

State of the Environment Monitoring: River Water Quality Annual Report 2014

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State of the Environment Monitoring: River Water Quality Annual Report 2014

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Executive summary

The Auckland Council operates a long-term river water quality monitoring programme throughout the region. The objectives of this monitoring include state of the environment reporting, identification of major environmental issues and the assessment of the efficacy of council policy initiatives and strategies. This report documents any changes to the monitoring programme and provides a summary of the data collected during 2014.

Water quality is assessed monthly at 36 sites around the region using a combination of field based and laboratory tested parameters. The results are presented as box plots, which display the variation in the measured parameters at each of the sites, and in tables, which provide a statistical summary of each parameter at each of the sites.

Water quality indices and classes were produced to show the complex water quality data in a simple form. In 2014 the rivers with the highest ranked water quality class were the Cascades Stream (Whakanewha) and Wairoa Tributary, followed by the Cascades Stream (Waitakere). These were the only three sites classified as having 'excellent' water quality in 2014. Poor water quality was observed in streams with a mix of urban and rural catchment land-use, with Omaru Creek having the lowest ranked water quality.

1 Introduction

1.1 Auckland's rivers

The Auckland region has an estimated 16,500 km of permanently flowing rivers, which increases to 28,240 km when intermittent and ephemeral rivers are included (Storey and Wadhwa, 2009). As no mainland location in the region is greater than 20 km from the coast, the catchment areas of each river are relatively small. Most rivers are less than a few metres wide and reach the sea before they merge with others to form larger rivers.

The relatively gentle topography of the Auckland region and the underlying geology also have a profound influence on the nature of the rivers, usually resulting in slow flowing, low gradient rivers with soft substrate beds. Fast flowing, high gradient rivers with hard stony substrates are mostly restricted to catchments that drain the Waitakere or Hunua Ranges.

1.2 Water quality

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

At a given point in a river, water quality is a function of the temperature, amount of nutrients, oxygen, sediment and other pollutants in the water, and is dependent upon many factors of its catchment. In the absence of human influences, these factors 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 River Environment Classification (REC) (Snelder *et al.*, 2004) classified each river in New Zealand by the land cover in its catchment, as this is known to affect the quality and quantity of water, the types of ecological habitats and flow patterns in the river. The classification used is based on the following land cover classes;

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

The majority (63%) of rivers within the Auckland region drain non-forested rural catchments (pastoral farming, horticulture and rural residential), followed by native forest catchments (21%), with exotic forest and urban catchments accounting for 8% each (Table 1).

The catchment land cover of rivers within the Auckland region is quite different from New Zealand as a whole (Table 1). Auckland's high population density means that a greater percentage of the region's rivers are classed as 'urban' compared to New Zealand overall, and are subsequently impacted by the associated environmental pressures.

Table 1

Catchment land cover for rivers in Auckland and New Zealand.

	% of rivers				
Land cover	Auckland	New Zealand			
Rural	63	43			
Native forest (inc. alpine)	21	51			
Exotic forest	8	5			
Urban	8	1			

1.3 Auckland Council's freshwater quality monitoring programmes

Under the Resource Management Act 1991 (RMA) Auckland Council is required to 'monitor the state of the whole or any part of the environment to the extent that is appropriate to enable the local authorities to effectively carry out its functions under the RMA' (Section 35 (2a) of the RMA). The State of the Environment monitoring and reporting programmes fulfil this requirement. One of the objectives of the Auckland Council's freshwater State of the Environment monitoring programme is to describe the quality of the region's freshwater resources through assessment and evaluation of environmental stressors and the efficacy of council's policy initiatives and management approaches. As such, the council's freshwater resource using a combination of physical, chemical and biological measures. The Auckland Council operates four monitoring programme, which is the focus of this report, and also the River Ecology, Lakes Water Quality and Groundwater Monitoring programmes, which are all reported on elsewhere.

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. This monitoring provides information on the temperature, amounts of nutrients, oxygen, sediment and other variables in the sampled rivers. The results enable Auckland Council to assess the life-supporting capacity of the river and its suitability for human use.

The River Water Quality Programme initially commenced with 8 sites in 1977-78 and ran until 1981; it was re-started with 17 sites in 1986 and has been running continuously ever since. The programme has evolved throughout its duration, with sites added or moved according to requirements. The programme was last reviewed in 2008 and subsequent changes were described in the 2009 Annual Report (Neale, 2010). Between 2009 and 2011 31 sites were 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, and data is used to provide information for the freshwater report cards (see http://stateofauckland.aucklandcouncil.govt.nz/). It should

be noted that two of the sites are monitored by the National Institute for Water and Atmospheric Research (NIWA) as part of the National River Water Quality Network (NRWQN).

The monitoring programme is regionally representative in that it monitors all sizes and types of rivers, and also covers the range of different catchment land cover classes found across the region. This enables 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.

1.4 Report scope

This report provides a tabular and graphical summary of the data collected from the 36 sites in the River Water Quality Programme during the 2014 calendar year. This data is also used to produce a Water Quality Index (WQI) class for each site, a system developed by the Canadian Council of Ministers for the Environment (CCME) (2001) which allows the complex water quality data to be communicated in a simple format (Appendix 1).

This is the 25th annual report since the inception of the River Water Quality Monitoring programme, and the tenth time since 2000 that the river water quality data has been reported separately from the marine and lake data. In addition to this annual report series, a comprehensive state and trends analysis of the water quality data was carried out in 2007 (see Scarsbrook, 2007).

All reports can be obtained from the publications area of the Auckland Council website (www.aucklandcouncil.govt.nz/publications).

2 Methods

2.1 Sample sites

The current River Water Quality Programme operates with a network of 36 sites (Table 3) with 34 operated by Auckland Council and 2 operated by NIWA. The location of the 36 sites is displayed in Figure 1.

2.2 Sampling methodology

For the 34 sites monitored by Auckland Council, all sample collection is carried out by council staff. Up to 21 water quality parameters are routinely monitored in the programme (Table 3). Six parameters are determined in the field using one of two portable water quality meters (YSI 556 Multiprobe System or EXO Sonde; both by YSI Inc.) and the remainder are determined by laboratory analysis.

A number of sites have no significant sources of heavy metals within their catchments and previous monitoring showed heavy metals to be below detection limits. These sites are therefore 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 2 as having no metals measured.

Quality control measures are undertaken in accordance with Auckland Council's internal standards which meet ISO 9001:2008. 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 are analysed under contract by Watercare Laboratory Services Ltd, an IANZ accredited laboratory. Analytical methods (for all analytes except metals) follow the "Standard Methods for the Examination of Water and Wastewater" 22nd Edition (APHA, 2012). Metal analytes are 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).

For the two National River Water Quality Network (NRWQN) sites, sample collection is carried out by NIWA field teams. The NRWQN sites are 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://secure.niwa.co.nz/wqis/index.do.

Table 2

Sites sampled in 2014 in the River Water Quality Programme, together with their location details, catchment land cover and record start date.

Site name	NZTM X	NZTM Y	Land cover	Analysis Type	Start date
Avondale Stream	1750600	5912264	Urban	Metals	2012
Cascades Stream (Waitakere)	1735628	5916378	Native forest	No Metals	1978
Cascades Stream (Whakanewha)	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
Ngakaroa 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
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 (NIWA operated)	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



The distribution of the 36 sampling sites used in the Auckland Council River Water Quality Programme for 2014.

Table 3

Parameters tested in 2014 in the River Water Quality Programme (laboratory test methods refer to those tests carried out by Watercare Services Ltd under contract).

Parameter	Code	Units	Method
Dissolved oxygen	DO (sat)	% sat	Portable YSI 556 meter/ EXO sonde
Dissolved oxygen	DO (ppm)	ppm	Portable YSI 556 meter/ EXO sonde
Temperature	Temp	°C	Portable YSI 556 meter/ EXO sonde
Conductivity	Cond	mS/cm	Portable YSI 556 meter/ EXO sonde
Salinity	Salinity	ppt	Portable YSI 556 meter/ EXO sonde
pH (field)	pН		Portable YSI 556 meter/ EXO sonde
pH (lab)	pН		APHA (2012) 4500-H B
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)
Soluble lead	Pb sol	µg/L	USEPA 200.8 (Modified)
Total Lead	Pb tot	µg/L	USEPA 200.8(Modified)
Escherichia coli	E. coli	cfu/100mL	USEPA Method 1603 (2002)

2.3 Data processing and analysis

All field and laboratory data collected by council are stored in the council's water quality archiving database (HYDSTRA). The data from the two sites operated by NIWA was extracted from the NIWA's web-based Water Quality Information System. The 2014 data was collated and used to produce:

- Box plots which display the variation in the measured parameters at each of the sites. These were produced in the software package Sigmaplot 12.0 using the default percentile functions.
- Summary tables which provide a statistical summary of each parameter at each site.
- WQIs were calculated based on the approach of the Canadian Council of Ministers of the Environment (2001) using the data for seven water quality parameters (Appendix 1). Each site was assigned a water quality class based on these water quality indices.

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 water quality data from the 2014 calendar year are presented as;

- box plots which display the variation in the measured parameters at each of the sites (Section 4.1).
- WQI calculated using the data for seven water quality parameters and an associated water quality class for each site (Section 4.3)
- tables which provide a statistical summary of each parameter at each site (Appendix 2)

3.1 Box plots

The following box plots show the variation within the 2014 data for each parameter tested at each of the 36 sites. 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.

3.2 Relevant Guideline Comparisons

To provide context for the data in the box plots described above, the data has been compared to National Objectives Framework (NOF) "national bottom lines" and ANZECC trigger values, where they are relevant:

• National Objectives Framework (NOF) national bottom lines

The National Policy Statement for Freshwater Management (NPSFM), 2014 provides a statutory context for the assessment of water quality in freshwater environments. The NPSFM includes two compulsory national values (ecosystem health and human health for recreation) and nine water quality attributes (parameters) that must be managed to meet these values. The National Objectives Framework (section CA of the NPSFM) provides the context for these nine water quality attributes, which are specified in Appendix 2 of the NPSFM. Each attribute has a series of both numeric and descriptive 'states': A, B, C and a National Bottom Line, D. The National Bottom Line is considered the minimum acceptable state for that attribute to meet the compulsory values. The relevant attributes for rivers and their associated national bottom lines are shown in Table 4 below:

Table 4:

National Objectives Framework "National Bottom Line" values for nitrate toxicity (total oxidised nitrogen), ammonia toxicity and Escherichia coli (E. coli). Also presented is 'State C' for *E. coli*, the primary contact recreation.

NOF attribute and associated value	Attribute measure	Numeric Attribute State (Value)
Nitrate toxicity for ecological health	Annual 95th percentile	9.8 mg/L
	Annual median	6.9 mg/L
Ammonia toxisity for applaciant bootth	Annual maximum	2.20 mg/L
	Annual median	1.30 mg/L
E. coli for human health for recreation (secondary contact)	Annual median	>1000 cfu/100 mL
E. coli for human health for recreation (primary contact, state "C")	Annual median	>540 and ≤1000 cfu/100 mL

ANZECC Guidelines

The Australia New Zealand Environment Conservation Council (ANZECC) Guidelines for Fresh and Marine Water Quality provides an authoritative guide for setting water quality objectives to maintain current and future environmental values for both natural and semi-natural water resources. The ANZECC guidelines present 'trigger values' for different levels of species protection (99, 95, 90 and 80%) based on toxicant-specific concentration-response data from a range of species. The data in this report has been compared to the ANZECC trigger values for copper, zinc and lead (Table 5). The trigger values can be applied to both total and soluble metals; however comparison with the soluble form of metals is more conservative in terms of stream ecological health.

Table 5:

ANZECC trigger values for copper, lead and zinc in freshwater.

Water Quality	Trigger Values for Freshwater (μg/L)							
Parameter	Level of Protection (% Species)							
	99%	95%	90%	80%				
Copper	1.0	1.4	1.8	2.5				
Zinc	2.4	8.0	15	31				
Lead	1.0	3.4	5.6	9.4				



Box plots showing the variation in dissolved oxygen % saturation (upper plot) and ppm (lower plot) at the 36 sites using data collected during the 2014 calendar year.





Box plots showing the variation in temperature (upper plot) and pH (lower plot) at the 36 sites using data collected during the 2014 calendar year.



Box plot showing the variation in Conductivity at the 36 sites using data collected during the 2014 calendar year. The upper plot has a y-axis which covers the full range of the data; the lower plot y-axis is limited to 1.2 to provide greater resolution for sites with lower Conductivity.



Box plots showing the variation in salinity at the 36 sites using data collected during the 2014 calendar year. The upper plot has a y-axis which covers the full range of the data; the lower plot y-axis is limited to 1.0 to provide greater resolution for sites with lower salinity. Note that no salinity data is collected for Hoteo River and Rangitopuni River.



Figure 6 Box plots showing the variation in suspended sediment (upper plot) and turbidity (lower plot) at the 36 sites using data collected during the 2014 calendar year. Note that no suspended sediment data is collected for Hoteo River and Rangitopuni River.



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 2014 calendar year. Note: the 95th percentile for Ammoniacal Nitrogen at Omaru Creek is 4.1 mg/L. NPSFM National Bottom Line values, as presented in Table 5, are displayed using dotted lines to give context to the data.



Box plots showing the variation in total nitrogen at the 36 sites using data collected during the 2014 calendar year.



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 2014 calendar year.



Box plots showing the variation in soluble copper (upper plot) and total copper (lower plot) at the 24 sites where it is monitored, using data collected during the 2014 calendar year. The ANZECC Guidelines, as presented in Table 6, are displayed using coloured lines to give context to the data.



Box plots showing the variation in soluble zinc (upper plot) and total zinc (lower plot) at the 24 sites where it is monitored, using data collected during the 2014 calendar year. The ANZECC Guidelines, as presented in Table 6, are displayed using coloured lines to give context to the data



Box plots showing the variation in soluble lead (upper plot) and total lead (lower plot) at the 24 sites where it is monitored, using data collected during the 2014 calendar year. The ANZECC Guidelines, as presented in Table 6, are displayed using coloured lines to give context to the data. These guidelines are not presented on the box plot for soluble lead (upper plot) as all data presented is well below the 99% guideline value (1 μ g/L). The 80% Guideline is also not included on the total lead box plot, as the value (9.4 μ g/L) is beyond the scale of the plot.



Box plot showing the variation in *E. coli* at the 36 sites using data collected during the 2014 calendar year. The upper plot has a y-axis which covers the majority of the data range; the lower plot y-axis is limited to 6000 to provide greater resolution for sites with lower *E. coli* levels, and shows the 1000cfu/100ml NOF annual median as a black dotted line. Note: The 95th percentiles for *E. coli* Papakura (PR), Otara (KH) and Omaru Creek are 950,000, 30000 and 340,000 cfu/100 mL, respectively.

3.3 Water Quality Indices and classes

Using the methodology described in Appendix 1, water quality indices and classes were calculated for each of the 36 sites (Table 6 and Figure 14).

Cascades Stream (Whakanewha) and Wairoa Tributary were classed as having the best water quality in 2014, both with a WQI score of 100. One other site, Cascades Stream (Waitakere) was classified as having excellent water quality, with a WQI score of 91.7 (Table 6). The Wairoa Tributary and Cascades Stream (Waitakere) both have native forest catchments and the Cascades Stream (Whakanewha) is in a predominantly rural catchment.

Eleven sites were classed as having good water quality and of these six had declined in water quality class from excellent in 2013. A further four sites had maintained a 'good' rating and at one site (Oakley Creek) the water quality class improved from 'Fair' in 2013 to 'Good' in 2014. This is the only urban site to be classed as 'Good' since 2009.

Class changes were observed in 19 sites, with 16 falling to a lower class and 3 rising to a higher class. Omaru Creek had the worst water quality of all the monitoring sites, with all parameters except turbidity exceeding the objective thresholds at some stage during the year. Nine other sites were also classed as 'Poor' in 2014. By comparison, only three sites were classed as 'Poor' in 2013. The 'Poor' water quality sites in 2014 were dominated by rural sites, with four in urban catchments. The 'Fair' class saw an even split, with six sites in both urban and rural catchments. There have been 7 demotions from 'Fair' to 'Poor' since 2013. Overall, 17 of the 36 sites had the same water quality class in 2014 and 2013 (Lockie and Neale, 2014). Only one site, the Hoteo River, exhibited a change of more than one water quality class level, from 'Good' to 'Poor'. This change related to an increase in the number of parameters with data points exceeding the acceptable range as calculated from the reference site data. In 2013 three parameters had data points that exceeded the reference range and in 2014 six parameters exceeded the reference range. No one parameter appeared to be the sole cause.

The WQI has been used since 2007 for reporting the results of the water quality programme and in the past, three-year rolling averages have been used to provide context for each year's results. However, this approach may mask some patterns. As such the 2014 WQI classes for each site are shown in Table 6 along with the previous three years WQI scores. This allows for a visual interpretation of how the sites are changing. The annual WQI scores are subject to the inherently variable nature of water quality data, but could indicate patterns in overall water quality.

In terms of catchment land use, native forest sites had the highest WQI classes, followed by exotic forest sites and then rural sites. Urban sites were typically the lowest classed land use in 2014, with all but one classed as either 'Fair' or 'Poor' (Table 7).

Table 6

Site based WQI scores and classes based on 2014 data. The 2011, 2012 and 2013 WQI data are presented to provide context. Classes are indicated by colour: Blue = "Excellent"; Green = "Good"; Orange = "Fair"; Red = "Poor".

Site	2011 WQI	2012 WQI	2013 WQI	2014 WQI	2014 WQI Class
Cascades Stream (Whakanewha)	-	-	91.7	100.0	Excellent
Wairoa Tributary	83.4	91.7	91.7	100.0	Excellent
Cascades Stream (Waitakere)	91.4	100.0	91.4	91.7	Excellent
Opanuku Stream	83.4	100.0	100.0	83.4	Good
West Hoe Stream	97.1	91.7	91.7	83.3	Good
Matakana River	83.3	58.3	74.6	83.1	Good
Nukumea Stream	-	83.4	91.6	83.1	Good
Mahurangi River (Water Supply)	66.5	65.9	74.6	82.6	Good
Riverhead Forest Stream	83.1	83.4	81.3	79.4	Good
Mahurangi River (Forestry HQ)	91.7	82.8	91.6	75.0	Good
Makarau River	75.0	66.1	91.3	75.0	Good
Waiwera River	91.6	66.1	82.4	74.3	Good
Onetangi Stream	-	-	90.2	73.3	Good
Oakley Creek	72.9	71.6	56.0	71.2	Good
Wairoa River	66.5	65.7	74.6	66.3	Fair
Oteha Stream	66.6	49.2	58.1	66.0	Fair
Lucas Creek	66.7	66.5	57.9	65.7	Fair
Kaukapakapa River	66.5	49.5	65.8	65.5	Fair
Vaughan Stream	74.0	57.1	57.6	64.8	Fair
Kumeu River	66.8	58.5	65.4	64.5	Fair
Waitangi River	46.8	76.8	69.5	62.2	Fair
Otara Creek (East Tamaki)	39.8	56.3	40.4	61.6	Fair
Ngakaroa Stream	61.7	80.9	72.6	59.3	Fair
Puhinui Stream	64.9	56.9	55.8	56.8	Fair
Avondale Stream	-	58.2	49.2	55.4	Fair
Pakuranga Creek (Botany Road)	38.6	55.0	55.3	53.7	Fair
Hoteo River (NIWA operated)	75.1	58.4	74.6	49.7	Poor
Okura Creek	66.7	66.4	57.1	48.1	Poor
Otara Creek (Kennel Hill)	49.5	56.4	57.0	47.9	Poor
Papakura Stream (Alfriston Rd)	-	46.5	50.1	47.5	Poor
Papakura Stream (Porchester Rd)	66.1	55.5	54.1	47.4	Poor
Whangamaire Stream	35.5	41.3	50.4	45.2	Poor
Otaki Creek	38.9	54.2	41.7	41.8	Poor
Rangitopuni River (NIWA operated)	57.9	74.9	56.9	38.9	Poor
Pakuranga Creek (Greenmount Drive)	40.3	36.3	42.7	37.0	Poor
Omaru Creek	47.9	57.6	56.1	31.4	Poor



The sampling sites used in the Auckland Council River Water Quality Programme for 2014 with labels coded by Water Quality Index Class

Table 7

Mean 2014 water quality index scores and water quality class for all sites within a catchment land cover class. Mean WQI scores for each catchment land cover class are also presented for 2011, 2012 and 2013 to give context to the data.

Land Cover (number of sites)	Average WQI 2011	Average WQI 2012	Average WQI 2013	Average WQI 2014	Water Quality Class 2014
Native forest (4)	88.8	91.7	91.6	89.5	Good
Exotic forest (2)	87.4	83.1	86.5	77.2	Good
Rural (19)	67.7	64.0	71.6	64.8	Fair
Urban (11)	52.6	56.2	53.0	53.5	Fair

4 Summary

This report summarises the results from the Auckland Council's long-term River Water Quality Monitoring programme for 2014. Water quality was assessed monthly at 36 sites across the region using a combination of field based and laboratory tested parameters. The results were presented as box plots to show variation within and between sites for each of the parameters. Guideline values from NPSFM and ANZECC were applied to appropriate box plots to provide context for the data. A statistical summary of each parameter at each site is presented in Appendix 2.

The data was also used to produce water quality indices, which summarise the complex multivariate dataset to facilitate communication, and allowed sites to be ranked and classed according to their water quality. The WQI indicated that during 2014 the best river water quality was in the Cascades Stream (Whakanewha) and Wairoa Tributary, followed by Cascades Stream (Waitakere). These were the only three sites classified as having excellent water quality in 2014. Poor water quality was observed in streams in a mix of urban and rural areas, with Omaru Creek having the lowest classed water quality in 2014.

5 Acknowledgements

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

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The data from the Rangitopuni River and Hoteo River sites are used under licence from NIWA.

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7 Appendix 1 – Water quality index

The communication of water quality data is often hampered by the volume of results and the complexity of the information. In this report, a water quality index developed by the Canadian Council of Ministers for the Environment (CCME) (2001) was applied to the river water quality data collected by the Auckland Council to enable improved understanding and communication of the work.

The CCME approach uses water quality results to produce four water quality indices, and these indices can be used to assign a water quality class to each monitoring site. The four indices are;

- Scope This represents 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 This represents 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 This represents 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 This represents an overall water quality index based on a combination of the three indices described above. It is calculated thus;

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

The divisor 1.732 normalises the resultant values to a range between 0 and 100, where 0 represents the "worst" water quality and 100 represents the "best" water quality.

The WQI index is used by Auckland Council to assign a water quality class to each site using the following ranges;

- Greater than 90 = excellent water quality
- Between 70 and 90 = good water quality
- Between 50 and 70 = fair water quality
- Lower than 50 = poor water quality

The above indices are calculated for each site based on seven water quality parameters (Table A1.1). The objectives against which the Auckland Council water quality data are tested are derived from the range observed at the three Auckland Council reference sites (Cascades Stream, Wairoa Tributary and West Hoe Stream) over the five years preceding this report (2009 to 2013). This represents a change from the 2007 and 2008 reports. It was considered thresholds based on the fixed period (2002 to 2006) used in the 2007 and 2008 reports, whilst providing consistency, would not capture natural variation in water quality, nor account for improvements in the measurement of

parameters (for example, improved meter performance or improvements in detection limits).

The ranges at these reference sites were used as this represents the best achievable water quality in Auckland. Therefore, the index represents the deviation from "natural" conditions in the Auckland Region, rather than indicating whether the water quality is suitable for a particular purpose.

Table A1.1

The seven water quality parameters, and their objectives, used to produce the water quality indices in this report. The objectives are based on the 98th percentile of the data from reference sites in the programme collected between 2009 and 2013.

Parameter	Objective (acceptable if)
Dissolved oxygen (% saturation)	Between 84 and 117%
рН	Between 6.4 and 7.9
Turbidity	Less than 38 NTU
Ammoniacal nitrogen	Less than 0.05 mg N l ⁻¹
Temperature	Less than 17 °C
Total phosphorus	Less than 0.10 mg P I ⁻¹
Total nitrogen	Less than 0.8 mg N I ⁻¹

8 Appendix 2 - Summary tables

Table A2.1

Dissolved oxygen (% saturation)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	61.9	92.2	78.2	77.9	2.88
Cascade Stream (Waitakere)	12	98.9	104.9	99.8	100.7	0.54
Cascades Stream (Whakanewha)	12	84.5	96.8	93.2	92.4	0.95
Hoteo River (NIWA operated)	12	80.1	95.8	91.3	90.1	1.43
Kaukapakapa River	12	37.6	91.9	83.8	75.5	4.85
Kumeu River	12	29.5	89.2	79.1	71.0	6.01
Lucas Creek	12	68.0	96.0	84.1	83.0	3.12
Mahurangi River (Forestry HQ)	12	90.4	102.2	95.8	95.7	0.82
Mahurangi River (Water Supply)	12	71.2	100.5	93.9	90.1	3.02
MakarauRiver	12	94.8	110.7	99.6	99.8	1.28
Matakana River	12	86.0	102.5	94.4	93.6	1.42
Ngakaroa Stream	12	74.4	100.1	92.2	90.3	2.34
Nukumea Stream	12	83.8	93.1	87.8	87.9	0.72
Oakley Creek	12	78.7	98.5	88.2	87.8	1.76
Okura Creek	12	8.4	95.8	74.7	72.2	7.08
Omaru Creek	10	2.4	103.1	86.0	79.0	9.04
Onetangi Stream	12	56.5	82.4	71.5	70.6	2.11
Opanuku Stream	12	86.9	100.3	96.2	95.3	1.17
Otaki Creek	10	52.0	90.5	81.9	78.6	3.55
Otara Creek (East Tamaki)	11	82.4	102.6	99.2	96.5	1.88
Otara Creek (Kennel Hill)	11	49.2	91.3	85.0	80.4	3.90
Oteha Stream	12	49.3	107.4	85.1	80.8	5.02
Pakuranga Creek (Botany Rd)	11	98.8	148.5	116.4	116.4	4.05
Pakuranga Creek (Greenmount Rd)	11	51.2	89.2	78.0	77.1	3.31
Papakura Stream (Alfriston Rd)	12	31.3	86.2	65.5	62.5	5.62
Papakura Stream (Porchester Rd)	12	65.0	90.7	85.3	82.5	2.38
Puhinui Stream	12	61.9	140.8	105.1	103.0	6.55
Rangitopuni River (NIWA operated)	11	1.6	92.0	69.6	54.8	11.71
Riverhead Stream	12	10.3	86.6	80.1	65.6	7.09
Vaughan Stream	12	30.0	84.8	73.5	70.3	4.54
Wairoa Tributary	11	97.1	103.8	98.7	99.6	0.73
Wairoa River	12	86.8	117.9	95.5	98.0	2.56
Waitangi River	12	58.3	94.4	76.3	76.6	3.55
Waiwera River	12	59.2	98.2	89.8	84.7	4.09
West Hoe Stream	12	83.9	92.9	88.9	89.1	0.79
Whangamaire Stream	12	71.5	113.7	93.7	92.5	3.76

Dissolved oxygen (ppm)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	6.16	10.02	8.25	8.10	0.378
Cascade Stream (Waitakere)	12	10.07	11.20	10.81	10.71	0.106
Cascades Stream (Whakanewha)	12	8.41	10.79	9.65	9.63	0.198
Hoteo River (NIWA operated)	12	7.40	10.60	8.95	9.06	0.248
Kaukapakapa River	12	3.74	10.10	8.71	7.81	0.596
Kumeu River	12	3.04	9.64	8.40	7.30	0.672
Lucas Creek	12	6.35	10.25	8.82	8.53	0.386
Mahurangi River (Forestry HQ)	12	8.70	10.68	10.22	9.86	0.216
Mahurangi River (Water Supply)	12	6.77	10.90	9.58	9.07	0.454
MakarauRiver	12	8.95	12.32	10.19	10.16	0.279
Matakana River	12	7.91	10.59	9.71	9.40	0.267
Ngakaroa Stream	12	7.50	10.46	9.92	9.40	0.331
Nukumea Stream	12	8.40	10.14	9.25	9.34	0.157
Oakley Creek	12	7.66	11.11	8.95	8.91	0.303
Okura Creek	12	0.86	10.81	7.49	7.66	0.788
Omaru Creek	11	0.23	10.11	8.68	7.91	0.830
Onetangi Stream	12	5.55	8.90	7.45	7.31	0.288
Opanuku Stream	12	8.71	11.08	10.39	10.00	0.261
Otaki Creek	11	4.78	9.55	7.46	7.58	0.372
Otara Creek (East Tamaki)	12	7.94	10.17	9.70	9.53	0.180
Otara Creek (Kennel Hill)	12	4.68	9.86	8.34	8.14	0.453
Oteha Stream	12	4.96	10.55	8.53	8.27	0.541
Pakuranga Creek (Botany Rd)	12	10.29	12.79	10.74	11.04	0.245
Pakuranga Creek (Greenmount Rd)	12	4.71	9.29	7.46	7.51	0.364
Papakura Stream (Alfriston Rd)	12	2.95	8.83	6.88	6.48	0.636
Papakura Stream (Porchester Rd)	12	6.04	9.74	8.95	8.50	0.366
Puhinui Stream	12	5.49	12.81	10.31	10.01	0.640
Rangitopuni River (NIWA operated)	11	0.20	10.30	6.90	5.79	1.263
Riverhead Stream	12	1.08	9.75	8.97	7.12	0.816
Vaughan Stream	12	2.67	9.46	7.23	7.25	0.541
Wairoa Tributary	11	10.29	11.18	11.05	10.91	0.089
Wairoa River	12	7.92	13.06	10.37	10.02	0.414
Waitangi River	12	5.77	9.62	7.75	7.87	0.422
Waiwera River	12	5.91	10.84	9.42	8.69	0.545
West Hoe Stream	12	8.68	10.29	9.65	9.52	0.132
Whangamaire Stream	12	7.09	11.82	10.02	9.63	0.457

Temperature (^oC)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	11.64	17.44	13.29	13.85	0.577
Cascade Stream (Waitakere)	12	10.49	15.47	11.92	12.60	0.506
Cascades Stream (Whakanewha)	12	9.80	16.37	13.73	13.58	0.577
Hoteo River (NIWA operated)	12	10.40	21.20	15.45	15.63	0.955
Kaukapakapa River	12	10.21	19.13	14.01	14.33	0.848
Kumeu River	12	10.40	18.75	14.16	14.53	0.829
Lucas Creek	12	10.58	18.66	14.03	14.32	0.650
Mahurangi River (Forestry HQ)	12	10.74	18.93	13.29	14.14	0.802
Mahurangi River (Water Supply)	12	10.94	20.94	14.59	15.53	0.989
Makarau River	12	10.60	19.88	14.53	14.73	0.872
Matakana River	12	11.70	20.36	15.03	15.38	0.883
Ngakaroa Stream	12	9.88	17.73	13.81	13.74	0.735
Nukumea Stream	12	10.11	15.24	12.54	12.68	0.480
Oakley Creek	12	9.99	18.49	14.85	14.90	0.678
Okura Creek	12	9.34	17.70	12.81	13.02	0.681
Omaru Creek	11	11.61	19.52	16.16	15.83	0.767
Onetangi Stream	12	10.11	16.60	14.14	13.95	0.577
Opanuku Stream	12	10.08	17.70	12.15	13.34	0.759
Otaki Creek	11	12.72	20.83	16.21	16.64	0.845
Otara Creek (East Tamaki)	12	12.14	18.71	15.79	15.90	0.640
Otara Creek (Kennel Hill)	12	11.88	19.80	15.78	15.67	0.837
Oteha Stream	12	11.02	18.03	14.25	14.46	0.641
Pakuranga Creek (Botany Rd)	12	11.94	23.29	17.76	17.29	0.940
Pakuranga Creek (Greenmount Rd)	12	13.12	21.16	17.40	17.17	0.792
Papakura Stream (Alfriston Rd)	12	10.70	18.84	14.17	14.28	0.773
Papakura Stream (Porchester Rd)	12	10.39	19.22	14.36	14.31	0.870
Puhinui Stream	12	11.79	21.27	17.69	16.97	1.002
Rangitopuni River (NIWA operated)	11	10.10	19.50	14.90	14.77	0.839
Riverhead Stream	12	8.76	15.52	11.57	12.12	0.618
Vaughan Stream	12	10.44	20.41	13.89	14.47	0.851
Wairoa Tributary	11	9.16	14.76	10.86	11.29	0.564
Wairoa River	12	10.72	19.78	13.99	14.68	0.956
Waitangi River	12	10.56	18.58	14.60	14.40	0.776
Waiwera River	12	10.36	19.58	14.02	14.69	0.921
West Hoe Stream	12	9.72	15.04	12.43	12.41	0.443
Whangamaire Stream	12	10.72	17.78	13.68	13.73	0.676

Conductivity (Millisiemens/cm @ 25°C)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	0.173	0.236	0.202	0.204	0.0062
Cascade Stream (Waitakere)	12	0.121	0.199	0.179	0.172	0.0072
Cascades Stream (Whakanewha)	12	0.196	0.238	0.226	0.222	0.0040
Hoteo River (NIWA operated)	12	0.174	0.225	0.188	0.192	0.0050
Kaukapakapa River	12	0.149	0.268	0.209	0.213	0.0097
Kumeu River	12	0.135	0.227	0.170	0.178	0.0081
Lucas Creek	12	0.192	0.354	0.254	0.254	0.0115
Mahurangi River (Forestry HQ)	12	0.159	0.198	0.175	0.176	0.0035
Mahurangi River (Water Supply)	12	0.146	0.231	0.186	0.187	0.0076
MakarauRiver	12	0.153	0.237	0.198	0.198	0.0062
Matakana River	12	0.154	0.219	0.193	0.189	0.0056
Ngakaroa Stream	12	0.149	0.239	0.164	0.176	0.0089
Nukumea Stream	12	0.163	0.208	0.185	0.183	0.0039
Oakley Creek	12	0.200	1.273	0.270	0.366	0.0860
Okura Creek	12	0.213	0.355	0.258	0.270	0.0138
Omaru Creek	11	0.192	0.741	0.327	0.340	0.0474
Onetangi Stream	12	0.379	0.532	0.488	0.474	0.0151
Opanuku Stream	12	0.110	0.165	0.146	0.143	0.0043
Otaki Creek	11	0.163	10.274	0.387	2.322	0.9930
Otara Creek (East Tamaki)	12	0.129	0.242	0.182	0.186	0.0086
Otara Creek (Kennel Hill)	12	0.152	0.314	0.192	0.206	0.0156
Oteha Stream	12	0.139	0.288	0.220	0.218	0.0126
Pakuranga Creek (Botany Rd)	12	0.178	0.340	0.300	0.295	0.0116
Pakuranga Creek (Greenmount Rd)	12	0.230	0.736	0.460	0.441	0.0425
Papakura Stream (Alfriston Rd)	12	0.155	0.202	0.174	0.177	0.0048
Papakura Stream (Porchester Rd)	12	0.172	0.219	0.188	0.194	0.0047
Puhinui Stream	12	0.178	0.232	0.198	0.200	0.0042
Rangitopuni River (NIWA operated)	12	0.206	0.294	0.228	0.240	0.0077
Riverhead Stream	12	0.187	0.266	0.212	0.215	0.0062
Vaughan Stream	12	0.247	4.110	0.294	0.723	0.3265
Wairoa Tributary	11	0.093	0.133	0.117	0.117	0.0036
Wairoa River	12	0.100	0.138	0.116	0.117	0.0036
Waitangi River	12	0.189	0.224	0.194	0.202	0.0039
Waiwera River	12	0.173	0.246	0.196	0.205	0.0061
West Hoe Stream	12	0.116	0.225	0.184	0.184	0.0090
Whangamaire Stream	12	0.227	0.342	0.306	0.302	0.0102

Salinty (ppt)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	0.08	0.11	0.10	0.10	0.003
Cascade Stream (Waitakere)	12	0.06	0.09	0.08	0.08	0.003
Cascades Stream (Whakanewha)	12	0.09	0.11	0.11	0.11	0.002
Hoteo River (NIWA operated)			Not measure	d at this si	te	•
Kaukapakapa River	12	0.07	0.13	0.10	0.10	0.005
Kumeu River	12	0.06	0.11	0.08	0.09	0.004
Lucas Creek	11	0.09	0.17	0.12	0.12	0.006
Mahurangi River (Forestry HQ)	12	0.07	0.09	0.08	0.08	0.002
Mahurangi River (Water Supply)	12	0.07	0.11	0.09	0.09	0.004
MakarauRiver	12	0.07	0.11	0.09	0.09	0.003
Matakana River	12	0.07	0.10	0.09	0.09	0.003
Ngakaroa Stream	12	0.07	0.11	0.08	0.08	0.004
Nukumea Stream	11	0.08	0.10	0.09	0.09	0.002
Oakley Creek	12	0.10	0.64	0.13	0.18	0.044
Okura Creek	11	0.10	0.17	0.12	0.13	0.006
Omaru Creek	10	0.09	0.36	0.15	0.16	0.026
Onetangi Stream	12	0.18	0.26	0.24	0.23	0.007
Opanuku Stream	12	0.05	0.08	0.07	0.07	0.002
Otaki Creek	10	0.08	5.83	0.24	1.37	0.607
Otara Creek (East Tamaki)	11	0.06	0.12	0.09	0.09	0.005
Otara Creek (Kennel Hill)	11	0.07	0.15	0.10	0.10	0.008
Oteha Stream	11	0.07	0.14	0.10	0.10	0.006
Pakuranga Creek (Botany Rd)	11	0.08	0.16	0.14	0.14	0.007
Pakuranga Creek (Greenmount Rd)	11	0.11	0.36	0.23	0.21	0.023
Papakura Stream (Alfriston Rd)	12	0.07	0.10	0.08	0.08	0.003
Papakura Stream (Porchester Rd)	12	0.08	0.10	0.09	0.09	0.002
Puhinui Stream	12	0.08	0.11	0.09	0.09	0.002
Rangitopuni River (NIWA operated)			Not measure	d at this si	te	
Riverhead Stream	12	0.09	0.13	0.10	0.10	0.004
Vaughan Stream	11	0.12	2.19	0.14	0.33	0.186
Wairoa Tributary	11	0.04	0.06	0.05	0.05	0.002
Wairoa River	12	0.05	0.06	0.06	0.06	0.002
Waitangi River	12	0.09	0.11	0.09	0.10	0.002
Waiwera River	12	0.08	0.12	0.09	0.10	0.003
West Hoe Stream	12	0.05	0.11	0.09	0.09	0.005
Whangamaire Stream	12	0.11	0.16	0.15	0.15	0.005

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Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	6.1	7.1	6.9	6.7	0.09
Cascade Stream (Waitakere)	12	6.2	7.8	7.4	7.3	0.14
Cascades Stream (Whakanewha)	11	6.7	7.3	7.0	7.0	0.05
Hoteo River (NIWA operated)	12	7.3	8.0	7.6	7.6	0.07
Kaukapakapa River	12	5.8	7.1	6.9	6.7	0.12
Kumeu River	12	5.3	6.9	6.6	6.5	0.14
Lucas Creek	11	6.7	7.4	7.1	7.1	0.07
Mahurangi River (Forestry HQ)	12	6.3	7.3	7.1	7.0	0.09
Mahurangi River (Water Supply)	12	6.4	7.6	7.1	7.1	0.09
MakarauRiver	12	6.3	7.7	7.4	7.2	0.12
Matakana River	12	6.0	7.7	7.2	7.0	0.13
Ngakaroa Stream	12	6.2	7.1	7.0	6.9	0.08
Nukumea Stream	11	5.7	7.3	6.6	6.5	0.17
Oakley Creek	12	6.5	7.5	7.3	7.2	0.09
Okura Creek	11	6.3	7.3	7.0	6.9	0.10
Omaru Creek	11	7.5	8.6	8.1	8.1	0.08
Onetangi Stream	11	6.6	7.2	6.8	6.9	0.05
Opanuku Stream	12	6.1	7.4	7.1	7.0	0.10
Otaki Creek	11	6.9	7.8	7.5	7.5	0.09
Otara Creek (East Tamaki)	12	6.7	7.6	7.2	7.2	0.08
Otara Creek (Kennel Hill)	12	6.7	7.4	7.2	7.1	0.07
Oteha Stream	11	6.7	7.8	7.0	7.0	0.09
Pakuranga Creek (Botany Rd)	12	6.9	8.1	7.4	7.5	0.08
Pakuranga Creek (Greenmount Rd)	12	7.0	7.7	7.5	7.5	0.06
Papakura Stream (Alfriston Rd)	12	5.9	6.8	6.5	6.5	0.07
Papakura Stream (Porchester Rd)	12	6.0	7.0	6.8	6.7	0.11
Puhinui Stream	12	6.6	8.6	7.4	7.4	0.16
Rangitopuni River (NIWA operated)	12	6.8	7.5	7.2	7.1	0.06
Riverhead Stream	12	4.9	7.0	6.5	6.2	0.17
Vaughan Stream	11	6.1	7.5	7.0	6.8	0.12
Wairoa Tributary	11	6.5	7.4	7.1	7.0	0.10
Wairoa River	12	6.1	7.7	6.9	6.9	0.13
Waitangi River	12	6.1	7.1	6.7	6.7	0.08
Waiwera River	12	6.2	7.3	7.1	7.0	0.10
West Hoe Stream	11	5.8	7.2	6.9	6.7	0.16
Whangamaire Stream	12	6.4	7.3	7.1	7.0	0.08

Suspended sediment (mg/L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	3.0	35.0	6.1	8.6	2.52
Cascade Stream (Waitakere)	12	0.4	5.6	1.2	1.6	0.41
Cascades Stream (Whakanewha)	12	0.8	12.0	3.0	4.2	0.92
Hoteo River (NIWA operated)			Not measure	d at this si	te	
Kaukapakapa River	12	1.4	40.0	3.6	7.2	3.16
Kumeu River	12	1.0	23.0	4.5	6.6	1.81
Lucas Creek	12	2.4	24.0	4.5	8.9	2.26
Mahurangi River (Forestry HQ)	12	0.8	51.0	2.5	7.2	4.07
Mahurangi River (Water Supply)	12	0.4	11.0	2.1	2.8	0.80
MakarauRiver	12	0.4	23.0	2.6	5.5	2.08
Matakana River	12	0.4	17.0	2.1	3.9	1.40
Ngakaroa Stream	12	0.4	14.0	2.0	3.0	1.08
Nukumea Stream	12	0.4	16.0	3.2	5.4	1.54
Oakley Creek	12	1.4	15.0	2.1	3.7	1.17
Okura Creek	12	2.0	18.0	7.0	8.9	1.54
Omaru Creek	12	1.7	43.0	3.7	7.6	3.35
Onetangi Stream	12	1.6	15.0	3.8	5.0	1.11
Opanuku Stream	12	0.4	6.0	1.5	1.8	0.45
Otaki Creek	12	1.4	27.0	11.0	11.5	2.61
Otara Creek (East Tamaki)	12	0.7	16.0	2.4	5.0	1.56
Otara Creek (Kennel Hill)	12	5.6	47.0	14.8	20.2	4.51
Oteha Stream	12	1.6	77.0	7.2	12.5	6.01
Pakuranga Creek (Botany Rd)	12	1.8	13.0	4.8	5.8	1.07
Pakuranga Creek (Greenmount Rd)	12	2.8	28.0	4.6	7.1	2.00
Papakura Stream (Alfriston Rd)	12	1.6	16.0	3.2	4.8	1.19
Papakura Stream (Porchester Rd)	12	0.4	14.0	3.6	4.2	0.99
Puhinui Stream	12	1.6	8.2	4.1	4.6	0.65
Rangitopuni River (NIWA operated)			Not measure	d at this si	te	
Riverhead Stream	12	0.8	6.8	3.5	3.6	0.62
Vaughan Stream	12	2.0	81.0	4.3	12.5	6.47
Wairoa Tributary	12	0.8	8.0	1.8	2.4	0.56
Wairoa River	12	0.8	9.3	2.7	3.6	0.72
Waitangi River	12	0.4	10.0	0.8	2.5	0.99
Waiwera River	12	1.6	18.0	2.5	4.1	1.33
West Hoe Stream	12	0.8	5.2	2.2	2.6	0.40
Whangamaire Stream	12	0.8	17.0	2.0	4.1	1.40

Turbidity (NTU)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	6.9	22.0	10.0	11.7	1.46
Cascade Stream (Waitakere)	12	0.8	13.0	1.5	3.6	1.24
Cascades Stream (Whakanewha)	12	4.5	34.0	8.6	12.6	2.73
Hoteo River (NIWA operated)	12	1.4	114.0	5.1	17.8	9.50
Kaukapakapa River	12	2.4	36.0	5.0	8.6	2.95
Kumeu River	12	3.3	35.0	7.4	11.1	2.88
Lucas Creek	12	3.4	30.0	6.3	10.8	2.71
Mahurangi River (Forestry HQ)	12	2.2	39.0	6.9	10.1	2.87
Mahurangi River (Water Supply)	12	1.1	27.0	4.1	6.5	2.09
MakarauRiver	12	1.2	25.0	4.3	7.3	2.33
Matakana River	12	1.1	19.0	3.2	5.2	1.55
Ngakaroa Stream	12	1.3	12.0	1.9	3.1	0.86
Nukumea Stream	12	5.0	13.0	6.8	7.9	0.76
Oakley Creek	12	2.0	22.0	2.7	4.7	1.63
Okura Creek	12	5.0	25.0	14.0	14.3	1.62
Omaru Creek	12	3.3	30.0	4.4	7.8	2.27
Onetangi Stream	12	4.6	18.0	7.3	8.6	1.17
Opanuku Stream	12	1.1	16.0	2.7	5.2	1.46
Otaki Creek	12	4.7	33.0	12.0	14.1	2.53
Otara Creek (East Tamaki)	12	1.7	33.0	4.1	9.2	3.07
Otara Creek (Kennel Hill)	12	5.2	70.0	11.9	24.1	6.45
Oteha Stream	12	2.0	100.0	9.0	17.5	7.81
Pakuranga Creek (Botany Rd)	12	4.6	19.0	7.3	9.3	1.38
Pakuranga Creek (Greenmount Rd)	12	4.5	40.0	7.5	12.3	3.20
Papakura Stream (Alfriston Rd)	12	1.9	21.0	4.8	6.8	1.63
Papakura Stream (Porchester Rd)	12	1.1	26.0	3.6	6.0	2.05
Puhinui Stream	12	2.2	12.0	4.7	5.7	0.93
Rangitopuni River (NIWA operated)	12	2.0	101.0	6.9	15.1	7.86
Riverhead Stream	12	3.9	17.0	9.5	9.6	1.32
Vaughan Stream	12	3.6	34.0	9.9	13.7	2.77
Wairoa Tributary	12	2.8	12.0	3.7	5.1	0.83
Wairoa River	12	1.3	16.0	3.7	5.6	1.44
Waitangi River	12	0.6	10.0	1.2	2.2	0.75
Waiwera River	12	1.1	23.0	4.1	5.9	1.79
West Hoe Stream	12	5.0	9.8	7.0	6.9	0.40
Whangamaire Stream	12	1.0	22.0	2.5	4.3	1.67

Ammoniacal Nitrogen (mg N /L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	0.019	0.610	0.038	0.097	0.0481
Cascade Stream (Waitakere)	12	0.003	0.010	0.003	0.004	0.0008
Cascades Stream (Whakanewha)	12	0.003	0.021	0.008	0.010	0.0015
Hoteo River (NIWA operated)	12	0.003	0.031	0.012	0.014	0.0026
Kaukapakapa River	12	0.003	0.043	0.020	0.020	0.0037
Kumeu River	12	0.003	0.046	0.020	0.020	0.0033
Lucas Creek	12	0.003	0.220	0.023	0.039	0.0166
Mahurangi River (Forestry HQ)	12	0.003	0.023	0.012	0.013	0.0017
Mahurangi River (Water Supply)	12	0.003	0.019	0.009	0.009	0.0017
MakarauRiver	12	0.003	0.025	0.007	0.009	0.0020
Matakana River	12	0.003	0.025	0.011	0.011	0.0022
Ngakaroa Stream	12	0.005	0.023	0.012	0.012	0.0015
Nukumea Stream	12	0.003	0.022	0.007	0.008	0.0015
Oakley Creek	12	0.008	0.028	0.014	0.015	0.0018
Okura Creek	12	0.009	0.064	0.023	0.032	0.0058
Omaru Creek	12	0.012	9.000	0.026	0.776	0.7476
Onetangi Stream	12	0.003	0.051	0.013	0.015	0.0037
Opanuku Stream	12	0.003	0.013	0.008	0.007	0.0010
Otaki Creek	12	0.033	2.100	0.108	0.285	0.1661
Otara Creek (East Tamaki)	12	0.003	0.300	0.052	0.076	0.0292
Otara Creek (Kennel Hill)	12	0.008	0.100	0.028	0.033	0.0080
Oteha Stream	12	0.009	0.039	0.029	0.028	0.0026
Pakuranga Creek (Botany Rd)	12	0.024	0.082	0.046	0.048	0.0054
Pakuranga Creek (Greenmount Rd)	12	0.083	0.520	0.260	0.264	0.0374
Papakura Stream (Alfriston Rd)	12	0.010	0.059	0.028	0.030	0.0047
Papakura Stream (Porchester Rd)	12	0.015	0.580	0.033	0.091	0.0457
Puhinui Stream	12	0.006	0.039	0.022	0.021	0.0033
Rangitopuni River (NIWA operated)	12	0.004	0.068	0.024	0.027	0.0054
Riverhead Stream	12	0.003	0.027	0.011	0.012	0.0019
Vaughan Stream	12	0.010	0.029	0.014	0.016	0.0017
Wairoa Tributary	12	0.003	0.016	0.004	0.006	0.0012
Wairoa River	12	0.003	0.024	0.010	0.011	0.0022
Waitangi River	12	0.003	0.020	0.004	0.006	0.0016
Waiwera River	12	0.003	0.036	0.009	0.012	0.0029
West Hoe Stream	12	0.003	0.021	0.006	0.006	0.0015
Whangamaire Stream	12	0.003	0.076	0.016	0.024	0.0070

Total oxidised Nitrogen (mg N /L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	0.1800	0.7900	0.3350	0.4033	0.05725
Cascade Stream (Waitakere)	12	0.0010	0.0360	0.0078	0.0092	0.00274
Cascades Stream (Whakanewha)	12	0.0300	0.1400	0.0795	0.0827	0.00988
Hoteo River (NIWA operated)	12	0.0005	0.4950	0.1255	0.1873	0.05550
Kaukapakapa River	12	0.0023	0.4500	0.1115	0.1523	0.04243
Kumeu River	12	0.0280	0.7400	0.2050	0.2553	0.06350
Lucas Creek	12	0.0073	1.5000	0.2100	0.3429	0.12066
Mahurangi River (Forestry HQ)	12	0.0300	0.1300	0.0780	0.0790	0.00871
Mahurangi River (Water Supply)	12	0.0010	0.2600	0.0650	0.0888	0.02713
MakarauRiver	12	0.0010	0.4500	0.0335	0.0942	0.03896
Matakana River	12	0.0010	0.1100	0.0120	0.0315	0.01070
Ngakaroa Stream	12	2.4000	6.1000	3.3000	3.4250	0.27583
Nukumea Stream	12	0.0010	0.0340	0.0120	0.0128	0.00278
Oakley Creek	12	0.7900	1.9000	1.3000	1.3183	0.09758
Okura Creek	12	0.0010	0.5500	0.1600	0.1883	0.05041
Omaru Creek	12	0.0100	2.3000	0.4700	0.6338	0.19022
Onetangi Stream	12	0.0056	0.1500	0.0870	0.0836	0.01064
Opanuku Stream	12	0.0010	0.1600	0.0515	0.0743	0.01836
Otaki Creek	12	0.2700	3.3000	0.7550	1.1175	0.26253
Otara Creek (East Tamaki)	12	0.2700	3.0000	0.9300	1.0408	0.22037
Otara Creek (Kennel Hill)	12	0.0100	1.6000	0.2250	0.3557	0.12687
Oteha Stream	12	0.0820	0.6900	0.2150	0.2869	0.05884
Pakuranga Creek (Botany Rd)	12	0.3800	2.5000	0.7750	0.9208	0.16098
Pakuranga Creek (Greenmount Rd)	12	0.2000	2.0000	0.5600	0.6267	0.12892
Papakura Stream (Alfriston Rd)	12	0.0190	0.9700	0.3700	0.4143	0.09847
Papakura Stream (Porchester Rd)	12	0.0010	0.9100	0.1250	0.2836	0.09029
Puhinui Stream	12	0.0010	0.9000	0.2600	0.3231	0.09217
Rangitopuni River (NIWA operated)	12	0.0005	0.6300	0.1105	0.1531	0.05207
Riverhead Stream	12	0.0130	0.0410	0.0245	0.0244	0.00288
Vaughan Stream	12	0.0010	0.5100	0.0605	0.1144	0.04512
Wairoa Tributary	12	0.0010	0.0590	0.0325	0.0321	0.00570
Wairoa River	12	0.0010	0.9100	0.2350	0.2843	0.09432
Waitangi River	12	0.1000	3.0000	1.7500	1.5975	0.29109
Waiwera River	12	0.0024	0.4200	0.0410	0.0921	0.03794
West Hoe Stream	12	0.0010	0.0450	0.0065	0.0099	0.00352
Whangamaire Stream	12	7.0000	16.0000	15.0000	13.8333	0.79614

Total Nitrogen (mg N /L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	0.360	1.500	0.585	0.754	0.1085
Cascade Stream (Waitakere)	12	0.005	0.240	0.047	0.068	0.0203
Cascades Stream (Whakanewha)	12	0.140	0.520	0.230	0.260	0.0328
Hoteo River (NIWA operated)	12	0.257	1.354	0.364	0.518	0.0961
Kaukapakapa River	12	0.280	1.200	0.520	0.594	0.0875
Kumeu River	12	0.290	1.600	0.535	0.643	0.1108
Lucas Creek	12	0.200	1.700	0.605	0.668	0.1222
Mahurangi River (Forestry HQ)	12	0.120	0.440	0.195	0.213	0.0252
Mahurangi River (Water Supply)	12	0.150	0.660	0.275	0.339	0.0447
MakarauRiver	12	0.140	0.910	0.260	0.352	0.0686
Matakana River	12	0.130	0.440	0.200	0.226	0.0248
Ngakaroa Stream	12	2.900	7.000	3.650	3.850	0.3108
Nukumea Stream	12	0.056	0.250	0.110	0.113	0.0150
Oakley Creek	12	1.300	2.200	1.650	1.658	0.0941
Okura Creek	12	0.400	1.200	0.620	0.694	0.0737
Omaru Creek	12	0.290	12.000	0.830	1.958	0.9418
Onetangi Stream	12	0.180	0.500	0.265	0.313	0.0330
Opanuku Stream	12	0.092	0.430	0.170	0.223	0.0350
Otaki Creek	12	0.850	4.200	1.300	1.782	0.3042
Otara Creek (East Tamaki)	12	0.440	3.700	1.550	1.537	0.2665
Otara Creek (Kennel Hill)	12	0.270	2.400	0.640	0.809	0.1724
Oteha Stream	12	0.370	1.100	0.505	0.603	0.0694
Pakuranga Creek (Botany Rd)	12	0.730	3.100	1.500	1.482	0.2039
Pakuranga Creek (Greenmount Rd)	12	0.690	2.800	1.200	1.358	0.1457
Papakura Stream (Alfriston Rd)	12	0.280	1.800	0.640	0.803	0.1368
Papakura Stream (Porchester Rd)	12	0.410	2.100	0.720	1.011	0.1584
Puhinui Stream	12	0.310	1.400	0.690	0.732	0.1058
Rangitopuni River (NIWA operated)	12	0.457	1.560	0.621	0.723	0.0882
Riverhead Stream	12	0.130	0.360	0.190	0.234	0.0246
Vaughan Stream	12	0.330	1.000	0.490	0.573	0.0671
Wairoa Tributary	12	0.076	0.170	0.095	0.109	0.0092
Wairoa River	12	0.140	1.400	0.520	0.587	0.1181
Waitangi River	12	0.380	3.500	2.150	1.964	0.3074
Waiwera River	12	0.180	0.780	0.280	0.335	0.0509
West Hoe Stream	12	0.010	0.110	0.053	0.055	0.0074
Whangamaire Stream	12	8.900	19.000	16.000	15.158	0.8299

Soluble Reactive Phosphorus (mg P /L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	0.005	0.031	0.015	0.015	0.0019
Cascade Stream (Waitakere)	12	0.011	0.026	0.021	0.020	0.0013
Cascades Stream (Whakanewha)	12	0.009	0.026	0.016	0.015	0.0016
Hoteo River (NIWA operated)	12	0.009	0.026	0.017	0.017	0.0017
Kaukapakapa River	12	0.014	0.043	0.022	0.025	0.0025
Kumeu River	12	0.009	0.023	0.016	0.016	0.0015
Lucas Creek	12	0.008	0.026	0.012	0.013	0.0014
Mahurangi River (Forestry HQ)	12	0.003	0.010	0.008	0.008	0.0006
Mahurangi River (Water Supply)	12	0.005	0.017	0.013	0.013	0.0010
MakarauRiver	12	0.005	0.017	0.012	0.011	0.0011
Matakana River	12	0.006	0.020	0.014	0.013	0.0014
Ngakaroa Stream	12	0.003	0.009	0.005	0.005	0.0006
Nukumea Stream	12	0.002	0.010	0.008	0.007	0.0007
Oakley Creek	12	0.011	0.046	0.028	0.027	0.0027
Okura Creek	12	0.012	0.050	0.017	0.019	0.0030
Omaru Creek	12	0.012	0.046	0.021	0.023	0.0026
Onetangi Stream	12	0.012	0.046	0.022	0.026	0.0031
Opanuku Stream	12	0.008	0.013	0.010	0.010	0.0005
Otaki Creek	12	0.010	0.058	0.026	0.029	0.0039
Otara Creek (East Tamaki)	12	0.006	0.023	0.010	0.012	0.0014
Otara Creek (Kennel Hill)	12	0.010	0.028	0.017	0.017	0.0015
Oteha Stream	12	0.006	0.021	0.014	0.013	0.0013
Pakuranga Creek (Botany Rd)	12	0.005	0.027	0.015	0.014	0.0016
Pakuranga Creek (Greenmount Rd)	12	0.012	0.041	0.035	0.033	0.0023
Papakura Stream (Alfriston Rd)	12	0.016	0.047	0.027	0.029	0.0026
Papakura Stream (Porchester Rd)	12	0.018	0.067	0.034	0.038	0.0049
Puhinui Stream	12	0.011	0.064	0.014	0.021	0.0044
Rangitopuni River (NIWA operated)	12	0.008	0.034	0.015	0.016	0.0021
Riverhead Stream	12	0.005	0.015	0.008	0.008	0.0008
Vaughan Stream	12	0.005	0.020	0.013	0.012	0.0012
Wairoa Tributary	12	0.021	0.042	0.032	0.032	0.0015
Wairoa River	12	0.006	0.023	0.014	0.014	0.0015
Waitangi River	12	0.004	0.015	0.007	0.007	0.0008
Waiwera River	12	0.003	0.020	0.011	0.012	0.0015
West Hoe Stream	12	0.005	0.011	0.008	0.008	0.0005
Whangamaire Stream	12	0.003	0.017	0.008	0.009	0.0013

Total Phosphorus (mg P /L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	0.016	0.072	0.047	0.046	0.0038
Cascade Stream (Waitakere)	12	0.015	0.050	0.029	0.031	0.0032
Cascades Stream (Whakanewha)	12	0.018	0.049	0.028	0.030	0.0029
Hoteo River (NIWA operated)	12	0.027	0.176	0.047	0.060	0.0122
Kaukapakapa River	12	0.030	0.100	0.062	0.060	0.0065
Kumeu River	12	0.025	0.072	0.048	0.047	0.0048
Lucas Creek	12	0.022	0.099	0.038	0.042	0.0062
Mahurangi River (Forestry HQ)	12	0.014	0.089	0.019	0.027	0.0060
Mahurangi River (Water Supply)	12	0.022	0.051	0.035	0.035	0.0025
MakarauRiver	12	0.013	0.053	0.028	0.031	0.0038
Matakana River	12	0.016	0.055	0.031	0.032	0.0038
Ngakaroa Stream	12	0.007	0.037	0.013	0.016	0.0025
Nukumea Stream	12	0.005	0.033	0.015	0.017	0.0024
Oakley Creek	12	0.042	0.075	0.053	0.057	0.0032
Okura Creek	12	0.026	0.210	0.058	0.075	0.0159
Omaru Creek	12	0.040	0.640	0.060	0.111	0.0484
Onetangi Stream	12	0.026	0.120	0.054	0.054	0.0073
Opanuku Stream	12	0.018	0.037	0.024	0.025	0.0016
Otaki Creek	12	0.046	0.260	0.125	0.130	0.0182
Otara Creek (East Tamaki)	12	0.021	0.088	0.034	0.044	0.0064
Otara Creek (Kennel Hill)	12	0.037	0.140	0.056	0.069	0.0094
Oteha Stream	12	0.031	0.100	0.055	0.056	0.0062
Pakuranga Creek (Botany Rd)	12	0.021	0.100	0.054	0.054	0.0067
Pakuranga Creek (Greenmount Rd)	12	0.078	0.150	0.099	0.108	0.0066
Papakura Stream (Alfriston Rd)	12	0.028	0.120	0.064	0.066	0.0070
Papakura Stream (Porchester Rd)	12	0.034	0.150	0.074	0.081	0.0101
Puhinui Stream	12	0.032	0.140	0.058	0.069	0.0099
Rangitopuni River (NIWA operated)	12	0.042	0.324	0.055	0.113	0.0313
Riverhead Stream	12	0.008	0.033	0.022	0.022	0.0025
Vaughan Stream	12	0.017	0.070	0.040	0.040	0.0042
Wairoa Tributary	12	0.028	0.092	0.044	0.047	0.0052
Wairoa River	12	0.024	0.057	0.040	0.040	0.0034
Waitangi River	12	0.008	0.041	0.015	0.017	0.0026
Waiwera River	12	0.018	0.047	0.032	0.033	0.0029
West Hoe Stream	12	0.007	0.038	0.012	0.015	0.0026
Whangamaire Stream	12	0.009	0.069	0.022	0.030	0.0055

Soluble Copper (µg/L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error	
Avondale Stream	12	0.62	3.80	1.50	1.50	0.236	
Cascade Stream (Waitakere)			Not measure	ed at this si	te		
Cascades Stream (Whakanewha)			Not measure	ed at this si	te		
Hoteo River (NIWA operated)			Not measure	ed at this si	te		
Kaukapakapa River			Not measure	ed at this si	te		
Kumeu River	12	0.64	1.70	0.85	0.95	0.097	
Lucas Creek	12	0.54	3.30	0.96	1.25	0.229	
Mahurangi River (Forestry HQ)	12	0.23	0.56	0.38	0.40	0.034	
Mahurangi River (Water Supply)	12	0.28	1.20	0.49	0.64	0.090	
MakarauRiver	12	0.38	1.00	0.67	0.65	0.058	
Matakana River	12	0.44	1.10	0.64	0.65	0.063	
Ngakaroa Stream			Not measure	ed at this si	te		
Nukumea Stream	12	0.15	0.55	0.31	0.31	0.035	
Oakley Creek	12	0.71	3.20	1.35	1.39	0.180	
Okura Creek	12	0.19	1.80	0.78	0.82	0.136	
Omaru Creek	12	0.72	2.70	1.45	1.69	0.201	
Onetangi Stream	Not measured at this site						
Opanuku Stream	Not measured at this site						
Otaki Creek	12	0.82	2.70	1.20	1.31	0.155	
Otara Creek (East Tamaki)	12	0.78	1.70	0.98	1.11	0.095	
Otara Creek (Kennel Hill)	12	0.58	2.30	1.20	1.25	0.141	
Oteha Stream	12	0.84	3.40	1.25	1.59	0.240	
Pakuranga Creek (Botany Rd)	12	0.75	2.30	1.15	1.27	0.148	
Pakuranga Creek (Greenmount Rd)	12	0.47	3.80	1.35	1.67	0.319	
Papakura Stream (Alfriston Rd)	12	0.34	1.50	0.75	0.76	0.104	
Papakura Stream (Porchester Rd)	12	0.28	2.80	0.92	1.06	0.196	
Puhinui Stream	12	0.65	1.60	1.20	1.16	0.092	
Rangitopuni River (NIWA operated)			Not measure	ed at this si	te		
Riverhead Stream	12	0.02	0.89	0.52	0.51	0.065	
Vaughan Stream	12	0.18	2.40	0.65	0.94	0.186	
Wairoa Tributary			Not measure	ed at this si	te		
Wairoa River	12	0.27	0.84	0.59	0.56	0.062	
Waitangi River			Not measure	ed at this si	te		
Waiwera River	12	0.16	0.99	0.46	0.51	0.072	
West Hoe Stream			Not measure	ed at this si	te		
Whangamaire Stream			Not measure	ed at this si	te		

Total Copper (µg/L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error	
Avondale Stream	12	1.00	5.70	2.15	2.23	0.343	
Cascade Stream (Waitakere)			Not measure	ed at this si	te	<u>.</u>	
Cascades Stream (Whakanewha)			Not measure	ed at this si	te		
Hoteo River (NIWA operated)			Not measure	ed at this si	te		
Kaukapakapa River			Not measure	ed at this si	te		
Kumeu River	12	0.73	3.00	1.15	1.40	0.217	
Lucas Creek	12	0.74	3.60	1.45	1.91	0.304	
Mahurangi River (Forestry HQ)	12	0.40	3.20	0.67	0.90	0.224	
Mahurangi River (Water Supply)	12	0.42	1.70	0.89	0.91	0.119	
MakarauRiver	12	0.42	2.30	0.81	0.95	0.159	
Matakana River	12	0.56	1.80	0.77	0.89	0.109	
Ngakaroa Stream			Not measure	ed at this si	te		
Nukumea Stream	12	0.35	0.69	0.47	0.51	0.036	
Oakley Creek	12	1.20	5.50	1.80	2.09	0.358	
Okura Creek	12	0.52	2.40	1.15	1.21	0.152	
Omaru Creek	12	1.50	6.20	2.80	2.97	0.378	
Onetangi Stream	Not measured at this site						
Opanuku Stream	Not measured at this site						
Otaki Creek	12	1.60	5.90	2.60	3.03	0.394	
Otara Creek (East Tamaki)	12	1.00	2.50	1.45	1.62	0.154	
Otara Creek (Kennel Hill)	12	1.00	4.00	1.70	2.08	0.283	
Oteha Stream	12	1.10	5.50	1.95	2.53	0.376	
Pakuranga Creek (Botany Rd)	12	1.10	3.60	1.65	1.98	0.234	
Pakuranga Creek (Greenmount Rd)	12	0.77	6.40	2.05	2.56	0.534	
Papakura Stream (Alfriston Rd)	12	0.41	2.30	1.00	1.06	0.168	
Papakura Stream (Porchester Rd)	12	0.40	4.20	1.10	1.46	0.292	
Puhinui Stream	12	0.85	2.50	1.60	1.65	0.144	
Rangitopuni River (NIWA operated)			Not measure	ed at this si	te		
Riverhead Stream	12	0.18	1.20	0.64	0.66	0.081	
Vaughan Stream	12	0.23	2.80	0.98	1.21	0.211	
Wairoa Tributary			Not measure	ed at this si	te		
Wairoa River	12	0.39	1.30	0.79	0.79	0.085	
Waitangi River			Not measure	ed at this si	te		
Waiwera River	12	0.48	1.80	0.68	0.86	0.124	
West Hoe Stream			Not measure	ed at this si	te		
Whangamaire Stream			Not measure	ed at this si	te		

Soluble Zinc (µg/L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error	
Avondale Stream	12	6.0000	48.0000	19.0000	19.7250	3.4654	
Cascade Stream (Waitakere)	Not measured at this site						
Cascades Stream (Whakanewha)	Not measured at this site						
Hoteo River (NIWA operated)	Not measured at this site						
Kaukapakapa River		Not measured at this site					
Kumeu River	12	1.5000	9.3000	1.8500	3.1583	0.7647	
Lucas Creek	12	0.8600	12.0000	4.1000	5.1050	1.1748	
Mahurangi River (Forestry HQ)	12	0.1500	1.3000	0.3200	0.4283	0.1041	
Mahurangi River (Water Supply)	12	0.1500	4.3000	1.2000	1.6725	0.3908	
MakarauRiver	12	0.1500	1.3000	0.3750	0.4908	0.1105	
Matakana River	12	0.1500	1.6000	0.3900	0.5245	0.1285	
Ngakaroa Stream			Not measure	ed at this si	te		
Nukumea Stream	12	0.1500	4.8000	1.1500	1.3242	0.3395	
Oakley Creek	12	4.7000	38.0000	7.2500	10.5583	2.6644	
Okura Creek	12	0.3200	4.1000	1.8000	1.9733	0.3352	
Omaru Creek	12	17.0000	230.0000	71.0000	85.9167	16.3153	
Onetangi Stream			Not measure	ed at this si	te		
Opanuku Stream	Not measured at this site						
Otaki Creek	12	7.4000	86.0000	22.0000	28.8000	6.3549	
Otara Creek (East Tamaki)	12	10.0000	48.0000	19.0000	21.9167	3.4299	
Otara Creek (Kennel Hill)	12	2.2000	38.0000	4.5000	9.2000	2.9619	
Oteha Stream	12	9.0000	61.0000	27.0000	29.5833	5.0967	
Pakuranga Creek (Botany Rd)	12	4.6000	70.0000	13.5000	17.0917	5.0739	
Pakuranga Creek (Greenmount Rd)	12	3.4000	67.0000	6.8000	12.1417	5.0592	
Papakura Stream (Alfriston Rd)	12	0.9700	9.6000	2.6000	3.3064	0.7343	
Papakura Stream (Porchester Rd)	12	1.3000	9.1000	2.7500	3.4583	0.6524	
Puhinui Stream	12	5.0000	51.0000	18.0000	23.2583	4.3460	
Rangitopuni River (NIWA operated)	Not measured at this site						
Riverhead Stream	12	1.9000	21.0000	4.5500	7.8417	1.9888	
Vaughan Stream	12	0.9700	12.0000	3.1500	4.0558	0.9564	
Wairoa Tributary			Not measure	ed at this si	te		
Wairoa River	12	0.1500	2.1000	0.5500	0.6767	0.1510	
Waitangi River	Not measured at this site						
Waiwera River	12	0.1500	2.7000	0.3800	0.6283	0.2245	
West Hoe Stream			Not measure	ed at this si	te		
Whangamaire Stream	Not measured at this site						

Total Zinc (µg/L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	9.00	65.00	26.00	26.62	4.595
Cascade Stream (Waitakere)	Not measured at this site					
Cascades Stream (Whakanewha)	Not measured at this site					
Hoteo River (NIWA operated)	Not measured at this site					
Kaukapakapa River	Not measured at this site					
Kumeu River	12	1.30	15.00	2.50	4.56	1.272
Lucas Creek	12	1.60	25.00	5.60	8.27	2.087
Mahurangi River (Forestry HQ)	12	0.15	10.00	0.67	1.60	0.788
Mahurangi River (Water Supply)	12	0.15	6.70	2.35	2.73	0.614
MakarauRiver	12	0.15	3.90	0.54	1.11	0.373
Matakana River	12	0.15	3.10	0.45	0.80	0.269
Ngakaroa Stream			Not measure	ed at this si	te	
Nukumea Stream	12	0.15	2.20	1.04	1.13	0.152
Oakley Creek	12	7.50	66.00	9.60	16.80	5.169
Okura Creek	12	1.20	6.80	2.60	3.28	0.547
Omaru Creek	12	57.00	330.00	88.00	115.33	21.282
Onetangi Stream	Not measured at this site					
Opanuku Stream	Not measured at this site					
Otaki Creek	12	22.00	120.00	41.50	49.08	7.537
Otara Creek (East Tamaki)	12	12.00	58.00	26.50	28.33	3.838
Otara Creek (Kennel Hill)	12	5.40	50.00	10.50	16.51	3.988
Oteha Stream	12	13.00	85.00	39.50	45.75	7.419
Pakuranga Creek (Botany Rd)	12	9.50	100.00	21.50	25.85	7.005
Pakuranga Creek (Greenmount Rd)	12	7.10	100.00	11.50	18.73	7.440
Papakura Stream (Alfriston Rd)	12	0.99	18.00	4.80	5.10	1.432
Papakura Stream (Porchester Rd)	12	1.70	15.00	4.00	5.99	1.307
Puhinui Stream	12	12.00	72.00	28.50	33.08	5.394
Rangitopuni River (NIWA operated)	Not measured at this site					
Riverhead Stream	12	2.60	23.00	5.80	9.22	2.119
Vaughan Stream	12	1.80	14.00	3.60	5.30	1.170
Wairoa Tributary			Not measure	ed at this si	te	
Wairoa River	12	0.15	3.80	0.79	1.25	0.342
Waitangi River	Not measured at this site					
Waiwera River	12	0.15	4.10	0.51	1.04	0.343
West Hoe Stream	Not measured at this site					
Whangamaire Stream	Not measured at this site					

Soluble Lead (µg/L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error	
Avondale Stream	12	0.05	0.46	0.25	0.25	0.038	
Cascade Stream (Waitakere)	Not measured at this site						
Cascades Stream (Whakanewha)	Not measured at this site						
Hoteo River (NIWA operated)			Not measure	d at this sit	e		
Kaukapakapa River			Not measure	d at this sit	te		
Kumeu River	12	0.03	0.42	0.11	0.13	0.032	
Lucas Creek	12	0.03	0.10	0.03	0.05	0.009	
Mahurangi River (Forestry HQ)	12	0.03	0.03	0.03	0.03	0.000	
Mahurangi River (Water Supply)	12	0.03	0.07	0.03	0.03	0.004	
MakarauRiver	12	0.03	0.05	0.03	0.03	0.002	
Matakana River	12	0.03	0.03	0.03	0.03	0.000	
Ngakaroa Stream			Not measure	d at this sit	e		
Nukumea Stream	12	0.03	0.03	0.03	0.03	0.000	
Oakley Creek	12	0.03	0.19	0.11	0.10	0.016	
Okura Creek	12	0.03	0.10	0.06	0.06	0.008	
Omaru Creek	12	0.03	0.33	0.08	0.12	0.030	
Onetangi Stream			Not measure	d at this sit	te		
Opanuku Stream	Not measured at this site						
Otaki Creek	12	0.03	0.33	0.12	0.14	0.030	
Otara Creek (East Tamaki)	12	0.03	0.16	0.07	0.08	0.012	
Otara Creek (Kennel Hill)	12	0.03	0.13	0.06	0.06	0.011	
Oteha Stream	12	0.03	0.19	0.08	0.08	0.015	
Pakuranga Creek (Botany Rd)	12	0.03	0.23	0.03	0.05	0.017	
Pakuranga Creek (Greenmount Rd)	12	0.03	0.15	0.03	0.05	0.013	
Papakura Stream (Alfriston Rd)	12	0.03	0.24	0.10	0.11	0.017	
Papakura Stream (Porchester Rd)	12	0.03	0.11	0.03	0.05	0.009	
Puhinui Stream	12	0.03	0.20	0.10	0.11	0.019	
Rangitopuni River (NIWA operated)	Not measured at this site						
Riverhead Stream	12	0.03	0.07	0.03	0.04	0.005	
Vaughan Stream	12	0.03	0.10	0.04	0.05	0.009	
Wairoa Tributary			Not measure	d at this sit	te		
Wairoa River	12	0.03	0.09	0.03	0.05	0.008	
Waitangi River			Not measure	d at this sit	te		
Waiwera River	12	0.03	0.06	0.03	0.03	0.003	
West Hoe Stream			Not measure	d at this sit	e		
Whangamaire Stream	Not measured at this site						

Total Lead (µg/L)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error	
Avondale Stream	12	0.56	6.80	1.70	2.30	0.567	
Cascade Stream (Waitakere)	Not measured at this site						
Cascades Stream (Whakanewha)	Not measured at this site						
Hoteo River (NIWA operated)		Not measured at this site					
Kaukapakapa River			Not measure	ed at this si	te		
Kumeu River	12	0.23	0.75	0.42	0.42	0.048	
Lucas Creek	12	0.06	1.20	0.15	0.26	0.093	
Mahurangi River (Forestry HQ)	12	0.03	0.29	0.04	0.06	0.021	
Mahurangi River (Water Supply)	12	0.03	0.80	0.07	0.12	0.062	
MakarauRiver	12	0.03	0.19	0.07	0.08	0.014	
Matakana River	12	0.03	0.45	0.06	0.08	0.034	
Ngakaroa Stream			Not measure	ed at this si	te		
Nukumea Stream	12	0.03	0.66	0.07	0.12	0.051	
Oakley Creek	12	0.45	3.30	0.82	1.30	0.282	
Okura Creek	12	0.03	0.49	0.14	0.18	0.035	
Omaru Creek	12	0.06	1.30	0.36	0.43	0.099	
Onetangi Stream	Not measured at this site						
Opanuku Stream	Not measured at this site						
Otaki Creek	12	0.30	5.40	0.63	1.25	0.413	
Otara Creek (East Tamaki)	12	0.16	1.50	0.29	0.45	0.110	
Otara Creek (Kennel Hill)	12	0.13	1.50	0.29	0.42	0.110	
Oteha Stream	12	0.03	2.50	0.24	0.44	0.194	
Pakuranga Creek (Botany Rd)	12	0.12	0.98	0.34	0.43	0.077	
Pakuranga Creek (Greenmount Rd)	12	0.08	0.73	0.23	0.32	0.061	
Papakura Stream (Alfriston Rd)	12	0.03	1.60	0.19	0.41	0.142	
Papakura Stream (Porchester Rd)	12	0.03	0.50	0.17	0.18	0.043	
Puhinui Stream	12	0.17	2.60	0.44	0.64	0.191	
Rangitopuni River (NIWA operated)	Not measured at this site						
Riverhead Stream	12	0.03	0.31	0.10	0.12	0.028	
Vaughan Stream	12	0.03	1.60	0.10	0.25	0.127	
Wairoa Tributary			Not measure	ed at this si	te		
Wairoa River	12	0.03	0.39	0.12	0.15	0.033	
Waitangi River	Not measured at this site						
Waiwera River	12	0.03	0.16	0.07	0.07	0.011	
West Hoe Stream			Not measure	ed at this si	te		
Whangamaire Stream	Not measured at this site						

Escherichia coli (cfu/100ml)

Site	Count	Minimum	Maximum	Median	Mean	Standard Error
Avondale Stream	12	810	31000	2700	6697	3038.7
Cascade Stream (Waitakere)	12	5	110	28	45	11.6
Cascades Stream (Whakanewha)	12	5	190	80	84	19.6
Hoteo River (NIWA operated)	12	29	2419	78	467	263.4
Kaukapakapa River	12	63	2000	170	390	155.9
Kumeu River	12	90	4100	350	730	321.8
Lucas Creek	12	54	13000	245	1898	1159.3
Mahurangi River (Forestry HQ)	12	34	2300	210	480	195.4
Mahurangi River (Water Supply)	12	48	740	125	238	65.4
MakarauRiver	12	81	1100	285	338	88.3
Matakana River	12	18	900	87	191	71.7
Ngakaroa Stream	12	54	560	90	195	52.8
Nukumea Stream	12	7	1200	59	195	96.8
Oakley Creek	12	380	2800	740	902	188.8
Okura Creek	12	36	2000	300	670	194.2
Omaru Creek	12	45	710000	595	62770	58916.6
Onetangi Stream	12	1	220	11	40	19.6
Opanuku Stream	12	140	930	330	383	69.5
Otaki Creek	12	1200	11000	3050	3800	831.2
Otara Creek (East Tamaki)	12	270	11000	890	2392	913.2
Otara Creek (Kennel Hill)	12	540	40000	2400	6563	3328.4
Oteha Stream	12	120	4800	485	1058	418.4
Pakuranga Creek (Botany Rd)	12	280	6700	1850	2227	504.3
Pakuranga Creek (Greenmount Rd)	12	99	3700	580	1334	391.7
Papakura Stream (Alfriston Rd)	12	210	2500	755	874	174.4
Papakura Stream (Porchester Rd)	12	590	2100000	2650	177691	174756.4
Puhinui Stream	12	9	7100	415	1072	577.1
Rangitopuni River (NIWA operated)	12	27	2419	225	390	186.9
Riverhead Stream	12	18	120	39	42	8.4
Vaughan Stream	12	13	4000	325	824	335.9
Wairoa Tributary	12	9	700	72	154	59.2
Wairoa River	12	90	800	265	290	56.4
Waitangi River	12	120	2000	235	421	149.7
Waiwera River	12	110	850	355	376	69.6
West Hoe Stream	12	9	1100	77	181	88.5
Whangamaire Stream	12	250	1400	525	678	105.9