

Water Quality in the Tukituki catchment

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State, trends and contaminant loads



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EXECUTIVE SUMMARY

Hawke's Bay Regional Council (HBRC) monitors water quality and river flow at a number of points across the Tukituki 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 Tukituki River catchment.

The aim of this study is to analyse the water quality and biomonitoring data collected by HBRC and NIWA between 1977 and 2008. In particular, the study aims at investigating the following points:

- the state of the Tukituki 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 contaminant loadings in the Tukituki River;
- the contribution of the different point source discharges and main tributaries to the measured contaminant loads in the catchment.

Generally, the microbiological water quality is good across the catchment – better than national median values for comparable systems- and improving over time. Water clarity is acceptable across the catchment, also better than national medians.

The largest single issue in the Tukituki catchment appears to be nutrient enrichment and associated periphyton growth, with a general degradation from upstream to downstream in the catchment. Macroinvertebrate communities also follow a pattern of degradation going downstream in the catchment. Nutrient concentration ratios indicate that the system is likely to be generally phosphorus limited, although periods of co-limitation or N-limitation are likely to occur during low river flows.

The analysis has revealed concerns about two tributaries:

- the upper Tukipo River (above SH50), which still has relatively good water quality, but not as good as the other upper catchment sites, and where significant increases of DRP and SIN and MCI decrease have been detected over the last 10 years;
- the Mangatarata Stream, where most parameters except ammonia and SIN indicate the most degraded water quality of all monitored sites.

Significant temporal trends indicating an increase of DRP concentration and a degradation of macroinvertebrate communities over time have been found at a number of sites in the Tukituki mainstem and in tributaries in the upper and middle catchment. Significant increasing trends of the SIN concentration have also been found in two tributaries, the Tukipo and Mangaonuku Rivers. The state of macroinvertebrate communities (measured as macroinvertebrate community index - MCI) appears to have degraded over time at a number of tributaries and mainstem sites in the upper and middle catchment. The causes for these temporal trends are unknown and should be investigated, including the possible influence of global weather cycles.

Nutrient load analysis indicates that the upper catchment (above SH50) yields approximately 6 Tonnes of DRP and 200 to 300 Tonnes of SIN per year. At Shagrock (the bottom point of the middle catchment), the annual loads are estimated at 30 to 50 Tonnes of DRP and 1,600 to 3,300 Tonnes of SIN per year. The nutrient loads remain constant or decrease in the lower catchment.

These figures indicate that the middle catchment, between SH50 and Shagrock, appears to receive the largest sources of nutrients, particularly at low river flows.

In the current situation, the point-source discharges from the Waipawa and Waipukurau oxidation ponds are the largest source of DRP, representing up to 70 % of the total DRP inputs to the upper and middle

catchment. After the oxidation pond upgrades in 2014, non-point source pollution in the Waipawa and Mangatarata catchments are expected to become the dominant inputs of DRP to the middle catchment.

SIN loads appear to not be associated with point source discharges, and is likely due to non-point source pollution from intensive agriculture in the Ruataniwha Plains.

If a management objective is to reduce the frequency and duration of algal blooms in the Tukituki River, managing DRP inputs to the system is an obvious priority target –this is consistent with the RRMP which puts emphasis on DRP management. It should be noted however, that managing only one nutrient is fraught with risk (Wilcock *et al.* 2007), particularly as some sites in the catchment appear to switch to SIN-limited conditions during periods of low river flow. In other words, SIN inputs to the Tukituki catchment waterways should also be managed.

In terms of achieving a reduction of the DRP loads to the Tukituki catchment, the discharges from the oxidation ponds are the number one target -which has already been addressed through consent conditions. The next largest contributors, the Waipawa and Mangatarata catchments should become the focus of active investigation and management.

An important consideration to bear in mind is the fact that even a drastic reduction in nutrient concentrations in the Tukituki 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 extended periods of low flow occurring in some summers. The benefits of a nutrient concentration reduction are more likely to be reduced algal growth rates and peak biomass, *i.e.* how fast and how often high algal biomass will occur, and how large the algal biomass and cover will be.

Further monitoring and investigations are recommended to better identify, and possibly manage, the sources of contaminants in the Tukituki catchment.

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Table 15: Annual and summer (November to April inclusive) SIN load in tonnes per year (T/Y). (a) provisional estimate based on 9 months of data. (b) estimate based on 6 months (January-June) data. N.D.:no data; I.D.: Insufficient data. 24

1. Context

1.1. Introduction

Hawke's Bay Regional Council (HBRC) monitors water quality and river flow at a number of points across the Tukituki 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 Tukituki River catchment.

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 Tukituki catchment until March 2008. In particular, the study aims at investigating the following points:

- the state of the Tukituki 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 contaminant loadings in the Tukituki River;
- the contribution of the different point source discharges and main tributaries to the measured contaminant loads in the catchment.

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

2. Methods

2.1. Original dataset

A complete extract of HBRC's water quality database for the Tukituki catchment was obtained from HBRC's Water Quality and Ecology teams. Since 1977, water quality has been monitored at 60 sites across the Tukituki catchment. The dataset available at each site greatly varied: some sites had extensive datasets spanning more than 30 years; other sites had only a few samples.

As part of its State of the Environment (SOE) and contact recreation monitoring programmes, HBRC regularly monitors water quality at 11 sites across the Tukituki catchment. Because of the amount of data, and the regularity of the sampling regime, these sites were used as the core dataset for the water quality state and trends analysis presented 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).

A further two sites, located at the bottom of the Tukipo (Tukipo at Ashcott Rd) and Waipawa (Waipawa at RDS) catchments are not part of the current monitoring programme, but have a significant amount of usable historical data. These sites were used in the contaminant load analysis presented in section 6 of this report.

In addition to the sites described above, NIWA has monitored water quality and river flow at two sites in the Tukituki catchment since 1989, the Tukituki River at Red Bridge, and the Makaroro River at Burnt Bridge. The Makaroro River site is considered a reference (*i.e.* un-impacted) site, and the data collected at this site is used in this report. For Tukituki at red Bridge, the NIWA data was used to assess consistency with HBRC data (refer to section 2.1), then HBRC data was used in this report.

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

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).

On few occasions, two samples were taken at the same site, on the same day, with different results obtained. The sample with results closest to the median for the site was kept, and the other one not used for further analysis. If the two samples were equally distributed around the median, the mean of the two samples’ results was calculated and used in the analysis.

Dissolved Oxygen (DO) Saturation calculated from DO concentration and Temperature data. Atmospheric pressure and elevation not being part of the dataset, it was considered that all samples were taken at sea level and normal atmospheric pressure (1013 mBa)

The dataset contains two indicators of bacteriological water quality: faecal coliforms (FC) and *Escherichia coli* (*E. coli*). Generally speaking, FC has been used in the SOE monitoring programme since 1990, and to test compliance with the provisions of the RRMP. *E.coli* was generally used from 1998 in the contact recreation monitoring programme, to test compliance with the Ministry for the Environment microbiological water quality guidelines (MfE, 2002). 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, there generally are a significant number of samples which 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.

2.2.1. Joined Monitoring sites

Two sites have been monitored on the Mangaonuku Stream (Mangaonuku at Tikokino Rd and Mangaonuku at Argyll Rd). The two sites are only a few kilometres apart. The Argyll Rd site dataset covers the 1994-2006 period, and the Tikokino Rd site covers 1994-1996 and 2007-2008. Joining the two sites to obtain a longer dataset allowing a more powerful temporal trend analysis was considered as an option. Samples were collected at the same dates at both sites during the 1994-1996 period. These samples were used to test differences between the two sites. A series of Wilcoxon paired rank test indicated significant differences between the two sites for DRP ($p < 0.05$) and TP ($p < 0.001$)¹, thus the two datasets could not be joined. The downstream-most site (Tikokino Rd) was considered to provide the better information about the Mangaonuku catchment as a whole, and was used in the analysis presented in this report.

Regular monitoring was undertaken at two close-by sites on the Tukituki River as part of HBRC’s state of the environment monitoring programme. Between 1993 and 1998, water quality was monitored at Tamumu Bridge. In 1998, the monitoring site was shifted to the Shagrock flow recorder, located only a couple of kilometres downstream. To my knowledge, there are no major tributaries or point source discharges, or major land use change between the two sites, i.e. there is no reason to believe the water quality would be different between the two sites. For the purpose of the analysis presented in this report, the datasets from the two sites have been joined under a unique site, “Tukituki at Shagrock”.

¹ The Argyll Rd site had higher median DRP (0.003 vs. 0.002 g/m³) and TP (0.022 vs. 0.016 mg/m³) concentrations.

2.2.2. Monthly series

The results used in this study were obtained as part of a number of monitoring programmes conducted by Hawke's Bay Regional Council, such as state of the environment (SOE), contact recreation, compliance or incidents monitoring programmes. As a result, the monitoring frequency differs from site to site, with time, and depending on the parameter. For example, SOE monitoring is done monthly, but has been quarterly for a period (1999 – 2004) in the past, and contact recreation monitoring for bacteriological water quality is done weekly, but only during summer. To conduct temporal trends analysis, regular time series (e.g. one monthly sample) are required, and a number of adjustments were made to prepare the dataset for this analysis:

- when several results were available for a parameter in one given month, the result taken on the day the river flow was closest to the average flow for that month was used in the analysis;
- on rare occasions, some sites had two samples in 1 month, but none the preceding or following month. When considered appropriate (e.g. when one sample was taken very close to the beginning or end of the month), and for the temporal trends analysis only, one of the samples was considered taken a few days earlier or later (i.e. in a different month), to obtain a more consistent dataset.

2.3. Flow data

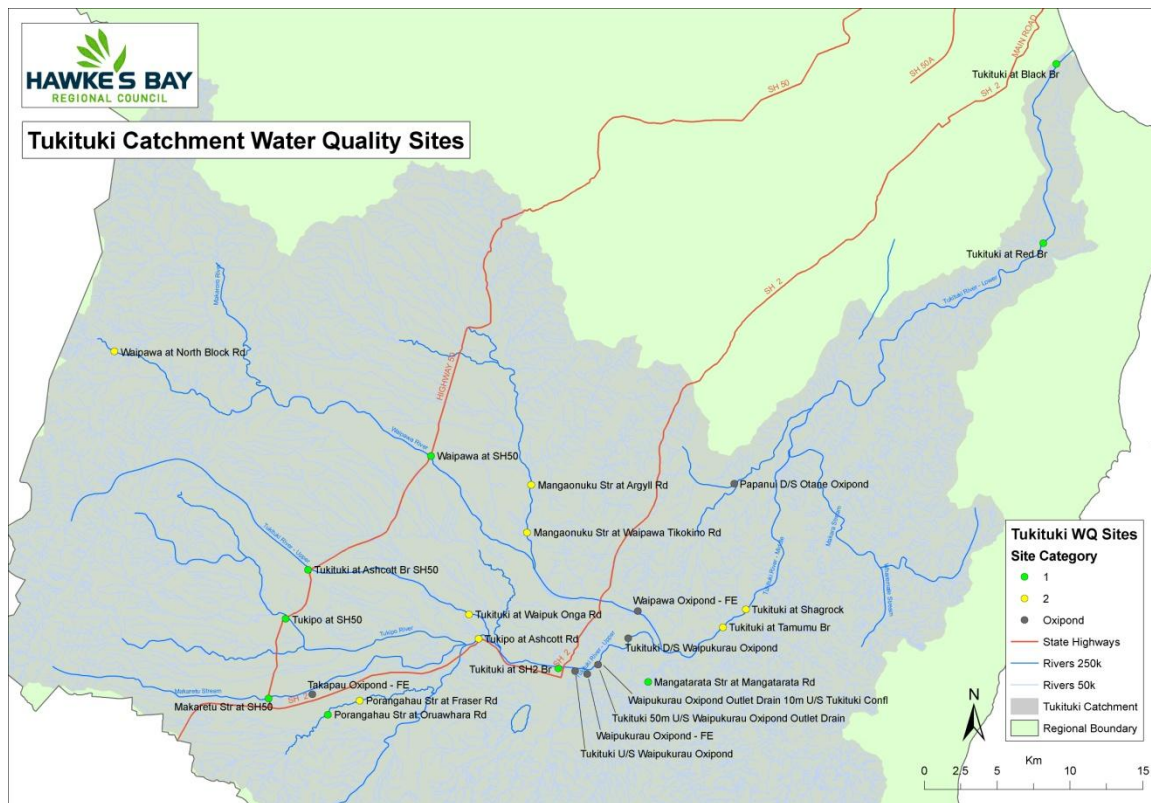
All flow data used in this report was provided by HBRC's Hydrology team. Continuous (15 min interval) flow data is available at five sites in the Tukituki catchment (Map 2): three sites on the Tukituki River main stem (Tapairu Rd, Shagrock and Red Bridge), one on the Tukipo River (SH50) and one on the Waipawa River (RDS). 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 3). All flow data used in this report was based on daily average flow.

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

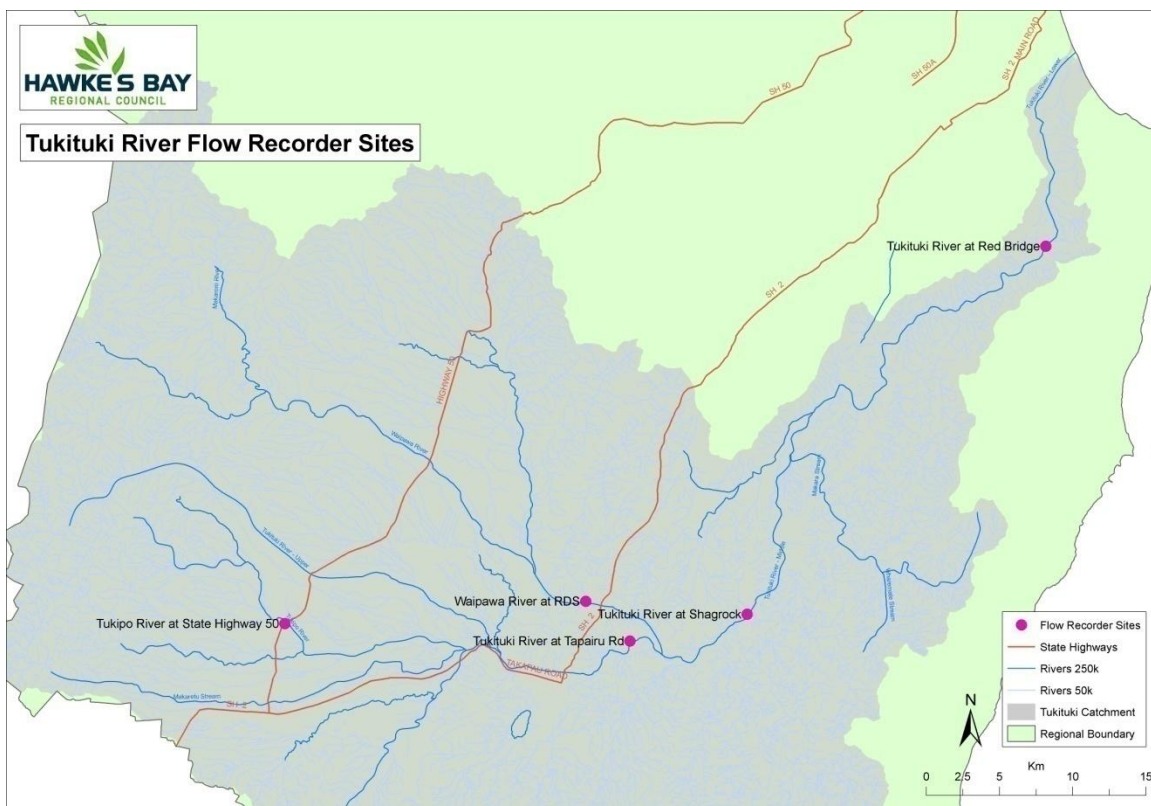
Flow (L/s)	Tukipo at SH 50	Tukituki at Tapairu Rd	Waipawa at RDS	Tukituki at Shagrock	Tukituki at Red Bridge
3× Median	2,243	27,582	25,723	59,502	64,794
Median	747.6	9,194	8,574	19,834	21,598
Lower Quartile	359.3	5,492	5,133	10,638	11,965
7-day MALF	149.0	2,632	3,025	5,175	6,141
Minimum	53.9	1,391	1,776	3,023	1,308
Data record	1976-2008	1987-2008	1988-2008	1988-2008	1968-2008

Table 2: Flow statistics calculated from synthetic flow records in the Tukituki catchment.

Flow (L/s)	Makaroro at Burnt Bridge	Makaretu at SH 50	Waipawa at SH50	Tukituki at SH50	Mangaonuku at Tikokino Rd	Porangahau at Oruawhara Rd	Tukipo at Ashcott Rd
3× Median	10,911	3,862	18,398	9,216	7,336	834	12,173
Median	3,637	1,287	6,133	3,071	2,445	278	4,058
Lower Quartile	2,364	786	3,798	1,913	1,588	147	2,168
7-day MALF	1,509	390.7	2,352	1,001	1,056	52.5	1,145
Minimum	478	245	1,530	665	754	20	693
Correlation with	Waipawa at RDS	Tukituki at Tapairu Rd	Waipawa at RDS	Tukituki at Tapairu Rd	Waipawa at RDS	Tukituki at Taiparu Rd	Tukipo at SH50



Map 1: Main water quality monitoring sites in the Tukituki catchment.



Map 2: Flow recorders in the Tukituki catchment.

Table 3: Summary of the water quality and flow data used in this study on the Tukituki catchment. 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.		
Tukituki at SH50 (Ashcott Br)	356	1994 - 2008	✓	✓	✓	✓	✓	Flow correlation (medium quality) with Tukituki at Tapairu Rd
Makaroro at Burnt Bridge	N/A	1989 - 2006	✓	✓	-	-	✓	NIWA national network site. Reference (unimpacted) site.
Waipawa at North Block Rd	278	1994 - 2000	✓	✓	✓	✓	-	Reference (unimpacted) site
Waipawa at SH50	280	1993 - 2008	✓	✓	✓	✓	✓	Gauged flow or flow correlation (high quality) with Waipawa at RDS
Tukipo at SH50	144	1977-1979 1994 - 2008	✓	✓	✓	✓	✓	Flow recorder site.
Makaretu at SH50	19	1982-1983 1994 – 2008	✓	✓	✓	✓	✓	Flow correlation (medium quality) with Tukituki at Tapairu Rd. Quarterly data 1994-2004, monthly afterwards
Tukituki at SH2	17	1977 - 2008	✓	✓	✓	-	87-08	Flow correlation (high quality) with Tukituki at Tapairu Rd. General data 1977-2000. Only Contact recreation monitoring after 2000.
Mangaonunku at Tikokino Rd	284	1993-1997 2007-2008	✓	✓	✓	1	✓	Gauged flow or flow correlation (medium quality) with Waipawa at RDS
Porangahau at Oruawhara Rd	397	1977 - 2008	✓	✓	✓	✓	87-08	Gauged flow or flow correlation (medium quality) with Tukituki at Tapairu Rd.
Tukipo at Ashcott Rd	21	1990-1996	✓	✓	✓	-	✓	Flow correlation (medium quality) with Tukipo at SH50
Tukituki at Tapairu Rd	25	1990 - 2000	✓	✓	✓	-	87 -08	Flow recorder site. Monitored by HBRC as site downstream of Waipukurau oxidation pond discharge
Waipawa at RDS	26	1990 - 2000	✓	✓	✓	-	✓	Flow recorder site
Tukituki at Shagrock	2403 + 281	1998 - 2008	✓	✓	✓	✓	✓	Flow recorder site. Joined dataset with Tukituki at Tamumu Bridge
Mangatarata at Mangatarata Rd	277	1994 -2000 2004-2008	✓	✓	✓	1	-	Flow: only some spot gauging. Water quality monitoring irregular between 1997 -2000.
Tukituki at Red Bridge	407	1977 - 2008	✓	✓	✓	✓	✓	Flow recorder site. Site also monitored by NIWA
TukiTuki at Black Bridge	15	1977 - 2008	✓	✓	✓	✓	✓	Flow correlation (medium quality) with Tukituki at Red Bridge
Tukituki upstream of Waipukurau oxidation pond	N/A	05-08	✓	DRP only	✓	-	✓	Central Hawke's Bay District Council self-monitoring data. Flow data from Tukituki at Tapairu Rd
Tukituki downstream of Waipukurau oxidation pond	N/A	05-08	✓	DRP only	✓	-	✓	Central Hawke's Bay District Council self-monitoring data. Flow data from Tukituki at Tapairu Rd
Waipawa upstream of Waipawa oxidation pond	N/A	05-08	✓	DRP only	✓	-	✓	Central Hawke's Bay District Council self-monitoring data. Flow data from Waipawa at RDS
Waipawa downstream of Waipawa oxidation pond	N/A	05-08	✓	DRP only	✓	-	✓	Central Hawke's Bay District Council self-monitoring data. Flow data from Waipawa at RDS

2.4. Data analysis

Descriptive statistics (mean, percentiles, confidence intervals), such as those provided in Appendix A and showed 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;
- during and outside the main bathing season (November to April inclusive) to tease out any difference in water quality between these two periods.

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 (including Kendall seasonal test) was carried out using NIWA's water quality trends software.

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 summing up the instantaneous flux:

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

When contaminant concentrations are known only at regular time intervals (e.g. monthly), the above formula can be approximated using a number of approaches. Two approximations methods were used in this report.

2.5.1. Averaging approach

This method uses the monthly average river flow and the monthly average contaminant concentration to estimate monthly loads. The annual load is then calculated by summing up the monthly loads. This method is particularly applicable when the contaminant concentration and river flow are independent variables (Richards, 1998).

Monthly load:

$$Load(month_i) = [Pollut](month_i) \cdot \int_{01/month_i}^{31/month_i} Flow(t) \cdot dt$$

Annual load:

$$Load(year_i) = \sum_{i=1}^{12} Load(month_i)$$

2.5.2. Ratio approach: The Beale ratio estimator

Ratio estimators use the year's data to calculate a mean daily load, then use the mean flow from days lacking concentration data to adjust the mean daily load. The annual load is obtained by multiplying the mean daily load by 365 (Richards, 1998). Ratio estimators assume that there is a positive linear relationship between river flow and contaminant load.

The basic assumption of a ratio estimator is that the ratio contaminant load/river flow for the entire year is the same as on days the contaminant concentration was measured.

$$\frac{\text{Average_daily_load}_{\text{year}}}{\text{Average_daily_flow}_{\text{year}}} = \frac{\text{Average_daily_load}_o}{\text{Average_daily_flow}_o}$$

where the subscript "year" refers to an average for the year, and the subscript "o" refers to an average over the days on which concentration was observed.

However, as daily load and daily flow are correlated variables, this ratio estimator is biased and a bias correction factor must be used. The Beale Ratio estimator is one way to correct the bias:

$$\text{Average_daily_load}_{\text{year}} = \text{Average_daily_load}_o \cdot \frac{\text{Average_daily_flow}_{\text{year}}}{\text{Average_daily_flow}_o} \cdot \frac{1 + \left(\frac{1}{n} - \frac{1}{N}\right) \frac{S_{lq}}{l_o q_o}}{1 + \left(\frac{1}{n} - \frac{1}{N}\right) \frac{S_{qq}}{q_o^2}}$$

Where: S_{lq} is the covariance between flow and pollutant flux, s_{qq} is the variance of the flow based on the days on which concentration was measured. N is the expected population size (365), and n is the number of concentration measures (generally 12, as we have one measure for each month). l_o and q_o represent the average daily flux and flow respectively on the days concentrations were measured.

The square root of the mean square error of the daily load (RMSE) provides an estimate of the standard deviation, and is given by:

$$RMSE = \sqrt{l_o^2 \left[\left(\frac{1}{n} - \frac{1}{N} \right) \left(\frac{S_{qq}}{q_o^2} + \frac{S_{ll}}{l_o^2} - 2 \frac{S_{lq}}{l_o q_o} \right) + \left(\frac{1}{n} - \frac{1}{N} \right)^2 \left(2 \frac{S_{qq}^2}{q_o^4} - 4 \frac{S_{qq}}{q_o^2} \frac{S_{lq}}{l_o q_o} + \frac{S_{lq}^2}{(l_o q_o)^2} + \frac{S_{qq}}{q_o^2} \frac{S_{ll}}{l_o^2} \right) \right]}$$

2.1. Tukituki at Red Bridge: comparison between NIWA and HBRC data

Water quality in the Tukituki River at red bridge is monitored by both Hawke's Bay regional Council (1977-2008) and NIWA (1989 – 2006). For "quality assurance" purposes, a statistical comparison of the data collected by the two agencies was undertaken. The methodology and results are presented in Appendix G. Although the monitoring programmes are not synchronised (i.e. the HBRC and NIWA samples are collected on different days), no significant differences were found, indicating that the results independently obtained by the two agencies are consistent.



Photo 1: Mangaonuku Stream at Tikokino Road.



Photo 2: Tukipo River at SH50.

3. Water quality in the Tukituki catchment

3.1. The Tukituki Catchment

The Tukituki River and its largest tributary, the Waipawa River, take their sources high in the Ruahine Ranges. The other major tributaries take their sources in the foothills of the Ruahine Ranges (Tukipo River and the Makaretu Stream), the Argyll Ranges bordering the catchment to the north (Mangaonuku Stream) and the Two Peaks Ranges, to the south of the catchment (Porangahau Stream, Mangatarata Stream). The Tukituki River flows into the Pacific Ocean on the East Coast of Hawke's Bay.

3.1.1. Geology and topography

The Tukituki headwaters are in the Ruahine Ranges, dominated by Triassic-Jurassic greywacke, a hard sedimentary rock. The Ruahine ranges foothills have an underlying geology of tertiary mudstone and sandstone, with deposited gravel, making the transition to an extensive sedimentary basin, the Ruataniwha Plains. This basin is bounded to the south, north and east by medium elevation hill ranges, dominated by sandstones and mudstones, but with significant outcrops of limestone, particularly in the middle catchment. More detailed information and maps can be found in two HBRC reports (Ludecke, 1988; HBRC, 2003).

3.1.2. Values

The Tukituki catchment supports a regionally significant brown and rainbow trout fishery. The angling activity is spread throughout the catchment, with the Tukituki River mainstem, and a number of its tributaries, including the Waipawa and Tukipo Rivers, and the Makaretu and Mangaonuku Streams the most sought after fisheries. The trout populations in the catchment are self sustaining, with trout spawning occurring in a number of tributaries.

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

The Tukituki catchment also supports significant ecological values associated with the aquatic and riparian ecosystems and significant habitats of indigenous fauna and flora (HBRC, 2003).

3.1.3. Landcover and landuse

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. Apart from some areas of exotic forestry, largely confined to the upper parts of the catchment, the rest of the catchment is largely deforested. Landuse in the catchment's hill country (northern, southern and eastern catchment boundaries) is predominantly low to medium intensity dry stock farming. The plains are dominated by intensive dairy farming, and horticulture, viticulture and cropping.

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 Tukituki catchment. These have primarily a regulatory purpose, particularly in relation to resource consents for activities having a potential or actual effect on water quality.

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 Tukituki river system. Table 4 summarises the reference values used in this report for different parts of the Tukituki catchment.

3.2.1. Water temperature

The RRMP defines a maximum water temperature of 25°C. However, scientific evidence suggests that this limit may not be adequate to fully protect the Tukituki catchment’s aquatic communities and trout fishery values.

Water temperatures above 19°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°C (Hay *et al.* 2007). A number of field and laboratory studies indicate that a maximum daily temperature of 21 to 23°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°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°C is recommended for the Upper Tukituki 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°C is recommended for the Middle and Lower Tukituki 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.

3.2.3. 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.

Hawke’s Bay Regional Council will be installing continuous DO, pH and temperature monitoring equipment at the Tukituki at Shagrock monitoring station.



Photo 3: Makaretu Stream at SH50 bridge.



Photo 4: Porangahau Stream at SH2 bridge.

3.2.1. 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.

Carbonaceous BOD₅ (cBOD₅) has been monitored in the Waipukurau and Waipawa oxidation pond discharges since 2005, but not in the receiving rivers upstream and downstream of the discharge points. As part of a joint approach between the Regional and District Councils, the full suite of state of the environment monitoring programme variables will now be analysed monthly upstream and downstream of both oxidation pond discharges.

There is no general formula to directly link BOD or TOC with DO. 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.

3.2.2. Water clarity and suspended solids

The RRMP defines a maximum suspended solids (SS) concentration of 10 mg/l throughout the Tukituki catchment, at all 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. This may be particularly relevant to the Tukituki and Waipawa headwaters in the Ruahine ranges, where a combination of sedimentary geology, high rainfall and steep topography are thought to be natural causes of relatively low water clarity (refer to section 3.3.4 of this report).

3.2.3. 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 (NH₄⁺) and un-ionised ammonia (NH₃). 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 4. The lowest value obtained was retained as the recommended overall guideline for each part of the catchment. For consistency with the upper catchment, a guideline value of 0.4g/m³ was recommended for the middle catchment. It is noted that the low ammonia threshold value recommended for the lower catchment is due to the high pH commonly recorded, in turn likely caused by high algal biomass.

Table 4: Maximum total ammonia-nitrogen (NH₄-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 Tukituki catchment.

Section of catchment	Site	Temperature (°C) 95 th %ile	pH 95 th %ile	Recommended Total NH ₄ -N guideline (mg/l)	
Upper catchment	Tukituki at SH50	19	8.0	0.9	0.4
	Tukipo at SH50	19	8.5	0.4	
	Makaretu at SH50	20	8.0	0.9	
	Waipawa at SH50	18	7.8	1.7	
Middle catchment	Tukituki at SH2	22	7.9	0.8	0.4
	Porangahauat Oruawhara Rd	20	8.5	0.5	
	Mangatarata	20	7.9	1.2	
	Tukituki at Shagrock	23	ND	22	
Lower catchment	Tukituki at Red Br	23	9.4	<0.18	0.18
	Tukituki at Black Br	23	9.3	<0.18	

3.2.4. Bacteriological water quality

Two indicators of the microbiological water quality have been routinely monitored in the Tukituki 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 upper Tukituki catchment, 200 in the middle catchment and 100 in the lower catchment. 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.

3.2.5. 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 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*/m² 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.

3.2.6. Macroinvertebrate communities

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

Table 5: Summary of recommended guidelines for the Tukituki catchment for physical, chemical and biological parameters.

Parameter	River flow	Upper catchment (Above SH50)	Middle Catchment (SH50 to Tamumu Bridge)	Lower catchment (below Tamumu Bridge)
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
SS (mg/l)	< 3* median	10	10	10
Ammonia-N (mg/l)	All	0.4	0.4	0.18
Periphyton biomass (mg <i>Chlo a</i> /m ²)	All	100	120	120
SIN (mg/l)	< Median	0.167	0.444	0.444
DRP (mg/l)	< Median	0.015	0.015	0.015
<i>E.coli</i> (/100mL)	All	550	550	550
Faecal coliforms (/100mL)	< Median	50	200	100
MCI	All	120	100	100



Photo 5: Tukituki River at SH2 bridge.

3.3. Water Quality of the Tukituki River

Table 6 to Table 8 provide a summary of the water quality at the main monitoring sites on the main stem of the Tukituki River.

3.3.1. Biological monitoring

There is a clear trend of increasing measured periphyton biomass (and decreasing rate of compliance with the guideline) going downstream in the Tukituki River. Macroinvertebrate community index values (MCI) values show the same pattern - a progressive degradation going downstream in the catchment.

Table 6: Summary of biomonitoring results at five monitoring sites on the Tukituki River. Sites are presented in the upstream to downstream order.

Parameter	Monitoring Site	Average	Minimum	Maximum	N. of Samples	% Compliance with standard	Standard/ Guideline
Periphyton biomass <i>Chlorophyll a</i> (mg/m ²)	SH50	118	22	390	5	80 (4/5)	120
	SH2	-	-	-	-	-	
	Shagrock	118	7	230	4	50 (2/4)	
	Red Bridge	264	20	660	5	40 (2/5)	
	Black Bridge	220	51	500	5	40 (2/5)	
Macroinvertebrate Community Index (MCI)	SH50	122	103	144	11	55 (6/11)	100
	SH2	-	-	-	-	-	
	Shagrock	112	90	129	7	86 (6/7)	
	Red Bridge	104	78	123	11	55 (6/11)	
	Black Bridge	86	75	118	7	14 (1/7)	

3.3.2. Nutrients

Both DRP and SIN concentrations indicate very good water quality at SH50. However, both nutrient concentrations increase rapidly between SH50 and SH2, where the level of compliance with the recommended guideline is relatively poor for DRP (61%) and very poor for SIN (9%). The level of compliance remains relatively stable between SH2 and Shagrock, in spite of the confluence with the Tukituki's largest tributary, the Waipawa River. The nutrient concentrations improve significantly in the lower catchment (Red Bridge and Black Bridge).

Although the nutrient concentrations at SH50 are generally acceptable, the periphyton biomass exceeded the guideline on 1 out of 5 sampling occasions. This could be caused by the very extended periods of low which occur in some summer seasons

The decrease in nutrients concentrations observed in the lower catchment may be due to increased consumption by the algal biomass – an hypothesis corroborated by the increased periphyton biomass in the lower catchment.

3.3.3. Microbiological water quality

E.coli concentrations recorded at the 5 monitoring sites along the Tukituki River have nearly always been below the MfE guideline (at least 95% compliance), indicating water of a swimmable standard most of the time.

The more stringent RRMP guideline is also generally complied with below median flow, although the levels of compliance at Shagrock and Black Bridge are marginally lower. The lower level of compliance with the RRMP guideline observed at SH50 is due to the lower guideline value (50/100 ml) rather than degraded water quality.

Table 7: Summary of dissolved Reactive phosphorus (DRP) and soluble inorganic nitrogen (SIN) at five monitoring sites on the Tukituki River. Sites are presented in the upstream to downstream order.

Parameter	Monitoring Site	Average	Median	90 th percentile	95 th percentile	N. of Samples	% Compliance with standard	Standard/ Guideline
DRP (g/m ³) Under median flow	SH50	0.003	0.002	0.005	0.005	44	95	0.015
	SH2	0.012	0.009	0.030	0.030	36	61	
	Shagrock	0.013	0.010	0.025	0.027	44	59	
	Red Bridge	0.006	0.002	0.012	0.022	41	90	
	Black Bridge	0.008	0.005	0.020	0.022	111	78	
SIN (g/m ³) Under median flow	SH50	0.08	0.06	0.16	0.20	44	91	0.167
	SH2	1.07	0.96	1.68	2.16	35	9	0.444
	Shagrock	0.79	0.68	1.31	1.66	40	18	
	Red Bridge	0.37	0.24	0.97	1.14	37	68	
	Black Bridge	0.35	0.22	0.96	1.16	105	70	

3.3.4. Water clarity and suspended solids

Suspended solids records indicate a generally good level of compliance with RRPM guideline. The lowest compliance rate is observed at SH50, which may be explained by the close proximity to the headwaters in the Ruahine ranges, where the very high erosion rates² bring suspended sediments down the river. The suspended sediments are likely to be greywacke finely ground/crushed in the high energy headwaters environment.

Similarly, median water clarity is better in the middle catchment than in the in upper catchment. The median water clarity decreases again in the lower catchment, to levels similar to those observed in the upper catchment. In the middle and lower catchment, water clarity complies with the 1.6m recreational waters guidelines between two thirds and three quarters of the time.

When considering only base flow conditions (below median flow) the upper catchment has the highest water clarity, and complies nearly 60% of the time with the 3.5m water clarity guideline for the protection of the trout fishery value. The mean water clarity remains stable around 3m in the rest of the catchment.

3.3.5. Other indicators

Records indicate that water pH is usually within the tolerance range of both native fish species and trout tolerance range (6.5 to 9.5) at most sites. However, high pH (above 9) is recorded on a regular basis at the two lower catchment sites. As such, the pH values observed in the lower Tukituki River should not be a significant stressor to aquatic life. However, the high pH values will increase ammonia toxicity (refer to section 3.2.3 of this report). High pH values are also a likely indicator of active algal growth³.

The median Total Organic carbon (TOC) concentrations generally increase when moving downstream in the catchment, indicative of progressive organic enrichment. This may be associated with the increase in algal biomass between the upper and lower Tukituki River.

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 Tukituki's aquatic biota. Water temperature in the Tukituki River is generally below guideline levels at all monitoring sites (results presented in Appendix A).

² Due to a combination of very steep topography and high rainfall.

³ During the day, algal production uses CO₂ faster than it can be replaced from the atmosphere, causing the dominant CO₂/HCO₃⁻ equilibrium to be displaced so that the pH is increased (HCO₃⁻ + H⁺ ↔ CO₂ + H₂O).

Table 8: Summary of water quality state at five monitoring sites on the Tukituki 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	90 th percentile	95 th percentile	N. of Samples	% Compliance with standard		Standard/ Guideline
pH	SH50	7.5	7.7	6.9-7.9	6.8-8.0	10	100 ^(a) / 50 ^(b)		5.0 to 9.5 ^(a) 6.7 to 7.8 ^(b)
	SH2	7.7	7.6	ID	ID	4	ID		
	Shagrock	8.0	7.8	7.5-8.7	7.3-8.7	7	100 ^(a) / 57 ^(b)		
	Red Bridge	8.5	8.6	7.8-9.0	7.4-9.4	7	89 ^(a) / 11 ^(b)		
	Black Bridge	8.2	8.2	7.2-9.2	7.2-9.3	7	100 ^(a) / 43 ^(b)		
Ammonia-N (g/m³)	SH50	0.02	0.01	0.03	0.04	98	100		0.4
	SH2	0.07	0.01	0.06	0.11	99	99		
	Shagrock	0.02	0.01	0.05	0.08	89	100		
	Red Bridge	0.02	0.01	0.03	0.04	73	100		0.18
	Black Bridge	0.03	0.01	0.04	0.08	221	97		
Water clarity (m) <3* Median flow	SH50	2.4	1.9	0.2	0.1	77	55		1.6
	SH2	2.4	2.5	0.9	0.6	31	68		
	Shagrock	2.6	2.8	1.0	0.5	88	75		
	Red Bridge	2.3	2.0	0.7	0.4	60	72		
	Black Bridge	2.3	2.0	0.7	0.4	75	69		
Water clarity (m) < Median flow	SH50	3.9	3.7	1.4	0.9	38	58 ^(c)	24 ^(d)	3.5 ^(c) 5 ^(d)
	SH2	3.1	3.0	1.6	1.6	20	35 ^(c)	5 ^(d)	
	Shagrock	3.2	3.0	2.2	1.3	69	31 ^(c)	7 ^(d)	
	Red Bridge	3.0	2.9	1.9	1.8	35	29 ^(c)	6 ^(d)	
	Black Bridge	2.9	2.9	1.7	1.4	48	29 ^(c)	8 ^(d)	
Suspended Solids (mg/l) <3* Median flow	SH50	23	3	56	115	93	71		10
	SH2	128	18	303	513	41	88		
	Shagrock	5	2	15	21	86	85		
	Red Bridge	4	2	10	12	60	90		
	Black Bridge	4	2	9	12	88	92		
<i>E. coli</i> (/100mL) All flows	SH50	49	12	161	193	40	98		550
	SH2	148	21	342	543	168	95		
	Shagrock	80	15	110	540	41	95		
	Red Bridge	73	18	121	157	40	98		
	Black Bridge	126	27	248	630	243	95		
Faecal coliforms (/100mL) Under median flow	SH50	55	23	85	153	28	75		50
	SH2	52	30	112	129	18	100		200
	Shagrock	117	80	286	390	51	84		
	Red Bridge	37	26	70	93	29	93		100
	Black Bridge	339	30	1280	1961	63	75		

3.4. Water quality in the Tukituki River Tributaries

3.4.1. MCI

Macroinvertebrate community index (MCI) results indicate that the upper catchment sites generally comply with the 120 guideline, indicative of clean water.

The Porangahau Stream generally does not comply with the guideline recommended for the middle and lower catchment (100), indicating probable moderate pollution. The Mangaonuku Stream and Mangatarata Stream were monitored on only one occasion, with the Mangaonuku Stream scoring 92 (indicative of probable moderate pollution), and the Mangatarata Stream scoring 70 – indicative of probable severe pollution. However, such one-off results should be taken with caution, as MCI results can be highly variable at some sites, and further monitoring is recommended at these two sites.

As already explained in paragraph 3.3.1, MCI scores tend to decrease in the Tukituki mainstem downstream of Shagrock.

3.4.2. Periphyton biomass

In the upper catchment, all sites generally comply, although periphyton biomass in excess of the recommended guidelines have been recorded at least once at each site. This may be due to the very long periods of low, stable flow experienced by the Hawke's Bay rivers (refer to section 7.2.1).

In the middle catchment, the tributaries generally do not comply with the guideline. It should be noted however, that only one sample was collected in the Mangaonuku and Mangatarata Streams, where further monitoring is recommended.

The lower Tukituki sites generally do not comply with the recommended guideline.

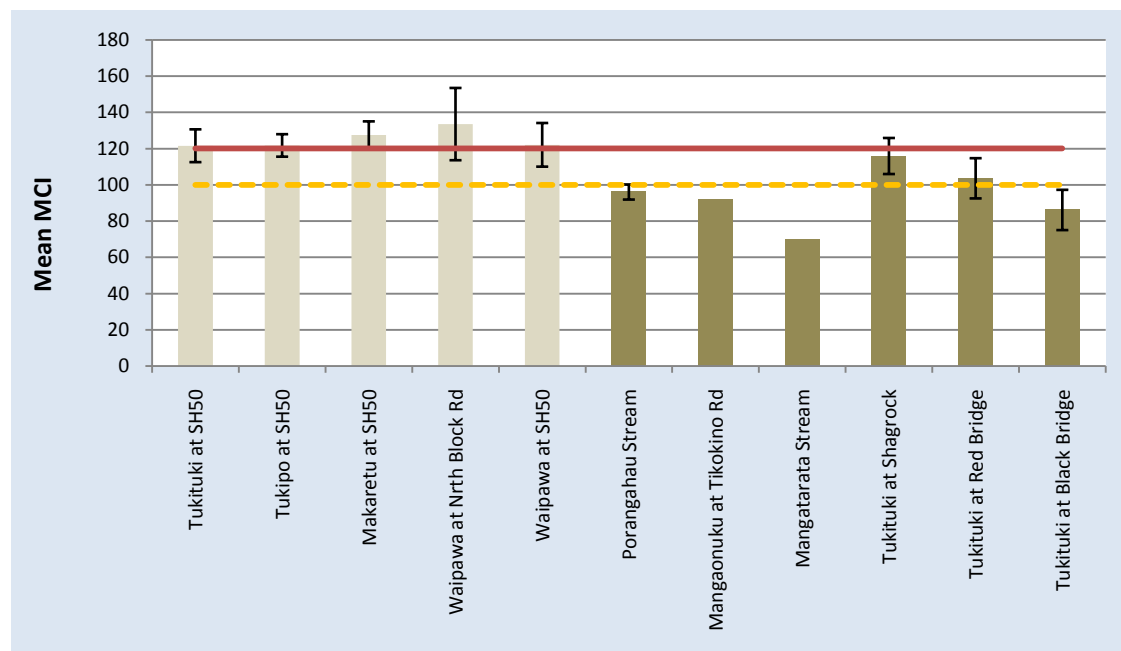


Figure 1: Mean macroinvertebrate community index (MCI) \pm 95% confidence interval. Sites in the upper catchment are in clear brown, sites in the middle and lower catchment are in dark brown. The solid red line represents the recommended guideline for the upper catchment; the dotted orange line represents the guideline for the middle and lower catchment.

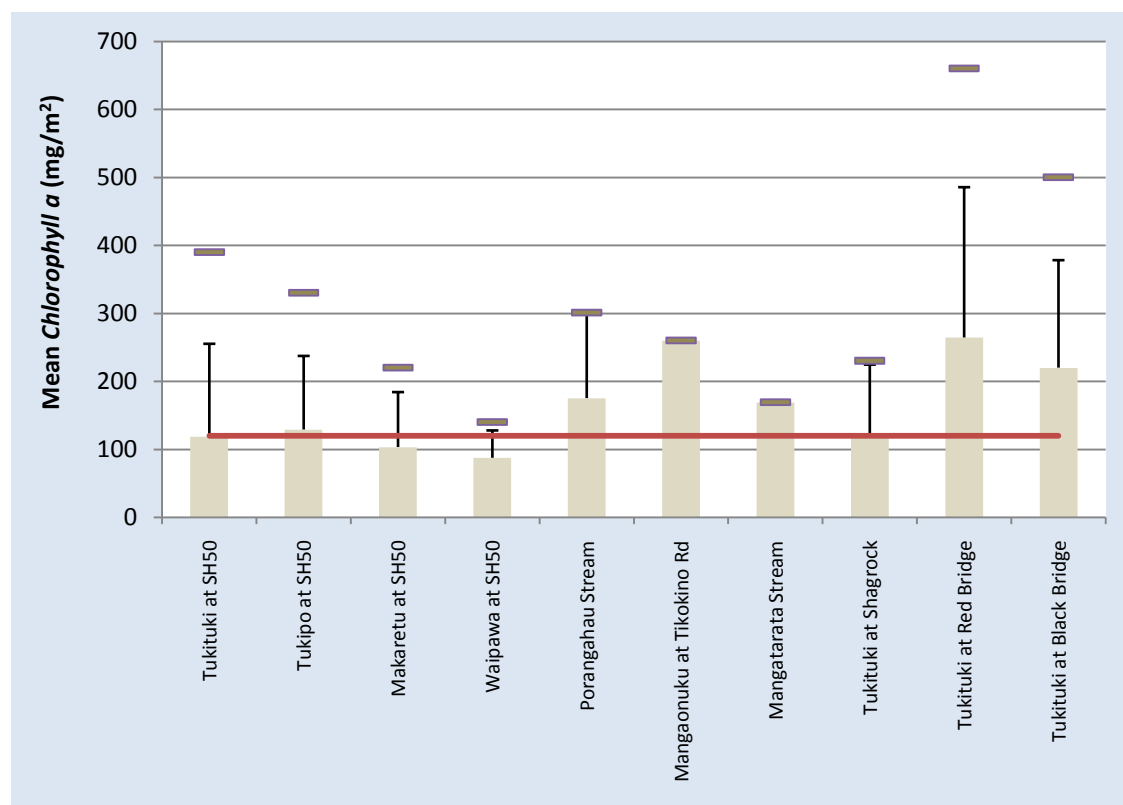


Figure 2: Maximum (rectangles) and mean (columns) periphyton biomass (mg chlorophyll a/m²) ± 95% confidence interval. The solid red line represents the recommended periphyton biomass guideline for the protection of recreational and trout fishery values.

3.4.3. Dissolved reactive phosphorus (DRP)

In the Tukituki mainstem, the DRP concentrations are highest in the middle catchment (SH2 and Taiparu Rd). Concentrations at Taiparu Rd are higher during low river flow, which is typical of sites influenced by point source discharges⁴. At Shagrock, Red Bridge and Black Bridge, the average DRP concentration decreases to an acceptable level at low river flows (below median flow).

The upper catchment monitoring sites (SH50) generally comply with the DRP guideline, with the notable exception of the Tukipo River. The DRP concentration at this latter site is higher at low river flows, which could indicate either the presence of a point-source contamination, or the contribution of phosphorus-rich groundwater to the Tukipo River's base flow.

The middle catchment tributaries have variable water quality. The Mangaonuku Stream has very low DRP concentrations at all flows. The Porangahau Stream exceeds the guideline at all flows, with concentrations comparable with those observed in the Tukituki at SH2. The Mangatarata Stream has by far the highest DRP concentration of all sites monitored in the catchment. Unfortunately, flow data is not available for this stream, which prevents any flow-related analysis. The reasons for the very high DRP in the Mangatarata Stream are unknown and should be investigated.

⁴ The influence of point source discharges generally becomes more at low river flows, primarily due to the lower dilution factors.

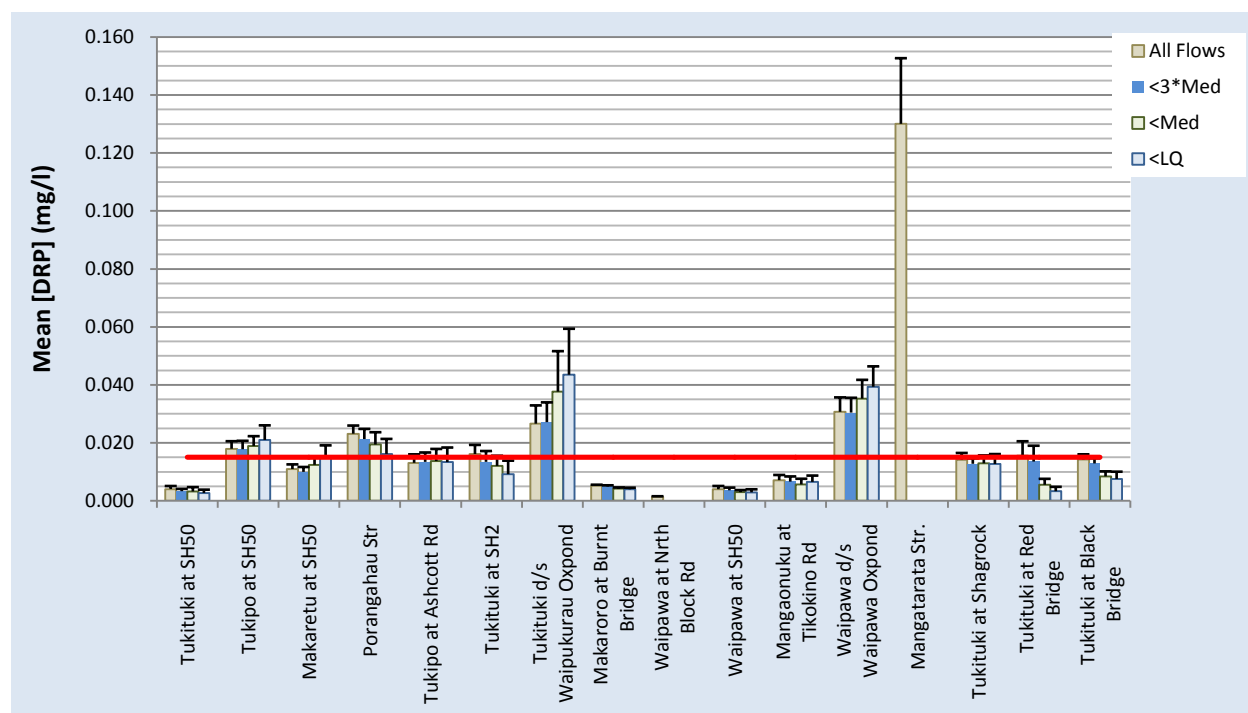


Figure 3: Mean DRP concentrations (mg/L) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ). The red line indicate the RRMP guideline (0.015 mg/L).

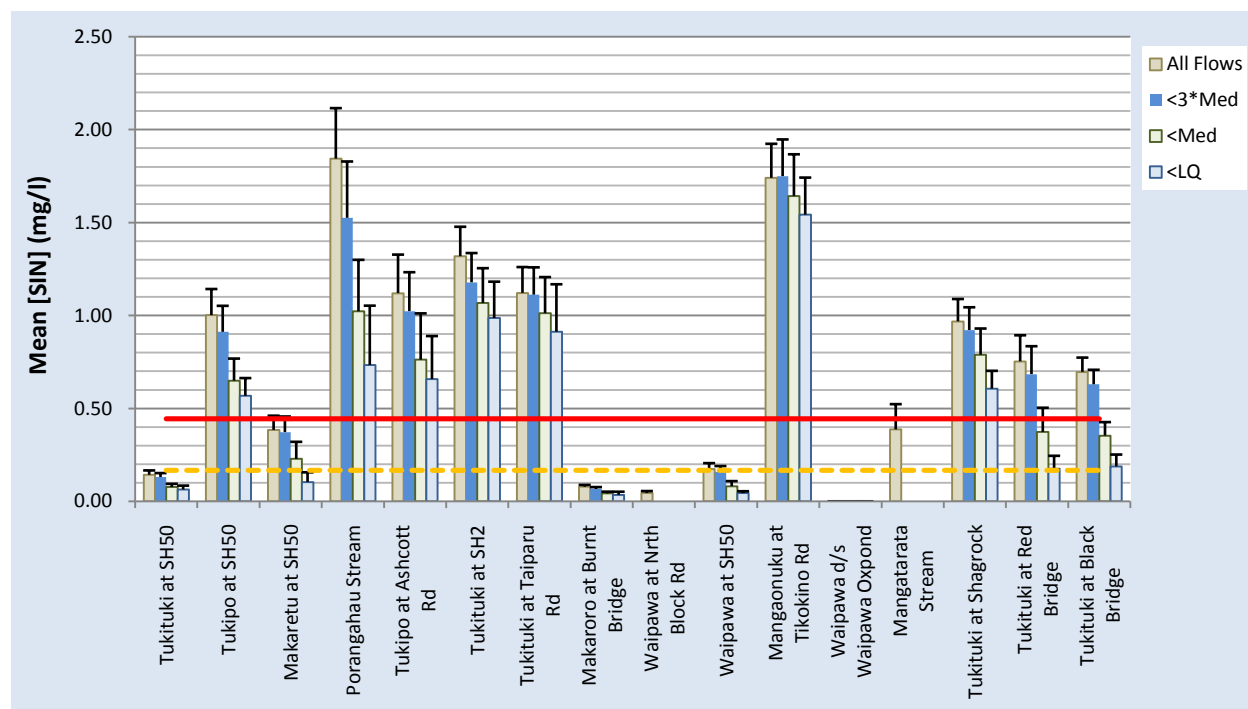


Figure 4: Mean SIN concentrations (mg/l) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ). The dotted orange line the recommended guideline for the upper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

3.4.1. Soluble inorganic Nitrogen (SIN)

In the Upper catchment, only the Tukituki and the Waipawa Rivers comply with the recommended guideline for SIN. The Makaretu at SH50 site does not comply with the upper catchment guideline, but generally complies with the lower catchment guideline. The elevated SIN concentrations measured in the Tukipo River at SH50 largely exceed both guidelines.

The highest SIN concentrations are recorded in the middle catchment – both the Tukituki mainstem and most tributaries generally exceed the guideline under any river flow condition. Two tributaries have different SIN vs. DRP patterns. The Mangaonuku Stream has elevated SIN concentrations, while it has low DRP concentrations. Conversely, the Mangatarata Stream has the lowest SIN concentration of the middle catchment, while it had by far the highest DRP concentration.

In a similar pattern to that observed for DRP, the SIN concentrations generally decrease in the lower catchment. Both Red Bridge and Black Bridge sites comply with the SIN guideline at low river flows.

Most sites present a consistent pattern of marked decrease in SIN concentration under low river flow conditions. This is consistent with the known migration routes of nitrate, which tends to be predominantly transported in solution in subsurface water, the rate of leaching being higher when the soils are wet.

3.4.1. 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 (< 4) indicate of N-limited conditions. Ratios between 4 and 20 are generally inconclusive or may indicate that the nutrient limitation may “switch” between the two nutrients at different times of the year/ flows. It is important to note that nutrient limitation may only occur when other factors controlling periphyton growth, such as sunlight, hydrological regime and biological activity are favourable and nutrient concentrations (at least one of them) are sufficiently low to limit periphyton growth. When both nutrients are in sufficient 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.

Plots of SIN/DRP ratios (Figure 5 and Figure 6) indicate that P-limited conditions seem to dominate throughout the catchment. In particular, sites like Tukipo at SH50, Mangaonuku at Tikokino Rd, Tukituki at SH2 and Shagrock always have SIN:DRP ratios well above 20:1.

However, a switch to co-limited conditions, or N-limited conditions seem to regularly occur during low flow conditions (below lower quartile flow) at a number of sites on the Tukituki mainstem (SH50 and Black Bridge) and tributaries (Makaretu and Waipawa Rivers).

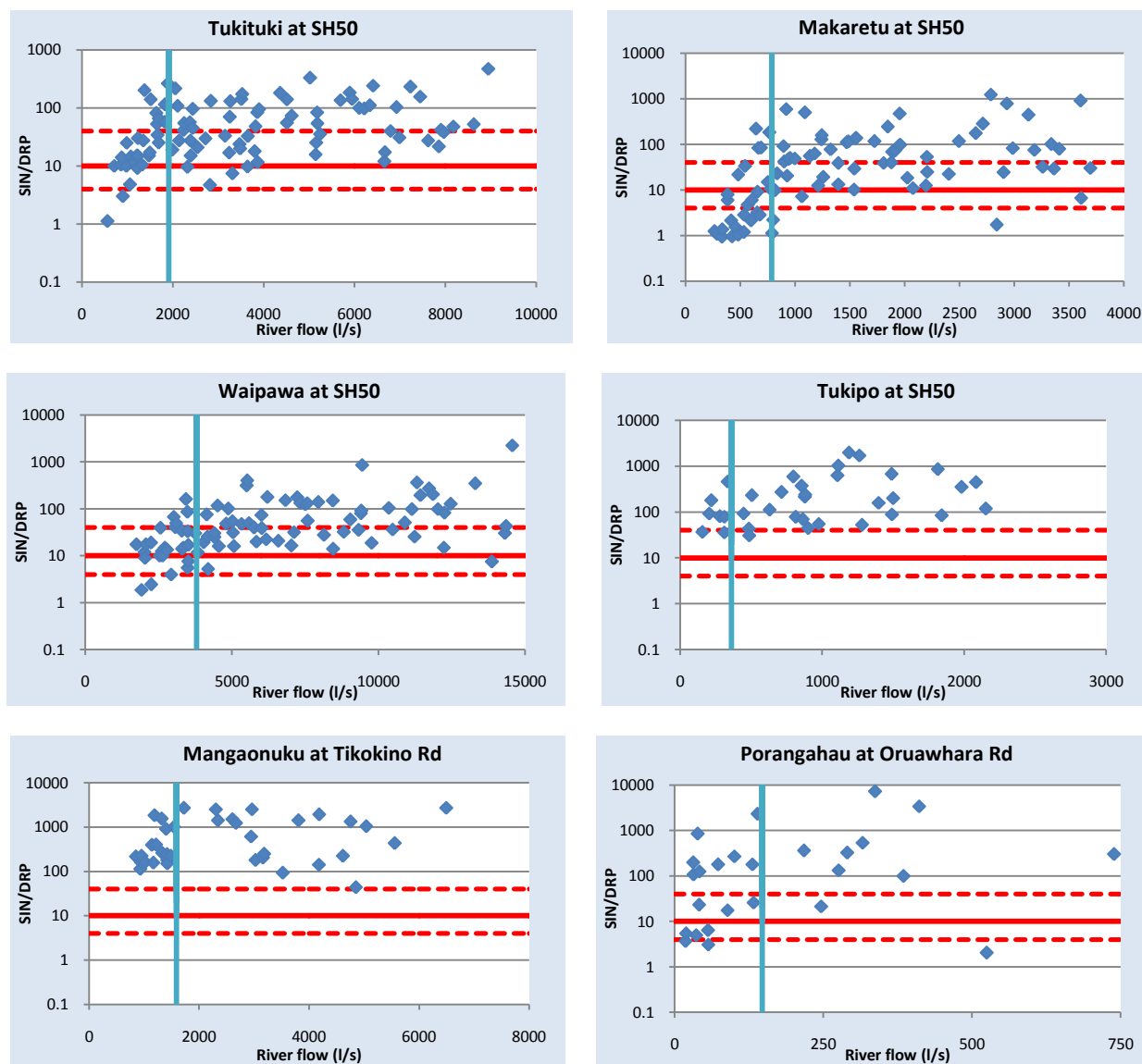


Figure 5: SIN:DRP ratio at monitoring sites in the upper Tukituki catchment. Data for river flows below 3* median flow and when either or both SIN and DRP concentrations are below guideline level (0.015 mg/l for DRP and 0.167 mg/l for SIN). The vertical blue line indicates the Lower quartile flow. Points 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.

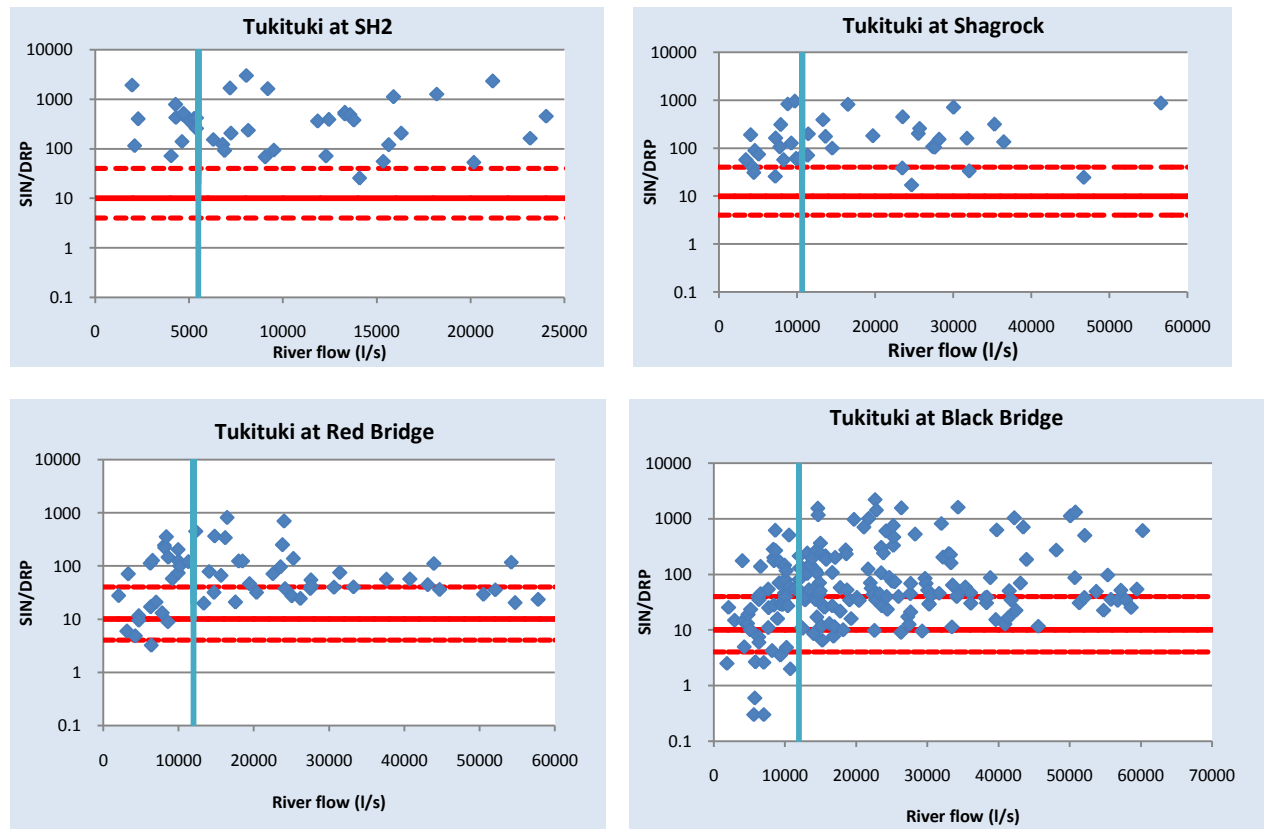


Figure 6: SIN:DRP ratio at monitoring sites in the middle and lower Tukituki catchment. Data for river flows below 3* median flow and when either or both SIN and DRP concentrations are below guideline level (0.015 mg/l for DRP and 0.167 mg/l for SIN). The vertical blue line indicates the Lower quartile 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.

3.4.2. Microbiological water quality

Figure 7 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.

The microbiological water quality is generally good across the Tukituki catchment, in both the mainstem and the tributaries. Most sites have a rate of compliance with the guideline (550 *E.coli*/100mL) in excess of 90%. A few sites have lower compliance rates:

- Two relatively small tributaries, the Porangahau and Mangatarata Streams (respectively 82 % and 84 % compliance); and
- Two sites downstream of oxidation pond discharges: Tukituki at Tapairu Rd and Waipawa downstream of Waipawa oxidation pond (respectively 82 % and 44% compliance).

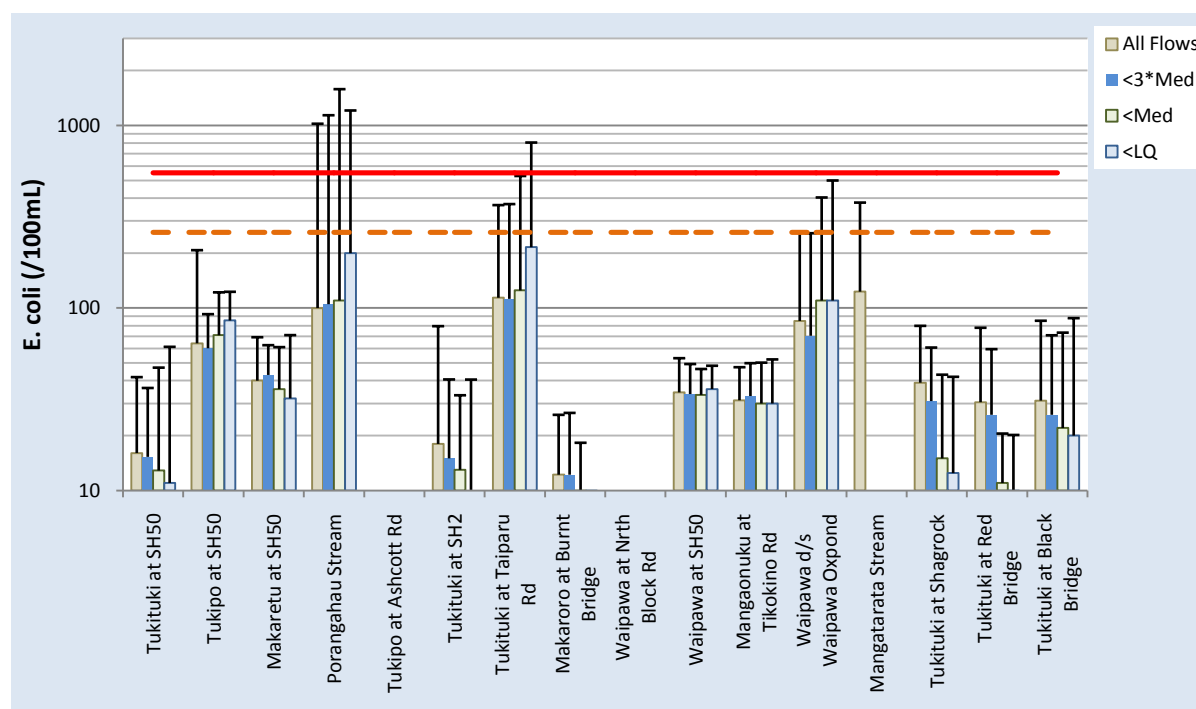


Figure 7: Median *E.coli* concentrations (/100mL) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ). The dotted orange line represents the recommended guideline 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 (550 *E.coli*/100 mL) as defined in the MfE microbiological water quality guidelines (2002).

3.4.1. Water Clarity

Water clarity records indicate that all sites largely comply with the guideline for recreational waters (1.6m), with the exception of the Mangatarata Stream (Figure 8).

Water clarity generally improves at lower river flows, and the average water clarity at all sites in the upper catchment and most sites in the middle catchment complies with the 3.5m guideline for the protection of trout fishery. The best average water clarity at low river flows is recorded in the Mangaonuku Stream, followed by the Makaroro River at Burnt Bridge, the Waipawa River at SH50 and the Tukituki River at SH50.

The Mangaonuku Stream is the only site where average water clarity at river flows below median complies with the very stringent 5m clarity. It should be noted that the 5m guideline corresponds to an idealised situation, and may not be realistic in the context of a catchment containing a large proportion of tertiary soft sedimentary rocks – such as the Tukituki catchment.

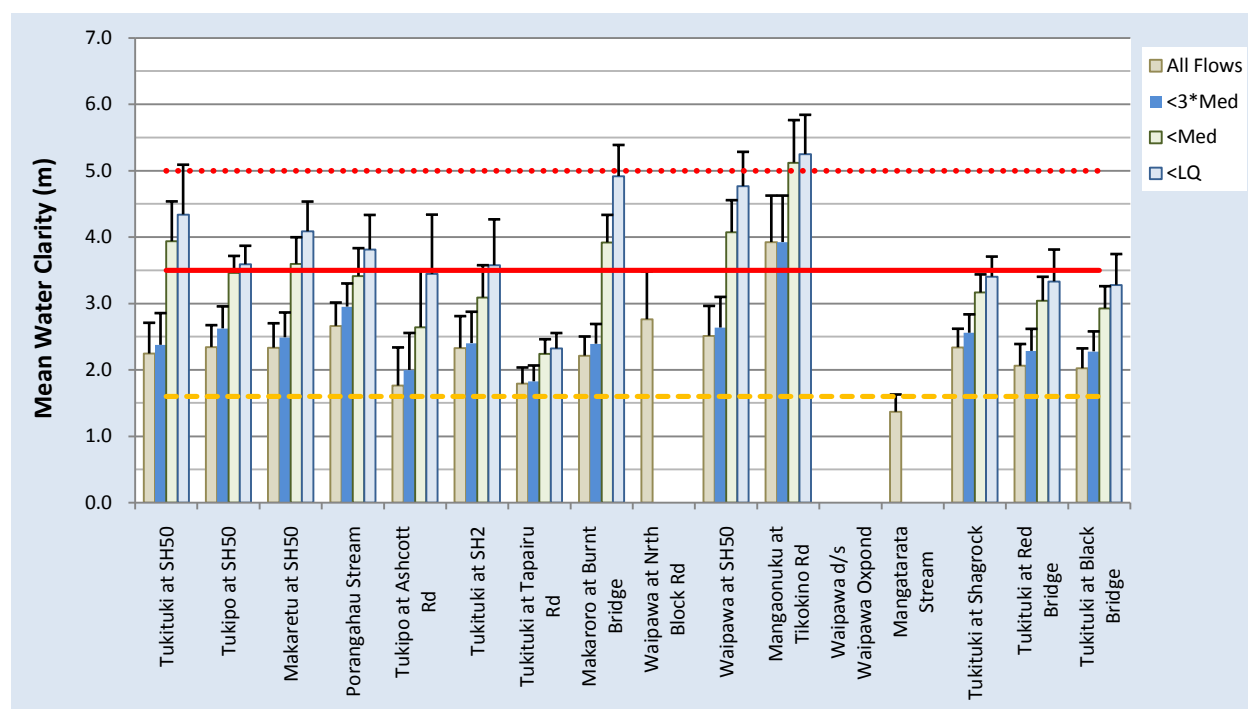


Figure 8: Mean water clarity (m) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ). The dotted yellow line represents the minimum clarity guideline for 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).

3.4.2. 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).

In the upper catchment, the Tukipo River has the highest concentrations of TOC, around 3mg/L.

In the Tukituki River main stem, the TOC concentrations generally increase between SH2 and Shagrock, and increase again at Red Bridge.

The Porangahau Stream has elevated TOC concentrations compared to the rest of the catchment. However, by far the highest TOC are to be found in the Mangatarata Stream – more than twice the concentrations found at any other monitoring site in the catchment.

Compliance with the 80% DO saturation guideline is generally excellent across the catchment (above 90% compliance), except at two sites: the Mangatarata Stream (65% compliance) and the Mangaonuku Stream (69% compliance). Further monitoring is recommended in these two streams, to investigate whether daily minimum DO concentrations (to be measured at dawn) are low enough to cause detrimental effects on aquatic life.

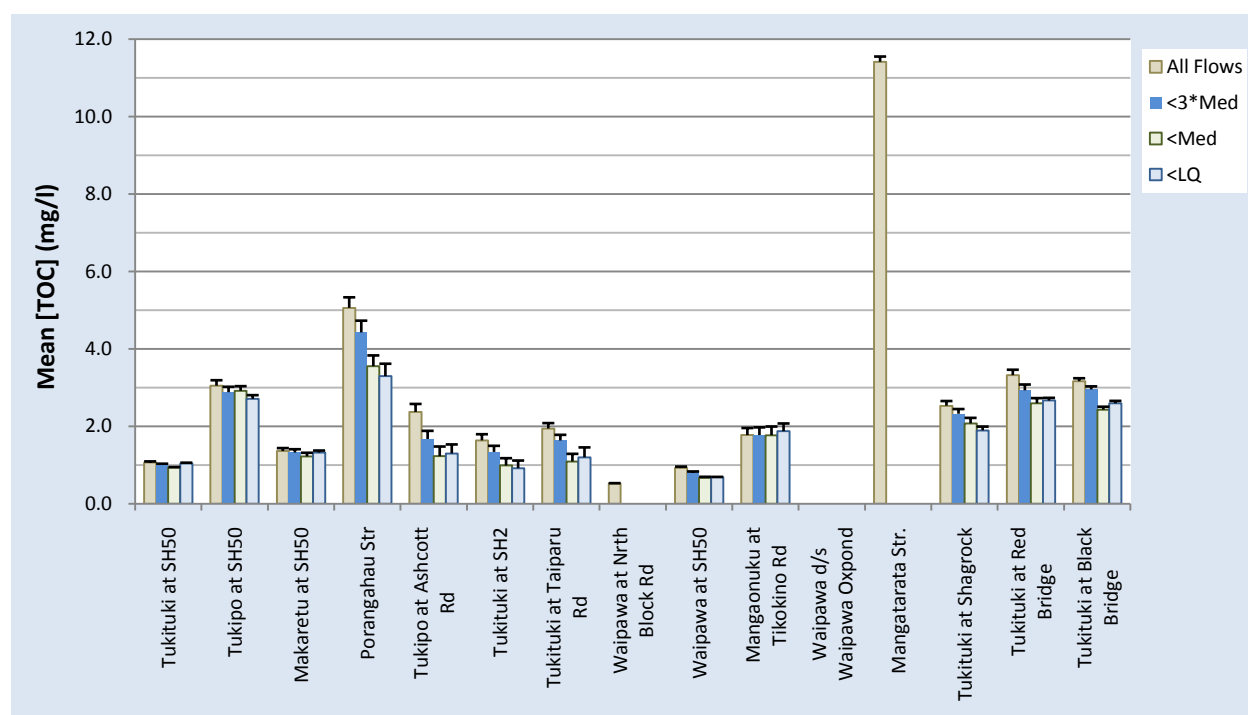


Figure 9: Mean total organic carbon (TOC) (mg/L) ± 95% confidence interval under different flow conditions: at all river flows (All flow), below three times the median flow (<3*Med), below median flow (<Med) and below the lower quartile flow (<LQ).

3.5. Comparison with national figures

A 2008 report prepared by NIWA for the ministry for the Environment to support the 2007 national state of the environment report presents a national summary of regional council data. In particular, the report provides national median values for some key water quality parameters, recorded at sites classified in 5 broad categories, based on the source of flow (upland/lowland) and the dominant land cover (natural/pastoral), the fifth category being urban streams (NIWA 2008).

The results obtained in the Tukituki catchment were compared to national figures, to provide a national perspective. Sites in the upper catchment were compared with national medians for upland rivers with a dominant pastoral land cover, and sites in the middle and lower catchment were compared with lowland/pastoral sites (NIWA 2008).

Across the whole catchment, water clarity was better than, or comparable with, the national medians. Similarly, the bacteriological water quality was usually better than nationally, except in the Mangatarata Stream.

In the upper catchment, nutrient concentrations in the Tukituki and Waipawa Rivers were comparable to (SIN), or better than (DRP), national median for the upland pastoral category. Nutrient concentrations in the Makaretu Stream are comparable with (DRP) or marginally above (SIN) national median. The Tukipo River has higher nutrient (DRP and SIN) concentrations than the national median

In the middle catchment, the DRP concentrations in the Tukituki mainstem are consistent with the national median, but the SIN concentrations are largely higher. In the Porangahau Stream, both SIN and DRP were more elevated than the national average for upland rivers (NIWA 2008). As observed previously, the Mangatarata Stream follows an unusual pattern, with very high DRP concentrations (8 times the national median), but very low SIN (1/3 of the national median).

Nutrient concentrations in the lower Tukituki River are marginally lower (DRP) or comparable with (SIN) national figures.

Table 9: Comparison of water quality statistics for the Tukituki catchment sites with national figures (1997-2002). The upper Tukituki catchment sites are compared with upland pastoral category and the middle and lower Tukituki catchments are compared with lowland pastoral category in (NIWA 2008). Green shading indicates better water quality than the national median, red shading indicate worse water quality than the national median.

Section of catchment	Site	DRP (mg/l, median)		SIN (mg/l, median)		<i>E.coli</i> (/100ml, 95 th percentile)		Clarity (m, median)	
		National median	Tukituki Site	National median	Tukituki Site	National median	Tukituki Site	National median	Tukituki Site
Upper catchment	Tukituki at SH50	0.009	0.002	0.10	0.10	517	188	1.5	1.7
	Tukipo at SH50		0.018		0.70		631		2.2
	Makaretu at SH50		0.010		0.19		40		2.0
	Waipawa at SH50		0.002		0.11		35		2.1
Middle catchment	Tukituki at SH2	0.014	0.011	0.55	1.16	1,542	513	1.2	2.5
	Porangahau		0.020		1.58		1,700		2.6
	Mangatarata		0.110		0.16		1,910		1.2
	Tukituki at Shagrock		0.013		0.84		400		2.6
Lower catchment	Tukituki at Red Br	0.014	0.009	0.55	0.58	1,542	484	1.2	1.9
	Tukituki at Black Br		0.010		0.56		1,506		1.9

3.6. Conclusions

Most parameters indicate relatively good water quality in the Tukituki River, which is consistent with the findings of the 2004 study (Stansfield, 2004). The microbiological water quality is generally good, indicating a low health risk to river users from pathogens of faecal origin. The generally low ammonia concentrations are unlikely to cause any acute or chronic toxic effects on the aquatic biota. The lower water clarity in the upper Tukituki and Waipawa Rivers is likely caused by natural erosion processes. Water clarity is generally good in the rest of the catchment, although there is a gradual degradation when moving towards the lower Tukituki River reaches.

At the catchment scale, the main water quality issue for the Tukituki River appears to be the nutrient enrichment and associated periphyton growth and degradation of the macroinvertebrate communities. The middle catchment, including the main stem and tributaries between SH50 and Shagrock generally have the highest nutrient concentrations. Nutrient concentrations generally decrease in the lower catchment, although this is likely due to the consumption of the nutrients by the algal biomass, which often exceeds acceptable levels. These results suggest that the middle catchment should be the priority for the analysis conducted in this report, and for future monitoring and management.

Two monitoring sites indicate degraded water quality, either in absolute terms (Mangatarata Stream) or relatively to similar sites (Tukipo at SH50).

Monitoring results for the Tukipo River at SH50 indicate that water quality is not as good as at other sites in the upper catchment. Among the upper catchment sites, the Tukipo River has the highest SIN, DRP, *E.coli* and TOC concentrations, as well as the highest mean periphyton biomass; all consistent with a moderately enriched system.

The Mangatarata Stream highest mean DRP, TOC and lowest dissolved oxygen (DO) concentrations of the whole Tukituki catchment. This degraded water quality is associated with the lowest MCI score in the catchment. However, nitrogen species, (including nitrate and ammonia) are relatively low. Phosphorus-rich rocks, such as limestone and mudstone, are well represented in the Mangatarata catchment, and could be the source of moderately elevated DRP concentration in the stream, although not to the levels actually measured. The very elevated DRP and TOC concentrations could suggest the influence of point source discharges, although one would expect the ammonia to be also elevated in this case. A flow-related analysis of the water quality data could have brought some clues as to the possible origin of the degraded water quality; unfortunately flow data (direct or correlated) is not readily available for this tributary.

4. Effects of point source discharges

This section provides an analysis of the effects of the two largest point source discharges in the Tukituki catchment:

- the discharge of treated domestic wastewater from the Waipukurau oxidation pond to the Tukituki River, approximately 3.5 kilometres downstream of the SH2 Bridge;
- the discharge of treated domestic wastewater from the Waipawa oxidation pond to the Waipawa River, approximately 4 kilometres upstream of its confluence with the Tukituki River.

The analysis presented in this section is based on the compliance data collected by the Central Hawke's Bay District Council as part of the conditions associated with the resource consents for these discharges.

The analysis was carried out at all river flows and at or below median flow, for consistency with the RRMP (most RRMP guidelines apply only when the river is at or below median flow). There was insufficient data to conduct a meaningful analysis at lower river flows (e.g. below lower quartile flow).

4.1. Waipukurau oxidation pond

4.1.1. DRP

Based on compliance samples collected by Central Hawke's Bay District Council, the Waipukurau oxidation pond discharges an average of 9.1 ± 0.8 kg DRP per day to the Tukituki River. There does not appear to be any correlation between the flow in the Tukituki River and the quantity of DRP discharged from the Waipukurau Oxidation pond⁵.

The average DRP concentration immediately upstream of the discharge is 0.037 ± 0.009 mg/l, and 0.037 ± 0.008 downstream of the discharge. There is no statistically significant difference between upstream and downstream of the discharge (Wilcoxon paired rank test). At river flows at or below median flow, the average DRP concentration upstream of the discharge is 0.034 ± 0.012 , and 0.043 ± 0.011 downstream of the discharge. There is still no statistically significant difference between upstream and downstream of the discharge (Wilcoxon paired rank test) (Figure 10).

It should be noted however, that the DRP concentrations measured at the upstream site appear unusually high. The median DRP concentration at SH2, located only 3.5 km upstream of the Waipukurau oxidation pond discharge was 0.011 mg/l for the period 1977 -2000. The reasons for the apparent DRP increase between the two sites are unknown, and further investigations are recommended, including:

- a paired monitoring programme, i.e. samples taken at the same time at both SH2 and the "upstream of discharge" sites, for a set period of time (6-12 months), to clarify whether there is any actual significant change in DRP concentration in the River;
- a careful examination of the exact location where samples are taken,
- an investigation of any potential significant source of DRP between the two sites.

The discharge of oxidation pond effluent from the Waipukurau wastewater treatment plant to the Tukituki River is subject to a resource consent issued in 2007. The resource consent conditions impose an upgrade of the treatment plant, and effluent quality limits after 2014. After this date, the DRP concentration in the effluent will be limited to a median concentration of 0.25 mg/l and a 90th percentile of 0.5 mg/l. Based on the median future concentration and the current average discharge volume, the average DRP load discharged to the Tukituki River after 2014 should be approximately 0.6 kg/day.

4.1.2. Ammonia and SIN

The compliance monitoring programme undertaken by Central Hawke's Bay District Council does not include monitoring of SIN. It does include ammonia-nitrogen ($\text{NH}_4\text{-N}$). SIN is the sum of ammonia, nitrate and nitrite nitrogen. Generally, ammonia nitrogen represents more than 80% of the SIN in an oxidation pond effluent, and can be used as a good indicator of the effect an oxidation pond discharge may have on the SIN concentration in the river.

Based on compliance data, the Waipukurau oxidation pond discharges an average of 48 ± 5 kg $\text{NH}_4\text{-N}$ per day to the Tukituki River.

The average $\text{NH}_4\text{-N}$ concentration immediately upstream of the discharge is 0.146 ± 0.082 mg/l, and 0.089 ± 0.032 mg/l downstream of the discharge, both well below the ammonia guideline. There is no statistically significant difference between upstream and downstream of the discharge (Wilcoxon paired rank test) (Figure 11)

⁵ This can be observed in situations where there is high stormwater/groundwater infiltration into the sewerage network, causing higher input volumes to the oxidation pond, causing in turn higher discharge volumes and higher contaminant loads in the discharge at times of high river flow.

At river flows at or below median flow, the average $\text{NH}_4\text{-N}$ concentration upstream of the discharge is 0.100 ± 0.039 mg/l, and 0.119 ± 0.051 mg/l downstream of the discharge. There is still no statistically significant difference between upstream and downstream of the discharge (Wilcoxon paired rank test).

4.1.3. Micobiological water quality

There is a small increase in the median faecal coliforms (FC) concentration downstream of the Waipukurau oxidation pond discharge. The difference becomes statistically significant ($p < 0.05$) at river flows below median (Figure 12). The rate of compliance with the RRMP guideline (200 FC/100mL) decreases downstream of the discharge, from 71 to 57 %.

4.1.4. Suspended solids

Suspended solids records indicate highly variable SS concentrations, both upstream and downstream of the discharge. There is a moderate increase in SS concentrations downstream of the discharge ($p < 0.05$, Wilcoxon paired rank test), although this difference is not significant anymore at river flows below median (Figure 13). If the pond discharge had a major effect on the SS concentrations in the river, one would have expected the difference to be exacerbated at low river flow.

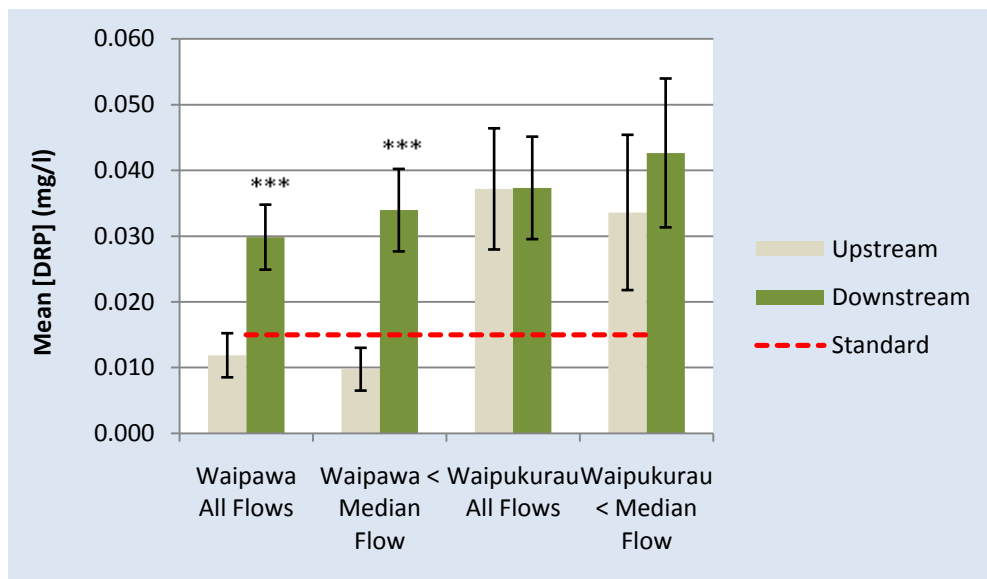


Figure 10: Average DRP concentrations (\pm 95% confidence interval) in the Waipawa and Tukituki Rivers upstream and downstream of the Waipawa and Waipukurau oxidation pond discharges. * indicates statistically significant differences ($p < 0.001$) using the Wilcoxon paired rank test.**

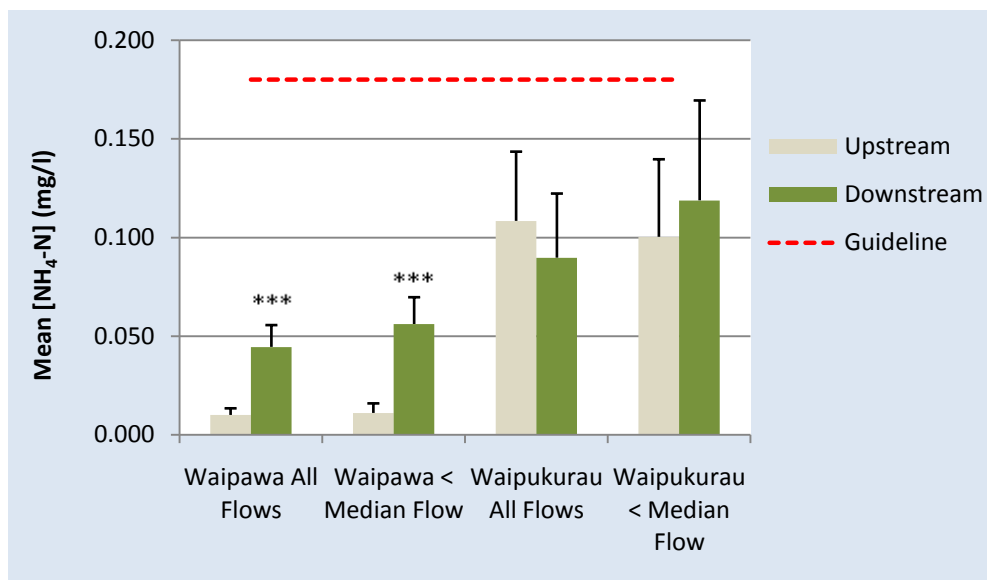


Figure 11: Average Ammonia nitrogen concentrations (\pm 95% confidence interval) in the Waipawa and Tukituki Rivers upstream and downstream of the Waipawa and Waipukurau oxidation pond discharges. * indicates statistically significant differences ($p < 0.001$) using the Wilcoxon paired rank test.**

4.2. Waipawa oxidation pond

4.2.1. DRP

Based on compliance samples collected by Central Hawke's Bay District Council, the Waipawa oxidation pond discharges an average of 6.7 ± 0.9 kg DRP per day to the Waipawa River. As per the Waipukurau Oxidation pond, there appears to be no correlation between the flow in the Waipawa River and the quantity of DRP discharged from the oxidation pond.

The average DRP concentration in the Waipawa River immediately upstream of the discharge is 0.012 ± 0.003 mg/l (below the RRMP guideline), and 0.030 ± 0.005 (twice the guideline) downstream of the discharge. A Wilcoxon paired rank test indicates a statistically significant difference between upstream and downstream of the discharge ($p < 0.001$).

At river flows at or below median flow, the average DRP concentration upstream of the discharge is 0.010 ± 0.003 , and 0.034 ± 0.006 downstream of the discharge. Again, a Wilcoxon paired rank test indicates a statistically significant difference between upstream and downstream of the discharge ($p < 0.001$) (Figure 10).

4.2.2. Ammonia

Based on compliance data, the Waipawa oxidation pond discharges an average of 19 ± 2.3 kg $\text{NH}_4\text{-N}$ per day to the Waipawa River.

The average $\text{NH}_4\text{-N}$ concentration immediately upstream of the discharge is 0.010 ± 0.003 mg/l, and 0.043 ± 0.011 mg/l downstream of the discharge. Although there is a statistically significant difference between upstream and downstream of the discharge ($p < 0.001$ Wilcoxon paired rank test), both upstream and downstream concentrations are well below the guideline value (Figure 11).

At river flows at or below median flow, the average $\text{NH}_4\text{-N}$ concentration upstream of the discharge is 0.011 ± 0.005 mg/l, and 0.056 ± 0.014 mg/l downstream of the discharge. Again, a Wilcoxon paired rank test indicates a statistically significant difference between upstream and downstream of the discharge ($p < 0.001$).

4.2.3. Microbiological water quality

The median faecal coliforms (FC) concentrations significantly increases ($p < 0.001$), Wilcoxon paired rank test) downstream of the Waipawa oxidation pond discharge (Figure 12).

The rate of compliance with the RRMP guideline (200 FC/100mL) when the flow in the River is below median) is lower downstream (45%) than upstream (76%) of the discharge.

4.2.4. Suspended solids

Similarly to the Waipukurau oxidation pond discharge, the data relating to Waipawa oxidation pond discharge indicate highly variable suspended solids (SS) concentrations, both upstream and downstream of the discharge. There is a moderate increase in SS concentrations downstream of the discharge ($p < 0.05$, Wilcoxon paired rank test), although this difference is not significant anymore at river flows below median (Figure 13). If the pond discharge had a major effect on the SS concentrations in the river, one would have expected the difference to be exacerbated at low river flow.

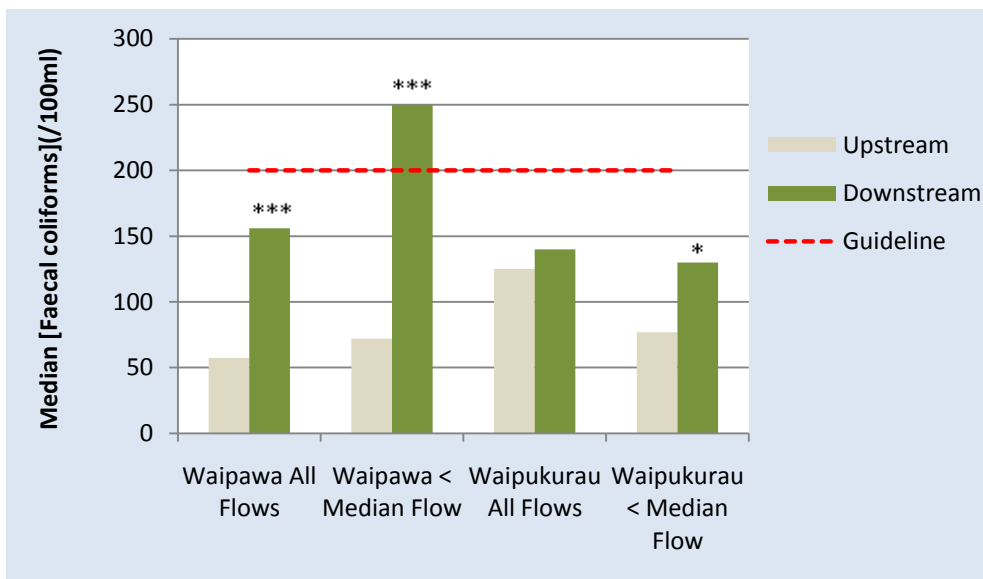


Figure 12: Median faecal coliforms concentration in the Waipawa and Tukituki Rivers upstream and downstream of the Waipawa and Waipukurau oxidation pond discharges. Stars indicate statistically significant differences (* for $p<0.05$; *** for $p<0.001$) on Wilcoxon paired rank test.

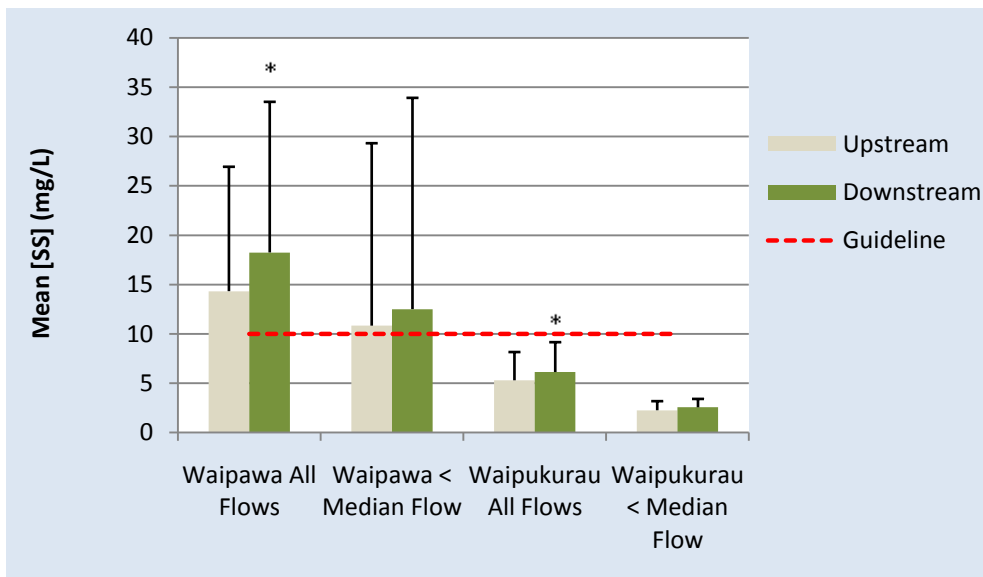


Figure 13: Mean suspended sediment (SS) concentrations (\pm 95% confidence interval) in the Waipawa and Tukituki Rivers upstream and downstream of the Waipawa and Waipukurau oxidation pond discharges. Stars indicate statistically significant differences (* for $p<0.05$; *** for $p<0.001$) on Wilcoxon paired rank test.

5. Temporal trends

The results of seasonal Kendall tests performed on data collected at 15 sites across Tukituki catchment are presented in Table 10 (MCI) and Table 11 (DRP, SIN, water clarity and *E.coli*).

MCI trends analysis was performed on all data available between 1998 and 2007. It should be noted however, that two facts may affect the meaningfulness of the analysis. First, sampling and taxonomic analysis of the samples were performed by two different organisations over the period. Variable level of skills between the different operators may affect the year-to-year consistency of the results. Second, sampling in 1998 and 1999 was performed in winter (August). Although MCI scores are generally relatively stable year-round at a given site, the higher summer water temperatures may seasonally exclude some temperature-sensitive taxa (e.g. stoneflies), in turn leading to lower MCI scores in summer. The analysis of MCI score trends presented in this report should therefore be taken with caution and should be re-assessed in the future as further monitoring results become available.

In the upper catchment, DRP concentrations have been increasing at all SH50 sites, at an average rate of 6% per year. Three of the four upper catchment sites present a decreasing trend in MCI score. It is noted that the fourth upper catchment site (Waipawa at SH50) also had a decreasing trend, although the probability of it being significant was just below the 95% threshold ($p=0.059$). The Tukipo at SH50 is the only site to present a significant trend for SIN (also an increase), and the only upper catchment site where microbiological water quality has not been improving. Interestingly, the Tukipo was also the only site in the upper catchment to breach both recommended guidelines for DRP and SIN.

In the middle catchment, increasing DRP trends were found in the Tukituki at Shagrock and the Mangaonuku Stream. Decreasing trends in DRP were found at both upstream (SH2) and downstream (Tapairu Rd) of the Waipukurau oxidation pond discharge. However, this is based on relatively old data (2000 and older). An analysis carried on a joined dataset downstream of the Waipukurau oxidation pond discharge (Tapairu Rd 1990-2000 and compliance data for 2005-08) did not indicate any significant trend. The situation in relation to SIN appears generally stable, except in the Mangaonuku Stream, where a significant increase over time was found. A significant decrease in MCI was found at Tukituki at Shagrock. The improving microbiological water quality trend observed in the upper catchment was also found in the Porangahau Stream and in the Tukituki at Shagrock.

No significant trends relating to water clarity were found in the middle or lower catchment. In the lower catchment, the only significant trend observed was a decrease in *E.coli* at Red Bridge.

Table 10: Summary of macroinvertebrate community index score at different monitoring sites in the Tukituki catchment.

	Site	MCI				
		Period analysed	N. of samples	Trend	p	Slope (%/year)
Upper catchment	Tukituki at SH50	98-07	10	↘	<0.05	- 3.0
	Tukipo at SH50	98-07	10	↘	<0.01	- 1.7
	Waipawa at SH50	98-07	10	-	-	-
	Makaretu at SH50	98-07	10	↘	<0.05	- 2.2
Middle catchment	Mangaonuku at Argyll Rd	01-06	6	-	-	-
	Porangahau at Oruawhara Rd	04-07	4	-	-	-
	Tukituki at Shagrock	99-07	8	↘	<0.05	- 4.7
Lower catchment	Tukituki at Red bridge	98-07	10	-	-	-
	Tukituki at Black Bridge	01-07	7	-	-	-

Table 11: Summary of temporal trends at different monitoring sites in the Tukituki catchment. Seasonal Kendall Test, Flow adjusted data, covariate adjustment method is LOWESS. NS: Not significant; N.D.; no data.

	Site	DRP				SIN				Water Clarity				E.coli			
		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	Tukituki at SH50	94-08	↗	<0.001	+ 6.3	94-08	-	NS	-	95-08	-	NS	-	97-08	↘	<0.01	- 12
	Tukipo at SH50	94-08	↗	<0.001	+ 6.3	94-08	↗	<0.001	+ 5.6	95-08	-	NS	-	95-08	-	NS	-
	Waipawa at SH50	93-08	↗	<0.005	+ 6.2	93-08	-	NS	-	93-08	-	NS	-	93-08	↘	<0.05	- 10
	Makaretu at SH50	94-08	↗	<0.001	+ 6.0	94-08	-	NS	-	94-08	↘	<0.05	- 2.7	97-08	↘	<0.005	- 11
Middle catchment	Mangaonuku at Argyll Rd	00-05	-	NS	-	00-05	-	NS	-	00-05	-	NS	-	00-05	-	NS	-
	Mangaonuku at Tikokino Rd	93-08	↗	<0.05	+ 9.6	93-08	↗	<0.05	+ 2.8	94-08	-	NS	-	94-08	-	<0.005	NS
	Tukituki at SH2	87-00	↘	<0.001	- 15	87-00	-	NS	-	94-00	-	NS	-	94-00	-	NS	-
	Tukituki D/S Waipuk. Oxpond	90-00	↘	<0.001	-15.7	90-00	-	NS	-	90-08	-	NS	-	99-08	-	NS	-
	Waipawa U/S Waipawa oxpond	05-08	-	NS	-	N.D.	-	-	-	N.D.	-	-	-	N.D.	-	-	-
	Waipawa D/S Waipawa oxpond	05-08	-	NS	-	N.D.	-	-	-	N.D.	-	-	-	N.D.	-	-	-
	Porangahau at Oruawhara Rd	87-08	-	NS	-	87-08	-	NS	-	87-08	-	NS	-	97-08	↘	0.065	- 16
	Mangatarata at Mangatarat Rd	98-07	-	NS	-	98-07	-	NS	-	98-06	-	NS	-	98-07	-	NS	-
	Tukituki at Shagrock	94-08	↗	<0.001	+ 3.2	94-08	-	NS	-	94-08	-	NS	-	99-08	↘	0.065	- 19
Lower catchment	Tukituki at Red bridge	97-08	-	NS	-	94-08	-	NS	-	97-08	-	NS	-	97-08	↘	<0.05	- 13
	Tukituki at Black Bridge	77-08	-	NS	-	79-08	-	NS	-	94-08	-	NS	-	90-08	-	NS	-

6. Contaminant loads analysis

This section of the report presents the results of an analysis of the contaminant loads in the Tukituki catchment. As identified in previous sections of this report, the key water quality issue in the Tukituki catchment appears to be nutrient enrichment. Therefore, this section concentrates on dissolved reactive phosphorus and soluble inorganic nitrogen.

The analysis presented in this section is three-fold.

Section 6.1 below presents the results of annual load estimates carried out at a number of sites in the catchment. At equal contaminant concentrations, the higher the flow in the river, the higher the contaminant load. Thus, the annual contaminant loads are very dependant upon each year's hydrological regime - a wet year will generally have a higher contaminant load than a dry year. Comparisons between sites should therefore always be carried out within one given year.

Section 6.2 presents an analysis of the relative contribution of each tributary or part of the catchment to the contaminant loads entering the River upstream of Shagrock (upper and middle catchment).

Section 6.3 presents an estimate of catchment yields, i.e. a sub-catchment by sub-catchment analysis of the quantity of nutrient in the rivers coming from non-point sources per unit of surface area.

6.1. Annual Loads

The annual loads of DRP and SIN were calculated at 9 sites in the Tukituki catchment for the years 2004-2005 to 2007-2008, following the methodologies described in section 2.5 of this report. The results are presented in Appendix E.

Over the four years covered by the calculations, 2004-2005 and 2005-2006 were wet relative to 2006-2007 and 2007-2008, which had long, dry summers (Table 12).

Table 12: Annual average daily flow t Tukituki at Shagrock for the 2004-2008 period.

	2004-05	2005-06	2006-07	2007-08
Annual average daily flow at Tukituki at Shagrock (L/s)	54,059	56,592	30,753	34,616

6.1.1. Dissolved reactive phosphorus (DRP)

Overall, the two calculation methods used to estimate annual DRP loads provided very similar results, except for years with incomplete datasets.

In the upper catchment (above SH50), the Waipawa River at SH50 has the highest annual DRP loads (1.2 to 3.2 T/Y), followed by the Tukipo at SH50 (0.8 – 1.9 T/Y), the Tukituki at SH50 (0.6 – 1.4 T/Y) and the Makaretu at SH50 (0.7 to 1 T/Y).

The annual DRP load in the Tukituki River at Shagrock varies between 30 and 60 Tonnes per year over the four years covered by the calculations. Similar numbers are obtained for the two lower catchment sites (Red Bridge and Black Bridge). The combined upper catchment (above SH50) DRP loads represent between 5 and 20% of the annual load estimated at Shagrock (Figure 14).

DRP loads in the lower catchment appear to be generally similar to those observed at Shagrock, suggesting that DRP inputs to the lower catchment are either:

- negligible by comparison with loads at Shagrock, or
- compensated by the “outputs” (e.g. consumption by the algal biomass, absorption).

When considering the DRP loads over the “summer” season (November to April inclusive), different patterns emerge in different years:

- on a wet-summer year, such as 2005-06, the loads estimated in the lower catchment are about double to those at Shagrock, suggesting significant DRP inputs to the lower catchment;
- on a dry summer, the DRP load is 80-90% lower at red Bridge than Shagrock, indicating that the best part of the DRP is taken out of the system, most likely through utilisation by the algal biomass.

6.1.1. Soluble Inorganic Nitrogen (SIN)

Similarly to DRP, the two calculation methods used to estimate annual SIN loads provided very similar results, except for years with incomplete datasets.

In the upper catchment (above SH50), the Waipawa and Tukipo Rivers have the highest annual SIN loads (65 to 120 T/Y each). The Tukituki at SH50 and the Makaretu at SH50 have lower annual SIN loads (20 to 50 T/Y each).

The estimated annual SIN load in the Tukituki River at Shagrock varied between 1,500 and 3,300 Tonnes per year, depending on the year and the calculation method. Annual loads at the two lower catchment sites (Red Bridge and Black Bridge) were estimated between 1,400 and 2,400 T/Y. The combined upper catchment (above SH50) SIN loads represent between 10 and 20% of the annual load estimated at Shagrock (Figure 15).

The SIN loads appear to follow very marked seasonal patterns. For example, the summer SIN load at Shagrock is between 8 and 11% of the annual load, suggesting that most of the SIN flows through the catchment during winter. This is completely consistent with the known seasonal patterns of nitrate movements, which tends to be transported dissolved in subsurface water- the rates of leaching being higher when the soils are water-saturated.

In all years analysed, the calculated SIN loads decrease in the lower catchment compared to Shagrock, suggesting that, in the lower catchment, SIN “outputs” (e.g. consumption by the algal biomass, absorption) exceed the inputs.

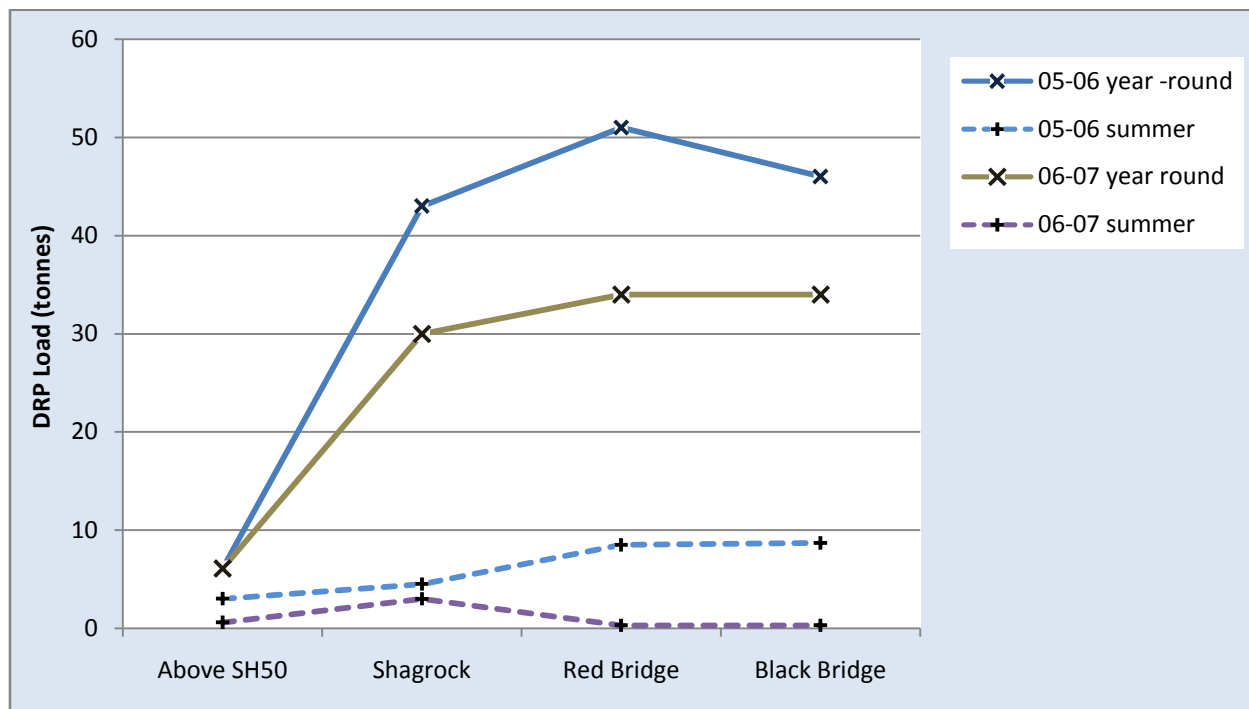


Figure 14: Annual and summer (November-April inclusive) DRP loads (Tonnes) in the Tukituki catchment, calculated with the “averaging” approach. Above SH50 refers to the sum of the loads calculated at the SH50 monitoring sites (Tukituki, Waipawa, Makaretu and Tukipo Rivers).

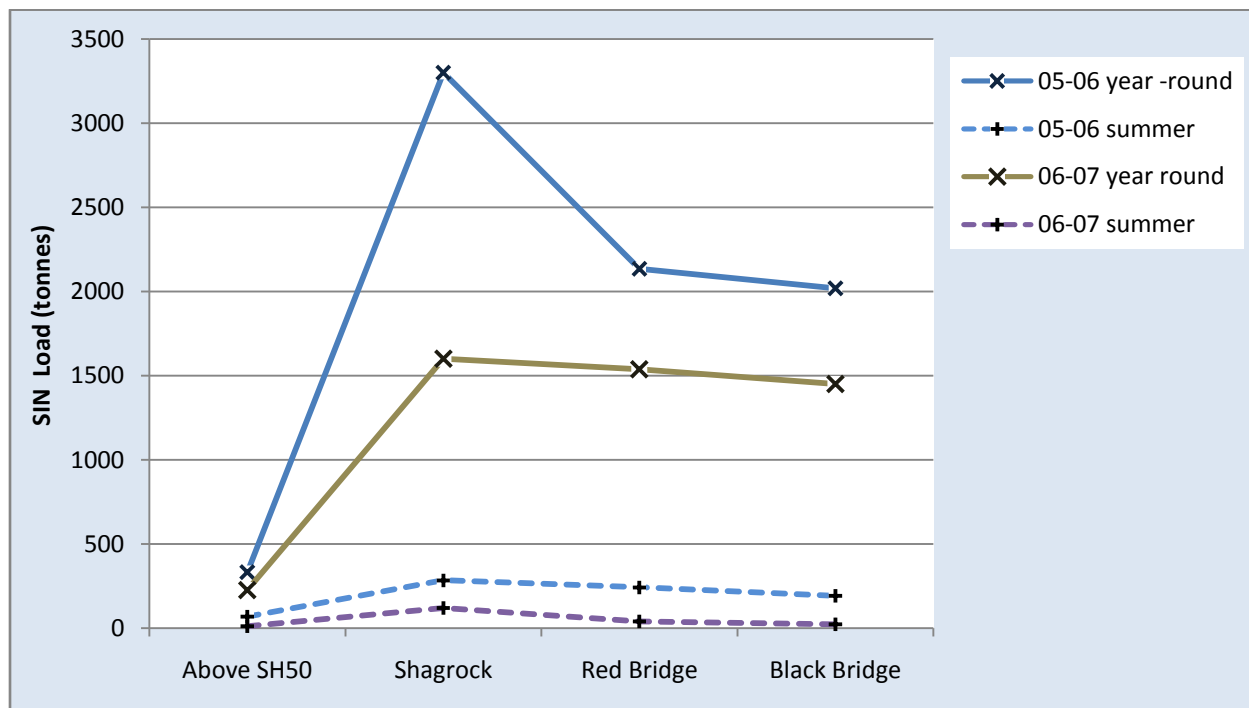


Figure 15: Annual and summer (November-April inclusive) SIN loads (Tonnes) in the Tukituki catchment, calculated with the “averaging” approach. Above SH50 refers to the sum of the loads calculated at the SH50 monitoring sites (Tukituki, Waipawa, Makaretu and Tukipo Rivers).

6.2. Load contributions

As concluded in previous sections, the middle catchment (above Shagrock) appears to be the part of the catchment where nutrient concentrations and loads increase rapidly. This section provides a scenario-based estimate of the relative contribution from the different tributaries/subcatchments to the nutrient loads at Shagrock.

6.2.1. Methodology

River sites: The approach taken was to estimate the DRP and SIN daily load at different points in the middle and upper catchment under different river flow conditions: median flow, 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. For example, the DRP concentration at Tukituki at SH50 at median flow was calculated as the average of the concentrations recorded at this site when the flow in the River was between the 45th and the 55th percentile of the flow distribution curve (refer to Appendix F for details).

In Figure 16 to Figure 20, the sub-catchments are labelled as follows:

- “Catchment upstream of SH50” is the sum of the inputs calculated at all four SH50 sites;
- “Tukituki between SH2 and SH50” represent the inputs to the Tukituki catchment between SH50 and SH2, excluding the Tukipo catchment (SH2 – SH50 - Tukipo at Ashcott Rd);
- “Tukipo d/s SH50” is the load inputs to the Tukipo catchment downstream of SH50 (Ashcott Rd – (Tukipo SH50 + Makaretu SH50). It does includes inputs from the Porangahau Stream;
- “Waipawa d/s SH50” ” is the load inputs to the Waipawa catchment downstream of SH50 (RDS-SH50). It includes inputs from the Mangaonuku catchment, but excludes the Waipawa oxidation pond discharge);
- “Mangatarata” represents the calculated inputs from the Mangatarata Stream catchment.

Oxidation pond discharges: No correlations between the DRP or SIN loads and river flow were found. The nutrient loads from the oxidation ponds were considered constant, and estimated as the average of the daily loads provided by the compliance records (refer to Section 4 of this report). The daily SIN loads from the oxidation pond discharges were taken as the average daily ammonia-N loads.

6.2.2. DRP

Current Situation: As expected, the total daily DRP inputs to the middle catchment decrease with the river flow (Figure 16), primarily due to a diminution in the inputs from the different sub-catchments. The catchment above SH50 (the sum of the Tukituki, Waipawa, Makaretu and Tukipo above SH50) contribute just under 10% of the total at all flows. The part of the Tukituki catchment between SH50 and SH2 makes a significant contribution (25%) at median flow, but it decreases greatly at low flows (3% at MALF). The Waipawa catchment (excluding the oxidation pond discharge) between SH50 and the confluence contribute between 7 and 14 % of the total at all flows (Figure 17).

The contribution of the oxidation pond discharges represents about 20% of the inputs at median flow, and increases at low flow, to nearly 70% when the river is at mean annual low flow.

Predicted situation after the oxidation pond upgrades (2014): After the 2014 upgrade, imposed through consent conditions, the oxidation pond discharges are expected to make a much smaller contribution than currently: 11% of the total at MALF and 3% at median flow.

The Waipawa catchment below SH50 will then be the biggest contributor, with its relative contribution increasing at low river flows. The Mangatarata Stream and upper catchment (above SH50) are the next biggest contributors at low flow.

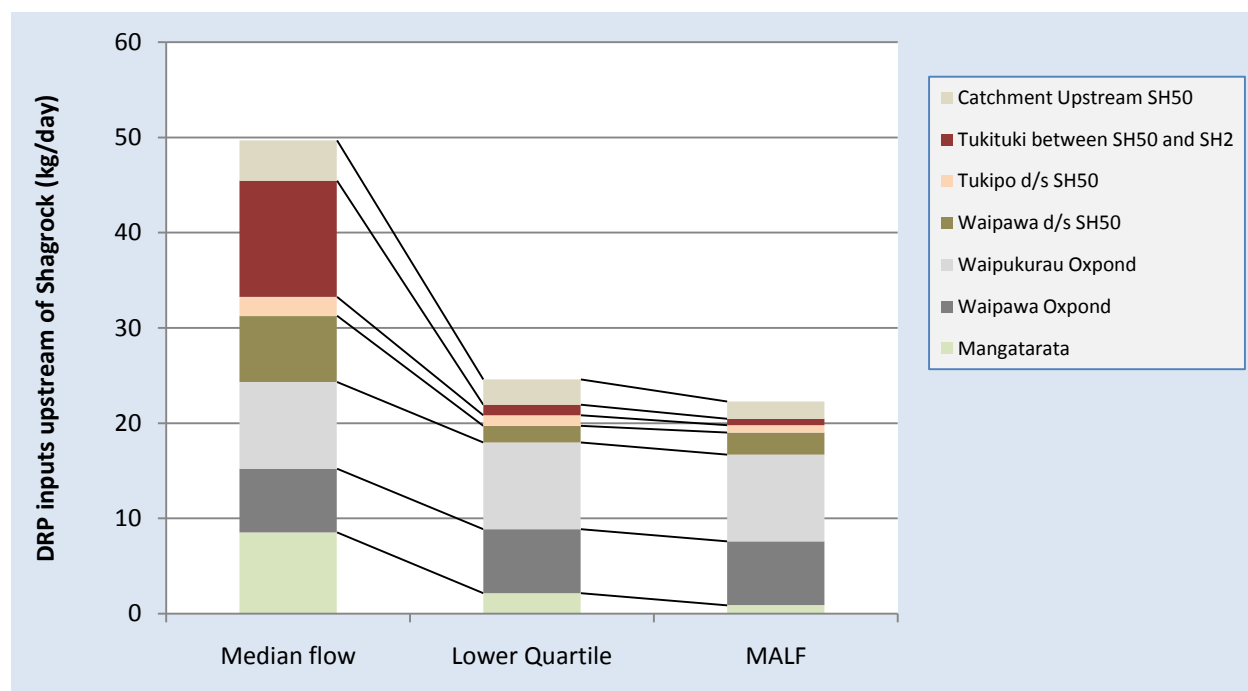


Figure 16: DRP inputs (kg/day) to the Tukituki River catchment upstream of the Tukituki at Shagrock monitoring station under three river flow conditions: median flow, lower quartile flow and 1-day Mean Annual Low Flow (MALF).

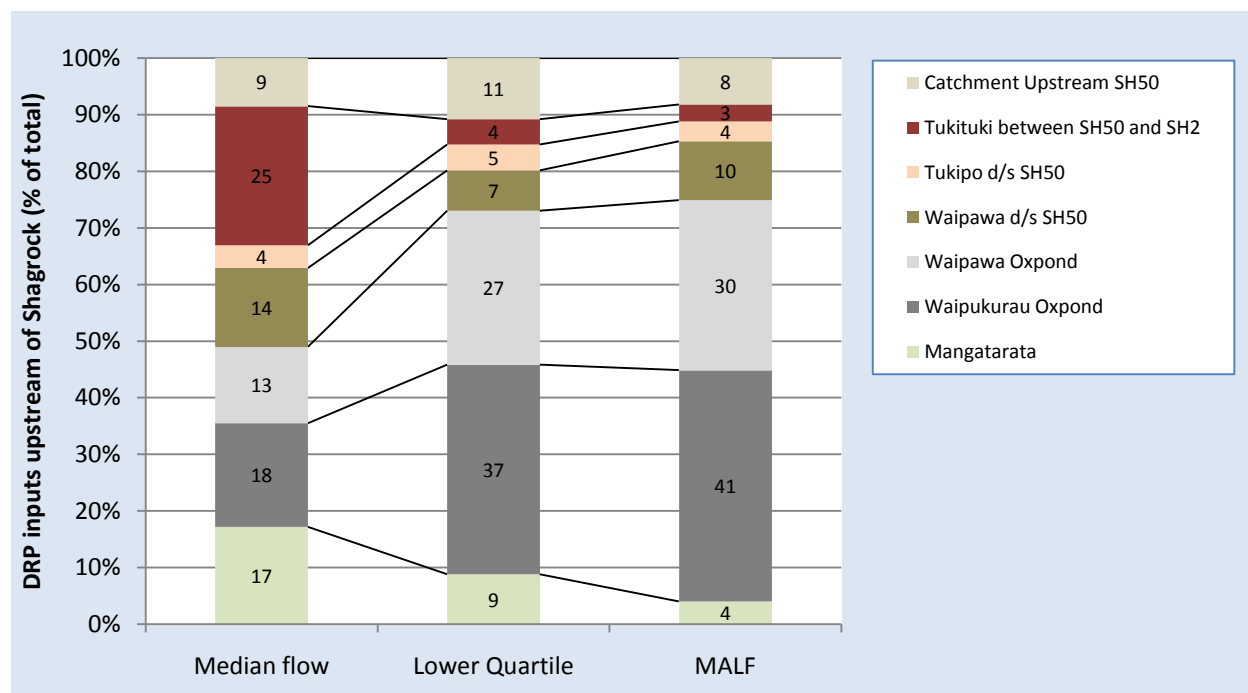


Figure 17: DRP inputs (as percentage of total) to the Tukituki River catchment upstream of the Tukituki at Shagrock monitoring station under three river flow conditions: median flow, lower quartile flow and 1-day Mean Annual Low Flow (MALF).

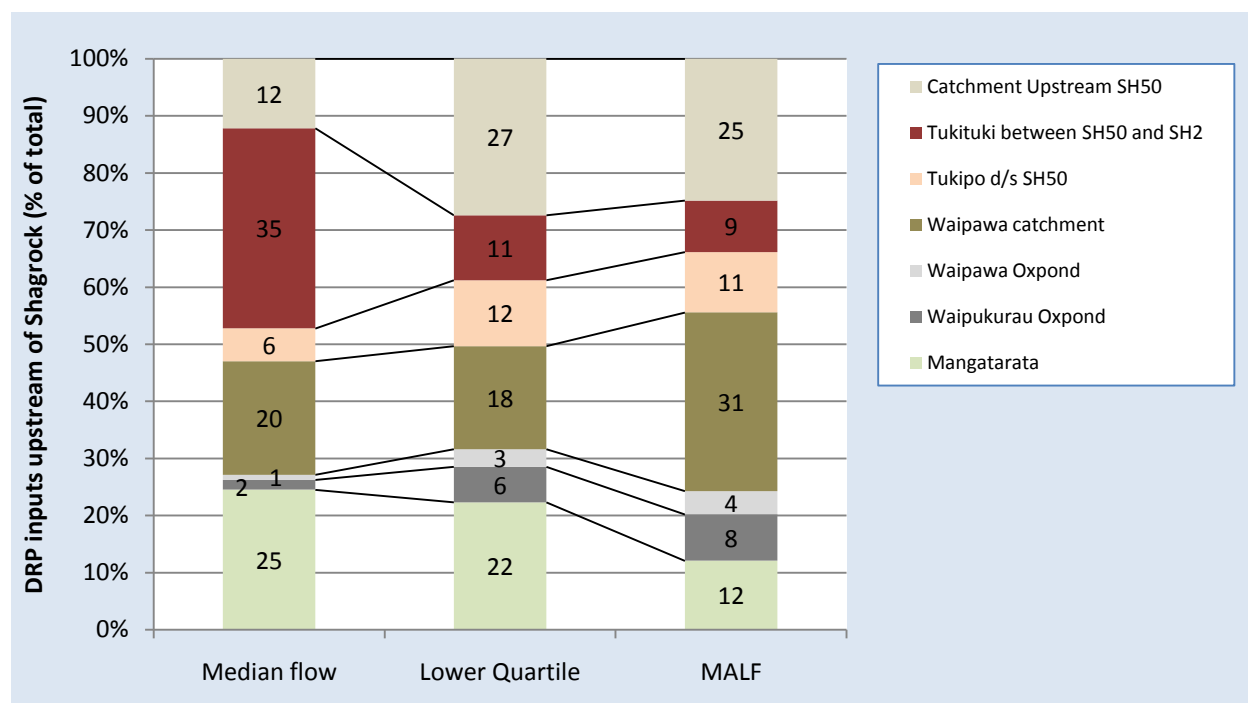


Figure 18: DRP inputs after the oxidation pond upgrade in 2014 (as percentage of total) to the Tukituki River catchment upstream of the Tukituki at Shagrock monitoring station under three river flow conditions: median flow, lower quartile flow and 1-day Mean Annual Low Flow (MALF).

6.2.3. SIN

The total SIN inputs to the middle catchment decrease sharply with the river flow: the total inputs at lower quartile flow and MALF are respectively less than half and less than a quarter of those at median flow (Figure 19).

By far the largest contributors to the total loads are the Tukituki and Waipawa catchments downstream of SH50. The oxidation ponds do not appear to make any significant contribution to the SIN loads in the Tukituki River at Shagrock, indicating that most of the SIN measured in the river is likely from non-point sources in the catchment.

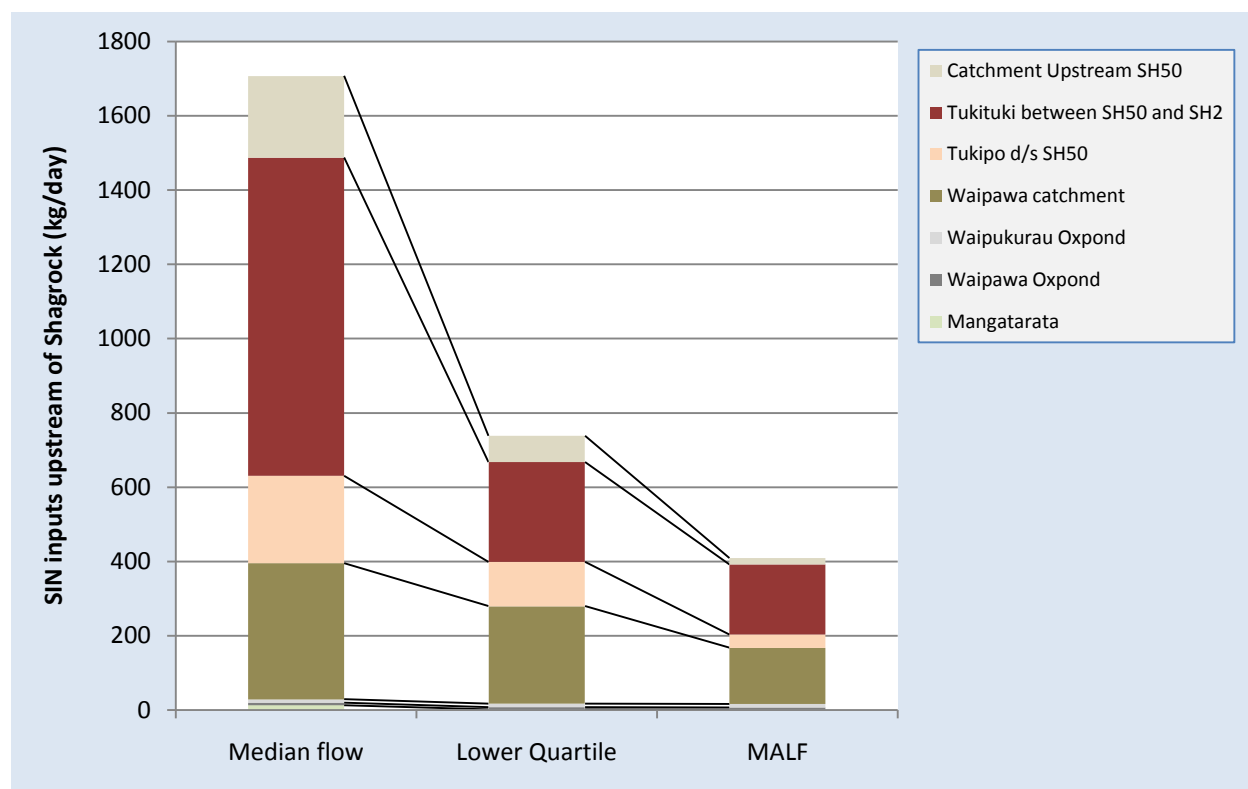


Figure 19: SIN inputs (kg/day) to the Tukituki River catchment upstream of the Tukituki at Shagrock monitoring station under three river flow conditions: median flow, lower quartile flow and 1-day Mean Annual Low Flow (MALF).

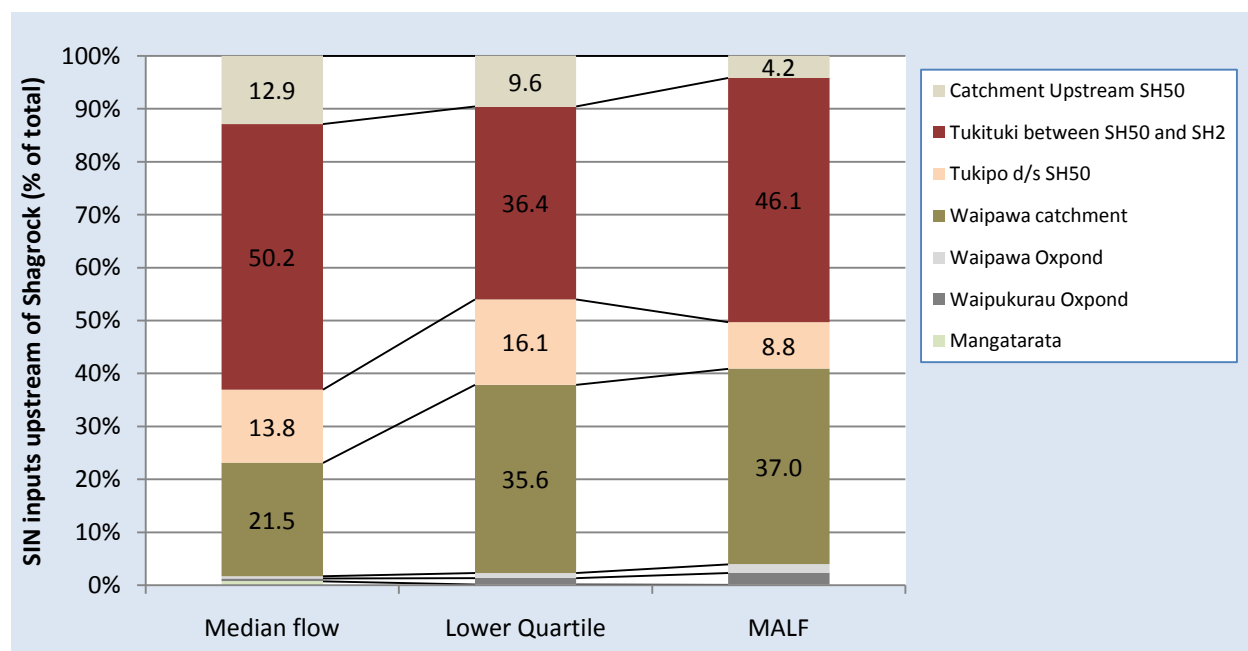


Figure 20: SIN inputs (as percentage of total) to the Tukituki River catchment upstream of the Tukituki at Shagrock monitoring station under three river flow conditions: median flow, lower quartile flow and 1-day Mean Annual Low Flow (MALF).

6.3. Catchment yields

The previous section presented the nutrient loads coming from the different sub-catchments as absolute numbers (i.e. kg per day). This section makes use of the same numbers (except the oxidation pond data, not used here), but related back to each sub-catchment size. The aim is to provide a broad estimate of the non-point source nutrient yield in each sub-catchment. The sub-catchments in Figure 21 and Figure 22 are the same as used in the previous section (refer to 6.2.1 for details).

It should be noted that the figures presented here are based on the nutrient concentrations measured in the water, and are expected to be significantly different from nutrient loss figures calculated at the paddock or farm scale. Generally speaking, it is considered that an attenuation factor of approximately 2 should be applied when trying to link nutrient loss from the land to nutrient in the waterways (i.e. only one third to one half of the nutrients lost from the land are measured in the waterways) (Clothier *et al.* 2007).

6.3.1. DRP

When the rivers are at median flow, the Tukituki catchment below SH50, the Mangatarata Stream and the Waipawa catchment below SH50 have the highest estimated daily yield of DRP (Figure 21). The Mangaonuku Stream catchment itself has a low DRP yield, so the high yield in the Waipawa catchment is probably due to inputs to the Waipawa mainstem and/or tributaries others than the Mangaonuku. The high yields in both the Tukituki and Waipawa catchments correspond well with the areas of high landuse intensity in the Ruataniwha Plains.

When considered as a whole, the upper catchment has a relatively moderate DRP yield, which decreases at low river flows. Surprisingly, the highest estimated DRP yield is in the Makaretu Stream catchment.

6.3.2. SIN

The SIN yield in all sub-catchments appears to be highly flow-dependant, and decrease sharply with the flow in the rivers.

The Tukituki catchment below SH50 has by far the highest estimated SIN yield, up to 45g/ha/day at median flow. The Porangahau, Mangaonuku, and Waipawa downstream of SH50 sub-catchments all have moderate SIN yields, in the vicinity of 10 g/ha/day at median flow (Figure 22).

Similarly to DRP, the Makaretu catchment above SH50 has the highest SIN yield of all upper catchment sites. With an estimated 10 g/ha/day at median flow, the SIN yield of the Makaretu catchment above SH50 is estimated to be about twice as much as the other SH50 sub-catchments (Figure 22).

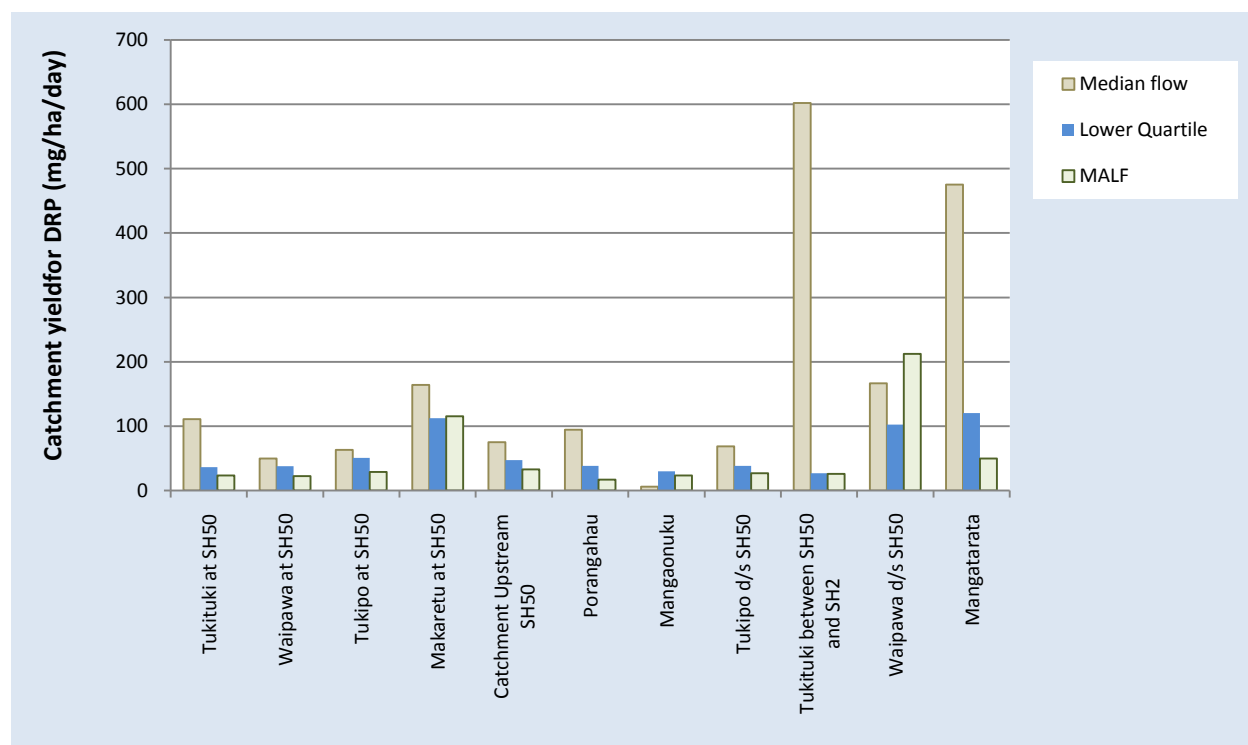


Figure 21: Estimated non-point source catchment yields for DRP (mg/ha/day) under different river flow conditions.

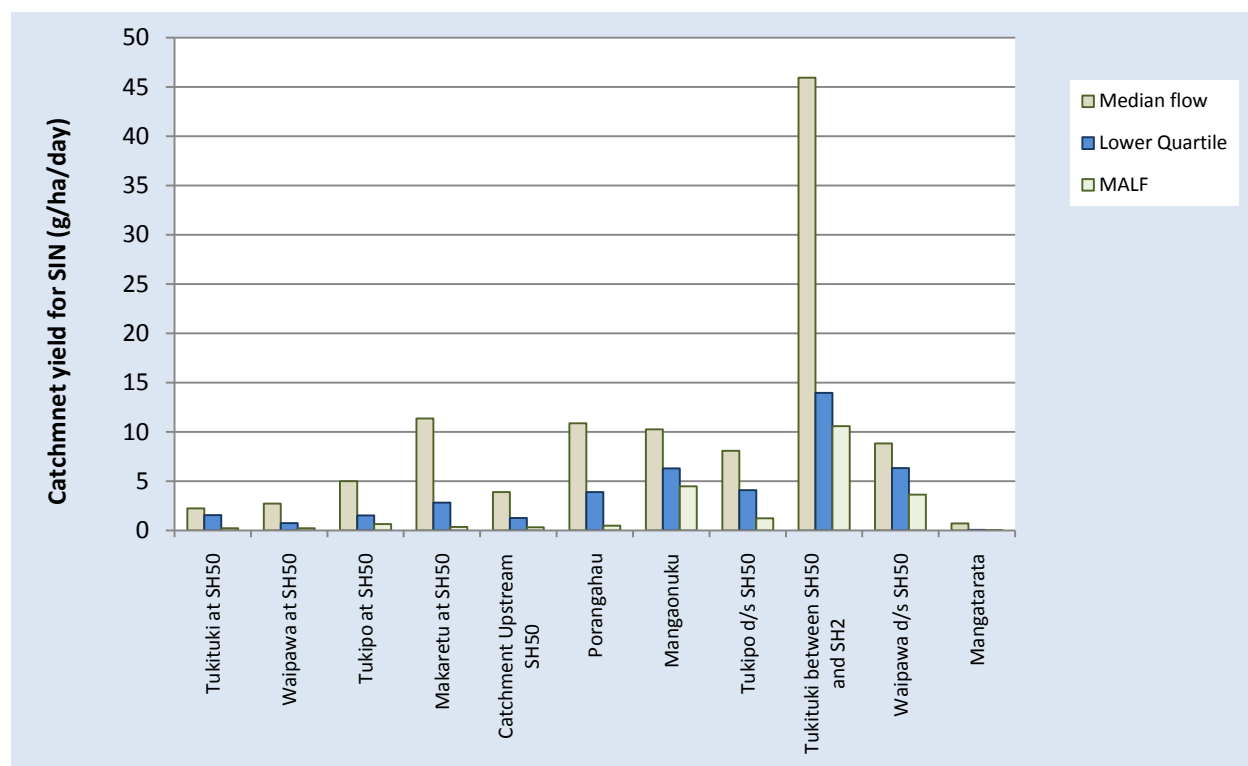


Figure 22: Estimated non-point source catchment yields for SIN (g/ha/day) under different river flow conditions.

7. Discussion and Conclusions

7.1. Water quality of the Tukituki River

7.1.1. Upper catchment (upstream of SH50)

Generally, all sites in the upper Tukituki catchment exhibited very good water quality.

The lower – compared to the other upper catchment sites- water clarity observed in the upper Tukituki and Waipawa Rivers are the likely result of natural causes.

Biological monitoring indicates healthy macroinvertebrate communities (MCI) and generally acceptable periphyton biomass. However, it is interesting to note that all upper catchment sites have exceeded periphyton biomass guideline at least once. This is possibly due to the very extended periods of low river flows sometimes occurring in the Hawke's Bay Region. The mean maximum annual accrual period⁶ for Tukituki at Red Bridge is 123 days, or a little over 4 months. Such very long accrual periods (i.e. the time between two significant floods) are known to allow the development of high periphyton biomass even with low nutrient concentrations (Biggs, 2000).

Although water quality is generally satisfactory, some significant temporal trends have been detected, indicating an increase in DRP concentrations and a decrease in MCI. The actual cause of the temporal trends observed remains unknown and should be investigated.

One site in the upper catchment exhibits marked signs of degraded water quality in comparison with the other upper catchment sites: the Tukipo River at SH50. It is the only site in the upper catchment which breaches both the DRP and SIN guidelines, has increasing DRP and SIN and decreasing MCI trends. This site also has the highest Total Organic Carbon (TOC) and *E.coli* concentrations. The causes of this situation need to be investigated, including the presence and influence of intensive land use in the upper Tukipo catchment.

7.1.2. Middle catchment (between SH50 and Shagrock)

Main Steam

A significant degradation of a number of water quality indicators (DRP, SIN, periphyton, MCI) is observed between the upstream and the downstream boundaries of the middle catchment (SH50 and Shagrock). Temporal trends also indicate DRP concentration increase and MCI degradation between 1998 and 2008 at Tukituki at Shagrock, whilst the bacteriological water quality was found to improve significantly over the same period.

Contaminant load analysis indicates that most DRP and SIN come from this part of the catchment. A significant increase in DRP concentration was also observed at Shagrock.

In the current situation, the DRP contribution from the Waipawa and Waipukurau oxidation ponds are the single largest source of DRP in the middle catchment, particularly at low river flows. The contribution from these two point source discharges is predicted to become relatively minor after the 2014 upgrade, imposed by way of resource consent conditions. The priority catchments to control DRP inputs to the Tukituki mainstem will then become the Waipawa and Tukituki catchments downstream of SH50, and the Mangatarata Stream. Although a significant contributor, the potential of the catchment above SH50 as a priority area for DRP management may require further investigations, as the sources of DRP may be predominantly natural (due to erosion) and more difficult to control.

⁶ i.e. the average of the longest annual period between two significant floods

The oxidation pond discharges do not appear to be significant contributors to the SIN loads in the middle Tukituki catchments. The largest contributors are the Tukituki and Waipawa catchments downstream of SH50.

The overall DRP and SIN patterns observed in the Tukituki catchment, i.e. SIN loads primarily of non-point source origin and a significant contribution from point-source discharges to the DRP loads, are consistent with the conclusions of studies undertaken in the neighbouring Upper Manawatu catchment, located in the Manawatu-Wanganui Region (Ledein *et al.* 2007)

Tributaries:

The Mangatarata Stream has the most degraded water quality of all the sites monitored in the catchment. Although the very elevated DRP and TOC concentrations could indicate direct contamination of the water, the actual causes of water quality degradation are unknown and should be investigated. Although the Mangatarata stream's contribution to the DRP inputs to the middle catchment is currently relatively minor, it is expected to represent 11 to 24 % of the total inputs after the oxidation pond upgrade – making the Mangatarata Stream an obvious candidate for targeted management.

The Mangaonuku Stream has elevated SIN, but low DRP. However, both DRP and SIN have been found to be increasing over time. Although they have been measured only once, periphyton biomass and macroinvertebrate communities have been found to be relatively poor. Further investigations are recommended to identify the causes of the increased SIN and DRP, and to confirm or otherwise the poor biological monitoring results in this valued trout fishery.

The Porangahau Stream also has relatively degraded water quality. However, it contributes only a small proportion of the middle catchment DRP loads (less than 1%), and may be a lesser priority than the two previous tributaries. It should also be noted that for at least parts of its course, the Porangahau Stream bed is dominated by fine sediments, making this stream relatively less sensitive to excessive periphyton growth.

7.1.3. Lower catchment

Only two sites have regularly been monitored in the lower Tukituki catchment, both on the main stem. The microbiological water quality and water clarity are generally good for a lowland river. No significant temporal trends were detected, except an improvement to the already good microbiological water quality.

Biological monitoring generally indicates high periphyton biomass and decreased MCI in the lower catchment - a degradation compared to the middle catchment.

A possible factor is the presence of more stable and slower flow conditions in the lower catchment, allowing algal proliferation and increased water temperatures, in turn affecting the macroinvertebrate communities. This explanation is somewhat supported by the contaminant loads analysis. During a dry summer year, nutrient concentration and annual and summer load decrease in the lower catchment, suggesting that a large part of the nutrients is consumed by the prolific algae biomass.

It is noted that no tributaries are monitored in the lower Tukituki catchment, therefore water quality in these tributaries and their possible influence on the Tukituki mainstem cannot be discussed.

7.1.4. Conclusions

Generally, the microbiological water quality is good (and improving), and water clarity is acceptable across the Tukituki catchment.

The largest single issue in the catchment appears to be nutrient enrichment and associated periphyton growth, with a general degradation from upstream to downstream in the catchment. It should be noted however, that all the sites across the catchment (including those with low levels of nutrients) do exceed

the periphyton guideline from time to time, which is probably due to the extended periods of low flows sometimes occurring in the region.

Significant temporal trends indicating an increase of DRP concentration and a degradation of macroinvertebrate communities over time have been found at a number of sites in the Tukituki mainstem and in tributaries in the upper and middle catchment. Significant increasing trends of the SIN concentration have also been found in two tributaries, the Tukipo and Mangaonuku Rivers. When considering medium term water quality trends, one should not discount the possible influence of El Nino/La Nina global weather patterns, which have an average return frequency of 6 years. La Nina years generally have long dry summers, which can affect key parameters such as water temperature and periphyton biomass (through the reduction in the frequency of floods), which in turn can affect macroinvertebrate communities. Notwithstanding the possible influence of global weather patterns, the causes of the temporal trends observed in the Tukituki catchment remain unknown and should be investigated.

Ratios between nitrogen and phosphorus indicate that DRP is the nutrient most likely to limit periphyton growth in most of the Tukituki system, making DRP the obvious priority management target.

The middle catchment, between SH50 and Shagrock appears to receive the largest sources of nutrients, particularly at low river flows. In the current situation, the point-source discharges from the Waipawa and Waipukurau oxidation ponds are the largest source of DRP. After the oxidation pond upgrades in 2014, non-point source pollution in the Waipawa and Mangatarata catchments are expected to become the dominant inputs of DRP to the middle catchment.

SIN loads appear to be predominantly from non-point sources in the Tukituki and Waipawa catchments between SH50 and Shagrock.

The analysis has revealed concerns about to tributaries:

- the upper Tukipo, which still has relatively good water quality, although not as good as the other upper catchment sites, and where significant increases of DRP and SIN and MCI decrease have been detected over the last 10 years;
- the Mangatarata Stream, where most parameters except ammonia and SIN indicate the most degraded water quality of all monitored sites.

7.2. Recommendations

7.2.1. Management implications

If a management objective is to reduce the frequency and duration of algal blooms, managing DRP inputs to the system is an obvious priority target – this is consistent with the RRMP which puts emphasis on P management. It should be noted however, that managing only one nutrient is fraught with risk (Wilcock *et al.* 2007), particularly as some sites in the catchment appear to switch to SIN-limited conditions during periods of low river flow.

In terms of achieving a reduction in the DRP loads to the Tukituki catchment, the oxidation ponds are the number one target- which has already been addressed through consent conditions. The next largest contributors, the Waipawa and Mangatarata catchments should become the target of active investigation and management. The sources of DRP in the upper catchment (above SH50) could be natural/ - i.e. associated with natural erosion processes- and may be much more difficult to manage.

An important consideration to bear in mind is the fact that even a drastic reduction in nutrient concentrations in the Tukituki 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.

It should be noted that the conclusions proposed in this report are based on the data available only. Some areas in the catchment are not monitored regularly and no conclusion can be drawn as to their water quality. Further, the scale of the conclusion is by necessity the same as the monitoring network, and can/should be refined by targeted monitoring and investigations. It is suggested that superimposing water quality and landuse information using modern GIS tools may be useful in identifying hotspots/priority areas for detailed instigations and/or management.

7.2.2. Further monitoring

Regular monitoring in the Tukituki at SH2 appears essential to better qualify water quality downstream of the Tukipo confluence and upstream of the Waipukurau oxidation pond discharges. It is noted that it is a contact recreation site, *i.e.* water samples are taken weekly for microbiological water quality monitoring. It is recommended that an additional sample be taken and analysed for the same suite of water quality parameters as SOE sites⁷.

High DRP concentrations have been observed upstream of the Waipukurau oxidation pond discharge, which requires further investigation, as detailed in section 4.1.1. It is recommended that monitoring be undertaken in parallel at SH2 and immediately upstream of the discharge, to attempt to understand the reasons for the apparent water quality differences between the two sites. For this reason, as well as for consistency of data across the catchment, it is recommended that monitoring at compliance sites be (*i.e.* upstream and downstream of the discharges) be monitored for the same parameters as the SOE sites – ideally synchronously.

If/when the discrepancies between SH2 and the upstream compliance site are clarified, it may then be possible to use only one site for both SOE and compliance purposes.

Biomonitoring was undertaken only once in the Mangaonuku and Mangatarata Streams, indicating poor MCI and high periphyton biomass. Additional monitoring is highly recommended to confirm or otherwise these results.

It is recommended that the sources of the degraded water quality in the upper Tukipo River and the Mangatarata Stream be investigated. The causes for relatively elevated nutrient yields in the upper Makaretu Stream catchment may also need to be investigated.

There appears to be no regular monitoring of the lower catchment tributaries, which prevents any analysis of the water quality in these waterways and the effect they may have on the Tukituki mainstem. Additional monitoring appears essential to be able to identify any significant sources of nutrients in the lower catchment.

⁷ This recommendation has been implemented since March 2008 (Graham Sevicke-Jones, *pers. comm.*)

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APPENDICES

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

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH ₃ -N (mg/L)	SIN (mg/L)	DRP (mg/L)	TP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
TukiTuki at SH50	Average	7.5	13	10	96	2.2	31.6	46	0.32	0.02	0.14	0.004	0.040	70	83	1.8	71	54	1.1	122	118
	Min	6.6	6	7	67	0.0	0.3	0	0.04	0.00	0.01	0.001	0.002	1	0.5	0.1	1	0	0.3	103	22
	5%ile	6.8	7	8	80	0.1	0.5	1	0.11	0.01	0.02	0.001	0.002	9	2	0.1	5	1	0.3	103	23
	10%ile	6.9	8	8	85	0.2	0.6	1	0.12	0.01	0.02	0.001	0.003	10	3	0.2	9	1	0.5	103	23
	25%ile	7.4	10	9	90	0.4	1.1	2	0.14	0.01	0.06	0.001	0.005	17	10	0.3	16	7	0.6	108	25
	Median	7.7	12	10	95	1.7	3.4	4	0.25	0.01	0.10	0.002	0.011	40	28	0.6	24	16	0.9	120	45
	75%ile	7.9	16	11	100	3.6	19.5	23	0.40	0.02	0.21	0.005	0.032	97	97	1.3	56	37	1.4	135	110
	90%ile	7.9	18	12	108	5.1	87.4	114	0.59	0.03	0.33	0.008	0.111	177	192	5.2	200	163	1.9	141	278
	95%ile	8.0	19	12	114	6.8	121.2	234	0.75	0.04	0.37	0.010	0.230	220	307	6.9	272	188	2.2	143	334
	Max	8.1	21	15	133	8.0	650.0	930	1.81	0.20	0.48	0.040	0.430	473	1412	26	640	587	4.1	144	390
	StDev	0.5	4.0	1.4	11	2.1	87	133	0.286	0.02	0.116	0.006	0.07	79	166	3.5	122	108	0.7	15	156
	95% C.I.	0.3	0.7	0.3	2.1	0.5	18	26	0.069	0.00	0.023	0.001	0.01	16	33	0.7	31	26	0.1	9	137
	Guideline	5 - 9.5	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	0.026	7			100	550		120	120
	%compliance	100	95	96	95	51	69	67	61	100	68	95	70	4			81	97		55	80
	N. of Samples	10	116	97	96	82	93	99	67	98	97	109	99	97		99	59	68	94	11	5
Tukipo at SH50	Average	7.8	13	10	97	2.3	8.2	12	1.34	0.018	1.00	0.018	0.037	178	148	1.8	588	192	3.0	122	129
	Min	7.3	6	7	65	0.1	0.2	0	0.47	0.003	0.13	0.001	0.010	7	3	0.0	22	9	0.7	103	29
	5%ile	7.4	7	8	79	0.3	0.4	1	0.54	0.005	0.24	0.001	0.016	14	6	0.1	37	13	1.5	107	32
	10%ile	7.4	8	8	80	0.6	0.5	1	0.62	0.005	0.36	0.001	0.020	19	8	0.1	44	26	1.6	111	34
	25%ile	7.6	10	9	89	1.1	0.6	2	0.73	0.005	0.50	0.007	0.024	28	16	0.3	100	38	2.0	117	42
	Median	7.7	13	10	96	2.2	1.3	2	1.01	0.010	0.70	0.018	0.031	60	49	0.7	170	64	2.8	122	84
	75%ile	7.9	16	11	103	3.3	3.0	5	1.80	0.022	1.45	0.023	0.038	119	193	1.9	305	132	3.9	130	160
	90%ile	8.2	19	12	114	4.1	10.0	11	2.45	0.036	2.05	0.030	0.061	395	322	5.9	822	299	4.4	131	262
	95%ile	8.5	19	13	121	4.7	32.5	39	2.87	0.044	2.40	0.047	0.077	706	571	7.8	1490	631	4.8	133	296
	Max	8.7	21	15	135	9.0	240	440	3.54	0.180	3.35	0.066	0.195	2374	1682	13	16000	4900	10.6	136	330
	StDev	0.4	4.0	1.6	13	1.5	29	49	0.778	0.022	0.710	0.014	0.03	377	250	2.7	2096	604	1.5	10	123
	95% C.I.	0.3	0.7	0.3	2.6	0.3	6	10	0.186	0.004	0.140	0.003	0.01	75	50	0.5	535	144	0.3	6	108
	Guideline	5 - 9.5	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	0.026	7			100	550		120	120
	%compliance	100	95	93	90	62	91	90	0	100	1	41	32	1			29	94		50	60
	N. of Samples	8	114	95	94	84	91	98	67	98	98	108	99	98	98	107	59	68	94	10	5
Makaroro at Burnt Bridge	Average	7.8	11	11	100	2.2	16.8		0.12	0.004	0.08	0.005	0.033	14	61	3.3	473				
	Min	7.4	4	9	90	0.0	0.2		0.02	0.001	0.00	0.001	0.000	1.0	0.4	0.2	66				
	5%ile	7.6	6	9	96	0.1	0.4		0.03	0.001	0.01	0.002	0.005	2.4	1.3	0.4	85				
	10%ile	7.6	6	9	97	0.1	0.5		0.04	0.001	0.01	0.003	0.005	3.4	1.9	0.5	100				
	25%ile	7.7	8	10	98	0.4	0.9		0.06	0.001	0.03	0.003	0.006	6.9	7.0	1.0	226				
	Median	7.8	11	11	99	1.6	2.5		0.10	0.003	0.07	0.005	0.010	12	25	1.7	289				
	75%ile	7.9	14	11	100	3.7	9.4		0.15	0.005	0.11	0.006	0.020	20	51	3.2	537				
	90%ile	7.9	17	12	102	5.4	38.6		0.22	0.007	0.17	0.008	0.066	28	131	5.6	753				
	95%ile	8.0	18	12	103	6.3	83.6		0.31	0.009	0.21	0.009	0.144	33	178	7.9	1475				
	Max	8.6	19	13	121	10.2	480		0.60	0.033	0.32	0.018	0.907	44	1520	69	2419				
	StDev	0.1	3.9	1.0	3	2.1	48		0.091	0.004	0.067	0.002	0.09	10	152	7.3	532				
	95% C.I.	0.0	0.5	0.1	0.4	0.3	6		0.013	0.000	0.009	0.000	0.01	1.4	21	1.0	217				
	Guideline	5 - 9.5	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	0.026	7			100	550		120	120
	%compliance	100	100	100	100	50	80		94	100	88	99	80	26			13				
	N. of Samples	212	213	209	209	210	213	0	199	199	199	212	213	199	199	200	23	0	0	0	0
Makaretu at SH50	Average	7.7	13	10	96	2.3	21.7	24	0.59	0.020	0.38	0.011	0.045	102	81	1.3	163	75	1.4	127	103
	Min	6.7	6	7	68	0.0	0.4	1	0.08	0.003	0.01	0.001	0.002	1	0	0.1	6	2	0.3	113	9

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH ₃ -N (mg/L)	SIN (mg/L)	DRP (mg/L)	TP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
ALL DATA	5%ile	7.4	7	8	79	0.2	0.5	1	0.11	0.005	0.03	0.001	0.009	1	1	0.1	18	4	0.4	115	10
	10%ile	7.4	8	8	81	0.3	0.6	1	0.11	0.005	0.03	0.001	0.011	2	1	0.2	27	10	0.7	117	11
	25%ile	7.6	10	9	88	0.9	1.0	2	0.20	0.005	0.07	0.004	0.015	7	6	0.3	42	17	1.0	120	13
	Median	7.8	12	10	96	2.0	2.4	2	0.34	0.010	0.19	0.010	0.020	33	22	0.9	76	40	1.2	120	114
	75%ile	7.9	16	11	104	3.6	5.4	6	0.89	0.020	0.70	0.015	0.031	94	119	1.5	114	68	1.5	133	160
	90%ile	8.0	19	12	113	4.9	28.2	33	1.31	0.034	0.98	0.022	0.059	203	253	3.1	544	181	2.1	138	196
	95%ile	8.1	20	12	118	5.4	68.3	98	1.54	0.061	1.15	0.029	0.100	494	300	4.4	664	303	2.4	148	208
	Max	8.4	24	15	132	6.0	944.0	923	2.55	0.270	1.70	0.038	0.970	1240	600	7.1	1300	860	8.2	157	220
	StDev	0.3	4.2	1.5	13	1.7	102	100	0.516	0.039	0.401	0.009	0.11	205	112	1.4	257	126	0.9	13	92
	95% C.I.	0.1	0.8	0.3	2.4	0.4	21	20	0.124	0.007	0.076	0.002	0.02	39	22	0.3	63	29	0.2	8	81
	Guideline	5 - 9.5	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	0.026	7			100	550		120	120
	%compliance	100	92	97	91	57	87	80	45	100	47	76	65	24			65	99		73	60
	N. of Samples	20	115	104	104	82	92	97	67	106	106	109	107	106	96	98	63	71	90	11	5
Porangahau at Oruawhara Rd	Average	7.8	14	11	104	2.7	6.7	5	2.12	0.020	1.84	0.023	0.051	258	93	1.3	1268	1062	5.1	96	175
	Min	6.8	6	7	66	0.2	0.2	1	0.26	0.003	0.05	0.001	0.006	2	0	0.0	25	1	1.8	90	58
ALL DATA	5%ile	6.9	8	7	71	0.6	0.3	1	0.34	0.005	0.09	0.001	0.020	4	0	0.0	45	13	2.3	91	60
	10%ile	6.9	9	8	82	1.0	0.4	2	0.38	0.005	0.16	0.001	0.020	7	1	0.0	55	22	2.7	92	62
	25%ile	7.2	11	9	91	1.6	0.7	2	0.81	0.005	0.45	0.010	0.030	23	5	0.1	94	48	3.3	95	69
	Median	8.0	15	10	101	2.6	1.4	2	1.95	0.010	1.58	0.020	0.040	70	32	0.3	225	100	4.3	98	171
	75%ile	8.4	18	12	117	3.7	3.1	5	2.95	0.030	2.86	0.031	0.060	147	99	1.4	605	329	5.9	99	278
	90%ile	8.5	20	13	128	4.3	8.8	14	4.29	0.040	4.15	0.043	0.075	321	261	2.2	2250	1500	8.5	99	292
	95%ile	8.5	20	14	136	4.6	21.6	26	4.78	0.061	4.40	0.050	0.114	667	328	4.7	4950	5175	9.2	99	296
	Max	8.5	22	16	173	6.3	156.0	60	5.90	0.130	6.03	0.089	0.570	7282	1405	25.3	18000	22000	15.1	99	301
	StDev	0.7	4.0	2.1	21	1.4	23	9	1.440	0.022	1.479	0.017	0.06	842	183	3.3	3536	3495	2.5	4	128
	95% C.I.	0.6	0.7	0.4	4.4	0.4	5	2	0.395	0.004	0.271	0.003	0.01	155	41	0.7	1022	924	0.6	4	125
	Guideline	5 - 9.5	24	6	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200	550		100	120
	%compliance	100	100	92	92	75	93	88	20	100	25	31	37	11			50	82		0	50
	N. of Samples	6	136	90	90	60	92	73	51	118	114	135	124	113	77	89	46	55	65	4	4
Tukipo at Ashcott Rd	Average		13.5	9.6	91.4	1.8	9.5	23	2	0.032	1.12	0.013	0.041	412	831	7.9	146		2.4		
	Min		6.0	7.3	69.2	0.1	0.3	0		0.001	0.14	0.001	0.001	9	22	0.1	4		0.9		
ALL DATA	5%ile		7.3	8.0	75.5	0.3	0.5	1		0.005	0.23	0.001	0.009	12	46	0.3	19		1.1		
	10%ile		8.0	8.2	79.5	0.4	0.6	1		0.010	0.26	0.001	0.012	21	69	0.4	33		1.1		
	25%ile		11.0	8.7	85.9	1.0	1.0	2		0.010	0.46	0.003	0.020	45	149	1.3	60		1.4		
	Median		13.5	9.3	90.5	1.6	2.0	4	2	0.010	0.85	0.010	0.028	130	398	3.3	80		1.7		
	75%ile		17.0	10.4	96.3	2.8	4.5	9		0.030	1.47	0.020	0.040	267	965	7.8	166		3.2		
	90%ile		18.4	11.0	102	3.0	29.8	45		0.086	2.53	0.030	0.099	1098	2461	13	381		3.6		
	95%ile		18.8	11.6	107	3.3	52.9	105		0.150	2.77	0.030	0.128	2181	3251	31	400		4.9		
	Max		22.0	13.2	129	3.9	150.0	280		0.220	3.66	0.060	0.236	3660	5115	104	885		5.5		
	StDev		3.9	1.2	11	1.1	23	56		0.05	1	0	0.04	749	1132	15	168		1.3		
	95% C.I.		0.9	0.3	2.8	0.6	5	19		0.01	0	0.003	0.01	193	273	4	55		0.5		
	Guideline	5 - 9.5	24	8	80	1.6	15	10		0.4	0.444	0.015	0.033	7			200			100	120
	%compliance		100	95	87	53	87	78		100	24	55	70	0			81				
	N. of Samples	0	73	60	60	15	67	32	1	66	66	65	66	58	66	64	36	0	23	0	0
Tukituki at SH2	Average	7.7	17	10	99	2.3	21.5	16	1.48	0.07	1.32	0.016	0.046	306	1571	15	83	128	1.6		
	Min	7.6	7	7	66	0.1	0.3	1	0.66	0.00	0.18	0.001	0.003	22	123	0.1	2	0	0.6		
ALL DATA	5%ile	7.6	9	8	81	0.4	0.5	1	0.69	0.01	0.41	0.001	0.005	26	211	0.4	4	1	0.8		
	10%ile	7.6	11	8	84	0.7	0.8	1	0.73	0.01	0.51	0.001	0.014	29	241	0.8	13	2	0.9		
	25%ile	7.6	15	9	90	1.1	1.3	2	1.03	0.01	0.76	0.003	0.020	43	391	1.9	21	5	1.0		
	Median	7.6	18	10	96	2.5	2.0	3	1.27	0.01	1.16	0.011	0.028	92	756	7	37	18	1.3		

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH ₃ -N (mg/L)	SIN (mg/L)	DRP (mg/L)	TP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m²)	
	75%ile	7.7	19	11	104	3.2	5.2	8	1.74	0.03	1.68	0.020	0.040	369	1962	18	121	58	1.8			
	90%ile	7.8	21	12	115	4.3	21.0	52	2.53	0.06	2.24	0.030	0.092	826	3202	27	202	303	2.6			
	95%ile	7.9	22	13	120	4.6	45.3	63	2.83	0.11	2.55	0.040	0.130	1375	4082	46	290	513	3.5			
	Max	7.9	26	15	187	5.2	1200.0	204	3.11	4.50	5.70	0.110	0.460	3010	17220	146	320	3873	6.9			
	StDev	0.2	3.9	1.4	17	1.4	113	37	0.8	0.45	0.8	0.02	0.07	516	2445	26	89	442	1.1			
	95% C.I.	0.2	0.5	0.3	3.1	0.5	15	11	0.4	0.09	0.2	0.00	0.01	104	557	6	32	62	0.4			
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200	550		100	120	
	%compliance	100	99	98	95	66	86	80	0	99	7	54	64	0			90	96				
	N. of Samples	4	279	108	108	32	211	45	12	99	99	110	89	95	74	74	30	198	38	0	0	
Tukituki at Taiparu Rd	Average	7.9	14	10	104	1.8	11.0	19	1.56	0.073	1.12	0.027	0.067	195	1432	26	552	448	1.9			
	Min	7.6	6	8	80	0.1	0.5	1	0.70	0.003	0.05	0.001	0.004	2	26	0	15	11	0.8			
	5%ile	7.7	8	8	84	0.4	0.8	1	0.72	0.010	0.31	0.001	0.025	8	188	1	29	19	0.8			
	10%ile	7.7	9	9	94	0.7	1.0	1	0.74	0.010	0.41	0.002	0.032	13	209	2	36	24	0.9			
	25%ile	7.8	11	9	97	1.1	1.5	2	1.19	0.040	0.67	0.008	0.040	25	421	7	88	72	1.0			
	Median	7.9	14	10	101	1.9	2.5	4	1.55	0.061	1.00	0.021	0.048	49	872	17	140	114	1.6			
	75%ile	8.1	17	11	108	2.4	6.0	14	1.75	0.080	1.47	0.040	0.063	129	1854	31	395	321	2.6			
	90%ile	8.2	20	12	114	2.8	23.0	86	2.35	0.140	1.95	0.050	0.134	580	3225	45	992	807	3.5			
	95%ile	8.2	21	13	131	3.0	68.0	90	2.63	0.170	2.46	0.060	0.171	799	4391	98	2130	1734	4.0			
ALL DATA	Max	8.3	25	15	168	4.0	125.0	145	2.91	0.420	2.95	0.210	0.336	2475	8901	173	11000	8953	6.2			
	StDev	0.3	4.1	1.5	17	0.9	23	34	0.7	0.1	0.6	0.03	0.06	400	1566	33	1407	1146	1.2			
	95% C.I.	0.4	0.8	0.3	6.9	0.2	5	10	0.4	0.0	0.1	0.01	0.01	87	341	7	310	253	0.4			
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200	550		100	120	
	%compliance	100	99	99	100	58	86	72	0	99	11	37	13	5			61	82				
	N. of Samples	3	111	99	24	50	81	47	12	81	81	82	79	81	81	82	79	79	39	0	0	
	Waipawa at Nth Block Rd	Average	7.5	9	10	92	2.8	3.5	6	0.09	0.013	0.05	0.001	0.006	46	3.0	0.12	5		0.5	134	
		Min	7.2	4	8	78	1.0	0.2	1	0.04	0.003	0.02	0.001	0.001	7	0.5	0.01	1		0.1	103	
		5%ile	7.2	5	8	80	1.1	0.3	1	0.05	0.003	0.02	0.001	0.001	8	0.8	0.01	1		0.2	109	
10%ile		7.3	6	9	82	1.3	0.5	1	0.06	0.003	0.02	0.001	0.002	10	1.1	0.01	1		0.2	115		
25%ile		7.3	7	9	89	1.6	0.5	1	0.07	0.009	0.03	0.001	0.003	17	2.0	0.02	1		0.4	133		
Median		7.4	9	10	93	2.1	1.0	2	0.09	0.010	0.04	0.001	0.003	38	2.2	0.09	1		0.4	143		
75%ile		7.6	12	11	96	3.7	3.1	4	0.10	0.014	0.06	0.001	0.007	64	4.1	0.14	3		0.7	144		
90%ile		7.7	14	12	102	4.6	12.0	14	0.13	0.023	0.08	0.002	0.014	92	5.4	0.25	6		0.9	144		
95%ile		7.8	14	12	103	5.3	15.0	17	0.17	0.026	0.09	0.003	0.017	100	5.9	0.29	22		0.9	145		
ALL DATA	Max	7.8	15	13	104	5.9	21.0	73	0.20	0.042	0.10	0.004	0.033	146	6.3	0.32	42		1.3	145		
	StDev	0.3	3.2	1.3	8	1.5	5	12	0.0	0.0	0.0	0.00	0.01	37	2.2	0.13	12		0.3	20		
	95% C.I.	0.4	0.9	0.4	4.9	0.7	2	4	0.0	0.0	0.0	0.00	0.00	15	2.0	0.11	7		0.1	20		
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200			120	120	
	%compliance	100	100	95	90	81	95	85	100	100	100	100	100	5			100			75		
	N. of Samples	3	45	38	10	16	41	41	10	25	25	34	42	22	5	5	12	0	23	4	0	
	Waipawa at SH50	Average	7.3	13	10	95	2.5	16.1	22	0.30	0.013	0.17	0.004	0.020	105	173	3.3	102	62	0.9	122	87
		Min	6.7	6	8	75	0.0	0.2	1	0.06	0.003	0.02	0.000	0.001	2	2	0.1	1	0	0.2	97	21
		5%ile	6.8	7	8	80	0.1	0.4	1	0.11	0.003	0.02	0.001	0.002	7	5	0.3	17	5	0.3	99	32
10%ile		6.8	8	9	84	0.2	0.4	1	0.11	0.005	0.03	0.001	0.003	10	6	0.4	20	7	0.3	100	44	
25%ile		7.2	10	9	90	0.4	0.7	2	0.14	0.005	0.06	0.001	0.004	17	20	0.6	30	17	0.3	107	78	
Median		7.4	13	10	95	2.1	2.0	2	0.23	0.008	0.11	0.002	0.007	36	60	1.0	48	35	0.7	128	78	
75%ile		7.6	16	11	101	4.2	13.0	13	0.40	0.017	0.26	0.005	0.016	99	214	2.8	138	70	1.2	131	120	
90%ile		7.7	18	11	105	5.3	31.1	43	0.60	0.029	0.42	0.008	0.051	199	459	6.4	252	140	1.6	136	132	
95%ile		7.8	19	12	108	5.8	50.5	57	0.66	0.030	0.46	0.010	0.058	351	717	8.8	336	250	2.0	152	136	

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH ₃ -N (mg/L)	SIN (mg/L)	DRP (mg/L)	TP (mg/L)	SIN/DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	FC (/100mL)	CoreLd Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
Mangaonuku at Tikokino Rd	Max	7.9	22	14	130	8.4	268.0	540	0.77	0.140	0.87	0.040	0.330	2260	1283	58	670	500	6.4	167	140
	StDev	0.4	3.8	1.1	9	2.1	42	70	0.2	0.0	0.2	0.01	0.04	254	258	8	122	82	1.0	20	46
	95% C.I.	0.3	0.7	0.2	1.8	0.4	9	14	0.0	0.0	0.0	0.00	0.01	50	51	1.5	30	19	0.2	12	40
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200	550		120	120
	%compliance	100	100	98	94	52	77	72	91	100	92	97	85	5			88	100		55	80
	N. of Samples	8	121	95	95	84	94	100	67	101	101	110	101	98	99	99	65	74	94	11	5
	Average	7.2	14	9	84	3.9	1.7	3	2.10	0.033	1.74	0.007	0.020	738	530	2.1	67	44	1.8	92	260
	Min	7.0	7	6	61	0.3	0.2	1	1.64	0.005	0.57	0.001	0.004	44	78	0.1	22	5	0.4	92	260
	5%ile	7.1	9	7	71	1.0	0.3	1	1.66	0.005	0.78	0.001	0.007	90	122	0.1	29	15	0.5	92	260
	10%ile	7.1	10	7	73	1.2	0.4	1	1.72	0.005	1.00	0.001	0.009	106	136	0.2	34	22	0.6	92	260
	25%ile	7.1	11	8	78	2.3	0.5	2	1.82	0.010	1.36	0.001	0.014	161	181	0.3	45	26	0.9	92	260
	Median	7.2	14	9	84	4.0	0.6	2	1.99	0.018	1.71	0.005	0.019	254	403	0.9	55	31	1.5	92	260
	75%ile	7.2	17	10	90	5.3	1.6	3	2.11	0.031	2.03	0.011	0.025	1255	668	2.1	57	44	2.4	92	260
	90%ile	7.3	17	11	98	6.3	2.9	5	2.80	0.072	2.52	0.016	0.029	1890	1154	5.9	141	66	3.3	92	260
	95%ile	7.3	17	11	104	7.1	4.0	10	2.86	0.117	2.72	0.019	0.035	2519	1587	8.9	164	140	3.5	92	260
	Max	7.3	19	12	107	7.5	24.0	32	3.19	0.210	3.99	0.025	0.048	2718	1841	13.9	180	160	4.3	92	260
	StDev	0.2	3.1	1.4	10	2.0	4	5	0.4	0.0	0.6	0.01	0.01	803	452	3.0	48	38	1.0		
	95% C.I.	0.3	0.8	0.4	3.1	0.7	1	2	0.2	0.0	0.2	0.00	0.00	237	129	0.9	27	16	0.3		
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200	550		100	120
	%compliance	100	100	69	62	84	97	93	0	100	0	86	93	0			100	100		0	0
	N. of Samples	2	54	39	39	31	38	44	18	47	47	50	46	44	47	46	12	21	37	1	1
Waipawa D/s Waipawa Oxpond ALL DATA	Average	15	13				16.4	18		0.043		0.031				25	582	197			
	Min	9	4				0.5	1		0.005		0.010				5.5	9	1			
	5%ile		10	4			0.6	1		0.005		0.012				5.9	39	22			
	10%ile		10	7			0.6	1		0.005		0.013				7.6	50	25			
	25%ile		11	8			0.8	1		0.020		0.020				10	113	33			
	Median		14	9			1.5	3		0.034		0.028				18	153	85			
	75%ile		17	10			6.0	8		0.070		0.043				24	275	145			
	90%ile		21	13			31.3	49		0.080		0.050				46	558	301			
	95%ile		23	23			65.2	102		0.105		0.054				76	1685	331			
	Max		27	105			300.0	220		0.110		0.067				146	10000	3100			
	StDev		4.5	17.1			53	44		0.0		0.01				27.82	1722	522			
	95% C.I.		1.5	5.8			18	15		0.0		0.00				9.35	579	176			
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7	8	9	200	550		100	120
	%compliance		159	82			109	121		147		126					35	44			
	N. of Samples	0	34	33	0	0	34	34	0	32	0	34	0	0	0	34	34	34	0	0	0
Mangatarata Stream	Average	7.7	13	9	101	1.4	11.2	12	1.16	0.037	0.39	0.130	0.208	8.2	8	3.8	644	457	11.4	70	169
	Min	7.1	6	4	35	0.2	0.5	1	0.06	0.003	0.01	0.003	0.046	0.0	0.0	0.1	34	7	4.6	70	169
	5%ile	7.3	7	6	60	0.2	0.9	1	0.44	0.005	0.02	0.010	0.081	0.1	0.1	0.2	55	26	8.2	70	169
	10%ile	7.4	8	6	69	0.3	1.2	2	0.62	0.005	0.02	0.028	0.096	0.1	0.1	0.2	62	38	8.5	70	169
	25%ile	7.7	10	8	76	0.7	1.7	2	0.74	0.005	0.03	0.056	0.139	0.3	0.2	0.9	94	64	9.6	70	169
	Median	7.8	13	9	84	1.2	4.2	5	0.93	0.018	0.16	0.110	0.193	1.6	1.0	2.5	210	123	10.9	70	169
	75%ile	7.9	17	10	94	2.1	14.8	15	1.41	0.047	0.57	0.181	0.250	5	7	4.8	620	305	13.0	70	169
	90%ile	7.9	20	11	104	2.5	28.1	29	2.23	0.103	1.15	0.238	0.324	10	31	8.1	1430	1297	14.8	70	169
	95%ile	7.9	20	12	107	3.1	43.7	50	2.33	0.138	1.45	0.304	0.373	36	44	11	2530	1910	16.7	70	169
	Max	8.0	23	13	1222	3.5	68.0	88	3.01	0.230	2.28	0.445	0.580	139	45	16	6200	4000	18.0	70	169
	StDev	0.3	4.4	1.9	139	0.9	16	17	0.6	0.0	0.5	0.09	0.10	24	14	4	1224	864	2.7		
	95% C.I.	0.2	1.0	0.4	33.0	0.3	4	4	0.2	0.0	0.1	0.02	0.02	6	6	2	389	255	0.7		

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH ₃ -N (mg/L)	SIN (mg/L)	DRP (mg/L)	TP (mg/L)	SIN/ DRP	SIN Ld (kg/day)	DRP Ld (kg/day)	FC (/100mL)	Coreltd Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200	550		100	120
	%compliance		100	71	65	37	76	64	12	100	71	7	0	85			47	84		0	0
	N. of Samples	6	75	69	68	46	70	73	42	58	58	67	74	55	19	19	38	44	56	1	1
Tukituki at Shagrock + Tamumu	Average	8.0	15	11	104	2.3	16.2	20	1.24	0.02	0.97	0.014	0.042	141	2791	40	194	91	2.5	116	118
	Min	7.1	7	8	82	0.0	0.2	1	0.25	0.00	0.12	0.001	0.006	17	59	1	1	0	0.4	90	7
	5%ile	7.3	9	8	84	0.2	0.5	1	0.52	0.00	0.26	0.001	0.012	21	166	2	9	1	0.7	95	13
	10%ile	7.5	9	9	87	0.4	0.5	1	0.61	0.01	0.37	0.002	0.017	24	279	2	25	1	0.9	99	18
	25%ile	7.7	12	9	91	1.2	0.8	2	0.71	0.01	0.51	0.005	0.022	32	569	6	42	6	1.3	105	36
	Median	7.8	15	10	100	2.6	1.9	2	1.11	0.01	0.84	0.013	0.029	60	1450	17	81	39	2.6	116	118
	75%ile	8.5	18	12	114	3.1	8.0	9	1.55	0.03	1.28	0.021	0.040	134	3790	39	160	78	3.5	126	200
	90%ile	8.7	20	12	130	3.8	26.5	22	2.17	0.05	1.78	0.025	0.069	385	6654	86	448	269	4.0	131	218
	95%ile	8.7	21	13	138	4.2	50.8	48	2.28	0.08	2.11	0.032	0.102	677	11667	164	588	400	4.7	138	224
	Max	8.7	25	15	168	6.8	471.0	760	2.56	0.21	2.37	0.074	0.430	950	16460	398	2500	920	6.7	145	230
	StDev	0.6	4.1	1.5	17	1.4	58	88	0.6	0.03	0.6	0.01	0.05	206	3528	68	364	166	1.3	16	109
	95% C.I.	0.4	0.7	0.3	3.1	0.3	12	17	0.1	0.01	0.1	0.00	0.01	44	755	14	78	41	0.3	10	106
	Guideline	5 to 9.5	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	0.033	7			200	550		100	120
	%compliance	100	98	98	100	68	84	78	10	100	15	56	60	0			80	97		90	50
	N. of Samples	7	130	118	118	98	94	100	67	89	87	99	100	86	84	96	84	63	83	10	4
Tukituki at Red Bridge	Average	8.4	16	11	111	2.1	60.2	50	1.02	0.02	0.75	0.016	0.062	119	2888	70	170	94	3.3	104	264
	Min	7.1	8	7	69	0.0	0.2	1	0.11	0.00	0.02	0.001	0.003	3	8	0	1	1	0.5	78	20
	5%ile	7.4	9	9	85	0.2	0.4	1	0.16	0.00	0.03	0.001	0.006	9	12	0	4	1	1.0	80	33
	10%ile	7.7	10	9	86	0.3	0.5	2	0.21	0.01	0.04	0.001	0.007	17	18	1	8	2	1.2	82	46
	25%ile	8.1	12	10	94	1.1	0.7	2	0.40	0.01	0.24	0.002	0.011	27	217	2	18	8	2.2	86	84
	Median	8.4	16	11	108	1.9	1.6	2	0.89	0.01	0.58	0.009	0.020	49	1334	14	39	31	3.0	116	228
	75%ile	8.8	20	12	121	2.8	3.4	7	1.57	0.02	1.20	0.022	0.037	119	3962	91	104	84	3.9	120	330
	90%ile	9.1	22	13	137	3.9	24.6	23	1.93	0.03	1.70	0.035	0.067	250	7902	172	268	133	5.5	121	528
	95%ile	9.5	23	14	146	4.6	44.2	48	2.18	0.04	1.82	0.045	0.100	409	10357	329	620	484	6.1	122	594
	Max	9.8	27	16	170	6.1	3240.0	2670	3.29	0.10	2.11	0.170	2.140	1257	22374	658	3600	1200	14.9	123	660
	StDev	0.8	4.5	1.6	21	1.4	402	318	0.7	0.02	0.6	0.02	0.25	199	4162	129	500	200	2.1	19	252
	95% C.I.	0.6	1.0	0.4	4.8	0.3	98	74	0.2	0.00	0.1	0.00	0.06	46	961	29	128	47	0.5	11	221
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	0.033	7			100	550		100	120
	%compliance	88	99	99	96	64	85	79	34	100	38	63	70	4			75	96		55	40
	N. of Samples	8	85	73	73	67	65	71	65	73	73	79	73	71	72	78	59	68	71	11	5
Tukituki at Black Bridge	Average	8.2	17	11	110	2.0	13.6	31	0.94	0.03	0.70	0.014	0.040	178	2459	53	442	205	3.2	86	220
	Min	7.2	7	6	61	0.0	0.2	1	0.11	0.00	0.01	0.001	0.001	0	3	0	1	0	0.3	75	51
	5%ile	7.2	9	8	78	0.1	0.5	1	0.15	0.01	0.03	0.001	0.003	6	15	1	5	1	0.9	75	56
	10%ile	7.2	11	8	87	0.3	0.6	1	0.17	0.01	0.04	0.001	0.009	11	35	1	8	3	1.0	76	62
	25%ile	7.4	14	10	96	1.0	1.0	2	0.30	0.01	0.20	0.002	0.013	27	213	2	22	14	1.4	78	78
	Median	8.2	18	11	107	1.8	1.9	2	0.77	0.01	0.56	0.010	0.020	48	1144	14	51	31	3.0	81	200
	75%ile	9.0	20	12	121	3.0	3.4	7	1.48	0.02	1.11	0.020	0.040	139	3528	59	327	81	4.1	86	271
	90%ile	9.2	22	13	139	3.9	10.2	24	1.90	0.04	1.59	0.030	0.070	515	5804	144	1885	661	5.3	102	408
	95%ile	9.3	23	15	149	4.4	24.4	54	2.14	0.08	1.79	0.041	0.097	1015	9624	198	2419	1506	5.7	110	454
	Max	9.4	27	19	183	6.0	2160.0	1840	2.49	1.16	2.22	0.068	1.520	2215	24871	807	3300	3000	21.0	118	500
	StDev	0.9	4.2	2.2	22	1.4	120	186	0.7	0.09	0.6	0.01	0.11	342	3705	97	791	476	2.5	15	180
	95% C.I.	0.7	0.4	0.3	3.3	0.3	13	36	0.2	0.01	0.1	0.00	0.01	46	496	13	145	54	0.5	11	158
	Guideline	5 - 9.5	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	0.033	7			100	550		100	120
	%compliance	100	99	93	95	60	93	81	100	97	42	57	68	6			64	89		14	40
	N. of Samples	7	434	166	166	86	337	102	67	221	219	232	220	216	214	227	115	298	91	7	5

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

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Core ^{ltd} Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
TukiTuki at SH50	Average	7.5	13	10	97	2.4	15.6	23	0.27	0.017	0.13	0.003	70	54	1.1	0.032	57	42	1.0	122	118
	Min	6.6	6	7	73	0.0	0.3	0	0.04	0.003	0.01	0.001	1	0	0.1	0.002	1	0	0.3	103	22
	5%ile	6.7	7	8	82	0.1	0.5	1	0.11	0.005	0.02	0.001	8	2	0.1	0.002	4	1	0.3	103	23
	10%ile	6.9	8	9	85	0.2	0.6	1	0.12	0.005	0.02	0.001	10	2	0.2	0.003	7	1	0.4	103	23
	25%ile	7.4	10	9	92	0.4	1.1	2	0.14	0.005	0.05	0.001	17	9	0.3	0.004	15	6	0.6	108	25
	Median	7.7	12	10	96	1.9	2.7	3	0.23	0.010	0.10	0.002	38	24	0.5	0.010	22	15	0.9	120	45
	75%ile	7.8	16	11	102	3.6	16.0	17	0.35	0.020	0.19	0.004	99	67	1.1	0.028	51	29	1.2	135	110
	90%ile	7.9	18	12	109	5.4	44.4	56	0.50	0.031	0.29	0.007	174	144	2.8	0.072	160	118	1.7	141	278
	95%ile	8.0	19	12	116	6.8	86.0	115	0.73	0.043	0.34	0.008	225	185	5.2	0.166	200	170	2.0	143	334
	Max	8.1	21	15	133	8.0	125.0	274	0.86	0.200	0.47	0.031	473	366	8	0.286	640	587	4.1	144	390
	StDev	0.5	4.0	1.4	10	2.1	28	50	0.180	0.025	0.104	0.004	80	68	1.6	0.06	100	85	0.6	15	156
	95% C.I.	0.3	0.8	0.3	2.1	0.5	6	10	0.045	0.005	0.021	0.001	17	14	0.3	0.01	27	21	0.1	9	137
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance	100	94	97	97	55	73	71	67	100	71	98	4			73	85	98		55	80
	N. of Samples	9	98	90	89	77	86	92	61	92	91	93	91	91	93	93	53	62	88	11	5
Tukipo at SH50	Average	7.8	13	10	97	2.6	2.1	3	1.22	0.018	0.91	0.018	164	83	1.2	0.032	248	99	2.9	122	129
	Min	7.3	6	7	65	0.1	0.2	0	0.47	0.003	0.13	0.001	7	3	0.0	0.010	22	9	0.7	103	29
	5%ile	7.4	8	8	80	0.7	0.4	1	0.54	0.005	0.24	0.001	14	6	0.1	0.016	33	11	1.5	107	32
	10%ile	7.4	8	8	82	1.0	0.4	1	0.58	0.005	0.31	0.001	16	7	0.1	0.020	52	22	1.6	111	34
	25%ile	7.6	10	9	90	1.5	0.5	2	0.69	0.005	0.47	0.006	26	13	0.2	0.024	100	38	2.0	117	42
	Median	7.7	13	10	96	2.8	1.0	2	0.90	0.010	0.64	0.018	52	36	0.6	0.030	165	60	2.6	122	84
	75%ile	7.9	17	11	104	3.5	2.1	2	1.65	0.020	1.39	0.023	112	110	1.2	0.037	298	122	3.8	130	160
	90%ile	8.2	19	12	112	4.2	3.3	6	2.20	0.033	1.85	0.031	417	236	2.9	0.044	475	156	4.3	131	262
	95%ile	8.5	20	13	120	4.8	5.4	9	2.63	0.042	2.17	0.051	669	257	3.5	0.058	797	292	4.4	133	296
	Max	8.7	21	15	135	9.0	35	54	3.54	0.180	3.35	0.066	1980	527	9	0.087	1400	870	6.0	136	330
	StDev	0.4	4.0	1.6	13	1.4	4	6	0.713	0.022	0.657	0.014	324	106	1.6	0.01	264	127	1.1	10	123
	95% C.I.	0.3	0.8	0.3	2.7	0.3	1	1	0.185	0.005	0.140	0.003	69	22	0.3	0.00	73	32	0.2	6	108
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance	100	94	94	91	71	99	96	0	100	1	41	1			36	28	98		50	60
	N. of Samples	8	100	83	82	73	78	85	57	85	85	94	85	85	94	86	50	59	81	10	5
Makaroro at Burnt Bridge	Average	7.8	11	11	100	2.4	8.8		0.11	0.003	0.07	0.005	14	34	2.1	0.019	484				
	Min	7.5	4	9	90	0.1	0.2		0.02	0.001	0.00	0.001	1	0	0.2	0.000	66				
	5%ile	7.6	6	9	96	0.1	0.4		0.03	0.001	0.01	0.002	2	1	0.4	0.004	84				
	10%ile	7.6	6	9	97	0.2	0.5		0.04	0.001	0.01	0.003	3	2	0.5	0.005	99				
	25%ile	7.7	8	10	98	0.5	0.8		0.06	0.001	0.02	0.003	6	6	0.9	0.006	233				
	Median	7.8	11	11	99	1.7	2.0		0.10	0.003	0.06	0.005	11	22	1.6	0.009	290				
	75%ile	7.9	15	11	100	3.9	6.1		0.15	0.005	0.11	0.006	20	43	2.7	0.016	575				
	90%ile	7.9	17	12	102	5.5	24.3		0.20	0.007	0.15	0.008	27	84	4.6	0.038	762				
	95%ile	8.0	18	12	103	6.5	43.0		0.24	0.009	0.19	0.009	32	132	5.6	0.073	1514				
	Max	8.6	20	13	121	10.2	110		0.41	0.033	0.32	0.016	44	258	7	0.277	2419				
	StDev	0.1	3.9	1.0	3	2.1	18		0.074	0.003	0.063	0.002	10	43	1.6	0.03	541				
	95% C.I.	0.0	0.5	0.1	0.4	0.3	3		0.011	0.001	0.009	0.000	1	6	0.2	0.00	226				
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance	100	99	100	100	55	85		96	100	91	99	28			86	14				
	N. of Samples	198	198	195	195	195	198	0	186	186	186	197	186	186	187	198	22	0	0	0	0
Makaretu at SH50	Average	7.7	13	10	96	2.5	8.0	10	0.56	0.021	0.37	0.010	104	63	1.1	0.035	153	63	1.3	127	103
	Min	6.7	6	7	68	0.1	0.4	1	0.08	0.003	0.01	0.001	1	1	0.1	0.002	16	2	0.3	113	9

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Corel ^{td} Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
<3*Med	5%ile	7.0	7	8	79	0.3	0.5	1	0.11	0.005	0.02	0.001	1	1	0.1	0.009	26	8	0.3	115	10
	10%ile	7.2	8	8	81	0.5	0.6	1	0.11	0.005	0.03	0.001	2	1	0.1	0.011	30	11	0.7	117	11
	25%ile	7.6	10	9	88	1.0	0.9	2	0.16	0.005	0.06	0.003	9	5	0.3	0.014	46	18	1.0	120	13
	Median	7.7	13	10	95	2.2	2.3	2	0.32	0.010	0.17	0.008	33	19	0.9	0.020	80	43	1.2	120	114
	75%ile	7.9	16	11	101	3.7	4.4	5	0.82	0.020	0.69	0.014	99	96	1.3	0.029	117	65	1.5	133	160
	90%ile	8.1	19	12	115	5.0	11.5	15	1.27	0.036	0.96	0.022	225	173	2.2	0.044	348	120	1.9	138	196
	95%ile	8.2	20	12	118	5.4	34.5	52	1.56	0.059	1.14	0.027	491	253	3.2	0.081	622	220	2.1	148	208
	Max	8.4	24	15	132	6.0	183.0	253	2.55	0.270	1.70	0.036	1240	403	7.1	0.507	1200	400	8.2	157	220
	StDev	0.5	4.2	1.5	13	1.7	23	32	0.519	0.042	0.403	0.008	202	83	1.1	0.07	217	78	0.9	13	92
	95% C.I.	0.3	0.8	0.3	2.7	0.4	5	7	0.129	0.009	0.084	0.002	42	17	0.2	0.01	59	20	0.2	8	81
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance	100	92	97	91	62	92	86	48	100	49	81	22			70	64	100		73	60
	N. of Samples	8	96	86	86	76	84	90	62	89	89	91	89	88	91	91	53	61	83	11	5
Porangahau at Oruawhara Rd	Average	7.8	15	11	105	3.0	6.5	4	1.80	0.018	1.52	0.021	296	51	0.6	0.050	942	957	4.4	96	175
	Min	6.8	7	7	66	0.3	0.2	1	0.26	0.003	0.07	0.001	2	1	0.0	0.006	25	1	1.8	90	58
	5%ile	6.9	8	7	72	1.2	0.3	1	0.34	0.005	0.10	0.001	5	1	0.0	0.018	41	16	2.3	91	60
	10%ile	6.9	9	8	81	1.6	0.3	1	0.35	0.005	0.17	0.001	7	1	0.0	0.022	52	22	2.7	92	62
	25%ile	7.1	12	9	93	2.1	0.6	2	0.71	0.005	0.37	0.007	23	6	0.0	0.030	94	41	3.2	95	69
	Median	8.4	15	10	102	2.9	1.2	2	1.85	0.010	1.40	0.022	68	24	0.2	0.039	190	105	4.1	98	171
	75%ile	8.4	18	12	118	3.8	2.9	4	2.68	0.022	2.36	0.030	125	63	0.8	0.057	543	265	5.1	99	278
	90%ile	8.5	20	14	128	4.3	5.4	5	3.37	0.040	3.37	0.043	316	121	1.7	0.069	870	682	6.8	99	292
	95%ile	8.5	20	14	134	5.0	7.0	14	3.57	0.040	3.84	0.049	792	215	1.8	0.075	2880	2700	8.6	99	296
	Max	8.5	22	16	168	6.3	156.0	30	5.02	0.080	4.72	0.055	7282	289	2.2	0.570	18000	22000	10.5	99	301
	StDev	0.8	3.9	2.1	21	1.3	26	5	1.209	0.016	1.256	0.015	1017	67	0.7	0.06	2998	3581	1.9	4	128
	95% C.I.	0.7	0.9	0.5	4.8	0.3	6	1	0.361	0.004	0.303	0.004	247	17	0.1	0.01	953	1035	0.5	4	125
<3*Med	Guideline	6.5 to 9.0	24	6	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance	100	100	92	92	86	96	93	23	100	30	37	12			37	53	87		0	50
	N. of Samples	5	75	72	72	51	67	60	43	69	66	75	65	61	75	78	38	46	55	4	4
	Average		13.8	9.6	92.5	2.0	5.2	15	2	0.026	1.02	0.013	365	500	5.1	0.030	117		1.7		
	Min		6.0	7.3	70.7	0.4	0.3	0		0.001	0.14	0.001	9	22	0.1	0.001	4		0.9		
	5%ile		7.1	8.0	77.6	0.7	0.5	1		0.005	0.22	0.001	12	40	0.2	0.008	17		1.0		
	10%ile		8.1	8.4	80.7	1.0	0.5	1		0.010	0.24	0.001	18	65	0.3	0.011	32		1.1		
	25%ile		11.0	8.7	86.8	1.2	1.0	2		0.010	0.41	0.003	44	112	1.1	0.017	56		1.4		
	Median		13.8	9.3	90.8	1.7	2.0	3	2	0.010	0.81	0.010	130	291	3.0	0.023	78		1.5		
	75%ile		17.0	10.5	96.6	2.8	3.0	6		0.019	1.36	0.020	233	578	7.6	0.030	159		1.7		
	90%ile		18.5	11.2	102	3.0	5.3	9		0.044	2.02	0.030	870	1231	12	0.040	215		2.5		
	95%ile		19.0	11.7	110	3.4	7.1	11		0.128	2.63	0.030	1694	1730	14	0.065	375		3.1		
Tukipo at Ashcott Rd	Max		22.0	13.2	129	3.9	150	280		0.220	3.66	0.060	3660	2659	33	0.236	400		3.6		
	StDev		4.0	1.2	11	1.0	20	56		0.04	1	0	707	574	6	0.03	102		0.7		
	95% C.I.		1.0	0.3	3.0	0.6	5	23		0.01	0	0.003	198	149	2	0.01	34		0.4		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10		0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		100	96	90	62	96	92		100	26	54	0			82	85				
	N. of Samples	0	62	51	51	13	57	24	1	57	57	54	49	57	54	56	34	0	15	0	0
	Average	7.7	17	10	100	2.4	15.7	11	1.48	0.031	1.18	0.013	375	1097	11	0.034	75	72	1.3		
	Min	7.6	7	7	80	0.4	0.3	1	0.66	0.003	0.18	0.001	22	123	0.1	0.004	2	0	0.6		
	5%ile	7.6	10	8	84	0.6	0.6	1	0.69	0.005	0.37	0.001	26	210	0.4	0.010	4	1	0.8		
	10%ile	7.6	11	9	87	0.9	0.8	1	0.73	0.009	0.45	0.001	35	233	0.8	0.015	12	1	0.8		
	25%ile	7.6	15	9	91	1.1	1.3	2	1.03	0.010	0.62	0.002	54	378	1.8	0.019	21	4	0.9		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10		0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		100	96	90	62	96	92		100	26	54	0			82	85				
	N. of Samples	0	62	51	51	13	57	24	1	57	57	54	49	57	54	56	34	0	15	0	0
Tukituki at SH2	Average	7.7	17	10	100	2.4	15.7	11	1.48	0.031	1.18	0.013	375	1097	11	0.034	75	72	1.3		
	Min	7.6	7	7	80	0.4	0.3	1	0.66	0.003	0.18	0.001	22	123	0.1	0.004	2	0	0.6		
	5%ile	7.6	10	8	84	0.6	0.6	1	0.69	0.005	0.37	0.001	26	210	0.4	0.010	4	1	0.8		
	10%ile	7.6	11	9	87	0.9	0.8	1	0.73	0.009	0.45	0.001	35	233	0.8	0.015	12	1	0.8		
<3*Med	25%ile	7.6	15	9	91	1.1	1.3	2	1.03	0.010	0.62	0.002	54	378	1.8	0.019	21	4	0.9		

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Corel ^{td} Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
	Median	7.6	18	10	96	2.5	2.0	2	1.27	0.017	1.05	0.010	118	656	6	0.027	32	15	1.2		
	75%ile	7.7	20	11	104	3.3	4.7	6	1.74	0.032	1.61	0.020	418	1603	17	0.040	107	50	1.7		
	90%ile	7.8	21	12	115	4.4	13.6	16	2.53	0.053	2.22	0.030	1186	2663	25	0.061	160	151	2.0		
	95%ile	7.9	22	13	120	4.6	26.3	33	2.83	0.100	2.29	0.030	1665	3445	27	0.089	240	416	2.3		
	Max	7.9	26	15	187	5.2	1200.0	204	3.11	0.240	3.00	0.110	3010	4247	141	0.168	320	1710	2.7		
	StDev	0.2	3.9	1.4	16	1.3	97	32	0.8	0.0	0.7	0.02	589	1040	18	0.03	80	179	0.5		
	95% C.I.	0.2	0.5	0.3	3.2	0.5	14	10	0.4	0.0	0.2	0.00	142	247	4	0.01	29	26	0.2		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200			100	120
	%compliance	100	99	99	99	68	90	88	0	100	10	61	0			68	93				
Tukituki at Taiparu Rd	N. of Samples	4	227	95	95	31	188	41	12	68	68	69	66	68	69	68	29	188	34	0	0
	Average	7.9	14	10	105	1.8	4.8	8	1.56	0.069	1.11	0.027	197	1133	21	0.057	549	446	1.6		
	Min	7.6	6	8	80	0.2	0.5	1	0.70	0.003	0.05	0.001	2	26	0	0.004	15	11	0.8		
	5%ile	7.7	8	8	84	0.5	0.7	1	0.72	0.010	0.29	0.001	7	187	1	0.023	28	19	0.8		
	10%ile	7.7	9	9	94	0.8	1.0	1	0.74	0.010	0.40	0.002	12	208	2	0.030	35	24	0.8		
	25%ile	7.8	11	9	97	1.1	1.2	2	1.19	0.040	0.65	0.008	24	404	7	0.040	86	70	1.0		
	Median	7.9	15	10	101	1.9	2.0	3	1.55	0.060	0.98	0.021	49	808	17	0.046	138	112	1.4		
	75%ile	8.1	17	11	108	2.5	4.7	7	1.75	0.080	1.46	0.040	127	1459	29	0.053	320	260	1.9		
	90%ile	8.2	20	13	114	2.8	9.9	17	2.35	0.137	1.95	0.050	572	2491	41	0.103	1038	845	3.0		
	95%ile	8.2	21	13	132	3.0	17.1	23	2.63	0.164	2.47	0.063	904	3264	46	0.119	2160	1758	3.3		
	Max	8.3	25	15	168	4.0	59.0	84	2.91	0.320	2.95	0.210	2475	5087	166	0.336	11000	8953	3.8		
	StDev	0.3	4.2	1.5	18	0.9	8	14	0.7	0.1	0.6	0.03	411	1073	23	0.04	1425	1160	0.9		
	95% C.I.	0.4	0.8	0.3	7.2	0.2	2	4	0.4	0.0	0.1	0.01	94	245	5	0.01	318	259	0.3		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance	100	99	99	100	59	95	81	0	100	12	36	5			14	62	83			
	N. of Samples	3	103	92	23	49	74	42	12	74	74	75	74	74	75	72	77	77	34	0	0
	Average	7.3	13	10	95	2.6	8.0	10	0.27	0.013	0.16	0.004	102	123	2.3	0.014	99	57	0.8	121	87
	Min	6.7	6	8	78	0.1	0.2	1	0.06	0.003	0.02	0.000	2	2	0.1	0.001	1	0	0.2	97	21
	5%ile	6.8	7	8	80	0.1	0.4	1	0.11	0.003	0.02	0.001	7	5	0.3	0.002	17	4	0.3	98	32
Waipawa at SH50	10%ile	6.8	7	9	85	0.2	0.4	1	0.11	0.005	0.03	0.001	10	6	0.4	0.002	20	7	0.3	100	44
	25%ile	7.2	9	9	90	0.8	0.7	2	0.14	0.005	0.06	0.001	17	19	0.5	0.004	31	17	0.3	104	78
	Median	7.4	13	10	95	2.5	1.7	2	0.20	0.009	0.10	0.002	36	48	1.0	0.007	48	34	0.7	120	78
	75%ile	7.6	16	11	101	4.2	10.2	9	0.39	0.017	0.21	0.005	99	189	2.3	0.014	139	67	1.1	131	120
	90%ile	7.7	18	11	105	5.4	26.2	37	0.54	0.029	0.36	0.007	178	329	4.8	0.044	244	132	1.5	139	132
	95%ile	7.8	19	12	107	5.9	37.6	49	0.61	0.030	0.44	0.009	331	444	7.5	0.054	322	229	1.8	153	136
	Max	7.9	22	14	130	8.4	53.9	70	0.73	0.140	0.87	0.039	2260	707	42	0.096	670	300	3.7	167	140
	StDev	0.4	3.9	1.1	9	2.1	13	16	0.2	0.0	0.2	0.00	257	156	5	0.02	115	66	0.6	21	46
	95% C.I.	0.3	0.8	0.2	1.9	0.5	3	3	0.0	0.0	0.0	0.00	53	32	1.0	0.00	29	16	0.1	13	40
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		120	120
	%compliance	100	100	98	94	55	81	77	95	100	95	99	5			87	88	100		50	80
	N. of Samples	8	100	87	87	78	85	91	62	93	93	93	91	93	93	93	59	68	86	10	5
	Average	7.2	14	9	85	3.9	1.6	2	2.10	0.033	1.75	0.007	759	464	1.9	0.019	69	45	1.8	92	260
	Min	7.0	7	6	61	0.3	0.2	1	1.64	0.005	0.57	0.001	44	78	0.1	0.004	22	5	0.4	92	260
	5%ile	7.1	9	7	71	1.0	0.3	1	1.66	0.005	0.78	0.001	89	121	0.1	0.007	28	14	0.5	92	260
	10%ile	7.1	9	8	73	1.2	0.4	1	1.72	0.005	0.99	0.001	114	135	0.2	0.008	34	21	0.5	92	260
	25%ile	7.1	11	8	79	2.3	0.5	2	1.82	0.007	1.36	0.001	162	174	0.3	0.014	46	26	0.9	92	260
	Median	7.2	14	9	84	4.0	0.5	2	1.99	0.018	1.71	0.004	248	342	0.9	0.019	55	33	1.5	92	260
	75%ile	7.2	16	10	90	5.3	1.1	2	2.11	0.031	2.03	0.010	1330	623	1.8	0.025	58	45	2.4	92	260
Mangaonuku at Tikokino Rd	90%ile	7.3	17	11	98	6.3	2.4	5	2.80	0.077	2.52	0.015	1915	868	5.4	0.029	150	73	3.4	92	260
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		120	120
	%compliance	100	100	98	94	55	81	77	95	100	95	99	5			87	88	100		50	80
	N. of Samples	8	100	87	87	78	85	91	62	93	93	93	91	93	93	93	59	68	86	10	5
	Average	7.2	14	9	85	3.9	1.6	2	2.10	0.033	1.75	0.007	759	464	1.9	0.019	69	45	1.8	92	260
	Min	7.0	7	6	61	0.3	0.2	1	1.64	0.005	0.57	0.001	44	78	0.1	0.004	22	5	0.4	92	260
	5%ile	7.1	9	7	71	1.0	0.3	1	1.66	0.005	0.78	0.001	89	121	0.1	0.007	28	14	0.5	92	260
	10%ile	7.1	9	8	73	1.2	0.4	1	1.72	0.005	0.99	0.001	114	135	0.2	0.008	34	21	0.5	92	260
	25%ile	7.1	11	8	79	2.3	0.5	2	1.82	0.007	1.36	0.001	162	174	0.3	0.014	46	26	0.9	92	260
	Median	7.2	14	9	84	4.0	0.5	2	1.99	0.018	1.71	0.004	248	342	0.9	0.019	55	33	1.5	92	260
	75%ile	7.2	16	10	90	5.3	1.1	2	2.11	0.031	2.03	0.010	1330	623	1.8	0.025	58	45	2.4	92	260
	90%ile	7.3	17	11	98	6.3	2.4	5	2.80	0.077	2.52	0.015	1915	868	5.4	0.029	150	73	3.4	92	260

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Corel ^{td} Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
Waipawa D/s Waipawa Oxpond <3*Med	95%ile	7.3	17	11	104	7.1	3.6	5	2.86	0.119	2.72	0.017	2520	1494	7.9	0.036	165	141	3.5	92	260
	Max	7.3	19	12	107	7.5	24.0	13	3.19	0.210	3.99	0.025	2718	1638	13.9	0.048	180	160	4.3	92	260
	StDev	0.2	3.0	1.4	10	2.0	4	3	0.4	0.0	0.7	0.01	826	400	2.9	0.01	49	39	1.1		
	95% C.I.	0.3	0.9	0.4	3.2	0.7	1	1	0.2	0.0	0.2	0.00	253	120	0.9	0.00	29	17	0.4		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance	100	100	71	63	84	97	95	0	100	0	91	0			93	100	100		0	0
	N. of Samples	2	46	38	38	31	35	41	18	43	43	43	41	43	43	43	11	20	35	1	1
	Average		15	12			15.8	17		0.045		0.030			19		608	202			
	Min		9	4			0.5	1		0.005		0.010			5.5		9	1			
	5%ile		9	4			0.6	1		0.005		0.012			5.9		38	21			
	10%ile		10	7			0.6	1		0.008		0.013			7.4		50	24			
	25%ile		11	8			0.8	1		0.020		0.020			10		110	32			
	Median		14	9			1.3	3		0.039		0.028			16		153	71			
	75%ile		17	10			4.5	6		0.070		0.040			21		298	163			
Tukituki at Shagrock + Tamumu <3*Med	90%ile		21	12			10.8	18		0.082		0.050			35		566	307			
	95%ile		23	16			66.8	103		0.106		0.055			43		1795	334			
	Max		27	105			300.0	220		0.110		0.067			70		10000	3100			
	StDev		4.5	17.4			54	45		0.0		0.01			13.51		1773	538			
	95% C.I.		1.6	6.1			19	16		0.0		0.01			4.68		614	187			
																		0			
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7	8	9	0.033	200	550		100	120
	%compliance		144	87			106	122		143		122					34	47			
	N. of Samples	0	32	31	0	0	32	32	0	30	0	32	0	0	32	0	32	32	0	0	0
	Average	8.3	15	10	104	2.6	5.7	5	1.19	0.024	0.92	0.013	141	1789	23	0.034	159	69	2.3	121	119
	Min	7.7	7	8	82	0.2	0.2	1	0.25	0.00	0.12	0.001	17	59	1	0.006	1	0	0.4	104	7
	5%ile	7.8	9	8	84	0.5	0.5	1	0.53	0.00	0.26	0.001	21	157	1	0.013	7	1	0.7	106	18
	10%ile	7.8	10	9	87	1.0	0.5	1	0.61	0.01	0.37	0.002	24	261	2	0.017	20	1	0.8	107	29
	25%ile	7.8	12	9	91	1.6	0.7	2	0.70	0.01	0.51	0.005	33	464	5	0.022	40	6	1.2	113	63
	Median	8.5	15	10	100	2.8	1.5	2	1.05	0.01	0.80	0.012	61	1025	15	0.027	80	31	2.5	121	119
	75%ile	8.6	18	12	114	3.2	3.8	4	1.51	0.03	1.24	0.020	136	2714	33	0.035	160	77	3.3	128	174
	90%ile	8.7	20	12	130	3.9	14.4	15	2.08	0.05	1.63	0.025	314	4277	52	0.052	360	221	3.8	134	208
	95%ile	8.7	21	13	137	4.4	27.6	21	2.26	0.07	2.08	0.027	757	5504	82	0.066	484	289	4.1	139	219
	Max	8.7	25	15	168	6.8	54.0	54	2.45	0.21	2.33	0.032	950	8481	109	0.195	1800	540	5.0	145	230
	StDev	0.5	4.1	1.5	17	1.3	11	9	0.6	0.03	0.5	0.01	210	1795	25	0.03	246	109	1.2	13	158
	95% C.I.	0.4	0.7	0.3	3.3	0.3	2	2	0.1	0.01	0.1	0.00	48	409	5	0.01	56	30	0.3	9	219
Tukituki at Red Bridge <3*Med																					
	Guideline		24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		98	98	100	76	91	85	11	100	15	57	0			67	81			100	50
	N. of Samples	5	116	105	105	86	81	86	55	75	74	86	73	74	86	87	73	51	70	8	2
	Average	8.5	16	11	113	2.3	3.5	4	0.89	0.01	0.68	0.014	112	1623	38	0.024	84	65	2.9	104	264
	Min	7.1	8	7	69	0.2	0.2	1	0.11	0.00	0.02	0.001	3	8	0	0.003	1	1	0.5	78	20
	5%ile	7.4	9	9	84	0.4	0.4	1	0.15	0.00	0.02	0.001	9	10	0	0.006	4	1	1.0	80	33
	10%ile	7.7	10	9	87	0.7	0.5	2	0.21	0.01	0.03	0.001	13	16	1	0.007	7	3	1.2	82	46
	25%ile	8.2	13	10	100	1.3	0.7	2	0.36	0.01	0.19	0.002	27	141	1	0.011	17	7	2.2	86	84
	Median	8.6	16	11	111	2.0	1.5	2	0.73	0.01	0.51	0.008	57	906	7	0.017	34	26	3.0	116	228
	75%ile	8.8	20	12	123	2.9	2.4	3	1.33	0.02	1.09	0.019	123	2863	41	0.031	87	69	3.6	120	330
	90%ile	9.2	22	13	138	4.0	6.4	10	1.75	0.03	1.61	0.027	259	4162	104	0.050	160	126	4.6	121	528
	95%ile	9.5	23	14	153	4.8	12.5	12	1.91	0.04	1.82	0.034	370	4277	122	0.062	280	155	5.0	122	594
	Max	9.8	27	16	170	6.1	46.7	38	2.40	0.10	2.11	0.170	810	9878	658	0.100	890	865	6.1	123	660
	StDev	0.8	4.6	1.7	21	1.3	7	6	0.6	0.02	0.6	0.02	155	1891	86	0.02	146	131	1.3	19	252

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Corel ^{td} Ecoli	TOC (mg/L)	MCI (Unit)	Chlo a (mg/m ²)
	95% C.I.	0.6	1.0	0.4	5.3	0.3	2	2	0.2	0.00	0.2	0.01	39	471	20	0.00	40	34	0.3	11	221
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	7			0.033	100	550		100	120
	%compliance	86	99	98	95	72	95	90	39	100	44	69	5			79	78	98		55	40
	N. of Samples	7	74	63	63	58	55	60	56	62	62	68	60	62	68	62	51	59	60	11	5
Tukituki at Black Bridge <3*Med	Average	8.4	17	11	112	2.3	3.8	4	0.81	0.03	0.63	0.013	181	1575	30	0.027	329	145	3.0	86	220
	Min	7.2	7	6	61	0.2	0.2	1	0.11	0.00	0.01	0.001	0	3	0	0.001	1	0	0.3	75	51
	5%ile	7.3	9	8	76	0.4	0.5	1	0.14	0.01	0.03	0.001	5	14	1	0.003	4	1	0.9	75	56
	10%ile	7.4	11	8	88	0.7	0.6	1	0.16	0.01	0.04	0.001	10	25	1	0.008	8	2	1.0	76	62
	25%ile	7.7	15	10	98	1.3	1.0	2	0.28	0.01	0.18	0.002	25	181	2	0.012	19	12	1.4	78	78
	Median	8.5	18	11	110	2.0	1.7	2	0.68	0.01	0.52	0.010	47	856	10	0.020	37	26	2.8	81	200
	75%ile	9.0	20	12	123	3.2	3.0	4	1.25	0.02	1.01	0.020	171	2489	39	0.035	161	71	3.9	86	271
	90%ile	9.2	22	14	140	4.0	6.1	9	1.61	0.04	1.48	0.030	525	4186	94	0.053	1213	300	4.5	102	408
	95%ile	9.3	23	15	152	4.6	10.8	12	1.84	0.08	1.73	0.040	988	5081	120	0.070	2008	864	5.0	110	454
	Max	9.4	27	19	183	6.0	180.0	34	2.39	1.16	2.22	0.068	2215	9281	179	0.186	2419	3000	21.0	118	500
	StDev	0.9	4.1	2.2	22	1.3	12	6	0.6	0.09	0.6	0.01	341	1842	40	0.02	643	377	2.6	15	180
	95% C.I.	0.7	0.4	0.4	3.6	0.3	1	1	0.2	0.01	0.1	0.00	48	259	5	0.00	126	45	0.6	11	158
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	7			0.033	100	550		100	120
	%compliance	67	99	93	94	69	98	92	100	98	47	63	7			74	69	93		14	40
	N. of Samples	6	392	145	145	75	309	88	58	196	194	206	191	194	202	195	100	271	78	7	5

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

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
TukiTuki at SH50	Average	7.6	15	10	97	3.9	3.7	4	0.21	0.014	0.08	0.003	50	13	0.5	0.012	55	39	0.9	119	118
	Min	6.9	7	7	73	0.7	0.3	1	0.04	0.003	0.01	0.001	1	0	0.1	0.002	1	0	0.3	103	22
	5%ile	7.1	9	8	79	0.9	0.5	1	0.10	0.003	0.02	0.001	5	1	0.1	0.002	2	1	0.3	103	23
	10%ile	7.2	10	8	87	1.4	0.5	1	0.11	0.005	0.02	0.001	9	2	0.1	0.002	5	1	0.3	103	23
	25%ile	7.7	13	9	93	2.8	0.6	1	0.12	0.005	0.03	0.002	13	3	0.2	0.003	12	3	0.6	107	25
	Median	7.8	16	9	96	3.7	1.0	2	0.15	0.005	0.06	0.002	26	9	0.3	0.004	23	13	0.8	119	45
	75%ile	7.9	18	11	100	4.7	1.7	2	0.23	0.013	0.11	0.003	57	20	0.4	0.008	44	24	1.2	131	110
	90%ile	7.9	19	11	108	6.9	4.0	3	0.32	0.029	0.16	0.005	127	31	0.8	0.013	85	60	1.5	137	278
	95%ile	7.9	20	12	109	7.0	4.8	4	0.52	0.041	0.20	0.005	192	36	1.1	0.025	153	120	1.8	139	334
	Max	7.9	21	12	127	8.0	93.0	126	0.75	0.120	0.22	0.031	266	43	8	0.246	640	587	4.1	141	390
	StDev	0.4	3.6	1.2	10	1.9	15	19	0.155	0.020	0.059	0.005	60	12	1.1	0.04	120	102	0.7	14	156
	95% C.I.	0.4	1.0	0.3	2.8	0.6	5	6	0.052	0.006	0.017	0.001	18	3	0.3	0.01	45	34	0.2	9	137
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	88	94	93	87	98	98	88	100	91	95	9			93	75	97		50	80
	N. of Samples	5	50	47	46	38	40	43	34	44	44	44	44	44	44	44	28	34	43	10	5
Tukipo at SH50	Average	7.9	15	10	97	3.5	0.8	2	0.90	0.016	0.65	0.019	62	23	0.5	0.031	295	117	2.9	121	129
	Min	7.3	8	7	65	1.4	0.2	0	0.47	0.003	0.13	0.001	7	3	0.0	0.012	22	9	1.2	103	29
	5%ile	7.3	9	8	78	2.5	0.3	1	0.50	0.005	0.24	0.001	14	5	0.0	0.016	28	10	1.5	107	32
	10%ile	7.4	10	8	80	2.8	0.4	1	0.54	0.005	0.30	0.003	14	6	0.1	0.022	36	21	1.6	110	34
	25%ile	7.5	12	8	89	3.0	0.5	2	0.65	0.005	0.45	0.013	22	8	0.2	0.026	130	44	1.9	116	42
	Median	7.7	16	9	97	3.4	0.5	2	0.74	0.010	0.53	0.020	31	13	0.5	0.030	230	71	2.9	118	84
	75%ile	8.2	18	11	107	3.9	0.7	2	1.03	0.021	0.71	0.024	71	23	0.8	0.037	330	133	3.9	128	160
	90%ile	8.5	19	12	116	4.6	1.4	2	1.66	0.040	1.32	0.029	108	55	1.0	0.042	548	197	4.3	131	262
	95%ile	8.6	20	12	120	4.9	2.0	2	1.80	0.042	1.51	0.033	226	79	1.1	0.045	810	322	4.3	134	296
	Max	8.7	21	13	124	5.1	4	5	2.13	0.055	1.94	0.066	465	110	1	0.069	1400	870	4.4	136	330
	StDev	0.7	3.5	1.6	14	0.8	1	1	0.424	0.014	0.397	0.012	84	25	0.4	0.01	292	154	1.1	10	123
	95% C.I.	0.8	0.9	0.5	4.1	0.3	0	0	0.142	0.004	0.119	0.003	25	8	0.1	0.00	106	51	0.3	7	108
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	89	88	88	97	100	100	0	100	2	32	2			28	14	97		44	60
	N. of Samples	3	55	43	42	38	38	42	34	43	43	50	43	43	50	43	29	35	41	9	5
Makaroro at Burnt Bridge	Average	7.9	13	10	100	3.9	1.3		0.08	0.003	0.04	0.004	9	10	1.0	0.007	399				
	Min	7.6	4	9	95	0.4	0.2		0.02	0.001	0.00	0.001	1	0	0.2	0.002	66				
	5%ile	7.7	7	9	96	1.0	0.3		0.03	0.001	0.01	0.002	1	1	0.3	0.004	74				
	10%ile	7.7	8	9	97	1.5	0.4		0.03	0.001	0.01	0.002	2	1	0.4	0.005	82				
	25%ile	7.8	11	9	99	2.4	0.6		0.04	0.001	0.01	0.003	4	2	0.5	0.005	100				
	Median	7.9	15	10	100	3.9	0.8		0.07	0.003	0.03	0.004	7	6	0.9	0.007	253				
	75%ile	7.9	17	11	101	5.3	1.5		0.10	0.005	0.06	0.005	11	13	1.3	0.009	454				
	90%ile	8.1	18	11	102	6.6	2.2		0.13	0.006	0.10	0.006	21	27	1.7	0.011	773				
	95%ile	8.2	19	12	103	7.0	3.4		0.16	0.007	0.13	0.007	25	32	1.8	0.013	1163				
	Max	8.6	20	13	106	10.2	9		0.24	0.012	0.19	0.010	33	50	3	0.018	1553				
	StDev	0.2	3.9	0.9	2	2.0	1		0.047	0.002	0.043	0.002	7	11	0.5	0.00	454				
	95% C.I.	0.0	0.8	0.2	0.4	0.4	0		0.010	0.000	0.009	0.000	2	2	0.1	0.00	281				
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	98	100	100	203	100		100	100	98	100	48			100	0				
	N. of Samples	88	88	87	87	87	88	0	83	82	82	88	82	82	83	88	10	0	0	0	0
Makaretu at SH50	Average	7.8	15	10	97	3.6	1.3	2	0.41	0.019	0.23	0.012	57	19	0.7	0.032	182	61	1.2	127	103
	Min	7.7	8	7	68	0.9	0.4	1	0.08	0.003	0.01	0.001	1	1	0.1	0.002	17	2	0.3	113	9

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
< Med	5%ile	7.7	9	8	80	1.6	0.5	1	0.10	0.005	0.02	0.001	1	1	0.1	0.009	26	2	0.3	115	10
	10%ile	7.7	10	8	84	1.8	0.5	1	0.11	0.005	0.03	0.001	1	1	0.1	0.012	29	9	0.4	117	11
	25%ile	7.7	13	9	91	2.6	0.6	2	0.12	0.005	0.04	0.006	2	2	0.3	0.015	46	17	0.8	119	13
	Median	7.8	16	10	98	3.5	0.9	2	0.21	0.005	0.09	0.011	12	5	0.8	0.020	76	36	1.1	120	114
	75%ile	7.9	18	11	104	4.5	1.5	2	0.34	0.019	0.22	0.018	50	17	1.0	0.028	130	65	1.3	133	160
	90%ile	7.9	20	11	115	5.4	2.8	4	0.98	0.031	0.76	0.024	143	71	1.3	0.037	590	159	1.8	140	196
	95%ile	8.0	21	12	117	5.7	3.1	5	1.25	0.034	0.98	0.032	211	92	1.4	0.043	685	226	2.1	148	208
	Max	8.0	24	13	121	6.0	5.5	6	2.55	0.250	1.19	0.036	595	119	1.6	0.500	1200	357	8.2	157	220
	StDev	0.1	3.8	1.4	12	1.3	1	1	0.505	0.039	0.318	0.009	118	31	0.4	0.07	263	78	1.2	13	92
	95% C.I.	0.1	1.1	0.4	3.3	0.4	0	0	0.163	0.011	0.092	0.003	34	9	0.1	0.02	93	25	0.3	8	81
Porangahau at Oruawhara Rd	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	50	550		120	120
	%compliance	100	84	94	94	93	100	100	65	100	67	68	39			70	32	100		70	60
	N. of Samples	4	51	49	49	42	41	46	37	46	46	47	46	45	47	47	31	37	44	10	5
	Average	7.9	16	11	109	3.4	4.6	2	1.28	0.014	1.02	0.019	145	16	0.2	0.037	1065	1221	3.6	96	133
	Min	6.8	9	7	69	1.1	0.2	1	0.26	0.003	0.07	0.001	3	1	0.0	0.006	25	1	1.8	90	58
	5%ile	7.0	10	7	71	1.6	0.3	1	0.30	0.005	0.09	0.001	5	1	0.0	0.017	33	12	2.1	91	59
	10%ile	7.1	12	8	82	2.0	0.3	1	0.34	0.005	0.13	0.001	5	1	0.0	0.020	56	21	2.4	92	61
	25%ile	7.6	13	9	96	2.6	0.4	2	0.46	0.005	0.23	0.006	18	2	0.0	0.027	96	44	2.8	95	65
	Median	8.4	17	11	109	3.6	0.7	2	1.19	0.010	0.72	0.021	48	7	0.1	0.033	255	110	3.5	99	72
	75%ile	8.5	18	12	122	4.2	1.4	2	1.91	0.020	1.67	0.030	108	24	0.3	0.046	573	282	4.2	99	171
< Med	90%ile	8.5	20	14	128	4.5	2.0	4	2.38	0.029	2.40	0.039	199	40	0.6	0.061	890	768	4.7	99	230
	95%ile	8.5	20	14	136	5.7	4.3	5	2.64	0.038	2.75	0.047	363	50	0.7	0.067	2035	5613	5.0	99	250
	Max	8.5	22	16	168	6.3	146.0	5	3.43	0.060	3.04	0.055	2327	63	0.9	0.073	18000	22000	5.7	99	270
	StDev	1.0	3.4	2.2	22	1.2	23	1	0.884	0.012	0.914	0.015	378	17	0.2	0.02	3488	4253	0.9	5	119
	95% C.I.	1.1	1.0	0.6	6.2	0.4	7	0	0.322	0.003	0.276	0.004	116	6	0.1	0.00	1341	1473	0.3	6	134
	Guideline	6.5 to 9.0	24	6	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance	100	100	89	91	94	98	100	34	100	45	39	17			51	46	84		0	67
	N. of Samples	3	48	47	47	33	41	38	29	45	42	46	41	37	46	49	26	32	36	3	3
	Average		15.6	9.6	96.4	2.6	2.4	3		0.021	0.76	0.014	304	179	2.7	0.026	118		1.2		
	Min		8.5	8.0	80.7	1.6	0.3	0		0.001	0.20	0.001	10	22	0.1	0.006	8		0.9		
Tukipo at Ashcott Rd	5%ile		9.4	8.0	81.2	1.6	0.4	1		0.010	0.22	0.001	12	24	0.2	0.009	17		1.0		
	10%ile		10.8	8.3	83.7	1.7	0.5	1		0.010	0.23	0.001	14	36	0.2	0.010	30		1.0		
	25%ile		13.5	8.7	88.7	1.7	0.7	2		0.010	0.29	0.001	37	71	0.3	0.015	62		1.1		
	Median		17.0	9.7	94.0	3.0	1.0	2		0.010	0.52	0.019	70	112	1.8	0.021	73		1.3		
	75%ile		18.5	10.3	99.7	3.0	2.0	4		0.016	0.95	0.020	230	185	4.5	0.030	101		1.4		
	90%ile		19.2	11.5	112	3.5	2.7	5		0.032	1.67	0.027	845	491	7	0.040	332		1.4		
	95%ile		20.3	11.6	127	3.7	5.7	8		0.039	2.03	0.030	1163	556	8	0.056	400		1.4		
	Max		22.0	13.2	129	3.9	25.0	11		0.180	2.60	0.030	2080	638	9	0.080	400		1.4		
	StDev		3.5	1.3	13	1.0	5	3		0.03	1	0	523	175	3	0.02	125		0.2		
	95% C.I.		1.3	0.5	5.2	0.9	2	2		0.01	0	0	229	69	1	0.01	66		0.1		
Tukituki at SH2	Guideline	6.5 to 9.0	24	8	80	1.6	15	10		0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		100	100	100	100	96	91		100	40	42	0			80	86				
	N. of Samples	0	29	23	23	5	25	11	0	25	25	24	20	25	24	25	14	0	7	0	0
	Average	7.7	18	10	102	3.1	2.7	3	1.39	0.029	1.07	0.012	401	542	6	0.028	52	52	1.0		
< Med	Min	7.6	10	8	82	1.0	0.3	1	0.72	0.003	0.36	0.001	22	123	0.1	0.005	2	0	0.6		
	5%ile	7.6	12	8	84	1.6	0.5	1	0.74	0.004	0.42	0.001	26	161	0.4	0.009	5	1	0.7		
	10%ile	7.6	14	8	89	1.6	0.7	1	0.77	0.006	0.52	0.001	32	210	0.4	0.012	12	1	0.8		
	25%ile	7.6	16	9	92	2.5	1.0	1	1.03	0.010	0.67	0.002	50	261	0.9	0.019	19	4	0.9		
	Median	7.6	18	10	99	3.0	1.7	2	1.18	0.021	0.96	0.009	122	405	4	0.022	30	13	1.0		

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m²)
	75%ile	7.8	20	11	106	3.7	2.8	3	1.42	0.027	1.23	0.020	414	655	10	0.030	83	30	1.1		
	90%ile	7.8	22	12	117	4.6	5.2	5	2.10	0.040	1.68	0.030	1286	1044	16	0.043	112	105	1.2		
	95%ile	7.9	23	13	127	4.6	8.4	8	2.61	0.089	2.16	0.030	1754	1369	19	0.068	129	319	1.3		
	Max	7.9	26	15	187	5.2	21.0	8	3.11	0.240	2.84	0.030	3010	1998	21	0.110	151	900	1.4		
	StDev	0.2	3.2	1.5	18	1.1	4	2	0.8	0.0	0.6	0.01	660	420	6	0.02	45	124	0.2		
	95% C.I.	0.2	0.5	0.4	4.6	0.5	1	1	0.5	0.0	0.2	0.00	219	139	2	0.01	21	20	0.1		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance	100	98	100	100	95	97	100	0	100	9	61	0			80	100	99			
N. of Samples	3	162	59	59	20	128	21	8	35	35	36	35	35	36	35	18	144	19	0	0	
Tukituki at Taiparu Rd < Med	Average	8.1	16	11	104	2.2	2.2	4	1.50	0.074	1.01	0.038	169	527	18	0.066	705	572	1.1		
	Min	7.9	9	8	80	1.0	0.5	1	0.73	0.003	0.16	0.001	2	26	0	0.026	15	11	0.8		
	5%ile	7.9	11	8	82	1.3	0.6	1	0.78	0.014	0.34	0.001	4	177	1	0.027	27	17	0.8		
	10%ile	7.9	11	9	93	1.3	0.8	1	0.83	0.019	0.55	0.002	9	188	1	0.034	35	23	0.8		
	25%ile	8.0	13	9	96	1.9	1.0	1	1.19	0.040	0.63	0.014	17	255	7	0.041	81	66	0.9		
	Median	8.1	17	10	102	2.3	1.1	2	1.44	0.065	0.96	0.030	35	408	12	0.048	154	125	1.0		
	75%ile	8.2	19	12	108	2.5	2.0	3	1.66	0.088	1.21	0.041	74	592	22	0.056	415	338	1.1		
	90%ile	8.2	20	13	113	3.0	4.0	4	2.05	0.130	1.62	0.069	527	1036	28	0.130	1470	1196	1.6		
	95%ile	8.3	21	13	118	3.1	5.3	9	2.48	0.149	2.01	0.094	847	1188	32	0.155	3050	2482	1.9		
	Max	8.3	25	15	168	4.0	15.0	42	2.91	0.320	2.87	0.210	1820	2214	166	0.336	11000	8953	1.9		
	StDev	0.3	3.6	1.7	18	0.6	3	9	0.7	0.1	0.6	0.04	381	433	28	0.06	1756	1430	0.3		
	95% C.I.	0.4	0.9	0.5	7.7	0.2	1	4	0.5	0.0	0.2	0.01	132	150	10	0.02	497	404	0.2		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance	100	98	98	100	82	100	95	0	100	9	28	9			10	54	79			
	N. of Samples	2	57	54	20	33	31	20	8	32	32	32	32	32	32	31	48	48	18	0	0
	Waipawa at SH50 < Med	Average	7.5	15	10	97	4.1	2.3	2	0.20	0.014	0.08	0.003	47	32	1.0	0.005	81	44	0.7	121
Min		6.7	7	8	78	0.3	0.2	1	0.06	0.003	0.02	0.001	2	2	0.1	0.001	1	0	0.2	97	21
5%ile		6.9	9	8	85	1.0	0.4	1	0.09	0.005	0.02	0.001	5	4	0.2	0.002	14	3	0.3	98	32
10%ile		7.1	10	9	89	2.0	0.4	1	0.11	0.005	0.02	0.001	7	5	0.3	0.002	18	5	0.3	99	44
25%ile		7.5	13	9	92	3.1	0.6	1	0.12	0.005	0.03	0.002	14	7	0.4	0.003	29	12	0.3	102	78
Median		7.6	15	10	98	4.1	0.8	2	0.16	0.005	0.07	0.002	25	20	0.6	0.005	47	33	0.6	112	78
75%ile		7.7	17	11	102	5.2	1.1	2	0.19	0.016	0.10	0.004	48	38	1.3	0.007	125	65	0.8	131	120
90%ile		7.8	19	11	106	5.9	4.1	3	0.43	0.025	0.12	0.007	89	51	2.2	0.010	185	95	1.0	142	132
95%ile		7.8	19	12	107	6.1	8.8	5	0.61	0.032	0.18	0.008	144	90	2.7	0.014	247	104	1.3	155	136
Max		7.9	22	13	117	8.4	29.0	15	0.73	0.140	0.63	0.013	402	298	4	0.015	260	195	3.7	167	140
StDev		0.4	3.3	1.1	7	1.6	5	2	0.2	0.0	0.1	0.00	73	48	1	0.00	74	41	0.6	23	46
95% C.I.		0.3	0.8	0.3	2.0	0.5	2	1	0.1	0.0	0.0	0.00	20	13	0.2	0.00	25	13	0.2	15	40
Guideline		6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		120	120
%compliance		100	100	96	98	93	96	98	95	100	98	100	10			100	91	100		44	80
N. of Samples		6	57	51	51	44	46	48	37	49	49	50	49	49	50	50	34	39	47	9	5
Mangaonuku at Tikokino Rd < Med		Average		16	8	83	5.1	0.7	2	1.90	0.036	1.64	0.006	742	195	0.6	0.017	88	45	1.8	92
	Min		12	6	61	2.4	0.2	1	1.66	0.005	0.78	0.001	114	78	0.1	0.004	34	22	0.4	92	260
	5%ile		14	7	72	3.2	0.3	1	1.71	0.005	0.79	0.001	149	89	0.1	0.007	39	23	0.4	92	260
	10%ile		14	7	74	3.7	0.3	1	1.75	0.005	0.97	0.001	157	118	0.1	0.008	45	23	0.5	92	260
	25%ile		15	8	78	4.2	0.4	1	1.83	0.005	1.38	0.001	176	137	0.2	0.014	55	27	0.6	92	260
	Median		16	8	81	5.3	0.5	2	1.90	0.019	1.71	0.004	254	170	0.5	0.017	56	30	1.4	92	260
	75%ile		17	9	87	5.9	0.6	2	2.01	0.038	1.90	0.009	1111	197	0.9	0.021	127	45	3.1	92	260
	90%ile		17	10	94	6.6	1.2	2	2.03	0.084	2.07	0.012	1900	298	1.2	0.024	165	66	3.5	92	260
	95%ile		17	11	99	7.1	2.0	3	2.07	0.125	2.53	0.012	2530	408	1.2	0.029	173	103	3.7	92	260
Max		19	12	107	7.5	2.2	5	2.10	0.210	2.71	0.015	2710	501	1.2	0.030	180	140	4.3	92	260	

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
Waipawa D/s Waipawa Oxpond	StDev		1.4	1.4	10	1.3	1	1	0.1	0.1	0.5	0.00	828	102	0.4	0.01	61	34	1.3		
	95% C.I.		0.6	0.6	4.4	0.6	0	0	0.1	0.0	0.2	0.00	363	45	0.2	0.00	49	20	0.6		
	Guideline		24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance		100	55	50	100	100	100	0	100	0	100	0			100	100	100		0	0
	N. of Samples	0	22	20	20	16	17	19	11	20	20	21	20	20	21	21	6	11	17	1	1
	Average		17	13			16.0	13		0.056		0.035			13		851	291			
	Min		10	4			0.5	1		0.005		0.010			5.5		9	1			
	5%ile		11	4			0.6	1		0.011		0.019			5.7		48	22			
	10%ile		12	4			0.6	1		0.016		0.019			6.0		140	31			
	25%ile		14	8			0.7	1		0.032		0.023			9		150	55			
	Median		17	9			0.9	1		0.060		0.035			11		250	110			
	75%ile		19	10			1.1	2		0.070		0.046			17		480	280			
	90%ile		22	11			1.8	3		0.086		0.051			20		753	323			
	95%ile		24	22			18.3	15		0.102		0.060			21		2780	488			
	Max		27	105			300.0	220		0.110		0.067			26		10000	3100			
< Med	StDev		4.3	22.3			67	49		0.0		0.01			5.74		2211	670			
	95% C.I.		1.9	10.0			29	21		0.0		0.01			2.52		969	294			
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7	8	9	0.033	200	550		100	120
	%compliance		110	58			85	95		111		105					30	50			
	N. of Samples	0	20	19	0	0	20	20	0	18	0	20	0	0	20	0	20	20	0	0	0
	Average	8.6	17	11	109	3.2	1.0	2	1.02	0.017	0.79	0.013	144	767	11	0.027	117	45	2.1	123	230
	Min	8.5	10	8	82	1.1	0.2	1	0.25	0.00	0.16	0.001	20	59	1	0.006	1	0	0.4	104	230
	5%ile	8.5	11	8	86	1.3	0.4	1	0.51	0.00	0.30	0.001	21	133	1	0.011	7	1	0.6	106	230
	10%ile	8.5	12	8	88	2.2	0.5	1	0.59	0.00	0.38	0.002	22	161	1	0.015	17	1	0.7	109	230
	25%ile	8.5	14	9	95	2.7	0.6	2	0.65	0.01	0.48	0.005	28	319	3	0.021	39	2	1.1	115	230
	Median	8.6	17	10	102	3.0	0.8	2	0.97	0.01	0.68	0.010	61	597	7	0.027	80	15	1.8	123	230
	75%ile	8.7	19	12	121	3.6	1.2	2	1.24	0.02	0.97	0.021	136	822	16	0.031	145	44	3.0	129	230
	90%ile	8.7	20	13	135	4.2	1.7	2	1.52	0.04	1.31	0.025	320	1646	22	0.038	286	92	3.8	137	230
	95%ile	8.7	23	13	141	5.2	2.2	3	2.06	0.05	1.66	0.027	821	2380	30	0.047	390	252	3.9	141	230
	Max	8.7	25	15	168	6.8	3.2	5	2.41	0.10	2.24	0.032	950	3192	39	0.057	460	300	4.2	145	230
Tukituki at Shagrock + Tamumu	StDev	0.1	3.6	1.6	19	1.1	1	1	0.5	0.02	0.5	0.01	225	739	10	0.01	118	79	1.2	14	#DIV/0!
	95% C.I.	0.2	0.8	0.4	4.5	0.3	0	0	0.2	0.01	0.1	0.00	70	229	3	0.00	32	28	0.4	11	#DIV/0!
	Guideline		24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		97	99	100	93	100	100	15	100	18	59	0			77	84			100	0
	N. of Samples	3	72	68	68	58	39	43	33	41	40	44	40	40	44	44	51	30	39	6	1
	Average	9.1	18	11	117	3.0	1.2	2	0.61	0.01	0.37	0.006	127	456	6	0.013	37	23	2.6	102	326
	Min	8.6	9	7	74	1.6	0.2	1	0.11	0.00	0.02	0.001	3	8	0	0.003	1	1	0.5	78	84
	5%ile	8.6	12	8	86	1.8	0.3	1	0.13	0.00	0.02	0.001	6	9	0	0.005	4	1	1.0	80	106
	10%ile	8.6	13	9	93	1.9	0.4	1	0.17	0.01	0.03	0.001	9	12	0	0.006	6	1	1.1	82	127
	25%ile	8.7	15	10	106	2.1	0.6	2	0.25	0.01	0.06	0.002	21	25	1	0.008	14	3	1.6	87	192
	Median	8.9	20	11	116	2.9	0.8	2	0.42	0.01	0.24	0.002	73	218	2	0.012	26	11	2.8	103	279
	75%ile	9.3	21	12	129	3.7	1.4	2	0.93	0.01	0.51	0.008	131	473	5	0.016	39	30	3.4	119	413
	90%ile	9.6	23	14	138	4.5	1.9	2	1.33	0.03	0.97	0.012	346	1444	16	0.024	70	65	3.9	120	561
	95%ile	9.7	23	14	155	5.0	2.2	3	1.61	0.03	1.14	0.022	387	1775	36	0.027	93	80	4.3	121	611
	Max	9.8	27	16	170	6.1	7.3	7	1.81	0.04	1.62	0.028	810	2300	40	0.032	260	110	5.5	121	660
Tukituki at Red Bridge	StDev	0.7	3.9	1.8	20	1.1	1	1	0.5	0.01	0.4	0.01	165	621	10	0.01	49	29	1.2	18	245
	95% C.I.	0.7	1.1	0.6	6.4	0.4	0	0	0.2	0.00	0.1	0.00	54	200	3	0.00	18	10	0.4	13	240
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	7			0.033	100	550		100	120

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m²)
	%compliance	67	98	97	97	100	100	100	62	100	68	90	8			100	93	100		50	25
	N. of Samples	3	46	39	39	35	32	36	34	37	37	41	36	37	41	37	29	35	36	8	4
BD 3.5 29																					
Tukituki at Black Bridge < Med	Average	8.6	19	11	115	2.9	1.7	2	0.55	0.03	0.35	0.008	122	437	9	0.020	339	133	2.4	86	220
	Min	7.5	9	6	61	1.1	0.2	1	0.11	0.00	0.01	0.001	0	3	0	0.003	2	0	0.5	75	51
	5%ile	7.6	12	7	76	1.4	0.4	1	0.13	0.01	0.02	0.001	3	7	1	0.003	4	1	0.8	75	56
	10%ile	7.8	14	8	88	1.7	0.5	1	0.15	0.01	0.03	0.001	5	15	1	0.007	6	1	1.0	76	62
	25%ile	8.2	17	10	100	1.9	0.9	2	0.19	0.01	0.05	0.001	15	45	1	0.010	13	9	1.2	78	78
	Median	8.8	19	11	115	2.9	1.3	2	0.37	0.01	0.22	0.005	40	217	3	0.016	30	22	1.8	81	200
	75%ile	9.1	21	12	131	3.7	2.0	2	0.73	0.02	0.53	0.011	136	561	12	0.020	97	53	3.4	86	271
	90%ile	9.3	23	13	142	4.3	3.0	4	1.37	0.03	0.96	0.020	263	1253	29	0.030	1280	246	4.2	102	408
	95%ile	9.3	24	14	150	5.3	4.2	6	1.54	0.05	1.16	0.022	491	1532	33	0.041	1961	821	4.8	110	454
	Max	9.4	27	17	174	6.0	15.0	7	1.80	1.16	1.61	0.048	1540	2206	52	0.186	2419	3000	9.3	118	500
	StDev	1.0	3.3	2.2	22	1.2	2	2	0.5	0.11	0.4	0.01	231	535	11	0.02	669	379	1.6	15	180
	95% C.I.	1.1	0.4	0.5	4.8	0.3	0	0	0.1	0.02	0.1	0.00	45	103	2	0.00	165	51	0.5	11	158
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	7			0.033	100	550		100	120
	%compliance	67	98	89	94	92	100	100	100	98	70	78	13			91	75	93		14	40
	N. of Samples	3	264	84	84	48	213	53	38	108	105	111	103	104	108	107	63	209	49	7	5

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

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
TukiTuki at SH50	Average	6.9	16	9	98	4.3	4.9	6	0.20	0.013	0.06	0.003	46	8	0.3	0.016	71	48	1.0	119	118
	Min	6.9	10	7	77	0.8	0.3	1	0.10	0.003	0.01	0.001	1	0	0.1	0.002	3	1	0.3	103	22
	5%ile	6.9	10	8	85	1.5	0.5	1	0.11	0.003	0.02	0.001	4	1	0.1	0.002	6	1	0.3	104	23
	10%ile	6.9	12	8	90	2.3	0.5	1	0.12	0.004	0.02	0.001	8	1	0.1	0.002	8	1	0.4	104	23
	25%ile	6.9	14	9	94	3.1	0.5	1	0.12	0.005	0.02	0.002	11	2	0.1	0.003	13	3	0.6	110	25
	Median	6.9	17	9	96	4.2	0.7	2	0.14	0.005	0.04	0.002	16	4	0.2	0.004	27	11	0.8	119	45
	75%ile	6.9	19	10	100	5.8	1.4	2	0.23	0.010	0.09	0.003	54	12	0.3	0.010	41	26	1.4	126	110
	90%ile	6.9	19	11	109	6.9	1.7	2	0.33	0.024	0.14	0.004	123	22	0.6	0.018	135	90	1.6	136	278
	95%ile	6.9	20	12	109	7.3	8.0	4	0.40	0.038	0.17	0.005	180	24	0.6	0.032	240	150	2.1	139	334
	Max	6.9	21	12	127	8.0	93.0	126	0.73	0.120	0.20	0.017	266	27	1	0.246	640	587	4.1	141	390
	StDev		3.2	1.2	9	1.9	18	24	0.147	0.023	0.055	0.003	63	8	0.2	0.05	148	123	0.8	13	156
	95% C.I.		1.1	0.4	3.4	0.7	7	9	0.063	0.008	0.020	0.001	23	3	0.1	0.02	69	50	0.3	9	137
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance	100	84	93	97	92	96	96	86	100	93	96	11			89	83	96		50	80
	N. of Samples	1	31	30	29	25	25	27	21	28	28	28	28	28	28	28	18	23	27	8	5
Tukipo at SH50	Average	7.5	16	9	96	3.6	0.6	1	0.82	0.016	0.57	0.021	59	12	0.4	0.034	287	105	2.7	118	79
	Min	7.3	9	7	73	2.6	0.2	1	0.48	0.005	0.18	0.001	7	3	0.0	0.012	38	11	1.2	103	29
	5%ile	7.3	10	8	80	2.8	0.2	1	0.51	0.005	0.25	0.001	14	5	0.0	0.022	81	27	1.3	105	31
	10%ile	7.3	11	8	80	2.8	0.3	1	0.55	0.005	0.36	0.003	15	6	0.1	0.023	118	32	1.5	108	33
	25%ile	7.4	15	8	89	3.1	0.4	1	0.63	0.005	0.47	0.014	21	7	0.2	0.029	190	56	1.7	113	39
	Median	7.5	17	9	93	3.4	0.5	2	0.70	0.010	0.55	0.020	28	10	0.4	0.034	260	86	2.5	117	63
	75%ile	7.6	18	11	107	4.0	0.7	2	0.83	0.019	0.61	0.026	52	13	0.6	0.038	350	132	3.9	124	103
	90%ile	7.6	20	12	112	4.6	0.9	2	1.19	0.039	0.73	0.031	90	18	0.7	0.044	484	156	4.3	128	137
	95%ile	7.7	20	12	112	4.7	1.4	2	1.69	0.053	0.93	0.043	167	20	0.9	0.045	562	219	4.4	129	149
	Max	7.7	21	12	116	4.9	3	2	1.80	0.055	1.39	0.066	465	42	1	0.069	660	400	4.4	130	160
	StDev	0.3	3.3	1.5	12	0.7	1	0	0.354	0.015	0.237	0.014	94	8	0.3	0.01	162	85	1.1	10	59
	95% C.I.	0.4	1.1	0.6	4.8	0.3	0	0	0.155	0.006	0.095	0.005	38	3	0.1	0.00	82	37	0.5	8	58
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance	100	88	85	88	100	100	100	0	100	0	28	4			21	13	100		33	75
	N. of Samples	2	32	26	25	22	20	23	20	24	24	29	24	24	29	24	15	20	23	6	4
Makaroro at Burnt Bridge	Average	7.9	16	10	101	4.9	0.6		0.07	0.004	0.03	0.004	7	6	0.7	0.006	84				
	Min	7.7	7	9	96	1.9	0.2		0.02	0.001	0.00	0.002	1	0	0.3	0.002	84				
	5%ile	7.7	10	9	96	2.5	0.3		0.03	0.001	0.01	0.002	1	1	0.3	0.003	84				
	10%ile	7.8	11	9	98	3.3	0.3		0.03	0.001	0.01	0.002	2	1	0.3	0.004	84				
	25%ile	7.8	14	9	100	4.1	0.4		0.04	0.002	0.01	0.003	3	1	0.4	0.005	84				
	Median	7.9	16	10	100	4.9	0.6		0.05	0.004	0.02	0.004	4	2	0.5	0.006	84				
	75%ile	8.0	18	10	102	5.7	0.8		0.08	0.005	0.03	0.005	9	5	0.9	0.007	84				
	90%ile	8.2	19	11	104	6.9	1.0		0.13	0.006	0.09	0.006	15	15	1.1	0.009	84				
	95%ile	8.3	19	11	105	7.1	1.2		0.20	0.006	0.14	0.007	23	28	1.2	0.010	84				
	Max	8.6	20	12	106	8.0	2		0.24	0.007	0.19	0.009	28	35	2	0.014	84				
	StDev	0.2	3.0	0.7	2	1.4	0		0.055	0.002	0.047	0.002	7	9	0.3	0.00					
	95% C.I.	0.1	1.0	0.2	0.8	0.5	0		0.019	0.001	0.017	0.001	2	3	0.1	0.00					
	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance	100	94	100	100	100	100		100	100	97	100	63			100	100				
	N. of Samples	35	35	34	34	35	35	0	31	30	30	35	30	30	31	35	1	0	0	0	0
Makaretu at SH50	Average		17	9	97	4.1	1.1	2	0.31	0.015	0.10	0.015	27	6	0.6	0.043	168	69	1.3	125	89
	Min		9	8	81	2.0	0.4	1	0.08	0.005	0.01	0.001	1	1	0.1	0.012	17	2	0.3	113	9

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
< LQ	5%ile		10	8	83	2.6	0.4	1	0.10	0.005	0.02	0.001	1	1	0.1	0.013	25	2	0.3	115	10
	10%ile		11	8	88	3.0	0.5	1	0.11	0.005	0.02	0.002	1	1	0.1	0.013	32	2	0.4	117	10
	25%ile		15	8	94	3.2	0.5	2	0.12	0.005	0.03	0.006	1	1	0.3	0.017	45	13	0.8	120	12
	Median		17	9	98	4.0	0.7	2	0.14	0.005	0.05	0.014	5	2	0.7	0.024	92	32	1.0	120	64
	75%ile		19	10	99	5.1	1.4	2	0.27	0.015	0.13	0.023	14	6	0.9	0.032	140	73	1.3	133	141
	90%ile		21	11	110	5.7	2.3	4	0.34	0.031	0.22	0.030	84	12	1.1	0.043	475	218	1.8	135	188
	95%ile		22	11	113	5.9	2.3	4	0.75	0.034	0.28	0.033	155	16	1.2	0.045	618	220	2.1	137	204
	Max		24	13	118	6.0	3.4	6	2.55	0.110	0.68	0.036	220	40	1.3	0.500	700	357	8.2	138	220
	StDev		3.9	1.2	9	1.1	1	1	0.521	0.021	0.137	0.011	55	8	0.4	0.09	205	91	1.5	9	100
	95% C.I.		1.4	0.5	3.3	0.4	0	0	0.218	0.008	0.052	0.004	21	3	0.1	0.03	100	39	0.6	7	98
Porangahau at Oruawhara Rd	Guideline	6.5 to 9.0	19	8	80	1.6	15	10	0.295	0.4	0.167	0.015	7			0.026	100	550		120	120
	%compliance		76	96	100	100	100	100	77	100	81	56	59			56	50	100		71	75
	N. of Samples	0	29	28	28	25	22	26	22	27	27	27	27	26	27	27	16	21	25	7	4
	Average	7.6	17	11	112	3.8	0.9	2	0.90	0.014	0.73	0.016	148	7	0.1	0.035	1498	738	3.3	96	133
	Min	6.8	10	7	70	1.6	0.2	1	0.26	0.003	0.03	0.001	3	0	0.0	0.014	68	1	1.8	90	58
	5%ile	6.9	12	7	82	1.9	0.3	1	0.27	0.005	0.07	0.001	4	1	0.0	0.017	68	7	1.8	91	59
	10%ile	7.0	13	8	90	2.2	0.3	1	0.33	0.005	0.09	0.001	5	1	0.0	0.020	81	52	2.2	92	61
	25%ile	7.2	15	9	98	3.2	0.4	2	0.36	0.005	0.17	0.002	9	1	0.0	0.024	110	82	2.7	95	65
	Median	7.6	18	11	112	3.8	0.6	2	0.51	0.010	0.26	0.017	24	3	0.1	0.033	380	200	3.3	99	72
	75%ile	8.0	20	12	123	4.3	1.2	2	1.29	0.020	0.98	0.025	104	9	0.1	0.043	643	318	4.1	99	171
< LQ	90%ile	8.2	20	14	132	5.4	1.9	4	1.89	0.030	2.17	0.030	190	23	0.2	0.061	890	575	4.4	99	230
	95%ile	8.3	21	15	154	6.2	2.8	4	2.00	0.036	2.60	0.038	253	27	0.3	0.064	5205	790	4.5	99	250
	Max	8.4	22	16	168	6.3	4.3	5	2.46	0.060	2.75	0.055	2327	28	0.3	0.069	18000	11006	4.8	99	270
	StDev	1.1	3.1	2.3	22	1.2	1	1	0.690	0.013	0.846	0.014	450	9	0.1	0.02	4410	2361	0.9	5	119
	95% C.I.	1.5	1.1	0.8	7.9	0.5	0	0	0.310	0.005	0.319	0.005	173	4	0.0	0.01	2161	1010	0.4	6	134
	Guideline	6.5 to 9.0	24	6	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance	100	100	90	97	95	100	100	53	100	59	48	23			56	31	86		0	67
	N. of Samples	2	30	30	30	21	26	24	19	29	27	29	26	22	29	32	16	21	23	3	3
	Average		18.2	9.4	99.7	3.4	4.0	3		0.018	0.66	0.013	358	91	1.5	0.024	212		1.3		
	Min		13.5	8.0	81.0	3.0	0.3	2		0.010	0.22	0.001	12	22	0.1	0.010	8		1.1		
Tukipo at Ashcott Rd	5%ile		14.8	8.2	83.7	3.0	0.3	2		0.010	0.22	0.001	13	22	0.2	0.012	22		1.1		
	10%ile		16.0	8.4	86.4	3.1	0.4	2		0.010	0.23	0.001	14	22	0.2	0.014	36		1.2		
	25%ile		17.0	8.8	92.0	3.2	0.5	3		0.010	0.37	0.006	31	29	0.5	0.015	78		1.3		
	Median		18.5	8.9	97.9	3.4	1.0	4		0.013	0.76	0.018	44	98	1.8	0.021	172		1.4		
	75%ile		19.4	9.8	103	3.7	1.9	4		0.020	0.85	0.020	792	126	2.2	0.033	400		1.4		
	90%ile		20.5	10.6	114	3.8	9.1	4		0.036	1.00	0.020	905	163	3	0.040	400		1.4		
	95%ile		21.3	11.1	121	3.9	17.1	4		0.038	1.06	0.020	1010	175	3	0.040	400		1.4		
	Max		22.0	11.6	129	3.9	25.0	4		0.040	1.12	0.020	1115	188	3	0.040	400		1.4		
	StDev		2.3	1.2	15	0.6	9	1		0.01	0	0	463	62	1	0.01	182		0.2		
	95% C.I.		1.4	0.9	11.1	0.9	6	1		0.01	0	0.005	321	43	1	0.01	159		0.2		
< LQ	Guideline	6.5 to 9.0	24	8	80	1.6	15	10		0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		100	100	100	100	88	100		100	38	36	0			75	60				
	N. of Samples	0	11	7	7	2	8	3	0	8	8	11	8	8	11	8	5	0	3	0	0
	Average	7.8	19	10	107	3.6	2.3	2	1.06	0.020	0.99	0.009	363	340	3	0.027	34	54	0.9		
Tukituki at SH2	Min	7.6	12	8	83	1.6	0.3	1	0.79	0.003	0.36	0.001	31	123	0.1	0.005	2	0	0.7		
	5%ile	7.6	15	8	84	2.0	0.5	1	0.83	0.006	0.50	0.001	37	151	0.3	0.009	7	1	0.7		
	10%ile	7.6	16	8	87	2.3	0.7	1	0.88	0.009	0.55	0.001	38	161	0.4	0.011	11	1	0.8		
	25%ile	7.7	17	9	92	3.0	1.0	1	1.03	0.010	0.73	0.002	62	215	0.6	0.017	17	3	0.8		

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
Tukituki at Taiparu Rd < LQ	Median	7.8	19	10	101	3.5	1.5	2	1.13	0.023	0.96	0.004	309	277	2	0.023	25	10	0.9		
	75%ile	7.8	21	11	115	4.5	2.2	2	1.16	0.025	1.16	0.017	427	411	4	0.029	41	26	1.0		
	90%ile	7.9	22	12	128	4.7	4.2	4	1.19	0.030	1.35	0.023	599	586	7	0.046	78	65	1.1		
	95%ile	7.9	23	14	161	4.9	5.5	6	1.19	0.033	1.72	0.030	954	680	9	0.064	80	329	1.2		
	Max	7.9	25	15	187	5.2	18.2	8	1.20	0.050	2.14	0.030	1925	794	12	0.086	81	900	1.2		
	StDev	0.2	2.7	1.8	25	1.1	3	2	0.2	0.0	0.4	0.01	446	184	3	0.02	29	142	0.1		
	95% C.I.	0.3	0.6	0.7	9.6	0.7	1	1	0.2	0.0	0.2	0.00	206	85	2	0.01	20	31	0.1		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200			100	120
	%compliance	100	98	100	100	100	97	100	0	100	6	72	0			83	100				
	N. of Samples	2	92	26	26	10	75	12	4	18	18	18	18	18	18	18	8	83	10	0	0
	Average		17	11	107	2.3	1.7	6	1.68	0.079	0.91	0.044	103	301	13	0.075	998	813	1.2		
	Min	0.0	11	8	83	1.0	0.5	1	1.68	0.019	0.16	0.002	2	26	1	0.034	29	24	0.8		
	5%ile		11	8	91	1.4	0.5	1	1.68	0.020	0.32	0.009	6	118	2	0.037	41	33	0.8		
	10%ile		12	9	96	1.6	0.5	1	1.68	0.023	0.47	0.015	9	174	3	0.040	68	55	0.8		
	25%ile		13	10	100	2.0	1.0	1	1.68	0.042	0.66	0.025	13	194	10	0.045	97	79	0.9		
	Median		17	11	104	2.4	1.0	2	1.68	0.068	0.86	0.039	18	240	12	0.050	265	216	1.0		
	75%ile		20	12	108	2.6	2.0	3	1.68	0.128	1.04	0.058	36	319	16	0.110	828	674	1.5		
	90%ile		21	13	114	2.9	3.6	12	1.68	0.137	1.24	0.072	69	511	22	0.130	2370	1929	1.9		
	95%ile		22	14	128	3.2	4.4	27	1.68	0.147	1.61	0.089	443	661	24	0.150	3895	3170	1.9		
	Max		25	15	168	4.0	5.0	42	1.68	0.160	2.24	0.120	1120	874	26	0.180	11000	8953	1.9		
	StDev		3.8	1.8	18	0.6	1	13		0.0	0.5	0.03	293	206	7	0.05	2098	1708	0.5		
	95% C.I.		1.2	0.6	8.9	0.2	1	9		0.0	0.3	0.02	154	108	4	0.03	727	592	0.4		
Waipawa at SH50 < LQ	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance		97	97	100	89	100	89	0	100	14	14	7			0	41	69			
	N. of Samples	0	36	36	16	27	13	9	1	14	14	14	14	14	14	13	32	32	7	0	0
	Average	7.4	16	9	96	4.8	0.8	1	0.17	0.011	0.04	0.003	28	12	0.7	0.005	81	38	0.7	115	87
	Min	6.7	10	8	78	2.2	0.2	1	0.06	0.003	0.02	0.001	2	2	0.1	0.001	12	1	0.3	97	21
	5%ile	6.8	13	8	87	2.7	0.3	1	0.07	0.003	0.02	0.001	3	3	0.2	0.002	15	3	0.3	98	32
	10%ile	6.9	14	8	90	3.1	0.4	1	0.10	0.005	0.02	0.001	5	4	0.3	0.002	19	4	0.3	99	44
	25%ile	7.2	15	9	92	4.0	0.4	1	0.11	0.005	0.02	0.002	10	6	0.4	0.003	29	11	0.3	102	78
	Median	7.7	17	9	97	5.1	0.6	2	0.12	0.005	0.03	0.002	15	7	0.5	0.005	55	36	0.6	112	78
	75%ile	7.7	18	10	101	5.6	0.7	2	0.17	0.016	0.07	0.002	34	20	0.6	0.007	105	55	0.7	130	120
	90%ile	7.7	19	10	105	5.9	1.2	2	0.23	0.023	0.08	0.006	57	25	1.5	0.010	177	77	1.1	133	132
	95%ile	7.7	19	11	106	6.3	1.2	2	0.45	0.028	0.09	0.008	81	26	1.9	0.013	243	96	1.4	134	136
	Max	7.7	22	12	110	8.4	4.6	3	0.73	0.030	0.10	0.013	162	27	3	0.015	260	102	3.7	136	140
	StDev	0.6	2.2	0.9	7	1.3	1	1	0.1	0.0	0.0	0.00	34	8	1	0.00	75	30	0.7	15	46
	95% C.I.	0.6	0.8	0.3	2.4	0.5	0	0	0.1	0.0	0.0	0.00	13	3	0.2	0.00	34	12	0.3	11	40
Mangaonuku at Tikokino Rd < LQ	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		120	120
	%compliance	100	100	93	97	100	100	100	96	100	100	100	15			100	89	100		38	80
	N. of Samples	3	32	30	30	26	23	26	23	27	27	27	27	27	27	27	18	23	26	8	5
	Average		16	8	83	5.2	0.7	2	1.90	0.028	1.54	0.007	482	159	0.6	0.017	95	45	1.9	92	260
	Min		12	6	61	3.5	0.2	1	1.66	0.005	0.78	0.001	114	78	0.1	0.007	34	22	0.4	92	260
	5%ile		14	7	70	3.8	0.2	1	1.71	0.005	0.79	0.001	144	87	0.1	0.008	38	22	0.4	92	260
	10%ile		15	7	73	4.0	0.3	1	1.75	0.005	0.91	0.001	155	108	0.1	0.010	42	23	0.5	92	260
	25%ile		16	8	78	4.4	0.5	1	1.83	0.005	1.27	0.002	162	134	0.2	0.015	55	26	0.7	92	260
	Median		16	8	81	5.3	0.5	2	1.90	0.011	1.71	0.007	224	166	0.6	0.017	55	30	1.4	92	260
	75%ile		17	9	88	5.7	0.6	2	2.01	0.031	1.83	0.010	403	185	1.1	0.021	150	47	3.3	92	260
	90%ile		17	10	96	6.7	1.7	3	2.03	0.071	1.97	0.012	1229	202	1.2	0.024	168	73	3.6	92	260
	95%ile		17	10	100	7.1	2.1	4	2.07	0.088	2.01	0.013	1613	227	1.2	0.025	174	107	3.8	92	260

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
Waipawa D/s Waipawa Oxpond	Max		19	11	107	7.5	2.2	5	2.10	0.120	2.02	0.015	1831	258	1.2	0.029	180	140	4.3	92	260
	StDev		1.3	1.2	11	1.1	1	1	0.1	0.0	0.4	0.00	525	45	0.4	0.01	66	36	1.4		
	95% C.I.		0.6	0.6	5.1	0.6	0	1	0.1	0.0	0.2	0.00	249	21	0.2	0.00	57	22	0.7		
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200	550		100	120
	%compliance		100	53	53	100	100	100	0	100	0	100	0			100	100	100		0	0
	N. of Samples	0	17	17	17	14	13	16	11	17	17	17	17	17	17	17	5	10	15	1	1
	Average		17	15			1.0	1		0.063		0.039			12		925	343			
	Min		10	4			0.5	1		0.018		0.019			5.7		50	23			
	5%ile		12	4			0.6	1		0.024		0.021			6.0		120	29			
	10%ile		13	4			0.6	1		0.028		0.022			6.6		150	34			
	25%ile		15	8			0.6	1		0.037		0.029			9		150	52			
	Median		17	9			0.8	1		0.070		0.038			12		250	110			
	75%ile		19	10			1.0	2		0.080		0.047			15		490	295			
	90%ile		23	12			1.5	3		0.096		0.056			19		554	338			
	95%ile		25	45			2.2	3		0.104		0.062			19		3399	1175			
	Max		27	105			3.5	3		0.110		0.067			20		10000	3100			
	StDev		4.5	26.0			1	1		0.0		0.01			4.71		2516	771			
	95% C.I.		2.3	13.6			0	0		0.0		0.01			2.38		1273	390			
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7	8	9	0.033	200	550		100	120
	%compliance		113	64			87	107		131		113					33	67			
	N. of Samples	0	15	14	0	0	15	15	0	13	0	15	0	0	15	0	15	15	0	0	0
Tukituki at Shagrock + Tamumu	Average	8.6	17	11	109	3.4	0.8	2	0.79	0.017	0.61	0.013	136	388	7	0.027	117	29	1.9	115	230
	Min	8.5	11	8	82	1.3	0.2	1	0.25	0.00	0.16	0.001	20	59	1	0.008	1	0	0.4	104	230
	5%ile	8.5	12	8	86	2.3	0.3	1	0.49	0.00	0.27	0.001	20	131	1	0.011	8	0	0.6	105	230
	10%ile	8.5	12	8	88	2.5	0.4	1	0.51	0.00	0.33	0.002	21	140	1	0.013	17	1	0.6	106	230
	25%ile	8.5	15	9	95	2.8	0.5	2	0.63	0.01	0.45	0.005	25	203	2	0.021	39	1	0.9	109	230
	Median	8.6	18	10	102	3.1	0.7	2	0.68	0.01	0.60	0.010	57	358	6	0.027	80	12	1.7	114	230
	75%ile	8.7	19	12	122	3.7	0.9	2	0.99	0.02	0.80	0.022	106	517	12	0.031	150	27	2.8	121	230
	90%ile	8.7	21	13	138	4.4	1.2	2	1.24	0.03	0.93	0.023	263	711	16	0.038	282	43	3.4	124	230
	95%ile	8.7	23	13	145	5.2	1.5	4	1.37	0.04	1.00	0.029	731	713	18	0.046	370	79	3.8	126	230
	Max	8.7	25	15	168	6.8	3.2	5	1.47	0.10	1.14	0.032	950	795	19	0.052	460	278	3.9	127	230
	StDev	0.2	3.4	1.7	20	1.0	1	1	0.3	0.02	0.2	0.01	238	214	6	0.01	118	64	1.1	12	
	95% C.I.	0.3	0.9	0.5	5.6	0.3	0	0	0.1	0.01	0.1	0.00	93	84	2	0.00	37	30	0.5	13	
	Guideline		24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		96	98	100	98	100	100	20	100	24	64	0			79	85			100	0
	N. of Samples	2	55	51	51	44	24	27	20	26	25	28	25	25	28	28	39	18	24	3	1
	Average	9.1	20	11	122	3.3	1.1	2	0.36	0.01	0.18	0.003	90	125	2	0.011	38	19	2.7	99	326
	Min	8.6	11	7	74	1.7	0.2	1	0.11	0.00	0.02	0.001	3	8	0	0.003	1	1	1.0	78	84
	5%ile	8.6	13	8	95	1.8	0.2	1	0.12	0.00	0.02	0.001	5	9	0	0.003	3	1	1.1	80	106
	10%ile	8.6	15	9	101	1.9	0.3	2	0.14	0.01	0.02	0.001	7	9	0	0.005	6	1	1.2	82	127
	25%ile	8.7	19	10	108	2.7	0.5	2	0.21	0.01	0.03	0.002	12	16	1	0.008	14	3	2.0	86	192
Tukituki at Red Bridge	Median	8.9	20	11	121	3.1	0.7	2	0.31	0.01	0.10	0.002	71	42	1	0.012	23	9	2.8	89	279
	75%ile	9.3	21	12	133	4.0	1.0	2	0.44	0.01	0.26	0.003	125	222	2	0.015	31	17	3.4	117	413
	90%ile	9.6	23	14	146	4.9	1.7	2	0.64	0.02	0.48	0.007	218	304	3	0.016	56	55	3.8	119	561
	95%ile	9.7	23	14	163	5.0	2.2	2	0.69	0.03	0.50	0.010	243	338	4	0.017	98	61	3.9	119	611
	Max	9.8	27	16	170	6.1	7.3	2	0.93	0.04	0.51	0.020	354	437	8	0.026	260	110	5.0	120	660
	StDev	0.7	3.3	2.0	21	1.2	2	0	0.2	0.01	0.2	0.00	94	132	2	0.01	60	27	1.0	18	245
	95% C.I.	0.7	1.2	0.8	8.1	0.5	1	0	0.1	0.00	0.1	0.00	38	53	1	0.00	28	11	0.4	13	240
	Guideline		24	8	80	1.6	15	10	0.614	0.4	0.444	0.015	7			0.033	200			100	120
	%compliance		96	98	100	98	100	100	20	100	24	64	0			79	85			100	0
	N. of Samples	2	55	51	51	44	24	27	20	26	25	28	25	25	28	28	39	18	24	3	1

		pH	TEMP (°C)	DO (mg/L)	SDO (%)	BD (m)	TURB (NTU)	SS (mg/L)	TN (mg/L)	NH 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)	Chlo a (mg/m ²)
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	7			0.033	100	550		100	120
	%compliance	67	97	96	96	100	100	100	82	100	88	96	13			100	94	100		43	25
	N. of Samples	3	32	26	26	23	20	23	22	24	24	27	23	24	27	24	17	22	23	7	4
Tukituki at Black Bridge < LQ	Average	9.1	20	10	112	3.3	1.4	2	0.33	0.01	0.19	0.008	74	147	5	0.019	475	138	2.6	82	262
	Min	8.8	10	7	73	1.4	0.2	1	0.11	0.00	0.01	0.001	0	3	0	0.003	2	0	0.8	75	78
	5%ile	8.9	14	7	76	1.6	0.5	1	0.12	0.01	0.01	0.001	1	4	0	0.003	6	1	0.9	76	96
	10%ile	8.9	16	8	88	1.8	0.5	1	0.13	0.01	0.02	0.001	3	7	1	0.007	9	1	1.0	77	115
	25%ile	9.0	18	9	97	2.2	0.8	2	0.17	0.01	0.03	0.001	9	16	1	0.012	16	7	1.2	80	170
	Median	9.1	20	10	114	3.3	1.2	2	0.24	0.01	0.08	0.002	29	45	2	0.016	29	20	2.4	81	236
	75%ile	9.2	22	12	127	4.0	1.9	2	0.47	0.01	0.27	0.010	75	207	6	0.020	365	45	3.3	82	328
	90%ile	9.3	23	12	139	5.2	2.3	3	0.64	0.03	0.53	0.020	175	402	14	0.030	1960	147	3.9	87	431
	95%ile	9.3	24	13	142	5.4	3.1	5	0.68	0.03	0.60	0.020	277	460	17	0.040	2419	1000	4.8	89	466
	Max	9.4	27	13	159	6.0	8.0	6	0.75	0.09	1.11	0.048	617	1096	34	0.088	2419	1874	9.3	91	500
	StDev	0.4	3.0	1.8	20	1.3	1	1	0.2	0.01	0.2	0.01	121	214	7	0.02	831	384	1.8	6	177
	95% C.I.	0.5	0.5	0.5	6.0	0.5	0	1	0.1	0.00	0.1	0.00	33	59	2	0.00	288	68	0.7	5	174
	Guideline	6.5 to 9.0	24	8	80	1.6	15	10	0.614	0.18	0.444	0.015	7			0.033	100	550		100	120
	%compliance	50	98	84	93	93	100	100	100	100	87	84	24			90	72	93		0	25
	N. of Samples	2	145	43	43	28	114	27	23	52	52	56	51	51	52	52	32	122	25	5	4

Appendix E: Annual load calculation results

Table 13: Annual and summer (November to April inclusive) DRP load in tonnes per year (T/Y). (a) provisional estimate based on 9 months of data. (b) estimate based on 6 months (January-June) data. N.D. :no data; I.D.: Insufficient data.

	Site	Period	2004-05		2005-06		2006-07		2007-08	
			Year- round	Summer	Year- round	Summer	Year- round	Summer	Year- round ^(a)	Summer
Upper catchment	Tukitiki at SH50	Averaging method	1.0	0.2	1.2	0.4	0.9	0.1	0.7	0.1
		Ratio estimation	0.8 ± 0.3	0.2 ± 0.4	1.4 ± 0.4	0.5 ± 0.4	0.8 ± 0.2	0.1 ± 0.03	0.6 ± 0.1	0.1 ± 0.01
	Waipawa at SH50	Averaging method	1.5	0.3	2.0	1.5	3.2	0.1	1.5	0.1
		Ratio estimation	1.3 ± 0.3	0.3 ± 0.4	2.1 ± 0.6	1.8 ± 1.0	3.0 ± 1.3	0.2 ± 0.1	1.2 ± 0.2	0.7 ± 0.01
	Tukipo at SH50	Averaging method	1.0	0.2	1.9	0.7	1.2	0.2	0.9	0.1
		Ratio estimation	0.8 ± 0.3	0.2 ± 0.6	1.6 ± 0.2	0.6 ± 0.4	1.2 ± 0.2	0.2 ± 0.1	0.7 ± 0.1	0.1 ± 0.02
	Makaretu at SH50	Averaging method	0.8	0.2	1.0	0.4	0.8	0.2	0.7	0.2
		Ratio estimation	0.7 ± 0.2	0.2 ± 0.3	0.9 ± 0.1	0.4 ± 0.3	0.6 ± 0.1	0.2 ± 0.1	0.6 ± 0.1	0.2 ± 0.1
Middle catchment	Mangaonuku at Tikokino Rd	Averaging method	N.D.	N.D.	N.D.	N.D.	0.7 ^(b)	0.2	2.3	0.2
		Ratio estimation	N.D.	N.D.	N.D.	N.D.	1.5 ± 0.3 ^(b)	0.3 ± 0.04	1.9 ± 0.4	0.2 ± 0.1
	Porangahau at Oruawhara Rd	Averaging method	0.5	0.1	0.9	0.6	0.4	0.1	0.7	0.03
		Ratio estimation	0.5 ± 0.1	0.1 ± 0.3	1.1 ± 0.3	0.9 ± 0.6	0.5 ± 0.1	0.1 ± 0.01	0.6 ± 0.1	0.03 ± 0.01
	Tukitiki at Shagrock	Averaging method	52	N.D.	43	4.5	30	3	61	1.7
		Ratio estimation	26 ± 9.3	N.D.	44 ± 10	7.0 ± 8.4	24 ± 5.5	2.6 ± 1.3	46 ± 12	2.0 ± 0.7
Lower catchment	Tukitiki at Red Bridge	Averaging method	37	3.3	51	8.5	34	0.3	41	0.3
		Ratio estimation	28 ± 9.9	3.3 ± 7.0	49 ± 11	13 ± 12	35 ± 10	0.4 ± 0.1	53 ± 8.7	0.4 ± 0.03
	Tukitiki at Black Bridge	Averaging method	35	4.8	46	8.7	34	0.3	43	0.5
		Ratio estimation	35 ± 7.2	7.1 ± 19	45 ± 11	12 ± 11	35 ± 10	0.4 ± 0.05	56 ± 10	0.6 ± 0.1

Table 14: Annual and summer (November to April inclusive) SIN load in tonnes per year (T/Y). (a) provisional estimate based on 9 months of data. (b) estimate based on 6 months (January-June) data. N.D. :no data; I.D.: Insufficient data.

	Site	Period	2004-05		2005-06		2006-07		2007-08	
			Year- round	Summer	Year- round	Summer	Year- round	Summer	Year- round ^(a)	Summer
Upper catchment	Tukitiki at SH50	Averaging method	41	4.4	47	8.9	35	1.8	33	1.0
		Ratio estimation	37 ± 15	8.8 ± 22	39 ± 8	11 ± 8.8	35 ± 10	1.9 ± 0.7	31 ± 7	1.1 ± 0.3
	Waipawa at SH50	Averaging method	68	8.1	120	36	69	2.9	101	2.5
		Ratio estimation	65 ± 18	14 ± 18	119 ± 22	52 ± 28	68 ± 19	3.4 ± 1.1	81 ± 18	2.8 ± 0.8
	Tukipo at SH50	Averaging method	84	11	100	16	81	4.5	101	3.2
		Ratio estimation	78 ± 28	17 ± 52	87 ± 17	18 ± 11	68 ± 21	4.8 ± 1.2	87 ± 13	3.8 ± 0.9
	Makaretu at SH50	Averaging method	38	4.1	64	7.0	40	1.6	25	0.9
		Ratio estimation	35 ± 12	6 ± 10	50 ± 14	8 ± 6	38 ± 14	1.8 ± 0.9	23 ± 4	1.0 ± 0.6
Middle catchment	Mangaonuku at Tikokino Rd	Averaging method	N.D.	N.D.	N.D.	N.D.	95 ^(b)	39	317	43
		Ratio estimation	N.D.	N.D.	N.D.	N.D.	169 ± 24 ^(b)	52 ± 6	279 ± 33	50 ± 4
	Porangahau at Oruawhara Rd	Averaging method	47	2.1	56	9.3	34	2.3	55	2.7
		Ratio estimation	45 ± 12	7.5 ± 18	43 ± 9	13 ± 9	33 ± 9	2.8 ± 1.0	47 ± 8	3.0 ± 0.5
	Tukitiki at Shagrock	Averaging method	3,075	I.D.	3,300	284	1,601	119	1,824	107
		Ratio estimation	1,933 ± 481	I.D.	2,328 ± 495	195 ± 256	1,263 ± 257	143 ± 34	1,503 ± 217	127 ± 35
Lower catchment	Tukitiki at Red Bridge	Averaging method	1,556	109	2,134	242	1,538	39	1,895	25
		Ratio estimation	1,379 ± 408	200 ± 416	1,588 ± 433	248 ± 229	1,480 ± 351	41 ± 15	2361 ± 398	28 ± 23
	Tukitiki at Black Bridge	Averaging method	1,515	97	2,018	192	1,451	23	1834	19
		Ratio estimation	1,297 ± 430	184 ± 522	1,514 ± 416	228 ± 212	1,381 ± 346	24 ± 16	2,283 ± 407	22 ± 17

Appendix F: Flow ranges for the contaminant load analysis

Flow ranges used in the for the contaminant load analysis. Range is upper and lower limit of 10 percentiles “block” of the flow distribution curve, centred on the flow value. For example, the flow range for median flow corresponds to the 45th to 55th percentile of the flow distribution curve. N. is the number of water quality samples taken in the flow range.

	Median Flow		Lower quartile		1 day MALF	
	Value	Range	Value	Range	Value	Range
Tukitiki at SH50	3,071	2,817 – 3,377	1,913	1,704 – 2,105	1,001	665 – 1,263
Waipawa at SH50	6,133	5,627 – 6,643	3,798	3,391 – 4,222	2,352	1,936 – 2,796
Tukipo at SH50	747.6	653.8- 845.4	359.3	298.5- 423.9	149.0	93- 201.2
Makaretu at SH50	1,287	1,178 – 1,420	786	695 – 869	391	245 - 486
Tukitiki at Ongonga Rd	2,753	2,442 – 3,115	1,376	1,155 – 1,612	382.5	116 - 680
Tukipo at Ashcott Rd	4,058	3,588 – 4,536	2,168	1,877 – 2,473	1,145	882 – 1,401
Mangaonuku at Tikokino Rd	2,445	2,260 – 2,632	1,588	1,437 – 1,742	1,056	904 – 1,220
Waipawa at RDS	8,574	7,821- 9,362	5,133	4,523- 5,721	3,025	2,407- 3,657
Porangahau at Oruawhara Rd	278	248 – 313	147	126 – 169	52	27 – 81
Tukitiki at Taiparu Rd	9,194	8,362 – 10,171	5,492	4,869 – 6,105	2,632	1,391 – 3,422
Tukitiki at Shagrock	19,834	17,869- 21,802	10,638	9,270- 12,287	5,175	3,023- 6,624
Tukitiki at Red Bridge	21,598	19,040-24,355	11,965	10,392– 13,505	6,141	3,869- 7,710
Tukitiki at Black Bridge	21,598	19,040-24,355	11,965	10,392– 13,505	6,141	3,869- 7,710

Appendix G: Comparison between HBRC and NIWA data at Tukituki at Red Bridge

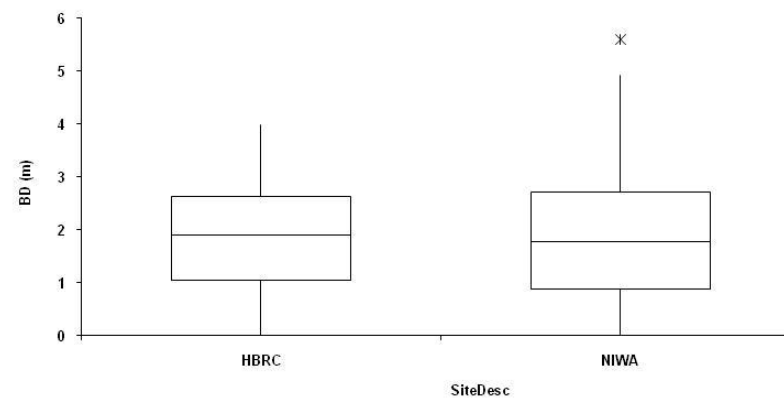
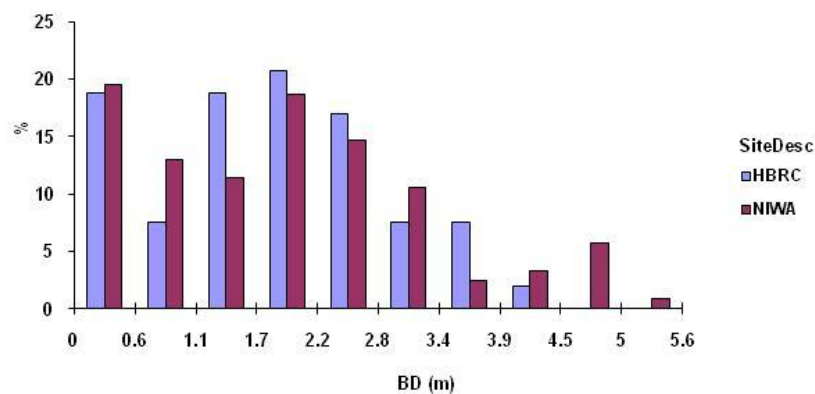
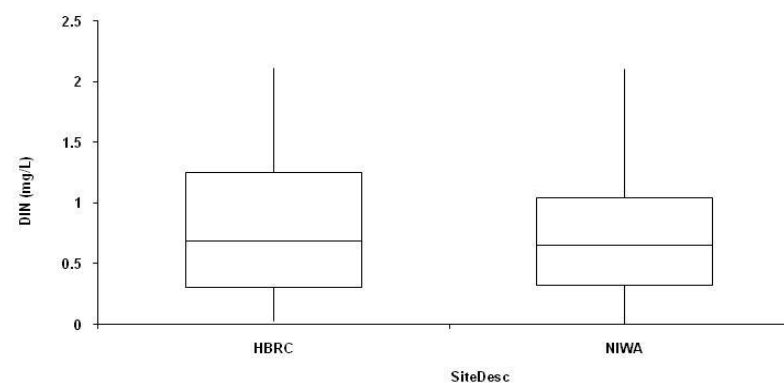
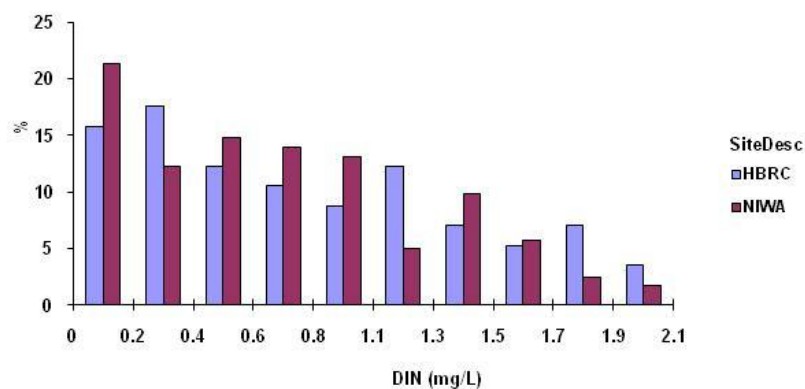
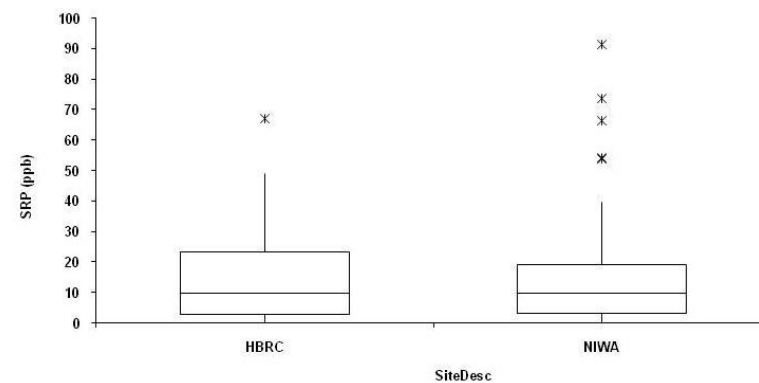
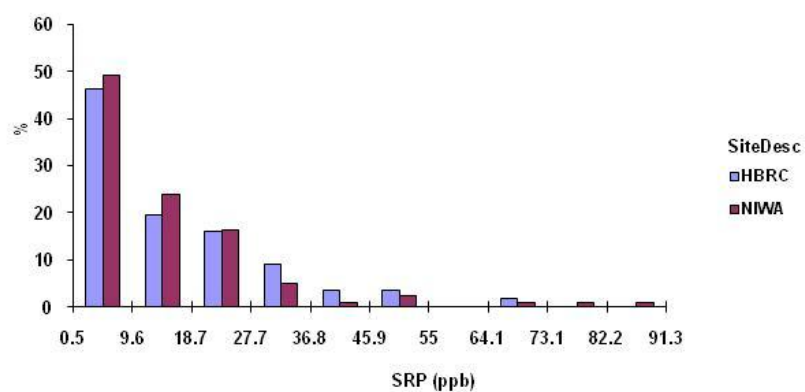
Tukituki at Redbridge - comparison of monitoring results obtained by NIWA and HBRC

- Period analysed: Oct96 to Dec06 (period in common for the two sites).
- NIWA monitoring is monthly,
- HBRC monitoring is quarterly till Jan 05, then monthly
- Sampling dates by the two agencies were different, thus a paired-sample statistical analysis was not possible.

All data analysis

	Agency	N. of samples	Average	Median	SD	Mann-Whitney test
DRP (mg/m ³)	HBRC	56	15.47	10.00	15.03	p= 0.41
	NIWA	122	13.61	10.01	15.18	
SIN (g/m ³)	HBRC	57	0.807	0.685	0.59	p= 0.36
	NIWA	122	0.712	0.657	0.52	
NH4-N (mg/m ³)	HBRC	57	0.015	0.007	0.017	p=0.03
	NIWA	122	0.010	0.006	0.011	
Clarity (m)	HBRC	53	1.80	1.9	1.06	p= 0.91
	NIWA	123	1.92	1.78	1.34	
Turb (NTU)	HBRC	56	11.0	1.7	39	p= 0.92
	NIWA	123	28.9	1.6	106	

All data analysis



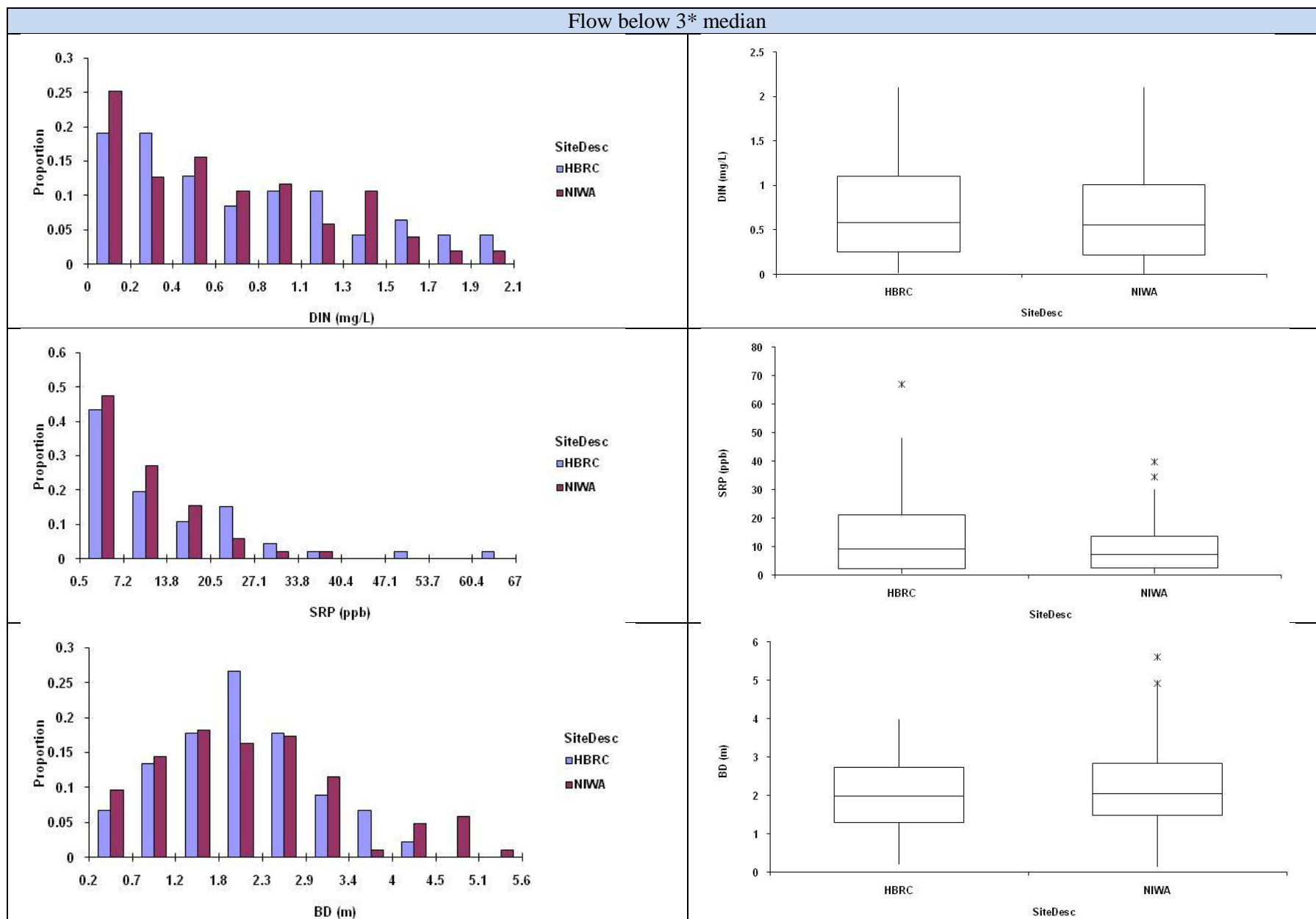
Analysis by season

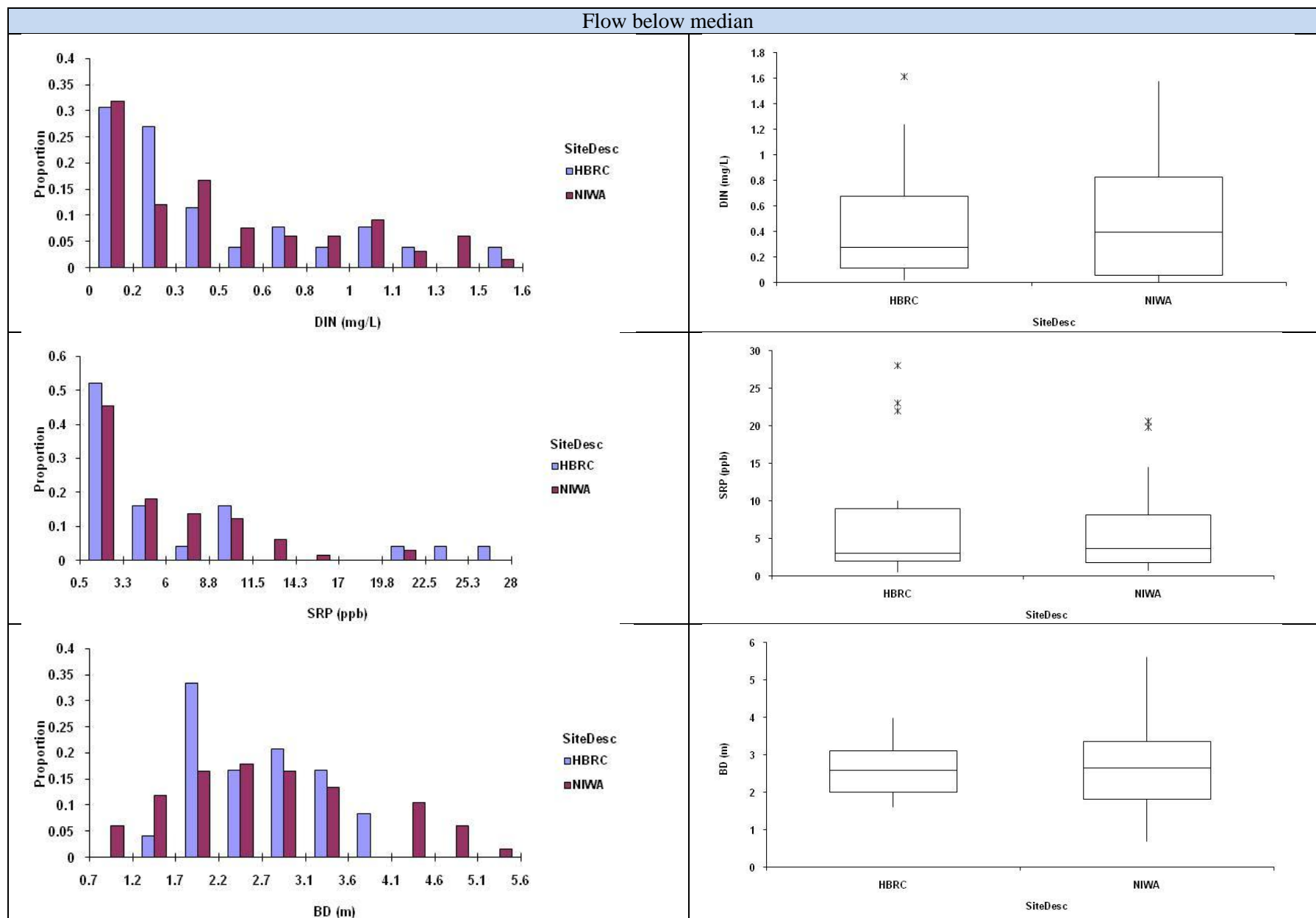
	Agency	N. of samples	Average	Median	SD	Mann-Whitney test
DRP (mg/m ³) 1 st quarter	HBRC	13	8.0	5.0	8.7	p= 0.73
	NIWA	30	7.5	3.2	9.5	
DRP (mg/m ³) 2 nd quarter	HBRC	14	17.7	12	16.4	P= 0.53
	NIWA	30	14.7	12.8	16.0	
DRP (mg/m ³) 3 rd quarter	HBRC	14	21.3	17.5	18.0	P= 0.87
	NIWA	29	21.5	18.5	21.2	
DRP (mg/m ³) 4 th quarter	HBRC	15	14.5	12.0	13.5	P= 0.74
	NIWA	33	11.2	10.0	8.0	
SIN (g/m ³) 1 st Quarter	HBRC	13	0.292	0.248	0.29	P= 0.28
	NIWA	30	0.250	0.162	0.29	
SIN (g/m ³) 2 nd Quarter	HBRC	14	0.788	0.613	0.57	P= 0.50
	NIWA	30	0.636	0.543	0.46	
SIN (g/m ³) 3 rd Quarter	HBRC	14	1.435	1.458	0.49	P= 0.15
	NIWA	29	1.227	1.280	0.47	
SIN (g/m ³) 4 th Quarter	HBRC	16	0.693	0.690	0.38	P= 0.58
	NIWA	33	0.749	0.777	0.36	
BD (g/m ³) 1 st Quarter	HBRC	13	1.9	1.9	1.2	P= 0.15
	NIWA	30	2.6	2.5	1.3	
BD (g/m ³) 2 nd Quarter	HBRC	13	1.8	1.93	1.2	P= 0.83
	NIWA	30	2.0	1.94	1.6	
BD (g/m ³) 3 rd Quarter	HBRC	15	1.5	1.6	0.8	P= 0.12
	NIWA	30	1.2	1.0	0.9	
BD (g/m ³) 4 th Quarter	HBRC	12	2.0	2.0	1.2	P= 0.65
	NIWA	33	1.8	1.8	1.1	

Analysis by flow category

(Comparison at flows below MALF was not possible due to insufficient data)

	Agency	N. of samples	Average	Median	SD	Mann-Whitney test
DRP (mg/m ³) <3*median	HBRC	46	13.0	9	13.6	P= 0.28
	NIWA	103	9.5	7.2	8.3	
DRP (mg/m ³) <median	HBRC	25	6.4	3.0	7.5	P= 0.95
	NIWA	66	5.4	3.6	4.6	
DRP (mg/m ³) <LQ	HBRC	13	3.4	2.0	3.0	P= 0.97
	NIWA	34	3.6	2.5	3.6	
103						
SIN (g/m ³) <3* Median	HBRC	47	0.746	0.583	0.60	P= 0.49
	NIWA	103	0.672	0.554	0.53	
SIN (g/m ³) < Median	HBRC	26	0.433	0.275	0.43	P= 0.95
	NIWA	66	0.482	0.396	0.45	
SIN (g/m ³) <LQ	HBRC	14	0.188	0.203	0.16	P= 0.96
	NIWA	34	0.376	0.199	0.44	
BD (g/m ³) <3* Median	HBRC	45	2.03	1.98	0.93	P= 0.63
	NIWA	104	2.22	2.05	1.21	
BD (g/m ³) < Median	HBRC	24	2.62	2.59	0.70	P= 0.92
	NIWA	67	2.72	2.65	1.12	
BD (g/m ³) <LQ	HBRC	12	2.76	2.82	0.76	P= 0.22
	NIWA	34	3.26	3.14	1.16	





Flow below Lower Quartile

