations ahead of the AMG meeting in August 2016 where the draft annual reports would be discussed.

The AMG met on 31 August 2016 to discuss the draft version of this annual report, as well as the draft version of the annual borefield report. Representatives from the following key stakeholders also attended this meeting: Wellington Fish and Game Council, The Kapiti Fly Fishing Club, Friends of the Waikanae River and Regional Public Health.

Recommendations received from the AMG are set out in the table below.

Table 7: Recommendations of the Adaptive Management Group

Adaptive Management Observations and Opportunities	Consideration with AMG Recommendations
Waikanae River - Periphyton ▪ The relationship between the visual inspection of periphyton and measure of chlorophyll a is well understood from the results to date and sufficient community measures had been collected for baseline monitoring to understand the species composition of the periphyton ▪ Chlorophyll-a tests typically take 20 days for results to be available and it is not effective to mitigate potential effects to river ecology of recharge. ▪ The benefits of continuing to collect periphyton samples for the last three months of baseline monitoring and the continued value of chlorophyll-a was discussed.	▪ Remove Chlorophyll-a triggers from Appendix 2a – as ineffective. ▪ AMG asked that GWRC considered the merits of removing chlorophyll-a sampling for the remaining three months. And if not that chlorophyll-a sampling be taken as pool sample at each of the five sites at a frequency of once per month. ▪ AMG asked that GWRC consider the merits of no further Community Periphyton measures in the remaining three months. (NB one sample remaining for baseline monitoring).
Waikanae River - Macroinvertebrate Measures ▪ Sufficient data have been collected to understand the macroinvertebrate communities and how they react to seasonal periphyton cover for baseline monitoring for the low and medium cover.	▪ AMG recommended that macroinvertebrate sampling is still taken of very high PeriWCC levels encounter (e.g. at 70%. percentage cover)

Adaptive Management Observations and Opportunities	Consideration with AMG Recommendations
Waikanae River - Fish surveys ■ Surveying migratory fish requires validation of whether or not fish migration is likely to be affected by the discharge of bore water (timing and quantity of bore water in river).	■ Remove requirement for further fish monitoring during baseline monitoring at along the river and upper tributaries to "tidy up" the consents while an alternative was agreed. ■ Confirm way forward to survey migratory fish (Alternative fish survey method).

Figure 10: AMG activities associated with this year's annual report

Appendix A

Operations Log

Water Treatment Plant Operations Log

Date	Action
29/07/2015	Start Bores K4, K5, K6 and KB4. Open Valve to swale to check calibration of swale flow meter recommissioned by Max Tarr and Cardno (Phil G) Dave Basset in attendance
	Shut bores off at 1650hrs. Map flows. Do print out attached. Flow analysis River Recharge and pretreament flow meters
23/09/2015	Moved max persons sign to top of steps
8/08/2015	Open day
	Reset Borefield Compliance alarms where possible. N2 Bore coms failure stale data from 2215hrs.
	1836m³ through swale on open day
	Filter #4 NTU increased to 0.033 @ 1940
20/08/2015	Clean Intake with a brush
	Air Sparge Both sides lots
	Flush scan Cyclone
	Clean and flush scan cyclone
	Clean Low range NTU Meter
	Run Mono Pumps
7/10/2015	Run K4 Bore
	Check Backwash Tanks
	Run Mono Pumps
	Flush Scan Cyclone
	Clean Scan Probe and Bowl
	Clean Low range NTU Meter
	Raw water drive pump trials - today
	Put PACL dosing into manual while new VSD drive for River water pumps being tested.
8/10/2015	Run K4 Bore
	Put Pump (R/W) up to 180l/s for testing.
	Raw water pump VSD control testing different ranges for efficiency
	Check Backwash tanks - run mono pumps
	Flush scan cyclone at intake
	Clean Scan Probe and Bowl
	Clean Low range NTU Meter
14/10/2015	Secure new airline with further cable ties, clean up some redundant cables, clips, clamps and rubbish
16/10/2015	Turn on KB4 to recharge river
	Flow at 840l/s (2200Hrs). Raw water 120l/s
	11pm -Turn off M2PP Valve
19/10/2015	Check Backwash tanks
	Test intake air sparge in Manual
	Remove air from fluoride probe
	Flush scan cyclone
	Flush scan probe and bowl
1/02/2016	Change Raw water pump duty Fix pump 1
	Check Swale Valve is to waste and not swale. Turned anticlockwise to close.

	Check intake shut gut, carry out manual sparge, open gate, release debris, close gate again to raise water in weir. Flush scan cyclone
24/02/2016	Opened Swale at 0800hrs
	Change raw water ump duty to Fix #1
	N2 bore started (run up with new electrical filters on
	Start all other bores - K10, KB4, K4, K5, K6, KB7, K12.
	1150hrs AFI - carried out manipulations of river flows to force River Recharge borefield hierarchy and set point to allow fine tuning - while bores were running for bore sampling.
	1630 turn off all bores testing and sample complete.
8/03/2016	Open intake gate for half a minute.
	Wash scan probe and bowl.
12/03/2016	Starting river recharge GWRC. Raw water pumps started trimming at 2010hrs last night(11/03/2016)

Appendix B

Waikanae River Aquatic Baseline Monitoring Report

Waikanae River Annual Aquatic Baseline Monitoring Report

A report on 2015/2016 aquatic data collection for water permits WGN130103 [33760] & [33761]

Prepared for Kāpiti Coast District Council

7 September 2016

Document Quality Assurance

Bibliographic reference for citation: Boffa Miskell Limited 2016. *Waikanae River Annual Aquatic Baseline Monitoring Report: A report on 2015/2016 aquatic data collection for water permits WGN130103 [33760] & [33761]*. Report prepared by Boffa Miskell Limited for Kāpiti Coast District Council.		
Prepared by:	Katherine de Silva Ecologist Boffa Miskell Limited	
Reviewed by	Dr Vaughan Keesing Assoc. Partner / Senior Ecologist Boffa Miskell Limited	
Status: Final	Revision / version: 8	Issue date: 7 September 2016
Use and Reliance. This report has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Boffa Miskell does not accept any liability or responsibility in relation to the use of this report contrary to the above, or to any person other than the client. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate, without independent verification, unless otherwise indicated. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.		

Template revision: 20140327 0000

File ref:W14039_340_Annual_Waikanae_data_report_Final_20160728 Rev8.docm

Cover photograph: Periphyton measure in the Waikanae River © BML 2015

TABLE OF CONTENTS

1.0 Introduction 5

2.0 Methods 6

2.1 Monitoring sites 6
2.2 Site Photos 8
2.3 Survey Transect setup 9
2.4 Monitoring methods 9
2.5 Data analyses 10

3.0 Water Quantity through the Monitoring Period 11

3.1 Rainfall and river flow 11
3.2 Abstraction 13
3.3 Water temperature 14
3.4 River Recharge 14

4.0 Shade and Substrate Quantity 14

5.0 Results 15

5.1 Water chemistry and temperature 15
5.2 Periphyton 20
5.3 Macroinvertebrates 27

6.0 Flow gauging 31

7.0 Summary and Recommendations 33

7.1 Summary 33
7.2 Recommendations for future monitoring 34

8.0 References 36

Appendix 1: Raw Water Chemistry Data (Manual)

Appendix 2: Raw Water Chemistry Data (Lab)

Appendix 3: Raw Periphyton Data (% Cover)

Appendix 4: Raw Periphyton Data (Chlorophyll-a)

Appendix 5: Raw Periphyton Data (Relative Abundance)

Appendix 6: Raw Macroinvertebrate Data (February)

Appendix 7: Raw Macroinvertebrate Data (March)

1.0 Introduction

Resource consent conditions 19 (Consent WGN130103 [33760]) and 21 (Consent WGN130103 [33761]) for Kāpiti Coast District Council's River Recharge with Groundwater Project (RRwGW Project) required the preparation of a '*Waikanae River Baseline Aquatic Monitoring Plan'* (Waikanae River BMP). That plan (as prepared by BML and certified by GWRC) requires the collection of:

- Periphyton data – including visual cover and community composition assessments, algal biomass 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. sample periods target each of a low, medium and high periphyton period);
- Water quality samples each fortnight (or flow depending, weekly); and
- A set of velocity measures taken at each periphyton visual cover estimation.

These requirements were updated following completion of the annual report and review of the 2014/2015 summer data (December 2015 to April 2016). Some elements of the original BMP have changed as a result of that monitoring analysis and review. GWRC received a draft of the Waikanae River BMP (dated 21st December 2015) on 3rd February 2016 for comment. A meeting was held with GWRC on 11th February 2016 and it was agreed that the final updated Waikanae River BMP could be submitted after the 2015/16 annual reporting period to include any recommendation from the Adaptive Management Group. Meeting notes were issues on the 15th March 2016 to GWRC.

The following changes were made to the 2015/2016 monitoring season requirements:

- Periphyton samples were taken each month for chlorophyll-a and samples for species assemblage and relative abundance were sent away for testing in February and March.
- The 2015/2016 monitoring season focused on moderate to high periphyton-macroinvertebrate community relationships as approved by GWRC on 31 November 2015. Therefore, macroinvertebrates were sampled once in February and March when periphyton levels were determined to be moderate to high.;
- Local freshwater fish population surveys and whitebait migration passage assessments were not conducted in this monitoring season. As at the end of 2015, several EFM surveys have supplied sufficient data and no further surveys of local fish populations are required as agreed with GWRC. Council are working GWRC and the AMG to agree a way forward with migratory fish sampling. It is proposed that the first whitebait passage assessment will be conducted immediately prior to the 2016/2017 monitoring period in November/ December 2016 once approved;
- No depth or velocity measures were taken within the 2015/2016 monitoring period as approved by GWRC on 30 November 2015. The requirement to measure algal biomass using the AFDM parameter was removed as part of this discussion.
- Monthly reporting requirements have been removed and a Waikanae River Annual Aquatic Baseline Monitoring Report will be provided to the Manager, Greater Wellington Regional Council as a complete record of the baseline data for each monitoring season.

Data is collected from two upstream "control" and three downstream "receiving" monitoring sites on the Waikanae River.

Full details of the consent conditions and the parameters and requirements for monitoring can be found in the BML "Waikanae River Baseline Aquatic Monitoring Plan" report dated 23rd February 2014 (prepared for KCDC) and subsequent draft BMP submitted to GWRC on 11th February 2016.

This report presents the findings from five months of data collection spanning December 2015 through to April 2016. This data adds to previous data sets collected from December 2014 to April 2015 and from March and April 2014. This monitoring season is the first season in which consented river recharge has occurred.. Raw data is provided in the appendices.

This baseline monitoring data will be part of the data set which informs the development of ongoing trigger levels.

2.0 Methods

2.1 Monitoring sites

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

- Two 'control' sites, (C1 and C2) located upstream of the Waikanae Water Treatment Plant (WTP); and
- Three 'receiving' sites, located at predetermined intervals downstream of the Waikanae WTP (R1, R2 and R3).

The locations of these sites are described in full in the Waikanae River BMP and shown in Map 1. At each site, a wooden stake was driven into the bank so that the site location (in addition to GPS location) can be re-sampled over time. The stakes driven into the banks in 2014 have since been removed or the river has removed them, nevertheless the GPS location and site photos, along with sampler familiarity, has allowed an accurate transect location each survey.

Currently, and for the purpose of this report, the control and receiving sites are replicate 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.

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

Flow gauging was under taken by NIWA at two of the previously used sites (NIWA 1 and 3 on Map 1).

Map 1: Waikanae River Monitoring locations (C1, C2, R1, R2 and R3) and NIWA sites where flow gauging is undertaken.

2.2 Site Photos

Photo 1: Site C1, taken on 11th January 2016

Photo 2: Site C2, taken on 14th March 2016

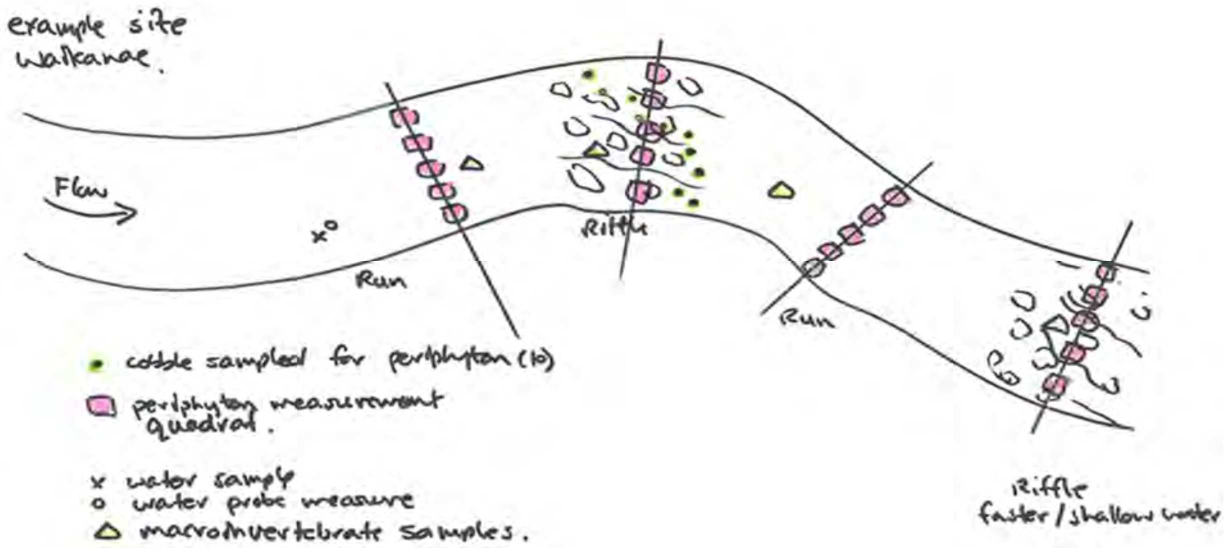
Photo 3: Site R1, taken on 29th March 2016

Photo 4: Site R2, taken on 18th April 2016

Photo 5: Site R3, taken on 18th April 2016

2.3 Survey Transect setup

A diagrammatic representation of the measurements undertaken at a site.



2.4 Monitoring methods

At each of the two control and three receiving sites the following parameters were measured, generally during fine weather and low-flow conditions (i.e., post-raised or flushing flow events). Full methods for this sampling programme are provided in Waikanae River BMP. In summary, the following parameters are required to be measured at each site in a set timetable (see Table 1) which is flow related (fortnightly sampling when river has a flow >1100L/s or else weekly when flows were <1100L/s).

1. Water chemistry and temperature:
   - pH;
   - Temperature (˚C);
   - Conductivity (µS/cm);
   - Dissolved reactive phosphorus (DRP, g/m^3);
   - Total phosphorus (TP, g/m^3);
   - Soluble inorganic nitrogen (SIN, g/m^3);
   - Total nitrogen (TN, g/m^3);
   - Nitrite nitrate nitrogen (g/m3)
   - Total ammonia (NH_4, g/m^3); and
   - Dissolved calcium (g/m^3).
2. Periphyton:
   - Potential hard bottom substrate available for periphyton growth is assessed;
   - Visual observations of percentage cover of periphyton at each site according to the Rapid Assessment Method (RAM) 1 & 2 methods of Biggs and Kilroy 2000; and

- Periphyton biomass, based on chlorophyll *a* measurements (B. J. Biggs & Kilroy, 2000), from multiple rock scrapings is collected from each site.

3. Benthic macroinvertebrates:
   - The macroinvertebrate community was sampled (at times relating to moderate/high periphyton abundance) 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 were calculated for each Surber sample: total abundance, taxonomic richness, Ephemeroptera, Plecoptera, Trichoptera (EPT) richness, EPT abundance, Macroinvertebrate Community Index (MCI), and the Quantitative Macroinvertebrate Community Index (QMCI).

Table 1. Sample activity by period for the current 2015-2016 Annual Report. Note samples are fortnightly unless flows < 1100L/S, macroinvertebrates are triggered by moderate/high periphyton biomass.

Period	Water Quality	Visual periphyton	Pooled Periphyton	Individual Periphyton	Macroinverteb rates
30th November – 4th December 2015	✓	✓	✓	Not required	Not required
7th – 11th December 2015	Flow above 1100L/s survey not required				
14th – 18th December 2015	✓	✓	✓	Not required	Not required
21st – 25th December 2015	✓	✓	✓	Not required	Not required
28th December 2015 – 1st January 2016	Christmas Break				
4th – 8th January 2016	Christmas Break				
11th – 15th January 2016	✓	✓	✓	Not required	Not required
18th – 22nd January 2016	Flow above 1100L/s survey not required				
25th – 29th January 2016	✓	✓	✓	Not required	Not required
1st – 5th February 2016	Flow above 1100L/s survey not required				
8th – 12th February 2016	✓	✓	Not required	✓	Not required
15th – 19th February 2016	✓	✓	✓	Not required	Not required
22nd – 26th February 2016	Flow above 1100L/s survey not required				
29th February – 4th March 2016	✓	✓	✓	Not required	✓
7th – 11th March 2016	✓	✓	Not required	✓	Not required
14th – 18th March 2016	✓	✓	✓	Not required	Not required
21st – 25th March 2016	✓	✓	✓	Not required	✓
28th March – 1st April 2016	✓	✓	✓	Not required	Not required
4th – 8th April 2016	✓	✓	✓	Not required	Not required
11th – 15th April 2016	Flow above 1100L/s survey not required				
18th – 22nd April 2016	✓	✓	✓	Not required	Not required
25th – 29th April 2016	Flow above 1100L/s survey not required				
2nd – 8th May 2016	✓	✓	✓	Not required	Not required

2.5 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 (monitoring period).

A non-metric multidimensional scaling (or NMDS) ordination[1] with 1000 random permutations, using abundance data, was used to determine if the macroinvertebrate community was similar among the five survey sites (C1, C2, R1, R2 and R3), and between sampling periods. 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 & Keough, 2002).

An analysis of similarities (ANOSIM), with 100 permutations, was then used to test for significant differences in macroinvertebrate community composition between particular dates. 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[2].

If ANOSIM revealed significant differences in macroinvertebrate community composition (i.e. $R \neq 0$ and $P \leq 0.05$) between the baseline sampling occasions, similarity percentages (SIMPER) were calculated[3] to show which macroinvertebrate taxa were driving these differences.

NMDS, ANOSIM and SIMPER analyses were performed in PRIMER version 6.1.

3.0 Water Quantity through the 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.

3.1 Rainfall and river flow

Weekly rainfall depths and average flow data during the summer of 2015-2016 is summarised in Table 2 and Figure 1.

---

[1] 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).

[2] 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).

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

Table 2. Background Waikanae rainfall and river flow records (data from GWRC) December 2015 to 4 May 2016

Week ending	7-day Rainfall (mm)	7-day average flow (L/s)	Week ending	7-day Rainfall (mm)	7-day average flow (L/s)
2/12/2015	44.7	6107	24/02/2016	66.4	6799
9/12/2015	1.5	5514	2/03/2016	0	2356
16/12/2015	25.9	3240	9/03/2016	2	1278
23/12/2015	5.1	2377	16/03/2016	13.5	1045
30/12/2015	0.5	2133	23/03/2016	9	989
6/01/2016	33.5	2721	30/03/2016	6.5	990
13/01/2016	11	2404	6/04/2016	57.5	5218
20/01/2016	29.6	2473	13/04/2016	18	2260
27/01/2016	5.5	1878	20/04/2016	0	1816
3/02/2016	0.5	1349	27/04/2016	5.1	1605
10/02/2016	0	1106	4/05/2016	5	1516
17/02/2016	5	1066			

Regular rainfall through the summer period helped to maintain river flows above the minimum flow threshold of 750 L/s.

Though there was a general flow recession, the rainfall meant that flows didn't drop to 1000 L/s until mid-February. Flows were then boosted by 66 mm of rain in the week ending 24 February 2016. Flows then dropped to below 1000 L/s during the latter part of March 2016, before flows recovered after 57 mm of rain in the first week of April 2016.

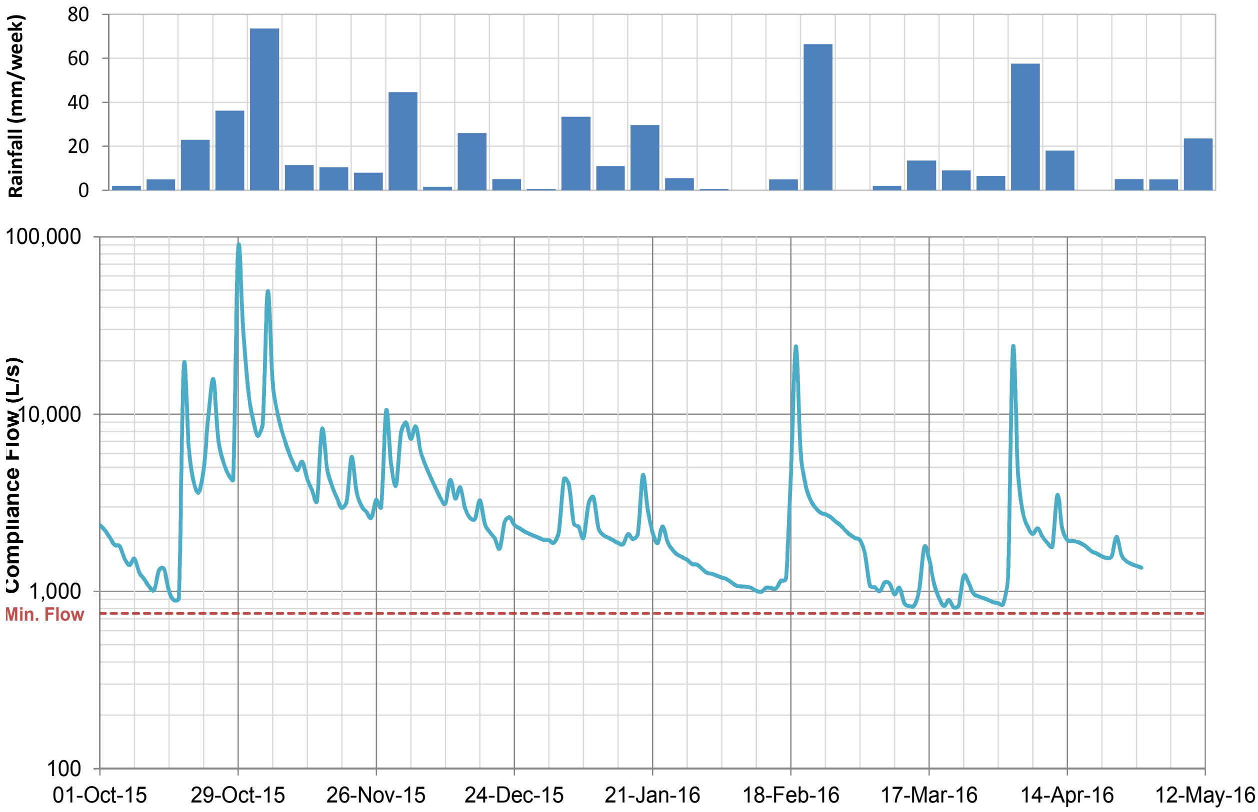


Figure 1: Weekly rainfall depths and recorded Compliance Flow at the Waikanae WTP

Flow gauging was carried out by NIWA at two locations downstream of the water treatment plant on five occasions (at approximately monthly intervals) between December 2015 and April 2016. These are reported in Section 6.

3.2 Abstraction

Figure 2 shows daily average abstraction from 1 October 2015 to 1 May 2016. During this period, the average abstraction was 12,853 m^3/day (149 L/s daily average), with a peak of 16,643 m^3/day (193 L/s). The peak abstraction occurred on 16 December 2015.

The average abstraction during 2015/2016 was higher than during the previous year, possibly reflecting generally higher river flows and no time with upstream flows below the abstraction threshold of 750 L/s. The peak abstraction during 2015/2016 was lower than the previous year. This may be due a wetter summer reducing water demand for activities such as garden watering.

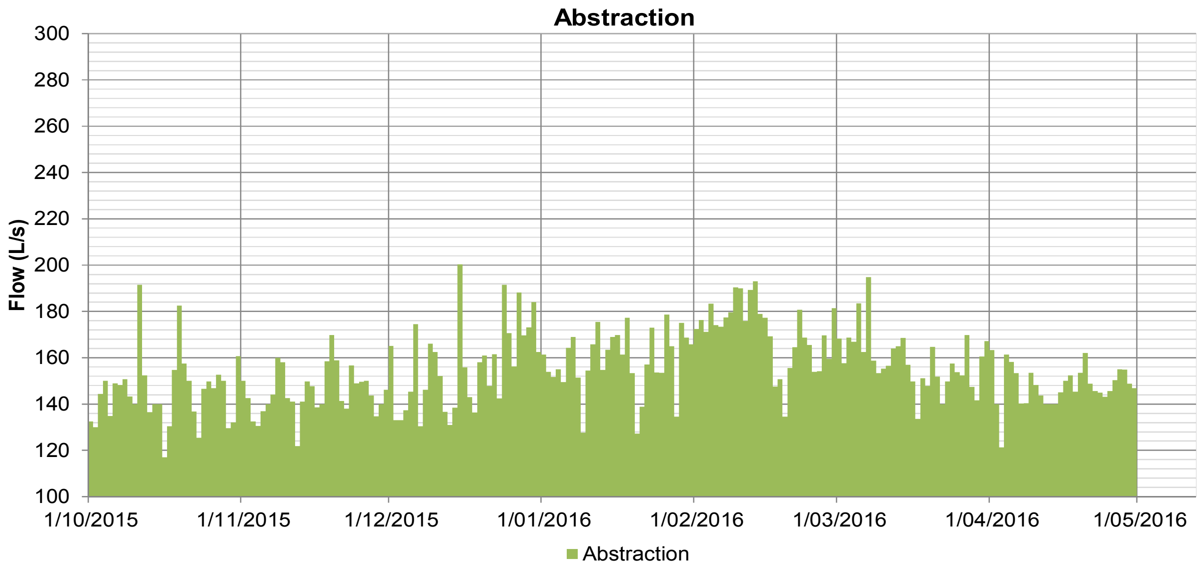


Figure 2: Waikanae River daily abstraction

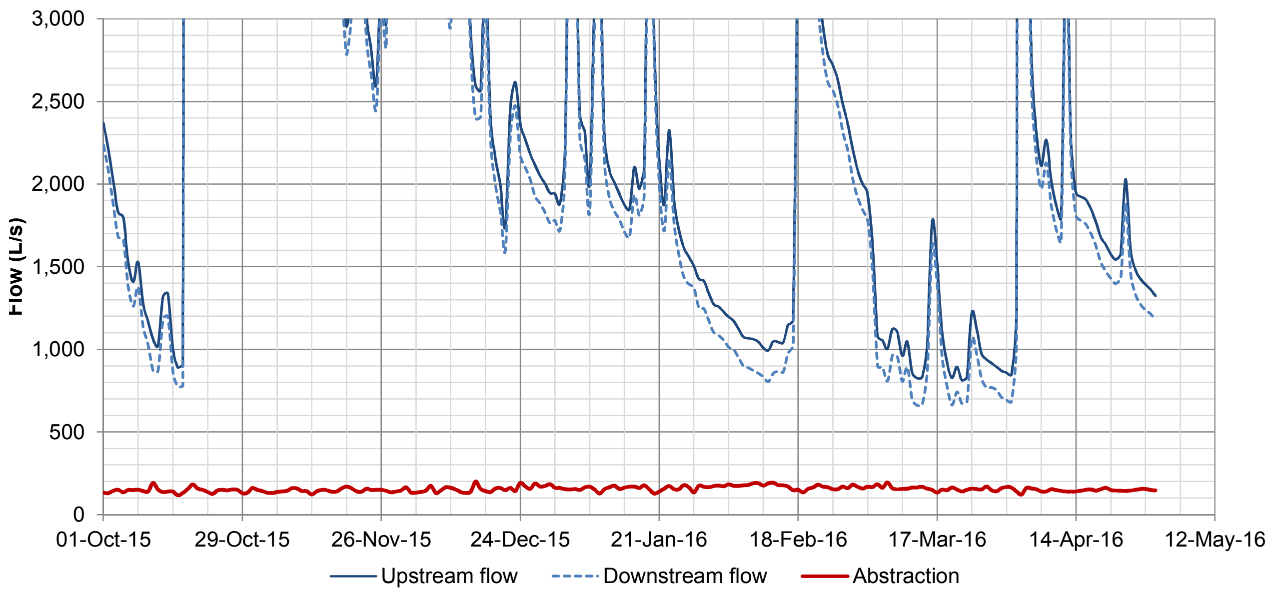


Figure 3: Waikanae River daily abstraction and calculated downstream flow

3.3 Water temperature

The water temperature of the Waikanae River has in the past been monitored and recorded by GWRC, this ceased on 19th December 2014. This means that it will not be possible to review the relationship between continuous water temperature and river flow during the summer flow recession. There are however, the weekly or fortnightly sampling measures and while not continuous these provide a window into water temperatures across the monitoring season.

3.4 River Recharge

Below are the dates when the Waikanae bore field was used for river recharge during the 2015-2016 monitoring period (December 2015 to April 2016):

- 12 to15 March 2016;
- 20 to 21 March 2016;
- 21 to 23 March 2016 and
- 30 March to 2 April 2016.

4.0 Shade and Substrate Quantity

This year (2015-2016) around 85% of the substrate within each 1m^2 quadrate along each of the five site transects were of sufficient size and hardness to support periphyton growth (Figure 4). The other 15% of the substrate was generally sands and/ or gravel.

Shading is as it was last season (no change), being largely absent at all monitoring sites. 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).

Average wetted width as of November 2015 is provided below, however please note wetted width of a river changes on a daily basis and is not re-measured each survey.

Table 3: Shade estimates

Transects	C1	C2	R1	R2	R3
Shading					
Riffle 1	10	0	0	0	0
Riffle 2	12.5	0	0	5	0
Run 1	10	0	0	0	0
Run 2	10	0	0	0	0
Average wetted width as of November 2015					
Riffle 1	10.5	10.2	15	11	10
Riffle 2	12.6	10.6	17.5	12.5	10
Run 1	13.1	13.1	23.2	10.2	20.3
Run 2	12.7	12.6	21	11.6	18.5

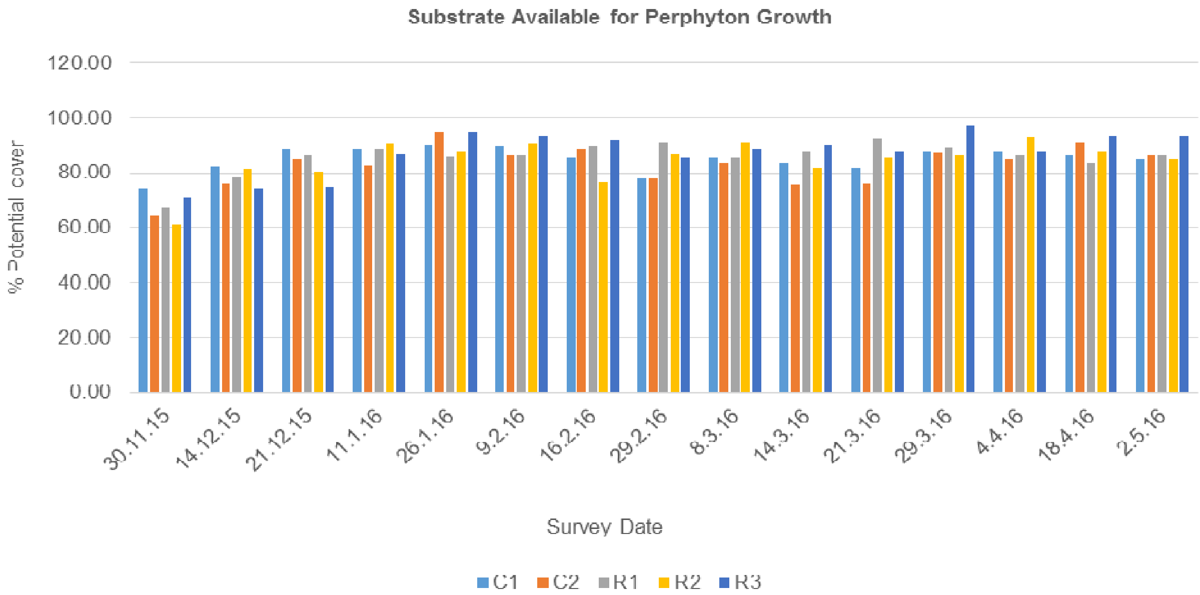


Figure 4: Average % potential substrate for algal growth per quadrate across monitoring sites on the Waikanae River.

5.0 Results

Throughout this report the sites are labelled as C1, C2, R1, R2 and R3. Reference to Map 1 may be required, but it should be remembered that C1 is the control site closest to the water treatment plant and C2 the upstream control site. R1, R2 and R3 are the sequence of downstream effect sites.

5.1 Water chemistry and temperature

Summary charts of water quality data are contained within the following sub-sections. Note that the data is not continuous, they are one point in time measures and plots are generally given as bar graphs.

5.1.1 pH

A raised spike in pH was recorded throughout March and in the first week of May (Figure 5) primarily for site R2. There are no discharging side streams, instream rubbish or other obvious source for change. Generally the values are within (even considering the raised values) “normal” levels. The remainder of the data shows a relatively stable pH at around 7.4.

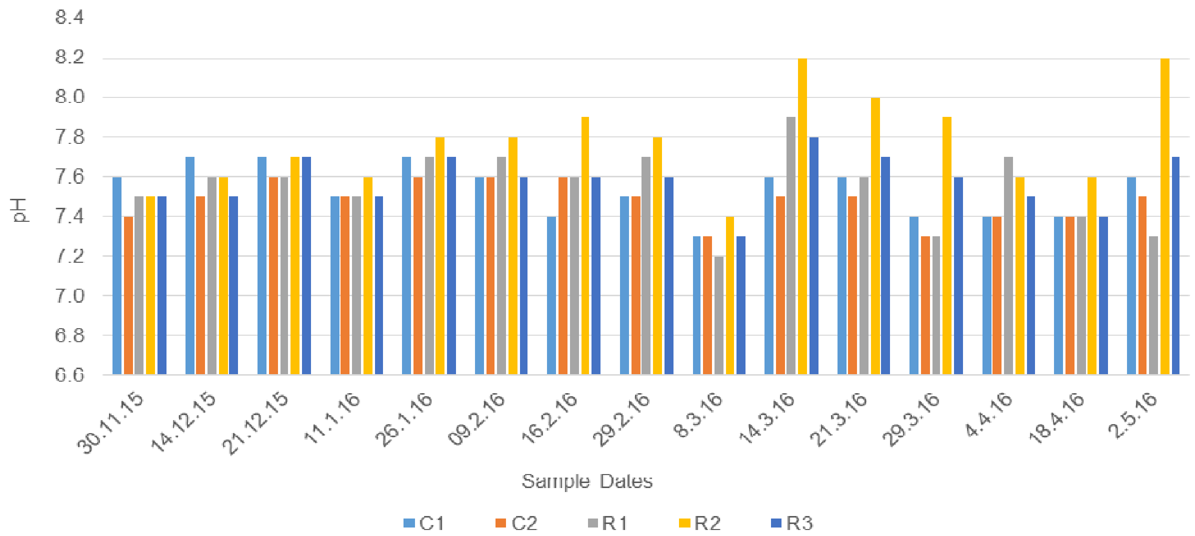


Figure 5: pH lab results across monitoring sites from December 2015 to May 2016 in the Waikanae River

5.1.2 Temperature

Water temperature varies throughout the day but the averaged trend from December through to May shows January and February to be the warmest months, at around 18 - 20°C. Temperatures decreased slightly in March to sit around 18°C. Each site was generally surveyed in the same order (with a few exceptions) during each sample period. Site R3 on most occasions was sampled first followed by R2, C2, C1 and R1. This consistent pattern of temperature change from low to high between sites R3 (coolest) and R1 (warmest) is evident in Figure 6 below and illustrates the daily temperature ranges.

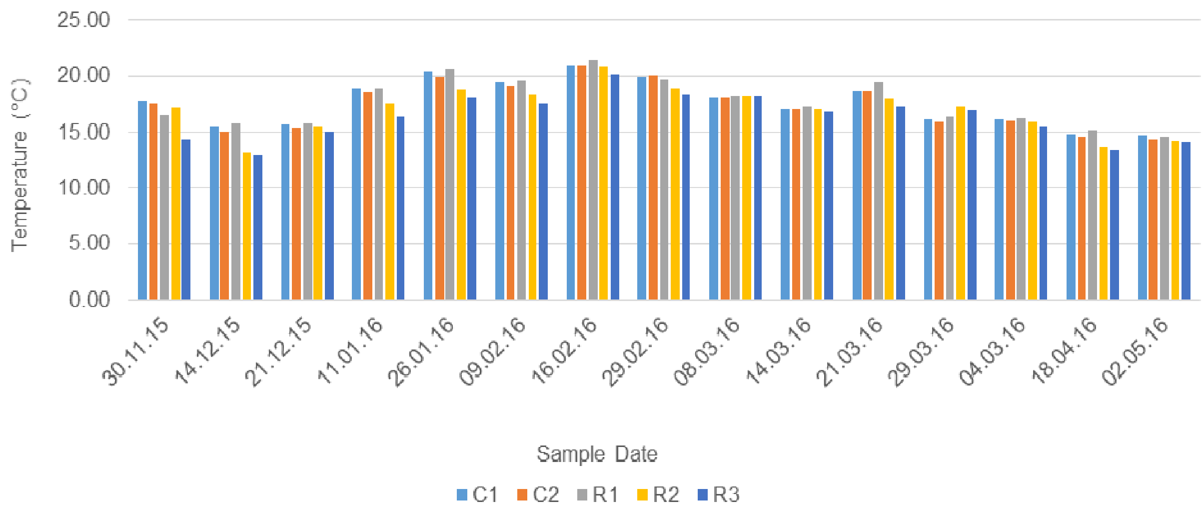


Figure 6: Temperature spot measures from December 2015 to May 2016 in the Waikanae River.

5.1.3 Conductivity

Results across all sites were generally similar, low and stable but for two exceptions. Conductivity increased slightly from around 10mS/m in December 2015 to nearly 12mS/m in mid-February 2016. Conductivity sat consistently around 11mS/m throughout February and March and dropped again towards the end of the monitoring season. Abnormal measures occurred in mid-March where 3 sites had high readings of around 17-18mS/m, which coincided with the river recharge in 12 to15 March 2015, and late March at site R3 (Figure 7) which coincides with the river recharge between 20 to 23 March 2015.

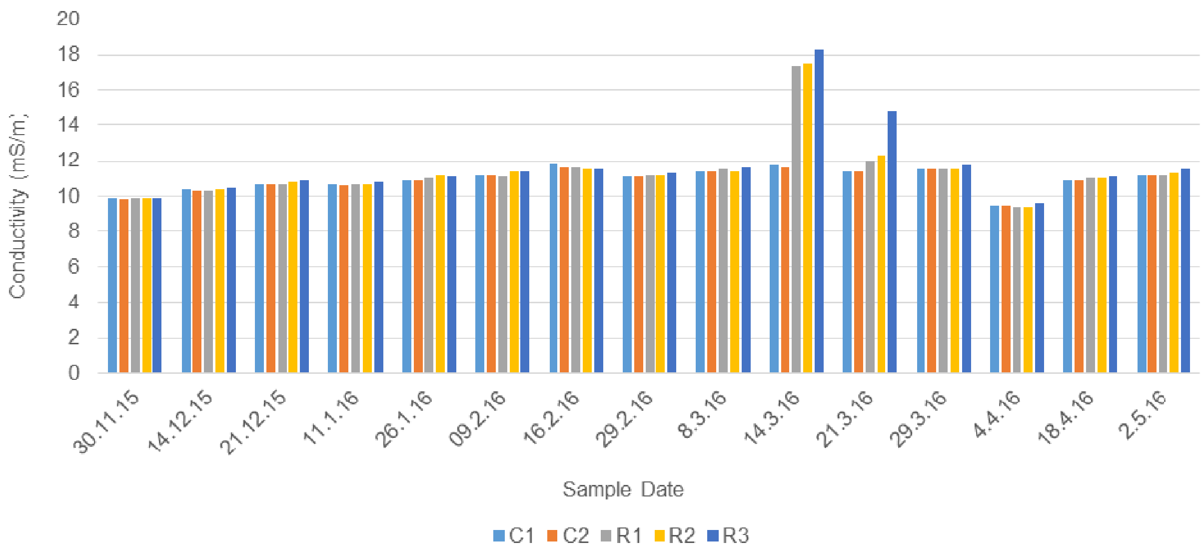


Figure 7: Conductivity spot measures from December 2015 to May 2016 in the Waikanae River

5.1.4 Total phosphorus

Total phosphorus was relatively low but fluctuated regularly throughout the monitoring season, generally between 0.010g/m^3 to 0.012g/m^3 (Figure 8), displaying no obvious trend or pattern. A few spikes are seen in mid-December and the start of April.

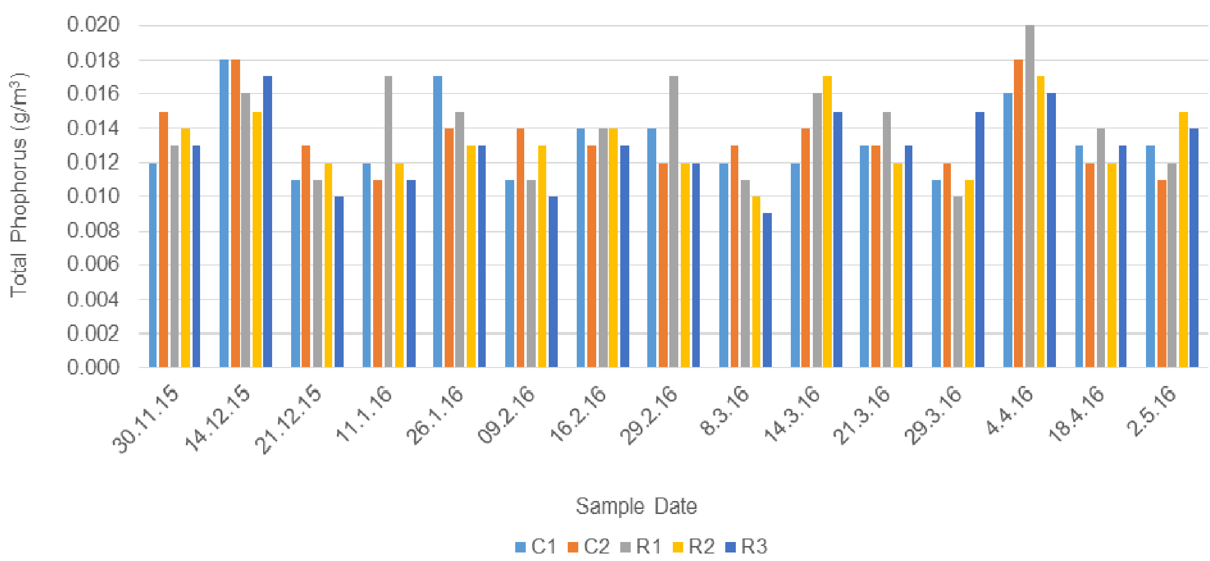


Figure 8: Total phosphorus measures across monitoring sites from December 2015 to May 2016 in the Waikanae River.

5.1.5 Dissolved reactive phosphorus (DRP)

DRP levels rose and dropped regularly throughout the survey period. One 'high' result was noted on 21st March 2016 for unknown reasons (Figure 9).

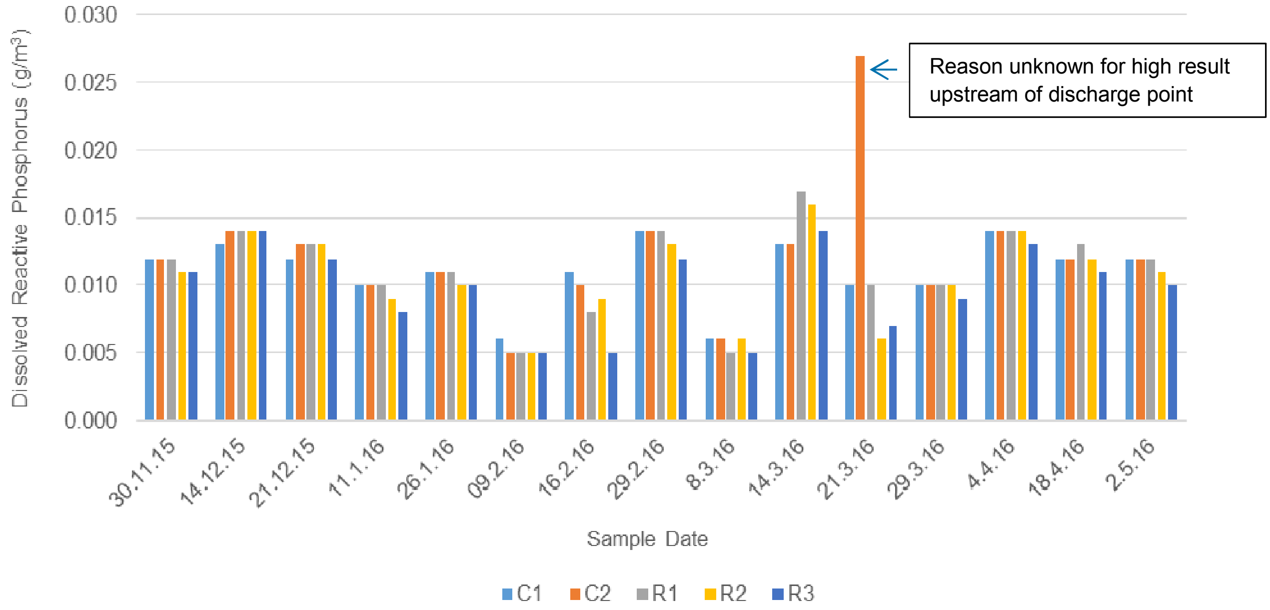


Figure 9: Dissolved reactive phosphorus results from December 2015 to May 2016 in the Waikanae River

5.1.6 Total Nitrogen

Total nitrogen levels oscillated throughout the season, peaking in March. One unusual 'high' reading occurred during the season on 18th April (over $0.45 g/m^3$ at R1). See Figure 10.

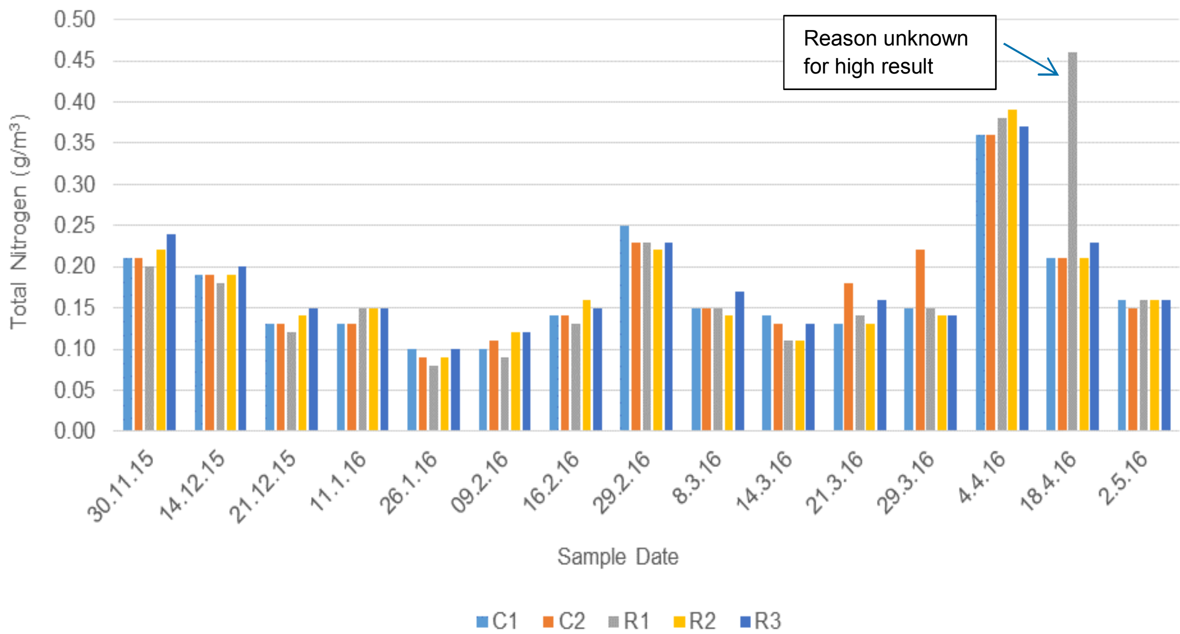


Figure 10: Total Nitrogen results across monitoring sites from December 2015 to May 2016 in the Waikanae River

5.1.7 Nitrite/Nitrate Nitrogen

Oscillating but low level nitrite-nitrate nitrogen levels were recorded throughout the monitoring season. However, a strong outlier sample result was received from the lab on 8th March regarding site R1 (Figure 11). The data received from the laboratory has been double checked and is correct. This abnormal sample result was 3.420g/m^3. A small increase in Nitrite/Nitrate Nitrogen also occurred mid-April reaching 0.350g/m^3. The red line across the R1 bar on 8th March indicates the actual data value is not shown on the chart.

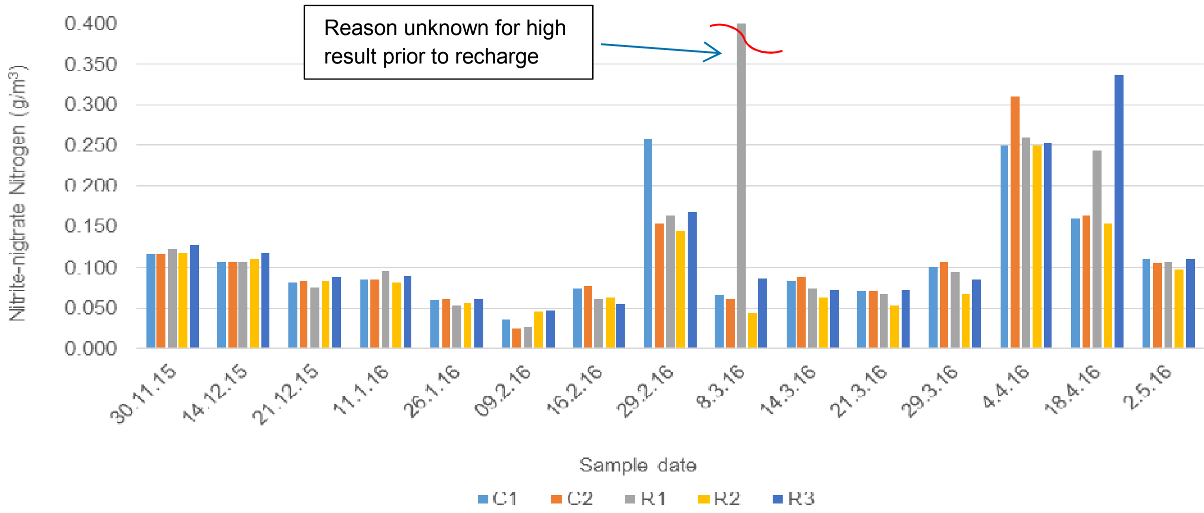


Figure 11: Nitrite/Nitrate Nitrogen measures from December 2015 to May 2016 in the Waikanae River.

5.1.8 Soluble Inorganic Nitrogen

Soluble inorganic nitrogen followed the same pattern as the nitrite/ nitrate nitrogen results above, with an anomalous reading on 8th March. Lab results returned a sample reading of 3.41g/m^3. The red line across the R1 bar on 8th March indicates the actual data value is not shown on the chart. A peak in soluble inorganic nitrogen levels also occurred across all sites at the end of February, in the first survey of April and at R3 on 18th April (Figure 12).

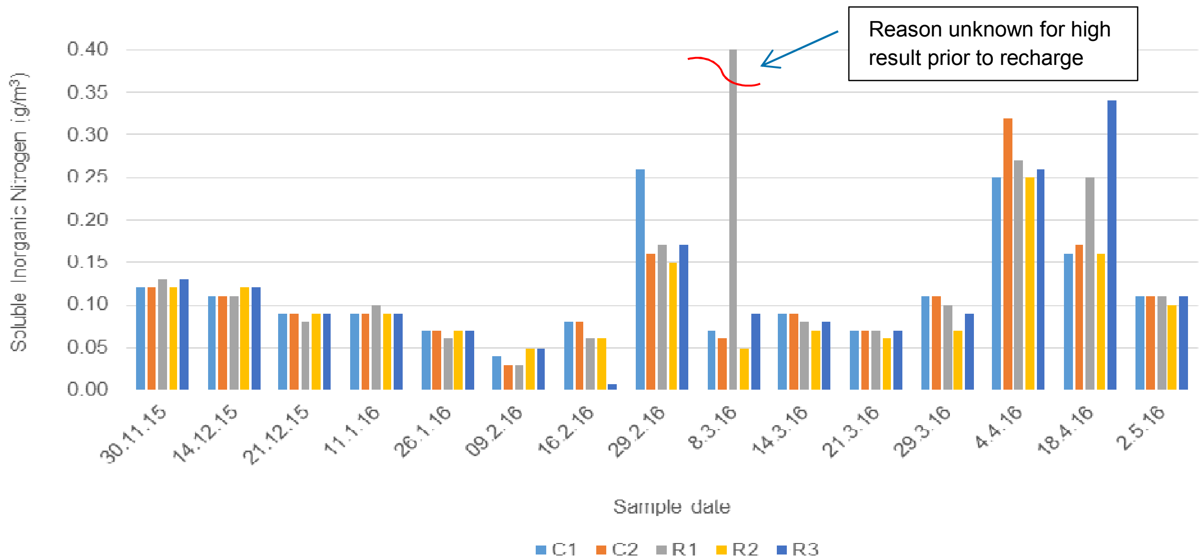


Figure 12: Soluble inorganic nitrogen measures from December 2015 to May 2016 in the Waikanae River.

5.1.9 Ammonia-Nitrogen

All measurements of ammonia nitrogen were <0.01, below the laboratory detection level.

5.1.10 Dissolved Calcium

Dissolved calcium was relatively stable throughout the monitoring period at around 5.0 g/m^3 (Figure 13).

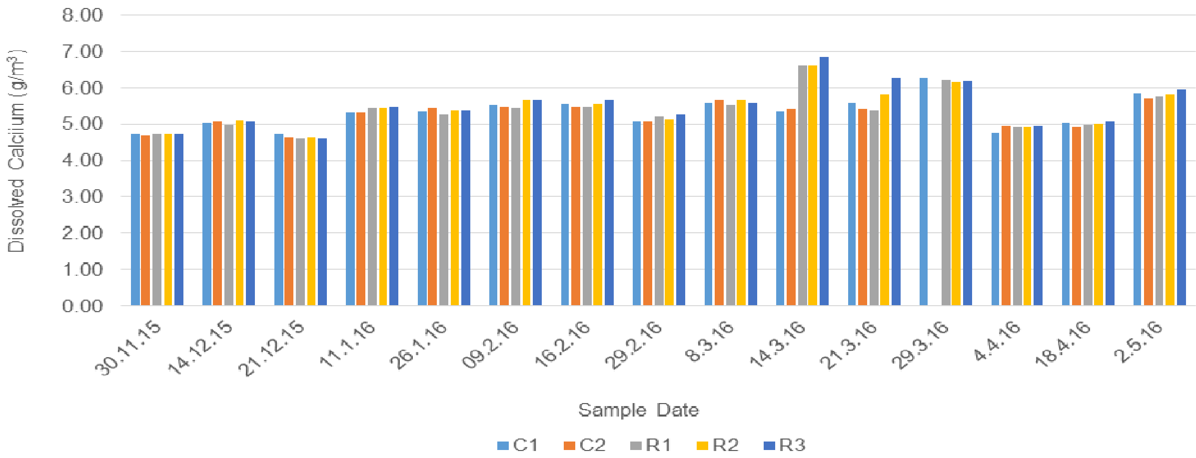


Figure 13: Dissolved calcium results from December 2015 to May 2016 in the Waikanae River.

5.1.11 Summary

Water chemistry across the sites was similar in general, but does contain some visible oscillations across the five months of monitoring; which moves the data away from producing trends. The key variations from the norm are listed below:

- There was a difference in pH value for site R2 in every survey in comparison to the other sites;
- Conductivity peaked on 14th March at all treatment sites (R1-R3);
- Both nitrite/ nitrate nitrogen and soluble inorganic nitrogen results showed an anomaly on 8th March;
- Higher results were seen in general for April in all three nitrogen analyses;
- DRP remains relatively high throughout the season; and
- There are no statistical differences between sites.

5.2 Periphyton

5.2.1 Periphyton Visual Assessments

Visual periphyton cover measures were taken from four across-river transects (in two runs and two riffles) and five quadrats per transect at each survey. The percentage cover on the hard substrate available for periphyton attachment was generally around 85% of the bed. The cover reported in the following graphs is the cover of that hard substrate available, not the total bed (remaining 15% gravel and/ or sand substrate).

Five graphs are presented: the first is the averaged cover of thin periphyton growth at each site (Figure 14); the second is the averaged medium periphyton mat cover per site (Figure 15); the third is the averaged thick periphyton growth present at each site (Figure 16); the fourth is the averaged filamentous periphyton growth across all sites (Figure 17); and in the fifth periphyton average cover in riffle and run habitat is shown (Figure 18).

There were several occasions of thick periphyton growth towards the end of the monitoring season when rainfall was low, air temperatures were high, and water levels in the Waikanae River were low.

Thin periphyton was present on most run substrate, at any time in high percentages, however other periphyton classes (medium, thick and filamentous) where consistently found to be growing in higher densities in riffle habitat. Thin periphyton was present across all habitat substrate, however due to the thick layers of filamentous algae above, this could not always be recorded.

Thick black algae increased at sites R3, R2 and C1 in the months of February and March to between 15% and 25% cover. February and March had consistently medium - high levels (5%-12%) of black algae as well as the single survey in May. Thick black and filamentous green algae were removed from rock surfaces after heavy rainfall events.

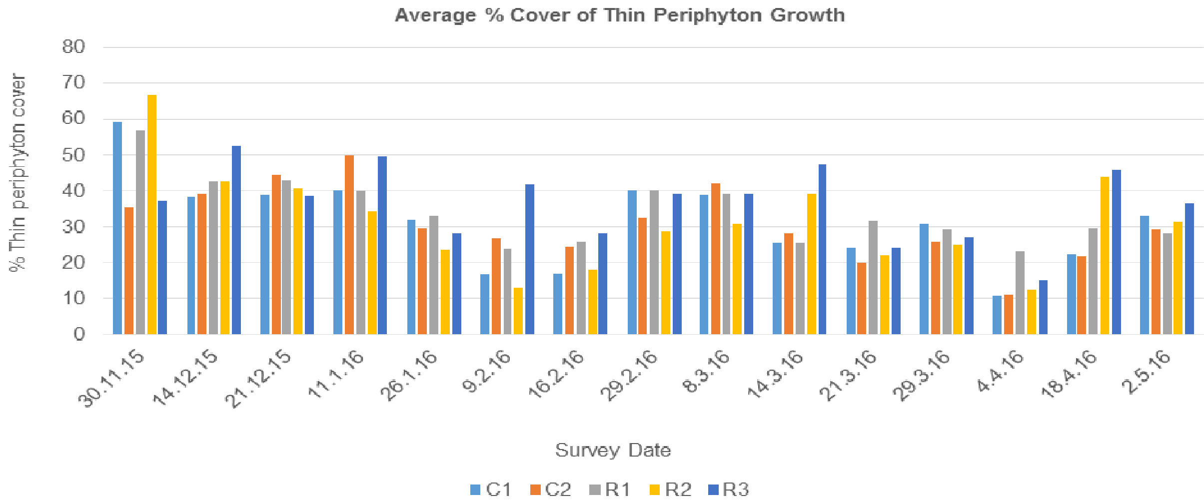


Figure 14: Average cover of thin film/ mat algae per quadrate across monitoring sites on the Waikanae River.

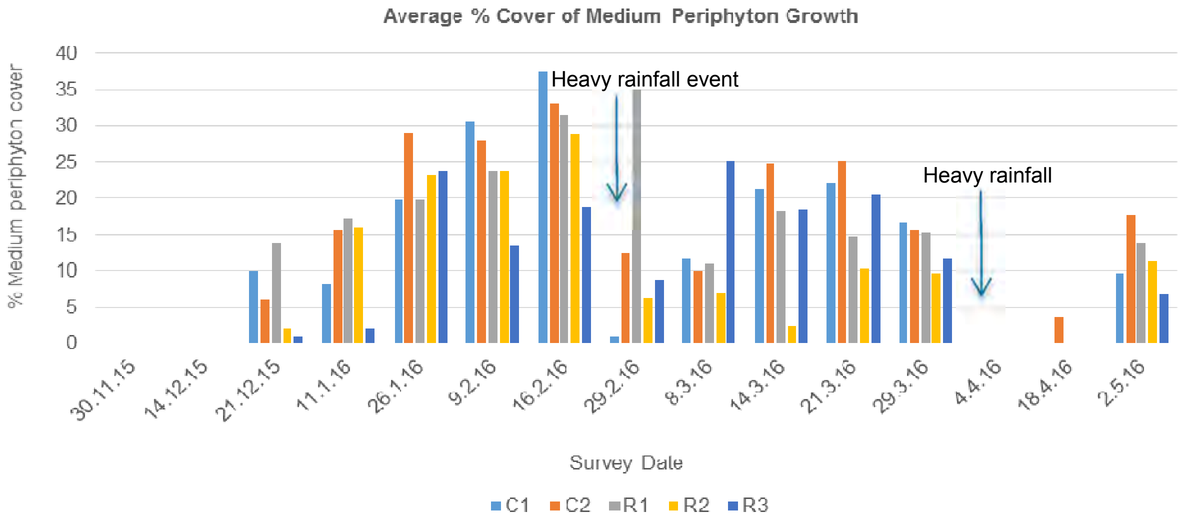


Figure 15: Average cover of medium film/ mat algae per quadrate across monitoring sites on the Waikanae River.

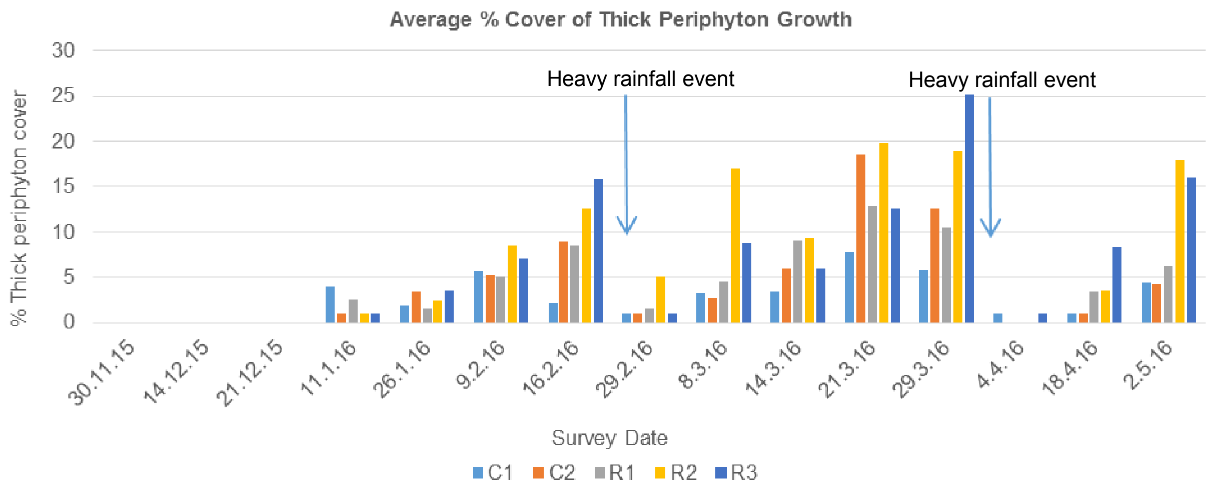


Figure 16: Average cover of thick periphyton growth at each site on the Waikanae River throughout the monitoring season.

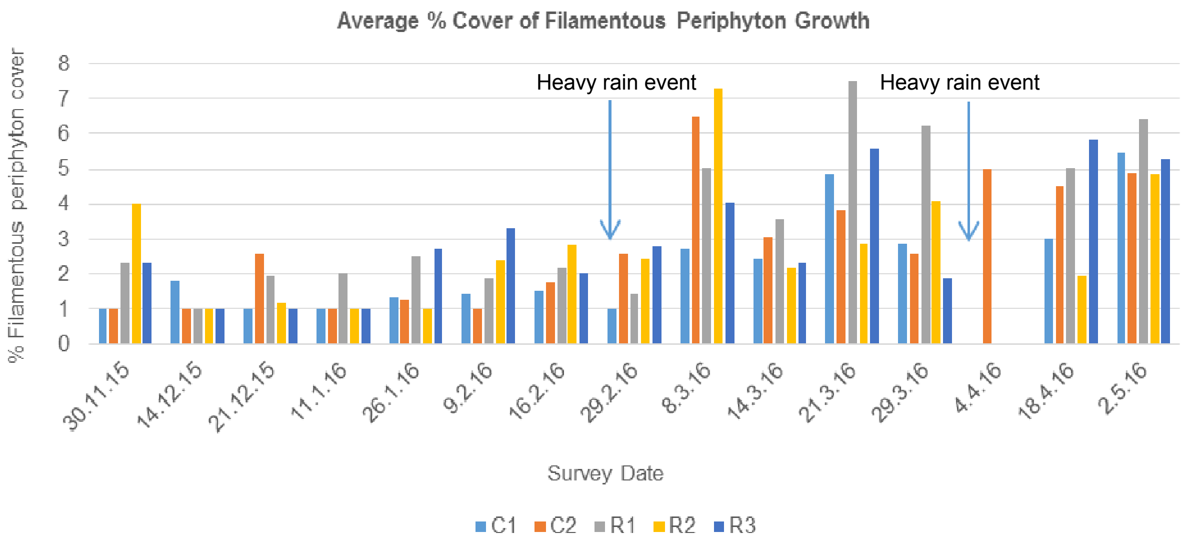


Figure 17: Average cover of filamentous algae growth at each site on the Waikanae River.

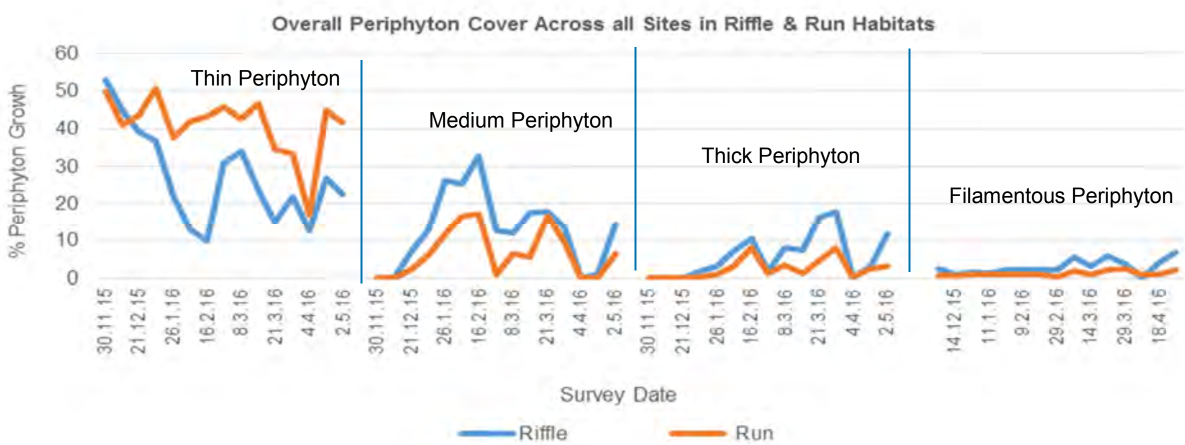


Figure 18: Periphyton cover differences across all monitoring sites on the Waikanae River in riffle & run habitats.

5.2.2 Periphyton Indices

Weighted Composite Cover (WCC) is a measure of periphyton abundance in terms of the stream bed covered (%) by two forms of periphyton; mats and filaments (Matheson, Quinn, & Hickey, 2012). While the New Zealand Periphyton Guideline (B. J. F. Biggs, 2000) provides separate aesthetic impact guidelines for identifying nuisance periphyton filamentous (≥30%) and mat (≥60%) cover, a composite cover guideline is useful for instances where both filamentous growths and mats occur (Matheson et al., 2012).

The WCC was calculated as %filamentous cover + (%mat cover/2) with an aesthetic nuisance guideline of ≥30% (Figure 19). Provisional general guidelines of <20%, 20-39%, 40-55% and >55% periphyton weighted composite cover are recommended as indicators of 'excellent', 'good', 'fair' and 'poor' ecological condition, respectively, at sites where other stressors are minimal (Matheson et al., 2012).

Most sites throughout the season had WCC weighting between 30-45% (good to fair ecological condition). No sites breeched the poor ecological condition with >55%, however some came close. Some sites throughout March almost reached 50% and sites C1 and R3 surpassed 50% twice. The last survey in May brought the highest and most consistent readings with all sites sitting on or above 50%.

The PSI is a biomass indices called periphyton "Sliminess" indices (Figure 20). The formula is based on percent cover for each thickness category (i.e., all colour categories combined). The PSI was calculated as PSI = {(%Thin mat/film) + (%Short filaments * 2) + (%Medium mat * 3) + (%Long filaments * 4) + (%Thick mat * 5)} / 5.

PSI increased gradually from 10 at the first survey on November 30th to around 40 in mid-February. PSI dropped to 10 again after each heavy rain event (19th February & 2nd May) which is related to the loss of medium, thick and filamentous algae after increased water flow.

.

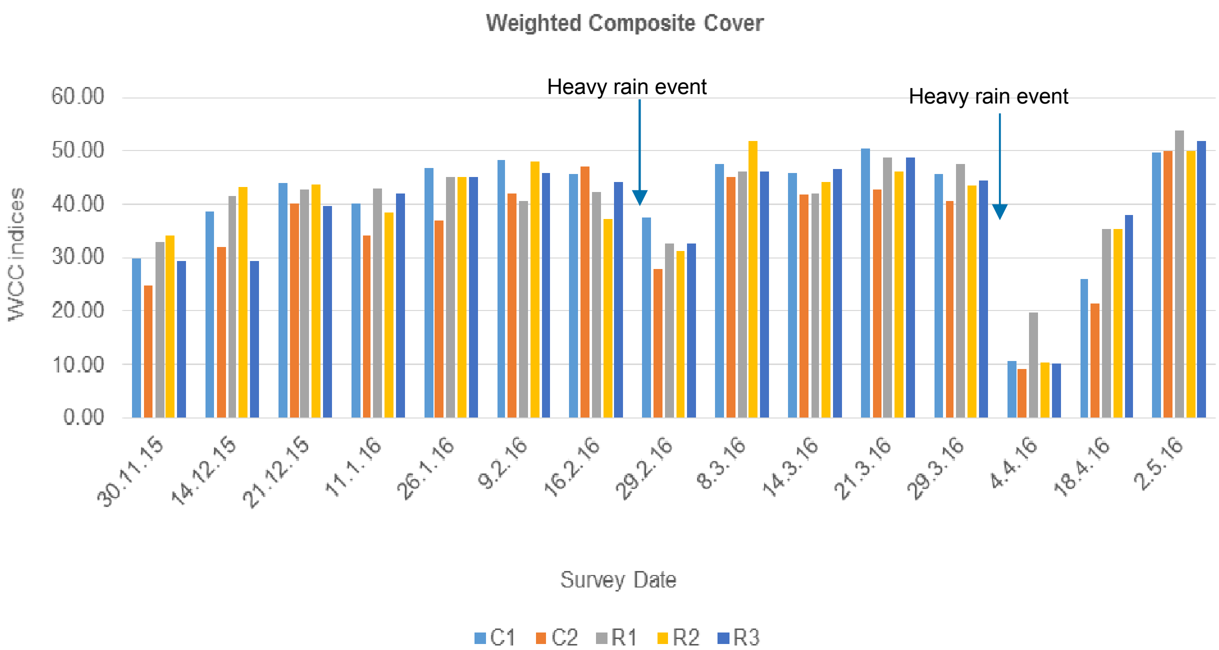


Figure 19: Weighted composite cover at all monitoring sites throughout the monitoring period December to May

Condition 19(c) [33761] requires investigation into the composite cover level of periphyton upstream and downstream of the recharge activities, and comparing the upstream and downstream sites to see if there are any effects on the rivers ecology that could be used to set on going triggers. The one exceedance occurred on the 18 April 2016 were all three downstream sites exceeded 30% PeriWCC cover and both upstream sites did not, this is a cease trigger under Appendix 2A of consent WGN130103. The cease trigger action requires ground water discharge to the river to be stopped immediately until the biomass reduces. There has been no river recharge since 2 weeks prior to this exceedance. The PeriWCC sample taken following this instance indicates that the growth is not a direct result of river recharge as all site have a similar high level of growth as shown in Figure 19 above.

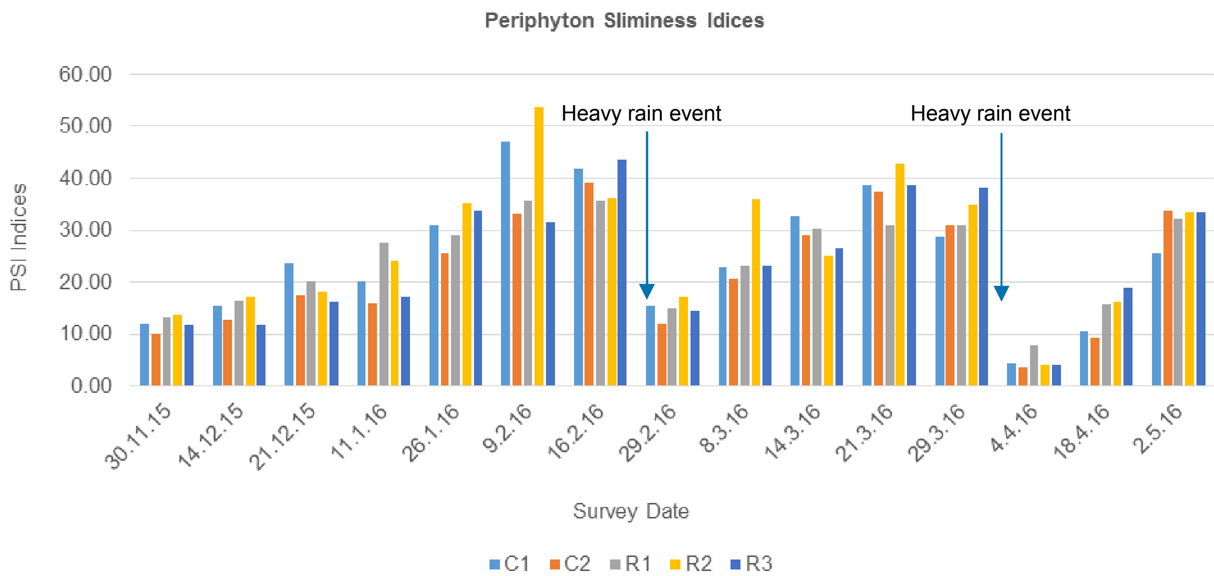


Figure 20: Periphyton sliminess indices at all monitoring sites throughout the monitoring period December to May

5.2.3 Quantitative Periphyton Measure – Chlorophyll-*a*

Chlorophyll-*a* is a pigment present in large quantities in most algae to enable photosynthesis. Chlorophyll-*a* is extracted from periphyton samples using an organic solvent (usually ethanol or acetone), and the concentration of chlorophyll *a* is then measured in a spectrophotometer. This gives a relative measure of autotrophic biomass (Matheson et al, 2012).

The Biggs (2000) guide delimits oligotrophic and eutrophic waterbodies as containing chlorophyll *a* bounds of 60mg/m^2 and 200 mg/m^2. The Manawatu Wanganui Regional Council recommends periphyton biomass standards of < 100mg/m^2.

The highest reading occurred on 8th March with R2 reaching almost 450 mg/m^2 (bar axis displays results up to 200mg/m^2). Six out of the fifteen survey times resulted in readings over 100mg/m^2. Three of these sample dates contained control sites over 100mg/m^2 (Figure 21).

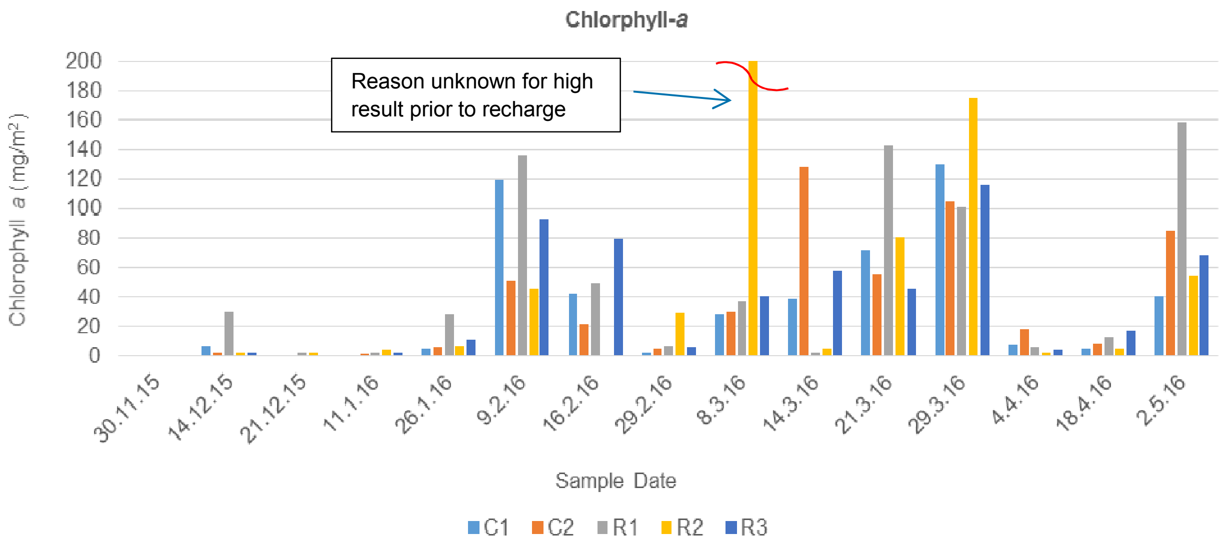


Figure 21: Average chlorophyll a (mg/m²) at each site from December to May at Waikanae River

The interim trigger relating to Condition 19b (chlorophyll a) was exceeded 3 times in the monitoring period. This condition requires investigation into the biomass of chlorophyll upstream and downstream of the recharge activities, and comparing the upstream and downstream sites to see if there are any effects on the rivers ecology. One of the exceedances was attributed to an erroneous data point (8 March). Of the remaining two; one occurred on 21 March 2016) while river recharge was taking place and the other occurred a month after the last river recharge for 2015/16 occurred on 2 May 2016. Appendix 2A of consent WGN130103 [33761], requires that groundwater discharge to the river is ceased immediately when a Chlorophyll a biomas exceeds 120mg/m³ (and not exceeded at any upstream monitoring site) as per the two instances above. Due to the laboratory processing time the samples taken on 21 March results were not available till after recharge was already ceased on the 23 March. The second exceedance on 2 May 2015 was the last sample from the monitoring period and the most recent river recharge occurred a month prior. No river recharge has occurs since.

5.2.4 Periphyton Species Richness & Community Composition

Both months sampled had a similar number of taxa making up the periphyton community (15 and 14 for February and March respectively).

Both February and March samples contained the same taxa of filamentous green algae (*Mougeotia* and *Stigeoclonium*) and Cyanobacteria (*Oscillatoria*/*Phormidium* and *Rivularia*).

The majority of diatoma taxa present in both samples were the same with a few exceptions; February had in addition *Achnanthidium,* and March samples contained *Gomphonema* and *Naviculoid* diatoms which February did not.

Filamentous red algae was found in very small quantities in February at site R3 (Table 4).

The periphyton group which causes most human and animal health issues (Cyanobacteria) were represented in the Waikanae River monitoring sites by two taxa (*Oscillatoria/ Phormidium* and *Rivularia*). These two taxa were the most frequently sampled and also had the highest density overall at every site including controls from both sample periods.

Relative abundance of periphyton taxa for February and March is shown in Figure 22 and Figure 23.

Table 4: Averaged relative abundance data for each site comparing February 2016 and March 2016

Taxa	C1		C2		R1		R2		R3	
	Feb	March	Feb	March	Feb	March	Feb	March	Feb	March
Filamentous green algae										
Mougeotia	2	2	4	9	6	13	5	10	10	0
Stigeoclonium	3	5	4	7	0	7	3	2	0	16
Filamentous red algae										
Audouinella	0	0	0	0	0	0	0	0	1	0
Cyanobacteria										
Oscillatoria/Phormidium	21	7	26	11	20	20	23	21	26	7
Rivularia	19	1	11	0	6	2	7	2	10	4
Filamentous diatoms										
Fragilaria	0	0	0	0	0	0	0	0	1	0
Melosira	4	0	4	0	5	6	8	7	6	0
Diatoma	0	0	0	0	0	0	0	1	0	0
Diatoma										
Achnanthidium	2	0	4	0	0	0	4	0	8	0
Cocconeis	1	1	0	1	1	0	0	4	2	0
Cymbella	4	2	10	2	7	5	5	10	8	3
Frustulia	2	0	3	1	3	2	3	5	6	0
Gomphoneis	5	2	5	1	2	3	0	11	0	0
Gomphonema	0	0	0	2	0	3	0	0	0	1
Naviculoid diatom	0	1	0	5	0	2	0	2	0	3
Nitzschia	0	1	1	2	2	1	0	1	6	2
Pinnularia	0	0	0	0	1	0	0	0	0	0
Synedra	0	1	2	0	1	3	0	5	2	6

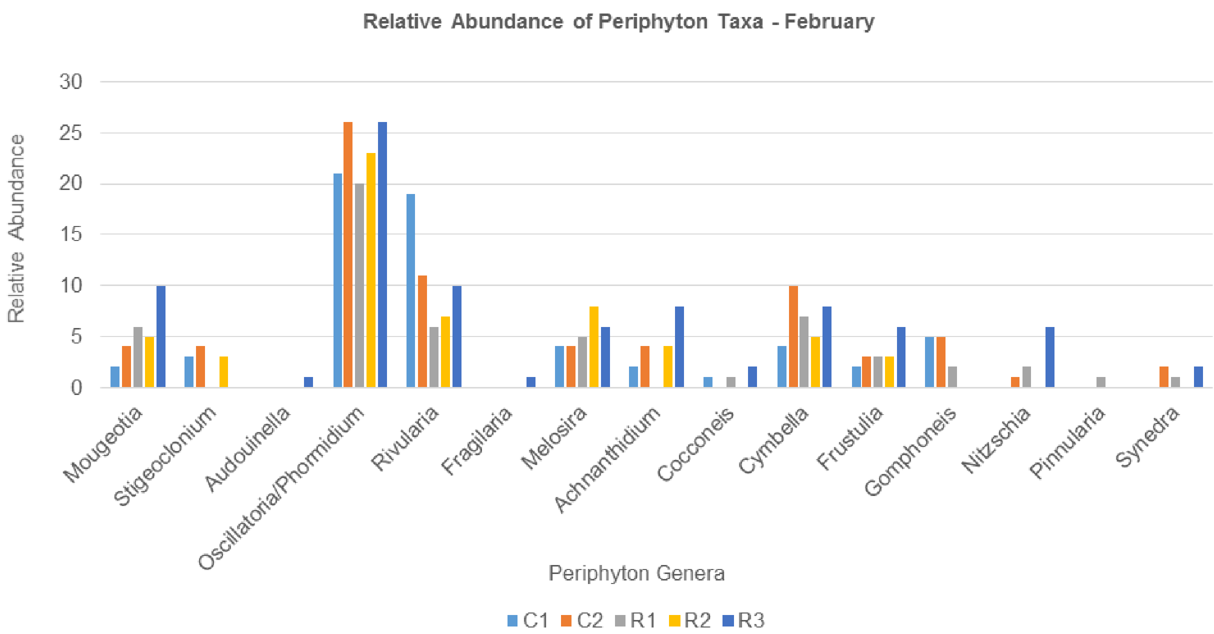


Figure 22: Periphyton taxa across the sites in the Waikanae River in early February 2016

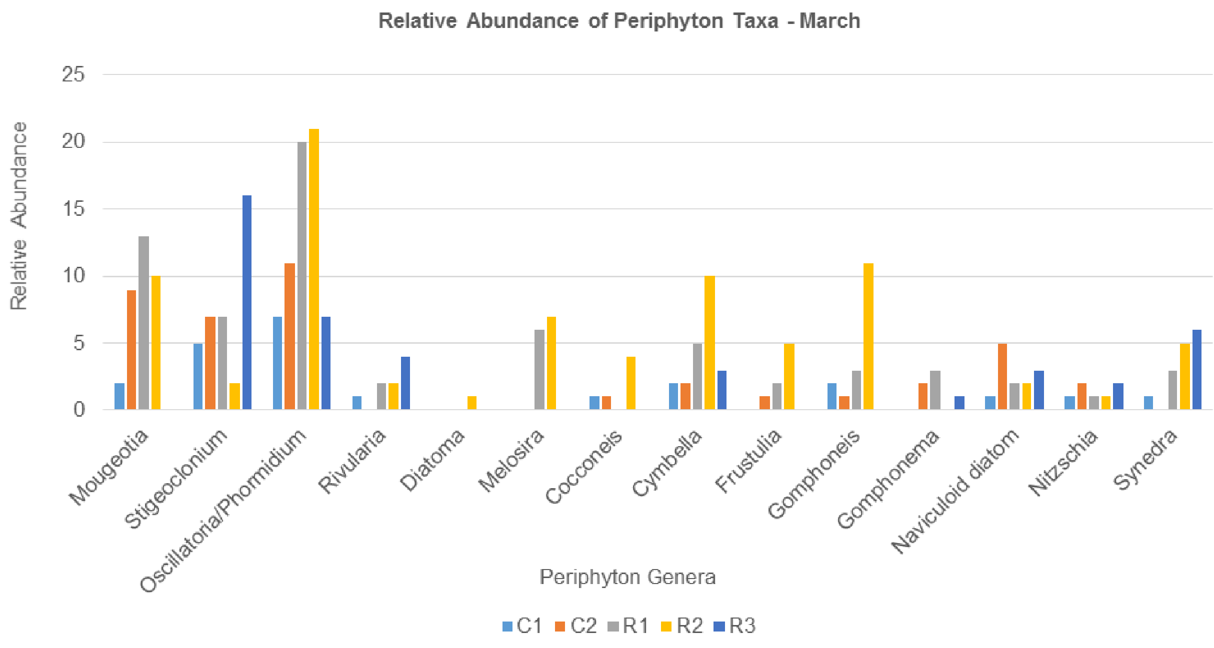


Figure 23: Periphyton community compositions in Waikanae River in early March 2016

5.3 Macroinvertebrates

The Waikanae River BMP proposes to sample macroinvertebrates either: (a) in a sequence after a flushing flood, or (b) throughout the summer-autumn period at three difference stages of periphyton growth (low, moderate and high).

It was considered at the start of the 2015/2016 monitoring season that sufficient information had been gathered in the previous 2014/2015 monitoring period to establish low - medium periphyton growth and macroinvertebrate conditions and relationships to this. The objective of the 2015/2016 monitoring season was to take two samples of benthic macroinvertebrates at times and in locations with high densities of periphyton growth.

As noted in Section 3.2, two flood events occurred during the monitoring period (19th February and 2nd April). Both events caused the periphyton levels, which were high prior to flooding, to drop to low levels. Both macroinvertebrate samples were taken immediately prior to the flood events in what for the Waikanae River appears to be relatively high periphyton cover, but in both cases the cover, while developing, was still only around 20%.

5.3.1 Macroinvertebrate Community Indices & Indicator Metrics

Five metrics are used to describe and compare the macroinvertebrate communities sampled. Each sampling occasion involved five replicate samples per site and so are a good spatial representation of each habitat type and are sufficient for reasonable statistical requirements. The following graphs present the averaged data for the five parameters required to be reported (abundance, taxa richness, EPT taxa richness, MCI and QMCI).

5.3.1.1 Average abundance of all macroinvertebrates

Averaged abundance was slightly raised in the “reaction sites (R)” compared to the “control” (C) sites, with the two monthly periods being similar (Figure 24). Site R1 had the highest total abundance and C1 the lowest in both sampled months.

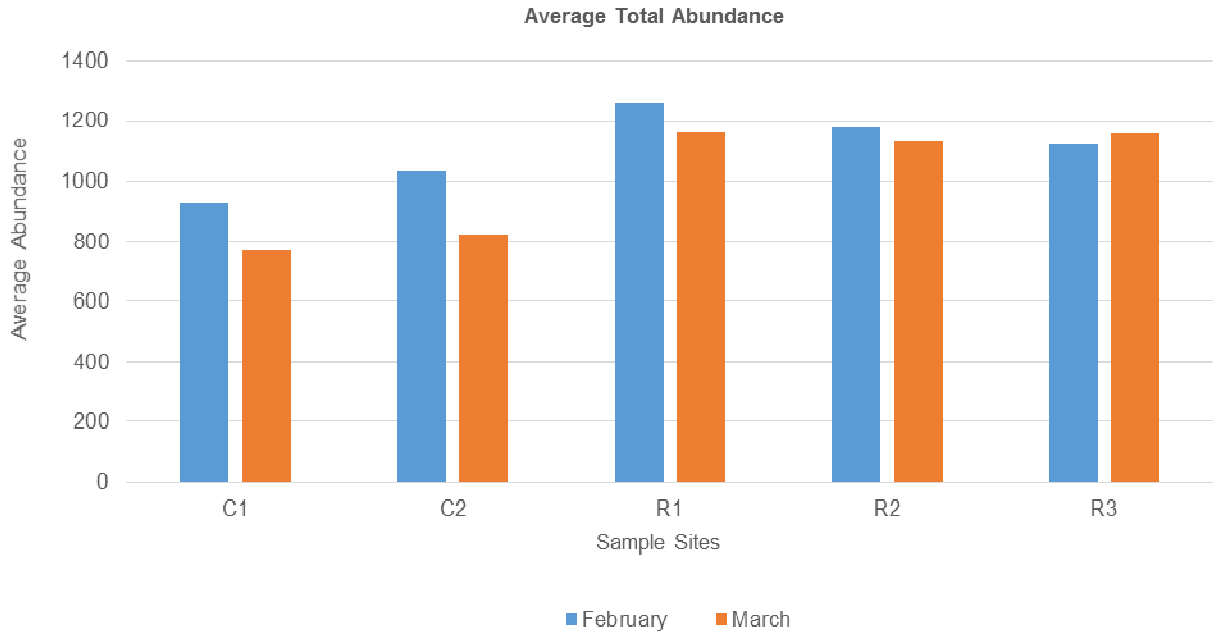


Figure 24: Averaged total abundance in February and March (2016) across all five monitoring sites at Waikanae River.

5.3.1.2 Taxa Richness

There was little difference between sites in taxa richness. Taxa richness was highest at site R1 (28 taxa) and lowest at R3 (21 taxa) (Figure 25). The month of sampling made no difference.

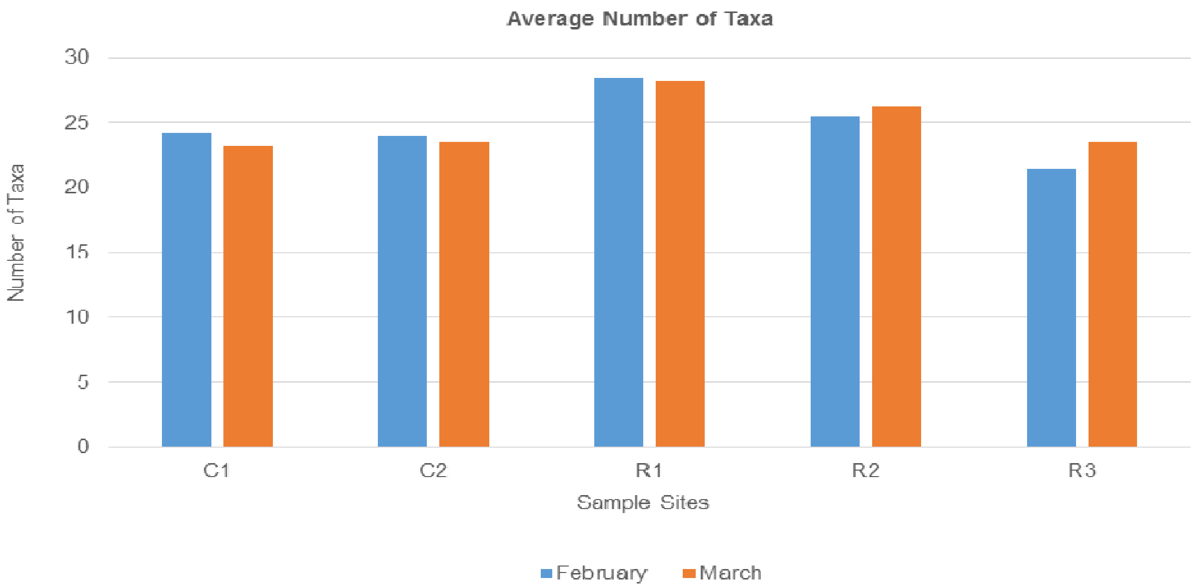


Figure 25: Taxa richness in February and March (2016) from all samples in the Waikanae River.

5.3.1.3 EPT Taxa Richness

The EPT taxa richness was similar between 11 and 16, with a slight reduction from February to March samples (Figure *26*). R1 had the highest and R3 the lowest number of EPT taxa.

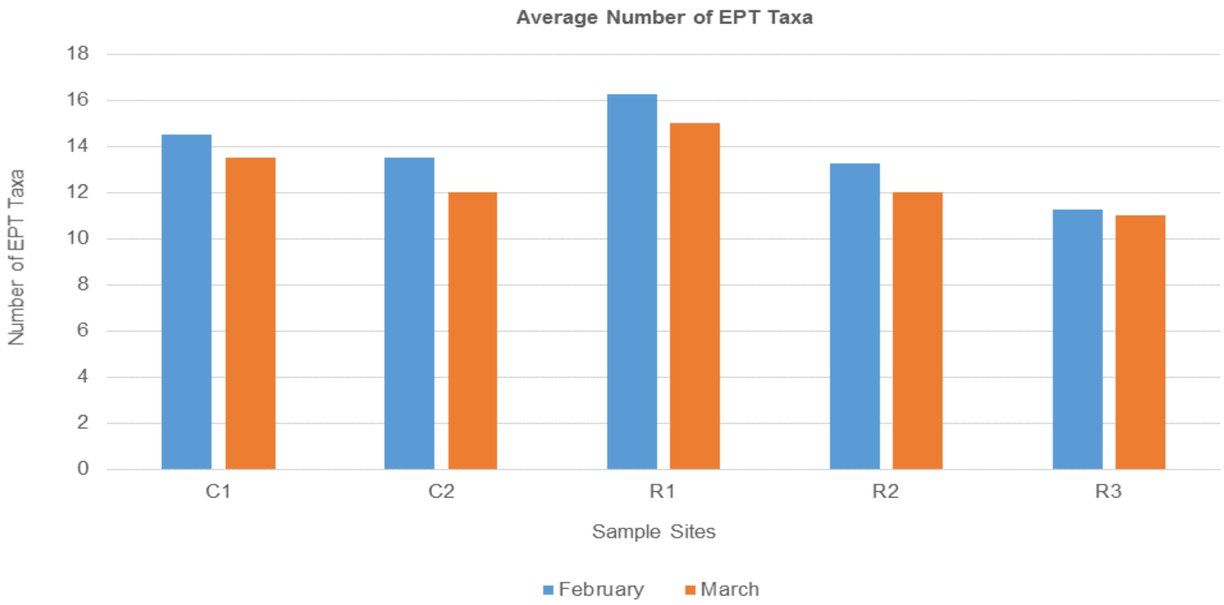


Figure 26: Average number of EPT taxa in February and March (2016) from all samples in the Waikanae River.

5.3.1.4 MCI

The MCI values are relatively high and generally fall into the “Good” (100-119) to “Excellent” (>119) quality thresholds (Stark & Maxted, 2007) (Figure 27). However, there appears to be a substantive difference between the sites. MCI measures were higher at the control sites than at the treatment sites. R1 had a very low comparative MCI score considering it previously ranked highest in EPT taxa, taxa richness and total abundance. March communities scored generally a little higher than February.

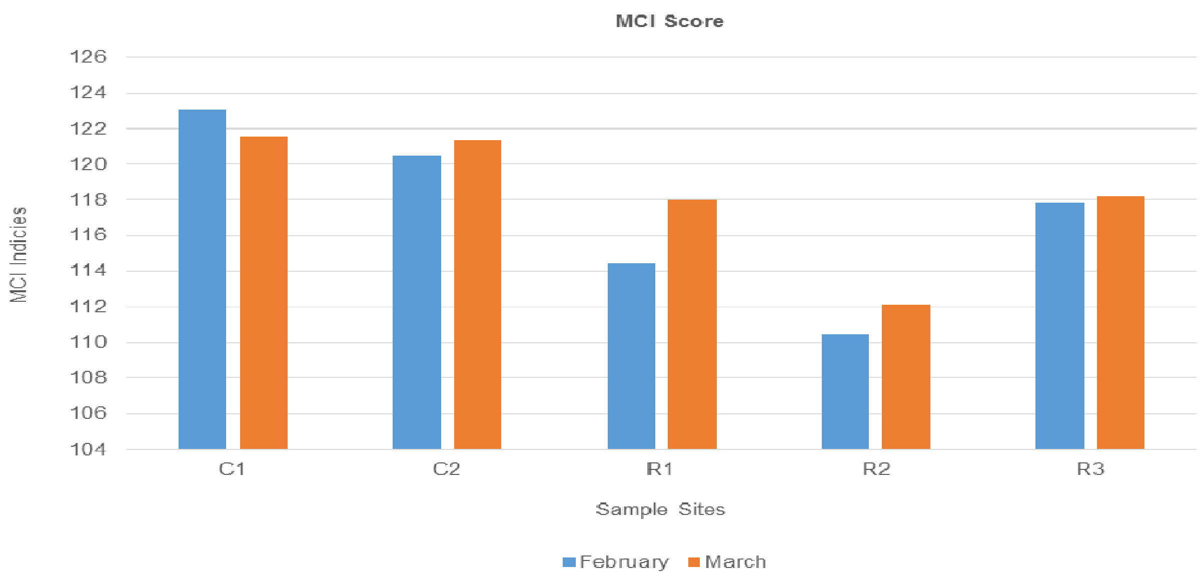


Figure 27: Averaged MCI in February and March (2016) from all samples in the Waikanae River.

5.3.1.5 QMCI

As with the MCI, the QMCI indices scores are generally high and suggest a healthy community and "excellent" water quality throughout (Figure 28). Both R1 and R2 sites had the lowest QMCI. Between months there was little variation except at C2 where the March result was much higher than the February one.

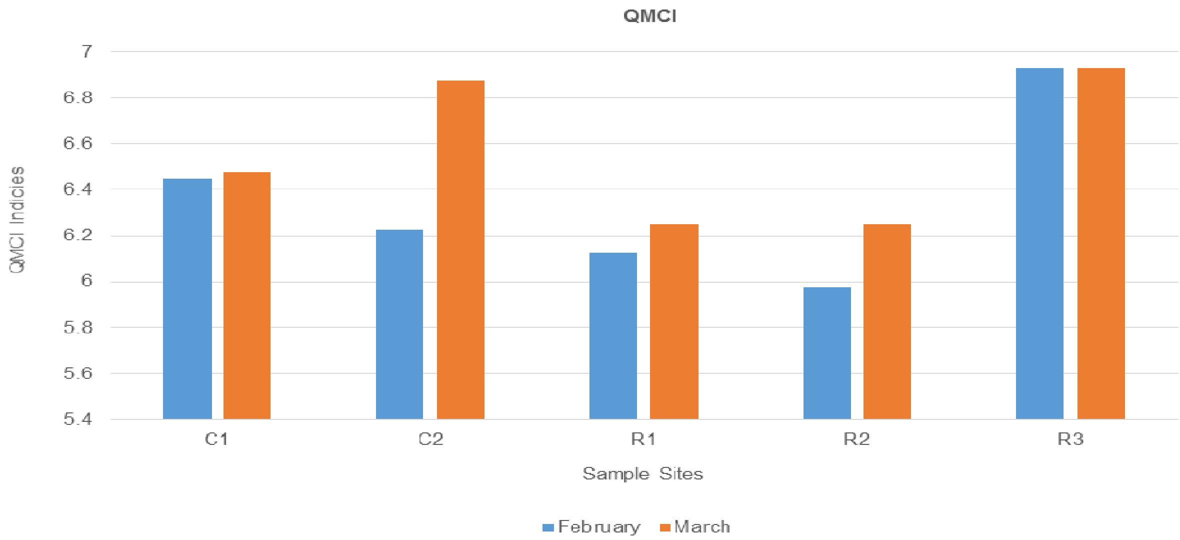


Figure 28: Averaged QMCI from all samples in the Waikanae River in 2016

5.3.2 Macroinvertebrate Community Composition

The following analysis looks at the differences between the macroinvertebrate communities in 2015 and 2016, where periphyton cover was different.

The NMDS ordination and ANOSIM results comparing the fauna across the sites showed that there were significant, albeit weak, differences among the macroinvertebrate communities found at the sampling locations across time. That is, generally all the same species are present, but in different abundances, and it is that difference on which the statistical analysis is operating. There may not be a meaningful biological difference, only a statistical one.

The NMDS ordination and ANOSIM results comparing the sites' fauna across the sample dates showed that there were significant, albeit weak, differences among the macroinvertebrate communities found during the four sampling occasions (time) i.e. there were subtle changes in community composition through time. The NMDS shows a reasonably tight cluster (Figure 29; ANOSIM: $R = 0.2682$, $P = 0.1$). The differences observed relate to variations of a few taxa, those that respond to periphyton in the main. Taxa between years "driving" this result include abundance of Deleatidium, and to a lesser degree Elmidae beetles, and between 2014 and 2015, Orthocladiinae flies.

Generally, however, the communities are similar in time and space.

As we did in 2015, we note that changes in EPT, most prominently the decline in Deleatidium and the increase in Orthodclad flies, signals, and is a response to, the mild but measured increase in matting algae and filamentous algae.

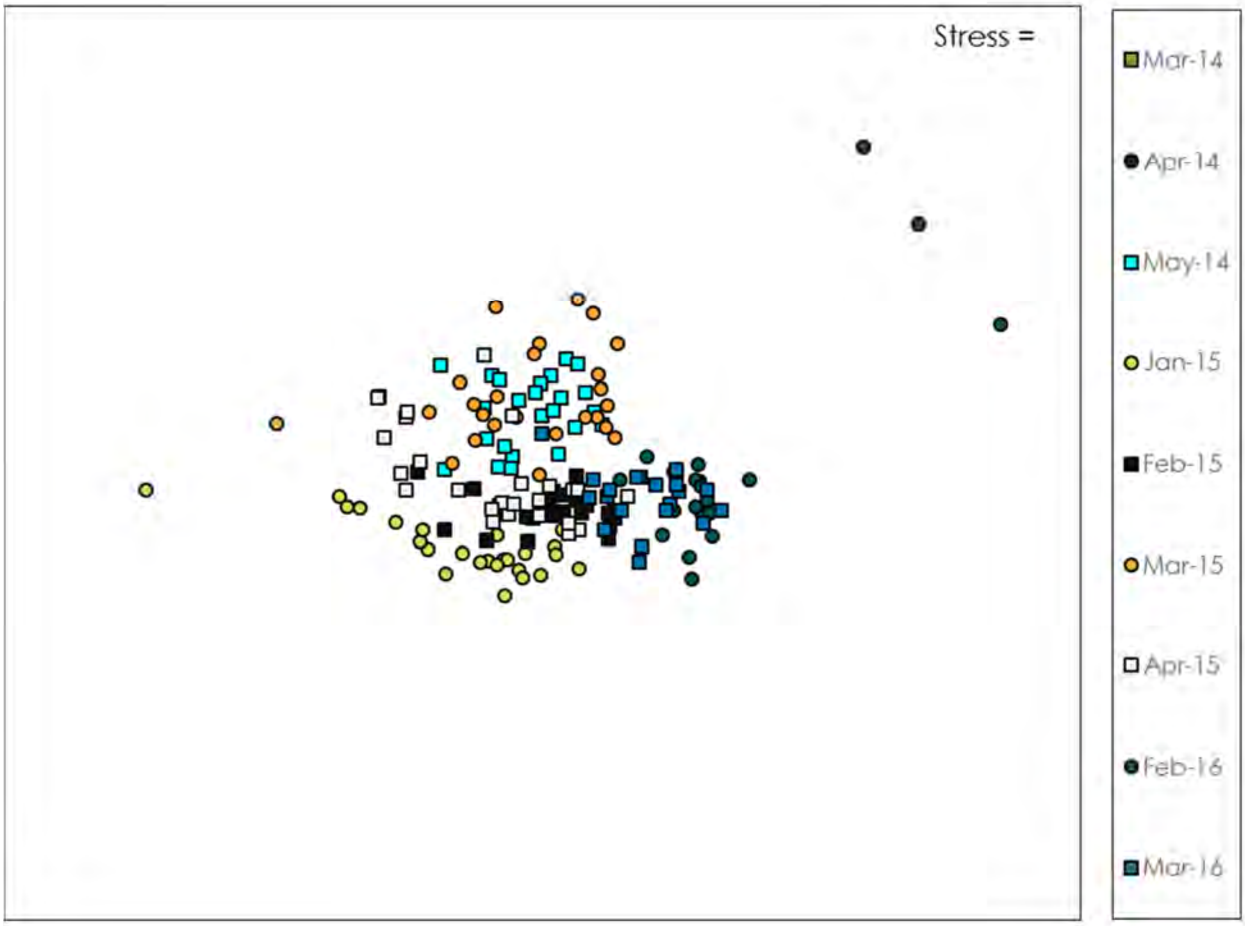


Figure 29: Non-metric multidimensional scaling (NMDS) ordination based on a Bray-Curtis matrix of dissimilarities calculated from macroinvertebrate abundance data collected in kick-net samples at 5 sites on each of 9 different dates. Note the NMDS gave a good rep representation of the actual community dissimilarities among the nine sampling occasions (dates) (two-dimensional stress = 0.14). Axes are identically scaled so that the sites closest together are more similar in community composition than those further apart.

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

Five sets of flow gauging's were conducted by NIWA during the summer of 2014/2015 at the locations specified in the Waikanae River BMP; just downstream of SH1 and alongside Jim Cook Park. The results are summarised in

Table 5, along with the daily mean ‘Flow’ reported on the GWRC website and flow downstream of the Waikanae WTP (calculated as the upstream flow minus the abstraction). The gauging’s carried out by NIWA since baseline monitoring began are plotted in Figure 30, which also shows the results of 12 sets of gauging’s carried out between 1993 and 2008 by GWRC at the same locations. The 2015-2016 gauging’s are labelled.

The 2015/2016 gauging’s undertaken by NIWA:

- Confirm the existing understanding that the Waikanae River loses about 300 L/s between SH1 and Jim Cook Park, when flows at the Waikanae WTP are lower than about 1,000 L/s; and
- Extend the relationship between SH1 and Jim Cook Park flows to include flows of more than 2000 L/s. Once flows get above about 1500 L/s, there is no net loss of flow between the two gauging points.

Table 5: 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)	Downstream flow (L/s)					
22/12/2015	2411	162	2249	Below SH1	2221	4.71	0.472	11:27
				Jim Cook Park	2258	3.94	0.573	12:54
22/01/2016	2136	157	1979	Below SH1	1674	4.11	0.408	8:11
				Jim Cook Park	1657	3.67	0.452	9:11
26/02/2016	1850	154	1693	Below SH1	1295	3.54	0.366	9:10
				Jim Cook Park	1192	2.21	0.639	10:08
18/03/2016	1831	151	1680	Below SH1	1113	3.01	0.37	14:26
				Jim Cook Park	968	2.31	0.42	13:24
22/04/2016	1211	146	1065	Below SH1	1037	4.43	0.234	11:07
				Jim Cook Park	713	1.69	0.424	12:53

Note: The upstream flow is the daily mean ‘Flow’, as published on the GWRC website.

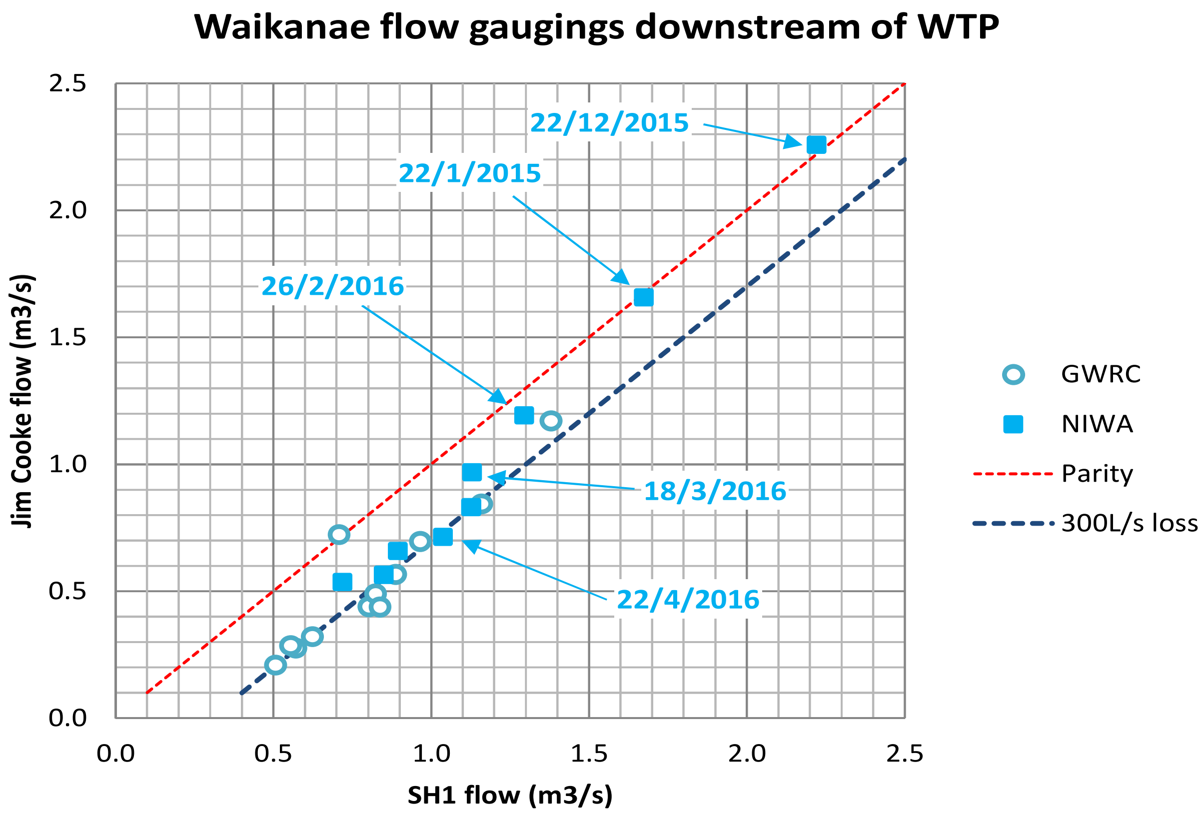


Figure 30; Waikanae River flow gauging's

7.0 Summary and Recommendations

7.1 Summary

This report builds on the previous two season's data collection experiences (2013/2014) and 2014/2015 (Boffa Miskell Ltd, 2014 and Boffa Miskell Ltd, 2015)). To date, there are now 13 months in total of aquatic baseline monitoring data, 2 months of these data is post partial recharge activity. There are a number of interesting points raised by this monitoring data in terms of the stability and condition of the current Waikanae River's water quality.

The data reported here, as well as the early analysis, indicate that the Waikanae River, by and large, has a stable water quality with a small but seasonally predictable temperature regime. Nutrient status can be described as generally being between oligotrophic and mesotrophic (i.e. a medium nutrient status, with DRP being the higher nutrient).

The first observable environmental change related to the recharge of water into the river form bore is the increase in conductivity, caused it would seem, by the increase in calcium added through the recharge water.

No other water quality or biotic parameter changed in any observable way related to recharge.

The 2015-2016 summer saw increased quantities of filamentous and thicker matting algae, including blue-green algae. However, no averaged measure was what can be considered high or very high. The averaged maximum was less than 30% and while the highest measured over the last three years, a

30% average cover is still only a moderate cover. The two floods in the measuring period reduced the cover appreciable and may have prevented a much higher late season cover. We also note a long warm summer period.

There were two periphyton interim trigger exceeded during the monitoring period. The Chlorophyll-a trigger was exceeded 3 times. The timing of these triggers exceedances does not indicate a relationship with river recharge. The Weighted Composite Cover (WCC) trigger was exceeded once. The WCC sample taken following this instance indicates that the growth is not a direct result of river recharge.

The macroinvertebrate samples this year represent a higher periphyton measure, the NMDS analysis indicates that the community had elements that appear to be a response to the increased periphyton, but that the core community is as every other year. Those variations in composition are as was predicted.

7.2 Recommendations for future monitoring.

The parameters being monitored to date are slow responders to what will typically be short term short duration "effects" – i.e. bore water introductions. So far calcium and conductivity are signalled as being responsive to in-river changes where measures are near and post the period of recharge. The DRP responses are variable but may also be correlated. The nutrients and other water quality parameters continue to appear to be wider upper catchment related longer term metrics. It is also noted that there are only three months of River baseline monitoring remaining.

1. Periphyton Measures – Discontinue twice annual community measure as sufficient baseline information has been collected as to the species composition of the Periphyton. Take one pooled sample Chlorophyll a per site monthly i.e. reduced from 5 separate samples per site each every second week (or weekly of flow drops below <1100 l/s). Sufficient baseline monitoring information has been collected to understand the relationship across the width of the river and a pooled sample is all that is required going forward that still provides a biomass measure which can be made relative to the visual measurement. We note that for the effects tests moving forward chlorophyll a is unlikely to be a trigger parameter as the time it takes to get lab returns precludes its use as a mechanism to halt recharge discharge. Going forward visual Periphyton measure to remain with one pooled sample per site per month in the remaining baseline measures.
   The AMG meeting to review the draft annual reports was held on the 31 August 2016. On further consideration we recommended that the Chlorophyll a sampling was removed in total for the final 3 months of baseline monitoring.
   The AMG request that the visual periphyton remains at the same frequency for the final three months of baseline monitoring.
2. Water Quality Measures – continue
3. Macroinvertebrate Measures – cease any further collections as there are now sufficient measures with sufficient periphyton levels to understand how the macroinvertebrate communities are prior to recharge and how they respond seasonal to increasing periphyton cover.
4. Fish - Noting that the recharge is highly unlikely to occur within the upward migration period of galaxid (or eel), the possibility of effects is minimal, and so too is an ability to measure it. While the year past has dropped the local fish measure and abandoned the upper tributary measures as untenable, we have proposed to undertake a whitebait trapping process in the upcoming year in early December (2017), as near as possible to the peak upward migration time. We recommend that in that time and if possible a recharge of water should be undertaken to coincide with a peak upward movement of whitebait and that we measure by

trapping (or lower river white-baiter observation) the presence of white bait below, at and above the recharge position. In the absence of upward migration at this time this test will not be possible as there are no fish in the river to monitor. This is likely to mean migration is already complete and there can be no recharge effect.

8.0 References

Biggs, B. J. F. (2000). New Zealand periphyton guideline: Detecting, monitoring and managing enrichment of streams. Prepared by NIWA for the Ministry for the Environment.

Biggs, B. J., & Kilroy, C. (2000). Stream periphyton monitoring manual. Wellington: Prepared by NIWA for the Ministry for the Environment.

Boffa Miskell Ltd. (2014). Waikanae River aquatic baseline monitoring data: A report on 2013/2014 aquatic data collection for water permits WGN130103 [31993] & [31994] (Report No. W14012). Prepared by Boffa Miskell Ltd for Kapiti Coast District Council.

Boffa Miskell Ltd. (2014). Waikanae River aquatic baseline monitoring data: A report on 2014/2015 aquatic data collection for water permits WGN130103 [33251] & [33252] (Report No. W14039). Prepared by Boffa Miskell Ltd for Kapiti Coast District Council.

Boffa Miskell Ltd. (2014). Waikanae River baseline aquatic monitoring plan: Kāpiti Water Supply RRwGW Scheme (Report No. W13121). Prepared by Boffa Miskell Ltd for Kapiti Coast District Council.

Matheson, F., Quinn, J., & Hickey, C. (2012). Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision making framework: Phases 1 and 2 final report (NIWA Client Report No. HAM2012-081). Hamilton: Prepared by NIWA for the Ministry for Science & Innovation Envirolink Fund.

Quinn, G. P., & Keough, M. J. (2002). Experimental design and data analysis for biologists. Cambridge, UK: Cambridge University Press.

Stark, J. D., & Maxted, J. R. (2007). A user guide for the Macroinvertebrate Community Index (Cawthron Report No. 1166). Cawthron Institute, prepared for the Ministry for the Environment.

Appendix C

Bore and River Water Quality Summary

Comments on following tables

Laboratory detection limits, resource consent condition and water quality guideline values have been added to the following tables.

Note the ANZECC (2000) Guidelines are applicable to the receiving body of water (in this case the Waikanae River) rather than the bore water discharge. Although the bore water exceeds the guideline values for some parameters, once the groundwater enters the river and is diluted it is expected that the concentrations in the river will be acceptable.

The water from all bores meets the Drinking-water Standards for New Zealand 2005 (revised 2008) maximum acceptable values, except for a slightly higher value for Nitrite Nitrogen in the KB4 Bore.

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 O2/m3	Total (NP) Organic Carbon g/m3	Alkalinity - Total g CaCO3/m3	Total Dissolved Solids g/m3	Bicarbonate g CaCO3/m3	Free CO2 g CO2/m3	Anion Sum meq/l
Laboratory detection limit				0.1		0.1	0.1	1	0.5	0.3	1	1	1	1
Resource consent WGN130103 [33761] condition 7		n/a	7.0 - 8.8	7.0 - 8.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Drinking-water Standards for New Zealand 2005 (revised 2008)		n/a	7.0-8.5 (GV)	7.0-8.5 (GV)	n/a	n/a	n/a	n/a	n/a	n/a	1000 (GV)	n/a	n/a	n/a
ANZECC 2000 Guidelines	99.00%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	95.00%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
KB4	Maximum	15	7.62	7.8	78	108	0.15	0.15	0.5	199	594	198	8	9.48
	Minimum	14.9	7.49	7.7	75.9	104	0.1	0.1	0.5	192	574	191	6	8.68
	Average	14.975	7.5625	7.75	77.3	106	0.1225	0.1225	0.5	196.25	582.25	195.25	7.25	9.18
	Number of Samples	4	4	4	4	4	4	4	4	4	4	4	4	4
K4	Maximum	16	7.41	7.8	46.8	64.4	0.21	0.21	1	113	354	113	9	5.45
	Minimum	15.1	7.32	7.7	44.6	59.2	0.13	0.13	0.9	108	326	108	7	5.15
	Average	15.525	7.365	7.75	45.4	61.9	0.16	0.16	0.925	110.25	340.5	110	8	5.285
	Number of Samples	4	4	4	4	4	4	4	4	4	4	4	4	4
K5	Maximum	16.5	7.92	7.7	77.5	106	0.1	0.1	0.7	216	582	214	4	9.09
	Minimum	15.9	7.87	7.7	76.4	104	0.1	0.1	0.7	214	571	212	4	8.87
	Average	16.2	7.895	7.7	76.95	105	0.1	0.1	0.7	215	576.5	213	4	8.98
	Number of Samples	2	2	2	2	2	2	2	2	2	2	2	2	2
K6	Maximum	14.8	7.5	7.8	60.6	110	0.07	0.07	0.7	281	606	279	11	10
	Minimum	14.8	7.5	7.7	60.6	110	0.07	0.07	0.7	281	606	279	11	10
	Average	14.8	7.5	7.75	60.6	110	0.07	0.07	0.7	281	606	279	11	10
	Number of Samples	1	1	1	1	1	1	1	1	1	1	1	1	1
K10	Maximum	15.9	7.46	7.8	77.5	83.6	0.46	0.46	0.6	214	460	213	12	7.09
	Minimum	15.1	7.19	7.36	53.7	79.4	0.07	0.07	0.1	11	436	11	<1	3.59
	Average	15.52	7.348	7.548	61.52	81.45	0.216	0.216	0.32	188.4	447.9	187.6	9.1	6.481
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10
Kb7	Maximum	16.2	7.76	7.8	60.9	63.9	0.5	0.5	12.8	97	352	97	3	5.63
	Minimum	15.2	7.47	7.61	42.2	61.8	0.04	0.04	<0.01	89	340	89	2	5.22
	Average	15.61	7.637	7.713	50.82	63.24	0.154	0.154	1.35	92.9	347.8	92.3	2.2	5.377
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10
K12	Maximum	15.8	7.76	7.8	43.8	50.4	0.42	0.42	0.2	91	277	91	3	4.35
	Minimum	15	7.17	7.17	32.6	49.5	0.03	0.03	<0.1	82	272	81	2	4.11
	Average	15.26	7.608	7.676	39.13	49.84	0.114	0.114	0.1	85.9	274.2	85.3	2.2	4.237
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10
N2	Maximum	17.1	7.46	7.8	39.4	43.2	0.68	0.68	0.4	82	237	82	5	3.81
	Minimum	14.5	7.09	7.17	27.7	41.2	0.03	0.03	<0.1	70	226	70	1	3.47
	Average	15.18	7.249	7.486	33.75	42.51	0.226	0.226	0.19	74.3	233.4	74.2	3.3	3.595
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10

River Sampling Dec 2015 to Apr 2016 (5 sites)	Maximum	21.45	8.84	8.2	1.108	18.3	39.6							
	Minimum	1.12	6.24	7.2	0.09	9.4	4.8							
	Average	16.39	7.64	7.58	0.12	11.28	10.67							
	Number of Samples	75	75	75	75	75	70							

Blended Bore Water Quality	Maximum	15.5	7.54	7.7	62.9	86.3	0.12	0.6	0.7	176	475	175	7	7.49
	Minimum	14.8	7.5	7.7	60.6	81.3	0.04	<0.5	0.5	151	447	150	6	7.26
	Average	15.13	7.53	7.70	61.97	84.27	0.08	0.60	0.60	162.00	463.33	161.33	6.33	7.34
	Number of Samples	3	3	3	3	3	3	3	3	3	3	3	3	3

Bore		Cation Sum meq/l	Ion Balance %	Fluoride g/m3	Chloride g/m3	Nitrite - Nitrogen g/m3	Bromide g/m3	Nitrate - Nitrogen g/m3	Sulphate g/m3	Ammonia Nitrogen g/m3	Total Hardness g CaCO3/m3	Boron - Dissolved g/m3	Calcium - Dissolved g/m3	Iron - Dissolved g/m3	Magnesium - Dissolved g/m3	Manganese - Dissolved g/m3
Laboratory detection limit		0.001	0.001	0.01	0.02	0.01	0.02	0.01	0.02	0.01	1	0.005	0.01	0.005	0.01	0.005
Resource consent WGN130103 [33761] condition 7		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	n/a	0.9	n/a	n/a	n/a	n/a
Drinking-water Standards for New Zealand 2005 (revised 2008)		n/a	n/a	1.5	250 (GV)	0.06	n/a	11.3	250 (GV)	1.5 (GV)	200 (GV)	1.4	n/a	0.2 (GV)	n/a	0.4
ANZECC 2000 Guidelines	99.00%	n/a	n/a	n/a	n/a	n/a	n/a	4.9	n/a	0.32	n/a	0.09	n/a	n/a	n/a	1.2
	95.00%	n/a	n/a	n/a	n/a	n/a	n/a	7.2	n/a	0.9	n/a	0.37	n/a	n/a	n/a	1.9
KB4	Maximum	10.2	28.8	0.05	219	0.09		<0.01	1.1	0.05	133	0.276	34	<0.005	11.6	0.021
	Minimum	5.25	0.69	0.03	195	<0.01		<0.01	1.06	0.04	118	0.253	30.2	<0.005	10.2	0.016
	Average	8.365	10.2775	0.04	210.25	0.26		<0.01	1.0775	0.0475	126	0.2625	32.1	<0.005	11.1	0.01875
	Number of Samples	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
K4	Maximum	5.62	26.6	0.23	114	<0.01	0.43	<0.01	18.3	0.02	39	0.105	5.77	0.006	5.89	0.184
	Minimum	3.12	2.35	0.2	107	<0.01	0.35	<0.01	17.2	0.02	36	0.082	5.32	<0.005	5.59	0.172
	Average	4.6725	9.35	0.215	110.25	<0.01	0.385	<0.01	17.725	0.02	37.75	0.09425	5.535	0.0035	5.7975	0.177
	Number of Samples	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
K5	Maximum	9.96	5.81	0.07	197	<0.01	0.67	<0.01	0.5	0.31	119	0.446	27.2	0.03	12.3	0.067
	Minimum	9.19	0.54	0.06	190	<0.01	0.66	<0.01	0.43	0.3	111	0.387	25.5	0.024	11.6	0.055
	Average	9.575	3.175	0.065	193.5	<0.01	0.665	<0.01	0.465	0.305	115	0.4165	26.35	0.027	11.95	0.061
	Number of Samples	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
K6	Maximum	9.99	0.16	0.04	191	<0.01	0.65	<0.01	0.22	0.44	130	0.642	29.1	<0.005	13.9	0.066
	Minimum	9.99	0.16	0.04	191	<0.01	0.65	<0.01	0.22	0.44	130	0.642	29.1	<0.005	13.9	0.066
	Average	9.99	0.16	0.04	191	<0.01	0.65	<0.01	0.22	0.44	130	0.642	29.1	<0.005	13.9	0.066
	Number of Samples	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K10	Maximum	8.2	36	0.04	127	0.02	0.59	<0.01	<0.02	0.25	196	0.178	50.5	0.008	13.3	0.169
	Minimum	7.54	3.61	0.03	115	<0.01	0.45	<0.01	<0.02	0.15	164	0.135	44.8	<0.005	11.3	0.145
	Average	7.75	9.52	0.032	120.4	<0.01	0.518	<0.01	<0.02	0.224	172	0.1576	47.15	0.003	12.42	0.1585
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Kb7	Maximum	6.18	6.93	0.08	132	0.02	0.52	<0.01	15.8	<0.01	69	0.534	14	0.037	8.34	0.016
	Minimum	5.18	0.34	0.06	119	<0.01	0.32	<0.01	13.5	<0.01	63	0.452	12.6	0.007	7.07	0.012
	Average	5.693	3.722	0.068	124.7	0.01	0.411	<0.01	14.78	<0.01	65.1	0.4982	13.18	0.0231	7.733	0.0137
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
K12	Maximum	4.95	7.79	0.09	90.6	0.02	0.33	<0.01	16.9	0.01	84	0.412	18.5	0.006	9.24	0.052
	Minimum	4.03	0.22	0.08	84.5	<0.01	0.26	<0.01	14.9	<0.01	73	0.363	16.2	<0.005	7.8	0.041
	Average	4.523	3.812	0.083	87.79	0.0075	0.29	<0.01	15.88	<0.01	77.7	0.3864	17.17	0.003	8.398	0.0465
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
N2	Maximum	4.08	6.56	0.17	73.9	<0.01	0.28	<0.01	21	0.05	102	0.064	28.5	0.022	7.46	0.097
	Minimum	3.56	0.28	0.15	65.5	<0.01	0.2	<0.01	19.4	0.01	87	0.024	24.1	<0.005	6.1	0.07
	Average	3.782	2.478	0.158	69.51	<0.01	0.24	<0.01	20.06	0.045	93.6	0.051	26.23	0.0113	6.725	0.0833
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
River Sampling Dec 2015 to Apr 2016 (5 sites)	Maximum												6.87			
	Minimum												4.62			
	Average												5.40			
	Number of Samples												74			
Blended Bore Water Quality	Maximum	7.7	2.94	0.13	163	<0.01	0.56	<0.002	9.57	0.17	100	0.319	23.1	<0.005	10.2	0.103
	Minimum	7.15	0.72	0.1	157	<0.01	0.53	<0.002	7.51	0.03	84	0.175	19.4	<0.005	8.58	0.092
	Average	7.37	1.76	0.12	159.67	<0.01	0.54	<0.002	8.33	0.10	90.00	0.24	20.67	<0.005	9.29	0.10
	Number of Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Bore		Potassium - Dissolved g/m3	Sodium - Dissolved g/m3	Total Phosphorus g/m3	Dissolved Reactive Phosphorus g/m3	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
Laboratory detection limit		0.01	0.02	0.005	0.005	0.05	0.001	0.0002	0.001	0.0005	0.0005	0.0005	0.002
Resource consent WGN130103 [33761] condition 7		n/a	n/a	n/a	n/a	n/a	0.03	0.0005	0.0022	0.0033	n/a	n/a	0.018
Drinking-water Standards for New Zealand 2005 (revised 2008)		n/a	200 (GV)	n/a	n/a	n/a	0.01	0.004	0.05	2	0.01	0.08	1.5 (GV)
ANZECC 2000 Guidelines	99.00%	n/a	n/a	n/a	n/a	n/a	0.001 (As III) 0.0008 (As V)	0.00006	0.00001	0.001	0.001	0.008	0.0024
	95.00%	n/a	n/a	n/a	n/a	n/a	0.024 (As III) 0.013 (As V)	0.0002	0.001	0.0014	0.0034	0.011	0.008
KB4	Maximum	6.43	172	0.037	0.037	0.06	<0.001	<0.0002	<0.001	0.0008	<0.0005	<0.0005	0.009
	Minimum	5.4	59.2	0.032	0.034	<0.05	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.006
	Average	5.9	131.05	0.03525	0.0355	0.05	<0.001	<0.0002	<0.001	0.0007	<0.0005	<0.0005	0.008
	Number of Samples	4	4	4	4	4	4	4	4	4	4	4	4
K4	Maximum	1.88	111	0.103	0.098	0.07	<0.001	<0.0002	<0.001	0.0017	<0.0005	<0.0005	0.056
	Minimum	1.63	54	0.096	0.088	<0.05	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.004
	Average	1.75	89.15	0.09975	0.0945	0.04	<0.001	<0.0002	<0.001	0.00036	<0.0005	<0.0005	0.02125
	Number of Samples	4	4	4	4	4	4	4	4	4	4	4	4
K5	Maximum	7.61	170	0.117	0.117	0.33	0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.002
	Minimum	6.77	156	0.115	0.112	0.32	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	<0.002
	Average	7.19	163	0.116	0.1145	0.325	0.0005	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.001
	Number of Samples	2	2	2	2	2	2	2	2	2	2	2	2
K6	Maximum	8.73	164	0.076	0.065	0.43	0.001	<0.0002	<0.001	0.0145	<0.0005	<0.0005	0.015
	Minimum	8.73	164	0.076	0.065	0.43	0.001	<0.0002	<0.001	0.0145	<0.0005	<0.0005	0.015
	Average	8.73	164	0.076	0.065	0.43	0.001	<0.0002	<0.001	0.0145	<0.0005	<0.0005	0.015
	Number of Samples	1	1	1	1	1	1	1	1	1	1	1	1
K10	Maximum	8.56	106	0.108	0.05	0.25	0.001	<0.0002	<0.001	0.0073	<0.0005	<0.0005	0.079
	Minimum	7.3	90.7	0.062	0.037	0.22	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.0016
	Average	7.785	95.63	0.0728	0.0425	0.236	0.001	<0.0002	<0.001	0.002	<0.0005	<0.0005	0.01606
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10
Kb7	Maximum	3.23	110	0.037	0.035	<0.05	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.006
	Minimum	2.39	88.3	0.031	0.029	<0.05	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	<0.002
	Average	2.715	99.58	0.0336	0.0308	<0.05	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.003
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10
K12	Maximum	2.44	76.1	0.071	0.049	<0.05	<0.001	<0.0002	<0.001	0.0022	<0.0005	<0.0005	0.005
	Minimum	1.6	58	0.046	0.042	<0.05	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.002
	Average	1.958	67.3	0.0506	0.0448	<0.05	<0.001	<0.0002	<0.001	0.0005	<0.0005	<0.0005	0.0043
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10
N2	Maximum	3.33	46.5	0.147	0.126	0.08	0.001	0.0003	<0.001	0.001	<0.0005	0.0007	0.009
	Minimum	2.63	38.7	0.126	0.118	<0.05	<0.001	<0.0002	<0.001	<0.0005	<0.0005	<0.0005	0.003
	Average	2.968	42.31	0.1359	0.1222	0.0375	0.0007	0.0002	<0.001	0.00043	<0.0005	0.0003	0.0055
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10

River Sampling Dec 2015 to Apr 2016 (5 sites)	Maximum			0.13	0.12	0.46							
	Minimum			0.009	0.005	0.08							
	Average			0.02	0.01	0.18							
	Number of Samples			75	75	75							

Blended Bore Water Quality	Maximum	5.13	135	0.088	0.081	0.2	0.001	<0.002	<0.001	0.0014	<0.005	<0.005	0.109
	Minimum	3.88	118	0.072	0.067	0.11	0.001	<0.002	<0.001	0.0014	<0.005	<0.005	0.109
	Average	4.53	125.67	0.08	0.08	0.16	0.00	<0.002	<0.001	0.00	<0.005	<0.005	0.11
	Number of Samples	3	3	3	3	3	3	3	3	3	3	3	3