

State of the Environment Monitoring:

River Water Quality Annual Report 2017

Laura Buckthought

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Approved for Auckland Council publication by:

Name: Eva McLaren

Position: Manager, Research and Evaluation (RIMU)

Name: Jonathan Benge

Position: Manager, Water Quality (RIMU)

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List of acronyms

- NIWA National Institute of Water and Atmospheric Research
- NOF National Objectives Framework
- NPSFM National Policy Statement for Freshwater Management
- NRWQN National River Water Quality Network – NIWA
- REC River Environment Classification

Executive summary

Auckland Council operates a long-term river water quality monitoring programme throughout the Auckland region. The primary objective of this monitoring is to report on the State of the Environment (SoE), as part of an assessment of the efficacy of Auckland Council's policies, rules, initiatives and strategies in undertaking its environmental management responsibilities under the Resource Management Act 1991 (RMA). This monitoring also helps underpin the requirement to take appropriate action (having regard to the methods available to the council under this Act) where this is shown to be necessary. This report provides a summary of the data collected during 2017 for selected rivers across the region.

Water quality is assessed monthly at 36 sites around the region using a combination of field and laboratory tested parameters. Annual water quality results are summarised as box plots to display the variation in the parameters measured at each of the sites, and this is supplemented with tables providing related basic summary statistics. The annual reporting provides an interim summary of water quality between the more comprehensive five yearly 'state and trend' reporting. Auckland Council also produces to assess its environmental management responsibilities.

A water quality index is calculated for the purpose of comparing overall water quality across sites and communicating this complex water quality data in a simple, easily understandable form. The sites are then ranked and assigned a water quality class based on this water quality index.

In 2017, the West Hoe Stream, a native forest site, was the only site classed as having 'excellent' water quality and ranked highest for water quality class in the region. By contrast, 'poor' water quality was observed in streams with a greater mix of urban and/or rural land cover. The two Pakuranga Creek sites (Botany Road and Greenmount Drive) had the lowest ranked water quality index scores in 2017. These are both predominantly urban sites in terms of land cover.

1 Introduction

1.1 Auckland's rivers

The Auckland region has an estimated 19,000km of permanently flowing rivers (Auckland Council Geomaps V 3.2.1.1). As no mainland stream reaches in the region are greater than 20km from the coast, the catchment areas of each river are relatively small, with most draining to the sea before they merge with others to form larger rivers. Consequently, the majority of permanent waterways are of first and second order in Auckland (Table 1), meaning they are small in length, with most less than a few metres wide.

The relatively gentle topography of most of the Auckland region and the underlying geology also influence the nature of its rivers, usually resulting in slow flowing, low gradient rivers with predominantly soft substrate beds derived from their underlying geology. Fast flowing, high gradient rivers with hard stony substrates are mostly restricted to catchments that drain the Waitākere Ranges, Hunua Ranges and Great Barrier Island.

Table 1: Permanent rivers of the Auckland region stratified by stream order (Storey & Wadhwa, 2009).

Stream order	Length (km)	% in order	Cumulative %
1	8753	52.7	52.7
2	4262	25.6	78.3
3	2121	12.7	91.0
4	1003	6.0	97.0
5	504	3.0	100

1.2 Water quality

The water quality (physical, chemical and microbiological characteristics) of a river partly determines how suitable it is for supporting animal and plant life and for use by people.

Water quality is defined by the values supported by a waterway, which are a function of the temperature, amount of nutrients, oxygen, sediment and other pollutants in the water. Values, functions and pollutants are influenced by the surrounding catchment land use. In the absence of human influences on the catchment, natural factors that influence water quality include climate, topography, geology and soil type. Where there are human influences, the type of land cover and activities in the river's catchment can also strongly affect water quality (Mason, 1998).

The sites in Auckland Council's River Water Quality Programme have been broadly grouped according to the River Environment Classification (REC) (Snelder et al., 2004), which classifies rivers by the dominant land cover in their catchments, as well as soil type, climate and topography among other variables. This national classification is used because land cover is well-known to affect the quality and quantity of water, the types of ecological habitats

and flow patterns in rivers (Snelder et al., 2010). The classification used in this report for Auckland river monitoring sites is broad and based on the following land cover classes:

- Native forest (including natural alpine environments¹)
- Exotic forest
- Rural (includes all non-forested rural land)
- Urban.²

The majority (67%) of rivers within the Auckland region drain non-forested rural catchments (pastoral farming, horticulture and rural residential), followed by native forest catchments (16%), with urban catchments accounting for 9% and exotic forest 8% (Table 2). These values are based on land cover data in the 2013 update to the River Environment Classification (Snelder et al., 2010).

The overall composition of catchment land cover for rivers within the Auckland region is quite different from that of New Zealand as a whole (Table 2). Auckland's high population density means that a large proportion of the region's rivers flow through urban catchments. The Auckland region also has considerably less land under native forest than the rest of New Zealand, making the environmental pressures in Auckland unique in a national context.

Table 2: Catchment land cover for rivers in Auckland and New Zealand (Snelder et al., 2010).

Land cover	% of rivers	
	Auckland	New Zealand
Rural	67	43
Native forest (incl. alpine)	16	51
Exotic forest	8	5
Urban	9	1

1.3 Auckland Council's freshwater monitoring programmes

One of the objectives of Auckland Council's freshwater State of the Environment (SoE) monitoring programme is to describe the quality of the region's freshwater resources, as required by the Resource Management Act 1991 (RMA). Auckland Council operates four monitoring programmes within the fresh water quality work stream: the river water quality programme, which is the focus of this report, along with river ecology, lake water quality and groundwater quality monitoring programmes, which are all reported elsewhere. All reports can be obtained from Knowledge Auckland: <http://www.knowledgeauckland.org.nz/>. This allows the effects of environmental stressors and the efficacy of council policy to be assessed and evaluated between domains and integrated through the hydrological cycle.

¹ No natural alpine environments exist in Auckland.

² If urban land exceeds 15% of catchment area, the site is classed as predominantly "urban".

1.3.1 River water quality programme

The river water quality programme monitors the physical, chemical and microbiological properties of 31 rivers, at 36 sites, monthly. This monitoring provides information on the temperature, nutrient concentrations, oxygen, suspended sediment and other variables in these rivers. The results enable Auckland Council to assess the life-supporting capacity of the river and its suitability for human use through time.

Programme design

The River Water Quality Programme initially commenced with eight sites in 1977-78 and ran this way until 1981; it was re-initiated with 17 sites in 1986 and has been running continuously ever since. The programme has evolved throughout its duration, with sites added or removed according to varying requirements. The programme was last reviewed internally in 2008 and subsequent changes were described in the 2009 River Water Quality Annual Report (Neale, 2010). Between 2009 and 2011, 31 sites were consistently monitored. Three new sites were added to the network at the beginning of 2012, and a further two in February of 2013, bringing the current total to 36 sites.

Each of the 36 sites is sampled monthly. The Hoteo River, is monitored exclusively by the National Institute for Water and Atmospheric Research (NIWA) as part of the National River Water Quality Network (NRWQN), and another, the Rangitopuni River, was monitored by NIWA up until (and including) June 2016, after which Auckland Council took over responsibility for sampling.

The monitoring programme is regionally representative in that it monitors a variety of sizes and types of rivers and represents the range of different catchment land cover classes and activities found across the region (Auckland Regional Council, 1995). This enables us to present a region-wide perspective on water quality and can allow for the extrapolation of the results to infer the likely water quality of rivers that are not sampled. As well as this report, the data is used to provide information for freshwater report cards which are a summary of information on water quality (see <http://stateofauckland.aucklandcouncil.govt.nz/>).

1.4 Report scope

This report provides a tabular and graphical summary of data collected from the 36 sites in the River Water Quality Programme during 2017. This data is also used to produce a water quality index class for each site.

This is the 28th annual report since the inception of the River water quality monitoring programme, and the 13th since 2000 that the river water quality data has been reported separately from the marine and lake data. The last five yearly state and trends analysis of water quality was reported in 2016, covering data for the period 2005 to 2014 (see Buckthought & Neale, 2016).

2 Methods

2.1 Sample sites

The current River Water Quality Programme operates with a network of 36 sites (Table 3 and Figure 1).

2.2 Sampling methodology

For the sites monitored by Auckland Council, sample collection was carried out by Auckland Council staff on a monthly basis, with individual sites visited within the same week each month. All field practices are conducted according to National Environmental Monitoring Standards (NEMS) safe acquisition of data Water Quality Part 1, 2 and 3 - Sampling, Measuring, Processing and Archiving of Discrete Water Quality Data (NEMS, 2009). Up to 18 water quality parameters are routinely monitored as part of the programme (Table 4). Six parameters are determined in the field using the EXO Sonde, a portable water quality meter by YSI Inc. and the remainder are determined by laboratory analysis.

There are four rivers that have multiple sampling sites including Mahurangi River, Otara Creek, Pakuranga Creek and Papakura Stream. In all cases, while the names of the rivers are the same, the site locations are chosen because they drain different types of catchments in terms of the land cover and land use. In the case of the Mahurangi River and Papakura Stream, these catchments are very large, and the sites are a large distance from each other. In the case of Otara Creek and Pakuranga Stream, these sites were strategically chosen as they represent water drained from different types of catchment land use within a highly urbanised area.

A number of sites within this monitoring network have no obvious sources of heavy metals associated with their catchments and previous monitoring identified heavy metals to be below detection limits. As a consequence, these sites are not routinely monitored for heavy metals but are tested on an intermittent basis. This testing was most recently carried out in 2009 and the results reported in Neale (2010). These sites are identified in Table 3 as having no metals measured. Prior to 2015 soluble and total lead were measured at all metals sites, but in most cases monitored results were less than laboratory detection limits. So, continuous monitoring has ceased for lead and these parameters will be monitored on an intermittent basis in future with additional copper and zinc monitoring. The removal of lead in fuels in the early 1990's, among other things, can be attributed to this apparent reduction in detection within Auckland streams.

Importantly, temporal bias likely exists in some records subject to diel variation because sample runs are timed to be consistent by station – variation between stations in DO, pH, temperature, conductivity and salinity is likely subject to this bias, meaning differences between stations could correspond to sampling approach rather than effects of land use or activity.

Quality control measures are undertaken in accordance with Auckland Council's internal Stream Water Quality Sampling Protocol. Auckland Council is also in the process of aligning

with NEMS quality control standards (released March 2019). This covers procedures for the collection, transport and storage of samples, methods for data verification and quality assurance to ensure consistency and accuracy across the monitoring programmes.

Laboratory samples were analysed under contract with the IANZ-accredited Watercare Laboratory Services Ltd, from January 2017 to June 2017. From July 2017 Auckland Council changed its laboratory service provider to Hills Laboratories Ltd (also IANZ accredited). Analytical methods (for all analytes except metals) for both laboratories follow the “Standard Methods for the Examination of Water and Wastewater” 22nd Edition (APHA, 2012). Metal analytes were tested according to US EPA Method 200.8 for the “Determination of Trace Metals in Waters and Wastes by Inductively Coupled Plasma – Mass Spectrometry” Revision 5.4 (US EPA, 1994).

The NRWQN site monitored by NIWA (Hoteo River) is monitored for the same parameters listed in Table 4, with the exception of salinity, suspended solids and heavy metals. Temperature and dissolved oxygen are determined in the field; the remainder are determined by laboratory tests at NIWA’s water quality laboratory in Hamilton. Further information can be obtained from <https://www.niwa.co.nz/freshwater/water-quality-monitoring-and-advice/national-river-water-quality-network-nrwqn>.

Table 3: Sites sampled in 2017 in the River Water Quality Programme, together with their location details, predominant catchment land cover (from REC layer) and record start date.

Site name	NZTM X	NZTM Y	Predominant land cover	Analysis type	Start date
Avondale Stream	1750600	5912264	Urban	Metals	2012
Cascades Stream (Waitākere)	1735628	5916378	Native forest	No Metals	1978
Cascades Stream (Waiheke)	1785942	5923254	Rural	No Metals	2013
Hoteo River (NIWA operated)	1735254	5972546	Rural	No Metals	1986
Kaukapakapa River	1735833	5944978	Rural	No Metals	2009
Kumeu River	1739252	5928781	Rural	Metals	1993
Lucas Creek	1751468	5934510	Urban	Metals	1993
Mahurangi River (Forestry HQ)	1747750	5965035	Exotic forest	Metals	1993
Mahurangi River (Water Supply)	1748864	5970457	Rural	Metals	1993
Makarau River	1736150	5953126	Rural	Metals	2009
Matakana River	1753500	5976481	Rural	Metals	1986
Ngakoroa Stream	1775164	5881624	Rural	No Metals	1993
Nukumea Stream	1749411	5951400	Native forest	Metals	2012
Oakley Creek	1751963	5917636	Urban	Metals	1994
Okura Creek	1751405	5938716	Rural	Metals	2003
Omaru Creek	1766268	5916749	Urban	Metals	1985
Onetangi Stream	1786243	5926204	Rural	No Metals	2013
Opanuku Stream	1742086	5915581	Rural	No Metals	1978
Otaki Creek	1764306	5907216	Urban	Metals	1985
Otara Creek (East Tamaki)	1767422	5907535	Urban	Metals	1986
Otara Creek (Kennell Hill)	1768335	5908376	Urban	Metals	1992
Oteha Stream	1751325	5933519	Urban	Metals	1986
Pakuranga Creek (Botany Rd)	1770686	5913036	Urban	Metals	1985
Pakuranga Creek (Greenmount Drive)	1769473	5910813	Urban	Metals	1985

Site name	NZTM X	NZTM Y	Predominant land cover	Analysis type	Start date
Papakura Stream (Alfriston Rd)	1774247	5902648	Rural	Metals	2012
Papakura Stream (Porchester Rd)	1771240	5900290	Rural	Metals	1993
Puhinui Stream	1766440	5904295	Urban	Metals	1994
Rangitopuni River	1744450	5932301	Rural	No Metals	1986
Riverhead Forest Stream	1737125	5933216	Exotic forest	Metals	2009
Vaughan Stream	1755414	5938729	Rural	Metals	2001
Wairoa River	1782682	5901720	Rural	Metals	1978
Wairoa Tributary	1786700	5892817	Native forest	No Metals	2009
Waitangi River	1754343	5878534	Rural	No Metals	2009
Waiwera River	1748628	5953665	Rural	Metals	1986
West Hoe Stream	1748314	5950610	Native forest	No Metals	2002
Whangamaire Stream	1763578	5884625	Rural	No Metals	2009



Figure 1: The distribution of the 36 sampling sites used in the Auckland Council River Water Quality Programme for 2017.

Table 4: Parameters tested in 2017 as part of the River Water Quality Programme (laboratory test methods refer to those tests carried out by Watercare Services Ltd. under contract).

Parameter	Abbreviation	Units	Method
Dissolved oxygen	DO (sat)	% sat	EXO sonde
Dissolved oxygen	DO (ppm)	mg/L	EXO sonde
Temperature	Temp	°C	EXO sonde
Conductivity	Cond	mS/c m	EXO sonde
Salinity	Salinity	ppt	EXO sonde
pH	pH		EXO sonde
Suspended solids	TSS	mg/L	APHA (2012) 2540 D
Turbidity	Turb	NTU	APHA (2012) 2130 B (modified)
Ammoniacal nitrogen	Ammonia	mg N/L	APHA (2012) 4500-NH3 G (Modified)
Total oxidised nitrogen	TON	mg N/L	APHA (2012) 4500-NO3 F (Modified)
Total nitrogen	TN	mg N/L	APHA (2012) 4500-P J, 4500-NO3 F (Modified)
Soluble reactive phosphorus	SRP	mg P/L	APHA (2012) 4500-P B, F (Modified)
Total phosphorus	TP	mg P/L	APHA (2012) 4500-P B, J (Modified)
Soluble copper	Cu sol	µg/L	USEPA 200.8 (Modified)
Total copper	Cu tot	µg/L	USEPA 200.8 (Modified)
Soluble zinc	Zn sol	µg/L	USEPA 200.8 (Modified)
Total zinc	Zn tot	µg/L	USEPA 200.8 (Modified)
Escherichia coli	E. coli	cfu/10 0mL	USEPA Method 1603 (2002)

2.3 Data processing and analysis

All field and laboratory data collected are stored in Auckland Council's water quality archiving database (HYDSTRA). The data from the site operated by NIWA was extracted from NIWA's web-based Water Quality Information System. The 2017 data was collated and used to produce:

- Box plots which display the annual variation in each parameter at each site including the median and interquartile range, with whiskers calculated at 5th and 95 percentiles.
- Summary tables providing a basic statistical summary of each parameter at each site (Appendix).
- Water Quality Index for each site based on the approach of the Canadian Council of Ministers of the Environment (2001) using the data for seven water quality parameters. Each site was assigned a water quality class based on this water quality index.

For the purposes of this report, censored laboratory results that were reported as below the limit of detection were halved as recommended by Chapman (1996). For example, a value reported as <1 mg/L would be included in the data analysis as 0.5 mg/L.

3 Results

The box plots in this section show the variation within observed water quality data at each site for the 2017, by predominant land cover (as identified by bar colours). The boxes represent the inter-quartile range (25th to 75th percentile) and the whiskers represent the 5th and 95th percentiles. The median is the centre line in each box. A basic statistical summary for each parameter at each site is also presented in the Appendix.

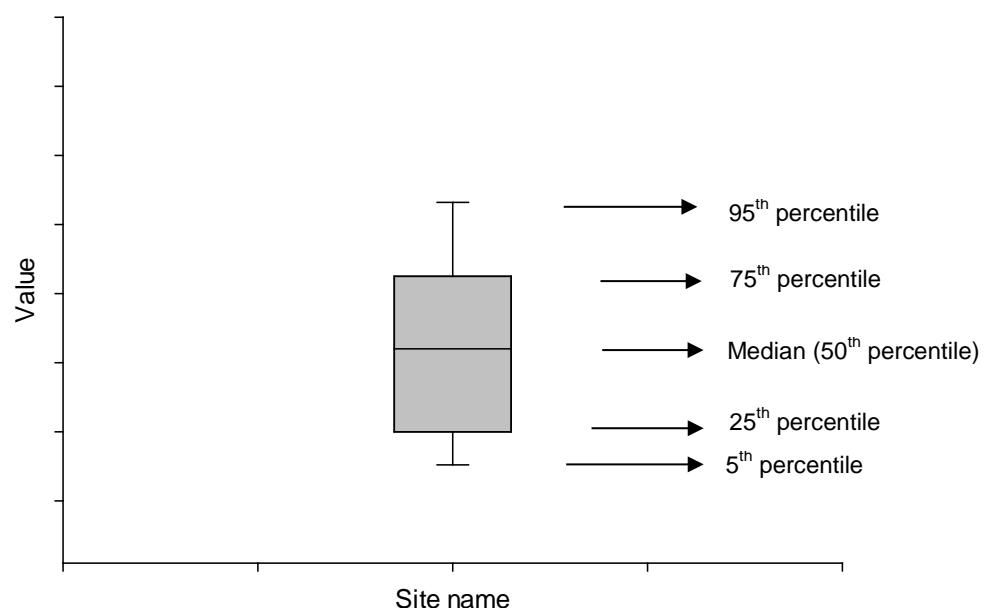


Figure 2: Infographic illustrating the different measures within a box plot

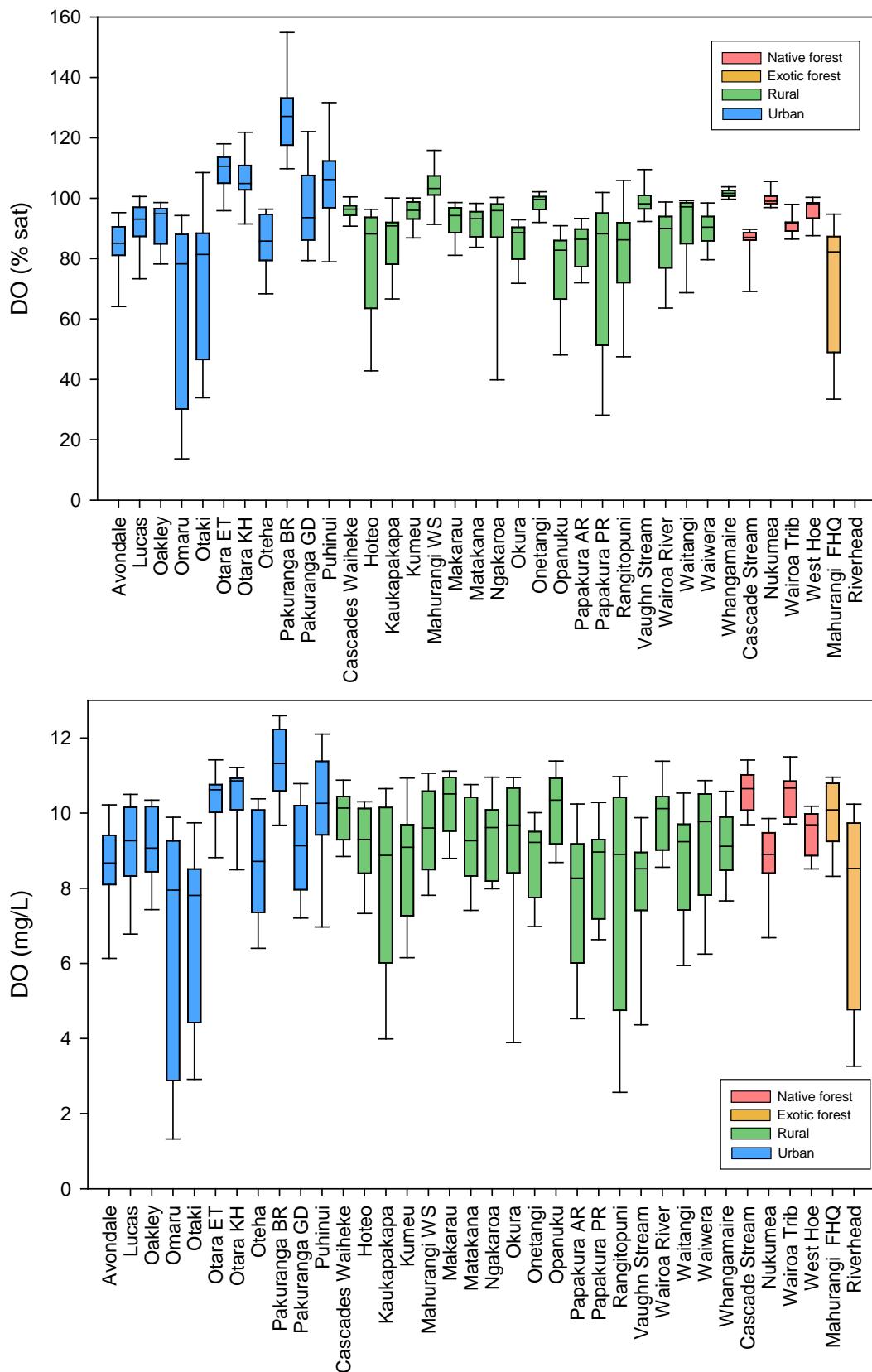


Figure 3: Box plots showing variation in dissolved oxygen as % saturation (upper plot) and concentration (mg/L) (lower plot) at 36 sites using data collected during the 2017 calendar year. Note that at the time of sampling, restoration works were being undertaken in the Oakley Creek and this has likely affected some results.

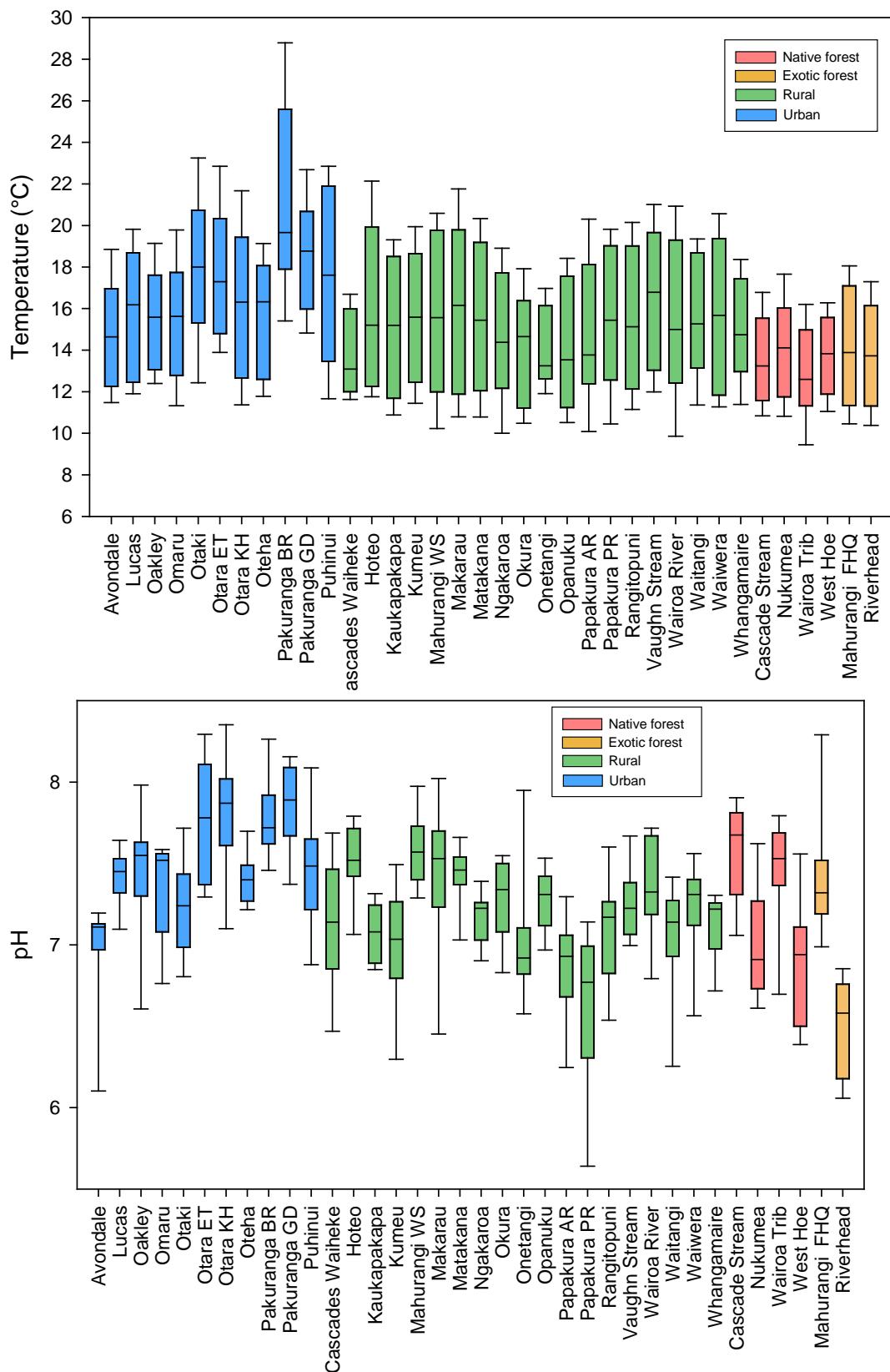


Figure 4: Box plots showing the variation in temperature (upper plot) and pH (lower plot) at the 36 sites using data collected during the 2017 calendar year.

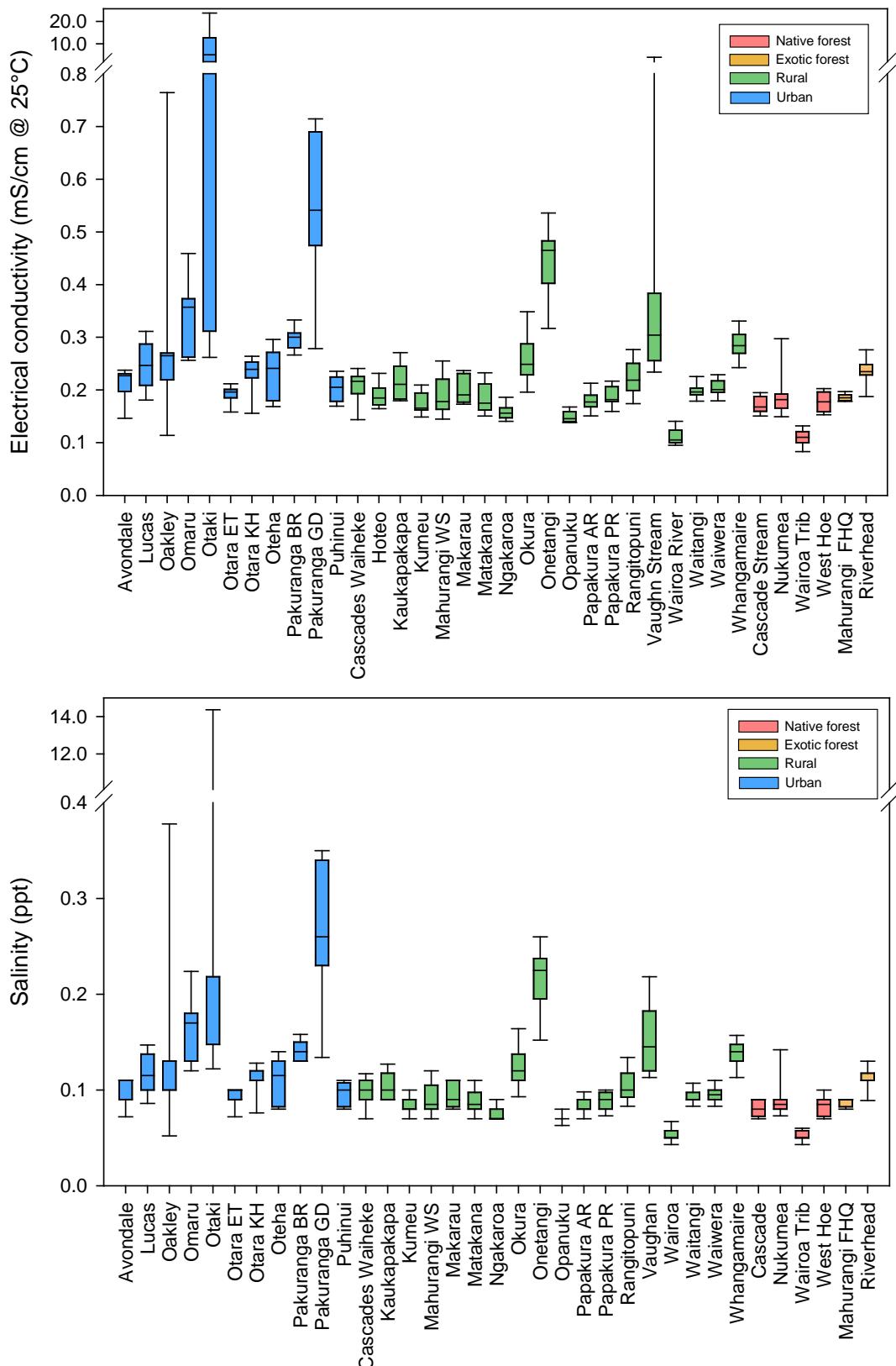


Figure 5: Box plots showing the variation in electrical conductivity (upper plot) and salinity (lower plot) at the 36 sites using data collected during the 2017 calendar year. No salinity data is collected by NIWA for the Hoteo River site. Note the Otaki Creek and Vaughan Stream can be tidally influenced and other sites can be influenced by saline water during large or king tides.

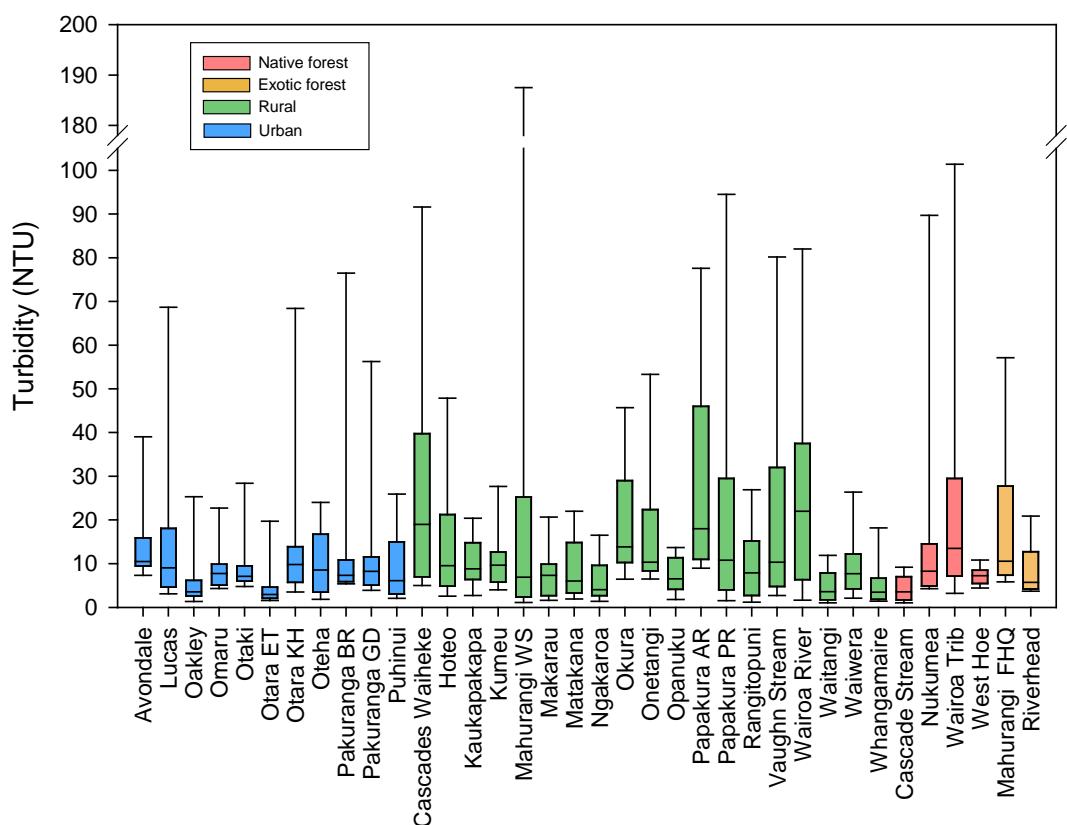
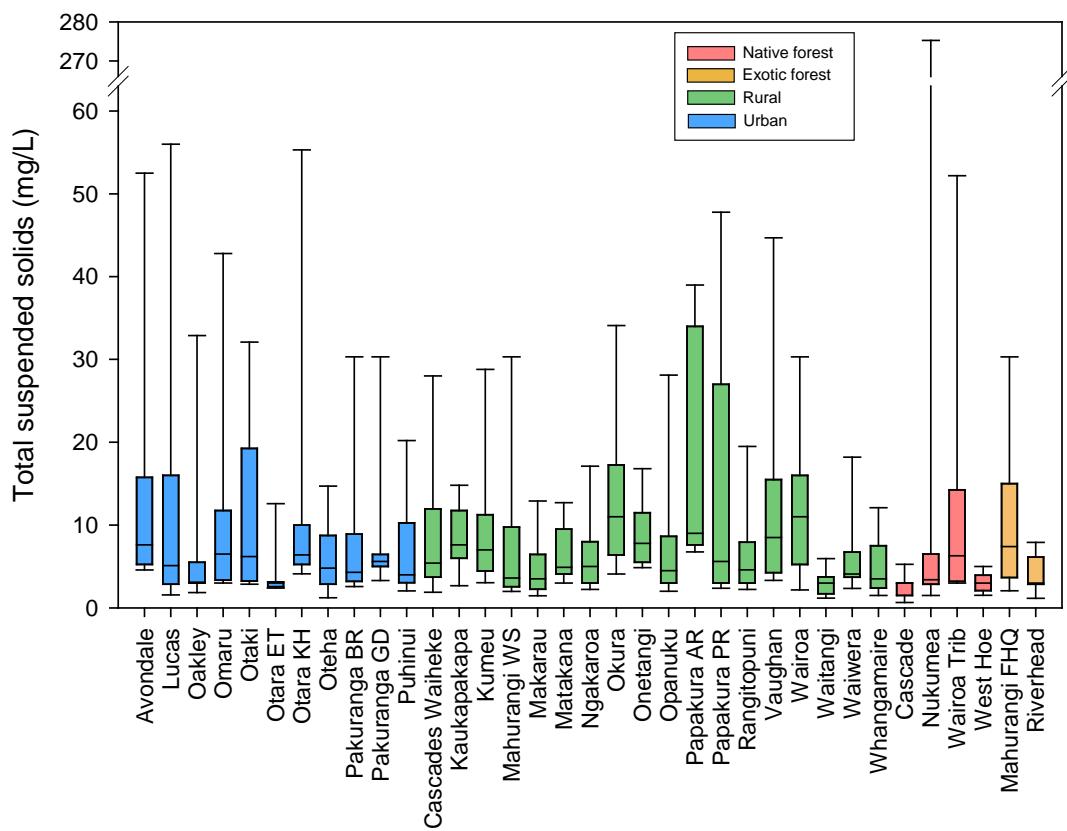


Figure 6: Box plots showing the variation in total suspended solids (upper plot) and turbidity (lower plot) at the 36 sites using data collected during the 2017 calendar year.

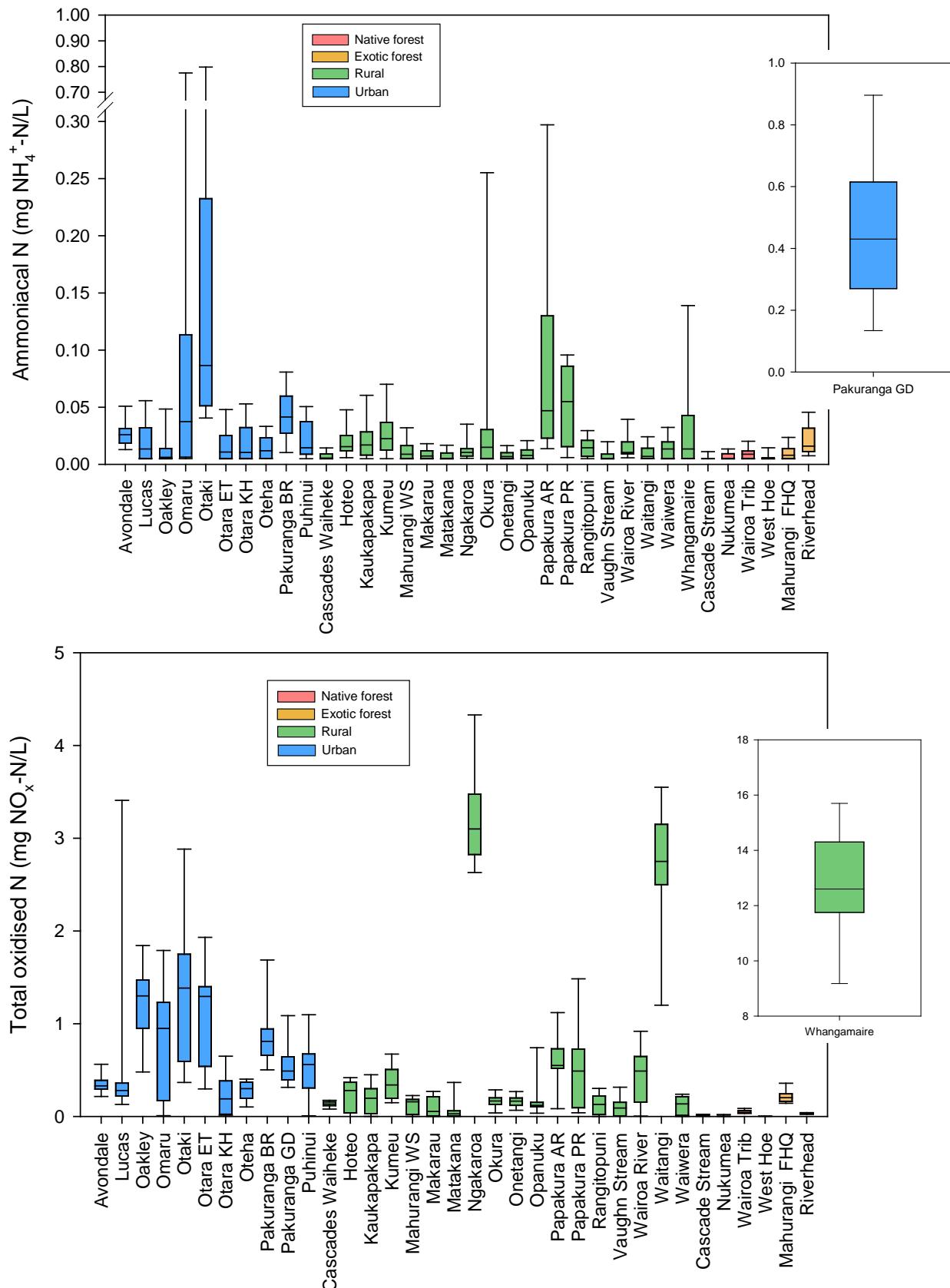


Figure 7: Box plots showing the variation in ammoniacal nitrogen (upper plot) and total oxidised nitrogen (lower plot) at the 36 sites using data collected during the 2017 calendar year.

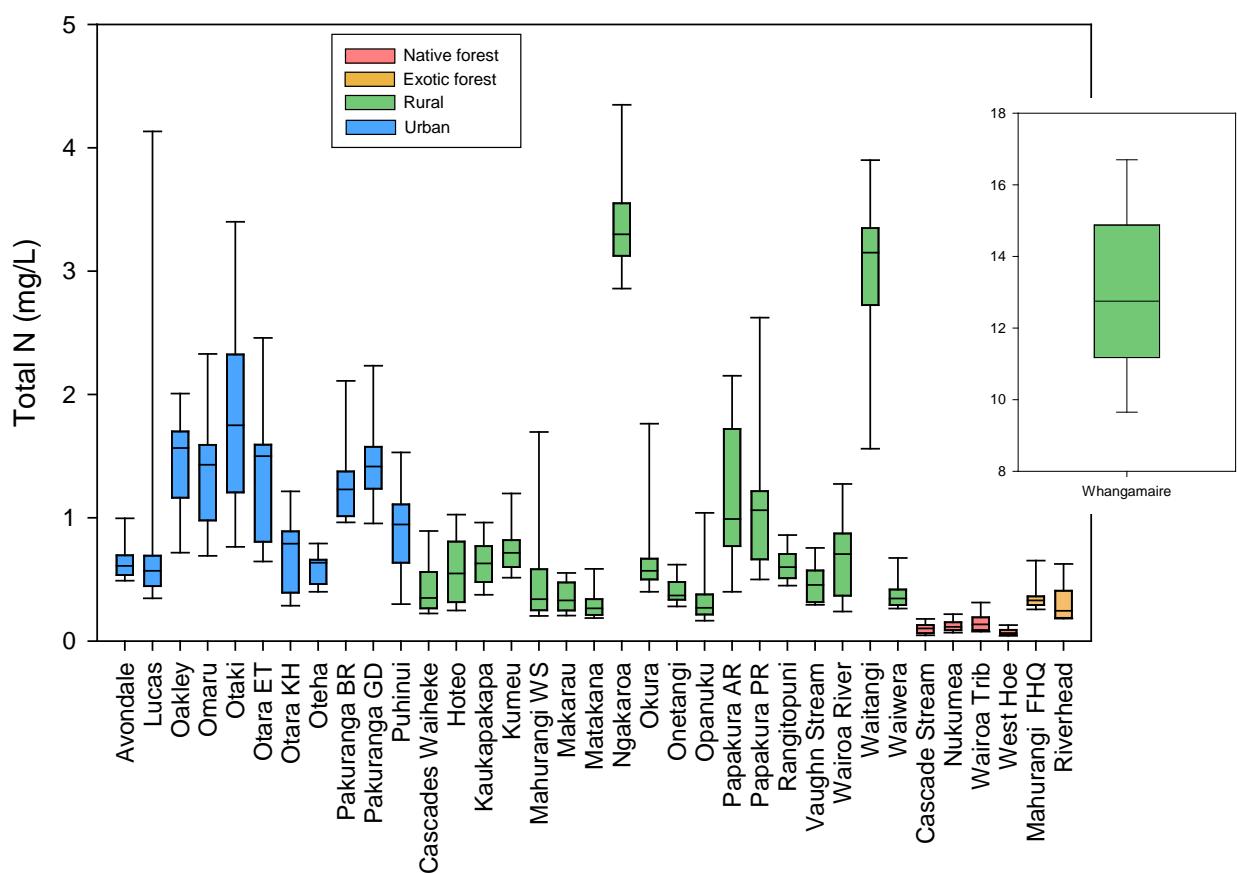


Figure 8: Box plot showing the variation in total nitrogen at the 36 sites using data collected during the 2017 calendar year.

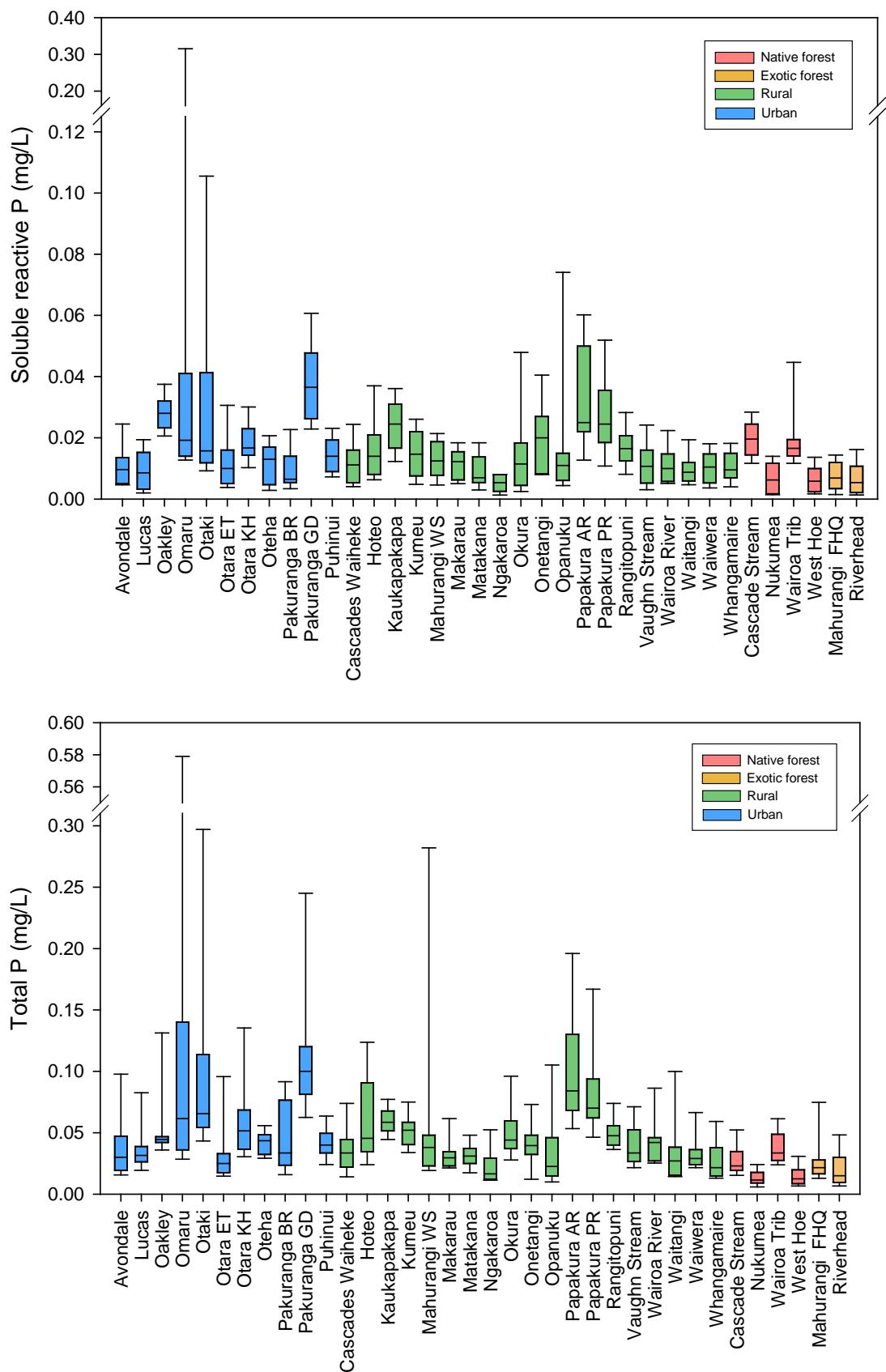


Figure 9: Box plots showing the variation in soluble reactive phosphorus (upper plot) and total phosphorus (lower plot) at the 36 sites using data collected during the 2017 calendar year.

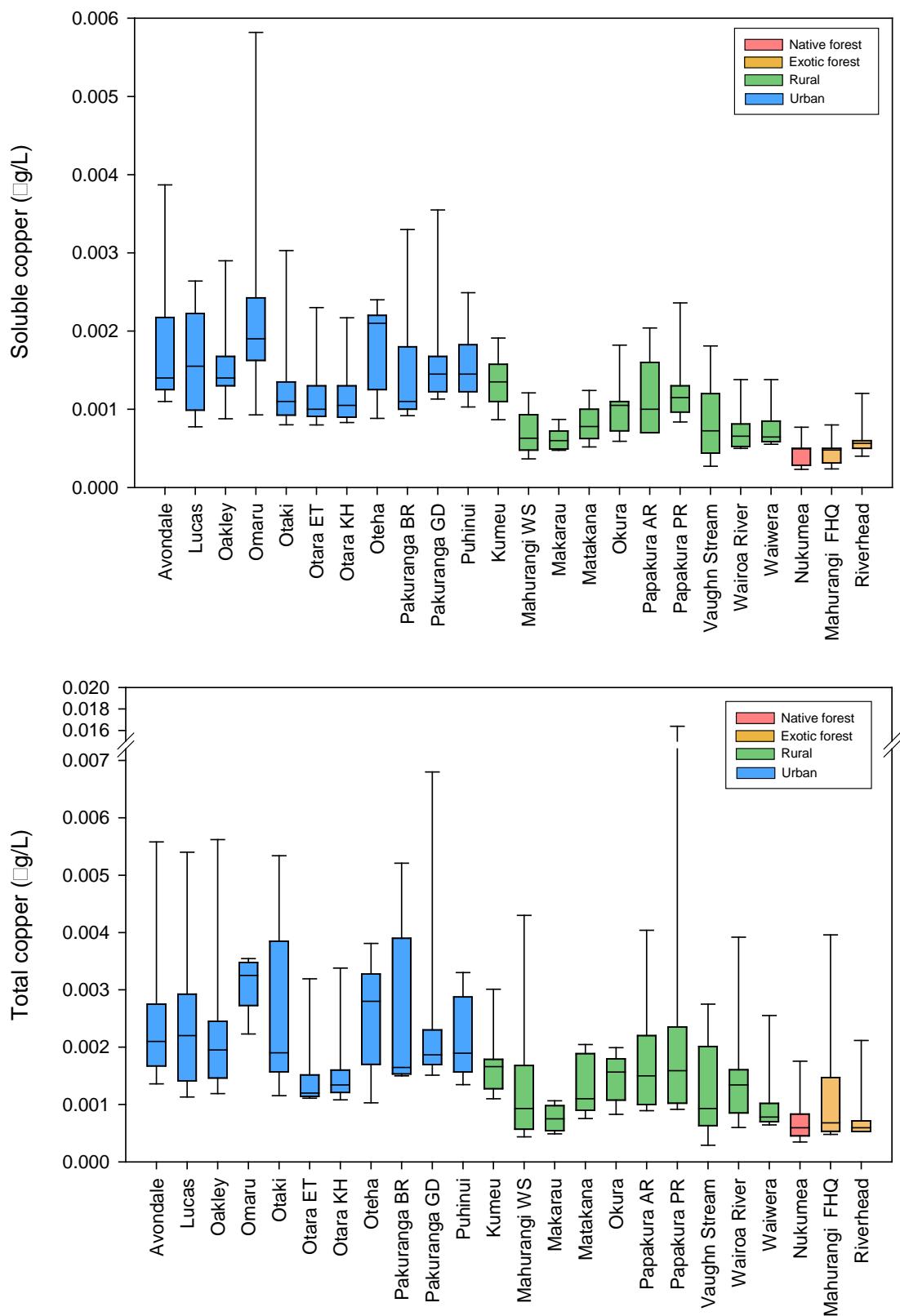


Figure 10: Box plots showing the variation in soluble copper (upper plot) and total copper (lower plot) at the 36 sites using data collected during the 2017 calendar year.

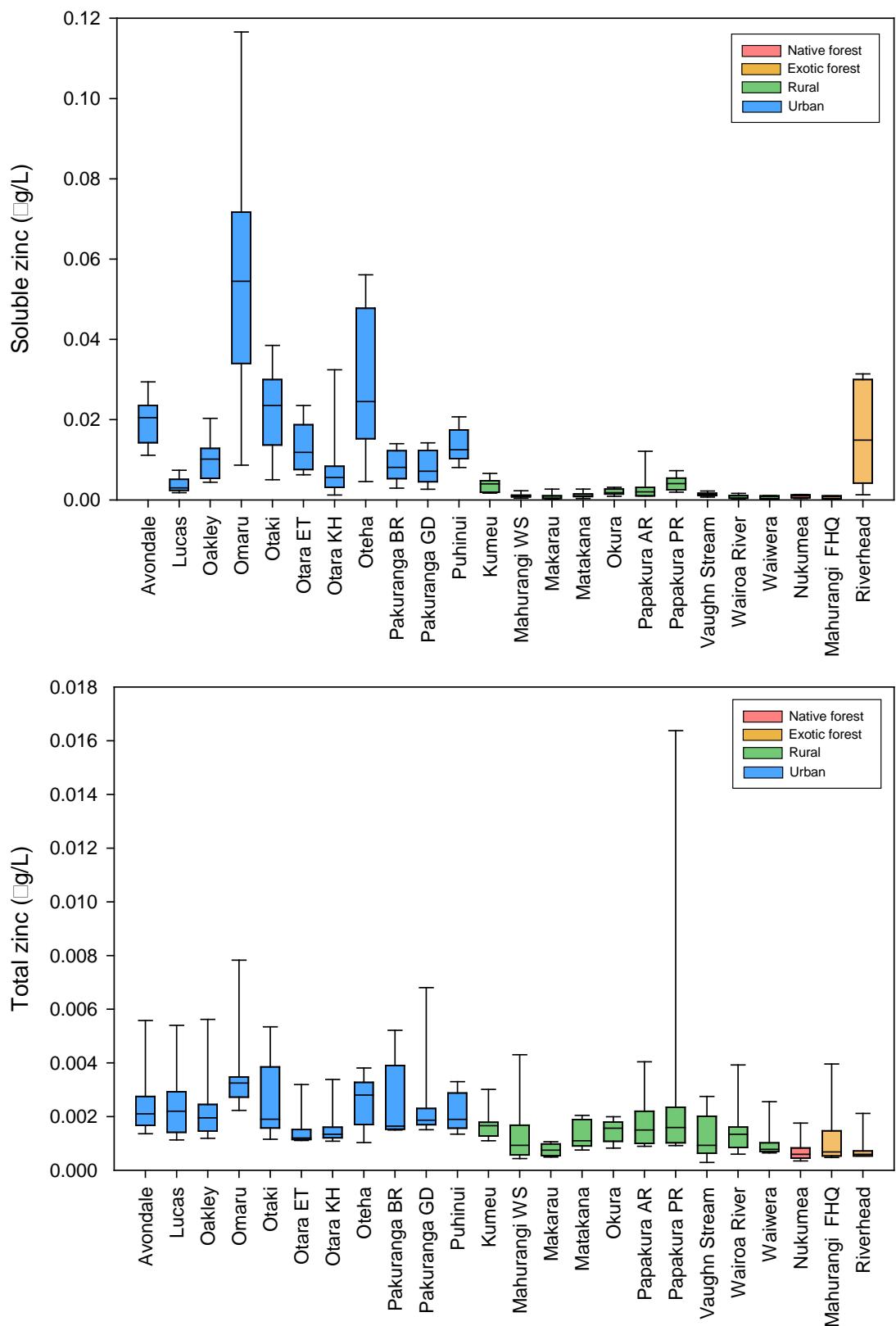


Figure 11: Box plots showing the variation in soluble zinc (upper plot) and total zinc (lower plot) at the 36 sites using data collected during the 2017 calendar year.

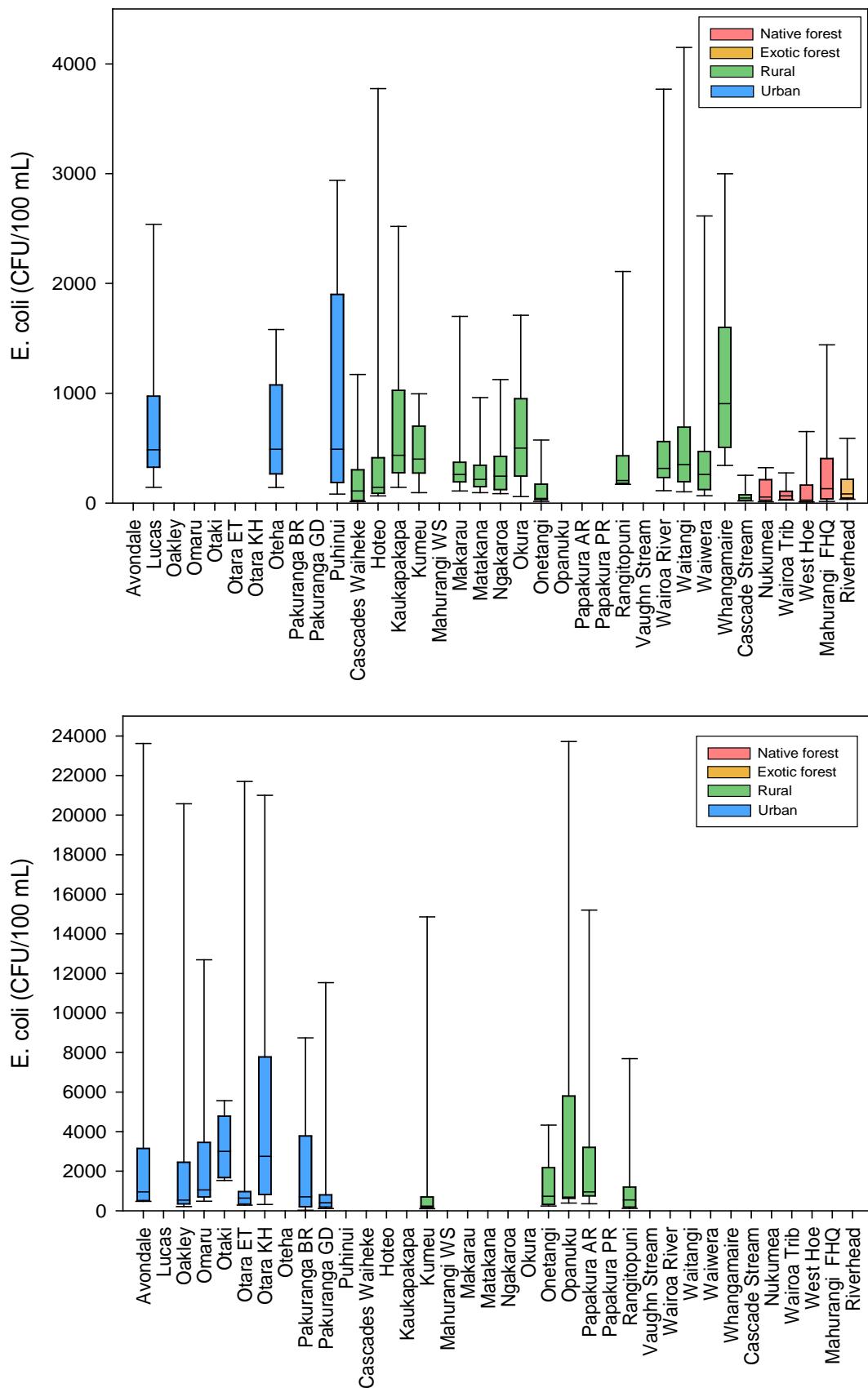


Figure 12: Box plots showing the variation in E.coli at sites with lower concentrations (upper plot) and higher concentrations (lower plot) using data collected during the 2017 calendar year.

3.1 Water Quality Index and classes

3.1.1 Water Quality Index methodology

The communication of water quality data can be a challenge due to the volume and complexity of the data. For this reason, a Water Quality Index (WQI) is calculated to provide a broad summary of the state of water quality at each site to enable improved understanding and communication of the generalised water quality state. We used a water quality index developed by the Canadian Council of Ministers for the Environment (CCME) (2001). This approach uses the water quality results of specific parameters to produce four water quality indices, from which a combined water quality class is then assigned.

The water quality indices are calculated for each site based on seven water quality parameters (Table 5). Baseline objective values, or thresholds for each of the seven parameters (Table 5), were derived from the data observed at three Auckland Council reference sites (Cascades Stream (Waitākere), Wairoa Tributary and West Hoe Stream) over the five years preceding this report (2010 to 2014). These reference sites represent water quality under natural or un-impacted environments in the Auckland region. Water quality data from all sites was tested against these thresholds to determine the relative deviation from natural conditions in the Auckland region.

Table 5: The seven water quality parameters, and their objectives, used to produce the CCME (2001) water quality index for Auckland state of environment river sites. The objectives are based on data from reference sites in the programme collected between 2010 and 2014.

Parameter	Objective (acceptable if...)
Dissolved oxygen (% saturation)	Between 84 and 105%
pH	Between 6.13 and 7.82
Turbidity	Less than 35 NTU
Ammoniacal nitrogen	Less than 0.036 mg N l ⁻¹
Temperature	Less than 17 °C
Total phosphorus	Less than 0.09 mg P l ⁻¹
Total nitrogen	Less than 0.53 mg N l ⁻¹

The CCME (2001) water quality index includes

- Scope – the percentage of parameters that failed to meet the objective at least once during the time period under consideration (the lower this index, the better).
- Frequency – the percentage of all individual tests that failed to meet the objective during the time period under consideration (the lower this index, the better).
- Magnitude – the amount by which failed tests exceeded the objective (the lower this index, the better). This is based on the collective amount by which individual tests are out of compliance with the objectives and is scaled to be between 1 and 100. This is the most complex part of the index derivation and the reader is referred to CCME (2001) for full details.

- WQI – an overall water quality index based on a combination of the above three indices:

$$WQI = 100 - [\{\sqrt{(\text{Scope}^2 + \text{Frequency}^2 + \text{Magnitude}^2)}\} \div 1.732]$$

**Note the divisor 1.732 normalises the results to a range between 0 and 100, with 0 being the “worst” possible water quality and 100 being the “best” possible water quality.*

A water quality “class” is then assigned to each site based on the following WQI ranges:

- Greater than 90 = “Excellent”
- Between 70 and 90 = “Good”
- Between 50 and 70 = “Fair”
- Lower than 50 = “Poor”

3.1.2 Water Quality Index results

Using the CCM (2001) methodology described above, water quality indices and classes were calculated for each of the 36 Auckland river state of the environment sites. The results are shown in Table 6 and Figure 13.

West Hoe Stream had the highest water quality index score in 2017 of 100 (Table 6). This was the only stream to have a class of “excellent”. Cascades Stream (Waitākere), Wairoa Tributary and Cascades Stream (Waiheke) all had WQI scores in the 80s (and were classed as “good”). All these are reference sites with native forest catchments with the exception of the Cascades Stream (Waiheke) which is a predominantly rural catchment located on Waiheke Island.

A total of nine sites were classed as “good”. Four of these were an improvement from 2016’s water quality index. In the case of the Waiwera Stream and Rangitopuni River this was an improvement by two water quality classes (poor to good). Five of these sites had catchments with predominantly rural land cover, three had native forest and one urban (Oteha Stream).

Eleven sites were classed as “fair”. All of these except two were a change from their respective 2016 water quality index class. Three sites (Mahurangi River FHQ), Vaughan Stream and Onetangi Stream) reduced from the “good” to “fair” class, while the remainder increased from the “poor” class. The majority of sites in the “fair” class have catchments with predominantly rural land use. There was also one urban site in this class (Puhinui Stream) and the two sites with exotic forest catchments (Mahurangi River (FHQ) and Riverhead Forest Stream).

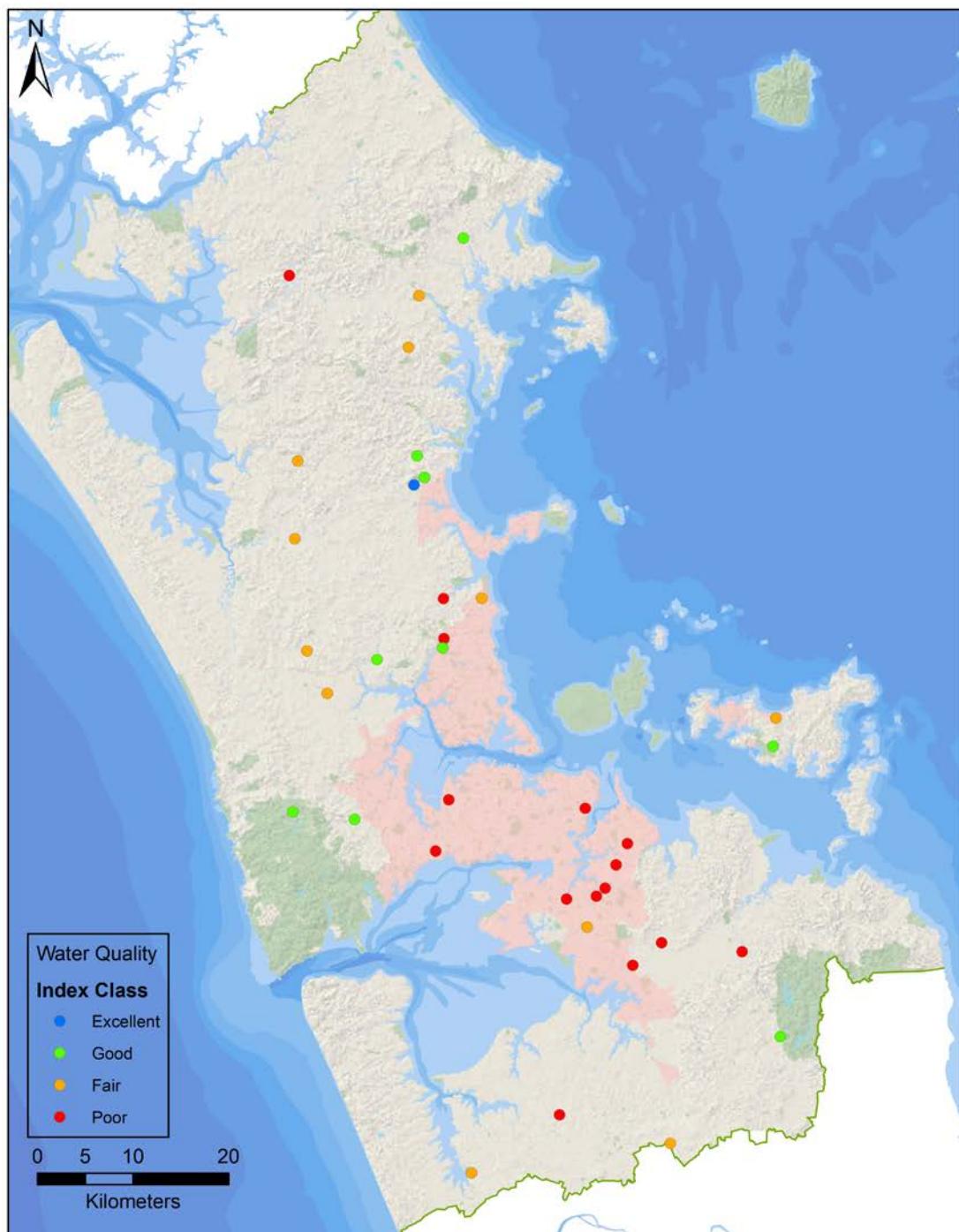
There were 15 sites within the “poor” water quality class. Seven of these were a continuation of the poor water class from 2016 and seven constituted a drop in class from “fair” to “poor”. There was one site, the Hoteo River that dropped two classes since 2016 from “good” to “poor”, however, the two years prior to that were also classed as “poor”. The majority of sites in the “poor” water quality class have urban catchments (nine) with the other six being rural

The CCMI (2001) water quality index has been used in Auckland to summarise results of the river water quality programme since 2007. The 2017 WQI classes for each site are shown in Table 6 along with the previous three years WQI scores. It is important to note that increases or decreases in the WQI scores over time do not indicate statistical and/or meaningful trends. For information on trends, refer to the most recent Auckland Council River Water Quality State and Trends Report on Knowledge Auckland:

<http://knowledgeauckland.org.nz/assets/publications/TR2016-008-River-water-quality-state-trends-Auckland-2005-2014.pdf>

Table 6: Water quality index scores (CCMI, 2001) since 2014 and narrative classes in 2017 for each site. The 2014, 2015 and 2016 WQI data are presented to provide context. Classes are indicated by colour: Blue = “Excellent”; Green = “Good”; Orange = “Fair”; Red = “Poor”.

Site	Land cover	2014	2015	2016	2017	2017 WQI Class
West Hoe Stream	Native forest	83.3	100	91.6	100.0	Excellent
Cascade Stream (Waitakere)	Native forest	91.7	91.7	74.9	83.4	Good
Wairoa Tributary	Native forest	100	100	83.4	83.2	Good
Cascades Stream (Waiheke)	Rural	100	75.1	58.1	82.5	Good
Nukumea Stream	Native forest	83.1	66.9	75.1	75.0	Good
Opanuku Stream	Rural	83.4	91.6	83.4	74.9	Good
Matakana River	Rural	83.1	74.8	83.3	74.8	Good
Waiwera Stream	Rural	74.3	66.3	49.4	74.3	Good
Oteha Stream	Urban	66	57.2	50.8	71.9	Good
Rangitopuni River	Rural	38.9	45.7	49.7	71.6	Good
Mahurangi River (Forestry HQ)	Exotic forest	75	66.1	83.4	66.5	Fair
Makarau River	Rural	75	64.8	49.2	65.8	Fair
Vaughan Stream	Rural	64.8	64	63.2	64.7	Fair
Kaukapakapa River	Rural	65.5	46.8	48	64.2	Fair
Kumeu River	Rural	64.5	45.4	38.8	63.1	Fair
Onetangi Stream	Rural	73.3	74.1	73.9	58.2	Fair
Riverhead Forest Stream	Exotic forest	79.4	81.3	49	57.4	Fair
Mahurangi River (Water Supply)	Rural	82.6	83.1	58.2	56.8	Fair
Ngakaroa Stream	Rural	59.3	64	49.4	56.7	Fair
Puhinui Stream	Urban	56.8	64.6	45.6	54.2	Fair
Waitangi River	Rural	62.2	66.6	58.3	50.5	Fair
Hoteo River	Rural	49.7	49.5	73.1	49.0	Poor
Wairoa River	Rural	66.3	82	56.6	48.6	Poor
Okura Creek	Rural	48.1	55.6	54.6	48.3	Poor
Lucas Creek	Urban	65.7	74.1	57.5	48.2	Poor
Oakley Creek	Urban	71.2	71.2	61.5	47.4	Poor
Omaru Creek	Urban	31.4	27.9	47.2	45.3	Poor
Otara Creek (East Tamaki)	Urban	61.6	72	27.1	43.5	Poor
Whangamaire Stream	Rural	45.2	42.6	30.9	42.8	Poor
Papakura Stream (Alfriston Rd)	Rural	47.5	47.4	53.7	40.7	Poor
Avondale Stream	Urban	55.4	64.2	63.3	40.3	Poor
Otaki Creek	Urban	41.8	35.4	31.5	40.1	Poor
Otara Creek (Kennel Hill)	Urban	47.9	56.9	39.3	37.9	Poor
Papakura Stream (Porchester Rd)	Rural	47.4	54.3	64	35.2	Poor
Pakuranga Creek (Botany Rd)	Urban	53.7	35.3	39.1	32.2	Poor
Pakuranga Creek (Greenmount Dr)	Urban	37	33.1	31.9	21.0	Poor



Water Quality Index Class 2017

Map Produced by
Research & Evaluation Unit.
Auckland Council



Figure 13: The River Water Quality Programme sampling sites for 2017 with labels coded by Water Quality Class.

Table 7: Mean 2017 water quality index scores and water quality class for all sites within a predominant land cover class. Mean WQI scores for each predominant land cover class are also presented for 2014, 2015 and 2016 to give context to the data.

Land Cover (number of sites)	Average WQI 2014	Average WQI 2015	Average WQI 2016	Average WQI 2017	Water Quality Class 2017
Native forest (4)	89.5	89	81.3	85.4	Good
Exotic forest (2)	77.2	74.4	66.2	61.9	Fair
Rural (19)	64.8	63.9	57.7	59.1	Fair
Urban (11)	53.5	52.1	45	43.8	Poor

4 Summary

This report summarises results from Auckland Council's long-term river water quality monitoring programme for 2017. Water quality was assessed monthly at 36 sites across the region using a combination of field and laboratory tested parameters. The results were presented as box plots to show variation within and between sites for each of the parameters. Note that comparison between-stations is subject to bias introduced by the sampling approach, notably for DO, pH and temperature.

A basic statistical summary of each parameter at each site was also presented (Appendix).

The data was also used to produce scores for the CCMI (2001) water quality index, which reduces data across multiple parameters into a single indication of water quality. Notably, the latter is not incorporated within the NPSFM national objective framework and useful for comparing between sites, but not otherwise linked to objectives or values for water quality as they are reported in New Zealand. Under the CCMI (2001) water quality index in 2017 the West Hoe stream had the highest score, followed by the Wairoa Tributary, Mahurangi River (Forestry HQ) and Opanuku Stream. A class of 'Poor' was observed in streams in a mix of urban and rural areas, as well as one exotic forest site. The Pakuranga Creek (Greenmount Drive) site was the worst ranked site in 2017 according to the CCMI (2001) approach.

5 Acknowledgements

The Auckland Council river water quality monitoring has benefitted from the efforts of numerous people since its inception in 1977.

During 2017 a number of Environmental Monitoring staff and students contributed to sample collection. Thanks go in particular to Luke Stanley and Maddison Jones for running the field programme. Laboratory analyses were carried out by Watercare Laboratory Services and Hills Laboratory.

The data from the Hoteo River site is used under licence from NIWA.

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7 Appendix: Summary tables

Table A1.1: Dissolved oxygen (% saturation)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	11	63.10	96.30	83.29	65.65	81.10	85.10	90.30	93.65
Cascade Stream	12	99.40	103.90	101.69	99.95	100.70	101.65	102.53	103.68
Cascades Stream (Waiheke)	12	89.40	100.50	96.12	91.88	94.73	96.40	97.38	100.39
Hoteo River (NIWA operated)	12	79.50	94.60	91.04	82.42	91.00	92.40	94.03	94.49
Kaukapakapa River	12	40.10	97.20	79.18	45.11	66.18	88.20	92.83	95.66
Kumeu River	12	63.20	103.20	86.61	69.53	81.00	90.85	91.60	97.54
Lucas Creek	12	72.80	101.30	90.57	73.79	88.00	93.10	96.55	99.98
Mahurangi River (Forestry HQ)	12	85.50	100.90	96.16	89.41	94.40	97.95	98.43	99.86
Mahurangi River (Water Supply)	12	86.90	100.50	95.10	86.90	93.38	96.00	98.45	99.79
Makarau River	12	89.80	117.80	103.51	92.66	101.30	103.25	106.08	114.23
Matakana River	12	78.80	99.20	92.41	83.04	89.03	94.30	96.55	98.05
Ngakaroa Stream	12	83.70	98.60	91.83	83.81	89.03	93.25	95.45	98.05
Nukumea Stream	12	64.10	89.70	85.13	73.34	86.25	87.05	88.05	89.70
Oakley Creek	11	76.90	98.80	91.63	80.25	88.20	94.90	96.60	98.25
Okura Creek	12	31.70	100.80	86.92	46.61	88.58	95.95	98.10	99.81
Omaru Creek	11	10.10	94.80	66.71	19.10	46.75	78.30	87.30	93.50
Onetangi Stream	12	70.60	93.90	85.36	72.91	80.03	88.65	90.20	92.03
Opanuku Stream	12	90.90	102.70	98.23	92.94	96.55	99.65	100.45	101.66
Otaki Creek	10	33.90	180.70	83.65	39.21	54.35	84.10	89.08	148.21
Otara Creek (East Tamaki)	11	94.00	119.00	109.18	98.75	105.15	110.60	113.45	116.55
Otara Creek (Kennel Hill)	11	89.00	124.60	106.24	95.20	103.35	104.90	110.15	117.75
Oteha Stream	12	66.00	96.40	85.56	70.29	79.48	85.85	94.70	96.35
Pakuranga Creek (Botany Rd)	11	109.00	159.90	127.08	111.00	118.10	127.10	133.00	147.45
Pakuranga Creek (Greenmount Rd)	11	78.40	125.20	96.72	80.85	88.25	93.60	105.35	117.40
Papakura Stream (Alfriston Rd)	11	43.60	91.80	76.77	54.80	69.35	82.80	85.95	89.55
Papakura Stream (Porchester Rd)	12	71.20	93.70	84.30	72.74	79.20	86.40	89.08	92.99
Puhinui Stream	12	72.50	131.90	106.03	84.33	99.03	106.20	111.18	131.52
Rangitopuni River	12	25.60	104.10	76.44	30.22	65.63	88.25	93.58	100.14
Riverhead Stream	12	29.90	97.40	71.91	36.39	60.78	82.25	86.05	92.51
Vaughan Stream	12	42.30	110.70	82.08	51.76	77.03	86.25	91.45	101.79
Wairoa Tributary	12	96.50	107.30	99.73	97.27	98.35	99.05	100.25	104.11
Wairoa River	12	91.10	112.20	99.12	93.36	96.70	98.15	100.70	107.25
Waitangi River	12	63.10	98.80	85.89	64.04	82.13	90.05	92.53	98.75
Waiwera River	12	67.10	99.20	91.43	70.13	88.45	97.15	98.45	99.20
West Hoe Stream	12	85.80	99.90	91.33	87.07	89.45	91.70	91.95	96.38
Whangamaire Stream	12	79.40	99.30	89.68	79.84	86.78	90.45	92.65	97.71

Table A1.2: Dissolved oxygen (mg/L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	11	6.020	10.32	8.500	6.305	8.165	8.670	9.285	10.07
Cascade Stream	12	9.580	11.550	10.60	9.789	10.20	10.65	10.97	11.30
Cascades Stream (Waiheke)	12	8.720	10.93	9.949	8.951	9.418	10.14	10.42	10.84
Hoteo River (NIWA operated)	12	7.300	10.30	9.125	7.355	8.400	9.300	9.975	10.30
Kaukapakapa River	12	3.710	10.80	8.089	4.222	6.205	8.875	9.970	10.53
Kumeu River	12	5.790	11.32	8.697	6.456	7.410	9.090	9.693	10.61
Lucas Creek	12	6.710	10.56	9.048	6.837	8.415	9.265	10.04	10.45
Mahurangi River (Forestry HQ)	12	8.050	11.00	9.934	8.540	9.335	10.09	10.75	10.92
Mahurangi River (Water Supply)	12	7.800	11.13	9.550	7.822	8.765	9.605	10.53	11.00
Makarau River	12	8.670	11.14	10.22	8.896	9.820	10.51	10.78	11.10
Matakana River	12	7.190	10.81	9.298	7.597	8.350	9.265	10.40	10.72
Ngakaroa Stream	12	7.920	11.15	9.389	8.047	8.258	9.615	10.04	10.79
Nukumea Stream	12	6.050	9.870	8.806	7.211	8.448	8.900	9.473	9.843
Oakley Creek	11	7.260	10.39	9.135	7.685	8.585	9.070	9.915	10.28
Okura Creek	12	3.060	10.96	9.009	4.584	8.443	9.680	10.63	10.94
Oamaru Creek	11	0.990	10.03	6.755	1.830	4.540	7.950	8.935	9.680
Onetangi Stream	12	6.830	10.16	8.790	7.105	7.885	9.220	9.455	9.885
Opanuku Stream	12	8.510	11.52	10.10	8.829	9.340	10.35	10.83	11.27
Otaki Creek	10	2.910	14.11	7.624	3.513	5.340	8.025	8.545	12.14
Otara Creek (East Tamaki)	11	8.520	11.55	10.37	9.255	10.09	10.62	10.75	11.21
Otara Creek (Kennel Hill)	11	8.180	11.24	10.41	8.960	10.18	10.86	10.92	11.18
Oteha Stream	12	6.160	10.45	8.580	6.606	7.460	8.715	9.868	10.32
Pakuranga Creek (Botany Rd)	11	9.500	12.62	11.31	9.940	10.78	11.32	11.92	12.56
Pakuranga Creek (Greenmount Rd)	11	7.020	10.81	9.043	7.490	8.070	9.130	9.825	10.75
Papakura Stream (Alfriston Rd)	11	4.160	10.45	7.806	5.075	6.405	8.270	9.040	9.930
Papakura Stream (Porchester Rd)	12	6.480	10.62	8.477	6.761	7.475	8.965	9.280	10.00
Puhinui Stream	12	6.240	12.12	10.18	7.577	9.628	10.26	11.30	12.09
Rangitopuni River	12	2.300	11.14	7.819	2.784	6.070	8.900	10.13	10.83
Riverhead Stream	12	2.900	10.40	7.553	3.560	5.843	8.525	9.498	10.10
Vaughan Stream	12	3.740	10.03	8.059	4.884	8.018	8.520	8.938	9.755
Wairoa Tributary	12	9.680	11.60	10.54	9.735	9.910	10.66	10.84	11.41
Wairoa River	12	8.530	11.640	9.936	8.585	9.433	10.12	10.36	11.17
Waitangi River	12	5.850	10.81	8.630	6.021	7.673	9.240	9.688	10.30
Waiwera River	12	6.010	10.88	9.172	6.450	8.140	9.775	10.47	10.85
West Hoe Stream	12	8.420	10.19	9.481	8.596	8.883	9.690	9.920	10.18
Whangamaire Stream	12	7.620	10.83	9.098	7.703	8.540	9.115	9.685	10.37

Table A1.3: Temperature (°C)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	11	11.43	19.18	14.67	11.54	13.00	14.63	16.20	18.38
Cascade Stream	12	10.67	17.12	13.58	10.98	11.76	13.24	15.40	16.50
Cascades Stream (Waiheke)	12	11.51	16.77	13.88	11.73	12.16	13.09	15.63	16.63
Hoteo River (NIWA operated)	12	11.70	22.50	16.02	11.81	12.35	15.20	19.57	21.84
Kaukapakapa River	12	10.63	19.41	15.17	11.08	11.93	15.19	18.27	19.23
Kumeu River	12	11.22	20.06	15.67	11.62	12.83	15.58	18.53	19.84
Lucas Creek	12	11.80	20.08	15.73	11.99	12.63	16.18	18.52	19.61
Mahurangi River (Forestry HQ)	12	10.23	18.24	14.08	10.64	11.48	13.88	16.93	17.91
Mahurangi River (Water Supply)	12	9.83	20.61	15.57	10.56	12.36	15.56	18.50	20.57
Makarau River	12	10.53	21.98	16.12	11.01	12.48	16.15	19.79	21.57
Matakana River	12	10.59	20.56	15.49	10.95	12.18	15.44	18.47	20.15
Ngakaroa Stream	12	9.88	19.25	14.62	10.11	12.85	14.38	17.09	18.62
Nukumea Stream	12	10.60	18.10	14.02	11.00	11.88	14.11	15.64	17.30
Oakley Creek	11	12.24	19.40	15.65	12.62	14.20	15.58	17.20	18.76
Okura Creek	12	10.45	18.32	14.14	10.51	11.32	14.65	16.37	17.59
Omaru Creek	11	11.28	20.30	15.38	11.39	13.61	15.63	17.06	19.02
Onetangi Stream	12	11.81	17.02	14.17	11.99	12.86	13.24	15.82	16.95
Opanuku Stream	12	10.26	18.49	14.30	10.72	11.44	13.53	17.38	18.37
Otaki Creek	10	12.17	23.46	17.95	13.33	15.84	18.01	20.09	22.53
Otara Creek (East Tamaki)	11	13.77	23.18	17.90	14.08	15.49	17.30	20.23	22.36
Otara Creek (Kennel Hill)	11	11.22	22.16	16.40	11.59	13.99	16.32	19.37	20.94
Oteha Stream	12	11.67	19.32	15.64	11.87	12.67	16.33	18.06	18.99
Pakuranga Creek (Botany Rd)	11	15.27	29.27	21.10	15.61	18.16	19.66	24.02	28.07
Pakuranga Creek (Greenmount Rd)	11	14.81	23.13	18.57	14.84	16.72	18.77	20.65	22.02
Papakura Stream (Alfriston Rd)	11	9.61	20.37	15.24	10.79	12.87	13.77	17.86	20.22
Papakura Stream (Porchester Rd)	12	9.80	19.95	15.54	10.99	13.09	15.44	18.43	19.71
Puhinui Stream	12	11.02	22.88	17.58	12.20	13.69	17.61	21.23	22.83
Rangitopuni River	12	11.01	20.60	15.46	11.26	12.22	15.12	18.98	19.77
Riverhead Stream	12	10.29	17.50	13.80	10.46	11.66	13.72	16.11	17.13
Vaughan Stream	12	11.75	21.21	16.34	12.19	13.40	16.79	18.72	20.84
Wairoa Tributary	12	9.27	16.53	12.93	9.59	11.61	12.59	14.87	15.93
Wairoa River	12	9.12	21.01	15.52	10.47	12.94	14.99	18.41	20.86
Waitangi River	12	11.25	19.36	15.51	11.45	13.58	15.26	18.06	19.34
Waiwera River	12	11.20	20.67	15.76	11.32	12.14	15.67	19.36	20.49
West Hoe Stream	12	10.86	16.28	13.74	11.21	11.99	13.83	15.24	16.27
Whangamaire Stream	12	11.36	18.60	14.88	11.41	13.33	14.74	16.72	18.17

Table A1.6: pH (pH units)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	11	6.03	7.20	6.93	6.21	6.97	7.28	7.13	7.19
Cascade Stream	12	7.02	7.91	7.58	7.09	7.37	7.68	7.80	7.90
Cascades Stream (Waiheke)	12	6.34	7.75	7.13	6.58	6.90	7.14	7.42	7.63
Hoteo River (NIWA operated)	12	6.96	7.80	7.52	7.15	7.428	7.52	7.70	7.78
Kaukapakapa River	12	6.84	7.33	7.08	6.86	6.90	7.08	7.24	7.30
Kumeu River	12	6.18	7.52	7.00	6.39	6.89	7.04	7.22	7.47
Lucas Creek	11	7.07	7.67	7.40	7.14	7.32	7.45	7.51	7.60
Mahurangi River (Forestry HQ)	11	6.98	8.48	7.40	7.00	7.24	7.32	7.47	8.01
Mahurangi River (Water Supply)	11	7.28	8.00	7.58	7.30	7.45	7.57	7.68	7.94
Makarau River	12	6.29	8.04	7.41	6.59	7.24	7.53	7.66	8.01
Matakana River	11	6.97	7.67	7.43	7.12	7.37	7.46	7.54	7.65
Ngakaroa Stream	12	6.90	7.42	7.16	6.91	7.05	7.23	7.26	7.37
Nukumea Stream	11	6.59	7.69	6.99	6.64	6.74	6.91	7.27	7.52
Oakley Creek	11	6.44	8.06	7.45	6.86	7.31	7.55	7.63	7.87
Okura Creek	11	6.81	7.56	7.29	6.86	7.19	7.34	7.48	7.53
Omaru Creek	11	6.73	7.59	7.33	6.81	7.13	7.52	7.55	7.58
Onetangi Stream	12	6.57	8.21	7.02	6.58	6.82	6.92	7.08	7.73
Opanuku Stream	12	6.93	7.56	7.28	7.00	7.15	7.31	7.41	7.51
Otaki Creek	10	6.80	7.73	7.22	6.82	7.04	7.24	7.36	7.67
Otara Creek (East Tamaki)	11	7.28	8.33	7.76	7.32	7.41	7.78	8.07	8.24
Otara Creek (Kennel Hill)	11	6.99	8.42	7.82	7.27	7.73	7.87	7.99	8.25
Oteha Stream	11	7.21	7.74	7.40	7.23	7.27	7.40	7.48	7.64
Pakuranga Creek (Botany Rd)	11	7.43	8.34	7.76	7.50	7.64	7.72	7.83	8.15
Pakuranga Creek (Greenmount Rd)	11	7.31	8.16	7.87	7.47	7.71	7.89	8.09	8.15
Papakura Stream (Alfriston Rd)	11	6.19	7.34	6.86	6.33	6.71	6.93	7.05	7.23
Papakura Stream (Porchester Rd)	12	5.52	7.15	6.62	5.74	6.44	6.77	6.96	7.13
Puhinui Stream	12	6.78	8.27	7.46	6.96	7.25	7.49	7.65	7.93
Rangitopuni River	12	6.51	7.73	7.09	6.56	6.94	7.17	7.24	7.49
Riverhead Stream	12	6.04	6.89	6.51	6.07	6.31	6.58	6.73	6.82
Vaughan Stream	10	6.99	7.70	7.25	7.02	7.08	7.23	7.37	7.56
Wairoa Tributary	12	6.69	7.82	7.42	6.70	7.38	7.53	7.64	7.77
Wairoa River	12	6.67	7.72	7.34	6.90	7.20	7.33	7.65	7.71
Waitangi River	12	5.99	7.47	7.05	6.47	6.95	7.14	7.26	7.37
Waiwera River	12	6.45	7.57	7.22	6.66	7.18	7.31	7.39	7.55
West Hoe Stream	11	6.37	7.60	6.89	6.42	6.53	6.94	7.07	7.50
Whangamaire Stream	12	6.66	7.32	7.11	6.76	6.99	7.22	7.25	7.29

Table A1.4: Conductivity (Millisiemens/cm @ 25°C)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	11	0.139	0.239	0.212	0.157	0.200	0.227	0.231	0.236
Cascade Stream	12	0.150	0.196	0.172	0.151	0.161	0.168	0.187	0.194
Cascades Stream (Waiheke)	12	0.141	0.243	0.205	0.146	0.195	0.217	0.225	0.239
Hoteo River (NIWA operated)	12	0.163	0.236	0.190	0.166	0.175	0.185	0.199	0.227
Kaukapakapa River	12	0.179	0.275	0.216	0.180	0.185	0.211	0.238	0.267
Kumeu River	12	0.146	0.211	0.174	0.151	0.163	0.166	0.187	0.208
Lucas Creek	12	0.170	0.316	0.247	0.190	0.214	0.247	0.277	0.307
Mahurangi River (Forestry HQ)	12	0.178	0.198	0.186	0.179	0.181	0.185	0.190	0.196
Mahurangi River (Water Supply)	12	0.143	0.255	0.189	0.146	0.164	0.178	0.204	0.255
Makarau River	12	0.173	0.238	0.201	0.173	0.178	0.191	0.230	0.236
Matakana River	12	0.149	0.236	0.183	0.152	0.163	0.175	0.202	0.229
Ngakaroa Stream	12	0.139	0.187	0.159	0.142	0.149	0.156	0.164	0.185
Nukumea Stream	12	0.145	0.337	0.191	0.153	0.169	0.182	0.191	0.264
Oakley Creek	11	0.092	0.887	0.293	0.147	0.228	0.265	0.269	0.580
Okura Creek	12	0.186	0.362	0.261	0.204	0.232	0.249	0.282	0.337
Oamaru Creek	11	0.255	0.473	0.335	0.258	0.267	0.357	0.372	0.439
Onetangi Stream	12	0.290	0.540	0.449	0.339	0.425	0.465	0.479	0.532
Opanuku Stream	12	0.138	0.170	0.150	0.138	0.140	0.146	0.158	0.166
Otaki Creek	10	0.258	24.357	7.344	0.275	0.350	5.148	10.439	21.354
Otara Creek (East Tamaki)	11	0.154	0.214	0.191	0.164	0.186	0.196	0.201	0.208
Otara Creek (Kennel Hill)	11	0.140	0.266	0.232	0.180	0.225	0.239	0.253	0.261
Oteha Stream	12	0.166	0.300	0.231	0.170	0.185	0.241	0.266	0.292
Pakuranga Creek (Botany Rd)	11	0.266	0.335	0.297	0.267	0.284	0.300	0.308	0.330
Pakuranga Creek (Greenmount Rd)	11	0.230	0.715	0.552	0.351	0.499	0.541	0.647	0.714
Papakura Stream (Alfriston Rd)	11	0.150	0.217	0.178	0.152	0.169	0.177	0.185	0.206
Papakura Stream (Porchester Rd)	12	0.157	0.218	0.188	0.161	0.179	0.182	0.203	0.216
Puhinui Stream	12	0.167	0.237	0.202	0.171	0.188	0.205	0.214	0.234
Rangitopuni River	12	0.165	0.284	0.222	0.182	0.201	0.219	0.242	0.270
Riverhead Stream	12	0.171	0.279	0.236	0.201	0.229	0.235	0.243	0.274
Vaughan Stream	12	0.226	5.539	0.740	0.240	0.259	0.304	0.343	2.729
Wairoa Tributary	12	0.076	0.135	0.109	0.089	0.100	0.110	0.117	0.129
Wairoa River	12	0.094	0.142	0.111	0.096	0.101	0.105	0.115	0.139
Waitangi River	12	0.175	0.229	0.199	0.182	0.192	0.196	0.202	0.222
Waiwera River	12	0.175	0.230	0.204	0.183	0.196	0.201	0.216	0.228
West Hoe Stream	12	0.152	0.203	0.178	0.154	0.164	0.178	0.194	0.202
Whangamaire Stream	12	0.240	0.339	0.286	0.244	0.277	0.284	0.303	0.324

Table A1.5: Salinity (ppt)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	11	0.070	0.110	0.101	0.075	0.095	0.110	0.110	0.110
Cascade Stream	12	0.070	0.090	0.081	0.070	0.078	0.080	0.090	0.090
Cascades Stream (Waiheke)	12	0.070	0.120	0.098	0.070	0.090	0.100	0.110	0.115
Kaukapakapa River	12	0.090	0.130	0.103	0.090	0.090	0.100	0.113	0.125
Kumeu River	12	0.070	0.100	0.083	0.070	0.080	0.080	0.090	0.100
Lucas Creek	12	0.080	0.150	0.118	0.091	0.100	0.115	0.133	0.145
Mahurangi River (Forestry HQ)	12	0.080	0.090	0.088	0.080	0.088	0.090	0.090	0.090
Mahurangi River (Water Supply)	12	0.070	0.120	0.090	0.070	0.080	0.085	0.095	0.120
Makarau River	12	0.080	0.110	0.095	0.080	0.088	0.090	0.110	0.110
Matakana River	12	0.070	0.110	0.088	0.070	0.080	0.085	0.093	0.110
Ngakaroa Stream	12	0.070	0.090	0.075	0.070	0.070	0.070	0.080	0.090
Nukumea Stream	12	0.070	0.160	0.091	0.076	0.080	0.085	0.090	0.127
Oakley Creek	11	0.040	0.440	0.142	0.070	0.105	0.130	0.130	0.285
Okura Creek	12	0.090	0.170	0.124	0.096	0.110	0.120	0.133	0.159
Omaru Creek	11	0.120	0.230	0.161	0.120	0.130	0.170	0.180	0.215
Onetangi Stream	12	0.140	0.260	0.218	0.162	0.205	0.225	0.233	0.260
Opanuku Stream	12	0.060	0.080	0.071	0.066	0.070	0.070	0.070	0.080
Otaki Creek	10	0.120	14.800	4.274	0.129	0.168	2.830	5.928	12.847
Otara Creek (East Tamaki)	11	0.070	0.100	0.090	0.075	0.090	0.090	0.095	0.100
Otara Creek (Kennel Hill)	11	0.070	0.130	0.111	0.085	0.110	0.110	0.120	0.125
Oteha Stream	12	0.080	0.140	0.110	0.080	0.088	0.115	0.130	0.140
Pakuranga Creek (Botany Rd)	11	0.130	0.160	0.143	0.130	0.135	0.140	0.150	0.155
Pakuranga Creek (Greenmount Rd)	11	0.110	0.350	0.268	0.170	0.240	0.260	0.315	0.350
Papakura Stream (Alfriston Rd)	11	0.070	0.100	0.083	0.070	0.080	0.080	0.090	0.095
Papakura Stream (Porchester Rd)	12	0.070	0.100	0.088	0.076	0.080	0.090	0.093	0.100
Puhinui Stream	12	0.080	0.110	0.096	0.080	0.088	0.100	0.103	0.110
Rangitopuni River	12	0.080	0.140	0.105	0.086	0.098	0.100	0.113	0.129
Riverhead Stream	12	0.080	0.130	0.112	0.097	0.110	0.110	0.113	0.130
Vaughan Stream	12	0.110	3.000	0.383	0.116	0.120	0.145	0.168	1.466
Wairoa Tributary	12	0.040	0.060	0.052	0.046	0.050	0.050	0.053	0.060
Wairoa River	12	0.040	0.070	0.053	0.046	0.050	0.050	0.053	0.065
Waitangi River	12	0.080	0.110	0.093	0.086	0.090	0.090	0.093	0.105
Waiwera River	12	0.080	0.110	0.096	0.086	0.090	0.095	0.100	0.110
West Hoe Stream	12	0.070	0.100	0.084	0.070	0.078	0.085	0.090	0.100
Whangamaire Stream	12	0.110	0.160	0.138	0.116	0.130	0.140	0.143	0.155

Table A1.7: Suspended sediment (mg/L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	4.40	60.00	14.88	4.73	5.75	7.60	15.25	46.25
Cascade Stream	12	0.50	5.80	2.74	0.78	2.10	3.00	3.00	4.81
Cascades Stream (Waiheke)	12	1.40	31.00	9.10	2.28	3.90	5.40	9.85	25.50
Kaukapakapa River	12	2.20	16.00	8.40	3.08	6.00	7.60	11.25	13.80
Kumeu River	12	2.80	36.00	9.52	3.24	5.35	7.00	9.75	22.80
Lucas Creek	12	1.20	71.00	12.53	1.86	2.95	5.10	12.00	43.50
Mahurangi River (Forestry HQ)	12	1.60	103.0	17.48	2.48	4.03	7.40	13.00	67.25
Mahurangi River (Water Supply)	12	2.00	175.0	23.22	2.00	2.85	3.60	9.25	111.2
Makarau River	12	1.40	15.00	4.87	1.51	2.75	3.50	6.15	11.15
Matakana River	12	3.00	13.00	6.25	3.00	4.30	4.90	6.50	12.45
Ngakaroa Stream	12	2.00	21.00	6.25	2.44	3.00	5.00	8.00	13.85
Nukumea Stream	12	1.30	380.0	37.24	1.69	2.95	3.40	5.50	188.1
Oakley Creek	12	1.70	38.00	7.66	1.98	3.00	3.10	4.50	28.65
Okura Creek	12	3.80	35.00	13.72	4.35	6.80	11.00	15.75	33.35
Omaru Creek	12	3.00	56.00	10.83	3.00	3.65	6.50	11.25	31.80
Onetangi Stream	12	4.80	18.00	8.92	4.91	6.50	7.80	10.50	15.80
Opanuku Stream	12	1.60	35.00	7.78	2.37	3.00	4.50	7.95	22.35
Otaki Creek	12	2.80	36.00	11.05	2.91	3.75	6.20	13.75	28.85
Otara Creek (East Tamaki)	12	2.40	16.00	4.08	2.40	2.85	3.00	3.05	9.73
Otara Creek (Kennel Hill)	12	4.00	73.00	12.85	4.22	5.75	6.40	10.00	40.55
Oteha Stream	12	0.80	15.00	6.25	1.57	2.95	4.80	8.25	14.45
Pakuranga Creek (Botany Rd)	12	2.40	87.00	12.78	2.73	3.60	4.30	8.30	49.05
Pakuranga Creek (Greenmount Rd)	12	3.00	120.0	15.02	3.55	5.00	5.60	6.15	58.62
Papakura Stream (Alfriston Rd)	11	6.70	39.00	17.50	6.85	7.70	9.00	29.00	39.00
Papakura Stream (Porchester Rd)	12	2.20	55.00	14.20	2.53	3.00	5.60	23.00	41.80
Puhinui Stream	12	2.00	22.00	7.20	2.11	3.15	4.00	8.75	18.70
Rangitopuni River	12	2.00	24.00	6.53	2.44	3.00	4.60	7.78	15.75
Riverhead Stream	12	0.80	8.40	4.03	1.46	2.95	3.00	5.38	7.52
Vaughan Stream	12	3.20	48.00	13.75	3.42	4.75	8.50	14.50	41.95
Wairoa Tributary	12	3.00	57.00	13.32	3.00	3.60	6.30	10.75	48.20
Wairoa River	12	2.00	89.00	17.55	2.33	5.75	11.00	16.00	56.00
Waitangi River	12	1.00	6.80	2.98	1.33	1.90	3.00	3.25	5.26
Waiwera River	12	2.00	23.00	6.08	2.66	3.90	4.10	6.25	14.20
West Hoe Stream	12	1.50	5.00	3.19	1.56	2.70	3.00	3.85	5.00
Whangamaire Stream	12	1.20	13.00	4.98	1.75	2.80	3.50	6.50	11.35

Table A1.8: Turbidity (NTU)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	6.60	45.0	15.13	7.98	9.83	10.50	15.70	34.00
Cascade Stream	12	0.95	9.3	4.34	1.14	2.17	3.55	6.88	9.14
Cascades Stream (Waiheke)	12	4.90	94.0	29.57	5.07	8.20	19.00	33.25	89.60
Hoteo River (NIWA operated)	12	2.16	54.30	14.95	2.94	5.86	9.54	17.35	42.48
Kaukapakapa River	12	2.50	22.0	10.23	2.89	7.33	8.80	13.60	19.09
Kumeu River	12	3.70	32.0	11.08	4.25	6.33	9.65	11.95	24.03
Lucas Creek	12	2.80	81.0	17.78	3.35	4.88	9.05	18.03	58.45
Mahurangi River (Forestry HQ)	12	5.60	132.0	25.14	6.04	7.93	10.55	25.25	85.25
Mahurangi River (Water Supply)	12	1.00	240.0	32.78	1.22	2.73	6.90	19.75	143.75
Makarau River	12	1.60	24.0	7.63	1.66	3.23	7.35	8.50	17.90
Matakana River	12	1.80	22.0	8.84	2.02	3.50	6.05	11.68	22.00
Ngakaroa Stream	12	1.30	17.6	6.31	1.47	3.03	4.05	8.20	15.62
Nukumea Stream	12	4.20	120.0	18.37	4.37	4.90	8.30	14.18	64.45
Oakley Creek	12	0.96	32.0	6.41	1.70	3.08	3.55	5.20	19.74
Okura Creek	12	6.40	46.0	20.23	6.51	10.75	13.85	29.00	45.45
Oamaru Creek	12	4.30	23.0	9.57	4.36	5.30	7.75	9.70	22.45
Onetangi Stream	12	6.30	56.0	18.13	6.63	8.93	10.35	19.13	51.05
Opanuku Stream	12	1.70	14.0	7.27	1.87	4.18	6.55	11.05	13.45
Otaki Creek	12	4.70	32.0	10.11	4.87	6.40	7.10	9.10	25.40
Otara Creek (East Tamaki)	12	1.42	25.0	5.17	1.68	2.30	2.95	4.48	15.27
Otara Creek (Kennel Hill)	12	3.50	90.0	16.05	3.56	6.18	9.80	13.30	50.46
Oteha Stream	12	1.60	24.0	10.58	2.04	4.10	8.55	14.65	24.00
Pakuranga Creek (Botany Rd)	12	5.30	102.0	16.08	5.47	6.23	7.35	10.48	55.25
Pakuranga Creek (Greenmount Rd)	12	3.60	75.0	13.41	4.15	5.43	8.25	10.65	40.63
Papakura Stream (Alfriston Rd)	11	8.60	85.0	28.13	9.50	11.20	18.00	41.50	66.50
Papakura Stream (Porchester Rd)	12	1.20	120.0	22.71	1.81	5.20	10.80	28.50	73.25
Puhinui Stream	12	2.00	28.0	9.49	2.11	3.23	6.10	13.00	24.15
Rangitopuni River	12	1.20	31.0	9.84	1.20	3.98	7.90	13.73	23.47
Riverhead Stream	12	3.60	23.0	8.70	3.82	4.48	5.75	12.25	19.15
Vaughan Stream	12	2.50	88.0	22.59	2.89	5.33	10.35	30.00	73.70
Wairoa Tributary	12	3.20	120.0	26.74	3.26	7.73	13.50	28.50	85.90
Wairoa River	12	1.40	100.0	26.91	1.84	7.98	22.00	34.50	67.00
Waitangi River	12	1.00	12.8	4.75	1.06	1.91	3.60	6.03	11.15
Waiwera River	12	2.10	32.0	9.53	2.16	5.35	7.70	11.68	21.66
West Hoe Stream	12	4.30	11.0	7.26	4.52	5.55	7.25	8.10	10.73
Whangamaire Stream	12	1.40	22.0	5.41	1.46	2.15	3.50	6.23	15.02

Table A1.9: Ammoniacal Nitrogen (mg N /L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.013	0.056	0.027	0.013	0.020	0.026	0.031	0.047
Cascade Stream	12	0.005	0.012	0.006	0.005	0.005	0.005	0.005	0.010
Cascades Stream (Waiheke)	12	0.005	0.015	0.007	0.005	0.005	0.006	0.008	0.014
Hoteo River (NIWA operated)	12	0.005	0.055	0.020	0.007	0.012	0.016	0.022	0.042
Kaukapakapa River	12	0.005	0.071	0.022	0.005	0.009	0.017	0.026	0.052
Kumeu River	12	0.005	0.080	0.027	0.005	0.014	0.023	0.032	0.062
Lucas Creek	12	0.005	0.063	0.019	0.005	0.005	0.014	0.026	0.050
Mahurangi River (Forestry HQ)	12	0.005	0.026	0.010	0.005	0.005	0.008	0.013	0.022
Mahurangi River (Water Supply)	12	0.005	0.036	0.012	0.005	0.005	0.009	0.014	0.029
Makarau River	12	0.005	0.019	0.009	0.005	0.005	0.007	0.012	0.017
Matakana River	12	0.005	0.018	0.008	0.005	0.005	0.005	0.010	0.016
Ngakaroa Stream	12	0.005	0.043	0.013	0.006	0.008	0.011	0.013	0.029
Nukumea Stream	12	0.005	0.015	0.007	0.005	0.005	0.005	0.008	0.012
Oakley Creek	12	0.005	0.055	0.013	0.005	0.005	0.006	0.012	0.043
Okura Creek	12	0.005	0.350	0.043	0.005	0.005	0.015	0.026	0.176
Oamaru Creek	12	0.005	1.000	0.136	0.005	0.009	0.038	0.081	0.587
Onetangi Stream	12	0.005	0.017	0.008	0.005	0.005	0.007	0.009	0.016
Opanuku Stream	12	0.005	0.022	0.010	0.005	0.005	0.008	0.012	0.020
Otaki Creek	12	0.040	1.020	0.192	0.041	0.062	0.087	0.218	0.613
Otara Creek (East Tamaki)	12	0.005	0.057	0.017	0.005	0.005	0.011	0.024	0.041
Otara Creek (Kennel Hill)	12	0.005	0.058	0.020	0.005	0.005	0.011	0.031	0.049
Oteha Stream	12	0.005	0.036	0.015	0.005	0.006	0.012	0.022	0.031
Pakuranga Creek (Botany Rd)	12	0.005	0.085	0.043	0.015	0.028	0.042	0.053	0.077
Pakuranga Creek (Greenmount Rd)	12	0.097	0.980	0.462	0.165	0.310	0.430	0.585	0.826
Papakura Stream (Alfriston Rd)	11	0.012	0.330	0.081	0.017	0.025	0.047	0.091	0.248
Papakura Stream (Porchester Rd)	12	0.005	0.096	0.050	0.007	0.023	0.055	0.072	0.095
Puhinui Stream	12	0.005	0.053	0.022	0.005	0.012	0.015	0.037	0.049
Rangitopuni River	12	0.005	0.032	0.015	0.005	0.010	0.015	0.021	0.028
Riverhead Stream	12	0.007	0.048	0.022	0.008	0.012	0.016	0.031	0.044
Vaughan Stream	12	0.005	0.021	0.008	0.005	0.005	0.005	0.009	0.019
Wairoa Tributary	12	0.005	0.023	0.009	0.005	0.005	0.009	0.011	0.018
Wairoa River	12	0.005	0.047	0.015	0.006	0.010	0.011	0.019	0.033
Waitangi River	12	0.005	0.026	0.010	0.005	0.005	0.007	0.013	0.023
Waiwera River	12	0.005	0.033	0.015	0.005	0.005	0.014	0.019	0.032
West Hoe Stream	12	0.005	0.017	0.006	0.005	0.005	0.005	0.005	0.012
Whangamaire Stream	12	0.005	0.168	0.032	0.005	0.006	0.014	0.032	0.115

Table A1.10: Total oxidised Nitrogen (mg N /L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.210	0.620	0.348	0.221	0.305	0.330	0.370	0.516
Cascade Stream	12	0.002	0.023	0.013	0.004	0.008	0.012	0.021	0.023
Cascades Stream (Waiheke)	12	0.066	0.178	0.136	0.094	0.119	0.135	0.158	0.174
Hoteo River (NIWA operated)	12	0.001	0.428	0.235	0.001	0.108	0.281	0.345	0.412
Kaukapakapa River	12	0.002	0.490	0.195	0.003	0.085	0.199	0.280	0.419
Kumeu River	12	0.140	0.730	0.366	0.157	0.213	0.340	0.483	0.626
Lucas Creek	12	0.118	4.700	0.639	0.141	0.228	0.280	0.340	2.335
Mahurangi River (Forestry HQ)	12	0.140	0.380	0.218	0.146	0.172	0.203	0.235	0.342
Mahurangi River (Water Supply)	12	0.002	0.230	0.121	0.002	0.053	0.159	0.175	0.225
Makarau River	12	0.002	0.270	0.102	0.002	0.006	0.055	0.203	0.270
Matakana River	12	0.002	0.470	0.070	0.002	0.005	0.029	0.058	0.283
Ngakaroa Stream	12	2.600	4.600	3.217	2.655	2.875	3.100	3.425	4.105
Nukumea Stream	12	0.001	0.024	0.007	0.002	0.003	0.005	0.008	0.020
Oakley Creek	12	0.370	2.000	1.228	0.574	1.118	1.300	1.458	1.714
Okura Creek	12	0.005	0.300	0.167	0.068	0.140	0.168	0.188	0.278
Oamaru Creek	12	0.002	2.000	0.809	0.016	0.224	0.950	1.210	1.615
Onetangi Stream	12	0.064	0.290	0.163	0.071	0.127	0.166	0.200	0.252
Opanuku Stream	12	0.032	0.980	0.189	0.039	0.108	0.120	0.151	0.544
Otaki Creek	12	0.320	3.300	1.353	0.408	0.685	1.385	1.650	2.536
Otara Creek (East Tamaki)	12	0.280	2.100	1.101	0.313	0.660	1.295	1.400	1.792
Otara Creek (Kennel Hill)	12	0.014	0.720	0.230	0.016	0.031	0.190	0.355	0.594
Oteha Stream	12	0.100	0.410	0.278	0.106	0.212	0.300	0.350	0.399
Pakuranga Creek (Botany Rd)	12	0.450	2.000	0.872	0.549	0.660	0.810	0.935	1.428
Pakuranga Creek (Greenmount Rd)	12	0.300	1.100	0.571	0.328	0.405	0.490	0.615	1.078
Papakura Stream (Alfriston Rd)	11	0.036	1.200	0.591	0.158	0.525	0.550	0.700	1.000
Papakura Stream (Porchester Rd)	12	0.028	1.800	0.536	0.052	0.142	0.490	0.723	1.223
Puhinui Stream	12	0.006	1.200	0.520	0.010	0.323	0.560	0.645	1.013
Rangitopuni River	12	0.002	0.330	0.134	0.002	0.061	0.130	0.202	0.281
Riverhead Stream	12	0.025	0.043	0.032	0.026	0.028	0.030	0.036	0.042
Vaughan Stream	12	0.001	0.370	0.104	0.002	0.007	0.093	0.131	0.272
Wairoa Tributary	12	0.032	0.096	0.057	0.034	0.048	0.059	0.065	0.081
Wairoa River	12	0.004	1.000	0.452	0.005	0.312	0.490	0.603	0.852
Waitangi River	12	0.900	3.700	2.658	1.450	2.500	2.750	3.050	3.425
Waiwera River	12	0.002	0.240	0.119	0.002	0.031	0.137	0.205	0.240
West Hoe Stream	12	0.001	0.005	0.003	0.001	0.002	0.004	0.005	0.005
Whangamaire Stream	12	8.400	16.000	12.817	9.830	11.850	12.600	14.300	15.450

Table A1.11: Total Nitrogen (mg N /L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.480	1.100	0.648	0.497	0.545	0.610	0.685	0.908
Cascade Stream	12	0.043	0.200	0.103	0.049	0.074	0.102	0.130	0.162
Cascades Stream (Waiheke)	12	0.220	0.940	0.438	0.226	0.275	0.350	0.560	0.852
Hoteo River (NIWA operated)	12	0.243	1.082	0.575	0.251	0.366	0.548	0.754	0.978
Kaukapakapa River	12	0.360	0.970	0.652	0.388	0.533	0.630	0.750	0.954
Kumeu River	12	0.490	1.200	0.765	0.534	0.620	0.715	0.813	1.195
Lucas Creek	12	0.340	5.400	0.985	0.351	0.475	0.570	0.658	3.079
Mahurangi River (Forestry HQ)	12	0.250	0.700	0.363	0.261	0.298	0.330	0.348	0.612
Mahurangi River (Water Supply)	12	0.200	2.100	0.528	0.206	0.270	0.340	0.548	1.358
Makarau River	12	0.200	0.570	0.358	0.211	0.263	0.330	0.465	0.537
Matakana River	12	0.180	0.660	0.301	0.191	0.218	0.265	0.340	0.523
Ngakaroa Stream	12	2.800	4.500	3.408	2.910	3.175	3.300	3.450	4.225
Nukumea Stream	12	0.063	0.230	0.123	0.072	0.094	0.115	0.138	0.207
Oakley Creek	12	0.560	2.100	1.470	0.846	1.288	1.565	1.700	1.930
Okura Creek	12	0.360	2.200	0.706	0.432	0.520	0.570	0.663	1.397
Oamaru Creek	12	0.640	2.600	1.362	0.734	0.993	1.430	1.570	2.105
Onetangi Stream	12	0.260	0.650	0.407	0.299	0.345	0.370	0.440	0.595
Opanuku Stream	12	0.155	1.300	0.364	0.174	0.225	0.270	0.373	0.821
Otaki Creek	12	0.620	3.700	1.857	0.884	1.255	1.750	2.175	3.150
Otara Creek (East Tamaki)	12	0.600	2.700	1.390	0.683	0.915	1.500	1.578	2.260
Otara Creek (Kennel Hill)	12	0.260	1.300	0.722	0.310	0.418	0.790	0.870	1.141
Oteha Stream	12	0.400	0.800	0.601	0.400	0.508	0.635	0.660	0.784
Pakuranga Creek (Botany Rd)	12	0.950	2.200	1.309	0.972	1.058	1.230	1.365	2.035
Pakuranga Creek (Greenmount Rd)	12	0.950	2.500	1.446	0.956	1.305	1.415	1.525	2.011
Papakura Stream (Alfriston Rd)	11	0.340	2.200	1.172	0.490	0.860	0.990	1.460	2.080
Papakura Stream (Porchester Rd)	12	0.470	3.100	1.124	0.525	0.668	1.060	1.205	2.226
Puhinui Stream	12	0.290	1.700	0.881	0.307	0.645	0.945	1.103	1.387
Rangitopuni River	12	0.450	0.910	0.618	0.450	0.530	0.600	0.695	0.817
Riverhead Stream	12	0.180	0.640	0.311	0.183	0.188	0.245	0.363	0.613
Vaughan Stream	12	0.290	0.800	0.468	0.296	0.325	0.455	0.538	0.718
Wairoa Tributary	12	0.074	0.360	0.153	0.078	0.094	0.136	0.184	0.272
Wairoa River	12	0.230	1.400	0.683	0.247	0.463	0.705	0.858	1.169
Waitangi River	12	1.200	3.900	2.992	1.860	2.775	3.150	3.250	3.900
Waiwera River	12	0.260	0.770	0.380	0.266	0.298	0.345	0.413	0.594
West Hoe Stream	12	0.041	0.130	0.076	0.044	0.057	0.065	0.090	0.128
Whangamaire Stream	12	9.200	17.00	13.08	10.03	11.73	12.75	14.63	16.45

Table A1.12: Soluble Reactive Phosphorus (mg P /L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.005	0.026	0.011	0.005	0.005	0.013	0.013	0.023
Cascade Stream	12	0.011	0.029	0.019	0.012	0.015	0.020	0.024	0.028
Cascades Stream (Waiheke)	12	0.004	0.025	0.012	0.004	0.006	0.011	0.016	0.024
Hoteo River (NIWA operated)	12	0.006	0.043	0.016	0.006	0.008	0.014	0.020	0.032
Kaukapakapa River	12	0.011	0.037	0.024	0.013	0.019	0.025	0.031	0.035
Kumeu River	12	0.004	0.027	0.015	0.005	0.008	0.015	0.022	0.025
Lucas Creek	12	0.002	0.020	0.009	0.002	0.004	0.009	0.014	0.019
Mahurangi River (Forestry HQ)	12	0.001	0.015	0.007	0.002	0.003	0.007	0.012	0.014
Mahurangi River (Water Supply)	12	0.004	0.022	0.013	0.005	0.009	0.012	0.018	0.021
Makarau River	12	0.005	0.019	0.011	0.005	0.007	0.012	0.015	0.018
Matakana River	12	0.003	0.019	0.009	0.003	0.006	0.007	0.013	0.018
Ngakaroa Stream	12	0.001	0.008	0.005	0.001	0.003	0.005	0.008	0.008
Nukumea Stream	12	0.001	0.014	0.007	0.002	0.002	0.006	0.009	0.014
Oakley Creek	12	0.020	0.039	0.028	0.021	0.024	0.028	0.032	0.036
Okura Creek	12	0.002	0.059	0.015	0.003	0.007	0.012	0.015	0.039
Oamaru Creek	12	0.012	0.420	0.058	0.013	0.015	0.019	0.033	0.229
Onetangi Stream	12	0.008	0.042	0.019	0.008	0.008	0.020	0.023	0.039
Opanuku Stream	12	0.004	0.099	0.017	0.005	0.006	0.011	0.015	0.053
Otaki Creek	12	0.009	0.110	0.032	0.010	0.012	0.016	0.030	0.102
Otara Creek (East Tamaki)	12	0.003	0.036	0.012	0.004	0.006	0.010	0.014	0.026
Otara Creek (Kennel Hill)	12	0.009	0.031	0.019	0.011	0.015	0.017	0.023	0.029
Oteha Stream	12	0.003	0.021	0.011	0.003	0.005	0.013	0.016	0.020
Pakuranga Creek (Botany Rd)	12	0.003	0.026	0.010	0.004	0.005	0.007	0.012	0.020
Pakuranga Creek (Greenmount Rd)	12	0.022	0.064	0.038	0.024	0.027	0.037	0.047	0.058
Papakura Stream (Alfriston Rd)	11	0.012	0.061	0.033	0.014	0.023	0.025	0.044	0.059
Papakura Stream (Porchester Rd)	12	0.009	0.057	0.028	0.012	0.021	0.025	0.035	0.048
Puhinui Stream	12	0.007	0.024	0.015	0.007	0.009	0.014	0.019	0.022
Rangitopuni River	12	0.007	0.031	0.017	0.009	0.013	0.017	0.020	0.026
Riverhead Stream	12	0.001	0.018	0.007	0.001	0.003	0.005	0.010	0.015
Vaughan Stream	12	0.003	0.026	0.012	0.003	0.006	0.011	0.016	0.023
Wairoa Tributary	12	0.011	0.045	0.021	0.012	0.015	0.017	0.019	0.044
Wairoa River	12	0.005	0.023	0.011	0.005	0.006	0.010	0.014	0.022
Waitangi River	12	0.004	0.020	0.010	0.005	0.006	0.009	0.012	0.019
Waiwera River	12	0.003	0.019	0.010	0.004	0.006	0.011	0.014	0.017
West Hoe Stream	12	0.002	0.014	0.007	0.002	0.003	0.006	0.010	0.013
Whangamaire Stream	12	0.003	0.019	0.011	0.005	0.008	0.010	0.015	0.018

Table A1.13: Total Phosphorus (mg P /L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.015	0.110	0.038	0.016	0.020	0.030	0.046	0.087
Cascade Stream	12	0.015	0.057	0.028	0.016	0.020	0.023	0.032	0.048
Cascades Stream (Waiheke)	12	0.012	0.081	0.036	0.016	0.024	0.034	0.044	0.068
Hoteo River (NIWA operated)	12	0.021	0.135	0.059	0.027	0.038	0.046	0.078	0.114
Kaukapakapa River	12	0.043	0.081	0.060	0.046	0.055	0.059	0.067	0.074
Kumeu River	12	0.032	0.080	0.051	0.035	0.043	0.052	0.058	0.071
Lucas Creek	12	0.019	0.099	0.036	0.020	0.027	0.032	0.036	0.069
Mahurangi River (Forestry HQ)	12	0.012	0.087	0.028	0.014	0.018	0.022	0.027	0.064
Mahurangi River (Water Supply)	12	0.018	0.360	0.066	0.020	0.025	0.038	0.044	0.217
Makarau River	12	0.021	0.072	0.032	0.022	0.025	0.030	0.032	0.053
Matakana River	12	0.015	0.048	0.032	0.019	0.025	0.031	0.036	0.048
Ngakaroa Stream	12	0.011	0.056	0.023	0.012	0.013	0.017	0.026	0.049
Nukumea Stream	12	0.005	0.025	0.014	0.007	0.009	0.012	0.017	0.023
Oakley Creek	12	0.035	0.160	0.054	0.037	0.042	0.045	0.046	0.107
Okura Creek	12	0.026	0.099	0.051	0.029	0.037	0.044	0.057	0.094
Oamaru Creek	12	0.027	0.720	0.136	0.030	0.038	0.062	0.140	0.462
Onetangi Stream	12	0.004	0.082	0.041	0.019	0.035	0.040	0.048	0.066
Opanuku Stream	12	0.009	0.130	0.034	0.011	0.016	0.023	0.046	0.084
Otaki Creek	12	0.040	0.330	0.102	0.046	0.055	0.066	0.101	0.270
Otara Creek (East Tamaki)	12	0.014	0.120	0.032	0.015	0.019	0.025	0.029	0.075
Otara Creek (Kennel Hill)	12	0.028	0.150	0.061	0.032	0.038	0.052	0.066	0.123
Oteha Stream	12	0.028	0.057	0.042	0.030	0.033	0.044	0.047	0.055
Pakuranga Creek (Botany Rd)	12	0.015	0.093	0.044	0.017	0.027	0.034	0.058	0.090
Pakuranga Creek (Greenmount Rd)	12	0.060	0.260	0.117	0.064	0.082	0.100	0.120	0.233
Papakura Stream (Alfriston Rd)	11	0.052	0.200	0.102	0.056	0.074	0.084	0.115	0.190
Papakura Stream (Porchester Rd)	12	0.046	0.190	0.083	0.047	0.062	0.070	0.093	0.148
Puhinui Stream	12	0.022	0.065	0.042	0.026	0.035	0.040	0.049	0.062
Rangitopuni River	12	0.036	0.075	0.050	0.037	0.040	0.048	0.053	0.073
Riverhead Stream	12	0.006	0.050	0.021	0.007	0.011	0.015	0.028	0.047
Vaughan Stream	12	0.021	0.072	0.040	0.022	0.028	0.034	0.052	0.070
Wairoa Tributary	12	0.023	0.062	0.039	0.025	0.029	0.034	0.048	0.061
Wairoa River	12	0.025	0.100	0.043	0.026	0.029	0.042	0.046	0.075
Waitangi River	12	0.014	0.110	0.036	0.015	0.016	0.027	0.037	0.091
Waiwera River	12	0.021	0.079	0.033	0.022	0.024	0.029	0.035	0.056
West Hoe Stream	12	0.006	0.035	0.015	0.007	0.010	0.013	0.019	0.027
Whangamaire Stream	12	0.013	0.064	0.027	0.013	0.016	0.022	0.035	0.055

Table A1.14: Soluble Copper (µg/L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	0.0011	0.0045	0.0018	0.0011	0.0014	0.0014	0.0021	0.0033	0.0011
Kumeu River	0.0008	0.0020	0.0013	0.0009	0.0011	0.0014	0.0015	0.0018	0.0008
Lucas Creek	0.0008	0.0027	0.0016	0.0008	0.0011	0.0016	0.0021	0.0026	0.0008
Mahurangi River (Forestry HQ)	0.0002	0.0008	0.0005	0.0003	0.0003	0.0005	0.0005	0.0008	0.0002
Mahurangi River (Water Supply)	0.0004	0.0013	0.0007	0.0004	0.0005	0.0006	0.0009	0.0011	0.0004
Makarau River	0.0005	0.0009	0.0006	0.0005	0.0005	0.0006	0.0007	0.0008	0.0005
Matakana River	0.0005	0.0013	0.0008	0.0005	0.0007	0.0008	0.0010	0.0012	0.0005
Nukumea Stream	0.0002	0.0008	0.0005	0.0002	0.0003	0.0005	0.0005	0.0007	0.0002
Oakley Creek	0.0007	0.0032	0.0016	0.0010	0.0013	0.0014	0.0016	0.0027	0.0007
Okura Creek	0.0006	0.0020	0.0010	0.0006	0.0008	0.0011	0.0011	0.0017	0.0006
Omara Creek	0.0006	0.0072	0.0023	0.0012	0.0017	0.0019	0.0023	0.0047	0.0006
Otaki Creek	0.0008	0.0036	0.0013	0.0008	0.0010	0.0011	0.0013	0.0026	0.0008
Otara Creek (East Tamaki)	0.0008	0.0026	0.0012	0.0008	0.0009	0.0010	0.0013	0.0021	0.0008
Otara Creek (Kennel Hill)	0.0008	0.0025	0.0012	0.0009	0.0009	0.0011	0.0013	0.0019	0.0008
Oteha Stream	0.0008	0.0024	0.0018	0.0010	0.0014	0.0021	0.0022	0.0024	0.0008
Pakuranga Creek (Botany Rd)	0.0009	0.0039	0.0015	0.0009	0.0010	0.0011	0.0016	0.0028	0.0009
Pakuranga Creek (Greenmount Rd)	0.0011	0.0043	0.0017	0.0012	0.0013	0.0015	0.0016	0.0029	0.0011
Papakura Stream (Alfriston Rd)	0.0007	0.0021	0.0012	0.0007	0.0007	0.0010	0.0016	0.0020	0.0007
Papakura Stream (Porchester Rd)	0.0008	0.0026	0.0013	0.0009	0.0011	0.0012	0.0013	0.0022	0.0008
Puhinui Stream	0.0010	0.0027	0.0016	0.0011	0.0013	0.0015	0.0017	0.0023	0.0010
Riverhead Stream	0.0004	0.0014	0.0006	0.0004	0.0005	0.0006	0.0006	0.0010	0.0004
Vaughan Stream	0.0002	0.0019	0.0009	0.0003	0.0005	0.0007	0.0012	0.0017	0.0002
Wairoa River	0.0005	0.0015	0.0007	0.0005	0.0006	0.0007	0.0007	0.0013	0.0005
Waiwera River	0.0006	0.0015	0.0008	0.0006	0.0006	0.0006	0.0008	0.0013	0.0006

Table A1.15: Total Copper (µg/L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.0013	0.0066	0.0025	0.0014	0.0017	0.0021	0.0027	0.0047
Kumeu River	12	0.0011	0.0034	0.0017	0.0011	0.0014	0.0017	0.0017	0.0027
Lucas Creek	12	0.0011	0.0060	0.0024	0.0012	0.0014	0.0022	0.0028	0.0049
Mahurangi River (Forestry HQ)	12	0.0005	0.0048	0.0012	0.0005	0.0006	0.0007	0.0012	0.0033
Mahurangi River (Water Supply)	12	0.0004	0.0049	0.0014	0.0004	0.0006	0.0009	0.0016	0.0038
Makarau River	12	0.0005	0.0011	0.0008	0.0005	0.0006	0.0008	0.0010	0.0011
Matakana River	12	0.0007	0.0021	0.0013	0.0008	0.0009	0.0011	0.0019	0.0020
Nukumea Stream	12	0.0003	0.0021	0.0007	0.0004	0.0005	0.0006	0.0007	0.0015
Oakley Creek	12	0.0011	0.0067	0.0023	0.0013	0.0015	0.0020	0.0024	0.0047
Okura Creek	12	0.0008	0.0020	0.0014	0.0008	0.0011	0.0016	0.0017	0.0020
Omara Creek	12	0.0022	0.0093	0.0037	0.0023	0.0030	0.0033	0.0034	0.0066
Otaki Creek	12	0.0011	0.0054	0.0025	0.0012	0.0016	0.0019	0.0030	0.0053
Otara Creek (East Tamaki)	12	0.0011	0.0039	0.0015	0.0011	0.0011	0.0012	0.0015	0.0026
Otara Creek (Kennel Hill)	12	0.0010	0.0040	0.0016	0.0011	0.0012	0.0013	0.0016	0.0029
Oteha Stream	12	0.0010	0.0039	0.0026	0.0011	0.0019	0.0028	0.0032	0.0037
Pakuranga Creek (Botany Rd)	12	0.0015	0.0053	0.0025	0.0015	0.0016	0.0016	0.0031	0.0051
Pakuranga Creek (Greenmount Rd)	12	0.0015	0.0086	0.0025	0.0015	0.0018	0.0019	0.0023	0.0053
Papakura Stream (Alfriston Rd)	11	0.0009	0.0043	0.0018	0.0009	0.0011	0.0015	0.0022	0.0037
Papakura Stream (Porchester Rd)	12	0.0009	0.0210	0.0035	0.0009	0.0012	0.0016	0.0023	0.0125
Puhinui Stream	12	0.0013	0.0033	0.0021	0.0014	0.0016	0.0019	0.0026	0.0033
Riverhead Stream	12	0.0005	0.0027	0.0008	0.0005	0.0005	0.0006	0.0007	0.0016
Vaughan Stream	12	0.0003	0.0029	0.0013	0.0003	0.0007	0.0009	0.0018	0.0026
Wairoa River	12	0.0006	0.0047	0.0015	0.0006	0.0009	0.0013	0.0015	0.0033
Waiwera River	12	0.0006	0.0032	0.0010	0.0007	0.0007	0.0008	0.0010	0.0020

Table A1.16: Soluble Zinc (µg/L)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.0102	0.0300	0.0196	0.0119	0.0148	0.0205	0.0225	0.0289
Kumeu River	12	0.0016	0.0067	0.0038	0.0018	0.0020	0.0040	0.0047	0.0065
Lucas Creek	12	0.0017	0.0076	0.0038	0.0019	0.0024	0.0030	0.0048	0.0072
Mahurangi River (Forestry HQ)	12	0.0003	0.0010	0.0007	0.0003	0.0004	0.0008	0.0010	0.0010
Mahurangi River (Water Supply)	12	0.0004	0.0025	0.0011	0.0005	0.0008	0.0010	0.0011	0.0021
Makarau River	12	0.0003	0.0034	0.0010	0.0003	0.0004	0.0010	0.0010	0.0021
Matakana River	12	0.0004	0.0029	0.0012	0.0004	0.0009	0.0010	0.0015	0.0025
Nukumea Stream	12	0.0003	0.0014	0.0009	0.0004	0.0007	0.0010	0.0012	0.0013
Oakley Creek	12	0.0043	0.0230	0.0100	0.0045	0.0055	0.0102	0.0123	0.0181
Okura Creek	12	0.0007	0.0032	0.0020	0.0011	0.0016	0.0018	0.0023	0.0031
Omara Creek	12	0.0081	0.1250	0.0558	0.0091	0.0440	0.0545	0.0633	0.1096
Otaki Creek	12	0.0030	0.0400	0.0226	0.0067	0.0150	0.0235	0.0300	0.0373
Otara Creek (East Tamaki)	12	0.0060	0.0250	0.0134	0.0065	0.0083	0.0119	0.0183	0.0223
Otara Creek (Kennel Hill)	12	0.0010	0.0330	0.0093	0.0014	0.0032	0.0056	0.0076	0.0319
Oteha Stream	12	0.0043	0.0570	0.0285	0.0048	0.0158	0.0245	0.0393	0.0554
Pakuranga Creek (Botany Rd)	12	0.0028	0.0140	0.0085	0.0030	0.0059	0.0081	0.0110	0.0140
Pakuranga Creek (Greenmount Rd)	12	0.0021	0.0143	0.0080	0.0031	0.0046	0.0072	0.0108	0.0141
Papakura Stream (Alfriston Rd)	11	0.0010	0.0140	0.0032	0.0010	0.0014	0.0020	0.0030	0.0093
Papakura Stream (Porchester Rd)	12	0.0018	0.0079	0.0041	0.0021	0.0026	0.0041	0.0048	0.0067
Puhinui Stream	12	0.0075	0.0210	0.0136	0.0085	0.0109	0.0125	0.0172	0.0205
Riverhead Stream	12	0.0003	0.0320	0.0158	0.0021	0.0052	0.0149	0.0300	0.0309
Vaughan Stream	12	0.0006	0.0024	0.0014	0.0008	0.0011	0.0014	0.0016	0.0021
Wairoa River	12	0.0003	0.0017	0.0009	0.0003	0.0007	0.0010	0.0010	0.0016
Waiwera River	12	0.0003	0.0011	0.0007	0.0003	0.0003	0.0009	0.0010	0.0010

Table A1.17: Total Zinc ($\mu\text{g/L}$)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	0.0149	0.0400	0.0257	0.0162	0.0218	0.0240	0.0308	0.0367
Kumeu River	12	0.0029	0.0123	0.0055	0.0030	0.0031	0.0055	0.0062	0.0104
Lucas Creek	12	0.0026	0.0240	0.0079	0.0032	0.0038	0.0050	0.0081	0.0204
Mahurangi River (Forestry HQ)	12	0.0004	0.0105	0.0021	0.0005	0.0009	0.0012	0.0019	0.0065
Mahurangi River (Water Supply)	12	0.0011	0.0146	0.0037	0.0012	0.0015	0.0019	0.0049	0.0098
Makarau River	12	0.0003	0.0057	0.0014	0.0005	0.0010	0.0012	0.0013	0.0034
Matakana River	12	0.0009	0.0050	0.0023	0.0009	0.0011	0.0020	0.0033	0.0045
Nukumea Stream	12	0.0007	0.0080	0.0019	0.0008	0.0011	0.0012	0.0017	0.0046
Oakley Creek	11	0.0056	0.0390	0.0160	0.0059	0.0076	0.0150	0.0162	0.0370
Okura Creek	12	0.0015	0.0065	0.0038	0.0022	0.0030	0.0034	0.0049	0.0059
Omara Creek	12	0.0240	0.1380	0.0754	0.0350	0.0613	0.0730	0.0853	0.1281
Otaki Creek	12	0.0183	0.0640	0.0353	0.0192	0.0240	0.0320	0.0420	0.0591
Otara Creek (East Tamaki)	12	0.0092	0.0310	0.0179	0.0102	0.0133	0.0167	0.0205	0.0305
Otara Creek (Kennel Hill)	12	0.0037	0.0530	0.0146	0.0043	0.0058	0.0099	0.0113	0.0464
Oteha Stream	12	0.0085	0.0780	0.0386	0.0093	0.0220	0.0320	0.0510	0.0775
Pakuranga Creek (Botany Rd)	12	0.0085	0.0340	0.0174	0.0092	0.0110	0.0142	0.0214	0.0313
Pakuranga Creek (Greenmount Rd)	12	0.0064	0.0240	0.0151	0.0073	0.0102	0.0165	0.0189	0.0224
Papakura Stream (Alfriston Rd)	11	0.0017	0.0200	0.0063	0.0018	0.0029	0.0040	0.0078	0.0165
Papakura Stream (Porchester Rd)	12	0.0025	0.0300	0.0089	0.0027	0.0035	0.0060	0.0100	0.0234
Puhinui Stream	12	0.0120	0.0350	0.0210	0.0124	0.0153	0.0210	0.0240	0.0323
Riverhead Stream	12	0.0023	0.0340	0.0178	0.0040	0.0062	0.0181	0.0298	0.0329
Vaughan Stream	12	0.0011	0.0069	0.0030	0.0013	0.0018	0.0026	0.0033	0.0067
Wairoa River	12	0.0006	0.0120	0.0032	0.0008	0.0015	0.0024	0.0035	0.0079
Waiwera River	12	0.0007	0.0037	0.0014	0.0007	0.0010	0.0012	0.0014	0.0026

Table A1.20: *Escherichia coli* (cfu/100ml)

Site	Count	Min	Max	Mean	5th %ile	25 th %ile	Median	75 th %ile	95th %ile
Avondale Stream	12	460	31000	4079	482	530	950	2650	17470
Cascade Stream	12	18	300	71	18	28	46	67	212
Cascades Stream (Waiheke)	12	10	1500	252	15	28	110	288	895
Hoteo River (NIWA operated)	12	56	5172	626	72	91	144	411	2612
Kaukapakapa River	12	94	2700	760	185	285	435	675	2370
Kumeu River	12	84	1100	487	104	298	400	700	908
Lucas Creek	12	81	3200	757	196	375	485	918	1990
Mahurangi River (Forestry HQ)	12	10	1800	322	19	41	130	375	1140
Mahurangi River (Water Supply)	12	94	19000	2260	108	190	235	633	11410
Makarau River	12	96	2000	446	120	198	260	330	1450
Matakana River	12	70	1200	306	114	150	215	335	760
Ngakaroa Stream	12	80	1200	372	91	128	245	415	1063
Nukumea Stream	12	9	340	111	13	42	55	178	307
Oakley Creek	12	180	26000	3432	235	423	540	1350	16045
Okura Creek	12	27	1800	665	84	335	500	850	1635
Oamaru Creek	12	420	15000	3005	530	700	1050	3350	10765
Onetangi Stream	12	8	700	126	20	34	42	96	469
Opanuku Stream	12	230	4600	1387	252	345	730	2125	4105
Otaki Creek	12	1500	5800	3217	1555	1825	3000	4525	5360
Otara Creek (East Tamaki)	12	270	28000	3386	298	340	640	923	16450
Otara Creek (Kennel Hill)	12	140	24000	5766	470	883	2750	7325	18500
Oteha Stream	12	99	1700	660	177	275	490	1025	1480
Pakuranga Creek (Botany Rd)	12	25	10000	2088	31	375	700	1925	7690
Pakuranga Creek (Greenmount Rd)	12	110	16000	1728	116	188	400	660	7805
Papakura Stream (Alfriston Rd)	11	350	28000	4487	455	640	690	5200	17300
Papakura Stream (Porchester Rd)	11	260	16000	3592	490	790	950	2850	14000
Puhinui Stream	12	60	3300	977	99	263	490	1700	2640
Rangitopuni River	12	170	2700	483	170	180	205	350	1617
Riverhead Stream	12	31	700	160	36	46	83	165	497
Vaughan Stream	12	100	10000	1473	139	200	545	1200	5765
Wairoa Tributary	12	25	280	92	28	33	65	83	269
Wairoa River	12	110	4400	817	116	258	315	540	3245
Waitangi River	12	90	5500	833	112	245	350	670	3025
Waiwera River	12	60	3500	544	72	168	260	423	1878
West Hoe Stream	12	9	800	133	9	16	26	148	525
Whangamaire Stream	12	300	3300	1198	377	623	905	1400	2750

Find out more: phone 09 301 0101, email
rimu@aucklandcouncil.govt.nz or visit
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