TAUMARERE CATCHMENT

WATER QUALITY UPDATE

Date: October 2016

Version: 1.0

CONTENTS

FIGURES

TABLES

1 Current monitoring in the catchment

Environmental monitoring currently conducted by Northland Regional Council in the Taumarere catchment is mostly confined to one long term monitoring site, some historical recreational swimming monitoring and a catchment investigation (Figure 1 & Table 1) as outlined below:

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: Waiharakeke at Stringers Road in the Taumarere catchment. This site has been monitored since 1996. Annual and five yearly reports are available here: http://www.nrc.govt.nz/Resource-Library-Summary/Environmental-Monitoring/State-of-the-Environment-Monitoring/

Stream invertebrate (macroinvertebrate) monitoring at RWQMN sites since 1997. Every site in the network is monitored once a year in summer. Monitoring at the Waiharakeke at Stringers Road started in 2007 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. 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/

Hydrological monitoring. There is an automatic telemetered water level recorder at the Waiharakeke at Stringer Road site.

Recreational swimming. The Recreational Swimming Water Quality Programme (RSWQP) is a joint project administered by the Northland Regional Council (the Council), in partnership with the Northland District Health Board (NDHB), the Far North District Council (FNDC), the Whangarei District Council (WDC) and the Kaipara District Council (KDC). Sites are monitored weekly over summer months from the end of November to the end of February. The Otiria was sampled at the Otiria at Swimming Hole site from 1999 to 2008 and the Tirohanga at Tirohanga Road has been sampled since 2001 Reports are available here: http://resources.nrc.govt.nz/upload/8983/Recreational%20Water%20Quality%20Report%202007-08.pdf

Otiria/Orauta Stream catchment investigation was a detailed monitoring programme initiated in August 2008 following water quality concerns identified through the recreational swimming water quality monitoring programme. Monitoring was carried out from August 2008 to December 2011. The report is available here: http://resources.nrc.govt.nz/upload/5181/Final%20_Otiria%20report_August%202008.pdf

As well as specific monitoring programmes some ad-hoc monitoring has also been carried out to check compliance with resource consent conditions and investigate environmental incidents.

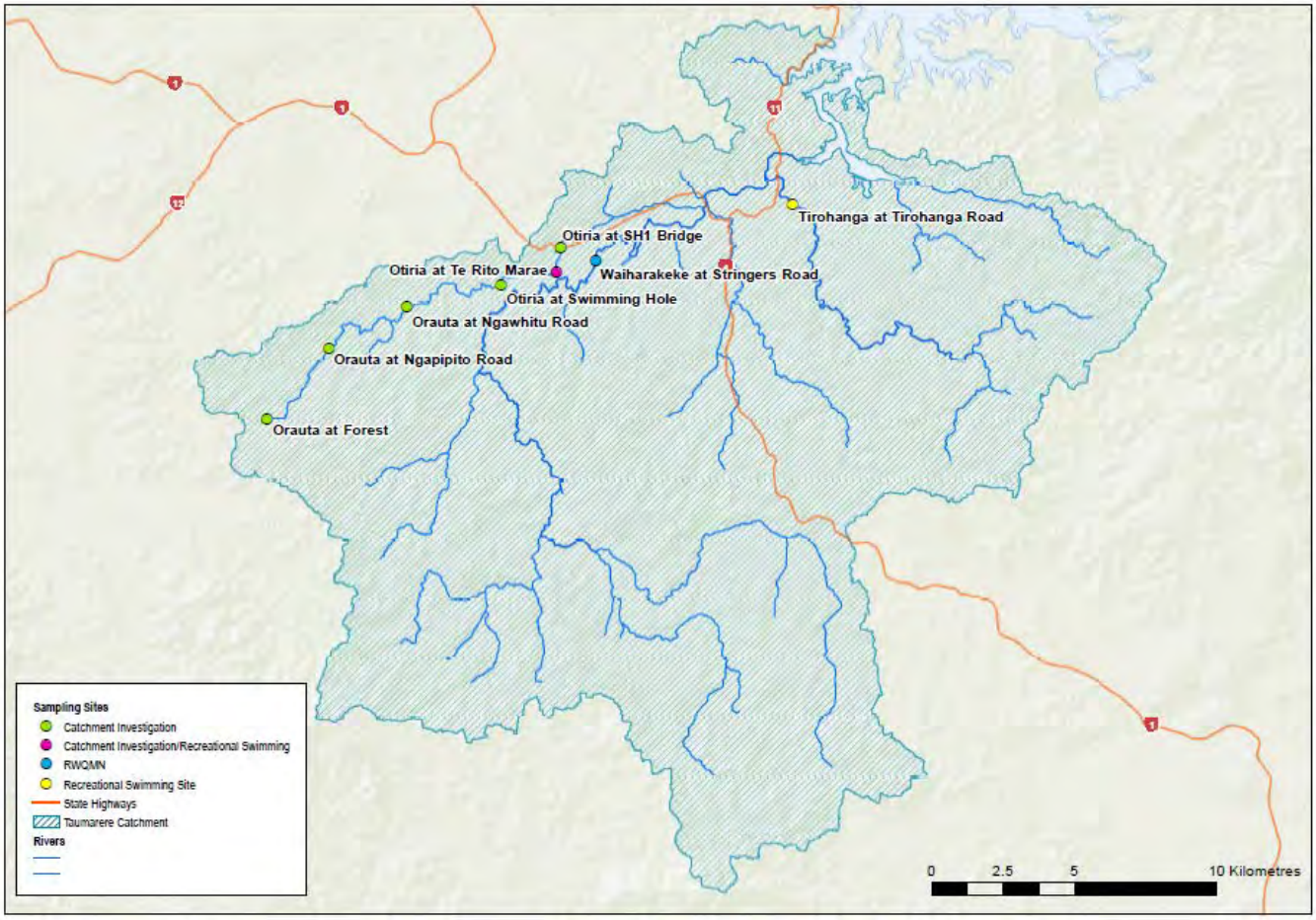

Figure 1: Taumarere catchment water quality monitoring sites.

Table 1: Taumarere catchment water quality monitoring sites.

Site Name	Location Number	Dominant surrounding land-use
Orauta at Forest	103354	pine forest
Orauta at Ngapipito Road	103353	pine forest and exotic grassland
Orauta at Ngawhitu Road	103352	pine forest and exotic grassland
Otiria at Te Rito Marae	109425	indigenous forest and exotic grassland
Otiria at swimming hole	105376	exotic grassland
Otiria at SH1	105324	exotic grassland
Waiharakeke at Stringers Road	100007	exotic grassland
Tirohanga at Tirohanga Road	102252	exotic grassland

Photos of 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 Taumarere catchment is the Waiharakeke at Stringers Road which has been sampled since 1996. Land Air Water Aotearoa (LAWA)[1], brings together water quality data from regional councils throughout New Zealand (Figure 2). The Waiharakeke at Stringers Road site recorded results for *E. coli*, black disc, turbidity, ammoniacal nitrogen, dissolved reactive phosphorous and total phosphorous ranking amongst the worst 25 to 50 percent of sites in New Zealand. Total Nitrogen, total oxidised nitrogen and pH ranked in the best 50 percent of sites.

Trend analysis carried out on the last 10 years of data show no meaningful changes in water quality and nutrient levels at the site (Figure 2).

The Regional Council sampled the Otiria Stream at the swimming hole below the waterfall from December 1999 to 2008 as part of the recreational swimming water quality monitoring programme. This highlighted water quality issues in the Otiria Stream and after review in 2008 (NRC, 2008), a detailed monitoring programme was undertaken from August 2008 to December 2011 at the following six sites: Orauta at Forest, Orauta at Ngapipito Road, Orauta at Ngawhitu Road, Otiria at SH1, Otiria at swimming hole and Otiria at Te Rito Marae (NRC, 2012). Results showed that bacterial water quality in the Otiria Stream deteriorated with distance downstream, most likely in response to land use practices. There were also some high ammoniacal nitrogen and turbidity results in the upper catchment in 2011 which were thought to be linked to forestry activities. With only three years of data there was insufficient data for statistically significant trend analyses although dissolved reactive phosphorous levels appeared to be decreasing in the catchment during the period of the study.

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

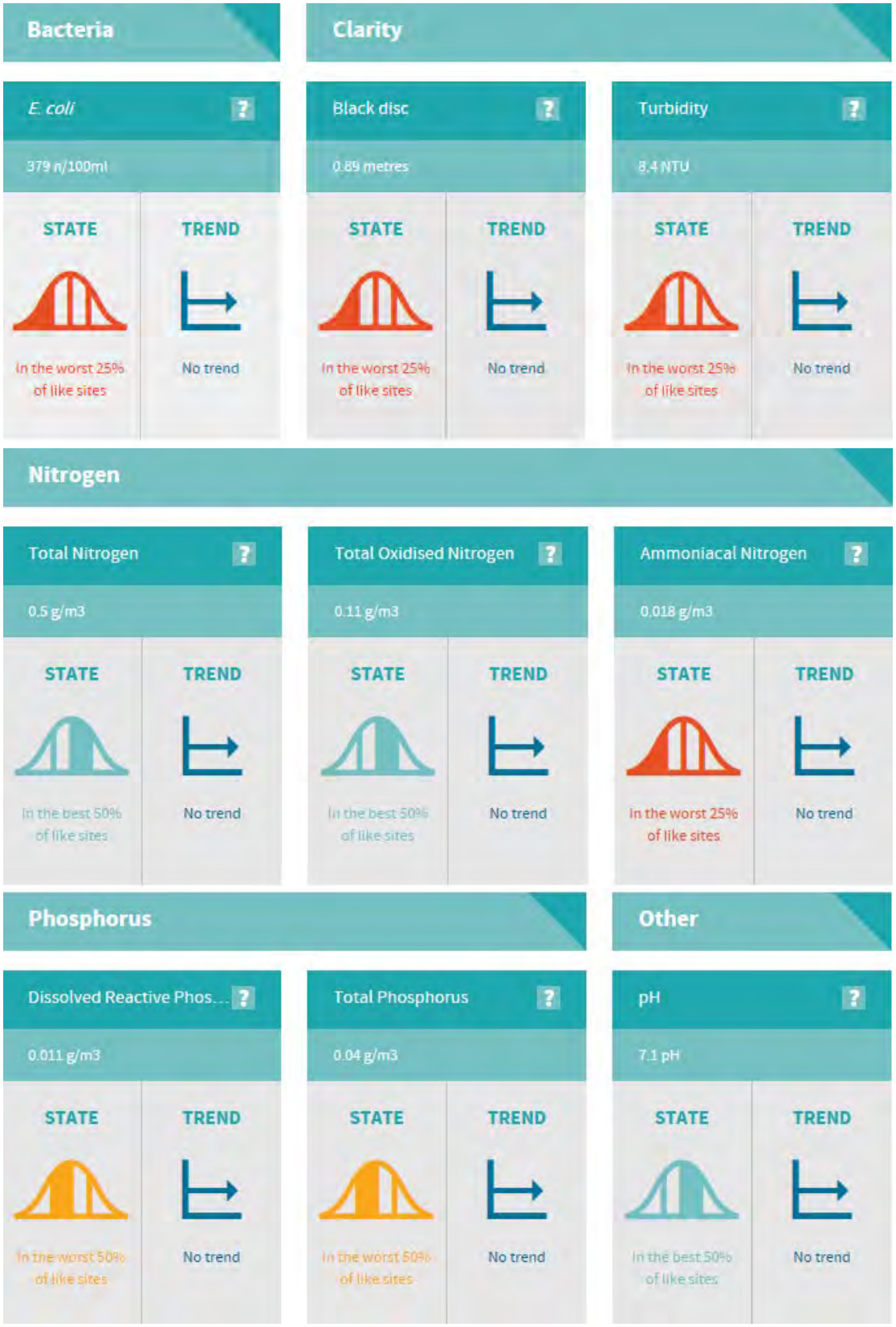

Figure 2: Current water quality state of the Waiharakeke at Stringers Road RWQMN site compared to similar sites in New Zealand with 10 year trends for nine water quality parameters.
(excerpt from Land Air Water Aotearoa (LAWA) website)

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	>1and ≤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
Escherichia coli *E. coli*/100mL	annual median (2nd contact recreation)	≤260	>260 and ≤540	>540 and ≤1000	>1000
	annual 95th percentile	≤260	>260 and ≤540	National bottom line	
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 water quality parameters are assessed against relevant trigger/guideline values (Table 3) as well as current NOF attributes. Trigger/guideline 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).

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)
Total Phosphorous	TP	ANZECC (2000)	<0.033 (mg/L)
Nitrate, nitrite, nitrogen	NNN	ANZECC (2000)	<0.444 (mg/L)
Ammoniacal nitrogen	NH_4	ANZECC (2000)	<0.021 (mg/L)
Total nitrogen	TN	ANZECC (2000)	<0.614 (mg/L)
Turbidity	TURB	ANZECC (2000)	<5.6 (NTU)
Escherichia coli	*E.coli*	MfE (2003)	<550 *E.coli*/100ml

2.3 Water quality results

The following section describes water quality in the Taumarere catchment using box and whisker plots 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 (Figure 3).

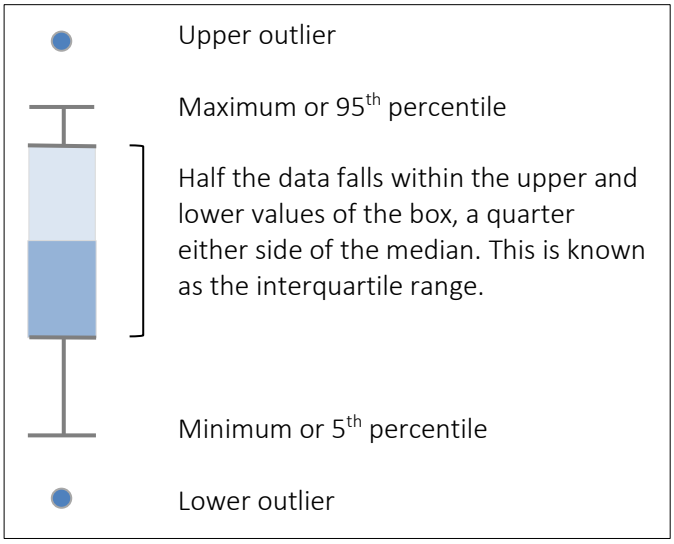

Figure 3: Boxplot description.

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.

Nitrate nitrogen

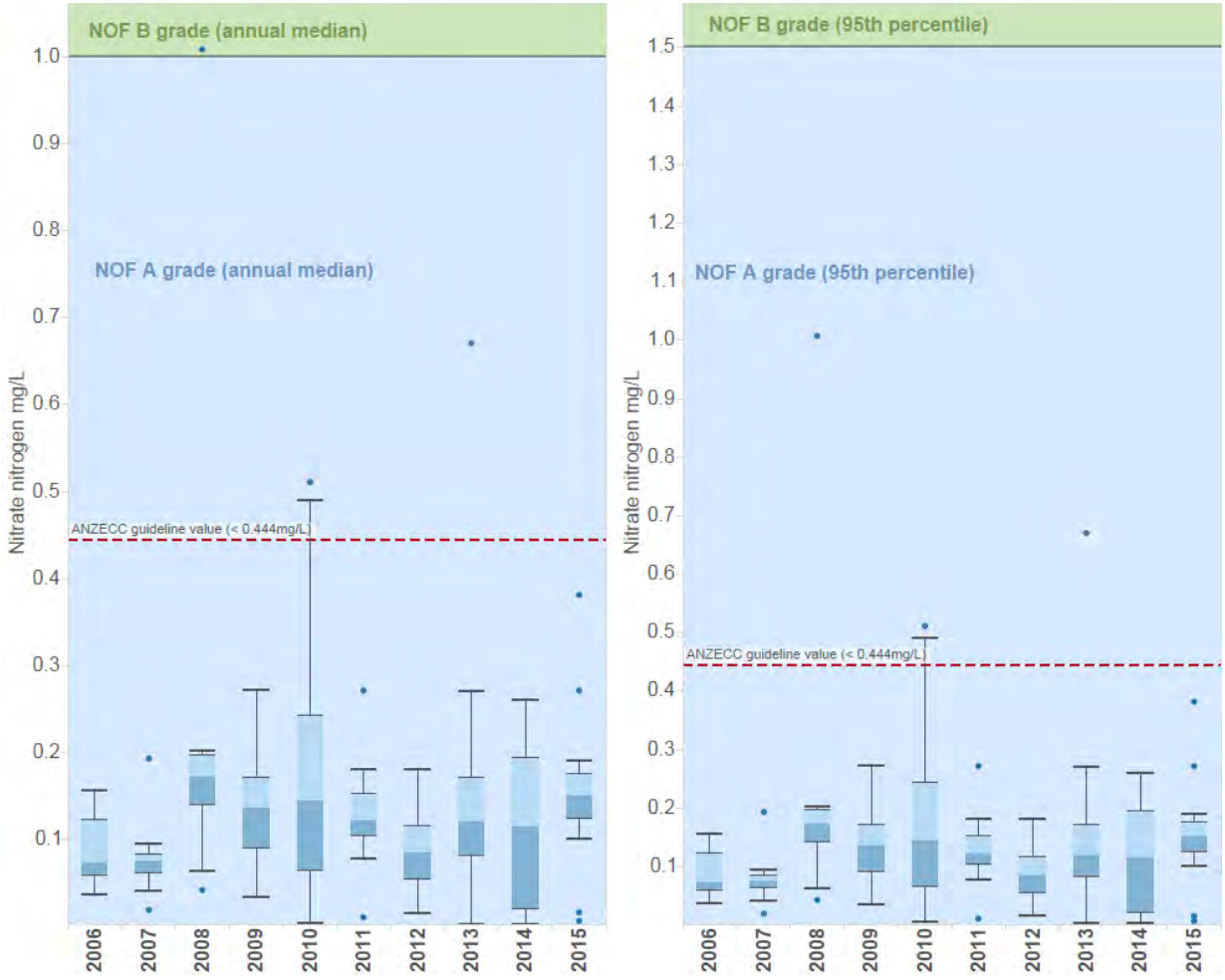

Figure 4: Nitrate nitrogen toxicity at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) with annual median (left) and 95th percentile (right) NOF grades for toxicity and ANZECC guideline value.

Annual nitrate toxicity median levels recorded between 2006 and 2015 at the Waiharakeke at Stringers Road site met national standards with median results well within the NOF A grade (≤1mg/L) and ANZECC guideline value (<0.444mg/L) (Figure 4, left). Annual 95th percentile levels (Figure 4, right) also met national standards with results within the NOF A grade (≤1.5mg/L) indicating that nitrate toxicity is not an issue at this site. Nitrate nitrogen was not measured in the Otiria Stream catchment investigation.

Ammoniacal nitrogen

Results from January 2006 to December 2015 indicate that annual median ammoniacal nitrogen levels recorded at the Waiharakeke site met both ANZECC guidelines and NOF toxicity standards. Results recorded were below the ANZECC guideline value and within the NOF A grade (≤0.03mg/L) (Figure 5, left). Annual maximums recorded were within the NOF A or B grade (Figure 5, right). Monthly results for the same time period indicate that ammoniacal nitrogen levels tended to be more elevated in summer and early autumn with greater extremes (Figure 6).

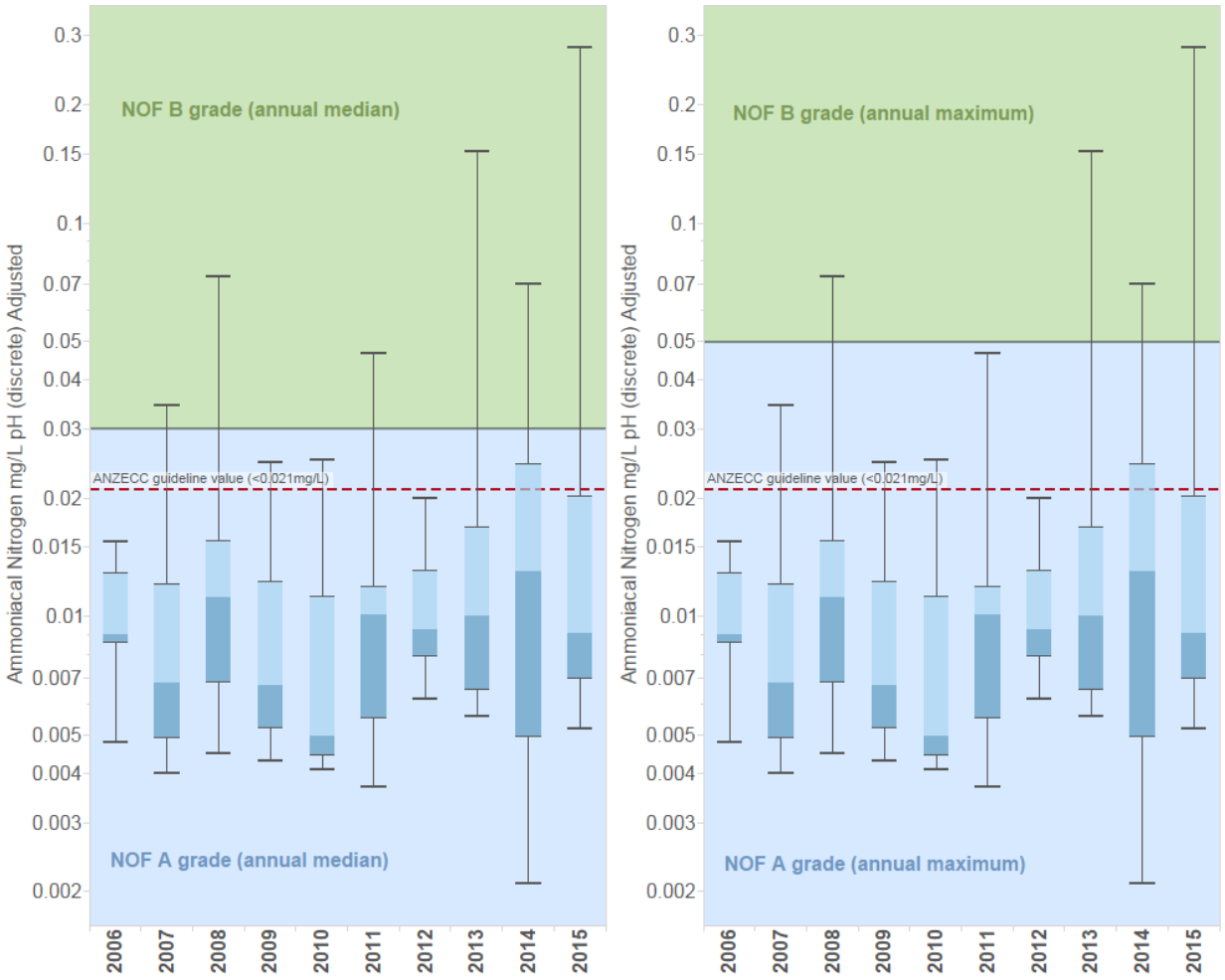

Figure 5: Ammoniacal nitrogen (logarithmic scale) at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) with NOF annual toxicity median (left) and maximum (right) grades as well as ANZECC guideline value.

Annual ammoniacal nitrogen results from the Otiria Stream catchment study from January 2009 to December 2011 compared to those from the long-term monitoring site at Waiharakeke during the same time period (Figure 8) show that the lowest median was recorded at the most upstream site, Orauta at Pine Forest in 2010 (0.012mg/L), and the highest (0.023 mg/L) at two sites; Orauta at Ngapipito Road and Otiria at Te Rito Marae in 2009 and 2010 respectively. All results graded A for the annual median NOF ammoniacal nitrogen toxicity standards (Figure 7). Maximums were also predominantly within the NOF A grade (Figure 8). The Waiharakeke site, the most downstream site, had the highest annual maximums and graded in the NOF B grade for all years from 2009 to 2011. Medians recorded at all sites were below the ANZECC guideline value with the exception of the Ngapipito Road and Te Rito Marae sites.

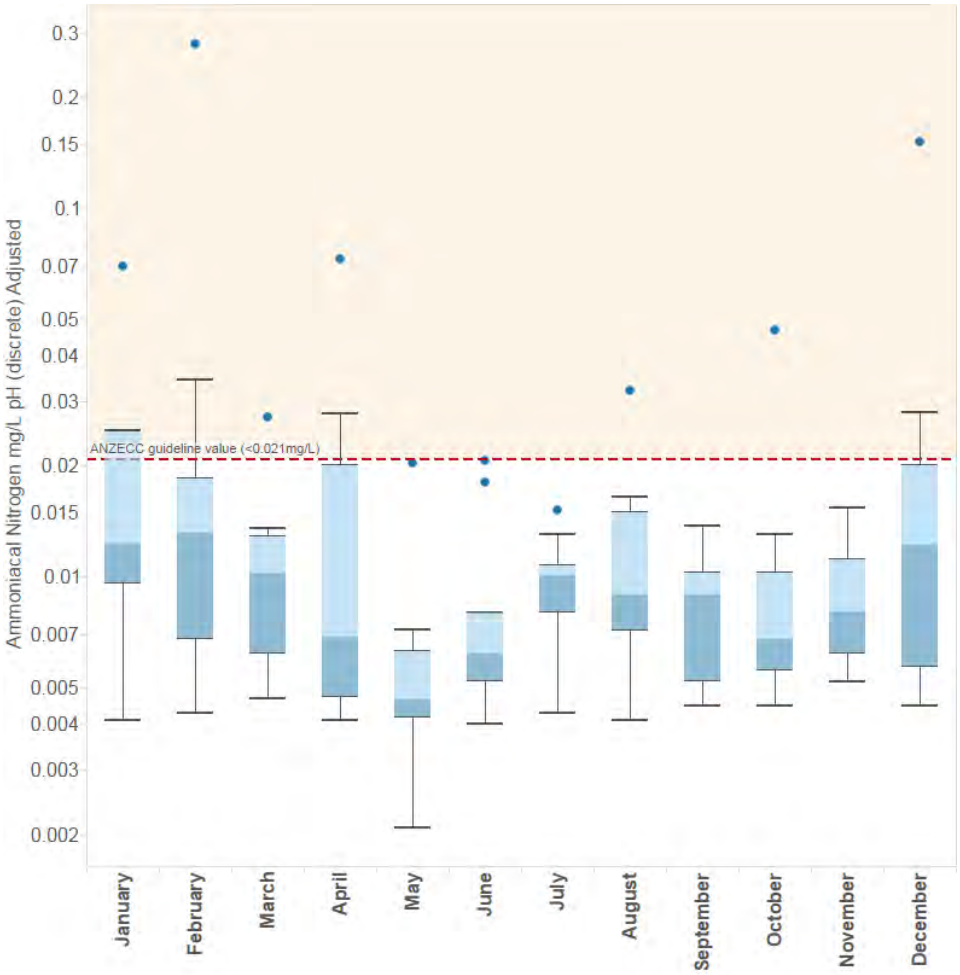

Figure 6: Seasonal boxplot of ammoniacal nitrogen at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) with ANZECC guideline value.

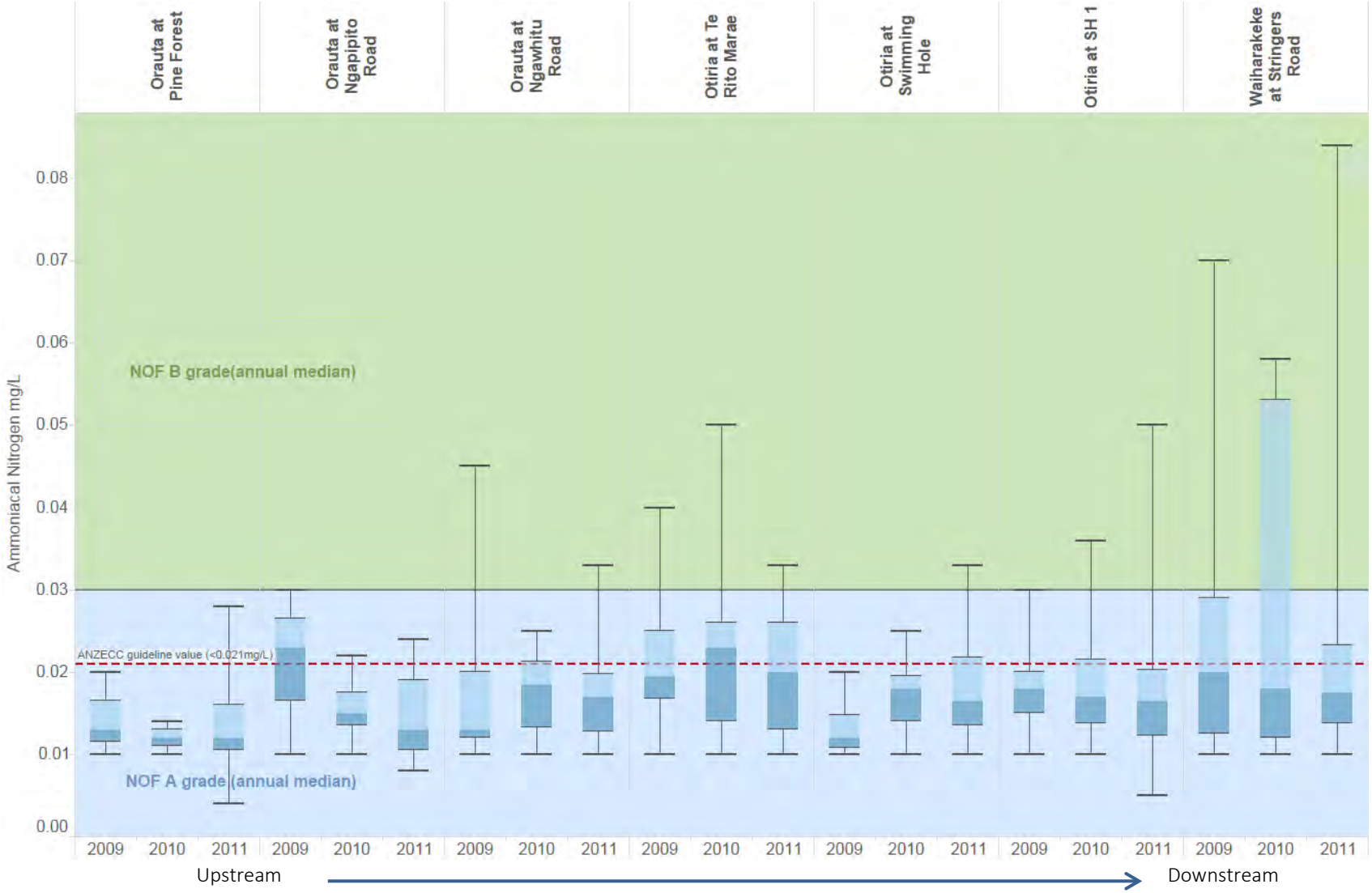

Figure 7: Annual median ammoniacal nitrogen results in the Otiria Stream catchment (January 2009 to December 2011) with NOF grades (annual median) for toxicity and ANZECC guideline value.

Note: ammoniacal nitrogen could not be pH adjusted as required by the NOF as pH was not measured in the Otiria Stream catchment investigation therefore results are an indication only.

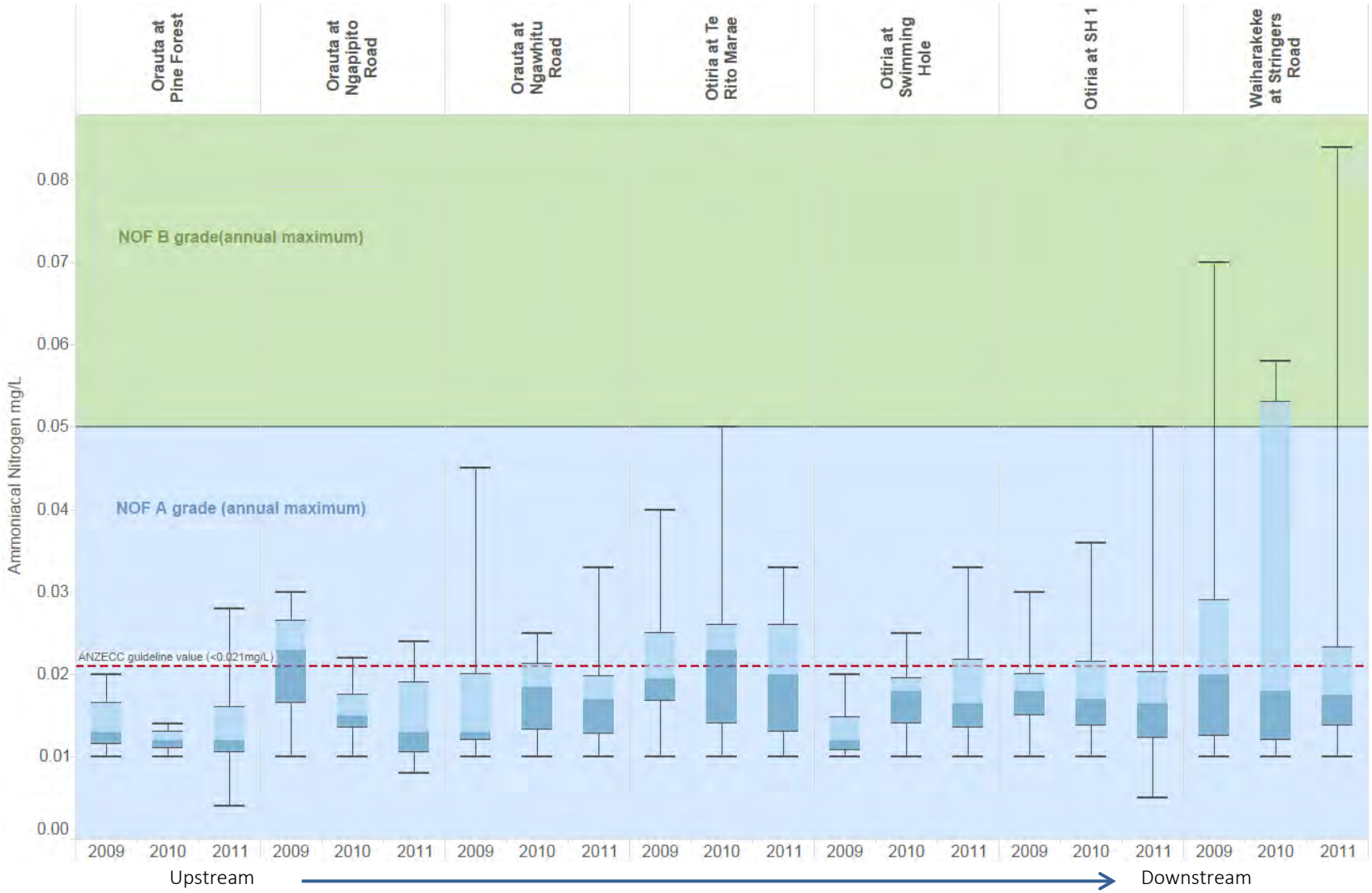

Figure 8: Annual maximum ammoniacal nitrogen results in the Otiria Stream catchment (January 2009 to December 2011) with NOF grades (annual maximum) for toxicity and ANZECC guideline value.

Note: ammoniacal nitrogen could not be pH adjusted as required by the NOF as pH was not measured in the Otiria Stream catchment investigation therefore results are an indication only.

Dissolved Reactive Phosphorous

There is currently no national standard for dissolved reactive phosphorous in the NOF. However, median levels recorded at the Waiharakeke site between 2005 and 2015 did not meet ANZECC guidelines with medians exceeding 0.01mg/L in every year with the exception of 2010 (Figure 9). These elevated results have the potential to cause stress to aquatic ecosystems.

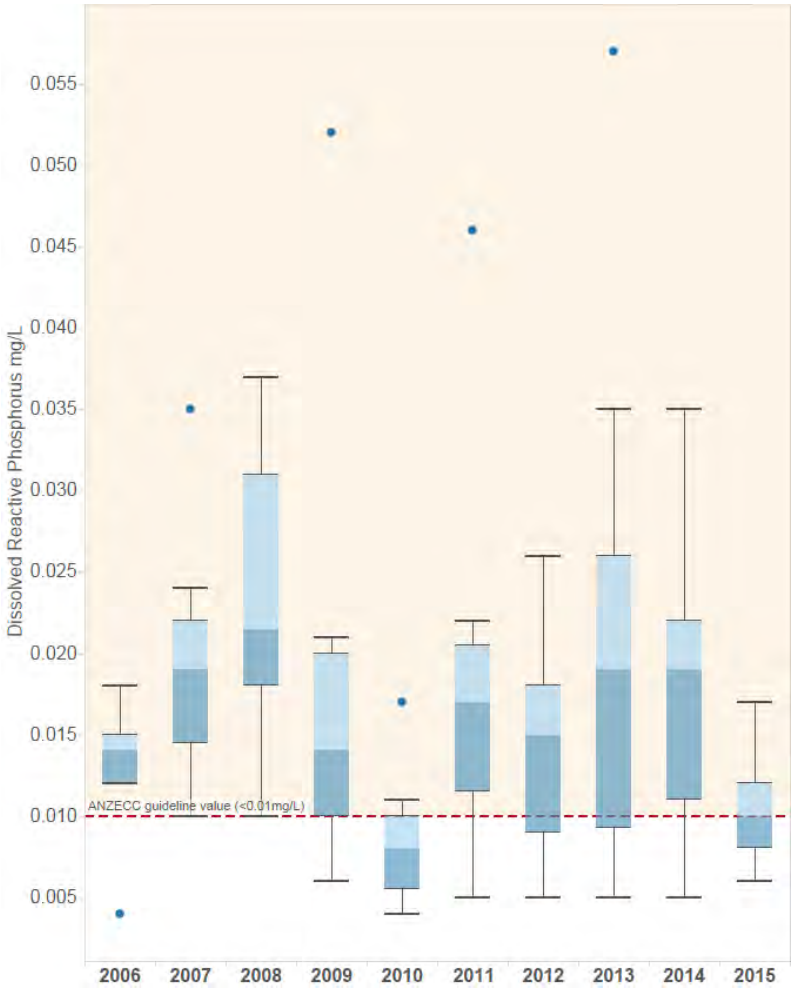

Figure 9: Annual dissolved reactive phosphorous results at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) with ANZECC guideline value.

Monthly results for the same time period indicate that dissolved reactive phosphorous levels tended to fluctuate more widely in summer and early autumn with higher extremes (Figure 10). The reason for this is unclear but may indicate point source discharges which become less diluted during low flow periods.

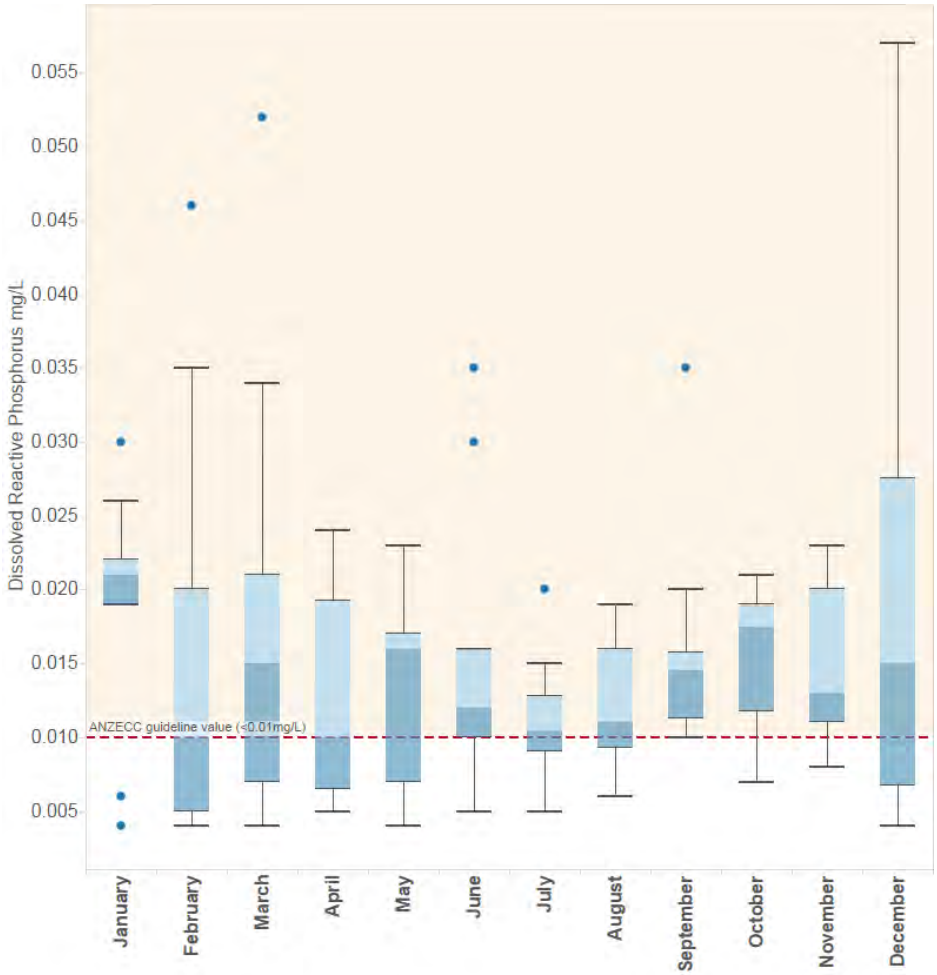

Figure 10: Monthly dissolved reactive phosphorous results at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) with and ANZECC guideline value.

Median dissolved reactive phosphorous levels recorded during the Otiria Stream catchment investigation (January 2009 to December 2011) and at the Waiharakeke site during the same period were elevated at the more downstream sites (Figure 11). All but the two most upstream sites, Orauta at Pine Forest and Orauta at Ngapipito Road, recorded median dissolved reactive phosphorous levels exceeding the ANZECC guideline value for lowland rivers (0.01mg/L). Levels generally increased from upstream to downstream sites with the lowest median recorded at the reference site, Orauta at Pine Forest (0.005mg/L), and the highest at Waiharakeke at Stringers Road (0.014mg/L), the most downstream site.

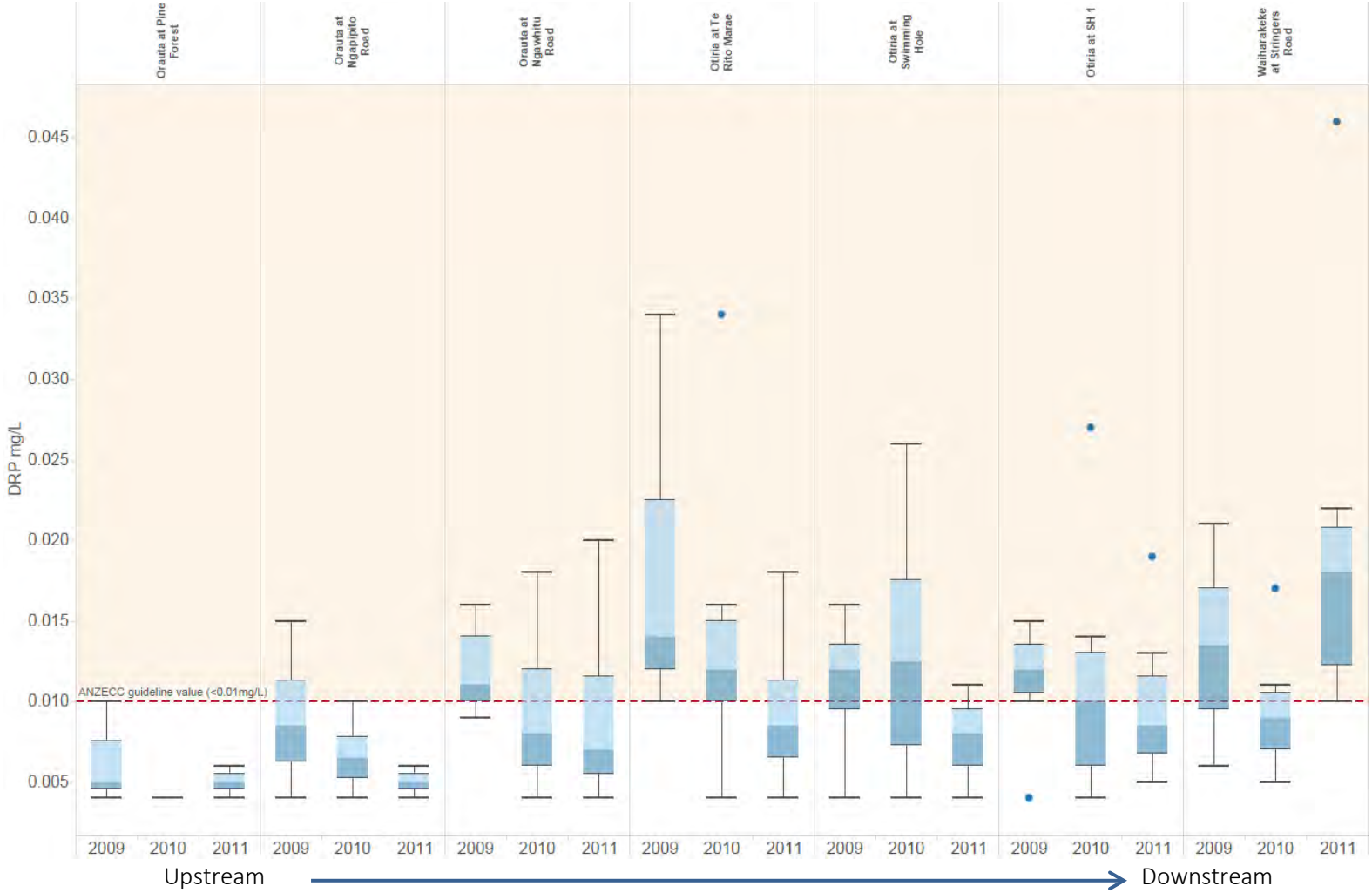

Figure 11: Annual dissolved reactive phosphorous results in the Otiria Stream catchment and Waiharakeke at Stringers Road water quality sites (January 2009 to December 2011) with ANZECC guideline value.

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 (Chl a) levels are used as a measure of periphyton biomass in the NOF. The main drivers for periphyton growth include light and nutrient levels. A regular monthly periphyton monitoring programme was initiated by Northland Regional Council in 2013 (initially only during summer months) at all suitable site part of the river water quality monitoring network (RWQMN), including the Waiharakeke at Stringers Road site. Results are presented in Figure 12.

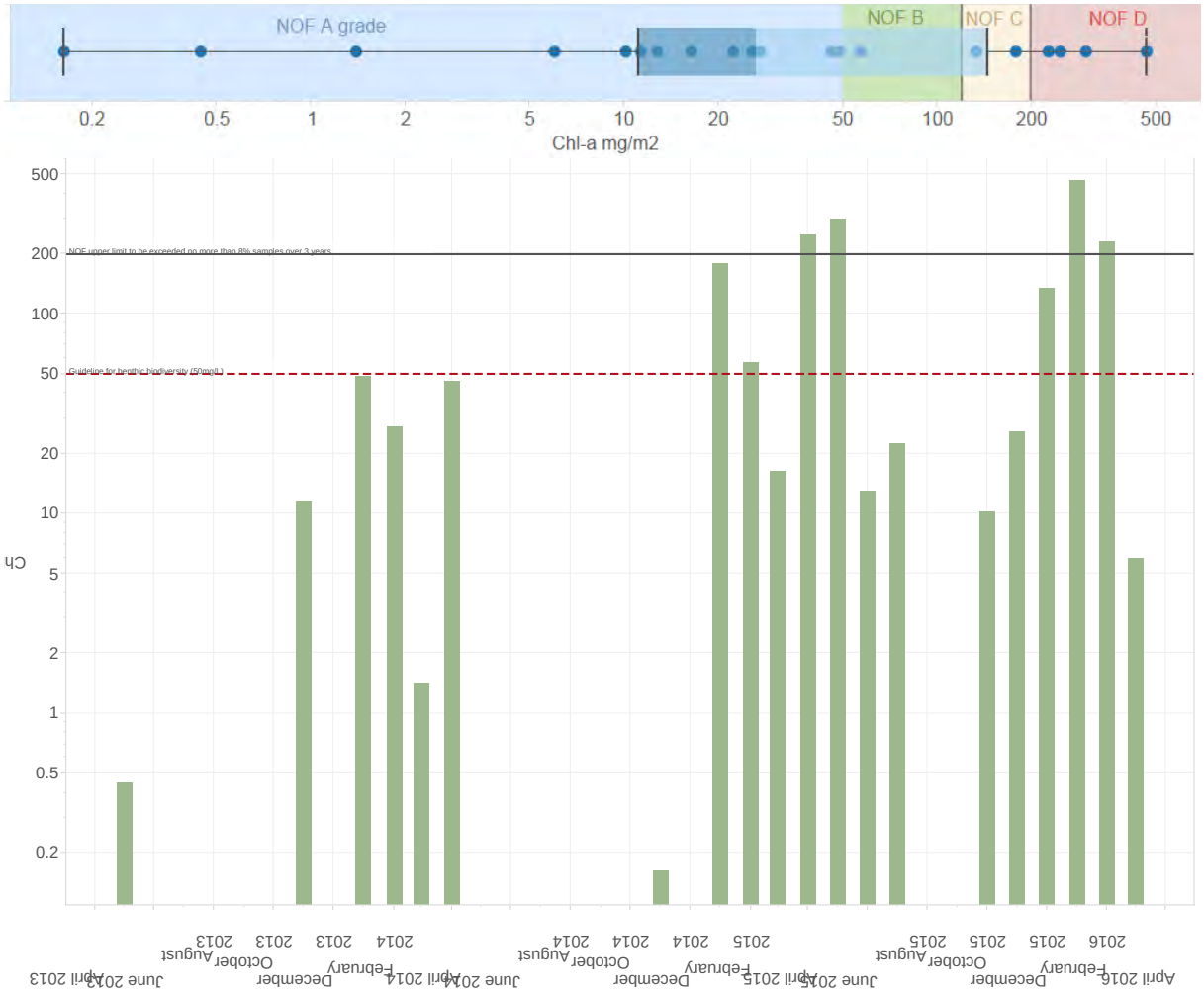

Figure 12: Chlorophyll a results (May 2013 to May 2016) at Waiharakeke at Stringers Road water quality site with corresponding boxplot with NOF grades. The C grade can be exceeded on no more than two occasions within three years.

The NOF standard for periphyton recommend at least three years of data to complete and interpret periphyton results. A maximum value of 200mg Chl a/m^2 can be exceeded on no more than two occasions within three years of monthly monitoring. Data currently available (April 2013 to May 2016)

for the Waiharakeke site indicate the site is prone to periphyton blooms and fails the NOF bottom line with two exceedances recorded in 2015 (April and May) and two in 2016 (January and February) (Figure 12).

Monthly results (Figure 12) indicate that blooms at the Waiharakeke site tended to occur in summer and autumn months. This coincides with elevated levels for nutrients that are the main drivers for periphyton growth, i.e. nitrogen and phosphorous. Phosphorous levels in the form of dissolved reactive phosphorous were elevated at this site with highest results recorded in summer and autumn (Figure 10). Although nitrogen levels – in the form of ammoniacal nitrogen and nitrate nitrogen – were generally low at the Waiharakeke at Stringers Road site, highest levels were also reached at this time of the year. This suggests that nitrogen may be a limiting nutrient in the catchment. In summer and autumn, a slight elevation of nitrogen levels combined with elevated dissolved reactive phosphorous background levels and warm temperatures are sufficient to initiate periphyton blooms resulting in chlorophyll a levels exceeding the NOF standard.

2.3.3 Water clarity

Good water clarity is important for light availability for periphyton growth, the primary food resource for stream life. 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.

There is currently no national standard for turbidity in the NOF. However, median annual turbidity levels recorded at the Waiharakeke site from January 2006 to December 2015 did not meet ANZECC guidelines for lowland rivers (5.6NTU) for most years with the exception of 2006, 2010 and 2015 (Figure 14).

Median turbidity levels recorded during the Otiria Stream catchment investigation (January 2009 to December 2011) and at the Waiharakeke at Stringers Road site during the same period were also elevated (Figure 14). All but one site, Orauta at Ngapipito Road, recorded turbidity levels exceeding the ANZECC guideline value for lowland rivers (5.6NTU). Results indicate that turbidity levels generally increased from upstream to downstream sites with the lowest median turbidity recorded at Orauta at Ngapipito Road (4.85NTU), and the highest at Waiharakeke at Stringers Road (8.65NTU). Elevated turbidity levels recorded at the Orauta at Pine forest site in 2011 are likely to be linked to forestry activity.

Rivers surrounded by pristine native forested catchments can also release elevated sediment loads following heavy rain, being a combination of sediment washed into the river from surrounding land and sediment re-suspension from the river bed due to the increased flows and streambank erosion. However, activities such as intensive agriculture, forestry harvesting and land subdivision, combined with a lack of riparian vegetation and/or stock access to waterways, generally generate additional sediment loads in catchments where human activities are present. Good land management practices such as stock exclusion, riparian planting, setbacks, and sediment control in forestry harvesting can help mitigate such impacts on waterways.

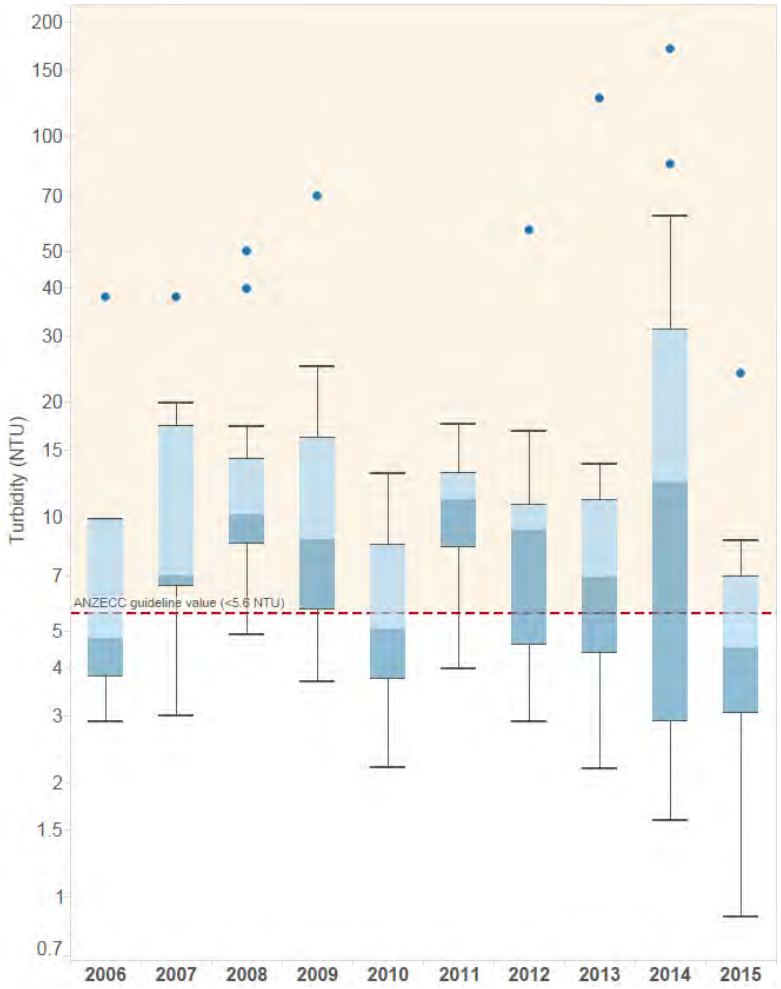

Figure 13: Annual turbidity results at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) with and ANZECC guideline value.

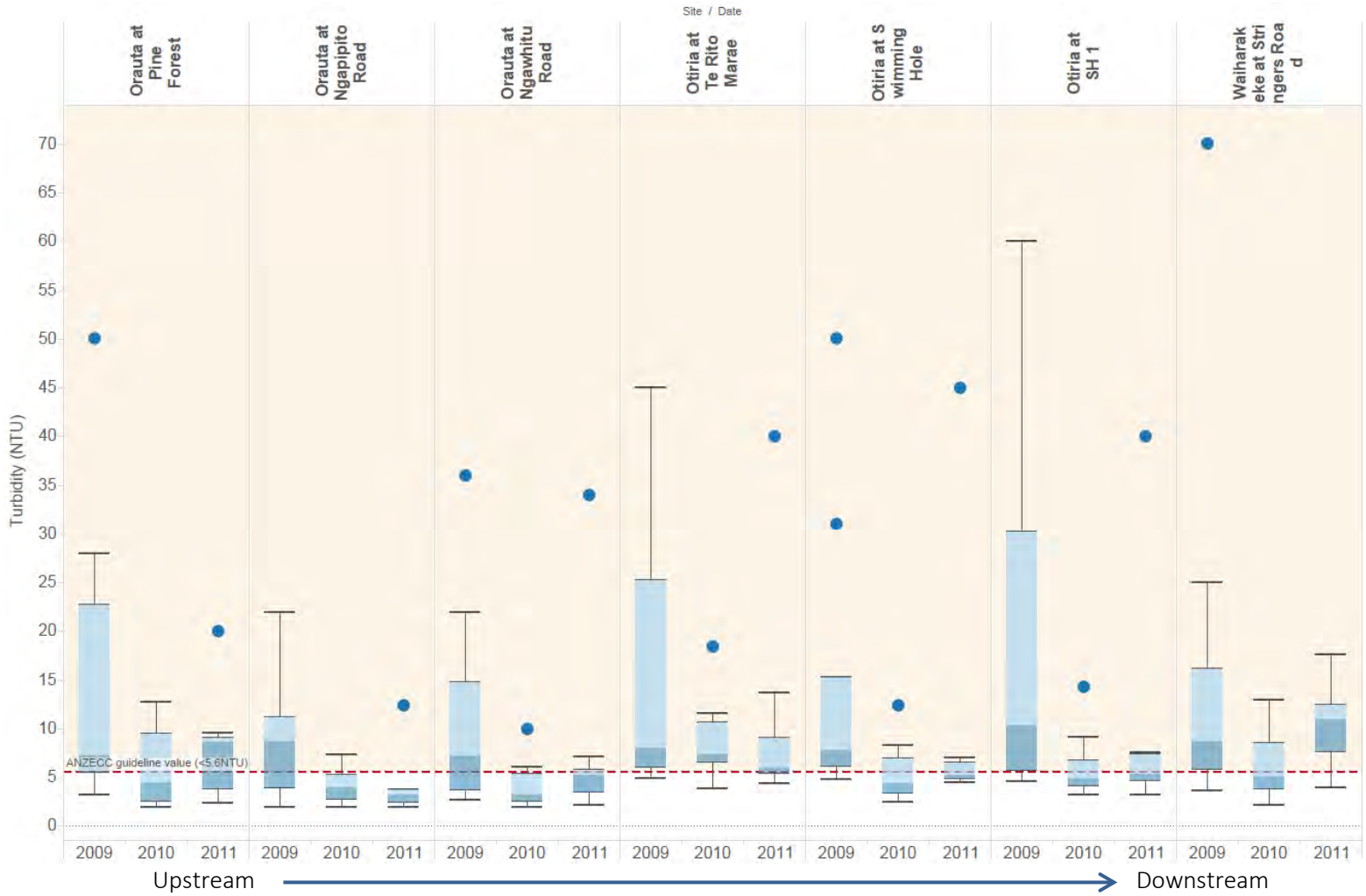

Figure 14: Annual turbidity results in the Otiria Stream catchment and Waiharakeke at Stringers Road water quality sites (August 2008 to December 2011) with ANZECC guideline value.

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 bacterium *E. coli* indicates contamination from faecal matter which can potentially contain harmful pathogens. Median *E. coli* levels recorded at the Waiharakeke at Stringers Road site (Figure 15, left) met NOF standard for secondary contact recreation (activities involving occasional immersion such as wading, boating, etc.) with a C grade in 2006 and a B grade for all subsequent years between 2007 and 2015. However *E. coli* levels were highly variable with elevated levels recorded, extending to the NOF D grade in five of the 10 years of sampling. At these levels people are exposed to a high risk of infection (greater than 5% risk) from contact with water. Microbial source tracking results indicate that the primary source of contamination within the catchment was ruminant with human markers also detected.

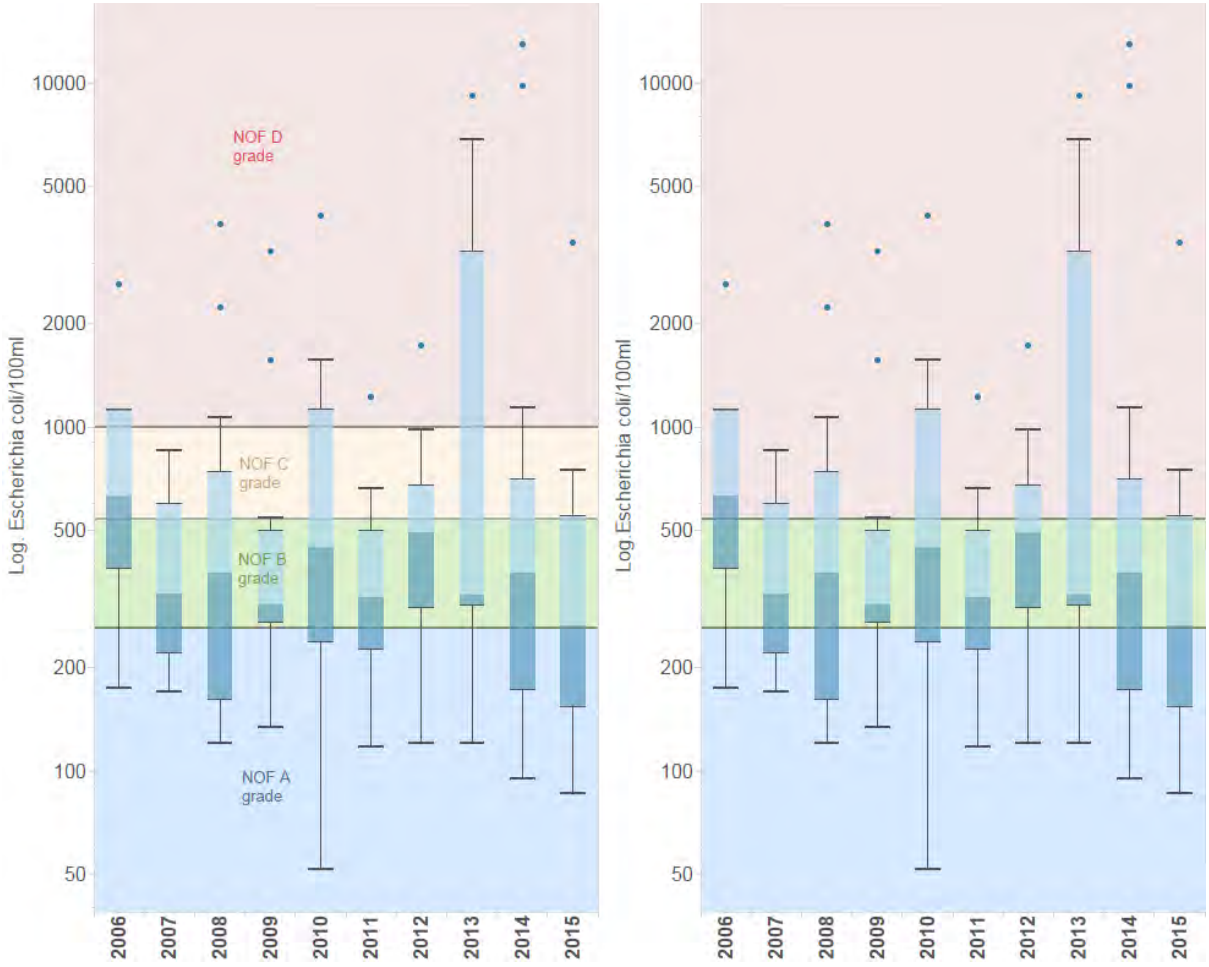

Figure 15: Annual *E. coli* levels at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) with NOF grades for secondary contact recreation (left) and primary contact recreation (right) (whiskers denote 95th percentile value).

The NOF standard for recreational swimming (primary contact recreation involving full immersion) has a limit of 540 *E. coli*/100mL for the annual 95th percentile. Where *E. coli* levels are below 540 *E. coli*/100mL it is considered that people have a low risk of infection when undertaking activities likely to involve full immersion. The Waiharakeke at Stringers Road site did not meet this standard in any year between 2006 and 2015 (
Figure 15, right).

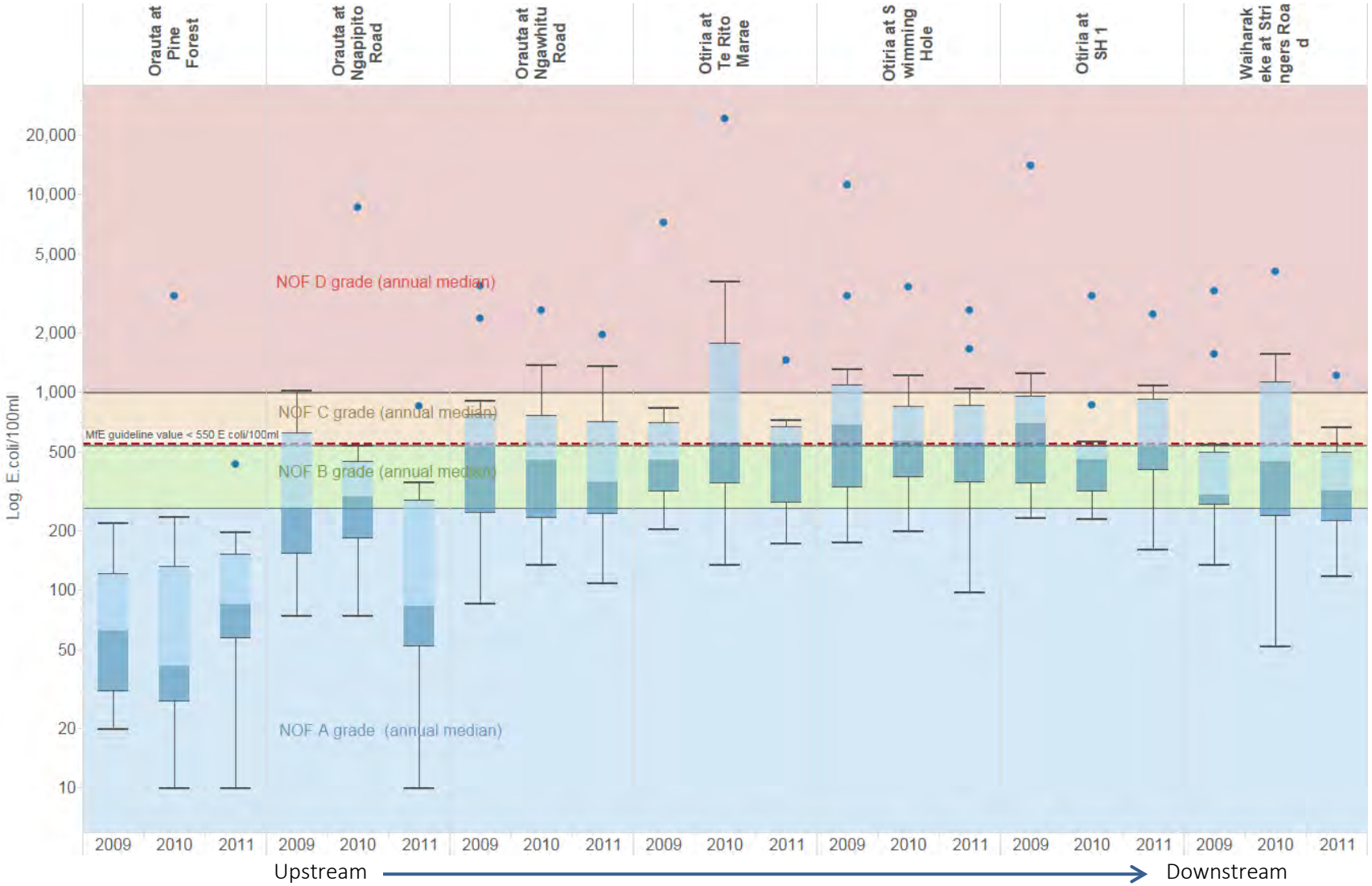

Figure 16: Annual *E. coli* results in the Otiria Stream catchment and Waiharakeke at Stringers Road water quality sites (January 2009 to December 2011) with NOF grades for secondary contact recreation (whiskers denote 95th percentile value) and ANZECC guideline value.

Annual median *E. coli* levels recorded during the Otiria Stream catchment investigation (January 2009 to December 2011) and at the Waiharakeke site during the same period (
Figure 16) were also predominantly in the NOF B grade for secondary contact recreation. The exceptions are the reference site at Pine Forest which consistently recorded *E. coli* levels in the NOF A grade and the Otiria at Swimming Hole which consistently recorded *E. coli* levels in the NOF C grade. The only site meeting the NOF standard for recreational swimming at all times was the reference site at Pine Forest.

It should be noted that natural background *E. coli* levels tend to be slightly more elevated in warm wet lowland areas compared to other river environments in New Zealand (McDowell et al, 2013). Nevertheless *E. coli* levels recorded indicate a substantial increase downstream from the reference site at the Orauta at Pine Forest site. This highlights anthropogenic influences in the catchment and the need for good land management and sewage disposal systems in protecting both waterways and the receiving marine environment.

2.3.1 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). In a slow flowing unshaded stream containing macrophytes (aquatic plants), there are likely to be large fluctuations in dissolved oxygen throughout the day compared to streams which are fast flowing within a shaded forested catchment (Figure 17).

Median dissolved oxygen levels recorded between January 2006 and December 2015 at the Waiharakeke at Stringers Road site were all above the RMA 1991 trigger value (≥80 % saturation). The lowest median dissolved oxygen level was recorded in 2010, a year when drought was declared twice, from January to May and then again in December (Metservice annual climate summary 2010). The largest fluctuations in dissolved oxygen levels were also recorded in 2010 from a low 50.5 to a high of 115.3 percent saturation. When water levels in a stream become very low temperatures increase and nutrients tend to become more concentrated creating ideal conditions for algal/macrophyte blooms and eutrophication. This often results in an increase in biological oxygen demand which can drive greater fluctuations in dissolved oxygen levels than under normal conditions.

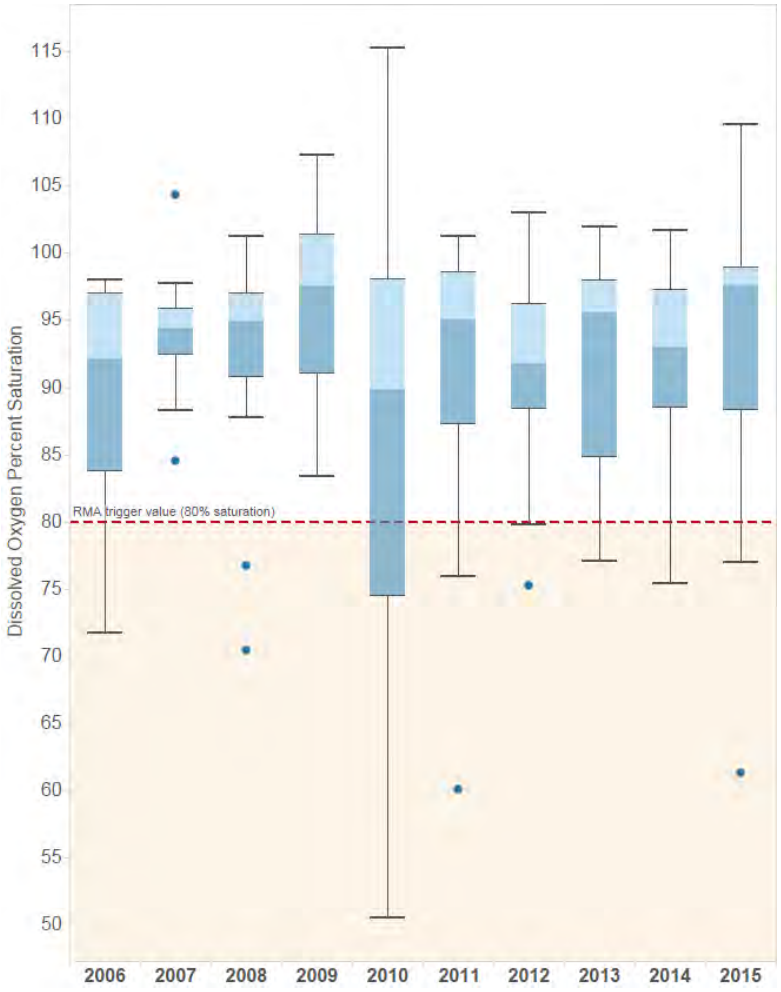

Figure 17: Dissolved oxygen at Waiharakeke at Stringers Road water quality site (January 2006 to December 2015) and RMA 1991 trigger value.

Annual median dissolved oxygen levels recorded during the Otiria Stream catchment investigation (January 2009 to December 2011) and at the Waiharakeke at Stringers Road site during the same period were above the RMA 1991 trigger value with the exception of the Orauta at Pine Forest site in 2010 (Figure 18).

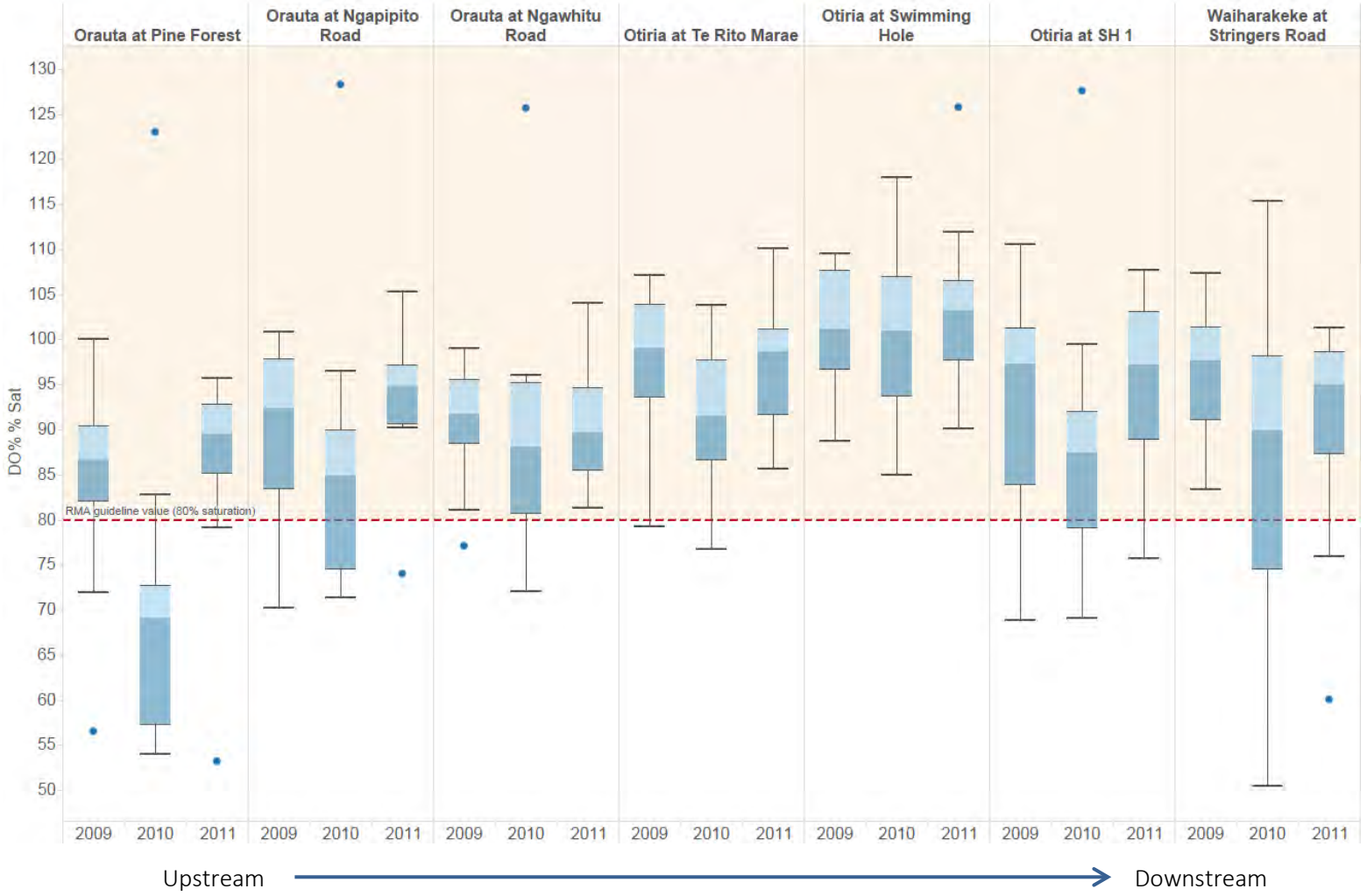

Figure 18: Annual median dissolved oxygen results in the Otiria Stream catchment and Waiharakeke at Stringers Road water quality sites (January 2009 to December 2011) with RMA 1991 trigger value.

2.3.2 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/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 taxa present, with categories in Table 4 used to determine the overall water quality level.

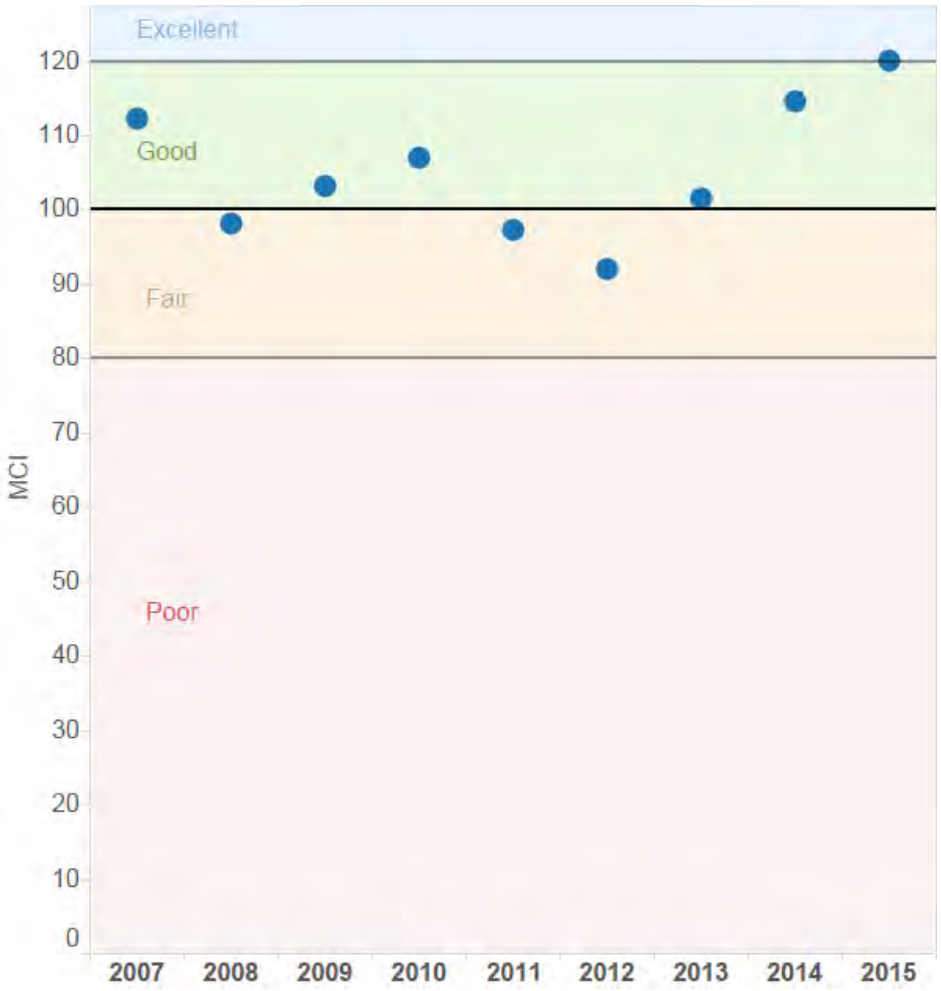

Figure 19: Macroinvertebrate Community Index (MCI) results for Waiharakeke at Stringers Road site from 2007 to 2015.

Table 4: Macroinvertebrates Community Index (MCI) 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

Macroinvertebrate sampling has been undertaken every summer at the Waiharakeke at Stringers Road site since 2007 (Figure 19). The site generally scored in the range of 100 to 120 indicating good water quality/possible mild pollution but sometimes dips below this to fair water quality/possible moderate pollution. In 2015 the MCI scored excellent water quality for the first time with a score of 120. No macroinvertebrate sampling was undertaken during the Otiria Stream catchment investigation.

2.3.3 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 (that is to say spend part of their life cycle at sea) so their presence is influenced by factors such as barriers to migration, distance inland as well as habitat availability, water quality, etc. However 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.

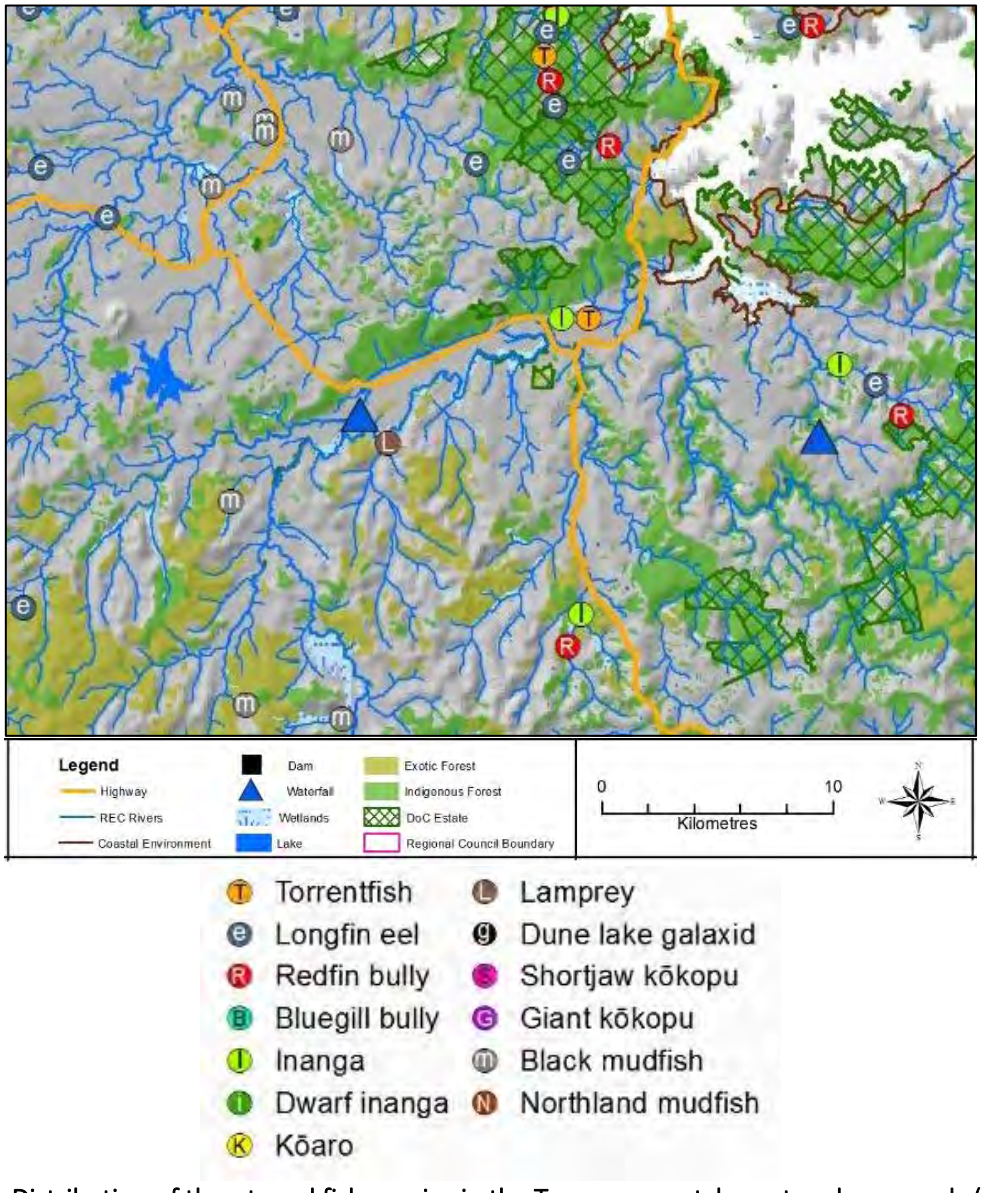

Figure 20: Distribution of threatened fish species in the Taumarere catchment and surrounds (McArthur and Beveridge, 2015).

To date nine native fish species as well as two pest fish species (catfish and gambusia) have been recorded in the Taumarere/Kawakawa catchment (Figure 20). Native species include several at risk or threatened species such as black mudfish, lamprey, longfin eel, inanga, torrent fish and redfin bully indicating high ecological value within the Taumarere catchment.

2.3.4 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 biodiversity. 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.

The rapid habitat assessment measures a number of key parameters to assess human impacts on stream biological condition (Clapcott 2015). In Figure 21 the Waiharakeke at Stringers Road site is compared to a reference site draining indigenous forest, the Waipapa at Forest Ranger. The habitat assessment data indicate that the Waiharakeke site compared favourably to the reference site. Despite its location in a pastoral catchment it features a fair amount of shade, with a degree of riparian shading of both native and exotic trees, and offers a number of habitats for both fish and invertebrates with instream debris, over hanging vegetation, etc. The site also recorded high scores for macroinvertebrate habitat and fish cover but lower scores for other attributes such as bank stability, bank vegetation and riparian buffer. The overall good habitat recorded at the site was also reflected by the relatively good MCI scores (Figure 19).

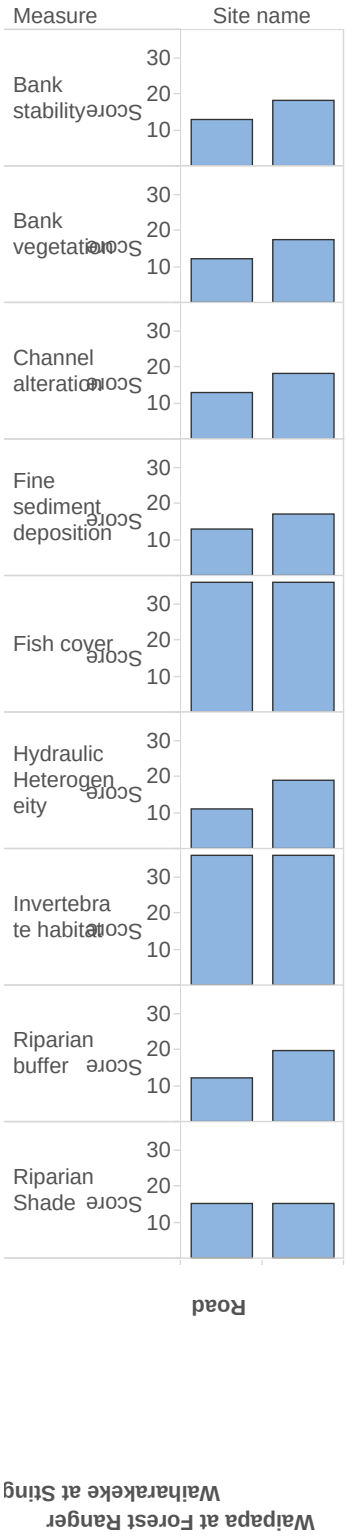

Figure 21: Rapid habitat results for Waiharakeke at Stringers Road compared to reference condition (Waipapa at Forest Ranger) in 2015.

2.4 Waiharakeke River NOF results 2006 to 2015

NOF grades from 2006 to 2014 at the RWQMN site Waiharakeke at Stringers Road are presented in Table 5. Water quality results recorded at the site were, with the exception of one year, consistently within the NOF A grades for nitrate nitrogen toxicity and NOF A or B grades for ammoniacal nitrogen. For secondary contact recreation *E. coli* results were within the NOF B grade for all years with the exception of the first year of sampling in 2006 where results were within the NOF C grade. Regular chlorophyll a sampling did not begin until April 2013. Three years of chlorophyll a data are required to calculate a NOF grade. Data recorded from April 2013 to April 2016 were within the NOF D grade, indicating periphyton blooms may be an issue at the Waiharakeke at Stringers Road site. Due to elevated levels of dissolved reactive phosphorous recorded at the site (Figure 9), nitrogen is likely to be a limiting nutrient and therefore small increases in nitrogen levels may be enough to trigger a periphyton bloom under stable flows.

Table 5: NOF grades from 2006 to 2015 at the Waiharakeke at Stringers Road site. (ND = no data)

Value	Ecosystem health										Human health	
Indicator (unit)	Nitrate nitrogen toxicity (mg/L)				Ammoniacal nitrogen toxicity (mg/L)				Periphyton (Chla mg/m^2)		*E. coli* (*E. coli*/100 mL)	
Year	1 year median		1 year 95%ile		1 year median		1 year max		3 year max		1 year median (secondary contact)	
2006	0.073	A	0.156	A	0.0090	A	0.0155	A	ND	ND	631	C
2007	0.082	A	0.094	A	0.0068	A	0.0345	A	ND	ND	329	B
2008	0.172	A	0.202	A	0.0112	A	0.0733	B	ND	ND	376	B
2009	0.136	A	0.272	A	0.0067	A	0.0248	A	ND	ND	304	B
2010	0.145	A	0.490	B	0.0050	A	0.0250	A	ND	ND	448	B
2011	0.122	A	0.180	A	0.0101	A	0.0469	A	ND	ND	320	B
2012	0.085	A	0.180	A	0.0093	A	0.0201	A	ND	ND	497	B
2013	0.120	A	0.270	A	0.101	A	0.1529	B	ND	ND	327	B
2014	0.115	A	0.260	A	0.0131	A	0.0702	B	ND	ND	379	B
2015	0.150	A	0.190	A	0.0091	A	0.2805	B	466.3	D	265	B

3 Water Quality Summary

Table 6: Water quality summary (January 2009 to December 2011) for sites in the Otiria Stream catchment and Waiharakeke at Stringers Road water quality sites using NOF attributes. (*=Unable to be pH adjusted as pH was not measured, ND = no data).

Water quality monitoring site	National Objective Framework (NOF) attributes						
	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/m²)
	Annual median A ≤1 B >1≤2.4 C >2.4≤6.9 D >6.9	95th percentile A ≤1.5 B >1.5 ≤3.5 C >3.5≤9.8 D >9.8	Annual median A ≤0.03 B .0.3≤0.24 C .0.24≤1.3 D.1.3	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	Annual 95th percentile A ≤260 B >260≤540 D >540	Chlorophyll a A ≤50 B >50≤120 C >120≤200 D >200
Orauta at Pine Forest							
2009	ND	ND	A	A*	A	A	ND
2010	ND	ND	A	A*	A	A	ND
2011	ND	ND	A	A*	A	A	ND
Orauta at Ngapipito Road							
2009	ND	ND	A	A*	B	D	ND
2010	ND	ND	A	A*	B	C	ND
2011	ND	ND	A	A*	A	B	ND
Orauta at Ngawhitu Road							
2009	ND	ND	A	A*	B	C	ND
2010	ND	ND	A	A*	B	D	ND
2011	ND	ND	A	A*	B	D	ND
Otiria at Te Rito Marae							
2009	ND	ND	A	A*	B	C	ND
2010	ND	ND	A	B*	C	D	ND
2011	ND	ND	A	A*	C	C	ND
Otiria at Swimming Hole							
2009	ND	ND	A	A*	C	D	ND
2010	ND	ND	A	A*	C	D	ND
2011	ND	ND	A	A*	C	D	ND
Otiria at SH1							
2009	ND	ND	A	A*	C	D	ND
2010	ND	ND	A	A*	B	C	ND
2011	ND	ND	A	B*	B	D	ND
Waiharakeke at Stringers Road	ND	ND					
2009	A	A	A	B	B	C	ND
2010	A	B	A	B	B	D	ND
2011	A	A	A	B	B	C	D

Table 7: Water quality summary (January 2009 to December 2011) for sites in the Otiria Stream catchment and Waiharakeke at Stringers Road water quality sites using national guideline/trigger values. (ND = no data)

Water quality monitoring site	ANZECC guidelines				RMA 1991	MfE 2003 aesthetics/recreation	Ecological indicators
	Nitrate, nitrite, nitrogen (mg/L)	Ammoniacal nitrogen (mg/L)	Dissolved reactive phosphorus (mg/L)	Turbidity (NTU)	Dissolved oxygen (% saturation)	*Escherichia coli* /100ml	*Macro-invertebrates*
	Annual median <0.444	Annual median <0.021	Annual median <0.01	Annual median <5.6	Annual median ≥80	Annual median >550	MCI score (Table 4)
Orauta at Pine Forest							
2009	ND	Below	Below	Above	Above	Below	ND
2010	ND	Below	Below	Below	Below	Below	ND
2011	ND	Below	Below	Below	Above	Below	ND
Orauta at Ngapipito Road							
2009	ND	Above	Below	Above	Above	Below	ND
2010	ND	Below	Below	Below	Above	Below	ND
2011	ND	Below	Below	Below	Above	Below	ND
Orauta at Ngawhitu Road							
2009	ND	Below	Above	Above	Above	Below	ND
2010	ND	Below	Below	Below	Above	Below	ND
2011	ND	Below	Below	Below	Above	Below	ND
Otiria at Te Rito Marae							
2009	ND	Below	Above	Above	Above	Below	ND
2010	ND	Above	Above	Above	Above	Above	ND
2011	ND	Below	Below	Below	Above	Below	ND
Otiria at Swimming Hole							
2009	ND	Below	Above	Above	Above	Above	ND
2010	ND	Below	Above	Below	Above	Above	ND
2011	ND	Below	Below	Below	Above	Above	ND
Otiria at SH1							
2009	ND	Below	Above	Above	Above	Above	ND
2010	ND	Below	Above	Below	Above	Below	ND
2011	ND	Below	Below	Below	Above	Below	ND
Waiharakeke at Stringers Road							
2009	Below	Below	Above	Above	Above	Below	Good
2010	Below	Below	Below	Below	Above	Below	Good
2011	Below	Below	Above	Above	Above	Below	Fair

Values in Table 6 and
Table 7 provide a summary of water quality/ecological health in the Taumarere catchment. The tables are not directly comparable as Table 6 refers to national standards (NOF) while Table 7 provides conservative numbers for physical and chemical measures in rivers to indicate which aquatic ecosystems may be exposed to stress using national guidelines and/or trigger values. The NOF is still under development, with a number of additional attributes currently being evaluated and, in its current form, does not address all the water quality issues of concern in Northland. For this reason other guidelines, trigger values and ecological indicators have been included to provide a more holistic overview of water quality in the catchment.

Without a targeted monitoring programme and monitoring sites limited to the north west of the Taumarere catchment (Figure 1) it is difficult to accurately assess water quality in the entire catchment. However results indicate that the main water quality issues in the Taumarere catchment include:

- Overall elevated phosphorous, sediment (turbidity) and *E. coli* levels within the catchment.
- Elevated ammoniacal nitrogen and *E. coli* levels at the Otiria at Te Rito Marae site which may indicate contamination by septic tank systems/poor land management practices.
- Elevated ammoniacal nitrogen levels at the Orauta at Ngapipito Road site.
- Elevated dissolved reactive phosphorous levels in the catchment. The most upstream site, Orauta at Pine Forest, draining foresty recorded the lowest annual median levels, which were below ANZECC guidelines. In contrast, between January 2006 and December 2015, the long-term monitoring site Waiharakeke at Stringers Road located in the lower part of the catchment, recorded median levels above the ANZECC guidelines for all years except 2010.
- *E. coli* levels recorded in the Otiria Stream catchment indicated degradation from the upstream site Orauta at Pine Forest, with results consistently within the NOF A grade for recreational swimming, to all other lower sites in the catchment consistently not meeting the NOF bottom line for recreational swimming (primary contact recreation).
- Of particular concern are the elevated E. coli levels at the Otiria at Swimming Hole site. Faecal source tracking shows mainly contamination from ruminants with some human markers.
- Elevated nitrogen levels in summer and autumn against high background levels of dissolved reactive phosphorous were enough to trigger significant periphyton blooms at the Waiharakeke at Stringers Road site, having an adverse effect on aquatic ecosystem health.

4 References

Australian and New Zealand Environment and Conservation Council, 2000, *Australian and New Zealand guidelines for fresh and marine water quality*. Volume 1.ANZECC: Canberra.

Boothroyd, I. K. G., Stark, J. D., 2000, *Use of Invertebrates in Monitoring*. In: K. C. Collier and M. J. Winterbourn, (eds). New Zealand Stream Invertebrates: Ecology and Implications for Management. New Zealand Limnological Society, Hamilton. Pp. 344-373.

LAWA (Land Air Water Aotearoa) website: http://www.lawa.org.nz/learn/factsheets/faecal-indicators/

McArthur, K.; Beveridge, A., 2015, *Freshwater Native Fish in Northland, Conservation status, critical habitat requirements and recommendations for management*. The Catalyst Group, Report No. 2015/036. 66p

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.

Ministry for the Environment, 2014, *National Policy Statement for Freshwater Management 2014*. Wellington: New Zealand.

Northland Regional Council, 2008. *Review of water quality information for Otiria Stream, Moerewa.* Northland Regional Council, Whāngārei, New Zealand.

Northland Regional Council, 2011, *Otiria Catchment Water Quality Summary Report February 2012.* Northland Regional Council, Whāngārei, New Zealand.

Northland Regional Council, 2012, *River Water Quality and Ecology 2007-2011*, Northland Regional Council: Northland Regional Council, Whāngārei, New Zealand.

Stark, J. D.; Boothroyd, I. K. G; Harding, J. S.; Maxted, J. R.; Scarsbrook, M. R., 2001, *Protocols for sampling macroinvertebrates in wadeable streams*. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

5 Abbreviations

- ANZECC: Australian and New Zealand Environment and Conservation Council
- Chl a: chlorophyll a
- 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
- TN: Total Nitrogen
- TP: Total Phosphorus
- TURB: Turbidity
- WNW: Waiora Northland Water

6 Appendix

Figure 22: Orauta at Pine Forest

Figure 23: Orauta at Ngawhitu Road

Figure 24: Otiria at Te Rito Marae

Figure 25: Otiria at Swimming Hole

Figure 26: Otiria at SH1

Figure 27: Waiharakeke at Stringers Road