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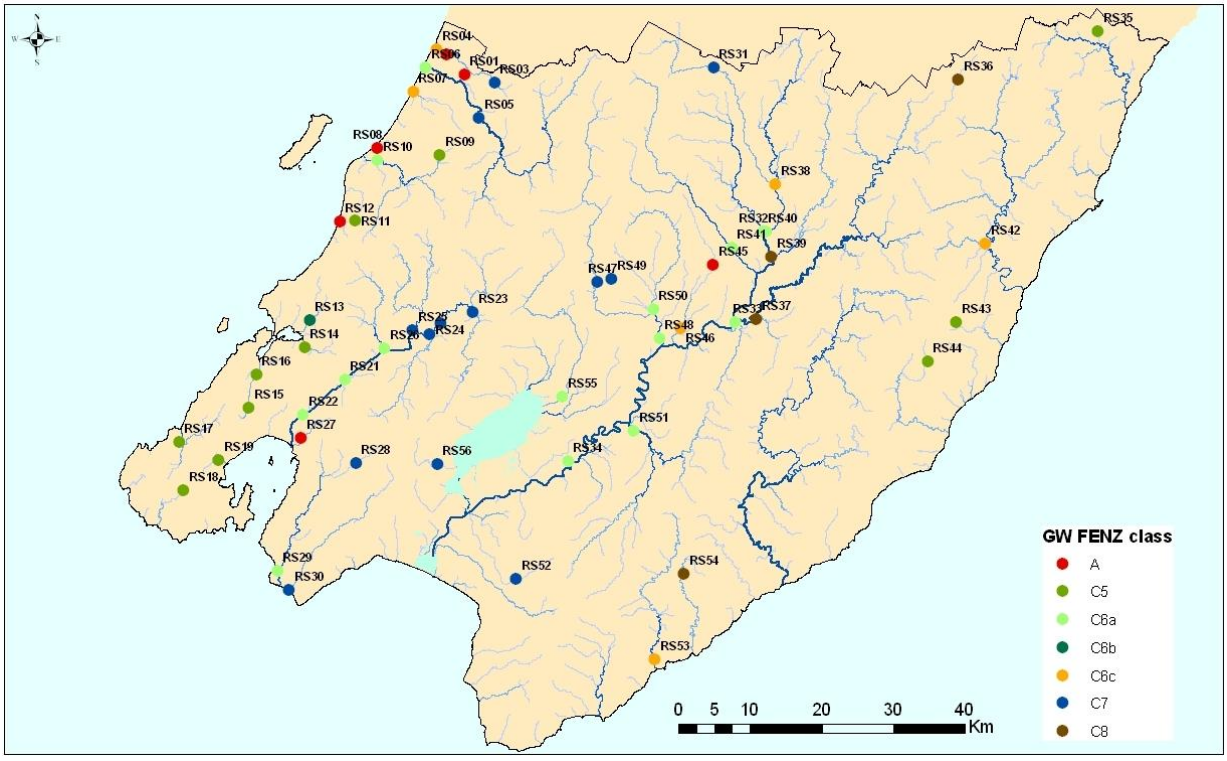
Nutrient status of rivers and streams in the Wellington Region

An analysis of State of the Environment monitoring data



June 2011

Nutrient status of rivers and streams in the Wellington Region
An analysis of State of the Environment monitoring data

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Report prepared for Greater Wellington Regional Council by

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Greater Wellington regional Council

EXECUTIVE SUMMARY

Greater Wellington Regional Council (GWRC) is in the process of developing technical recommendations to support the Council's second generation Regional Freshwater Plan. As part of this work, Rivers State of the Environment (RSoE) water quality data is being analysed to identify the state, trends and management options for the region's rivers and streams. This report is part of a series of technical reports on the Wellington region's streams and rivers, destined to inform and support the policy development process.

The aim of this report is to provide data analysis and interpretation in relation to the nutrient status of the 56 RSoE freshwater water quality monitoring sites, for the five-year period spanning between July 2004 and June 2009. Here, the term "nutrient status" is intended to include:

- the overall nutrient richness of the stream/river;
- the ability of these nutrients to cause algal growth; and
- the relative abundance of the two main macronutrients, nitrogen (N) and phosphorus(P), in relation to their potential to enhance/limit algal growth.

The spatial framework of this work is defined by 11 river classes based on the Freshwater Environments of New Zealand (FENZ) framework (Leathwick *et al.*, 2008). This study also looks into nutrient status patterns across the region's two major river systems, the Ruamahanga River and Hutt River.

This work puts particular focus on:

- The relationship between nutrient status and river/stream flow;
- The nutrient status of river and stream sites under low anthropogenic pressure conditions (reference/low impact sites);
- The nutrient status of rivers and streams across the different river classes and catchments;
- The changes in nutrient status caused, or contributed to, by human activities, including landuse and point source discharges or landuse and/or point source discharges.

In the Wellington region, 39 out of 56 long-term monitoring sites (69%) meet the ANZECC guideline for DIN, with an additional five sites (10%) below twice the guideline. High median DIN concentrations (more than twice the guideline) are measured at 12 sites (21%). Comparison with national figures indicates that about two thirds of the Wellington region's monitoring sites have a lower median DIN concentration than the national median for comparable sites. Reference conditions are characterised by very low to low DIN concentrations.

With regards to DRP, just over half (53%) of the RSoE monitoring sites meet the ANZECC guideline, with an additional 11 sites (19%) below twice the guideline value. High DRP concentrations are found at 15 (27%) sites. Similarly, just over half (53%) of the RSoE sites present a lower median DRP concentration than the national median for their national class. DRP appears to be naturally present in moderately elevated concentrations in some streams, possibly a reflection of groundwater interactions in areas of phosphorus-rich sedimentary geology.

As a result of low DIN and low to moderate DRP concentrations, reference sites in the region are likely to be dominated by co-limited or N-limited conditions. A number of non-reference sites have similar dissolved nutrient concentrations to those of reference sites and have a similar likely limiting nutrient status. Overall, 23 sites (41%) in the region are likely to be either N-limited or co-limited.

In many streams and rivers with developed catchments, inputs from point-source discharges (e.g. municipal wastewater) and non-point (e.g. agricultural or urban landuse) sources, lead to an increase in the concentrations of both DIN and DRP. In catchments dominated by pastoral landuse, the inputs of DIN are often proportionally greater than those of DRP, which causes a departure from the reference (N-limited or co-limited) conditions to more P-limited systems. A pattern is commonly noted, in which sites

that are generally P-limited tend to switch back to co-limited or N-limited conditions under low stream/river flow conditions. Overall 21 (38%) out of the 56 RSoE sites appear to be P-limited, with 11 being likely to switch to co- or N-limited conditions at times. At some sites, the inputs of both DIN and DRP concentrations are so high that both dissolved nutrients are likely to be readily available to algae growth at all times, i.e. are unlikely to exert any significant limitation on periphyton or macrophyte, growth. This may be the case for 12 (21%) of the current RSoE sites.

Of the RSoE sites, 25% present a significant periphyton growth issue, and a further 30% present a moderate periphyton issue. Although macrophyte cover and biomass are not formally assessed as part of the RSoE programme, visual observations indicate regular or occasional nuisance macrophyte growths at a number of sites in the region, in particular at 7 out of the 10 RSoE sites where periphyton is not monitored. Overall, there is no indication of any periphyton or macrophyte issues at 30% of the RSoE sites.

Reference and non-reference typical nutrient concentrations, nutrient limitation and periphyton growth are described for each FENZ class and summarised in Table 20 and Table 25 of this report.

The Ruamahanga River itself appears to be reasonably robust to the effects of nutrient enrichment, i.e. only very moderate periphyton issues were identified in the middle and lower Ruamahanga River in spite of quite elevated dissolved nutrient concentrations. The high frequency of freshes, is probably the key factor limiting periphyton growth in this river. However, many tributaries of the Ruamahanga River, particularly the eastern Wairarapa tributaries, do not have the same frequency of freshes and present significant issues associated with periphyton and/or macrophyte growth.

The Hutt River presents a moderate periphyton biomass and cover issue in its lower catchment, as well as cyanobacteria proliferations in its middle and lower reaches, in spite of relatively low levels of nutrients. As such, it appears to be much more sensitive to nutrient enrichment than the Ruamahanga River, and future increases in dissolved nutrient inputs may very well result in increased periphyton growth. Dissolved nutrient ratios provide a reasonably strong indication that the Hutt River is essentially P-limited, and DRP inputs to the river will need to be carefully managed in the future.

Most river and stream systems in the Wellington Region or their downstream receiving environments appear to be, to some various degree, sensitive to the effects of nutrient enrichment, and may require some form of nutrient management to protect their aesthetic, recreational and ecological values. The findings of this study, supported by other studies and recent expert recommendations, indicate that, in most situations management of both nitrogen and phosphorus is required. In some situations, a priority can be given to the management of one nutrient (e.g. phosphorus), but it is recommended that this decision be based on a robust understanding of the risks, and likely success, of this approach.

This report also makes a number of recommendations for future monitoring and investigations. In particular, it was identified that all urban stream RSoE sites largely exceeded the ANZECC guidelines and national medians for both DRP and DIN. It is recommended that the causes of the very elevated nutrient concentrations at these sites, and in other urban streams in the region, be investigated.

Excessive macrophyte growth appears to be a significant issue at a number of sites in the region, but is not formally monitored as part of the RSoE programme. It is recommended that protocols be put in place to formally monitor macrophyte cover and/or biomass as part of the RSoE programme, to better ascertain the existence, and extent, of this potential issue.

Finally it is recommended that a nutrient load analysis be conducted for the Hutt River catchment, to determine the contribution of the different tributaries to the nutrient loads carried by the Hutt River under different flow conditions.

CONTENTS

Table of Contents

Figures

Tables

1 Context

1.1 Introduction

Greater Wellington Regional Council (GWRC) is in the process of developing technical recommendations to support the Council's second generation Natural Resource Management Plan. As part of this work, data from the regional Rivers State of the Environment (RSoE) monitoring programme are being analysed to identify the state, trends and management options for the region's rivers and streams.

This report is part of a series of technical reports on the Wellington region's streams and rivers, destined to inform and support the policy development process.

1.2 Aims

The aim of this report is to provide data analysis and interpretation in relation to the nutrient status of the 56 RSoE water quality monitoring sites. Here, the term "nutrient status" is intended to include:

- the overall nutrient richness of the stream/river;
- the ability of these nutrients to cause algal growth; and
- the relative abundance of the two main macronutrients (N and P), in relation to their potential to enhance/limit algal growth.

The spatial framework of this work is defined by the river classification recently undertaken by GWRC (Warr, 2010a). This classification, based on the Freshwater Environments of New Zealand (FENZ) framework (Leathwick *et al.*, 2008), resulted in the definition of 11 river classes.

Natural catchment boundaries define hydrologically linked systems, and constitute a natural framework for water quality analysis and reporting. This study also looks into nutrient status patterns across the region's geographical units, in particular the region's two major river systems, the Ruamahanga River and Hutt River.

This work puts particular focus on:

- The relationship between nutrient status and river/stream flow;
- The nutrient status of river and stream sites under low anthropogenic pressure conditions (reference/low impact sites);
- The nutrient status of rivers and streams across the different river classes and catchments;
- The changes in nutrient status caused, or contributed to, by human activities, including landuse and point source discharges or landuse and/or point source discharges.

1.3 Scope and limitations

This study is a desktop study based on GWRC's State of the Environment data for rivers and streams. It does not include non-riverine environments such as lakes, wetlands estuaries or marine coastal ecosystems.

This study is primarily focused on a descriptive analysis of the nutrient status of the region's rivers and streams. The guidelines that are used in this report are national guidelines, and do not constitute recommendations of water quality objectives, standards or guidelines for the Wellington region.

This report is part of a series of technical reports to support the development of regional water quality policy for the Wellington region, and should be read in conjunction with other reports, including the river classification report (Warr, 2010a), the freshwater objectives reports (Warr, 2010b and 2010c) and the water quality limits reports (Ausseil 2011 a to d).

1.4 Background on nutrients, periphyton and aquatic macrophytes

Periphyton is the brown or green slime or filaments coating stones, wood or any other stable surfaces in streams and rivers. In some situations, periphyton can proliferate and form thick mats of green or brown filaments on the river bed. The proliferation of periphyton can affect a number of values associated with stream and rivers, including ecosystem health, recreational and aesthetic values, and trout fishery values.

Periphyton growth is generally controlled by a number of physical (e.g. substrate, river flow, sunlight, temperature) chemical (e.g. bioavailable nutrients) and biological (e.g. grazing by invertebrates) phenomena (Biggs, 2000).

Not all streams or rivers provide habitat favourable to excessive periphyton growth. For example, stream beds dominated by fine (sand or silts) materials are unsuitable for periphyton attachment. Thick, closed canopy above a stream bed, or deep turbid rivers will restrict the amount of sunlight reaching the river bed, thus limiting plant growth.

Periphyton biomass in a stream or river is forever changing, as result of a dynamic equilibrium between periphyton growth and biomass loss (chiefly through hydrological influence and invertebrate grazing). Generally speaking, floods re-set periphyton biomass at a low level. The recession and low flow periods following a flood are termed "accrual period" during which periphyton biomass increases to reach a "peak biomass". Both the peak biomass and the speed at which it is reached can be increased by high available nutrient concentrations in the water.

In situations when other factors are favourable, particularly during periods of low/stable river flows, high nutrient concentrations are likely to result in undesirable periphyton proliferation. The setting of nutrient concentration-based guidelines or standards is often used as a way of maintaining periphyton growth at acceptable levels. It should be noted however, that very long accrual periods (i.e. a long time between two significant floods) are known to allow the development of high periphyton biomass even at low nutrient concentrations (Biggs, 2000).

The forms of nitrogen that plants can assimilate directly (i.e. bioavailable) include oxides of nitrogen (nitrate- and nitrite- nitrogen) and total ammonia nitrogen, the sum of which is called Dissolved Inorganic Nitrogen (DIN). Dissolved Reactive Phosphorus (DRP) is generally considered as the measurement of bioavailable phosphorus.

Both nitrogen and phosphorus are needed for periphyton growth in an average weight ratio of 7.5:1, as defined in the Redfield equations (Stumm and Morgan, 1996 in Wilcock *et al.*, 2007). A ratio of approximately 7.5 is the theoretical limit between N-limited (ratio<7.5) and P-limited (Ratio >7.5) conditions.

The DIN/DRP ratio can be a useful indicator of which DIN or DRP is the likely limiting nutrient for periphyton growth. Generally, elevated DIN/DRP ratios (above 20) are indicative of P-limited conditions, and low ratios (<4) indicative of N-limited conditions. Ratios between 4 and 20 are generally inconclusive or may indicate that the nutrient limitation may "switch" between the two nutrients at different times of the year/ flows. It is important to note that nutrient limitation may only occur when other factors controlling periphyton growth, such as sunlight, hydrological regime and biological activity are favourable and nutrient concentrations (at least one of DIN or DRP) are sufficiently low to limit periphyton growth. When both nutrients are in sufficient supply, nutrient concentration is unlikely to limit algal growth.

As explained above, periphyton biomass is "reset" by flood events, and periphyton growth will occur during the flow recession period until the next flood event, to generally reach its peak near the end of the accrual period. As a result, nutrient concentrations and ratios during stable and low flow periods are critical in controlling peak periphyton biomass. However, although peak biomass generally occurs during low flow conditions, it is the result of ambient conditions during the whole flow recession period. In other

words, nutrient concentrations and ratios during the period preceding the low flow situation are equally important in controlling peak periphyton biomass (Wilcock *et al.*, 2007).

From a resource management point of view, DIN:DRP ratios can provide a useful indication of which nutrient should be managed as a priority. However, care should be taken when interpreting DIN:DRP ratios. In particular, DIN:DRP ratios measured at one site should not be used in isolation. In particular, one needs to consider the likeliness of nutrient limitation of periphyton growth at that site. For example, if physical conditions at the site are unfavourable for periphyton growth, then periphyton will not grow to nuisance levels, regardless of nutrient abundance. Conversely, if both nutrients are present in elevated concentrations, the controls exerted by nutrient concentrations over periphyton growth will be weak, or inexistent, regardless of DIN:DRP ratios. These situations are often termed as "un-limited".

Finally, one also has to consider the presence and nutrient status of the downstream environment that receive the water from that river or stream site (Wilcock *et al.*, 2007). For example, if a stream is strongly P-limited but discharges into a N-limited river or harbour, a management regime solely focused on phosphorus may protect the stream values, but probably not the harbour's. Rather, both nutrients should be managed in this situation.

It should also be stressed that, although a useful indicator, DIN:DRP ratios do not provide a definitive answer, and bioassays, such as nutrient diffusing substrates, are generally viewed as a more reliable method to determine nutrient limitation.

In soft-bottom streams, plant growth is often dominated by macrophytes (i.e. vascular flowering plants) rather than algae. Contrary to algae, macrophytes have root systems and their primary source of nutrient uptake is from the sediments (through the roots). As a result, the relationship between dissolved nutrients and macrophyte growths is not as clear as with periphyton growth, i.e. dissolved nutrient concentrations are not a direct key driver of macrophyte growth. Instead, total nutrients inputs (i.e. including bound to sediments), channel and hydrological characteristics (depth, velocity, etc.), and, importantly, sunlight tends to control macrophyte growth (Wilcock et al. 2007).

Further, macrophytes can provide a solid substrate for periphyton attachment, particularly green filamentous species. The resulting total biomass (periphyton + macrophytes) can be very high and adversely affect the aesthetic/amenity and ecological values of these streams, but is not often formally monitored.

1.5 Report outline

The following sections of this report present an analysis of SoE monitoring results relating to dissolved nutrient concentrations and ratios and periphyton growth.

Section 2 presents the data and information that were used as the basis for this report, along with the analysis methods.

The first of the "results" sections (Section 2.4) presents a regional overview, including a comparison with national figures.

Section 4 provides an analysis for each of the seven river ecosystem classes (Warr 2010a) represented in the RSoE programme.

Section 5 provides an analysis centred on the region's two main river catchments, the Hutt and Ruamahanga river catchments.

Finally, Section 6 provides an overall conclusion and draws together the management implications of the analysis presented in this report. It also identifies information gaps and makes suggestions for future monitoring.

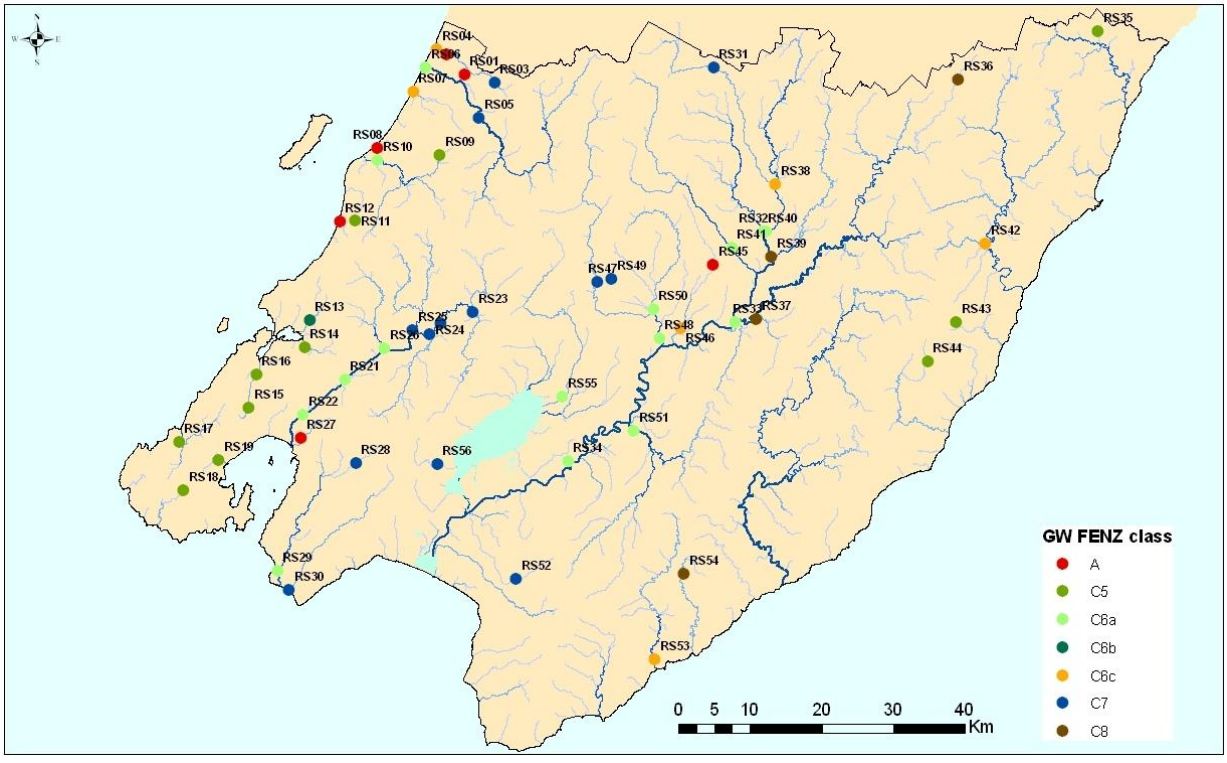
2 Data and Methods

2.1 Stream and river classes

As indicated above, the spatial framework of this work is defined by the draft river classification recently undertaken by GWRC (Warr, 2010a), resulting in the definition of 11 river classes. Of these, only seven are represented in the current RSoE network and used in this report (Table 1; Map 1).

Table 1: Summary of FENZ classification in the Wellington region (from Warr, 2010a).

GW FENZ class	Stream length (km)	No. of RSoE sites (reference sites)
A	3299 (27%)	6 (0)
C5	3076 (25%)	11 (0)
C8	1867 (15%)	4 (0)
C7	1729 (14%)	13 (8)
C10	924 (8%)	0
C6a	426 (3.5%)	15 (0)
UR	356 (2.9%)	0
C1	279 (2.3%)	0
C6c	198.48 (1.6%)	6 (0)
C6b	17.45 (0.1%)	1(0)
B	3.42 (0.03%)	0



Map 1: Outline of the Wellington region, and location of the RSoE monitoring sites. FENZ classification as per Warr, 2010a.

2.2 Monitoring sites

GRWC's RSoE monitoring programme for the July 2004 to June 2009 includes 56 river/stream sites across the Wellington region[1]. The following information/classification was assigned to each monitoring site (information provided by GW for this study):

- One of the seven FENZ classes represented in the RSoE network, as per Warr (2010a);
- An anthropogenic pressure category, based on human development in the catchment above each monitoring site, as "reference", "best available" or "impacted";
- An elevation category (lowland or upland), using a 150m elevation threshold, consistent with the ANZECC guidelines (2000);
- Land cover data for the catchment above each monitoring site, based on the Land Cover Database, Version 2 (LCDBII);
- a main catchment or geographical area (Table 2).

2.3 Monitoring determinands

Monitoring undertaken by Greater Wellington Regional Council and directly relevant to this study includes:

- Monthly monitoring of the concentrations in different chemical forms of nitrogen and phosphorus, including the dissolved inorganic fraction: Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorus (DRP);
- Monthly semi-quantitative assessments of periphyton cover, except at soft-bottom sites. Data were available for 46 sites;
- Annual monitoring of periphyton biomass at 46 sites. The protocols used for periphyton biomass and cover monitoring are summarised in Appendix E.

Unless otherwise stated, all water quality and periphyton data used in this report relate to the July 2004 to June 2009 period (i.e. 5 full years).

It should be noted that periphyton biomass monitoring is generally undertaken in riffles, and periphyton cover monitoring in runs. This may explain the differences in compliance with biomass and cover guidelines observed at some sites. Monitoring of periphyton cover in runs rather than riffles may underestimate periphyton cover in larger rivers (e.g. the Ruamahanga and Hutt rivers) as runs are deeper than riffles and so may be less suitable for periphyton growth.

As part of GWRC's SoE monitoring programme, periphyton biomass is monitored only once in any given year. Although monitoring is undertaken during summer or autumn after a period of at least 14 days (and generally 21 days) of stable flows, it is still unlikely to capture the maximum biomass reached on any one year, as many rivers have accrual periods exceeding 21 days several times per year. Under this sampling regime, high periphyton biomasses certainly indicate the presence of an excessive periphyton growth issue, but the reverse is not necessarily true, i.e. high periphyton biomass may have been missed by the infrequent sampling regime. In this regard, the periphyton cover data, collected monthly at each SoE site, provide a useful complement to the biomass data. This monthly assessment is much less unlikely to miss significant periphyton growth issues. As such, the combination of periphyton cover and biomass data enables a useful assessment of potential issues associated with excessive periphyton growth, and the two sets of data are used conjointly in this report to provide a general assessment of periphyton issues at each site.

[1] Monitoring at RS01 (Mangapouri Stream at Rahui Rd) was discontinued in October 2009. As a result, the SoE water quality monitoring network currently comprises 55 sites.

Table 2: Greater Wellington Regional Council's existing RSoE sites (NZTM Grid references).

Site No.	Site Name	X	Y	Site class	FENZ	Elevation	Catchment/area
RS01	Mangapouri @ Rahui Rd	1783373	5484901	Impacted	A	Lowland	Kapiti
RS02	Mangapouri @ Bennetts Rd	1780903	5487645	Impacted	A	Lowland	Kapiti
RS03	Waitohu @ Forest Park	1787593	5483689	Reference	C7	Upland	Kapiti
RS04	Waitohu @ Norfolk Cres	1779537	5488304	Impacted	C6c	Lowland	Kapiti
RS05	Otaki @ Pukehinau	1785426	5478749	Reference	C7	Lowland	Kapiti
RS06	Otaki @ Mouth	1777982	5485886	Impacted	C6a	Lowland	Kapiti
RS07	Mangaone @ Sims Rd	1776242	5482407	Impacted	C6c	Lowland	Kapiti
RS08	Ngarara @ Field Way	1771180	5474620	Impacted	A	Lowland	Kapiti
RS09	Waikanae @ Mangaone Walkway	1779974	5473638	Reference	C5	Upland	Kapiti
RS10	Waikanae @ Greenaway Rd	1771223	5472915	Impacted	C6a	Lowland	Kapiti
RS11	Whareroa @ Waterfall Rd	1768074	5464532	Best avail.	C5	Lowland	Kapiti
RS12	Whareroa @ QE Park	1765976	5464400	Impacted	A	Lowland	Kapiti
RS13	Horokiri @ Snodgrass	1761804	5450653	Impacted	C6b	Lowland	Mana/Makara
RS14	Pauatahanui @ Elmwood Bridge	1761097	5446783	Impacted	C5	Lowland	Mana/Makara
RS15	Porirua @ Glenside	1753289	5438364	Impacted	C5	Lowland	Mana/Makara
RS16	Porirua @ Milk Depot	1754366	5443031	Impacted	C5	Lowland	Mana/Makara
RS17	Makara @ Kennels	1743530	5433635	Impacted	C5	Lowland	Mana/Makara
RS18	Karori @ Makara Peak	1744212	5426874	Impacted	C5	Lowland	Mana/Makara
RS19	Kaiwharawhara @ Ngaio Gorge	1749069	5431077	Impacted	C5	Lowland	Mana/Makara
RS20	Hutt River @ Te Marua	1780071	5450158	Impacted	C7	Lowland	Hutt
RS21	Hutt River @ Manor Park	1766679	5442285	Impacted	C6a	Lowland	Hutt
RS22	Hutt River @ Boulcott	1760858	5437486	Impacted	C6a	Lowland	Hutt
RS23	Pakuratahi Below Farm Creek	1784607	5451677	Impacted	C7	Lowland	Hutt
RS24	Mangaroa @ Te Marua	1778543	5448643	Impacted	C7	Lowland	Hutt
RS25	Akatarawa @ Hutt Confluence	1776183	5449184	Impacted	C7	Lowland	Hutt
RS26	Whakatikei @ Riverstone	1772256	5446747	Impacted	C6a	Lowland	Hutt
RS27	Waiwhetu @ Wainui Hill Bridge	1760565	5434141	Impacted	A	Lowland	Hutt
RS28	Wainuiomata @ Manuka Track	1768242	5430634	Reference	C7	Upland	Rimutaka
RS29	Wainuiomata u/s White Bridge	1757316	5415724	Impacted	C6a	Lowland	Rimutaka
RS30	Orongorongo River	1758930	5413094	Impacted	C7	Lowland	Rimutaka
RS31	Ruamahanga @ McLays	1818149	5485809	Reference	C7	Upland	Ruamahanga
RS32	Ruamahanga @ Te Ore Ore	1825574	5463019	Impacted	C6a	Lowland	Ruamahanga
RS33	Ruamahanga @ Gladstone	1821208	5450327	Impacted	C6a	Lowland	Ruamahanga
RS34	Ruamahanga @ Pukio	1797832	5431010	Impacted	C6c	Lowland	Ruamahanga
RS35	Mataikona Trib.	1871844	5490906	Best avail.	C5	Lowland	Nth. Wairarapa
RS36	Taueru @ Castlehill	1852300	5484198	Best avail.	C8	Upland	Ruamahanga
RS37	Taueru @ Gladstone	1824148	5450815	Impacted	C8	Lowland	Ruamahanga
RS38	Kopuaranga @ Stewarts	1826761	5469569	Impacted	C6c	Lowland	Ruamahanga
RS39	Whangaehu u/s Confluence	1826267	5459407	Impacted	C8	Lowland	Ruamahanga
RS40	Waipoua @ Colombo Rd	1825018	5462890	Impacted	C6a	Lowland	Ruamahanga
RS41	Waingawa @ South Rd	1820716	5460649	Impacted	C6a	Lowland	Ruamahanga
RS42	Whareama @ Gauge	1856090	5461229	Impacted	C6c	Lowland	Nth. Wairarapa
RS43	Motuwaireka @ headwaters	1852017	5450302	Best avail.	C5	Lowland	Nth. Wairarapa
RS44	Totara @ Stronvar	1848025	5444916	Impacted	C5	Upland	Nth. Wairarapa
RS45	Parkvale Trib. @ Lowes Res.	1818094	5458352	Best avail.	A	Lowland	Ruamahanga
RS46	Parkvale Stream at weir	1813515	5449469	Impacted	C6c	Lowland	Ruamahanga
RS47	Waiohine @ Gorge	1801889	5455995	Reference	C7	Lowland	Ruamahanga
RS48	Waiohine @ Bicknells	1810615	5448099	Impacted	C6a	Lowland	Ruamahanga
RS49	Beef Creek @ headwaters	1803963	5456398	Reference	C7	Upland	Ruamahanga
RS50	Mangatarere at SH2	1809768	5452160	Impacted	C6a	Lowland	Ruamahanga
RS51	Huangarua @ Ponatahi Bridge	1807009	5435213	Impacted	C6a	Lowland	Ruamahanga
RS52	Tauanui @ Whakatomotomo Rd	1790648	5414515	Reference	C7	Lowland	Ruamahanga
RS53	Awhea @ Tora Rd	1809951	5403289	Impacted	C6c	Lowland	South Wairarapa
RS54	Coles Creek trib.	1814020	5415217	Best avail.	C8	Lowland	South Wairarapa
RS55	Tauherenikau @ Websters	1797082	5439942	Impacted	C6a	Lowland	Lake Wairarapa
RS56	Waiorongomai @ Forest Park	1779604	5430559	Reference	C7	Lowland	Lake Wairarapa

2.4 Flow data

GWRC also continuously monitors river flow at 42 sites across the region. However, only 19 of these sites correspond directly with a SoE water quality monitoring site. GWRC has therefore undertaken work to provide flow estimates at many water quality sites. The following data were made available for this study:

- Mean daily flow on each sampling day, available at 12 sites;
- A flow category estimate on each sampling day, given as one of four flow categories: below half median flow, half median flow to median flow, median flow to three times median flow and above three time median flow. Flow category data were available for 45 sites (including the 12 sites where mean daily flow data were available);
- An estimate of mean accrual period, for 50 of the 56 sites;

2.5 Data analysis

2.5.1 Statistical analysis

Descriptive statistics (mean, percentiles, confidence intervals), as well as compliance with the different guidelines(expressed as a percentage of the total number of samples available), such as those provided in Appendix F and in different tables and figures in this report were calculated using a number of macros developed for Microsoft® Excel 2007.

Graphs in this report are generally presented with error bars corresponding to the 95th confidence interval, to provide a visual representation of the precision of the estimate of the median value. This was preferred to an estimate of data variability (such as standard deviation). General statistics for each site, including standard deviation values are provided in Appendix F.

For sites where flow data were available, water quality data were generally analysed:

- at all river flows ((i.e. all available data);
- under base flow conditions (i.e. all data collected at river flows at or below median flow);
- under low flow conditions (i.e. data collected below half median flow).

Wilcoxon paired rank tests were used to compare two groups of paired data, such as comparing nutrient concentrations at two monitoring sites with the same sampling dates.

2.5.2 Guidelines

For the purpose of this work the default trigger values in the ANZECC (2000) guidelines were used as benchmark values for nutrient concentrations. Guideline DRP and DIN concentrations are defined for upland (>150m elevation) and lowland streams and rivers (Table 3).

In a similar fashion, the New Zealand periphyton guidelines (Biggs, 2000) were used as reference values for periphyton biomass and cover, as summarised in Table 4. The New Zealand periphyton guidelines recommend two levels of protection:

- 50 mg chlorophyll *a*/ m^2 for the protection of aquatic biodiversity. It is important to note that this is a very low level of maximum biomass, and this guideline should only be applied to streams and rivers where high invertebrate biodiversity can reasonably be expected. This level of periphyton biomass is very stringent, and temporary, moderate exceedances of the standard can be expected, even in systems close to their natural state (Dr. Barry Biggs, NIWA, pers. comm. in Ausseil and Clark, 2007);

- 120 mg chlorophyll *a*/ m^2 for the protection of trout habitat and aesthetics/recreational values. This biomass level is also suitable to protect a wide range of biodiversity values in slightly enriched systems (Dr Barry Biggs, NIWA, pers. comm. in Ausseil and Clark, 2007).

There are no established numerical thresholds for nutrient concentration over which nutrient limitation ceases to be significant. For the purpose of this report, it was considered that conditions were un-limited when the monthly average concentration of both nutrients exceed the "eutrophic" thresholds for systems with a 20 days mean accrual period defined in the New Zealand periphyton guidelines (Biggs, 2000). These are 0.026 mg/L for DRP and 0.295 mg/L for DIN.

Table 3: Summary of the default trigger values for ANZECC (2000) guidelines for dissolved nutrient concentrations. The concentration of DIN was calculated as the sum of the guidelines for ammoniacal nitrogen and oxides of nitrogen (NO_x-N).

	DRP (g/m^3)	SIN (g/m^3)
Upland streams	0.009	0.177
Lowland streams	0.010	0.465

Table 4: Summary of the periphyton biomass and cover guidelines used in this report (adapted from Biggs, 2000).

Instream value	Diatoms/ cyanobacteria		Filamentous algae	
	Biomass (mg Chlorophyll *a*/m^2)	Cover (%)	Biomass (mg Chlorophyll *a*/m^2)	Cover (%)
Biodiversity (Reference conditions)	50	-	50	-
Aesthetics and recreation	-	-	120	30
Trout habitat and angling	200	60	120	30

2.5.3 Comparison with national figures

A 2008 report prepared by NIWA for the Ministry for the Environment to support the 2007 national state of the environment report presents a national summary of all regional council data. In particular, the report provides national median values for some key water quality parameters, recorded at sites classified in 5 broad categories, based on the REC classification, using the source of flow (upland/lowland) and the dominant land cover (natural/pastoral), the fifth category being urban streams (NIWA 2008). The RSoE monitoring results from the Wellington region used in this report were compared to national figures, to provide a national perspective.

Land cover information for the catchment upstream of each site was used to classify the Regional SoE sites and enable comparison with similar site classes in (NIWA, 2008). Sites with more than 30% of their catchment in urban areas were classified as "urban". All sites with 30% or more of their catchment in pasture were classified as "pastoral". Sites with 70% or more of their catchment in indigenous vegetation were classified as "natural". Sites were classified as "forested" when the sum of indigenous cover, exotic forest and scrub exceeded 70% of the catchment. Exotic forest has nutrient leaching rates only marginally higher than indigenous vegetation (Li *et al.*, 2005), and "forested" sites were compared with sites with "natural" landcover in the NIWA (2008) report. An elevation of 150 m was used as the cut-off between lowland and upland sites.

3 Regional overview

3.1 Nutrient status

Of the 56 RSoE sites, seven are located at elevations 150 m and above, i.e. are classified as "upland" in the ANZECC guidelines. The remaining 49 sites are classified as "lowland". Sites are compared with their respective relevant guidelines in the following paragraphs. Results are presented in Table 5, Figure 1 and Figure 2.

3.1.1 DIN

The overall median DIN concentration for the region, calculated from the median concentration at all the RSoE sites, is 0.237 mg/l. The inter-quartile range is 0.056 – 0.564 mg/L, (i.e. one quarter of the sites has a median DIN concentration below 0.056 mg/l, and one quarter of the sites is above 0.564 mg/L).

The median DIN concentration at all seven upland sites largely comply with the upland ANZECC guideline. These sites include five "reference" sites, one "best available" site and one "impacted" site. All seven sites' median DIN concentrations fit within the range 0.016 – 0.110 mg/L.

With regards to the lowland sites, 65% (32 out of 49) of them comply with the ANZECC guideline for lowland streams. An extra 5 sites (10%) have median DIN concentrations less than twice the ANZECC guideline. The remaining 12 sites (24%) have median DIN concentrations in excess of 1 mg/L, and up to 7 mg/L.

The three highest median DIN concentrations are recorded in the Mangapouri Stream at Rahui Rd (RS01), the Parkvale Tributary at Lowes Reserve (RS45) and the Mangaone Stream at Sims Rd (RS07).

Only four reference sites are available for lowland streams. All four have amongst the lowest median DIN concentrations in the region: 0.018 to 0.047 mg/L. Interestingly the upper end of the range of median DIN concentrations measured at lowland reference sites is lower than that of the upland reference sites (0.047 vs. 0.110 mg/L).

DIN concentrations at "best available" sites are generally consistent with those of reference sites, although two sites have significantly higher concentrations: the Whareroa Stream at Waterfall Road (RS11) and particularly the Parkvale Tributary at Lowes Reserve (RS45, a spring-fed site), where the second highest DIN median concentration in the region is recorded (4.5 mg/L).

3.1.2 DRP

The regional median DRP concentration is 0.009 mg/L, (i.e. corresponds to the ANZECC guideline for upland streams). The interquartile range is 0.006 to 0.022 mg/L.

Median DRP concentrations at upland sites range from 0.002 to 0.013 mg/L. Interestingly, a number of these sites, including some reference sites, have moderately elevated DRP concentrations, in excess of the ANZECC guideline. This indicates that there are natural sources of DRP in parts of the region, probably associated with phosphorus-rich tertiary sedimentary rocks that are abundant in the region.

Just over half (51%) of the lowland sites have a median DRP concentration below the ANZECC guideline. Among those that exceed the guideline, 9 (18%) have median DRP concentrations less than twice the ANZECC guideline. All other sites have median DRP concentrations ranging from 0.022 to 0.044 mg/L, with the exception of the Mangatarere Stream at SH2, where the median DRP concentration is 0.097 mg/L. The very high DRP concentration in the Mangatarere Stream at SH2 is considered to be largely due to the discharge of treated wastewater from the Carterton wastewater treatment plant (Milne *et al.*, 2010).

Table 5: Summary of median dissolved nutrients concentrations at RSoE sites.

Sites	Number of sites	DIN (mg/L)					DRP (mg/L)				
		Min	LQ	Med	UQ	Max	Min	LQ	Med	UQ	Max
All sites	56	0.018	0.056	0.237	0.564	7.400	0.002	0.006	0.009	0.022	0.097
Reference sites	9	0.018	0.030	0.031	0.047	0.110	0.002	0.005	0.008	0.009	0.013
Best available	6	0.022	0.040	0.074	0.304	4.515	0.004	0.006	0.008	0.014	0.034
Impacted	41	0.018	0.100	0.305	1.011	7.400	0.002	0.006	0.013	0.025	0.097
Upland	7	0.030	0.035	0.085	0.094	0.110	0.002	0.005	0.008	0.010	0.013
Lowland	49	0.018	0.065	0.286	0.605	7.400	0.004	0.006	0.009	0.022	0.097
Urban	4	0.560	1.044	1.303	1.575	2.100	0.025	0.028	0.035	0.042	0.043
Upland forested	13	0.018	0.041	0.090	0.286	1.500	0.002	0.005	0.006	0.013	0.097
Upland pastoral	1	0.305					0.018				
Lowland forested	12	0.022	0.076	0.098	0.133	0.235	0.002	0.005	0.008	0.010	0.014
Lowland pastoral	26	0.018	0.289	0.465	1.119	7.400	0.006	0.008	0.017	0.028	0.097

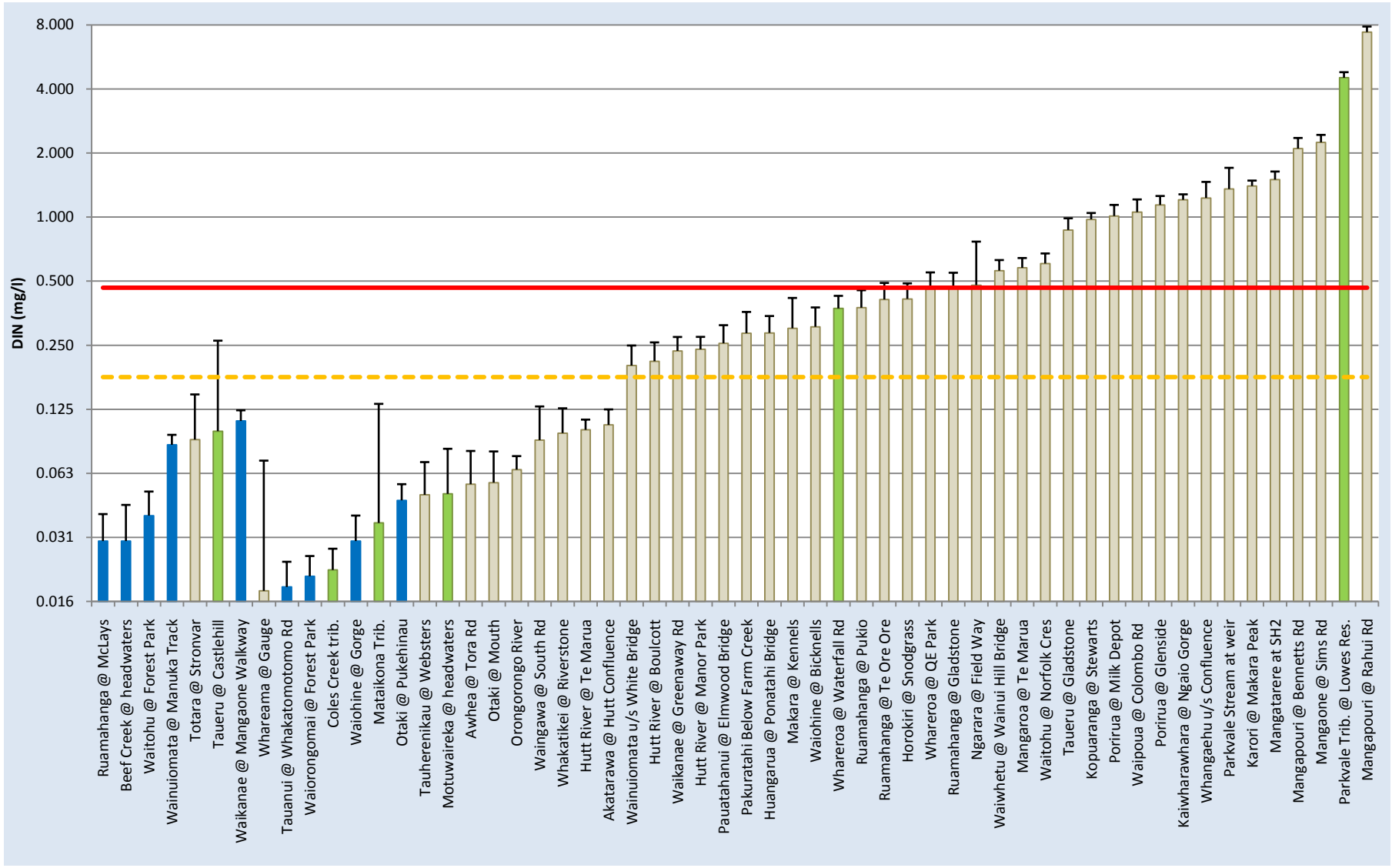


Figure 1: Median DIN concentration at RSoE sites (± 95% confidence interval). Upland sites are on the left-hand side (Ruamahanga at McLays to Waikanae at Mangaone Walkway). Reference sites are in blue, "best available" sites in green. The orange dotted line represents the ANZECC guideline for upland streams. The solid red line represents the ANZECC guideline for lowland streams. NOTE: the vertical scale is on a Log(2) scale.

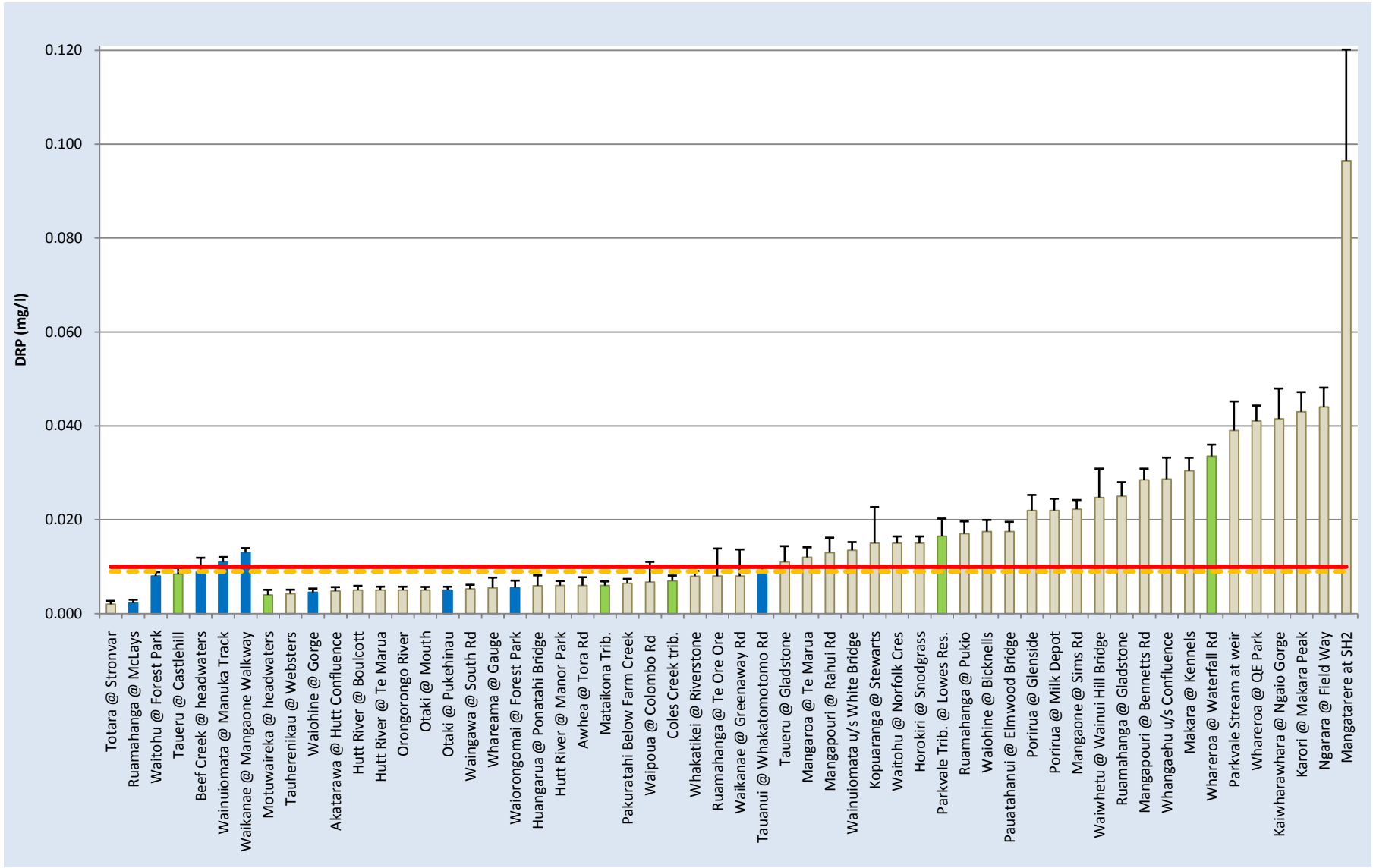


Figure 2: Median DRP concentration at RSoE sites (± 95% confidence interval). Upland sites are on the left-hand side (Ruamahanga at McLays to Waikanae at Mangaone Walkway). Reference sites are in blue, "best available" sites in green. The orange dotted line represents the ANZECC guideline for upland streams. The solid red line represents the ANZECC guideline for lowland streams.

3.1.3 Periphyton

As explained in Section 2.3, two types of periphyton data are available, biomass and cover. Periphyton biomass data were collected once per year in summer, following a period of stable river flows. Six data points (2004 to 2009 summers) are available at 46 of the 56 RSoE sites. Stream bed material at the 10 remaining sites is dominated by fine material, making these sites unsuitable for significant periphyton growth. Periphyton cover is visually estimated monthly at 46 sites.

Results (presented in Figure 3) indicate that:

- 8 sites (17%) have never exceeded any of the guidelines. Among these, we find sites located in the upper reaches of the region's larger rivers, either on the mainstem (Ruamahanga at McLays, Hutt at Te Marua, Otaki River at Pukehinau, Waikanae at Mangaone Walkway) or on tributaries (Waiohine at Gorge, Akatarawa at Hutt confluence), and reference sites on smaller rivers (Wainuiomata at Manuka Track and Waitohu at Forest Park). Although not all of these sites are classified as reference sites, they all have an upstream catchment largely dominated by native vegetation.
- An additional three sites (7%) have only breached the most stringent periphyton guideline biomass for the protection of high biodiversity values (50 mg/m^2). As explained in section 2.5.2, this guideline is very stringent, and should only be applied to sites with high biodiversity values. The Waingawa at South Road only marginally exceeded this guideline once, with all other biomass values at very low levels (<20 mg/m^2), indicating that periphyton growth is probably not a significant issue at this site. The other two sites (RS32, Ruamahanga at Te Ore Ore and RS45, Parkvale Tributary at Lowes Reserve), are lowland sites within essentially pastoral landscapes, where some level of nutrient enrichment is expected, and where the 120 mg/m^2 periphyton biomass guideline is probably the most relevant.
- Five sites have only breached one of the periphyton cover guidelines on one occasion. One-off exceedance should probably not been seen as a strong indication of an issue associated with periphyton growth, unless supported by additional information. These sites are the Whareroa at Waterfall Road (RS11), the Pakuratahi below Farm Creek (RS23), the Ruamahanga at Gladstone (RS33), the Waiohine at Bicknells (RS48) and the Beef Creek at Headwaters (RS49);
- 16 sites (35%) have breached the periphyton biomass guideline once out of six occasions, and/or have breached the periphyton cover guidelines on 2 to 5 occasions, indicating that the aesthetics and trout fishery values may be compromised at times, essentially indicating the existence of a moderate periphyton issue[2], or a possible significant periphyton growth issue that should be investigated further;
- The remaining 14 sites (41%) have regularly (5 times or more) breached the cover guidelines, and/or exceeded the biomass guideline at least once, indicating that the presence of a significant periphyton growth issue.

3.1.4 DIN:DRP ratios

As explained in Section 1.4, DIN:DRP ratio are a useful tool to describe the balance of dissolved nutrient concentrations. Generally low ratios (below 4) indicate that if periphyton growth is limited by nutrients (and not by other factors), then DIN is likely to be limiting. Conversely, high ratios (>20) generally indicate P-limited conditions. Ratios between these limits generally indicate co-limitations. The reader

[2] RSoE data at RS21, Hutt River at Manor Park, shows that periphyton cover guidelines were only exceeded once. However, issues associated with excessive periphyton growth, in particular abundant cyanobacterial mats have been observed at, and directly above and below this site, and it is considered that moderate periphyton issues are present at this site (Summer Warr, pers. comm.). This site was thus included in these 16 sites.

should also bear in mind the limitations and necessary precautions associated with the use of DIN:DRP ratios (refer Sections 1.4 and 2.5.2).

Monitoring results (presented in Figure 4, and summarised in Table 6) indicate that, of the 56 RSoE sites:

- Three sites have low DIN:DRP ratios, strongly indicative of N-limited conditions under all river flow conditions. Two of these sites are reference sites (Tauanui at Whakatomotomo Rd (RS52) and Waiorongomai at Forest Park(RS56)), and one is a "best available" site (Coles Creek Tributary – RS54));
- Beef Creek at Headwaters has a median DIN:DRP ratio just above 4 (4.1), but the absence of flow data at this site precludes any flow-related analysis. At this site, the median DIN:DRP of 4.1 indicates that strongly N-limited conditions occur approximately half of the time; the 90th percentile of DIN:DRP ratios is 20, indicating that P-limited conditions only rarely occur. In other words, conditions at this reference site appear to switch between N-limited and co-limited. This site is a reference site;
- Six RSoE sites have median DIN:DRP ratios between 4 and 20 under all flow conditions, but display a strong pattern of decreasing DIN:DRP ratios under decreasing river flow conditions, indicating that N-limited conditions are likely to predominate under base flow conditions. These sites are the Whareama at Gauge (RS42), Waitohu at Forest Park (RS03), Mataikona Tributary (RS35), Waiohine at Gorge (RS47), Awhea at Tora Rd (RS53), and Pauatahanui at Elmwood Bridge (RS14);
- Three sites also have median DIN:DRP between 4 and 20, but the absence of flow data at these sites precludes any flow-related analysis. The Ngarara Stream at Field Way (RS08) has a stream bed dominated by soft sediments, making it unsuitable for periphyton attachment. The median DIN:DRP ratio is 10, and the interquartile range is 4-21, which could indicate co-limited conditions. However, the elevated concentrations of both DIN and DRP indicate that any algae growth at this site would be unlikely to be limited by nutrients. The Taueru at Castlehill (RS36) has a median DIN:DRP ratio of 11, with an interquartile range of 4-36. This along with low to moderate nutrient concentrations, indicates that conditions probably switch between N- and P-limited conditions at this site. The Totara at Stronvar (RS44) has DIN:DRP ratio of 18, indicating a tendency toward P-limited conditions. However, the interquartile range of 4-66 indicates that N-limited conditions do prevail on a regular basis (a quarter of the time) at this site. Very low nutrient concentration indicates a probable strong nutrient co-limitation at this site.
- Eleven sites present DIN:DRP ratios between 4 and 20 under all flow conditions, indicating that co-limited conditions, or a regular switch between P- and N-limited conditions are likely to dominate at these sites. These sites are the Wainuiomata at Manuka Track (RS28), the Waikanae at Mangaone Walkway (RS09), the Otaki at Pukehinau (RS05), Orongorongo River (RS30), Otaki at Mouth (RS06), Ruamahanga at McLays (RS31), Tauherenikau at Websters (RS55), Whakatikei at Riverstone (RS26), Motuwaireka at Headwater (RS43), Wainuiomata u/s White Bridge (RS29) and Waiohine at Bicknells (RS48);
- A further 4 sites also present DIN:DRP ratios between 4 and 20 under all flow conditions, but elevated concentrations of both nutrients (refer to section 2.5.2 of this report) indicate that any nutrient limitation is likely to be weak or non-existent. This is particularly the case for the Mangatarere Stream at SH2 (RS50), but also, to a lesser extent, for the Whareroa at Waterfall Rd (RS11), Whareroa at QE Park (RS12), Makara at Kennels (RS17) and Ruamahanga at Gladstone (RS33);
- Five sites have median DIN:DRP ratios in excess of 20, indicative of generally P-limited conditions. However, the median ratio at these sites drops between 4 and 20 under base and/or low flow conditions, indicating that conditions may switch between P-limited and co-limited on a regular basis, particularly under lower flow conditions. These sites are the Waingawa at South

Road (RS41), the Ruamahanga at Pukio (RS34) and the Akatarawa at Hutt confluence (RS25), Waikanae at Greenaway Rd (RS10), Horokiri at Snodgrass (RS13);

- Six sites have median DIN:DRP ratios in excess of 20 under all flow categories analysed, indicating a predominance of P-limited conditions, although co-limited conditions may occur up to 45% of the time at these sites. These sites are: Hutt at Te Marua (RS20), Huangarua at Ponatahi Bridge (RS51), Waitohu at Norfolk Cres (RS04), Hutt River at Manor Park (RS21), Hutt River at Boulcott (RS22), Ruamahanga at Te Ore Ore (RS32);
- Seven sites present median DIN:DRP in excess of 20 and high concentrations of both nutrients, indicative of un-limited, or weakly limited conditions. These sites are the Waiwhetu at Wainui Hill Bridge (RS27), Parkvale Stream at Weir (RS46), the Kaiwharawhara at Ngaio Gorge (RS19), Karori at Makara Peak (RS18), Whangaehu u/s confluence (RS39) and Mangapouri at Bennett Rd (RS02);
- Finally, nine sites present high DIN:DRP ratios nearly all the time, with 10th percentile of DIN:DRP ratios in excess of 20, indicating strongly P-limited conditions at all times. None of these sites are reference sites. These sites are: Pakuratahi below Farm Creek (RS23), Mangaroa at Te Marua (RS24), Porirua at Glenside (RS15), Porirua at Milk Depot (RS16), Mangaone at Sims Road (RS07), Mangapouri at Rahui Rd (RS01), Parkvale tributary at Lowes Reserve (RS45) and Waipoua at Colombo Rd (RS40), Kopuaranga at Stewarts (RS38) and Taueru at Gladstone (RS37).

Table 6: Summary of nutrient limitation indications provided by DIN:DRP ratio analysis at RSoE sites.

Number of sites	% of total sites	DIN:DRP ratios	Likely limitation	Sites
3	5%	Low ratios at all flows	N-limited	RS52, RS54, RS56
1	2%	Relatively low ratio but no flow data	N-limited or co-limited	RS49
6	11%	Moderate (4 to 20) overall ratios Decreasing ratios at low flows	Co-limited generally N-limited under base flow	RS42, RS03, RS35, RS47, RS53, RS14
13	22%	Moderate (4 to 20) overall ratios (Low nutrient concentrations)	Co-limited	RS36, RS44, RS28, RS09, RS05, RS30, RS06, RS31, RS55, RS26, RS43, RS29, RS48
6	11%	Moderate (4 to 20) overall ratios (High nutrient concentrations)[(a)]	Un-limited, or weak nutrient limitation	RS08, RS11, RS12, RS17, RS33, RS50
5	9%	High (>20) overall Moderate at base flow	P-limited Co-limited at base flow	RS41, RS34, RS25, RS10, RS13,
6	11%	High (>20) overall ratios Moderate ratios frequent	P-limited Co-limited at times	RS20, RS51, RS04, RS21, RS22, RS32
6	11%	High (>20) median ratios (High nutrient concentrations)[(a)]	Un-limited, or weak nutrient limitation	RS02, RS18, RS19, RS27, RS46, RS39
10	18%	High (>20) ratios at all flows	Strongly P-limited	RS01, RS07, RS15, RS16, RS23, RS24, RS37, RS38, RS40, RS45

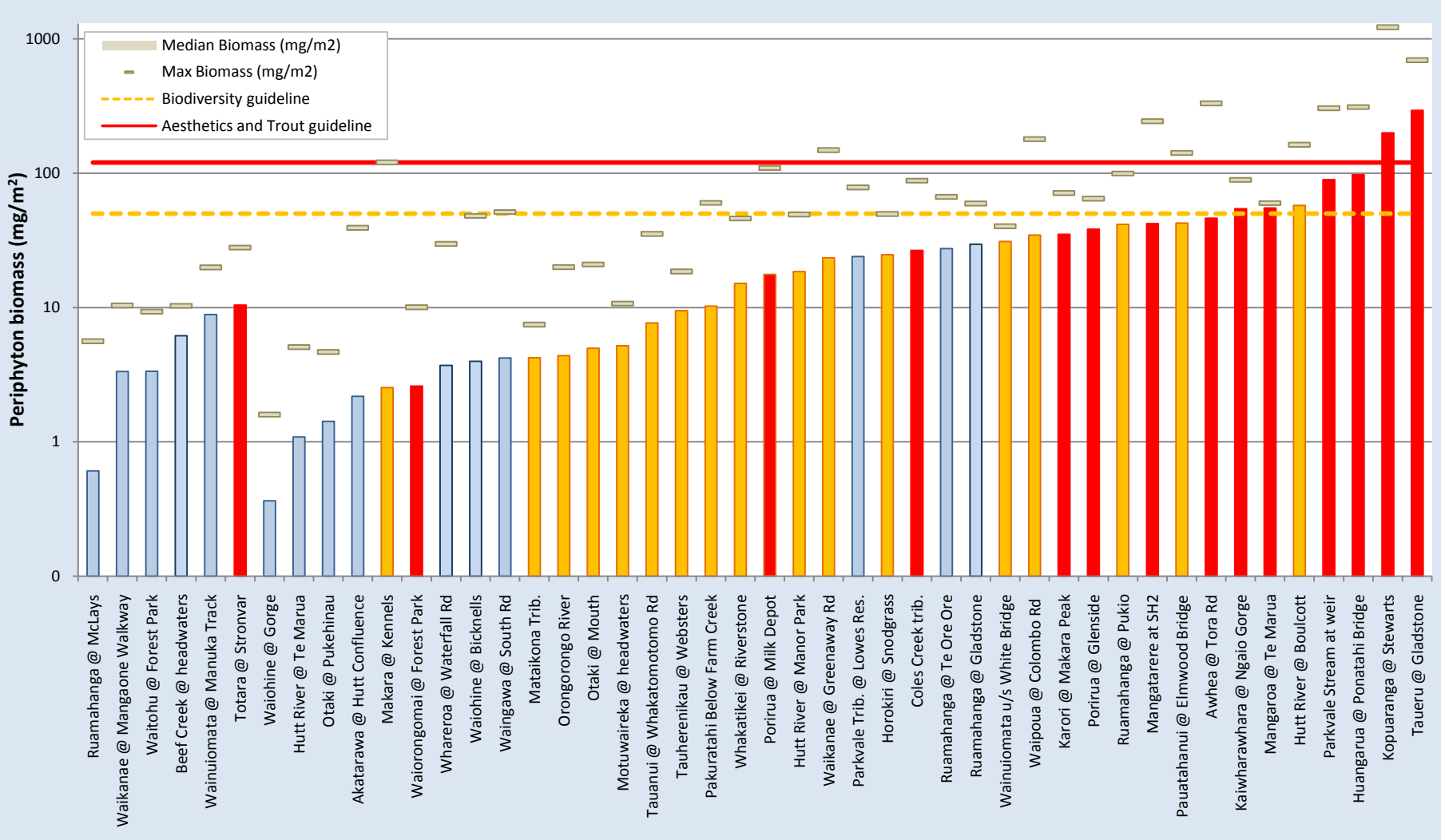


Figure 3: Median (bars) and maximum (rectangles) periphyton *biomass* (mg chlorophyll *a*/m^2). Upland sites are on the left-hand side (Ruamahanga at McLays to Totara at Stronvar). The solid red line represents the periphyton *biomass* guideline for the protection of aesthetic and trout fishery values (120 mg/m^2). The dotted orange line represents the periphyton *biomass* guideline for the protection of high biodiversity values (50 mg/m^2). The blue bars indicate sites where periphyton *cover* guidelines were never exceeded, orange bars indicate sites where periphyton *cover* guidelines were exceeded one to four times and red bars indicate sites where the periphyton *cover* guidelines were exceeded five times or more.

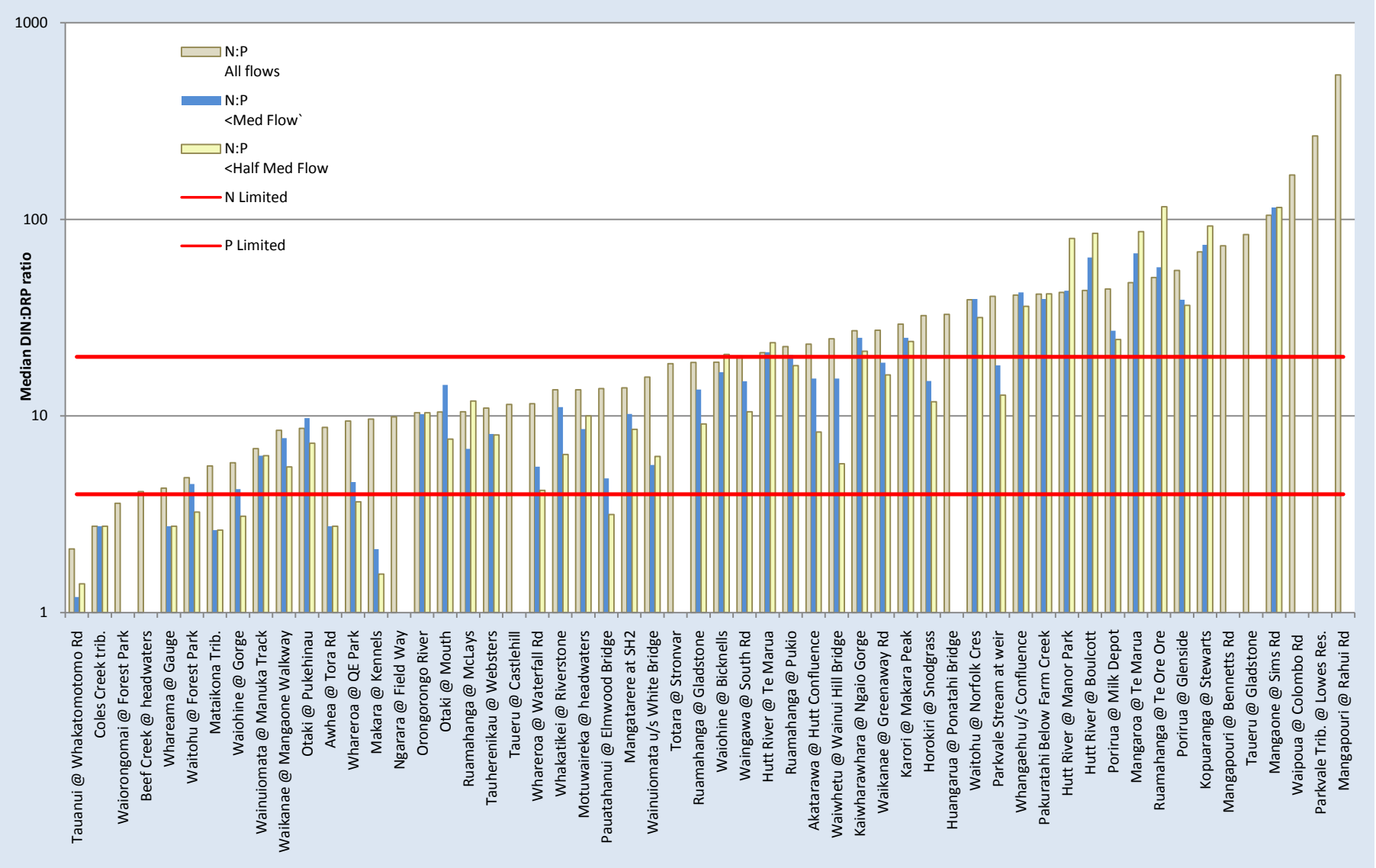


Figure 4: Median DIN:DRP ratios under different river flow conditions: at all river flows, at or below median flow and at or below half median flow. The part of the graph above the top (dashed) red line (DIN:DRP =20) is indicative of P-limited conditions; below the bottom (solid) red line (DIN:DRP=4) is indicative of N-limited conditions.

3.2 Comparisons with national figures

To provide some element of national comparison for the region's rivers and streams, the median DIN and DRP concentrations measured as part of the RSoE programme are compared with published national figures (NIWA, 2008). The comparison is made within elevation and land use classes, as detailed in Section 2.5.3 of this report.

3.2.1 DIN

Overall, the median DIN concentrations at 21 out of the 56 (37.5%) RSoE sites exceed the national median for their respective classes (Figure 5). This means that about two thirds of the RSoE sites have better (lower) median DIN concentrations than the national median, indicating that rivers in the Wellington region have, overall, lower DIN concentrations than nationally.

The regional median DIN concentration is lower (Table 7) than the corresponding national median for the three main classes represented in the Wellington region: Upland Native/Forested, Lowland Native and Lowland Pastoral. Together, these three classes represent more than 90% of the RSoE sites. In the urban class, three out of four sites exceed the national median. The fifth class (Upland Pastoral) is represented by only one site in the Wellington region (Waiohine at Bicknells, RS48), which exceeds the national median DIN concentration for this class.

Table 7: Median DIN (g/m^3) concentrations for different classes of streams (based on the River Environment Classification), nationally (as per NIWA 2008) and regionally (RSoE sites).

Class	National median	Regional median	% RSoE sites below national median	N. RSoE
Upland Native/Forested	0.089	0.050	69%	13
Upland Pastoral	0.111	0.305	0%	1
Lowland Native/Forested	0.125	0.098	75%	12
Lowland pastoral	0.570	0.465	58%	26
Urban	0.900	1.303	25%	4

3.2.2 DRP

Overall, just over half (53%) of the RSoE sites present lower median DRP concentrations than the national median for their national class (Figure 6). This indicates that, from a regional perspective, DRP concentrations across the Wellington region are probably consistent with what is measured in the rest of the country.

However, the regional medians for pastoral sites – both upland and lowland- exceed the national figures, and all of the Wellington region's urban sites largely exceed the national median (Table 8). This is balanced by sites with a catchment dominated by native or forested land use, where more than two thirds of sites have lower median DRP concentrations than the national median.

Table 8: Median DRP (g/m^3) concentrations for different classes of streams (based on the River Environment Classification), nationally (as per NIWA 2008) and regionally (RSoE sites).

Class	National median	Regional median	% RSoE sites below national median	N. RSoE
Upland Native/Forested	0.006	0.005	69%	13
Upland Pastoral	0.009	0.018	0%	1
Lowland Native/Forested	0.010	0.008	75%	12
Lowland pastoral	0.016	0.017	46%	26
Urban	0.017	0.035	0%	4

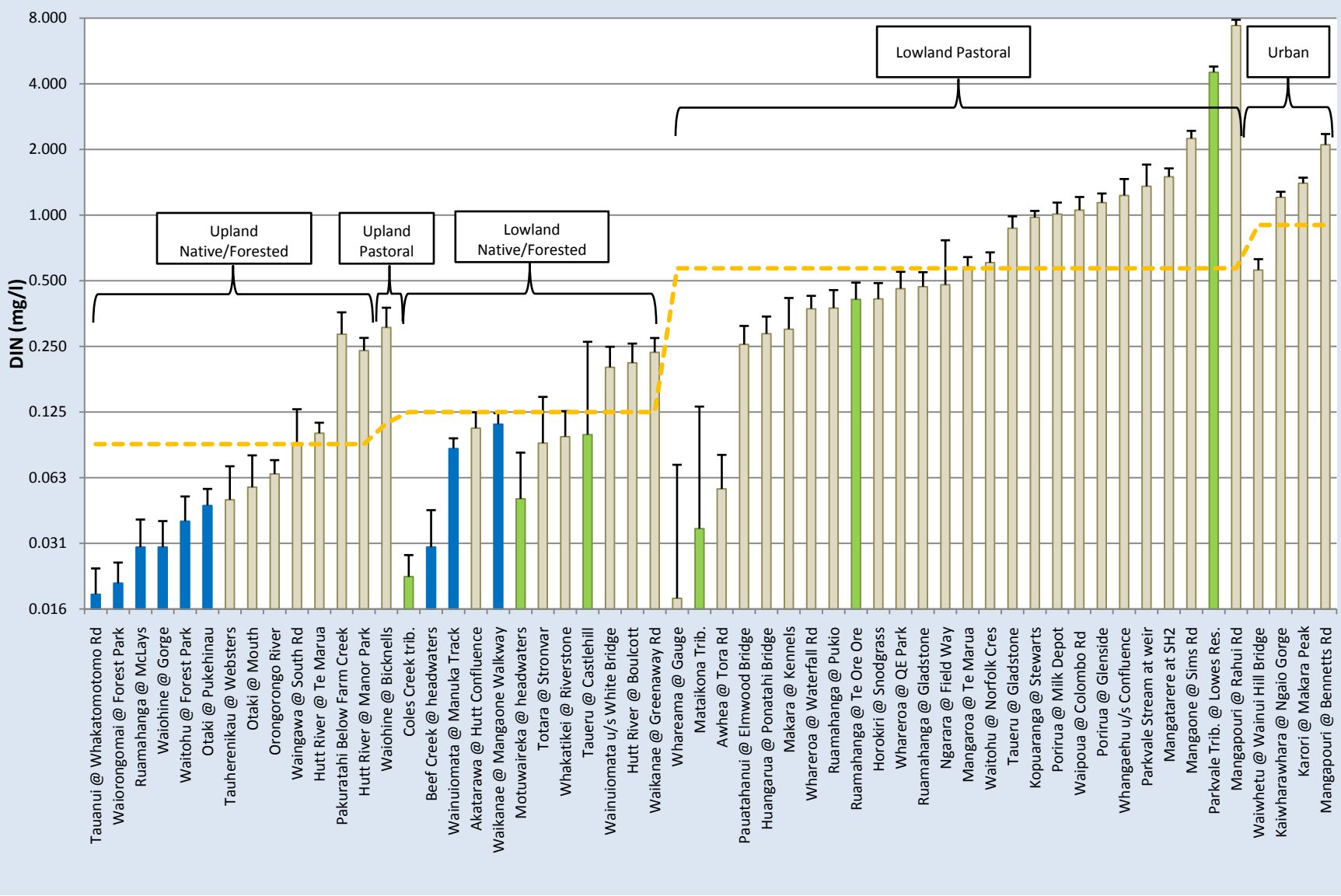


Figure 5: Median DIN concentrations at RSoE sites in different REC elevation/catchment landuse classes. The dotted orange line represents the national median DRP concentrations for each class.

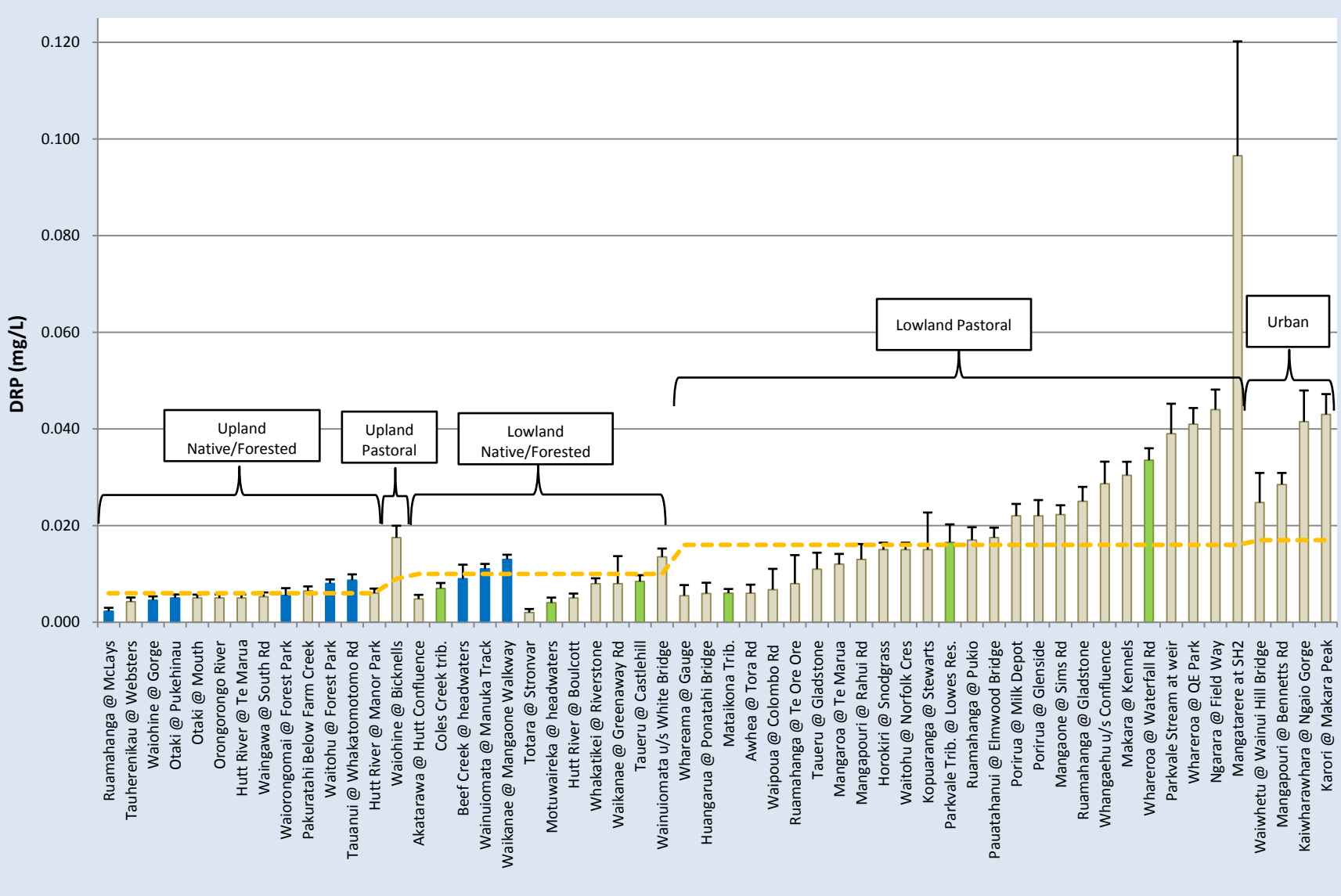


Figure 6: Median DRP concentrations at RSoE sites in different REC elevation/catchment landuse classes. Blue bars represent "reference" sites. Green bars represent "best available" sites. The dotted orange line represents the national median DRP concentrations for each class.

4 FENZ river classes

This section examines nutrient concentration, nutrient ratio, and periphyton cover and biomass data within each FENZ-based stream class (Warr, 2010a) represented in the existing RSoE network.

4.1 Class C5

Class C5 includes small streams occurring in moderately coastal locations with mild, maritime climates and low frequencies of days with significant rainfall. Stream gradients are generally moderate and substrates are predominantly coarse gravels (Warr, 2010a).

This class is represented by 11 sites, including one reference site (RS09, Waikanae at Mangaone Walkway) and three "best available" sites (RS11, Whareroa at Waterfall Road; RS35, Mataikona Tributary and RS43, Motuwaireka at headwaters).

Six of the seven "impacted" sites are streams in the Mana/Makara area, with the last site (RS44, Totara Stream at Stronvar) in the Northern Wairarapa area (Table 9).

All sites in the C5 class have mean accrual periods in excess of 20 days, meaning relatively stable flow conditions. In particular, the Waikanae River at Mangaone Walkway, the Whareroa Stream at Waterfall Rd, the Mataikona Tributary at Sugar Loaf Rd, the Motuwaireka at Headwaters, the Pauatahanui Stream at Elmwood Bridge, and the Totara Stream at Stronvar all have mean accrual periods in excess of 26 days, a strong indication of likely prolonged accrual periods in summer, favouring the establishment of periphyton.

Table 9: Class C5 RSoE sites, and summary of land use in the catchment upstream of each site.

Site No.	Site Name	Site class	Elevation	Land use (% catchment)			
				Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS09	Waikanae @ Mangaone Walkway	Reference	Lowland	86	12	2	0
RS11	Whareroa @ Waterfall Rd	Best available	Lowland	21	45	34	0
RS35	Mataikona Trib.	Best available	Lowland	62	7	31	0
RS43	Motuwaireka @ Headwaters	Best available	Lowland	68	32	0	0
RS14	Pauatahanui @ Elmwood Bridge	Impacted	Lowland	21	18	60	1
RS15	Porirua @ Glenside	Impacted	Lowland	13	16	45	25
RS16	Porirua @ Milk Depot	Impacted	Lowland	12	20	39	28
RS17	Makara @ Kennels	Impacted	Lowland	3	52	43	2
RS18	Karori @ Makara Peak	Impacted	Lowland	42	5	3	50
RS19	Kaiwharawhara @ Ngaio Gorge	Impacted	Lowland	36	18	8	38
RS44	Totara @ Stronvar	Impacted	Lowland	1	97	2	0

4.1.1 DIN

At 0.110 mg/L, the median DIN concentration in the Waikanae River at Mangaone Walkway (RS09) is well below the well below the ANZECC upland (0. 177 mg/L) guideline. There does not appear to be any significant variation in the DIN concentration under base or low flow conditions (Figure 7).

Similar or lower DIN concentrations are recorded at two of the three "best available" sites (RS35, Mataikona Tributary and RS43, Motuwaireka at headwaters). Similarly to the reference site, the DIN concentrations remain stable across a range of river flow conditions.

The third "best available" site (RS11, Whareroa at Waterfall Road) has a higher median DIN concentration (0.372 mg/L), well in excess of the ANZECC upland guideline but still below the ANZECC lowland guideline (0.465 mg/L). There is a strong pattern of decreasing DIN concentration at lower river flows, with the median DIN under low flow conditions (0.180 mg/L) comparable to the upland ANZECC guideline.

Of the other sites, three largely comply with the lowland ANZECC guideline. At two of these sites (RS14, Pauatahanui at Elmwood Bridge and RS17, Makara at Kennels), there is again a strong pattern of decreasing DIN concentration at lower flows, with the median DIN concentrations under base flow conditions (0.100 and 0.070 mg/L respectively) well below the upland ANZECC guideline, and comparable with reference conditions at RS09. The median DIN concentration at the third site (RS44, Totara at Stronvar) is also comparable (0.090 mg/L) to those measured at the reference site.

The remaining four sites have median DIN concentrations well in excess of the lowland ANZECC guideline, representing a 10 to 14-fold increase compared with reference conditions. Two of these sites, both on the Porirua Stream (RS15 at Glenside and RS16 at Milk Depot) display a clear pattern of reduced median DIN concentrations under base stream flow conditions, although they always remain well in excess of the lowland ANZECC guideline. Median DIN concentrations at the other two sites (RS18, Karori at Makara Peak and RS19, Kaiwharawhara at Ngaio Gorge) remain stable under low flow conditions.

4.1.2 DRP

The median DRP concentration at the C5 reference site (RS09, Waikanae River at Mangaone Walkway) of 0.013 mg/L exceeds both the upland (0.009 mg/L) and lowland (0.010 mg/L) ANZECC guidelines. Similar to DIN, the median DRP concentration at this site remains similar at lower river flows (Figure 8).

Three sites had lower (than reference conditions) median DRP concentrations, including two of the three "best available' sites (RS35, Mataikona Tributary and RS43, Motuwaireka at headwaters) and the Totara Stream at Stronvar (RS44).

All other sites have DRP concentrations well in excess of the ANZECC guidelines and the concentrations measured under reference conditions. The highest DRP concentrations are recorded at sites RS18 (Karori at Makara Peak) and RS19 (Kaiwharawhara at Ngaio Gorge), the same two sites where the highest DIN concentrations are measured.

At most sites, there is a pattern of increasing median DRP concentrations under lower flow conditions. These patterns are generally observed in situations where there are point-source discharges into the streams, or when the base flow conditions are dominated by inputs from phosphorus-rich groundwater.

4.1.3 Periphyton

Periphyton biomass and cover at the reference site in this class (Waikanae River at Mangaone Walkway) have always been low, well below the recommended guidelines for the protection of aquatic values (Table 10).

All three "best available" sites have always complied with even the most stringent periphyton biomass guideline, although all three sites, including the two sites that have nutrient concentrations lower than the reference site, show occasional exceedances of the filamentous algae cover guidelines. Mean accrual period at these three sites are in excess of 26 days (Appendix A), which indicates a relatively low level of flow disturbance. Stable flow conditions are likely to lead to the establishment of significant periphyton cover, even though the biomass appears to remain at low levels, possibly controlled by the low nutrient concentrations.

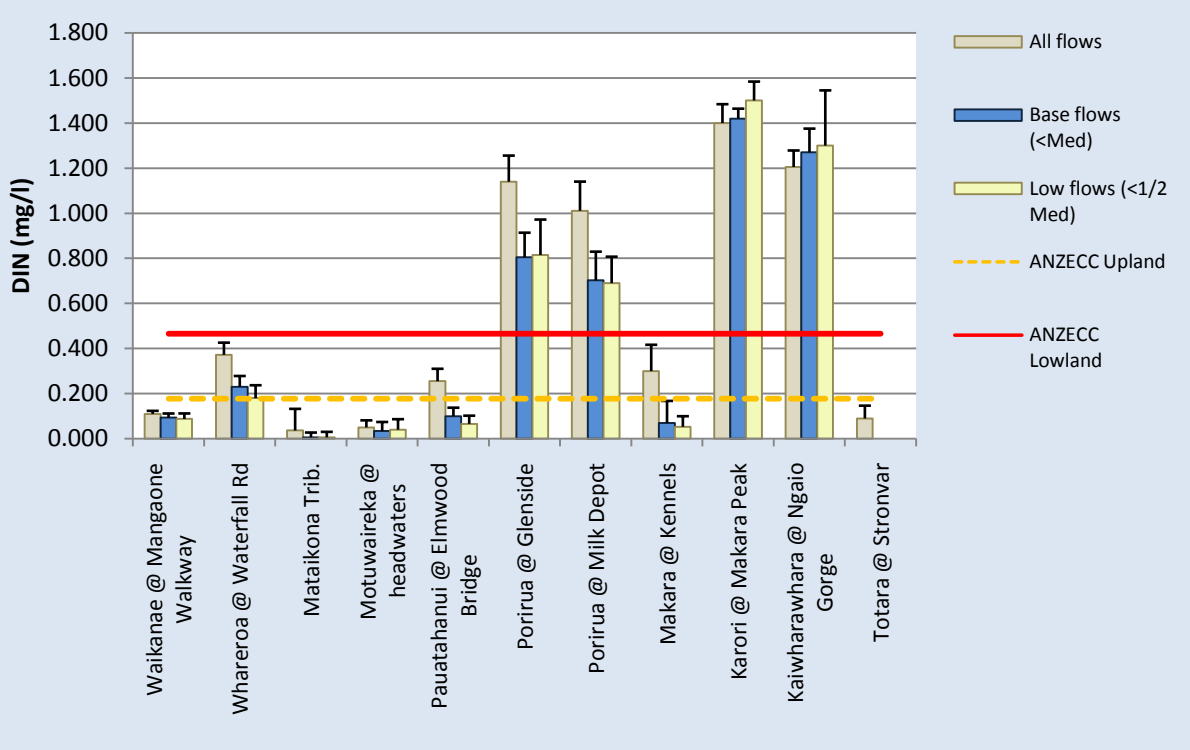


Figure 7: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the C5 FENZ Class.

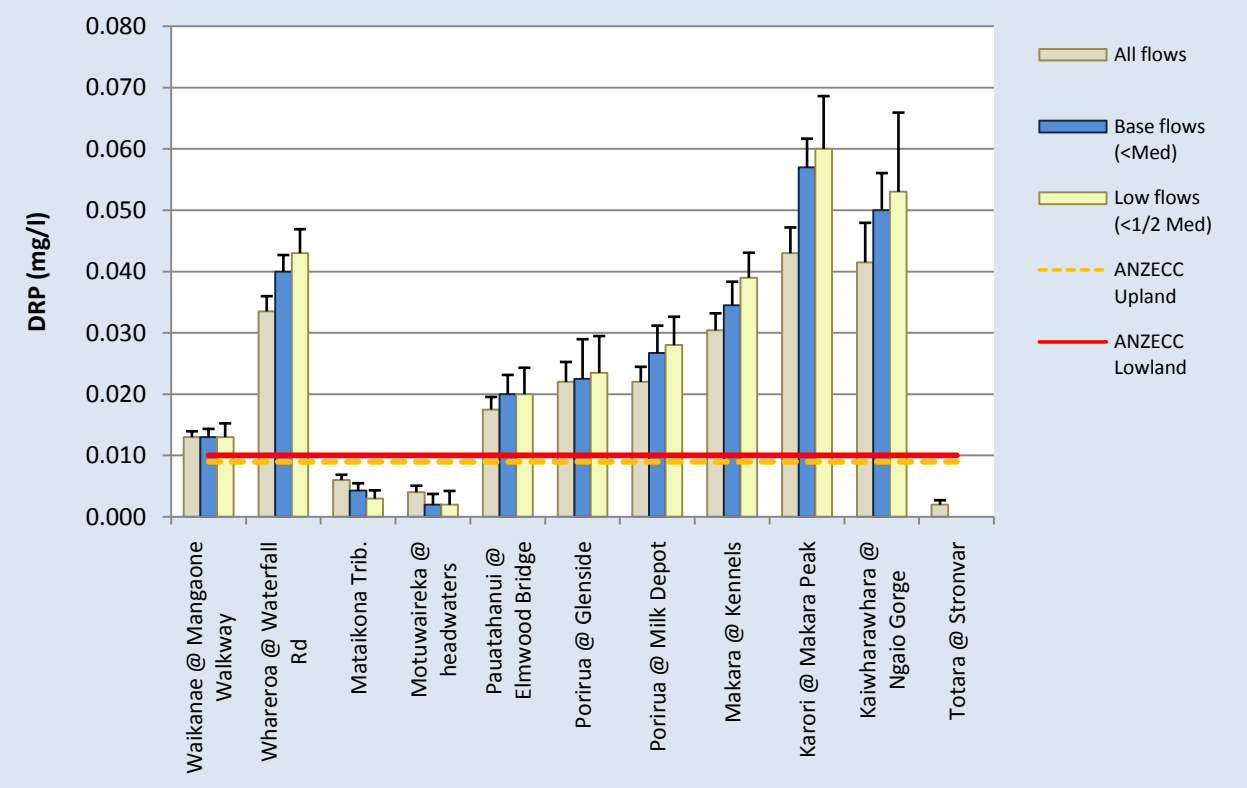


Figure 8: Median DRP concentrations (±95 % confidence interval) for RSoE sites in the C5 FENZ Class.

Monitoring shows compliance with the periphyton biomass guideline, but regular exceedances of the periphyton cover guidelines in the Totara Stream at Stronvar, in spite of nutrient concentrations similar to (DIN) or lower than (DRP) reference concentrations. Abundant periphyton growth at this site is believed to be encouraged by physical habitat conditions at the site, in particular the long accrual periods[3] that regularly occur in small streams in the eastern Wairarapa hills, and the lack of riparian cover/shading.

These results indicate that, even with low nutrient concentrations, some exceedances should be expected in Class 5 streams if habitat conditions are favourable to periphyton growth.

Two of the other "impacted" sites (Makara at Kennels and Pauatahanui at Elmwoood Bridge) show occasional breaches of both the biomass and cover guidelines. Nuisance macrophyte growth also frequently occurs in the slow sections of these streams, but generally not at the monitoring sites themselves (Alton Perrie, pers. comm.).

The remaining four "impacted" sites show regular (i.e. 5 times or more) exceedances of the filamentous periphyton cover guideline, but have never been found to exceed the biomass guideline applicable to these sites (120 mg/m^2).

4.1.4 Nutrient limitations

The DIN:DRP ratios at the reference site for this class (RS09) indicate generally co-limited conditions, with a tendency towards lower ratios, i.e. N-limited conditions, at lower river flows (the median DIN:DRP ratio at flows below half median flow is 6) (Figure 9).

Similarly, DIN:DRP ratios at the three "best available" sites indicate a predominance of co-limited conditions most of the time, with a tendency towards lower ratios at lower river flows. This pattern is particularly apparent in the Mataikona tributary (RS35), where DIN:DRP ratios strongly indicate N-limited conditions under base flow conditions. It should be noted however, that high concentrations of both nutrients at the Whareroa at Waterfall Rd (RS11) probably means that any nutrient limitation is weak.

Out of the seven "impacted" sites, two (RS14 and RS17) show similar patterns, with a move from co-limited conditions towards N-limited conditions under low flow situations. This pattern is particularly marked in the Makara Stream at Kennels (RS17), where there is a very strong indication of N-limited conditions under base flow conditions.

Four of the impacted sites exhibit high DIN:DRP ratios, indicating possible P-limited conditions. These four sites are also those where very high DIN concentrations are measured, i.e. the imbalance is primarily caused by the high DIN concentrations. These four sites present Two of these sites present moderate (the two monitoring sites on the Porirua Stream, RS15 and RS16)) or high (Karori at Makara Peak, RS18 and Kaiwharawhara at Ngaio Gorge, RS19) DRP concentrations, indicating that any nutrient limitation is likely to be weak (RS15 and RS16) or non-existent (RS18 and RS19).

The Totara Stream at Stronvar has a median DIN:DRP of 18, generally indicative of co-limited conditions. When looking at individual data points, it appears that conditions "switch" frequently between N-limited conditions (DIN:DRP < 4 approximately 25% of the time) and P-limited conditions (DIN:DRP>20 approximately 48% of the time). The general pattern remains the same when looking only at the summer (November to April period), but with a predominance of N-limited conditions (36%) and co-limited conditions (44%), and less commonly P-limited conditions (20%).

[3] The mean accrual period for the Totara at Stronvar site is 32 days (Appendix A).

Table 10: Summary of exceedances of periphyton guidelines at RSoE sites in the C5 class.

Site No.	Site Name	Site class	Biomass		Cover	
			50mg/m^2	120 mg/m^2	Mats	Filamentous
RS09	Waikanae @ Mangaone Walkway	Reference	0	0	0	0
RS11	Whareroa @ Waterfall Rd	Best available	0	0	0	1
RS35	Mataikona Trib.	Best available	0	0	1	1
RS43	Motuwaireka @ Headwaters	Best available	0	0	2	3
RS14	Pauatahanui @ Elmwood Bridge	Impacted	3	1	0	3
RS15	Porirua @ Glenside	Impacted	1	0	0	6
RS16	Porirua @ Milk Depot	Impacted	1	0	0	5
RS17	Makara @ Kennels	Impacted	1	1	2	0
RS18	Karori @ Makara Peak	Impacted	1	0	1	6
RS19	Kaiwharawhara @ Ngaio Gorge	Impacted	3	0	0	6
RS44	Totara @ Stronvar	Impacted	0	0	3	10

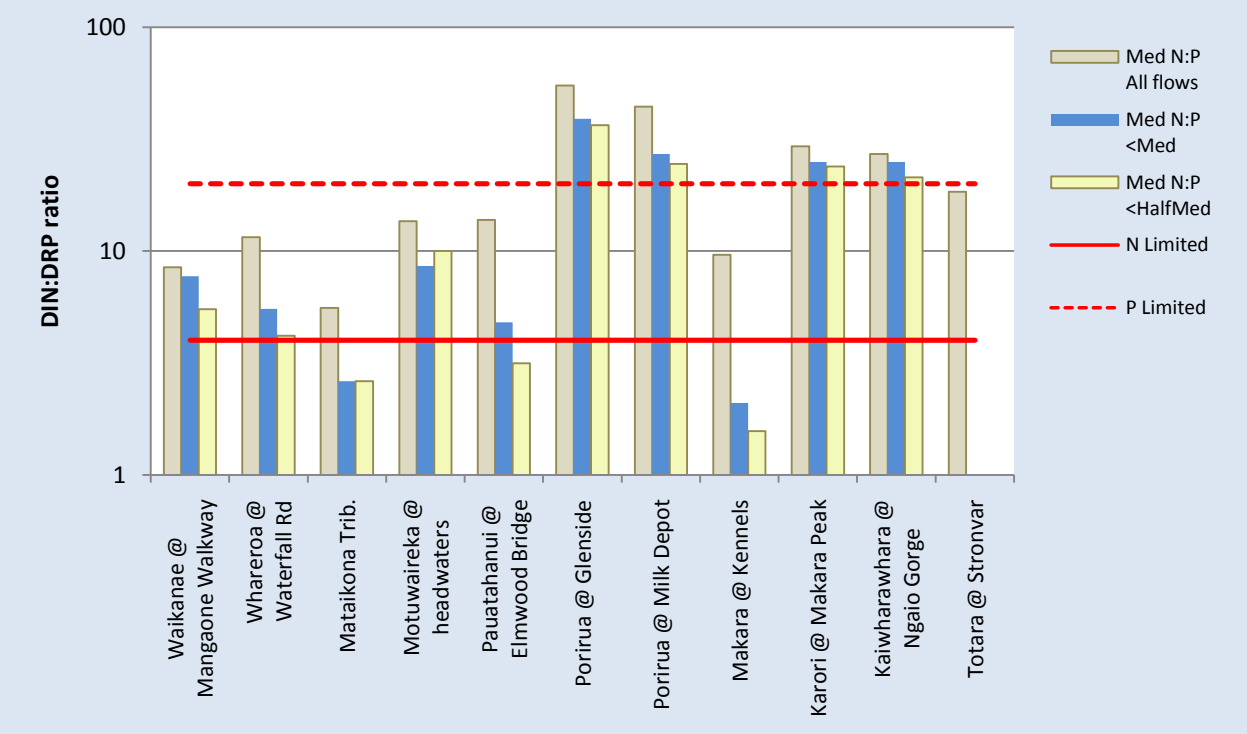


Figure 9: Median DIN:DRP ratios at RSoE sites in the C5 FENZ class. The part of the graph above the top (dashed) red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom (solid) red line (DIN:DRP =4) is indicative of N-limited conditions.

4.1.5 Conclusions

Reference and "best available" conditions in the C5 class indicate low DIN concentrations, and DRP concentrations that can be naturally moderately elevated. Co-limited conditions prevail, with a tendency towards N-limited conditions at low river flows. Periphyton growth remains low at the only reference site in this class.

Even sites with low nutrient concentrations show occasional exceedances of periphyton guidelines, particularly the periphyton cover guidelines. This is the case at the three "best available" sites. The Totara Stream also shows regular excessive periphyton growth in spite of very low nutrient concentrations. This is important in setting expectations for this class of streams, (i.e. moderate periphyton growth, characterised by generally low biomass but high cover, can be expected even under low nutrient concentrations, as long as physical habitat remains particularly suitable for periphyton growth). The long periods of stable or low flows naturally experienced by some of these streams are certainly significant factors in explaining the moderately elevated periphyton growths, but anthropogenic influences, such as the reduction of base flows through water abstraction, and particularly the removal of riparian shading are other likely significant contributors to the problem. This underlines the importance of riparian cover and preservation of base flows in small streams.

However, sites with higher nutrient concentrations, in particular the four sites with very elevated DIN concentrations (the two sites on the Porirua Stream, the Kaiwharawhara Stream and Karori Stream) display increased exceedances of the filamentous periphyton cover guideline.

The three remaining sites (Makara at Kennel, Pauatahanui at Elmwood Bridge and Mataikona Tributary) display occasional exceedances of periphyton cover and/or biomass guidelines, and a strong indication of N-limiting conditions during periods of low river flows. The direct management implication is that any increase in DIN inputs, particularly during periods of low flows may directly result into an increase in periphyton growth. DIN should therefore be managed as a priority in these catchments.

Finally, the Pauatahanui and Porirua streams act as nutrient source for the downstream receiving environment, i.e. the Porirua Harbour. Given the presence of localised macroalgae proliferation issues in the Porirua harbour (e.g. Stevens and Robertson, 2009), nutrient inputs to these streams should be managed in relation to algae growth issues in both the harbour and the streams themselves.

4.2 Class C7

Class C7 predominantly contains streams and rivers occurring in the lowland hills of the Tararua, Aorangi and Rimutaka ranges, with mild climates and low frequencies of days with significant rainfall. Stream gradients are generally steep and substrates are generally coarse gravels.

This class contains sites in the upper reaches of the Region's main rivers, including the Otaki, Hutt and Ruamahanga Rivers and their tributaries. As such it provides some information on "upstream conditions" for rivers and streams in Class C6a.

Thirteen regional SoE sites are classified as C7, including 8 that are considered as reference sites. The reference sites are presented on the left-hand side of the following graphs (Waitohu at Forest Park to Waiorongomai at Forest Park).

The uppermost Hutt River site (Hutt at Te Marua) is classified as "impacted" (primarily due to water abstraction) but has 87% of its catchment in native vegetation, with an additional 7% in scrub and exotic forest, making this site a "close to reference" or best available site for the Hutt River in relation to nutrients. Similarly, the 95% of the catchment above the Orongorongo River monitoring site is forested (84% native vegetation and 11% scrub), and 96% of the catchment above the Akatarawa at Hutt confluence monitoring site is forested (79% native vegetation, 16% exotic forest and 1% scrub). Of the thirteen sites, only the Mangaroa at Te Marua classifies as "pastoral" land-use (Table 11).

Most of the C7 sites are characterised by relatively low mean accrual periods (i.e. less than 20 days), meaning that periphyton will generally have limited periods of time to establish peak biomass (Appendix A). This is particularly the case for the upper reaches of the main rivers, i.e. the Ruamahanga at McLays (13 days), Waiohine at Gorge (15 days), Hutt River at Te Marua (15 days) and the Otaki at Pukehinau (16 days). On the other hand, the Mangaroa at Te Marua, Wainuiomata at Manuka Track and the Tauanui at Whakatomotomo Rd are characterised by more stable flow conditions (mean accrual periods of 24, 27 and 24 days respectively).

Table 11: Class C7 RSoE sites, and summary of land use in the catchment upstream of each site.

Site No.	Site Name	Site class	Elevation	Land use			
				Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS03	Waitohu @ Forest Park	Reference	Upland	94	4	2	0
RS05	Otaki @ Pukehinau	Reference	Lowland	95	1	2	0
RS28	Wainuiomata @ Manuka Track	Reference	Upland	100	0	0	0
RS31	Ruamahanga @ McLays	Reference	Upland	99	0	0	0
RS47	Waiohine @ Gorge	Reference	Lowland	98	1	0	0
RS49	Beef Creek @ Headwaters	Reference	Upland	100	0	0	0
RS52	Tauanui @ Whakatomotomo Rd	Reference	Lowland	100	0	0	0
RS56	Waiorongomai @ Forest Park	Reference	Lowland	100	0	0	0
RS20	Hutt River @ Te Marua	Impacted	Lowland	87	7	6	0
RS23	Pakuratahi Below Farm Creek	Impacted	Lowland	70	17	13	0
RS24	Mangaroa @ Te Marua	Impacted	Lowland	49	18	32	1
RS25	Akatarawa @ Hutt Confluence	Impacted	Lowland	79	17	3	0
RS30	Orongorongo River	Impacted	Lowland	84	11	2	0

4.2.1 DIN

All 8 reference sites present low median DIN concentrations, ranging from 0.018 to 0.085 mg/L, all well below the ANZECC guideline for upland rivers. DIN concentrations at these reference sites appear stable at different river flows (Figure 10).

Of the remaining five sites:

- The Hutt River at Te Marua has a median DIN concentration (0.100 mg/L) slightly above the range of reference conditions, but still well below the ANZECC upland guideline;
- The Pakuratahi below Farm Creek (RS23) has a higher median DIN concentration (0.285 mg/L), in excess of the ANZECC guideline for upland streams, but still well below the lowland guideline;
- The Mangaroa at Te Marua (RS24) has the highest DIN concentrations in this class, and is the only C7 site with a median that exceeds the ANZECC guideline for lowland streams. Interestingly, this site is also the C7 class with the highest proportion (32%) of its catchment in pastoral land use;
- The remaining two sites (Akatarawa and Orongorongo Rivers) have median DIN concentrations within the range of concentrations measured at reference sites. Both sites also have 95% or more of their catchment in native or exotic forest and scrub.

4.2.2 DRP

Seven out of the 8 reference sites complied with the upland ANZECC guidelines. The range of median DRP concentrations at these sites was 0.002 to 0.009 mg/L (Figure 11).

The remaining reference site, the Wainuiomata at Manuka Track, has a higher median DRP concentration than the rest of the reference sites: 0.011 mg/L, increasing to 0.013 mg/L under low flow conditions.

All but one of the non-reference sites have DRP concentrations within the range of concentrations measured at reference sites, and the median concentration complied with the upland ANZECC guideline. The Mangaroa at Te Marua has the highest median DRP concentration of this class (0.012 mg/L), although only marginally higher than the Wainuiomata at Manuka Track. The DRP concentrations at this site decrease with stream flow conditions to a median of less than 0.007 mg/L under low flow conditions.

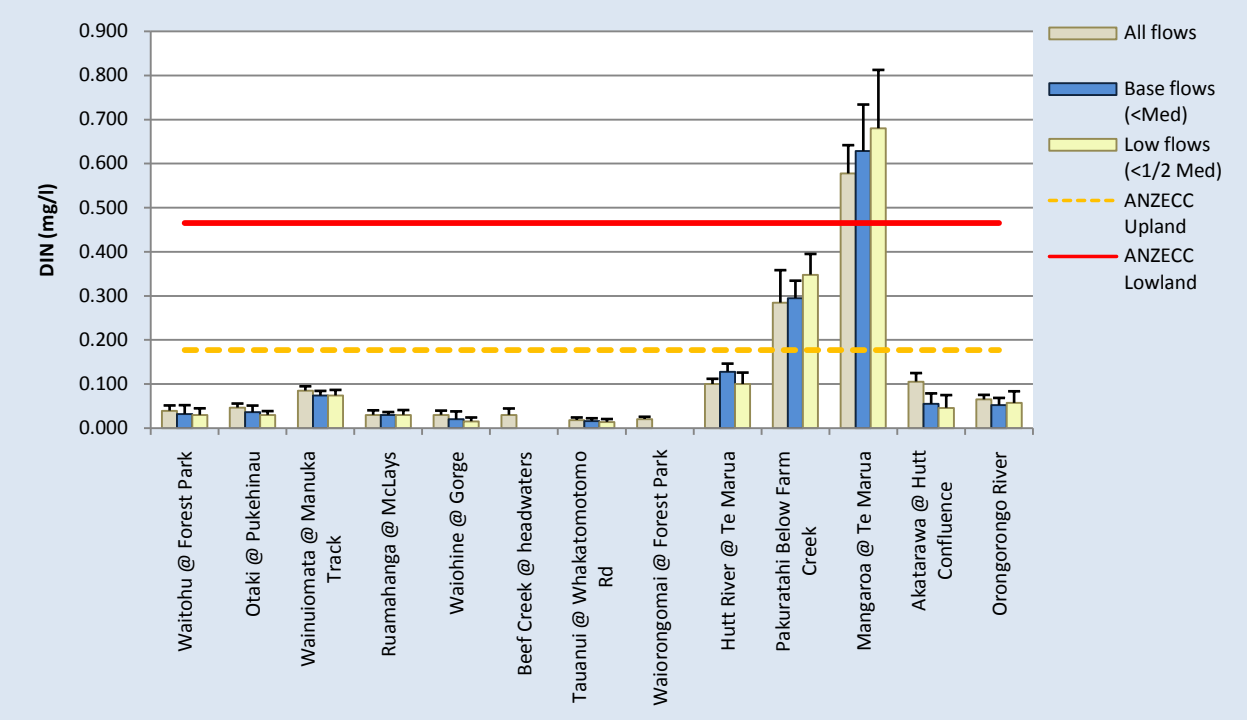


Figure 10: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the C7 FENZ Class.

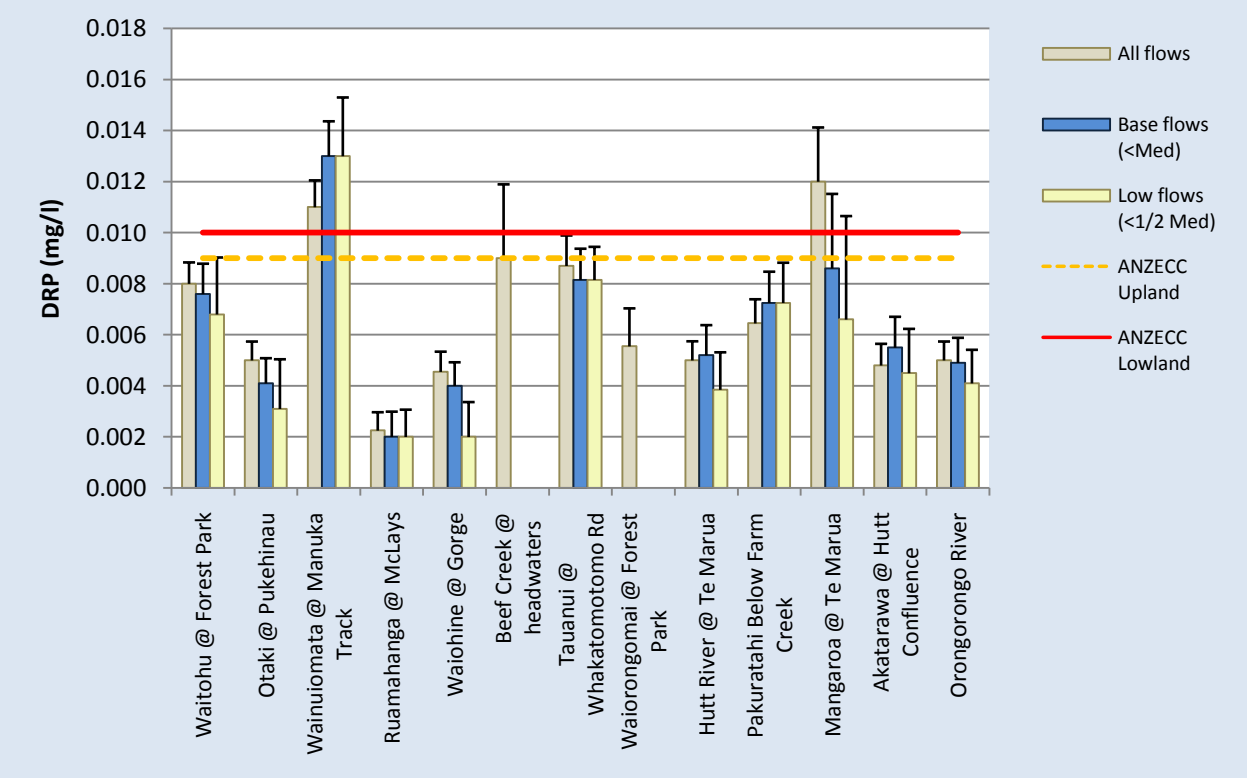


Figure 11: Median DRP concentrations (±95 % confidence interval) for RSoE sites in the C7 FENZ Class.

4.2.3 Periphyton

All sites in the C7 class have always complied with the 120 mg chlorophyll *a*/m^2 biomass guideline, and all but two also always complied with the more stringent 50 mg chlorophyll *a*/m^2 for the protection of high biodiversity values (Table 12). The Pakuratahi River breached this guideline only once, and only marginally (60 mg/m^2). The Mangaroa at Te Marua exceeded this guideline on most sampling occasions (4 out 6). As explained in section 2.5.2, occasional exceedances of this guideline do not necessarily indicate a significant periphyton growth issue, but regular exceedances may compromise high biodiversity values. The Mangaroa at Te Marua is the only site that breaches both the mat and filamentous cover guidelines. It also has by far the highest median periphyton biomass of this class.

The Waiorongomai at Forest Park shows regular breaches of the filamentous algae cover guidelines, in spite of very low biomass (median =3 mg/m^2).

Table 12: Summary of exceedances of periphyton guidelines at RSoE sites in the C7 FENZ class.

Site No.	Site Name	Site class	Biomass		Cover	
			50 mg/m^2	120 mg/m^2	Mats	Filamentous
RS03	Waitohu @ Forest Park	Reference	0	0	0	0
RS05	Otaki @ Pukehinau	Reference	0	0	0	0
RS28	Wainuiomata @ Manuka Track	Reference	0	0	0	0
RS31	Ruamahanga @ McLays	Reference	0	0	0	0
RS47	Waiohine @ Gorge	Reference	0	0	0	0
RS49	Beef Creek @ headwaters	Reference	0	0	1	0
RS52	Tauanui @ Whakatomotomo Rd	Reference	0	0	0	1
RS56	Waiorongomai @ Forest Park	Reference	0	0	0	9
RS20	Hutt River @ Te Marua	Impacted	0	0	0	0
RS23	Pakuratahi Below Farm Creek	Impacted	1/6	0	0	1
RS24	Mangaroa @ Te Marua	Impacted	4/6	0	1	6
RS25	Akatarawa @ Hutt Confluence	Impacted	0	0	0	0
RS30	Orongorongo River	Impacted	0	0	0	2

4.2.4 DIN:DRP ratios

Three reference sites (Otaki at Pukehinau, Wainuiomata at Manuka Track and Ruamahanga at McLays) have median DIN:DRP ratios between 4 and 20 at all river flows, indicating a dominance of co-limited conditions (Figure 12, also refer to the graphs in Appendix D).

Two other reference sites (Waitohu at Forest Park and Waiohine at Gorge) have median DIN:DRP ratios below the 7.5 Redfield limit, and dropping further towards N-limited conditions under low river flow situations. Plots of DIN:DRP vs stream flow confirm that conditions at these sites are generally indicative of either co-limited or N-limited conditions (Appendix D).

Very low DIN:DRP ratios at the Tauanui at Whakatomotomo Rd strongly indicate N-limited conditions at this site. The last two reference sites, Beef Creek at Headwaters and Waiorongomai at Forest Park present median DIN:DRP ratios of 4 or less, with more than 75% of sampling occasions below 6 (Appendix F), indicating that N-limited conditions dominate at these sites, with co-limited conditions the remainder of the time. The absence of flow data for these sites precludes any flow-related analysis.

The Hutt River at Te Marua is predominantly P-limited at all flows, but with frequent co-limited conditions (also refer to Appendix D).

DIN:DRP ratios at Pakuratahi below Farm Creek and Mangaroa at Te Marua indicate a dominance of P-limited conditions at all flows.

Conditions at the Akatarawa at Hutt confluence appear to change between P-limited and co-limited conditions. However, N-limited conditions also occur about one third of the time when the flow is below half median flow.

Lastly, the Orongorongo River presents a dominance of co-limited conditions at all flows.

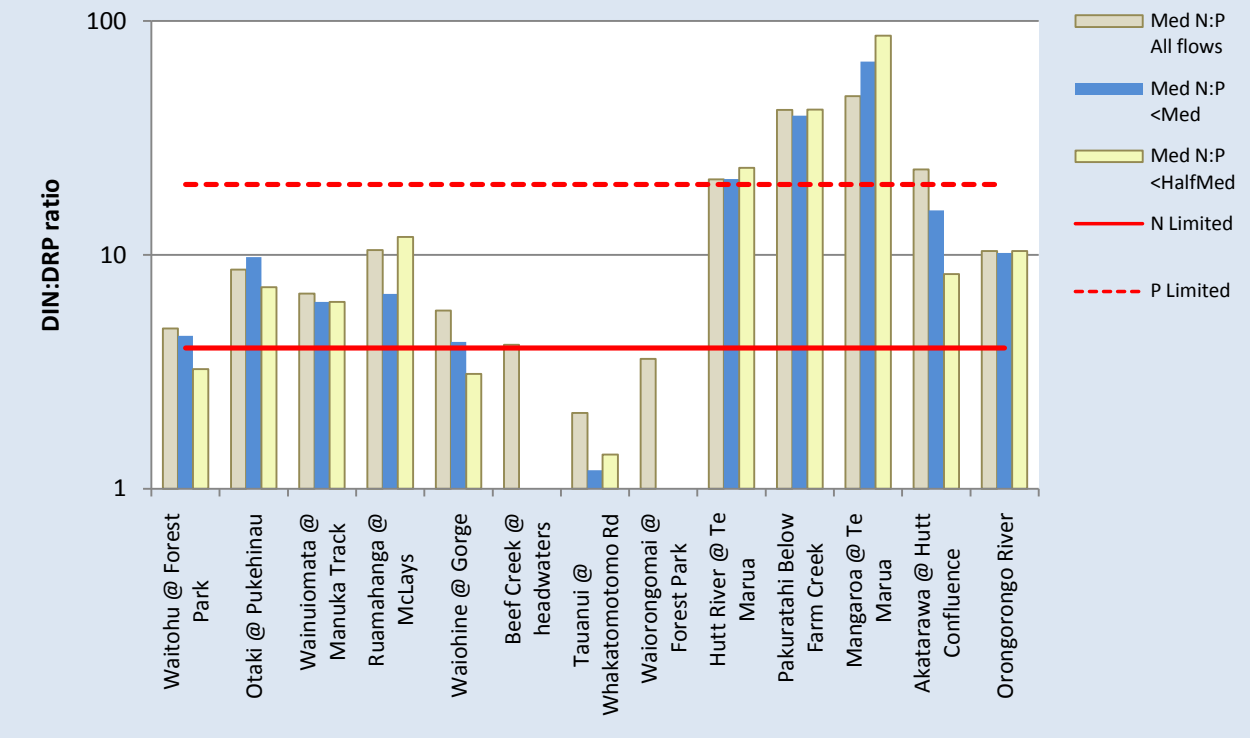


Figure 12: Median DIN:DRP ratios at RSoE sites in the C7 FENZ class. The part of the graph above the top (dashed) red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom (solid) red line (DIN:DRP =4) is indicative of N-limited conditions.

4.2.5 Conclusions

Most RSoE sites in the C7 class are representative of reference conditions, with 8 true reference sites and 3 additional sites that have 94% or more of their catchment in native or exotic forest, which makes them in effect close to reference sites for nutrients.

Median DRP concentrations under reference conditions in the C7 class are within a 0.002-0.009 mg/L range, except at one site. The Wainuiomata River at Manuka Track presents a higher median DRP concentration than the other reference sites (0.010 to 0.013 mg/L). This shows that similarly to what was noted in the C5 class, some streams in the C7 class can naturally have moderately elevated DRP concentrations. DRP concentrations at reference sites generally remain stable or decrease at low river flows.

The Mangaroa River at Te Marua is the only site that exceeds the "normal" DRP reference concentration range, although it does not exceed the concentrations observed in the upper Wainuiomata River.

Reference median DIN concentrations in the C7 class are very low, within a 0.020 to 0.085 mg/L range, and stable under different river flow conditions.

The sites that exceed the reference DIN range are the only two sites of this class with a significant proportion of their catchment in pastoral land use. The Pakuratahi below Farm Creek has only 13% of its catchment in pastoral landuse, and only exceeds the reference DIN range by a factor of 2.5. The Mangaroa at Te Marua has 32% of its catchment in pasture and cropping, and largely exceeds the reference range (7 times the upper bound) and the ANZECC guideline for lowland rivers.

Periphyton biomass remains very low at all sites, except in the Mangaroa at Te Marua where it regularly exceeds the stringent guideline for the protection of high biodiversity values (50 mg/m^2). The periphyton cover guidelines are exceeded regularly at two sites, the Waiorongomai at Forest Park, a reference site, and the Mangaroa at Te Marua.

Reference conditions in the C7 class are clearly dominated by a mix of co-limited and N-limited situations. Anthropogenic inputs of DIN at the only two sites influenced by pastoral landuse appear to cause a shift towards P-limited conditions.

4.3 Class C6a

Class C6a contains river sections with an upstream catchment dominated by class C7 streams. This includes streams and rivers fed by the Tararua, Rimutaka and Aorangi ranges. This class is primarily represented by the lower reaches of the region's larger rivers, such as the Otaki, Hutt and Ruamahanga rivers. These rivers generally have an open channel with cobble and gravel substrate and gentle gradient.

There are 15 RSoE sites classified as C6a (Table 13). Due to extensive development in the catchments of all C6a rivers in the Wellington region there are no reference sites available in this class. Class C7 reference sites in the upper Otaki, Hutt and Ruamahanga rivers and their tributaries provide the most relevant reference conditions for C6a sites.

Mean accrual periods are quite variable across this class (Appendix A). Sites on the Ruamahanga mainstem, as well as the Otaki River at Mouth, The Waingawa River at South Road, the Waiohine at Bicknells and the Tauherenikau at Websters have low mean accrual periods (14-17 days), indicative of frequent flow events that would "reset" periphyton biomass to near-zero levels. The Hutt River sites, the Waipoua at Colombo Road and the Mangatarere Stream have moderate mean accrual periods, in the order of 20 days. At the other end of the spectrum, the remaining four sites have high mean accrual periods (in excess of 26 days), making them more susceptible to long periphyton accrual periods.

4.3.1 DIN

The median DIN concentration at the Otaki at Mouth site is higher than at the upper Otaki site, but still within the range of reference DIN concentrations in the C7 class and well below the upland ANZECC guideline. Similarly, the Tauherenikau at Websters, the Waingawa at South Road and the Whakatikei at Riverstone have low median DIN concentrations (< 0.100 mg/L), within or marginally above the range of C7 reference conditions (Figure 13).

The Waikanae River at Greenway Road shows some increase compared with the reference DIN concentrations measured at C7 in the coastal Kapiti area, i.e. the upper Otaki and Waitohu sites (0.047 and 0.040 mg/L respectively). However, the DIN concentration in the Waikanae River decreases with the river flow, to 0.080 mg/l during periods of low river flows. A very similar pattern is observed in the Wainuiomata River at White Bridge, where the overall median DIN concentration (0.201 mg/L) is more than twice that of the reference upper Wainuiomata site (0.085 mg/L), but base flow DIN concentrations (0.065 mg/L) fall well within the range of reference conditions.

The two Hutt River sites in this class (at Manor Park and at Boulcott) have median DIN concentrations of 0.210 and 0.240 mg/l, stable with river flow. Although these concentrations still comply with the lowland

ANZECC guideline, they are more than twice the concentration in the upper Hutt River (at Te Marua, in Class C7), and 2-3 times the upper end of range of reference concentrations for the C7 class.

The overall median DIN concentration at the three sites in the middle and lower reaches of the Ruamahanga River (Te Ore ore, Gladstone and Pukio) are approximately 10-15 times the median concentration in the upper Ruamahanga River (at McLays – 0.030 mg/L), but remain below the lowland ANZECC guideline. DIN concentrations appear stable with flow at Te Ore Ore, but decrease sharply at low flow at Pukio.

The Waipoua at Colombo Road has an elevated median DIN concentration, more than twice the ANZECC guideline for lowland streams. Seventy-four percent of this site's upstream catchment is in pastoral, cropping or urban land use.

The Mangatarere at SH2 has the highest median DIN concentration of all C6a sites, due to a mixture of point- and non point-source discharges (Milne *et al.*, 2010).

The median DIN concentration in the Waiohine River at Bicknells is approximately 10 times higher than that in the upper river at the Gorge site (reference site), but still below the ANZECC guideline for lowland streams. This site is located approximately 4.5km downstream of the confluence with the Mangatarere Stream.

The Huangarua at Ponatahi Bridge has similar DIN concentrations to the Waiohine at Bicknells, *i.e.* above the range of reference conditions but still below the ANZECC guideline.

Table 13: Class C6a RSoE sites, and summary of land use in the catchment upstream of each site.

Site No.	Site Name	Site class	Elevation	Land use (% catchment)			
				Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS06	Otaki @ Mouth	Impacted	Lowland	88	3	8	0
RS10	Waikanae @ Greenaway Rd	Impacted	Lowland	65	16	18	1
RS21	Hutt @ Manor Park	Impacted	Lowland	69	16	11	4
RS22	Hutt @ Boulcott	Impacted	Lowland	67	15	12	6
RS26	Whakatikei @ Riverstone	Impacted	Lowland	65	26	8	0
RS29	Wainuiomata u/s White Bridge	Impacted	Lowland	65	21	9	6
RS32	Ruamahanga @ Te Ore Ore	Impacted	Lowland	26	4	67	1
RS33	Ruamahanga @ Gladstone	Impacted	Lowland	20	8	70	1
RS34	Ruamahanga at Pukio	Impacted	Lowland	24	7	68	1
RS40	Waipoua @ Colombo Rd	Impacted	Lowland	22	3	71	3
RS41	Waingawa @ South Rd	Impacted	Lowland	74	4	19	0
RS48	Waiohine @ Bicknells	Impacted	Lowland	64	4	30	1
RS50	Mangatarere @ SH2	Impacted	Lowland	43	7	49	1
RS51	Huangarua @ Ponatahi Bridge	Impacted	Lowland	18	4	78	0
RS55	Tauherenikau @ Websters	Impacted	Lowland	69	5	25	0

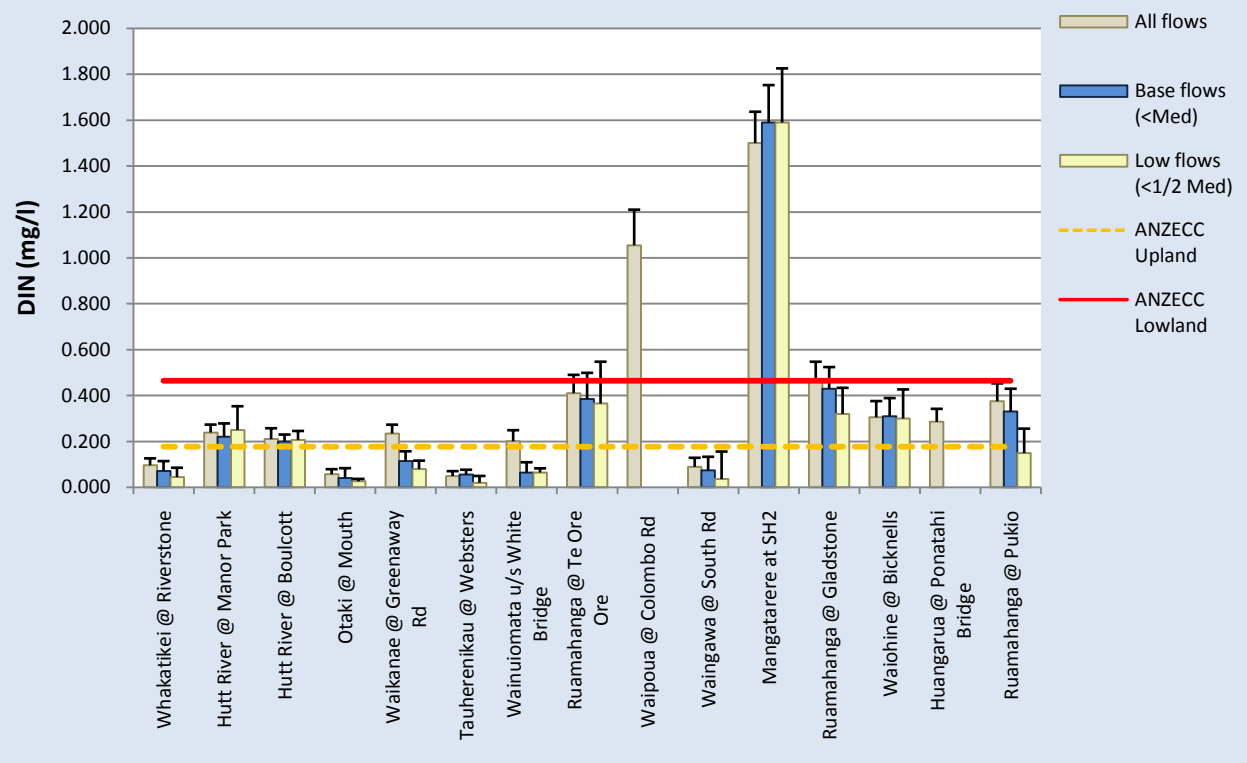


Figure 13: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the C6a FENZ Class.

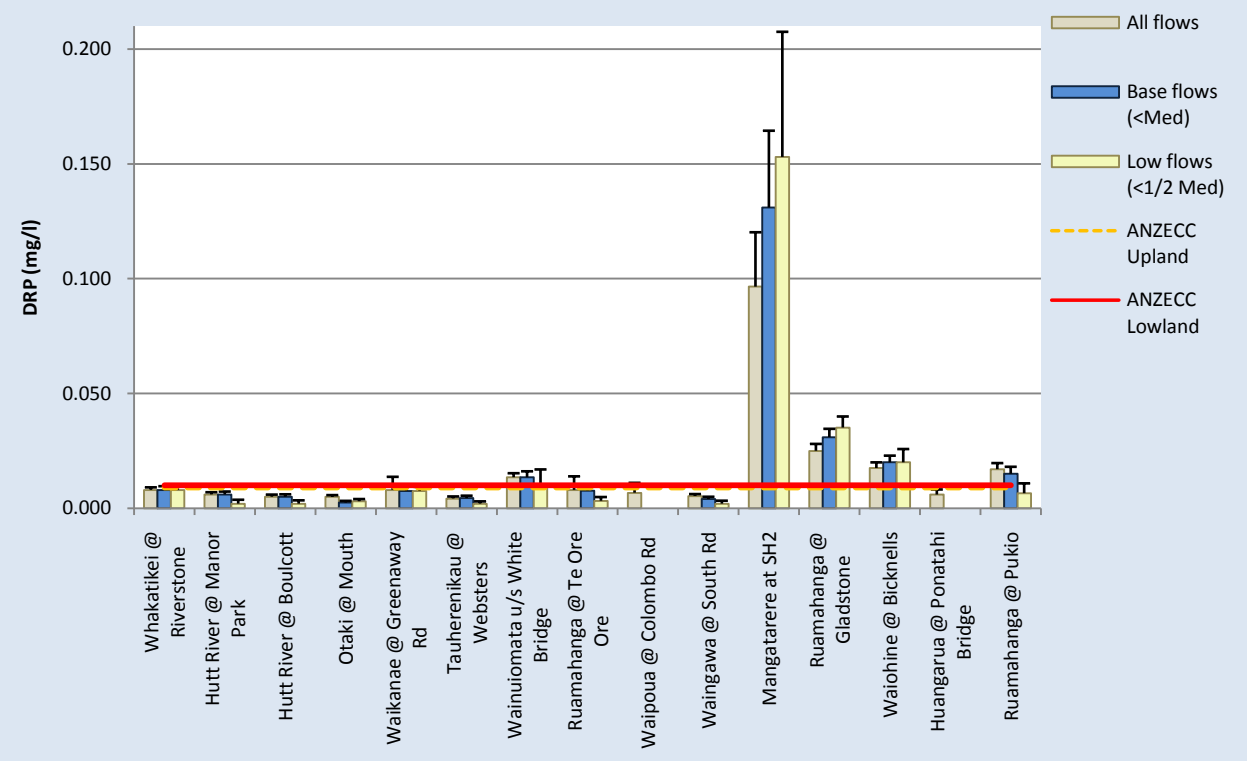


Figure 14: Median DRP concentrations (±95 % confidence interval) for RSoE sites in the C6a FENZ Class.

4.3.2 DRP

The Mangatarere at SH2 has by far the highest DRP concentration in the class, but also of all sites in the Wellington region (Figure 14). This site is located downstream of the discharge of treated wastewater from the Carterton wastewater treatment plant. There is a clear pattern of increasing DRP concentrations with decreasing stream flows, which is consistent with impacts associated with point-source discharges. More details on the Mangatarere catchment water quality can be found in a technical report recently produced by Greater Wellington Regional Council (Milne *et al.*, 2010).

The median DRP concentration in the Waiohine at Bicknells is 0.018 mg/l at all flows and 0.020 mg/L under base flow conditions. This is more than 3 times the reference concentration for this river (at Gorge), and outside the range of reference DRP in C7 class. This site is located downstream of the confluence with the Mangatarere Stream, so is likely influenced by water quality from the Mangatarere catchment, as well as land use in the middle Waiohine catchment.

The middle and lower Ruamahanga River sites present interesting DRP patterns. Te Ore Ore has an overall median DRP of 0.008 mg/L. This concentration is higher than in the upper Ruamahanga catchment (McLays) but still within the range of reference DRP concentrations from C7 sites. The median DRP concentration at Te Ore Ore drops to 0.003 mg/L under low flow conditions, i.e. towards the lower end of the range for C7 sites under low flow conditions. The decrease in DRP concentrations under low flow conditions may be due to the utilisation of the pool of available nutrients by the algal biomass. By contrast, the median DRP concentration at Gladstone is 0.025 mg/L, increasing to 0.031 mg/L under low flow conditions. Te Ore Ore and Gladstone are respectively upstream and downstream of the Masterton wastewater treatment plant discharge to the Ruamahanga River and the confluence of a number of tributaries, including the Waipoua, Whangaehu, Waingawa and Taueru rivers. The increase in DRP concentrations under low river flow conditions is consistent with the effects of a point-source discharge. It is noted however that the new resource consent for the Masterton wastewater treatment plant does not allow direct discharges during periods of low river flow. A decrease in low flow DRP concentrations is therefore expected in the future, once the existing treatment plant is upgraded. The overall median DRP concentration at Pukio is 0.017 mg/L. Similarly to what is observed at Te Ore Ore, the median DRP concentration drops considerably under low flow conditions, to 0.007 mg/L.

The Wainuiomata River at White Bridge presents a median DRP of 0.014 mg/L, similar to the reference conditions for this river (0.013 mg/L at Manuka Track).

The two Hutt River sites (Manor Park and Boulcott) have median DRP concentrations (0.005 and 0.006 mg/L respectively) well within the range of reference conditions from class C7, and similar to what is measured in the upper reaches of the Hutt River at Te Marua.

4.3.3 Periphyton

Six sites (Otaki at Mouth, Hutt at Manor Park, Whakatikei at Riverstone, Wainuiomata u/s White Bridge, Waiohine at Bicknells and Tauherenikau at Websters) have always complied with both the 50 and the 120 mg/m^2 periphyton biomass guidelines. Occasional exceedances of the periphyton cover guidelines have however been reported at all these sites.

The three Ruamahanga River sites and the Waingawa at South Road appear to occasionally exceed the most stringent (50 mg/m^2) biomass guideline, but have always complied with the higher (120 mg/m^2) guideline, which is probably more relevant to these lowland rivers. These sites also generally comply with the periphyton cover guidelines.

Table 14: Summary of exceedances of periphyton guidelines at RSoE sites in the C6a FENZ class.

Site No.	Site Name	Site class	Mean Accrual (days)	Biomass		Cover	
				50 mg/m^2	120 mg/m^2	Mats	Filamentous
RS06	Otaki @ Mouth	Impacted	16.7	0/6	0/6	3	1
RS10	Waikanae @ Greenaway Rd	Impacted	28.1	2/6	1/6	1	1
RS21	Hutt @ Manor Park	Impacted	19.5	0/6	0/6	1	0
RS22	Hutt @ Boulcott	Impacted	20.1	3/6	1/6	1	1
RS26	Whakatikei @ Riverstone	Impacted	26.2	0/6	0/6	0	4
RS29	Wainuiomata u/s White Bridge	Impacted	27	0/6	0/6	1	5
RS32	Ruamahanga @ Te Ore Ore	Impacted	16	2/6	0/6	0	0
RS33	Ruamahanga @ Gladstone	Impacted	14.3	1/6	0/6	1	0
RS40	Waipoua @ Colombo Rd	Impacted	21.8	2/6	1/6	4	1
RS34	Ruamahanga @ Pukio	Impacted	20.4	3/6	0/6	0	4
RS41	Waingawa @ South Rd	Impacted	15	1/6	0/6	0	0
RS48	Waiohine @ Bicknells	Impacted	14.2	0/6	0/6	0	1
RS50	Mangatarere @ SH2	Impacted	21.4	3/6	1/6	3	10
RS51	Huangarua @ Ponatahi Bridge	Impacted	29	4/6	3/6	3	18
RS55	Tauherenikau @ Websters	Impacted	14.9	0/6	0/6	0	4

Three sites, the Waikanae at Greenaway Rd, the Hutt at Boulcott and the Waipoua at Colombo Rd, have exceeded the 50 mg/m^2 guideline on at least 2 out of 6 occasions, and the higher 120 mg/m^2 biomass guideline once. Occasional exceedances of the periphyton cover guidelines (both mats and filamentous guidelines) have also been reported at these sites. . However, weekly assessment of periphyton cover undertaken between November and March as part of the Recreational Water Quality Monitoring Programme suggests more frequent exceedances, as well at the other Hutt River site in this class (RS21, Hutt River at Manor Park). High algal biomass at these sites is generally dominated by the potentially toxic cyanobacteria genus *Phormidium* (Warr 2010). Together these results and observations indicate a moderate periphyton growth issue at these four sites.

Monitoring results for the Mangatarere Stream at SH2 site indicate that periphyton biomass has exceeded the 50 mg/m^2 guideline regularly, and the higher 120 mg/m^2 biomass guideline once. The periphyton cover guidelines for both mats and filamentous growths are also exceeded on a regular basis. The Huangarua at Ponatahi Bridge is the only site in the class that exceeds all guidelines, including the 120 mg/m^2 biomass guideline, on a regular basis. Interestingly this site also has the longest mean accrual period in this class (29 days). These results are indicative of a significant periphyton growth issue at both sites.

4.3.4 DIN:DRP ratios

DIN:DRP ratios for the Otaki River at Mouth indicate a predominance of co-limited conditions (Figure 15), i.e. similar to the reference conditions for this river (Otaki at Pukehinau in class C7).

The Waikanae River site is probably essentially P-limited, with some co-limited conditions during periods of low flows. N-limited conditions appear to be rare at this site: only 9% of low flow samples show DIN:DRP ratios below 7.5.

DIN:DRP ratios at both Hutt River sites strongly indicate P-limited conditions at all times.

The Whakatikei, Wainuiomata and Tauherenikau Rivers appear to be dominated by co-limited conditions, with a tendency towards N-limited conditions at low flows.

The Ruamahanga at Te Ore Ore appears to be clearly P-limited. The ratios become indicative of co-limited conditions at Gladstone, although the relatively elevated concentrations of both nutrients probably mean that the nutrient limitation is quite weak. This is essentially due to a significant increase in the DRP concentration between the two sites (the DIN concentration remains similar). In this situation, it would appear that the DRP inputs between these two sites (including the imput from the Masterton WWTP discharge) are removing the DRP limitation existing at Te Ore Ore. Ratios at Pukio are indicative of weakly P-limited conditions.

DIN:DRP ratios for the Waipoua River at Colombo Rd site are virtually always (more than 96% of the time) above 20, providing a strong indication of dominant P-limited conditions at this site. Similarly, P-limited conditions appear to dominate at the Huangarua at Ponatahi Bridge site, although co-limited conditions may occur about 25 % of the time.

The Waingawa at South Road is probably P-limited, but with frequent occurrences of co-limited and even N-limited conditions at low flows. The Waiohine at Bicknells is essentially P-limited, with frequent co-limited conditions.

Finally, given the very high DIN and DRP concentrations measured at the Mangatarere at SH2 site, periphyton growth is not likely to be nutrient-limited at this site, regardless of DIN:DRP ratios.

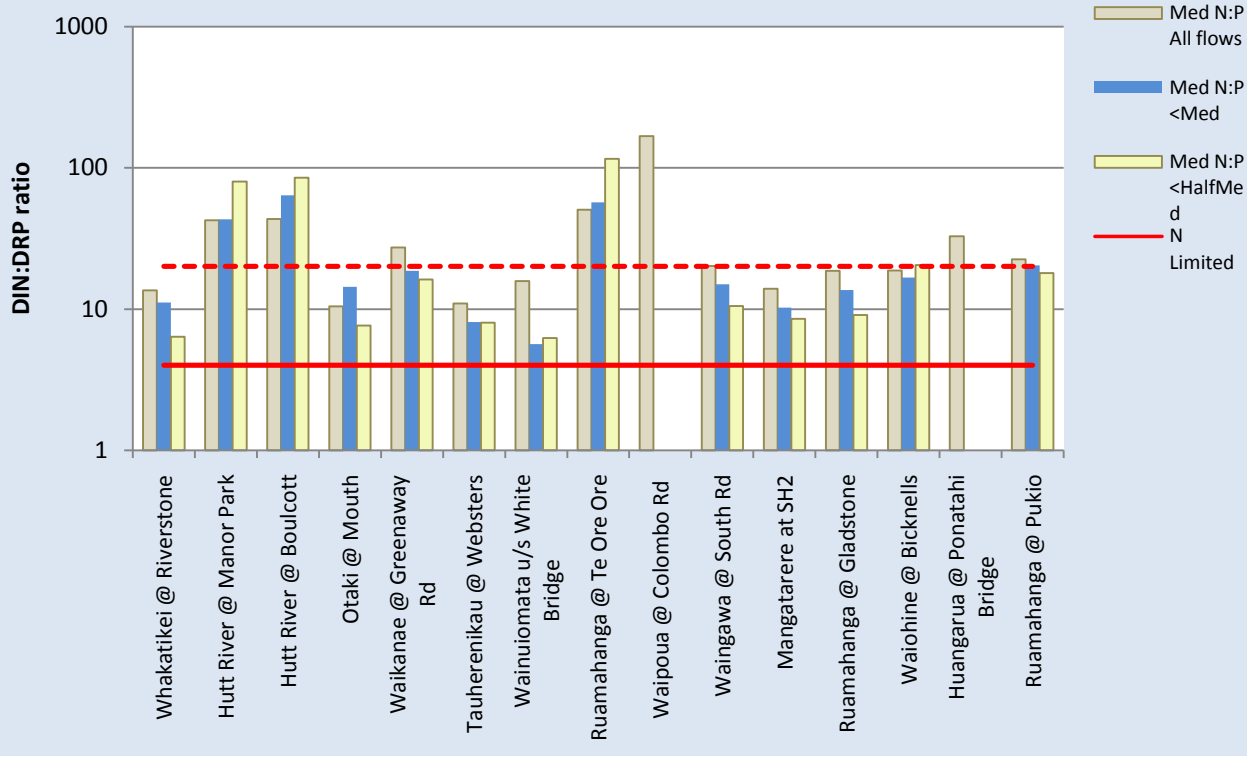


Figure 15: Median DIN:DRP ratios at RSoE sites in the C6a FENZ class. The part of the graph above the top (dashed) red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom (solid) red line (DIN:DRP =4) is indicative of N-limited conditions.

4.3.5 Conclusions

All sites but two in the C6a class comply with the lowland DIN ANZECC guideline. Median DIN concentrations at both the Waipoua at Colombo Rd and the Mangatarere at SH2 sites are more than twice the guideline.

All sites but four comply with the lowland DRP ANZECC guidelines. One, the Wainuiomata u/s White Bridge, only marginally breaches the guideline, and concentrations at this site are similar to the reference conditions for this river. The other three sites largely breach the guideline and are directly (Mangatarere at SH2 and Ruamahanga at Gladstone) or indirectly (Waiohine at Bicknells) influenced by point-source discharges of treated municipal wastewater.

The Otaki at Mouth site presents little changes in nutrient concentrations and DIN:DRP compared with its reference site on the upper Otaki River (Otaki at Pukehinau). However, this site was found to occasionally exceed the periphyton cover guidelines for mats and filamentous algae, whilst no exceedances were observed at the reference site. The observed increase in algae cover is likely due to physical conditions being more favourable to periphyton growth, i.e. a widening of the river channel, reduced overhead shade and a decrease in water velocity.

The middle and lower reach sites of the Hutt River show some moderate DIN and DRP increase compared with the upper reach monitoring site at Te Marua. Whilst the upper Hutt River is predominantly co-limited, the middle and lower reach sites seem to predominantly be P-limited. This is primarily due to the DIN concentrations in the middle river increasing proportionally more than the DRP concentrations.

Similarly to the Hutt River, the reference conditions on the Ruamahanga River appear to be co-limited. Moderate increase in both DRP and DIN concentrations occur in the middle catchment, but with relatively more DIN inputs in the system, the middle Ruamahanga River appears to be predominantly P-limited at Te Ore Ore. Significant inputs of DRP between Te Ore Ore and Gladstone appear to be removing the P limitation.

4.4 Class A

Class A is represented by mostly small streams in coastal or inland locations with gentle gradients and generally silty or sandy substrates (Warr, 2010a).

Class A is represented by 6 sites, with no true reference site. One site (RS45, Parkvale Tributary at Lowes Reserve), is considered as “best available” (Warr, pers. comm.), primarily because the headwaters of this spring-fed stream are within a small native forest reserve. As a result, instream and riparian habitat are of excellent quality, but intensive landuse (dairying) surrounds the reserve, and elevated nitrate concentrations are present in the shallow groundwater that feeds the stream.

Because Class A streams often have soft substrates, they are commonly dominated by aquatic vascular plants (macrophytes) rather than periphyton. Nutrients associated with bottom sediments tend to be more important for macrophyte growth than nutrients dissolved in the water column. However, dissolved nutrients in these systems remain important from a resource management perspective, both as an indicator of overall nutrient status and as sources of nutrients to downstream receiving environments.

The Parkvale tributary (RS45) is part of the Ruamahanga catchment, and the Waiwhetu Stream (RS27) is a tributary of the Hutt River estuary (it discharges at the Hutt River’s mouth, adjacent to the Wellington Harbour). Many class A streams are tributaries of Lake Wairarapa. The other RSoE sites are on coastal streams in the Kapiti area and discharge into coastal waters.

Table 15: Class A RSoE sites, and summary of land use in the catchment upstream of each site.

Site No.	Site Name	Site class	Elevation	Land use (% catchment)			
				Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS45	Parkvale Trib @ Lowes Res.	Impacted	Lowland	0	15	85	0
RS01	Mangapouri @ Rahui Rd	Impacted	Lowland	9	1	87	2
RS02	Mangapouri @ Bennetts Rd	Impacted	Lowland	3	4	52	42
RS08	Ngarara @ Field Way	Impacted	Lowland	23	10	46	17
RS12	Whareroa @ QE Park	Impacted	Lowland	18	11	66	4
RS27	Waiwhetu @ Wainui Hill Bridge	Impacted	Lowland	28	19	0	53

4.4.1 DIN

The median DIN concentration in the Mangapouri Stream at Rahui Road (RS01) is the highest recorded in the region, at over 7 mg/L (i.e. more than 15 times the lowland ANZECC guideline). This site is located in the upper reaches of the Mangapouri Stream. There is a second monitoring site on the lower reaches of the stream (RS02, Mangapouri at Bennetts Road) where the median DIN concentration is significantly lower (2.1 mg/L), although still more than 4 times the lowland ANZECC guideline (Figure 16).

In spite of being a "best available" site, Parkvale Tributary at Lowes Reserve (RS45) has the second highest median DIN concentration in the region (4.5 mg/L), i.e. nearly 10 times the lowland ANZECC Guideline. This stream is spring-fed, and the high DIN concentration reflects the high groundwater nitrate concentrations in this intensive agriculture area.

The other three sites in Class A comply with the lowland ANZECC guideline for DIN. The two sites where flow data were available (Whareroa at QE Park and Waiwhetu at Wainui Hill) indicate a typical pattern of DIN concentration reduction at low stream flows.

4.4.2 DRP

All sites within this class largely exceed the DRP ANZECC guideline for lowland streams (Figure 17).

The only "best available" site in the class (RS45, Parkvale Tributary at Lowes Reserve) has a median DRP concentration of 0.017 mg/L, i.e. 1.7 times the lowland ANZECC guideline.

The Mangapouri at Rahui Road has the lowest median DRP concentration of the class, at 0.013 mg/L. However, the median DRP concentration increases significantly in the lower reaches of the Mangapouri Stream, to 0.029 mg/L at Bennetts Road.

The other three sites largely exceed the lowland ANZECC guideline, and are among the highest recorded across the region.

The Waiwhetu Stream at Wainui Hill Bridge shows a clear pattern of increasing DRP concentration at lower stream flows that may be related to point source inputs. The Whareroa at QE Park shows stable DRP concentrations at different stream flows.

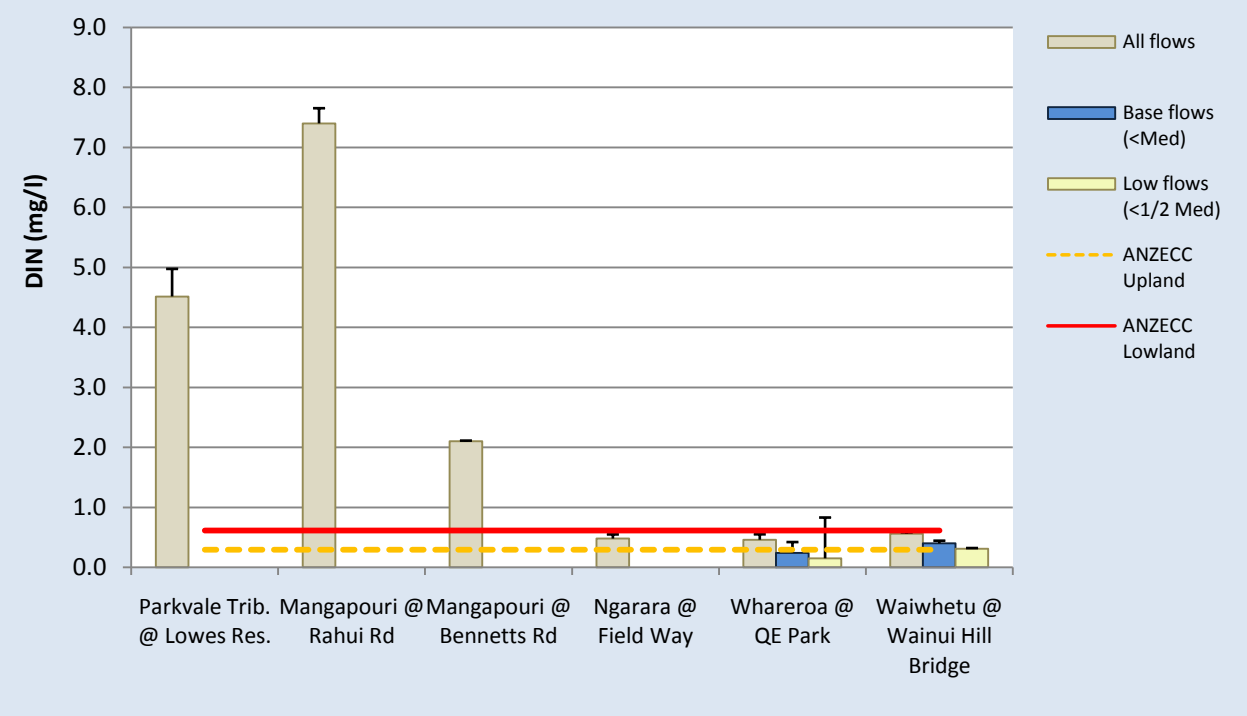


Figure 16: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the A FENZ Class.

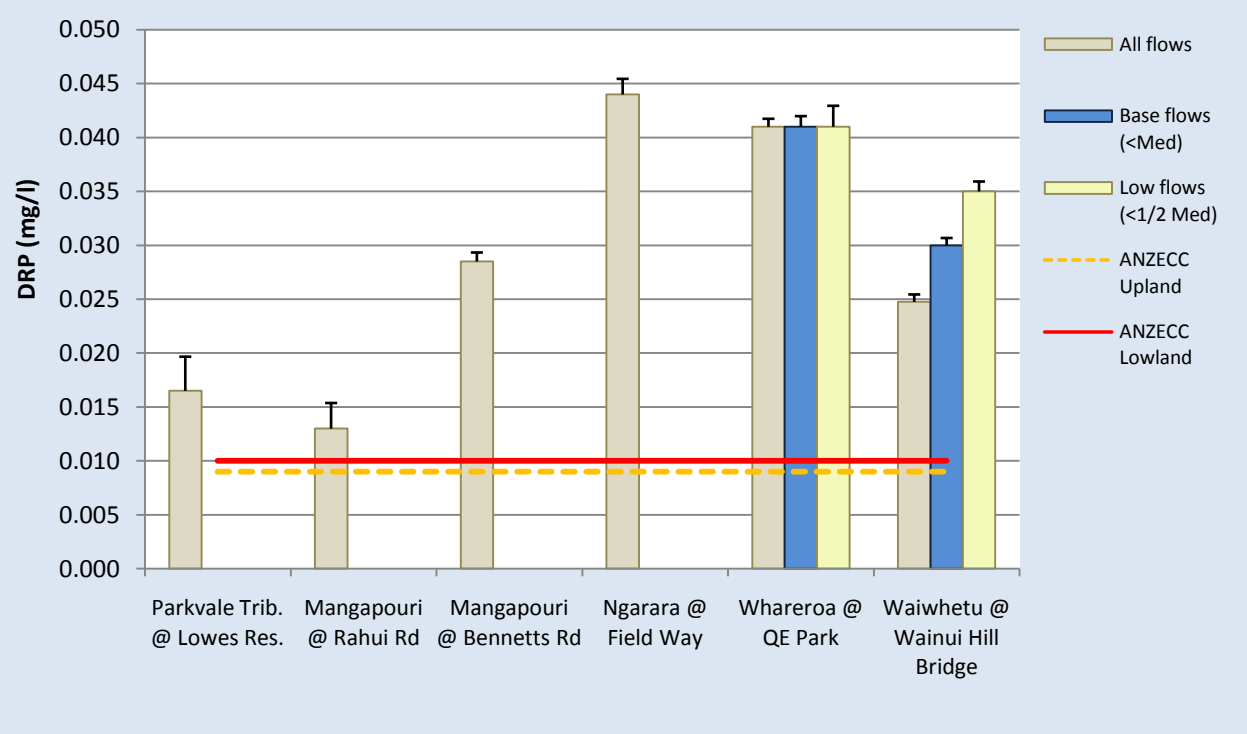


Figure 17: Median DRP concentrations (±95 % confidence interval) for the RSoE sites in the A FENZ Class.

4.4.3 Periphyton

The Parkvale Tributary at Lowes Reserve (RS45) is the only Class A site where periphyton monitoring is undertaken. No breach of any of the periphyton guidelines have been recorded at this site to date.

The bed substrate at all other Class A sites is dominated by fine material (sands and silts), which is unsuitable for periphyton attachment and growth (hence periphyton growth is not monitored at these sites). Formal macrophyte biomass or cover data were not available for these sites, but visual observations by Greater Wellington Regional Council staff indicates that (Alton Perrie, pers. comm.):

- regular nuisance macrophyte growth (i.e. regularly covering most of the stream channel) occurs in the Mangapouri Stream immediately downstream of the Bennetts Rd monitoring site;
- regular presence of macrophytes species, with occasional nuisance growths at the Whareroa Stream at QE Park monitoring site.

4.4.4 DIN:DRP ratios

The Parkvale Tributary (RS45) and the Mangapouri Stream sites (RS01 and RS02) present very elevated DIN:DRP ratios, reflecting the strong imbalance between the two dissolved nutrients, primarily due to the very high DIN concentrations measured in these streams. DRP is also relatively elevated at these three sites (medians 0.016 mg/L at RS01, 0.019 mg/L at RS45 and 0.029 at RS02), meaning that any DRP limitation would be relatively weak.

The Ngarara at Field Way (RS08) and Whareroa at QE Park (RS12) show median DIN:DRP ratios around 10, indicating co-limited or un-limited conditions. However, the Whareroa Stream shows a clear pattern of decreasing DIN:DRP ratios during periods of low stream flows.

DIN:DRP are generally elevated in the Waiwhetu Stream, but decrease during periods of low flows, which reflects the opposite flow-related patterns in DIN (decrease with stream flow) and DRP (increase with decreasing stream flows) concentrations observed at this site.

Although all but the Parkvale Tributary at Lowes Reserve (RS45) site are soft bottomed streams and unlikely to develop excessive periphyton growth, the DIN:DRP ratios are relevant in that they provide some information on the balance between the two dissolved nutrients

4.4.5 Conclusions

Stream sites monitored in class A show elevated concentrations of either or both DIN and DRP. Issues directly associated with excessive periphyton growth are unlikely to occur in these streams due to their soft-bottomed nature, but macrophyte growths reach nuisance levels at a number of sites. Decisions relating to nutrient management in these streams should also consider the role these streams play as a nutrient source to downstream receiving environments, such as larger river systems, estuaries and coastal waters. Although not well represented in the RSoE monitoring programme, some streams classified as class A do have hard substrate and have the potential to support high periphyton biomass.

Reference conditions for Class A are difficult to define in the absence of true reference sites in this class, and will have to be extrapolated from other classes.

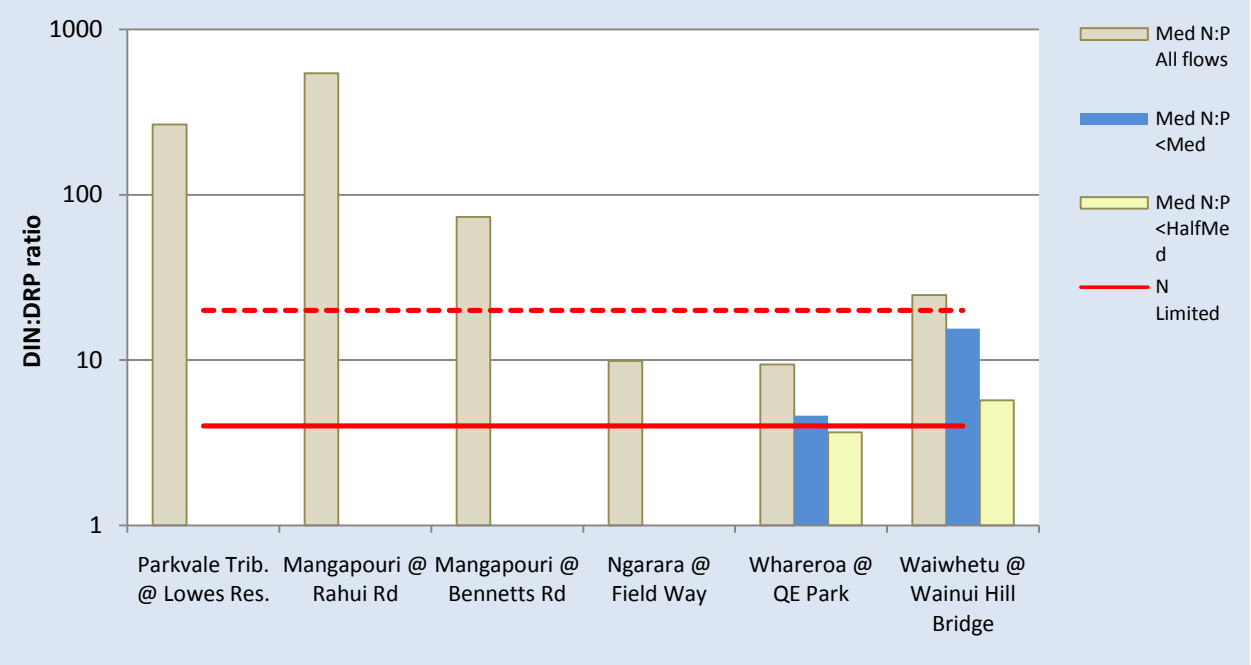


Figure 18: Median DIN:DRP ratios at RSoE sites in the A FENZ class. The part of the graph above the top (dashed) red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom (solid) red line (DIN:DRP =4) is indicative of N-limited conditions.

Table 16: Class C8 RSoE sites, and summary of land use in the catchment upstream of each site.

Site No..	Site Name	Site class	Elevation	Land use (% catchment)			
				Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS36	Taueru @ Castlehill	Best available	Upland	19	34	48	0
RS54	Coles Creek trib.	Best available	Lowland	90	0	10	0
RS37	Taueru @ Gladstone	Impacted	Lowland	7	15	78	0
RS39	Whangaehu u/s Confluence	Impacted	Lowland	3	5	91	0

4.5 Class C8

Class C8 is represented by small inland streams with mild climates and a low frequency of days with significant rainfall. Stream gradients are moderate and substrates are generally coarse gravels. C8 streams are located in the eastern Wairarapa hill country and northern Tararua Range.

The RSoE monitoring network includes four C8 sites, including two "best available" sites, the Taueru River at Castlehill (RS36) and a tributary of Coles Creek (RS54). The other two sites include a site on the lower Taueru River at Gladstone (RS37) and a site on the Whangaehu River just upstream of its confluence with the Ruamahanga River Table 16.

The Coles Creek tributary is part of a coastal catchment in southern Wairarapa. The Taueru and Whangaehu rivers are tributaries of the Ruamahanga River, joining it between the Ruamahanga at Te Ore Ore and Gladstone monitoring sites.

Sites within this class are characterised by long (Coles Creek tributary, 27 days) to very long (Taueru River, 35 days at Castlehill and 45 days at Gladstone) mean accrual periods, making them susceptible to extended periods of periphyton accumulation.

4.5.1 DIN

The two "best available" sites display reasonably low median DIN concentrations (0.099 mg/L in the Taueru River at Castlehill, and 0.022 mg/L in the Coles Creek tributary), consistent with the range of reference concentrations measured at reference sites in the C5 and C7 classes. Both sites are well below the ANZECC upland guideline. DIN concentrations at the only site with flow data (Coles Creek tributary) do not appear to vary significantly with flow (Figure 19).

The lower Taueru River site (RS37) and the Whangaehu River site have high median DIN concentrations, about twice the lowland ANZECC guideline and 8 to 12 times the top of the range of reference concentrations measured at reference sites in the C5 and C7 classes. The Whangaehu u/s confluence displays a weak pattern of decreasing DIN concentrations at lower river flows.

4.5.2 DRP

The two "best available" sites present median DRP concentrations of 0.007 to 0.008 mg/L (Figure 20). Again, these are within the range of concentrations measured at reference sites in the C5 and C7 classes, indicating that these two sites are probably acceptable reference sites for nutrients in this class.

The lower Taueru site presents a moderately elevated median DRP concentration, marginally in excess of the ANZECC guideline for lowland streams. The Whangaehu River has a high DRP concentration, 3-4 times higher than reference conditions, and more than twice the lowland ANZECC guideline.

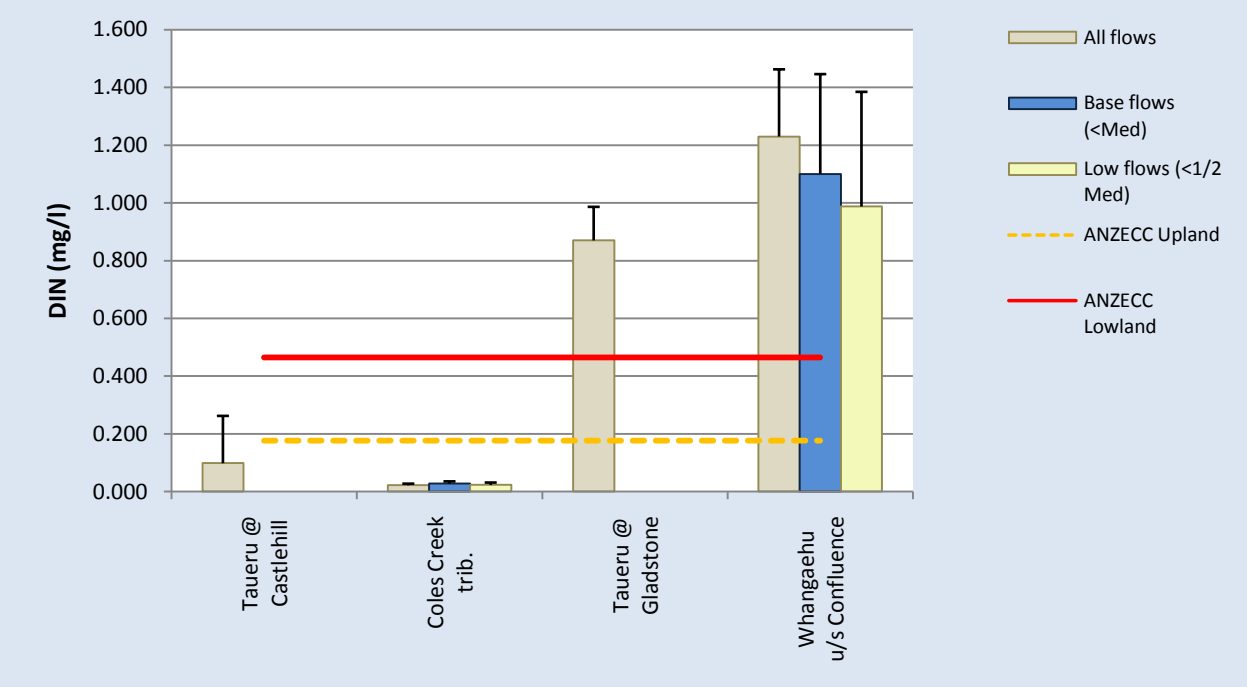


Figure 19: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the C8 FENZ Class.

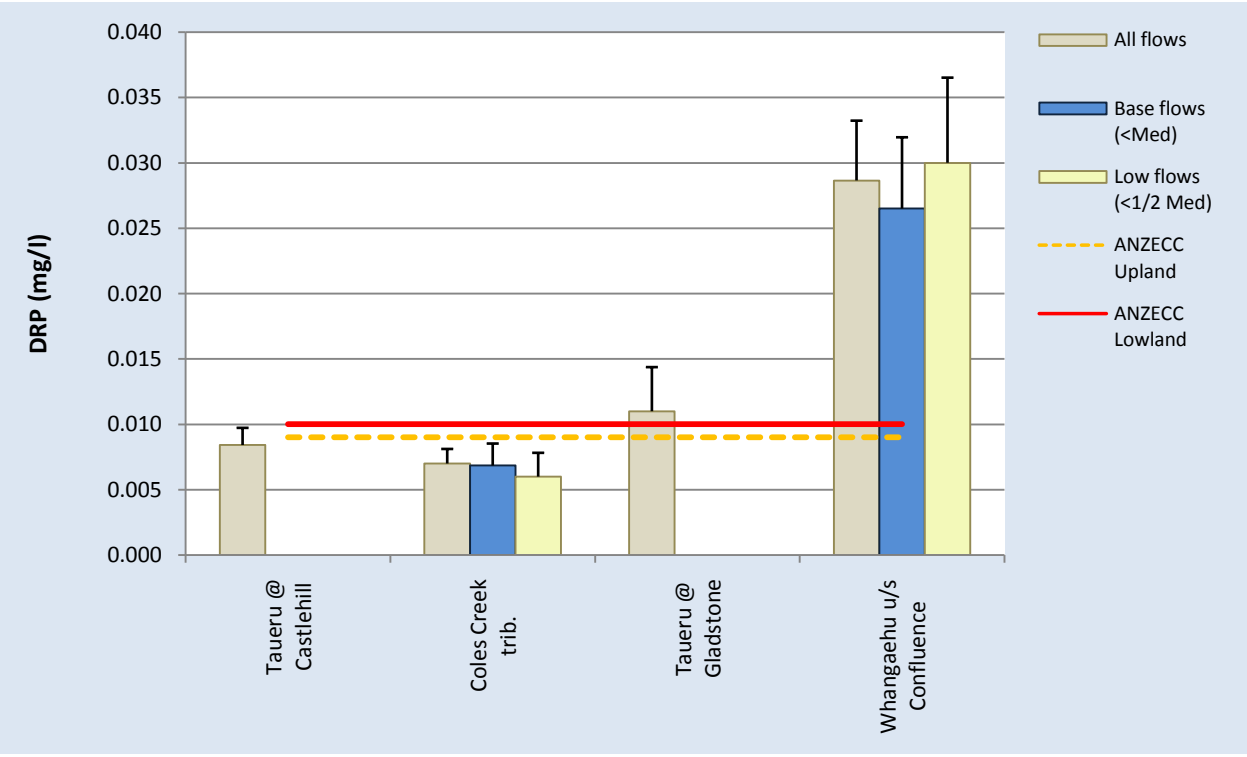


Figure 20: Median DRP concentrations (±95 % confidence interval) for RSoE sites in the C8 FENZClass.

4.5.3 Periphyton

Only two sites in the C8 class are monitored for periphyton biomass and cover. Stream bed material at the Whangaehu River (RS39) and the upper Taueru (RS36) monitoring sites is dominated by soft sediments, i.e. are unsuitable for periphyton attachment. However, visual observations indicate that nuisance macrophyte growths occur regularly in the lower Whangaehu River. Significant periphyton biomass can also be present at this site during periods of stable low flows, in the form of green filamentous algae, loosely attached to macrophytes, or free-growing on the river bed (Alton Perrie, pers. comm., and Photograph 1).

The Coles Creek tributary regularly presents moderate periphyton biomass and excessive filamentous algae cover. This site experiences long periods of stable and/or low flows, and commonly stops flowing (Alton Perrie, Pers. comm.), which may explain the excessive periphyton growth in spite of the low dissolved nutrient concentrations measured at this site.

The lower Taueru River site (at Gladstone, RS37) presents excessive periphyton biomass and cover most of the time. Visual observations indicate that excessive macrophyte growth is also regularly present at this site (Alton Perrie, pers. comm.). Elevated nutrient concentrations and very long accrual periods (45 days mean accrual period) make this site very susceptible to large plant (macrophyte and periphyton) accumulation.

Table 17: Summary of exceedances of periphyton guidelines at RSoE sites in the C8 class.

Site No.	Site Name	Site type	Biomass		Cover	
			50 mg/m^2	120 mg/m^2	mats	filamentous
RS36	Taueru @ Castlehill	Best available	ND	ND	ND	ND
RS54	Coles Creek trib.	Best available	2/6	0/6	0	9
RS37	Taueru @ Gladstone	Impacted	6/6	4/6	1	22
RS39	Whangaehu u/s Confluence	Impacted	ND	ND	ND	ND

Photograph 1: Whangaehu River upstream of its confluence with the Ruamahanga River (Photograph by Alton Perrie).

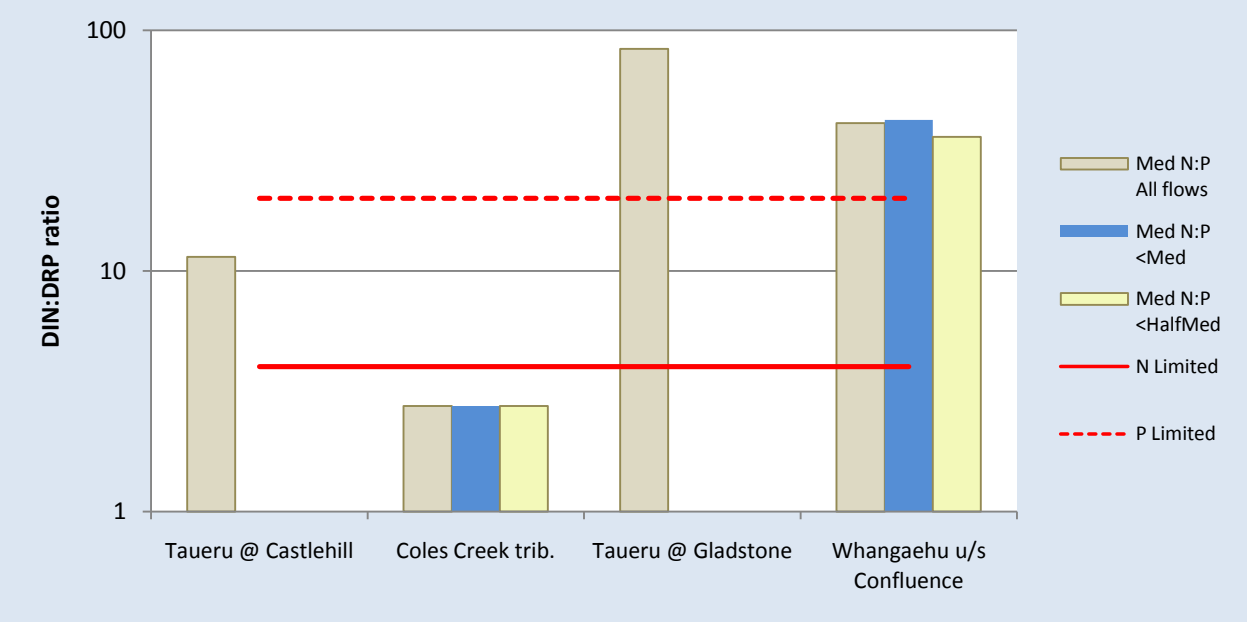


Figure 21: Median DIN:DRP ratios at RSoE sites in the C8 FENZ class. The area above the top (dashed) red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom (solid) red line (DIN:DRP =4) is indicative of N-limited conditions.

4.5.4 Nutrient limitation

DIN:DRP ratios at the Coles Creek tributary site are strongly indicative of N-limited conditions at all times. The Upper Taueru site appears to be dominated by co-limited conditions. These observations are consistent with reference conditions in the C5 and C7 classes, further confirming that these two sites are probably relevant near-reference sites for nutrients in the C8 class.

The lower Taueru River and the Whangaehu River sites both present high median DIN:DRP ratios, indicative of a relative over-abundance of N. The moderate DRP concentrations measured at the lower Taueru River site mean that this site is probably P-limited most of the time.

The interpretation is different for the Whangaehu River site, where the elevated concentrations of both DIN and DRP at all river flows mean that periphyton growth in this river is not likely to be limited by dissolved nutrient availability (un-limited). The Whangaehu River is a major tributary of the middle reaches of the Ruamahanga River, and together with nutrient inputs from the Masterton WWTP discharge at Homebush and other tributaries may contribute significantly to the nutrient loads measured in the Ruamahanga at Gladstone.

4.5.5 Conclusions

The two “best available” sites indicate that streams and rivers in the C8 class are likely to have naturally low DIN (below 0.100 mg/L), and moderate DRP (0.007-0.008 mg/L) concentrations. Algal growth is likely to be naturally N-limited or co-limited.

Excessive periphyton may occur in small streams in this class, even at low nutrient concentrations, as observed in the Coles Creek Tributary. This observation reinforces the fact that physical habitat conditions are an essential driver of periphyton growth in smaller streams.

The Whangaehu River site has high DIN and DRP concentrations, with a relative over-abundance of DIN. Although significant periphyton biomass does seem to occur at this site, its growth is unlikely to be limited by nutrient availability. The Whangaehu River may also contribute significantly to the nutrient loads measured in the Ruamahanga at Gladstone.

4.6 Class C6b

Class C6 includes the mid and lower reaches of most of the major rivers in the Wellington region. These include rivers draining the Tararua, Rimutaka and Aorangi Ranges as well as those draining lower elevation, more soft sedimentary catchments in Kapiti and eastern Wairarapa.

Class C6b is a subset of the C6 class and is represented by C6 stream segments with the upstream catchment dominated by class C5 streams. This includes the Horokiri and lower Pauatahanui streams (two tributaries of the Pauatahanui arm of the Porirua Harbour) as well as some stream segments on the Wairarapa coast.

Class C6b is represented by only one RSoE site, the Horokiri Stream at Snodgrass (RS13), a lowland, non-reference site. The catchment upstream of this site is about half (55%) indigenous forest and scrub, and half (45%) pasture (Table 18). This site is characterised by a long mean accrual period (33 days). Reference conditions for this class should be sought in the class C5 reference sites.

For convenience, this site has been added to the visual displays for the C6c class (Table 18 and Table 19, Figure 22 to Figure 24).

4.6.1 DIN

The overall median DIN concentration for the Horikiri Stream at Snodgrass is 0.413 mg/L, about 4 times the reference concentrations in class C5 (0.090 – 0.110 mg/L), but still below the lowland ANZECC guideline. The median DIN concentration decreases significantly at stream flows below median (0.155 mg/L) and below half median (0.120 mg/L) (Figure 22).

4.6.2 DRP

The median DRP concentration for the Horokiri Stream at Snodgrass is 0.015 mg/L, which is higher than the class C5 reference conditions (0.009 to 0.013 mg/L), and about 1.5 times the lowland ANZECC guideline. This stream has, however, lower DRP concentrations than the other monitored tributaries of the Porirua Harbour (Pauatahanui and Porirua streams).

4.6.3 Periphyton biomass and cover

Yearly monitoring results indicate generally low periphyton biomass at the Horokiri stream site, with the highest biomass of 50 mg/m^2 recorded in 2007. Monthly visual assessment indicates occasional (four times) exccedances of the filamentous algae cover guideline.

4.6.4 Nutrient limitation

DIN:DRP ratios indicate generally P-limited conditions, but with a mix of P-limited, co-limited and N-limited conditions when the stream flow falls below half median flow (refer to graph in Appendix D).

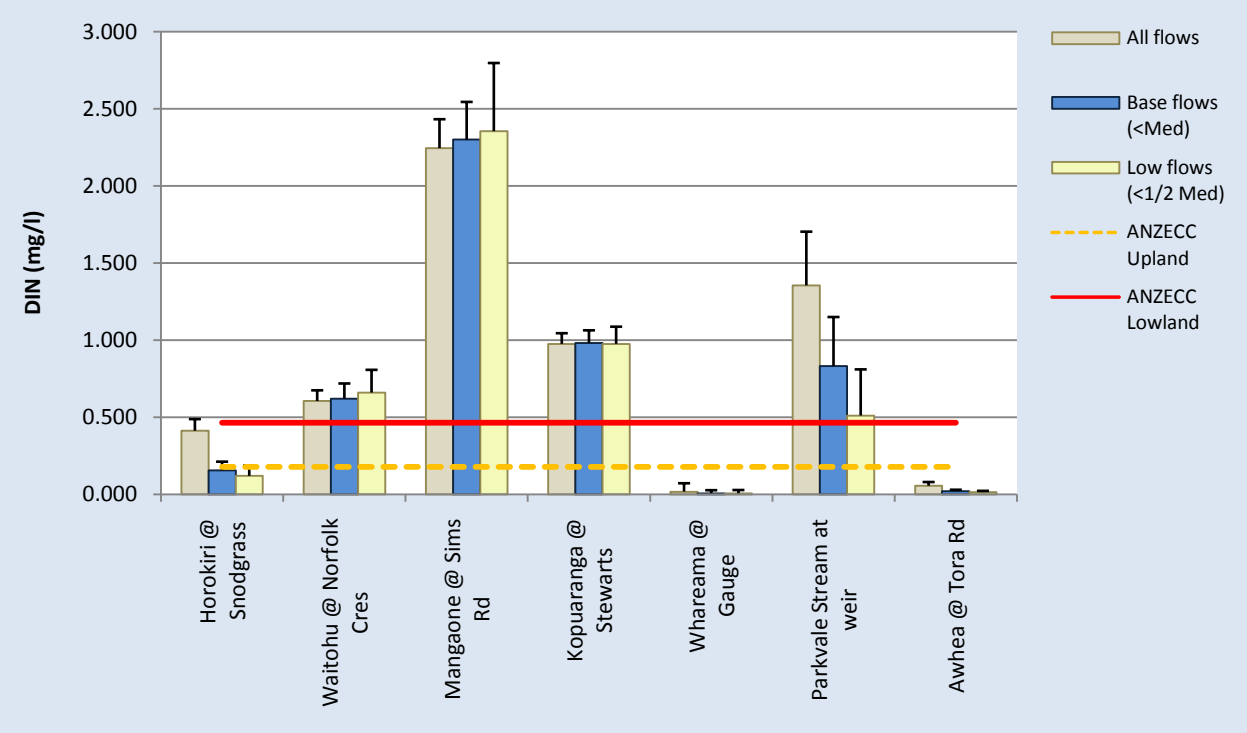


Figure 22: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the C6b and C6c FENZ classes.

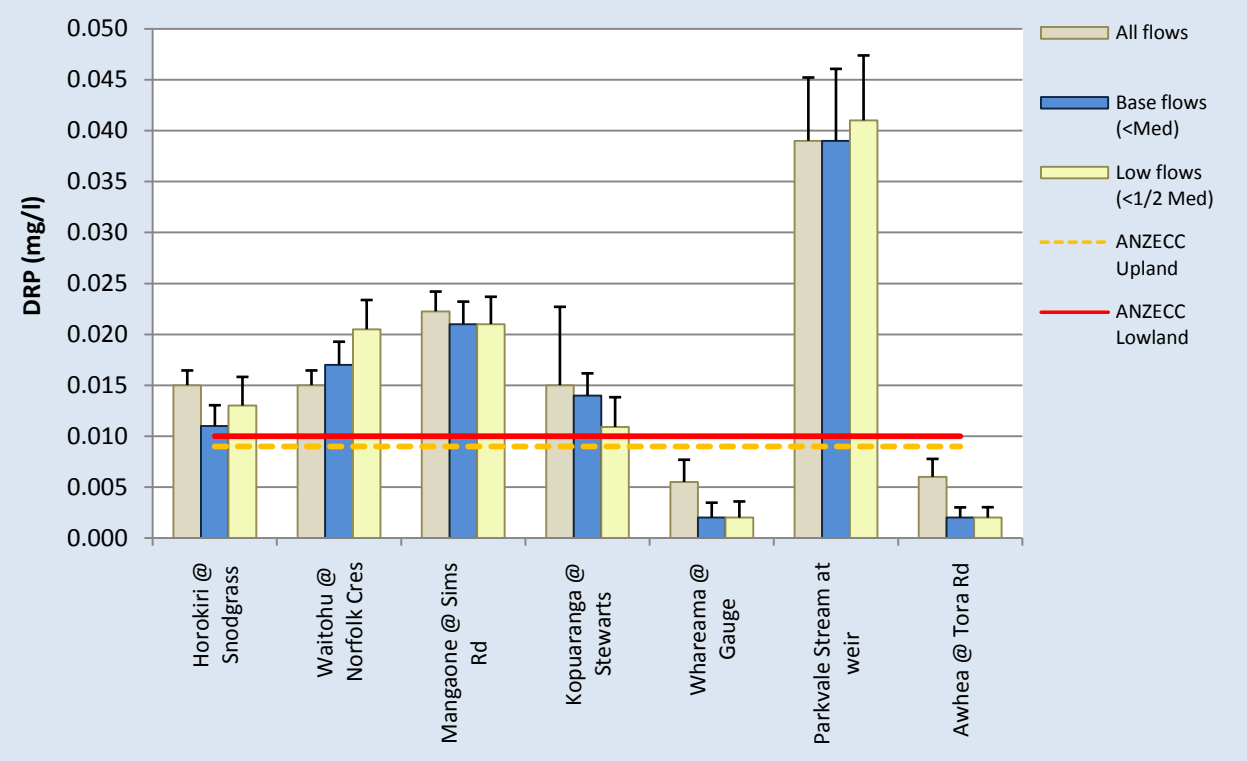


Figure 23: Median DRP concentrations (±95 % confidence interval) for RSoE sites in the C6b and C6c FENZ classes.

4.7 Class C6c

Class C6 includes the mid and lower reaches of most of the major rivers in the Wellington region (Figure 3). These include rivers draining the Tararua, Rimutaka and Aorangi Ranges as well as those draining lower elevation, more soft sedimentary catchments in Kapiti and eastern Wairarapa. Class C6c is a subset of the C6 class. C6c streams are C6 stream segments with the upstream catchment dominated by streams in class A or class C8. This includes streams on the Wairarapa and Kapiti Coasts as well as streams in the central Wairarapa valley.

Class C6c is represented by 6 RSoE sites, all lowland, non-reference sites. The upstream catchments of most of these sites are largely dominated by pastoral land use (Table 18). Reference sites within this class are not available, i.e. streams within this class are generally within developed catchments. "Best available" conditions in classes A and C8 can be used to provide an indication of reference for this class.

The Waitohu Stream has moderate mean accrual periods (in the order of 20 days), but all other sites in this class have long to very long mean accrual periods (27 to 49 days), making them susceptible to extended periods of periphyton accumulation.

Table 18: Class C6b and C6c RSoE sites, and summary of landuse in the catchment upstream of each site.

Site No.	Site Name	Site class		Elevation	Land use (% catchment)			
					Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS13	Horokiri @ Snodgrass	C6b	Impacted	Lowland	11	43	45	0
RS04	Waitohu @ Norfolk Cres	C6c	Impacted	Lowland	34	11	47	7
RS07	Mangaone @ Sims Rd	C6c	Impacted	Lowland	16	12	71	1
RS38	Kopuaranga @ Stewarts	C6c	Impacted	Lowland	5	4	91	0
RS42	Whareama @ Gauge	C6c	Impacted	Lowland	11	19	69	0
RS46	Parkvale Stream at weir	C6c	Impacted	Lowland	0	1	98	0
RS53	Awhea @ Tora Rd	C6c	Impacted	Lowland	26	10	64	0

4.7.1 DIN

Two sites, the Whareama at Gauge (RS42) and the Awhea at Tora Rd (RS53) have low median DIN concentrations (0.018 and 0.056 mg/L respectively), that fall within the range of 'best available" conditions in the Class C8, and reference conditions in other classes (C5 and C7) in the region (Figure 22).

The Waitohu at Norfolk Crescent (RS04). has a moderately elevated median DIN concentration (0.605 mg/L), in excess of the lowland ANZECC guideline, and much higher than the median (0.040 mg/L) measured in the upper Waitohu Stream (RS03, at Forest Park). DIN concentrations at the Norfolk Road site appear to remain stable with flow.

The Kopuaranga at Stewarts and the Mangaone at Sims Rd have elevated median DIN concentrations under all river flow conditions, well in excess of the lowland ANZECC guidelines. DIN concentrations at these sites appear to remain stable at different flows.

The Parkvale Stream at Weir also has an elevated overall median DIN concentration (1.355 mg/L), but concentrations undergo a significant reduction when stream flow drops, to a median of 0.511 mg/L under low flow conditions.

4.7.2 DRP

Similarly to what is observed for the DIN concentrations, the Whareama at Gauge (RS42) and the Awhea at Tora Rd (RS53) have low (both 0.006mg/L) median DRP concentrations that fall within the range of "best available" DRP concentrations in the C8 class, but also within the range of true reference conditions in the C5 and C7 classes.

In the Waitohu Stream, the moderate overall median DRP concentration (0.015 mg/L) increases under low flow conditions to 0.020 mg/L. As a comparison, the reference site on the upper Waitohu Stream (RS03) has median DRP concentrations of 0.007 to 0.008 mg/L. The Kopuaranga at Stewarts also presents a moderately elevated overall median DRP concentration (0.015 mg/L), but the opposite pattern is observed, with a reduction of the median DRP concentration under low flow conditions.

The Mangaone at Sims Road and the Parkvale Stream have the highest median DRP concentrations of the C6c class (0.022 and 0.039 mg/L respectively). These concentrations remain stable under different stream flow conditions.

4.7.3 Periphyton biomass and cover

Only three of the seven sites in this class are monitored for periphyton biomass and cover (Table 19). The three sites that are not monitored for periphyton biomass or cover are unsuitable for periphyton growth (soft-bottomed).

All three sites where periphyton is monitored exceeded both the periphyton biomass and cover guidelines on a regular basis.

Formal macrophyte biomass or cover data were not available for these sites, but visual observations by Greater Wellington Regional Council staff indicates (Alton Perrie, pers. comm.):

- regular nuisance macrophyte growth (i.e. regularly covering most of the stream channel) at three sites: Mangaone at Sims Road, Whareama at Gauge, and Parkvale Stream at Weir;
- regular presence of macrophytes, with occasional nuisance growths at two sites: the Waitohu at Norfolk Cres and Kopuaranga at Stewarts.

Table 19: Summary of periphyton guideline exceedances at RSoE sites in the C6b and C6c FENZ classes.

Site No.	Site Name	Site class	Biomass		Cover	
			50 mg/m^2	120 mg/m^2	Mats	Filamentous
RS13	Horokiri @ Snodgrass	C6b	0/6	0/6	0	4
RS04	Waitohu @ Norfolk Cres	C6c	ND	ND	ND	ND
RS07	Mangaone @ Sims Rd	C6c	ND	ND	ND	ND
RS38	Kopuaranga @ Stewarts	C6c	5/6	5/6	0	19
RS42	Whareama @ Gauge	C6c	ND	ND	ND	ND
RS46	Parkvale Stream @ weir	C6c	4/6	2/6	1	14
RS53	Awhea @ Tora Rd	C6c	3/6	2/6	0	17

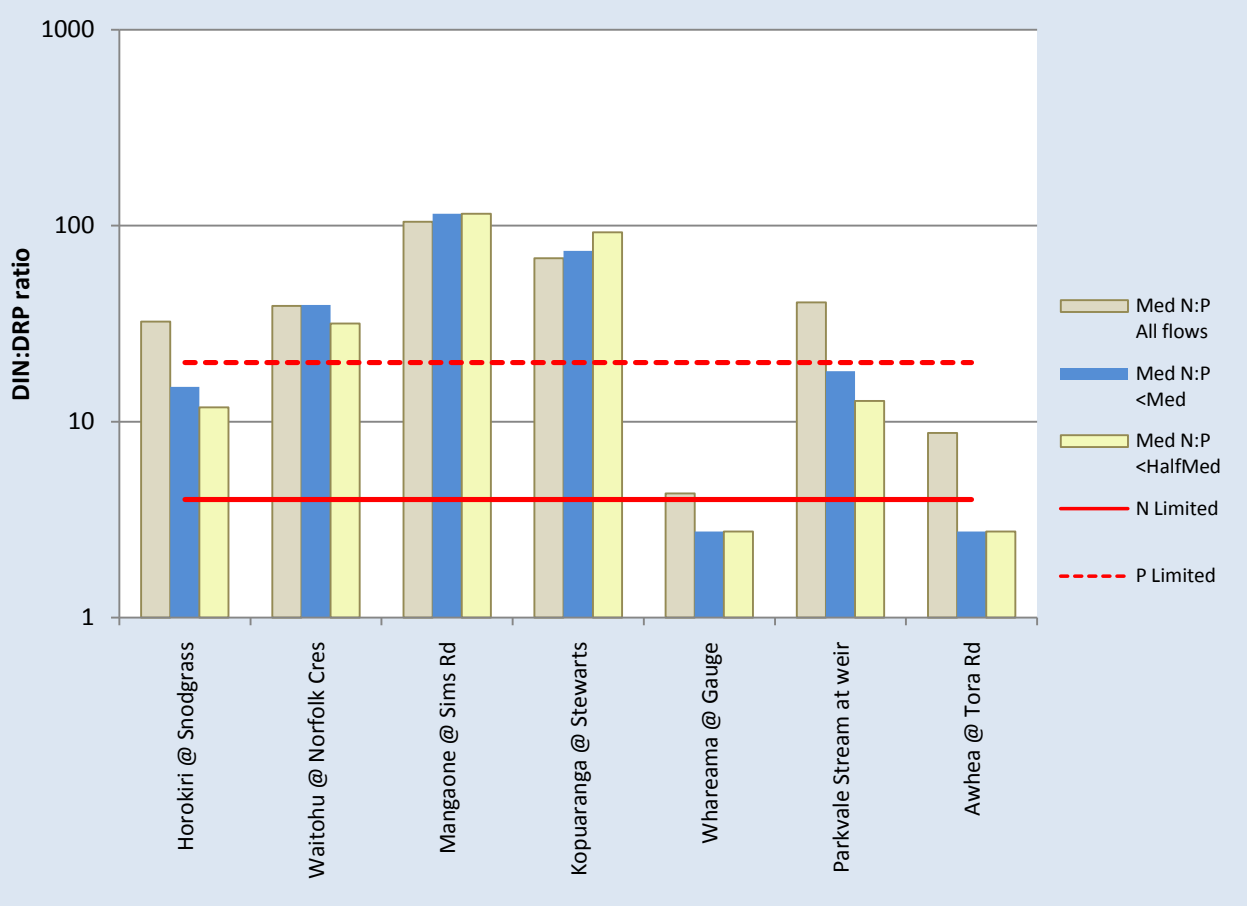


Figure 24: Median DIN:DRP ratios at RSoE sites in the C6b and C6c FENZ classes. The area above the top (dashed) red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom (solid) red line (DIN:DRP =4) is indicative of N-limited conditions.

4.7.4 Nutrient limitation

The Waitohu at Norfolk Cres. and the Mangaone at Sims Rd have high DIN:DRP ratios under all flow conditions, indicative of a relative over-abundance of dissolved N vs. P. However, the elevated concentrations of both DIN and DRP at all river flows mean that plant growth at these sites is unlikely to be limited by dissolved nutrient availability.

The Kopuaranga at Stewarts also presents high DIN:DRP ratios at all flows, and only moderate DRP concentrations, a strong indication of P-limited conditions.

Dissolved nutrient ratios at the Parkvale Stream at Weir indicate an overall over-abundance of DIN, but with more balanced ratios under low flow conditions. The high nutrient concentrations measured at this site even at low stream flow mean that any nutrient limitation is unlikely.

Both the Whareama at Gauge and the Awhea at Tora Rd appear to be dominated by N-limited conditions, although co-limited conditions are possible in the Awhea at Tora Rd at flows above median flow.

4.7.5 Conclusions

All sites in the C6c class are on relatively small streams. All but the Waitohu Stream have long to very long mean accrual periods, making them very susceptible to heavy plant (periphyton and/or macrophytes) accumulation. As a result, even the sites with low dissolved nutrient concentrations present regular nuisance growth of periphyton (Awhea at Tora Rd) or macrophytes (Whareama at Gauge). Sites with higher dissolved nutrient concentrations (Mangaone at Sims Rd, Parkvale Stream at Weir and Kopuaranga at Stewarts) also present regular nuisance periphyton and/or macrophyte growths.

The Waitohu Stream at Norfolk Crescent has a much shorter mean accrual period (18.5 days) than the other small streams in the C6c class. Occasional (rather than regular) excessive macrophyte growths are observed at this site. The pattern of DRP increase under low flow conditions observed at this site is often associated with point-source discharges (as observed in the Mangatarere Stream at SH2, or in the Ruamahanga at Gladstone for example). Its causes in the Waitohu Stream are unknown but may need to be investigated. Interestingly, a similar pattern was also identified at another site located in an urban area, but with no known point source-discharges – the Waiwhetu Stream at Wainui Hill.

Table 20 below presents a summary of typical nutrient concentrations and likely nutrient limitation in each FENZ class, under reference, low pressure (“best non-reference) and impacted conditions.

Table 20: Summary of median nutrient concentrations and limitation under reference, best non-reference and impacted conditions. RSoE indicates the site number as per Table 2. ⇔: nutrient concentration stable with flow; ⇗: nutrient concentration increases when river flow decreases; ⇘: nutrient concentration decreases with river flow.

Class / catchment	Reference conditions				Best non-reference (current)				Impacted (current)			
	DIN (mg/L)	DRP (mg/L)	Limitation	RSoE	DIN (mg/L)	DRP (mg/L)	Limitation	RSoE	DIN (mg/L)	DRP (mg/L)	Limitation	RSoE
C5	0.110 (⇔)	0.013 (⇔)	Co- limited tending N-limited at low flows	09	0.037-0.050 (⇘ or ⇔)	0.004-0.006 (⇘)	N-limited or Co-limited	35, 43	0.255-0.372 (⇘)	0.018-0.035 (⇗)	N-limited	11, 14, 17
					0.090	0.002	Co-limited	44	0.289-0.511 (⇘ or ⇔)	0.022-0.043 (⇗or ⇔)	P-limited	15, 16, 18, 19
C7	0.018 -0.085 (⇔)	0.002 – 0.011 (⇔)	N-limited or co-limited	3, 5, 28, 31, 47, 49, 52, 56	0.065-0.106 (⇘ or ⇔)	0.005 (⇘ or ⇔)	Co-limited or P-limited	20, 25, 30	0.285 –0.578 (⇗)	0.006 –0.012 (⇘ or ⇔)	P-limited	23, 24
C6a	Reference sites in C7				0.050 – 0.097 (⇔ or ⇘)	0.004–0.008 (⇔ or ⇘)	Co-limited or P-limited	6, 55, 41, 26	0.210 – 0.240 (⇔)	0.005-0.006 (⇘)	P-limited	21, 22
									0.410-0.470 (⇔)	0.008 (⇘)	P-limited	32
										0.025 (⇗)	Co-limited	33
									1.50 (⇔)	0.097 (⇗)	Unlimited	50
									0.201 -0.300 (⇘ or ⇔)	0.008-0.018 (⇘ or ⇔)	P-limited or co-limited	10, 29, 48
									0.30 – 1.00 (?)	0.006-0.007 (?)	P-limited	40, 51
A	Unavailable				0.460-0.560 (⇘)	0.013-0.017 (?)	Co-limited or Un-limited or P-limited	(a)	2.10-7.40 (?)	0.025-0.044 (⇔ or ⇗)	Un-limited or Co-limited or P-limited	(b)
C8	Unavailable				0.022 – 0.100 (⇔)	0.006 –0.008 (⇔)	N-limited or co-limited	36, 37, 54	1.23 (⇔)	0.029 (⇔)	Unlimited	39
C6b	Reference sites in C5				Unavailable				0.413 (⇘)	0.015 (⇔)	P-limited tending co-limited at low flows	13
C6c	Unavailable				0.018 – 0.099 (⇔)	0.006 –0.008 (⇔ or ⇘)	N-limited or co-limited	38, 42, 53	0.375 (⇘)	0.017 (⇘)	P-limited	34
									1.4 – 2.2 (⇔ or ⇘)	0.022 - 0.040 (⇔)	Unlimited	07, 46

(a): Sites 8, 12 and 27 for DIN; Sites 45 and 01 for DRP (b): Sites 1, 2 and 45 for DIN; Sites 2, 8, 12 and 27 for DRP

5 Major River catchments

5.1 Hutt River catchment

The RSoE monitoring network comprises 8 sites in streams and rivers in the Hutt River catchment, including three on the Hutt River itself, at Te Marua in the upper catchment, at Manor Park in the middle catchment and at Boulcott in the lower catchment.

All sites are classified as "impacted" although the Hutt at Te Marua, the Whakatikei at Riverstone and the Akatarawa at Hutt confluence have more than 90% of their catchment in indigenous vegetation, scrub or exotic forest (Table 21), and can be considered close to reference sites in relation to their nutrient status.

Three sites, the Pakuratahi below Farm Creek, and the Hutt River at Manor Park and at Boulcott have only a relatively small part of their catchment in pastoral (11-13%) and urban land use (0-6%). The Mangaroa at Te Marua is the only site in the Hutt catchment with more than 30% of its catchment in pastoral land use.

The Waiwhetu Stream flows through urban suburbs of eastern Lower Hutt for most of its length and flows into the Hutt River at its mouth. More than half (53%) of its catchment is classified as urban.

In all the figures and tables in this section, the sites are presented in their upstream-to-downstream order in the catchment.

Table 21: Summary of RSoE sites in the Hutt River catchment, and summary of land use in the catchment upstream of each site.

Site No.	Site Name	Site class	Elevation	Land use (% catchment)			
				Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS23	Pakuratahi Below Farm Creek	Impacted	Lowland	70	17	13	0
RS20	Hutt River @ Te Marua	Impacted	Lowland	87	7	6	0
RS24	Mangaroa @ Te Marua	Impacted	Lowland	49	18	32	1
RS25	Akatarawa @ Hutt Confluence	Impacted	Lowland	79	17	3	0
RS26	Whakatikei @ Riverstone	Impacted	Lowland	65	26	8	0
RS21	Hutt River @ Manor Park	Impacted	Lowland	69	16	11	4
RS22	Hutt River @ Boulcott	Impacted	Lowland	67	15	12	6
RS27	Waiwhetu @ Wainui Hill Bridge	Impacted	Lowland	28	19	0	53

5.1.1 DIN

Within the Hutt River mainstem, all three sites have median DIN concentrations well below the ANZECC lowland guideline (Figure 25). The median DIN concentration at Te Marua remains low under all flow conditions (in the order of 0.1 mg/L), and within the range of median DIN concentrations recorded at true reference sites in the region. The median DIN concentration increases significantly[4] in the middle catchment, then remains stable in the lower catchment (0.200 to 0.240 mg/L). DIN concentrations at these three sites do not appear to vary significantly with flow.

The two tributaries that have more than 90% of their catchment in indigenous, scrub or exotic forestry (Akatarawa and Whakatikei) also have the lowest median DIN concentrations of the tributaries (in the order of 0.100 mg/L).

The other three tributaries have significantly higher median DIN concentrations than all the mainstem sites[5]. The Mangaroa at Te Marua has the highest median DIN concentration in the catchment, well in excess of the ANZECC lowland guideline. The Waiwhetu Stream is the only other site in the Hutt catchment where the overall median DIN concentration exceeds the lowland guideline. However, there is a strong pattern of decreasing DIN concentrations with decreasing stream flows at this site.

5.1.2 DRP

In the Hutt River mainstem, all three sites have low overall median DRP concentrations, between 0.005 and 0.006 mg/L (Figure 26), within the range of reference conditions in the region. Lower DRP concentrations are measured during periods of low flows (below half median flow), particularly in the middle (Manor Park) and lower (Boulcott) Hutt River (0.002 mg/L).

In the tributaries, the Akatarawa River has median DRP concentrations similar to the Hutt River mainstem. The Whakatikei and Pakuratahi present slightly more elevated median DRP concentrations, but still below the ANZECC upland guideline, and well within the range of reference concentrations in the region.

The overall median DRP concentration in the Mangaroa River at Te Marua is significantly[6] more elevated than in the Hutt River at Te Marua, although it drops to 0.009 mg/L under median flows, and to 0.007 under half median flows.

The Waiwhetu Stream has very elevated DRP concentrations, with a clear pattern of increasing DRP at lower stream flows. This pattern is consistent with that observed in waterways that receive point-source discharges in the region (e.g. the Mangatarere Stream at SH2 and the Ruamahanga River at Gladstone), and in other regions (Ausseil, 2008). It is possible that sewage leaks and industrial stormwater discharges may be a contributing factor (Juliet Milne pers. comm.).

[4] Wilcoxon paired rank test, $p<0.01$
[5] Wilcoxon paired rank test, $p<0.05$
[6] Wilcoxon paired rank test, $p<0.01$

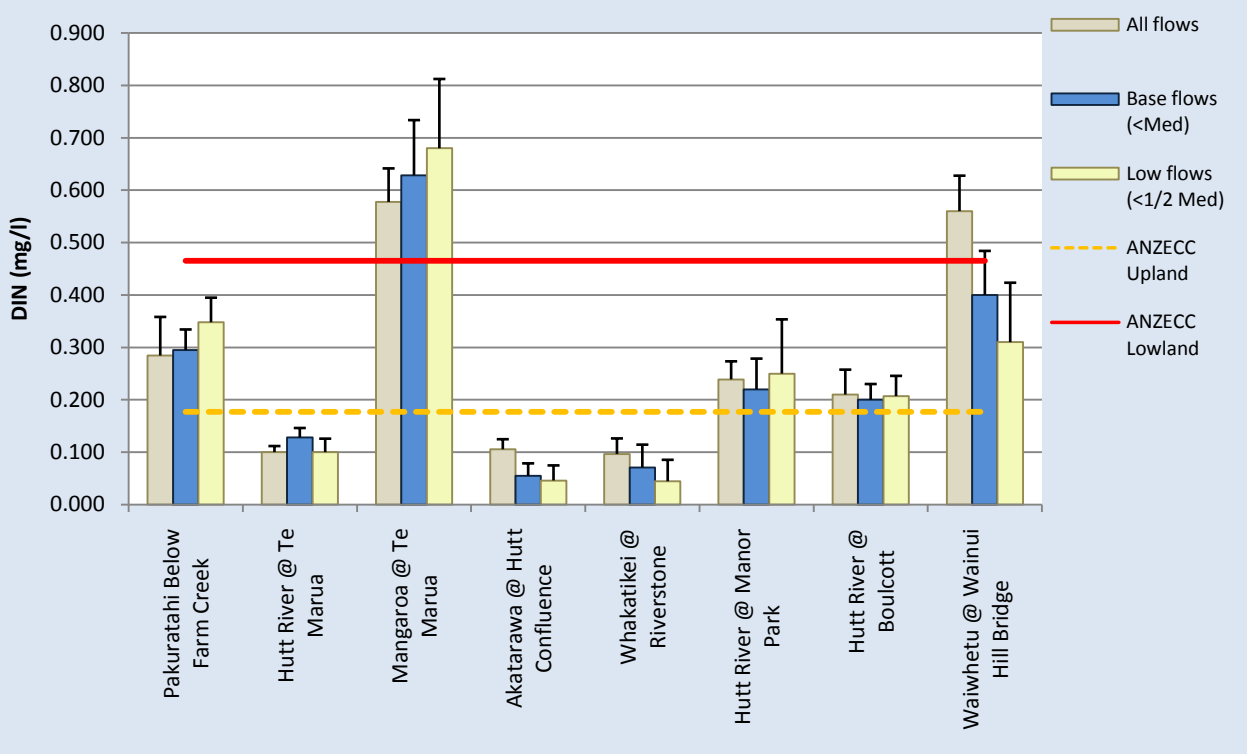


Figure 25: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the Hutt River catchment.

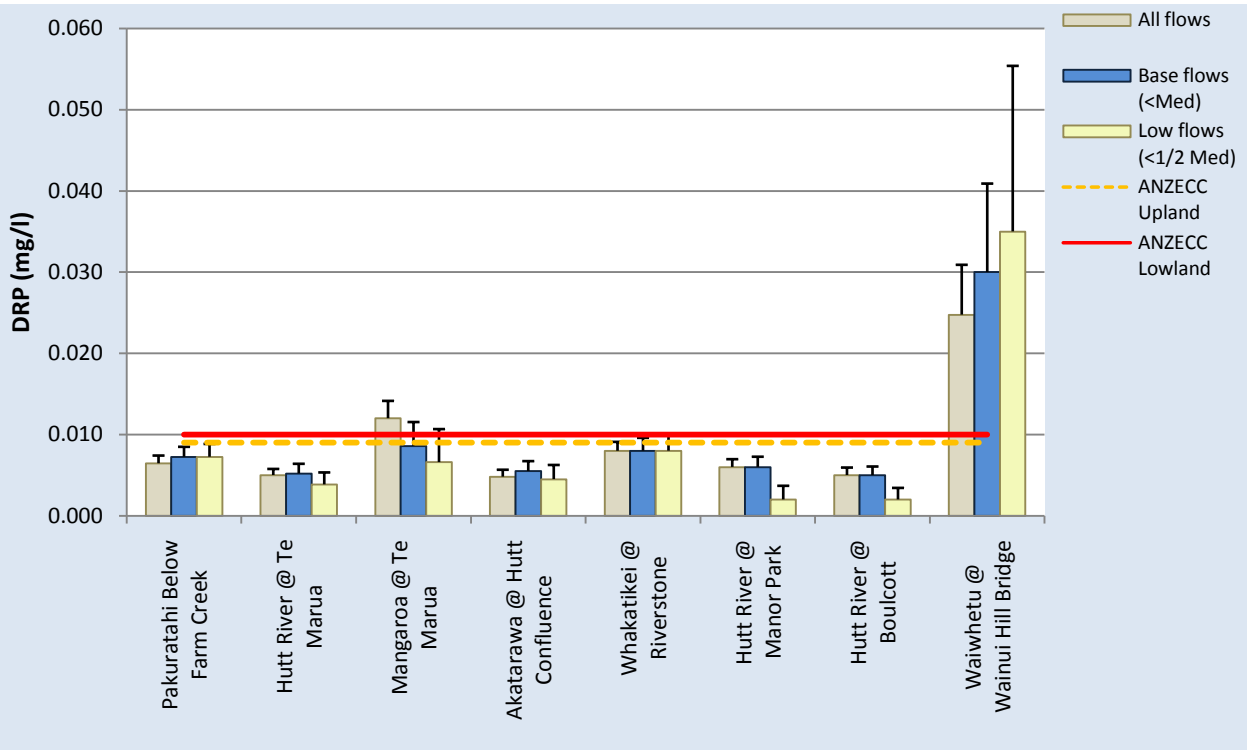


Figure 26: Median DRP concentrations (±95 % confidence interval) for RSoE sites in the Hutt River catchment.

5.1.3 Periphyton biomass and cover

Periphyton biomass and cover in the Hutt River at Te Marua appears to always be very low (maximum recorded of 5 mg/m^2). There is a significant increase in periphyton biomass going downstream in the Hutt River main stem, from Te Marua (median 1 mg/m^2) to Manor Park (19 mg/m^2) to Boulcott (57 mg/m^2) (Table 22). Periphyton biomass at Boulcott regularly reaches moderate levels, with three out of six annual sampling results near or in excess of 100 mg/m^2. Periphyton cover was recorded to reach nuisance levels on two occasions only, although weekly cover data collected at other sites under Greater Wellington's separate summer recreational water quality monitoring programme indicates nuisance periphyton can occur more frequently in the middle and lower Hutt River (Juliet Milne, pers. comm.). In addition to the weekly frequency, assessments of periphyton cover undertaken under the recreational water quality monitoring programme are more rigorous in that assessment is made over 20 views spread over four transects in both run and riffle habitat (as opposed to 10 views over a single transect in a run) (Juliet Milne, pers. comm.). It is recommended that the suitability this periphyton cover assessment method be investigated for implementation as part of the RSoE monitoring programme.

In recent years, the presence of toxic cyanobacteria growths in the Hutt River have come to the public's attention. Cyanobacteria presence and cover is now regularly monitored by the regional council over the bathing season. Recent data indicate that toxic cyanobacteria blooms were recorded in the Hutt River over much of the 2008/09 bathing season (Warr, 2009; Ryan and Warr, 2010). Widespread growth of potentially toxic cyanobacteria has been recorded in the Hutt River every summer since periphyton monitoring began under the recreational water quality monitoring programme in 2006. The response to toxic algal blooms includes close monitoring of 'flushing' river flows and the use of two different warning signs, in accordance with the Ministry for the Environment's draft cyanobacteria guidelines (Woods *et al.*, 2009):

- 'medium risk' – when there have been no flushing flows for two weeks and flows are low or significant cover of cyanobacterial mats (20-50%) is present.
- 'high risk' – where cyanobacterial mats cover more than 50% of the river bed, dislodged cyanobacterial mats are present in shallow waters or a dog or human illness is reported. (Warr, 2009).

In the tributaries, the Pakuratahi generally has low periphyton biomass (median 10 mg/m^2), although it exceeded the 50 mg/m^2 guideline on one occasion. The periphyton cover guidelines were exceeded only once at this site, in relation to filamentous algae. The Akatarawa River always presents low periphyton biomass (median 2 mg/m^2, maximum 39 mg/m^2) and cover. The Whakatikei at Riverstone also has generally low periphyton biomass, but exceeds the periphyton cover guidelines for filamentous algae cover on occasion. The Mangaroa River regularly presents moderate periphyton biomass (median 55 mg/m^2), the highest of all monitored Hutt River tributaries. This site also has the highest incidence of excessive periphyton cover of the 8 sites monitored in the catchment.

The Waiwhetu Stream's bed is dominated by soft sediment, which makes it unsuitable for periphyton attachment.

5.1.4 DIN:DRP ratios

The Hutt River at Te Marua is predominantly P-limited at all flows (Figure 27), but with frequent co-limited conditions. DIN:DRP ratios appear stable at different river flow conditions (also refer to the graph presented in Appendix D). Nutrient ratios indicate a more strongly established DRP limitation, probably associated with the increase in DIN concentrations observed between the upper (Te Marua) and the middle/lower (Manor Park and Boulcott) river reaches. The DRP limitation appears to strengthen at low river flow, a reflection of the decreasing DRP concentrations and stable DIN concentrations at low river flows.

The Pakuratahi and Mangaroa river sites also appear to be strongly dominated by P-limited conditions.

The Whakatikei River site appears to generally be co-limited, but with an increase in the occurrence of N-limited conditions at lower stream flows. Conditions at the Akatarawa at Hutt confluence appear to change between P-limited and co-limited conditions. However, N-limited conditions also occur about one third of the time when the flow is below half median flow.

Table 22: Summary of exceedances of periphyton guidelines at RSoE sites in the Hutt River catchment.

Site No.	Site Name	Biomass		Cover	
		50 mg/m²	120 mg/m²	Mats	Filamentous
RS23	Pakuratahi Below Farm Creek	1/6	0/6	0	1
RS20	Hutt River @ Te Marua	0/6	0/6	0	0
RS24	Mangaroa @ Te Marua	4/6	0/6	1	6
RS25	Akatarawa @ Hutt Confluence	0/6	0/6	0	0
RS26	Whakatikei @ Riverstone	0/6	0/6	0	4
RS21	Hutt River @ Manor Park	0/6	0/6	1	0
RS22	Hutt River @ Boulcott	3/6	1/6	1	1
RS27	Waiwhetu @ Wainui Hill Bridge	ND	ND	ND	ND

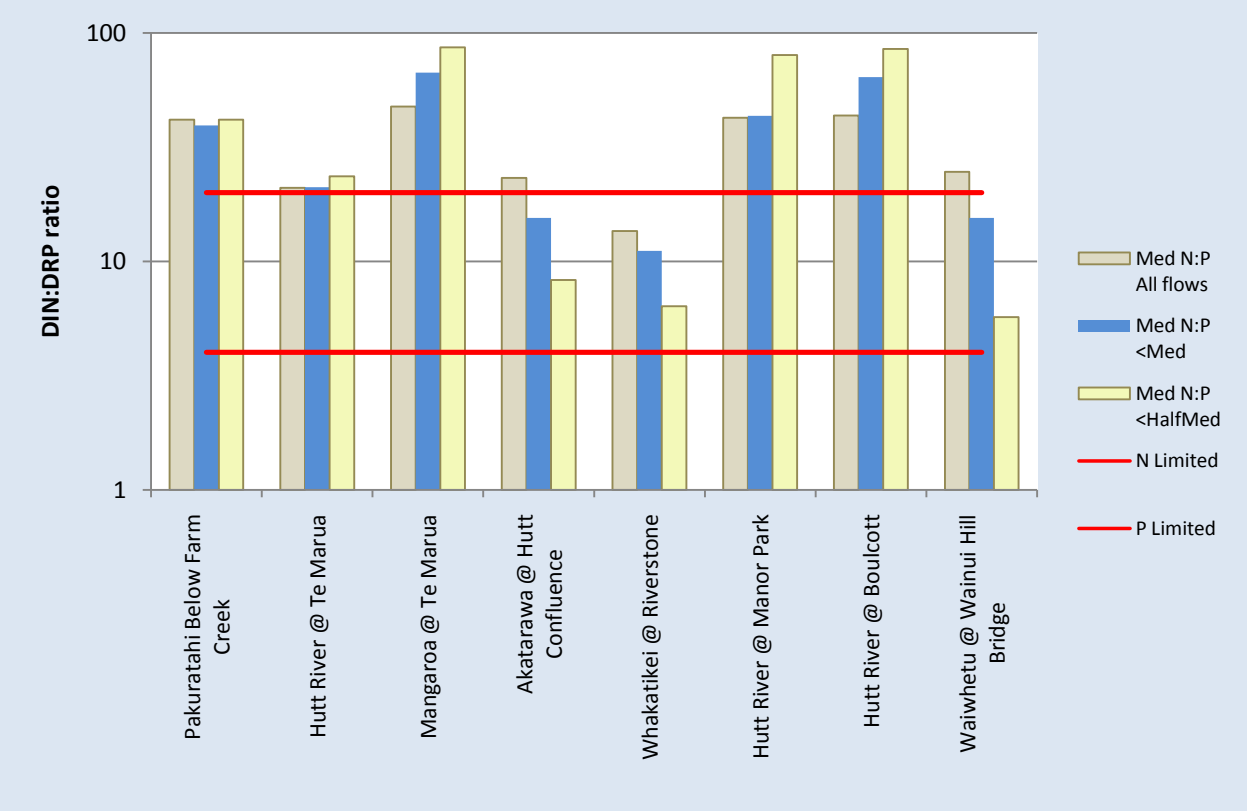


Figure 27: Median DIN:DRP ratios at RSoE sites in the Hutt River catchment. The area above the top red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom red line (DIN:DRP =4) is indicative of N-limited conditions.

5.1.5 Conclusions

The uppermost Hutt River site (Te Marua) and two tributaries (Akatarawa and Whakatikei) present nutrient concentrations consistent with the range of reference conditions observed in the region. These sites are also the three sites in the Hutt catchment that have less than 10% of their catchment in pastoral or urban land use. Periphyton biomass generally remains low at these sites, although occasional exceedancesof the filamentous algae cover guideline have been observed in the Whakatikei River.

The upper reaches of the Hutt River appear to be dominated by P-limited conditions, but with frequent occurrence of co-limited conditions. The moderate but significant increases in DIN concentrations observed in the Hutt River at Manor Park and Boulcott mean that periphyton growth in the middle and lower river reaches is very likely to be P-limited. Although the periphyton biomass increases significantly between the upper, middle and lower reaches of the Hutt River, RSoE monitoring data indicate that it generally remains moderate. It is noted however, that nuisance cyanobacterial blooms are frequent in the Hutt River, particularly in dry years, an issue that is better represented by periphyton cover data collected under the Recreational Water Quality monitoring programme than that by the RSoE monitoring programme. The removal of the co-limited conditions means that the periphyton growth may now primarily be controlled by the DRP inputs, rather than by both nutrients. The direct management implication of this observation is that additional DRP inputs to the Hutt catchment may directly result in increased periphyton growth.

The Mangaroa River presents higher DIN concentrations than the rest of the Hutt catchment, and may contribute significantly to the DIN increase in the Hutt River. Similarly, the Pakuratahi has higher DIN concentrations and the Whakatikei has higher DRP concentrations than the Hutt River mainstem. It is suggested that a nutrient load analysis would be useful in determining the contribution of the different tributaries to the nutrient loads carried by the Hutt River under different flow conditions.

The Waiwhetu Stream presents moderate DIN and high DRP concentrations. The pattern of increasing DRP concentrations at lower stream flow may be indicative of point-source discharge(s) to this stream. The Waiwhetu Stream joins the Hutt River near its mouth, thus will not contribute to the growth of periphyton in the Hutt River mainstem, but may act as a source of nutrients to the Hutt Estuary, where widespread macroalgae cover has been identified (Stevens and Robertson, 2010). It is suggested that the nutrient load analysis could be extended to the Hutt Estuary.

5.2 Ruamahanga River catchment

The Ruamahanga River catchment is the largest in Wellington region. The RSoE monitoring programme includes 18 sites within this catchment (Table 23). Four sites are on the Ruamahanga River itself, including a reference site where it emerges from the Tararua Forest Park (RS31, at McLays). The sites on tributaries include three reference and two "best available" sites.

The Ruamahanga mainstem and some of its tributaries that have their headwaters high in the Tararua Range are characterised by short accrual periods: 13 to 15 days at Ruamahanga at McLays, Waiohine at Gorge, and Waingawa at South Rd. The mean accrual period then increases to 16 days at Te Ore Ore, 14.3 days at Gladstone and 20.4 days at Pukio.

Beef Creek at Headwaters, Mangatarere at SH2, Waipoua at Colombo Road and Tauanui at Whakatomotomo Rd have mean accrual periods similar to that of the Ruamahanga at Pukio (19 to 24 days). The other tributaries have longer mean accrual periods, up to 49 days for the Parkvale Stream, making them more susceptible to excessive accumulation of periphyton and/or macrophytes.

In all the figures and tables below, the sites are presented in their upstream-to-downstream order in the catchment.

Table 23: RSoE sites in the Ruamahanga River catchment, and summary of land use in the catchment upstream of each site.

Site No.	Site Name	Site class	Elevation	Land use (% catchment)			
				Indigenous	Exotic forest + scrub	Pasture + cropping	Urban
RS31	Ruamahanga @ McLays	Reference	Upland	99	0	0	0
RS38	Kopuaranga @ Stewarts	Impacted	Lowland	5	4	91	0
RS32	Ruamahanga @ Te Ore Ore	Impacted	Lowland	26	4	67	1
RS40	Waipoua @ Colombo Rd	Impacted	Lowland	22	3	71	3
RS39	Whangaehu u/s Confluence	Impacted	Lowland	3	5	91	0
RS41	Waingawa @ South Rd	Impacted	Lowland	74	4	19	0
RS36	Taueru @ Castlehill	Best avail.	Upland	19	34	48	0
RS37	Taueru @ Gladstone	Impacted	Lowland	7	15	78	0
RS33	Ruamahanga @ Gladstone	Impacted	Lowland	20	8	70	1
RS45	Parkvale Trib. @ Lowes Res.	Best avail.	Lowland	0	15	85	0
RS46	Parkvale Stream at weir	Impacted	Lowland	0	1	98	0
RS47	Waiohine @ Gorge	Reference	Lowland	98	1	0	0
RS50	Mangatarere @ SH2	Impacted	Lowland	43	7	49	1
RS49	Beef Creek @ headwaters	Reference	Upland	100	0	0	0
RS48	Waiohine @ Bicknells	Impacted	Lowland	64	4	30	1
RS51	Huangarua @ Ponatahi Bridge	Impacted	Lowland	18	4	78	0
RS34	Ruamahanga @ Pukio	Impacted	Lowland	24	7	68	1
RS52	Tauanui @ Whakatomotomo Rd	Reference	Lowland	100	0	0	0

5.2.1 DIN

Median DIN concentrations in the upper Ruamahanga at McLays, and at the other three reference sites in the catchment are very low, below 0.030 mg/L (Figure 28).

There is a significant increase in DIN concentrations between McLays and the next site down the Ruamahanga River, at Te Ore Ore, where the median DIN concentration sits just below the ANZECC lowland guideline, at 0.410 mg/L. There is a slight, but statistically significant[1] increase in DIN concentration between Te Ore Ore and Gladstone, followed by a return to concentrations similar to Te Ore Ore at Pukio in the lower catchment reaches.

The DIN concentrations remain stable at decreasing river flows at McLays and Te Ore Ore, but decrease slightly at Gladstone and more sharply at Pukio. At low flows (i.e. below median flow) the median DIN concentration at Pukio is significantly[7] lower than at Te Ore Ore and at Gladstone.

In the tributaries, two of the non-reference sites have higher than reference median DIN concentrations but still meet the upland ANZECC guideline, and have significantly lower DIN concentrations than the Ruamahanga mainstem downstream of Te Ore Ore (Waingawa at South Rd, Taueru at Castlehill).

Two tributaries, the Waiohine at Bicknells and the Huangarua at Ponatahi Bridge, present median DIN concentrations similar to that of the mainstem at Pukio.

The remaining seven tributary sites largely exceed the ANZECC guideline for lowland streams, and have higher DIN concentrations than the Ruamahanga mainstem. The Kopuaranga Stream, Waipoua River, Whangaehu River, Taueru River, Parkvale stream and Mangatarere Stream therefore probably act as nutrient sources to the Ruamahanga River mainstem.

5.2.2 DRP

DRP concentrations measured in the Ruamahanga at McLays are among the lowest in the Wellington region (0.002 mg/L). There is a significant[8] increase in DRP concentration between the point where the river leaves the Tararua Forest Park (McLays) and the Te Ore Ore monitoring site (0.008 mg/L) (Figure 29). There is another significant increase between Te Ore Ore and Gladstone (0.025 mg/L). The overall median DRP concentration then undergoes a significant decrease between Gladstone and Pukio (0.017 mg/L). The flow-related patterns followed by the DRP concentrations at these four sites are interesting: DRP concentrations remain stable at different flow categories at McLays, a pattern consistent with that observed at other upland reference sites in the region. At Te Ore Ore, the DRP concentration decreases at low river flows, which may be associated with the use of DRP by the algal biomass. At Gladstone, the DRP concentration sharply increases at low river flows, which is consistent of a typical pattern associated with point-source discharges – the Masterton wastewater treatment plant discharge is located upstream of the Gladstone monitoring site. At Pukio, the pattern is similar to that observed at Te Ore Ore, i.e. a decrease in DRP at lower river flows.

The Mangatarere at SH2 monitoring site has the highest DRP concentrations of all RSoE sites. The very high DRP concentration at this site is thought to be due primarily to the discharge of treated wastewater from the Carterton wastewater treatment plant (Milne et al., 2010). Similarly to what is observed in the Ruamahanga at Gladstone, the DRP concentrations follow an increasing pattern at low river flows, which is consistent with the effects of a point-source discharge.

[7] Wilcoxon paired rank test, $p<0.05$
[8] Wilcoxon paired rank test, $p<0.01$

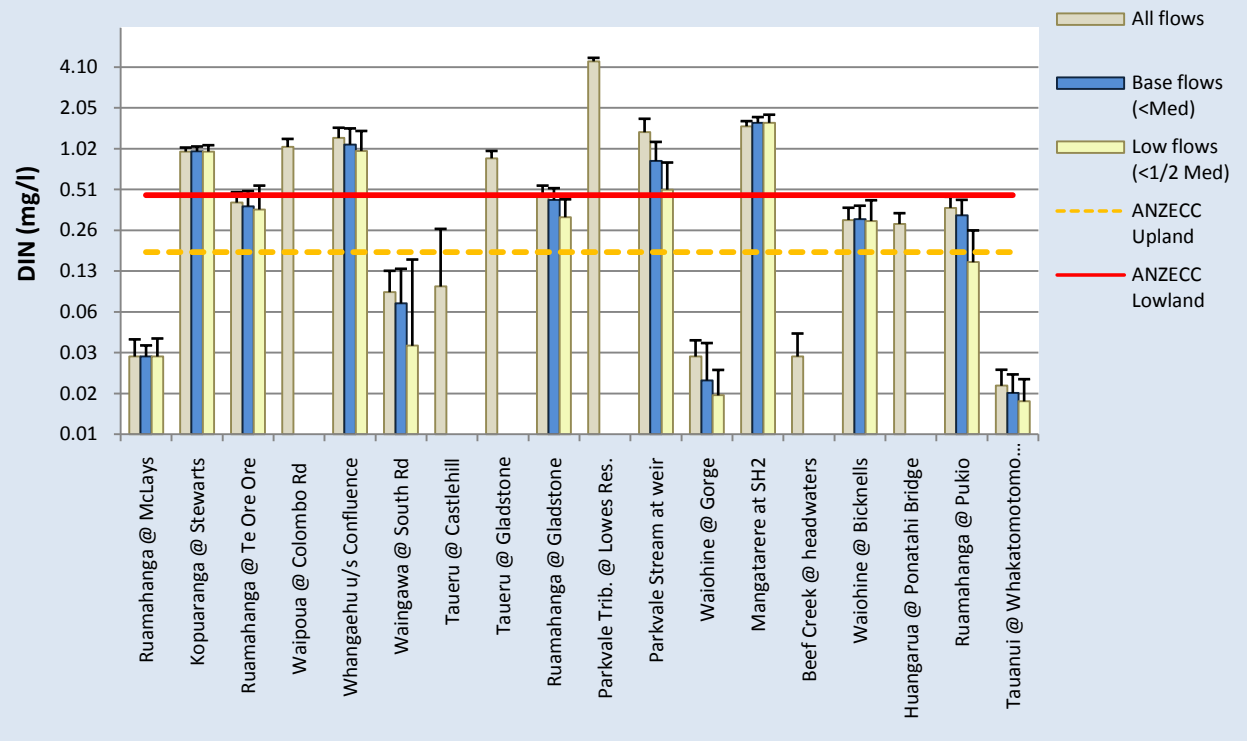


Figure 28: Median DIN concentrations (±95 % confidence interval) for RSoE sites in the Ruamahanga River catchment. Note the logarithmic scale.

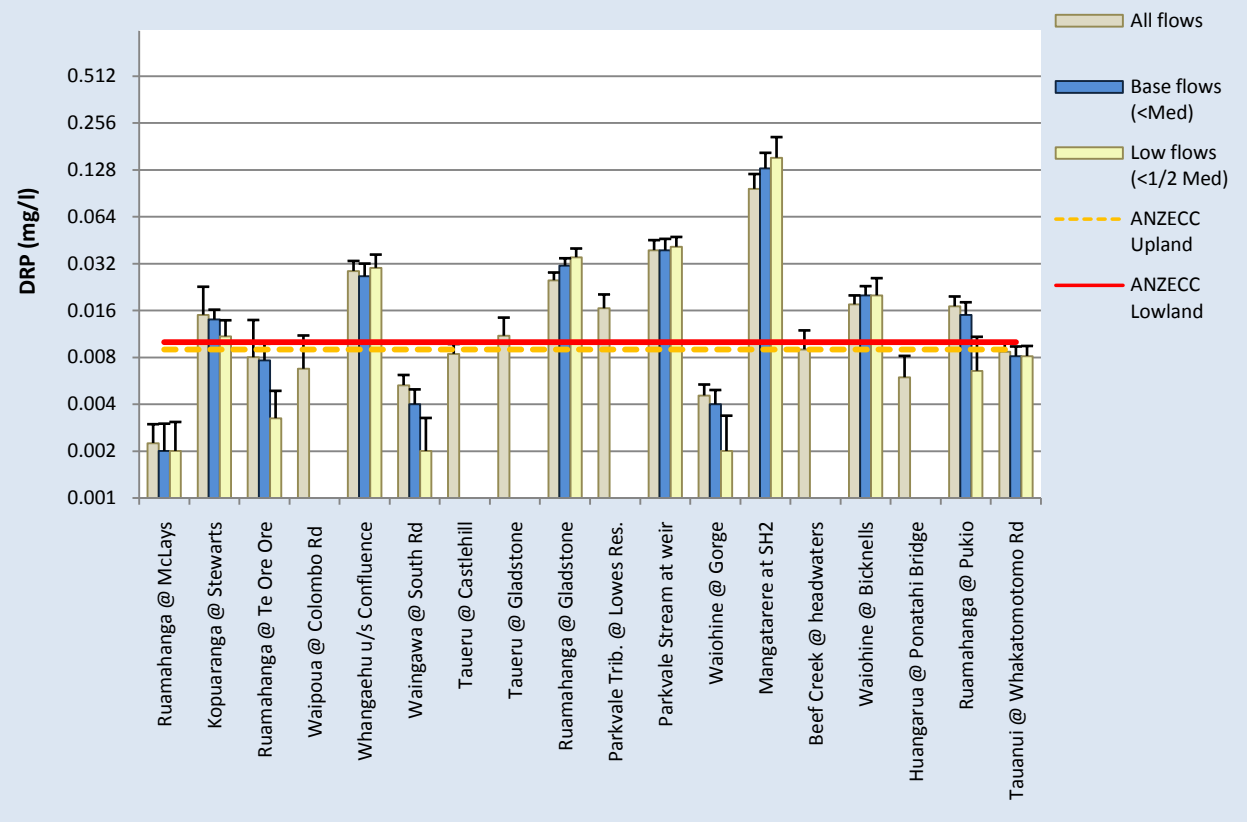


Figure 29: Median DRP concentrations (±95 % confidence interval) for RSoE sites in the Ruamahanga River catchment. Note the logarithmic scale.

The Waiohine River at Gorge is a reference site located at the point where the river exits the Tararua Forest Park. The DRP concentrations at this point are low (0.004 mg/L), well within the range of reference conditions. A significant increase in DRP concentration occurs between the Gorge site and Waiohine at Bicknells, which is likely caused by a mixture of non-point source and point source discharges (this site is located downstream of the point where the Mangatarere Stream flows into the Waiohine River). A pattern of increasing DRP concentrations at decreasing river flows is apparent at this site, which may be a result of the discharge of Carterton's wastewater to the Mangatarere Stream.

The other two reference sites located on tributaries of the Ruamahanga River (Beef Creek at Headwaters and Tauanui at Whakatomotomo Rd) have median DRP concentrations that are significantly higher (0.009 mg/L) than the other two reference sites in the catchment (0.002 to 0.004 mg/L). Tertiary sedimentary geology can result in moderately elevated DRP concentrations in groundwater and springs, and the higher DRP concentrations in the Tauanui River may be associated with groundwater interactions (Daughney, 2010). However, DRP source(s) at the Beef Creek site are unclear. The upper Ruamahanga and Waiohine rivers take their sources near the top of the Tararua Range and are essentially rain-fed systems, which accounts for the lower natural DRP levels.

The Waipoua, Waingawa, and Huangarua rivers present median DRP concentrations of the same order as those measured in the Ruamahanga at Te Ore Ore, i.e. lower than those measured at Gladstone and Pukio.

The Kopuaranga Stream and lower Taueru River sites have moderately elevated median DRP concentrations, in excess of the lowland ANZECC guideline for DRP. The Whangaehu River and Parkvale Stream both have elevated (in the order of 0.030 mg/L) DRP concentrations at all river flows. The role of these tributaries as source of dissolved nutrients to the Ruamahanga River may also need to be assessed.

5.2.3 Periphyton biomass and cover

Monitoring data indicate that periphyton biomass and cover always remain very low in the Ruamahanga River at McLays (median biomass of 1 mg/m^2). The median periphyton biomass increases significantly[9] at Te Ore Ore (median of 27 mg/m^2), then remains essentially stable down to Gladstone (30 mg/m^2), resulting in occasional breaches of the 50 mg/m^2 biomass guideline for the preservation of high biodiversity values (Table 24). The higher biomass guideline for the protection of aesthetic, recreational and trout fishing values was always complied with at both sites. The periphyton cover guidelines were only breached once (mats) at Gladstone, but periphyton cover data are not significantly different between the two sites. It is possible that periphyton cover in the Ruamahanga River is under-estimated by the current assessment method which involves assessment over a single transect in run habitat. In larger rivers such as the lower Ruamahanga, run habitat is relatively deep and may not be as suitable for periphyton growth as riffle habitat. As already mentioned in this report, it is recommended that the assessment method for periphyton cover at RSoE sites is updated to be consistent with that used by the recreational water quality monitoring programme. This information should be used in the future to reassess the extent and severity of periphyton cover issues (if any) in the middle and lower Ruamahanga River.

There appears to be a small increase in periphyton growth at Pukio compared with Gladstone, resulting in higher median biomass (although the difference is not statistically different), more regular breaches of the 50 mg/m^2 biomass guideline and some breaches of the filamentous algae cover guideline. Similarly to the other Ruamahanga River sites, the 120 mg/m^2 guideline was never exceeded at this site.

The mean accrual period at Pukio is longer than at Gladstone, and the extra time allowed for periphyton growths between two freshes, as well as lower water velocities in the lower river, may be the main reason

[9] Wilcoxon paired rank test, $p<0.01$

for the slight increase in periphyton growth. The lower dissolved nutrient concentrations, and particularly the decrease in both DRP and DIN concentrations between Gladstone and Pukio at lows river flows is consistent with nutrient use by the algal biomass.

Periphyton data for the Waiohine River at Gorge site are very similar to what is observed in the Ruamahanga River at McLays: consistently very low periphyton biomass and cover.

Periphyton biomass is also consistently low at the other two reference sites, Beef Creek at Headwaters and Tauanui at Whakatomotomo Rd, although slightly (and significantly) higher than at the other two reference sites. Both stream sites have also exceeded the periphyton cover guideline on one occasion.

Similarly to the Ruamahanga River between McLays and Te Ore Ore, periphyton biomass and cover in the Waiohine River undergo a slight, but statistically significant, increase between the Gorge and Bicknells sites, although not resulting in any guideline exceedances. Similar periphyton biomass levels are measured in the Waingawa River, with only one very marginal (51 mg/m^2) breach of the 50 mg/m^2 biomass guideline.

Occasional exceedances of both the biomass and cover guidelines in the Waipoua at Colombo Road indicate a moderate periphyton growth issue that may require further monitoring. This site is also affected by cyanobacteria growth (Warr, 2009).

The Whangaehu is essentially a soft-bottomed river, and periphyton biomass and cover are not formally monitored at this site. However, regular nuisance macrophyte growths are observed (Alton Perrie, pers. comm.). High periphyton biomass can also develop in these systems during periods of low flows, either attached to the macrophytes or free growing on the stream substrate. This suggests that periphyton cover should be monitored at this site.

The five other tributary sites (Kopuaranga at Stewarts, Taueru at Gladstone, Parkvale Stream, Mangatarere at SH2 and Huangarua at Ponatahi Bridge) present regular exceedances of periphyton biomass and/or cover (filamentous algae) guidelines, indicating a significant periphyton growth at these sites. These sites all have moderate to long mean accrual periods.

In addition to the Whangaehu River, regular presence of nuisance macrophyte growth is also reported at three sites (Taueru at Gladstone and the two Parkvale Stream sites), as well as occasionally in the Kopuaranga at Stewarts.

5.2.4 Nutrient limitation

The Ruamahanga River at McLays appears to be dominated by co-limited conditions (median DIN:DRP of 11), with regular changes between N-limited (about 25% of the time) and P-limited conditions (about 22% of the time) (Figure 30). The DIN:DRP ratios appear essentially stable under different river flow conditions, which reflects the DIN and DRP concentration stability with flow observed earlier on.

The DIN:DRP ratios at Te Ore Ore are strongly indicative of P-limited conditions, particularly at low river flows. Both dissolved nutrient concentrations increase significantly between McLays and Te Ore Ore, but with a proportionally greater increase of DIN causing a shift from co-limited conditions at McLays to P-limited conditions at Te Ore Ore.

DIN:DRP ratios at Gladstone may be indicative of a return to co-limited conditions. However, this is essentially due to the sharp increase in DRP concentrations measured at Gladstone, rather than a decrease in DIN concentrations. At Gladstone, both dissolved nutrients are present in relatively high concentrations at all flows, and it is doubtful whether any nutrient limitation of periphyton growth actually exists at this site. This is further supported by the fact that there does not appear to be any significant increase in periphyton biomass or cover between Te Ore Ore and Gladstone.

DIN:DRP ratios at the Ruamahanga at Pukio site indicate essentially P-limited conditions, with frequent co-limited conditions and some N-limited conditions (20% of the time) during periods of low river flow.

In the tributaries, the three reference sites appear to be dominated by N-limited conditions, particularly during periods of low river flows. The Waingawa at South Road is likely to be co-limited, or to shift from one limiting nutrient to the other. The Waiohine at Bicknells appears to be essentially P-limited, but with frequent co-limited conditions. The Waipoua at Colombo Road, Parkvale tributary, Taueru at Gladstone, Kopuaranga at Stewarts and Huangarua at Ponatahi Bridge are likely to be strongly P-limited.

Due to their elevated concentrations of both nutrients, periphyton growth in the Mangatarere at SH2, the Whangaehu River and the Parkvale Stream at Weir are unlikely to be limited by dissolved nutrient availability.

5.2.5 Conclusions

The Ruamahanga River and its tributaries appear to be characterised by low natural levels of DIN. DRP also appears to be naturally present in low to very low concentrations in rain-fed rivers originating near the top of the Tararua Range, but in moderate concentrations in smaller streams that have their source at the foothills. As a result, reference conditions in this catchment appear to be co-limited or N-limited, with very low to low periphyton growth.

Dissolved nutrient inputs into the Ruamahanga River upstream of Te Ore Ore result in significant increase in both DIN and DRP concentrations, but the proportionally greater increase in DIN causes a shift from co-limited conditions at McLays to P-limited conditions at Te Ore Ore. However, the increase in DRP concentrations between the two sites also means that any nutrient limitation of periphyton growth will be exerted at a higher biomass level, i.e. the conditions at Te Ore Ore will, in theory and all other things being equal, allow greater periphyton growth than at Mc Lays. This proposed mechanism is supported by the monitoring data, showing significantly higher periphyton biomass at Te Ore Ore compared with McLays. The DRP inputs between Te Ore Ore and Gladstone are likely to remove any nutrient limitation that may occur at Te Ore Ore, although this does not seem to result in increased periphyton growth.

There appears to be increased periphyton growth at the most downstream site on the Ruamahanga mainstem. The mean accrual period at Pukio is longer than at Gladstone, and the extra time allowed for periphyton growth between two freshes, as well as lower water velocities in this lower river reach, may be the main reasons for the slight increase in periphyton growth. The lower dissolved nutrient concentrations, and particularly the decrease in both DRP and DIN concentrations between Gladstone and Pukio at low river flows is consistent with nutrient use by the algal biomass between these two sites.

Within the tributaries, a number of sites always present low periphyton biomass and cover. These are the three reference sites, the Waiohine at Bicknells and the Waingawa at South Road. These two sites also have the shortest mean accrual period of the whole catchment, apart from the Ruamahanga River itself. The Waingawa at South Rd has low dissolved nutrient concentrations, so the acceptable periphyton levels appear a logical outcome. However, the Waiohine at Bicknells does have moderately elevated DIN and DRP, but it is probable that the frequent freshes maintain periphyton at acceptable levels, in spite of the relatively elevated nutrient concentrations.

All other tributaries present regular excessive periphyton and/or macrophyte growths. This indicates that, whilst the Ruamahanga River itself appears to be reasonably robust to nutrient enrichment (probably due to its very “flashy” nature), many of its tributaries are more sensitive to the effects of eutrophication, with likely detrimental effects on their ecological and recreational values.

Table 24: Summary of exceedances of periphyton guidelines at RSoE sites in the Ruamahanga River catchment.

Site No.	Site Name	Site class	Elevation	Biomass		Cover	
				50 mg/m²	120 mg/m²	Mats	Filamentous
RS31	Ruamahanga @ McLays	Reference	Upland	0/6	0/6	0	0
RS38	Kopuaranga @ Stewarts	Impacted	Lowland	5/6	5/6	0	19
RS32	Ruamahanga @ Te Ore Ore	Impacted	Lowland	2/6	0/6	0	0
RS40	Waipoua @ Colombo Rd	Impacted	Lowland	2/6	1/6	4	1
RS39	Whangaehu u/s Confluence	Impacted	Lowland	ND	ND	ND	ND
RS41	Waingawa @ South Rd	Impacted	Lowland	1/6	0/6	0	0
RS36	Taueru @ Castlehill	Best avail.	Upland	ND	ND	ND	ND
RS37	Taueru @ Gladstone	Impacted	Lowland	6/6	4/6	1	22
RS33	Ruamahanga @ Gladstone	Impacted	Lowland	1/6	0/6	1	0
RS45	Parkvale Trib. @ Lowes Res.	Best avail.	Lowland	2/6	0/6	0	0
RS46	Parkvale Stream at weir	Impacted	Lowland	5/6	2/6	1	14
RS47	Waiohine @ Gorge	Reference	Lowland	0/6	0/6	0	0
RS50	Mangatarere at SH2	Impacted	Lowland	3/6	1/6	3	10
RS49	Beef Creek @ headwaters	Reference	Upland	0/6	0/6	1	0
RS48	Waiohine @ Bicknells	Impacted	Lowland	0/6	0/6	0	1
RS51	Huangarua @ Ponatahi Bridge	Impacted	Lowland	3/6	3/6	3	18
RS34	Ruamahanga @ Pukio	Impacted	Lowland	3/6	0/6	0	4
RS52	Tauanui @ Whakatomotomo Rd	Reference	Lowland	0/6	0/6	0	1

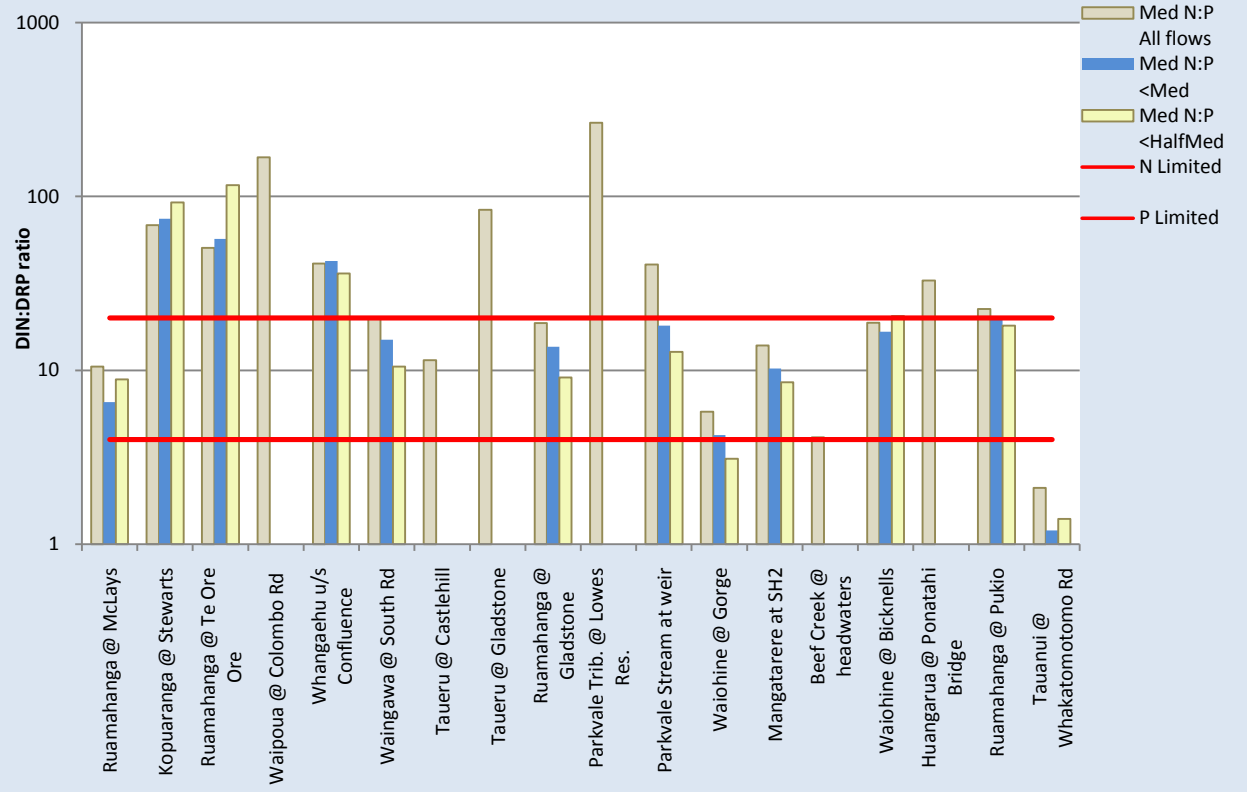


Figure 30: Median DIN:DRP ratios at RSoE sites in the Ruamahanga River catchment. The area above the top red line (DIN:DRP=20) is indicative of P-limited conditions; below the bottom red line (DIN:DRP =4) is indicative of N-limited conditions.

6 Summary and recommendations

6.1 Nutrient concentrations

In the Wellington region, 39 out of 56 long-term monitoring sites (69%) meet the ANZECC guideline for DIN, with an additional five sites (10%) below twice the guideline. High median DIN concentrations (more than twice the guideline) are measured at 12 sites (21%). Comparison with national figures indicates that about two thirds of the Wellington region's monitoring sites have a lower median DIN concentration than the national median for comparable sites. This could mean that either the overall picture of DIN contamination of streams and rivers in the Wellington region is better than the rest of the country taken as a whole, or that sites with expected low DIN concentrations (such as reference or near-reference) are over-represented in the Wellington RSoE monitoring network compared with the rest of the country. This consideration will be important to bear in mind when the existing regional water quality monitoring network is next reviewed. As expected, and documented across the country, there appears to be a very clear relationship between the amount of pastoral landuse in the catchment and instream DIN concentrations.

With regards to DRP, just over half (53%) of the RSoE monitoring sites meet the ANZECC guideline, with an additional 11 sites (19%) below twice the guideline value. High DRP concentrations are found at 15 (27%) sites. Similarly, just over half (53%) of the RSoE sites present a lower median DRP concentration than the national median for their national class. One interesting observation with regards to DRP is the fact that it appears to be naturally present in moderately elevated concentrations in some streams, possibly a reflection of groundwater interactions in areas of phosphorus-rich sedimentary geology.

It was outside the scope of this report to investigate in-depth the drivers of nutrient concentrations in the region's streams and rivers. It is recommended that this analysis be undertaken, with special attention paid to the influence of land-use, geology and in-stream biomass on the DIN and DRP concentrations in natural or developed catchments.

A special note should be made of the high nutrient concentrations measured in the Wellington region's urban streams. All urban stream sites largely exceeded the ANZECC guidelines for both DRP and DIN. Nearly all of them also largely exceeded the national medians for urban streams, in spite of these national medians being more than two times (DIN) and 1.7 times (for DRP) higher than the ANZECC guidelines.

6.2 Effects of nutrients

Table 25 summarises the issues associated with periphyton growth. A number (0) indicates that no issues associated with periphyton biomass or cover have been identified at this site, (1) indicates a moderate or potential issue, identified as occasional[10] breaches of the relevant guidelines for each site; (2) indicates a significant issue identified as regular[11] breaches of the relevant guidelines. Similarly, macrophyte issues are summarised with (1) for a moderate issue, and (2) for significant issue, based on a summary of visual observations provided by Greater Wellington Regional Council's environmental science staff (Alton Perrie, pers. comm..).

Across the 56 RSoE monitoring sites, 10 sites are considered unsuitable for periphyton attachment and are not monitored for periphyton biomass or cover. No formal monitoring of macrophyte cover or biomass is undertaken at these sites, but visual observations indicate the existence of significant issues associated with macrophyte growth at some sites. Visual observations also indicate that high periphyton biomass can

[10] One exceedance of the periphyton biomass guideline and/or 2 to 4 exceedances of the periphyton cover guidelines.

[11] Two or more exceedances of the periphyton biomass guideline and/or a combined total number of exceedances of any guideline of 5 or more.

develop at some of these sites, either as free-growing masses, or associated with macrophytes (i.e. growing on it or tangled with it). It is recommended that at least visual assessment of macrophyte and periphyton cover be undertaken and recorded monthly, to enable a more robust assessment of this issue.

To briefly summarise, of the 56 RSoE sites:

- 14 sites (25%) present a significant periphyton growth (biomass and/or cover) issue. Of these, two appear to also have regular nuisance macrophyte growth, and one has occasional nuisance macrophyte growth;
- 17 sites (30%) have a moderate periphyton issue. Of these, two sites also appear to regularly develop nuisance macrophyte growths;
- Of the 10 sites not monitored for periphyton growth, 4 have significant macrophyte growth and 2 occasional growth;
- One site does not appear to have any periphyton growth issue but presents regular nuisance macrophyte growth;
- Overall, there is no indication of any moderate or significant periphyton or macrophyte issues at 18 RSoE sites (32%).

It should also be noted that a number of these streams and rivers flow into downstream receiving environments such as larger rivers, estuaries/harbours or lakes that may be susceptible to the effects of nutrient enrichment. Clearly, management decisions in relation to these streams need to account for the potential effects in downstream receiving environments as well as in-stream effects.

In this report, it is noted that a small number of sites in the region display relatively high periphyton growth in spite of very low dissolved nutrient concentrations. These are generally small streams with long accrual periods and often low water velocities and limited riparian shading. Without entering in the details of what factors determine the accumulation of nuisance periphyton growth, this illustrates the fact that nutrient concentrations are only one aspect of the problem, and that instream/riparian and hydrological regimes are also important factors to consider.

It was outside the scope of this report to investigate in-depth the drivers of nuisance periphyton or macrophyte growths. This analysis should be undertaken alongside the analysis of the factors influencing dissolved nutrient concentrations, as already mentioned above.

6.3 Nutrient limitation

Table 25 summarises the findings of this report in terms of likely nutrient limitation. The first letter indicates which nutrient is likely to be limiting. A repeat of that letter indicates a strong indication of limitation by that nutrient. For example NN symbolises a strong indication of N-limited conditions. NP indicates likely co-limited conditions. The letter(s) in brackets indicate what conditions some sites appear to switch to, particularly during periods of low flows. For example, P (NP) symbolises a site that is generally P-limited but switches to co-limited conditions at times.

As a result of low DIN and low to moderate DRP concentrations, reference sites in the region are likely to be dominated by co-limited or N-limited conditions. A number of non-reference sites have similar dissolved nutrient concentrations to those of reference sites and have a similar likely limiting nutrient status. Overall, 23 sites (41%) in the region are likely to be either N-limited or co-limited.

In many streams and rivers with developed catchments, inputs from point-source discharges (e.g. municipal wastewater) and non-point (e.g. agricultural or urban landuse) sources, lead to an increase in the concentrations of both DIN and DRP.

In catchments dominated by pastoral landuse, the inputs of DIN are often proportionally greater than those of DRP, which causes a departure from the reference (N-limited or co-limited) conditions to more P-limited systems. DIN inputs to stream systems are generally highly seasonal, being primarily driven by soil moisture conditions (a wet soil comparatively leaches more nitrate than a dry soil). As a result, a

pattern is commonly noted, of sites that are generally P-limited, but tend to switch back to co-limited or N-limited conditions under low stream/river flow conditions. Overall 21 (38%) out of the 56 RSoE sites appear to be P-limited with 11 being likely to switch to co- or N-limited conditions at times.

At some sites, the inputs of both DIN and DRP concentrations are so high that both dissolved nutrients are likely to be readily available to algae growth at all times, i.e. are unlikely to exert any significant limitation on periphyton or macrophyte, growth. This may be the case for 12 (21%) of the current RSoE sites.

The mechanisms and intensity of inputs and in-stream attenuation are specific to each catchment, and result in different dissolved nutrient balances, and thus likely limiting nutrient at each site. In all cases where both nutrient concentrations increase, the direct consequence is that nutrient limitation, if any, of algae growth, will act at a higher biomass level than under reference conditions. In other words, this means that, in situations where other factors (such as physical habitat and hydrological conditions) are favourable to periphyton growth, periphyton growth will increase, regardless of current nutrient limitation status. This will need to be carefully considered when making recommendations in relation to the management of one only, or both, nutrients in a catchment.

Of course, one has to bear in mind that these conclusions are only based on the analysis of dissolved nutrient ratios, which only provide an indication of nutrient limitation and should be confirmed by bioassays, such as nutrient diffusing substrates.

6.4 Main catchments

When looking at the region's two largest catchments, the Ruamahanga River itself appears to be reasonably robust to the effects of nutrient enrichment, i.e. only very moderate periphyton issues were identified at the most downstream in spite of quite elevated dissolved nutrient concentrations, particularly at Te Ore Ore. The high frequency of freshes, that regularly "reset" periphyton biomass to low levels, is probably the key factor limiting periphyton growth in this river. It should be noted however that many tributaries of the Ruamahanga River, particularly the eastern Wairarapa tributaries, do not have the same frequency of freshes and present significant issues associated with periphyton and/or macrophyte growth.

The Hutt River presents a moderate periphyton biomass and cover issue in its lower catchment, as well as cyanobacteria proliferations in its middle and lower reaches, in spite of relatively low levels of nutrients. As such, it appears to be much more sensitive to nutrient enrichment than the Ruamahanga River, and future increases in dissolved nutrient inputs may very well result in increased periphyton growth. Dissolved nutrient ratios provide a reasonably strong indication that the Hutt River is essentially P-limited, and DRP inputs to the river will need to be carefully managed in the future.

6.5 Management implications and recommendations

6.5.1 Need for nutrient management

When considering water quality management, one of the key questions is whether each stream, river or the whole of a catchment will require some form of nutrient management to protect aesthetic, recreational and ecological values.

In response to a similar question, a panel of national experts recommended that nutrient management was generally required for the control of periphyton growth, except where nutrient inputs were not likely to give rise to adverse effects in the said stream or in downstream environments (Wilcock et al. 2007). Shading can be efficient at suppressing periphyton growth, but only in relatively small waterways. High water turbidity, associated with significant depth can also prevent plant growth by limiting the amount of sunlight reaching the bottom. Such systems may not require nutrient management, as long as they do not flow into a nutrient-sensitive environment, such as a larger hard-bottomed river, a lake or a low energy coastal environment (i.e. estuary or harbour). Even in these systems, controlling macrophyte growth may still require some form of nutrient management.

Over two thirds of the RSoE sites (68 %) present moderate or significant issues associated with periphyton and/or macrophyte growth, and most would probably require some form of nutrient management, sometimes associated with instream and riparian habitat management, if algae and/or macrophyte growth were to be controlled at acceptable levels. Of the 18 sites that currently do not present any algae or macrophyte issues, 14 have suitable physical habitat characteristics for the development of periphyton (i.e. hard bed sediment), and may be at risk of excessive periphyton growth if nutrient concentrations were to increase. Nutrient limits may not be required at the remaining four sites, although this would need to be assessed on a case-by-case basis. In particular the sensitivity of other reaches of these streams and of downstream receiving environments would need to be assessed. In conclusion, situations where nutrient limits are not required may exist in the Wellington Region, but assuming that the RSoE network is representative of regional conditions, these situations are expected to be uncommon.

In small streams with a limited base flow, naturally or as a result of human activities, periphyton can grow to nuisance levels even when ambient dissolved nutrient concentrations are low. In these situations, flow and riparian management are essential to maintain or restore healthy aquatic ecosystems. Nutrients should still be managed to avoid effects on downstream receiving environments.

6.5.2 Priority nutrients

A logical step following the analysis of limiting nutrients would be to focus any nutrient management on the limiting nutrient for each stream, river or catchment.

This approach has been used by a number of regional councils in New Zealand. As an example, both Horizons Regional Council's Manawatu Catchment Water Quality Regional Plan and Hawke's Bay Regional Council's Regional Resource Management Plan (RRMP) set water quality standards or guidelines relating to DRP concentrations in rivers, but none relating to DIN. These decisions were made on the premise that these river systems were primarily P-limited, as well as on the perception that DRP primarily originated from point-source discharges and would likely be easier to control. However, the seasonal and flow-related patterns of nutrient limitation need to be carefully considered. Overall medians of DIN:DRP ratios may indicate strongly P-limited conditions, but flow-related analysis often indicate a pattern of co-limited or N-limited conditions at low flows. Recent studies have indicated that N-limited conditions become dominant in many parts of the Manawatu catchment (McArthur *et al.*, 2009) and the Hawke's Bay main catchments (Ausseil, 2008; Ausseil 2009a and 2009b). These findings certainly lead to questioning the possible outcomes or risks associated with management of DRP only.

As indicated in the paragraphs above, careful consideration also needs to be given to the natural background nutrient concentrations, before making management decisions relating to nutrient controls. The strong indication of P-limited conditions commonly seen in rivers and streams in developed catchments is often simply the expression of disproportionally high DIN inputs rather than a natural characteristic of these waterways. The moderately elevated concentrations of DRP naturally occurring in a number of streams in the Wellington region mean that management strategies solely focused on phosphorus will only ever be able to limit DRP concentrations to close to their natural levels. In these situations, uncontrolled DIN concentrations may result in excessive periphyton growth.

Finally, the intra-catchment connectivity of rivers and streams mean that different limiting nutrient conditions may apply to different parts of the catchments or their downstream receiving environment at any given time. Both the Ruamahanga and Hutt catchments are prime examples of this situation, where the limiting nutrient in some of their tributaries is different from that in the main river. As a result, a single-nutrient management strategy based on the mainstem may not deliver the expected outcome in the tributaries and vice-versa.

In response to a similar question, Wilcock et al. (2007) concluded that management of both dissolved nutrients is generally required, although priority nutrients may be able to be defined where there is a strong indication of that nutrient being limiting. That is not to say that management strategies should be equally divided between the two main nutrients, but more that the definition of management priorities should based on a comprehensive understanding of the risks, and likely success, associated with managing one nutrient rather than the other.

6.5.3 Further work and investigations

As indicated earlier, this report was primarily aimed at providing a description of the regional monitoring sites' nutrient status. It was beyond the scope of this project to investigate the key drivers of nutrient concentrations and periphyton growth. It is anticipated that other reports in this series of technical reports series will provide a more in-depth analysis trying to link the different pieces of the puzzle, including land-use, dissolved nutrient concentrations, periphyton biomass and cover, and descriptors of the hydrological regime. Part of this work will be undertaken to underpin the definition of recommended dissolved nutrient limits for the Wellington region's rivers and streams.

Along the course of this report, a number of points were raised that may require further investigation or action. These include:

a) Further investigations in the degraded state of the four RSoE sites with a predominantly urban upstream catchment. It is suggested that this investigation could comprise:
   - a study of the sources/causes of elevated dissolved nutrient concentrations at these sites;
   - an assessment of other water quality determinands at these sites – is the issue limited to nutrients, or is water quality in these streams generally degraded?
   - additional monitoring or investigations to determine whether other urban sites in the region have comparable water quality – i.e. are the four RSoE sites representative of urban streams in the Wellington region?

b) Further investigations in the sources of elevated DRP concentrations in the Waiwhetu Stream and the Waitohu Stream at Norfolk Crescent, with particular regard to the cause of the increasing DRP concentrations at low stream flows.

In response to concerns raised by GWRC staff about the possible underestimation of periphyton cover by RoSE data, particularly at large river sites, it is recommended that the RSoE periphyton cover monitoring method be reviewed. In particular, the suitability of the method used for the recreational water quality monitoring programme (20 views spread over four transects in both run and riffle habitat, as opposed to 10 views over a single transect in a run) be investigated for use/implementation as part of the RSoE programme.

In addition, reports of visual observations indicate that nuisance macrophyte growth is likely to be a significant issue at a number of sites in the region. It is recommended that protocols be put in place to formally monitor macrophyte cover and/or biomass as part of the SoE programme, to better ascertain the existence, and extent, of this potential issue. It is also suggested that at least a visual assessment of visible algae growths be undertaken at soft-bottomed monitoring sites, given the reported presence of significant amounts of filamentous algae, either "free-growing" or growing on macrophytes, at soft-bottom sites.

Finally it is recommended that a nutrient load analysis be conducted for the Hutt River catchment, to determine the contribution of the different tributaries to the nutrient loads carried by the Hutt River under different flow conditions. This analysis should focus as a priority on DRP, which appears to be the key controlling nutrient in the Hutt catchment.

Table 25: Summary of periphyton (biomass and cover) and macrophyte issues and likely nutrient limitation at RSoE sites. Refer to main text for table key.

Site No.	Site Name	Site class	FENZ	Catchment /area	Biomass issue	Cover issue	Macrophyte issue	Likely limitation
RS01	Mangapouri @ Rahui Rd	Impacted	A	Kapiti	Unsuit.	Unsuit.	N.D.	PP
RS02	Mangapouri @ Bennetts Rd	Impacted	A	Kapiti	Unsuit.	Unsuit.	2	Unlimited
RS03	Waitohu @ Forest Park	Reference	C7	Kapiti	0	0	N.D.	NP (N)
RS04	Waitohu @ Norfolk Cres	Impacted	C6c	Kapiti	Unsuit.	Unsuit.	1	P (NP)
RS05	Otaki @ Pukehinau	Reference	C7	Kapiti	0	0	N.D.	NP
RS06	Otaki @ Mouth	Impacted	C6a	Kapiti	0	1	N.D.	NP
RS07	Mangaone @ Sims Rd	Impacted	C6c	Kapiti	Unsuit.	Unsuit.	2	PP
RS08	Ngarara @ Field Way	Impacted	A	Kapiti	Unsuit.	Unsuit.	N.D.	Unlimited
RS09	Waikanae @ Mangaone Walkway	Reference	C5	Kapiti	0	0	N.D.	NP
RS10	Waikanae @ Greenaway Rd	Impacted	C6a	Kapiti	1	1	N.D.	P (NP)
RS11	Whareroa @ Waterfall Rd	Best avail.	C5	Kapiti	0	0	N.D.	Unlimited
RS12	Whareroa @ QE Park	Impacted	A	Kapiti	Unsuit.	Unsuit.	1	Unlimited
RS13	Horokiri @ Snodgrass	Impacted	C6b	Mana/Makara	0	1	N.D.	P (NP)
RS14	Pauatahanui @ Elmwood Bridge	Impacted	C5	Mana/Makara	1	1	2	NP (N)
RS15	Porirua @ Glenside	Impacted	C5	Mana/Makara	0	2	N.D.	PP
RS16	Porirua @ Milk Depot	Impacted	C5	Mana/Makara	0	2	N.D.	PP
RS17	Makara @ Kennels	Impacted	C5	Mana/Makara	1	1	2	Unlimited
RS18	Karori @ Makara Peak	Impacted	C5	Mana/Makara	0	2	N.D.	Unlimited
RS19	Kaiwharawhara @ Ngaio Gorge	Impacted	C5	Mana/Makara	0	2	N.D.	Unlimited
RS20	Hutt River @ Te Marua	Impacted	C7	Hutt	0	0	N.D.	P (NP)
RS21	Hutt River @ Manor Park	Impacted	C6a	Hutt	0	1	N.D.	P (NP)
RS22	Hutt River @ Boulcott	Impacted	C6a	Hutt	1	1	N.D.	P (NP)
RS23	Pakuratahi Below Farm Creek	Impacted	C7	Hutt	0	0	N.D.	PP
RS24	Mangaroa @ Te Marua	Impacted	C7	Hutt	0	2	N.D.	PP
RS25	Akatarawa @ Hutt Confluence	Impacted	C7	Hutt	0	0	N.D.	P (NP)
RS26	Whakatikei @ Riverstone	Impacted	C6a	Hutt	0	1	N.D.	NP
RS27	Waiwhetu @ Wainui Hill Bridge	Impacted	A	Hutt	Unsuit.	Unsuit.	N.D.	Unlimited
RS28	Wainuiomata @ Manuka Track	Reference	C7	Rimutaka	0	0	N.D.	NP
RS29	Wainuiomata u/s White Bridge	Impacted	C6a	Rimutaka	0	1	N.D.	NP
RS30	Orongorongo River	Impacted	C7	Rimutaka	0	1	N.D.	NP
RS31	Ruamahanga @ McLays	Reference	C7	Ruamahanga	0	0	N.D.	NP
RS32	Ruamahanga @ Te Ore Ore	Impacted	C6a	Ruamahanga	0	0	N.D.	P (NP)
RS33	Ruamahanga @ Gladstone	Impacted	C6a	Ruamahanga	0	0	N.D.	Unlimited
RS34	Ruamahanga @ Pukio	Impacted	C6a	Ruamahanga	0	1	N.D.	P (NP)
RS35	Mataikona Trib.	Best avail.	C5	Nth. Wairarapa	0	1	N.D.	NP (N)
RS36	Taueru @ Castlehill	Best avail.	C8	Ruamahanga	Unsuit.	Unsuit.	N.D.	NP
RS37	Taueru @ Gladstone	Impacted	C8	Ruamahanga	2	2	2	PP
RS38	Kopuaranga @ Stewarts	Impacted	C6c	Ruamahanga	2	2	1	PP
RS39	Whangaehu u/s Confluence	Impacted	C8	Ruamahanga	Unsuit.	Unsuit.	2	Unlimited
RS40	Waipoua @ Colombo Rd	Impacted	C6a	Ruamahanga	1	1	N.D.	PP
RS41	Waingawa @ South Rd	Impacted	C6a	Ruamahanga	0	0	N.D.	P (NP)
RS42	Whareama @ Gauge	Impacted	C6c	Nth. Wairarapa	Unsuit.	Unsuit.	2	NP (N)
RS43	Motuwaireka @ headwaters	Best avail.	C5	Nth. Wairarapa	0	1	N.D.	NP
RS44	Totara @ Stronvar	Impacted	C5	Nth. Wairarapa	0	2	N.D.	NP
RS45	Parkvale Trib. @ Lowes Res.	Best avail.	A	Ruamahanga	0	0	N.D.	PP
RS46	Parkvale Stream at weir	Impacted	C6c	Ruamahanga	2	2	2	Unlimited
RS47	Waiohine @ Gorge	Reference	C7	Ruamahanga	0	0	N.D.	NP (N)
RS48	Waiohine @ Bicknells	Impacted	C6a	Ruamahanga	0	1	N.D.	NP
RS49	Beef Creek @ headwaters	Reference	C7	Ruamahanga	0	0	N.D.	N (NP)
RS50	Mangatarere at SH2	Impacted	C6a	Ruamahanga	1	2	N.D.	Unlimited
RS51	Huangarua @ Ponatahi Bridge	Impacted	C6a	Ruamahanga	2	2	N.D.	P (NP)
RS52	Tauanui @ Whakatomotomo Rd	Reference	C7	Ruamahanga	0	0	N.D.	NN
RS53	Awhea @ Tora Rd	Impacted	C6c	Sth Wairarapa	2	2	N.D.	NP (N)
RS54	Coles Creek trib.	Best avail.	C8	Sth Wairarapa	0	2	N.D.	NN
RS55	Tauherenikau @ Websters	Impacted	C6a	Lk Wairarapa	0	1	N.D.	NP
RS56	Waiorongomai @ Forest Park	Reference	C7	Lk Wairarapa	0	2	N.D.	NN

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APPENDICES

Appendix A: Summary description of RSoE sites

Site									Catchment									
N.	Site Name	X	Y	Site class	FENZ Class	Substrate	Elevation (150m threshld)	Mean Accrual (day)	Catchment /area	Size (ha)	RE C S-O_F	Indig. cover	Exotic forest	Scrub	Pasture/ Cropping	Urban	Other	REC class
RS01	Mangapouri @ Rahui Rd	1783373	5484901	Impacted	A	S	Lowland	n/a	Kapiti	69	L	9	1	0	87	2	0	LP
RS02	Mangapouri @ Bennetts Rd	1780903	5487645	Impacted	A	S	Lowland	n/a	Kapiti	698	L	3	3	1	52	42	0	Ur
RS03	Waitohu @ Forest Park	1787593	5483689	Reference	C7	H	Upland	18.5	Kapiti	1269	H	94	0	4	2	0	0	UN
RS04	Waitohu @ Norfolk Cres	1779537	5488304	Impacted	C6c	S	Lowland	18.5	Kapiti	5144	L	34	8	3	47	7	2	LP
RS05	Otaki @ Pukehinau	1785426	5478749	Reference	C7	H	Lowland	16	Kapiti	30548	H	95	1	0	2	0	1	UN
RS06	Otaki @ Mouth	1777982	5485886	Impacted	C6a	H	Lowland	16.7	Kapiti	34343	H	88	2	1	8	0	1	UN
RS07	Mangaone @ Sims Rd	1776242	5482407	Impacted	C6c	S	Lowland	n/a	Kapiti	5292	L	16	11	1	71	1	1	LP
RS08	Ngarara @ Field Way	1771180	5474620	Impacted	A	S	Lowland	n/a	Kapiti	1930	L	23	9	1	46	17	4	LP
RS09	Waikanae @ Mangaone Walkway	1779974	5473638	Reference	C5	H	Upland	30	Kapiti	1037	L	86	12	0	2	0	0	LN
RS10	Waikanae @ Greenaway Rd	1771223	5472915	Impacted	C6a	H	Lowland	28.1	Kapiti	12948	L	65	15	1	18	1	0	LF
RS11	Whareroa @ Waterfall Rd	1768074	5464532	Best avail.	C5	H	Lowland	26	Kapiti	105	L	21	23	22	34	0	0	LP
RS12	Whareroa @ QE Park	1765976	5464400	Impacted	A	S	Lowland	n/a	Kapiti	1654	L	18	9	2	66	4	1	LP
RS13	Horokiri @ Snodgrass	1761804	5450653	Impacted	C6b	H	Lowland	32.8	Mana/Makara	2893	L	11	28	15	45	0	0	LP
RS14	Pauatahanui @ Elmwood Bridge	1761097	5446783	Impacted	C5	H	Lowland	30	Mana/Makara	3793	L	21	14	4	60	1	0	LP
RS15	Porirua @ Glenside	1753289	5438364	Impacted	C5	H	Lowland	20.9	Mana/Makara	1423	L	13	4	12	45	25	1	LP
RS16	Porirua @ Milk Depot	1754366	5443031	Impacted	C5	H	Lowland	20.7	Mana/Makara	3347	L	12	9	11	39	28	0	LP
RS17	Makara @ Kennels	1743530	5433635	Impacted	C5	H	Lowland	24.6	Mana/Makara	3615	L	3	12	40	43	2	0	LP
RS18	Karori @ Makara Peak	1744212	5426874	Impacted	C5	H	Lowland	21	Mana/Makara	689	L	42	2	3	3	50	0	Ur
RS19	Kaiwharawhara @ Ngaio Gorge	1749069	5431077	Impacted	C5	H	Lowland	25.6	Mana/Makara	1632	L	36	6	12	8	38	0	Ur
RS20	Hutt River @ Te Marua	1780071	5450158	Impacted	C7	H	Lowland	15.2	Hutt	19279	H	87	3	4	6	0	0	UN
RS21	Hutt River @ Manor Park	1766679	5442285	Impacted	C6a	H	Lowland	19.5	Hutt	55964	H	69	13	3	11	4	0	UF
RS22	Hutt River @ Boulcott	1760858	5437486	Impacted	C6a	H	Lowland	20.1	Hutt	60770	L	67	12	3	12	6	1	LF
RS23	Pakuratahi Below Farm Creek	1784607	5451677	Impacted	C7	H	Lowland	14.9	Hutt	8074	H	70	8	9	13	0	0	UN
RS24	Mangaroa @ Te Marua	1778543	5448643	Impacted	C7	H	Lowland	23.8	Hutt	10410	L	49	15	3	32	1	0	LP
RS25	Akatarawa @ Hutt Confluence	1776183	5449184	Impacted	C7	H	Lowland	19.6	Hutt	11642	L	79	16	1	3	0	0	LN
RS26	Whakatikei @ Riverstone	1772256	5446747	Impacted	C6a	H	Lowland	26.2	Hutt	8184	L	65	24	2	8	0	0	LF
RS27	Waiwhetu @ Wainui Hill Bridge	1760565	5434141	Impacted	A	S	Lowland	17.7	Hutt	1459	L	28	0	19	0	53	0	Ur
RS28	Wainuiomata @ Manuka Track	1768242	5430634	Reference	C7	H	Upland	27.2	Rimutaka	2686	L	100	0	0	0	0	0	LN
RS29	Wainuiomata u/s White Bridge	1757316	5415724	Impacted	C6a	H	Lowland	27	Rimutaka	13158	L	65	5	16	9	6	0	LF
RS30	Orongorongo River	1758930	5413094	Impacted	C7	H	Lowland	16.6	Rimutaka	9406	H	84	0	11	2	0	2	UN
RS31	Ruamahanga @ McLays	1818149	5485809	Reference	C7	H	Upland	13.2	Ruamahanga	6398	H	99	0	0	0	0	1	UN
RS32	Ruamahanga @ Te Ore Ore	1825574	5463019	Impacted	C6a	H	Lowland	16	Ruamahanga	30500	L	26	3	1	67	1	1	LP
RS33	Ruamahanga @ Gladstone	1821208	5450327	Impacted	C6a	H	Lowland	14.3	Ruamahanga	132452	L	20	7	1	70	1	1	LP

Site									Catchment									
N.	Site Name	X	Y	Site class	FENZ Class	Subs trate	Elevation (150m threshld)	Mean Accrual (day)	Catchment /area	Size (ha)	RE C S-O_F	Indig. cover	Exotic forest	Scrub	Pasture/ Cropping	Urb an	Other	REC class
RS34	Ruamahanga @ Pukio	1797832	5431010	Impacted	C6a	H	Lowland	20.4	Ruamahanga	243356	L	24	6	1	68	1	1	LP
RS35	Mataikona Trib.	1871844	5490906	Best avail.	C5	H	Lowland	28	N. Wairarapa	213	L	62	7	0	31	0	0	LP
RS36	Taueru @ Castlehill	1852300	5484198	Best avail.	C8	S	Upland	35	Ruamahanga	1799	L	19	16	18	48	0	0	LF
RS37	Taueru @ Gladstone	1824148	5450815	Impacted	C8	H	Lowland	45.4	Ruamahanga	49247	L	7	14	1	78	0	0	LP
RS38	Kopuaranga @ Stewarts	1826761	5469569	Impacted	C6c	H	Lowland	28.1	Ruamahanga	16049	L	5	3	1	91	0	0	LP
RS39	Whangaehu u/s Confluence	1826267	5459407	Impacted	C8	S	Lowland	n/a	Ruamahanga	14389	L	3	5	0	91	0	0	LP
RS40	Waipoua @ Colombo Rd	1825018	5462890	Impacted	C6a	H	Lowland	21.8	Ruamahanga	17106	L	22	1	2	71	3	0	LP
RS41	Waingawa @ South Rd	1820716	5460649	Impacted	C6a	H	Lowland	15	Ruamahanga	14176	H	74	3	1	19	0	2	UN
RS42	Whareama @ Gauge	1856090	5461229	Impacted	C6c	S	Lowland	36	N. Wairarapa	39878	L	11	18	1	69	0	0	LP
RS43	Motuwaireka @ headwaters	1852017	5450302	Best avail.	C5	H	Lowland	30	N. Wairarapa	353	L	68	32	0	0	0	0	LF
RS44	Totara @ Stronvar	1848025	5444916	Impacted	C5	H	Upland	32	N. Wairarapa	1150	L	1	94	3	2	0	0	LF
RS45	Parkvale Trib. @ Lowes Res.	1818094	5458352	Best avail.	A	H	Lowland	49	Ruamahanga	18	L	0	15	0	85	0	0	LP
RS46	Parkvale Stream at weir	1813515	5449469	Impacted	C6c	H	Lowland	49	Ruamahanga	5239	L	0	1	0	98	0	0	LP
RS47	Waiohine @ Gorge	1801889	5455995	Reference	C7	H	Lowland	15.1	Ruamahanga	18549	H	98	1	0	0	0	1	UN
RS48	Waiohine @ Bicknells	1810615	5448099	Impacted	C6a	H	Lowland	14.2	Ruamahanga	37742	H	64	4	0	30	1	1	UP
RS49	Beef Creek @ headwaters	1803963	5456398	Reference	C7	H	Upland	19	Ruamahanga	287	L	100	0	0	0	0	0	LN
RS50	Mangatarere at SH2	1809768	5452160	Impacted	C6a	H	Lowland	21.4	Ruamahanga	11743	L	43	7	0	49	1	0	LP
RS51	Huangarua @ Ponatahi Bridge	1807009	5435213	Impacted	C6a	H	Lowland	29	Ruamahanga	30912	L	18	4	0	78	0	0	LP
RS52	Tauanui @ Whakatomotomo Rd	1790648	5414515	Reference	C7	H	Lowland	24	Ruamahanga	2172	H	100	0	0	0	0	0	UN
RS53	Awhea @ Tora Rd	1809951	5403289	Impacted	C6c	H	Lowland	27	S. Wairarapa	15028	L	26	10	0	64	0	1	LP
RS54	Coles Creek trib.	1814020	5415217	Best avail.	C8	H	Lowland	27	S. Wairarapa	169	L	90	0	0	10	0	0	LN
RS55	Tauherenikau @ Websters	1797082	5439942	Impacted	C6a	H	Lowland	14.9	Lke Wairarapa	15721	H	69	1	4	25	0	1	UN
RS56	Waiorongomai @ Forest Park	1779604	5430559	Reference	C7	H	Lowland	16	Lke Wairarapa	2507	H	100	0	0	0	0	0	UN

Appendix B: RSoE sites sorted by decreasing median DIN concentration

SITE_N	Site Name	Site class	FENZ	Catchment/area	Median DIN (g/m^3)	DIN Std Dev	Median DRP (g/m^3)	DRP Std Dev
RS01	Mangapouri @ Rahui Rd	Impacted	A	Kapiti	7.400	1.815	0.013	0.013
RS45	Parkvale Trib. @ Lowes Res.	Best available	A	Ruamahanga	4.515	1.031	0.017	0.014
RS07	Mangaone @ Sims Rd	Impacted	C6c	Kapiti	2.245	0.741	0.022	0.008
RS02	Mangapouri @ Bennetts Rd	Impacted	A	Kapiti	2.100	0.998	0.029	0.009
RS50	Mangatarere at SH2	Impacted	C6a	Ruamahanga	1.500	0.539	0.097	0.094
RS18	Karori @ Makara Peak	Impacted	C5	Mana/Makara	1.400	0.330	0.043	0.017
RS46	Parkvale Stream at weir	Impacted	C6c	Ruamahanga	1.355	1.376	0.039	0.025
RS39	Whangaehu u/s Confluence	Impacted	C8	Ruamahanga	1.230	0.919	0.029	0.018
RS19	Kaiwharawhara @ Ngaio Gorge	Impacted	C5	Mana/Makara	1.205	0.289	0.042	0.025
RS15	Porirua @ Glenside	Impacted	C5	Mana/Makara	1.140	0.457	0.022	0.013
RS40	Waipoua @ Colombo Rd	Impacted	C6a	Ruamahanga	1.055	0.612	0.007	0.017
RS16	Porirua @ Milk Depot	Impacted	C5	Mana/Makara	1.011	0.511	0.022	0.010
RS38	Kopuaranga @ Stewarts	Impacted	C6c	Ruamahanga	0.976	0.273	0.015	0.030
RS37	Taueru @ Gladstone	Impacted	C8	Ruamahanga	0.870	0.459	0.011	0.013
RS04	Waitohu @ Norfolk Cres	Impacted	C6c	Kapiti	0.605	0.274	0.015	0.006
RS24	Mangaroa @ Te Marua	Impacted	C7	Hutt	0.578	0.253	0.012	0.008
RS27	Waiwhetu @ Wainui Hill Bridge	Impacted	A	Hutt	0.560	0.267	0.025	0.024
RS08	Ngarara @ Field Way	Impacted	A	Kapiti	0.479	1.135	0.044	0.016
RS33	Ruamahanga @ Gladstone	Impacted	C6a	Ruamahanga	0.470	0.305	0.025	0.012
RS12	Whareroa @ QE Park	Impacted	A	Kapiti	0.460	0.352	0.041	0.013
RS13	Horokiri @ Snodgrass	Impacted	C6b	Mana/Makara	0.413	0.297	0.015	0.006
RS32	Ruamahanga @ Te Ore Ore	Impacted	C6a	Ruamahanga	0.410	0.316	0.008	0.023
RS34	Ruamahanga @ Pukio	Impacted	C6a	Ruamahanga	0.375	0.308	0.017	0.010
RS11	Whareroa @ Waterfall Rd	Best available	C5	Kapiti	0.372	0.214	0.034	0.010
RS48	Waiohine @ Bicknells	Impacted	C6a	Ruamahanga	0.305	0.280	0.018	0.010
RS17	Makara @ Kennels	Impacted	C5	Mana/Makara	0.300	0.461	0.030	0.011
RS51	Huangarua @ Ponatahi Bridge	Impacted	C6a	Ruamahanga	0.286	0.224	0.006	0.009
RS23	Pakuratahi Below Farm Creek	Impacted	C7	Hutt	0.285	0.291	0.006	0.004
RS14	Pauatahanui @ Elmwood Bridge	Impacted	C5	Mana/Makara	0.255	0.218	0.018	0.008
RS21	Hutt River @ Manor Park	Impacted	C6a	Hutt	0.239	0.136	0.006	0.004
RS10	Waikanae @ Greenaway Rd	Impacted	C6a	Kapiti	0.235	0.150	0.008	0.022
RS22	Hutt River @ Boulcott	Impacted	C6a	Hutt	0.210	0.187	0.005	0.004
RS29	Wainuiomata u/s White Bridge	Impacted	C6a	Rimutaka	0.201	0.191	0.014	0.007
RS09	Waikanae @ Mangaone Walkway	Reference	C5	Kapiti	0.110	0.053	0.013	0.004
RS25	Akatarawa @ Hutt Confluence	Impacted	C7	Hutt	0.106	0.076	0.005	0.003
RS20	Hutt River @ Te Marua	Impacted	C7	Hutt	0.100	0.046	0.005	0.003
RS36	Taueru @ Castlehill	Best available	C8	Ruamahanga	0.099	0.648	0.008	0.005
RS26	Whakatikei @ Riverstone	Impacted	C6a	Hutt	0.097	0.117	0.008	0.004
RS44	Totara @ Stronvar	Impacted	C5	Northern Wairarapa	0.090	0.224	0.002	0.003
RS41	Waingawa @ South Rd	Impacted	C6a	Ruamahanga	0.090	0.155	0.005	0.003
RS28	Wainuiomata @ Manuka Track	Reference	C7	Rimutaka	0.085	0.038	0.011	0.004
RS30	Orongorongo River	Impacted	C7	Rimutaka	0.065	0.040	0.005	0.003
RS06	Otaki @ Mouth	Impacted	C6a	Kapiti	0.057	0.089	0.005	0.003
RS53	Awhea @ Tora Rd	Impacted	C6c	South Wairarapa	0.056	0.095	0.006	0.007
RS43	Motuwaireka @ headwaters	Best available	C5	Northern Wairarapa	0.050	0.123	0.004	0.004
RS55	Tauherenikau @ Websters	Impacted	C6a	Lake Wairarapa	0.050	0.083	0.004	0.003
RS05	Otaki @ Pukehinau	Reference	C7	Kapiti	0.047	0.035	0.005	0.003
RS03	Waitohu @ Forest Park	Reference	C7	Kapiti	0.040	0.046	0.008	0.003
RS35	Mataikona Trib.	Best available	C5	Northern Wairarapa	0.037	0.379	0.006	0.003
RS31	Ruamahanga @ McLays	Reference	C7	Ruamahanga	0.030	0.040	0.002	0.003
RS49	Beef Creek @ headwaters	Reference	C7	Ruamahanga	0.030	0.056	0.009	0.011
RS47	Waiohine @ Gorge	Reference	C7	Ruamahanga	0.030	0.038	0.005	0.003
RS54	Coles Creek trib.	Best available	C8	South Wairarapa	0.022	0.021	0.007	0.004
RS56	Waiorongomai @ Forest Park	Reference	C7	Lake Wairarapa	0.021	0.020	0.006	0.006
RS52	Tauanui @ Whakatomotomo Rd	Reference	C7	Ruamahanga	0.018	0.022	0.009	0.005
RS42	Whareama @ Gauge	Impacted	C6c	Northern Wairarapa	0.018	0.214	0.006	0.009

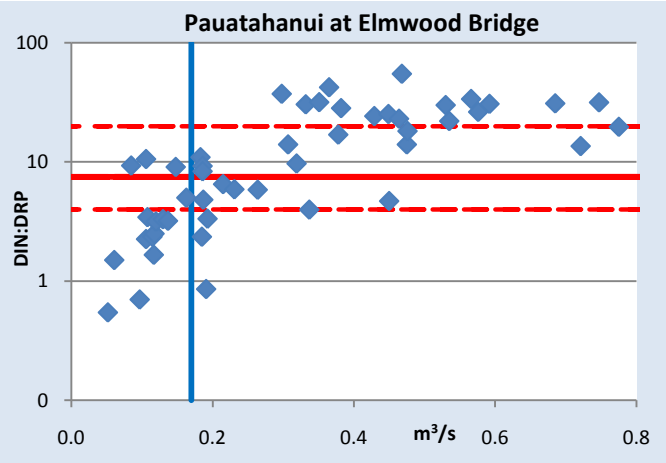
Appendix C: RSoE sites sorted by decreasing median DRP concentration

SITE_N	Site Name	Site class	FENZ	Catchment/area	Median DIN (g/m^3)	SIN Std Dev	Median DRP (g/m^3)	DRP Std Dev
RS50	Mangatarere at SH2	Impacted	C6a	Ruamahanga	1.500	0.539	0.097	0.094
RS08	Ngarara @ Field Way	Impacted	A	Kapiti	0.479	1.135	0.044	0.016
RS18	Karori @ Makara Peak	Impacted	C5	Mana/Makara	1.400	0.330	0.043	0.017
RS19	Kaiwharawhara @ Ngaio Gorge	Impacted	C5	Mana/Makara	1.205	0.289	0.042	0.025
RS12	Whareroa @ QE Park	Impacted	A	Kapiti	0.460	0.352	0.041	0.013
RS46	Parkvale Stream at weir	Impacted	C6c	Ruamahanga	1.355	1.376	0.039	0.025
RS11	Whareroa @ Waterfall Rd	Best available	C5	Kapiti	0.372	0.214	0.034	0.010
RS17	Makara @ Kennels	Impacted	C5	Mana/Makara	0.300	0.461	0.030	0.011
RS39	Whangaehu u/s Confluence	Impacted	C8	Ruamahanga	1.230	0.919	0.029	0.018
RS02	Mangapouri @ Bennetts Rd	Impacted	A	Kapiti	2.100	0.998	0.029	0.009
RS33	Ruamahanga @ Gladstone	Impacted	C6a	Ruamahanga	0.470	0.305	0.025	0.012
RS27	Waiwhetu @ Wainui Hill Bridge	Impacted	A	Hutt	0.560	0.267	0.025	0.024
RS07	Mangaone @ Sims Rd	Impacted	C6c	Kapiti	2.245	0.741	0.022	0.008
RS15	Porirua @ Glenside	Impacted	C5	Mana/Makara	1.140	0.457	0.022	0.013
RS16	Porirua @ Milk Depot	Impacted	C5	Mana/Makara	1.011	0.511	0.022	0.010
RS48	Waiohine @ Bicknells	Impacted	C6a	Ruamahanga	0.305	0.280	0.018	0.010
RS14	Pauatahanui @ Elmwood Bridge	Impacted	C5	Mana/Makara	0.255	0.218	0.018	0.008
RS34	Ruamahanga @ Pukio	Impacted	C6a	Ruamahanga	0.375	0.308	0.017	0.010
RS45	Parkvale Trib. @ Lowes Res.	Best available	A	Ruamahanga	4.515	1.031	0.017	0.014
RS38	Kopuaranga @ Stewarts	Impacted	C6c	Ruamahanga	0.976	0.273	0.015	0.030
RS04	Waitohu @ Norfolk Cres	Impacted	C6c	Kapiti	0.605	0.274	0.015	0.006
RS13	Horokiri @ Snodgrass	Impacted	C6b	Mana/Makara	0.413	0.297	0.015	0.006
RS29	Wainuiomata u/s White Bridge	Impacted	C6a	Rimutaka	0.201	0.191	0.014	0.007
RS09	Waikanae @ Mangaone Walkway	Reference	C5	Kapiti	0.110	0.053	0.013	0.004
RS01	Mangapouri @ Rahui Rd	Impacted	A	Kapiti	7.400	1.815	0.013	0.013
RS24	Mangaroa @ Te Marua	Impacted	C7	Hutt	0.578	0.253	0.012	0.008
RS28	Wainuiomata @ Manuka Track	Reference	C7	Rimutaka	0.085	0.038	0.011	0.004
RS37	Taueru @ Gladstone	Impacted	C8	Ruamahanga	0.870	0.459	0.011	0.013
RS49	Beef Creek @ headwaters	Reference	C7	Ruamahanga	0.030	0.056	0.009	0.011
RS52	Tauanui @ Whakatomotomo Rd	Reference	C7	Ruamahanga	0.018	0.022	0.009	0.005
RS36	Taueru @ Castlehill	Best available	C8	Ruamahanga	0.099	0.648	0.008	0.005
RS03	Waitohu @ Forest Park	Reference	C7	Kapiti	0.040	0.046	0.008	0.003
RS32	Ruamahanga @ Te Ore Ore	Impacted	C6a	Ruamahanga	0.410	0.316	0.008	0.023
RS10	Waikanae @ Greenaway Rd	Impacted	C6a	Kapiti	0.235	0.150	0.008	0.022
RS26	Whakatikei @ Riverstone	Impacted	C6a	Hutt	0.097	0.117	0.008	0.004
RS54	Coles Creek trib.	Best available	C8	South Wairarapa	0.022	0.021	0.007	0.004
RS40	Waipoua @ Colombo Rd	Impacted	C6a	Ruamahanga	1.055	0.612	0.007	0.017
RS23	Pakuratahi Below Farm Creek	Impacted	C7	Hutt	0.285	0.291	0.006	0.004
RS21	Hutt River @ Manor Park	Impacted	C6a	Hutt	0.239	0.136	0.006	0.004
RS53	Awhea @ Tora Rd	Impacted	C6c	South Wairarapa	0.056	0.095	0.006	0.007
RS35	Mataikona Trib.	Best available	C5	Northern Wairarapa	0.037	0.379	0.006	0.003
RS51	Huangarua @ Ponatahi Bridge	Impacted	C6a	Ruamahanga	0.286	0.224	0.006	0.009
RS56	Waiorongomai @ Forest Park	Reference	C7	Lake Wairarapa	0.021	0.020	0.006	0.006
RS42	Whareama @ Gauge	Impacted	C6c	Northern Wairarapa	0.018	0.214	0.006	0.009
RS41	Waingawa @ South Rd	Impacted	C6a	Ruamahanga	0.090	0.155	0.005	0.003
RS22	Hutt River @ Boulcott	Impacted	C6a	Hutt	0.210	0.187	0.005	0.004
RS20	Hutt River @ Te Marua	Impacted	C7	Hutt	0.100	0.046	0.005	0.003
RS30	Orongorongo River	Impacted	C7	Rimutaka	0.065	0.040	0.005	0.003
RS06	Otaki @ Mouth	Impacted	C6a	Kapiti	0.057	0.089	0.005	0.003
RS05	Otaki @ Pukehinau	Reference	C7	Kapiti	0.047	0.035	0.005	0.003
RS25	Akatarawa @ Hutt Confluence	Impacted	C7	Hutt	0.106	0.076	0.005	0.003
RS47	Waiohine @ Gorge	Reference	C7	Ruamahanga	0.030	0.038	0.005	0.003
RS55	Tauherenikau @ Websters	Impacted	C6a	Lake Wairarapa	0.050	0.083	0.004	0.003
RS43	Motuwaireka @ headwaters	Best available	C5	Northern Wairarapa	0.050	0.123	0.004	0.004
RS31	Ruamahanga @ McLays	Reference	C7	Ruamahanga	0.030	0.040	0.002	0.003
RS44	Totara @ Stronvar	Impacted	C5	Northern Wairarapa	0.090	0.224	0.002	0.003

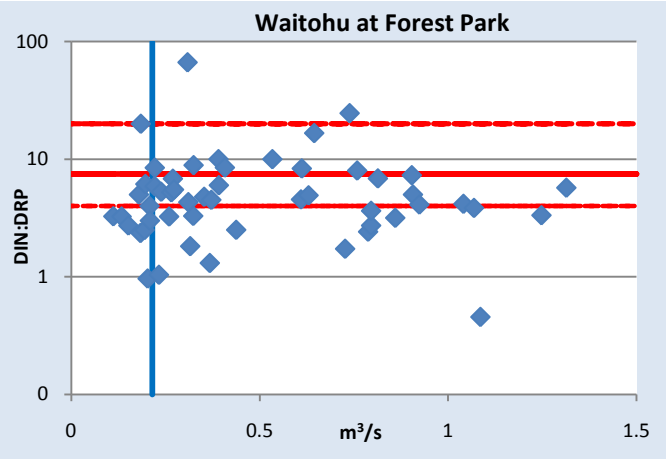
Appendix D: DIN:DRP / river flow graphs

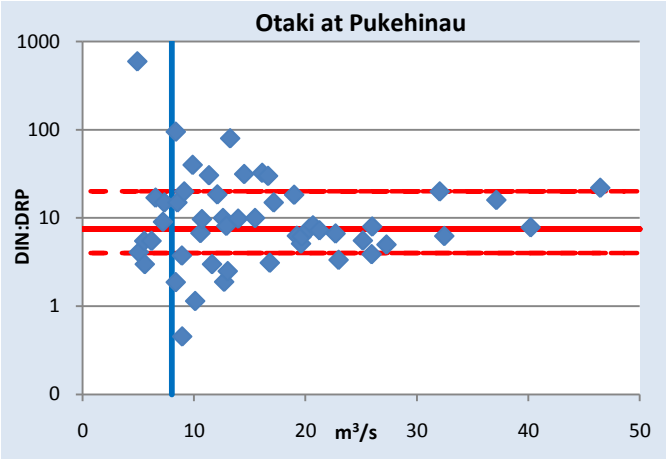
<u>Interpretation of graphs</u>: DIN:DRP ratios at sites where average daily flow data is available for the days of sampling. Only points from samples collected at flows below flood flows (3 median flow) are represented on these graphs. The solid red line represents the Redfield ratio (7.5). Points above the top dashed red line (DIN:DRP = 20) are indicative of P-limited conditions. Points below the bottom dashed redline (DIN:DRP = 4) are indicative of N-limited conditions. The vertical blue lines indicates the half-median flow.*

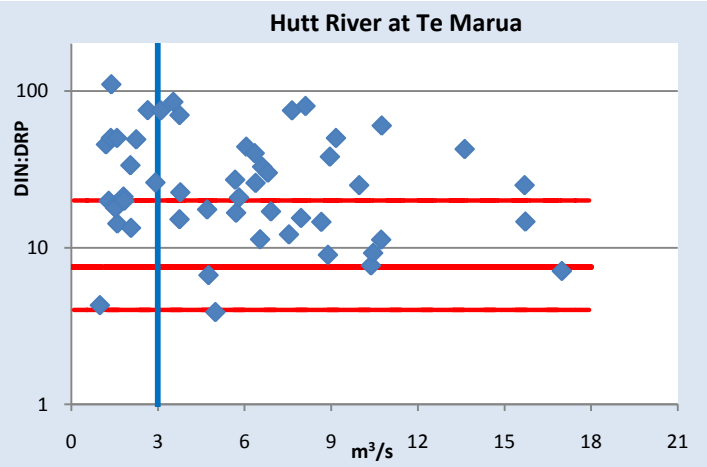
C5 Sites

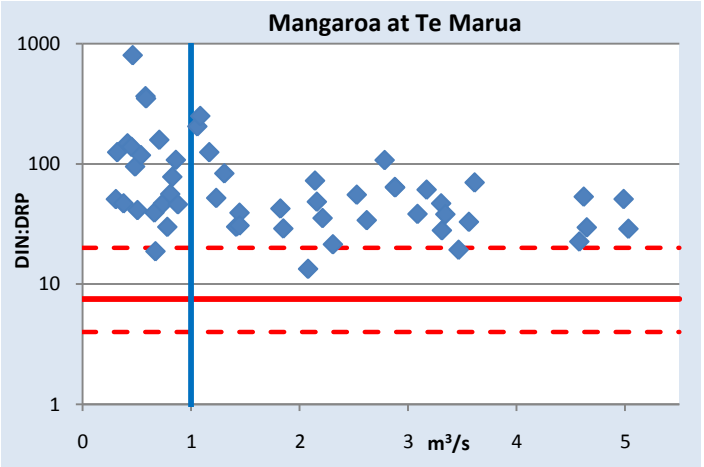


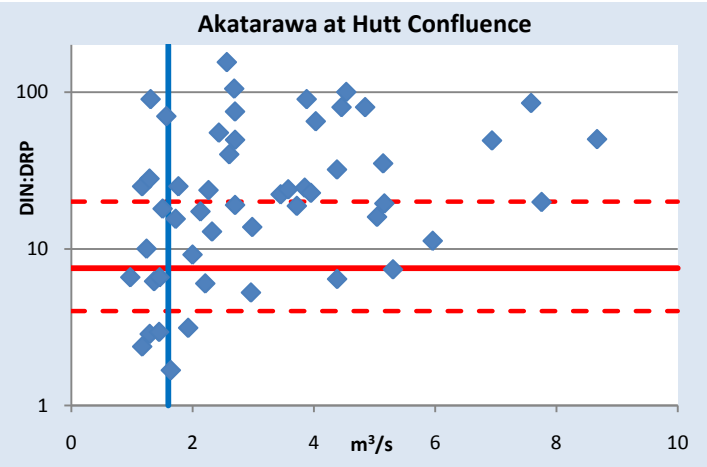
Class C7 RSoE sites

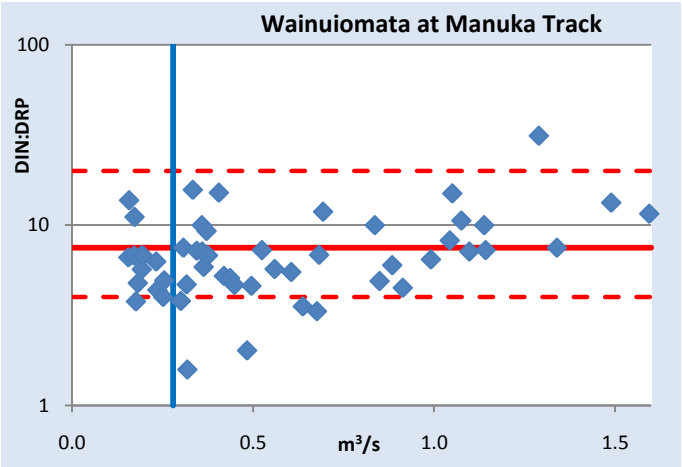




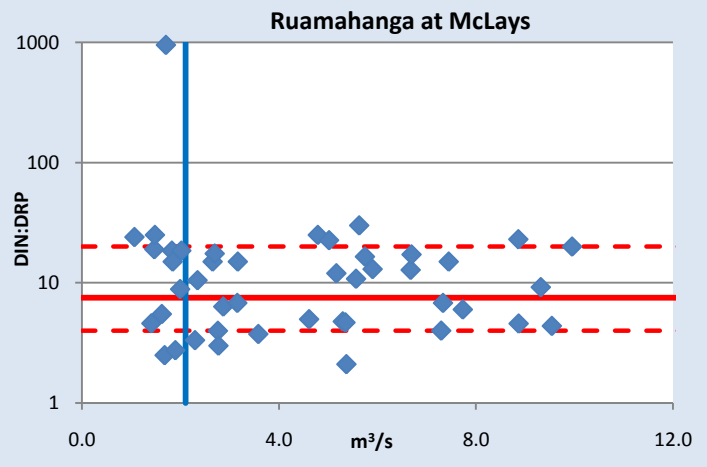


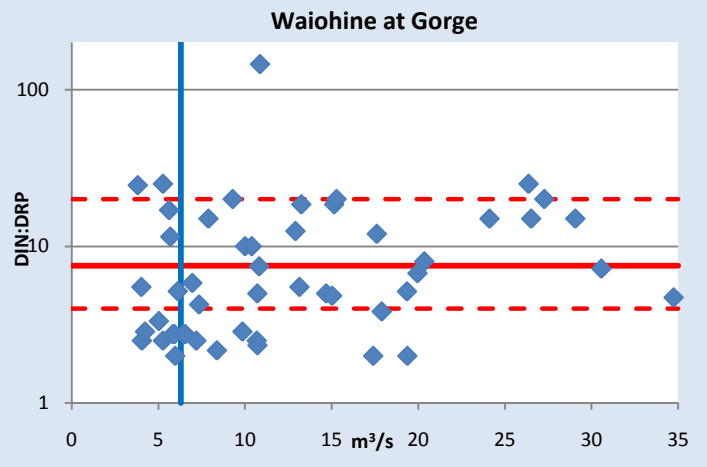




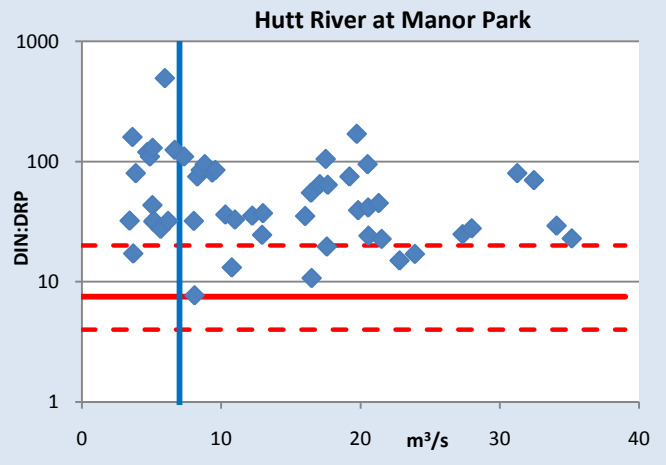


Class C7 RSoE sites (continued)

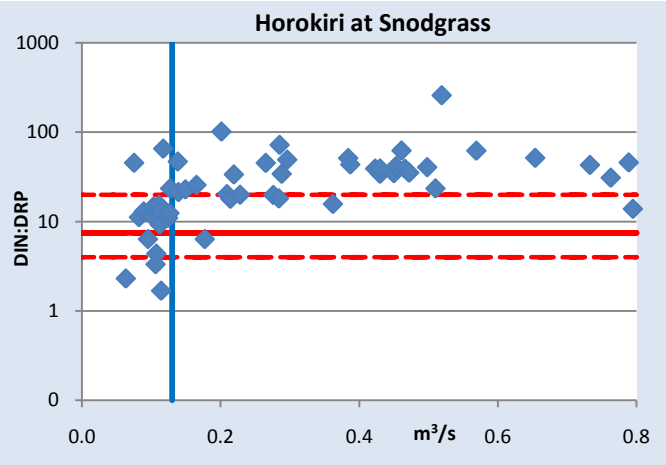




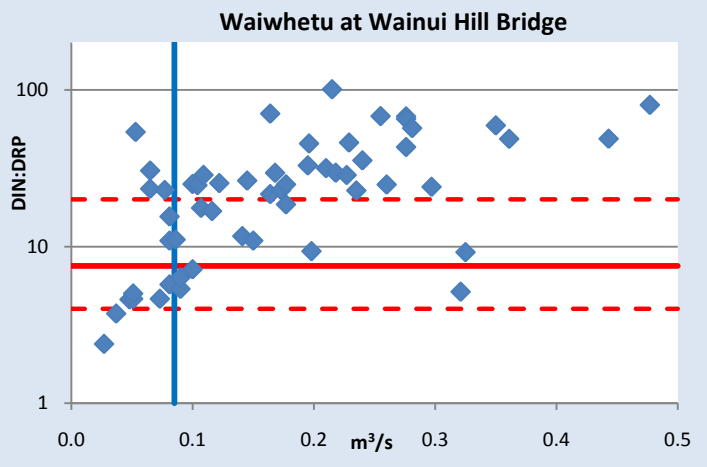
C6a Sites



C6b RSoE sites



Class A RSoE sites



Appendix E: RSoE periphyton monitoring protocols

Periphyton assessments are limited to the 46 RSoE sites with hard bottomed substrates.

1. Monthly assessment of visible streambed cover

Over the reporting period, periphyton cover was determined by estimating the percentage of visible mats (>0.3 cm thick) and filaments (>2 cm long) present on the stream or river bed within a 20 cm diameter metal ring. Ten observations are made across the width of the stream or river, along a transect. If the stream or river is not wide enough for 10 observations, five observations are made across the width of the waterway in two locations at the site. Two transects of five observations (usually to 0.6 m depth) are also used where it was not possible to wade across more than half of the river's width.

Visible streambed assessments are typically carried out in a run, as opposed to riffle or pool-type habitats.

2. Annual assessment of periphyton biomass

Periphyton samples for quantitative biomass assessments (chlorophyll *a* and AFDM) are collected over January to April 2010 at the time of macroinvertebrate sample collection. Sampling protocols followed quantitative method 1a (QM-1a), as outlined in the stream periphyton monitoring manual (Biggs & Kilroy 2000).

Biomass assessments are carried out on periphyton samples collected in riffle-type habitats in close proximity to macroinvertebrate sampling sites.

Appendix F: Summary of RSoE data

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS01	Mangapouri Stream at Rahui Rd A (Lowland/ Impacted)	Average	0.016	6.912	657						
		Min	0.002	1.020	18						
		5%ile	0.007	3.394	108						
		10%ile	0.007	4.716	258						
		25%ile	0.009	6.178	317						
		50%ile (median)	0.013	7.400	542						
		75%ile	0.021	8.125	815						
		90%ile	0.025	8.630	1112						
		95%ile	0.033	9.053	1278						
		Max	0.088	9.630	4050						
		StDev	0.013	1.815	585						
		95% C.I.	0.00	0.46	148						
		Guideline	0.01	0.465							
		%compliance	37	0							
		N. of Samples	60	60	60						
RS02	Mangapouri Stream at Bennetts Rd A (Lowland/ Impacted)	Average	0.029	2.266	89						
		Min	0.013	0.060	2						
		5%ile	0.016	0.913	25						
		10%ile	0.019	1.190	32						
		25%ile	0.022	1.585	45						
		50%ile (median)	0.029	2.100	73						
		75%ile	0.034	3.030	125						
		90%ile	0.043	3.413	162						
		95%ile	0.048	3.913	189						
		Max	0.053	4.640	270						
		StDev	0.009	0.998	57						
		95% C.I.	0.002	0.253	15						
		Guideline	0.01	0.465							
		%compliance	0	3							
		N. of Samples	60	60	60						
RS03	Waitohu Stream at Forest Park C7 (Upland/ Reference)	Average	0.009	0.048	7	0.008	0.048	7	0.008	0.033	5
		Min	0.002	0.005	0	0.002	0.006	1	0.005	0.014	1
		5%ile	0.005	0.015	1	0.005	0.014	1	0.005	0.014	2
		10%ile	0.005	0.017	2	0.005	0.016	2	0.005	0.015	2
		25%ile	0.006	0.028	3	0.005	0.020	3	0.005	0.016	3
		50%ile (median)	0.008	0.040	5	0.008	0.032	5	0.007	0.030	3
		75%ile	0.011	0.050	7	0.012	0.050	6	0.012	0.041	5
		90%ile	0.013	0.080	11	0.013	0.080	9	0.014	0.043	6
		95%ile	0.014	0.102	21	0.014	0.105	15	0.014	0.072	13
		Max	0.016	0.320	67	0.014	0.320	67	0.014	0.100	20
		StDev	0.003	0.046	9	0.003	0.056	12	0.004	0.025	5
		95% C.I.	0.001	0.012	2	0.001	0.020	4	0.002	0.015	3
		Guideline	0.009	0.177		0.009	0.177		0.009	0.177	
		%compliance	66	98		65	97		64	100	
		N. of Samples	58	58	58	31	31	31	11	11	11

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS04	Waitohu Stream at Norfolk Crescent C6c (Lowland/ Impacted)	Average	0.016	0.627	45	0.017	0.653	45	0.020	0.667	35
		Min	0.008	0.236	12	0.008	0.236	13	0.014	0.236	14
		5%ile	0.010	0.250	14	0.009	0.245	14	0.014	0.238	15
		10%ile	0.011	0.300	15	0.011	0.340	15	0.014	0.266	16
		25%ile	0.012	0.428	23	0.013	0.457	21	0.017	0.579	21
		50%ile (median)	0.015	0.605	39	0.017	0.620	39	0.021	0.660	32
		75%ile	0.019	0.761	58	0.021	0.785	58	0.023	0.830	43
		90%ile	0.024	0.967	75	0.027	0.980	70	0.027	0.977	57
		95%ile	0.027	1.106	93	0.029	1.075	82	0.028	1.012	64
		Max	0.035	1.460	183	0.035	1.460	183	0.030	1.050	70
		StDev	0.006	0.274	32	0.006	0.280	33	0.005	0.260	17
		95% C.I.	0.001	0.069	8	0.002	0.098	12	0.003	0.147	10
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	8	35		10	29		0	17	
		N. of Samples	60	60	60	31	31	31	12	12	12
RS05	Otaki River at Pukehinau C7 (Lowland/ Reference)	Average	0.005	0.051	15	0.005	0.045	17	0.004	0.026	8
		Min	0.002	0.005	0	0.002	0.005	0	0.002	0.011	3
		5%ile	0.002	0.011	2	0.002	0.008	1	0.002	0.011	3
		10%ile	0.002	0.019	3	0.002	0.011	2	0.002	0.011	4
		25%ile	0.002	0.033	5	0.002	0.024	4	0.002	0.018	5
		50%ile (median)	0.005	0.047	8	0.004	0.036	10	0.003	0.030	6
		75%ile	0.008	0.060	18	0.007	0.058	19	0.006	0.035	12
		90%ile	0.009	0.080	32	0.008	0.068	34	0.008	0.037	16
		95%ile	0.010	0.123	42	0.008	0.128	64	0.009	0.037	16
		Max	0.014	0.190	95	0.011	0.190	95	0.009	0.038	17
		StDev	0.003	0.035	18	0.003	0.041	22	0.003	0.011	6
		95% C.I.	0.001	0.009	5	0.001	0.015	8	0.002	0.008	4
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	97	100		97	100		100	100	
		N. of Samples	60	59	59	30	29	29	8	7	7
RS06	Otaki River at Mouth C6a (Lowland/ Impacted)	Average	0.005	0.068	19	0.004	0.073	24	0.003	0.024	9
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	1	0.002	0.005	1	0.002	0.005	2
		10%ile	0.002	0.006	2	0.002	0.005	1	0.002	0.005	2
		25%ile	0.002	0.032	6	0.002	0.012	3	0.002	0.012	3
		50%ile (median)	0.005	0.057	10	0.003	0.040	14	0.003	0.026	8
		75%ile	0.007	0.081	25	0.005	0.090	26	0.004	0.031	12
		90%ile	0.008	0.101	45	0.006	0.130	65	0.005	0.040	18
		95%ile	0.009	0.131	65	0.007	0.180	83	0.005	0.045	22
		Max	0.015	0.680	110	0.008	0.680	110	0.005	0.050	25
		StDev	0.003	0.089	22	0.002	0.123	29	0.001	0.015	8
		95% C.I.	0.001	0.023	6	0.001	0.043	10	0.001	0.011	5
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	98	98		100	97		100	100	
		N. of Samples	60	60	60	31	31	31	8	8	8

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS07	Mangaone Stream at Sims Road Bridge C6c (Lowland/ Impacted)	Average	0.023	2.212	108	0.022	2.198	111	0.022	2.277	104
		Min	0.009	0.385	15	0.010	0.385	15	0.018	1.320	63
		5%ile	0.015	0.986	28	0.015	1.173	47	0.019	1.523	68
		10%ile	0.016	1.248	50	0.017	1.326	56	0.019	1.725	74
		25%ile	0.018	1.800	70	0.018	1.900	70	0.020	2.175	92
		50%ile (median)	0.022	2.245	105	0.021	2.300	115	0.021	2.355	115
		75%ile	0.027	2.713	134	0.026	2.600	146	0.024	2.475	120
		90%ile	0.030	3.000	172	0.028	2.952	163	0.026	2.750	124
		95%ile	0.032	3.336	182	0.030	3.000	175	0.027	2.875	126
		Max	0.055	4.140	270	0.039	3.300	270	0.027	3.000	128
		StDev	0.008	0.741	54	0.006	0.649	53	0.003	0.552	25
		95% C.I.	0.002	0.188	14	0.002	0.245	20	0.003	0.442	20
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	3	2		4	4		0	0	
		N. of Samples	60	60	60	27	27	27	6	6	6
RS08	Ngarara Stream at Field Way A (Lowland/ Impacted)	Average	0.042	0.626	17						
		Min	0.008	0.019	0						
		5%ile	0.016	0.040	1						
		10%ile	0.021	0.044	1						
		25%ile	0.030	0.170	4						
		50%ile (median)	0.044	0.479	10						
		75%ile	0.050	0.731	21						
		90%ile	0.059	1.000	42						
		95%ile	0.065	1.232	49						
		Max	0.095	8.800	93						
		StDev	0.016	1.135	18						
		95% C.I.	0.004	0.287	4						
		Guideline	0.01	0.465							
		%compliance	2	48							
		N. of Samples	60	60	60						
RS09	Waikanae River at Mangaone Walkway C5 (Upland/ Reference)	Average	0.013	0.119	10	0.013	0.107	9	0.013	0.095	8
		Min	0.006	0.032	3	0.006	0.032	3	0.008	0.032	3
		5%ile	0.009	0.052	3	0.008	0.046	3	0.008	0.037	3
		10%ile	0.009	0.054	4	0.009	0.052	4	0.009	0.044	4
		25%ile	0.011	0.079	5	0.010	0.071	5	0.009	0.057	5
		50%ile (median)	0.013	0.110	8	0.013	0.094	8	0.013	0.088	6
		75%ile	0.016	0.150	12	0.016	0.126	12	0.016	0.118	10
		90%ile	0.018	0.181	17	0.017	0.177	17	0.018	0.165	13
		95%ile	0.020	0.231	19	0.019	0.202	19	0.020	0.173	15
		Max	0.025	0.261	25	0.023	0.261	19	0.023	0.178	19
		StDev	0.004	0.053	5	0.004	0.053	5	0.004	0.047	5
		95% C.I.	0.001	0.014	1	0.001	0.018	2	0.002	0.025	2
		Guideline	0.009	0.177		0.009	0.177		0.009	0.177	
		%compliance	13	87		22	88		29	93	
		N. of Samples	60	60	60	32	32	32	14	14	14

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS10	Waikanae River at Greenaway Rd C6a (Lowland/ Impacted)	Average	0.011	0.240	35	0.008	0.164	31	0.007	0.119	21
		Min	0.002	0.040	3	0.002	0.040	4	0.002	0.040	4
		5%ile	0.002	0.051	6	0.002	0.049	7	0.002	0.046	6
		10%ile	0.002	0.061	9	0.002	0.051	7	0.002	0.050	7
		25%ile	0.006	0.108	15	0.003	0.076	12	0.004	0.060	10
		50%ile (median)	0.008	0.235	27	0.008	0.115	19	0.008	0.080	16
		75%ile	0.011	0.333	41	0.010	0.228	37	0.009	0.185	27
		90%ile	0.014	0.412	63	0.014	0.354	62	0.011	0.225	39
		95%ile	0.015	0.441	106	0.015	0.383	111	0.012	0.237	44
		Max	0.176	0.860	145	0.043	0.480	145	0.015	0.258	58
		StDev	0.022	0.150	29	0.008	0.118	34	0.004	0.074	15
		95% C.I.	0.006	0.038	7	0.003	0.042	12	0.002	0.036	7
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	73	97		80	97		88	100	
		N. of Samples	60	60	60	30	30	30	16	16	16
RS11	Whareroa Stream at Waterfall Rd C5 (Lowland/ Low Impact)	Average	0.033	0.400	15	0.040	0.257	7	0.043	0.210	5
		Min	0.014	0.030	1	0.027	0.030	1	0.032	0.030	1
		5%ile	0.016	0.140	3	0.027	0.118	3	0.033	0.078	2
		10%ile	0.021	0.150	3	0.030	0.138	3	0.033	0.118	2
		25%ile	0.027	0.198	5	0.035	0.165	3	0.040	0.150	3
		50%ile (median)	0.034	0.372	12	0.040	0.230	6	0.043	0.180	4
		75%ile	0.040	0.600	23	0.045	0.355	9	0.047	0.270	7
		90%ile	0.045	0.672	34	0.048	0.405	12	0.051	0.367	11
		95%ile	0.048	0.715	40	0.051	0.465	15	0.054	0.372	11
		Max	0.056	0.850	53	0.056	0.650	24	0.056	0.374	12
		StDev	0.010	0.214	13	0.007	0.132	5	0.007	0.105	3
		95% C.I.	0.002	0.054	3	0.003	0.048	2	0.004	0.057	2
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	0	62		0	93		0	100	
		N. of Samples	60	60	60	29	29	29	13	13	13
RS12	Whareroa Stream at QE Park A (Lowland/ Impacted)	Average	0.043	0.499	13	0.043	0.315	8	0.042	0.298	7
		Min	0.021	0.060	1	0.025	0.060	1	0.025	0.060	1
		5%ile	0.026	0.074	2	0.029	0.070	1	0.026	0.066	2
		10%ile	0.029	0.107	3	0.034	0.073	2	0.028	0.071	2
		25%ile	0.035	0.174	4	0.035	0.130	3	0.035	0.087	3
		50%ile (median)	0.041	0.460	9	0.041	0.240	5	0.041	0.150	4
		75%ile	0.053	0.711	19	0.053	0.410	8	0.045	0.410	8
		90%ile	0.059	0.864	27	0.059	0.702	17	0.058	0.445	16
		95%ile	0.066	1.186	36	0.060	0.712	20	0.060	0.790	23
		Max	0.087	1.600	38	0.061	1.300	31	0.061	1.300	31
		StDev	0.013	0.352	10	0.011	0.275	7	0.011	0.335	8
		95% C.I.	0.003	0.089	3	0.004	0.100	3	0.006	0.182	5
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	0	50		0	83		0	92	
		N. of Samples	60	60	60	29	29	29	13	13	13

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS13	Horokiri Stream at Snodgrass C6b (Lowland/ Impacted)	Average	0.014	0.454	37	0.012	0.217	22	0.013	0.166	16
		Min	0.002	0.030	2	0.005	0.030	2	0.005	0.030	2
		5%ile	0.005	0.054	4	0.005	0.038	3	0.006	0.032	2
		10%ile	0.006	0.080	9	0.006	0.053	4	0.006	0.043	3
		25%ile	0.010	0.225	15	0.008	0.097	11	0.008	0.065	6
		50%ile (median)	0.015	0.413	32	0.011	0.155	15	0.013	0.120	12
		75%ile	0.018	0.692	46	0.016	0.339	24	0.016	0.265	15
		90%ile	0.021	0.877	63	0.018	0.425	46	0.018	0.384	32
		95%ile	0.022	0.950	73	0.019	0.486	59	0.021	0.420	50
		Max	0.028	1.100	260	0.028	0.510	102	0.028	0.460	66
		StDev	0.006	0.297	36	0.005	0.152	22	0.006	0.142	16
		95% C.I.	0.001	0.075	9	0.002	0.056	8	0.003	0.067	8
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	27	55		46	93		41	100	
		N. of Samples	60	60	60	28	28	28	17	17	17
RS14	Pauatahanui Stream at Elmwood Bridge C5 (Lowland/ Impacted)	Average	0.019	0.290	20	0.021	0.132	8	0.024	0.088	4
		Min	0.005	0.012	1	0.006	0.012	1	0.016	0.014	1
		5%ile	0.009	0.029	1	0.010	0.016	1	0.016	0.017	1
		10%ile	0.009	0.040	2	0.012	0.030	2	0.016	0.023	1
		25%ile	0.015	0.095	5	0.016	0.050	2	0.019	0.038	2
		50%ile (median)	0.018	0.255	14	0.020	0.100	5	0.020	0.066	3
		75%ile	0.022	0.424	30	0.026	0.180	9	0.029	0.125	4
		90%ile	0.029	0.614	43	0.032	0.280	14	0.033	0.172	9
		95%ile	0.033	0.651	56	0.038	0.350	31	0.037	0.214	10
		Max	0.047	0.900	105	0.047	0.395	37	0.047	0.270	11
		StDev	0.008	0.218	22	0.009	0.107	9	0.009	0.072	3
		95% C.I.	0.002	0.055	5	0.003	0.038	3	0.004	0.036	2
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	12	80		6	100		0	100	
		N. of Samples	60	60	60	31	31	31	15	15	15
RS15	Porirua Stream at Glenside Overhead Cabl C5 (Lowland/ Impacted)	Average	0.023	1.153	66	0.023	0.851	62	0.023	0.830	39
		Min	0.002	0.350	11	0.002	0.350	12	0.009	0.500	28
		5%ile	0.009	0.529	18	0.007	0.508	20	0.010	0.561	28
		10%ile	0.013	0.615	26	0.008	0.540	26	0.012	0.621	29
		25%ile	0.016	0.770	33	0.014	0.675	30	0.019	0.678	31
		50%ile (median)	0.022	1.140	55	0.023	0.805	39	0.024	0.815	37
		75%ile	0.029	1.460	75	0.029	1.035	54	0.030	0.935	45
		90%ile	0.033	1.723	101	0.033	1.180	77	0.032	1.109	53
		95%ile	0.036	1.929	122	0.035	1.200	80	0.033	1.155	54
		Max	0.093	2.240	545	0.093	1.670	545	0.033	1.200	56
		StDev	0.013	0.457	70	0.017	0.282	100	0.009	0.226	10
		95% C.I.	0.003	0.116	18	0.006	0.109	39	0.006	0.157	7
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	7	3		15	4		13	0	
		N. of Samples	60	60	60	26	26	26	8	8	8

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS16	Porirua Stream at Milk Depot C5 (Lowland/ Impacted)	Average	0.023	1.108	61	0.026	0.766	37	0.027	0.637	24
		Min	0.005	0.005	0	0.006	0.300	11	0.015	0.300	11
		5%ile	0.010	0.445	18	0.011	0.373	14	0.017	0.360	15
		10%ile	0.013	0.500	21	0.013	0.476	19	0.020	0.420	19
		25%ile	0.017	0.716	27	0.019	0.600	23	0.022	0.500	21
		50%ile (median)	0.022	1.011	44	0.027	0.702	27	0.028	0.690	24
		75%ile	0.029	1.485	85	0.032	0.855	33	0.032	0.759	27
		90%ile	0.033	1.828	117	0.040	1.021	61	0.034	0.798	30
		95%ile	0.038	2.004	140	0.046	1.143	108	0.036	0.813	31
		Max	0.059	2.200	321	0.059	2.100	140	0.038	0.828	32
		StDev	0.010	0.511	52	0.012	0.338	30	0.007	0.179	6
		95% C.I.	0.002	0.129	13	0.004	0.128	11	0.005	0.117	4
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	7	7		7	11		0	22	
		N. of Samples	60	60	60	27	27	27	9	9	9
RS17	Makara Stream at Kennels C5 (Lowland/ Impacted)	Average	0.031	0.470	18	0.033	0.179	7	0.038	0.098	3
		Min	0.007	0.005	0	0.007	0.005	0	0.021	0.006	0
		5%ile	0.017	0.024	1	0.012	0.013	0	0.021	0.021	1
		10%ile	0.018	0.030	1	0.021	0.024	1	0.027	0.027	1
		25%ile	0.024	0.064	2	0.028	0.034	1	0.032	0.031	1
		50%ile (median)	0.030	0.300	10	0.035	0.070	2	0.039	0.053	2
		75%ile	0.040	0.754	30	0.043	0.236	8	0.044	0.153	4
		90%ile	0.045	1.233	41	0.045	0.400	19	0.047	0.243	8
		95%ile	0.049	1.372	51	0.047	0.545	29	0.049	0.264	8
		Max	0.061	1.510	82	0.052	1.490	37	0.052	0.340	8
		StDev	0.011	0.461	19	0.011	0.282	9	0.009	0.101	3
		95% C.I.	0.003	0.117	5	0.004	0.098	3	0.004	0.047	1
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	2	57		3	91		0	100	
		N. of Samples	60	60	60	32	32	32	18	18	18
RS18	Karori Stream at Makara Peak Mountain Bi C5 (Lowland/ Impacted)	Average	0.044	1.302	34	0.054	1.428	28	0.060	1.445	25
		Min	0.008	0.340	12	0.030	1.170	17	0.041	1.200	17
		5%ile	0.017	0.513	18	0.034	1.200	20	0.042	1.210	19
		10%ile	0.027	0.770	19	0.037	1.220	20	0.042	1.220	20
		25%ile	0.031	1.300	23	0.045	1.365	23	0.048	1.355	21
		50%ile (median)	0.043	1.400	29	0.057	1.420	25	0.060	1.500	24
		75%ile	0.057	1.510	39	0.062	1.540	32	0.067	1.540	27
		90%ile	0.064	1.581	49	0.069	1.590	38	0.077	1.580	35
		95%ile	0.069	1.600	58	0.074	1.595	42	0.082	1.585	36
		Max	0.087	1.680	122	0.087	1.600	49	0.087	1.590	38
		StDev	0.017	0.330	17	0.013	0.124	8	0.015	0.142	6
		95% C.I.	0.004	0.083	4	0.005	0.044	3	0.009	0.084	4
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	2	5		0	0		0	0	
		N. of Samples	60	60	60	31	31	31	11	11	11

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS19	Kaiwharawhara Stream at Ngaio Gorge C5 (Lowland/Impacted)	Average	0.046	1.171	33	0.052	1.211	25	0.058	1.183	22
		Min	0.002	0.016	0	0.028	0.016	0	0.039	0.016	0
		5%ile	0.023	0.729	13	0.031	0.825	13	0.040	0.499	7
		10%ile	0.026	0.849	17	0.035	0.982	16	0.040	0.982	13
		25%ile	0.032	1.055	21	0.042	1.085	21	0.044	1.185	18
		50%ile (median)	0.042	1.205	27	0.050	1.270	25	0.053	1.300	21
		75%ile	0.053	1.320	37	0.056	1.400	29	0.059	1.400	27
		90%ile	0.066	1.463	48	0.070	1.490	36	0.078	1.440	32
		95%ile	0.082	1.524	57	0.082	1.555	37	0.096	1.465	35
		Max	0.180	1.900	235	0.114	1.600	39	0.114	1.490	37
		StDev	0.025	0.289	30	0.017	0.299	8	0.022	0.414	10
		95% C.I.	0.006	0.073	8	0.006	0.105	3	0.013	0.245	6
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	2	2		0	3		0	9	
		N. of Samples	60	60	60	31	31	31	11	11	11
RS20	Hutt River at Te Marua Intake Site C7 (Lowland/ Impacted)	Average	0.005	0.110	31	0.005	0.120	34	0.005	0.118	36
		Min	0.002	0.030	4	0.002	0.030	4	0.002	0.030	4
		5%ile	0.002	0.043	7	0.002	0.037	5	0.002	0.047	11
		10%ile	0.002	0.052	8	0.002	0.061	11	0.002	0.060	14
		25%ile	0.002	0.080	15	0.002	0.092	17	0.002	0.093	18
		50%ile (median)	0.005	0.100	21	0.005	0.128	21	0.004	0.100	24
		75%ile	0.007	0.140	46	0.008	0.150	50	0.007	0.147	49
		90%ile	0.009	0.171	71	0.009	0.177	75	0.009	0.188	63
		95%ile	0.010	0.189	75	0.010	0.188	82	0.009	0.196	84
		Max	0.012	0.220	110	0.012	0.220	110	0.010	0.220	110
		StDev	0.003	0.046	24	0.003	0.048	28	0.003	0.053	27
		95% C.I.	0.001	0.012	6	0.001	0.018	10	0.001	0.026	13
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	95	100		96	100		100	100	
		N. of Samples	60	60	60	27	27	27	16	16	16
RS21	Hutt River Opposite Manor Park Golf Club C6a (Lowland/ Impacted)	Average	0.006	0.262	68	0.005	0.254	78	0.005	0.285	101
		Min	0.002	0.091	8	0.002	0.100	8	0.002	0.120	17
		5%ile	0.002	0.110	13	0.002	0.111	15	0.002	0.148	24
		10%ile	0.002	0.138	17	0.002	0.144	23	0.002	0.160	29
		25%ile	0.002	0.190	28	0.002	0.170	32	0.002	0.193	32
		50%ile (median)	0.006	0.239	43	0.006	0.220	43	0.002	0.250	80
		75%ile	0.009	0.320	85	0.008	0.275	95	0.007	0.296	123
		90%ile	0.011	0.409	126	0.010	0.343	126	0.010	0.320	148
		95%ile	0.012	0.456	165	0.010	0.384	148	0.010	0.521	261
		Max	0.016	0.990	495	0.013	0.990	495	0.010	0.990	495
		StDev	0.004	0.136	73	0.003	0.161	90	0.003	0.204	118
		95% C.I.	0.001	0.034	18	0.001	0.058	33	0.002	0.103	60
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	88	95		97	97		100	93	
		N. of Samples	60	60	60	29	29	29	15	15	15

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS22	Hutt River at Boulcott C6a (lowland/ Impacted)	Average	0.006	0.240	61	0.005	0.205	65	0.004	0.203	75
		Min	0.002	0.070	7	0.002	0.080	9	0.002	0.099	14
		5%ile	0.002	0.083	14	0.002	0.089	12	0.002	0.099	18
		10%ile	0.002	0.099	19	0.002	0.099	19	0.002	0.099	20
		25%ile	0.002	0.158	25	0.002	0.140	29	0.002	0.150	31
		50%ile (median)	0.005	0.210	44	0.005	0.200	64	0.002	0.207	85
		75%ile	0.008	0.281	85	0.007	0.259	100	0.006	0.255	108
		90%ile	0.010	0.338	126	0.009	0.328	127	0.008	0.305	131
		95%ile	0.013	0.366	136	0.009	0.334	135	0.009	0.329	144
		Max	0.015	1.500	326	0.010	0.343	165	0.010	0.330	165
		StDev	0.004	0.187	53	0.003	0.082	44	0.003	0.076	48
		95% C.I.	0.001	0.047	13	0.001	0.030	16	0.001	0.039	24
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	92	98		100	100		100	100	
		N. of Samples	60	60	60	29	29	29	15	15	15
RS23	Pakuratahi River 50m Below Farm Creek C7 (Lowland/ Impacted)	Average	0.007	0.317	64	0.008	0.299	55	0.007	0.343	72
		Min	0.002	0.083	6	0.002	0.110	8	0.002	0.200	28
		5%ile	0.002	0.110	13	0.002	0.124	11	0.002	0.215	30
		10%ile	0.002	0.129	21	0.004	0.172	22	0.002	0.230	33
		25%ile	0.005	0.228	32	0.006	0.238	30	0.005	0.283	38
		50%ile (median)	0.006	0.285	42	0.007	0.295	39	0.007	0.348	42
		75%ile	0.009	0.348	69	0.010	0.351	49	0.009	0.384	65
		90%ile	0.012	0.422	132	0.012	0.429	107	0.011	0.460	155
		95%ile	0.014	0.440	160	0.013	0.466	157	0.012	0.498	189
		Max	0.016	2.400	429	0.014	0.550	275	0.012	0.550	275
		StDev	0.004	0.291	68	0.003	0.106	55	0.003	0.096	68
		95% C.I.	0.001	0.074	17	0.001	0.039	21	0.002	0.047	33
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	82	95		75	93		81	88	
		N. of Samples	60	60	60	28	28	28	16	16	16
RS24	Mangaroa River at Te Marua C7 (Lowland/ Impacted)	Average	0.013	0.589	84	0.010	0.647	124	0.011	0.734	143
		Min	0.002	0.010	1	0.002	0.010	1	0.002	0.300	19
		5%ile	0.002	0.280	18	0.002	0.309	24	0.002	0.319	29
		10%ile	0.004	0.299	22	0.002	0.388	30	0.002	0.388	38
		25%ile	0.006	0.475	32	0.005	0.500	42	0.005	0.568	47
		50%ile (median)	0.012	0.578	48	0.009	0.629	67	0.007	0.680	87
		75%ile	0.017	0.705	79	0.014	0.739	135	0.015	0.835	141
		90%ile	0.021	0.831	149	0.017	0.934	260	0.021	1.065	352
		95%ile	0.030	0.927	255	0.026	1.133	358	0.031	1.220	387
		Max	0.043	1.600	800	0.035	1.600	800	0.035	1.600	800
		StDev	0.008	0.253	118	0.008	0.294	156	0.009	0.302	182
		95% C.I.	0.002	0.064	30	0.003	0.105	56	0.004	0.132	80
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	45	25		53	20		60	15	
		N. of Samples	60	60	60	30	30	30	20	20	20

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS25	Akatarawa River at Hutt Confluence C7 (Lowland/ Impacted)	Average	0.005	0.112	38	0.005	0.080	29	0.005	0.058	22
		Min	0.002	0.012	2	0.002	0.012	2	0.002	0.019	2
		5%ile	0.002	0.019	3	0.002	0.014	2	0.002	0.020	3
		10%ile	0.002	0.021	5	0.002	0.019	3	0.002	0.020	3
		25%ile	0.002	0.050	10	0.002	0.037	6	0.002	0.020	5
		50%ile (median)	0.005	0.106	23	0.006	0.055	16	0.005	0.046	8
		75%ile	0.007	0.150	66	0.007	0.110	34	0.007	0.058	26
		90%ile	0.009	0.191	91	0.008	0.150	75	0.008	0.132	66
		95%ile	0.009	0.211	100	0.010	0.195	98	0.009	0.158	79
		Max	0.016	0.430	155	0.016	0.310	155	0.010	0.180	90
		StDev	0.003	0.076	37	0.003	0.067	36	0.003	0.051	29
		95% C.I.	0.001	0.019	9	0.001	0.024	13	0.002	0.029	16
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	97	100		97	100		100	100	
		N. of Samples	60	60	60	31	31	31	12	12	12
RS26	Whakatikei River at Riverstone C6a (lowland/ Impacted)	Average	0.008	0.131	22	0.008	0.103	15	0.009	0.073	10
		Min	0.002	0.005	0	0.002	0.005	0	0.002	0.005	0
		5%ile	0.002	0.010	1	0.002	0.005	1	0.003	0.005	1
		10%ile	0.002	0.030	3	0.002	0.022	2	0.004	0.010	1
		25%ile	0.005	0.057	7	0.005	0.034	6	0.007	0.031	4
		50%ile (median)	0.008	0.097	14	0.008	0.071	11	0.008	0.045	6
		75%ile	0.011	0.179	30	0.010	0.130	24	0.011	0.088	11
		90%ile	0.013	0.233	45	0.012	0.169	39	0.013	0.158	20
		95%ile	0.014	0.321	69	0.014	0.230	41	0.014	0.219	29
		Max	0.025	0.690	130	0.025	0.690	45	0.014	0.290	41
		StDev	0.004	0.117	24	0.005	0.125	13	0.004	0.078	11
		95% C.I.	0.001	0.030	6	0.002	0.043	5	0.002	0.041	6
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	72	97		78	97		71	100	
		N. of Samples	60	60	60	32	32	32	14	14	14
RS27	Waiwhetu Stream at Wainui Hill Bridge A (Lowland/ Impacted)	Average	0.031	0.578	29	0.039	0.450	18	0.045	0.365	14
		Min	0.008	0.162	2	0.008	0.162	2	0.008	0.162	2
		5%ile	0.010	0.200	5	0.011	0.173	4	0.010	0.162	3
		10%ile	0.013	0.246	5	0.013	0.198	5	0.014	0.168	4
		25%ile	0.015	0.378	11	0.020	0.280	6	0.025	0.200	5
		50%ile (median)	0.025	0.560	25	0.030	0.400	16	0.035	0.310	6
		75%ile	0.036	0.756	40	0.042	0.590	25	0.046	0.430	23
		90%ile	0.061	0.970	60	0.072	0.782	30	0.106	0.597	29
		95%ile	0.075	0.991	68	0.106	0.897	44	0.124	0.713	40
		Max	0.130	1.200	101	0.130	1.000	70	0.130	0.870	54
		StDev	0.024	0.267	22	0.030	0.231	15	0.037	0.209	15
		95% C.I.	0.006	0.068	6	0.011	0.084	6	0.020	0.113	8
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	8	42		7	66		8	77	
		N. of Samples	60	60	60	29	29	29	13	13	13

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS28	Wainuiomata River at Manuka Track C7 (lowland/ Impacted)	Average	0.012	0.089	8	0.012	0.076	7	0.012	0.076	7
		Min	0.005	0.019	2	0.006	0.019	2	0.006	0.022	4
		5%ile	0.007	0.037	4	0.007	0.030	3	0.007	0.045	4
		10%ile	0.007	0.050	4	0.008	0.039	4	0.008	0.061	4
		25%ile	0.009	0.068	5	0.009	0.061	5	0.009	0.065	5
		50%ile (median)	0.011	0.085	7	0.013	0.074	6	0.013	0.074	6
		75%ile	0.015	0.108	10	0.015	0.093	7	0.016	0.088	7
		90%ile	0.018	0.130	14	0.018	0.110	11	0.018	0.102	10
		95%ile	0.020	0.150	16	0.018	0.120	14	0.018	0.105	12
		Max	0.022	0.230	31	0.020	0.150	16	0.018	0.110	14
		StDev	0.004	0.038	5	0.004	0.029	3	0.004	0.023	3
		95% C.I.	0.001	0.010	1	0.001	0.010	1	0.002	0.012	2
		Guideline	0.009	0.177		0.009	0.177		0.009	0.177	
		%compliance	33	97		29	100		38	100	
		N. of Samples	60	60	60	31	31	31	13	13	13
RS29	Wainuiomata River Upstr of White Bridge C6a (Lowland/ Impacted)	Average	0.013	0.225	23	0.013	0.108	9	0.013	0.057	8
		Min	0.002	0.005	0	0.002	0.005	0	0.002	0.006	1
		5%ile	0.004	0.017	1	0.006	0.006	1	0.003	0.006	1
		10%ile	0.006	0.020	1	0.007	0.018	1	0.004	0.008	1
		25%ile	0.008	0.047	3	0.009	0.025	2	0.009	0.044	2
		50%ile (median)	0.014	0.201	16	0.014	0.065	6	0.011	0.065	6
		75%ile	0.016	0.371	30	0.016	0.136	14	0.015	0.072	11
		90%ile	0.019	0.549	49	0.018	0.268	22	0.018	0.078	17
		95%ile	0.023	0.561	66	0.019	0.333	26	0.031	0.097	21
		Max	0.046	0.630	158	0.046	0.580	34	0.046	0.120	25
		StDev	0.007	0.191	27	0.007	0.129	9	0.011	0.032	7
		95% C.I.	0.002	0.048	7	0.003	0.045	3	0.006	0.018	4
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	38	83		38	97		50	100	
		N. of Samples	60	60	60	32	32	32	12	12	12
RS30	Orongorongo River at Orongorongo Station C7 (lowland/ Impacted)	Average	0.006	0.066	15	0.005	0.061	16	0.004	0.062	19
		Min	0.002	0.005	2	0.002	0.005	2	0.002	0.014	3
		5%ile	0.002	0.015	3	0.002	0.010	3	0.002	0.015	3
		10%ile	0.002	0.020	3	0.002	0.015	3	0.002	0.015	3
		25%ile	0.004	0.030	7	0.002	0.026	4	0.002	0.025	9
		50%ile (median)	0.005	0.065	10	0.005	0.053	10	0.004	0.057	10
		75%ile	0.008	0.086	21	0.007	0.085	24	0.005	0.090	29
		90%ile	0.009	0.122	32	0.009	0.138	32	0.008	0.130	42
		95%ile	0.011	0.151	37	0.009	0.155	47	0.008	0.148	55
		Max	0.013	0.160	70	0.011	0.160	70	0.009	0.160	70
		StDev	0.003	0.040	14	0.003	0.046	16	0.002	0.048	20
		95% C.I.	0.001	0.010	3	0.001	0.016	6	0.001	0.026	11
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	93	100		97	100		100	100	
		N. of Samples	60	60	60	32	32	32	13	13	13

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS31	Ruamahanga River at McLays C7 (Upland/ Reference)	Average	0.004	0.036	12	0.004	0.027	10	0.003	0.027	11
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	2	0.002	0.005	1	0.002	0.005	1
		10%ile	0.002	0.012	3	0.002	0.005	1	0.002	0.005	1
		25%ile	0.002	0.021	5	0.002	0.016	3	0.002	0.006	3
		50%ile (median)	0.002	0.030	11	0.002	0.030	7	0.002	0.030	9
		75%ile	0.005	0.038	17	0.006	0.037	16	0.004	0.038	19
		90%ile	0.007	0.050	24	0.008	0.045	19	0.007	0.050	23
		95%ile	0.008	0.064	26	0.008	0.050	23	0.007	0.055	24
		Max	0.019	0.304	51	0.009	0.062	25	0.007	0.062	25
		StDev	0.003	0.040	10	0.003	0.016	8	0.002	0.020	9
		95% C.I.	0.001	0.010	3	0.001	0.006	3	0.001	0.011	5
		Guideline	0.009	0.177		0.009	0.177		0.009	0.177	
		%compliance	98	98		100	100		100	100	
		N. of Samples	60	59	59	25	24	24	14	13	13
RS32	Ruamahanga River at Te Ore Ore C6a (Lowland/ Impacted)	Average	0.012	0.464	77	0.008	0.466	95	0.005	0.450	127
		Min	0.002	0.016	2	0.002	0.016	6	0.002	0.016	6
		5%ile	0.002	0.099	8	0.002	0.169	15	0.002	0.113	19
		10%ile	0.002	0.128	10	0.002	0.231	26	0.002	0.200	25
		25%ile	0.005	0.288	31	0.003	0.288	33	0.002	0.268	37
		50%ile (median)	0.008	0.410	51	0.008	0.385	57	0.003	0.365	116
		75%ile	0.011	0.554	93	0.009	0.541	130	0.009	0.460	189
		90%ile	0.016	0.791	196	0.011	0.777	204	0.010	0.710	232
		95%ile	0.027	0.992	215	0.014	0.974	246	0.011	1.112	311
		Max	0.182	1.800	400	0.034	1.800	400	0.011	1.800	400
		StDev	0.023	0.316	77	0.006	0.328	89	0.003	0.395	105
		95% C.I.	0.006	0.080	20	0.002	0.114	31	0.002	0.182	49
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	70	62		78	66		89	78	
		N. of Samples	60	60	60	32	32	32	18	18	18
RS33	Ruamahanga River at Gladstone C6a (Lowland/ Impacted)	Average	0.028	0.505	21	0.033	0.479	17	0.037	0.395	11
		Min	0.007	0.054	2	0.012	0.054	2	0.023	0.054	2
		5%ile	0.012	0.120	4	0.021	0.199	4	0.025	0.176	3
		10%ile	0.014	0.163	6	0.023	0.230	5	0.025	0.199	5
		25%ile	0.021	0.260	10	0.025	0.260	9	0.029	0.253	6
		50%ile (median)	0.025	0.470	19	0.031	0.429	14	0.035	0.320	9
		75%ile	0.034	0.608	28	0.041	0.600	19	0.045	0.476	18
		90%ile	0.045	0.870	36	0.046	0.864	28	0.052	0.663	20
		95%ile	0.051	1.104	41	0.052	0.996	32	0.054	0.854	21
		Max	0.057	1.640	102	0.055	1.220	102	0.055	1.100	24
		StDev	0.012	0.305	16	0.010	0.274	17	0.010	0.246	7
		95% C.I.	0.003	0.077	4	0.004	0.095	6	0.005	0.114	3
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	3	50		0	63		0	72	
		N. of Samples	60	60	60	32	32	32	18	18	18

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS34	Ruamahanga River at Pukio C6a (Lowland/ Impacted)	Average	0.017	0.419	30	0.015	0.360	29	0.011	0.209	29
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.015	2	0.002	0.005	1	0.002	0.005	1
		10%ile	0.006	0.088	10	0.003	0.026	4	0.002	0.005	1
		25%ile	0.010	0.178	14	0.006	0.128	13	0.005	0.072	10
		50%ile (median)	0.017	0.375	23	0.015	0.330	20	0.007	0.149	18
		75%ile	0.022	0.595	38	0.022	0.478	39	0.019	0.278	37
		90%ile	0.027	0.782	47	0.026	0.778	51	0.024	0.372	57
		95%ile	0.030	0.950	88	0.028	0.910	89	0.027	0.526	97
		Max	0.061	1.550	145	0.030	1.140	140	0.030	0.970	140
		StDev	0.010	0.308	28	0.009	0.292	29	0.009	0.231	35
		95% C.I.	0.003	0.078	7	0.003	0.100	10	0.004	0.107	16
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	27	62		36	73		67	94	
		N. of Samples	60	60	60	33	33	33	18	18	18
RS35	Mataikona tributary at Sugar Loaf Rd C5 (Lowland/ Low Impact)	Average	0.006	0.130	48	0.005	0.030	12	0.005	0.029	13
		Min	0.002	0.005	0	0.002	0.005	0	0.002	0.005	0
		5%ile	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		10%ile	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		25%ile	0.002	0.006	3	0.002	0.005	1	0.002	0.005	1
		50%ile (median)	0.006	0.037	6	0.004	0.006	3	0.003	0.006	3
		75%ile	0.008	0.130	25	0.007	0.022	4	0.006	0.020	3
		90%ile	0.010	0.202	66	0.008	0.052	25	0.009	0.050	25
		95%ile	0.012	0.325	113	0.009	0.105	47	0.009	0.110	55
		Max	0.016	2.870	1435	0.016	0.320	160	0.016	0.320	160
		StDev	0.003	0.379	189	0.003	0.061	31	0.003	0.065	33
		95% C.I.	0.001	0.096	48	0.001	0.022	11	0.001	0.025	13
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	93	97		97	100		96	100	
		N. of Samples	60	60	60	30	30	30	26	26	26
RS36	Taueru River at Castlehill C8 (Upland/ Low Impact)	Average	0.009	0.264	46						
		Min	0.002	0.005	0						
		5%ile	0.002	0.010	1						
		10%ile	0.005	0.017	2						
		25%ile	0.006	0.037	4						
		50%ile (median)	0.008	0.099	11						
		75%ile	0.012	0.330	36						
		90%ile	0.013	0.472	77						
		95%ile	0.014	0.631	181						
		Max	0.031	4.950	825						
		StDev	0.005	0.648	119						
		95% C.I.	0.001	0.164	30						
		Guideline	0.009	0.177							
		%compliance	60	63							
		N. of Samples	60	60	60						

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS37	Taueru River at Gladstone C8 (Lowland/ Impacted)	Average	0.015	0.971	222						
		Min	0.002	0.239	8						
		5%ile	0.002	0.327	13						
		10%ile	0.002	0.490	17						
		25%ile	0.005	0.630	28						
		50%ile (median)	0.011	0.870	84						
		75%ile	0.021	1.243	295						
		90%ile	0.030	1.710	700						
		95%ile	0.038	1.900	903						
		Max	0.074	2.050	1025						
		StDev	0.013	0.459	289						
		95% C.I.	0.003	0.116	73						
		Guideline	0.01	0.465							
		%compliance	47	10							
		N. of Samples	60	60	60						
RS38	Kopuaranga River at Stuarts C6c (Lowland/ Impacted)	Average	0.020	0.991	81	0.014	1.006	96	0.012	1.001	114
		Min	0.002	0.422	3	0.002	0.647	27	0.002	0.647	39
		5%ile	0.005	0.599	25	0.004	0.693	41	0.004	0.712	43
		10%ile	0.009	0.683	28	0.005	0.731	45	0.005	0.724	53
		25%ile	0.010	0.809	52	0.009	0.852	58	0.008	0.852	65
		50%ile (median)	0.015	0.976	68	0.014	0.981	74	0.011	0.976	93
		75%ile	0.020	1.127	95	0.017	1.125	113	0.016	1.125	141
		90%ile	0.027	1.271	138	0.020	1.215	163	0.020	1.211	200
		95%ile	0.035	1.418	198	0.025	1.358	210	0.025	1.245	230
		Max	0.243	1.890	324	0.027	1.805	324	0.027	1.805	324
		StDev	0.030	0.273	56	0.006	0.240	62	0.007	0.254	72
		95% C.I.	0.008	0.069	14	0.002	0.083	21	0.003	0.111	31
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	28	2		38	0		50	0	
		N. of Samples	60	60	60	32	32	32	20	20	20
RS39	Whangaehu River at 250m from Confluence C8 (Lowland/ Impacted)	Average	0.032	1.386	73	0.028	1.371	96	0.030	1.309	94
		Min	0.006	0.114	2	0.006	0.114	2	0.006	0.114	2
		5%ile	0.011	0.311	6	0.008	0.283	7	0.007	0.268	7
		10%ile	0.014	0.399	8	0.011	0.382	8	0.012	0.335	8
		25%ile	0.020	0.711	22	0.018	0.565	19	0.017	0.516	13
		50%ile (median)	0.029	1.230	41	0.027	1.100	42	0.030	0.988	36
		75%ile	0.041	1.880	74	0.037	2.048	88	0.041	1.740	107
		90%ile	0.054	2.720	162	0.047	2.901	321	0.048	2.840	277
		95%ile	0.066	3.022	321	0.055	2.971	374	0.059	3.002	401
		Max	0.095	4.670	503	0.065	3.530	503	0.065	3.530	503
		StDev	0.018	0.919	97	0.015	0.966	130	0.016	0.992	136
		95% C.I.	0.005	0.232	25	0.005	0.346	46	0.007	0.397	54
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	5	13		10	17		8	21	
		N. of Samples	60	60	60	30	30	30	24	24	24

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS40	Waipoua River at Colombo Rd Bridge C6a (Lowland/ Impacted)	Average	0.009	1.122	293						
		Min	0.002	0.006	3						
		5%ile	0.002	0.334	24						
		10%ile	0.002	0.456	53						
		25%ile	0.002	0.658	93						
		50%ile (median)	0.007	1.055	168						
		75%ile	0.011	1.478	353						
		90%ile	0.015	1.910	724						
		95%ile	0.015	2.197	950						
		Max	0.131	2.650	1300						
		StDev	0.017	0.612	306						
		95% C.I.	0.004	0.155	77						
		Guideline	0.01	0.465							
		%compliance	73	12							
		N. of Samples	60	60	60	60	60	60			
RS41	Waingawa River at South Rd C6a (Lowland/ Impacted)	Average	0.005	0.129	39	0.005	0.118	43	0.004	0.131	56
		Min	0.002	0.005	1	0.002	0.005	3	0.002	0.005	3
		5%ile	0.002	0.021	3	0.002	0.018	4	0.002	0.009	4
		10%ile	0.002	0.026	5	0.002	0.025	5	0.002	0.017	4
		25%ile	0.002	0.051	9	0.002	0.035	8	0.002	0.030	6
		50%ile (median)	0.005	0.090	20	0.004	0.074	15	0.002	0.036	11
		75%ile	0.007	0.123	47	0.007	0.108	37	0.007	0.079	16
		90%ile	0.008	0.303	65	0.008	0.162	61	0.008	0.267	131
		95%ile	0.011	0.401	83	0.009	0.363	136	0.008	0.608	304
		Max	0.016	1.000	500	0.012	1.000	500	0.008	1.000	500
		StDev	0.003	0.155	71	0.003	0.179	91	0.003	0.252	129
		95% C.I.	0.001	0.039	18	0.001	0.059	30	0.001	0.120	61
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	92	97		94	94		100	88	
		N. of Samples	60	60	60	35	35	35	17	17	17
RS42	Whareama River at Gauge C6c (Lowland/ Impacted)	Average	0.009	0.154	16	0.004	0.025	4	0.004	0.023	4
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		10%ile	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		25%ile	0.002	0.005	3	0.002	0.005	2	0.002	0.005	2
		50%ile (median)	0.006	0.018	4	0.002	0.006	3	0.002	0.006	3
		75%ile	0.013	0.272	21	0.004	0.006	3	0.003	0.006	3
		90%ile	0.021	0.458	31	0.007	0.020	10	0.006	0.020	10
		95%ile	0.026	0.586	43	0.013	0.174	11	0.012	0.133	10
		Max	0.038	0.780	290	0.021	0.270	17	0.021	0.270	17
		StDev	0.009	0.214	38	0.004	0.061	4	0.004	0.061	4
		95% C.I.	0.002	0.054	10	0.001	0.021	1	0.002	0.022	1
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	68	90		91	100		93	100	
		N. of Samples	60	60	60	33	33	33	29	29	29

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS43	Motuwaireka Stream at headwaters C5 (Lowland/ Low Impact)	Average	0.005	0.096	32	0.006	0.073	27	0.006	0.073	24
		Min	0.002	0.005	0	0.002	0.005	0	0.002	0.005	0
		5%ile	0.002	0.005	1	0.002	0.005	1	0.002	0.005	2
		10%ile	0.002	0.005	2	0.002	0.005	1	0.002	0.005	2
		25%ile	0.002	0.020	3	0.002	0.005	3	0.002	0.006	3
		50%ile (median)	0.004	0.050	14	0.002	0.034	9	0.002	0.040	10
		75%ile	0.007	0.115	29	0.008	0.077	23	0.008	0.084	20
		90%ile	0.011	0.252	90	0.013	0.130	54	0.014	0.130	41
		95%ile	0.013	0.312	132	0.015	0.335	116	0.016	0.258	62
		Max	0.022	0.560	280	0.022	0.560	280	0.022	0.560	280
		StDev	0.004	0.123	53	0.005	0.121	58	0.006	0.119	56
		95% C.I.	0.001	0.031	14	0.002	0.041	20	0.002	0.047	22
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	86	97		79	97		76	96	
		N. of Samples	59	59	59	34	34	34	25	25	25
RS44	Totara Stream at Stronvar C5 (Upland/ Impacted)	Average	0.004	0.181	45						
		Min	0.002	0.005	1						
		5%ile	0.002	0.005	2						
		10%ile	0.002	0.005	3						
		25%ile	0.002	0.010	4						
		50%ile (median)	0.002	0.090	18						
		75%ile	0.006	0.295	66						
		90%ile	0.008	0.541	110						
		95%ile	0.010	0.615	150						
		Max	0.012	0.914	270						
		StDev	0.003	0.224	54						
		95% C.I.	0.001	0.057	14						
		Guideline	0.009	0.177							
		%compliance	92	63							
		N. of Samples	60	60	60						
RS45	Parkvale tributary at Lowes Reserve A (Lowland/ Low Impact)	Average	0.019	4.424	407						
		Min	0.002	0.130	23						
		5%ile	0.004	3.555	88						
		10%ile	0.006	3.681	138						
		25%ile	0.011	4.133	165						
		50%ile (median)	0.017	4.515	266						
		75%ile	0.023	5.005	454						
		90%ile	0.029	5.409	606						
		95%ile	0.035	5.478	1272						
		Max	0.093	5.800	2730						
		StDev	0.014	1.031	492						
		95% C.I.	0.004	0.280	134						
		Guideline	0.01	0.465							
		%compliance	21	4							
		N. of Samples	52	52	52						

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS46	Parkvale Stream at Weir C6c (Lowland/ Impacted)	Average	0.044	1.738	57	0.044	1.136	42	0.045	0.642	21
		Min	0.012	0.005	0	0.012	0.005	0	0.019	0.005	0
		5%ile	0.018	0.069	1	0.019	0.049	1	0.029	0.037	1
		10%ile	0.019	0.125	3	0.023	0.077	1	0.032	0.056	1
		25%ile	0.029	0.616	13	0.031	0.221	4	0.037	0.135	3
		50%ile (median)	0.039	1.355	41	0.039	0.831	18	0.041	0.511	13
		75%ile	0.054	2.833	85	0.050	1.740	59	0.051	0.810	20
		90%ile	0.073	3.400	146	0.065	2.836	118	0.062	1.244	40
		95%ile	0.090	4.115	179	0.072	2.980	158	0.065	2.171	75
		Max	0.140	5.440	229	0.140	3.400	229	0.097	2.970	156
		StDev	0.025	1.376	59	0.023	1.029	56	0.016	0.732	34
		95% C.I.	0.006	0.348	15	0.007	0.319	17	0.006	0.299	14
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	0	20		0	30		0	48	
		N. of Samples	60	60	60	40	40	40	23	23	23
RS47	Waiohine River at Gorge C7 (Lowland/ Reference)	Average	0.005	0.034	11	0.004	0.032	12	0.004	0.020	8
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	2	0.002	0.005	2	0.002	0.005	1
		10%ile	0.002	0.006	2	0.002	0.006	2	0.002	0.005	2
		25%ile	0.002	0.019	3	0.002	0.011	3	0.002	0.006	3
		50%ile (median)	0.005	0.030	6	0.004	0.020	4	0.002	0.016	3
		75%ile	0.006	0.039	15	0.006	0.033	11	0.006	0.029	10
		90%ile	0.007	0.050	20	0.007	0.050	20	0.007	0.045	22
		95%ile	0.008	0.051	25	0.009	0.055	25	0.008	0.049	25
		Max	0.020	0.290	145	0.011	0.290	145	0.010	0.050	25
		StDev	0.003	0.038	19	0.003	0.050	26	0.003	0.016	8
		95% C.I.	0.001	0.010	5	0.001	0.018	9	0.001	0.008	4
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	97	100		97	100		100	100	
		N. of Samples	60	60	60	31	31	31	14	14	14
RS48	Waiohine River at Bicknells C6a (Lowland/ Impacted)	Average	0.018	0.380	24	0.020	0.371	20	0.022	0.373	19
		Min	0.004	0.028	1	0.008	0.052	2	0.009	0.052	2
		5%ile	0.008	0.098	7	0.009	0.135	8	0.009	0.123	5
		10%ile	0.009	0.119	9	0.010	0.159	9	0.009	0.172	8
		25%ile	0.011	0.180	12	0.014	0.203	12	0.012	0.250	12
		50%ile (median)	0.018	0.305	19	0.020	0.310	17	0.020	0.300	21
		75%ile	0.022	0.458	29	0.025	0.456	24	0.030	0.419	28
		90%ile	0.031	0.851	50	0.031	0.748	31	0.036	0.719	30
		95%ile	0.036	0.942	55	0.036	0.808	44	0.037	0.792	33
		Max	0.058	1.310	92	0.039	0.940	62	0.039	0.856	37
		StDev	0.010	0.280	19	0.008	0.220	13	0.011	0.233	10
		95% C.I.	0.002	0.071	5	0.003	0.079	4	0.006	0.127	5
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	22	75		13	73		23	77	
		N. of Samples	60	60	60	30	30	30	13	13	13

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS49	Beef Creek at Headwaters C7 (Upland/ Reference)	Average	0.012	0.047	6						
		Min	0.002	0.005	0						
		5%ile	0.005	0.012	1						
		10%ile	0.005	0.014	1						
		25%ile	0.006	0.025	2						
		50%ile (median)	0.009	0.030	4						
		75%ile	0.013	0.051	6						
		90%ile	0.017	0.070	10						
		95%ile	0.018	0.088	20						
		Max	0.088	0.340	57						
		StDev	0.011	0.056	9						
		95% C.I.	0.003	0.014	2						
		Guideline	0.009	0.177							
		%compliance	50	97							
		N. of Samples	60	59	60						
RS50	Mangatarere Stream at State Highway 2 C6a (Lowland/ Impacted)	Average	0.121	1.527	19	0.165	1.634	13	0.202	1.667	11
		Min	0.024	0.390	4	0.049	0.931	4	0.085	0.931	4
		5%ile	0.034	0.854	6	0.058	0.986	6	0.092	0.939	5
		10%ile	0.046	0.928	7	0.078	1.058	6	0.098	1.122	6
		25%ile	0.056	1.108	9	0.111	1.265	7	0.119	1.283	6
		50%ile (median)	0.097	1.500	14	0.131	1.590	10	0.153	1.590	9
		75%ile	0.148	1.825	23	0.201	1.968	16	0.253	1.975	11
		90%ile	0.227	2.210	35	0.274	2.370	22	0.394	2.342	17
		95%ile	0.285	2.412	48	0.398	2.421	30	0.450	2.490	22
		Max	0.450	3.160	64	0.450	2.770	34	0.450	2.770	33
		StDev	0.094	0.539	14	0.099	0.484	8	0.118	0.510	7
		95% C.I.	0.024	0.137	3	0.033	0.163	3	0.054	0.235	3
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	0	2		0	0		0	0	
		N. of Samples	60	60	60	34	34	34	18	18	18
RS51	Huangarua River at Ponatahi Bridge C6a (Lowand/ Impacted)	Average	0.009	0.300	52						
		Min	0.002	0.005	1						
		5%ile	0.002	0.006	3						
		10%ile	0.002	0.028	7						
		25%ile	0.002	0.140	20						
		50%ile (median)	0.006	0.286	33						
		75%ile	0.012	0.400	59						
		90%ile	0.021	0.597	112						
		95%ile	0.026	0.726	138						
		Max	0.037	0.960	265						
		StDev	0.009	0.224	55						
		95% C.I.	0.002	0.057	14						
		Guideline	0.01	0.465							
		%compliance	70	80							
		N. of Samples	60	60	60						

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS52	Tauanui River at Whakatomotomo Rd C7 (Lowland/ Reference)	Average	0.009	0.025	4	0.009	0.016	2	0.009	0.017	2
		Min	0.002	0.005	0	0.005	0.005	0	0.005	0.005	0
		5%ile	0.002	0.005	0	0.005	0.005	0	0.005	0.005	0
		10%ile	0.005	0.005	0	0.006	0.005	0	0.006	0.005	0
		25%ile	0.006	0.006	1	0.006	0.005	1	0.006	0.006	1
		50%ile (median)	0.009	0.018	2	0.008	0.013	1	0.008	0.014	1
		75%ile	0.012	0.040	4	0.010	0.020	4	0.010	0.020	4
		90%ile	0.014	0.053	8	0.013	0.040	6	0.013	0.040	6
		95%ile	0.015	0.062	18	0.014	0.044	7	0.014	0.044	7
		Max	0.031	0.100	25	0.014	0.050	8	0.014	0.050	8
		StDev	0.005	0.022	5	0.003	0.014	2	0.003	0.015	2
		95% C.I.	0.001	0.006	1	0.001	0.006	1	0.001	0.006	1
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	66	100		77	100		80	100	
		N. of Samples	58	58	58	22	22	22	20	20	20
RS53	Awhea River at Tora Rd C6c (Lowand/ Impacted)	Average	0.008	0.094	15	0.004	0.022	7	0.004	0.020	7
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	2	0.002	0.005	1	0.002	0.006	1
		10%ile	0.002	0.006	2	0.002	0.006	2	0.002	0.006	2
		25%ile	0.002	0.013	3	0.002	0.006	2	0.002	0.006	2
		50%ile (median)	0.006	0.056	9	0.002	0.014	3	0.002	0.014	3
		75%ile	0.010	0.165	16	0.006	0.028	10	0.006	0.021	10
		90%ile	0.016	0.241	29	0.007	0.052	12	0.007	0.048	10
		95%ile	0.022	0.270	61	0.009	0.061	23	0.007	0.060	24
		Max	0.032	0.350	90	0.012	0.080	40	0.010	0.080	40
		StDev	0.007	0.095	19	0.003	0.021	9	0.002	0.020	9
		95% C.I.	0.002	0.024	5	0.001	0.008	3	0.001	0.008	4
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	77	100		97	100		100	100	
		N. of Samples	60	60	60	29	29	29	23	23	23
RS54	Coles Creek tributary at Lagoon Hill Rd C8 (Lowland/ Low Impact)	Average	0.007	0.026	6	0.007	0.028	7	0.007	0.028	7
		Min	0.002	0.005	0	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	1	0.002	0.005	1	0.002	0.006	2
		10%ile	0.002	0.005	1	0.002	0.006	2	0.002	0.006	2
		25%ile	0.002	0.007	2	0.002	0.016	2	0.002	0.014	2
		50%ile (median)	0.007	0.022	3	0.007	0.025	3	0.006	0.023	3
		75%ile	0.010	0.032	7	0.010	0.036	6	0.010	0.038	6
		90%ile	0.013	0.057	17	0.013	0.060	18	0.011	0.056	16
		95%ile	0.014	0.065	25	0.014	0.064	27	0.013	0.065	20
		Max	0.018	0.100	44	0.018	0.087	44	0.018	0.087	44
		StDev	0.004	0.021	9	0.005	0.020	10	0.004	0.021	9
		95% C.I.	0.001	0.006	2	0.002	0.008	4	0.002	0.009	4
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	78	100		75	100		78	100	
		N. of Samples	54	54	54	28	28	28	23	23	23

Site	Site Name		All flows			Flows below median flow			Flows below half median flow		
			DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio	DRP (mg/L)	DIN (mg/L)	DIN:DRP Ratio
RS55	Tauherenikau River at Websters C6a (Lowand/ Impacted)	Average	0.005	0.077	21	0.005	0.055	15	0.004	0.051	14
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	3	0.002	0.005	3	0.002	0.005	2
		10%ile	0.002	0.016	4	0.002	0.006	3	0.002	0.005	3
		25%ile	0.002	0.028	6	0.002	0.020	4	0.002	0.008	4
		50%ile (median)	0.004	0.050	11	0.004	0.030	8	0.002	0.020	8
		75%ile	0.007	0.103	24	0.007	0.068	17	0.006	0.036	13
		90%ile	0.009	0.165	41	0.009	0.140	36	0.007	0.166	31
		95%ile	0.009	0.193	70	0.009	0.167	59	0.007	0.187	46
		Max	0.020	0.470	165	0.011	0.253	85	0.009	0.253	85
		StDev	0.003	0.083	26	0.003	0.059	20	0.002	0.072	21
		95% C.I.	0.001	0.021	7	0.001	0.022	7	0.001	0.030	8
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	97	98		103	107		74	74	
		N. of Samples	60	60	60	29	29	29	23	23	23
RS56	Waiorongomai River at Forest Park C7 (Lowland/ Reference)	Average	0.006	0.025	6						
		Min	0.002	0.005	1						
		5%ile	0.002	0.005	1						
		10%ile	0.002	0.005	1						
		25%ile	0.002	0.006	2						
		50%ile (median)	0.006	0.021	4						
		75%ile	0.009	0.034	7						
		90%ile	0.010	0.050	15						
		95%ile	0.012	0.055	23						
		Max	0.039	0.100	35						
		StDev	0.006	0.020	7						
		95% C.I.	0.001	0.005	2						
		Guideline	0.01	0.465							
		%compliance	92	100							
		N. of Samples	60	60	60						

Appendix G: RSoE periphyton biomass data (mg/m^2 Chlorophyll *a*)

Site Name	Class	2004	2005	2006	2007	2008	2009	Median	Max
Mangapouri Stream at Rahui Rd	A	*	*	*	*	*	*		
Mangapouri Stream at Bennetts Rd	A	*	*	*	*	*	*		
Waitohu Stream at Forest Park	C7	9	9	4	3	1	1	3	9
Waitohu Stream at Norfolk Crescent	C6c	*	*	*	*	*	*		
Otaki River at Pukehinau	C7	0	5	2	2	1	1	1	5
Otaki River at Mouth	C6a	2	5	12	21	5	3	5	21
Mangaone Stream at Sims Road Bridge	C6c	*	*	*	*	*	*		
Ngarara Stream at Field Way	A	*	*	*	*	*	*		
Waikanae River at Mangaone Walkway	C5	3	3	10	4	4	0	3	10
Waikanae River at Greenaway Rd	C6a	27	12	71	148	5	20	23	148
Whareroa Stream at Waterfall Rd	C5	1	0	5	3	5	30	4	30
Whareroa Stream at QE Park	A	*	*	*	*	*	*		
Horokiri Stream at Snodgrass	C6b	6	15	43	50	12	34	25	50
Pauatahanui Stream at Elmwood Bridge	C5	20	34	33	114	51	141	42	141
Porirua Stream at Glenside Overhead Cable	C5	7	37	12	39	64	43	38	64
Porirua Stream at Milk Depot	C5	12	24	10	11	109	39	18	109
Makara Stream at Kennels	C5	2	1	3	120	2	6	3	120
Karori Stream at Makara Peak Mountain Bike	C5	16	37	33	41	33	71	35	71
Kaiwharawhara Stream at Ngaio Gorge	C5	33	47	22	88	89	61	54	89
Hutt River at Te Marua Intake Site	C7	1	0	5	2	1	1	1	5
Hutt River Opposite Manor Park Golf Club	C6a	0	4	19	29	49	18	19	49
Hutt River at Boulcott	C6a	0	1	163	98	112	17	57	163
Pakuratahi River 50m Below Farm Creek	C7	1	1	60	16	28	4	10	60
Mangaroa River at Te Marua	C7	1	10	58	58	52	60	55	60
Akatarawa River at Hutt Confluence	C7	0	3	2	2	39	2	2	39
Whakatikei River at Riverstone	C6a	2	2	46	20	17	14	15	46
Waiwhetu Stream at Wainui Hill Bridge	A	*	*	*	*	*	*		
Wainuiomata River at Manuka Track	C7	5	20	10	9	9	7	9	20
Wainuiomata River Upstr of White Bridge	C6a	23	31	6	31	32	40	31	40
Orongorongo River at Orongorongo Station	C7	1	7	3	6	0	20	4	20
Ruamahanga River at McLays	C7	2	6	0	1	0	0	1	6
Ruamahanga River at Te Ore Ore	C6a	27	67	11	12	62	28	27	67
Ruamahanga River at Gladstone Bridge	C6a	13	12	4	46	59	47	30	59
Ruamahanga River at Pukio	C6a	61	0	5	63	99	22	42	99
Mataikona tributary at Sugar Loaf Rd	C5	4	2	2	5	7	7	4	7
Taueru River at Castlehill	C8	*	*	*	*	*	*		
Taueru River at Gladstone	C8	346	87	85	241	693	477	293	693
Kopuaranga Stream at Stewarts	C6c	19	204	195	173	1221	690	199	1221
Whangaehu River at 250m from Confluence	C8	*	*	*	*	*	*		
Waipoua River at Colombo Rd Bridge	C6a	14	17	179	35	79	35	35	179
Waingawa River at South Rd	C6a	1	3	15	2	6	51	4	51
Whareama River at Gauge	C6c	*	*	*	*	*	*		
Motuwaireka Stream at headwaters	C5	2	7	8	11	2	3	5	11
Totara Stream at Stronvar	C5	3	28	28	5	6	15	10	28
Parkvale tributary at Lowes Reserve	A	19	10	65	78	29	18	24	78
Parkvale Stream at weir	C6c	92	87	17	239	78	304	90	304
Waiohine River at Gorge	C7	1	2	0	0	0	0	0	2
Waiohine River at Bicknells	C6a	4	3	4	27	1	48	4	48
Beef Creek at headwaters	C7	3	4	10	9	5	7	6	10
Mangatarere River at State Highway 2	C6a	72	11	29	55	243	2	42	243
Huangarua River at Ponatahi Bridge	C6a	7	229	72	45	310	123	97	310
Tauanui River at Whakatomotomo Rd	C7	3	7	9	11	35	1	8	35
Awhea River at Tora Rd	C6c	19	35	57	140	331	36	46	331
Coles Creek tributary at Lagoon Hill Rd	C8	6	12	8	61	88	42	27	88
Tauherenikau River at Websters	C6a	6	2	11	19	7	12	9	19
Waiorongomai River at Forest Park	C7	3	1	4	10	1	2	3	10