# Focus Catchments water quality update 2021

Bay of Plenty Regional Council
Environmental Publication 2021/10

Prepared by (He mea whakarite nā)
Malea Zygadlo (Environmental Scientist), Lauren Mahon (Environmental Science Support), and Rochelle Carter (Principal Advisor, Science)

Approved for Issue by (Kua Whakaaetia Kia Tāngia nā)
Rob Donald (Science Manager)

5 Quay Street
P O Box 364
Whakatāne
NEW ZEALAND

ISSN: 1175-9372 (Print)
ISSN: 1179-9471 (Online)

# Update record

| Reviewer | Description of change | Date | Version |
|---|---|---|---|
| Rochelle Carter | Reviewed for final content and structure | 16 July 2021 | 3.12 |
| Rob Donald | Reviewed and approved for publication | 23 July 2021 | 4.0 |

# Acknowledgements (He mihi)

Thanks must go to Bay of Plenty Regional Council (BOPRC)/Toi Moana Land Management Officers and Data Services Team who collected environmental data over the last summer. This report and the recommendations in it would not have been possible without this valuable information.

Bay of Plenty Regional Council's Laboratory Team processed and analysed all the water quality samples and our thanks go to them for their dedication. Staff from Data Services and Science teams provided timely information and responses to queries. Their patience is appreciated in the development of this report.

Of course, gratitude must be expressed for landowners and tāngata whenua who allowed access to many sampling sites on private properties.

Supportive and constructive feedback was given by Rochelle Carter which ensured the information was helpful and relevant to the Land Management Teams and the community.

We also wish to thank the document specialists at Toi Moana for their professionalism editing and formatting this report.

# Executive summary (Whakarāpopototanga Matua)

The Focus Catchments programme was developed in response to Bay of Plenty Regional Council's new Key Performance Indicator to improve swimmability in the Long Term Plan 2018-2028, and to better align land management work programmes with the emerging Essential Freshwater policy framework from the Ministry for the Environment. Several water quality investigations were requested and actioned in 2018-2020 to accurately identify catchment-specific issues and develop appropriate actions to achieve environmental enhancement, and these investigations were reported in Mahon et al. (2020)[1].

This report provides updates on the recommended monitoring from Mahon et al. (2020) to answer specific questions and further advise/support land management activities for the Coastal Catchment Team. The targeted monitoring regimes undertaken as a result of the recommendations made, provided useful information specific to the concern, and in many cases have addressed the original request or concern. As a result, the recommendations made in this report are fewer than previously. Key recommendations made here include:

- Investigating actions for reducing upper catchment contamination and examining results to come in the Kaiate Falls Catchment.
- Implementing land management actions directed by the results in Te Mania and Kopuaroa catchments.
- Continue monitoring on the Otangimoana River in the Upper Rangitaiki Catchment.

This report provides an update on Focus Catchments where the recommendations made in Mahon et al. (2020) were carried out. The remaining Focus Catchments are either reported separately or do not have sufficient new data to be reported on here.

[1] *Mahon, L., Zygadlo, M., Carter, R., Crawshaw, J., & Dare, J. (2020). Focus Catchments Water Quality 2020/Te Kounga Wai O Ngā Kurawai E Arotahia Ana. Bay of Plenty Regional Council Environmental Publication 2020/04.*

# Contents (Ngā Rārangi Take)

# Glossary (Kuputaka)

**A440** - Colour Absorbance Coefficient at 440nm is a measure of yellow substance in the water.

**Ammoniacal-N** – Ammoniacal-Nitrogen covers two forms of nitrogen: ammonia ($NH_3$) and ammonium ($NH_4$).

**ANZECC** – Australian and New Zealand Environment and Conservation Council. Author of the Australian and New Zealand Guidelines (ANZG) for Fresh & Marine Water Quality (2018)[2] with ARMCANZ. ANZG – Australian and New Zealand Guidelines for Fresh & Marine Water Quality, produced by ANZECC & ARMCANZ (2018)[2].

Aquatic Macrophytes are major plants in waterways, such as aquatic ferns, mosses, water-lily and weeds. They represent a stable habitat in rivers and lakes, providing for fish and invertebrates. Many exotic macrophytes have been introduced to New Zealand and these have had major impacts on both river and lake ecosystems throughout the country. Aquatic macrophytes obtain nutrients from the water column, limiting nutrients available to fish.

**ARMCANZ** - Agriculture and Resource Management Council of Australia and New Zealand. Author of the Australian and New Zealand Guidelines for Fresh & Marine Water Quality (ANZG) (2018)[2] with ANZECC.

**Attribute** – a measurable characteristic (numeric, narrative, or both) that can be used to assess the extent to which a particular value is provided for.

**Biophysical class** - a biophysical classification for water quality in the Bay of Plenty based on the dominant catchment geology and upstream catchment slope. The biophysical classification is comprised of three classes: Non-Volcanic, Volcanic+Steep (VA Steep) and Volcanic+Gentle (VA Gentle). The advantage of the biophysical classification approach is that it is valid across the region, as it is based on the premise that geology and slope are the proximate driving variables influencing both water quality and ecology[3].

**BOP IBI** – Bay of Plenty Index of Biotic Integrity. This is a Bay of Plenty–specific biological metric to quantify the ecological health of a stream. It is a “summary” index that uses macroinvertebrate indices (e.g. EPT richness, % worms, % snails) and shows how different each site is to that of reference sites under natural, or “least disturbed” conditions.

Conductivity is an indirect measure of charged particles in water. Conductivity is commonly used to indicate the total dissolved solids in water. The more dissolved salts in the water the higher the conductivity.

**DGV** – Default Guideline Values for physical and chemical stressors are values used to compare the state of water quality attributes to the expected values in reference ecosystems. Reference conditions are defined as the chemical and physical conditions that can be expected in rivers and streams with minimal or no anthropogenic influence[2].

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[2] *ANZECC & ARMCANZ. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. https://www.waterquality.gov.au/anz-guidelines/guideline-values/default*

[3] *Snelder, T., Fraser, C., & Suren, A. (2016). Defining Freshwater Management Units for the Bay of Plenty Region. Land Water People, Client Report 2016-001, Lyttleton, New Zealand.*

**DO** - Dissolved Oxygen is the measure of the concentration of oxygen dissolved in the water. Aquatic life depend on oxygen to breathe, but this nutrient decreases with the growth of other nutrients and algae in the waterway.

**DIN** - Dissolved Inorganic Nitrogen is the sum of nitrate, nitrite and ammonia.

**DRP** - Dissolved Reactive Phosphorus is a measure of the dissolved phosphorus compounds that are readily available for use by plants and algae.

**DWQ** - Drain Water Quality is any canal or drain (other than MEV) that is part of a land drainage scheme identified in Schedule 5 of the Regional Natural Resources Plan (RNRP). Excludes privately owned drains.

***E. coli*** – *Escherichia coli* is a bacteria commonly found in the guts and faeces of warm-blooded mammals (including people) and birds. People can get sick if they drink, gather shellfish from, or swim in water that has high levels of *E. coli*. Common sources of *E. coli* bacteria are animal waste from farm stock and water fowl, storm water run-off and sewerage leaks.

Enterococci is a bacteria that occurs naturally in the gut of humans and animals, including mammals, birds, fish, and reptiles.

Epifauna/macrofauna – Animals living on the surface of the sea bed (e.g. shellfish, worms, crabs and isopods). Macrofauna are the larger animals retained by >0.5mm mesh sieves.

**EPT** – the number and percentage of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxa in a sample.

**Fish IBI** – Fish Index of Biotic Integrity is the sum of 12 metrics which describe aspects of the freshwater fish community in relation to elevation and distance to the sea, to produce a single index score. This Fish IBI score is associated with an integrity class (Excellent; Good; Moderate; Poor; No fish) which can be used to assess overall stream health based on the presence of fish at a site (Suren, 2016)[4].

**LUC** – The Land Use Capability is a classification system of the suitability of land to long term sustained production.

**MEV** - Modified waterways with Ecosystem Values are modified watercourses that are part of land drainage schemes that provide aquatic habitats or migratory pathways for indigenous fish species.

**MCI** – Macroinvertebrate Community Index. A biological metric based on the presence or absence of invertebrates in a stream to assess stream ecological health. The MCI classifies stream health into four classes (Excellent; Good; Fair; Poor).

**MWQG** – New Zealand Microbial Water Quality Guidelines.

**N** - Nitrogen is an essential nutrient for plant growth that occurs naturally in rivers. High concentrations of Nitrogen stimulates excessive algae growth, which deteriorate river habitats and can be toxic to aquatic life.

**NERMN** – The Bay of Plenty Regional Councils' Natural Environment Regional Monitoring Network. Fulfils the statutory requirement of local government under the Resource Management

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*[4] Suren, A. (2016). Development of a Fish Index of Biotic Integrity for the Bay of Plenty. Bay of Plenty Regional Council Environmental Publication 2016/11.*

Act (1991) to monitor and report on the State of the Environment, and to provide scientifically defensible information on the physical, chemical and biological characteristics of the natural resources of the Bay of Plenty region to assist in the preparation of BOPRC policies and plans, and monitoring of the effectiveness of such plans and policies.

**NNN** - Nitrate Nitrite Nitrogen is a combination of nitrate nitrogen ($NO_3^-$) and nitrite nitrogen ($NO_2^-$).

Periphyton is the slime and algae found on the bed of streams and rivers. They are a fundamental part of river ecosystems and are highly responsive to degradation of water quality.

pH indicates the level of acidity and alkalinity on a logarithmic scale of 0 to 14, with low numbers being acidic and high numbers basic. Extreme pH causes harm to fish and invertebrates.

**QMCI** – Quantitative Macroinvertebrate Community Index. A biological metric using relative abundance of stream invertebrates to quantify the ecological health of a stream. This metric is more sensitive to changes in the relative abundance of stream taxa than the MCI.

**RBL** - Regional Base Line refers to rivers and streams that have not otherwise been classified as Natural State (River), Natural State (Lake), Managed State (Lakes), Aquatic Ecosystem (Bay of Plenty), Contact Recreation, Water Supply, DWQ or MEV in the Regional Natural Resources Plan (RNRP).

**REC** – River Environment Classification. The REC was developed by NIWA for MfE to provide a spatial framework for regional scale environmental monitoring and reporting, environmental assessment and management.

**TN** - Total Nitrogen is the sum of all organic and inorganic forms of nitrogen that are found in a water sample (i.e., nitrate-nitrogen ($NO_3$-N), nitrite-nitrogen ($NO_2$-N), Ammoniacal-nitrogen ($NH_4$-N) and organic nitrogen such as amino acids or plant tissue. High Total Nitrogen can be a cause of eutrophication in lakes, estuaries and coastal waters and can cause algal blooms.

**TP** – Total Phosphorus is a measure of all forms of Phosphorus that are found in a sample, including dissolved and particulate, organic and inorganic. High levels of Total Phosphorus in water can come from either wastewater or run-off from agricultural land. Too much Phosphorus can encourage the growth of nuisance plants such as algal blooms.

**TSS** - Total Suspended Solids are particles of silt, clay, or organic matter suspended in a water. They affect invertebrate food quality and cause sedimentation of streams and estuaries. Hill country or stream bank erosion is a key contributor, often caused by stock traffic that loosen the soil in those sensitive areas. Soil type in a catchment affects the amount of suspended sediment. The faster a stream flows, the more suspended solids it can transport. When fine particles settle in slower-moving downstream areas, the spaces between rocks and gravel are filled making the bottom habitat unsuitable for fish and other aquatic species. Suspended solids can also impact on ecosystem health by reducing light penetration or clogging gills.

**WMA** – Water Management Areas defined by BOPRC to give practical geographic areas for delivering on the requirements of the National Policy Statement for Freshwater Management (NPSFM) requirements across the region.

# 1 Introduction (Kupu Whakataki)

## 1.1 Focus Catchment programme

The Focus Catchments programme was developed in response to Bay of Plenty Regional Council's new Key Performance Indicator to improve swimmability in the Long Term Plan 2018-2028, and to better align land management work programmes with the emerging Essential Freshwater policy framework from the Ministry for the Environment. Several water quality investigations were implemented between 2018-2020 to accurately identify catchment-specific issues and develop appropriate actions to achieve environmental enhancement, and these investigations were reported in Mahon et al. (2020)[5]. Land management actions and follow up monitoring programmes were recommended in that report and the outcomes of the subsequent water quality investigations are provided in this report.

## 1.2 Purpose of this report (Take)

This report provides updates on the recommended monitoring from Mahon et al. (2020) to answer specific questions and further advise/support land management activities for the Coastal Catchment Team.

Scientific monitoring recommendations of Mahon et al. (2020)

- Repeat summer monitoring in the Kaiate Falls Catchment to monitor the impact of stock removal and riparian protection.
- Investigate low dissolved oxygen levels in Te Mania, Kopuaroa and Upper Rangitāiki catchments.
- Investigate increasing (worsening) total suspended solids trends in Ōhiwa Catchment.
- Investigate elevated Ammoniacal-N and dissolved reactive phosphorus in Te Mania Catchment.
- Complete load estimates for Ammoniacal-N, *E. coli* and TSS in Te Mania Catchment.
- Erosion assessments and turbidity monitoring on the Rangitāiki River.

## 1.3 Structure of this report (Te Hanganga o te Pūrongo)

The structure of this report is similar to that used in Mahon et al. (2020), as the intended audience, use and purpose is the same.

Part 2 provides an overview of the consistent methodologies used for all the Focus Catchments in this report. This information is relevant for all remaining sections in the report unless specified otherwise. Chapters 3-7 provide results and further recommendations for each of the Focus Catchments, which required further study (see above). Chapters 3-7 are all structured in the same way including: summary of key points; summarising the catchment and key issues; reporting recent monitoring results; discussing findings and implications for management of that Focus Catchment; and

[5] *Mahon, L., Zygadlo, M., Carter, R., Crawshaw, J., & Dare, J. (2020). Focus Catchments Water Quality 2020/Te Kounga Wai O Ngā Kurawai E Arotahia Ana. Bay of Plenty Regional Council Environmental Publication 2020/04.*

making recommendations for future monitoring if required, and areas to focus land management activities on. Appendices are attached at the end of each chapter that contain individual site reports including summary statistics, and other data where applicable. Chapter 8 summarises the recommendations made for each reported Focus Catchment.

# 2 Methodology (Huarahi)

## 2.1 Water quality data collection/Te Kohikohinga Raraunga Kounga Wai

Bay of Plenty Regional Council's Coastal Catchment Land Management Team, Science, and Laboratory and Data Services staff carried out sample collection.

Physical attributes (water temperature, dissolved oxygen and conductivity) were recorded on hand-held water quality meters.

Water samples were stored on ice until transported to the laboratory. Samples were processed for the parameters specified in Table 2.1, to meet the aims of each catchment monitoring programme.

It should be noted that these samples are spot samples taken at inconsistent times of day, which does not capture the diurnal variation in physical attributes such as temperature, pH and dissolved oxygen. Additionally, sampling limited to a short time period does not represent the established seasonal variation seen in some catchments for some attributes.

Supplementary environmental/climate data was sourced where needed, to complete data cleansing and catchment rainfall and/or flow analysis from the nearest Natural Environment Regional Monitoring Network (NERMN) site with rainfall and/or flow monitoring. Approximate rainfall accumulations associated with sampling dates were viewed in Aquarius.

## 2.2 Lab analyses/Ngā Tātari Taiwhanga

Analyses were performed by the Bay of Plenty Regional Council Laboratory. Table 2.1 details the methods used for chemical/biological analysis of water samples.

*Table 2.1 Laboratory methods used for analyses of chemical and biological parameters in water samples*

| Parameter | Method | Detection Limit/Units |
|---|---|---|
| Ammonium Nitrogen (NH4-N) | APHA 4500-NH3 H (modified) by Flow Injection Analyser | 0.002 $g/m^3$ |
| Nitrate-Nitrite-Nitrogen (NNN) | APHA 4500-NO3- I (modified) by Flow Injection Analyser | 0.001 $g/m^3$ |
| Total Nitrogen (TN) | APHA 4500-P J (modified) by Flow Injection Analyser | 0.01 $g/m^3$ |
| Dissolved Reactive Phosphorus (DRP) | APHA 4500-P G by Flow Injection Analyser | 0.001 $g/m^3$ |
| Total Phosphorus (TP) | APHA 4500-P J by Flow Injection Analyser | 0.001 $g/m^3$ |
| Turbidity | APHA 2130 B (modified) by white light turbidity meter | 0.1 NTU |
| pH | APHA method 4500-H+ measurement at 25° C. | 0.1 |
| Conductivity | APHA Method 2510B | 1 µS/cm at 25°C |
| Total Suspended Solids (TSS) | APHA 2540 D dried at 103-105°C | 1 $g/m^3$ |
| Water Clarity (Transmissivity) | C-Star Transmissometer | 0.18 m |
| *Escherichia coli (E.coli)* | APHA 9213D by membrane filtration (mTEC agar) | 1 cfu/100mL |

## 2.3 Statistical analysis/Huarahi

RStudio was used to create summary statistics and graphical representations of water quality data for all Focus Catchment chapters. Specific statistics are detailed in each catchments chapter.

## 2.4 Comparisons to previous research and freshwater guidelines/Huarahi

The catchment median of each attribute was calculated for simple catchment-scale comparison to guidelines and previous research. Where water quality investigations sampled tributaries across the catchment (to investigate spatial variation of water quality), the site median was calculated for each attribute to enable comparison between tributaries.

Water quality results from Focus Catchments, which have NERMN water quality monitoring sites, were compared to median values for the appropriate biophysical class (adopted from Hamill et al., 2020)[6]. This provides context for results to similar sites in the Bay of Plenty. The Te Mania and Upper Rangitāiki Focus Catchments are in the VA Gentle biophysical classes (VA Gentle median), while Ōhiwa and Waitao catchments are in the VA Steep biophysical class (VA Steep median).

Site medians were compared to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) Default Guideline Values (DGV's) for physical and chemical stressors. These guidelines were established based on reference sites throughout New Zealand in different River Environment Classifications (REC). Reference conditions are determined from locations where there is minimal or no anthropogenic influence. Depending on the stressor, there are two different percentiles that are determined for the DGV:

- The 80th percentile for those physical and chemical stressors that are harmful at high values (e.g. nitrate, Ammoniacal-N, phosphorus, TSS).
- The 20th percentile for those that are harmful at low values (e.g. dissolved oxygen, water clarity).

The DGV's for the warm wet low elevation REC, which include Te Mania, Ōhiwa, Kaiate and Kopuaroa Focus Catchments, and the cool wet hill REC (Upper Rangitāiki Focus Catchment) are given in Table 2.2 and Table 2.3 below.

*Table 2.2 ANZG physical and chemical stressor Default Guideline Values for warm wet low elevation REC class (ANZECC & ARMCANZ, 2018)[7].*

| Parameter | ANZG DGV threshold | Value |
|---|---|---|
| Conductivity | 80th percentile | 115 µS/cm |
| Dissolved Oxygen | 20th percentile | 92% |
| pH | 20th percentile | 7.26 |
| Total Nitrogen | 80th percentile | 0.292 $g/m^3$ |

[6] *Hamill, K. Dare, J. and Gladwin, J. (2020). River Water Quality State and Trends in the Bay of Plenty to 2018: Part A. Publication prepared for the Bay of Plenty Regional Council. River Lake Ltd, Whakatāne, New Zealand.*

[7] *ANZECC & ARMCANZ. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. https://www.waterquality.gov.au/anz-guidelines/guideline-values/default*

| Parameter | ANZG DGV threshold | Value |
|---|---|---|
| Ammoniacal Nitrogen | 80th percentile | 0.01 $g/m^3$ |
| Nitrite Nitrate Nitrogen | 80th percentile | 0.065 $g/m^3$ |
| Total Phosphorus | 80th percentile | 0.024 $g/m^3$ |
| Dissolved Reactive Phosphorus | 80th percentile | 0.014 $g/m^3$ |
| Total Suspended Solids | 80th percentile | 8.8 $g/m^3$ |
| Turbidity | 80th percentile | 5.2 NTU |
| Water Clarity | 20th percentile | 0.8 m |

*Table 2.3 ANZG physical and chemical stressor Default Guideline Values for cool wet hill REC class (ANZECC & ARMCANZ, 2018) [8].*

| Parameter | ANZG DGV threshold | Value |
|---|---|---|
| Conductivity | 80th percentile | 95 µS/cm |
| Dissolved Oxygen | 20th percentile | 86% |
| pH | 20th percentile | 7.35 |
| Total Nitrogen | 80th percentile | 0.238 $g/m^3$ |
| Ammoniacal Nitrogen | 80th percentile | 0.006 $g/m^3$ |
| Nitrite Nitrate Nitrogen | 80th percentile | 0.087 $g/m^3$ |
| Total Phosphorus | 80th percentile | 0.016 $g/m^3$ |
| Dissolved Reactive Phosphorus | 80th percentile | 0.008 $g/m^3$ |
| Total Suspended Solids | 80th percentile | 2.6 $g/m^3$ |
| Turbidity | 80th percentile | 2.4 NTU |
| Water Clarity | 20th percentile | 1.6 m |

These are not toxicity thresholds, rather they are where 80% of reference sites within this REC fall below (or above for dissolved oxygen and water clarity) this value. So values higher (worse) (or lower(worse) for dissolved oxygen and water clarity) than the DGV indicate that there is ‘potential risk’ of adverse effects at that site and triggers the need for further investigation. It is stressed that these are the ‘default’ guideline values of reference condition sites, and most of the sites monitored are highly modified environments. Whist the DGVs are provided here as an indication of what the sites would have been like with minimal human impact, using local data should be favoured and this has been achieved by comparing to long-term regional water quality monitoring where appropriate data was available.

To give some context around the *E. coli* concentrations in all Focus Catchment monitoring, the *E. coli* results were compared to the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MWQG) (MfE, 2003)[9]. Whilst it is acknowledged that some sites sampled are drains and therefore not used for

[8] *ANZECC & ARMCANZ. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. https://www.waterquality.gov.au/anz-guidelines/guideline-values/default*

[9] *Ministry for the Environment. (2003). Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Publication reference number ME474.*

swimming, this comparison simply provides an indication of what healthy recreational contact conditions are.

*Table 2.4 Threshold values and implications for health of the Microbiological Water Quality Guidelines for Freshwater Recreational Areas (MfE, 2003)[9].*

| MWQG Threshold | Numerical value | Implication |
|---|---|---|
| Acceptable | <260 cfu/100 mL | Safe for swimming |
| Alert | 260-550 cfu/100 mL | Caution advised |
| Action | >550 cfu/100 mL | Unsafe for swimming |

# 3 Kaiate Falls, Tauranga

## 3.1 Summary (Whakarāpopototanga Matua)

- The Otawera Sub-catchment remains the main source of *E. coli* contamination.
- Within the Otawera Sub-catchment, the Owairoa tributary has the highest bacterial loading.
- Partnering with iwi to investigate and manage the contamination source in the Owairoa sub-catchment is recommended.

## 3.2 Introduction (Kupu Whakataki)

Kaiate Falls is a popular recreational reserve and swimming site in the Tauranga Harbour Catchment, and has been monitored as part of the Bay of Plenty recreational bathing programme since 2007. A permanent health warning has been in place at Kaiate Falls since 2015 due to bacterial (*E. coli*) contamination. There has been extensive research completed across this catchment since 2015, with the intention to identify sources of contamination to improve water quality and make Kaiate Falls swimmable again.

A number of Environmental Programmes have been agreed to and are in various stages of completion. The main objective of the plans are to remove stock from waterways and critical source areas while providing riparian buffer zones to prevent contamination entering Rangataua Bay.

## 3.3 Purpose (Take)

The aim of this chapter is to provide results of the 2020/2021 catchment water quality investigation. Following the recommendations of both Hudson (2019) and Mahon et al. (2020). The aims for the 2020/2021 water quality-monitoring programme in the Kaiate Catchment were to:

1 Strengthen the flow relationship between the ‘control’ monitoring site Owairoa off Waitao Road and the rated site at Kaiate Falls Road.

2 Monitor change particularly in the Otawera Sub-catchment as livestock have been removed and significant fencing/planting has occurred.

3 Update the *E. coli* load for each of the monitored sites.

## 3.4 Background (Kupu Whakamārama)

As summarised in Mahon et al. (2020), NERMN ecology monitoring in the Kaiate Catchment has shown macroinvertebrates are in a ‘very good’ state and there are minor improving trends. However, the historic state of water quality, in reference to swimming/recreational contact, has been poor, with the number of samples in the Action/Alert modes of the MWQG increasing (worsening) since 2014. During both the 2018/2019 and 2019/2020 bathing seasons, Kaiate Falls was in the “E” Attribute Band for *E. coli* in the NPS-FM (MfE, 2020). Faecal Source Tracking identified a dominant ruminant (majority cattle) source of *E. coli*, with avian bacteria also present. The most significant transport pathway of faecal bacteria was identified as direct deposition into streams, with overland flow in rainfall events also contributing. In 2019 and 2020, monitoring showed that the greatest proportion of bacterial contamination in the Kaiate Stream was from the Otawera Stream, specifically the Owairoa sub-catchment. Another site was added in the upper Owairoa Stream in 2019/2020, where eDNA results included possums and birds, in contrast to the lower Owairoa site which recorded eDNA of cattle and deer. The downstream increase in both *E. coli* concentrations and loads between these two sites indicated that a large proportion of the faecal contamination in the lower Otawera Stream was sourced between the upper and lower sites on the Owairoa tributary.

## 3.5 Methodology (Huarahi)

All field and sampling techniques, laboratory and data analyses followed standard BOPRC methods as outlined in Section 2. Site selection was the same as those used in Mahon et al. (2020) for the Kaiate catchment. Site locations are shown in Figure 3.1.

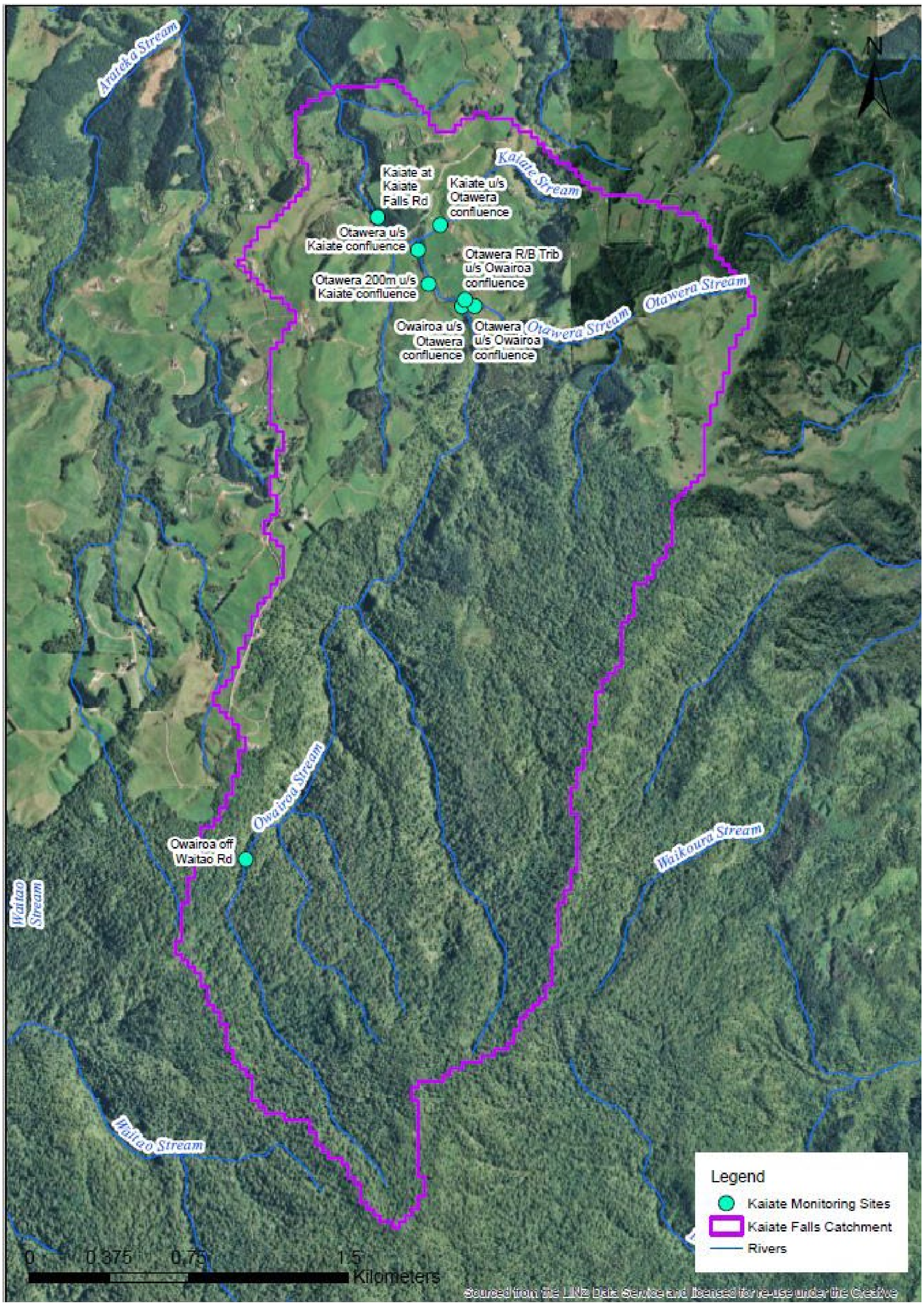



*Figure 3.1 Kaiate monitoring sites for the 2020/2021 monitoring season.*

### 3.5.1 Flow gauging

Flow measurements were carried out via wading gauging following the National Environmental Monitoring Standard for open channel flow measurement (NEMS, 2013) at three locations (Table 3.1). Flow relationships developed over 2019/2020 with the continuously rated Kaiate at Kaiate Falls site were utilised for the remaining sites.

*Table 3.1 Stream flow measurement methods for each sampling site in 2020/2021.*

| Site Name | Method of flow measurement |
|---|---|
| Kaiate at Kaiate Falls Road | Rating and wading gauging |
| Kaiate u/s Otawera confluence | Wading gauging |
| Otawera u/s Kaiate confluence | Flow relationship |
| Otawera 200m u/s Kaiate confluence | Equivalent to Otawera u/s Kaiate confluence |
| Otawera R/B Tributary u/s Owairoa confluence | Flow relationship |
| Otawera u/s Owairoa confluence | Flow relationship |
| Owairoa u/s Otawera confluence | Flow relationship |
| Owairoa off Waitao Road | Wading gauging |

### 3.5.2 Data cleansing

Conductivity and dissolved oxygen measurements were not recorded on 21 December 2020 due to a malfunctioning YSI handheld water quality meter. All results were reviewed, and no data was excluded from analysis.

### 3.5.3 Data analysis

Site and catchment medians for all water quality attributes were calculated. Comparisons to appropriate guidelines and previous research in the Waitao Catchment are made as detailed in Mahon et al. (2020). In addition to comparison against the MWQG, sites where sufficient data existed were compared to the *E. coli* attribute state bands in the NPS-FM (MfE, 2020).

The overall *E. coli* load was calculated by multiplying the *E. coli* concentration by the flow at the time of sampling. Site-specific flow relationships with the continuously rated Kaiate at Kaiate Falls Road site were investigated again for the sites that did not have strong enough relationships in previous seasons. Synthetic flow was generated for sites where the site-specific relationships were reliable. If a reliable relationship did not exist then data points without a gauging were not used in the load estimates.

## 3.6 Results 2020/2021 (Ngā Otinga 2020/2021)

### 3.6.1 Kaiate at Kaiate Falls Road - Bathing Season

During the 2020/2021 bathing season, *E. coli* measured at Kaiate Falls Road exceeded the Action threshold value in the MWQG, of 550 cfu/100 mL, 64% of the time (see Figure 3.2). This is a decrease on the 86% of samples over the Action threshold the previous summer monitoring period (2019/2020). Over the 2020/2021 summer, no samples were below the Acceptable threshold of 260 cfu/100 mL, while samples were above the Alert threshold 36% of the time. This is the first time no samples have been below the 'Safe' threshold of 260 cfu/100 ml. Kaiate Falls remains in the "E" attribute band in the NPS-FM

(Dare, *in prep*.).

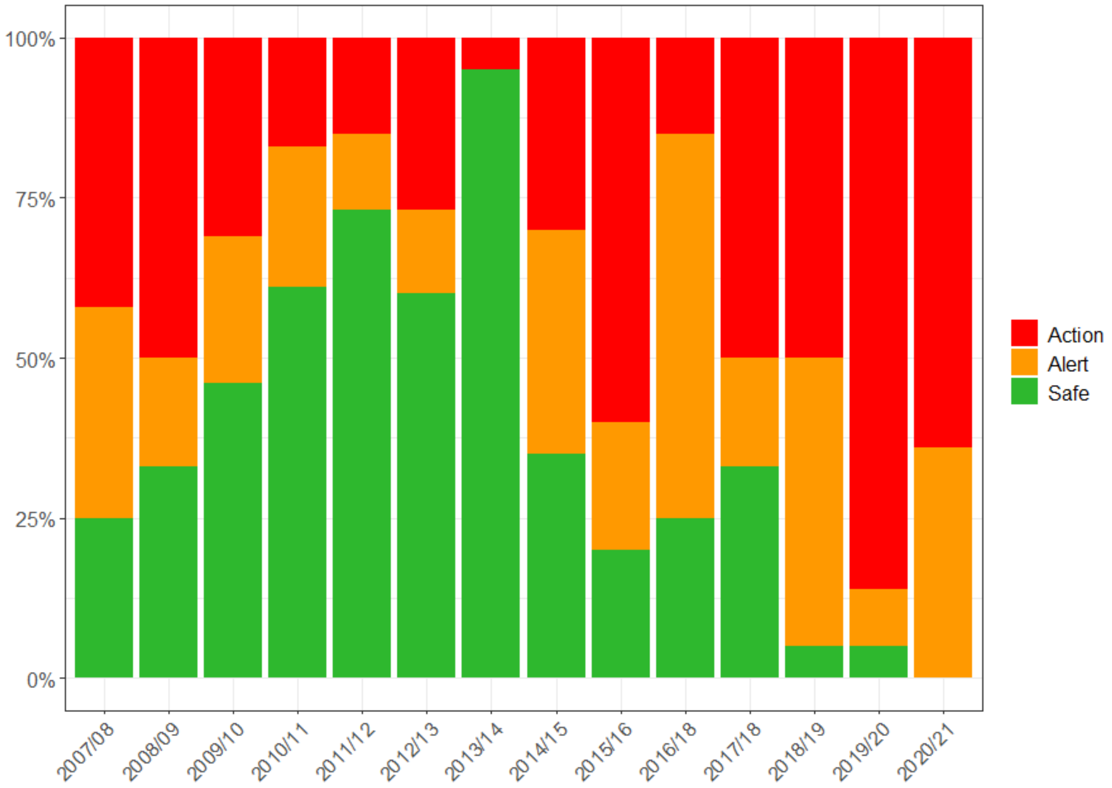



*Figure 3.2 Percentage of E. coli samples at Kaiate at Kaiate Falls Road within the MWQG thresholds, 2007-2021. The coloured bands illustrate the E. coli thresholds of the MWQG.*

### 3.6.2 Catchment results

Results for physical stream parameters were in line with previous results in the Kaiate Catchment. As expected the upper site in native forest (Owairoa off Waitao Road) had the lowest median conductivity, turbidity and temperature (Figures 3.3 and 3.4), in comparison to sites in the developed areas of the catchment downstream. Some elevated turbidity and *E. coli* concentrations were associated with a significant rainfall event in mid-February (see Figures 3.6 and 3.7). The median *E. coli* concentration across the catchment was 600 cfu/100 mL (see Figure 3.5), which was higher (worse) than results from 2019/2020 monitoring. This is consistent with 2019/2020 being a baseflow season (very little rainfall) and 2020/2021 having more rainfall events (Refer to Figure 3.7). The catchment median for *E. coli* in 2020/2021 was also higher (worse) than the VA Steep median, as would be expected given the established history of elevated faecal contamination in the Kaiate Sub-catchment.

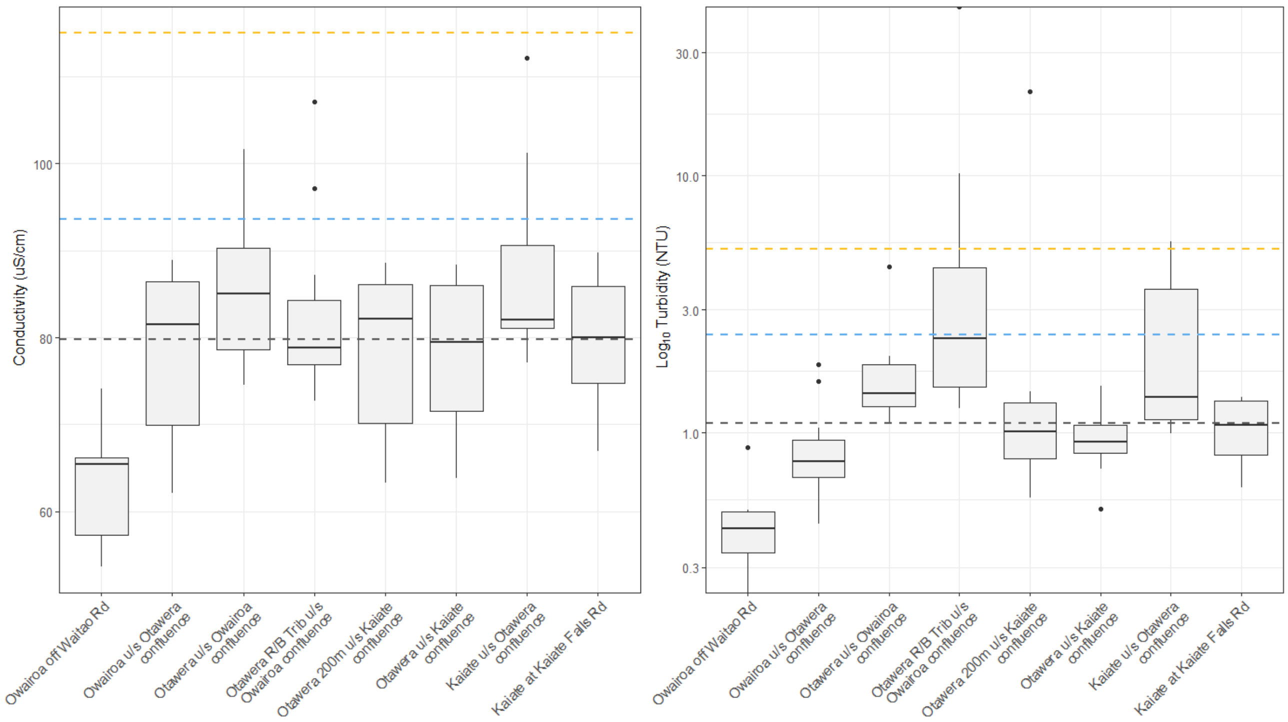



*Figure 3.3 Conductivity and Turbidity results in the Kaiate Falls Catchment, 2020/2021. Comparative values shown are the ANZG DGV (yellow), the VA Steep median (blue), and the catchment median 2020/2021 (grey).*

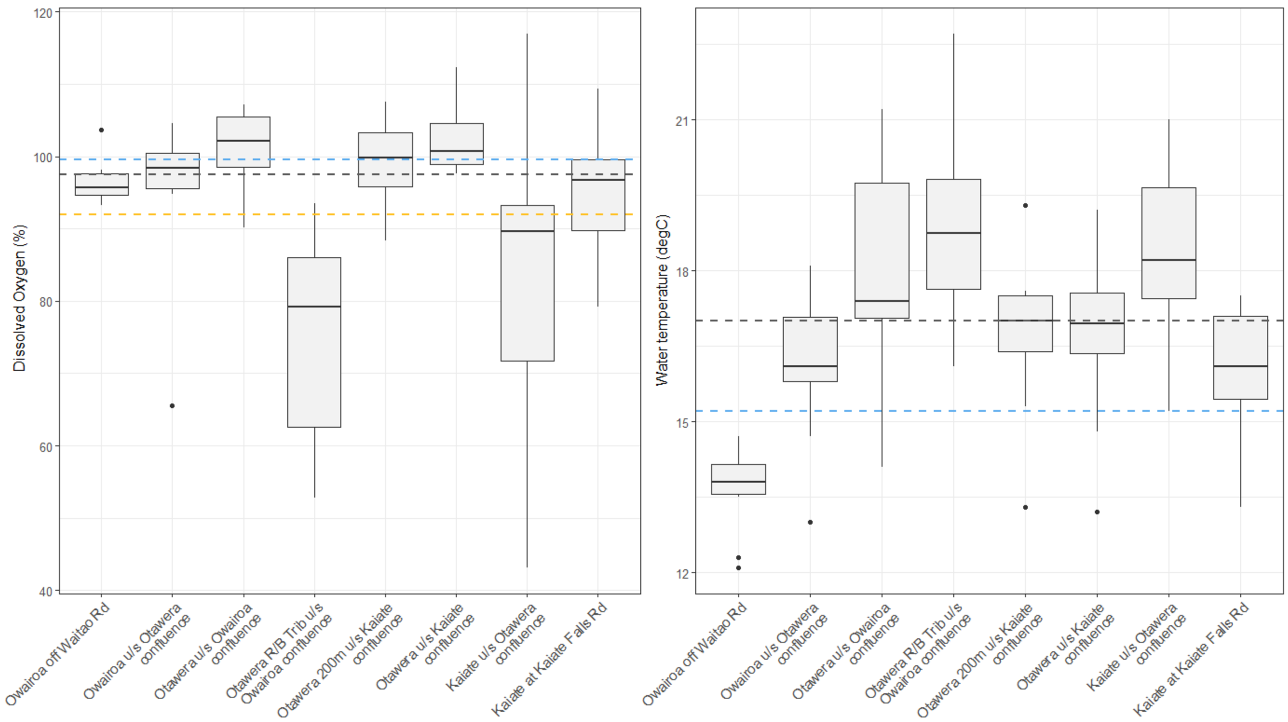



*Figure 3.4 Dissolved oxygen and water temperature results in the Kaiate Falls Catchment, 2020/2021. Comparative values shown are the ANZG DGV (yellow), the VA Steep median (blue), and the catchment median 2020/2021 (grey).*

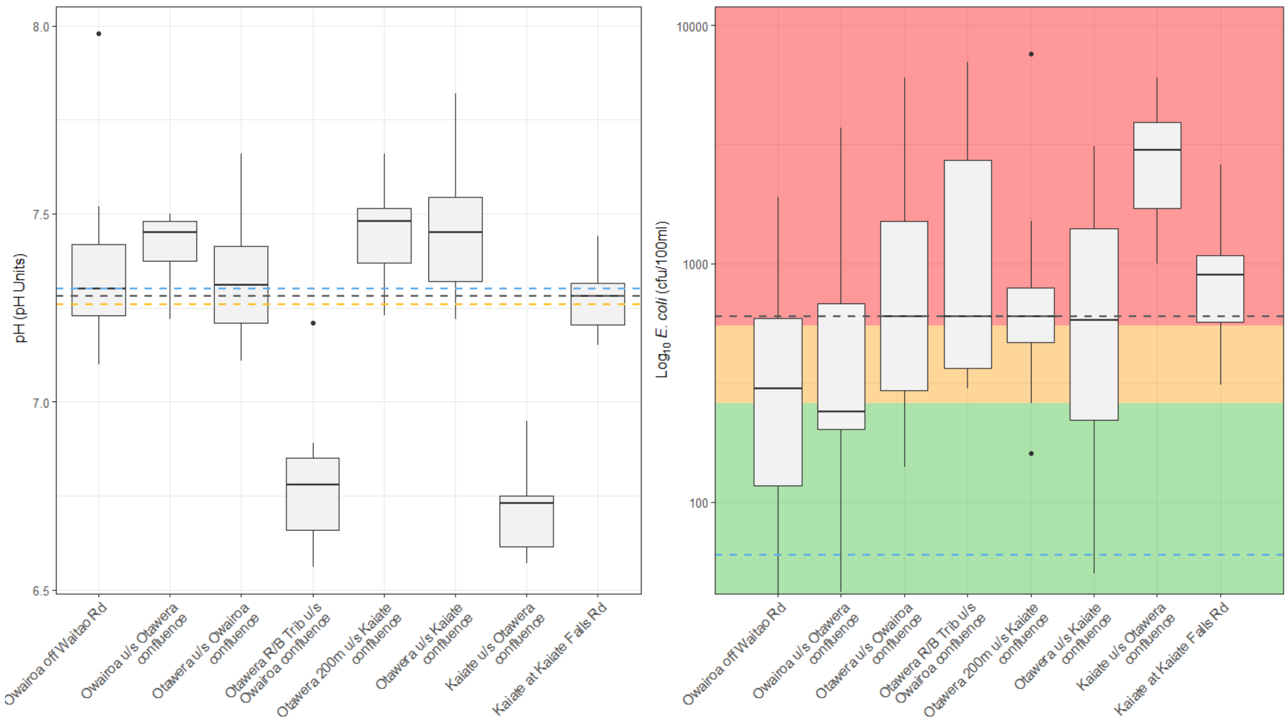



*Figure 3.5 pH and E. coli concentration results in the Kaiate Falls Catchment, 2020/2021. Comparative values shown are the ANZG DGV (yellow), the VA Steep median (blue), and the catchment median 2020/21 (grey). The coloured bands illustrate the E. coli thresholds of the MWQG.*

### 3.6.3 Rainfall and flow

There were four rainfall events 24 hours prior to sampling times over the 2020/2021 period, the most significant of which was 15 mm on 15 February 2021 (see Table 3.2). Daily rainfall over the monitoring season is shown in Figure 3.6.

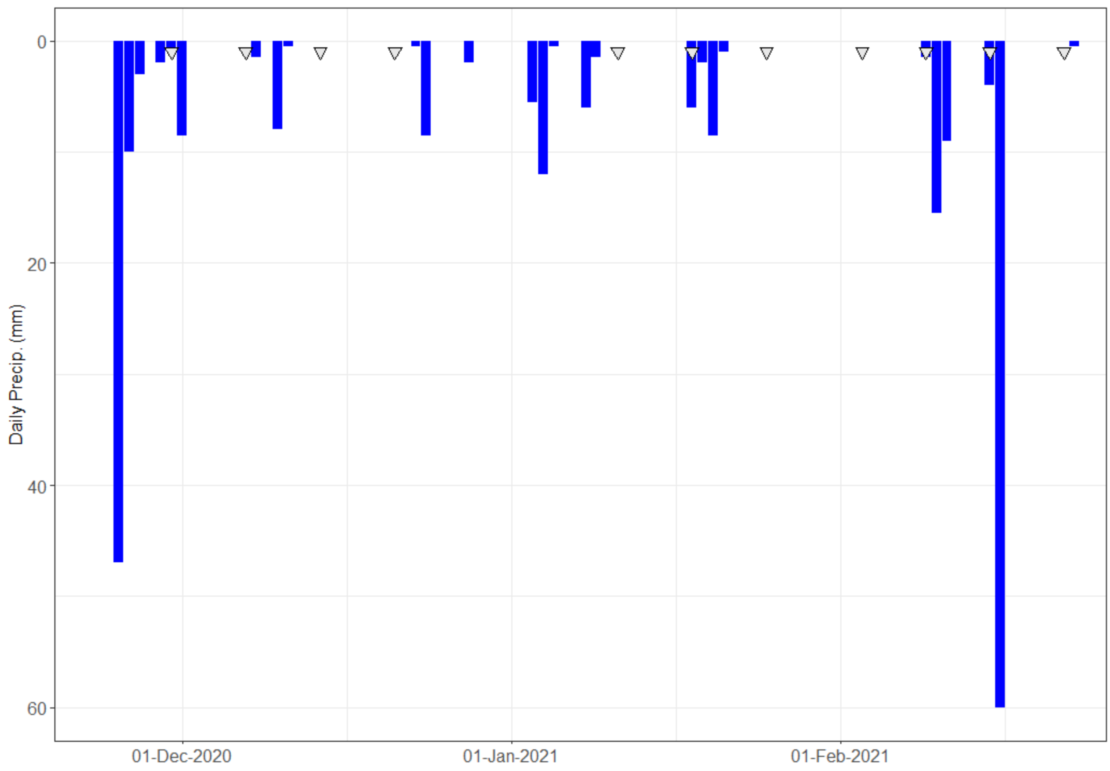



*Figure 3.6 Daily rainfall at Waimapu at McCarrols between 19 November 2020 and 26 February 2021. Sample days indicated by triangles.*

The water level recorder based at Kaiate Falls Road provides the most accurate information as to whether rainfall has generated overland flow, and subsequently increased the water level in the Kaiate Stream. The flow in the Kaiate Stream over three monitoring periods is shown in Figure 3.7. The recent monitoring period shows variable flows that are on average in between the 2018/2019 and 2019/2020 monitoring periods.

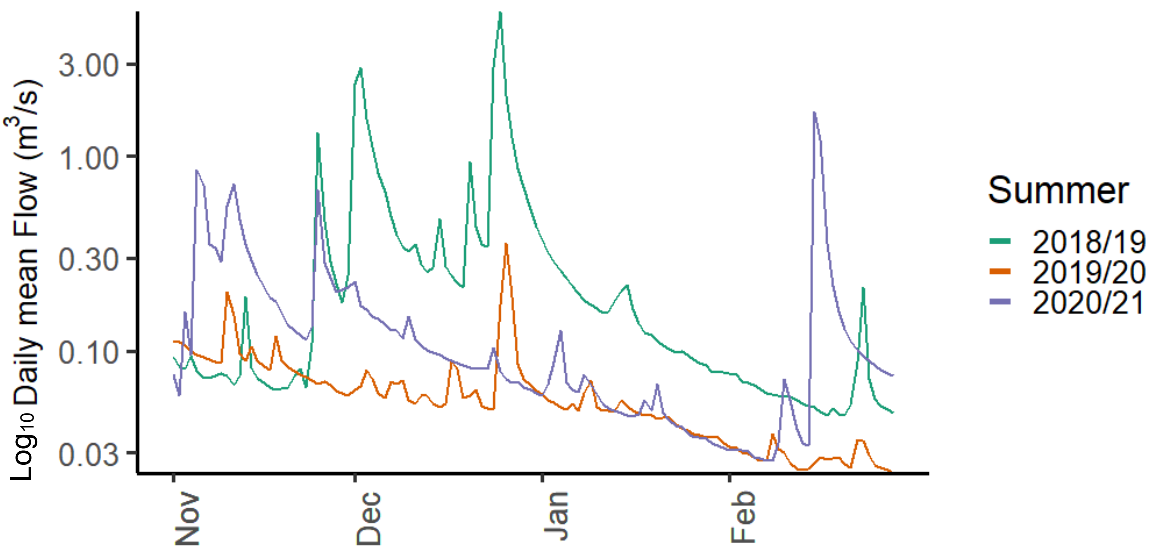



*Figure 3.7 Flow at continuously rated Kaiate at Kaiate Falls Road site over the three summer monitoring periods. Note log scale of y-axis.*

Unlike the 2019/2020 monitoring season, the 2020/2021 season captured some rainfall events. Tables 3.2 and 3.3 below show the *E. coli* concentrations at each site during rainfall sample days and no rainfall sample days respectively. This clearly shows the increase in contamination during rainfall across the catchment, particularly in the Otawera Sub-catchment. It also shows that the Kaiate tributary (Kaiate u/s Otawera confluence) is high under all conditions.

*Table 3.2 E. coli concentrations (cfu/100 ml) at monitoring sites from the 2020/2021 monitoring programme when rain had occurred 24 hours prior to sample time. Results are colour coded to the E. coli thresholds of the MWQG (Red = Action, Orange = Alert, Green = Safe).*

| Date | Owairoa off Waitao Road | Owairoa u/s Otawera confluence | Otawera u/s Owairoa confluence | Otawera R/B Trib u/s Owairoa confluence | Otawera 200 m u/s Kaiate confluence | Otawera u/s Kaiate confluence | Kaiate u/s Otawera confluence | Kaiate at Kaiate Falls Road | Rainfall 24 hours prior* (mm) |
|---|---|---|---|---|---|---|---|---|---|
| 30/11/20 | 580 | 100 | 1900 | 2300 | 560 | 50 | 3600 | 900 | 2 |
| 18/01/21 | 1900 | 900 | 900 | 7000 | 1500 | 3100 | 4300 | 2600 | 6 |
| 9/02/21 | 170 | 800 | 3200 | 1500 | 700 | 1300 | 6000 | 1300 | 0.5 – 2[1] |
| 15/02/21 | 600 | 3700 | 6000 | 6000 | 7600 | 2300 | 6000 | 1900 | 2 – 15[1] |

*Rain gauge at adjacent catchment at Waimapu at McCarrols site and therefore volumes may not be wholly accurate for the Kaiate Catchment.
[1]Rainfall volume at first sample time (Owairoa off Waitao Road) to last sample time as it was raining during sampling.

*Table 3.3 E. coli concentrations (cfu/100 ml) at monitoring sites from the 2020/2021 monitoring programme when there had been no rain 24 hours prior to the sample times. Results are colour coded to the E. coli thresholds of the MWQG (Red = Action, Orange = Alert, Green = Safe).*

| Date | Owairoa off Waitao Road | Owairoa u/s Otawera confluence | Otawera u/s Owairoa confluence | Otawera R/B Trib u/s Owairoa confluence | Otawera 200 m u/s Kaiate confluence | Otawera u/s Kaiate confluence | Kaiate u/s Otawera confluence | Kaiate at Kaiate Falls Road |
|---|---|---|---|---|---|---|---|---|
| 7/12/20 | 41 | 42 | 360 | 490 | 160 | 210 | 3200 | 310 |
| 14/12/20 | 80 | 170 | 140 | 310 | 700 | 190 | 3000 | 430 |
| 21/12/20 | 43 | 240 | 150 | 400 | 260 | 230 | 1300 | 560 |
| 11/01/21 | 220 | 240 | 500 | 3200 | 500 | 400 | 2000 | 900 |
| 25/01/21 | 410 | 240 | 1200 | 600 | 600 | 580 | 1000 | 580 |
| 3/02/21 | 300 | 320 | 600 | 300 | 440 | 1500 | 1700 | 600 |
| 22/02/21 | 1200 | 580 | 240 | 330 | 900 | 600 | 1700 | 900 |

### 3.6.4 Flow relationships

Mahon et al. (2020) determined flow relationships with the continuously rated site for the majority of sampling sites. Two sites showed relationships that were not suitable for low flow conditions and one site had minimal data points to build a relationship on. The 2020/2021 sampling season built on the data available for these three sites in an attempt to develop appropriate flow relationships for future use.

Owairoa off Waitao Road only had three measured gaugings over the 2019/2020 sampling season. Mahon et al. (2020) compared using actual gaugings only, and synthetic flow gaugings for the load calculations. As there was minimal difference in the median load, results between the two methods, the synthetic flow gaugings were used to include more data. An additional five wading gaugings were measured over the 2020/2021 sampling season, providing eight gaugings in total to investigate a relationship with the continuously rated site. Figure 3.8 shows a strong linear relationship between Owairoa off Waitao Road and the continuously rated site at Kaiate at Kaiate Falls Road. This relationship is not vastly different to the relationship utilised in Mahon et al. (2020) ($y = 0.128x – 0.0017$ versus $y = 0.1131x – 0.0013$ for 2019/20 and 2020/21 respectively). However, loadings estimated in Mahon et al. (2020) are still updated in this report to reflect this new relationship.

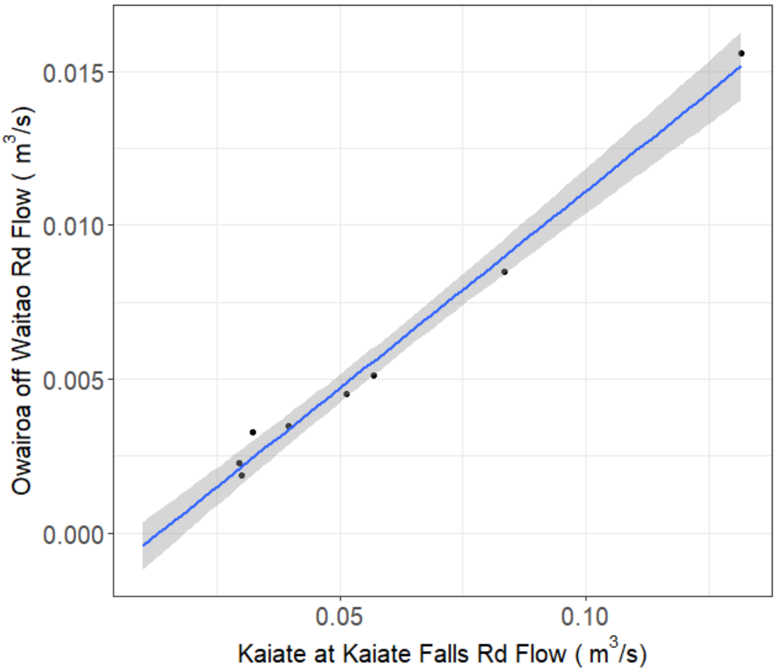



*Figure 3.8 Relationship between flow at Owairoa off Waitao Road and Kaiate at Kaiate Falls Road.*

In Mahon et al. (2020), Kaiate u/s Otawera Confluence and Otawera R/B Tributary u/s Owairoa confluence sites showed reasonable relationships but resulted in negative flow values during low flow conditions, which was dominant over the 2019/2020 sampling season. As a result, only actual gaugings were used in the load estimate calculations. The monitoring programme for 2020/2021 included wading gaugings at Kaiate u/s Otawera confluence. Figure 3.9 shows the relationship with the new gaugings. This does not show an improved relationship and several negative values are calculated using the relationship equation. While this is the ‘main stem’ of the Kaiate Stream, it is a much smaller contribution to the downstream Kaiate Falls compared to the Otawera Stream. The catchment characteristics are also different to that of the Otawera Sub-catchment in that it has a much lower gradient resulting in a boggy environment. It is perhaps therefore unsurprising that a reliable relationship cannot be found. As a result, only the actual gaugings at this site were continued to be used in the loading calculations.

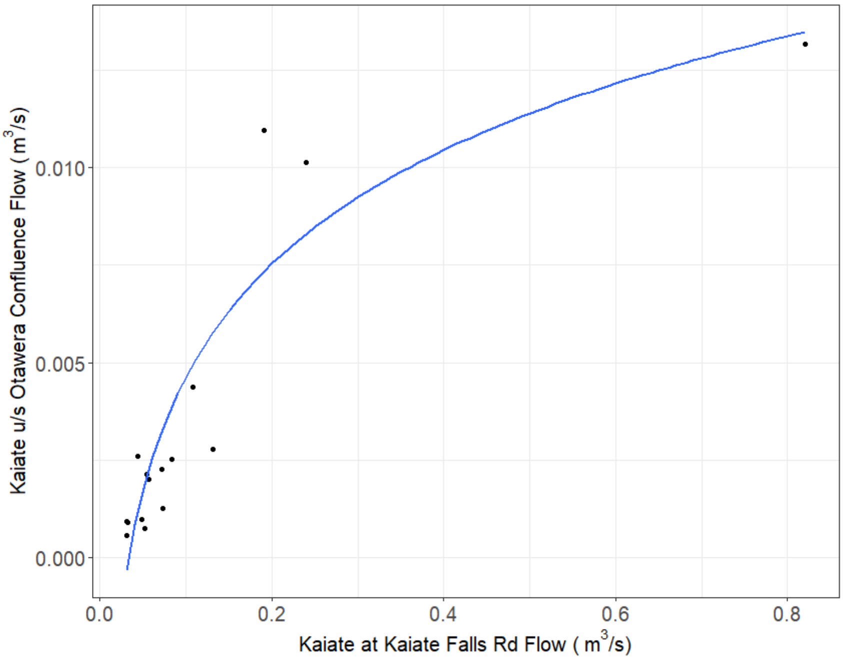



*Figure 3.9 Relationship between flow at Kaiate u/s Otawera confluence and Kaiate at Kaiate Falls Road.*

Volumetric gaugings were undertaken at Otawera R/B Tributary u/s Owairoa confluence on every sample event over the 2019/2020 sample season. In Mahon et al. (2020), records for a handful of these gaugings could not be found. These records have since been located and the relationship updated (Figure 3.10), providing an appropriate relationship to use over the 2020/21 sampling season.

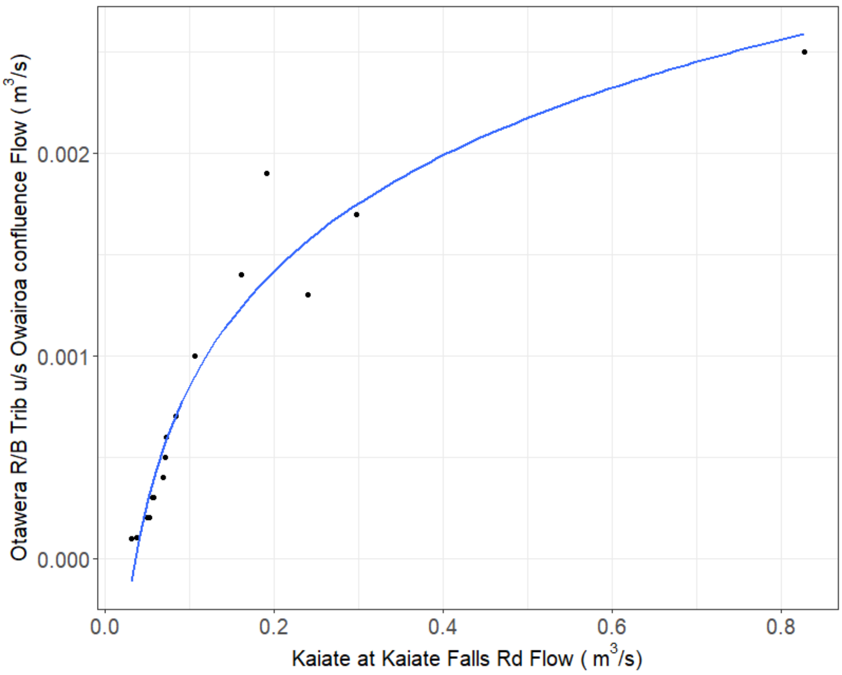



*Figure 3.10 Relationship of flow between Otawera R/B Tributary u/s Owairoa confluence and Kaiate at Kaiate Falls Road.*

### 3.6.5 E. coli load

It is difficult to predict the impact that contaminant inputs from individual sub-catchments may have on downstream water quality without the knowledge of loads. The product of flow and concentration at the time of sampling provides an estimate of the instantaneous load. Load is expressed in terms of contaminants mass (cfu) per unit of time (seconds). Figure 3.11 shows a box and whisker graph of the load estimates over the 2018/2019, 2019/2020, and 2020/2021 monitoring periods combined. The combined data shows the Otawera Sub-catchment to be contributing the majority of the *E. coli* load. This catchment comprises the main Otawera Stream, the incoming tributary of the Owairoa Stream, and a small un-named tributary on the right bank of the Otawera Stream. The site with the highest (worst) loading contribution within the Otawera Sub-catchment is Owairoa u/s Otawera confluence.

A comparison of the three monitoring periods is shown in Figure 3.12. The three periods had differing climate conditions, where the 2018/2019 and 2020/2021 years had variable rainfall capturing some rain events, while the 2019/2020 period had very low rainfall and would be considered a baseflow monitoring season. The 2020/2021 monitoring period shows an increase in the contribution of load from the 'control' site (Owairoa off Waitao Road) compared to the 2019/2020 season. The contribution from Kaiate u/s Otawera confluence also increased over the 2020/2021 season in comparison to both previous seasons. This indicates an increase in faecal contamination from these two sites, which could be a result of a higher number of sample collection days during rainfall. Previously the Kaiate at Kaiate Falls Road site has been more or less equivalent to the loads estimated for the lower Otawera Stream. This season there has been an increase, which is likely a result of the increased input from the Kaiate Stream upstream of the Otawera confluence. Nonetheless, the results still consistently point to the Otawera Sub-catchment being the dominant source of faecal contamination, and within the Otawera Catchment the Owairoa Stream dominates.

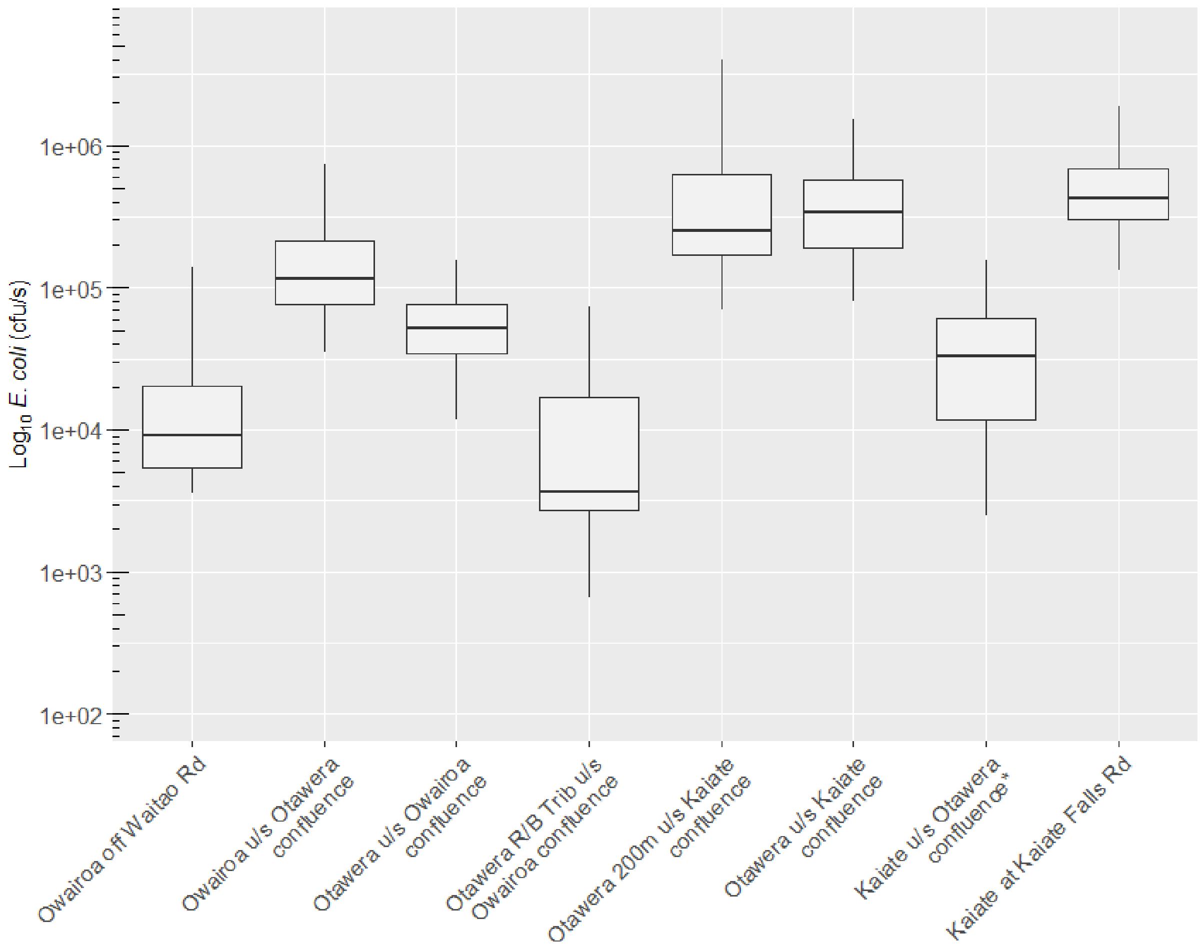



*Figure 3.11* *E. coli load for all sites and summers sampled (2018-2021). Sites are arranged from upstream to downstream (left to right). Note $log_{10}$ scale on y-axis. Sites with asterisks (*) are sites where only actual gauging data has been used due to the lack of flow relationship with the Kaiate at Kaiate Falls Road site.*

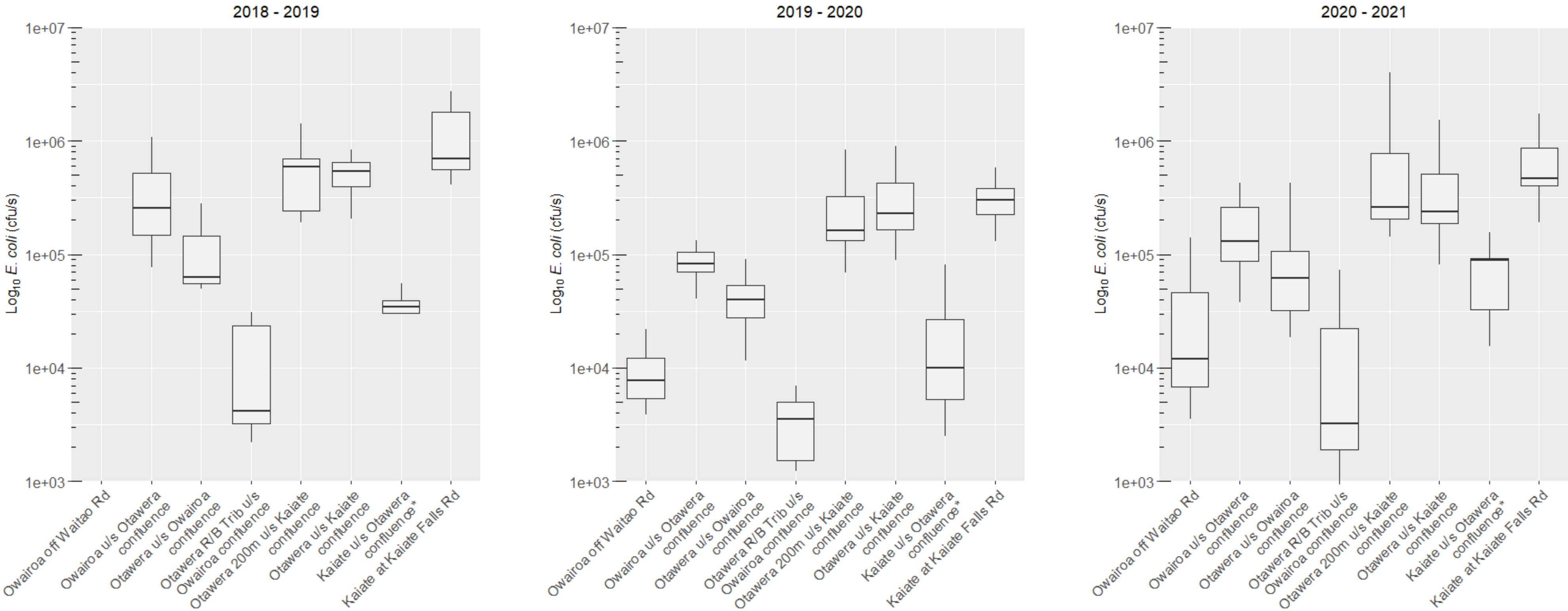



*Figure 3.12* *E. coli load for all sites sampled over the 2018/2019, 2019/2020 and 2020/2021 summers. Sites are arranged from upstream to downstream (left to right). Note $log_{10}$ scale on y-axis. Sites with asterisks (*) are sites where only actual gauging data has been used due to the lack of flow relationship with the Kaiate at Kaiate Falls Road site.*

## 3.7 Discussion (Matapakitanga)

The 2020/2021 data reinforces the findings of previous monitoring seasons, but also identifies some other matters that have not previously been identified as key considerations. The comparison between two variable rainfall monitoring seasons and one baseflow seasons has allowed for further interrogation of the effect of rainfall on the *E. coli* loading, which is discussed below. Each of the 2020/2021 monitoring programme aims are also discussed below.

### 3.7.1 Strengthen the flow relationship between the 'control' monitoring site Owairoa off Waitao Road and the rated site at Kaiate Falls Road.

A strong relationship between flow at the 'control' monitoring site and the rated site has been developed with the additional gaugings measured this season. This relationship can be used going forward to estimate loads, reducing the resourcing requirements for future monitoring programmes for flows that are in the range of those already captured. Any higher-flow sampling should be coupled with gaugings to ensure the flow relationship to the rated site at Kaiate Falls Road remains appropriate.

As discussed in Mahon et al. (2020), all gaugings done thus far have been undertaken over the summer period, i.e. low flow conditions. To gain a more accurate picture of *E. coli* load over the full range of flow conditions, additional monitoring (both flow measurement and *E. coli* analysis) would be required. However, this is not considered necessary at this stage, given the period of interest is over the bathing (summer) season, and sources of contamination have been identified.

### 3.7.2 Monitor change particularly in the Otawera tributary as livestock have been removed and significant fencing/planting has occurred.

Our understanding is that livestock in the native forest block (located around the site Owairoa u/s Otawera confluence) were removed before the summer monitoring programme for 2020/2021 began. This provided us an opportunity to monitor any changes as a result of this mitigation action.

Overall, the *E. coli* loading over the 2020/2021 monitoring season is higher than that of the previous baseflow season in 2019/2020, but is lower than that in 2018/2019 (which had comparable rainfall to 2020/2021). When understanding changes at Owairoa u/s Otawera confluence, we must take into account the changes occurring upstream at the 'control' site. The current results suggest that the 'control' site reacts strongly to rainfall runoff, hence the observed increase in loading from this site compared to 2019/2020 (Table 3.2). The increase could also be a product of increased pest numbers such as possum and deer. Unfortunately, access to the 'control' site in 2018/2019 was not possible and therefore comparisons between similar runoff conditions is also not possible presently. But it is important to note this increase in the upstream control site in context of the results seen at the Owairoa u/s Otawera site.

Previously we had discussed that the catchment appears to have a strong baseflow signature of *E. coli* and at some locations even an inverse relationship with flow, that is the *E. coli* is diluted with increased rainfall (Hudson, 2019; Mahon et al., 2020). The addition of the 'control' site capturing rainfall events this summer has assisted in understanding this relationship more. In comparison to the 2019/2020 results, the loading has increased at Owairoa u/s Otawera even though livestock have been removed from this location. It is possible that runoff is having a greater effect than what previous results suggested, and any changes at the Owairoa u/s Otawera confluence are potentially being masked by the increase upstream. However, the difference in loads between the 'control' site and Owairoa u/s Otawera is similar both seasons (9.3% and 9.2% for 2019/2020 and 2020/2021 respectively), suggesting that either we are yet to realise the benefits of the removal of livestock, or it has not provided a significant reduction in *E. coli* loading to the system. In addition to this, there is the possibility of increased pest numbers, as mentioned above, increasing *E. coli* contamination. It is likely that there is not one reason here and that a combination of these factors are what have resulted in the outcomes seen this monitoring season.

Significant information and data is also being collected for a number of research projects with MfE and Institute of Environmental Science and Research (ESR). This data will provide insight into the source of *E. coli* in the upper catchment (native forest block), providing valuable information to understand the bacterial contamination characteristics in the upper catchment.

Significant fencing and planting within the wider catchment has also occurred since the 2019/2020 monitoring programme. However, it is expected to take a number of years before improvement from these mitigations are observed and measurable.

#### 3.7.3 **Update the *E. coli* load for each of the monitored sites.**

The order of contribution to bacterial loading has largely remained the same over the three monitoring seasons. The Otawera Sub-catchment is consistently the main contributor to the bacterial loading at Kaiate Falls. Changes within this sub-catchment are discussed above.

As discussed in section 3.6, the Kaiate tributary contribution to Kaiate Falls has increased compared to the previous seasons. Significant fencing has occurred upstream of this area, however, one area is yet to be fenced. Given that livestock are currently grazed in this area, it would be reasonable to expect some concentration of the livestock in the unfenced area. This may explain the increase in loading from the Kaiate tributary this season. Observations this season from monitoring personnel have also indicated that potentially stock have been grazing in this area more often compared to previous seasons. Although this cannot be confirmed at this stage, it may also explain some of the increase in bacterial loading at this site.

## 3.8 Recommendations (Ngā Tūtohutanga)

#### 3.8.1 **Investigate upper catchment results from MfE and ESR**

Results from the research projects undertaken by MfE and ESR will be due in the next year. The results discussed here should be reviewed again once the research data is made available. FST results from the 2020/2021 monitoring programmes are also due in the coming months.

#### 3.8.2 **Partner with local iwi to reduce contamination in Owairoa Sub-catchment**

The majority of the contamination is coming from the Owairoa Sub-catchment, which is almost exclusively in native bush. As suggested in Mahon et al. (2020), an updated biodiversity survey would assist in understanding the number of pest animals in the bush block and their potential impact on bacterial contamination. Partnering with local iwi to undertake this survey as well as manage pest numbers would be valuable.

#### 3.8.3 **Ongoing monitoring**

Any future monitoring will need to include flow measurements at Kaiate u/s Otawera confluence due to the lack of flow relationship found at this site. All remaining sites monitored this 2020/2021 season could rely on the flow relationships developed.

Monitoring should continue to record changes as a result of the mitigation actions taking place. Consideration could be given to reducing the frequency to fortnightly rather than weekly given that relatively consistent patterns have emerged. This would reduce the resourcing requirement significantly.

## 3.9 Conclusion (Whakakapinga)

Kaiate Falls has had a permanent public health warning in place since 2015. Research in the Kaiate Falls Catchment has been undertaken since 2015 to identify the source of bacterial contamination and inform actions, to ultimately improve water quality enough to allow the health warning to be lifted.

There have been some changes this monitoring season in the proportion of contributions each sub-catchment has to Kaiate Falls. However, these changes can be explained with both the wider understanding of what stage the mitigation actions are at, and climate conditions. The major contribution is still from the Otawera Sub-catchment and the Owairoa tributary within that. The increase at the Kaiate tributary emphasises the importance of fencing off all waterways to make a measurable improvement. Upcoming results from national research projects should also shed some light on questions surrounding the upper catchment.

## 3.10 References (Ngā Tohutoro)


Dare, J. (in prep.). Recreational Waters Surveillance Report, 2020/2021 Bathing Season. Bay of Plenty Regional Council Environmental Publication 2021.

Hudson, N. (2019). *Review of Faecal Indicator Bacteria Contaminant Loads – Kaiate Stream, Tauranga Harbour Catchment*. NIWA report for Bay of Plenty Regional Council, June 2019. Hamilton, New Zealand.

Mahon, L., Zygadlo, M., Carter, R., Crawshaw, J., & Dare, J. (2020). *Focus Catchments Water Quality 2020/Te Kounga Wai O Ngā Kurawai E Arotahia Ana*. Bay of Plenty Regional Council Environmental Publication 2020/04.

Ministry for the Environment. (2020). *National Policy Statement for Freshwater Management 2020*. Wellington, New Zealand.

National Environmental Monitoring Standards. (2013). *Open Channel Flow Measurement*. National Environmental Monitoring Standards, New Zealand.

# Appendix A1: Kaiate site summaries

## Owairoa off Waitao Road

20 July 2021

### Summary statistics

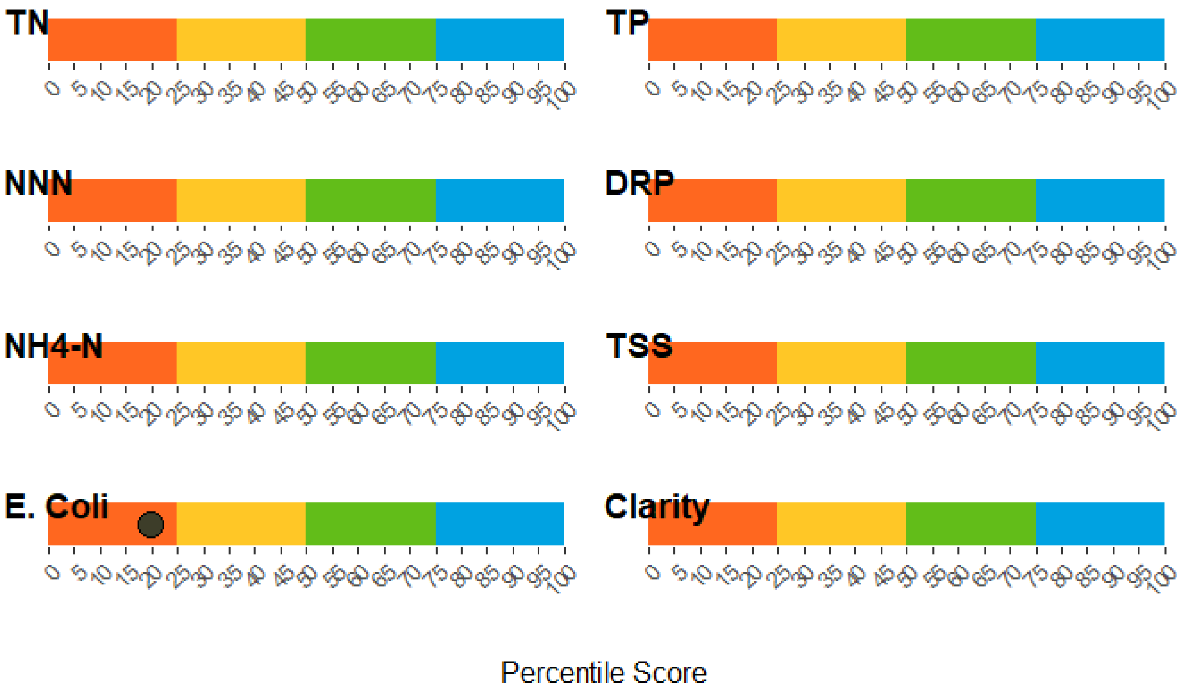
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | | | | | | | | | |
| **Nitrate Nitrite Nitrogen (g/m3)** | | | | | | | | | |
| **Total Ammoniacal Nitrogen (g/m3)** | | | | | | | | | |
| **Total Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Reactive Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Oxygen Sat (%)** | 21 | 92.4 | 103.7 | 96.4 | 96.3 | 99.3 | 93.2 | 2.6 | 0.6 |
| **Dissolved Oxygen (g/m3)** | 22 | 8.35 | 10.45 | 9.65 | 9.71 | 10.43 | 8.37 | 0.63 | 0.14 |
| **Escherichia coli (cfu/100ml)** | 26 | 41 | 1900 | 435 | 275 | 1275 | 52 | 461 | 90 |
| **Total Suspended Solids (g/m3)** | | | | | | | | | |
| **Turbidity (NTU)** | 26 | 0.2 | 2.0 | 0.6 | 0.5 | 1.7 | 0.2 | 0.4 | 0.1 |
| **Water Clarity (m)** | | | | | | | | | |
| **Conductivity (mS/cm)** | 26 | 53.0 | 74.1 | 62.1 | 61.8 | 69.7 | 54.3 | 4.9 | 1.0 |
| **pH (pH Units)** | 26 | 7.1 | 8.0 | 7.3 | 7.3 | 7.5 | 7.1 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 20 | 11.5 | 16.6 | 14.0 | 13.9 | 15.9 | 12.1 | 1.3 | 0.3 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-03-23 | 2021-03-22 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-03-25 | 2021-03-22 | NA | NA | NA | NA | NA | NA |
| All | 2019-11-27 | 2021-03-22 | 26 | 275 | 1420 | 50 | 26.9 | 23.1 |

# Kaiate at Kaiate Falls Road

20 July 2021

## Summary statistics

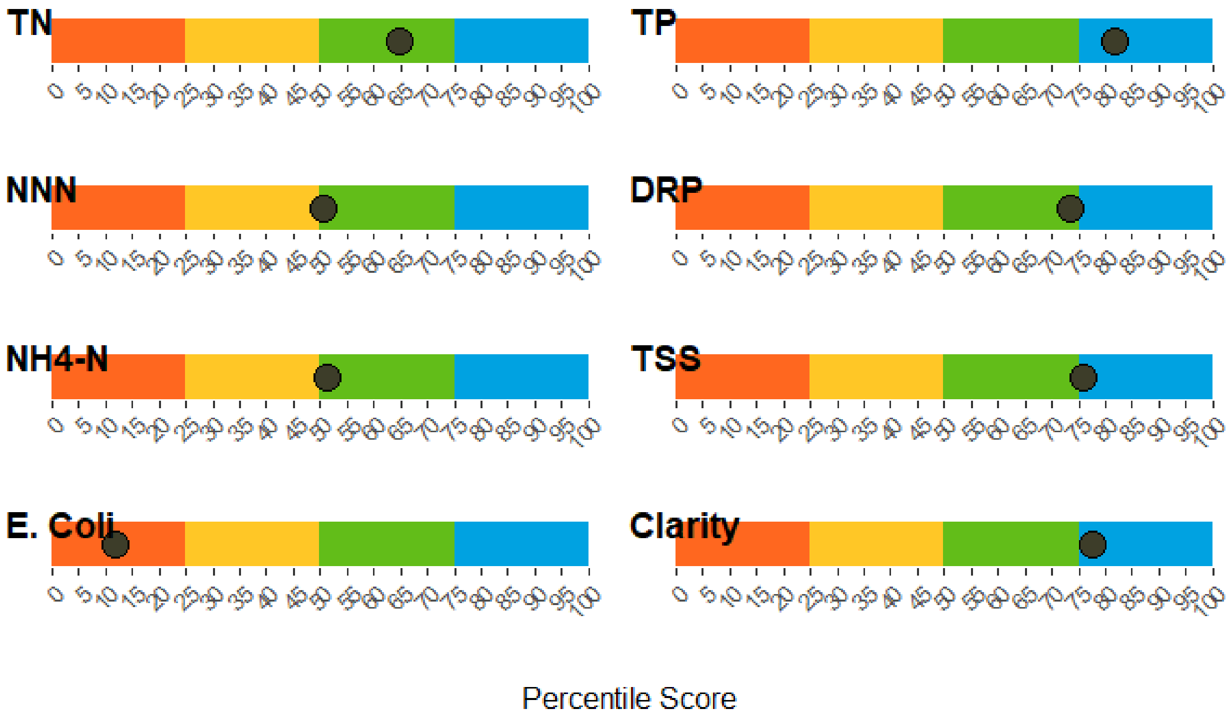
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 10 | 0.14 | 0.60 | 0.40 | 0.43 | 0.59 | 0.18 | 0.16 | 0.05 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 9 | 0.09 | 0.56 | 0.36 | 0.42 | 0.55 | 0.11 | 0.17 | 0.06 |
| **Total Ammoniacal Nitrogen (g/m3)** | 10 | 0.006 | 0.027 | 0.013 | 0.012 | 0.022 | 0.006 | 0.006 | 0.002 |
| **Total Phosphorus (g/m3)** | 10 | 0.019 | 0.028 | 0.023 | 0.021 | 0.028 | 0.019 | 0.004 | 0.001 |
| **Dissolved Reactive Phosphorus (g/m3)** | 10 | 0.008 | 0.018 | 0.012 | 0.012 | 0.016 | 0.008 | 0.003 | 0.001 |
| **Dissolved Oxygen Sat (%)** | 72 | 79.2 | 130.0 | 98.2 | 98.5 | 109.9 | 84.0 | 8.6 | 1.0 |
| **Dissolved Oxygen (g/m3)** | 73 | 7.16 | 13.50 | 9.57 | 9.59 | 11.06 | 7.89 | 1.01 | 0.12 |
| **Escherichia coli (cfu/100ml)** | 453 | <1 | 38000 | 800 | 460 | 2440 | 41 | 2078 | 98 |
| **Total Suspended Solids (g/m3)** | 10 | 1.22 | 5.30 | 2.30 | 2.10 | 4.26 | 1.30 | 1.22 | 0.39 |
| **Turbidity (NTU)** | 74 | 0.6 | 3.1 | 1.1 | 1.0 | 1.8 | 0.7 | 0.4 | 0.0 |
| **Water Clarity (m)** | 10 | 1.24 | 4.79 | 3.27 | 3.12 | 4.64 | 1.71 | 1.08 | 0.34 |
| **Conductivity (mS/cm)** | 44 | 53.3 | 111.0 | 77.3 | 76.2 | 101.9 | 60.8 | 12.0 | 1.8 |
| **pH (pH Units)** | 45 | 6.7 | 7.4 | 7.2 | 7.2 | 7.4 | 6.8 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 74 | 8.5 | 23.6 | 16.4 | 17.0 | 19.8 | 10.5 | 2.9 | 0.3 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-03-23 | 2021-03-22 | 209 | 520 | 2910 | 23.9 | 30.6 | 45 |
| 10 Years | 2011-03-25 | 2021-03-22 | 369 | 460 | 2610 | 35 | 25.5 | 39.3 |
| All | 2007-12-04 | 2021-03-22 | 453 | 460 | 2485 | 34.9 | 25.4 | 39.5 |

# Otawera u/s Kaiate confluence

20 July 2021

## Summary statistics

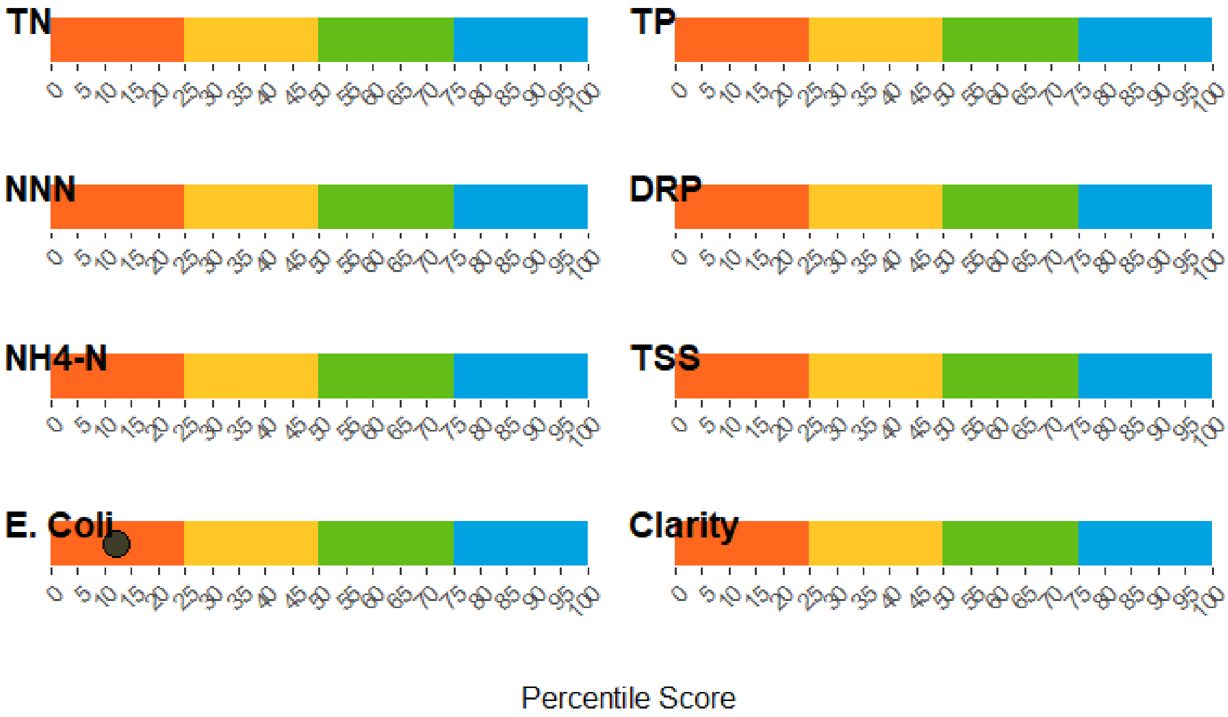
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | | | | | | | | | |
| **Nitrate Nitrite Nitrogen (g/m3)** | | | | | | | | | |
| **Total Ammoniacal Nitrogen (g/m3)** | | | | | | | | | |
| **Total Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Reactive Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Oxygen Sat (%)** | 54 | 93.2 | 112.3 | 102.6 | 101.8 | 110.5 | 97.7 | 4.1 | 0.6 |
| **Dissolved Oxygen (g/m3)** | 54 | 8.48 | 10.77 | 9.67 | 9.71 | 10.35 | 8.91 | 0.47 | 0.06 |
| **Escherichia coli (cfu/100ml)** | 59 | 50 | 3100 | 605 | 450 | 1640 | 159 | 565 | 74 |
| **Total Suspended Solids (g/m3)** | | | | | | | | | |
| **Turbidity (NTU)** | 60 | 0.5 | 34.4 | 2.1 | 0.9 | 3.4 | 0.6 | 5.2 | 0.7 |
| **Water Clarity (m)** | | | | | | | | | |
| **Conductivity (mS/cm)** | 31 | 50.8 | 89.0 | 74.9 | 78.0 | 88.3 | 58.5 | 10.3 | 1.8 |
| **pH (pH Units)** | 31 | 7.0 | 7.8 | 7.4 | 7.4 | 7.6 | 7.1 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 54 | 0.1 | 25.9 | 17.6 | 17.6 | 21.1 | 14.6 | 3.2 | 0.4 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-24 | 2021-02-22 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-25 | 2021-02-22 | NA | NA | NA | NA | NA | NA |
| All | 2018-12-05 | 2021-02-22 | 30 | 450 | 2300 | 23.3 | 33.3 | 43.3 |

# Otawera 200 m u/s Kaiate confluence

20 July 2021

## Summary statistics

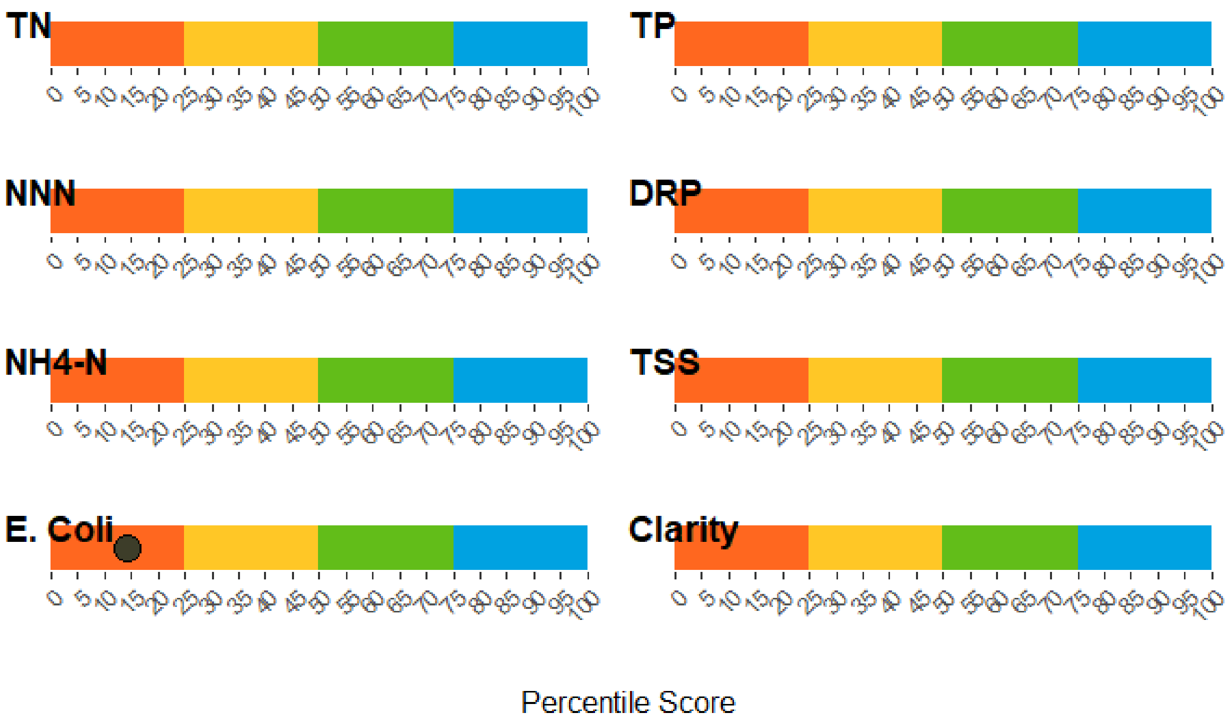
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | | | | | | | | | |
| **Nitrate Nitrite Nitrogen (g/m3)** | | | | | | | | | |
| **Total Ammoniacal Nitrogen (g/m3)** | | | | | | | | | |
| **Total Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Reactive Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Oxygen Sat (%)** | 36 | 88.3 | 146.4 | 103.4 | 103.0 | 113.6 | 92.8 | 9.2 | 1.5 |
| **Dissolved Oxygen (g/m3)** | 36 | 8.14 | 14.45 | 9.88 | 9.81 | 11.30 | 8.61 | 1.06 | 0.18 |
| **Escherichia coli (cfu/100ml)** | 42 | 2 | 7600 | 670 | 385 | 1595 | 50 | 1182 | 182 |
| **Total Suspended Solids (g/m3)** | | | | | | | | | |
| **Turbidity (NTU)** | 31 | 0.6 | 21.2 | 1.8 | 1.1 | 2.7 | 0.6 | 3.6 | 0.7 |
| **Water Clarity (m)** | | | | | | | | | |
| **Conductivity (mS/cm)** | 32 | 51.6 | 90.0 | 74.9 | 76.2 | 89.2 | 56.9 | 11.0 | 2.0 |
| **pH (pH Units)** | 32 | 6.8 | 7.8 | 7.4 | 7.5 | 7.6 | 7.0 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 34 | 10.4 | 22.6 | 17.1 | 17.1 | 21.1 | 13.0 | 2.5 | 0.4 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-24 | 2021-02-22 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-25 | 2021-02-22 | NA | NA | NA | NA | NA | NA |
| All | 2016-06-01 | 2021-02-22 | 31 | 500 | 1595 | 32.3 | 22.6 | 45.2 |

# Kaiate u/s Otawera confluence

20 July 2021

## Summary statistics

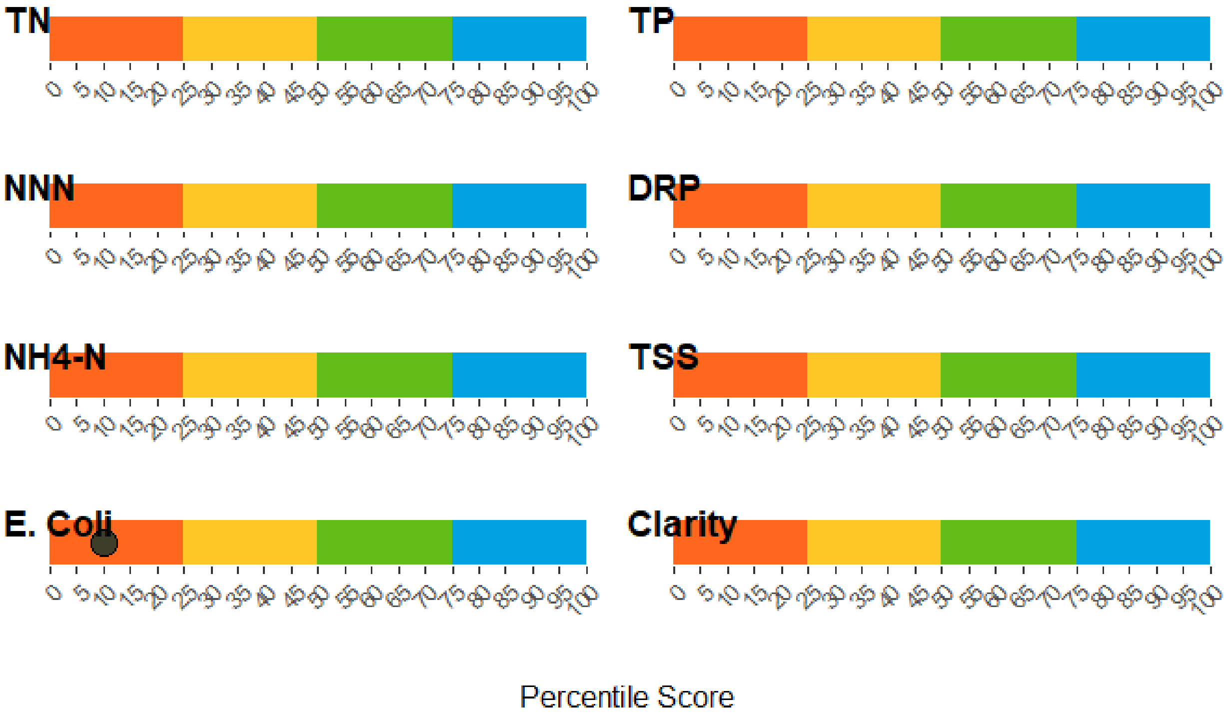
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | | | | | | | | | |
| **Nitrate Nitrite Nitrogen (g/m3)** | | | | | | | | | |
| **Total Ammoniacal Nitrogen (g/m3)** | | | | | | | | | |
| **Total Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Reactive Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Oxygen Sat (%)** | 60 | 43.2 | 133.5 | 92.3 | 94.4 | 104.2 | 68.2 | 13.6 | 1.8 |
| **Dissolved Oxygen (g/m3)** | 60 | 4.00 | 12.63 | 8.56 | 8.92 | 9.94 | 6.06 | 1.33 | 0.17 |
| **Escherichia coli (cfu/100ml)** | 68 | 31 | 6000 | 1225 | 540 | 4322 | 119 | 1483 | 180 |
| **Total Suspended Solids (g/m3)** | | | | | | | | | |
| **Turbidity (NTU)** | 58 | 0.9 | 8.2 | 2.3 | 1.6 | 5.8 | 0.9 | 1.7 | 0.2 |
| **Water Clarity (m)** | | | | | | | | | |
| **Conductivity (mS/cm)** | 32 | 70.0 | 112.1 | 84.7 | 82.0 | 106.1 | 72.7 | 10.4 | 1.8 |
| **pH (pH Units)** | 32 | 6.6 | 7.4 | 6.8 | 6.8 | 7.1 | 6.6 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 61 | 14.5 | 22.6 | 18.7 | 18.3 | 21.5 | 16.5 | 1.7 | 0.2 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-24 | 2021-02-22 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-25 | 2021-02-22 | NA | NA | NA | NA | NA | NA |
| All | 2016-06-01 | 2021-02-22 | 31 | 1400 | 5995 | 9.7 | 19.4 | 71 |

# Owairoa u/s Otawera confluence

20 July 2021

## Summary statistics

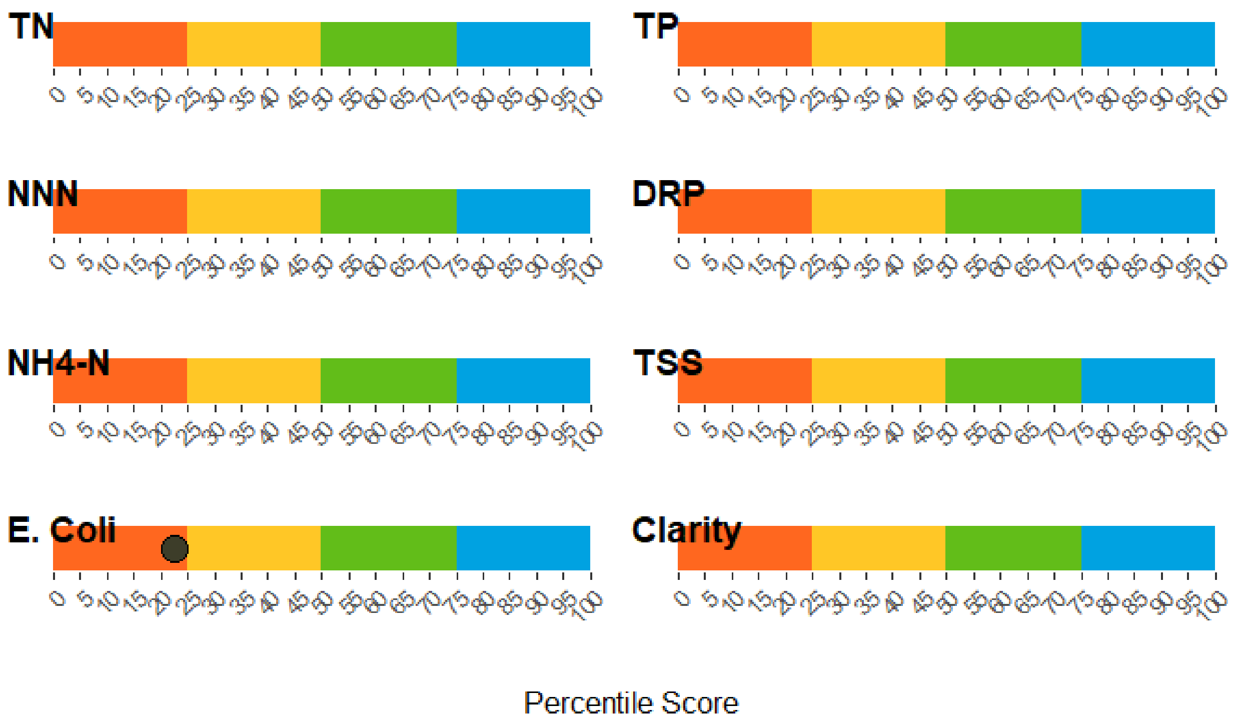
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | | | | | | | | | |
| **Nitrate Nitrite Nitrogen (g/m3)** | | | | | | | | | |
| **Total Ammoniacal Nitrogen (g/m3)** | | | | | | | | | |
| **Total Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Reactive Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Oxygen Sat (%)** | 40 | 65.6 | 130.6 | 97.8 | 98.0 | 106.3 | 83.9 | 8.9 | 1.4 |
| **Dissolved Oxygen (g/m3)** | 40 | 6.20 | 12.98 | 9.56 | 9.48 | 11.29 | 7.24 | 1.17 | 0.18 |
| **Escherichia coli (cfu/100ml)** | 47 | 2 | 3700 | 374 | 230 | 870 | 26 | 603 | 88 |
| **Total Suspended Solids (g/m3)** | | | | | | | | | |
| **Turbidity (NTU)** | 37 | 0.4 | 2.2 | 1.0 | 0.9 | 2.1 | 0.5 | 0.5 | 0.1 |
| **Water Clarity (m)** | | | | | | | | | |
| **Conductivity (mS/cm)** | 38 | 49.3 | 88.9 | 74.1 | 78.0 | 87.6 | 55.2 | 10.2 | 1.7 |
| **pH (pH Units)** | 38 | 6.8 | 7.5 | 7.3 | 7.4 | 7.5 | 7.1 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 40 | 9.6 | 22.5 | 16.3 | 16.2 | 20.4 | 13.0 | 2.5 | 0.4 |

## State of the site

### Comparison Plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-03-23 | 2021-03-22 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-03-25 | 2021-03-22 | NA | NA | NA | NA | NA | NA |
| All | 2016-05-31 | 2021-03-22 | 37 | 230 | 1745 | 64.9 | 16.2 | 18.9 |

# Otawera R/B Tributary u/s Owairoa confluence

20 July 2021

## Summary statistics

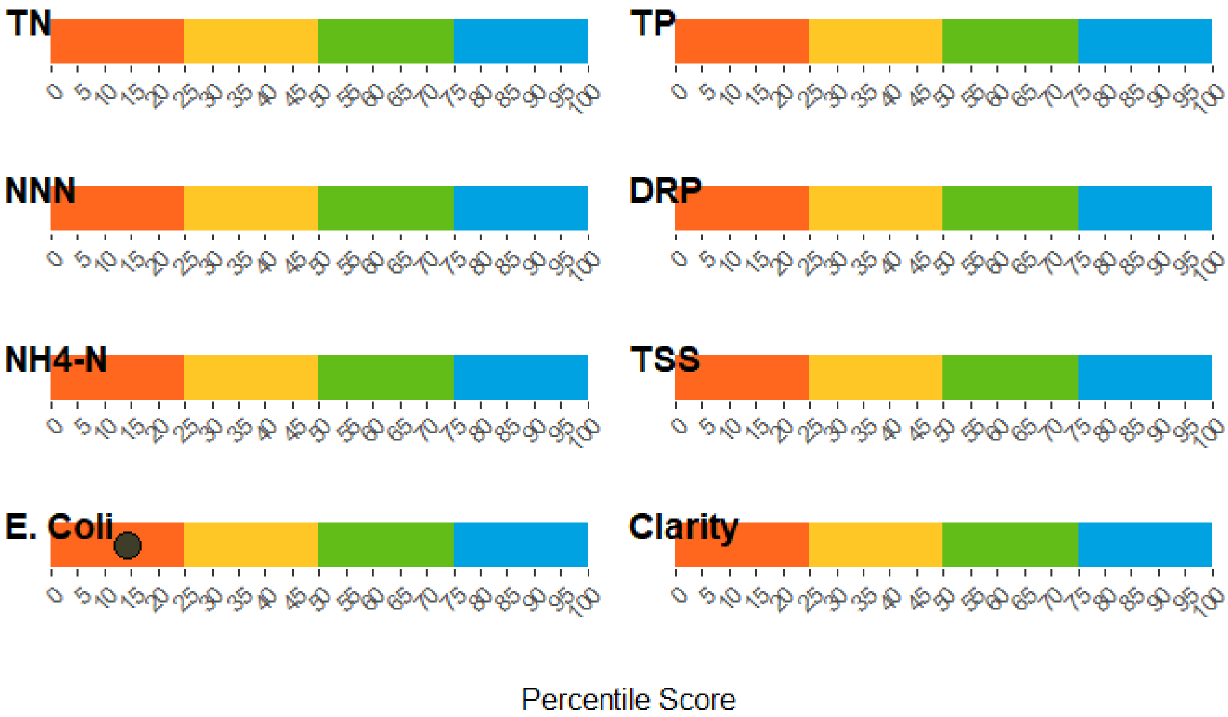
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | | | | | | | | | |
| **Nitrate Nitrite Nitrogen (g/m3)** | | | | | | | | | |
| **Total Ammoniacal Nitrogen (g/m3)** | | | | | | | | | |
| **Total Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Reactive Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Oxygen Sat (%)** | 35 | 47.2 | 121.1 | 82.3 | 87.0 | 102.8 | 53.4 | 16.1 | 2.7 |
| **Dissolved Oxygen (g/m3)** | 36 | 4.54 | 11.53 | 7.72 | 8.13 | 9.79 | 4.84 | 1.63 | 0.27 |
| **Escherichia coli (cfu/100ml)** | 42 | 19 | 11400 | 1320 | 385 | 5998 | 39 | 2299 | 355 |
| **Total Suspended Solids (g/m3)** | | | | | | | | | |
| **Turbidity (NTU)** | 31 | 0.7 | 207.0 | 13.6 | 2.3 | 40.1 | 0.7 | 37.5 | 6.7 |
| **Water Clarity (m)** | | | | | | | | | |
| **Conductivity (mS/cm)** | 32 | 61.8 | 108.0 | 79.1 | 77.9 | 101.7 | 64.9 | 10.8 | 1.9 |
| **pH (pH Units)** | 32 | 6.4 | 7.2 | 6.7 | 6.7 | 6.9 | 6.5 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 36 | 15.0 | 23.2 | 18.5 | 17.8 | 23.0 | 15.6 | 2.2 | 0.4 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-24 | 2021-02-22 | NA | NA | NA | **NA** | **NA** | **NA** |
| 10 Years | 2011-02-25 | 2021-02-22 | NA | NA | NA | **NA** | **NA** | **NA** |
| All | 2016-05-31 | 2021-02-22 | 31 | 510 | 6950 | **16.1** | **35.5** | **48.4** |

# Otawera u/s Owairoa confluence

20 July 2021

## Summary statistics

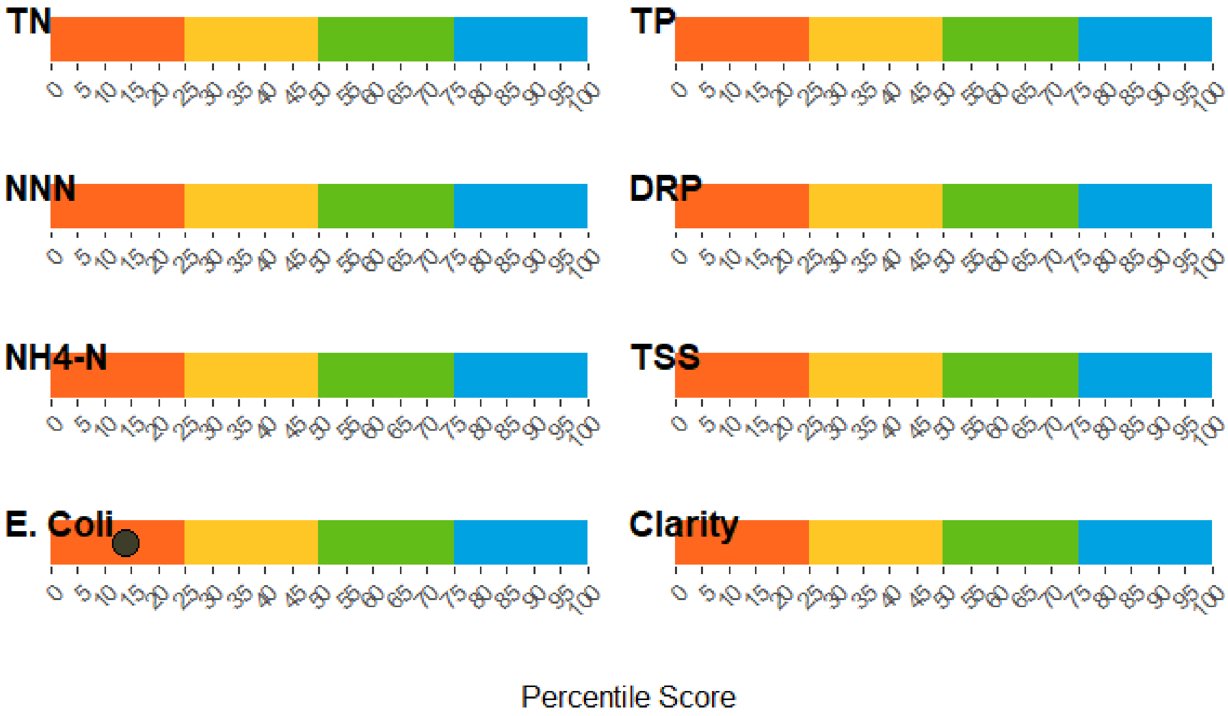
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | | | | | | | | | |
| **Nitrate Nitrite Nitrogen (g/m3)** | | | | | | | | | |
| **Total Ammoniacal Nitrogen (g/m3)** | | | | | | | | | |
| **Total Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Reactive Phosphorus (g/m3)** | | | | | | | | | |
| **Dissolved Oxygen Sat (%)** | 40 | 90.1 | 141.7 | 106.1 | 105.7 | 115.5 | 95.3 | 8.2 | 1.3 |
| **Dissolved Oxygen (g/m3)** | 40 | 8.45 | 13.48 | 9.99 | 9.98 | 10.94 | 8.95 | 0.81 | 0.13 |
| **Escherichia coli (cfu/100ml)** | 47 | 14 | 11560 | 896 | 390 | 2810 | 86 | 1860 | 271 |
| **Total Suspended Solids (g/m3)** | | | | | | | | | |
| **Turbidity (NTU)** | 36 | 1.1 | 8.2 | 2.2 | 1.7 | 5.1 | 1.1 | 1.6 | 0.3 |
| **Water Clarity (m)** | | | | | | | | | |
| **Conductivity (mS/cm)** | 37 | 62.0 | 110.0 | 83.3 | 85.1 | 99.9 | 66.4 | 11.2 | 1.8 |
| **pH (pH Units)** | 37 | 7.0 | 8.6 | 7.3 | 7.3 | 7.7 | 7.0 | 0.3 | 0.0 |
| **Water Temperature (degC)** | 40 | 12.6 | 23.7 | 17.9 | 17.5 | 21.9 | 14.1 | 2.5 | 0.4 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-03-23 | 2021-03-22 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-03-25 | 2021-03-22 | NA | NA | NA | NA | NA | NA |
| All | 2016-05-31 | 2021-03-22 | 36 | 410 | 5160 | 27.8 | 33.3 | 38.9 |

# 4 Te Mania, Katikati

## 4.1 Summary (Whakarāpopototanga Matua)

- Isolated areas of water quality concerns are from a combination of stream morphology, landuse, and catchment characteristics.
- Generally, the larger sub-catchment is contributing the highest loadings of water quality contaminants.

## 4.2 Introduction (Kupu Whakataki)

The Te Mania Catchment is located south of Katikati, approximately 1,300 ha in area, and flows in a northeast direction to Tauranga Harbour. This has been selected as one of the Focus Catchments because long term monitoring has shown persistent elevated bacterial and nutrient concentrations, as well as sediment accumulation in the Rereatukahia Estuary receiving environment.

The Te Mania Catchment has an extensive history of land and stream management work such as riparian fencing, revegetation and fish passage remediation, and is part of the Project Parore/Uretara Estuary Managers community Care Group. All of these activities are aimed at improving water quality in the catchment and estuarine receiving environment.

## 4.3 Purpose (Take)

The purposes of this chapter are to summarise water quality investigations in the Te Mania Catchment recommended by Mahon et al. (2020); address outstanding aims from the previous monitoring programme; and provide further direction for land management to address identified water quality issues.

## 4.4 Background (Kupu Whakamārama)

NERMN monitoring in this catchment since 1990 has shown elevated TSS, Ammoniacal-N and *E. coli* concentrations in the worst 50% (TSS and Ammoniacal-N), and worst 25% (*E. coli*) of NERMN sites in the Bay of Plenty. Worsening trends were seen in TP, DRP, TN, NNN and *E. coli*, while improving trends were found for TSS, turbidity, conductivity and Ammoniacal-N (Hamill et al., 2020). The 2020 river water quality trend update (Dare, 2021), showed worsening trends for TN, NNN, *E. coli*, and clarity, while an improving trend was detected for DRP. The ecological state of the Te Mania Stream was 'very good', with no significant trends in invertebrate communities over time, indicating a stable ecological condition. Nutrient enrichment and sediment loss from the Te Mania Catchment may be negatively impacting the receiving environment, as seen in the high mud content of estuary sediments. Seagrass coverage has decreased noticeably and mangrove coverage has increased. Monitoring by the Uretara Estuary Managers Care Group over recent years indicates poor species diversity and abundance of benthic fauna in the estuary.

A catchment-wide water quality investigation over the 2019/2020 summer (Mahon et al., 2020) found that both overland flow and direct deposition of faecal material (from ruminants and birds) were contributing to the high *E. coli* concentrations across the catchment. Ammoniacal-N concentrations increased downstream, and the tributaries showed the most variation in TSS results. Several sites had low dissolved oxygen and / or high Ammoniacal-N, so follow-up site investigations were recommended. One of the aims of the 2019/2020 investigation was to estimate contaminant loads for *E. coli*, TSS and

Ammoniacal-N from each tributary. This was not completed due to a lack of flow information required to achieve this.

## 4.5 Methodology (Huarahi)

Following the recommended actions and outstanding aims from Mahon et al. (2020), the aims of water quality work in 2020 were to:

1 Investigate longitudinal changes in DRP in the upper Te Mania Catchment.

2 Quantify spatial extent and / or cause of low DO in two tributaries, and Ammoniacal-N in one tributary.

3 Estimate loadings from sub-catchments for *E. coli*, TSS and Ammoniacal-N to direct land management priorities.

Sites were selected to meet these aims based on existing water quality sites and desktop assessments, including reviews of resource consents, land use and catchment characteristics. This was followed by site visits to investigate representativeness of stream conditions, and site safety and access. Site locations are shown in Figure 4.1 and Appendix B1.

All field and sampling techniques, laboratory and data analyses followed standard BOPRC methods as outlined in Section 2. For aim 1, three samples at each site were collected on 28 October, 4 November and 10 November 2020. Site investigations for aim 2 were completed on 28 September and 29 September. The water quality data used for aim 3 was from the 2019/2020 catchment monitoring between 26 November 2019 and 4 February 2020.

Flow information used for aim 3 was collated from wading gaugings since 2008 in the Te Mania Catchment, following the National Environmental Monitoring Standard (2013) for open channel flow measurement, or previous standards where applicable. Seven of the 12 water quality sites had small gauging datasets ($n \leq 5$), which were mostly targeted at low flow monitoring. Concern has been raised about the representativeness of catchment hydrology from this data and the lack of data at the higher flow ranges. While one site (Te Mania R/B tributary d/s Lund Road) had six gaugings, there was a large amount of variability in these data points due to several dams disrupting natural stream flow. Therefore, this site, and other sites with less than five gaugings, were excluded from further analysis for aim 3. This was largely due to gaugings not occurring at the time of sampling, thus needing a higher level of confidence in the flow relationships.

For each of the sites used to meet aim 3 (Figure 4.1), site-specific flow relationships with the continuously rated Te Mania at 87 Sharp Road site, were investigated for the potential to provide flow information, as there were no gaugings on the 2019/2020 water quality sampling days. Synthetic flow was generated for sites where the relationships were reliable, and contaminant loads were calculated by multiplying concentration by synthetic flow at the time of sampling. The relative contribution of total contaminant load from each sub-catchment to Te Mania 500 m u/s SH 2, was estimated. Specific yield was calculated by averaging TSS and Ammoniacal-N loads per month, then dividing by the total area of each sub-catchment. This allowed comparison across different sized catchment. Loads per month were selected as there is not enough data to provide loads per year which is the usual unit for loads.

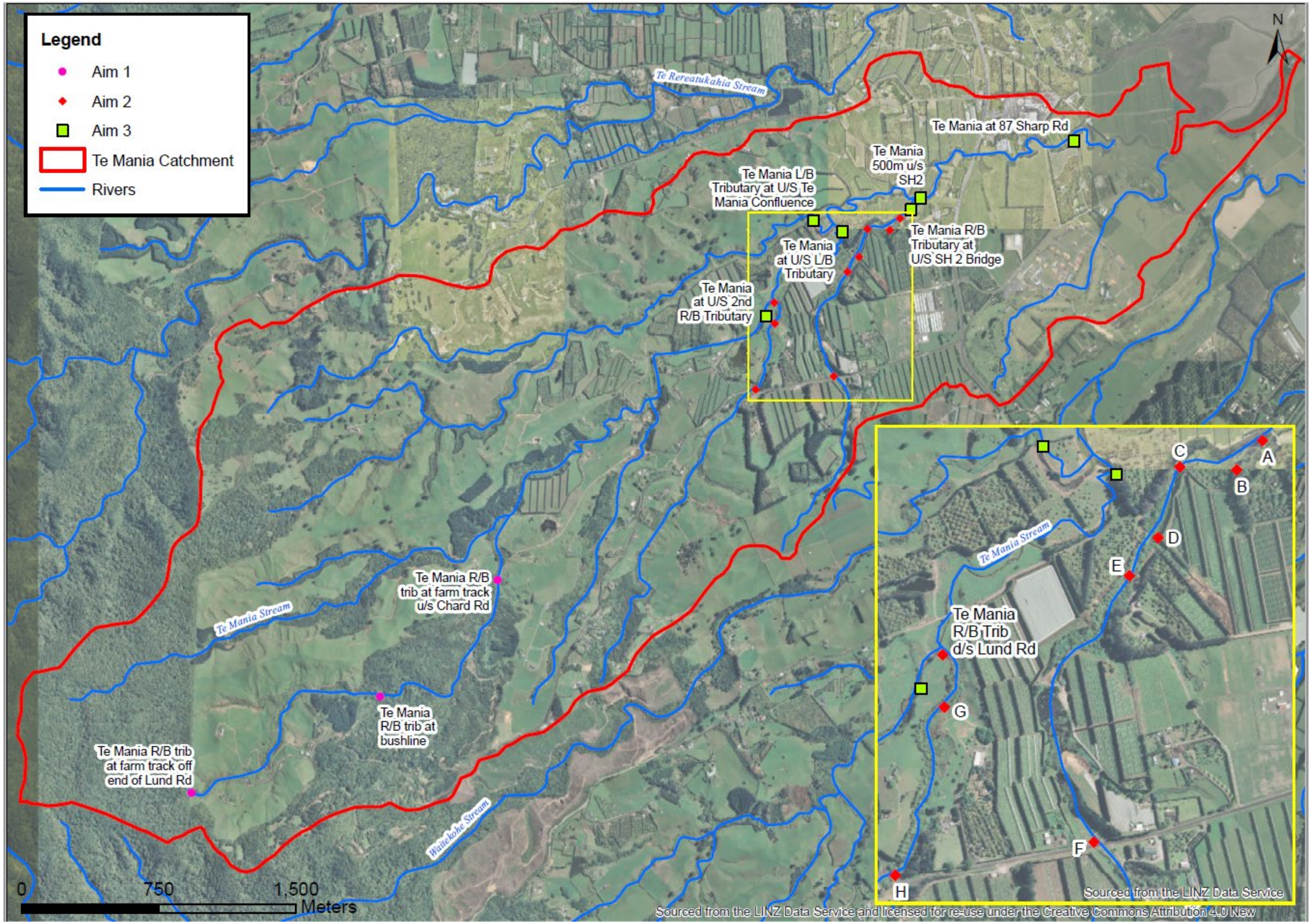



*Figure 4.1 Map of sites in the Te Mania Catchment for each aim. Location details are listed in Appendix B1.*

## 4.6 Results 2020/2021 (Ngā Otinga 2020/2021)

### 4.6.1 Investigate longitudinal changes in DRP in the Upper Te Mania Catchment

Field measurements of physical stream attributes were similar to previous results from Mahon et al. (2020) as shown in comparison to the 2019/2020 catchment median in Figure 4.2 below, and did not show any outliers across sites or time. Lower conductivity, DO, water temperature, DRP and TP results at the upper site were expected, given the site conditions of the small 'control' stream in native forest upstream of major anthropogenic influences.

As seen in Figure 4.3, both DRP and TP concentrations increase downstream from Te Mania R/B tributary at farm track off end of Lund Road to Te Mania R/B tributary at bushline. This is consistent with results in this tributary from Mahon et al. (2020). Downstream increases in phosphorus attributes have been reported in other Bay of Plenty Rivers (Hamill et al., 2020). This is to be expected in this tributary with very steep topography and incised gully streams. The LUCs of this sub-catchment are 6e, 7e and 8e where these LUC classes represent slopes ≥26°, and 'e' indicates an erosion limitation to land use (Lynn et al., 2009). One result at Te Mania R/B tributary at bushline for both TP and DRP was higher (worse) than the DGV, however as shown by the VA Gentle medians (Figure 4.3), phosphorus is naturally expected to be high in volcanic-derived soils in the Bay of Plenty (Hamill et al., 2020).

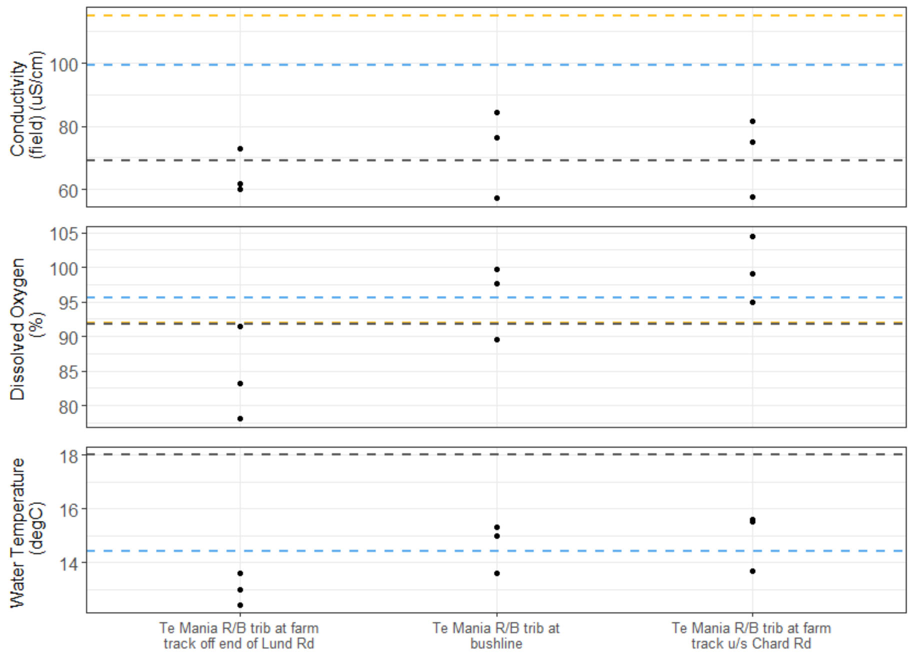



*Figure 4.2 Conductivity, dissolved oxygen and water temperature results in the upper Te Mania Catchment, 2020. Comparative values shown are the ANZG DGV[10] (yellow), the VA Gentle median[11] (blue), and the catchment median 2019/2020 (grey). Sites are ordered upstream to downstream (left to right).*

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*[10] ANZG DGVs are used to compare the state of water quality attributes to the expected chemical and physical conditions in reference ecosystems with minimal or no anthropogenic influence[2]*

*[11] VA Gentle medians represent the median value of water quality attributes for the Volcanic+Gentle biophysical class in the Bay of Plenty, based on the premise that geology and slope are the proximate driving variables influencing both water quality and ecology[11]*

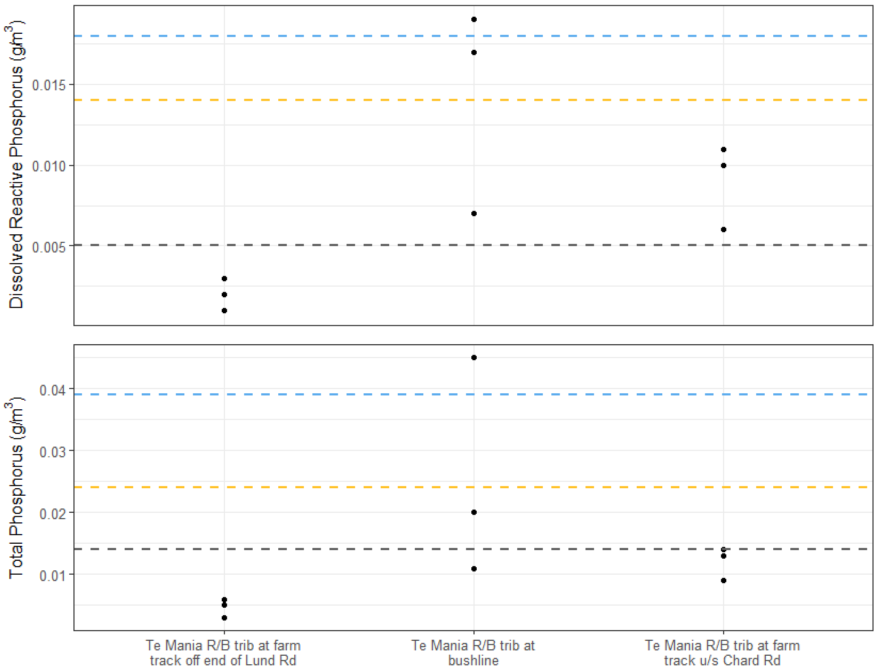



*Figure 4.3 Phosphorus concentrations in the upper Te Mania Catchment, 2020. Comparative values shown are the ANZG DGV (yellow), the VA Gentle median (blue), and the catchment median 2019/2020 (grey). Sites are ordered upstream to downstream (left to right).*

### 4.6.2 Quantify spatial extent and / or cause of low DO in two tributaries, and Ammoniacal-N in one tributary

Site investigations revealed that the two tributaries (see Figure 4.1) are small (first or second order), have been dammed or diverted in the past to make ponds, and now include large, shallow, unshaded ponds interspersed with boggy, heavily sedimented wetland areas. Both tributaries had significant organic matter and excessive macrophyte growth in September 2020 (see site photos in Appendix B1).

Dissolved oxygen levels at sites A to F ranged from 27% to 105%, and water temperature was approximately 15°C (see Table 4.1). Site B had the lowest DO concentration of all sites, where an eel was observed air breathing at the surface. However, this appears to be localised as DO recovered to 85% at site A, 90 m downstream. Over the summer of 2019/2020, the stream bed was observed to be dry upstream between site C and B, but resumed flowing downstream between site B and site A (landowner, personal communication, 28 September 2020). This suggests a groundwater influence in this section of the stream.

The second tributary studied for this aim recorded DO ≤80% at Te Mania R/B Tributary d/s Lund Road and site H (see Table 4.1). Water temperature was slightly higher than sites A-F on the other stream. The variation in DO and temperature between sites Te Mania R/B Tributary d/s Lund Road, G & H suggests that stream morphology and site characteristics (as seen in Appendix B1) limit oxygen saturation in this tributary and behaves more like a wetland than a freshwater stream. The site characteristics such as the wetland-like environment, high organic matter and macrophytes are likely all contributing to an environment where ammoniacal-N is high relative to NNN.

*Table 4.1 Dissolved oxygen and temperature results for two sub-catchments in September 2020. Site photos are shown in Appendix B1.*

| Site | Date & time | Dissolved Oxygen (%) | Water Temperature (°C) |
|---|---|---|---|
| A | 28/09/2020 12:56 | 85 | N/A |
| B | 28/09/2020 13:05 | 27 | 15.0 |
| C | 28/09/2020 13:10 | 95 | N/A |
| D | 28/09/2020 13:30 | 105 | 15.5 |
| E | 28/09/2020 14:00 | 78 | 15.7 |
| F | 28/09/2020 15:11 | 48 | 15.7 |
| BQ606537 Te Mania R/B tributary d/s Lund Road | 28/09/2020 15:48 | 80 | 16.6 |
| G | 28/09/2020 15:31 | 95 | 18.3 |
| H | 29/09/2020 14:10 | 67 | 16.0 |

#### 4.6.3 Estimate loadings from sub-catchments for *E. coli*, TSS and Ammoniacal-N to direct land management priorities

Since the publication of Mahon et al. (2020), additional flow information has been gathered in the Te Mania Catchment to allow contaminant loads to be estimated. It is important to remember that the contaminant loads estimated are only applicable to the 2019/2020 summer and it is not appropriate to assume contaminant loads outside of that time period. The loads of contaminants may change with time and circumstances as this is a natural environment with many variables. The additional flow information does allow comparison across the catchment with the intention of suggesting priority sub-catchments for mitigation of faecal bacteria, sediment and nitrogen issues.

Four sites were used to represent sub-catchments (see Figure 4.6) so that the relative proportion each contributed to the overall contaminant loads at a downstream site could be estimated for the 2019/2020 summer. The downstream site could be selected from either the NERMN site, Te Mania at 87 Sharp Road, or Te Mania 500 m u/s SH 2. Figure 4.5 compares flows at both sites for the 2019/2020 summer, which shows the low flow conditions of the 2019/2020 summer in contrast to all summer flows between 2017 and 2021. It was determined that the downstream site should be Te Mania 500 m u/s SH 2, despite less gaugings (n=4), because it was sampled at the same time as the other catchment sites, and is therefore more representative of the catchment, climate and flow conditions of the 2019/2020 monitoring period than the NERMN site. The equations to estimate the flow at the time of sampling, based on the relationship to flow at the rated NERMN site, are shown in Table 4.2.

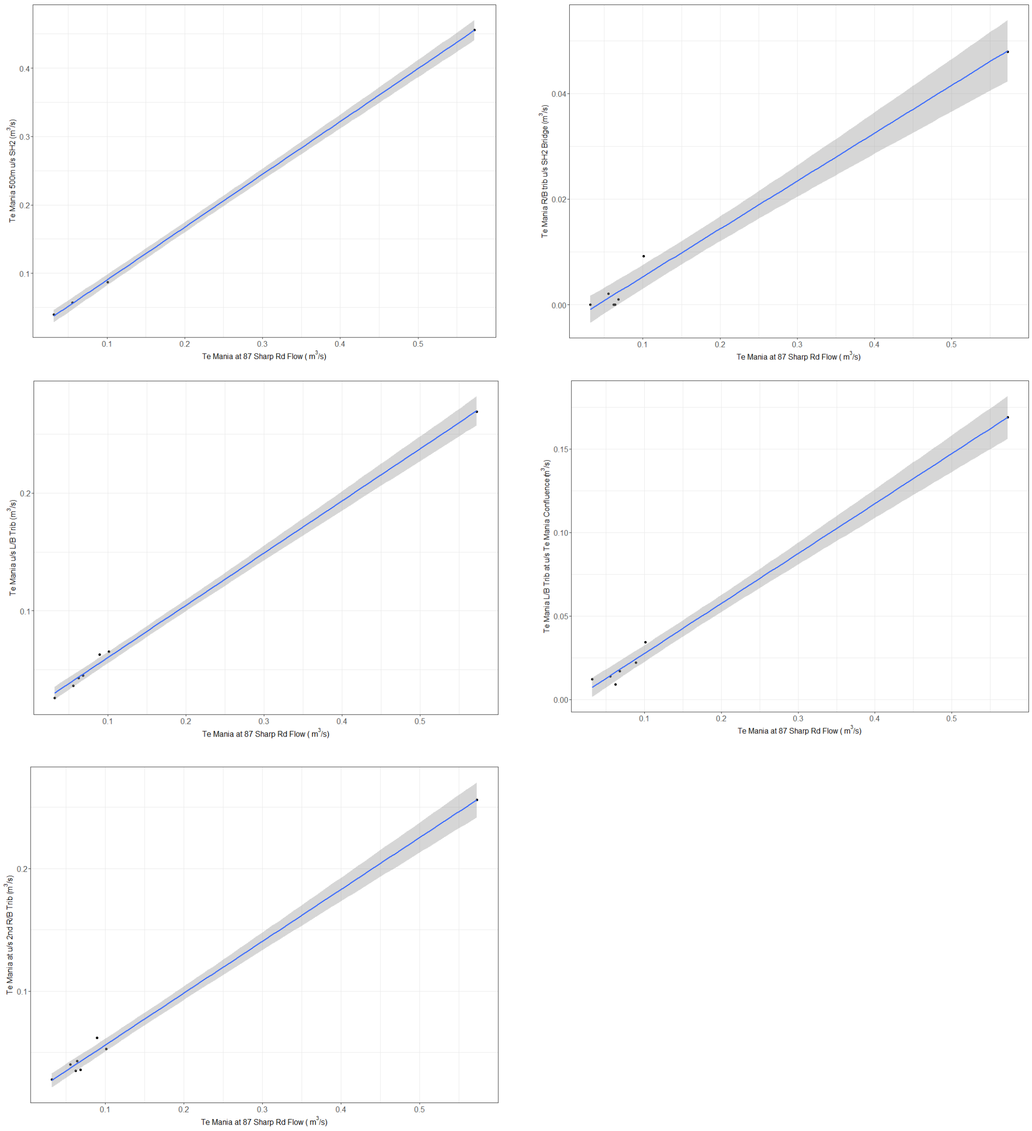


*Figure 4.4* *Flow relationships between water quality sample sites and Te Mania at 87 Sharp Road.*

*Table 4.2* *Equations for synthetic flow estimates based on relationships to Te Mania at 87 Sharp Road.*

| Site Name | Number of gaugings | Relationship Equation |
|---|---|---|
| Te Mania 500 m u/s SH 2 | 4 | y = 0.7726x + 0.013 |
| Te Mania R/B tributary u/s SH 2 bridge | 7 | y = 0.0871x - 0.0018 |
| Te Mania at u/s L/B Tributary | 7 | y = 0.4424x + 0.0166 |
| Te Mania L/B Tributary at u/s Te Mania Confluence | 7 | y = 0.2945x + 0.0002 |
| Te Mania at u/s 2nd R/B Tributary | 8 | y = 0.4174x + 0.0169 |

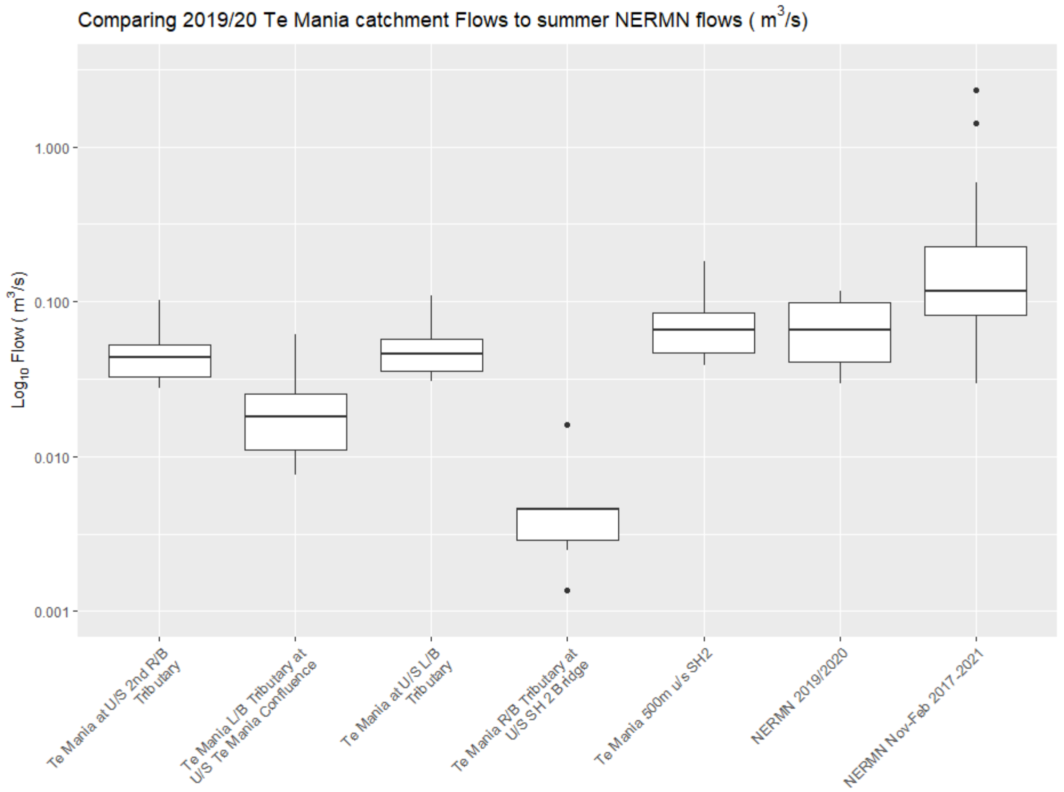



*Figure 4.5 Comparison of flows in the Te Mania Catchment sites to the flows at the NERMN site over 2019/2020 and summer months 2017-2021.*

The product of flow and concentration at the time of sampling provides an estimate of the instantaneous load. Load is expressed in terms of contaminants mass per unit of time for each of the attributes described below.

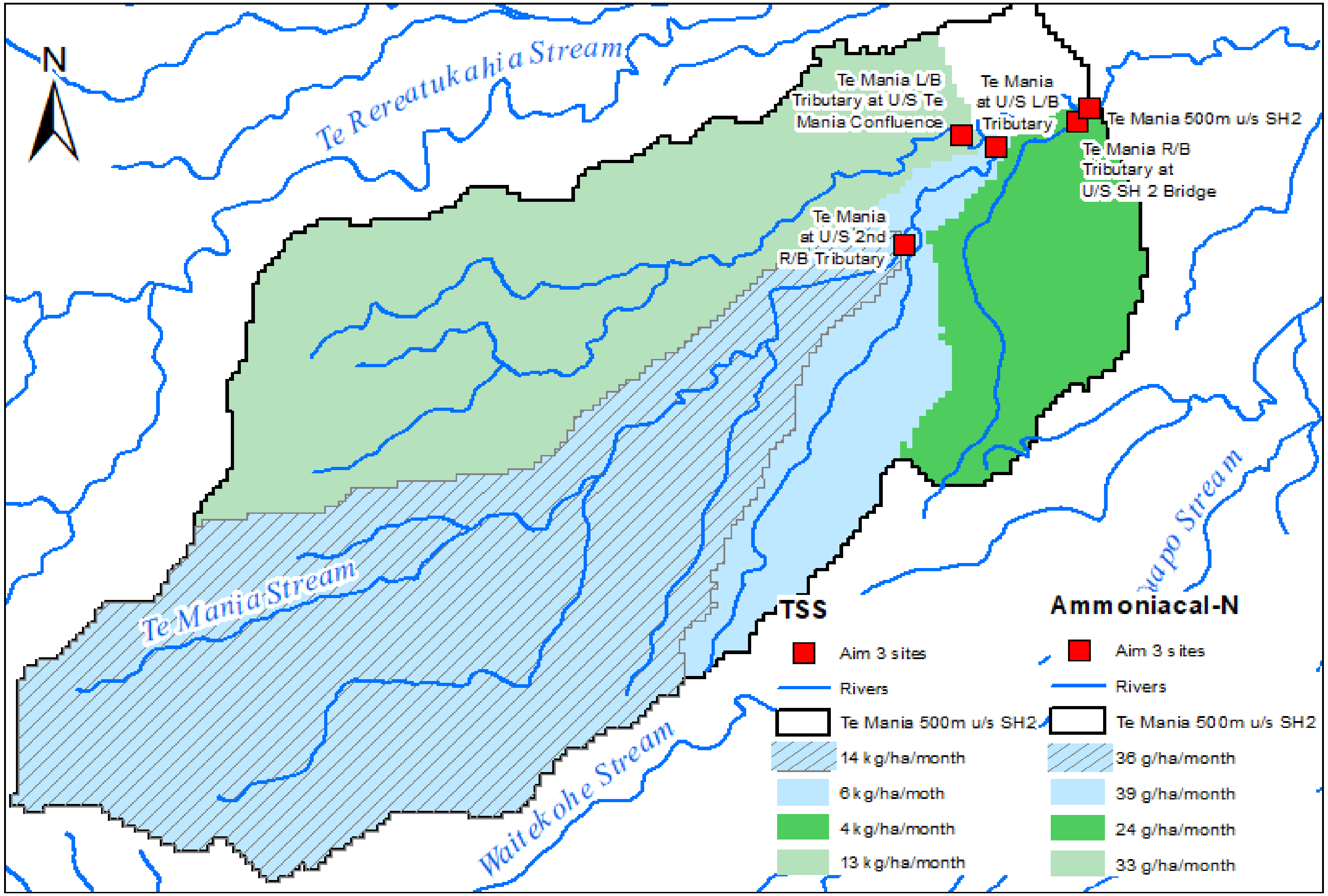



*Figure 4.6 Size and location of the sub-catchments from which contaminant loads were estimated for the 2019/2020 summer. Yields for TSS and Ammoniacal-N are detailed in the associated legends. Note the Te Mania at U/S L/B Tributary catchment consists of the light blue fill and the light blue with hatching.*

*E. coli* loads, 2019/2020

The contribution of each sub-catchment to the overall load of faecal bacteria at Te Mania 500 m u/s SH 2 in the 2019/2020 season is represented in Figure 4.7 below. Approximately 60% of the *E.coli* load came from Te Mania at U/S L/B Tributary, with approximately 35% from Te Mania L/B Tributary at U/S Te Mania Confluence. This is proportional to the size of the catchments (see Figure 4.6). Within the largest sub-catchment (621 ha), Te Mania at U/S 2nd R/B Tributary (512 ha) in particular delivers more faecal bacteria than the other branch. The smallest tributary in the lower catchment contributes approximately 5% of the total downstream, which is in line with expectations given the very small flow recorded here in 2019/2020.

TSS loads, 2019/2020

Figure 4.7 below shows the contribution of each sub-catchment to the total TSS load downstream. Te Mania L/B Tributary at U/S Te Mania Confluence had the largest contribution (approximately 55%) followed by Te Mania at U/S L/B Tributary (approximately 40%). As expected, the smallest load (≤5%) was from Te Mania R/B Tributary at U/S SH 2 Bridge, the smallest catchment.

By calculating the average TSS load over time per hectare, we can estimate that there is a similar average yield of sediment from both of the upper sub-catchments. Te Mania L/B Tributary at U/S Te Mania Confluence (average 13 kg/ha/month over summer) and Te Mania at U/S 2nd R/B Tributary have a higher average yield (14 kg/ha/month) than Te Mania at U/S L/B Tributary (average 6 kg/ha/month over summer). The Te Mania at U/S L/B Tributary site captures both the Te Mania at U/S 2nd R/B Tributary sub-catchment as well as an additional 109 ha sub-catchment (see Figure 4.6 for context). The higher yields in the upper catchment is not surprising given the high LUC and present land use (as discussed above and in section 4.7). The flatter gradient and slower flows in the lower catchment, likely causes sediment to drop out of the water column by the next site downstream (Te Mania at U/S L/B Tributary, reduction in yield from 14 to 6 kg/ha/month). It is also important to note that sediment may be re-suspended with increased flow events, or erosion events may temporarily alter the loads from a specific stream.

Ammoniacal Nitrogen loads, 2019/2020

The largest contribution to Ammoniacal-N loading came from Te Mania at U/S L/B Tributary (approximately 68%). The average yield for this sub-catchment was 39 g/ha/month. The second highest proportion was from Te Mania L/B Tributary at U/S Te Mania Confluence at approximately 28% of the total load (average Ammoniacal-N yield 33 g/ha/month, 349 ha area). Te Mania at U/S 2nd R/B Tributary had an average yield of 36 g/ha/month over 512 ha. Again, the smallest tributary showed the lowest total load at approximately 5% - see figure 4.7.

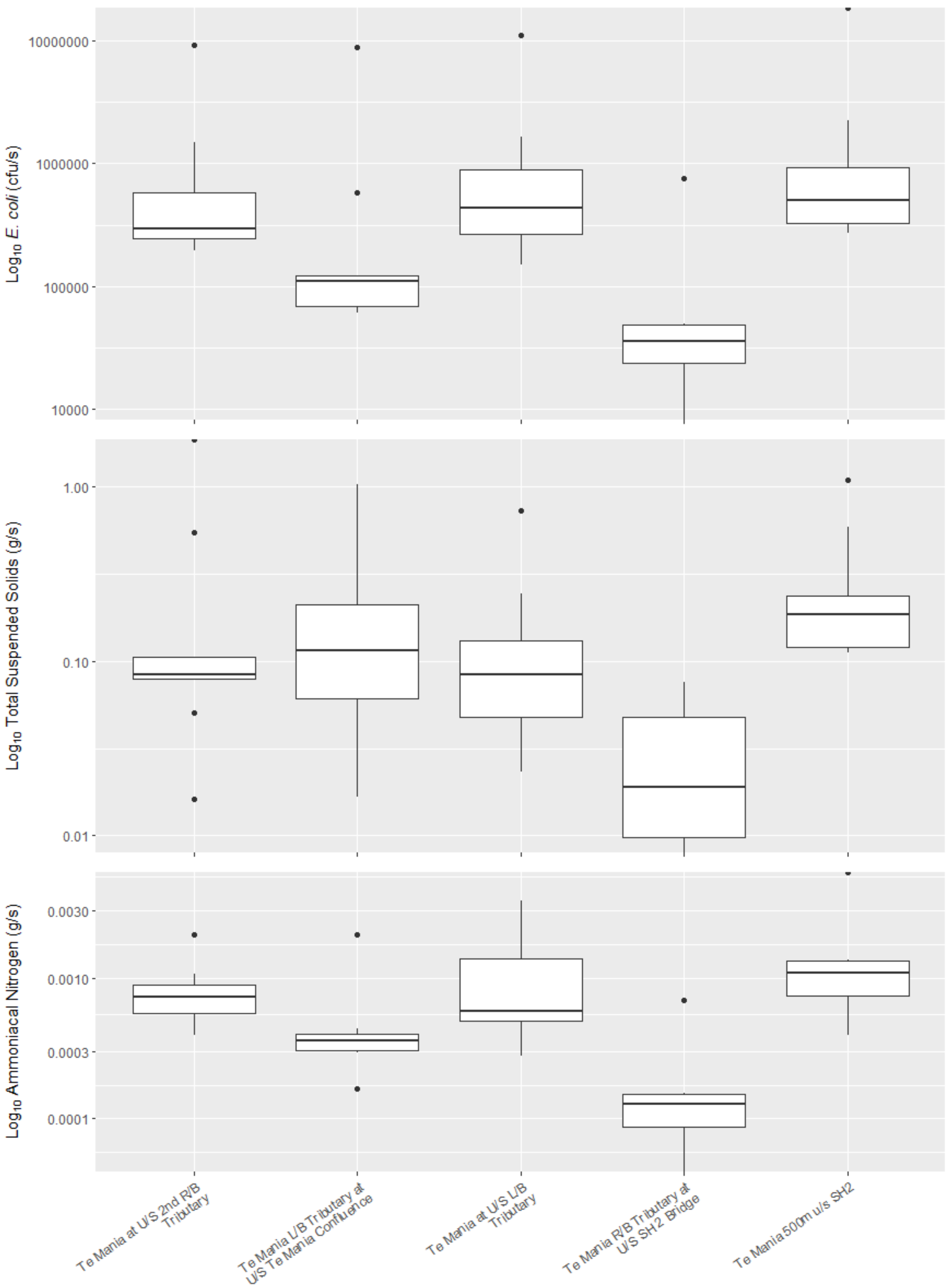



*Figure 4.7* *Estimated E. coli, TSS and Ammoniacal-N loads in the Te Mania catchment from the 2019/2020 monitoring season. Note that Te Mania at U/S 2nd R/B Tributary is a tributary of Te Mania at U/S L/B Tributary (see figure 4.6 sub-catchment map), and the differing y-axes scales*

## 4.7 Discussion (Matapakitanga)

Water quality sampling and analysis in the Te Mania Catchment in 2020, was designed to answer questions from the 2019/2020 monitoring programme, and to fulfil outstanding aims. The outcome for each aim is discussed below.

### 4.7.1 Investigate longitudinal changes in DRP in the upper Te Mania Catchment

DRP and TP concentrations increased downstream from the 'control' site, which is in line with existing research in the Te Mania Catchment and wider region. There were no recorded or observed point sources of phosphorus-rich water in this stream and the majority of this sub-catchment does not have a recent history of phosphorus application. Other possible influences could include earthworks, farm tracks, soil erosion, geothermal or groundwater springs, which are common in the lower Te Mania Catchment and neighbouring catchments (e.g. geothermal bores for heating). It should be noted that this portion of the catchment is very steep with the majority being LUC Classes 6 and 7 (>26$^{o}$) and therefore more prone to sediment and phosphorus loss under pastoral land use.

Based on existing information, increasing DRP and TP levels downstream are likely a reflection of the current land use (pastoral grazing of drystock, exotic forestry, and native forest) in the upper Te Mania Catchment where there are higher LUC classes. Higher LUC classes (steeper slopes and prone to erosion) either require strong soil conservation measures to use for grazing, or are increasingly unsuitable for pastoral, arable and commercial forestry land uses (Lynn et al., 2009). Potential mitigations for these land uses in this catchment include:

- Extensive retirement of Critical Source Areas (CSA)
- Better farm track management with respect to water management
- More deliberate stock and pasture management matched to suitability of terrain
- Permanent retirement of steepest areas to native forest.

### 4.7.2 Quantify spatial extent and / or cause of low DO in two tributaries, and Ammoniacal-N in one tributary

Based on existing information, low DO levels seen in the Te Mania Catchment in 2019/2020 summer are likely due to the influence of stream morphology and climate conditions on water quality.

It is reasonable to expect excessive growth of macrophytes in summer especially *Glyceria maxima* with nutrient enrichment, low flows, and warmer temperatures. Dissolved oxygen levels can be reduced by high rates of bacterial decomposition of organic matter, and a lack of atmospheric re-aeration in slow-moving or stagnant waterbodies (Wilcock and Croker, 2004). Furthermore, the elevated temperatures in the ponds due to lack of riparian vegetation would further increase bacterial decomposition rates, reducing DO levels even more. Groundwater interaction with surface water may also be contributing to lower DO levels in the lower Te Mania catchment. Groundwater is known to have lower DO levels than surface water due to isolation from atmospheric oxygen sources and consumption of oxygen by hydrochemical and biochemical processes (Freeze and Cherry, 1979).

There are no current Surface Water Take or Land Use – Damming and Diversion consents between sites A to F. There is a current Land Use – Damming and Diversion consent and Surface Water Take consent upstream of site F. At site G, a Surface Water Take consent was surrendered in 1998. There are two current Land Use – River Structure consents and two current Land Use – Damming and Diversion consents upstream of site H.

It is suggested that variable water quality across sites A-H reflects the stream characteristics with dams, ponds and wetland areas. Stream remediation activities such as removing unused dam or diversion structures, increasing riparian shading, controlling invasive macrophytes, and reducing nutrient inputs from surrounding land uses could improve stream conditions in both of these sub-catchments and support higher DO levels, particularly in warm, dry summers.

#### 4.7.3 **Estimate loadings from each site for *E. coli*, TSS and Ammoniacal-N to direct land management priorities**

*E.coli* loads

Both the concentration (Mahon et al. 2020) and loads of *E.coli* increase downstream in the Te Mania Catchment, which is to be expected with increasing catchment area and stream discharge. In the Te Mania Catchment, the largest *E. coli* load(s) in the 2019/2020 summer were coming from the largest sub-catchments Te Mania at U/S L/B Tributary, Te Mania L/B Tributary at U/S Te Mania Confluence and Te Mania at U/S 2nd R/B Tributary (see Figure 4.1). Hamill et al. (2020) reported increasing bacteria concentrations downstream in the Kaituna and Tarawera rivers, which reflects increasing catchment area and flow. In the Kaiate Falls Catchment, the majority of the *E. coli* load is coming from the largest tributaries (Mahon et al., 2020).

Based on the relative contribution of each sub-catchment to the total *E.coli* load in the lower catchment in the 2019/2020 summer, mitigations for faecal bacteria contamination are recommended to focus on the catchment of the main Te Mania Stream, and within that the sub-catchment of Te Mania at U/S 2nd R/B Tributary.

TSS loads

Mahon et al (2020) showed that the concentration of TSS increases downstream in the Te Mania Catchment, which is associated with increasing catchment area and stream discharge. The loads however, are relatively similar from the three sub-catchments. There may be some deposition of sediment in the lower catchment due to reduced slope compared to TSS loads from the upper sites, and several variables can influence the sediment loads of streams including variation in flow/rainfall, stream bank erosion and disturbance of the stream bed. Nevertheless, larger catchment areas are correlated with increasing sediment concentrations in the wider Bay of Plenty (Hamill et al., 2020).

Based on the relative contribution of each sub-catchment to the total TSS load in the lower catchment in the 2019/2020 summer, mitigations for sediment contamination are recommended to focus on the areas upstream of Te Mania L/B Tributary at U/S Te Mania Confluence and Te Mania at U/S 2$^{nd}$ R/B Tributary.

Ammoniacal-N loads

In the 2019/2020 summer, the greatest proportion of Ammoniacal-N loading was coming from Te Mania at U/S L/B Tributary. Ammoniacal-N yields were similar across the sub-catchments.

Nitrogen levels increase downstream in other Bay of Plenty rivers (Kaituna and Tarawera) in response to greater catchment area and the addition of significant tributaries (Hamill et al., 2020). While nitrogen cycles are complex and respond to many variables in an ecosystem, the dominance of the largest sub-catchment on total Ammoniacal-N loads, provides a starting point for prioritised nitrogen mitigation in the Te Mania catchment.

## 4.8 Conclusion (Whakakapinga)

Building on water quality monitoring in the Te Mania Catchment over the 2019/2020 summer, recent investigations have found that DRP and TP increases downstream in the upper catchment in response to the current land uses. Heavily modified stream environments in the lower catchment were likely a strong driver of poor DO levels in very low flow conditions. The largest sub-catchment (Te Mania at U/S L/B Tributary) was contributing the greatest *E.coli* and Ammoniacal-N loads to the lower catchment, while most TSS load was coming from Te Mania L/B Tributary at U/S Te Mania Confluence.

These investigations confirm that the upper catchment is a proportionately large contributor to contaminant loads of Ammoniaca-N, TSS and *E.coli* with the steepness of terrain being a main driver. The relative contribution from the two main watersheds may be responsive to changes in land management.

This report suggests that land use change and nutrient management could mitigate the phosphorus, sediment and *E.coli* losses from the upper catchment. Physical remediation of the smaller streams in the lower catchment, alongside reducing sedimentation and nutrient inputs, could improve oxygen levels and improve habitat for aquatic species. No additional water quality monitoring is recommended at this stage. The current NERMN site in the lower catchment continues to provide long-term environmental data, which can be used to monitor significant changes in the Te Mania Catchment over time.

## 4.9 Recommendations (Ngā Tūtohutanga)

1. Focus land management activities in the upper catchment on sediment reducing mitigation or landuse change. Implementing measures for sediment management will likely have a mitigating effect for the loss of phosphorus and bacteria also.
2. Reduce nutrient loss and restore flow in two streams by removing unused dams and diversions to improve dissolved oxygen and ammoniacal-N concentrations

## 4.10 References (Ngā Tohutoro)


Freeze, R. A. & Cherry, J.A. (1979). *Groundwater*. Prentice-Hall, Inc.

Hamill, K. Dare, J. and Gladwin, J. (2020). *River Water Quality State and Trends in the Bay of Plenty to 2018: Part A*. Publication prepared for the Bay of Plenty Regional Council. River Lake Ltd, Whakatāne, New Zealand.

Lynn, I.H., Manderson, A.K., Page, M.J., Harmsworth, G.R., Eyles, G.O., Douglas, G.B., Mackay A.D., & Newsome, P.J.F. (2009). *Land Use Capability Survey Handbook – a New Zealand handbook for the classification of land* (3rd ed.). AgResearch, Landcare Research and GNS Science.

Mahon, L., Zygadlo, M., Carter, R., Crawshaw, J., & Dare, J. (2020). *Focus Catchments  Water Quality 2020/Te Kounga Wai O Ngā Kurawai E Arotahia Ana*. Bay of Plenty Regional Council Environmental Publication 2020/04.

National Environmental Monitoring Standards. (2013). *Open Channel Flow Measurement*. National Environmental Monitoring Standards, New Zealand.

Wilcock, R.J., & Croker, G.F. (2004). Distribution of carbon between sediment and water in macrophyte dominated lowland streams. *Hydrobiologia 520*: 143–52.

# Appendix B1: Te Mania

*Table A1 Location details for water quality investigations in the Te Mania Catchment, 2020. ● = relates to Aim 1, ◆ = relates to Aim 2, ■ = relates to Aim 3 in Section 4.5.*

| Site | Easting (NZTM) | Northing (NZTM) | Aim |
|---|---|---|---|
| Te Mania R/B tributary at farm track u/s Chard Road | 1854514 | 5833923 | 1 ● |
| Te Mania R/B tributary at bushline | 1853870 | 5833285 | 1 ● |
| Te Mania R/B tributary at farm track off end of Lund Road | 1852839 | 5832759 | 1 ● |
| A | 1856724 | 5835908 | 2 ◆ |
| B | 1856679 | 5835858 | 2 ◆ |
| C | 1856535 | 5835844 | 2 ◆ |
| D | 1856488 | 5835692 | 2 ◆ |
| E | 1856427 | 5835610 | 2 ◆ |
| F | 1856350 | 5835037 | 2 ◆ |
| Te Mania R/B tributary d/s Lund Road | 1856025 | 5835440 | 2 ◆ |
| G | 1856028 | 5835327 | 2 ◆ |
| H | 1855923 | 5834966 | 2 ◆ |
| Te Mania 500 m u/s SH 2 | 1856827 | 5836013 | 3 ■ |
| Te Mania R/B Tributary at U/S SH 2 Bridge | 1856774 | 5835950 | 3 ■ |
| Te Mania at U/S L/B Tributary | 1856400 | 5835829 | 3 ■ |
| Te Mania at U/S 2nd R/B Tributary | 1855979 | 5835368 | 3 ■ |
| Te Mania L/B Tributary at U/S Te Mania Confluence | 1856242 | 5835889 | 3 ■ |

(a)  (b) 

*Figure A1 Site A upstream (a) and downstream (b)*

*Figure A2 Pond at site B*

*Figure A3 Site C looking upstream*

(a)

(b)

*Figure A4 Site D looking upstream (a) and the pond (b)*

*Figure A5 Stream at Site E*

(a)

(b)

*Figure A6 Upstream of site E (a and b*

(a) (b) (c)

*Figure A7 Site F looking upstream (a), at Site F (b) and looking downstream (c)*

# Appendix B2:
# Te Mania site summaries

## Te Mania at U/S 2nd R/B Tributary

20 July 2021

### Summary statistics

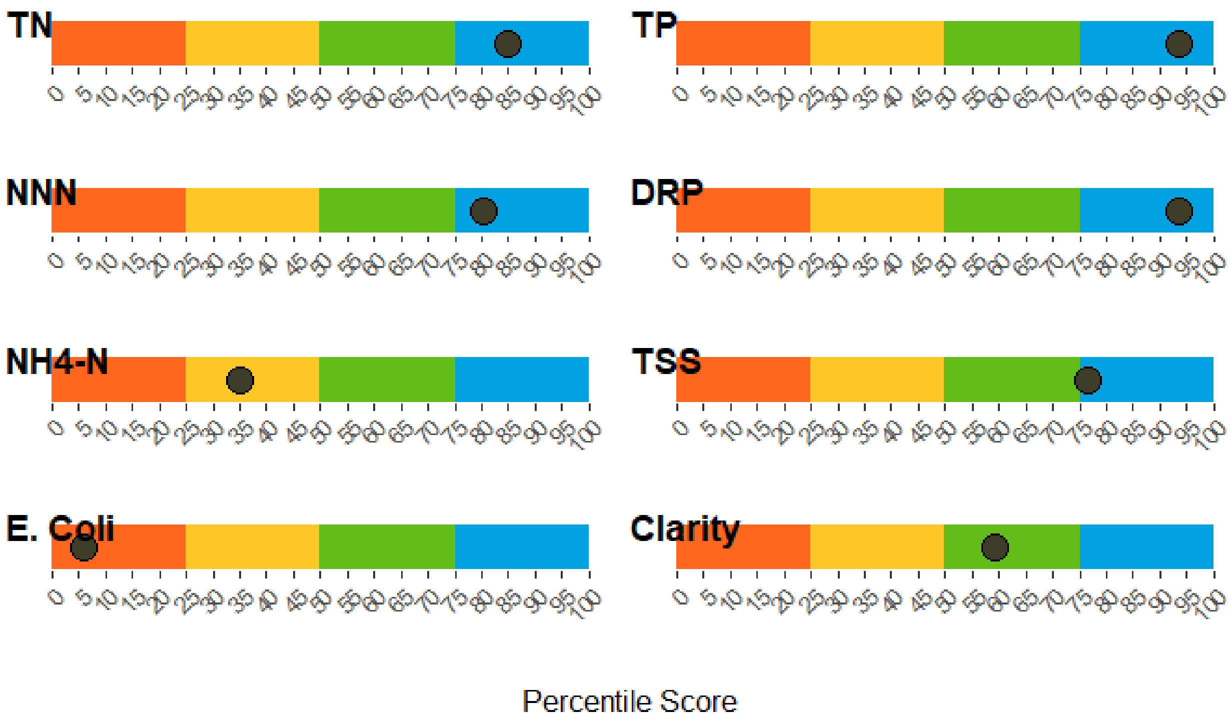
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 9 | 0.10 | 0.33 | 0.20 | 0.18 | 0.30 | 0.13 | 0.07 | 0.02 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 9 | 0.03 | 0.18 | 0.10 | 0.08 | 0.18 | 0.04 | 0.06 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 9 | 0.009 | 0.028 | 0.018 | 0.020 | 0.025 | 0.010 | 0.006 | 0.002 |
| **Total Phosphorus (g/m3)** | 9 | 0.008 | 0.022 | 0.012 | 0.011 | 0.019 | 0.008 | 0.004 | 0.001 |
| **Dissolved Reactive Phosphorus (g/m3)** | 9 | 0.003 | 0.006 | 0.004 | 0.003 | 0.006 | 0.003 | 0.001 | 0.000 |
| **Dissolved Oxygen Sat (%)** | 9 | 88.7 | 95.7 | 92.8 | 93.5 | 95.5 | 88.8 | 2.5 | 0.8 |
| **Dissolved Oxygen (g/m3)** | 9 | 7.97 | 9.43 | 8.75 | 8.76 | 9.31 | 8.13 | 0.44 | 0.15 |
| **Escherichia coli (cfu/100ml)** | 9 | 430 | 9000 | 2080 | 900 | 6760 | 446 | 2769 | 923 |
| **Total Suspended Solids (g/m3)** | 9 | <1 | 35.20 | 6.03 | 2.00 | 23.25 | 0.83 | 11.03 | 3.68 |
| **Turbidity (NTU)** | 9 | 1.6 | 6.5 | 3.0 | 3.1 | 5.4 | 1.7 | 1.5 | 0.5 |
| **Water Clarity (m)** | 9 | 1.44 | 2.83 | 2.06 | 2.08 | 2.80 | 1.47 | 0.49 | 0.16 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | | | | | | | | | |
| **Water Temperature (degC)** | 9 | 14.4 | 21.2 | 18.2 | 18.3 | 21.0 | 15.3 | 2.0 | 0.7 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site’s percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the ‘Surveillance, alert, and action level’ framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC’s water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2015-02-05 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2010-02-06 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| All | 2019-11-26 | 2020-02-04 | 9 | 900 | NA | 0 | 33.3 | 66.7 |

# Te Mania L/B Tributary at U/S Te Mania Confluence

20 July 2021

## Summary statistics

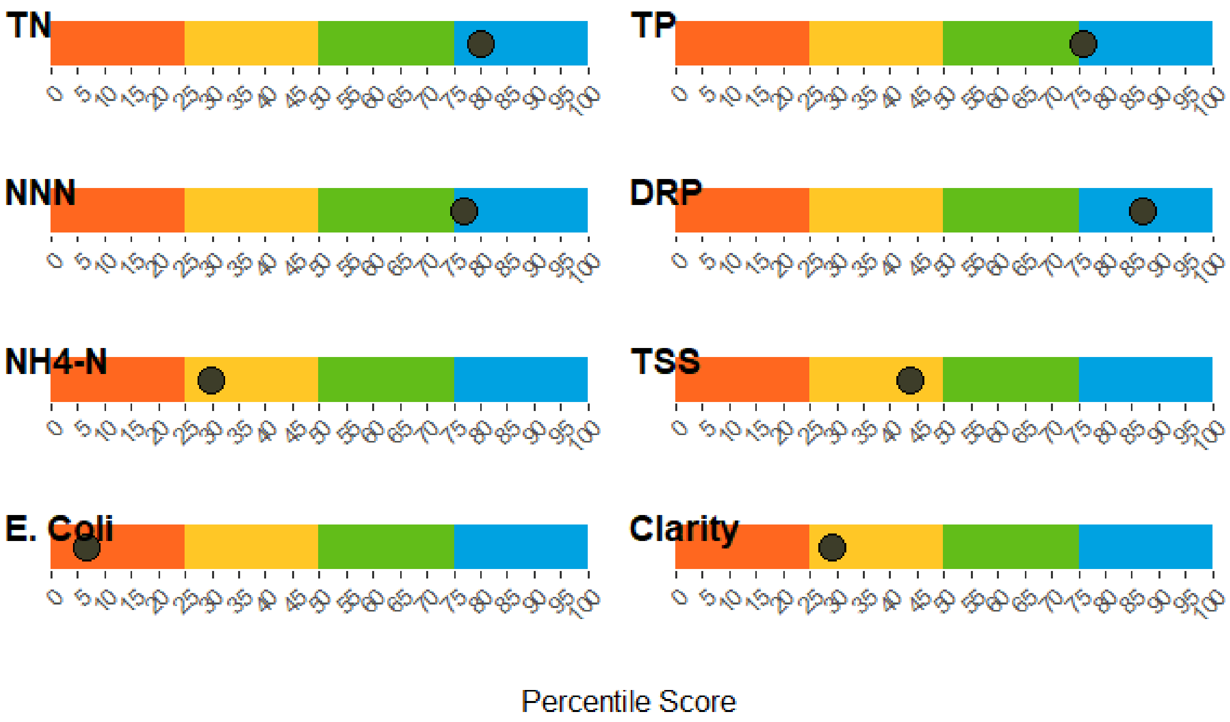
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 9 | 0.21 | 0.50 | 0.27 | 0.25 | 0.42 | 0.22 | 0.09 | 0.03 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 9 | 0.07 | 0.17 | 0.11 | 0.11 | 0.15 | 0.08 | 0.03 | 0.01 |
| **Total Ammoniacal Nitrogen (g/m3)** | 9 | 0.009 | 0.058 | 0.027 | 0.024 | 0.053 | 0.010 | 0.017 | 0.006 |
| **Total Phosphorus (g/m3)** | 9 | 0.012 | 0.049 | 0.026 | 0.026 | 0.042 | 0.014 | 0.011 | 0.004 |
| **Dissolved Reactive Phosphorus (g/m3)** | 9 | 0.004 | 0.009 | 0.006 | 0.006 | 0.008 | 0.004 | 0.001 | 0.000 |
| **Dissolved Oxygen Sat (%)** | 9 | 85.9 | 94.3 | 91.1 | 91.5 | 94.1 | 86.9 | 2.7 | 0.9 |
| **Dissolved Oxygen (g/m3)** | 9 | 7.57 | 9.13 | 8.57 | 8.81 | 9.07 | 7.67 | 0.55 | 0.18 |
| **Escherichia coli (cfu/100ml)** | 9 | 320 | 14400 | 2431 | 800 | 9920 | 368 | 4573 | 1524 |
| **Total Suspended Solids (g/m3)** | 9 | 2.20 | 16.75 | 7.84 | 6.60 | 16.25 | 2.20 | 5.20 | 1.73 |
| **Turbidity (NTU)** | 9 | 2.7 | 11.8 | 6.4 | 6.5 | 10.9 | 2.8 | 3.0 | 1.0 |
| **Water Clarity (m)** | 9 | 0.74 | 2.27 | 1.23 | 1.15 | 1.89 | 0.84 | 0.42 | 0.14 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | | | | | | | | | |
| **Water Temperature (degC)** | 9 | 15.4 | 21.9 | 18.5 | 18.1 | 21.7 | 16.0 | 2.0 | 0.7 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2015-02-05 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2010-02-06 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| All | 2019-11-26 | 2020-02-04 | 9 | 800 | NA | 0 | 33.3 | 66.7 |

# Te Mania at U/S L/B Tributary

20 July 2021

## Summary statistics

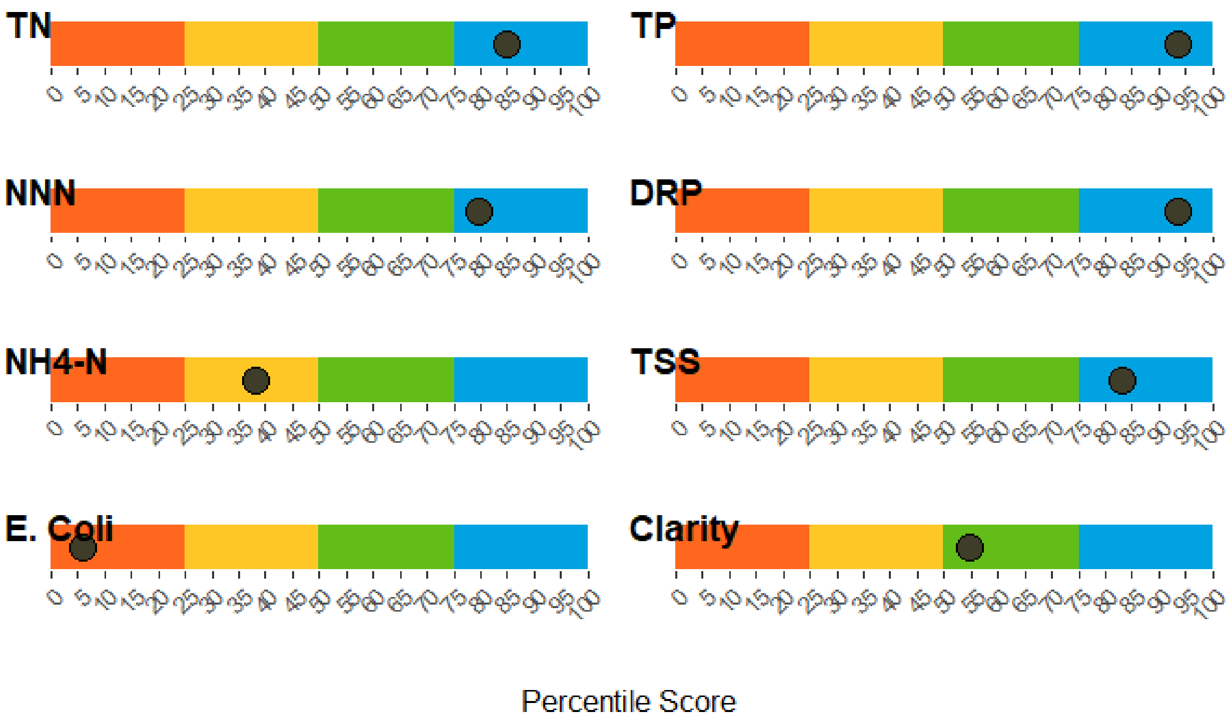
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 9 | 0.12 | 0.37 | 0.22 | 0.18 | 0.33 | 0.14 | 0.08 | 0.03 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 9 | 0.03 | 0.18 | 0.11 | 0.09 | 0.17 | 0.04 | 0.06 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 9 | 0.006 | 0.032 | 0.019 | 0.018 | 0.031 | 0.008 | 0.009 | 0.003 |
| **Total Phosphorus (g/m3)** | 9 | 0.002 | 0.024 | 0.011 | 0.011 | 0.020 | 0.004 | 0.006 | 0.002 |
| **Dissolved Reactive Phosphorus (g/m3)** | 9 | 0.002 | 0.005 | 0.004 | 0.003 | 0.005 | 0.002 | 0.001 | 0.000 |
| **Dissolved Oxygen Sat (%)** | 9 | 91.6 | 105.6 | 95.3 | 93.9 | 103.0 | 92.0 | 4.4 | 1.5 |
| **Dissolved Oxygen (g/m3)** | 9 | 8.25 | 9.61 | 8.99 | 9.05 | 9.55 | 8.35 | 0.47 | 0.16 |
| **Escherichia coli (cfu/100ml)** | 9 | 430 | 10100 | 2311 | 910 | 7500 | 446 | 3110 | 1037 |
| **Total Suspended Solids (g/m3)** | 9 | <1 | 8.00 | 2.79 | 1.47 | 7.47 | 0.90 | 2.64 | 0.88 |
| **Turbidity (NTU)** | 9 | 2.6 | 7.2 | 3.7 | 3.1 | 6.0 | 2.7 | 1.5 | 0.5 |
| **Water Clarity (m)** | 9 | 1.05 | 2.45 | 1.86 | 1.94 | 2.39 | 1.13 | 0.46 | 0.15 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | | | | | | | | | |
| **Water Temperature (degC)** | 9 | 14.3 | 21.1 | 18.3 | 18.0 | 21.0 | 15.2 | 2.1 | 0.7 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2015-02-05 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2010-02-06 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| All | 2019-11-26 | 2020-02-04 | 9 | 910 | NA | 0 | 33.3 | 66.7 |

## Te Mania R/B Tributary at U/S SH 2 bridge

20 July 2021

### Summary statistics

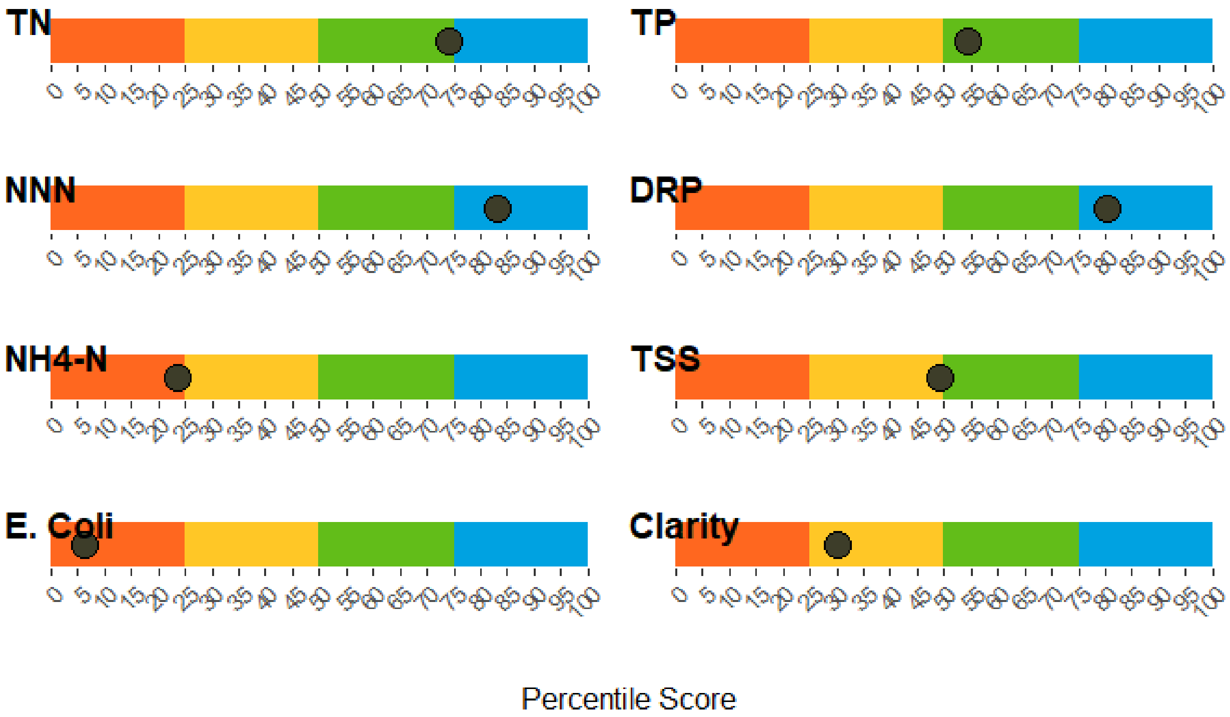
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 6 | 0.23 | 0.69 | 0.40 | 0.31 | 0.67 | 0.24 | 0.19 | 0.08 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 6 | 0.03 | 0.26 | 0.09 | 0.06 | 0.21 | 0.03 | 0.09 | 0.03 |
| **Total Ammoniacal Nitrogen (g/m3)** | 6 | 0.025 | 0.043 | 0.032 | 0.032 | 0.041 | 0.026 | 0.006 | 0.002 |
| **Total Phosphorus (g/m3)** | 6 | 0.027 | 0.173 | 0.063 | 0.040 | 0.147 | 0.028 | 0.056 | 0.023 |
| **Dissolved Reactive Phosphorus (g/m3)** | 6 | 0.006 | 0.020 | 0.011 | 0.009 | 0.018 | 0.007 | 0.005 | 0.002 |
| **Dissolved Oxygen Sat (%)** | 6 | 32.6 | 54.3 | 43.5 | 45.1 | 52.3 | 33.9 | 7.5 | 3.1 |
| **Dissolved Oxygen (g/m3)** | 6 | 3.20 | 4.91 | 4.06 | 4.23 | 4.76 | 3.28 | 0.61 | 0.25 |
| **Escherichia coli (cfu/100ml)** | 6 | 490 | 4700 | 1562 | 850 | 4000 | 512 | 1626 | 664 |
| **Total Suspended Solids (g/m3)** | 6 | 2.60 | 11.80 | 5.96 | 5.67 | 10.55 | 2.76 | 3.34 | 1.36 |
| **Turbidity (NTU)** | 6 | 4.5 | 22.7 | 8.3 | 5.0 | 19.1 | 4.5 | 7.2 | 2.9 |
| **Water Clarity (m)** | 6 | 0.93 | 1.81 | 1.26 | 1.19 | 1.73 | 0.93 | 0.36 | 0.15 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | | | | | | | | | |
| **Water Temperature (degC)** | 6 | 16.1 | 19.8 | 18.5 | 19.1 | 19.7 | 16.5 | 1.4 | 0.6 |

## State of the site

**Comparison plots**

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




**Microbiological guidelines assessment**

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2015-01-15 | 2020-01-14 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2010-01-16 | 2020-01-14 | NA | NA | NA | NA | NA | NA |
| All | 2019-11-26 | 2020-01-14 | 6 | 850 | NA | 0 | 16.7 | 83.3 |

# Te Mania 500 m u/s SH 2

20 July 2021

## Summary statistics

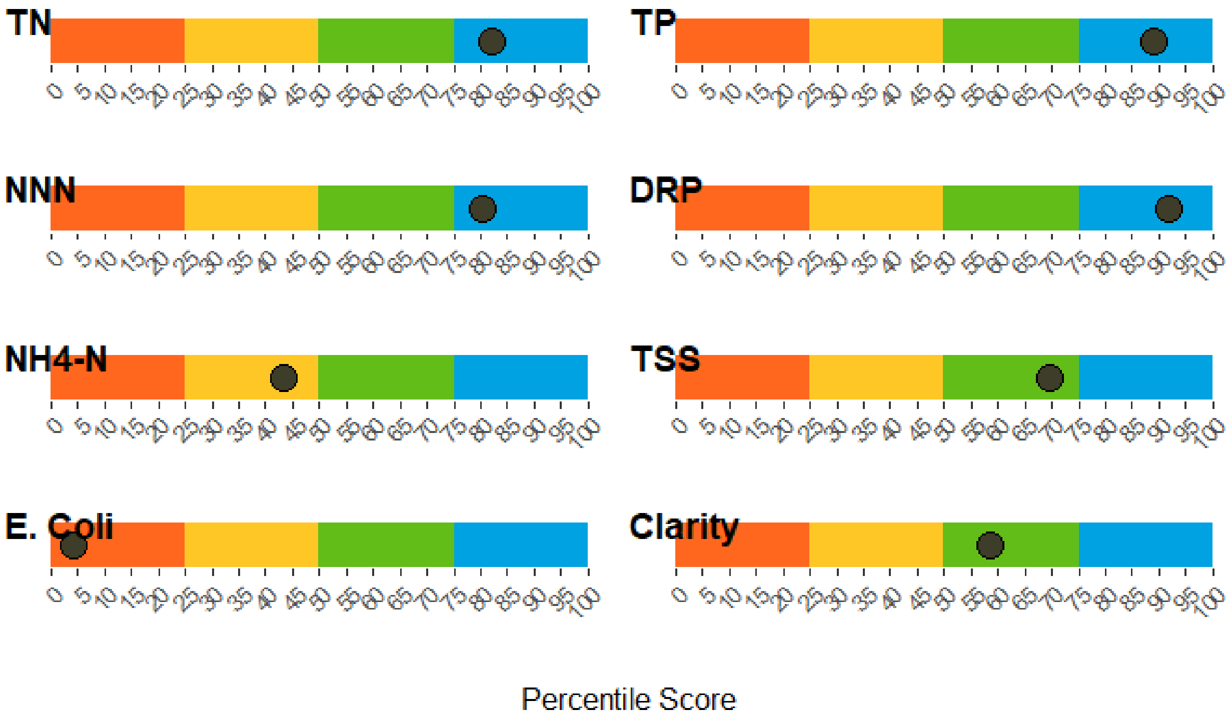
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 9 | 0.13 | 0.44 | 0.24 | 0.22 | 0.36 | 0.15 | 0.08 | 0.03 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 9 | 0.03 | 0.18 | 0.10 | 0.08 | 0.17 | 0.04 | 0.05 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 9 | 0.006 | 0.031 | 0.018 | 0.016 | 0.031 | 0.008 | 0.008 | 0.003 |
| **Total Phosphorus (g/m3)** | 9 | 0.010 | 0.034 | 0.017 | 0.015 | 0.029 | 0.010 | 0.008 | 0.003 |
| **Dissolved Reactive Phosphorus (g/m3)** | 9 | 0.003 | 0.009 | 0.004 | 0.004 | 0.007 | 0.003 | 0.002 | 0.001 |
| **Dissolved Oxygen Sat (%)** | 9 | 82.2 | 93.3 | 88.6 | 89.3 | 92.4 | 83.2 | 3.4 | 1.1 |
| **Dissolved Oxygen (g/m3)** | 9 | 7.28 | 9.00 | 8.35 | 8.50 | 8.94 | 7.49 | 0.56 | 0.19 |
| **Escherichia coli (cfu/100ml)** | 9 | 350 | 10300 | 2292 | 1200 | 7540 | 366 | 3176 | 1059 |
| **Total Suspended Solids (g/m3)** | 9 | 1.40 | 15.00 | 4.38 | 2.80 | 11.40 | 1.41 | 4.28 | 1.43 |
| **Turbidity (NTU)** | 9 | 2.6 | 6.5 | 3.7 | 3.4 | 5.7 | 2.6 | 1.2 | 0.4 |
| **Water Clarity (m)** | 9 | 0.93 | 2.36 | 1.87 | 2.06 | 2.33 | 1.16 | 0.44 | 0.15 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | | | | | | | | | |
| **Water Temperature (degC)** | 9 | 14.9 | 21.3 | 18.3 | 18.1 | 20.9 | 15.8 | 1.8 | 0.6 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2015-02-05 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2010-02-06 | 2020-02-04 | NA | NA | NA | NA | NA | NA |
| All | 2019-11-26 | 2020-02-04 | 9 | 1200 | NA | 0 | 33.3 | 66.7 |

# 5 Kopuaroa, Te Puke

## 5.1 Summary (Whakarāpopototanga Matua)

- Low DO was not observed over the 2020/2021 summer.
- The previous occurrence of the low DO was likely due to the drain-like habitat conditions exacerbated over periods of low flows and high temperatures.
- Work on reducing contaminant loading in the catchment should continue.

## 5.2 Introduction (Kupu Whakataki)

The Kopuaroa Stream is a small tributary of the Kaituna River, located between Te Puke and Pāpāmoa Hills Regional Park. The Kopuaroa Catchment (10,045 ha) has been selected as one of the BOPRC Focus Catchments because previous monitoring identified elevated nutrient, sediment and bacterial contamination. The Kopuaroa Catchment is also one of the contributing catchments to the Maketū Estuary, which is in poor ecological health.

## 5.3 Purpose (Take)

The purpose of this chapter is to provide outcomes from the 2020/2021 water quality investigations. Following the recommendation by Mahon et al. (2020), the aim of this monitoring was to investigate the source of low DO levels at Kopuaroa at Te Puke Highway in the 2019/2020 summer, to help prioritise land management action.

## 5.4 Background (Kupu Whakamārama)

Investigations by Mahon et al. (2020), supported previous studies which found that levels of TSS, Ammoniacal-N and *E. coli* bacteria were elevated within the Kopuaroa Catchment and were worst in the lower catchment. Excess nutrients may promote unwanted plant and algae growth, in both the Kopuaroa Catchment and the receiving environments of the Kaituna River and Maketū Estuary. Similarly, excess sediment can impact stream and estuarine habitats, whilst elevated *E. coli* increases the risk of infection for humans who come into contact with water through swimming, boating or gathering kaimoana. Contaminant reductions of 63%, 38% and 60% for Nitrogen, Phosphorus and *E. coli* respectively, are estimated for the estuary to be in better health (Park, unpublished; Scholes, unpublished). Mahon et al. (2020), recommended land management actions in specific parts of the Kopuaroa Catchment, which support the reductions in nutrient, bacteria and sediment loads. Since then, BOPRC is actively engaging four of the catchments farming operations through its targeted funding of environmental programs. This assistance includes:

- The construction of over 5.6 km of riparian margins to restrict stock access to both wetland and streams.
- The exclusion of stock and ongoing pest plant and animal control of an 18 ha priority biodiversity site.
- The planting of over 3000 native plants across 7000 $m^2$ of riparian margins retired from pasture.
- The enhancement of existing wetlands and the construction of new wetland habitat.
- Re-battering of existing farm drains to meet the Dairy NZ best practice guidelines.

Communication is ongoing with other key stakeholders and major land owners within the Kopuaroa Catchment to support the roll out of additional offers of technical support and financial assistance to give effect to the recommended mitigations from Mahon et al. (2020).

While results in Mahon et al. (2020) were consistent with water quality in lowland agricultural catchments in the Bay of Plenty, one site in the Kopuaroa Canal at Te Puke Highway, had lower dissolved oxygen (DO) than expected without an obvious explanation. The presence of native fish in the upper catchment showed that this stream is a migration pathway for native fish and the low DO levels observed may be a barrier to fish migration.

## 5.5 Methodology (Huarahi)

Seven additional sites were selected upstream and downstream of the original site (Kopuaroa at Te Puke Highway), based on representation of stream conditions and land use, accessibility, and safety (Figure 5.1 and table B1).

Water temperature, DO and conductivity, were measured at all eight sites using a calibrated hand-held water quality meter. Sampling took place on 27 October 2020 (10:20 am-11:20 am) and 10 March 2021 (10:30 am-11:45 am), however, sites A and B were not safe to access in October, and site D was dry in March. Unfortunately, due to resourcing constraints, we were not able to undertake sampling over the December 2020 – February 2021 period.

Supplementary climate data was sourced from NIWA's Virtual Climate Station Network (temperature) and NERMN site Kaituna at Marshalls Farm (rainfall). Results were assessed against the weather prior to sampling and stream conditions at the time of collection. All data was included in analysis. Comparisons were made to the 2018-2020 Kopuaroa Catchment median, and the Kaituna WMA MEV median as reported in Mahon et al. (2020) for context against like sites.


*Figure 5.1 Locations for dissolved oxygen investigation in the Kopuaroa Canal, October 2020-March 2021. Location attributes are listed in Appendix C1. Arrows indicate direction of flow.*

## 5.6 Results 2020/2021 (Ngā Otinga 2020/2021)

Water temperature, conductivity and DO, were consistent across sites monitored in both October 2020 and March 2021. Results were generally within expected ranges for the observed habitat conditions (little riparian shade, shallow channel – see photos in Appendix C1), previous results in this catchment, and comparable sites (Mahon et al., 2020). However, DO at all sites in March, was lower (worse) than the median for the Kopuaroa Catchment 2018-2020, and the Kaituna MEV median (Figure 5.2). Conductivity and water temperature were lower in March than October. Sampling was conducted at approximately the same time of day for both sampling events, and as such, the lower water temperature in March may be a response to more rainfall prior to sampling (10 mm) compared to October sampling (~3 mm).

Sites B and D (small tributaries into the main channel), had DO concentrations below 60% (Figure 5.2), however, there was no observable impact on temperature and DO downstream of these drainage canals. The discharges were fully mixed by site A (5 m downstream of site B) and Kopuaroa at Te Puke Highway (32 m downstream of site D). The Kopuaroa Canal is 4.5 m wide at point B, and 4.1 m wide at point D. These discharges are therefore mixed within the “reasonable mixing” distance (3 x stream width at point of discharge (RNRP DW R3)), which indicates that (at the time of monitoring), effects on DO in the Kopuaroa Canal are localised.

In March 2021, conductivity increased downstream between sites G to F, below a drain. A cloudy plume was observed from this drain (see Figure C3 in appendix C1), which could be responsible for the increase in conductivity on this day, but no samples were taken to confirm this. The colour difference appeared to be fully mixed by 10 m downstream (visually), and conductivity decreased downstream through sites E, Kopuaroa at Te Puke Highway and site C. The width of the Kopuaroa Canal at the point of this discharge is 3.5 m, indicating localised impacts similar to other discharges in this Canal.

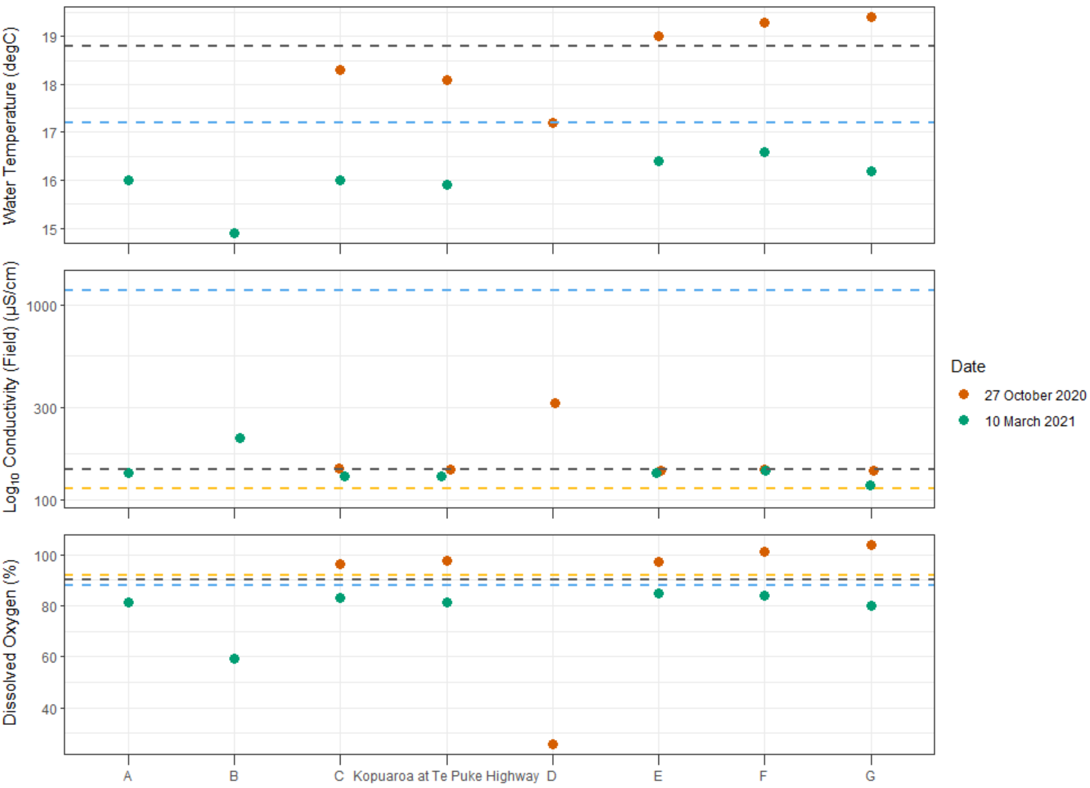



*Figure 5.2 Water quality results for the Kopuaroa Canal, 2020/2021. Sites are ordered upstream to downstream, left to right. Comparative values shown are the ANZG DGV (yellow), the Kaituna MEV median (blue), and the catchment median 2018-2020 (grey).*

## 5.7 Discussion (Matapakitanga)

The 2019/2020 summer was warmer and drier than the 2020/2021 summer, which may be why very low DO at Kopuaroa Canal at Te Puke Highway was only recorded in December 2019 and January 2020. Although monitoring could not be achieved over the December to February timeframe, the consistency in temperature and DO along the Kopuaroa Canal both upstream and downstream of drain discharges in October 2020 and March 2021 suggests that these attributes respond to poor stream conditions which are common in the Kaituna drainage networks. As reported by Park (2010), Carter, Davis & Suren (*unpublished*) and Suren & Carter (2018), drainage networks are characterised by a lack of riparian shading and warm water temperatures in summer, stagnant or slow flowing water, sedimentation and excessive aquatic plant growth (see site photos in Appendix C1). These modified drain ecosystems are known to exhibit extreme high and low DO levels as a response to large amounts of primary productivity. Low DO levels are a common phenomenon in many modified lowland waterways throughout New Zealand (Larned et al., 2004; Wilding, Brown & Collier, 2012), and has potential adverse impacts on fish communities (Wilding, Brown & Collier, 2012; Franklin 2014).

Based on data so far, the low DO levels seen at Kopuaroa at Te Puke Highway, in 2019/2020 were likely a result of seasonal variation in rainfall and temperature, compounded by the ecological conditions of the Canal. There are localised impacts on DO as observed in the smaller drains in October 2020 and March 2021. The presence of fish in these drains and canals highlights their importance as habitat and migratory pathways. Subsequently, efforts should be made to improve stream health by reducing the nutrient, bacteria and sediment inputs into the drains in line with the recommendations for the wider Kaituna WMA. Increasing riparian shading will also help with improving DO levels and reducing stream temperature.

## 5.8 Conclusion (Whakakapinga)

Previous monitoring in the Kopuaroa Catchment indicated poor oxygen concentrations and habitat health in the Kopuaroa Canal, potentially acting as a barrier to migratory native fish. This investigation was designed to explore the extent of the DO issue in the Kopuaroa Canal from the 2019/2020 summer. Investigations were undertaken twice over the 2020/2021 summer. Low DO levels were not observed in the Kopuaroa Canal over the 2020/2021 site visits. This suggests that the issue may have been driven by the lack of rainfall and hence lower flows over the 2019/2020 summer, which would be consistent with how a drain-like system would react.

## 5.9 Recommendations (Ngā Tūtohutanga)

1. Proceed with the recommendations of Mahon et al. (2020) for faecal bacteria mitigation, preventing sediment loss, and nutrient reduction in the Kopuaroa Catchment.
2. Support the work underway across the Kaituna WMA to reduce contaminant loading to the Maketū Estuary.

## 5.10 References (Ngā Tohutoro)

Carter, R., Davis, M., & Suren, A. *unpublished*. Results from synoptic survey in the Kaituna, Maketū, Pongakawa and Waitahanui WMA. Internal Memorandum to Pim de Monchy dated 6 June 2017. Bay of Plenty Regional Council, Whakatāne, New Zealand.

Dare, J. (2021). *River water quality state and trends in the Bay of Plenty: 2020 update*. Bay of Plenty Regional Council Environmental Publication 2021/05.

Franklin, P. A. (2014). Dissolved oxygen criteria for freshwater fish in New Zealand: a revised approach. *New Zealand Journal of Marine and Freshwater Research 48*(1): 112-126.

Larned, S. T., Scarsbrook, M. R., Snelder, T. H. and Biggs, B. J. F. (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.

Mahon, L., Zygadlo, M., Carter, R., Crawshaw, J., & Dare, J. (2020). *Focus Catchments Water Quality 2020/Te Kounga Wai O Ngā Kurawai E Arotahia Ana*. Bay of Plenty Regional Council Environmental Publication 2020/04.

Park, S. (2010). *Water quality survey of the lower Kaituna Catchment 2007-2008*. Bay of Plenty Regional Council Publication 2010/01.

Park, S. *unpublished*. Setting interim guidelines for nutrient loads to Maketū and Waihī Estuaries. Internal Memorandum to Shane Iremonger dated 16 November 2018. Bay of Plenty Regional Council, Whakatāne, New Zealand.

Scholes, P. *unpublished*. Estimating bacterial load reductions to Maketū and Waihī estuaries. Internal Memorandum to James Low and Nicola Green dated 15 November 2018. Bay of Plenty Regional Council, Whakatāne, New Zealand.

Suren, A. & Carter, R. (2018). *Ecological and water quality conditions of drains and land drainage canals in the Rangitāiki and Kaituna Plains*. Bay of Plenty Regional Council Environmental Publication 2018/05.

Wilding, T. K., Brown, E. and Collier, K. J. (2012). Identifying dissolved oxygen variability and stress in tidal freshwater streams of northern New Zealand. *Environmental Monitoring and Assessment 184*(10): 6045-6060.

# Appendix C1: Site locations

*Table B1 Location details for dissolved oxygen investigations in the Kopuaroa Canal, 2020-2021. Sites are listed downstream to upstream*

| Site | Easting (NZTM) | Northing (NZTM) | 27/10/2020 sample time | 10/03/2021 sample time |
|---|---|---|---|---|
| A | 1891025 | 5816714 | N/A | 10:46 |
| B | 1891024 | 5816708 | N/A | 10:53 |
| C | 1890959 | 5816754 | 10:30 | 10:30 |
| Kopuaroa at Te Puke Highway | 1890887 | 5816767 | 10:19 | 10:07 |
| D | 1890856 | 5816763 | 10:46 | N/A |
| E | 1890842 | 5816758 | 10:47 | 11:20 |
| F | 1890752 | 5816702 | 11:00 | 11:37 |
| G | 1890735 | 5816690 | 11:05 | 11:45 |

(a)

(b)

*Figure C1 Looking downstream at Site C in October 2020 (a) and March 2021 (b)*

(a) (b)

(a) (b)

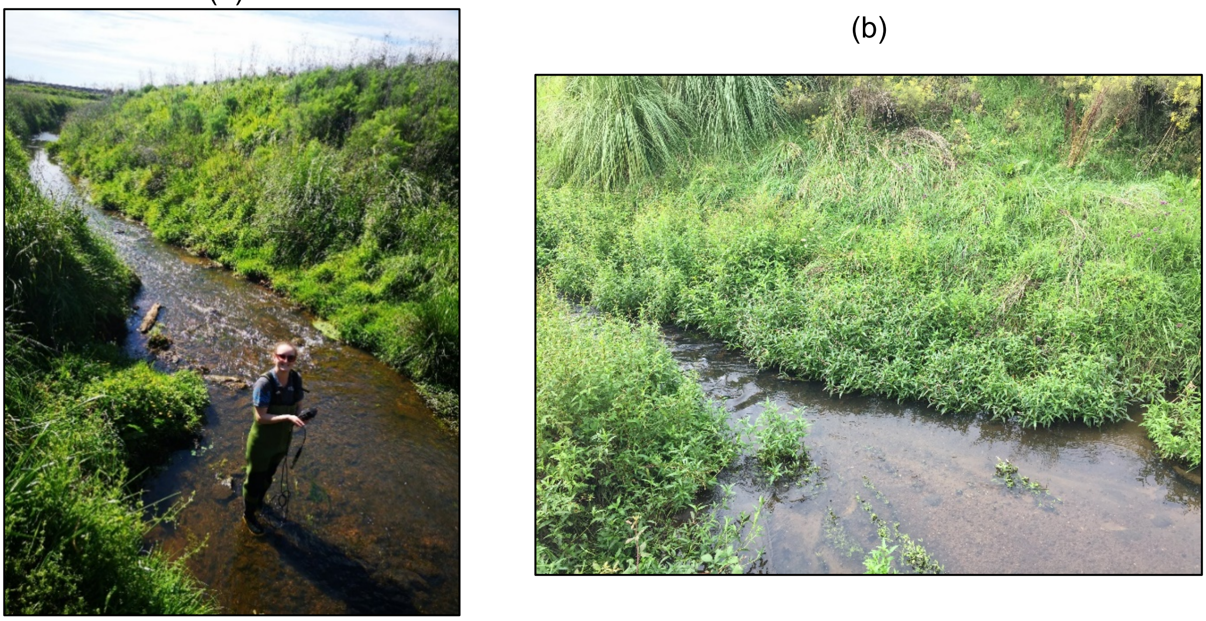


*Figure C2 Kopuaroa at Te Puke Highway in October 2020 (a) and March 2021 (b)*

(a)

(b)

*Figure C3 Looking upstream at Site F in October 2020 (a) and March 2021 (b). Quarry Road Drain enters the Kopuaroa Canal from the right in these photos.*

# 6 Upper Rangitāiki, Taupō

## 6.1 Summary (Whakarāpopototanga Matua)

- Investigations into low dissolved oxygen (DO) in the Otamatea River were undertaken.
- Additional monthly monitoring at one site on the Otangimoana Stream continues.
- Lower DO concentrations in the upper Otamatea River were not able to be isolated to a specific area. Lower DO due to groundwater inputs are hypothesised to be the source.
- NNN concentrations on the Otangimoana River are elevated. Continued monitoring is recommended.

## 6.2 Introduction (Kupu Whakataki)

The Upper Rangitāiki Catchment is east of Taupō and includes the headwaters of the Rangitāiki River, Otamatea River, Otangimoana Stream, and Mangatiti Stream, all of which are tributaries of the Rangitāiki River. Exotic forestry accounts for 52% of the catchment land use, with smaller amounts of sheep and beef, deer and dairy farming, and vegetable production. Pumice soils dominate the catchment providing well drained soils with low nutrient reserves and weak soil strength.

The Upper Rangitāiki Catchment has been selected as one of the Focus Catchments because of high nutrient concentrations, specifically high NNN, present at the NERMN sites on the Rangitāiki and Otamatea Rivers. The Upper Rangitāiki Catchment is also particularly susceptible to erosion due to the pumice soils, and land use may be exacerbating this.

## 6.3 Purpose (Take)

The aim of this chapter is to provide updates and/or results on investigations over 2020/2021 summer. The investigations actioned, were based on the recommendations in Mahon et al (2020). Outcomes are discussed and further recommendations made.

## 6.4 Background (Kupu Whakamārama)

The Upper Rangitāiki is well known for its clear waters, but also has the highest (worst) NNN concentrations in the Bay of Plenty region. The Focus Catchment has two NERMN sites, both of which have shown these high concentrations over a long time period. Mahon et al (2020) summarised catchment monitoring which provided evidence of high NNN concentrations across the catchment with the Otamatea and Otangimoana being significantly higher (worse) than the Rangitāiki. The current state (5-year median) of NNN at the Otamatea (2.3 mg/L) (Dare, 2021) is very close to the National Bottom Line for NNN in the NPS-FM 2020 (2.4 mg/L). Invertebrate communities in the Upper Rangitāiki catchment in 2014 were 'Poor' to 'Excellent', but with most in 'Excellent', which indicates that the Focus Catchment is largely unaffected by organic enrichment (Mahon et al., 2020). Water quality modelling in the Rangitāiki WMA showed that the Otangimaona River contributes a significant proportion of TN load to Lake Matahina and Lake Aniwaniwa (Carter et al, 2021; Mahon et al, 2020)

Recommendations for water quality actions from Mahon et al (2020) consisted of;

### 6.4.1 Dissolved Oxygen survey at Otamatea west of masts

DO at the site Otamatea west of masts was found to be markedly lower compared to other river sites in the catchment. Groundwater was potentially identified as a cause, but it was also noted that this site was downstream of the two only dairy farms in the catchment. An initial investigation was recommended to determine the temporal and spatial extent of the lower DO and to determine if groundwater influence was a likely cause.

### 6.4.2 Erosion assessments and turbidity monitoring on the Rangitaiki River

The Rangitaiki River had higher TSS and turbidity readings in comparison to the Otamatea and Otangimoana. It was recommended that the Rangitaiki be prioritised for erosion assessments and that the deployment of turbidity loggers during rainfall might assist with this. This has not been progressed since Mahon et al (2020) and will therefore, not be reported on any further in this report.

### 6.4.3 Ongoing monitoring

It was recommended that some form of ongoing monitoring could be investigated on the Otangimoana, given its high NNN values and modelled contribution to the downstream lakes. Monitoring in the Otangimana Sub-catchment was assessed following recommendations in Mahon et al (2020). Five samples had been collected at Otangimoana at Forestry Road as part of the catchment monitoring in the Upper Rangitaiki. This sample size is not sufficient for statistical comparison to data collected at a later date. It was determined that monitoring should continue in the sub-catchment due to NNN concentrations being high, its contribution to the downstream lakes, and that some land management changes had occurred.

## 6.5 Methodology (Huarahi)

This section describes the methodology for recommendations 1) and 3).

### 6.5.1 Dissolved oxygen in the Otamatea River

A desktop review of the Otamatea River upstream and downstream of the site Otamatea west of masts included assessing discharge consents, representativeness of land use, and ease of access and site safety. Exact locations were finalised on the day of deployment as described below and details are given in Figure 6.1 and Table 6.1. Loggers were deployed for an initial period of two weeks between 23 November and 8 December 2020.

A handheld YSI water quality meter was used to observe physical stream parameters for any obvious areas of upwelling upstream and downstream from the original site Otamatea west of masts. The water temperature, DO and conductivity was recorded for the time of deployment at each site. Site locations were between 50 m-150 m upstream and downstream, dependent on the depth of the river, bank vegetation and safe access with equipment. HOBO U26-001 dissolved oxygen loggers were attached to metal stakes and secured in the stream bed, with the loggers at approximately half the stream depth.

HOBO loggers were set to record at 15 minute intervals and HOBOware Pro was used to process the data.

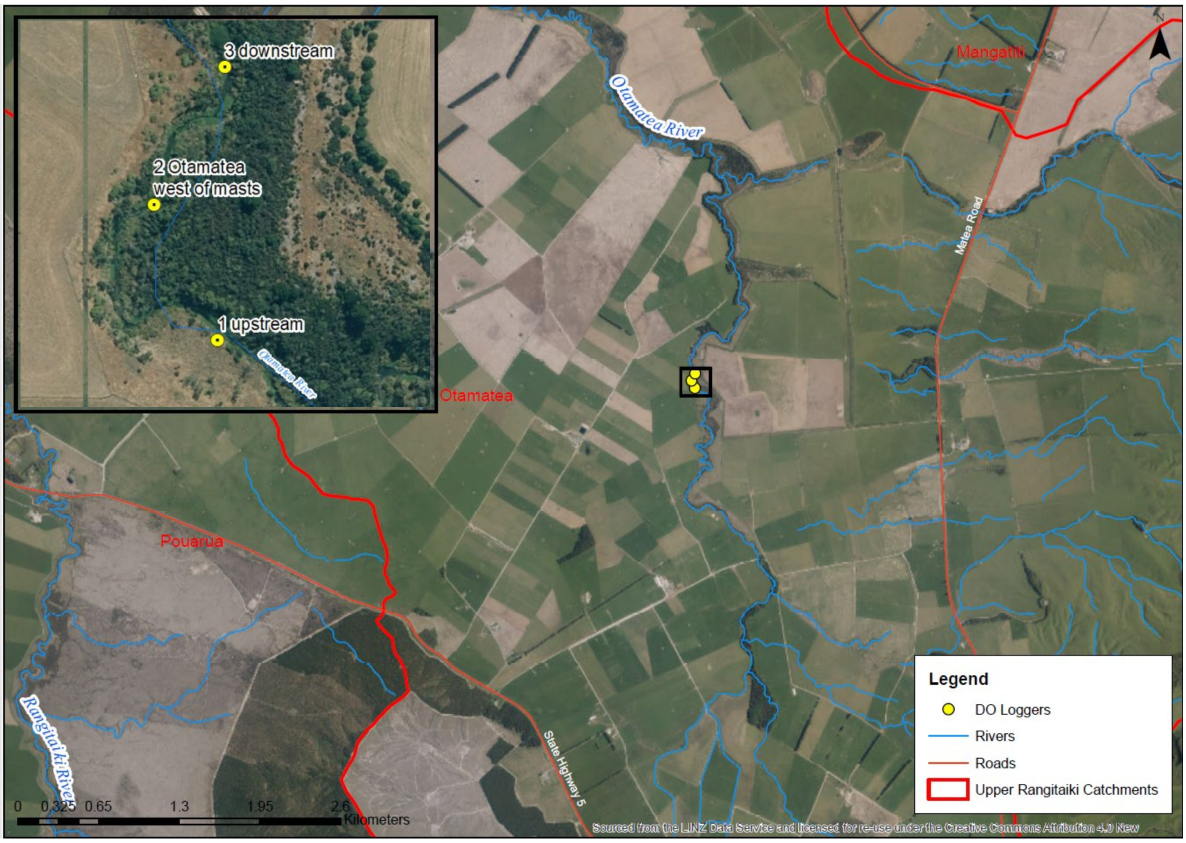



*Figure 6.1* *Locations of dissolved oxygen loggers in the Otamatea River*

*Table 6.1* *Dissolved Oxygen logger deployment site locations.*

| Site | Easting (NZTM) | Northing (NZTM) |
|---|---:|---:|
| Site 1<br>118 m Upstream of Site 2 | 1897657 | 5692097 |
| Site 2<br>Otamatea west of masts (FC762215) | 1897629 | 5692154 |
| Site 3<br>75 m Downstream of Site 2 | 1897660 | 5692213 |

Rainfall information was taken from Rangitāiki at Kokomoa, which is approximately 7.5 km east from the sites.

### 6.5.2 Ongoing Monitoring – Otangimoana

Monthly water quality samples were collected, December 2020 to April 2021, at the existing Otangimoana at Forestry Road site (Figure C1.1). No further samples were taken in this sub-catchment. Sample collection was carried out by Bay of Plenty's Regional Council Data Services team and followed the processes outlined in Section 2

## 6.6 Results 2020/2021 (Ngā Otinga 2020/2021)

### 6.6.1 Dissolved oxygen in the Otamatea River

No upwelling was identified through visual observations or isolated low DO with the handheld meter while wading up and down the Otamatea Stream between sites 1 and 3 (approximately 190 m). Dissolved oxygen at the three sites and rainfall for the 23 November to 8 December 2020 is shown in Figure 6.1. No significant difference in DO concentrations is observed between the sites. The upstream site has more 'noise' compared to the other two sites. This could be from instrumentation differences or a result of environmental interference such as weed growth. There is a clear effect from rainfall on both DO and temperature at all three sites. Rainfall appears to cause irregular DO and temperature in both small events (as low as <2 mm) and larger events (>10 mm).

The 1-day minimum, and 7-day mean minimum, over the two week period is 5.73 and 6.05 mg/L respectively. This would place this reach in the 'C' attribute state in the NPS-FM. Suggesting some occasional minor stress on aquatic organisms could be occurring (MfE, 2020).

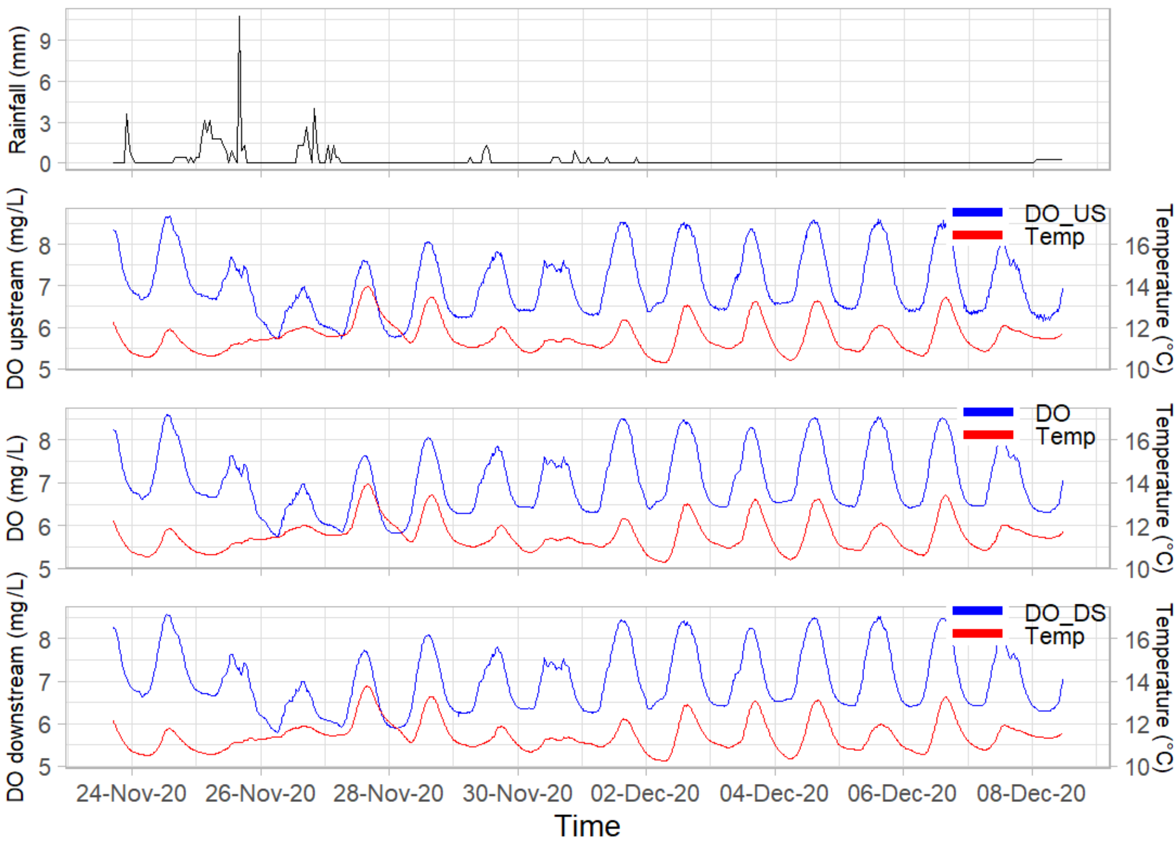



*Figure 6.2 Dissolved oxygen concentrations and temperature upstream, at Otamatea west of masts, and downstream. Rainfall volume also presented from Rangitaiki at Kokomoa rainfall gauge.*

### 6.6.2 Ongoing monitoring – Otangimoana

The focus of the continued monitoring at Otangimoana was to assess the NNN concentrations. Other water quality parameters were analysed to complete the understanding of the current state for the river at this location. Total nitrogen and NNN species are presented in this section, while other water quality results are tabulated in Appendix D3.

NNN concentrations are consistently elevated ranging from 1.96 g/m$^3$ – 2.22 g/m$^3$, well above the DGV and catchment median for the Upper Rangitāiki Catchment (Figure 6.3). Samples have only been collected over the summer period and are therefore reflective of low flow and low rainfall conditions. NNN makes up the majority of TN indicating minimal organic nitrogen present at this location.

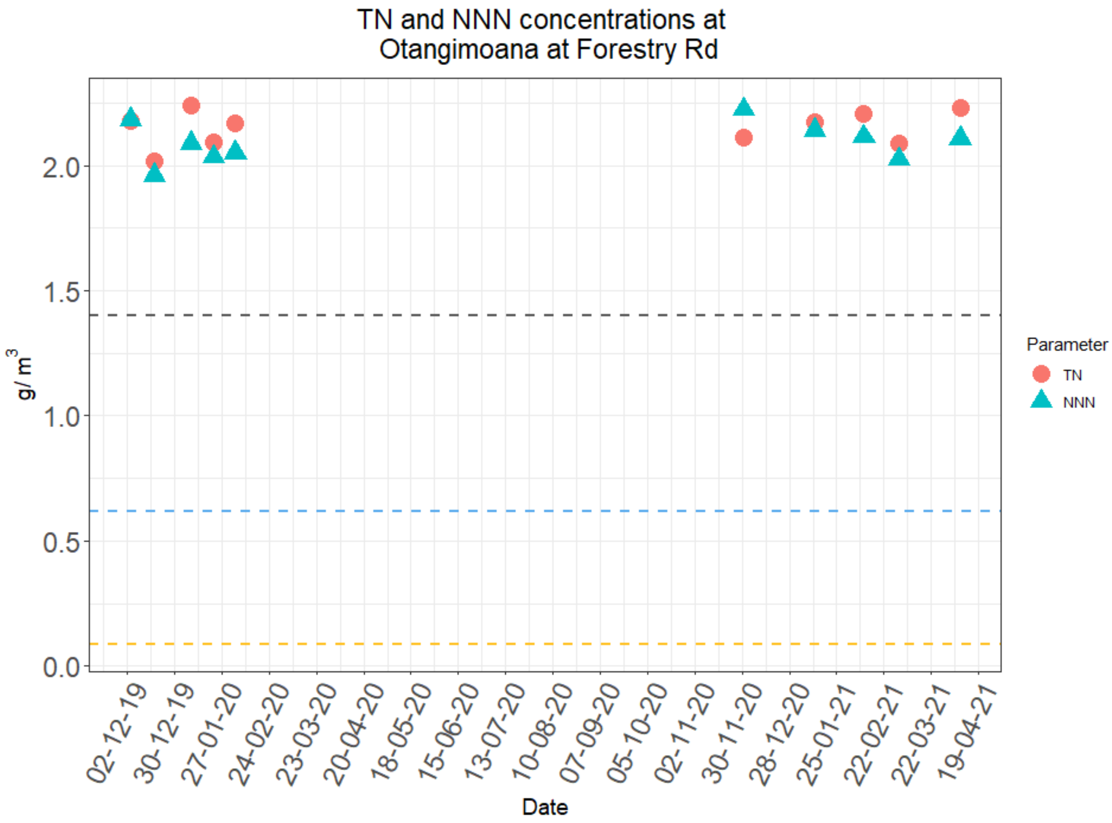



*Figure 6.3 TN and NNN results for 2019-2021 monitoring at Otangimoana at Forestry Road. Comparative NNN values shown are the ANZG DGV (yellow), the VA Gentle median (blue), and the catchment median (grey)*

## 6.7 Discussion (Matapakitanga)

### 6.7.1 Dissolved Oxygen at Otamatea west of masts

Rainfall can have a range of effects on DO concentrations resulting from runoff and first flush effects, disturbance of the streambed, and altering the hydrological conditions. These effects are seen in the results in Figure 6.2. The effects observed suggests that even in small rain events leaching and / or runoff of the well-drained pumice soils is occurring.

The results do not isolate the lower DO concentrations to an area at the investigated scale, suggesting that the lower DO concentrations are present at a larger scale. There are two aspects to the low DO that are being investigated here 1) Does the DO get low enough for adverse ecological effects? 2) What is the source of the lower DO? Based on the two week period of data collected, the DO can get to concentrations where minor stress to aquatic organisms may be observed. While there is macrophyte growth in this reach of the river, the lower DO concentrations are not matched by higher concentrations i.e. oversaturation, which would be expected in a scenario of overgrowth of macrophytes or periphyton. As such, observations thus far lean towards a lower DO due to groundwater influence along the upper reaches of the Otamatea River. Although there is known spring influence in this catchment (Green, 2018), the extent of the groundwater influence is not well understood. Investigating the groundwater influence to the upper Otamatea River would be beneficial in understanding the DO concentrations observed.

#### 6.7.2 Otangimoana monitoring

As identified in Mahon et al (2020), the Otangimoana is likely a key tributary to nitrogen loadings downstream. It is both high in NNN concentration and the modelled anthropogenic proportion. To date we have only collected samples over the summer period, however, these results indicate that the river is close to the NPS-FM bottom line for NNN (2.4 $g/m^3$). Concentrations may vary over winter, especially considering the pumice soil nature of the catchment. NNN shows strong seasonality at Rangitāiki at SH5 (lower NNN concentrations in winter), however the Otamatea does not show statistically significant seasonal variation (Hamill et al., 2020). Other water quality parameters are not of specific concern as identified in Mahon et al (2020) (Appendix D3). The dataset to date for Otangimoana is limited in both sample size (n=10) and seasonal coverage. The farms in this sub-catchment have undergone some changes to land management practices over the last few years (pers. Comms. Kendall Smith). As such, this site should be considered for increased monitoring. Whether this is on a short-term basis to gain an understanding of the state over winter and provide a larger sample size, or as an ongoing monitoring site (this would need to be considered as part of the review of our monitoring networks with the NPS-FM).

### 6.8 Conclusion (Whakakapinga)

Following recommendations made in Mahon et al (2020), two investigations were actioned over the 2020/2021 summer period. A short-term investigation into lower DO concentrations in the upper Otamatea River and continued monitoring of water quality parameters on the Otangimoana River. Results of the DO investigation indicate that evidence for lower DO concentrations caused by high respiration rates in the river due to macrophytes and/or periphyton is low. The strongest theory at this stage is the groundwater influence to the upper reaches.

The water quality results from Otangimoana at Forestry Road confirm the high NNN concentrations. Other water quality parameters have not been identified to be of particular concern. The current dataset is limited to summer monitoring, data from the remaining seasons would be beneficial to understand the current state of nutrients in the Otangimoana River.

### 6.9 Recommendations (Ngā Tūtohutanga)

#### 6.9.1 Dissolved oxygen in Upper Otamatea

DO loggers should be installed along a larger spatial scale, i.e. as close to the headwaters of the Otamatea as possible and >500 m downstream of the Otamatea west of masts site. This would assist in determining where the DO starts to increase before reaching the downstream site (Otamatea u/s Dam) where DO concentrations are equivalent to the rest of the catchment. As identified in Mahon et al (2020), aerial thermal imagery would be an effective way of identifying groundwater inputs also.

This would require at least 3 days of fieldwork and additional processing time. If resourcing is available over the summer period, it is recommended that these actions are undertaken.

### 6.9.2 Otangimoana monitoring

Results from over the summer period further highlight the high NNN concentrations observed on the Otangimoana River. The modelled contribution to the downstream lakes and anthropogenic proportion also reinforce the potential importance of the Otangimoana tributary to NNN loading on downstream sensitive environments. We would therefore recommend that monitoring is continued until October 2021 on a monthly basis to obtain a larger dataset and gain some winter data.

## 6.10 References (Ngā Tohutoro)


Carter, R., Tingey, D. and Scholes, P., Bermeo, S. (2021). Modelled surface water quality for Rangitaiki and Kaituna Water Management Areas. Bay of Plenty Regional Council Environmental Publication 2021/03.

Green, M. (2018). Interim summary of spring survey and monitoring in the Bay of Plenty 2015-2017. Internal Report 2018/02. Bay of Plenty Regional Council, Whakatāne, New Zealand

Hamill, K. Dare, J. and Gladwin, J. (2020). River Water Quality State and Trends in the Bay of Plenty to 2018: Part A. Publication prepared for the Bay of Plenty Regional Council. River Lake Ltd, Whakatāne, New Zealand.

Mahon, L., Zygadlo, M., Carter, R., Crawshaw, J., & Dare, J. (2020). *Focus Catchments WaterQuality 2020/Te Kounga Wai O Ngā Kurawai E Arotahia Ana*. Bay of Plenty Regional Council Environmental Publication 2020/04.

Ministry for the Environment. (2020). National Policy Statement for Freshwater Management 2020. Wellington, New Zealand.

# Appendix D1: Site Map

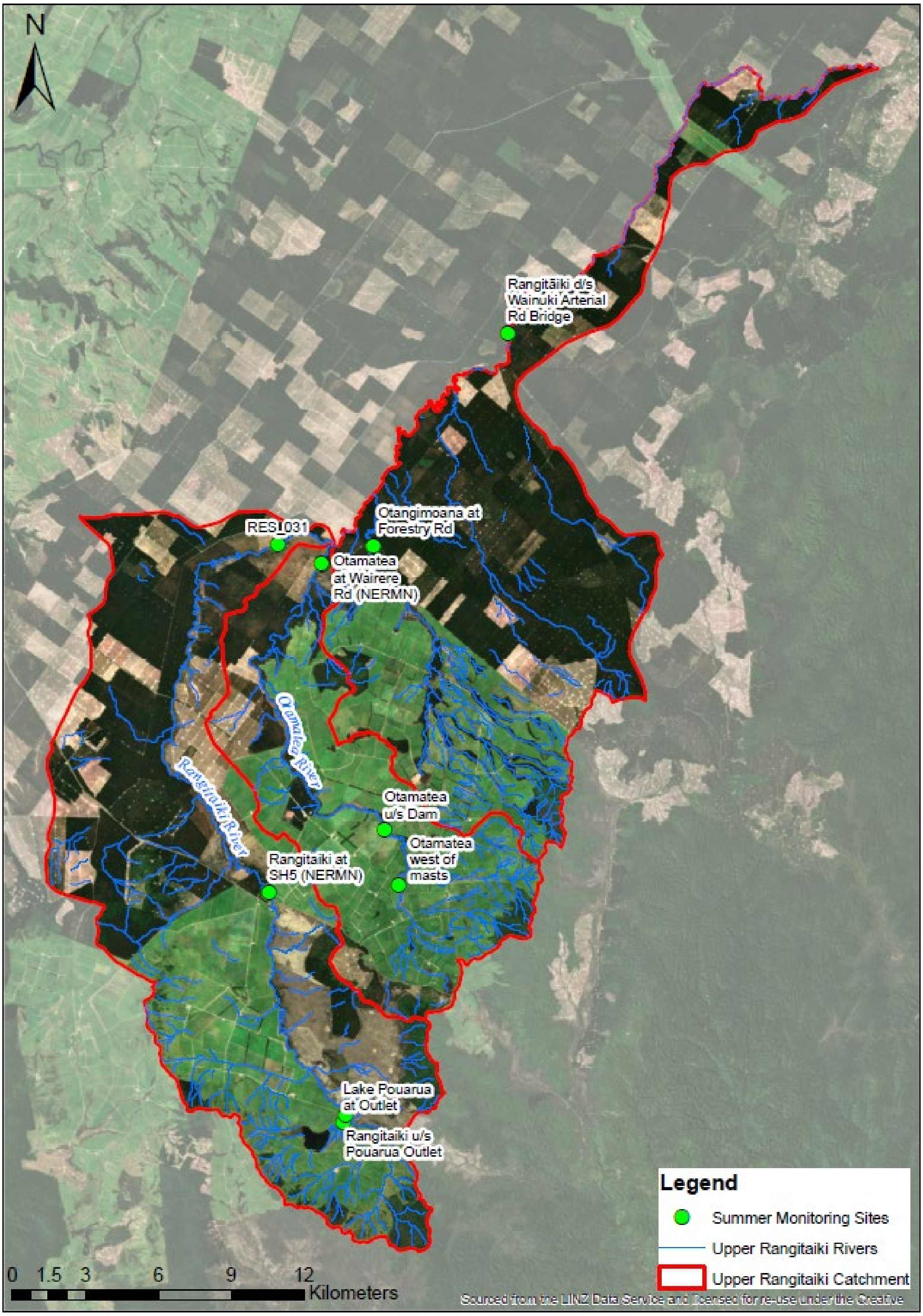



*Figure C1.1 Water quality-monitoring locations in the Upper Rangitaiki.*

# Appendix D2: DO walkover results

*Table C2.1 Water quality measurements at time of logger deployment in the Otamatea River.*

| Date and time | Site | Logger | Water Temperature (□C) | Dissolved Oxygen (%) | Dissolved Oxygen (mg/L) | Conductivity (Field) (µS/cm) |
|---|---|---|---|---|---|---|
| 23/11/2020 13:10 | Site 3 | 3 | 12.2 | 92.8 | 9.14 | 110 |
| 23/11/2020 12:00 | Site 2 Otamatea west of masts FC762215 | 2 | 11.8 | 88.2 | 8.8 | 110 |
| 23/11/2020 12:48 | Site 1 | 1 | 12.1 | 92.0 | 9.10 | 105 |

*Table C2.2 Water quality measurements at time of logger retrieval in the Otamatea River.*

| Date and time | Site | Water Temperature (□C) | Dissolved Oxygen (%) | Dissolved Oxygen (mg/L) | Conductivity (Field) (µS/cm) | Water Temperature (□C) |
|---|---|---|---|---|---|---|
| 8/12/2020 13:10 | Site 3 | 3 | 11.7 | 77.2 | 7.72 | 119 |
| 8/12/2020 11:45 | Site 2 Otamatea west of masts FC762215 | 2 | 11.7 | 76.4 | 7.64 | 118 |
| 8/12/2020 12:15 | Site 1 | 1 | 11.7 | 78 | 7.79 | 114 |

# Appendix D3: Otangimoana water quality results

*Table C3.1 Water quality results for samples collected at Otangimaoan at Forestry Road.*

| Site | Location Name | Date and Time | Ammoniacal N ($g/m^3$) | Conductivity (uS/cm) | DO (%) | DRP ($g/m^3$) | E coli (cfu/100 ml) | TN ($g/m^3$) | NNN ($g/m^3$) | DO ($g/m^3$) | TP ($g/m^3$) | pH | TSS ($g/m^3$) | Turbidity (NTU) | Water Clarity (m) | Water Temp (degC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FD660605 | Otangimoana at Forestry Road | 4/12/2019 0:00 | 0.002 | NA | NA | 0.023 | 13 | 2.18 | 2.18 | 9.79 | 0.021 | 6.85 | 2 | 0.53 | 9.8 | 11.7 |
| FD660605 | Otangimoana at Forestry Road | 18/12/2019 9:01 | 0.006 | NA | 99.5 | 0.024 | 670 | 2.02 | 1.96 | 9.16 | 0.024 | 6.84 | 1.2 | 0.92 | 6.2 | 11.6 |
| FD660605 | Otangimoana at Forestry Road | 9/01/2020 8:20 | 0.007 | NA | 98.3 | 0.023 | 24 | 2.24 | 2.09 | 10.01 | 0.024 | 6.96 | 1.1 | 0.73 | 6.0 | 10.7 |
| FD660605 | Otangimoana at Forestry Road | 22/01/2020 8:18 | 0.008 | NA | 96.1 | 0.022 | 6 | 2.10 | 2.03 | 9.52 | 0.026 | 6.86 | 0.2 | 0.48 | 10.0 | 11.8 |
| FD660605 | Otangimoana at Forestry Road | 4/02/2020 8:40 | 0.003 | NA | 95.4 | 0.023 | 52 | 2.17 | 2.05 | 9.45 | 0.026 | 6.74 | 0.9 | 0.49 | 6.8 | 11.8 |
| FD660605 | Otangimoana at Forestry Road | 1/12/2020 2:10 | 0.004 | 99.4 | 106 | 0.022 | 19 | 2.11 | 2.22 | 10.41 | 0.025 | 6.94 | 2.2 | 0.59 | 6.9 | 12.5 |
| FD660605 | Otangimoana at Forestry Road | 11/01/2021 14:10 | 0.003 | 107.1 | 103.7 | 0.022 | 13 | 2.18 | 2.14 | 10.06 | 0.028 | 7 | 1.7 | 0.32 | 6.3 | 12.8 |
| FD660605 | Otangimoana at Forestry Road | 9/02/2021 12:20 | 0.007 | 100 | 94.9 | 0.022 | 7 | 2.21 | 2.12 | 9.31 | 0.023 | 6.84 | 1.2 | 0.86 | 8.8 | 11.7 |
| FD660605 | Otangimoana at Forestry Road | 2/03/2021 13:45 | 0.004 | 105 | 99.2 | 0.025 | 16 | 2.09 | 2.03 | 9.8 | 0.021 | 6.87 | 1.2 | 0.54 | 6.8 | 12.3 |
| FD660605 | Otangimoana at Forestry Road | 7/04/2021 14:20 | 0.004 | 100.5 | 100.7 | 0.025 | 12 | 2.23 | 2.11 | 10.18 | 0.024 | 6.74 | 1.2 | 0.40 | 8.7 | 11.7 |

# Appendix D4: Upper Rangitaiki site summaries

## Rangitaiki at SH 5

20 July 2021

### Summary statistics

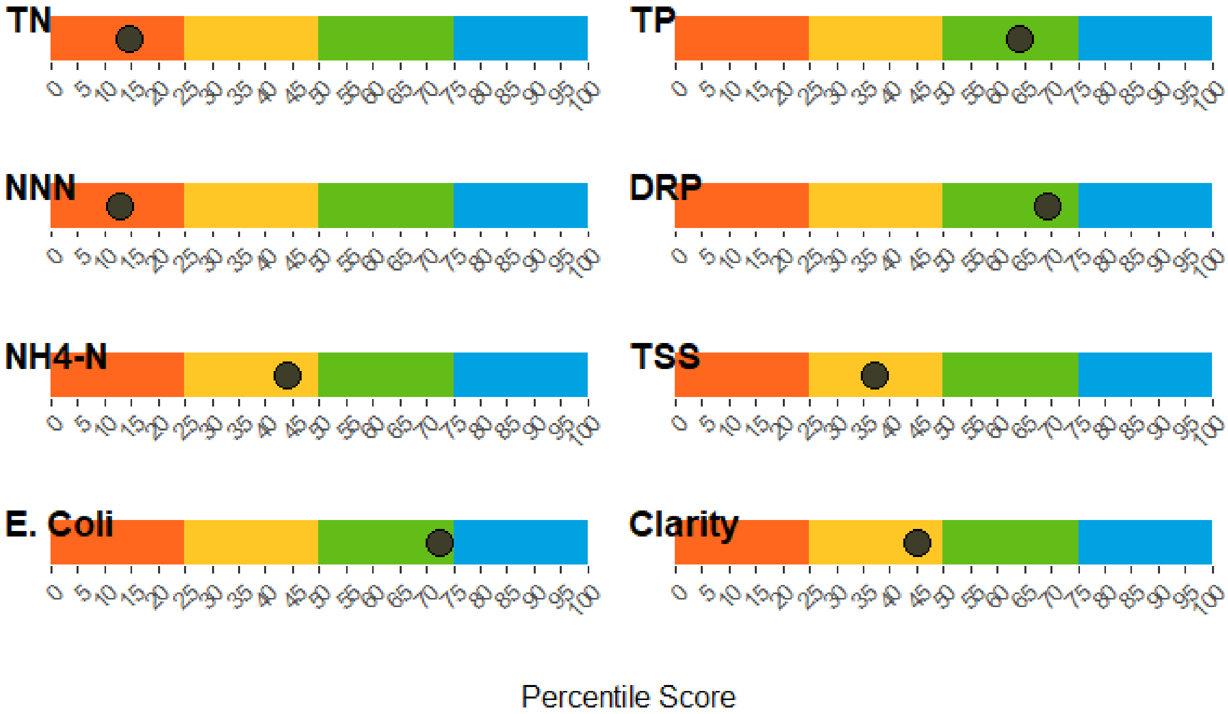
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 97 | 0.78 | 2.42 | 1.39 | 1.35 | 1.88 | 0.99 | 0.30 | 0.03 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 116 | 0.61 | 2.36 | 1.29 | 1.26 | 1.81 | 0.77 | 0.33 | 0.03 |
| **Total Ammoniacal Nitrogen (g/m3)** | 116 | <0.002 | 0.036 | 0.016 | 0.015 | 0.029 | 0.006 | 0.007 | 0.001 |
| **Total Phosphorus (g/m3)** | 116 | 0.011 | 0.189 | 0.034 | 0.033 | 0.049 | 0.018 | 0.020 | 0.002 |
| **Dissolved Reactive Phosphorus (g/m3)** | 116 | 0.003 | 0.038 | 0.015 | 0.014 | 0.027 | 0.007 | 0.006 | 0.001 |
| **Dissolved Oxygen Sat (%)** | 91 | 86.5 | 105.6 | 94.7 | 94.6 | 101.9 | 88.7 | 3.7 | 0.4 |
| **Dissolved Oxygen (g/m3)** | 110 | 7.50 | 11.60 | 9.64 | 9.59 | 10.44 | 8.94 | 0.57 | 0.05 |
| **Escherichia coli (cfu/100ml)** | 115 | <1 | 1100 | 78 | 23 | 272 | 4 | 175 | 16 |
| **Total Suspended Solids (g/m3)** | 116 | <1 | 66.00 | 12.44 | 8.11 | 36.00 | 2.87 | 11.61 | 1.08 |
| **Turbidity (NTU)** | 116 | 1.1 | 16.0 | 3.3 | 3.0 | 6.7 | 1.4 | 2.1 | 0.2 |
| **Water Clarity (m)** | 98 | 0.45 | 3.92 | 1.78 | 1.60 | 3.41 | 0.79 | 0.76 | 0.08 |
| **Conductivity (mS/cm)** | 112 | 48.0 | 650.0 | 87.3 | 81.1 | 101.9 | 69.5 | 55.2 | 5.2 |
| **pH (pH Units)** | 116 | 6.3 | 7.6 | 6.9 | 6.9 | 7.2 | 6.6 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 114 | 7.4 | 16.2 | 11.2 | 11.1 | 13.9 | 8.3 | 1.8 | 0.2 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-07-13 | 2021-07-12 | 60 | 30 | 450 | 93.3 | 1.7 | 5 |
| 10 Years | 2011-07-15 | 2021-07-12 | 89 | 27 | 264 | 95.5 | 1.1 | 3.4 |
| All | 1999-07-08 | 2021-07-12 | 115 | 23 | 290 | 94.8 | 1.7 | 3.5 |

## Otamatea at Wairere Road

20 July 2021

### Summary statistics

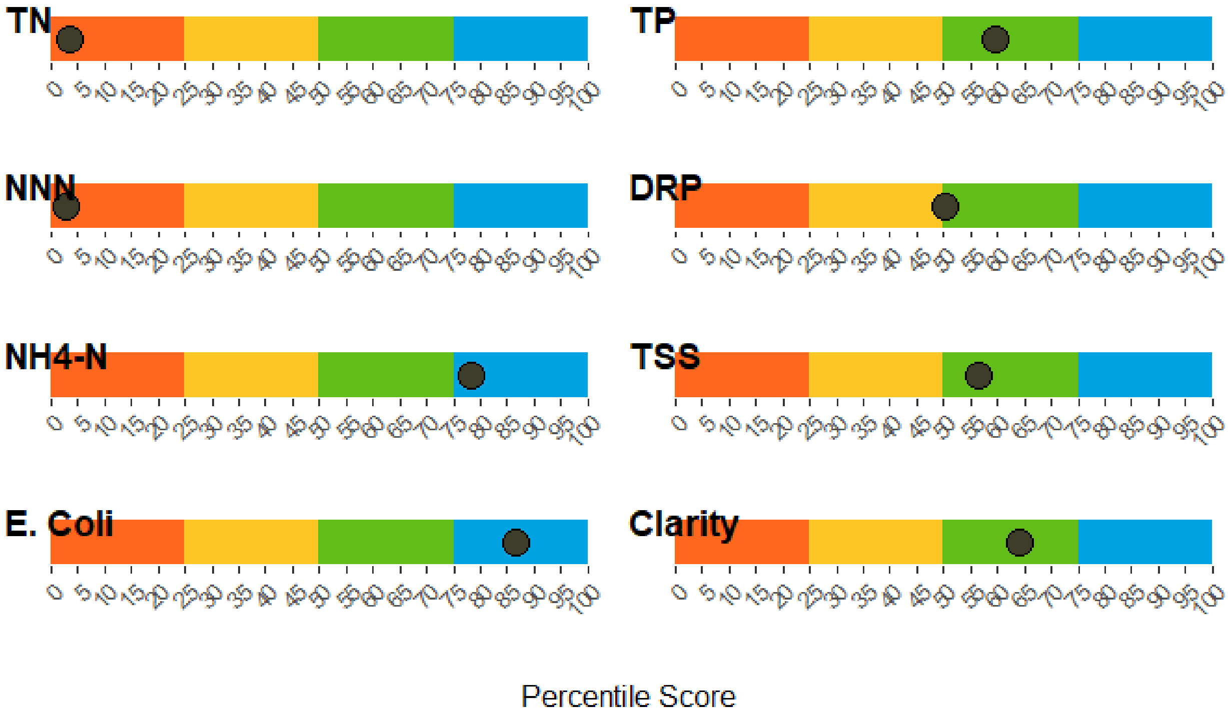
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 98 | 1.72 | 3.12 | 2.41 | 2.41 | 2.67 | 2.17 | 0.18 | 0.02 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 96 | 1.49 | 2.69 | 2.33 | 2.31 | 2.65 | 2.12 | 0.18 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 97 | <0.002 | 0.052 | 0.007 | 0.005 | 0.012 | 0.002 | 0.008 | 0.001 |
| **Total Phosphorus (g/m3)** | 98 | 0.004 | 0.094 | 0.036 | 0.036 | 0.063 | 0.011 | 0.016 | 0.002 |
| **Dissolved Reactive Phosphorus (g/m3)** | 98 | <0.001 | 0.052 | 0.023 | 0.023 | 0.036 | 0.010 | 0.009 | 0.001 |
| **Dissolved Oxygen Sat (%)** | 88 | 92.5 | 112.3 | 104.7 | 105.0 | 110.2 | 99.1 | 3.5 | 0.4 |
| **Dissolved Oxygen (g/m3)** | 93 | 8.94 | 11.85 | 10.58 | 10.59 | 11.41 | 9.82 | 0.52 | 0.05 |
| **Escherichia coli (cfu/100ml)** | 95 | <1 | 940 | 43 | 7 | 159 | 1 | 142 | 15 |
| **Total Suspended Solids (g/m3)** | 98 | <1 | 24.00 | 5.73 | 4.51 | 15.27 | 1.67 | 4.55 | 0.46 |
| **Turbidity (NTU)** | 99 | 0.4 | 7.3 | 1.5 | 1.2 | 2.9 | 0.6 | 1.0 | 0.1 |
| **Water Clarity (m)** | 97 | 0.60 | 5.80 | 2.55 | 2.30 | 4.76 | 1.09 | 1.14 | 0.12 |
| **Conductivity (mS/cm)** | 94 | 63.6 | 142.2 | 110.7 | 112.0 | 121.6 | 89.0 | 10.1 | 1.0 |
| **pH (pH Units)** | 99 | 6.6 | 7.9 | 7.4 | 7.4 | 7.8 | 7.0 | 0.3 | 0.0 |
| **Water Temperature (degC)** | 95 | 7.7 | 15.0 | 11.6 | 11.7 | 14.5 | 8.9 | 1.8 | 0.2 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-07-14 | 2021-07-13 | 62 | 8 | 200 | 96.8 | 1.6 | 1.6 |
| 10 Years | 2011-07-16 | 2021-07-13 | 90 | 7 | 150 | 97.8 | 1.1 | 1.1 |
| All | 2010-01-21 | 2021-07-13 | 95 | 7 | 172 | 96.8 | 1.1 | 2.1 |

# Otangimoana at Forestry Road

20 July 2021

## Summary statistics

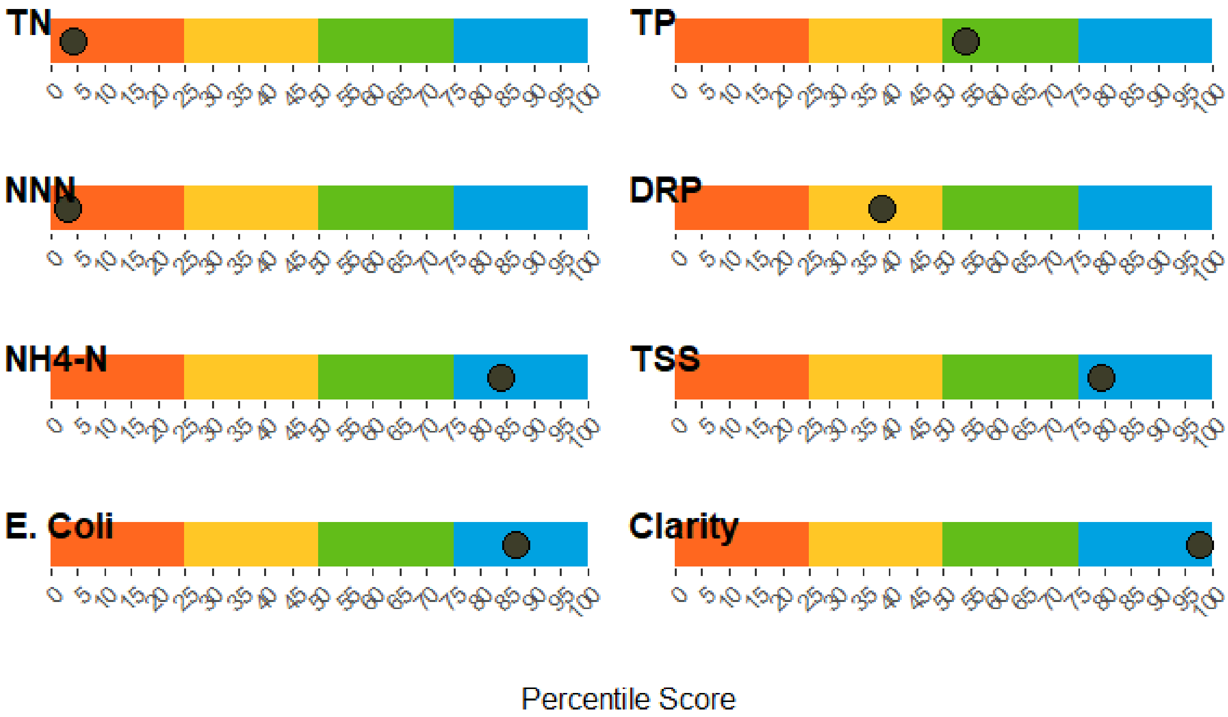
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 31 | 1.88 | 2.48 | 2.20 | 2.21 | 2.36 | 1.95 | 0.13 | 0.02 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 31 | 1.96 | 2.39 | 2.17 | 2.18 | 2.37 | 1.99 | 0.12 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 31 | <0.002 | 0.010 | 0.004 | 0.004 | 0.008 | 0.002 | 0.002 | 0.000 |
| **Total Phosphorus (g/m3)** | 31 | 0.021 | 0.059 | 0.038 | 0.041 | 0.054 | 0.024 | 0.012 | 0.002 |
| **Dissolved Reactive Phosphorus (g/m3)** | 31 | 0.022 | 0.040 | 0.029 | 0.029 | 0.036 | 0.022 | 0.006 | 0.001 |
| **Dissolved Oxygen Sat (%)** | 31 | 13.3 | 109.6 | 96.3 | 98.8 | 107.6 | 82.7 | 16.8 | 3.0 |
| **Dissolved Oxygen (g/m3)** | 32 | 1.51 | 11.52 | 9.83 | 10.09 | 11.23 | 8.77 | 1.67 | 0.29 |
| **Escherichia coli (cfu/100ml)** | 32 | <1 | 670 | 36 | 7 | 75 | 1 | 118 | 21 |
| **Total Suspended Solids (g/m3)** | 32 | <1 | 8.00 | 2.55 | 1.83 | 7.64 | 0.46 | 2.23 | 0.39 |
| **Turbidity (NTU)** | 32 | 0.3 | 3.5 | 0.7 | 0.6 | 1.1 | 0.3 | 0.6 | 0.1 |
| **Water Clarity (m)** | 35 | 1.70 | 12.68 | 7.28 | 7.36 | 10.73 | 2.88 | 2.72 | 0.46 |
| **Conductivity (mS/cm)** | 27 | 64.9 | 875.0 | 122.8 | 93.6 | 106.9 | 75.8 | 150.6 | 29.0 |
| **pH (pH Units)** | 32 | 6.7 | 7.8 | 6.9 | 6.9 | 7.1 | 6.8 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 32 | 9.9 | 12.8 | 11.2 | 11.4 | 12.4 | 9.9 | 0.7 | 0.1 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological Guidelines Assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-07-14 | 2021-07-13 | 24 | 7 | 237 | 95.8 | 0 | 4.2 |
| 10 Years | 2011-07-16 | 2021-07-13 | NA | NA | NA | NA | NA | NA |
| All | 2015-10-22 | 2021-07-13 | 32 | 7 | 98 | 96.9 | 0 | 3.1 |

# 7 Ōhiwa Harbour, Ōhope/Ōhiwa

## 7.1 Summary (Whakarāpopototanga Matua)

- Monitoring has been underway to support the development of the SedNet model. This has included monitoring at five sites across the Ohiwa Harbour Catchment.
- Further actions have not been progressed due to prioritisation of the model development.

## 7.2 Introduction (Kupu Whakataki)

The Ōhiwa Harbour is a highly valued estuary for its recreational and natural environments. It is home to a multitude of marsh and shore birds, shellfish and fish species (Bevan, 2018). Sedimentation in the Harbour has been threatening the condition and this was largely the basis for being selected as one of the Focus Catchment. The NERMN site on the Nukuhou River has also shown many water quality parameters to be in the worst 25% of all NERMN sites (Hamill, 2020)

## 7.3 Purpose (Take)

The purpose of this chapter is to provide an update on progress with the recommendations from Mahon et al. (2020), and provide recommendation for future monitoring.

## 7.4 Background (Kupu Whakamārama)

Ecological monitoring in the Ōhiwa Harbour shows shellfish populations are affected by the high level of mud in the sediment. Mahon et al. (2020) reported that monitoring to date in the Nukuhou Sub-catchment had provided limited insight into areas that could be targeted to reduce sediment runoff. A new programme of monitoring for the development of a catchment model was in preparation. It is expected that this model (SedNet) will provide useful insight into where the sediment is coming from and where in the catchment land management efforts should be focussed.

Recommendations from Mahon et al. (2020) are listed below with updates on progress;

### 7.4.1 Catchment model monitoring

A monitoring programme was outlined for the requirements of the Ōhiwa SedNet model development. This included baseflow and storm event monitoring. Water quality results to date are presented in Section 7.5.

### 7.4.2 Continuation of monitoring at Nukuhou at Bell Road and Nukuhou at Burnett Road

Monthly monitoring along the Nukuhou River had been occurring for several years. Two sites were recommended to continue due to degrading trends, while the others were discontinued as a sufficient dataset had been collected to compare to in the future. This monitoring has continued and will continue until July 2021 when trends can be reassessed. An Action Plan will likely be required, should a degrading trend still be apparent.

### 7.4.3 Additional Sediment Monitoring

Some options for sediment monitoring, additional to the monitoring for the catchment model, were proposed. This included aerial photography and the deployment of turbidity loggers. These actions have not yet been progressed as the focus has been on collecting data for the model development. These could still be undertaken once resourcing becomes available, although the usefulness of the information should be assessed once the results from the model are received.

### 7.4.4 Nutrient and bacteria monitoring

This recommended that additional nutrient and bacteria monitoring be put on hold until outcomes of the model are provided. As recommended, this has not been progressed further than the monitoring required for the model development. Any monitoring can be re-assessed once the results of the model are received.

The remainder of this chapter summarises the water quality results collected for the SedNet model.

## 7.5 Methodology

Samples collected for the SedNet model, were not based on a regular sampling regime but more opportunistic to provide sufficient data for the model to be calibrated. While opportunistic, the aim was to obtain data over the colder/wetter months and warmer/drier months. Rain events were also targeted. This provided 21 samples from August 2020 to February 2021 and an additional five to six rain events. Storm event monitoring consisted of one grab sample from each site during or soon after a rain event to provide a snapshot of conditions under rainfall. Sample collection was carried out by Bay of Plenty's Regional Council Science team and followed the processes outlined in Section 2.

Previous monitoring in Ohiwa Harbour focussed on the Nukuhou Sub-catchment. Information from the other inputs and tributaries is required to inform the SedNet model, hence the monitoring has focussed on the Tunanui, Wainui, Waingaroa and Kutarere watercourses. Figure 7.1 shows the sample locations for these watercourses in relation to the Nukuhou sites and Table 7.1 details the site information.

Water quality results are presented as box and whisker graphs and compared to the Nukuhou Sub-catchment median (based off analysis in Mahon et al, 2020), the NERMN VA/Steep median and the ANZG DGV (where appropriate).

*Table 7.1 Site location details for SedNet monitoring in the Ohiwa Harbour Catchment.*

| Site ID | Location Name | Easting (NZTM) | Northing (NZTM) | Purpose |
|---|---|---|---|---|
| **ML143033** | Nukuhou at Kererutahi (Wainui Road) | 1961434 | 5780337 | Water Quality |
| **LL534603** | Tunanui Tributary at Burma Road | 1955348 | 5786031 | Water Quality |
| **LL694447** | Wainui at Wainui Road | 1956948 | 5784479 | Water Quality |
| **ML122068** | Waingarara at Wainui Road | 1961223 | 4010066 | Water Quality |
| **ML373104** | Kutarere at Kutarere Wharf Road | 1963738 | 5781040 | Water Quality |
| **MK453465** | Nukuhou at Nukuhou North | 1964531 | 5774659 | Rainfall |

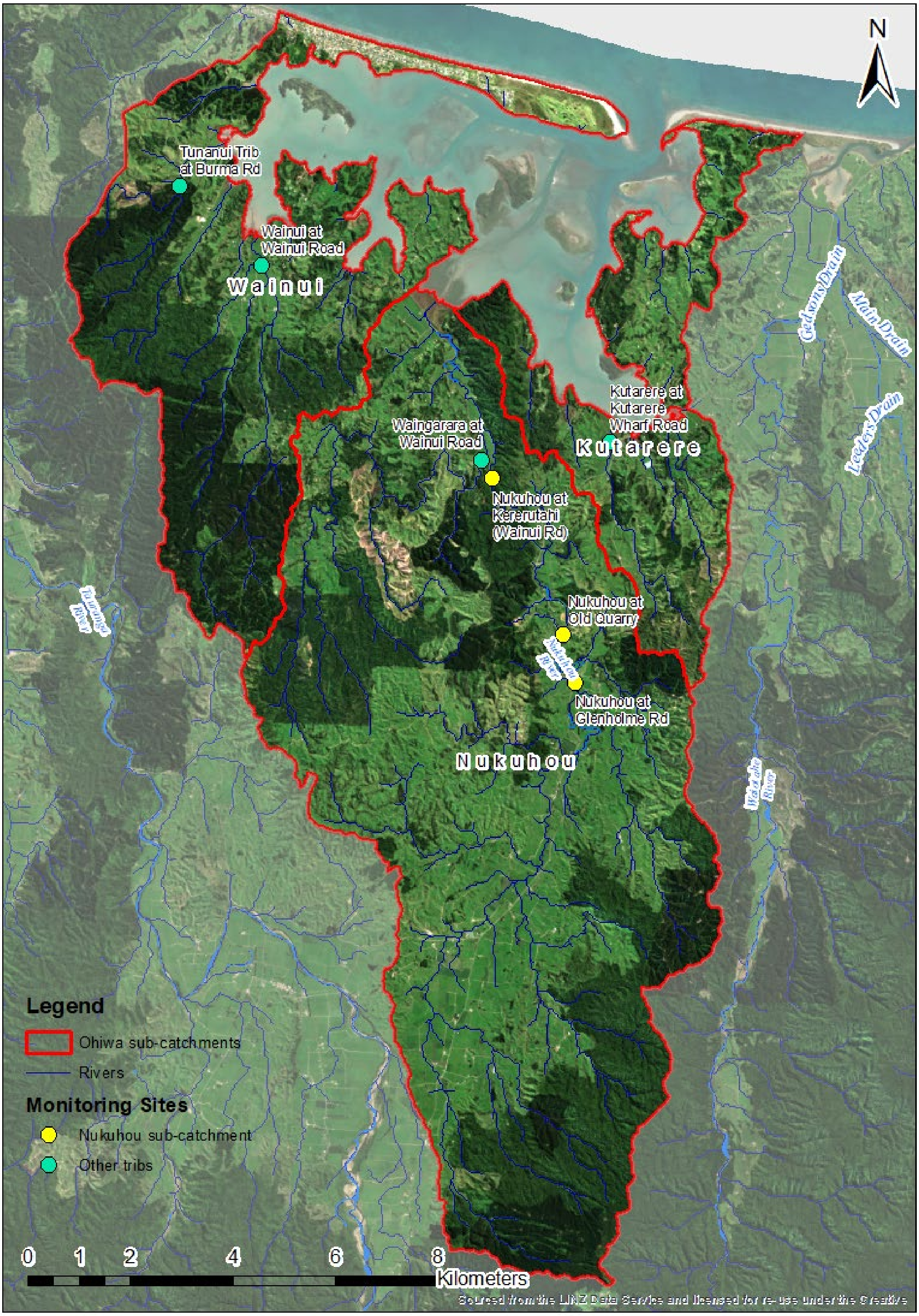



*Figure 7.1 Water quality monitoring sites along the Nukuhou river (yellow) and other watercourses in the Ohiwa Harbour catchment (blue).*

## 7.6 Results

Water quality results from the SedNet monitoring are presented in the sections below.

### 7.6.1 Baseflow

**Field parameters**

Figures 7.2–7.3 show field parameters are relatively consistent across the catchment and with the Nukuhou River median (grey dashed line). pH is consistently higher in these smaller watercourses compared to the Nukuhou River, but are consistent with the NERMN VA Steep median.

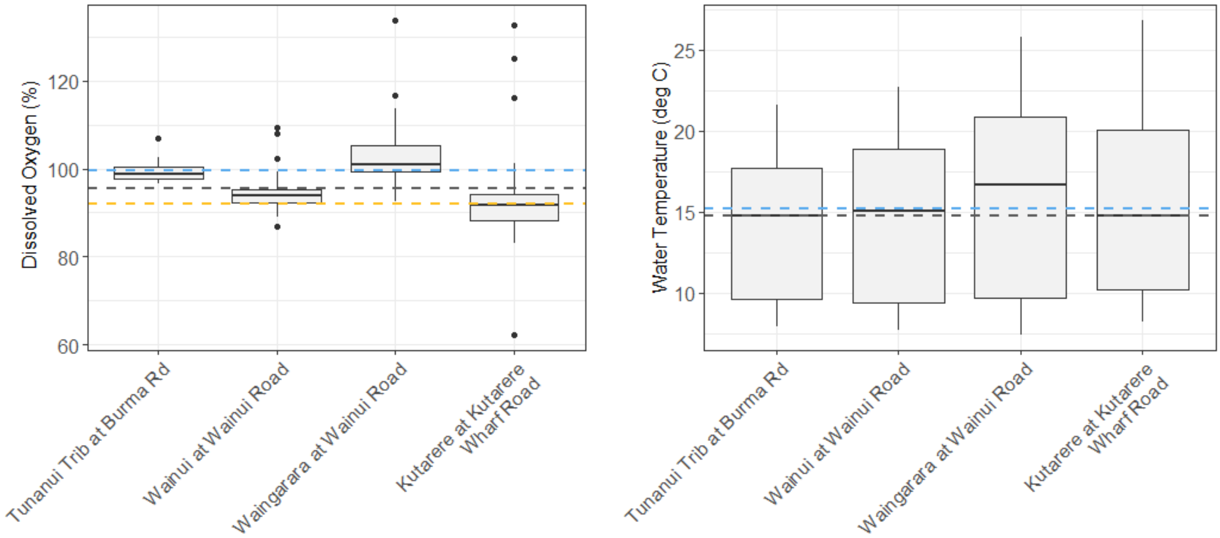



*Figure 7.2 Dissolved oxygen (left) and water temperature (right) results from monitoring August 2020 to March 2021. Sites are ordered from east to west (left to right). Dashed lines represent; Grey – Nukuhou River median, yellow – ANZG DGV, blue – NERMN VA Steep median.*

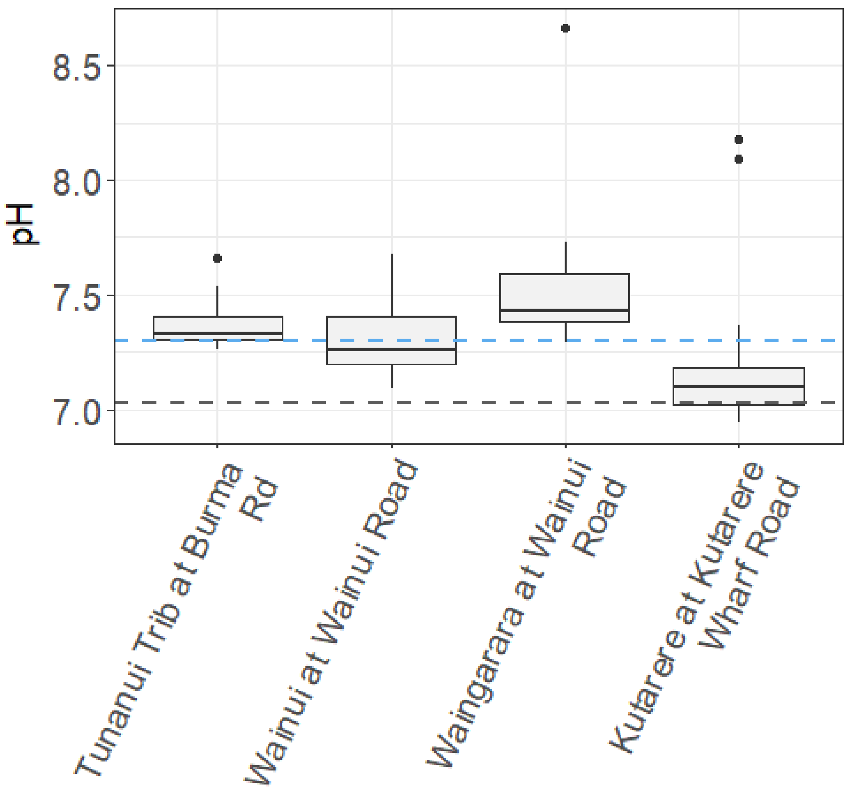



*Figure 7.3 pH results from monitoring August 2020 to March 2021. Sites are ordered from east to west (left to right). Dashed lines represent; Grey – Nukuhou River median, blue – NERMN VA Steep median.*

**Nutrients**

Concentrations of nutrients are relatively consistent across the catchment. Total nitrogen and NNN are significantly lower in these watercourses compared to the Nukuhou River median (Figure7.4). While flows are not reported on here, these watercourses are visually observed to be smaller than the Nukuhou River. As such, the lower nitrogen concentrations along with the obvious lower flows suggest that these sites would not be significant contributors to nitrogen loading in the Ohiwa Harbour.

Ammoniacal-N concentrations (Figure 7.5) are significantly higher at Wainui at Wanui Road and Kutarere at Kutarere Wharf Road compared to the other two sites and the Nukuhou River median. Kutarere at Kutarere Wharf Road may be impacting occasionally on the 5% most sensitive species (after considering pH adjustment) (MfE, 2020).

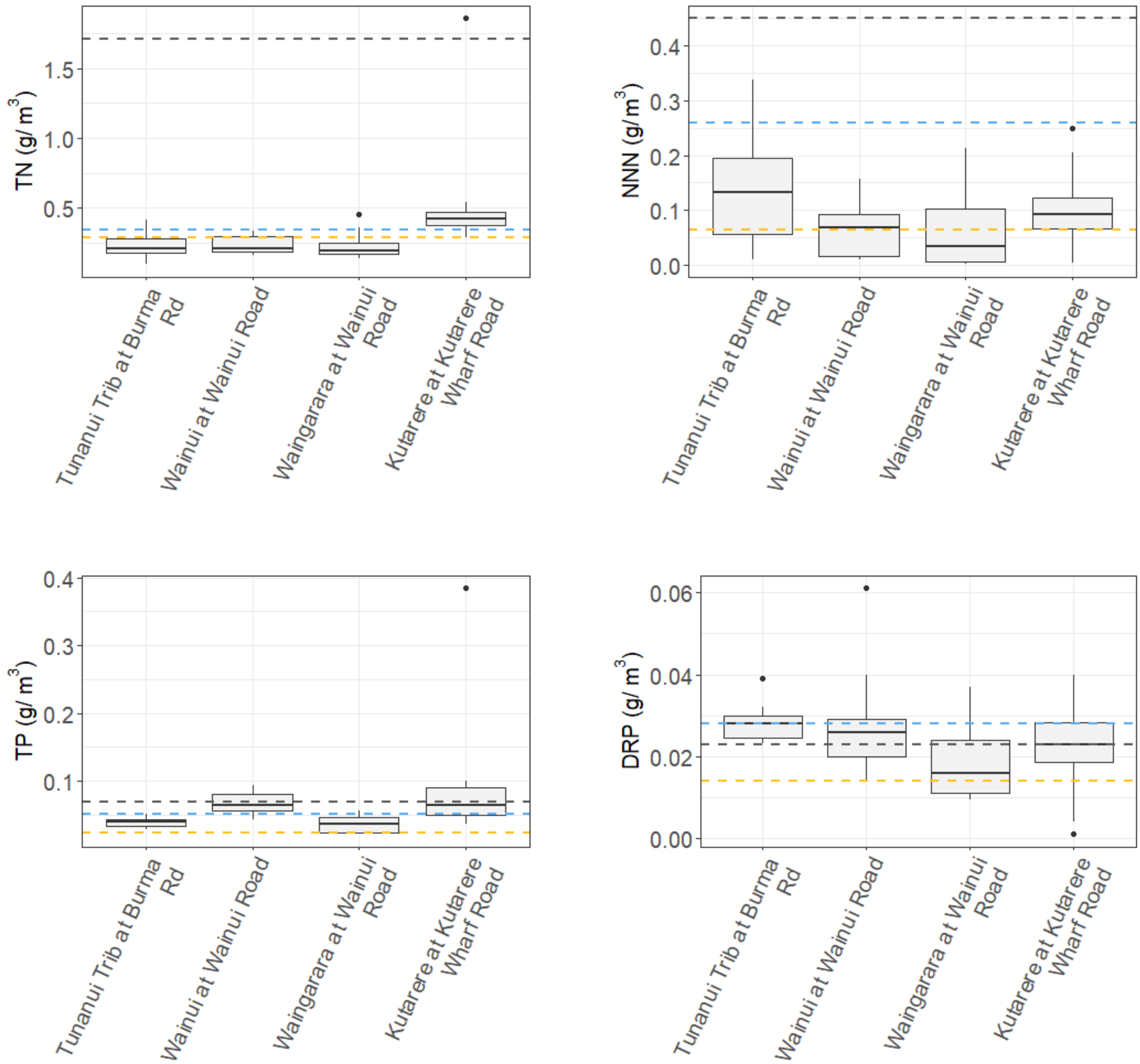



*Figure 7.4* *TN, NNN, TP and DRP concentrations from monitoring August 2020 to March 2021. Sites are ordered from east to west (left to right). Dashed lines represent; Grey – Nukuhou River median, yellow – ANZG DGV, blue – NERMN VA Steep median.*

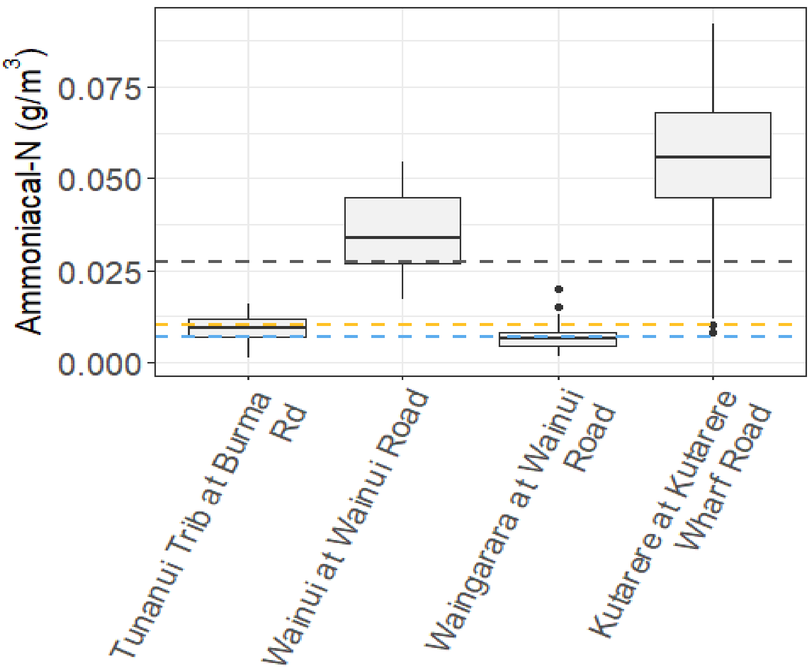



*Figure 7.5* *Ammoniacal-N concentrations from monitoring August 2020 to March 2021. Sites are ordered from east to west (left to right). Dashed lines represent; Grey – Nukuhou River median, yellow – ANZG DGV, blue – NERMN VA Steep median.*

**Sediment**

TSS concentrations are generally below the Nukuhou River median and DGV. Under baseflow conditions, these watercourses would not appear to be contributing significantly to the Ohiwa Harbour compared to the Nukuhou River.

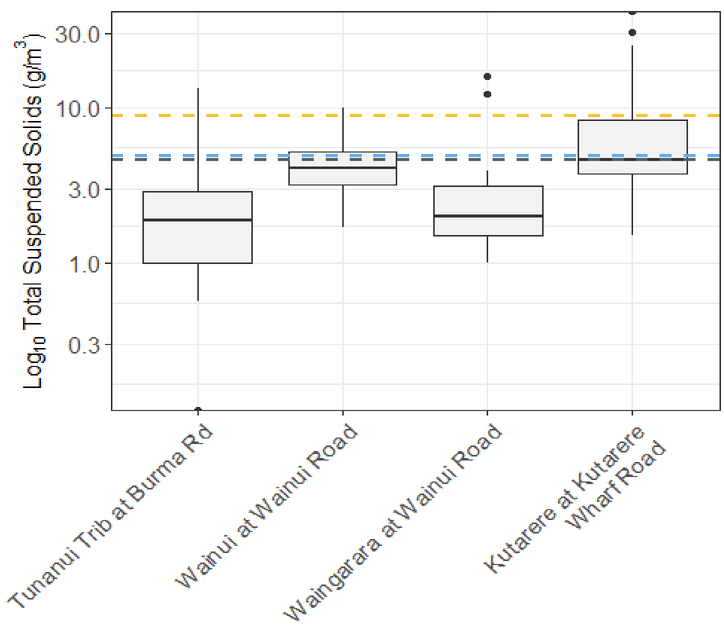



*Figure 7.6* *TSS concentrations from monitoring August 2020 to March 2021. Sites are ordered from east to west (left to right). Dashed lines represent; Grey – Nukuhou River median, yellow – ANZG DGV, blue – NERMN VA Steep median*

**Bacteria**

Bacterial contamination has not previously been identified as a concern for the Ohiwa Harbour, and concentrations in the Nukuhou River have generally been below the 'Action' threshold. These results suggest the Kutarere at Kutarere Wharf Road has some bacterial contamination under baseflow conditions. Tunanui Tributary at Burma Road and Wainui at Wainui Road are also elevated in relation to the Nukuhou River median and when compared to the recreational guidelines (MfE, 2003).

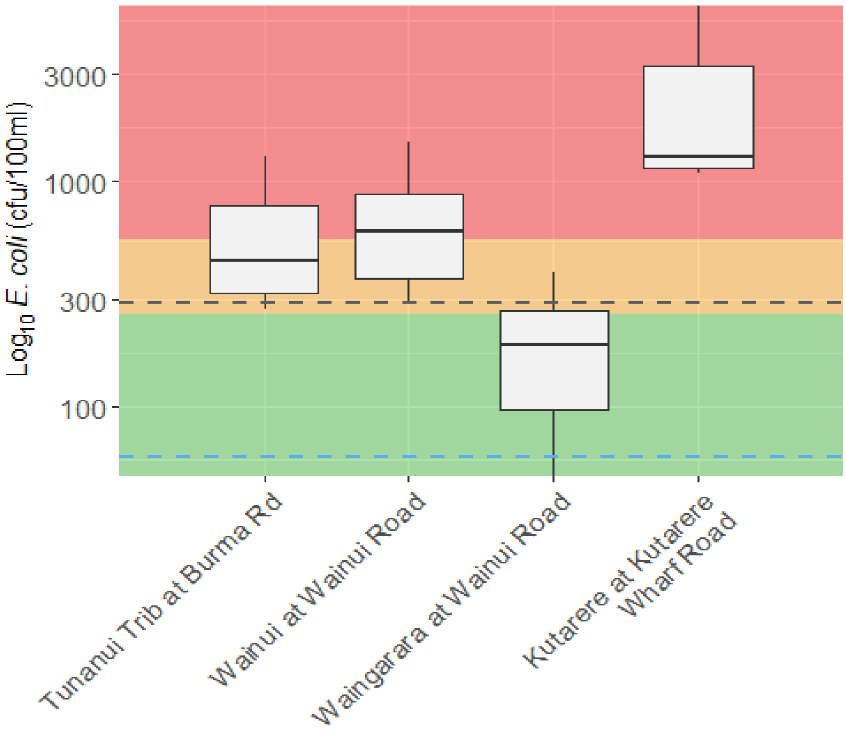



*Figure 7.7 E. coli concentrations from monitoring August 2020 to March 2021. Sites are ordered from east to west (left to right). Dashed lines represent; Grey – Nukuhou River median, blue – NERMN VA Steep median.*

### 7.6.2 Storm event monitoring

A range of parameters were analysed from the storm event sampling, however the contaminant of particular interest for Ōhiwa Harbour is sediment. As such, TSS is presented here and remaining results are tabulated in Appendix E1.

The rain event sampling to date does not indicate any consistency in sites that may be contributing higher loads during rainfall, nor is their consistency between TSS concentrations and the magnitude of the rain event. Wainui at Wainui Road is perhaps more often higher in TSS concentrations relative to the remaining sites. The Nukuhou site appears to be consistently lower than the other sites. This does not rule out the Nukuhou as a significant sediment contributor, both because the Nukuhou is a larger river compared to the other watercourses (although flow is not recorded for these events), and the data is limited.

The February samples were taken on the same day, the first while it was raining and the second approximately three to four hours post the rainfall event. The results do not show consistently higher TSS concentration either during or after the rain event, indicating that the sub-catchments react differently to rainfall. Flow information, travel times, gradient and settling are all factors that should be assessed when interpreting rainfall event data. We only have two samples for this one event and limited information on the other factors, so should therefore be interpreted with caution.

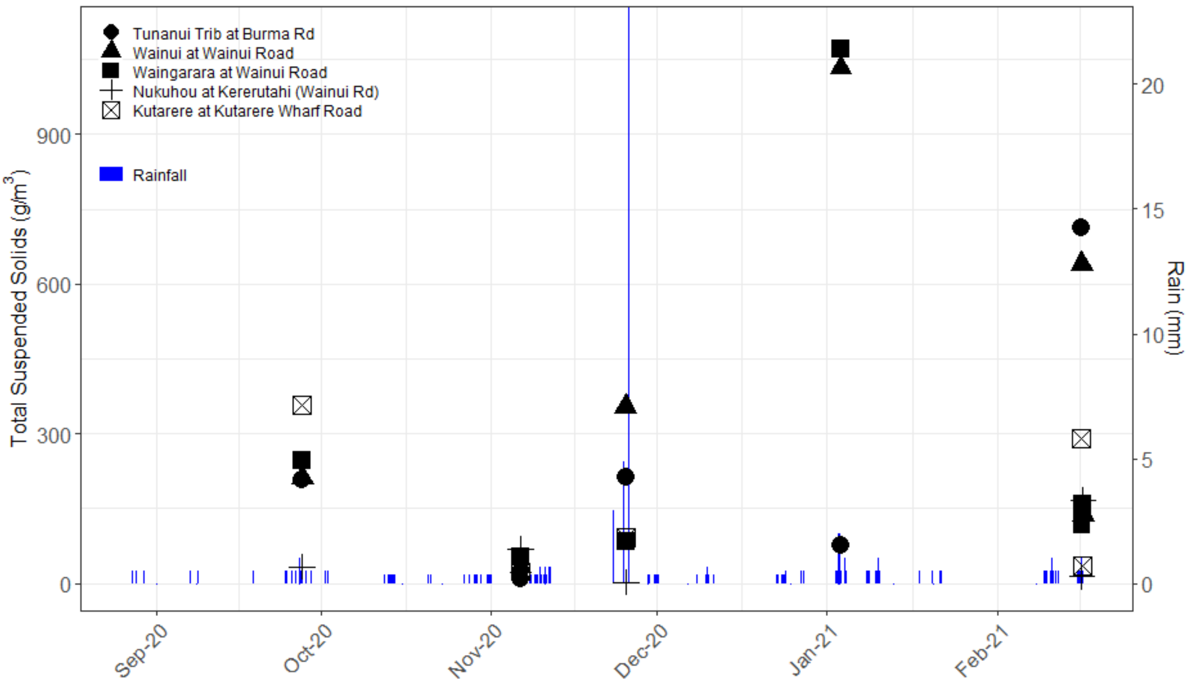



*Figure 7.8 Total suspended solids concentrations at the 2021 monitoring sites during rainfall events. Rain depth is represented by the blue bars. Rain data obtained from Nukuhou at Nukuhou North rain gauge*

## 7.7 Discussion

This update on the Ohiwa Catchment focusses on four key watercourses in the catchment outside of the Nukuhou River. Water quality parameters at these sites are generally consistent or better when compared to the Nukuhou River median. Kutarere at Kutarere Wharf Road however, does have elevated bacterial contamination and ammoniacal-N. The Kutarere site is adjacent to a small dairy farm, which could be a source of bacteria and ammoniacal-N. The dwellings in this catchment are also on septic tank systems, there are a few potential dwellings upstream of this site that could have the potential for the septic tank systems to influence the watercourse. Faecal source tracking or upstream and downstream sampling would help identify if the dairy farm or septic tank are influencing the ammoniacal-N and bacteria levels.

Rain event monitoring does not indicate any strong patterns between sites or in relation to the size of rain events. The objective of this monitoring was to provide some data for the SedNet model and is therefore not comprehensive enough to be able to analyse site responses to rainfall events. Interpretation of key areas for sediment management should await the results of the SedNet model.

## 7.8 Conclusion

Previously water quality sampling in the Ohiwa Harbour Catchment had focussed on the Nukuhou Sub-catchment as the Nukuhou River drains approximately two thirds of the harbours catchment. The state and contributions to the harbour from other watercourses is not well understood. Water quality monitoring began in August 2020 at four other key watercourses with the aim of collecting opportunistic samples over the wetter and drier months. Some rain events were also targeted.

Generally, the concentrations across the other watercourses are lower or similar to what is recorded along the Nukuhou River. Kutarere at Kutarere Wharf Road was elevated in *E. coli* and ammoniacal-N.

## 7.9 Recommendations

The Kutarere stream could be investigated further for bacterial and ammoniacal-N contamination with upstream and downstream monitoring as well as FST.

The water quality results do not indicate any other issues that would trigger investigative monitoring. Storm event water quality samples may continue to be collected (dependant on resourcing) to inform the SedNet model development. At this stage, no further monitoring is recommended.

Trend results from the Nukuhou River monitoring will be assessed late 2021 and recommendations made on the continuation of the monitoring.

## 7.10 References (Ngā Tohutoro)


Bevan, L., (2018). State of the Environment for Ōhiwa Harbour and Catchment 2018. Bay of Plenty Regional Council Environmental Publication 2018/08.

Hamill, K. Dare, J. and Gladwin, J. (2020). River Water Quality State and Trends in the Bay of Plenty to 2018: Part A. Publication prepared for the Bay of Plenty Regional Council. River Lake Ltd, Whakatāne, New Zealand.

Mahon, L., Zygadlo, M., Carter, R., Crawshaw, J., & Dare, J. (2020). *Focus Catchments Water Quality 2020/Te Kounga Wai O Ngā Kurawai E Arotahia Ana*. Bay of Plenty Regional Council Environmental Publication 2020/04.

Ministry for the Environment. (2020). *National Policy Statement for Freshwater Management 2020*. Wellington, New Zealand.

Ministry for the Environment. (2003). *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*. Publication reference number ME474.

# Appendix E1: Storm even water quality results

*Table D1.1 Storm event monitoring results for the Ohiwa Harbour Catchment.*

| Location Name | Time | Ammoniacal N ($g/m^3$) | Cond. (Field) (uS/cm) | DO (%) | DRP ($g/m^3$) | *E coli* (cfu / 100 ml) | Enterococci (cfu/100 ml) | Faecal coliforms (cfu / 100 ml) | TN ($g/m^3$) | NNN ($g/m^3$) | DO ($g/m^3$) | TP ($g/m^3$) | pH | TSS ($g/m^3$) | Turbidity (NTU) | Water Temp (degC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tunanui Tributary at Burma Road | 27/09/2020 13:10 | 0.005 | 96.7 | 97.7 | 0.056 | NA | NA | NA | 1.27 | 0.2 | 10.04 | 0.278 | 7.13 | 208 | 146 | 14.2 |
| Tunanui Tributary at Burma Road | 6/11/2020 7:10 | 0.011 | 106.9 | 94.8 | 0.034 | NA | NA | NA | 0.618 | 0.35 | 9.5 | 0.064 | 7.28 | 10.75 | 19 | 15.4 |
| Tunanui Tributary at Burma Road | 25/11/2020 10:25 | 0.016 | 73.8 | 98.9 | 0.034 | 21000 | 4400 | 21000 | 1.542 | 0.294 | 10.41 | 0.281 | 7.1 | 214.29 | 154 | 13.2 |
| Tunanui Tributary at Burma Road | 3/01/2021 13:07 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 76 | 20.6 | NA |
| Tunanui Tributary at Burma Road | 16/02/2021 8:14 | 0.02 | 75.5 | 98.1 | 0.032 | 6000 | 600 | 6000 | 1.613 | 0.324 | 9.34 | 0.402 | 7.02 | 713.33 | 484 | 17.5 |
| Tunanui Tributary at Burma Road | 16/02/2021 13:53 | 0.017 | 90 | 97.2 | 0.028 | 4800 | 6800 | 4900 | 0.911 | 0.444 | 9.2 | 0.138 | 7.47 | 139 | 98.2 | 18.1 |
| Wainui at Wainui Road | 27/09/2020 13:25 | 0.041 | 108 | 93.3 | 0.043 | NA | NA | NA | 1.226 | 0.203 | 9.49 | 0.354 | 7.01 | 212 | 126 | 15.1 |
| Wainui at Wainui Road | 6/11/2020 6:25 | 0.027 | 94.2 | 88.4 | 0.031 | NA | NA | NA | 0.761 | 0.226 | 8.8 | 0.125 | 7.07 | 34 | 45.8 | 15.7 |
| Wainui at Wainui Road | 25/11/2020 9:07 | 0.153 | 98.8 | 89.1 | 0.115 | 49000 | 39000 | 49000 | 2.672 | 0.262 | 9.3 | 0.84 | 6.9 | 354 | 221 | 13.7 |
| Wainui at Wainui Road | 3/01/2021 12:15 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1032 | 283 | NA |
| Wainui at Wainui Road | 16/02/2021 7:36 | 0.042 | 99.2 | 86.9 | 0.042 | 6000 | 600 | 6000 | 2.157 | 0.164 | 8.16 | 0.612 | 6.89 | 640 | 352 | 18.2 |
| Wainui at Wainui Road | 16/02/2021 13:05 | 0.032 | 91.5 | 88.3 | 0.03 | 5800 | 6000 | 7500 | 1.066 | 0.285 | 8.13 | 0.243 | 6.84 | 138 | 145 | 19.3 |
| Waingarara at Wainui Road | 27/09/2020 13:55 | 0.025 | 91.5 | 93.5 | 0.024 | NA | NA | NA | 1.509 | 0.186 | 9.76 | 0.295 | 7.25 | 246 | 122 | 15.8 |
| Waingarara at Wainui Road | 6/11/2020 7:00 | 0.035 | 79.5 | 91.8 | 0.027 | NA | NA | NA | 1.124 | 0.312 | 9 | 0.165 | 7.08 | 54 | 41.6 | 16.7 |
| Waingarara at Wainui Road | 25/11/2020 10:05 | 0.029 | 89.2 | 95.7 | 0.041 | 32000 | 33000 | 40000 | 0.781 | 0.089 | 9.8 | 0.164 | 7.22 | 84.5 | 55.7 | 14.2 |
| Waingarara at Wainui Road | 3/01/2021 12:50 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1070 | 295 | NA |
| Waingarara at Wainui Road | 16/02/2021 8:06 | 0.019 | 101.2 | 91.5 | 0.044 | 6000 | 600 | 6000 | 0.896 | 0.111 | 8.48 | 0.239 | 7.11 | 118 | 90.9 | 19 |
| Waingarara at Wainui Road | 16/02/2021 13:37 | 0.016 | 73 | 95.5 | 0.014 | 8000 | 6000 | 13900 | 1.141 | 0.161 | 8.65 | 0.24 | 6.97 | 158 | 145 | 20.2 |
| Nukuhou at Kererutahi (Wainui Road) | 27/09/2020 13:35 | 0.042 | 102.3 | 95.2 | 0.028 | NA | NA | NA | 0.936 | 0.434 | 9.43 | 0.125 | 7.22 | 33.5 | 20.4 | 15.8 |
| Nukuhou at Kererutahi (Wainui Road) | 6/11/2020 6:40 | 0.193 | 97.2 | 78.4 | 0.048 | NA | NA | NA | 2.257 | 0.542 | 7.61 | 0.325 | 6.89 | 70 | 24.1 | 16.9 |
| Nukuhou at Kererutahi (Wainui Road) | 25/11/2020 9:40 | 0.021 | 100.1 | 90.8 | 0.022 | 2500 | 1500 | 2600 | 0.51 | 0.291 | 9.21 | 0.068 | 7.16 | 3 | 4.15 | 14.6 |
| Nukuhou at Kererutahi (Wainui Road) | 3/01/2021 12:30 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1250 | 456 | NA |
| Nukuhou at Kererutahi (Wainui Road) | 16/02/2021 7:48 | 0.039 | 105.2 | 85.8 | 0.029 | 3700 | 6800 | 3800 | 0.923 | 0.269 | 7.89 | 0.135 | 7.2 | 13.67 | 10 | 19.3 |
| Nukuhou at Kererutahi (Wainui Road) | 16/02/2021 13:16 | 0.108 | 100.2 | 83.4 | 0.037 | 6000 | 6000 | 6000 | 1.811 | 0.348 | 7.7 | 0.382 | 6.97 | 166 | 104 | 19.4 |
| Kutarere at Kutarere Wharf Road | 27/09/2020 13:45 | 0.132 | 99.3 | 92.6 | 0.038 | NA | NA | NA | 2.248 | 0.342 | 9.17 | 0.386 | 6.9 | 358 | 214 | 15.9 |

| Location Name | Time | Ammoniacal N ($g/m^3$) | Cond. (Field) (uS/cm) | DO (%) | DRP ($g/m^3$) | *E coli* (cfu / 100 ml) | Enterococci (cfu/100 ml) | Faecal coliforms (cfu / 100 ml) | TN ($g/m^3$) | NNN ($g/m^3$) | DO ($g/m^3$) | TP ($g/m^3$) | pH | TSS ($g/m^3$) | Turbidity (NTU) | Water Temp (degC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kutarere at Kutarere Wharf Road** | 6/11/2020 6:50 | 0.117 | 184.9 | 85.6 | 0.047 | NA | NA | NA | 1.13 | 0.239 | 8.35 | 0.147 | 6.98 | 23.5 | 7.03 | 16.7 |
| **Kutarere at Kutarere Wharf Road** | 25/11/2020 9:51 | 0.156 | 163 | 88.7 | 0.066 | 41000 | 34000 | 48000 | 1.466 | 0.208 | 9.05 | 0.454 | 6.98 | 92.4 | 76.9 | 14.4 |
| **Kutarere at Kutarere Wharf Road** | 16/02/2021 7:56 | 0.053 | 230.8 | 84.6 | 0.056 | 6000 | 6000 | 6000 | 1.622 | 0.171 | 7.85 | 0.501 | 7.03 | 291 | 144 | 18.9 |
| **Kutarere at Kutarere Wharf Road** | 16/02/2021 13:26 | 0.085 | 458.9 | 87.2 | 0.067 | 6000 | 6000 | 6000 | 1.275 | 0.232 | 7.93 | 0.241 | 6.92 | 35 | 35.6 | 20 |

# Appendix E2: Ōhiwa site summaries

## Tunanui Tributary at Burma Road

20 July 2021

### Summary statistics

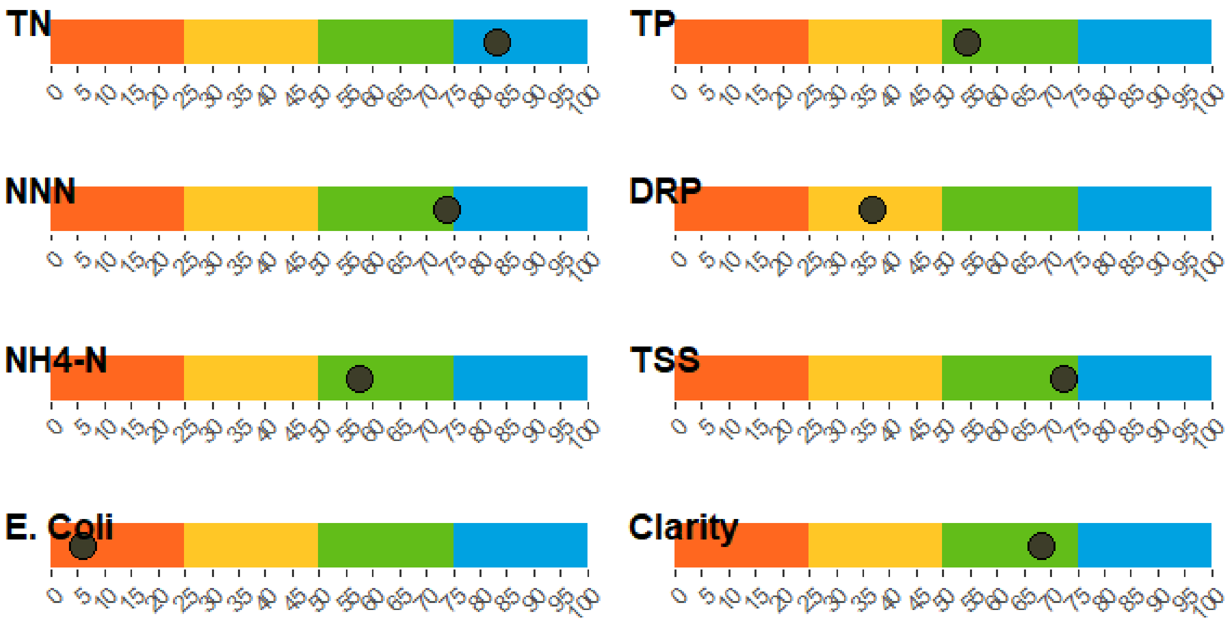
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 27 | 0.10 | 1.61 | 0.41 | 0.21 | 1.46 | 0.13 | 0.42 | 0.08 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 27 | 0.01 | 0.44 | 0.17 | 0.15 | 0.35 | 0.03 | 0.12 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 27 | <0.002 | 0.020 | 0.010 | 0.010 | 0.017 | 0.003 | 0.005 | 0.001 |
| **Total Phosphorus (g/m3)** | 27 | 0.029 | 0.402 | 0.075 | 0.040 | 0.280 | 0.030 | 0.093 | 0.018 |
| **Dissolved Reactive Phosphorus (g/m3)** | 27 | 0.023 | 0.056 | 0.030 | 0.030 | 0.038 | 0.024 | 0.006 | 0.001 |
| **Dissolved Oxygen Sat (%)** | 26 | 94.8 | 107.0 | 98.9 | 98.4 | 102.3 | 96.5 | 2.4 | 0.5 |
| **Dissolved Oxygen (g/m3)** | 26 | 9.05 | 11.79 | 10.23 | 9.89 | 11.68 | 9.20 | 0.94 | 0.19 |
| **Escherichia coli (cfu/100ml)** | 9 | 270 | 21000 | 3942 | 900 | 15000 | 282 | 6738 | 2246 |
| **Total Suspended Solids (g/m3)** | 27 | <1 | 713.33 | 52.65 | 2.56 | 212.40 | 0.24 | 145.29 | 27.96 |
| **Turbidity (NTU)** | 27 | 0.8 | 484.0 | 35.8 | 1.8 | 151.6 | 1.0 | 99.1 | 19.1 |
| **Water Clarity (m)** | 9 | 1.48 | 3.70 | 2.71 | 2.53 | 3.64 | 1.70 | 0.72 | 0.24 |
| **Conductivity (mS/cm)** | 1 | 120.6 | 120.6 | 120.6 | 120.6 | 120.6 | 120.6 | NA | NA |
| **pH (pH Units)** | 26 | 7.0 | 7.7 | 7.3 | 7.3 | 7.5 | 7.1 | 0.1 | 0.0 |
| **Water Temperature (degC)** | 26 | 7.9 | 21.6 | 14.3 | 15.1 | 19.6 | 8.8 | 4.1 | 0.8 |

## State of the site

**Comparison plots**

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




**Microbiological guidelines assessment**

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-19 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-20 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| All | 2020-11-25 | 2021-02-17 | 9 | 900 | NA | 0 | 44.4 | 55.6 |

# Wainui at Wainui Road

20 July 2021

## Summary statistics

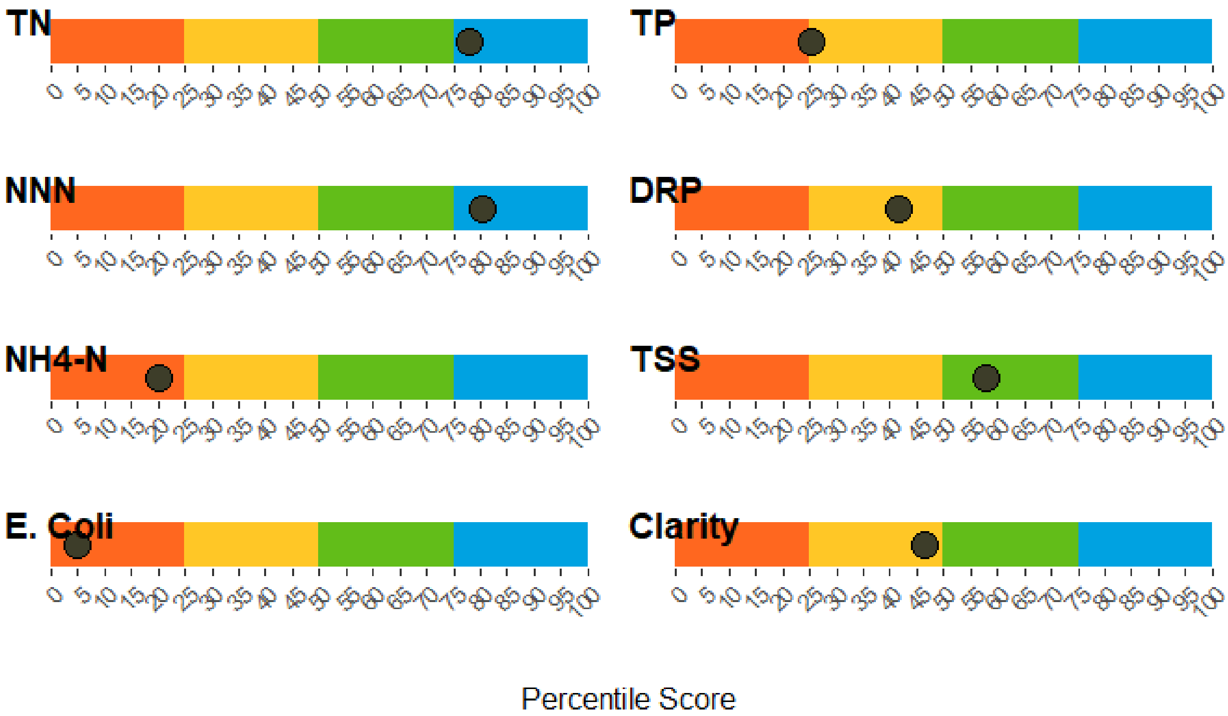
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 26 | 0.16 | 2.67 | 0.49 | 0.27 | 1.92 | 0.18 | 0.63 | 0.12 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 26 | 0.01 | 0.28 | 0.10 | 0.08 | 0.25 | 0.01 | 0.08 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 26 | 0.017 | 0.153 | 0.041 | 0.037 | 0.054 | 0.022 | 0.025 | 0.005 |
| **Total Phosphorus (g/m3)** | 26 | 0.044 | 0.840 | 0.139 | 0.076 | 0.547 | 0.047 | 0.188 | 0.037 |
| **Dissolved Reactive Phosphorus (g/m3)** | 26 | 0.014 | 0.115 | 0.032 | 0.028 | 0.056 | 0.018 | 0.019 | 0.004 |
| **Dissolved Oxygen Sat (%)** | 26 | 86.9 | 109.4 | 94.0 | 93.7 | 106.5 | 87.3 | 5.6 | 1.1 |
| **Dissolved Oxygen (g/m3)** | 26 | 8.09 | 11.28 | 9.59 | 9.40 | 11.07 | 8.14 | 1.00 | 0.20 |
| **Escherichia coli (cfu/100ml)** | 9 | 290 | 49000 | 7234 | 1000 | 31800 | 302 | 15826 | 5275 |
| **Total Suspended Solids (g/m3)** | 27 | 1.67 | 1032.00 | 92.71 | 4.38 | 554.20 | 2.67 | 234.81 | 45.19 |
| **Turbidity (NTU)** | 27 | 1.0 | 352.0 | 46.8 | 4.7 | 264.4 | 2.6 | 94.7 | 18.2 |
| **Water Clarity (m)** | 9 | 1.24 | 2.05 | 1.67 | 1.65 | 2.04 | 1.28 | 0.29 | 0.10 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | 26 | 6.8 | 7.7 | 7.2 | 7.2 | 7.5 | 6.9 | 0.2 | 0.0 |
| **Water Temperature (degC)** | 26 | 7.7 | 22.7 | 15.0 | 15.3 | 21.2 | 9.0 | 4.6 | 0.9 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

Table 4 contains an assessment of Escherichia coli data against the 'Surveillance, alert, and action level' framework for freshwater, part of the Microbiological Guidelines for Marine and Freshwater Recreational Areas (2002). This framework is designed to inform the public of the bathing risk at a particular site, based on the results of a single water quality sample. Although many of BOPRC's water quality monitoring sites are not specifically monitored for swimming purposes, this framework can provide a useful indicator of the extent of faecal contamination that may pose a risk to human health.

Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-19 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-20 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| All | 2020-08-28 | 2021-02-17 | 9 | 1000 | NA | 0 | 22.2 | 77.8 |

# Waingarara at Wainui Road

20 July 2021

## Summary statistics

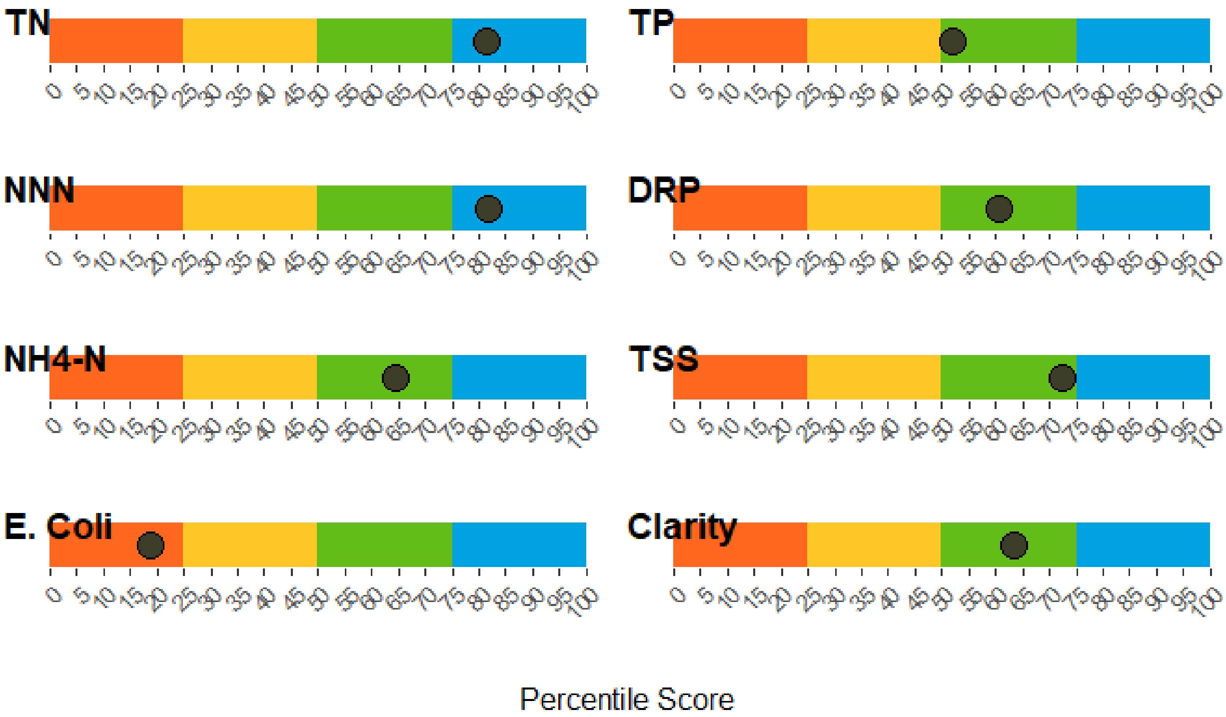
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 26 | 0.14 | 1.51 | 0.39 | 0.23 | 1.14 | 0.14 | 0.37 | 0.07 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 26 | <0.001 | 0.31 | 0.09 | 0.07 | 0.21 | 0.00 | 0.09 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 26 | <0.002 | 0.035 | 0.011 | 0.008 | 0.028 | 0.003 | 0.009 | 0.002 |
| **Total Phosphorus (g/m3)** | 26 | 0.021 | 0.295 | 0.072 | 0.042 | 0.240 | 0.022 | 0.078 | 0.015 |
| **Dissolved Reactive Phosphorus (g/m3)** | 26 | 0.009 | 0.044 | 0.020 | 0.018 | 0.040 | 0.010 | 0.010 | 0.002 |
| **Dissolved Oxygen Sat (%)** | 26 | 91.5 | 133.6 | 101.5 | 100.8 | 115.9 | 92.0 | 9.0 | 1.8 |
| **Dissolved Oxygen (g/m3)** | 26 | 8.27 | 12.20 | 10.12 | 9.84 | 11.94 | 8.38 | 1.23 | 0.24 |
| **Escherichia coli (cfu/100ml)** | 9 | 49 | 32000 | 5244 | 290 | 22400 | 61 | 10469 | 3490 |
| **Total Suspended Solids (g/m3)** | 27 | <1 | 1070.00 | 66.64 | 2.53 | 219.60 | 1.15 | 208.93 | 40.21 |
| **Turbidity (NTU)** | 27 | 1.4 | 295.0 | 29.7 | 2.6 | 138.1 | 1.5 | 65.8 | 12.7 |
| **Water Clarity (m)** | 9 | 1.34 | 3.43 | 2.43 | 2.27 | 3.39 | 1.62 | 0.65 | 0.22 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | 26 | 7.0 | 8.7 | 7.4 | 7.4 | 7.7 | 7.1 | 0.3 | 0.1 |
| **Water Temperature (degC)** | 26 | 7.4 | 25.8 | 16.1 | 16.7 | 23.7 | 9.1 | 5.4 | 1.1 |

## State of the site

**Comparison plots**

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




**Microbiological guidelines assessment**

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Data is summarised into three periods: 5 years, 10 years, and all available data. The overall percentage of samples that fit into each category, for each period, are calculated on the right of the table. You can gain an understanding of the prevalence of faecal contamination by comparing the percentage of samples that fall into each category, across time periods.

*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-19 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-20 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| All | 2020-08-28 | 2021-02-17 | 9 | 290 | NA | 44.4 | 22.2 | 33.3 |

# Nukuhou at Kererutahi (Wainui Road)

20 July 2021

## Summary statistics

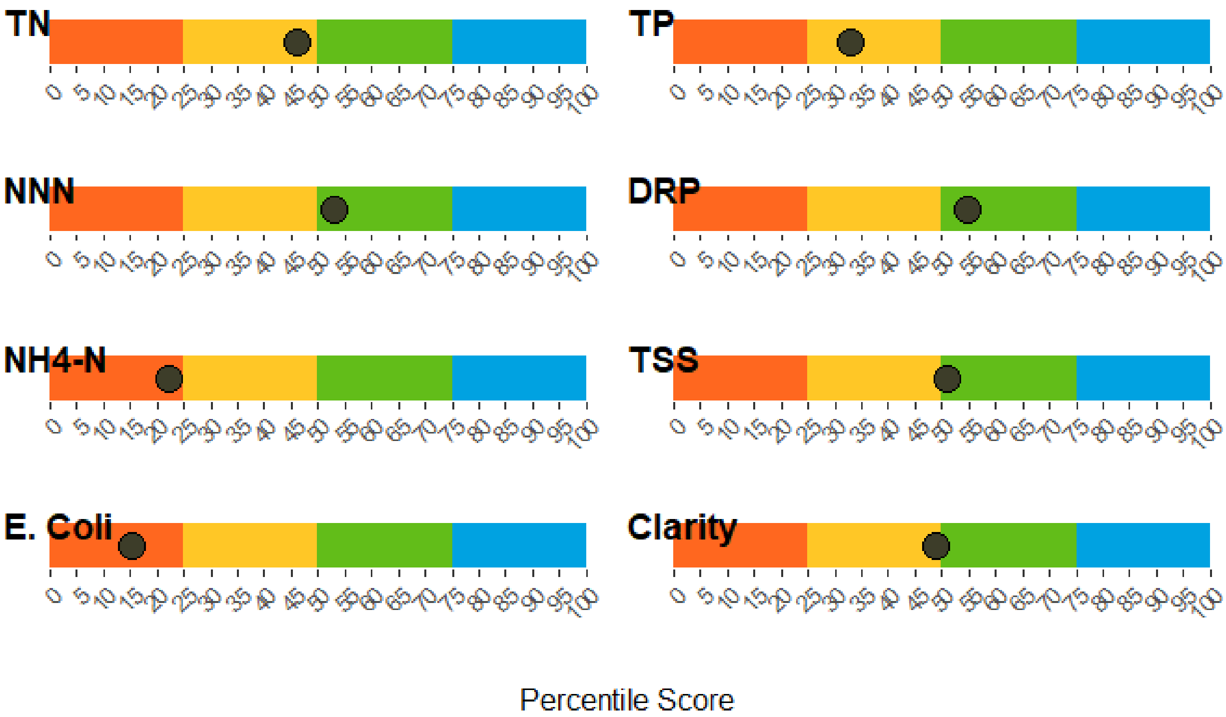
*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 26 | 0.38 | 2.26 | 0.75 | 0.68 | 1.59 | 0.40 | 0.42 | 0.08 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 27 | 0.17 | 0.63 | 0.39 | 0.38 | 0.62 | 0.20 | 0.14 | 0.03 |
| **Total Ammoniacal Nitrogen (g/m3)** | 26 | 0.008 | 0.193 | 0.041 | 0.034 | 0.097 | 0.009 | 0.038 | 0.007 |
| **Total Phosphorus (g/m3)** | 26 | 0.039 | 0.382 | 0.088 | 0.064 | 0.278 | 0.041 | 0.082 | 0.016 |
| **Dissolved Reactive Phosphorus (g/m3)** | 26 | 0.012 | 0.048 | 0.023 | 0.021 | 0.043 | 0.015 | 0.009 | 0.002 |
| **Dissolved Oxygen Sat (%)** | 147 | 75.5 | 144.1 | 95.1 | 93.0 | 122.7 | 80.7 | 12.1 | 1.0 |
| **Dissolved Oxygen (g/m3)** | 200 | 6.73 | 16.81 | 9.51 | 9.47 | 11.61 | 7.34 | 1.37 | 0.10 |
| **Escherichia coli (cfu/100ml)** | 67 | 42 | 30000 | 1562 | 360 | 5730 | 80 | 4243 | 518 |
| **Total Suspended Solids (g/m3)** | 200 | <1 | 1250.00 | 27.22 | 5.31 | 88.48 | 1.40 | 102.38 | 7.24 |
| **Turbidity (NTU)** | 69 | 2.8 | 456.0 | 14.9 | 5.2 | 23.7 | 3.2 | 55.4 | 6.7 |
| **Water Clarity (m)** | 9 | 1.05 | 1.91 | 1.63 | 1.73 | 1.87 | 1.23 | 0.26 | 0.09 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | 69 | 6.3 | 8.1 | 7.1 | 7.1 | 7.6 | 6.7 | 0.3 | 0.0 |
| **Water Temperature (degC)** | 200 | 5.3 | 23.7 | 15.3 | 15.1 | 22.1 | 8.9 | 4.4 | 0.3 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).




### Microbiological guidelines assessment

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*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-19 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-20 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| All | 2020-08-28 | 2021-02-17 | 9 | 320 | NA | 22.2 | 44.4 | 33.3 |

# Kutarere at Kutarere Wharf Road

20 July 2021

## Summary statistics

*Table 1 Summary statistics calculated from all available data.*

| Parameter | n | Min | Max | Mean | Med | 95th | 5th | SD | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Total Nitrogen (g/m3)** | 26 | 0.29 | 2.25 | 0.69 | 0.44 | 1.80 | 0.32 | 0.54 | 0.11 |
| **Nitrate Nitrite Nitrogen (g/m3)** | 26 | <0.001 | 0.34 | 0.12 | 0.11 | 0.25 | 0.01 | 0.08 | 0.02 |
| **Total Ammoniacal Nitrogen (g/m3)** | 26 | 0.008 | 0.156 | 0.063 | 0.058 | 0.128 | 0.010 | 0.035 | 0.007 |
| **Total Phosphorus (g/m3)** | 26 | 0.037 | 0.501 | 0.132 | 0.078 | 0.437 | 0.042 | 0.138 | 0.027 |
| **Dissolved Reactive Phosphorus (g/m3)** | 26 | <0.001 | 0.067 | 0.028 | 0.026 | 0.064 | 0.005 | 0.016 | 0.003 |
| **Dissolved Oxygen Sat (%)** | 26 | 62.2 | 132.7 | 92.8 | 89.8 | 122.9 | 83.3 | 13.8 | 2.7 |
| **Dissolved Oxygen (g/m3)** | 26 | 5.45 | 11.10 | 9.24 | 9.27 | 10.82 | 7.87 | 1.28 | 0.25 |
| **Escherichia coli (cfu/100ml)** | 9 | 200 | 41000 | 7478 | 4400 | 27000 | 560 | 12795 | 4265 |
| **Total Suspended Solids (g/m3)** | 26 | 1.50 | 358.00 | 37.87 | 5.83 | 241.35 | 2.00 | 87.09 | 17.08 |
| **Turbidity (NTU)** | 26 | 1.1 | 214.0 | 22.8 | 4.8 | 127.2 | 3.0 | 49.5 | 9.7 |
| **Water Clarity (m)** | 9 | 0.42 | 1.32 | 0.83 | 0.67 | 1.26 | 0.44 | 0.36 | 0.12 |
| **Conductivity (mS/cm)** | | | | | | | | | |
| **pH (pH Units)** | 26 | 6.9 | 8.2 | 7.1 | 7.1 | 7.9 | 6.9 | 0.3 | 0.1 |
| **Water Temperature (degC)** | 26 | 8.2 | 26.8 | 16.0 | 16.3 | 25.3 | 9.4 | 5.3 | 1.0 |

## State of the site

### Comparison plots

This figure compares median values for eight different measurements collected at the site, against the distribution of data from all sites in the Bay of Plenty region. The grey dot represents the site's percentile score (0% = worst, 100% = best), with each coloured segment representing 25% of the overall distribution. The segment colour scheme ranges from (worst 25% of sites) to blue (best 25% of sites).

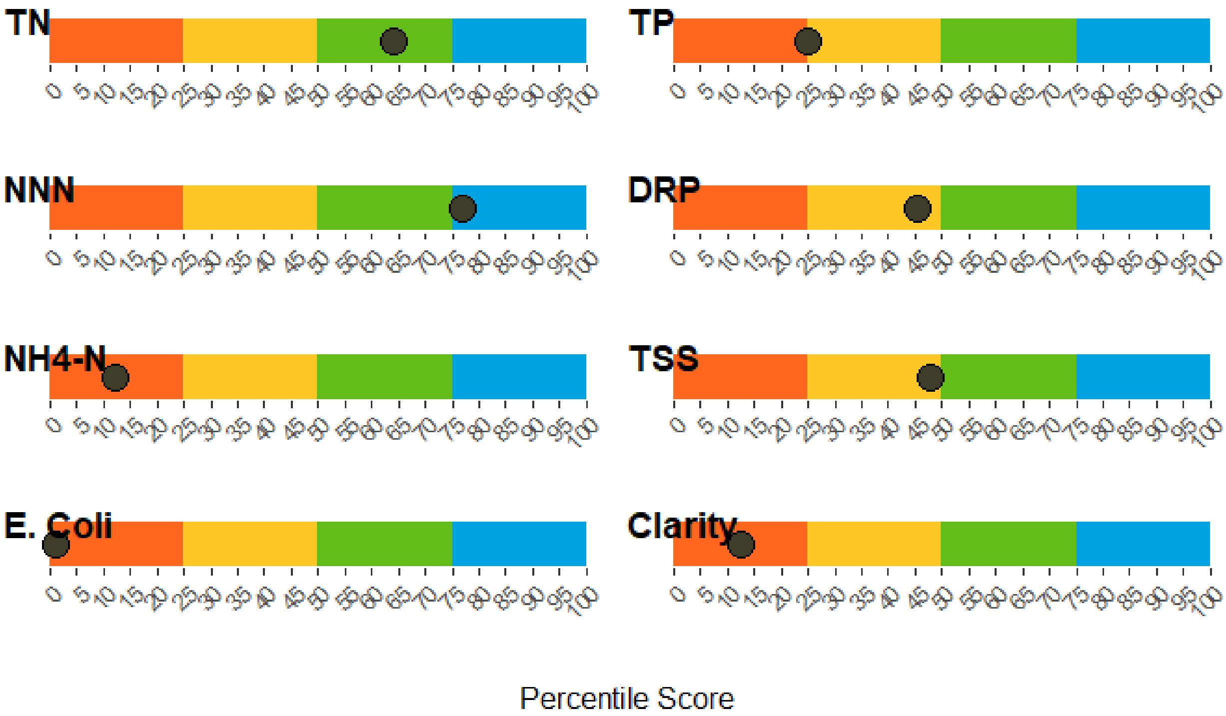


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*Table 4 Surveillance, alert, and action levels for freshwater*

| Timeframe | Start | End | n | Median | Perc95 | Green | Amber | Red |
|---|---|---|---|---|---|---|---|---|
| 5 Years | 2016-02-19 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| 10 Years | 2011-02-20 | 2021-02-17 | NA | NA | NA | NA | NA | NA |
| All | 2020-08-28 | 2021-02-17 | 9 | 4400 | NA | 11.1 | 0 | 88.9 |

# 8 Summary of recommendations

This section summarises the recommendation made in this report. For details on each of these recommendations, refer to the recommendations section in the relevant chapter.

**Kaiate Falls**

1 Investigate upper catchment results from MfE and ESR

2 Partner with local iwi to reduce contamination in Owairoa sub-catchment

3 Ongoing monitoring

**Te Mania**

1 Implement land management mitigations based on the results provided.

**Kopuaroa**

1 Proceed with the recommendations of Mahon et al. (2020) for faecal bacteria mitigation, preventing sediment loss, and nutrient reduction in the Kopuaroa catchment.

2 Support the work underway across the Kaituna WMA to reduce contaminant loading to the Maketū Estuary.

**Upper Rangitaiki**

1 Dissolved oxygen in upper Otamatea.

2 Otangimoana monitoring.

**Ohiwa**

1 Kutarere Stream could be investigated for faecal and ammoniacal-N contamination.

2 Assess trends for the Nukuhou River monitoring with updated data.