Freshwater contact recreational water quality at Taranaki sites

State of the Environment Monitoring
Annual Report
2019-2020

Technical Report 2020-01

Working with people | caring for Taranaki

Taranaki
Regional Council

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Private Bag 713
Stratford

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Executive summary

This survey of sixteen recognised freshwater contact recreational sites in the Taranaki region was the twenty-fourth of an on-going programme designed to annually monitor the bacteriological quality of lakes, rivers and streams at popular contact recreational sites during each bathing season. It forms a component of the State of the Environment bathing beaches trend monitoring programme, which commenced in the 1995-1996 summer period. Two sites (at Lakes Ratapiko and Opunake) were monitored in this programme during this 2019-2020 period for the fourteenth time, partly as a component of the more recently instituted cyanobacteria programme (covering four lakes) instigated after consultation with Taranaki District Health Board. A site in the lower Waitara River was added in the 2010-2011 period at the joint request of Taranaki Healthcare and NPDC, and two additional sites in the lower reaches of the Waiwhakaiho River and Te Henui Stream (both adjacent to the New Plymouth walkway) were included in the programme in the 2012-2013 period. The sixteen sites have been graded for recreational suitability (SFRG) according to MfE, 2003 guidelines, in part based upon the immediately preceding five seasons of monitoring data (where such data existed) although short-comings of this grading methodology are acknowledged. A re-assessed SFRG also has been provided by inclusion of the current season's data for comparative purposes and this showed minimal change of the microbiological water quality gradings over this latest five year period.

The Waimoku Stream site is sampled on a three-yearly frequency and it was monitored during the period under review. This stream is known to carry extremely high levels of bacterial contamination due to its resident waterfowl population (pukeko, ducks), and a warning sign advising against recreational use of the stream is permanently in place. It is now monitored primarily for its potential impact on Oakura beach's water quality (refer *Bathing Beach Water Quality State of the Environment Monitoring Report Summer 2019-2020*, technical report 2020-82).

A further site (Lake Rotokare) has been monitored since 2007, principally for planktonic cyanobacteria. Additional comprehensive flowing water benthic cyanobacteria monitoring (at nine river/stream sites) was undertaken in the current period for the seventh time in this state of the environment programme.

Changes were made in 2016-2017 to follow protocols for reporting on the Land and Water Aotearoa (LAWA) website: sampling frequency at four of the most popular sites (Lake Rotomanu, Waiwhakaiho River at Merrilands Domain, and Kaupokonui and Waingongoro river mouths) was increased to weekly, mainly in dry weather, from December to February inclusive, and extended to March in 2017-2018.

The 2019-2020 monitoring period was cut short in March 2020 by the advent of the Covid-19 pandemic, resulting in two fewer (eleven) sampling runs than in previous seasons for trend monitoring.

The results of the 2019-2020 survey have continued to illustrate variability in bacteriological water quality, with the highest quality achieved at the Urenui River estuary and lower Patea River sites where marked seawater intrusion is the norm (under high tide conditions), and Lake Ratapiko. Impacts on bacteriological water quality at some sites, particularly the lower reaches of the Waiwhakaiho River and Te Henui Stream, were due principally to resident wild fowl populations in the vicinity of recreational usage sites (as confirmed previously by inspections and DNA marker surveys).

In terms of *E. coli*, bacteriological water quality in the latest survey period was similar in comparison with historical surveys. The total number of samples falling within the "Alert" or "Action" categories (31% of samples, or 35% if the samples of the Waimoku are included) across the 16 recognised bathing sites was slightly higher than the recorded long-term average. However, it should be noted that the "Action" category is the only category for which swimming is not recommended. In the 2019-2020 season, 85% of all samples (excluding the Waimoku) met the national bathing guideline. Of the 15% of samples that exceeded the guideline, 11% arose from just two sites - the two New Plymouth urban sites. Bird life was mainly responsible for the exceedances at these sites.

Two sites recorded all single samples in either the 'Alert' or the 'Action' mode of the MfE, 2003 guidelines (Te Henui Stream near East End beach and Waimoku Stream at Oakura), while one site (Waiwhakaiho River opposite Lake Rotomanu) recorded nine of eleven samples in those modes. Nine other sites from time to time exhibited single sample entries, mainly into the 'Alert' mode of the 2003 guidelines, at some time during the season. Seven of these sites had numbers which entered the 'Action' mode, a slight increase the number and frequency of guideline exceedances in comparison with many previous seasons' results.

To a certain extent these exceedances were probably a feature common to the mid and lower reaches of rivers and streams draining developed (particularly agricultural) catchments throughout New Zealand.

Notably, no exceedance of the MfE 'Action' guideline was found in the Waiwhakaiho River at Merrilands Domain (mid urban New Plymouth and downstream of agricultural land), whereas 8 of 11 samples exceeded this guideline further downstream near this river's mouth.

At most sites, minimal follow-up sampling was performed when deemed necessary following exceedances of the 'Action' limit, as in most cases bacteriological quality was found to have returned to typical levels within short time frames or the causes were well established from historical data. Permanent health warning signage had been erected by New Plymouth District Council (on the direction of Taranaki District Health Board) following past exceedances of 'Action' levels at the lower Waiwhakaiho River, Waimoku Stream and Te Henui Stream sites, and of 'Alert' levels at Waitara. Temporary signage was required at the Lake Rotomanu, Timaru Stream and upper Patea, mid and lower Waingongoro and Waitara Rivers sites following single sample 'Action' levels, but single sample 'Alert' level exceedances at other sites were not necessarily signposted.

Temporal trends over the 1996-2020 period have been evaluated on the basis of seasonal median *E. coli* number for the seventeen sites that have ten years or more data (and will continue to be assessed annually). Three sites (Te Henui and Waimoku Streams and lower Waiwhakaiho River) have shown a statistically significant increasing trend. No other sites have shown statistically significant trends (positive or negative) in seasonal median *E. coli* numbers.

Additional sampling (in accordance with the MfE, 2003 guidelines for datasets for grading purposes) at four principal usage sites (Lake Rotomanu and Waiwhakaiho, Kaupokonui and Waingongoro Rivers) occurred largely in dry weather and resulted in little change in the overall median bacteriological numbers.

Overall, the 2019-2020 monitoring year saw lower than usual levels of planktonic cyanobacteria, especially at Lake Rotokare, which typically has had high bio-volume levels during the summer months. However, Lake Opunake, unlike the other three lakes, had higher than usual levels, and recorded its first ever exceedance of the Action level bio-volume. This necessitated warning notices to avoid contact recreation for 9 days from late February 2020.

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored. Monitoring frequency was increased from fortnightly to weekly in response to 'Alert' levels found on several occasions. The 'Action' mode trigger level was reached once, in February 2020, when bed coverage in Kaupokonui Stream at the beach domain led to the posting of warning notices to contact recreational users. Two sites (Waingongoro and Kaupokonui Rivers at mouth) exceeded the 'Alert' mode trigger level for bed coverage on a total of nine surveys. The 'Alert' mode trigger level for exposed mats was exceeded at five sites (Waingongoro River at Ohawe, Kaupokonui River at the mouth, Waiwhakaiho River at the last riffle and at Merrilands Domain, and Manganui River at Everett Park) on a total of seven individual site surveys, and for detaching or detached mats accumulating on the river's edge at the same sites (except the lower Waiwhakaiho site) on a total of 15 surveys. Levels of benthic cyanobacteria were higher than in the previous three seasons, and similar to the preceding two seasons, probably a reflection of the relative amounts of rainfall causing freshes that scour streambeds of periphyton.

Timely reporting of the results of bacteriological water quality and cyanobacteria numbers/cover was undertaken by use of the Taranaki Regional Council website (www.trc.govt.nz) and LAWA website (www.lawa.org.nz), as well as liaison with territorial local authorities and the Health Protection Unit of Taranaki District Health Board, throughout the survey season of 2019-2020.

For the fourth time, this report also discusses the monitoring results in the light of the criteria for primary recreational use of water bodies ('swimmability') set out in the National Objectives Framework that is attached to the *National Policy Statement for Freshwater Management 2014*.[1]

It is recommended that annual bacteriological monitoring of selected freshwater sites be continued (in conjunction with the coastal bathing water programme) by use of a similar sampling format over a five month (November to March inclusive) contact recreational period to provide information for trend detection purposes and for assessment of suitability for contact recreational usage. Cyanobacteria monitoring at the four lakes sites and nine stream/river sites at a lesser frequency is also recommended to continue. A further recommendation involves appropriate scheduling of the annual round of dairy wastes disposal systems and advice provided in relation to stock access to watercourses to attempt to reduce the frequency of exceedances of recreational limits particularly in catchments where historical problems from this source have been located.

[1] These criteria are to be applied all year round regardless of river or weather suitability for bathing. The *National Policy Statement for Freshwater Management 2020* was promulgated after the bathing season discussed herein. It now introduces criteria for water quality that are to be specifically applied to recognised recreational bathing sites monitored during the bathing season. Future SEM reports will instead reference the latter criteria, as they are more relevant.

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1 Introduction

1.1 General

The Resource Management Act 1991 (RMA) established new requirements for local authorities to undertake environmental monitoring. Section 35 of the RMA requires local authorities to monitor, among other things, the state of the environment of their region or district, to the extent that is appropriate to enable them to effectively carry out their functions under the Act.

To this effect, the Taranaki Regional Council ('the Council') has established a state of the environment monitoring (SEM) programme for the region. This programme is outlined in the Council's 'State of the Environment Monitoring Procedures Document', which was prepared in 1997. The monitoring programme is based on the significant resource management issues that were identified in the Council's Regional Policy Statement for Taranaki (1994).

The SEM programme is made up of a number of individual monitoring activities, many of which are undertaken and managed on an annual basis (from 1 July to 30 June). For these annual monitoring activities, summary reports are produced following the end of each monitoring year (i.e., after 30 June). Where possible, individual consent monitoring programmes have been integrated within the SEM programme to save duplication of effort and minimise costs. The purpose of annual SEM reports is to summarise regional environmental monitoring activity results for the year, and provide an interpretation of these results, together with an update of trends in the data.

Annual SEM reports act as 'building blocks' towards the preparation of the regional state of the environment report every five years. The Council's first, or baseline, state of the environment report was prepared in 1996 (TRC, 1996), summarising the region's progress in improving environmental quality in Taranaki over the past two decades. The second report (for the period 1995-2000) was published in 2003 (TRC, 2003). Data spanning the ten year period 1995 to 2005 have been used in the preparation of a trend report (TRC, 2006). The third State of the Environment report (for the period 1995 to 2007) was published (TRC, 2009) and included trend reporting and the fourth report (for the 1995 to 2014 period) has been published (TRC, 2015c). The provision of appropriate computer software statistical procedures allows regular reporting on trends in the environmental quality over time, in relation to Council's ongoing monitoring activities, now that there has been an accumulation of a comprehensive dataset of sufficient duration to permit a meaningful analysis of trends (i.e. minimum of 10 years).

This report summarises the results for the sites surveyed in the Freshwater contact recreational water quality SEM programme over the 2019-2020 monitoring year, the 24th year of the programme.

1.2 Background

The microbiological water quality at bathing beaches along the Taranaki coast has been monitored by the Taranaki Regional Council (and its predecessors) since 1979, with systematic surveys undertaken since 1987. A more comprehensive annual bathing beach monitoring programme was first implemented during the 1995-1996 summer as an ongoing component of the state of the environment monitoring (SEM) programme for the Taranaki region.

Freshwater bathing and recreational sites were added during the 1996-1997 summer and integrated within the bathing beach bacteriological water quality monitoring programme in order to maximise the efficiency of field sampling procedures and protocols. This format has been continued in the summer periods since this date, with an additional component of cyanobacteria monitoring instituted at three lake sites since the 2006-2007 summer and an additional lake site in 2007-2008, and nine river and stream sites monitored for the benthic cyanobacteria component of the SEM periphyton programme. These results are also reported as appropriate in the current report.

The SEM freshwater contact recreational water quality programme has three objectives:

- to characterise the bacteriological and cyanobacterial quality of principal recreation waters in the Taranaki area, and more specifically to determine their suitability for contact recreation;
- to identify changes in contact recreational bacteriological water quality over time. Therefore the detection of trends is an important component in programme design; and
- to assess compliance with recreational water quality guidelines.

*[Note: Contact recreation concerns water-based activities involving a high probability of accidental water ingestion. This mainly applies to bathing, but may also include water- and jet-skiing, surfing, boardsailing, etc. Bathing, kayaking, and water skiing are the principal freshwater contact recreational usages identified. More recently, the term 'swimmability' has entered popular usage to denote waters used for primary contact recreation.]***.**

2 Standards and guidelines

Prior to 2003, the Council used guidelines for the management of recreational and marine shellfish-gathering waters (MfE, 1998), which replaced the provisional guidelines (DOH, 1992). These guidelines were developed (by MfE and MoH) to assist water managers to implement the Resource Management Act (1991) and the Health Act (1956) for the purposes of shellfish-gathering and contact recreation (refer to previous annual reports for more information on these historical guidelines). Guidelines issued in 2003 are now relevant to this programme. These guidelines are detailed below.

2.1 Microbiological water quality guidelines

Guidelines have been prepared by Ministry for the Environment in conjunction with the Ministry of Health (MfE, 2003). Changes to the *E. coli* freshwater recreational guideline values were made for the purpose of regularly assessing single samples against suitability for recreation, and thus providing information on current (ie, at time of sampling) suitability for recreational use. The current freshwater guidelines are now more reflective of New Zealand conditions. 'Alert' and 'Action' guideline levels are used for surveillance throughout the bathing season. They may be summarised as follows (Table 1), with the marine levels included within the table as some of the Taranaki sites monitored are in the lower, tidal reaches of rivers and streams.

Table 1 Surveillance, alert and Action levels for freshwaters (2003)

Mode	Acceptable (green)	Alert (amber)	Action (red)
Freshwater (*E. coli*/100 ml)	≤260	261-550	>550
Marine (enterococci/100 ml)	≤140	141-280	>280 (2 consecutive samples)
Procedure	• Continue routine monitoring	• Increase sampling to daily • Undertake sanitary survey • Identify sources of contamination • Consult CAC to assist in identifying possible source	• Increase sampling to daily • Undertake sanitary survey • Identify sources of contamination • Consult CAC to assist in identifying possible source • Erect warning signs • Inform the public through the media that a public health problem exists

CAC = Catchment Assessment Checklist

It is important to understand if bacteriological quality enters the 'Alert' status, it is still deemed suitable for swimming and other recreational uses. If bacteriological quality enters the 'red' (Action) level then the bathing area will be considered highly unsuitable for recreation, a public health problem is deemed to exist, and swimming is not recommended.

Sampling is generally conducted weekly, but with the proviso that it should be under conditions when the river is suitable and used for bathing. For example, this precludes sampling under conditions of river freshes when high flows and turbid conditions would make bathing hazardous and in any case people would be less inclined to bathe. The Council endeavours to collect 13 samples per season under bathing conditions. In addition, at four of the most popular sites a further 7 samples are collected between November and March regardless of prevailing weather and river conditions, to facilitate the calculation of the Microbiological Assessment Category (see next section). Also, weekly sampling regardless of weather and river conditions was undertaken between December 2019 and March 2020 at four of the most popular sites, to align with and assess the reporting protocols for the LAWA website and to enhance the provision of timely information to the public during holiday periods.

2.2 Suitability for recreation grade (SFRG)

Components of the guidelines include sanitary surveys/inspections together with assessments of historical microbiological data which, when combined, provide an overall suitability for recreation grade, which describes the general condition of a site based on both risk and indicator bacteria numbers. The Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MfE, 2003) provide for the grading of recreational water bodies utilising Microbiological Assessment Categories (using historical data), and Sanitary Inspection Categories which generate a measure of the susceptibility of water bodies to faecal contamination (ranging from high to low risk). The SFRG therefore describes the general historical and perceived potential risk condition of a site based on both risk factors and indicator bacteria water quality (worst-case over the long term). A grade is established on the basis of the most recent five years' data and recalculation of a grade may be performed annually, although grades should be reassessed on a five-yearly basis.

SFRGs categories are very good, good, fair, poor, and very poor. Sites graded very good are those where it is believed they will almost always comply with the guideline values for recreation, and there are few sources of faecal contamination in the catchment. Consequently, there is a low risk of illness from bathing. Sites graded very poor are in catchments with significant sources of faecal contamination, and it is generically considered that they will rarely pass the guidelines. The risk of illness from bathing at these sites is deemed within the Guidelines to be high, and swimming is not recommended. For the remaining beaches (good, fair and poor) it is recommended that weekly monitoring be carried out during the bathing season to the extent that is practicable. The public is to be informed when guideline values are exceeded and swimming is not recommended (MfE, 2003).

All of the freshwater sites included in the bathing sites programme have been graded by the Council according to these criteria, using all historical SEM microbiological water quality data extending over the November 2014 to March 2019 period (i.e. the five years immediately preceding the current season as required by the Guidelines). The relevant information is provided in Appendix 1 and is summarised in Table 2. Recalculated gradings taking the results of the latest season into account are given in Table 59 of this report.

Table 2 Suitability for recreation grade for freshwater sites for the period November 2014 to March 2019

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100 ml)			SFR Grade	% of all samples not exceeding 'Action' level (ie: ≤ 550 E.coli)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	727	65	D	Very poor	87

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100 ml)			SFR Grade	% of all samples not exceeding 'Action' level (ie: ≤ 550 E.coli)
		95 %ile	Number of samples	Category		
Waiwhakaiho R: Merrilands domain	High	512	65	C	Poor	95
Waiwhakaiho R at L.Rotomanu	High	4850	65	D	Very poor	23
Te Henui S: mouth	High	5550	65	D	Very poor	12
Patea R: King Edward Park	High	828	65	D	Very poor	83
Patea R. boatramp, Patea	High	10	65	A	Poor	100
Waingongoro R: Eltham camp	High	782	65	D	Very poor	92
Waingongoro R: Ohawe beach	High	545	65	C	Poor	95
Kaupokonui R: Beach domain	High	740	65	D	Very poor	90
L Opunake: adjacent boat ramp	High	1123	65	D	Very poor	90
Timaru S: Lower Weld Road	High	1162	65	D	Very poor	83
Oakura R: d.s SH45	High	1675	65	D	Very poor	86
Waitara R: Town wharf	High	1050	65	D	Very poor	90
Urenui R: estuary	High	110	65	A	Poor	98
Manganui R: Everett Park	High	393	65	C	Poor	98
L Ratapiko: boatramp	High	216	64	B	Poor	98
L Rotokare: adjacent boatramp	Low	342	44	C	Fair	97

Although all but one of the sites' SFRGs suggest possible high risks associated with contact recreational usage, the poor to very poor gradings have been very strongly influenced by the underlying agricultural nature of the catchments in question (within the Sanitary Investigation Category). The 5-year microbiological data, however, indicate that all but two sites (Te Henui Stream and lower Waiwhakaiho River) would not have entered the 'Action' guideline (ie would have exceeded guidelines) on more than 17% of all sampling occasions, that is, fourteen sites achieved the guideline on 83% or more of occasions. That is, the data show the SFRG gradings to be highly precautionary.

The Patea River estuary site has not reached the 'Action' mode during the previous five seasons, under the sampling protocols of the SEM programme; and the Urenui River estuary site, the Everett Park site in the Manganui River, and the Lake Ratapiko boat ramp site, entered this 'Action' level on only one or two occasions during the same five-year period.

As explained above, in general, these data indicate shortcomings in the grading system set out within the Guidelines for these sites based upon landuse/perceived impacts and the use of extremes (95% confidence levels) in bacteriological quality data (ie the 'worst case' data), rather than actual monitoring or representative data measured throughout the bathing seasons. Council's contact recreational water quality programme results confirm that the Guideline gradings do not reflect the recreational water quality experienced by recreational users. They show only susceptibility and predominantly reflect perceptions and suppositions about how some land uses might influence quality, as designated 'risk factors'. It is the view of the Council that when there is regular and systematic testing of the actual quality, those results reflect actual levels and are far more informative to recreational water users. Gradings should not be used to make

any statement about how safe water actually is for recreational purposes. Rather, the Council emphasises the importance of continued systematic and on-going testing and timely public notification in terms of the reporting of actual contact recreational water quality and assessments against guidelines.

2.3 Cyanobacteria

In 2009, the Ministry for the Environment released an interim guidance document entitled "New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters" (MfE, 2009). These guidelines provide a national alert–level framework for assessing the public health risk from cyanobacteria associated with contact recreation in lakes and rivers. Table 3 below shows the alert-level framework for benthic cyanobacteria.

Table 3 Alert level framework for benthic cyanobacteria

Alert level	Actions
Surveillance (green mode) Up to 20% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Undertake fortnightly surveys between spring and autumn at representative locations in the water body where known mat proliferations occur and where there is recreational use. • Take scrapings every second survey for microscopic identification, to compare with visual assessments in order to ensure cyanobacteria are being recorded accurately, and to provide an indication of the species present.
Alert (amber mode) 20–50% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Notify the public health unit. • Increase sampling to weekly. • Recommend erecting an information sign that provides the public with information on the appearance of mats and the potential risks. • Consider increasing the number of survey sites to enable risks to recreational users to be more accurately assessed. • If toxigenic cyanobacteria dominate the samples, testing for cyanotoxins is advised. If cyanotoxins are detected in mats or water samples, consult the testing laboratory to determine if levels are hazardous.
Action (red mode) *Situation 1:* Greater than 50% coverage of potentially toxigenic cyanobacteria attached to substrate; or *Situation 2:* up to 50% where potentially toxigenic cyanobacteria are visibly detaching from the substrate, accumulating as scums along the river's edge or becoming exposed on the river's edge as the river level drops.	• Immediately notify the public health unit. • If potentially toxic taxa are present then consider testing samples for cyanotoxins.. • Notify the public of the potential risk to health.

a The alert-level framework is based on an assessment of the percentage of river bed that a cyanobacterial mat covers at each site. However, local knowledge of other factors that indicate an increased risk of toxic cyanobacteria (e.g., human health effects, animal illnesses, prolonged low flows) should be taken into account when assessing a site status and may, in some cases, lead to an elevation of site status (e.g., from surveillance to action), irrespective of mat coverage.

Over the period that planktonic cyanobacteria monitoring of lakes has been undertaken, the guidelines outlined in Table 3 have been utilised (TDHB, 2006), as agreed with all parties at the time of the inception of

this addition to the programme, until the 2014-2015 period when the volumetric guidelines were also included (Table 4).

Table 4 Planktonic cyanobacteria guidelines for lake monitoring

Mode	Cells (per ml)	Biovolume (mm^3/l)
Low risk	Less than 2,000	<0.5
Medium risk	2,000 and 15,000	0.5 -1.8
High risk	More than 15,000	>1.8

3 Monitoring methodology

3.1 Program design

The Council's Freshwater Recreational Water Quality programme consists of two primary components: State of the Environment monitoring and extended monitoring. The purpose of each component, and its respective sampling protocols, is discussed in sections 3.1.1 and 3.1.2.

It should be noted that the existing programme was designed and implemented prior to the release of the 1998 and 2003 guidelines. Therefore, for trend detection monitoring purposes, consistency in programme design is essential and will be maintained where possible. Results are interpreted in this report with reference to the 2003 guidelines for the purposes of comparative assessment with contact recreational guidelines.

3.1.1 State of the environment monitoring

The locations of the eighteen sites sampled by the various components of the 2019-2020 programme are shown in Figure 1 and summarised in Table 5.

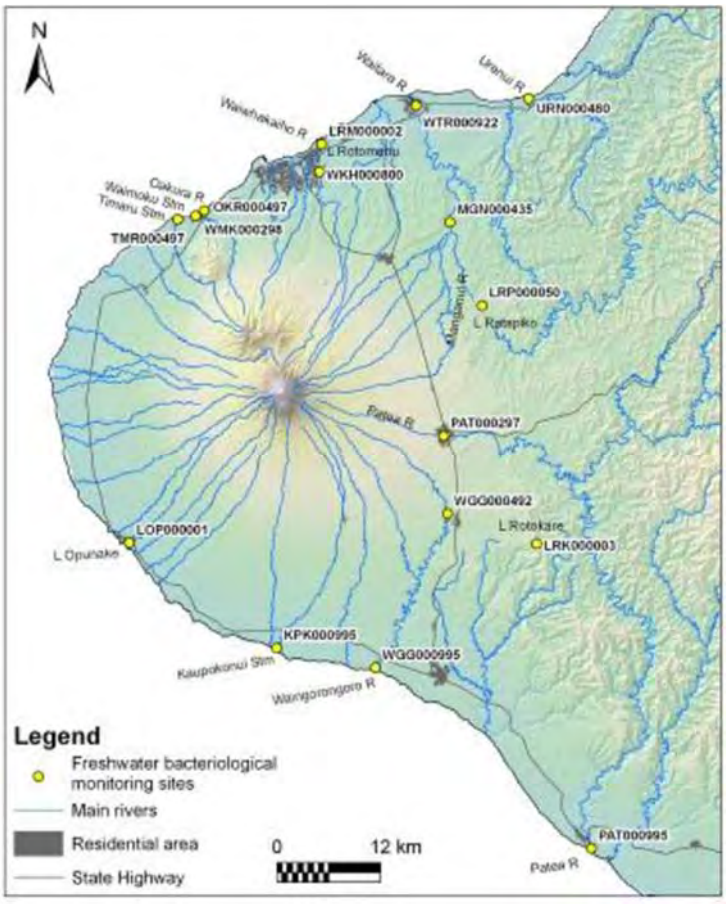


Figure 1 Location of freshwater contact recreation survey sites in 2019-2020

Having established its general state and the degree of influence on the nearby coastal waters of Oakura beach, sampling of the Waimoku Stream site at Oakura Beach was reduced in intensity from 2011 with sampling programmed for every third season thereafter (ie sampled in 2013-2014, 2016-2017 and 2019-2020). Given the permanent warning signs at the Waimoku Stream, and its extremely shallow nature, the Waimoku Stream is not a designated bathing site in its own right. Two sites (Te Henui Stream at the mouth

and lower Waiwhakaiho River adjacent to Lake Rotomanu) were added to the 2011-2012 programme, in recognition of increased recreational usage of these areas.

For sampling convenience, all sites were included with the coastal bathing beaches runs undertaken over the same five month period from early November 2019 to mid-March 2020. Ten sites, relatively close to stream mouths, were potentially affected by tidal influences (see conductivity data later in this report).

Table 5 Location of bathing water bacteriological and cyanobacteria sampling sites

Site	GPS Location		Site code	Bacteriological	Benthic Cyanobacteria	Planktonic Cyanobacteria
L Rotomanu: western beach	E 1696309	N 5678128	LRM000002	✓		✓
Waiwhakaiho R: Merrilands domain	E 1696059	N 5674931	WKH000800	✓	✓	
Waiwhakaiho R at L.Rotomanu	E 1696587	N 5678336	WKH000950	✓	✓	
Te Henui S: mouth, East End	E 1694213	N 5677047	THN000499	✓	✓	
Patea R: King Edward Park	E 1710433	N 5644464	PAT000297	✓	✓	
Patea R. boat ramp, Patea	E 1727517	N 5596784	PAT000995	✓		
Waingongoro R: Eltham camp	E 1710861	N 5635349	WGG000492	✓	✓	
Waingongoro R: Ohawe beach	E 1702531	N 5617624	WGG000995	✓	✓	
Kaupokonui R: Beach domain	E 1691110	N 5619893	KPK000995	✓	✓	
L Opunake: adjacent boatramp	E 1674029	N 5632022	LOP000001	✓		✓
Timaru S: Lower Weld Road	E 1697622	N 5669438	TMR000497	✓		
*Waimoku S: Oakura Beach	E 1681725	N 5669851	WMK000298	✓		
Oakura R: d/s SH45 bridge	E1682721	N 5670440	OKR000497	✓	✓	
Waitara R: Town wharf	E 1707203	N 5682572	WTR000922	✓		
Urenui R: estuary	E 1720245	N 5683370	URN000480	✓		
Manganui R: Everett Park	E 1711149	N 5669127	MGN000435	✓	✓	
L Ratapiko: boatramp	E 1714913	N 5659488	LRP000050	✓		✓
L Rotokare: adjacent boatramp	E 1721182	N 5631898	LRK000003	(✓)		✓

[Notes: ( ) sporadic; * monitored for its influence on water quality along Oakura Beach

Sample collection, field measurements, and analyses were undertaken according to documented Taranaki Regional Council procedures. It was intended that, on average, three samples would be collected from each of the sites in each month when hydrological flow conditions permitted, within two hours of high tide (due to the format of the coastal programme). Sampling commenced in late November 2019 with three of the sampling surveys performed prior to January 2020. The survey period was shortened by the advent of the Covid-19 pandemic and consequent national lock-down on 25 March, resulting in two fewer surveys than the usual thirteen. The majority of the surveys were performed over the mid-late summer period, prior to autumn. Bathing water samples were taken between 0900 and 1600 hours (NZDT), with none collected within a three day period following significant river/stream fresh conditions. [NB: sub-regional differences in rainfall patterns have caused difficulties at various sites in the past as local rainfall may impact on bacteriological quality on isolated occasions]. Where necessary, a 2 m sampling pole was used for bacteriological sample collection immediately beneath the water surface and at a minimum of calf depth at the sites. Eleven samples were collected from all sites.

Samples were analysed for *E. coli* bacteria, turbidity and conductivity. In addition, at each of the sites the following information was recorded: time, water temperature, weather, colour/appearance, estimation of

algal cover on the streambed, number of bathers and other users, presence of wildfowl, etc., and flow characteristics. All sites' locations (map references and GPS co-ordinates) and descriptions are stored in the Council's Taradise and ESAM computer databases and all analytical results were stored in the Lab database following standard sample registration procedures.

Results were sent by e-mail to the (New Plymouth, Stratford and South Taranaki) district councils and Taranaki district health board, and posted on the Taranaki Regional Council website (https://www.trc.govt.nz/environment/maps-and-data/regional-overview/?measureID=11) for public notification, as soon as data checking had been completed. The results were also included on the national Land, Air, Water Aotearoa (LAWA) website (https://www.lawa.org.nz/explore-data/swimming). The Taranaki District Health Board no longer posted the results on its recreational water safety webpage after 2015-2016, instead introducing links to the regional and district councils' and national websites, and continuing to give general advice on water safety. In 2019-2020, the three district councils maintained sections on recreational water quality on their respective websites, using the data produced by the Regional Council.

In previous monitoring years, where results fell in the 'Action' mode, further investigations (e.g. sampling and inspections) were performed when considered necessary i.e. where historical databases and staff expertise indicated this was warranted. Since December 2016, health risk warning signs have been erected by District Councils as soon as practicable after receiving a single 'Action' level result, whether for freshwater or marine recreational sites. The signs were removed after a single result below 'Action' level.

Cyanobacteria information was included on the regional council website for all lake sites and river/stream sites.

3.1.2 Extended monitoring

The revised guidelines (MfE, 2003) require weekly surveillance monitoring during the 5-month recreational period, with a minimum of 20 data points collected, regardless of weather conditions or state of the tide, also facilitating the calculation of the Microbial Assessment Category. Following consultation with the three territorial local authorities and Taranaki District Health Board, TRC undertook to add seven sampling occasions to the SEM protocol (13 dry weather samples per season, representing conditions most conducive to bathing) at two of the most popular freshwater recreational sites (Lake Rotomanu and Waiwhakaiho River at Merrilands Domain) in the 2003-04 period and this additional monitoring has continued annually since. These seven sampling occasions were systematically selected (one per week), where possible in weeks not sampled by the SEM programme and were performed regardless of prior weather conditions or tides but adhering to all other SEM programme protocols and using documented sampling methods. Both sites were signposted advising the public of monitoring activity. Also, the additional data were included on the TRC website [Note: These additional data have not been used for trend detection purposes as they do not comply with the format of the originally established SEM programme].

In the 2016-2017 period, monitoring frequency was increased to at least weekly between December and February at four of the most popular freshwater recreational sites (Lake Rotomanu, Waiwhakaiho River at Merrilands Domain, Kaupokonui River at mouth, and Waingongoro River at Ohawe), to align fully with the MfE guidelines and the reporting protocols for the LAWA website. Monitoring over the Christmas to New Year period was specifically included to increase the provision of timely information on suitability for bathing to the public during holiday periods. When possible, the SEM protocol of dry weather monitoring (near high water for estuarine sites) was followed. In weeks when weather or tide did not meet the SEM protocol, sampling occurred no later in the week than Thursday to allow posting of results on local and national websites before the weekend.

In the 2017-2018 period, the duration at higher monitoring frequency was increased, to run from mid-December to the end of March. [Note: These additional data have not been used for trend detection purposes as they do not comply with the format of the originally established SEM programme].

3.1.3 Follow up monitoring

As recommended by the national guidelines (MfE, 2003), a follow up sample may be collected when a routine monitoring sample reaches 'Alert' or 'Action' mode (see Section 2.1). Follow up samples can be useful in determining the source of a high *E. coli* number, the longevity of the event, and for updating the site's suitability for bathing. These samples are generally collected as soon as reasonably practicable in the days following the high result, though follow ups may be deemed inappropriate under certain circumstances. For example, if wet weather ensues, a follow up sample may not be collected due to contamination from run-off masking the source in question. In some instances, when routine surveys are scheduled within close succession, the subsequent survey may substitute a dedicated follow up survey.

3.1.4 Cyanobacteria

After consultation with Taranaki District Health Board, planktonic cyanobacteria monitoring commenced at each of the three lake sites in the 2006-2007 bathing season and has continued to date, including an additional lake site (Lake Rotokare). Cyanobacteria can produce toxicity in recreational waters which pose risks to humans and animals by contact or consumption during recreational activities. Lake samples were collected for microscopic analysis and enumeration which were performed in the TRC biological laboratory. A more comprehensive benthic cyanobacteria monitoring programme for the river and stream sites was instigated in the 2013-2014 period and continued over 2019-2020, the results of which are included in this report.

As part of the State of the Environment Freshwater Nuisance Periphyton monitoring programme, the Council undertakes a series of benthic cyanobacteria surveys during the recreational period each year. Monitoring is undertaken at nine sites within the Taranaki region that are established as popular for swimming and other fresh water-based activities.

The sampling period extends from 1 November to 31 March each year. Initially, the surveys are carried out in accordance with the sample frequencies listed in Table 6, which then may vary depending upon the percentage cover of benthic cyanobacteria detected previously at a site.

Table 6 Frequency of sampling for benthic cyanobacteria

Percentage of cyanobacterial mat cover per site	Level (MfE guidelines)	Frequency of sampling
Up to 20%	Surveillance [green mode]	Monthly
20-50%	Alert [amber mode]	Fortnightly
>50%	Action [red mode]	Weekly

At each site, measurements at four transects, using five evenly spaced viewing circles, were made across the streambed to a maximum depth of 0.6m. Two transects were established in riffle habitat and two transects in run habitat. Percentage cover of benthic cyanobacteria was estimated in each viewing circle for cyanobacteria mats greater than 1mm thick. Samples of benthic cyanobacteria were taken for laboratory analysis where species could not be identified on site. An average percentage cover per transect was calculated from which an average percentage cover for the site also was calculated. Average percentage cover results were then interpreted using the MfE level framework guidelines in Table 6. Monitoring was also extended to include information on exposed and detaching mats in accordance with relevant criteria.

Up until the 2016-2017 monitoring period the standard monitoring programme has consisted of seven sampling occasions spread over a five-month period from October to March. Sampling frequency was increased to ten sampling occasions (bi-monthly) in 2017-2018.

3.2 Analysis

3.2.1 Sample analysis

Historically, samples were analysed for *E. coli*, faecal coliforms, enterococci, conductivity, and turbidity. *E. coli* and faecal coliform numbers were obtained using the mTEC agar method #9213-d, Standard Methods for the Examination of Waters and Wastewaters (APHA, 2005). Enterococci were quantified using the EPA modified method #1600 on mEI agar (EPA, 1986).

In the 2017-2018 summer period, it was decided to stop analysing for faecal coliforms and enterococci, except for enterococci at one estuarine site (at Urenui river mouth), in order to optimise the efficiency of the laboratory; given the increase in overall sampling intensity in recent years. Both routine and follow up samples were tested for *E. coli* using the faster, and technically easier, 18-hour Colilert (IDEXX) Quanti-Tray system (APHA Method 2223 B). See Section 3.1.3 for an explanation of when follow up samples are required. *E. coli* are the nationally designated indicator for assessing the bacteriological state of freshwaters.

The 2019-2020 summer was the second bathing season following the closure of the Council laboratory. Instead, all samples were sent to Hill Laboratories for analysis. *E. coli* continued to be tested using the Colilert (IDEXX) Quanti-Tray system. Enterococci were quantified using a membrane filtration method (APHA, 9230 C (modified) 23rd ed. 2017). Turbidity was measured using a Hach 2100N IS turbidimeter instead of a WTW Cyberscan turbidimeter, and in 2019-2020 the method was changed from white light (APHA 2130 B 22nd edit, 2012), reported in NTU, to near infrared light (ISO 7027:1999 (E) (modified)), reported in FNU, to align with the National Environmental Monitoring Standard (NEMS).

At each of the sites the following additional information was recorded: time, water temperature, weather condition, wind condition, colour/appearance of water, and number of bathers and other users.

3.2.2 Long term trend analysis

Long term trend analysis is only carried out with the results from the SEM programme in order to determine the trends of recreational water quality around Taranaki under dry weather conditions. For sites with sufficient data (≥10 years), non-parametric trend analysis was performed using annual median *E. coli* data. For each site, a LOWESS (Logically Weighted Scatterplot) line (tension 0.4) was fitted to a temporal scatter plot of the *E. coli* median data. Statistical significance of the trend was tested using a Mann-Kendall test. The sign (+/-) of the Kendall tau value was used to assess whether the trend was positive or negative and the significance of the trend was determined using the p value ($p < 0.05$ = significant).

When multiple correlations are undertaken, there is a chance that some will be found to be significant purely by chance. In order to deal with this potential problem, the Benjamini-Hochberg False Discovery Rate (FDR) method was applied to the results of the Mann-Kendall test. Further justification for this statistical approach can be found in Stark and Fowles (2006).

4 Results

Sampling times in relation to tidal conditions (particularly for estuarine sites, see Appendix II), weather conditions and sites' usage information are contained in Appendices III and IV. Timing of sampling in relation to river flows is illustrated by Figure 7, Figure 20, Figure 28, Figure 33, Figure 38, Figure 47, Figure 58 and Figure 66. Those illustrate that the majority of the sampling occasions coincided with steady to low river recession flow conditions. In 2019-2020, sampling for trend monitoring was not known to be affected by localised rainfall, or by a prior increase in river flows, except at the lower Waitara River site where delayed effects of rainfall are known to occur. However, where possible, no sampling was undertaken within three days following significant river freshes. A total of 11 samples was collected at each site during the period from late November 2019 to mid-March 2020.

Sampling was confined to weekdays during the period, and no public holidays were included due to sampling personnel and laboratory schedules' requirements. For these reasons, recreational usage of the waters was generally less intensive, often with no apparent usage at the time of sampling. However, all sites are known to be regularly utilised for bathing and other contact recreational activities, particularly at weekends, dependent on suitable weather conditions (see Appendix IV of TRC, 1999). The two additional sites included in the 2001-2002 programme (Patea River at Stratford and Waingongoro River at Eltham), and monitored annually since then, have been identified as used locally for bathing and other recreational purposes. The two lake sites (Ratapiko and Opunake) added to the 2006-2007 programme are also used for these purposes, while Lake Rotokare (added in the 2007-2008 season for cyanobacteria monitoring) is used extensively for recreational boating activities. The lower Patea River site (added in 2007-2008 year as a result of a Patea Wastewater Treatment Plant consent monitoring condition) is used principally for boating purposes. The lower Waitara River site (added in 2009-2010) is used for boating and bathing purposes, more so after the construction of a new wharf in the town. The Te Henui Stream and lower Waiwhakaiho River sites (added in 2011-2012) are both used for bathing (the latter more particularly) as the New Plymouth coastal walkway has provided improved access.

From time to time, public interest has focused on additional sites where sporadic sampling may be undertaken as a consequence after appropriate consideration.

All results (SEM, MfE and follow up monitoring) are presented and discussed on a site-by-site basis for the sampling period, which extended from 27 November 2019 to 13 March 2020 and totalled eleven sampling occasions at each site for (SEM) trend monitoring, with eight more sampling occasions at the four sites where additional (MfE) sampling was undertaken. The statistical analyses do not include follow-up sampling results, as they were collected in response to particular events (resulting in high *E. coli* numbers) and are therefore not random, and potentially not representative of typical bathing conditions.

Supplementary data and observations are presented in the appendices.

4.1 Lake Rotomanu

A total of 20 samples were collected at this western beach site over the summer. Eleven of the 13 scheduled SEM samples were collected, as well as eight MfE samples and one follow up sample.

At the times of the surveys, conducted mostly in mid to late morning, there was limited bathing usage of the lake recorded, with boating, jet-skiing, kayaking, walking/dog-walking or picnicking activities occurring on most occasions in the summer school holiday period.

Ducks were present on the lake or in the vicinity of the lake edge throughout most the period. Public feeding of the ducks has been observed previously. Gulls were present or common on the banks on several occasions. A wetland had been created several years ago at Peringa Park to improve the quality of stormwater runoff entering the lake. A bank retaining wall was emplaced at the western beach sampling site in August 2018 (Photo 1).

A recreational water quality advisory sign was erected by NPDC on the access road to the lake in June 2017, in addition to the existing TRC sign at the monitoring site (Photo 1, the original sign on the right is in the far background on the left).

Photo 1 Signs at Lake Rotomanu

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 2. The complete survey results are presented in Appendix I and summarised in Table 7.

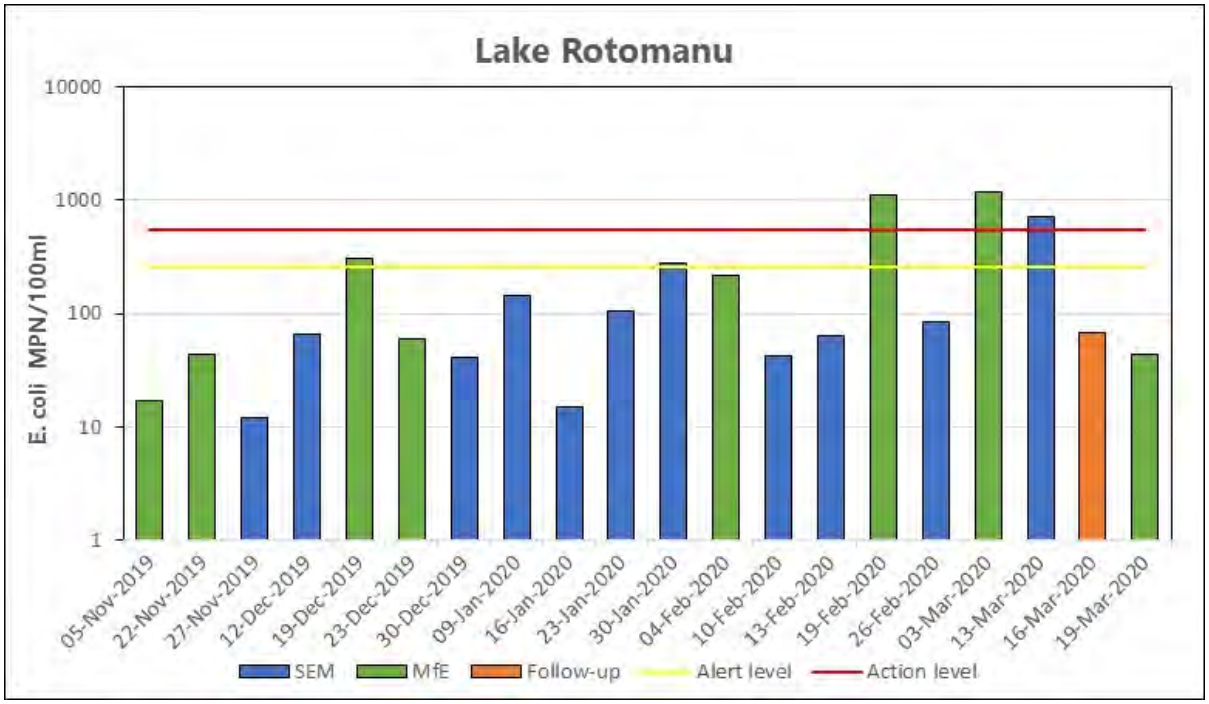


Figure 2 *E. coli* results for Lake Rotomanu

Table 7 Statistical summary for Lake Rotomanu

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	128	169	145
	E. coli	MPN/100 ml	11	12	727	66
	Temperature	°C	11	21.0	26.0	23.0
	Turbidity	FNU	11	3.5	15.4	8.4
SEM + MfE samples	Conductivity	µS/cm@25°C	19	116	169	141
	E. coli	MPN/100 ml	19	12	1203	66
	Temperature	°C	19	18.5	26.9	22.8
	Turbidity	FNU	19	1.6	15.4	8.5

The lake, which is close to the coast, is replenished from time to time by inflow from the nearby Waiwhakaiho River. Water quality was relatively good although it was generally noticeably turbid (median turbidity: 8.4; range: 11.9 FNU), possibly as a result of fluctuating concentrations of suspended algae and/or fine sediment. Water temperatures were relatively high (above 20°C) through most of the period with a maximum of 26.9°C (in early February 2020) and a range of 8.4°C. Conductivity had a narrow range through the season.

Generally, bacteriological quality was relatively good considering that the inflow to the lake is from the lower reaches of a river draining a developed catchment. However, elevated numbers of *E. coli* (in the 'Action' mode) were found on three occasions, in February and March 2020, the first after wet weather, the latter two in dry weather. Run-off from recent light rainfall may have affected the first result. Ducks, which were common on the water around the sampling point on the second sampling occasion, were a likely source for the other events. NPDC adjusted the signage to reflect the increased health risk from recreational use of the lake. Resampling was undertaken as soon as weather permitted in each instance, twice as part of

routine weekly sampling. In all, the warnings remained in place for about three weeks, although one intermediate result was at Surveillance level.

The additional (MfE) sampling resulted in no change in the overall seasonal median bacteria number, but increased the range, probably due to the proximity of wet weather on some of the sampling survey occasions, and two further Action levels were reached. The median turbidity with the additional samples was similar (about 8 FNU) and the turbidity range wider (1.6 to 15.4 FNU) than for the standard SEM sampling surveys.

4.1.1 Comparison with guidelines

E. coli numbers from Lake Rotomanu over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 8.

Table 8 Performance against guidelines at Lake Rotomanu

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample>550/100 ml
SEM samples	1 [9%]	1 [9%]
SEM+MfE samples	2 [11%]	3 [16%]

Three single samples were recorded in the 'Action' category, one during SEM trend surveys, and two during additional MfE surveys, one after wet weather. All other samples, from both SEM and additional weekly sampling, were within 'Surveillance' mode.

4.1.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Lake Rotomanu over 24 summers are presented in Figure 3.

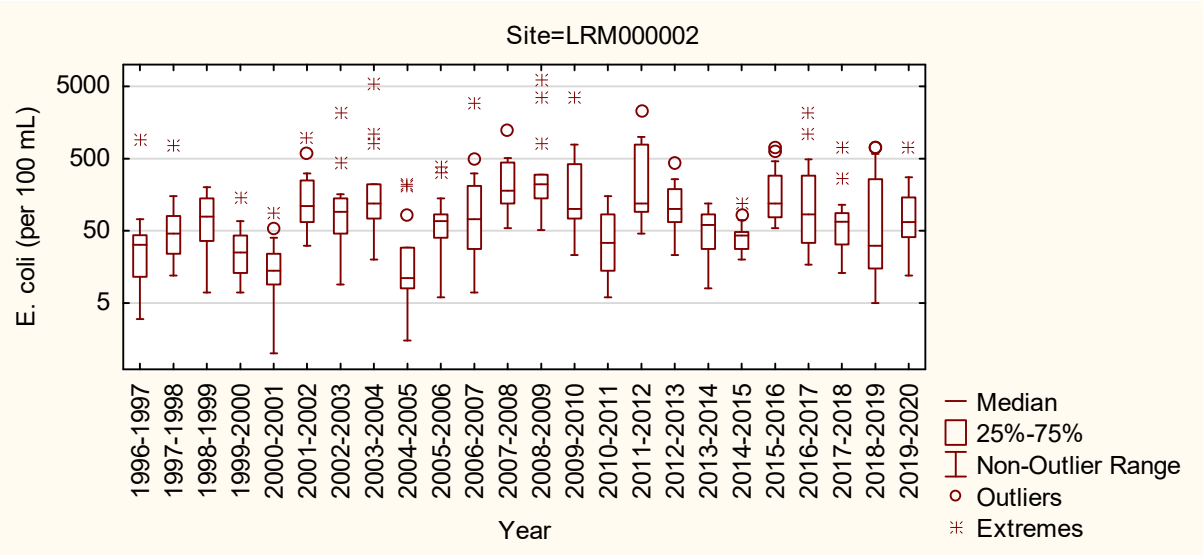


Figure 3 Box and whisker plots of *E. coli* for all summer SEM surveys at Lake Rotomanu

The median and maximum *E.* coli values (66 and 727 MPN/100 ml, respectively) obtained for the 2019-2020 summer were both near the middle of the range recorded for this site over the previous twenty-three survey seasons. The median value remained well below the 'Alert' level of the 2003 MfE guidelines.

4.1.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median *E. coli* data for 24 summer seasons (Figure 4) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

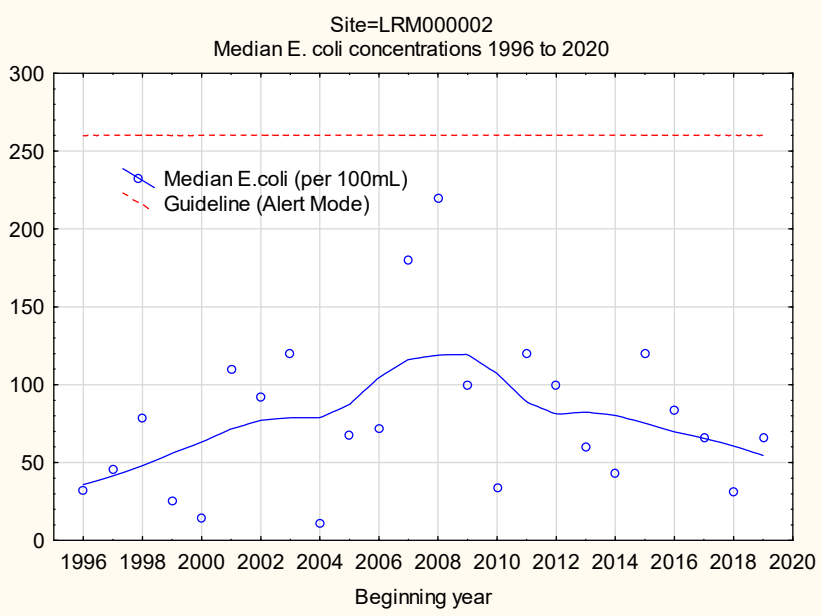


Figure 4 LOWESS trend analysis of median *E. coli* data at Lake Rotomanu

Overall, a positive trend, but not statistically significant or important increase in median *E. coli* numbers, has been found over the twenty-four seasons of monitoring. None of these seasonal medians has exceeded the 'Alert' or 'Action' modes.

4.1.4 Cyanobacteria

Planktonic cyanobacteria levels during the recreational monitoring year were generally low. The Alert level was triggered on two occasions and the Action level was never triggered.

Planktonic cyanobacteria were monitored on ten occasions throughout the season with results presented in Table 9 and Figure 5.

Table 9 Cyanobacteria cell counts and bio-volumes for Lake Rotomanu [Health warning: >1.8 mm^3/l]

Date	Cyanobacteria total cell count (cells/ml)	Bio-volume (mm^3/l)	Principal species by biovolume	Mode
26/09/2019	0	0.00	No cyanobacteria	Surveillance
05/11/2019	0	0.00	No cyanobacteria	Surveillance
26/11/2019	0	0.00	No cyanobacteria	Surveillance
04/12/2019	0	0.00	No cyanobacteria	Surveillance
19/12/2019	0	0.00	No cyanobacteria	Surveillance
09/01/2020	27	0.01	*Dolichospermum planctonicum*	Surveillance
23/01/2020	0	0.00	No cyanobacteria	Surveillance
04/02/2020	3120000	1.28	Picocyanobacteria	Alert
20/02/2020	301	0.03	*Microcystis aeruginosa*	Surveillance

Date	Cyanobacteria total cell count (cells/ml)	Bio-volume (mm^3/l)	Principal species by biovolume	Mode
12/03/2020	2000000	0.82	Picocyanobacteria	Alert

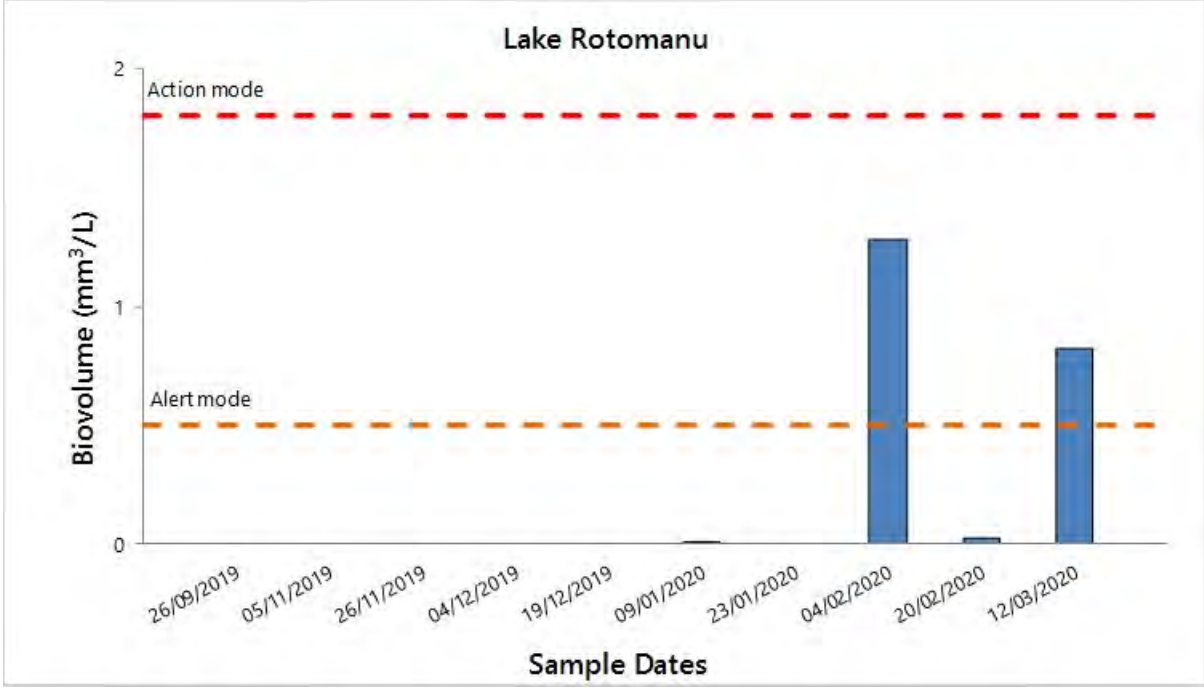


Figure 5 Cyanobacteria bio-volume at Lake Rotomanu [Health warning: >1.8 mm^3/l]

4.2 Waiwhakaiho River at Merrilands Domain

A total of 19 samples were collected at this site over the summer. Eleven of the 13 scheduled SEM samples were collected, as well as eight MfE samples.

Some recreational usage was recorded at the time of the surveys, with bathing noted on three occasions. Dog-walking was recorded five times in 2019-2020. Birdlife was noted on five occasions, when one to three ducks and a shag were observed. The weather was heavily clouded or overcast on six occasions, five of them during the additional MfE surveys, and moderate rainfall immediately preceded two of the additional, surveys.

River flow information is illustrated in Figure 7. There were no flood events after mid-December 2019 and a flow recession to below MALF occurred over two months to mid-February 2020, punctuated with occasional freshes.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 6. The complete survey results are presented in Appendix I and summarised in Table 10.

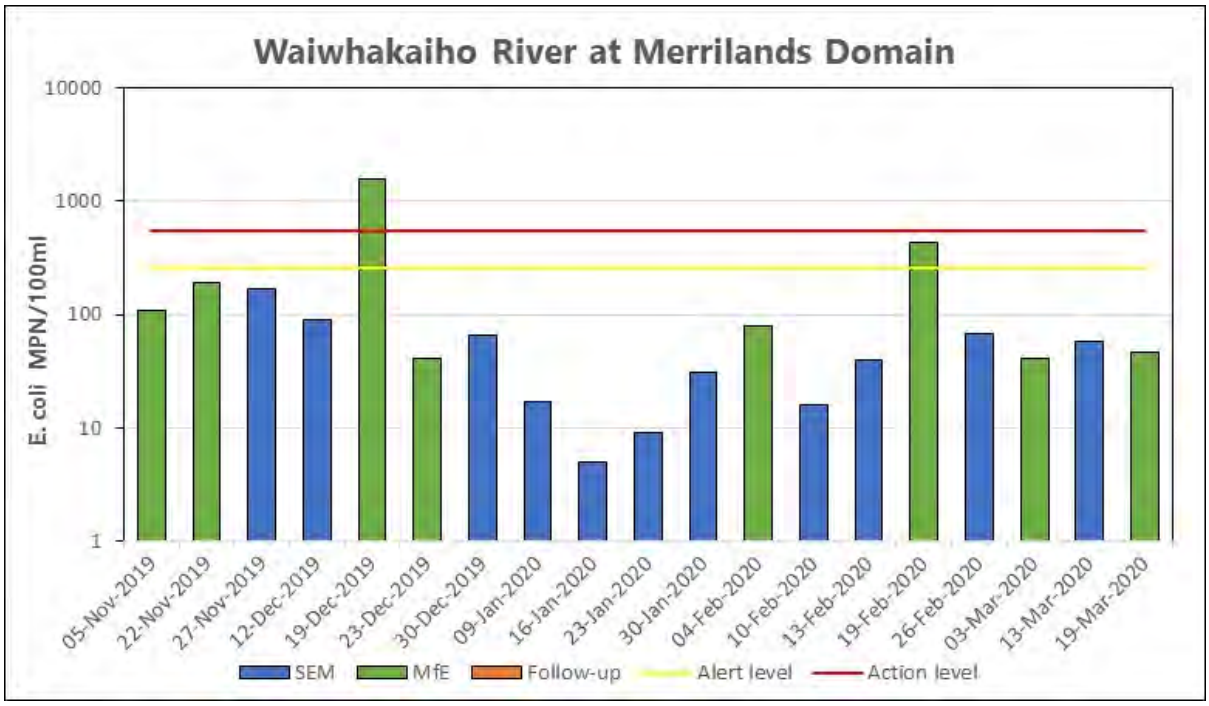


Figure 6 *E. coli* results for the Waiwhakaiho River at Merrilands Domain

Table 10 Statistical summary for the Waiwhakaiho River at Merrilands Domain

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	129	213	164
	E. coli	MPN/100 ml	11	5	171	40
	Temperature	°C	11	16.2	22.6	19.8
	Turbidity	NTU	11	0.39	0.85	0.70
SEM + MfE samples	Conductivity	µS/cm@25°C	19	79	213	164
	E. coli	MPN/100 ml	19	5	1553	58
	Temperature	°C	19	15.5	24.7	19.7

Parameter		Units	Number of samples	Minimum	Maximum	Median
	Turbidity	NTU	19	0.39	3.9	0.72

This river drains an extensively developed farmland catchment prior to flowing through two kilometres of urban New Plymouth upstream of this popular domain and recreational area sited in the lower reaches of the river nearly 4 km from the sea.

Water temperatures varied over a moderate range of 9.2°C between late November and mid-March, with a maximum of 24.7°C in mid-afternoon in early February 2020. Conductivity and turbidity results were generally indicative of very clean, clear, relatively high water quality, but moderate to widespread algal cover (up to 65% mats) was common throughout the period during flow recessions.

Considering the influence of agricultural activities, particularly dairying in the catchment, bacteriological water quality was relatively high. The additional MfE samples, mostly taken in cloudy or overcast weather, increased the median from 40 to 58 MPN/100 ml, or 45%.

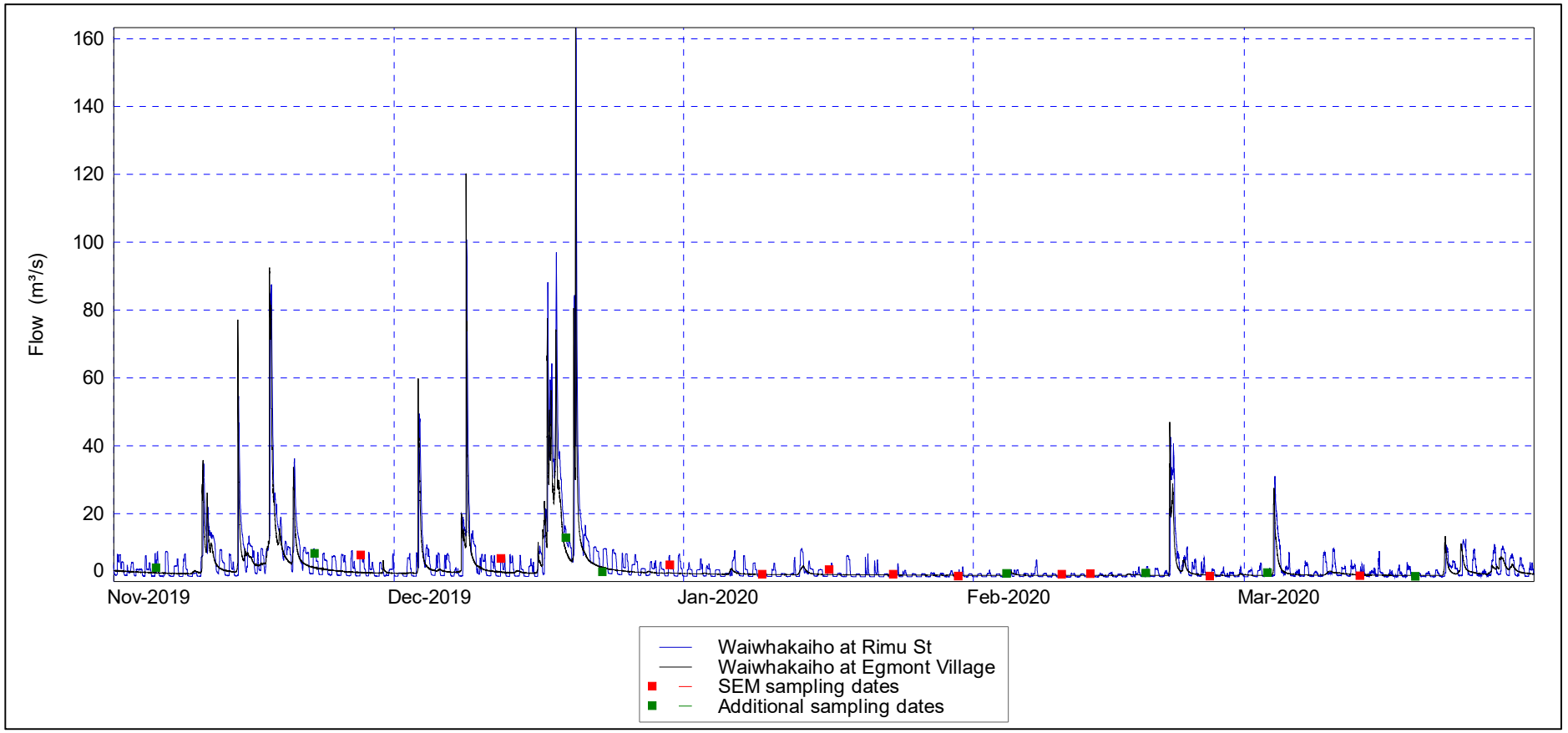


Figure 7 Flow in the Waiwhakaiho River during the survey period

4.2.1 Comparison with guidelines

E. coli numbers from Waiwhakaiho River at Merrilands Domain over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 11.

Table 11 Performance against guidelines at Waiwhakaiho River Merrilands Domain

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	**ACTION Single sample >550/100 ml**
SEM samples	0 [0%]	0 [0%]
SEM + MfE samples	1 [5%]	1 [5%]

Action mode was triggered on one occasion, during an MfE survey a day after moderate rainfall in mid-December. No follow-up survey was carried out after the Action level, though a routine survey four days later returned results back at "Surveillance" level. Alert mode level was exceeded on one occasion, during an MfE survey after moderate rainfall in mid-February. Bacteriological water quality measured at this site was therefore within the acceptable standard for contact recreation usage for the majority of the survey period.

On the occasion that Action mode was recorded, NPDC adjusted the permanent sign at the upper car park and erected a temporary sign at the lower car park to warn against swimming.

4.2.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected for Waiwhakaiho River at Merrilands Domain over 24 summers are presented in Figure 8.

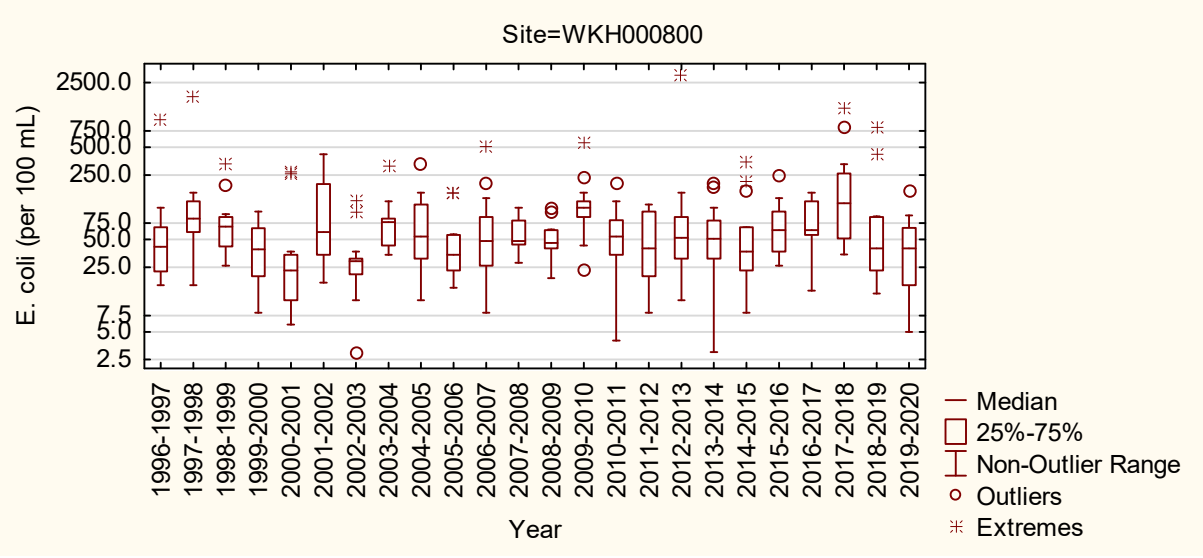


Figure 8 Box and whisker plots of *E. coli* for all summer SEM surveys of Waiwhakaiho River at Merrilands Domain

The median *E. coli* number in the 2019-2020 period was slightly lower than most recorded to date, all of which have been much lower than the 'Alert' level of the 2003 MfE guidelines.

4.2.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the twenty-four seasons of data by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median values (Figure 9) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

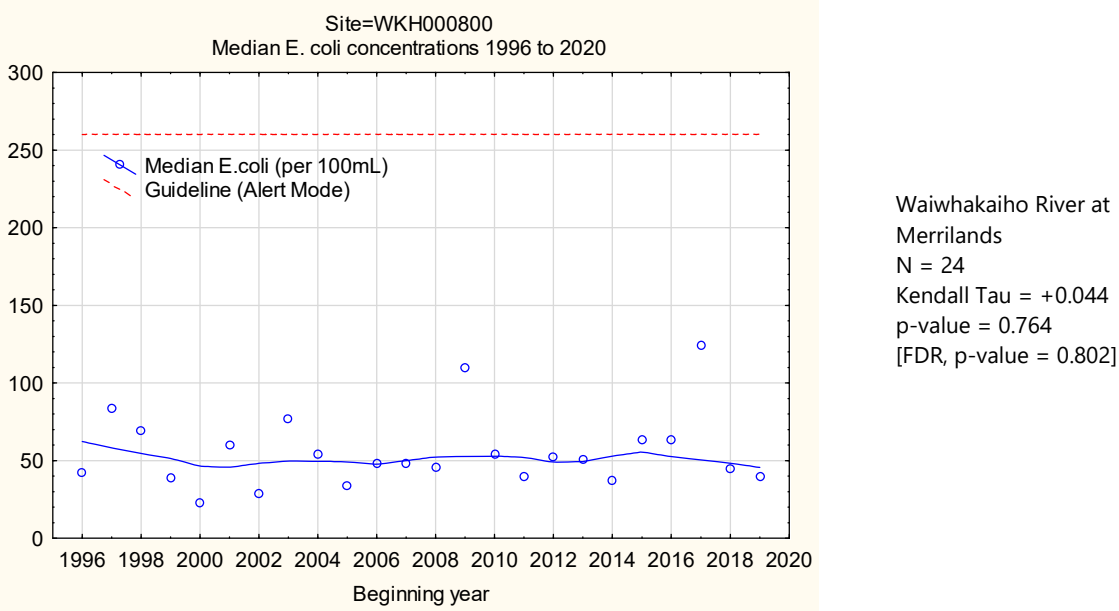


Figure 9 LOWESS trend analysis of median *E. coli* at the Waiwhakaiho River, Merrilands Domain

A slight, unimportant and statistically insignificant increase in median *E.coli* numbers has been found over the twenty-four seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.2.4 Cyanobacteria

Benthic cyanobacteria were monitored on 11 occasions during the 2019-2020 season. Results are presented in Table 12 and illustrated in Figure 10.

Table 12 Benthic cyanobacteria data for the Waiwhakaiho River at Merrilands Domain

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
04/11/2019	11	No	Minor	Alert
15/11/2019	9	No	No	Surveillance
21/11/2019	8	No	No	Surveillance
04/12/2019	2	No	No	Surveillance
19/12/2019	8	No	No	Surveillance
08/01/2020	0	No	No	Surveillance
23/01/2020	0	No	No	Surveillance
04/02/2020	0	No	No	Surveillance
19/02/2020	0	No	No	Surveillance
05/03/2020	0	No	No	Surveillance

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
18/03/2020	0	No	No	Surveillance

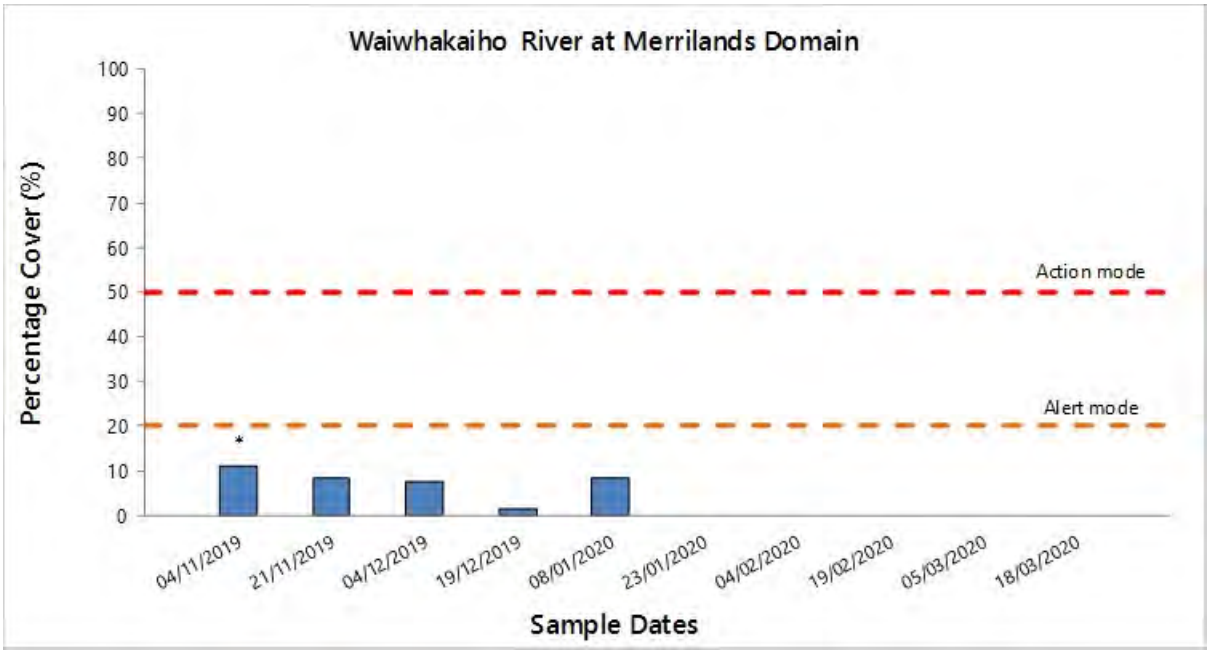


Figure 10 Percentage benthic cyanobacteria cover at the Waiwhakaiho River at Merrilands Domain site

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and ⁺ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Photos 2 and 3 Exposed cyanobacteria mats, Waiwhakaiho River at Merrilands Domain

Benthic cyanobacteria coverage was generally low throughout the season (ranging from 0 to 11%). The 'Action' or 'Alert' level was never exceeded for percentage cover. The benthic cyanobacteria found were *Microcoleus* sp. Detaching mats were not observed at either significant or minor levels. Minor levels of exposed mats were visible on one occasion which triggered the 'Alert' level. In total, the 'Alert' level was triggered on one occasion.

The cause of the exposed mats when the cover percentage was low can be attributed to the daily fluctuations in flow caused by the release of water from the upstream Mangorei hydro-electric power scheme. When the hydro scheme was not releasing water (e.g. in early morning) river levels were low, exposing mats. The mats were present on the top of boulders so that no cyanobacteria were immersed in water during these low flows. Higher flows would inundate the top of the boulders and thus stop the cyanobacteria from drying out. It appeared that other algae (green algae and diatoms) could not compete with *Microcoleus* sp under this hydrological regime.

4.3 Waiwhakaiho River adjacent to Lake Rotomanu

Photo 4 A typical gull population immediately upstream of the Waiwhakaiho River, Lake Rotomanu site

A total of 11 samples were collected at this site over the summer, all scheduled SEM samples.

No usage of this site was recorded at the time of the sampling surveys. In previous years, some whitebaiting (in season), dog-walking on the banks of the river and swimming has been observed. Seagulls were frequently present at this site with large numbers of gulls present along the lower reaches of the river upstream of this site (Photo 4). Ducks were present on several occasions.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 11. The complete survey results are presented in Appendix I and summarised in Table 13. River flow information is illustrated in Figure 11 as it is also applicable to this site.

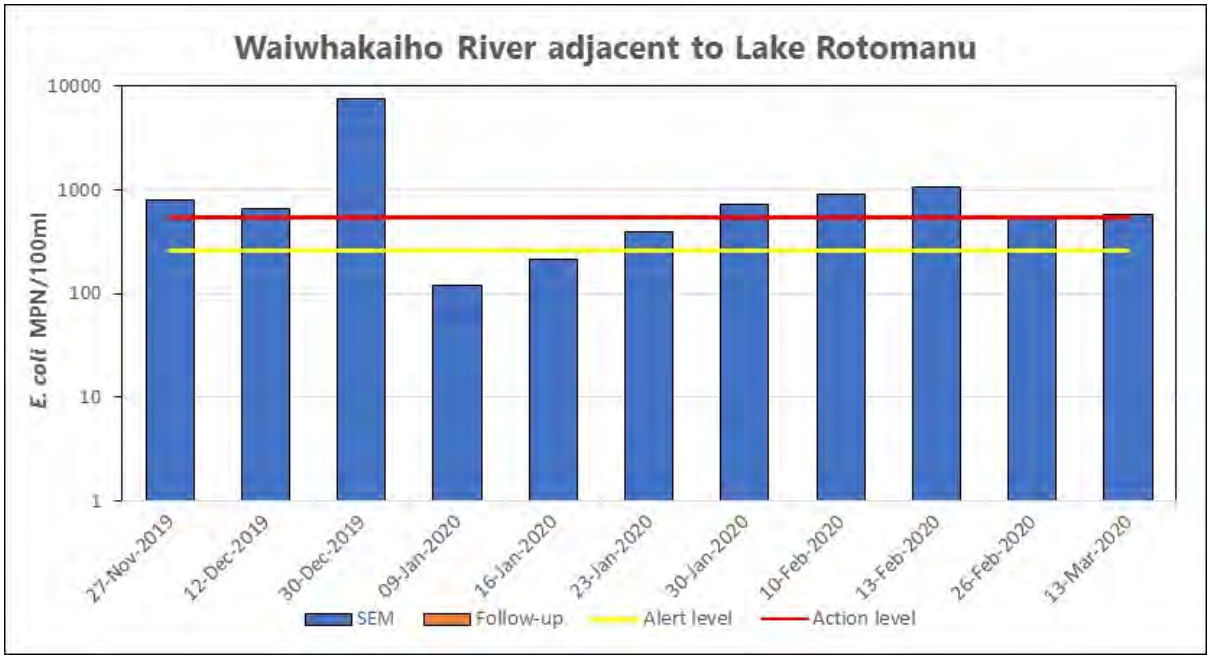


Figure 11 *E. coli* results for Waiwhakaiho River adjacent to Lake Rotomanu

Table 13 Statistical summary for Waiwhakaiho River adjacent to Lake Rotomanu

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	133	9,120	148
	E. coli	MPN/100 ml	11	121	7,700	656
	Temperature	°C	11	18.3	25.1	20.8
	Turbidity	FNU	11	0.56	1.13	0.70

This river drains an extensively developed farmland catchment prior to flowing through six kilometres of urban New Plymouth upstream of this popular recreational area sited in the lower reaches of the river about 700 m from the sea.

Large flocks of seagulls are known to roost on the river bed in the lower reaches between Merrilands and this site near the more recently constructed walkway bridge.

[Note: During the 2011-2012 period (TRC, 2012) faecal source DNA tracking marker analyses found that the Merrilands Domain samples contained bacteria only indicative of ruminants origin on one occasion and of ruminants and wildfowl origin on another occasion. However, samples from the lower river site (adjacent to Lake Rotomanu) were found to contain bacteria very specifically of gull origin on both occasions and a faint indication of ruminant origin on the latter sampling occasion. No bacteria of human origin were found at either site on either sampling occasion.]

In the current survey period, water temperatures varied over a moderate range of 6.8˚C between late November and mid-March, with a maximum of 25.1˚C in late morning in late January 2020. Conductivity and turbidity results were indicative of clean, clear, relatively high water quality, but significant algal cover (mainly moderate to widespread mats) was noted through the majority of the period. There were three instances of partial seawater ingress during the period.

Bacteriological water quality was poor with numbers varying over very wide ranges with a high median *E. coli* value of 656 per 100 ml, particularly in comparison with numbers found at the upstream Merrilands Domain site (median: 40 per 100 ml). Individual sample *E.coli* numbers exceeded 399 per 100 ml on all but three occasions, often coincident with the presence of large gull populations. The marked river flow fluctuations due to increased morning HEP generation could be expected to exacerbate wildfowl (gull) faecal contamination by inundation of river shingle areas where birds roost during lower flow periods. No follow-up surveys were deemed necessary as the cause of elevated numbers (in the 'Action' mode) had been well documented, and permanent public warning signage was in place.

4.3.1 Comparison with guidelines

E. coli numbers from Waiwhakaiho River opposite Lake Rotomanu over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 14.

Table 14 Performance against guidelines at Waiwhakaiho River adjacent to Lake Rotomanu

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT **Single sample** **261-550/100 ml**	**ACTION** **Single sample** **>550/100 ml**
SEM samples	1 [9%]	8 [73%]

Photo 5 Health risk signage, lower Waiwhakaiho River

Eight single samples were recorded within the 'Action' mode and one sample in the 'Alert' mode during the season. Bacteriological water quality measured at this site was seldom within the acceptable standard for contact recreational usage through the survey period and therefore appropriate warning signage was required at this site adjacent to the walkway throughout the survey period (Photo 5). Appropriately worded signage should be retained on a permanent basis in future.

4.3.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected for Waiwhakaiho River opposite Lake Rotomanu over 24 summers are presented in Figure 12. [Note: Some of these data had been collected prior to the current year from time to time for consent monitoring purposes].

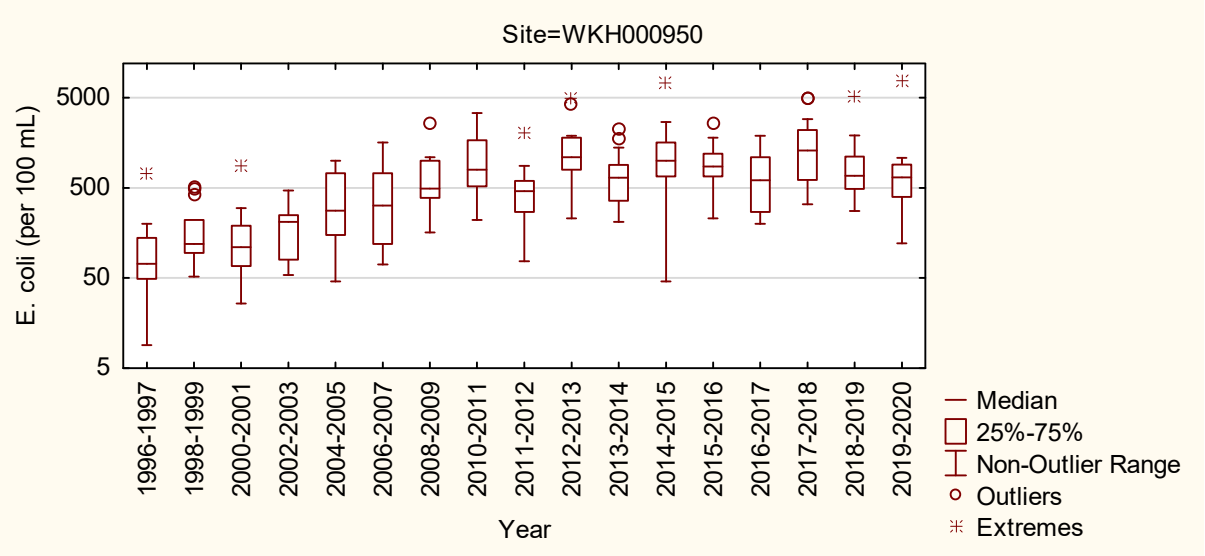


Figure 12 Box and whisker plots of *E. coli* for all summer SEM surveys in the Waiwhakaiho River adjacent to Lake Rotomanu

The median *E.coli* number in the 2019-2020 period was the seventh highest recorded to date, maintaining a trend of high medians in more recent years (Figure 12). Most medians had been below the 'Action' level of the 2003 MfE guidelines, but since 2003-2004 all medians have been within or exceeded the 'Alert' level, with the latest eight medians in excess of the 'Action' guideline.

4.3.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the seventeen seasons of data (over 24 years) by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 13). Testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discover Rate (FDR) analysis has been performed.

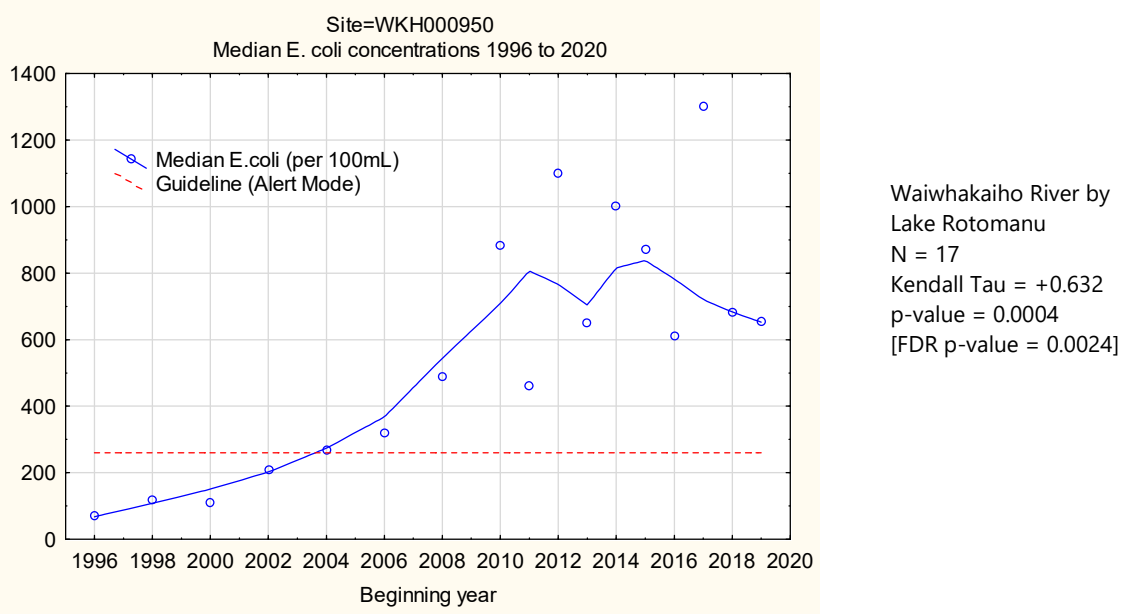


Figure 13 LOWESS trend plot of median E.coli data for the Waiwhakaiho River, adjacent to Lake Rotomanu

There has been a very significant trend ($p < 0.01$) of increasing median *E.coli* numbers over the seventeen seasons of monitoring, which is of importance given that four of these more recent seasonal medians have exceeded the 'Alert' mode and another nine are within the 'Action' mode.

4.3.4 Cyanobacteria

Benthic cyanobacteria were monitored on 11 occasions throughout the season. Results are presented in Table 15 and illustrated in Figure 14**.**

Table 15 Benthic cyanobacteria data for Waiwhakaiho River at last riffle below Lake Rotomanu

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	10	No	Minor	Alert
15/11/2019	4	Minor	Minor	Alert
21/11/2019	8	No	No	Surveillance
04/12/2019	1	No	No	Surveillance
19/12/2019	8	No	No	Surveillance
08/01/2020	6	No	No	Surveillance
23/01/2020	5	No	No	Surveillance
04/02/2020	1	No	No	Surveillance
19/02/2020	2	No	No	Surveillance
05/03/2020	0	No	No	Surveillance
18/03/2020	0	No	No	Surveillance

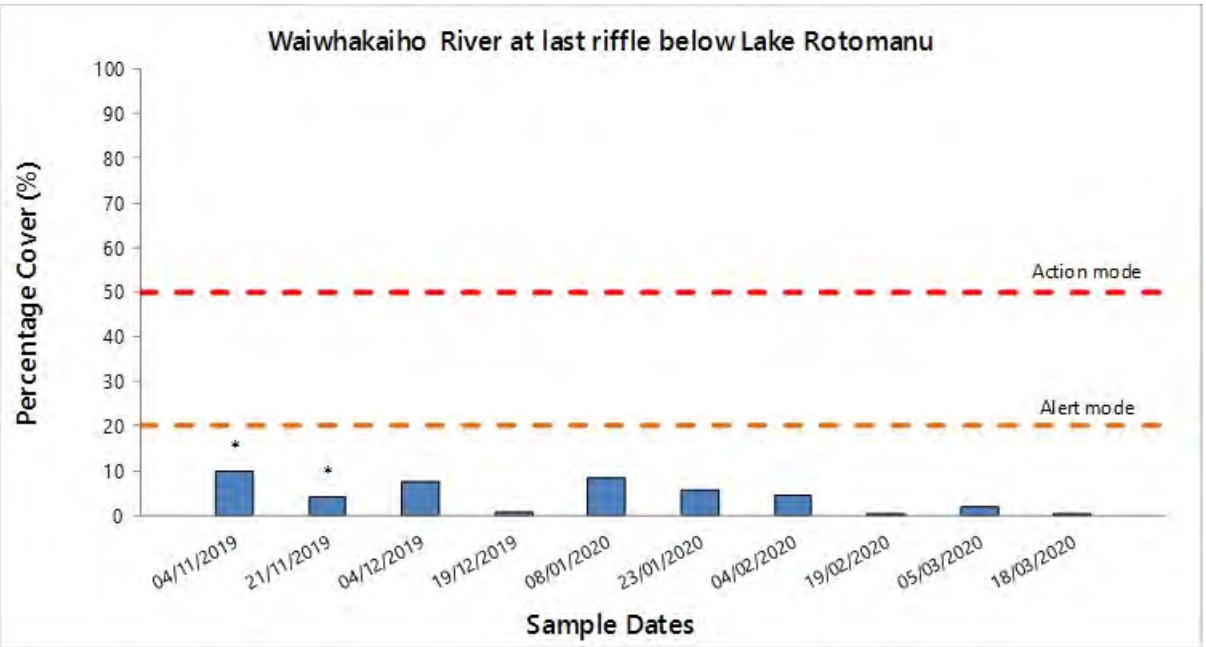


Figure 14 Percentage benthic cyanobacteria cover at Waiwhakaiho River at last riffle below Lake Rotomanu.

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and ⁺ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was low throughout the season (ranging from 0 to 10 %). The 'Action' or 'Alert' level was never exceeded for percentage cover. The benthic cyanobacteria found were *Microcoleus* sp. Detaching mats reached minor levels on one occasion which triggered the 'Alert' level. Minor levels of exposed mats were visible on two occasions which triggered the 'Alert' level. In total, the 'Alert' level was triggered on two occasions.

4.4 Te Henui Stream at the mouth, East End

A total of 11 samples were collected at this site over the summer, all scheduled SEM samples.

Some usage of this site and adjacent playground was recorded at the time of the sampling surveys, with bathing noted on three occasions. One to ten persons were on the banks or bridge on nine of the eleven monitoring occasions. Fishing off the bridge was not noted this season. Dogs were seen on four occasions, twice with bathers. Whitebaiting (in season) from the banks of the stream has been observed in many past seasons.

Ducks were common at this site on most survey occasions and gulls also were present, where they have been encouraged by people feeding the birdlife.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 15. The complete survey results are presented in Appendix I and summarised in Table 16.

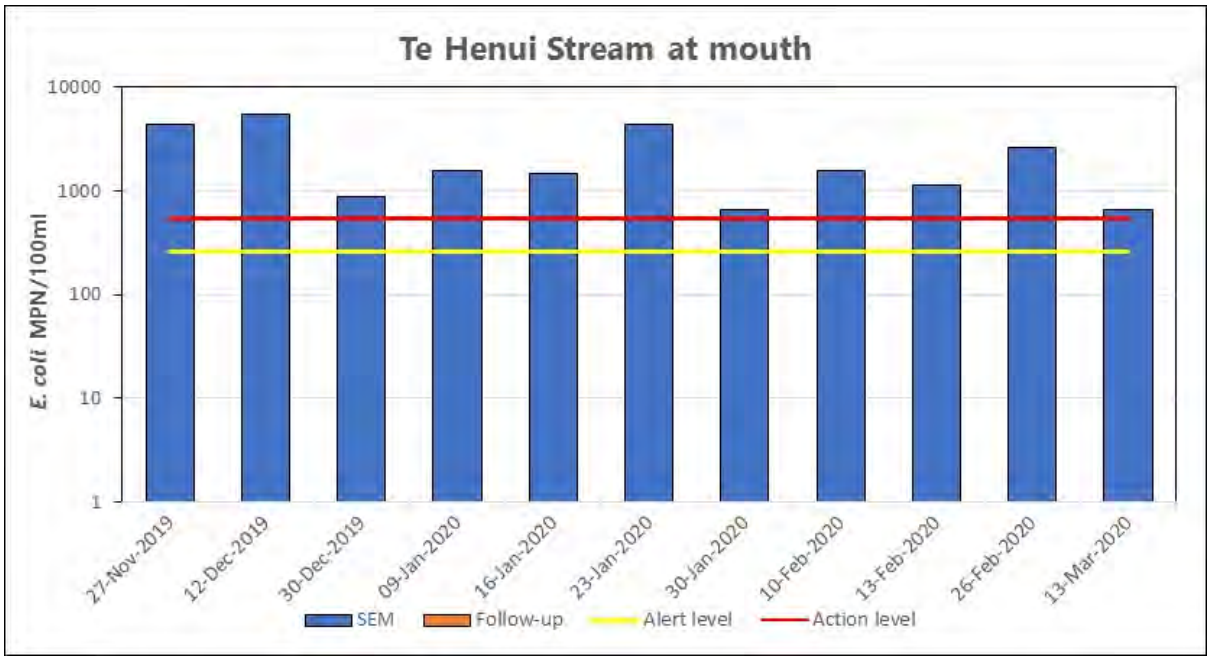


Figure 15 *E.coli* results for Te Henui Stream at mouth, East End

Table 16 Statistical summary for Te Henui Stream at mouth, East End

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	1,786	36,500	14,650
	E. coli	MPN/100 ml	11	656	5,480	1,552
	Temperature	°C	11	15.4	22.9	19.0
	Turbidity	FNU	11	0.72	4.8	1.48

The stream drains an extensively developed farmland catchment prior to flowing through urban New Plymouth upstream of this popular recreational area sited in the lower reaches of the stream at the coast adjacent to the walkway. Poor historical bacteriological quality, considered to be attributable mainly to wildfowl, resulted in two low tide and two high tide surveys' samples in the 2011-2012 season being forwarded to Cawthron Institute, Nelson for faecal source DNA tracking marker analyses. The initial low tide sample (which followed wet weather) contained bacteria of ruminant, gull, and human origins while the second low tide, fine weather sample's bacteria were of ruminant, wildfowl, and human origins. The high tide, fine weather samples both contained bacteria with slight traces of ruminant origin, while only the second sample's bacteria were of wildfowl, and human origins. While wildfowl, gull, and ruminant derived bacteria might have been expected in the lower reaches of this stream, the presence of bacteria from human origin warranted further investigation (which was discussed and initiated with the Taranaki Area Health Board and New Plymouth District Council). No further incidents of human markers were found at this site near the mouth of the stream nor at several sites upstream and into the rural reaches.

In the current season, water temperatures varied over a moderate range of 7.5˚C between late November and mid-March, with a high maximum of 22.9˚C in late-morning in late-January 2020. Conductivity and turbidity results were indicative of clean, clear, relatively high water quality, subject to tidal incursions of seawater from time to time. The water often appeared green, as a result of extensive algal cover.

Bacterial water quality in the 2019-2020 season was very poor with a wide range of numbers and very high median *E. coli* number of 1,552 per 100 ml and the highest minimum value recorded.

4.4.1 Comparison with guidelines

E. coli numbers from Te Henui Stream at the mouth over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 17.

Table 17 Performance against guidelines at Te Henui Stream at mouth, East End

Parameter	Number of exceedances of E. coli guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	0 [0%]	11 [100%]

All single samples were recorded within the 'Action' mode during the season. Bacteriological water quality measured at this site therefore was outside the acceptable standard for contact recreational usage on 100% of monitoring occasions. No additional sampling surveys were required as the source of these elevated numbers was well established and documented. Appropriate signage therefore was required at this site adjacent to the New Plymouth walkway throughout the survey period and was the subject of periodic public enquiries. The coastal bathing waters monitored nearby at East End beach met the enterococci guidelines on all occasions during the season (that is, no occurrences within the 'Action' level).

4.4.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected for Te Henui Stream at the mouth over 18 summers are presented in Figure 16.

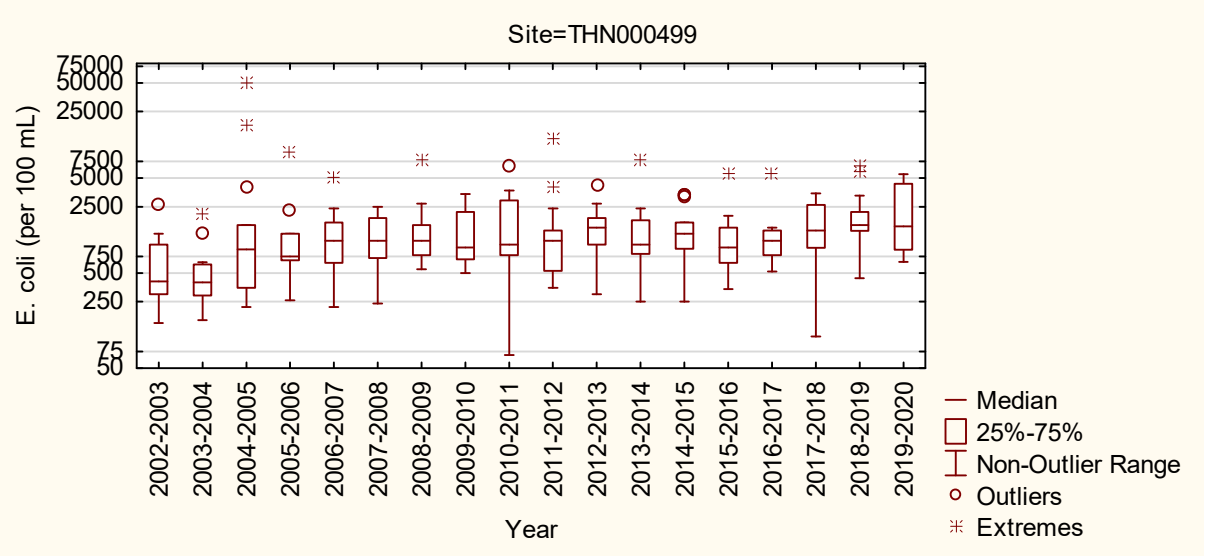


Figure 16 Box and whisker plots of *E. coli* for all summer SEM surveys of Te Henui Stream at mouth, East End

The median *E. coli* number in the 2019-2020 period was the third highest of the medians recorded over the last 18 seasons (Figure 16), and well above the 'Alert' level of the 2003 MfE guidelines. All but the first two of the 18 median numbers to date have also been in the 'Action' level. A wide range of numbers has also been typical for this site.

4.4.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the eighteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 17) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

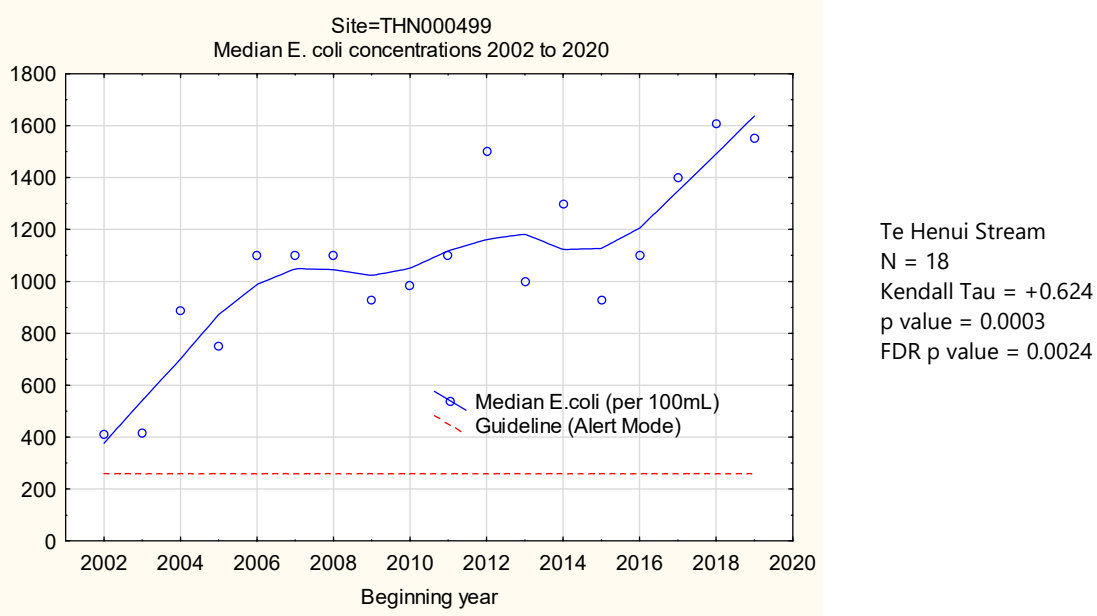


Figure 17 LOWESS trend analysis of median *E.coli* data at Te Henui Stream mouth, East End

A temporal trend of increasing median *E. coli* numbers has been found over the eighteen seasons of monitoring. (Note: This trend was statistically very significant at $p<0.01$, including after FDR analysis: $p=0.002$ after FDR correction). Only the two earliest of these seasonal medians were within the 'Alert' mode, with all others exceeding the 'Action' mode.

4.4.4 Cyanobacteria

Benthic cyanobacteria were monitored on 10 occasions during the season. Results are presented in Table 18 and Figure 18.

Table 18 Benthic cyanobacteria data for Te Henui Stream near the mouth, East End

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	0	No	No	Surveillance
21/11/2019	0	No	No	Surveillance
04/12/2019	1	No	No	Surveillance
19/12/2019	0	No	No	Surveillance
08/01/2020	2	No	No	Surveillance
23/01/2020	0	No	No	Surveillance
04/02/2020	0	No	No	Surveillance
19/02/2020	0	No	No	Surveillance
05/03/2020	0	No	No	Surveillance
18/03/2020	0	No	No	Surveillance

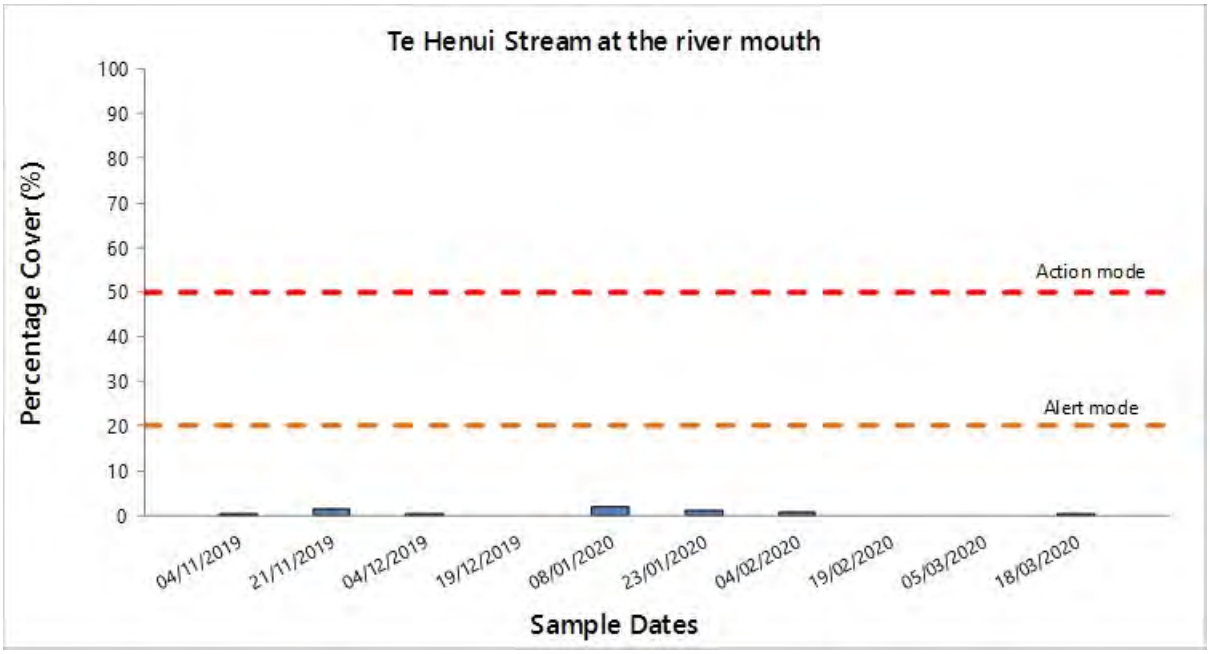


Figure 18 Percentage benthic cyanobacteria cover at Te Henui Stream at the mouth

Note that 'Action' and 'Alert' mode lines are for percentage cover only. * and + symbols over a bar indicate where the status has been raised to 'Alert' or 'Action' mode respectively due to detaching or exposed mats

There was no benthic cyanobacteria coverage throughout the season. The 'Action' or 'Alert' level was never exceeded for percentage cover or for the presence of detaching or exposed mats and therefore no action at the site was required.

4.5 Patea River at King Edward Park, Stratford

A total of 12 samples were collected at this site over the summer. Eleven of the 13 scheduled SEM samples were collected, as well as one follow up sample.

Recreational usage of this river site was recorded at the time of four of the sampling surveys: on the bank in December 2019, and fishing (twice) and swimming in January 2020). In many previous seasons, swimming, picnicking, and walking or resting on the banks, sometimes with dogs, has been observed.

One or two ducks were observed on the water on three occasions over the monitoring period.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Table 19. The complete survey results are presented in Appendix I and summarised in Figure 19. River flow records are presented in Figure 20.

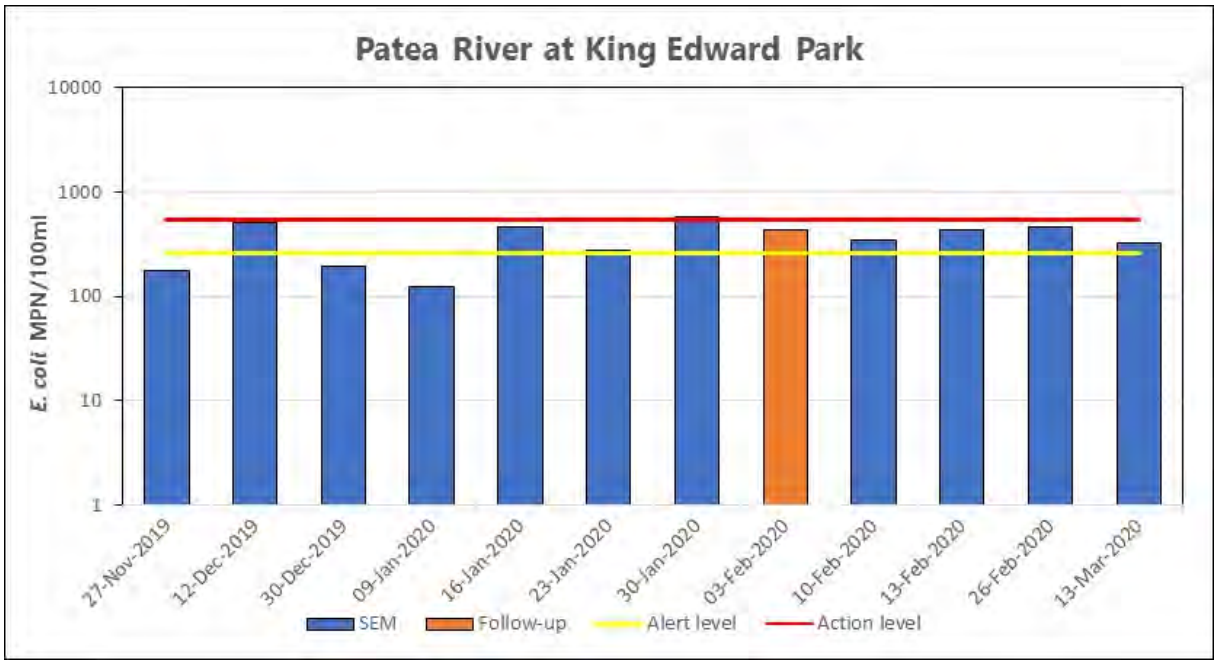


Figure 19 *E. coli* results for Patea River at King Edward Park, Stratford

Table 19 Statistical for Patea River at King Edward Park, Stratford

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	100	126	113
	E. coli	MPN/100 ml	11	126	579	345
	Temperature	°C	11	12.4	17.7	14.9
	Turbidity	FNU	11	0.54	1.86	0.79

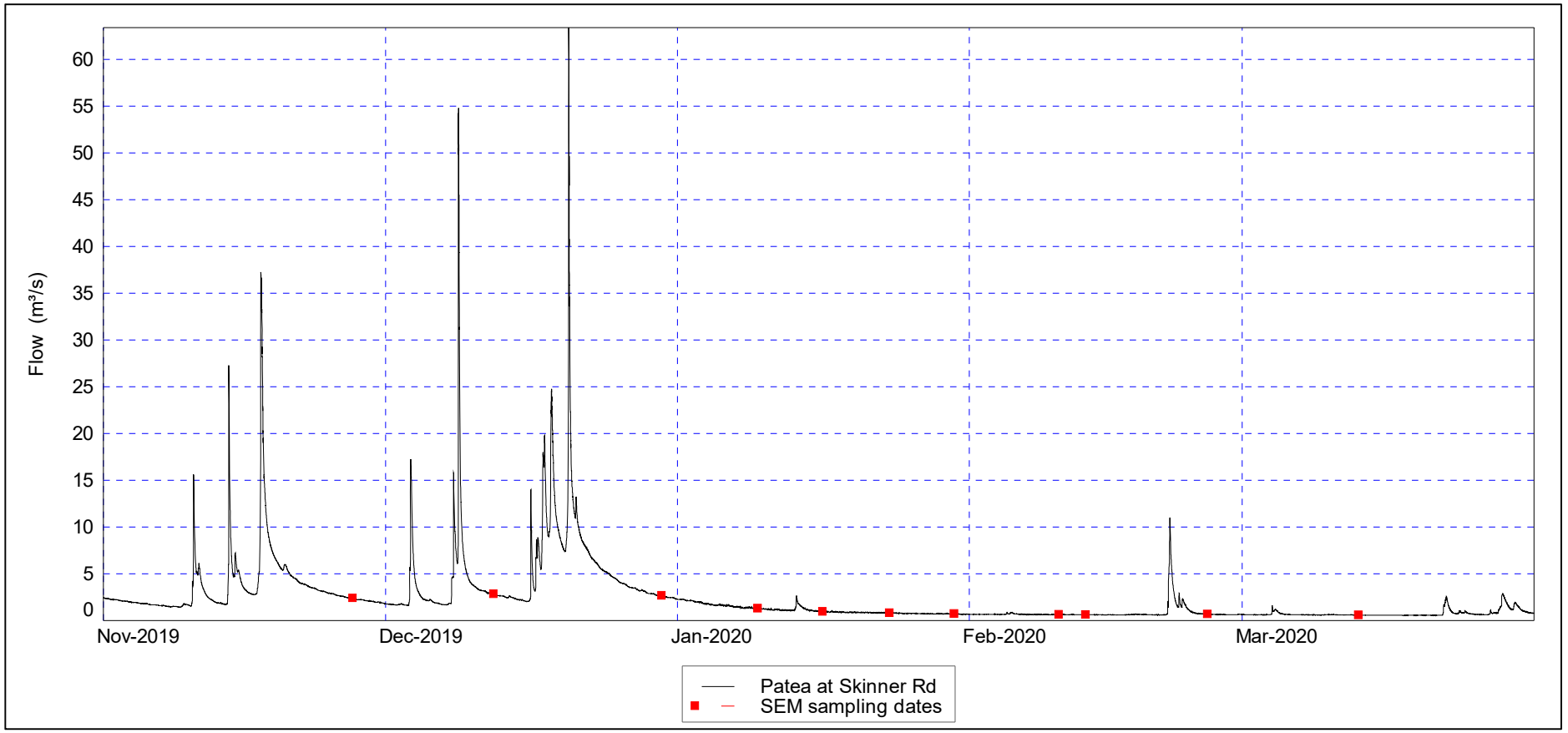


Figure 20 Flow in the Patea River at Skinner Rd during the survey period

This ring plain river drains a developed agricultural catchment. The survey site is situated within King Edward Park in Stratford township, approximately 11 km downstream of the National Park boundary, with several consented dairy ponds' treated wastes discharges in the catchment upstream of the site. River water was generally relatively clear (turbidity ≤ 2 NTU on all occasions) and uncoloured or green or green-brown in appearance with a relatively low and narrow range of conductivity levels. The median turbidity increased substantially in 2018-2019 over the previous season, from 0.7 to 1.3 NTU, probably as a result of using a different turbidimeter, then changed to 0.79 FNU in 2019-2020, possibly owing to a change in test method, while the median *E. coli* reduced, from 411 MPN/100 mL for both previous years, to 345 MPN/100 ml, using the same test method as for those two years.

Water temperatures had a narrow range of 5.3°C for this site (at an elevation of 300 m asl), with a maximum of 17.7°C recorded in late January 2020 (at 1000 hrs).

Bacteriological water quality was moderate to poor for the mid reaches of this Taranaki ring plain river draining a predominantly agricultural catchment. One number exceeded the 'Action' level, in late January. A health warning sign was erected immediately by Stratford District Council, which remained in place until test results from follow-up sampling reduced to below 'Action' level, that is, about 4 days.

In 2017-2018, an investigation of the source(s) of faecal contamination was undertaken in response to elevated *E. coli* numbers from December 2017 onwards. Additional samples were taken at the Park; several surveys of water quality in the catchment within and above Stratford were conducted; and inspections of farm dairy waste disposal systems upstream were undertaken. The water quality analysis included DNA testing of samples taken under both dry and wet weather conditions.

No human waste contamination was found. A small avian influence was apparent in dry weather conditions. The greatest source of faecal bacteria was of ruminant origin, most likely bovine given the predominance of dairy farming. The ruminant markers appeared to be aged, consistent with farm pond discharges. Significant *E. coli* loadings came from the Konini (Paetahi) and Mangarangi sub-catchments, both of which receive farm dairy pond discharges.

All farm waste disposal systems upstream had been inspected in September 2017: there was generally good compliance with resource consent conditions. Unscheduled re-inspections undertaken in February 2018 found no unauthorised discharge.

To address the potential effects of farm dairy wastes on surface water quality, TRC has sent out strong signals that discharge to land is the preferred disposal option throughout the region, and this will be pursued as a rule within the next regional water plan (in preparation). For the last five years, all consents issued to provide for farm dairy wastes only allow continued discharge to surface water for a short transition period, typically two years, while land disposal is instituted, or when conditions for land disposal (and recreational use of streams) are unsuitable.

4.5.1 Comparison with guidelines

E. coli numbers for Patea River at King Edward Park, Stratford over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 20.

Table 20 Performance against guidelines at Patea River at King Edward Park, Stratford

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT **Single sample** **261-550/100 ml**	**ACTION** **Single sample** **>550/100 ml**
SEM samples	7 [64%]	1 [9%]

One single sample fell (just) within the 'Action' mode, and another seven samples fell in the 'Alert' mode. These numbers occurred between mid-December 2019 and mid-March 2020, in early morning to early-afternoon. In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was within guidelines for contact recreational usage for the majority of the survey period.

4.5.2 Comparison with previous summer surveys

Summary statistics for the SEM *E.coli* data collected at King Edward Park, Stratford over 19 summers are presented in Figure 21.

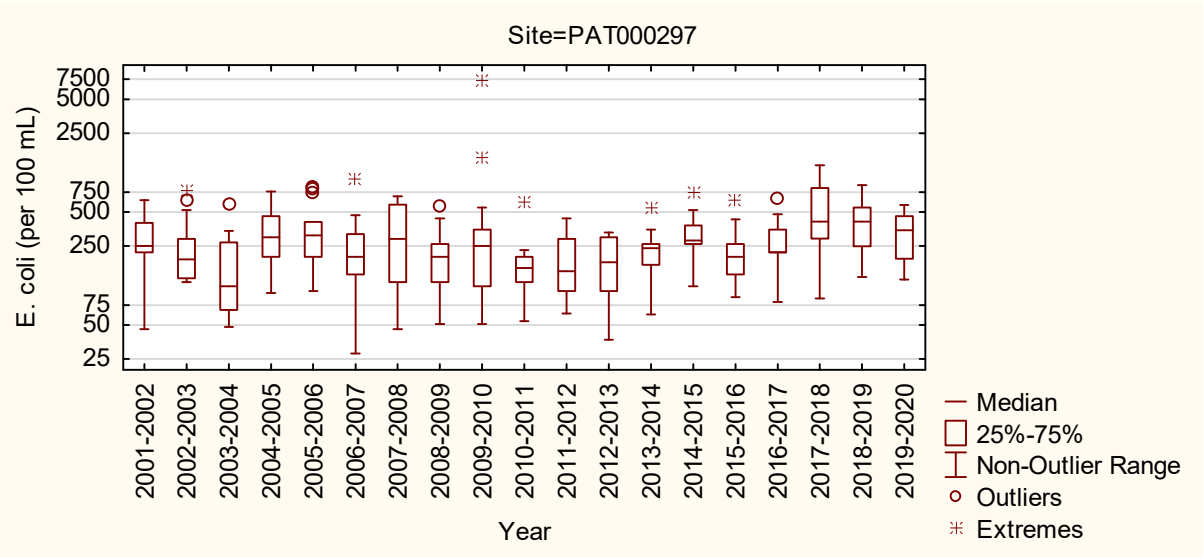


Figure 21 Box & whisker plots of *E. coli* for all summer surveys of Patea River at King Edward Park, Stratford

The median *E.* coli number in the 2019-2020 period was the third-highest recorded to date, and followed the highest two medians recorded. The range of numbers was relatively narrow, and the maximum number was lower than most of the maxima recorded to date.

4.5.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the nineteen seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 22) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

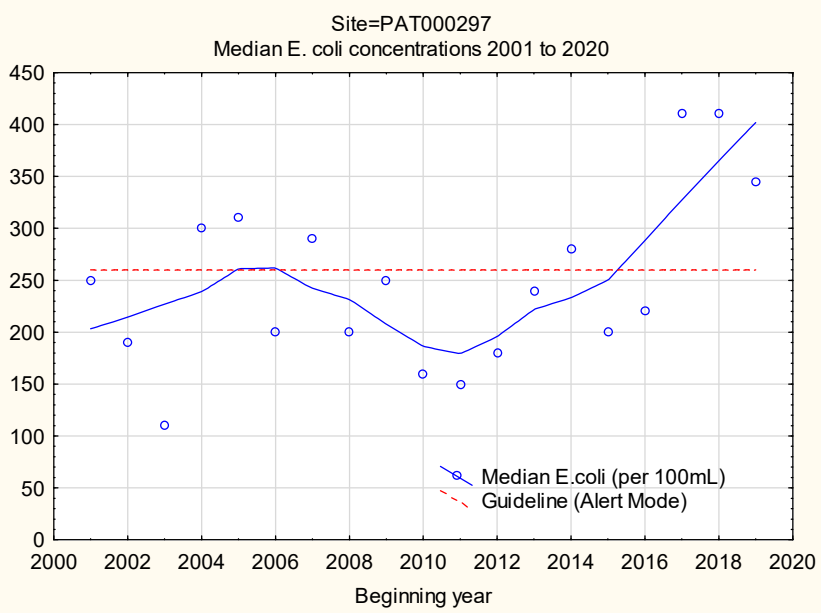


Figure 22 LOWESS trend plot of median E.coli data at the Patea River, King Edward Park, Stratford

A statistically insignificant temporal trend of increasing median *E.coli* numbers has been found over the nineteen monitoring seasons. Seven of these seasonal medians exceeded the 'Alert' mode but none has exceeded the 'Action' mode.

4.5.4 Cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season. Results are presented in Table 21 and Figure 23.

Table 21 Benthic cyanobacteria data for the Patea River, Edward Park site

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	4	No	No	Surveillance
21/11/2019	0	No	No	Surveillance
04/12/2019	1	No	No	Surveillance
19/12/2019	0	No	No	Surveillance
08/01/2020	0	No	No	Surveillance
23/01/2020	0	No	No	Surveillance
04/02/2020	0	No	No	Surveillance
19/02/2020	0	No	No	Surveillance
05/03/2020	0	No	No	Surveillance
18/03/2020	0	No	No	Surveillance

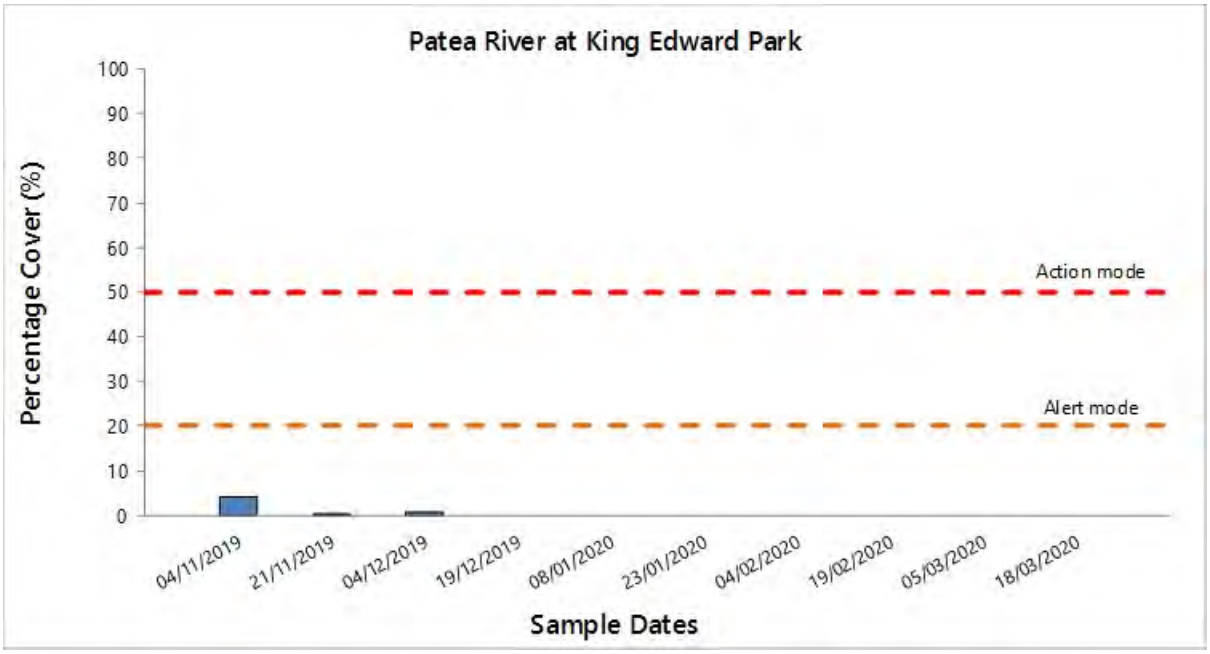


Figure 23 Percentage benthic cyanobacteria cover at the Patea River, Edward Park site.

Note that 'Action' and 'Alert' mode lines are for percentage cover only. * and + symbols over a bar indicate where the status has been raised to 'Alert' or 'Action' mode respectively due to detaching or exposed mats

Benthic cyanobacteria coverage was very low throughout the season (range from 0 to 4%). The benthic cyanobacteria found were *Microcoleus* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover or for the presence of exposed or detaching mats and therefore no action at the site was required.

4.6 Patea River at the boat ramp, Patea

A total of 11 samples were collected at this site over the summer, all scheduled SEM samples.

Bathing usage of this river site was recorded only once at the time of sampling surveys, several of which were in early to mid-morning and none after midday. Boating and fishing were noted from time to time at this site with boating as the main activity as this is a popular launching site for fishermen, judging by the number of boat trailers often in the parking area.

During the 2011-2012 period Taranaki Regional Council undertook microbial source tracking (MST) using DNA marker techniques at this site and an upstream site at SH3 bridge on two occasions (high and low tides). Faecal coliform bacteria were found to have been sourced predominantly from cattle on both occasions at the two sites while gulls contributed to populations at the boat ramp site under both tidal conditions and a faint trace of human source derivation was found (downstream of the Patea WWTP treated discharge) at the boat ramp site, but only under low tidal flow conditions.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 24. The complete survey results are presented in Appendix I and summarised in Table 22.

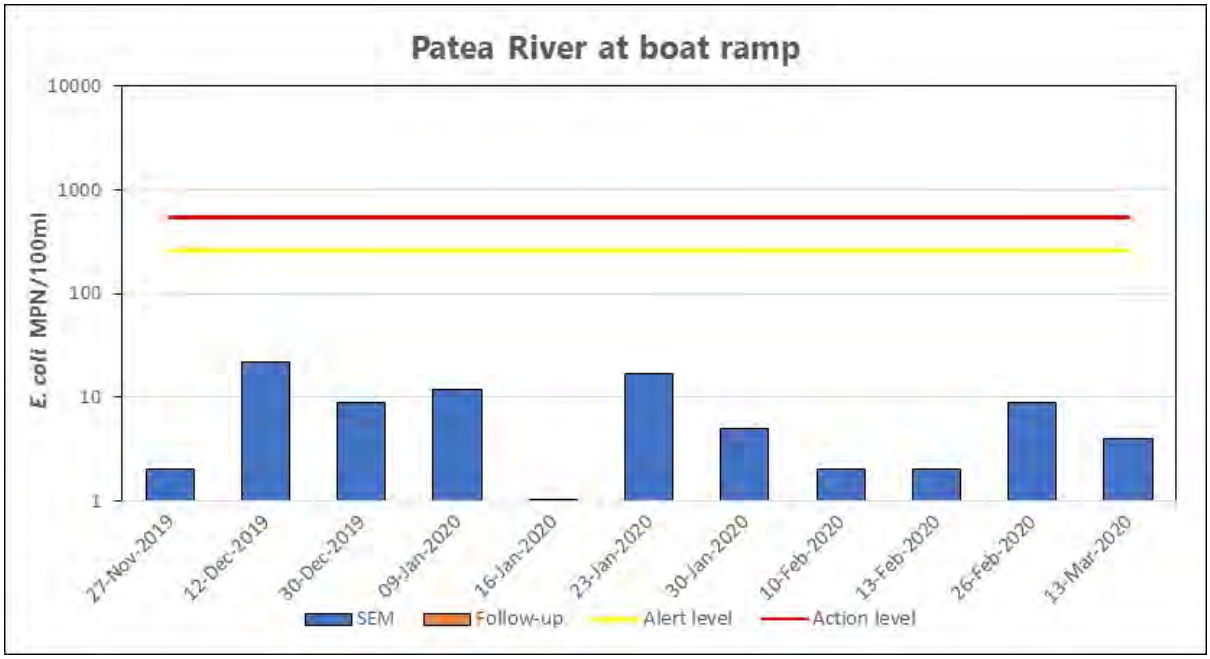


Figure 24 *E.coli* results for Patea River at boat ramp, Patea

Table 22 Statistical summary for Patea River at boat ramp, Patea

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	48900	52500	51500
	E. coli	MPN/100 ml	11	<1	22	5
	Enterococci	cfu/100 ml	11	<1	33	7
	Temperature	°C	11	17.4	20.9	18.9
	Turbidity	FNU	11	0.77	16.3	8.8

This ring plain river drains an extensively developed agricultural catchment. The survey site is situated some 45km downstream of the Patea HEP dam and 300 metres upstream of the river mouth. Flows in the lower river are regulated by operational requirements of the HEP station and associated consent conditions. There are consented dairy ponds' treated wastes discharges in the catchment upstream of the site and the consented upgraded Patea Wastewater Treatment Plant discharges upstream of the boat ramp (by about 0.7 km).

River water was usually turbid and milky pale green in appearance. High conductivity levels typical of seawater ingress at high tide occurred on most occasions, with lower conductivity levels at high river flows. Water temperatures had a narrow range of 3.5˚C, affected by the coastal seawater influence, with a maximum of 20.9˚C recorded in late morning in mid-February 2020.

Bacteriological water quality was good for the lower reaches of this Taranaki ring plain river (median: 5 *E.coli* per 100 ml and 7 enterococci per 100 ml) draining a predominantly agricultural catchment. This was due to the coastal seawater influence under high tide conditions and, to a lesser extent, the high bacteriological quality of the upstream lake waters released from the hydro dam. The existing recreational sampling programme was performed around higher tidal conditions for SEM trend purposes (due to its incorporation within the coastal sites programme) at times when aspects of public usage are likely to be more predominant at this site. Poorer bacteriological water quality could be expected under outflowing low tide conditions as emphasised by a consent monitoring programme undertaken at low tide at this site over the same recreational period (under similar sampling protocols) when a median *E. coli* bacterial number of 110

per 100 ml (with numbers ranging from 41 to 300 per 100 ml) was found with numbers tending to be higher when seawater intrusion was less apparent.

4.6.1 Comparison with guidelines

E. coli numbers for Patea River at the boat ramp, Patea over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 23.

Table 23 Performance against guidelines at Patea River at boat ramp, Patea

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	0 [0%]	0 [0%]

No single sample fell within the 'Alert' or 'Action' modes at any time during the monitoring period.

The bacteriological water quality at this site was within the acceptable guideline for contact recreational usage throughout the season recognising that all sampling occasions coincided with high tides and therefore a predominance of higher quality saline water mixing with poorer quality river water at this estuarine site. This was comparable with data for the nearby 'Mana' Bay coastal site adjacent to the river mouth monitored in the current season [median enterococci: 5 per 100 ml; range enterococci: <1-55 per 100 ml] for consent and SEM purposes.

4.6.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected for Patea River at Patea boat ramp over 13 summers are presented in Figure 25.

Twelve previous SEM sampling seasons have been surveyed at this site. Otherwise, prior sampling has been confined to consent monitoring surveys (TRC 2020, in prep). A statistical comparison of all summers' survey data is presented graphically in Appendix VI for all sites. A much shorter data period exists for this Patea River site (at Patea boat ramp) which was added in 2007-2008. These data are illustrated in Figure 25.

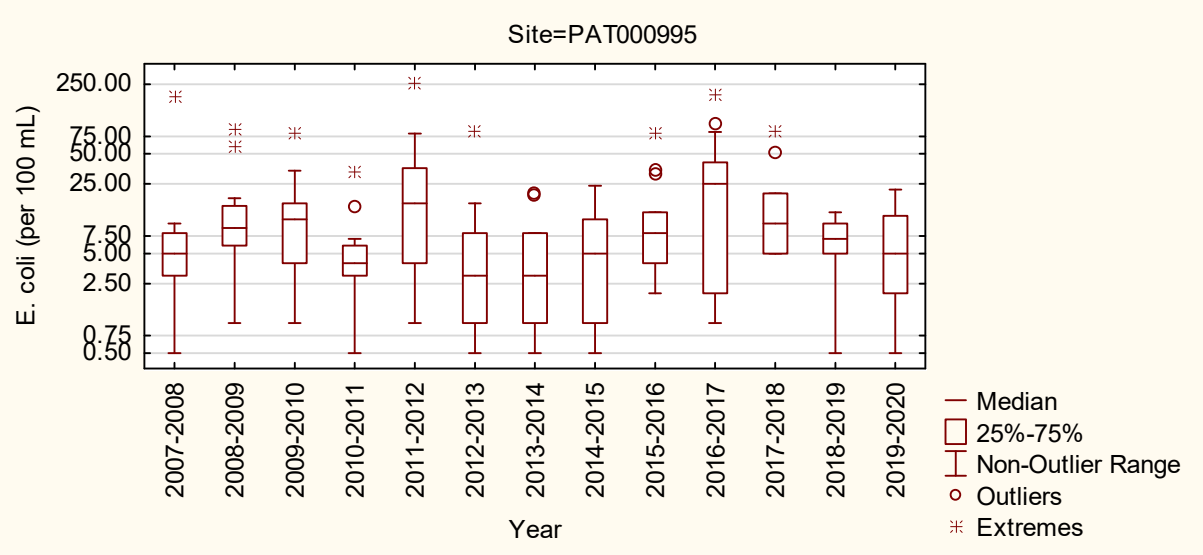


Figure 25 Box & whisker plots of *E. coli* for all summer SEM surveys of Patea River at boat ramp, Patea

Relatively similar (very low) median *E. coli* numbers have been found by these thirteen seasons' surveys with a moderate range of numbers, and with all the maximum values found to date having remained below the 'Alert' level. The recent season's range of numbers was typical of the ranges found in the previous seasons. (Note that the higher detection limit of the Colilert test method in saline water, of 10 MPN/100 ml, in comparison to that of the previously used membrane filtration method, of 1 cfu/100 ml, affected the 25% quartile and lower values in 2017-2018, but the more sensitive membrane filtration method was reinstated for 2018-2019).

In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was in compliance with the acceptable level for all of the period.

4.6.2.1 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the thirteen seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 26) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamin-Hochberg False Discovery Rate (FDR) analysis.

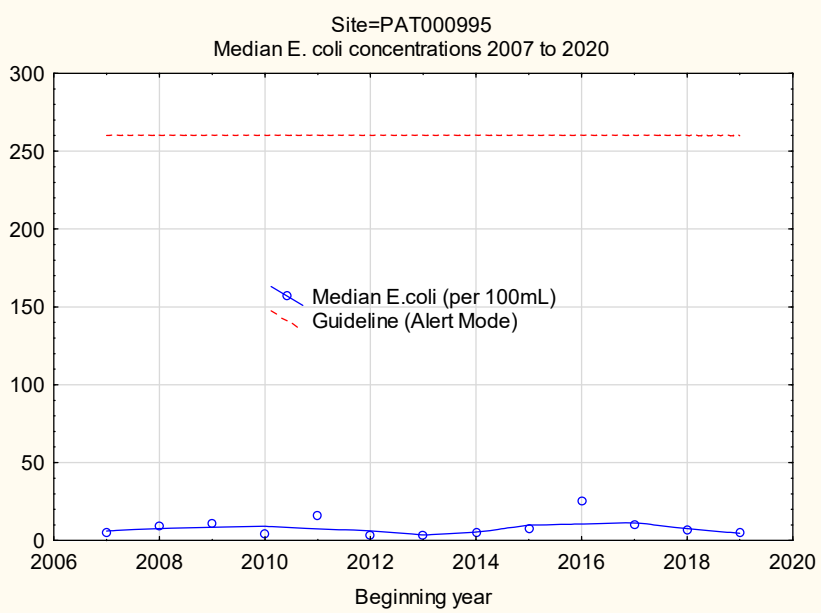


Figure 26 LOWESS trend plot of median *E. coli* data for Patea River at boat ramp, Patea

A slight, unimportant, and statistically insignificant increase in median *E. coli* numbers has been found over the thirteen seasons of monitoring. None of these medians has exceeded the 'Alert' or 'Action' modes.

4.7 Waingongoro River at Eltham Camp

A total of 13 samples were collected at this site over the summer. Eleven of the 13 scheduled SEM samples were collected, as well as two follow-up samples.

Bathing usage of this river site was recorded at the time of one sampling survey, and camp activities may have included more of this and other recreational usage as the camp was occupied on several occasions.

Sheep were present in the paddock adjacent to this unfenced site on five of the eleven monitoring occasions, but no birdlife was recorded.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 27. The complete survey results are presented in Appendix I and summarised in Table 24. Flow records are illustrated in Figure 28**.**

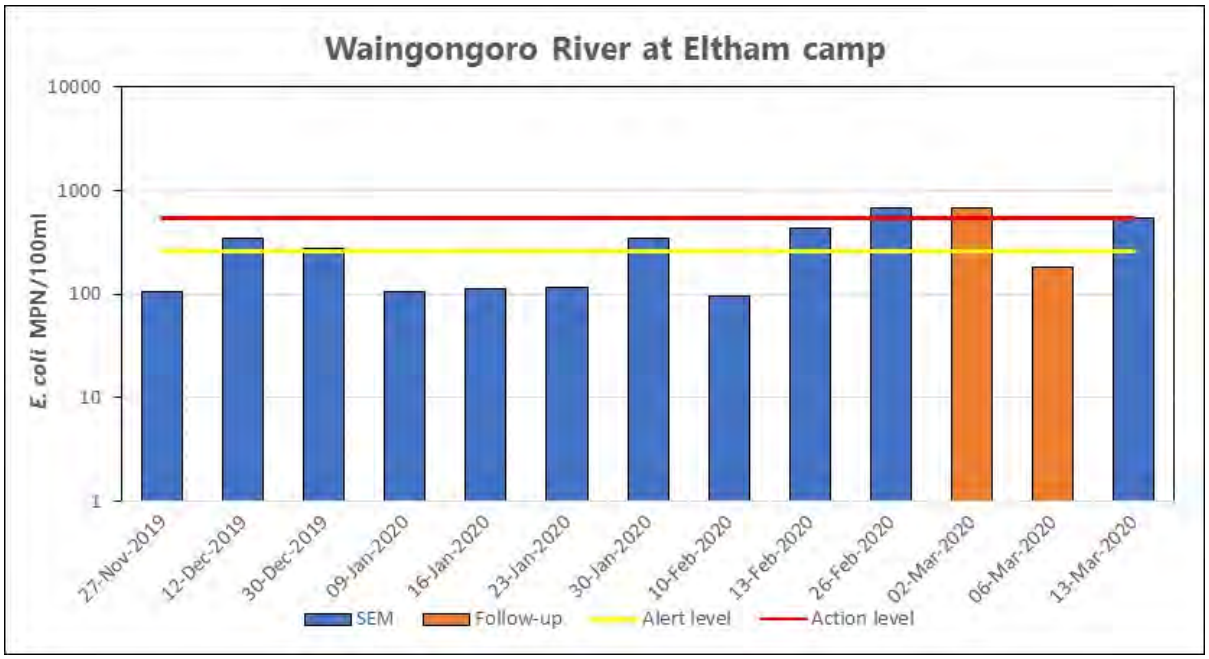


Figure 27 *E. coli* results for Waingongoro River at Eltham Camp

Table 24 Statistical summary for Waingongoro River at Eltham Camp

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	124	166	141
	E. coli	MPN/100 ml	11	96	687	276
	Temperature	°C	11	13.6	18.3	16.7
	Turbidity	FNU	11	0.65	3.9	1.58

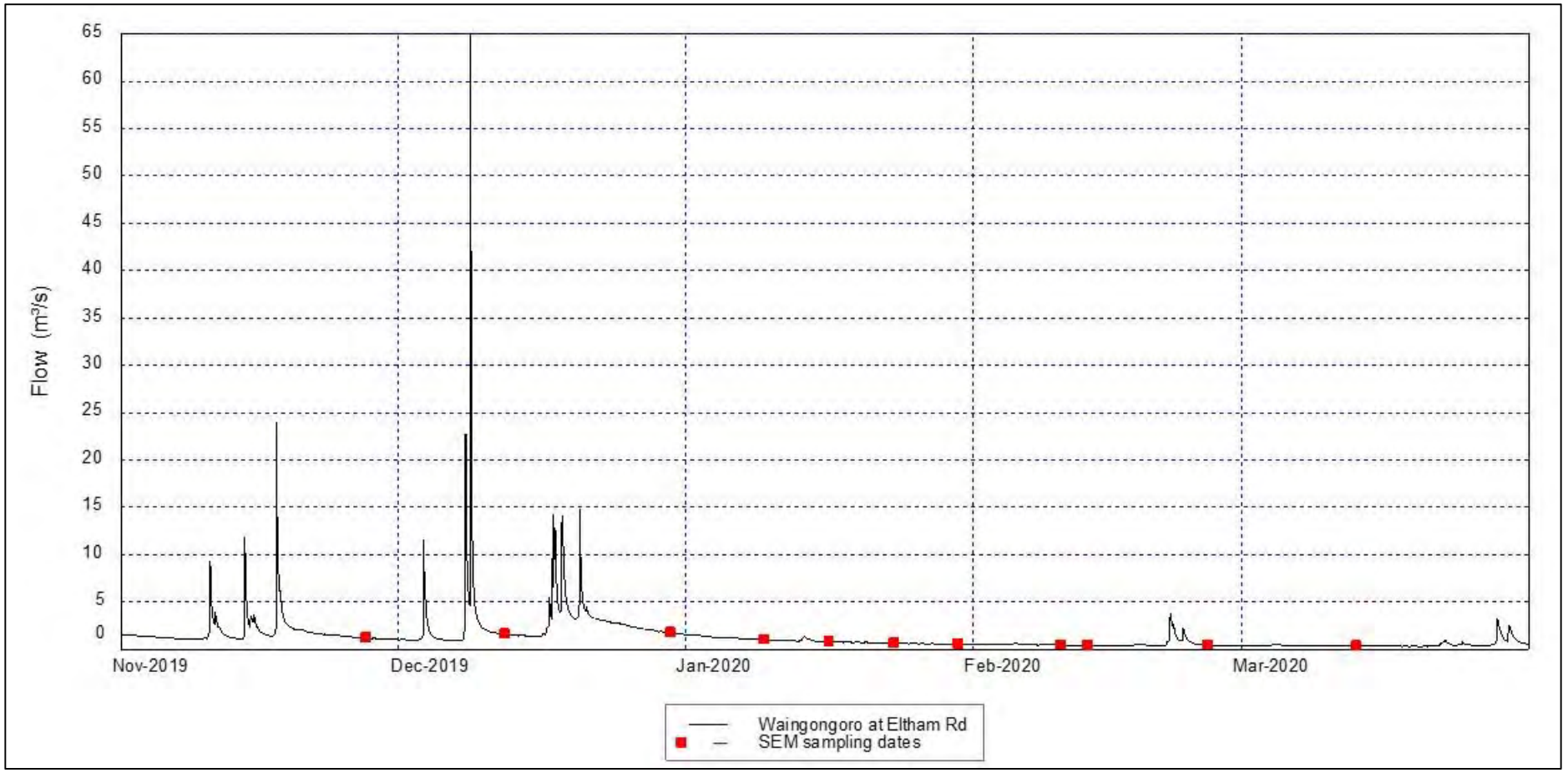


Figure 28 Flow in Waingongoro River at Eltham during the survey period

This ring plain river drains an extensively developed agricultural catchment, with the survey site situated in Eltham some 21 km below the National Park boundary. River water was generally relatively clear to slightly turbid (occasionally) in appearance with moderate conductivity levels. Water temperatures were within a relatively narrow range (4.7˚C) with a maximum of 18.3˚C in mid-morning in late January 2020.

Bacteriological water quality (median *E.*coli: 276 per 100 ml) was lower than typical of the mid reaches of a Taranaki ring plain river draining a predominantly agricultural catchment. This was also apparent in comparison with the nearby Eltham Road (state of the environment physicochemical monitoring) site where a median *E.coli* number of 190 per 100 ml (range: 6 to 59,000 per 100 ml) has been recorded by monthly sampling since 1995.

4.7.1 Comparison with guidelines

E. coli numbers for the Waingongoro River at Eltham Presbyterian camp over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 25.

Table 25 Performance against guidelines at the Waingongoro River, Eltham Camp site

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	5 [45%]	1 [9%]

Five single samples fell within the 'Alert' mode and one sample reached the 'Action' mode. The highest *E. coli* number occurred in early-morning in late February 2020. Two follow-up samples were taken, the first also being within 'Action" mode, though the cause of the elevated *E. coli* numbers was not determined. A health risk warning sign was erected by STDC while the samples were at 'Action' mode.

4.7.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Waingongoro River at Eltham camp over 19 summers is presented in Figure 29.

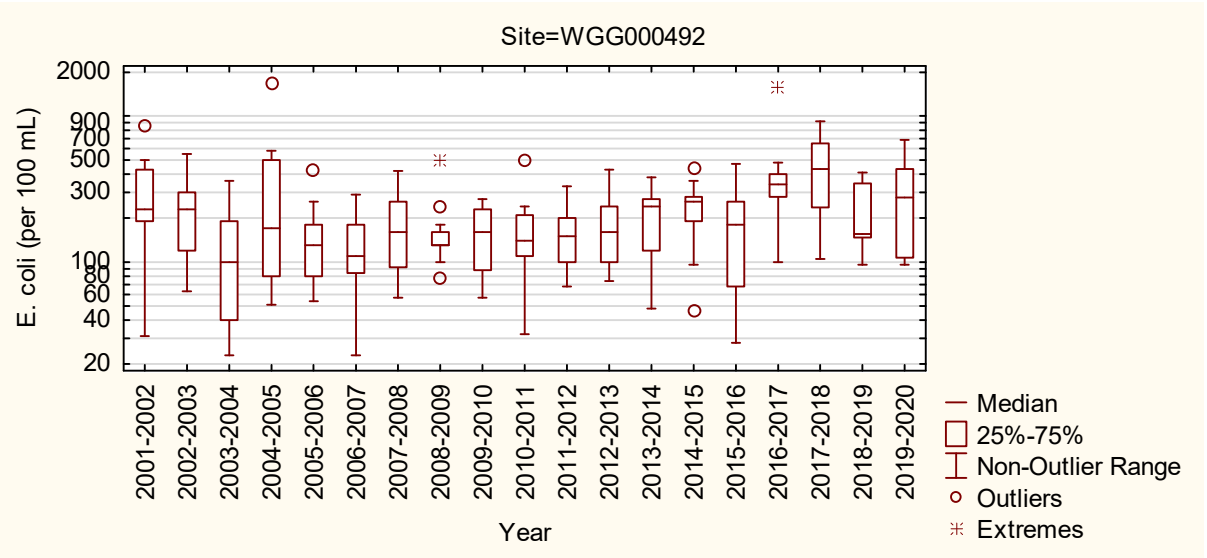


Figure 29 Box and whisker plots of *E. coli* for all summer surveys in Waingongoro River at Eltham Camp

A deterioration in *E.coli* bacterial water quality in the 2019-2020 season was indicated by a median number which was within the upper-range of the medians recorded over the eighteen preceding seasons (Figure 29).

4.7.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the nineteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 30) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

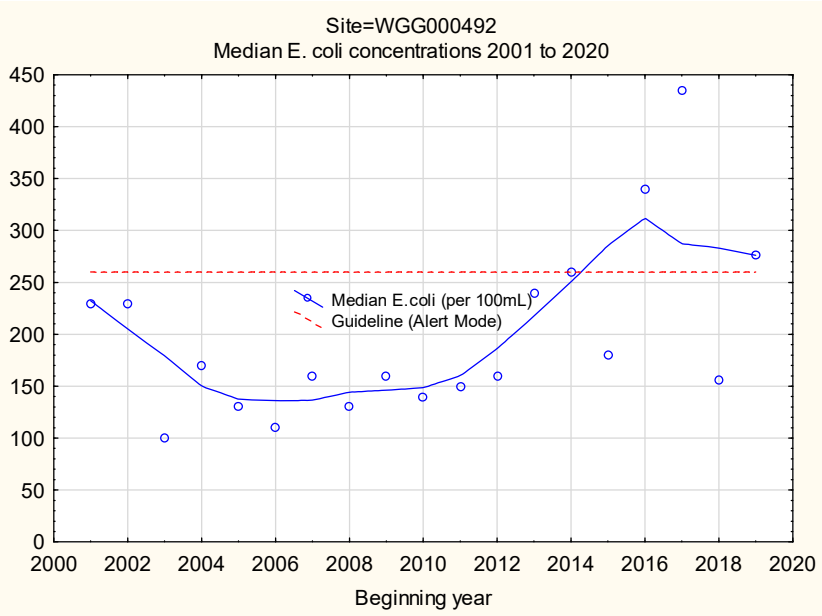


Figure 30 LOWESS trend plot of median *E.coli* data for Waingongoro River at Eltham camp

A statistically insignificant temporal trend of increasing median *E. coli* numbers has been found over the nineteen seasons of monitoring. (Note: This trend was statistically significant at $p < 0.05$ but not after FDR analysis, the p level being 0.023, increasing to 0.104 after FDR correction). None of these seasonal medians exceeded the 'Action' mode.

4.7.4 Cyanobacteria

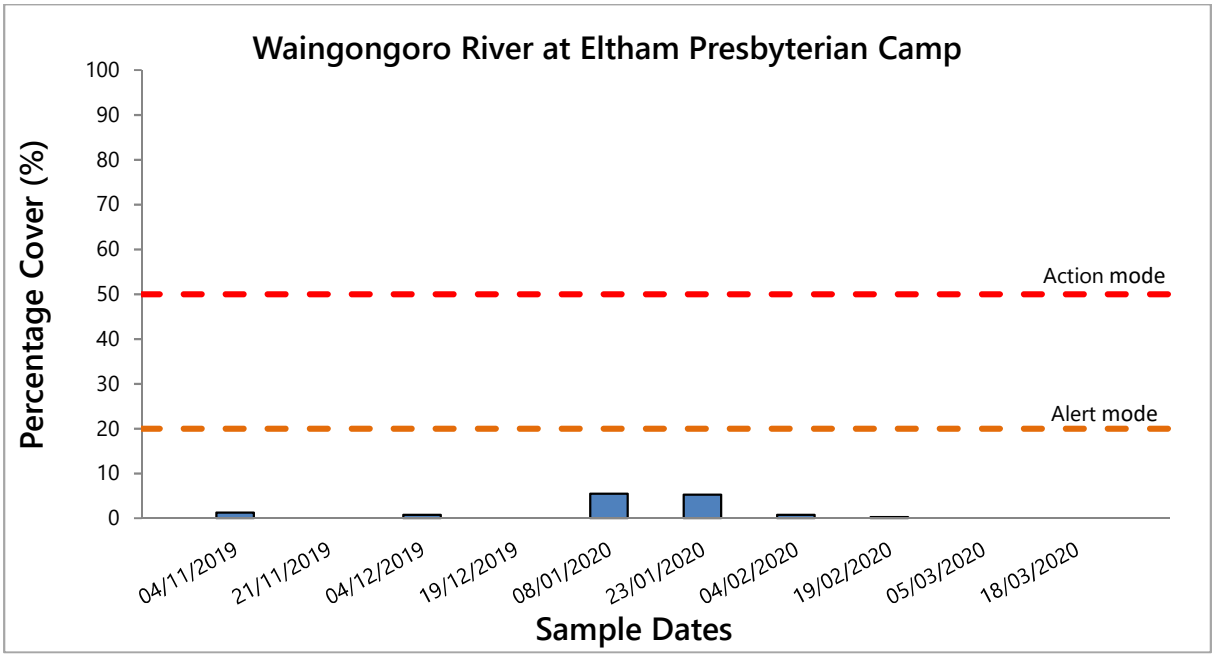
Benthic cyanobacteria were monitored on ten occasions throughout the season. Results are presented in Table 26 and Figure 31.

Table 26 Percentage benthic cyanobacteria cover, detached and exposed mats at the Waingongoro River at Eltham Presbyterian Camp

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	1	No	No	Surveillance
21/11/2019	0	No	No	Surveillance
04/12/2019	1	No	No	Surveillance
19/12/2019	0	No	No	Surveillance
08/01/2020	6	No	No	Surveillance

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
23/01/2020	5	No	No	Surveillance
04/02/2020	1	No	No	Surveillance
19/02/2020	0	No	No	Surveillance
05/03/2020	0	No	No	Surveillance
18/03/2020	0	No	No	Surveillance

Figure 31 Percentage benthic cyanobacteria data for the Waingongoro River at Eltham Presbyterian Camp



Note: 'Action' and 'Alert' mode lines are for percentage cover only. * and + symbols over a bar indicate where the status has been raised to 'Alert' or 'Action' mode respectively due to detaching or exposed mats

Benthic cyanobacteria coverage was low throughout the season (ranging from 0 to 6%). The benthic cyanobacteria found were *Microcoleus* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover or for the presence of exposed or detaching mats and therefore no action at the site was required.

4.8 Waingongoro River at Ohawe Beach

A total of 20 samples were collected at this site over the summer. Eleven of 13 scheduled SEM samples were collected, as well as eight MfE samples and one follow up sample. Rainfall preceded sampling on one occasion.

Bathing usage of this site was recorded on one of the sampling occasions. Whitebaiting was recorded three occasions (on all samplings within the season), and fishing was recorded once. Livestock were not present in the paddock upstream of the site during the 2019-2020 season, nor at the river's edge or in the river, as had been the case on occasions in the past (TRC, 2010). A few ducks were also noted on occasions.

In the 2012-2013 season, samples from two separate fine weather, low tide, very low flow conditions (mid to late summer) surveys at sites upstream of the township and near mouth were forwarded to Cawthron Institute, Nelson for faecal source DNA tracking marker analyses. Both surveys found low *E.coli* numbers (ranging from 51 to 92 cfu/100 ml upstream and 43 to 60 cfu/100 ml downstream of the township) which

comprised bacteria of only ruminant and wildfowl origins, typical for the lower reaches of ringplain streams and not indicative of septic tank waste disposal issues.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 32 and summarised in Table 27. The complete survey results are presented in Appendix I. River flow records are illustrated in Figure 33.

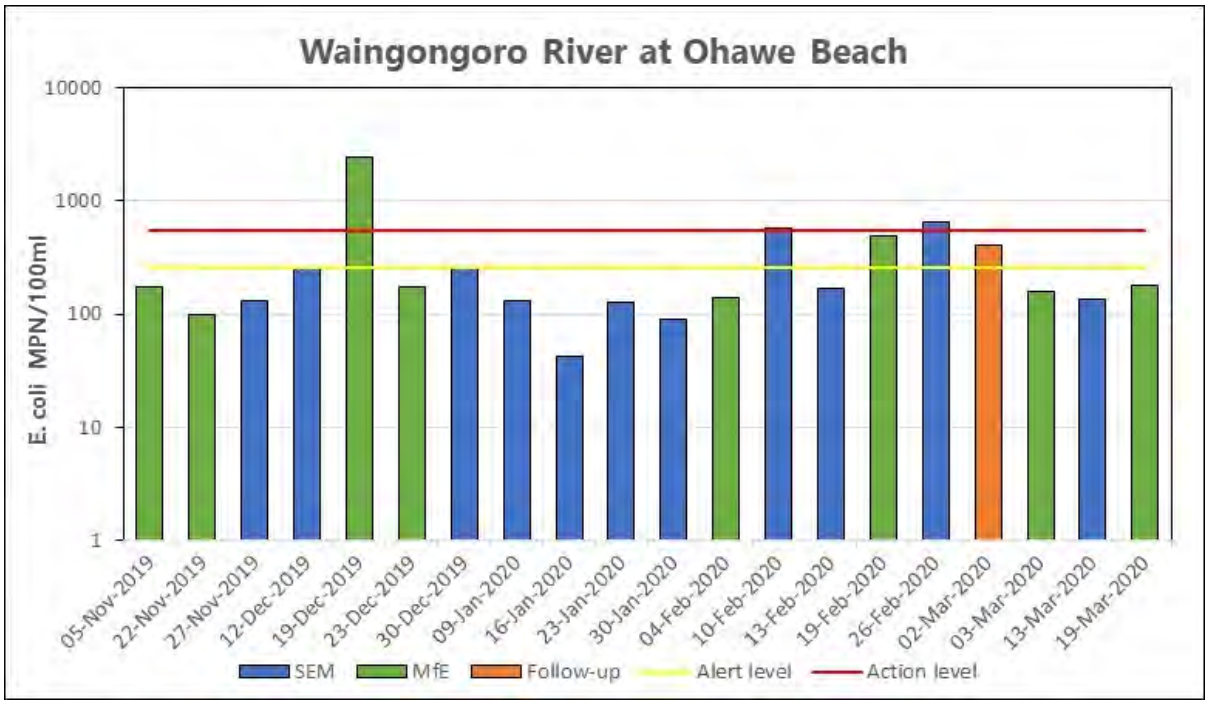


Figure 32 *E.coli* results for Waingongoro River at Ohawe Beach

Table 27 Statistical summary for Waingongoro River at Ohawe Beach

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	148	257	219
	E. coli	MPN/100 ml	11	42	649	135
	Temperature	°C	11	16.2	22.8	18.1
	Turbidity	FNU	11	1.00	3.0	1.61
SEM + MfE samples	Conductivity	µS/cm@25°C	19	142	257	211
	E. coli	MPN/100 ml	19	42	2420	167
	Temperature	°C	19	13.8	22.8	17.7
	Turbidity	FNU	19	0.70	15.0	1.61

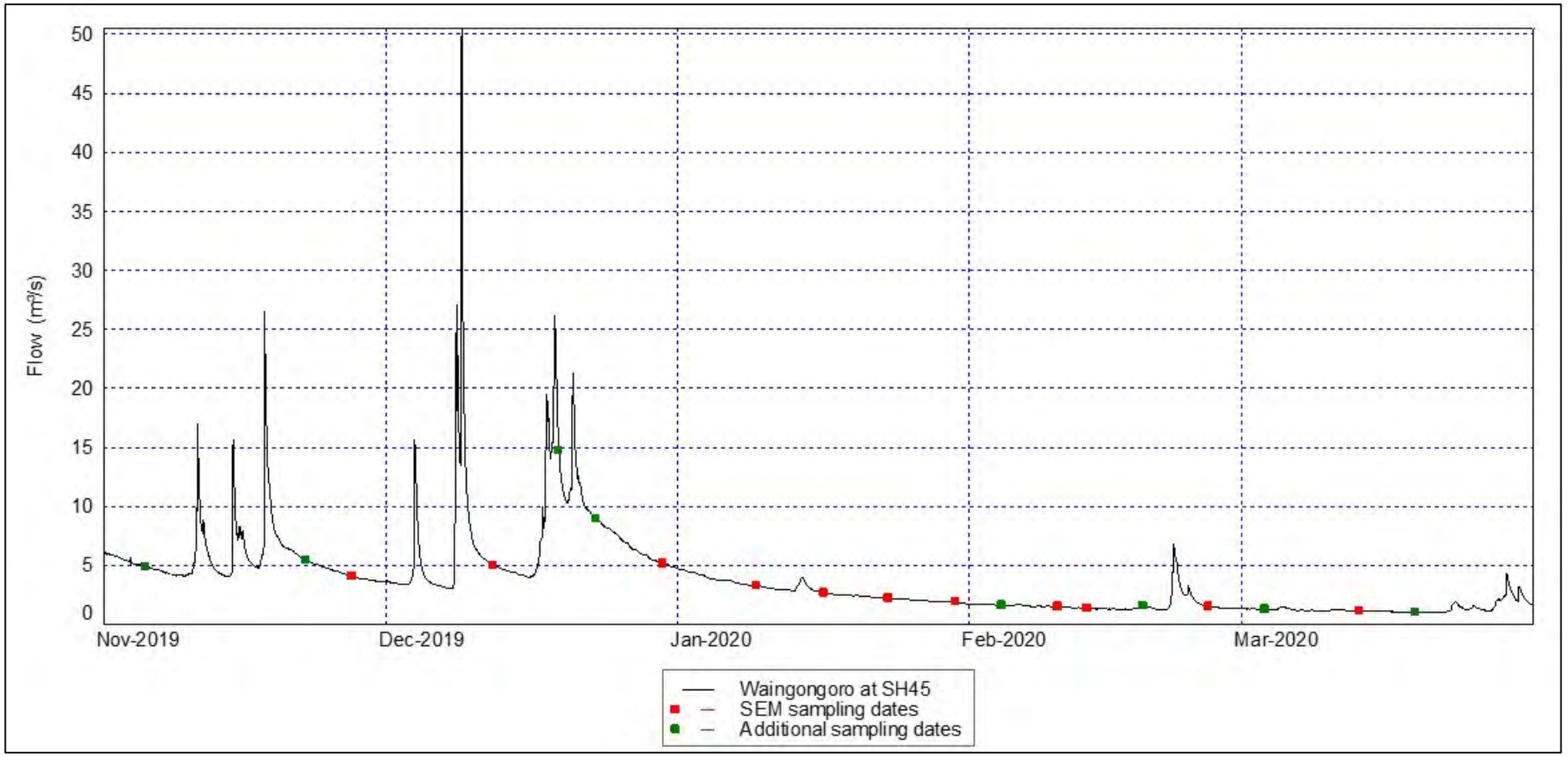


Figure 33 Flow in Waingongoro River at SH45 during the survey period

This river drains an extensively farmed catchment and receives point source industrial wastes (in its mid-reaches) and dairy pond wastes (more than 100 treatment systems) discharges. These industrial (meatworks) wastes are predominantly diverted out of the river (to land irrigation) during summer months, while the Eltham WWTP municipal and industrial wastes discharge was diverted permanently out of the catchment in winter 2010. The site is in the lower reaches of the river immediately upstream of the mouth, but is generally not tidal, although occasional upstream surging in the ponded area has been noted during low river flow and high tidal conditions during late summer.

The range of water temperatures was moderate (6.6°C) with a maximum of 22.8˚C recorded at midday in late January 2020. Conductivity values were typical of the lower reaches of a Taranaki ring plain river. Saltwater influence was not found, as it has been under very high tides in previous years. Turbidity values during trend monitoring were indicative of relatively clear water on most occasions, consistent with the presence of some fine colloidal material in suspension (ie: < 2.5 NTU on most occasions), typical of the lower reaches of a ring plain river.

Bacteriological water quality (Figure 32) was typical of the lower reaches of a Taranaki ring plain river receiving agricultural run-off and point source discharges in the catchment. This was also apparent in comparison with the nearby (state of the environment physicochemical monitoring) site at SH45 where monthly sampling since mid-1998 (under all weather conditions) has recorded a median *E. coli* number of 220 per 100 ml (and range from 3 to 41,000 per 100 ml). Uncontrolled livestock access to the river immediately upstream of this site near the mouth, particularly during low flow periods, was not recorded during the current season, which was an improvement on historical incidents.

4.8.1 Comparison with guidelines

E. coli numbers for the Waingongoro River at Ohawe Beach over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 28.

Table 28 Performance against guidelines at Waingongoro River at Ohawe Beach

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT **Single sample** **261-550/100 ml**	**ACTION** **Single sample** **>550/100 ml**
SEM samples	1 [9%]	2 [18%]
SEM+MfE samples	1 [5%]	3 [16%]

Three single samples were recorded in the 'Action' category, two during SEM surveys in February 2020, the other in mid-December 2019 during a fresh. The 'Alert' mode was exceeded on two occasions, during a trend survey in late December 2019, and an additional survey in February. Health risk warning signage was deployed by STDC after the 'Action' level *E. coli* numbers. On both dry-weather occasions, follow-up sampling (coincidental with an advanced weekly sampling after the first event) returned results below Action level, and the sign was removed.

4.8.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Waingongoro River at Ohawe Beach over 24 summers is presented in Figure 34.

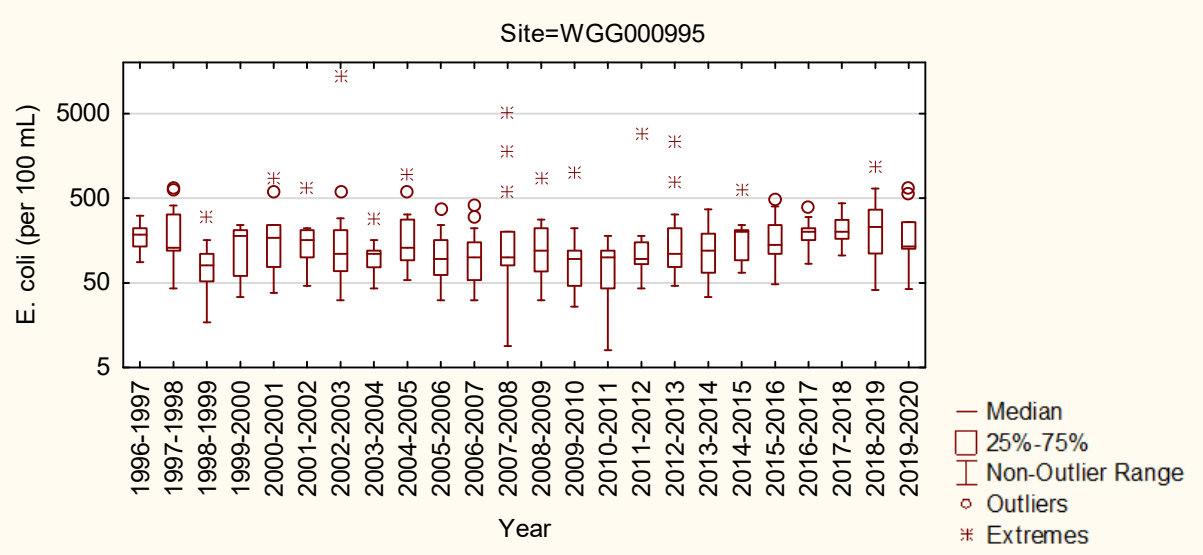


Figure 34 Box and whisker plots of *E. coli* for all summer surveys in Waingongoro River at Ohawe Beach

Median *E. coli* bacteria number for the 2019-2020 period was in the mid-range of annual values found over the previous twenty-three seasons, and the lowest in six years (Figure 34).

A moderately wide range of *E. coli* numbers was recorded in the recent 2019-2020 period in comparison with past seasons' ranges.

4.8.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the twenty-four seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 35) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

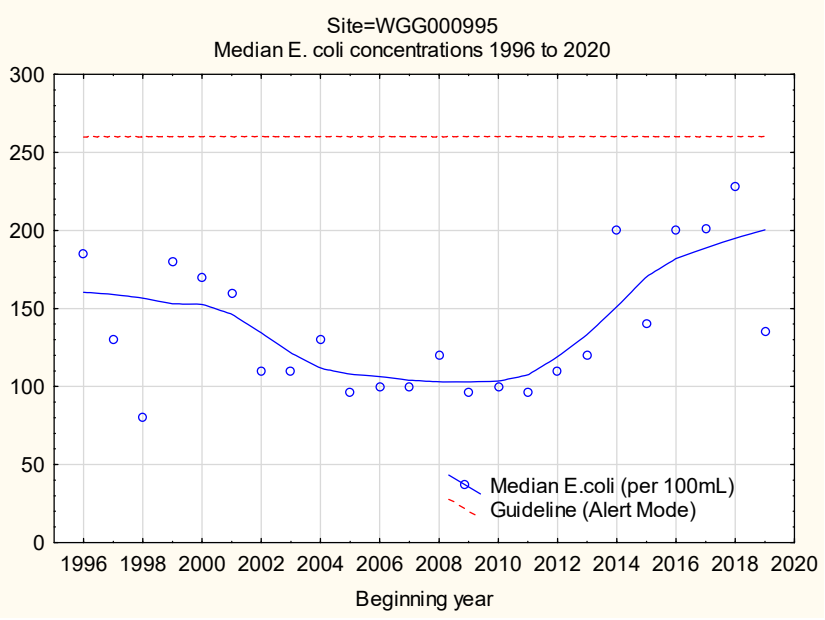


Figure 35 LOWESS trend plot of median E.coli numbers (per 100 ml) for the 1996 to 2020 period at the Waingongoro River Ohawe beach site

Overall, a statistically insignificant increasing trend in median *E.coli* number was found over the twenty-four seasons of monitoring. The trend had been a statistically significant reduction at the p <0.05 level after the

2012-2013 season, but no longer significant due to the more recent increase in median number. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.8.4 Cyanobacteria

Benthic cyanobacteria were monitored on 11 occasions during the season. Results are presented in Table 29 and Figure 36.

Table 29 Benthic cyanobacteria data for the Waingongoro River at Ohawe Beach

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	13	No	No	Surveillance
21/11/2019	3	No	No	Surveillance
04/12/2019	0	No	No	Surveillance
19/12/2019	0	No	No	Surveillance
08/01/2020	7	No	No	Surveillance
23/01/2020	31	Minor	Minor	Alert
28/01/2020	22	Minor	No	Alert
04/02/2020	26	Minor	Minor	Alert
19/02/2020	7	No	No	Surveillance
05/03/2020	2	No	No	Surveillance
18/03/2020	0	No	No	Surveillance

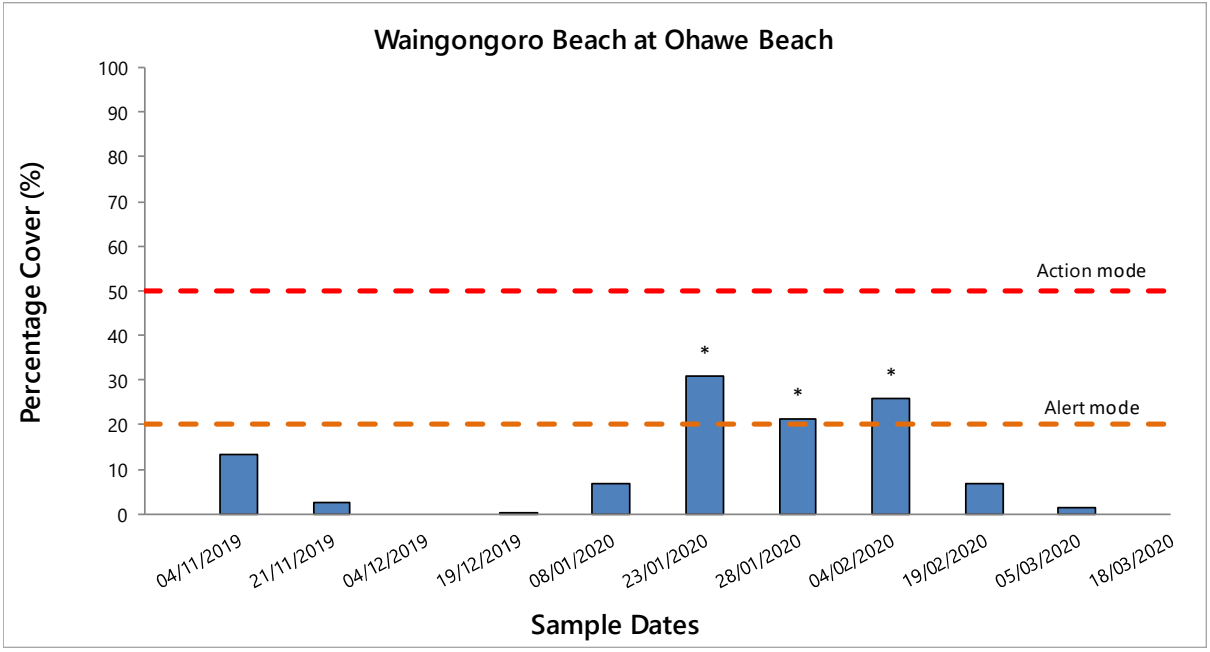


Figure 36 Percentage benthic cyanobacteria cover, for the Waingongoro River Ohawe beach site

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and ⁺ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was low for the majority of the monitoring period, with eight of the 11 surveys between 0% to 13% streambed coverage. Three surveys had coverage at the 'Alert' level. The benthic cyanobacteria found were *Microcoleus* sp. Minor levels of detaching mats were observed on three

occasions, triggering the 'Alert' level, and minor levels of exposed mats were observed on two occasions, which triggered the 'Alert' response. In total there were three surveys that triggered the 'Alert' level.

4.9 Kaupokonui River at Beach Domain

A total of 19 samples were collected at this site over the summer. Eleven of 13 scheduled SEM samples were collected, as well as eight MfE samples one of which was also a follow up sample. Rainfall immediately preceded sampling on one occasion. Four of the additional surveys occurred within two hours of low tide.

Moderate usage at this site by bathers was recorded at the time of the sampling surveys, and other recreational usage, including whitebaiting (in season), fishing, walking and picnicking on the banks was occurring on several survey occasions at this popular site where the camping ground was consistently in use. The site was characterised by the tidal ponded nature of this reach of the river on the majority of occasions, particularly under high tide and low river flow conditions. No stock access was noted near the river's edge upstream of the domain during the current season. A few ducks were noted on a several occasions.

During the 2012-2013 season, additional fine weather samples were collected on two separate low tide, very low flow conditions (mid-summer and end of the season) at this site and analysed (by Cawthron Institute, Nelson) for faecal source DNA tracking markers. Low *E.coli* numbers (26 and 17 cfu/100 ml) were found to be coincident with bacteria of only ruminant and wildfowl origin indicative of no septic tank wastes disposal issues at the beach, with numbers typical of the lower reaches of ring-plain streams.

River flow records for the current 2019-2020 season are provided in Figure 38.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 37 and summarised in Table 30. The complete survey results are presented in Appendix I.

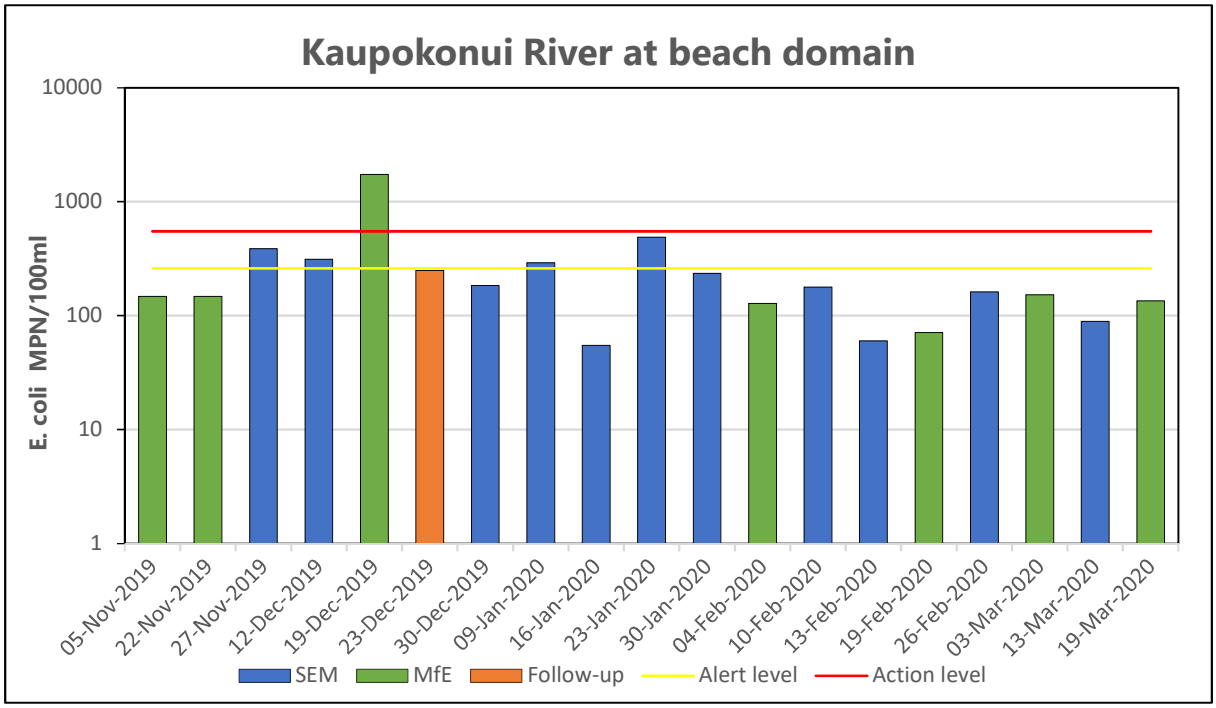


Figure 37 *E. coli* results for Kaupokonui River at the beach domain

Table 30 Statistical summary for Kaupokonui River at the beach domain

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	173	1919	205
	E. coli	MPN/100 ml	11	55	488	184
	Temperature	°C	11	17.8	24.7	19.6
	Turbidity	FNU	11	0.74	3.3	2.1
SEM + MfE samples	Conductivity	µS/cm@25°C	19	144	1919	201
	E. coli	MPN/100 ml	19	55	1733	162
	Temperature	°C	19	13.6	24.7	18.9
	Turbidity	FNU	19	0.74	5.8	1.51

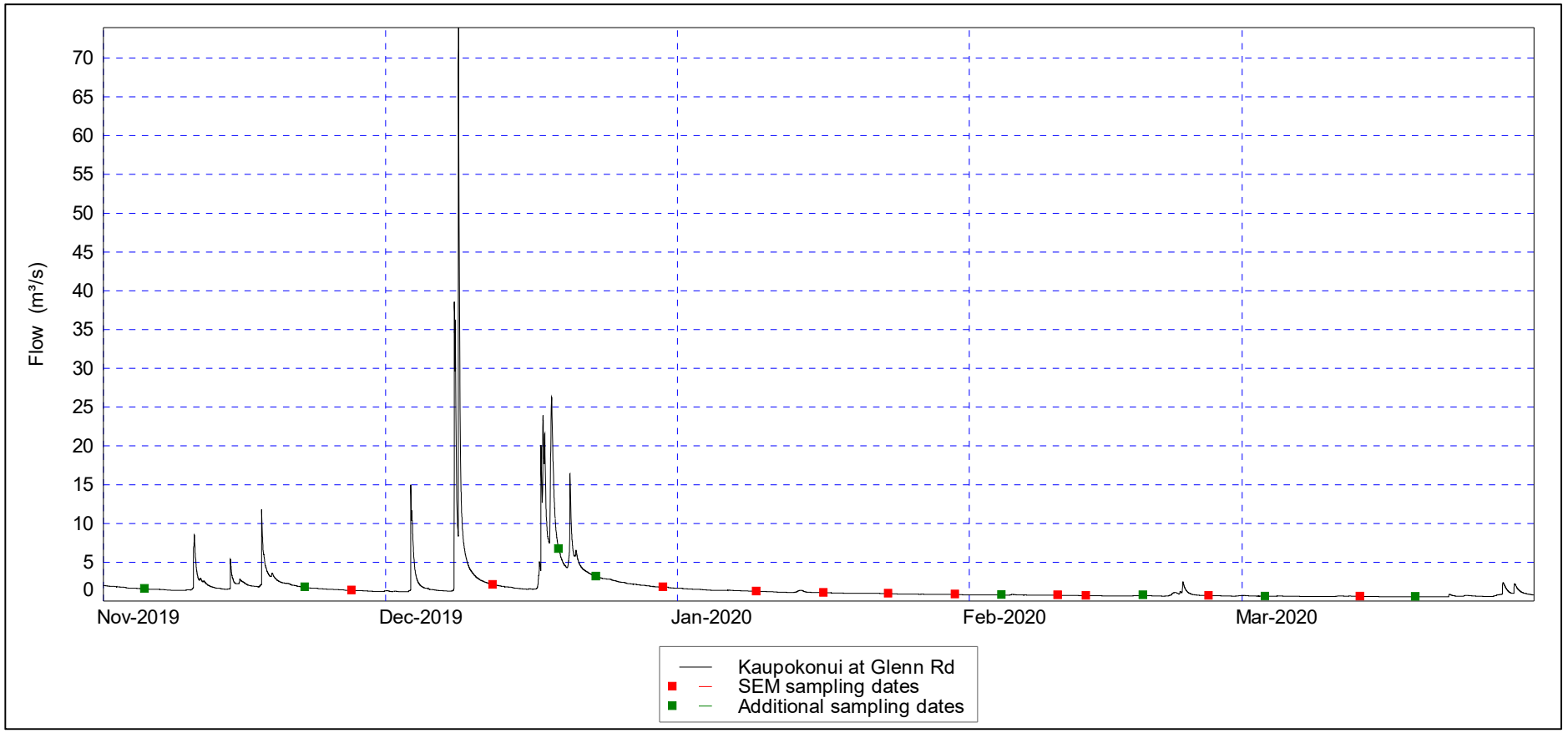


Figure 38 Flow in the Kaupokonui River at Glenn Rd during the survey period

This river also drains an extensively farmed catchment and receives point source wastes discharges from dairy pond wastes treatment systems, and in its mid-reaches from the Fonterra Kapuni lactose plant (cooling waters) and the Kaponga township municipal wastewater treatment system.

The site is located in the lower reach of the river near the mouth and on several occasions was noted as tidal (incoming surges, upstream or very slow flow) in terms of flow conditions. Elevated conductivity levels on two occasions indicated some seawater influence near high tide under low flow conditions throughout the monitoring period. Otherwise, these conductivity levels were relatively stable (144 to 231 µS/m at 25°C) and typical of the lower reaches of a Taranaki ring plain river.

Turbidity levels were mostly typical of lower ring plain river reaches with minimal impacts of suspended algal matter though were increased markedly (to >3.0 FNU) by sediment suspended during larger tidal surges, and during a rainfall event in mid-December 2019. Foaming was seldom noticeable in the ponded reach of the river and toward the edges, unlike in some previous periods when foaming and suspended algal matter reduced the aesthetic quality of this reach from time to time. Water temperatures varied over a moderately wide range of11.1°C with a maximum of 24.7°C recorded in late January 2020. This temperature was recorded at 1235 hrs and would be expected to have increased later in the day and on other occasions, particularly as most of the surveys were performed before 1325 hrs at this site.

Bacteriological water quality was moderately good and better than that recorded in the lower reaches of the nearby Waingongoro River (see section 4.7), and similar to that found from time to time in the lower reaches of a Taranaki ring plain river draining a predominantly agricultural catchment.

Previous surveys have noted that bacteriological water quality deteriorated in this tidal pool reach of the river, probably as a result of the ponding of the flow and 'accumulation' of slugs of poorer quality downstream flow. This may have been as a result of upstream stock access, point source dairy effluent discharges and/or various other non-point source runoff, emphasising the importance of control and surveillance of dairy shed wastewater disposal practices, particularly in lower reaches of ring plain catchments utilised for bathing and recreational purposes. As well, many flocks of ducks have been recorded in reaches of the river upstream of this site.

During SEM surveys, four 'Alert' levels and no 'Action' levels were recorded, between end of November and mid-January 2020. There was tidal surging, or saline influence was measured, on two of these occasions.

During MfE surveys, no 'Alert' level and one 'Action' level was recorded, in mid-December 2019. The Action level result was affected by rainfall.

Relatively poor aesthetic water quality has been noted from time-to-time at this site, mainly in the form of surface froth (particularly toward the river margins) and fragments of periphyton suspended in the water column. These aspects of physical water quality were not as apparent during the 2019-2020 season.

4.9.1 Comparison with guidelines

E. coli numbers for the Kaupokonui River at the beach domain over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 31.

Table 31 Performance against guidelines at Kaupokonui River at the Beach Domain

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	4 [36%]	0 [0%]
SEM+MfE samples	4 [21%]	1 [5%]

One single sample was recorded in the 'Action' category, during an MfE survey on a steep flow recession. The 'Alert' mode was exceeded on four occasions, all during SEM surveys, when tidal effects were apparent. Health risk warning signage was deployed by STDC after the 'Action' level *E. coli* number. The follow-up survey coincided with an MfE survey immediately before Christmas and returned a number in the acceptable range. The signage was removed accordingly.

In summary, bacteriological water quality at this ponded lower river site was within guidelines for contact recreational usage for the large majority of the survey period.

4.9.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Kaupokonui River at the beach domain over 24 summers is presented in Figure 39.

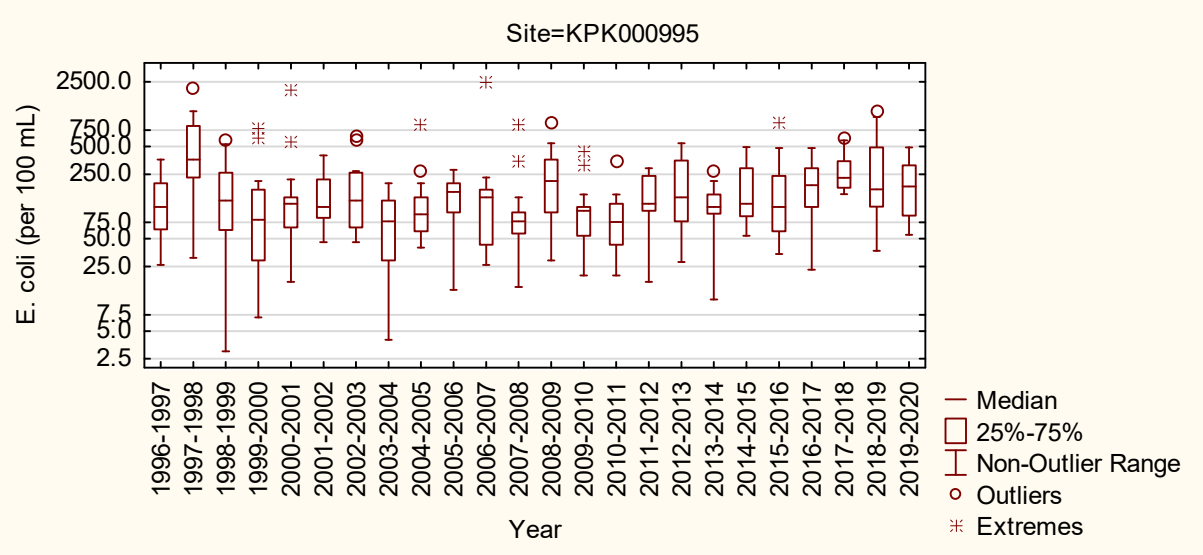


Figure 39 Box and whisker plots of *E. coli* for all summer surveys in the Kaupokonui River at the Beach Domain

Improved *E. coli* bacterial water quality in terms of median number, and a moderate range compared with many of the previous twenty-three survey seasons, was recorded over the 2019-2020 season (Figure 39). The median *E. coli* number was the fifth highest of all other seasons' medians to date and the seasonal maximum was in the upper-range of those for the twenty-four years of record.

4.9.2.1 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the twenty-four seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 40) and testing

the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

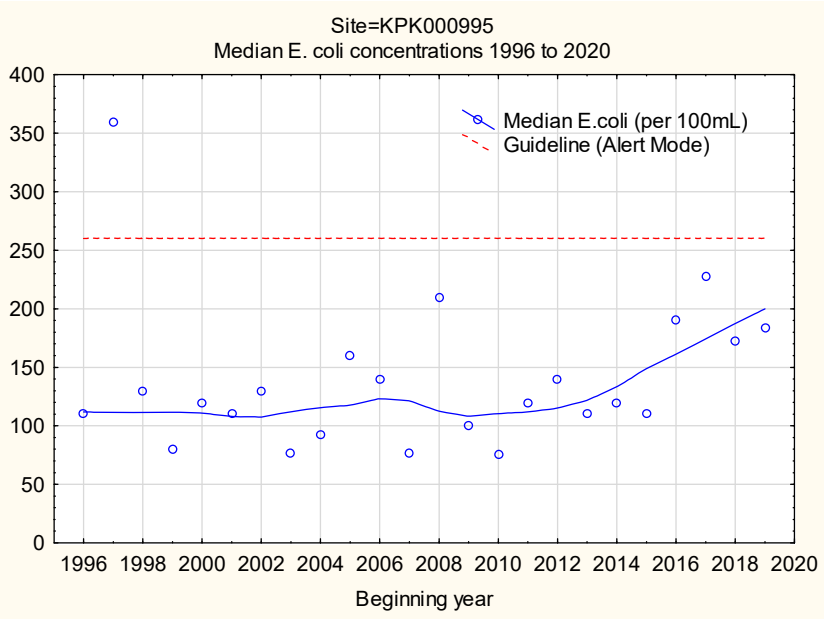


Figure 40 LOWESS trend plot of median *E. coli* data at the Kaupokonui River beach domain site

A slight, and statistically insignificant, increasing trend in median *E. coli* numbers was found over the twenty-four seasons of monitoring. One of these seasonal medians (1997-1998 season) exceeded the 'Alert' mode but none has exceeded the 'Action' mode.

4.9.3 Cyanobacteria

Benthic cyanobacteria were monitored on 13 occasions during the season. Results are presented in Table 32 and Figure 41.

Table 32 Percentage benthic cyanobacteria cover, detached and exposed mats at the Kaupokonui River at Beach Domain

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	10	No	No	Surveillance
21/11/2019	6	No	No	Surveillance
04/12/2019	5	No	No	Surveillance
19/12/2019	2	No	No	Surveillance
08/01/2020	23	Minor	No	Alert
14/01/2020	27	Minor	No	Alert
23/01/2020	48	Minor	No	Alert
28/01/2020	39	Minor	No	Alert
04/02/2020	58	Minor	No	Action
19/02/2020	50	Minor	Minor	Alert
28/02/2020	22	Minor	No	Alert

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
05/03/2020	9	No	No	Surveillance
18/03/2020	8	Minor	No	Alert

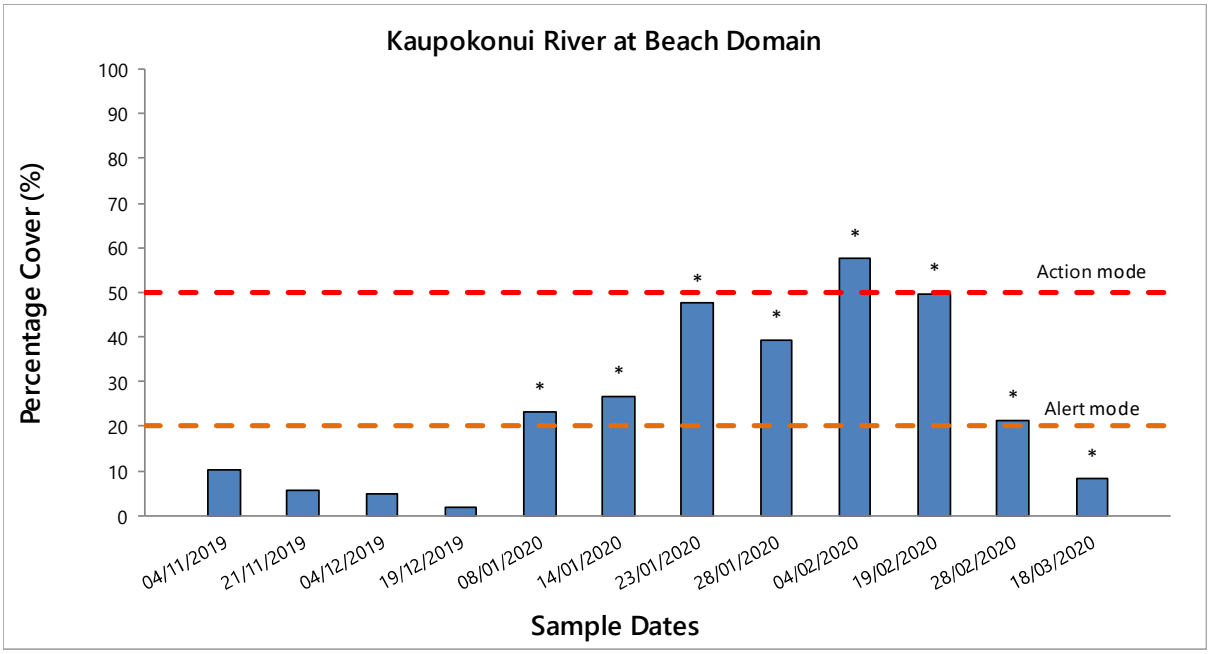


Figure 41 Benthic cyanobacteria data for Kaupokonui River at Beach Domain.

Note: 'Action' and 'Alert' mode lines are for percentage cover only. * and + symbols over a bar indicate where the status has been raised to 'Alert' or 'Action' mode respectively due to detaching or exposed mats

Benthic cyanobacteria coverage was moderate with seven surveys having coverage of over 20%, though coverage significantly dropped to low levels by the end of summer. The benthic cyanobacteria found were *Microcoleus* sp. The 'Action' level was exceeded for percentage cover on one occasion, and came close to being exceeded on two other occasions. The 'Alert' level for cover was exceeded on six occasions. Minor detaching mats were observed on eight occasions which triggered the 'Alert' level. Minor levels of exposed mats were observed on one occasion which triggered the 'Alert' level. In total, the 'Action' level was triggered on one occasion and the 'Alert' level was triggered on seven occasions. This made the site in terms of percentage cover and detaching mats the worst site monitored for the current monitoring period.

4.10 Lake Opunake

Eleven of the 13 scheduled SEM samples were collected over the summer, before the covid-19 pandemic stopped sampling.

No bathing or boating usage of the lake was noted on any occasion, but picnicking and camping activities were recorded occasionally. Ducks were noted regularly on the lake or in the vicinity of the lake edge, and numbers were high on some occasions. Swans and geese were also present on several occasions. Large numbers of these wildfowl frequently have been present on the picnic area grass verge adjacent to the lake edge, attracted from time to time by food provided by picnickers. There was no repeat of the thick unsightly, algal scum prevalent on the lake surface for several weeks during mid to late summer in the 2010-2011 season (TRC, 2011), although some emergent weed was noted from mid-February onwards.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 42 and summarised in Table 33.

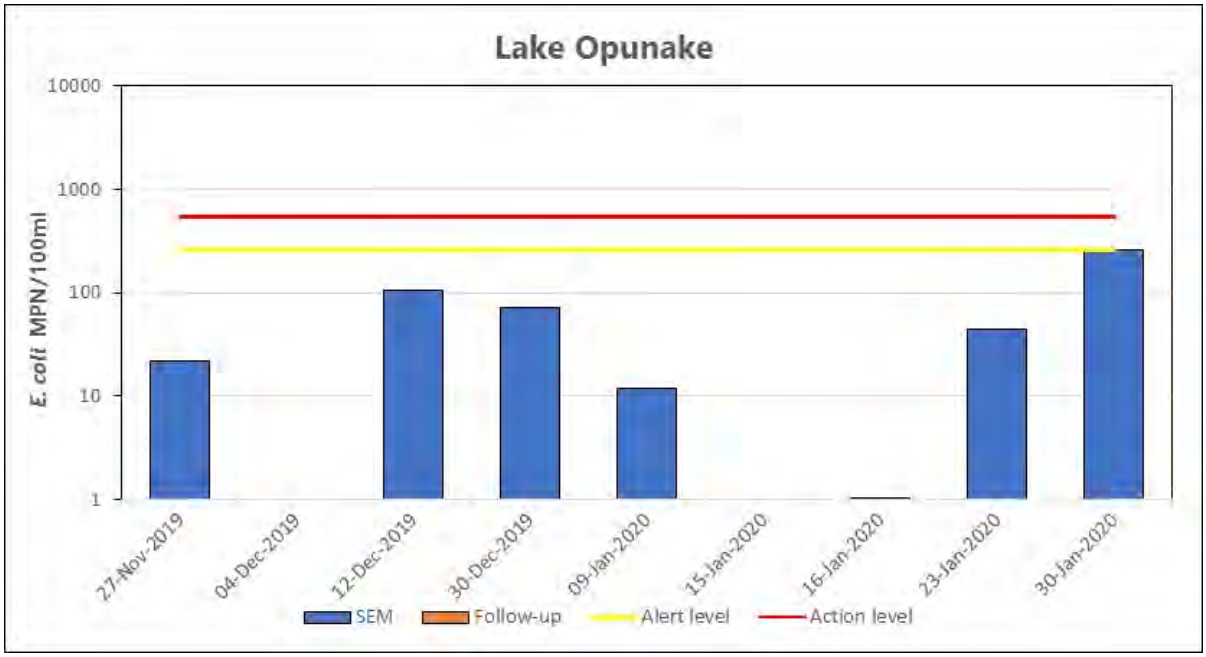


Figure 42 *E. coli* results for Lake Opunake

Table 33 Statistical summary for Lake Opunake

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	125	197	149
	E. coli	MPN/100 ml	11	1	260	39
	Temperature	°C	11	21.0	25.9	22.2
	Turbidity	FNU	11	1.41	3.1	2.1

The lake is formed by the diversion of water from the nearby Waiaua River (as a component of the Waiaua HEP scheme) and is close to the coast.

Water clarity was fair with a median turbidity of 2.1 FNU, substantially higher than the median value for the previous 14 years (1.2 NTU), which is consistent with the higher levels of cyanobacteria found in 2019-2020, but may also be due to use of a different turbidimeter and analytical method that may produce higher values. Previous monitoring has indicated relatively high clarity as a result of minimal sediment disturbance and/or limited suspended algae in the water column. Good water quality has been due, in part, to the lake's short residence time, with regular replenishment as a result of local hydroelectric power scheme usage. Median water temperature (22.2°C) was the fifth highest recorded, with a moderate range (4.9°C) and relatively high maximum (25.9°C) value. Conductivity varied over a fairly narrow range (72 µS/m @ 25˚C) reflecting river inflow conditions.

Generally, bacteriological quality was good, the median number (39 *E. coli* per 100 ml) being the lowest recorded, over a relatively narrow range, which usually has been influenced in part by the inflow to the lake originating from the lower reaches of a river draining a developed catchment, and also by the local wildfowl population. In previous seasons, marked fluctuations in numbers have occurred which were most likely associated with this bird population, particularly in instances where ducks had been attracted to the immediate vicinity of the monitoring site by picnickers feeding the birds.

4.10.1 Comparison with guidelines

E. coli numbers for Lake Opunake over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 34.

Table 34 Performance against guidelines at Lake Opunake

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	0 [0%]	0 [0%]

No single sample exceedance of the 'Action' or 'Alert' modes occurred during the period, and one single sample was recorded within the 'Alert' mode.

In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was good throughout the sampling season.

4.10.2 Comparison with previous summer surveys

Summary statistics for the SEM *E.* coli data collected at Lake Opunake over 14 summers is presented in Figure 43.

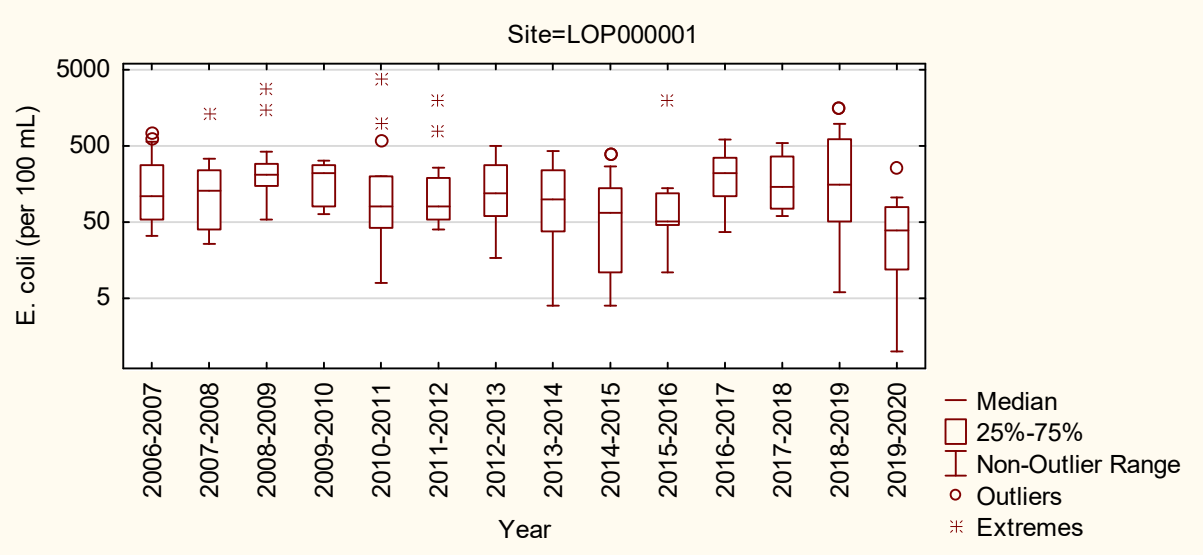


Figure 43 Box and whisker plots of *E. coli* for all summer SEM surveys at Lake Opunake

The median *E. coli* number in the 2019-2020 season was lowest for the fourteen seasons' surveys to date (Figure 43).

4.10.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the fourteen seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 44) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

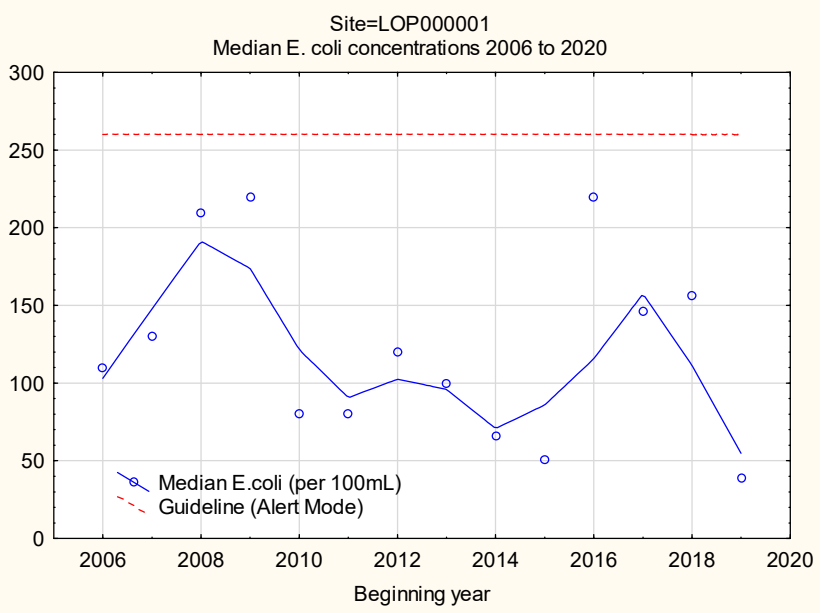


Figure 44 LOWESS trend plot of median *E. coli* data at the Lake Opunake site

Overall, a statistically insignificant decreasing trend in median *E. coli* numbers was found over the fourteen seasons of monitoring. None of these seasonal medians has exceeded the 'Alert' mode.

4.10.4 Cyanobacteria

Planktonic cyanobacteria were monitored on nine occasions throughout the season with results presented in Table 35 and Figure 45.

Table 35 Cyanobacteria counts (cells/mL) at Lake Opunake [Health warning: >1.8 mm^3/l]

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm^3/l)	Principal species by biovolume	Mode
05/11/2019	0	0.00	No cyanobacteria	Surveillance
25/11/2019	0	0.00	No cyanobacteria	Surveillance
04/12/2019	0	0.00	No cyanobacteria	Surveillance
19/12/2019	122	0.03	*Dolichospermum circinale*	Surveillance
09/01/2020	1600	0.61	*Dolichospermum planctonicum*	Alert
23/01/2020	9771	2.02	*Dolichospermum circinale*	Action
04/02/2020	2504	0.53	*Dolichospermum circinale*	Alert
26/02/2020	783	0.16	*Dolichospermum circinale*	Surveillance
12/03/2020	3960	1.54	*Dolichospermum planctonicum*	Alert

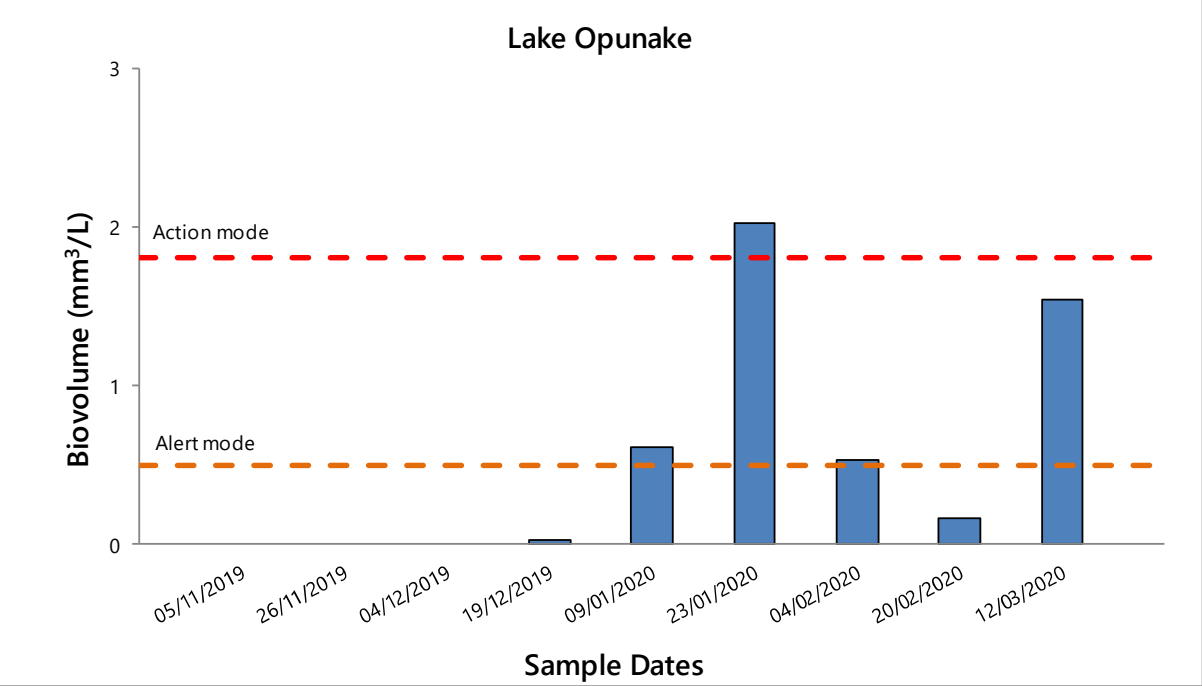


Figure 45 Cyanobacteria counts (cells/ml) at Lake Opunake [Health warning: >1.8 mm^3/l]

Planktonic cyanobacteria levels during the recreational monitoring period were generally low. The Alert level was triggered on three occasions and the Action level was triggered once. STDC erected health risk warning signage accordingly.

4.11 Timaru Stream at Weld Road (near mouth)

A total of 12 samples were collected at this site over the summer. Eleven of 13 scheduled SEM samples were collected, as well as one follow up sample.

Bathing usage was noted at this site on two sampling occasions and paddle boarding and kayaking once each between December and March, while walking, sometimes with dogs, was recorded on other occasions during the season. In previous seasons, fishing (whitebaiting in season and rod fishing) and horse riding have been observed. The site had been a popular camping area (until it was closed by NPDC during early 2005) and access point to the sea coast, but camping has occurred from time to time across on the true left bank. The site, to a certain extent tidal, showed varying degrees of saltwater penetration, particularly under very low flow recession conditions toward late summer. The general direction of flow was upstream on two of the eleven monitoring occasions with slack water or upstream surging noted on two other occasions. Gulls were present on occasions, and dogs from time to time. In previous years, larger numbers of gulls, and horse riders, have been observed.

A recreational water quality advisory sign was erected by NPDC at the car park adjacent to the monitoring site in summer 2016-2017 (Photo 8).

The adjustable cursor was set to "no swimming or food gathering" (orange alert) on one occasion in summer 2019-2020, in mid-March following an Action *level E. coli* result. This sign has been used to advise against shellfish gathering (orange alert), in relation to advisories from MBiE on paralytic shellfish poison.

Photo 6 Sign at Timaru Stream mouth, Weld Road car park

Previously, analyses for faecal source DNA tracking markers (by Cawthron Institute, Nelson) were undertaken on two fine weather, low tide, samples collected under very low flow conditions in January and early April 2013. Low *E.coli* numbers (80 and 40 per 100 ml) were found to be coincident with bacteria of ruminant and wildfowl origin, typical of sites in the lower reaches of streams and rivers elsewhere on the ringplain.

River flow records for the 2019-2020 season are provided in Figure 47.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 46 and summarised in Table 36. The complete survey results are presented in Appendix I.

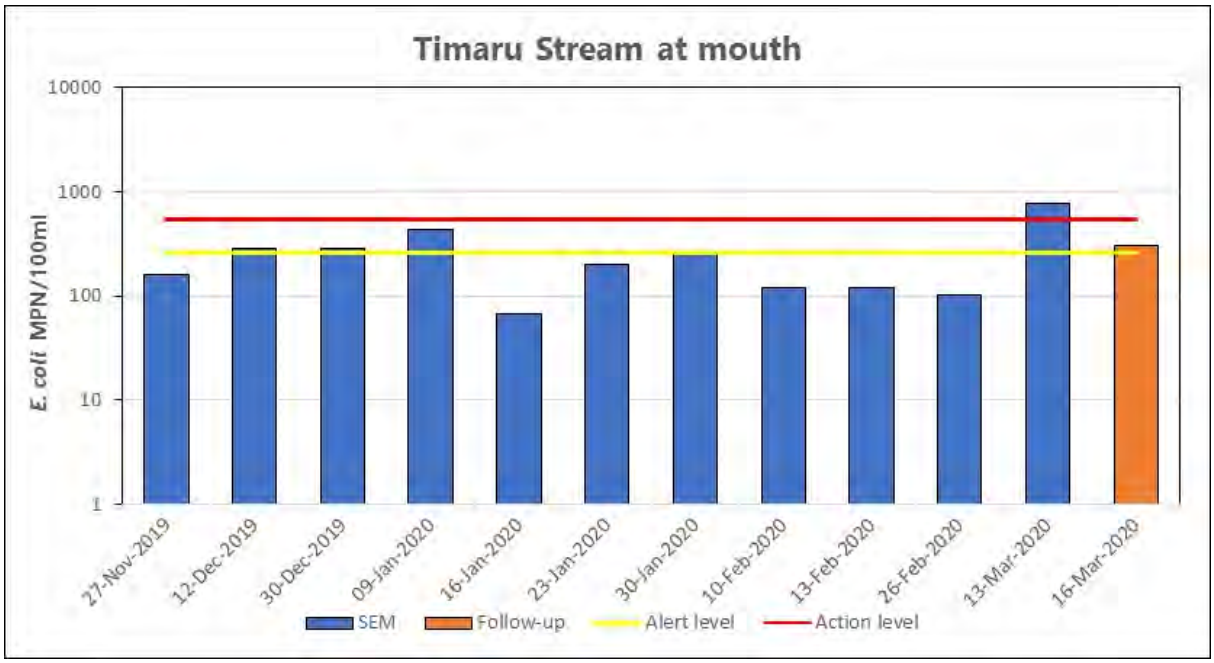


Figure 46 *E.coli* results for Timaru Stream at Weld Road

Table 36 Statistical summary for Timaru Stream at Weld Road

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	137	18,410	969
	E. coli	MPN/100 ml	11	68	770	204
	Temperature	°C	11	15.5	23.5	18.1
	Turbidity	FNU	11	0.38	2.6	0.62

This river drains a moderately farmed catchment (five consented dairy farm discharges) receiving point and non-point source discharges from dairy farms, although it is relatively short in length, rising partly in the nearby Kaitake range and the north-western area of Egmont National Park. Conductivity levels varied markedly in response to saltwater penetration at this site and were elevated on all but one occasion during routine monitoring and particularly in mid to late summer-autumn under low stream flow conditions.

Turbidity levels were very low on all but two occasions through the season, consistent with the generally clear appearance of the river. Minimal algal cover was noted in association with the good aesthetic appearance of the river due to the sandy substrate at this deeper, ponded site. Water temperature varied over a moderate range of 8.0°C with a maximum water temperature of 23.5°C recorded in early afternoon in late January 2020. This maximum could have been expected to have been exceeded later in the day.

Bacteriological water quality at this site was generally average and typical of the lower reaches of other Taranaki ring plain streams draining agricultural catchments. In view of the record high median *E. coli* level for the 2016-2017 season (330 cfu/100 ml), an investigation into the cause(s) was carried out in 2017-2018, involving resampling on several occasions, re-inspection of the farm dairy waste disposal systems, and survey of riparian areas above the monitoring site. Water samples, taken in December 2017 and January 2018 (both at 'Action' level for *E. coli*), were subjected to PCR marker analysis to establish possible microbial sources, whether human, avian, ruminant or equine. No human or horse marker was detected, and some (possibly aged) ruminant marker and avian marker were present. The farm waste disposal and riparian inspections found nothing amiss.

Stock access to the lower stream (which was crossed to reach adjacent farmland at times) during the prolonged dry period of the 2007-2008 season (requiring remedial action after incidents were reported by the general public) was not repeated or recorded in any subsequent seasons nor in the current season. Surveys in other rivers with tidal pool reaches have found that bacteriological water quality may deteriorate probably as a result of ponding of the flow and 'accumulation' of slugs of poorer quality downstream flow, and some higher *E. coli* numbers were coincidental with more ponded conditions (during elevated conductivity events). Ponding appears to have increased in the last four seasons.

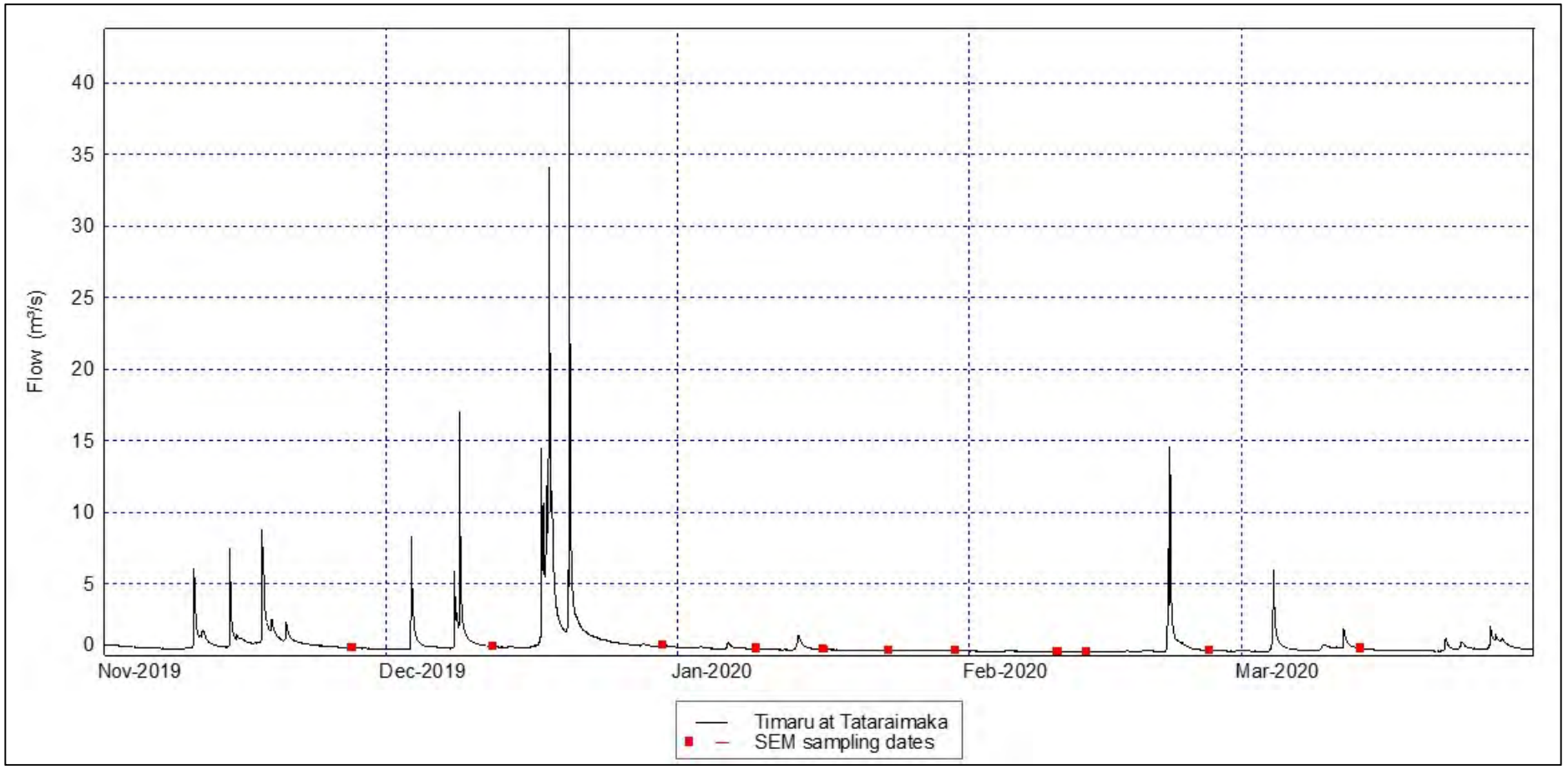


Figure 47 Flow in the Timaru Stream at Tataraimaka during the survey period

4.11.1 Comparison with guidelines

E. coli numbers for the Timaru Stream at Weld Road over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 37.

Table 37 Performance against guidelines at Timaru Stream at Weld Road

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	3 [27%]	1 [9%]

Three single samples were recorded in the 'Alert' mode, and one sample was recorded in the 'Action' mode during the period. Poorer bacteriological water quality tended to coincide with sampling earlier in the day. On the occasion that the 'Action' level was exceeded, NPDC adjusted the health advisory sign at the stream mouth to warn against swimming. Follow-up sampling after 3 days indicated that water quality for contact recreation had returned to an acceptable level.

In terms of the 2003 contact recreation guidelines, the bacteriological water quality at the site was moderate, although partly affected by the ponding caused by the site's proximity to the sea coast.

4.11.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Timaru Stream mouth over 23 summers is presented in Figure 48.

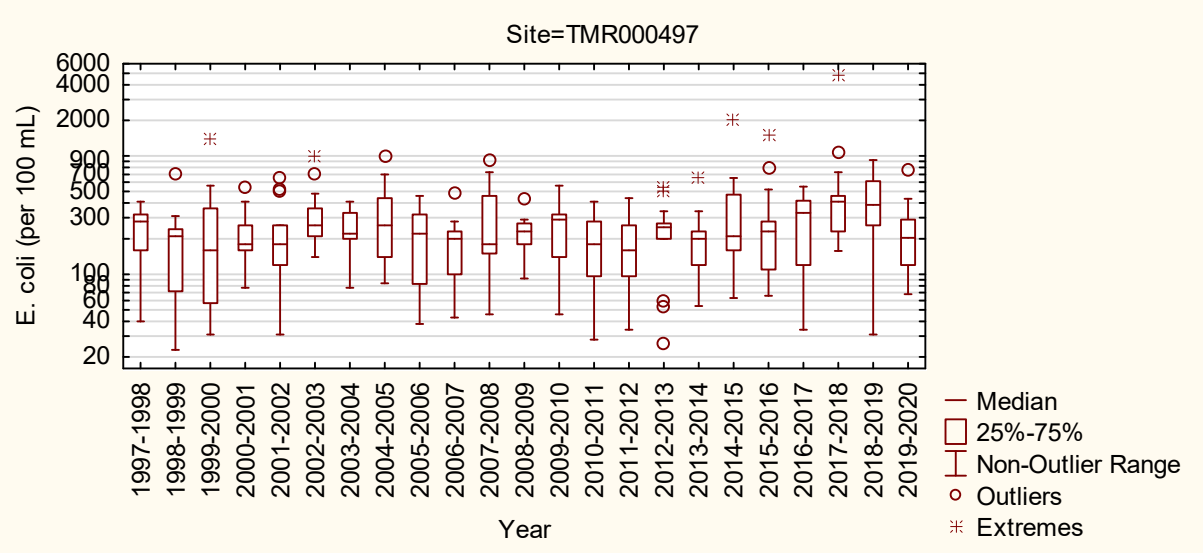


Figure 48 Box and whisker plots of *E.coli* for all summer surveys in the Timaru Stream at lower Weld Road

The median *E. coli* number for the 2019-2020 season was near the average of medians recorded over twenty-three years of monitoring, following the highest three years' on record. Numbers over the 2019-2020 season had a moderate range (Figure 48).

4.11.3 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the twenty-three seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 49) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.

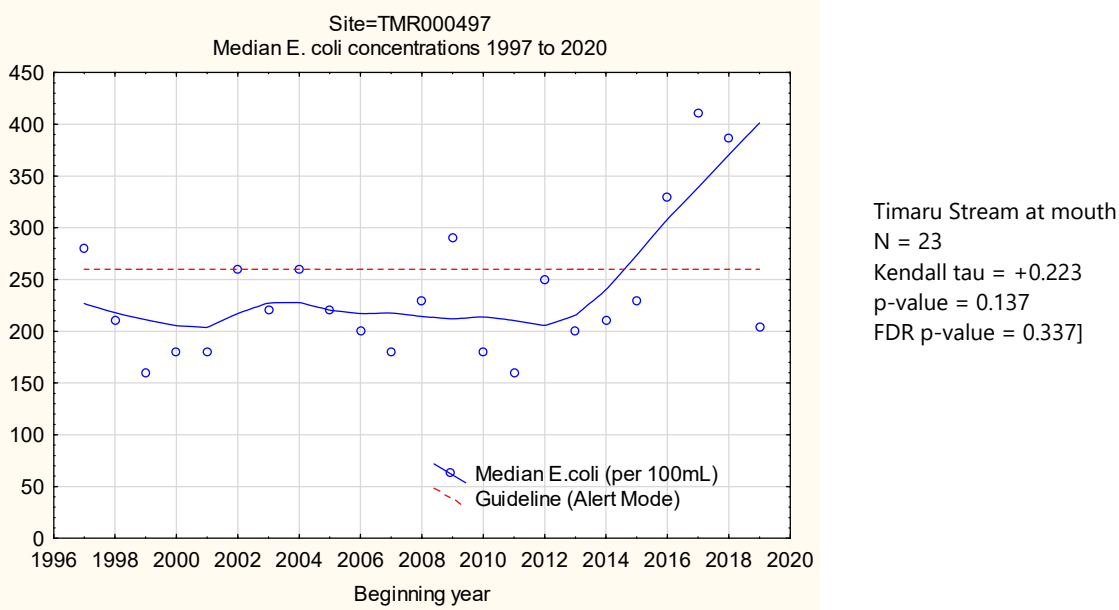


Figure 49 LOWESS trend plot of median *E. coli* data at Timaru Stream, lower Weld Road site

An overall slight, increasing trend in median *E. coli* numbers has been found over the twenty-three seasons of monitoring which has not been statistically significant. None of these seasonal medians exceeded the 'Action' mode, although the medians for the initial, 2008-2009 and the previous three seasons entered the 'Alert' mode and three others have been very close to the 'Alert' mode from time to time at this site.

4.11.4 Cyanobacteria

No benthic cyanobacteria surveys were performed at this site as it is often ponded above a sandy substrate due to tidal influences.

4.12 Waimoku Stream at Oakura Beach

The easy access to this small stream which flows and often ponds across Oakura beach, the most popular recreational beach in north Taranaki, provides a convenient contact recreational area for children in particular. Bacteriological monitoring and various investigation surveys have been performed at this site from time-to-time, particularly in relation to septic tank wastes disposal in Oakura, the interpretation of coastal bathing beach water quality, and for assessment of the effectiveness of Council's water policies. Such a survey at the mouth and upstream of Oakura township during the 1998-1999 bathing period, and two more recent catchment surveys in the 2004-2005 (TRC, 2005) and 2009-2010 periods (TRC, 2010a) indicated that the relatively high bacterial numbers found in the stream at the coast were also apparent in the Waimoku Stream upstream of the township, where some stock access and extensive wildfowl populations contributed to high bacterial numbers. This was particularly apparent in certain tributaries upstream of the coastal township and therefore not attributable to domestic wastes disposal practices within Oakura township. Historical data have highlighted the poor bacteriological water quality regularly exhibited in this stream resulting in considerable publicity. More appropriate, permanent health warning

signage was erected by NPDC in consultation with the Area Health Board in positions of public prominence. As a consequence, bacteriological samples collected during the first half of the 2009-2010 programme were also analysed by Cawthron Institute, Nelson using faecal source DNA tracking marker techniques in association with high *E.coli* numbers at this site. All samples were found to contain bacteria indicative of wildfowl (principally ducks and other species) origin, with minimal ruminant (cattle) sources and no indications of human origin. (Note: Currently, there are no markers available for specific pukeko faecal identification). These results were consistent with the conclusions of the catchment survey reports referenced above. Planting of streamside vegetation as a component of a riparian management scheme (in cooperation with landowners) although contributing to aspects of bacteriological water quality improvement in the lower reaches of the stream may also provide habitat for wildfowl species. Management of dairy farm wastes in the catchment will also continue to be monitored in conjunction with bathing water quality as a long-term component of the SEM programme. The completion of a newly reticulated sewerage system (by NPDC in 2010), with Oakura domestic wastewater collected and pumped to the New Plymouth WWTP, will also ensure that surface water bacteriological water quality will not be compromised by septic tank effluent seepages in the township.

The frequency of monitoring at this site was reduced to triennial surveys following the 2010-2011 survey, with the 2019-2020 survey being the third at this frequency.

Eleven of 13 scheduled SEM samples were collected.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 50 and summarised in Table 38. The complete survey results are presented in Appendix I.

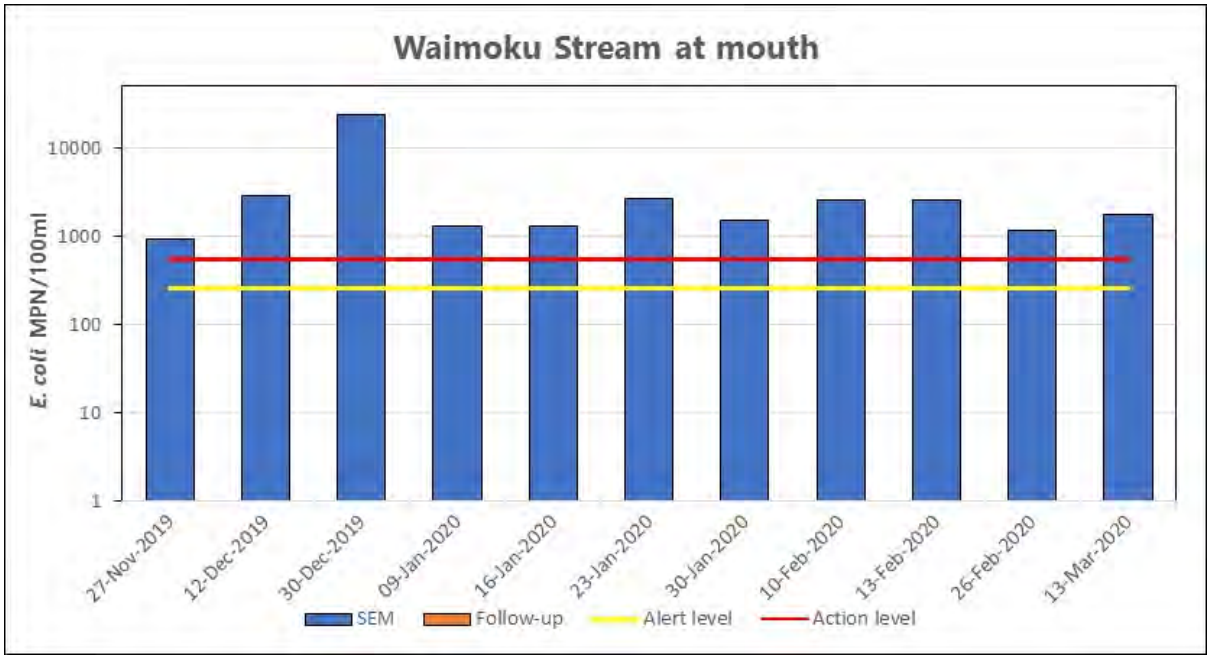


Figure 50 *E.coli* results for Waimoku Stream at Oakura beach

Table 38 Statistical summary for Waimoku Stream at Oakura beach

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	168	529	183
	E. coli	MPN/100 ml	11	934	>24200	1785
	Temperature	°C	11	13.4	21.0	15.9
	Turbidity	FTU	11	0.92	3.3	1.4

This stream drains a catchment receiving very few dairy point source discharges together with non-point source run-off from these dairy farms over a relatively short distance from its source in the Kaitake Range to the sea. The stream flows for a short distance through Oakura township where sewage disposal is mainly via a pumped reticulation system (transferring sewage to the New Plymouth Wastewater Treatment Plant) that was completed by NPDC in 2009, although not all domestic wastes have been connected to this system. Wildfowl (ducks and pukeko in particular) are present in significant numbers on the stream or at the stream edges, particularly in some of the smaller tributaries (TRC, 2005 and TRC, 2010a), and have been confirmed as major sources of faecal contamination by DNA marker investigations.

Conductivity levels were relatively stable throughout the survey period with two of instances of slight salt water intrusion recorded. The stream was relatively clear in appearance. The streambed had widely varying cover (0 to 100%) of periphyton growth, depending on the proximity of sampling time to freshes. Water temperatures varied over a moderate range of 6.6°C with a maximum water temperature of 21.0°C recorded in early afternoon in late January 2020. Water temperatures later in the day could be anticipated to exceed the maximum recorded as all sampling at this site was performed prior to 1350 hrs.

Bacteriological water quality was very poor throughout the survey period, and characterised by high *E. coli* numbers. Although elevated numbers have also been found in other ponded tidal reaches of ring-plain rivers and streams, numbers in this small stream were comparatively much higher. On-site farm dairy waste disposal practices during the season indicated a good standard of compliance. However, the presence of ducks (and other wildfowl, particularly pukeko) and possibly some stock access to this small stream and tributaries upstream of the survey site could be expected to have contributed substantially to these elevated bacterial numbers (see TRC, 2005 and TRC, 2010a).

4.12.1 Comparison with guidelines

E. coli numbers for the Waimoku Stream at Oakura beach over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 39.

Table 39 Performance against guidelines at Waimoku Stream at Oakura beach

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT **Single sample** **261-550/100 ml**	**ACTION** **Single sample** **>550/100 ml**
SEM samples	0 [0%]	11 [100%]

All thirteen single samples were recorded in the 'Action' mode,

In summary, bacterial water quality at this site at the mouth of this small stream consistently failed to achieve the guidelines for contact recreational usage throughout the survey period as it has in the past. However, the coastal bathing waters monitored adjacent to the stream mouth (main Oakura beach) met the

enterococci 'Surveillance' mode guideline on 17 of 19 sampling occasions (median: 18 per 100 ml), with two individual samples entering the 'Alert' mode and none entering the (first stage of) 'Action' mode in these coastal waters. The proximity of this small inflow from the Waimoku Stream only slightly impacted on the main beach water quality.

4.12.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Waimoku Stream mouth over 18 summers since 1996-97 is presented in Figure 48.

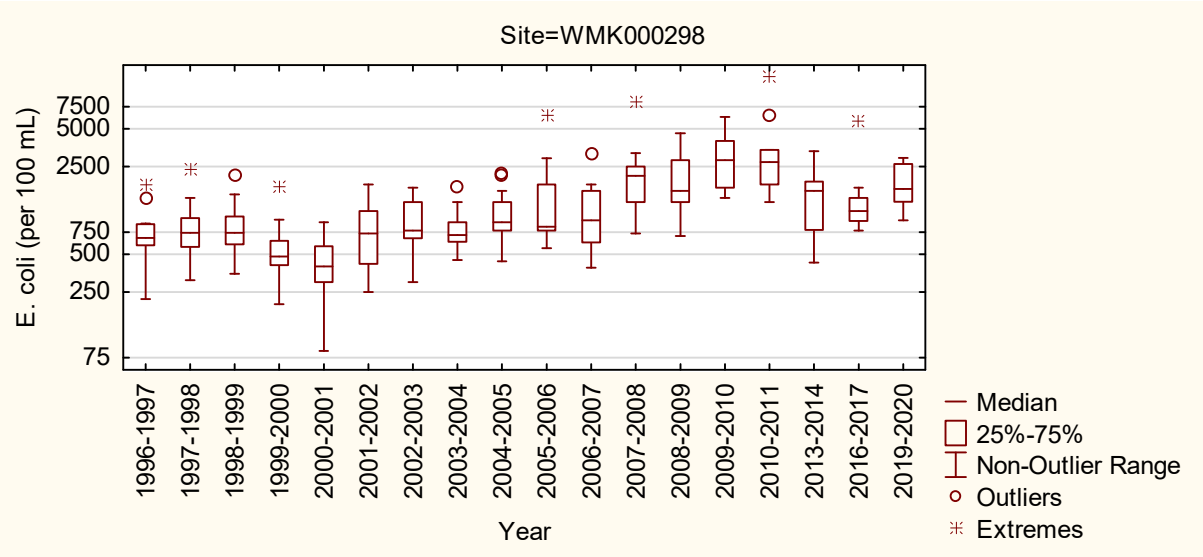


Figure 51 Box and whisker plots of *E.coli* for all summer surveys in the Waimoku Stream at Oakura beach

The very high median *E. coli* number for the 2019-2020 season continued the more recent seasons' high median bacterial levels, with the equal fifth highest median of the eighteen seasons' surveys and a relatively wide range of numbers. The trend of relatively high minimum numbers also continued, indicative of poor bacterial water quality, long associated with this small predominantly agricultural catchment stream with high wildfowl numbers.

4.12.3 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the eighteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 49) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.

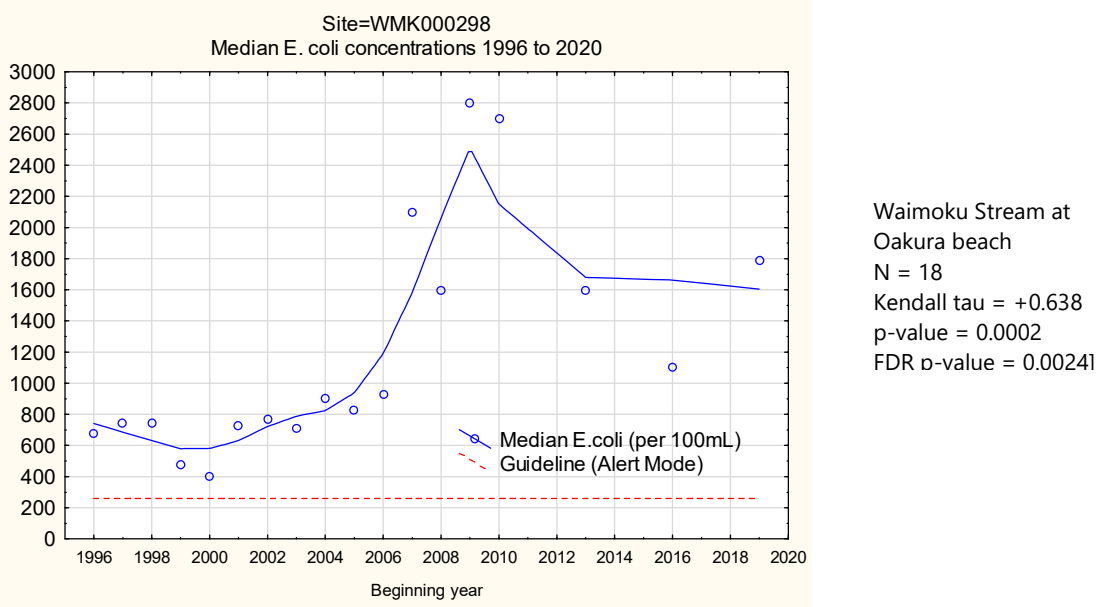


Figure 52 LOWESS trend plot of median *E. coli* data at Waimoku Stream, Oakura beach site

A very significant increasing trend in median *E. coli* numbers has been found over the eighteen seasons of monitoring. All of these seasonal medians exceeded the 'Alert' mode and all but two of the earlier seasonal medians have exceeded the 'Action' mode.

4.13 Oakura River below SH45

Eleven of the 13 scheduled SEM samples were collected.

Bathing usage was recorded on five occasions at this site where people were often present on the riverbank at this very accessible tidal site. Whitebaiting (in season) and rod fishing have been observed in previous years. Ponding and upstream surging frequently occurred under high tide conditions, and gulls and dogs were recorded occasionally on or in the river. Stock access opposite the site has been apparent in some previous seasons, but was not recorded during the current period.

A recreational water quality advisory sign was erected by NPDC at the car park adjacent to the monitoring site in summer 2016-2017 (Photo 7).

The adjustable cursor may be set to "no health warning in place" (green) "no swimming or food gathering" (orange alert) or "no dogs or swimming" (red alert for cyanobacteria). No alert was indicated during the summer 2019-2020 monitoring period.

Photo 7 Sign at Oakura River mouth

Faecal source DNA tracking markers analyses (by Cawthron Institute, Nelson) had been performed on two low tide, fine weather samples collected in mid-January 2013 and early April 2013 under very low flow conditions upstream of Oakura township as well as the usual site. *E. coli* numbers were low (80 and 23 per 100 ml upstream and 100 and 20 per 100 ml downstream) and found to be coincident with bacteria of ruminant and wildfowl origin only, similar to the lower reaches of ring-plain rivers and streams elsewhere.

All data for this site, from the 2019-2020 summer period, are presented in Figure 53 and summarised in Table 40. The complete survey results are presented in Appendix I.

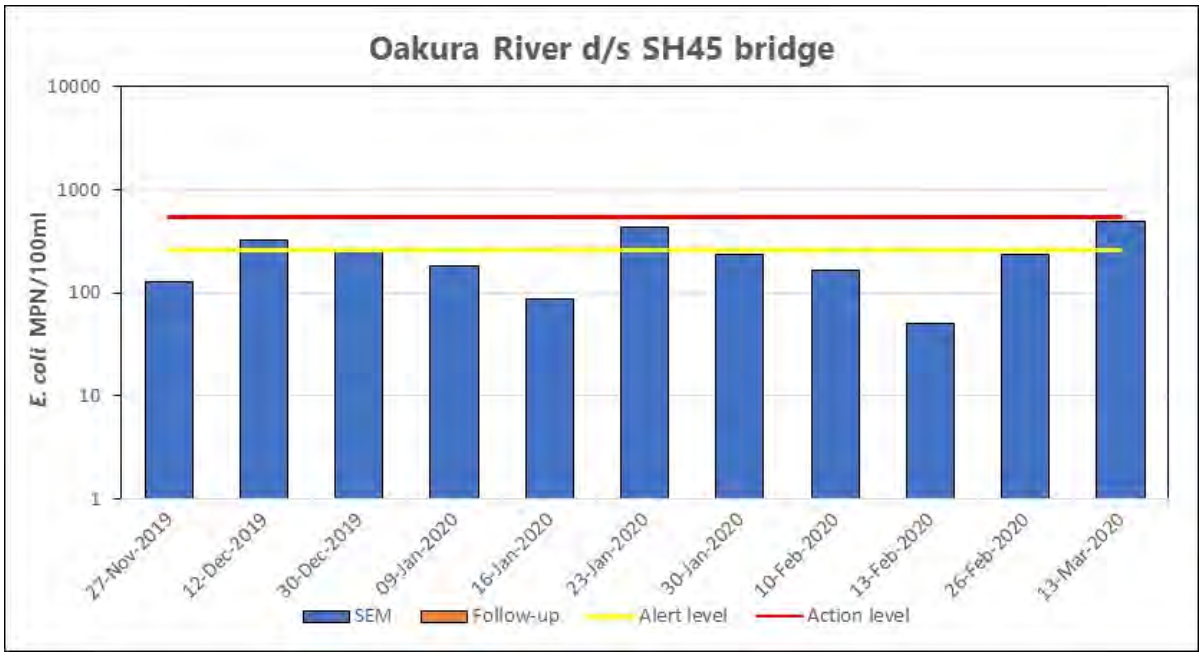


Figure 53 *E. coli* results for Oakura River below SH45

Table 40 Statistical summary for Oakura River below SH45

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	104	3,370	286
	E. coli	MPN/100 ml	11	50	488	238
	Temperature	°C	11	15.6	24.2	18.9
	Turbidity	FNU	11	0.22	3.5	0.65

This river drains a mainly agricultural catchment (three consented dairy farm discharges to surface water) with the survey site established in the popular short tidal reach between SH45 and the mouth of the river. The river was noted as tidal with ponding or inflowing obvious on two sampling occasions. Conductivity levels indicated a variable influence of saltwater intrusion on at least seven sampling occasions during the season. The more significant intrusions occurred mainly in low flow conditions during the latter half of this season. On each occasion the river was relatively clear in appearance, except during a king tide in mid-February. There was no algal substrate cover, due to the sandy nature of much of the substrate. Water temperatures varied over a moderate range (8.6°C) during the period reaching a maximum of 24.2°C in mid-afternoon in late January 2020, but below the maximum water temperature which might be anticipated later in the day as all sampling at this site occurred no later than 1400 hrs.

Bacteriological water quality was generally moderate, but with a relatively narrow range of *E. coli* numbers with no value over the acceptable guideline. Bacteriological water quality was not dissimilar to that found elsewhere in ponded tidal reaches of ring-plain rivers and streams, probably as a result of the occasional 'accumulation' of slugs of poorer quality downstream flow. This may have resulted from upstream stock access, agricultural non-point source runoff and/or point source discharges.

4.13.1.1 Comparison with guidelines

E. coli numbers for the Oakura River at the mouth over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 41.

Table 41 Performance against guidelines at Oakura River below SH45

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	3 [23%]	0 [0%]

Three single samples fell within the 'Alert' mode, and no sample entered the 'Action' mode. Health warning signage (Photo 7) was not required to be displayed at this site by NPDC.

In terms of the 2003 contact recreation guidelines, the bacteriological water quality at the site was relatively poor, though it was within the acceptable single sample guidelines for contact recreational usage throughout the sampling season.

4.13.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Oakura River mouth over 24 summers is presented in Figure 54.

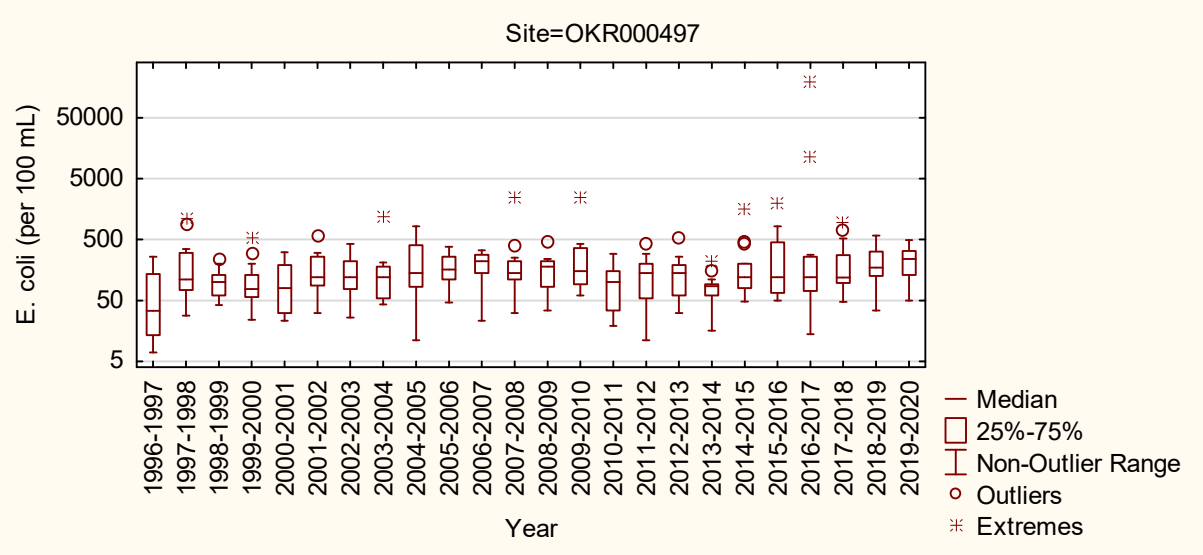


Figure 54 Box and whisker plots of *E. coli* for all summer surveys in the Oakura River below SH45

The median *E. coli* number was the highest recorded, and the range was in the middle of past seasons' results (Figure 54). No median *E. coli* numbers have exceeded the 2003 guidelines for contact recreational usage over the twenty-four seasons of monitoring.

4.13.3 Long-term trend analysis

Trend analysis of these median E. coli numbers has been performed for the twenty-four seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 55) and testing the significance of any trend using the Mann-Kendall test at 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.

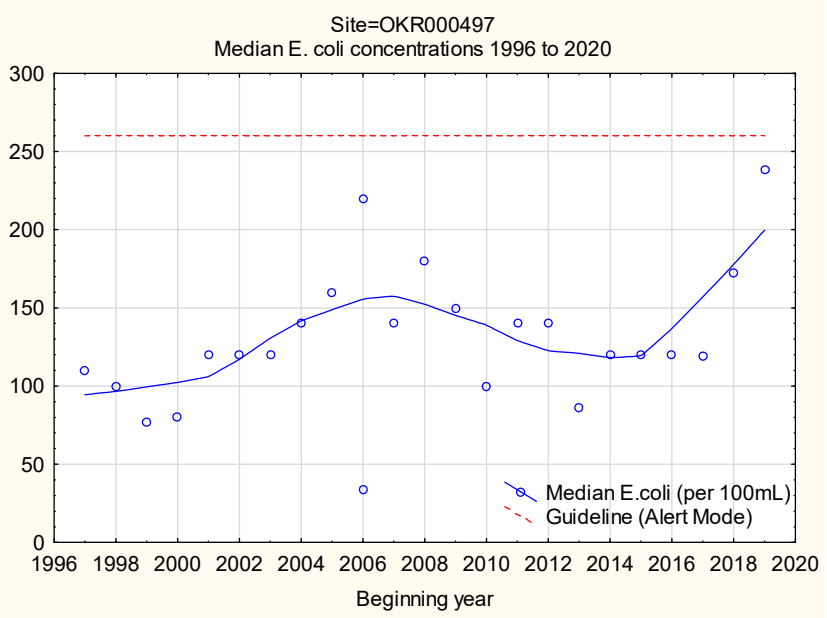


Figure 55 LOWESS trend plot of median *E.coli* data at the Oakura River, SH 45 site

An increasing, but insignificant, overall trend in median *E. coli* numbers has been found over the twenty-four seasons of monitoring. However, none of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.13.4 Cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season in a more appropriate reach, upstream of the SH45 bridge, with results presented in Table 42 and Figure 56.

Table 42 Percentage benthic cyanobacteria cover, detached and exposed mats at the Oakura River upstream of SH45 Bridge

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	0	No	No	Surveillance
21/11/2019	2	No	No	Surveillance
04/12/2019	1	No	No	Surveillance
19/12/2019	0	No	No	Surveillance
08/01/2020	2	No	No	Surveillance
23/01/2020	1	No	No	Surveillance
04/02/2020	1	No	No	Surveillance
19/02/2020	0	No	No	Surveillance
05/03/2020	0	No	No	Surveillance
18/03/2020	1	No	No	Surveillance

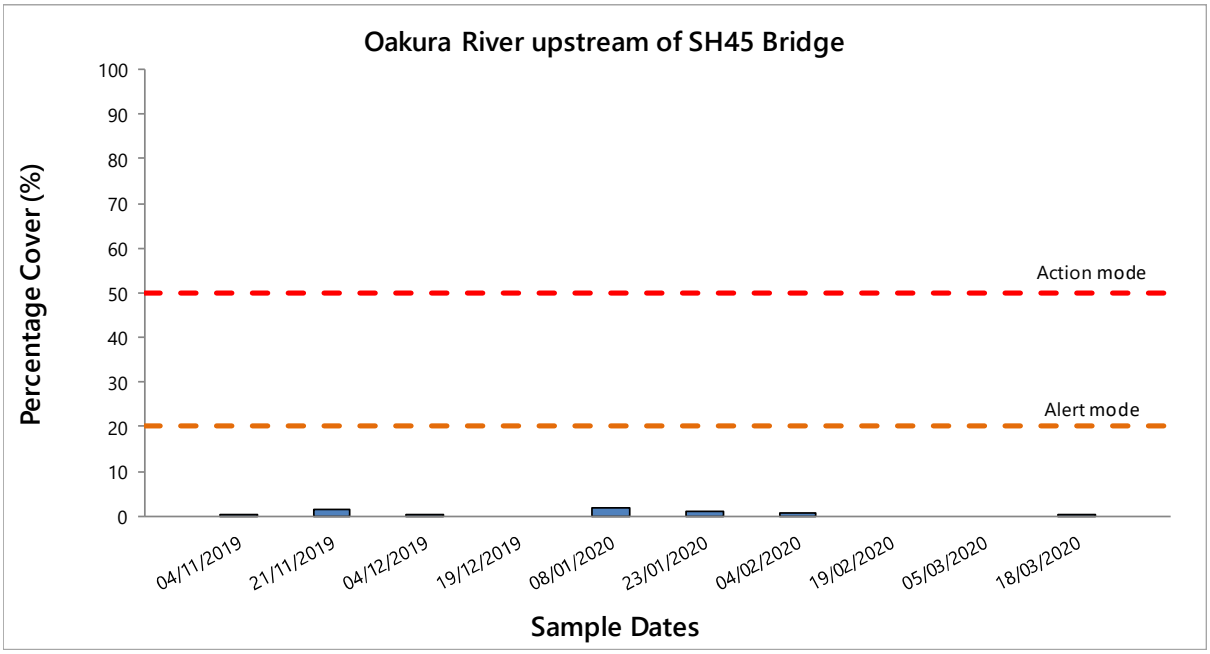


Figure 56 Percentage benthic cyanobacteria cover at the Oakura River upstream of SH45 Bridge.

Note: Action' and 'Alert' mode lines are for percentage cover only. * and + symbols over a bar indicate where the status has been raised to 'Alert' or 'Action' mode respectively due to detaching or exposed mats

Benthic cyanobacteria coverage was very low throughout the season (ranging from 0 to 2%). The benthic cyanobacteria found were *Microcoleus* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover or for detaching and exposed mats.

4.14 Waitara River at the town wharf, Waitara

A total of 12 samples were collected at this site over the summer. Eleven of 13 scheduled SEM samples were collected, and one follow up sample.

Bathing usage of this river site at the town wharf was recorded twice at the time of sampling surveys, the majority of which were prior to midday. Rowing and fishing were each recorded once, and persons were walking, biking, sitting at the wharf on occasions. Whitebaiting and canoeing on the river have been noted from time-to-time in previous seasons. Ducks were often present during the period, sometimes common.

Concerns relating to the source of faecal bacteria found at this site by past monitoring, led TRC to undertake additional microbial source tracing (MST) using DNA marker techniques at four sites in the lower Waitara River during the 2010-2011 season (TRC, 2011b). In summary, faecal bacteria found at this Town Wharf site were sourced predominantly from cattle (under all tidal and flow conditions) with some indication of bacteria of human origin under high tide and flood conditions. Upstream (Bertrand Road site) faecal bacteria were totally of cattle origin whilst downstream (on both sides of the river mouth), faecal bacteria of cattle (all occasions), wildfowl and human (occasional) derivation were found.

All *E.* coli data for this site, from the 2019-2020 summer period, are presented in Figure 57 and summarised in Table 43. The complete survey results are presented in Appendix I. River flow information is illustrated in Figure 58.

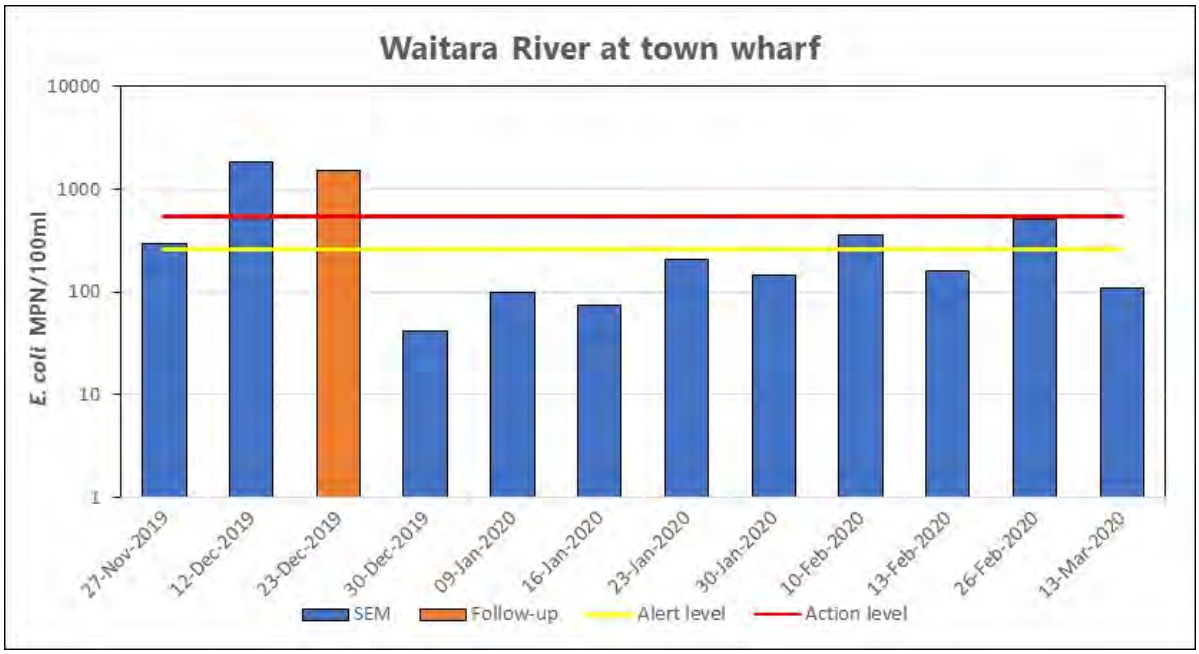


Figure 57 *E.coli* results for Waitara River at the town wharf, Waitara

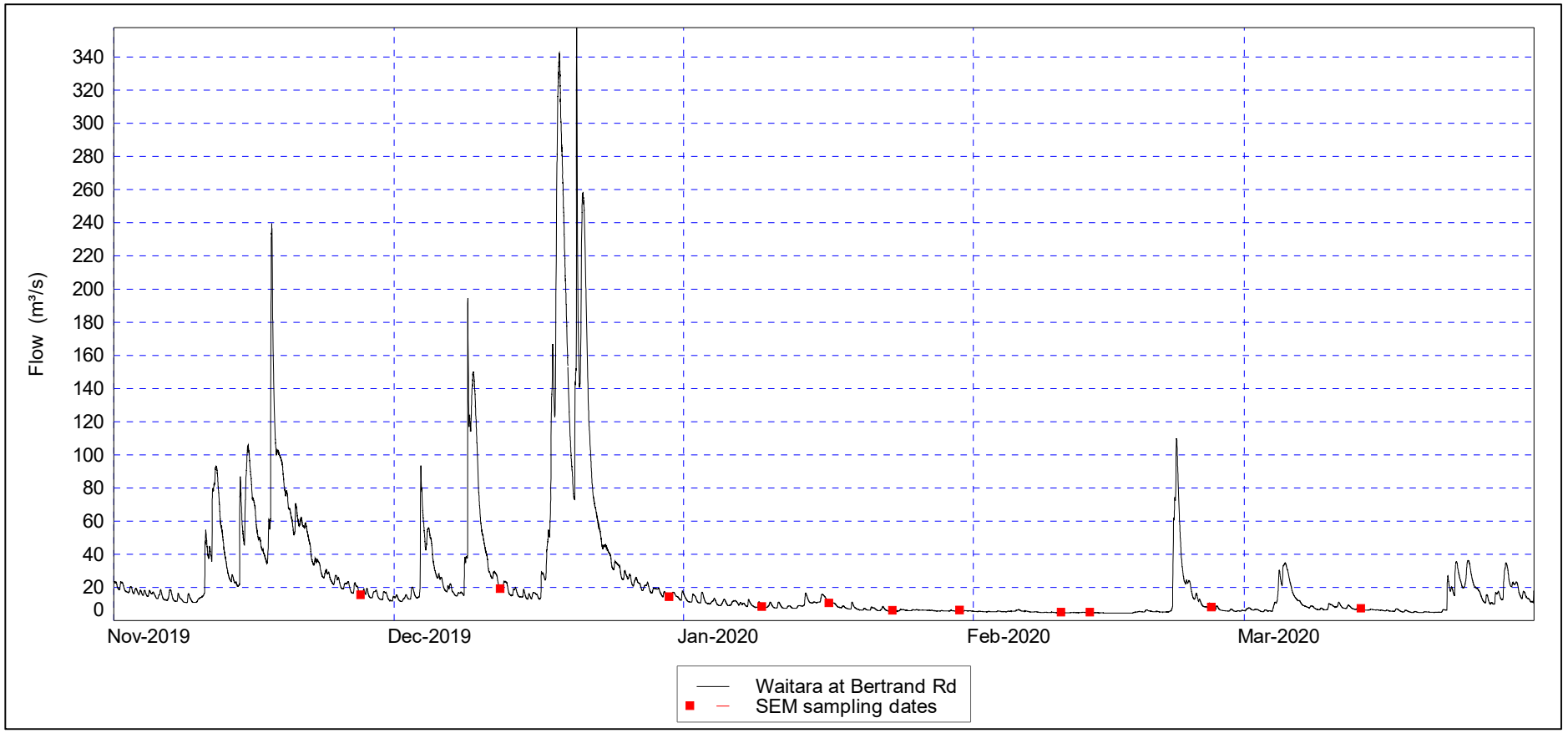


Figure 58 Flow in the Waitara River at Bertrand Road during the survey period

Table 43 Statistical summary for Waitara River at the town wharf, Waitara

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	6,610	37,770	13,530
	E. coli	MPN/100 ml	11	41	1,850	160
	Temperature	°C	11	17.5	23.6	20.3
	Turbidity	FNU	11	2.6	46	3.3

This ring plain and eastern hill country river drains an extensively developed agricultural catchment. The survey site is situated in the lower tidal reaches of this large river, some 1.5 km upstream of the river mouth. There are consented dairy ponds treated wastes discharges in the catchment upstream of the site particularly in the Manganui River sub catchment (see 4.16). River water was generally slightly turbid, green-brown to turbid brown in appearance. Elevated conductivity levels typical of seawater ingress near high tide occurred on all sampling occasions, and occasionally coincidental with ponded or very slow downstream flow conditions.

Water temperatures had a moderate range of 6.1˚C partly due to the coastal seawater influence, with a highest recorded maximum of 23.6˚C recorded in early afternoon in late January 2020. All of the samples were collected before 1330 hrs and therefore maximum river temperatures (which tend to occur later in the afternoon) were not recorded.

Bacteriological water quality was moderate, and typical for the lower reaches of this large Taranaki eastern hill country and ring plain river draining a predominantly agricultural catchment subject to coastal seawater influence under high tide conditions (median 160 *E.coli* MPN/100 ml).The existing recreational sampling programme was performed around higher tidal conditions for SEM trend purposes (due to its incorporation within the coastal sites programme) at times when public usage is often more predominant at this site. Poorer bacteriological water quality might be expected under outflowing low tide conditions, although monitoring undertaken 6km further upstream (at the flow recorder site at Bertrand Road) over the recreational period 2009-2014 has found a lower median *E.coli* bacterial number of 67 cfu/100 ml but a wider range of *E. coli* numbers (6 to 5,000 cfu/100 ml).

4.14.1 Comparison with guidelines

E. coli numbers for the Waitara River at the town Wharf over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 44.

Table 44 Performance against guidelines at Waitara River at town wharf

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	3 [27%]	1 [9%]

Three single samples fell within the 'Alert' mode and one sample within the 'Action' mode during the monitoring period. The 'Action' level occurred in mid-December 2019, less than five days after a substantial rainfall event in the hinterland. It has been noted, during past survey periods, that the three-day post rainfall sampling protocols followed by the SEM programme for the other (ringplain) catchment sites are not necessarily appropriate for baseline assessments of bacteriological water quality at this site near the mouth

of this predominantly eastern hill country catchment river as a result of the lag effects of rainfall run-off further upstream within this large catchment.

These issues were discussed with the Area Health Board and NPDC staff and appropriately worded health warning signage was permanently installed at the town wharf prior to the 2010-2011 season. However, the permanency of this signage was problematic due in part to vandalism. A new, recreational water quality advisory sign was erected by NPDC at the entrance to the town wharf in summer 2016-2017 (Photo 8).

In summary, the bacteriological water quality at this estuarine site was within guidelines for contact recreation for the large majority ot the survey period.

Photo 8 Sign at entrance to Waitara town wharf

4.14.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Waitara River Town Wharf site over 11 summers is presented in Figure 59.

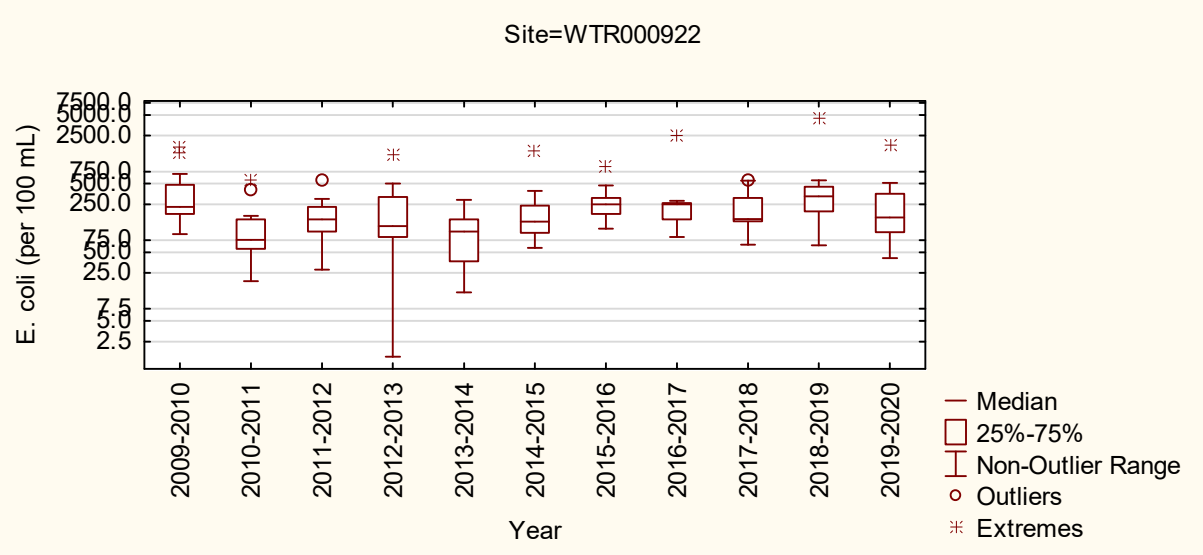


Figure 59 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waitara River at the town wharf, Waitara

The median *E. coli* number found by this eleventh season's survey was in the middle of the numbers previously recorded. The range of *E. coli* numbers was the third widest recorded, owing to one high value.

4.14.3 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the eleven seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 60) and testing the significance of any trend using the Mann-Kendall test at 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.

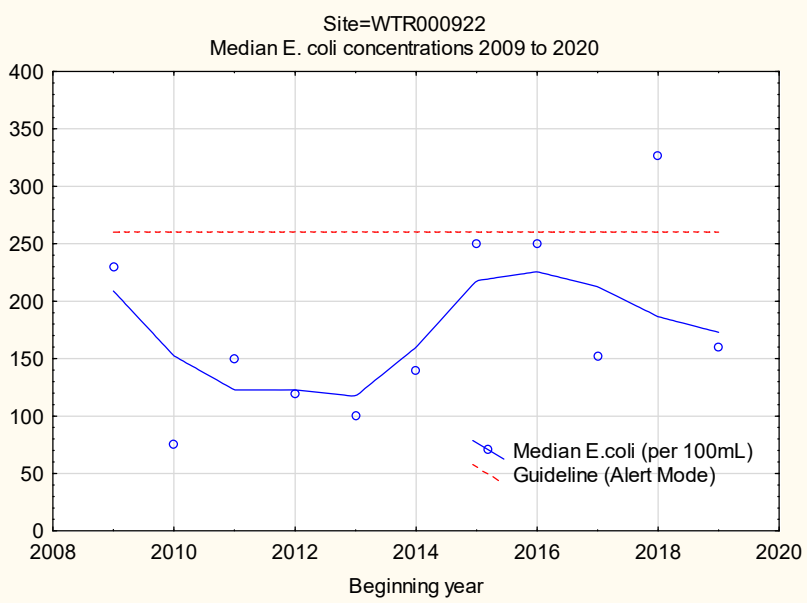


Figure 60 LOWESS trend plot of median *E.coli* data for the Waitara River at the town wharf, Waitara

An increasing, but not statistically significant, overall trend in median *E. coli* numbers has been found over the initial eleven seasons of monitoring. One of these seasonal medians exceeded the 'Alert' mode but none has exceeded the 'Action' mode.

4.15 Urenui River at the estuary

Eleven of 13 scheduled SEM samples were collected, and no follow up samples were required.

Bathing usage was noted on five occasions and some boating during the 2019-2020 sampling surveys at this tidal site. This is a very popular site during weekends and holiday periods (see TRC, 1999 and TRC, 2008a, TRC, in prep), with these and picnicking and other recreational activities taking place.

All enterococci data for this site, from the 2019-2020 summer period, are presented in Figure 61 and summarised in Table 45. The complete survey results are presented in Appendix I.

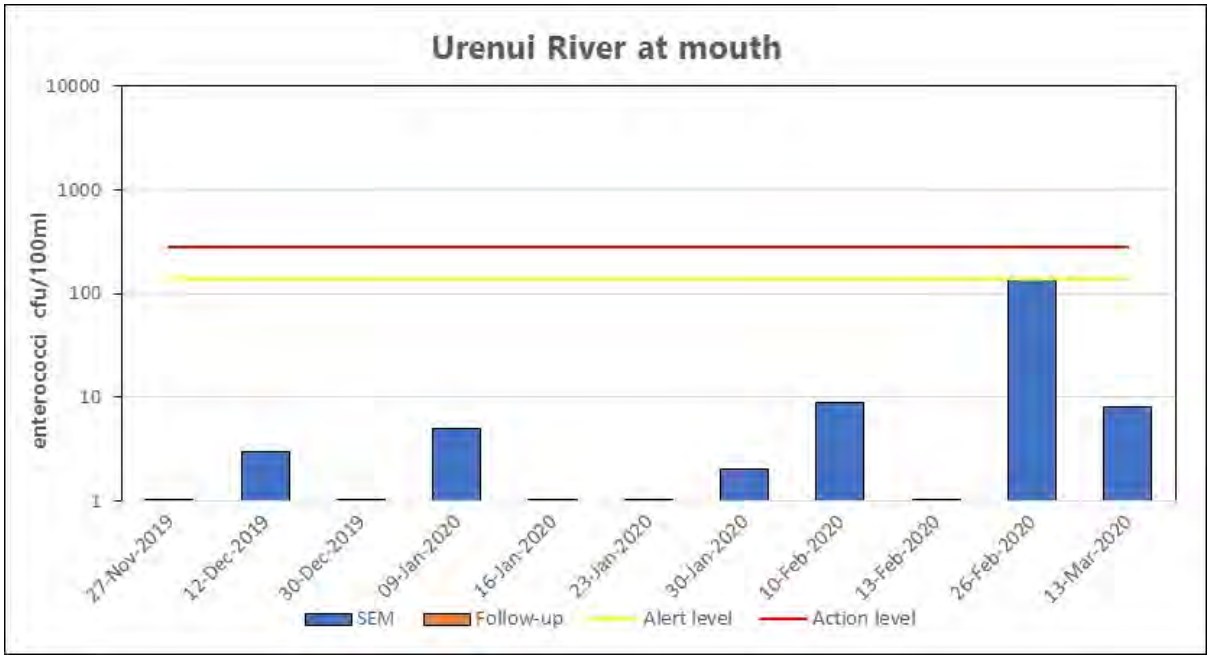


Figure 61 Enterococci numbers for the Urenui River at the estuary during the survey season

Table 45 Statistical summary for Urenui River at the estuary

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	50,800	52,600	51,700
	E. coli	MPN/100 ml	11	<1	210	5
	Enterococci	cfu/100 ml	11	<1	140	2
	Temperature	°C	11	15.1	21.5	19.9
	Turbidity	FNU	11	1.38	17.5	3.7

This hill country catchment river typically is turbid under low tide conditions in the tidal lower reaches of the estuary where it is extensively used by visitors and the holiday population based at the Urenui Beach settlement. High tide conditions resulted in aesthetic improvements within the estuary. Under high tide sampling conditions, the minimum (1.4 FNU) and median turbidity (3.7 FNU) levels were indicative of moderately turbid conditions typical of mixing of the more discoloured river flow with inflowing, clearer seawater. The river at this site was generally described as relatively uncoloured to blue-green to green-brown in appearance and varying between clear to slightly turbid to turbid. Conductivity levels were characteristic of coastal saltwater on all occasions. Moderately high water temperatures (median of 19.9°C), more typical of coastal seawater temperatures, varied over a moderate range of 6.6°C during the sampling period with a maximum of 21.5°C recorded near midday in late January 2020. All sampling however, was undertaken prior to 1320 hrs when water temperatures could have been expected to have been cooler than later in the day, depending upon the state of the tide.

Bacteriological water quality was generally very good as a result of the seawater tidal intrusion into the estuary. Poorer bacteriological river water quality might be expected under low outflowing tidal conditions as comparative sampling at the semi-tidal upstream SH3 bridge site to date has identified significantly higher numbers of both bacteriological species (e.g. medians for *E. coli* [390 per 100 ml] and enterococci [165 per 100 ml]). The existing sampling programme was designed around higher tidal conditions (for SEM trend purposes and due to its incorporation within the coastal sites sampling programme) at times when bathing is more predominant at this site.

4.15.1 Comparison with guidelines

Comparison with the 2003 guidelines for contact usage is summarised in Table 46 using the marine guidelines, which are considered to be more appropriate for this estuarine site.

Table 46 Performance against guidelines at Urenui River mouth

Parameter	Number of exceedances of enterococci guidelines	
	ALERT Single sample 141-280/100 ml	ACTION Two samples >280/100 ml
SEM samples	0 [0%]	0 [0%]

No single sample fell within the 'Alert' mode or within the 'Action' mode for saline water during the monitoring period. The same results occurred in terms of the freshwater guidelines (for *E. coli*).

The bacteriological water quality at this site was within the acceptable guidelines for contact recreational usage throughout the season, recognising that all sampling occasions coincided with mid to high tides and therefore a predominance of high quality saline water mixing with poorer quality river water at this estuarine site. This was consistent with data for the nearby Urenui Beach coastal site (median enterococci: 3 per 100 ml) monitored over eight seasons (since 1996-1997) to date.

4.15.2 Comparison with previous summer surveys

Summary statistics for the SEM enterococci data collected for Urenui River at the mouth over 24 summers is presented in Figure 62.

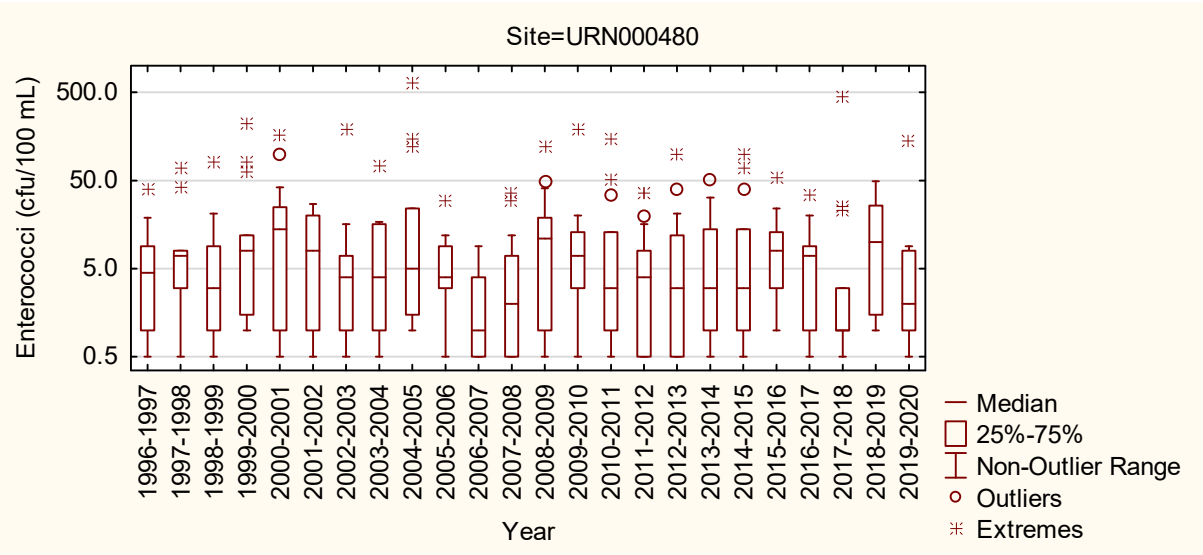


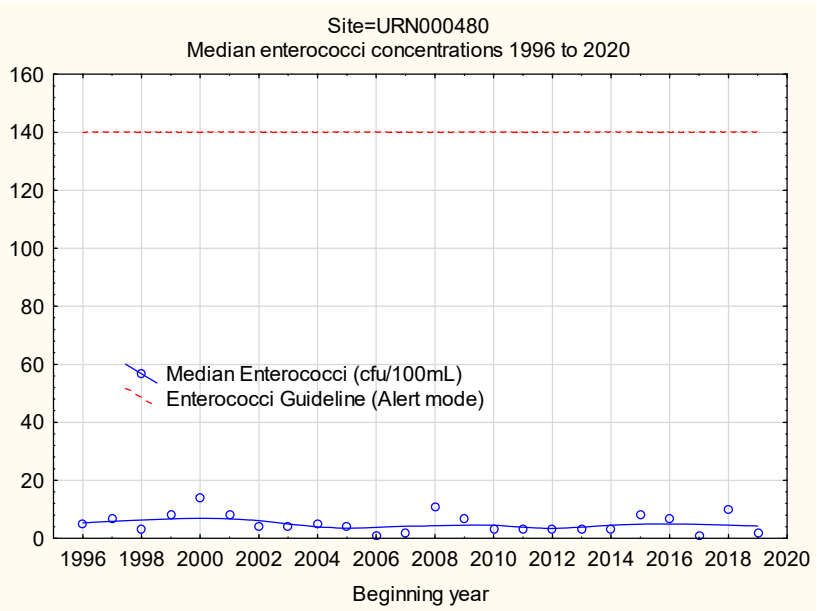
Figure 62 Box and whisker plots of enterococci for all summer surveys in the Urenui River at the estuary

The high bacteriological water quality of the Urenui River estuary, during high tide conditions, continued during the 2019-2020 season (Figure 62). This has been emphasised by all seasonal median enterococci numbers being less than 15 enterococci (per 100 ml). The range was relatively wide for enterococci during the 2019-2020 season as a result of a single higher sample number of 140 enterococci per 100 ml during the period.

The high bacteriological quality of the coastal sea water intrusion was the major influence on the bacteriological water quality of the lower quality river water at this estuarine site during preferred recreational usage (i.e. higher tide) conditions.

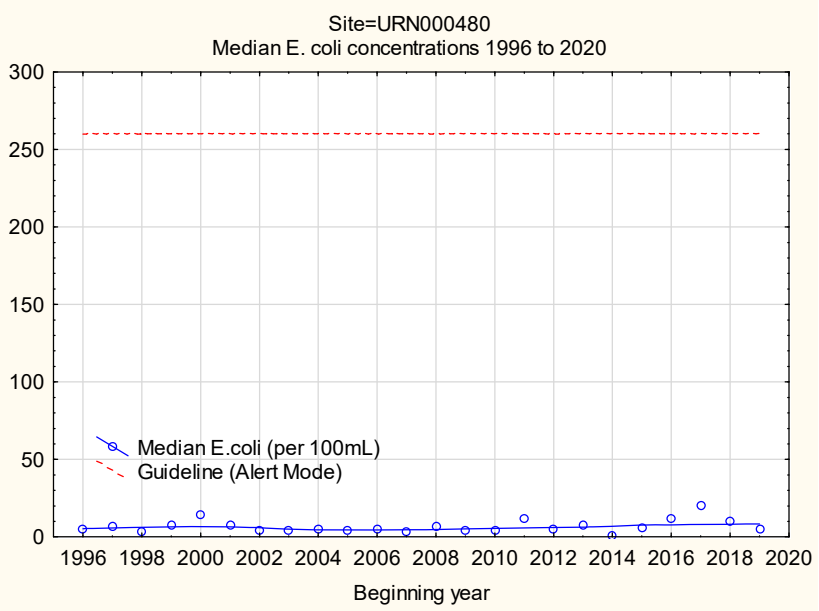
4.15.3 Long-term trend analysis

Trend analysis of median enterococci and *E. coli* numbers has been performed for the twenty-four seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 63 and Figure 64) and testing the significance of any trend using the Mann-Kendall test at 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.



Urenui River mouth - enterococci
N = 24
Kendall tau = - 0.210
p-value = 0.151
FDR p-value = 0.337

Figure 63 LOWESS trend plot of median enterococci data at the Urenui River, estuary site



Urenui River mouth – *E. coli*
N = 24
Kendall tau = +0.145
p-value = 0.322
FDR p-value = 0.483

Figure 64 LOWESS trend plot of median *E. coli* data at the Urenui River, estuary site

No statistically significant trends in median enterococci or *E. coli* numbers (after FDR applications) have been found over the twenty-four seasons of monitoring which have indicated an overall unimportant decrease in enterococci bacteria and a slight increase in *E.coli* bacteria numbers (both at very low median numbers) over this period. None of these medians exceeded the 'Alert' or 'Action' modes for either marine or freshwater contact recreational usage.

4.16 Manganui River at Everett Park (downstream of Kurapete Stream)

A total of 11 samples were collected at this site over the summer. All 11 scheduled SEM samples were collected, and no follow up samples were required.

Bathing or other usage of this river site was noted once at the time of sampling occasions during the survey period, though the site is nearby to an outdoor adventure camp. Minimal birdlife was noted at this site during this season.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 65 and summarised in Table 47. The complete survey results are presented in Appendix I. River flow records are illustrated in Figure 66.

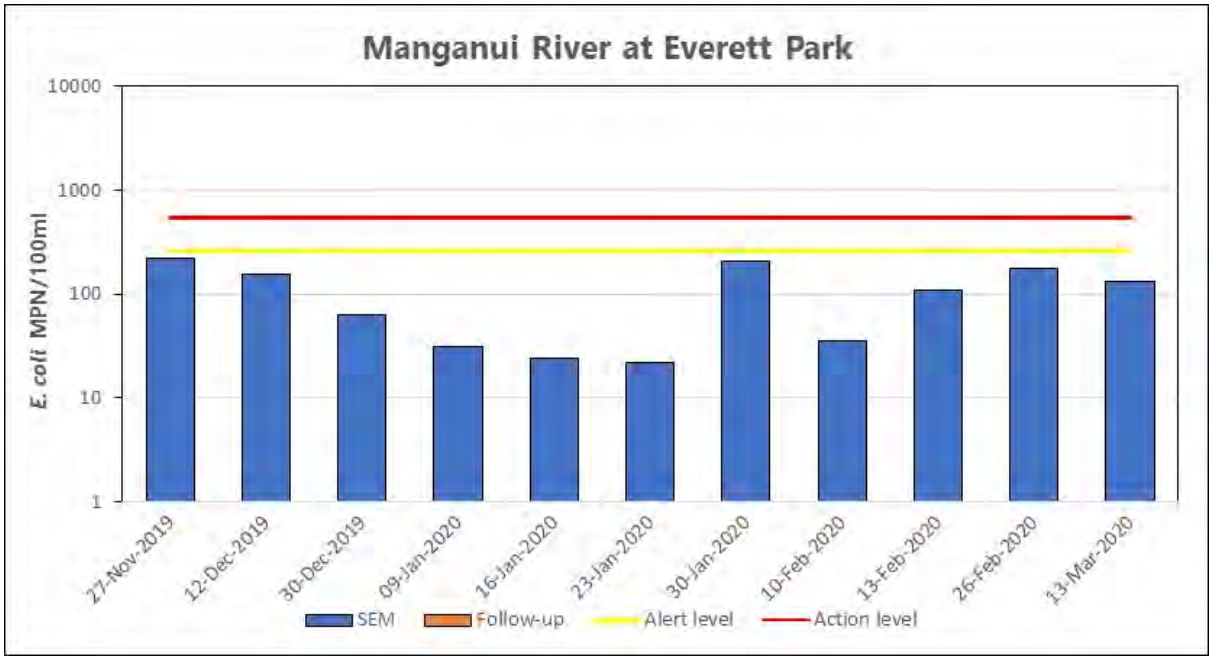


Figure 65 *E. coli* numbers for the Manganui River at Everett Park (downstream of the Kurapete Stream) during the survey season

Table 47 Statistical summary for Manganui River at Everett Park (downstream of the Kurapete Stream)

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	110	133	118
	E. coli	MPN/100 ml	11	22	219	108
	Temperature	°C	11	15.1	22.4	18.0
	Turbidity	FNU	11	0.62	1.55	0.83

This ring plain river drains an extensively developed agricultural catchment, the site surveyed being situated at Everett Park approximately 300 m downstream of the Kurapete Stream confluence, and about 500 m below another (less utilised) Manganui River recreational site, upstream of the Kurapete Stream. Since the

1999-2000 season's survey, discharges from the Inglewood municipal oxidation ponds' system into the Kurapete Stream (approximately 8 km upstream of the survey site) have been diverted out of the stream to the New Plymouth wastewater treatment plant.

The river was clear and green-brown or colourless at the time of the majority of the sampling surveys, with relatively low and a narrow range of conductivity levels. Water temperatures varied over a moderate range of 7.3°C with the maximum temperature (22.4°C) recorded in late morning in late January 2020. Higher temperatures could be expected later in the day as no sampling surveys were performed after 1145 hrs at this site.

Bacteriological water quality was good for this site during the 2019-2020 survey period with none of the numbers recorded during the period above 219 *E. coli* per 100 ml (Figure 65).

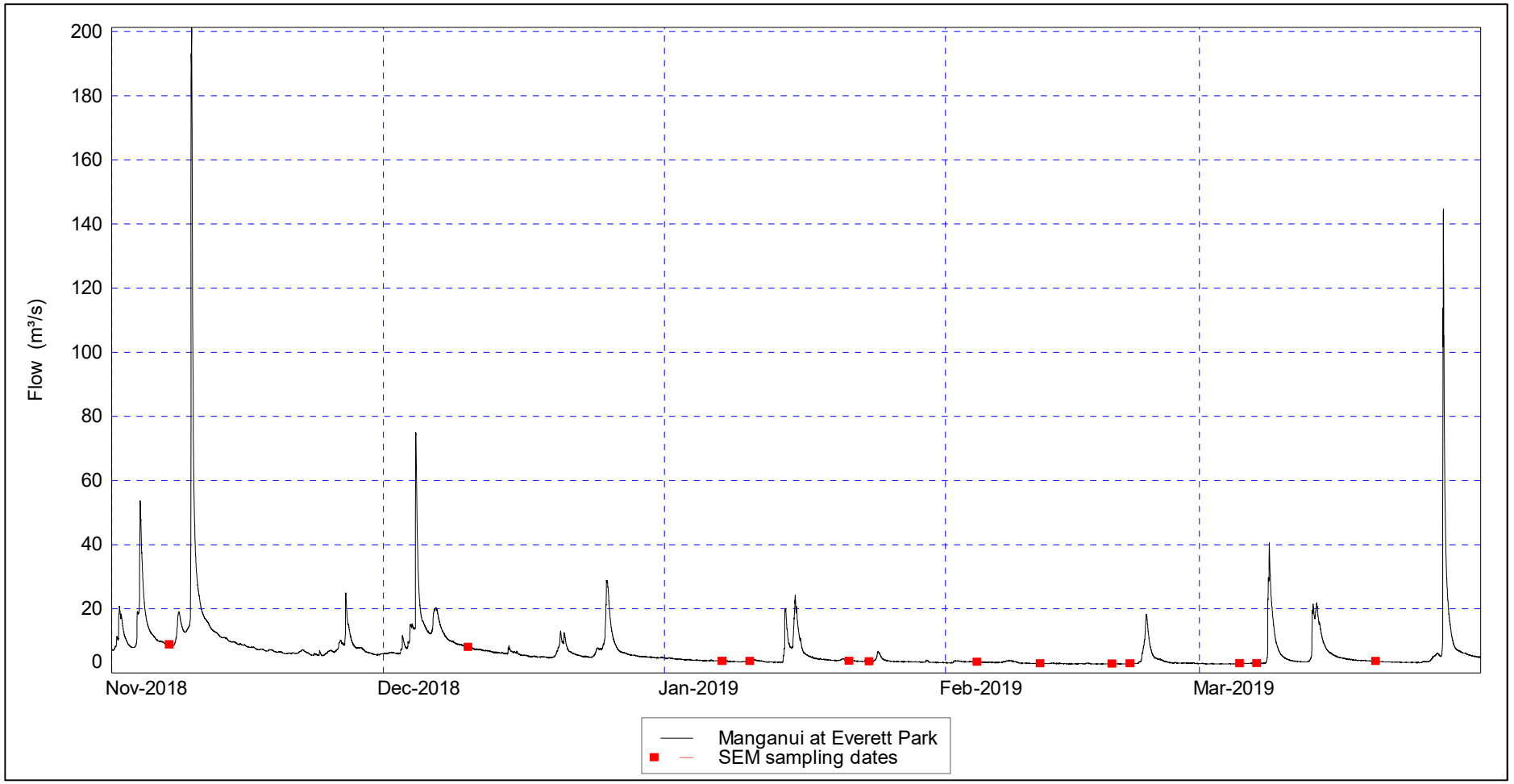


Figure 66 Flow in the Manganui River at Everett Park during the survey period

4.16.1 Comparison with guidelines

E. coli numbers for the Manganui River at Everett Park over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 48.

Table 48 Performance against guidelines at Manganui River at Everett Park

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	0 [0%]	0 [0%]

No single samples fell in the 'Alert' mode or within the 'Action' mode at any time during the season.

Bacteriological water quality at this site in terms of contact recreational usage was acceptable considering the impacts of farming activities, particularly in relation to the residual flow remaining in the river in mid-catchment downstream of the Motukawa HEP diversion (i.e., significant abstraction of upper catchment water for hydroelectric power production purposes).

4.16.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Manganui River at Everett Park over 24 summers is presented in Figure 67.

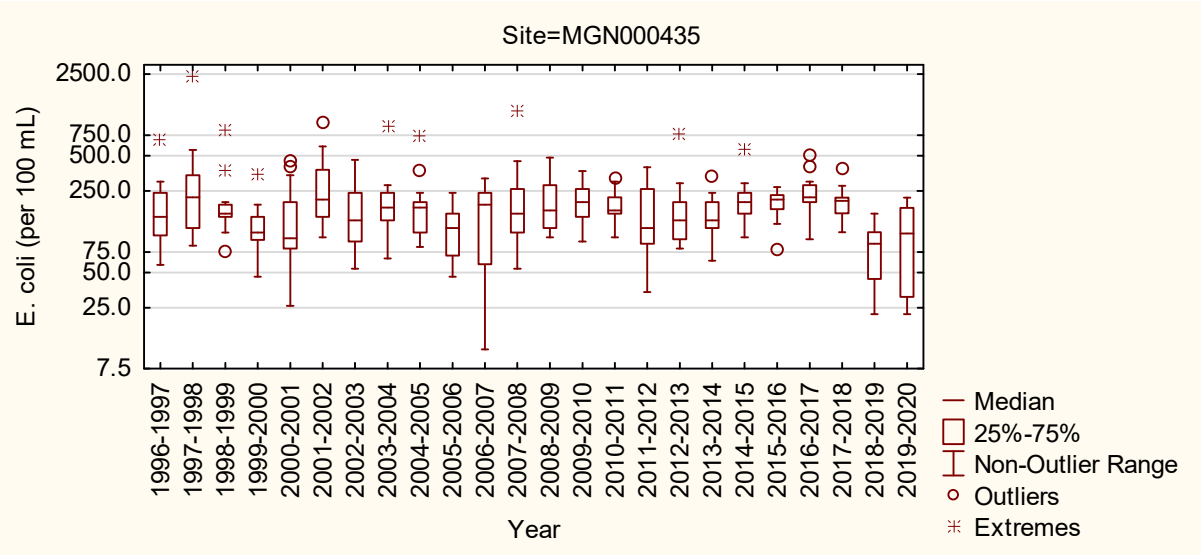


Figure 67 Box and whisker plots of *E. coli* for all summer surveys in the Manganui River at Everett Park

The median *E. coli* number for the 2019-2020 season was the third to lowest of the twenty-four seasons' medians recorded since the inception of the programme in 1996-97, following the lowest median the previous season (Figure 67). No single sample entered the alert mode. The range of *E. coli* numbers was lower than typical of those recorded to date, mainly due to a low maximum number of 219 per 100 ml, the second to lowest of seasonal maxima recorded to date at this site.

4.16.3 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the twenty-four seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 68) and testing

the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.

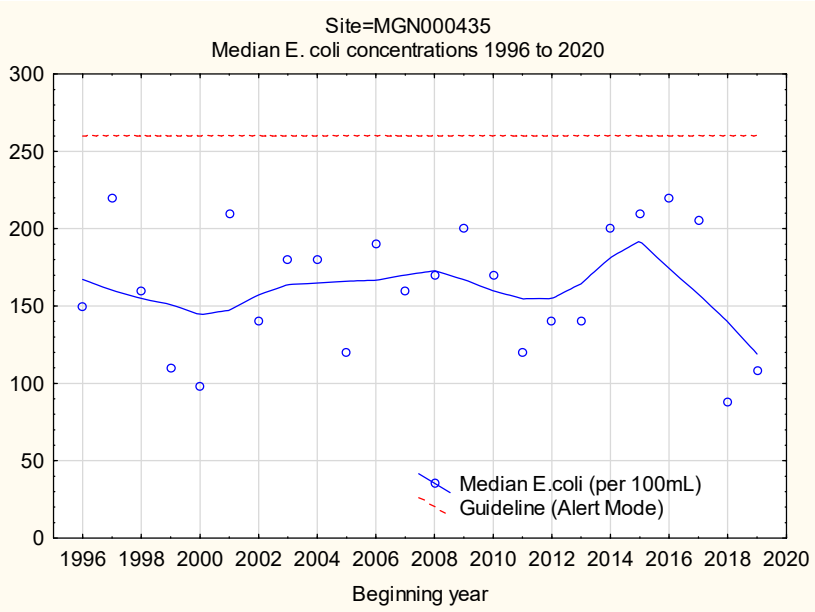


Figure 68 LOWESS trend plot of median *E.coli* data at the Manganui River, Everett Road site

A slight, unimportant, and statistically insignificant increase in median *E. coli* numbers has been found over the twenty-four seasons of monitoring. None of these seasonal medians has exceeded the 'Alert' or 'Action' modes.

4.16.4 Cyanobacteria

Benthic cyanobacteria were monitored on 12 occasions through the season with results presented in Table 49 and Figure 69.

Table 49 Percentage benthic cyanobacteria cover, detached and exposed mats at the Manganui River at Everett Park

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
04/11/2019	3	No	No	Surveillance
21/11/2019	0	No	No	Surveillance
04/12/2019	0	No	No	Surveillance
19/12/2019	0	No	No	Surveillance
08/01/2020	14	Minor	No	Alert
15/01/2020	14	Minor	No	Alert
23/01/2020	9	Minor	No	Alert
28/01/2020	8	No	Minor	Alert
04/02/2020	8	No	No	Surveillance
19/02/2020	6	No	No	Surveillance
05/03/2020	7	No	No	Surveillance
18/03/2020	1	No	No	Surveillance

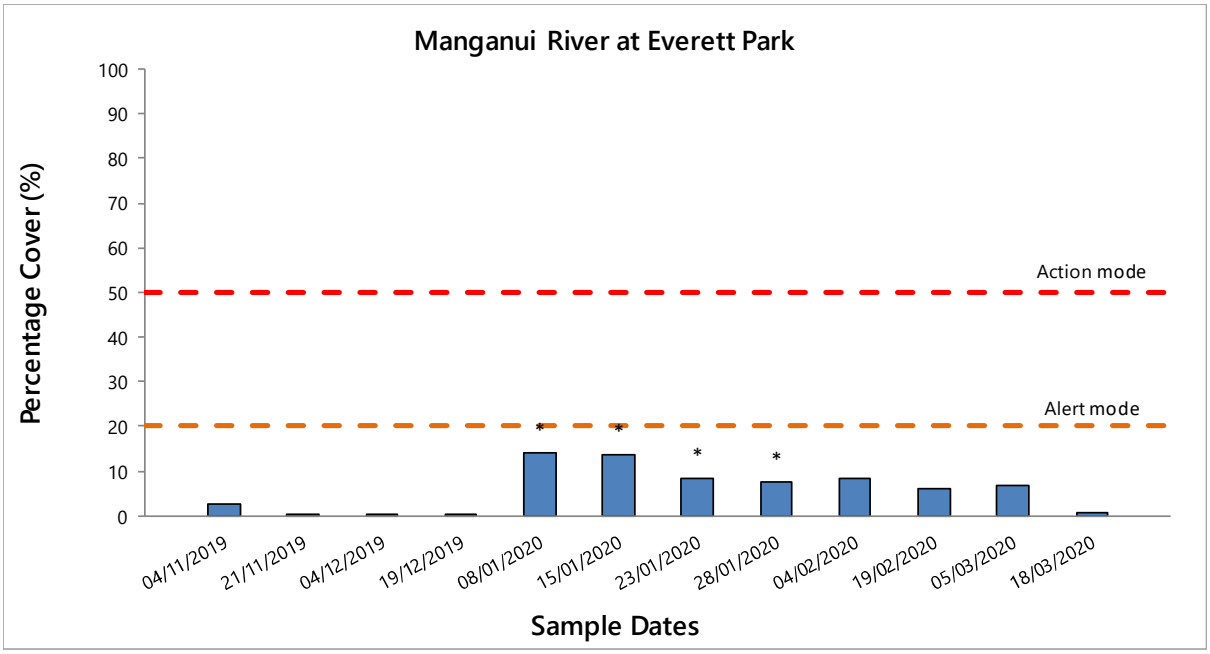


Figure 69 Percentage benthic cyanobacteria cover at the Manganui River at Everett Park. '

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and ⁺ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was low for the monitoring period (range from 0 to 14%). The 'Action' level was never exceeded for percentage cover or for detaching and exposed mats. The benthic cyanobacteria found were *Microcoleus* sp. Detaching mats reached minor levels on three occasions, which triggered the 'Alert' level. Minor levels of exposed mats were visible on one occasion, which triggered the 'Alert' level. In total, the 'Alert' level was triggered on four occasions.

4.17 Lake Ratapiko

A total of 11 samples were collected at this site over the summer. Eleven of 13 scheduled SEM samples were collected, and no follow up samples were required

Bathing usage of the lake was observed on one occasion. Jet-skiing was recorded on two occasions. However, the lake is commonly used for boating and fishing purposes, particularly at weekends and holidays. Ducks were present occasionally in low numbers. Minimal stock access to the lake margins was recorded, unlike on some past occasions (TRC, 2013). The lake is usually drawn down for maintenance purposes at the end of the season, after sampling for recreational water quality finishes.

All *E. coli* data for this site, from the 2019-2020 summer period, are presented in Figure 70 and summarised in Table 50.

The complete survey results are presented in Appendix I.

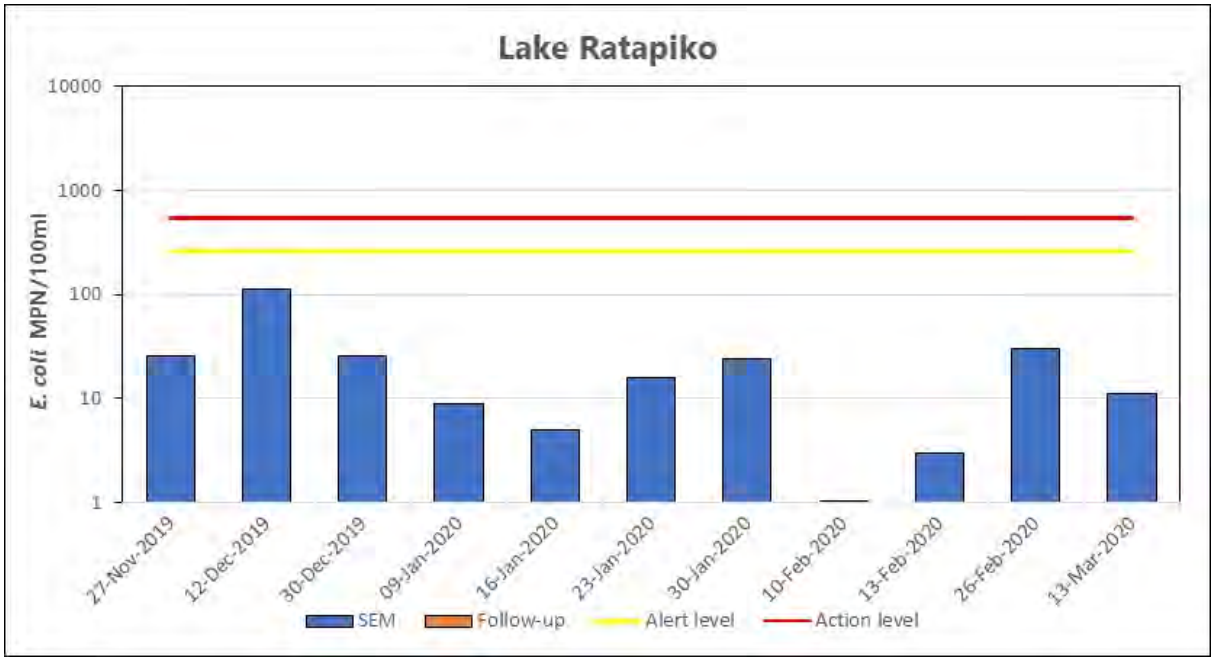


Figure 70 *E. coli* results for Lake Ratapiko

Table 50 Statistical summary for Lake Ratapiko

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	11	87	114	95
	E. coli	MPN/100 ml	11	<1	112	24
	Temperature	°C	11	18.9	24.0	19.9
	Turbidity	FNU	11	1.38	2.3	1.78

The lake is replenished by diversion water flow from the mid reaches of the Manganui River via the Motukawa HEP scheme. Water quality was generally very good with minimal variation in clarity (median turbidity: 1.78 FNU; range of turbidity: 0.92 NTU) as a result of low suspended algae populations possibly due to short retention times in the lake. Water temperatures were relatively high over a moderate range of 5.1˚C for the period with a maximum of 24.0˚C (mid-morning in late January 2010) although all of the measurements were recorded prior to 1220 hrs. Conductivity showed low variation (up to 27 µS/cm) during the period.

Generally, bacteriological quality was good considering that the inflow to the lake is from the mid reaches of a river draining a developed farmland catchment.

4.17.1 Comparison with guidelines

E. coli numbers for Lake Ratapiko over the 2019-2020 summer are summarized against the guidelines for freshwater contact usage in Table 51.

Table 51 Performance against guidelines at Lake Ratapiko

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100 ml	ACTION Single sample >550/100 ml
SEM samples	0 [0%]	0 [0%]

No single sample exceedance of the 'Action' mode or was recorded within the 'Alert' mode during the review period.

Bacteriological water quality was good and within acceptable guidelines for contact recreational usage throughout the survey period.

4.17.2 Comparison with previous summer surveys

Summary statistics for the SEM *E.* coli data collected at Lake Ratapiko over 14 summers is presented in Figure 71.

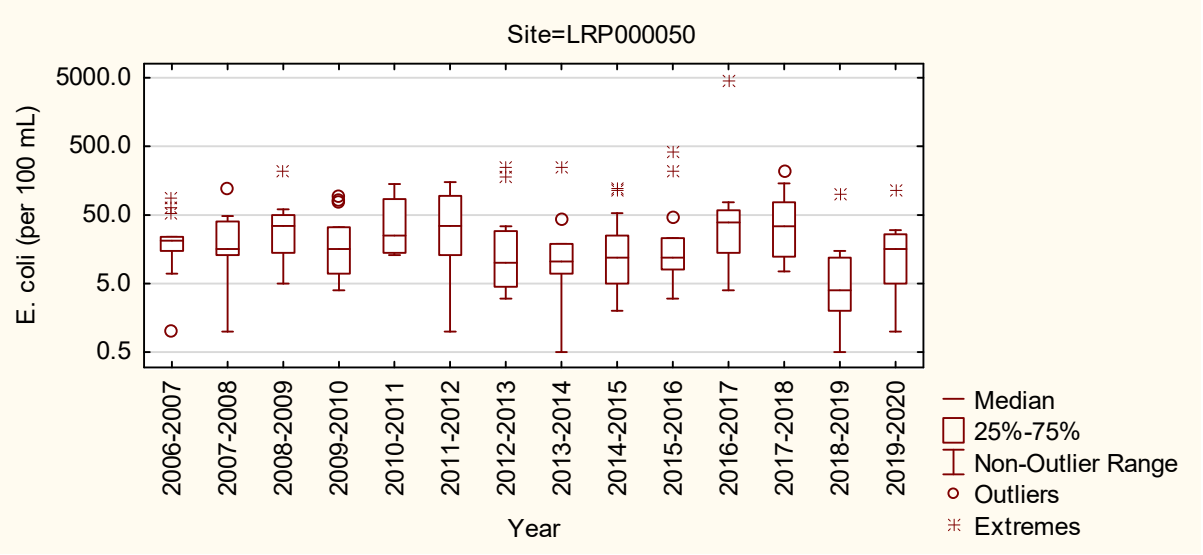


Figure 71 Box and whisker plots of *E.coli* for all summer SEM surveys at Lake Ratapiko

A low median *E. coli* number was found by the latest season's survey and a moderate range of numbers was recorded. All seasonal medians have been low, with this season's being the in the middle of numbers recorded for the fourteen seasons' medians to date.

4.17.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the fourteen seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 72) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

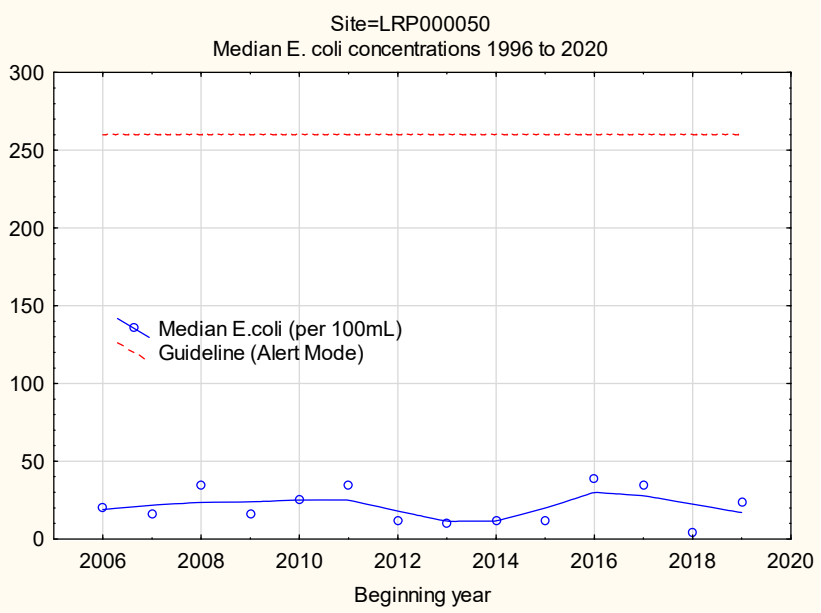


Figure 72 LOWESS trend plot of median *E. coli* data at the Lake Ratapiko site

No statistically significant trends in median *E.coli* numbers have been found over the fourteen seasons of monitoring, which have indicated an unimportant decrease in *E.coli* numbers over this period. None of these medians exceeded the 'Alert' or 'Action' modes for freshwater contact recreational usage.

4.17.4 Cyanobacteria

Planktonic cyanobacteria were monitored on nine occasions throughout the season. The results of these analyses are presented in Table 52 and Figure 70.

Table 52 Cyanobacteria cell counts and biovolumes for Lake Ratapiko [Health warning: >1.8 mm^3/l]

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm^3/l)	Principal species by biovolume	Mode
05/11/2019	0	0.00	No cyanobacteria	Surveillance
26/11/2019	0	0.00	No cyanobacteria	Surveillance
04/12/2019	0	0.00	No cyanobacteria	Surveillance
19/12/2019	0	0.00	No cyanobacteria	Surveillance
09/01/2020	0	0.00	No cyanobacteria	Surveillance
23/01/2020	0	0.00	No cyanobacteria	Surveillance
04/02/2020	0	0.00	No cyanobacteria	Surveillance
26/02/2020	0	0.00	No cyanobacteria	Surveillance
12/03/2020	0	0.00	No cyanobacteria	Surveillance

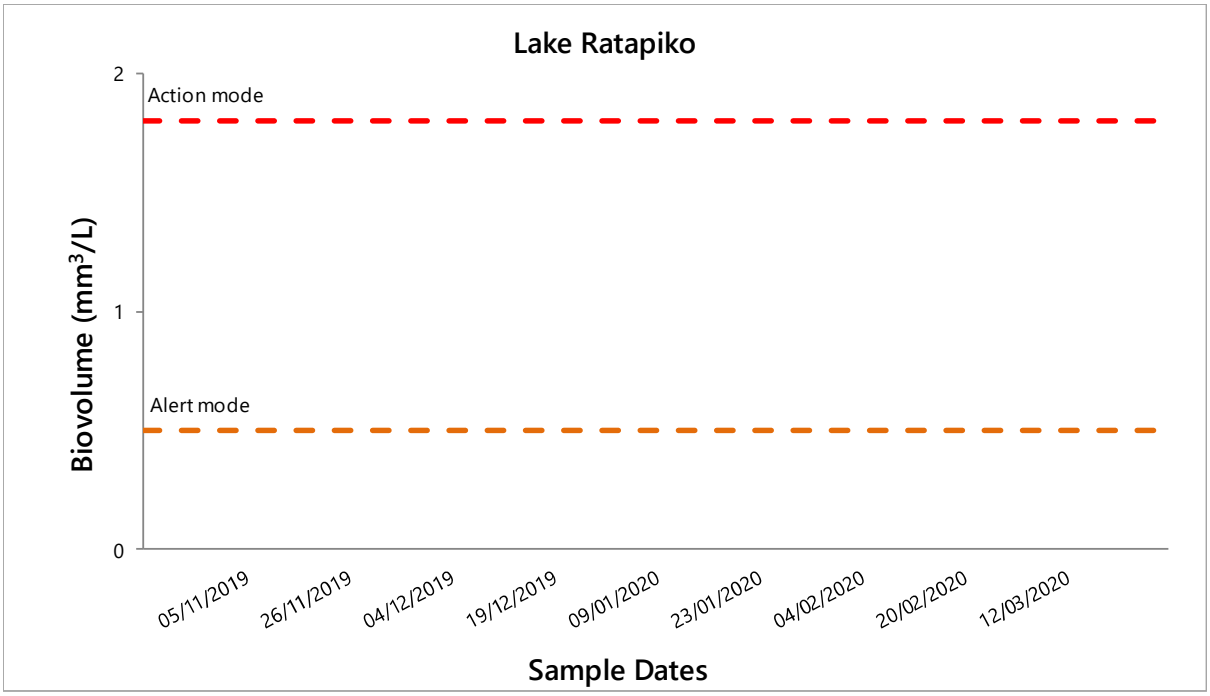


Figure 73 Cyanobacteria biovolume at Lake Ratapiko

Planktonic cyanobacteria levels during the recreational monitoring year had no recorded cyanobacteria. Alert and Action levels were never triggered.

4.18 Lake Rotokare

Cyanobacteria monitoring of this lake was instigated in the 2007-2008 season in recognition of this small lake's recreational usage, particularly for boating activities. A reduced bacteriological monitoring programme was also included, as considered appropriate. The boating season is restricted to the period from 1 December to 1 May by the STDC in recognition of the status of the Rotokare Scenic Reserve.

Some bacteriological water quality monitoring was also undertaken in conjunction with the cyanobacteria monitoring during the 2019-2020 season, with the lake sampled on nine occasions between early November 2019 and mid-March 2020. [Note: bacteriological monitoring is not a component of the SEM programme at this lake].

Usage of the lake by walkers (visitors) and for camping, was recorded during the 2019-2020 surveys, all of which occurred on week days, and around midday except one in early morning. The boat ramp was unlocked the entire season, unlike most previous years. Birdlife, a few ducks and pukeko, were observed at the lake margin on the majority of monitoring occasions, and swans once. The lake appeared clear, with brown colour, throughout most of the period with some turbidity in early and mid-January 2020.

The bacteriological water quality data for this site are presented in Table 53 with a statistical summary provided in Appendix I.

Table 53 Statistical summary for Lake Rotokare

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM+MfE samples	Conductivity	µS/cm@25°C	9	127	151	133
	E. coli	MPN/100 ml	9	<1	50	19
	Temperature	°C	9	19.2	24.9	21.4
	Turbidity	FNU	9	0.96	8.0	1.72

In general, bacteriological water quality was good, as might be expected for a small, bush clad lake with only small inflows and relatively low wildfowl numbers. Conductivity levels were very stable (range: 24 µS/cm) through the period despite variations in inflow during the season. Water temperatures varied over a moderate range of 5.7˚C with a maximum of 24.9˚C recorded in early February 2020. Turbidity was relatively low (median: 1.72 FNU) with the range (7 FNU) reflecting some variability in abundances of suspended algae in the water column during the season.

No bacterial numbers from routine sampling entered the 'Action' level on any occasion during the season. It should be noted that in past seasons the overriding health warnings on both the Regional Council website and on the sites at the lake and road access have related to cyanobacteria level exceedances of guidelines (see below), and not to bacterial numbers. It has been noted in the past, that as cyanobacteria numbers decreased later in some seasons, coincidentally *E.coli* bacterial numbers increased.

4.18.1 Cyanobacteria

Planktonic cyanobacteria at Lake Rotokare were monitored on nine occasions throughout the season with results presented in Table 54 and Figure 74.

Table 54 Cyanobacteria cell counts and biovolumes for Lake Rotokare [Health warning: >1.8 mm^3/l]

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm3/l)	Principal species by biovolume	Mode
05/11/2019	0	0.00	No cyanobacteria	Surveillance
25/11/2019	2405	0.51	*Dolichospermum circinale*	Alert
04/12/2019	7709	1.16	*Dolichospermum circinale*	Alert
19/12/2019	12270	1.54	*Dolichospermum lemmermannii*	Alert
09/01/2020	463	0.11	*Dolichospermum circinale*	Surveillance
23/01/2020	1383	0.13	*Dolichospermum lemmermannii*	Surveillance
04/02/2020	663	0.14	*Dolichospermum circinale*	Surveillance
26/02/2020	100	0.01	*Dolichospermum circinale*	Surveillance
12/03/2020	27118	1.22	*Dolichospermum lemmermannii*	Alert

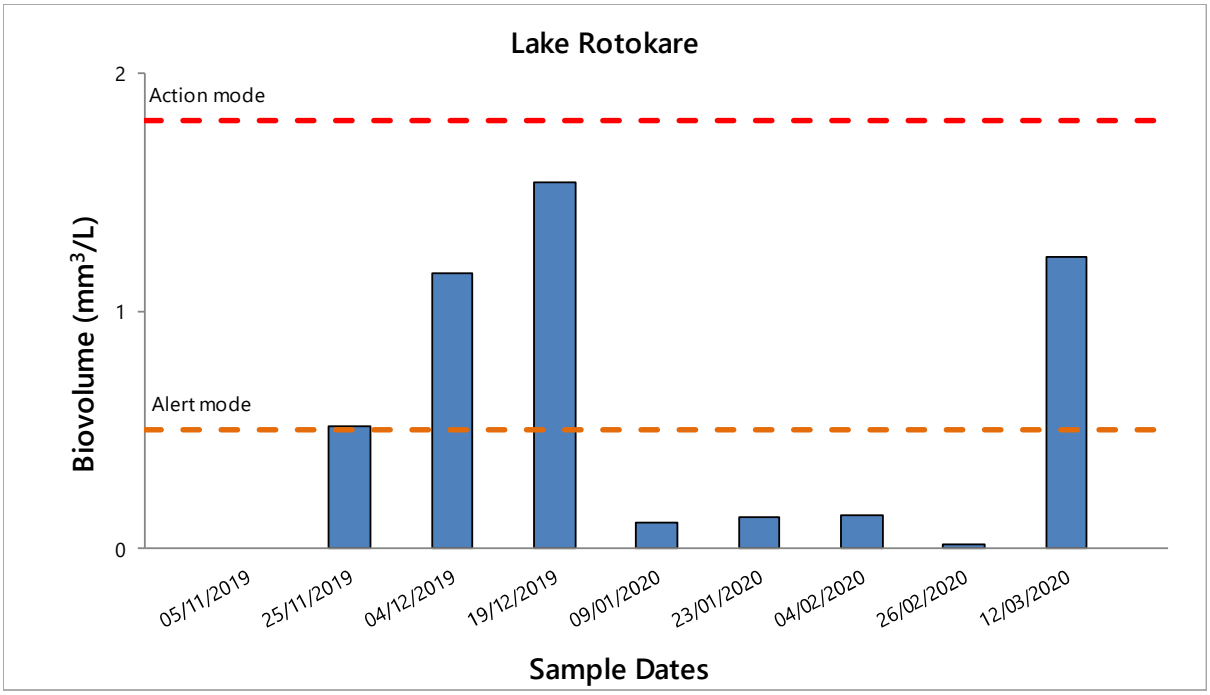


Figure 74 Cyanobacteria counts (cells/ml) at Lake Rotokare [Health warning: >1.8 mm^3/l]

There were moderate levels of planktonic cyanobacteria bio-volumes recorded in late spring and early-summer, but levels fell from mid-summer onwards and were quite low. Unusually, the second highest bio-volume was recorded during the last survey in autumn. Another survey was scheduled for late March but the survey was cancelled due to the coronavirus pandemic. The Alert level was triggered on four occasion and the Action level was never triggered. The results were the lowest levels of cyanobacteria recorded to date for the lake.

In most previous years, the installation of a blue-green algal hazard warning sign by the STDC has occurred upon advice from the Taranaki Area Health Board, once levels have exceeded the health guideline (>1.8mm^3/l), usually from early December to February. The Health Board may then require algal toxin testing.

5 Discussion

5.1 General data summary

A comparative summary of results of the twenty-fourth summer bacteriological quality freshwater survey involving seventeen contact recreational sites in the Taranaki region is provided in Appendix VI and Table 55. Results for *E.* coli are illustrated in Figure 75, and a comparison of all sites' summer data is presented in Appendix VI in the form of a statistical 'box and whisker' plot.

Table 55 Statistical summary of results for the sites sampled in the SEM freshwater contact recreational water quality survey, 2019-2020

Site		Temperature (°C)	Conductivity @ 25°C (µS/cm)	E. coli (MPN/100 ml)	Enterococci (cfu/100 ml)	Turbidity (FNU)
Lake Rotomanu	Median	23.0	145	66		8.4
	Minimum	21.0	128	12		3.5
	Maximum	26.0	169	727		15.4
	No. of samples	11	11	11		11
Waiwhakaiho River at Merrilands Domain	Median	19.8	164	40		0.70
	Minimum	16.2	129	5		0.39
	Maximum	22.6	213	171		0.85
	No. of samples	11	11	11		13
Waiwhakaiho River adjacent to L. Rotomanu	Median	20.8	148	656		0.70
	Minimum	18.3	133	121		0.56
	Maximum	25.1	9120	7700		1.13
	No. of samples	11	11	11		11
Te Henui Stream at mouth, East End	Median	19.0	14650	1552		1.48
	Minimum	15.4	1786	656		0.72
	Maximum	22.9	36500	5480		4.8
	No. of samples	11	11	11		11
Patea River at King Edward Park, Stratford	Median	14.9	113	345		0.79
	Minimum	12.4	100	126		0.54
	Maximum	17.7	126	579		1.86
	No. of samples	11	11	11		11
Patea River at boatramp, Patea	Median	18.9	51500	5	7	8.8
	Minimum	17;4	48900	<1	<1	0.77
	Maximum	20.9	52500	22	33	16.3
	No. of samples	11	11	11	11	11
Waingongoro River at Eltham camp	Median	16.7	141	276		1.58
	Minimum	13.6	124	96		0.65
	Maximum	18.3	166	687		3.9
	No. of samples	11	11	11		11
Waingongoro River at Ohawe Beach	Median	18.1	219	135		1.61
	Minimum	16.2	148	42		1.00
	Maximum	22.8	257	649		3.0
	No. of samples	11	11	11		11
Kaupokonui River at beach domain	Median	19.6	205	184		2.1
	Minimum	17.8	173	55		0.74
	Maximum	24.7	1919	488		3.3
	No. of samples	11	11	11		11
Lake Opunake adjacent to boat ramp	Median	22.2	149	39		2.1
	Minimum	21.0	125	1		1.41
	Maximum	25.9	197	260		3.1
	No. of samples	11	11	11		11
Timaru Stream at Weld Road (near mouth)	Median	18.1	969	204		0.62
	Minimum	15.5	137	68		0.38
	Maximum	23.5	18410	770		2.6
	No. of samples	11	11	11		11

Site		Temperature (°C)	Conductivity @ 25°C (µS/cm)	E. coli (MPN/100 ml)	Enterococci (cfu/100 ml)	Turbidity (FNU)
Waimoku Stream at Oakura beach	Median	15.9	183	1785		1.40
	Minimum	13.4	168	934		0.92
	Maximum	21.0	529	>24200		3.3
	No. of samples	11	11	11		11
Oakura River d/s of SH45 bridge	Median	18.9	286	238		0.65
	Minimum	15.6	104	50		0.22
	Maximum	24.2	3370	488		3.5
	No. of samples	11	11	11		11
Waitara River at town wharf, Waitara	Median	20.3	13530	160		3.3
	Minimum	17.5	86610	41		2.6
	Maximum	23.6	37770	1850		46
	No. of samples	11	11	11		11
Urenui River at estuary	Median	19.9	51700	5	2	3.7
	Minimum	15.1	50800	<1	<1	1.38
	Maximum	21.5	52600	210	140	17.5
	No. of samples	11	11	11	11	11
Manganui River d.s of Kurapete S. (Everett Park)	Median	18.0	118	108		0.83
	Minimum	15.1	110	22		0.62
	Maximum	22.4	133	219		1.55
	No. of samples	11	11	11		11
Lake Ratapiko at boat ramp	Median	19.9	95	24		1.78
	Minimum	18.9	87	<1		1.38
	Maximum	24.0	112	112		2.3
	No. of samples	11	11	11		11

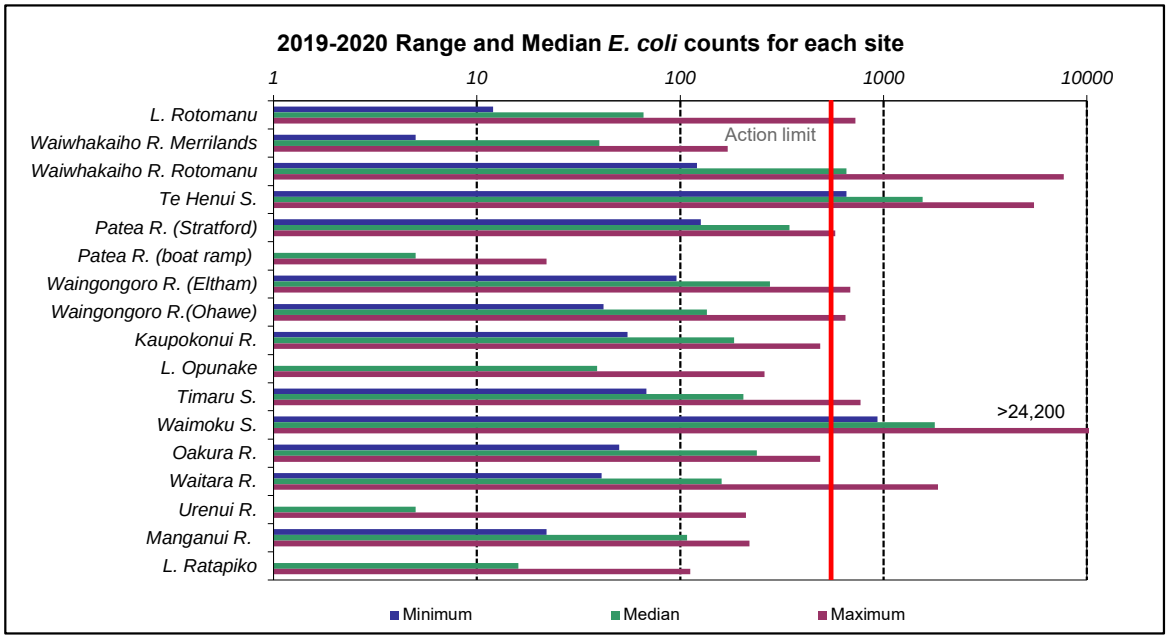


Figure 75 Ranges and medians *of E. coli* numbers recorded from all sites by the SEM programme over the 2019-2020 survey season

Non-exceedance of the 2003 guidelines has varied amongst the seventeen freshwater contact recreational sites sampled during the survey period (Figure 75 and Table 56), to the same degree as recorded in many of the previous seasons. In relation to the guidelines, three sites (Waiwhakaiho River at Lake Rotomanu, Te Henui Stream at East End beach and Waimoku Stream at Oakura beach) regularly failed to be below the *E. coli* 'Action' guideline suitable for contact recreation. In terms of median *E. coli* numbers, these were also the only sites with the median number in the 'Action' (>550 *E. coli* per 100 ml) mode. Two sites (Patea River

at Stratford and Waingongoro River at Eltham camp) had median numbers in the 'Alert' (>260 *E. coli* per 100 ml) mode. None of the other sites had a median number in the 'Action' or 'Alert' mode.

Table 56 Number of occasions single sample *E.coli* numbers entered the 'Alert' and 'Action' modes and percentage [%] of samples which were below these modes, 2019-2020

Site	' Surveillance' mode	'Alert' mode	'Action' mode
Lake Rotomanu at western beach	[82%]	1	1
Waiwhakaiho River at Merrilands Domain	[100%]	0	0
Waiwhakaiho River adjacent to L Rotomanu	[18%]	1	8
Te Henui Stream at mouth, East End	[0%]	0	11
Patea River at King Edward Park, Stratford	[27%]	7	1
Patea River at boatramp, Patea	[100%]	0	0
Waingongoro River at Eltham Camp	[45%]	5	1
Waingongoro River at Ohawe beach	[73%]	1	2
Kaupokonui River at beach domain	[64%]	4	0
Lake Opunake at boat ramp	[100%]	0	0
Timaru Stream at Weld Road	[64%]	3	1
Waimoku Stream at Oakura beach[1]	[0%]	0	11
Oakura River at SH45	[73%]	3	0
Waitara River at town wharf, Waitara	[64%]	3	1
Urenui River at estuary*	[100%]	0	0
Manganui River at Everett Park	[100%]	0	0
Lake Ratapiko at boat ramp	[100%]	0	0

[Notes: N = 11 samples; * = enterococci number;] [1] Not a regional bathing site

Six sites maintained numbers below the 'Alert' mode at all times throughout the season, while an additional two sites maintained numbers below the 'Action' mode (Table 56 and Table 58) at all times, so, of the 16 recognised bathing sites, eight (50%) never had a non-compliance during the 2019-2020 season, and one other (giving 56% altogether) had only two non-compliances. In, and including the Waimoku Stream site, terms of the overall monitoring season, twenty-eight 'Alert' levels (15% of numbers) and thirty-seven 'Action' levels (20% of numbers) resulted over the period representing an overall 65% achievement of the 'Surveillance' contact recreational guideline (compared with 60%, 60% and 61% achievement in the 2016-2017, 2017-2018 and 2018-2019 seasons, respectively). These percentage figures included samples from the Waimoku in 2016-2017, but not in the two more recent seasons. Excluding the Waimoku Stream site, and reviewing only the 'Action' level samples (i.e. those which indicate swimming poses an unacceptable risk), 85 % of all samples met the bathing guideline in 2019-2020. Of those 15 % of samples that were non-compliant, 11% were from just two urban sites – the lower Waiwhakaiho River and the Te Hēnui Stream. Both sites have high bird populations. Comparing levels of compliance for the same suite of sites over the past four years, the 85.2% compliance rate in 2019-2020 follows on from 79.3% in 2018-2019, 79.2% in 2017-2018 and 86.0% in 2016-2017.

In terms of guidelines attainment, the sites may be ranked in the following order for the 2019-2020 season:

1= Patea River at boat ramp, Patea

1= Urenui River at estuary

1= Lake Ratapiko

1= Lake Opunake at boat ramp

1= Waiwhakaiho River at Merrilands Domain

1= Manganui River at Everett Park

7 Oakura River d/s SH45 bridge

8 Kaupokonui River at beach domain

9 Lake Rotomanu

10= Waitara River at town wharf

10= Timaru Stream at Weld Road (near mouth)

12 Waingongoro River at Eltham

13 Patea River at King Edward Park

14 Waingongoro River at Ohawe Beach

15 Waiwhakaiho River adjacent to Lake Rotomanu

16 Te Hēnui Stream at mouth, East End

17 Waimoku Stream at Oakura beach.

Overall, a wide range from poor to very good bacteriological water quality was measured at the seventeen sites. In terms of results to date, this represented no overall change, with measured water quality improving at some sites and reducing at others. In terms of median *E. coli* numbers, by far the best bacteriological quality was again found in the two estuarine sites, on the Patea and Urenui Rivers, both sites' median number was 5 *E.coli* per 100 ml. The estuarine sites are strongly influenced by seawater penetration during high tide conditions. The programme focused on high tide periods due to its design and integration with the coastal bathing water quality monitoring programme. While future programmes' designs could give consideration to extending sampling to include low tide timing of sampling (at tidal sites), if this becomes necessary, it is essential that the high-tide format is retained for future trend monitoring purposes.

Based upon median *E. coli* bacterial numbers for the survey period, the following ranking of sites (in descending water quality) may be used to summarise results:

1= Patea River at boatramp, Patea

1= Urenui River at estuary

3 Lake Ratapiko

4 Lake Opunake at boat ramp

5 Waiwhakaiho River at Merrilands Domain

6 Lake Rotomanu

7 Manganui River at Everett Park (d/s of Kurapete Stream)

8 Waingongoro River at Ohawe Beach

9 Waitara River at town wharf, Waitara

10 Kaupokonui River at beach domain

11 Timaru Stream at Weld Road (near mouth)

12 Oakura River d/s of SH 45 bridge

13 Waingongoro River at Eltham camp

14 Patea River at King Edward Park, Stratford

15 Waiwhakaiho River adjacent to Lake Rotomanu

16 Te Henui Stream at mouth, East End

17 Waimoku Stream at Oakura beach.

The three highest rankings remained at the three sites which were highest ranked for the last several seasons. The three lowest rankings also remained at the same three sites. The biggest improvement in ranking, in comparison with the 2018-2019 season, occurred in the Lake Opunake at the boat ramp and Waitara River at the town wharf, although the median *E. coli* numbers were well within the previous range. Waingongoro River at Eltham camp slipped down in the rankings (six places to thirteenth) in terms of seasonal median bacteriological water quality.

5.2 Comparison with twenty-three previous summers' surveys

A statistical comparison of each summer's survey *E. coli* data is presented graphically in Appendix VI for all sites. Shorter data periods exist for the Patea River (at King Edward Park, Stratford) and Waingongoro River (at Eltham camp) which were added in 2001-2002, two lakes' sites (Lakes Ratapiko and Opunake) which were added in 2006-2007, the site in the lower reaches of the Patea River which was added in the 2007-2008 season, the site in the lower Waitara River which was added in the 2009-2010 season, and the sites in the lower reaches of the Waiwhakaiho River and Te Henui Stream which were added in the 2011-2012 season.

In general terms, *E. coli* bacteriological water quality was within ranges generally similar to those recorded over most previous summer bathing seasons. There was marked deterioration at four sites and improvement at three sites in terms of median numbers, in comparison with the previous summer's results (as determined on the basis of >20% change where the median value was ≥10 per100 ml). Variability in quality between bathing seasons at each site may be related to a variety of reasons including hydrological conditions, stock access, wildlife presence, and dairy farm wastes disposal practices in particular.

All seasons' results have been summarised in terms of comparisons with the single sample modes of the MfE, 2003 guidelines for each site over the period since the state of the environment monitoring programme commenced (over the 1996-1997 season). This summary is presented in Table 58.

Noting that there is some variability in the numbers of sites included in each season's programme, conformity with the 'Surveillance' guidelines has occurred on 68% of sampling occasions over the combined twenty-four seasons to date with the worst seasons (2016-2017 and 2017-2018) showing 60% guidelines conformity and the best seasons (1996-1997 and 1999-2000) 82% conformity with the guidelines. The latest season, at 65% conformity, showed some improvement over the previous three seasons (2016-2017, 2017-2018 and 2018-2019) which were at or near the historical minimum. (Note that in any comparison between seasons, variability in selection of monitored sites should be taken into account).

A ranking of sites based upon the historical average conformity with the surveillance mode guideline for the period 1996 to date can be summarised as follows:

1 Patea River at boat ramp, Patea

2 Urenui River at estuary

3 Lake Ratapiko

4 Waiwhakaiho River at Merrilands Domain

5 Lake Rotomanu

6 Waingongoro River at Ohawe Beach

7 Manganui River at Everett Park.

8 Oakura River at SH45

9 Kaupokonui River at beach domain

10 Lake Opunake

11 Waingongoro River at Eltham Camp

12 Waitara River at town wharf, Waitara

13 Patea River at King Edward Park, Stratford

14 Timaru Stream at Weld Road

15 Waiwhakaiho River adjacent to Lake Rotomanu

16 Te Henui Stream at mouth, East End

17 Waimoku Stream at Oakura beach

One estuarine site (the Patea River) has never reached the 'Alert' *E.coli* level of the guidelines over the 24 seasons to date. All sites ranked above tenth have not exceeded guidelines on an average of at least 75% of seasonal sampling occasions. The poorest bacteriological water quality (less than 6 % of seasonal sampling occasions within guidelines) has been recorded at the Waimoku and Te Henui Stream mouths where the resident wildfowl population has been the principal contributor to elevated *E.coli* numbers. This has also been the case for the Waiwhakaiho River adjacent to Lake Rotomanu, the third worst site.

Temporal trending of season's median *E.coli* numbers at each of the sixteen sites, with a minimum of ten years' data, was undertaken statistically for the period 1996 to 2020. Three of these sites have shown a statistically significant ($p < 0.01$ after FDR application) trend in median *E.coli* numbers:

- Waimoku Stream at Oakura beach had a very strong trend of increasing median *E. coli* numbers of the 24 year period (18 seasons) to date which was significant at $p<0.01$ after FDR application
- Te Henui Stream at the mouth had a very strong trend of increasing median *E. coli* numbers over the 18 year period to date which was significant at $p<0.01$ after FDR application
- Waiwhakaiho River opposite Lake Rotomanu had a very strong trend of increasing median *E.coli* numbers over the 24 year period (17 seasons) to date which was significant at $p < 0.01$ after FDR application

A ranking of the order of the significance of the temporal trends at those sites with a minimum of ten seasons' data (sixteen sites) is provided in Table 57.

Table 57 Ranking of sites in terms of significant temporal trends in median *E.coli* numbers over the period 1996 to 2020

Site location	Valid N	p-level	FDR-corrected p value	Trend
Waimoku Stream at Oakura beach	18	0.0002	0.0024	↑↑↑
Te Henui Stream mouth, East End	18	0.0003	0.0024	↑↑↑
Waiwhakaiho River at Lake Rotomanu	17	0.0004	0.0024	↑↑↑
Waingongoro River at Eltham camp	19	0.0231	0.1037	↑
Oakura River d/s SH45 bridge	24	0.0739	0.2517	↑
Waitara River at town wharf	11	0.0839	0.2517	↑
Timaru Stream at end of Weld Road	23	0.1367	0.3370	↑

Site location	Valid N	p-level	FDR-corrected p value	Trend
Urenui River at estuary - enterococci	24	0.1509	0.3370	↓
Patea River at King Edward Park	19	0.1772	0.3370	↑
Kaupokonui River at Beach Domain	24	0.1872	0.3370	↑
Waingongoro River at Ohawe Beach	24	0.3104	0.4830	↑
Urenui River at estuary	24	0.3220	0.4830	↑
Lake Opunake at boat ramp	14	0.4063	0.5626	↓
Lake Rotomanu western beach	24	0.6173	0.7828	↑
Lake Ratapiko at boat ramp	14	0.6523	0.7828	↓
Waiwhakaiho River at Merrilands Domain	24	0.7643	0.8022	↑
Manganui River at Everett Park	24	0.8005	0.8022	↑
Patea River at boat ramp, Patea	13	0.8022	0.8022	↑

[NB: * = enterococci; ↑ = deteriorating: ↓= improving]

In summary, three sites have shown a statistically significant increasing temporal trend and no sites significant decreasing temporal trends in seasonal median *E. coli* numbers. The other less significant trends indicate gradual improvement (three sites) or deterioration (twelve sites) in seasonal median numbers.

Table 58 Seasonal summaries of single sample *E.coli* numbers in 'Surveillance'. 'Alert'. 'Action' modes for the period 1996 to date (13 samples per season*)

Site Season	1996-1997		1997-1998		1998-1999		1999-2000		2000-2001		2001-2002		2002-2003		2003-2004		2004-2005		2005-2006		2006-2007		2007-2008		2008-2009		2009-2010		2010-2011		2011-2012		2012-2013		2013-2014		2014-2015		2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		Average per season		
Lake Rotomanu at western beach	0	1	0	1	0	0	0	0	0	0	1	2	1	1	0	3	0	0	2	0	2	1	4	1	3	3	1	3	0	0	0	5	1	0	0	0	0	0	2	2	3	2	0	1	0	3	1	1	11	1	1
Waiwhakaiho River at Merrilands Domain	0	1	0	1	1	0	0	0	1	0	2	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	2	1	1	0	0	12.5	<0.5	<0.5
Waiwhakaiho River adj. to L. Rotomanu	0	1	*		3	0	*		2	1	*		3	0	*		2	5	*		1	6	*		7	5	*		1	9	5	5	0	12	5	7	1	11	0	12	2	8	3	10	4	9	1	8	4.5	2.5	6
Te Henui Stream at mouth, East End	*		*		*		*		*		*		7	5	7	4	1	10	1	11	2	10	2	10	1	12	2	11	1	11	4	9	1	12	1	11	0	12	3	10	1	12	0	12	2	11	0	11	1	2	10
Patea River at King Edward Park, Stratford	*		*		*		*		*		5	1	2	2	3	1	5	3	5	3	3	1	3	4	3	1	4	2	0	1	4	0	4	0	3	0	8	1	2	1	5	1	7	5	6	3	8	1	7.5	4	1.5
Patea River at boatramp, Patea	*		*		*		*		*		*		*		*		*		*		*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0
Waingongoro River at Eltham Camp	*		*		*		*		*		4	1	6	0	1	0	4	2	1	0	1	0	3	0	1	0	1	0	1	0	1	0	3	0	4	0	5	0	3	0	9	1	5	4	4	0	5	1	9.5	3	<0.5
Waingongoro River at Ohawe Beach	2	0	2	2	1	0	0	0	0	2	0	1	1	2	1	0	2	2	1	0	2	0	0	3	1	1	0	1	0	0	0	1	1	2	1	0	0	1	3	0	3	0	4	0	4	2	1	2	11	1	1
Kaupokonui River at beach domain	1	0	3	6	2	1	0	2	1	1	2	0	1	2	0	0	1	1	1	0	0	1	1	1	3	1	2	0	1	0	1	0	4	0	1	0	5	0	2	1	4	0	2	2	3	3	4	0	10	2	1
Lake Opunake at boat ramp	*		*		*		*		*		*		*		*		*		*		1	3	2	1	2	2	5	0	0	3	0	2	5	0	3	0	3	0	0	1	3	1	4	0	1	4	0	0	9.5	2	1.5
Timaru Stream at Weld Road	*		7	0	1	1	2	2	3	0	2	1	4	2	4	0	3	3	4	0	2	0	2	3	4	0	6	1	4	0	3	0	4	0	2	1	3	2	2	2	9	0	5	3	5	4	3	1	8.5	3.5	1
Waimoku Stream at Oakura Beach	2	9	2	11	3	10	8	3	5	5	3	9	1	12	1	12	2	11	0	13	2	11	0	13	0	13	0	13	0	13	*		*		2	11	*		*		0	13					0	11	0.5	2	10.5
Oakura River at SH45	0	0	2	2	0	0	2	0	2	0	1	1	1	0	0	1	3	2	3	0	4	0	1	1	1	0	4	1	1	0	2	0	1	0	0	0	2	1	1	3	1	2	2	2	3	1	3	0	11	1.5	0.5
Waitara River at town wharf, Waitara	*		*		*		*		*		*		*		*		*		*		*		*		*		2	3	1	1	2	0	3	1	3	0	2	1	5	1	2	1	4	1	5	2	3	1	9	3	1
Urenui River at estuary	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	13	<0.5	<0.5
Manganui River at Everett Park	1	1	3	1	1	1	1	0	3	0	3	2	2	0	1	1	1	1	0	0	2	0	2	1	4	0	3	0	2	0	3	0	1	1	1	0	1	1	1	0	5	0	2	0	0	0	0	0	10.5	2	0.5
Lake Ratapiko at boat ramp	*		*		*		*		*		*		*		*		*		*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	13	<0.5	<0.5
Average per site**	0.7	1.4	2.1	2.7	1.2	1.3	1.4	0.9	1.7	0.9	2.1	1.6	2.2	2.0	1.6	1.8	2.0	3.1	1.5	2.3	1.5	2.2	1.3	2.5	1.9	2.4	1.9	2.3	0.7	2.2	1.6	1.4	1.8	1.8	1.5	1.8	1.9	1.9	1.6	2.1	2.8	2.5	2.4	2.7	2.4	2.7	2.0	2.5			
% overall non-exceedance of 2003 guidelines	82		63		80		82		80		71		67		74		61		71		71		70		67		68		77		78		72		74		71		72		60		60		61		65		68		

* 11 samples only in 2019-2020

** pro rata 13 samples per season

5.3 General

The Taranaki Regional Council will continue to ensure that attention is given to the appropriate timing of dairy shed wastes disposal inspections and repeat inspections when necessary in specific catchments, to ensure that river and stream bacteriological water quality is not compromised by inappropriate wastes disposal practices. However, initiatives proposed by the revision of the Regional Freshwater Plan (particularly the provisions for riparian fencing and interception planting, and the diversion of dairy ponds treated wastewaters to land irrigation) should result in further improvements in bacteriological surface water quality. There is also a need to encourage farmers to refrain from allowing direct stock access to natural surface waters and/or fording stock through streams particularly under summer-autumn low flow conditions.

It is intended that the improved liaison initiated over the 2000-2001 season with territorial local authorities and the Health Protection Unit of Taranaki Healthcare, and maintained to date, will continue with particular regard to the frequency and immediacy of reporting bathing water quality and cyanobacteria results during the survey period and in particular by usage of the District and Regional Councils' websites. All sites' results were displayed on these websites throughout the 2018-2020 survey period and all instances of exceedance of guidelines were advised to the appropriate authorities.

Few follow-up investigations were necessary over the 2019-2020 season and there were no obvious immediate issues with poor operation of dairy wastes disposal systems contributing to elevated numbers in receiving waters. In most cases, occasionally at lakes and mainly in the lower reaches of three urban streams, wildfowl contamination was responsible for elevation in numbers, particularly where public feeding of birds occurred at recreational sites. No isolated instances were related to localised rainfall during the regular, state of the environment monitoring surveys. On some occasions, particularly during lower flow periods, stock access problems, and/or cumulative impacts of consented wastewater discharges may have contributed.

In particular sub-catchments, appropriate publicity and timing of the annual round of dairy inspections has assisted with mitigation of these effects. Regular reviews of the sites' grading system will be performed and maintenance of the programme of increased sampling frequency (weekly from December to March) will continue at the four principal freshwater contact recreation usage sites. Planktonic cyanobacteria monitoring will also continue at lake sites (at a slightly lesser frequency to the bacteriological monitoring) and the benthic cyanobacteria periphyton monitoring will continue at the river/stream sites.

On cyanobacteria, in 2017-2018 the number of scheduled sampling occasions was increased from seven to about ten over the five month period from November to March, that is, to fortnightly. This was in response to high cyanobacteria levels found in Lakes Rotokare and Rotomanu in 2016-2017, and to increased public interest.

For planktonic cyanobacteria, of the four designated lake monitoring sites, one had bio-volumes exceeding contact recreational guidelines during the 2019-2020 season, requiring the erection of warning signs: Lake Opunake for nine days in late summer (February/March). This was the first exceedance of the Action level, which may in part be due to changes at the hydroelectric scheme at the lake which has altered the flushing regime and lake levels. The other three lakes had lower the usual cyanobacteria levels, especially Lake Rotokare, which typically has high bio-volume levels in the summer months. Medium risk level was reached in Lake Rotokare on four occasions (in early and late summer), and in Lake Rotomanu on two occasions (late summer). No cyanobacteria were found in Lake Ratapiko during the monitoring period.

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored. The benthic bacteria found were always *Microcoleus* sp. One (Kaupokonui) site reached over the 50% coverage that would trigger the 'Action' level for that criterion (MfE and MoH, 2009), and two sites (Kaupokonui and

Waingongoro at Ohawe) on a total of nine occasions had over 20% coverage, exceeding the 'Alert' level that triggers weekly monitoring. Exposed mats exceeded the 'Alert' level at five sites on a total of seven occasions. Visibly detaching mats or detached mats accumulating on the river's edge exceeded the 'Alert' level at four sites on a total of 15 occasions. Action level was not reached for either exposed or detached mats at any site monitored. In total, there was one occasion when a site was placed at 'Action' level and there were 17 occasions when a site was placed at 'Alert' level. Exposed mats were generally caused by falling water levels during summer or, for the two sites on the Waiwhakaiho River, the result of daily fluctuations in river flow caused by the release of water by a hydro scheme. Significant detaching or detached mats would be correlated with streambed coverage in combination with the age of the cyanobacteria mats that periodically slough off.

Monitoring before the 2014-2015 season was focussed on streambed percentage cover, though information on exposed and detaching mats was collected. No sites had previously triggered the 'Action' or 'Alert' level before the 2014-15 sampling season based on the exposed or detaching mats criteria. Currently, the guidelines do not give any direction about how much exposed, detaching or detached mats is required to trigger the 'Action' level (MfE and MoH, 2009). The Council has adopted an approach based on best judgement practices to report minor and significant levels of exposed or detaching mats which trigger the 'Alert' and 'Action' level respectively as it better reflects the actual potential danger of benthic cyanobacteria. To date there have been no reported incidences of humans or animals in the Taranaki Region having been harmed by toxins produced by benthic cyanobacteria though there may have been unreported incidences.

Levels of cyanobacteria were higher than in the 2018-2019, 2017-2018 and 2016-2017 seasons, and similar to the preceding two seasons, probably a reflection of the relative amounts of rainfall causing freshes that scour streambeds of periphyton.

The Suitability for Recreation Grading (SFRG) referenced earlier in this report (Section 2.2) may now be re-assessed to include the 2019-2020 microbiological data enabling a comparison of the five year 2014-2019 period (Table 2) with the latest SFRG for the 2015-2020 period (presented in Table 59).

Table 59 Suitability for recreation grade for freshwater sites for the period November 2015 to March 2020

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100 ml)			SFR Grade	% of all samples in compliance (ie: ≤550 *E.coli*)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	727	63	D	Very poor	85
Waiwhakaiho R: Merrilands domain	High	553	63	D	Very Poor	95
Waiwhakaiho R at L.Rotomanu	High	4854	63	D	Very poor	25
Te Henui S: mouth	High	5570	63	D	Very poor	11
Patea R: King Edward Park	High	834	63	D	Very Poor	82
Patea R. boat ramp, Patea	High	84	63	A	Poor	100
Waingongoro R: Eltham camp	High	786	63	D	Very Poor	90
Waingongoro R: Ohawe beach	High	604	63	D	Very Poor	93

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100 ml)			SFR Grade	% of all samples in compliance (ie: ≤550 *E.coli*)
		95 %ile	Number of samples	Category		
Kaupokonui R: Beach domain	High	762	63	D	Very-Poor	90
L Opunake: adjacent boat ramp	High	1180	63	D	Very Poor	90
Timaru S: Lower Weld Road	High	966	63	D	Very poor	84
Waimoku S: mouth	High	11250	24	D	Very poor	0
Oakura R: d/s SH45	High	1300	63	D	Very poor	87
Waitara R: Town wharf	High	1232	63	D	Very poor	90
Urenui R: estuary	High	123	63	A	Poor	98
Manganui R: Everett Park	High	330	63	C	Poor	100
L Ratapiko: boat ramp	Moderate	217	61	B	Good	98
L Rotokare: adjacent boat ramp	Very Low	192	39	B	Very good	100

Few differences between the two five-year periods were apparent when comparing Table 2 and Table 59.

There were minimal changes in gradings at all sites, although in terms of the 95 percentile *E.coli* number: there was a moderate improvement at the Timaru Stream, Oakura and Manganui River and Lake Rotokare sites and deterioration at the Patea River at King Edward Park and the boat ramp and Waitara River at town wharf sites. Five sites (Waiwhakaiho at Lake Rotomanu, Timaru Stream, Oakura River, Manganui River and Lake Rotokare) had fewer samples in excess of the 'Action' level over the most recent five-year period, while five sites (Lake Rotomanu, Kaupokonui Stream, Patea River at King Edward Park, Timaru Stream, Waingongoro River at Ohawe beach, Waitara River at town wharf, Oakura River, and Waiwhakaiho River at Lake Rotomanu and at Merrilands Domain) had more samples (by 1-2%) in the 'Action' mode. Two sites deteriorated in terms of the MAC assessment, which resulted in two changes in SFR grading, from 'poor' to 'very poor' for the Waiwhakaiho River at Merrilands domain and Waingongoro River at Ohawe Beach sites. One site improved in MAC assessment: Lake Rotokare from 'fair' to 'very good'. There were no other changes in MAC or SFR grades.

As outlined earlier in this report and also by the Ministry for the Environment, SFRG and MAC gradings do not represent actual water quality (and hence suitability for swimming) at any particular time. '*This indicator update* [of SFRG gradings] *cannot tell you whether it is safe to swim today at a particular spot and does not replace the site-specific information available on regional and district council websites which can help people understand the likely health risk when deciding whether to go swimming.. While beach grades provide information about the typical state of a beach, regional and district councils also use weekly monitoring to inform the public of more immediate health risks when measured bacteria concentration exceed 'action thresholds'. These action thresholds are based on levels of risk drawn from international guidelines confirmed by New Zealand studies.*' ('Recreational water quality in New Zealand indicator update' October 2012, INFO 653, Ministry for the Environment). [Suitability for recreation grading] '*reflects a precautionary approach to managing public health risks….it does not tell us whether a site is suitable for primary contact recreation on a particular day*'. ('Suitability for swimming update', August 2013, Ministry for the Environment website).

5.4 Water quality at bathing sites and the 2017 NOF 'Clean Water' Swimmability criteria

In February 2017 MfE released a suite of discussion documents which included proposals to further amend the National Objectives Framework (NOF). The proposals were given effect to later in the calendar year. The NOF specifies compulsory national criteria for various parameters used to categorise water quality in terms of suitability for various uses and values. Included in the NOF amendments were new criteria to be applied to water used for primary recreation (colloquially referred to as 'swimmability'). These requirements also included new protocols around sampling. The 2017 criteria are presented in Table 60. The 2017 NOF does not include a national bottom line (compulsory minimum standard), but the previous government announced its intention that 90% of the nation's rivers should be in the yellow, green, or blue categories by 2040.

Table 60 *E. coli* swimming categories proposed in draft 'Clean Water' document, 2017

CATEGORY	PERCENTAGE OF EXCEEDANCES OVER 540: E. COLI PER 100 Ml	MEDIAN: E. COLI PER 100 ml	95TH PERCENTILE: E. COLI PER 100 Ml	PERCENTAGE OF SAMPLES ABOVE 260: E. COLI PER 100 Ml	NARRATIVE DESCRIPTION
Blue	< 5 per cent	≤ 130	≤ 540	< 20 per cent	Excellent for swimming
Green	5-10 per cent	≤ 130	≤ 1000	20-30 per cent	Good for swimming most of the time
Yellow	10-20 per cent	≤ 130	≤ 1200	20-34 per cent	Fair to swim in some of the time
Orange	20-30 per cent	>130	> 1200	> 34 per cent	Intermittently suitable to swim in
Red	> 30 per cent	>260	> 1200	> 50 per cent	Not safe to swim in.

The latest iteration of freshwater bathing quality categorisation is set out in the National Policy Statement for Freshwater Management 2020 (NPS-FM). It defines four attribute states for primary contact, which are based on the 95th percentile result for samples collected during the bathing season at recognised bathing sites (that is, the attribute state is defined by the highest result in any collection of results, once the highest 5% of results are discarded).

Attribute state and description	Numeric attribute state (expressed as *E coli* per 100 ml)
Excellent	<130
Good	130-260
Fair	260-540
Poor (below national bottom line)	>540

These criteria have been designed specifically for application within bathing monitoring programmes, over the earlier and more widely applicable so-called 'swimmability' criteria. It should be noted that these criteria were published after the completion of the 2019-2020 programme, and are not discussed further in this present report.

The monitoring data from Taranaki's freshwater bathing sites for the past five seasons (Table 59) have been analysed against the 2017 NOF criteria for 'swimmability'. Results are shown in Table 61. It should be noted that in some cases, a single criterion has been applied by MfE across several gradings. In this case, the categorisation in Table 61 has been based on the highest category in which a result applies.

What becomes apparent is that gradings denoting degrees of suitability for swimming vary immensely according to the particular criterion. As examples, the quality of the Patea River at King Edward Park, Waingongoro River at Eltham camp and Timaru Stream at Lower Weld Road is either good, intermittent or not safe to swim in, depending on the choice of criterion. This lack of rationalisation between criteria is not helpful for conveying 'swimmability' to the public.

Table 61 *E. coli* swimming categories for freshwater sites for the period November 2015 to March 2020, according to MfE 2017

CATEGORY/SITE	N 'SEM' samples/All samples	PERCENTAGE OF EXCEEDANCES OVER 540: E. COLI PER 100 Ml		MEDIAN: E. COLI PER 100 Ml		95TH PERCENTILE: E. COLI PER 100 Ml		PERCENTAGE OF SAMPLES ABOVE 260: E. COLI PER 100 Ml	
L Rotomanu: western beach	63/109	14	16	84	92	727	1101	25	26
Waiwhakaiho R: Merrilands domain	63/108	4.8	8.3	60	66	553	1325	7.9	14
Waiwhakaiho R at L.Rotomanu	63	76		770		4854		90	
Te Henui S: mouth	63	89		1396		5570		98	
Patea R: King Edward Park	63	19		320		834		60	
Patea R. boat ramp, Patea	63	0		9		84		0	
Waingongoro R: Eltham camp	63	13		276		786		51	
Waingongoro R: Ohawe beach	63/101	6.3	6.9	180	196	604	649	30	30
Kaupokonui R: Beach domain	63/101	9.5	8.9	184	184	762	854	33	36
L Opunake: adjacent boat ramp	63	11		105		1181		22	
Timaru S: Lower Weld Road	63	18		285		966		56	
Oakura R: d/s SH45	63	14		148		1300		29	
Waitara R: Town wharf	63	11		240		1232		40	
Urenui R: estuary	63	1.6		10		123		1.6	
Manganui R: Everett Park	63	0		178		330		13	
L Ratapiko: boat ramp	61	1.6		15		217		3.3	
L Rotokare: adjacent boat ramp	39	0		54		192		2.6	

6 Recommendations

As a result of the 2019-2020 summer freshwater contact recreation bacteriological survey it is recommended:

1. THAT the 2020-2021 survey be performed at sixteen regular sites continuing with the existing sampling protocols during the season extending from 1 November to 31 March (and into April, if necessary).
2. THAT the 2020-2021 survey includes additional samples collected at the four principal usage sites (Lake Rotomanu, Waiwhakaiho River at the Merrilands Domain, Waingongoro River at Ohawe and Kaupokonui River at the mouth) in accordance with MfE, 2003 guidelines.
3. THAT the 2020-2021 summer survey includes cyanobacteria monitoring at the three lake sites and an additional lake (Rotokare) site and benthic cyanobacteria monitoring at nine of the river and stream sites fortnightly on at least ten occasions.
4. THAT follow-up sampling (after guideline exceedances) be performed when deemed necessary by TRC staff.
5. THAT appropriate timing of the annual dairy farms inspection round be incorporated into the programme for catchments where issues relating to exceedances of contact recreational standards have been identified and advice and publicity be provided in relation to the prevention of stock access to natural water.
6. THAT reporting of results be performed as appropriate during the season, and in an Annual Report upon completion of the season's programme.
7. THAT the appropriate statistical trend detection procedures be applied to the data and reported in the Annual Report.

Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

'Action' mode	Single sample greater than 550 *E. coli* cfu/100 ml.
'Alert' mode	Single sample greater than 260 E. *coli* cfu/100 ml.
Bathers	Those who enter the water, and either partially or fully immerse themselves.
Bathing season	Generally the bathing season extends between 1 November and 31 March.
Catchment Assessment Checklist (CAC)	A checklist to identify potential catchment risk factors of faecal contamination for water recreational quality, used in establishing the Sanitary Inspection Category of a monitoring site
cfu	Colony forming units. A measure of the concentration of bacteria usually expressed as per 100 ml sample.
Condy	Conductivity, an indication of the level of dissolved salts in a sample, measured at 25°C and expressed in microsiemens/centimetre (µS/cm)
Contact recreation	Recreation activities that bring people physically in contact with water, involving a risk of involuntary ingestion or inhalation of water.
Cyanobacteria	Also known as blue-green algae, are a phylum of bacteria that obtain their energy from photosynthesis. Typically, benthic cyanobacteria grow on stream beds, and planktonic cyanobacteria form floating colonies in lakes. Usually expressed as bio-volume per ml of sample.
E. coli	*Escherichia coli*, member of the Enterobacteriaceae, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 ml of sample.
Enterococci	Members of the Streptococcus group of bacteria characterised as faecal in origin. Enterococci provide an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 ml of sample.
Faecal coliform	An indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 ml of sample.
Faecal Indicator Bacteria (FIB)	Micro-organisms selected as indicators of faecal contamination.
False Discovery Rate (FDR)	The expected proportion of true hypothesis rejected out of the total number of rejections.
Fluorimetric Turbidity Unit (FNU)	Measure of turbidity using infrared light.
Follow-up sample	Second sample taken to confirm an initial high result; usually within 24-72 hours depending on accessibility/sample turnaround time, etc.
Median	Central value when values are arranged in order of magnitude.
Microbiological Assessment Category (MAC)	A measurement of water quality over time as provided by historical (five years) microbiological results – A, B, C or D
Nephelometric Turbidity Unit (NTU)	Measure of turbidity using white light.

RMA Resource Management Act 1991 and subsequent amendments.

Sanitary Inspection Category (SIC)	A measure of the susceptibility of a water body to faecal contamination – Very High, High, Moderate, Low or Very Low.
Suitability for Recreation Grade (SFRG)	A combination of Sanitary Inspection Category (SIC) and Microbiological Assessment Category (MAC), describes the general condition of a site at any given time, based on both risk and indicator bacteria numbers.
Temp	Temperature, measured in °C (degrees Celsius).

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Appendix I

Bacteriological results for all sites
2019-2020 monitoring year

Lake Rotomanu (Site Code LRM000002)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
5.11.19	1145	20.3	129	4.0	17	MfE
22.11.19	1200	21.7	136	1.6	44	MfE
27.11.19	1050	23.0	128	4.6	12	SEM
12.12.19	1105	23.0	130	3.5	66	SEM
19.12.19	0950	20.5	121	6.4	308	MfE
23.12.19	1015	21.1	116	9.3	60	MfE
30.12.19	1235	23.1	131	14.1	41	SEM
9.01.20	0952	21.1	132	15.4	144	SEM
16.01.20	1405	21.4	146	8.2	15	SEM
23.01.20	1015	24.5	140	12.6	105	SEM
30.01.20	1100	26.0	147	5.5	276	SEM
4.02.20	1125	26.9	141	8.5	219	MfE
10.02.20	1100	22.8	150	7.1	42	SEM
13.02.20	1313	24.9	162	8.4	64	SEM
19.02.20	0945	24.7	165	9.1	1120	MfE
26.02.20	0910	22.6	145	8.6	86	SEM
3.03.20	1125	25.3	151	10.6	1203	MfE
13.03.20	1030	21.0	169	8.6	727	SEM
16.03.20	1145	21.7	154	8.4	67	FOLLOW-UP
19.03.20	1120	18.5	152	9.0	44	MfE

Waiwhakaiho River at Merrilands (Site Code WKH000800)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
5.11.19	1330	19.5	143	1.1	108	MfE
22.11.19	1235	17.2	118	0.7	193	MfE
27.11.19	1120	19.2	137	0.8	171	SEM
12.12.19	1131	19.7	129	0.5	91	SEM
19.12.19	1010	15.6	79	1.7	1553	MfE
23.12.19	0800	16.1	101	1.6	41	MfE
30.12.19	1323	20.4	151	0.6	66	SEM
9.01.20	1028	17.9	168	0.7	17	SEM
16.01.20	1435	20.4	213	0.8	5	SEM
23.01.20	1105	21.6	185	0.9	9	SEM
30.01.20	1030	22.6	164	0.8	31	SEM
4.02.20	1430	24.7	171	0.0	80	MfE
10.02.20	1215	19.8	182	0.5	16	SEM
13.02.20	1350	21.3	173	0.4	40	SEM
19.02.20	1215	21.3	175	3.9	435	MfE
26.02.20	0845	18.4	139	0.6	67	SEM
3.03.20	1220	20.6	169	0.6	41	MfE
13.03.20	1005	16.2	148	0.7	58	SEM
19.03.20	0830	15.5	164	0.5	47	MfE

Waiwhakaiho River beside Lake Rotomanu (Site Code WKH000950)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	1100	19.6	133	1.1	813	SEM
12.12.19	1110	21.0	133	0.6	656	SEM
30.12.19	1245	21.6	136	0.9	7700	SEM
9.01.20	1003	18.9	148	0.6	121	SEM
16.01.20	1415	20.8	539	0.7	213	SEM
23.01.20	1035	22.5	168	0.6	399	SEM
30.01.20	1105	25.1	169	0.7	733	SEM
10.02.20	1105	20.2	9120	1.0	908	SEM
13.02.20	1325	22.6	2060	1.1	1076	SEM
26.02.20	0920	20.1	142	0.6	554	SEM
13.03.20	1045	18.3	147	0.6	573	SEM

Te Henui Stream

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	1015	15.4	13880	1.6	4350	SEM
12.12.19	1034	18.7	6830	0.7	5480	SEM
30.12.19	1150	20.7	1786	1.1	882	SEM
9.01.20	0920	16.4	3780	1.6	1576	SEM
16.01.20	1330	20.6	14650	2.5	1467	SEM
23.01.20	1000	20.7	6160	1.4	4350	SEM
30.01.20	1140	22.9	20400	1.5	657	SEM
10.02.20	1030	17.5	36500	4.8	1552	SEM
13.02.20	1245	20.0	24000	1.3	1145	SEM
26.02.20	1010	19.0	15250	1.7	2610	SEM
13.03.20	1131	17.5	28900	1.4	656	SEM

Patea River, King Edward Park, Stratford (Site Code PAT000297)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	1230	15.5	100	1.5	179	SEM
12.12.19	1140	14.9	116	0.5	517	SEM
30.12.19	0815	13.2	118	0.7	193	SEM
9.01.20	1325	14.7	109	1.2	126	SEM
16.01.20	1040	13.6	108	1.9	461	SEM
23.01.20	1320	16.8	113	0.7	276	SEM
30.01.20	1000	17.7	129	0.5	579	SEM
3.02.20	0940	18.3	120	0.8	435	FOLLOW-UP
10.02.20	1240	15.0	115	0.8	345	SEM
13.02.20	0915	16.2	128	1.4	435	SEM
26.02.20	0755	14.8	104	0.8	461	SEM
13.03.20	0910	12.4	113	0.8	328	SEM

Patea River, boatramp, Patea (Site Code PAT000995)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Enterococci	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	cfu/100 ml	
27.11.19	0800	17.4	51400	8.8	2	1	SEM
12.12.19	0805	19.0	50400	1.5	22	7	SEM
30.12.19	1025	18.6	48900	7.3	9	2	SEM
9.01.20	0815	17.4	51700	9.3	12	10	SEM
16.01.20	1200	18.5	50600	13.4	1	<1	SEM
23.01.20	0815	18.9	51500	0.8	17	15	SEM
30.01.20	1110	20.9	51700	7.2	5	2	SEM
10.02.20	0840	19.7	52500	16.3	2	9	SEM
13.02.20	1130	20.9	51400	12.5	2	4	SEM
26.02.20	0948	20.3	52200	14.8	9	30	SEM
13.03.20	1050	18.7	51700	2.3	4	33	SEM

Waingongoro River, Eltham Camp (Site Code WGG000492)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	1115	17.0	124	1.9	107	SEM
12.12.19	1120	16.7	137	0.7	345	SEM
30.12.19	0840	14.6	142	1.6	276	SEM
9.01.20	1210	16.2	166	1.2	107	SEM
16.01.20	1100	15.0	133	1.9	114	SEM
23.01.20	1200	18.1	138	1.1	118	SEM
30.01.20	1020	18.3	155	1.6	345	SEM
10.02.20	1210	16.9	141	1.6	96	SEM
13.02.20	0940	17.4	156	1.5	435	SEM
26.02.20	0854	15.8	130	3.9	687	SEM
2.03.20	1145	18.5	137	1.1	687	FOLLOW-UP
6.03.20	1315	17.8	141	1.5	183	FOLLOW-UP
13.03.20	1000	13.6	159	1.3	548	SEM

Waingongoro River, near mouth – (Site Code WGG000995)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	mS/m@20°C	FNU	MPN/100 ml	
5.11.19	0925	16.6	187	3.3	172	MfE
22.11.19	1010	15.3	167	0.7	99	MfE
27.11.19	0915	17.3	177	3.0	132	SEM
12.12.19	0905	17.1	168	1.1	260	SEM
19.12.19	0910	13.8	142	15.0	2420	MfE
23.12.19	0820	16.1	169	3.2	172	MfE
30.12.19	0930	17.1	195	2.3	261	SEM
9.01.20	0930	16.2	211	2.1	130	SEM
16.01.20	1255	18.8	202	1.6	42	SEM
23.01.20	0925	19.5	212	1.7	126	SEM
30.01.20	1205	22.8	217	1.3	91	SEM
4.02.20	1020	22.8	226	1.5	140	MfE
10.02.20	0945	18.1	257	1.2	579	SEM
13.02.20	1235	22.0	216	1.6	167	SEM
19.02.20	1137	21.6	219	2.0	488	MfE
26.02.20	1047	18.9	148	2.8	649	SEM
2.03.20	1050	19.6	220	1.3	411	FOLLOW-UP
3.03.20	1025	19.5	229	1.5	159	MfE
13.03.20	1205	17.7	224	1.0	135	SEM
19.03.20	1055	15.5	228	1.1	183	MfE

Kaupokonui River at beach (Site Code: KPK000995)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
5.11.19	1000	17.4	183	3.2	148	MfE
22.11.19	1045	16.5	168	0.8	148	MfE
27.11.19	0940	17.8	173	3.3	387	SEM
12.12.19	0930	18.0	176	0.7	313	SEM
19.12.19	0935	13.6	144	5.8	1733	MfE
23.12.19	0900	16.9	186	2.9	249	MfE/FOLLOWUP
30.12.19	1145	18.9	189	1.3	184	SEM
9.01.20	1005	17.8	222	1.2	291	SEM
16.01.20	1320	20.1	189	2.3	55	SEM
23.01.20	1000	20.3	205	1.4	488	SEM
30.01.20	1235	24.7	210	3.0	236	SEM
4.02.20	1050	24.0	210	1.5	128	MfE
10.02.20	1020	18.4	1919	2.1	178	SEM
13.02.20	1035	21.5	219	1.1	60	SEM
19.02.20	1205	24.3	201	0.9	71	MfE
26.02.20	1120	21.0	191	2.2	162	SEM
3.03.20	1100	21.0	204	1.1	153	MfE
13.03.20	1300	19.6	1859	2.5	89	SEM
19.03.20	1015	15.9	231	0.8	135	MfE

Lake Opunake (Site Code LOP000001)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	1035	21.1	125	1.6	22	SEM
12.12.19	1025	22.2	135	1.4	105	SEM
30.12.19	1305	21.9	139	1.5	71	SEM
9.01.20	1110	21.0	145	2.1	12	SEM
16.01.20	1405	22.5	138	2.7	1	SEM
23.01.20	1110	23.0	149	3.1	44	SEM
30.01.20	1335	25.9	159	2.1	260	SEM
10.02.20	1130	22.0	178	2.7	14	SEM
13.02.20	1340	23.8	173	2.8	10	SEM
26.02.20	1220	24.2	178	1.7	39	SEM
13.03.20	1355	21.7	197	1.8	79	SEM

Timaru Stream, near mouth (Site Code: TMR0000497)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	0815	16.4	969	1.8	161	SEM
12.12.19	0848	17.0	658	0.4	285	SEM
30.12.19	0930	17.4	362	0.6	291	SEM
9.01.20	0744	15.5	137	0.5	435	SEM
16.01.20	1150	18.9	518	0.7	68	SEM
23.01.20	0835	17.2	330	0.6	204	SEM
30.01.20	1255	23.5	1715	0.5	248	SEM
10.02.20	0930	18.1	18410	2.6	122	SEM
13.02.20	1040	19.1	1067	0.9	120	SEM
26.02.20	1245	20.5	5150	0.6	101	SEM
13.03.20	1355	18.6	1116	0.6	770	SEM
16.03.20	1105	17.7	475	0.7	308	FOLLOW-UP

Waimoku Stream at Oakura beach(Site Code: WMK0000298)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	0845	13.4	191	3.3	934	SEM
12.12.19	0915	14.4	172	1.1	2920	SEM
30.12.19	0950	15.7	168	2.8	>24200	SEM
9.01.20	0807	13.6	168	1.4	1309	SEM
16.01.20	1130	15.9	529	2.2	1314	SEM
23.01.20	0840	16.8	183	1.7	2720	SEM
30.01.20	1325	21.0	178	1.4	1515	SEM
10.02.20	0850	14.8	179	0.9	2610	SEM
13.02.20	1110	16.4	335	1.5	2610	SEM
26.02.20	1225	18.9	184	1.1	1153	SEM
13.03.20	1330	16.4	515	1.4	1785	SEM

Oakura River, near mouth (Site Code: OKR000497)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	0915	16.4	1846	0.9	130	SEM
12.12.19	0935	17.3	286	0.2	326	SEM
30.12.19	1000	17.4	133	0.6	249	SEM
9.01.20	0827	15.6	104	0.3	185	SEM
16.01.20	1110	19.2	228	0.6	86	SEM
23.01.20	0900	19.7	180	0.7	435	SEM
30.01.20	1400	24.2	482	0.5	238	SEM
10.02.20	0950	18.0	3730	0.8	167	SEM
13.02.20	1130	19.9	416	0.7	50	SEM
26.02.20	1120	18.9	121	0.7	238	SEM
13.03.20	1301	20.7	369	3.5	488	SEM

Waitara River at town wharf, Waitara (Site Code WKH000922)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	1045	20.2	8040	4.1	295	SEM
12.12.19	0921	19.3	14120	46.0	1850	SEM
23.12.19	1115	17.7	7160	86.0	1500	FOLLOW-UP
30.12.19	1130	20.1	6610	3.3	41	SEM
9.01.20	0940	17.5	8780	3.3	98	SEM
16.01.20	1340	21.6	9610	5.0	74	SEM
23.01.20	0900	21.0	13530	3.3	211	SEM
30.01.20	1325	23.6	20000	2.6	146	SEM
10.02.20	1005	18.6	37700	3.2	355	SEM
13.02.20	1215	20.3	37000	3.6	160	SEM
26.02.20	1225	21.9	10500	10.0	512	SEM
13.03.20	1215	20.4	26600	3.0	110	SEM

Urenui River at estuary (Site Code: URN000480)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Enterococci	Programme
	NZST	°C	µS/cm@25°C	FNU	cfu/100 ml	cfu/100 ml	
27.11.19	0945	18.3	50800	6.9	10	<1	SEM
12.12.19	1030	21.5	51100	3.1	19	3	SEM
30.12.19	1245	18.4	51700	2.5	1	1	SEM
9.01.20	0900	15.1	51600	17.5	8	5	SEM
16.01.20	1220	17.9	50900	4.7	5	1	SEM
23.01.20	0815	19.9	52600	4.0	3	<1	SEM
30.01.20	1215	20.7	52400	2.8	1	2	SEM
10.02.20	0910	18.0	52200	6.2	11	9	SEM
13.02.20	1315	19.9	52100	1.4	4	1	SEM
26.02.20	1120	21.5	52600	9.4	210	140	SEM
13.03.20	1115	20.4	51700	4.8	1	8	SEM
27.11.19	0945	18.3	50800	6.9	10	1	SEM
12.12.19	1030	21.5	51100	3.1	19	3	SEM

Manganui River d/s of Kurapete Stream (Site Code: MGN000435)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	0840	17.3	118	0.8	219	SEM
12.12.19	1125	20.0	133	0.6	155	SEM
30.12.19	1035	17.9	111	0.8	64	SEM
9.01.20	1135	16.4	114	1.6	31	SEM
16.01.20	1100	17.4	115	1.4	24	SEM
23.01.20	1030	19.9	118	0.8	22	SEM
30.01.20	1100	22.4	113	1.1	206	SEM
10.02.20	1140	18.0	121	0.8	35	SEM
13.02.20	1035	18.8	122	1.1	108	SEM
26.02.20	1005	18.6	110	0.9	179	SEM
13.03.20	1000	15.1	122	0.7	133	SEM

Lake Ratapiko

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
27.11.19	0810	19.0	93	1.6	26	SEM
12.12.19	1205	19.9	87	1.5	112	SEM
30.12.19	1010	19.4	110	1.9	26	SEM
9.01.20	1215	19.7	95	1.8	9	SEM
16.01.20	1030	19.7	114	2.3	5	SEM
23.01.20	1105	22.5	99	2.1	16	SEM
30.01.20	1030	23.4	95	2.0	24	SEM
10.02.20	1215	24.0	94	1.4	1	SEM
13.02.20	1000	21.9	94	1.5	3	SEM
26.02.20	0923	20.6	89	1.9	30	SEM
13.03.20	0925	18.9	111	1.4	11	SEM

Lake Rotokare

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	FNU	MPN/100 ml	
5.11.19	1150	20.0	131	1.2	12	SEM
27.11.19	1145	21.9	129	1.7	23	SEM
19.12.19	1125	20.1	127	2.2	32	SEM
6.01.20	1255	19.6	134	2.8	12	SEM
9.01.20	1240	19.2	133	8.0	15	SEM
23.01.20	1240	23.6	134	1.1	1	SEM
4.02.20	1230	24.9	151	2.6	22	SEM
26.02.20	0823	21.6	135	1.2	19	SEM
12.03.20	1100	21.4	132	1.6	50	SEM

Appendix II

High tide times

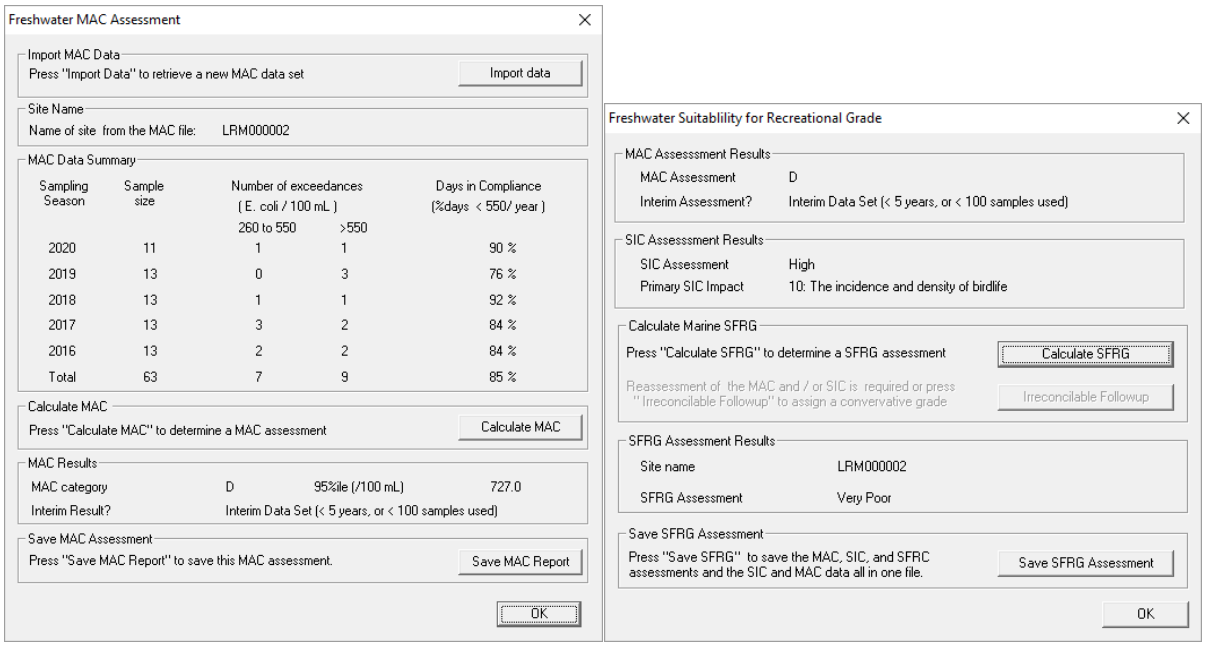
Appendix II High tide times

Date	Programme	Day	Time (NZST)	Height (m)
05 Nov 2019	MfE	Tuesday	1611	2.7
22 Nov 2019	MfE	Friday	0529	3.0
27 Nov 2019	SEM	Wednesday	0956	3.6
12 Dec 2019	SEM	Thursday	0940	3.4
19 Dec 2019	MfE	Thursday	1522	3.2
23 Dec 2019	MfE	Monday	0713	3.2
30 Dec 2019	SEM	Monday	1220	3.3
09 Jan 2020	SEM	Thursday	0837	3.2
16 Jan 2020	SEM	Thursday	1400	3.4
23 Jan 2020	SEM	Thursday	0846	3.2
30 Jan 2020	SEM	Thursday	1306	3.2
04 Feb 2020	MfE	Tuesday	1725	2.7
10 Feb 2020	SEM	Monday	1031	3.8
13 Feb 2020	SEM	Thursday	1239	3.7
19 Feb 2020	MfE	Wednesday	0639	2.9
26 Feb 2020	SEM	Friday	1127	3.4
03 Mar 2020	MfE	Tuesday	0925	2.6
13 Mar 2020	SEM	Friday	1227	3.7
19 Mar 2020	MfE	Thursday	0822	2.9

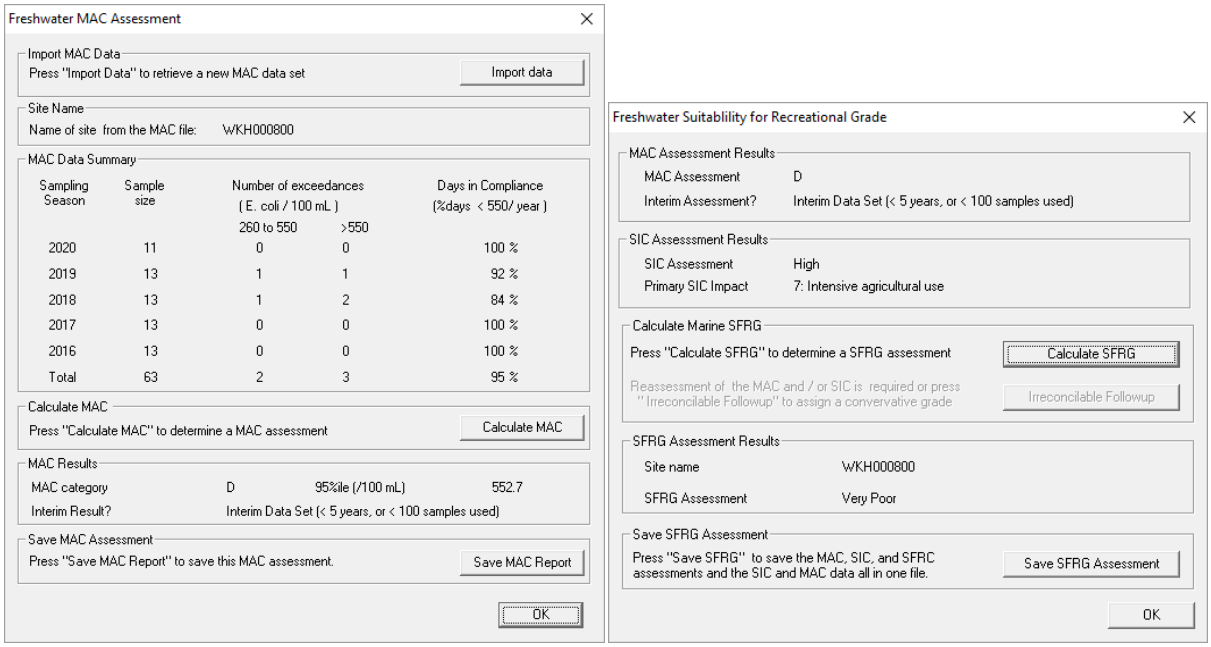
Appendix III

MAC Assessments 2015-2020

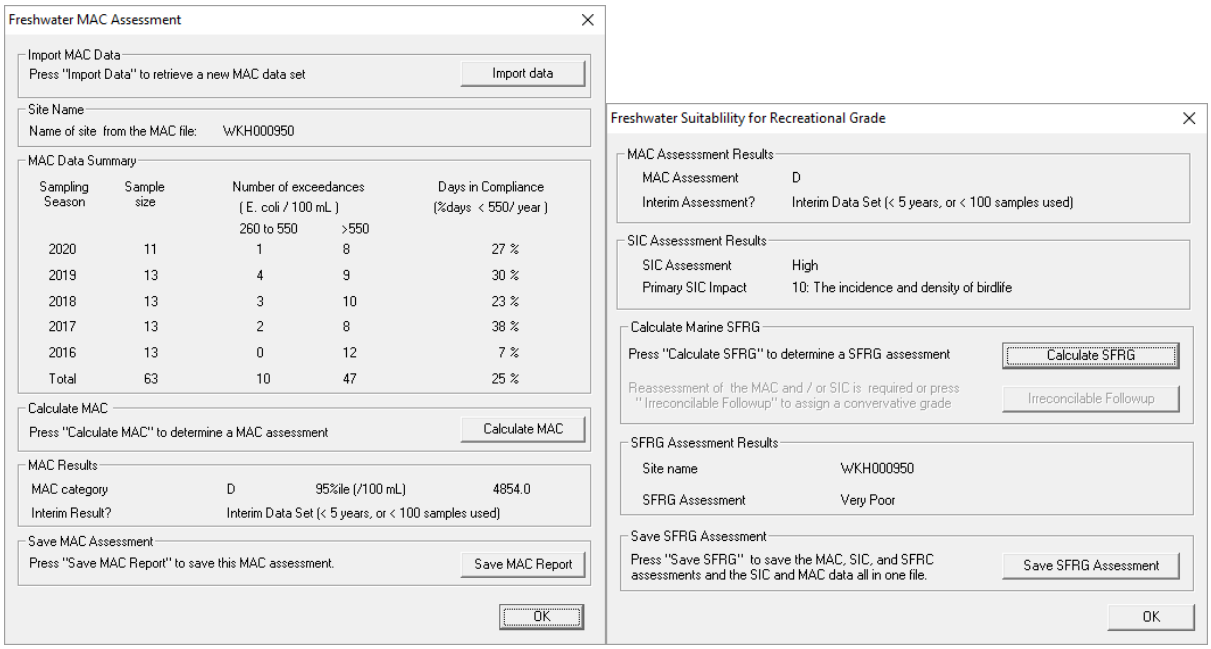
Lake Rotomanu



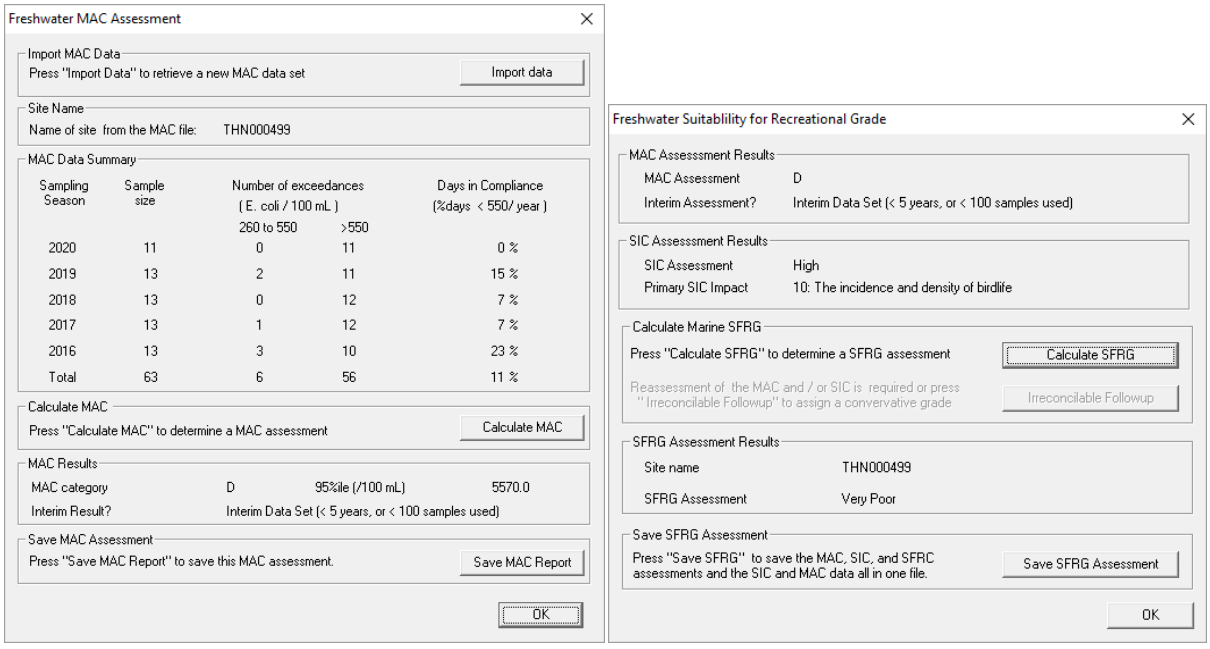
Waiwhakaiho River at Merrilands Domain



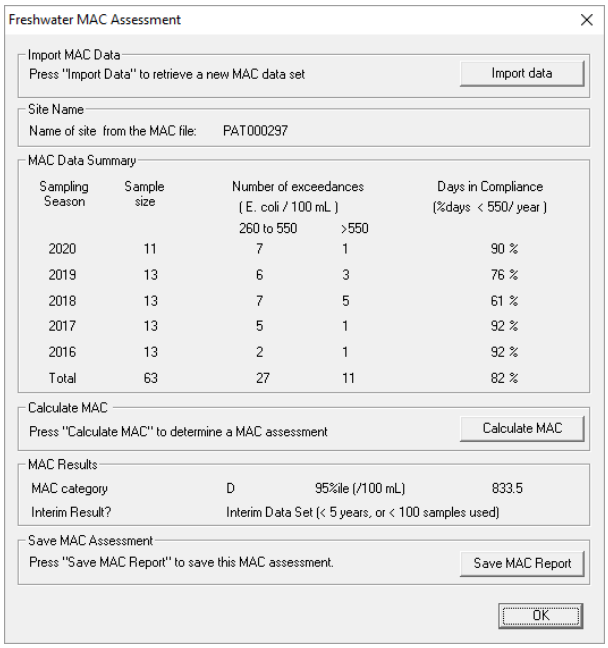
Waiwhakaiho near Lake Rotomanu

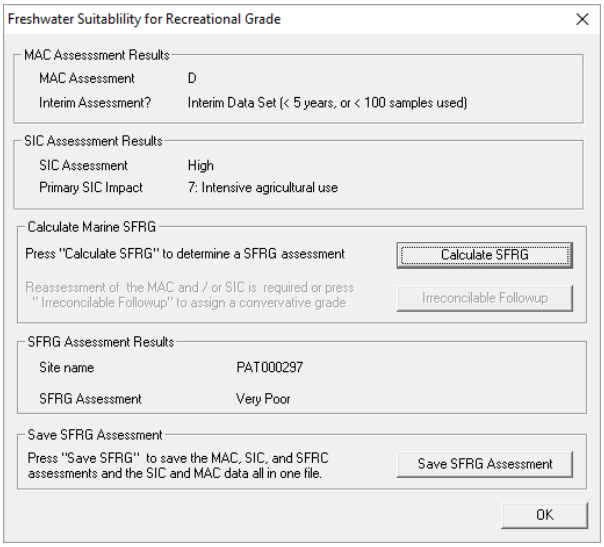


Te Henui Stream: mouth

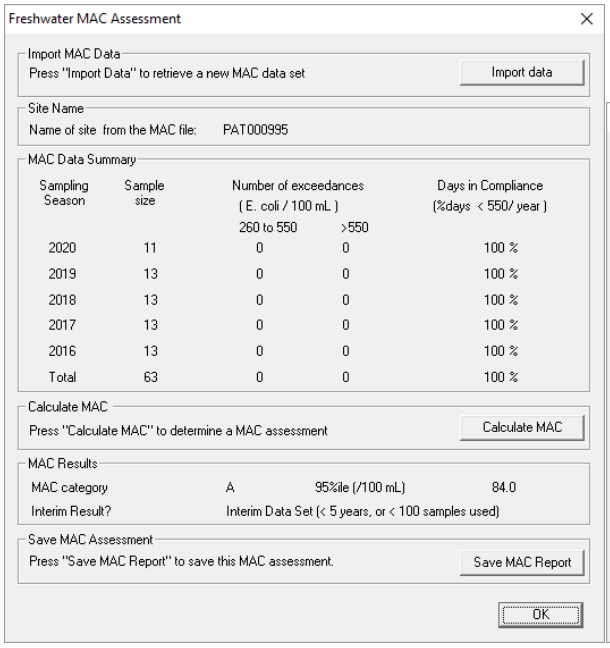


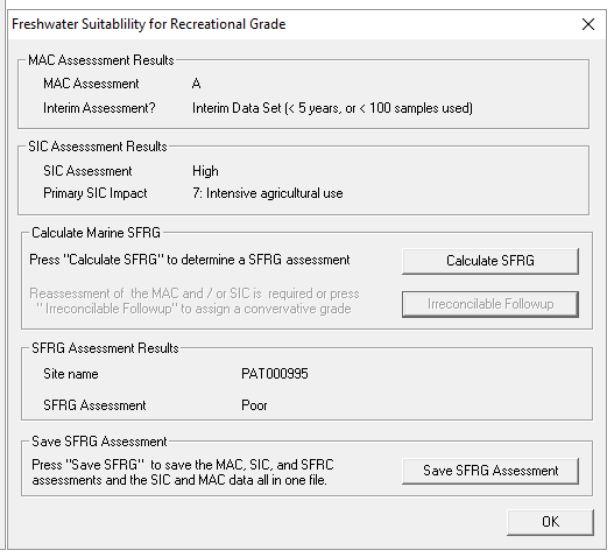
Patea River at Stratford





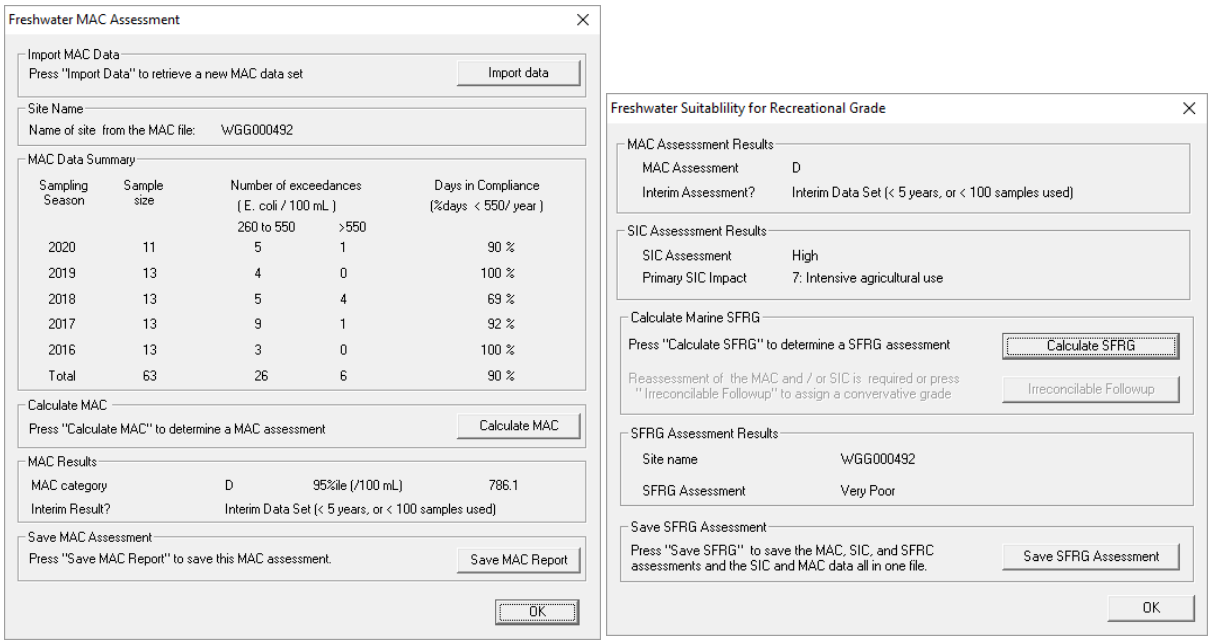
Patea River at boat ramp, Patea



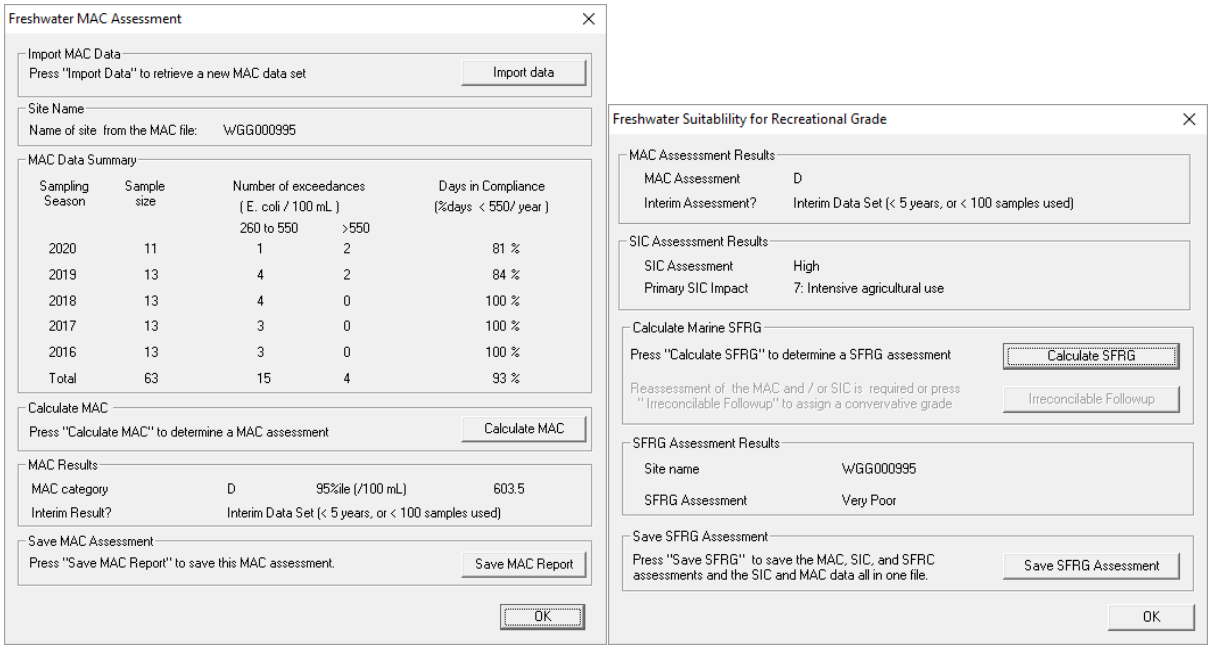


Patea River at boat ramp was Follow up, irreconcilable flow-up and SFRG Assessment resulted in Poor.

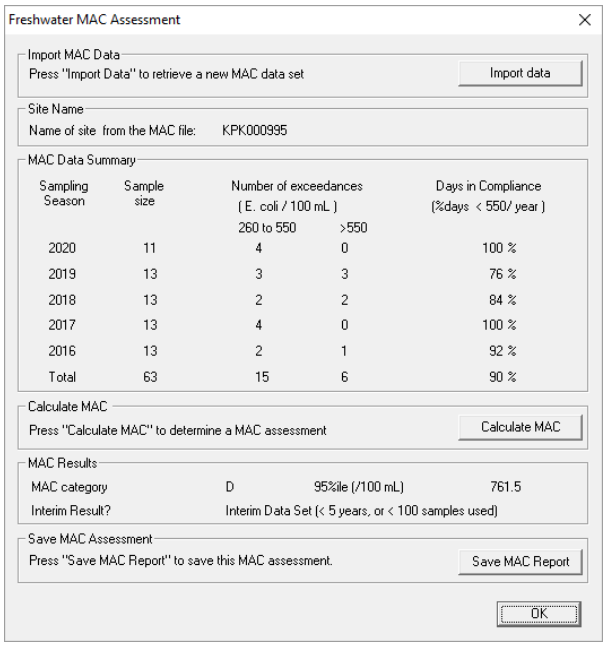
Waingongoro River at Eltham camp

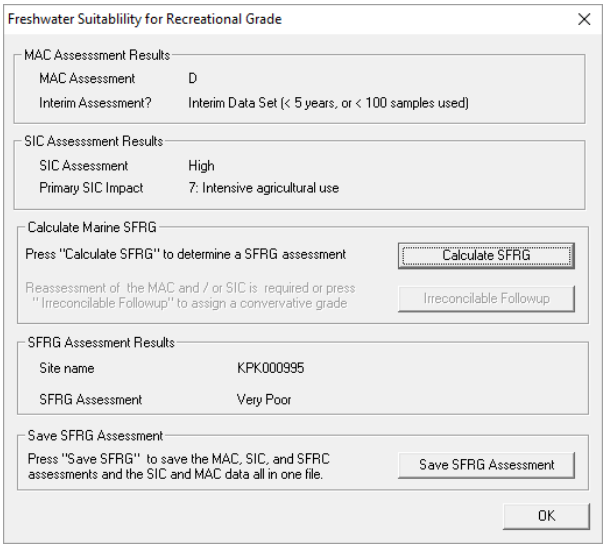


Waingongoro River at Ohawe beach

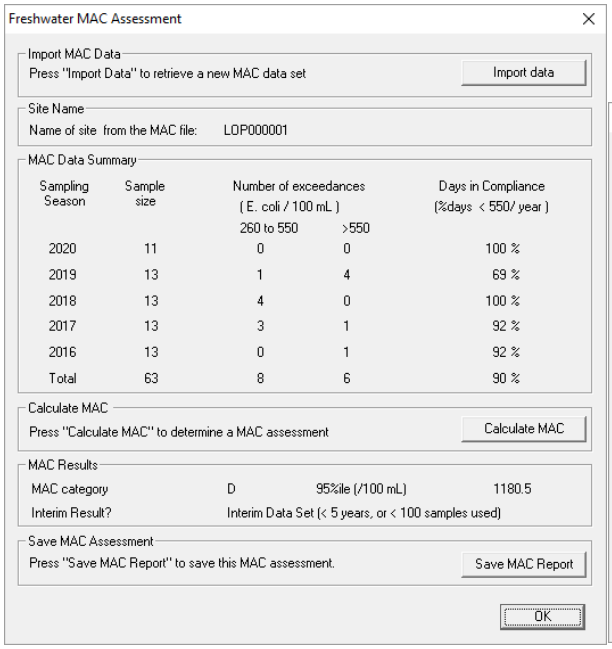


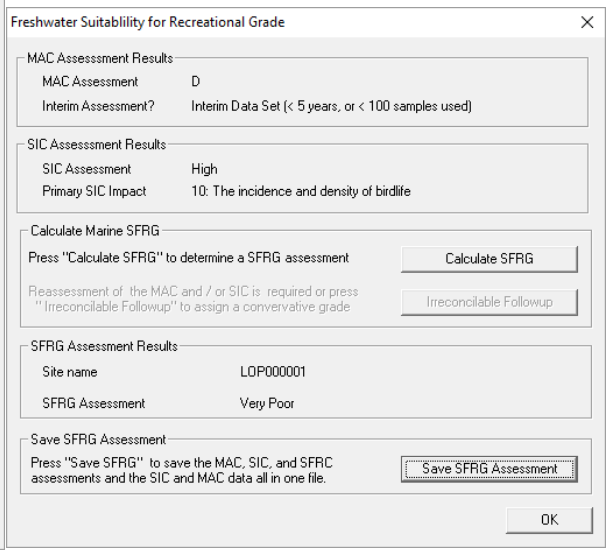
Kaupokonui River at beach domain



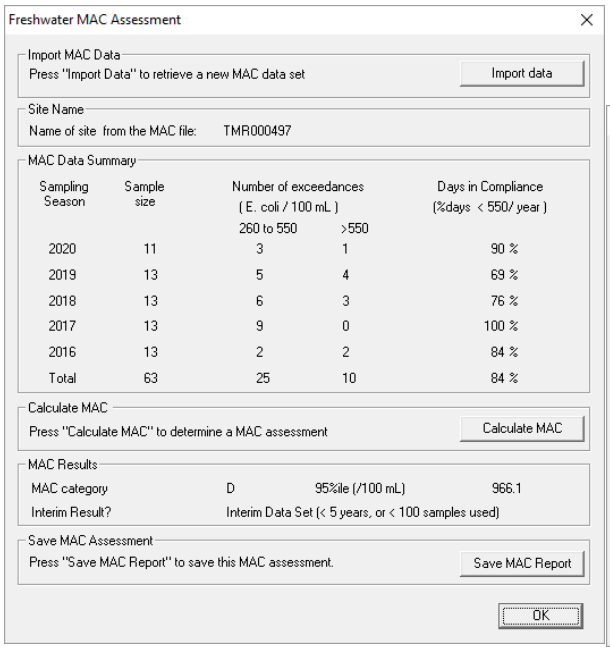


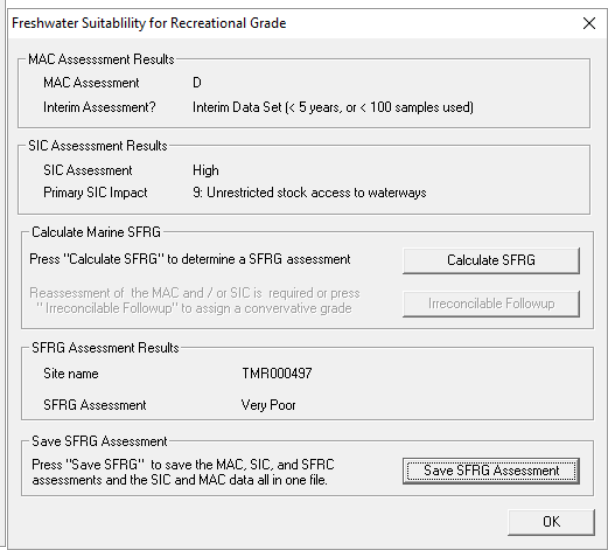
Lake Opunake



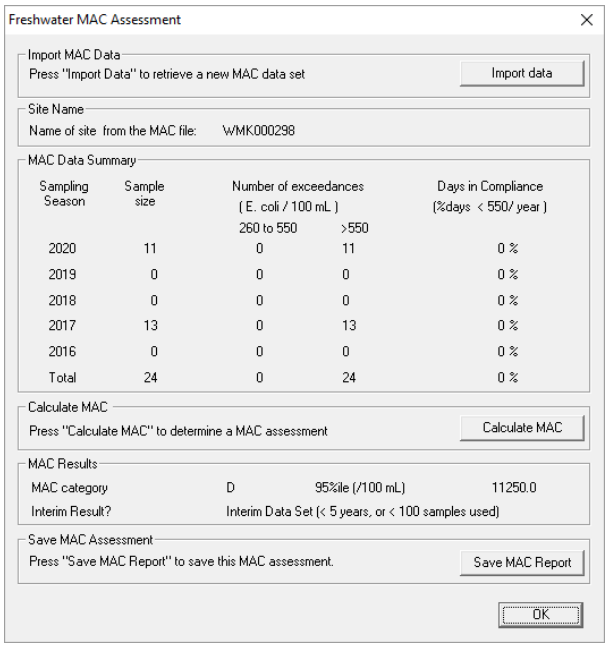


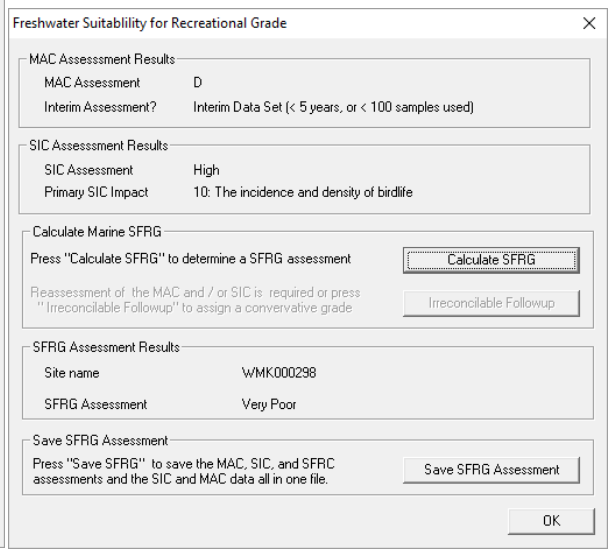
Timaru Stream at Weld Road



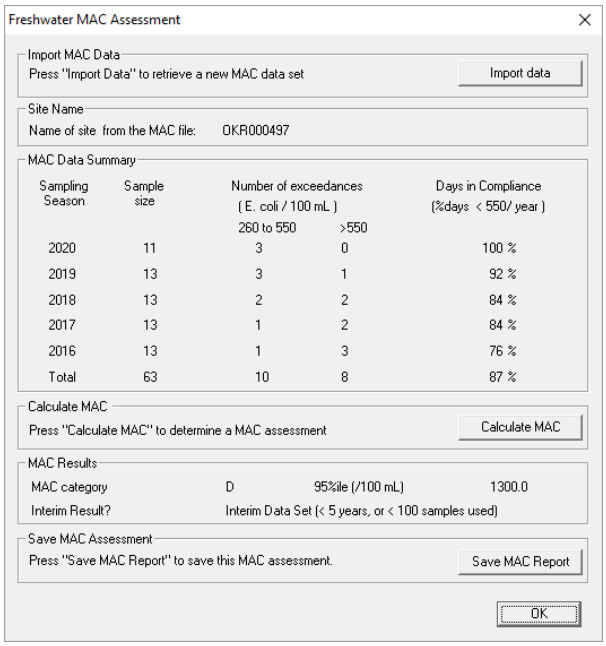


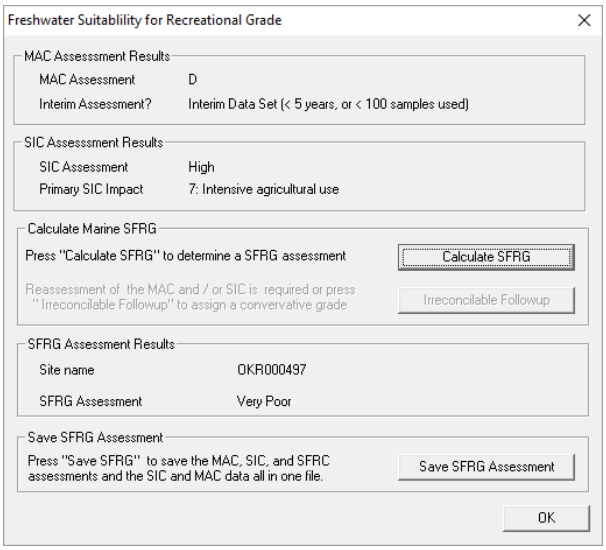
Waimoku Stream



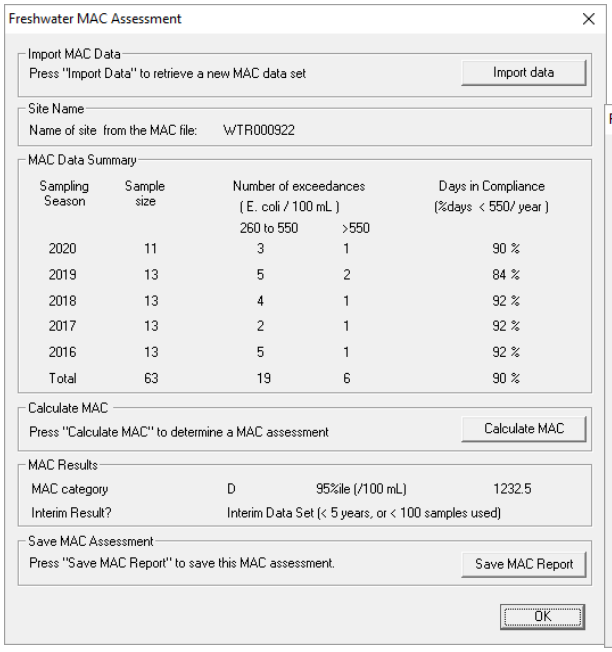


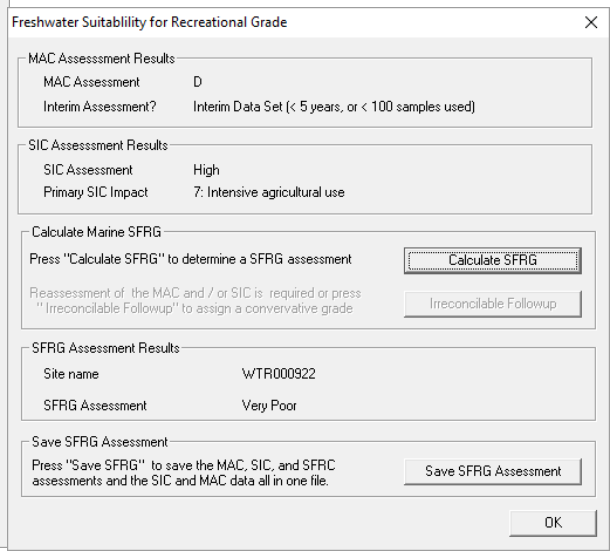
Oakura River d/s SH45



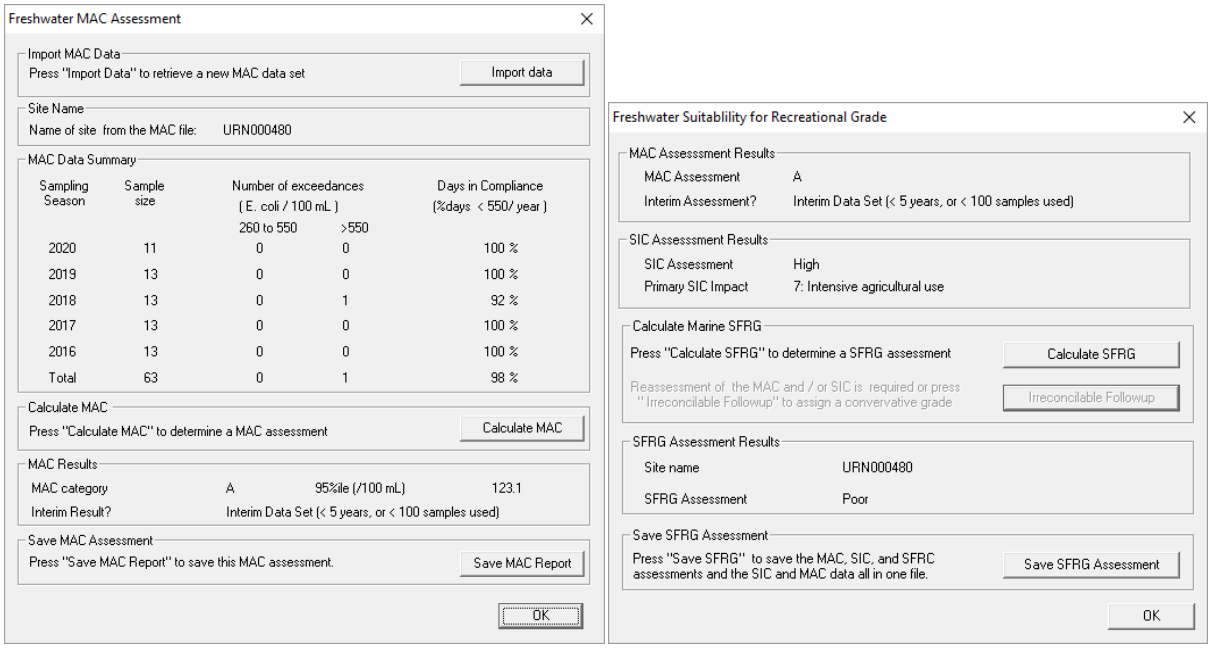


Waitara River



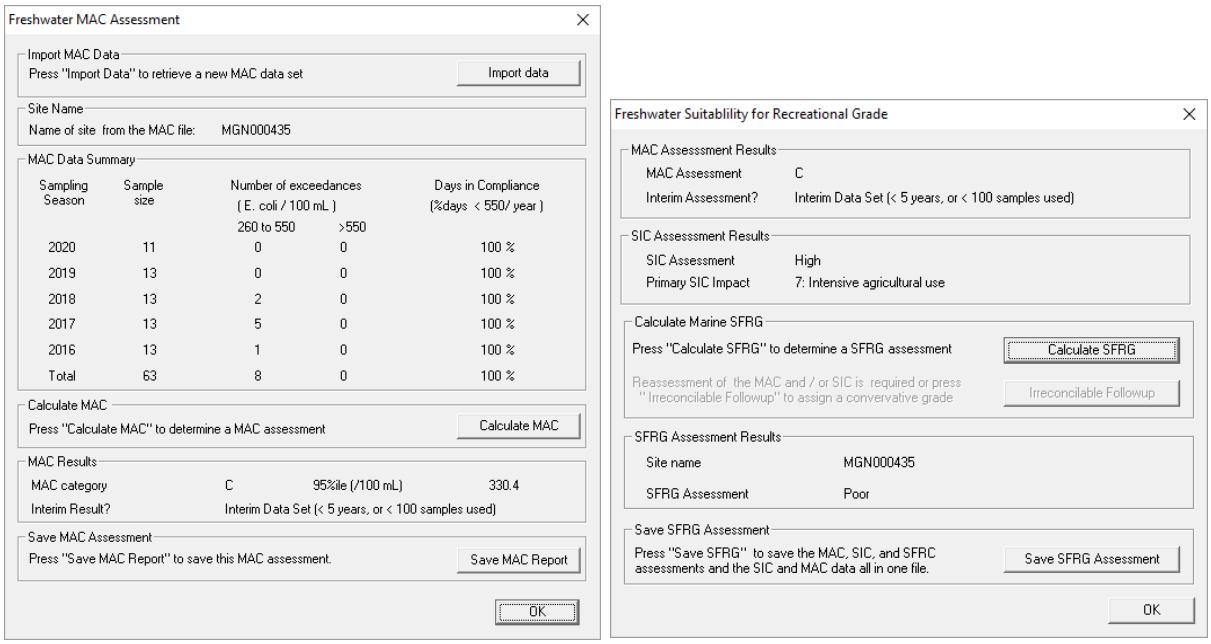


Urenui River at estuary

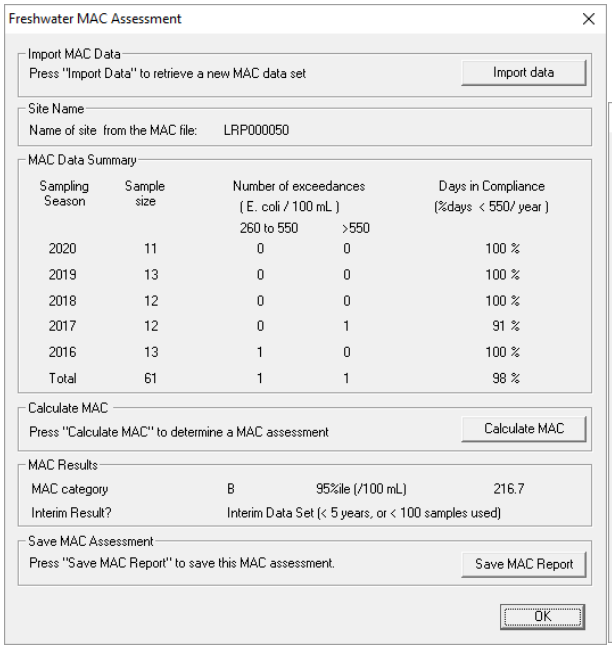


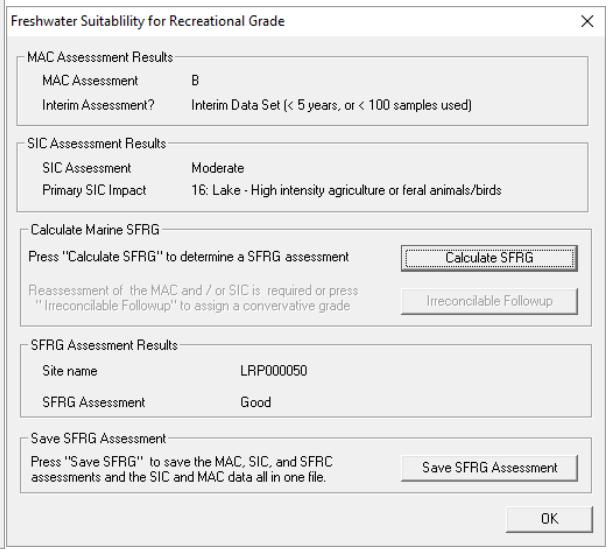
Urenui River was Follow up, irreconcilable follow-up and SFRG Assessment resulted in Poor

Manganui River at Everett Park

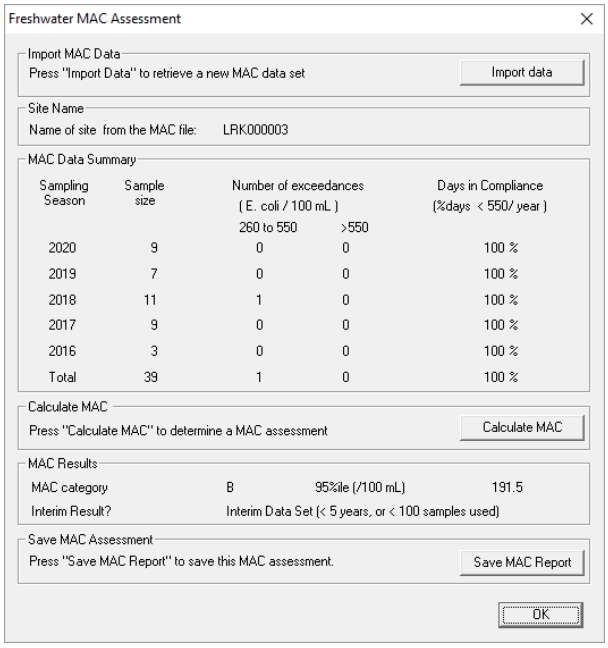


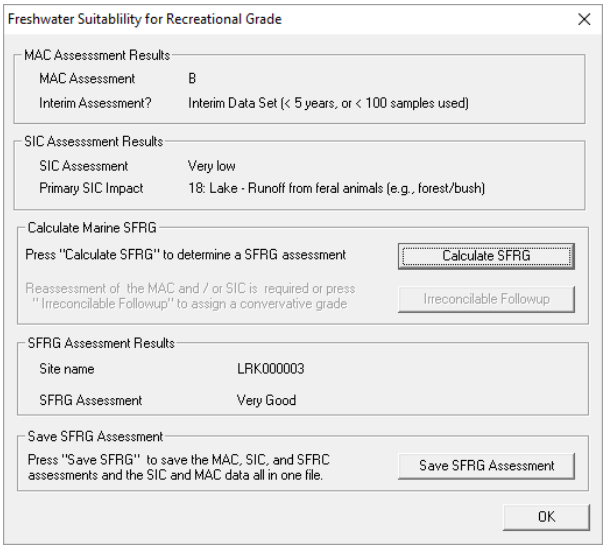
Lake Ratapiko





Lake Rotokare





Appendix IV

Sampling conditions and public usage recorded at each site

Site Lake Rotomanu (Site Code: LRM000002) Rainfall site : Mangati at SH3

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
05 Nov 2019	MFE	Fine	5/8 (broken)		Slightly turbid, green	Flat	0/5	Sign green; ~30 gulls on water, 23 on bank	0	0
22 Nov 2019	MFE	Fine	1/8 (few)		Turbid, brown	Flat	0/5 (2 picnicking, 3 feeding ducks and fish)	Sign green; 6 eels, 2 giant carp, 36 ducks+4 ducklings on water; 9 gulls on banks	0	5.4
27 Nov 2019	SEM	Fine	3/8 (scattered)		Turbid, brown	Rippled	1/3 (jetski, shore)	Sign green; 3 gulls on bank	0	0
12 Dec 2019	SEM	Fine, N breeze	1/8 (few)		Turbid, brown	Rippled	0/2 (lunching)	Sign green; 2 ducks 2 coots? on water; 6 gulls, 12 ducks on bank	0	0
19 Dec 2019	MFE	Fine	4/8 (scattered)		Turbid, brown	Rippled	4/2 (1 jetski, 3 in boat, 2 shore)	Sign green; 5 ducks on water, 2 on bank,	2.8	36.8
23 Dec 2019	MFE	Fine			Greenish brown	Rippled	15+/14 (5 children swimming, 3 boats, 1 jetski, 14 ashore)	Sign green; ,6 ducks on water, 1 dog. Several people in cars	0	10.6
30 Dec 2019	SEM	Fine	3/8 (scattered)		Turbid, brown	Rippled	4/18 (jetski, shore)	Sign green; 1 duck, on water	3.2	4.6
09 Jan 2020	SEM	Fine	5/8 (broken)		Turbid, brown	Rippled	4/13 (jetski, shore)	Sign green; 2 ducks on water	0	0.6
16 Jan 2020	SEM	Fine	1/8 (few)		Turbid, brown	Rippled	4/3 (jetski, shore)	Sign green; 3 ducks on water, 21 gulls on bank,	0	4.8
23 Jan 2020	SEM	Fine	4/8 (scattered)		Slightly turbid, Brown	Rippled	12/18 (boating/ swimming, sitting picnicking	Sign green; 2 ducks on water, 1 dog on bank	0	0
30 Jan 2020	SEM	Fine	1/8 (few)		Turbid, brown	Rippled	3/0 (boat)	Sign green; 3 ducks on water	0.2	2.6

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
04 Feb 2020	MFE	Fine	5/8 (broken)		Turbid, brown	Rippled	2/2 (kayaks)	Sign green; 30+ ducks on water, 7 gulls on bank	0	0
10 Feb 2020	SEM	Fine	3/8 (scattered)		Turbid, brown	Rippled	0/0	Sign green; 20+ ducks on water, 12 gulls on bank	0	0
13 Feb 2020	SEM	Fine	2/8 (few)		Turbid, brown	Rippled	10 kayaking/0	Sign green; 1 eel, 1 ducks, 5 seagulls on water, 25+ gulls on bank	0	0
19 Feb 2020	MFE	Fine	6/8 (broken)		Turbid, brown	Rippled	1 fishing/0	Sign green; 2 ducks on water, 1 gull on bank	1.6	3.2
26 Feb 2020	SEM	Fine, still	3/8 (scattered)		Turbid, orange - brown	Flat	1 kayaker/1 dog walker	Sign orange;,3 ducks on water	0	0
03 Mar 2020	MFE	Fine, light breeze	5/8 (broken)		Turbid, brown	Rippled	0/4 walking	Sign orange; 13 ducks on water, 30 gulls, 1 duck on bank. Sign should have been at green, based on recent E. coli and cyanobacteria data.	0	0
13 Mar 2020	SEM	Fine	0/8 (fine)		Turbid, brown	Rippled	0/2 (sitting by bank)	Sign orange; 1 duck on water, 2 gulls on bank	0.2	1.2
16 Mar 2020	FOLLOW UP	Fine, calm	5/8 (broken)		Turbid, brown	Flat	1/0 (boat)	Signs orange; 20 gulls on bank	0	0
19 Mar 2020	MFE	Fine, overcast	8/8 (overcast)		Turbid, brown	Flat	0/1 (dog walker)	Sign green, no birdlife, 1 dog	0	0

Site Waiwhakaiho River at Merrilands (Site Code: WKH000800) Rainfall site: Waiwhakaiho at Egmont Village

Sampling Date.	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
05 Nov 2019	MFE	Fine, slight breeze	0/8 (fine)	1% long,1% thick	Clear, colourless	D/S	0/2	No birdlife	0	0
22 Nov 2019	MFE	Fine/ slight breeze	6/8 (broken)	0% long,75% thick	Clear, colourless	D/S	0/0	Sign green; no birdlife	0	9.5
27 Nov 2019	SEM	Fine	4/8 (scattered)	10% long,60% thick	Clear, green/brown	D/S	0/0	Sign green; no birdlife	0	0
12 Dec 2019	SEM	Fine	1/8 (few)	0% long,50% thick	Clear, brown	D/S	0/5 (tanning)	Sign green; 2 dogs on bank	0	0
19 Dec 2019	MFE	Fine	4/8 (scattered)	10% long,60% thick	Slightly turbid,green	D/S	0/0	Sign green; 1 duck on water	7.5	76.5
23 Dec 2019	MFE	Fine	1/8 (few)	5% thick	Clear, colourless	D/S	0/1 (dog walker, 1 dog)	Sign orange;1 bird on bank	0	11.5
30 Dec 2019	SEM	Fine	2/8 (few)	20% long,60% thick	Clear, green	D/S	0/1 (dog walker, 2 dogs	Sign green; no birdlife	4.5	11
09 Jan 2020	SEM	Fine	4/8 (scattered)	40% long,35% thick	Clear, colourless	D/S	0/4	Sign green; no birdlife	0	0.5
16 Jan 2020	SEM	Fine	6/8 (broken)	25% long,40% thick	Clear, green	D/S	3/3 (swimming, walkers+2 dogs)	Sign green; no birdlife	0	5
23 Jan 2020	SEM	Fine, calm	4/8 (scattered)	35% long,50% thick	Clear, green	D/S	3/1 (swimming, bank)	Sign green; no birdlife, some foaming	0	0
30 Jan 2020	SEM	Fine	1/8 (few)	35% long,50% thick	Clear, green	D/S	2/0 (dogs)	Sign green; no birdlife	1	2.5
04 Feb 2020	MFE	Fine	7/8 (broken)	20% long,40% thick	Clear, green	D/S	1/1 (dog)	Sign green; no birdlife	0	0
10 Feb 2020	SEM	Fine	0/8 (fine)	25% long,65% thick	Clear,green	D/S	0/0	Sign green; no birdlife	0	0
13 Feb 2020	SEM	Fine	3/8 (scattered)	20% long,50% thick	Clear, green	D/S	0/0	Sign green; 3 ducks on water	0	0
19 Feb 2020	MFE	Fine	8/8 (overcast)	40% long,60% thick	Clear, green	D/S	0/0	Sign green; 2 ducks on water	6.5	19

Sampling Date.	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
26 Feb 2020	SEM	Fine, still	0/8 (fine)	25% long,75% thick	Clear, colourless	D/S	0/1 (dog walker)	Sign green;1 dog on bank,	0	0
03 Mar 2020	MFE	Overcast, drizzle	8/8 (overcast)	30% long,60% thick	Clear, colourless - brown	D/S	0/0	Sign green;1 black shag on bank	0	0
13 Mar 2020	SEM	Fine, light breeze	0/8 (fine)	0% long,30% thick	Clear, uncoloured	D/S	0/0	Sign green; no birdlife	0	1
19 Mar 2020	MFE	Fine, overcast	8/8 (overcast)	50% long,50% thick	Clear, colourless	D/S	0/0	Sign green; no birdlife	0.5	0.5

Site Waiwhakaiho River adjacent to Lake Rotomanu (Site Code: WKH000950) Rainfall site: Mangati at SH3

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	Fine	3/8 (scattered)	0% long,25% thick,80	Clear, green	U/S	0/0	No birdlife	0	0
12 Dec 2019	Fine, N wind	1/8 (few)	0% long,25% thick,80	Clear, brown	D/S	0/0	Sign OK; 15 ducks on bank	0	0
30 Dec 2019	Fine	4/8 (scattered)	10% long,20% thick	Clear, green	D/S	0/0	No sign; 20 ducks on bank	3.2	4.6
09 Jan 2020	Fine, calm	3/8 (scattered)	0% long,70% thick	Clear, uncoloured	D/S	0/0	No sign; black backed gulls common (20+)	0	0.6
16 Jan 2020	Fine	1/8 (few)	15% long,25% thick	Clear, green	D/S	0/0	No sign, 4 ducks on water, 4 ducks and 1 gull on banks	0	4.8
23 Jan 2020	Fine, calm	5/8 (broken)	15% long,65% thick	Clear, uncoloured	D/S	0/0	No sign; gulls colony upstream (100+). Slight film on water surface	0	0
30 Jan 2020	Fine	1/8 (few)	15% long,60% thick	Clear, green	D/S	0/0	No sign, 3ducks on water, 9 ducks 2 seagulls on banks	0.2	2.6
10 Feb 2020	Fine	3/8 (scattered)	-	Clear, green	U/S	0/0	No sign; gull colony upstream, 5 ducks on water, 7 on banks	0	0
13 Feb 2020	Fine	2/8 (few)	-	Clear, uncoloured	D/S	0/0	No sign,5 shags, 8 ducks, 100+ seagulls,2 ducks	0	0
26 Feb 2020	Fine	1/8 (few)	0% long,75% thick	Clear, colourless	D/S	0/0	Sign – orange. ,low number of gulls u/s	0	0
13 Mar 2020	Fine	0/8 (fine)	0% long,80% thick	Clear, uncoloured	D/S	0/0	Cyanobacteria sloughed off rocks by fresh	0.2	1

Site Te Henui Stream at mouth, East End (Site Code: THN000499) Rainfall site: Brooklands Zoo at New Plymouth

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	Fine	2/8 (few)	0% long, 0% thick	Slightly turbid, blue/brown	U/S, surging	0/10 (walking)	Permanent TDHB warning signs, 3 ducks on water, 3 gulls on bank	0	0
12 Dec 2019	Fine, calm	1/8 (few)	0% long, 0% thick	Clear, green	D/S	1/2 (dog in water)	10 ducks on water	0	0.2
30 Dec 2019	Fine	6/8 (broken)		Clear, grey	D/S	0/3 (duck-feeding)	25 ducks on water, 4 on bank	4.6	6.4
09 Jan 2020	Fine	5/8 (broken)		Clear, none	D/S	0/2	2 ducks on water	0	0.4
16 Jan 2020	Fine	1/8 (few)		Clear, green	U/S, surging	0/6 (+2 dogs)	5 ducks,on water	0	4.6
23 Jan 2020	Fine	3/8 (scattered)	0% long, 20% thick	Clear, none	D/S	3/8-12 (swimming, banks)	No birdlife	0	0
30 Jan 2020	Fine, breezy	1/8 (few)		Clear, green	D/S	1/5 (swimming with dog)	8 ducks on water	0.8	3.8
10 Feb 2020	Fine	5/8 (broken)		Slightly turbid, green	U/S	0/0	10 ducks and 5 gulls on water, 5 gulls on bank	0	0
13 Feb 2020	Fine	5/8 (broken)		Clear, green	U/S	0/0	17 gulls on bank	0	0
26 Feb 2020	Fine	0/8 (fine)		Slightly turbid, brown - green	Slack	0/1 (dog walker)	~20 ducks, 3 gulls on water, 1 duck on bank	0	0
13 Mar 2020	Sunny	0/8 (fine)	0% long, 0% thick	Slightly turbid, green brown	U/S	0/5	29 ducks upstream, 22 on bank	0	1

Site Patea River, King Edward Park, Stratford (Site Code: PAT000297) Rainfall site: Patea at Stratford

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine, light breeze	0/8 (fine)	0% long, 0% thick	Clear, slight brown	D/S	0/0	1 duck,	0	0
12 Dec 2019	SEM	Fine, calm	0/8 (fine)	0% long, 0% thick	Clear, uncoloured	D/S	0/2	No birdlife	0	0
30 Dec 2019	SEM	Fine, light breeze	4/8 (scattered)	0% long, 0% thick	Clear, brown tinge	D/S	0/0	No birdlife, light rain preceding	0.5	3
09 Jan 2020	SEM	Fine, light breeze	3/8 (scattered)	0% long, 0% thick	Clear, uncoloured	D/S	0/2 (fishing)	No birdlife	0	0.5
16 Jan 2020	SEM	Fine	0/8 (fine)		Clear, uncoloured	D/S	3/0 (swimmers)	No birdlife	0	17
23 Jan 2020	SEM	Fine	6/8 (broken)	0% long, 0% thick	Clear, light brown	D/S	0/0	No birdlife	0	0
30 Jan 2020	SEM	Fine	0/8 (fine)	0% long, 0% thick	Clear, uncoloured	D/S	0/1 (fisher)	No birdlife	0.5	0.5
03 Feb 2020	FOLLOW UP	Fine	1/8 (few)		Clear, uncoloured		0/0	SDC health warning, 2 ducks	0	0
10 Feb 2020	SEM	Fine, calm	0/8 (fine)		Clear, uncoloured	D/S	0/0	No birdlife	0	0.5
13 Feb 2020	SEM	FIne, light breeze	1/8 (few)	0% long, 5% thick	Clear, brown tinge	D/S	0/0	1 duck	0	0
26 Feb 2020	SEM	Fine	0/8 (fine)	0% long, 0% thick	Clear, uncoloured		0/0	No birdlife	0	0
13 Mar 2020	SEM	Fine, still	0/8 (fine)	0% long, 5% thick	Clear, brown tinge	D/S	0/0	No birdlife	0.5	3

Site Patea River, boat ramp, Patea (Site Code: PAT000995) Rainfall site: Patea at Bore 3

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	Fine	1/8 (few)		Turbid, grey/blue	D/S	0/0	No birdlife,,flow swirling u/s on far bank. m	0	0
12 Dec 2019	Fine, mod SW breeze	0/8 (fine)		Slightly turbid, grey	U/S	0/0	No birdlife	0	0
30 Dec 2019	Fine, mod N wind	7/8 (broken)		Turbid,Grey blue	D/S	0/0	No birdlife	0.2	0.2
09 Jan 2020	Fine, light Breeze	7/8 (broken)		Clear, grey/blue	D/S	0/0	1 duck on bank	0	0
16 Jan 2020	Fine	0/8 (fine)		Slightly turbid, light blue	U/S	0/0	No birdlife	0	0.6
23 Jan 2020	Fine, light Breeze	0/8 (fine)		Clear,Blue/Grey	D/S	1/4 (1 boat on water, 2 being launched, 2 fishing)	No birdlife	0	0
30 Jan 2020	Fine	0/8 (fine)		Slightly turbid, green/blue	D/S	1 swimmer/3 people 1 dog	No birdlife	0	0
10 Feb 2020	Fine, overcast	7/8 (broken)		Clear, blue/grey	D/S	0/0	3 gulls, d/s flow with swirling upstream	0	0
13 Feb 2020	Fine, light-mod breeze	2/8 (few)		Turbid, murky green/blue	D/S	0/0	2 gulls; d/s flow with swirling upstream	0	0
26 Feb 2020	Fine	0/8 (fine)		Slightly turbid, grey	U/S	2/3 (1 boat on water/3 unloading a boat.; 20+ boat trailers parked)	No birdlife	0	0
13 Mar 2020	Fine, breezy from sea	0/8 (fine)		Turbid, green	U/S	0/0	No birdlife	0	1.4

Site Waingongoro River, Eltham camp (Site Code: WGG000492) Rainfall site: Patea at Stratford

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine	0/8 (fine)	0% long, 0% thick	Clear, slightly light brown	D/S	0/0	No birdlife,20+ sheep in paddock	0	0
12 Dec 2019	SEM	FIne	1/8 (few)	0% long, 0% thick	Clear, uncoloured	D/S	5 Kids/20-30 Kids	No birdlife	0	0
30 Dec 2019	SEM	Spitting, light breeze	7/8 (broken)	5% long, 5% thick	Clear, brown tinge	D/S	0/0	No birdlife, sheep;. light rain preceding	0.5	3
09 Jan 2020	SEM	Fine, noderate breeze	6/8 (broken)	20% long, 10% thick	Clear, uncoloured	D/S	0/0	No birdlife	0	0.5
16 Jan 2020	SEM	Fine	0/8 (fine)	20% thick, 0% long	Clear,Uncoloured	D/S	0/0	No birdlife	0	17
23 Jan 2020	SEM	Fine, overcast	7/8 (broken)	20% long, 15% thick	Clear, light Brown	D/S	0/0	No birdlife; 20+ sheep	0	0
30 Jan 2020	SEM	Fine	0/8 (fine)	0% long, 10% thick	Clear, uncoloured	D/S	0/0	No birdlife	0.5	0.5
10 Feb 2020	SEM	Fine, calm	0/8 (fine)	5% long, 10% thick	Clear, uncoloured	D/S	0/0	No birdlife,10 Sheep,	0	0.5
13 Feb 2020	SEM	Fine, light breeze	1/8 (few)	10% long, 0% thick	Clear, brown tinge	D/S	0/0	No birdlife	0	0
26 Feb 2020	SEM	Fine	0/8 (fine)	0% long, 0% thick	Clear, uncoloured		0/0	No birdlife	0	0
02 Mar 2020	FOLLOW UP	fine, calm	8/8 (overcast)	25% long, 70% thick	Clear, light brown	D/S	0/0	No birdlife	0	4.5
06 Mar 2020	FOLLOW UP	fine	1/8 (few)	10% long, 5% thick	Clear, brown	D/S	0/0	health risk warning,15 sheep, footprints at river's edge	0	16.5
13 Mar 2020	SEM	Fine, still	0/8 (fine)	25% long, 50% thick	Clear, brown	D/S	0/0	No birdlife; small fish; sheep in paddock	0.5	3

Site Waingongoro River, near mouth (Site Code: WGG000995) Rainfall site: Kaupokonui at Glenn Road

Sampling Date	Programme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
05 Nov 2019	MFE	Fine, light E breeze	3/8 (scattered)	0% long, 5% thick	Clear, brown tinge	D/S	0/2 (whitebaiters)	No birdlife; 1 dog	0	0
22 Nov 2019	MFE	Fine, light breeze	1/8 (few)	10% thick	Clear, uncoloured	D/S	0/2 (whitebaiters)	No birdlife, pesticide/herbicide survey	0	3
27 Nov 2019	SEM	Fine	0/8 (fine)	0% long,10% thick	Slightly turbid, brown	D/S	2/6 (all whitebaiters)	1 duck, 1 dog	0	0
12 Dec 2019	SEM	Fine, calm	0/8 (fine)	0% long,50% thick	Clear, uncoloured	D/S	0/0	No birdlife	0	0
19 Dec 2019	MFE	Fine	1/8 (few)		Turbid, brown	D/S	0/0	No birdlife	31	97
23 Dec 2019	MFE / FOLLOWUP	Fine, calm	2/8 (few)	20% long,0% thick	Clear, light brown	D/S	3/0	No birdlife	0	12
30 Dec 2019	SEM	Fine, overcast, still	6/8 (broken)	0% long, 90% thick	Slightly turbid, brown/green	D/S	0/0	No birdlife	1.5	5
09 Jan 2020	SEM	Fine, light breeze	4/8 (scattered)	50% long, 5% thick	Clear, light brown	D/S	1/0 (fishing)	No birdlife	0	0
16 Jan 2020	SEM	Fine	0/8 (fine)	30% thick, 0% long	Clear,uncoloured	D/S	0/0	No birdlife	0	1
23 Jan 2020	SEM	Fine, Light Breeze	2/8 (few)	10% long, 5% thick	Clear, slight brown	D/S	0/0	No birdlife	0	0
30 Jan 2020	SEM	Fine	0/8 (fine)	0% long, 20% thick	Clear, uncoloured	D/S	0/0	1 gull	0	0
04 Feb 2020	MFE	Fine	0/8 (fine)	50% thick ,0% long	Clear, uncoloured	D/S	0/0	No birdlife	0	0
10 Feb 2020	SEM	Fine	5/8 (broken)	5% long, 5% thick	Clear, light brown	D/S	0/1 (dog walker)	3 Mallard ducks	0.5	5
13 Feb 2020	SEM	Fine, mod breeze	3/8 (scattered)	0% long, 0% thick	Clear, brown	slack	0/0	2 health warning signs, no birdlife, small fish	0	0
19 Feb 2020	MFE	Fine	0/8 (fine)	50% thick, 0% long	Clear, uncoloured	D/S	0/0	No birdlife	4	6

Sampling Date	Programme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
26 Feb 2020	SEM	Fine	0/8 (fine)		Clear, light brown	D/S	0/0	No birdlife	0	0
02 Mar 2020	FOLLOW UP	Fine, northerly	7/8 (broken)	0% long, 95% thick	Slightly turbid, ,light brown	D/S	0/0	Health risk warning sign on ground below signpost at (locked) gateway to entrance track. No birdlife	0	3
03 Mar 2020	MFE	Fine, light breeze	7/8 (broken)	0% long, 75% thick	Clear, brown	D/S	0/0	Health risk warning fallen down; 2 ducks	0	0
13 Mar 2020	SEM	Fine, slight breeze	0/8 (fine)	0% long, 0% thick	Clear, ,brown	D/S	0/0	Small fish school, 4 ducks. Took extra sample of foam.	0	3.5
19 Mar 2020	MFE	Fine, light breeze, warm	7/8 (broken)	0% long, 0% thick	Clear, brown	D/S	0/9 (leaving area)	2 ducks; thin brown algae widespread	0	0

Site Kaupokonui River, beach domain (Site Code: KPK000995) Rainfall site: Kaupokonui at Glenn Road

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
05 Nov 2019	MFE	Fine, light N breeze	2/8 (few)	0% long, 50% thick	Clear, uncoloured	D/S	0/0	10 gulls,	0	0
22 Nov 2019	MFE	Fine, light breeze	1/8 (few)	0% long, 50% thick	Slightly turbid, light brown		0/0	1 goose	0	3
27 Nov 2019	SEM	Fine	0/8 (fine)	0% long, 0% thick	Slightly turbid, green/brown	D/S	0/8 (whitebaiters)	3 ducks	0	0
12 Dec 2019	SEM	Fine, light breeze	0/8 (fine)	0% long, 0% thick	Clear, uncoloured	slack	2/6 (swimmers)	5 ducks on water, 10-20 other birds	0	0
19 Dec 2019	MFE	Fine	1/8 (few)	0% long, 30% thick	Slightly turbid, light brown	D/S	0/0	No birdlife	31	97
23 Dec 2019	MFE / FOLLOW-UP	Fine, light breeze	3/8 (scattered)	0% long, 0% thick	Clear, light brown	D/S	0/0	No birdlife	0	6
30 Dec 2019	SEM	Overcast, fine, light breeze	7/8 (broken)	0% long, 0% thick	Clear, Green tinge	U/S	5/11 (swimming, fishing, banks)	1 duck; 2 persons swimming in sample area	1.5	5
09 Jan 2020	SEM	Fine, light Breeze	4/8 (scattered)	60% long, 5% thick	Clear, light brown	D/S	0/6 (3 fishing,)	2 ducks, 1 gull	0	0
16 Jan 2020	SEM	Fine	0/8 (fine)		Clear, uncoloured	U/S	0/5	5 gulls	0	1
23 Jan 2020	SEM	Fine, mod breeze	2/8 (few)	15% long, 15% thick	Clear, green/brown	U/S	2/5 (2swimming, 2 fishing)	No birdlife	0	0
30 Jan 2020	SEM	Fine	0/8 (fine)		Clear, brownish	U/S	4/3 (swimming, walkers)	No birdlife	0	0
04 Feb 2020	MFE	Fine	0/8 (fine)	20% thick, 0% long	Clear, uncoloured	D/S	0/0	No birdlife	0	0
10 Feb 2020	SEM	Fine, mod breeze	2/8 (few)	Too dark to see	Slightly turbid, brown/dark green	U/S	0/1 (fishing at mouth)	Cyanobacteria warning sign, No birdlife	0.5	5
13 Feb 2020	SEM	Fine, mod breeze	1/8 (few)	0% long, 0% thick	Clear, brown tinge	D/S	0/4 (walking, picnicking)	Sign fallen down. No birdlife	0	0
19 Feb 2020	MFE	Fine	0/8 (fine)	40% thick, 0% long	Clear, uncoloured	D/S	0/2 (walking)	No birdlife	4	6

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
26 Feb 2020	SEM	Fine	0/8 (fine)		Clear, uncoloured	U/S	0/5	No birdlife	0	0
03 Mar 2020	MFE	Fine, light breeze	7/8 (broken)		Clear, uncoloured	U/S	0/4 (2 ridden horses,, 2 walkers)	No birdlife	0	0
13 Mar 2020	SEM	Fine, slight breeze	0/8 (fine)	0% long, 0% thick	Clear, brown	U/S	0/6 (cars on bank)	No birdlife. Floating seaweed	0	3.5
19 Mar 2020	MFE	Fine, still, cold	8/8 (overcast)	0% long, 0% thick	Clear, dark brown tinge	U/S	0/0	No birdlife	0	0

Site Lake Opunake (Site Code: LOP000001) Rainfall site: Taungatara at Eltham Road

Sampling Date	Programme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine, light breeze	1/8 (few)	0% long, 0% thick	Clear, uncoloured	Rippled	0/0	30+ ducks, 2 geese, 1 swan on water	0	0
12 Dec 2019	SEM	Fine, light breeze	1/8 (few)	0% long, 0% thick	Clear, light brown	Rippled	0/0	20 ducks,	0	0
30 Dec 2019	SEM	Overcast, fine, light breeze	8/8 (overcast)		Clear, uncoloured	Flat	0/0	12 ducks on water, 1 on bank	1	3.5
09 Jan 2020	SEM	Fine, light breeze	5/8 (broken)	30% long, 0% thick	Slightly turbid, brown	Rippled	0/6 (sitting/picnicking)	Ducks common	0	0
16 Jan 2020	SEM	Fine	0/8 (fine)		Clear, light brown	Rippled	0/0	Ducks common	0	0.5
23 Jan 2020	SEM	Fine, light breeze	1/8 (few)	Too turbid to see	Slightly turbid, brown	Flat	0/8 (freedom campers)	Ducks v common,, 7 Canadian geese, 4 black swans,	0	0
30 Jan 2020	SEM	Fine	0/8 (fine)		Slightly turbid, dark green	Flat	0/5-10 camping	Ducks v common	3.5	6
10 Feb 2020	SEM	Fine, light breeze	4/8 (scattered)	Too turbid to see	Clear, green	Flat	0/5 (parked cars)	Health safety sign removed. Ducks v common, 10 geese, 6 black swans	0	0
13 Feb 2020	SEM	Fine, light breeze	2/8 (few)		Turbid, brown	Flat	0/0 - 1 empty car	Ducks common. Lake weed matting on surface	0	0
26 Feb 2020	SEM	Fine	0/8 (fine)		Clear, light brown	Flat	0/2	Ducks v common,10 black swans,	0	0
13 Mar 2020	SEM	Fine, slight breeze	0/8 (fine)		Turbid, dark brown	Rippled	0/2 cars	Ducks common, much weed in lake.	0	4

Site Timaru Stream, near mouth (Site Code: TMR000497) Rainfall site: Stony at Mangatete Bridge

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine	4/8 (scattered)	0% long, 0% thick	Clear, colourless	U/S	0/0	NPDC sign g;reen,1 seagull	0	0
12 Dec 2019	SEM	Fine	1/8 (few)	0% long, 0% thick	Clear, colourless	U/S	9/1 (swimming, paddle-boarding surfing, walker)	Sign green,2 gulls, 20 fish,	0	0
30 Dec 2019	SEM	Fine	4/8 (scattered)	0% long, 0% thick	Clear, grey	D/S	2/5 (paddling, walking,1 dog, dune buggy	Sign green,1 gull	6	10
09 Jan 2020	SEM	Light spits, offshore wind	7/8 (broken)	0% long, 0% thick	Clear, uncoloured	D/S	0/0	Sign green;, swallows	0	1
16 Jan 2020	SEM	Fine	0/8 (fine)		Clear, grey	D/S	5/3	Sign green; no birdlife	0	11.5
23 Jan 2020	SEM	Fine	3/8 (scattered)	0% long, 0% thick	Clear, none	D/S	2/2 1 dog in water	Sign green, no birdlife	0	0
30 Jan 2020	SEM	Fine, breezy	1/8 (few)		Clear, brown	D/S	0/0	Sign green, no birdlife	0	7.5
10 Feb 2020	SEM	Fine	6/8 (broken)		Slightly turbid, green	D/S	0/0	Sign green, no birdlife	0	0
13 Feb 2020	SEM	Fine	7/8 (broken)	0% long, 15% thick	Clear, uncoloured	Slack	0/0	Sign green, no birdlife	0	0
26 Feb 2020	SEM	Fine	0/8 (fine)	0% long, 0% thick	Clear, colourless	Slack	0/1	Sign green,5 gulls, stream meanders 50m upshore due to sand spit. Mouth open (restricted).	0	0
13 Mar 2020	SEM	Fine, light breeze	0/8 (fine)	0% long, 0% thick	Clear, colourless	D/S	0/0	Sign green, 4 gulls	0	3.5
16 Mar 2020	FOLLOW UP	Fine, light westerly	5/8 (broken)		Clear, uncoloured	D/S	1/0 (kayaker)	Sign orange, no birdlife	0	0

Site Waimoku Stream, at mouth (Site Code: WMK000298) Rainfall site: Mangorei Upper at Forest Hill

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine	3/8 (scattered)	0% long, 0% thick	Clear, colourless	D/S	0/0	Permanent health warning signs, no birdlife,	0	0
12 Dec 2019	SEM	Fine, calm	1/8 (few)	0% long, 20% thick	Clear, colourless	D/S	0/2 (wading)	No birdlife	0	0.2
30 Dec 2019	SEM	fine	6/8 (broken)	60% long, 0% thick	Clear, brown	D/S	0/0	No birdlife	4.6	6.4
09 Jan 2020	SEM	Fine	3/8 (scattered)	10% long, 30% thick	Clear, colourless	D/S	0/4, 1 dog	No birdlife	0	0.4
16 Jan 2020	SEM	Fine	0/8 (fine)	0% long, 20% thick	Slightly turbid, brown	D/S	7/3	No birdlife. Very Little flow, Significant pooling just d/s of culvet.	0	8
23 Jan 2020	SEM	Fine	2/8 (few)	10% long, 70% thick	Clear, colourless	D/S	0/0	5 gulls 3 swallows,	0	0
30 Jan 2020	SEM	Fine breezy	1/8 (few)	10% long, 80% thick	Clear, brown	D/S	3/3	No birdlife Significant pooling	0.2	3.8
10 Feb 2020	SEM	Fine	7/8 (broken)	10% long, 40% thick	Slightly turbid, brown / grey	D/S	0/0	No birdlife	0	0
13 Feb 2020	SEM	Fine	7/8 (broken)	30% long, 70% thick	Clear, colourless	D/S	0/0	No birdlife	0	0
26 Feb 2020	SEM	Fine	0/8 (fine)	1% long,50% thick	Clear, colourless	U/S	0/0	No birdlife, Stream mouth restricted (not closed), causing it to pool.	0	0
13 Mar 2020	SEM	Sunny, Breeze	1/8 (few)		Clear, colourless	D/S	0/0	No birdlife	0	1

Site Oakura River, near mouth (Site Code: OKR000497) Rainfall site: Mangorei Upper at Forest Hill

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine	2/8 (few)	0% long, 0% thick	Clear, green	D/S	1/4 (wading, bank)	Green,0,0,HT at NP 0956 NZST, 3.6 m	0	0
12 Dec 2019	SEM	Fine, W breeze	0/8 (fine)	0% long, 0% thick	Clear, green	D/S	2/4 (swimming, 4 tea) 1 dog in, 1 dog out	Sign green, no birdlife	0	0.2
30 Dec 2019	SEM	fine	4/8 (scattered)	0% long, 0% thick	Clear, green	D/S	0/0	Sign green, no birdlife	4.6	6.4
09 Jan 2020	SEM	Fine	6/8 (broken)	0% long, 10% thick	Clear, uncoloured	D/S	0/0	Sign green 8 gulls	0	0.4
16 Jan 2020	SEM	Fine	0/8 (fine)		Clear, green	D/S	5/21	Sign green, no birdlife	0	8
23 Jan 2020	SEM	Fine	4/8 (scattered)	0% long, 10% thick	Clear, uncoloured	D/S	0/8 sitting	Sign green, no birdlife	0	0
30 Jan 2020	SEM	Fine, breezy	2/8 (few)		Clear, green	D/S	15/17	Sign green, 2 gulls,	0.2	3.8
10 Feb 2020	SEM	Fine	5/8 (broken)		Clear, green	D/S	1 dog/1	Sign green, no birdlife	0	0
13 Feb 2020	SEM	Fine	5/8 (broken)	0% long, 30% thick	Clear, green	D/S	0/1	Sign green, no birdlife	0	0
26 Feb 2020	SEM	Fine	0/8 (fine)		Clear, colourless	U/S	0/~50 (school group at domain)	Sign green, 1 dog d/s, Flaky sludge drying on river bank near water line. Refer #2439379	0	0
13 Mar 2020	SEM	Fine, light breeze	1/8 (few)		Clear, colourless	U/S	4/6 (swimming)	Sign green, no birdlife	0	1

Site Waitara River at town wharf, Waitara (Site Code: WTR000922) Rainfall site: Motunui M39 at Weston W3

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine, windy	7/8 (broken)		Turbid, dark green	D/S	1/4 (1 rower, 1 runner, 2 walking, 1 biking)	NPDC sign green, no birdlife	0	0
12 Dec 2019	SEM	Fine, N wind	0/8 (fine)		Turbid, brown	D/S	0/0	Sign green,10 ducks	0	0
23 Dec 2019	FOLLOW UP	Overcast and hot	7/8 (broken)		Turbid, green/brown	D/S	0/2 on wharf	Sign red, 5 ducks Water level below gauge, very turbid	0	2.2
30 Dec 2019	SEM	Fine, rain overnight, mod westerly	1/8 (few)		Turbid, green/Tan	U/S	0/9 (one fishing and 8 bystanders)	Sign red, 8 ducks. Permanent health warning sign in place.	3.8	6.4
09 Jan 2020	SEM	Fine, light W	7/8 (broken)		Turbid, green/grey	D/S	0/4 (walking, 1 dog)	Sign green, 8 ducks,	0	0.8
16 Jan 2020	SEM	Fine	0/8 (fine)	0% long, 10% thick	Slightly turbid, green	D/S	0/4 swimmers	Sign green,11 ducks, Dead pigeon in water by wharf ladder	0	8
23 Jan 2020	SEM	Fine, slight breeze	6/8 (broken)		Turbid, dark green	U/S	0/0	Sign green, no birdlife	0	0
30 Jan 2020	SEM	Fine, strong breeze	0/8 (fine)		Slightly turbid, green	D/S	12/2	Sign green, 5 ducks	0	1.8
10 Feb 2020	SEM	Fine, calm	1/8 (few)		Turbid, murky green	U/S	0/0	Sign green, 3 ducks,	0	0
13 Feb 2020	SEM	fine, little wind	6/8 (broken)		Slightly turbid, green	U/S	0/0	Sign green, 1 duck	0	0
26 Feb 2020	SEM	Fine	0/8 (fine)		Turbid, solid yellow green	D/S	0/0	Signgreen,1 duck	0	0
13 Mar 2020	SEM	Fine, minimal breeze	0/8 (fine)		Slightly turbid, green yellow	U/S	0/1	Sign green,13 ducks	0	0

Site Urenui River at estuary (Site Code: URN000480) Rainfall site: Uruti at Kaka Road

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine, breeze	3/8 (scattered)		Slightly turbid, greeny blue	U/S	0/0	NPDC health warning sign red, 2 oyster catchers	0	0
12 Dec 2019	SEM	Fine	0/8 (fine)		Clear, blue/green	U/S	1/0 (boat)	Sign red, 2 oyster catchers	0	0
30 Dec 2019	SEM	Fine, rain overnight, light westerly	2/8 (few)		Clear, green	U/S	10/40	No birdlife	1	5.5
09 Jan 2020	SEM	Fine, westerly	7/8 (broken)		Slightly turbid, murky green	U/S	1/10 (boat)	No birdlife	0	0
16 Jan 2020	SEM	Fine	0/8 (fine)		Clear, brown/green		4/56ni	Sign red, no birdlife	0	20.5
23 Jan 2020	SEM	Fine	3/8 (scattered)		Clear, blue green	U/S	0/0	Sign red at ramp, no birdlife	0	0
30 Jan 2020	SEM	Fine, slight breeze	1/8 (few)		Slightly turbid, blue	U/S	3/2	Sign red, no birdlife	1.5	7.5
10 Feb 2020	SEM	Fine	1/8 (few)		Slightly turbid, green-grey	U/S	0/4	Sign red, 17 gulls,1 duck	0	0
13 Feb 2020	SEM	Fine, slight breeze	2/8 (few)		Clear, blue	U/S	2/0	Sign red (at boat ramp),3 birds	0	0
26 Feb 2020	SEM	Fine, slight breeze	0/8 (fine)		Turbid, brown-green	U/S	0/2	Sign red at, boat ramp, 10 gulls	0	0
13 Mar 2020	SEM	Fine, light breeze	1/8 (few)		Slightly turbid, green Brown	U/S	2/0	Sign red (boat ramp),15 gulls,3 black shags,	0	4

Site Manganui River d/s of Kurapete Stream (Site Code: MGN000435) Rainfall site: Manganui at Everett Park

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine, no wind	3/8 (scattered)	0% long, 0% thick	Clear, ,colourless/ light tan	D/S	0/0	DoC signs only, no birdlife	0	0
12 Dec 2019	SEM	Fine, very hot	0/8 (fine)	5% long, 0% thick	Clear, brown	D/S	0/2 (swimmers leaving)	1 duck	0	0
30 Dec 2019	SEM	Fine, rain overnight.	2/8 (few)	25% long, 10% thick	Clear, green/brown	D/S	0/0	No birdlife	2.5	9.5
09 Jan 2020	SEM	Fine, NW wind (light to mod)	4/8 (scattered)	70% long, 20% thick	Clear, clear/brown	D/S	0/3	No birdlife	0	1.5
16 Jan 2020	SEM	Fine	0/8 (fine)	35% long, 50% thick	Clear, brown	D/S	0/0	No birdlife	0	13
23 Jan 2020	SEM	Fine, still, warm	7/8 (broken)	0% long, 100% thick	Clear, brown green	D/S	0/0	No birdlife	0	0
30 Jan 2020	SEM	Fine, slight breeze	1/8 (few)	0% long, 100% thick	Clear, slight blue green	D/S	0/0	No birdlife	1.5	2
10 Feb 2020	SEM	Fine, light breeze	0/8 (fine)	0% long, 100% thick	Clear, colourless	D/S	0/0	No birdlife	0	0
13 Feb 2020	SEM	Fine slight breeze	7/8 (broken)	95% thick, 5% long	Clear, slight brown tinge	D/S	0/0	4 ducks	0	0
26 Feb 2020	SEM	Fine, calm	0/8 (fine)	0% long, 95% thick	Clear, light green-brown	D/S	0/0	No birdlife, black disc: 2.16 m	0	0.5
13 Mar 2020	SEM	Fine	0/8 (fine)	2% long, 95% thick	Clear, colourless	D/S	0/1	No birdlife	0	0.5

Site Lake Ratapiko (Site Code: LRP000050) Rainfall site: Manganui at Everett Park

Sampling Date	Pro-gramme	Weather		Conditions			Site usage		Rainfall (mm)	
		General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
27 Nov 2019	SEM	Fine, strong wind	4/8 (scattered)	0% long, 0% thick	Clear, colourless/tan	Rippled	0/0	No swimming sign, 1 shag	0	0
12 Dec 2019	SEM	Fine	0/8 (fine)		Clear, brown	Rippled	0/1 (car)	No birdlife	0	0
30 Dec 2019	SEM	Fine, rain overnight, mod westerly	4/8 (scattered)		Turbid, brown	Rippled	4/7 (2 boat with doughnut; two jetskis)	No birdlife	2.5	9.5
09 Jan 2020	SEM	Fine, light-mod NW wind	3/8 (scattered)		Slightly turbid, dark green/brown	Rippled	1.72/4 (jetski)	No birdlife	0	1.5
16 Jan 2020	SEM	Fine	0/8 (fine)	10% long, 30% thick	Clear, brown	Rippled	0/0	1 shag,5 NZ Scaup,	0	13
23 Jan 2020	SEM	Fine, slight breeze	7/8 (broken)	0% long, 0% thick	Turbid, dark green	Rippled	0/0	No birdlife	0	0
30 Jan 2020	SEM	Fine, slight breeze	1/8 (few)	0% long, 0% thick	Slightly turbid, green Brown	Rippled	1/1 (swimming)	No birdlife	1.5	2
10 Feb 2020	SEM	Fine	0/8 (fine)	0% long, 0% thick	Clear, colourless	Rippled	0/0	4 birds,	0	0
13 Feb 2020	SEM	Overcast, slight-mod breeze	7/8 (broken)	0% long, 0% thick	Slightly turbid, dark green	Rippled	0/2	3 small birds,1 duck,	0	0
26 Feb 2020	SEM	Fine, slight breeze	0/8 (fine)		Clear, light brown	Rippled	0/0	,4 birds	0	0.5
13 Mar 2020	SEM	Fine slight breeze	0/8 (fine)		Clear, brown	Rippled	0/0	10 black shags	0	0.5

Appendix V

Sampling conditions and public usage recorded at three sites during the cyanobacteria programme

Site Lake Opunake (Site Code: LOP000001) Rainfall site: Taungatara at Eltham Road

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Direction of flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
05 Nov 2019	Fine, light SE breeze	1/8 (few)		Clear, slightly green	Rippled	0/0	3 ducks + ducklings	0.0	0.0
04 Dec 2019	Fine breezy	2/8 (few)	To much weed	Clear, green	Rippled	0/0	20 ducks, 9 geese, 7 swans on water, 25 ducks on bank	16.0	22.5
19 Dec 2019	Fine	7/8 (broken)		Clear, brown	Rippled	0/0	50 ducks, 2 geese,	11.0	58.5
09 Jan 2020	Fine, light breeze	5/8 (broken)	30% long,0% thick	Slightly Turbid, brown	Rippled	0/6 (sitting/picnicking)	15+ ducks on water, 9 ducks on bank	0.0	0.0
23 Jan 2020	Fine, light breeze	1/8 (few)		Slightly turbid, brown	Flat	0/8 (freedom campers)	40+ Mallard, 7 Canadian Geese, 4 Black Swans on water, 5 ducks on bank	0.0	0.0
04 Feb 2020	Fine	1/8 (few)		Slightly turbid, dark Green	Rippled	0/0	STDC health warning (for cyanobacteria), 50 ducks on water, 15 on banks,	0.0	0.0
26 Feb 2020	Fine	0/8 (fine)		Clear, light brown	Flat	0/2	50+ ducks, 10 black swans on water, 10 ducks on banks	0.0	0.0
13 Mar 2020	Fine, slight breeze	0/8 (fine)		Turbid, dark brown	Rippled	0/2 cars	5 ducks on water and on banks ,Lots of weed in lake.	0.0	0.0

Site Lake Ratapiko (Site Code: LRP000050) Rainfall site: Manganui at Everett Park

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
05 Nov 2019	Fine, S breeze	3/8 (scattered)	5% long, 0% thick	Slightly turbid, brown	Rippled	0/0	Shag/ passerine birds on shore,	0.0	0.0
04 Dec 2019	Fine breezy	5/8 (broken)		Turbid, brown	Rippled	0/0	No birdlife	11.0	27.5
19 Dec 2019	Fine	5/8 (broken)	Too turbid	Turbid, blue	Rippled	0/0	No birdlife	4.5	64.5
09 Jan 2020	Fine, light-mod NW wind	3/8 (scattered)		Slightly turbid, dark green/brown	Rippled	¼ (jetski)	No birdlife	0.0	1.5
23 Jan 2020	Fine, slight breeze	7/8 (broken)	0% long, 0% thick	Turbid, dark green	Rippled	0/0	No birdlife	0.0	0.0
04 Feb 2020	Fine with a breeze	5/8 (broken)		Turbid, green	Rippled	1 /0 (jetski)	No birdlife	0.0	0.0
26 Feb 2020	Fine, slight breeze	0/8 (fine)		Clear, light brown	Rippled	0/0	4 birds,	0.0	0.5
13 Mar 2020	Fine slight breeze	0/8 (fine)		Clear, brown	Rippled	0/0	10 black shags on bank	0.0	0.5

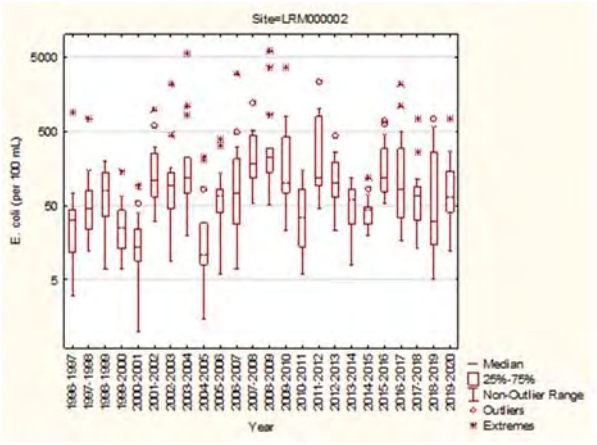
Site Lake Rotokare (Site Code: LRK000003) Rainfall site: Mangaehu at Bridge

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
05 Nov 2019	Fine, moderate N breeze	1/8 (few)	0% long, 0% thick	Clear, brown	Rippled	0/0	No birdlife	0	0
27 Nov 2019	Fine, moderate breeze	0/8 (fine)	0% long, 10% thick	Clear, brown	Choppy	0/1 (tent/freedom camper)	4 swans, 2 ducks	0	0
19 Dec 2019	Fine	2/8 (few)		Clear, light brown	Rippled	0/0	No birdlife	9.5	54.5
06 Jan 2020	Fine, strong breeze	2/8 (few)		Slightly turbid, brown	Rippled	0/0	1 pukeko	1.5	1.5
09 Jan 2020	Fine, light breeze	4/8 (scattered)		Turbid, brown	Rippled	2/9 (jetski & wakeboarding, sitting/walking)	No birdlife	0	0
23 Jan 2020	Fine	6/8 (broken)	15% thick, 0% long	Clear, yellow/brown	Rippled	0/5 (freedom campers)	10 ducks	0	0
04 Feb 2020	Fine	1/8 (few)		Clear, brown	Rippled	0/0	10 ducks	0	0
26 Feb 2020	Fine	0/8 (fine)	0% long, 0% thick	Clear, uncoloured	Flat	0/20+ (campers)	6 ducks, 3 pukeko, 1 shag,	0	0
12 Mar 2020	Fine	0/8 (fine)		Clear, tannin brown	Flat	0/15	5 mallard ducks	0.5	7

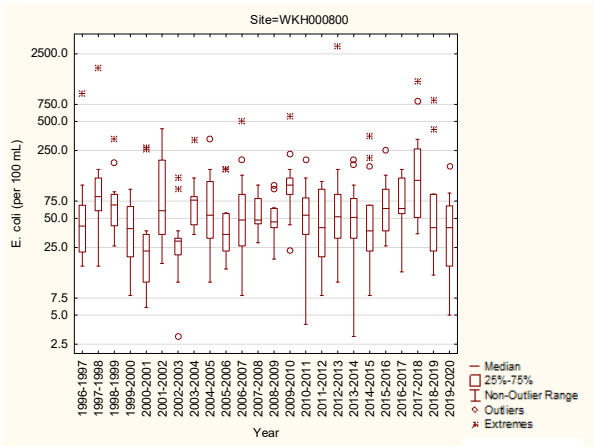
Appendix VI

Comparative annual box and whiskers plots of SEM data for *E.coli* for the period 1996-2020

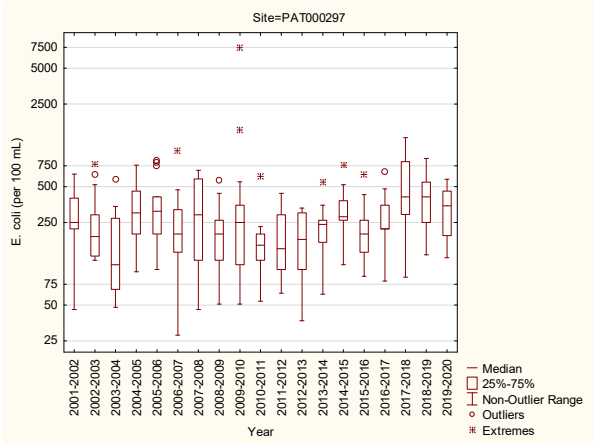
Lake Rotomanu



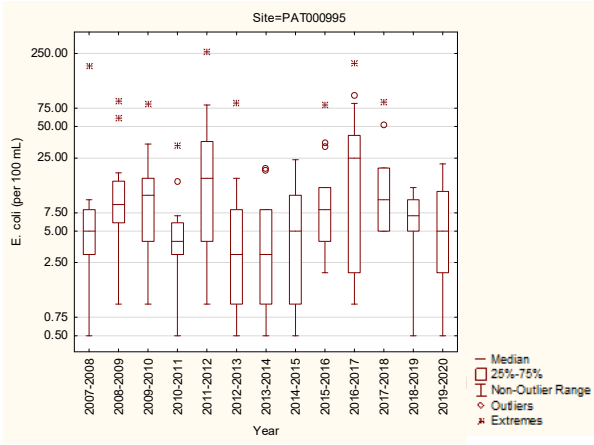
Waiwhakaiho River at Merrilands Domain



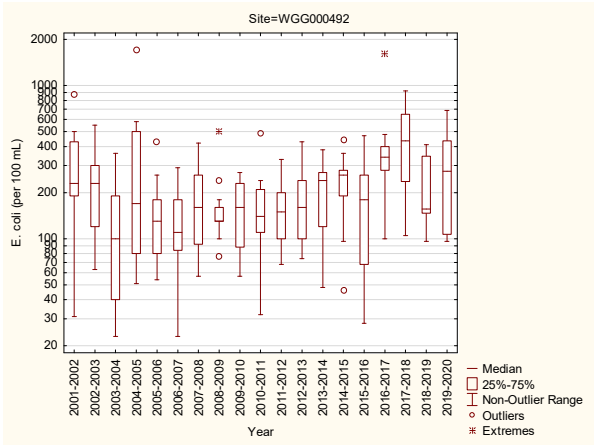
Patea River at Stratford



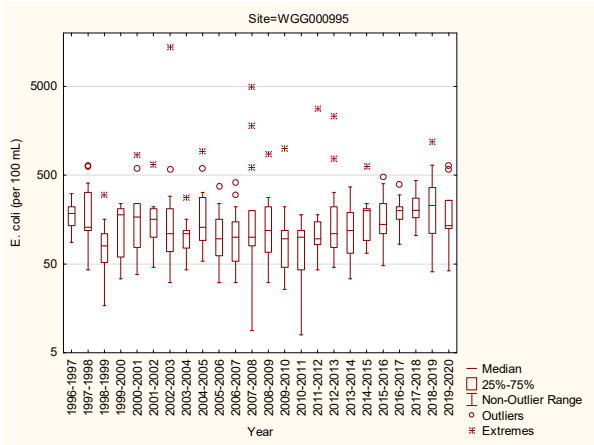
Patea River at Patea boat ramp



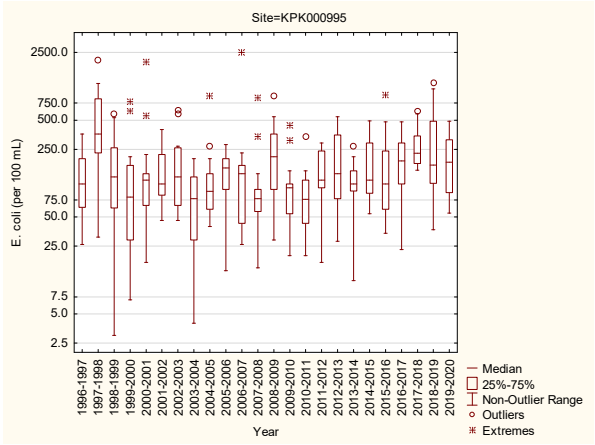
Waingongoro R at Eltham



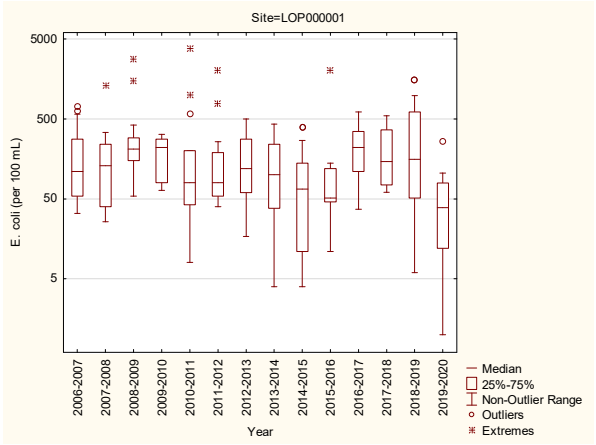
Waingongoro R at Ohawe



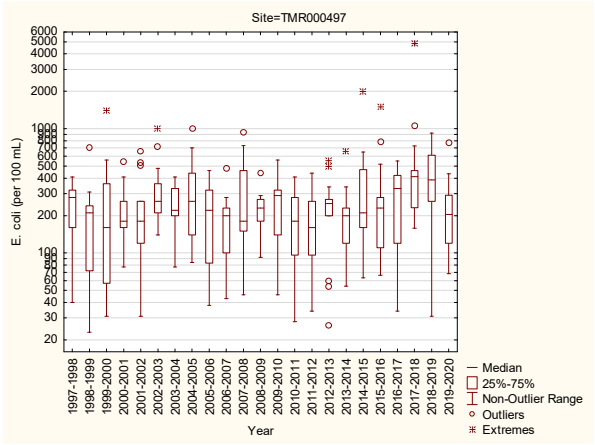
Kaupokonui River



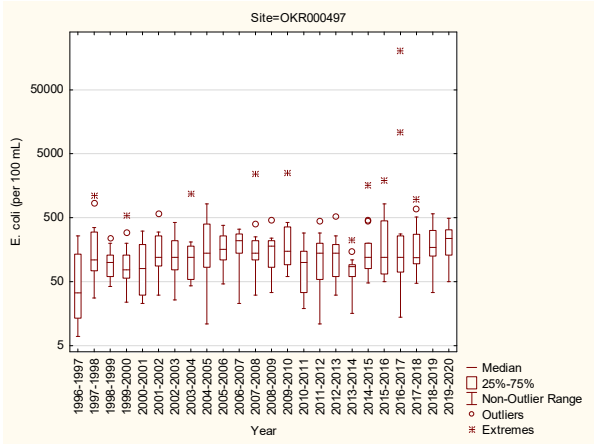
Lake Opunake



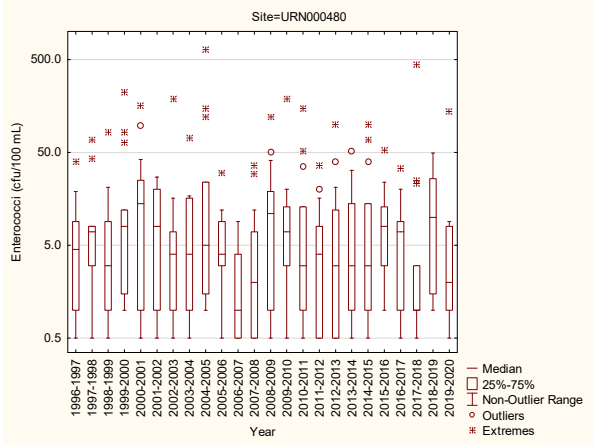
Timaru Stream



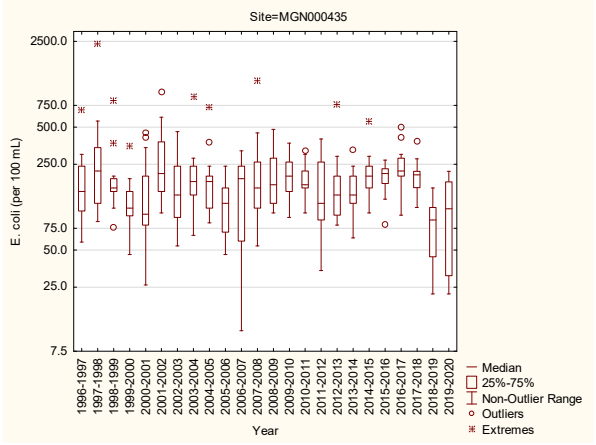
Oakura River



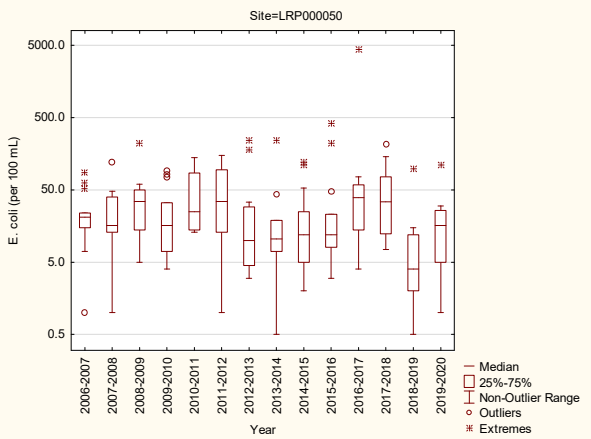
Urenui River



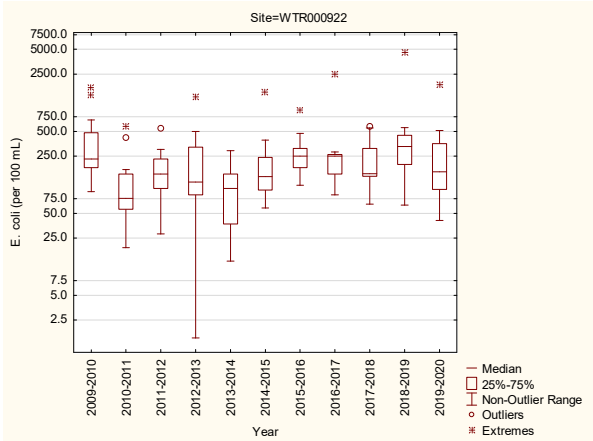
Manganui River



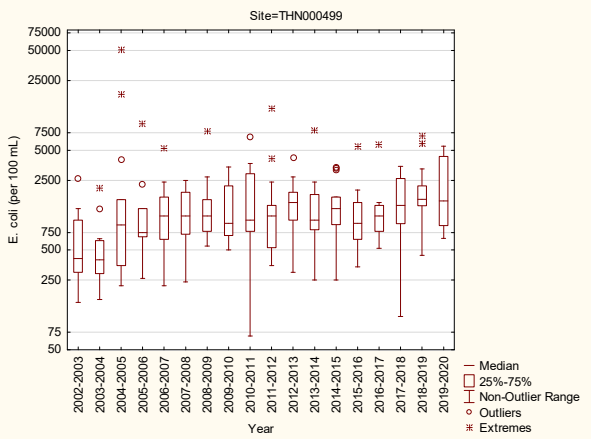
Lake Ratapiko



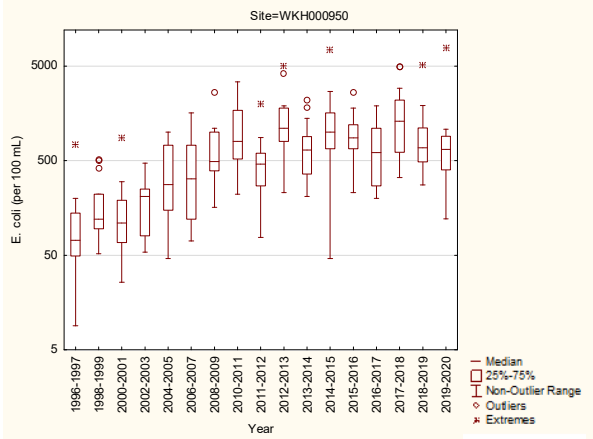
Waitara River at town wharf



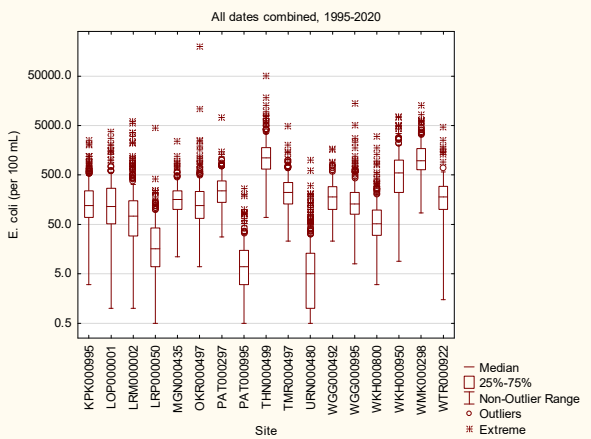
Te Henui mouth, East End



Waiwhakaiho adjacent to L.Rotomanu



All sites combined, 1995 - 2020



All sites individually, 2019 – 2020