DOUBTLESS BAY CATCHMENT

WATER QUALITY UPDATE

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Version: 1.0

Putting Northland first

WAIORA NORTHLAND WATER

NORTHLAND REGIONAL COUNCIL

CONTENTS

FIGURES

TABLES

1 Current monitoring in the catchment

The following environmental monitoring is currently conducted by Northland Regional Council in the Doubtless Bay catchment:

River Water Quality Monitoring Network (RWQMN) established in 1996. Thirty six river sites throughout Northland encompassing 22 river catchments are monitored monthly for a range of parameters, including temperature, dissolved oxygen, pH, water clarity, nutrients and bacterial levels. This monitoring includes one site in the Oruru River catchment located at Oruru Road approximately 300m downstream of the bowling club, or 5.8km up the road from the one lane bridge in Taipa. This site was added to the Network in 2007. Annual and five yearly reports are available here:
http://www.nrc.govt.nz/Resource-Library-Summary/Environmental-Monitoring/State-of-the-Environment-Monitoring/

Waiora Northland Water (WNW) water quality sites were established in July 2014 consisting of 29 sites distributed between the Whangarei Harbour, Mangere, Waitangi and Doubtless Bay priority catchments and bringing the total number of sites monitored in Northland to 66. In total 10 sites are currently monitored in the Doubtless Bay catchment spread between the three main sub-catchments; Mangonui Harbour, Taipa River and Awapoko River and incorporating the Oruru River RWQMN site (Figure 1).

Stream invertebrate (macroinvertebrate) monitoring at RWQMN sites since 1997. Every site in the Network is monitored once a year in summer. Monitoring at the one network site on Oruru River started in 2008 and WNW sites were monitored for the first time in 2015. Annual reports are available here:
http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Rivers-and-streams/

Stream habitat assessments at RWQMN sites since 2004. Historically assessments were carried out every second year. The Oruru River site was assessed in 2008, 2010 and 2012. Since 2014 habitat assessments are undertaken alongside the macroinvertebrate monitoring programme annually. Reports are available here:
http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Rivers-and-streams/

Lake Water Quality Monitoring Network (LWQMN) was established in 2005. Twenty eight lakes throughout Northland are monitored four times a year for a range of parameters including total and dissolved nutrients, chlorophyll α, suspended solids, water clarity, pH, temperature and dissolved oxygen. This monitoring includes one location at the deepest point in each lake. Each lake is sampled at the surface and bottom and temperature/dissolved oxygen profiles are recorded. Monitoring is conducted in Lake Waiporohita, a small dune lake (5.6 ha) located near Tokerau Beach on the Karikari Peninsula. Annual reports are available here:
http://www.nrc.govt.nz/Resource-Library-Summary/Environmental-Monitoring/State-of-the-Environment-Monitoring/

Groundwater Water Quality Monitoring Network (GWQMN) monitors 31 groundwater bores throughout Northland encompassing 27 aquifers. These bores are monitored every three months for a range of parameters, including temperature, dissolved oxygen, pH, water, nutrients and bacterial levels. This monitoring includes three bores located in Taipa,

Cable Bay and Coopers Beach. Annual and five yearly State of Environment reports are available here:
http://www.nrc.govt.nz/Resource-Library-Summary/Environmental-Monitoring/State-of-the-Environment-Monitoring/

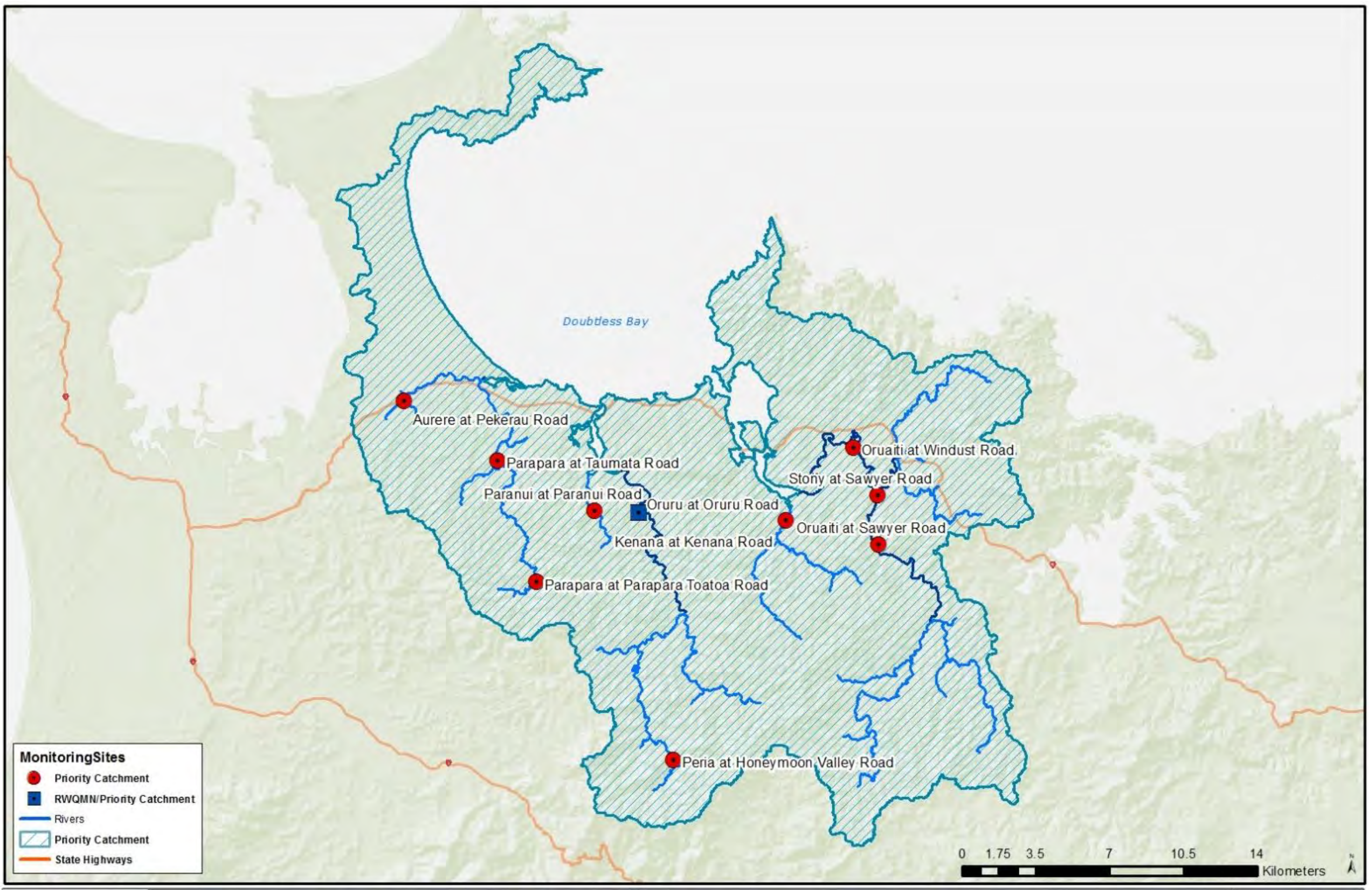


Figure 1: Doubtless Bay catchment RWQMN and WNW water quality monitoring sites.

Table 1: Doubtless Bay catchment water quality monitoring sites.

Site name	Easting	Northing
Aurere at Pekerau Road	1633654	6127865
Parapara at Parapara Toatoa Road	1639905	6119265
Parapara at Taumata Road	1638075	6125035
Paranui at Paranui Road	1642652	6122666
Peria at Honeymoon Valley Road	1645966	6111291
Oruru at Oruru Road	1644740	6122563
Kenana at Kenana Road	1651704	6122183
Oruaiti at Sawyer Road	1655830	6121640
Stony at Sawyer Road	1656071	6123396
Oruaiti at Windust Road	1654905	6125633

Photos of the sampling sites are presented in the Appendix.

2 River ecosystem and water quality

The ecological health, or integrity of river ecosystems is related to a number of environmental factors including, but not limited to, the availability of suitable habitat types (e.g. diverse range of substrate sizes, aquatic plants, large woody debris and varied flow types), food and light availability, disturbance and water quality. It is important to note that the relationship between ecosystem health and environmental factors is often very complex and unpredictable.

Ecological health in rivers and streams is dependent on water quality parameters such as, in no particular order, temperature and dissolved oxygen, clarity, nutrients, suspended solids and faecal pathogens. Faecal pathogens are not known to affect aquatic ecosystems, but affect the suitability of a water body for swimming and stock drinking water. Biological monitoring information such as invertebrates, periphyton, habitat assessments and fish, can be used to help determine influences of water quality on river ecosystems, however as mentioned above causal effects are not always clear. Current national standards and guidelines outlined below are used to facilitate inter-site comparisons of the state of water quality in the region's rivers and streams.

2.1 Long term water quality results and trends

Currently the only site with long term water quality data in the Doubtless Bay catchment is the Oruru at Oruru Road. This site has been monitored since 2007. Land Air Water Aotearoa (LAWA)[1], a website which brings together water quality data from regional councils throughout New Zealand, currently provides results for *E. coli*, turbidity and nutrients, i.e. nitrogen and phosphorus, which rank amongst the worst 50 percent of similar sites in New Zealand at this site (Figure 2). Black disc, a measure of water clarity, and dissolved reactive phosphorous, are amongst the worst 25 percent.

Trend analysis for the past ten years indicates no meaningful change at Oruru Road. When the time period for analysis is reduced to the last five years (not shown), results also indicate no meaningful change occurring.

The addition of monitoring sites within the catchment will help identify problematic areas/sub-catchments for targeted water quality improvement management in Doubtless Bay. Although there is only just over a year of data this report outlines preliminary results and compares them to appropriate national bench marks/standards for this purpose.

[1] For more information visit: http://www.lawa.org.nz/explore-data/northland-region/

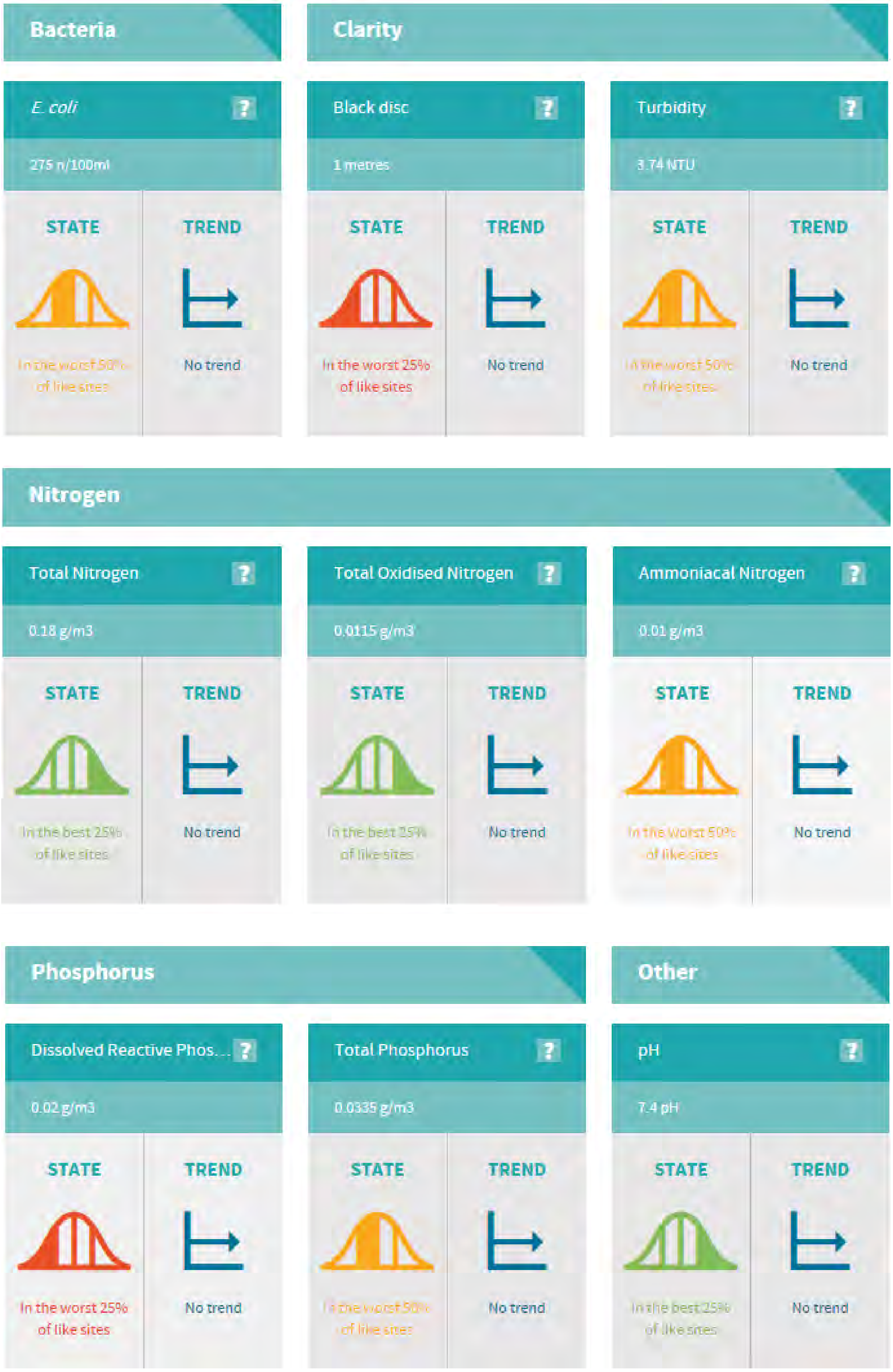


Figure 2: Current water quality state of the Oruru at Oruru Road RWQMN site compared to similar sites in New Zealand with 10 year trends for nine water quality parameters (excerpt from Land Air Water Aotearoa (LAWA) website).

2.2 National water quality standards and guidelines

The National Policy Statement for Freshwater Management (NPS-FM) was introduced by the Government in 2011 as part of the first phase of freshwater reforms. It was updated in 2014 with a National Objectives Framework (NOF) and includes targets to provide direction to Regional Councils around maintaining and improving water quality. It includes a number of grades as well as 'national bottom lines' (Table 2) – thresholds of water quality attributes that good management should prevent our waterways from reaching in a consistent way across the country. Councils are obliged to maintain or improve water quality within their regions. They cannot simply let conditions degrade down to the bottom line. The NOF water quality grades provide a reporting framework to assess water quality. The bottom line is the point separating a C from a failing D grade.

Table 2: National Objectives Framework attributes and grades.

Attributes		**National Objectives Framework grades**			
		A	B	C	D
Ammoniacal nitrogen toxicity (mg/L)	annual median	≤0.03	>0.03 and ≤0.24	>0.24 and ≤1.30	>1.30
	annual maximum	≤0.05	>0.05 and ≤0.40	>0.40 and ≤2.20	>2.20
Nitrate nitrogen toxicity (mg/L)	annual median	≤1	>1 and ≤2.4	>2.4 and ≤6.9	>6.9
	annual 95th percentile	≤1.5	>1.5 and ≤3.5	>3.5 and ≤9.8	>9.8
E. coli/100 mL	annual median (2nd contact recreation)	≤260	>260 and ≤540	>540 and ≤1000	>1000
Periphyton chlorophyll-a (mg/m^2)	exceeds no more than 8% samples over 3 years	≤50	>50 and ≤120	>120 and ≤200	>200

Key

A	Similar to reference conditions
B	Slightly impacted
C	Moderately impacted (lower/upper limit national bottom line)
National bottom line	
D	Degraded/unacceptable (must be managed to C or better)

The NOF is still under development with a number of additional attributes to be added in the near future. In the interim other water quality parameters not currently covered by the NOF are assessed against relevant trigger/guideline values (Table 3). These values differ from the NOF in that they are not national standards and therefore do not entail statutory obligations, but instead provide conservative numbers for physical and chemical measurements in rivers above or below which aquatic ecosystems may be exposed to stress. In this report annual medians are compared to the trigger/guideline values (Table 3).

There are four major rivers and streams within the Doubtless Bay catchment: the Oruaiti and Oruru rivers, and Parapara and Aurere streams. Historically only the Oruru at Oruru Road site has been monitored as part of the monthly region wide River Water Quality Monitoring Network (RWQMN). Since July 2014 nine additional sites have been monitored (Figure 1).

Table 3: National guideline values for the protection of aquatic ecosystems.

Identifier	Abbreviation	Reference	Trigger/guideline value
Dissolved oxygen	DO	RMA 1991 Third Schedule	≥80 % saturation
Dissolved reactive phosphorus	DRP	ANZECC (2000)	≤0.010 mg/L
Turbidity	TURB	ANZECC (2000)	≤5.6 NTU

2.3 Water quality results

The following section describes water quality in the Doubtless Bay catchment using box and whisker plots (Figure 3) to graphically display the distribution of water quality data based on a five value summary: the minimum value, first quartile, median, third quartile, and maximum. The central rectangle spans the first quartile to the third quartile (the *interquartile range* or *IQR*) covering the middle 50% of data. A segment inside the rectangle shows the median and "whiskers" above and below the box show the minimum and maximum values or the 95th percentile values depending on the parameter being measured. Stars indicate outliers and circles far out values (not displayed in Figure 3).

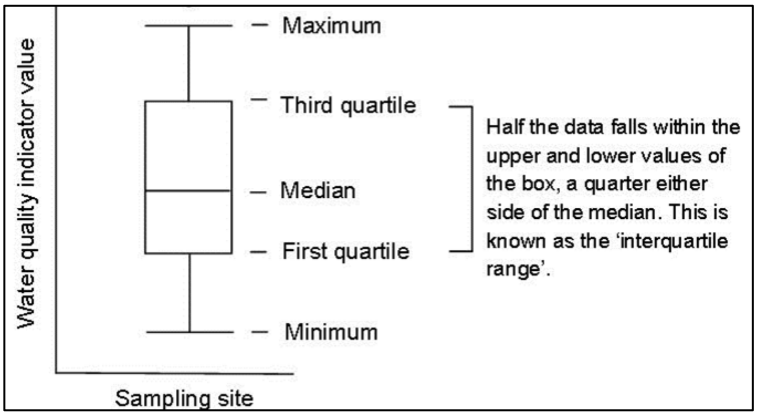


Figure 3: Box and whisker plot description.

Just over a year of water quality data has now been collected at nine new sites in the Doubtless Bay priority catchment since sampling began in July 2014. This adds to data already collected at the long-term RWQMN sampling site. It is very difficult to accurately interpret water quality data without several years of data to smooth out the impacts of weather patterns, climatic conditions, seasonal variation, etc. Data collected from July 2014 to June 2015 indicate that the main water quality issues in the Doubtless Bay may include elevated phosphate and *E coli.* as well as low dissolved oxygen levels and mediocre ecosystem health (indicated by aquatic insects or macroinvertebrates). The Aurere at Pekerau Road site at the very bottom of the Aurere sub-catchment stands out in particular as having degraded water quality; this site receives water from almost the entire sub-catchment and is also impacted by stock access at the sampling site. Note: results for the Oruru at Oruru Road site only include data for the same time period to provide consistency.

2.3.1 Nutrient levels

Nitrogen and phosphorus are the two main nutrients required by algae, plants and animals for metabolism and growth. Nitrogen and phosphorus naturally occur in water as a result of natural processes, such as the erosion of soil, atmospheric deposition, and the breakdown of organic matter. Nitrogen is highly soluble and can leach through soil, whereas phosphorus usually enters water in direct discharges or associated with sediment. Whilst nutrients are necessary for sustaining life, high levels of nitrogen and phosphorus can cause excessive growth of aquatic plants and algae, and reduce overall water quality.

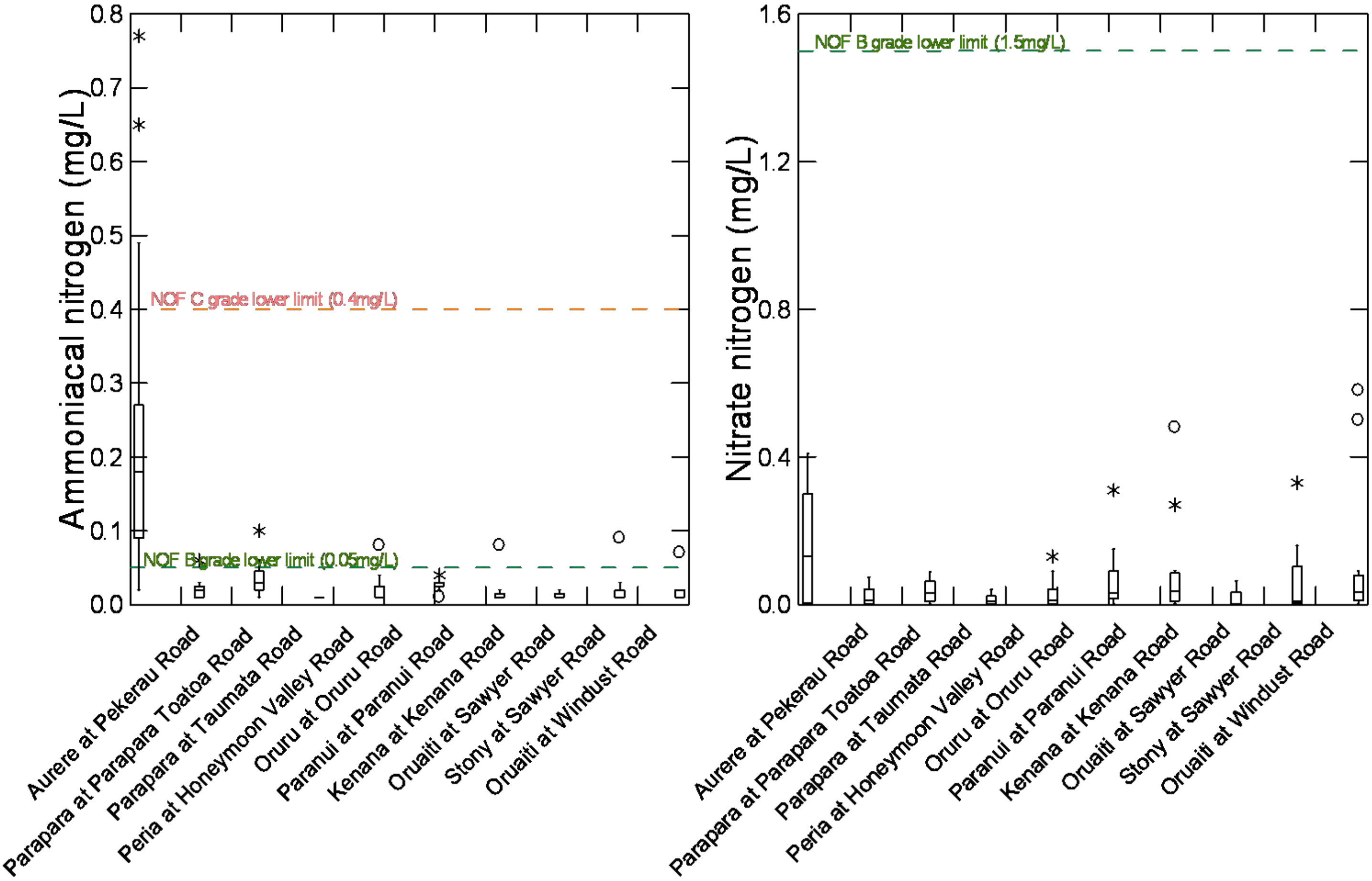


Figure 4: Nutrient toxicity results.
4.1. Ammoniacal nitrogen toxicity (July 2014 to June 2015) with annual maximum NOF grades.
4.2. Nitrate nitrogen toxicity (July 2014 to June 2015) with 95th percentile NOF grades.

Results indicate that nitrogen levels generally meet toxicity guidelines within the Doubtless Bay catchment with the annual maximum for ammoniacal nitrogen toxicity (Figure 4.1) falling into the NOF A or B grades for all sites with the exception of the Aurere at Pekerau Road site, where the annual maximum falls into the NOF C grade. All results for nitrate toxicity (Figure 4.2) fall into the NOF A grade.

There is currently no guideline for dissolved reactive phosphorous in the NOF. However, many sites within the Doubtless Bay catchment (Figure 5) recorded levels well above ANZECC guideline value for lowland rivers (0.01mg/L), in particular Aurere at Pekerau Road, Kenana at Kenana Road, Oruru at Oruru Road and Peria at Honeymoon Valley Road. The Peria at Honeymoon Valley Road site is considered a reference site, draining mainly native vegetation. Results recorded at this site may indicate naturally elevated phosphorous levels within the catchment related to geology.

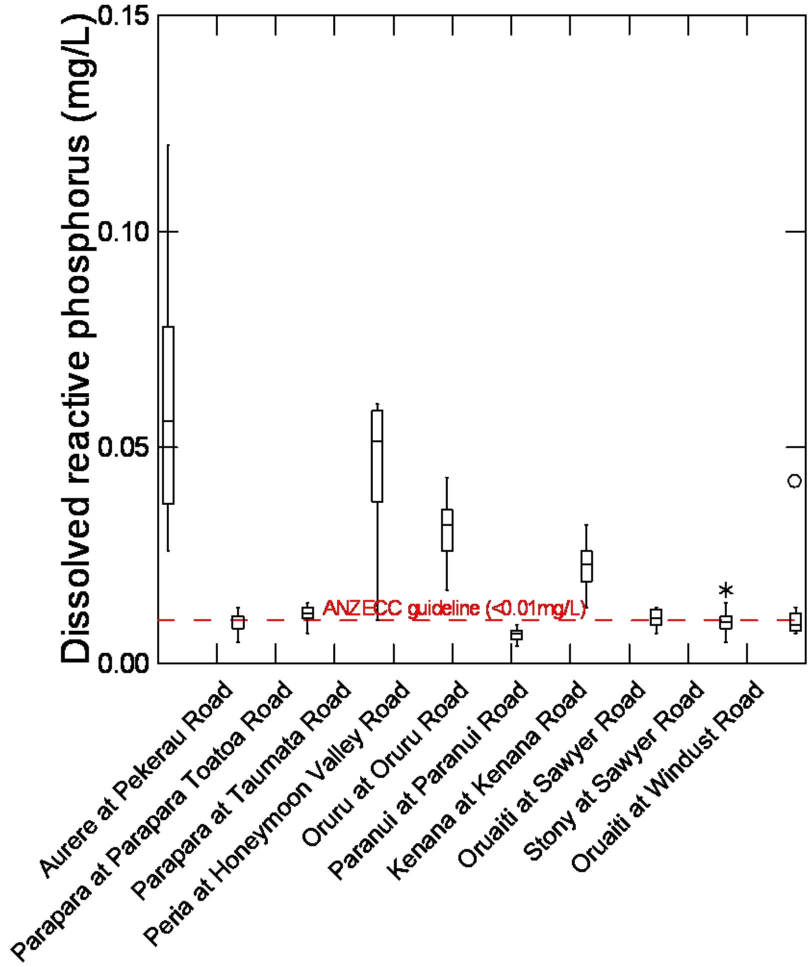


Figure 5: Dissolved reactive phosphorus (July 2014 to June 2015) with ANZECC guideline value.

2.3.2 Periphyton community

Periphyton is the slime and algae community growing on river and stream beds. As the primary producer in stream ecosystems, it is an important indicator of ecosystem health. It has the ability to respond quickly to changes in water quality and form excessive growths under ideal conditions, affecting instream values, such as biodiversity and recreational use.

Chlorophyll a levels are used as a measure of periphyton biomass in the NOF. The main drivers for periphyton growth include light and nutrient levels. However, periphyton growth normally requires a stable substrate such as rocks and cobbles to become established, and many streams in Northland have a substrate of mainly fine sediment which is easily disturbed, making it difficult for periphyton to become established. Just four of the 10 Doubtless Bay water quality sites have a stony substrate suitable for sampling and are monitored monthly for periphyton cover and Chl a levels; three sites on the Oruaiti and its tributary, Stony Creek and Peria at Honeymoon Valley Road.

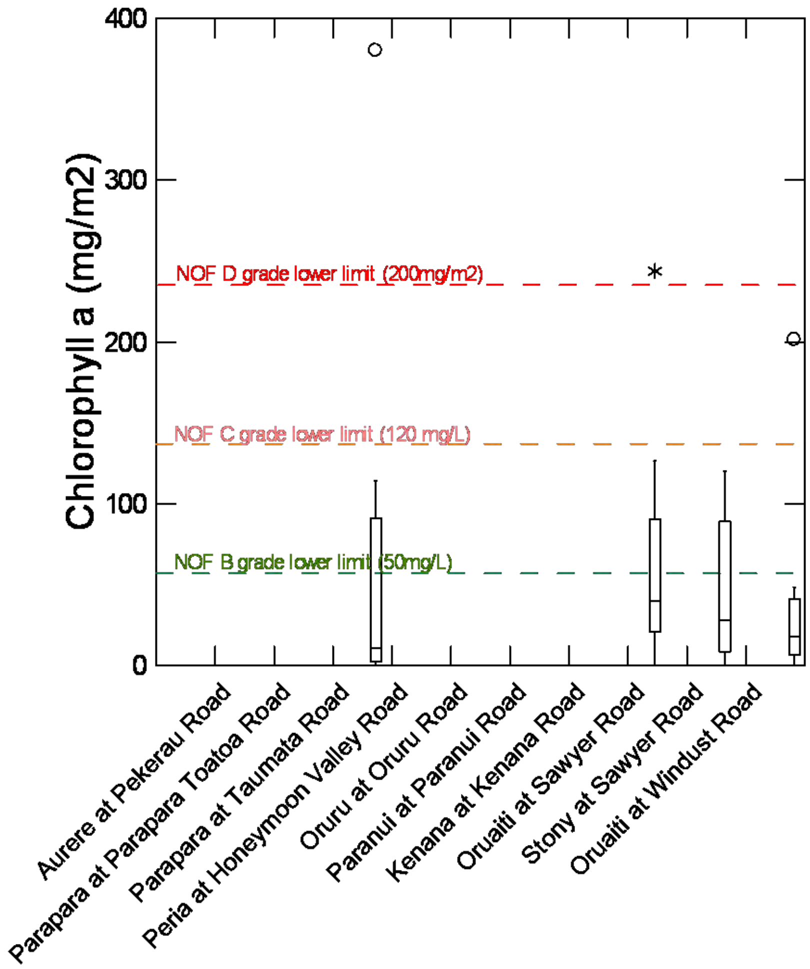


Figure 6: Chlorophyll a (July 2014 to June 2015) with corresponding NOF grades.

The NOF guidelines recommend at least three years of data to complete and interpret periphyton results. One year of data currently available suggest that some sites may be prone to periphyton blooms and fail the bottom line of a maximum value of 200mg Chl a/m^2 exceeded on no more than two occasions within three years (Figure 6).

2.3.3 Water clarity

Good water clarity is important to ensure light availability for periphyton growth. Clear water is also important for visual feeding by fish and invertebrates. Water clarity is influenced by a number of factors including suspended sediment and algal biomass. Suspended sediments are typically elevated following large rainfall events, causing low water clarity and high turbidity. Turbidity is one measure of water clarity.

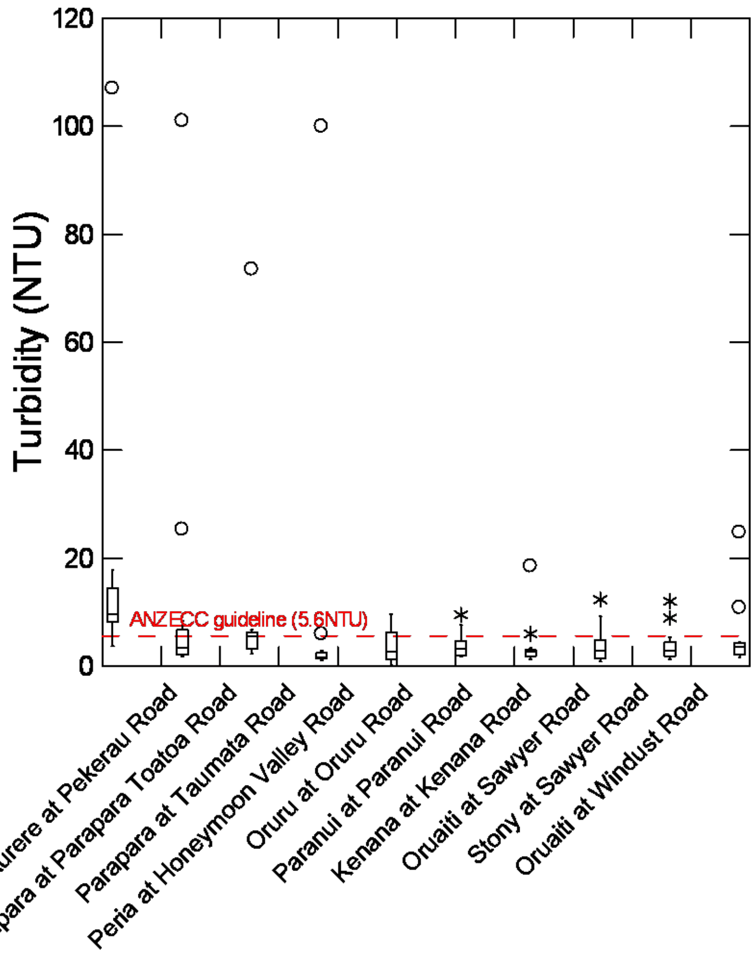


Figure 7: Turbidity (July 2014– June 2015) with ANZECC guideline value.

Currently there is no measure for turbidity in the NOF. However, median turbidity levels from July 2014 to June 2015 have been relatively low (Figure 7) with most samples meeting ANZECC guideline for lowland rivers and some elevated levels probably associated with high rainfall events, the Aurere at Pekerau Road being the exception. However, these results should be viewed with caution as historical results at the Oruru at Oruru Road site recorded high median turbidity levels, i.e. 6.65NTU between Jan 2007 and Dec 2011. The levels recorded between July 2014 and June 2015 are likely to be the result of settled weather patterns, with lower than average rainfall.

Even rivers in pristine native forested catchments have elevated sediment levels following heavy rain, being a combination of sediment washed into the river from surrounding land, and sediment re-suspension from the river bottom due to the increased flows and streambank erosion. However, where there is intensive agriculture, forestry harvesting, subdivision, a lack of riparian vegetation and/or stock access to waterways, sediment loads increase considerably. The effects on turbidity from these activities are exacerbated in the Doubtless Bay catchment due to the highly erodible red volcanic soils in the area. The soils are made of very fine textured clay sediment, much of which stays suspended in water indefinitely, reducing water clarity. These soils require careful land management to avoid further water quality deterioration.

2.3.4 Faecal pathogens – Escherichia coli (*E. coli*)

Although faecal pathogens are not known to affect aquatic ecosystems they are of concern for both human and animal health. The faecal indicator bacteria *E. coli* indicates contamination from faecal matter which can potentially contain harmful pathogens. *E. coli* levels recorded in the Doubtless Bay catchment predominantly fall into the NOF A or B grade for secondary contact recreation (activities involving occasional immersion such as wading, boating, etc.) with median *E. coli* levels below 1000 *E. coli*/100mL (Figure 8). However *E. coli* levels at the Aurere at Pekerau Road site were highly elevated with a median falling into the NOF C grade.

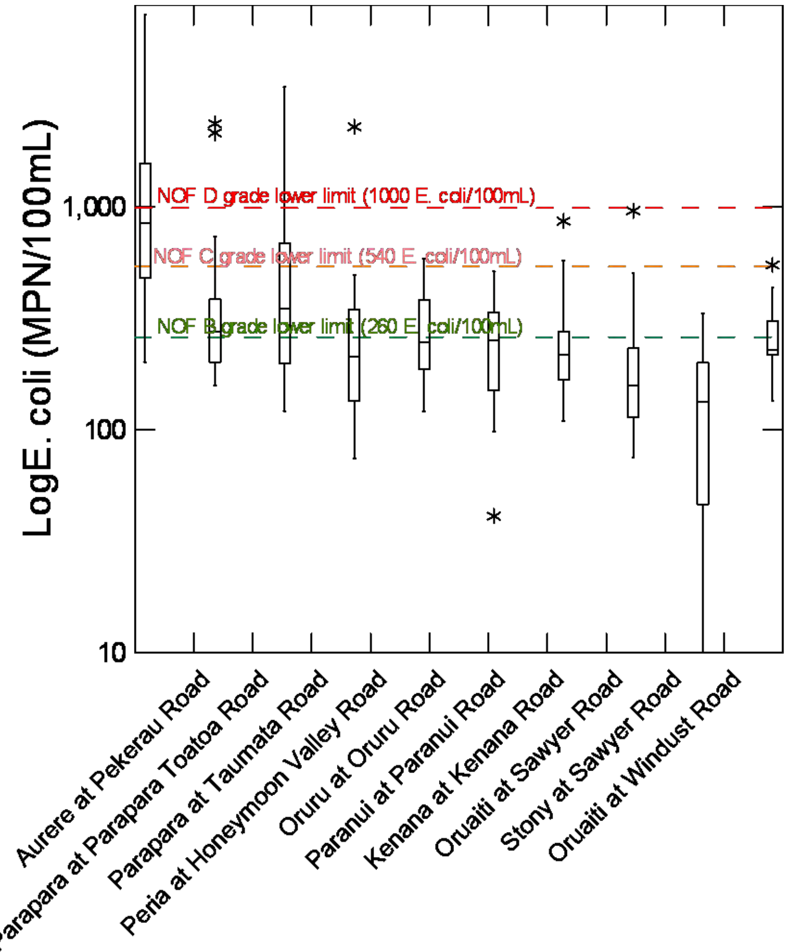


Figure 8: Annual *E. coli* levels (logarithmic scale) (July 2014 to June 2015) with corresponding NOF grades for secondary contact recreation.

It should be noted that natural background *E. coli* levels tend to be slightly higher in warm wet lowland areas such as Northland compared to other river environments in New Zealand (McDowell *et. Al.*, 2013). Nevertheless the excessive levels of *E. coli* in the Aurere highlight the need for good land management and sewage disposal systems in protecting both the freshwater and the receiving marine environment in the Doubtless Bay.

Microbial source tracking analyses are also performed on samples collected at three sites in the Doubtless Bay catchment: Paranui at Paranui Road, Kenana at Kenana Road and Oruaiti at Windust Road. These analyses are only performed when *E. coli* levels exceed 540 *E. coli*/100mL in a sample. Results from this testing indicate that the primary source of contamination is ruminant, but human markers have also been detected on several occasions in previous testing in the Awapoko sub-catchment (Table 4).

Table 4: Microbial source tracking results in the Doubtless Bay catchment. Results in bold indicate a strong positive marker.

Site name	Date Collected	Results
Aurere at D/S Blacks Quarry	10/07/2014	Ruminant
Aurere at Pekerau Road	17/03/2014	Ruminant, wildfowl
Aurere at Pekerau Road	10/07/2014	Ruminant
Kenana at Kenana Road	12/08/2014	Ruminant
Kenana at Kenana Road	12/02/2015	Ruminant, wildfowl, plant
Kenana at Kenana Road	8/12/2015	Ruminant
Mania at SH10	13/08/2014	Ruminant
Mania at SH10	6/11/2014	Ruminant
Mania at SH10	8/07/2015	**Ruminant**
Oruaiti at Windust Road	18/06/2014	Ruminant
Oruaiti at Windust Road	9/12/2014	Ruminant
Oruaiti at Windust Road	13/01/2015	Ruminant, plant
Oruru at Oruru Road	16/04/2014	Ruminant
Oruru at Oruru Road	18/06/2014	Ruminant
Oruru at Oruru Road	13/08/2014	Ruminant
Oruru at Oruru Road	13/04/2015	Low level or aged faecal from ruminant and wildfowl
Oruru at Oruru Road	12/05/2015	Ruminant, Wildfowl
Paranui at Paranui Road	13/01/2015	Plant
Paranui at Paranui Road	13/04/2015	No fresh source of faecal pollution
Parapara at SH10	17/03/2014	Ruminant
Parapara at SH10	10/07/2014	Ruminant
Parapara at Taumata Road	10/07/2014	Ruminant
Parapara Trib at Parapara Road	12/03/2014	Ruminant
Parapara Trib at Parapara Road	17/03/2014	Ruminant, Human
Parapara Trib at Parapara Road	10/07/2014	Ruminant

2.3.5 Dissolved oxygen

Dissolved oxygen is important for freshwater invertebrates and fish, with some species being more sensitive to low oxygen levels than others. Dissolved oxygen levels vary with temperature, biological activity and how quickly it transfers from the atmosphere. Biological activity includes microbial activity by bacteria and primary production by plants and algae and can be associated with the presence of certain pollutants, particularly organic matter such as sewage effluent, decaying aquatic vegetation and animal manures. Aquatic plants photosynthesise during the day (producing oxygen) and respire at night (consuming oxygen). A slow moving lower energy river containing high levels of macrophytes (aquatic plants) is likely to exhibit large fluctuations in dissolved oxygen throughout a 24-hour period, compared to rivers such as the Peria River tributary at Honeymoon Valley Road, within pristine native habitat with little or no aquatic plants and a faster flow.

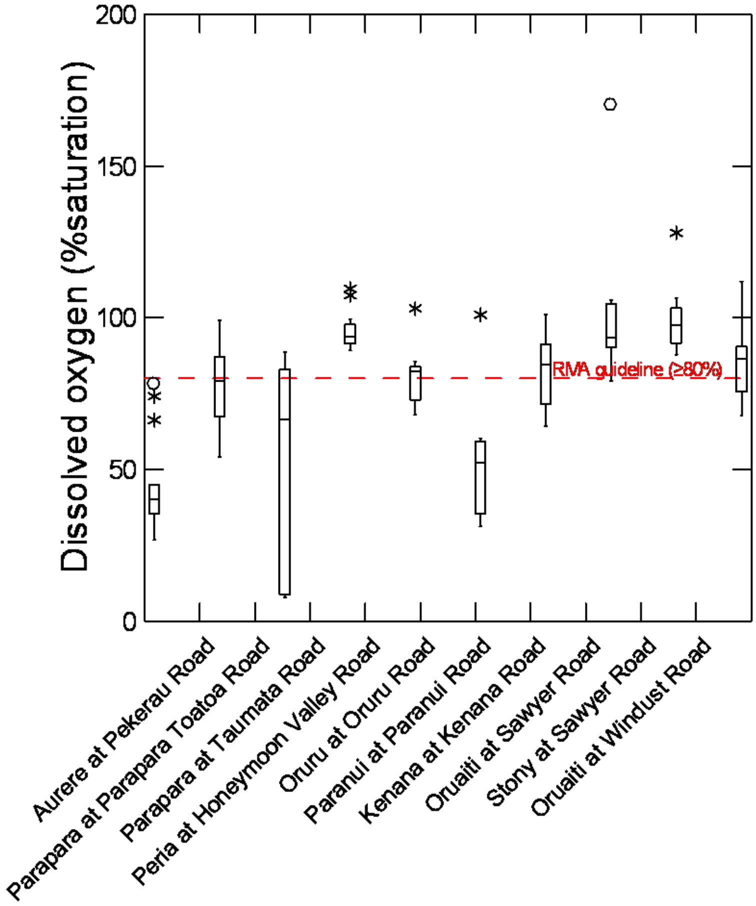


Figure 9: Dissolved oxygen (July 2014 to June 2015) with the RMA 1991 trigger value.

Dissolved oxygen levels were relatively low at many sites in the Doubtless Bay catchment (Figure 9) with almost half of the medians falling below the recommended trigger value. Between 2014 and 2015 the lowest dissolved oxygen recorded in the Parapara at Taumata Road was 7.8%, well below recommended trigger value and at a level which would put aquatic plants and animals under stress. The low dissolved oxygen levels are reflected by the poor macroinvertebrate scores recorded at the site (Figure 10). The highest dissolved oxygen level recorded was 170.1% at the Oruaiti at Sawyer Road.

2.3.6 Invertebrate community health

Stream invertebrates (macroinvertebrates) are used as biological indicators of water quality and stream health. As they live in the stream environment over an extended period of time they are a good indicator of overall water quality and ecosystem health. The Macroinvertebrate Community Index (MCI) is an indicator of organic enrichment and pollution, where taxa are assigned predetermined scores on a scale of 1 to 10 depending on their inherent sensitivity to pollution. The MCI score at a site is based on the taxa present, with the categories in Table 5 used to determine the overall water quality level.

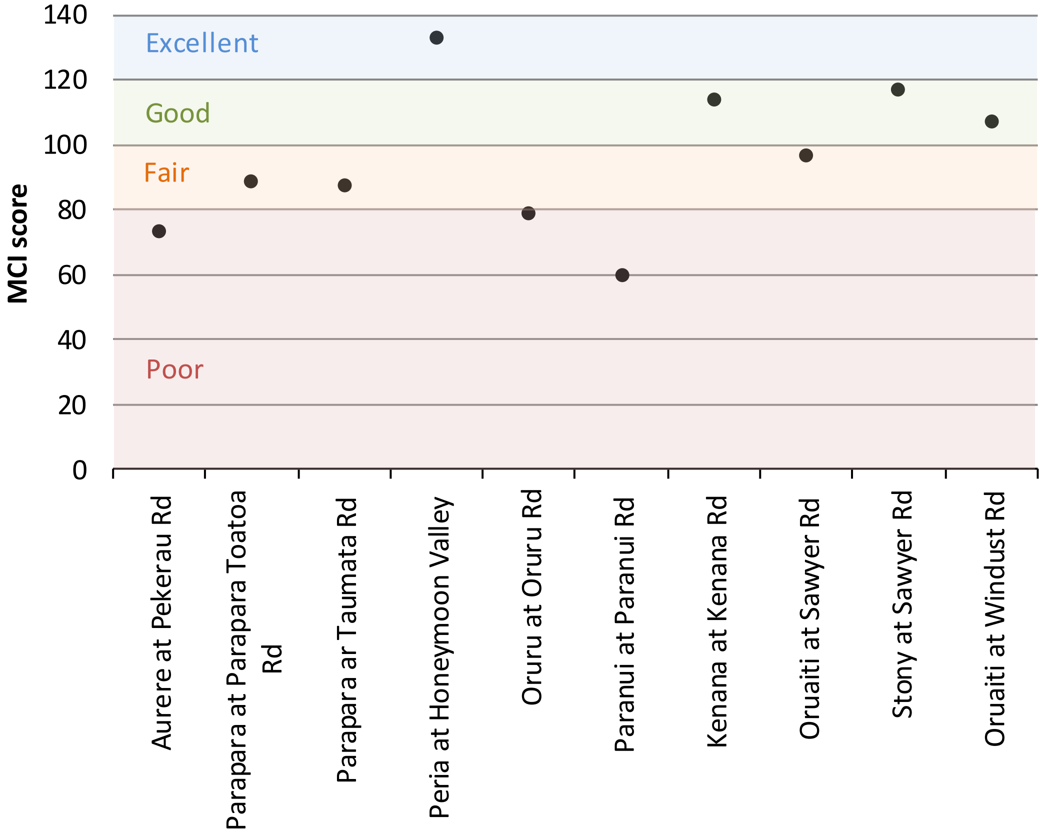


Figure 10: Macroinvertebrate Community Index (MCI) results, summer 2014/15.

Table 5: Macroinvertebrate Community Index scoring system (Boothroyd and Stark, 2000).

Category	MCI	Stream/river state
Excellent	> 120	Clean water
Good	100 – 119.9	Possible mild pollution
Fair	80 – 99.9	Probable moderate pollution
Poor	< 80	Probable severe pollution

Results for summer 2014-2015 (Figure 10) suggest that:

- one site has excellent water quality,
- three have good water quality,
- three have fair water quality,
- and three have poor water quality.
- The streams with the poorest macroinvertebrate scores correspond to those with the lowest dissolved oxygen levels, Oruru at Oruru Road, Aurere at Pekerau Road, Parapara at Taumata Road, Parapara at Parapara Toatoa Road and Paranui at

Paranui Road (Figure 9). The Peria at Honeymoon Valley Road had the highest MCI score of all sites scoring 133.

2.3.7 Fish community

The use of fish as an indicator of ecological health is complex in New Zealand by the fact that many species are diadromous (spend part of their life cycle at sea) so their presence is influenced by factors such as barriers to migration and distance inland as well as habitat availability and water quality. Fish are an important part of the food web and their absence will skew normal predator-prey relationships. Their presence is an important measure of ecological stability and underpins a stream's ecological value.

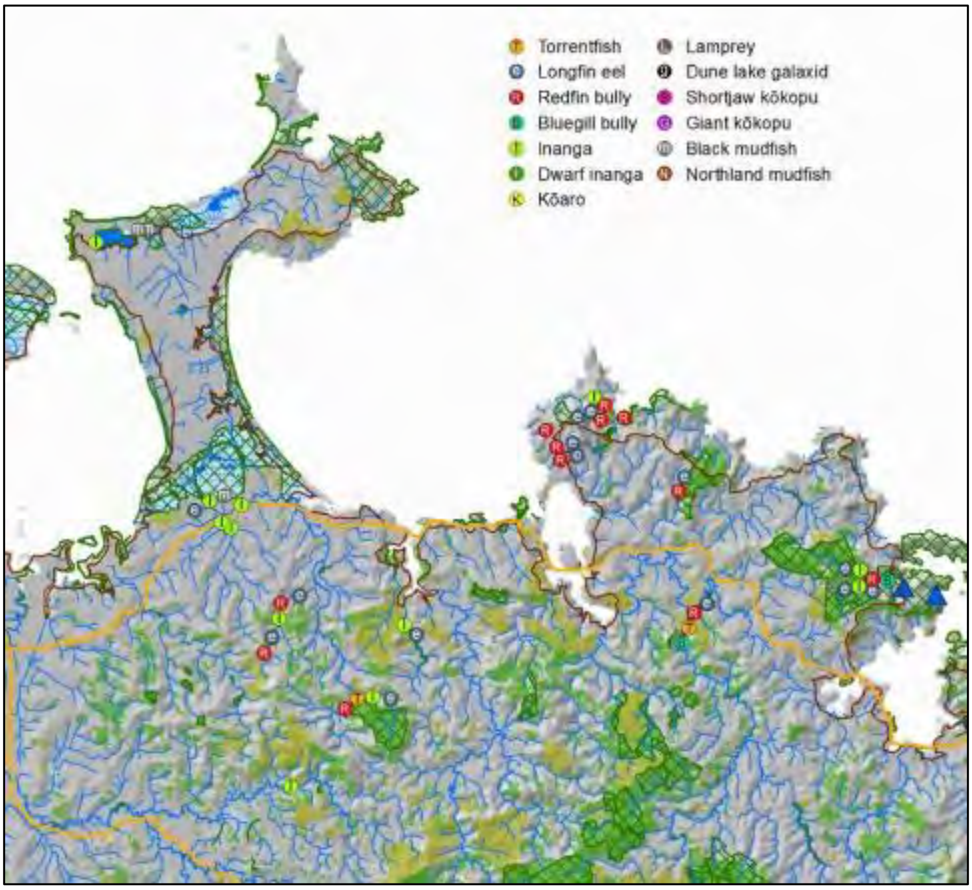


Figure 11: Distribution of threatened fish species in the Doubtless Bay Catchment (McArthur, 2015).

The Doubtless Bay catchment has historical records of ten native fish species including several at risk and threatened species including longfin eel, inanga, bluegill bully, torrent fish and redfin bully (Figure 11). The pest fish gambusia has also been recorded in the catchment. To help protect the current population of native fish Northland Fish and Game have agreed not to release trout into the Doubtless Bay Catchment.

2.3.8 Stream habitat quality

Where there is a diverse habitat available with a variety of flow types (runs riffles and pools), instream debris and good quality riparian vegetation, there tends to be high ecological health. Different flow types offer a variety of different habitats, encouraging greater diversity. Riparian cover stabilises banks, provides a sink for nutrients, traps sediment, and provides shade during hot summer months as well as a source of food in the form of falling vegetation and terrestrial invertebrates.

Half the sites monitored in the Doubtless Bay have a habitat score of less than 50 percent of the reference condition (Figure 12) using the Waipoua River at SH 12 as the reference site. Lower scoring sites such as the Oruru at Oruru Road and Aurere at Pekerau Road have a surrounding land use of mainly pasture, stock have access to the river, there is very little shading from exotic cover and the banks are relatively unstable. They also show evidence of high sediment loads, often associated with high intensity land use and stock access, with most of the substrate being composed of sediment/sand providing little habitat diversity with a mainly uniform substrate and flow type (NRC 2012) and have two of the lowest MCI scores (Figure 10).

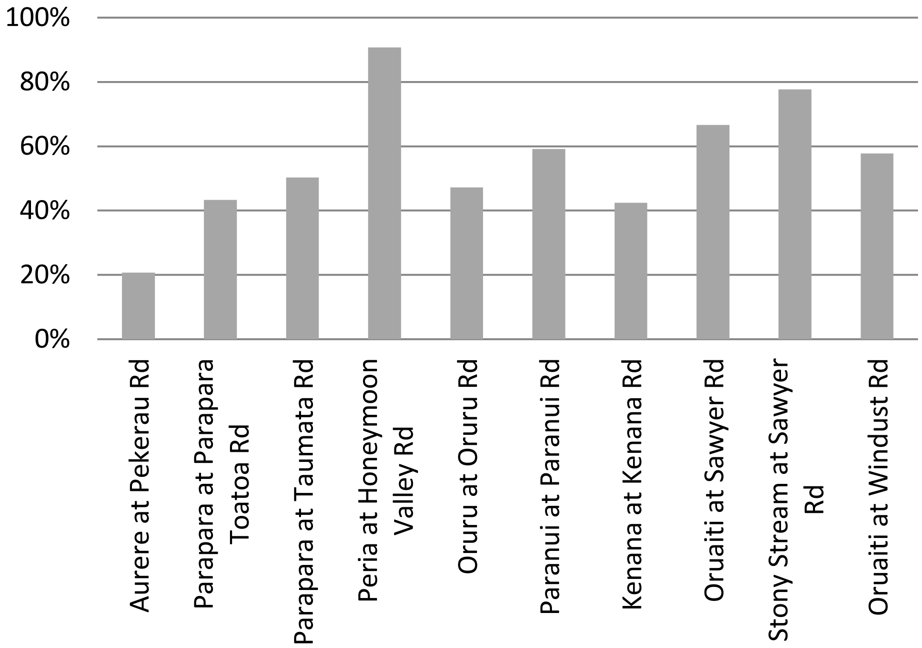


Figure 12: Rapid habitat results shown as a percentage of reference condition (Waipoua at SH12) for Doubtless Bay water quality monitoring sites, summer 2014/15.

The highest habitat score of 90 percent of reference condition was recorded at the Peria at Honeymoon Valley Road site. This site is located high in the Taipa catchment, draining mainly native vegetation, with plenty of shading, a stony substrate and a variety of habitat types. It also recorded the highest MCI score of all sites at 118 (Figure 10).

2.3.9 NOF results 2012 to 2014

NOF grades from 2012 to 2014 at the RWQMN site Oruru at Oruru Road are presented in Table 6. Although ammoniacal nitrogen and nitrate nitrogen toxicity levels and *E. coli* (for secondary contact recreation) were within the NOF A grade in 2012 and 2013, in 2014 results for both ammoniacal nitrogen toxicity, and *E. coli* dropped from an NOF A to a B grade.

Table 6: NOF grades from 2012 to 2014 at the RWQMN site in the Doubtless Bay catchment.

Value	Ecosystem health										Human health	
Indicator (unit)	Ammoniacal nitrogen toxicity (mg/L)				Nitrate nitrogen toxicity (mg/L)				Periphyton (Chla mg/m^2)		*E. coli* (*E. coli* /100 mL)	
Site name	1 year median		1 year max		1 year median		1 year 95%ile		3 year max		1 year median (secondary contact)	
2012												
Oruru at Oruru Road	0.013	A	0.040	A	0.010	A	0.195	A	ND	ND	173	A
2013												
Oruru at Oruru Road	0.012	A	0.027	A	0.008	A	0.068	A	ND	ND	155	A
2014												
Oruru at Oruru Road	0.016	A	0.064	B	0.039	A	0.170	A	ND	ND	338.5	B

ND: no data

3 Water quality summary

Table 7: Water quality summary (July 2014 to June 2015) for sites in the Doubtless Bay catchment as well as a reference site Peria Stream (draining native vegetation) using NOF attributes and other guideline/trigger values.

Water quality monitoring site	National Objective Framework (NOF) attributes				ANZECC guideline value		RMA 1991	Ecological indicators	
	Nitrate nitrogen toxicity (mg/L)	Ammoniacal nitrogen toxicity (mg/L)	Escherichia coli (*E. coli*/100mL)	Periphyton exceeds no more than 8% of samples (Chl a mg/m^2)	Dissolved reactive phosphorus (mg/L)	Turbidity (NTU)	Dissolved Oxygen (% saturation)	Macro-invertebrates	Stream habitat
	95th percentile A ≤1.5 B >1.5 ≤3.5 C >3.5≤9.8 D >9.8	Annual maximum A ≤0.05 B>.05≤0.4 C >0.4≤2.2 D >2.2	Annual median A ≤260 B >260≤540 C >540≤1000 D >1000	Chlorophyll a A ≤50 B >50≤120 C >120≤200 D >200	Annual median <0.01	Annual median <5.6	Annual median ≥80	MCI score (Table 5)	% rating compared with reference site
Aurere at Pekerau Road	A	C	C	ND	Above	Above	Below	73.6	21
Parapara at Parapara Toatoa Road	A	B	B	ND	Below	Below	Below	89	43
Parapara at Taumata Road	A	B	B	ND	Above	Above	Below	87.45	50
Peria at Honeymoon Valley Road	A	A	A	B	Above	Below	Above	132.86	91
Oruru at Oruru Road	A	B	A	ND	Above	Below	Above	79.23	47
Paranui at Paranui Road	A	A	A	ND	Below	Below	Below	60	59
Kenana at Kenana Road	A	B	A	ND	Above	Below	Above	114	42
Oruaiti at Sawyer Road	A	A	A	C	Above	Below	Above	97	67
Stony at Sawyer Road	A	B	A	B	Below	Below	Above	117	78
Oruaiti at Windust Road	A	B	A	A	Below	Below	Above	107	58

Values in Table 6 are not directly comparable; some refer to national standards while others provide conservative numbers for physical and chemical measures in rivers above or below to indicate which aquatic ecosystems may be exposed to stress.

Results for the Peria at Honeymoon Valley Road site, draining almost entirely native vegetation, provide a reference. The NOF is still under development with a number of additional attributes currently being evaluated. In its current form the NOF does not address all the water quality issues of concern in Northland. For this reason a number of other guidelines, trigger values and ecological indicators have been included to provide a more holistic overview of water quality in the catchment.

- Based on very limited data monitoring results (2014-2015) water quality generally meets most current NOF standards in the Doubtless Bay catchment.
- The reference site Peria at Honeymoon Valley Road recorded elevated dissolved reactive phosphorus levels indicating naturally elevated levels within the catchment related to geology.
- The Aurere sub-catchment has a number of water quality and ecological issues including elevated dissolved reactive phosphorus, high turbidity, low dissolved oxygen levels, and generally poor habitat and MCI results.
- Ecological health is generally poor within the Doubtless Bay catchment with six out of ten sites scoring fair or poor MCI grades and five out of ten scoring 50 percent or less of reference condition for habitat.

4 Lake ecosystem and water quality

The ecological health of lake ecosystems are related to a number of environmental factors including, but not limited to, the availability of suitable habitat types, e.g. diverse range of emergent and submerged indigenous plants, lack of invasive exotic species, disturbance and high water quality. It is important to note that the relationship between ecosystem health and environmental factors is often very complex and unpredictable.

4.1 Water quality results

Lake water quality parameters of concern in terms of ecological health are, in no particular order, dissolved oxygen, clarity, nutrients, suspended solids and chlorophyll a levels (Figure 13). Faecal pathogens are not known to affect aquatic ecosystems, but do affect the suitability of a water body for recreational use and stock drinking water.

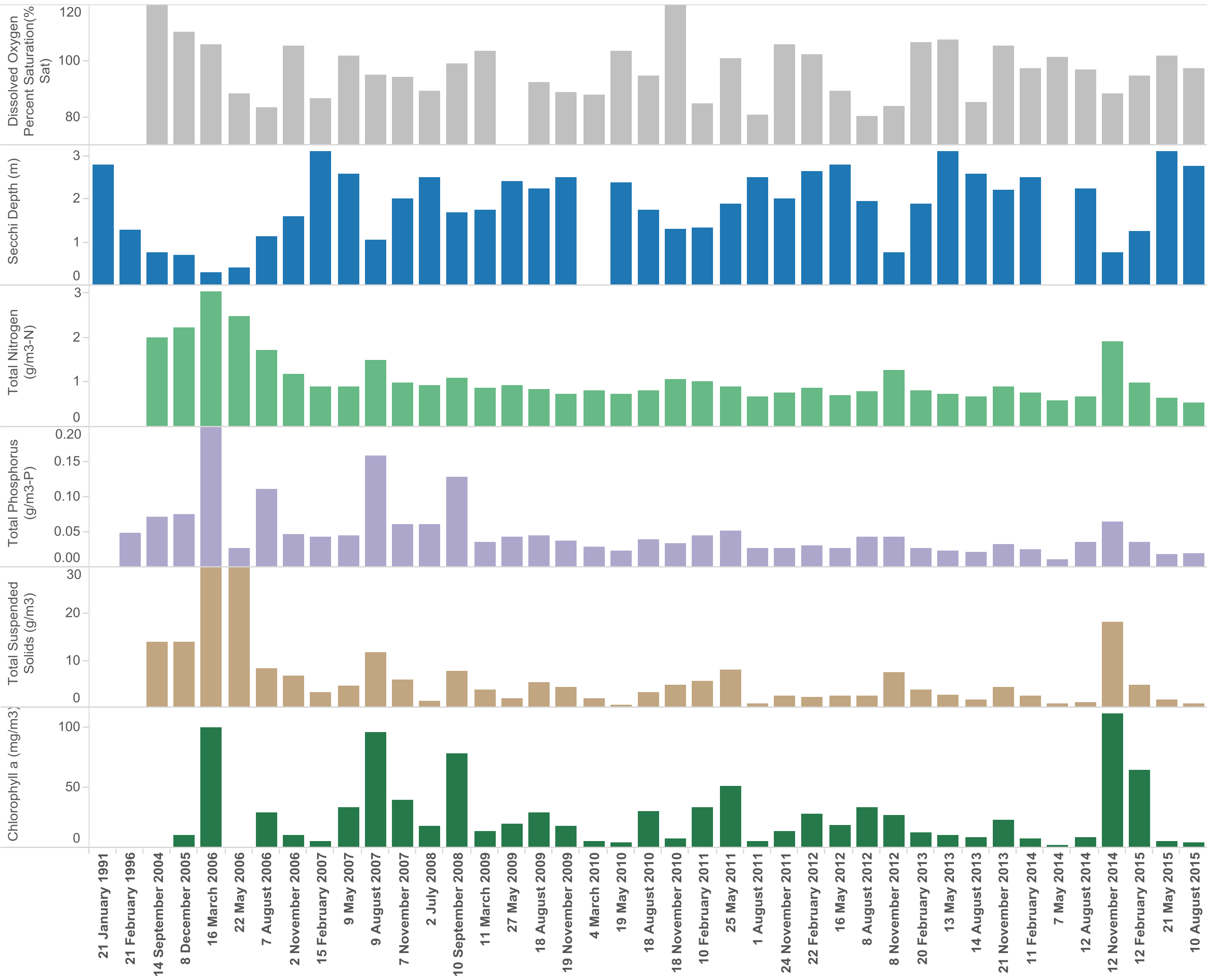


Figure 13: Water quality results for Lake Waiporohita.

4.1.1 Trophic level index

The Trophic Level Index (TLI) can be used to determine the state of lakes (Burns et al., 2000). The TLI is calculated using four key variables: chlorophyll α (an indicator of algal biomass), water clarity, total nitrogen (TN) and total phosphorus (TP) (Table 8). Together, these provide an indication of a lake's overall ecosystem health. The overall score is categorised into seven trophic states indicating progressively more nutrient enrichment, more algal productivity and reduced water clarity. The trophic states of most relevance in the Northland region are:

- Microtrophic lakes which are very clean,
- Oligotrophic lakes which have low levels of nutrients and algae,
- Mesotrophic lakes which have moderate levels of nutrients and algae,
- Eutrophic lakes which are green and murky, with higher amounts of nutrients and algae,
- Supertrophic lakes which are fertile and saturated in phosphorus and nitrogen, with very high algae growth and blooms during calm sunny periods,
- Hypertrophic lakes which are highly fertile and supersaturated in phosphorus and nitrogen. They are rarely suitable for recreation and habitat for desirable aquatic species is limited.

Table 8: Trophic states relevant to Northland lakes and related water quality ranges defining each trophic level (Burns et al., 2000).

Lake type	Trophic level	Chlorophyll α (mg/m^3)	Clarity (m)	TP (mg/m^3)	TN (mg/m^3)
Microtrophic	1.0 – 2.0	0.33 – 0.82	25 – 15	1.8 – 4.1	34 – 73
Oligotrophic	2.0 – 3.0	0.82 – 2.0	15 – 7.0	4.1 – 9.0	73 – 157
Mesotrophic	3.0 – 4.0	2.0 – 5.0	7.0 – 2.8	9.0 – 20	157 – 337
Eutrophic	4.0 – 5.0	5.0 – 12	2.8 – 1.1	20 – 43	337 – 725
Supertrophic	5.0 – 6.0	12 – 31	1.1 – 0.4	43 – 96	725 – 1558
Hypertrophic	6.0 – 7.0	> 31	< 0.4	> 96	> 1558

4.1.1.1 Lake Waiporohita

Lake Waiporohita is a small dune lake (5.6ha) classified as *outstanding* in the Northland Lakes Strategy which is located near Tokerau Beach on the Karikari Peninsula. This shallow lake (maximum depth of 3.5m) is located in a pastoral dominated catchment which is completely fenced. Lake Waiporohita is listed as a dune lake in Schedule E of the Regional Water and Soil Plan (RWSP) and therefore subject to particular controls on water extractions.

Figure 14: Lake Waiporohita.

4.1.1.2 Lake Rotopokaka (Coca Cola)

Lake Rotopokaka is classified as having *medium* ecological value in the Northland Lakes Strategy and is approximately 11ha in area, and 3.5m deep. The surrounding catchment is manuka scrub, with pohutukawa, cabbage tree and flax along the eastern margin. The lake has no inflows or outflows. Access is off Ramp Road, with well-formed tracks to the western and northern shores. Lake Rotopokaka is listed as a dune lake in Schedule E of the RWSP and therefore subject to particular controls on water extractions. Lake Rotopokaka is not currently sampled as part of the Lake Water Quality Monitoring Programme.

Figure 15: Lake Rotopokaka.

4.1.2 Lake water quality

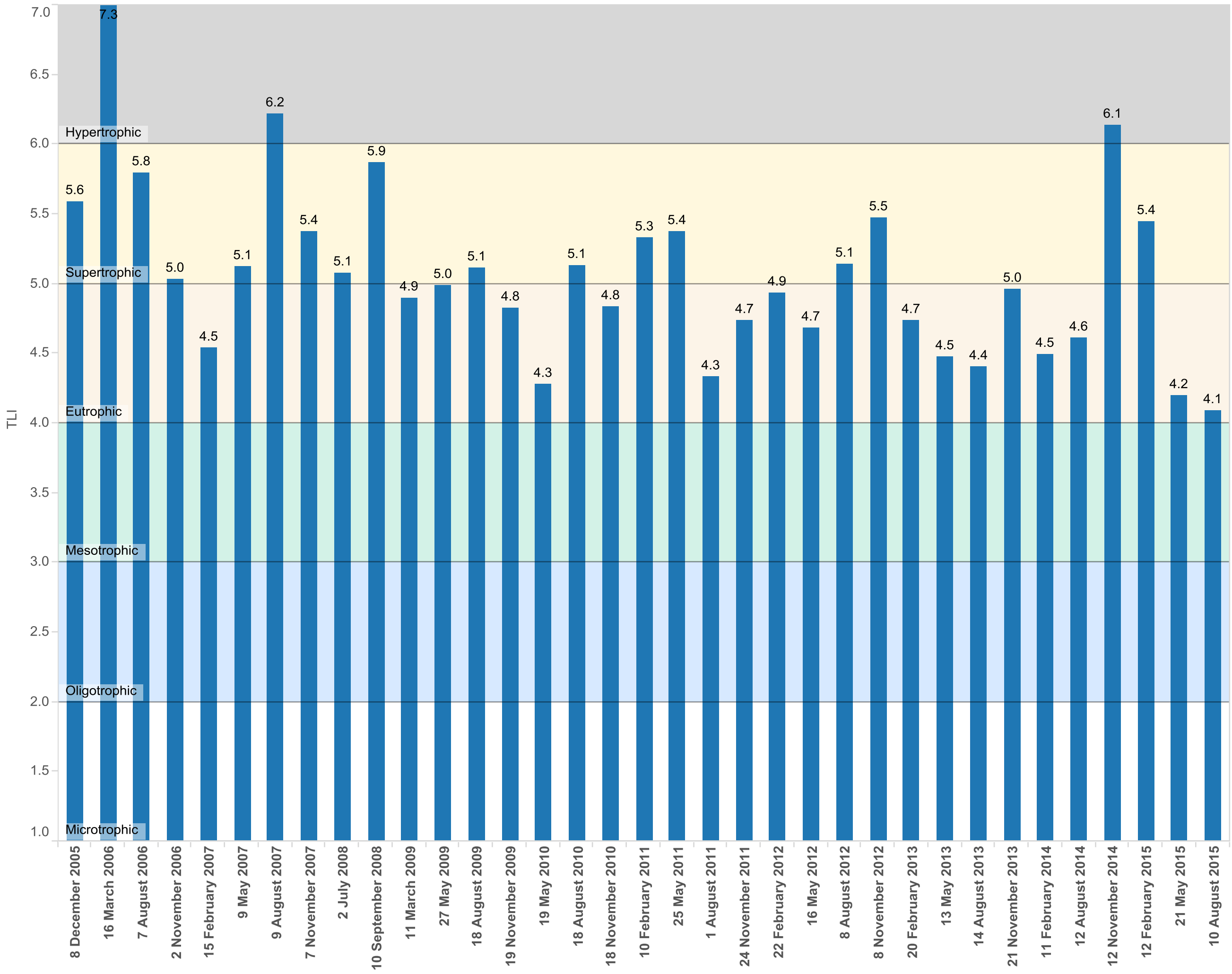


Figure 16: Trophic level index results for Lake Waiporohita from 2009 to 2014.

Lake Waiporohita fluctuated between eutrophic and hypertrophic states between 2005 and 2015 (**Error! Reference source not found.**) which means it is fertile and saturated in phosphorus and nitrogen, with very high algae growth and blooms during dry settled weather periods. High nutrient loads are likely to be associated with land run-offs and leaching of contaminants such as effluent, fertiliser and sediment from pastoral land. High bird densities and nutrient recycling from bottom sediments may also contribute to the nutrient levels recorded within the lake. However the lake's catchment has been fenced and during the 2005 to 2015 monitoring period, signs of improving water quality have been observed.

4.2 Biodiversity assessment

The lake biodiversity assessment provides an overall ranking for each lake taking into account endangered species identified, wetland extent, species composition, submerged vegetation abundance and composition measured by the Submerged Plant Indicator (SPI), water bird, fish and aquatic invertebrate presence and abundance as assessed by the National Institute of Water and Atmospheric research (NIWA) (Wells and Champion, 2011).

The SPI component is based on the macrophyte (aquatic plants) community structure and composition (Clayton and Edwards 2006(a) (b)). There are three indices:

- Native Condition Index: a measure of the native vegetation within a lake. A higher score means a healthier, more diverse community of native plants growing to greater depths.
- Invasive Condition Index: a measure of the invasive vegetation within a lake. A higher score means greater impact from exotic plants.
- Lake SPI: is a combination of the Native Condition Index and the Invasive Condition Index and provides an overall indication of the lake ecological condition. The higher the score the better the ecological condition of the lake.

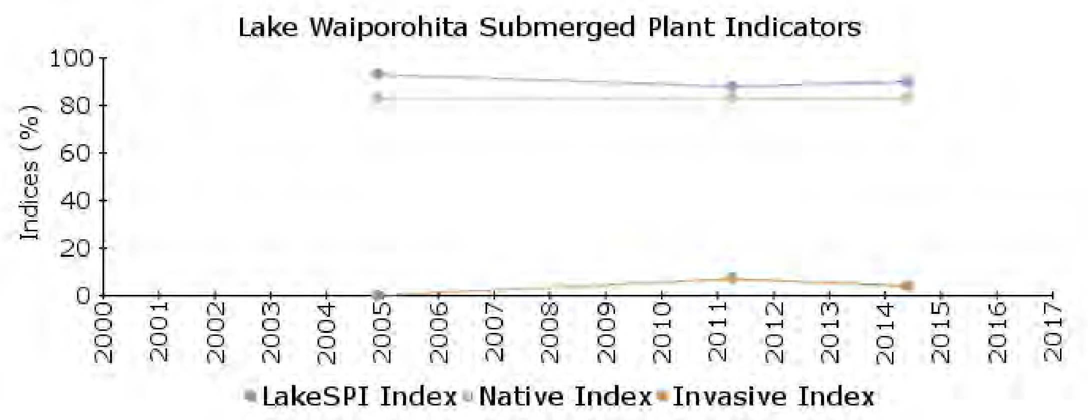
Lake SPI is presented as a percentage of a lake's maximum scoring potential and relates to the depth of each lake.

Lake SPI grades:

- >75% "Excellent"
- >50-75% "High"
- >20-50% "Moderate"
- >0-20% "Poor"
- 0 "Non-vegetated"

Incorporating the Lake SPI, the biodiversity assessment is based on three components; indigenous biota, endangered species (both plant and animal) and habitat availability and is interrelated with water quality. Each parameter is scored on a scale of 1 -6 and then ranked as either Outstanding; High; Moderate-High; Moderate; Low-Moderate; or Low. Outstanding lakes are of national importance, high in diversity and contain self-sustaining populations of endangered species. Low ranked lakes are usually de-vegetated with poor water quality or infested with invasive pest species.

Despite its low water quality Lake Waiporohita is ranked as 'Outstanding' as the lake contains nationally endangered plants and birds with indigenous submerged plant communities. The lake has been surveyed three times for Lake SPI. On each occasion it was graded as 'excellent', scoring 93% in 2005, 88% in 2010 and 90% in 2014 (Figure 17) reflecting the extent of native vegetation. The slight decline reflects the appearance of small amounts of the invasive species *Utricularia gibba* (Wells et. Al., 2011 and 2014). Increased spread of pest plants is likely to reduce this ranking which has remained the same since records began in 2005.



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Excellent	90%	83%	4%
March 2011	Excellent	88%	83%	7%
November 2004	Excellent	93%	83%	0%

Figure 17: Lake Waiporohita Submerged Plant Index score.

Table 9: Animal species identified in lake Waiporohita (green = rare/endangered, red=pest species).

Native Species	Exotic Species
bittern (*Botaurus poiciloptilus*)	black swan (*Cygnus atrelus)*.
Caspian tern (*Sterna caspia*).	Mallard (*Anus platyrhyncus*).
dabchick (*Poliocephalus rufopectus*)	Canada Geese (Branta canadensis)
Grey duck (*Anas superciliosa)*	water boatmen (*Sigara arguta).*
Common bully (*G. cotidianus*)	gambusia (*Gambusia affinnis*).
leech (*Richardsonianus mauianus*)	

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6 Abbreviations

- ANZECC: Australian and New Zealand Environment and Conservation Council
- D/S: downstream
- DO: Dissolved Oxygen
- DRP: Dissolved Reactive Phosphorus
- *E. coli*: Escherichia coli
- IQR: interquartile range
- LAWA: Land Air Water Aotearoa
- MCI: Macroinvertebrate Community Index
- MfE: Ministry for the Environment
- NIWA: National Institute of Water and Atmospheric research
- NOF: National Objective Framework
- NPS-FM: National Policy Statement for Freshwater Management
- NTU: Nephelometric Turbidity Units
- RMA 1991: Resource Management Act 1991
- RWQMN: River Water Quality Monitoring Network
- SH: State Highway
- SPI: Submerged Plant Indicator
- TLI: Trophic Level Index
- TN: Total Nitrogen
- TP: Total Phosphorus
- TURB: Turbidity
- WNW: Waiora Northland Water

7 Appendix

Figure 18: Parapara at Parapara Toatoa Road

Figure 19: Parapara at Taumata Road

Figure 20: Peria at Honeymoon Valley Road

Figure 21: Oruru at Oruru Road


Figure 22: Paranui at Paranui Road


Figure 23: Kenana at Kenana Road

Figure 24: Oruaiti at Sawyer Road

Figure 25: Stoney Creek at Sawyer

Figure 26: Oruaiti at Windust Raod