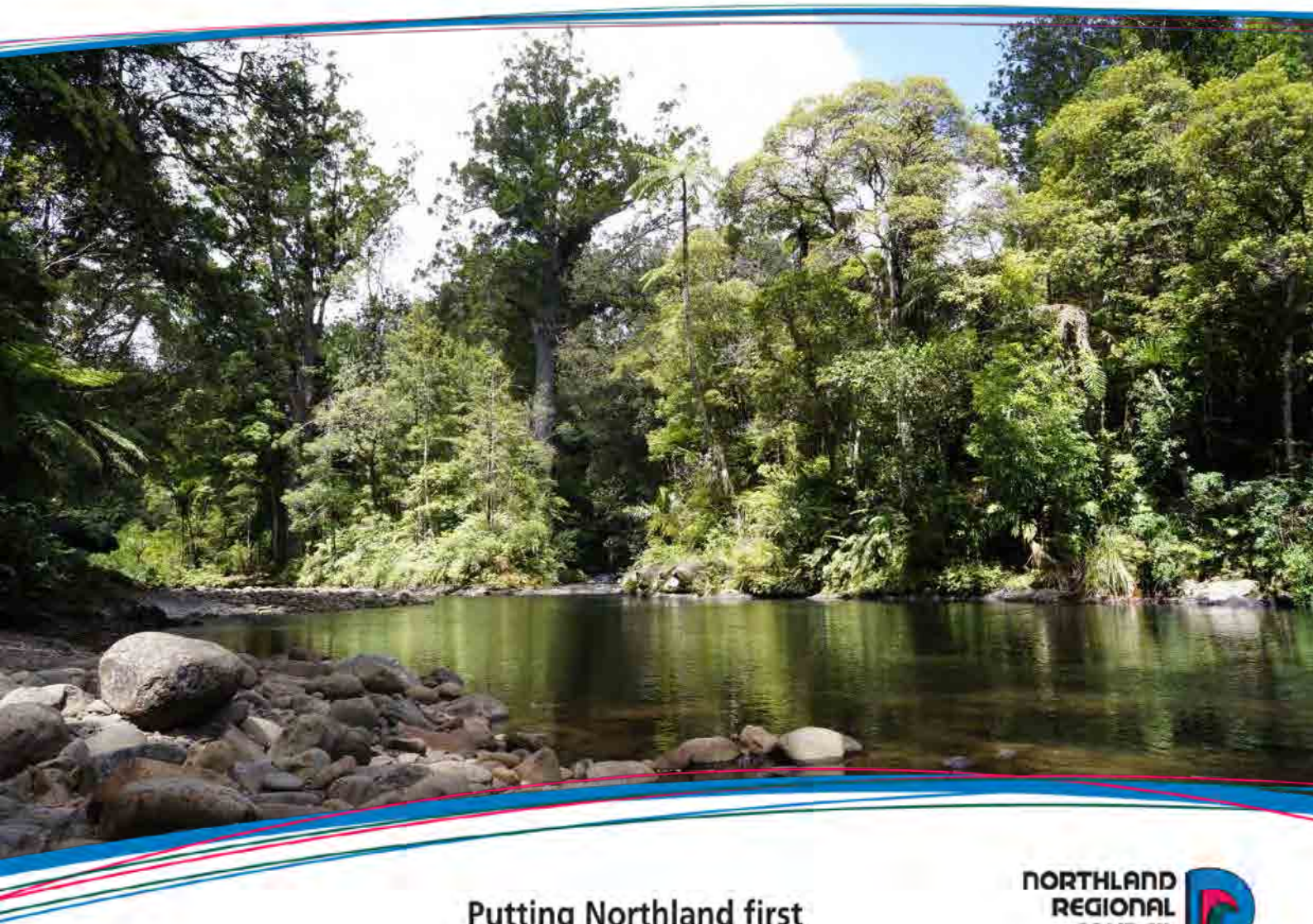
River water quality and ecology in Northland

State and trends 2007-2011



Putting Northland first

NORTHLAND REGIONAL COUNCIL

River water quality and ecology in Northland

State and trends 2007-2011

John Ballinger

Carol Nicholson

Jean-Charles Perquin

Emma Simpson

Putting Northland first

NORTHLAND REGIONAL COUNCIL

Executive Summary

This report provides a snapshot on the current state of water quality and ecosystem health at 36 Northland River Water Quality Monitoring Network (RWQMN) sites for the time period January 2007 to December 2011. Trends in water quality are presented at 24 sites with comparatively long records.

As well as physical and nutrient data, E.coli (bacterial indicator), habitat, periphyton, macroinvertebrate and fish data (where available) is presented to give an overall indication of ecosystem health. A score card for individual sites (Appendix A) provides an overall Water Quality Index (WQI) score as well as pass rates for each attribute against relevant national guidelines.

WATER QUALITY STATE, TRENDS AND DRIVERS

In Northland the main issues with water quality are faecal pollution and poor visual clarity (affected by fine suspended sediment) and phosphate. 88% of RWQMN sites failed the livestock drinking water (ANZECC 2000) guidelines for E.coli, 53% failed the national guideline (trigger value) for turbidity and 50% failed the national guideline for phosphate between January 2007 and December 2011. These sites also tend to have poor ecosystem health with poor habitat and degraded macroinvertebrate communities, and are almost exclusively sites where the surrounding land use is predominantly pastoral. This is consistent with national findings that pastoral land use strongly degrades water quality (Ballantine *et al.* 2010; Ballantine and Davies-Colley 2013; Larned *et al.* 2004). Sites downstream of harvested pine forestry, such as the Mangahahuru River at Main Road and Apotu Road, have also been severely impacted on occasions. Three rivers in particular indicate high nutrient yields in comparison to other RWQMN sites and warrant further investigation. These are Awanui at Waihu Channel, Waipao at Draffin Road, and Wairua at Purua.

From a national perspective nitrogen levels in Northlands rivers compare favourably with the rest of New Zealand. However, phosphate levels, while good in forested catchments, tend to be elevated in lowland rural areas when compared to national data. High phosphorus seems to be a regional characteristic that is possibly a legacy of marine sediments. Compared to national data E.coli levels and visual clarity are poorer across all land use types, including reference sites (McDowell *et al.* 2013). Plausibly, both the issues of high faecal contamination and poor visual clarity relate to deeply weathered clay soils in Northland, with rapid runoff and slow or restricted infiltration (Collins *et al.* 2006). These clay soils yield very fine plate-shaped particles that are near maximally efficient light attenuators and settle extremely slowly (Davies-Colley and Smith 2001). So while sediment yields are 'modest' in Northland (Hicks *et al.* 2011), the sediment suspended in river waters results in very turbid and 'muddy' rivers. Microbial Source Tracking at a selection of RWQMN rivers have showed that 66% returned positive markers for ruminant contamination, 26% for wildfowl, 6% plant decay, and 2% dog. No sites in the RWQMN returned markers for human sources of faecal contamination.

Overall there are several positive changes in water quality detected in the trend analysis for 2003 to 2011. Significant improving trends in dissolved reactive phosphorus and total phosphorus were recorded at 9 and 12 sites respectively. These trends were recorded across all catchment land use types; native forest, exotic forest, urban and pastoral. Significant improving trends were also observed

in total nitrogen across four sites (Awanui at Waihue Channel, Mangakahia at Twin Bridges, Punakitere at Taheke Recorder and Waipapa at Forest Ranger). Improvements in water clarity were detected at six sites, with the majority of these located in intensive pastoral farming catchments. Three improving trends were recorded at the Mangere at Knights Road site, which has a large proportion of dairying (40% of the 76% pastoral land). The council has been actively working alongside dairy farmers in this catchment to minimise the impact of discharges.

Negative trends include two sites with degrading levels of dissolved oxygen (Kaihu at Gorge and, Mangakahia River at Titoki Bridge), four with degrading turbidity levels (Mangahahuru at Apotu Road, Mangahahuru at Main Road, Victoria at Thompsons Bridge, and Waitangi at Waimate Road) and five sites with degrading Macroinvertebrate Community Index (MCI) results (Waiarohia at Whau Valley, Waipapa at Forest Ranger, Waitangi at Waimate Road, Whakapara at Cableway and Manganui at Mititai Road). Land use for these sites is dominated by pine plantation or pastoral land uses. Recent harvesting of pines and associated increased sediment runoff can be linked to degrading turbidity levels at both Mangahahuru sites. The Waipoua River in the Waipoua Forest and the Mangahahuru River at Main Road both show a significant increasing trend in E.coli levels despite being within forested catchments. This could be linked to the presence of feral animals like pigs, possums and goats.

Conclusions

The majority of RWQMN sites (61%) are in a degraded condition. Ecological health is also poor with 66% of MCI scores and 60% of habitat scores being within degraded categories. Almost all RWQMN rivers, within all land cover types (including reference sites) had visual clarity and E.coli levels worse than the national median. While these results suggest naturally higher background levels than other reference sites around New Zealand for these measures, they also highlight the sensitivity of Northland rivers to land use activities and the need for careful land management practices to enhance water quality and in particular ecosystem health.

Recommendations

To help improve the management of Northland's rivers and quality of downstream coastal waters the following actions are recommended:

- Create more reference sites
- Develop regional water quality and MCI guidelines using reference data
- Investigate limiting nutrients in rivers
- Carry out more continuous monitoring during summer low flows
- Better integration of river monitoring with estuary and coastal monitoring
- Add temporary sites from new catchments to the RWQMN to help fill the monitoring gaps in our region
- Engage in more flood event monitoring (sediment, microbes)
- Develop further the council's fish, macrophyte and sedimentation monitoring programmes
- Foster community monitoring.

Contents

1. Introduction

Northland Regional Council has statutory responsibility for water quality in the rivers and streams of the Northland region for natural state, public water supply, livestock water supply, recreation and amenity, and aquatic habitat. To help assess the effectiveness of water management for these values the council monitors the physio-chemical attributes along with biological and physical measures of ecosystem health in Northland's rivers and streams.

Rivers are hydrological fluxes, carrying pollutants as well as water, whereas most other waters (wetlands, lakes, estuaries, groundwater) have more the character of hydrological storages. None of Northland's rivers are considered major on a national scale as the region's narrow land mass means most rivers are relatively short with small catchments. Most of the major rivers flow into harbours and estuaries rather than discharging directly to the open coast, and as a consequence contamination in these rivers may have severe effects on these sheltered environments. One such river, the Northern Wairoa, is Northland's largest river, draining a catchment area of 3,650 square kilometers, or 29% of Northland's land area, which discharges into the Kaipara Harbour.

Northland is prone to both droughts and floods. Flows in rivers vary considerably with rainfall with high intensity storms causing flash floods, while prolonged dry spells lead to very low flows in many smaller catchments. Because Northland is dominated by deeply weathered geology and fine clay soils, its rivers are generally characterised as being slow flowing and muddy.

Northland's River Water Quality Monitoring Network (RWQMN) was established in September 1996 and initially included nine river sites throughout Northland. Since 1996 a further 23 sites have been added to the network. The four Northland sites in the National River Water Quality Network monitored by National Institute of Water and Atmospheric Research Limited (NIWA) are also incorporated into the regional network. There are currently 36 sites throughout Northland that are monitored monthly for water quality. Monitoring the state of the environment is a specific requirement for regional councils under section 35(2)(a) of the Resource Management Act (RMA) 1991.

Report purpose and scope

This report presents the current state and trend of water quality in the rivers and streams across the Northland Region and whether or not this has improved, stayed the same, or deteriorated. It also provides some information on ecosystem health. Trend analysis was carried out at 21 sites (sites with 5 years or more data). The state is affected by inter-annual climate variation such as floods and droughts whereas trends give the overall picture of whether water quality is improving, degrading or remaining stable. A similar report presents the state and trends of water quality/ecosystem health from the extensive Lake Water Quality Monitoring Network (LWQMN), and the receiving coastal environment. This information is vital to monitor the effectiveness of current policy in the protection/enhancement of natural waters in the region, as well as identifying areas of declining or persistently low water quality where further investigation is required.

The water quality assessment focuses on State of the Environment (SoE) data, comparing the medians for six variables at each site against national water quality guidelines (Table 1) to calculate a Water Quality Index (WQI). Macroinvertebrate, periphyton and fish monitoring data is also presented for each site (where available), giving an indication of the ecosystem health of rivers.

2. Overview of river and stream monitoring in Northland

Monitoring objectives

The aim of the council's River Water Quality Monitoring Network (RWQMN) programme is to:

1. Assist the detection of changes to spatial and temporal changes in fresh water quality.
2. Determine the suitability of fresh waters for designated uses.
3. Provide information to assess the effectiveness of regional policies and plans.
4. Provide information to assist in targeted investigations where mitigation of poor water quality is desired.
5. Contribute to the understanding of freshwater biodiversity in the region.

Monitoring variables

Physio-chemical data is collected at each of the 36 SOE sites monthly. This includes up to 12 water quality attributes; dissolved oxygen (DO), E.coli, visual clarity, turbidity, temperature, pH, ammoniacal nitrogen (NH_4), Nitrate-nitrite nitrogen (NNN), total nitrogen (TN), dissolved reactive phosphorous (DRP), total phosphorus (TP) and flow.

Water quality is generally assessed against Australian and New Zealand Environment and Conservation Council 'default' trigger values for lowland aquatic ecosystems (cited here as ANZECC: 2000). There were some exceptions, as outlined in Table 1. In terms of microbiological water quality, the main E.coli trigger values relate to livestock drinking water, not contact recreation because the council has a separate swimming water quality monitoring programme to assess the suitability of popular river sites for contact recreation. The ANZECC (2000) livestock water trigger values recommend a season median of 100 thermotolerant coliforms/100mL.

While the ANZECC trigger values are cited here, the National Policy Statement for Freshwater (NPS – FW) is about to recommend a National Objectives Framework (NOF) with limits for many water quality attributes that will supersede ANZECC.

Table 1: 'Guidelines' and trigger values used to assess the current state of water quality in the Northland Region.

Parameter	Abbreviation	'Guideline'	Reference
Dissolved oxygen (% saturation)	DO	≤80	RMA 1991 Third schedule
Dissolved reactive phosphorus (mg/l)	DRP	≤0.010	ANZECC 2000 – lowland
Thermotolerant coliforms (E.coli) (cfu/100ml)	E.coli	≤100	ANZECC 2000 – livestock drinking water
Ammoniacal nitrogen (mg/l)	NH4	≤0.021	ANZECC 2000 – lowland
Nitrate-nitrite nitrogen (mg/l)	NNN	≤0.444	ANZECC 2000 – lowland
Turbidity (NTU)	TURB	≤5.6	ANZECC 2000 – lowland

Monitoring sites

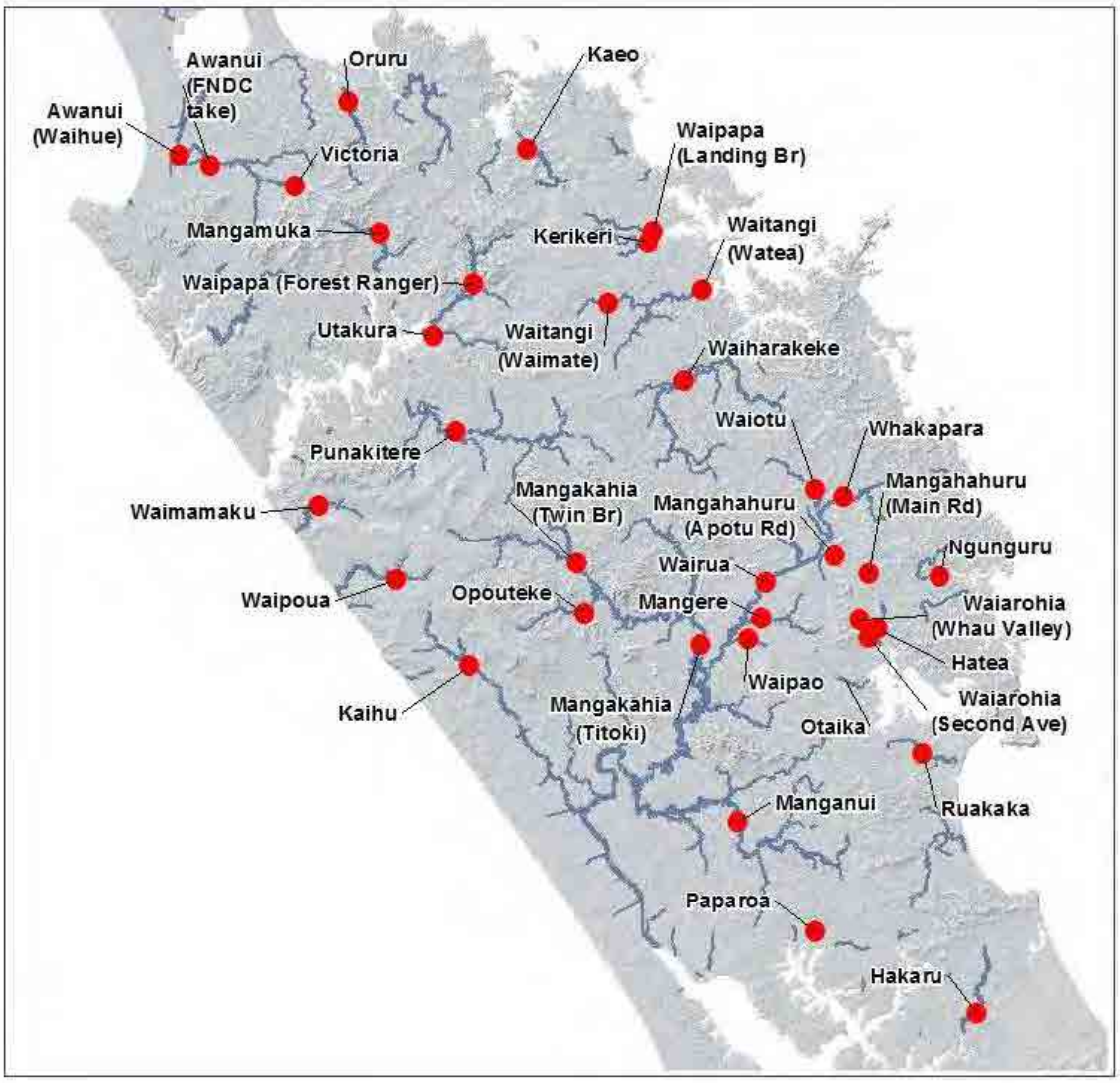


Figure 1: Map showing the 36 Regional Water Quality Monitoring Network sites. River Environment Classification (REC) metadata is available in Table 3.

The ANZECC (2000) trigger values for lowland aquatic ecosystems are intended to be compared against the median values from independent samples at a site. These trigger values are not legal standards and exceedances do not necessarily mean an adverse environmental effect would result (that is, they are not effects-based). Rather, they can be considered 'nominal thresholds' (Ballantine *et al.* 2010), where a breach is an 'early warning' mechanism to alert resource managers to a potential problem or emerging change that may warrant site-specific investigation or remedial action (ANZECC 2000).

Water Quality Index (WQI)

A water quality index is used to facilitate inter-site comparisons of the state of water quality in the region's rivers and streams. This approach has been used at both a regional (for example, Piere *et al.* 2012; Ozane: 2012), and a national level (Larned *et al*. 2005). The water quality index is calculated

using the median values for the following six variables: dissolved oxygen (% saturation), turbidity, ammoniacal nitrogen, nitrite-nitrate nitrogen, dissolved reactive phosphorus, and *Escherichia coli*, and assessed against the guideline values in Table 1.

The application of the water quality index enables water quality at each site to be classified into one of four categories:

- **Excellent**: median values for all six variables are within guideline values.
- **Good**: median values for five of the six variables are within guideline values, of which dissolved oxygen is one variable that must be met.
- **Fair**: median values for three or four of the six variables are within guideline values, of which dissolved oxygen is one variable that must be met.
- **Poor**: median values for <3 of the six variables comply with guideline values.

Sites with a grade of good, fair or poor represent degraded sites as the median value of at least one of the six key water quality variables is not within the guideline values. The degree of degradation is relative, with good sites having the least degraded water quality and poor sites the most degraded water quality.

Nutrient Loadings and Yields

Nutrient loadings can give an estimate of the amount of nutrients leaving a catchment over a given time period (Stansfield 2011). An average yearly nutrient loading for the 2007 to 2011 time period is calculated for each site by multiplying average yearly nutrient concentrations by average yearly flow. As the council data is based on spot samples, this is an indicative estimate as nutrient levels fluctuate constantly throughout the day and according to flow.

Catchment yields are also useful for identifying problem catchments with high nutrient outputs. These are calculated by dividing the loading estimate by catchment area upstream of the sampling site.

Biological monitoring

Macroinvertebrates

Macroinvertebrate monitoring is undertaken annually by the council during summer low flows to detect changes in the aquatic macroinvertebrate communities resulting from human-induced stresses, for example, contaminants entering the waterway. Macroinvertebrates are normally abundant in lotic (running water) ecosystems, and are commonly used in the assessment of water quality as their diverse communities provide varied responses to changing environmental conditions (Boothroyd and Stark, 2000) with different species having different tolerances to pollution (Pohe 2011). Macroinvertebrates are good time-integrating indicators of local conditions because they live in the river/stream and are affected by the environmental conditions over an extended period of time, unlike chemical measurements, which are snapshots of the waterway at that point, at that moment in time. However, it must be recognised that macroinvertebrates are to some extent dependent on local

(reach-scale) conditions and do not fully integrate over space (the catchment) or indicate downstream effects as do most water quality variables – so water quality and bio-indicators are complementary in SoE work and both are needed.

Each species has a tolerance score, the Macroinvertebrate Community Index (MCI) being calculated from the tolerance scores for all species present at a particular site. Initial macroinvertebrate monitoring in New Zealand was carried out following the procedures of Stark (1985), and have been revised several times (Stark 1993; Stark 1998; and Stark *et al.* 2001). More recent publications added revised tolerance scores for taxa collected from soft-bottomed sites (Stark and Maxted: 2004, 2007); the resulting MCI scores being labelled MCI-sb. The council uses soft-bottomed tolerance scores for naturally occurring soft-bottomed sites. All soft-bottomed sites that are deemed to be 'human induced' are calculated using the MCI, that is, derived from hard-bottomed tolerance scores. Table 2 shows the tolerance range for each water quality class.

Table 2: Interpretation of Macroinvertebrate Community Index (MCI) scores

Quality class	MCI and MCI-sb
Excellent	≥120
Good	100-119
Fair	80-99
Poor	<80

PERIPHYTON

Periphyton refers to the photosynthetic algae and bacteria that grow on stream substrate. It is naturally occurring and important for sustaining stream life (Biggs 2000). However, in response to such factors as elevated nutrient levels and high temperatures, it can form thick growths of mats and/or filaments which can adversely affect in stream values such as contact recreation, stream biodiversity and aesthetics. Periphyton monitoring was started in 2007 and was carried out annually in conjunction with the macroinvertebrate monitoring programme following the quantitative method 1b of Biggs & Kilroy (2000) to assess periphyton biomass and species composition. Recently this has been revised to a quarterly monitoring programme using the methods outlined in Kilroy *et al.* (2008).

FISH

While there are limited records, data from the New Zealand Freshwater Fish database (NZFFD) has been extracted for each site where available. Fish communities, like macroinvertebrates, provide a good indication of habitat quality. Different species have different tolerances to water quality/habitat degradation. Fish community composition, diversity and density are useful indicators of river health.

HABITAT ASSESSMENTS

In general, water quality, habitat and biological diversity in rivers are closely linked. To provide a fuller picture of river health, the council undertakes habitat assessments at all river water quality monitoring sites every two years, based on protocols outlined in Pfankuch (1975), 'Stream Reach Inventory and Channel Stability Evaluation'.

The habitat assessment involves assigning scores to the following stream characteristics: aquatic habitat abundance, aquatic habitat diversity, hydrologic heterogeneity, channel alteration, bank stability, channel shade, and riparian vegetation. Habitat quality for aquatic biota is broken down into four categories: optimal, sub-optimal, marginal and poor. Biennial reports can be downloaded from the council's website.

River Environment Classification (REC)

The River Environment Classification System (REC) (Snelder *et al.* 2002) classifies rivers according to physical factors such as climate, source of flow for the river water, topography, geology, and catchment land cover e.g. forest, pasture or urban. Each river, depending on its unique set of physical factors, can respond differently to the pressures placed on it, which is an important consideration when assessing river water quality. The underlying bedrock of Northland rivers is mainly volcanic acidic, soft sedimentary and hard sedimentary geology. While volcanic soils are usually highly fertile, all of Northland's soils tend to be deeply weathered owing to the warm moist climate and are often highly leached with low fertility (Roberts *et al.* 1996). The soil tends to be acidic and low in natural phosphorus and sulfur, so lime and superphosphate are needed for pasture growth. Nutrients which aren't utilised by plants can leach into water, with this process exacerbated by Northland's high rainfall. In addition soft sedimentary soils are prone to erosion and during high rainfall this soil can be transported into water resulting in elevated sediment and nutrient loads.

Table 3 River Environment Classification information for RWQMN sites.

RWQMN Site	Area (hectares)	Land use (% cover)						REC geology	REC Valley land form	REC Climate
		Native forest	Exotic forest	Scrub	Pasture	Urban	Other			
Waipapa at Forest Ranger	12,047	86	9	1	3	0	1	Soft sedimentary	Low gradient	Warm wet
Waipoua at SH12 Rest Area	6479	90	1	3	6	0	0	Volcanic acidic	Medium gradient	Warm wet
Hātea u/s Mair Park Bridge	4282	19	25	2	35	18	1	Volcanic acidic	Low gradient	Warm wet
Kaihū at Gorge	11,512	29	17	0	54	0	0	Volcanic acidic	Medium gradient	Warm wet
Kerikeri at Stone Store Bridge	9863	13	3	4	68	3	9 (orchard)	Volcanic acidic	Medium gradient	Warm wet
Mangakāhia at Twin Bridges	24,399	34	30	1	34	0	1	Volcanic acidic	Low gradient	Warm wet
Ngunguru at Waipoka Road	5061	31	23	4	41	0	1	Hard sedimentary	Low gradient	Warm wet
Opouteke at Suspension Bridge	10,806	33	60	2	5	0	0	Volcanic acidic	Low gradient	Warm wet
Waiarohia at Whau Valley	858	79	2	2	13	0	4 (orchard)	Hard sedimentary	Low gradient	Warm wet
Waiarohia at Rust Avenue	1794	54	2	2	17	21	4 (orchard)	Hard sedimentary	Low gradient	Warm wet
Waimamaku at SH12	10,176	61	4	3	32	0	0	Volcanic acidic	Low gradient	Warm wet
Waipapa at Waipapa Landing	3361	4	6	3	56	3	28 (orchard)	Volcanic acidic	Medium gradient	Warm wet
Waitangi at Watea	30,018	14	8	7	68	1	2	Hard sedimentary	Medium gradient	Warm wet
Waitangi at Waimate Road	5048	25	8	7	60	0	0	Volcanic acidic	Low gradient	Warm wet
Awanui at FNDC Watertake	21,919	31	8	6	55	0	0	Soft sedimentary	Low gradient	Warm wet
Awanui at Waihue Channel	31,236	28	6	5	59	1	1	Soft sedimentary	Low gradient	Warm wet
Hakaru at Topuni Creek Farm	8188	20	7	2	70	0	2	Soft sedimentary	Low gradient	Warm wet
Kaeo at Dip Road	9795	41	14	16	29	0	0	Soft sedimentary	Low gradient	Warm wet
Mangahahuru at Apotu Road	4378	17	47	4	28	3	1	Hard sedimentary	Low gradient	Warm wet
Mangahahuru at Main Road	2103	16	79	2	3	0	0	Hard sedimentary	Low gradient	Warm wet
Mangakāhia at Titoki Bridge	81,024	29	31	4	36	0	0	Volcanic acidic	Low gradient	Warm wet
Mangamuka at Iwiatua Road	3640	87	1	6	6	0	0	Volcanic acidic	Low gradient	Warm wet
Manganui at Mititai Road	41,173	15	7	2	75	0	1	Soft sedimentary	Low gradient	Warm wet
Oruru at Oruru Road	17,237	34	13	15	37	0	1	Volcanic acidic	Low gradient	Warm wet
Otaika at Otaika Valley Road	34,192	19	13	3	59	0	6 (orchard)	Soft sedimentary	Low gradient	Warm wet
Paparoa at Walking Bridge	3573	13	6	2	78	1	0	Soft sedimentary	Low gradient	Warm wet
Punakitere at Taheke Recorder	32,541	19	17	7	55	1	1	Soft sedimentary	Low gradient	Warm wet
Utakura at Okaka Road Bridge	11,693	19	9	4	55	0	12 (lake)	Hard sedimentary	Medium gradient	Warm wet

Victoria at Thompsons Bridge	2670	70	6	12	12	0	0	Volcanic acidic	Low gradient	Warm wet
Waiharakeke at Stringers Road	23,256	19	26	9	44	0	2	Soft sedimentary	Low gradient	Warm wet
Waiotu at SH1	12,106	28	6	2	63	0	1	Hard sedimentary	Low gradient	Warm wet
Waipao at Draffin Road	3580	8	2	0	69	0	21 (orchard)	Volcanic acidic	Low gradient	Warm wet
Wairua at Purua	54,426	21	11	2	65	0	1	Hard sedimentary	Low gradient	Warm wet
Whakapara at Cableway	16,414	32	12	3	53	0	0	Hard sedimentary	Low gradient	Warm wet
Mangere at Knight Road	7576	21	1	1	76	0	1	Soft sedimentary	Low gradient	Warm wet
Ruakaka at Flyger Road	4726	22	3	4	71	0	0	Soft sedimentary	Low gradient	Warm wet

3. Water quality state and trends

This section provides a regional overview of water quality state and trend analysis, and periphyton and macroinvertebrate monitoring. This information is then considered in a national context.

Water quality state

Regional context

Analysis of RWQMN water quality, macroinvertebrate and habitat data collected at 36 sites during the period January 2007 to December 2011 (Table 5, Figure 2) found that:

- 14 (38%) were graded) as 'good or 'excellent' using the Water Quality Index (WQI) indicating that at least five or six of the key indicator variables met the guideline values.
- 12 (34%) were graded as 'good or 'excellent' using the Macroinvertebrate Community Index (MCI) score threshold in national guidelines provided by Stark and Maxted (2007).
- 14 (40%) of sites were graded as having 'Optimal' or 'Sub-Optimal' habitat following the protocol detailed in Pfankuch (1975), Stream Reach Inventory and Channel Stability Evaluation.

The remaining sites, depending on the attribute, were classed as having fair/marginal water quality (62%), poor MCI scores (66%), or poor aquatic habitat (60%) Although there are a limited number of sites that fit into the native forest and exotic forest REC categories, there is an indication of a link between land cover, and water quality, macroinvertebrate health (MCI) and habitat quality (Figure 11). Sites with a predominance of native forest in the catchment tend to have good water quality. As the proportion of exotic forest/pastoral land in a catchment increases, water quality tends to degrade. All the sites graded as poor are located in sites where the predominant land cover is exotic forestry or pasture. Conversely both sites graded as excellent for water quality have catchments dominated by native forest. These patterns are also reported nationally (Davies-Colley 2013). Sixty-nine percent of RWQMN sites are classified as fair or poor by the MCI. This is likely a result of high levels of deposited sediment in streams which reduces habitat and food availability for invertebrates, filling the interstitial places between stones and smothering/restricting algal growth for grazers. Ruakaka at Flyger Road has an excellent MCI grading despite having poor water quality. This site is within a bush remnant and demonstrates that good habitat availability/native cover is a strong driver of ecosystem health.

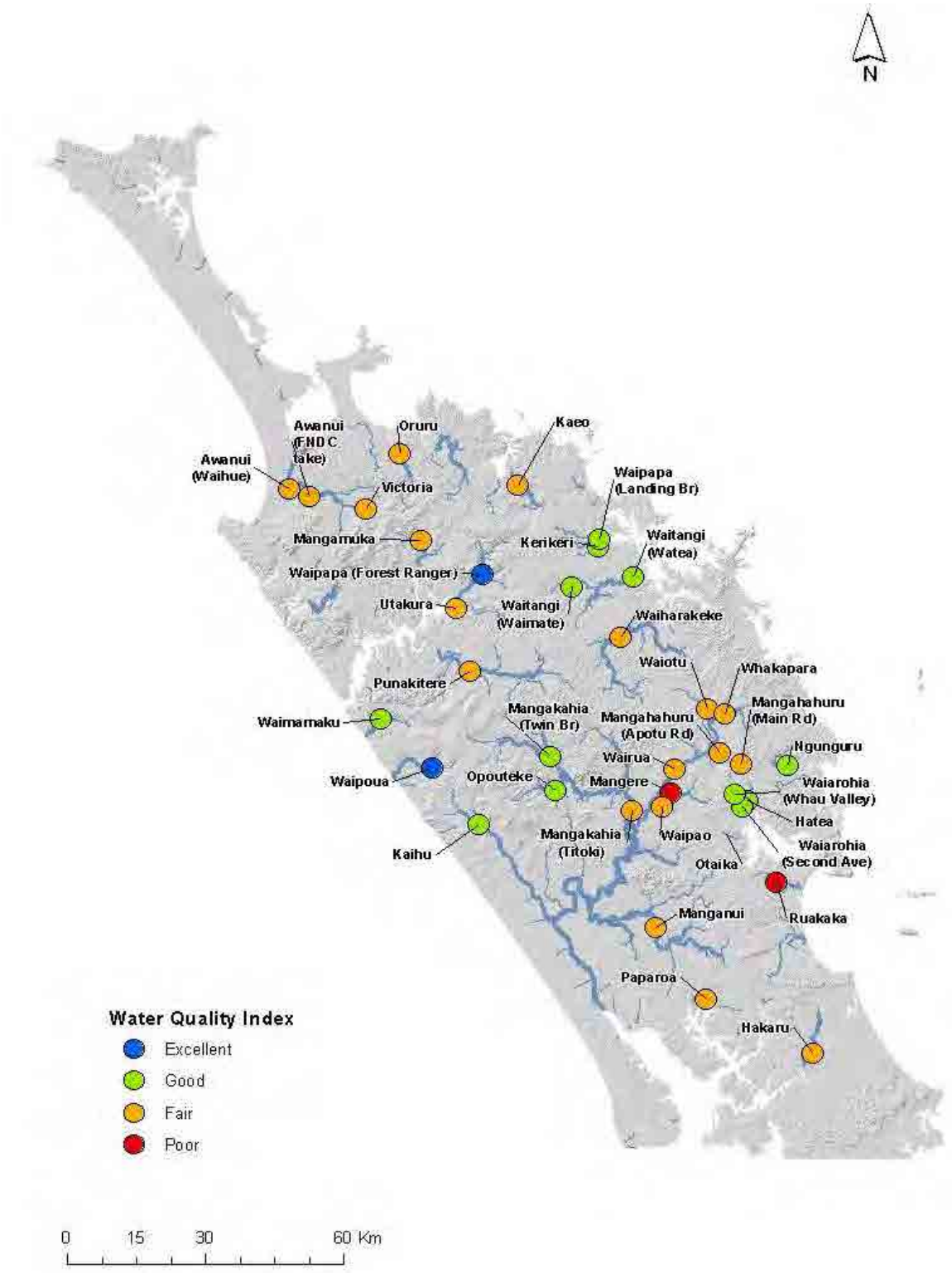


Figure 2: Surface freshwater quality classifications for the Northland region based on the River Water Quality Monitoring Network.

Table 4: Water Quality Index grades for river water quality monitoring sites sampled at monthly intervals over the period 2007-2011, based on comparisons of median values with guideline values for six key variables (see Table 1). A green tick indicates the median falls within the guideline, while a cross indicates the median is not within the guideline.

Site	DO (% sat)	DRP (mg/L)	E.coli (MPN/100ml)	NH4 (mg/L)	NNN (mg/L)	Turbidity (NTU)	MCI	Water Quality Index
Waipapa at Forest Ranger	96 ü	0.005 ü	78 ü	0.003 ü	0.013 ü	1.8 ü	118	Excellent
Waipoua at SH12	101 ü	0.003 ü	63 ü	0.005 ü	0.022 ü	2.3 ü	129	Excellent
Hātea u/s Mair Park	105 ü	0.008 ü	397 û	0.010 ü	0.385 ü	4.1 ü	95	Good
Kaihū at Gorge	100 ü	0.005 ü	153 û	0.005 ü	0.226 ü	3.2 ü	87	Good
Kerikeri at Stone Store	101 ü	0.007 ü	240 û	0.010 ü	0.410 ü	2.1 ü	77	Good
Mangakāhia at Twin Bridges	109 ü	0.003 ü	121 ü	0.005 ü	0.032 ü	2.7 ü	95	Good
Ngunguru at Waipoka Road	97 ü	0.010 ü	305 û	0.010 ü	0.093 ü	5.5 ü	90	Good
Opouteke at Suspension Bridge	107 ü	0.004 ü	174 û	0.005 ü	0.036 ü	2.7 ü	93	Good
Waiarohia at Whau Valley	96 ü	0.010 ü	504 û	0.010 ü	0.402 ü	5.6 ü	92	Good
Waiarohia at Rust Ave	107 ü	0.010 ü	414 û	0.010 ü	0.365 ü	2.5 ü	80	Good
Waimamaku at SH12	103 ü	0.005 ü	393 û	0.005 ü	0.012 ü	3.3 ü	102	Good
Waipapa Stm at Waipapa Ldg	96 ü	0.005 ü	173 û	0.010 ü	0.324 ü	2.2 ü	81	Good
Waitangi at Watea	101 ü	0.005 ü	140 û	0.007 ü	0.248 ü	3.7 ü	61*	Good
Waitangi at Waimate Road	98 ü	0.006 ü	454 û	0.010 ü	0.407 ü	5.0 ü	99	Good
Awanui at FNDC Watertake	82 ü	0.017 û	301 û	0.010 ü	0.039 ü	6.0 û	95	Fair
Awanui at Waihue Channel	87 ü	0.043 û	309 û	0.020 ü	0.053 ü	9.1 û	85*	Fair
Hakaru at Topuni Creek	103 ü	0.047 û	302 û	0.017 ü	0.260 ü	9.5 û	82	Fair

Table 4. Continued

Site	DO (% sat)		DRP (mg/L)		E.coli (MPN/100ml)		NH4 (mg/L)		NNN (mg/L)		Turbidity (NTU)		MCI	Water Quality Index
Kaeo at Dip Road	95	ü	0.005	ü	627	û	0.010	ü	0.045	ü	6.4	û	96	Fair
Mangahahuru at Apotu Road	97	ü	0.027	û	572	û	0.020	ü	0.350	ü	6.9	û	77*	Fair
Mangahahuru at Main Road	96	ü	0.010	ü	227	û	0.010	ü	0.069	ü	6.0	û	102	Fair
Mangakāhia at Titoki Bridge	95	ü	0.006	ü	237	û	0.011	ü	0.062	ü	5.9	û	100*	Fair
Mangamuka at Iwiatua Road	94	ü	0.030	û	272	û	0.005	ü	0.007	ü	1.0	ü	107	Fair
Manganui at Mititai Road	82	ü	0.039	û	135	û	0.012	ü	0.173	ü	9.4	û	69*	Fair
Oruru at Oruru Road	84	ü	0.021	û	292	û	0.010	ü	0.026	ü	6.7	û	73*	Fair
Otaika at Otaika Valley Road	84	ü	0.016	û	596	û	0.027	û	1.268	û	5.1	ü	No data	Fair
Paparoa at Walking Bridge	89	ü	0.020	û	573	û	0.020	ü	0.094	ü	8.9	û	80	Fair
Punakitere at Taheke	100	ü	0.017	û	419	û	0.010	ü	0.407	ü	6.2	û	95	Fair
Utakura at Okaka Road Bridge	88	ü	0.011	û	327	û	0.014	ü	0.136	ü	18.4	û	71*	Fair
Victoria at Thompsons Bridge	94	ü	0.016	û	170	û	0.010	ü	0.008	ü	2.0	ü	111	Fair
Waiharakeke at Stringers	95	ü	0.016	û	357	û	0.014	ü	0.117	ü	8.6	û	103*	Fair
Waiotu at SH1	93	ü	0.020	û	377	û	0.020	ü	0.250	ü	8.3	û	75*	Fair
Waipao at Draffin Road	102	ü	0.030	û	620	û	0.010	ü	2.600	û	2.7	ü	101*	Fair
Wairua at Purua	92	ü	0.016	û	84	ü	0.019	û	0.342	ü	8.4	û	76*	Fair
Whakapara at Cableway	97	ü	0.020	û	187	û	0.010	ü	0.262	ü	6.2	û	91*	Fair
Ruakaka at Flyger Road	80	ü	0.087	û	542	û	0.038	û	0.385	ü	18.3	û	120*	Poor
Mangere at Knight Road	84	ü	0.054	û	691	û	0.040	û	0.596	û	6.9	û	76*	Poor

* Calculated using Macroinvertebrate Community Index soft bottom (MCI-sb)

Table 5: Water Quality Index grades (2007-2011) for River Water Quality Monitoring Network sites. Sites are graded by comparing median values with ANZECC guidelines. Main catchment land cover(s) are listed in order of most dominant to least dominant. Harvest is forest that has recently been harvested. The Macroinvertebrate Community Index scores for both hard (MCI) and soft bottomed (MCI-sb) sites are based on the median value over the period 2007-2011. The habitat scores are based on habitat assessments undertaken in 2012.

Catchment	Geology	Land Use (LAWNZ)	Habitat score	MCI and MCI-sb	Water quality index
Waipapa at Forest Ranger	Soft sedimentary	Lowland Forest	Optimal	Good	Excellent
Waipoua at SH12 Rest Area	Volcanic acidic	Upland Forest	Optimal	Excellent	Excellent
Hātea u/s Mair Park Bridge	Volcanic acidic	Lowland Forest	Sub-Optimal	Fair	Good
Kaihū at Gorge	Volcanic acidic	Lowland Forest	Sub-Optimal	Fair	Good
Kerikeri at Stone Store Bridge	Volcanic acidic	Lowland Rural	Sub-Optimal	Poor	Good
Mangakāhia at Twin Bridges	Volcanic acidic	Lowland Forest	Sub-Optimal	Fair	Good
Ngunguru at Waipoka Road	Hard sedimentary	Lowland Forest	Marginal	Fair	Good
Opouteke at Suspension Bridge	Volcanic acidic	Lowland Forest	Marginal	Fair	Good
Waiarohia at Whau Valley	Hard sedimentary	Lowland Rural	Sub-Optimal	Fair	Good
Waiarohia at Rust Avenue	Hard sedimentary	Lowland Urban	Marginal	Good	Good
Waimamaku at SH12	Volcanic acidic	Lowland Forest	Sub-Optimal	Good	Good
Waipapa at Waipapa Landing	Volcanic acidic	Lowland Rural	Sub-Optimal	Good	Good
Waitangi at Watea	Hard sedimentary	Lowland Rural	Marginal	Poor*	Good
Waitangi at Waimate Road	Volcanic acidic	Lowland Rural	Marginal	Fair	Good

* Calculated using Macroinvertebrate Community Index soft bottom (MCI-sb).

Table 5: continued

Catchment	Geology	Land Use (LAWNZ classification)	Habitat score	MCI and MCI-sb Score	Water quality index
Awanui at FNDC Watertake	Soft sedimentary	Lowland Rural	Marginal	Fair	Fair
Awanui at Waihue Channel	Soft sedimentary	Lowland Rural	Marginal	Fair*	Fair
Hakaru at Topuni Creek Farm	Soft sedimentary	Lowland Rural	Sub-Optimal	Fair	Fair
Kaeo at Dip Road	Soft sedimentary	Lowland Rural	Poor	Fair	Fair
Mangahahuru at Apotu Road	Hard sedimentary	Lowland Rural	Poor	Poor*	Fair
Mangahahuru at Main Road	Hard sedimentary	Lowland Forest	Sub-Optimal	Good	Fair
Mangakāhia at Titoki Bridge	Volcanic acidic	Lowland Rural	Marginal	Good*	Fair
Mangamuka at Iwiatua Road	Volcanic acidic	Lowland Forest	Marginal	Good	Fair
Manganui at Mititai Road	Soft sedimentary	Lowland Rural	Marginal	Poor	Fair
Oruru at Oruru Road	Volcanic acidic	Lowland Rural	Marginal	Poor*	Fair
Otaika at Otaika Valley Road	Soft sedimentary	Lowland Rural	No data	No data	Fair
Paparoa at Walking Bridge	Soft sedimentary	Lowland Rural	Poor	Fair	Fair
Punakitere at Taheke Recorder	Soft sedimentary	Lowland Rural	Sub-Optimal	Fair	Fair
Utakura at Okaka Road Bridge	Hard sedimentary	Lowland Rural	Marginal	Poor*	Fair
Victoria at Thompsons Bridge	Volcanic acidic	Lowland Forest	Sub-Optimal	Good	Fair
Waiharakeke at Stringers Road	Soft sedimentary	Lowland Rural	Marginal	Good*	Fair
Waiotu at SH1	Hard sedimentary	Lowland Rural	Marginal	Poor*	Fair
Waipao at Draffin Road	Volcanic acidic	Lowland Rural	Marginal	Good*	Fair
Wairua at Purua	Hard sedimentary	Lowland Rural	Marginal	Poor*	Fair
Whakapara at Cableway	Hard sedimentary	Lowland Rural	Marginal	Fair*	Fair
Mangere at Knight Road	Soft sedimentary	Lowland Rural	Marginal	Poor*	Poor
Ruakaka at Flyger Road	Soft sedimentary	Lowland Rural	Sub-Optimal	Excellent*	Poor

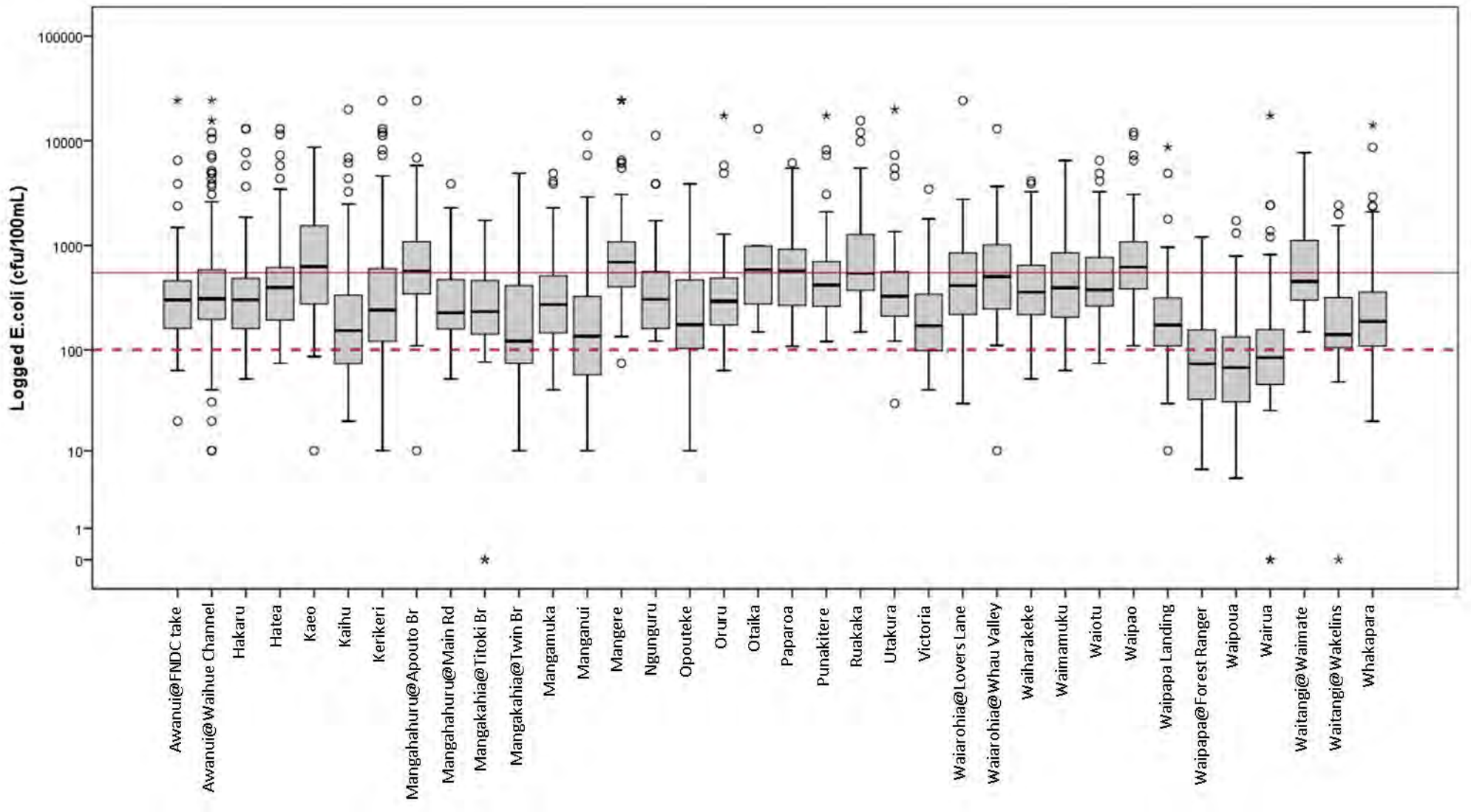


Figure 3: Box plot summarising the range and mean E.coli levels recorded across all 36 RWQMN sites from 2007 to 2011. The dashed red line indicates the livestock drinking water guideline (100 E.coli/100mL), while the unbroken red line indicates the MfE/MoH suitability for swimming guideline (550 E.coli/100mL)

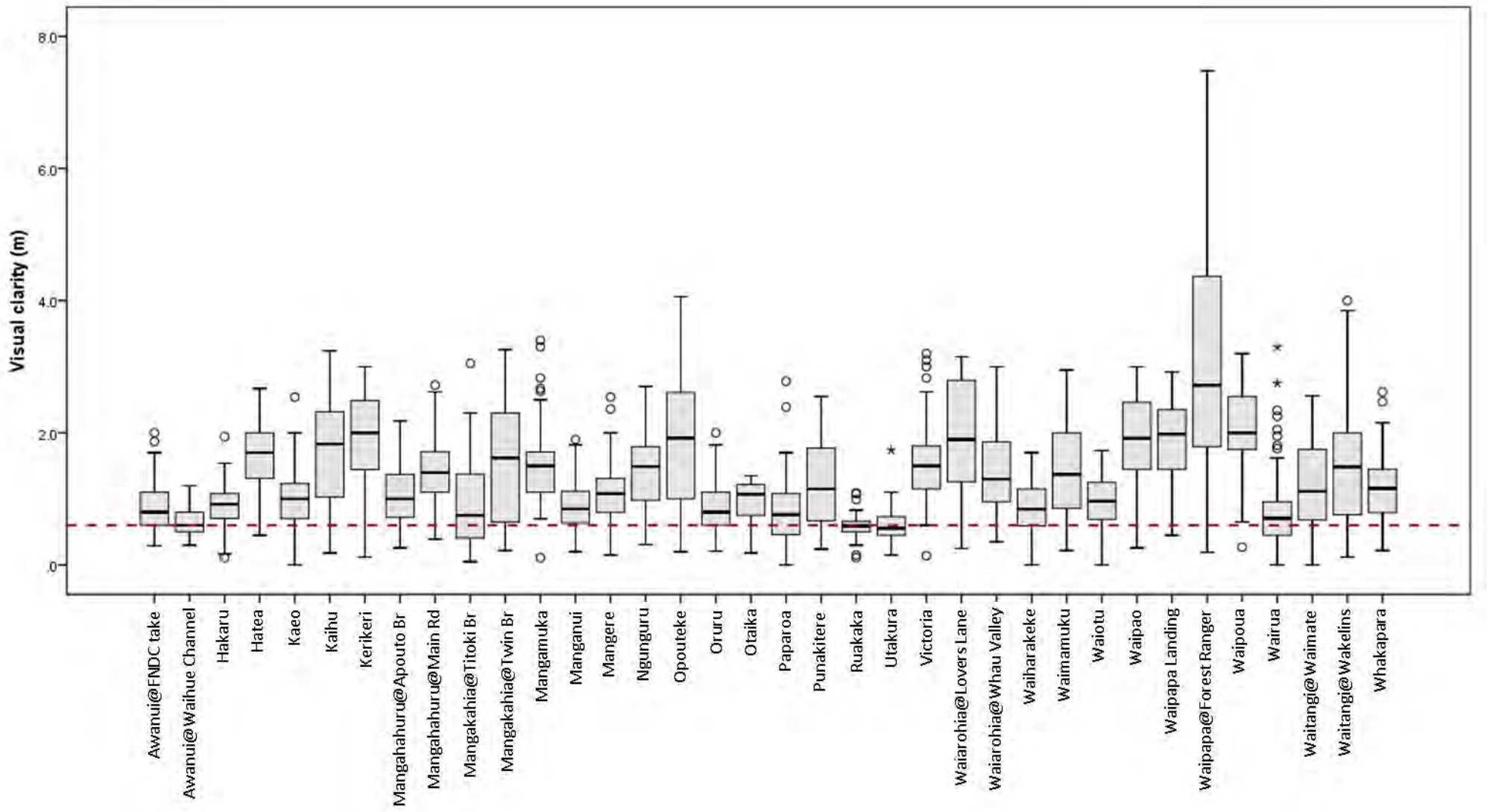


Figure 4: Box plot summarising the range and mean of clarity levels recorded across all 36 RWQMN sites from 2007 to 2011. The dashed red line indicates the ANZECC clarity guideline (>0.6m)

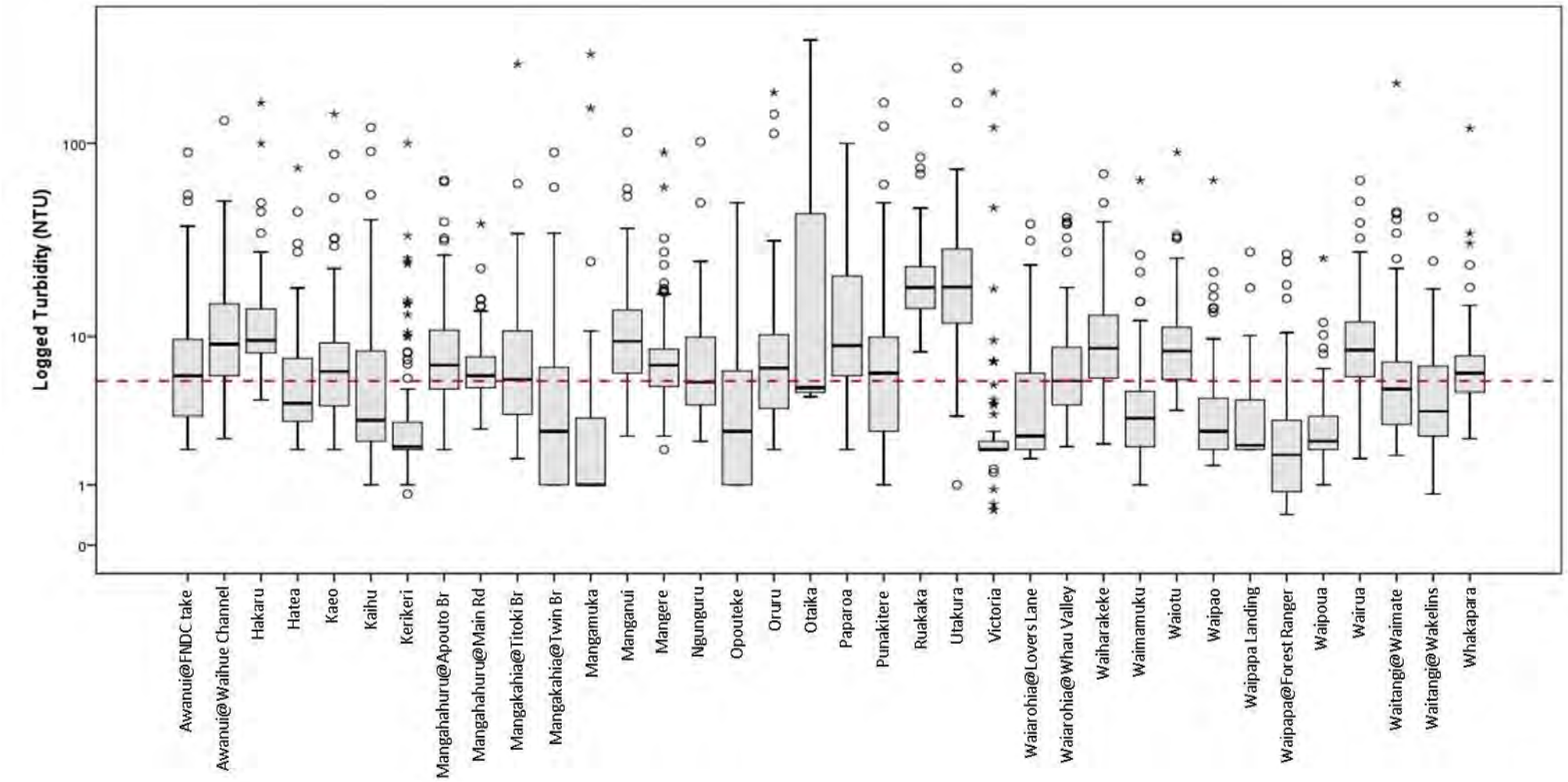


Figure 5: Box plot summarising the range and mean of turbidity levels recorded across all 36 RWQMN sites from 2007 to 2011. The dashed red line indicates the ANZECC turbidity trigger value (<5.6 NTU)

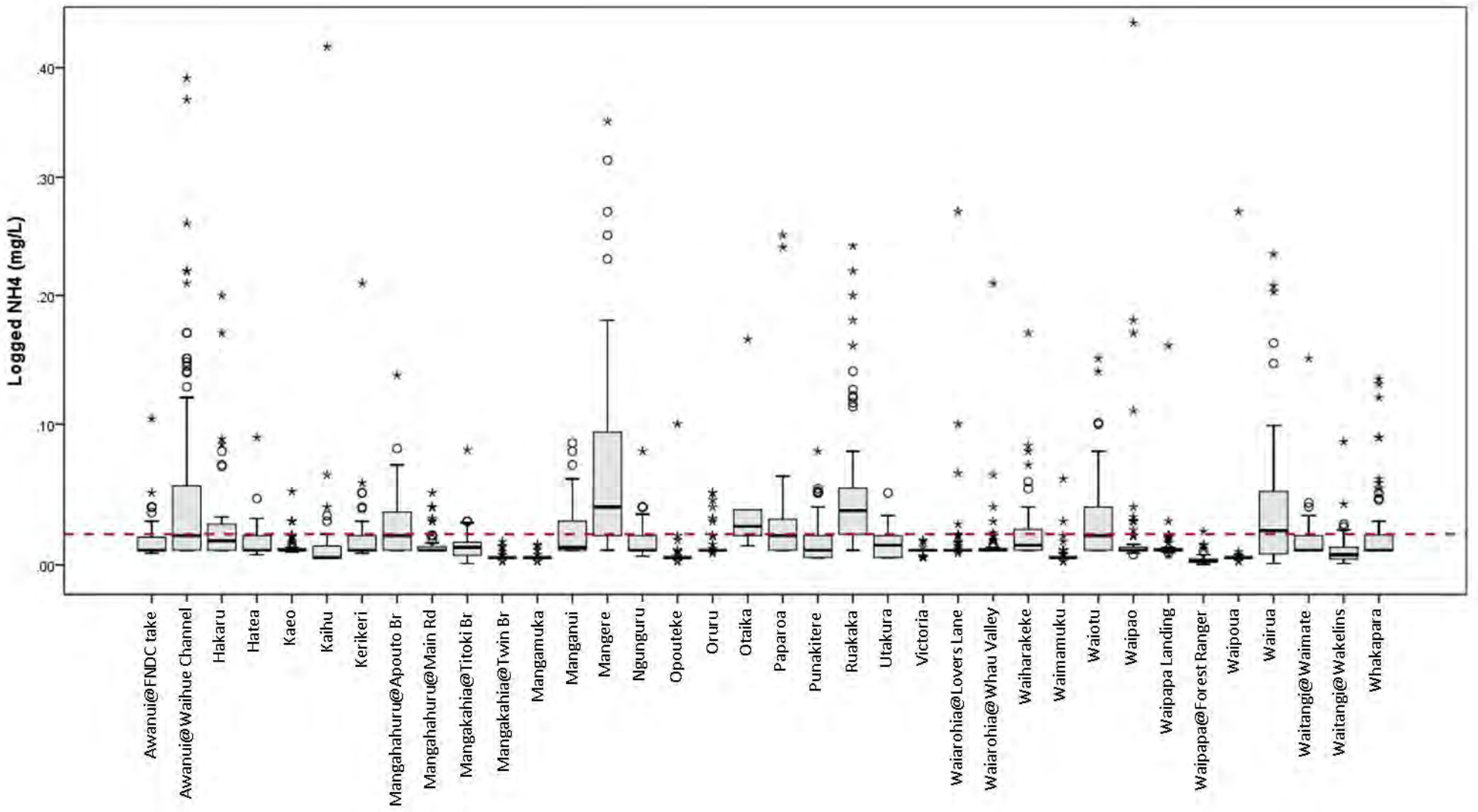


Figure 6: Box plot summarising the range and mean of Ammoniacal nitrogen (NH4) levels recorded across all 36 RWQMN sites from 2007 to 2011. The dashed red line indicates the ANZECC ammoniacal nitrogen guideline (<0.021 mg/L).

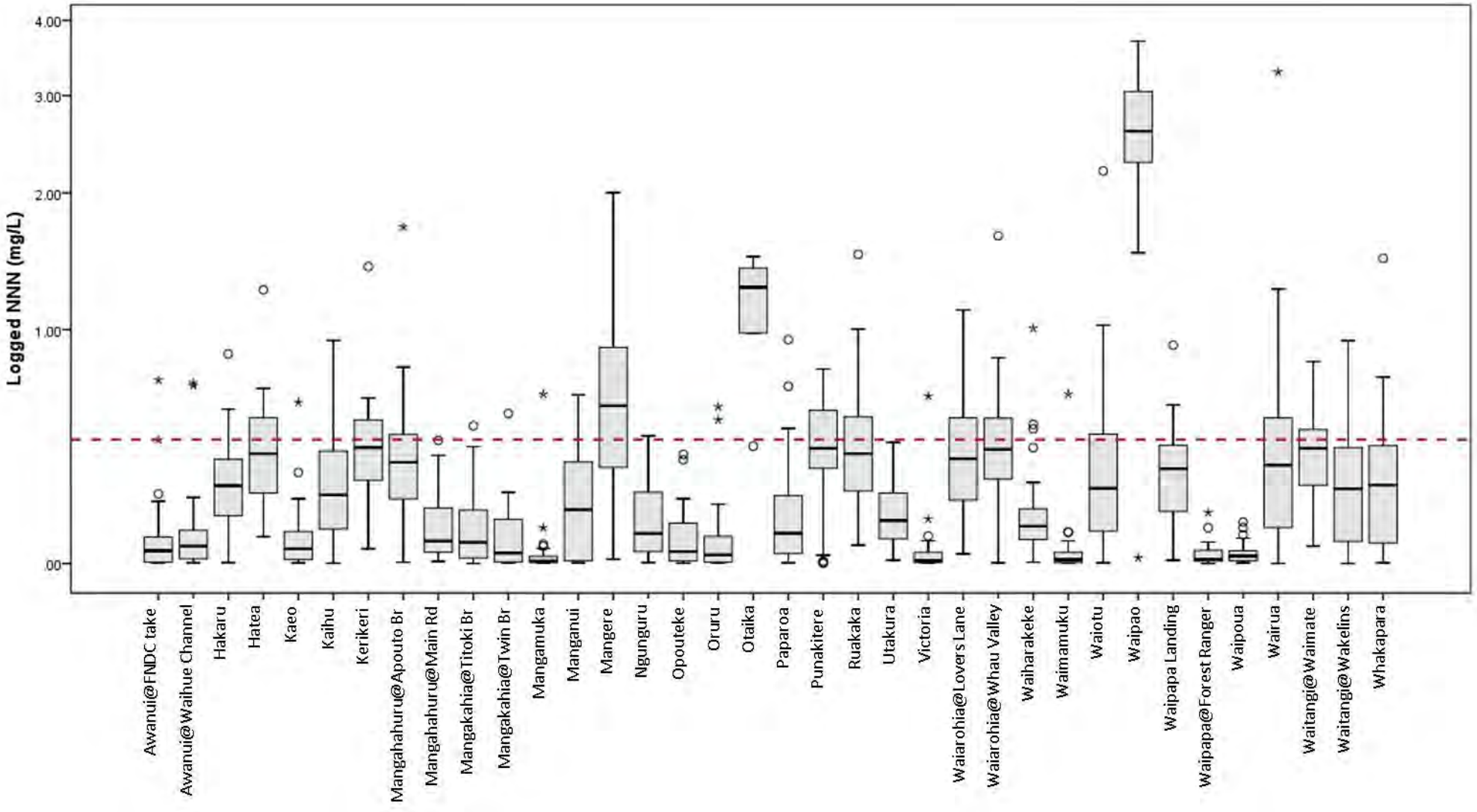


Figure 7: Box plot summarising the range and mean of Nitrite-nitrite nitrogen (NNN) levels recorded across all 36 RWQMN sites from 2007 to 2011. The dashed red line indicates the ANZECC nitrate, nitrite nitrogen guideline (<0.444 mg/L)

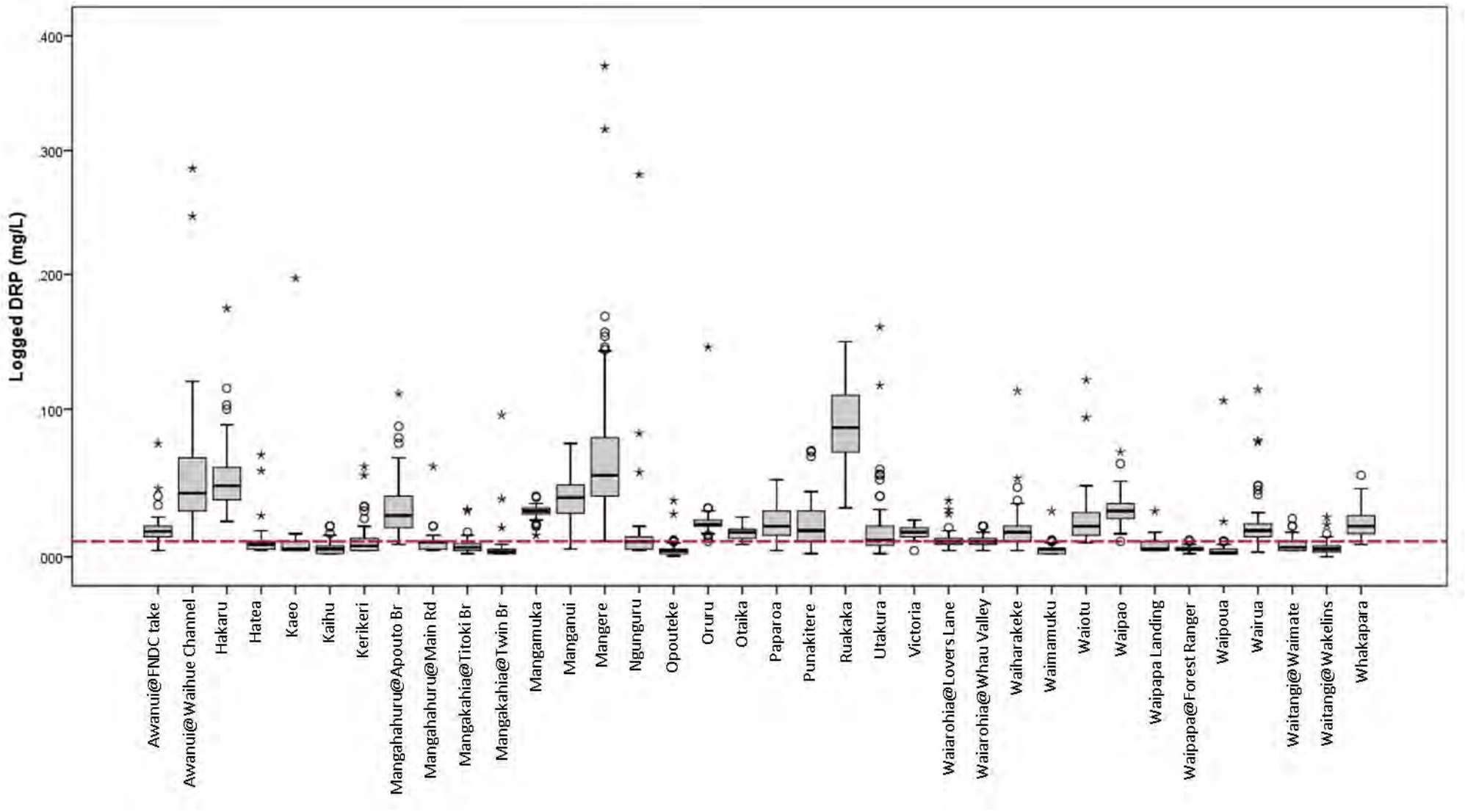


Figure 8: Box plot summarising the range and mean of nutrients Dissolved Reactive Phosporous (DRP) levels recorded across all 36 RWQMN sites from 2007 to 2011. The dashed red line indicates the ANZECC dissolved reactive phosphorus guideline (<0.01 mg/L)

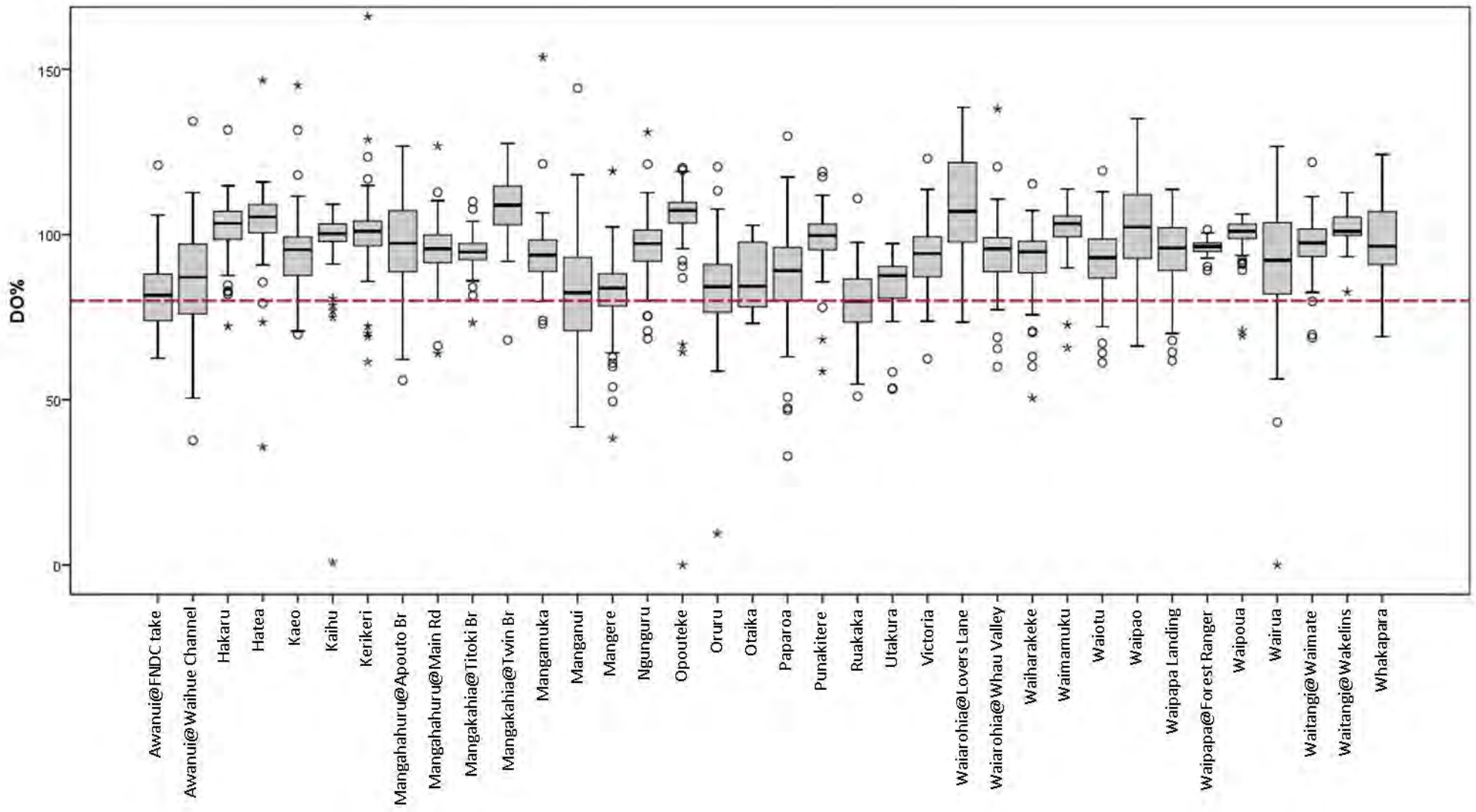


Figure 9: Box plot summarising the range and mean of dissolved oxygen levels recorded across all 36 RWQMN sites from 2007 - 2011. The red dotted line indicates the RMA guideline (>80% saturation).

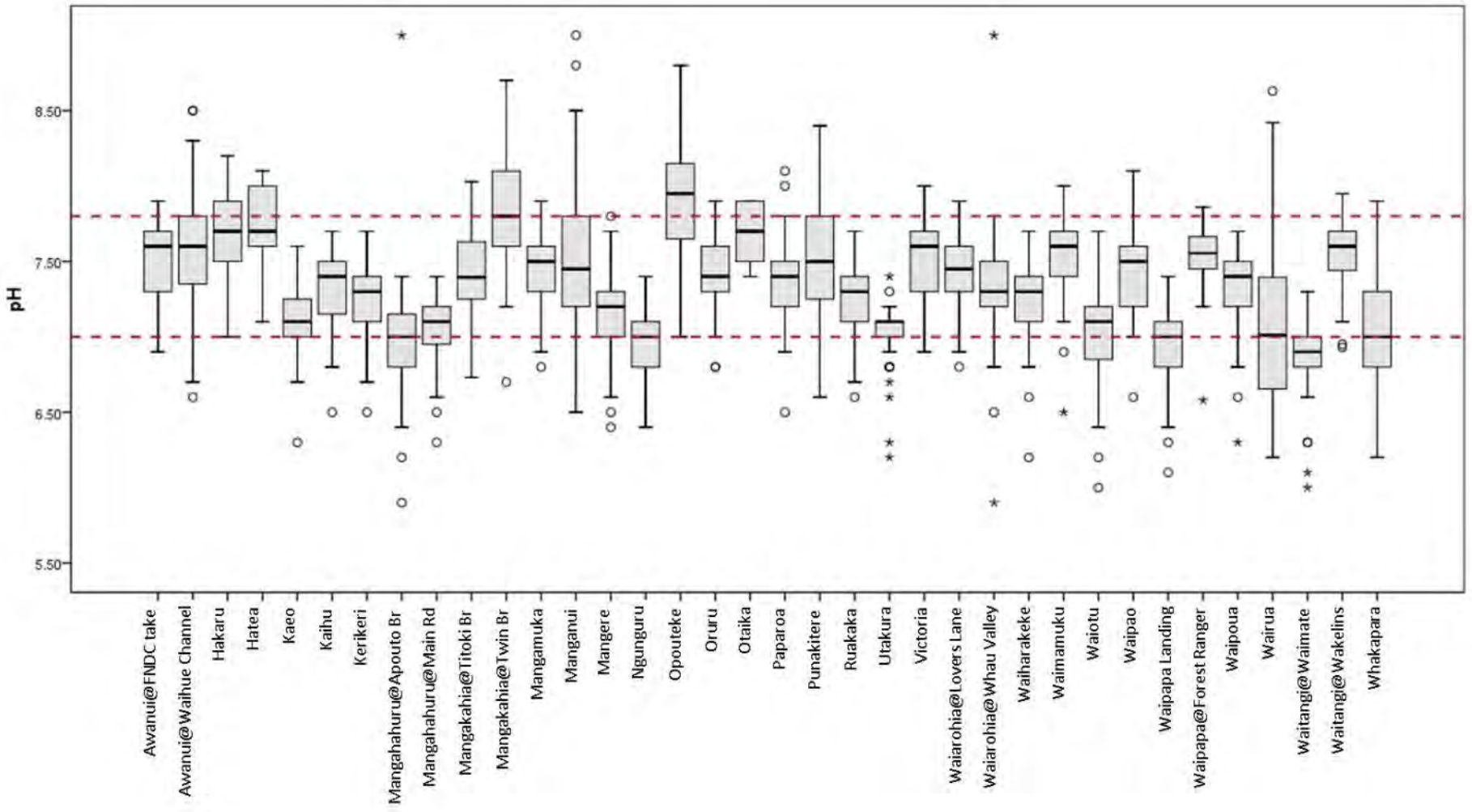


Figure 10: Box plot summarising the range and mean of pH levels recorded across all 36 RWQMN sites from 2007 - 2011. The red dotted lines indicates the ANZECC guidelines (7.2–7.8).

National context

The strong association between land use/cover and river health in the Northland region is consistent with findings in other regions of New Zealand (Perrie *et al.* 2012; Ozane 2012; Davies-Colley 2013). Rivers and streams located within catchments dominated by native forest tend to have good water quality, healthy invertebrate and fish fauna and fewer nuisance algal blooms than rural and urban catchments.

There is a difficulty with comparing water quality data nationally as historically there has been little consistency in the selection of SoE monitoring sites, the sampling protocols, frequency of sampling, and analytical methods between regions. However, as in Greater Wellington Regional Councils recent water quality report (Perrie *et al.* 2012), the recent development of the Land and Water New Zealand (LAWNZ) www.landandwater.org.nz initiative, which analyses water quality data sets on a national scale, provides a useful benchmark against which regional physio-chemical water quality results can be compared (Table 6). Comparing data from January 2004 to December 2011 from LAWNZ:

Table 6: Median values for selected water quality variables grouped according to their altitude (upland/lowland) and dominant landcover (forest/rural/urban), based on the LAWNZ state analysis for the period 2004 - 2011. The number of sites above and below/equal to the national median are also presented. Note: there was insufficient data for Northland urban sites so this category has been excluded.

	Regional median	National median (n)	No of RWQMN sites worse than the national median	No of RWQMN sites better/equal to national median
Upland forest				
Visual clarity (m)	2.12	2.68 (47)	1	0
Ammonical nitrogen	0.005	0.005 (51)	0	1
Nitrite-nitrite nitrogen	0.017	0.079 (50)	0	1
Total nitrogen (mg/L)	0.105	0.153 (48)	0	1
Dissolved reactive	0.005	0.009 (51)	0	1
Total phosphorous	0.008	0.016 (48)	0	1
E. col (cfu/100ml)	63	14 (45)	1	0
Lowland forest				
Visual clarity (m)	1.58	2.13 (89)	8	0
Ammonical nitrogen	0.005	0.005 (117)	2	6
Nitrite-nitrite nitrogen	0.0465	0.074 (108)	3	5
Total nitrogen (mg/L)	0.20775	0.195 (79)	5	3
Dissolved reactive	0.00525	0.007 (117)	0	8
Total phosphorous	0.0185	0.013 (73)	5	3
E. col (cfu/100ml)	247.75	63 (97)	8	0
Lowland rural				
Visual clarity (m)	1	1.13 (344)	12	7
Ammonical nitrogen	0.01	0.012 (499)	8	11
Nitrite-nitrite nitrogen	0.267	0.382 (479)	5	14
Total nitrogen (mg/L)	0.57	0.717 (454)	5	14
Dissolved reactive	0.02	0.013 (490)	13	6
Total phosphorous	0.0475	0.034 (443)	15	4
E.coli (cfu/100ml)	350	175 (475)	16	3

- The single upland forest site (reflecting the fact that the majority of Northland RWQMN sites fitt into the lowland category) compared very favourably to national water quality data with most measures better than the national average. E.coli and visual clarity were the exception.

- Lowland forest sites were spread fairly evenly above and below national averages with the exceptions being levels of dissolved reactive phosphorous which were all better than the national average and E.coli levels and visual clarity which were worse at every site.

- Lowland rural sites compare very favourably nationally for nitrogen measures with the majority of sites being better than the national median. However. phosphate levels tend to be high, with the majority of sites being worse than the national average. Both visual clarity and E.coli levels tend to be worse than the national median.

- Almost all RWQMN rivers, within all land cover types (including native forest reference sites) had visual clarity and E.coli levels worse than the national median, suggesting Northland has naturally higher background levels for these measures.

It is difficult to assess trend on a national scale at the present time but in the future, with regional councils moving to adopt standardised protocols for both water quality and ecological data collection, as well as the ongoing development of LAWNZ and a national river condition indicator, this will become possible. Water quality trend analysis carried out by the National Institute of Water and Atmospheric Research (NIWA) on 77 NRWQN sites throughout New Zealand on a much larger time scale (from 1989 – 2007) indicated a degrading trend in NNN, TN, DRP and TP at a national level which was attributed to the intensification of pastoral farming (Ballantine and Davies-Colley 2010).

Trends in water quality

Long term trend analysis was carried out on RWQMN sites with more than five years of water quality data (24 sites). The data period used for the trend analysis was from January 2003, or when sampling began, to the end of 2011. Water quality data was flow adjusted to eliminate the influence that flow has on water quality attributes such as nutrient levels, visual clarity and E.coli levels. A summary of the results can be found in Table 7 below.

Overall there were several positive changes in water quality between 2003 and 2011. Improvements were seen across all nutrient attributes; in particular total phosphorus with 13 out of the 24 sites recording a decreasing trend in concentration. Several sites exhibited improving trends across several nutrient attributes including the Kaeo, Kaihu, Mangakahia River at Twin Bridges, Mangere, Opouteke, Punakitere and Ruakaka rivers (Table 7).

Decreasing trends in ammoniacal nitrogen at several sites is a good indication of improvements in discharges in the catchments. Many of the sites are situated in pastoral catchments and include the Kaeo, Kaihu, Mangakahia, Mangere, Opouteke, Punakitere, Ruakaka and Waitangi rivers.

Increasing trends in water clarity (an improvement in water quality) have been recorded at six sites (Mangakahia at Titoki bridge, Mangakahia at Twin Bridges, Punakitere, Waiarohia at Second Ave,

Waiarohia at Whau Valley and Waipapa with two of those sites (Waiarohia at Second Ave and Waiarohia at Whau Valley) having a corresponding reducing trend in turbidity. Turbidity and visual clarity are typically strongly inversely correlated (Davies-Colley and Smith 2001; Davies-Colley *et al.* 2014 in press).

Degrading trends in turbidity have been observed at four sites; Mangahahuru Stream at Main Rd and Apotu Rd, Victoria River and Waitangi River at Waimate North.

The Waipoua River in the Waipoua Forest and the Mangahahuru River at Main Road both show degrading trends in E.coli levels despite being within forested catchments. For the Mangahahuru this may be related to plant decay following forestry harvesting in the area. Another scenario is increased understory productivity with harvesting of trees, leading to an increase in feral animal numbers (pigs). This phenomenon has been observed elsewhere in the North Island, although is yet to be published (R Davies-Colley, pers comm. 12 March 2014).

At the majority of sites macroinvertebrate health, measured using the MCI, remained stable, but five sites exhibited a degrading trend; Waiarohia at Whau Valley, Waipapa at Forest Ranger, Waitangi at Waimate Road, Whakapara and Manganui.

Table 7: Trends for 24 River Water Quality Monitoring Network (RWQMN) sites from when records began to 2011. Green arrows indicate an improving trend, red arrows a degrading trend. An empty cell indicates no significant trend.

Site	Dissolved Oxygen %	E.coli	Clarity	Turbidity	Temperature	pH	Ammoniacal Nitrogen	Nitrate/Nitrite Nitrogen	Total Nitrogen	Dissolved Reactive Phosphorus	Total Phosphorus	MCI
Awanui River Waihue channel									↓		↓	
Awanui River FNDC take												
Kaeo River					↑		↓	↓		↓		
Kaihu River	↓						↓	↓		↓		
Mangahahuru Stream Apotu Rd				↑							↓	
Mangahahuru Stream Main Rd		↑		↑	↑							
Mangakahia River Titoki bridge	↓		↑			↓						
Mangakahia River Twin Bridges			↑				↓	↓	↓	↓	↓	
Manganui River						↑						↓
Mangere River							↓			↓	↓	
Opouteke River							↓			↓	↓	
Punakitere River			↑				↓		↓	↓	↓	

Ruakaka River							↓			↓	↓	
Victoria River			↓	↑						↓		
Waiarohia Stream Rust Ave			↑	↓		↑				↓	↓	
Waiarohia Stream Whau Valley			↑	↓		↑		↓			↓	↓
Waiharakeke Stream											↓	
Waiotu River											↓	
Waipapa River Forest Ranger			↑					↓	↓		↓	↓
Waipoua River		↑						↓		↓	↓	
Wairua River										↓		
Waitangi River Waimate North				↑		↓	↓					↓
Waitangi River Watea												
Whakapara River												↓

Temporal Trends

Temporal trend analysis performed on flow-adjusted physio-chemical data found that water quality was typically stable at the majority of RWQMN sites for the period January 2007 to December 2011. A total of 65 'meaningful' trends (i.e. statistically significant) were identified across 10 variables, i.e. 27% of a possible 240 trends. Of these almost half were associated with 3 variables; ammonia (NH4, 8 sites), dissolved reactive phosphorous (DRP, 11 sites) and total phosphorous (TP, 13 sites). In all cases these were improving trends. The reasons for these improvements is unclear but as they were also well represented within the two reference sites (Waipoua and Waipapa Rivers), it could be related to natural factors like less rainfall-runoff rather than changes in land management. Encouragingly a number of degraded pastoral sites are showing improvements, although many sites still recorded median concentrations which exceeded national guideline levels.

A few sites exhibited degrading trends in water quality, most notably the Mangahahuru Stream at Main road with declining trends in E.coli, turbidity and temperature. This may well be linked to recent forest harvesting and sediment runoff within the upper catchment. In addition, the elevated E.coli levels could be associated with plant decay. Further downstream the Mangahahuru site at Apouto Road also exhibited a degrading trend in turbidity. The Waipoua River at SH12 showed elevated E.coli levels. The cause of this is unclear, considering the upper catchment is predominantly native forest, but it could be linked to the presence of feral animals like pigs, possums and goats.

4. Water quality drivers

This section discusses the primary issues affecting the region's rivers, and key management issues are identified. The section concludes with an assessment of data gaps and recommendations for future water quality management.

Primary issues affecting river and stream health

The patchy nature of native vegetation in the Northland region, along with a complex geology of sedimentary and volcanic rocks and coupled with high rainfall, makes assessing the impact of land use on waterways complex. Most rivers in New Zealand have their headwaters within high altitude, forest-clad catchments before entering pastoral lowland areas where they become impacted by human activities. This is not the case in Northland with its rolling countryside and numerous patches of native bush and plantation forestry. The headwaters of many Northland rivers are within, or very close to, farm land with streams typically running through intermittent stands of native bush/plantation forest dotted in a rolling landscape of pasture, making it difficult to find suitable forested reference sites. Even the Waipoua River which flows through native forest and plantation forestry for most of its length has a small amount of pastoral farming in the headwaters above the RWQMN site. Even so, catchments dominated by native forest (Mangakāhia at Twin Bridges, Waipapa at Forest Ranger and the Waipoua at SH12 Rest Area) exhibit better water quality than those in rural/urban catchments. The sites in poorest condition, Mangere at Knight Road and Ruakaka at Flyger Road are within catchments of high intensity farming and are characterised by elevated nutrient levels, poor visual clarity, and high faecal contamination (E.coli).

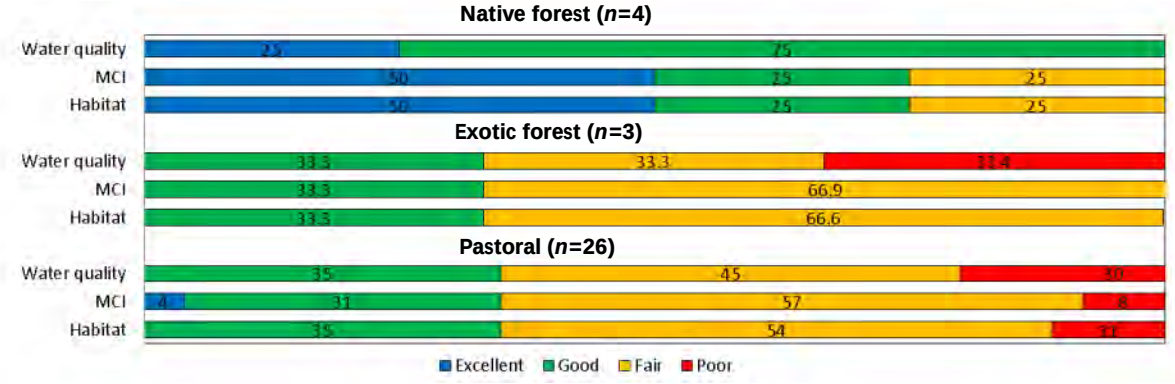


Figure 11: Breakdown of water quality and macroinvertebrate health and habitat grades for 33 of RWQMN sites grouped according to their REC landcover class (one pastoral site with no MCI data and 2 urban sites are excluded).

Plausibly, both the issues of high faecal contamination and poor visual clarity relate to deeply weathered clay soils in the Northland region, with rapid runoff and slow or restricted infiltration

(Collins *et al.* 2006) which yield very fine plate-shaped particles that are near maximally efficient light attenuators and settle extremely slowly (Davies-Colley and Smith 2001).

The modest correlation of median turbidity versus percentage pasture in Northland's rivers (Table 8) is probably to be expected given widespread clay soils. The comparatively weak correlation of median E.coli versus percentage pasture in Northland rivers, compared to nationally (Ballantine and Davies-Colley 2013; Davies-Colley 2013; Howard-Williams *et al.* 2010), is a little surprising. This may reflect the diversity of Northland catchments and channel conditions as they affect (1) entry of microbes to water and (2) sunlight-induced dieoff of bacteria. For example, the Wairua at Purua has rather low faecal pollution despite a very high percentage pastoral catchment, possibly because it is a large (by Northland standards) open and slow-flowing in which water is strongly sunlight-exposed. Relatively high faecal pollution in rivers draining forested catchments in Northland is a little surprising, and this may reflect incursion of feral animals (a source of faecal pollution) together with inhibition of sunlight dieoff by riparian shade (R Davies-Colley, pers comm. 12 March 2014). The moderate correlations between nutrient levels and percentage pasture compared to strong correlations nationally (Howard-Williams et al. 2010) may reflect the complex mixture of land use, soil types, and lack of reference sites in Northland.

Table 8: Correlation matrices for water quality attribute medians versus percentage pasture and turbidity.

Attribute	Pearson correlation		Spearman correlation	
	% pasture	Turbidity	% pasture	Turbidity
E.coli	0.27	0.28	0.27	0.35*
Turbidity	0.47**	-	0.52**	-
NH-4	0.54**	0.61**	0.61**	0.77**
NNN	0.36*	-0.08	0.56**	0.20
DRP	0.45**	0.59**	0.50**	0.60**
DO	-0.39**	-0.59**	-0.34*	-0.54**

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

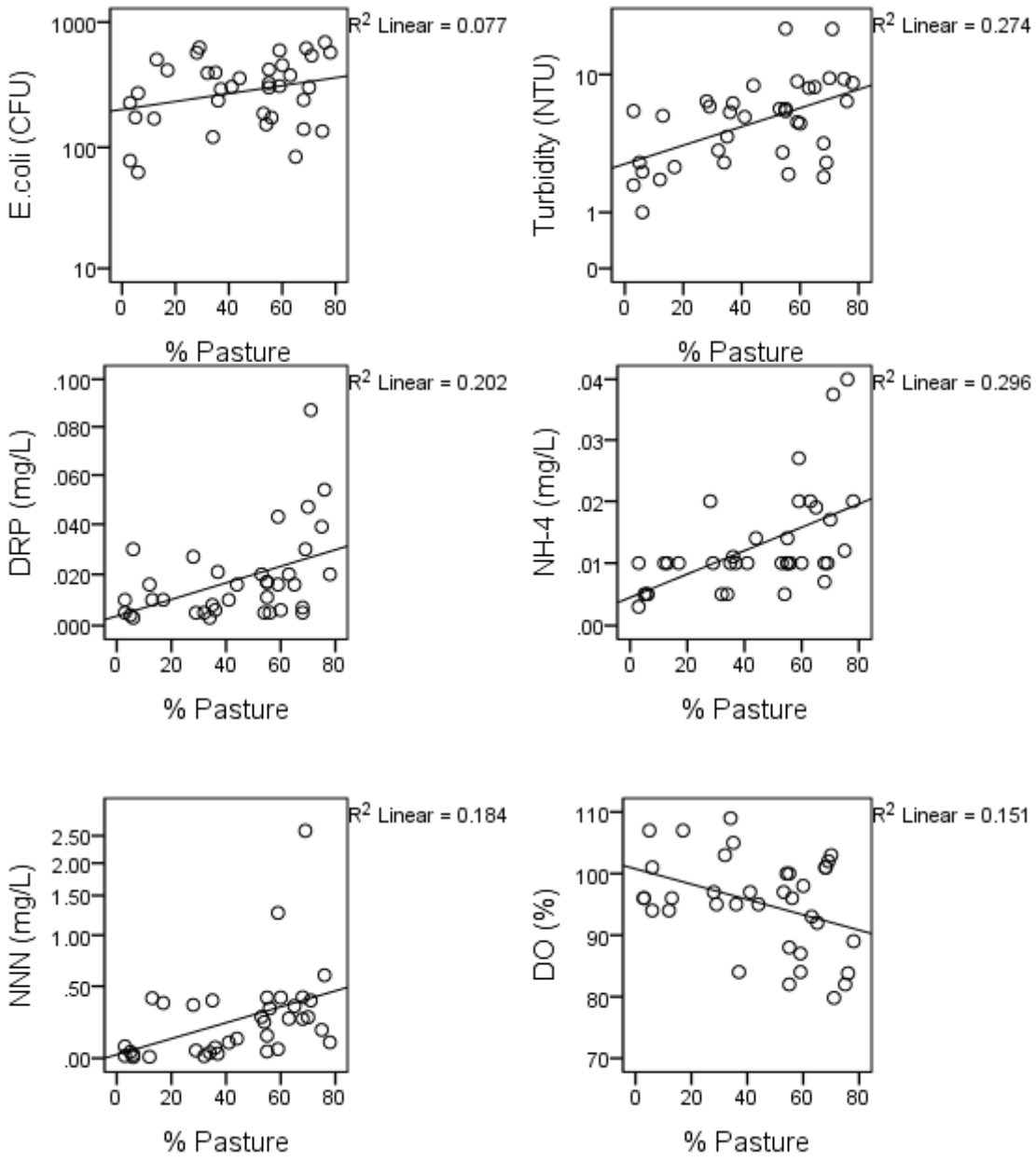


Figure 12: Plots of water quality attributes versus percentage pasture with linear regression at the 36 RWQMN sites.

Microbiological contamination.

Perhaps the most significant issue impacting on Northland water quality is faecal contamination as indicated by E.coli levels (Table 4, Figure 3). Only three out of 36 RWQMN sites had a median E.coli result which passed the ANZECC (2000) standard for livestock drinking water. Two of these (Waipapa at Forest Ranger and the Waipoua at SH12 Rest Area) were in catchments dominated by native forest. The third, Wairua River at Purua, is in a pastoral catchment.

Compared to national data (McDowell *et al.* 2013), all sites in both upland forest and lowland forest categories (Table 6) had E.coli levels above the national median. McDowell *et al.* (2013) utilised the

River Environmental Classification (REC) to take into account natural variation related to climate, topography and geology, indicating that reference/background levels of E.coli in warm wet lowlands are much higher than for any other REC class. Just three of the 19 lowland rural sites had levels below the national median (Manganui at Mititai Bridge, Waipapa at Landing Bridge and Whakapara at Cableway). At 20 of the 36 RWQMN sites the maximum E.coli counts are in excess of 10,000 MPN/100ml. These high counts are usually associated with livestock access to rivers or high rainfall events increasing runoff from the land and causing sewage/stormwater overflows. In a few cases these elevated levels can be attributed to high numbers of waterfowl. Microbial Source Tracking (MST) at Hatea at Mair Park, Kerikeri at Stone Store and Ngunguru at Waipoka Rd has traced the source to be mainly from wildfowl which tend to congregate at these sites (NRC 2013). The widespread occurrence of elevated E.coli levels highlight the need to discharge farm effluent to land where possible, establish vegetated riparian margins, exclude livestock from streams, and address sewage/storm water infrastructure issues in urban areas.

Elevated faecal pollution in rivers can also impact on the coastal environment, particularly as most rivers in Northland discharge into harbours and estuaries. Contaminants within sheltered harbour systems tend to take longer to disperse than those draining into the open coast where ocean currents and greater exposure to climatic conditions tends to aid dispersal. Furthermore, contamination of bivalve shellfish which are consumed by humans is more of an issue with discharges to enclosed coastal waters. The yearly Recreational Swimming Water Quality Programme, which monitors 24 fresh water and 61 coastal sites weekly during summer months, shows that Ministry for the Environment guidelines for recreation swimming at coastal sites are sometimes exceeded and none of the 15 sites classified for recreational shellfish gathering were within the MfE guidelines for recreational shellfish gathering during 2010-2011 (NRC 2011).

Historically there has been a lack of suitable sewage reticulation and treatment infrastructure in the region and with the rapid growth of the dairy industry, appropriate farm management practices to maintain water quality have not always been in place. This has been exacerbated by the poor infiltration rates of Northland's clay soils in wet weather. However, since 2007, wastewater upgrades have come online in both Mangawhai and Whāngārei, and consents have been granted for new wastewater reticulation in Ruakaka and Kerikeri. Farm management practices are improving with a move to land-based discharge of effluents (over 50% of the 726 consented dairy farm effluent discharges predominantly use land-based applications), the fencing of farm streams and farm water quality improvement plans being put into place in priority catchments. However, it should be acknowledged (as mentioned above) that land-based disposal is problematic in Northland with its climate of high rainfall in winter months. The soil is often poorly drained and easily saturated and unsuitable for irrigation. Because of this, the storage capacity for farm effluent ponds needs to be greater than in many other parts of New Zealand. This, however, can be an advantage in summer months with large capacity ponds providing a good source of water/nutrients for so-called "deferred" irrigation when Northland is prone to drought. Deferred irrigation is recognised nationally as one of the best ways to help mitigate the effects of faecal contamination by livestock on New Zealand waters (Collins *et al.* 2007), and is actively promoted by the Council.

MICROBIAL SOURCE TRACKING

Microbial source tracking analyses encompass several scientific techniques used to assist in identifying the source of bacterial contamination in water, including: faecal sterol ratio (FSR) analysis, fluorescent whitening agents (FWAs) and polymerase chain reaction (PCR) markers. The source of contamination is determined by combining the results from the above analyses. Markers for the following host groups have been developed – human, wildfowl (ducks and/or gulls), ruminants (includes sheep, cattle, deer and goats), possums and pigs – as well as a general indicator for faecal contamination.

Since 2008 a total of 46 samples have been analysed from rivers in the RWQMN. Of those samples, 31 (66%) returned positive markers for ruminant contamination, 12 (26%) wildfowl, 3 (6%) plant decay, and 1 (2%) dog (Figure 13). Often a result will indicate faecal contamination from multiple sources, such as at Whangarei Falls on the Hatea River (Table 9). However, based on MST results the majority of faecal contamination appears to be coming from ruminants, such as in the Ngunguru, Mangamuka, Waimamuku, Opouteke and Kaeo catchments. No sites in the RWQMN returned markers for human sources of faecal contamination (Table 9, Figure 13).

Table 9: Results from Microbial Source Tracking work undertaken since 2008. Please note that most MST is carried out through the council's Recreational Bathing programme and therefore some MST samples have been collected at the bathing site rather than the RWQMN site. R= Ruminant, W= Wildfowl, D=Dog, P=Plant decay.

Site	2008	2009	2010	2011	2012	2013
Ruakaka River below motor camp					R	R
Tirohanga Stream						R/P
Waitangi River						R/W/P
Hatea River at Whangarei Falls	R/W	W/W	R/W/W/D			
Waiharakeke Stream	R/W					
Kerikeri at Stone Store				R/R/W	R/R/W	W/P
Mangamuka River at Iwitaua Rd				R/R/R	R	
Waimamuku River at SH12 Bridge				R/R/R		
Kaeo River at Dip Rd				R/R/R	R/R	
Mangahahuru Stream at Apouto Rd				R/W		
Ngunguru River at Waipoka Rd Picnic area				R/R/R		
Kaihu River at Campground				R/R/W		
Opouteke River at Suspension Br			R	R		

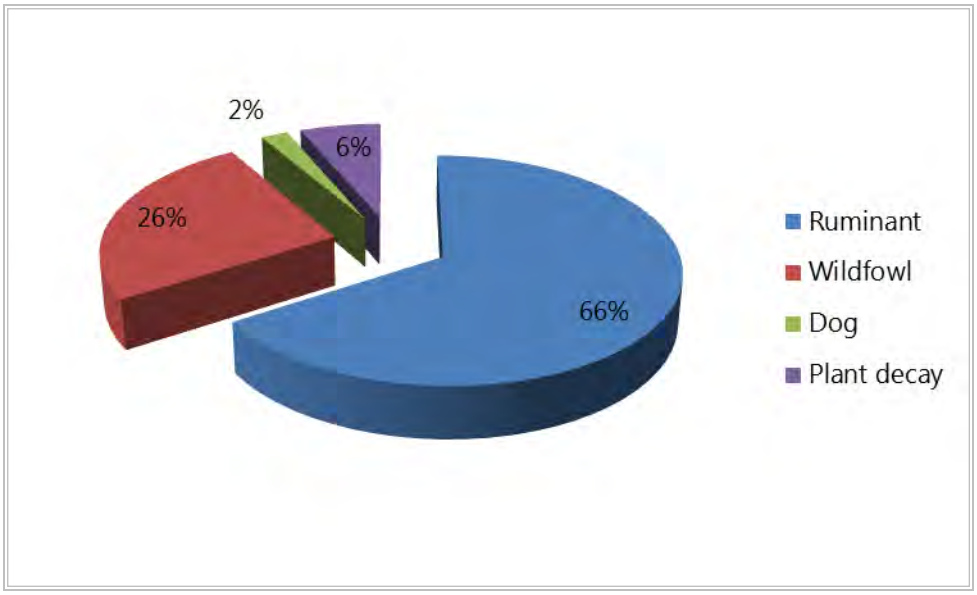


Figure 13: Results from MST analysis at RWQMN rivers since 2008.

Fine sediment and water clarity issues

Sediment is another key diffuse pollutant impacting the health of Northland's rivers and streams. The impacts of sediment include the deposition of sediment in rivers and coastal waters, the effects of suspended sediment on visual clarity and light penetration, and sediment's ability to transport microbes and other pollutants.

While the modelled sediment loads in Northland are only modest by national standards (Hicks *et al.* 2011), the problem is most of the sediment is layer clays which are intensely light-scattering. When surface runoff carries these clay particles into water, the colloidal nature of the particles can result in their remaining in suspension for long periods, and even in low concentrations can cause major discolouration. So Northland rivers tend to be muddy despite fairly modest sediment loads and yields, and it is this muddiness that is probably the main problem (Davies-Colley *et al.* 2014 in press).

When compared to the ANZECC guidelines for turbidity, eighteen (50%) of the 36 RWQMN sites failed the guideline (Table 4). Likewise all upland forest sites and lowland forest sites and 63% of all lowland rural sites had visual clarity below the national median (Table 6). The majority of these sites are located in areas where the underlying geology is deeply weathered soft sediments and very prone to erosion. The unstable nature of the geology combined with Northland's high rainfall means that many of the region's rivers are more vulnerable to erosion issues bought about by human activities than in other areas of New Zealand. Land clearance, wetland drainage and poor land management practices have resulted in a substantial increase in sediment loads to waterways compared to rivers in a natural state. Many rivers in Northland are deeply incised with unstable banks which frequently slump sediment into the river channel. These bank slumping blocks can 'bleed' fine sediment even at low flows, reducing visual water clarity and impacting in-channel habitat for aquatic animals (R Davies-Colley, pers comm. 12 March 2014). This process is exacerbated by livestock access, which causes pugging and accelerated erosion (Figure 14).

Figure 14: Slumping banks and pugging of stream banks by cattle increase sediment loads at the Waitangi River, Waimate Road site (left) and a tributary of the Mangahahuru River (right).

Runoff from earthworks and forestry harvesting are also known to increase sediment loads to rivers with the effects of these activities potentially more extreme due to Northland's seasonal rainfall and layer clay soils. Fine sediment causes degradation of aquatic habitat for invertebrates and fish, smothering food sources, reducing habitat availability and impacting on the hunting ability of visual feeders (Clapcott *et al.* 2011). Although there is insufficient data to assess the status of the fish fauna at these locations, all sites with poor visual clarity and higher levels of deposited sediment had correspondingly degraded macroinvertebrate communities.

Figure 15: Sediment running out of a harvested forest catchment into the Opouteke River.

The impact of excessive sediment in the coastal environment can create fundamental changes in sediment composition and geomorphology which can ultimately modify the coastal ecology. In the Whangarei Harbour sediment loads have increased tenfold since historical deforestation occurred (Swales *et al.* 2013) and the Kaipara Harbour and Bay of Islands are accumulating sediments at rates that are in the upper range of sediment accumulation rates in North Island estuaries and coastal marine environments (Swales *et al.* 2010). These sediments accumulate as mud in sheltered bays and inlets close to major catchment outlets and have been linked to the expansion of mangrove habitat (Swales *et al.* 2007).

Despite poor turbidity results and impaired clarity in a national context, most sites in the RWQMN pass the ANZECC 2000 guidelines for water clarity (Figure 4). The exceptions are the Awanui at Waiohue Channel and the Utakura at Okaka Rd Bridge, which are at the bottom of catchments where deposited sediment levels are likely to be highest, and the Ruakaka at Flyger Road which is half way down a catchment dominated by pasture.

Suspended sediment sampling was started in 2013 and is now routinely collected at RWQMN sites. In addition automated event-based sediment samplers (ISCO samplers) collect multiple samples during floods at the Manganui, Wairua and Mangakahia at Titoki river sites as part of a NIWA-led project within a (MoBIE-funded) programme to investigate light attenuation impacts in the Kaipara system.

Nutrient enrichment

The majority of RWQMN sites (31 out of 36 - 86%) pass the ANZECC national guidelines for NH4/NNN however 19 out of the 36 sites (53%) failed the DRP guideline during the January 2007 to December 2011 period (Table 4). The Otaika at Otaika Valley Road and Mangere at Knights Road failed all three nutrient guidelines used in the water quality index (NH4, NNN and DRP). The Ruakaka at Flygers Road and the Wairua at Purua failed both NH4 and DRP guideline while the Waipao at Draffin Road failed NNN and DRP guidelines. All these sites are within catchments dominated by high intensity agriculture. Nutrient load and yield estimates (Figures 17, 18 and 19), reveal four sites of particular concern that warrant further investigation:

1. The Waipao has the highest NNN yields per hectare (16 kg/ha year) within the RWQMN, almost triple the levels in the next highest-yielding catchment (Kerikeri at Stone Store). There is a high level of cropping and a number of orchards in the catchment, land uses that typically involve high levels of fertiliser application.

2. The Wairua at Purua has excessive river loads of all three nutrient measures used in the WQI, particularly NNN (Figure 19). This may be associated with the high productivity of the swamp land itself, together with the impacts from the Hikurangi drainage scheme which results in stagnant flood water being periodically pumped back into the river from behind the flood banks.

3. The Awanui at Wairau Channel, downstream of the Kaitaia sewage treatment plant, has very high loads and yields of both DRP and NH4, far in excess of the site just upstream of the

Kaitaia township (Awanui at FNDC Take). The results suggest the discharge from the sewage treatment plant could be having an adverse effect on the receiving environment.

4. The Victoria River site, despite its catchment being dominated by native forest, has elevated DRP, NH4 yields and raised E.coli levels. As the site is in close proximity to a number of lifestyle blocks, this may indicate that seepage is occurring from septic tanks, or that livestock access to the river, and/or density on these properties needs to be investigated.

Compared to national data, nitrogen levels are relatively evenly spread above and below the median for both lowland and upland forest types (Table 6). However, in lowland rural rivers, most sites (14 out of 19 [74%]) had NNN and TN levels better than the national average. Eleven out of 19 (58%) sites had NH4 levels better than the national average.

Phosphate levels tended to be largely better than the national average in both upland and lowland forest types for both DRP and TP. However, in lowland rural rivers, this is reversed with DRP and TP levels tending to be worse than the national average (13 out of 19 [68%] and 15 out of 19 [79%]) respectively. This may be consistent with the high turbidity results because phosphorus, which tends to bind to clay particles and organic matter, tends to be transported with eroded sediments into surface water. Some of the calcareous marine mudstones in Northland are naturally high in phosphate and so erosion of this material will add phosphate to water-borne sediment (B Cathcart, NRC Land Management Specialist pers comm. 2013).

The occurrence of elevated nutrient levels (particularly nitrogen) is associated with nuisance periphyton growth that can degrade ecosystem health and other instream values such as contact recreation and aesthetics (Kilroy *et al.* 2008). Periphyton records for the Northland region are limited but the data which is available confirms that corresponding with low nitrogen levels, most RWQMN sites tend to have low algal biomass, well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Those sites with elevated nutrient levels have no periphyton data due to the muddy substrate being unsuitable for periphyton growth. The exception is Ruakaka at Flyger Road which historically has low levels of periphyton growth. However this site is within a bush remnant with low light conditions and poor visual clarity which is likely to be limiting periphyton growth (Figure 7).

Figure 16: High sediment deposition and low light conditions under riparian shade vegetation can restrict periphyton growth [Ruakaka at Flyger Road]).

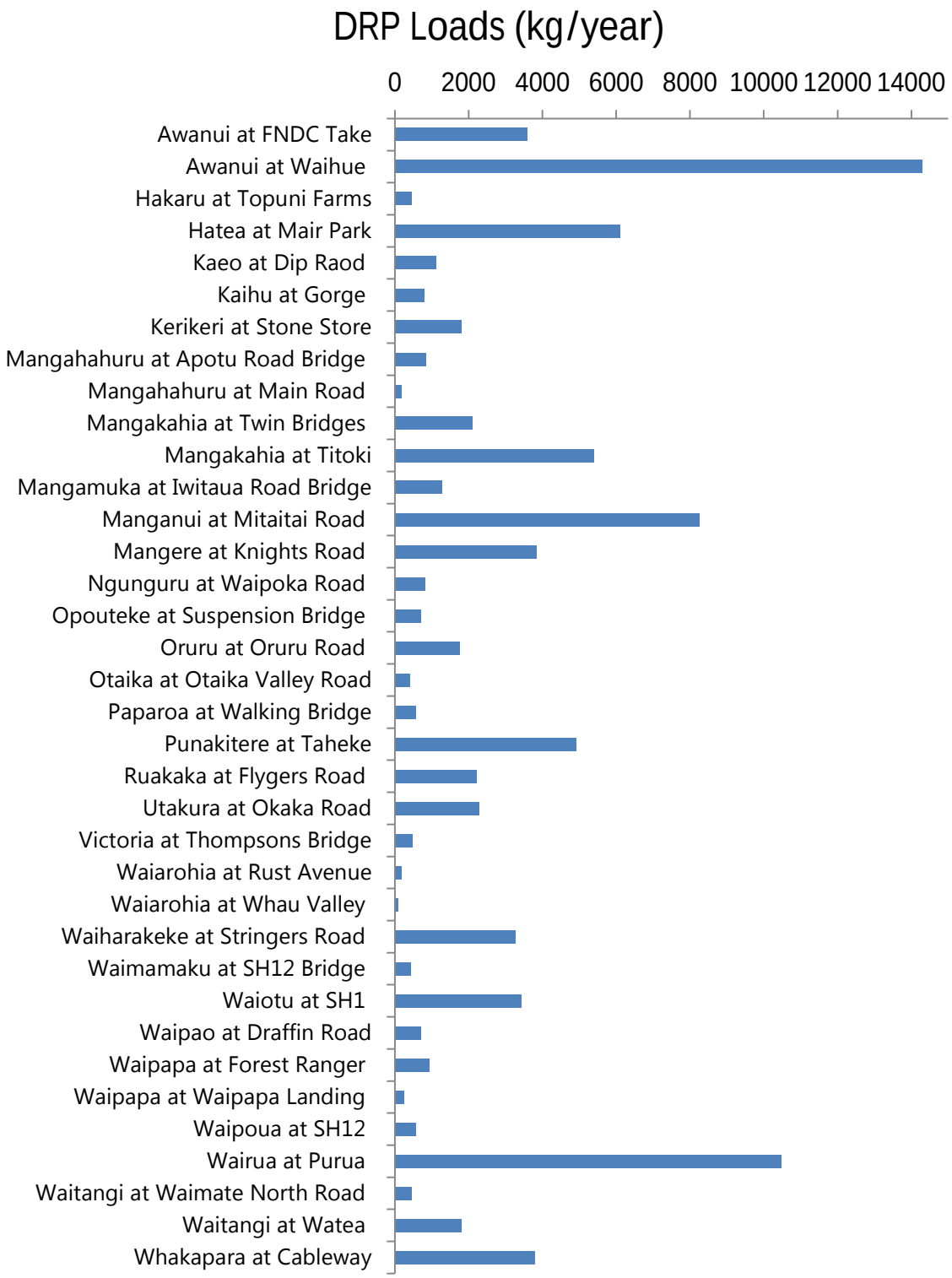


Figure 17a: Estimated dissolved reactive phosporous (DRP) river loads recorded across all 36 RWQMN sites from 2007 to 2011. Note these are estimates based on monthly spot measurements.

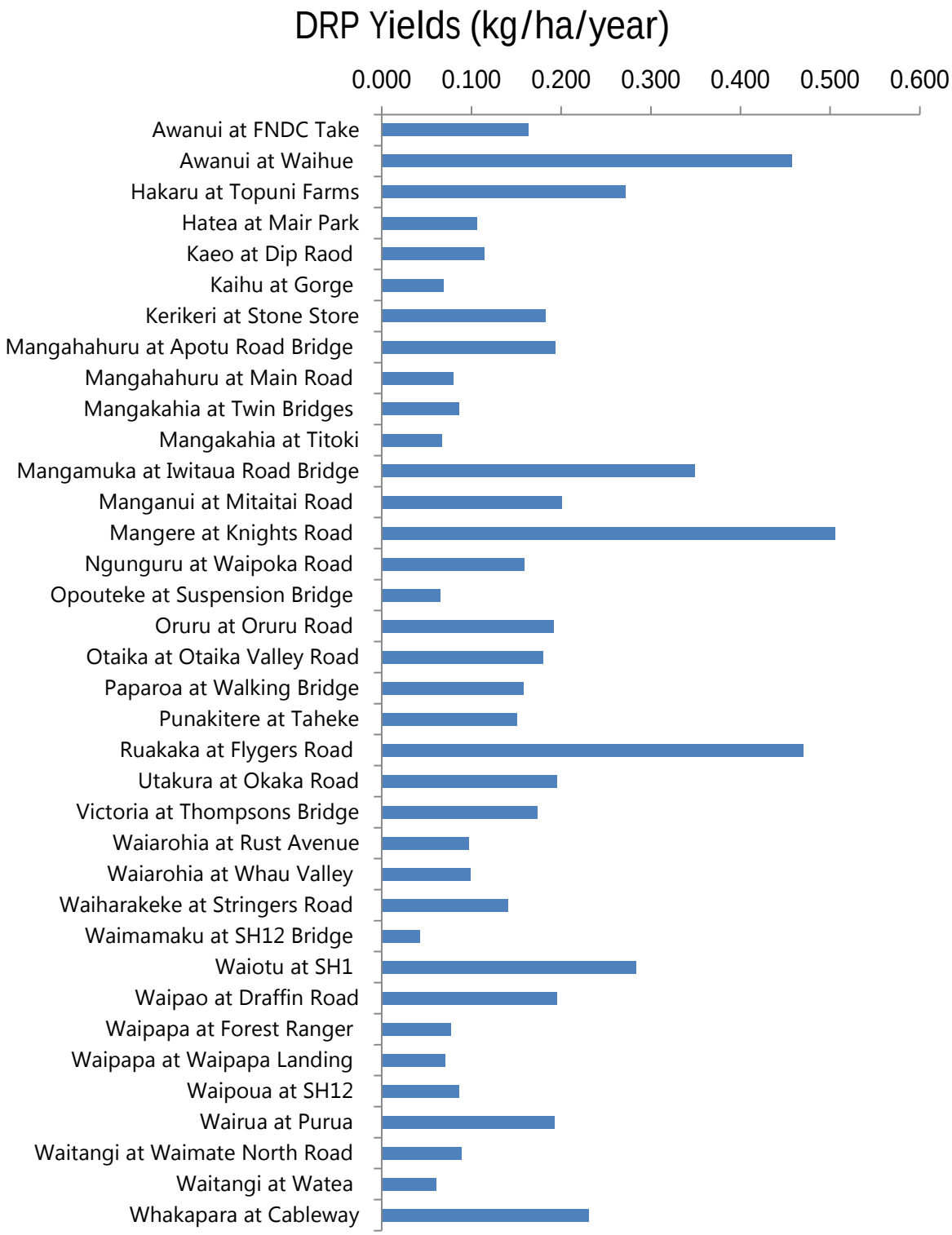


Figure 17b: Estimated dissolved reactive phosporous (DRP) catchment yields recorded across all 36 RWQMN sites from 2007 to 2011. Note these are estimates based on monthly spot measurements.

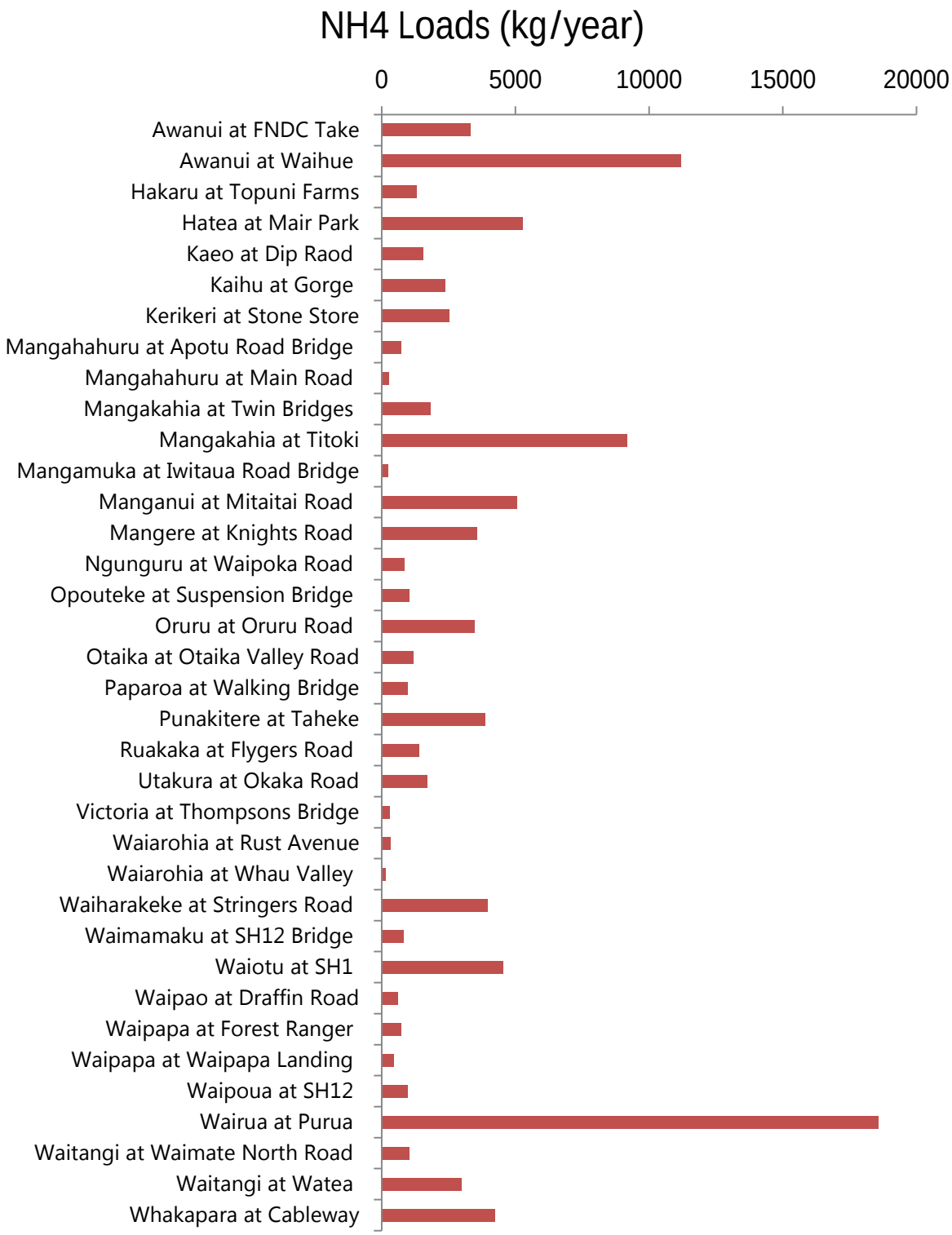


Figure 18a: Estimated ammoniacal nitrogen (NH4) river loads recorded across all 36 RWQMN sites from 2007 to 2011. Note these are estimates based on monthly spot measurements.

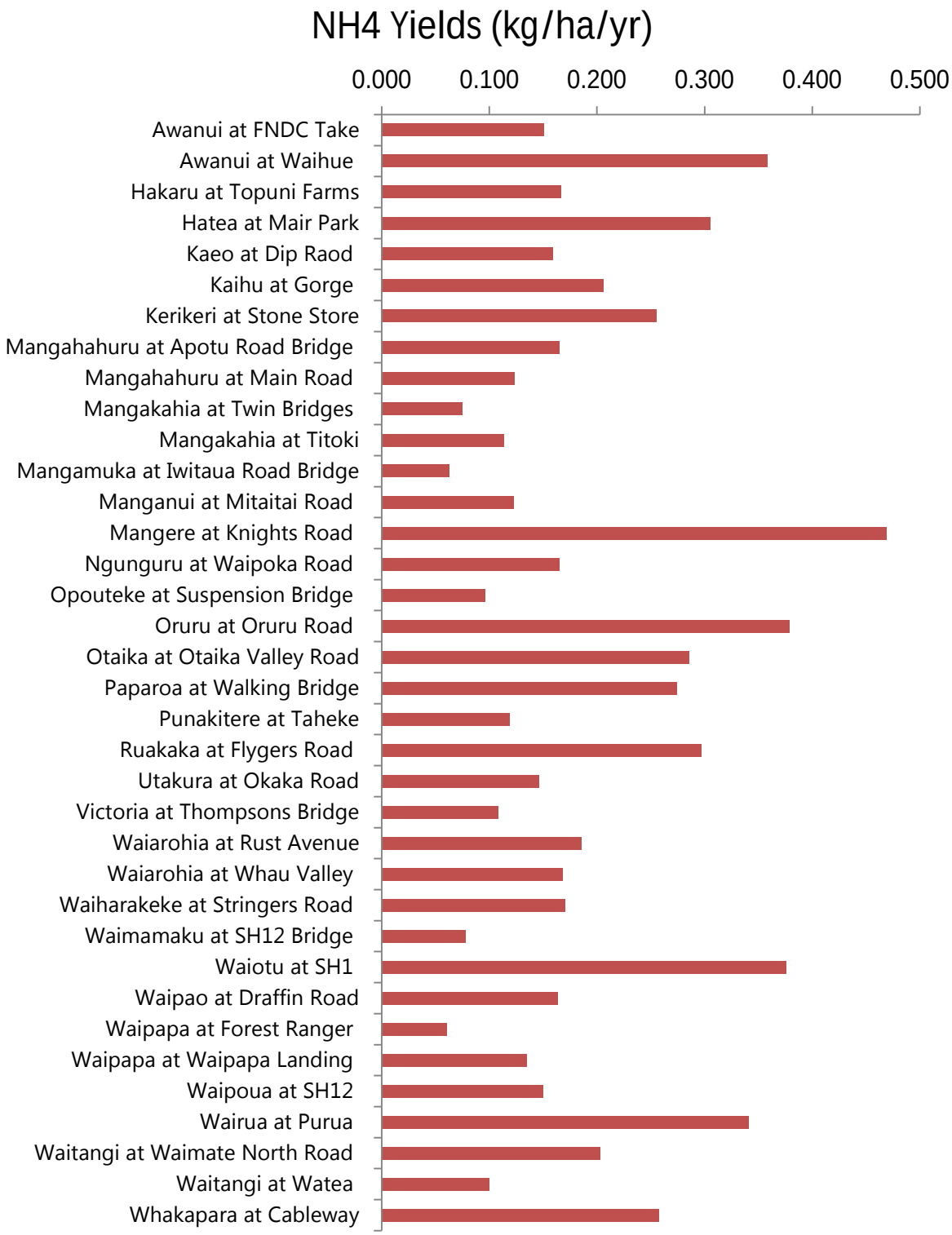


Figure 18: Estimated ammoniacal nitrogen (NH4) catchment yields recorded across all 36 RWQMN sites from 2007 to 2011. Note these are estimates based on monthly spot measurements.

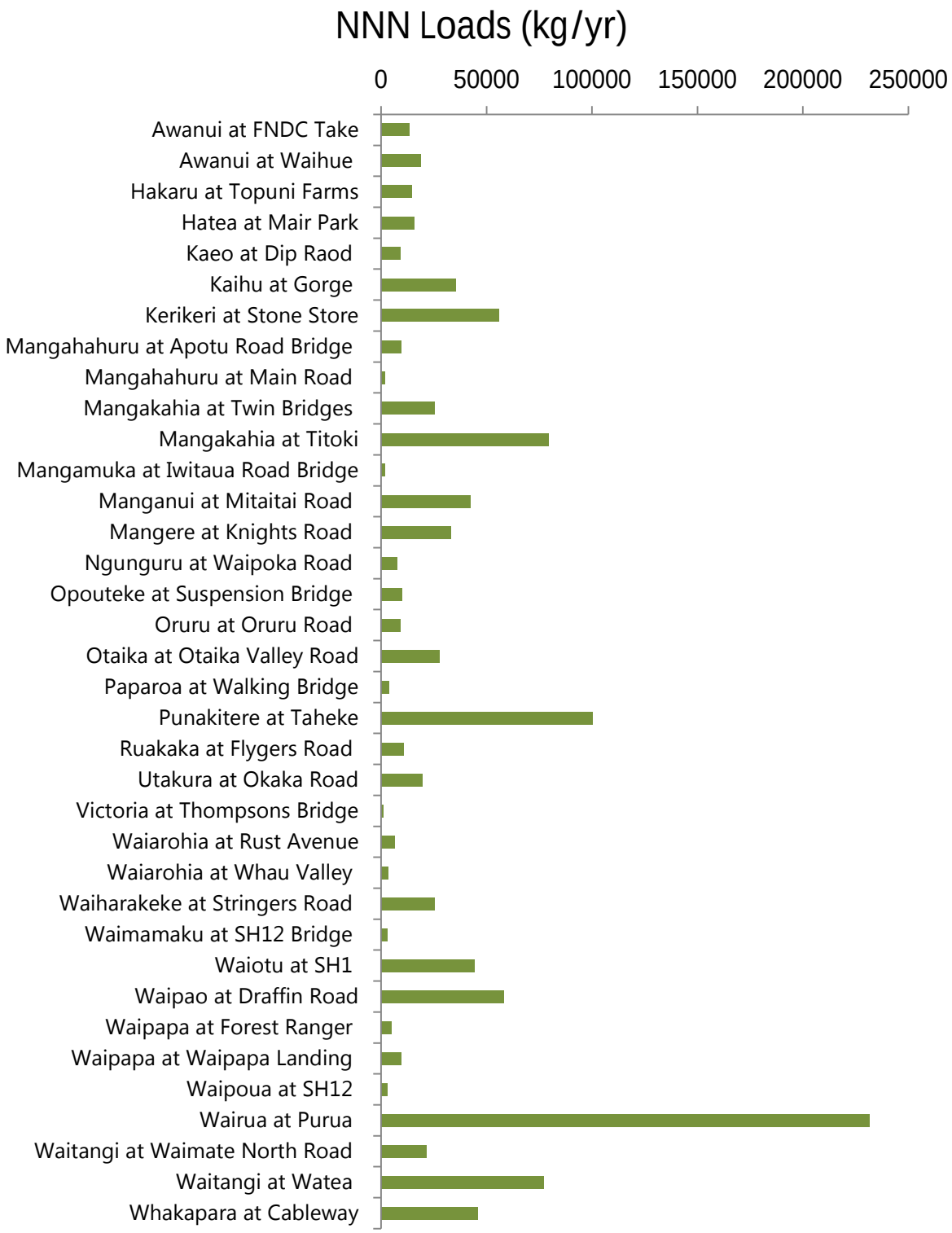


Figure 19a: Estimated nitrite-nitrite nitrogen (NNN) river loads recorded across all 36 RWQMN sites from 2007 to 2011. Note these are estimates based on monthly spot measurements.

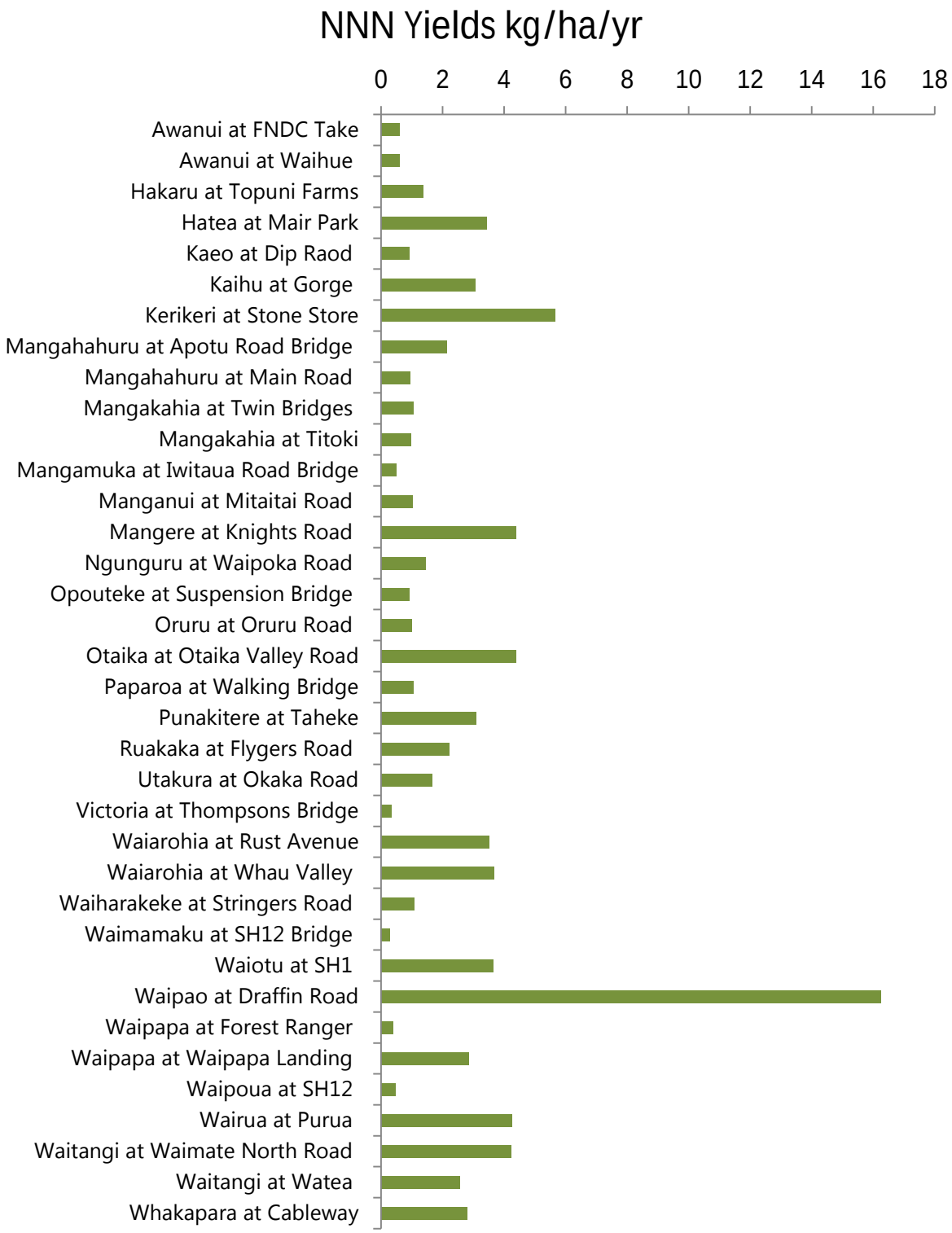


Figure 19b: Estimated nitrite-nitrite nitrogen (NNN) catchment yields recorded across all 36 RWQMN sites from 2007 to 2011. Note these are estimates based on monthly spot measurements.

Dissolved Oxygen

Dissolved oxygen is an indicator of the health of freshwater ecosystems. Fish and other aquatic life require dissolved oxygen to breathe. When dissolved oxygen levels are depleted, aquatic animals can become stressed and die. Oxygen depletion is commonly caused by organic pollutants breaking down in waterways, elevated water temperatures or night-time respiration by dense algal blooms/macrophytes in nutrient-rich waters. All RWQMN sites passed the MfE guidelines for dissolved oxygen between 2007 and 2011 (Figure 9). However, this monitoring data was collected during the day when DO levels are at their highest so it is recommended that continuous monitoring be undertaken to detect night-time low DO levels.

Habitat degradation

Habitat quality, along with water quality, is strongly aligned with ecosystem health. Where there is a diverse habitat available with a variety of flow types (runs riffles and pools) and good quality riparian vegetation/cover, there tends to be high ecological health (MacGibbon and Tipa 2001) and a diverse, healthy macroinvertebrate population (Stark 2011). For example the Waipoua Forest at SH12 has optimal habitat with stable, dense native riparian margins, a variety of habitat types and an excellent Macroinvertebrate Community Index (MCI). The Paparoa at Walking Bridge, on the other hand, has marginal habitat, no cover/shade, unstable banks, is channelised with very little habitat diversity and has a poor MCI score (Figure 20). Good riparian cover also provides shade, limiting periphyton cover and restricting temperatures in hot summer months. The maximum spot temperature reading at Waipoua between 2007 and 2011 was 19.9^{o}C compared to 24.3^{o}C at Paparoa, close to the critical 25^{o}C upper limit for many fish and invertebrate species.

Figure 20: Waipoua River (left) has good quality habitat and a correspondingly good MCI. The Paparoa River (right) is channelised with poor habitat quality and a poor MCI.

The Ruakaka River at Flyger Road demonstrates the strong driving force of habitat quality in determining ecological health. Despite elevated nutrient levels and poor visual clarity from upstream, the sampling site which is situated within a bush remnant, has an excellent MCI score. Not only does riparian cover provide shade and limit periphyton growth, it can also intercept and attenuate nutrients, sediments and pathogens, improve bank stability, improve habitat diversity by providing

woody and leafy debris and provide an allocthonous source of food in the form of terrestrial insects which drop into the stream. Conversely, situations where the MCI score is low and yet there is good habitat quality can be an indication of some form of toxic pollution or sedimentation. The Waiarohia at Whau Valley is an example of this. Despite a sub-optimal habitat score and good water quality the macroinvertebrate community is degraded (Pohe, 2011) and warrants further investigation.

Monitoring limitations and knowledge gaps

Northland Regional Council's State of the Environment monitoring programme provides a significant amount of information on the health of waters in the Northland region. However, as understanding of the issues surrounding fresh water ecosystem health and its monitoring have developed, some limitations and knowledge gaps have become apparent as follows:

- The RWQMN has a lack of **reference sites** to enable comparisons of similar types of streams within and between similar geologies, elevations etc. Until recently there have been only two sites sampled that drain unmodified catchments of at least 85% native forest (the criteria for reference site used by Waikato Regional Council (Collier *et al.* 2005)) out of a total of 36 sites sampled annually. A new reference site has been added at the Mangere River in the Pukenui Forest but the addition of a few more reference sites would greatly help in assessing the true state of Northland's waters against similar ecotypes in their natural state.

- National **guidelines** do not always provide an appropriate benchmark against which water quality can be measured as they do not take into account natural catchment characteristics/reference conditions (McDowell *et al.* 2013). This is evidenced by naturally higher E.coli levels in the two reference sites, (Waipapa at Forest Ranger and the Waipoua at SH12 Rest Area [Table 4]) when compared to reference rivers in other REC classes around New Zealand (Table 6). The DRP and NH4 levels at these sites also sit close to the guidelines (Table 4). Regional specific guidelines for the Northland region would allow for more effective interpretation of water quality results and the setting of realistic water quality objectives and limits.

- The **MCI** results also indicate there may be a need for a region specific index with the two 'pristine' sites in the region; in particular, the Waipapa River at Forest Ranger often not meeting the grade for excellent water quality (although an accurate assessment is difficult, due to a lack of true reference sites in the RWQMN).

- While not all rivers require nutrient management to manage nuisance periphyton blooms (those rivers with soft substrate and not discharging to lentic systems and with low macrophyte cover), all others need some form of nutrient management. Although nutrient management is not necessary to control periphyton growth in soft bottomed streams, it is still a sound strategy for, 1) reducing inputs to sediment that might otherwise stimulate unwanted macrophyte growth, 2) managing downstream (hard-substrate) waters that might be subject to periphyton blooms, and 3) avoiding eutrophication problems in downstream environments like lakes, estuaries and coastal waters. The most rigorous method for assessing

periphyton response to nutrients is to conduct **nutrient diffusing substrate assays** (Wilcock *et al*. 2007). It is recommended that preliminary work be carried out to identify rivers which would benefit from limiting nutrient work given the potential management implications of implementing the NPS-FW.

- Current monitoring of river water quality is almost exclusively based on spot samples. **Continuous monitoring,** especially during low flow conditions, could provide valuable information relating to extremes in attributes e.g. diurnal peaks and troughs in dissolved oxygen levels, and maximum water temperature in shallow unshaded streams. Collecting this information seems prudent given the likely requirements for continuous monitoring during summer low flows for the National Objectives Framework.

- River water quality is important not merely to characterise the rivers themselves, but also in regards to the effects of pollutants on downstream receiving waters. The high faecal pollution and low visual clarity (and 'muddiness') of many Northland rivers is perhaps of most concern to downstream coastal waters such as the Kaipara Harbour. For this reason, **better integration of river with estuary and coastal monitoring** is advised.

- While the RWQMN provides good information on the general state and trends in river water quality in Northland, there are still many water bodies that have no, or very little, monitoring data. A programme to progressively 'fill the gaps' in the region by **adding sites temporarily to the RWQMN** in order to calculate their current water quality state is advised.

- **Engage in more flood event monitoring (sediment, microbes)** – this information would improve the council's understanding of faecal contamination levels, sources, and pathogens, and the relationship to turbidity – leading to improved management of microbial hazards in the region.

- Some important aspects of stream health have not been monitored to date. These include **fish community condition, macrophyte cover and sedimentation**. There is also only limited periphyton data although a quarterly periphyton monitoring programme is now underway. This lack of information limits the effectiveness of the SoE monitoring programme to assess both the water quality and ecological health of Northland waters. For example, both periphyton and macrophytes utilise available nutrients in a stream which in turn reduces ambient nutrient concentrations (Matheson *et al.* 2012) impacting on water quality results. The recent developments of standardised protocols for fish monitoring (David *et al.* 2010), in stream sedimentation monitoring (Clapcott *et al.* 2011) and macrophyte monitoring (Collier *et al.* 2007) as well as stream habitat assessments (Harding *et al* 2009) will be utilised to further develop the SoE monitoring programme and fill these knowledge gaps.

- Communities in Northland are becoming increasing motivated to try and improve water quality in Northland. At the same time the council has a need for further monitoring data to inform management decisions and so should **foster community monitoring** (citizen science) where practical. A parallel community/council pilot study by Richard Storey from NIWA is investigating the usefulness of community monitoring to regional councils, and should offer insights into how this might work in Northland.

A Northland Regional Council initiative, Waiora Northland Water, will implement the National Policy Statement for Freshwater Management (NPS-FW) in Northland. The NPS-FW is about facilitating the setting of community objectives and limits for freshwater water management that will help prioritise efforts, identify appropriate guidelines, and monitor progress towards completing objectives for water management. Implementing the NPS-FW will facilitate the holistic management of both freshwater and coastal ecosystems in Northland and will provide more data to expand our knowledge of fresh water quality and ecology in these environments.

Recommendations

To help improve the management of Northland's rivers and the quality of downstream coastal waters the following actions are recommended:

- Create more reference sites
- Develop regional water quality and MCI guidelines using reference data
- Investigate limiting nutrients in rivers
- Carry our more continuous monitoring during summer low flows
- Better integration of river monitoring with estuary and coastal monitoring.
- Add temporary sites from new catchments to the RWQMN to help fill the monitoring gaps in our region
- Engage in more flood event monitoring (sediment, microbes)
- Develop further the council's fish, macrophyte and sedimentation monitoring programmes
- Foster community monitoring.

5. Conclusions

As seen nationally (Davies-Colley 2013), water quality in Northland shows a clear link between catchment land use and water quality with half of the RWQMN sites graded as good, and all sites graded as excellent falling within catchments dominated by native/exotic forestry (Table 5). Conversely 23 out of the 26 sites graded as fair, and all sides graded as poor, are within catchments dominated by lowland pastoral/urban land use. The main issues with water quality are E.coli and fine sediment that degrades water clarity. Only three out of 36 RWQMN sites had a median E.coli result which passed the ANZECC (2000) standard for livestock drinking water and half the RWQMN sites passed the ANZECC guideline for turbidity. Median nitrate and dissolved oxygen levels are largely

within guideline values although some sites still have frequent breaches of nitrate guidelines and have evidence of elevated catchment yields. DRP levels are elevated with just over half of sites failing the DRP standard during the January 2007 to December 2011 reporting period. Sites which failed both nitrate and phosphate guidelines are all within catchments dominated by high intensity agriculture.

Ecological results are not as clearly defined with some 'decoupling' between water quality, habitat quality and aquatic biodiversity as measured by macroinvertebrate health (as yet there is insufficient periphyton and fish data available to make any meaningful comparisons). This is likely to be associated with geographical and climatic factors including the slow flowing, low gradient nature of many of Northland streams and muddy waters associated with deeply weathered geology exacerbated by human activities (50% of sites failed the ANZECC guidelines for turbidity). High sediment loads in rivers lead to high levels of deposited sediment, particularly in slow flowing streams, which directly affects the ecological health of a waterway, decreasing its "mauri" or life-supporting capacity (Clapcot *et al.* 2011) on occasion in spite of apparent good water quality. However, Northland rivers have fairly modest sediment loads (Hicks *et al.* 2011) and tend to be muddy because most of the sediment is layer clays with very fine plate-shaped particles with high light attenuation. So it is this muddiness that is probably of greater concern than sediment loads (Davies-Colley *et al.* 2014 in press). It's also plausible that the issue of high faecal contamination can to some extent be explained by the slow or restricted infiltration properties of the clay soils which can create rapid runoff (Collins *et al.* 2007).

Trend analysis indicates that water quality at the majority of RWQMN sites remains stable. Those sites that did show statistically significant trends were generally improvements. At some sites this could be associated with improved land use practices but at others the reason is unclear. As similar trends were observed at forested reference sites, natural factors such as climate variability (particularly as it affects flow regimes) are likely to be involved. Ecological health has also remained stable at the majority of sites, although five show a significant decline in macroinvertebrate health, often despite improving nutrient levels. The reason for this is unclear but may be related to a number of factors such as changes in flow and increased sediment deposition.

The majority of RWQMN sites (61%) are in a degraded condition. Ecological health is also poor with 66% of MCI scores and 60% of habitat scores being within degraded categories. Almost all RWQMN rivers, within all land cover types (including reference sites), had visual clarity and E.coli levels worse than the national median. While these results suggest naturally higher background levels than other reference sites around New Zealand for these measures, they also highlight the sensitivity of Northland rivers to land use activities and the need for careful land management practices to enhance water quality and in particular ecosystem health.

6. References

Ballantine, D; Davies-Colley, R. (2013). Water quality trends in New Zealand Rivers: 1989-2009. Environmental monitoring and assessment. DOI 10.1007/s10661-013-3508-5.

Ballantine, D; Davis-Colley, R. (2009) Water quality trends at National River Water Quality Network sites for 1989-2007. Ministry for the Environment, Wellington. 43p.

Ballantine, D; Booker, D; Unwin, M; Snelder, T. (2010). Analysis of National River Water Quality Data for the period 1998-2007. NIWA. NIWA Client Report: CHC2010-038. 72p.

Clapcott, J; Young, R; Harding, J; Matthaei, C; Quinn, J. Death, R. (2011). Sediment assessment methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Report prepared for the Ministry of the Environment.

Collier, K; Kelly, J; Champion, P. (2007) Regional guidelines for ecological assessments of freshwater environments: Aquatic plant cover in wadeable streams. Waikato Regional Council document 1106963, Hamilton.

Collier, K; Haigh, A; Kelly, J. (2005). Development of a reference site network for invertebrate monitoring in wadeable streams in the Waikato. Waikato Regional Council report ISSN:1172-4005.

Collins, R; McLeod M; Hedley, M; Donnison, A; Close, M; Hanly, J; Horne, D; Ross, C; Davies-Colley, R; Bagshaw, C; Matthews, L. (2007). Best management practices to mitigate faecal contamination by livestock of New Zealand waters. New Zealand Journal of Agricultural Research 50: 267-278.

Courtney, L; Clements, W. (1998). Effects of acidic pH on benthic macroinvertebrate communities in stream ecosystems. Hydrobiologia. 379: 135-145.

David, B; Hamer, M; Collier, K; Lake, M; Surrey, G; McArthur, K; Nicholson, C; Perrie, A; and Dale, M. (2010). A standardised sampling protocol for robust assessment of reach-scale fish community diversity in wadeable New Zealand Streams. New Zealand Journal of Marine and Fresh Water Research, 44: 177-187.

Davies-Colley, R. (2013). River Water Quality in New Zealand: an Introduction and Overview. Chapter 2-12 in Dymond J. (Ed.) "Ecosystem Services in New Zealand – Conditions and Trends" Manaaki Whenua Press. Pp 432-447.

Davies-Colley, R; Ballantine, D; Elliott, A; Hughes, A; Swales, A; Gall, M. (in press 2014). Light attenuation – a more effective basis for managing fine suspended sediment than mass concentration? Water science and technology.

Harding, J; Clapcott, J; Quinn, J; Hayes, J; Joy, M; Strorey, R; Greig, H; Hay, J; James, T; Beech, M; Ozanne, R; Meredith, A; Boothroyd, I. (2009). Stream habitat assessment protocols for wadeable rivers and streams of New Zealand. University of Canterbury, Christchurch.

Howard-Williams, C; Davies-Colley, R; Rutherford, J; Wilcock, R. (2011). Diffuse pollution and freshwater degradation: New Zealand Perspectives. Invited paper presented at the 14th International Conference of the IWA Diffuse Pollution Specialist Group, (IWA DIPCON2010), Chateau Mont Sainte-Anne, Quebec City, Canada, 12-17 September, 2010. Published by OECD. Pp 126-140.

Kilroy, C; Biggs, B; Death, R. (2008). A periphyton monitoring plan for the Manawatu-Wanganui region. NIWA Client Report: CHC2008-03

Larnard, S; Scarsbrook, M; Snelder, T; Norton, N; Biggs, B. (2004). Water quality in low elevation streams and rivers of New Zealand: Recent state and trends in contrasting land cover classes. New Zealand Journal of Marine and Freshwater Research 38: 347-366.

Matheson, F; Quinn, J; Hickey, C. (2012). Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision making framework: Phases 1 and 2 final report. NIWA Client Report No. HAM2012-081

McDowell R; Snelder, T; Cox, N; Booker, D; Wilkock, R. (2013). Establishment of reference or baseline conditions of chemical indicators in New Zealand stream and rivers relative to present conditions. Marine and Freshwater Research, 2013,64, 387-400.

McGibbon, R; Tipa, G. (2001). Managing Waterways on Farms. MfE Report 385. 204pp.

Northland Regional Council (2011). Recreational Swimming Water Quality in Northland. Summer 2010-2011. Recreational swimming programme

Northland Regional Council (2013). Recreational Swimming Water Quality in Northland. Summer 2012-2013. Recreational swimming programme

Ozane, R. (2012). State of the environment: Surface water quality in Otago. Otago Regional Council Publication No. ISBN 978-478-37641-8.

Perrie A. (2007). The state of water quality in selected rivers and streams in the Wellington region, 2003-2006. Greater Wellington Council Publication No. GW/EMI-T07/218, Wellington.

Perrie, A; Morar, S; Milne. J; Greenfield, S. (2012). River and stream water quality and ecology in the Wellington region. Greater Wellington Council Publication No. GW/EMI-T-12/143, Wellington.

Pfankuch, D. (1975). Stream Reach Inventory and Channel Stability Evaluation. U.S.D.A Forest Service, Region 1, Missoula, Montana.

Pohe, S. (2011). Northland Macroinvertebrate monitoring programme 2011. NRC Report. 40pp.

Roberts, A; Morton, J; O'Connor, M; Edmeades, D. (1996). Building a solid foundation for pasture production in Northland: P, K, S and lime requirements. Proceedings of the New Zealand Grassland Association 57: 119-125.

Snelder, T; Biggs, B. (2002). Multiscale river environmental classification for water resources management. Journal of the American Water Resources Association. Volume 38,5.

Stansfield, B. (2011). Water quality monitoring and analysis – a short course for environmental monitoring officers. Environmental Impact Assessments Client Report CONF 2011-1.

Stark J; Maxted J. (2007). A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No.1166. 58pp.

Stark, J. (2011). Aquatic invertebrate communities of the Manawatu – Wanganui Region - 2011 State of the Environment Report. Prepared for Horizons Regional Council. HRC Report No. 2001/EXT/1210, Stark Environmental Report No.2011-13. 109p.

Swales, A; Gibbs, M; Pritchard, M; Budd, R; Olsen, G; Ovenden, R; Costley, K; Hermanspahn, N; Griffiths, R. (2013). Whangarei Harbour sedimentation. Sediment accumulation rates and present-day sediment sources. NIWA Client Report HAM2013-143.

Swales, A; Ovenden, R; Wadha, S; Rendle, D. Bay of Islands OS20/20 Survey Report (2010). NIWA Client Report No. WLG2010-38.

Swales, A; Bell, R; Ovenden, R; Hart, C; Horrocks, M; Hermanspahn, N; Smith, R. (2007). Mangrove-habitat expansion in the Southern Firth of Thames: sedimentation processes and coastal hazard mitigation. NIWA Client Report HAM2006-138.

Tripole, S; Vallania, A; del Carmen Corigliano, M. (2008). Benthic macroinvertebrate tolerance to water acidity in the Grande river sub-basin (San Luis, Argentina). Limnetica, 27 (1): 29-38.

Wilcock, B; Biggs, B; Death, R; Hickey C; Larned, S; Quinn, S. (2007). Limiting nutrients for controlling undesirable periphyton growth. NIWA Client Report HAM2007-006.

7. Acknowledgments

We would like to acknowledge and thank Dr Rob Davies-Colley, Principal Scientist - Water Quality at the National Institute of Water and Atmospheric Research (NIWA) for peer reviewing the draft version of this report.

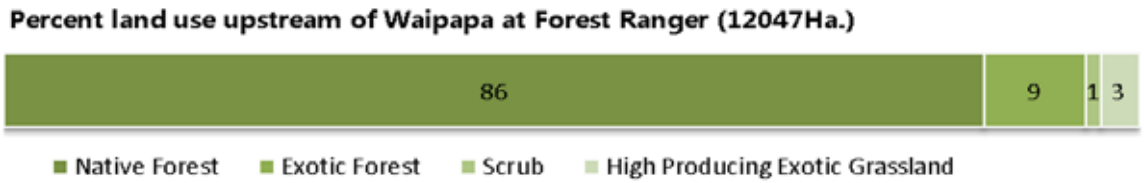
Appendix A - River and stream score cards

The following section provides a score card displaying the water quality status according to the Water Quality Index for each site in the RWQMN (Table 1). A summary of water quality data is presented alongside site descriptions, land use information and any available ecological information.

Waipapa at Forest Ranger

Description

The Waipapa River originates in the Puketi forest in central Northland, meandering through farmland until it reaches the upper Hokianga Harbour. The sampling site is in the upper reaches in predominantly native forest, with some small areas of exotic forest in the headwaters. The geology of the Waipapa River is soft sedimentary. This site is in near pristine condition. The Waipapa site is one of four sites in Northland that are part of the National River Water Quality Network (NRWQN) operated by NIWA.



Waipapa at Forest Ranger: Stream Health 2007- 2011

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	96.4	0.005	77.7	0.003	0.0125	1.825
Minimum	89.1	0.002	6.3	0.0005	0.0005	0.42
Maximum	101.5	0.011	1203.31	0.023	0.163	27.3
n	66	66	66	66	66	66
Pass	66	65	45	65	66	55
Fail	0	1	21	1	0	11
Percentage pass	100.0%	98.5%	68.2%	98.5%	100.0%	83.3%
Median compliant	Yes	yes	yes	yes	yes	yes
Classification: Excellent						

Water Quality

The Waipapa River is classed as having excellent overall water quality as summarised in the table above. All six variables DO, DRP, E.coli, NH4, NNN, and turbidity, used to assess the WQI have medians within national guidelines. With a predominance of native forest in its upper catchment nutrient yields per hectare of land are low compared to other Northland RWQMN sites at an estimated 0.077 kg, 0.061 kg and 0.385 kg of DRP, NH4 and NNN per year respectively which equates to relatively low river loads of 928 kg, 730 kg and 4,632 kg a year.

Trends

Trend analysis indicates that clarity, nitrogen and phosphorous levels are all improving at this site. However, macroinvertebrate health is declining.

Habitat Quality

The habitat assessment is consistent with the WQI scoring the site as optimal. The catchment use at this site is native forest. No livestock have access to the river, there is 45% shading, the banks are stable and the heterogeneous nature of the river provides both riffle run and pool habitat.

Aquatic Biodiversity

The good WQI and habitat score is reflected in the generally good condition of the macro-invertebrate community. Between 2007 and 2011, MCI scores have ranged from 110.8 and 127.8 with a median value of 118.3 (good). However, despite apparent good water quality, macroinvertebrate health has showed a steady decline and warrants further investigation. There are no fish records for this river on the NZFFD.

Periphyton

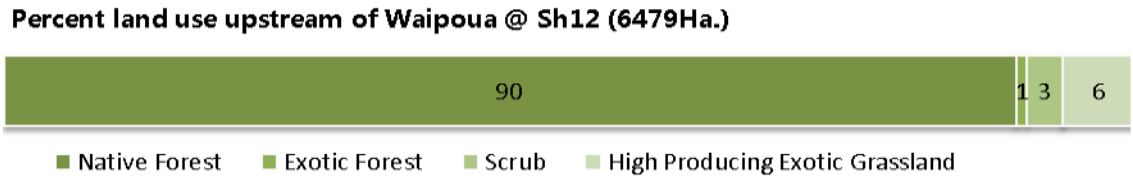
The Waipapa River at Forest Ranger typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The site does however occasionally have high levels of periphyton which may be linked to prolonged dry periods and high temperatures often experienced

at this site over the summer period. In 2010, when there was a particularly long dry period, periphyton levels exceeded the guidelines for clean water macro-invertebrates which may account for the slightly impaired macro-invertebrate score at this site.

Waipoua at SH12

DESCRIPTION

The Waipoua River originates in the Waipoua Forest, on the West Coast of Northland. The river cuts through volcanic soils and has a predominantly native forest catchment. The Waipoua River site is the only site in the network that is classified as "hill elevation" by the '*River Environment Classification*' (NIWA & MfE 2004) and therefore the results have been compared to the trigger values for an upland river.



Waipoua at SH12 Rest Area: Stream Health 2007- 2011

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	101	0.0025	67.5	0.005	0.0225	2.3
Minimum	69.4	0.002	5	0.0025	0.002	1
Maximum	106.2	0.106	1720	0.27	0.131	26
n	63	59	60	60	60	57
Pass	61	57	44	59	60	49
Fail	2	2	16	1	0	8
% PASS	96.8%	96.6%	73.3%	98.3%	100.0%	86.0%
Median compliant	yes	yes	yes	yes	yes	yes
Classification: Excellent						

WATER QUALITY

The Waipoua River is classed as having excellent overall water quality as summarised in the table above. All six variables (DO, DRP, E.coli, NH4, NNN, and turbidity) used to assess the WQI have medians within the national guidelines. With a predominance of native forest in its upper catchment, nutrient yields per hectare of land are low compared to other Northland RWQMN sites at an estimated 0.087kg, 0.149kg and 0.456kg of DRP, NH4 and NNN per year respectively. This equates to low river loads of 560kg, 968kg and 2,956kg per year.

TRENDS

Trend analysis for this site indicates that there is an improving trend in nitrate and phosphorous levels but faecal indicator levels (E.coli) are degrading. Further investigation is required to determine the reason for this trend.

HABITAT QUALITY

The habitat assessment is consistent with the WQI scoring the site as optimal. The catchment use at this site is native forest. No livestock have access to the river, there is 60% shading from native cover, the banks are stable and the heterogeneous nature of the river offers a variety of habitat types such as riffle pools and runs.

AQUATIC BIODIVERSITY

High water and habitat quality is also reflected in the diverse nature of the macro-invertebrate community. The macro-invertebrate community is the most healthy and diverse of all sites in the program. Between 2007 and 2011, MCI scores ranged from 118.9 to 135.5 with a median value of 128.5 (excellent). Although a recent survey only recorded five native fish species at this site (banded kokopu, koaro, shortjaw kokopu, longfin eel and koura), NZFFD historical surveys in the lower reaches of the river record a diverse native fish community (torrent fish, redfin bully, common bully, longfin eel, shortfin eel, lamprey, smelt, inanga, koaro, banded kokopu and shortjaw kokopu). A causeway further downstream is causing a severe barrier to fish passage, preventing/limiting fish access to this valuable upstream habitat. Two of the species present in the catchment are regionally rare, one is sparse and another is in decline (koaro, banded kokopu lamprey and shortjaw kokopu respectively (Allibone *et al* 2009)). If fish passage was restored, the conservation value of this site would be greatly enhanced.

PERIPHYTON

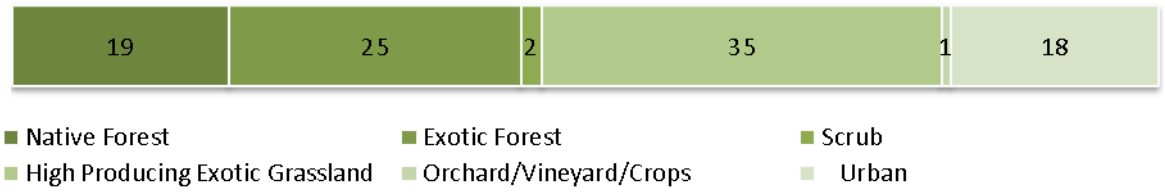
The Waipoua River typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by diatoms and desmids although blue green algae are common at this site and dominated the community in 2009.

Hatea at Mair Park

DESCRIPTION

The Hatea River begins as the Waitaua River (which originates from the Springs Flat area just north of Kamo) and flows southeast through Tikipunga and Mair Park then out into the Whangarei Harbour. There is a mix of urban, native forest and pastoral land in the catchment.

Percentage land use upstream of Hatea @ Mair Park (4282Ha.)



Hatea at Mair Park

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	105.35	0.008	396.5	0.01	0.385	4.1
Minimum	35.7	0.004	74	0.007	0.083	2
Maximum	146.7	0.068	12997	0.57	1.25	75
n	46	40	48	45	42	47
Pass	43	32	3	36	25	33
Fail	3	8	45	9	17	14
Percentage pass	93.5%	80.0%	6.3%	80.0%	59.5%	70.2%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Hatea River is classed as having good overall water quality as summarised in the table above. Five of the WQI variables, DO, DRP, NH4, NNN, and turbidity, have medians within national guidelines; however, E.coli levels exceed guidelines with a median of 396.5 MPN/100ml and ranging from 74 to 12997 during the 2007 – 2011 period. Despite its good overall rating, further investigation of nutrient results indicates several issues with water quality at this site. With just under half of the upper catchment forested and the remainder largely in pasture and orchards, land runoff yields of NNN are moderate compared to other Northland RWQMN sites at 0.305 kg hectare of land respectively. However, NH4 and DRP yields are elevated at an estimated 3.4 kg and 0.106 kg per hectare respectively. These yields equate to comparatively moderate river loads of NNN (15,560 kg/year) but elevated NH4 and DRP loads (5,265 and 6,106 kg/year respectively). Elevated levels of E.coli and high river loadings of NH4 and DRP may be linked to the high number of water fowl that congregate at the site as well as the Hatea sewage pump station which has been a regular point source of pollution during high rainfall events where raw sewage would discharge into the Hatea River. Recent upgrades by Whangarei District Council to install a 1,000,000 litre storage and treatment facility will help improve water quality. Faecal source tracking at Whangarei Falls (upstream of pump station) identified ruminant and wildfowl as the main source of faecal contamination.

Trends

There is insufficient data for trend analysis at this site.

Habitat quality

The habitat assessment is consistent with the WQI scoring the site as sub-optimal. The surrounding land use is native forest and scrub, there is 75% shade from mainly native cover and the banks are stable with no livestock access. However, the upstream land use includes urban and pastoral land and a sewage discharge.

Aquatic Biodiversity

Despite a good WQI result, the macro-invertebrate community is degraded with a median MCI score of 94.7 (fair) ranging from 82.0 – 102.9 from 2007 to 2011. This may be associated with frequent elevated nitrogen levels and high river loads of NH4 and DRP. Recent surveys in the Hatea catchment recorded a moderate diversity of six native fish species in the Waikoromiko Stream, a tributary below the Whangarei falls (longfin eel, redfin bully, giant bully, crans bully, inanga and banded kokopu) and a low species diversity of three native species above the falls (longfin eel, shortfin eel, and an abundance of crans bully). Freshwater crabs and the pest species gambusia were also present above the falls. Historical surveys show a diverse native fish community (torrent fish, redfin bully, common bully, giant bully, longfin eel, shortfin eel, smelt, inanga, koaro, grey mullet, parore and banded kokopu) within the wider catchment.

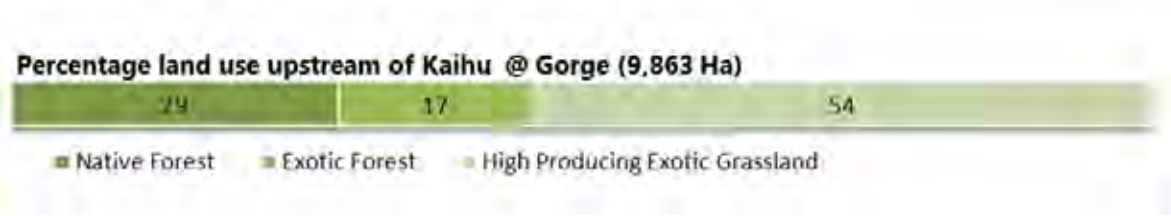
Periphyton

The Hatea River upstream of Mair Park Bridge typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by diatoms. Blue green algae are sometimes present.

Kaihu at Gorge

DESCRIPTION

The Kaihu River originates in native forest to the west of Trounson Kauri Park and drains into the Wairoa River in Dargaville. The catchment is a mix of exotic and native forestry, agriculture and horticulture but dairy farming is the predominant land-use. Kaihu River is one of six sites in the network that have volcanic acidic geology.



Kaihu at gorge

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	100	0.005	153	0.005	0.226	3.2
Minimum	0.83	0.002	20	0.005	0.001	1
Maximum	109.2	0.02	19863	0.42	0.938	120
n	64	59	60	60	60	57
Pass	60	52	24	55	50	39
Fail	4	7	36	5	10	18
Percentage pass	93.8%	88.1%	40.0%	91.7%	83.3%	68.4%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Kaihu River is classed as having good overall water quality as summarised in the table above. Five of the WQI variables, DO, DRP, NH4, NNN, and turbidity, have medians within national guidelines however E.coli levels exceed guidelines with a median of 153 MPN/100ml and ranging from 20 to 19863 during the 2007 – 2011 period. With almost half of the upper catchment forested, nutrient yields per hectare of land are low to medium compared to other Northland RWQMN sites at an estimated 0.069 kg, 0.206 kg and 3.06 kg of DRP, NH4 and NNN per year respectively. In the river this equates to low DRP loads of 792 kg per year and moderate loads of NH4 (2,371.6 kg/year) and NNN (35,255 kg/year). Elevated levels of E.coli are likely to be associated with a number of influences including runoff from high intensity farming and livestock access upstream of the site.

Trends

Trend analysis indicates that both nitrogen and phosphorous levels are improving but dissolved oxygen levels are showing signs of deterioration.

Habitat quality

The habitat assessment data is consistent with the standard of water quality, scoring the site as sub-optimal. The surrounding land use is native and exotic forest, there is a high level of shading from native cover (70%), livestock do not have access to the site, the banks are stable and the river provides both riffle and run habitat.

Aquatic Biodiversity

Despite a good WQI result, the macro-invertebrate community is consistently degraded at this site, scoring 'poor' with a range of 79.4 to 99.6 and a median of 87.1. This may be related to somewhat elevated river loads of NH4 and NNN as well as sedimentation indicated by 31.6% of samples failing turbidity standards. A recent survey recorded a moderate diversity of seven native fish species at this site (longfin eel, shortfin eel, inanga, crans bully, grey mullet, koura and torrentfish). Historical NZFFD surveys show a rich diversity within the wider catchment with records of other species including common bully, redfin bully, black mudfish, smelt, the regionally rare banded kokopu and shortjaw kokopu and lamprey which are sparse (Miller & Holland 2007).

Periphyton

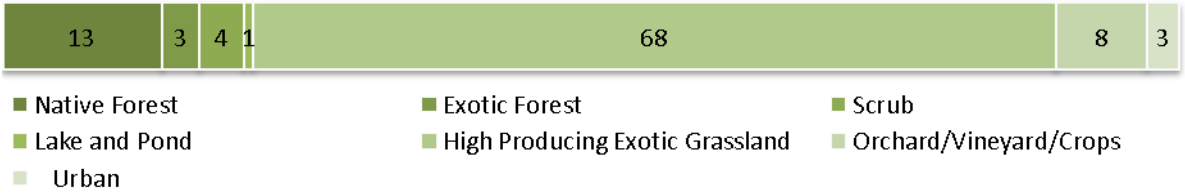
The Kaihu River at Gorge typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by diatoms and desmids. Blue green algae have been present in some years.

Kerikeri at Stone Store Bridge

Description

The Kerikeri River originates to the east of the Puketi Forest, and flows east into the Kerikeri Inlet. The catchment contains a range of land use, including pastoral, horticulture (orchards), agriculture (crops) and forestry (pine plantations). There are small areas of native forest in the headwaters. High numbers of water fowl tend to congregate at this site.

Percentage land use upstream of Kerikeri @ Stone Store Bridge (9863Ha.)



Kerikeri River at Stone Store Bridge

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	101.15	0.007	240	0.01	0.41	2.1
Minimum	61.5	0.004	10	0.008	0.045	0.8
Maximum	203	0.06	24192	0.21	1.41	100
n	52	51	121	53	53	118
Pass	48	37	34	45	32	101
Fail	4	14	87	8	21	17
Percentage pass	92.3%	72.5%	28.1%	84.9%	60.4%	85.6%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Kerikeri River at Stone Store Bridge is classed as having good overall water quality as summarised in the table above. Five of the WQI variables(DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines.However, E.coli levels exceed guidelines with a median of 240 MPN/100ml and ranging from 10 to 24192 MPN/100ml during the 2007 – 2011 period. Despite its good overall rating, further investigation of nutrient results indicates some issues with water quality at this site. Land use in the upper catchment at this site is predominantly high producing grassland and includes a number of orchards and vineyards. Nutrient yields per hectare of land are high compared to other Northland RWQMN sites at an estimated 0.182 kg, 0.255 kg and 5.6 kg of DRP, NH4 and NNN per year respectively. In the river this equates to relatively moderate DRP and NH4 loads of 1800 kg and 2518 kg per year but elevated NNN loads of 55,668 kg per year. The high E.coli levels and elevated NNN loads are likely to be related to water fowl contamination, runoff from farming and horticulture and the impacts of forestry harvesting, with accompanying nitrate leaching and elevated E.coli levels associated with decomposition of organic material. Faecal source tracking identified wildfowl and ruminant as the main sources of faecal contamination at this site.

Trends

Trend analysis indicates that there are no significant trends for any of the attributes measured as part of the River Water Quality Monitoring Network Programme for this site.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as sub-optimal. The surrounding land use is native forest, scrub, lifestyle and urban. There is 20 percent shade from a mixture of exotic and native cover, livestock do not have access to the river, the banks are stable and the nature of the river offers both pool rapid and run type habitat. hHowever, high intensity land use upstream, including farming, forestry and horticulture, is likely to be impacting water quality at the sampling site.

Aquatic Biodiversity

Despite good WQI and habitat quality results the macro-invertebrate community is degraded consistently scoring 'poor' with a range of 75.3 to 84.5 and a median of 77 (fair) which is likely to be linked to somewhat elevated yearly nutrient loads. Records on the NZFFD in proximity to this site include a high diversity of twelve fish compared to other RWQMN sites. These include eleven native species; longfin eel, shortfin eel, common bully, giant bully, cockabully, crans bully, redfin bully, bluegill bully, inanaga and grey mullet, the regionally rare banded kokopu (Miller & Holland 2007) and the pest fish gambusia which is known to attack native fish (Rowe 2007). Elsewhere in the catchment, there are also records of torrent fish, crans bully and koura. Because of the migratory nature of the majority of New Zealand native species, spending part of their lifecycle at sea, there is a trend of increasing diversity with decreasing distance to the sea (McDowall, 2000). The Kerikeri River at Stone Store Bridge is a coastal site in close proximity to the Kerikeri estuary so could be expected to have a high diversity.

Periphyton

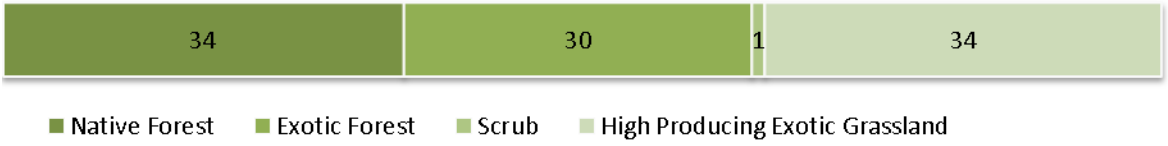
The Kerikeri River at Stone Store typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by diatoms and desmids although blue green algae and filamentous green algae are common.

Mangakahia at Twin Bridges

DESCRIPTION

The Mangakahia River originates from Matarua Forest and flows southwest until it reaches the Wairua River. There are two sites on the Mangakahia River in the network; one at Twin Bridges and the other at Titoki Bridge, in the lower reaches. The Twin Bridges lie at the confluence of the Awaroa and Mangakahia Rivers. The sampling site is directly downstream of this confluence. The upstream catchment is a mixture of native forest, plantation forestry, and beef and sheep farming, with an acidic, volcanic underlying geology.

Percentage land use upstream of Mangakahia @Twin Bridges (24399Ha.)



Mangakahia at Twin Bridges

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	108.9	0.00325	121	0.005	0.032	2.7
Minimum	68.1	0.002	10	0.0025	0.001	1
Maximum	127.6	0.096	4884	0.016	0.56	90
n	41	40	41	41	41	38
Pass	40	37	23	41	40	28
Fail	1	3	18	0	1	10
Percentage pass	97.6%	92.5%	39.0%	100.0%	97.6%	73.7%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Mangakahia River at Twin Bridges is classed as having excellent overall water quality as summarised in the table above. All six variables DO, DRP, E.coli, NH4, NNN, and turbidity, used to assess the WQI are within national guidelines. With its mainly forested upstream catchment, nutrient yields per hectare of land are low compared to other Northland RWQMN sites at an estimated 0.086 kg, 0.075 kg and 1.044 kg of DRP, NH4 and NNN per year respectively which equates to comparatively moderate river loads of 2091 kg, 1825.6 kg and 25,466 kg per year.

Trends

Trend analysis indicates that both nitrogen and phosphorous levels are improving at this site.

Habitat quality

The habitat assessment is inconsistent with the WQI scoring the site as sub-optimal. The surrounding land use is native and exotic forest, there is a high level of shading from native cover (40%) and livestock do not have access to the site. However, the banks are unstable, and there is evidence of quite high sediment loads, with much of the substrate being made up of silt/sand which is likely to be associated, at least in part, with forest harvesting.

Sediment flowing into the Mangakahia from the Awaroa River (a catchment where there has been recent pine harvesting)

Aquatic Biodiversity

The sub-optimal habitat is reflected in the impoverished nature of the macro-invertebrate community with a median MCI score of 94.5 (fair) ranging between 91.7 and 96.7 between 2007 and 2011. This may well be linked to a lack of habitat availability, with sediment smothering much of the substrate. A recent survey recorded a moderate diversity of seven native fish species at this site (longfin eel, shortfin eel, inanga, crans bully, common bully, grey mullet and torrentfish). Historical NZFFD surveys also record banded kokopu within the catchment which is regionally rare and lamprey which are sparse (Miller & Holland 2007).

Periphyton

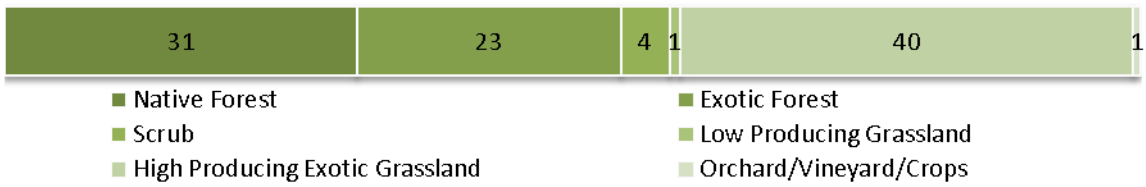
The Mangakahia at Twin Bridges typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000) although in 2012 the guidelines were exceeded. Periphyton communities here are dominated by diatoms and desmids. Blue green algae have been present in some years.

Ngunguru at Waipoka Road

Description

The Ngunguru River originates in Waipaipai to the west of the Tutukaka Coast and flows through the Glenbervie forest out into the Ngunguru Estuary. Half of the catchment is pastoral, with the rest a mixture of *Pinus radiata* and native forest. The site is situated in the lower reaches of the river before the river becomes saline.

Percent land use upstream of Ngunguru @ Waipoka Road (5061Ha.)



Ngunguru at Waipoka Rd

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	97.3	0.01	305	0.01	0.093	5.5
Minimum	68.5	0.004	121	0.006	0.003	2.3
Maximum	131	0.28	11199	0.08	0.46	102
n	51	49	51	51	51	48
Pass	47	35	3	41	49	25
Fail	4	14	48	10	2	23

Percentage pass	92.2%	71.4%	5.9%	80.4%	96.1%	52.1%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

WATER QUALITY

The Ngunguru River has good overall water quality as summarised in the table above. Five of the WQI variables(DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines. However, E.coli levels exceed guidelines with a median of 305 MPN/100ml ranging from 121 to 11199 MPN/100ml and, despite medians passing the guidelines, individual turbidity samples failed on 48% of occasions during the 2007 – 2011 period. With a predominance of native and exotic forest in its upper catchment, nutrient yields per hectare of land are moderate to low compared to other Northland RWQMN sites at an estimated 0.159 kg, 0.165 kg and 1.46 kg of DRP, NH4 and NNN per year respectively which equates to low river loads of 805 kg, 834 kg and 7,382 kg a year. The high E.coli levels and quite frequent breaches of turbidity levels (40% of sampling occasions) are likely to be related to runoff from farming and forestry harvesting with elevated sediment loads and high E.coli levels associated with decomposition of organic material.

Trends

There is insufficient data for trend analysis at this site.

HABITAT QUALITY

The habitat assessment data is inconsistent with the WQI, scoring the site as 'marginal'. The surrounding land use is native forest, scrub and pasture, there is 20% shade from native/exotic riparian cover. However, livestock has access to the site, the banks are unstable and the river is very slow flowing with predominantly pool habitat and a high percentage of silt/sand substrate.

AQUATIC BIODIVERSITY

The marginal habitat is reflected in the impoverished nature of the macro-invertebrate community with a range of 87.8 to 90.0 and a median of 90.0 (fair). This is likely to be linked to the marginal habitat and high levels of sediment as indicated by frequent breaches of turbidity with a minimum of 2.3 NTU and a maximum of 102 NTU. High levels of sediment reduce habitat and food availability for invertebrates, filling the interstitial places between stones and smothering/ restricting algal growth for grazers. This site has no fish records on the NZFFD; however, a diversity of ten native fish is recorded within the larger catchment including longfin eel, shortfin eel, koura, torrent fish, inanga, giant bully, smelt, redfin bully, common bully and banded kokopu which are regionally rare (Miller & Holland 2007).

PERIPHYTON

There is no periphyton data for this site.

Opouteke at Suspension Bridge

DESCRIPTION

The Opouteke River drains predominantly exotic forestry (pine forest), through a small area of pasture, before reaching the Mangakahia River. Pastoral use in the area includes sheep and beef and dairy farming. Acidic volcanic rocks make up the underlying geology.

Opouteke at Suspension Bridge

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	107.3	0.004	174	0.005	0.036	2.7
Minimum	0	0.0005	10	0.0025	0.001	1
Maximum	120.2	0.037	3873	0.1	0.382	50
n	60	59	60	60	60	57
Pass	57	56	19	59	60	40
Fail	3	3	41	1	0	17
Percentage pass	95.0%	94.9%	31.7%	98.3%	100.0%	70.2%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Opouteke River River has 'good' overall water quality as summarised in the table above. Five of the WQI variables(DO, DRP, NH4, NNN, and turbidity), have medians within national guidelines. However, E.coli levels exceed guidelines with a median of 174 MPN/100ml, ranging from 10 to 3873 MPN/100ml, and despite medians passing the guidelines, individual turbidity samples failed on 30% of occasions during the 2007 – 2011 period. With almost entirely native and exotic forest in its upper catchment, nutrient yields per hectare of land are low at this site compared to other Northland RWQMN sites at an estimated 0.065kg, 0.096kg and 0.922kg of DRP, NH4 and NNN per year respectively. This equates to low river loads of 701kg, 1034kg and 9,968 kg per year. The high E.coli levels are related to farm runoff and livestock access to the stream, as shown by faecal source tracking which identified ruminant as the source of faecal contamination.

Trends

Trend analysis indicates that both nitrogen and phosphorous levels are improving at this site.

Habitat Quality

The habitat assessment data is inconsistent with the WQI, scoring the site as 'marginal'. The site is situated on a dairy farm, there is very little shading and livestock has access to the site. Despite a wide variety of habitat types, the substrate is smothered in sediment.

Aquatic Biodiversity

The marginal habitat is reflected in the impoverished nature of the macro-invertebrate community with a range of 88.5 to 96.3 and a median of 93.2 (fair). This is likely to be linked to high levels of sediment reducing habitat and food availability for invertebrates, filling the interstitial places between stones and smothering/restricting algal growth for grazers. There are no fish records for this river on the NZFFD.

Periphyton

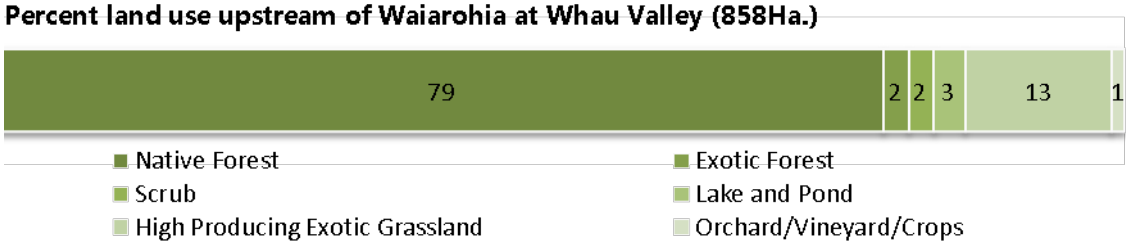
The Opouteke River typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by diatoms and desmids. Blue green algae have been present in some years.

Waiarohia at Whau Valley

DESCRIPTION

The Waiarohia Stream is a small stream originating from Pukenui Forest and the Western Hills in Whangarei. The upper catchment is mainly native forest with some exotic forestry. The stream flows through a small area of low intensity farm land (mostly lifestyle blocks), before it reaches residential housing and the central business area of Whangarei. This site is located upstream of the majority of residential housing in the upper catchment of the Waiarohia Stream.

Percent land use upstream of Waiarohia at Whau Valley (858Ha.)



Waiarohia at Whau Valley

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	95.7	0.01	504	0.01	0.402	5.6
Minimum	60	0.004	10	0.01	0.002	2.1
Maximum	138	0.02	12997	0.21	1.64	42
n	67	58	61	62	60	61
Pass	61	39	4	57	37	32
Fail	6	19	57	5	23	29
Percentage pass	91.0%	67.2%	6.6%	91.9%	61.7%	52.5%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Waiarohia Stream at Whau Valley has 'good' overall water quality as summarised in the table above. Five of the WQI variables (DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines. However, E.coli levels exceed guidelines with a median of 504 MPN/100ml ranging from 10 to 12997 MPN/100ml and there are frequent breaches of nitrogen and phosphate levels (despite yearly medians being compliant). This is likely to be associated with livestock access to the stream, septic tanks on lifestyle blocks as well as rural run-off. Overall though, with a predominance of native forest in its upper catchment, nutrient yields per hectare of land are low to moderate compared to other Northland RWQMN sites at an estimated 0.099 kg, 0.168 kg and 3.7 kg of DRP, NH4 and NNN respectively per year and river loads are low at 85.2 kg, 144 kg and 3,148 kg.

Trends

Trend analysis indicates that clarity, turbidity and phosphate levels are improving at this site; however, pH levels and macroinvertebrate community health (MCI) are degrading.

Habitat quality

The habitat assessment data is consistent with the WQI, scoring the site as 'sub-optimal'. There is 75% shade with both native and exotic cover, and the heterogeneous nature of the stream offers a variety of habitat types such as riffle, pools and runs. However, livestock have access to the stream.

Aquatic Biodiversity

The macro-invertebrate community does not reflect the good habitat and WQI at this site, scoring a median of 92.3 or 'fair'. MCI scores ranged from 91.7 to 101.9 during 2007 to 2011 period. However historically, between 1997 (when records began) and 2001, the macroinvertebrate community was healthy, always scoring a 'good' or 'excellent' MCI. Since this time, scores have steadily declined despite improving phosphate and turbidity levels, and this warrants further investigation. Frequent breaches of nitrogen and phosphate levels (despite yearly medians being compliant) or other contaminants may be associated with the decline as well as degrading pH levels. A recent survey recorded just two native species at this site (longfin and shortfin eel), although there are historical records of longfin eel, shortfin eel, banded kokopu, inanga, redfin bully and torrent fish within the wider catchment. The pest fish gambusia was also identified at this site which is of concern as it has been found to attack native fish (Rowe 2007).

Periphyton

There is no periphyton data for this site.

Waiarohia at Rust Avenue

DESCRIPTION

The Waiarohia Stream is a small stream originating from Pukenui Forest and the Western Hills in Whangarei. The upper catchment is mainly native forest with some exotic forestry. The stream flows through a small area of low intensity farmland and lifestyle blocks, before it reaches residential housing and the central business area of Whangarei. This site is located in the central business area and was added to the RWQMN in 2005-06 to look at urban influences on water quality. Results for this site can be compared to the upstream site in Whau Valley.

Waiarohia at Rust Avenue

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N, g/m3- N, g/m3-N	NTU
Median	107	0.01	413.5	0.01	0.3645	2.5
Minimum	73.5	0.004	30	0.008	0.029	1.7
Maximum	138.5	0.037	24192	0.27	1.12	39
n	65	58	60	60	60	57
Pass	61	39	5	56	36	42
Fail	4	19	55	4	24	15
Percentage pass	93.8%	67.2%	8.3%	93.3%	60.0%	73.7%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

WATER QUALITY

The Waiarohia Stream at Rust Avenue has 'good' overall water quality as summarised in the table above. Five of the WQI variables (DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines. Howeve,r E.coli levels exceed guidelines with a median of 413.5 MPN/100ml ranging from 30 to 24192 MPN/100ml during the 2007 – 2011 period. Although the overall medians meet guideline standards, similarly to the upstream site, NNN, DRP and TURB levels frequently exceed guideline levels, breaching on 33%, 40% and 26% of sampling occasions respectively. Again this is likely to be associated with livestock access to the stream, as well as urban/rural ru off. Turbidity levels improve at the downstream site, possibly as a result of no livestock access at the site. Overall though, with more than 50% of native forest in its upper catchment, nutrient yields per hectare of land are low to moderate compared to other Northland RWQMN sites at an estimated 0.097 kg, 0.185 kg and 3.5 kg of DRP, NH4 and NNN respectively per year and, although higher than the upstream site, river loads are low at 174 kg, 332 kg and 6,281 kg a year.

TRENDS

Trend analysis indicates that phosphorous levels are improving at this site; however, pH levels are degrading in line with the upstream site.

HABITAT QUALITY

The habitat assessment data is inconsistent with the WQI, scoring the site as 'marginal'. Although there is 40% shade from mainly native cover and the banks are relatively stable with no livestock access, the stream is highly modified and within the Whangarei urban area, and the substrate is covered with a thin layer of sediment. The stream is also likely to be impacted by stormwater runoff and industrial discharges.

AQUATIC BIODIVERSITY

The marginal habitat is reflected in the impoverished nature of the macro-invertebrate community with a 77.5 to 83.3 and a median of 80.4 or "fair'. This is likely to be linked to high levels of sediment reducing habitat and food availability for invertebrates, filling the interstitial places between stones and smothering/restricting algal growth for grazers, as well as frequent breaches of nitrogen and phosphate levels. Unlike the upstream site at Whau Valley, which had a healthy macro-invertebrate community when records began, this site has consistently scored poorly. A recent fish survey at this site recorded a moderate species diversity of six native species (longfin eel, shortfin eel, redfin bully, crans bully, giant bully and torrent fish). The NZFFD also records inanga; however, at the time of sampling this species is likely to have migrated downstream for spawning.

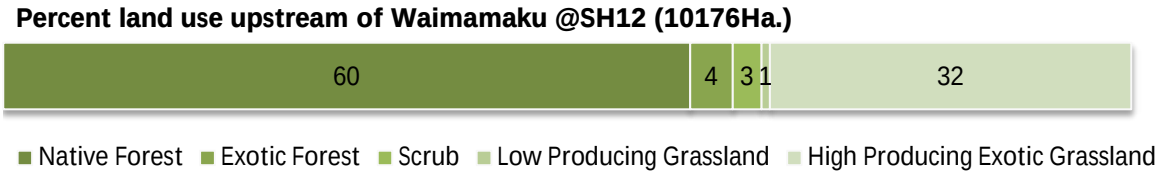
PERIPHYTON

The Wairohia Stream at Rust Avenue often has high algal biomass above the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community tends to be dominated by diatoms and desmids. Blue green algae are sometimes present.

Waimamaku at SH12

DESCRIPTION

The Waimamaku River begins north of the Waipoua forest and flows west through Waimamaku township, eventually reaching the West Coast south of the Hokianga Harbour. The catchment is dominated by native forest in the upper reaches and is mainly pastoral in the lower catchment. The sampling site is located in the lower reaches of the river, after it passes through Waimamaku township.



Waimamaku at SH12

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	103.3	0.005	393	0.005	0.012	3.3
Minimum	65.7	0.002	63	0.0025	0.001	1
Maximum	113.8	0.03	6488	0.06	0.652	65
n	51	50	51	51	51	48
Pass	49	48	5	49	50	38
Fail	2	2	46	2	1	10
Percentage pass	96.1%	96.0%	9.8%	96.1%	98.0%	79.2%
Median	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Waimamuku River has 'good' overall water quality as summarised in the table above. Five of the WQI variables(DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines. However, E.coli levels exceed guidelines with a median of 393 MPN/100ml ranging from 63 to 6488 MPN/100ml during the 2007 – 2011 period. Faecal source tracking identified ruminant as the source of this contamination, indicating that it originates from high production farmland which makes up 32% of the upstream catchment. With a predominance of native forest in its upper catchment, nutrient yields per hectare of land are low compared to other Northland RWQMN sites at an estimated 0.042kg, 0.078kg and 0.277kg of DRP, NH4 and NNN per year respectively which equates to low river loads of 428kg, 796kg and 2,821kg per year.

Trends

There is insufficient data for trend analysis at this site.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as sub-optimal. Although the catchment use at this site is pasture, the majority of the catchment is dominated by native forest and there is a high level of shading (40%). The site does however have unstable banks and livestock can access the river which accounts for the elevated faecal counts as supported by three faecal source tracking samples.

Aquatic Biodiversity

The good water quality and habitat scores are reflected in the good condition of the macro-invertebrate community which also rates as 'good' with a median of 101.9. There are no fish records for this river on the NZFFD.

Periphyton

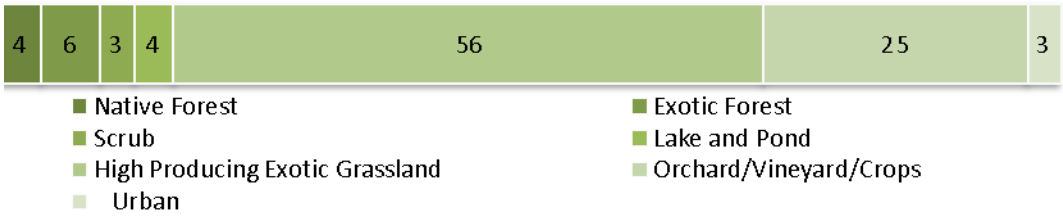
The Waimamaku at SH12 typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000), although in 2012 the guidelines were exceeded. Periphyton communities here are dominated by diatoms and desmids.

Waipapa at Waipapa Landing

DESCRIPTION

The Waipapa Stream is fed by Lake Manuwai and flows east out into the Kerikeri Inlet. The stream passes through a mixture of land use types, including pastoral, horticulture (orchards) and lifestyle blocks. The underlying geology is predominantly acidic volcanic.

Pecent land use upstream of Waipapa at Waipapa Landing (3361Ha.)



Waipapa at Waipapa Landing

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	95.9	0.005	173	0.01	0.324	2.15
Minimum	61.8	0.004	10	0.007	0.01	2
Maximum	113.7	0.03	8664	0.16	0.91	28
n	53	51	53	53	53	50
Pass	49	48	17	51	40	42
Fail	4	3	36	2	13	8
PERCENTAGE PASS	92.5%	94.1%	32.1%	96.2%	75.5%	84.0%
Medium compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Waipapa Stream at Waipapa Landing has 'good' over-all water quality as summarised in the table above. Five of the WQI variables (DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines. However, E.coli levels exceed guidelines with a median of 173 MPN/100ml ranging from 10 to 8664 MPN/100ml; and NNN and turbidity levels often exceed guidelines with 25% and 16% of samples respectively failing the standards (although the overall medians are compliant). With a predominance of high producing grasslands, orchards, vineyards and crops in the upper catchment, DRP yields per hectare of land are low compared to other Northland RWQMN sites at an estimated 0.071kg, but NH4 and NNN levels are somewhat elevated at 0.138 kg and 2.8 kg a year. Being a small catchment feeding into a relatively large stream, this equates to low river loads of 237kg, 453kg and 9,554 kg per year. The high E.coli levels and some elevated nitrogen and turbidity results are probably linked to runoff from high intensity agriculture and horticulture within the area as well as possible seepage from septic tank systems.

Trends

Trend analysis indicates that both clarity and nutrient levels are improving at this site.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as sub-optimal. There is 40% shade with both native and exotic cover, livestock do not have access to the river, the banks are stable and the nature of the river offers both pool, cascade and run type habitat. However the river also shows evidence of high sediment loads (often associated with high intensity land use) with frequent breaches of the turbidity standard and 35% of the substrate being composed of sediment/sand.

Aquatic Biodiversity

The impoverished nature of the macroinvertebrate community is inconsistent with the good water quality and habitat results for this site, consistently scoring 'fair' with a range of 68.5 to 97.5 and a median of 80.79. This is likely to be linked to the influences of brackish water (this site is very close to the coast and is tidal) as well as high levels of sediment reducing habitat and food availability for invertebrates, filling the interstitial places between stones and smothering/restricting algal growth for grazers. There is also a low diversity of fish recorded on the NZFFD in proximity to this site which includes just four native species; common bully, longfin eel, shortfin eel, and the regionally rare banded kokopu (Miller & Holland 2007). The pest fish species gambusia was also identified which is a concern as it is known to prey on native fish (Rowe 2007). Elsewhere in the catchment there are records of redfin bully and the exotic fish, trout and goldfish.

Periphyton

The Waipapa at Waipapa Landing typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by diatoms and desmids although blue green algae are common at this site and dominated the community in 2009.

Waitangi at Watea

Description

The Waitangi River originates in the middle of Northland and flows east, where it joins the coast at Waitangi. There are two sites on the Waitangi River that form part of the RWQMN; one at Waimate North and the other at Watea near Waitangi. The catchments of both sites are dominated by pastoral farming. However, the geology of the upstream site at Waimate North is predominantly volcanic acidic, while the site at Watea is dominated by hard sediments.

Waitangi at Watea

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	101	0.005	140.1	0.007	0.248	3.65
Minimum	82.6	0.0005	48.8	0.001	0.0005	0.8
Maximum	112.7	0.026	2419.2	0.087	0.935	42.3
n	66	66	65	66	66	66
Pass	66	59	28	60	52	46
Fail	0	7	37	6	14	20
Percentage pass	100.0%	89.4%	43.1%	90.9%	78.8%	69.7%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

WATER QUALITY

The Waitangi River at Watea has 'good' overall water quality as summarised in the table above. Five of the WQI variables(DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines. However, E.coli levels exceed guidelines with a median of 140.1 MPN/100ml ranging from 48.8 to 2419.2 MPN/100ml during the 2007 – 2011 period. Although the overall medians are compliant, NNN and turbidity levels also often exceeded guidelines with 21% and 30% of samples respectively failing the standards. The elevated E.coli, NNN and turbidity levels are likely to be linked to runoff from pastoral farming in the area and septic tank systems. The Watea site, although graded the same, has better pass rates for all measures of the WQI, particularly E.coli, compared to the upstream site at Waimate Road, probably as a result of livestock access at the upper site. With a predominance of high producing grasslands in the upper catchment DRP, NH4 and NNN yields per hectare of land are low to moderate compared to other Northland RWQMN sites at an estimated 0.060 kg, 0.1 kg and 2.6kg respectively. This equates to low river loads of DRP at 1810 kg, but moderate to high levels of NH4 and NNN of 2989 kg and 77,105 kg

TRENDS

Trend analysis indicates that there are no significant trends for any of the attributes measured as part of the River Water Quality Monitoring Network Programme for this site.

HABITAT QUALITY

The habitat assessment data is inconsistent with the WQI, scoring the site as 'marginal'. The surrounding land use is a mixture of native scrub and lifestyle, there is little shading and the homogenous nature of the river means that there is only one type of habitat/flow type available (run). Although livestock do not have access to the stream there is evidence of high sediment loads with frequent breaches of the turbidity guideline and 37% of the substrate being composed of sediment/sand.

AQUATIC BIODIVERSITY

The marginal habitat is reflected in the impoverished nature of the macro-invertebrate community with a median score of 61.2 'poor' and a range of 49.4 to 70.6. As well as limited habitat availability this is likely to be linked to elevated nutrient levels favouring more pollution-tolerant species and high levels of sediment reducing habitat and food availability for invertebrates, filling the interstitial places between stones and smothering/ restricting algal growth for grazers. Although there are no recent surveys at this site, a recent survey at the upstream Waimate site recorded just three native species (longfin eel, shortfin eel and crans bully) along with the pest fish gambusia. This site can be expected to have similar low diversity with the Haruru Falls further downstream causing a severe barrier to fish passage. There are historical records on the NZFFD of longfin eel, shortfin eel, common bully, crans bully koura and burgundy mudfish as well as banded kokopu, (which are regionally rare (Miller & Holland 2007)) within the wider catchment, as well as three pest fish species gambusia, rudd and tench. The presence of gambusia within the catchment is a concern as they are known to attack native fish (Rowe 2007).

PERIPHYTON

There is no periphyton data for this site.

Waitangi at Waimate North Road

DESCRIPTION

The Waitangi River originates just east of Lake Omapere and flows into the Bay of Islands. There are two sites on Waitangi River in the RWQMN; one in the upper to mid reaches at Waimate North and the other in the lower reaches at Watea. At the Waimate North site, the catchment is a mix of beef, sheep and dairy farming, with significant areas of native forest in the headwaters. The underlying geology is predominantly acidic volcanic.

Waitangi at Waimate Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	97.5	0.006	453.5	0.01	0.407	5
Minimum	68.8	0.004	148	0.01	0.053	1.8
Maximum	121.9	0.025	7701	0.15	0.82	200
n	60	57	60	60	60	57
Pass	57	51	0	50	35	32
Fail	3	6	60	10	25	25
Percentage pass	95.0%	89.5%	0.0%	83.3%	58.3%	56.1%
Median compliant	yes	yes	no	yes	yes	yes

Classification: Good

Water Quality

The Waitangi at Waimate Road has 'good' overall water quality as summarised in the table above. Five of the WQI variables (DO, DRP, NH4, NNN, and turbidity) have medians within national guidelines. However, E.coli levels exceed guidelines with a median of 453.5 MPN/100ml ranging from 148 to 7701 MPN/100ml during the 2007 – 2011 period. Although the overall medians are within national guidelines, NNN and turbidity levels also often exceeded guidelines with 41% and 44% of samples respectively failing the standards. These breaches are likely to be linked to high intensity agriculture within the area. With a predominance of high producing grassland in its upper catchment, DRP yields per hectare of land are low at an estimated 0.89 kg per year compared to other Northland RWQMN sites but NH4 and NNN levels are somewhat elevated at 0.203 kg, 4.2 kg per year respectively. Draining a relatively small area, this equates to comparatively low river loads of DRP and NH4 at 448 kg and 1,024 kg but elevated levels of NNN at 21,315 kg of a year.

Trends

Trend analysis indicates that pH and nitrogen levels are improving at this site; however, turbidity and MCI results are degrading.

Habitat Quality

The habitat assessment data is inconsistent with the WQI, scoring the site as 'marginal'. The substrate is dominated by sediment including silt and/or sand and fine gravel, has no riparian canopy cover, and a surrounding land-use dominated by pastoral activity. The river is subject to frequent erosion/cutting and deposition.

Aquatic Biodiversity

The MCI results are inconsistent with good water quality result and range from 87.8 to 102.1 with a median of 99.3 or 'fair' and have showed a steady decline. The impoverished macro-invertebrate community is likely to be linked to elevated E.coli and turbidity levels, as well as elevated NNN loads in the river. The rivers decline is probably most affected by sedimentation issues caused by the unstable nature of the river banks which is exacerbated by livestock access to the site. High levels of sediment reduce habitat and food availability for invertebrates, filling the interstitial places between stones and smothering/ restricting algal growth for grazers. A recent fish survey recorded just three native species (longfin eel, shortfin eel and crans bully) along with the pest fish gambusia which has been known to attack native fish (Rowe 2007). The low fish diversity will also be linked to the Haruru Falls further downstream which are a severe barrier to fish passage. Longfin and shortfin eel are good climbers whilst crans bully are non-migratory and therefore not as impacted by the barrier. There are also historical records on the NZFFD of common bully, koura and burgundy mudfish as well as banded kokopu, which are regionally rare (Miller & Holland 2007) and the pest fish species gambusia, rudd and tench within the wider catchment. The presence of gambusia within the catchment is a concern as they are known to attack native fish (Rowe 2007).

Periphyton

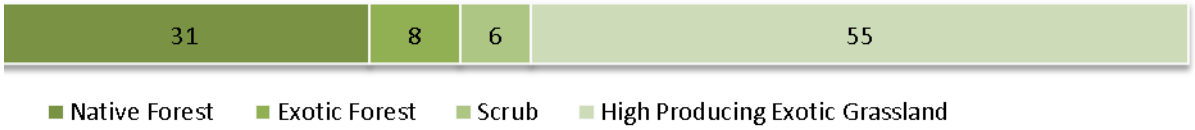
The Waitangi at Waimate Road has only been sampled once for periphyton, in 2007. On this occasion it had low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community was dominated by diatoms and desmids.

Awanui at FNDC water take

DESCRIPTION

The Awanui River originates from Raetea Forest (in the Mangamuka ranges) and meanders north for a significant distance through pasture and the Kaitaia Township, eventually flowing into the Rangaunu Harbour. There are three sites in the network on the Awanui River system; one in the upper reaches on Victoria River, one in the mid-reaches at the FNDC water take and one in the lower reaches directly above Waihue channel.

Pecentage landuse upstream of Awanui FNDC Water Take (21,919 Ha.)



Awanui at FNDC watertake

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	81.65	0.0165	301	0.01	0.0385	6
Minimum	62.6	0.004	20	0.008	0.002	2
Maximum	121	0.076	24192	0.104	0.722	90
n	60	58	60	60	60	57
Pass	34	7	8	50	59	25
Fail	26	51	52	10	1	32
Percentage pass	56.7%	12.1%	13.3%	83.3%	98.3%	43.9%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Awanui River at FNDC water take has 'fair' over-all water quality as summarised in the table above. Three of the WQI variables (DO, NH4, and NNN) have medians within national guidelines. However, DRP, E.coli and turbidity levels exceed guidelines with medians of 12.1g/m3,453.5 MPN/100ml and 6 NTU respectively during the 2007 – 2011 period. DO levels also often exceeded guidelines with 42.3% of samples failing the standards. These breaches are likely to be linked to septic tanks, the runoff from agriculture, and storm water discharges within the area. The means of the upstream site at Victoria River also fail DRP and E.coli standards but pass for turbidity. Despite almost half of the upper catchment being in forest or scrub, DRP and NH4 yields are somewhat elevated (similar to the Victoria River site) at an estimated 0.16 kg and 0.15 kg per hectare compared to other Northland RWQMN sites but NNN levels are low at 0.6 kg per year. This equates to elevated river loads of DRP and NH4 at 3581 kg and 3,309 kg but relatively low levels of NNN at 13,301 kg of a year.

Trends

Trend analysis indicates that there are no significant trends for any of the attributes measured as part of the River Water Quality Monitoring Network Programme for this site.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as 'marginal'. The surrounding land use is a mixture of lifestyle, pasture and urban, there is a limited amount of shade from a mixture of exotic and native cover, the banks are relatively unstable and livestock have access to the stream. There is also evidence of a high sediment load at this site with a very poor turbidity score.

Aquatic Biodiversity

The poor water quality and habitat results are reflected in the degraded nature of the macro-invertebrate community with a median MCI score of 94.5 'fair' and a range of 83.6 to 100. There are no fish records for this site.However, the NZFFD records high fish diversity within the wider catchment of longfin eel, shortfin eel, inanga, banded kokopu, smelt, giant bully redfin bully, crans bully, common bully, koura and black mudfish. The pest fish gambusia is also recorded within the catchment which a concern is given that is known to attack native fish (Rowe 2007).

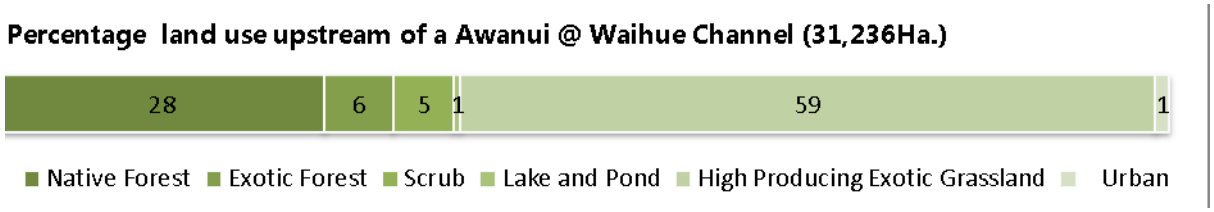
Periphyton

The Awanui River at FNDC water take typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000) although in 2007 periphyton levels exceeded both the clean water and aesthetic guidelines. Periphyton communities here are dominated by diatoms and desmids although blue green algae and filamentous green algaes are common.

Awanui at Waihue Channel

DESCRIPTION

This site is the lowest of three sites on the Awanui River system and is located directly downstream of the discharge from the Kaitaia oxidation ponds and upstream of the Waihue Channel. At this point, the Awanui River has flowed through more than 30km of agricultural land and the Kaitaia Township. The *'River Environment Classification'* identifies this site as a low elevation river with soft sediment geology and pastoral land use.



Awanui at Waihue Channel

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	87.1	0.043	309	0.02	0.053	9.05
Minimum	37.7	0.01	10	0.01	0.002	2.4
Maximum	134.3	1.5	24192	0.39	0.708	130
n	93	90	180	104	59	56
Pass	64	2	21	61	57	13
Fail	29	88	159	43	2	43
Percentage pass	68.8%	2.2%	11.7%	58.7%	96.6%	23.2%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Awanui River at Waihau Channel water take has 'fair' overall water quality as summarised in the table above. Three of the WQI variables (DO, NH4, and NNN) have medians within national guidelines. However, DRP, E.coli and turbidity levels exceed guidelines, with medians of 0.043 g/m3, 309 MPN/100ml and 9.05 NTU respectively. Despite the medians passing the standard, individual DO and NNN samples also often exceed guidelines, with 31% and 41% of samples failing respectively. Percentage pass rates are better for all WQI measures at the upstream site at FNDC Take. DRP and NH4 yields per hectare of land are highly elevated compared to other Northland RWQMN sites at an estimated 0.46 kg and 0.36 kg per year, but NNN levels are low at 0.6 kg per year. River loads show a corresponding trend, with DRP and NH4 levels very high at 14,285 kg of DRP and 11,183 kg of NH4, and NNN loads low at 18,719 kg of a year. These highly elevated DRP, NH4 and E.coli levels are almost certainly associated with the Kaitaia sewage treatment plant discharge just upstream of this site. Compared to the Awanui at FNDC Take, just before the Awanui River reaches Kaitaia, DRP and NH4 loads to the river have more than doubled.

Trends

Trend analysis for this site indicates that there is an improving trend in nitrate and phosphorous levels at this site.

HabitaT quality

The habitat assessment results are consistent with the WQI scoring the site as 'marginal'. The surrounding land use at this site is mainly pasture, livestock have access to the river and, although there is 50% shading and the banks are relatively stable, the homogenous nature of the river provides only run-type habitat/flow. The stream is likely to be impacted by upstream agricultural land use as well as the soft sedimentary geology of the area. It shows evidence of a high sediment load with 50% of the substrate being composed of sediment/sand and very high turbidity levels.

Aquatic Biodiversity

The low water and habitat quality is reflected in the degraded nature of the macro-invertebrate community with a median MCI of 85.3 'fair' ranging from 72.5 to 101.2. Records on the NZFFD in proximity to this site also show a very low diversity of just one species, shortfin eel. However, within the wider catchment, the NZFFD records a high fish diversity of longfin eel, shortfin eel, inanga, banded kokopu, smelt, giant bully redfin bully, crans bully, common bully, koura and black mudfish. The pest fish gambusia is also recorded within the catchment which a concern is given that is known to attack native fish (Rowe 2007).

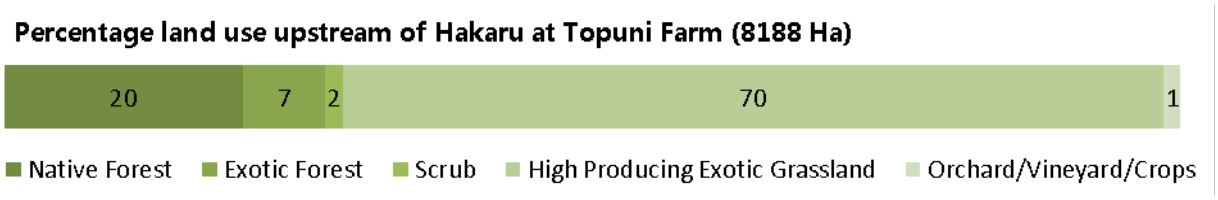
Periphyton

There is no periphyton data for this site.

Hakaru River

Description

The Hakaru River originates in native bush and pine forestry in the Brynderwyn hills and flows south through farmland until it reaches the Topuni River. The Topuni River feeds into an arm of the Kaipara harbour. The underlying geology in the catchment is a mixture of volcanic acidic, and hard and soft sedimentary rock. The site is located at the bottom of the catchment, above the saline influence.



Hakaru at Topuni Creek Farm

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	103.4	0.047	302	0.0165	0.2595	9.5
Minimum	72.2	0.023	52	0.01	0.003	4.3
Maximum	131.7	0.174	12997	0.2	0.861	160
n	53	51	52	52	52	49
Pass	52	0	4	36	46	4
Fail	1	51	48	16	6	45
Percentage pass	98.1%	0.0%	7.7%	69.2%	88.5%	8.2%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

WATER QUALITY

The Hakaru River at Topuni Creek has 'fair' overall water quality as summarised in the table above. Three of the WQI variables (DO, NH4, and NNN) have medians within national guidelines. However, DRP E.coli and turbidity levels exceed guidelines, with medians of 0.047/m3, 302 MPN/100ml and 9.5 NTU respectively during the 2007 – 2011 period. NNN levels also often exceeded guidelines with 30% of samples failing the standards. With a predominance of high producing grassland in its upper catchment DRP and NH4 yields per hectare of land are somewhat elevated compared to other Northland RWQMN sites at an estimated 0.27 kg and 0.17 kg per year respectively, but NNN levels are relatively low at 1.4 kg per year. This equates to river loads of 3581 kg of DRP, 3,309 kg NH4 and 13,301 kg of NNN a year. The poor water quality is likely to be related to nutrient runoff and high sediment loads from agricultural land use as well as the soft sedimentary geology of the area.

TRENDS

Trend analysis indicates that there are no significant trends for any of the attributes measured as part of the River Water Quality Monitoring Network Programme for this site.

HABITAT QUALITY

The habitat assessment data is inconsistent with the WQI, scoring the site as sub-optimal. The surrounding land use is a mixture of native scrub, planted forest and pasture. There is 35% shading from both native and exotic cover, and the nature of the river offers both run, riffle and cascade type habitat. However, livestock have access to one bank of the river and there is evidence of a high sediment load with 43% of the substrate being composed of sediment/sand.

AQUATIC BIODIVERSITY

The low water quality is reflected in the degraded nature of the macro-invertebrate communitywith a median MCI score of 81.6 and a range of 73.2 to 93.2. There are no fish records for this river on the NZFFD.

PERIPHYTON

The Hakaru River typically has high algal biomass above the guidelines for both 'clean water' macroinvertebrates (Biggs 2000) and above that for aesthetics. Periphyton communities here are dominated by diatoms and blue green algae have been present on all sampling occasions.

Kaeo at Dip Road

DESCRIPTION

The Kaeo River begins north of Waipapa and flows north into the Whangaroa Harbour. Just under half of the catchment is native forest and scrub, with the remainder in pine forestry, lifestyle blocks or pastoral farming. The underlying geology of the river is soft sediments. The site is located below the township of Kaeo, just before the influence of salt water.

Percentage land use upstream of Kaeo @ Dip Road (9795Ha.)

Kaeo at Dip Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	95.4	0.005	627	0.01	0.045	6.35
Minimum	69.8	0.004	10	0.009	0.002	2
Maximum	145.1	0.197	8664	0.051	0.613	140
n	57	57	59	59	59	56
Pass	52	53	3	55	58	25
Fail	5	4	56	4	1	31
Percenatge pass	91.2%	93.0%	5.1%	93.2%	98.3%	44.6%
Median compliant	yes	yes	no	yes	yes	no

Classification: Fair

Water Quality

The Kaeo River at Dip Road has 'fair' overall water quality as summarised in the table above. Four of the WQI variables (DO, DRP, NH4, and NNN) have medians within national guidelines. However, E.coli and turbidity levels exceed guidelines, with medians of 627 MPN/100ml and 6.35 NTU respectively during the 2007 – 2011 period. With a predominance of native and exotic forestry in its upper catchment DRP and NH4 yields per hectare of land are somewhat elevated compared to other Northland RWQMN sites at an estimated 0.11 kg and 0.16 kg per year respectively, but NNN levels are relatively low at 0.91 kg per year. This equates to river loads of 792 kg of DRP, 2,372 kg NH4 and 35,255 kg of NNN a year. The poor water quality is likely to be related to high sediment loads from tree harvesting and runoff from agricultural land use. Elevated E.coli levels are linked to farm runoff and livestock access to the river, as shown by faecal source tracking results which identified ruminant as the source of contamination.

Trends

Trend analysis indicates that both nitrogen and phosphate levels are improving at this site but temperature levels are degrading.

Habitat Quality

The habitat assessment data is consistent with the WQI scoring the site as poor. The surrounding land use is a mixture of lifestyle, pasture and urban. The banks are unstable, there is very little shading and the homogenous nature of the river provides only run type habitat/flow. The site is likely to be impacted by upstream land use as well as the soft sedimentary geology of the area and shows evidence of high sediment loads (often associated with forestry harvesting and high intensity land use/livestock access) with 39 percent of the substrate being composed of sediment/sand and very high turbidity levels.

Aquatic Biodiversity

The low water and habitat quality is reflected in the degraded nature of the macro-invertebrate community with a median MCI of 96.2 'fair 'and a range of 81.7 to 122.9. Records on the NZFFD in proximity to this site show a low diversity of five fish species; longfin eel, shortfin eel, common bully, redfin bully and smelt. Elsewhere in the catchment there are also records of inanga, giant bully and the regionally rare banded kokopu (Miller & Holland 2007).

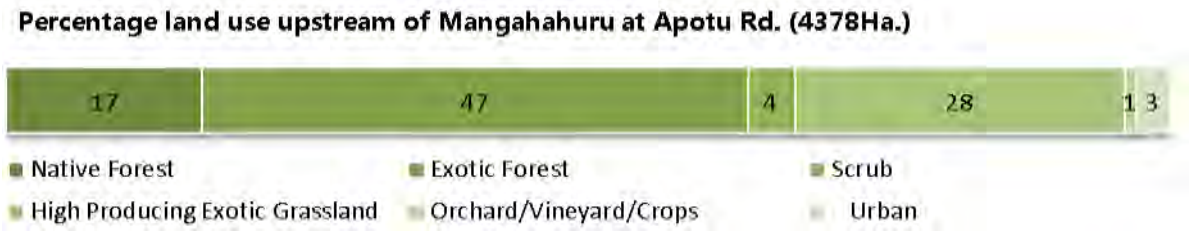
Periphyton

There is no periphyton data for this site.

Mangahahuru at Apotu Road

DESCRIPTION

The Mangahahuru Stream, which begins in *Pinus radiata* forestry southeast of Hikurangi,, is a small tributary of the Wairua River. Other than the exotic forestry in the headwaters, the remainder of the catchment consists mainly of native forest/scrub and agricultural land use, with an increasing number of lifestyle blocks. The underlying geology is hard sedimentary.



Mangahahuru at Apotu Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	97.4	0.027	572	0.02	0.35	6.9
Minimum	55.9	0.008	10	0.01	0.004	2
Maximum	126.8	0.111	24192	0.137	1.71	65
n	61	58	60	60	60	57
Pass	54	5	3	38	40	17
Fail	7	53	57	22	20	40
Percentage pass	88.5%	8.6%	5.0%	63.3%	66.7%	29.8%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Mangahahuru at Apotu Road has 'fair' overall water quality as summarised in the table above. Three of the WQI variables(DO, NH4, and NNN) have medians within national guidelines. However, DRP, E.coli and turbidity levels exceed guidelines, with medians of 0.027 g/m3, 627 MPN/100ml and 6.35 NTU respectively during the 2007 – 2011 period. Nutrient yields per hectare of land are high compared to other Northland RWQMN sites at an estimated 0.19 kg, 0.17 kg and 2.15 kg of DRP, NH4 and NNN per year respectively. This equates to somewhat elevated loads of DRP (726 kg a year) in the river but low levels of NH4 and NNN at 845kg, and 9,393 kg a year respectively. These yields and loads are considerably higher than the upstream site at Main Road with a predominance of pine forest in its upper catchment. This suggests an influence from intensive farming in the area as well as discharges from industrial areas upstream of the site. Results from faecal source tracking identified ruminant and wildfowl as the sources of contamination.

Trends

Phosphate levels are improving but water clarity is degrading at this site.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as poor. The banks are unstable and the homogenous nature of the river only provides run type habitat/flow. Livestock do not have access to the stream at the site; however, the surrounding land use is mainly pasture and there is very little shading. The river shows evidence of high sediment loads (often associated with forest harvesting and high intensity land use/livestock access) with 50 percent of the substrate being composed of sediment/sand and very high turbidity levels.

Aquatic Biodiversity

The diversity and abundance in the macro-invertebrate community reflects the poor water and habitat quality at this site with a median MCI score of 76.9 'poor' and a range of 64.6 to 85.2. A recent fish survey recorded just three native species (longfin eel, shortfin eel and crans bully). There are historical records of rainbow trout as well as banded kokopu, which are regionally rare (Miller & Holland 2007) within the wider catchment.

Periphyton

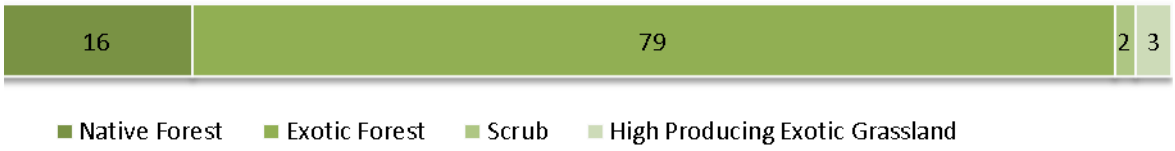
The Mangahahuru at Apotu Road has only been sampled once for periphyton, in 2007. On this occasion it had low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community consisted mainly of red algae, diatoms and filamentous algae.

Mangahahuru at Main Road

DESCRIPTION

The Mangahahuru Stream, which begins in *Pinus radiata* forest to the southeast of Hikurangi, is a small tributary of the Wairua River. The sampling site is located in the upper catchment and therefore the predominant land use in this area is exotic forestry. The site was added to the RWQMN in 2005-06 as a representative of a river system on hard, sedimentary rock surrounded by exotic forestry. It provides a good comparison to the Mangahahuru Stream site at Apotu Road.

Percentage land use upstream of Mangahahuru @ Main Rd (2103Ha.)



Mangahahuru at Main Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	95.7	0.0095	227	0.01	0.069	6
Minimum	64	0.004	52	0.01	0.006	2.8
Maximum	126.8	0.06	3873	0.05	0.44	39
n	61	58	60	60	60	57
Pass	59	46	11	53	60	21
Fail	2	12	49	7	0	36
Percentage pass	96.7%	79.3%	18.3%	88.3%	100.0%	36.8%
Mean	yes	yes	no	yes	yes	no

Classification: Fair

Water Quality

Whilst the Mangahahuru at Main Road has better pass rates for all measures of the WQI compared to the downstream site at Apotu Road, it is still classified as having 'fair' overall water quality as summarised in the table above. Four of the WQI variables (DO, DRP, NH4, and NNN) have medians within national guidelines. However, E.coli and turbidity levels exceed guidelines, with medians of 227 MPN/100ml and 6 NTU respectively during the 2007 – 2011 period. With a predominance of native and exotic forestry in its upper catchment DRP, NH4 and NNN yields per hectare of land are moderate compared to other Northland RWQMN sites at an estimated 0.08 kg and 0.12 kg and 0.93 kg a per year respectively. This equates to low river loads of 167 kg of DRP, 259 kg of NH4 and 1,955 kg of NNN a year. Failure of E.coli and turbidity standards may be linked to logging activities in the area and associated organic decay and sediment runoff.

Trends

E.coli, turbidity and temperature levels are degrading at this site.

Habitat quality

The habitat assessment data is inconsistent with the WQI scoring the site as sub-optimal. The surrounding land use is a mixture of native scrub and pasture, there is 90% shading from mature native riparian cover, no livestock access and the banks are stable. The heterogeneous nature of the river provides both riffle, run and waterfall habitat.

Aquatic Biodiversity

The diversity and abundance in the macro-invertebrate community does not reflect the poor water quality at this site but does reflect the good habitat score and moderate nutrient levels with a median MCI score of 102.4 'good' and a range of 100.4 to 120.5. This is two grades better than the downstream site at Apotu Road. A recent survey recorded a low diversity of four native fish species at this site (longfin eel, crans bully, koura and the regionally rare banded kokopu). Historical NZFFD surveys also record shortfin eel and the exotic species rainbow trout and goldfish within the catchment. The pest fish gambusia was also identified at this site which is of concern as it has been found to attack native fish (Rowe 2007). The low fish diversity in this stream is likely to be at least partly linked to a monitoring weir low in the catchment which is blocking access to upstream habitat for most migratory species.

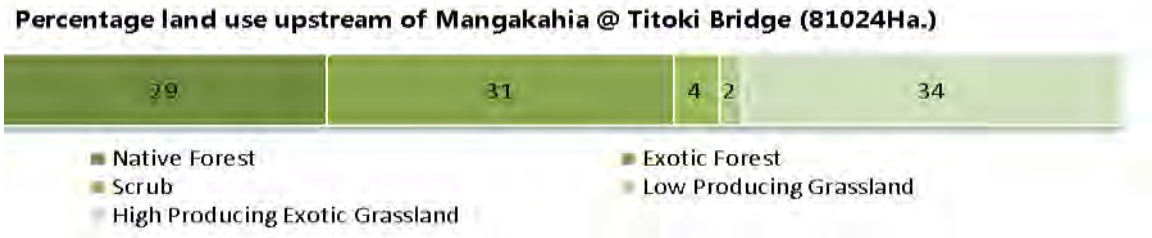
Periphyton

The Mangahahura Stream at Main Road has only been sampled once for periphyton, in 2007.. On this occasion it had high algal biomass above the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community was dominated by diatoms and filamentous green algae with a small amount of blue green algae.

Mangakahia at Titoki

DESCRIPTION

The Mangakahia River originates in native bush near Waipoua Forest and flows southwest until it reaches the Wairua River. There are two sites on the Mangakahia River; one mid-catchment at Twin Bridges and the other at Titoki Bridge in the lower reaches. By the time the Mangakahia River reaches the settlement of Titoki, surrounding land use is predominantly beef and dairy farming, with an underlying geology of acidic volcanic rock. This site is one of four sites in Northland that are part of the National River Water Quality Network, administered by NIWA.



Mangakahia at Titoki Bridge

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	94.7	0.006	237.95	0.0105	0.062	5.88
Minimum	73.3	0.002	75.9	0.001	0.0005	1.7
Maximum	110	0.031	3448	0.081	0.504	250
n	66	66	64	66	66	66
Pass	65	57	10	61	65	32
Fail	1	9	54	5	1	34
Percentage	98.5%	86.4%	15.6%	92.4%	98.5%	48.5%
Median compliant	yes	yes	no	yes	yes	no

Classification: Fair

Water Quality

The Mangakahia River at Titoki Bridge has 'fair' overall water quality as summarised in the table above. Water quality has deteriorated considerably from the upstream site at Twin Bridges where it graded as 'excellent'. Four of the WQI variables (DO, DRP, NH4, and NNN) have medians within national guidelines. However, E.coli and turbidity levels exceed guidelines, with medians of 237.95 MPN/100ml and 5.88 NTU respectively during the 2007 – 2011 period. Yields of DRP and NNN have reduced to 0.067 and 0.979kg a hectare per year from the upstream site at Twin Bridges, but NH4 yields have increased to 0.113 kg a year. River loads for all three measures have increased considerably at the downstream site to 5,389 kg of DRP, 9,176 kg of NH4 and 79,324 kg of NNN per year. Increase nutrient yields and loads, failure of E.coli and TURB standards are likely to be linked to high intensity farming in the area as well as logging activities (with associated organic decay and sediment runoff).

Trends

Trend analysis indicates that clarity and pH levels are improving at this site; however, dissolved oxygen levels are degrading.

Habitat quality

The habitat assessment data is consistent with the WQI scoring the site as marginal. The surrounding land use is pasture, there is little riparian cover/shade, the banks are unstable and the homogenous nature of the river means that there is only one type of habitat/flow type available (run). The river is not fenced at this site meaning cattle have access to the stream causing elevated faecal counts (E.coli levels). In addition, the relatively unstable banks are likely to be eroding and will be exacerbated by the trampling of cattle increasing sediment loads on the river and reducing clarity.

Aquatic Biodiversity

The diversity and abundance in the macro-invertebrate community reflects the poor water and habitat quality at this site with a median MCI score of 99.8 'fair' and a range of 79 to 111. The NZFFD, as well as a recent survey at the upstream site of the Mangakahia at Twin Bridges, records relatively high native species diversity within the catchment. The nine species include; longfin eel, shortfin eel, inanga, crans bully, common bully, grey mullet and torrentfish, banded kokopu which is regionally rare and lamprey which are sparse (Miller & Holland 2007).

Periphyton

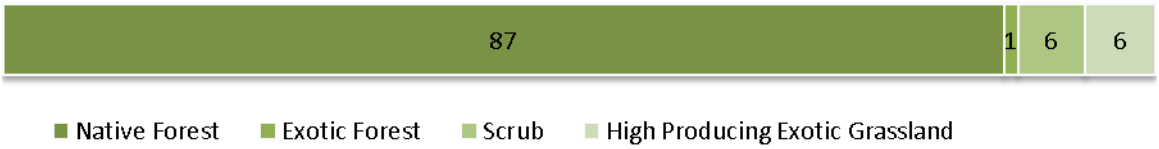
The Mangakahia River at Titioki has only been sampled once, in 2007, for periphyton. On this occasion it had high algal biomass above the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community was dominated by red algae, filamentous green algae and blue green algae.

Mangamuka at Iwitea Road

DESCRIPTION

The Mangamuka River begins in the Mangamuka Forest. The river then flows south into the upper reaches of the Hokianga Harbour. In the lower reaches, the river passes through pastoral land; however, the upper catchment is dominated by native forest. The sampling site is located upstream of the confluence between the Mangamuka and Iwitaua Stream.

Percentage land use upstream of Mangamuku @ Iwitea Road (3640Ha.)



Mangamuka at Iwiatua Road

Site Number	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	93.8	0.03	272	0.005	0.007	1
Minimum	72.9	0.014	41	0.0025	0.001	1
Maximum	153.7	0.04	4884	0.014	0.652	280
n	53	51	53	53	53	49
Pass	49	0	11	53	52	40
Fail	4	51	42	0	1	9
Percentage pass	92.5%	0.0%	20.8%	100.0%	98.1%	81.6%
Median compliant	yes	no	no	yes	yes	yes

Classification: Fair

Water Quality

The Mangamuka River at Iwiatua Road is classed as having fair overall water quality as summarised in the table above. Four of the WQI variables (DO, NH4, NNN, and turbidity) are within national guidelines; however, DRP and E.coli levels exceed guidelines with medians of 0.03g/m3 and 272 MPN/100ml respectively during the 2007 – 2011 period. With a predominance of native forest in its upper catchment, nitrate yields per hectare of land are low compared to other Northland RWQMN sites at an estimated, 0.063kg and 0.482kg of NH4 and NNN per year respectively. DRP levels are high, however, at 0.349kg per hectare, which may be linked to leaching from the underlying geology of unstable mudstone and limestone in the Hokianga area (B Cathcart, NRC Land Management Specialist pers comm. 2013). Being a small catchment these loads equate to moderate loads of DRP and low loads of NH4 and NNN at 1272kg, 229kg and 1,753 kg per year respectively.

Trends

There is insufficient data for trend analysis at this site.

Habitat quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use is pastoral and although the river is fenced off from livestock, cows are regularly seen in the river. There is no shading from native cover, the banks are unstable and the homogenous nature of the river means that there is only run type habitat/flow available.

Aquatic Biodiversity

The macroinvertebrate community does not reflect the poor water quality and habitat results, consistently grading as 'good' with a range of 101 to 117.3 and a median of 106.9. The moderate to low nutrient loads in the river, as well as the upstream land use of mainly native forest, may account for the MCI being better than expected. Invertebrates are known to sometimes drift downstream from more pristine upstream sites and, although they may not survive long, they can influence MCI results (Stark and Maxted 2007). There are no fish records for this river on the NZFFD.

Periphyton

The Mangamuku River at Iwiatua Road typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000) although in 2010, after an extremely dry summer, the guidelines were exceeded. Periphyton communities here are dominated by diatoms and desmids. Blue green algae have been present in some years.

Manganui at Mititai Road

DESCRIPTION

The Manganui is a major tributary into the Wairoa River, flowing from the western fringes of the Marertu forest to join the Wairoa just east of Dargaville. The river runs through extremely low gradient, predominantly pastoral land, with some native and exotic forest scattered through the catchment. The underlying geology at the site is soft sediments.

Percentage land use upstream of Manganui @ Mitaitai Road (41173)

Manganui at Mititai Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	82.4	0.039	135	0.012	0.173	9.4
Minimum	41.8	0.005	10	0.01	0.002	2.5
Maximum	144.3	0.076	11199	0.086	0.648	114
n						
Pass	35	2	29	41	54	11
Fail	26	57	31	19	6	46
Percentage pass	57.4%	3.4%	48.3%	68.3%	90.0%	19.3%
Median Compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Manganui River at Mititai Road Road is classed as having fair overall water quality as summarised in the table above. Three of the WQI variables (DO, NH4, and NNN) are within national guidelines. hHowever, DRP, E.coli and turbidity levels exceed guidelines with medians of 0.039g/m3, 135 MPN/100ml and 9.4 NTU respectively during the 2007 – 2011 period. DO and NH4 levels are also frequently elevated (43% and 32% of samples respectively exceeding guidelines). With a predominance of high producing grassland in its upper catchment, DRP yields per hectare of land are high compared to other Northland RWQMN sites at an estimated 0.2 kg per year;, while NH4 and NNN levels are somewhat elevated at 0.123 kg, 1.1 kg per year respectively. Draining a relatively large area this equates to comparatively high river loads 8,250 kg, 5050 kg and 42,452 kg a year. The high turbidity, and nutrient loads may be linked to leaching from the underlying geology of unstable mudstone and limestone (B Cathcart, NRC Land Management Specialist pers comm. 2013) exacerbated by tree felling operations, farm runoff and livestock access to the river (which will also be contributing to high E.coli levels).

Trends

Trend analysis for this site indicates that pH levels are degrading at this site, along with macroinvertebrate health.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use at this site is a mixture of native scrub and pasture and there is livestock access, the banks are unstable and there is very little shading. The river shows evidence of high sediment loads with 50 percent of the substrate being composed of sediment/sand and high turbidity (TURB) levels. This is likely to be associated with the soft sedimentary geology of the area as well as forestry, high intensity land use and livestock access.

Aquatic Biodiversity

The MCI results are consistent with the poor water quality results and range from 48.9 to 80 with a median of 68.9 or 'poor'. They have showed a steady decline since records began in 2001 which may be linked to the degrading pH levels. There are no fish records on the NZFFD for this site.

Periphyton

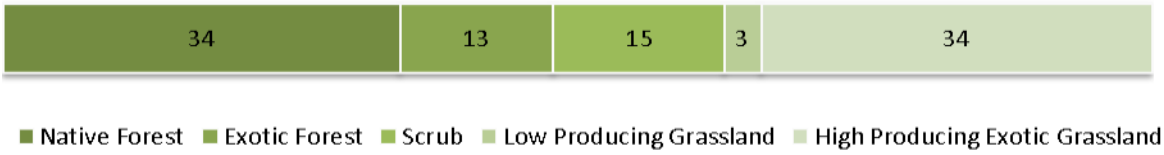
No periphyton data is available for this site.

Oruru at Oruru Road

DESCRIPTION

The Oruru River originates from the Otangaroa forest and flows north through native forest and scrub. In the lower catchment, the river meanders through pastoral dominated land eventually flowing out into the Taipa River. Underlying geology is dominated by volcanic acidic rock, with some areas of soft sediments.

Percent land use upstream of Oruru @ Oruru Road (17237Ha.)



Oruru at Oruru Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	84.2	0.021	292	0.01	0.026	6.65
Minimum	9.5	0.01	63	0.008	0.002	2
Maximum	120.5	0.145	17329	0.05	0.592	180
n	52	51	53	53	53	50
Pass	35	1	8	47	51	21
Fail	17	50	45	6	2	29
Percentage pass	67.3%	2.0%	15.1%	88.7%	96.2%	42.0%
Mean compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Oruru River at Oruru Road is classed as having fair overall water quality as summarised in the table above. Three of the WQI variables (DO, NH4, and NNN) are within national guidelines. hHowever, DRP, E.coli and turbidity levels exceed guidelines with medians of 0.021g/m3, 292 MPN/100ml and 6.65 NTU respectively during the 2007 – 2011 period. Catchment DRP yields per hectare of land are high at an estimated 0.2 kg, per year compared to other Northland RWQMN sites, and NH4 and NNN levels are somewhat elevated at 0.379 kg, 0.989 kg per year respectively. Draining a relatively large area this equates to moderate river loads 1,755 kg, 3,474 kg and 9,068 kg a year. The high DRP levels, elevated faecal indicators (E.coli) and high turbidity may be linked to farm runoff and livestock access to the river, as well as the underlying geology of unstable mudstone and limestone (B Cathcart, NRC Land Management Specialist pers comm. 2013) in the area.

Trends

There is insufficient data for trend analysis at this site.

Habitat Quality

The habitat assessment data is consistent with the WQI scoring the site as marginal. The surrounding land use at this site is mainly pasture, livestock have access to the river, there is very little shading and the banks are relatively unstable. The river shows evidence of high sediment loads (often associated with high intensity land use/livestock access and exacerbated by the unstable geology) with 33 percent of the substrate being composed of sediment/sand and high turbidity levels.

Aquatic Biodiversity

The poor water and habitat quality is reflected in a degraded macroinvertebrate community consistently grading as 'poor' /'fair' with a range of 71.9 to 84.5 and a median of 73. There is just one fish record for this catchment on the NZFFD which records just a single species, the regionally rare banded kokopu (Miller & Holland 2007). However the greater Doubtless Bay catchment has records of nine native fish species on the National Freshwater Fish Database. These include longfin eel, shortfin eel, inanga, giant bully, common bully, smelt, torrent fish, redfin bully and banded kokopu. The pest fish gambusia which is known to attack native fish (Rowe 2007) is also in the catchment.

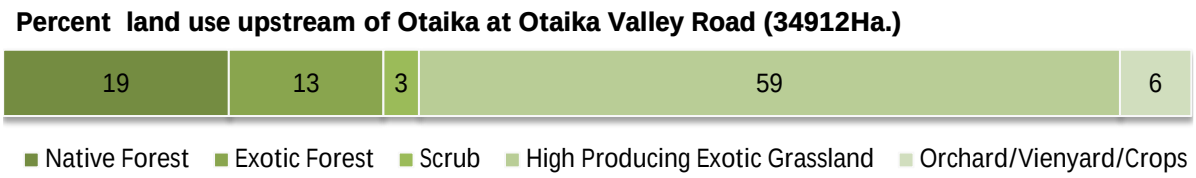
Periphyton

There is no periphyton data for this site.

Otaika at Otaika Valley Road

DESCRIPTION

The Otaika Stream originates near the township of Maugatepere and flow eastwards through a mixture of mainly beef and dairy farms, skirting an area of native forest before entering into the Whangarei harbour. The underlying geology is soft sedimentary.



Otaika at Otaika Valley Road

	DO%	DRP	*E.coli*	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	84.35	0.016	596	0.0265	1.2675	5.1
Minimum	73.1	0.008	148	0.013	0.416	4.5
Maximum	102.8	0.026	12997	0.165	1.483	330
n	6	6	6	6	6	3
Pass	4	1	0	2	1	2
Fail	2	5	6	4	5	1
Percentage pass	66.7%	16.7%	0.0%	33.3%	16.7%	66.7%
Mean compliant	yes	no	no	no	no	yes

Classification: Fair

WATER QUALITY

The Otaika River at Otaika Valley Road is classed as having fair overall water quality as summarised in the table above. Two of the WQI variables (DO and turbidity) are within national guidelines. However, DRP, E.coli, NH4 and NNN levels exceed guidelines with medians of 0.016g/m3, 596 MPN/100ml and 0.02675 g/m3 and 1.2675 g/m3 respectively during the 2007 – 2011 period. With much of the upper catchment used for high intensity farming and horticulture, nutrient yields per hectare are moderate to high compared to other Northland RWQMN sites with DRP, NH4 and NNN levels at 0.179 kg, 0.285 and 4.38 kg per year respectively. The high nutrient levels and elevated faecal indicators may be linked to farm and horticultural runoff and livestock access to the river, as well as the underlying geology of unstable mudstone and limestone (B Cathcart, NRC Land Management Specialist pers comm. 2013) in the area.

TRENDS

There is insufficient data for trend analysis at this site.

HABITAT QUALITY

This is a new site and has not been assessed as part of the Habitat Assessment Monitoring Programme. At the sampling site, the habitat appears to be of quite high quality with a high percentage of mainly native cover, plenty of shade and a good diversity of run, riffle and pool habitat. However the banks are unstable, livestock have access to the stream and the upstream land use is mainly pastoral. With high nutrient and E.coli levels it would appear that this site is being heavily impacted by human activities.

AQUATIC BIODIVERSITY

There is no macroinvertebrate data for this site. Two historical records on the NZFFD for the wider catchment record five native species (smelt, common bully, koura, shortjaw kokopu and banded kokopu). Shortjaw kokopu and banded kokopu are regionally rare (Miller & Holland 2007).

PERIPHYTON

There is no periphyton data for this site.

Paparoa at Walking Bridge

DESCRIPTION

The Paparoa Stream is a soft sediment-bottomed stream, which is set in a catchment dominated by high production farmland, with pockets of pine forestry and native bush. The stream flows west into an arm of the Kaipara harbour. The site is located in the park in Paparoa Township.

Percent land use upstream of Paparoa at Walking Bridge (3573Ha.)

Paparoa at walking bridge

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	89.1	0.02	573	0.02	0.0935	8.9
Minimum	33	0.004	108	0.01	0.002	2
Maximum	129.8	0.051	6131	0.7	0.942	100
n	53	51	52	52	52	49
Pass	40	9	2	34	49	10
Fail	13	42	50	18	3	39
Percentage pass	75.5%	17.6%	3.8%	65.4%	94.2%	20.4%
Median complianant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Paparoa Stream at Walking Bridge Road is classed as having fair overall water quality as summarised in the table above. Three of the WQI variables (DO, NH4 and NNN) are within national guidelines. However, DRP, E.coli and turbidity levels exceed guidelines with medians of 0.02g/m3, 573 MPN/100ml and 8.9 NTU respectively during the 2007 – 2011 period. NH4 levels also breach guideline values for 45% of samples despite the median being compliant. With much of the upper catchment in high producing grassland, nutrient yields per hectare are estimated as high compared to other Northland RWQMN sites, with DRP and NH4 at 0.158 kg, 0.274 kg a year respectively . However, they are low for NNN with yearly yields of 1.1 kg per year. High nutrient yields, E.coli levels and clarity breaches may be linked to runoff from the high intensity farming in the area as well as seepage from septic tanks on lifestyle blocks and exacerbated by the underlying geology of unstable mudstone and limestone (B Cathcart, NRC Land Management Specialist pers comm. 2013). Tree felling operations may also be adding to nutrient and sediment loads.

Trends

There is insufficient data for trend analysis at this site.

Habitat Quality

The habitat assessment data is consistent with the WQI scoring the site as 'poor'. The surrounding land use at this site is mainly pasture and lifestyle blocks with a small amount of urban. Although the banks are relatively stable and livestock do not have access to the stream, there is very little shading and macrophytes are abundant. The river shows evidence of high sediment loads with 100 percent of the substrate being composed of sediment/sand and a very poor turbidity score. This is likely to be associated with the soft sedimentary geology of the area as well as forestry/high intensity land use/livestock access.

Aquatic Biodiversity

The poor water and habitat quality is reflected in a degraded macroinvertebrate community with MCI scores ranging from 58 to 95.7 with a median of 80 (fair). There are no fish records on the NZFFD for this site.

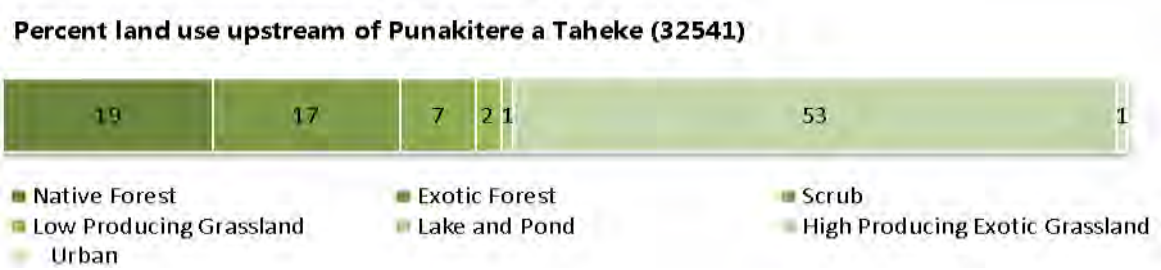
Periphyton

There is no periphyton data for this site.

Punakitere at Taheke

DESCRIPTION

The Punakitere River originates from a wetland to the southwest of Kaikohe and is a major tributary of the Waima River (which flows into the Hokianga Harbour). The catchment is predominantly agricultural land use with an underlying geology of soft sediments.



Punakitere at Taheke Recorder

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	99.7	0.017	419	0.01	0.407	6.2
Minimum	58.6	0.002	120	0.005	0.001	1
Maximum	119	0.071	17329	0.08	0.78	160
n	61	59	60	60	60	57
Pass	58	19	1	48	33	25
Fail	3	40	59	12	27	32
Percentage pass	95.1%	32.2%	1.7%	80.0%	55.0%	43.9%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Punakitere River at Taheke is classed as having fair overall water quality as summarised in the table above. Three of the WQI variables (DO, NH4 and NNN) are within national guidelines. However, DRP, E.coli and turbidity levels exceed guidelines with medians of 0.017g/m3, 419 MPN/100ml and 6.2 NTU respectively during the 2007 – 2011 period. Despite the median being compliant, NNN levels are also frequently elevated with 45% of samples exceeding guidelines. With just over half of the upper catchment in high producing exotic grassland, nutrient yields per hectare are moderate to high compared to other Northland RWQMN sites at 0.151 kg, 0.119 kg, 3.1 kg a year respectively. This equates to high river loads of 4905 kg of DRP, 3868 kg of NH4 100, and 130 kg of NNN. The poor water quality is likely to be related to nutrient and sediment runoff from the underlying geology of unstable mudstone and limestone in the Hokianga area (B Cathcart, NRC Land Management Specialist pers comm. 2013) exacerbated by runoff from high intensity agricultural land use.

Trends

Trend analysis indicates that nitrogen and phosphate levels and clarity are improving at this site.

Habitat Quality

The habitat assessment data is not consistent with the WQI, scoring the site as sub-optimal. The surrounding land use is native scrub and pasture. There is 20 percent shade from a mixture of thin native and exotic cover, livestock do not have access to the river, the banks are stable and the nature of the river offers both run and riffle type habitat. However, there is evidence of high sediment loads (often associated with high intensity land use/livestock access/unstable geology) with 56 percent of the substrate being composed of sediment/sand and a very poor turbidity scores

Aquatic Biodiversity

The MCI results are not entirely consistent with the WQI for this site, grading as 'good/fair' with a range of 87.6 to 101.6 and a median of 95. The good quality habitat may account for this. There are no fish records for this river on the NZFFD.

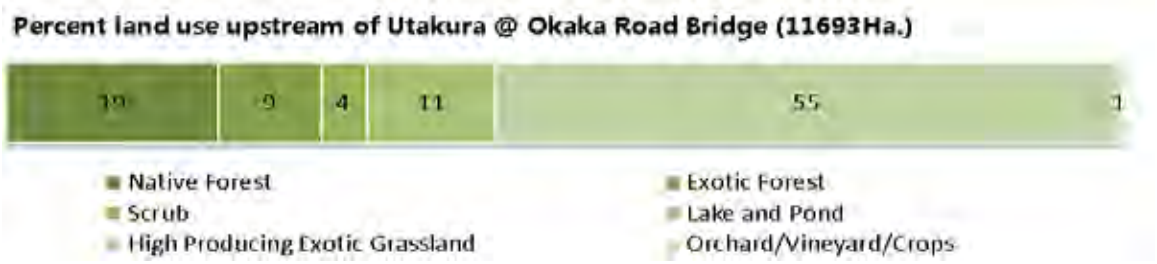
Periphyton

The Punakitere River at Taheke has only been sampled once, in 2007, for periphyton. On this occasion it had high algal biomass above the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community was dominated diatoms and blue green algae.

Utakura at Okaka Road Bridge

Description

The Utakura River is fed by Lake Omapere, to the north of Kaikohe, and flows west into the Waihou River arm of the Hokianga Harbour. The catchment is dominated by farmland with areas of native forest, pine forest and manuka scrub.



Utakura at Okaka Road Bridge

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	87.55	0.011	327	0.0135	0.136	18.4
Minimum	53.3	0.002	30	0.005	0.01	1
Maximum	97.3	0.16	19863	0.05	0.432	240
n	52	51	52	52	52	49
Pass	41	25	4	46	52	3
Fail	11	26	48	6	0	46
Percentage pass	78.8%	49.0%	7.7%	88.5%	100.0%	6.1%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

WATER QUALITY

The Utakura at Okaka Road Bridge is classed as having fair overall water quality as summarised in the table above. Three of the WQI variables (DO, NH4 and NNN) are within national guidelines. HJowever, DRP, E.coli and turbidity levels exceed guidelines with medians of 0.011g/m3, 327 MPN/100ml and 18.4 NTU respectively during the 2007 – 2011 period. With just over half of the upper catchment in high producing exotic grassland, nutrient yields per hectare are high to moderate compared to other Northland RWQMN sites at 0.195 kg, 0.146 kg, and 1.7 kg a year respectively. This equates to high river loads of DRP of 2,285 kg and moderate loads of NH4 and NNN at 1704 kg, and 19,463 kg per year respectively. The water quality at this site is influenced by the degraded water of Lake Omapere at its source, as well as farm runoff exacerbated by the underlying geology of unstable mudstone and limestone (B Cathcart, NRC Land Management Specialist pers comm. 2013) in the Hokianga area. Tree felling operations may also be adding to nutrient and sediment loads.

TRENDS

There is insufficient data for trend analysis at this site.

HABITAT QUALITY

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use at this site is mainly pasture with a small amount of forestry. Although the banks are stable and there is 70% shading, livestock have access to the river and the homogenous nature of the river means that there is only run habitat/flow available. The river shows evidence of high sediment loads (often associated with forestry, high intensity land use/livestock access/unstable geology) with 50 percent of the substrate being composed of sediment/sand and very poor turbidity results.

AQUATIC BIODIVERSITY

The macroinvertebrate community reflects the poor water and habitat quality at this site, grading as 'fair'/'poor' with a range of 66.9 to 94.5 and a median of 70.8. Fish records on the NZFFD in proximity to this site include a moderate diversity of seven fish. These include six native species(longfin eel, shortfin eel, common bully, smelt, inanga and koura) and one pest fish species, gambusia which is known to attack native fish (Rowe 2007). There are also records of torrent fish elsewhere in the catchment.

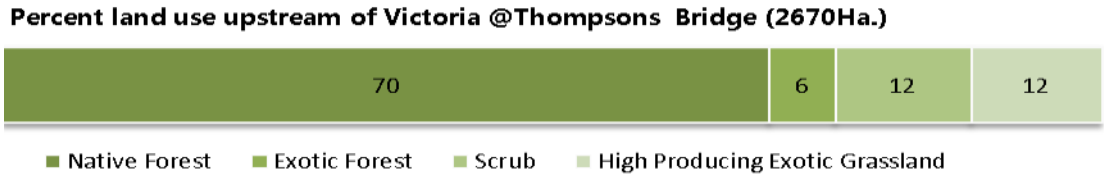
PERIPHYTON

There is no periphyton data for this site.

Victoria River at Thompsons Bridge

DESCRIPTION

The Victoria River begins in native forest in the Mangamuka Ranges, and runs north through pasture before joining the Awanui River near Kaitaia. The site is located approximately two kilometres downstream of the forest, in pastoral land use; however, the upstream catchment is dominated by native forest. The geology of this site is classified as volcanic acidic.



Victoria at Thompsons Bridge

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	94.25	0.016	170	0.01	0.008	2
Minimum	62.4	0.004	41	0.005	0.002	0.5
Maximum	123	0.024	3448	0.017	0.642	180
n	60	58	60	60	60	57
Pass	56	7	21	60	59	49
Fail	4	51	39	0	1	8
Percentage pass	93.3%	12.1%	35.0%	100.0%	98.3%	86.0%
Median compliant	yes	no	no	yes	yes	yes

Classification: Fair

Water Quality

The Victoria River is classified as having fair water quality as summarised in the table above. Four of the WQI index variables (DO, NH4, NNN, and turbidity), are within national guidelines. However, DRP, and E.coli medians exceed guidelines. Despite much of the upper catchment being in native forest, estimated nutrient yields per hectare/year for DRP and NH4 are elevated at 0.173 kg and 0.108 kg respectively. NNN yields are low, at 0.341 kg per hectare, as would be expected. The elevated DRP and NH4 yields and raised E.coli levels could be linked to septic tank seepage, livestock access upstream and farm runoff to the river.

Trends

Trend analysis indicates that water clarity is declining but phosphorous levels are improving at this site.

Habitat Quality

The habitat assessment data is inconsistent with the WQI, scoring the site as sub-optimal. Although the catchment use at this site is pasture the majority of the upstream catchment is dominated by native forest. There is a high level of shading (30%) and the heterogeneous nature of the river provides riffle and run, pool and waterfall habitat. Livestock do not have access to the river. The site does, however, have unstable banks and there is evidence of occasional periphyton blooms during summer months.

Aquatic Biodiversity

The macro-invertebrate community suggests better water quality than the chemical data for this site would indicate but is consistent with a good habitat score and low levels of nitrates in the river. MCI scores have ranged between 104.5 and 118.8 between 2007 and 2011 with a median score of 111.1 (good). Although there are no records for this particular site, catchment records suggest a moderately diverse native fish community. Historical results in the NZFFD record torrent fish, redfin bully, common bully, longfin eel, shortfin eel, smelt, koura and the banded kokopu which is regionally rare (Miller & Holland 2007) within the catchment. One exotic species, rainbow trout, is also recorded.

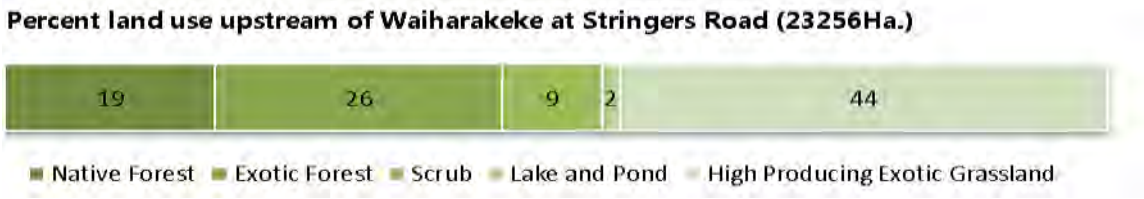
Periphyton

The Victoria River at Thompsons Bridge typically has low algal biomass well below the guidelines for ‘clean water’ macroinvertebrates (Biggs 2000) although in 2010, after an extremely dry summer, the guidelines were exceeded. Periphyton communities here are dominated by diatoms and desmids.

Waiharakeke at Stringers Road

DESCRIPTION

The Waiharakeke Stream is a major tributary of the Kawakawa River, which flows into the Waikare Inlet in the Bay of Islands. The Waiharakeke River originates in the Motatau Forest and flows north through a mixture of pine forestry, pastoral land, indigenous forest and a major wetland system before reaching Moerewa. The underlying geology is hard sedimentary.



Waiharakeke at Stringers Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	94.8	0.016	357	0.0135	0.117	8.6
Minimum	50.5	0.004	52	0.01	0.004	2.2
Maximum	242.7	0.113	4106	0.17	1.007	70
n	60	58	60	60	60	57
Pass	51	17	5	44	57	14
Fail	9	41	55	16	3	43
Percentage pass	85.0%	29.3%	8.3%	73.3%	95.0%	24.6%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Waiharakeke at Stream is classified as having 'fair' water quality as summarised in the table above. Three of the WQI index variables (DO, NH4, and NNN) are within national guidelines. However, DRP, and E.coli and turbidity medians exceed guidelines with medians of 0.016g/m3, 357 MPN/100ml and 8.6 NTU respectively during the 2007 – 2011 period. With just under half of the upper catchment in high producing grassland, DRP, NH4 and NNN yields per hectare of land are moderate compared to other Northland RWQMN sites at an estimated 0.14 kg and 0.17 kg and 1.1 kg a per year respectively. This equates to high river loads of DRP (3,269 kg) and relatively moderate loads of, 3,956 kg of NH4 and 25,175 kg of NNN a year. The high DRP and E.coli levels and poor clarity may be linked to farm runoff from the high intensity farming in the area exacerbated by the underlying geology of unstable mudstone and limestone (B Cathcart, NRC Land Management Specialist pers comm. 2013).

Trends

Trend analysis indicates that the only significant trend at this site is that phosphate levels are improving

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use is a mixture of pasture, lifestyle properties and native scrub. Although there is 70% riparian cover/shade from a mixture of exotic and native cover, the banks are relatively stable and livestock do not have access, the stream shows evidence of a high sediment load with 47 percent of the substrate being composed of sediment/sand and a very poor turbidity score. This is likely to be linked to the soft sedimentary geology of the area as well as pastoral land use upstream.

Aquatic Biodiversity

The macro-invertebrate community suggests better water quality than the physio-chemical data for this site would indicate but is consistent with the habitat score and moderate nitrate levels. MCI scores have ranged between 97.3 and 122 between 2007 and 2011 with a median score of 103.1 (good). There is very limited fish data for the catchment with just one record on the NZFFD for the native shortfin eel.

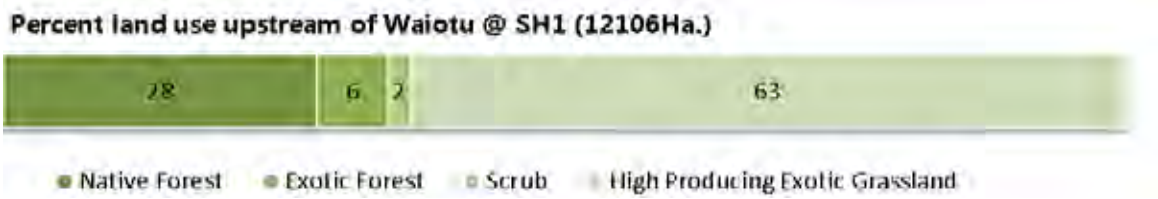
Periphyton

The Waiharakeke Stream at Stringers Road typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by diatoms with blue green algae commonly occurring.

Waiotu at SH1

DESCRIPTION

The Waiotu River is a hard sediment bottomed river within a predominantly agricultural catchment. The river originates in the hills to the northeast of State Highway One, between Kawakawa and Whangarei, and runs into the Whakapara River to form the greater Wairua River.



Waiotu at SH1

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	93	0.02	376.5	0.02	0.2495	8.3
Minimum	61.3	0.009	74	0.01	0.002	3.7
Maximum	119.3	0.121	6488	0.15	2.2	90
n	61	58	60	60	60	57
Pass	53	3	2	35	44	13
Fail	8	55	58	25	16	44
Percentage pass	86.9%	5.2%	3.3%	58.3%	73.3%	22.8%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Waioutu at SH1 is classified as having 'fair' water quality as summarised in the table above. Three of the WQI index variables (DO, NH4, and NNN) are within national guidelines. However, DRP, and E.coli and turbidity medians exceed guidelines with medians of 0.02g/m3, 376.5 MPN/100ml and 8.3 NTU respectively during the 2007 – 2011 period. Despite the medians passing the guidelines, NH4 and NNN levels often exceeded (on 42% and 27% of sampling occasions respectively). With most of the upper catchment in high producing grassland, DRP and NNN yields per hectare of land are high compared to other Northland RWQMN sites at an estimated 0.28 kg and 3.6 kg a per year respectively and NH4 levels are very high at 0.38 kg per hectare. This equates to elevated river loads of 3,431 kg of DRP, 4,543 kg of NH4 and 44,045 kg of NNN a year. The high nutrient levels, poor clarity and elevated faecal indicators may be linked to farm runoff and livestock access to the river. The reasons for the very high levels of NH4 are unclear and warrant further investigation.

Trends

Trend analysis for this site indicates that there is an improving trend in phosphorous levels at this site.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use at this site is mainly pasture and although the banks are stable, livestock have access to the river, and there is very little shading. The river shows evidence of high sediment loads (often associated with high intensity land use/livestock access) with 33 percent of the substrate being composed of sediment/sand and very poor turbidity scores.

Aquatic Biodiversity

The impoverished macroinvertebrate community reflects the poor water and habitat quality, with a median score of 75.3 (fair) ranging from 57.4 to 100. There are no fish records on the NZFFD for this site.

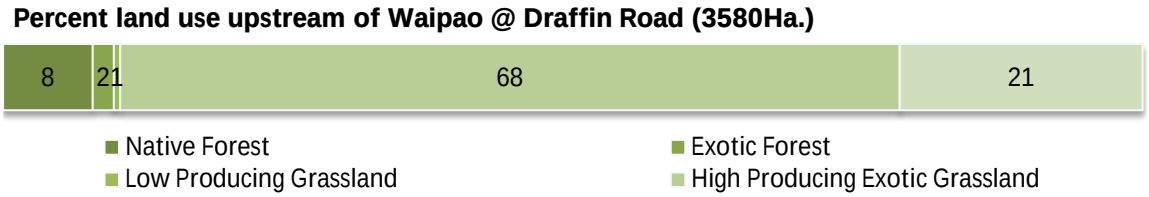
Periphyton

The Waioutu at SH1 has only been sampled once for periphyton, in 2007. On this occasion it had low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community was dominated by diatoms although there were also relatively high percentages of red, filamentous green and blue green algaes.

Waipao at Draffin Road

DESCRIPTION

The Waipao Stream was added to the RWQMN in 2007-08. The Waipao Stream begins as the Kauritutahi Stream to the west of Mangatapere (the Kauritutahi Stream becomes Waipao as it flows west towards Poroti). At Poroti, a number of springs feed into the stream and the stream itself eventually feeds into the Wairua River. The catchment of the stream is largely agricultural and includes high production farmland, orchards, crops and some small lifestyle blocks.



Waipao at Draffin Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	102.3	0.03	620	0.01	2.6	2.7
Minimum	66.3	0.01	109	0.007	0.017	1.5
Maximum	135.1	0.07	12033	0.443	3.7	65
n	65	64	65	65	65	62
Pass	61	1	2	54	1	51
Fail	4	63	63	11	64	11
Percentage pass	93.8%	1.6%	3.1%	83.1%	1.5%	82.3%
Median compliant	yes	no	no	yes	no	yes

Classification: Fair

Water Quality

The Waipao Stream at Draffin Road is classified as having 'fair' water quality as summarised in the table above. Three of the WQI index variables (DO, NH4, and turbidity) are within national guidelines. However, DRP, E.coli and NNN medians exceed guidelines with medians of 0.03g/m3, 620 MPN/100ml and 2.6 g/m3 respectively during the 2007 – 2011 period. With most of the upper catchment in high producing grassland, orchards and cropping DRP and NH4 yields per hectare of land are high compared to other Northland RWQMN sites at an estimated 0.20 kg and 0.16 kg per year respectively; and NNN levels are very high at 16 kg per hectare. This equates to elevated river loads of 700 kg of DRP, 586 kg of NH4 and 58,148 kg of NNN a year. The high nutrient levels are likely to be linked to runoff from this highly productive land. Elevated E.coli levels may be linked to farm runoff, livestock access to the river upstream and/or possible seepage from septic tank systems. The very high levels of NNN warrant further investigation. A possibly is that this is associated with orchards and cropping in the area, as these land uses are often associated with high use of fertiliser.

Trends

Trend analysis indicates that both nitrogen and phosphate levels are improving at this site but the already highly elevated faecal indicator levels are degrading still further.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The land use at the site is pastoral, there is little riparian cover, the stream is slow flowing with only run type habitat and has an abundance of macrophytes. However, the stream is fenced and recent riparian plantings will improve habitat quality over time. The majority of the Waipao stream and its tributary the Tapahina are now fenced and planted under the Waipao Rehabilitation Plan, developed and funded as part of consent conditions for water takes from the Waipao River in the vicinity of the Poroti Springs. The plan is run by a number of local stakeholders and has improved habitat quality within the catchment.

Aquatic Biodiversity

The relatively good condition of the macro-invertebrate community suggests better water quality than both the WQI and habitat quality would indicate. MCI scores have ranged between 91.5 and 118 between 2007 and 2011 with a median score of 100.7 (good). The reason for this is unclear. The NZFFD, in proximity to this site shows a low diversity of just three fish species (shortfin eel, crans bully, and koura). This low diversity is to be expected with the Wairua falls downstream forming a barrier to most fish species. Elsewhere in the catchment there are also records of gambusia which is known to attack native fish (Rowe 2007).

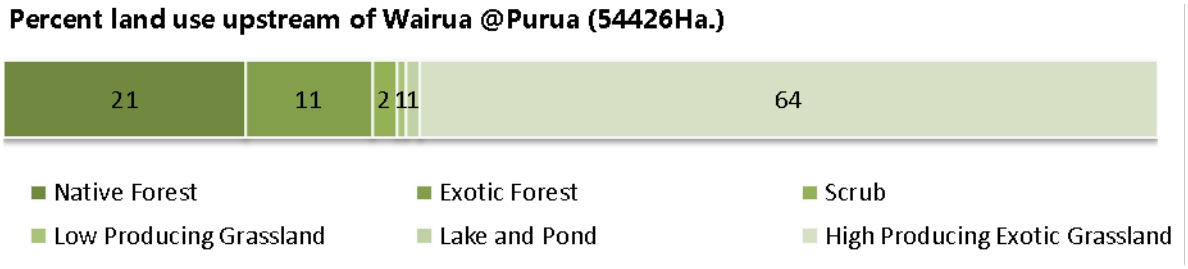
Periphyton

There is no periphyton data for this site.

Wairua at Purua

DESCRIPTION

The Wairua River above Whangarei flows southwest into the Kaipara Harbour. It is one of the major tributaries of the greater Wairoa River. The catchment upstream of the sampling site is predominantly pastoral. The river cuts through hard sediments along a low gradient. The Wairua River site at Purua is one of four sites in Northland that are part of the National River Water Quality Network administered by NIWA.



Wairua at Purua

Site name	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	92.1	0.016	84	0.019	0.342	8.4
Minimum	56.3	0.003	25.6	0.001	0.0005	1.7
Maximum	126.7	0.114	17328.7	0.234	3.291	65
n	53	54	52	54	54	54
Pass	46	9	38	29	34	12
Fail	12	45	14	25	20	42
Percentage pass	79.3%	16.7%	73.1%	53.7%	63.0%	22.2%
Median	yes	no	yes	no	yes	no

Classification: Fair

Water Quality

The Wairua River at Purua is classified as having 'fair' water quality as summarised in the table above. Three of the WQI index variables (DO, E.coli and NNN) are within national guidelines. However DRP, NH4 and turbidity medians exceed guidelines with medians of 0.016g/m3, 0.019g/m3 620 and 8.4 NTU respectively during the 2007 – 2011 period. Although the medians meet the guidelines, individual samples also frequently fail the NH4 and NNN guidelines on 46% and 37% of occasions respectively. With most of the upper catchment in high producing grassland, DRP and NH4 and NNN yields per hectare of land are high compared to other Northland RWQMN sites, at an estimated 0.19 kg, 0.34 kg and 4.3 kg a per year respectively. This equates to highly elevated river loads of 10,462 kg of DRP, 18,550 kg of NH4 and 231,555 kg of NNN a year. These excessive nutrient loads are likely to be related to a number of factors, including farm runoff and drainage from the highly productive Hikurangi Swamp Drainage Scheme. Upstream of this site is about 30km of river channel which is constrained by stopbanks and spillways which spill water into one of seven "pockets" of land during high flow events. Each pocket has a pump station and flood water is pumped back into the main river once levels have fallen. By the time the water is returned to the river (sometimes after several weeks) it is nutrient enriched and stagnant and has a significant detrimental effect on downstream water quality.

Trends

Trend analysis for this site indicates that phosphate levels are improving at this site.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use at this site is mainly pasture and although the banks are relatively stable, livestock have access to the river and there is very little shading. The river shows evidence of high sediment loads (often associated with high intensity land use/livestock access) with 54 percent of the substrate being composed of sediment/sand and a very poor turbidity score.

Aquatic Biodiversity

The impoverished macroinvertebrate community reflects the poor water and habitat quality at this site. MCI results range from 56 to 86.4 with a median score of 75.7 (fair). There are no fish records on the NZFFD for this site.

Periphyton

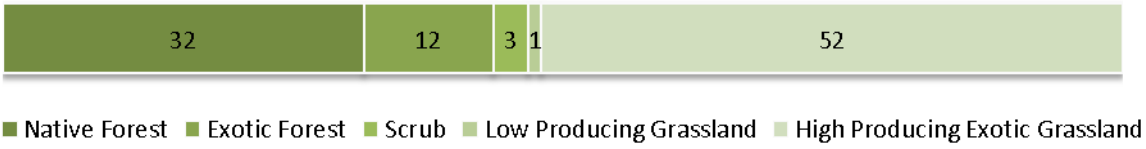
No periphyton data is available for this site.

Whakapara at Cableway

DESCRIPTION

The Whakapara River originates from the ranges east of Hikurangi and Whakapara, eventually joining the Waiotu River, forming the headwaters of the greater Wairua River. The river cuts through hard sediments formed from faulted greywacke, along a relatively low gradient. The upstream catchment is dominated by forested hills and pastoral farming.

Percent land use upstream of Whakapara @ Cableway (16414Ha.)



Whakapara at Cableway

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	96.5	0.02	187	0.01	0.262	6.2
Minimum	69.1	0.008	20	0.01	0.002	2.4
Maximum	124.2	0.054	14136	0.134	1.47	119
n	61	58	60	60	60	57
Pass	51	4	20	47	47	21
Fail	10	54	40	13	13	36
Percentage pass	83.6%	6.9%	33.3%	78.3%	78.3%	36.8%
Median compliant	yes	no	no	yes	yes	no

Classification: Fair

Water Quality

The Whakapara River at Cableway is classified as having 'fair' water quality as summarised in the table above. Three of the WQI index variables (DO, NH4 and NNN) are within national guidelines. However, DRP, E.coli and turbidity medians exceed guidelines with medians of 0.02g/m3, 187 MPN/100ml and 6.2 NTU respectively during the 2007 – 2011 period. With about half of the upper catchment in high producing grassland, DRP and NH4 and NNN yields per hectare of land are high compared to other Northland RWQMN sites, at an estimated 0.23 kg and 0.26 and 2.8 kg a per year respectively. This equates to elevated river loads of 3,795 kg of DRP, 4,219 kg of NH4 and 45,894 kg of NNN a year. The poor water quality is likely to be related to nutrient runoff from pastoral farming and the impacts of forestry harvesting.

Trends

Trend analysis indicates that there are no significant trends for any of the physio-chemical attributes at this site. However, macroinvertebrate health is declining.

Habitat quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use is a mixture of pasture and native scrub. There is very little shading, the homogenous nature of the river means that there is only one type of habitat/flow type available (run) and livestock have access to the river. This site also shows evidence of high sediment loads (often associated with high intensity land use/livestock access) with 37 percent of the substrate being composed of sediment/sand; and a very poor turbidity score.

Aquatic Biodiversity

The MCI results reflect the poor water and habitat quality at this site with a median score of 90.6 (fair) ranging from 67.6 to 101.8 and are showing a declining trend. There are no fish records for this river on the NZFFD.

Periphyton

The Whakapara River at Cableway has only been sampled once, in 2007, for periphyton. On this occasion it had low algal biomass below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). The periphyton community was dominated by filamentous green algae and diatoms.

Mangere at Knight Road

DESCRIPTION

The Mangere River is a low-lying, sluggish tributary to the Wairua River which flows through a mostly intensive agricultural catchment. The river begins as the Mangere Stream, which flows east out of the Pukenui Forest near Whangarei. It becomes a river on the flats before joining the Wairoa River just west of Kokopu. For the most part, soft sedimentary rocks make up the underlying geology.

Percentage land use upstream of Mangere @ Knight Road (7576Ha.))

Mangere at Knight Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	83.8	0.054	691	0.04	0.596	6.9
Minimum	38.3	0.01	74	0.01	0.013	2
Maximum	119.2	0.373	24192	0.35	2	90
n	111	108	111	109	109	97
Pass	76	1	1	31	41	33
Fail	35	107	110	78	68	64
Percentage pass	68.5%	0.9%	0.9%	28.4%	37.6%	34.0%
Median compliant	yes	no	no	no	no	no

Classification: Poor

Water Quality

The Mangere at Knight Road is classified as having 'poor' water quality as summarised in the table above. Only one of the WQI index variables (DO) is within national guidelines. DRP, E.coli, NH4, NNN and turbidity medians exceed guidelines with medians of 0.054g/m3, 691 MPN/100ml. 0.04 g/m3. 0.596 g/m3 and 6.9 NTU respectively during the 2007 – 2011 period. With the majority of the upper catchment in high producing grassland, DRP and NH4 and NNN yields per hectare of land are high compared to other Northland RWQMN sites at an estimated 0.51 kg and 0.47 and 4.4 kg a per year respectively. This equates to elevated river loads of 3,831 kg of DRP, 3,553 kg of NH4 and 33,203 kg of NNN a year. The high faecal indicator, nutrient levels and poor clarity are likely to be associated with the soft sedimentary geology of the area as well as high intensity land use/livestock access.

Trends

Trend analysis for this site indicates that there are improving trends in nitrates and phosphates at this site. In particular 32% less ammonia (NH4) has been discharged to the Mangere at Knights Bridge during the reporting period.

Habitat Quality

The habitat assessment data is consistent with the WQI, scoring the site as marginal. The surrounding land use at this site is mainly pasture, livestock have access to the river and although there is 30% shading from mainly native cover and the banks are relatively stable, the homogenous nature of the river provides only run type habitat/flow. The river also shows evidence of high sediment loads with 32 percent of the substrate being composed of sediment/sand and a very poor turbidity score.

Aquatic Biodiversity

The impoverished macroinvertebrate community reflects the poor water and habitat quality at this site with MCI results ranging from 68.4 to 79.9 and a median score of 75.5 (poor). Fish diversity in the Mangere catchment is poor, with only five species of freshwater fish being recorded. These include the longfin eel, shortfin eel, crans bully and common bully. A recent survey run by Dairy NZ in conjunction with Northland Regional Council also recorded a single brown trout within the catchment. The poor fish community is likely to be a reflection of the degraded habitat and water quality in the Mangere Catchment as well as the Mangere and Wairoa falls downstream which form a barrier for most migratory fish species.

Periphyton

There is no periphyton data for this site.

Ruakaka at Flyger Road

DESCRIPTION

The Ruakaka River catchment is relatively small and runs east from Ruakaka forest to Bream Bay. The catchment is dominated by pastoral land with areas of the upper catchment in native bush. The underlying geology at the site is mainly soft sediments.

Ruakaka at Flyger Road

	DO%	DRP	E.coli	NH4	NNN	TURB
	% Sat	g/m3-P	MPN/100ml	g/m3-N	g/m3 N	NTU
Median	79.8	0.087	541.5	0.0375	0.3845	18.3
Minimum	51	0.032	148	0.01	0.056	8.2
Maximum	110.9	0.149	15531	0.241	1.5	85
n	61	59	60	60	60	56
Pass	29	0	0	15	36	0
Fail	32	59	60	45	24	56
Percentage pass	47.5%	0.0%	0.0%	25.0%	60.0%	0.0%
Median	no	no	no	no	yes	no

Classification: Poor

Water Quality

The Ruakaka at Flyger Road is classified as having 'poor' water quality as summarised in the table above. Only one of the WQI index variables (NNN) is within national guidelines. DO, DRP, E.coli, NH4 and turbidity medians exceed guidelines with medians of 79.8 % Sat, 087g/m3, 541.5 MPN/100ml. 0.0375 g/m3 and 18.3 NTU respectively during the 2007 – 2011 period. With the majority of the upper catchment in high producing grassland, DRP, NH4 and NNN yields per hectare of land are high compared to other Northland RWQMN sites at an estimated 0.47 kg and 0.30 kg and 2.2 kg a per year respectively. This equates to somewhat elevated river loads of 2,220 kg of DRP, 1,404 kg of NH4 and 10,458 kg of NNN a year. The high nutrient levels and poor clarity may be linked to farm runoff from the high intensity farming in the area as well as the soft sedimentary nature of the underlying geology.

Trends

Both nitrogen and phosphate levels are improving at this site.

Habitat Quality

The habitat assessment data is not consistent with the WQI, scoring the site as sub-optimal. This is because the habitat assessment is carried out within a DoC reserve, whereas the water flowing into the reserve has come from farmland upstream. At the sampling site the surrounding land use is native forest and scrub, there is 80% shading, the banks are stable, and there is no livestock access. However, the river shows evidence of high sediment loads with 65 percent of the substrate being composed of sediment/sand and a very poor turbidity score. This is likely to be associated with the soft sedimentary geology of the area as well as high intensity land use/livestock access upstream.

Aquatic Biodiversity

The good condition of the macro-invertebrate community suggests much better water quality than the WQI score for this site indicates. This is probably a reflection of the good quality habitat available. MCI scores have ranged between 101.5 and 122.3 between 2007 and 2011 with a median score of 119.7 (good). Fish records on the NZFFD in proximity to this site include a moderate diversity of seven native fish. These include longfin eel, shortfin eel, common bully, redfin bully, giant bully, inanga and koura. Elsewhere in the catchment there are also records of koaro and banded kokopu which are regionally rare (Miller & Holland 2007).

Periphyton

The Ruakaka River typically has low algal biomass well below the guidelines for 'clean water' macroinvertebrates (Biggs 2000). Periphyton communities here are dominated by red algae, diatoms and blue green algae. This does not reflect the poor water quality at the site. Normally high nutrient loads are associated with high algal blooms however periphyton growth is limited by low light conditions.

Appendix B - Summary of water quality data

Summary of chemical water quality data and comparison with guideline/trigger values at 36 River Water Quality Monitoring Network sites between January 2007 and December 2011. Median values that do not comply with a guideline value are shown in bold font.

Site name	Ammoniacal nitrogen (mg/L)					Nitrate nitrite nitrogen (mg/L)					Dissolved reactive phospohorus (mg/L)					Water Quality Index
	Median	Min	Max	*n*	Results ≤0.021	Median	Min	Max	*n*	Results ≤0.444	Median	Min	Max	*n*	Results ≤0.010	
Waipapa R at Forest	0.003	0.0005	0.023	66	98.5%	0.0125	0.0005	0.163	66	100.0%	0.005	0	0.011	66	98.5%	Excellent
Waipoua at SH12	0.005	0.0025	0.27	60	98.3%	0.0225	0.002	0.131	60	100.0%	0.0025	0	0.106	59	96.6%	Excellent
Hātea u/s Mair Park	0.01	0.007	0.57	45	80.0%	0.385	0.083	1.25	42	59.5%	0.008	0	0.068	40	80.0%	Good
Kaihū at Gorge	0.005	0.005	0.42	60	91.7%	0.226	0.001	0.938	60	83.3%	0.005	0	0.02	59	88.1%	Good
Kerikeri at Stone Store	0.01	0.008	0.21	53	84.9%	0.41	0.045	1.41	53	60.4%	0.007	0	0.06	51	72.5%	Good
Mangakāhia at Twin Brdgs.	0.005	0.0025	0.016	41	100.0%	0.032	0.001	0.56	41	97.6%	0.00325	0	0.096	40	92.5%	Good
Ngunguru at Waipoka Rd	0.01	0.006	0.08	51	80.4%	0.093	0.003	0.46	51	96.1%	0.01	0	0.28	49	71.4%	Good
Opouteke at Suspension	0.005	0.0025	0.1	60	98.3%	0.036	0.001	0.382	60	100.0%	0.004	0	0.037	59	94.9%	Good
Waiarohia at Whau Valley	0.01	0.01	0.21	62	91.9%	0.402	0.002	1.64	60	61.7%	0.01	0	0.02	58	67.2%	Good
Waiarohia at Rust Ave	0.01	0.008	0.27	60	93.3%	0.3645	0.029	1.12	60	60.0%	0.01	0	0.037	58	67.2%	Good
Waimamaku at SH12	0.005	0.0025	0.06	51	96.1%	0.012	0.001	0.652	51	98.0%	0.005	0	0.03	50	96.0%	Good
Waipapa Str at Waipapa Ldg	0.01	0.007	0.16	53	96.2%	0.324	0.01	0.91	53	75.5%	0.005	0	0.03	51	94.1%	Good
Waitangi at Watea	0.007	0.001	0.087	66	90.9%	0.248	0.0005	0.935	66	78.8%	0.005	0	0.026	66	89.4%	Good
Waitangi at Waimate Rd	0.01	0.01	0.15	60	83.3%	0.407	0.053	0.82	60	58.3%	0.006	0	0.025	57	89.5%	Good
Awanui at FNDC watertake	0.01	0.008	0.104	60	83.3%	0.0385	0.002	0.722	60	98.3%	**0.0165**	0	0.076	58	12.1%	Fair
Awanui at Waihue Channel	0.02	0.01	0.39	104	58.7%	0.053	0.002	0.708	59	96.6%	**0.043**	0.01	1.5	90	2.2%	Fair
Hakaru at Topuni Creek	0.0165	0.01	0.2	52	69.2%	0.2595	0.003	0.861	52	88.5%	**0.047**	0.02	0.174	51	0.0%	Fair
Kaeo at Dip Road	0.01	0.009	0.051	59	93.2%	0.045	0.002	0.613	59	98.3%	0.005	0	0.197	57	93.0%	Fair
Mangahahuru at Apotu Rd	0.02	0.01	0.137	60	63.3%	0.35	0.004	1.71	60	66.7%	**0.027**	0.01	0.111	58	8.6%	Fair
Mangahahuru at Main Rd	0.01	0.01	0.05	60	88.3%	0.069	0.006	0.44	60	100.0%	0.0095	0	0.06	58	79.3%	Fair
Mangakāhia at Titoki Brdg	0.0105	0.001	0.081	66	92.4%	0.062	0.0005	0.504	66	98.5%	0.006	0	0.031	66	86.4%	Fair

Site name	Ammoniacal nitrogen (mg/L)					Nitrate nitrite nitrogen (mg/L)					Dissolved reactive phospohorus (mg/L)					Water Quality Index
	Median	Min	Max	*n*	Results ≤0.021	Median	Min	Max	*n*	Results ≤0.444	Median	Min	Max	*n*	Results ≤0.010	
Mangamuka at Iwiatua Rd	0.005	0.0025	0.014	53	100.0%	0.007	0.001	0.652	53	98.1%	**0.03**	0.01	0.04	51	0.0%	Fair
Manganui at Mititai Rd	0.012	0.01	0.086		68.3%	0.173	0.002	0.648		90.0%	**0.039**	0.01	0.076		3.4%	Fair
Oruru at Oruru Rd	0.01	0.008	0.05	53	88.7%	0.026	0.002	0.592	53	96.2%	**0.021**	0.01	0.145	51	2.0%	Fair
Otaika at Otaika Valley Rd	**0.0265**	0.013	0.165	6	33.3%	**1.2675**	0.416	1.483	6	16.7%	**0.016**	0.01	0.026	6	16.7%	Fair
Paparoa at walking bridge	0.02	0.01	0.7	52	65.4%	0.0935	0.002	0.942	52	94.2%	**0.02**	0	0.051	51	17.6%	Fair
Punakitere at Taheke	0.01	0.005	0.08	60	80.0%	0.407	0.001	0.78	60	55.0%	**0.017**	0	0.071	59	32.2%	Fair
Utakura at Okaka Rd Bridge	0.0135	0.005	0.05	52	88.5%	0.136	0.01	0.432	52	100.0%	**0.011**	0	0.16	51	49.0%	Fair
Victoria at Thompsons	0.01	0.005	0.017	60	100.0%	0.008	0.002	0.642	60	98.3%	**0.016**	0	0.024	58	12.1%	Fair
Waiharakeke at Stringers	0.0135	0.01	0.17	60	73.3%	0.117	0.004	1.007	60	95.0%	**0.016**	0	0.113	58	29.3%	Fair
Waiotu at SH1	0.02	0.01	0.15	60	58.3%	0.2495	0.002	2.2	60	73.3%	**0.02**	0.01	0.121	58	5.2%	Fair
Waipao at Draffin Road	0.01	0.007	0.443	65	83.1%	**2.6**	0.017	3.7	65	1.5%	**0.03**	0.01	0.07	64	1.6%	Fair
Wairua at Purua	0.019	0.001	0.234	54	53.7%	0.342	0.0005	3.291	54	63.0%	**0.016**	0	0.114	54	16.7%	Fair
Whakapara at cableway	0.01	0.01	0.134	60	78.3%	0.262	0.002	1.47	60	78.3%	**0.02**	0.01	0.054	58	6.9%	Fair
Ruakaka at Flyger Rd	**0.0375**	0.01	0.241	60	25.0%	0.3845	0.056	1.5	60	60.0%	**0.087**	0.03	0.149	59	0.0%	Poor
Mangere at Knight Rd	**0.04**	0.01	0.35	109	28.4%	**0.596**	0.013	2	109	37.6%	**0.054**	0.01	0.373	108	0.9%	Poor

Site name	Dissolved oxygen (% saturation)					Turbidity (NTU)					E.coli (MPN/100mL)					Water Quality Index
	Median	Min	Max	*n*	Results ≥80%	Median	Min	Max	*n*	Results ≤5.6	Median	Min	Max	*n*	Results ≤126	
Waipapa Rv at Forest	96.4	89.1	101.5	66	100.0%	1.825	0.42	27.3	66	83.3%	77.7	6.3	1203	66	68.2%	Excellent
Waipoua at SH12	101	69.4	106.2	63	96.8%	2.3	1	26	57	86.0%	67.5	5	1720	60	73.3%	Excellent
Hātea u/s Mair Park	105.35	35.7	146.7	46	93.5%	4.1	2	75	47	70.2%	**396.5**	74	12997	48	6.3%	Good
Kaihū at Gorge	100	0.83	109.2	64	93.8%	3.2	1	120	57	68.4%	**153**	20	19863	60	40.0%	Good
Kerikeri at Stone Store	101.15	61.5	203	52	92.3%	2.1	0.8	100	118	85.6%	**240**	10	24192	121	28.1%	Good
Mangakāhia at Twin Brdgs.	108.9	68.1	127.6	41	97.6%	2.7	1	90	38	73.7%	121	10	4884	41	56.1%	Good
Ngunguru at Waipoka Rd	97.3	68.5	131	51	92.2%	5.5	2.3	102	48	52.1%	**305**	121	11199	51	5.9%	Good
Opouteke at Suspension	107.3	0	120.2	60	95.0%	2.7	1	50	57	70.2%	**174**	10	3873	60	31.7%	Good
Waiarohia at Whau Valley	95.7	60	138	67	91.0%	5.6	2.1	42	61	52.5%	**504**	10	12997	61	6.6%	Good
Waiarohia at Rust Ave	107	73.5	138.5	65	93.8%	2.5	1.7	39	57	73.7%	**413.5**	30	24192	60	8.3%	Good
Waimamaku at SH12	103.3	65.7	113.8	51	96.1%	3.3	1	65	48	79.2%	**393**	63	6488	51	9.8%	Good
Waipapa Str at Waipapa Ldg	95.9	61.8	113.7	53	92.5%	2.15	2	28	50	84.0%	**173**	10	8664	53	32.1%	Good
Waitangi at Watea	101	82.6	112.7	66	100.0%	3.65	0.8	42.3	66	69.7%	**140.1**	48.8	2419	65	43.1%	Good
Waitangi at Waimate Rd	97.5	68.8	121.9	60	95.0%	5	1.8	200	57	56.1%	**453.5**	148	7701	60	0.0%	Good
Awanui at FNDC watertake	81.65	62.6	121	60	56.7%	**6**	2	90	57	43.9%	**301**	20	24192	60	13.3%	Fair
Awanui at Waihue Channel	87.1	37.7	134.3	93	68.8%	**9.05**	2.4	130	56	23.2%	**309**	10	24192	180	11.7%	Fair
Hakaru at Topuni Creek	103.4	72.2	131.7	53	98.1%	**9.5**	4.3	160	49	8.2%	**302**	52	12997	52	7.7%	Fair

Site name	Dissolved oxygen (% saturation)					Turbidity (NTU)					E.coli (MPN/100mL)					Water Quality Index
	Median	Min	Max	*n*	Results ≥80%	Median	Min	Max	*n*	Results ≤5.6	Median	Min	Max	*n*	Results ≤126	
Kaeo at Dip Road	95.4	69.8	145.1	57	91.2%	**6.35**	2	140	56	44.6%	**627**	10	8664	59	5.1%	Fair
Mangahahuru at Apotu Rd	97.4	55.9	126.8	61	88.5%	**6.9**	2	65	57	29.8%	**572**	10	24192	60	5.0%	Fair
Mangahahuru at Main Rd	95.7	64	126.8	61	96.7%	**6**	2.8	39	57	36.8%	**227**	52	3873	60	18.3%	Fair
Mangakāhia at Titoki Brdg	94.7	73.3	110	66	98.5%	**5.875**	1.7	250	66	48.5%	**237.95**	75.9	3448	64	15.6%	Fair
Mangamuka at Iwiatua Rd	93.8	72.9	153.7	53	92.5%	1	1	280	49	81.6%	**272**	41	4884	53	20.8%	Fair
Manganui at Mititai Rd	82.4	41.8	144.3		57.4%	**9.4**	2.5	114		19.3%	**135**	10	11199		48.3%	Fair
Oruru at Oruru Rd	84.2	9.5	120.5	52	67.3%	**6.65**	2	180	50	42.0%	**292**	63	17329	53	15.1%	Fair
Otaika at Otaika Valley Rd	84.35	73.1	102.8	6	66.7%	5.1	4.5	330	3	66.7%	**596**	148	12997	6	0.0%	Fair
Paparoa at walking bridge	89.1	33	129.8	53	75.5%	**8.9**	2	100	49	20.4%	**573**	108	6131	52	3.8%	Fair
Punakitere at Taheke	99.7	58.6	119	61	95.1%	**6.2**	1	160	57	43.9%	**419**	120	17329	60	1.7%	Fair
Utakura at Okaka Rd Bridge	87.55	53.3	97.3	52	78.8%	**18.4**	1	240	49	6.1%	**327**	30	19863	52	7.7%	Fair
Victoria at Thompsons	94.25	62.4	123	60	93.3%	2	0.5	180	57	86.0%	**170**	41	3448	60	35.0%	Fair
Waiharakeke at Stringers	94.8	50.5	242.7	60	85.0%	**8.6**	2.2	70	57	24.6%	**357**	52	4106	60	8.3%	Fair
Waiotu at SH1	93	61.3	119.3	61	86.9%	**8.3**	3.7	90	57	22.8%	**376.5**	74	6488	60	3.3%	Fair
Waipao at Draffin Road	102.3	66.3	135.1	65	93.8%	2.7	1.5	65	62	82.3%	**620**	109	12033	65	3.1%	Fair
Wairua at Purua	92.1	56.3	126.7	53	79.3%	**8.4**	1.7	65	54	22.2%	84	25.6	17329	52	73.1%	Fair
Whakapara at cableway	96.5	69.1	124.2	61	83.6%	**6.2**	2.4	119	57	36.8%	**187**	20	14136	60	33.3%	Fair
Ruakaka at Flyger Rd	**79.8**	51	110.9	61	47.5%	**18.3**	8.2	85	56	0.0%	**541.5**	148	15531	60	0.0%	Poor
Mangere at Knight Rd	83.8	38.3	119.2	111	68.5%	**6.9**	2	90	97	34.0%	**691**	74	24192	111	0.9%	Poor