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Water Quality in the Ngaruroro catchment

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State, trends and contaminant loads

September 2009

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Cover Photograph: Ngaruroro River at Kuripapango.

All photographs by Olivier Ausseil.

EXCUTIVE SUMMARY

Hawke's Bay Regional Council (HBRC) monitors water quality and river flow at a number of points across the Ngaruroro catchment and has produced a comprehensive report on the state and trends of water quality across the region, based on data collected between 1998 and 2003 (Stansfield 2004).

The present report was commissioned by HBRC to obtain an up-to-date and independent analysis of the state of the water quality in the Ngaruroro River catchment.

The aim of this study is to analyse the water quality and biomonitoring data collected by Hawke's Bay Regional Council in the Ngaruroro catchment until March 2008. In particular, the study aims at investigating the following points:

- the state of the Ngaruroro River and its main tributaries;
- temporal trends, *i.e.* are the water quality or the ecological indicators getting better or worse over time?;
- the annual and daily nutrient loadings in the Ngaruroro River.

This report also makes recommendation for future water quality monitoring and management in the Ngaruroro catchment.

Microbiological water quality is very good across all sites monitored in the Ngaruroro catchment- better than national values for comparable systems and stable or improving over time.

There is a clear spatial pattern of water clarity degradation along the course of Ngaruroro River, from excellent at Kuripapango to below recreational guidelines in the lower catchment. Water clarity degradation starts in the upper catchment, and it is suggested that accelerated erosion in pastoral and commercial forestry land above Whanawhana could be a significant contributing factor. In the rest of the catchment, the decline in water clarity is gradual along the course of Ngaruroro River, and it seems clear that the cause cannot be narrowed down to a single factor in a single area. It is suggested that superimposing water quality, geology, topography and land use information using modern GIS tools may be useful in identifying hotspots/priority areas for detailed instigations and/or management. No temporal trends were identified in relation to suspended sediment concentrations in the catchment.

Although an increasing trend is apparent when going downstream in the catchment, nutrient concentrations remain relatively low in the Ngaruroro main stem – lower than ANZECC guidelines and national medians for comparable sites. Periphyton guidelines are exceeded on occasions at all sites monitored in the catchment, but nuisance periphyton seem to occur more frequently in the middle and lower catchment than in the upper catchment. However, this remark is based on only a very limited number of results, and will need to be tested following further monitoring of periphyton growth. Increasing trends in both SIN and DRP have been identified in the middle and lower catchment (Ohiti and Fernhill), making future monitoring of periphyton biomass and cover all the more critical.

During periods of low river flow, the nutrient status of the river tends to switch from a phosphorus-limited or co-limited situation to a nitrogen- limited situation. Controlling the inputs of both nutrients to the river appears essential to control periphyton growth, with an particular emphasis on controlling SIN inputs during periods of low river flows.

In 2000, monitoring started at two sites on the Ngaruroro River immediately upstream and downstream of a large dairy farming operation- Hawke's Bay Dairies- to identify any effects this intensive dairy unit may have on the Ngaruroro River's water quality. The possible direct effects (i.e. immediately downstream of the farm) of these changes on the River's aquatic life remain uncertain, and further biological monitoring and more in-depth analysis of existing data is recommended. However, the data available and the analysis presented in this report indicates that HB Dairies is contributing to the cumulative effects on water clarity and nutrient enrichment observed in the Ngaruroro River.

Two tributaries of the lower Ngaruroro River have been included in HBRC's state of the environment programme since 2000, the Waitio Stream and the Tutaekuri-Waimate Stream. Both show similar indications of degraded water quality, although one – the Tutaekuri-Waimate- appears more degraded than the other. It is probable that both streams could greatly beneficiate from improved riparian management. The Tutaekuri-Waimate has also been identified as a significant source of nutrients to the lower Ngaruroro River.

Further monitoring and investigations are recommended to better identify the sources of water clarity degradation and nutrients in the Ngaruroro catchment. Recommendations are also made to modify the current monitoring network to provide a better balance between monitoring the Ngaruroro River main stem and its tributaries.

CONTENTS

Table of Contents

Figures

Tables

1. Context

1.1. Introduction

Hawke's Bay Regional Council (HBRC) monitors water quality and river flow at a number of points across the Ngaruroro catchment and has produced a comprehensive report on the state and trends of water quality across the region, based on data collected between 1998 and 2003 (Stansfield 2004).

The present report was commissioned by HBRC to obtain an up-to-date and independent analysis of the state of the water quality in the Ngaruroro River catchment. This report is part of a series of technical reports covering all major catchments in the Hawke's Bay Region, currently being prepared to serve as a base for the upcoming 2009 Hawke's Bay Regional Council's state of the environment report.

1.2. Aim and scope of the study

The aim of this study is to analyse the water quality and biomonitoring data collected by Hawke's Bay Regional Council in the Ngaruroro catchment until March 2008. In particular, the study aims at investigating the following points:

- the state of the Ngaruroro River and its main tributaries;
- temporal trends, *i.e.* are the water quality or the ecological indicators getting better or worse over time?;
- the annual and daily nutrient loadings in the Ngaruroro River;

This report also makes recommendation for future water quality monitoring and management in the Ngaruroro catchment.

2. Methods

2.1. Original dataset

A complete extract of HBRC's water quality database for the Ngaruroro catchment was obtained from HBRC's Water Quality and Ecology teams.

As part of its State of the Environment (SOE) and contact recreation monitoring programmes, HBRC regularly monitors water quality at nine sites across the Ngaruroro catchment. Seven of these sites are on the Ngaruroro River main stem, and two on tributaries: the Waitio Stream and the Tutaekuri-Waimate Stream (Map 1). Most sites are monitored quarterly, with the data records starting between 1978 and 2000. Due to changes in laboratory analysis procedures[1], only the data collected from January 1994 was used in this report. Average daily flow at each site for each day of sampling was obtained, either by direct measurement or by correlation with a flow recorder site (Table 1, Table 2).

In addition to the sites described above, NIWA has monitored water quality and river flow at two sites on the main stem of the Ngaruroro River: at Kuripapango and at Chesterhope Bridge since 1989. To maintain consistency with the other monitoring sites, only the data from August 1994 was used in this report, unless specifically mentioned. All data in relation to both these sites was provided by NIWA for the purpose of this report.

Table 3 provides a summary of the data used in this study.

[1] Prior to 1994, the laboratory quantification limit for DRP, ammonia-N and Nitrate N was 0.02 g/m^3. A large proportion of results fall below this limit. As a comparison, the RRMP defines a guideline DRP concentration of 0.015 g/m^3. Post 1994, the detection limits were 0.002 (DRP) to 0.005 g/m^3 (ammonia-N).

2.2. Water quality data preparation

The dataset contained a small proportion of "less than detection limit" results. To conduct statistical analysis, such "censored" data should be replaced by numerical values. The "less than" values represented less than 10% of the total dataset for each parameter and were replaced by half of the detection limit, which is consistent with the recommendations of Scarsbrook and McBride (2007).

2.2.1. Bacterial indicators

The dataset contains two indicators of bacteriological water quality: faecal coliforms (FC) and *Escherichia coli* (*E. coli*). As part of HBRC's state of the environment monitoring programme, FC was used between 1990 and 2007, and *E. coli* has been used since 2004. Typically, *E. coli* comprise 85-90 % of faecal coliforms in natural waters over several orders of magnitude (Wilcock, 2008), and good, site-specific correlations can be obtained between the two parameters. At each given monitoring site, a significant number of samples, collected between 1994 and 2007, have been tested for both indicators. These were used to calculate site-specific correlations between the two indicators. To obtain a more consistent dataset, covering a longer period of time, a synthetic *E. coli* data series (correl^{td} *E. coli*) was created for each monitoring site. This dataset was used in particular in the time trends analysis.

2.2.2. Quarterly series

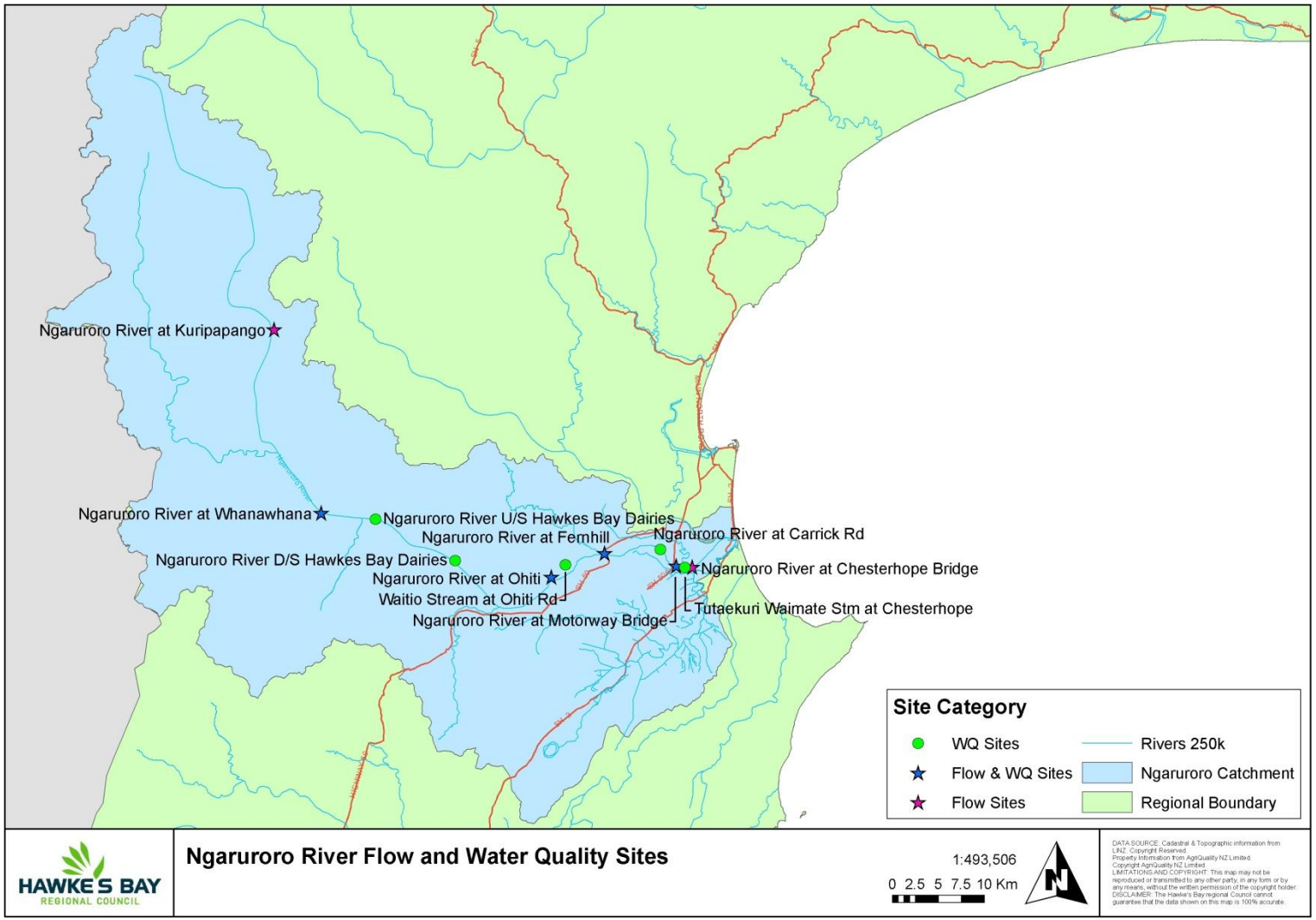
The current state of the environment (SoE) monitoring programme for the Ngaruroro catchment comprises quarterly monitoring in February, May, August and November, with additional monthly monitoring every 5 years (Graham Sevicke-Jones, pers. comm.). However, the frequency and regularity of monitoring has varied somewhat between 1994 and 2008. To maintain consistency with the current quarterly monitoring programme, and allow for comparison with future analysis, the time trend analysis was conducted using quarterly series.

2.3. River flow data

All flow data used in this report was provided by HBRC's Hydrology team. Continuous (15 min interval) flow data is available at three sites on the main stem of the Ngaruroro River. Two of these sites (Kuripapango and Chesterhope) are operated by NIWA, the third one (Whanawhana) is operated by HBRC. River flow data for the other water quality monitoring sites was obtained from either direct flow gauging or correlation with the above flow recorder sites. Table 1 and Table 2 provide a summary of flow statistics at the eleven Ngaruroro catchment water quality monitoring sites used in this report.

Table 1: Flow statistics calculated from data collected at the different flow recorder sites in the Ngaruroro catchment.

Flow (L/s)	Ngaruroro at Kuripapango	Ngaruroro at Whanawhana	Ngaruroro at Chesterhope
3× Median	35,181	74,949	75,528
Median	11,727	24,983	25,176
Lower Quartile	7,297	15,031	13,222
7-day MALF	4,118	7,873	5,642
Minimum	849	1,401	2,141
Data record	1963 - 2008	1960 - 2008	1976 - 2008



Map 1: Water quality and flow monitoring sites in the Ngaruroro catchment (Map: Hawke's Bay Regional Council).

Table 2: Flow statistics calculated from synthetic flow records in the Ngaruroro catchment. (Note that the same flow statistics were used for the sites upstream and downstream of Hawke's Bay Dairies.

Flow (L/s)	Ngaruroro at HB Dairies	Ngaruroro at Ohiti	Waitio Stream at Ohiti Rd	Ngaruroro at Fernhill	Ngaruroro at Carrick Rd	Ngaruroro at Motorway	Tutaekuri Waimate Stream
3× Median	79,303	80,161	2,180	69,411	71,106	67,653	10,999
Median	26,434	26,720	727	23,137	23,702	22,551	3,666
Lower Quartile	16,511	15,373	661	11,674	11,768	11,062	2,802
7-day MALF	9,382	8,147	619	3,577	4,179	3,774	2,254
Minimum	2,929	3,772	594	-	-	-	1,920
Correlation with	Ngaruroro at Whanawhana	Ngaruroro at Chesterhope	Ngaruroro at Chesterhope	Ngaruroro at Whanawhana	Ngaruroro at Fernhill	Ngaruroro at Chesterhope	Ngaruroro at Chesterhope

Table 3: Summary of the water quality and flow data used in this study on the Ngaruroro catchment. Sites ordered from upstream to downstream. Phy-Chem: Physico-chemical parameters (temperature, pH, conductivity and dissolved oxygen). Nutrients comprise dissolved reactive phosphorus (DRP) and soluble inorganic nitrogen (SIN). Bacto: bacteriological data (*E. coli* and faecal coliforms). Biom: Biomonitoring (macroinvertebrate and periphyton data

Monitoring site	HBRC Site ID	Water quality data					Flow data	Comments
		Record Period	Parameters					
			Phy-Chem	Nutrients	Bacto	Biom.		
Ngaruroro at Kuripapango	N/A	1994 – 2008	✓	✓	✓	-	✓	NIWA site. Longer water quality record exists (1989 – 2008), but only 1994 -2008 data was used for consistency with other sites. *E. coli* data only for the 2005-2008 period.
Ngaruroro at Whanawhana	299	1994 – 2008	✓	✓	✓	✓	✓	Flow recorder site
Ngaruroro u/s HB Dairies	2593	2000 - 2008	✓	✓	✓	✓	✓	Generally paired upstream/downstream samples. Only four years of biological data
Ngaruroro d/s HB Dairies	2594	2000 - 2008	✓	✓	✓	✓	✓	
Ngaruroro at Ohiti	353	1994 – 2008	✓	✓	✓	✓	✓	Flow obtained by correlation with Ngaruroro at Chesterhope.
Waitio Stream at Ohiti	2591	2000 - 2008	✓	✓	✓	✓	✓	Flow obtained by correlation with Ngaruroro at Chesterhope.
Ngaruroro at Fernhill	354	1994 – 2008	✓	✓	✓	✓	✓	Flow obtained by correlation with Ngaruroro at Whanawhana.
Ngaruroro at Carrick Road	2503	2000 - 2008	✓	✓	✓	✓	✓	Flow obtained by correlation with Ngaruroro at Fernhill.
Ngaruroro at Motorway Bridge	2504	2000 - 2008	✓	✓	✓	✓	✓	Flow obtained by correlation with Ngaruroro at Chesterhope.
Tutaekuri-Waimate Stream at Chesterhope	431	2000 - 2008	✓	✓	✓	-	✓	Flow obtained by correlation with Ngaruroro at Chesterhope.
Ngaruroro at Chesterhope	N/A	1994 – 2008	✓	✓	✓	-	✓	NIWA site. Longer water quality record exists (1989 – 2008), but only 1994 -2008 data was used for consistency with other sites. *E. coli* data only for the 2005-2008 period.

2.4. Data analysis

Descriptive statistics (mean, percentiles, confidence intervals), such as those provided in Appendix A and in different tables and figures in this report were calculated with a number of macros developed for Microsoft® Office Excel 2007.

To provide more in-depth analysis, water quality data was generally analysed:

- year-round at all flows (i.e. all data available),
- under 3* median flow, to remove the potential influence of flood flows;
- under the lower quartile (25th percentile) flow, to reflect low river flow conditions;

Mann-Whitney tests were used to compare two groups of unpaired data (e.g. winter/summer comparisons). Wilcoxon paired rank tests were used to compare two groups of paired data (e.g. comparing contaminant concentration at two sites with the same sampling dates).

Temporal trend analysis (Kendall seasonal test) was carried out using NIWA's water quality trends software. Probability p- values were subsequently adjusted by False Discovery rate methodology (FDR). Trend analysis for *E. coli* was performed on Log-transformed data.

2.5. Annual Contaminant loads

Contaminant loads are the amount of contaminant carried by the river through one point, or more correctly one transversal section of the river in a given length of time. Calculation methods generally assume that the contaminant concentration is homogenous across the section of river. Annual loads were calculated for water years spanning 1 July-30 June.

When both continuous river flow and contaminant concentration data are available, instantaneous contaminant flux can be calculated at any point in time, and an estimate of the contaminant load during a given period of time can be calculated by simply integrating the instantaneous flux:

$$Load(year_i) = \int_{01/01/year_i}^{31/12/year_i} Pollut(t) \cdot Flow(t)\, dt$$

When contaminant concentrations are known only at regular time intervals (e.g. monthly), the above formula can be approximated using a number of approaches. The "averaging approach" described below was used in this report. This method uses the average river flow and the average contaminant concentration over a given period of time (e.g. one month or 3 months) to estimate contaminant loads transported during that period of time. The annual load is then calculated by summing up the loads. This method is particularly applicable when the contaminant concentration and river flow are independent variables (Richards, 1998)..

Quarterly load: $$Load(Quarter_i) = Pollut(Quarter_i) \cdot \overline{Flow(Quarter_i)}$$

Annual load: $$Load(year_i) = \sum_{i=1}^{4} Load(Quarter_i)$$

The precision and accuracy of an annual contaminant load estimate improves with the number of samples, and annual loads are generally estimated from results with at least a monthly frequency. The HBRC data available in the Ngaruroro catchment has a quarterly (three-monthly) frequency, with samples generally taken in February, May, August and November. Any load estimation based on only four samples per year is unlikely to be very precise or accurate, and the results need to be considered with caution.

The two NIWA sites (Kuripapango and Chesterhope) are monitored monthly. The annual DRP and SIN loads were estimated at both sites for each year of a 10-year period (July 1998 to June 2008), using results obtained monthly and quarterly (i.e. considering only the water quality samples taken in February, May, August and November). The results, summarised in Table 4 below, indicate that, over a 10-year period, the two methods seem to deliver very consistent information. Paired T-tests did not indicate any statistically significant differences between the results of the two methods.

Whilst the absolute numbers still need to be taken with caution, it appears that annual loads calculated from quarterly sampling should be adequate to compare contaminant loads at different sites sampled concurrently within a given catchment.

Table 4:Results of annual loads estimations (averaging method) based on monthly and quarterly sampling, at the two sites monitored by NIWA in the Ngaruroro catchment. Data from 1998 to 2008.

Site	Mean DRP load (T/Y ± 95% confidence interval) based on		Mean SIN load (T/Y ± 95% confidence interval) based on	
	Quarterly samples	Monthly samples	Quarterly samples	Monthly samples
Ngaruroro at Kuripapango	1.1 ± 0.2	1.2 ± 0.3	6.6 ± 1.8	7.3 ± 1.6
Ngaruroro at Chesterhope	11.7 ±2.2	11.5 ± 2.0	187 ± 61	195 ± 53

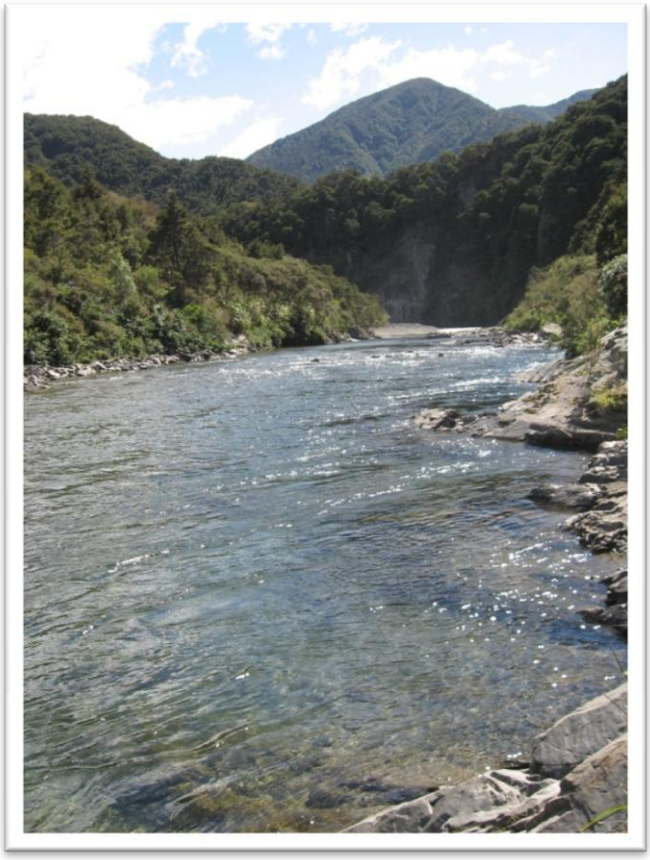


Photo 1: Ngaruroro at Kuripapango.

Photo 2: Ngaruroro River Upstream of Hawke's Bay Dairies.

3. Water quality in the Ngaruroro catchment

3.1. The Ngaruroro Catchment

The Ngaruroro River takes its sources high in the Ruahine Ranges. At Kuripapango, and down to Whanawhana, the Ngaruroro is a fast flowing river over a bed made of rocky outcrops, boulders and large cobble. The catchment headwaters, within the Ruahine Forest Park have predominantly native vegetation assemblages, dominated by native forest, with native shrubland and tussock associations above the tree line. The rest of the upper catchment is largely dominated by a mix of native vegetation, although pasture represents about a quarter of the catchment area above Whanawhana (Table 5).

Past Whanawhana and down to Ohiti, the Ngaruroro River becomes a semi-braided river, flowing in a relatively wide and flat channel bordered by steep hill country. The land use in this part of the catchment is predominantly dry stock farming, with one large intensive dairy operation (Hawke's Bay Dairies) near the Ngaruroro mainstem downstream of Whanawhana. Specific monitoring of the River upstream and downstream of this farm has been undertaken since 2000.

Downstream of Ohiti, the River leaves the hill country to enter a landscape of plains and low rolling hill. The river channel is wide and flat, with a low gradient leading to a semi-braided morphology, constrained on each side by stopbanks. The area is a zone of groundwater recharge: the River loses approximately 5 m^3/s, or 20% of its median flow, to groundwater between Ohiti and Fernhill. The Ngaruroro River then flows eastwards to an estuary shared with the Tutaekuri River. It flows into the Pacific Ocean on the East Coast of Hawke's Bay, South of Napier.

The Ngaruroro catchment supports a regionally significant brown and rainbow trout fishery. The angling activity is spread throughout the catchment, with the Ngaruroro mainstem the most sought after fishery. The trout populations in the catchment are self sustaining, with trout spawning occurring in the mainstem and a number of tributaries.

Recreational activities, such as swimming canoeing/kayaking and fishing occur throughout the catchment.

The Ngaruroro catchment also supports significant ecological values associated with its aquatic and riparian ecosystems and significant habitats of indigenous fauna and flora.

Table 5: Catchment area and vegetation land cover above monitoring sites in the Ngaruroro catchment. (Landcover source: land cover database 2 - LCDBII).

Monitoring site	Catchment area (km^2)	Landcover (% of surface water catchment area above each site)					
		Tussock	Native forest	Native shrubland	Exotic forest	Pasture	Others
Ngaruroro at Kuripapango	370	17	48	33	<1	<1	<2
Ngaruroro at Whanawhana	1093	11	34	23	2	26	<4
Ngaruroro u/s HB Dairies	1384	9	25	18	4	43	<2
Ngaruroro d/s HB Dairies	1482	9	25	18	4	43	<2
Ngaruroro at Ohiti	1750	7	22	15	3	49	<4
Ngaruroro at Fernhill	1930	7	21	15	3	49	<5
Ngaruroro at Carrick Rd	1947	7	21	15	3	49	<5
Ngaruroro at Motorway	1951	7	21	15	3	49	<5
Waitio at Ohiti	42	<1	<1	<1	<1	98	<2
Tutaekuri-Waimate	56	<1	<1	<1	<1	93	6[(a)]
Ngaruroro at Chesterhope	2007	6.7	21	15	4	48	<5

[(a)] including 5% orchards and vineyards

3.2. Water quality Standards and Guidelines

Hawke's Bay Regional Council's Regional Resource Management Plan (RRMP) defines a number of surface water quality guidelines applying to the Ngaruroro catchment. These have primarily a regulatory purpose, particularly in relation to resource consents for activities having a potential or actual effect on water quality. The RRMP defines three sections of the catchment, above Fernhill, between Fernhill and Motorway Bridge, and below the Motorway Bridge. Different suspended sediment (SS) and faecal coliforms (FC) guidelines apply to each of the three zones defined by the RRMP.

However, the RRMP zones do not correspond to observable changes in the river morphology or in the catchment's topography or land use. Further, as described above, the catchment above Fernhill is quite diverse, with obvious differences between the forested, mountainous upper catchment above Whanawhana and the deforested, hill country farming middle catchment. For the purpose of this report, three sections have been defined in the Ngaruroro catchment, to reflect the changing nature of the River along its course:

- Upper catchment: form the source to Whanawhana;
- Middle catchment: between Whanawhana and Ohiti,
- Lower catchment, below Ohiti.

Although they may not be directly applicable to a regulatory context, environmental guidelines are commonly used in describing the general state of a natural resource. In particular, this report makes extensive use of indicators based on the percentage of samples which comply with environmental guidelines or standards. The 2000 ANZECC Guidelines, the 2002 MfE guidelines for microbiological water quality and the NZ periphyton guidelines (Biggs, 2000) are three documents to consider in relation to surface water quality.

The paragraphs below briefly discuss water quality guidelines and standards for the main physical, chemical, microbiological and biological parameters commonly used in assessing the "health" of a river system, and their appropriateness for the Ngaruroro river system. Table 6 summarises the reference values used in this report for different parts of the Ngaruroro catchment.

3.2.1. Water temperature

The RRMP defines a maximum water temperature of 25^{o}C. However, scientific evidence suggests that this limit may not be adequate to fully protect the Ngaruroro catchment's aquatic communities and trout fishery values.

Water temperatures above 19^{o}C are likely to cause behavioural disturbances of trout, such as cessation of feeding (Hay *et al*. 2007) and may exclude stoneflies (Quinn and Hickey, 1990).

The incipient lethal temperature of brown trout increases with acclimation to a plateau at 24.7^{o}C (Hay *et al*. 2007). A number of field and laboratory studies indicate that a maximum daily temperature of 21 to 23^{o}C will adequately protect most common macroinvertebrate and native fish species (Ausseil and Clark, 2007). Recent research also indicates that stoneflies may be present at occasional temperatures of 22-23^{o}C if other water quality and habitat parameters are suitable for these sensitive species (Dr. John Quinn, pers. comm.).

A maximum water temperature of 19^{o}C is recommended for the upper catchment to avoid behavioural disturbances of trout and exclusion of sensitive invertebrate taxa such as stoneflies observed at higher temperatures. A maximum water temperature of 23^{o}C is recommended for the middle and lower Ngaruroro catchment to protect most macroinvertebrate species and avoid the potential lethal effects of high temperature on trout.

In this report, compliance with these limits is assessed against the 95th percentile of the data collected at the monitoring sites. It is noted however, that, due to the natural diurnal fluctuation of water temperature,

"spot" monitoring data may not adequately capture daily maximum temperature, and continuous monitoring is preferable.

3.2.2. Water pH

Background information on the effects of pH on New Zealand native aquatic biota is scant. One study indicates that a number of native fish species show a definite avoidance of pH values below 6.5, and that pH range of 7 to 9.5 should not be toxic to most NZ fish species (West *et al.*, 1997).

Raleigh *et al.* (1986) suggest the tolerable range of water pH for brown trout is 5 to 9.5, with an optimal range of 6.7 to 7.8. Both the tolerable and optimal pH ranges for trout have been used as benchmark values in this report, for all three parts of the catchment.

3.2.1. Dissolved oxygen (DO)

The RRMP sets a minimum dissolved oxygen concentration of 80% saturation, applying at all river flows. This is consistent with the RMA S69 standard for waters being managed for fishery purposes. This guideline is used in this report.

It should be noted however that instantaneous measurements taken as part of the SOE monitoring programme may have limited value in terms of assessing compliance with the guideline. DO concentration varies diurnally, with maximum values generally late afternoon and minimum values at dawn. Thus, only measurements taken early in the morning, or continuous monitoring, can provide some useful measure of the daily minimum DO concentration actually occurring in the river.

3.2.2. Organic load

A common cause of deleterious DO depletion is the instream degradation of organic matter by heterotrophic bacteria. Biochemical oxygen demand (BOD) and total organic carbon (TOC) are commonly used indicators of the organic load carried by the water.

TOC is routinely measured as part of HBRC's state of the environment monitoring programme. This indicator was selected by HBRC to provide better information in waterways with relatively low organic enrichment [2].

There is no general formula to directly link BOD or TOC with instream DO concentrations. Only site-specific modelling can assist in understanding how the dissolved oxygen concentration reacts to instream organic loads. For this reason, it is difficult to define acceptable TOC concentration thresholds, and this indicator was only used as an indicator of spatial and temporal trends in this report.

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[2] BOD concentrations in New Zealand natural waterways with no point source discharges are often below laboratory quantification limit (often 1 g/m^3).

Photo 3: Ngaruroro River downstream of Hawke's Bay Dairies.

Photo 4: Ngaruroro River at Ohiti.

3.2.3. Water clarity and suspended solids

The RRMP defines a maximum suspended solids (SS) concentration of 10 mg/l upstream of the Motorway Bridge, and 25 mg/l downstream. The guideline applies at all river flows. High suspended solids concentrations are expected naturally during floods. For this reason, it is generally recommended to exclude flood flows from a "state of the resource" assessment. Accordingly compliance with the SS standard was assessed at river flows at or below three times the median flow in this report.

The RRMP defines a minimum water clarity of 1.6 m for contact recreation waters. This standard is used in this report, at flows at or below three times the median flow.

However, a water clarity of 1.6m may not be sufficient to maintain the foraging efficiency of drift feeding trout, and Hay *et al.* (2007) recommend minimum water clarity of 5m for regionally significant trout fisheries and 3.5m for trout fisheries of lesser importance. These limits should apply only under base flow conditions (under median flow). The same report notes that there may be situations where these guidelines may be unattainable due to natural causes, and they should be taken with some caution.

In this report, the 5m guideline was used in relation to the upper Ngaruroro catchment and the 3.5m guideline in relation to the middle and lower catchments.

3.2.4. Ammonia

Ammonia can be toxic to many aquatic species, and is a common pollutant in treated domestic, agricultural and industrial wastewater discharges. In aqueous solution, ammonia exists in two chemical forms: the ammonium cation (NH_4^+) and un-ionised ammonia (NH_3). The respective proportion of these forms is determined by a chemical equilibrium governed by pH and temperature. The higher the pH and temperature, the higher the proportion of unionised ammonia. Unionised ammonia being by far the most toxic form to aquatic life, the toxicity of ammonia increases with pH and temperature.

The 2000 ANZECC guidelines define a maximum unionised concentration of 0.035 mg/L (35 ppb) for the 95% protection level. The guidelines also provide tables and formulas to calculate the concentration of total ammonia corresponding to this threshold under different temperature and pH conditions.

The approach taken in this report was to use the 95th percentile of the pH and temperature data distribution observed at different monitoring sites to calculate the total ammonia concentration corresponding to the ANZECC 95% protection level (35 ppb unionised ammonia). The results are summarised in Table 6. The lowest value obtained was retained as the recommended overall guideline for the catchment. Both this guideline and the RRMP guideline (0.1 mg/l) are used in this report.

Table 6: Maximum total ammonia-nitrogen (NH_4-N) concentration recommended by the 2000 ANZECC guidelines for the protection of 95% of aquatic species. Calculations based on ANZECC Guidelines table 8.3.6, 95% protection level (0.035 mg/l un-ionised ammonia),. and 95th percentile of water temperature and pH data recorded at monitoring sites in the Ngaruroro catchment.

Site	Temperature (°C) 95th %ile	pH 95th %ile	ANZECC NH_4-N guideline (mg/l) for each site	Recommended catchment guideline (mg NH_4-N/l)
Ngaruroro at Kuripapango	17.9	8.1	0.850	0.20
Ngaruroro at Whanawhana	18.9	8.2	0.636	
Ngaruroro at Ohiti	21.0	8.4	0.358	
Waitio Stream at Ohiti Rd	17.4	ND	ND	
Ngaruroro at Fernhill	21.5	8.4	0.348	
Ngaruroro at Carrick Rd	20.2	ND		
Ngaruroro at Motorway Bridge	21.2	ND		
Ngaruroro at Chesterhope	23.7	8.8	<0.24	
Tutaekuri-Waimate at Chesterhope	17.6	ND		

3.2.5. Bacteriological water quality

Two indicators of the microbiological water quality have been routinely monitored in the Ngaruroro catchment, faecal coliforms (FC) and *Escherichia coli* (*E. coli*). Both are used as indicators of the presence of pathogens of faecal origin in the water, in turn linked with the level of health risk to water users.

The RRMP defines guideline values of 50 faecal coliforms/100mL in the Ngaruroro catchment down to Fernhill, 100 FC/100ml between Fernhill and motorway Bridge, and 150 FC/100ml downstream of the Motorway Bridge. This guideline applies at river flows at or below median flow.

The 2002 microbiological water quality guidelines (MfE, 2002) define a three-mode management system for recreational freshwaters: Acceptable/green (*E. coli* < 260/100mL); Alert/Amber (*E. coli* < 550/100mL) and Red/Action (*E. coli* >*550*/100mL). The red mode indicates an unacceptable level of health risks to contact recreation users (*e.g.* swimmers). These are single-value criteria, designed to trigger further investigation and additional sampling (amber mode) and positive action to identify the source(s) of contamination and warn recreational users (red mode).

The 550 *E. coli*/100mL has been used in this report to assess suitability for swimming at all river flows. As *E. coli* are a subset of total faecal coliforms, the RRMP guideline is more stringent than the MfE guideline.

3.2.6. Periphyton biomass, DRP and SIN

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 water body values, including life-supporting capacity, recreational and aesthetic values and trout fishery.

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 flow 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 concentration in the water.

As part of HBRC's monitoring programme, periphyton biomass is monitored only once in any given year, after a stable flow (i.e. 2 to 3 weeks without any major hydrological disturbance). As such, a once-per-year sample is not intended to capture the full range of periphyton biomass occurring in a year. Rather, the timing of the monitoring (after a period of stable flow), makes it suitable to provide an indication of the peak biomass likely to be reached during this accrual period. 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 with low nutrient concentrations (Biggs, 2000).

The New Zealand periphyton guidelines (Biggs, 2000) recommend a maximum periphyton biomass of 120 mg *chlorophyll a*/m^2 for the protection of trout habitat and 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.), and was used in this report.

Periphyton growth is generally controlled by a number of physical (e.g. river flow, sunlight, temperature) chemical (e.g. bioavailable nutrient concentration – DRP and SIN) and biological (e.g. grazing by invertebrates) phenomena. 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 concentrations guidelines or standards is generally used as a way of maintaining periphyton growth below unacceptable levels.

The RRMP defines a maximum DRP concentration of 0.015 mg/l when flow in the river is at or below median flow. This guideline was used in this report. The RRMP does not set maximum concentrations for the other macronutrient, nitrogen. As default values, the ANZECC guidelines for dissolved nitrogen oxides (NO_x – nitrate + nitrite) are recommended for soluble inorganic nitrogen (SIN): 0.167 mg/l in the upper catchment and 0.444 mg/l in the middle and lower catchment, applying when the flow in the river is at or below median flow.

3.2.7. Macroinvertebrate communities

Macroinvertebrate communities are commonly used as an indicator of water quality and ecosystem health. A macroinvertebrate community index (MCI) guideline of 120[3] is recommended for the upper catchment, and 100 for the middle and lower catchment. These recommendations are consistent with the advice provided in (Hay *et al.* 2007) to protect trout fisheries.

Table 7: Summary of recommended guidelines for the Ngaruroro catchment for physical, chemical and biological parameters.

Parameter	River flow	Upper catchment (Above Whanawhana)	Middle Catchment (Whanawhana to Ohiti)	Lower catchment (below Ohiti)
Temperature (°C)	All	19	24	24
pH (tolerance range)	All	5.0 – 9.5	5.0 – 9.5	5.0 – 9.5
pH (optimum range)	All	6.7 – 7.8	6.7 – 7.8	6.7 – 7.8
DO (% saturation)	All	80	80	80
Clarity - contact recreation (m)	< 3* median	1.6	1.6	1.6
Clarity (m) (trout)	< 3* median	5	3.5	3.5
Suspended Solids (SS) (mg/l)	< 3* median	10	10	25
Ammonia-N (mg/l)	All	0.2	0.2	0.2
Periphyton biomass (mg *Chlo a*/m^2)	All	120	120	120
SIN (mg/l)	< Median	0.167	0.167	0.444
DRP (mg/l)	< Median	0.015	0.015	0.015
E. coli (/100mL)	All	550	550	550
Faecal coliforms (/100mL)	< Median	50	50	150
MCI	All	120	100	100

[3] Scores above 120 are indicative of clean water; scores of 100 to 119 are indicative of possible mild pollution, scores between 80 and 100 are indicative of probable moderate degradation, and scores less than 80 are indicative of severe pollution.

3.3. Water Quality of the Ngaruroro River

HBRC currently monitors water quality at 9 sites in the Ngaruroro catchment. Three of these sites have been monitored for 15 years or longer, and the other six have only been monitored since 2000. The two sites monitored by NIWA have been monitored since 1989 – although only data post-1994 has been used in this report (refer to Table 3 for details of the data records). In this section, the tables summarise data obtained at the five long term monitoring sites on the Ngaruroro River mainstem:

- the three HBRC sites (Whanawhana, Ohiti and Fernhill) and
- the two NIWA site: Kuripapango at the top of the catchment, and Chesterhope at the bottom.

The figures (graphs) display all the information available at all sites, meaning that the information relates to a 15-year record period for the 5 main sites, and an 8-year record period for all other sites.

The tables should be seen as the main "state of the environment" information, as it is based on robust, relatively long-term records. The figures provide additional information on sections of the Ngaruroro River and two of its tributaries, the Waitio Stream and the Tutaekuri-Waimate Stream.

3.3.1. Biological monitoring

Macroinvertebrate community index (MCI) results are reasonably consistent along the mainstem of the Ngaruroro and in the Waitio Stream. The guideline score of 100 is generally met most of the time at all sites, except at Chesterhope, where it is met only 58% of the time. These results would tend to indicate "probable moderate pollution" at this site. It is interesting to note that the more stringent 120 guideline, indicative of clean water is only met one third of the time at the top of the catchment at Kuripapango and two thirds of the time at Whanawhana (Table 8 and Figure 1).

Periphyton biomass data indicates that the 120 mg/m^2 guideline has been exceeded at least once at the most upstream sites (Whanawhana and upstream of HB Dairies), and twice at all other sites (downstream of HB Dairies, Ohiti, Fernhill). Although the small number of available valid results (between 4 and 6 at each sites) does not allow to draw firm conclusions, the data seems to indicate an increased occurrence of nuisance periphyton growth in the middle and lower catchment compared to the upper catchment (Table 9 and Figure 2). Monitoring undertaken by NIWA at Kuripapango and Chesterhope does not include periphyton biomass, but a visual estimate of algal cover of the visible river bed is provided. Data indicates that nuisance periphyton cover[4] has never been recorded at Kuripapango, but has been recorded 8 times in 20 years of records at Chesterhope.

[4] NZ periphyton guidelines for the protection of recreational/aesthetic values: more than 30% cover by green filamentous algae >2cm long and/or more than 60% cover by diatom mats >0.3cm thick (Biggs, 2000)

Photo 5: Ngaruroro River at Fernhill.

Table 8: Summary of Macroinvertebrate Community Index (MCI) results at five monitoring sites on the Ngaruroro River. Sites are presented in the upstream to downstream order.

Monitoring Site	Average	Minimum	Maximum	N. of Samples	% Compliance with standard	Standard/ Guideline
Ngaruroro at Kuripapango	116	104	130	11	27% (3/11)	120
Ngaruroro at Whanawhana	128	112	147	14	64 % (9/14)	
Ngaruroro at Ohiti	112	100	122	10	100 % (10/10)	100
Ngaruroro at Fernhill	116	99	138	14	93% (13/14)	
Ngaruroro at Chesterhope	101	91	124	12	58 (7/12)	

Table 9: Summary of periphyton biomass (mg Chlorophyll a /m2) results at five monitoring sites on the Ngaruroro River. Sites are presented in the upstream to downstream order. N.D. No data.

Monitoring Site	Average	Minimum	Maximum	N. of Samples	% Compliance with standard	Standard/ Guideline
Ngaruroro at Kuripapango	N.D.	N.D.	N.D.	0	-	120
Ngaruroro at Whanawhana	99	2	361	6	83% (5/6)	
Ngaruroro at Ohiti	103	31	220	6	67% (4/6)	
Ngaruroro at Fernhill	95	39	140	6	67% (4/6)	
Ngaruroro at Chesterhope	N.D.	N.D.	N.D.	0	-	

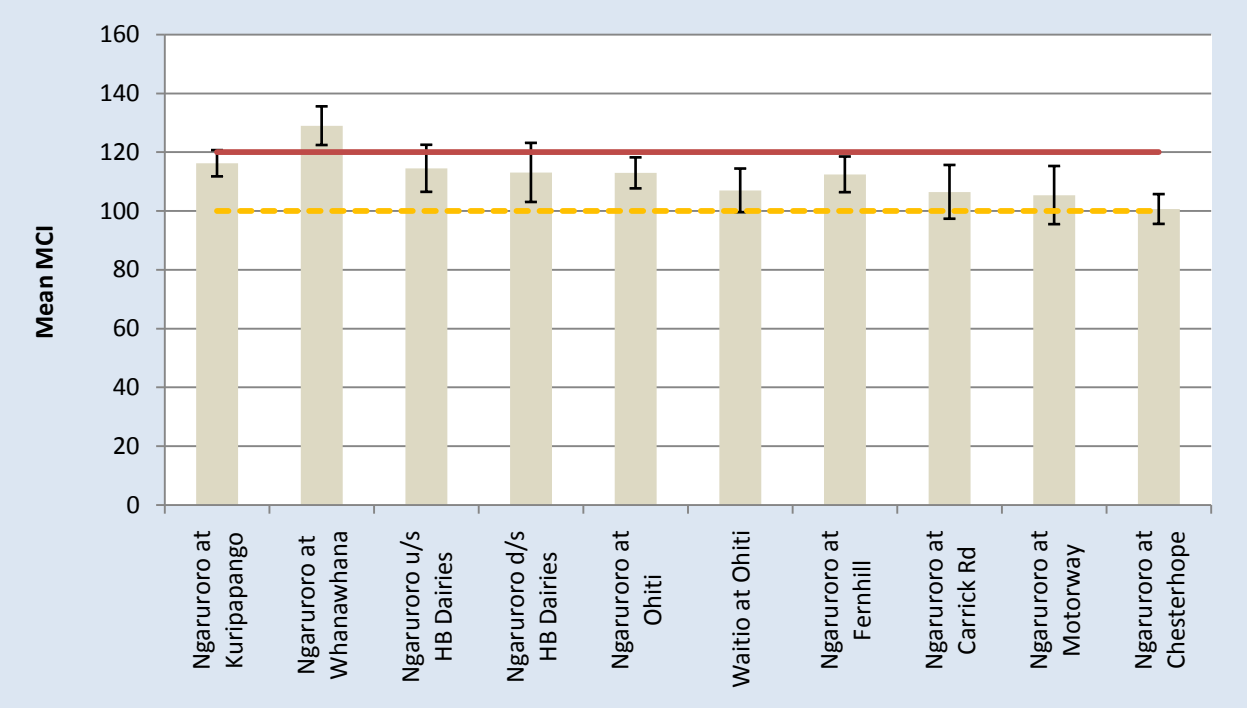

Figure 1: Mean macroinvertebrate community index (MCI) ± 95% confidence interval. The solid red line represents the recommended guideline for the upper catchment; the dotted orange line represents the guideline for the middle and lower catchment.

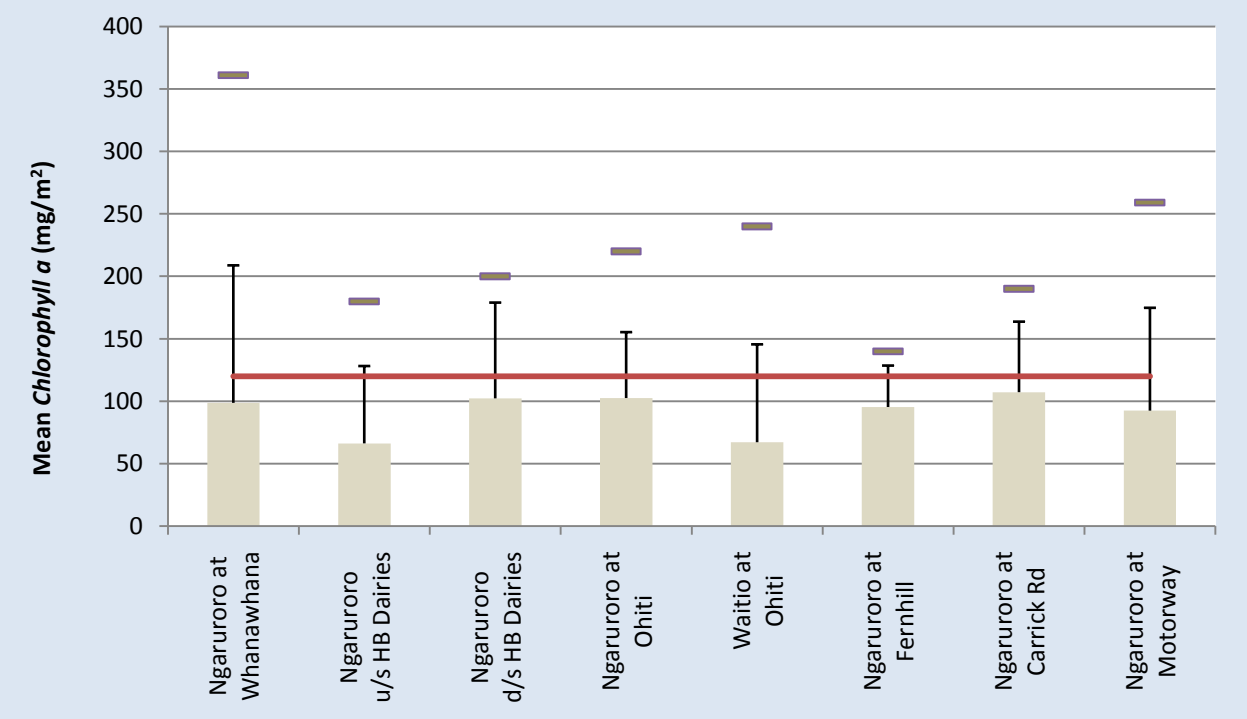

Figure 2: Maximum (rectangles) and mean (columns) periphyton biomass (mg chlorophyll a/m^2) ± 95% confidence interval (vertical bars). The solid red line represents the recommended periphyton biomass guideline for the protection of recreational and trout fishery values.

3.3.2. Nutrients

The results in Table 10 show that both DRP and SIN concentrations in the Ngaruroro River nearly always comply with the recommended guidelines. Although the DRP concentrations clearly follow an increasing pattern going downstream, they remain well below the RRMP guideline of 0.015 mg/l.

In the upper catchment, there is a marked increase in SIN concentration between Kuripapango and Whanawhana. Although nitrogen leaching from commercial forestry is generally expected to be slightly higher than from native forest[5], the exact causes of the increase are unknown. The SIN concentrations gradually increase in the middle Ngaruroro River, between Whanawhana and Ohiti.

Downstream of Ohiti, the overall SIN concentrations (i.e. calculated at all river flows) tend to remain stable in the lower catchment. However, when considering the base river flows, there is a strong pattern of decreasing SIN concentrations when going downstream. This pattern is visible at river flows below median, but becomes particularly obvious below lower quartile flow (Figure 4).

Although the nutrient concentrations at all sites are generally below guideline levels, the periphyton biomass exceeded the guideline once at Whanawhana and twice at Ohiti and Fernhill. This could be caused by the very extended periods of low that occur in some summer seasons. The decrease in SIN concentrations observed in the lower catchment at low river flows may be due to increased consumption by the algal biomass, although this hypothesis will need to be confirmed.

The two monitored tributaries (Waitio and Tutaekuri-Waimate Streams) have by far the highest DRP concentrations in the catchment (Figure 3) These are the only two sites to regularly breach the RRMP guideline for DRP (respectively 45% and 64% of the time in the Waitio and Tutaekuri-Waimate). These two streams also have the highest SIN concentrations, although they generally remain well below the ANZECC guideline for lowland streams (Figure 4).

Table 10: Summary of dissolved Reactive phosphorus (DRP) and soluble inorganic nitrogen (SIN) at five monitoring sites on the Ngaruroro River. Sites are presented in the upstream to downstream order.

Parameter	Monitoring Site	Average	Median	90th percentile	95th percentile	N. of Samples	% Compliance with standard	Standard/ Guideline
DRP (g/m^3) Under median flow	Kuripapango	0.002	0.001	0.003	0.003	97	100	0.015
	Whanawhana	0.002	0.002	0.005	0.007	50	100	
	Ohiti-	0.003	0.002	0.008	0.009	45	100	
	Fernhill	0.004	0.004	0.010	0.012	45	100	
	Chesterhope	0.006	0.005	0.009	0.011	81	100	
SIN (g/m^3) Under median flow	Kuripapango	0.006	0.005	0.011	0.013	95	100	0.167
	Whanawhana	0.053	0.041	0.099	0.118	50	96	
	Ohiti-	0.089	0.084	0.150	0.159	45	96	
	Fernhill	0.081	0.074	0.158	0.164	46	100	0.444
	Chesterhope	0.038	0.015	0.117	0.131	79	100	

[5] N-leaching from pine forests is generally reported as 1-2 kg N/ha/year, vs. 1 kg/ha/year for native forest in New Zealand (Li *et al.* 2005)

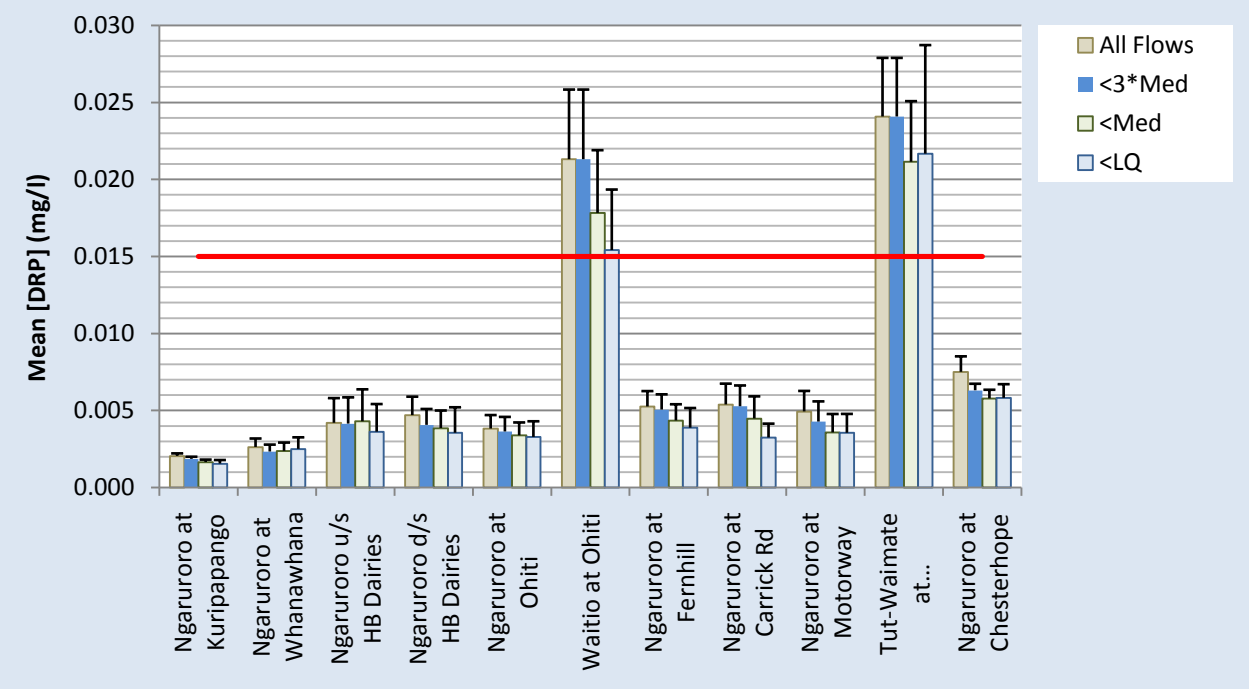

Figure 3: Mean DRP concentrations (mg/L) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ). The red line indicates the RRMP guideline (0.015 mg/L).

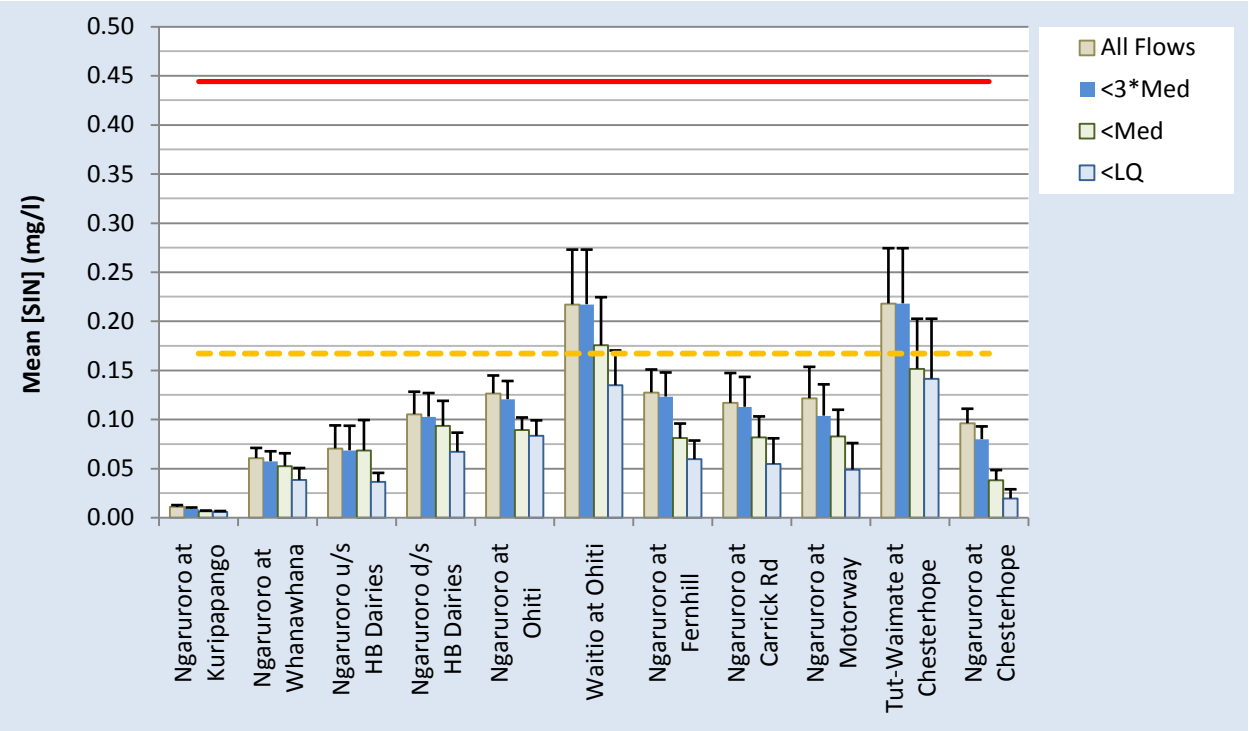

Figure 4: Mean SIN concentrations (mg/l) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ). The dotted orange line is the recommended guideline for the upper catchment (0.167 mg/L) and the plain red line indicates the recommended guideline for the middle and lower catchment (0.444mg/l).

3.3.1. Nutrient limitation

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 SIN/DRP ratio can be a useful indicator of which of SIN or DRP is the likely limiting nutrient for periphyton growth. Generally, elevated SIN/DRP ratios (above 20) are indicative of P-limited conditions, and low ratios (below 4) indicate 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 them) are sufficiently low to limit periphyton growth. When both nutrients are in ample supply, nutrient concentration is unlikely to limit algal growth. For this study, this meant using the SIN:DRP ratios only outside flood flows (i.e. below three times median) and when the DRP concentration was below the RRMP standard (0.015 mg/l) or the SIN concentration was below 0.167 mg/l.

It should be stressed that, although a useful indicator, SIN:DRP ratios do not provide a definite answer, and bioassays, such as nutrient diffusing substrates, are generally viewed as a more reliable method to determine nutrient limitation (Wilcock *et al.* 2007).

Plots of SIN/DRP ratios (Figure 5) indicate that the Ngaruroro at Kuripapango and the Tutaekuri-Waimate Stream appear to generally be N-limited, particularly during periods of low river flows.

At the other sites, a majority of the points fall between the two dashed lines, indicating large periods of co-limitation or non-limitation. Both P- and N-limited conditions do appear to occur at most sites in the Ngaruroro catchment, although at different times. At a number of sites, P-limited conditions seem to dominate during periods of relatively high river flow. However, a switch to co-limited conditions, or N-limited conditions seems to regularly occur during low flow conditions (below lower quartile flow) at a number of sites. This pattern is particularly apparent at Whanawhana, Ohiti, Fernhill and Chesterhope.

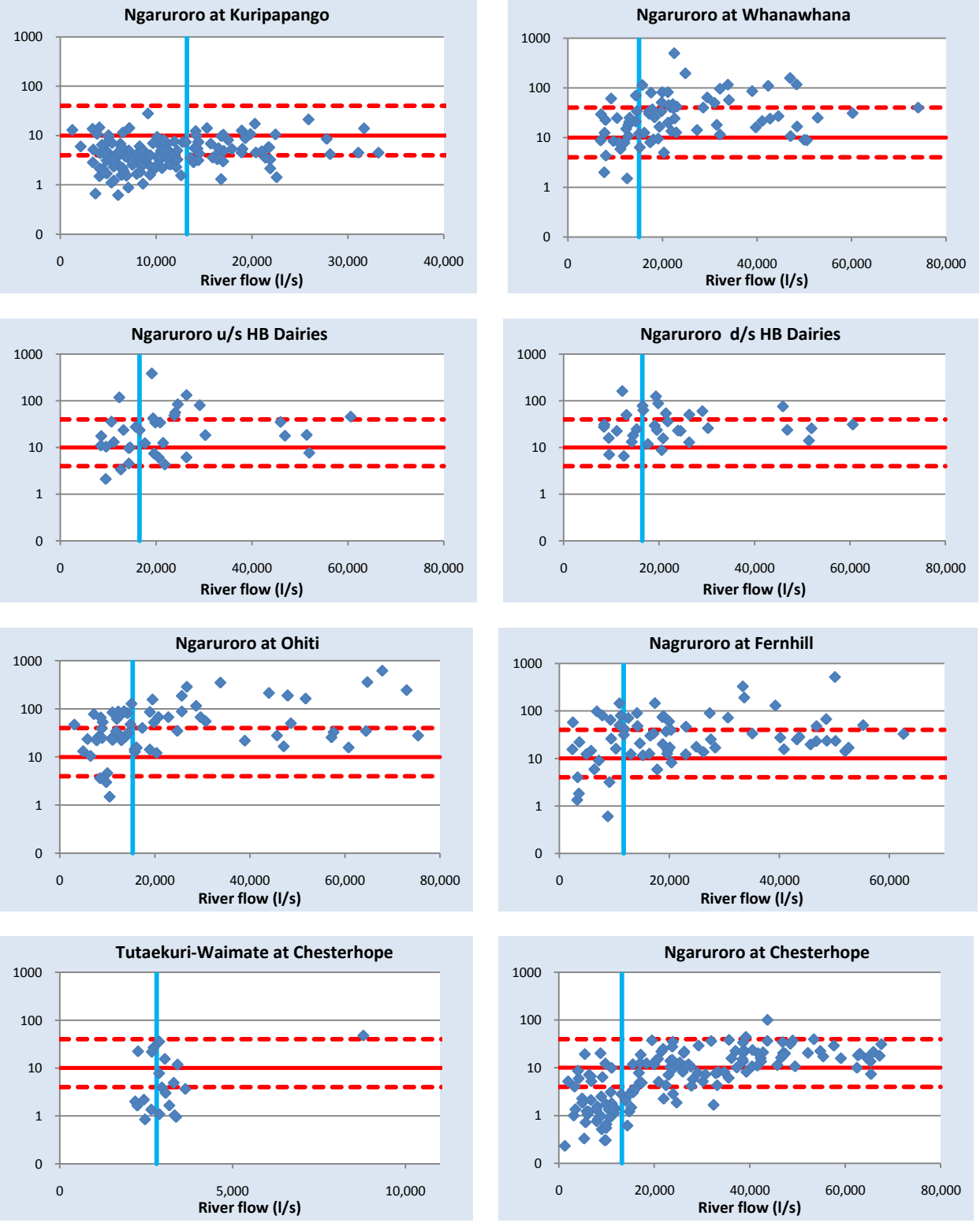

Figure 5: SIN:DRP ratio at monitoring sites in the Ngaruroro catchment. Data for river flows below 3* median flow and when either or both SIN and DRP concentrations are below guideline level (0.015 mg/l for DRP and 0.167 mg/l for SIN. The vertical blue line indicates the lower quartile flow. Points above the top dashed horizontal red line are indicative of P-limited conditions. Points below the bottom red dashed line are indicative of N-limited conditions.

3.3.2. Microbiological water quality

E. coli concentrations recorded at the 5 main monitoring sites along the Ngaruroro River have nearly always been below the MfE guideline (at least 98% compliance), indicating water of a swimmable standard nearly all the time, including periods of higher river flows.

The more stringent RRMP guideline, relating to Faecal coliforms, is also generally complied with below median flow at Whanawhana. However, it is only complied with slightly more than half of the time at Ohiti and Fernhill (Table 11).

Figure 6 presents a summary of the dataset obtained by correlating and merging the *E. coli* and faecal coliforms results, as explained in section 2.2 of this report. It indicates that, although there is an increase downstream of Whanawhana, the water quality is generally suitable for contact recreation along the whole Ngaruroro River and the two tributaries regularly monitored, the Waitio and Tutaekuri-Waimate Streams.

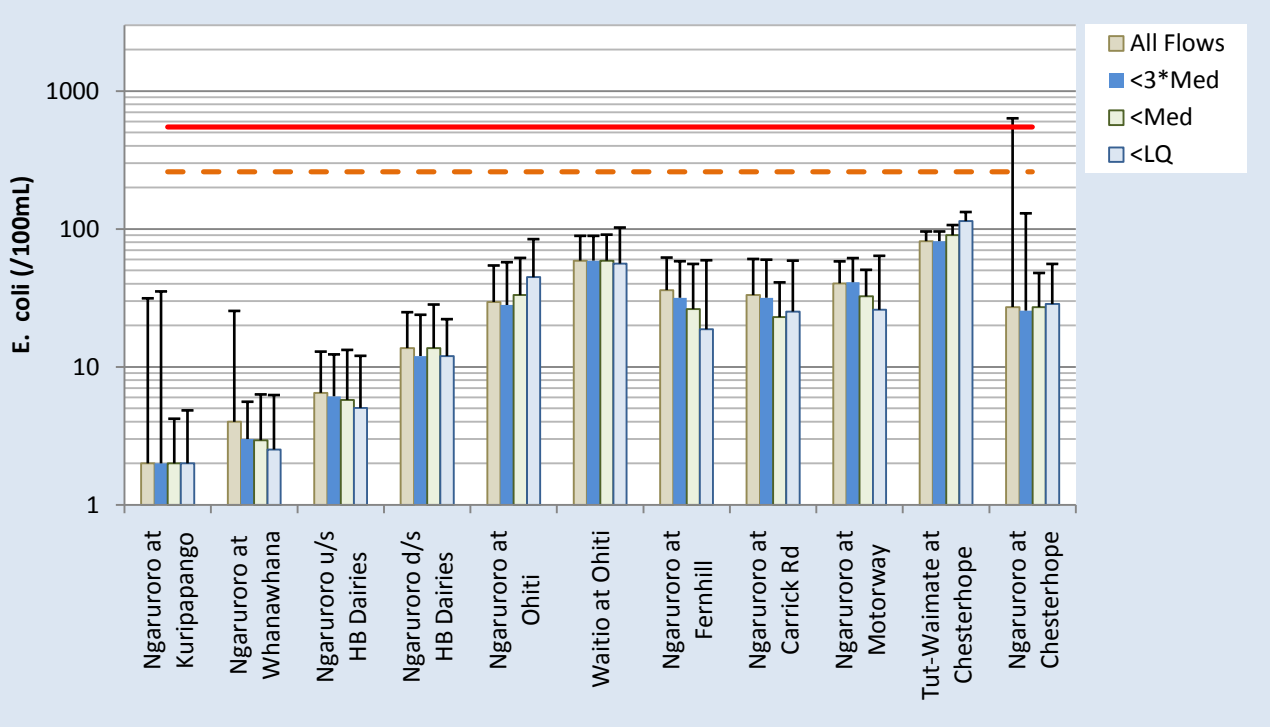

Figure 6: Median *E. coli* concentrations (/100mL) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ). The dotted orange line represents the recommended guideline for the threshold between Green and Amber modes (260 *E. coli*/100 mL); the solid red line represents the threshold between Amber and Red modes (260 *E. coli*/100 mL) as defined in the MfE microbiological water quality guidelines (2002).

Table 11: Summary of water quality state at five monitoring sites on the Ngaruroro River. pH: two guideline ranges have been used, corresponding to (a) tolerable and (b) optimal range for trout. Water clarity: two guideline ranges have been used 3.5m (c) and 5m (d) corresponding to different levels of protection of the trout fishery values. ID: Insufficient data.

Parameter	Monitoring Site	Average	Median	10th / 90th percentile	5th / 95th percentile	N. of Samples	% Compliance with standard		Standard/ Guideline
pH	Kuripapango	7.8	7.8	7.6 – 8.0	7.5 – 8.1	168	100(a)	51(b)	5.0 to 9.5 (a) 6.7 to 7.8 (b)
	Whanawhana	7.8	7.8	7.4 – 8.1	7.2 – 8.2	35	100(a)	57 (b)	
	Ohiti-	7.8	7.8	7.4 – 8.2	7.2 – 8.4	35	100(a)	54 (b)	
	Fernhill	7.9	7.8	7.5 – 8.3	7.4 – 8.4	36	100(a)	56 (b)	
	Chesterhope	8.2	8.1	7.8 – 8.7	7.8 – 8.8	167	100(a)	7 (b)	
Ammonia-N (g/m3)	Kuripapango	0.003	0.002	0.005	0.006	166	100		0.2
	Whanawhana	0.016	0.010	0.030	0.039	81	100		
	Ohiti-	0.015	0.010	0.031	0.044	80	100		
	Fernhill	0.016	0.010	0.031	0.034	78	100		
	Chesterhope	0.004	0.003	0.007	0.010	163	100		
Water clarity (m) <3* Median flow	Kuripapango	5.7	5.4	2.7	2.1	151	97		1.6
	Whanawhana	3.0	2.8	0.4	0.3	49	65		
	Ohiti-	2.3	1.8	0.6	0.3	41	54		
	Fernhill	1.8	1.5	0.2	0.1	48	44		
	Chesterhope	1.6	1.2	0.3	0.2	153	37		
Water clarity (m) < Median flow	Kuripapango	6.7	6.5	4.2	3.8	98	97(c)	79	3.5(C) 5(d)
	Whanawhana	4.0	3.6	1.7	1.4	35	54(c)	31(d)	
	Ohiti-	2.7	2.1	1.2	0.9	33	27(c)	15(d)	
	Fernhill	2.4	2.0	0.8	0.7	33	18(c)	9(d)	
	Chesterhope	2.4	2.3	1.1	1.0	81	14(c)	4(d)	
Suspended Solids (mg/l) <3* Median flow	Kuripapango	N.D.	N.D.	N.D.	N.D.	0	-		10
	Whanawhana	5.3	2.0	12.1	14.4	74	89		
	Ohiti-	14	3.2	25	51	68	78		
	Fernhill	16	4.0	50	70	72	69		
	Chesterhope	N.D.	N.D.	N.D.	N.D.	0	-		25
E. coli (/100mL) All flows	Kuripapango	22	2	20	41	43	98		550
	Whanawhana	3	1	10	12	17	100		
	Ohiti-	41	8	50	165	17	100		
	Fernhill	53	12	107	260	17	100		
	Chesterhope	464	27	218	1834	43	93		
Faecal coliforms (/100mL) Under median flow (RRMP Guideline)	Kuripapango	N.D.	N.D.	N.D.	N.D.	0	-		50
	Whanawhana	13	9	35	43	31	100		
	Ohiti-	82	49	150	200	31	52		
	Fernhill	89	43	262	348	29	55		
	Chesterhope	N.D.	N.D.	N.D.	N.D.	0	-		150

3.3.3. Water clarity and suspended solids

Water clarity at Kuripapango is generally excellent, as expected in the upper catchment dominated by hard sedimentary geology and natural landcover with minimal physical disturbance. It complies with all recommended guidelines most of the time, including the very stringent 5m clarity at flows below median flow (Table 11 and Figure 7).

There is a strong pattern of water clarity degradation when going downstream along the Ngaruroro River. At Whanawhana, the river only complies with the recreational guideline (1.6m) 65 % of the time, against 97 % of the time at Kuripapango. During base flow conditions (below median flow), the water clarity is also generally significantly less than at Kuripapango, and complies with the recommended guideline for regionally significant trout fisheries (5m) only about one third of the time (against 79% of the time at Kuripapango). The considerable drop in water clarity observed between Kuripapango and Whanawhana could be due to the increased erosion rates in deforested land (about 25% of the catchment above Whanawhana) and in commercial forestry (3% of the catchment), compared with the predominant undisturbed native vegetation upstream of Kuripapango.

The pattern of water clarity degradation persists along the river, both in terms of median values, and in terms of compliance with the guidelines. At Ohiti, the River still meets the recreational water guideline (1.6m) more than half of the time, but only 37% of the time at Chesterhope.

Suspended solids records indicate a generally good level of compliance with RRPM guideline, although the same spatial trend as with water clarity is observed (i.e. a degradation from upstream to downstream).

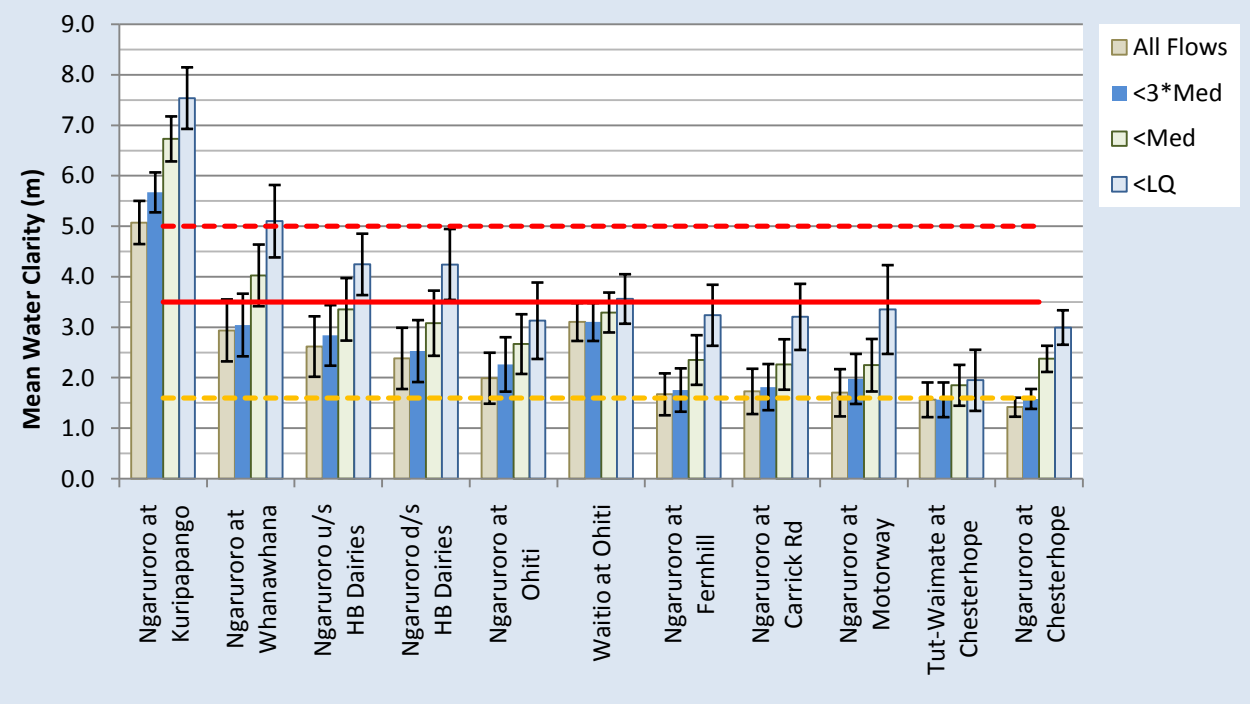

Figure 7: Mean water clarity (m) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ).The dotted yellow line represents the minimum clarity guideline for recreational waters (1.6m). The red lines represent the recommended water clarity guidelines for the protection of the trout fishery value: 3.5m (solid red line) and 5 m (dotted red line).

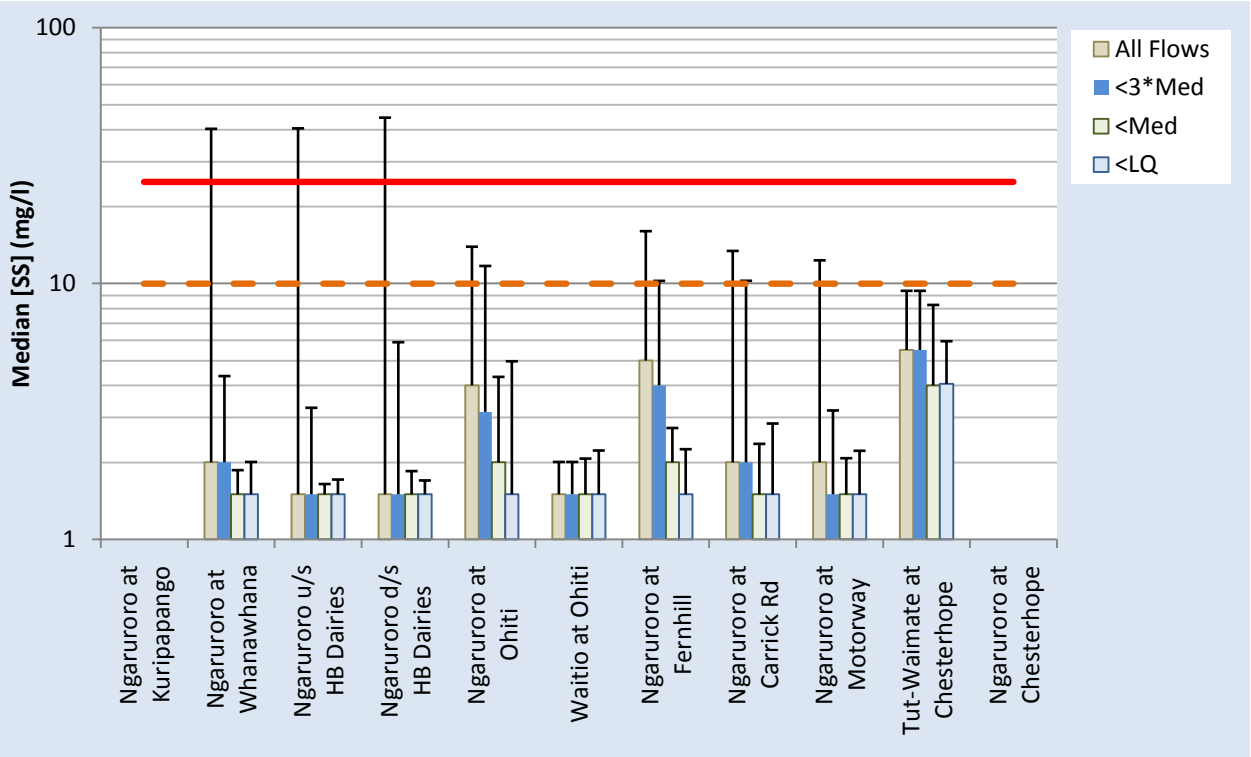

Figure 8: Median Suspended solids (mg/l) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ).The dotted yellow line represents the RRMP guideline for the upper and middle catchment, down to Fernhill. The solid red line represents the RRMP guideline for the catchment downstream of Fernhill.

3.3.1. pH and ammonia

Records indicate that water pH is always within the tolerance range of both native fish species and trout (6.5 to 9.5) at all five main Ngaruroro River sites. However, moderately high pH (above 8.5) is recorded on a regular basis at Chesterhope and, to a lesser extent at Ohiti and Fernhill. As such, the pH values observed in the lower Ngaruroro River should not be a significant stressor to aquatic life. However, high pH values increase ammonia toxicity and are an indicator of likely active plant (algae or macrophytes) growth[6].

Ammonia concentrations are well below guideline level at all sites. These concentrations are not expected to cause any chronic or acute toxic effects on the aquatic biota. Water temperature in the Ngaruroro River and the two monitored tributaries is generally below guideline levels at all monitoring sites (results presented in Appendix A).

[6] During the day, algal production uses CO_2 faster than it can be replaced from the atmosphere, causing the dominant CO_2/HCO_3^- equilibrium to be displaced so that the pH is increased ($HCO_3^- + H^+ \leftrightarrow CO_2 + H_2O$).

3.3.2. Total Organic Carbon (TOC) and Dissolved oxygen

TOC provides an indication of the amount of organic matter in the water column. Whilst relatively low levels are a normal, natural part of the ecosystem, elevated levels are a likely indicator of organic enrichment, either as a result of direct input of organic input (e.g. from a discharge) or as a result of accelerated primary production (e.g. algal growth).

Results presented in Figure 9 indicate a general increase in TOC between the upper (less than 1mg/l at Whanawhana) and the lower river (median concentration of approximately 2 mg/l). Of interesting note is the increase between upstream and downstream of Hawke's Bay Dairies, followed to a return to close to upstream concentrations at Ohiti. The effects of HB dairies on the river's water quality are explored in further detail in section 4 of this report. TOC concentrations in the Tutaekuri-Waimate Stream and the Waitio Stream are similar to those observed in the Ngaruroro main stem.

Compliance with the 80% DO saturation guideline (assessed at river flows below 3* median) is generally good across the catchment (above 90% compliance), except in the two tributaries (results presented in Appendix B).

The Waitio Stream has not complied with the DO guideline on 21 % of monitoring occasions. The lowest DO concentration recorded in the Waitio Stream was 6.9 mg/l. Whilst this concentration is unlikely to cause more than slight effects on adult trout, it is considered unsuitable for trout spawning (Table 12 and Table 13). Most records of DO below 8 mg/l in the Waitio Stream occurred in May, June and August, i.e. during the trout spawning season.

The Tutaekuri-Waimate has not complied with the guideline 61% of the time, and the lowest recorded DO concentration was 5.4 mg/l. DO concentrations between 5 and 6 mg/l are likely to cause a moderate level of impairment to adult trout (Table 12) and are very unsuitable for trout spawning (Table 13).

Importantly, the DO measurements are taken at the time of water quality sampling, i.e. during hours of broad daylight. As explained in section 3.2.1, DO follows diurnal cycle, with minimum DO concentrations generally occurring during late night/early morning. In other words, routine monitoring is unlikely to have captured the minimum DO concentrations occurring in each stream, and DO concentrations well below the daylight concentrations are likely to occur at night. Interestingly, TOC concentrations in the Tutaekuri-Waimate Stream are generally reasonably low, in any case not significantly higher than in the Ngaruroro River. Low Oxygen concentrations are therefore unlikely to be caused by heterotrophic degradation of suspended organic matter. Rather, oxygen depletion is more likely caused by respiration and degradation of the heavy macrophyte and periphyton growths present on its banks and bed (Photo 7).

Table 12: Minimum dissolved Oxygen concentrations (mg/l) recommended by the U.S. Environmental Protection Agency to confer five levels of protection for waters containing "other life stages" (i.e. not early life stages) salmonids (adapted from Dean and Richardson 1999), and corresponding DO saturation.

Acceptable degree of impairment	DO (mg/L)	Saturation (%) at			
		10°C	16 °C	19 °C	24 °C
None	8	71	81	86	95
Slight	6	53	61	65	71
Moderate	5	44	51	54	59
Severe	4	35	41	43	48
Acute	3	27	30	32	36

Table 13: Dissolved Oxygen concentrations (mg/L) recommended by the U.S. Environmental Protection Agency to confer five levels of protection for waters containing early life stages of salmonids (adapted from Dean and Richardson, 1999).

Degree of impairment acceptable	Early life stages	
	Water column	Intra-gravel
None	11	8
Slight	9	6
Moderate	8	5
Severe	7	4
Acute	6	3

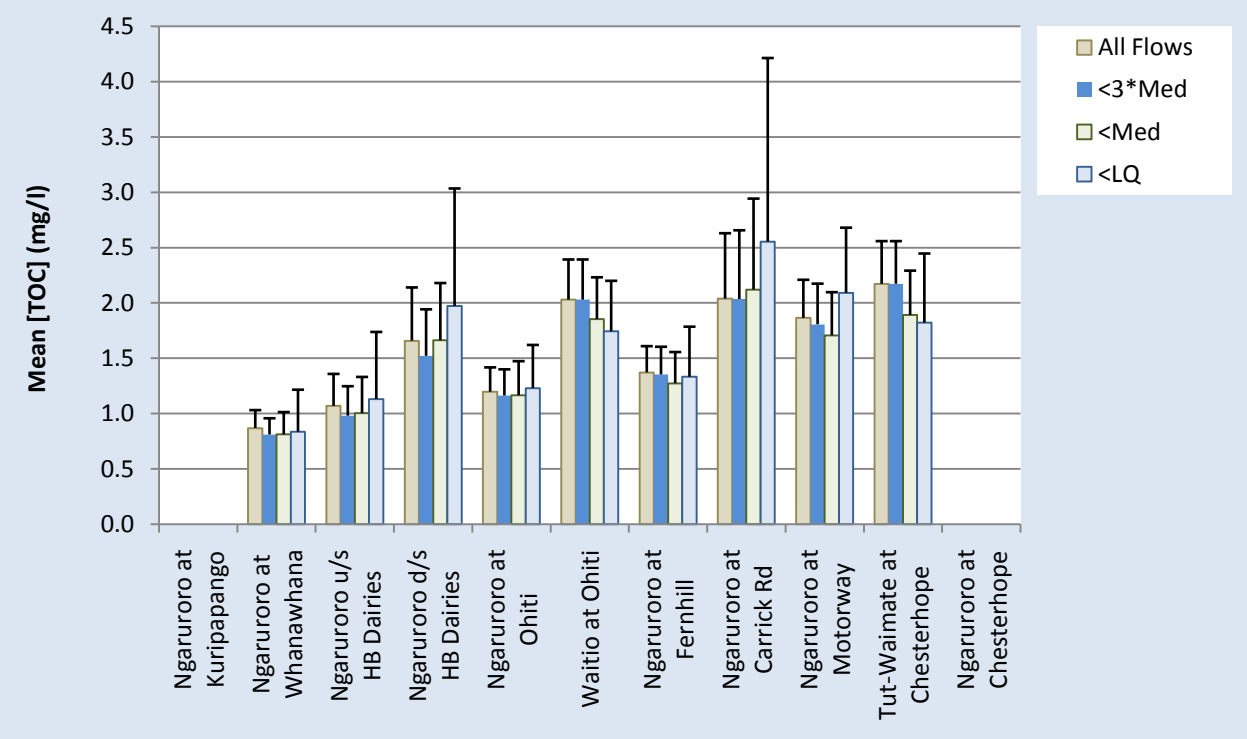

Figure 9: Mean total organic carbon (TOC) (mg/L) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ).

3.4. Comparison with national figures

3.4.1. Methodology

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 regional council data collected between 1996 and 2000. The report uses the River Environment Classification (REC) to define 5 broad classes, based on the source of flow (upland/lowland) and the dominant land cover (natural/pastoral), the fifth category being urban streams (NIWA 2008).

To provide a national perspective, the results obtained in the Ngaruroro catchment were compared to national figures. The comparisons with national figures were undertaken according to each site's REC classification:

- The two upper catchment sites (Kuripapango and Whanawhana), and the two sites upstream and downstream of Hawke's Bay Dairies have a REC classification of Hill/Natural land cover, and were compared with national medians for Upland/Natural (U/N);
- All other sites on the Ngaruroro River have a classification of Hill/Pastoral, and were compared with Upland/Pastoral sites;
- The two tributaries, Waitio and Tutaekuri-Waimate Streams, are classified lowland/pastoral.

3.4.2. Results

The two upper catchment sites have generally better water quality than the national median for upland/native sites, except for the water clarity at Whanawhana, which is similar to the national average Table 12).

The two sites upstream and downstream of HB Dairies are also classified upland/native. Both sites have better DRP and *E. coli* concentrations than the national medians, but worse water clarity. The increase in SIN observed downstream of HB Dairies means that this is the only site in the Ngaruroro catchment with a median SIN concentration higher than the national median for its class.

All other sites on the Ngaruroro mainstem have lower DRP, SIN and *E. coli* concentrations than the national medians for sites in the same class. Water clarity at these five sites is generally slightly lower than the national median, except at Chesterhope, where it is markedly lower.

The two tributaries have excellent *E. coli* concentrations compared to the national median. The Waitio Stream also has excellent water clarity for a lowland/pastoral stream. Although SIN concentrations in both streams are higher than in the Ngaruroro mainstem, they are considerably lower than the national median for lowland streams. Median DRP concentration in the Tutaekuri-Waimate Stream is the highest of the catchment, and significantly worse than the national median for this class of streams.

Table 14: Comparison of water quality statistics for the Ngaruroro catchment sites with national figures from (NIWA 2008). Green shading indicates better water quality than the national median, red shading indicate worse water quality than the national median.

Site	Class	DRP (mg/l, median)		SIN (mg/l, median)		*E. coli* (/100ml, 95th percentile)		Clarity (m, median)	
		National median	Ngaruroro site	National median	Ngaruroro site	National median	Ngaruroro site	National median	Ngaruroro site
Ngaruroro at Kuripapango	Upland/ Natural	0.006	0.002	0.077	0.008	117	2	2.9	5.0
Ngaruroro at Whanawhana			0.002		0.048		1		2.9
Ngaruroro u/s HB Dairies			0.002		0.055		2		2.4
Ngaruroro u/s HB Dairies			0.004		0.096		4		2.1
Ngaruroro at Ohiti	Upland/ Pastoral	0.009	0.002	0.111	0.102	517	8	1.5	1.4
Ngaruroro at Fernhill			0.004		0.090		12		1.4
Ngaruroro at Carrick Rd			0.004		0.080		19		1.4
Ngaruroro at Motorway			0.004		0.084		18		1.4
Ngaruroro at Chesterhope			0.007		0.070		27		1.1
Waitio Stream at Ohiti	Lowland/ Pastoral	0.016	0.016	0.570	0.144	1,542	23	1.2	3.1
Tut-Waimate at Chesterhope			0.023		0.208		75		1.1

4. Effects of HB Dairies

This section provides an comparison of the water quality monitoring results obtained in the Ngaruroro River upstream and downstream of a large dairy farming operation located along the river's true left bank, approximately 10km downstream of Whanawhana. The analysis presented in this section is based on monitoring results obtained between November 2000 and August 2008. Paired samples (i.e. taken the same day upstream and downstream) were compared using Wilcoxon paired rank tests. All comparisons except biomonitoring (MCI and chlorophyll a) are based on 31 to 36 pairs of samples.

Monitoring results indicate moderate but statistically significant:

- reduction in water clarity;
- increase in variables relating to nutrient (SIN, DRP) and organic enrichment (TOC), with in particular, a near-doubling of the median SIN concentration;
- increase in bacterial indicators of faecal contamination (*E. coli*, FC);
- changes in water chemistry, such as increases in electrical conductivity, and calcium and magnesium concentrations.

No statistically significant changes were detected on macroinvertebrate community index (MCI). However, MCI is only a generic index, particularly useful in state of the environment-type reporting, but of limited value when attempting to directly compare two sites. A more in-depth analysis of the macroinvertebrate monitoring data is strongly recommended.

Based on only four "paired" results, there appears to be a moderate increase in periphyton biomass downstream of HB Dairies, and an increase in guideline breaches (2 out of 4 samples downstream, *vs.* 1 out of four samples downstream). The paired rank Wilcoxon test did not return any statistically significant difference for this parameter, but the very low number of samples limits the meaning of this result. Given the observed increase in both DRP and SIN downstream of the discharge, further, regular monitoring of periphyton biomass and cover is recommended upstream and downstream of HB Dairies.

It should be noted, that, in spite of statistically significant water quality degradation downstream of HBD, water quality remains high, with good levels of compliance with the guidelines relating to water clarity, microbiological water quality and nutrients. The water quality degradation should however be placed in catchment-wide context, i.e. its contribution to the issues identified at the catchment scale, such as water clarity degradation and nutrient enrichment/periphyton growth. In this context, the changes identified above indicate that HB Dairies contributes to the cumulative effects on water clarity and nutrient enrichment observed in the Ngaruroro River.

Table 15: Water quality in the Ngaruroro River upstream and downstream of Hawke's Bay Dairies. Mean values ± 95% confidence interval. Paired upstream and downstream results were compared by Wilcoxon paired rank test.

Indicator	Site	Median ± 95% C.I.	% compliance with guideline	Comparison	
				P	change
Water clarity (m) <3*median flow	Upstream	2.7 ± 0.6	66 %	<0.005	↘
	Downstream	2.2 ± 0.6	59 %		
SS (mg/l) <3*median flow	Upstream	1.5 ± 1.8	91 %	<0.01	↗
	Downstream	1.5 ± 4.4	85 %		
DRP (mg/l) <3*median flow	Upstream	0.002 ± 0.001	100 %	<0.05	↗
	Downstream	0.003 ± 0.001	100 %		
SIN (mg/l) <3*median flow	Upstream	0.048 ± 0.025	92 %	<0.001	↗
	Downstream	0.094 ± 0.024	88 %		
TOC (mg/l)	Upstream	0.6 ± 0.3	N/A	<0.05	↗
	Downstream	1.1 ± 0.4			
DO (mg/l)	Upstream	0.6 ± 0.3	N/A	<0.05	↗
	Downstream	1.1 ± 0.4			
Chlorophyll a (mg/m^2)	Upstream	30 ± 62	80 %	NS	-
	Downstream	90 ± 77	50 %		
MCI	Upstream	115 ± 8	80 %	NS	-
	Downstream	113 ± 10	75 %		
E. coli (/100ml) All flows	Upstream	2 ± 4	100	<0.05	↗
	Downstream	4 ± 8	100		
FC (/100ml) < median flow	Upstream	10 ± 11	85%	<0.001	↗
	Downstream	34 ± 21	70 %		
Conductivity ($\mu S.cm^{-2}$)	Upstream	118 ± 7	N/A	<0.001	↗
	Downstream	125 ± 7	N/A		
Magnesium (mg/l)	Upstream	1.9 ± 0.1	N/A	<0.001	↗
	Downstream	2.0 ± 0.1	N/A		
Calcium (mg/l)	Upstream	12 ± 1	N/A	<0.001	↗
	Downstream	13 ± 1	N/A		

5. Temporal trends

The results of seasonal Kendall tests (followed by FDR adjustment) performed on data collected at the 11 sites across the Ngaruroro catchment are presented in Table 16 (DRP, SIN, water clarity and *E. coli*). The trend analysis for *E. coli* was performed on Log-transformed data.

The length of data records vary according to the sites. At the five main sites[7], data from 1994 to 2008 were analysed, whilst only 2000-2008 data were available at all other sites.

MCI trends analysis was performed on all data available between 1994 and 2007, at 10 sites (no biomonitoring data for the Tutaekuri-Waimate Stream). No significant trends were found at any of the 10 sites.

No significant trends were detected in relation to suspended solids

Increasing DRP and SIN trends were found in the Ngaruroro at Ohiti and Fernhill. Interestingly, these trends were not found at the next "main" site downstream, Chesterhope. An increasing SIN trend was also identified in the Waitio Stream.

Photo 6: Waitio Stream at Ohiti Road.

[7] Kuripapango, Whanawhana, Ohiti, Fernhill and Chesterhope.

Table 16: Summary of temporal trends at different monitoring sites in the Ngaruroro catchment. Seasonal Kendall Test, Flow adjusted data, covariate adjustment method is LOWESS. NS: Not significant; ID: insufficient data; ND: no data.

		Dissolved Reactive Phosphorus (DRP)				Soluble Inorganic Nitrogen (SIN)				Suspended solids (SS)				*E.coli*			
	Site	Period analysed	Trend	p	Slope (%/year)	Period analysed	Trend	P	Slope (%/year)	Period analysed	Trend	p	Slope (%/year)	Period analysed	Trend	p	Slope (%/year)
Upper catchment	Ngaruroro at Kuripapango	94 - 08	-	NS	-	94 - 08	-	NS	-	94 - 08	-	NS	-	ID	-	-	-
	Ngaruroro at Whanawhana	94 - 08	-	NS	-	94 - 08	-	NS	-	94 - 08	-	NS	-	97-08	↘	<0.01	- 14
Middle catchment	Ngaruroro u/s HB Dairies	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-
	Ngaruroro u/s HB Dairies	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-
	Ngaruroro at Ohiti	94 - 08	↗	<0.05	+ 7.7	94 - 08	↗	<0.05	+ 4.0	94 - 08	-	NS	-	97-08	-	NS	-
	Waitio at Ohiti	00 - 08	-	NS	-	00 - 08	↗	<0.05	+ 12	00 - 08	-	NS	-	00 - 08	↘	<0.05	- 16
	Ngaruroro at Fernhill	94 - 08	↗	<0.05	+ 8.4	94 - 08	↗	<0.05	+ 4.9	94 - 08	-	NS	-	97-08	-	NS	-
Lower catchtment	Ngaruroro at Carrick Rd	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-
	Ngaruroro at Motorway	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-
	Tut-Waimate at Chesterhope	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-	00 - 08	-	NS	-
	Ngaruroro at Chesterhope	94 - 08	-	NS	-	94 - 08	-	NS	-	94 - 08	-	NS	-	ID	-	-	-

6. Contaminant load analysis

The aim of this section is to provide an estimate of the contaminant loads transported by different reaches of the Ngaruroro River, and to estimate the contribution from the tributaries, both on an annual and a daily low flow basis.

As identified in previous sections of the report, water clarity degradation and nutrient enrichment appear to be the two key issues in the Ngaruroro catchment.

Water clarity is dependant upon the concentration (but also size and nature) of sediments suspended in the water column. The possibility to estimate suspended solids (SS) loads in the Ngaruroro River was assessed, but was rejected, as it was considered that meaningful estimates could not be obtained with the data available, for the following reasons.

Only quarterly data was available, at only 9 of the 11 sites (SS are not monitored by NIWA). SS concentrations undergo huge changes during peak flows, to several hundred times the base flow levels. As a result, the vast majority of the SS loads is transported during flood flows. Whether or not one of these flood flows is captured by the quarterly sampling would have a huge influence on the final load estimation. This is true for most contaminants, but in the case of the SS is exacerbated by the highly skewed data distribution. Quarterly data was considered insufficient to calculate SS loads on an annual basis

The key issue identified in relation to water clarity in the Ngaruroro catchment is the reduction from more than 5m at Kuripapango to less than 1.5 m at Chesterhope. To suitably provide information on the water clarity issue, the associated variable (SS) would need to be sensitive within this range of water clarity. However, the current detection limit used by HBRC for SS is 3 mg/l. At Whanawhana for example, SS concentrations of less than 3 mg/l have corresponded to black disc reading of 1.4 to 7 metres. Any attempt to use SS data during periods of low river flow is likely to result in the use of mostly censored data (i.e. "less than"), negating the possibility to produce meaningful estimates of low flow daily loads.

Annual and low flows daily loads were therefore estimated for nutrients only.

6.1. Annual Loads

Annual loads were estimated using the "averaging" approach described in section 2.5 of this report.

6.1.1. Dissolved reactive phosphorus (DRP)

The average annual DRP load at Kuripapango is estimated at 1.1 Tonnes per year (T/Y). It then rises sharply in the upper catchment, to 3.8 T/Y at Whanawhana, and in the middle catchment, to 7.6 T/Y at Ohiti. It is estimated to remain relatively stable around 8 T/Y down to Motorway Bridge, then rise again to 12 T/Y at Chesterhope. Thus, the average annual load at Chesterhope is estimated to be approximately 10 times higher than at Kuripapango, although the median flow is only about twice as much.

Summer loads (November to April) are estimated to represent about one quarter of the annual load at Kuripapango and Chesterhope, i.e. three quarters of the DRP load are transported during the May to October period.

Of note is the sharp increase in average annual DRP load between upstream and downstream of Hawke's Bay Dairies, from 4.9 to 7.4 T/year, i.e. approximately a 50% increase.

The contribution from the Waitio Stream appears small in comparison to the Ngaruroro main stem (0.7 T/Y). At 4.7 T/Y, the Contribution from the Tutaekuri-Waimate appears very significant, as it represents more than half of the average annual load estimated between Ohiti and Motorway Bridge. The DRP

inputs from this stream could be the cause of, or a contributing factor to, the increase in estimated DRP load observed at Chesterhope.

6.1.1. Soluble Inorganic Nitrogen (SIN)

There is a regular increase in average annual SIN load between Kuripapango (7 T/year) and Ohiti (223 T/Y), then an apparent slight decrease to Fernhill (188 T/Y), possibly due to the flow loss between Ohiti and Fernhill (although the decrease may be within the range of uncertainty associated with the estimation method). The average annual SIN load then remains stable between 160 and 190 T/Y in the lower catchment.

Summer loads are estimated to represent between 20% (at Kuripapango) and 30% (at Chesterhope) of the annual load.

There is a near-doubling of average annual SIN loads between upstream (80 ± 33 T/Y) and downstream (152 ± 54 T/Y) of Hawke's Bay Dairies.

Inputs from the Tutaekuri Waimate Stream are estimated to be approximately 45 T/Y, or about a quarter of the estimated load at Chesterhope. The Waitio Stream is estimated to make a much smaller contribution (7 T/Y).

Photo 7: Tutaekuri-Waimate at Chesterhope.

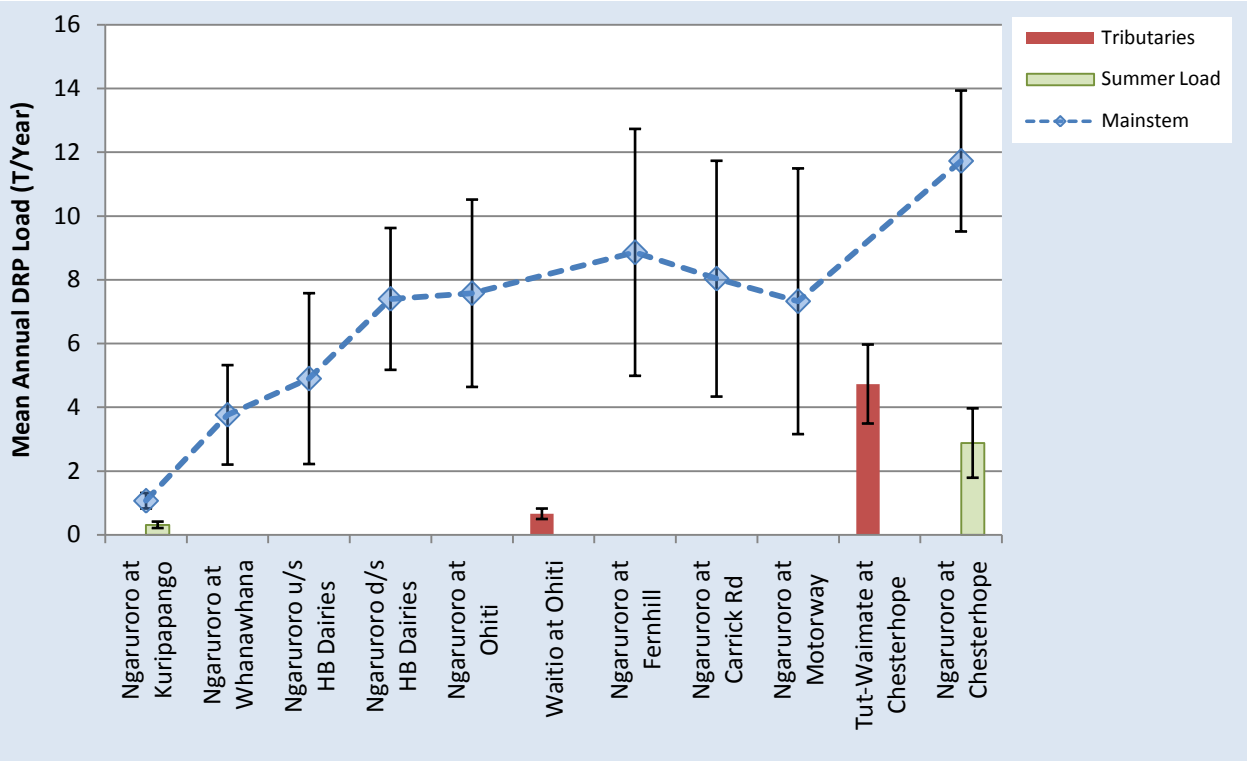

Figure 10: Estimated annual DRP loads (Tonnes/year) at monitoring sites on the Ngaruroro mainstem, and on tributaries. Summer load calculated at the NIWA sites (November-April inclusive), ± 95% confidence interval.

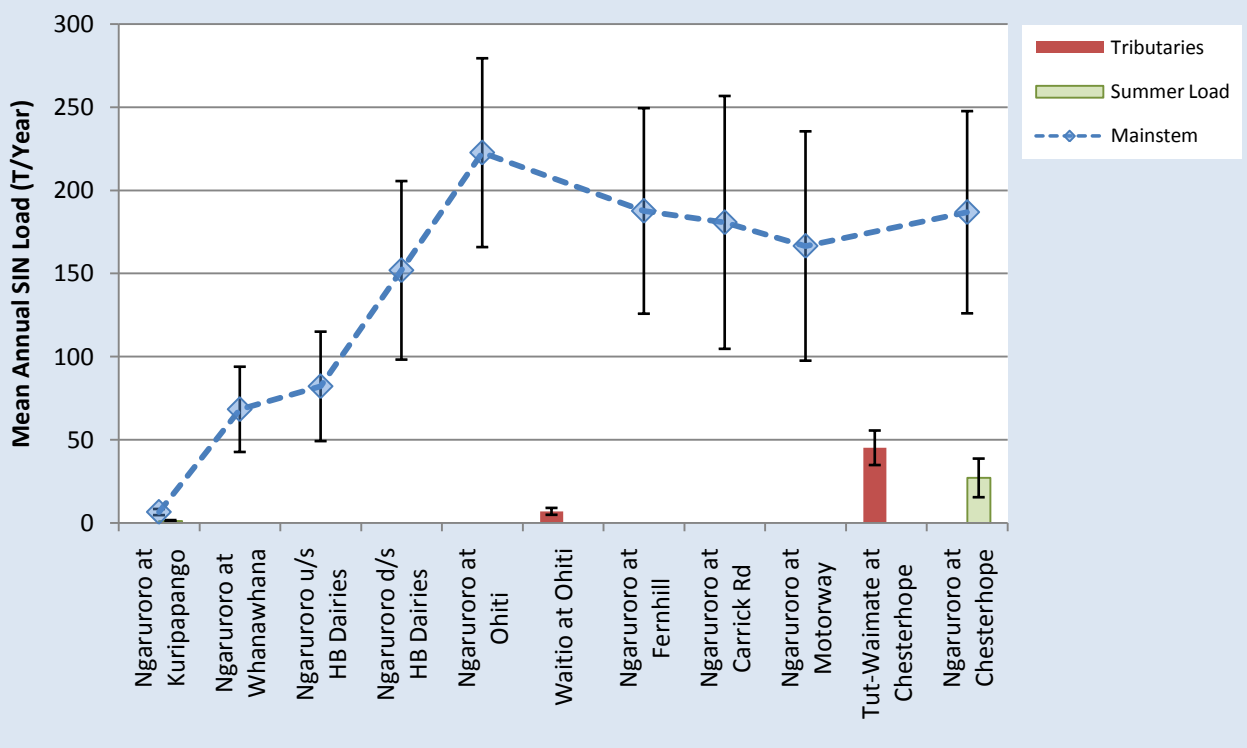

Figure 11: Estimated annual SIN loads (Tonnes/year) at monitoring sites on the Ngaruroro mainstem, and on tributaries. Summer load calculated at the NIWA sites (November-April inclusive), ± 95% confidence interval.

6.2. Nutrient loads during low flows

6.2.1. Methodology

The approach taken was to estimate the DRP and SIN daily load at the different monitoring sites under different low river flow conditions: lower quartile flow and mean annual low flow (MALF). The nutrient concentrations at the different monitoring sites under each river flow condition were estimated from the actual dataset, as the average concentration recorded when the flow is at or close to the flow in each scenario.

6.2.2. DRP

The low flow daily DRP loads are estimated to more than double between Kuripapango and Whanawhana, then to increase again at Ohiti (Figure 12). This is consistent with the DRP concentration and annual loads patterns already described in this report.

The low flow daily DRP loads are then estimated to decrease markedly in the lower catchment, down to motorway Bridge, then increase again at Chesterhope. The inputs from the Tutaekuri-Waimate Stream are estimated to represent two – to four times the DRP load at Motorway Bridge, and is a likely cause of, or contributing factor to, the DRP load increase estimated to occur at Chesterhope. Again this is consistent with the annual load analysis, although the likely influence of the Tutaekuri-Waimate Stream on the DRP in the Ngaruroro River seems to be exacerbated during periods of low river flows.

It is noted that an increase between upstream and downstream of HBD is apparent at lower quartile flow, but not at MALF.

6.2.1. SIN

The daily low flow SIN load is estimated to gradually increase between Kuripapango and Ohiti, then to decrease in the lower catchment. The daily load at Chesterhope is not estimated to increase compared to Fernhill, in spite of the inputs from the Tutaekuri-Waimate Stream (estimated to be 70-100% of the upstream Ngaruroro loads) (Figure 13).

The SIN load decrease in the lower catchment is likely associated with a combination of flow loss between Ohiti and Fernhill and the exhaustion of the pool of SIN in the water due to the uptake by the algal biomass. This is to be put in parallel with the SIN:DRP ratio graphs presented earlier in this report (Figure 5), which indicate that SIN becomes the limiting nutrient during periods of low river flows, i.e. the first nutrient to become exhausted in the water column during periods of active algae growth.

6.3. Catchment nutrient yields during low flows

The previous section presented the nutrient loads coming from the catchments above each monitoring site as absolute numbers (i.e. kg per day). This section makes use of the same numbers, but related back to the size of the catchment above each monitoring site. The aim is to provide a broad estimate of the non-point source nutrient yield in each sub-catchment.

Results indicate that the estimated DRP yields in the two monitored tributaries are much higher than those for the Ngaruroro mainstem sites. In particular, yields in the Tutaekuri-Waimate catchment are between 20 and 100 times higher than those of the middle and lower Ngaruroro river (Figure 14).

Similarly, SIN yields in the Waitio and Tutaekuri-Waimate catchments are estimated to be markedly higher than for the Ngaruroro mainstem sites. Also of note is the apparent yield increase between upstream and downstream of HB dairies (Figure 15).

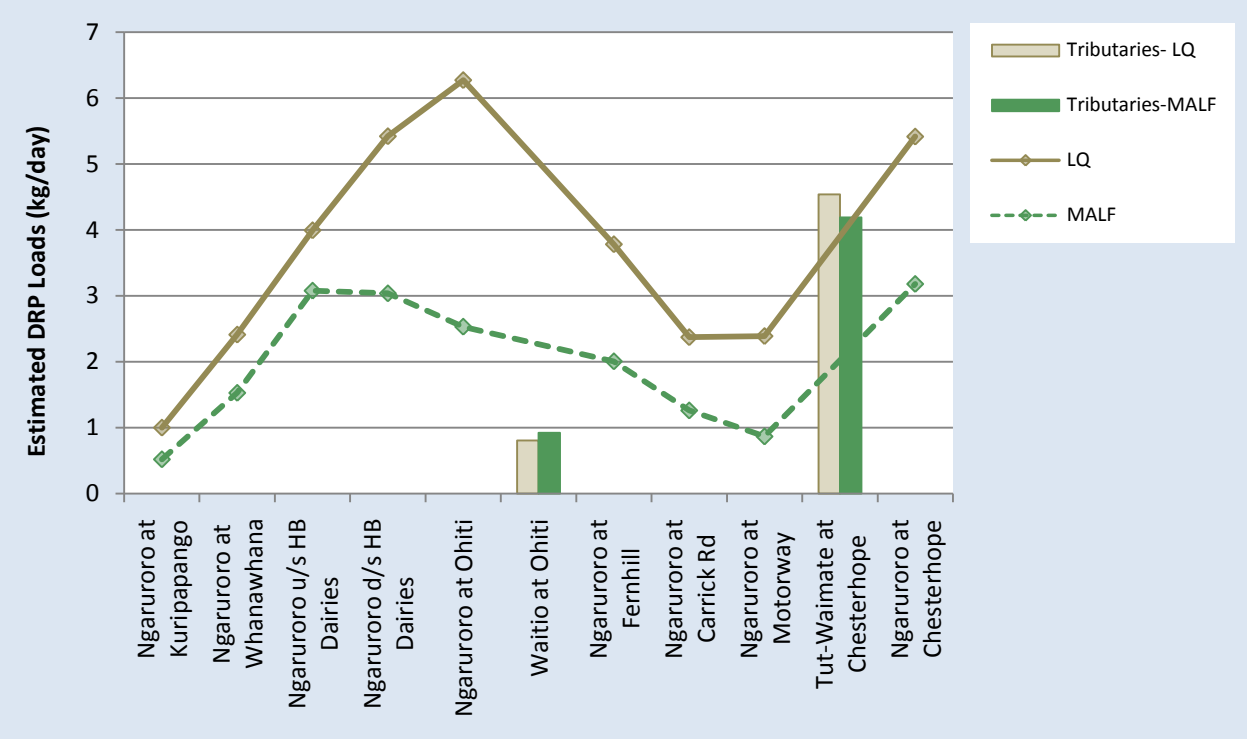

Figure 12: Estimated daily DRP loads (kg/day) in the Ngaruroro catchment under low river flow conditions: lower quartile flow and 7-day Mean Annual Low Flow (MALF).

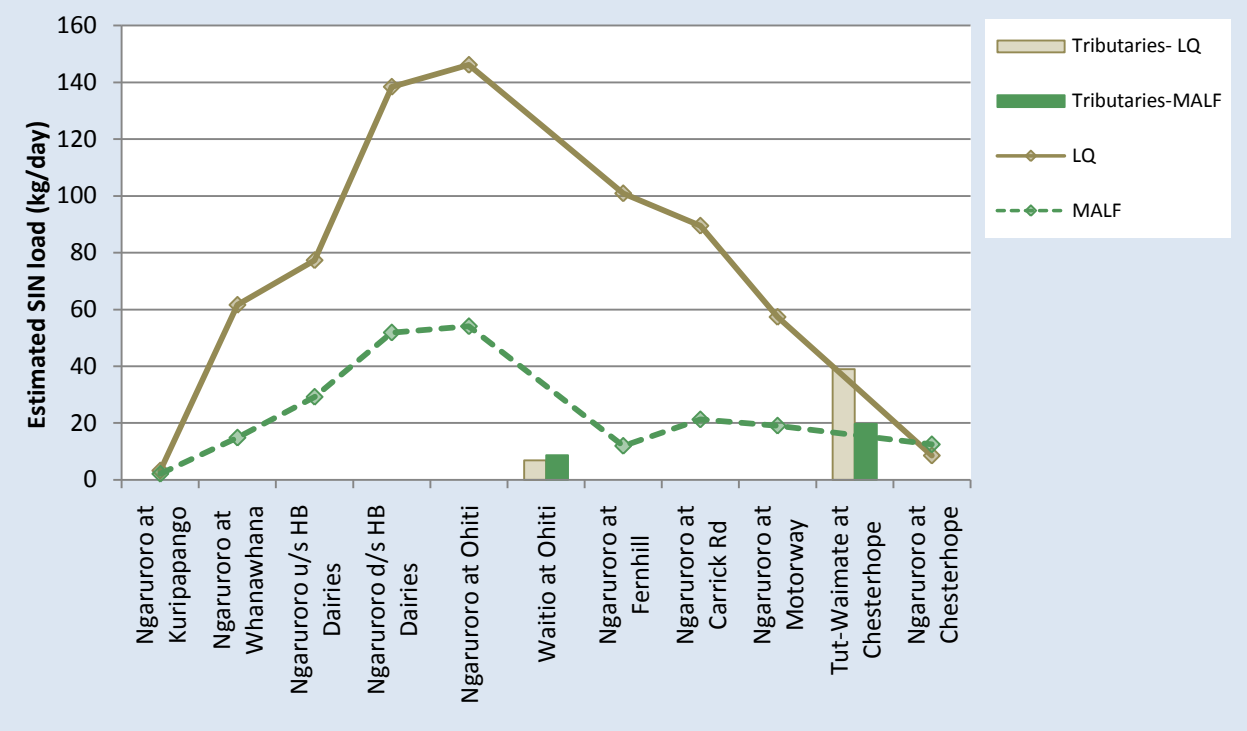

Figure 13: Estimated daily SIN loads (kg/day) in the Ngaruroro catchment under low river flow conditions: lower quartile flow and 7-day Mean Annual Low Flow (MALF).

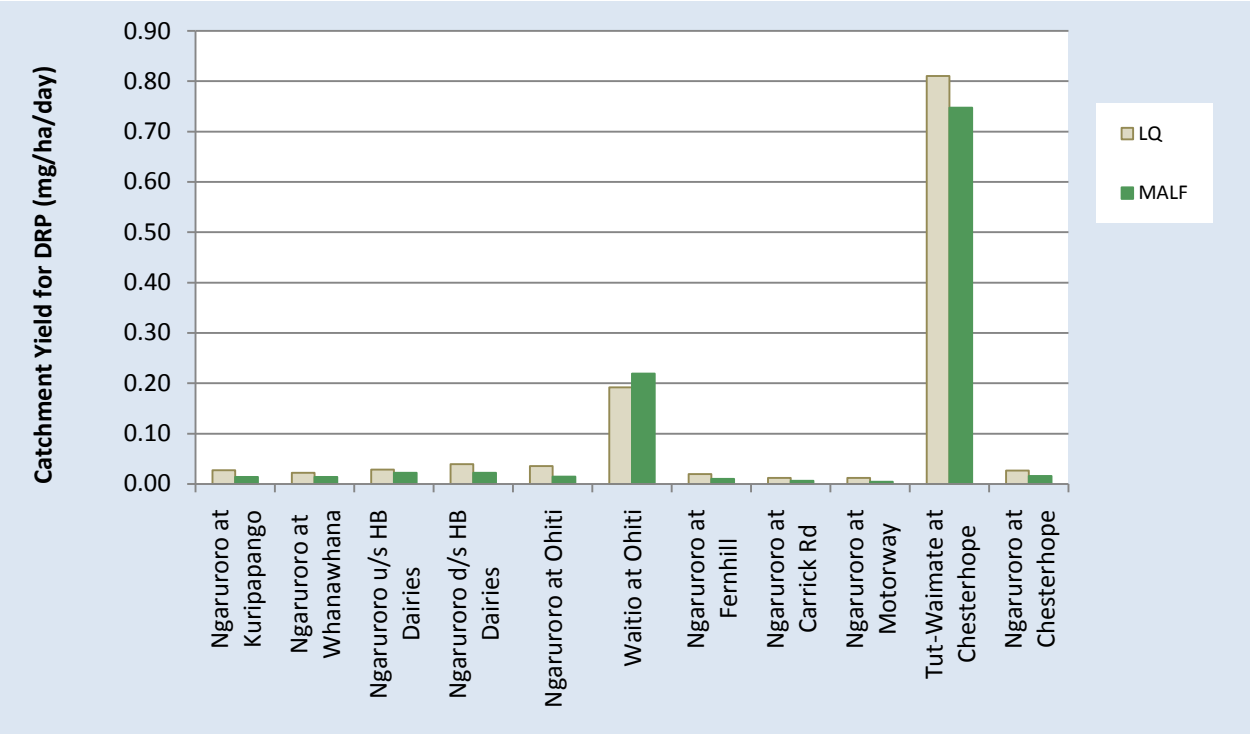

Figure 14: Estimated catchment yield for DRP during low flow conditions.

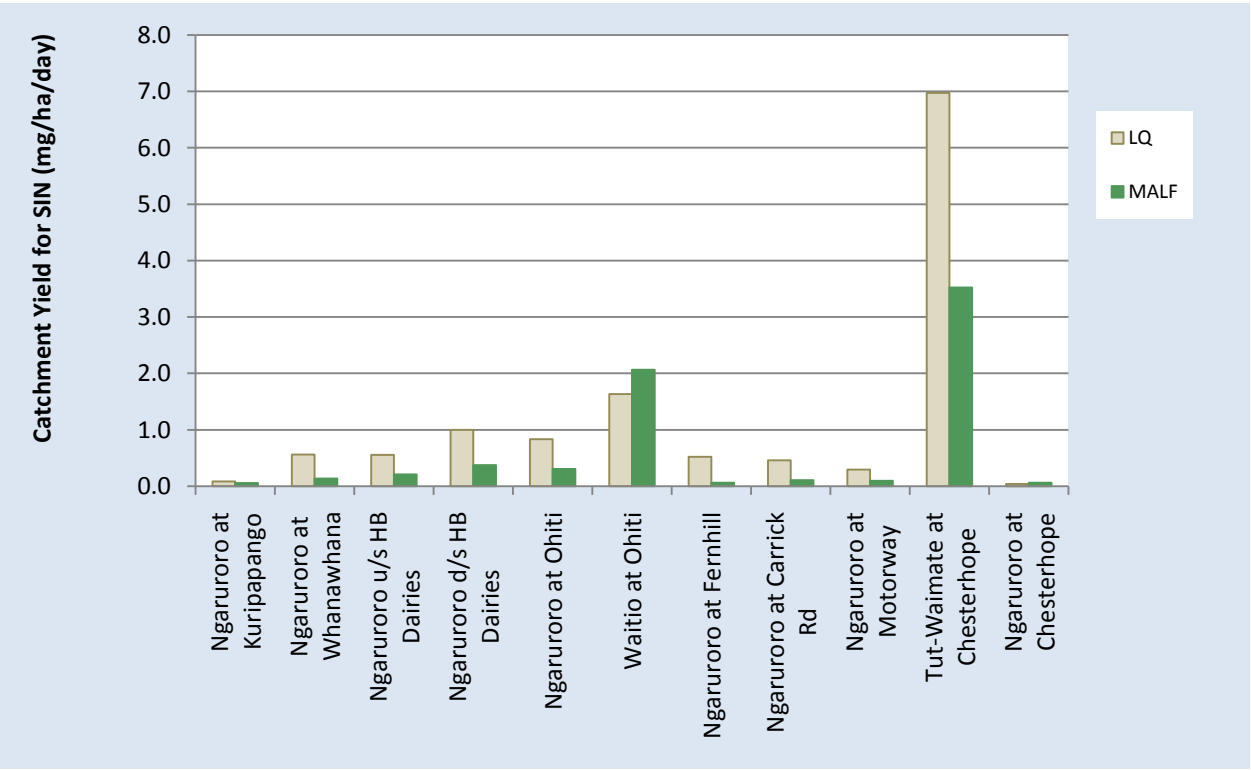

Figure 15: Estimated catchment yield for SIN during low flow conditions.

7. Discussion and Conclusions

7.1. Water quality of the Ngaruroro Catchment

7.1.1. Microbiological water quality

Microbiological water quality is very good across all sites monitored in the Ngaruroro catchment - better than national values for comparable systems and stable or improving over time. Based on the data available, microbiological water quality is nearly always of swimmable standard, indicating a low health risk to river users from pathogens of faecal origin.

7.1.2. Water clarity

Water clarity at Kuripapango in the upper catchment is excellent, particularly during base flows and this site can be considered a reference site for the catchment.

Although still acceptable, water clarity has somewhat degraded by the time it reaches Whanawhana, where median water clarity (calculated below three times median flow) drops to 2.8 metres from 5.4 metres at Kuripapango. Although the causes for this degradation have not been determined, accelerated erosion rates in steep hill country pasture and commercial forestry (particularly during and following harvest) are likely contributors.

Further gradual degradation of the water clarity occurs along the course of the Ngaruroro River. Median water clarity (calculated below three times median flow) drops from 2.8 m at Whanawhana to 2.7 m upstream of Hawke's Bay Dairies, 2.2 m downstream of Hawke's Bay Dairies, 1.8 m at Ohiti, 1.5 m at Fernhill, to finally fall to 1.2m at Chesterhope, well below the ANZECC guidelines for recreational waters and the national median for similar sites.

Because the decrease in water clarity is gradual along the course of Ngaruroro River, it seems clear that the cause cannot be narrowed down to a single factor in a single area. The information provided by the State of the Environment monitoring allows us to identify the issue, but not to (nor is it designed to) identify its cause, and specific investigations are accordingly recommended. It is suggested that superimposing water quality, geology, topography and land use information using modern GIS tools may be useful in identifying hotspots/priority areas for detailed investigations and/or management. Water quality monitoring of tributaries of the upper and middle Ngaruroro catchment would also be useful in this context.

7.1.3. Macroinvertebrates

The MCI scores generally recorded at Kuripapango are somewhat lower than what would be expected at sites with pristine water quality, which tends to indicate that MCI scores between 100 and 130 are indicative of excellent water quality for this catchment. MCI scores remain consistently above 100 downstream of Kuripapango, which indicates relatively healthy invertebrate communities. The exception is at Chesterhope, where scores between 90 and 100 are regularly obtained, which is indicative of moderate degradation.

7.1.4. Nutrients and periphyton

Although an increasing trend is apparent when going downstream in the catchment, nutrient concentrations remain relatively low in the Ngaruroro main stem – lower than ANZECC guidelines and national medians for comparable sites. Periphyton guidelines are exceeded on occasions at all sites monitored in the catchment, but nuisance periphyton growths seem to occur more frequently in the middle (downstream of Hawke's Bay Dairies and Ohiti) and lower catchment (Fernhill) than in the upper

catchment (Whanawhana and upstream of HBD). However, this remark is based on only a very limited number of results, and will need to be tested following further monitoring of periphyton growth.

Increasing trends in both SIN and DRP have been identified in the middle and lower catchment (Ohiti and Fernhill), making future monitoring of periphyton biomass and cover all the more critical.

Nutrient loadings increase sharply between Kuripapango and Ohiti, suggesting that the main sources of nutrient may be in the middle catchment. Nutrient loadings remain stable in the lower catchment until Chesterhope where the DRP loading (both on an annual basis and during low flow periods) increases again. The DRP brought by the Tutaekuri-Waimate Stream is likely to contribute significantly to the DRP loads observed an Chesterhope, particularly during periods of low river flows. The estimated nutrient yields are much higher than in the rest of the catchment, identifying the Tutaekuri-Waimate as a strong candidate for targeted nutrient management investigation and action.

During periods of low river flow, the nutrient status of the river tends to switch from a phosphorus-limited or co-limited situation to a nitrogen- limited situation. Controlling the inputs of both nutrients to the river appears essential to control periphyton growth, with a particular emphasis on controlling SIN inputs during periods of low river flows.

7.1.5. Hawke's Bay Dairies

In 2000, monitoring started at two sites on the Ngaruroro River immediately upstream and downstream of a large dairy farming operation- Hawke's Bay Dairies- to identify any effects this intensive dairy unit may have on the Ngaruroro River's water quality. Comparison of samples taken near-simultaneously upstream and downstream indicates moderate but statistically significant changes in water quality in the Ngaruroro River in relation to a large number of parameters, including a decrease in water clarity, and an increase in DRP, SIN, suspended solids and total organic carbon. The pattern of increasing in-river nutrients is confirmed by the nutrient load analysis presented in this report, showing annual loads increases of 50% for DRP and 90% (near-doubling) for SIN downstream of the dairy operation.

The possible direct effects (i.e. immediately downstream of the farm) of these changes on the River's aquatic life remain uncertain, and further biological monitoring and more in-depth analysis of existing data is recommended. However, the data available and the analysis presented in this report indicates that, although the changes in water quality are only moderate, HB dairies is contributing to the cumulative effects on water clarity and nutrient enrichment observed in the Ngaruroro River.

7.1.6. Tributaries

Two tributaries of the lower Ngaruroro River have been included in HBRC's state of the environment programme since 2000, the Waitio Stream and the Tutaekuri-Waimate. Both show similar indications of degraded water quality, although one – the Tutaekuri-Waimate- appears more degraded than the other.

The two streams are the only sites in the catchment to regularly breach the Regional Plans' DRP guideline of 0.015 mg/l. SIN levels in both streams are also more elevated than in the Ngaruroro River itself, but remain below the ANZECC guideline and the national median for lowland streams. Nutrient yields in these catchments are estimated to be much higher than for the Ngaruroro catchment as a whole.

In both streams, low DO concentration seems to occur regularly, possibly caused by the heavy macrophyte growth on the stream margins. Based on the available data, the oxygen depletion appears moderate in the Waitio Stream, but much more pronounced in the Tutaekuri Waimate Stream - to levels where the stream may be unsuitable to adult trout or trout spawning. Additional dissolved oxygen monitoring (either continuous monitoring by instream probe, or spot measurements at dawn) is recommended to fully ascertain the extent of the problem.

It is probable that both streams could greatly beneficiate from riparian retirement and planting: the bank stabilisation provided by plant roots and the protection from stock damage, and the shading from plants is

likely to limit the growth of macrophytes on the stream margins, in turn improving night time dissolved oxygen and stream habitat.

7.2. Recommendations

7.2.1. Management implications

The water clarity degradation and nutrient enrichment appear to be occurring along most of the Ngaruroro River, from non-point, or diffuse, sources. The scale of the information presented in this report is by necessity the same as the monitoring network, and can/should be refined by targeted monitoring and investigations. A number of general management recommendations can however be made.

If a management objective is to reduce the frequency and duration of algal blooms in the Ngaruroro River, both SIN and DRP inputs to the system should be managed, but with a particular emphasis put on controlling the inputs of SIN during periods of low river flows. This recommendation is consistent with those made by a panel of experts on limiting nutrients (Wilcock *et al.* 2007). It should be noted that the current regional plan (RRMP) does not contain any specific water quality guidelines relating to SIN, and the planning implications of any nutrient control measure would need to be carefully assessed.

An important consideration to bear in mind is the fact that even a drastic reduction in nutrient concentrations in the Ngaruroro River is unlikely to totally prevent algal proliferations. As demonstrated in the upper catchment, even sites with low nutrient concentrations have exceeded the periphyton biomass guideline at least once. These occasional exceedances are likely associated with the natural characteristics of the catchment and its climate – particularly the extended periods of low flow the Hawke's Bay is renowned for. A reduction in nutrient concentrations is more likely to result in reduced algal growth rates and peak biomass, i.e. how fast and how often high algal biomass will occur, and how large to the algal biomass and cover will be.

The sharp reduction in water clarity observed between Kuripapango and Whanawhana indicates probable significant sediment inputs during periods of base river flow in this part of the catchment. About 45% of the catchment between Kuripapango and Whanawhana is in pasture (40%) and commercial exotic forestry (5%). Improved erosion and sediment loss control measures would be necessary to limit the degradation of water clarity in this part of the catchment. Additional monitoring and targeted investigations are also recommended below to help prioritise areas contributing to sediment loss to the waterways.

Finally, the recommendation to improve riparian management in the Waitio and Tutaekuri-Waimate Stream catchments is reiterated.

7.2.2. Further monitoring/investigations

Investigations

As explained above, the water clarity degradation and nutrient enrichment observed along the course of the Ngaruroro River are gradual, and the causes cannot be narrowed down to a single factor in a single area. Rather, a range of factors, natural and anthropogenic, are likely to be involved. It is suggested that superimposing water quality, geology, topography and land use information using modern GIS tools may be useful in identifying hotspots/priority areas for detailed investigations and/or management. In particular, erosion and sediment loss to the waterways in the upper catchment between Kuripapango and Whanawhana should be a priority for such investigations.

Only a limited amount of reliable periphyton biomass data is currently available, and will need to be completed to fully ascertain frequency and severity of nuisance algal growth along the Ngaruroro River main stem. In particular, continued periphyton biomass monitoring is recommended at Whanawhana, upstream and downstream of HB Dairies (to assess the direct effects of the activity on the river's

ecology), and Ohiti and Fernhill. Given the nutrient concentrations and loadings changes at Chesterhope, it is strongly recommended to undertake periphyton biomass monitoring at this site. As explained in further detail below, the additional data collected at Carrick Road and Motorway Bridge does not appear to be critically useful, and monitoring at one or both of these sites could be discontinued.

There are some indications that the Tutaekuri-Waimate Stream could be in a degraded, and further monitoring, including continuous dissolved oxygen monitoring during periods of low flows and biological monitoring (macroinvertebrates and periphyton) are recommended.

Monitoring programme

The current monitoring regime is quarterly sampling, with monthly sampling every five years. This regime seems suitable for state of the environment monitoring and reporting purposes in the Ngaruroro catchment, and no change to the sampling frequency is recommended at this stage.

In terms of the monitoring network, i.e. the location of the monitoring sites, the general observation is that there are a lot (9) of sites on the Ngaruroro River main stem, and only two on tributaries. Monitoring water quality in tributaries often provides critical information on the sources of contaminants, and it is suggested that the monitoring network in the Ngaruroro catchment could be reshuffled somewhat to achieve a better balance between main stem and tributary monitoring. It is suggested below that one, or maybe two monitoring sites could be spared in the lower Ngaruroro catchment without loss of critical information. The freed-up resources could be usefully redirected towards monitoring major tributaries of the upper or middle Ngaruroro catchment – where most of the nutrient enrichment and water clarity degradation seems to occur.

There are currently four monitoring sites in the lower Ngaruroro River, three monitored by HBRC, and one by NIWA.

The most upstream site, Fernhill, is a long-term site in HBRC state of the environment monitoring programme, and is strategically located immediately downstream of the groundwater recharge area, and it is recommended to maintain monitoring at this site.

The most downstream site, Chesterhope, is also a long-term site, part of NIWA's national network since 1989. Information gathered at this site is critical to assess the degree of change in the lower catchment, and monitoring should continue. The only caveat is to ensure that data from this site is consistent and comparable with the data collected at the other monitoring sites. At the very least, periphyton biomass monitoring, should be undertaken at Chesterhope. Better still, sampling at this site should be coordinated with the rest of the catchment (i.e. all sites within the catchment are done on the same day). This could be achieved by either coordinating the NIWA and HBRC sampling programmes, or by HBRC undertaking their own quarterly sampling at Chesterhope.

The two sites between Fernhill and Chesterhope (Carrick Road and Motorway Bridge) are only located a few kilometres apart with no major tributaries in between. Based on the analysis presented in this report, the information from these two sites does not appear to be significantly different from one another or from that collected at Fernhill. It is suggested that monitoring at one or both of these sites could be discontinued without loss of critical information.

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APPENDICES

Appendix A: Summary of data – all river flows/year round

SiteID		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro at Whanawhana	Average	7.8	12.6	10	96	2.9	20.4	32.4	0.310	0.016	0.003	0.043	0.061	0.003	47	210	9	0.026	29	18	0.9	128	99
	Min	7.1	6.0	7	60	0.0	0.0	0.5	0.040	0.002	0.001	0.002	0.003	0.001	2	3	1	0.001	0	0	0.2	112	2
	5%ile	7.2	6.6	8	74	0.3	0.3	0.5	0.062	0.003	0.001	0.005	0.017	0.001	4	14	1	0.002	1	0	0.3	113	2
ALL DATA	10%ile	7.4	7.0	8	80	0.4	0.4	0.5	0.092	0.005	0.001	0.008	0.019	0.001	8	26	1	0.002	1	0	0.3	113	3
	25%ile	7.7	9.0	9	90	0.9	0.6	1.5	0.111	0.005	0.001	0.017	0.030	0.001	12	45	2	0.003	3	1	0.5	117	6
Upland	Median	7.8	12.5	10	97	2.7	1.4	2.0	0.144	0.010	0.003	0.033	0.048	0.002	24	87	3	0.005	8	4	0.7	129	53
	75%ile	7.9	15.8	11	101	4.6	4.1	6.0	0.314	0.022	0.003	0.050	0.078	0.003	50	209	7	0.012	18	10	1.1	140	113
	90%ile	8.1	18.5	13	108	6.6	13.8	16.8	0.580	0.030	0.006	0.092	0.114	0.006	110	484	13	0.027	38	22	1.4	142	241
	95%ile	8.2	18.9	13	118	6.9	34.6	54.5	0.792	0.039	0.009	0.101	0.154	0.008	117	624	40	0.051	43	31	2.1	144	301
	Max	8.5	20.0	15	125	7.2	910.0	1470.0	3.752	0.110	0.021	0.230	0.249	0.012	498	2555	130	0.610	780	563	4.1	147	361
	StDev	0.3	4.1	2	13	2.2	109.9	174.6	0.544	0.015	0.004	0.041	0.047	0.003	73	358	21	0.088	114	78	0.7	13	138
	95% C.I.	0.1	0.9	0	3	0.6	24.5	38.3	0.149	0.003	0.001	0.009	0.010	0.001	16	78	5	0.019	33	21	0.2	7	110
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.2			0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	96	94	88	63	91	84	71	100			95	100	10			89	98	98		64	83
	N	35	85	52	52	51	77	80	51	81	47	80	81	82	81	81	82	81	46	51	75	14	6

Ngaruroro at Ohiti	Average	7.8	14.3	10	95	2.0	13.5	23.5	0.309	0.015	0.002	0.108	0.127	0.004	73	543	14	0.024	86	55	1.2	112	103
	Min	7.1	6.7	6	67	0.2	0.2	0.5	0.065	0.002	0.001	0.002	0.003	0.001	2	3	1	0.001	10	1	0.1	100	31
	5%ile	7.2	7.4	8	72	0.2	0.5	1.0	0.110	0.003	0.001	0.020	0.037	0.001	9	25	1	0.002	14	3	0.3	101	40
ALL DATA	10%ile	7.4	8.3	8	80	0.2	0.7	1.0	0.132	0.003	0.001	0.032	0.050	0.001	13	36	1	0.003	19	4	0.4	103	49
	25%ile	7.6	10.4	9	89	0.6	1.4	1.5	0.167	0.005	0.001	0.054	0.066	0.001	22	91	2	0.006	32	14	0.6	106	69
	Median	7.8	14.5	10	94	1.4	3.6	4.0	0.250	0.010	0.003	0.088	0.102	0.002	40	184	4	0.011	52	30	0.7	113	84
	75%ile	8.0	18.0	11	102	2.9	15.5	20.0	0.370	0.020	0.003	0.140	0.164	0.005	82	715	12	0.027	77	53	1.7	120	120
	90%ile	8.2	20.8	11	109	5.0	41.1	67.0	0.497	0.031	0.003	0.200	0.242	0.009	186	1550	45	0.055	153	104	2.9	121	175
	95%ile	8.4	21.0	12	116	5.4	58.9	110.0	0.709	0.044	0.003	0.272	0.310	0.011	246	2242	78	0.075	226	156	3.1	122	198
	Max	8.7	24.0	14	136	8.0	130.0	268.0	1.530	0.050	0.017	0.356	0.378	0.026	618	3497	114	0.237	680	490	3.8	122	220
	StDev	0.3	4.6	1	13	1.8	23.6	45.6	0.237	0.013	0.002	0.078	0.083	0.004	97	777	24	0.035	128	92	1.0	9	66
	95% C.I.	0.1	1.0	0	4	0.5	5.4	9.9	0.064	0.003	0.001	0.017	0.018	0.001	21	174	5	0.008	36	25	0.2	5	53
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.2			0.167	0.015	7			0.026	50	550		100	120
	%compliance	100	82	94	89	46	75	68	64	100			76	99	5			73	50	100		100	67
	N	35	76	47	47	50	75	81	53	80	47	79	80	81	80	77	78	81	48	53	75	10	6

SiteID		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Waitio Stream at Ohiti Rd	Average		14.7	9	90	3.1	1.1	2.0	0.447	0.014	0.004	0.199	0.217	0.021	11	13	1	0.037	141	79	2.0	108	67
	Min		11.5	7	63	1.2	0.5	0.5	0.000	0.003	0.001	0.004	0.009	0.002	1	0	0	0.008	23	1	0.5	96	1
	5%ile		12.6	7	66	1.4	0.5	0.5	0.194	0.003	0.001	0.035	0.044	0.006	4	2	0	0.014	26	11	0.6	96	2
ALL DATA	10%ile		13.0	7	70	1.4	0.6	1.0	0.218	0.003	0.002	0.047	0.056	0.007	4	3	0	0.016	29	16	0.6	97	2
	25%ile		13.3	8	82	2.3	0.7	1.5	0.265	0.005	0.003	0.083	0.107	0.010	7	5	0	0.021	50	23	1.0	103	5
	Median		14.5	9	91	3.1	0.9	1.5	0.427	0.005	0.003	0.120	0.144	0.016	10	8	1	0.027	95	59	2.1	107	14
	75%ile		16.5	10	100	4.0	1.3	1.8	0.560	0.015	0.004	0.282	0.301	0.030	13	16	2	0.048	147	94	3.1	111	103
	90%ile		17.1	10	105	4.9	1.8	4.0	0.794	0.028	0.007	0.482	0.495	0.044	18	35	3	0.057	331	145	3.4	118	185
	95%ile		17.4	11	112	5.0	2.0	5.1	0.810	0.036	0.007	0.604	0.620	0.048	21	43	4	0.061	408	184	3.6	122	213
	Max		18.0	13	121	5.1	3.2	9.0	0.839	0.100	0.014	0.640	0.650	0.051	54	45	4	0.257	750	541	4.3	126	240
	StDev		1.7	1	14	1.2	0.6	1.6	0.215	0.021	0.003	0.179	0.177	0.014	8	13	1	0.039	152	96	1.1	10	98
	95% C.I.		0.5	0	4	0.4	0.2	0.5	0.068	0.007	0.001	0.056	0.056	0.005	3	4	0	0.012	51	30	0.4	7	78
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.2			0.167	0.015	7			0.026	50	550		100	120
	%compliance		100	82	79	85	100	100	31	100			56	46	26			46	26	100		71	67
	N	0	39	39	39	39	33	39	39	39	39	39	39	39	39	39	39	39	34	39	38	7	6

Ngaruroro at Fernhill	Average	7.9	14.9	10	97	1.7	14.2	25.0	0.302	0.016	0.002	0.109	0.128	0.005	49	436	16	0.048	98	65	1.4	116	95
	Min	6.9	7.0	8	71	0.1	0.2	0.5	0.053	0.002	0.001	0.002	0.003	0.001	1	2	0	0.001	7	1	0.2	99	39
	5%ile	7.4	8.3	8	77	0.1	0.7	1.0	0.082	0.003	0.001	0.010	0.020	0.001	4	6	1	0.002	12	1	0.4	100	42
ALL DATA	10%ile	7.5	9.0	8	82	0.2	0.8	1.5	0.109	0.004	0.001	0.020	0.031	0.001	9	27	1	0.003	13	5	0.5	103	45
	25%ile	7.7	10.5	9	91	0.4	1.2	2.0	0.141	0.005	0.001	0.041	0.054	0.001	15	65	2	0.008	25	12	0.6	110	64
	Median	7.8	15.0	10	97	1.4	3.2	5.0	0.278	0.010	0.003	0.073	0.090	0.004	26	143	5	0.015	56	36	1.0	112	106
	75%ile	8.0	19.0	11	104	2.8	16.0	22.8	0.427	0.022	0.003	0.150	0.164	0.007	58	520	20	0.037	108	71	2.0	123	125
	90%ile	8.3	21.0	11	109	3.6	36.7	69.5	0.536	0.031	0.003	0.223	0.288	0.012	90	1430	41	0.062	265	188	3.0	133	135
	95%ile	8.4	21.5	12	118	4.7	61.7	124.4	0.639	0.034	0.005	0.342	0.356	0.014	145	1703	63	0.075	398	285	3.2	136	138
	Max	9.0	25.0	15	132	5.8	140.0	334.0	0.774	0.090	0.024	0.490	0.519	0.018	519	2497	143	1.700	580	460	5.3	138	140
	StDev	0.4	4.5	1	12	1.5	26.1	49.7	0.183	0.016	0.003	0.100	0.105	0.004	73	601	25	0.191	129	95	1.0	12	41
	95% C.I.	0.1	1.0	0	3	0.4	6.0	11.0	0.050	0.004	0.001	0.022	0.023	0.001	16	133	6	0.042	37	26	0.2	6	33
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.2			0.167	0.015	7			0.026	50	550		100	120
	%compliance	100	76	96	90	41	74	64	55	100			76	97	9			68	48	100		93	67
	N	36	85	56	52	51	73	78	51	78	45	77	78	78	77	78	78	79	46	51	73	14	6

SiteID		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Tutaekuri-Waimate stream u/s Ngaruroro river Chesterhope	Average		14.5	8	80	1.6	4.2	9.9	0.634	0.024	0.004	0.189	0.218	0.024	11	93	9	0.074	128	88	2.2		
	Min		10.9	5.4	53	0.4	0.5	0.5	0.102	0.003	0.001	0.001	0.012	0.004	1	2	1	0.009	28	20	0.3		
	5%ile		12.1	5.7	57	0.4	0.7	1.0	0.111	0.003	0.001	0.009	0.025	0.006	1	6	2	0.020	48	33	0.7		
	10%ile		12.5	6.3	62	0.4	0.8	1.4	0.121	0.004	0.001	0.015	0.028	0.008	1	7	2	0.021	54	40	0.7		
	25%ile		12.6	6.8	64	0.7	1.4	3.0	0.312	0.005	0.003	0.026	0.040	0.014	3	11	4	0.029	78	60	1.0		
	Median		14.4	8.0	75	1.1	2.3	5.5	0.549	0.022	0.004	0.184	0.208	0.023	9	53	7	0.040	120	82	2.4		
ALL DATA	75%ile		16.0	9.9	96	2.4	4.6	10.8	0.715	0.038	0.006	0.315	0.344	0.035	13	135	10	0.062	150	108	3.0		
	90%ile		17.5	10.2	105	3.3	12.0	29.0	0.800	0.050	0.008	0.396	0.449	0.038	22	258	23	0.085	241	134	4.0		
	95%ile		17.6	10.7	107	3.4	13.5	32.5	1.212	0.061	0.008	0.509	0.560	0.040	28	280	25	0.104	260	154	4.1		
	Max		19.6	11.8	111	4.0	19.3	57.0	4.300	0.080	0.010	0.547	0.635	0.046	48	446	33	1.100	270	240	4.2		
	StDev		2.0	1.7	18	1.1	4.5	12.2	0.724	0.021	0.002	0.160	0.177	0.012	10	109	8	0.173	68	45	1.2		
	95% C.I.		0.6	0.5	6	0.3	1.6	3.9	0.233	0.007	0.001	0.051	0.056	0.004	3	35	3	0.055	23	14	0.4		
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	150	550		100	120
	%compliance		100	50	39	38	97	74	59	100			42	29	39			34	76	100			
	N	0	38	38	38	37	32	38	37	38	38	38	38	38	38	38	38	38	33	38	38	0	0

Ngaruroro River at Carrick Rd	Average		14.2	10	95	1.7	11.4	18.2	0.486	0.009	0.002	0.104	0.117	0.005	34	368	15	0.024	91	60	2.0	110	107
	Min		6.6	7	73	0.1	0.5	0.5	0.105	0.003	0.001	0.004	0.015	0.001	3	3	0	0.002	5	1	0.3	93	49
	5%ile		8.3	8	79	0.1	0.6	1.4	0.109	0.003	0.001	0.008	0.017	0.001	4	7	1	0.002	10	3	0.5	96	51
ALL DATA	10%ile		8.7	8	81	0.2	0.6	1.5	0.123	0.003	0.001	0.009	0.022	0.001	6	15	1	0.003	17	10	0.6	98	52
	25%ile		10.0	9	88	0.4	0.9	1.5	0.220	0.005	0.001	0.028	0.036	0.002	11	37	1	0.006	28	16	0.6	102	57
	Median		13.3	9	94	1.4	2.3	2.0	0.305	0.005	0.001	0.067	0.080	0.004	22	115	5	0.010	49	33	1.8	107	78
	75%ile		18.7	10	100	2.9	7.2	15.0	0.468	0.010	0.003	0.165	0.175	0.008	43	363	19	0.030	110	71	2.9	116	162
	90%ile		20.0	11	112	4.2	31.9	54.4	0.665	0.013	0.003	0.214	0.226	0.012	73	957	39	0.067	170	122	3.2	123	179
	95%ile		20.2	13	116	4.4	52.0	94.8	1.511	0.019	0.003	0.294	0.306	0.013	86	1258	56	0.082	266	184	3.3	130	184
	Max		21.6	15	136	4.9	100.0	168.0	3.120	0.070	0.007	0.362	0.373	0.016	142	2417	107	0.140	540	480	11.2	136	190
	StDev		4.4	1	13	1.4	21.9	35.4	0.621	0.012	0.001	0.095	0.095	0.004	33	562	22	0.032	106	85	1.9	13	64
	95% C.I.		1.4	0	4	0.4	7.6	11.4	0.203	0.004	0.000	0.030	0.030	0.001	10	179	7	0.010	36	27	0.6	9	56
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	100	550		100	120
	%compliance		100	95	92	44	78	73	89	100			74	97	13			76	70	100		88	60
	N	0	39	39	39	39	32	37	36	38	38	38	38	38	38	38	38	38	33	37	38	8	5

SiteID		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro River at Motorway Bridge	Average		14.2	10	95	1.7	10.5	16.3	0.497	0.009	0.003	0.107	0.122	0.005	58	408	16	0.024	86	53	1.9	110	92
	Min		6.5	7	67	0.1	0.5	0.5	0.102	0.003	0.001	0.001	0.012	0.001	4	4	0	0.002	4	1	0.5	94	40
	5%ile		8.5	8	73	0.1	0.6	1.0	0.109	0.003	0.001	0.008	0.019	0.001	5	10	1	0.002	9	5	0.5	95	41
	10%ile		8.8	8	79	0.2	0.6	1.4	0.111	0.003	0.001	0.010	0.025	0.001	6	19	1	0.003	12	6	0.6	96	41
	25%ile		10.2	9	88	0.5	1.0	1.5	0.156	0.005	0.001	0.033	0.044	0.002	14	45	2	0.007	33	15	0.9	101	43
	Median		13.8	10	91	1.4	2.2	2.0	0.286	0.005	0.001	0.070	0.084	0.004	23	115	4	0.010	61	40	1.7	105	48
ALL DATA	75%ile		18.1	10	100	2.2	5.4	12.3	0.443	0.011	0.003	0.153	0.164	0.008	45	568	16	0.018	119	63	2.8	120	72
	90%ile		19.3	12	115	3.6	33.0	59.3	0.601	0.022	0.003	0.264	0.275	0.011	115	1293	48	0.066	164	116	3.3	126	184
	95%ile		21.2	12	117	5.1	52.9	84.4	1.143	0.031	0.006	0.333	0.366	0.012	150	1522	59	0.084	226	132	3.5	131	222
	Max		22.5	13	123	5.6	92.0	149.0	5.064	0.036	0.046	0.362	0.373	0.016	732	2649	112	0.220	390	270	3.9	136	259
	StDev		4.3	1	13	1.5	20.6	32.5	0.880	0.009	0.007	0.101	0.102	0.004	121	618	25	0.040	84	57	1.1	14	94
	95% C.I.		1.3	0	4	0.5	7.0	10.3	0.280	0.003	0.002	0.032	0.032	0.001	38	194	8	0.013	28	18	0.3	10	82
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	100	550		100	120
	%compliance		100	95	88	43	82	74	89	100			74	97	15			82	68	100		75	80
	N	0	40	40	40	40	33	38	38	39	39	39	39	39	39	39	39	39	34	39	39	8	5

Ngaruroro River u/s Hawke's Bay Dairies	Average		13.7	10	97	2.6	16.5	24.9	0.281	0.020	0.002	0.047	0.070	0.003	45	196	10	0.040	30	15	1.1	114	66
	Min		6.6	8	76	0.1	0.4	0.5	0.110	0.003	0.001	0.008	0.020	0.001	2	16	1	0.002	3	1	0.3	99	13
	5%ile		7.3	8	81	0.2	0.5	0.9	0.112	0.003	0.001	0.011	0.022	0.001	4	24	1	0.002	3	1	0.3	102	14
	10%ile		8.1	8	86	0.5	0.6	1.0	0.115	0.005	0.001	0.013	0.024	0.001	6	25	1	0.003	5	1	0.3	105	15
	25%ile		9.7	9	89	1.0	0.7	1.5	0.137	0.005	0.001	0.018	0.033	0.002	10	44	2	0.004	6	3	0.5	114	18
ALL DATA	Median		12.9	10	95	2.4	1.0	1.5	0.176	0.005	0.001	0.038	0.055	0.002	18	100	4	0.007	10	6	0.7	115	30
	75%ile		17.9	11	105	4.1	1.8	2.0	0.351	0.010	0.003	0.059	0.071	0.005	44	276	10	0.014	29	17	1.2	120	90
	90%ile		19.1	12	111	5.2	13.4	18.3	0.641	0.020	0.003	0.084	0.118	0.008	120	497	17	0.029	68	41	2.6	122	144
	95%ile		20.1	13	114	5.5	22.3	27.3	0.698	0.023	0.003	0.136	0.170	0.009	137	697	39	0.098	107	52	2.9	122	162
	Max		20.5	13	129	6.1	437.0	757.0	0.960	0.453	0.004	0.170	0.456	0.011	384	1098	75	0.590	240	94	4.0	123	180
	StDev		4.4	1	11	1.8	75.7	122.4	0.210	0.071	0.001	0.038	0.075	0.003	69	257	16	0.130	47	20	0.9	9	71
	95% C.I.		1.4	0	4	0.6	25.8	38.9	0.066	0.022	0.000	0.012	0.023	0.001	22	81	5	0.041	16	6	0.3	8	62
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.2			0.167	0.015	7			0.026	50	550		100	120
	%compliance		90	97	94	60	91	84	67	97			92	100	15			85	82	100		80	80
	N	0	39	36	35	35	33	38	39	39	39	39	39	39	39	39	39	39	34	39	39	5	5

SiteID		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro River d/s Hawke's Bay Dairies	Average		14.3	10	96	2.4	21.6	31.2	0.345	0.010	0.002	0.093	0.105	0.005	37	331	18	0.026	57	28	1.7	112	102
	Min		6.5	8	79	0.1	0.5	0.5	0.126	0.003	0.001	0.013	0.028	0.001	4	23	1	0.002	3	1	0.3	99	30
	5%ile		8.5	8	81	0.2	0.5	0.5	0.140	0.003	0.001	0.025	0.032	0.001	7	41	1	0.003	7	1	0.4	101	33
	10%ile		8.8	8	83	0.5	0.6	0.8	0.148	0.004	0.001	0.031	0.039	0.001	10	44	1	0.003	10	1	0.5	103	36
	25%ile		10.3	9	89	1.1	0.8	1.5	0.192	0.005	0.001	0.047	0.058	0.002	15	90	2	0.004	18	6	0.7	109	44
	Median		13.9	10	98	2.1	1.4	1.5	0.245	0.005	0.002	0.082	0.096	0.004	24	162	6	0.009	34	14	1.2	113	90
ALL DATA	75%ile		18.0	11	102	3.4	3.0	5.0	0.414	0.012	0.003	0.116	0.133	0.007	50	361	15	0.014	65	32	2.4	116	148
	90%ile		20.6	11	107	5.0	25.5	43.5	0.614	0.020	0.003	0.164	0.180	0.010	77	679	35	0.036	150	62	3.1	121	179
	95%ile		21.0	11	109	5.6	44.1	68.5	0.825	0.023	0.003	0.209	0.219	0.010	97	1201	84	0.058	180	112	4.0	122	190
	Max		21.3	12	119	5.9	474.0	791.0	1.440	0.040	0.003	0.348	0.360	0.015	162	2378	165	0.459	360	137	6.8	124	200
	StDev		4.4	1	10	1.7	86.3	131.7	0.265	0.008	0.001	0.069	0.070	0.004	34	468	35	0.076	73	34	1.5	10	78
	95% C.I.		1.4	0	3	0.6	30.9	43.0	0.087	0.003	0.000	0.022	0.023	0.001	11	153	12	0.025	26	11	0.5	10	77
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.2			0.167	0.015	7			0.026	50	550		100	120
	%compliance		83	88	97	55	83	78	58	100			86	100	8			83	71	100		75	50
	N	0	36	32	32	31	30	36	36	36	36	36	36	36	36	36	36	36	31	36	36	4	4

Ngaruroro at Chesterhope	Average	8.2	15.8	10	105	1.4	22.7		0.186	0.004		0.091	0.096	0.008	13	689	60	0.047				101	
	Min	7.7	7.6	9	93	0.0	0.3		0.032	0.000		0.000	0.002	0.001	0	0	0	0.005				91	
	5%ile	7.8	8.7	9	96	0.1	0.6		0.046	0.001		0.001	0.003	0.003	1	2	2	0.008				92	
ALL DATA	10%ile	7.8	9.3	9	97	0.2	0.8		0.062	0.001		0.002	0.005	0.003	1	3	3	0.008				92	
	25%ile	7.9	11.3	10	99	0.4	1.3		0.083	0.002		0.012	0.015	0.005	3	13	5	0.012				94	
	Median	8.1	15.8	10	103	1.1	3.2		0.129	0.003		0.064	0.070	0.007	10	157	13	0.016				100	
	75%ile	8.4	20.0	11	109	2.1	8.6		0.218	0.005		0.137	0.142	0.008	19	541	28	0.023				103	
	90%ile	8.7	22.6	12	115	3.2	38.8		0.322	0.007		0.205	0.220	0.011	27	1025	53	0.070				109	
	95%ile	8.8	23.7	12	119	4.0	79.0		0.551	0.010		0.302	0.305	0.014	36	2450	107	0.154				116	
	Max	9.3	27.3	14	139	5.6	608.0		1.303	0.024		0.489	0.513	0.061	101	25364	3961	0.780				124	
	StDev	0.3	4.9	1	8	1.3	76.6		0.183	0.004		0.094	0.096	0.007	12	2359	328	0.120				9	
	95% C.I.	0.1	0.7	0	1	0.2	11.6		0.028	0.001		0.014	0.015	0.001	2	362	50	0.018				5	
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015				0.033				100	
	%compliance	100	93	100	100	33	82		97	100			99	95				83				58	
	N	167	172	172	172	172	169	0	161	163	0	169	163	169	163	163	169	167	0	0	0	12	0

SiteID		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro at Kuripapango	Average	7.8	10.6	11	99	5.1	3.2		0.064	0.003		0.009	0.011	0.002	6	26	4	0.009				116	
	Min	7.2	3.3	8	90	0.0	0.1		0.012	0.000		0.000	0.000	0.000	1	0	0	0.001				104	
	5%ile	7.5	4.6	9	97	0.4	0.2		0.023	0.001		0.002	0.002	0.001	2	1	0	0.002				106	
ALL DATA	10%ile	7.6	5.3	9	97	0.9	0.3		0.026	0.001		0.002	0.003	0.001	2	2	0	0.002				108	
	25%ile	7.7	6.8	10	99	3.1	0.3		0.035	0.001		0.003	0.005	0.001	3	3	1	0.003				112	
	50%ile (median)	7.8	10.1	10	100	5.0	0.6		0.047	0.002		0.005	0.008	0.002	5	7	2	0.004				116	
	75%ile	7.9	13.9	11	100	6.9	1.2		0.080	0.003		0.010	0.013	0.003	7	19	3	0.005				120	
	90%ile	8.0	16.7	12	101	8.5	3.6		0.104	0.005		0.025	0.028	0.003	11	56	8	0.011				125	
	95%ile	8.1	17.9	12	102	9.4	12.0		0.134	0.006		0.031	0.034	0.004	14	108	14	0.021				127	
	Max	8.7	20.6	13	103	14.4	150.0		0.502	0.009		0.049	0.053	0.006	28	784	104	0.289				130	
	StDev	0.2	4.3	1	2	2.9	14.6		0.057	0.002		0.010	0.010	0.001	4	72	9	0.027				8	
	95% C.I.	0.0	0.6	0	0	0.4	2.2		0.009	0.000		0.001	0.002	0.000	1	11	1	0.004				4	
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.2			0.167	0.015				0.026				120	
	%compliance	100	97	100	100	87	97		98	100			100	100				96				27	
	N. of Samples	168	172	171	171	171	170	0	164	166	0	172	166	172	166	166	166	170	0	0	0	11	0

Appendix B: Summary of data – river flows under 3* median flow (<3*med)

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro at Whanawhana	Average	7.8	12.7	10	96	3.0	3.1	5.3	0.300	0.015	0.003	0.040	0.038	0.057	0.002	43	133	5	0.016	12	7	128	99
	Min	7.2	6.0	7	60	0.2	0.0	0.5	0.040	0.002	0.001	0.002	0.002	0.003	0.001	2	3	1	0.001	0	0	112	2
	5%ile	7.3	6.6	8	74	0.3	0.3	0.5	0.060	0.003	0.001	0.006	0.006	0.017	0.001	6	13	1	0.002	1	0	113	2
	10%ile	7.5	7.0	8	81	0.4	0.4	0.5	0.090	0.005	0.001	0.008	0.007	0.019	0.001	8	25	1	0.002	1	0	113	3
	25%ile	7.7	9.0	9	92	1.3	0.5	1.5	0.108	0.005	0.001	0.017	0.016	0.028	0.001	12	42	2	0.003	3	1	117	6
<3*median	Median	7.8	12.5	10	98	2.8	1.0	2.0	0.141	0.010	0.003	0.030	0.032	0.046	0.002	24	81	3	0.005	7	3	129	53
	75%ile	7.9	16.1	11	101	4.8	2.9	5.0	0.313	0.021	0.003	0.048	0.051	0.072	0.003	47	167	6	0.011	15	10	140	113
	90%ile	8.1	18.5	13	109	6.6	6.1	12.1	0.519	0.029	0.006	0.079	0.075	0.111	0.005	93	334	11	0.018	35	19	142	241
	95%ile	8.2	19.0	14	119	6.9	12.8	14.4	0.701	0.036	0.010	0.100	0.081	0.119	0.007	116	452	13	0.022	41	28	144	301
	Max	8.5	20.0	15	125	7.2	37.0	64.0	3.752	0.110	0.021	0.230	0.230	0.249	0.010	498	534	41	0.610	50	36	147	361
	StDev	0.3	4.1	2	13	2.2	5.5	10.3	0.561	0.015	0.004	0.039	0.037	0.045	0.002	65	135	6	0.070	13	9	13	138
	95% C.I.	0.1	0.9	1	4	0.6	1.3	2.3	0.160	0.003	0.001	0.009	0.011	0.010	0.000	15	31	1	0.016	4	3	7	110
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35				0.167	0.015	7			0.026	50	550	120	120
	%compliance	100	96	94	90	65	97	89	72	100				96	100	8			95	100	100	64	83
	N. Samples	33	80	49	49	49	71	74	47	74	43	73	46	74	75	74	74	75	75	42	47	14	6
Ngaruroro at Ohiti	Average	7.9	14.8	10	94	2.3	8.8	13.8	0.306	0.016	0.002	0.102	0.106	0.121	0.004	78	348	8	0.018	88	58	109	107
	Min	7.2	7.2	6	67	0.2	0.2	0.5	0.065	0.002	0.001	0.002	0.013	0.003	0.001	2	3	1	0.001	10	2	100	31
	5%ile	7.4	8.0	8	70	0.3	0.4	1.0	0.103	0.003	0.001	0.023	0.024	0.038	0.001	6	24	1	0.002	15	4	101	38
	10%ile	7.5	9.0	8	81	0.6	0.6	1.0	0.130	0.003	0.001	0.032	0.033	0.049	0.001	13	34	1	0.003	20	7	102	45
<3*median	25%ile	7.7	11.0	9	89	1.1	1.1	1.5	0.156	0.005	0.001	0.052	0.052	0.065	0.001	22	85	1	0.006	30	14	105	66
	Median	7.8	15.0	10	94	1.8	2.4	3.2	0.235	0.012	0.003	0.085	0.084	0.094	0.002	39	144	4	0.008	49	28	107	90
	75%ile	8.0	18.1	10	102	3.1	6.1	10.0	0.360	0.020	0.003	0.130	0.134	0.159	0.004	85	331	8	0.017	76	54	113	130
	90%ile	8.2	20.8	11	106	5.0	21.7	24.9	0.490	0.031	0.003	0.187	0.190	0.220	0.008	188	968	20	0.044	150	102	120	184
	95%ile	8.4	21.0	12	109	5.5	39.3	51.0	0.720	0.044	0.003	0.223	0.230	0.261	0.009	273	1482	40	0.053	240	164	120	202
	Max	8.7	24.0	13	119	8.0	130.0	268.0	1.530	0.050	0.003	0.356	0.358	0.378	0.026	618	2002	83	0.237	680	490	121	220
	StDev	0.3	4.4	1	11	1.8	18.5	36.0	0.253	0.013	0.001	0.070	0.074	0.077	0.004	104	466	14	0.031	137	99	8	73
	95% C.I.	0.1	1.1	0	4	0.5	4.5	8.6	0.074	0.003	0.000	0.017	0.022	0.019	0.001	25	112	3	0.007	42	29	6	64
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35				0.167	0.015	7			0.026	50	550	120	120
	%compliance	100	80	93	90	54	83	78	67	100				79	99	6			84	51	100	14	60
	N. Samples	30	64	40	39	41	64	68	45	67	39	66	42	67	68	67	67	68	68	41	44	7	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Waitio Stream at Ohiti Rd	Average		14.7	9	90	3.1	1.1	2.0	0.447	0.014	0.004	0.199	0.201	0.217	0.021	11	13	1	0.037	141	79	108	67
	Min		11.5	7	63	1.2	0.5	0.5	0.000	0.003	0.001	0.004	0.007	0.009	0.002	1	0	0	0.008	23	1	96	1
	5%ile		12.6	7	66	1.4	0.5	0.5	0.194	0.003	0.001	0.035	0.037	0.044	0.006	4	2	0	0.014	26	11	96	2
	10%ile		13.0	7	70	1.4	0.6	1.0	0.218	0.003	0.002	0.047	0.047	0.056	0.007	4	3	0	0.016	29	16	97	2
	25%ile		13.3	8	82	2.3	0.7	1.5	0.265	0.005	0.003	0.083	0.085	0.107	0.010	7	5	0	0.021	50	23	103	5
<3*median	Median		14.5	9	91	3.1	0.9	1.5	0.427	0.005	0.003	0.120	0.122	0.144	0.016	10	8	1	0.027	95	59	107	14
	75%ile		16.5	10	100	4.0	1.3	1.8	0.560	0.015	0.004	0.282	0.286	0.301	0.030	13	16	2	0.048	147	94	111	103
	90%ile		17.1	10	105	4.9	1.8	4.0	0.794	0.028	0.007	0.482	0.485	0.495	0.044	18	35	3	0.057	331	145	118	185
	95%ile		17.4	11	112	5.0	2.0	5.1	0.810	0.036	0.007	0.604	0.610	0.620	0.048	21	43	4	0.061	408	184	122	213
	Max		18.0	13	121	5.1	3.2	9.0	0.839	0.100	0.014	0.640	0.640	0.650	0.051	54	45	4	0.257	750	541	126	240
	StDev		1.7	1	14	1.2	0.6	1.6	0.215	0.021	0.003	0.179	0.179	0.177	0.014	8	13	1	0.039	152	96	10	98
	95% C.I.		0.5	0	4	0.4	0.2	0.5	0.068	0.007	0.001	0.056	0.056	0.056	0.005	3	4	0	0.012	51	30	7	78
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35				0.167	0.015	7			0.026	50	550	120	120
	%compliance		100	82	79	85	100	100	31	100				56	46	26			46	26	100	14	67
	N. Samples	0	39	39	39	39	33	39	39	39	39	39	39	39	39	39	39	39	39	34	39	7	6

Ngaruroro at Fernhill	Average	7.9	15.0	10	96	1.8	8.4	16.0	0.297	0.016	0.002	0.105	0.106	0.123	0.005	50	335	12	0.045	91	60	116	95
	Min	7.4	7.0	8	71	0.1	0.2	0.5	0.053	0.002	0.001	0.002	0.003	0.003	0.001	1	2	0	0.001	7	1	99	39
	5%ile	7.5	8.3	8	77	0.1	0.6	1.0	0.079	0.003	0.001	0.010	0.010	0.020	0.001	4	6	1	0.002	12	1	100	42
	10%ile	7.5	9.0	8	81	0.2	0.8	1.5	0.101	0.005	0.001	0.020	0.020	0.030	0.001	8	25	1	0.003	13	4	103	45
	25%ile	7.7	10.5	9	88	0.6	1.1	1.5	0.138	0.005	0.001	0.038	0.038	0.052	0.001	15	57	2	0.008	25	11	110	64
<3*median	Median	7.8	15.3	10	96	1.5	2.9	4.0	0.275	0.010	0.001	0.069	0.075	0.086	0.005	26	127	5	0.014	47	32	112	106
	75%ile	8.1	19.0	11	104	3.0	8.0	17.0	0.397	0.022	0.003	0.148	0.148	0.159	0.006	59	327	14	0.030	94	54	123	125
	90%ile	8.3	21.0	11	109	3.8	30.8	50.3	0.538	0.032	0.003	0.205	0.201	0.270	0.012	90	943	32	0.053	248	136	133	135
	95%ile	8.5	21.5	12	116	4.8	36.4	70.3	0.651	0.036	0.004	0.345	0.303	0.364	0.013	146	1440	46	0.067	393	265	136	138
	Max	9.0	25.0	12	119	5.8	47.5	150.0	0.774	0.090	0.005	0.490	0.400	0.519	0.016	519	2259	88	1.700	580	460	138	140
	StDev	0.4	4.6	1	11	1.5	12.0	27.0	0.186	0.016	0.001	0.101	0.094	0.106	0.004	76	488	16	0.197	127	93	12	41
	95% C.I.	0.1	1.0	0	3	0.4	2.9	6.2	0.053	0.004	0.000	0.023	0.028	0.025	0.001	18	113	4	0.045	38	27	6	33
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35				0.167	0.015	7			0.026	50	550	120	120
	%compliance	100	76	96	90	44	81	69	57	100				78	99	10			73	52	100	29	67
	N. Samples	34	80	52	48	48	67	72	47	72	41	71	44	72	72	71	72	72	73	42	47	14	6

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Tutaekuri-Waimate stream at Chesterhope	Average		14.5	8	80	1.6	4.2	9.9	0.634	0.024	0.004	0.189	0.193	0.218	0.024	11	93	9	0.074	128	88		
	Min		10.9	5	53	0.4	0.5	0.5	0.102	0.003	0.001	0.001	0.001	0.012	0.004	1	2	1	0.009	28	20		
	5%ile		12.1	6	57	0.4	0.7	1.0	0.111	0.003	0.001	0.009	0.011	0.025	0.006	1	6	2	0.020	48	33		
	10%ile		12.5	6	62	0.4	0.8	1.4	0.121	0.004	0.001	0.015	0.015	0.028	0.008	1	7	2	0.021	54	40		
	25%ile		12.6	7	64	0.7	1.4	3.0	0.312	0.005	0.003	0.026	0.028	0.040	0.014	3	11	4	0.029	78	60		
<3*median	Median		14.4	8	75	1.1	2.3	5.5	0.549	0.022	0.004	0.184	0.191	0.208	0.023	9	53	7	0.040	120	82		
	75%ile		16.0	10	96	2.4	4.6	10.8	0.715	0.038	0.006	0.315	0.321	0.344	0.035	13	135	10	0.062	150	108		
	90%ile		17.5	10	105	3.3	12.0	29.0	0.800	0.050	0.008	0.396	0.404	0.449	0.038	22	258	23	0.085	241	134		
	95%ile		17.6	11	107	3.4	13.5	32.5	1.212	0.061	0.008	0.509	0.517	0.560	0.040	28	280	25	0.104	260	154		
	Max		19.6	12	111	4.0	19.3	57.0	4.300	0.080	0.010	0.547	0.555	0.635	0.046	48	446	33	1.100	270	240		
	StDev		2.0	2	18	1.1	4.5	12.2	0.724	0.021	0.002	0.160	0.162	0.177	0.012	10	109	8	0.173	68	45		
	95% C.I.		0.6	1	6	0.3	1.6	3.9	0.233	0.007	0.001	0.051	0.052	0.056	0.004	3	35	3	0.055	23	14		
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2				0.444	0.015	7			0.033	150	550	100	120
	%compliance		100	50	39	38	97	74	59	100				42	29	39			34	76	100		
	N. Samples	0	38	38	38	37	32	38	37	38	38	38	38	38	38	38	38	38	38	33	38	0	0

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro River at Carrick Rd	Average		14.4	10	94	1.8	7.8	13.1	0.487	0.009	0.002	0.100	0.101	0.113	0.005	34	297	12	0.020	86	56	110	107
	Min		6.6	7	73	0.1	0.5	0.5	0.105	0.003	0.001	0.004	0.005	0.015	0.001	3	3	0	0.002	5	1	93	49
	5%ile		8.2	8	78	0.1	0.6	1.4	0.109	0.003	0.001	0.008	0.008	0.017	0.001	4	7	1	0.002	10	3	96	51
	10%ile		8.6	8	81	0.2	0.6	1.5	0.122	0.003	0.001	0.009	0.011	0.021	0.001	6	15	1	0.003	17	10	98	52
	25%ile		11.0	9	88	0.6	0.8	1.5	0.215	0.005	0.001	0.026	0.026	0.036	0.002	10	35	1	0.006	27	16	102	57
<3*median	Median		14.2	9	94	1.5	2.0	2.0	0.286	0.005	0.001	0.064	0.065	0.077	0.004	21	107	5	0.009	49	32	107	78
	75%ile		19.0	10	98	2.9	5.0	8.5	0.460	0.010	0.003	0.156	0.158	0.168	0.007	45	302	18	0.018	104	62	116	162
	90%ile		20.0	11	109	4.2	20.3	42.0	0.706	0.014	0.003	0.194	0.196	0.206	0.012	74	902	36	0.051	168	113	123	179
	95%ile		20.3	11	115	4.4	36.2	73.0	1.653	0.021	0.003	0.280	0.282	0.292	0.013	91	1074	44	0.067	230	146	130	184
	Max		21.6	13	119	4.9	67.1	98.0	3.120	0.070	0.007	0.362	0.363	0.373	0.016	142	2122	57	0.140	540	480	136	190
	StDev		4.4	1	11	1.4	14.6	24.9	0.640	0.012	0.001	0.093	0.093	0.093	0.004	34	449	16	0.028	105	85	13	64
	95% C.I.		1.4	0	3	0.5	5.2	8.2	0.215	0.004	0.000	0.030	0.030	0.030	0.001	11	147	5	0.009	37	28	9	56
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2				0.444	0.015	7			0.033	100	550	100	120
	%compliance		100	95	92	46	83	77	88	100				75	97	14			81	74	100	88	60
	N. Samples	0	37	37	37	37	30	35	34	36	36	36	36	36	36	36	36	36	36	31	35	8	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro River at Motorway Bridge	Average		15.0	10	95	2.0	2.9	4.1	0.512	0.010	0.003	0.088	0.090	0.104	0.004	63	208	8	0.016	89	54	110	92
	Min		8.5	7	67	0.3	0.5	0.5	0.102	0.003	0.001	0.001	0.001	0.012	0.001	4	4	0	0.002	4	1	94	40
	5%ile		8.7	8	73	0.4	0.6	1.0	0.108	0.003	0.001	0.006	0.006	0.018	0.001	5	9	1	0.002	9	4	95	41
	10%ile		9.5	8	79	0.5	0.6	1.1	0.110	0.003	0.001	0.009	0.010	0.023	0.001	5	18	1	0.003	10	6	96	41
	25%ile		11.6	9	88	1.0	0.9	1.5	0.141	0.005	0.001	0.020	0.021	0.035	0.002	11	26	1	0.007	36	15	101	43
<3*median	Median		15.7	9	91	1.6	1.7	1.5	0.267	0.005	0.001	0.054	0.055	0.065	0.002	21	76	3	0.009	61	41	105	48
	75%ile		18.7	10	101	2.7	3.3	4.3	0.420	0.011	0.003	0.120	0.120	0.146	0.006	70	206	5	0.012	120	64	120	72
	90%ile		19.4	11	116	4.3	5.9	13.3	0.668	0.028	0.003	0.203	0.205	0.215	0.011	122	577	16	0.019	167	116	126	184
	95%ile		21.4	12	119	5.1	10.4	16.5	1.633	0.032	0.007	0.289	0.289	0.310	0.011	185	822	39	0.024	266	162	131	222
	Max		22.5	12	123	5.6	16.0	17.0	5.064	0.036	0.046	0.362	0.363	0.373	0.014	732	1467	55	0.220	390	270	136	259
	StDev		4.1	1	14	1.5	3.5	4.9	0.944	0.010	0.008	0.092	0.092	0.093	0.004	131	328	13	0.037	89	60	14	94
	95% C.I.		1.4	0	5	0.5	1.3	1.7	0.322	0.003	0.003	0.031	0.031	0.032	0.001	45	112	4	0.013	32	20	10	82
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2				0.444	0.015	7			0.033	100	550	100	120
	%compliance		100	94	88	50	96	88	88	100				85	100	18			97	66	100	75	80
	N. Samples	0	34	34	34	34	28	32	33	33	33	33	33	33	33	33	33	33	33	29	33	8	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro River u/s Hawke's Bay Dairies	Average		14.1	10	97	2.8	2.3	3.3	0.261	0.021	0.002	0.045	0.045	0.069	0.003	44	137	7	0.025	21	13	114	66
	Min		6.6	8	76	0.2	0.4	0.5	0.110	0.003	0.001	0.008	0.002	0.020	0.001	2	16	1	0.002	3	1	99	13
	5%ile		7.3	8	81	0.7	0.5	0.9	0.112	0.003	0.001	0.011	0.011	0.022	0.001	4	23	1	0.002	3	1	102	14
	10%ile		8.1	8	85	0.9	0.6	1.0	0.115	0.005	0.001	0.013	0.013	0.024	0.001	5	25	1	0.003	5	1	105	15
	25%ile		10.8	9	89	1.5	0.7	1.5	0.135	0.005	0.001	0.018	0.018	0.031	0.002	10	42	2	0.004	6	2	114	18
<3*median	Median		14.2	10	95	2.7	0.8	1.5	0.161	0.005	0.001	0.037	0.037	0.048	0.002	18	82	4	0.007	9	6	115	30
	75%ile		18.0	11	104	4.2	1.4	2.0	0.345	0.010	0.003	0.057	0.059	0.070	0.004	43	173	9	0.011	23	15	120	90
	90%ile		19.2	12	112	5.3	4.1	8.0	0.551	0.020	0.003	0.078	0.079	0.104	0.008	101	287	14	0.021	55	36	122	144
	95%ile		20.1	13	115	5.5	11.2	18.3	0.662	0.024	0.003	0.111	0.112	0.174	0.009	145	356	17	0.029	67	47	122	162
	Max		20.5	13	129	6.1	19.1	22.0	0.720	0.453	0.004	0.170	0.170	0.456	0.011	384	658	36	0.590	130	94	123	180
	StDev		4.3	1	11	1.7	4.2	5.3	0.185	0.074	0.001	0.036	0.036	0.077	0.003	71	141	7	0.097	27	19	9	71
	95% C.I.		1.4	0	4	0.6	1.5	1.8	0.060	0.024	0.000	0.012	0.012	0.025	0.001	23	46	2	0.032	10	6	8	62
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35				0.167	0.015	7			0.026	50	550	100	120
	%compliance		89	97	94	66	97	91	69	97				92	100	17			92	87	100	80	80
	N. Samples	0	36	33	33	32	30	35	36	36	36	36	36	36	36	36	36	36	36	31	36	5	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro River d/s Hawke's Bay Dairies	Average		14.8	10	96	2.5	3.2	6.1	0.326	0.010	0.002	0.090	0.090	0.103	0.004	39	231	9	0.010	46	26	112	102
	Min		6.5	8	79	0.2	0.5	0.5	0.126	0.003	0.001	0.013	0.013	0.028	0.001	7	23	1	0.002	3	1	99	30
	5%ile		8.4	8	81	0.4	0.5	0.5	0.139	0.003	0.001	0.024	0.024	0.032	0.001	8	40	1	0.003	6	1	101	33
	10%ile		8.7	8	83	0.7	0.6	0.6	0.146	0.005	0.001	0.028	0.028	0.037	0.001	12	44	1	0.003	9	1	103	36
	25%ile		12.0	9	89	1.3	0.7	1.5	0.190	0.005	0.001	0.042	0.045	0.055	0.002	16	86	2	0.004	18	4	109	44
<3*median	Median		14.5	10	98	2.2	1.3	1.5	0.232	0.005	0.002	0.077	0.077	0.094	0.003	26	159	5	0.008	30	12	113	90
	75%ile		18.0	11	102	3.6	2.1	3.0	0.413	0.013	0.003	0.113	0.113	0.125	0.006	51	230	12	0.013	53	30	116	148
	90%ile		20.6	11	107	5.1	8.5	14.0	0.532	0.020	0.003	0.152	0.153	0.172	0.009	78	598	20	0.024	100	56	121	179
	95%ile		21.0	11	110	5.6	14.5	26.0	0.720	0.025	0.003	0.216	0.217	0.227	0.010	103	679	23	0.034	163	114	122	190
	Max		21.3	12	119	5.9	25.1	62.0	1.440	0.040	0.003	0.348	0.350	0.360	0.010	162	1148	45	0.037	190	137	124	200
	StDev		4.3	1	10	1.7	5.6	12.9	0.255	0.009	0.001	0.069	0.070	0.070	0.003	35	252	9	0.009	49	35	10	78
	95% C.I.		1.5	0	4	0.6	2.1	4.4	0.087	0.003	0.000	0.024	0.024	0.024	0.001	12	86	3	0.003	18	12	10	77
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35				0.167	0.015	7			0.026	50	550	100	120
	%compliance		82	86	97	59	93	85	61	100				88	100	6			91	75	100	75	50
	N. Samples	0	33	29	29	29	27	33	33	33	33	33	33	33	33	33	33	33	33	28	33	4	4

Ngaruroro at Chesterhope	Average	8.2	16.3	10	106	1.6	4.9		0.141	0.003		0.075		0.080	0.006	12	266	16	0.018				
	Min	7.7	7.7	9	94	0.1	0.3		0.032	0.000		0.000		0.002	0.001	0	0	0	0.005				
	5%ile	7.8	8.8	9	97	0.2	0.6		0.045	0.001		0.001		0.003	0.002	1	2	2	0.007				
	10%ile	7.9	9.7	9	98	0.3	0.7		0.060	0.001		0.002		0.004	0.003	1	3	3	0.008				
	25%ile	8.0	12.3	10	100	0.6	1.1		0.081	0.002		0.009		0.011	0.005	3	10	5	0.012				
<3*median	Median	8.2	16.2	10	104	1.2	2.8		0.115	0.003		0.056		0.061	0.006	10	108	11	0.015				
	75%ile	8.5	20.3	11	111	2.4	5.4		0.183	0.004		0.121		0.124	0.008	19	412	23	0.019				
	90%ile	8.7	22.7	12	116	3.3	11.2		0.250	0.006		0.175		0.180	0.009	28	799	37	0.027				
	95%ile	8.8	23.9	12	120	4.1	18.6		0.297	0.007		0.213		0.223	0.011	36	911	45	0.043				
	Max	9.3	27.3	14	139	5.6	45.0		0.557	0.018		0.407		0.414	0.017	101	2529	103	0.093				
	StDev	0.3	4.8	1	8	1.2	6.6		0.089	0.002		0.078		0.080	0.003	13	373	15	0.013				
	95% C.I.	0.1	0.8	0	1	0.2	1.1		0.015	0.000		0.013		0.013	0.000	2	61	2	0.002				
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614					0.444	0.015				0.033				
	%compliance	100	92	100	100	37	93		100					100	99				93				
	N. Samples	148	153	153	153	153	149	0	143	145	0	150	0	145	150	145	145	150	148	0	0	0	0

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro at Kuripapango	Average	7.8	10.9	10	99	5.7	0.7		0.053	0.002		0.007		0.009	0.002	5	11	2	0.004				
	Min	7.4	3.3	8	92	0.4	0.1		0.012	0.000		0.000		0.000	0.000	1	0	0	0.001				
	5%ile	7.6	4.6	9	97	2.1	0.2		0.022	0.000		0.001		0.002	0.001	1	1	0	0.002				
	10%ile	7.7	5.0	9	97	2.7	0.3		0.025	0.001		0.002		0.003	0.001	2	2	0	0.002				
	25%ile	7.7	6.8	10	99	3.9	0.3		0.032	0.001		0.003		0.004	0.001	3	2	1	0.003				
<3*median	Median	7.8	11.1	10	99	5.4	0.5		0.045	0.002		0.004		0.007	0.002	4	5	1	0.003				
	75%ile	7.9	14.1	11	100	7.3	0.9		0.065	0.003		0.008		0.011	0.002	7	13	2	0.004				
	90%ile	8.0	17.1	12	101	9.0	1.3		0.099	0.005		0.013		0.017	0.003	11	29	4	0.006				
	95%ile	8.1	18.1	12	102	9.6	1.7		0.108	0.006		0.024		0.025	0.003	14	37	6	0.007				
	Max	8.7	20.6	13	103	14.4	8.5		0.157	0.009		0.038		0.040	0.005	28	110	9	0.019				
	StDev	0.2	4.5	1	2	2.5	0.9		0.029	0.002		0.007		0.007	0.001	4	15	2	0.002				
	95% C.I.	0.0	0.7	0	0	0.4	0.1		0.005	0.000		0.001		0.001	0.000	1	2	0	0.000				
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295					0.167	0.015				0.026				
	%compliance	100	97	100	100	97	100		100					100	100				100				
	N. Samples	149	152	151	151	151	150	0	146	147	0	151	0	147	151	147	147	147	150	0	0	0	0

Appendix C: Summary of data – river flows under median flow (<med)

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngarururo at Whanawhana	Average	7.9	14.1	10	97	4.0	1.0	1.8	0.249	0.013	0.003	0.037	0.053	0.002	41	79	3	0.018	13	8	0.8	128	99
	Min	7.6	6.5	7	60	1.3	0.0	0.5	0.040	0.002	0.001	0.002	0.003	0.001	2	3	1	0.001	1	0	0.2	112	2
	5%ile	7.7	7.6	8	79	1.4	0.3	0.5	0.056	0.003	0.001	0.006	0.014	0.001	5	10	1	0.002	1	0	0.3	113	2
<median	10%ile	7.7	8.8	8	82	1.7	0.3	0.5	0.078	0.003	0.001	0.007	0.017	0.001	6	16	1	0.002	1	0	0.3	113	3
	25%ile	7.7	10.9	9	92	2.7	0.5	1.0	0.109	0.005	0.001	0.016	0.026	0.001	10	32	1	0.003	4	1	0.4	116	6
	Median	7.8	15.0	10	98	3.6	0.6	1.5	0.140	0.010	0.003	0.022	0.041	0.002	22	54	2	0.004	9	3	0.6	129	53
	75%ile	7.9	17.1	11	105	5.4	1.2	2.0	0.314	0.021	0.003	0.040	0.064	0.002	41	87	3	0.007	15	11	0.8	140	113
	90%ile	8.2	18.5	12	112	6.8	2.1	3.2	0.529	0.028	0.005	0.077	0.099	0.005	80	151	7	0.012	35	24	1.6	142	241
	95%ile	8.3	19.1	13	122	7.0	3.5	4.6	0.662	0.032	0.006	0.100	0.118	0.007	100	193	9	0.019	43	30	2.3	145	301
	Max	8.5	20.0	15	125	7.2	5.9	6.0	1.316	0.040	0.021	0.230	0.249	0.009	498	484	18	0.610	50	36	3.6	147	361
	StDev	0.2	3.8	2	13	1.8	1.1	1.3	0.251	0.010	0.004	0.044	0.047	0.002	74	90	3	0.086	14	10	0.7	13	138
	95% C.I.	0.1	1.0	1	4	0.6	0.3	0.4	0.082	0.003	0.001	0.012	0.013	0.001	21	25	1	0.024	5	3	0.2	7	110
	Guideline	6.5-9.5	19	8	80	3.5	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	95	95	92	54	100	100	67	100			96	100	12			96	100	100		62	83
	N. Samples	18	56	38	38	35	48	49	36	50	33	49	50	50	50	50	50	50	31	34	49	13	6
Ngarururo at Ohiti	Average	8.0	16.1	10	95	2.7	2.3	3.8	0.312	0.013	0.002	0.075	0.089	0.003	47	111	4	0.009	82	55	1.2	109	107
	Min	7.4	7.8	8	70	0.2	0.2	0.5	0.065	0.002	0.001	0.002	0.003	0.001	2	3	1	0.001	10	2	0.1	100	31
	5%ile	7.6	9.7	8	78	0.9	0.4	0.6	0.090	0.003	0.001	0.019	0.031	0.001	4	22	1	0.002	17	4	0.3	101	38
<median	10%ile	7.7	11.1	8	88	1.2	0.5	1.0	0.119	0.003	0.001	0.032	0.041	0.001	11	26	1	0.003	21	6	0.4	102	45
	25%ile	7.8	13.0	9	90	1.4	0.8	1.5	0.144	0.005	0.001	0.044	0.057	0.001	16	49	1	0.004	33	17	0.5	105	66
	Median	7.9	16.0	9	94	2.1	1.6	2.0	0.219	0.010	0.002	0.070	0.084	0.002	34	96	2	0.007	49	33	0.6	107	90
	75%ile	8.1	19.3	10	102	3.5	2.4	3.3	0.360	0.019	0.003	0.100	0.123	0.004	68	144	6	0.010	85	58	1.9	113	130
	90%ile	8.4	20.9	11	106	5.2	3.9	5.0	0.659	0.026	0.003	0.130	0.150	0.008	88	223	8	0.014	150	104	2.8	120	184
	95%ile	8.6	21.0	11	110	5.5	4.6	6.0	0.778	0.039	0.003	0.147	0.159	0.009	120	264	12	0.017	200	138	3.2	120	202
	Max	8.7	24.0	12	119	8.0	21.0	52.0	1.530	0.050	0.003	0.177	0.189	0.014	186	297	13	0.052	620	470	3.8	121	220
	StDev	0.3	3.9	1	10	1.7	3.2	7.9	0.290	0.012	0.001	0.041	0.043	0.003	41	76	3	0.009	112	84	1.0	8	73
	95% C.I.	0.2	1.2	0	4	0.6	1.0	2.3	0.099	0.004	0.000	0.012	0.013	0.001	12	22	1	0.003	39	29	0.3	6	64
	Guideline	6.5-9.5	19	8	80	3.5	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	74	94	93	27	98	96	67	100			96	100	9			96	52	100		14	60
	N. Samples	16	43	31	30	33	42	45	33	45	30	44	45	45	45	45	45	45	31	33	44	7	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Waitio Stream at Ohiti Rd	Average		15.0	9	90	3.3	1.0	2.0	0.417	0.015	0.004	0.156	0.176	0.018	11	10	1	0.034	135	75	1.9	108	67
	Min		11.8	7	65	1.3	0.5	0.5	0.000	0.003	0.001	0.004	0.009	0.002	1	0	0	0.008	23	1	0.5	96	1
	5%ile		12.8	7	67	1.4	0.5	0.5	0.174	0.003	0.001	0.030	0.043	0.006	4	2	0	0.014	26	12	0.6	96	2
<median	10%ile		13.0	7	71	1.7	0.6	1.0	0.207	0.003	0.001	0.046	0.054	0.007	4	3	0	0.016	29	17	0.6	97	2
	25%ile		13.6	9	82	2.5	0.6	1.5	0.235	0.005	0.003	0.073	0.103	0.009	6	5	0	0.019	49	26	0.8	103	5
	Median		15.0	9	92	3.2	0.8	1.5	0.418	0.005	0.003	0.117	0.131	0.015	10	7	1	0.025	90	59	1.8	107	14
	75%ile		16.5	10	101	4.3	1.2	2.0	0.529	0.020	0.004	0.157	0.190	0.021	14	10	1	0.032	136	94	2.7	111	103
	90%ile		17.2	10	104	4.9	1.6	3.8	0.764	0.030	0.007	0.357	0.378	0.040	17	21	2	0.052	266	132	3.4	118	185
	95%ile		17.4	11	108	5.0	1.8	4.8	0.809	0.056	0.008	0.467	0.478	0.042	20	28	3	0.056	370	158	3.5	122	213
	Max		18.0	11	114	5.1	3.2	9.0	0.839	0.100	0.014	0.602	0.619	0.048	54	39	3	0.257	750	541	3.9	126	240
	StDev		1.7	1	13	1.2	0.6	1.7	0.211	0.023	0.003	0.143	0.143	0.012	9	9	1	0.042	149	94	1.1	10	98
	95% C.I.		0.6	0	4	0.4	0.2	0.6	0.072	0.008	0.001	0.049	0.049	0.004	3	3	0	0.014	54	32	0.4	7	78
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance		100	82	79	91	100	100	36	100			67	55	27			55	28	100		14	67
	N. Samples	0	33	33	33	33	28	33	33	33	33	33	33	33	33	33	33	33	29	33	32	7	6
Ngaruroro at Fernhill	Average	8.1	16.9	10	96	2.4	1.9	3.2	0.262	0.015	0.002	0.066	0.081	0.004	37	98	5	0.049	89	58	1.3	116	95
	Min	7.6	9.5	8	71	0.6	0.2	0.5	0.053	0.002	0.001	0.002	0.003	0.001	1	2	0	0.001	7	1	0.2	99	39
	5%ile	7.7	10.5	8	77	0.7	0.6	1.0	0.069	0.003	0.001	0.010	0.017	0.001	2	5	0	0.002	11	1	0.3	100	42
<median	10%ile	7.7	11.9	8	79	0.8	0.7	1.0	0.088	0.003	0.001	0.014	0.020	0.001	5	10	1	0.003	13	1	0.5	102	45
	25%ile	7.7	13.6	9	89	1.1	1.0	1.5	0.121	0.005	0.001	0.025	0.048	0.001	12	30	1	0.006	25	9	0.6	109	64
	Median	8.0	17.0	9	96	2.0	1.6	2.0	0.177	0.010	0.001	0.054	0.074	0.004	22	81	3	0.010	43	26	0.8	113	106
	75%ile	8.3	20.0	10	104	3.2	2.7	4.0	0.355	0.020	0.003	0.086	0.114	0.006	58	126	6	0.015	98	61	2.0	124	125
	90%ile	8.5	21.2	11	109	4.2	3.7	6.6	0.539	0.029	0.003	0.142	0.158	0.010	80	222	12	0.021	262	179	2.9	133	135
	95%ile	8.7	22.2	11	117	5.2	4.0	7.8	0.669	0.033	0.004	0.150	0.164	0.012	96	293	19	0.038	348	245	3.1	136	138
	Max	9.0	25.0	12	119	5.8	5.9	12.0	0.774	0.090	0.005	0.184	0.204	0.013	146	354	26	1.700	490	353	3.6	138	140
	StDev	0.4	3.8	1	12	1.4	1.3	2.5	0.199	0.016	0.001	0.048	0.051	0.004	36	87	6	0.249	119	85	1.0	12	41
	95% C.I.	0.2	1.0	0	4	0.5	0.4	0.7	0.069	0.005	0.000	0.014	0.015	0.001	10	25	2	0.072	43	29	0.3	7	33
	Guideline	6.5-9.5	19	8	80	3.5	15	10	0.295	0.35			0.444	0.015	7			0.026	50	550		120	120
	%compliance	100	67	95	88	18	100	98	72	100			100	100	16			93	55	100		31	67
	N. Samples	18	54	37	34	33	42	45	32	46	29	45	46	45	45	46	45	46	29	32	44	13	6

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Tutaekuri-Waimate stream at Chesterhope	Average		15.1	8	81	1.9	3.0	7.1	0.625	0.020	0.004	0.128	0.152	0.021	9	38	5	0.078	142	99	1.9		
	Min		12.5	5	56	0.4	0.5	0.5	0.102	0.003	0.001	0.001	0.012	0.004	1	2	1	0.009	48	24	0.3		
	5%ile		12.5	6	59	0.5	0.6	1.0	0.108	0.003	0.001	0.007	0.021	0.007	1	6	1	0.018	61	44	0.6		
	10%ile		12.5	6	62	0.8	0.8	1.0	0.114	0.003	0.001	0.013	0.027	0.008	1	6	2	0.020	66	55	0.7		
	25%ile		13.4	7	64	1.0	1.1	1.5	0.198	0.005	0.003	0.022	0.034	0.012	2	8	3	0.027	86	68	0.9		
<median	Median		15.2	8	78	1.5	2.1	4.0	0.450	0.013	0.003	0.104	0.136	0.020	5	35	5	0.036	130	90	1.9		
	75%ile		16.0	10	98	2.7	3.3	6.3	0.669	0.030	0.005	0.206	0.234	0.030	13	60	8	0.052	180	122	2.8		
	90%ile		17.5	10	104	3.3	4.6	10.3	0.796	0.043	0.007	0.251	0.279	0.036	22	73	9	0.068	254	146	3.1		
	95%ile		18.0	10	106	3.5	6.0	24.7	1.827	0.050	0.008	0.326	0.387	0.038	25	96	9	0.098	260	167	3.4		
	Max		19.6	11	111	4.0	19.3	57.0	4.300	0.067	0.009	0.508	0.556	0.039	36	148	11	1.100	270	240	4.0		
	StDev		2.0	2	18	1.1	3.8	11.5	0.847	0.018	0.002	0.124	0.137	0.011	9	36	3	0.201	69	45	1.1		
	95% C.I.		0.7	1	7	0.4	1.5	4.2	0.319	0.007	0.001	0.046	0.051	0.004	3	13	1	0.075	27	17	0.4		
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	150	550		100	120
	%compliance		100	50	46	48	96	89	67	100			57	36	54			39	68	100			
	N. Samples	0	28	28	28	27	24	28	27	28	28	28	28	28	28	28	28	28	25	28	28	0	0
Ngaruroro River at Carrick Rd	Average		16.1	9	95	2.3	2.0	2.7	0.419	0.010	0.002	0.068	0.082	0.004	35	101	5	0.015	69	41	2.1	110	107
	Min		9.5	7	73	0.3	0.5	1.0	0.105	0.003	0.001	0.004	0.015	0.001	3	3	0	0.002	5	1	0.3	93	49
	5%ile		10.3	8	77	0.7	0.6	1.5	0.107	0.003	0.001	0.007	0.016	0.001	3	5	0	0.002	8	3	0.5	96	51
	10%ile		11.3	8	82	0.9	0.6	1.5	0.113	0.003	0.001	0.009	0.018	0.001	4	11	1	0.003	12	5	0.6	98	52
	25%ile		12.7	9	88	1.3	0.8	1.5	0.160	0.005	0.001	0.018	0.032	0.002	9	20	1	0.005	24	13	0.6	102	57
<median	Median		16.0	9	94	1.9	1.4	1.5	0.240	0.005	0.001	0.061	0.072	0.004	18	63	2	0.008	47	23	1.8	107	78
	75%ile		19.8	10	101	3.1	2.8	3.0	0.419	0.010	0.003	0.117	0.128	0.006	58	130	6	0.011	94	38	2.9	116	162
	90%ile		20.0	10	109	4.3	4.5	6.2	0.546	0.016	0.003	0.146	0.160	0.011	77	240	17	0.017	156	96	3.2	123	179
	95%ile		20.7	11	115	4.5	5.1	7.8	1.063	0.030	0.004	0.165	0.175	0.012	116	300	19	0.052	169	118	3.4	130	184
	Max		21.6	13	119	4.9	5.6	9.0	3.120	0.070	0.007	0.170	0.186	0.014	142	379	24	0.140	290	200	11.2	136	190
	StDev		3.7	1	11	1.3	1.6	2.2	0.619	0.014	0.001	0.055	0.056	0.004	38	104	7	0.028	68	46	2.1	13	64
	95% C.I.		1.4	0	4	0.5	0.7	0.9	0.248	0.005	0.001	0.021	0.021	0.001	15	40	3	0.011	28	18	0.8	9	56
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	100	550		100	120
	%compliance		100	93	93	59	100	100	92	100			92	100	19			92	74	100		88	60
	N. Samples	0	27	27	27	27	22	25	24	26	26	26	26	26	26	26	26	26	23	25	26	8	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Ngaruroro River at Motorway Bridge	Average		15.8	10	96	2.2	1.7	2.2	0.539	0.011	0.004	0.066	0.083	0.004	67	102	4	0.015	75	45	1.7	110	92
	Min		8.5	7	67	0.5	0.5	0.5	0.102	0.003	0.001	0.001	0.012	0.001	4	4	0	0.002	4	1	0.5	94	40
	5%ile		9.9	8	76	0.7	0.6	1.0	0.106	0.003	0.001	0.005	0.016	0.001	5	8	1	0.002	9	3	0.5	95	41
	10%ile		11.1	8	85	0.9	0.6	1.0	0.110	0.003	0.001	0.009	0.021	0.001	5	15	1	0.003	9	6	0.6	96	41
	25%ile		12.6	9	90	1.2	0.8	1.5	0.121	0.005	0.001	0.017	0.031	0.002	11	22	1	0.006	29	7	0.7	101	43
<median	Median		15.8	9	92	1.8	1.4	1.5	0.240	0.005	0.001	0.047	0.062	0.002	20	70	2	0.008	58	33	1.6	105	48
	75%ile		19.0	10	108	3.2	2.5	2.5	0.428	0.012	0.003	0.102	0.126	0.004	71	159	4	0.010	111	55	2.6	120	72
	90%ile		19.8	12	117	4.7	3.3	4.4	0.741	0.030	0.004	0.138	0.149	0.009	129	210	10	0.013	156	107	3.0	126	184
	95%ile		21.5	12	120	5.1	3.4	5.0	2.124	0.033	0.008	0.140	0.150	0.011	215	224	15	0.016	169	122	3.4	131	222
	Max		22.5	12	123	5.6	3.5	7.0	5.064	0.036	0.046	0.330	0.366	0.011	732	583	16	0.220	330	220	3.9	136	259
	StDev		3.8	1	14	1.4	1.1	1.5	1.025	0.010	0.009	0.069	0.073	0.003	141	117	4	0.040	72	49	1.1	14	94
	95% C.I.		1.4	0	5	0.5	0.4	0.6	0.380	0.004	0.003	0.025	0.027	0.001	52	43	2	0.015	28	18	0.4	10	82
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	100	550		100	120
	%compliance		100	93	93	59	100	100	86	100			96	100	21			96	72	100		75	80
	N. Samples	0	29	29	29	29	24	27	28	28	28	28	28	28	28	28	28	28	25	28	28	8	5
Ngaruroro River u/s Hawke's Bay Dairies	Average		15.4	10	98	3.4	1.0	1.4	0.273	0.024	0.002	0.041	0.068	0.003	47	106	5	0.027	24	15	1.0	114	66
	Min		8.0	8	76	0.9	0.4	0.5	0.110	0.003	0.001	0.008	0.020	0.001	2	16	1	0.002	3	1	0.3	99	13
	5%ile		9.7	8	86	1.1	0.5	0.7	0.111	0.003	0.001	0.010	0.021	0.001	4	20	1	0.002	4	1	0.3	102	14
	10%ile		10.6	8	88	1.4	0.6	1.0	0.114	0.005	0.001	0.012	0.024	0.001	4	25	1	0.003	5	2	0.3	105	15
	25%ile		12.2	9	90	1.8	0.6	1.5	0.127	0.005	0.001	0.015	0.027	0.002	10	33	2	0.003	6	4	0.5	114	18
<median	Median		16.2	10	96	3.4	0.8	1.5	0.158	0.005	0.001	0.035	0.047	0.002	18	63	3	0.006	10	6	0.6	115	30
	75%ile		18.2	11	105	4.8	1.1	1.5	0.346	0.010	0.003	0.056	0.068	0.004	42	116	7	0.008	25	17	1.2	120	90
	90%ile		19.5	11	113	5.4	1.6	2.0	0.641	0.020	0.003	0.075	0.111	0.007	121	216	11	0.013	60	41	2.6	122	144
	95%ile		20.3	13	115	5.5	2.2	2.0	0.677	0.026	0.003	0.114	0.182	0.009	162	302	13	0.024	68	48	2.8	122	162
	Max		20.5	13	129	6.1	3.6	2.0	0.720	0.453	0.004	0.170	0.456	0.011	384	658	18	0.590	130	94	3.0	123	180
	StDev		3.6	1	11	1.6	0.7	0.4	0.198	0.083	0.001	0.038	0.085	0.003	78	130	4	0.108	29	21	0.9	9	71
	95% C.I.		1.3	1	4	0.6	0.3	0.1	0.072	0.030	0.000	0.014	0.031	0.001	28	47	2	0.039	11	8	0.3	8	62
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance		86	96	96	80	100	100	66	97			90	100	21			93	85	100		40	80
	N. Samples	0	29	26	26	25	25	28	29	29	29	29	29	29	29	29	29	29	26	29	29	5	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngarururo River d/s Hawke's Bay Dairies <median	Average		16.3	10	98	3.1	1.2	1.7	0.332	0.011	0.002	0.079	0.094	0.004	39	147	6	0.007	50	30	1.7	112	102
	Min		10.0	8	79	1.0	0.5	0.5	0.126	0.003	0.001	0.013	0.028	0.001	7	23	1	0.002	3	1	0.3	99	30
	5%ile		10.8	8	83	1.2	0.5	0.5	0.137	0.003	0.001	0.024	0.034	0.001	7	40	1	0.003	7	1	0.3	101	33
	10%ile		12.3	8	89	1.3	0.5	0.5	0.144	0.005	0.001	0.031	0.041	0.001	10	42	1	0.003	10	1	0.5	103	36
	25%ile		13.4	9	90	2.0	0.7	1.5	0.177	0.005	0.001	0.044	0.056	0.002	16	75	2	0.003	17	5	0.6	109	44
	Median		17.0	9	98	2.8	1.0	1.5	0.215	0.008	0.002	0.070	0.087	0.002	24	104	3	0.006	34	14	1.1	113	90
	75%ile		18.9	11	105	4.0	1.5	1.5	0.394	0.015	0.003	0.094	0.105	0.006	50	187	8	0.009	65	31	2.6	116	148
	90%ile		20.8	11	108	5.4	2.1	3.0	0.614	0.020	0.003	0.114	0.141	0.009	83	232	13	0.012	136	82	3.1	121	179
	95%ile		21.0	11	111	5.8	3.0	3.3	0.757	0.030	0.003	0.145	0.171	0.010	116	284	17	0.017	168	119	3.4	122	190
	Max		21.3	11	119	5.9	3.0	4.0	1.440	0.040	0.003	0.348	0.360	0.010	162	678	19	0.033	190	137	5.9	124	200
	StDev		3.4	1	10	1.5	0.8	0.9	0.283	0.009	0.001	0.064	0.066	0.003	38	131	5	0.007	52	38	1.3	10	78
	95% C.I.		1.3	1	4	0.6	0.3	0.3	0.109	0.004	0.000	0.025	0.025	0.001	15	50	2	0.003	21	15	0.5	10	77
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance		77	82	95	77	100	100	62	100			92	100	8			96	70	100		25	50
	N. Samples	0	26	22	22	22	22	26	26	26	26	26	26	26	26	26	26	26	23	26	26	4	4

Ngarururo at Chesterhope	Average	8.4	18.6	10	110	2.4	1.8		0.098	0.003		0.035	0.038	0.006	7	56	6	0.013					
	Min	7.8	8.2	9	94	0.5	0.3		0.032	0.000		0.000	0.002	0.001	0	0	0	0.005					
	5%ile	8.0	11.5	9	100	1.0	0.5		0.044	0.000		0.001	0.003	0.003	0	2	1	0.007					
	10%ile	8.0	13.0	9	102	1.1	0.6		0.047	0.001		0.001	0.003	0.003	1	2	2	0.008					
	25%ile	8.2	15.7	10	104	1.4	0.8		0.066	0.002		0.004	0.006	0.004	1	4	3	0.009					
<median	Median	8.4	19.0	10	108	2.3	1.3		0.084	0.003		0.012	0.015	0.005	3	14	6	0.013					
	75%ile	8.6	21.6	11	115	3.2	2.4		0.115	0.004		0.055	0.057	0.007	10	81	9	0.016					
	90%ile	8.8	23.9	11	118	4.1	3.3		0.165	0.005		0.109	0.117	0.009	16	169	11	0.018					
	95%ile	9.0	24.4	12	123	4.9	4.5		0.186	0.007		0.125	0.131	0.011	22	247	14	0.023					
	Max	9.3	27.3	14	139	5.6	9.9		0.297	0.010		0.209	0.211	0.013	38	356	25	0.033					
	StDev	0.3	4.2	1	8	1.2	1.5		0.051	0.002		0.046	0.046	0.003	8	83	4	0.005					
	95% C.I.	0.1	0.9	0	2	0.3	0.3		0.011	0.000		0.010	0.010	0.001	2	18	1	0.001					
	Guideline	6.5-9.5	23	8	80	3.5	15	25	0.614				0.444	0.015				0.033					
	%compliance	100	85	100	100	14	100		100				100	100				100					
	N. Samples	79	81	81	81	81	80	0	78	79	0	81	79	81	79	79	81	80	0	0	0	0	0

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Ngaruroro at Kuripapango	Average	7.9	12.0	10	99	6.7	0.6		0.051	0.002		0.004	0.006	0.002	5	4	1	0.003					
	Min	7.6	3.3	8	92	1.6	0.2		0.012	0.000		0.000	0.000	0.000	1	0	0	0.001					
	5%ile	7.7	4.6	9	97	3.8	0.2		0.019	0.000		0.001	0.002	0.001	1	1	0	0.001					
	10%ile	7.7	5.5	9	97	4.2	0.2		0.024	0.001		0.002	0.003	0.001	2	1	0	0.002					
	25%ile	7.8	8.6	9	99	5.3	0.3		0.032	0.001		0.002	0.004	0.001	2	2	1	0.002					
<median	Median	7.9	12.1	10	99	6.5	0.4		0.044	0.002		0.003	0.005	0.001	4	3	1	0.003					
	75%ile	8.0	15.8	11	100	8.1	0.6		0.062	0.003		0.005	0.008	0.002	5	6	1	0.004					
	90%ile	8.1	17.7	12	101	9.3	1.0		0.095	0.004		0.008	0.011	0.003	9	9	2	0.005					
	95%ile	8.1	18.5	12	102	10.6	1.2		0.106	0.005		0.012	0.013	0.003	12	10	2	0.006					
	Max	8.7	20.6	13	103	14.4	4.0		0.141	0.006		0.020	0.022	0.005	28	21	3	0.010					
	StDev	0.1	4.5	1	2	2.3	0.5		0.028	0.001		0.003	0.004	0.001	4	3	1	0.001					
	95% C.I.	0.0	0.9	0	0	0.4	0.1		0.006	0.000		0.001	0.001	0.000	1	1	0	0.000					
	Guideline	6.5-9.5	19	8	80	5	15	10	0.295				0.167	0.015				0.026					
	%compliance	100	95	100	100	79	100		100				100	100				100					
	N. Samples	96	98	97	97	98	97	0	94	95	0	97	95	97	95	95	95	96	0	0	0	0	0

Appendix D: Summary of data – river flows under lower quartile flow (<LQ)

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Ngaruroro at Whanawhana	Average	8.0	15.8	10	98	5.1	0.6	1.9	0.178	0.014	0.002	0.023	0.038	0.003	20	36	2	0.034	11	6	0.8	126	99
	Min	7.7	10.0	8	76	2.7	0.2	0.5	0.040	0.002	0.001	0.002	0.003	0.001	2	3	1	0.002	1	0	0.2	112	2
	5%ile	7.8	10.5	8	85	2.7	0.2	0.5	0.051	0.003	0.001	0.004	0.004	0.001	2	3	1	0.002	2	0	0.3	113	2
	10%ile	7.8	10.8	9	86	2.9	0.3	1.0	0.056	0.003	0.001	0.005	0.013	0.001	4	9	1	0.002	3	1	0.3	113	3
	25%ile	7.8	13.9	9	92	3.7	0.3	1.5	0.092	0.005	0.001	0.007	0.018	0.002	8	16	1	0.003	7	1	0.4	115	6
<LQ	Median	7.9	16.7	10	98	5.4	0.5	1.5	0.112	0.011	0.001	0.018	0.034	0.002	15	32	2	0.004	10	3	0.5	125	53
	75%ile	8.1	18.5	10	103	6.7	0.6	2.0	0.137	0.022	0.003	0.030	0.050	0.002	25	46	2	0.007	11	8	0.6	139	113
	90%ile	8.4	19.1	11	108	7.0	1.1	3.0	0.460	0.030	0.003	0.045	0.070	0.003	34	66	3	0.012	18	12	1.9	140	241
	95%ile	8.4	19.4	12	115	7.0	1.9	3.2	0.493	0.036	0.004	0.049	0.074	0.007	61	87	7	0.016	27	18	2.6	143	301
	Max	8.5	20.0	15	125	7.2	2.0	6.0	0.580	0.040	0.007	0.100	0.122	0.008	70	96	7	0.610	41	30	3.6	147	361
	StDev	0.3	3.1	1	11	1.6	0.5	1.2	0.164	0.011	0.002	0.022	0.028	0.002	18	26	2	0.132	10	8	0.9	13	138
	95% C.I.	0.2	1.2	1	5	0.7	0.2	0.5	0.076	0.005	0.001	0.010	0.012	0.001	8	11	1	0.056	5	4	0.4	7	110
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	89	100	95	100	100	100	78	100			100	100	19			95	100	100		58	83
	N. Samples	7	27	21	21	19	19	20	18	21	15	20	21	21	21	21	21	21	14	16	21	12	6
Ngaruroro at Ohiti	Average	8.1	17.5	9	96	3.1	2.1	4.2	0.249	0.015	0.002	0.068	0.083	0.003	42	79	3	0.010	101	66	1.2	109	107
	Min	7.9	11.0	8	70	0.2	0.2	0.5	0.065	0.002	0.001	0.002	0.003	0.001	2	3	1	0.001	20	4	0.1	100	31
	5%ile	7.9	11.6	8	87	1.2	0.4	0.5	0.077	0.003	0.001	0.015	0.025	0.001	3	16	1	0.002	27	6	0.3	101	38
	10%ile	7.9	12.5	8	89	1.4	0.4	1.0	0.103	0.003	0.001	0.029	0.036	0.001	5	24	1	0.003	27	6	0.4	102	45
	25%ile	7.9	15.0	9	90	1.9	0.7	1.1	0.132	0.005	0.001	0.037	0.052	0.001	22	36	1	0.004	39	19	0.5	105	66
<LQ	Median	8.0	18.0	9	93	2.6	1.3	1.5	0.189	0.012	0.002	0.064	0.083	0.002	29	82	2	0.007	62	45	0.6	107	90
	75%ile	8.3	20.5	10	101	4.3	1.9	2.8	0.303	0.020	0.003	0.088	0.103	0.004	65	103	4	0.011	96	66	2.0	113	130
	90%ile	8.5	20.9	11	109	5.4	3.1	4.2	0.413	0.033	0.003	0.130	0.144	0.006	84	130	6	0.016	160	114	2.8	120	184
	95%ile	8.6	21.0	11	112	5.6	4.5	13.7	0.695	0.046	0.003	0.142	0.158	0.008	89	166	7	0.026	240	167	3.5	120	202
	Max	8.7	24.0	11	119	8.0	21.0	52.0	0.857	0.050	0.003	0.177	0.189	0.014	128	235	12	0.052	620	470	3.8	121	220
	StDev	0.3	3.5	1	11	1.9	3.9	9.7	0.198	0.013	0.001	0.042	0.044	0.003	32	53	3	0.010	130	97	1.1	8	73
	95% C.I.	0.2	1.3	0	5	0.8	1.5	3.5	0.081	0.005	0.000	0.015	0.016	0.001	11	19	1	0.004	56	40	0.4	6	64
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	62	90	95	78	96	93	74	100			97	100	13			93	43	100		14	60
	N. Samples	11	29	21	20	23	27	30	23	30	20	29	30	30	30	30	30	30	21	23	30	7	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Waitio Stream at Ohiti Rd	Average		15.3	9	93	3.6	0.9	2.0	0.361	0.019	0.004	0.112	0.135	0.015	11	7	1	0.035	152	83	1.7	109	80
	Min		11.8	7	65	1.4	0.5	0.5	0.000	0.003	0.001	0.004	0.009	0.002	1	0	0	0.008	27	1	0.5	96	1
	5%ile		12.7	7	66	2.0	0.5	0.5	0.137	0.003	0.001	0.020	0.042	0.006	4	1	0	0.013	30	19	0.5	99	2
	10%ile		13.3	7	73	2.2	0.5	1.0	0.201	0.003	0.001	0.038	0.045	0.007	4	2	0	0.014	39	20	0.6	101	3
	25%ile		14.1	9	88	2.6	0.6	1.5	0.224	0.005	0.003	0.056	0.084	0.009	6	4	0	0.020	49	29	0.7	107	6
<LQ	Median		15.4	9	95	3.4	0.7	1.5	0.367	0.007	0.003	0.099	0.122	0.014	9	6	1	0.023	85	56	1.5	108	22
	75%ile		16.5	10	102	4.8	1.0	2.0	0.452	0.020	0.003	0.125	0.162	0.020	14	8	1	0.028	160	93	2.5	112	130
	90%ile		17.3	10	104	5.0	1.4	2.9	0.563	0.030	0.007	0.209	0.230	0.025	19	12	1	0.038	370	134	3.1	120	196
	95%ile		17.5	10	111	5.0	1.7	4.0	0.651	0.091	0.010	0.241	0.264	0.034	21	13	2	0.047	389	168	3.5	123	218
	Max		18.0	11	114	5.1	1.8	9.0	0.790	0.100	0.014	0.358	0.380	0.042	54	19	2	0.257	750	541	3.6	126	240
	StDev		1.7	1	13	1.2	0.4	1.7	0.179	0.027	0.003	0.081	0.084	0.009	11	4	0	0.050	174	111	1.1	10	104
	95% C.I.		0.7	0	5	0.5	0.2	0.7	0.075	0.011	0.001	0.034	0.035	0.004	5	2	0	0.021	76	46	0.5	8	91
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance		100	86	86	95	100	100	41	100			73	59	36			55	30	100		17	60
	N. Samples	0	22	22	22	22	19	22	22	22	22	22	22	22	22	22	22	22	20	22	21	6	5

Ngaruroro at Fernhill	Average	8.3	18.9	9	101	3.2	1.1	2.4	0.174	0.017	0.002	0.042	0.060	0.004	35	38	2	0.095	89	54	1.3	117	95
	Min	7.7	11.8	8	78	1.1	0.2	0.5	0.053	0.002	0.001	0.002	0.003	0.001	1	2	0	0.002	10	1	0.3	99	39
	5%ile	7.8	12.7	8	91	1.5	0.3	1.0	0.060	0.003	0.001	0.009	0.008	0.001	1	2	0	0.006	12	1	0.4	100	42
	10%ile	7.9	13.4	9	93	1.8	0.5	1.0	0.070	0.003	0.001	0.010	0.016	0.001	2	5	0	0.007	15	1	0.5	101	45
	25%ile	8.1	16.9	9	95	2.2	0.7	1.5	0.090	0.005	0.001	0.020	0.029	0.002	5	14	1	0.008	24	2	0.6	109	64
<LQ	Median	8.3	19.9	9	99	3.1	0.9	1.5	0.121	0.005	0.001	0.033	0.050	0.003	16	29	1	0.010	39	19	0.8	113	106
	75%ile	8.4	21.0	10	108	4.0	1.1	3.1	0.186	0.025	0.003	0.056	0.080	0.006	59	47	3	0.015	95	61	1.9	125	125
	90%ile	8.8	22.2	11	116	5.2	1.7	4.2	0.388	0.033	0.003	0.086	0.115	0.006	82	85	5	0.024	231	155	2.9	134	135
	95%ile	8.9	22.8	11	119	5.4	2.2	6.1	0.427	0.058	0.003	0.090	0.145	0.009	100	108	5	0.085	316	230	3.0	136	138
	Max	9.0	25.0	11	119	5.8	3.8	7.0	0.519	0.090	0.003	0.150	0.160	0.011	145	137	5	1.700	400	288	3.6	138	140
	StDev	0.4	3.3	1	10	1.3	0.8	1.7	0.135	0.022	0.001	0.036	0.044	0.003	40	36	2	0.368	114	83	1.0	12	41
	95% C.I.	0.3	1.2	0	5	0.6	0.4	0.8	0.064	0.009	0.000	0.016	0.019	0.001	18	15	1	0.157	59	41	0.5	7	33
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	39	100	95	94	100	100	82	100			100	100	30			90	57	100		33	67
	N. Samples	8	28	20	19	18	18	20	17	21	14	20	21	20	20	21	20	21	14	16	20	12	6

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Tutaekuri-Waimate stream at Chesterhope	Average		15.0	8	74	1.9	2.5	4.8	0.367	0.021	0.004	0.116	0.142	0.022	9	32	5	0.130	166	104	1.8		
	Min		12.5	5	56	0.8	0.5	1.0	0.102	0.005	0.001	0.001	0.012	0.006	1	2	1	0.020	82	59	0.3		
	5%ile		12.5	6	59	0.9	0.7	1.3	0.104	0.005	0.001	0.003	0.020	0.007	1	4	1	0.024	84	61	0.4		
	10%ile		12.6	6	62	1.0	0.9	1.5	0.106	0.005	0.001	0.006	0.028	0.008	1	6	2	0.027	86	62	0.5		
	25%ile		14.1	7	63	1.1	1.4	1.5	0.120	0.005	0.003	0.017	0.035	0.011	2	7	3	0.033	94	75	0.9		
<LQ	Median		15.2	7	66	1.7	2.2	4.1	0.391	0.022	0.003	0.142	0.163	0.020	5	35	4	0.039	165	114	1.9		
	75%ile		16.0	8	81	2.6	3.8	7.3	0.517	0.030	0.005	0.190	0.221	0.034	15	52	8	0.058	223	130	2.5		
	90%ile		17.4	10	99	3.3	4.6	8.9	0.670	0.039	0.006	0.203	0.258	0.038	22	59	8	0.062	261	143	2.9		
	95%ile		17.5	10	101	3.6	4.6	9.9	0.765	0.045	0.007	0.238	0.284	0.038	24	63	9	0.529	266	147	3.4		
	Max		17.5	10	102	4.0	4.6	11.0	0.860	0.050	0.009	0.280	0.313	0.039	27	68	9	1.100	270	150	4.0		
	StDev		1.7	2	16	1.1	1.5	3.4	0.258	0.015	0.002	0.098	0.108	0.012	9	24	3	0.306	73	33	1.1		
	95% C.I.		1.0	1	9	0.6	1.0	1.9	0.153	0.009	0.001	0.056	0.061	0.007	5	14	2	0.173	45	19	0.6		
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	150	550		100	120
	%compliance		100	25	25	50	100	92	82	100			50	33	58			25	50	100			
	N. Samples	0	12	12	12	12	9	12	11	12	12	12	12	12	12	12	12	12	10	12	12	0	0
Ngaruroro River at Carrick Rd	Average		17.9	9	97	3.2	1.0	2.2	0.240	0.013	0.002	0.038	0.055	0.003	24	28	2	0.019	80	41	2.6	110	107
	Min		11.5	7	73	1.3	0.5	1.0	0.105	0.005	0.001	0.004	0.015	0.001	3	3	0	0.002	8	1	0.3	93	49
	5%ile		11.8	8	80	1.4	0.5	1.3	0.106	0.005	0.001	0.006	0.016	0.001	3	4	0	0.002	9	2	0.4	96	51
	10%ile		12.6	8	86	1.6	0.6	1.5	0.107	0.005	0.001	0.007	0.016	0.002	3	5	0	0.002	11	3	0.5	98	52
	25%ile		16.0	9	93	2.2	0.6	1.5	0.114	0.005	0.001	0.009	0.018	0.002	7	12	1	0.007	37	10	0.6	102	57
<LQ	Median		19.7	9	97	3.2	0.7	1.5	0.201	0.005	0.001	0.018	0.031	0.004	15	18	1	0.008	49	25	2.0	107	78
	75%ile		20.0	10	101	4.2	1.0	1.8	0.307	0.006	0.001	0.063	0.080	0.004	40	34	2	0.010	95	35	3.0	116	162
	90%ile		20.8	10	110	4.5	1.8	2.0	0.422	0.032	0.003	0.086	0.119	0.005	53	61	3	0.017	173	79	3.2	123	179
	95%ile		21.2	10	113	4.7	2.4	5.5	0.485	0.051	0.005	0.111	0.135	0.005	63	80	4	0.072	232	140	6.8	130	184
	Max		21.6	11	116	4.9	2.9	9.0	0.548	0.070	0.007	0.140	0.150	0.006	75	100	5	0.140	290	200	11.2	136	190
	StDev		3.4	1	11	1.2	0.8	2.3	0.150	0.020	0.002	0.043	0.046	0.002	23	28	1	0.038	87	57	2.9	13	64
	95% C.I.		1.8	0	6	0.7	0.5	1.3	0.093	0.011	0.001	0.024	0.026	0.001	13	16	1	0.022	54	34	1.7	9	56
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	100	550		100	120
	%compliance		100	92	92	85	100	100	100	100			100	100	25			92	70	100		88	60
	N. Samples	0	13	13	13	13	9	11	10	12	12	12	12	12	12	12	12	12	10	11	12	8	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Ngaruroro River at Motorway Bridge	Average		17.0	9	94	3.4	0.9	1.8	0.166	0.012	0.001	0.033	0.049	0.004	18	30	2	0.028	88	47	2.1	104	105
	Min		11.2	7	67	0.8	0.5	1.0	0.102	0.005	0.001	0.001	0.012	0.002	4	4	0	0.002	9	1	0.5	94	40
	5%ile		11.6	8	79	1.1	0.6	1.0	0.103	0.005	0.001	0.003	0.013	0.002	4	5	1	0.002	11	3	0.6	95	41
	10%ile		12.4	8	88	1.4	0.6	1.0	0.104	0.005	0.001	0.004	0.014	0.002	5	7	1	0.002	14	5	0.6	96	42
	25%ile		15.7	9	90	2.2	0.6	1.5	0.110	0.005	0.001	0.010	0.023	0.002	6	14	1	0.007	29	7	1.6	98	46
<LQ	Median		17.4	9	91	3.4	0.7	1.5	0.116	0.005	0.001	0.015	0.030	0.002	10	19	2	0.009	57	26	2.0	103	60
	75%ile		19.1	9	96	4.7	1.0	1.5	0.181	0.016	0.001	0.036	0.052	0.005	18	33	3	0.011	120	43	2.8	107	119
	90%ile		19.5	10	113	5.1	1.5	1.9	0.282	0.030	0.003	0.087	0.122	0.006	31	50	5	0.017	178	101	3.3	114	203
	95%ile		20.9	11	118	5.3	1.6	3.4	0.345	0.033	0.003	0.114	0.136	0.007	53	83	5	0.119	254	160	3.4	117	231
	Max		22.5	11	123	5.6	1.7	5.0	0.407	0.035	0.003	0.140	0.150	0.008	75	115	5	0.220	330	220	3.5	120	259
	StDev		3.3	1	14	1.6	0.4	1.2	0.100	0.011	0.001	0.044	0.046	0.002	21	31	2	0.064	101	64	1.0	9	104
	95% C.I.		1.8	1	8	0.9	0.3	0.7	0.059	0.007	0.000	0.026	0.027	0.001	12	19	1	0.038	66	38	0.6	7	102
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614	0.2			0.444	0.015	7			0.033	100	550		100	120
	%compliance		100	92	92	83	100	100	100	100			100	100	45			91	67	100		67	75
	N. Samples	0	12	12	12	12	8	10	11	11	11	11	11	11	11	11	11	11	9	11	11	6	4

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m^2)
Ngaruroro River u/s Hawke's Bay Dairies	Average		17.1	10	102	4.2	0.7	1.4	0.257	0.008	0.002	0.025	0.037	0.004	22	38	4	0.052	14	8	1.1	114	66
	Min		12.0	8	88	2.6	0.4	0.5	0.110	0.005	0.001	0.008	0.020	0.001	2	16	1	0.003	3	1	0.3	99	13
	5%ile		12.1	8	91	2.7	0.5	0.8	0.111	0.005	0.001	0.009	0.021	0.001	3	17	1	0.003	4	1	0.3	102	14
	10%ile		12.3	8	92	2.9	0.5	1.0	0.111	0.005	0.001	0.009	0.021	0.002	4	19	1	0.004	5	1	0.3	105	15
	25%ile		14.4	9	94	3.4	0.6	1.4	0.115	0.005	0.001	0.014	0.024	0.002	10	25	2	0.006	6	2	0.3	114	18
<LQ	Median		18.2	10	101	4.2	0.7	1.5	0.137	0.005	0.001	0.016	0.031	0.002	11	30	2	0.006	9	5	0.5	115	30
	75%ile		19.4	10	105	5.3	0.8	1.5	0.344	0.010	0.003	0.037	0.047	0.003	24	53	3	0.010	11	6	2.2	120	90
	90%ile		20.4	11	114	5.5	1.0	1.5	0.580	0.015	0.003	0.049	0.058	0.009	34	65	8	0.014	21	8	2.9	122	144
	95%ile		20.5	12	121	5.7	1.0	1.7	0.671	0.017	0.003	0.052	0.064	0.010	68	69	10	0.244	45	25	2.9	122	162
	Max		20.5	13	129	6.1	1.1	2.0	0.720	0.020	0.004	0.056	0.071	0.011	118	75	12	0.590	69	50	3.0	123	180
	StDev		3.2	1	11	1.1	0.2	0.4	0.209	0.005	0.001	0.017	0.016	0.003	30	20	3	0.162	19	13	1.1	9	71
	95% C.I.		1.7	1	6	0.6	0.1	0.2	0.114	0.003	0.001	0.009	0.009	0.002	17	11	2	0.088	11	7	0.6	8	62
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance		69	100	100	100	100	100	62	100			100	100	23			92	91	100		40	80
	N. Samples	0	13	13	13	13	10	12	13	13	13	13	13	13	13	13	13	13	11	13	13	5	5

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro River d/s Hawke's Bay Dairies	Average		18.1	10	102	4.2	0.8	1.3	0.289	0.008	0.002	0.055	0.067	0.004	34	69	4	0.009	37	17	2.0	112	102
	Min		12.8	8	89	2.6	0.5	0.5	0.126	0.005	0.001	0.013	0.028	0.001	7	23	1	0.003	7	1	0.3	99	30
	5%ile		12.9	8	90	2.8	0.5	0.8	0.131	0.005	0.001	0.018	0.031	0.001	7	32	1	0.003	11	1	0.3	101	33
	10%ile		13.0	8	90	3.1	0.5	1.0	0.135	0.005	0.001	0.023	0.033	0.002	7	40	1	0.004	14	1	0.3	103	36
	25%ile		15.8	9	98	3.2	0.6	1.3	0.144	0.005	0.001	0.031	0.041	0.002	15	42	2	0.004	18	2	0.5	109	44
<LQ	Median		19.4	9	99	4.2	0.7	1.5	0.190	0.005	0.001	0.042	0.062	0.002	23	46	3	0.007	35	12	1.8	113	90
	75%ile		20.8	11	106	5.2	0.8	1.5	0.313	0.009	0.003	0.079	0.091	0.005	29	88	5	0.009	43	27	3.1	116	148
	90%ile		21.0	11	108	5.8	1.1	1.5	0.678	0.015	0.003	0.101	0.111	0.007	50	114	7	0.013	67	31	3.4	121	179
	95%ile		21.2	11	114	5.9	1.5	1.5	0.731	0.018	0.003	0.107	0.117	0.009	106	138	9	0.023	72	44	4.7	122	190
	Max		21.3	11	119	5.9	1.8	1.5	0.783	0.020	0.003	0.113	0.123	0.010	162	163	11	0.033	78	56	5.9	124	200
	StDev		3.4	1	9	1.2	0.4	0.3	0.233	0.005	0.001	0.034	0.033	0.003	44	41	3	0.008	23	17	1.8	10	78
	95% C.I.		2.0	1	5	0.7	0.3	0.2	0.138	0.003	0.000	0.020	0.019	0.002	26	24	2	0.005	15	10	1.1	10	77
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295	0.35			0.167	0.015	7			0.026	50	550		120	120
	%compliance		45	82	100	100	100	100	73	100			100	100	18			91	78	100		25	50
	N. Samples	0	11	11	11	11	8	11	11	11	11	11	11	11	11	11	11	11	9	11	11	4	4

Ngaruroro at Chesterhope	Average	8.6	19.7	10	113	3.0	1.3		0.083	0.003		0.017	0.020	0.006	3	12	4	0.013					
	Min	8.0	12.4	9	96	1.1	0.3		0.032	0.000		0.000	0.002	0.001	0	0	0	0.005					
	5%ile	8.1	13.7	9	101	1.4	0.4		0.042	0.001		0.000	0.002	0.002	0	1	1	0.006					
	10%ile	8.2	14.5	9	103	1.6	0.5		0.044	0.001		0.001	0.003	0.003	1	2	1	0.007					
	25%ile	8.3	16.6	10	107	2.3	0.7		0.061	0.002		0.002	0.004	0.003	1	3	2	0.009					
<LQ	Median	8.5	20.0	10	113	3.0	0.9		0.082	0.002		0.004	0.008	0.005	1	5	3	0.013					
	75%ile	8.7	23.0	11	117	3.4	1.4		0.094	0.004		0.013	0.015	0.007	4	10	5	0.016					
	90%ile	8.9	24.3	12	122	4.8	2.2		0.127	0.005		0.049	0.052	0.010	8	27	6	0.019					
	95%ile	9.1	24.6	13	126	5.2	2.9		0.144	0.007		0.061	0.071	0.012	12	57	8	0.022					
	Max	9.3	27.3	14	139	5.6	9.9		0.181	0.010		0.137	0.142	0.013	20	107	9	0.033					
	StDev	0.3	3.9	1	9	1.2	1.5		0.034	0.002		0.030	0.031	0.003	5	20	2	0.006					
	95% C.I.	0.1	1.2	0	3	0.3	0.5		0.010	0.001		0.009	0.009	0.001	1	6	1	0.002					
	Guideline	6.5-9.5	23	8	80	1.6	15	25	0.614				0.444	0.015				0.033					
	%compliance	100	75	100	100	89	100		100				100	100				100					
	N. Samples	43	44	44	44	44	44	0	44	44	0	44	44	44	44	44	44	44	0	0	0	0	0

Site		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	SIN (mg/L)	DRP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	TP (mg/L)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	CHLA (mg/m²)
Ngaruroro at Kuripapango	Average	8.0	13.8	10	99	7.5	0.4		0.055	0.002		0.003	0.006	0.002	5	3	1	0.003					
	Min	7.6	5.0	8	92	3.7	0.2		0.018	0.000		0.000	0.000	0.000	1	0	0	0.001					
	5%ile	7.7	7.2	8	96	4.6	0.2		0.019	0.001		0.001	0.002	0.001	1	1	0	0.002					
	10%ile	7.8	8.1	9	97	5.0	0.2		0.024	0.001		0.002	0.003	0.001	2	1	0	0.002					
	25%ile	7.9	11.0	9	99	5.9	0.3		0.032	0.001		0.002	0.004	0.001	2	2	0	0.002					
<LQ	Median	8.0	14.0	10	99	7.4	0.3		0.047	0.002		0.003	0.005	0.001	4	2	1	0.003					
	75%ile	8.0	17.1	10	100	8.7	0.5		0.065	0.003		0.004	0.007	0.002	6	3	1	0.004					
	90%ile	8.1	18.1	11	102	10.5	0.8		0.101	0.004		0.006	0.009	0.002	11	5	1	0.004					
	95%ile	8.1	19.7	11	102	11.7	0.9		0.114	0.005		0.008	0.011	0.003	13	6	1	0.005					
	Max	8.7	20.6	12	103	14.4	1.3		0.141	0.006		0.012	0.016	0.005	15	9	2	0.006					
	StDev	0.2	4.0	1	2	2.2	0.2		0.031	0.001		0.002	0.003	0.001	4	2	0	0.001					
	95% C.I.	0.0	1.1	0	1	0.6	0.1		0.008	0.000		0.001	0.001	0.000	1	0	0	0.000					
	Guideline	6.5-9.5	19	8	80	1.6	15	10	0.295				0.167	0.015				0.026					
	%compliance	100	92	100	100	100	100		100				100	100				100					
	N. Samples	52	52	52	52	52	52	0	52	52	0	52	52	52	52	52	52	52	0	0	0	0	0

Appendix E: Annual load calculation results

Table 17: Estimated annual DRP load in tonnes per year (T/Y).

Monitoring site	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008
Ngaruroro at Kuripapango	1.3	1.2	1.2	0.5	0.7	1.3	0.6	0.9	1.8	1.1
Ngaruroro at Whanawhana	1.5	1.1	3.7	6.1	9.3	3.1	5.3	2.3	3.6	1.7
Ngaruroro u/s HB Dairies	ND	ND	ID	1.3	12.4	3.6	7.8	3.3	3.3	2.6
Ngaruroro d/s HB Dairies	ND	ND	ID	7.9	11.9	ID	9.6	4.3	6.3	4.5
Ngaruroro at Ohiti	2.0	2.5	6.4	2.9	16.3	12.7	11.6	7.9	7.4	6.2
Waitio Stream at Ohiti	ND	ND	ID	0.2	0.8	0.7	0.7	0.9	0.8	0.6
Ngaruroro at Fernhill	4.8	5.9	ID	3.3	23.2	5.9	10.1	10.6	9.4	6.5
Ngaruroro at Carrick Road	ND	ND	ID	2.7	17.6	5.9	11.0	8.5	6.3	4.3
Ngaruroro at Motorway Bridge	ND	ND	ID	2.1	18.8	3.9	9.7	7.1	4.5	5.1
Tutaekuri-Waimate Stream at Chesterhope	ND	ND	ID	1.5	4.7	6.5	5.1	5.9	5.7	3.7
Ngaruroro at Chesterhope	9.4	6.9	12.2	18.0	10.7	11.7	8.8	13.1	17.1	9.4

Table 18: Estimated annual SIN load in tonnes per year (T/Y).

Monitoring site	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008
Ngaruroro at Kuripapango	10.1	11.5	7.6	3.4	3.8	3.5	3.4	6.4	7.7	8.4
Ngaruroro at Whanawhana	74	68	85	25	170	48	43	79	62	29
Ngaruroro u/s HB Dairies	ND	ND	ID	124	162	44	57	82	51	56
Ngaruroro d/s HB Dairies	ND	ND	ID	61	227	ID	214	189	117	104
Ngaruroro at Ohiti	262	149	175	82	284	170	175	379	337	216
Waitio Stream at Ohiti	ND	ND	ID	2.2	6.4	6.6	5.3	10.5	8.9	9.2
Ngaruroro at Fernhill	218	108	ID	123	380	73	126	242	245	175
Ngaruroro at Carrick Road	ND	ND	ID	81	358	60	134	231	231	171
Ngaruroro at Motorway Bridge	ND	ND	ID	75	321	57	116	219	216	161
Tutaekuri-Waimate Stream at Chesterhope	ND	ND	ID	18	57	57	44	51	53	38
Ngaruroro at Chesterhope	140	88	148	148	115	174	157	433	215	252

Appendix F: Flow ranges for the contaminant load analysis