

Review of the River Water Quality and Aquatic Ecology Monitoring Programmes 2016



Review of the Tasman District Council's River Water Quality and Aquatic Ecology Monitoring Programmes

September 2016

Document Status: Final

Council invests heavily in monitoring the health of rivers. The focus of this review is on the River Water Quality Monitoring Programme which provides information on the current condition of waterways ('state') and changes to that condition over time ('trend'). The scope of this review is wide, covering the programme aims, sampling sites, field methods and data management. This review also discusses the connections between the River Water Quality Monitoring Programme, Contact Recreation Water Quality Monitoring Programme, Freshwater Fish Monitoring Programme, Groundwater Quality and Level Monitoring Programme and Hydrology Monitoring Programme.

Prepared by:

Trevor James¹

Jonathan McCallum¹

Roger Young²

Reviewed by:

Rob Smith¹

File Ref: G:\Environmental\Trevor James\Surface Water Quality\Rivers - streams\RWQMP

¹Tasman District Council
189 Queen Street
Private Bag 4
RICHMOND

²Cawthron Institute
98 Halifax Street East
Private Bag 2
NELSON

Executive Summary

The main changes to Council's river water quality and aquatic ecology monitoring programmes proposed in this review are:

- To reduce the number of sampling sites in the River Water Quality Monitoring Programme (from almost 60 to 29) and sample every site monthly, rather than quarterly
- To move from sampling only at base-flows to sampling at all flows (unless conditions are unsafe)
- To collect all chosen water quality parameters at all sites
- To formalise a dedicated investigations programme

These changes were implemented in July 2016.

Table of Contents

Part 1 – Introduction	7
1.1 Scope	7
1.2 Purpose.....	7
1.3 Background.....	7
Overview of the RWQMP programme in its current form	8
Part 2 – Key questions about River Health	10
Part 3 – Recommended Changes to the RWQMP	15
3.1 Revised objectives of the programme.....	15
3.2 Sampling Frequency and Timing.....	15
3.3 Site Network Design	16
How many monitoring sites are required	16
Key criteria for selection of sites	17
3.4 Parameters/attributes.....	21
Parameters to be Measured.....	21
Further discussion on Selected Parameters	23
Water Clarity	23
Ammoniacal nitrogen.....	24
Periphyton.....	25
Re-suspendable sediment	26
Bed Sediment Generally.....	26
Parameters Considered and Dismissed	27
Chlorophyll-a	27
Macrophytes	27
3.5 Integration with other related monitoring programmes	28
Freshwater Fish Monitoring Programme	28
3.6 New Monitoring Programmes that should be Considered.....	28
Lake monitoring	28
Stream Habitat	28
Part 4 – Investigation Programmes	29
4.1 Periodic Continuous Dissolved Oxygen and Temperature Sampling.....	30
4.2 Sediment source sampling	30
Part 5 – Data management	31
Flow and river water quality data	31
Flow measurement units.....	31
Identifying quarterly and monthly monitoring data in Hilltop	31
Part 6 – Further Discussion	32
Future Innovation Opportunities	32
Modelling	32
Links between the RWQMP and other monitoring programmes.....	32
Conclusion	33
References.....	34

Appendix A – Changes to RWQMP Considered and Rejected	35
A1 - Random site selection	35
Appendix B – Monitoring Site Densities by Region	37
Appendix C – Monitoring Site Network Design	40
C1 - REC Class Coverage	40
Climate	40
Geology	40
Source of Flow	41
Landcover	41
Stream Order	42
Appendix D – Reasons for Retaining and Removing Across All Sites	43
Appendix E - River Water Quality Investigations in Tasman	48
Appendix F – Costing for the RWQMP	50
Important Assumptions	50
Summary	50
On-site staff time	50
Driving time	51
Other staff time	52
Lab parameters	52
Appendix G - 2016 Review focus questions	53

Part 1 – Introduction

1.1 Scope

The focus of this review is on the River Water Quality Monitoring Programme (RWQMP) and associated investigations. The review critically assesses all aspects of the RWQMP including the aims of the programme, sampling network design (sites), field methods and data management. It also identifies gaps in the assessment of the health of rivers and lakes generally in Tasman and comments on the balance of effort over water quality, water quantity and aquatic ecology monitoring programmes.

1.2 Purpose

The purpose of the review is to optimise the outputs from the monitoring programme to ensure it:

1. Delivers information that is not only useful, but critical to answering the key questions Council is tasked with answering
2. Is scientifically robust and generally able to stand up in the Environment Court
3. Is as efficient as possible with the resources available

1.3 Background

The health of rivers, lakes and estuaries is considered the key environmental concern to the majority of New Zealanders (Hughey et al 2013). To ensure that the values of these environments are maintained or improved, it is fundamental to run effective monitoring programmes. Council is also required to maintain and improve the quality of freshwater systems as part of the requirements of the National Policy Statement for Freshwater Management 2014 (NPS-FM). It would be impossible to develop a comprehensive programmes to answer all the questions the community may ask about rivers, lakes and estuaries. Instead, a prioritisation process is required to rank the questions of greatest importance.

Tasman District Council's River Water Quality Monitoring Programme (RWQMP) is the primary water quality monitoring programme for the district's rivers and streams. The Contact Recreation Water Quality Monitoring Programme (CRWQMP) is closely related but focused on a reduced set of parameters at popular swimming sites, over summer. The Freshwater Fish monitoring programme looks at fish community composition, for a limited number of sites. Because estuaries are the sink for many contaminants from rivers and their state is governed to a large extent by the quality of water from rivers flowing into them, any consideration of the RWQMP must also consider the Estuary Monitoring Programme (EMP). The Groundwater Quality Monitoring Programme (GWQMP) produces very important information for assessing the health of the source of water for monitoring sites on spring-fed streams. At risk spring fed streams are prevalent in the Waimea Plains, Takaka township/Motupipi and Murchison. The water quality of lakes also affects rivers dominated by a lake source of flow e.g. the Buller and Gowan Rivers and Otuhie Creek (near Paturau). However, given the very small area of the catchment of the lakes not in natural land cover, the risk of degraded water

quality in these lakes is very low and so Council does not have a Lakes Monitoring Programme. Hydrology monitoring programmes are also fundamental for understanding changes to the quantity and quality of water in our rivers. River flow records are used to calculate critical flow metrics (e.g. Mean Annual Low Flow) that can be used for developing limits to water takes and ensure the health of rivers is maintained.

Various reports from these monitoring programmes have provided a lot of useful information. For example, a large report about river water quality was completed in late 2015, contact recreation water quality reports are produced annually, a groundwater quality report produced in 2010, and estuary reports have been produced (mostly) on an annual basis since 2006.

Overview of the RWQMP programme in its current form

The River Water Quality Monitoring Programme (RWQMP) was initiated to achieve the following six aims:

1. To determine the quality of surface waters in the District in reference to accepted standards (for public health, recreational and ecological reasons).
2. To identify trends in water quality.
3. To identify cumulative environmental effects from multiple discharges into surface waters.
4. To understand the nature of surface water quality problems/issues in order to provide information for defensible management responses. Such responses include seeking reviews to Council resource management plans, regulations, and resource consent conditions.
5. To identify new issues and monitoring requirements.
6. To identify factors that cause change in surface water quality (i.e. impact monitoring).

Details of the design

The RWQMP began in 1999 and has grown, both in the number of sites and parameters measured. It has been partially reviewed twice prior to this review. In 2005, a number of sites on smaller streams were added at the expense of a few sites on larger rivers. Total Suspended Solids was also removed as a measurement parameter (James, 2005). In 2014, the sampling frequency at five sites was increased to monthly (James, 2014).

Immediately prior to the present review, the programme comprised:

- Quarterly sampling at about 60 sites, at base flows
- Investigations into the source of concerning contamination in conjunction with the quarterly programme
- Monthly sampling at nine sites mostly near the mouth of major rivers (Waimea, Motueka – 3 sites, Sherry, Takaka, Aorere, Kaituna and Buller at Longford).
- Macroinvertebrate sampling on an annual basis at 25 sites.
- Periphyton monitoring (using a modified version of RAM2, Biggs and Kilroy, 2000) at all sites in the spring, summer and autumn quarterly sampling rounds and the monthly sampling rounds from November to April.

- Summer campaigns of continuous sampling of dissolved oxygen and water temperature at about 20 sites on an annual basis. The sites differed each year and few were on large rivers which have little risk of low dissolved oxygen.

Because of the high variability of water quality data, sampling at quarterly sites was only carried out at base flows. As a consequence of this sampling strategy, relatively little is known about water quality after rain or during flood flow conditions at the monitored sites.

The programme generally targeted areas where the most significant human pressures, such as point and non-point source discharges, exist or were suspected. This is where there is more intensive land use and where large proportions of the catchment are developed for production. In addition, a few sites (10%) were selected as reference sites (i.e. sites that have little or no influence from the pressures experienced at sites further downstream). Along with the high risk and reference criteria, sites in the programme were chosen to try to achieve a balance across the following:

- a) Geographical spread throughout the District;
- b) Range of waterway sizes represented (from large main-stem rivers to small creeks);
- c) Range of different environmental pressures represented at different sites;
- d) In areas with high human use (such as for recreation or drinking) or significant ecological values.

The design of the RWQMP involved careful choice of indicators (attributes or measures) of water quality. The choice of environmental indicators differed from site to site depending on the values present (ecological, cultural, recreational and/or aesthetic). Some of these values (ecosystem health and human health for recreation) are compulsory according to the National Objectives Framework (NOF) as outlined in the NPS-FM. Monitoring programmes should inform whether these values are being provided for, sometimes for specific reaches of river. Indicators were chosen partly to reflect community values, as well as to be consistent with indicators recommended by the Ministry for the Environment (1998).

While information from the RWQMP will give clues as to the cause of poor water quality, it is often only after intensive sampling within a catchment that clear conclusions of cause and effect relating to specific land-use activities can be drawn. Such follow-up investigations are undertaken on a prioritised basis.

Detailed information on the design of the monitoring programme and methods used can be found in *River Water Quality in Tasman District 2015* (Tasman District Council, 2015) and *River Water Quality Monitoring Programme Vol 1* (Tasman District Council, 2010).

The importance of integrating **water quality monitoring** with **habitat and ecological monitoring** is recognised but at this stage the only integration is that a few RWQMP sites have been sampled to quantify their fish communities and habitat. Because of the size of the job of reporting on river water quality, it has proven difficult to report on both these areas with the same resources.

Part 2 – Key questions about River Health

This review began by listing what we considered to be the key questions asked about the health of freshwater environments in Tasman (see Table 1). Posing good questions lies at the heart of good science and hence essential to effective monitoring. Up until now, however, specific questions have not been clearly stated and no critical assessment about the ability of current monitoring programmes to answer the questions has been done. The ability to answer the question is categorised into “very limited”, “limited”, and “reasonable”. We noted that none of questions can be answered in a comprehensive fashion given current constraints.

Table 1: Key Questions about the Health of Freshwater Environments. A basic assessment of Council’s ability to answer each of these questions is described as well as the monitoring programme tasked with answering the question.

Note: Questions listed in blue relate to the state and trend, those in green related to understanding the drivers, purple relates to policy. Acronyms: RWQMP = River Water Quality Monitoring Programme, CRWQMP = Contact Recreation Water Quality Monitoring Programme, NRWQN = National River Water Quality Network, FFMP = Freshwater Fish Monitoring Programme, EMP = estuary monitoring programme, HMP = Hydrology Monitoring Programmes, FLAG process = Freshwater and Land Advisory Group – a collaborative governance committee, LAWA = Land Air Water Aotearoa – collaborative website for Regional Council reporting.

Question about River Health	Current Programme’s Performance to Answer this Question	Comments	Monitoring & Reporting Programmes
<p>1a. What is the state and trend of river water quality in <u>Tasman at monitoring sites</u>?</p> <p>Relative to attribute limits and bands set by NPS-FM or best available guidelines. How many improving and degrading water quality trends are there in Tasman? Are we meeting the ‘maintain or improve’ requirement of the NPS-FM? What is the state of various types of streams? E.g. spring-fed, lowland, intermittently flowing.</p>	<p>Reasonable to assess the state. Very useful information has been provided about the state of monitoring sites across different land uses and river types. Patterns such as the poor state of urban and unshaded streams in pastoral catchments, have been identified consistently and sampling more sites has only reinforced this.</p> <p>Limited trend information. While there is 17 years of data for many sites, quarterly sampling means there is a limited ability to pick up trends in a timely manner. Only 20 significant, meaningful and relevant trends were found (this is a surprisingly low number). At least 60 data points are recommended for trend analyses (LAWA); it takes 15</p>	<p>To date the programme has served Council well allowing us to understand what and where the key issues are in our region and provide useful information for policy making. Monitoring or investigations have occurred in most of the higher risk catchments throughout the region. Due to sites being selected, rather than chosen randomly, the information is only related to sites in the monitoring programme. It is not possible to comment on ‘overall’ state and</p>	<p>RWQMP 5-yearly report</p> <p>LAWA</p>

Question about River Health	Current Programme's Performance to Answer this Question	Comments	Monitoring & Reporting Programmes
	years of quarterly sampling to achieve this.	trends in the region (see below); even to discuss for example if "lowland pastoral sites are improving".	
1b. What is the overall state and trend of river water quality in Tasman?	Limited. Due to non-random site selection, it is not possible to make robust conclusions about overall water quality state and trends throughout Tasman. We are only able to estimate state across the whole district with the help of models which are available for two macro-invertebrate indices and water clarity. Accurate models for other parameters are not currently available. It is possible that effective models will be available in 10 or more years.	It is very expensive to answer this question well because there is a need for many sites chosen randomly.	RWQMP including models (water clarity and macroinvertebrate community index (MCI)) 5-yearly report
1c. What is the state and trend of river water quality at high risk sites ?	Reasonable. Most catchments or sub-catchments with the highest risk of issues have been covered.	If there are no problems at high risk sites then there is unlikely to be problems elsewhere.	RWQMP 5-yearly report
1d. What is the state and trend of river water quality in <u>New Zealand</u> ?	Limited. National data sets sample all key parameters at all sites monthly. Because it is not considered good practice to mix monthly and quarterly data sets, Council's data is rejected.	While Council's main responsibility is to its region and ratepayers, there is an obligation (not legally binding as yet) to support national level reporting. Given there are benefits to Council of sampling monthly, there is a relatively low marginal cost to provide New Zealand Inc with good data.	RWQMP 5-yearly report LAWA Contribution to National State of the Environment (SOE) freshwater domain reports
2a. What is the state of swimming waters ?	Reasonable. All our most popular and high risk swimming holes are monitored according to guidelines. We know where the problem sites are and investigations to determine		CRWQMP Annual report to Council (Environment and Planning Committee)

Question about River Health	Current Programme's Performance to Answer this Question	Comments	Monitoring & Reporting Programmes
2b. Is it safe to swim at a popular swimming spot today ?	the source(s) of contaminants are regularly undertaken. Limited. Unfortunately, when there is a risk to health the warning is issued about two days later when the sample results come back from the lab, by which time the risk may have passed.	We are working on a project to predict when there will be an exceedance of water quality guidelines at sites affected by the Motueka River Plume. This will be used to issue warnings at the time the risk is present.	Motueka Plume monitoring for modelling
3. What are the reasons (cause and effect) for various states and trends? What is the effect of particular activities ? Land use or specific pressure e.g. dairy races. What tributaries produce the most load?	Reasonable. Since Council's monitoring began various projects have been undertaken to determine the cause of various activities e.g. faecal contamination load from cow crossings in the Sherry catchment. Some situations are complex and can take lots of resources to solve e.g. Pohara Creek.	As a result of these investigations Council and the community has worked together to find and implement solutions to the issues and have often had enduring success. There are still many worthy investigations yet to be initiated.	Targeted investigations and reports Summarised in 5-yearly RWQ report
What is the river flow required to maintain water quality and ecological health in Tasman rivers? Natural flow versus quantity taken? Have the minimum flow and allocation limits applied to particular rivers maintained the key values identified for them?	Reasonable. Tasman's river flow and rainfall monitoring covers most major catchments and river types. Where there is no continuous flow record, good correlations to continuous flow monitoring sites are often available.		HMP FLAG
5. What water quality limits (attributes or loads) should we put in place to ensure specific values/objectives are met ?	Limited from the point of view that contaminant loads cannot be determined because the quarterly sampling is only done at base flow which is usually when only a small fraction of some contaminants (e.g. sediment) is discharged to the waterway	Setting limits is required as part of the NPS for Freshwater Management and the National Objectives Framework that goes with that.	FLAG

Question about River Health	Current Programme's Performance to Answer this Question	Comments	Monitoring & Reporting Programmes
	<p>(usually about 99% of sediment is discharged during floods).</p> <p>Reasonable from the point of view that attribute states are able to be set with reasonable knowledge across a variety of catchments. Even with almost 60 sites there are many catchments about which we know little.</p>		
<p>What is the state (abundance and diversity) of fish (including trout) and river-nesting birds in streams across Tasman? In which locations are rare fish found? E.g. giant kokopu, lamprey. What is the state of stream habitat (the most common cause) that contributes to this state? What potential is there for improvement to this state?</p>	<p>Limited. Budget is currently not available to carry out detailed fish, river-nesting birds or habitat surveys. However, from 2005-2012 reasonable information was collected to determine the diversity and relative abundance of fish in Tasman streams and link some cause and effects e.g. fish passage barriers.</p>	<p>While habitat and disturbance are important issues for river nesting birds, predators are a large confounding issue. There is a much more direct impact on fish from human activities in rivers.</p>	<p>FFMP Models (Leathwick et al 2008 & Joy 2013)</p>
<p>6. Has a particular stream restoration project been successful?</p>	<p>Limited. Most surveys have compared sites with good habitat and low level of disturbance with those of poor habitat and highly disturbed. There are a few before and after results for the likes of Reservoir Ck. in Richmond.</p>	<p>However, many studies nationwide show that if certain habitat is provided as well as fish passage and toxins are acceptable, it is likely the aquatic ecology will improve accordingly over time.</p>	<p>FFMP</p>
<p>Where are the most significant sites in rivers (for protection of cultural, economic, environmental and ecological, or social values)? e.g. recreation, wetlands, outstanding riverscapes</p>	<p>Limited in some areas e.g. inanga spawning sites (only a few days of surveys so far) location and state of trout spawning sites, cultural sites Outstanding riverscapes</p> <p>Reasonable in other areas e.g.</p>	<p>RiVAS process produced reasonable assessment of the significance of particular values. It involved a one-off process using an expert-panel approach</p>	<p>RiVAS FLAG Investigations (e.g. inanga spawning and swimming site popularity survey)</p>

Question about River Health	Current Programme's Performance to Answer this Question	Comments	Monitoring & Reporting Programmes
	Relative popularity of swimming holes and bathing beaches wetland mapping project whitewater kayaking native fish river-nesting birds		
Are the outstanding values of key iconic sites being maintained?	Limited. E.g. effects on water clarity and periphyton at Pupu Springs, Motueka outstanding trout fishery.	E.g. Pupu springs, Buller and Motueka WCO areas.	RWQMP 5-yearly report FLAG
What is the state and trend of the ecological health of estuaries ? Where are the major sediment loads coming from?	Reasonable. Our estuary monitoring programme has mapped habitats, muddiness and macro-algae on several occasions for our most at-risk estuaries and some reference estuaries, as well as recorded estuary sediment level fluctuations since 2008. Limited idea of source of sediment loads.	Estuaries are the sink of many contaminants from the catchment, particularly fine sediment. Fine sediment is an issue in many of our estuaries.	EMP
What is the state and trend of Tasman's lakes ? Lakes include Rotoiti, Rotoroa, Otuhie and Kaihoka. Also, what is the state and trend of sink-hole ponds in the Takaka Valley e.g. Lake Killarney? What is the aquatic weed status of Tasman's lakes?	Very limited. One-survey in 2000 at Lake Rotoiti and 2009 at lakes Otuhie, and Kaihoka. Lake Killarney is experiencing algal blooms which concerns the local community (a project is being set up to address that).	Most of our lakes have a very low risk of contamination.	Two one-off investigations with no plans to repeat
What is the state and trend of groundwater quality and level influencing streams?	Reasonable. Quarterly sampling since the 1990's as well as synoptic surveys. Limited knowledge of leaching rates to groundwater from various land uses. Work is underway to set up lysimeter trials.	Very close relationship of groundwater quality in Neimann Creek with a groundwater bore about 1km away.	GWQMP

Part 3 – Recommended Changes to the RWQMP

3.1 Revised objectives of the programme

1. To determine the state and trends in surface water quality in the District in reference to accepted standards, NPS-FM requirements and to maintain defined values.
2. To identify the drivers of surface water quality in the District, to inform defensible management responses. Such responses include seeking reviews to Council resource management plans, regulations, and resource consent conditions.
3. To determine the effectiveness of policy implementation – are key values being maintained/improved?

3.2 Sampling Frequency and Timing

It is recommended that sampling be carried out monthly at all core sites at all flows (unless staff consider conditions unsafe). The sampling will be conducted on the same day/week of the month for all sites within a particular Water Management Area (Waimea, Motueka, Takaka, Aorere and Buller). To the extent possible, sampling will be conducted in a consistent order on each day to help ensure that samples from each site are collected at a consistent time of day. This is important for parameters that vary significantly over a day – e.g. temperature, pH, dissolved oxygen.

The main reason to move to monthly sampling is to greatly **increase our ability to detect trends**. It is proposed that the emphasis of the programme as a whole should shift from a primary focus on ‘state’ to more balanced effort between ‘state and trends’. Monthly sampling allows trend analyses to be performed with greater statistical power than is possible with quarterly sampling. This means, with a higher sampling frequency, trends can be detected more quickly and with more certainty.

The ability to detect trends sooner has benefits for Council and the community. It will allow Council to better show that the requirements of the National Policy Statement for Freshwater Management 2014 are being met at a regional level (particularly “maintain or improve”). It will allow the community to receive timely feedback on whether efforts to improve water quality are proving and worthwhile.

Other reasons for monthly sampling include:

- Bringing the programme in line with most of the rest of New Zealand (TDC is one of only two Councils still doing quarterly monitoring in their main surface water quality programme)
- Resolves the over-sampling of sites issue where quarterly and monthly sampling currently occurs (*Waimea at SH6, Motueka at Gorge and Woodstock, Takaka at Kotinga, Aorere at Le Comte, Kaituna at upstream track start*).

Disadvantages and limitations of monthly sampling include:

- Increased sampling at sites where very little change is expected from year to year, both in terms of data and catchment land use – although changes cannot always be anticipated.

- A lower geographic, river class and stream size range coverage and density of sites in the district if 29 sites, rather than 60, are kept as core sites.
- While there would be more chance of picking up compliance issues related to poor land use practice due to greater observation time with the increased frequency of driving between sites, the reduced regional coverage means that some areas will get visited very infrequently.

The additional cost of increased sampling can be partly offset by reducing the number of core sites. If the current set of quarterly sites were sampled monthly, the programme cost is estimated to triple.

Consideration was given to running both a quarterly and a monthly sampling programme in tandem, as we were, with only a few more monthly monitoring sites. However, this has the disadvantage of introducing confusion and complexity to analysis and reporting. Any advantages of running both types of sampling programme at the same time (wider spatial coverage) are likely to be outweighed by the disadvantages of running both types of programme (inability to detect trends, increased cost, lower geographic coverage, inability to provide useful data for national initiatives). For example, in order to analyse quarterly and monthly data sets together you need to take the middle month of the three months of samples taken in that season and not the median. This effectively ‘wastes’ data.

3.3 Site Network Design

Once the change to monthly monitoring frequency was decided, attention was turned to the network design. The key questions with the design were:

1. How many monitoring sites are needed
2. How should sites be chosen
3. What proportion of sites should be reference sites

How many monitoring sites are required

We were clear that we cannot afford a larger network of sites than we currently have (57), nor can we afford the large number of sites required if a stratified random site selection process was used (see Appendix A) to answer the question of the general state of RWQ in Tasman (models may help us to do that anyway).

The yardstick we applied was that site densities should be in line with the median across NZ’s regional monitoring programmes within the working landscape (5.5 sites per 1000km²). This was chosen as the minimum. See Appendix B for further details. When the monitoring network was analysed to determine which of the current sites should be discontinued and which should be added, a total number of monitoring sites of 29 was arrived at (including the three NWQN sites sampled by NIWA). Tasman District Council will continue to use data from the NWQN sites and will be open to the sampling transferring to Council if a satisfactory arrangement can be made. The site density for 29 sites was about **eight sites per 1000km²**.

The recommendation is for a reduction in the number of sites from 57 to 29 (see Table 1 below).

Table 1. Changes to the number of core RWQ sites. Full details of the sites removed and retained are provided in Appendix D.

Existing number of sites	57
Sites removed	30
Sites retained	27
Sites added	2 - Takaka at Lindsays Bridge and Wai-iti at Livingston Rd (reinstated)
Total sites for monthly sampling	29 (includes 3 NRWQN sites)

Nine sites have been sampled without a break since 1999 and four of these are suggested for removal. The sites suggested for removal are Motupiko at Christies, Wangapeka at Walter Pk, Takaka at Harwoods and Aorere at Devils Boots.

In order to increase our analytical power we should use Nelson City Council monitoring sites in urban and reference environments to better determine how waterways influenced by this land use compare to other land uses.

Key criteria for selection of sites

The over-riding criteria for selection of sites are relative **value** and **risk**. It is important to have evidence that water quality is being maintained or improved in waterbodies that support high values (e.g. for recreation, ecology, cultural, economic etc) to the community, as required in the Regional Policy Statement and in the NPS-FM. Council has some quantitative information on relative “value” to assist in the site selection process. For example, trout values in the Motueka catchment, kayaking values in the Buller catchment, and swimming in the Lee and Roding Rivers. Further information on relative value has stemmed from the Takaka Freshwater Management Unit where a collaborative and consultative process to identify water quality values and limits has been conducted. Similarly, it is important to identify any trends in water quality at sites with a high risk of water quality degradation.

Following value and risk, there is a need for the site network to be representative of various **land uses, stream classes (climate, source of flow and geology)** and **stream sizes**. The proposed network includes sites in all the most common climate, geology, source of flow and landcover classes. However, some of the less common classes are not represented (e.g. cool dry and warm extremely wet climate; volcanic basic geology; exotic forest land cover). Ideally it would be good to have some sites dominated by exotic forest land cover, however, it should be remembered that sites such as the Wairoa at Irvines, Motupiko at 250m u-s Motueka Rv and Sherry at Blue Rock have a relatively large proportion of exotic forest in their catchments and will reflect the effects of forestry activities. The proposed sites include sites of all sizes (Orders 1-6), but small streams are under-represented in terms of their contribution to total stream length in the Tasman District. This level of under-representation is expected to be considerably less if related to stream-bed area, flow or range of supported values.

Proportion of Reference Sites

We aim to retain a target of at least 10% of sites as reference sites. Four sites in the proposed network could be considered as reference sites (native vegetation >90%): Motueka at Gorge, Hunter Creek at Kikiwa, Wangapeka 5.5km upstream Dart River and Kaituna at upstream Track Start. Appropriate reference sites from other regions can also potentially be used to compare to impacted sites. For example, there are two water quality monitoring sites in the Nelson City region, 8 sites in Marlborough and 12 sites in the West Coast, which have an upstream catchment area with greater than 90% native vegetation and similar climate and geology to sites within the Tasman District (Table 2).

Table 2. Potential reference sites from other regions

Region	Site	Climate	Source of Flow	Geology	% Native vegetation
Nelson	Maitai South Branch at Intake	CW	H	VB	0.98
Nelson	Brook at Motor Camp	CW	H	HS	0.94
Marlborough	Black Birch Stream at water intake	CD	H	HS	0.95
Marlborough	Awatere River at Awapiri	CD	M	HS	0.95
Marlborough	Wairau @ Dip Flat	CW	M	HS	0.99
Marlborough	Graham River at road bridge	CW	L	HS	0.97
Marlborough	Branch River at Weir Intake	CW	M	HS	0.96
Marlborough	Waitohi River at State Highway One	CW	L	HS	0.96
Marlborough	Pelorus River @ Bridge	CW	H	HS	0.92
Marlborough	Pelorus River at Kahikatea Flat	CW	H	HS	0.92
WestCoast	Seven Mile Ck @ u/s Tillers Mine Ck	CX	H	SS	1.00
WestCoast	Okutua Ck @ New Rd Br-Okarito Forest	CX	L	AI	1.00
WestCoast	Hohonu Rv @ Mitchells-Kumara Rd Br	CX	H	PI	0.99
WestCoast	Seven Mile Ck @ Dunollie 400m u/s Ox Pd	CX	H	SS	0.98
WestCoast	Sawyers Ck @ Bush Fringe	CX	L	SS	0.98
WestCoast	Crooked Rv @ Rotomanu-Bell Hill Rd	CX	H	HS	0.98
WestCoast	Haast @ Roaring Billy	CX	GM	HS	0.98
WestCoast	Grey @ Waipuna	CX	H	PI	0.97
WestCoast	Seven Mile Ck @ SH6 Rapahoe	CX	L	SS	0.96
WestCoast	Seven Mile Ck @ 300m d/s Raleigh Ck	CX	L	SS	0.95
WestCoast	Ford Ck @ Blackball-Taylorville Rd	CX	L	SS	0.94
WestCoast	Buller @ Te Kuha	CX	L	PI	0.91

It is also worth remembering that there is some existing data from three sites in the Tasman District that also have catchment areas with more than 90% native vegetation, but are no longer part of the proposed monitoring network (Riwaka @ Northbranch Source, Onekaka @ u-s Ironstone, Takaka at Harwoods). Note that sites such as Sherry at Cave, Reservoir at u-s Marlborough Cres, Aorere at Devils Boots and Powell at Glenview Rd are considered reference sites but do not have such a dominance of native vegetation in the catchment (these will also no longer be part of the network).

See Figure 1 for a map of proposed sites and Table 3 for sites in the proposed programme.

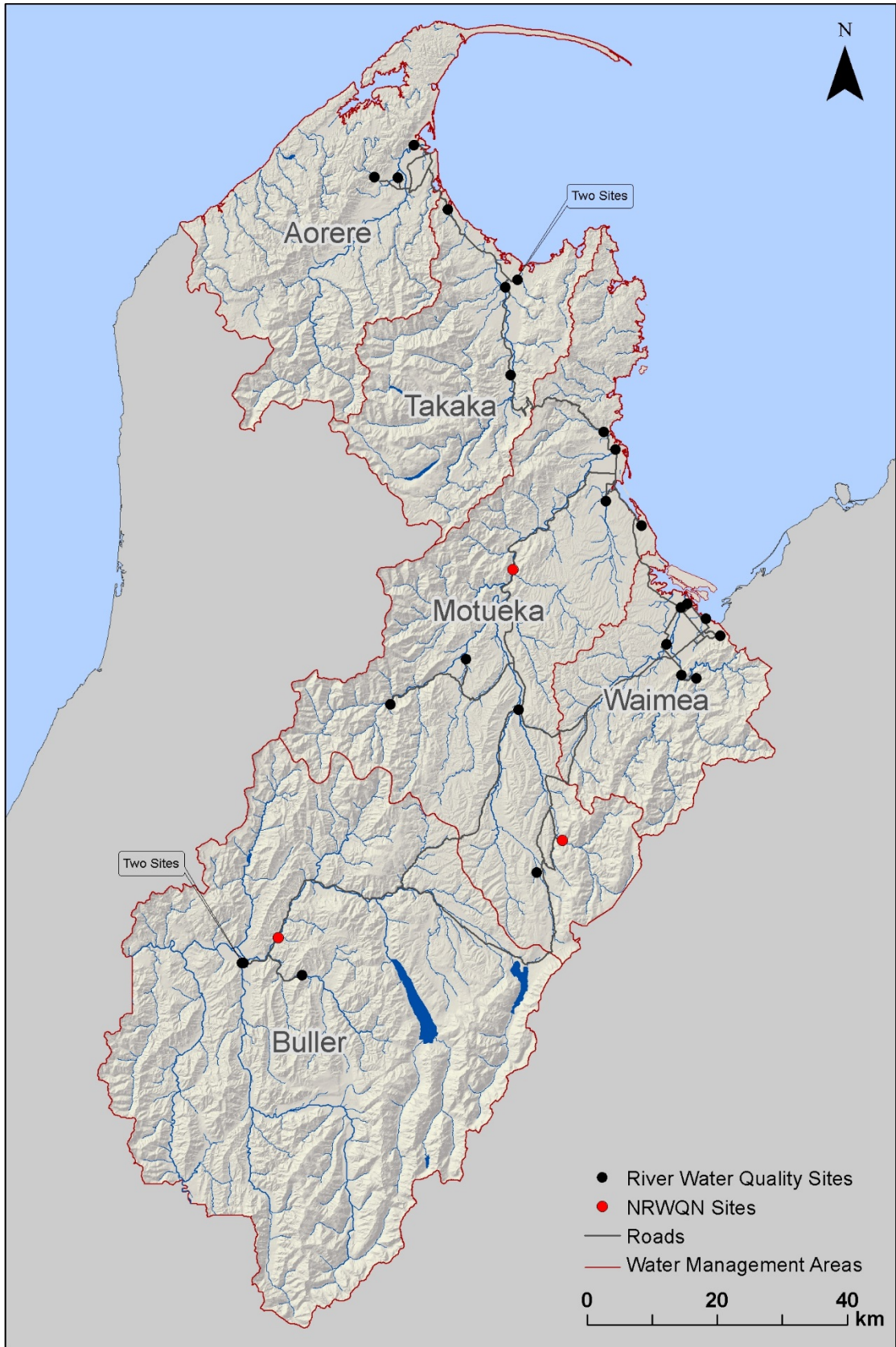


Figure 1. Map of Proposed River Water Quality Monitoring Programme Site Network

	Borck Ck @ 400m ds Lower Queen St	Critical site for Waimea FMU and effects urbanisation, likely to get significantly more of Richmond' existing stormwater, spring-fed streams are rare,
	Neimann Ck @ 600m us Landsdowne Rd	Critical site for Waimea FMU and effects urbanisation, spring-fed streams are rare, high NO3, monitor recovery after habitat improvements, close to
Buller	Mangles @ Gorge	LTR, intensive land use in catchment that is important to keep an eye on. Important trout fishery.
	Matakitaki @ SH6 Murchison	LTR, very important kayaking river,
	Murchison Ck @ 20m d-s SH6	LTR, highest faecal in district, high risk stream.
	Buller @ Longford	LTR, NRWQN site.
Motueka / Moutere / Riwaka	Hunters @ Kikiwa	LTR, the only true reference site in Moutere Hill Country. Very strong case to keep as representative of small streams in the Moutere. Useful to compare by side. Nationally important. Has to be monthly sampling.
	Motueka @ Gorge	LTR, HS
	Motueka @ Woodstock	LTR, HS
	Motueka @ SH60	Ex2C, currently monthly.
	Motupiko @ 250m u-s Motueka Rv	LTR, likely increase in land use intensity if irrigation water is provided, Phormidium issue,
	Sherry @ Blue Rock	LTR, HS, intensive land use in catchment, a lot of work that has gone on to improve WQ in this catchment, currently monthly,
	Wangapeka @ 5km u-s Dart	LTR, critical reference site for Motueka (very different REC type (geology/land cover) to Motueka Gorge)
	Riwaka @ Hickmotts	LTR, HS, Ex2C
	Tasman Vly Stm @ u-s Jesters Hse	LTR, ongoing faecal contamination, WQ potential to change with considerable and rapid rural-residential development planned upstream, high potential
	Moutere @ Riverside	Large catchment upstream with intensive land use. HS under consideration.
Golden Bay	Motupipi @ Reillys Br	LTR, HS, high risk of degrading WQ due to water takes in Takaka FMU reducing dilution.
	Powell @ 40m u-s Motupipi Rv	LTR, right beside Reilly Br site (= cheap)
	Takaka @ Kotinga	LTR, HS, Ex2C, very important site for the catchment, not far upstream from tidal influence.
	Takaka @ Lindsays Br	Early warning for rising NO3 from dairy farms into Pupu Springs
	Onekaka @ Shambala Br	LTR, very high value native fishery, moderate risk upstream, drive by to Aorere (= cheap)
	Springs River @ d-s Pupu Springs	Very high values for water clarity and amenity. Need to protect against periphyton growth.
	Aorere @ Le Comte	LTR, Ex2C (marine farming potentially impacted)
	Kaituna @ 500m u-s Track start	No other reference sites in Aorere catchment
	Kaituna @ Sollys Rd	LTR, intensive dairy farming u-s, live issue with Mackay Ck

Key:

LTR - long term reference

FCR - faecal contamination

Ex2C - export to estuary

Existing monitoring site

1st priority site

2nd priority site

3.4 Parameters/attributes

It is proposed to collect all chosen parameters across all the sites (currently we don't sample nutrients at all sites) with the exception of dissolved organic carbon which will only be sampled at Takaka at Lindsay's Bridge. This approach avoids the need to make assumptions about the risk of water quality change at particular sites or the state and trends for unsampled parameters. Other reasons for this change are:

- It is important to know the water quality characteristics of sites that are supporting the full range of community-defined values, to inform more accurate and region-specific limit setting. For example, while it is useful to know the nutrient concentrations at sites where periphyton blooms are common, it is also informative to know the concentrations at sites where blooms are rarely seen.
- It is also important to know if there are trends in water quality parameters, even if they are still well below levels of concern. If trends are identified, then restorative action can be taken before negative effects will occur. However, levels of some parameters are currently usually 10 times lower than levels considered likely to significantly affect river values (e.g. nitrate maxima at the majority of sites around 0.05 g/m³).
- National level reporting is conducted only on sites with a minimum core set of water quality parameters. Tasman District data will be used for national reporting if the sites meet these minimum criteria.
- Analysis and reporting is more efficient and understandable if all chosen parameters are measured at all sites. For example, comments can be made on the proportion of sites with nutrient concentrations below a certain level. There is very little increase in staff time in the field associated with the extra sample collection

Parameters to be Measured

Visual assessment

1. **Water clarity** – black disc
2. **Water colour** (through periscope)
3. The presence of **bank erosion**
4. The presence of **riparian vegetation clearance**
5. **Weather** at time of sampling (wind direction, wind speed, cloud cover, rain/drizzle/ overcast/sun)

Multiparameter sonde measurements

6. Specific **conductivity**
7. **Water temperature** (spot readings)
8. **Dissolved oxygen** - % saturation and concentration (spot readings)
9. **pH** (note: field pH will be phased out and replaced with analysis at the lab because of the time it takes to calibrate and clean, as well as the cost of calibration fluids. Lab measurements might be more precise than field measurement)

Samples for Lab analysis:

10. **Turbidity**
11. ***E. coli***
12. **Faecal coliforms** (can be useful to know faecal coliform to *E.coli* ratios as it can help narrow down a potential contaminant source, comes free of charge with *E.coli*)
13. **Nitrate-N**
14. **Nitrite-N**
15. **Ammoniacal-N**

16. **Dissolved reactive phosphorus**
17. **Total phosphorus**
18. **Total nitrogen**

Note: TP and TN are less useful than the other nutrients as it is the soluble fraction that is the issue. However, it does help determine if there is a particulate source and therefore a reservoir that could become soluble.

Sediment assessment

19. **Resuspendable solids** (3 shuffle scores in runs). Note: Work is underway to adjust the shuffle scores to suit the water depth and velocity. There are sites where no suitable water depth and velocity can be found.
20. **Fine sediment colour** (to help determine the source of the sediment)
21. **Fine sediment coverage**. Change to sampling in runs only – no longer sampling in a riffle and a pool as at most sites pools aren't available and riffles can be some distance away and very seldom have any fine sediment cover and if there is it can be hard to see. Assume that if there is high % cover of fine sediment in a run then it will be in the interstices in the riffle also.
22. **Suspendable benthic sediment** (6 Quorer samples, once per year during summer)
23. **Substrate size class distribution** - Wolman walk (categorising 100 particles into size classes,). This is the only method that analyses all substrate size classes. Do analysis of variability over time (use summer student) and then if reasonably consistent, sample only 5 yearly.

Note: Embeddedness will be discontinued.

Periphyton assessment

24. **Filamentous green algae coverage** (%)
25. ***Phormidium* coverage** (%)
26. ***Didymo* coverage** (%)
27. **Periphyton score** (from October to April using a modified version of RAM2 with 15 or 20 views through bathyscope)

Macroinvertebrate community

28. **Macroinvertebrate community** kick-net sample in riffles (once per year, during summer)

Additional Parameters to be sampled five-yearly:

- **Anions and cations** (Ca, Mg, Mn, K, Na, Cl, SO₄, HCO₃, Fe) Dissolved
- **Hardness** (note: hardness is tested routinely where nitrate is elevated (over 1g/m³) to calculate toxicity)
- **Acidity and alkalinity**
- **Dissolved organic carbon** (CDOM)
- **Zinc and Chromium** in fine sediments in urban streams

This suite was last sampled at all core sites in 2013 and so will next be sampled in 2018.

The downside of sampling all the above parameters at all sites is obviously the cost. This proposal will increase lab costs by approximately 150% of the current quarterly programme (refer Appendix F).

Further discussion on Selected Parameters

Water Clarity

While it takes more time getting the average of 3 readings, replicate readings help to ensure that clarity has not been unduly affected by staff disturbance of the bed when placing the disc in the upstream position.

Over the years a lot of effort has been put into QA for black disc readings to maintain consistency between staff. We generally get differences of less than 5%. However, the differences in water clarity readings between staff and summer student can be more than 10% (for example, the bathing water results for 2015 versus 2016).

The small 50mm discs have not been consistently used when faced with water of low clarity. This is because clarities of under 1m are so rare and so it is easier to forget. While the 50mm and 20mm diameter discs are not always used for black disc readings, there will be a greater need to be vigilant about adhering to the proper method in this respect.

High flow water clarity measurements will be of limited value because water in this condition is not used for recreation because it can be dangerous (people can get swept away) and not pleasant to swim in. It will be important to be able to tag the high flow data so it does not get used for analysis with respect to reporting recreation value.

In high flows it is proposed to use a bucket to fill a portable/foldable trough and measure black disc clarity in the trough.

Water clarity could alternatively be measured using a transmissometer (green light). Transmissometry would have advantages at sites where there is abundant growth of aquatic plants making it difficult to sight the black disc. It takes time to clear a sighting lane (with a rake or by hand) and then wait for the water to come clear (usually 10-15 minutes). However, usually the time to wait for the water to clear is not wasted time because of the other things we can do at the time. This is a problem for about six months of the year.

A transmissometer is being used to sample bimonthly at Springs River 600m downstream from Pupu Springs (instrument owned by NZ King Salmon and operated by Envirolink Ltd on our behalf). Sampling of Pupu Springs itself is desired due to the iconic values of the site, but the precision of measurements appears to be relatively low when water clarity is so high. Black disc measurements are very difficult at this site due to macrophytes.

We have decided not to use transmissometers at any site for the following reasons:

- they are very expensive
- they take a lot of time to calibrate that is not recouped by the few sites where water weed is a problem
- they have a less dynamic range (so you have to dilute samples in relatively dirty water, again taking time

Another option is to look for places that have full shade (not dappled light) or even create shade with shade cloth to reduce or eliminate macrophyte growth.

Turbidity

Tasman District Council has been analysing samples for turbidity for all core sites in the lab since our programme began in 1999. Lab turbidity is useful, especially for extrapolating the visual clarity-turbidity relationship at times when flow is so low or weed so thick that black disc measurement is difficult. Usually visual clarity and turbidity are quite closely (inversely) related in a particular river (e.g., Hughes et al. 2014).

Consideration was made as to whether sampling for turbidity should continue. Reasons to continue include:

- Long data sets will be wasted.
- Required at some sites where black disc readings are impossible e.g. small streams with clear water and small pools.
- Useful in flood-flow situations instead of constructed trough arrangement for black disc (required due to OSH risk of sampling in flooded rivers)
- Relatively low cost \$5/sample (for 40 sites 12x/year = \$2400)

Reasons why we should discontinue sampling for turbidity:

- Cost saving
- Little information is lost by dropping this parameter because we measure black disc water clarity.
- Usually turbidity is very low and at those low levels there is low accuracy.
- This parameter was not analysed in the latest RWQ report. It was given a low priority given the effort needed in data analysis for this reporting project.

Another option is to only sample turbidity at sites where there are practical issues with taking a black disc measurement (e.g. Neimann Creek, Reservoir Creek, or during high flow events).

Overall it was decided to keep turbidity measurements at all sites.

E.coli

The proposed changes to the sampling programme will mean that more *E.coli* data is collected across a range of flows. This will enable relationships between flow and *E.coli* to be developed, which may allow predictions of when sites are suitable (or not) for recreation.

Ammoniacal nitrogen

Consideration was made as to whether sampling for ammoniacal nitrogen should continue. Reasons to continue include:

- Ammoniacal nitrogen can cause toxic effects on stream life and is also a potential issue as a nutrient and required in order to calculate DIN.
- Most Councils sample this parameter
- Relatively low cost (\$9.27 per sample in 2016)

Reasons why we should discontinue sampling:

- Ammonia-N concentrations are nearly always very low and mostly trending lower, so the risk to ecosystem health is very low.

Overall it was decided that the benefits outweigh the negatives and to keep ammoniacal nitrogen measurements at all sites.

Periphyton

Periphyton (using Chlorophyll-*a*) is an attribute for the compulsory ecosystem health objective listed in the NOF. The cover of benthic cyanobacteria and filamentous green algae are very relevant in the community (as documented in the FLAG process). Arguably the most important measure of periphyton is cover of filamentous green algae >2cm. We also sample the coverage of different periphyton types using the RAM2 method, but we have not measured periphyton biomass using chlorophyll-*a* (see justification in section 3.4).

In 2010 we started using a bathyscope instead of individual stones (as stipulated in the RAM2 method) to assess an area of stream bed instead of the area of a stone. This was because of the difficulty of assessing coverage of filamentous green algae that extend beyond the stone. You generally need to pick up a stone to assess cover and therefore do not see the filamentous green algae attached to another stone that is covering that stone.

Matheson et al. (2012; 2016) have proposed the use of a weighted composition cover score for periphyton that is calculated as the sum of the filamentous cover and half the mat cover. The aim of this weighted score is to come up with a single periphyton score that is closely linked with community values such as fishing/aesthetics. It is likely that the NOF will be updated to include this periphyton cover attribute, as an alternative to the current periphyton biomass (chlorophyll *a*) attribute.

Periphyton needs to be sampled monthly as the 3 samples/year (as per the quarterly programme; did not sample in winter) is not enough to make sense of the data given the variability at a site. Often there is only one in 5-10 samples over the 30% cover threshold at a site and the others at or near zero. Only about 25% of sites have ever had filamentous green algae >2cm long with a bed coverage of greater than 30%. Periphyton cover at the remainder of sites is generally very low. In the future there may be more accurate and rapid methods for periphyton assessment e.g. the 'Infratorch' (based on pigment analysis). Percentage filamentous green algae usually doesn't correlate well with RAM2 score.

NOF requires % exceedence over a 12 month period. However, it could be argued that periphyton growth is light limited and therefore not necessary to sample from May to September (inclusive). So it is better to concentrate monitoring during the seven months from October to April inclusive. By not sampling in winter it helps to ensure that the fieldwork can get done in time for the courier in Golden Bay (earlier courier cut-off times in Takaka in winter). Even though it takes a lot less time to sample periphyton in winter when there is very little of it, it still takes 8-10 minutes/site instead of 20 minutes for complex periphyton cover.

Macro-invertebrates

Council uses standard methods stipulated in the Macro-invertebrate Protocols (using protocols C1 and P1) for sampling and processing macroinvertebrate samples. This includes using the standard stand-down period of >3 weeks following a flood 3x the previous base flow.

Given that invertebrates are sampled using a quantitative Surber sampler at NRWQN sites (potentially at different times), it is suggested that Council also **collect samples at each of the NRWQN sites by semi-quantitative kick net.**

A national initiative is underway to help further standardise macroinvertebrate sampling and processing protocols. There may be changes required to methods arising from this national macro-invertebrate working group. These changes are likely to be formalised via NEMS. Macro-invertebrate sampling is likely to become a

compulsory variable to sample under the NPS-FWM, making it more important to sample at all sites (large river sites are currently not sampled for invertebrates).

We may need to run the invertebrate sampling programme separately from the rest of the RWQMP if we cannot get the required stable base flow period.

Re-suspendable sediment

Fine sediment is a very high priority attribute (e.g. Freshwater Science Society workshopped issue). It is a very relevant measure to check the potential reason for a particular macro-invertebrate condition. The shuffle method is still semi-quantitative and a “heads up if there is a problem” type of indicator. It is appropriate to do it annually alongside macro-invertebrate sampling given the time it takes per sample. The volumetric Quorer method is used to quantify Suspendable Benthic Sediment Volume (SBSV). There is high variability between replicates for sites with high levels of resuspendable sediment. This may be due to poor recording of depth of penetration of bed (this is being tightened up) or high natural variability within a run.

In time we may be able to come up with a valid attribute state/ threshold for SBSV to use in planning documents or resource consent conditions.

Despite SBSV being costly in staff time it was decided that annual sampling alongside invertebrate sampling should continue. This takes about 1 hour per site (sampling and processing).

There are some sites where the Quorer method is not possible, i.e. non-wadeable, soft-bottomed and bouldery rivers.

Note: We have made the following changes to the protocol for this measurement: There are markings inside the barrel to record the volume of water it contains. In the calculation of SBSV, however, the volume of water in the barrel is not required. Instead, the water depth is used. We will alter the field methods so that the water depth is recorded. This change will avoid the need to convert water volume to water depth (a confusing task when it is unknown which barrel was used at which site).

This method will be reviewed in 2019 (between replicate variability) when data analysis for the next SER is started.

Bed Sediment Generally

The Wolman substrate size distribution analysis is an important measure of habitat alongside invertebrate sampling. Plot % of size classes on bars for each year. This method has a long history of use and is a well-established and accepted method.

Parameters Considered and Dismissed

Chlorophyll-a (Chl-a)

Chl-a is a useful measure of periphyton biomass because it takes into account mat thickness which can be of similar concern from an ecological perspective as filamentous green algae but is less of a concern from an aesthetic perspective. Chl-a is a compulsory attribute under the NPS-FWM, but this may be changed in the future to include periphyton cover.

There are several reasons why we have decided not to start sampling for chl-a:

- Visual assessments of periphyton cover distinguish sites as effectively as Chl-a (Kilroy et al. 2013)
- high variability at a site and over time and therefore a lot of samples must be taken at a site and pooled in order to be representative
- It will take several years to build up a reasonable dataset to produce useful information
- Several Councils have found poor relationships between Chl-a and filamentous green algae cover, as well as with other measures of ecosystem health (e.g. dissolved oxygen).
- Additional lab budget of \$4,434 is required (\$21.32/sample x 26 sites x 8/year)
- This measure is also costly in staff time.
- A periphyton %-cover type attribute, such as the weight composite cover score described by Matheson et al (2012;2016) may be included in the NOF in future, removing the need to sample Chl-a (several experts tend to favour the cover-type measures)

Given the long term value of the periphyton cover data, we are not intending to make changes to this unless stipulated by NEMS.

Macrophytes

Several Councils are sampling macrophytes (either cover, volume, species composition) as part of their river monitoring programmes. The reasons for this are:

- Macrophytes clearly exert a high degree of influence over water quality (e.g. dissolved oxygen) and habitat
- Helps identify biosecurity issues from pest plants such as *Egeria*, *Lagarosiphon* and *Hornwort*.

However, we do not recommend sampling this parameter because it is not well related to anthropogenic pressures (including land use), but more to riparian shading, fine sediment content of the bed, macrophyte species present and flood frequency/source of flow. Lowland spring-fed streams are much more likely to have macrophytes than rain-fed rivers.

Total Suspended Solids

It would take a long time to get enough measurements at high flows to get robust estimates of fine sediment loads, even with monthly samples. This is because the vast majority of the load will occur during infrequent high flow periods. It would take over 10 years to start to get a useful relationship between flow and TSS which could be used to estimate loads.

To get more robust estimates of sediment load you need to install continuous turbidity loggers and do targeted sampling of high flows to get a good site-specific correlation between turbidity and TSS. You can then interpolate the synthetic continuous TSS data to give loads. This is the approach undertaken by Murray Hicks and Les Basher for the three sites on the Motueka (Basher et al. 2011).

3.5 Integration with other related monitoring programmes

Freshwater Fish Monitoring Programme

It is valid to sample fish for the purpose of detecting any impact from a particular activity or to determine the presence of rare fish (important biodiversity measure). There are potentially strong connections between RWQ and fish abundance and diversity. For fish monitoring, survey methods which provide information on more than just presence/absence are preferable. For example, national protocols for diversity and abundance monitoring have been developed (e.g. David et al. 2010; Joy et al. 2013). Analysis of population size structure, fish growth rates and fish condition also offer potentially useful metrics of fish community health.

It is recommended to increase the sampling frequency of fish monitoring and try to include abundance methods as much as possible. About 20% of wadeable core sites should be sampled on a 3-yearly rotation. The remaining 50% of the budget should go to investigation sites. Note that it is not possible to sample at about 50-60% of core RWQ sites as they are not wadeable. Additionally there are budget implications for any increased effort in this area.

3.6 New Monitoring Programmes that should be Considered

Lake monitoring

There is currently no monitoring of lakes. Risks of degrading water quality in lakes Rotoroa, Rotoiti, Otuhie are very low and Kaihoka Lakes relatively low. The main risk of contamination of Lake Rotoiti would be from Black Valley Stream which is currently monitored. However, there is a risk of weed and pest fish incursion. There is high national interest in lakes and nearly all other councils are monitoring their lakes (so Tasman is an exception). The need for lake information is more a national need and therefore lacks justification at a Regional level. Additionally costs are high as monthly sampling is required and the use of a boat need to be considered.

Preliminary sampling of Lake Killarney is under way but a comprehensive sampling plan needs to be developed.

Stream Habitat

Knowing the state of stream habitat in the region would help us understand what is driving aquatic biodiversity and help quantify how much effort it may take to restore aquatic biodiversity values. For example, given the widespread issue of low dissolved oxygen and high water temperatures in small lowland pastoral streams, it would be very useful to know how much riparian tree cover there is in these streams and therefore enable us to quantify the cost of riparian fencing and planting to improve the state of these streams.

There are four types of methods that could be employed:

1. Desktop assessment using remote sensing and analysis. With LiDAR, high resolution aerial photos and other GIS layers, channel form and riparian cover can be assessed reasonably cheaply at a regional scale.

2. Rapid habitat protocols (Clapcott J, 2015) allow a site to be scored and therefore record trends over time (unlike the Stream Habitat Assessment Protocol). These are field methods and can easily be carried out by summer students. This would be appropriate to assess reaches affected by rock rip-rap river protection work and gravel relocation and extraction, which are suspected at reducing habitat quality for trout populations in the Motupiko and Riwaka Rivers. This monitoring, and potentially the employment of the Natural Character Index (Fuller et al. 2015) may occur as part of Council's Engineering Department's Global Rivers resource consent for riverbed maintenance works.
3. Detailed field habitat assessments are useful to understand reach-scale processes and are most appropriate when doing fish surveys. Parameters include: percentage of a river with pools over a set depth, shading, vegetation and others.
4. Assessment of connectivity (fish passage) is undertaken during a week's campaign each year. This involves assessment of structures to provide for fish passage.

It is recommended that a desktop GIS-based assessment of riparian condition and channel form be scoped and costed.

Part 4 – Investigation Programmes

Investigations are intensive and usually for a short period of time. Investigations are considered critical to provide information in the following situations:

- Determine cause and effect, such as what and where is the source of a particular contaminant polluting a particular waterway
- Determine daily flux of parameters such as dissolved oxygen and temperature

It is suggested that 25-30% of the RWQMP budget in any one year be devoted to investigations. Where possible these should be coordinated with other work programmed to occur in an area, mostly these will be standalone targeted initiatives.

4.1 Periodic Continuous Dissolved Oxygen and Temperature Sampling

It is proposed that:

- We aim for at least three deployments of sensors (at least 7 sondes) over the months from December-March inclusive.
- If possible, deployments of temperature-dissolved oxygen loggers should be 7-days or more. However, it is far better to have a short deployment duration of 3-4 days and collect a short period of high quality data, than try to collect long records of poor quality data or no data at all. The frequency of rainfall events, even in summer-autumn mean that there are few opportunities to reliably deploy sondes during a stable flow period. So staff should look to conduct 3-4 day deployments.
- While the majority of sampling sites will be on smaller at-risk streams/investigation sites and tributaries of the core RWQMP sites, every site in the monthly RWQMP should be sampled over the next 10 years, including the large river sites.
- The frequency of sampling at a site should be at least once every five years. This would not be enough to provide useful trend information. Without detailed information on likely variability between replicate samples it's not possible to do a full formal power analysis, but making some general assumptions it looks like five deployments would have very low power (<0.25) of detecting a 10% change per year. Smaller changes would be even less likely to be detected. Even a 20% change per year is only likely to be detected 50% of the time (i.e. Power 0.5) with just five deployments. **With 20 deployments, you start to get reasonable power to detect 2-5% changes per year.** It is likely that the larger river sites will have good dissolved oxygen. However, it is important to have an understanding of how this key parameter varies at sites throughout the region.
- Consider replacing or purchasing more D-Opto-type sensors as budget allows.
- More sampling at reference sites needs to be carried out (about 10% of effort). The main reason for this would be to determine the effects of climate change and therefore the "uncontrollable background".
- Install temperature loggers at all core sites. In this way chronic effects on fish and invertebrates are quantified.

The importance of dissolved oxygen and water temperature as attributes of water quality are increasingly demonstrated the more we collect such data. Continuous measurement is fundamental for such attributes that vary so much throughout a 24-hour period. The equipment required is too costly for it to be feasible to collect dissolved oxygen data continuously at all sites, but temperature loggers are relatively cheap (\$250 each). MfE is considering inclusion of water temperature and dissolved oxygen for all sites in the NOF, but is unlikely to force Councils to monitor for 365 days/year as this would involve a big cost and would be practically difficult to achieve (would probably require duplicate loggers).

4.2 Sediment source sampling

Given the importance of sediment contamination, it is important to determine the source of such sediment. Bank erosion was determined as a big source in the Moutere Hill country but sources from forest harvesting on steep country in the Bryant ranges is suspected to be high. staff are developing a proposal to add a separate programme for sampling TSS after rain e.g. in Lee-Roding. the existing proposal is to use NIWA to do an Envirolink-funded project to scope a study looking into tracking the

source (e.g. using the chemistry of various geologies). Sediment cores in the Moutere could reveal rates of deposition from forestry activities.

Part 5 – Data management

Flow and river water quality data

It is important to continue to collect flow data along with river water quality data. This will allow for additional analyses e.g. flow adjusted trends, nutrient/E.coli loads to sensitive receiving environments such as estuaries, loads from particular discharges. Flow data derived from a good correlation to a similar site in the area is acceptable. To date staff have not used this as a standard reporting information source but expect to do so in the future.

Flow measurement units

As for all parameters, the units need to be checked. Occasionally, flow measurements (Flow for WQ in Hilltop) are input in L/sec rather than m^3/sec . These errors leave flow measurements that are several orders of magnitude greater than expected. To reduce these errors, we will implement an additional check of the flow data. This check involves running a script after each RWQ round to find values greater than 100 times the median flow for sites that are gauged.

Identifying quarterly and monthly monitoring data in Hilltop

During the data analysis with both data biased to low flow (quarterly programme) and unbiased to flow (monthly programmes), we found that it is difficult to determine whether a sample was collected for the quarterly or monthly monitoring programmes. Once we change to sampling all sites monthly sampling at any flow condition, this will not be a problem.

Data collected for both programmes are kept together under the same site names in Hilltop. This is preferable because data users often wish to see all the data collected for a site at once (in the same plot). Keeping data for the same site in the same location is a good approach. To make it easier to separate quarterly and monthly samples during data analysis, we will add 'flags' to each measurement in Hilltop indicating the programme it came from.

This could be implemented in three steps:

1. Allow each River Water Quality data source in Hilltop to accept two new pieces of ancillary data (called IsMonthly and IsQuarterly) in the format of binary variables (they can only be True or False). This is similar to the way non-detects are handled in Hilltop. It will be useful to have both IsMonthly and IsQuarterly because it will reduce ambiguity for samples that are collected for BOTH the monthly and quarterly programmes.

2. Assign values to IsMonthly and IsQuarterly for the existing River Water Quality data. There is a table of known monthly samples in <G:\Environmental\Trevor James\Surface Water Quality\Reports\SER 2015\R Input>
3. Modify the procedure for importing new data into Hilltop to ensure the ancillary data is included.

In practice, there are likely to be additional steps required to implement this change. These additional steps will become clear after discussing this proposal with Information Services (Ian Brown is key to this).

Part 6 – Further Discussion

Future Innovation Opportunities

Modelling

Models are currently used for fish, water clarity and macro-invertebrate distribution. While we can't rely too heavily on models and they will never replace real data, they are potentially useful for getting an unbiased picture of water quality for the whole region.

The most exciting potential of modelling is predictive estimates of health risk for contact recreation. In the future models for water temperature and dissolved oxygen may become reliable to use for regional reporting. Models for *E.coli* and fine sediment are currently inaccurate.

Links between the RWQMP and other monitoring programmes

Information from different programmes should complement each other. For example, when examining sediment deposition in estuaries, it is helpful to also collect TSS from river sites during or immediately after a flood event.

Before dropping sites or parameters, consider their importance for other monitoring programmes.

How can we better integrate Council's Groundwater Quality and River Water Quality Monitoring Programmes? Integration is particularly important in the Waimea Plains where there is a lot of groundwater and surface water monitoring. Nitrate, for example, is measured in the GW sampling programme. In addition to the quarterly monitoring of groundwater at core sites there is a 5-yearly rotation of monitoring groundwater at a much larger set of bores as well as emergent springs.

Conclusion

The changes that are proposed to the RWQMP network will bring this programme into line with most other council monitoring programmes around the country and enable many of the likely questions about water quality in the district to be answered. The change to monthly monitoring across all flow conditions will provide a good indication of the state of water quality at the sampling sites and provide sufficient statistical power to detect any trends in water quality in a timely manner. All chosen water quality parameters will be measured at all sites, providing good information on the characteristics of sites that are facing issues, as well as the characteristics of healthy sites that are providing for all the values that the community desires. Unfortunately, the increased cost of moving to monthly sampling has had to be balanced by decreasing the number of sites in the sampling network. However, the reduced number of sites still covers the key catchments throughout the district and the majority of the climate, geology and land use classes.

References

Biggs, BJF, Kilroy, C; 2000. Stream Periphyton Monitoring Manual.

Clapcott J 2015. National rapid habitat assessment protocol development for streams and rivers. Prepared for Northland Regional Council. Cawthron Report No. 2649.

Fuller, IC., Death, RG., & Death, AM. (2015, June). Developing an index of natural character to monitor change in river condition in response to river engineering. Presented at [IS Rivers](#). Lyon. [Conference Oral Presentation]

Hughey, K, Kerr, G, & Cullen, R (2013). Public perceptions of New Zealand's environment: 2013.

James, T. 2005. Review of Tasman District Council Surface Water Quality Monitoring Programme.

James, T. 2014. Review of Tasman District Council Surface Water Quality Monitoring Programme.

Joy, M; 2013. A fish index of biotic integrity (IBI) for the Tasman-Nelson region.

Kelly, D; Meredith, A; Stevenson, M; 2014. Review of Environment Canterbury's State of the Environment Water Quality Monitoring Programme for Rivers. Report # R13/5. ISBN 978-1-927234-25-9 (print), 978-1-927234-26-6 (web)

Kilroy, C; Booker DJ; Drummond, L; Wech, JA; Snelder, TH: 2013. Estimating periphyton standing crop in streams: a comparison of chlorophyll a sampling and visual assessments. *NZ Journal of Marine and Fresh*

Leithwick, J, Julian, K, Elith, J, Rowe, D; 2008. Predicting the distributions of freshwater fish species for all New Zealand's rivers and streams. NIWA client report: HAM2008-005. NIWA Project: DOC06212

Matheson, F; Quinn, J; Unwin, M; 2016. Instream plant and nutrient guidelines; Review and development of an extended decision-making framework, Phase 3. NIWA CLIENT REPORT No: HAM2015-064. *Prepared for Ministry of Business, Innovation and Employment Envirolink Fund, January 2016*. With contributions from: Karen Shearer, Cawthron Institute; John Hayes, Cawthron Institute; Cathy Kilroy, NIWA; Ton Snelder, Aqualinc; Doug Booker, NIWA; Annika Wagenhoff, Cawthron Institute; Suzie Wood, Cawthron Institute.

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 Report* No. HAM2012-081: 127.

Tasman District Council; 2014. River Water Quality Monitoring Programme. A Statement of Programme Design and Procedures.

Appendix A – Changes to RWQMP Considered and Rejected

A1 - Random site selection

Reason for considering:

Redesign of the monitoring site network based on stratified random site selection, rather than the current risk-based design is the most scientifically robust and ideal because it makes it possible to answer the question ‘What is the general state of water quality in rivers and streams throughout the Tasman District?’. Random site selection in this manner allows for statements about overall water quality at the scale of the district to be made, for example, ‘30% of streams in Tasman District have levels of disease-causing organisms within the C-band’. At present, statements such as this cannot be made because the current sites are not necessarily representative of the region as a whole and the available water quality models for some key variables do not produce reliable predictions for the Tasman District. No other network design can come close to achieving this without using models that have inherent uncertainty.

Random site selection would involve identifying all accessible river segments in the REC network, dividing them into reference and impact groups and selecting a set of river segments from each group randomly (but still considering practical constraints such as access points – this is known as ‘stratified random’ site selection). Some analysis is required to determine the minimum number of [x] reference sites and [y] impact sites required.

This network design has been employed by one other council in New Zealand for their biomonitoring programmes (invertebrates and fish).

Reasons for Rejecting:

The main reason for rejecting a redesign of the network based on a stratified random site selection is the very large cost involved. This cost could be in the order of 3-5 times that of the current programme, but it is difficult to estimate the increase in cost without first randomly choosing a set of sites. Other reasons include:

- Abandonment of the current monitoring site network and the large investment that has gone into it.
- An increase in the cost of the programme due to:
 - a greater length of time spent travelling to and accessing the sites because they may be more scattered throughout the region e.g. Maruia and Westhaven
- If all core sites are randomly sampled, it is unlikely that any of the existing core sites will be retained. This will mean that trend info from these core sites will no longer be available.

Instead, we will have to rely on models to try to determine the state of particular attributes across all rivers. Currently the only reliable models available are for water clarity and MCI, but it is hoped that more will be available in the future. We will retain a sampling network of sites chosen on the basis of risk of degradation in river health condition and importance or value of particular sites and waterbodies.

Notes about models:

- Models only available for MCI, fish presence and water clarity
- temperature models are acceptable, outside of groundwater influence

- DO models are some way off
- periphyton models work well for nutrients in particular stream types but need work to compare across stream types
- *E.coli* models are not useful as this attribute is so dependent on particular practices on particular farms
- Before predictions can be made for the Tasman District, all models require validation using data collected from the RWQMP sites. If there are no sites in a particular REC class then the models can't be validated for that class.

Appendix B – Monitoring Site Densities by Region

Methods

Two RWQ site densities were calculated as follows:

- Density of RWQ sites in working landscape (sites/1000km²)
- Density of RWQ sites by total area of region (sites/1000km²)

Site densities were calculated using the number of sites in the latest RWQ report from each region.

The working landscape was the total area of a region minus DOC public conservation area within the region.

The density of RWQ sites by length of stream network (sites/1000km of stream) was considered but is likely to give similar results because there is a close correlation between the area of a region and the length of the stream network within it.

Results

The median site densities for the 16 regions were as follows:

- By working landscape: 5.5 sites/1000km²
- By total area of region: 3.9 sites/1000km²

If the median values were used as a benchmark, how many sites should Tasman have? Results are rounded up.

- By working landscape: $5.5 \text{ sites/1000km}^2 \times 3700\text{km}^2 = 21$
- By total area of region: $3.9 \text{ sites/1000km}^2 \times 9800\text{km}^2 = 39$

Tasman currently has 59 sites in the RWQ monitoring programme. Of these, 51 sites are in the working landscape (59 minus 8 references sites). In the plots below, the density of RWQ sites in each New Zealand region are shown.

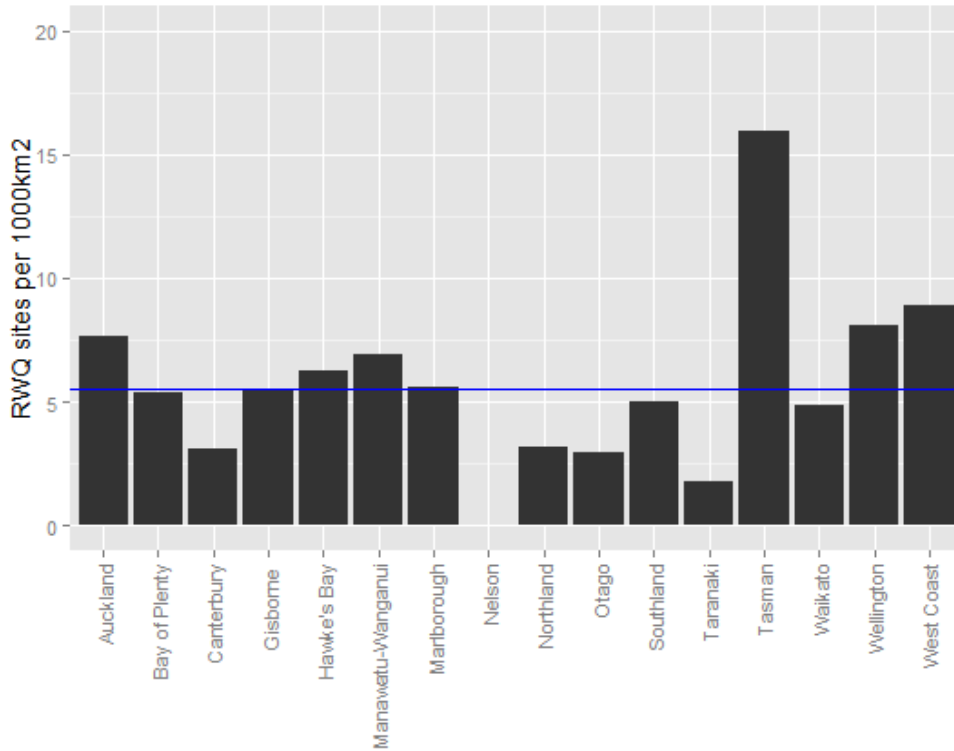


Figure 2. Density of RWQ sites in the working landscape for each New Zealand region with the median (blue line). The value for Nelson was 79.1 RWQ sites per 1000km² (not shown).

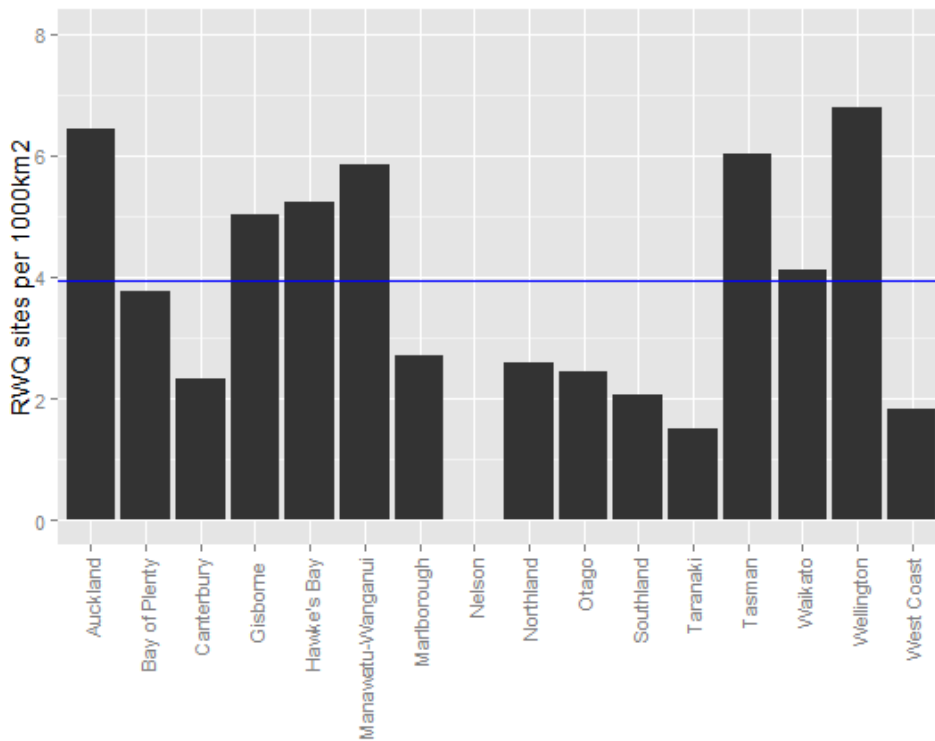


Figure 3. Density of RWQ sites by total area of region with the median (blue line). The value for Nelson was 62.9 RWQ sites per 1000km² (not shown).

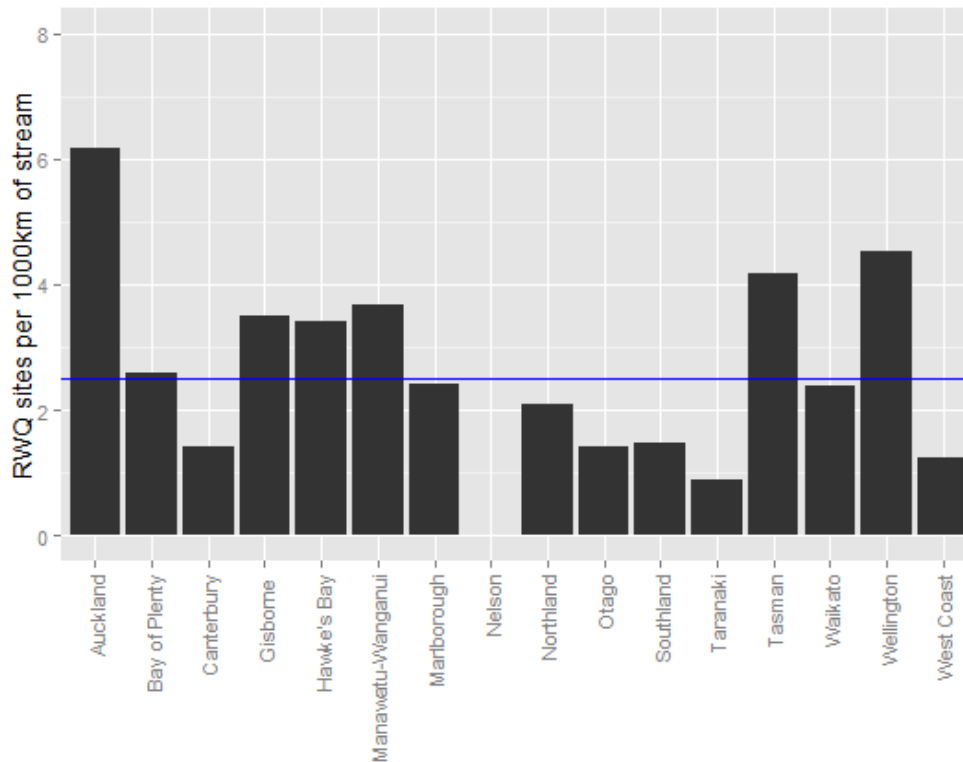


Figure 4. Density of RWQ sites by total length of stream in the region with the median (blue line).

Table 4. Data used to calculate RWQ site densities for New Zealand regions

Region	RWQ Sites (number)	Working Area (km ²)	Total Area (km ²)
Northland	36	11406	13941
Auckland	36	4700	5600
Waikato	105	21567	25598
Bay of Plenty	47	8700	12447
Gisborne	42	7700	8351
Hawke's Bay	74	11770	14164
Taranaki	11	6044	7273
Manawatu-Wanganui	130	18771	22215
Wellington	55	6785	8124
West Coast	43	4849	23336
Canterbury	106	34277	45346
Otago	78	26347	31990
Southland	71	14144	34347
Tasman	59	3708	9786
Nelson	28	354	445
Marlborough	34	6079	12484

Appendix C – Monitoring Site Network Design

C1 - REC Class Coverage

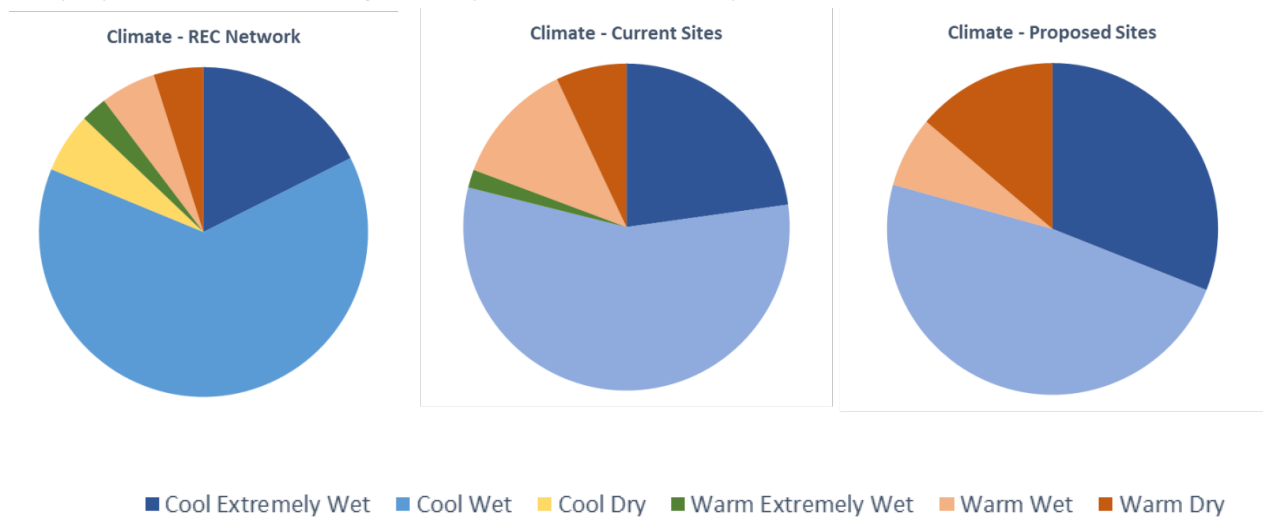
The pie charts show the proportion of sites in each River Environment Classification category for:

- REC network river segments in the Tasman District excluding those on DOC estate
- The sites currently in the RWQ programme (n = 57)
- The proposed RWQ sites (n = 29)

When the 3rd priority sites (shown in Table 2) are included, the pie charts for the proposed sites remain very similar, other than Stream Order, in which the new Order 7 category is introduced.

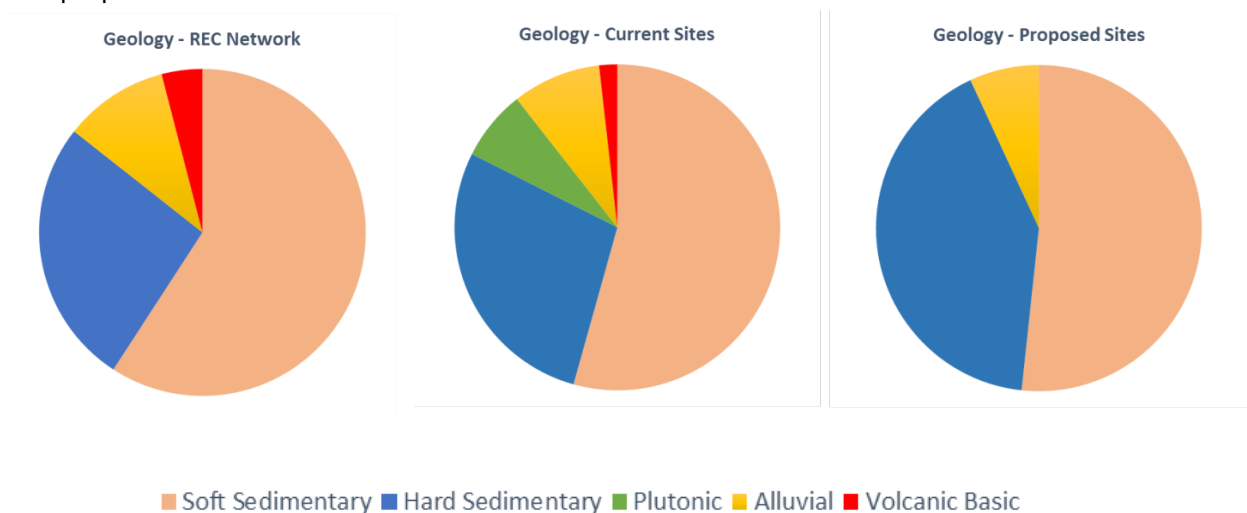
Climate

The proposed sites are missing Cool Dry and Warm Extremely Wet sites.



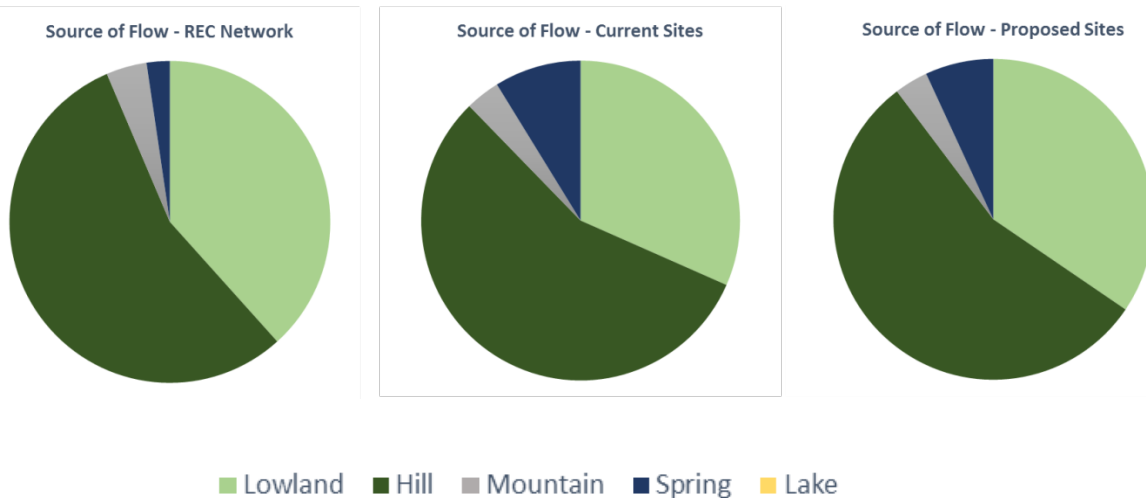
Geology

The proposed sites do not include Plutonic or Volcanic Basic sites.



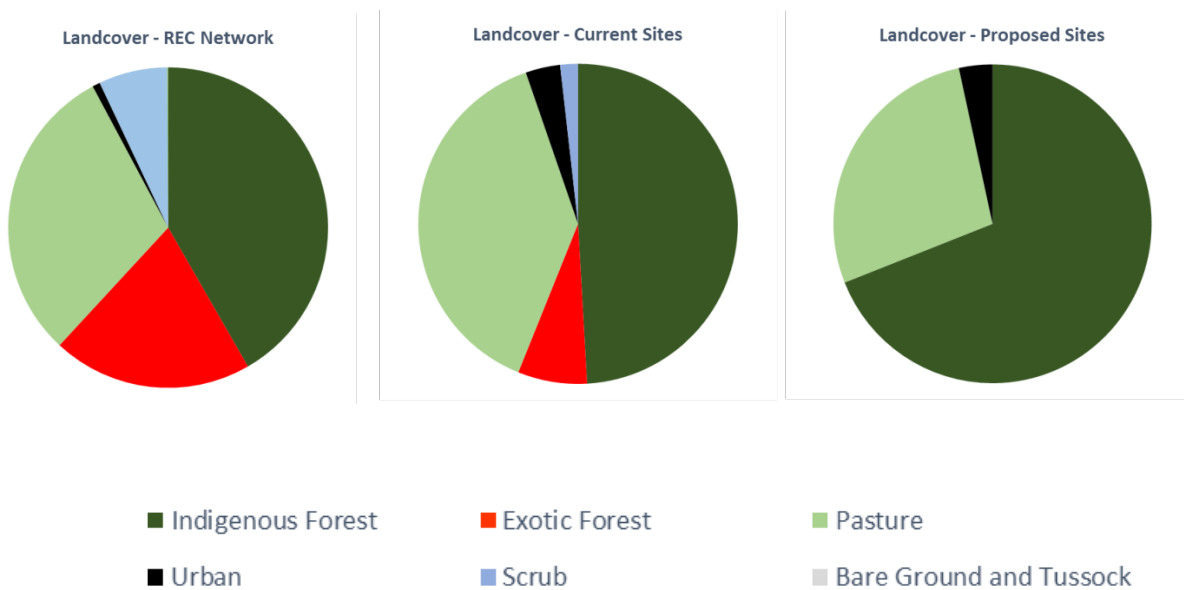
Source of Flow

A similar proportion of each category are present in both the current and proposed sites.



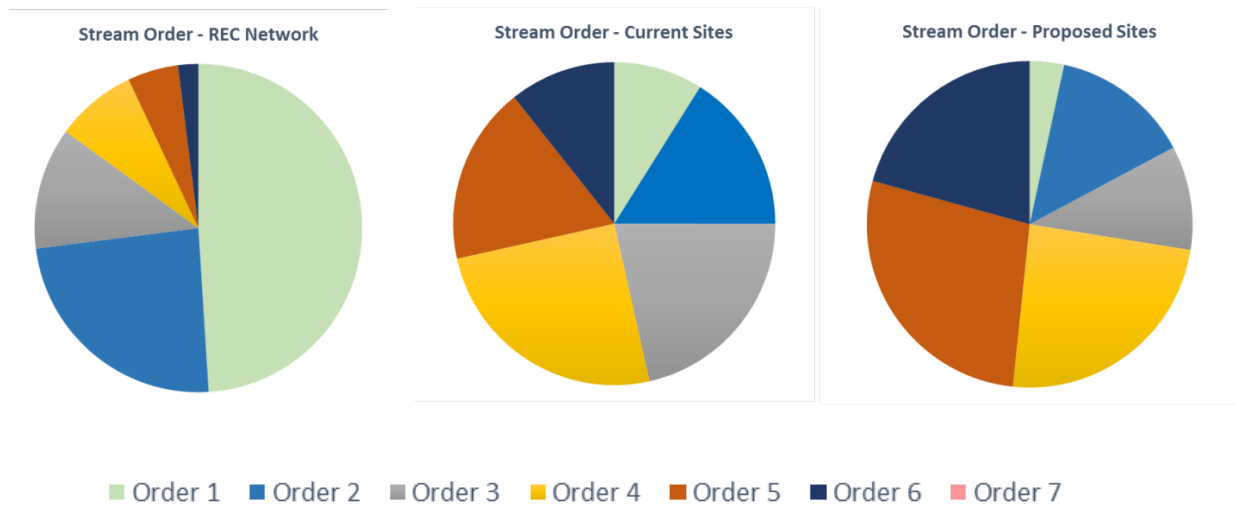
Landcover

The proposed sites are missing Exotic Forest and Scrub sites.



Stream Order

A similar proportion of each category are present in both the current and proposed sites.



Appendix D – Reasons for Retaining and Removing Across All Sites

	Site	Reasons to Keep/Add	Reasons to Remove
Waimea	Roding @ Twin Bridges	LTR, forestry, dam and lifestyle blocks. Important swimming site	Covered by BWQMP, low fish values
	Lee @ Meads Br	LTR, HS, critical site if Lee Dam goes ahead. Relatively close to office = cheap	
	Wairoa @ Irvines	LTR, HS, Important to take into account of Lee vs Wairoa u-s Lee. Relatively close to office = cheap	
	Wairoa @ Pig Vly	LTR,	Not a good reference site due to forestry upstream.
	Wai-iti @ Livingston Rd	HS, large developed catchment upstream, toxic algae issue, flows into Waimea which is highly valued	Limited WQ issues
	Waimea @ SH60 Appleby	LTR, HS, Ex2C, expected change with water take claw back, Phormidium issue, close to office = cheap, existing monthly site	
	Neimann Ck @ 600m u-s Lansdowne Rd	Critical site for Waimea FMU and effects of land use intensification, high ecol value with GK potential, main "canary" for dam/irrigation project, likely restoration project to occur in future, close to Richmond office = cheap	
	Borck Ck @ 400m ds Lower Queen St	Critical site for Waimea FMU and effects urbanisation, likely to get significantly more of Richmond' existing stromwater, spring-fed streams are rare, high nitrate, monitor recovery after habitat improvements, close to Richmond office = cheap.	
	Reservoir Ck @ 20m d-s Salisbury Rd	LTR, waterway with largest urban proportion in catchment, close to office = cheap	

	Reservoir Ck @ u-s Marlborough Cr	LTR,	Only reference site for urban land use (still affected by dam, cattle and forestry). Forestry won't start again until about 2030. Little change?
	Redwood Vly @ Greenacres Rd	Catchment land use typical for a small Moutere Hill stream flowing to the Waimea Inlet - good to characterise and then use to model other similar streams. Wide community of interest around Waimea Inlet. Relatively close to office = cheap	Goes to ground within 100m downstream for 1-2 months/yr
	Pearl Ck @ 200m us tidegate	Critical site for Waimea FMU and effects of land use intensification, high ecological value with GK potential, restoration project needs feedback, different aquifer feed of Neimann. Close to Richmond office = cheap	
Motueka 1	Hunters @ Kikiwa	LTR, the only true reference site in Moutere Hill Country. RY - very strong case to keep as representative of small streams in the Moutere and similar catchment size, climate, aspect, geology, side by side. Nationally important. Has to be monthly sampling.	No longer have operational hydrology weir and recorder as NIWA have abandoned this site. Hydro site expensive to reinstate. Involves about 40 min (return) of driving from Kikiwa site.
	Kikiwa @ Kikiwa	LTR,	No longer have operational hydrology weir and recorder as NIWA have abandoned this site. Hydro site expensive to reinstate. Involves about 40 min (return) of driving from Kikiwa site.
	Graham @ farm forest bdy	LTR,	No longer have operational hydrology weir and recorder as NIWA have abandoned this site. Hydro site expensive to reinstate. Involves about 40 min (return) of driving from Kikiwa site.
	Motueka @ Gorge	LTR, HS	
	Motupiko @ Christies	LTR, HS, impt reference site for lower Motupiko	

	Motupiko @ 250m u-s Motueka Rv	LTR, likely increase in land use intensity if irrigation water is provided, Phormidium issue,	
	Wangapeka @ Walter Peak	LTR, HS, relatively high risk.	
	Wangapeka @ 5km u-s Dart	LTR, critical reference site for Motueka (very different REC type (geology/land cover) to Motueka Gorge)	Long drive upstream to this site = costly. Enough reference data to compare to Walters Peak
	Sherry @ Matariki Br	LTR, appropriate to keep going as sonde and E.coli, a lot of work that has gone on to improve WQ in this catchment	
	Sherry @ Blue Rock	LTR, HS, intensive land use in catchment, a lot of work that has gone on to improve WQ in this catchment, currently monthly,	
	Sherry @ u-s Cave Ck	LTR, impt reference site for farming (isolates forestry)	Only a reference site for farming land use. All catchment upstream is in forestry.
	Sherry @ u-s Granity	LTR, reference site for dairy farming, a lot of work that has gone on to improve WQ in this catchment	
	Motueka @ u-s Wangapeka	LTR, Cumulative effects from Mot u-s Motupiko, Tapawera WWTP, Tadmor, Hinetai etc. Go right past on way to Wangapeka at Walters = no cost	Land use intensification u-s should be captured by Motupiko
Motueka 2	Motueka @ Woodstock	LTR, HS	
	Motueka @ Woodmans Bend	LTR, HS, Ex2C (used in Mot ICM). Currently quarterly.	
	Motueka @ SH60	Ex2C, currently monthly.	
	Riwaka @ Hickmotts	LTR, HS, Ex2C	
	Riwaka @ Northbranch Source	LTR, Iconic water at resurgence	
	Moutere @ Riverside	Large catchment upstream with intensive land use. HS under consideration.	
	Waihero @ Cemetery	LTR, typical sheep/beef farm on Moutere country, useful hydrological record.	Small catchment and only represents one farm upstream. Large dam has undue influence. Similar to Kikiwa and Redwood but in a much warmer zone (good comparison)
	Tasman Vly Stm @ u-s Jesters Hse	LTR, ongoing faecal contamination, WQ potential to change with considerable and rapid rural-residential development planned	

		upstream, high potential to improve habitat. Important to have a stream of this size.	
	Seaton Vly @ Stafford Dr	LTR, catchment likely to undergo change to rural residential in next 10 years	Very small stream. Little change??
	Biggs Ck @ Hewitts Rd	Only one farm upstream that is not managed well. Need to keep an eye on	
	Brooklyn @ Westbank Rd	LTR, only interested in faecal discharges	Little change?
	Little Sydney @ Factory Rd	LTR, issues with septic tanks and farming reoccur periodically.	Small creek with relatively poor habitat in the low-mid reaches.
Golden Bay	Winter @ 50m u-s Totaranui Rd	LTR, FCR (moderate, receiving env. sensitive)	
	Motupipi @ Abel Tasman Dr	LTR, Ex2C, can assess Cryptomonas bloom and check in with Fred	
	Motupipi @ Reillys Br	LTR, HS, high risk of degrading WQ due to water takes in Takaka FMU reducing dilution.	
	Powell @ Glenview Rd	LTR, important reference site. Still some risk from dairying activity.	Little change???
	Powell @ 40m u-s Motupipi Rv	LTR, right beside Reilly Br site (=cheap)	
	Motupipi @ Factory Farm Br	LTR, u-s one of the main karst springs	
	Watercress @ u-s dairy factory	LTR, important reference site. Still some risk from dairying activity.	
	Takaka @ Kotinga	LTR, HS, Ex2C, very important site for the catchment, not far upstream from tidal influence, existing monthly site	
	Takaka @ Lindsays Br	Early warning for rising NO3 from dairy farms into Pupu Springs	
	Takaka @ Harwoods	LTR, HS	
	Onekaka @ u-s Ironstone	LTR, HS, important reference site	Little change???
	Onekaka @ Shambala Br	LTR, very high value native fishery, moderate risk upstream, drive by to Aorere (=cheap)	
		Onahau @ Onahau Rd	LTR, issues in past with 2 dairy farms upstream - still some issues on-going
	Aorere @ Devils Boots	LTR, HS	

	Aorere @ Le Comte	LTR, Ex2C (marine farming potentially impacted)	
	Collingwood @ Boat Ramp	LTR, worst bathing site in district so need to keep an eye on.	Not good mixing of Burton Ale and Aorere
	Kaituna @ Track start	No other reference sites in Aorere catchment	4 years is enough data (2001 & 2013-2015)
	Kaituna @ Sollys Rd	LTR, intensive dairy farming u-s, live issue with Mackay Ck	
	Mackay Ck @ 50m u-s Kaituna	LTR, elevated N & faecal indicator bacteria	
Buller	Black Valley Stm @ 30m u-s Lake	LTR, increasing urbanisation and concerning degrading trends in macro-invertebrate metrics. The only stream with potential to adversely affect the lake. The lake is iconic.	This REC type is well represented. Out of the way = costly.
	Mangles @ Gorge	LTR, intensive land use in catchment that is important to keep an eye on. Important trout fishery.	Very little change
	Mangles @ 1.5km u-s Tutaki	LTR, if there is an issue at the Mangles Gorge site, it is important to know if it is from the Tutaki or Mangles	Very few issues and unlikely to change. Gorge site will alert us to issues and therefore need to sample upstream. Extra 25min drive from gorge site. Periphyton possibly affected by willows shading and reducing coverage.
	Matakitaki @ SH6 Murchison	LTR, very imp't kayaking river,	Heavy natural siltation
	Murchison Ck @ 20m d-s SH6	LTR, highest faecal in district, high risk stream.	
	Hinehaka	High risk, potentially high value	Very small creek --> unlikely to affect Buller. Short record.
	Buller @ Longford	LTR, NRWQN site.	
	Buller @ OSullivans	Integrates effects from all side catchments to compare to Longford.	Short record
	Maruia @ 1km u-s Buller	Large catchment not otherwise monitored at all. Relatively low risk.	Very good water quality and lots of dilution. No hydro site. ... So why bother
	Buller d-s Maruia	Bottom of FMU. Export from region	

Colour coding: 1st priority monthly sites, 2nd priority monthly sites, sites monitored by NIWA

Appendix E - River Water Quality Investigations in Tasman

The table below lists all investigations on-going or proposed which attempt to find the cause(s) and effect of contamination as at June 2016. They will be set in November and will be revised annually.

Site	Contaminant	Type	Status	Comment
Motueka River Plume – flood sampling	Faecal	Grab sample	On-going	The issue is having info as to when to warn the public of a health risk due to particular flood and environmental conditions. Data used to validate model relating Motueka and Riwaka Rivers to Kaiteriteri and Stephens Bay. Preferable to have samples collected on the rising and falling limb of the hydrograph. Ben Knight is working on a thermal imaging camera that may make this sampling redundant. This is because he will be able to determine the hydrodynamics and therefore use that to drive a hydrodynamic model rather than using a statistical model.
Murchison (Ned's) Creek, Murchison	Faecal – ruminant	Catchment	On hold pending analysis	Need to get lower end fenced. It has been way too long waiting for the landowner. Ask Bernard to follow up.
Clay Creek, Bainham	Faecal – ruminant	Catchment	Live	Langford race still being remediated to direct effluent into swales
Tukurua Stream	Faecal – ruminant	Catchment	Live but next steps unclear	A lot of time has been spent trying to find the sources. There has been success but remaining sources elusive.
Pohara Creek	Faecal (avian?)	Catchment	On hold pending analysis. Next steps unclear	There is a need to again analyse the data to check for patterns. Need to meet with hydro staff to look for any useful data from the sonde deployment (initial data exploration showed little useful info).
Sherry River (including Biggs Ck etc)	Faecal – ruminant	Catchment	On hold pending analysis of patterns over the 4 sites	Need to work with Dennis Mead (the main landowner in Biggs Ck catchment) to reduce contaminant loading (Bernard). Look at farm plans again.
Tasman Valley Stream	Faecal - human	Catchment	On hold	Potentially the Harakeke subdivision will clean up the remaining septic tank issues. A septic tank survey has never been completed (initial compliance survey undertaken).
Redwood Valley Stream	Organic substance with high BOD		In progress	First sonde deployment happened in Dec 2015
Onahau @ Onahau Rd	Faecal – ruminant	Grab sample	On-going	Need to keep an eye on the 2 dairy farms upstream. faecal indicator

				bacteria results seem to be trending for the worse.
Motupipi River	Macrophyte coverage	Longitudinal transect down main stem	Yet to begin	Determine macrophyte coverage and phytoplankton bloom (in the reach near Abel Tasman Drive) following a flood over bridges hollow (last occurred on 24 March 2016)
Riwaka River	Fine sediment	Catchment	Yet to begin	Data from Hickmotts shows degrading trends in MCI metrics, increase in E.coli and decrease in water clarity
Neimann Creek	Faecal and nitrate	Catchment groundwater	Yet to begin	Relies on groundwater surveys
Regional Sonde deployment	DO and temperature	Catchment	On-going	About 3 rounds each summer with 6-7 sondes has yielded very useful info to date. Has targeted at-risk catchments mostly.
Urban stream sediment sampling	Zn, Cr, Pb, PAH's	Catchment		Repeat work of Jenny Easton and Trevor James in 2010.
Cadmium in stream sediment in pastoral catchments	Cd	Grab samples		
Plantation Forest harvesting and roading	Fine sediment	Catchment	Yet to begin	Choose catchment prior to logging and roading and use BACI design.
Sediment source tracking	Fine sediment	Catchment	Under way	NIWA doing most of this work. Envirolink funding much of the project.

Appendix F – Costing for the RWQMP

Important Assumptions

For the purpose of this draft costing, it is assumed that:

- Three sites in the proposed programme continue to be monitored by NIWA
- The same set of field parameters are collected in both the current and proposed RWQ programmes
- Two sediment methods (the Quorer and the Wolman walk) and the macroinvertebrate sampling are conducted once per year during summer
- The periphyton method (with 20 views) is conducted from October to May

Summary

Table 5. Summary of programme characteristics and costs. Staff times are rounded to the nearest whole day.

	Current programme	Proposed programme	Change
Sites monitored by TDC	57	26	
Number of rounds per year	4	12	
On-site time per year (staff-days)	28	34	
Driving time per year (staff-days)	22	51	
Other time* per year (staff-days)	12	18	
Total time per year (staff-days)	62	103	+66%
Total lab costs per year (\$)	12100	30800	+155%

* Includes fieldwork planning, prep, clean up and data entry.

On-site staff time

Time estimates are based on discussions with field staff following the RWQ round in February 2016.

Table 6. Field parameters, on-site times, the number of sites per round and number of sampling occasions per year. Highlighted methods are not conducted every round. Gauging is for fast guagings (e.g. 20sec verticals). Time estimates are corrected for the number of people involved (2 people x 20min = 40min).

Current RWQ programme				
Method	Approx. time (staff-min)	Sites per round	No. per year	Time per year (staff-days)
Sediment Quorer (2 people)*	50	29	1	3.02
Sediment Wolman	15	29	1	0.91
Sediment Shuffle	5	57	4	2.38
Water Clarity	10	57	4	4.75
Macroinvertebrates	15	45	1	1.41
Periphyton 20 views	15	57	3	5.34
Gauging	25	14	4	2.92
Other tasks^	15	57	4	7.13
Subtotal	150			28

Proposed RWQ programme				
Method	Approx. time (staff-min)	Sites per round	No. per year	Time per year (staff-days)
Sediment Quorer (2 people)*	50	23	1	2.40
Sediment Wolman	15	23	1	0.72
Sediment Shuffle	5	23	12	2.88
Water Clarity	10	26	12	6.50
Macroinvertebrates	15	24	1	0.75
Periphyton 20 views	15	26	8	6.50
Gauging	25	7	12	4.38
Other tasks^	15	26	12	9.75
Subtotal	150			34

* Plus 30 mins per site for processing samples in the office

^ Sonde readings, fine sediment coverage, water samples and filling in the fieldsheet

Based on the time estimates above, two people would take on average 25 minutes to complete the standard methods (sediment shuffle, water clarity, periphyton and other tasks) at a site.

For the standard methods and a gauging, two people would take on average 35 minutes.

For the full suite of methods (including sediment methods and macroinvertebrates) two people would take on average 65 minutes at a site.

For the full suite of methods and a gauging, two people would take on average 75 minutes.

Driving time

Driving times are best guesses. The actual driving time per round will depend on the route taken between sites, the order in which the sites are visited, the starting point (e.g. Richmond or Takaka), traffic, weather conditions and other factors.

Table 7. Driving time estimates for the RWQ programme. Time estimates are corrected for the number of people involved (2 people x 3hrs = 6hrs).

RWQ Group	Driving time per round for current programme (hours)	Driving time per round for proposed programme (hours)
Waimea (2 people)	6	5
Motueka 1 (2 people)	8	8
Motueka 2 (2 people)	7	7
Motueka 3 (2 people)	7	-
Golden Bay (2 people*)	12	10
Buller (1 person)	4	4
Subtotal	44	34

* The driving time for Golden Bay allows for one person to drive from Richmond to Takaka, return.

Other staff time

In conducting the RWQ programme, staff time is spent before and after the fieldwork. Before the fieldwork, tasks include calibrating instruments, preparing gear, printing field sheets and calling landowners for access where necessary. After the fieldwork, tasks include dropping samples at the courier, putting gear away and entering field sheets.

Table 8. Estimates of time required for various other tasks per RWQ round.

	Time per round for current programme (hours)	Time per round for proposed programme (hours)
Before fieldwork	12	6
After fieldwork	12	6
Subtotal	24	12

Lab parameters

In the proposed sampling programme, all lab parameters are measured at all sites. One parameter (pH) is measured in the field for the current programme but in the lab for the proposed programme.

Table 9. Lab parameter costs and quantities per round. Lab prices are from Hill Laboratories tender document dated May 2014. Lab prices increase by 1.5% per year.

	Cost per sample (2016 \$)	Samples per round in current programme	Samples per round in proposed programme
DIN	0	20	26
DRP	6.18	20	26
<i>E. coli</i>	24.73	57	26
Faecal coliforms	0	57	26
Nitrate-N	14.42	20	26
Ammonia-N	9.27	37	26
Total Nitrogen	15.25	20	26
Total Phosphorus	11.33	20	26
Turbidity	5.15	47	26
Hardness	7.21	10	26
pH	5.15	0	26
Subtotal	98.69	308	286

Appendix G - 2016 Review focus questions

Key Questions We Need to Answer of the Programme:

1. Assuming that there will be no increase in budget, where would you re-allocate resources.
2. What are the gaps in the monitoring programme?
3. Is there unnecessary redundancy in the programme (in network design, parameters etc)?
4. What are the key interventions to improve river health? If there were an increase in budget what would be the priorities for additional monitoring effort? In other words, if you were in charge of the programme what are the 5-10 key things that you would change if resourcing wasn't a consideration?
5. Is there justification to maintain quarterly and well as monthly sampling at the same sites?
6. Which are the next key sites that should become monthly sampling sites?
7. Should we be monitoring our lakes? (if done annually what is the key month and parameters (e.g. Chl a profile and upper / lower Nutrient sample)?) All our lakes (Rotoiti, Rotoroa, Kaihoka x2 and Otuihe)?

Detailed points to consider:

1. Monthly and quarterly programmes.
 - a. Can we achieve some integration of these programmes on a practical basis. Currently sampling 16x/yr at monthly sites (except Motueka at SH60). Probably more than is necessary. Base flow data will be kept separate from rain-influenced.
 - b. Can we drop quarterly monitoring where there is monthly? Lose comparisons on the day.
2. Potential to take over NWQN sites (Motueka at Gorge and Woodstock, and Buller at Longford) from NIWA. To sample these as well as Sherry Rv, Motueka at SH60 and Waimea at SH60 would be an 8 hour day ex Richmond (5 hours driving and 3 hours sampling).
3. **Network Design:**
 - a. Balance between large rivers and small creeks
 - b. Coverage of river classes.
 - c. Reference sites:
 - i. Given lower variability, can we reduce sampling frequency of reference sites? E.g. Kaituna at Track start. Should we bring back Waingaro at Hanging Rock for a time. What about a rolling/rotating programme for reference sites.
 - ii. Do we need more reference sites from a regional perspective (particularly for modelling purposes)? – Considering NIWA's recommendations... the following could work (km = return): Anatoki (10km), Waingaro (18km) and Rolling (2km if we continue with Wangapeka) ... but the following are too expensive due to travel time: e.g. Rappahannock (100km), Glenroy & Matakītaki at Blue Rock (80km), Owen (20km).
 - d. Must consider key sites in each FMU.
 - i. Takaka – Waikoropupu (water clarity/transmissivity, periphyton), Takaka at Lindsays Br & Paynes Ford (water clarity, nitrate, periphyton)
 - ii. Given our 5 FMU's what are the key sites in each that need particular consideration
 - e. Capturing all major land-uses:

- i. Add roving sites in forestry catchments. Could be difficult to manage if forestry companies don't stick to proposed harvest plans.
 - f. Relative investment ratio between fish and stream habitat monitoring versus River Water Quality Monitoring.
- 4. Parameters:
 - a. Should we remove the following: **turbidity, Ammoniacial-N**. Specifically, does recording water clarity and water colour remove the need for turbidity measurements?
 - b. Should we add **transmissivity in place of water clarity**?
 - c. **Periphyton** –
 - i. Anticipate any changes to RAM2?
 - ii. Improve % cover estimate to a more quantitative measure based on quadrats.
 - iii. Increase frequency (monthly from Nov-Apr) at sites where it is known to be an issue. We can do this at the same time as the monthly sampling
 - iv. Chlorophyl-a : The Periphyton attribute specified in the National Policy Statement for Freshwater Management (NPSFM 2014) is chlorophyll-a (measured in mg of chlorophyll-a per m²). While we would like to discuss this, Council at this stage is not considering this for the following reasons: 1. There is very limited *Chl*-a data available in Tasman, 2. *Chl*-a data is expensive to collect and analyse (requires fortnightly or monthly sampling over 3 years at least), 3. There is high variability over a reach over time, much of this unrelated to human land use factors.
 - d. **Macro-invertebrates** – keep to strategy of sampling only small to medium-sized waterways? Expand to more small-medium-sized waterway sites or rely on modelling? Expand to twice annually at existing sites? Or expand to all sites annually?
 - e. **Fine sediment** load and sediment source tracking, particularly from streams flowing to estuaries such as Waimea and Moutere. Given the high cost, what is the minimum programme we can get away with (e.g. auto-samplers for 10-12 flood events)
 - f. **Fish** – how to better integrate the water quality and fish monitoring. To date the fish monitoring programme has targeted sites at risk of some development activity (e.g. water take or diversion) and only occasionally at RWQ sites. Are there key reference/risk sites we should be monitoring.
 - g. **Water clarity**. How do disc size (Rob Davies-Colley has a paper on this) and sunlight affect black disc water clarity? Currently we do not adjust the clarity measurements using these variables. Should we? If not, why should we continue to record this information? We cannot get the sunlight data if we wanted too. Sun goes behind clouds so can't use rainfall or sunlight hours data. We have a LiCor sensor, but this is only used for Sonde deployments.
 - h. Can our **visual estimates of fine sediment deposits** be simplified? Currently three estimates of habitat length, three estimates of fine sediment cover and three estimates of sand cover are required. Is this data useful when the habitat length surveyed is typically less than 10m (a fraction of a site)? Could we improve our estimates of fine sediment cover by (1) focusing on a single habitat type and (2) examining all of that habitat type within a site? I think we forget about pools at least because they are often not present at a site.
 - i. Do we need to record **river appearance** (clear, slightly turbid or turbid) when we already have water clarity and turbidity? There are investigations where we don't sample for these parameters. This is a simple check against the data.

- j. How can we use the depth and velocity estimates taken during the resuspendable solids shuffle protocol to adjust the shuffle index? If this is not possible, why should we continue to record it? This is a good point. I think we need to standardise as best we can.
- k. **Weather on day of sampling.** Can we eliminate the recording of cloud cover (I think so), air temperature (maybe), wind direction (no if there are discharges to air nearby (e.g. liming of paddocks you want to know the wind direction) and rainfall (this is very important – it should be made as a comment in Hilltop) from our field sheets? We do not use these for data analysis. How often is this information used? If it is used occasionally, how is it used? Can this be replaced with data from climate stations as the need arises?

5. **Sonde deployment programme.**

- a. Is the programme achieving useful information such that it is worth continuing with?
- b. Should we add more structure by having core sites on a rotation
- c. Do we continue with only small and medium-sized waterways – i.e. higher risk sites
- d. Or do we continue to 'explore the region' and add sites in high risk sites of interest
- e. Do we concentrate effort into a catchment with more sites to determine spatial extent of dissolved oxygen issues and potential sources of organic pollution.