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Environment Southland – Review of State of the Environment Water Quality Monitoring Programme

April 2010

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Report prepared for Environment Southland by:

Dr Olivier Ausseil
Senior Water Quality Scientist
Aquanet Consulting Limited

Peer Review:

Kirsten Meijer
Water Quality Scientist
Environment Southland

Acknowledgments to:

Steven Ledington (Water Resources Scientist)
Karen Wilson (Groundwater Scientist)
Greg Larkin (Coastal Scientist)
Roger Hodson (Environmental Technical Officer - Living Streams)
John Prince (Manager Environmental Information)
Rachael Millar (Principal Planner)
Chris Jenkins (Senior Scientific Officer – Hydrology)

EXECUTIVE SUMMARY

As part of its State of the Environment (SoE) monitoring programme, Environment Southland monitors water quality and river biology at a number of points across the Southland Region. The SoE water quality monitoring programme was last formally reviewed in 1997 (Hamill, 1997).

River catchments, and the pressures they face, are an ever changing environment. New or emerging environmental issues, changes in community expectations and the development of new management and policy frameworks all mean that the information requirements of statutory authorities such as the Regional Councils are also constantly evolving.

Environment Southland has started a review of its State of the Environment water quality monitoring programme, to ensure that it delivers the data and information required in the Council's water resource management. Environment Southland contracted Aquanet Consulting to provide recommendations for this review.

This review covers the streams and rivers water quality and aquatic ecology monitoring programme. It specifically excludes the contact recreation monitoring programme, and lakes, wetlands and coastal waters.

The first step in the review process was to identify the Organisation's current and future water quality information requirements, to ensure that the data collected was able to inform essential Regional Council processes such as State of the Environment reporting, policy development, Regional Plan effectiveness monitoring and plan/policy implementation. This formed the basis for key recommendations relating to representativeness, monitoring determinands, monitoring frequency, and monitoring site categories and locations.

Environment Southland's Proposed Regional Freshwater Plan is very close to being fully operational. It defines the water management framework for the Southland Region, in particular surface water bodies classification, water quality issues and water quality standards.

The Proposed Plan's surface stream and river classes (10 classes), along with the Surface Water Resource Zones framework (17 zones covering the Region), provided the spatial framework for this review. One of the review's aims was to ensure that all classes and zones were adequately represented in the monitoring network.

The Proposed Plan's water quality issues and water quality standards provided guidance with regards to the list of water quality and ecology determinands that should be included in the SoE monitoring programme.

In the current programme, the general monitoring frequency is monthly for water quality and annually for ecosystems (macroinvertebrates, periphyton and sedimentation) monitoring. These frequencies are considered sufficient and adapted to providing data for a number of essential data analysis processes, such as analysis of state, compliance with standards and temporal trends, and should be maintained.

Flow data is essential to some data analysis processes, such as estimation of contaminant loads and temporal trends analysis. In recent years, Environment Southland has invested a significant amount of resources and work in establishing actual or virtual (modelled) flow datasets at most water quality monitoring sites. This effort can only be commended, and should be extended to any new water quality site established following this review.

The current water quality monitoring programme comprises 68 water quality sites, monitored monthly, and 76 ecosystems sites, monitored annually. The main constraint placed on this review was to maintain an equivalent level of monitoring effort and associated costs. Although the spatial coverage of the current

monitoring programme is acceptable, the review process has identified a number of gaps. In particular, a number of Proposed Freshwater Plan classes and a number of Surface Water Resource Zones receive no or little water quality monitoring. This was associated with a general under-representation of reference sites in the water quality network.

The recommended programme includes 94 water quality and 106 ecosystems sites. However, under the recommended monitoring regime, not all sites are monitored every year, and the number of sites monitored every year, which directly defines the level of monitoring effort, remains unchanged.

To improve the monitoring network's spatial coverage and definition, it is recommended to define two categories of monitoring sites, and adapt the monitoring frequency accordingly.

- *Core sites*: These sites represent the network's backbone. They are long-term monitoring sites, generally placed on main rivers or main tributaries, and/or at sites where long-term issues have been identified. They are the key sites on which long-term analysis will rest, in particular temporal and spatial trends analysis, and it is recommended that these sites be monitored every year;
- *Satellite Sites*: The role of these sites will be to refine the scale of spatial information. For example, data from these sites may be used to calculate contaminant loads from each sub-catchment above a "core site" under specific flow conditions. It is recommended that these sites generally be monitored every three years, on a catchment-by-catchment rolling basis.

One recommended addition to the water quality monitoring programme is the taking of water quality samples at seven sites in the Fiordland and Stewart Island zones, to provide some background water quality information for these areas. The recommended approach is to take water quality samples when Environment Southland staff are already present at these sites as part of another monitoring programme, to keep the additional cost associated with this sampling relatively minor.

Overall, the recommended water quality and ecosystems monitoring programmes offer an improved representation of the different Proposed Freshwater Plan Classes and Surface Water Resource Zones in the Southland Region, as well as a better spatial resolution of the data inside each catchment. It is expected that the data collected will constitute a robust basis for the organisation's information requirements relating to water quality and aquatic ecology.

The recommended programme is based on the current planning and management framework, and the current level of knowledge of the river catchments and their state, trends, and pressures. A monitoring programme has every reason to be a living framework, and frequent changes and adjustments are justified and even advisable in response to situation changes (e.g. emerging intensification in an area), or as new information, technology or budgets become available.

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1. Introduction

1.1. Introduction

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River catchments, and the pressures they face, are an ever changing environment. New or emerging environmental issues, changes in community expectations and the development of new management and policy frameworks all mean that the information requirements of statutory authorities such as the Regional Councils are also constantly evolving.

Environment Southland has started a review of its State of the Environment water quality monitoring programme, to ensure that it delivers the data and information required in the Council's water resource management. Environment Southland contracted Aquanet Consulting to provide recommendations for this review.

1.2. Aim and scope of the project

1.2.1. Aim

The project's primary aim is to align the information collected by the monitoring programme with the Organisation's current and future information requirements. The first step in the process is therefore to identify these information requirements. Then, by anticipating future information needs, including the nature of the data required and the type of analysis that will be performed, the data that should be collected now, and where it should be collected, can be identified.

Councils can only devote finite resources to monitoring programmes, and the review is also the opportunity to rationalise the number of monitoring sites, their locations and the variables measured.

1.2.2. Scope

This review covers the streams and rivers water quality and aquatic ecology monitoring programme. It specifically excludes the contact recreation monitoring programme, and lakes, wetlands and coastal waters.

This review provides recommendations relating to the number and location of monitoring sites, the variables monitored (determinands), and the monitoring frequency, but it does not detail monitoring/sampling methodologies or measurement/analytical procedures.

Although recommendations are made relating to the location of monitoring sites, one has to bear in mind this is a desktop exercise, and local-scale details such as exact location of the monitoring site, their access, or their suitability for different types of monitoring cannot be determined without ground truthing.

1.3. Approach

State of the environment reporting is one of the Regional Councils' statutory functions. Traditionally, SoE monitoring programme have been only viewed as data gathering tools for State of the Environment reporting. However, one view developed and implemented by an increasing number of Regional Councils, is that water quality SoE monitoring programmes are the Organisation's primary environmental data gathering tools, and should not be dissociated from the full range of water quality-related activities of the Organisation. In other words, the data gathered should, on top of forming the base for state of the environment reporting, be able to inform processes such as policy development, plan effectiveness

monitoring (in particular, monitoring against plan objectives/outcomes), resource consents and catchment /land management programmes.

The proposed approach for this review is to identify the Organisation's current and future water quality information requirements, then to "back-engineer" a suitable monitoring programme to deliver this information to the Organisation in a timely and cost efficient manner.

The first step is to consider the current context, including the current monitoring network, the management framework and the policy context, in particular the Proposed Water Plan for Southland (Section 2 of this report). Where possible and relevant to this review process, Southland's regional context is compared with other regions in New Zealand. From this, a number of general guiding principles are drawn regarding the recommended monitoring programme (Section 3). Section 4 of this report considers each of the Region's catchments and Water resource Zones, and provides detailed recommendations on the location of the monitoring sites.

To better inform the review process, a workshop was held on 30th June and 1st July 2009 in Invercargill. Participants to the workshop were Environment Southland's water quality, hydrology, groundwater, surface water allocation, coastal and policy specialists. The workshop allowed the identification of surface water quality and quantity, landuse, groundwater, hydrology and coastal water quality issues associated with each catchment, as well as a wealth of practical information.

2. Context

2.1. Current monitoring programmes

Environment Southland's current water quality and river ecology State of the Environment monitoring programme comprises:

- 68 surface water quality sites, monitored monthly. The sites and the determinands monitored are summarised in Appendix A.
- 76 ecosystem sites, where macroinvertebrate and periphyton communities are monitored once per year following a period of low river flow (Appendix A).
- Map 1 to Map 17 also show the current water quality and ecosystem monitoring sites in each Water Resource Zone.

The water quality and ecosystem monitoring sites are not always associated. Both water quality and ecosystem monitoring are undertaken at 31 sites, which leaves 33 "water quality only" sites and 42 "ecosystems only" sites.

The programme also includes two fixed dissolved oxygen probes permitting the continuous monitoring of dissolved oxygen concentration in the river. These probes are currently installed at the Mataura River at Gore and Mataura River at Wyndham sites.

The "Living Streams" programmes also provide water quality data on 3 selected sub-catchments in the region. The Living Streams programmes include intensive water quality monitoring at the sub-catchment scale, and the implementation of land management "best practices", including riparian and nutrient management with the involvement of the local farming community.

In addition to the SoE programme, the contact recreation programme undertakes weekly monitoring of bacteriological water quality at 6 swimming sites across the Region during the main bathing season (December to March inclusive).

The surface water quantity monitoring programme also provides an essential complement to the surface water quality programme by providing river flow data at most water quality sites, either directly from, or by correlation with, flow monitoring sites.

Environment Southland also implements a groundwater quality and quantity and a coastal water quality monitoring programmes, which are important to consider in this review process due to their obvious links with surface freshwater quality.

2.2. Regional Policy framework

Environment Southland's Proposed Regional Freshwater Plan is very close to being fully operational. It defines the water management framework for the Southland Region, in particular:

Surface water bodies classification: the Proposed Regional Freshwater Plan defines 13 classes of surface freshwater bodies, including 10 stream/river classes. Seven classes are based on a combination of elevation and river bed type (Mountain/Hill/ Lowland – Hard Bed/Soft Bed). The remaining three classes correspond to different parts of the Mataura catchment primarily dictated by the Mataura National Water Conservation Order (Mataura 1, 2 and 3).

Water quality standards: the Proposed Regional Freshwater Plan defines numerical water quality standards to protect the values of 9 of the 10 stream/river classes. The tenth class, "Natural State" is associated with one narrative standard ("the natural quality of the water shall not be altered"). Table 1 provides a summary of the Proposed Regional Water Plan's water quality standards.

Water quality issues: The Proposed Regional Freshwater Plan identifies a number of surface water quality issues, including microbial contamination, sediment/water quality and nutrient-fuelled excessive periphyton/plant growth. It also notes that these issues can be exacerbated by low flows and lost riparian vegetation and shading. It should be noted that these issues are not specific to the Southland Region, and are, to a large extend, faced by most regions in New Zealand. The proposed Plan also identifies that the biggest challenge to the region is the threat to water quality from non-point source discharges. Again, this appears to be the case in most regions in New Zealand, where the environmental effects of point source discharges are increasingly well managed through resource consents, but the non-point source pollution and its effects on water quality appear to be a rising concern. This should be an important guiding consideration for this review process.

Objectives: Section 3.1 of the Proposed Regional Freshwater Plan defines the water quality outcomes the plan sets to achieve within the next 10 years, including:

- (2) There will be no reduction of water quality in the Southland Region beyond the zone of reasonable mixing for discharges;
- (3) Water quality will be maintained in Natural State Waters;
- (4) The water quality of surface water bodies will be maintained and enhanced so that it is suitable for bathing in popular bathing sites, trout and native fish, stock drinking water and Ngāi Tahu cultural values, including mahinga kai;
- (5) An improvement in the water quality and in particular a minimum 10 percent reduction in levels of microbiological contaminants, nitrate and phosphorus and a minimum 10 percent improvement in water clarity will be achieved in hill, lowland and spring-fed surface water bodies over 10 years from the date this Plan becomes operative;
- (6) Discharges to water bodies will not result in levels of toxic substances that harm humans, domestic animals including stock or aquatic life;
- (8) The significant adverse effects of discharging during low flows are avoided;
- (10) Stormwater discharges will meet water quality standards and current ANZECC sediment guidelines by 2010;
- (11) Freshwater quality does not have an adverse effect on coastal water quality.

Table 1: Summary of Environment Southland's Proposed Regional Water Plan water quality standards for stream/river classes (as per November 2009).

Class	Temperature (°C)		pH	DO (% Sat.)	Clarity < med. flow (m)	NH_4- N (mg/l)	Faecal coliforms (/100ml)		E. coli (/100ml)	Algae		Chlorophyll a (mg/m^2)		MCI	sQMCI
	Max	Δ					Max	median		Cover (%)	Biomass (g/m^2)	Max	Monthly mean		
Lowland/Soft	23	+ 3 + 1 (a)	6.5 to 9	80	1.3	(b)	1,000	-	130(c)	-	-	-	-	80	3.5
Lowland/Hard	23 11(d)	+ 3 + 1 (a)	6.5 to 9	80	1.6	(b)	1,000	-	130(c)	30 (e) 60(f)	35	120 (e) 200 (f)	-	90	4.5
Hill	23 11(d)	+ 3 + 1 (a)	6.5 to 9	80	1.6	(b)	1,000	-	130(c)	30 (e) 60(f)	35	120 (e)	-	100	5.5
Mountain	23 11(d)	+ 3 + 1 (a)	7.2 to 8	99	3.0	0.32	-	-	130	30 (e)	35	50 (e)	-	120	7
Lake fed	23 11(d)	+ 3 + 1 (a)	7.2 to 8	99	3.0	0.32	-	-	130	-	-	50	15	90	4.5
Spring fed	23 11(d)	+ 3 + 1 (a)	6.5 to 9	99	3.0	0.32	1,000	-	130(c)	-	-	50	15	90	4.5
Mataura 1	-	+ 3 + 1 (a)	6 to 8.5	6 mg/l	No conspicuous change	-	10,000	200	-	-	-	-	-	-	-
Mataura 2	-	+ 3 + 1 (a)	6 to 8.3	6 mg/l	No conspicuous change	-	-	200	-	-	-	-	-	-	-
Mataura 3	-	+ 3 + 1 (a)	6 to 9	5 mg/l	No conspicuous change	-	1,000		-	-	-	-	-	-	-

(a) daily maximum temperature increase of no more than 3°C when the background water temperature is 16°C or less, and of no more than 1°C when the background water temperature is above 16°C.
(b) pH-dependant maximum total ammonia nitrogen concentration, from 0.18 g/m^3 at pH 9 to 2.57 g/m^3 at pH 6 (0.90 g/m^3 at pH 8).
(c) at and within 1 km upstream of popular bathing sites.
(d) in trout spawning areas during May to September.
(e) Filamentous algae.
(f) Diatom and cyanobacteria.

Two additional narrative standards apply to all classes:

- There shall be no bacterial or fungal slime growths visible to the naked eye as obvious plumose growths or mats. Note that this standard applies to within the zone of reasonable mixing for a discharge.
- Fish shall not be rendered unsuitable for human consumption by the presence of contaminants

2.3. Management framework

Seventeen surface water resource zones (WRZ) have been defined by Environment Southland. Although these are not contained in the proposed plan, they are used routinely by Environment Southland, and, as such, constitute the day-to-day framework for the organisation's current catchment management.

Environment Southland has produced a very useful publication summarising the extent, general characteristics and surface water monitoring of each of these WRZ.

2.4. Summary of information requirements and monitoring programme objectives

The policy and management framework described above provides obvious guidance as to the monitoring that should be undertaken in the Southland Region. It also gives a reasonably clear indication of the type of data analysis that will have to be performed, as summarised in the points below.

2.4.1. Determinands

To assess compliance with the Plan's water quality standards, the SOE water quality monitoring programme should, *a minima*, include the water quality determinands used in the Plan, as summarised in Table 1. Detection limits should also be consistent with the numerical water quality standards. As can be seen in Table 1, the list of determinands used as standards differs between the different water classes. Strictly speaking, only the determinands used as standards could be monitored in each class to assess compliance with the standards. However, it is recommended that all determinands in Table 1 be monitored at all sites to improve catchment- and regional-scale comparisons. A number of other determinands are not used directly as water quality standards, but relate directly (i.e. as cause or consequence) to some of the plan's water quality standards. For example, it is essential to monitor nutrient concentrations (both nitrogen and phosphorus) in relation to the periphyton biomass or cover standards. Turbidity, suspended sediments and sediment deposition are related to the water clarity standard, and organic matter to the dissolved oxygen concentration standard.

2.4.2. Representativeness

The most basic requirement for a State of the Environment monitoring programme is to provide sufficient, robust data for State of the Environment reporting, one of the Regional Councils' statutory responsibilities. A monitoring network should therefore cover all main river types found in the region (i.e. Regional Plan classes), as well as a range of conditions (i.e. reference *vs*. impacted conditions). In some circumstances, it could be recommended that the proportion of monitoring sites in each class follow the proportion of waterways in each class. However, in a region like Southland, this would mean that a large proportion of sites would fall within the Natural State class in the Fiordland National Park – which has very obvious practical limits. Further, it seems appropriate from a management perspective that a proportionately larger amount of monitoring effort be devoted to catchments or parts of catchments where significant water quality issues have been identified or are suspected. On balance, it is recommended that representativeness be used to guide the decision-making process on site location, but should not impede the programme's ability to deliver catchment management-orientated information.

2.4.3. Monitoring frequency

Some of the plan standards are very prescriptive in relation to monitoring frequency. For example, the faecal coliforms standard for the Mataura 1 and Mataura 2 classes are based on a median value calculated on "no fewer than five samples taken over not more than a 30-day period". In the same fashion, the chlorophyll *a* standards for the "Lake Fed" and "Spring Fed" are based on an absolute maximum and a maximum monthly mean value. This implies that, in order to formally assess compliance with this standard, chlorophyll *a* biomass should be measured monthly. With the exception of these specific

requirements, the Regional Plan does not provide direct guidance, and the monitoring frequency should be guided by practical (including costs) and technical considerations, to ensure that the data collected is suitable for robust analysis, as detailed below. Across the country, some Regional Councils in New Zealand have quarterly monitoring for all or part of their SoE monitoring programme (e.g. West Coast, Hawke's Bay), but most, including Southland, currently undertake monthly monitoring.

2.4.4. Future data analysis

Analysis of state of the environment and assessment of compliance with water quality standards: This generally requires a sizeable dataset covering the different times of the year and river flow conditions. Although there is no set frequency required for this type of analysis, monthly monitoring for water quality and annual biomonitoring generally delivers adequate datasets within a few years.

Analysis of temporal trends: Temporal trends analysis is commonly performed using the Kendall seasonal test (Scarsbrook and McBride 2007a). It is generally considered that this test requires a minimum of 5 years of data gathered at regular intervals (e.g. weekly/monthly/quarterly/annually). There is no set sampling frequency to undertake temporal trends analysis - it can be performed on one single annual sample for biomonitoring data. However, the ability to detect trends in water quality data can be influenced by the sampling frequency. Scarsbrook and McBride (2007b) have determined that monthly sampling allowed the detection of more significant water quality trends than with quarterly sampling in the Hawke's Bay region; monthly sampling also allowed an earlier detection of trends. Assessing success against Environment Southland's Plan outcome 5 (10% improvement in 10 years) will require at least 10 years of data. A 10% change over 10 years corresponds to an average annual change of 1%, which is a reasonably low rate of change. A monthly monitoring frequency consistent over the years will provide a much better chance at detecting significant temporal trends than, say, quarterly monitoring. It is strongly recommended that the monitoring frequency be maintained to monthly at all monitoring sites where analysis of temporal trends will be performed. It is also noted that river flow data (i.e. mean daily river flow on the day of water quality sampling) is also required for the flow- adjusted trends analysis.

Contaminant loads/yields: Contaminant load and catchment yield analysis can be a very useful way to identify sources of contaminants at the catchment or sub-catchment scale (Ausseil, 2008 and 2009; McArthur 2008), leading to prioritisation of investigation and plan implementation and/or catchment management efforts. The analysis can be conducted on an annual basis (annual loads) or on a daily basis, generally at a given river flow (e.g. daily loads at MALF). Annual loads are particularly useful to communicate broad figures about the catchment. They are also very environmentally relevant in situations with an semi-enclosed receiving environment, such as a lake or an estuary. The calculation of annual loads generally requires regularly spaced data – monthly data being generally considered acceptable for contaminants such as nutrients. It is noted however, that the accuracy of the annual load estimates improves with sampling frequency, and continuous monitoring provides much improved estimates, particularly for determinands like suspended sediments, the concentration of which vary hugely with river flows. Flow-related load analysis, particularly low flow analysis, is useful when the environmental issue is particularly present at low river flows- the most relevant example probably being nutrients. This type of analysis requires a good spatial coverage of the catchment, a good coverage of specific river flow situations (usually low flows), and ideally synchronous monitoring at a catchment scale (i.e. all sites within the catchment being monitored on the same day). Flow data on day of sampling and basic flow statistics (e.g. exceedance percentiles, average monthly flow, etc…) are also required for contaminant load analysis.

2.4.5. Monitoring of discharges and compliance monitoring

Plan outcomes 2, 6 and 8 directly refer to the management of effects associated with point source discharges. The monitoring of point source discharges is generally undertaken as part of resource consent conditions, and normally falls outside the scope of state of the environment monitoring. However, compliance monitoring is generally strictly limited to what is imposed by way of consent conditions, which generally concentrates on the monitoring of effects immediately downstream of the zone of reasonable mixing and/or is limited to some contaminants. The monitoring of larger scale effects, including the residual effects of the discharge several kilometres downstream, or the cumulative effects of several discharges or of point- and non-point source discharges, is not often well covered by consent conditions. In these cases, it may be appropriate for the SoE monitoring programme to cover these aspects.

2.4.6. Stormwater discharges

Stormwater discharges are intermittent in nature, and generally associated with a wide range of contaminants generally not monitored as part of a routine SoE water quality monitoring programme, such as metals and organic micropollutants. As such, stormwater monitoring is quite specific and would generally sit outside the "routine" SoE water quality monitoring programme. Adequate monitoring of the effects of stormwater on receiving waterbodies should include water quality and sediment monitoring.

Water quality monitoring should be timed to correspond with the discharge of the "first flush" of stormwater into the system. This generally means monitoring the discharge itself and the receiving environment upstream and downstream of the discharge point, 1 to 2 hours after the onset of the first significant rainfall following a period (several days) of dry weather. As such, it seeks to identify the short term effects of the stormwater discharge on the receiving environment's water quality.

Sediment monitoring is generally undertaken under base flow conditions. The analysis of remanent pollutants (such as metals and some organic micropollutants) seeks to identify the potential for residual or accumulative effects after the stormwater discharges have stopped.

Appendix B provides some more detailed recommendations with regards to stormwater monitoring (timing and determinands).

3. General recommendations

3.1. Programme size and site categories

The recommendations from this review process can potentially bear on a number of components of the monitoring programme, such as the number of sites, the site location, the nature of the monitoring and the determinands monitored and the monitoring frequency.

Ultimately however, the overall "size" of the monitoring programme will be restrained by the annual budget devoted to it. The constraint placed on this review process is to maintain the overall size/cost to its current level.

As explained above, the general monitoring frequency should be maintained to its current level (i.e. monthly for water quality monitoring and annually for biological monitoring), to ensure the robustness of the subsequent data analysis. This does not mean however that the current number of sites constitutes the absolute limit. A significant proportion of the sites can justifiably be monitored for one year every two or three years. The recommended approach is to define two categories of sites

- *Core sites*: These sites represent the core of the monitoring network. They are generally sites with a reasonably long-term water quality record, and monthly water quality and annual biomonitoring monitoring at these sites should be maintained in the future. River flow information should also be

available, either directly at the site or by correlation with a relevant flow site. They are the key sites on which any long-term analysis will rest, in particular temporal and spatial trends analysis.

- *Satellite Sites*: The role of these sites will be to refine the scale of spatial information. For example, data from these sites may be used to calculate contaminant loads from each sub-catchment above a "core site" under specific flow conditions. The data does not have to be long-term for this type of analysis, but should be synchronous with the rest of the catchment (for contaminant load/yield analysis), and should ideally provide a good coverage of any situation of special interest (e.g. low river flow conditions). This can be achieved by either or both regular (e.g. monthly) or flow-related monitoring (e.g. low flow monitoring).

Reference sites are monitoring sites with an unmodified upstream catchment (sites classified as Natural State), or sites with low level of development pressure in their catchment. These sites provide information on reference conditions, i.e. what water quality would be expected in this catchment in a pristine or very low pressure environment. Some of these sites have an existing long-term dataset and/or are located on main rivers, and should be considered "core" sites. Other reference sites, e.g. those located on smaller side tributaries, may be considered "satellite" sites.

3.2. Determinands

Table 2 for summary of determinands provides a summary of the determinands recommended for the freshwater monitoring programme, as detailed below.

3.2.1. Biological monitoring

Currently, biological monitoring is undertaken annually at 76 sites across the Southland region. It includes sampling macroinvertebrate and algal communities.

The state of macroinvertebrate communities is widely used as an indicator of water quality and ecosystem health. It is a particularly useful indicator as macroinvertebrates live continuously in the streams and rivers, and respond to a range of pressures (such as temperature, organic enrichment, eutrophication and sedimentation), thus they provide an integrated indicator of ecosystem health. A number of indices are commonly calculated to provide a summary of macroinvertebrate communities, such as MCI, QMCI, %EPT, %EPT taxa, etc. The proposed regional Water Plan defines standards based on MCI and/or SQMCI for some water classes (refer to Table 1). It is recommended that these indices be calculated at all sites where macroinvertebrate monitoring occurs (even in classes with no MCI or SQMCI standards), to improve catchment or regional scale comparisons.

Monitoring of periphyton community composition, as well as biomass and cover of river bed are also essential indicators of the nutrient enrichment of a river system. Excessive periphyton growth affects a number of river values and is a result of a number of variables, including nutrient enrichment. In the current context where the nutrient enrichment of waterways from agricultural non point sources is one of the most prominent water quality issues nationally, it is essential to collect robust periphyton information. Only where this monitoring shows excessive/nuisance growth can controls on nutrients justifiably be put in place. The corollary to this is that elevated nutrient concentrations in a stream or river are not necessarily of environmental concern if it is not causing excessive algae/plant growth in the stream or in a downstream environment (such as a larger river, lake or an estuary).

Monitoring of periphyton biomass and cover is currently done once per year following a period of at least two to three weeks of low river flow (defined as less than three times MALF[1]), which is adequate to provide a reasonable indication of the high end of the range of periphyton biomass/cover encountered at

[1] Mean Annual Low Flow

the site. This monitoring is suitable for an assessment against the periphyton biomass standards in most of the Proposed Freshwater Plan river classes.

However, two of the Proposed Freshwater Plan water classes ("Lake Fed" and "Spring Fed") have chlorophyll *a* standards based on a maximum monthly mean value, in addition to the absolute maximum. This implies that, in order to formally assess compliance with this standard, chlorophyll *a* biomass should be measured monthly in these two classes. Periphyton biomass monitoring is a relatively time-consuming exercise, and monthly monitoring would be associated with a significant additional expense. It is suggested that annual monitoring should be undertaken in a similar fashion to the other classes, but additional monthly monitoring could be undertaken only if there are strong suspicions of an existing or emerging significant issue (e.g. if annual monitoring results regularly exceed the monthly mean biomass standard, or in response to anecdotal observations/community concerns).

A number of existing or potential ecosystems monitoring sites have been discounted or may be discounted in the future as being "unsuitable" for some of the ecosystems monitoring. This is particularly the case of soft-bottom streams (i.e. where the stream bed is dominated by fine sediments). These streams generally do not provide suitable habitat for significant periphyton growth, which means that the presence/absence of periphyton is generally not reported. With regards to the macroinvertebrate communities, the MCI or QMCI generally used in hard-bottom streams are not suitable for soft-bottom streams. The consequence is that soft-bottom streams are sometimes under-represented in regional monitoring programmes. It is recommended that a representative number of soft-bottom streams be included in the ecosystems monitoring network. Macroinvertebrate communities should be assessed using exiting sampling methods and reporting indices such as the Soft-bottomed MCI, or SbMCI. Visual estimates of macrophytes and periphyton (even if nil) should also be reported.

3.2.2. Nutrients

Monitoring of different chemical forms of nitrogen and phosphorus is recommended, as they are key drivers of eutrophication in freshwater and estuarine systems.

In reasonably fast-flowing rivers and streams, nutrient recycling is generally considered minor, and the chemical forms of nitrogen and phosphorus directly available to algae growth should be monitored. These are the soluble forms – Soluble Reactive Phosphorus (SRP) and Soluble Inorganic Nitrogen (SIN) (Wilcock *et al.* 2007).

SIN is the sum of three forms of soluble inorganic nitrogen: ammonia-, nitrite- and nitrate- nitrogen. Ammonia-N is also a toxicant and one of the Proposed Freshwater Plan's water quality standards, and should be measured. Nitrate- and nitrite-N can be measured separately, or together as NOx (a test often called NNN by the laboratories). There is generally limited interest in measuring Nitrite-N concentration in surface waters, except in particular circumstances (such as a point source discharge). The NNN test is also cheaper than the sum of the two separate tests for nitrate and nitrite, and is more and more commonly used by regional Councils. However, Southland's Proposed Plan Outcome 5 specifically refers to changes in nitrate concentration. Assessment of progress against this plan outcome requires the specific measurement of nitrate- N. Environment Southland analysis results currently include ammonia- nitrogen and NNN, but also nitrate- and nitrite-nitrogen. This allows both the calculation of SIN and direct assessment against outcome 5 of the proposed freshwater plan.

In lakes, estuaries and coastal waters, the concentration of total N and total P (rather than the soluble forms) are generally considered a better indicator of the risk of algae proliferation. Monitoring of TN and TP is therefore particularly important at river sites located immediately upstream of lakes or estuaries, particularly if eutrophication issues have been identified in these receiving environments. TN and TP are also useful variables in the river monitoring network, at they allow a better understanding of the nutrient sources across the catchments. A number of predictive modelling tools, such as CLUES, are also based on

total, rather than dissolved, nutrient loads or concentrations. Environment Southland currently monitors TN and TP at all its river sites, and it is recommended that it be maintained.

3.2.3. Water clarity and colour

Water clarity and colour are directly related to a number of ecological and recreational/aesthetic values.

The Proposed Freshwater Plan defines minimum water clarity values (applying at river flows below median flow) for all but the "Mataura" surface water bodies classes. The three "Mataura" classes have a standard requiring no conspicuous change in water clarity or colour. Water clarity, measured using the black disc method, is currently routinely monitored as part of Environment Southland's SoE monitoring programme, and it is recommended that this be maintained at all sites.

3.2.4. Suspended sediment and turbidity

The proposed Freshwater Plan does not define any standards relating to turbidity, or suspended or deposited sediments. However, both suspended and deposited sediments can have significant effects on the ecological and recreational values of the waterbodies.

Turbidity is a relatively robust and inexpensive field or laboratory measurement that is often used as a surrogate or complement to water clarity and/or suspended solids measurements. Robust statistical relationships can generally be defined between turbidity and water clarity or turbidity and suspended solids, although these generally have to be site- or catchment specific. Turbidity can also be "continuously" (e.g. at 15 minutes intervals) monitored with probes placed in the river. Reasonably robust suspended solid annual load estimates can be calculated based on continuous turbidity data, and a site-specific turbidity /SS "rating curve".

As part of the SoE programme, Environment Southland has recently started monitoring total suspended solids instead of turbidity (which was measured until 2008). This change is justified as TSS provides a more direct measure in relation to potential effects than turbidity. It also relates more directly to the measurement of deposited sediment, a recent addition to Environment Southland's monitoring programme (see section 3.2.5 below).

However, it should be noted that laboratory methods usually have a detection limit of 3mg SS/l, which leads to the dominance of censored (i.e. less than detection limit) data under clear water conditions.

From a management perspective, it can be useful to provide an estimate of the amount of sediment carried in the catchment over various timeframes (e.g. annually or over a specific flood event). This is particularly relevant in situations where specific issues have been identified, such as accelerated erosion or excessive sedimentation in the river or in downstream lakes or estuaries.

There are, however some severe limitations to the use of monthly SS or turbidity data to estimate annual sediment loads. SS concentrations undergo huge changes during peak flows, to several hundred times the base flow concentrations. As a result, the vast majority of the annual SS load is transported during flood flows. Whether or not one or several of these flood flows are captured by the monthly sampling would have a huge influence on the final load estimation. This is true for most contaminants, but in the case of the SS is exacerbated by the highly skewed data distribution.

As a result, continuous monitoring is the most robust way of estimating suspended solids loads transported in a catchment. Continuous SS monitoring is not practicable, and continuous turbidity monitoring associated with monthly suspended solids and turbidity monitoring (to establish the rating curves) is recommended at sites where issues associated with accelerated erosion and/or sedimentation in downstream environments have been identified.

3.2.5. Deposited sediment

The deposition of fine sediment on and in the bed of streams, rivers and lakes is a significant issue which can affect a number of values, including ecological, and aesthetic/recreational values. Although there seems to be a general acceptance of the significance of the issue in New Zealand, there are no nationally or internationally accepted protocols for the measurement of deposited sediments, and few Regional Councils have traditionally monitored deposited fine sediments as part of their SoE programme.

Environment Southland has recently (since summer 2009) started annual monitoring of the cover of fine sediment deposited on the river bed, following a methodology recommended by the University of Otago (Wagenhoff, 2008). The implementation of this monitoring placed Environment Southland in a leading position nationally, and is firmly supported.

It should be noted that a group of Regional Councils, including Environment Southland, have initiated through the Envirolink Tools funding scheme, a project aiming at establishing national protocols and guidelines in relation to fine deposited sediments. The delivery of this project is expected in June 2011. It is recommended that Environment Southland monitoring protocols be then reviewed to align with the national guidelines.

3.2.6. Temperature and pH

The proposed Freshwater Plan defines water temperature and pH standards for all surface water body classes, and these determinands should be monitored as part of the routine SoE monitoring programme. It should be noted however, that both temperature and pH undergo changes on a seasonal, but also diurnal basis. Spot measurement only provide a snapshot of pH and temperature at the time of measurement and may be of limited value to formally assess compliance with the Proposed Plan standards. It is recommended that monthly monitoring of these determinands be maintained as part of the routine SoE programme, and that continuous temperature and/or pH be undertaken if/where monthly monitoring indicate potential issues (such as non-compliance with the standard).

3.2.7. Dissolved oxygen

Dissolved oxygen (DO) is essential for aerobic forms of river life, including most plants and animals. As explained Davies-Colley and Wilcock (2004), the dissolved oxygen concentration at any point in time will be a resulting balance between a number of processes:

- Oxygen-consuming respiration by aquatic life (bacteria, plants and animals);
- Oxygen-producing photosynthesis by aquatic plants and cyanobacteria,
- Exchanges between the water and the atmosphere that tend to re-establish equilibrium at "saturation" level (in turn largely dependant on the water temperature). This process (reaeration) is mostly controlled by the degree of turbulent mixing occurring. Thus, a swift-flowing river is well reaerated, whereas a sluggish stream has poor uptake of atmospheric oxygen.

The DO concentration in the water is subject to diurnal variations governed by the three processes above, leading to maximum levels (which can be significantly higher than the equilibrium 100% saturation) in mid afternoon when photosynthesis is at maximum intensity, and minimum levels at dawn (after a whole night of oxygen consuming respiration, and no photosynthesis). Low levels of DO can be a major stressor to aquatic life, including fish, invertebrates and micro-organisms, which depend upon oxygen for their efficient functioning.

DO is currently routinely monitored as part of Environment Southland's SoE monitoring programme, both in the field (hand-held probe) and in the laboratory[2]. The doubling-up of the measurement is

[2] Winkler / iodometric titration with azide modification. APHA 4500-O C 21st ed 2005.

explained by the perceived low reliability of the hand-held probes. Although this probably achieves better analytical performance, one should question the real usefulness of the data gathered.

Indeed, day-time instantaneous ("spot") measurements only provide a snapshot of the DO concentration in the river at the time of sampling, but provide little information on the daily minimum concentrations. As such, they are of very limited value in terms of SoE reporting or to assess compliance with the DO standards. Although low daytime DO measurements do indicate a possible significant issue worth of further investigation, reasonably high concentration does not mean that the DO concentration remains acceptable at night. Thus, only measurements taken late at night/early in the morning, or continuous monitoring, can provide some useful measure of the daily minimum DO concentration actually occurring in the river.

For this reason, it is recommended that less effort be spent on DO "spot" measurement, and more on continuous DO monitoring. This includes the discontinuation of DO laboratory measurements, the increased/optimised use of the existing DO probes, and, if possible, the purchase and running of two additional DO probes.

General recommendations for the use of the DO probes include :

- Probes should be installed at sites where organic enrichment is known or suspected, and/or at sites with high DO-dependant values (high ecological/fishery values, salmonids spawning areas);
- Keep the probes mobile to try and capture the critical periods at each site, such as: summer low flows in main rivers, late summer in salmon spawning tributaries;
- The probes can generally be worked as pairs, to provide paired synchronous records, upstream and downstream of an area of special interest (e.g. area of intensive land use, point source discharges, confluence of a degraded tributary). Paired probes should obviously be placed in comparable sites (i.e. avoid one at the bottom of a long slow pool and one just after a fast riffle).

Appendix A provides a list of proposed sites for continuous DO monitoring.

3.2.8. Organic Load

A common cause of deleterious DO depletion is the instream degradation of organic matter by heterotrophic bacteria. Biochemical oxygen demand (BOD) and total organic carbon (TOC) are commonly used indicators of the organic load carried by the water. A measure of organic load is useful in a SoE programme, as an indicator of organic enrichment caused by point- or non point- source discharges.

BOD is commonly monitored in relation to point source discharges, and is a useful determinand in this context. However, laboratory quantification limits (in the order of 1 or 2 mg/l) are greater than the BOD concentration generally encountered in natural waters, making routine BOD monitoring of this determinand of limited value in a SoE context.

Organic carbon (total or dissolved) is another indicator of the amount of organic matter in the water column. Due to lower quantification limits than for BOD, this determinand can provide better information in waterways with relatively low organic enrichment. However, the measured TOC concentration is sometimes largely dominated by algae matter (i.e. endogenous source), rather than organic load discharged to the river (exogenous source), which can confuse the results. Further, TOC is an expensive laboratory test, and routine monitoring of this parameter as part of the SoE programme would significantly increase the programme's laboratory analysis costs. Whilst it is not recommended to include this determinand in the routine SoE monitoring programme, it could be a useful addition at selected sites where significant non-point source inputs of organic carbon is possible or suspected. For example TOC may be useful in assessing the seasonal effects of dairy herd wintering in parts of catchments with otherwise generally low intensity land use, such as sites in the Aparima catchment (Hamilton Burn, Otautau Stream), or in the Mataura catchment (Mataura River, Sandstone Stream, North Peak Stream, etc.). Appendix A provides the detail of sites where TOC monitoring may be useful.

Environment Southland currently monitors $cBOD_5$ at a few (7 sites) selected sites in relation to point source discharges of treated domestic and/or industrial wastewater. It is recommended to maintain this monitoring to identify any trends associated with the discharges. Monitoring of BOD at all sites in the monitoring network is however not recommended, as most results would be likely to be below the detection limit.

3.2.9. Bacteriological water quality

Water contaminated by human or animal faecal material can pose a health risk to recreational users, or to livestock. The level of health risk associated with faecal contamination is generally assessed with bacteriological indicators. Three bacterial indicators are commonly used in new Zealand in relation to recreational waters or livestock drinking water:

- *Escherichia coli*, commonly called *E. coli* is the indicator generally used to assess health risk in freshwater recreational waters (MfE, 2002). *E. coli* is also used as a standard in the Proposed Freshwater Plan for all but the three Mataura river classes. It is recommended that this indicator be routinely monitored at all sites as part of the SoE monitoring programme.
- Faecal coliforms (FC) is the recommended indicator in relation to the health risk to livestock drinking (ANZECC 2000) and people gathering shellfish (MfE, 2002). The proposed freshwater Plan also defines FC concentration standards for all river classes, and this indicator should also be monitored as part of the routine SoE monitoring programme.
- Enterococci is the recommended indicator in relation to contact recreation in coastal waters (MfE, 2002). Monitoring this parameter is recommended at river sites that may have a direct impact on coastal water quality (i.e. generally sites at the downstream end of catchments).

As part of its Contact Recreation monitoring programme, Environment Southland monitors microbiological water quality at 6 sites across the region, weekly during the summer (December to March) period. The results of this monitoring enable timely public information and reporting, but also assessment of compliance with the Mataura 1 and Mataura 2 faecal coliforms standards. The inclusion of bacteriological water quality determinands in the main SoE programme provides a very useful complement to the CR programme. In particular, by providing year-round, long-term data at a much wider range of sites, the SOE data is more likely to enable the identification of sources of contaminantion.

3.3. Guiding principles for the site location

The following guiding principles are recommended for the selection of monitoring sites:

- *Align the monitoring sites with the surface water resource zones framework*: This generally means placing monitoring sites at the top and bottom of each management zone, and/or at transition points between two zones;
- *Generally place sites at (or near) the bottom of catchments*, to capture water quality and flow from the whole catchment. This means generally placing the sites at the bottom of the zone on mainstem river sites (as recommended above), and immediately upstream of the confluence with the mainstem river on the tributaries. This provides better spatial coverage for catchment scale contaminant load analysis;
- *Availability of flow data at water quality monitoring sites*: As explained in section 2.4.4 of this report, flow data is essential to a number of data analysis methods, and, as far as possible it is recommended that flow data be available at all water quality monitoring sites, either by aligning flow and water quality monitoring sites, or by establishing flow correlations with nearby flow recording sites. This principle is already implemented to a very large extend in the current monitoring programme, and should be extended to any new site;

- *Align as much as possible water quality and biomonitoring sites*, to enable better cross-analysis between the two programmes (e.g. using water quality data to explain biological monitoring results, and vice-versa);
- *Maintain long-term sites* to keep building on long-term records which are particularly useful in temporal trends analysis;
- *Ensure representativeness* at the region's and the catchment scale;
- *Include reference sites* for each river class and each catchment. It is noted that reference sites are generally located near the top of the catchments, and access is often an issue. In some situations, "near-reference" or "low pressure" sites have to be used.
- "*Core" sites*: are generally on mainstem rivers, or main tributaries, at the top or the bottom of zones /catchments, ideally making the best use of existing sites, particularly those with long-term records;
- *"Satellite" sites*: should generally be placed at the bottom of subcatchments, or comprise pairs of sites upstream/downstream of areas of special interest (such as areas of intensive farming, or farming intensification, or areas prone to accelerated erosion, etc.).

3.4. Monitoring frequency and timing

3.4.1. Water quality monitoring

Environment Southland's SoE water quality monitoring programme currently operates on a monthly basis. This frequency offers a good compromise between operational costs and robustness of the dataset, and should be maintained. The recommended list of field and laboratory determinands associated with this monthly monitoring is summarised in Table 2. It is recommended that the monthly monitoring programme be re-organised to ensure that, as far as practicable, monitoring is concurrent (i.e. same day) within each given catchment. Each sampling occasion not only adds to the existing data but also provides a snapshot of water quality across the whole catchment on that day. Concurrent data across the catchment is particularly useful for analysis (such as daily load/yield analysis) aimed at tracking contaminant sources at the catchment scale.

A number of determinands (pH, temperature, DO) undergo considerable variations on a diurnal basis and are best monitored continuously, rather than with "spot" measurements. The running of continuous monitoring probes is recommended to robustly assess compliance with the relevant plan standards. The estimation of sediment loads also requires continuous turbidity monitoring. However, the significant capital and operational costs will place severe limitations on the number of sites that can be continuously monitored at any given time. It is recommended that a list of priority sites be prepared for each determinand, and that monitoring between these sites be optimised (for example by moving DO probes to different paired sites after each summer). In this context, the results of "spot" monthly monitoring can assist in defining priorities. Appendix A provides recommendations in relation to continuous monitoring.

3.4.2. Ecosystems monitoring

The ecosystem monitoring (macroinvertebrates and periphyton) is undertaken on an annual basis. This frequency is consistent with the *modus operandi* of most regional councils in the country, and, again, offers a good compromise between data requirement and operational costs. However, annual monitoring will not allow direct assessment of compliance with some of the Proposed Freshwater Plan standards (monthly mean periphyton biomass standards for the Lake Fed and Spring fed surface waterbodies classes). As explained in section 3.2.1, specific additional monitoring could be undertaken if, and where, significant issues are suspected.

Environment Southland has initiated annual monitoring of deposited fine sediments at each ecosystem monitoring site. Such monitoring is a very useful addition to the ecosystem monitoring programme and is strongly supported.

3.4.3. Site categories

Through the review process, it appeared essential that a number of monitoring sites be added to the monitoring network, to improve its spatial resolution and representativeness. Maintaining the overall monitoring effort to its current level and increasing the number of monitoring sites are not incompatible objectives. The recommended approach is to define two categories of monitoring sites (as defined in Section 3.1), and adapt the monitoring frequency for each category:

- *Core sites:* These sites represent the core of the monitoring programme, where the more in-depth data analysis (such as temporal trends analysis). Monitoring at these sites should be undertaken on a "permanent" basis, i.e. every year (in opposition to the "rolling" regime recommended for "satellite" sites);
- *Satellite sites:* These sites primarily aim at improving the spatial resolution or the representativeness of the monitoring network within each catchment. It is recommended to undertake monitoring at these sites for one year every three years on a catchment by catchment rolling basis. For example during year 1, all satellite sites in the Waiau and Aparima catchments would be monitored ; then, during year two, all satellite sites within the Mataura catchment would be monitored.

3.4.4. Sites monitored by NIWA

A limited number of river sites are monitored monthly for water quality by NIWA, and Environment Southland make use of these data as part of its normal SoE reporting. However, NIWA monitoring does not include some of the determinands routinely monitored by Environment Southland. To complete the dataset, Environment Southland undertakes additional monthly monitoring at these sites for the few determinands not monitored by NIWA (e.g. *E. coli*, total suspended solids and black disc clarity). Although this approach may result in some small cost savings, it introduces several issues which compromise the overall dataset's integrity:

- NIWA data is generally only made available to the Regional Council on a 6-monthly basis, potentially causing unwanted delays in obtaining the data;
- Sampling and analytical procedures are not exactly the same, potentially compromising the dataset's homogeneity;
- More importantly, in any given month, monitoring is generally not undertaken on the same days by the two organisations, which means that data at these sites are collected on different days on the same month for different determinands. It also means that the data are not collected synchronously across the catchment, which may impede some data analysis (refer to Section 3.4).

It is recommended that Environment Southland undertake monitoring for the full suite of determinands at all the monitoring sites in its network. It is also suggested that the NIWA data can be used in the future as a reference, or calibration check, as well as for long-term water quality trends analysis.

3.4.5. National and Regional consistency

A project aiming at improving consistency of regional State of the Environment monitoring programmes across New Zealand has recently been initiated by the country's Regional Councils. This project will look in detail into the monitoring programmes of all Regional Councils and identify gaps, discrepancies and commonalities in field and laboratory methods and protocols used by the different Regional Councils. The aim of the project is to improve the consistency of environmental data collected nationally, and enable more robust inter-regional comparisons and national reporting. This project may identify or recommend changes that may be relevant to Environment Southland's water quality and aquatic ecology State of the Environment monitoring programmes, and may result in different outcomes to those recommended in this report.

Table 2: Recommended Determinands for the SOE water quality and ecosystems monitoring.

Determinand		Field/laboratory	Frequency	Detection limit	Comment
Ecosystem monitoring	Periphyton (biomass and cover)	Both	Annually	N/A	Reporting indices should at least include AFDM and *chlorophyll a* biomass, as well as filamentous algae and cyanobacteria/diatom cover for direct assessment against Proposed Freshwater Plan standards
	Macroinvertebrate communities	Both	Annually	N/A	Reporting indices should at least include MCI and SQMCI, for direct assessment against Proposed Freshwater Plan standards
	Deposited sediment	Field	Annually	N/A	Protocol as per Wagenhoff 2008
Water quality monitoring (monthly sampling)	DRP	Laboratory	Monthly		All sites
	NNN	Laboratory	Monthly		All sites. Required to calculate SIN
	Nitrate-N (NO_3-N((g/m^3)	Laboratory	Monthly		All sites
	Ammonia-N (NH_4-N)	Laboratory	Monthly		All sites
	TN and TP	Laboratory	Monthly		Only required at sites upstream of lakes or estuaries
	Temperature (^oC)	Field	Monthly		All sites - hand-held equipment
	pH	Field	Monthly		All sites - hand-held equipment
	Turbidity	Laboratory	Monthly		At sites/catchments identified for continuous turbidity monitoring
	Suspended Solids (g/m^3)	Laboratory	Monthly		All sites.
	Black Disc Clarity (m)	Field	Monthly		All sites.
	$cBOD_5$ (g/m^3)	Laboratory			At identified sites only (in relation to point source discharges)
	DO (mg/l and % Saturation)	Field	Monthly		All sites - hand-held equipment
	Conductivity	Field	Monthly		All sites - hand-held equipment
	Chloride	Laboratory	Monthly		At identified sites only (in relation to groundwater interaction)
	E. coli (/100ml)	Laboratory	Monthly		All sites
	Faecal coliforms (/100ml)	Laboratory	Monthly		All sites
	Enterococci (/100ml)	Laboratory	Monthly		At sites upstream of coastal recreational sites
Continuous monitoring	Turbidity	Field			At priority sites only
	DO	Field			At priority sites only
	Temperature	Field			
	pH	Field			

4. Recommended monitoring sites

The Environment Southland Region has been divided into 17 surface water resource zones, which follow surface catchment boundaries. Some of these zones encompass parts of the larger catchments (for example, the Mataura River catchment is divided into 4 zones), whilst some others cover a number of smaller catchments (e.g. the Fiordland zone). The following section of the report makes recommendations for the location and category (core, reference or satellite) of monitoring sites in each zone. For concision, the comments below are purposely kept in bullet-point style. Appendix A summarises, for each recommended monitoring site, its location, classification, as well and the recommended monitoring frequency and determinands.

4.1. Aparima Water Resource Zone

Notes

- The Aparima water resource zone encompasses the entire Aparima River catchment;
- The Aparima River flows into an estuary, where issues with faecal coliforms (shellfish gathering), high sedimentation rate and macro-algae proliferation have been identified;
- The current water quality monitoring network comprises 3 sites on the Aparima River mainstem, and five sites on main tributaries;
- The landuse downstream of Etalvale is more intensive than in the upper catchment;
- The landuse between Dunrobin and Etalvale is intensifying;
- A lot of the sediment issue identified in the estuary appears to be coming from the Pourakino River;
- A flow site is being installed on the Pourakino River at Valley Rd, a few kilometres upstream of site 18 (Pourakino River at Ermedale Rd).

Comments

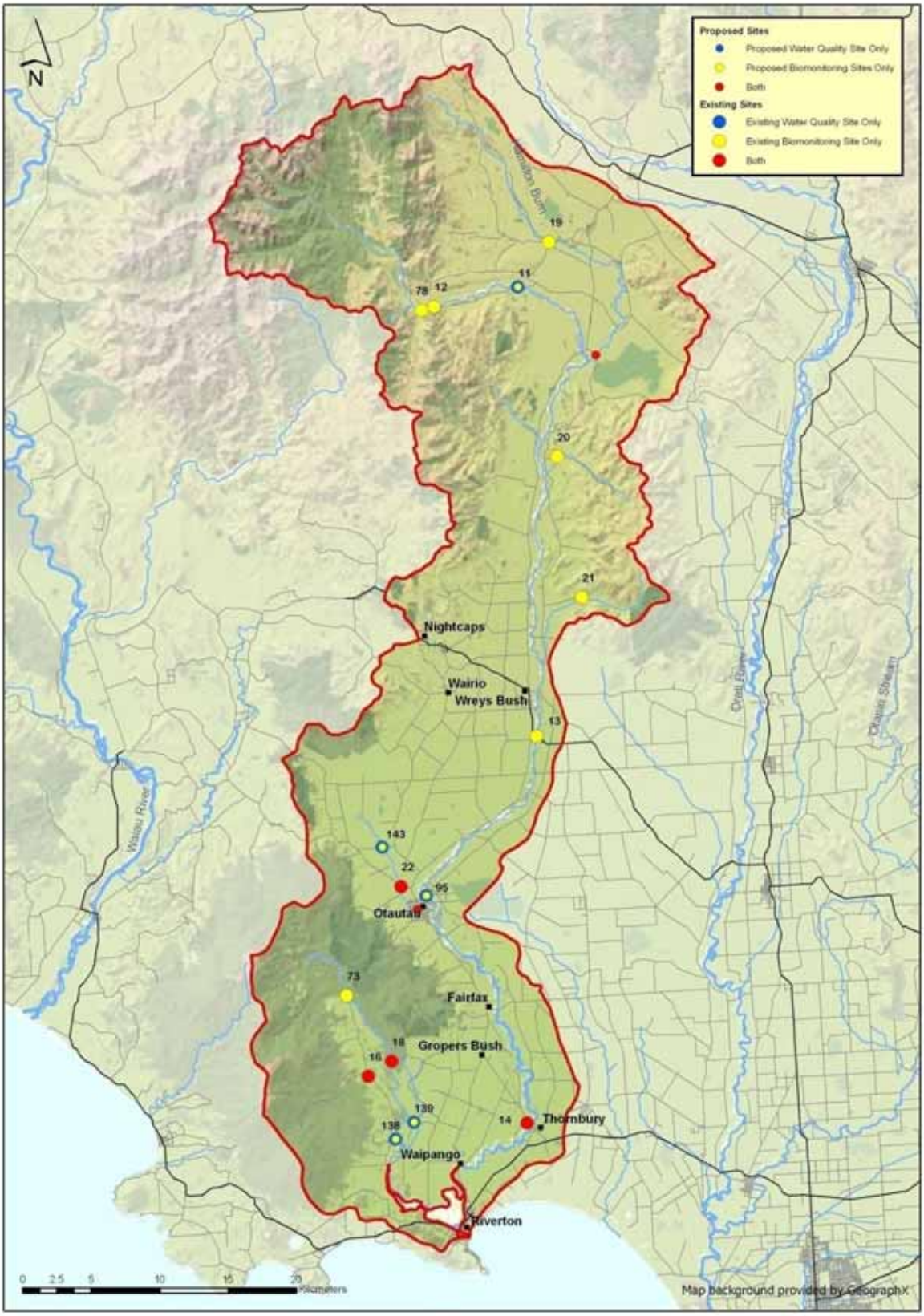
- There is no water quality monitoring site on the middle Aparima River mainstem (i.e. between Dunrobin and Otautau);
- The downstream-most monitoring site on the Otautau Stream (site 22) is far from the bottom of the catchment and may not adequately "capture" the whole of the Otautau Stream catchment;
- Hamilton Burn is a valued trout and eel fishery. The catchment is not currently subject to intensive land use pressures, but the potential for intensification has been identified (especially wintering of dairy cows as it is good free-draining soil). Biomonitoring is currently undertaken at Goodall Road, but not water quality monitoring.

Recommendations

- Add a monitoring site on the Aparima at, or near, Etalvale to capture the possible effects of land use intensification between Dunrobin and Etalvale. Note that the exact location of the monitoring site needs to be determined to ensure easy/safe access and site suitability;
- Move the lower Otautau Stream monitoring site (site 22) closer to the bottom of the catchment, to capture more of the catchment. The most logical location is the flow monitoring site at Otautau, a few hundred metres upstream of the confluence. Monitoring in the Otautau township is an added positive return as the site is very visible by the public;
- Add a monitoring site on Hamilton Burn, possibly at the flow site at Waterloo Rd, but preferably lower down the catchment. A possible site location is Hamilton Burn at Affleck Rd (2,136,130/5,480,530), a few hundred metres above the confluence with the Aparima River. Field site investigation is required. Given the current low level of land use pressure, it is recommended to

install this site as a "rolling" site. Monitoring frequency could be increased to yearly if the land use pressure increases, or if monitoring results identify significant issues;

- Cascade Creek is a reference site with already a good baseline of data. Recommend changing the monitoring frequency to rolling;
- Rolling frequency is also recommended for the Opouriki Stream at Tweedie Rd monitoring site;
- Due to its likely role in estuary sedimentation, the Pourakino River is a good candidate for continuous turbidity monitoring (and associated monthly SS and turbidity monitoring). The Traill Rd site captures most of the catchment except the Opouriki Stream confluence. Ideally, water quality and continuous turbidity monitoring should be undertaken downstream of the Opouriki Stream confluence, to capture all of the Pourakino River catchment. However, the upper limit of the tidal zone appears to be very close to the confluence, which would compromise the monitoring. Field assessment should be conducted to determine the upstream limit of the tidal influence in relation to the Opourikli Stream confluence;
- *Enterococci* should be monitored at Aparima at Thornbury and at Pourakino at Traill Road, in relation to coastal contact recreation water quality.



Map 1: Current and recommended monitoring sites in the Aparima Surface Water Resource Zone.

4.2. Coastal Longwoods

Notes

- This zone covers the coastal area between the Aparima and Waiau catchments;
- Contains a number relatively short coastal catchments;
- Identified as high vulnerability for groundwater;
- Increasing pressure on both water quality and quantity due to dairy development/intensification;
- A number of coastal contact recreation and shellfish sites exhibit poor water quality even during dry periods, and in spite of the open nature of the coast;

Comments

- No current water quality river monitoring site.

Recommendations

- Waimeamea Stream is the largest in the zone and has a mostly undeveloped catchment. A monitoring site on this stream would be useful as an example of a coastal stream in good condition/ reference site, but not as a representation of increased landuse pressure or coastal water quality issues. Water quality could be monitored at the current biomonitoring site at Young Rd (2,104,400/5,425,800);
- Kenny Creek, north of Pahia Point has good access, and coastal contact recreation sites near its mouth, and intensive landuse in its catchment. Recommended monitoring site (subject to site investigation): Kenny Stream at SH99 (2,104,700/5,421,440);
- *Enterococci* should be monitored at both sites, in relation to coastal contact recreation water quality.

Map 2: Current and recommended monitoring sites in the Coastal Longwoods Surface Water Resource Zone.

4.3. Mataura catchment

General notes

- The Mataura catchment is the largest river catchment in the Southland region[3];
- The Mataura catchment faces high water quality and quantity pressures, due to intensive landuse and industrial and domestic water takes and discharges;
- Most of the Mataura catchment is covered by a National Water Conservation Order, primarily to protect the nationally significant brown trout fishery;
- Currently, the water quality monitoring in the Mataura catchment spans over 4 days (Monday-Thursday). As recommended in section 3.4, it is preferable that monitoring across one given catchment be undertaken in as short a time span as possible (i.e. one to two days).

4.3.1. Upper Mataura

Notes

- The Mataura River mainstem is covered by the NWCO, and is a nationally significant trout fishery. There is an important contact recreation site at Garston;
- The landuse above Garston is quite extensive, although the valley between Kingston and the Mataura Valley has some reasonably intensive irrigated beef units, with the potential for more intensive development, including wintering of dairy herds;
- The landuse around Athol is more intensive;
- Brightwater spring dominates the river flow (60% of mainstem flow) during periods of low flow;
- The largest surface tributary is the Eyre Creek. This is not a noted fishery, and is a rain dominated, very flashy system. Eyre Creek is not currently monitored;
- The current water quality and biological monitoring network comprises two sites on the Mataura River mainstem (at Garston and Parawa). Biomonitoring is also undertaken upstream of Garston, at Mataura d/s Robert Creek confluence (reference site).

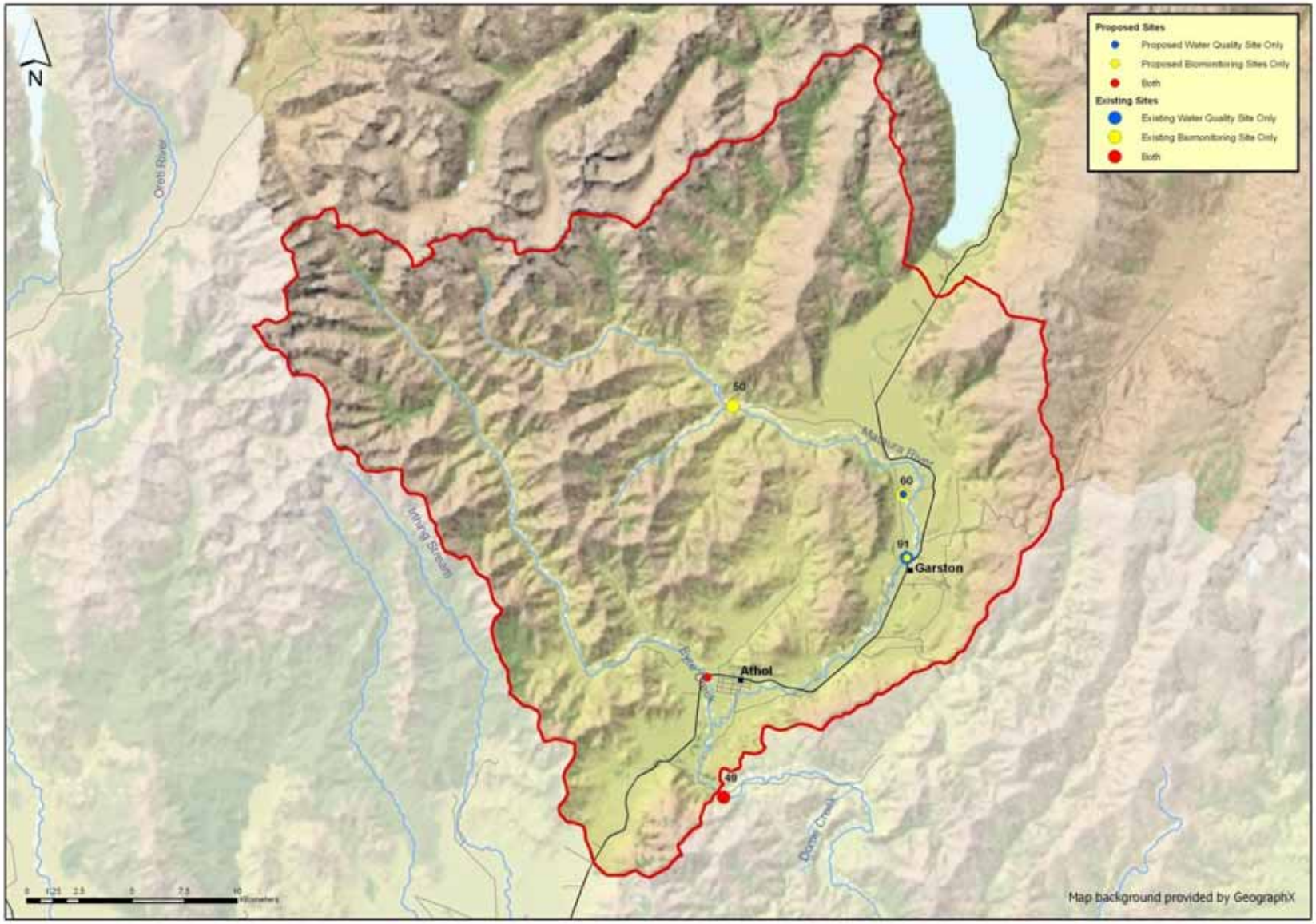
Comments

- The two water quality sites on the mainstem (at Garston and Parawa) are ideally placed to capture any water quality changes caused by more intensive landuse between the two sites (although the influence of Eyre Creek may need to be investigated – see recommendation below).

Recommendations:

- Add a monitoring site on Eyre Creek. In addition to collecting some useful information on this major tributary of the upper Mataura, the data will assist in analysing any water quality changes in the Matauara River between Garston and Parawa. Recommended site: Eyre Creek at SH6 (Athol-Five Rivers Highway) GPS: 2,163,000/5,512,770;
- Some consideration was given to adding a monitoring site on one of the tributaries from the plain between Kingston and Mataura valley (e.g. Allen Creek). There are currently no apparent water quality issues at Garston, and the additional site is not recommended for the time being;
- Add a monitoring site at Brightwater Spring. This will add a spring fed site to the network and will provide very useful information to understand water quality in the Mataura River at low flows. Conductivity and chloride should also be monitored in the spring and in the Mataura River at Gartson and Parawa as a tracer of groundwater influence.

[3] The Mataura catchment is 5,382 km^2. The Waiau/Te Anau/Manapouri catchment is larger (8,173 km^2) but is primarily a lakes catchment.



Map 3: Current and recommended monitoring sites in the Upper Mataura Surface Water Resource Zone.

4.3.2. Mid-Mataura

Notes

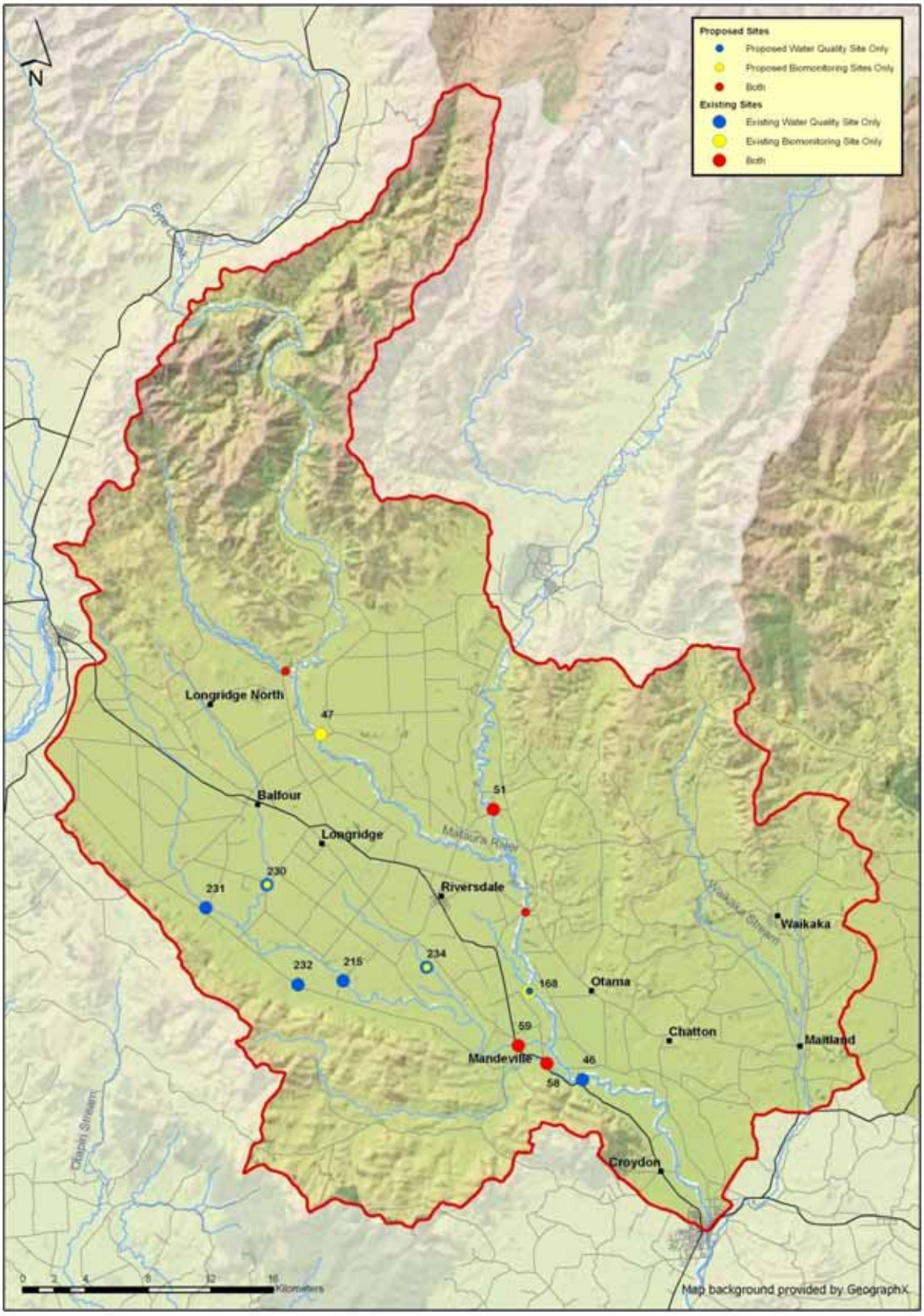
- The Mid-Mataura River loses flow to groundwater upstream of Riversdale and gains a lot of groundwater inflows downstream of Riverdale, i.e. Riversdale is the point of lowest flow;
- The area is identified as a groundwater "hotspot" due to the pressures on both groundwater quantity (abstractions) and quality (increasing nitrogen concentrations);
- A very significant nitrogen concentration increase occurs in the Mid Mataura mainstem, associated with the groundwater inflows;
- Waimea Stream Catchment (including Sandstone Creek) is monitored under the "Living Streams" programme. It has very high nitrate concentrations;
- Periphyton proliferation issues have been identified in the Mataura mainstem, starting downstream of the Waimea confluence.

Comments

- The current monitoring network includes a site at the top (Parawa) and bottom (Gore) of the zone, which provides excellent coverage of the surface water entering and exiting the zone;
- Site 46 (Mataura River at Otamita Bridge) is downstream of the confluence with the Waimea and Otamita Streams. This site should be maintained as it captures the influence of these two streams on the Mataura River mainstem;
- Monitoring sites 58 and 59 on the Waimea and Otamita Streams are ideally placed, immediately upstream of their confluence with the Mataura River, and should be maintained;
- Similarly, site 51 (Waikaia River at Waipounamu Bridge) is ideally placed just upstream of the confluence with the Mataura River and should be maintained;
- There are no water quality monitoring sites on the one remaining major tributary – the Tomogalak Stream.

Recommendations:

- The current network provides good coverage of the zone with 7 current sites in the zone, on both the Mataura River mainstem and its tributaries;
- Add a site on the Mataura mainstem near Riversdale to improve the dataset's spatial resolution in a river reach where significant water quality changes seem to occur. The site could be located upstream or downstream of the Waikaia River confluence. A site downstream would provide some water quality data for the Mataura mainstem upstream of the Waimea Stream confluence. This would allow direct comparison with site 46 (Mataura River at Otamita Bridge), which would provide a direct mean of assessing the influence of surface- and groundwater inputs from the Waimea catchment on the Mataura River's water quality. Biomonitoring is currently undertaken at Keowns Bridge, approximately 15km upstream of the Waikaia confluence. Water level is currently monitored at the Pyramid Bridge, approximately 4 km downstream of the Waikaia confluence. It is recommended that water quality and ecosystems monitoring be undertaken at the Pyramid Bridge water level site (this provides a site with water quality, ecosystem and river flow monitoring). To allow for robust comparisons, this site should be monitored with the same frequency as the Otamita Bridge site (i.e. a "core" site);
- It is also recommended to add a "satellite" site on the Tomogalak Stream. Possible site (subject to site investigation): Tomogalak at Ardlussa Rd (2,169,800/5,484,600).



Map 4: Current and recommended monitoring sites in the Mid Mataura Surface Water Resource Zone.

4.3.3. Waikaia

Notes:

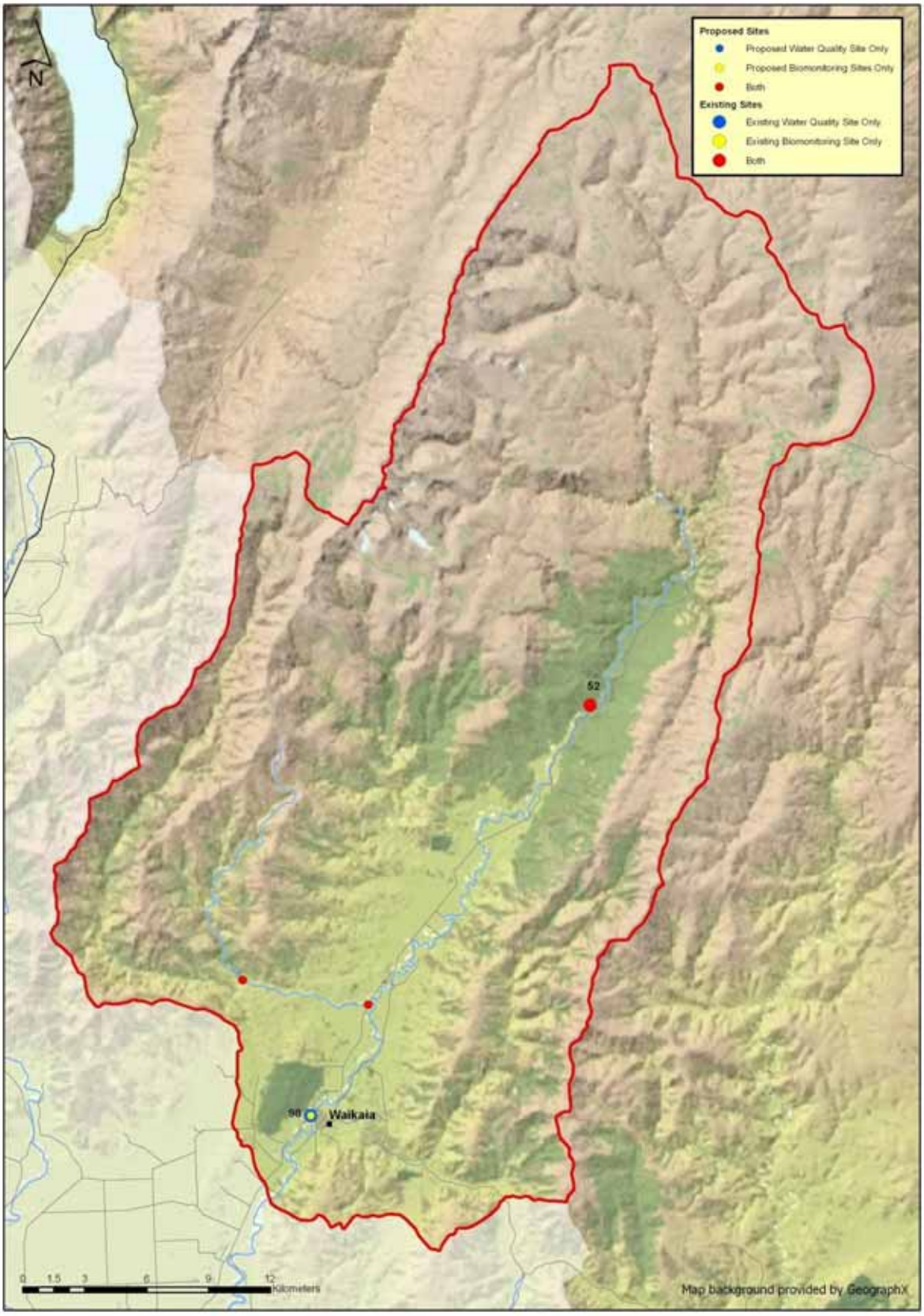
- The surface water resource zone only covers part of the Waikaia catchment, from the source to the Mahers Beach flow recorder;
- Upper catchment (upstream of Piano Flat) is mostly in native vegetation;
- Downstream of Piano Flat, there is a lot of cultivation in reasonably steep hill country, and land "re-clearing" (i.e. clearing of secondary scrub);
- Lower down the catchment, there is more intensive agriculture above Waikaia, with increased irrigation and dairy farms, particularly in the Steeple Burn lower catchment;
- Flow monitoring at Piano Flat and Mahers beach, flood warning site at Waikaia;
- Water quality monitoring upstream of Piano Flat and at Waikaia.

Comments:

- The water quality and ecosystems monitoring site upstream of Piano flat provides a good reference site. Consideration was given to moving this site to the Piano Flat flow recorder. However, there is a camping ground and cribs/huts at Piano Flat, which could have some effect on water quality, and it is recommended to maintain the current site location;
- The downstream water quality site is at Waikaia, a few kilometres upstream of the Mahers Beach flow recorder. Consideration was given to moving the water quality site to Mahers beach, to capture the whole of the management zone. However, there are no major tributaries or groundwater influence between Waikaia and Mahers Beach, and water quality and river flow are not expected to be significantly different between the two sites. Moving the water quality site to Mahers Beach would be of limited benefit and would discontinue a data record starting in 2003. There is a contact recreation monitoring site at Waikaia. It is recommended to maintain the water quality monitoring site at Waikaia;
- There is no monitoring of tributaries in this zone.

Recommendations:

- Maintain the water quality monitoring sites to their current locations;
- Undertake ecosystems monitoring at the Waikaia River at Waikaia monitoring site;
- Due to the active land clearance and potential erosion issue, continuous turbidity monitoring (at Piano Flat and Mahers Beach) may be useful;
- Add two monitoring sites (rolling basis) on Steeple Burn. The exact location of the upstream site will require further investigation, but in should be within the foothills, upstream of the intensive landuse area (general area of 2,183,000/5,496,800). The downstream site should be near the confluence with the Waikaia River: Steeple Burn at Piano Flat Rd (2,189,100/5,495,600). It is noted that good flow correlation is available with the Mahers Beach flow recorder.



Map 5: Current and recommended monitoring sites in the Waikaia surface water resource zone.

4.3.4. Lower Mataura

Notes

- The Lower Mataura water resource zone extends from Gore to the River mouth;
- The western side of the valley (true right bank) has intensive dairying;
- The eastern side of the catchment is gently rolling hill country, with some forestry into the top of the left bank tributaries (Mimihau Stream and Mokoreta River);
- Site 45 (Mataura River d/s Mataura Bridge) was established to track the effects of discharges (Alliance plant, MDF plant) on the Mataura River's water quality – this site should be maintained;
- The current network offers thorough coverage of the mainstem: monitored at the top of the zone (site 85 at Gore, above the Waikaka River confluence), then at Mataura (Site 45, see above), downstream of the Mimihau and Mokoreta confluence (NIWA Site at Mataura island Bridge, Site 44) and near bottom of catchment (Site 43, Mataura at Gorge Road);
- There is a good coverage of the tributaries as well: Waikaka Stream at Gore, Mimihau Stream at the top (site 57 – originally set up to follow effects of pine forestry on water quality) and bottom (at Wyndham - site 117), Mokoreta River at Wyndham River Road (near bottom of catchment, site 54), and Otaremika at Seaward Downs (site 84).

Comments:

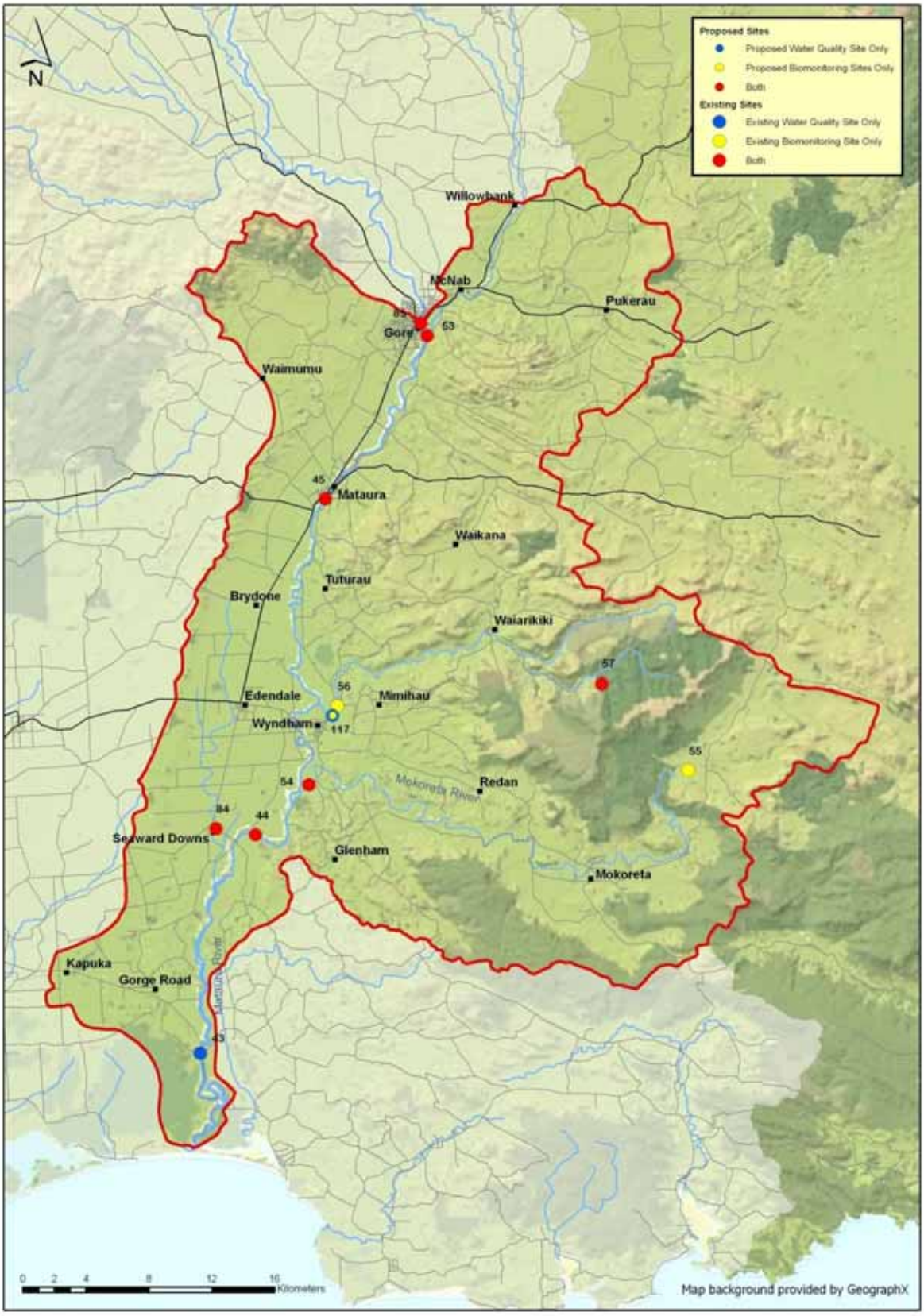
- The current network offers thorough coverage of this zone;
- Mimihau Stream water quality and biomonitoring site are a few kilometres apart, but this appears to be due to the unsuitability of the Wyndham water quality site for macroinvertebrate sampling;
- The monitoring site on the Otaremika site is not at the bottom of the catchment, and does not capture a few side tributaries (e.g. Ives Creek).

Recommendations:

- Generally, maintain the current network;
- If possible, regroup Mimihau Stream water quality and biomonitoring sites (subject to suitable macroinvertebrate sampling habitat);
- Subject to site investigation, it is recommended to move the Otaremika Stream monitoring site to McCall Rd to capture all side tributaries (2,183,650/5,414,550);
- Monitor *Enterococci* in the lower river (Site 43, Mataura at Gorge Road), in relation to coastal water contact recreation monitoring.

4.4. Oreti Catchment

- The upper Oreti catchment (upstream of Mossburn) is covered by a recent (August 2008) National Water Conservation Order (NWCO). The NWCO primarily protects river flow, but does include strong water quality provisions;
- The Oreti catchment currently comprises three surface water resource zones (Upper and Lower Oreti and Makarewa), but Environment Southland is considering creating two zones within the current Upper Oreti Zone, to follow the limits of the NWCO. This change is supported;
- Two sites on the Oreti River are monitored by NIWA (Lumsden Bridge and Wallacetown);
- The estuary the Oreti River flows into is part of the Waihopai surface water resource zone.



Map 6: Current and recommended monitoring sites in the Lower Mataura surface water resource zone.

4.4.1. Upper Oreti

Notes

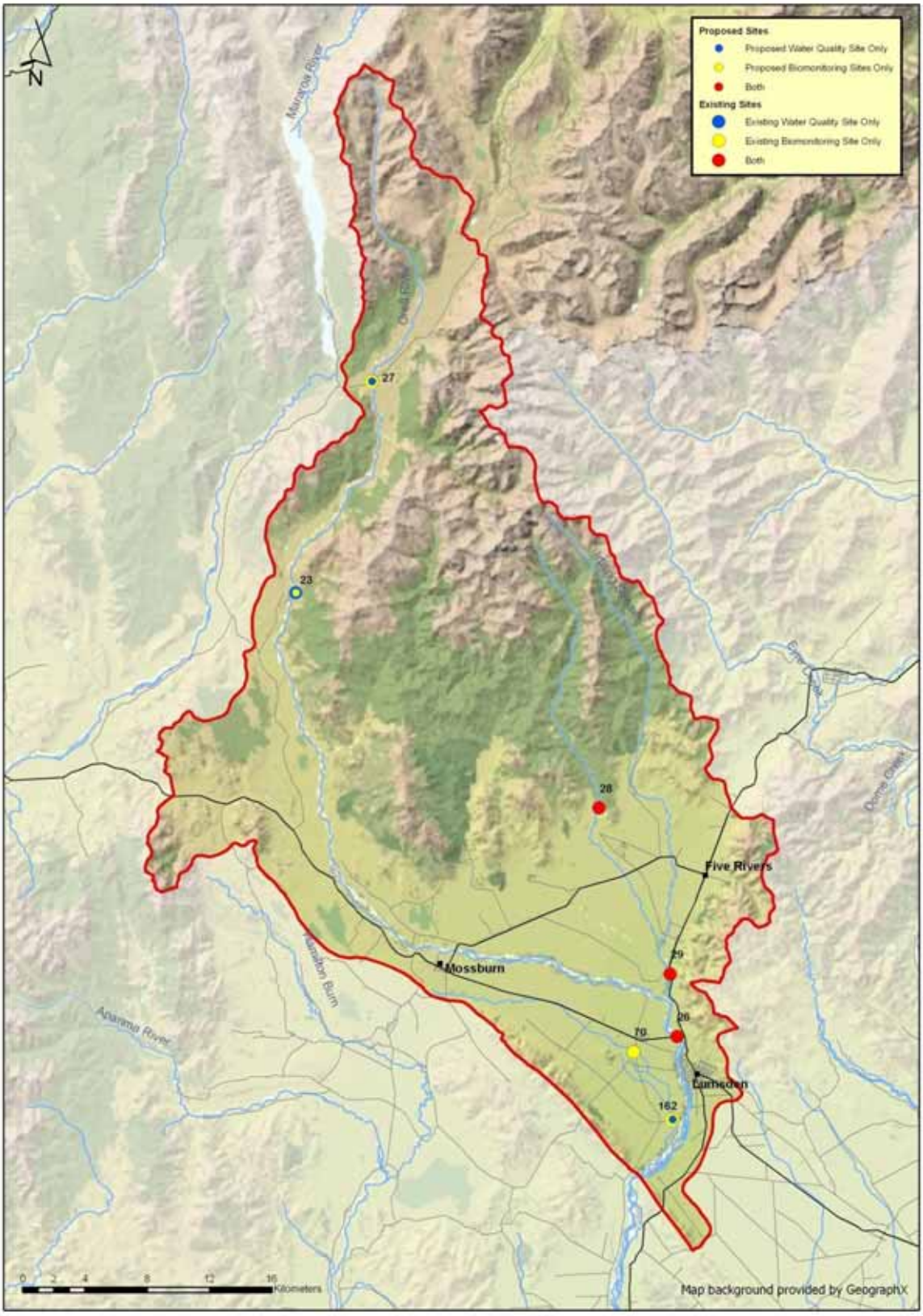
- The Oreti River water quality and flow are monitored at Three Kings, which is a near-reference/low pressure site for the river;
- Some conversion of red tussock land to pasture between Three kings and Mossburn; which may lead to water quality changes;
- Large scale dairy conversion and intensification downstream of Mossburn;
- Site 28 on Cromel Stream is a reference site. It is also located in a groundwater recharge zone, and can provide useful background information on the water quality entering the groundwater recharge;
- Site at the bottom of Irthing Stream is also a flow site, and should be maintained;
- The zone limit at Ram Hill corresponds to a natural groundwater restriction point;
- Periphyton monitoring on Murray Creek indicates quite prolific algae growth.

Comments:

- No biomonitoring at Three Kings;
- Good coverage of reference sites (one on mainstem, one on side tributary);
- There is currently no monitoring near Mossburn, which is the downstream limit of the NWCO;
- There is currently no water quality monitoring on Murray Creek;
- No monitoring at bottom of zone (Ram Hill);
- There are currently two biomonitoring sites on Murray Creek: Site 70 (Murray Creek at Double Road) in the middle catchment and Site 162 (Murray Creek at Cummings Rd) at the bottom of the catchment, but no water quality monitoring site. Both sites are classified as Spring Fed.

Recommendations

- Add a monitoring site at the downstream limit of the NWCO to monitor any changes potentially associated with the current conversion of red tussock land to pasture. This addition is consistent with Environment Southland's intention to split the water resource zone in two. There are several access points to the river in the area, and the exact location of the monitoring site should be confirmed by field investigation;
- Add a monitoring site at the bottom of the zone (Ram Hill). The monitoring site should be located either upstream or downstream of the mixing zone with Murray Creek;
- Oreti at Lumsden Bridge is currently monitored by NIWA, with Environment Southland undertaking some monitoring as described in Section 3.4.4. The Ram Hill site fits Environment Southland's management framework, and it is recommended that the monitoring efforts be concentrated at this site (as a permanent site), whilst maintaining some monitoring effort at Lumsden Bridge, as "rolling" site;
- Add water quality monitoring on Murray Creek at Double Road (Site 162). This enables some water quality monitoring on this tributary which appears to be under some landuse pressure, and includes a Spring Fed site to the water quality monitoring network;
- Shift Cromel Stream site (Site 28) to rolling monitoring frequency;
- The Oreti at McKellars Flat (Site 27) biomonitoring site is classified as "Mountain". It is recommended to also undertake water quality monitoring at this site, to include a "Mountain" site in the monitoring network (there are none in the current monitoring programme). This site also provides a reference site for the Oreti River.



Map 7: Current and recommended monitoring sites in the Upper Oreti surface water resource zone.

4.4.2. Lower Oreti Zone

Notes

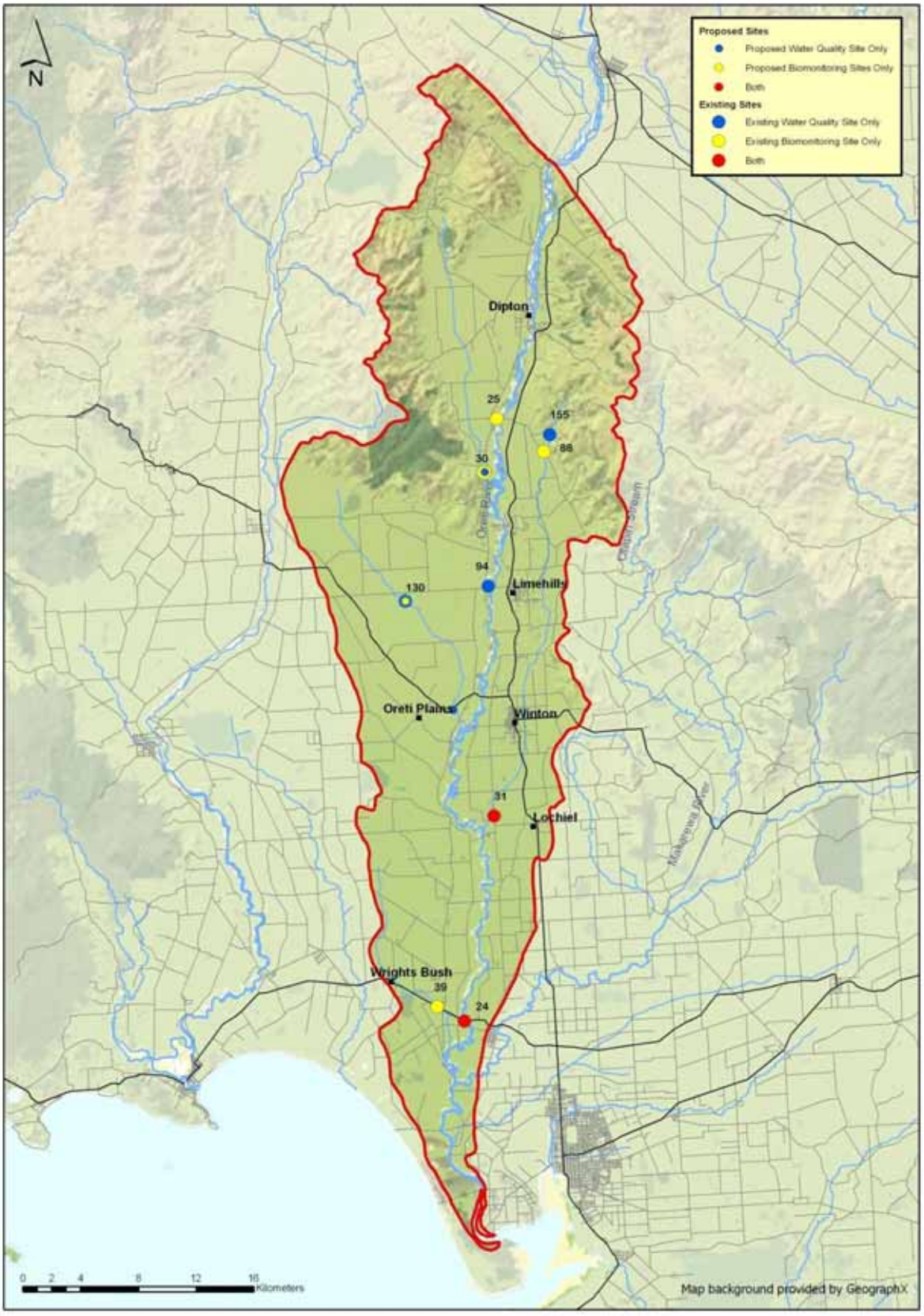
- Landuse in Dipton Flat, near the top of the zone, on the western side (true right bank) of the Oreti River, is principally forestry on hills and foothills, and traditionally had dairy wintering blocks in the flats. In recent years, more main dairy units (i.e. year round instead of wintering units) have appeared;
- Biological monitoring shows abundant periphyton growth in Dipton Stream;
- Bog Burn is one of the national "best practice" dairy catchments (intensive monitoring, implementation of landuse "best practices"). Environment Southland has one water quality site in the middle reaches of Bog Burn (Site 130, Bog Burn d/s hundred line Rd);
- The current network includes water quality monitoring on the Oreti River mainstem at Centre Bush (Site 94) and Wallacetown (Site 24). The latter is also a NIWA monitoring site. Biomonitoring is undertaken at Benmore and Wallacetwon;
- There are two monitoring (water quality and biomonitoring) sites on the main left bank tributary – Winton Stream, downstream of the Winton Dam (Site 155), in the upper catchment and at Lochiel (Site 31) near the bottom of the catchment. Biomonitoring is undertaken at Benmore-Otapiri Rd (Site 88), a few kilometres downstream of Site 155.

Comments

- The current monitoring network offers a reasonable coverage of the Oreti River mainstem. However, Wallacetown (Site 24) is a NIWA site, which may pose synchronisation issues;
- Good coverage of 2 of the 3 main tributaries, although it is noted that the Bog Burn site does not capture the whole catchment;
- Water quality and ecosystem monitoring sites are often separate;
- There is no water quality monitoring on the zone's third main tributary (Dipton Stream).

Recommendations

- Full water quality monitoring by Environment Southland at Oreti at Wallacetown is recommended (as per section 3.4.4);
- It is recommended to add a water quality monitoring site at the bottom of the Bog Burn catchment, to adequately "capture" the whole catchment (SH96 2,144,600/5,442,400 or Spar Bush-Winton Rd (2,145,000/5,441,900). The current Bog Burn monitoring site (Site 130) may, or may not, be maintained in the future, depending on Environment Southland's continued involvement in this "best practice" catchment programme;
- In accordance with the general recommendations in section 3.3, it is recommended to, as much as possible, regroup water quality and ecosystems monitoring sites. The recommended way forward includes scoping out the possibility of undertaking ecosystems monitoring at Oreti at Centre Bush (Site 94), and of regrouping the two upper Winton Stream sites (either at Site 88 or Site 155). Monitoring should continue as per the current programme until this investigation is completed;
- Add a water quality monitoring site (rolling frequency) on Dipton Stream, at the current biomonitoring site (Site 30, Dipton Stream at Southend Hill Rd). It is understood that simulated flow data is available for this site.



Map 8: Current and recommended monitoring sites in the Lower Oreti surface water resource zone.

4.4.3. Makarewa Zone

Notes

The current water quality monitoring network includes:

- three reference sites on Makarewa River (Site 122), Otapiri Stream (Site 120) and Dunsdale Stream (Site 38);
- One site on a side tributary (Tussock Creek at Cooper Road, Site 135);
- One site at the bottom of catchment (Makarewa at Wallacetown, Site 32);
- One site on a tributary of the lower Oreti (Waikiwi Stream), just on the edge of Invercargill and in a very degraded state.

The current biomonitoring network is generally different from the water quality network. It includes:

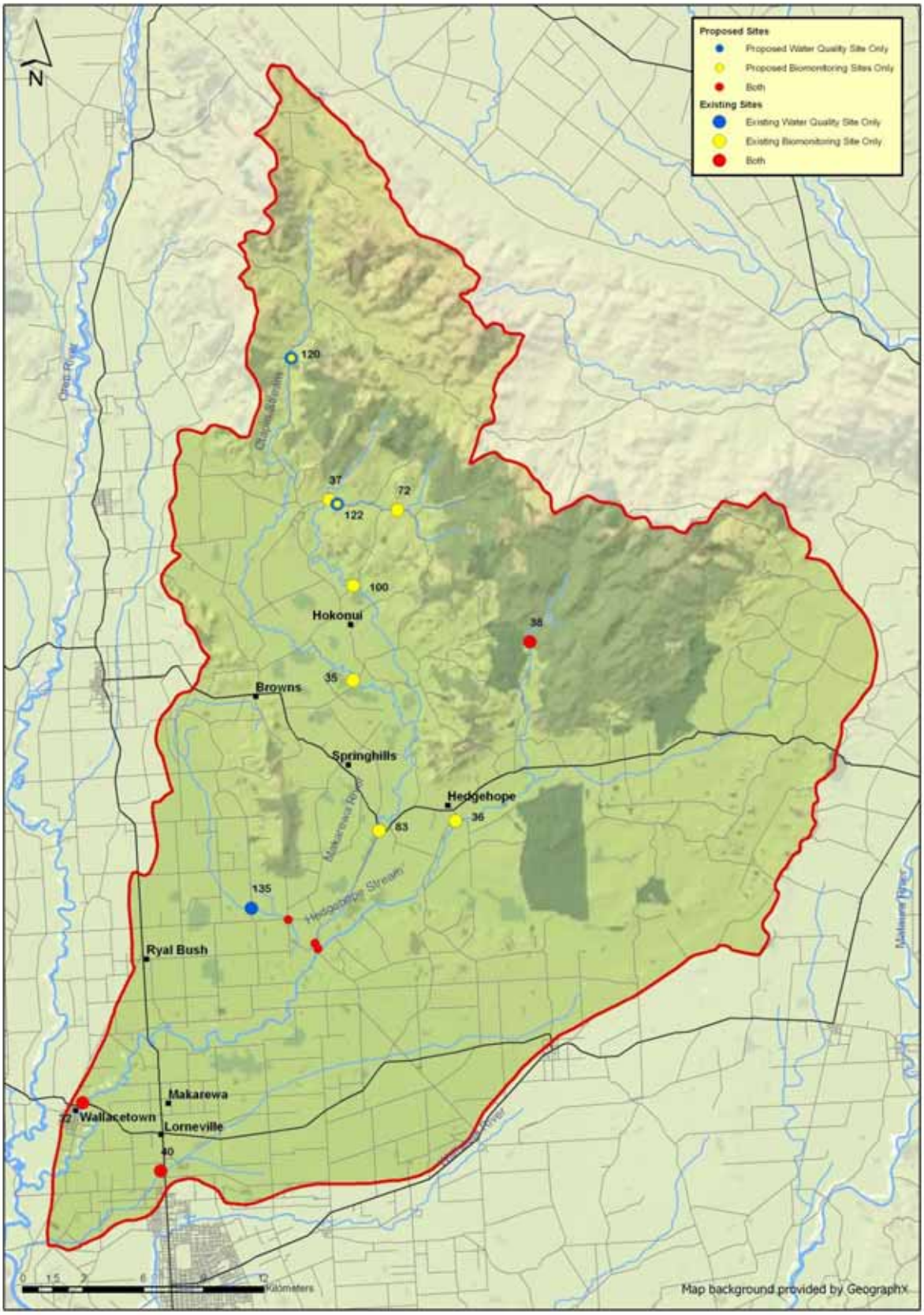
- A reference site on a tributary of the upper Makarewa River (Silver Stream, Site 37);
- Three sites on the Makarewa River: King Rd (site 100), Winton-HedgeHope Highway (Site 83) and Wallacetown (Site 32);
- One site on the middle Hedgehope Stream (Block Rd, Site 36);
- One site on a tributary of the upper Makarewa River (Trenders Creek at Hall Road, Site 72);
- Biomonitoring is also undertaken at the Dunsdale Stream (Site 38), the Tussock Creek (Site 135) and the Waikiwi Stream (Site 40) water quality sites.

Comments

- Excellent coverage of reference sites;
- Insufficient water quality coverage of the middle zone, between the reference sites and the one site at the bottom of the zone (Makarewa at Wallacetown – Site 32);
- Site 135 on Tussock Creek is in the middle catchment, i.e. it dos not capture the whole of Tussock Creek catchment;
- Site on Waikiwi Stream is mid- catchment but is a long-term site and should be maintained;
- Generally, water quality and ecosystems sites are not well aligned, and, wherever possible, some realignment is advisable (e.g. Site 122 (water quality) and site 100 (biomonitoring) on the upper Makarewa).

Recommendations

- Improve the water quality coverage of the middle zone. In particular, the following additions are recommended:
  - one site near the bottom of the Hedgehope Stream catchment, between the Titipua Stream and the confluence with the Makarewa River. The exact location needs to be determined by field investigation. A tentative location is Hedgehope Stream above Makarewa (E/N: 2,159,550/5,428,300)
  - one site on the Makarewa River above the Hedgehope Stream confluence. A possible location is Makarewa above Hedgehope (E/N: 2159400/5428600).
- Shift the Tussock Creek site to lower down the catchment. A possible location, subject to field investigation, is Tussock Creek at Horton Road (2,158,060/5,429,770);
- Shift all three reference sites to rolling frequency;
- Regroup upper Makarewa water quality and biomonitoring sites at Lora Gorge Rd;
- Shift the Makarewa at Winton-Hedgehope Highway biomonitoring site (Site 83) to the new water quality site Makarewa above Hedgehope;
- Shift the Hedgehope Stream at Block Rd biomonitoring site (Site 36) to the new water quality site Makarewa above Hedgehope;
- Undertake biomonitoring at the upper Otapiri Stream site (Site 120).



Map 9: Current and recommended monitoring sites in the Makarewa Surface Water Resource Zone.

4.5. Waimatuku Zone

Notes

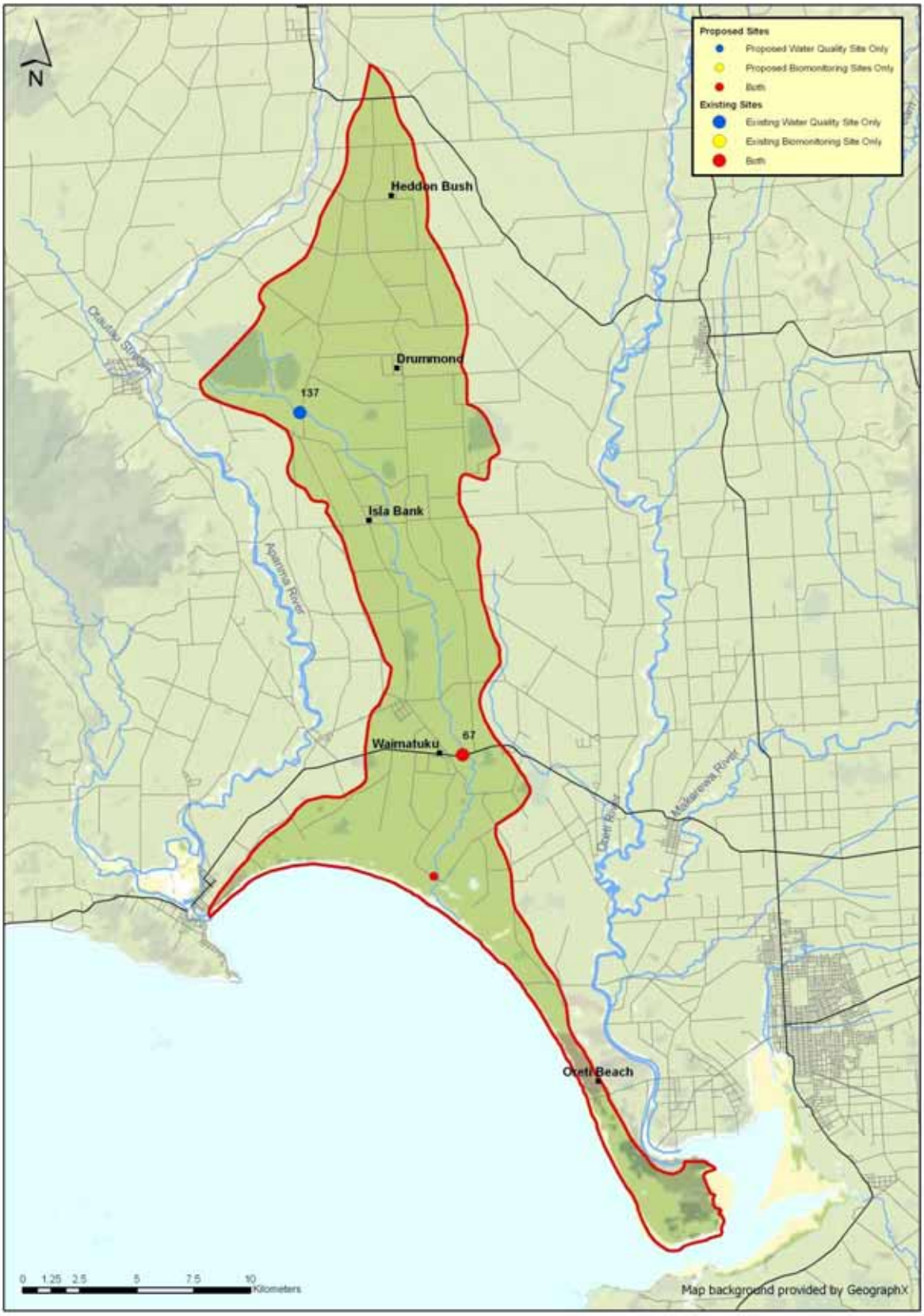
- The Waimatuku Zone covers the entire Waimatuku Stream catchment;
- Takes its source in a large wetland area East of Otautau, the Bayswater peat Bog;
- Base flow sustained by a number of springs in the middle catchment;
- Landuse in most of the catchment used to be mostly cereal cropping;
- Booming dairy conversion in the last 8 years. Current cow number around 45,000;
- Good brown trout fishery and spawning values, good whitebait fishery in the lagoon;
- Hard bottom stream in spite of swampy surroundings;
- High habitat values in lagoon/estuary, but high faecal coliforms and nuisance algae (*Gracilaria*, *Enteromorpha* and *Ulva*);
- No flow record in the catchment;
- The current monitoring network comprises two water quality monitoring sites, one immediately below the swamp (Site 137), and the other about two thirds down the catchment, at Waimatuku (Site 67). Biomonitoring is also undertaken at the latter site.

Comments

- Site 67 has one of the most degraded water of the whole region. This site is only two thirds down the catchment and does not capture the whole catchment.

Recommendations

- Site 137 is useful as a "reference" site for the catchment and should be maintained, but could be shifted to rolling frequency;
- It is suggested that site 67 could be shifted downstream, to capture more of the catchment. There are a number of road access points to the lower Waimatuku Stream, such as SH99 (2,138,050/5,423,350), Mountain View (2,138,200/5,421,600) or Waimatuku South Road (2,136,780/5,418,000). The exact monitoring location should be determined by field investigation;
- If possible, establish an actual or virtual (by correlation) flow record for this site;
- Total nitrogen and phosphorus should be monitored at the downstream site, in relation to macroalagae growth in the estuary, as well as *Enterococci* in relation to contact recreation in coastal waters.



Map 10: Current and recommended monitoring sites in the Waimatuku Surface Water Resource Zone.

4.6. Te Anau/Manapouri Zone

Notes

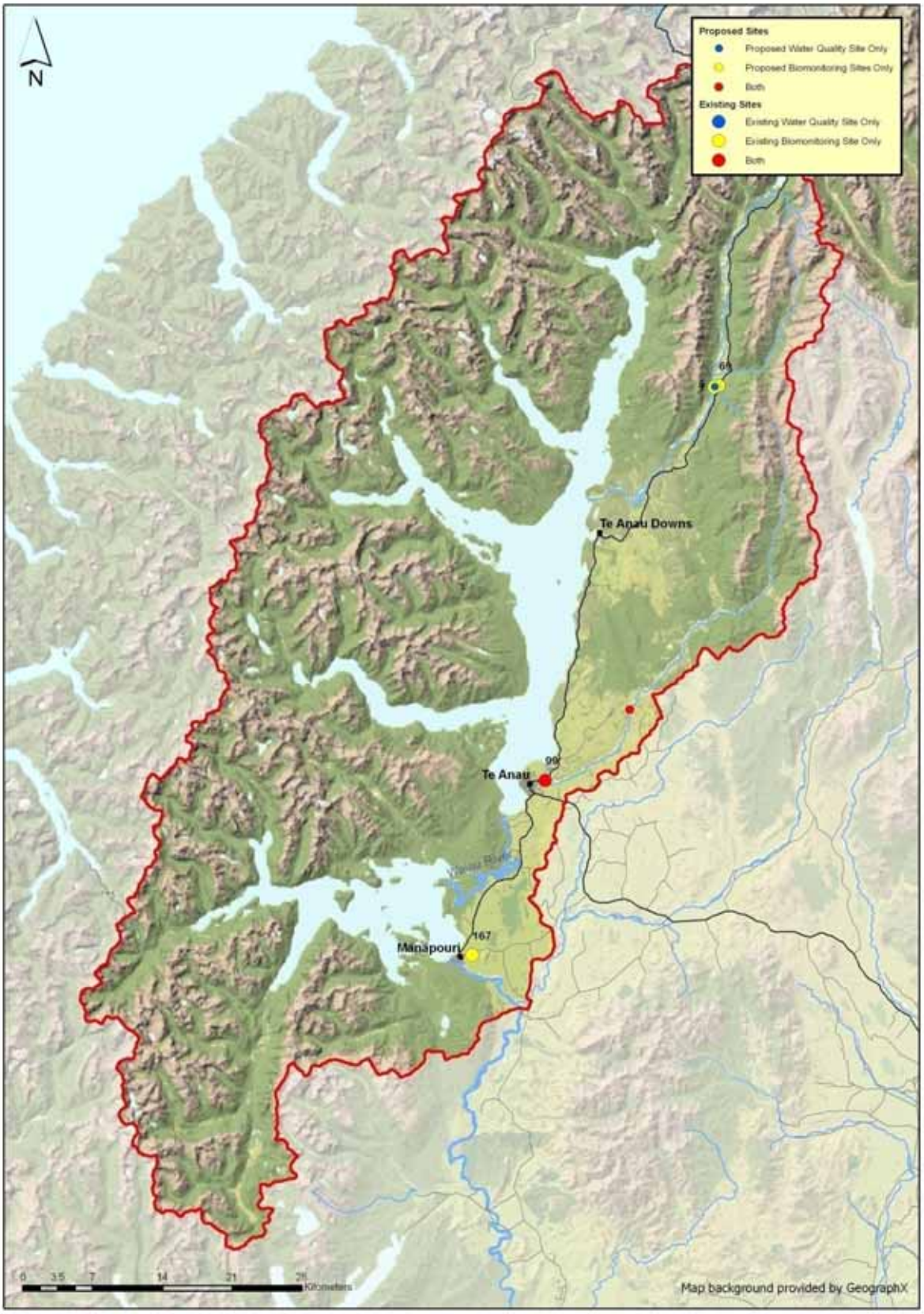
- All water allocation in this zone is locked up for hydro electricity generation, which precludes any irrigation-based agricultural development;
- The Eglington and Upukerora Rivers are excellent trout fisheries
- A lot of deer farming on Te Anau flats;
- Currently, there is only one water quality monitoring site in this zone, on the Upukerora at Te Anau. Biomonitoring at this site indicates abundant periphyton growth;
- Biomonitoring is also undertaken on the Eglington River at McKay Creek confluence (Site 5) and at Home Creek at Manapouri (Site 167).

Comments

- Generally speaking, Natural State and Mountain sites are under-represented in the current water quality monitoring network.
- Home Creek is classified as Spring Fed;
- There are no reference water quality sites in this zone

Recommendations

- Undertake water quality monitoring at the Eglington River biomonitoring site. This site can be used as a reference site for the zone and is classified Natural State;
- Add one site on the Upukerora River above the Te Anau Flats, to provide a reference site for the Upukerora River. Monitoring at this site may assist in understanding the influence of farming on the Te Anau flats (particularly deer farming) on the Upukerora River's water quality. Access may be problematic, but may be possible at the end of Sinclair Rd (Approx. 2,107,000/5,527,000) or via Dale Rd (2,107,200/5,527,300). The exact monitoring site location should be determined by field investigation.



Map 11: Current and recommended monitoring sites in the Te Ananu/Manapuri Surface Water Resource Zone.

4.7. Mararoa Zone

Notes

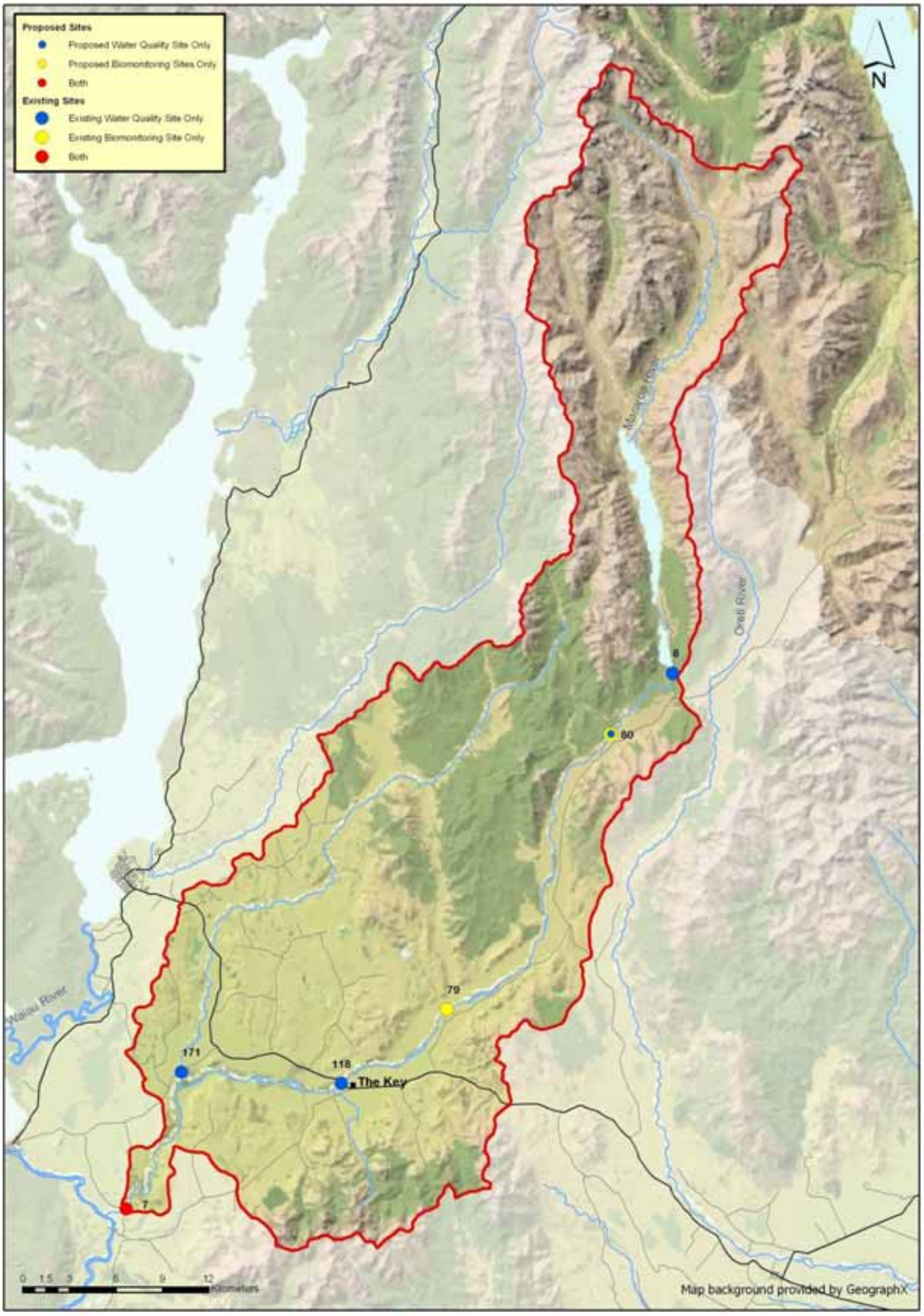
- The upper two thirds of the catchment are in native vegetation;
- Excellent rainbow trout fishery;
- The Mararoa River flow is diverted to Lake Manapouri (instead of flowing into the Waiau River), except during flood flows;
- River flow is monitored by NIWA at the bottom of the zone (at Weir Rd);
- Water quality monitoring on mainstem at South Mavora lake (Site 8), about three quarters down the catchment (the Keys, site 118) and at the bottom of the catchment Weir Rd (site 7);
- The main tributary is the Whitestone River, monitored for water quality upstream of its confluence with the Mararoa River. No flow data is available for this tributary and a virtual flow record cannot be developed by correlation with Mararoa at Weir Rd due to groundwater influence;
- Biomonitoring of the Mararoa River is undertaken at Kiwiburn (Site 80), several kilometres downstream of the South Mavora lake water quality site (Site 8), and upstream of The Keys (Mararoa at Road Bridge, Site 79).

Comments

- The current monitoring network offers good coverage of both the Mararoa mainstem and its main tributary (Whitestone River);
- The upper Mararoa River biomonitoring and water quality sites are distinct;

Recommendations

- In accordance with the general recommendations in section 3.3, it is recommended to, as much as possible, regroup water quality and ecosystems monitoring sites. It is recommended to shift the water quality monitoring in the upper Mararaoa from South Mavora Lake (Site 8) to Kiwi Burn (Site 80);
- Consideration was given to shifting the mid-catchment biomonitoring site (Site 79) to the water quality site (The Keys, Site 118). However, very fast flowing water at the Keys may make biomonitoring at this site hazardous, and the Road bridge site (Site 79) should be maintained for biomonitoring.
- It is recommended to shift the Whitestone River site (Site 171, Whitestone River d/s Manapouri Hillside) to rolling frequency.



Map 12: Current and recommended monitoring sites in the Mararoa Surface Water Resource Zone.

4.8. Waiau Zone

Notes

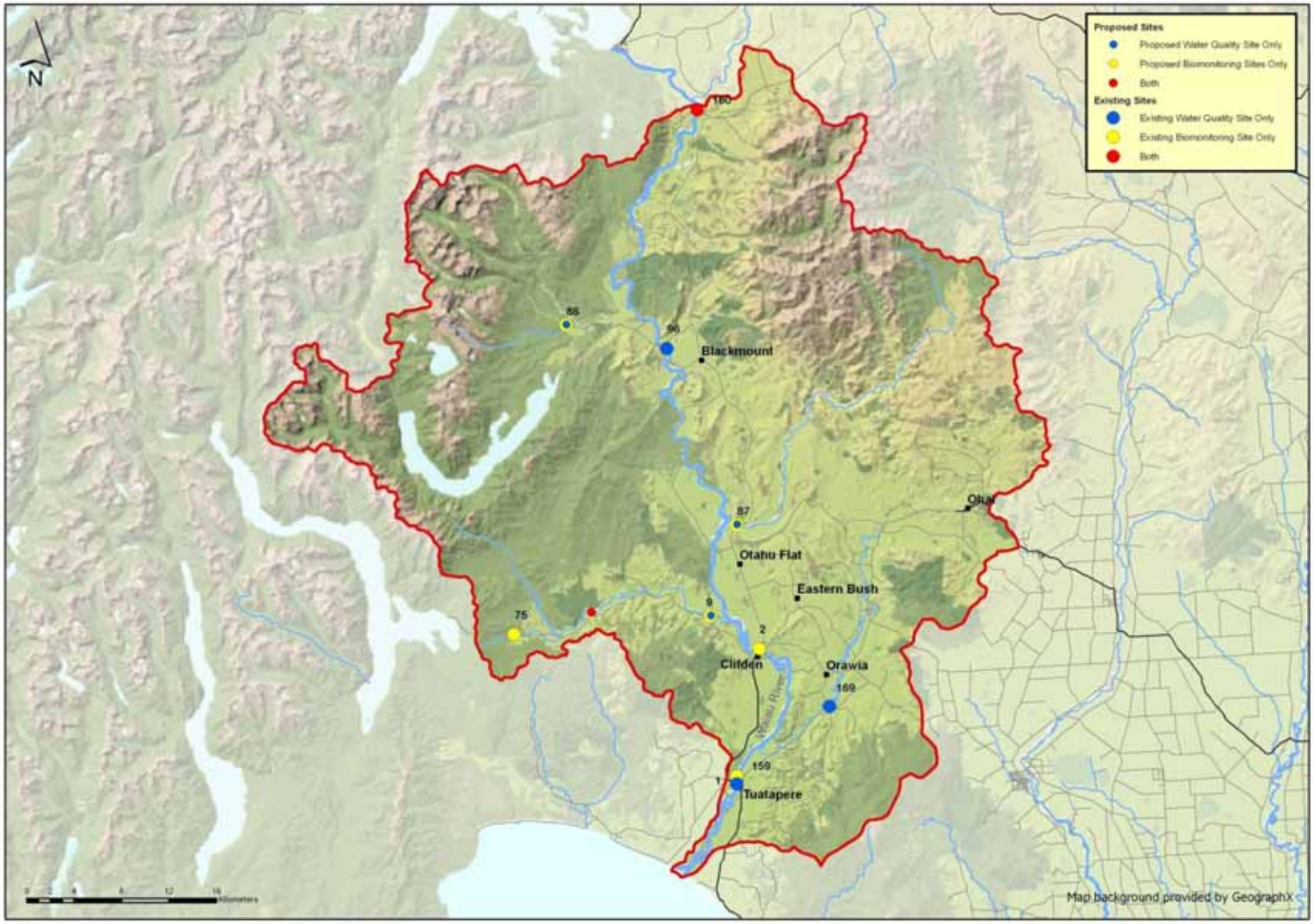
- All water allocation is locked up for hydro electricity generation, which precludes any irrigation-based agricultural development;
- Some dairying in the flats between the Waikari River confluence and Tuatapere;
- The Waiau River mainstem is currently monitored at the top of the zone (at Duncraigen Rd, Site 160), at Sunnyside (site 96) and just above Tuatapere (Site 1);
- Of the side tributaries, only the Orauea River is monitored at Orawia-Pukemaori Rd (site 169);
- Site 169 will also become a flow monitoring site;
- Other main tributaries such as Pig Creek, Waikari River and Lill Burn only have biomonitoring sites;
- Based on biomonitoring results and observations, Lill Burn appears to have good water quality and habitat in its upper reaches, but quite degraded in it lower catchment, primarily due to beef stud farming with poor farming practices In particular, free stock access to waterways appears to be causing significant bank/bed erosion and sediment release.

Comments

- The current coverage of the Waiau River mainstem appears acceptable. Although it is not right at the bottom of the catchment, the Tuatapere site (Site 1) captures most of the catchment. It is also a long-term site, and it is recommended to maintain it;
- Water quality monitoring of Lill Burn would be useful to ascertain the suspected effects of farming practices. Monitoring should be undertaken upstream and downstream of the area of concern.;
- The Waikari River drains a significant area of farmland, but has no water quality monitoring;
- There is currently no water quality reference site for the zone.

Recommendations

- Although water quality and biological monitoring at the Waiau River at Tuatapere are unly undertaken approximately 400m apart, two distinct sites have been identified in the database (Site 1 for water quality and Site 159 for ecosystems monitoring). There are no tributaries joining the Waiau River, or activities that may have a significant impact on water quality between these two sites. For clarity and consistency of reporting, it is suggested that only one site name and number could be used, with the site access details kept as part of internal procedures;
- Add two water quality monitoring sites on Lill Burn. One site should be located at the bottom of the catchment, and one immediately upstream of the area of concern. It is recommended to undertake three years of monitoring, and assess the results after this period of time. The monitoring frequency can then be re-evaluated;
- The downstream site location could be Lill Burn at Lill Burn – Monowai Rd (2,097,200/5,453,900). Access to upstream site may be problematic. A possible site could be on Hindley Rd (2,087,140/5,454,200), although field investigations should be carried out to confirm site accessibility and suitability (i.e. confirm that it is upstream of the area of concern).
- If the above site cannot be positively confirmed, other options may need to be investigated. There may be another access to Lill Burn (2,084,000/5,452,500). One other option would be to use the biomonitoring site on Thicket Burn (at Lill Burn Valley Rd – 2080600/5452300) as reference for Lill Burn;
- Add water quality monitoring (rolling frequency) at the biomonitoring site on the lower Wairaki River (Site 87), to provide some background information on water quality in this major tributary;
- Add water quality monitoring at the biomonitoring site on Pig Creek (Site 86), to provide a reference site (Natural State class) for this zone.



Map 13: Current and recommended monitoring sites in the Waiau Surface Water Resource Zone.

4.9. Coastal Catlins Zone

Notes

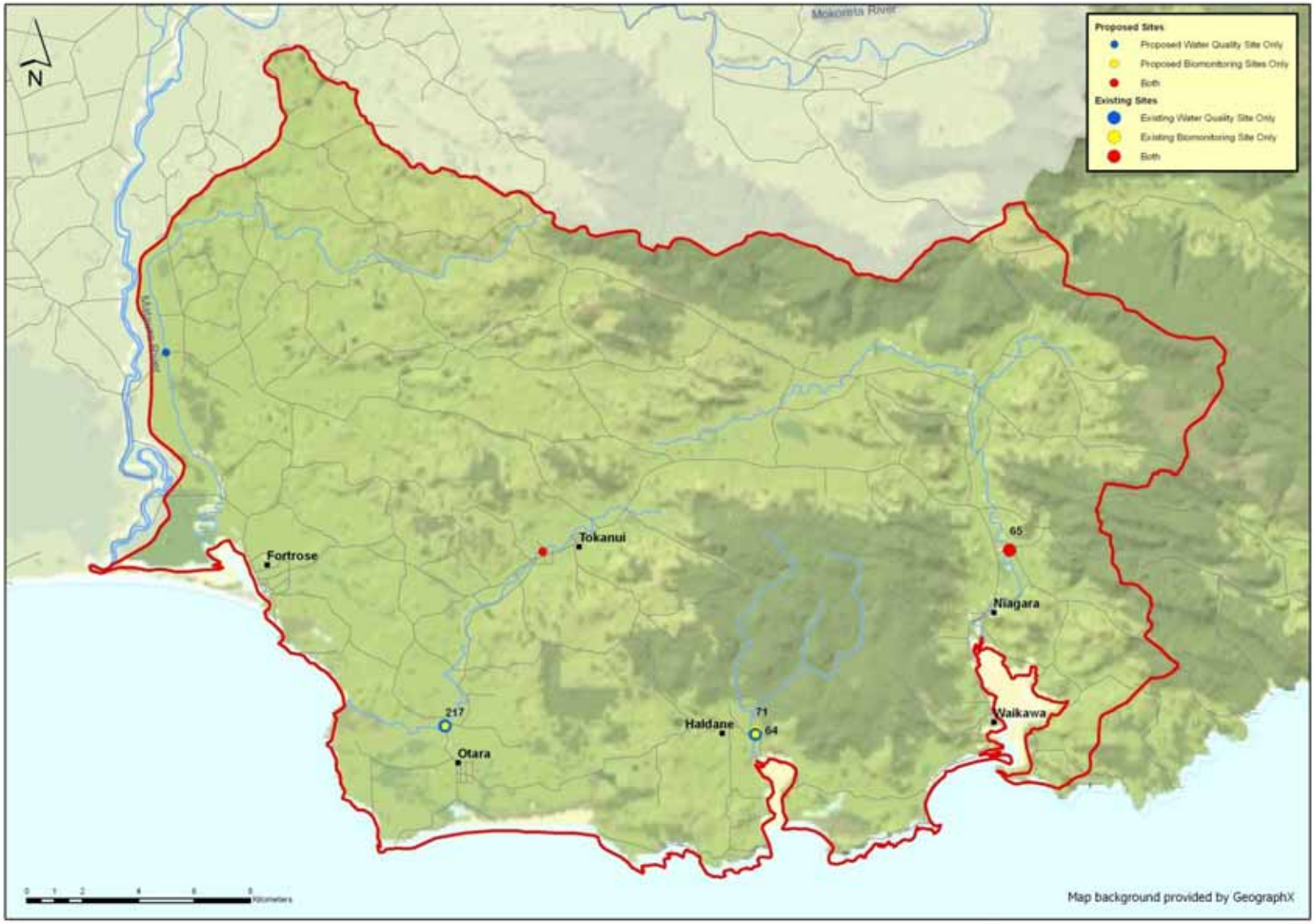
- The Coastal Catlins Zone covers a number of coastal catchments including (from West to East) the Titiroa Stream, the Tokanui River, the Waikopikopiko Stream and the Waikawa River;
- The flow site on the Waikawa River at Biggar Rd (near the water quality site at Progress Valley-Site 65) provides good flow correlation to all other waterways in the zone;
- Some dairy conversions are occurring west of the Tokanui River;
- The Titiroa Stream flows into Toetoes Harbour, a shared estuary with the Mataura River. Titiroa Stream is an important whitebait fishery. Toetoes Harbour is part of the Lower Mataura Zone;
- There are a number of coastal lakes in the zone. There could be some value in monitoring water quality in tributaries flowing into these lakes, but this should be undertaken as part of the lakes water quality monitoring programme;
- Monitoring in the Waikawa Estuary has indicated a significant sedimentation issue, with most sediment likely coming from the hills in the upper catchment;
- The Waikawa River is also a significant lamprey fishery;
- The current water quality monitoring network comprises three sites, on the lower Waikawa River (Site 65), the Waikopikopiko Stream (Site 64 – a reference site) and the Tokanui River (Site 217).

Comments

- The current monitoring network provides a reasonably good coverage of the zone, although there are no sites on the Titiroa Stream, and no sites in the upper Waikawa and Tokanui Rivers, to compare with the lower catchment impacted sites;
- The Waikopikopiko Stream site (at Haldane Curio Bay, Site 64) provides a good reference site for the zone, and for coastal lowland soft bed streams in general;
- The water quality and flow monitoring sites on the Waikawa River are a few kilometres apart. There could be some benefit in regrouping them;
- Site 217 on the Tokanui River is the most downstream access to the River, and a good site to assess the effects of intensive dairying on this river, and should be maintained.

Recommendations

- Some consideration was given to shifting the Waikawa river water quality/biomonitoring site at Progress Valley Rd (Site 65) to the flow monitoring site at Biggar Rd. However, there is good flow correlation with Biggar Rd, and shifting the site would mean interrupting a reasonably long-term water quality data record. On balance, it is recommended to maintain the water quality/flow monitoring site at Progress valley Rd;
- Undertake continuous turbidity monitoring at Biggar Road, to link the sedimentation issue in the Waikawa Estuary to sediment loads transported by the River. In time, there may be a need for a sediment monitoring programme in the Waikawa catchment, to identify subcatchments with accelerated erosion, and prioritise areas for specific land management/erosion control programme;
- Add a monitoring site (rolling frequency) on the Tokanui River, upstream of the area of intensive dairying. A possible site location, subject to field investigation is downstream of Tokanui (2,197,700/5,396,750);
- Add a rolling site on Titiroa Stream. A possible access point upstream of the zone influenced by tides is Fleming Rd (2,184,200/5,403,850);
- Shift Site 64 (Waikopikopiko Stream at Haldane Curio Bay) to rolling monitoring frequency, and regroup the water quality and biomonitoring sites;
- Undertake TN/TP monitoring at Waikawa, Waikopikopiko and Titiroa sites (all three flow in enclosed harbours, with the Waikopikopiko providing reference data).



Map 14: Current and recommended monitoring sites in the Coastal Catlins Surface Water Resource Zone.

4.10. Waihopai Zone

Notes

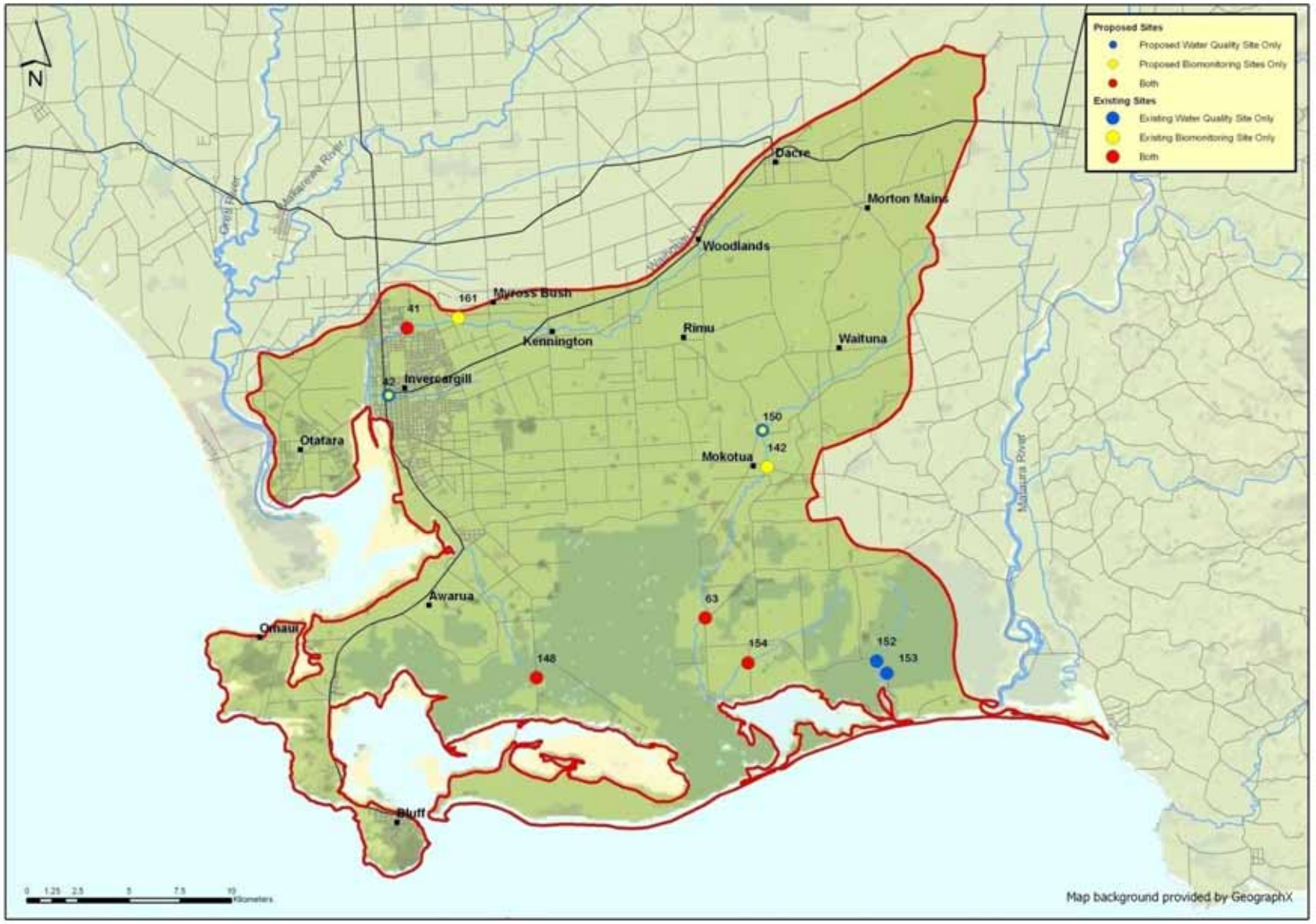
- The Waihopai water resource zone covers the entire Waihopai River catchment, as well as the coastal catchments feeding into the New River Estuary, Bluff Harbour and the Waituna Lagoon;
- Most of the Waihopai catchment drains intensively farmed land. The Waihopai River also receives stormwater discharges from Invercargill and a mixture of small point source discharges (meatworks effluent, timber treatment plant, treated sewage and a number of commercial discharges);
- Significant environmental issues have been identified in the New River Estuary, with the Waihopai River thought to be a significant source of contaminants;
- Environment Southland runs a "Living Streams" programme on parts of the Waihopai catchment, which involves intensive water quality studies, and targeted riparian and nutrient management programme, with the involvement of the community;
- There may be new industrial development in the future along SH1 between Invercargill and Bluff – along the Southern edge of New River Estuary;
- A large area of the Zone is unmodified wetland areas on conservation land (including the Waituna Wetlands). The Waituna Lagoon is identified as an internationally significant wetland, under the Ramsar convention;
- Another Living Streams programme is being implemented on a tributary of the Waituna Creek, Moffat Creek;
- There are eight SoE water quality monitoring sites in the zone (excluding the Living Streams sites);
- Site 148 on Mokotua Creek is immediately downstream of DoC land and is a reference site for wetland-fed creeks in the area;
- Sites 152 (Currans Creek) and 153 (Currans Creek tributary) can also be considered reference sites.

Comments

- The current network offers a good coverage of the zone with 8 sites, including 3 reference sites. The Living Streams programmes also ensure there is abundant water quality information in the zone;
- There are two monitoring sites in the Currens Creek catchment;
- The monitoring sites on the Waihopai River and Otepuni Creek seem appropriately placed at the bottom of the catchments, given that the living streams programme provides detailed water quality information on the upper parts of the catchments.

Recommendations

- Discontinue monitoring at Site 153 (Currans Creek Tributary), as it appears to be duplicating information obtained at Site 152 (on Currans Creek);
- Shift the remaining two reference sites (152 and 148) to rolling monitoring frequency;
- Undertake TN/TP and *Enterococci* monitoring at all sites that flow into enclosed harbours, in relation to eutrophication (algae) and recreational quality of coastal waters.



Map 15: Current and recommended monitoring sites in the Waihopai Surface Water Resource Zone.

4.11. Fiordland Zone

Notes:

- This Zone covers all of Fiordland national Park except the Te Anau/Manapouri and Waiau catchment, and is the largest in the Southland Region.
- Most waterbodies in this Zone are classified as Natural State under the Proposed freshwater Plan;
- There are currently no water quality or flow monitoring site in this zone;
- Biomonitoring is undertaken at one site near Tuatapere on a small coastal Creek (Rowallan Burn). However, this is not an ideal water quality site as its catchment has been logged in the past, and is not representative of the zone (not classed as Natural State).

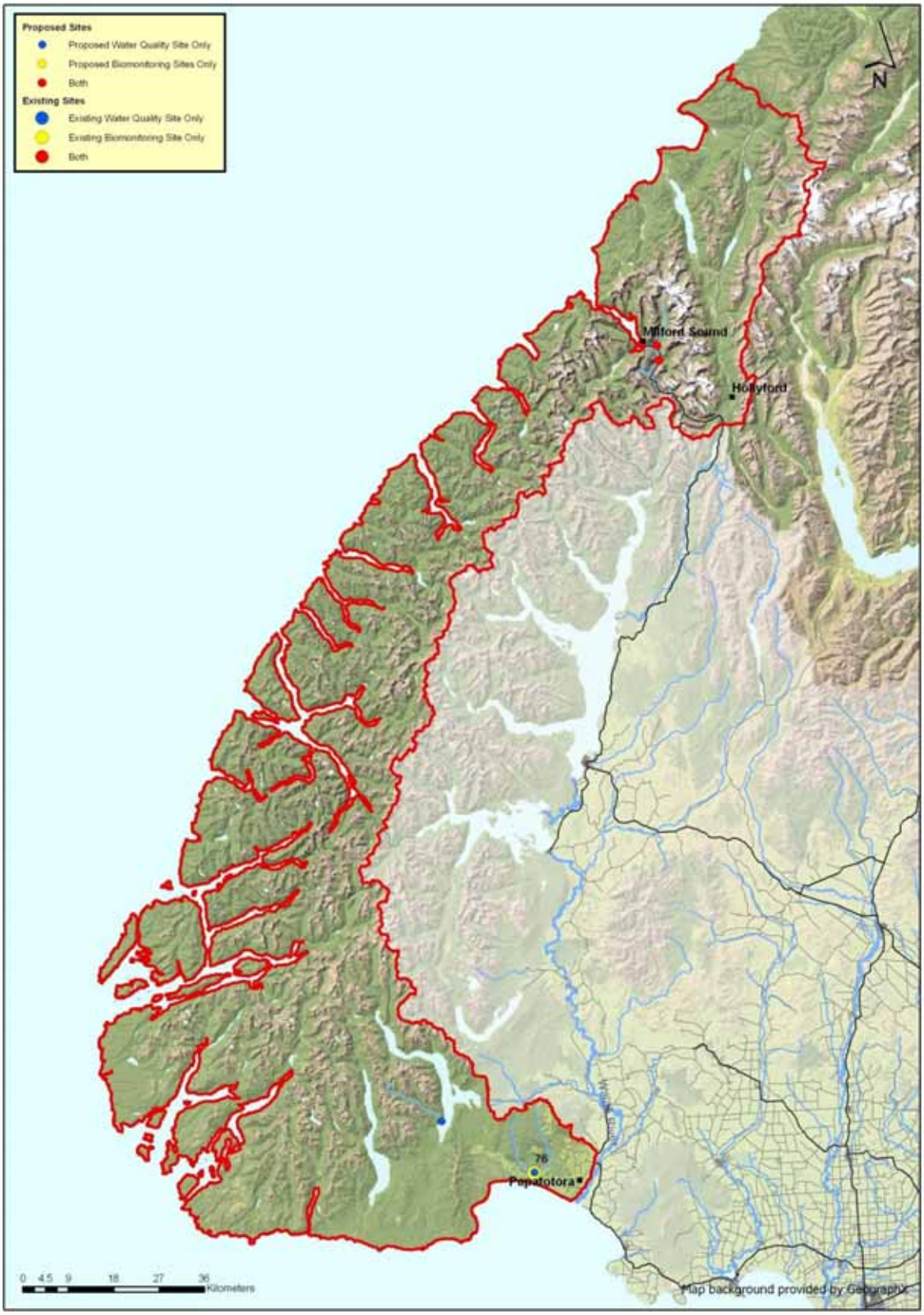
Comments:

- It would be useful to gain some knowledge of the water quality in the zone, primarily as Natural State /reference data;
- The small number of access point and the long travelling distances to them are obvious obstacles to a full scale, regular monitoring programme in this Zone;
- Monitoring frequency is not particularly critical as these systems are unlikely to be under significant development pressure now or in the foreseeable future. Sampling could be done yearly during biological monitoring, or more often if alternative arrangements can be made.

Recommendations

Different possibilities have been identified for inclusion in the water quality monitoring programme:

- Tributaries of Lake Hauroko: Lake Hauroko is likely to be monitored as part of Environemnt Southland's lakes water quality monitoring programme. When lake water samples are taken – by boat-, samples could be taken in tributaries, such as Caroline Burn. Sampling frequency would have to follow the Lakes sampling programme (i.e. likely quarterly);
- Milford Sound: due to the presence of a rain gauge at Milford Sound, Environment Southland staff regularly travel to Milford Sound. Biomonitoring is also undertaken once per year on the Eglington River (this site is in the Te Anau/Manapouri Zone, but is on the road to Milford Sound). Samples of the Cleddau and Tutoko Rivers could be taken on these occasions;
- It is also recommended that water quality monitoring be undertaken at the Rowallan Burn site once per year during the ecosystems monitoring.



Map 16: Current and recommended monitoring sites in the Fiordland Surface Water Resource Zone.

4.12. Stewart Island Zone

Notes

- The zone covers the Whole of Stewart Island/Rakiura;
- Most of Stewart Island is a National Park (Rakiura National Park);
- Three main catchments (Freshwater, Rakeahua and Lords Rivers) and a multitude of smaller coastal catchments. The vast majority of Stewart Island's catchments are essentially unmodified and covered in primary native forest;
- Most streams and rivers are classified Natural State under the proposed Regional Plan, with the exception of areas where historical logging has taken place, around Halfmoon Bay, Port Adventure and Toitoi Flat. These areas are classified Lowland Hard Bed;
- There is currently no freshwater water quality monitoring taking place, but there is one biomonitoring site on Mill Creek, and two coastal contact recreation sites in Halfmoon Bay.

Comments

- Some water quality monitoring would be useful to provide some background information on the water quality characteristics of this unique environment;
- Most of the zone is in natural state, and, to ensure representativeness, any monitoring site should be within this class;
- Mill Creek (biomonitoring site) has reasonably easy access, but is not classified as natural state, and has some logging and small scale farming in its catchment.

Recommendations

- To provide some representative water quality data, monitoring should ideally be undertaken in one of the main rivers (Freshwater, Rakeahua or Lords River) above the zone of tidal influence and one smaller coastal stream such as one of the small streams flowing in Mason Bay;
- Access (and cost) are the two main constraints to establishing a water quality monitoring programme on Stewart Island;
- Monitoring frequency is not particularly critical as these systems are unlikely to be under significant development pressure now or in the foreseeable future. Sampling could be done yearly during biological monitoring, or more often if arrangements can be made with staff from another organisation;
- The recommended approach is to undertake ecosystems and water quality monitoring once per year every three years at three sites, Mill Creek, one site on a main river and one site on a small coastal stream.

Map 17: Current monitoring sites in the Stewart Island Surface Water Resource Zone.

5. Conclusions

5.1. Number of sites

The current water quality monitoring programme comprises 68 water quality sites, monitored monthly, and 76 ecosystems sites, monitored annually. The main constraint placed on this review was to maintain an equivalent level of monitoring effort and associated costs.

The main recommended programme includes 94 water quality and 104 ecosystems sites. However, under the recommended monitoring regime, not all sites are monitored every year. As indicated in Table 3, the number of sites monitored every year, which directly defines the level of monitoring effort, remains unchanged.

The only recommended addition to the water quality monitoring programme is the taking of water quality samples at seven sites in the Fiordland and Stewart Island zones. Under the recommended regime, these samples would be taken on occasions when Environment Southland staff are already on site (e.g. for ecosystems, or lake water quality monitoring), and the additional cost for the water quality monitoring *per se.* would only correspond to a small amount of staff time and laboratory costs.

5.2. Representativeness and coverage

5.2.1. Proposed Freshwater Plan classes

The Proposed freshwater Plan defines 10 classes of rivers and streams. The "Mataura 1" class is very small in size, and only covers a short reach of the Mataura River upstream of Gore. Monitoring Site 85, Mataura at Gore, is located only a few hundred metres downstream of the "Mataura 1" class and can be considered as representative of this class. This site is considered a "core" site, and both monthly water quality and annual ecosystems monitoring are recommended on a permanent basis.

Similarly, the Mataura 2 class covers only two short reaches of the Mataura River near the Mataura and Otamita townships. This class is covered in both the current and recommended water quality monitoring programmes by Site 46, Mataura River at Otamita Bridge. However, ecosystems monitoring had to be discontinued at this site in 2008 due to safety concerns.

One class (Mountain) is not currently monitored for water quality, and two other classes (Natural State and Spring Fed) are under-represented in the water quality monitoring programme (only one site in each class). By contrast, these three classes are reasonably well represented in the Ecosystems monitoring programme. In effect, the current water quality monitoring programme covers 9 of the 10 Proposed Plan classes (Table 4).

The recommended programme ensures that all Proposed Freshwater Plan classes are represented in both the water quality and the ecosystems monitoring programmes, and that at least one reference site is monitored in each class (Table 4).

Table 6 provides a summary of the land area covered by each Proposed Freshwater Plan class, and the proportion of monitoring sites (relative to the total number of monitoring sites in the network) in each class. It clearly indicates that a large proportion of the Southland Region (54 %) is classified as Natural State, but only a much smaller proportion of monitoring sites (3.2 % of water quality sites and 8.5 % of biomonitoring sites) fall within this class. The other classes are comparatively over-represented in the monitoring network. This is to be expected as the remoteness of most of the areas classified as Natural State largely impedes access. The comparatively higher pressures on the water resources of other classes also justify more intense monitoring effort. This is consistent with the principles defined in Section 2.4.2 of this report. Table 7 presents the same statistics, but excluding the Natural State class. It shows a general alignment between the percentage of land area covered by each Freshwater Plan Class and the proportion of monitoring sites in each class.

Table 3: Summary of the number of sites monitored each year in the current and recommended monitoring programme.

	Water quality monitoring		Ecosystems monitoring	
	Current	Recommended	Current	recommended
Total number of sites	68	94	76	106
Sites monitored every year (core sites)	68	53	76	59
Sites monitored every year for the first 3 years	0	2	0	2
Sites monitored every 3 years(rolling sites)	0	39	0	45
Sites monitored each year (Monitoring effort)	68	68	76	76

Table 4: Summary of monitoring sites number in each Proposed Freshwater Plan class, under the current and recommended monitoring programmes. Site numbers are total number of sites and number of reference sites.

Proposed Freshwater Plan Class	Water Quality				Biomonitoring			
	Existing		Recommended		Existing		Recommended	
	Total	Reference	Total	Reference	Total	Reference	Total	Reference
Natural State	1	1	8[a]	8[a]	5	5	7	7
Lowland Soft Bed	14	2	22[b]	5	18	2	22	4
Lowland Hard Bed	19	5	23[c]	8	20	3	26	4
Hill	10	3	14	4	12	4	16	6
Mountain	0	0	1	1	1	1	1	1
Lake Fed	4	1	4	1	5	2	4	1
Spring fed	1	1	4	2	3	1	3	1
Mataura 1	1[d]	1[d]	1[d]	1[d]	1[d]	1[d]	1[d]	1[d]
Mataura 2	1	1	1	1	0	0	0	0
Mataura 3	19	3	23	3	10	1	19	3

[a] Includes 5 sites in Fiordland or Stewart Island, where annual or quarterly water quality sampling is recommended.
[b] Includes one site in Fiordland, where annual water quality monitoring is recommended.
[c] Includes one site in Stewart Island, where annual water quality monitoring is recommended.
[d] Site 85, Mataura River at Gore, is considered representative of this class.

Table 5: Summary of monitoring site numbers in each Surface Water Resource Zone.

Surface Water Zone	Water Quality monitoring				Ecosystems monitoring			
	Existing programme		Recommended		Existing programme		Recommended	
	Total	Reference	Total	Reference	Total	Reference	Total	Reference
Aparima	8	3	11	4	10	5	16	6
Coastal Longwoods	0	0	2	1	1	1	2	1
Upper Mataura	2	1	4	2	4	3	5	3
Mid Mataura	9	0	9	0	5	0	8	0
Waikaia	2	1	4	2	1	1	4	2
Lower Mataura	9	0	9	0	10	1	9	1
Upper Oreti	4	2	9	3	6	2	9	3
Makarewa	6	3	8	3	10	2	11	4
Lower Oreti	5	2	7	2	6	1	7	1
Waimatuku	2	1	2	1	1	0	1	0
Te Anau/Manapouri	1	0	3	2	4	3	5	4
Mararoa	4	1	4	1	4	2	3	1
Waiau	4	0	8	2	7	2	8	3
Coastal Catlins	3	1	5	1	2	1	5	1
Waihopai	8	3	7	2	6	1	7	1
Fiordland[a]	0	0	4	3	1	0	3	2
Stewart Island[a]	0	0	3	2	1	0	3	2
TOTAL	68	17	101	32	76	24	106	35

[a] Annual monitoring frequency for water quality sampling

5.2.1. Surface Water Resource Zones

Water quality monitoring

Under the current monitoring programme, water quality is monitored in 14 of the 17 surface water resource zones (Table 5).

Remoteness and/or difficult access explain the absence of regular water quality monitoring in the Fiordland and Stewart Island zones. However, access is possible, and ecosystems monitoring is currently undertaken at one site in each of these zones. The recommended approach is to take advantage of the presence of Environment Southland staff at these locations in relation to other monitoring programmes (e.g. river ecosystems monitoring, lake water quality monitoring, etc.) to collect some water quality data. Although infrequent in nature, this monitoring should allow to build, over time, some relevant water quality information on these systems. Monitoring in these zones also allows a better coverage of the "Natural State" Proposed Plan class, which is underrepresented under the current monitoring programme (Table 4).

The third zone where water quality is not currently monitored is Coastal Longwoods. Access does not appear to be a significant issue, and the recommended programme includes 2 sites in this zone, including one reference site.

The TeAnau/Manapouri zone is, by size, the second largest zone in the region, but has only one water quality monitoring site in the current monitoring programme. The absence of significant pressures on a large proportion of this zone and its inaccessibility means that a large number of monitoring sites is probably not justified, nor practicable. However, some improved coverage of both reference and impacted sites is recommended. The recommended programme includes three sites in this zone.

Of note is also the absence of reference sites in four zones (in addition to the Fiordland and Stewart Island zones, discussed above) in the current monitoring programme: Lower and Mid Mataura, Te Anau/Manapouri and Waiau. The recommended programme includes reference sites in the Te Anau/Manapouri and Waiau Zones. Due to the heavy land pressure in the Mid- and Lower Mataura zones, reference sites relevant may be difficult to find, and in any case, would only be representative of small streams. Reference sites relevant to the mid and lower Mataura River are located in the Upper Mataura and the Waikaia zones.

Ecosystems monitoring

The current ecosystems monitoring network covers all of the Proposed Plan classes, and most of the recommendations correspond to small adjustments, the addition of reference sites and a more pronounced alignment between the water quality and the ecosystems monitoring sites.

Of note however, is the case of Fiordland and Stewart Island. Under the current programme, there is only one monitoring site in each of the Fiordland and Stewart Island zones. However, both these sites are in catchments with some past or present level of development, and are not classified as "Natural State". These sites probably do not provide the best representation of these zones dominated by Natural State classification. The recommended programme includes two additional reference/natural state sites in each zone.

Table 6: Surface area of the different Proposed Freshwater Plan classes and number and proportion of existing and recommended monitoring sites in each class (water quality sites with recommended annual or quarterly monitoring are excluded).

Surface Water Zone	Surface area		Water Quality				Biomonitoring			
			Existing programme		Recommended		Existing programme		Recommended	
	Km^2	% Total	N. sites	% total	N. sites	% total	N. sites	% total	N. sites	% total
Natural State	16,691	54 %	1	1.5 %	3	3.2 %	5	6.6 %	9	8.5 %
Lowland Soft Bed	3,433	11 %	14	21%	21	22 %	18	24 %	24	23 %
Lowland Hard Bed	4,492	15 %	18	28 %	22	23 %	20	26 %	25	24 %
Hill	1,671	5.4%	10	15 %	14	15 %	12	16 %	16	15 %
Mountain	247	0.8 %	0	0 %	1	1.1 %	1	1.3 %	1	1.0 %
Lake Fed	102	0.3%	4	5.8 %	4	4.3 %	5	6.6 %	4	3.8 %
Spring fed	400	1.3 %	1	1.5 %	4	4.3 %	3	3.9 %	5	4.7 %
Mataura 1	0.4	<0.01 %	1[(a)]	1.5 %	1[(b)]	1.1 %	1[(b)]	1.3 %	1[(b)]	1.0%
Mataura 2	1.0	<0.01 %	1	1.5 %	1	1.1 %	0	0 %	0	0 %
Mataura 3	4,050	13 %	18	28 %	23	24 %	10	13 %	21	20 %

[(a)] Site 85, Mataura River at Gore, is considered representative of this class.

Table 7: Surface area of the different Proposed Freshwater Plan classes excluding Natural State and number and proportion of existing and recommended monitoring sites in each class (water quality sites with recommended annual or quarterly monitoring are excluded).

Surface Water Zone	Surface area		Water Quality				Biomonitoring			
			Existing programme		Recommended		Existing programme		Recommended	
	Km^2	% Total	N. sites	% total	N. sites	% total	N. sites	% total	N. sites	% total
Lowland Soft Bed	3,433	24 %	14	21%	21	23 %	18	25 %	22	22 %
Lowland Hard Bed	4,492	31 %	18	27 %	22	24 %	20	28 %	26	26 %
Hill	1,671	12 %	10	15 %	14	15 %	12	17 %	16	16 %
Mountain	247	0.8 %	0	0 %	1	1.1 %	1	1.4 %	1	1.0 %
Lake Fed	102	0.7%	4	6.0 %	4	4.4 %	5	7.0 %	4	4.0 %
Spring fed	400	1.3 %	1	1.5 %	4	4.4 %	3	4.2 %	3	3.0 %
Mataura 1	0.4	<0.01 %	1[(a)]	1.5 %	1[(b)]	1.1 %	1[(b)]	1.4 %	1[(b)]	1.0 %
Mataura 2	1.0	0.01 %	1	1.5 %	1	1.1 %	0	0 %	0	0 %
Mataura 3	4,050	28 %	18	27 %	23	25 %	9	13 %	19	19 %

[(a)] Site 85, Mataura River at Gore, is considered representative of this class.

5.3. Conclusion

The recommended water quality and ecosystems monitoring programme can broadly be summarised with the following points:

- Monitor the sites and at the frequency in Appendix A;
- Monitor the determinands summarised in Table 2. Details of additional, site-specific determinands can be found in Appendix A;
- As much as possible, monitor all sites within a catchment in as short a timeframe as possible (i.e. same day or within 2 days);
- Undertake continuous DO monitoring at sites where an issue is suspected. A reasonably large number of sites can be covered with a limited number of probes by shifting the probes every year, or more often. Appendix A provides a summary of sites where continuous DO monitoring is recommended within the next few years;
- Undertake continuous turbidity monitoring in catchments with a significant erosion or sediment deposition issue. Appendix A provides a summary of sites where continuous turbidity monitoring is recommended within the next few years;
- Analyse the datasets on a regular basis, to identify any significant gaps, such as water quality data collected at low river flows. Undertake targeted monitoring to address any data gaps. One likely example is the requirement to undertake some targeted low flow sampling across a catchment, to provide sufficient data for a low flow contaminant load analysis.

Overall, the recommended water quality and ecosystems monitoring programmes offer an improved representation of the different Proposed Freshwater Plan Classes and surface water resource zones in the Southland Region, as well as a better spatial resolution of the data inside each catchment. It is expected that the data collected will constitute a robust basis for the organisation's information requirements relating to water quality and aquatic ecology.

The recommended programme is based on the current planning and management framework, and the current level of knowledge of the river catchments and their state, trends, and pressures. A monitoring programme has every reason to be a live framework, and frequent changes and adjustments are justified and even advisable when the situation changes (e.g. emerging intensification in an area), or as new information, technology or budgets become available.

REFERENCES

1. **ANZECC. (2000).** Australia and New Zealand Guidelines for Fresh and Marine Water Quality. *Australian and New Zealand Environment and Conservation Council. Agriculture and Resource Management Council of Australia and New Zealand. ISBN 09578245 0 5.*
2. **Ausseil O. (2008)**. Water quality in the Tukituki catchment – State, trends and contaminant loads. *Prepared for the Hawke's Bay Regional Council by Aquanet Consulting Ltd.*
3. **Ausseil O. (2009)**. Water quality in the Ngaruroro catchment – State, trends and contaminant loads. *Prepared for the Hawke's Bay Regional Council by Aquanet Consulting Ltd.*
4. **Davies-Colley R. and Wilcock B. (2004)**. Water Quality and chemistry in running waters. *In Freshwaters of New Zealand, New Zealand Hydrological Society and New Zealand Limnological Society. ISBN 0-476-00708-9.*
5. **Hamill K. (1997).** State of the environment monitoring network – Freshwater ecology programme. *Southland Regional Council publication N. 90.*
6. **MfE (2002).** Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. *Ministry of Health and Ministry for the Environment. Updated in June 2003. MfE Number 474. ISBN 0-478-24091-0.*
7. **Scarsbrook M. R. and McBride G. B. (2007a)**. Best practice guidelines for the statistical analysis of freshwater quality data. *Prepared for the Ministry for the Environment by the National Institute for Water and Atmospheric Research (NIWA). NIWA client report: HAM2007-088.*
8. **Scarsbrook M. and McBride G. (2007b).** Effects of sampling frequency on water quality trends analysis in the hawke's bay Region. *Prepared for Hawke's Bay regional Council. NIWA Client report HAM 2007-042.*
9. **Wagenhoff A. (2008).** Field Protocol: Measuring Deposited Fine Sediment in Streams. *Prepared for Environment Southland by the University of Otago. Envirolink medium advice grant number 488-ESRC211.*
10. **Wilcock B., Biggs B., Death R., Hickey C., Larned S. and Quinn J. (2007)**. Limiting nutrients for controlling undesirable periphyton growth. *Prepared for Horizons Regional Council. NIWA Client Report HAM2007-006.*

APPENDICES

Appendix A: Summary of existing and recommended monitoring programmes

Site: Ref: Reference Site; LP: Low Pressure Site; I: Impacted Site
WQ Existing/ New: N: New water quality monitoring site; E: Existing water quality monitoring site; 0: no water quality monitoring at this site;
WQ Site Cat: P: Permanent (Core) site; R: Rolling (3-yearly) site; 0: no water quality monitoring at this site;
TN/TP: Recommended total Nitrogen and total phosphorus monitoring at sites marked with a "1";
Cont Turb: Recommended continuous turbidity monitoring at sites marked with a "1";
Cont DO: Recommended continuous dissolved oxygen monitoring at sites marked with a "1";
Cl: Recommended chloride monitoring at sites marked with a "1";
BOD: Recommended carbonaceous five-day BOD monitoring at sites marked with a "1";
ENT: Recommended total *Enterococci* monitoring at sites marked with a "1";
TOC: Recommended total organic carbon monitoring at sites marked with a "1"
Biom Existing/ New: N: New biomonitoring site; E: Existing biomonitoring site; 0: no biomonitoring at this site;
Biom Site Cat: P: Permanent (Core) site; R: Rolling (3-yearly) site; 0: no biomonitoring at this site;

Site ID	Zone	Site Name	Easting	Northing	Water Plan Quality Class	Site	WQ Existing /New	WQ Site Cat	TN/ TP	Cont Turb	Cont DO	Cl	BOD	ENT	TOC	Biom Existing /New	Biom Site Cat
TBA	Aparima	Aparima at Etalvale	TBA	TBA	Hill	I	N	P	0	0	0	0	0	0	0	N	P
19	Aparima	Hamilton Burn at Goodall Road	2132700	5488800	Hill	LP	0	0	0	0	0	0	0	0	0	E	P
11	Aparima	Aparima River at Dunrobin	2130425	5485544	Hill	LP	E	P	0	0	0	0	0	0	0	N	P
12	Aparima	Aparima River u/s Dunrobin	2124300	5484100	Hill	I	0	0	0	0	0	0	0	0	0	E	0
78	Aparima	North Ethal Stream u/s Dunrobin Valley R	2123400	5483800	Hill	Ref	0	0	0	0	0	0	0	0	0	E	P
TBA	Aparima	Hamilton Burn at Affleck Rd	2136134	5480527	Lowland Hard Bed	LP	N	R	0	0	0	0	0	0	0	N	R
20	Aparima	Taringatura Creek at Taromaunga	2133300	5473100	Hill	I	0	0	0	0	0	0	0	0	0	E	P
21	Aparima	Hillpoint Stream at Waikana Road	2135100	5462800	Lowland Hard Bed	I	0	0	0	0	0	0	0	0	0	E	P
13	Aparima	Aparima River at Wreys Bush	2131800	5452700	Lowland Hard Bed	I	0	0	0	0	0		0	0	0	E	0
143	Aparima	Otautau Stream at Waikouro	2120511	5444579	Lowland Hard Bed	I	E	P	0	0	0	0	0	0	1	N	P
22	Aparima	Otautau Stream at Otautau-Tuatapere Road	2121900	5441700	Lowland Hard Bed	I	E	0	0	0	0		0	0	0	E	0
95	Aparima	Aparima River at Otautau	2123733	5441039	Lowland Hard Bed	I	E	P	0	0	0	0	0	0	0	N	P
TBA	Aparima	Otautau Stream at Otautau	2123104	5440000	Lowland Hard Bed	I	N	P	0	0	0	0	1	0	1	N	P
73	Aparima	Pourakino River at Jubilee Hill Road	2117900	5433700	Lowland Hard Bed	I	0	0	0	0	0	0	0	0	0	E	R
18	Aparima	Pourakino River at Ermedale Road	2121200	5428900	Lowland Hard Bed	LP	E	R	0	0	0	0	0	0	0	E	R
16	Aparima	Cascade Creek at Pourakino Valley Road	2119500	5427800	Lowland Hard Bed	Ref	E	R	0	0	0	0	0	0	0	E	R
139	Aparima	Opouriki Stream at Tweedie Road	2122835	5424447	Lowland Soft Bed	I	E	R	0	0	0	0	0	0	0	N	R
14	Aparima	Aparima River at Thornbury	2131100	5424400	Lowland Hard Bed	I	E	P	1	1	0	0	0	1	0	E	P
138	Aparima	Pourakino River at Traill Road	2121484	5423196	Lowland Hard Bed	I	E	P	1	1	0	0	0	1	0	N	P
TBA	Coastal Catlins	Titiroa Stream at Fleming Rd	2184200	5403850	Lowland Soft Bed	I	N	R	1	0	0	0	0	1	0	N	R
65	Coastal Catlins	Waikawa River at Progress Valley	2214400	5396800	Lowland Soft Bed	I	E	P	1	1	0	0	0	1	0	E	P

Site ID	Zone	Site Name	Easting	Northing	Water Plan Quality Class	Site	WQ Existing /New	WQ Site Cat	TN/ TP	Cont Turb	Cont DO	Cl	BOD	ENT	TOC	Biom Existing /New	Biom Site Cat
TBA	Coastal Catlins	Tokanui River d/s Tokanui	2197700	5396750	Lowland Soft Bed	I	N	R	0	0	0	0	0	1	0	N	R
217	Coastal Catlins	Tokanui River at Fortrose Otara Road	2194200	5390500	Lowland Soft Bed	I	E	P	0	0	0	0	0	1	0	N	P
71	Coastal Catlins	Waikopikopiko Stream at Haldane	2205300	5390300	Lowland Soft Bed	Ref	0	0	0	0	0	0	0	0	0	E	0
64	Coastal Catlins	Waikopikopiko Stream at Haldane Curio Bay	2205300	5390200	Lowland Soft Bed	Ref	E	R	1	0	0	0	0	1	0	N	R
66	Coastal Longwoods	Waimeamea River at Young Rd	2104500	5425800	Lowland Hard Bed	LP	N	R	0	0	0	0	0	1	0	E	R
TBA	Coastal Longwoods	Kenny Creek at SH99	2104700	5421440	Lowland Hard Bed	I	N	R	0	0	0	0	0	1	0	N	R
TBA	Fiordland	Tutoko River above confluence	2110900	5602300	Natural State	Ref	N	Q	1	0	0	0	0	0	0	N	R
TBA	Fiordland	Cleddau River at Suspension Bridge	2111400	5599300	Natural State	Ref	N	Q	1	0	0	0	0	0	0	N	R
TBA	Fiordland	Carolin Burn above Lake	2068200	5448200	Natural State	Ref	N	Q	1	0	0	0	0	0	0	0	0
76	Fiordland	Rowallan Burn East at Rowallan Road	2086644	5438005	Lowland Soft Bed	LP	N	A	0	0	0	0	0	0	0	E	R
85	Lower Mataura	Mataura River at Gore	2196700	5448700	Mataura 3	I	E	P	0	0	1	1	1	0	0	E	P
53	Lower Mataura	Waikaka Stream at Gore	2197115	5447913	Lowland Soft Bed	I	E	P	0	0	0	0	0	0	1	E	P
45	Lower Mataura	Mataura River 200m d/s Mataura Bridge	2190634	5437518	Mataura 3	I	E	P	0	0	1	0	1	0	0	E	P
77	Lower Mataura	Mimihau Stream South at Venlaw Forest	2207600	5426200	Mataura 3	I	0	0	0	0	0	0	0	0	0	0	0
57	Lower Mataura	Mimihau Stream Tributary at Venlaw Forest	2208200	5425800	Mataura 3	I	E	P	0	0	0	0	0	0	0	E	P
56	Lower Mataura	Mimihau Stream at Mimihau School Road	2191400	5424400	Mataura 3	I	0	0	0	0	0	0	0	0	0	E	0
117	Lower Mataura	Mimihau Stream at Wyndham	2191100	5423800	Mataura 3	I	E	P	0	0	0	0	0	0	0	N	P
55	Lower Mataura	Mokoreta River at Egremont Road	2213700	5420300	Mataura 3	LP	0	0	0	0	0	0	0	0	0	E	R
54	Lower Mataura	Mokoreta River at Wyndham River Road	2189600	5419400	Mataura 3	I	E	P	0	0	0	0	0	0	0	E	P
84	Lower Mataura	Oteramika Stream at Seaward Downs	2183700	5416600	Lowland Soft Bed	I	E	P	0	0	0	0	0	0	0	E	P
44	Lower Mataura	Mataura River at Mataura Island Bridge	2186200	5416200	Mataura 3	I	E	P	0	0	1	0	1	0	0	E	P
43	Lower Mataura	Mataura River at Gorge Road	2182700	5402300	Mataura 3	I	E	P	1	1	0	0	0	1	0	0	0
TBA	Mid Mataura	Tomogalak Stream at Arldlussala Rd	2169800	5484600	Mataura 3	I	N	R	0	0	0	0	0	0	0	N	R
47	Mid Mataura	Mataura River at Keowns Road Bridge	2172046	5480614	Mataura 3	I	0	0	0	0	0	0	0	0	0	E	
51	Mid Mataura	Waikaia River at Waipounamu Bridge Road	2183066	5475811	Mataura 3	I	E	P	0	0	0	1	0	0	0	E	P
-	Mid Mataura	Longridge Stream at Sandstone	2168600	5471000	Mataura 3	I	E	P	0	0	0	0	0	0	0	N	P
-	Mid Mataura	Waimea Stream at Pahiwi-Balfour Road	2164700	5469500	Mataura 3	I	E	P	0	0	0	0	0	0	0	0	0
TBA	Mid Mataura	Mataura River at Pyramid Bridge	2185139	5469221	Mataura 3	I	N	P	0	0	1	1	0	0	0	N	P
-	Mid Mataura	Sandstone Stream at Kingston Crossing Rd	2178807	5465711	Mataura 3	I	E	P	0	0	0	0	0	0	1	N	P
215	Mid Mataura	Waimea Stream at Nine Mile Road	2173480	5464820	Mataura 3	I	E	R	0	0	0	1	0	0	0	0	0
-	Mid Mataura	North Peak Stream at Waimea Valley Road	2170600	5464600	Mataura 3	I	E	P	0	0	0	0	0	0	1	0	
168	Mid Mataura	Meadow Burn at Roundhill Rd	2185385	5464175	Spring Fed	I	N	R	0	0	0	1			0	E	R
59	Mid Mataura	Waimea Stream at Mandeville	2184674	5460690	Mataura 3	I	E	P	0		1	1	0	0	0	E	P

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58	Mid Mataura	Otamita Stream at Mandeville	2186483	5459549	Mataura 3	I	E	R	0	1	0	1	0	0	0	E	R
46	Mid Mataura	Mataura River at Otamita Bridge	2160500	5450500	Mataura 2	I	E	P	0	0	1	1	0	0	0	0	0
50	Upper Mataura	Mataura River d/s Robert Creek Confluenc	2164227	5525583	Mataura 3	Ref	0	0	0	0	0	0	0	0	0	E	R
60	Upper Mataura	Brightwater Spring	2172331	5521422	Spring fed	Ref	N	R	0	0	0	1	0	0	0	E	R
91	Upper Mataura	Mataura River at Garston	2172500	5518400	Mataura 3	LP	E	P	0	0	0	1	0	0	1	N	P
TBA	Upper Mataura	Eyre Creek at SH6	2163000	5512700	Mataura 3	I	N	R	0	0	0	1	0	0	0	N	R
49	Upper Mataura	Mataura River at Parawa	2163800	5506970	Mataura 3	I	E	P	0	0	1	1	0	0	1	E	P
52	Waikaia	Waikaia River u/s Piano Flat	2199869	5510155	Mataura 3	Ref	E	P	0	1	0	0	0	0	0	E	P
TBA	Waikaia	Steeple Burn above flats	2183000	5496800	Mataura 3	LP	N	R	0	0	0	0	0	0	0	N	R
TBA	Waikaia	Steeple Burn at Piano Flat Rd	2189100	5495600	Mataura 3	I	N	R	0	0	0	0	0	0	0	N	R
98	Waikaia	Waikaia River at Waikaia	2186300	5490200	Mataura 3	I	E	P	0	1	0	0	0	0	0	N	P
25	Lower Oreti	Oreti River at Benmore	2147620	5462600	Hill	I	0	0	0	0	0	0	0	0	0	E	P
155	Lower Oreti	Winton Stream d/s Winton Dam	2151300	5461500	Lowland Hard Bed	LP	E	P	0	0	0	0	1	0	0	0	0
88	Lower Oreti	Winton Stream at Benmore - Otapiri Road	2150900	5460300	Lowland Hard Bed	LP	0	0	0	0	0	0	0	0	0	E	P
30	Lower Oreti	Dipton Stream at South Hillend Road	2146800	5458900	Lowland Hard Bed	I	N	R	0	0	0	0	0	0	0	E	R
94	Lower Oreti	Oreti River at Centre Bush	2147250	5451050	Hill	I	E	P	0	0	0	0	0	0	0	0	0
130	Lower Oreti	Bog Burn d/s Hundred Line Road	2141298	5449941	Lowland Hard Bed	I	E	P	0	0	0	0	0	0	0	N	P
TBA	Lower Oreti	Bog Burn at SH96	2144600	5442400	Lowland Hard Bed	I	N	P	0	0	0	0	0	0	0	0	
31	Lower Oreti	Winton Stream at Lochiel	2147450	5435040	Lowland Hard Bed	I	E	P	0	0	0	0	1	0	0	E	P
39	Lower Oreti	Waianiwa Creek 1 at Lornville Riverton H	2143500	5421800	Lowland Soft Bed	I	0	0	0	0	0	0	0	0	0	E	R
24	Lower Oreti	Oreti River at Wallacetown	2145400	5420800	Lowland Hard Bed	I	E	P	0	0	0	0	0	0	0	E	P
120	Makarewa	Otapiri Stream at Otapiri Gorge	2158200	5457800	Lowland Hard Bed	Ref	E	R	0	0	0	0	0	0	0	N	R
37	Makarewa	Silver Stream at Lora Gorage Road	2160100	5450700	Lowland Soft Bed	LP	0	0	0	0	0	0	0	0	0	E	P
122	Makarewa	Makarewa River at Lora Gorge Road	2160500	5450500	Lowland Soft Bed	LP	E	R	0	0	0	0	0	0	0	N	P
72	Makarewa	Trenders Creek at Hall Road	2163500	5450200	Lowland Soft Bed	I	0	0	0	0	0	0	0	0	0	E	R
100	Makarewa	Makarewa River at King Rd	2161300	5446400	Lowland Soft Bed	I	0	0	0	0	0	0	0	0	0	E	0
38	Makarewa	Dunsdale Stream at Dunsdale Reserve	2170100	5443600	Lowland Soft Bed	Ref	E	R	0	0	0	0	0	0	0	E	P
35	Makarewa	Otapiri Stream at Anderson Road	2161300	5441700	Lowland Hard Bed	I	0	0	0	0	0	0	0	0	0	E	P
36	Makarewa	Hedgehope Stream at Block Road	2166400	5434700	Lowland Soft Bed	I	0	0	0	0	0	0	0	0	0	E	0
83	Makarewa	Makarewa River at Winton - Hedgehope Hwy	2162600	5434200	Lowland Soft Bed	I	0	0	0	0	0	0	0	0	0	E	0
135	Makarewa	Tussock Creek at Cooper Road	2156200	5430400	Lowland Soft Bed	I	E	0	0	0	0	0	0	0	0	0	0
TBA	Makarewa	Tussock Creek at Horton Road	2158060	5429770	Lowland Soft Bed	I	N	R	0	0	0	0	0	0	1	N	R
TBA	Makarewa	Makarewa River above Hedgehope	2159400	5428600	Lowland Soft Bed	I	N	P	0	0	0	0	0	0	0	N	P

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TBA	Makarewa	Hedgehope Stream above Makarewa	2159550	5428300	Lowland Soft Bed	I	N	P	0	0	0	0	0	0	0	N	P
32	Makarewa	Makarewa River at Wallacetown	2147800	5420600	Lowland Soft Bed	I	E	P	0	0	0	0	1	0	0	E	P
40	Makarewa	Waikiwi Stream at North Road	2151700	5417200	Lowland Hard Bed	I	E	R	0	0	0	0	0	0	0	E	P
TBA	Upper Oreti	Oreti River at Ram Hill	TBD	TBD	Hill	I	N	P	0	0	0	0	0	0	1	N	P
TBA	Upper Oreti	Oreti River at Mossburn	TBD	TBD	Hill	I	N	P	0	0	0	0	0	0	0	N	P
27	Upper Oreti	Oreti River at McKellars Flat	2134500	5531300	Mountain	Ref	N	R	0	0	0	0	0	0	0	E	R
23	Upper Oreti	Oreti River at Three Kings	2129600	5517700	Hill	LP	E	P	0	0	0	0	0	0	0	N	P
28	Upper Oreti	Cromel Stream at Selby Road	2149100	5503900	Hill	Ref	E	R	0	0	0	0	0	0	0	E	R
29	Upper Oreti	Irthing Stream at Ellis Road	2153678	5493225	Hill	I	E	R	0	0	0	0	0	0	0	E	P
26	Upper Oreti	Oreti River at Lumsden Bridge	2154100	5489200	Hill	I	E	R	0	0	0	0	0	0	0	E	R
70	Upper Oreti	Murray Creek at Cumming Road	2151300	5488200	Spring Fed	I	0	0	0	0	0	0			0	E	R
162	Upper Oreti	Murray Creek at Double Road	2153819	5483858	Spring Fed	I	N	R	0	0	0	0	0	0	0	E	R
TBA	Stewart Is	Main River	TBD	TBD	Natural State	Ref	N	A	1	0	0	0	0	0	0	N	R
TBA	Stewart Is	Coastal Stream	TBD	TBD	Natural State	Ref	N	A	1	0	0	0	0	0	0	N	R
TBA	Stewart Is	Mill Creek u/s Back Rd Bridge (Stewart Is)	2137401	5357039	Lowland Hard Bed	LP	N	A	1	0	0	0	0	0	0	E	R
8	Mararoa	Mararoa River at Mavora Lake	2132200	5532500	Lake Fed	Ref	E	0	0	0	0				0	0	
80	Mararoa	Mararoa River at Kiwiburn	2128200	5528600	Lake Fed	LP	N	P	1	0	0	0	0	0	0	E	P
79	Mararoa	Mararoa River at Mararoa Road Bridge	2117600	5510800	Hill	I	0	0	0	0	0	0	0	0	0	E	R
171	Mararoa	Whitestone River d/s Manapouri-Hillside	2100473	5506748	Hill	I	E	R	0	0	0	0	0	0	0	0	0
118	Mararoa	Mararoa River at The Key	2110800	5506000	Hill	I	E	P	0	0	0	0	0	0	1	0	0
7	Mararoa	Mararoa River at Weir Road	2096900	5497900	Hill	I	E	P	0	0	0	0	0	0	0	E	P
69	Te Anau/Manapouri	McKay Creek at Milford Road	2115900	5559500	Natural State	Ref	0	0	0	0	0	0	0	0	0	E	R
5	Te Anau/Manapouri	Eglington River at McKay Creek Confluence	2115500	5559400	Natural State	Ref	N	R	0	0	0	0	0	0	0	E	R
TBA	Te Anau/Manapouri	Upukerora River at Sinclair Rd	2107000	5527000	Hill	Ref	N	R	0	0	0	0	0	0	0	N	R
99	Te Anau/Manapouri	Upukerora River at Milford/Te Anau Road Bridge	2098500	5519900	Hill	I	E	P	1	0	0	0	0	0	0	E	P
167	Te Anau/Manapouri	Home Creek at Manapouri	2091183	5502308	Spring Fed	Ref	0	0	0	0	0	0	0	0	0	E	P
160	Waiau	Waiau River at Duncraigen Road	2096068	5496558	Lake Fed	I	E	P	1	0	0	0	0	0	0	E	P
86	Waiau	Pig Creek at Borland Lodge	2085000	5478400	Natural State	Ref	N	R	0	0	0	0			0	E	R
96	Waiau	Waiau River at Sunnyside	2093500	5476400	Lake Fed	I	E	R	0	0	0	0	0	0	0	0	0
87	Waiau	Wairaki River at Blackmount Road	2099400	5461600	Lowland Soft Bed	I	N	R	0	0	0	0	0	0	0	E	R
TBA	Waiau	Lill Burn at Hindley Rd	2087140	5454200	Lowland Soft Bed	LP	N	P3	0	1	0	0	0	0	0	N	P3
9	Waiau	Lill Burn at Lill Burn-Monowai Rd	2097200	5453900	Lowland Soft Bed	I	N	P3	0	0	0	0	0	0	0	E	P3
75	Waiau	Thicket Burn at Lake Hauroko	2080600	5452300	Natural State	Ref	0	0	0	0	0	0	0	0	0	E	R

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2	Waiau	Waiau River 100m u/s Clifden Bridge	2101300	5451100	Lake Fed	I	0	0	0	0	0	0	0	0	0	E	R
169	Waiau	Orauea River at Orawia Pukemaori Road	2107228	5446229	Lowland Soft Bed	I	E	R	0	0	0	0	0	0	0	0	
159	Waiau	Waiau River u/s Tuatapere	2099381	5440341	Lake Fed	I	0	0	0	0	0	0	0	0	0	E	P
1	Waiau	Waiau River at Tuatapere	2099400	5439700	Lake Fed	I	E	P	0	0	0	0	0	0	0	0	
161	Waihopai	Waihopai River at Waihopai Dam	2155800	5415200	Lowland Hard Bed	I	0	0	0	0	0	0	0	0	0	E	P
41	Waihopai	Waihopai River u/s Queens Drive	2153300	5414700	Lowland Hard Bed	I	E	P	1	0	0	0	0	1	0	E	P
42	Waihopai	Otepuni Creek at Nith Street	2152400	5411400	Lowland Soft Bed	I	E	P	1	0	0	0	0	1	0	N	P
150	Waihopai	Waituna Creek at Mokotua	2170700	5409700	Lowland Soft Bed	I	E	R	0	0	0	0	1	0	0	N	R
142	Waihopai	Waituna Creek at Gorge Road	2170920	5407890	Lowland Soft Bed	I	0	0	0	0	0	0	0	0	0	E	0
63	Waihopai	Waituna Creek at Marshall Road	2167900	5400500	Lowland Soft Bed	I	E	P	1	0	0	0	1	1	0	E	P
152	Waihopai	Currens Creek at Waituna Lagoon Road	2176300	5398400	Lowland Hard Bed	Ref	E	R	1	0	0	0	0	1	0	0	0
154	Waihopai	Moffat Creek at Moffat Road	2170000	5398300	Lowland Hard Bed	I	E	P	1	0	0	0	0	1	0	E	P
153	Waihopai	Currens Creek Triburary at Waituna lagoon	2176800	5397800	Lowland Hard Bed	Ref	E	0	0	0	0	0	0	0	0	0	0
148	Waihopai	Mokotua Stream at Awarua	2159641	5397576	Natural State	Ref	E	R	1	0	0	0	0	1	0	E	R
137	Waimatuku	Waimatuku Stream d/s Bayswater Bog	2130900	5438400	Spring Fed	LP	E	R	0	0	0	0	0	1	0	0	0
67	Waimatuku	Waimatuku Stream at Lornville Riverton H	2138039	5423345	Lowland Hard Bed	I	E	0	0	0	0	0	0	0	0	E	0
TBA	Waimatuku	Waimatuku at Waimatuku South Rd	2136780	5418000	Lowland Hard Bed	I	N	P	1	0	0	0	0	1	0	N	P

Appendix B: Stormwater recommendations

These recommendations are referring to the monitoring of the potential effects of urban stormwater discharges on the receiving environment's water and/or sediment quality.

Generally, it is recommended to undertake sampling in upstream and downstream (after reasonable mixing) of significant urban stormwater discharges, or areas with a number of discharges.

Timing

Timing is particularly critical when monitoring stormwater. The stormwater and river water samples must be taken relatively shortly after the onset of a significant rain event (e.g. 5mm of rain). This is in order to capture the "first flush" when most contaminants are present. The preceding dry period is also a key parameter, to allow for sufficient time for contaminant deposition in the catchment.

Generally speaking, water (discharge and/or receiving water) sampling should occur 1-2 hours after the onset of the first significant rainfall following at least 3 days without rain.

Sediment sampling should generally be undertaken during a period of stable flow (i.e. not during rainfall).

Monitoring parameters.

Parameters		Detection limit	Stormwater (discharges)	Receiving environment	
				Water	Sediment
Water clarity / Sediments	Black Disc [(a)]	N/A		✓	
	TSS	1 g/m^3	✓	✓	
	Turbidity	0.1 NTU		✓	
Pathogen indicators	*E.coli*	10 /100mL	✓	✓	
Organic load	Total $cBOD_5$	1 g/m^3	✓	✓	
	Soluble $cBOD_5$	1 g/m^3	✓	✓	
Metals	Total Zinc (Zn)	1 mg/m^3 (water) 20 mg/kg d.wt (sed.)	✓	✓	✓
	Total Cadmium (Cd)	0.05 mg/m^3 (water) 0.5 mg/kg d.wt (sed.)	✓	✓	✓
	Total Chromium (Cr)	0.5 mg/m^3 (water) 5 mg/kg d.wt (sed.)	✓	✓	✓
	Total Nickel (Ni)	0.5 mg/m^3 (water) 1 mg/kg d.wt (sed.)	✓	✓	✓
	Total Copper (Cu)	1 mg/m^3 (water) 5 mg/kg d.wt (sed.)	✓	✓	✓
	Total Lead (Pb)	0.5 mg/m^3 (water) 5 mg/kg d.wt (sed.)	✓	✓	✓
Organic toxicants	Total petroleum hydrocarbons (TPH)	Trace test	✓	✓	✓
	Semi Volatile Organic Compounds (SVOC)	Trace test	✓	✓	✓