Freshwater contact recreational water quality at Taranaki sites State of the Environment Monitoring Annual Report 2018-2019

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Executive summary

This survey of sixteen recognised freshwater contact recreational sites in the Taranaki region was the twenty-third 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 2018-2019 period for the thirteenth 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.

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 sixth 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 results of the 2018-2019 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 lower than normal in comparison with historical surveys. The total number of samples falling within the "Alert" or "Action" categories (39% of samples) across the 16 recognised bathing sites was among the highest recorded. However, it should be noted that the "Action" category is the only category for which swimming is not recommended. In the 2018-2019 season, 79% of all samples met the national bathing guideline. Of the 21% of samples that exceeded the guideline, 10% 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 Waiwhakaiho River opposite Lake Rotomanu). Ten 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. Nine of these sites had counts which entered the 'Action' mode, a slight increase in 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, only two exceedances of the MfE 'Action' guideline were found in the Waiwhakaiho River at Merrilands Domain (mid urban New Plymouth and downstream of agricultural land), whereas 9 of 13 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 the New Plymouth District Council (on the direction of Taranaki District Health Board) following past exceedances of 'Action' levels at the lower Waiwhakaiho River and Te Henui Stream sites, and of 'Alert' levels at Waitara. Temporary signage was required at the Lakes Rotomanu and Opunake, Timaru Stream and Oakura, Kaupokonui, upper Patea and lower Waingongoro Rivers sites following single sample 'Action' levels, but single sample 'Alert' level exceedances at other sites were not necessarily signposted.

Temporal trends over the 1996-2019 period have been evaluated on the basis of seasonal median *E. coli* count for the sixteen sites that have ten years or more data (and will continue to be assessed annually). Two sites (Te Henui Stream 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* counts.

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.

Cyanobacteria blooms were recorded at Lake Rotomanu over two months from mid-November 2018, and at Lake Rotokare in December 2018 and January 2019. This necessitated warning notices to avoid contact recreation in these two lakes during much of the first half of the recreational period. Low to moderate levels of planktonic cyanobacteria were found in Lakes Opunake and Ratapiko.

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. Two sites (Waingongoro and Kaupokonui Rivers at mouth) exceeded the 'Alert' mode trigger level for bed coverage on a total of eight surveys. Exposed mats exceeded the 'Action' level in Kaupokonui River at the beach domain in November 2018, triggering warning notices to contact recreational users. The 'Alert' mode trigger level for exposed mats was exceeded at four sites on a total of 15 individual site surveys, and for detaching or detached mats accumulating on the river's edge at the same four sites (Waingongoro River at Ohawe, Kaupokonui River at the mouth, and Waiwhakaiho River at the last riffle and at Merrilands Domain) on a total of 13 surveys. Levels of cyanobacteria were higher than in the previous two seasons, but lower than 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 2018-2019.

For the third 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*.

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.

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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 2018-2019 monitoring year, the 23rd 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*/100ml)	≤260	261-550	>550
Marine (enterococci/100ml)	≤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 mid-December 2018 and March 2019 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 counts. 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 2013 to March 2018 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 57 of this report.

Table 2 Suitability for recreation grade for freshwater sites for the period November 2013 to March 2018

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100ml)			SFR Grade	% of all samples not exceeding 'Action' level (ie: ≤ 550 E.coli)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	699	65	D	Very poor	92
Waiwhakaiho R: Merrilands domain	High	332	65	C	Poor	96

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100ml)			SFR Grade	% of all samples not exceeding 'Action' level (ie: ≤ 550 E.coli)
		95 %ile	Number of samples	Category		
Waiwhakaiho R at L.Rotomanu	High	3392	65	D	Very poor	26
Te Henui S: mouth	High	3962	65	D	Very poor	12
Patea R: King Edward Park	High	816	65	D	Very poor	87
Patea R. boatramp, Patea	High	84	65	A	Poor	100
Waingongoro R: Eltham camp	High	782	65	D	Very poor	92
Waingongoro R: Ohawe beach	High	417	65	C	Poor	98
Kaupokonui R: Beach domain	High	512	65	C	Poor	95
L Opunake: adjacent boat ramp	High	473	65	C	Poor	96
Timaru S: Lower Weld Road	High	1162	65	D	Very poor	87
Oakura R: d.s SH45	High	1675	65	D	Very poor	87
Waitara R: Town wharf	High	659	65	D	Very poor	93
Urenui R: estuary	High	140	65	B	Poor	98
Manganui R: Everett Park	High	393	65	C	Poor	98
L Ratapiko: boatramp	High	230	60	B	Poor	98
L Rotokare: adjacent boatramp	Low	310	42	C	Very good	100

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 13% of all sampling occasions, that is, fourteen sites achieved the guideline on 87% or more of occasions. That is, the data shows 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 Waiwhakaiho River Merrilands domain site, the Everett Park site in the Manganui River, the Lake Ratapiko boat ramp site, the Ohawe Beach site in the lower Waingongoro River, and the Lake Opunake 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 sixteen sites sampled by the various components of the 2018-2019 programme are shown in Figure 1 and summarised in Table 5.

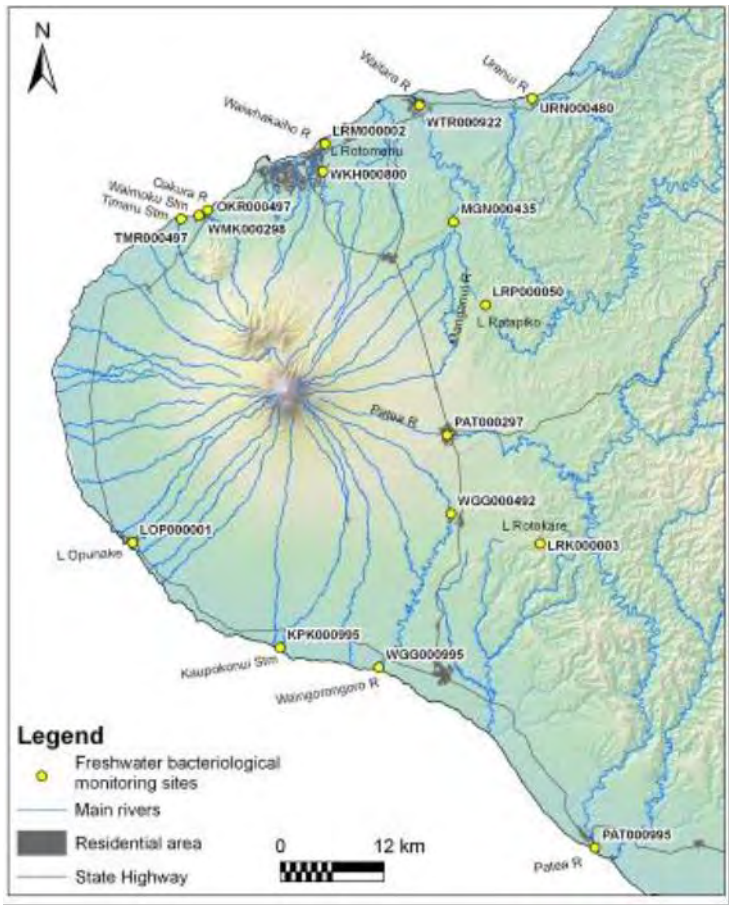


Figure 1 Location of freshwater contact recreation survey sites in 2018-2019

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 and 2016-2017). 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 2018 to mid-March 2019. 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	✓		
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	(✓)		✓

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 early November 2018 with two of the sampling surveys performed prior to January 2019. The majority of the surveys were performed over the latter half of the summer and early autumn period. Bathing water samples were taken between the hours of 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 localised 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. Thirteen 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) 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 posted on the Taranaki Regional Council website (http://www.trc.govt.nz/#mapTab6), for both public and local health authority notification, as soon as data checking had been completed. The results were also included on the national Land, Air, Water Aotearoa (LAWA) website (http://www.lawa.org.nz/explore-data/taranaki-region/river-quality/). 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 2018-2019, the three district councils (New Plymouth, Stratford and South Taranaki) 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* count, 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 2018-2019, 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 2018-2019 summer marked the first 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). Specific conductivity was measured using a Hach 2100N IS turbidimeter ISO 7027:1999 (E) (modified) instead of a WTW Cyberscan turbidimeter.

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 55 and Figure 63. Those illustrate that the majority of the sampling occasions coincided with steady to low river recession flow conditions. In 2018-2019, 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 13 samples was collected at each site during the period from early November 2018 to mid-March 2019.

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 7 November 2018 to 25/26 March 2019 and totalled thirteen 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* counts) 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 24 samples were collected at this western beach site over the summer. All 13 scheduled SEM samples were collected, as well as eight MfE samples and three follow up samples, the last on 20 June 2019.

At the times of the surveys, conducted mostly in early to mid-morning, there was limited bathing usage of the lake recorded, with boating, jet-skiing, kayaking, and walking/dog-walking activities occurring on some occasions. Picnicking has been observed in previous seasons.

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. The lake level was lowered in early January 2019 for the inlet channel to be cleared of debris and silt (under consent 0298-3, on 21 January), and further in mid-March for repairs to the outlet pipe, which eventually were carried out in mid-May 2019. 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, June 2017 and August 2018

All *E. coli* data for this site, from the 2018-2019 summer period, are presented in Figure 2. The complete survey results are presented in Appendix I and summarised in Table 7.

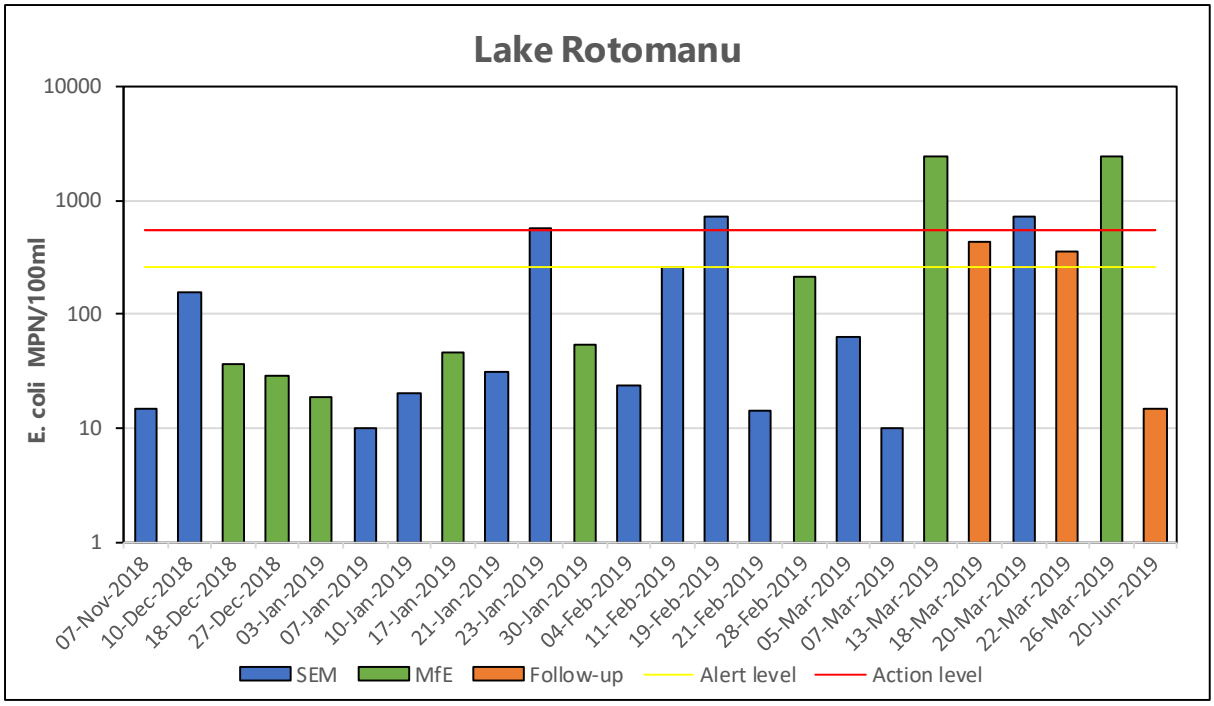


Figure 2 *E. coli* results for Lake Rotomanu

Table 7 Statistical summary for Lake Rotomanu

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	13	121	151	141
	E. coli	MPN/100ml	13	10	727	31
	Temperature	°C	13	19.4	26.0	24.5
	Turbidity	NTU	13	4.7	22	7.9
SEM + MfE samples	Conductivity	µS/cm@25°C	21	121	151	138
	E. coli	MPN/100ml	21	10	>2420	47
	Temperature	°C	21	19.4	26.0	22.0
	Turbidity	NTU	21	1.6	22	7.5

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: 7.9; range: 3.2 NTU), 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 26.0°C (in mid-December 2018 and early February 2019) and a range of 6.6°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, from the trend monitoring, elevated numbers of *E. coli* (in the 'Action' mode) were found on three occasions, in mid-January, February and March 2019. Ducks, which were common on the water around the sampling point on all three sampling occasions, were a likely cause. NPDC adjusted the signage to reflect the increased health risk from recreational use of the lake. Resampling undertaken shortly after the first two incidents returned *E. coli* numbers back to 'Surveillance' level, and the sign was readjusted accordingly. Resampling following the 26

March incident was not practical until mid-June, as the lake level was kept low until the outlet was repaired in mid-May, and a period of wet weather followed refilling.

The additional (MfE) sampling resulted in a moderate increase (from 31 to 47 *E.coli* per 100 ml, or 52%) in the overall seasonal median bacteria number, 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 NTU) and the turbidity range wider (1.2 to 22 NTU) than for the standard SEM sampling surveys.

4.1.1 Comparison with guidelines

E. coli counts from Lake Rotomanu over the 2018-2019 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 261-550/100ml**	**ACTION** **Single sample>550/100 ml**
SEM samples	0 [0%]	3 [23%]
SEM+MfE samples	0 [0%]	5 [24%]

Five single samples were recorded in the 'Action' category, two during SEM trend surveys, and three during additional MfE surveys 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 23 summers are presented in Figure 3.

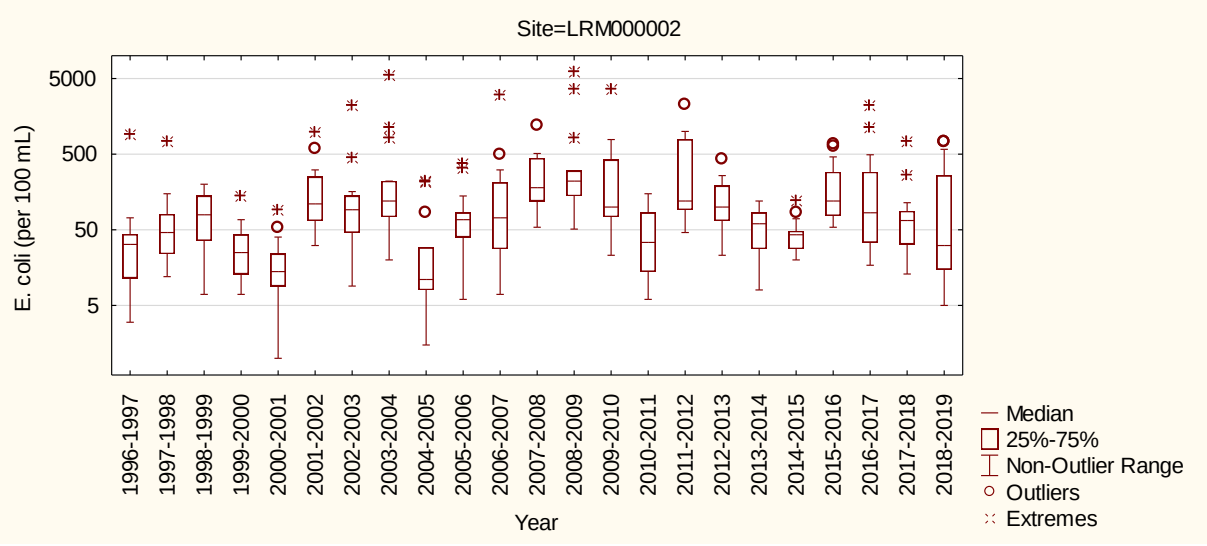


Figure 3 Box and whisker plots of *E. coli* for all summer SEM surveys at Lake Rotomanu

The median *E.* coli value (31 MPN/100m) indicated higher bacterial water quality, but there was a wider range (10 to 727 MPN/100mL), in 2018-2019 compared with most of the previous twenty-two 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 23 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.

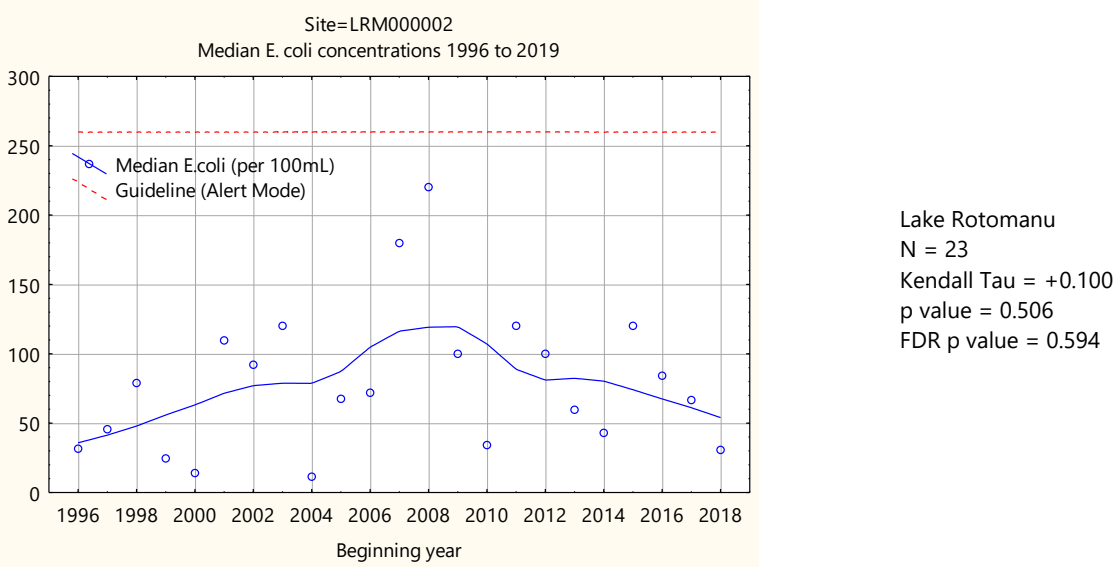


Figure 4 LOWESS trend analysis of median *E. coli* data at Lake Rotomanu

Overall, a positive trend, but not statistically significant or important increase in median *E. coli* numbers, has been found over the twenty-three 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 low overall (median bio-volume 0.33 mm^3/L). There was a high degree of variability, with bio-volumes fluctuating between no cyanobacteria detected and high levels (range 0.00-4.24 mm^3/L).

Planktonic cyanobacteria were monitored on eleven occasions throughout the season with results presented in Table 9 and Figure 5. The first sample was taken earlier than usual, in mid-September, as high cyanobacteria levels were encountered at the beginning of the previous monitoring period, in early November 2017.

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
17/09/2018*	2,471	0.33	*Limnococcus cf. limneticus*	Surveillance
07/11/2018	903	0.18	*Limnococcus cf. limneticus*	Surveillance
22/11/2018	10,000,715	4.24	Picocyanobacteria	Action
06/12/2018	5,714,290	2.34	Picocyanobacteria	Action
18/12/2018	6,987,179	2.86	Picocyanobacteria	Action
03/01/2019	8,560,000	3.51	Picocyanobacteria	Action
17/01/2018	1,176	0.03	*Limnococcus cf. limneticus*	Surveillance

Date	Cyanobacteria total cell count (cells/mL)	Bio-volume (mm^3/L)	Principal species by biovolume	Mode
30/01/2018	11,964,0	1.68	*Limnococcus cf. limneticus*	Alert
11/02/2019	40	0.02	*Dolichospermum planctonicum*	Surveillance
28/02/2019	0	0.00	No cyanobacteria present	Surveillance
20/03/2019	1,000	0.01	*Coelosphaerium*	Surveillance

* Additional sample for earlier assessment

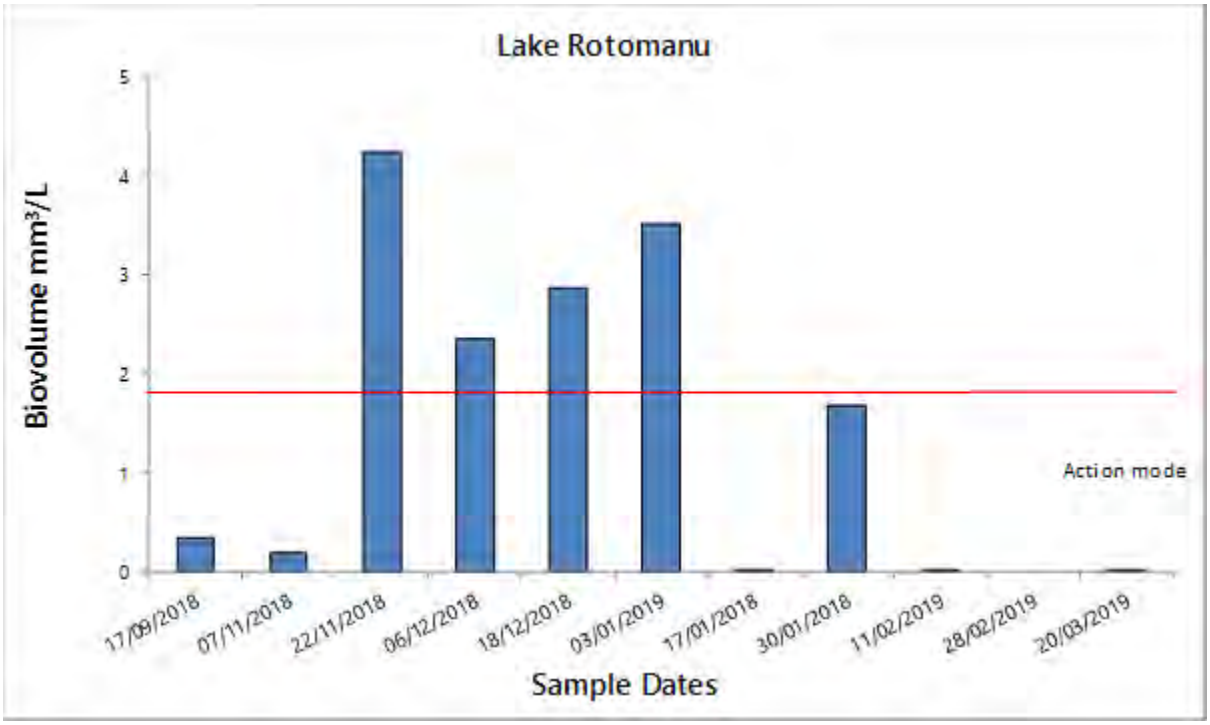


Figure 5 Cyanobacteria bio-volume at Lake Rotomanu

Following the high cyanobacteria bio-volume detected in mid-November 2018, NPDC changed the adjustable health warning sign at the main entrance to the lake to 'no swimming', and erected a similar, temporary sign at the western beach. The signs were readjusted/removed when the cyanobacteria bio-volume reduced to below 'Action' level in mid-February 2019, after a period of three months while cyanobacteria bio-volumes were continuously high.

4.2 Waiwhakaiho River at Merrilands Domain

A total of 22 samples were collected at this site over the summer. All 13 scheduled SEM samples were collected, as well as eight MfE samples and one follow up sample.

Some recreational usage was recorded at the time of the surveys, with bathing noted on one occasion. Dog-walking was recorded five times in 2018-2019. Birdlife was noted on two occasions, when one or two ducks were observed. The weather was overcast on ten occasions, six of them during the SEM surveys, and moderate rainfall immediately preceded one of the additional, MfE surveys.

River flow information is illustrated in Figure 7. There were no flood events between mid-November 2018 and late March 2019, and a flow recession to below MALF occurred over three months to early March 2019, punctuated with occasional freshes.

All *E. coli* data for this site, from the 2018-2019 summer period, are presented in Figure 6. The complete survey results are presented in Appendix I and summarised in Table 10.

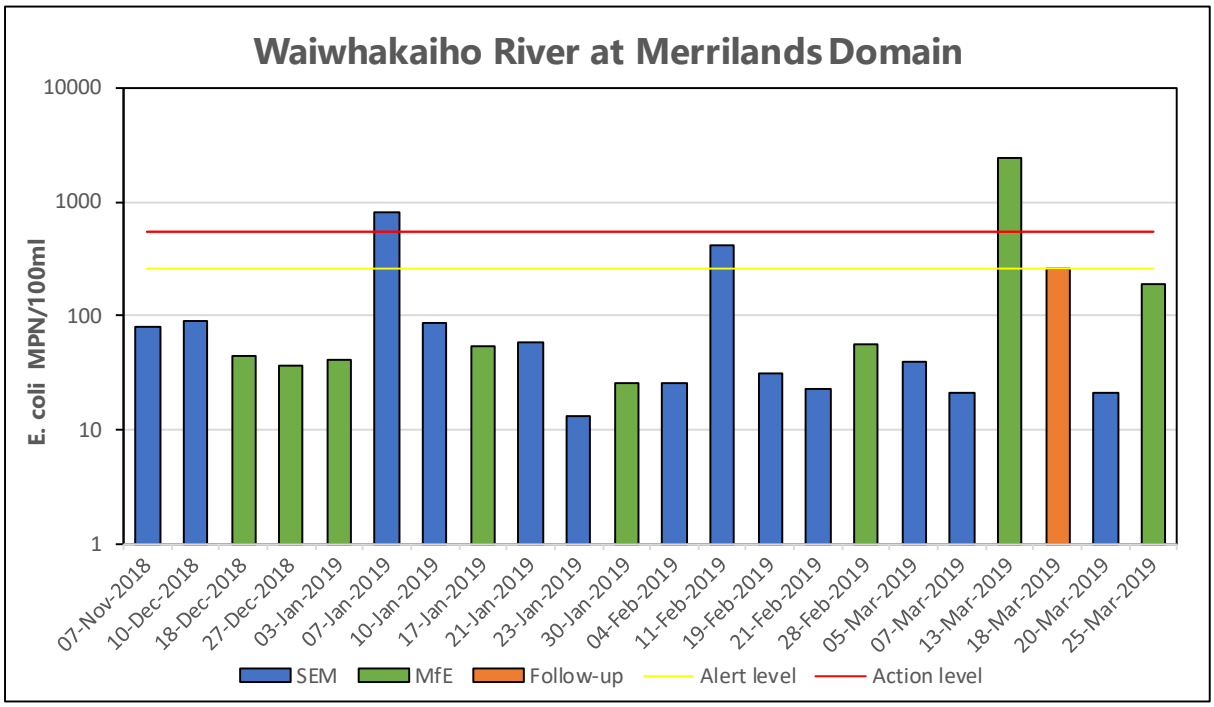


Figure 6 *E. coli* results for the Waiwhakaiho River at Merrilands Domain

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	13	121	180	171
	E. coli	MPN/100ml	13	13.0	823	40
	Temperature	°C	13	16.2	23.7	21.2
	Turbidity	NTU	13	0.4	2.2	1.0
SEM + MfE samples	Conductivity	µS/cm@25°C	21	88	180	163
	E. coli	MPN/100ml	21	13.0	2420	45
	Temperature	°C	21	16.2	24.0	20.7
	Turbidity	NTU	21	0.4	11.4	1.0

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 7.8°C between early November and late March, with a maximum of 24.0°C in early morning in late January 2019. Conductivity and turbidity results were generally indicative of very clean, clear, relatively high water quality, but moderate to widespread algal cover (up to 100% 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 fine weather, made little difference to the statistics.

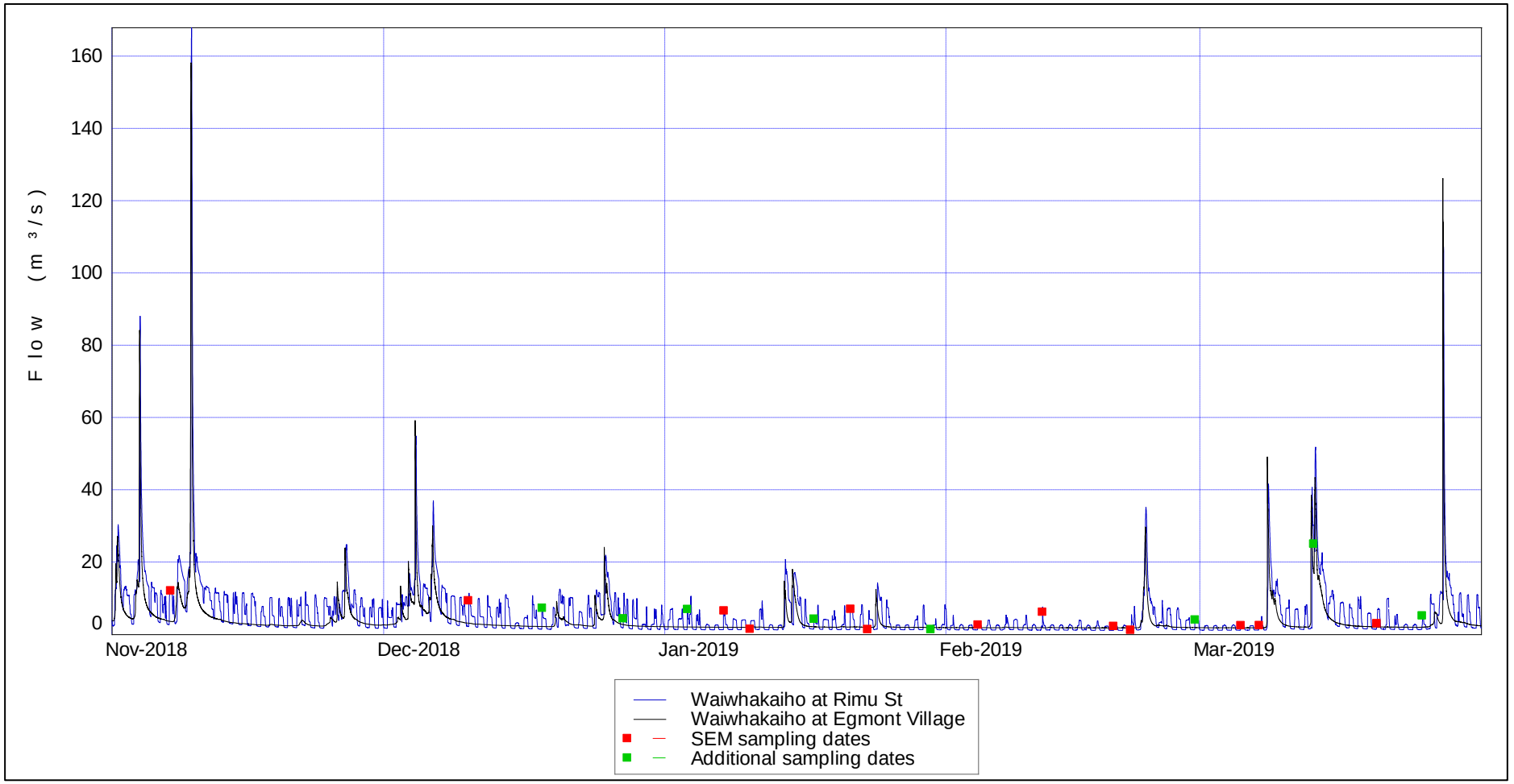


Figure 7 Flow in the Waiwhakaiho River during the survey period

4.2.1 Comparison with guidelines

E. coli counts from Waiwhakaiho River at Merrilands Domain over the 2018-2019 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 261-550/100ml	ACTION Single sample >550/100 ml
SEM samples	1 [8%]	1 [8%]
SEM + MfE samples	1 [5%]	2 [10%]

Action mode was triggered on two occasions, once during a SEM survey in dry weather in early January, and once during a MfE survey after significant rainfall in mid-March. Alert mode level was exceeded on one occasion, during an SEM survey in mid-February. Follow-up surveys were carried out after both of the Action levels (the first follow up also being a routine survey), with results back at 'Surveillance' level on each occasion. Bacteriological water quality measured at this site was therefore within the acceptable standard for contact recreation usage for the majority of the survey period.

After the first elevated *E. coli* result, investigations by inspection and additional water testing led to the discovery of cattle entering the river about 3 km upstream. This was addressed with the farmer concerned. Gulls were also found, bathing in the river (Photo 2 and Photo 3).

Photo 2 and Photo 3 Cattle and gulls in Waiwhakaiho River above Merrilands Domain, January 2019

On the two occasions 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 23 summers are presented in Figure 8.

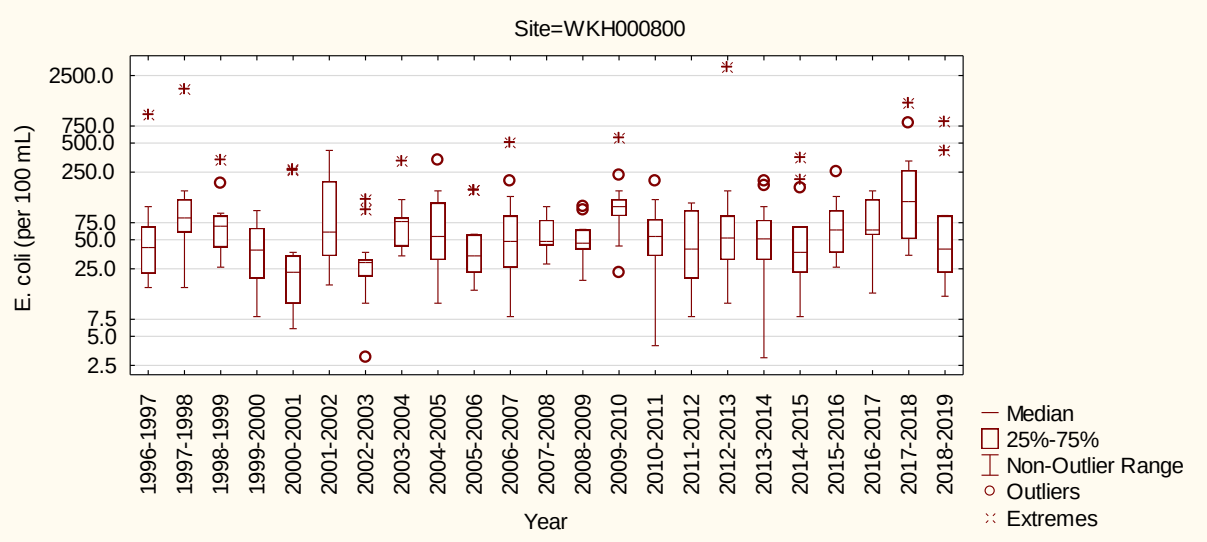


Figure 8 Box and whisker plots of *E. coli* for all summer SEM surveys of Waiwhakaiho River at Merrilands Domain

The median *E. coli* number in the 2018-2019 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-three seasons of data by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (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.

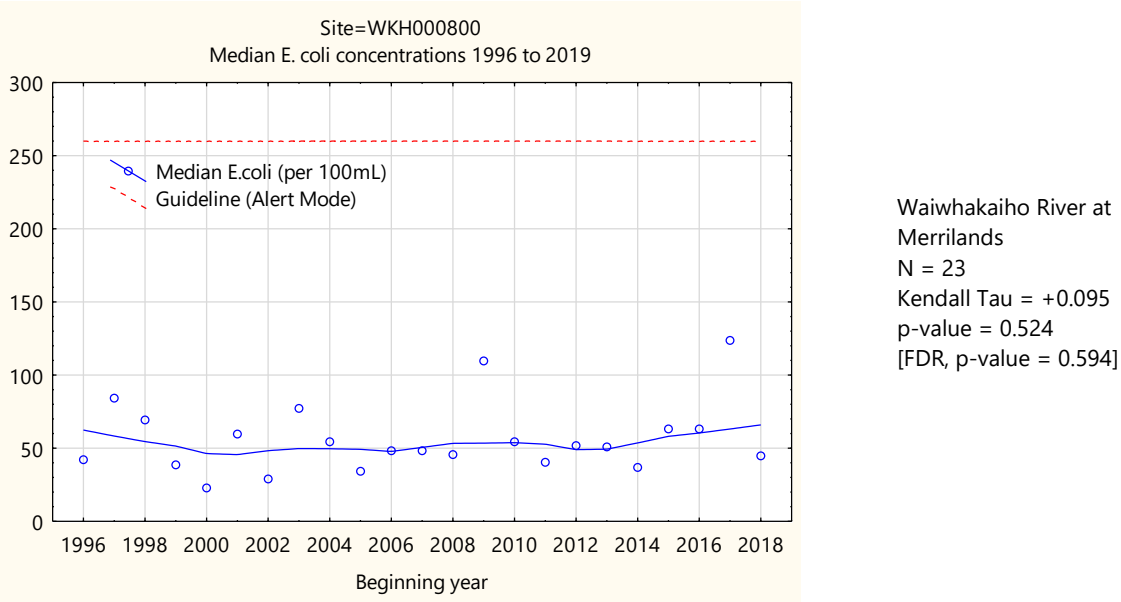


Figure 9 LOWESS trend analysis of median *E. coli* at the Waiwhakaiho River, Merrilands Domain

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

4.2.4 Cyanobacteria

Benthic cyanobacteria were monitored on 13 occasions during the 2018-2019 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
05/11/2018	19	No	No	Surveillance
22/11/2018	7	No	No	Surveillance
05/12/2018	4	No	Minor	Alert
18/12/2018	4	No	Minor	Alert
03/01/2019	3	Minor	Minor	Alert
08/01/2019	2	No	No	Surveillance
17/01/2019	2	No	No	Surveillance
30/01/2019	1	No	No	Surveillance
12/02/2019	0	No	No	Surveillance
27/02/2019	0	No	No	Surveillance
12/03/2019	1	No	Minor	Alert
21/03/2019	1	No	No	Surveillance
27/03/2019	0	No	No	Surveillance

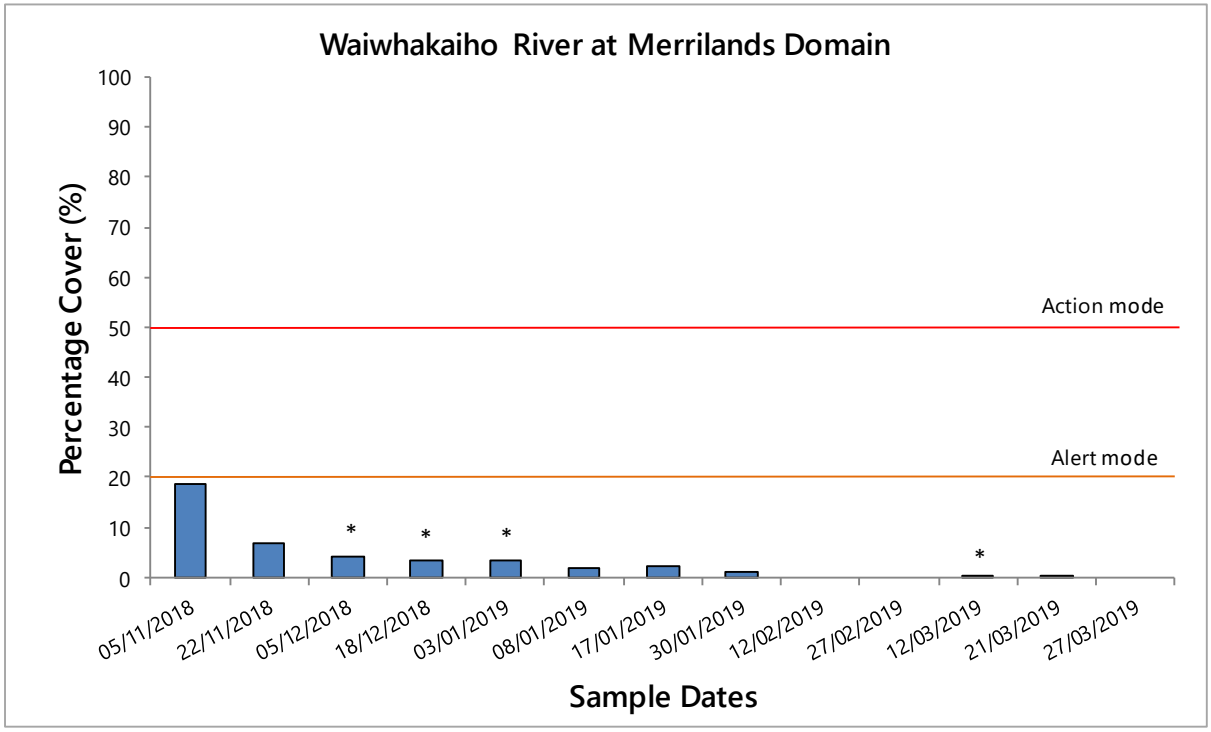


Figure 10 Percentage benthic cyanobacteria cover at the Waiwhakaiho River at Merrilands Domain site

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 4 and 5 Exposed cyanobacteria mats, Waiwhakaiho River at Merrilands Domain

Benthic cyanobacteria coverage was generally low throughout the season with a median value of only 2%. There was one occasion where it exceeded 10% coverage (range from 0 to 19%). 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 four occasions which triggered the 'Alert' level. In total, the 'Alert' level was triggered on four occasions.

The cause of the high number of 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 (eg, in early morning) river levels were low and mats were exposed. 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 6 A typical gull population immediately upstream of the Waiwhakaiho River, Lake Rotomanu site

A total of 13 samples were collected at this site over the summer, all scheduled SEM samples.

Minor usage of this site was recorded at the time of the sampling surveys, with some whitebaiting (in season), dog-walking on the banks of the river and swimming. Seagulls (extremely abundant) were frequently present at this site with large numbers of gulls present along the lower reaches of the river upstream of this site (Photo 6). Ducks were present on several occasions.

All *E. coli* data for this site, from the 2018-2019 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.

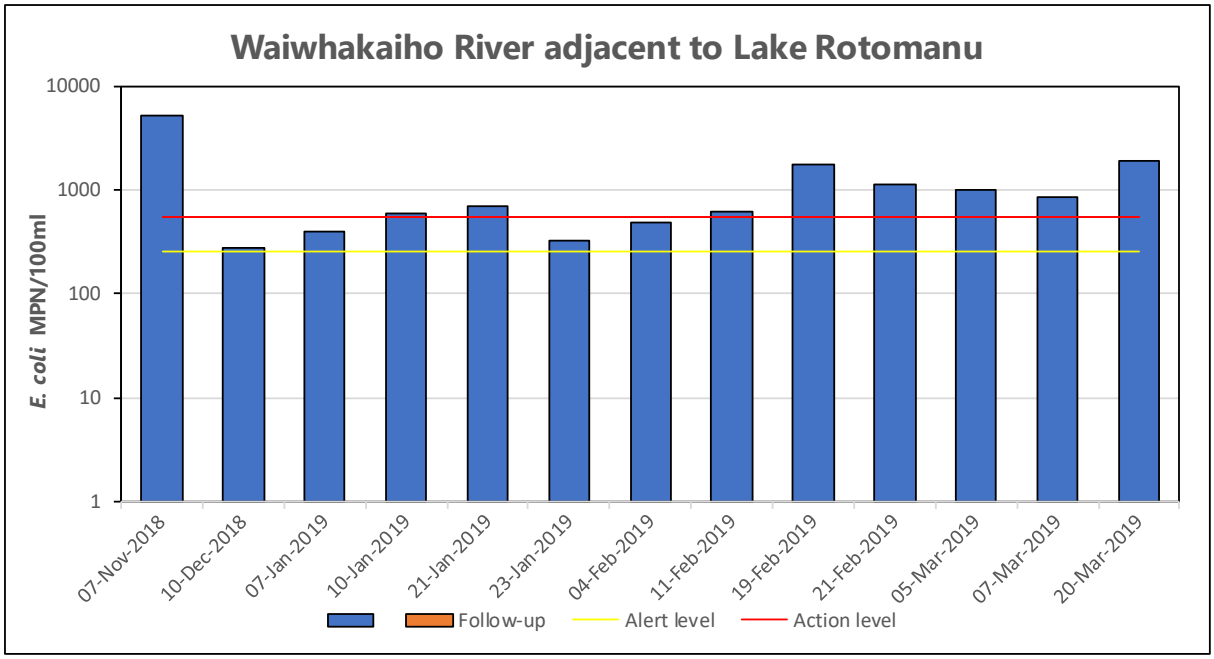


Figure 11 *E. coli* results for Waiwhakaiho River adjacent to Lake Rotomanu

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	13	118	4,660	188
	E. coli	MPN/100ml	13	278	5,170	683
	Temperature	°C	13	16.2	26.4	22.4
	Turbidity	NTU	13	0.6	2.9	1.0

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 700m 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 8.2˚C between early November and mid-March, with a maximum of 26.4˚C in mid-afternoon in mid-February 2019. 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 five 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 683 per 100 ml, particularly in comparison with numbers found at the upstream Merrilands Domain site (median: 40 per 100 ml). Individual sample *E.coli* counts exceeded 487 per 100 ml on all but four occasions, 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 counts (in the 'Action' mode) had been well documented, and permanent public warning signage was in place.

4.3.1 Comparison with guidelines

E. coli counts from Waiwhakaiho River opposite Lake Rotomanu over the 2018-2019 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 261-550/100ml	**ACTION Single sample >550/100 ml**
SEM samples	4 [31%]	9 [69%]

Photo 7 Health risk signage, lower Waiwhakaiho River

Nine single samples were recorded within the 'Action' mode and four samples 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 7). 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 23 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].

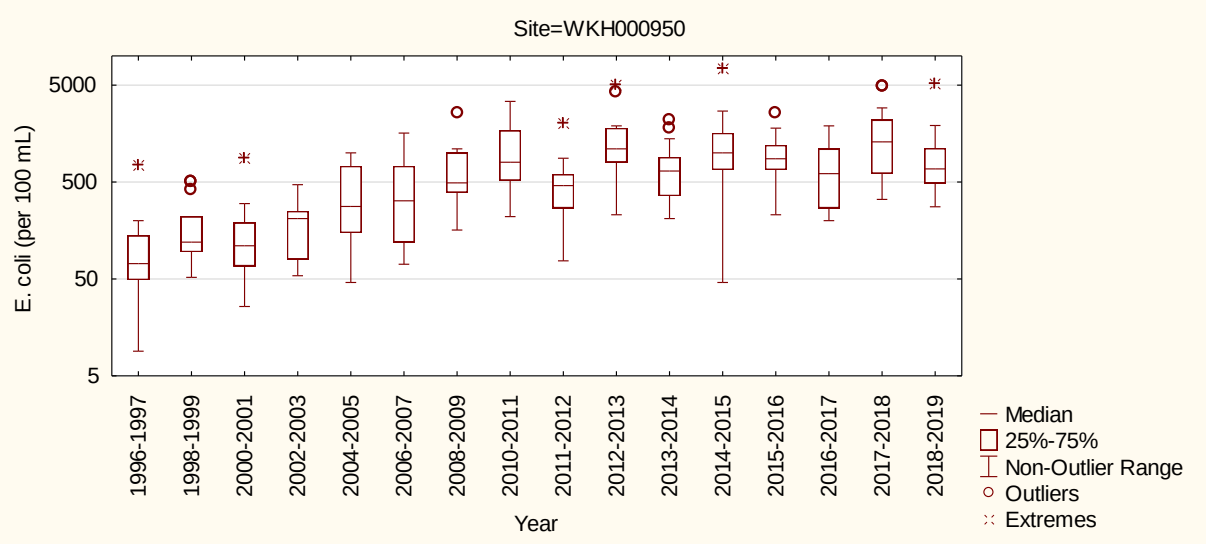


Figure 12 Box and whisker plots of *E. coli* for all summer SEM surveys in the Waiwhakaiho River adjacent to Lake Rotomanu

The median *E.coli* number in the 2018-2019 period was the sixth 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 seven medians in excess of the 'Action' guideline. The minimum *E. coli* number in 2018-2019 was the sixth highest recorded, indicating a high baseline.

4.3.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the sixteen seasons of data (over 22 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.

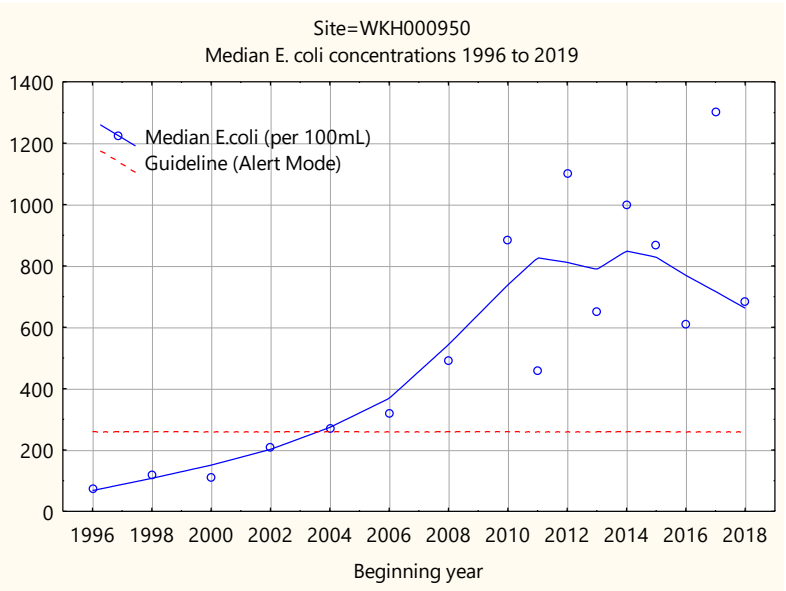


Figure 13 LOWESS trend plot of median E.coli data for the Waiwhakaiho River, adjacent to Lake Rotomanu

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

4.3.4 Cyanobacteria

Benthic cyanobacteria were monitored on 13 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
05/11/2018	4	No	No	Surveillance
22/11/2018	0	No	No	Surveillance
05/12/2018	2	No	No	Surveillance
18/12/2018	1	No	No	Surveillance
03/01/2019	3	Minor	Minor	Alert
08/01/2019	3	No	No	Surveillance
17/01/2019	0	No	No	Surveillance
30/01/2019	0	No	No	Surveillance
12/02/2019	0	No	No	Surveillance
27/02/2019	0	No	No	Surveillance
12/03/2019	0	No	Minor	Alert
21/03/2019	1	No	Minor	Alert
27/03/2019	0	No	No	Surveillance

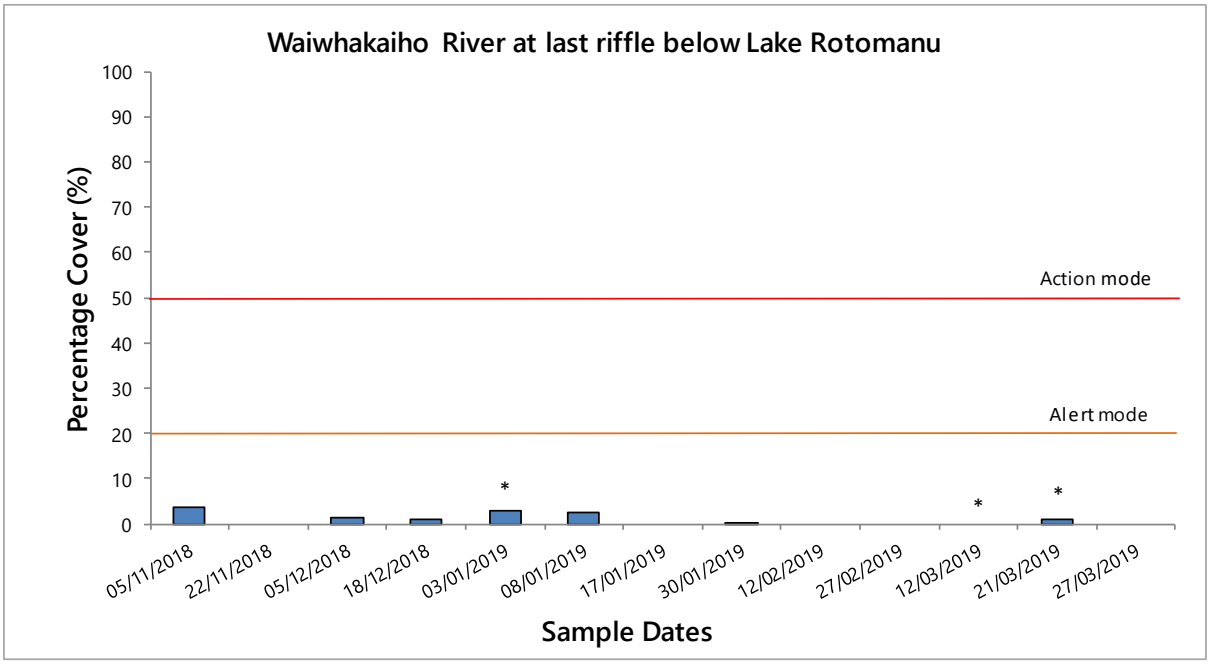


Figure 14 Percentage benthic cyanobacteria cover at Waiwhakaiho River at last riffle below Lake Rotomanu.

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 generally very low throughout the season (ranging from 0 to 4%). The benthic cyanobacteria found were *Microcoleum* sp. Detaching mats reached minor levels on one occasion which triggered the 'Alert' level. Minor levels of exposed mats were visible on three occasions which triggered the 'Alert' level. In total, the 'Alert' level was triggered on three occasions.

4.4 Te Henui Stream at the mouth, East End

A total of 13 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 one occasion. One to five persons were on the banks or bridge on nine occasions, once for a picnic. Fishing off the bridge was noted on one occasion. Dogs were seen on three occasions, once 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 2018-2019 summer period, are presented in Figure 15. The complete survey results are presented in Appendix I and summarised in Table 16.

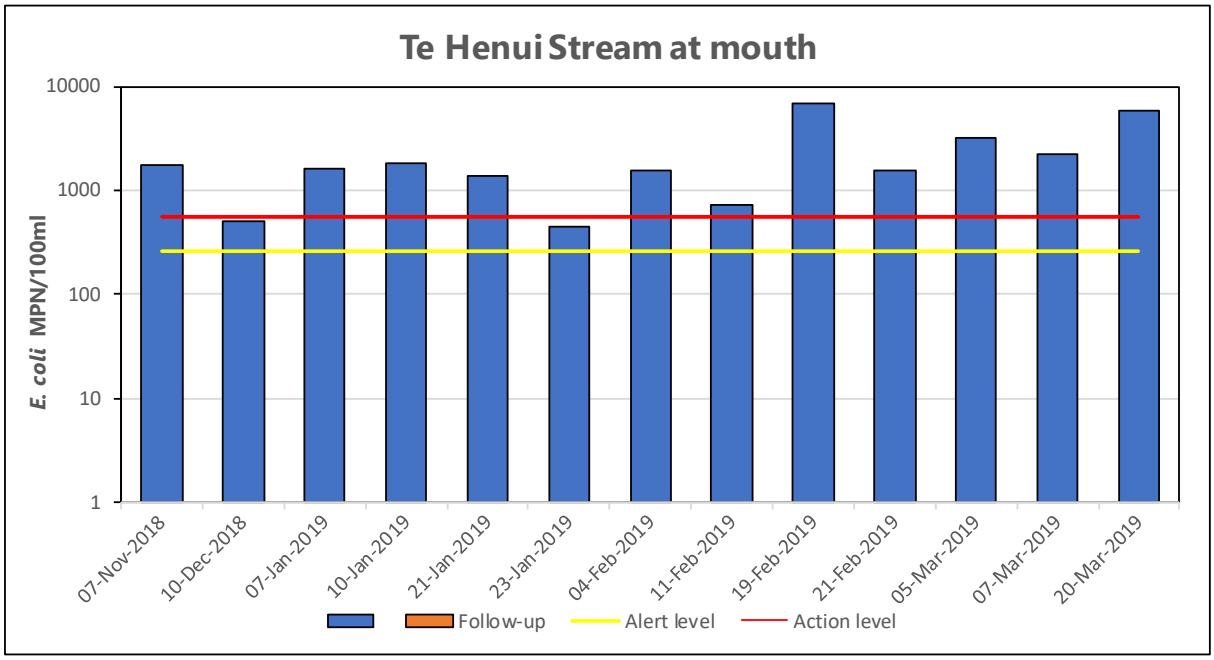


Figure 15 *E.coli* results for Te Henui Stream at mouth, East End

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	13	205	43,200	17,590
	E. coli	MPN/100ml	13	443	6,870	1,607
	Temperature	°C	13	15.2	23.8	19.8
	Turbidity	NTU	13	0.6	8.2	1.6

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, gulls, 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 8.6˚C between early November and mid-March, with a high maximum of 23.8˚C in mid-afternoon in mid-February 2019. 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 2018-2019 season was very poor with a wide range of counts and very high median *E. coli* count of 1,607 per 100 ml and a relatively high minimum count.

4.4.1 Comparison with guidelines

E. coli counts from Te Henui Stream at the mouth over the 2017-2018 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 261-550/100ml	ACTION Single sample >550/100 ml
SEM samples	2 [15%]	11 [85%]

Only two single samples were recorded below the 'Action' mode during the season, which were at 'Alert' level. Bacteriological water quality measured at this site therefore was outside the acceptable standard for contact recreational usage on 85% of monitoring occasions. No additional sampling surveys were required as the source of these elevated counts 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 17 summers are presented in Figure 16.

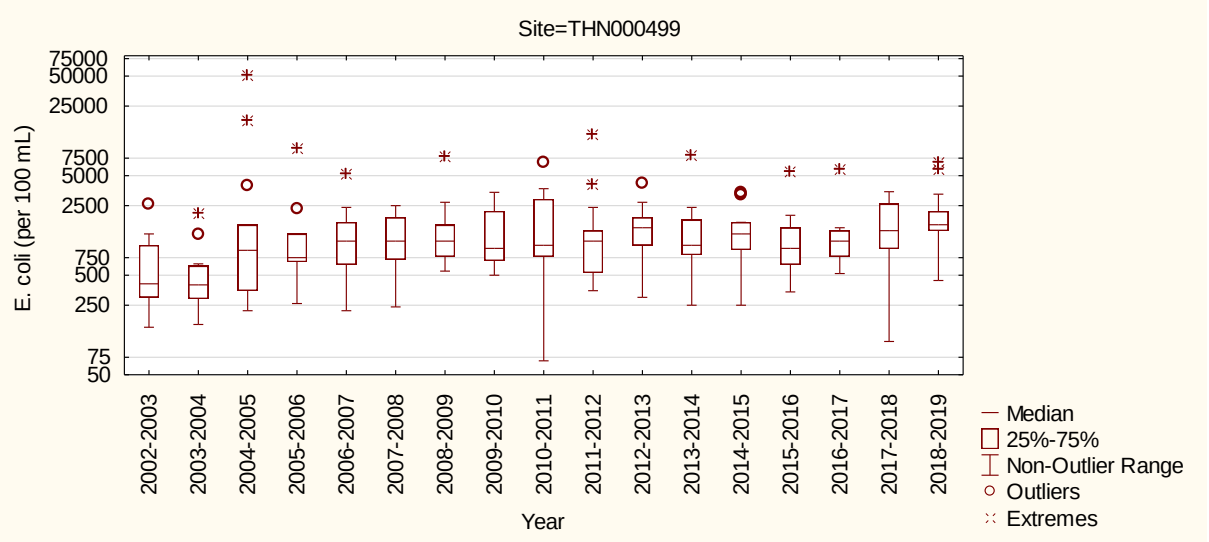


Figure 16 Box and whisker plots of *E. coli* for all summer SEM surveys of Te Henui Stream at mouth, East End

The median *E. coli* number in the 2017-2018 period was the second highest of the medians recorded over the last 17 seasons (Figure 16), and well above the 'Alert' level of the 2003 MfE guidelines. All but the first two of the 16 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 seventeen 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.

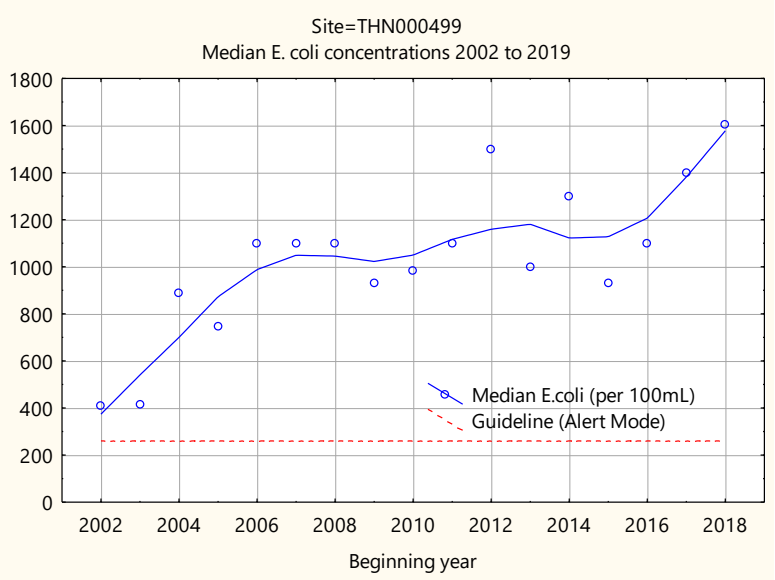


Figure 17 LOWESS trend analysis of median *E.coli* data at Te Henui Stream mouth, East End

A temporal trend of increasing median *E. coli* numbers has been found over the seventeen seasons of monitoring. (Note: This trend was statistically very significant at $p<0.01$, including after FDR analysis:

p=0.008 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 11 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
05/11/2018	0	No	No	Surveillance
22/11/2018	0	No	No	Surveillance
05/12/2018	0	No	No	Surveillance
18/12/2018	0	No	No	Surveillance
03/01/2019	0	No	No	Surveillance
17/01/2019	0	No	No	Surveillance
30/01/2019	0	No	No	Surveillance
12/02/2019	0	No	No	Surveillance
27/02/2019	0	No	No	Surveillance
12/03/2019	0	No	No	Surveillance
27/03/2019	0	No	No	Surveillance

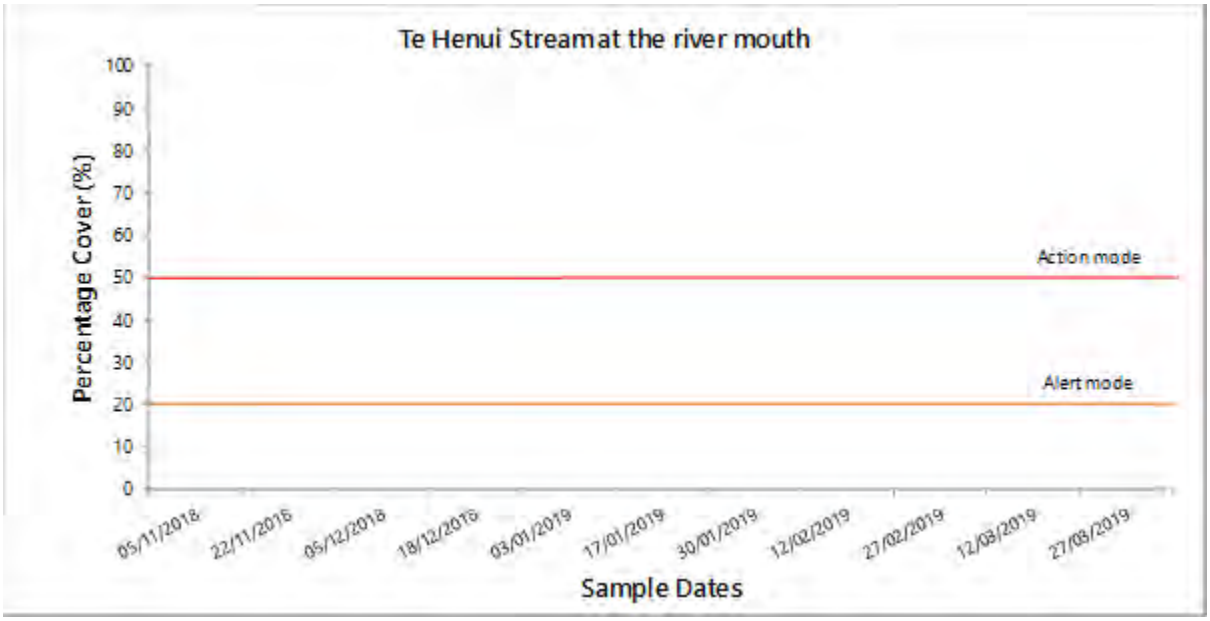


Figure 18 Percentage benthic cyanobacteria cover at Te Henui Stream at the mouth

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 14 samples were collected at this site over the summer. All 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 only one of the sampling surveys (fishing in January 2019). In many previous seasons, swimming, picnicking, and walking or resting on the banks, sometimes with dogs, has been observed.

A few (1-7) ducks were observed on the water on two monitoring occasions over the monitoring period.

All *E. coli* data for this site, from the 2018-2019 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.

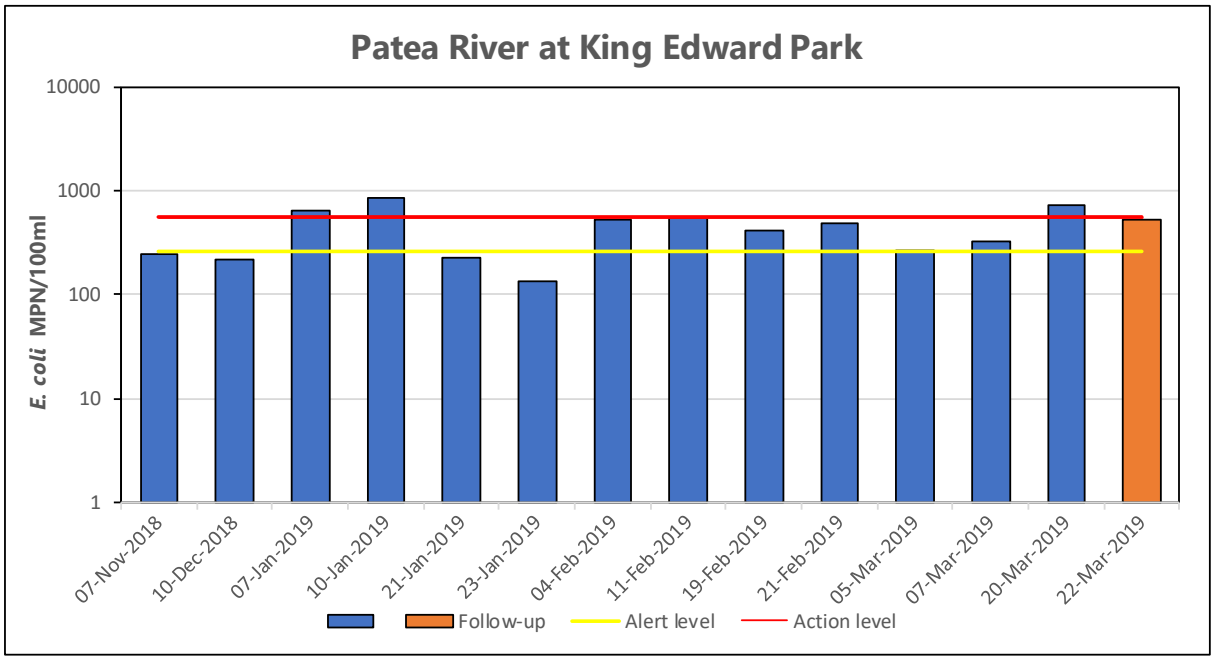


Figure 19 *E. coli* results for Patea River at King Edward Park, Stratford

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	13	102	122	114
	E. coli	MPN/100ml	13	133	866	411
	Temperature	°C	13	14.0	19.5	16.7
	Turbidity	NTU	13	0.87	2.0	1.28

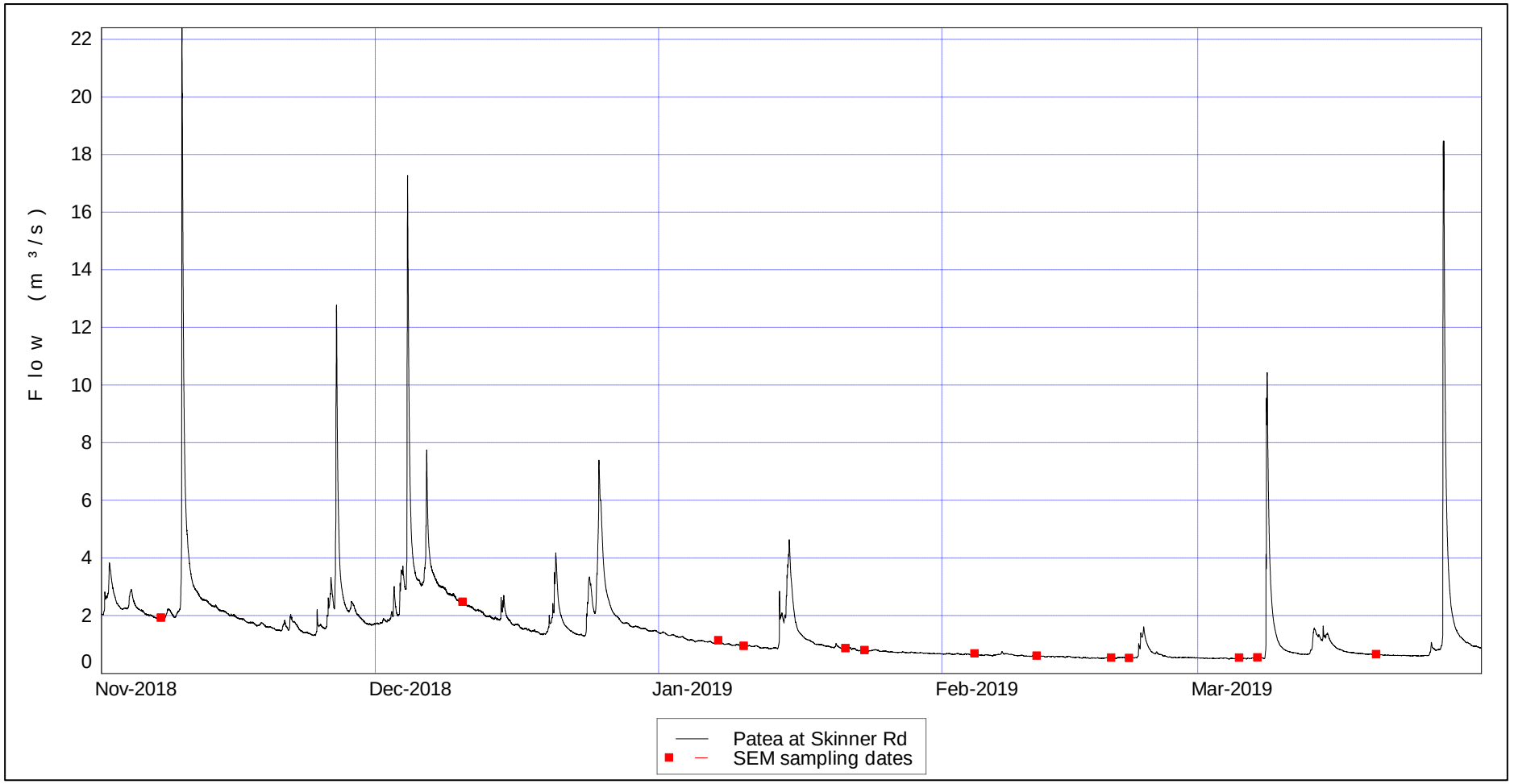


Figure 20 Flow in the Patea River at Skinner Rd during the survey period

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, while the median *E. coli* remained unchanged and elevated, at 411 MPN/100mL, using the same test method as the previous year.

Water temperatures had a narrow range of 5.5°C for this site (at an elevation of 300 m asl), with a maximum of 19.5°C recorded in late January 2019 (at 1355 hrs).

Bacteriological water quality was poor for the mid reaches of this Taranaki ring plain river draining a predominantly agricultural catchment. Three counts exceeded the 'Action' level, two (consecutive) in early January, and one in mid-March. A health warning sign was erected immediately by Stratford District Council after both events, which remained in place until test results from follow-up sampling reduced to below 'Action' level, that is, about 14 days in January and 2 days in March.

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 four 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 counts for Patea River at King Edward Park, Stratford over the 2018-2019 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** **261-550/100ml**	**ACTION** **Single sample** **>550/100 ml**
SEM samples	6 [46%]	3 [23%]

Three single samples fell within the 'Action' mode, and another six samples fell in the 'Alert' mode. These counts occurred between early December 2018 and late March 2019, in early morning to mid-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 18 summers are presented in Figure 21.

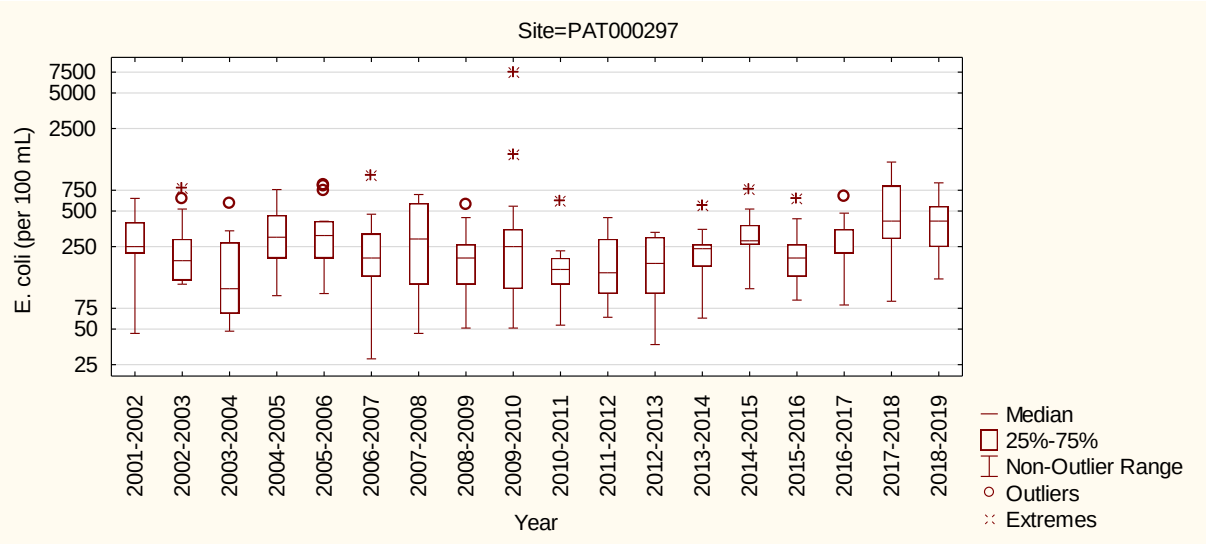


Figure 21 Box & whisker plots of *E. coli* for all summer surveys of Patea River at King Edward Park, Stratford

The median *E.* coli number in the 2018-2019 period was the equal-highest recorded to date and 100 MPN/100 ml above the maximum of the range of historical medians recorded for this site. The range of counts was relatively wide, and the lower 25 percentile value was relatively high.

4.5.3 Long-term trend analysis

Trend analysis of these median *E.coli* numbers has been performed for the eighteen seasons of data by first applying 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.

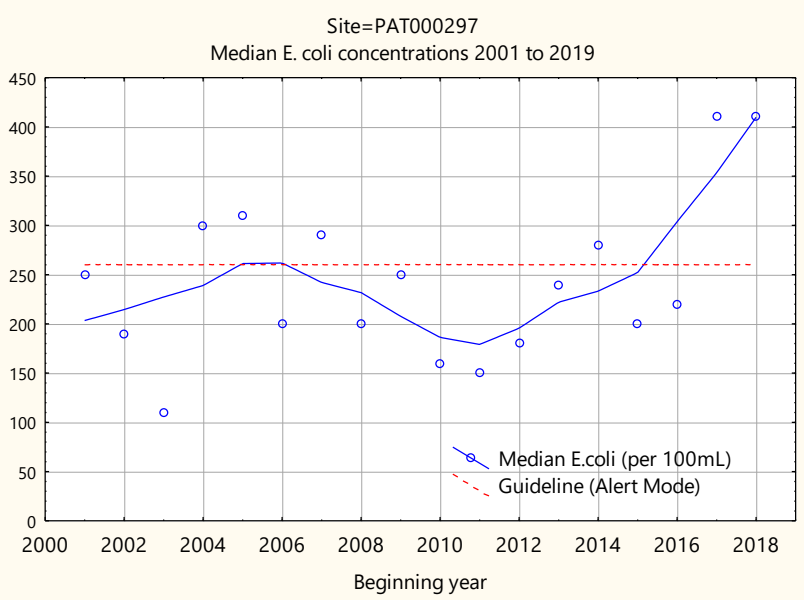


Figure 22 LOWESS trend plot of median E.coli data at the Patea River, King Edward Park, Stratford

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

4.5.4 Cyanobacteria

Benthic cyanobacteria were monitored on eleven 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
05/11/2018	1	No	No	Surveillance
22/11/2018	0	No	No	Surveillance
05/12/2018	0	No	No	Surveillance
18/12/2018	0	No	No	Surveillance
03/01/2019	1	No	No	Surveillance
17/01/2019	0	No	No	Surveillance
30/01/2019	0	No	No	Surveillance
12/02/2019	0	No	No	Surveillance
27/02/2019	0	No	No	Surveillance
12/03/2019	0	No	No	Surveillance
27/03/2019	0	No	No	Surveillance

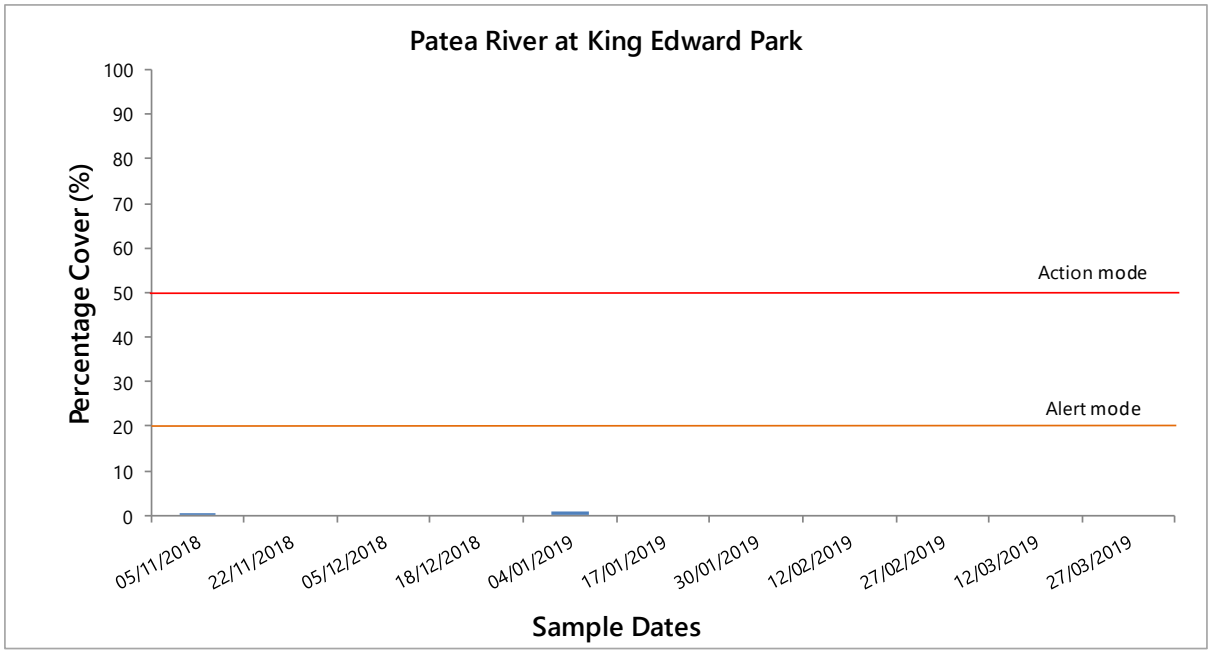


Figure 23 Percentage benthic cyanobacteria cover at the Patea River, Edward Park site.

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 1%). 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 13 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, all except two of which were in the morning. 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 2018-2019 summer period, are presented in Figure 24. The complete survey results are presented in Appendix I and summarised in Table 22.

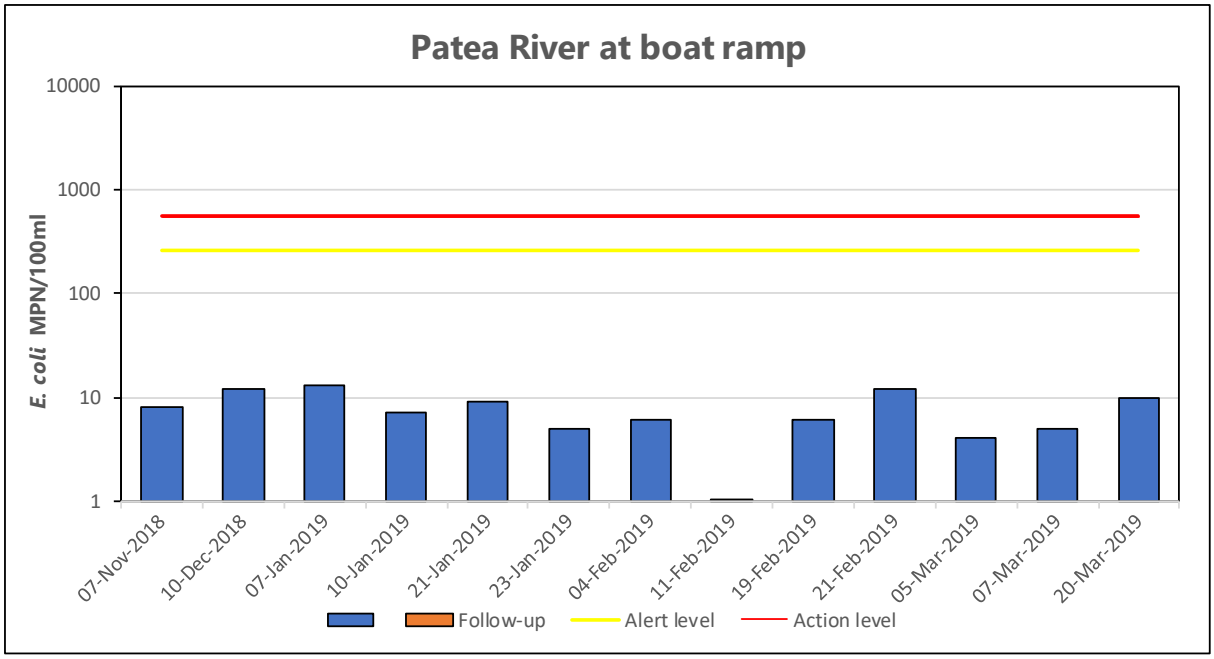


Figure 24 *E.coli* results for Patea River at boat ramp, Patea

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	13	53600	54600	53900
	E. coli	MPN/100ml	13	<1	13	7
	Enterococci	cfu/100ml	12	<1	11	5
	Temperature	°C	13	15.9	21.6	20.5
	Turbidity	NTU	13	2.3	33	17

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 moderate range of 5.7˚C, affected by the coastal seawater influence, with a maximum of 21.6˚C recorded at midday in mid-February 2019.

Bacteriological water quality was good for the lower reaches of this Taranaki ring plain river (median: 7 *E.coli* per 100 ml and 5 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 90

per 100 ml (with counts ranging from 27 to 600 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 counts for Patea River at the boat ramp, Patea over the 2018-2019 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 261-550/100ml	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: 10 per 100 ml; range enterococci: <1-58 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 12 summers are presented in Figure 7.

Eleven previous SEM sampling seasons have been surveyed at this site. Otherwise prior sampling has been confined to consent monitoring surveys (TRC 2014a). 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.

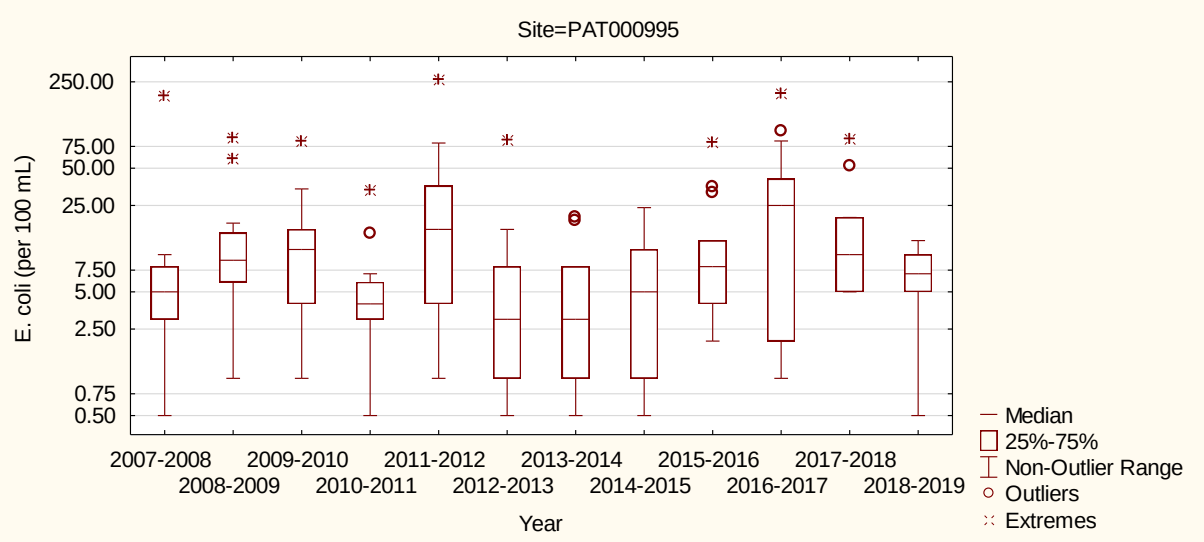


Figure 25 Box & whisker plots of *E. coli* for all summer SEM surveys of Patea River at boat ramp, Patea

Relatively similar (very low) median *E. coli* numbers have been found by these twelve seasons' surveys with a moderate range of counts with all the maximum values found to date having remained below the 'Alert'

level. The recent season's range of counts 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 twelve 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.

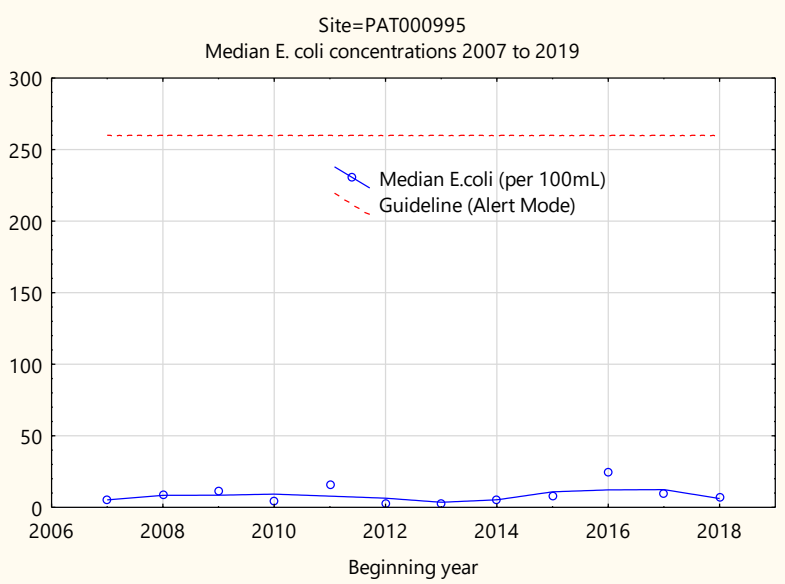


Figure 26 LOWESS trend plot of median *E. coli* data for Patea River at boat ramp, Patea

A slight, unimportant, and statistically insignificant increase in median *E. coli* numbers has been found over the twelve 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, all scheduled SEM samples.

Bathing usage of this river site was not recorded at the time of sampling surveys, though camp activities may have included 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 thirteen monitoring occasions, but no birdlife was recorded.

All *E. coli* data for this site, from the 2018-2019 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**.**

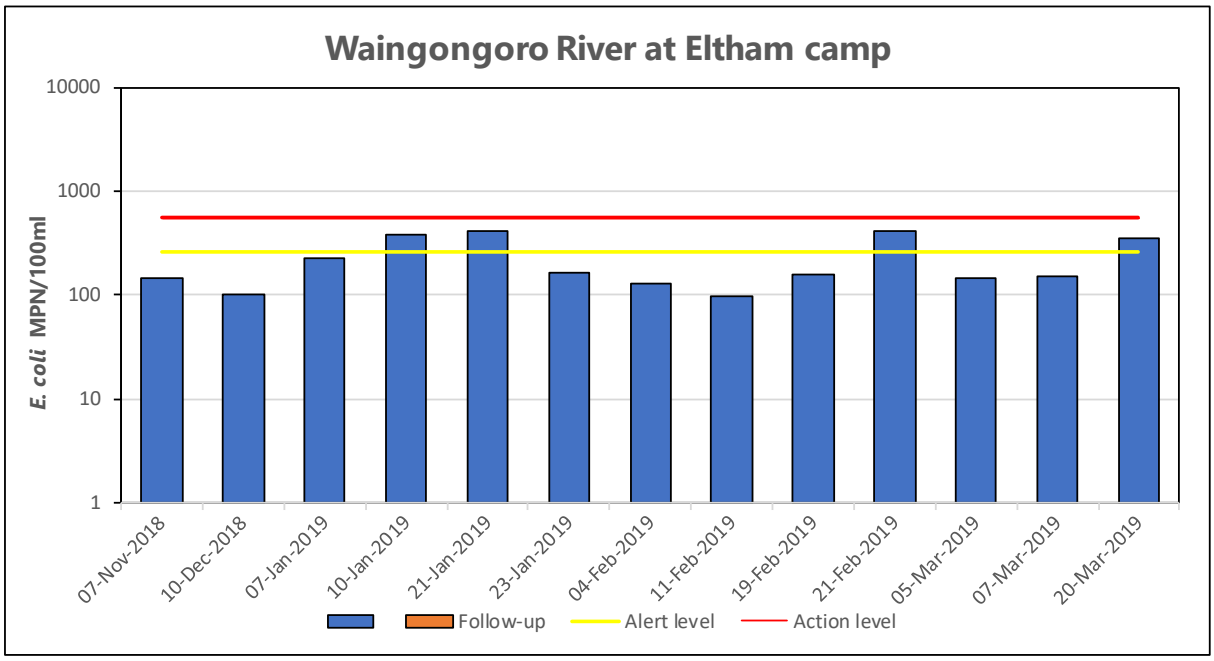


Figure 27 *E. coli* results for Waingongoro River at Eltham Camp

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	13	123	153	137
	E. coli	MPN/100ml	13	96	411	156
	Temperature	°C	13	16.8	22.2	19.1
	Turbidity	NTU	13	1.06	1.80	1.52

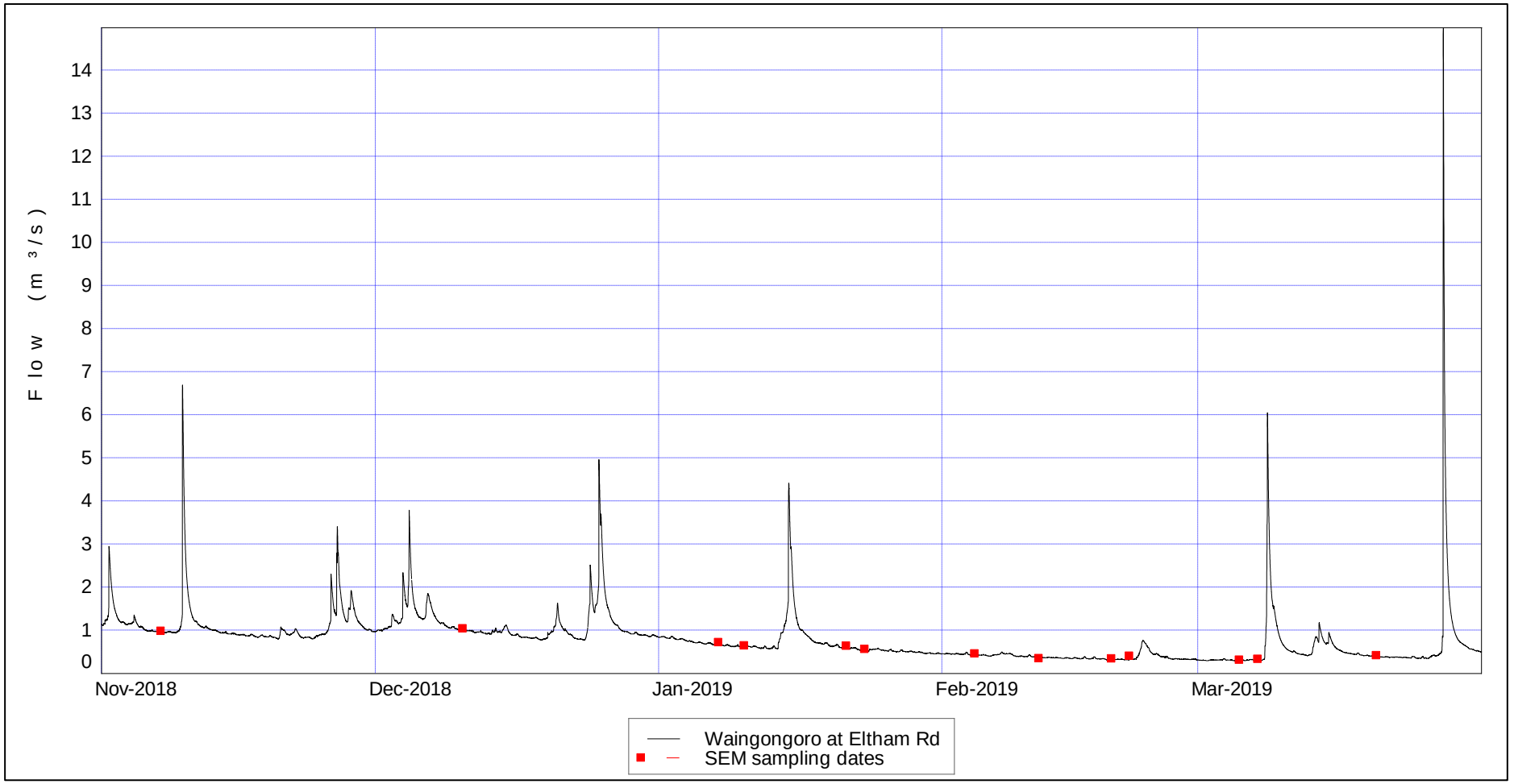


Figure 28 Flow in Waingongoro River at Eltham during the survey period

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 (5.4˚C) with a maximum of 22.2˚C in in mid-afternoon in early February 2019.

Bacteriological water quality (median *E.*coli: 156 per 100 ml) was typical of the mid reaches of a Taranaki ring plain river draining a predominantly agricultural catchment. This was comparable with the nearby Eltham Road (state of the environment physicochemical monitoring) site where a median *E.coli* count of 175 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 counts for the Waingongoro River at Eltham Presbyterian camp over the 2018-2019 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 261-550/100ml	ACTION Single sample >550/100 ml
SEM samples	4 [31%]	0 [0%]

Four single samples fell within the 'Alert' mode but no sample reached the 'Action' mode. The highest *E. coli* numbers (in the 'Alert' mode) occurred in mid-January and mid-February 2019 during relatively low flow periods. In general, these results were typical of bacteriological counts obtained at the site just downstream at Eltham Road (by the longer term physicochemical SEM programme), although the latter programme samples throughout the year under more variable river flows and climatological conditions

4.7.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Waingongoro River at Eltham camp over 18 summers is presented in Figure 29.

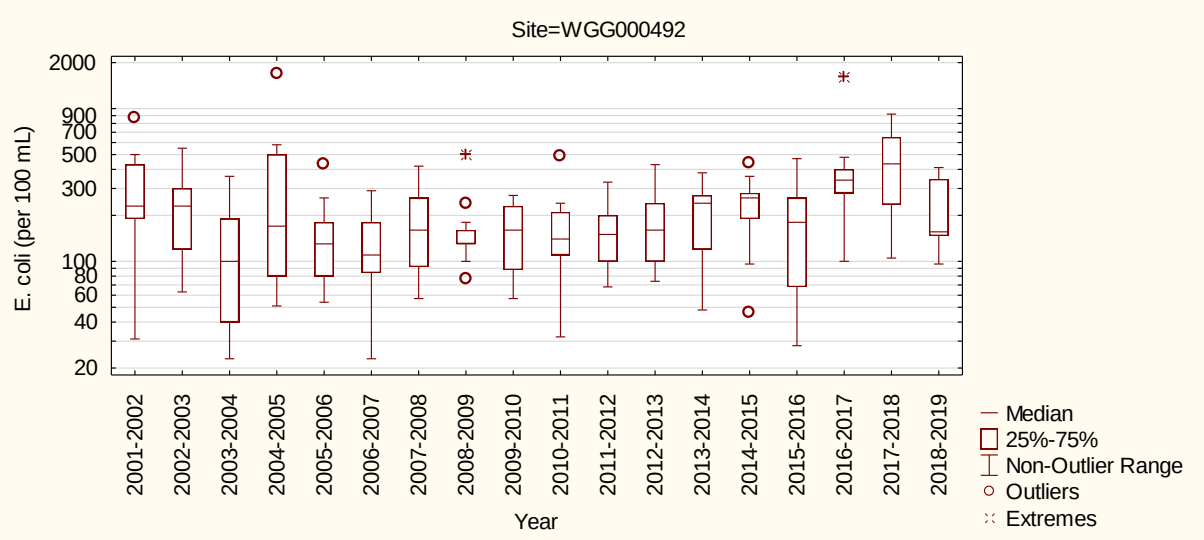


Figure 29 Box and whisker plots of *E. coli* for all summer surveys in Waingongoro River at Eltham Camp

An improvement in *E.coli* bacterial water quality in the 2018-2019 season was indicated by a median count which was within the mid-range of the medians recorded over the seventeen preceding seasons (Figure 29).

4.7.3 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 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.

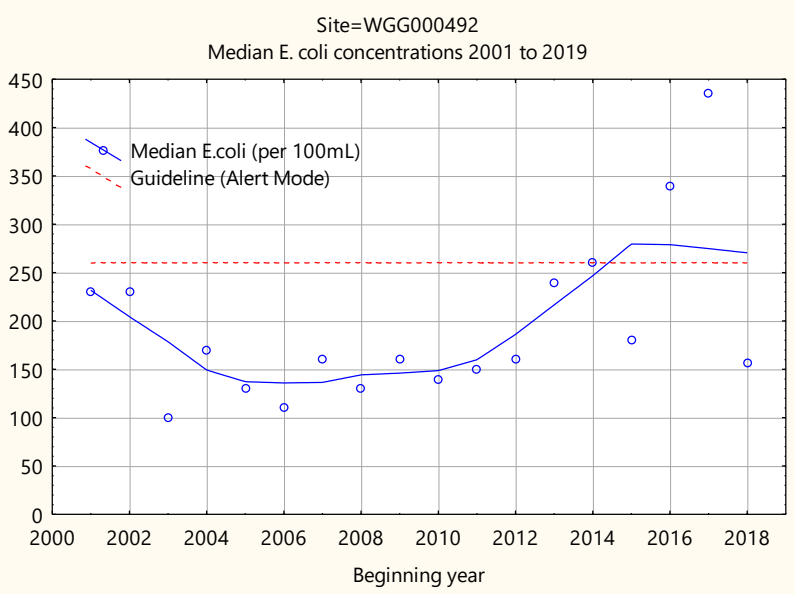


Figure 30 LOWESS trend plot of median *E.coli* data for Waingongoro River at Eltham camp

A statistically insignificant temporal trend of increasing median *E. coli* numbers has been found over the eighteen seasons of monitoring. (Note: This trend was almost statistically significant at $p < 0.05$ but not after FDR analysis, the p level being 0.054, increasing to 0.263 after FDR correction). None of these seasonal medians exceeded the 'Action' mode.

4.7.4 Cyanobacteria

Benthic cyanobacteria were monitored on eleven 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
05/11/2018	0	No	No	Surveillance
22/11/2018	0	No	No	Surveillance
05/12/2018	0	No	No	Surveillance
18/12/2018	1	No	No	Surveillance
03/01/2019	1	No	No	Surveillance
17/01/2019	0	No	No	Surveillance
30/01/2019	2	No	No	Surveillance
12/02/2019	0	No	No	Surveillance
27/02/2019	0	No	No	Surveillance

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
12/03/2019	0	No	No	Surveillance
27/03/2019	0	No	No	Surveillance

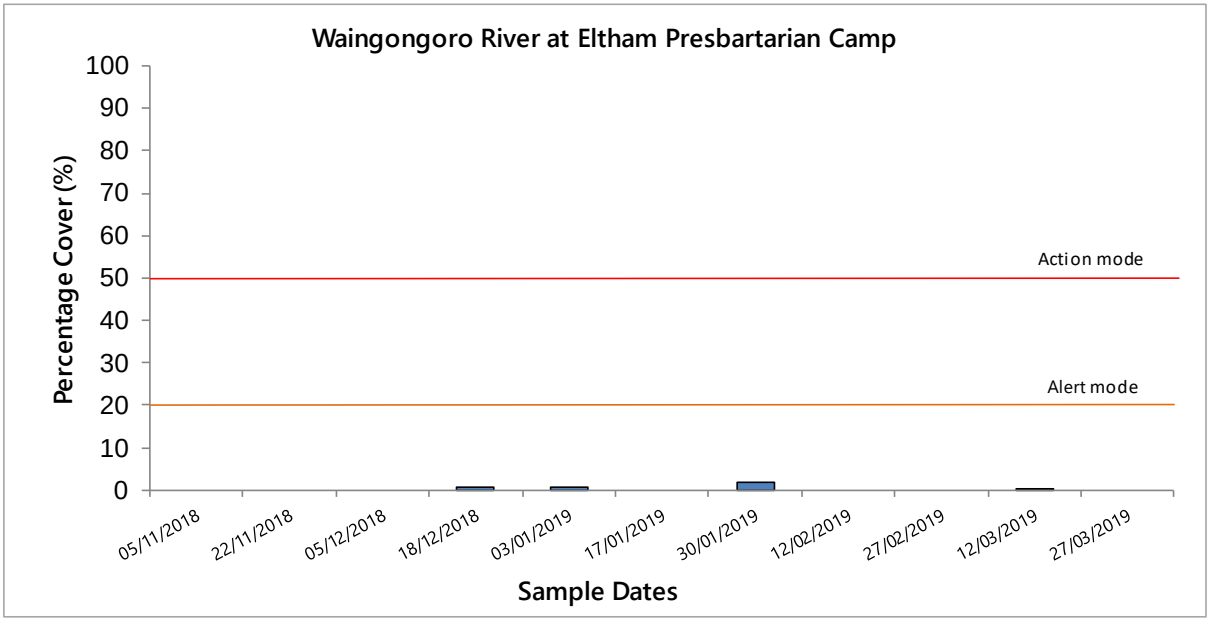


Figure 31 Percentage benthic cyanobacteria data for the Waingongoro River at Eltham Presbyterian Camp

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 2%). 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 22 samples were collected at this site over the summer. All 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 three of the sampling occasions. Whitebaiting was not recorded (although only one sampling was within the season), and fishing was recorded once. Livestock were present in the paddock upstream of the site on one occasion during the 2018-2019 season, but none were noted 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* counts (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 2018-2019 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.

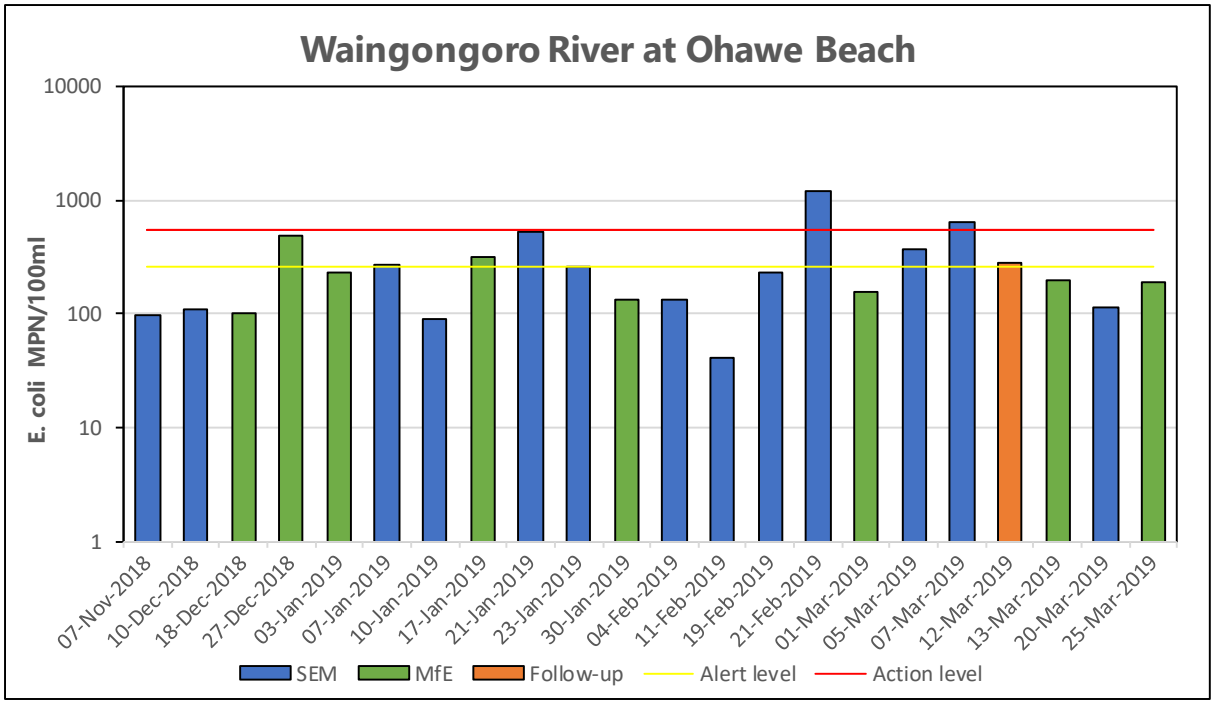


Figure 32 *E.coli* results for Waingongoro River at Ohawe Beach

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	13	191	14,790	219
	E. coli	MPN/100ml	13	41	1203	228
	Temperature	°C	13	17.9	23.4	21.0
	Turbidity	NTU	13	0.99	4.6	1.78
SEM + MfE samples	Conductivity	µS/cm@25°C	21	164	14,790	218
	E. coli	MPN/100ml	21	41	1203	196
	Temperature	°C	21	16.3	23.4	20.9
	Turbidity	NTU	21	0.71	4.6	1.78

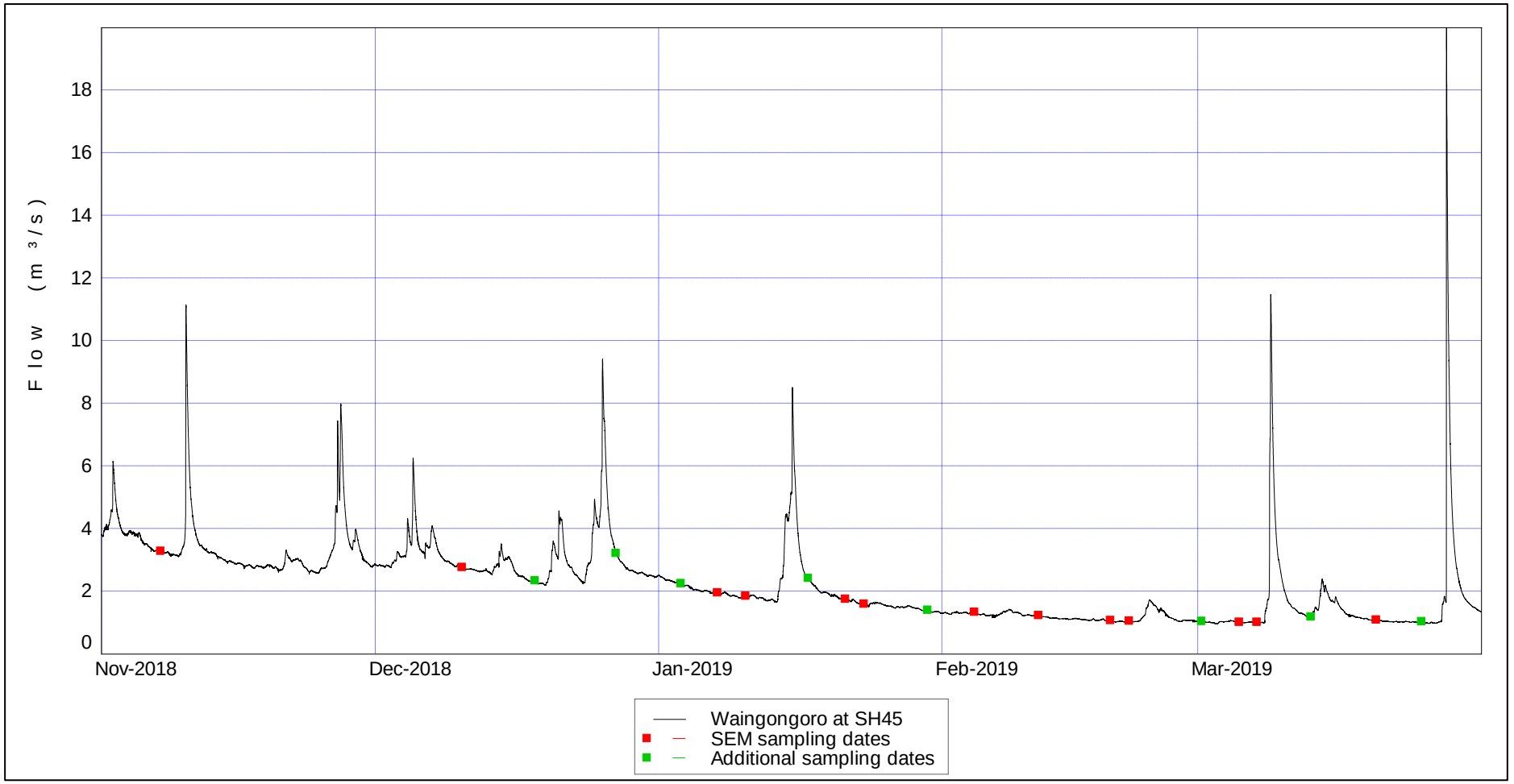


Figure 33 Flow in Waingongoro River at SH45 during the survey period

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 (5.5°C) with a maximum of 23.4˚C recorded in mid-afternoon in mid-February 2019. Conductivity values were typical of the lower reaches of a Taranaki ring plain. Saltwater influence occurred on one occasion, on 21 February 2019, when sampling coincided with a king tide (3.9 m at Port Taranaki). 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* count 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 counts for the Waingongoro River at Ohawe Beach over the 2018-2019 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 261-550/100ml	**ACTION Single sample >550/100 ml**
SEM samples	4 [31%]	2 [15%]
SEM+MfE samples	6 [29%]	2 [10%]

Two single samples were recorded in the 'Action' category, both during SEM surveys, one in mid-February 2019 that was affected by sediment suspended during a king tide, the other in early-March in dry weather. The 'Alert' mode was exceeded on six occasions, four during trend surveys in January and March 2019, and two during additional surveys in December and March. Health risk warning signage was deployed by STDC after the 'Action' level *E. coli* counts. On both occasions, follow-up sampling (delayed by a small fresh 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 23 summers is presented in Figure 34.

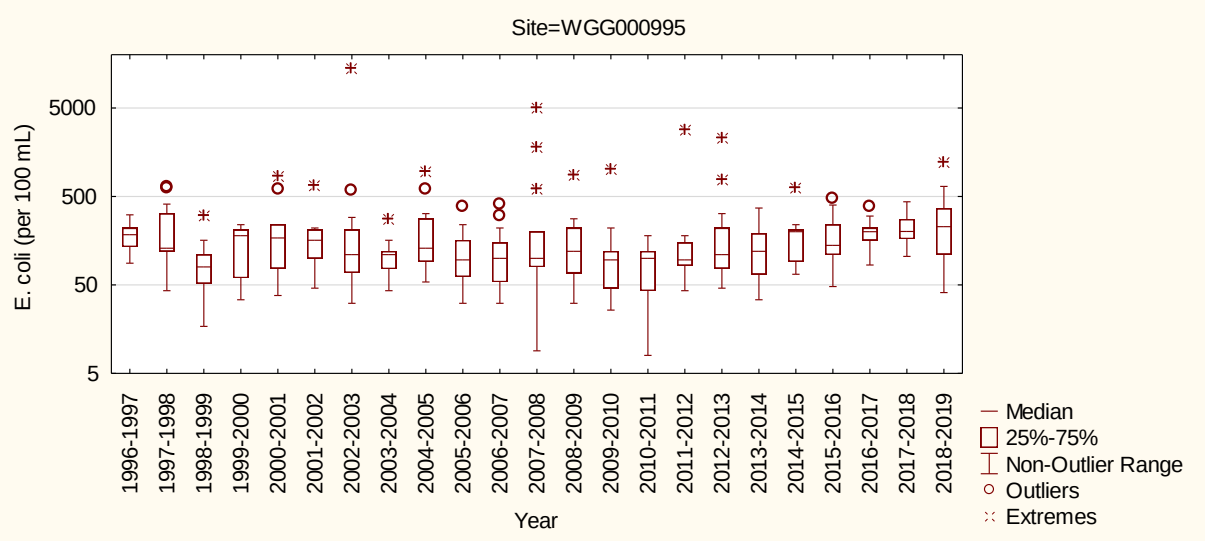


Figure 34 Box and whisker plots of *E. coli* for all summer surveys in Waingongoro River at Ohawe Beach

Median *E. coli* bacteria number for the 2018-2019 period was slightly more than the highest value found over the previous twenty-two seasons, in 2017-2018 (Figure 34).

A moderately wide range of *E. coli* numbers was recorded in the recent 2018-2019 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-three 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.

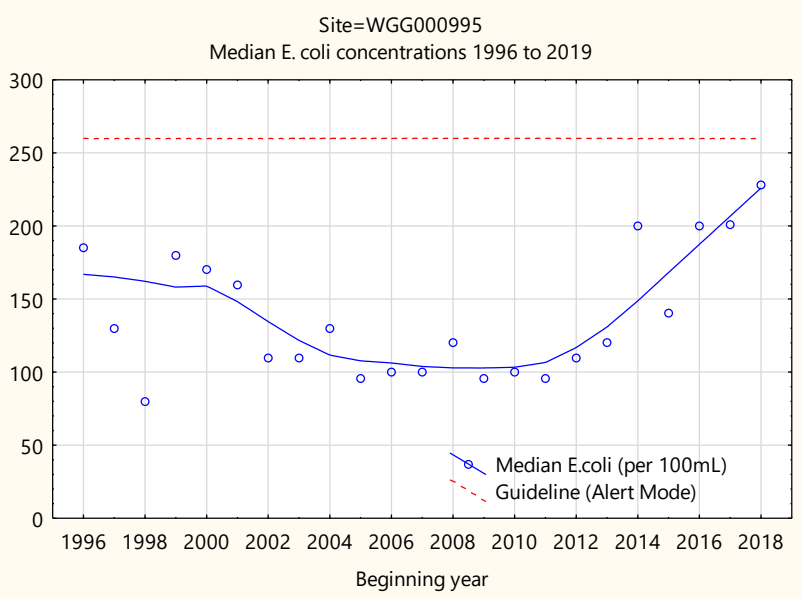


Figure 35 LOWESS trend plot of median E.coli numbers (per 100ml) for the 1996 to 2019 period at the Waingongoro River Ohawe beach site

Overall, a statistically insignificant increasing trend in median *E.coli* number was found over the twenty-three 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 15 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
05/11/2018	2	No	No	Surveillance
22/11/2018	2	No	No	Surveillance
05/12/2018	4	No	No	Surveillance
18/12/2018	10	No	Minor	Alert
03/01/2019	13	Minor	No	Alert
08/01/2019	14	No	No	Surveillance
17/01/2019	11	No	No	Surveillance
30/01/2019	17	No	Minor	Alert
07/02/2019	27	Minor	Minor	Alert
12/02/2019	11	No	Minor	Alert
19/02/2019	26	Minor	Minor	Alert
27/02/2019	0	No	No	Surveillance
12/03/2019	0	No	Minor	Alert
21/03/2019	0	No	No	Surveillance
27/03/2019	0	No	No	Surveillance

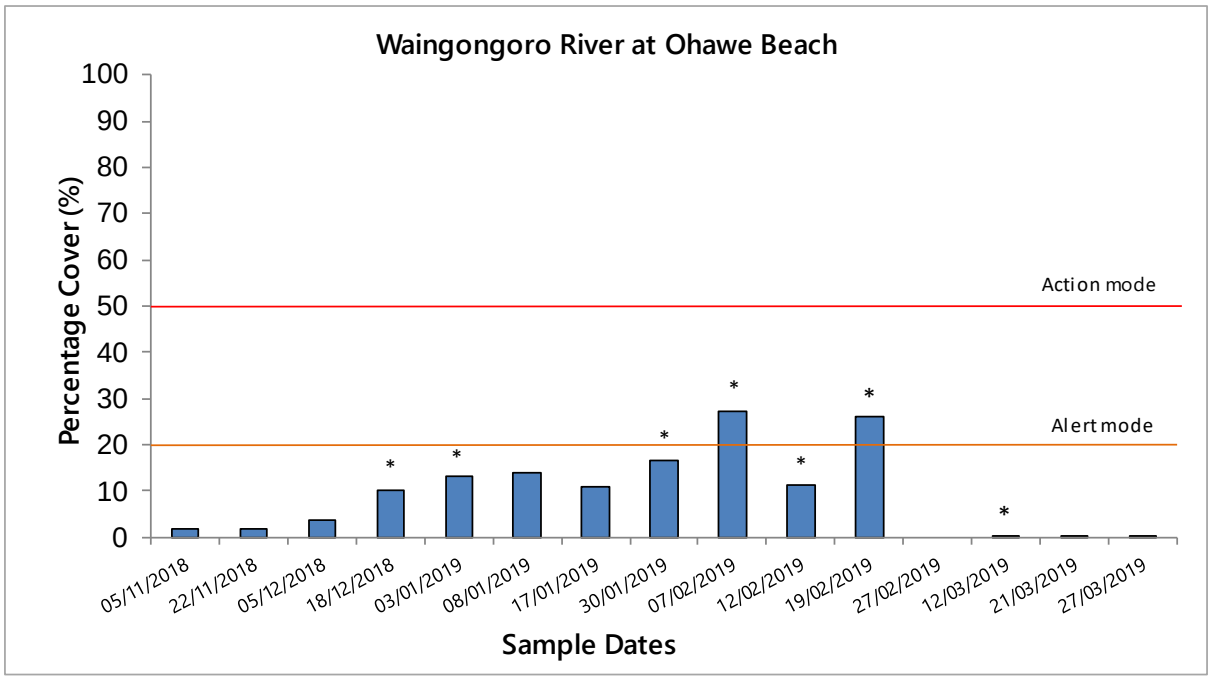


Figure 36 Percentage benthic cyanobacteria cover, for the Waingongoro River Ohawe beach site

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 moderately low for the majority of the monitoring period, with six of the 15 surveys between 10% to 19% streambed coverage. Two 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 six occasions, which triggered the 'Alert' response. In total there were seven surveys that triggered the 'Alert' level.

4.9 Kaupokonui River at Beach Domain

A total of 22 samples were collected at this site over the summer. All 13 scheduled SEM samples were collected, as well as eight MfE samples and one follow up samples. 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 fishing, walking and picnicking on the banks, and horse riding (once) 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* counts (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 2018-2019 season are provided in Figure 38.

All *E. coli* data for this site, from the 2018-2019 summer period, are presented in Figure 37 and summarised in Table 30. The complete survey results are presented in Appendix I.

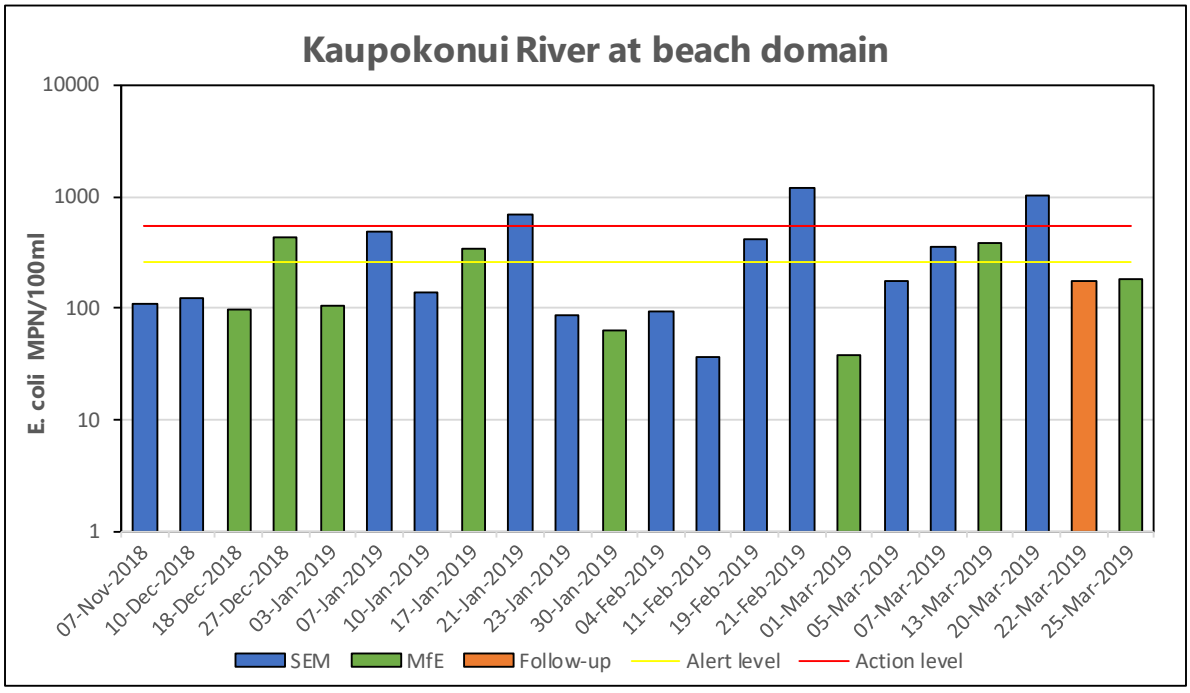


Figure 37 *E. coli* results for Kaupokonui River at the beach domain

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	13	166	5230	194
	E. coli	MPN/100ml	13	37	1203	172
	Temperature	°C	13	18.3	23.8	21.3
	Turbidity	NTU	13	0.90	16.0	1.61
SEM + MfE samples	Conductivity	µS/cm@25°C	21	152	5230	188
	E. coli	MPN/100ml	21	37	1203	172
	Temperature	°C	21	16.5	24.6	21.2
	Turbidity	NTU	21	0.90	16.9	1.81

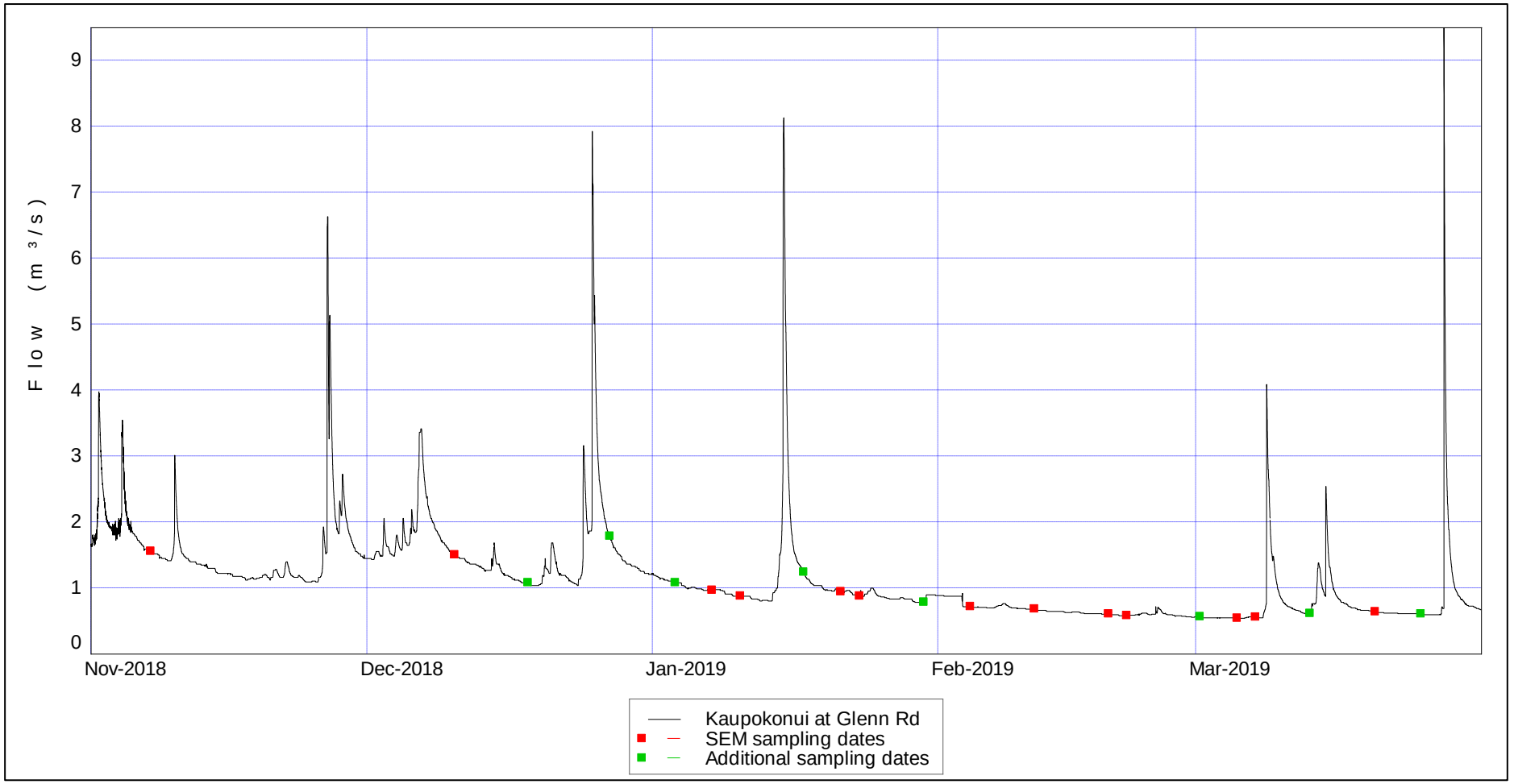


Figure 38 Flow in the Kaupokonui River at Glenn Rd during the survey period

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 six occasions indicated some seawater influence near high tide under low flow conditions throughout the monitoring period. Otherwise, these conductivity levels were relatively stable (167 to 223 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 up to 17 NTU) by sediment suspended during larger tidal surges. 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 of 9.1°C with a maximum of 24.6°C recorded in in late January 2019. This temperature was recorded at 1130 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 1315 hrs at this site.

Bacteriological water quality was moderately good and similar to that recorded in the lower reaches of the nearby Waingongoro River (see section 4.7), and 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, three 'Alert' levels and three 'Action' levels were recorded, between mid-January and mid-March 2019. There was tidal surging, or saline influence was measured, on all but one occasion.

During MfE surveys, three 'Alert' levels and no 'Action' levels were recorded, between late December and mid-March 2018. All three Alert level results were 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 2018-2019 season.

4.9.1 Comparison with guidelines

E. coli counts for the Kaupokonui River at the beach domain over the 2018-2019 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 261-550/100ml	**ACTION Single sample >550/100 ml**
SEM samples	3 [23%]	3 [23%]
SEM+MfE samples	6 [29%]	3 [14%]

Three single samples were recorded in the 'Action' category, all during SEM trend surveys, when tidal effects were apparent. The 'Alert' mode was exceeded on six occasions, three during SEM surveys, and three during MfE surveys which all were affected by rainfall. Health risk warning signage was deployed by STDC after the 'Action' level *E. coli* counts in dry weather. Follow-up surveys were undertaken after the three Action level numbers in dry weather (two as routine SEM or MfE samplings, in mid-January and early March), and all returned numbers in the acceptable range. The signs were removed accordingly.

In summary, bacteriological water quality at this ponded lower river site was within guidelines for contact recreational usage for the 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 23 summers is presented in Figure 39.

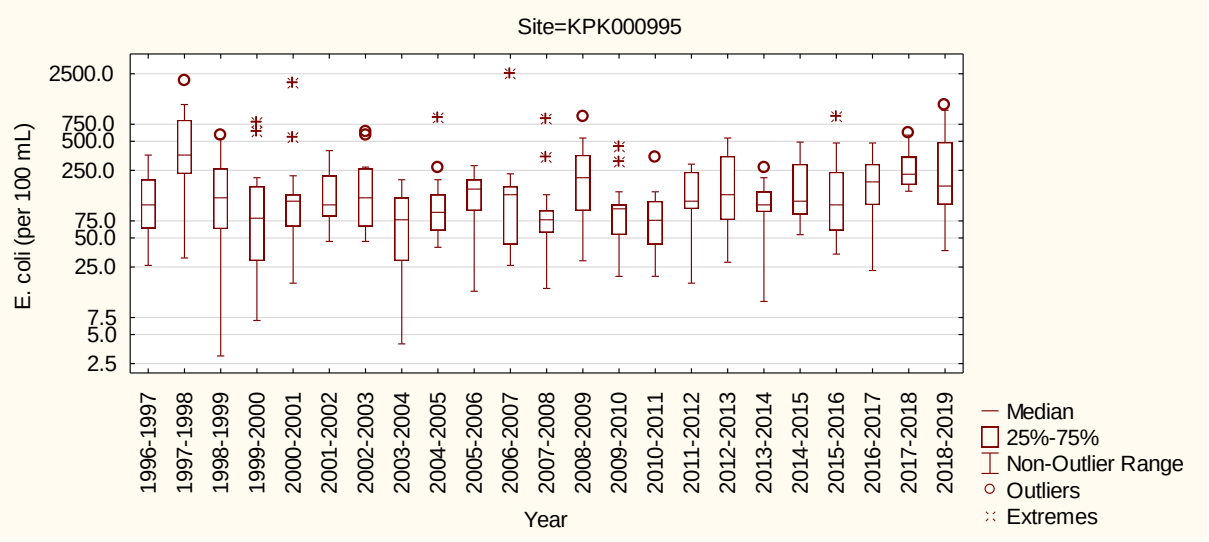


Figure 39 Box and whisker plots of *E. coli* for all summer surveys in the Kaupokonui River at the Beach Domain

Improved *E. coli* bacterial water quality in terms of median number, but a wide range compared with many of the previous twenty-two survey seasons, was recorded over the 2018-2019 season (Figure 39). The median *E. coli* count 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-three 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-three 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.

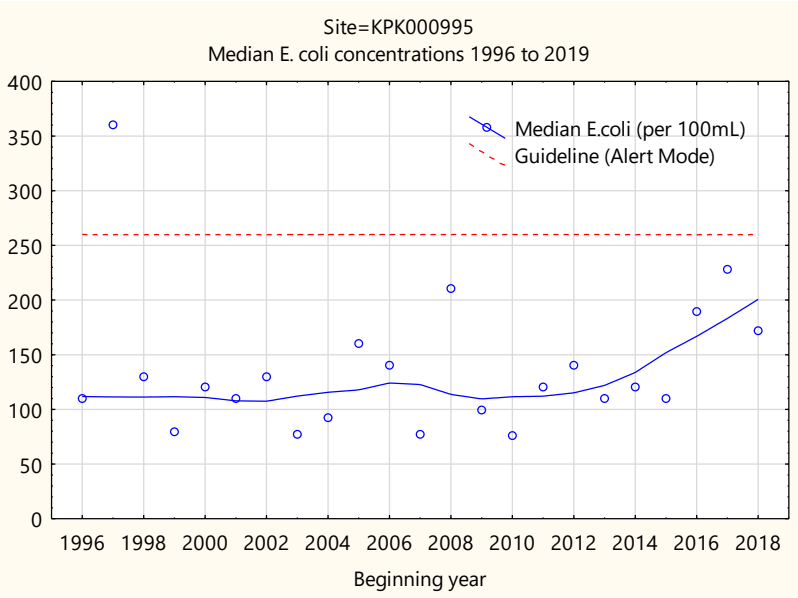


Figure 40 LOWESS trend plot of median *E. coli* data at the Kaupokonui River beach domain site

A slight, and statistically insignificant, increasing trend in median *E. coli* counts was found over the twenty-three 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 18 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
05/11/2018	27	No	No	Surveillance
13/11/2018	31	Yes	No	Action
22/11/2018	28	Yes	Minor	Action
27/11/2018	10	No	Minor	Alert
05/12/2018	16	No	No	Surveillance
18/12/2018	12	No	No	Surveillance
03/01/2019	9	Minor	No	Alert
08/01/2019	16	No	No	Surveillance
17/01/2019	11	No	No	Surveillance
30/01/2019	25	Minor	No	Alert
07/02/2019	24	Minor	No	Alert
12/02/2019	20	Minor	No	Alert

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
19/02/2019	22	Minor	No	Alert
27/02/2019	12	Minor	No	Alert
05/03/2019	6	Minor	No	Alert
12/03/2019	6	Minor	No	Alert
21/03/2019	4	No	No	Surveillance
27/03/2019	2	No	No	Surveillance

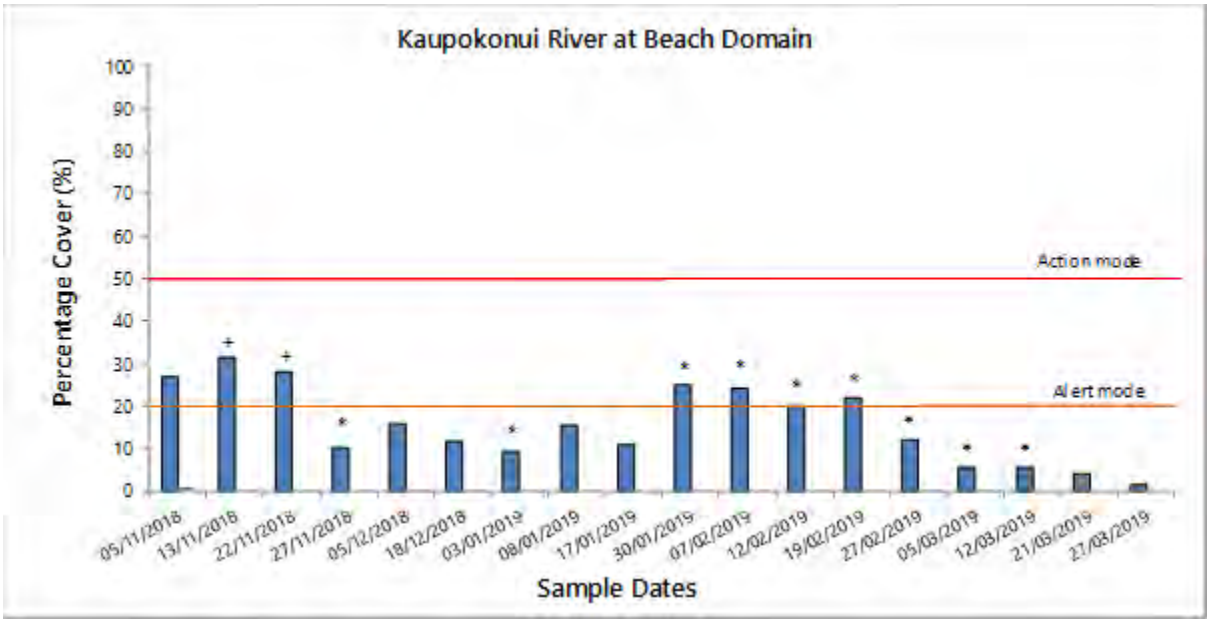


Figure 41 Benthic cyanobacteria data for Kaupokonui River at Beach Domain.

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 never exceeded for percentage cover but the 'Alert' level for cover was exceeded on seven occasions. Significant detaching mats were observed on two occasions which triggered the 'Alert' level and minor detaching mats were observed on eight occasions which triggered the 'Alert' level. Minor levels of exposed mats were observed on two occasions which triggered the 'Alert' level. In total, the 'Action' level was triggered on two occasions and the 'Alert' level was triggered on nine 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

A total of 15 samples were collected at this site over the summer. All 13 scheduled SEM samples were collected, and two follow up samples.

No bathing or boating usage of the lake was noted on any occasion, nor picnicking activities as has been recorded occasionally (sometimes with dogs present) at the time of sampling surveys in previous years. Sunbathing, fishing and feeding the ducks were each noted on one occasion. Ducks were noted regularly on the lake or in the vicinity of the lake edge on most occasions, in relatively low numbers compared with previous seasons. 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).

All *E. coli* data for this site, from the 2018-2019 summer period, are presented in Figure 42 and summarised in Table 33.

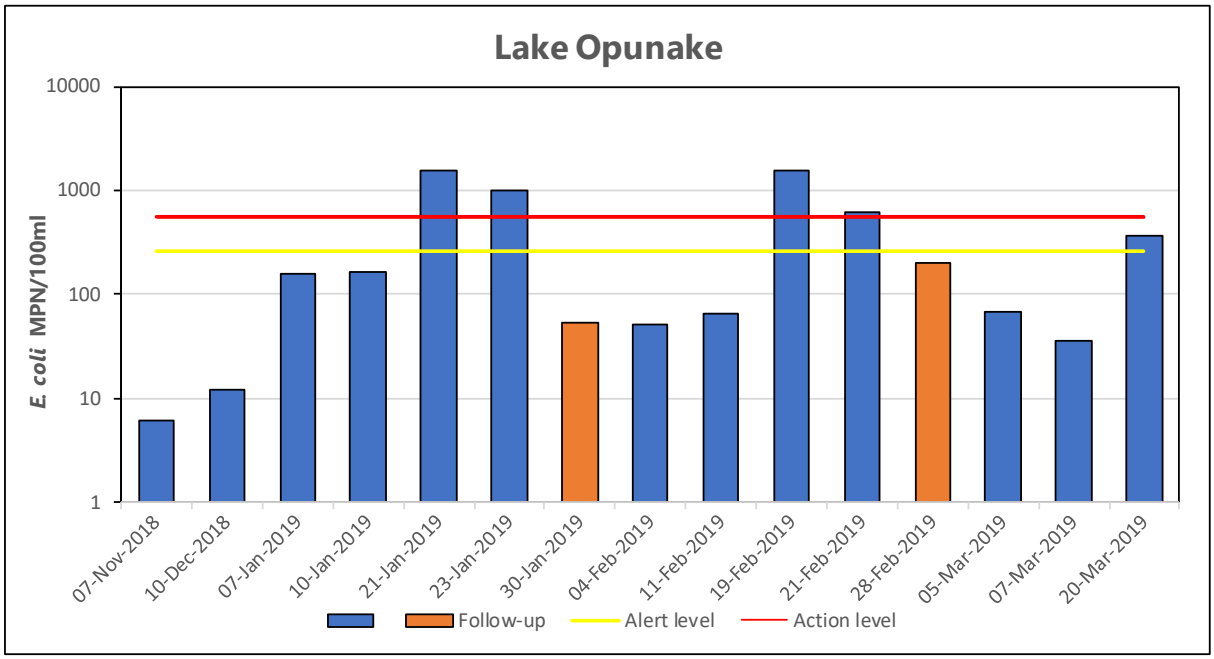


Figure 42 *E. coli* results for Lake Opunake

Table 33 Statistical summary for Lake Opunake

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	13	142	192	171
	E. coli	MPN/100ml	13	6	1,553	156
	Temperature	°C	13	19.5	26.3	23.4
	Turbidity	NTU	13	1.83	3.9	2.8

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 2.8 NTU, substantially higher than the median value for the previous 13 years (1.2 NTU), which is consistent with the higher levels of cyanobacteria found in 2018-2019, but may also be due to use of a different turbidimeter that tends to 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 (23.4°C) was the fourth highest recorded, with a moderate range (5.8°C) and higher maximum (26.3°C) value than usual. Conductivity varied over a fairly narrow range (50 µS/m @ 25˚C) reflecting river inflow conditions.

Generally, bacteriological quality was moderate, the median count (156 *E. coli* per 100 ml) being the fourth highest recorded, over a relatively wide range, 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 counts 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 counts for Lake Opunake over the 2018-2019 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 261-550/100ml	ACTION Single sample >550/100 ml
SEM samples	1 [8%]	4 [31%]

Four single sample exceedances of the 'Action' mode occurred during the period, and one single sample was recorded within the 'Alert' mode. The 'Action' level exceedances occurred in pairs, two days apart, in mid-January and mid-February. Follow up sampling was undertaken after each (consecutive sampling) event, and the *E. coli* number was at an acceptable level on both occasions. STDC issued a press release about the first event, and erected a health warning sign after both events.

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

4.10.2 Comparison with previous summer surveys

Summary statistics for the SEM *E.* coli data collected at Lake Opunake over 13 summers is presented in Figure 43.

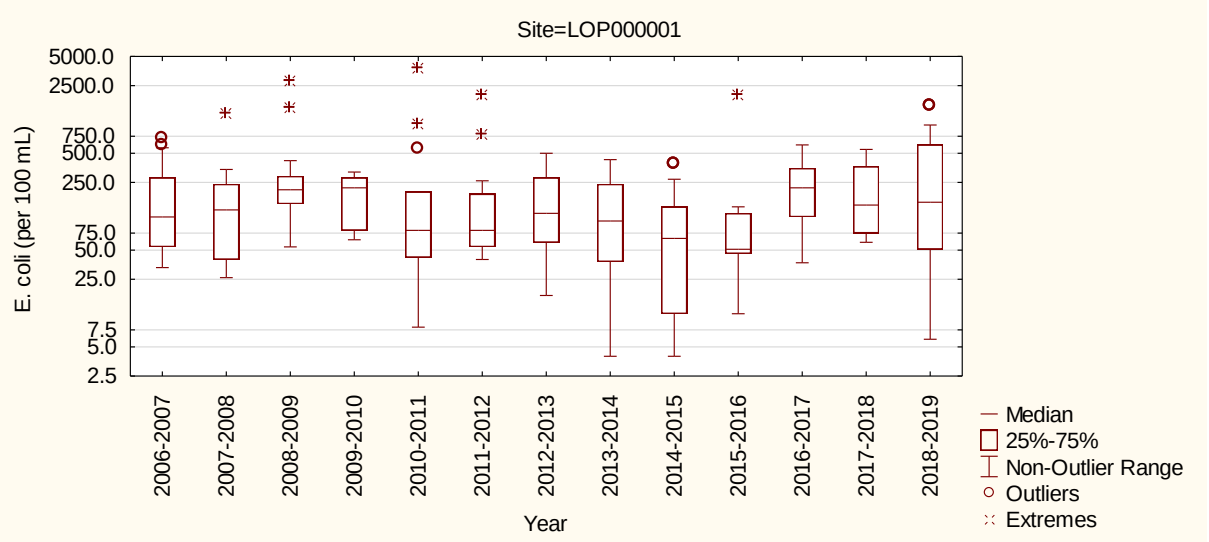


Figure 43 Box and whisker plots of *E. coli* for all summer SEM surveys at Lake Opunake

The median *E. coli* number in the 2018-2019 season was fourth to the highest for the thirteen 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 thirteen 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.

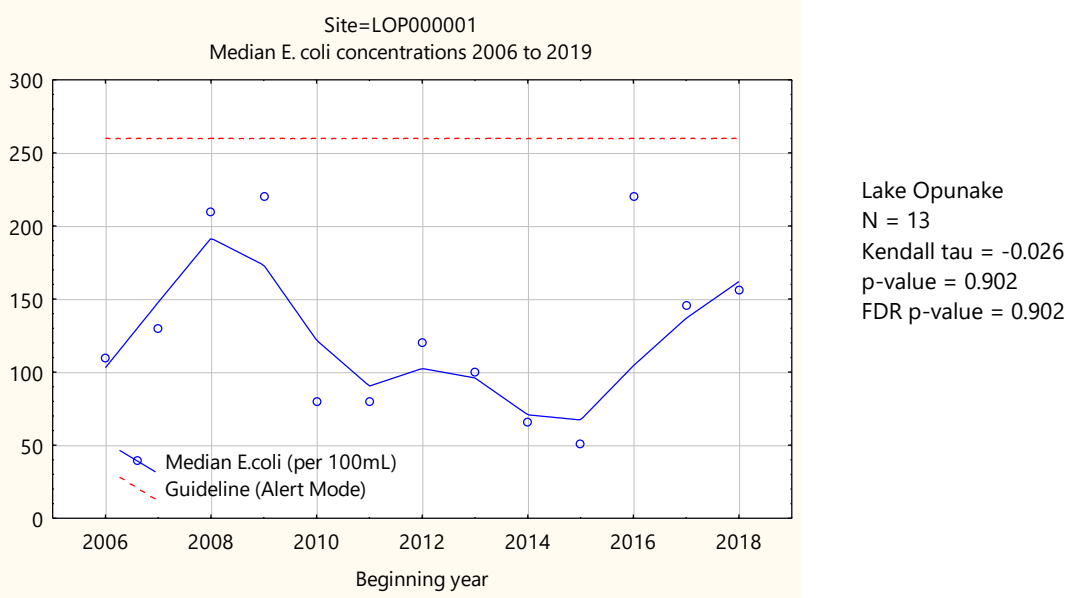


Figure 44 LOWESS trend plot of median *E. coli* data at the Lake Opunake site

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

4.10.4 Cyanobacteria

Planktonic cyanobacteria were monitored on ten 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
07/11/2018	8,520	0.44	*Dolichospermum circinale*	Surveillance
22/11/2018	146	0.03	*Dolichospermum spiroides*	Surveillance
06/12/2018	3,135	0.66	*Dolichospermum spiroides*	Alert
18/12/2018	5,880	1.23	*Dolichospermum spiroides*	Alert
03/01/2019	1,092	0.23	*Dolichospermum spiroides*	Surveillance
17/01/2019	3,267	0.69	*Dolichospermum spiroides*	Alert
30/01/2019	0	0.00	No cyanobacteria present	Surveillance
11/02/2019	0	0.00	No cyanobacteria present	Surveillance
28/02/2019	41	0.00	*Dolichospermum lemmermannii*	Surveillance
20/03/2019	0	0.00	No cyanobacteria present	Surveillance

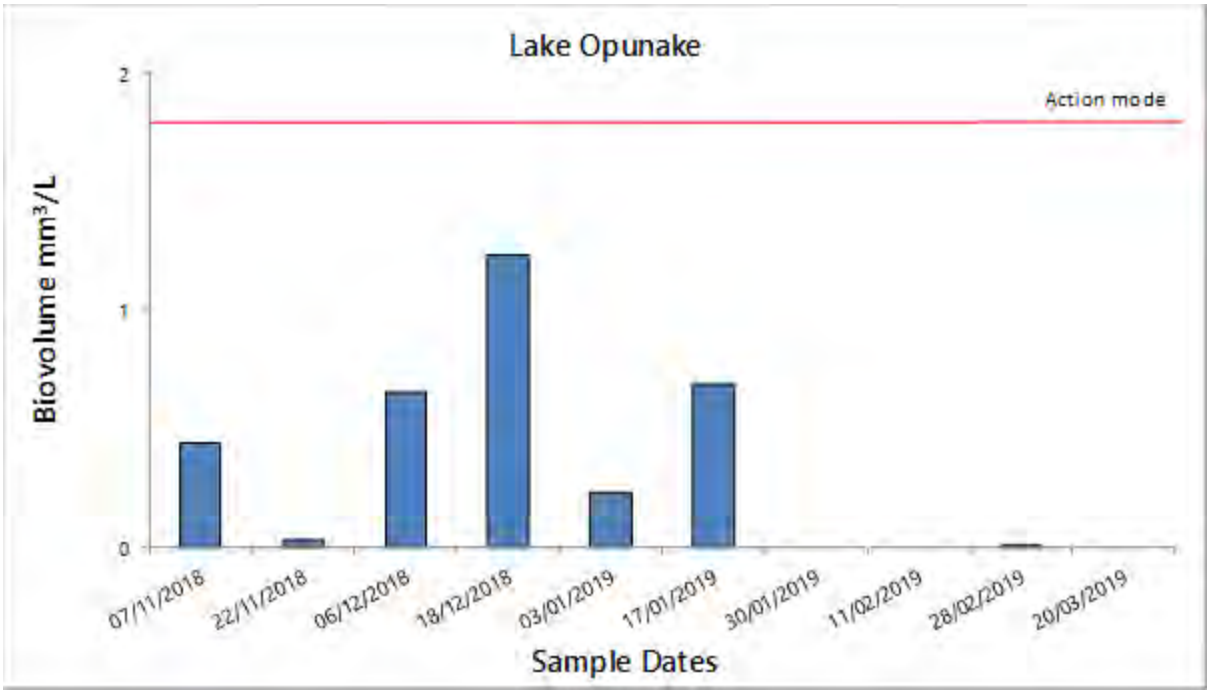


Figure 45 Cyanobacteria counts (cells/ml) at Lake Opunake [Health warning: >1.8 mm^3/L]

Planktonic cyanobacteria levels during the recreational monitoring period had low biovolume (median 0.13 mm^3/L). There was a moderate degree of variability with biovolumes, fluctuating between no cyanobacteria and moderate levels (range 0.00-1.23 mm^3/L).

4.11 Timaru Stream at Weld Road (near mouth)

A total of 16 samples were collected at this site over the summer. All 13 scheduled SEM samples were collected, as well as three follow up samples.

Bathing usage was noted at this site on two sampling occasions and paddle boarding once between November 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 three of the sixteen monitoring occasions with slack water or upstream surging noted on three other occasions. Gulls, sometimes in large numbers, oystercatchers and shags were present on occasions, with dogs and evidence of horses from time to time.

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 four occasions in summer 2018-2019, for 6 days in November 2018, 3 days in late February and 11 days in March 2019. This sign was also used to advise against shellfish gathering (orange alert), in July 2018, in relation to an advisory from MBiE on paralytic shellfish poison.

Photo 8 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* counts (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 2018-2019 season are provided in Figure 47.

All *E. coli* data for this site, from the 2018-2019 summer period, are presented in Figure 46 and summarised in Table 36. The complete survey results are presented in Appendix I.

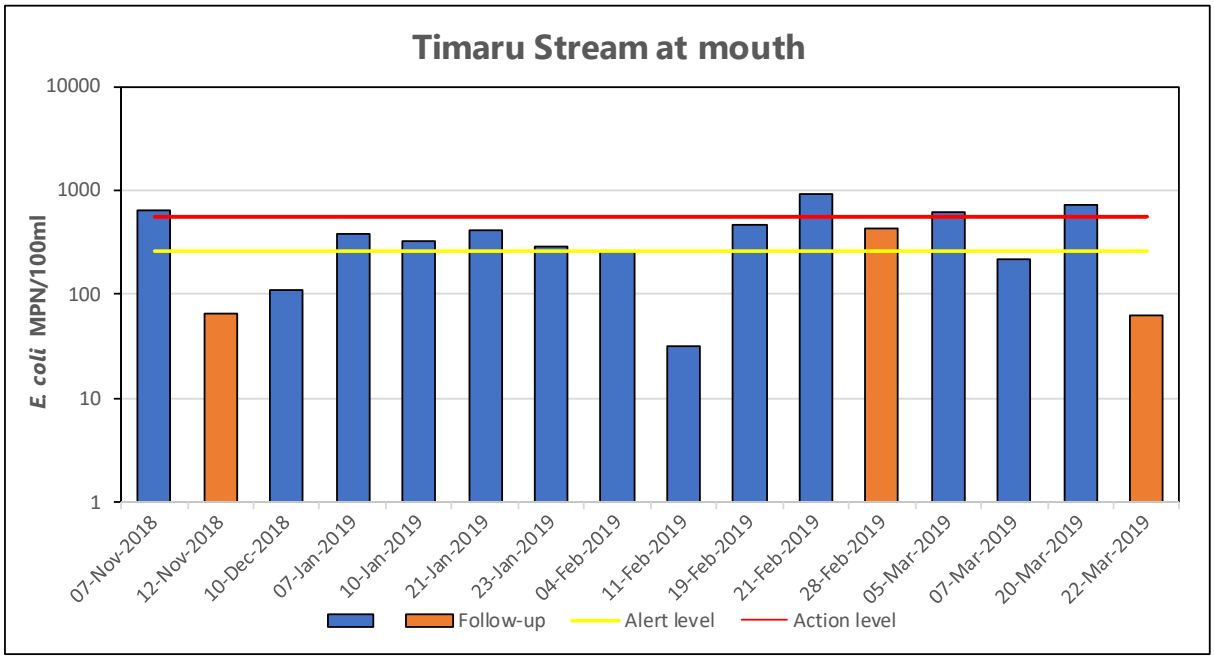


Figure 46 *E.coli* results for Timaru Stream at Weld Road

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	13	115	15,060	294
	E. coli	MPN/100ml	13	31	921	387
	Temperature	°C	13	15.2	23.3	20.6
	Turbidity	NTU	13	0.52	3.9	0.72

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 four 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 8.1°C with a maximum water temperature of 23.3°C recorded in early afternoon in mid-February 2019. This maximum could have been expected to have been exceeded later in the day.

Bacteriological water quality at this site was generally below average and probably poorer than 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 on 7 December 2017 and 30 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 several high *E. coli* counts were coincidental with more ponded conditions (during elevated conductivity events). Ponding appears to have increased in the last three seasons.

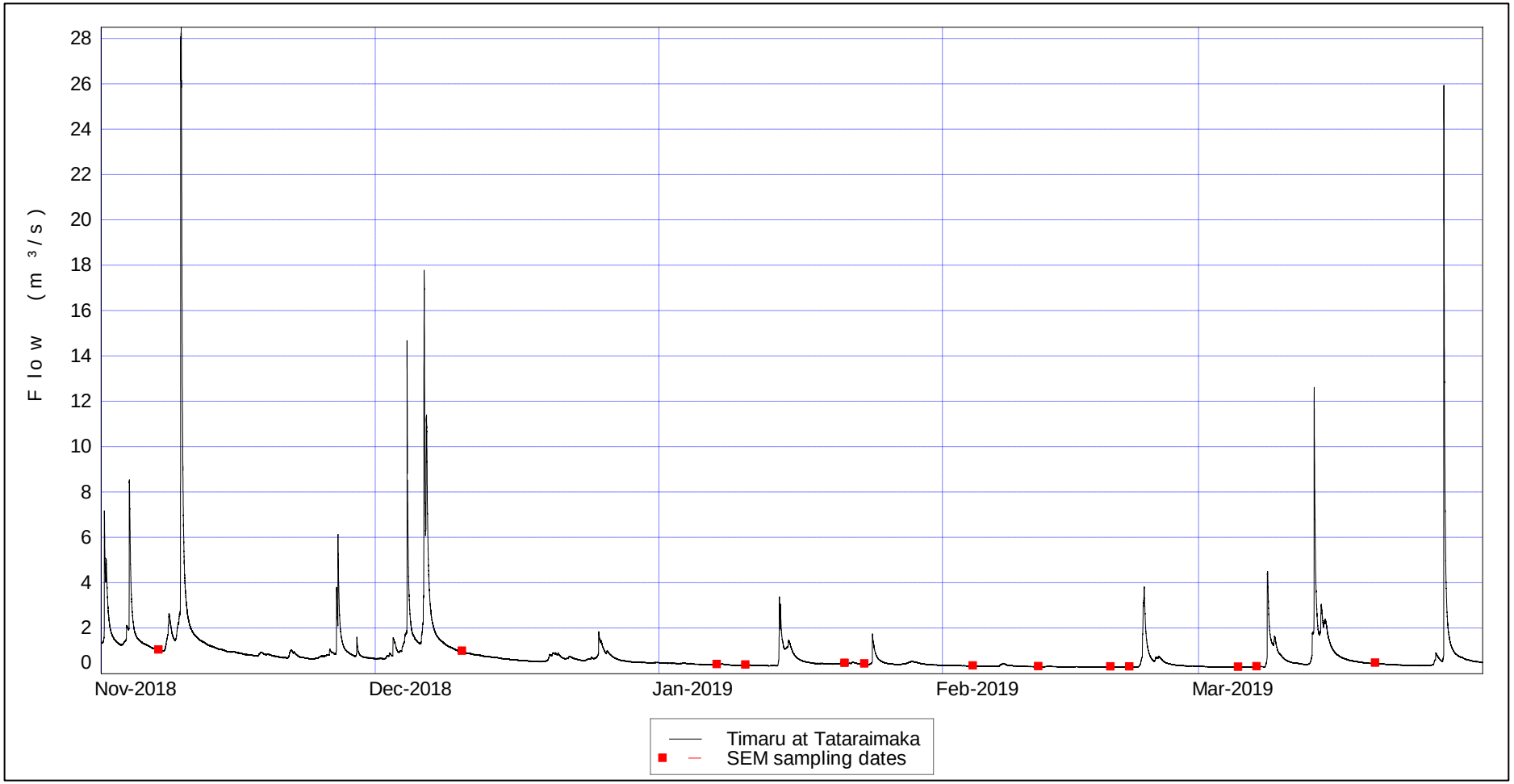


Figure 47 Flow in the Timaru Stream at Tataraimaka during the survey period

4.11.1 Comparison with guidelines

E. coli counts for the Timaru Stream at Weld Road over the 2018-2019 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 261-550/100ml	ACTION Single sample >550/100 ml
SEM samples	5 [38%]	4 [31%]

Five single samples were recorded in the 'Alert' mode, and four samples were recorded in the 'Action' mode during the period. Poorer bacteriological water quality tended to coincide with sampling earlier in the day. On each 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 2 to 7 days (delayed by rainfall twice) indicated in each case 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 relatively poor, 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 22 summers is presented in Figure 48.

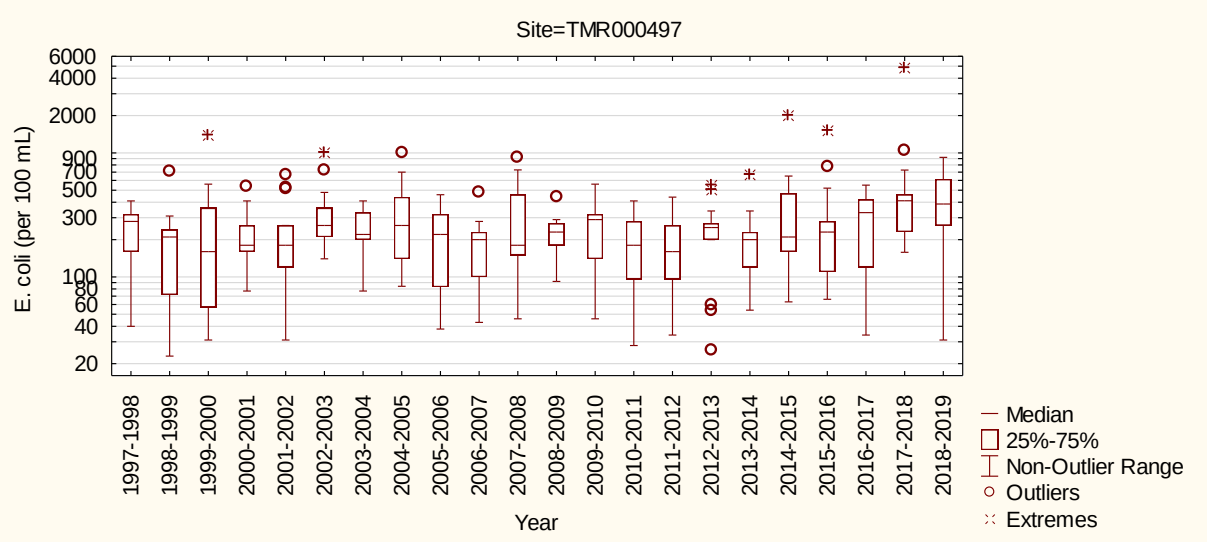


Figure 48 Box and whisker plots of *E.coli* for all summer surveys in the Timaru Stream at lower Weld Road

The median *E. coli* count for the 2018-2019 season was the second highest recorded over twenty-two years of monitoring, following the highest in 2017-2018. Counts over the 2018-2019 season had a relatively wide range (Figure 48), while both the upper and the lower quartile values were the highest recorded.

4.11.3 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the twenty-two 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.

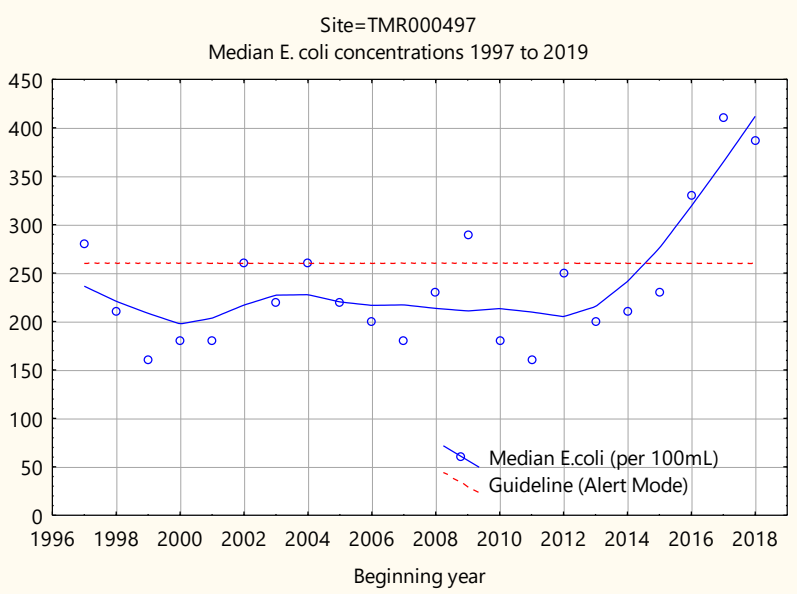


Figure 49 LOWESS trend plot of median *E. coli* data at Timaru Stream, lower Weld Road site

An overall slight, increasing trend in median *E. coli* numbers has been found over the twenty-two 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 most recent 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 counts 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 early in the season 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* counts 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 recent 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 2016-2017 survey being the second at this frequency. Therefore, no monitoring was performed over the 2018-2019 period.

4.13 Oakura River below SH45

A total of 14 samples were collected at this site over the summer. All 13 scheduled SEM samples were collected, as well as one follow up sample.

Bathing usage was recorded on four occasions at this site where people were often present on the riverbank at this very accessible tidal site. Whitebaiting was occurring (in season), and rod fishing has 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 9).

The adjustable cursor was set to "no swimming or food gathering" (orange alert) on one occasion in summer 2018-2019, for about 7 days from late February 2019. This sign was also used to advise against shellfish gathering (orange alert), in July 2018, in relation to an advisory from MBiE on paralytic shellfish poison.

Photo 9 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* counts 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 2018-2019 summer period, are presented in Figure 50 and summarised in Table 38. The complete survey results are presented in Appendix I.

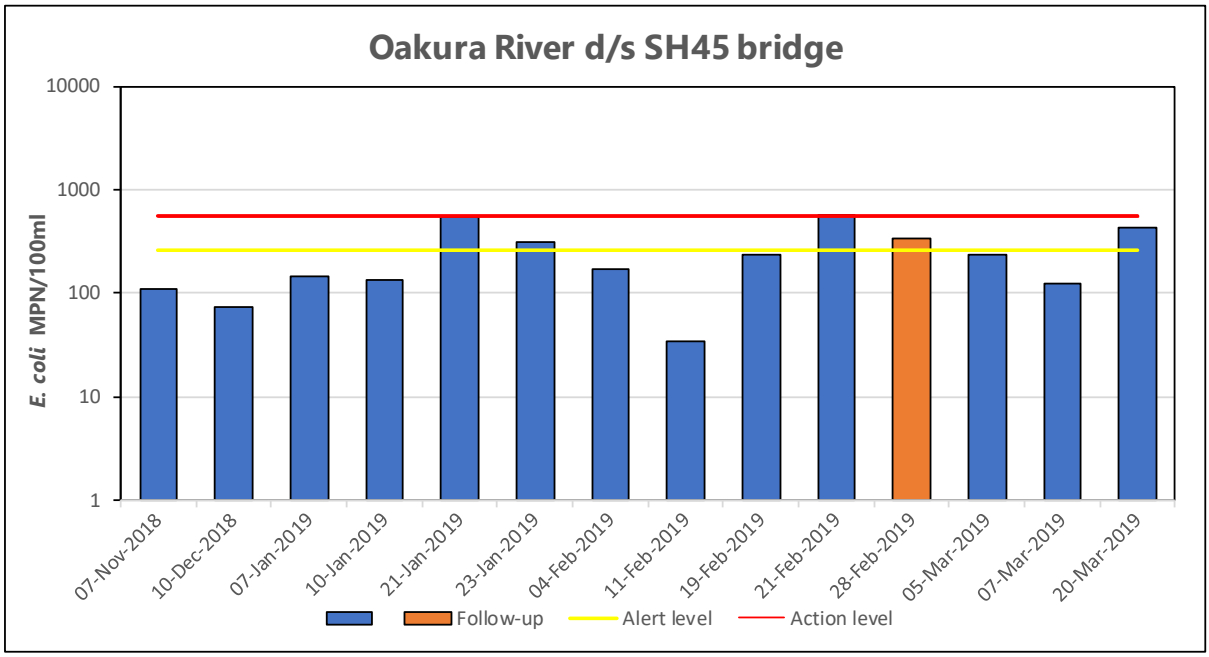


Figure 50 *E. coli* results for Oakura River below SH45

Table 38 Statistical summary for Oakura River below SH45

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	13	93	34,900	297
	E. coli	MPN/100ml	13	34	579	172
	Temperature	°C	13	15.1	22.6	19.7
	Turbidity	NTU	13	0.35	1.78	0.68

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 seven 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, and a layer of sludge accumulated on the bed and banks in March. Water temperatures varied over a moderate range (7.5°C) during the period reaching a maximum of 22.6°C in early afternoon in mid-February 2019, but below the maximum water temperature which might be anticipated later in the day as all sampling at this site occurred no later than 1300 hrs.

Bacteriological water quality was generally moderate, but with a relatively narrow range of *E. coli* numbers that included one value slightly 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 counts for the Oakura River at the mouth over the 2018-2019 summer are summarized against the guidelines for freshwater contact usage in Table 39.

Table 39 Performance against guidelines at Oakura River below SH45

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
SEM samples	3 [23%]	1 [8%]

Three single samples fell within the 'Alert' mode, and one sample entered the 'Action' mode. Health warning signage (Photo 9) was required to be displayed at this site by NPDC for the seven days from when the action level was reported to when follow-up sampling showed return to acceptable level (after a delay brought by wet weather), and appropriate public advice was provided on the District and Regional Council and LAWA websites.

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 for the majority of 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 23 summers is presented in Figure 51.

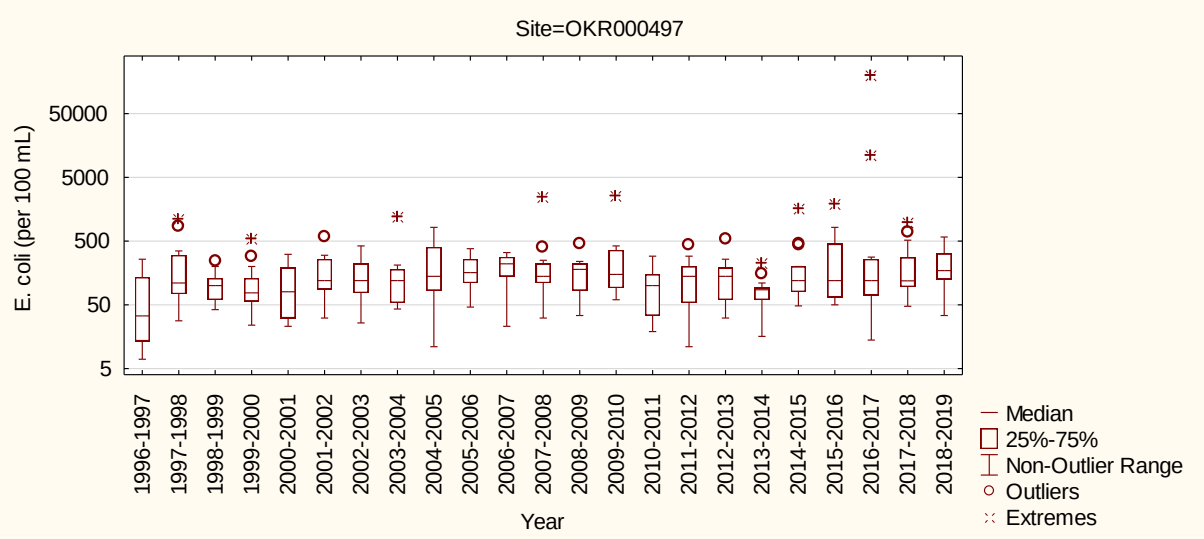


Figure 51 Box and whisker plots of *E. coli* for all summer surveys in the Oakura River below SH45

The median *E. coli* count was the third highest recorded, and the range was in the middle of past seasons' results (Figure 51). No median *E. coli* counts have exceeded the 2003 guidelines for contact recreational usage over the twenty-three seasons of monitoring.

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

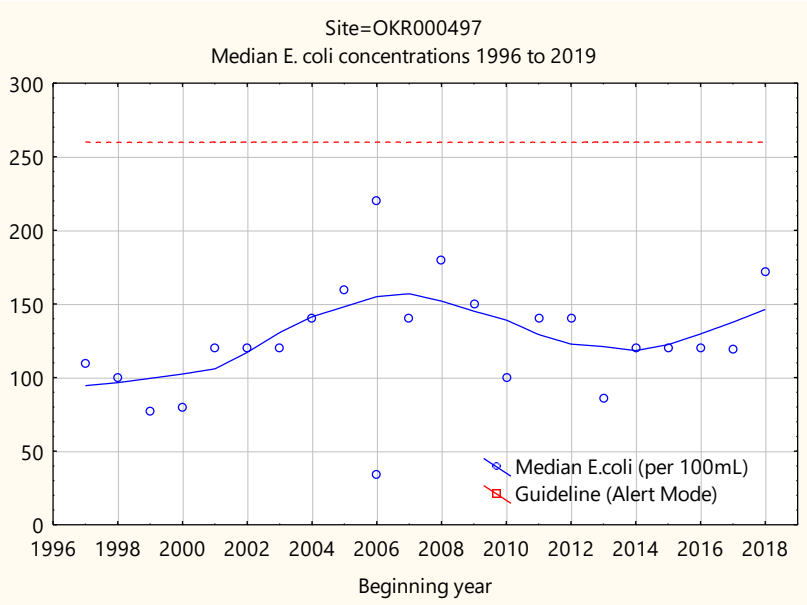


Figure 52 LOWESS trend plot of median *E.coli* data at the Oakura River, SH 45 site

An increasing, but no longer significant, overall trend in median *E. coli* counts has been found over the twenty-three seasons of monitoring. However, none of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.13.4 Cyanobacteria

Benthic cyanobacteria were monitored on eleven occasions during the season in a more appropriate reach, upstream of the SH45 bridge, with results presented in Table 40 and Figure 53.

Table 40 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
05/11/2018	0	No	No	Surveillance
22/11/2018	0	No	No	Surveillance
05/12/2018	0	No	No	Surveillance
18/12/2018	0	No	No	Surveillance
03/01/2019	2	No	No	Surveillance
17/01/2019	0	No	No	Surveillance
30/01/2019	2	No	No	Surveillance
12/02/2019	1	No	No	Surveillance
27/02/2019	1	No	No	Surveillance
12/03/2019	0	No	No	Surveillance

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
27/03/2019	0	No	No	Surveillance

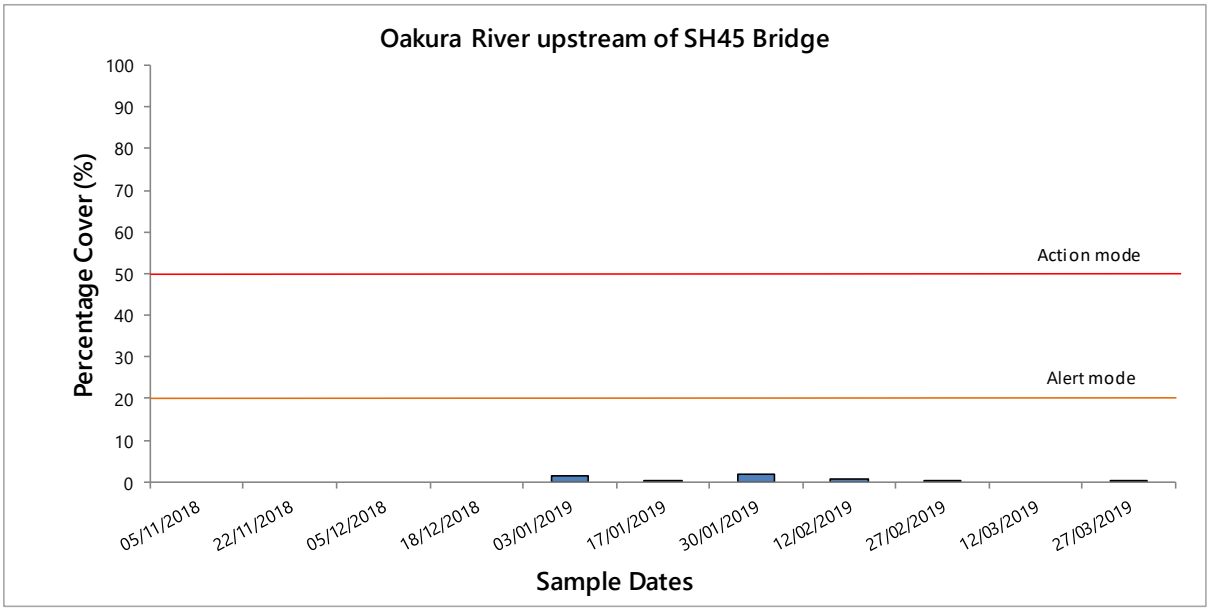


Figure 53 Percentage benthic cyanobacteria cover at the Oakura River upstream of SH45 Bridge.

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 14 samples were collected at this site over the summer. All 13 scheduled SEM samples were collected, and one follow up sample.

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

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 2018-2019 summer period, are presented in Figure 54 and summarised in Table 41. The complete survey results are presented in Appendix I. River flow information is illustrated in Figure 55.

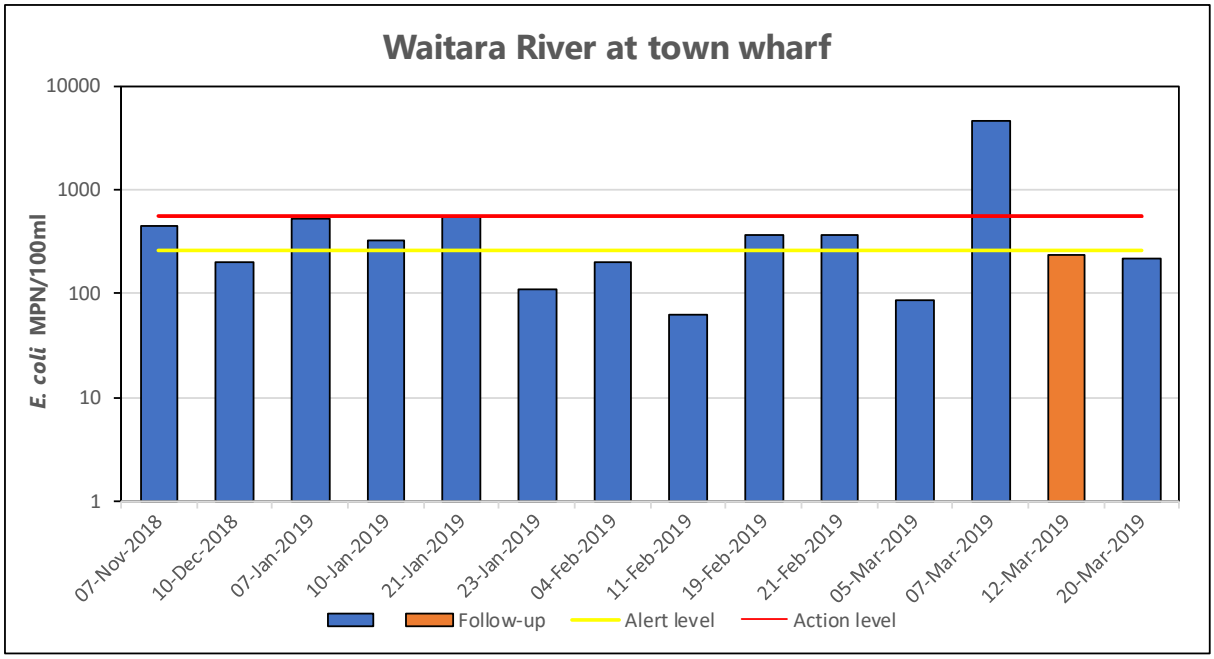


Figure 54 *E.coli* results for Waitara River at the town wharf, Waitara

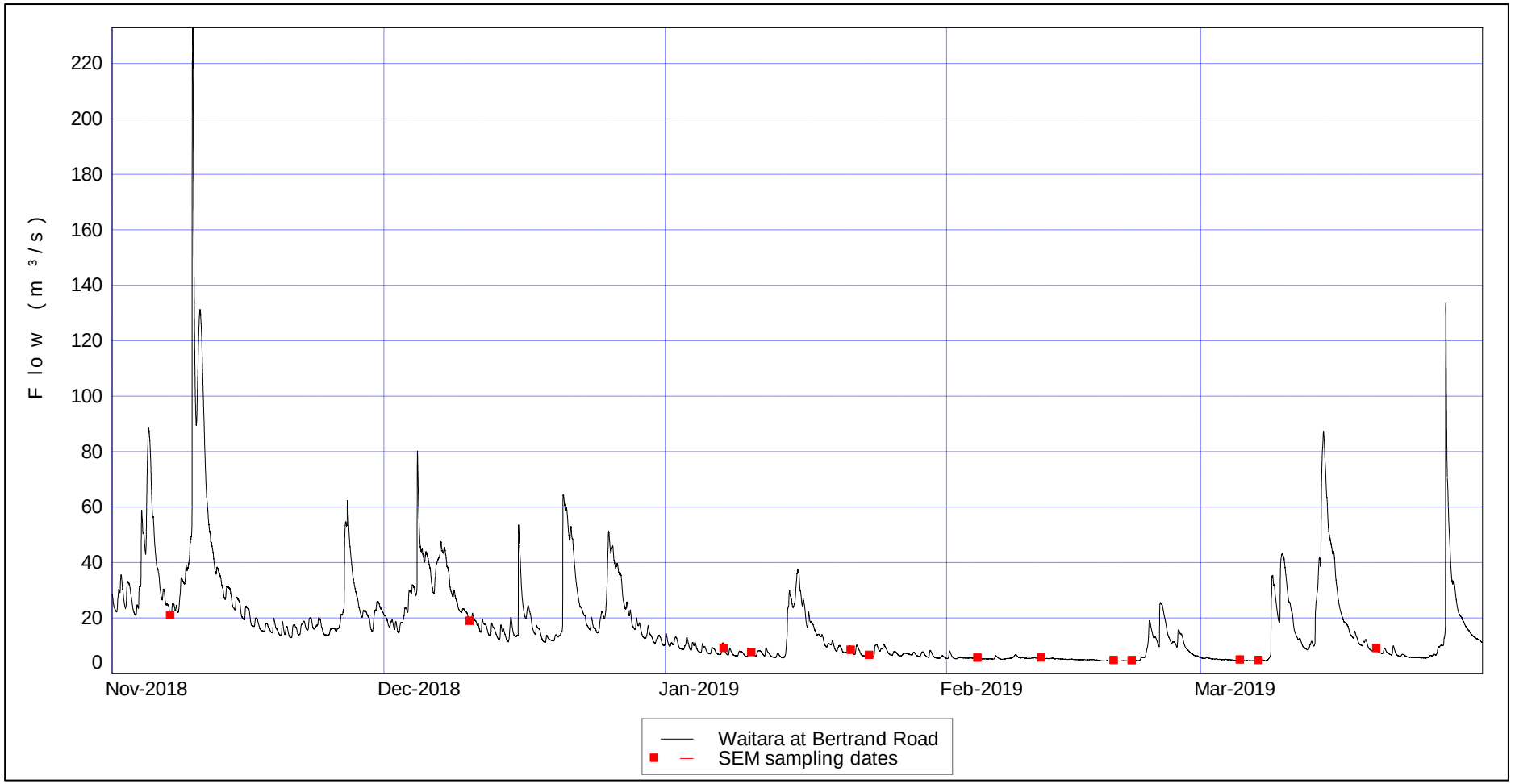


Figure 55 Flow in the Waitara River at Bertrand Road during the survey period

Table 41 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	13	8,480	50,100	28,000
	E. coli	MPN/100ml	13	63	4610	327
	Temperature	°C	13	16.4	25.5	20.6
	Turbidity	NTU	13	1.79	40	3.5

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 9.1˚C partly due to the coastal seawater influence, with a highest recorded maximum of 25.5˚C recorded in late morning in mid-February 2019. All of the samples were collected before 1310 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 327 *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).

4.14.1.1 Comparison with guidelines

E. coli counts for the Waitara River at the town Wharf over the 2018-2019 summer are summarized against the guidelines for freshwater contact usage in Table 42.

Table 42 Performance against guidelines at Waitara River at town wharf

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
SEM samples	5 [38%]	2 [15%]

Five single samples fell within the 'Alert' mode and two samples within the 'Action' mode during the monitoring period. The 'Action' level was just exeeded (by 6 MPN/100 mL) in early January 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. The second 'Action' level,

recorded in early March 2019, was one of the highest *E. coli* values recorded for the site in dry weather, and is unexplained.

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 whart in summer 2016-2017 (Photo 10).

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 10 Sign at entrance to Waitara town wharf

4.14.1.2 Comparison with previous summer surveys

Summary statistics for the SEM *E. coli* data collected at Waitara River Town Wharf site over 10 summers is presented in Figure 56.

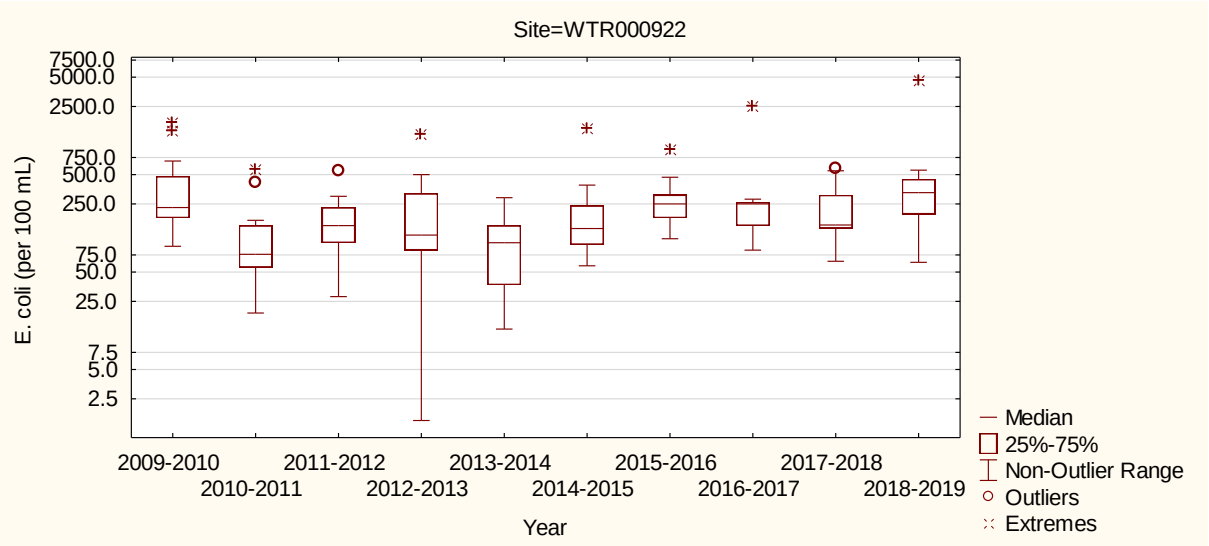


Figure 56 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waitara River at the town wharf, Waitara

The median *E. coli* number found by this tenth season's survey was the highest recorded, and was above the 'Alert' mode for the first time. The range of *E. coli* numbers was the widest recorded, owing to one, unexplained high value.

4.14.2 Long-term trend analysis

Trend analysis of these median *E. coli* numbers has been performed for the ten seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 57) and testing the

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

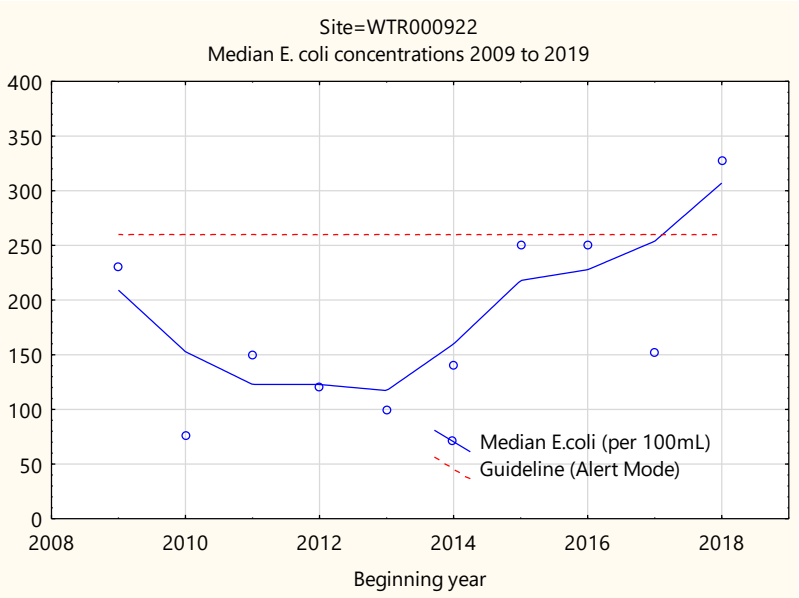


Figure 57 LOWESS trend plot of median *E.coli* data for the Waitara River at the town wharf, Waitara

An increasing, but not statistically significant, overall trend in median *E. coli* counts has been found over the initial ten 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

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

Bathing usage was noted on six occasions and some fishing during the 2018-2019 sampling surveys at this tidal site. This is a very popular site during weekends and holiday periods (see TRC, 1999 and TRC, 2008a), with these and boating, picnicking and other recreational activities taking place.

All enterococci data for this site, from the 2018-2019 summer period, are presented in Figure 58 and summarised in Table 43. The complete survey results are presented in Appendix I.

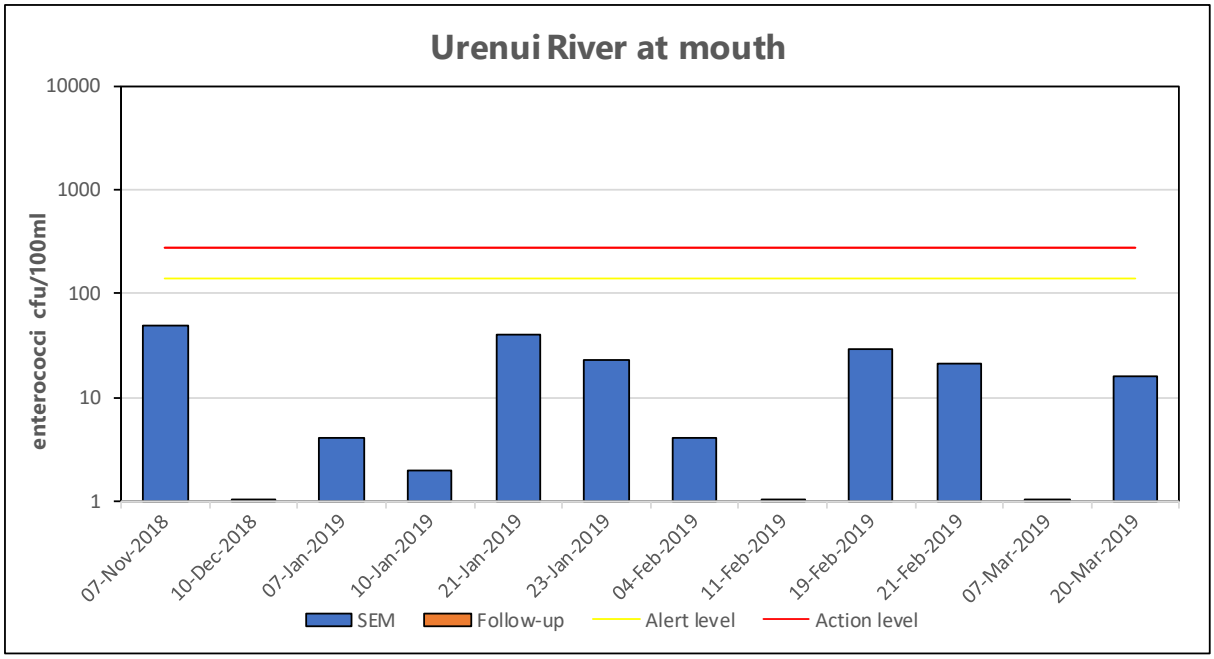


Figure 58 Enterococci numbers for the Urenui River at the estuary during the survey season

Table 43 Statistical summary for Urenui River at the estuary

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	13	52,700	55,100	54,000
	E. coli	MPN/100ml	13	<1	100	10
	Enterococci	cfu/100ml	12	1	49	10
	Temperature	°C	13	17.1	23.3	20.7
	Turbidity	NTU	13	0.68	11.1	5.4

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 (0.7 NTU) and median turbidity (5.4 NTU) levels were indicative of moderately turbid conditions typical of mixing of the more discoloured river flow with inflowing, cleaner 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 20.7°C), more typical of coastal seawater temperatures, varied over a moderate range of 6.2°C during the sampling period with a maximum of 23.3°C recorded in early afternoon in mid-February 2019. All sampling however, was undertaken prior to 1305 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 all three 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 44 using the marine guidelines, which are considered to be more appropriate for this estuarine site.

Table 44 Performance against guidelines at Urenui River mouth

Parameter	Number of exceedances of enterococci guidelines	
	ALERT Single sample 141-280/100ml	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 100ml) monitored over eight seasons 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 23 summers is presented in Figure 59.

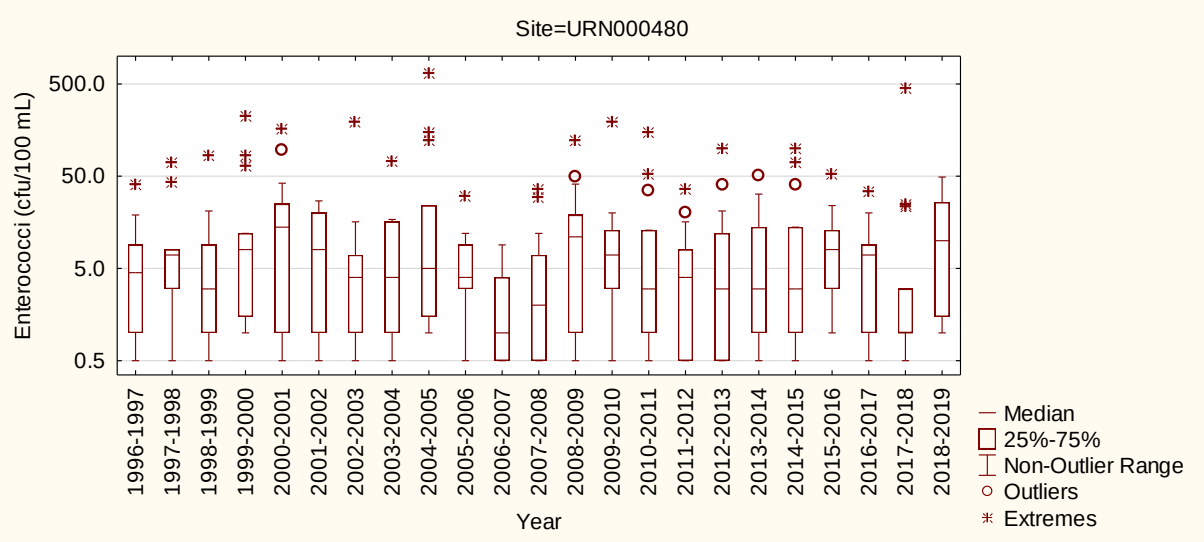


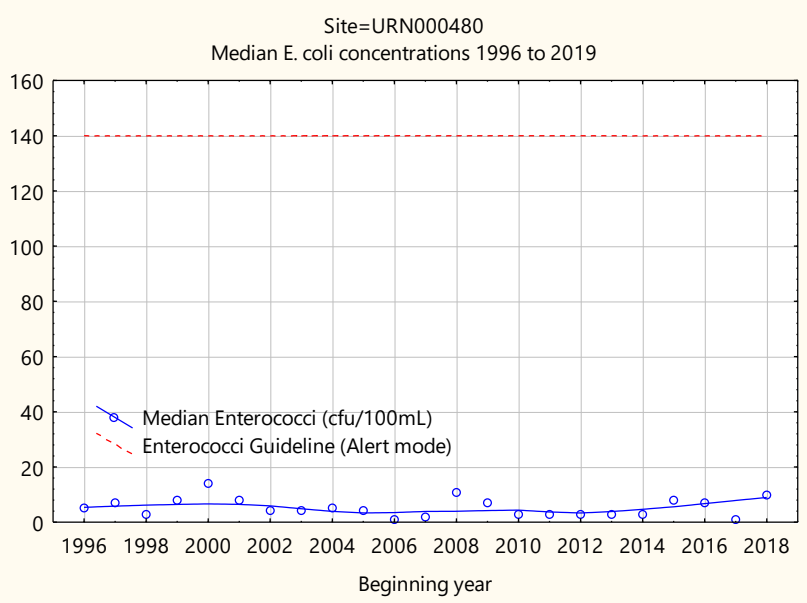
Figure 59 Box and whisker plots of enterococci for all summer surveys in the Urenui River at the estuary

The high bacteriological water quality of the Urenui River estuary, during high tide conditions, continued during the 2018-2019 season (Figure 59). This has been emphasised by all seasonal median enterococci counts being less than 15 enterococci (per 100 ml). The range was relatively narrow for enterococci during the 2018-2019 season as a result of no single sample count in excess of 49 enterococci per 100 ml.

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.

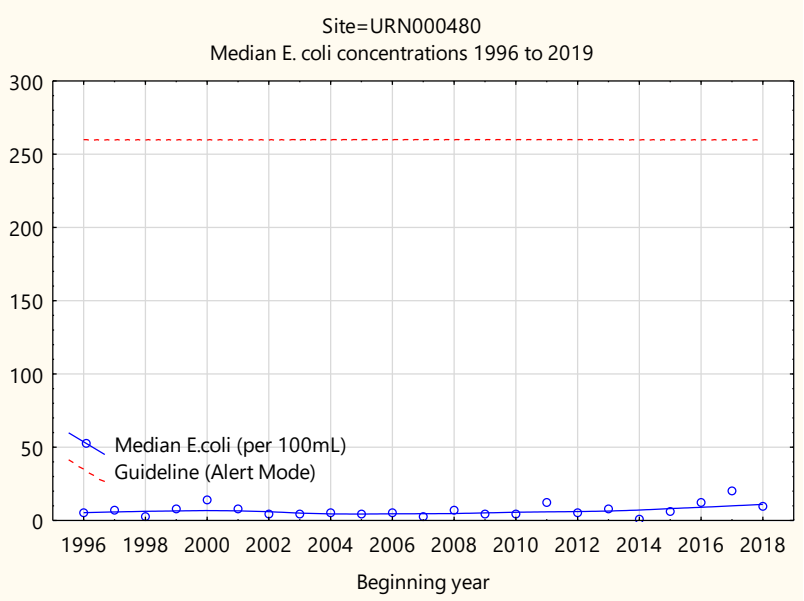
4.15.3 Long-term trend analysis

Trend analysis of median enterococci and *E. coli* numbers has been performed for the twenty-three seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 60 and Figure 61) 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 = 23
Kendall tau = - 0.154
p-value = 0.302
FDR p-value = 0.549

Figure 60 LOWESS trend plot of median enterococci data at the Urenui River, estuary site



Urenui River mouth – *E. coli*
N = 23
Kendall tau = 0.170
p-value = 0.257
FDR p-value = 0.549

Figure 61 LOWESS trend plot of median *E. coli* data at the Urenui River, estuary site

No statistically significant trends in median enterococci or *E. coli* counts (after FDR applications) have been found over the twenty-three 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 13 samples were collected at this site over the summer. All 13 scheduled SEM samples were collected, and no follow up samples were required.

Bathing or other usage of this river site was noted twice 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 2018-2019 summer period, are presented in Figure 62 and summarised in Table 45. The complete survey results are presented in Appendix I. River flow records are illustrated in Figure 63.

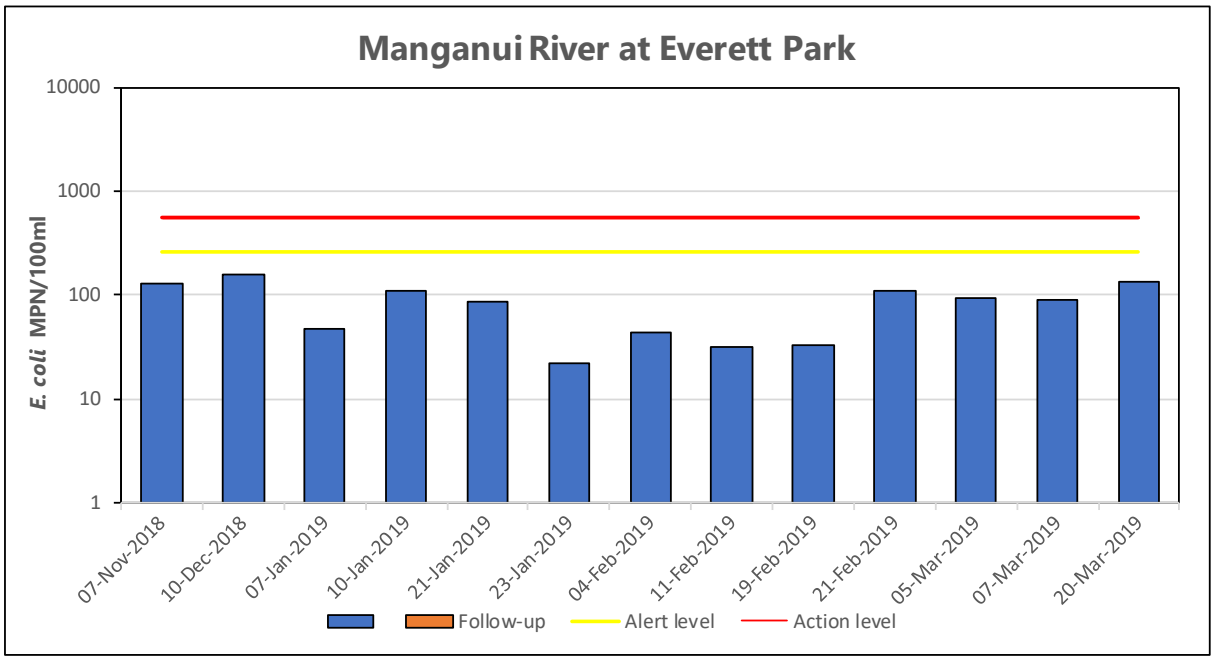


Figure 62 *E. coli* numbers for the Manganui River at Everett Park (downstream of the Kurapete Stream) during the survey season

Table 45 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	13	112	120	116
	E. coli	MPN/100ml	13	22	160	88
	Temperature	°C	13	15.9	22.5	19.1
	Turbidity	NTU	13	0.73	4.4	1.15

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 6.6°C with the maximum temperature (22.5°C) recorded in mid-afternoon in mid-January 2019. Higher

temperatures could be expected later in the day as no sampling surveys were performed after 1355 hrs at this site.

Bacteriological water quality was good for this site during the 2018-2019 survey period with none of the counts recorded during the period above 160 *E. coli* per 100 ml (Figure 62).

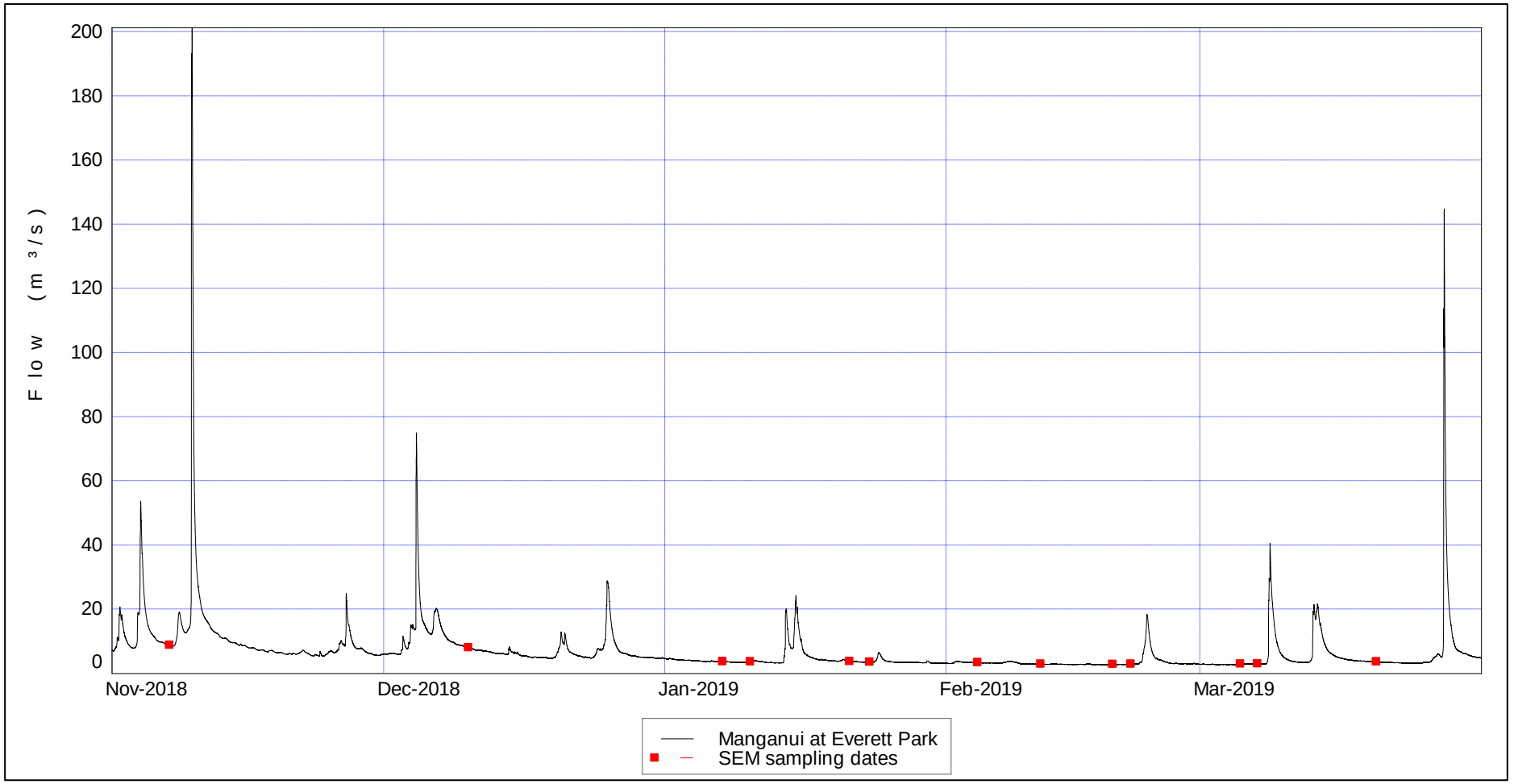


Figure 63 Flow in the Manganui River at Everett Park during the survey period

4.16.1 Comparison with guidelines

E. coli counts for the Manganui River at Everett Park over the 2018-2019 summer are summarized against the guidelines for freshwater contact usage in Table 46.

Table 46 Performance against guidelines at Manganui River at Everett Park

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	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 23 summers is presented in Figure 64.

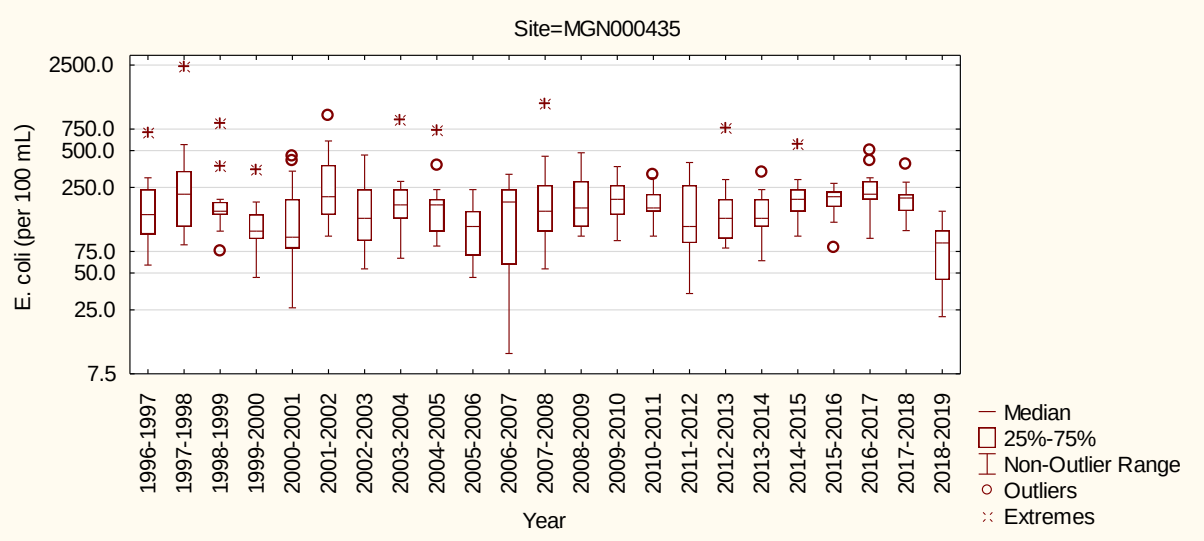


Figure 64 Box and whisker plots of *E. coli* for all summer surveys in the Manganui River at Everett Park

The median *E. coli* count for the 2018-2019 season was the lowest of the twenty-three seasons' medians recorded since the inception of the programme in 1996-97 (Figure 64). 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 count of 160 per 100 ml, the 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-three seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 65) 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.

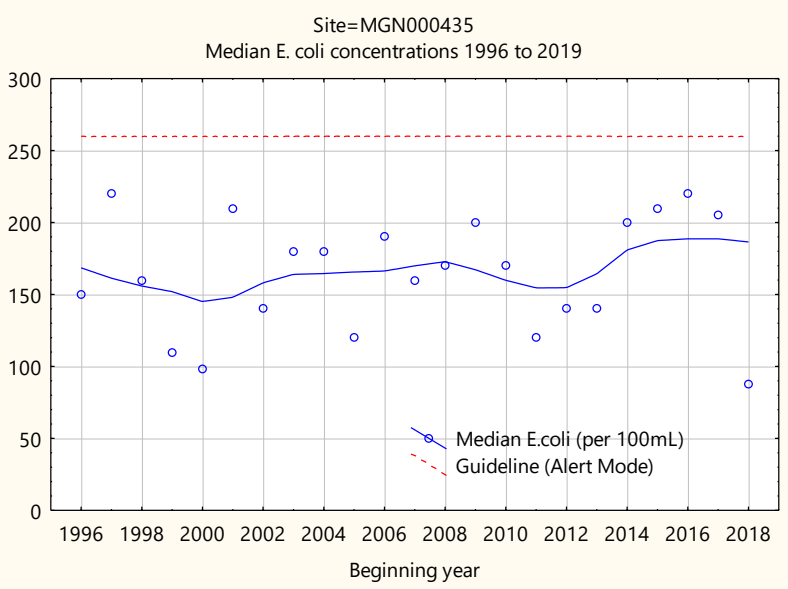


Figure 65 LOWESS trend plot of median *E.coli* data at the Manganui River, Everett Road site

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

4.16.4 Cyanobacteria

Benthic cyanobacteria were monitored on 11 occasions through the season with results presented in Table 47 and Figure 66.

Table 47 Percentage benthic cyanobacteria cover, detached and exposed mats at the Manganui River at Everett Park

Date	Average cyanobacteria % cover	Detaching mats	Exposed mats	Mode
05/11/2018	0	No	No	Surveillance
22/11/2018	1	No	No	Surveillance
05/12/2018	0	No	No	Surveillance
18/12/2018	11	No	No	Surveillance
03/01/2019	18	No	No	Surveillance
17/01/2019	1	No	No	Surveillance
30/01/2019	5	No	No	Surveillance
12/02/2019	8	No	No	Surveillance
27/02/2019	2	No	No	Surveillance
12/03/2019	2	No	No	Surveillance
27/03/2019	1	No	No	Surveillance

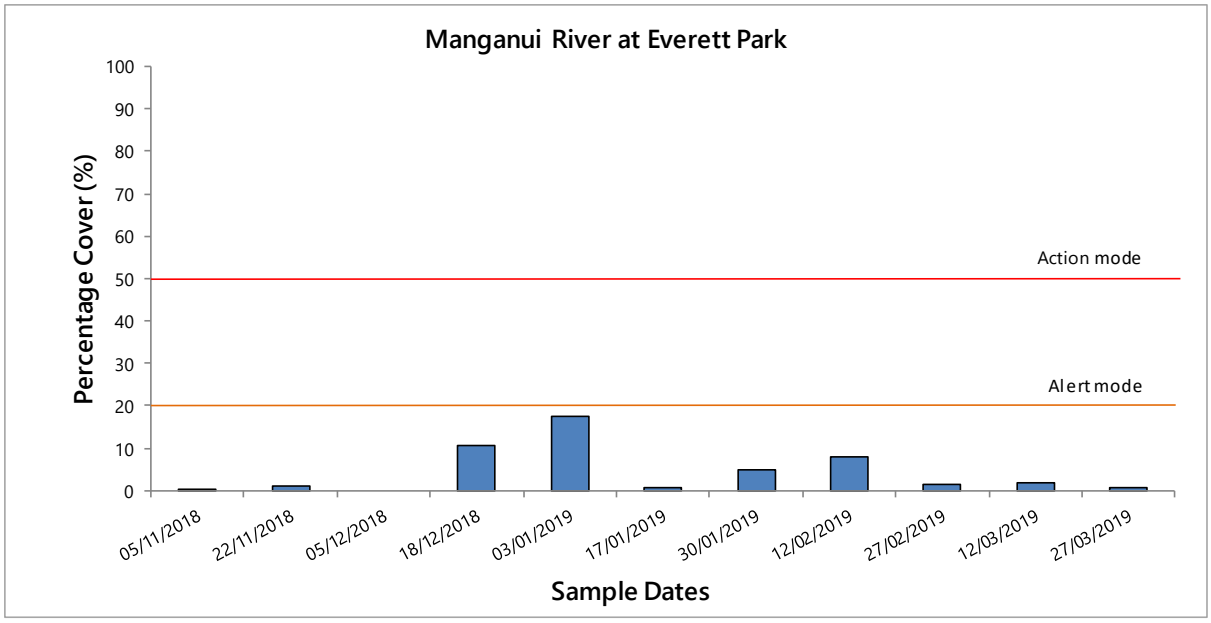


Figure 66 Percentage benthic cyanobacteria cover at the Manganui River at Everett Park. '

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 with a median of 2% (range from 0 to 18%). The 'Action' and 'Alert' levels were never exceeded for percentage cover or for detaching and exposed mats. The benthic cyanobacteria found were *Microcoleus* sp.

4.17 Lake Ratapiko

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

Bathing usage of the lake was not observed. Jet-skiing was recorded on one occasion. However, the lake is commonly used for boating and fishing purposes, particularly at weekends and holidays. Ducks were present occasionally in low or common numbers. Minimal stock access to the lake margins was recorded, unlike on some past occasions (TRC, 2013). The lake was drawn down for maintenance purposes at the end of this season, after sampling for recreational water quality finished.

All *E. coli* data for this site, from the 2018-2019 summer period, are presented in Figure 67 and summarised in Table 48.

The complete survey results are presented in Appendix I.

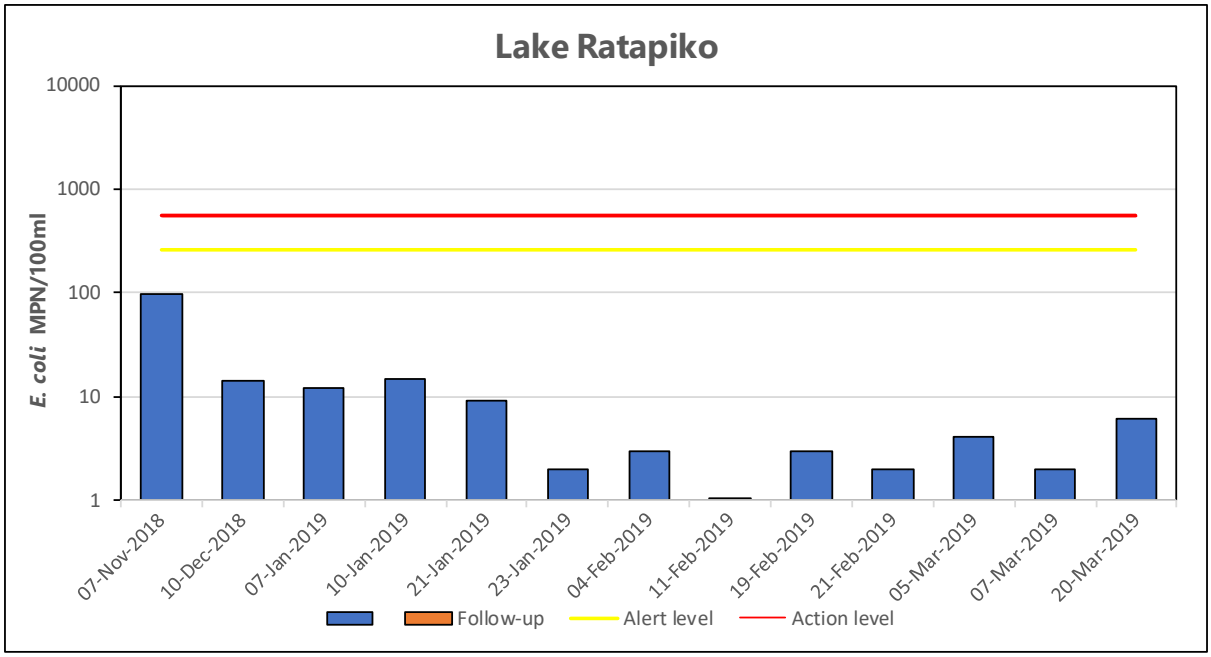


Figure 67 *E. coli* results for Lake Ratapiko

Table 48 Statistical summary for Lake Ratapiko

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM samples	Conductivity	µS/cm@25°C	13	91	102	96
	E. coli	MPN/100ml	13	<1	99	4
	Temperature	°C	13	16.3	26.3	22.3
	Turbidity	NTU	13	0.78	2.0	1.4

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: 1.4 NTU; range of turbidity: 1.2 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 moderately wide range of 10.0˚C for the period with a maximum of 26.3˚C (early afternoon in early February 2019) although all of the measurements were recorded prior to 1420 hrs. Conductivity showed very low variation (up to 11 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 counts for Lake Ratapiko over the 2018-2019 summer are summarized against the guidelines for freshwater contact usage in Table 49.

Table 49 Performance against guidelines at Lake Ratapiko

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	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 13 summers is presented in Figure 68.

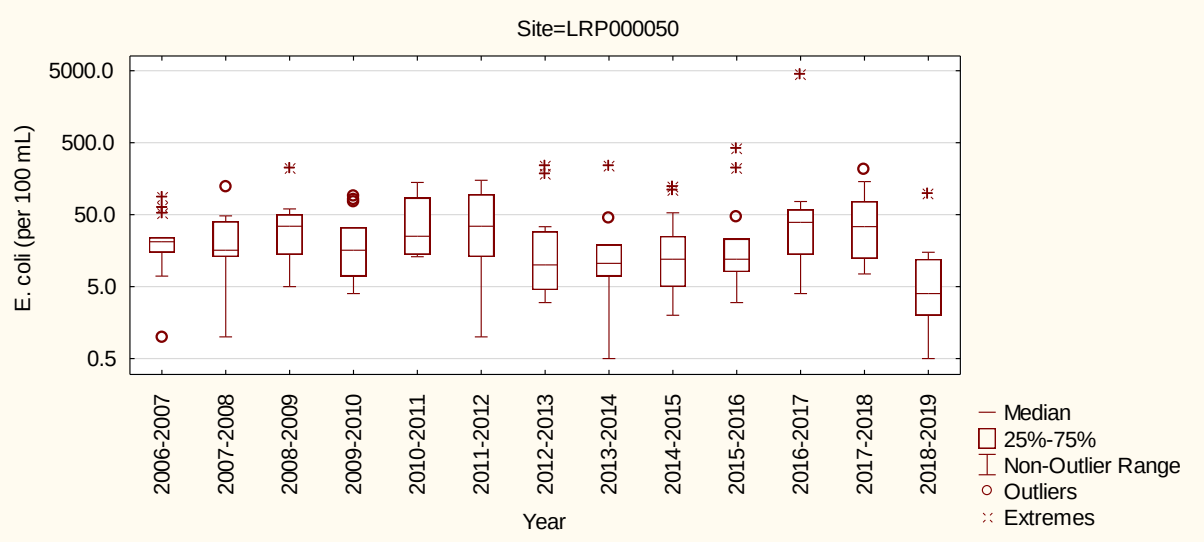


Figure 68 Box and whisker plots of *E.coli* for all summer SEM surveys at Lake Ratapiko

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

4.17.3 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 69) 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.

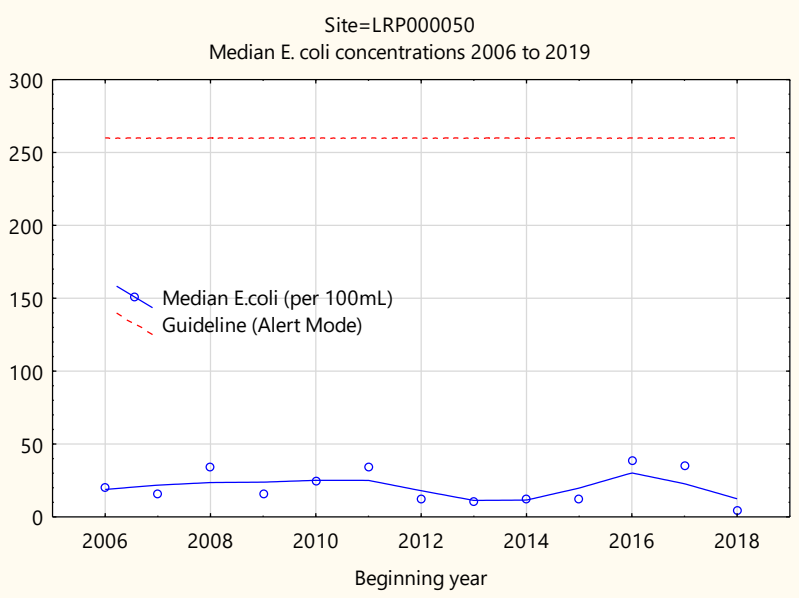


Figure 69 LOWESS trend plot of median *E. coli* data at the Lake Ratapiko site

No statistically significant trends in median *E.coli* counts have been found over the thirteen 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 ten occasions throughout the season. The results of these analyses are presented in Table 50 and Figure 70.

Table 50 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
07/11/2018	0	0.00	No cyanobacteria present	Surveillance
22/11/2018	0	0.00	No cyanobacteria present	Surveillance
06/12/2018	0	0.00	No cyanobacteria present	Surveillance
18/12/2018	0	0.00	No cyanobacteria present	Surveillance
03/01/2018	0	0.00	No cyanobacteria present	Surveillance
17/01/2018	288	0.06	*Dolichospermum spiroides*	Surveillance
30/01/2018	236	0.02	*Dolichospermum lemmermannii*	Surveillance
11/02/2019	22,400,00	0.92	Picocyanobacteria	Alert
28/02/2019	976	0.09	*Dolichospermum lemmermannii*	Surveillance
20/03/2019	0	0.00	No cyanobacteria present	Surveillance

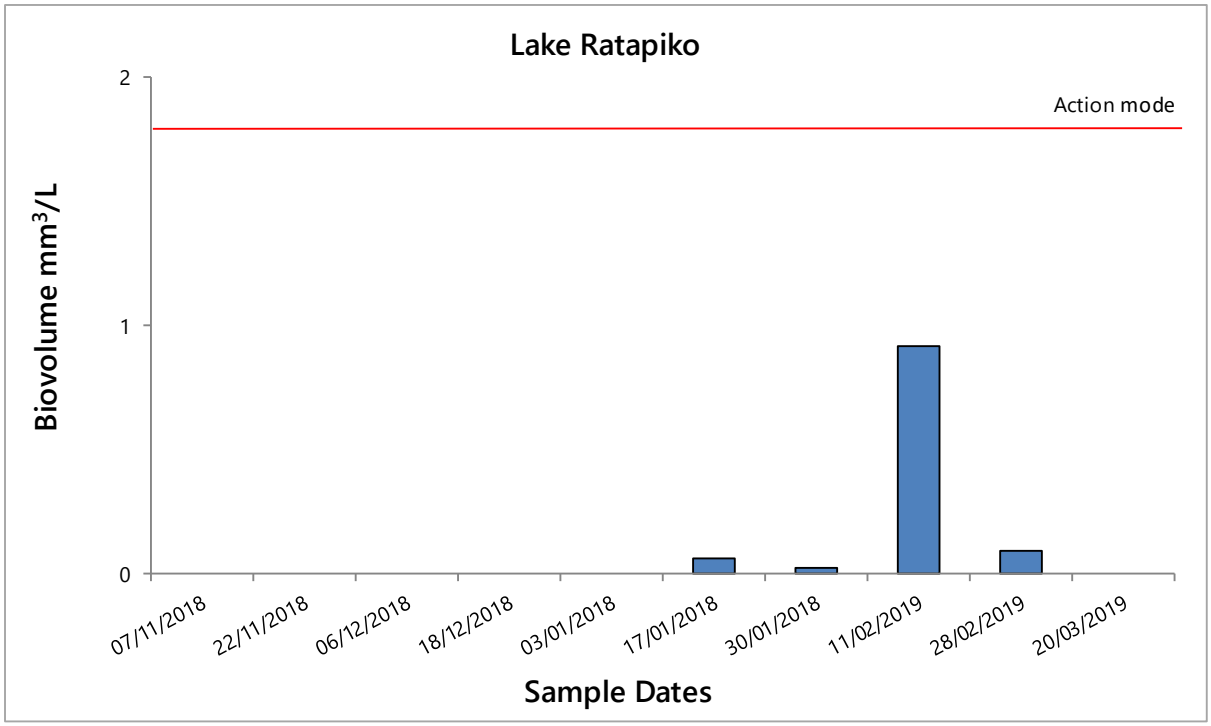


Figure 70 Cyanobacteria biovolume at Lake Ratapiko

Planktonic cyanobacteria had low biovolume levels throughout the recreational monitoring year (median biovolume 0.00 mm^3/L). There was a moderate degree of variability, with biovolumes fluctuating between no cyanobacteria and moderate levels (range 0.00-0.92 mm^3/L).

Previously, no cyanobacteria had been found in this lake during any of the monitoring periods from 2006 to 2013 with the exception of low numbers of *Anabaena* present in the latter part of the 2007-2008 season following a lengthy, extremely low flow period. Also, moderate numbers of *Anabaena* were found during late January 2014 during a dry period, but these numbers reduced rapidly by late February 2014 and none were found by the survey of mid-March 2014. A similar event, with a near 'high risk' bloom of *Picocyanobacteria* occurred briefly in February 2016. The relatively short lake water residence time (due to hydroelectric power generation usage) may be a factor in the control of these bacteria populations.

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 2018-2019 season, with the lake sampled on seven occasions between early November 2018 and mid-March 2019. [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 2018-2019 surveys, all of which occurred on week days between mid-morning and mid-afternoon. The boat ramp was locked from early December until mid-February. Birdlife, a few ducks and pukeko were observed at the lake margin on the majority of monitoring occasions. The lake appeared turbid, green or green-brownish throughout most of the period with a clearer appearance at the beginning and end of the period.

The bacteriological water quality data for this site are presented in Table 51 with a statistical summary provided in Appendix I.

Table 51 Statistical summary for Lake Rotokare

Parameter		Units	Number of samples	Minimum	Maximum	Median
SEM+MfE samples	Conductivity	µS/cm@25°C	7	136	144	140
	E. coli	MPN/100ml	7	14	62	41
	Temperature	°C	7	17.6	24.3	22.1
	Turbidity	NTU	7	0.85	18.8	8.4

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: 8 µS/cm) through the period despite variations in inflow during the season. Water temperatures varied over a moderate range of 6.7˚C with a maximum of 24.3˚C recorded in late January 2019. Turbidity was relatively high (median: 8.4 NTU) with the range (18 NTU) reflecting the variability in abundances of suspended algae in the water column during the season. Highest turbidities (≥ 8 NTU) were coincidental with peaks in cyanobacteria concentrations in December 2018 and January 2019.

No bacterial counts 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 counts. 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 52 and Figure 71.

Table 52 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
06/11/2018	154	0.03	*Dolichospermum circinale*	Surveillance
22/11/2018	0	0.00	No cyanobacteria present	Surveillance
06/12/2018	53333	11.20	*Dolichospermum circinale*	Action
17/12/2018	98000	20.58	*Dolichospermum circinale*	Action
03/01/2019	95455	20.05	*Dolichospermum circinale*	Action
30/01/2018	193556	40.65	*Dolichospermum circinale*	Action
11/02/2019	7100	1.49	*Dolichospermum circinale*	Alert
28/02/2019	1368	0.29	*Dolichospermum circinale*	Surveillance
20/03/2019	0	0	No cyanobacteria present	Surveillance

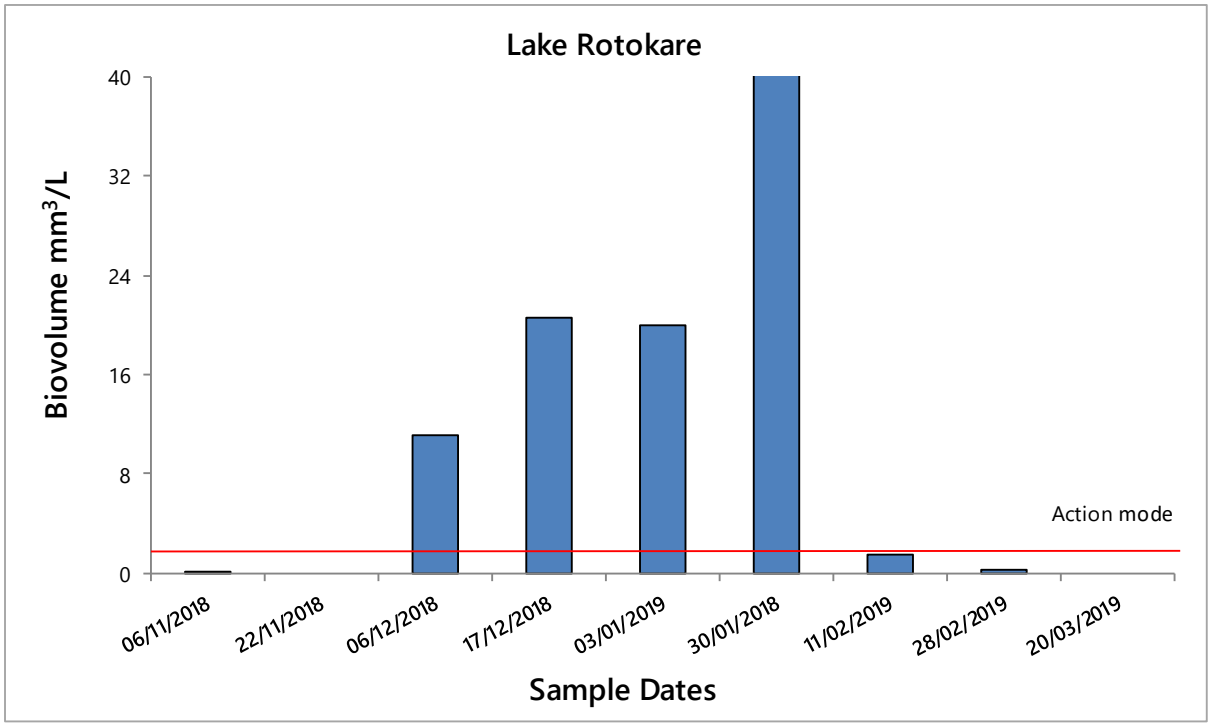


Figure 71 Cyanobacteria counts (cells/ml) at Lake Rotokare [Health warning: >1.8 mm^3/L]

There were high levels of planktonic cyanobacteria biovolumes recorded in early and mid-summer (median biovolume 20.3 mm^3/L) and generally levels were moderately high (median biovolume 1.49 mm^3/L). Cyanobacteria biovolume levels then decreased to low levels from late summer onwards.

The installation of a blue-green algal hazard warning sign by the STDC upon advice from the Taranaki Area Health Board occurred once levels exceeded the health guideline (>1.8mm^3/L) from early December to February. The District Health Board did not require algal toxin testing during the period.

5 Discussion

5.1 General data summary

A comparative summary of results of the twenty-third summer bacteriological quality freshwater survey involving sixteen contact recreational sites in the Taranaki region is provided in Appendix VI and Table 53. Results for *E.* coli are illustrated in Figure 72, and a comparison of all sites' summer data is presented in Appendix VI in the form of a statistical 'box and whisker' plot.

Table 53 Statistical summary of results for the sites sampled in the SEM freshwater contact recreational water quality survey, 2018-2019

Site		Temperature (°C)	Conductivity @ 25°C (µS/cm)	E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Turbidity (NTU)
Lake Rotomanu	Median	24.5	141	31		7.9
	Minimum	19.4	121	10		4.7
	Maximum	26.0	151	727		22
	No. of samples	13	13	13		13
Waiwhakaiho River at Merrilands Domain	Median	20.7	171	45		1.0
	Minimum	16.2	121	13		0.4
	Maximum	23.7	180	2420		2.2
	No. of samples	13	13	13		13
Waiwhakaiho River adjacent to L. Rotomanu	Median	22.4	188	683		1.0
	Minimum	16.2	118	278		0.6
	Maximum	26.4	5170	5170		2.9
	No. of samples	13	13	13		13
Te Henui Stream at mouth, East End	Median	19.8	17590	1607		1.6
	Minimum	15.2	205	443		0.6
	Maximum	23.8	43200	6870		8.2
	No. of samples	13	13	13		13
Patea River at King Edward Park, Stratford	Median	16.7	114	411		1.2
	Minimum	14.0	102	133		0.9
	Maximum	19.5	122	866		2.0
	No. of samples	13	13	13		13
Patea River at boatramp, Patea	Median	20.5	53900	7	5	17
	Minimum	15.9	53600	<1	<1	2.3
	Maximum	21.6	54600	11	11	33
	No. of samples	13	13	13	13	13
Waingongoro River at Eltham camp	Median	19.1	137	156		1.5
	Minimum	16.8	123	96		1.1
	Maximum	22.2	153	411		1.8
	No. of samples	13	13	13		13
Waingongoro River at Ohawe Beach	Median	21.0	219	228		1.8
	Minimum	17.9	191	41		1.0
	Maximum	23.4	1203	1203		4.6
	No. of samples	13	13	13		13
Kaupokonui River at beach domain	Median	21.3	194	172		1.6
	Minimum	18.3	166	37		0.9
	Maximum	23.8	5230	1203		16
	No. of samples	13	13	13		13
Lake Opunake adjacent to boat ramp	Median	23.4	171	156		2.8
	Minimum	19.5	142	6		1.8
	Maximum	26.3	192	1553		3.9
	No. of samples	13	13	13		13
Timaru Stream at Weld Road (near mouth)	Median	20.6	294	387		0.7
	Minimum	15.2	115	31		0.5
	Maximum	23.3	15060	921		3.9
	No. of samples	13	13	13		13

Site		Temperature (°C)	Conductivity @ 25°C (µS/cm)	E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Turbidity (NTU)
Oakura River d/s of SH45 bridge	Median	19.7	297	172		0.7
	Minimum	15.1	93	34		0.4
	Maximum	22.6	34900	579		1.8
	No. of samples	13	13	13		13
Waitara River at town wharf, Waitara	Median	20.6	28000	327		3.5
	Minimum	16.4	8480	63		1.8
	Maximum	25.5	50100	4610		40
	No. of samples	13	13	13		13
Urenui River at estuary	Median	20.7	54000	10	10	5.4
	Minimum	17.1	52700	<1	1	0.7
	Maximum	23.3	55100	100	49	11
	No. of samples	13	13	13	13	13
Manganui River d.s of Kurapete S. (Everett Park)	Median	19.2	116	88		1.2
	Minimum	15.9	112	22		0.7
	Maximum	22.5	120	160		4.4
	No. of samples	13	13	13		13
Lake Ratapiko at boat ramp	Median	22.3	96	4		1.4
	Minimum	16.3	91	<1		0.8
	Maximum	26.3	102	99		2.0
	No. of samples	13	13	13		13

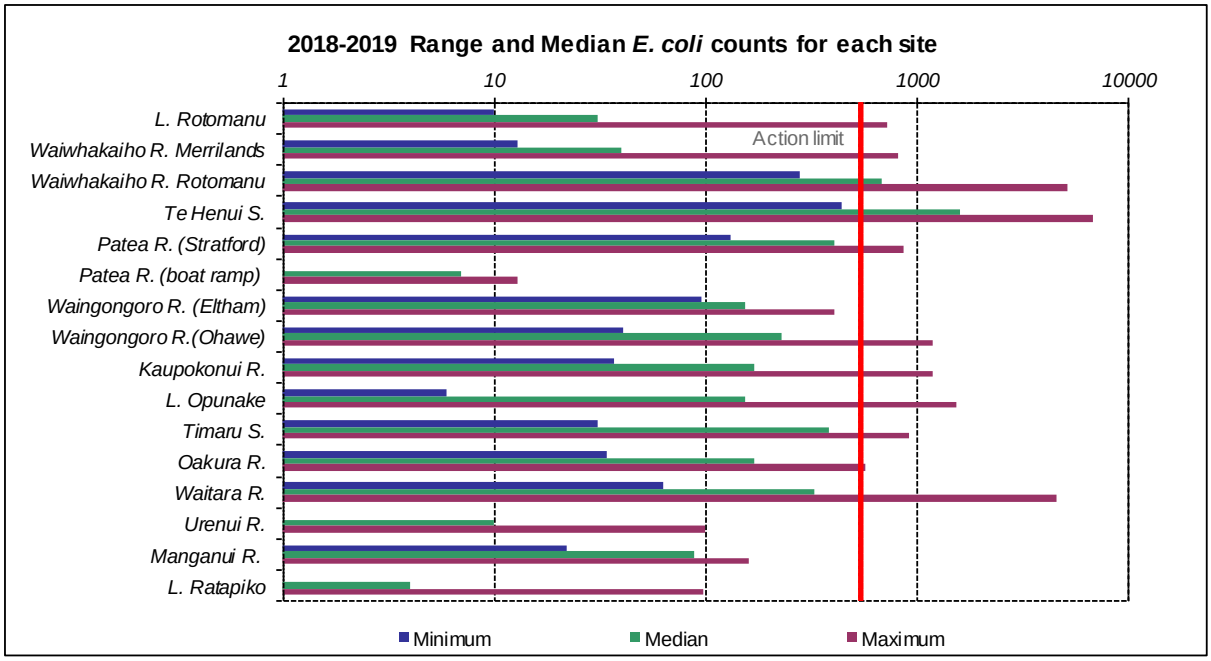


Figure 72 Ranges and medians *of E. coli* numbers recorded from all sites by the SEM programme over the 2018-2019 survey season

Non-exceedance of the 2003 guidelines has varied amongst the sixteen freshwater contact recreational sites sampled during the survey period (Figure 72 and Table 54), to the same degree as recorded in many of the previous seasons. In relation to the guidelines, two sites (Waiwhakaiho River at Lake Rotomanu and Te Henui Stream at East End beach) regularly failed to be below the *E. coli* 'Action' guideline suitable for contact recreation. In terms of median *E. coli* counts, these were also the only sites with the median count in the 'Action' (>550 *E. coli* per 100ml) mode. Three sites (Patea River at Stratford, Timaru Stream at mouth and Waitara River at the town wharf) had median counts in the 'Alert' (>260 *E. coli* per 100 ml) mode. None of the other sites had a median count in the 'Action' or 'Alert' mode.

Table 54 Number of occasions single sample *E.coli* counts entered the 'Alert' and 'Action' modes and percentage [%] of samples which were below these modes, 2018-2019

Site	' Surveillance' mode	'Alert' mode	'Action' mode
Lake Rotomanu at western beach	[77%]	0	3
Waiwhakaiho River at Merrilands Domain	[85%]	1	1
Waiwhakaiho River adjacent to L Rotomanu	[0%]	4	9
Te Henui Stream at mouth, East End	[0%]	2	11
Patea River at King Edward Park, Stratford	[31%]	6	3
Patea River at boatramp, Patea	[100%]	0	0
Waingongoro River at Eltham Camp	[69%]	4	0
Waingongoro River at Ohawe beach [2]	[54%]	4	2
Kaupokonui River at beach domain	[54%]	3	3
Lake Opunake at boat ramp	[62%]	1	4
Timaru Stream at Weld Road	[31%]	5	4
Oakura River at SH45	[69%]	3	1
Waitara River at town wharf, Waitara	[46%]	5	2
Urenui River at estuary*	[100%]	0	0
Manganui River at Everett Park	[100%]	0	0
Lake Ratapiko at boat ramp[1]	[100%]	0	0

[Notes: N = 13 samples; * = enterococci count;] [2] Not a regional bathing site

Four sites maintained counts below the 'Alert' mode at all times throughout the season, while an additional site maintained counts below the 'Action' mode (Table 54 and Table 56) at all times, so, of the 16 recognised bathing sites, four (25%) never had a non-compliance during the 2018-2019 season, and another four (25%, giving 50% altogether) had only one or two non-compliances. In terms of the overall monitoring season, thirty-eight 'Alert' levels (18% of counts) and forty-three 'Action' levels (21% of counts) resulted over the period representing an overall 61% achievement of the 'Surveillance' contact recreational guideline (compared with 71%, 72%, 60% and 60% achievement in the 2014-2015, 2015-2016, 2016-2017 and 2017-2018 seasons, respectively). Reviewing only the 'Action' level samples (i.e. those which indicate swimming poses an unacceptable risk), 79 % of all samples met the bathing guideline in 2018-2019. Of these 21% of samples that were non-compliant, 10% 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 79.3% compliance rate in 2018-2019 follows on from 79.2% in 2017-2018, 86.0% in 2016-2017 and 84.1% in 2015-2016. Thus, while bacteriological levels generally were higher in the latest period, this did not lead to a noticeable increase in conditions when swimming would have involved an unacceptable risk.

In terms of guidelines attainment, the sites may be ranked in the following order for the 2018-2019 season:

1= Patea River at boat ramp, Patea

1= Lake Ratapiko

1= Urenui River at estuary

1= Manganui River at Everett Park

5 Waingongoro River at Eltham

6 Waiwhakaiho River at Merrilands Domain

7 Oakura River d/s SH45 bridge

8 Waingongoro River at Ohawe Beach

9 Waitara River at town wharf

10 Lake Rotomanu

11 Kaupokonui River at beach domain

12 Patea River at King Edward Park

13 Lake Opunake at boat ramp

14 Timaru Stream at Weld Road (near mouth)

15 Waiwhakaiho River adjacent to Lake Rotomanu

16 Te Hēnui Stream at mouth, East End.

Overall, a wide range from poor to very good bacteriological water quality was measured at the sixteen 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* counts, by far the best bacteriological quality was again found in the two estuarine sites, on the Patea and Urenui Rivers, and this season at Lake Ratapiko, where all three sites' median count was ≤10 *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 Lake Ratapiko

2 Patea River at boatramp, Patea

3 Urenui River at estuary

4 Lake Rotomanu

5 Waiwhakaiho River at Merrilands Domain

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

7= Waingongoro River at Eltham camp

7= Lake Opunake at boat ramp

9= Oakura River d/s of SH 45 bridge

9= Kaupokonui River at beach domain

11 Waingongoro River at Ohawe Beach

12 Waitara River at town wharf, Waitara

13 Timaru Stream at Weld Road (near mouth)

14 Patea River at King Edward Park, Stratford

15 Waiwhakaiho River adjacent to Lake Rotomanu

16 Te Henui Stream at mouth, East End

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 2017-2018 season, occurred in the Waingongoro River at Eltham camp, although the median *E. coli* count was well within the previous range. Oakura River below SH45 slipped down in the rankings (four places to ninth equal) in terms of seasonal median bacteriological water quality

5.2 Comparison with twenty-two 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 two sites and improvement at eight sites in terms of median counts, 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 56.

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 70% of sampling occasions over the combined twenty-three seasons to date with the worst seasons (2016-2017 and 2017-2018, by 1%) showing 60% guidelines conformity and the best seasons (1996-1997 and 1999-2000) 82% conformity with the guidelines. The previous two seasons (2016-2017 and 2017-2018) were the historical minimum and the latest season showed slight improvement. (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

1= Urenui River at estuary

1= Lake Ratapiko

4 Waiwhakaiho River at Merrilands Domain

5= Oakura River at SH45

5= Waingongoro River at Ohawe Beach

5= Lake Rotomanu

8 Manganui River at Everett Park

9 Kaupokonui River at beach domain

10= Waingongoro River at Eltham Camp

10= Lake Opunake

12 Waitara River at town wharf, Waitara

13 Timaru Stream at Weld Road

14 Patea River at King Edward Park, Stratford

15 Waiwhakaiho River adjacent to Lake Rotomanu

16 Te Henui Stream at mouth, East End

One estuarine site (the Patea River) has never reached the 'Alert' *E.coli* level of the guidelines over the 22 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 Te Henui Stream mouth where the resident wildfowl population has been the principal contributor to elevated *E.coli* counts. This has also been the case for the Waiwhakaiho River adjacent to Lake Rotomanu, the second worst site.

Temporal trending of season's median *E.coli* counts at each of the sixteen sites, with a minimum of ten years' data, was undertaken statistically for the period 1996 to 2019. Two of these sites have shown a statistically significant ($p < 0.01$ after FDR application) trend in median *E.coli* counts:

- Waiwhakaiho River opposite Lake Rotomanu had a very strong trend of increasing median *E.coli* numbers over the 23 year period (16 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 17 year period to date which was significant at $p<0.05$ 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 55.

Table 55 Ranking of sites in terms of significant temporal trends in median *E.coli* counts over the period 1996 to 2019

Site location	Valid N	p-level	FDR-corrected p value	Trend
Waiwhakaiho River at Lake Rotomanu	16	0.0002	0.0038	↑↑↑
Te Henui Stream mouth, East End	17	0.0009	0.0080	↑↑↑
Waingongoro River at Eltham camp	18	0.0542	0.2628	↑
Waitara River at town wharf	10	0.0704	0.2628	↑
Timaru Stream at end of Weld Road	22	0.0773	0.2628	↑
Oakura River d/s SH45 bridge	23	0.2027	0.5492	↑
Urenui River at estuary	23	0.2571	0.5492	↑
Urenui River at estuary - enterococci	23	0.3022	0.5492	↓
Kaupokonui River at Beach Domain	23	0.3167	0.5492	↑
Waingongoro River at Ohawe Beach	23	0.3436	0.5492	↑
Patea River at King Edward Park	18	0.3553	0.5492	↑
Manganui River at Everett Park	23	0.4345	0.5935	↑
Lake Ratapiko at boat ramp	13	0.4879	0.5935	↓
Lake Rotomanu western beach	23	0.5057	0.5935	↑
Waiwhakaiho River at Merrilands Domain	23	0.5237	0.5935	↑
Patea River at boat ramp, Patea	12	0.5775	0.6136	↑
Lake Opunake at boat ramp	13	0.9015	0.9016	↓

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

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

Table 56 Seasonal summaries of single sample *E.coli* counts 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		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	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	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	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	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	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	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	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	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	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	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	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					0.5	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	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	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	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	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	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			
% 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		70		

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 2018-2019 survey period and all instances of exceedance of guidelines were advised to the appropriate authorities.

Few follow-up investigations were necessary over the 2018-2019 season and there were no obvious immediate issues with poor operation of dairy wastes disposal systems contributing to elevated counts 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 counts, 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, two had bio-volumes exceeding contact recreational guidelines during the 2018-2019 season, requiring the erection of warning signs: Lake Rotokare for two months from early summer (December and January), and Lake Rotomanu for two months from late spring (mid-November to mid-January). Lake Opunake reached medium risk level on three occasions in early to mid-summer, and Lake Ratapiko on one occasion in late summer.

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored. The benthic bacteria found were always *Microcoleus* sp. No site reached over the 50% coverage that would trigger the 'Action' level for that criterion (MfE and MoH, 2009), and two sites on a total of eight occasions had over 20% coverage, exceeding the 'Alert' level that triggers weekly monitoring. Exposed mats exceeded the 'Action' level at one site (Kaupokonui River at beach domain) on two occasions in late spring, requiring the erection of warnng signs, and the 'Alert' level at four sites on a total of 15 occasions. Visibly detaching

mats or detached mats accumulating on the river's edge exceeded the 'Alert' level at four sites on a total of 13 occasions. Action level was not reached for either exposed or detached mats at any site monitored.

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 2017-2018 and 2016-2017 seasons, and lower than in 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 2018-2019 microbiological data enabling a comparison of the five year 2013-2018 period (Table 2) with the latest SFRG for the 2014-2019 period (presented in Table 57.

Table 57 Suitability for recreation grade for freshwater sites for the period November 2014 to March 2019

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100ml)			SFR Grade	% of all samples in compliance (ie: ≤550 *E.coli*)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	727	65	D	Very poor	87
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. boat ramp, 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

Site	Sanitary Inspection Category	Microbiological assessment E.coli (cfu/100ml)			SFR Grade	% of all samples in compliance (ie: ≤550 *E.coli*)
		95 %ile	Number of samples	Category		
L Ratapiko: boat ramp	High	216	64	B	Poor	98
L Rotokare: adjacent boat ramp	Very Low	342	44	C	Fair	97

Few differences between the two five-year periods were apparent when comparing Table 2 and Table 57.

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 estuarine Patea River and Urenui River sites and deterioration at the Waiwhakaiho River at Merrilands domain, Waingongoro River at Ohawe beach, Kaupokonui River at beach domain, Lake Opunake and Waitara River at town wharf sites.. No site had fewer samples in excess of the 'Action' level over the most recent five-year period, while ten sites (Lake Opunake, 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 (6%, 5%, 5%, 4%, 4%, 3%, 3%, 3%, 3% and 1% more, respectively) 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 Lake Opunake and Kaupokonui River at beach domain sites. 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 new criteria are presented in Table 58. The 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. The current government's position on this is not clear.

Table 58 *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 100ML	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 monitoring data from Taranaki's freshwater bathing sites for the past five seasons (Table 57) have been analysed against the proposed 2017 NOF criteria for 'swimmability'. Results are shown in Table 59. 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 58 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. For example, the quality of the Oakura River below SH45 can apparently be variously rated as 'excellent', 'good', or 'only intermittently suitable' for swimming. Likewise, the Patea River at King Edward Park is either good, intermittent or not safe to swim in, and the Waingongoro River at Ohawe Beach could be variously graded as 'excellent' through to only 'intermittently safe', depending on the choice of criterion. This lack of rationalisation between criteria is not helpful for conveying 'swimmability' to the public.

Table 59 *E. coli* swimming categories for freshwater sites for the period November 2014 to March 2019, 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 100ML		95TH PERCENTILE: E. COLI PER 100 ML		PERCENTAGE OF SAMPLES ABOVE 260: E. COLI PER 100 ML	
L Rotomanu: western beach	65/110	12	13	70	85	727	946	22	21
Waiwhakaiho R: Merrilands domain	65/109	4.6	8.3	60	66	512	1180	9.2	14
Waiwhakaiho R at L.Rotomanu	65	78		870		4850		92	
Te Henui S: mouth	65	88		1300		5550		97	
Patea R: King Edward Park	65	17		291		828		60	
Patea R. boat ramp, Patea	65	0		9		10		0	
Waingongoro R: Eltham camp	65	7.7		260		782		48	
Waingongoro R: Ohawe beach	65/95	4.6	5.3	200	200	545	551	26	27
Kaupokonui R: Beach domain	65/95	9.2	7.4	178	190	740	726	34	55
L Opunake: adjacent boat ramp	65	9.2		120		1123		26	
Timaru S: Lower Weld Road	65	17		292		1162		55	
Oakura R: d/s SH45	65	14		130		1675		28	
Waitara R: Town wharf	65	11		216		1050		37	
Urenui R: estuary	65	1.5		10		110		1.5	
Manganui R: Everett Park	65	1.5		190		393		15	
L Ratapiko: boat ramp	63	1.6		15		216		3.2	
L Rotokare: adjacent boat ramp	43	2.3		42		342		9.3	

6 Recommendations

As a result of the 2018-2019 summer freshwater contact recreation bacteriological survey it is recommended:

1. THAT the 2019-2020 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 2019-2020 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 2019-2020 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.
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
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 counts.
Temp	Temperature, measured in °C (degrees Celsius).

Bibliography and references

Abbott, S.E; Caughley, B.P; Ionas, G; and Learmonth, J; 2006. Effect of water fowl on recreational water quality. Water 2006 International Conference, Auckland, NZ. 25pp.

APHA (2005). Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and the Water Environment Federation.

Benjamini,Y and Hochberg, Y, 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society B (57):289-300.*

Canterbury Regional Council, 1993: Bathing water quality in Canterbury: Recreational water quality survey results for 1992.93. Canterbury Regional Council Report 93(15).

Deely, J, Hodges, S, McIntosh, J, and Bassett, D, 1997: Enterococcal numbers measured in waters of marine, lake, and river swimming sites of the Bay of Plenty, New Zealand. NZ Jour. Mar F. W. Res. V31: 89-101.

Department of Health, 1992: Provisional microbiological water quality guidelines for recreational and shellfish gathering waters in New Zealand. Public Health Services, Department of Health, Wellington.

EPA (United States Environmental Protection Agency), 1986. Ambient water quality criteria for bacteria. EPA Report 440.5-84-002.

McBride, G B; Salmond, C E; Bandaranayake, D R; Turner, S J; Lewis, G D; Till, D G, 1998: Health Effects of Marine Bathing in New Zealand. International Journal of Environmental Health Research 8(3). In press.

MfE, 1998: Bacteriological water quality guidelines for marine and fresh water: Guidelines for the management of recreational and marine shellfish-gathering waters. Ministry for the Environment publication.

MfE, 2003: Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment and Ministry of Health, Wellington.

MfE, 2008: Environment New Zealand 2007. Ministry for the Environment publication ME 847.

MfE, 2012: Recreational water quality in New Zealand indicator update October 2012; INFO 653, October 2012.

MfE, 2014: National Policy Statement for Freshwater Management 2014; Ministry for the environment publication ME 1155, July 2014.

MfE, 2017: Clean Water: 90% of rivers and lakes swimmable by 2040. Ministry for the Environment publication ME 1293. February 2017.

MfE and MoH, 2009: Cyanobacteria in Recreational Fresh Waters – Interim Guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by SA Wood, DP Hamilton, WJ Paul, KA Safi and WM Williamson. Wellington: Ministry for the Environment.

Stark, JD and Fowles, CR 2006: An approach to the evaluation of temporal trends in Taranaki State of the Environment Macroinvertebrate Data. Cawthron Institute Report No 1135. 88pp.

Taranaki District Health Board, 2006: Proposed cyanobacteria incident plan for Taranaki. 24pp (draft).

TRC, 1996: State of the Environment – Taranaki Region 1996. Taranaki Regional Council.

TRC, 1997: Freshwater bathing water quality of selected Taranaki sites. Survey results for summer 1996-97. Technical Report 97-4.

TRC, 1998: Freshwater bathing water quality at selected Taranaki sites. State of the Environment Report. Summer 1997-98. Technical Report 98-20.

TRC, 1999: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 1998-99. Technical Report 99-18.

TRC, 2000: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 1999-2000. Technical Report 2000-06.

TRC, 2001: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2000-2001. Technical Report 2001-07.

TRC, 2002: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2001-2002. Technical Report 2002-01.

TRC, 2002: State of the Environment Monitoring Report: Bathing Beach Water Quality 2000-2001 and 2001-2002. Technical Report 2002-45.

TRC, 2003: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2002-2003. Technical Report 2003-05.

TRC, 2003: 'Taranaki – our place, our future' Report on the state of the environment of the Taranaki region – 2003'. TRC publication, 206pp.

TRC, 2004: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2003-2004. Technical Report 2004-19.

TRC, 2004b: Bacteriological water quality of the Waimoku catchment. TRC Technical Report 2004-21.

TRC, 2005: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2004-2005. Technical Report 2005-09.

TRC, 2006: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2005-2006. Technical Report 2006-32.

TRC, 2007: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2006-2007. Technical Report 2007-11.

TRC, 2008: Recreational use of coast, rivers and lakes in Taranaki 2007-2008. TRC Report.

TRC, 2008a: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report. Summer 2007-2008. Technical Report 2008-02.

TRC, 2009: Taranaki Where We Stand. State of the Environment Report 2009. TRC, 284p.

TRC, 2009a: Bathing beach water quality. State of the Environment Report. Summer 2008-2009. Technical Report 2009-11.

TRC, 2009b: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2008-2009 . Technical Report 2009-12.

TRC, 2010: Bathing beach water quality. State of the Evironment monitoring report. Summer 2009-2010. Technical Report 2010-08.

TRC, 2010a: A further [summer 2010] visual assessment of the Waimoku catchment in relation to bacteriological water quality issues. Internal report.

TRC, 2010b: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2009-2010 . Technical Report 2010-11.

TRC, 2011: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2010-2011 . Technical Report 2011-01.

TRC, 2012: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2011-2012 . Technical Report 2012-02.

TRC, 2013: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2012-2013 . Technical Report 2013-01.

TRC, 2014: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2013-2014 . Technical Report 2014-01.

TRC, 2015: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2014-2015 . Technical Report 2015-01.

TRC, 2015b: Quality assurance of lake cyanobacteria processing. Internal Memo document number 1494870.

TRC, 2015c: Taranaki - as one. State of the environment report 2015 TRC, 267p.

TRC, 2016: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2015-2016 . Technical Report 2016-01.

TRC, 2016b: South Taranaki District Council Waverley, Kaponga, Manaia and Patea Municipal Wasteater Treatment Plant Systems Monitoring Programmes Annual Report 2015-2016. Technical Report 2016-30.

TRC, 2017: Freshwater contact recreational water quality at selected Taranaki sites. State of the Environment Report Summer 2016-2017 . Technical Report 2017-01.

TRC, 2017: Bathing beach water quality. State of the Environment monitoring report. Summer 2016-2017. Technical Report 2017-02.

TRC, 2018: Bathing beach water quality. State of the Environment monitoring report. Summer 2017-2018. Technical Report 2018-02.

Wood, S.A., Paul, W.J., and Hamilton, D.P. 2008: Cyanobacteria Biovolumes for the Rotorua Lakes. Prepared for Environment Bag of Plenty. Cawthron Report No. 1504.

Appendix I

Bacteriological results for all sites
2018-2019 monitoring year

Lake Rotomanu (Site Code LRM000002)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1025	19.4	121	6.5	15	SEM
10.12.18	0825	21.9	123	7.9	156	SEM
18.12.18	1200	26.0	126	12.5	37	MfE
27.12.18	0910	22.8	128	11.4	29	MfE
3.01.19	1115	24.3	133	14.0	19	MfE
7.01.19	1120	24.7	130	11.7	10	SEM
10.01.19	0945	24.7	132	8.4	20	SEM
17.01.19	1010	22.8	129	1.6	47	MfE
21.01.19	1040	24.5	138	8.7	31	SEM
23.01.19	0830	23.4	137	9.6	579	SEM
30.01.19	0940	24.7	138	6.1	55	MfE
4.02.19	1140	26.0	141	6.4	24	SEM
11.02.19	1530	25.7	142	9.6	260	SEM
19.02.19	1150	24.5	148	22.0	727	SEM
21.02.19	0910	24.0	146	6.3	14	SEM
28.02.19	1015	19.8	148	6.4	210	MfE
5.03.19	1125	20.4	149	7.0	64	SEM
7.03.19	1135	22.7	148	5.5	10	SEM
13.03.19	1110	20.9	141	7.5	>2420	MfE
18.03.19	1205	25.3	151	4.6	435	FOLLOW-UP
20.03.19	1315	24.7	151	4.7	727	SEM
22.03.19	1450	25.0	149	5.8	359	FOLLOW-UP
26.03.19	0935	22.9	151	6.9	2420	MfE

Waiwhakaiho River at Merrilands (Site Code WKH000800)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1145	16.2	121	1.0	80	SEM
10.12.18	0800	17.2	125	1.0	89	SEM
18.12.18	1130	21.8	154	1.1	45	MfE
27.12.18	0930	19.0	108	1.4	36	MfE
3.01.19	1140	18.6	153	0.8	41	MfE
7.01.19	1215	21.9	166	1.9	823	SEM
10.01.19	0930	21.3	171	1.2	88	SEM
17.01.19	1030	22.2	137	11.3	53	MfE
21.01.19	1135	21.2	166	1.5	59	SEM
23.01.19	0820	19.1	156	0.7	13	SEM
30.01.19	0740	24.0	163	0.9	26	MfE
4.02.19	1245	23.7	175	0.6	26	SEM
11.02.19	1505	23.0	175	1.1	411	SEM
19.02.19	1130	21.8	177	0.8	31	SEM
21.02.19	0815	20.5	180	2.2	23	SEM
28.02.19	1115	18.0	160	0.6	56	MfE
5.03.19	1225	17.9	172	0.6	40	SEM
7.03.19	1300	21.2	174	0.9	21	SEM
13.03.19	1300	16.5	88	4.9	2420	MfE
18.03.19	1049	20.8	149	0.9	260	FOLLOW-UP
20.03.19	1205	20.7	152	0.4	21	SEM
25.03.19	1210	18.7	171	0.5	193	MfE

Waiwhakaiho River beside Lake Rotomanu (Site Code WKH000950)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1050	16.2	118	0.8	5170	SEM
10.12.18	0850	19.2	127	0.8	278	SEM
7.01.19	1130	22.4	4660	1.3	399	SEM
10.01.19	0955	21.7	188	1.1	598	SEM
21.01.19	1050	22.8	278	1.4	683	SEM
23.01.19	0840	21.2	452	1.8	328	SEM
4.02.19	1150	25.6	174	0.7	487	SEM
11.02.19	1535	26.4	1728	1.0	620	SEM
19.02.19	1200	23.6	3880	2.1	1785	SEM
21.02.19	0840	20.5	1074	2.9	1112	SEM
5.03.19	1135	18.5	169	0.8	987	SEM
7.03.19	1155	23.2	174	0.8	860	SEM
20.03.19	1305	22.8	158	0.6	1918	SEM

Te Henui Stream

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	0950	15.2	5340	1.4	1789	SEM
10.12.18	1010	18.5	205	0.7	504	SEM
7.01.19	1045	20.2	18190	1.6	1607	SEM
10.01.19	1050	20.4	2710	1.1	1850	SEM
21.01.19	0950	19.6	30100	3.2	1396	SEM
23.01.19	0955	18.2	40700	8.2	443	SEM
4.02.19	1055	21.1	446	0.8	1552	SEM
11.02.19	1425	23.8	763	0.6	738	SEM
19.02.19	1045	19.8	43200	1.9	6870	SEM
21.02.19	0935	19.9	35400	3.7	1576	SEM
5.03.19	1040	16.4	558	1.1	3260	SEM
7.03.19	1105	18.5	17590	2.0	2190	SEM
20.03.19	1040	19.8	21300	3.9	5790	SEM

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

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1345	14.5	102	1.2	249	SEM
10.12.18	1410	16.7	104	1.3	219	SEM
7.01.19	1350	19.1	109	1.4	649	SEM
10.01.19	0830	16.0	118	2.0	866	SEM
21.01.19	1140	16.3	109	1.4	228	SEM
23.01.19	1355	19.5	111	0.9	133	SEM
4.02.19	1435	18.4	114	0.9	517	SEM
11.02.19	1000	15.9	116	0.9	548	SEM
19.02.19	1345	17.4	122	1.5	411	SEM
21.02.19	1235	16.7	119	1.3	488	SEM
5.03.19	1340	14.0	119	1.1	261	SEM
7.03.19	1350	15.8	122	1.7	326	SEM
20.03.19	1330	17.0	112	1.3	727	SEM
22.03.19	1505	15.9	112	1.2	517	FOLLOW-UP

Patea River, boatramp, Patea (Site Code PAT000995)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Enterococci	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	cfu/100ml	
7.11.18	0905	15.9	53700	33.0	8	<1	SEM
10.12.18	1025	19.3	53700	17.0	12	3	SEM
7.01.19	0930	20.9	54400	22.0	13	5	SEM
10.01.19	1130	21.0	54400	17.7	7	6	SEM
21.01.19	0930	20.5	54500	17.3	9	5	SEM
23.01.19	1015	20.5	54600	31.0	5	5	SEM
4.02.19	0935	21.0	54400	13.5	6	<10	SEM
11.02.19	1230	21.6	53600	2.3	1	1	SEM
19.02.19	0920	20.7	53800	19.0	6	1	SEM
21.02.19	1035	20.9	53800	12.3	12	11	SEM
5.03.19	0905	18.7	53900	12.4	4		SEM
7.03.19	0950	19.4	53800	15.3	5	2	SEM
20.03.19	0905	20.0	54300	3.5	10	5	SEM

Waingongoro River, Eltham Camp (Site Code WGG000492)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1305	16.8	125	1.6	148	SEM
10.12.18	1350	19.1	123	1.7	103	SEM
7.01.19	1330	21.2	134	1.6	228	SEM
10.01.19	0850	17.4	137	1.6	387	SEM
21.01.19	1245	18.1	132	1.6	411	SEM
23.01.19	1330	21.7	132	1.2	166	SEM
4.02.19	1410	22.2	135	1.2	130	SEM
11.02.19	1430	21.5	138	1.1	96	SEM
19.02.19	1320	20.7	146	1.8	156	SEM
21.02.19	1210	19.0	153	1.5	411	SEM
5.03.19	1315	17.2	146	1.5	147	SEM
7.03.19	1330	19.1	146	1.5	154	SEM
20.03.19	1300	20.0	138	1.3	345	SEM

Waingongoro River, near mouth – (Site Code WGG000995)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	mS/m@20°C	NTU	MPN/100ml	
7.11.18	1230	17.9	200	1.9	98	SEM
10.12.18	1150	20.8	191	2.3	111	SEM
18.12.18	1115	21.5	206	2.2	102	MfE
27.12.18	0800	18.0	164	3.5	488	MfE
3.01.19	1035	21.7	196	2.1	231	MfE
7.01.19	1045	21.6	203	1.9	272	SEM
10.01.19	1240	22.7	202	1.8	91	SEM
17.01.19	0915	17.9	182	3.3	313	MfE
21.01.19	1035	19.8	210	2.0	517	SEM
23.01.19	1120	22.1	219	3.2	261	SEM
30.01.19	1030	22.6	215	1.1	131	MfE
4.02.19	1325	23.2	219	1.1	135	SEM
11.02.19	1350	23.4	218	1.0	41	SEM
19.02.19	1040	20.9	231	1.2	228	SEM
21.02.19	1150	21.0	14790	4.6	1203	SEM
1.03.19	1010	16.3	235	0.7	153	MfE
5.03.19	1240	18.3	234	1.0	365	SEM
7.03.19	1115	19.4	234	1.1	649	SEM
12.03.19	1300	20.3	222	1.3	276	FOLLOW-UP
13.03.19	0915	20.1	234	1.4	196	MfE
20.03.19	1235	21.2	226	1.1	115	SEM
25.03.19	1130	19.9	233	1.7	193	MfE

Kaupokonui River at beach (Site Code: KPK000995)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1205	18.3	172	1.6	111	SEM
10.12.18	1220	21.2	166	2.6	122	SEM
18.12.18	1145	23.1	179	2.4	96	MfE
27.12.18	0900	18.3	152	3.7	435	MfE
3.01.19	1125	22.6	177	2.0	104	MfE
7.01.19	1120	22.4	182	1.8	488	SEM
10.01.19	1310	23.2	182	1.7	141	SEM
17.01.19	1010	18.9	168	2.3	345	MfE
21.01.19	1105	19.9	869	3.0	687	SEM
23.01.19	1200	21.8	5230	16.9	87	SEM
30.01.19	1115	24.6	188	3.9	63	MfE
4.02.19	1245	23.8	187	1.0	93	SEM
11.02.19	1130	22.3	188	1.0	37	SEM
19.02.19	1245	22.4	387	1.1	416	SEM
21.02.19	1220	20.7	4550	1.8	1203	SEM
1.03.19	1100	16.5	199	1.2	38	MfE
5.03.19	1210	18.5	199	1.6	172	SEM
7.03.19	1155	20.2	194	1.4	361	SEM
13.03.19	0950	20.0	203	1.7	387	MfE
20.03.19	1205	21.3	389	0.9	1046	SEM
22.03.19	1410	21.6	598	1.5	172	FOLLOW-UP
25.03.19	1045	19.6	195	1.8	179	MfE

Lake Opunake (Site Code LOP000001)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1130	19.5	143	2.7	6	SEM
10.12.18	1310	23.4	142	1.9	12	SEM
7.01.19	1150	22.8	159	2.8	156	SEM
10.01.19	1405	26.2	160	3.4	167	SEM
21.01.19	1205	23.7	170	2.4	1553	SEM
23.01.19	1240	25.0	171	2.2	980	SEM
30.01.19	1210	24.3	171	2.6	54	FOLLOW-UP
4.02.19	1210	26.1	182	3.4	51	SEM
11.02.19	1250	25.7	188	3.9	64	SEM
19.02.19	1145	22.5	189	3.4	1553	SEM
21.02.19	1245	23.3	192	3.9	613	SEM
28.02.19	0930	18.0	179	3.4	201	FOLLOW-UP
5.03.19	1140	20.0	180	2.9	69	SEM
7.03.19	1245	21.6	181	2.7	36	SEM
20.03.19	1125	23.3	169	1.8	365	SEM

Timaru Stream, near mouth (Site Code: TMR0000497)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	0800	15.2	172	0.5	649	SEM
12.11.18	1240	16.6	96	0.5	64	FOLLOW-UP
10.12.18	1220	20.6	115	0.6	111	SEM
7.01.19	0845	21.9	241	0.6	387	SEM
10.01.19	1200	21.4	294	0.6	326	SEM
21.01.19	0805	19.1	1045	0.9	416	SEM
23.01.19	1145	21.2	15060	3.9	292	SEM
4.02.19	0815	21.1	493	0.8	260	SEM
11.02.19	1220	23.3	250	0.6	31	SEM
19.02.19	0930	18.1	951	0.7	461	SEM
21.02.19	1110	20.6	5510	2.3	921	SEM
28.02.19	0800	17.5	298	0.7	435	FOLLOW-UP
5.03.19	0820	18.4	273	1.0	613	SEM
7.03.19	0855	19.2	254	0.7	221	SEM
20.03.19	0805	19.2	9660	1.5	727	SEM
22.03.19	1405	20.2	1583	0.6	63	FOLLOW-UP

Oakura River, near mouth (Site Code: OKR000497)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	0845	15.1	173	0.4	110	SEM
10.12.18	1120	19.2	93	0.4	74	SEM
7.01.19	0930	21.0	297	0.7	148	SEM
10.01.19	1245	21.3	930	0.4	135	SEM
21.01.19	0850	19.7	1321	0.8	548	SEM
23.01.19	1100	20.9	3490	0.6	317	SEM
4.02.19	0920	21.1	214	0.7	172	SEM
11.02.19	1300	22.6	126	0.4	34	SEM
19.02.19	0945	19.5	2090	0.8	231	SEM
21.02.19	1050	20.3	34900	1.8	579	SEM
28.02.19	0910	16.6	211	0.9	344	FOLLOW-UP
5.03.19	0925	17.6	166	0.5	238	SEM
7.03.19	0940	18.5	159	0.7	126	SEM
20.03.19	0915	18.9	7080	0.9	435	SEM

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

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	1125	16.4	10880	40.0	448	SEM
10.12.18	1130	20.2	8480	12.0	199	SEM
7.01.19	1100	22.3	12330	3.9	528	SEM
10.01.19	1215	22.4	32400	4.0	327	SEM
21.01.19	1105	21.7	13450	3.5	556	SEM
23.01.19	1205	22.0	28800	4.0	110	SEM
4.02.19	1015	24.6	16850	2.7	197	SEM
11.02.19	1120	25.5	26400	2.2	63	SEM
19.02.19	1035	20.1	43100	3.0	373	SEM
21.02.19	1015	20.6	50100	3.5	359	SEM
5.03.19	0820	19.2	28000	2.5	86	SEM
7.03.19	0935	18.5	47000	2.6	4610	SEM
12.03.19	1310	21.2	8000	4.9	235	FOLLOW-UP
20.03.19	0920	20.6	32100	1.8	216	SEM

Urenui River at estuary (Site Code: URN000480)

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Enterococci	Programme
	NZST	°C	µS/cm@25°C	NTU	cfu/100ml	cfu/100ml	
7.11.18	1035	17.1	53100	7.8	100	49	SEM
10.12.18	1245	21.4	53500	4.0	2	1	SEM
7.01.19	1010	19.6	52700	5.4	19	4	SEM
10.01.19	1120	21.2	53400	4.7	6	2	SEM
21.01.19	1005	17.5	54700	7.1	20	40	SEM
23.01.19	1055	17.5	55100	6.8	13	23	SEM
4.02.19	0935	21.4	54800	3.2	5	4	SEM
11.02.19	1305	23.3	53400	0.6	<1	1	SEM
19.02.19	1125	21.7	54000	3.9	90	29	SEM
21.02.19	1150	21.2	53900	8.9	20	21	SEM
5.03.19	0920	19.2	54100	5.6	2		SEM
7.03.19	1100	20.1	54100	2.3	1	1	SEM
20.03.19	0800	20.7	54200	11.1	10	16	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	NTU	MPN/100ml	
7.11.18	0910	15.9	113	1.3	131	SEM
10.12.18	0830	16.8	116	1.2	160	SEM
7.01.19	0850	20.6	120	4.4	48	SEM
10.01.19	1010	20.6	119	1.4	111	SEM
21.01.19	0845	19.4	119	1.3	86	SEM
23.01.19	1355	22.5	118	1.1	22	SEM
4.02.19	1205	22.4	112	0.9	44	SEM
11.02.19	1040	20.5	115	0.7	31	SEM
19.02.19	0900	18.0	116	2.6	33	SEM
21.02.19	0900	18.7	115	1.2	108	SEM
5.03.19	1110	16.7	116	1.2	93	SEM
7.03.19	0830	16.8	115	1.1	88	SEM
20.03.19	1055	19.1	119	0.8	133	SEM

Lake Ratapiko

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
7.11.18	0820	16.3	93	1.5	99	SEM
10.12.18	0750	18.4	94	1.4	14	SEM
7.01.19	0825	22.8	97	2.0	12	SEM
10.01.19	0935	23.3	96	1.6	15	SEM
21.01.19	0800	21.8	91	1.2	9	SEM
23.01.19	1420	25.3	93	1.4	2	SEM
4.02.19	1230	26.3	96	1.2	3	SEM
11.02.19	1015	24.1	97	1.2	1	SEM
19.02.19	0825	22.3	98	1.7	3	SEM
21.02.19	0830	22.7	96	1.4	2	SEM
5.03.19	1140	20.8	101	1.1	4	SEM
7.03.19	0800	19.6	102	1.2	2	SEM

Lake Rotokare

Date	Time	Temperature	Conductivity	Turbidity	E. coli	Programme
	NZST	°C	µS/cm@25°C	NTU	MPN/100ml	
6.11.18	1209	17.6	136	1.7	15	SEM
18.12.18	0830	23.4	144	14.3	14	SEM
3.01.19	0940	22.1	139	18.8	58	SEM
30.01.19	0830	24.3	138	10.7	31	SEM
11.02.19	1400	24.4	0	0.0	0	SEM
21.02.19	0815	22.1	140	2.7	62	SEM
13.03.19	1230	21.2	144	2.1	1046	SEM
20.03.19	1230	21.5	142	0.9	46	SEM

Appendix II

High tide times

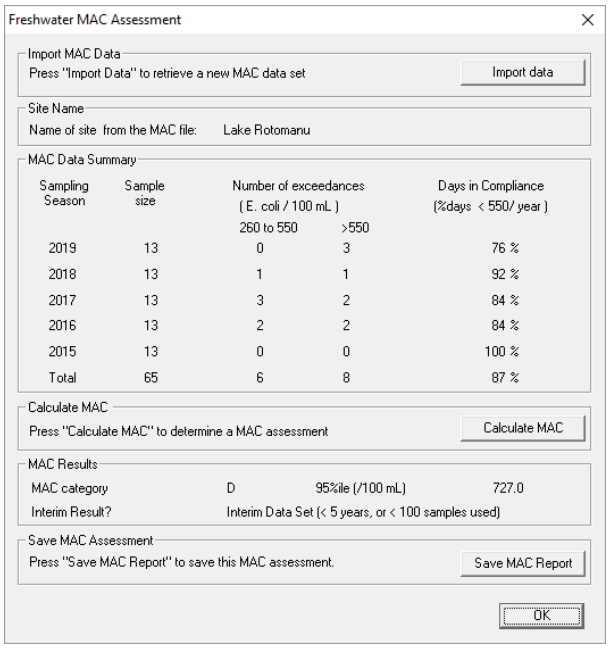
Appendix II High tide times

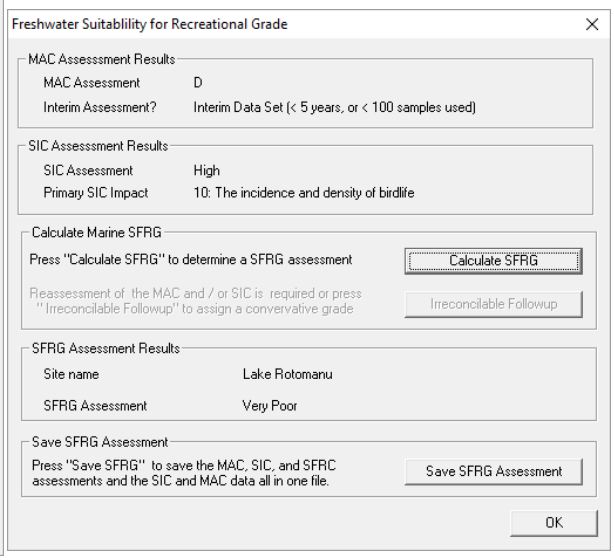
Date	Programme	Day	Time (NZST)	Height (m)
07 Nov 2018	SEM	Wednesday	0916	3.6
10 Dec 2018	SEM	Monday	1126	3.3
18 Dec 2018	MFE	Tuesday	0544	2.8
27 Dec 2018	MFE	Thursday	1314	3.5
03 Jan 2019	MFE	Thursday	0753	3.1
07 Jan 2019	SEM	Monday	1034	3.4
10 Jan 2019	SEM	Thursday	1218	3.3
17 Jan 2019	MFE	Thursday	0556	2.9
21 Jan 2019	SEM	Monday	0942	3.7
23 Jan 2019	SEM	Wednesday	1119	3.8
30 Jan 2019	MFE	Wednesday	0519	2.8
04 Feb 2019	SEM	Monday	0941	3.3
11 Feb 2019	SEM	Monday	1341	3.1
19 Feb 2019	SEM	Tuesday	0927	3.7
21 Feb 2019	SEM	Thursday	1102	3.9
28 Feb 2019	MFE	Thursday	1713	2.7
05 Mar 2019	SEM	Tuesday	0918	3.2
07 Mar 2019	SEM	Thursday	1023	3.4
13 Mar 2019	MFE	Wednesday	1357	3.0
20 Mar 2019	SEM	Wednesday	0908	3.7
26 Mar 2019	MFE	Tuesday	1337	3.1

Appendix III

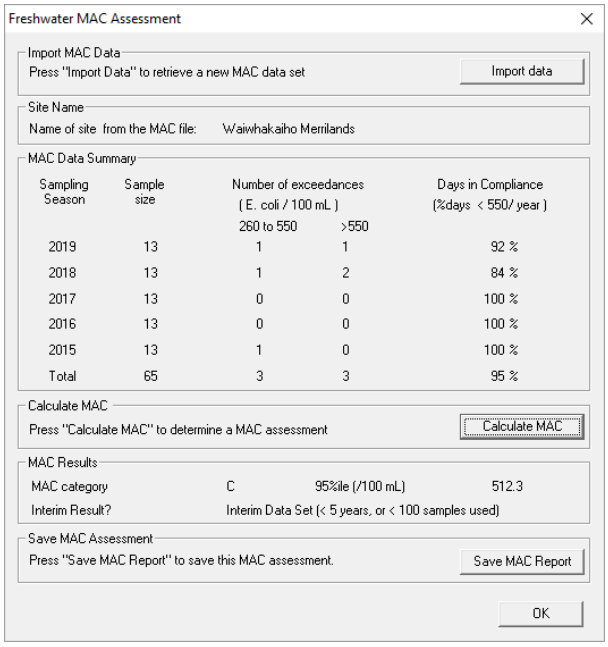
MAC Assessments 2014-2019

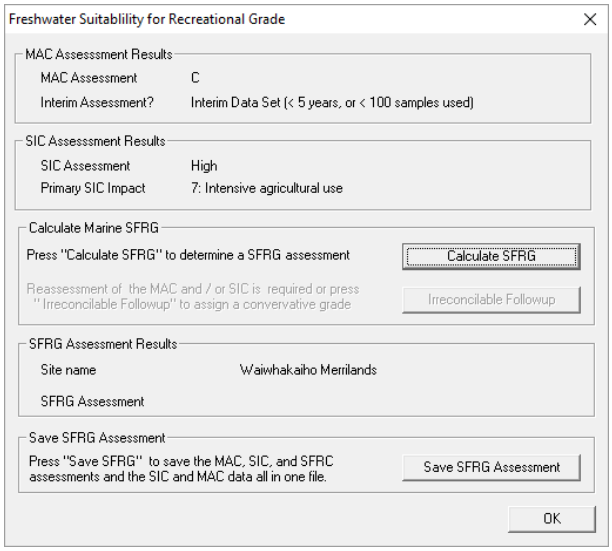
Lake Rotomanu



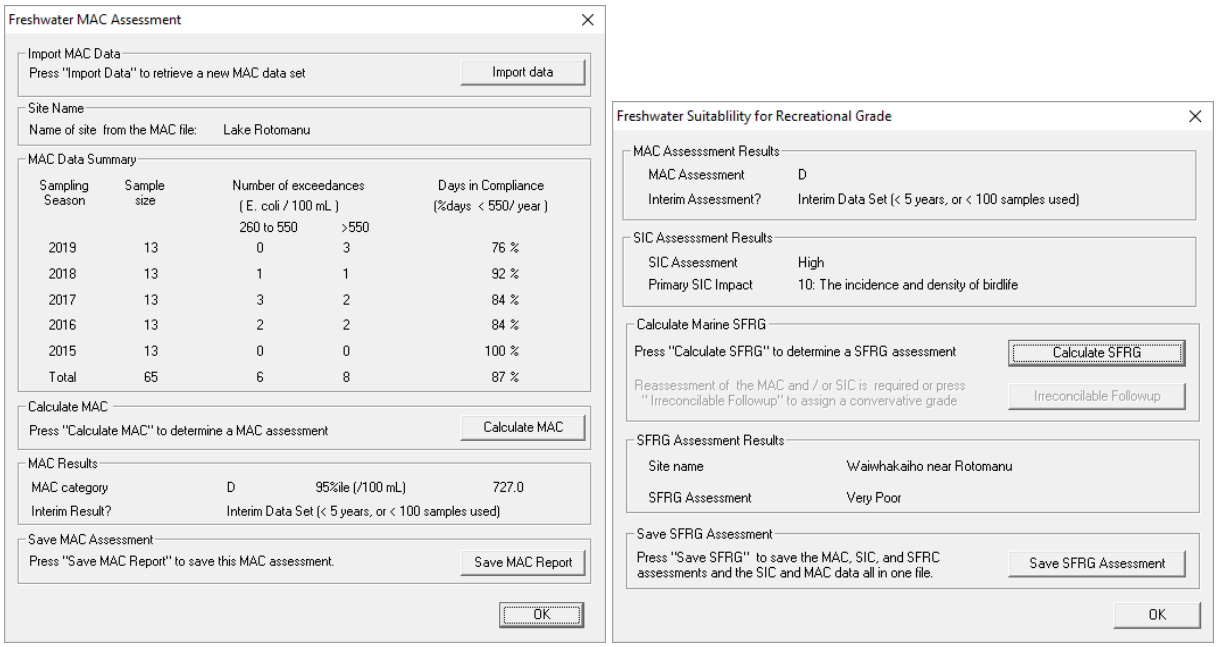


Waiwhakaiho River at Merrilands Domain

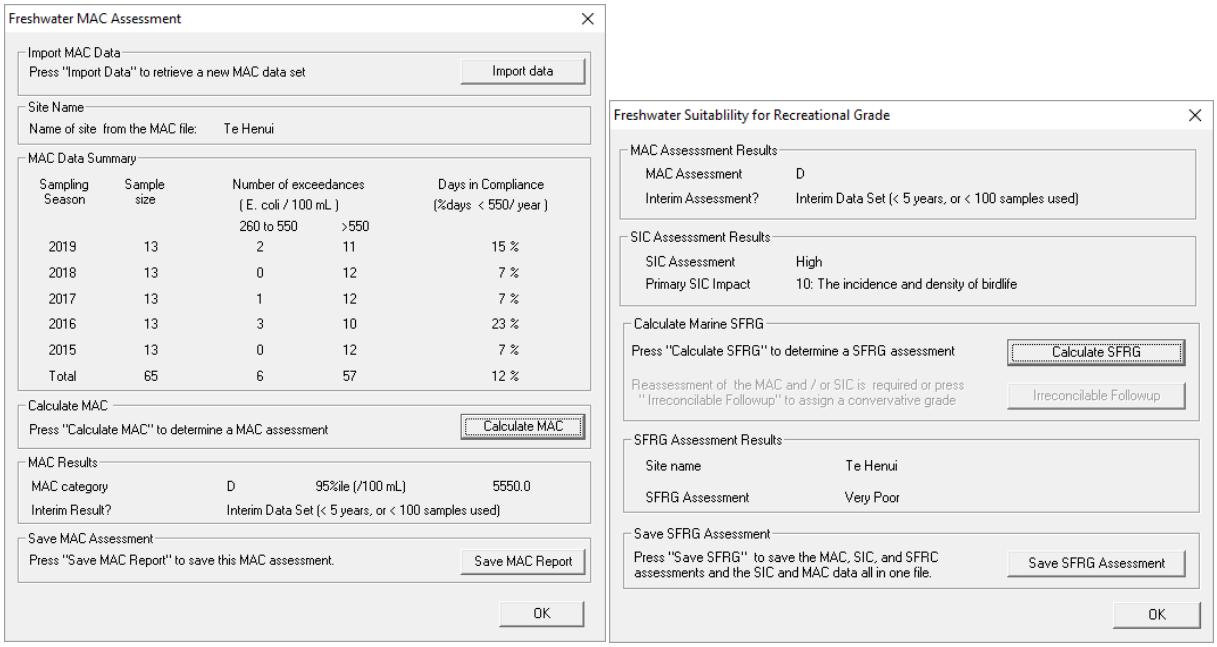




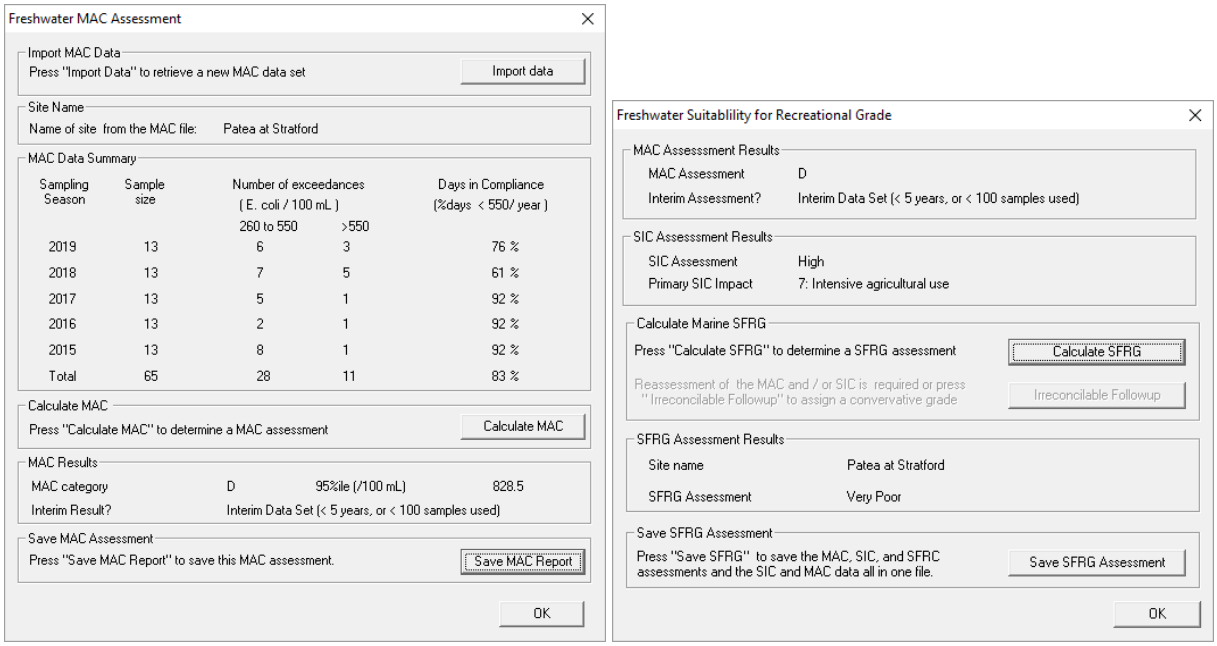
Waiwhakaiho near Lake Rotomanu



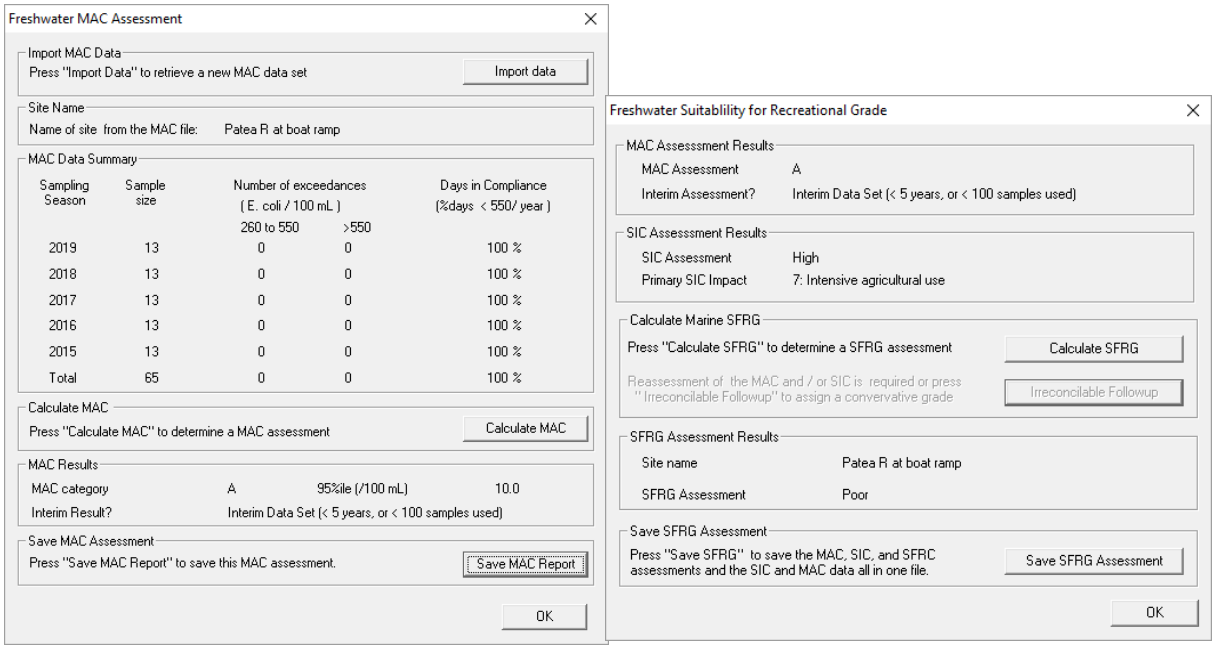
Te Henui Stream: mouth



Patea River at Stratford

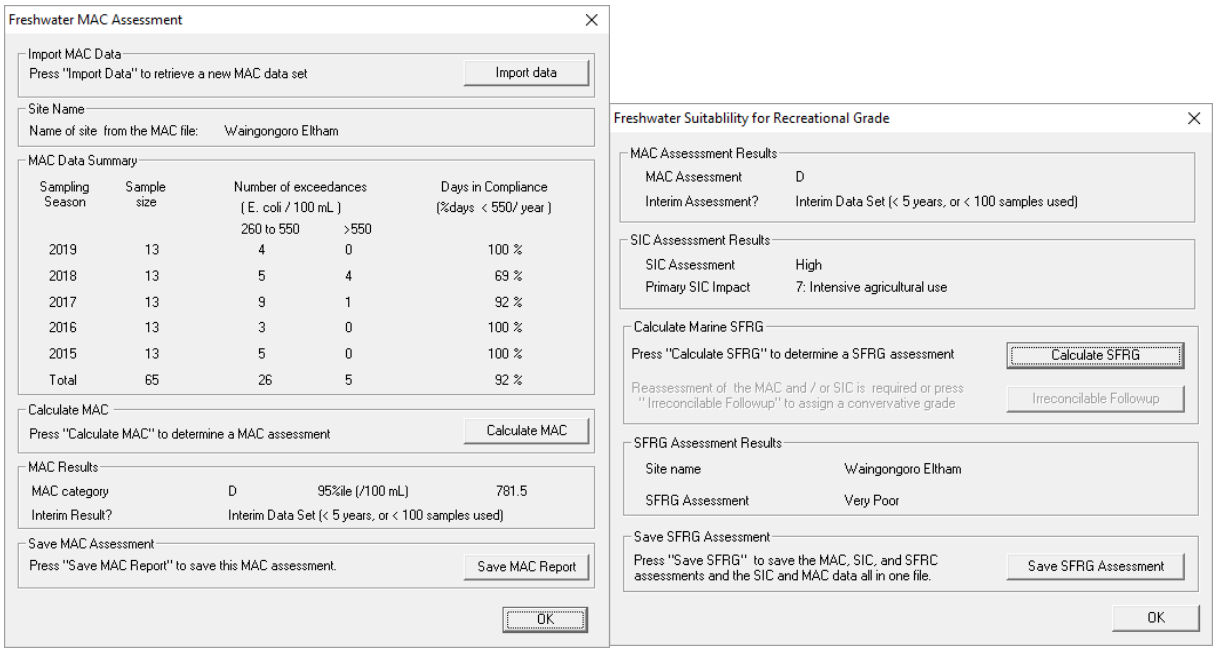


Patea River at boat ramp, Patea

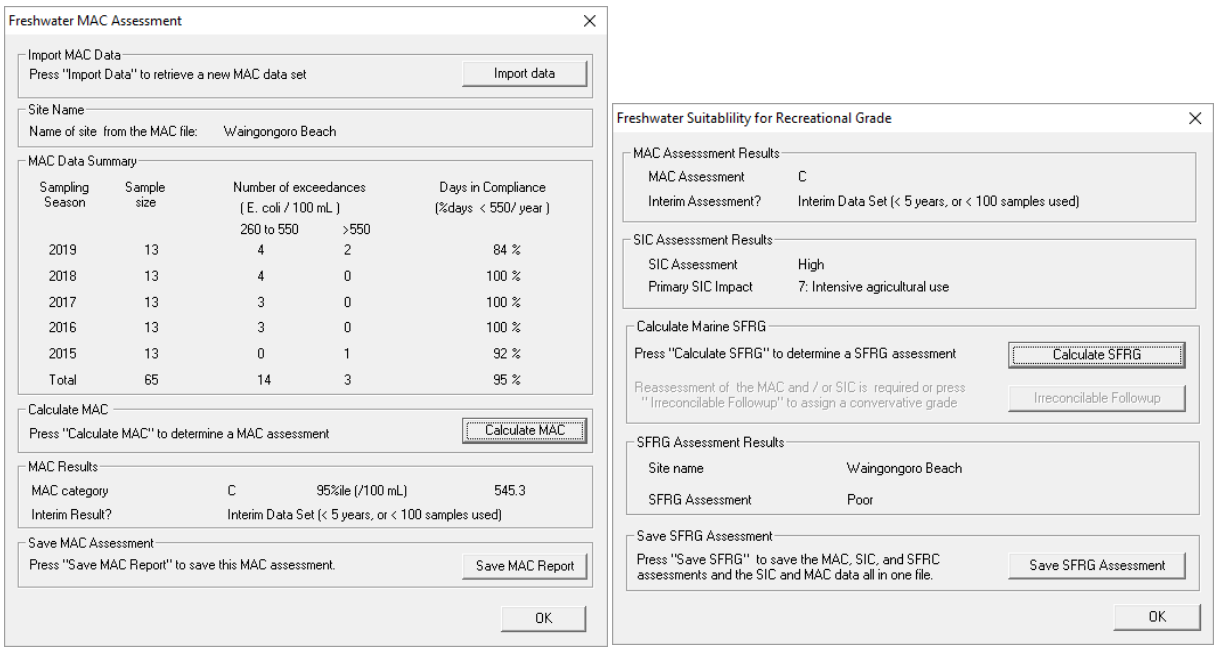


Patea River at boat ramp was Follow up, irreconcilable flow-up and SFRG Assessment resulted in Poor.

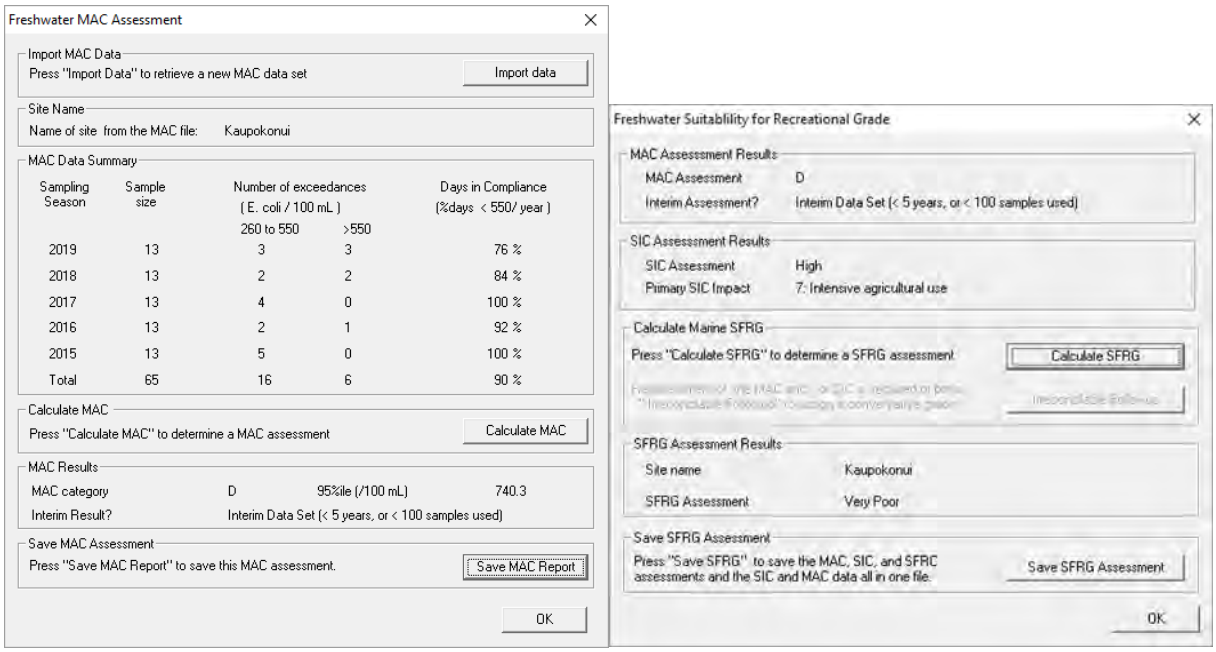
Waingongoro River at Eltham camp



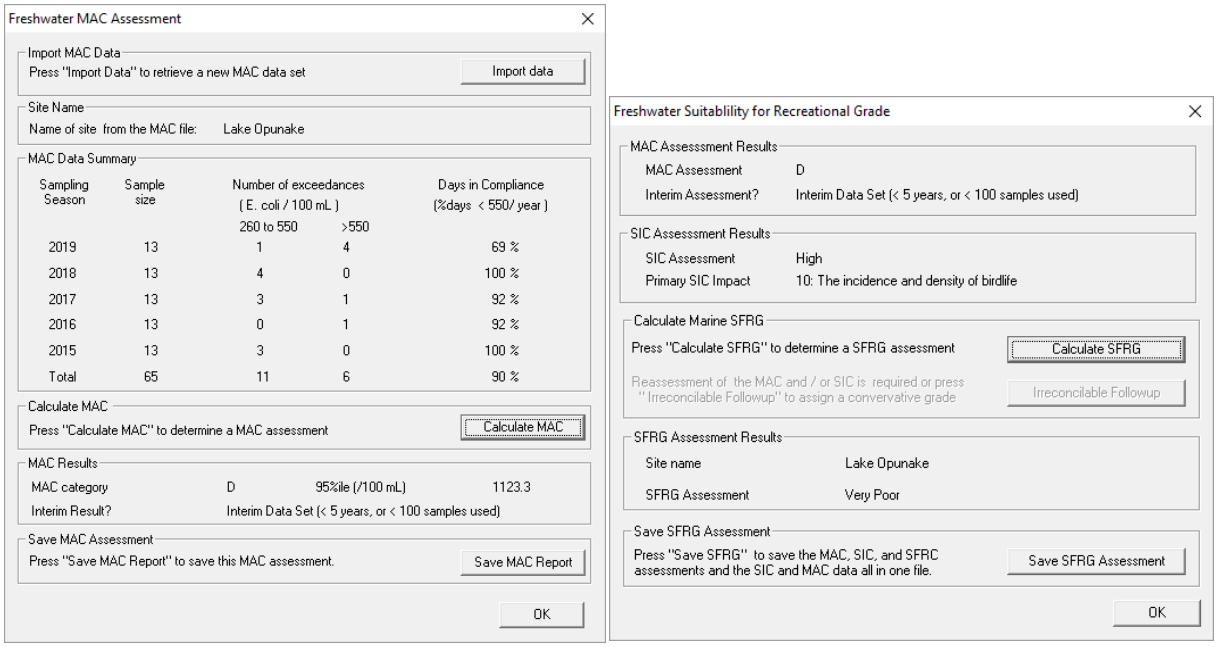
Waingongoro River at Ohawe beach



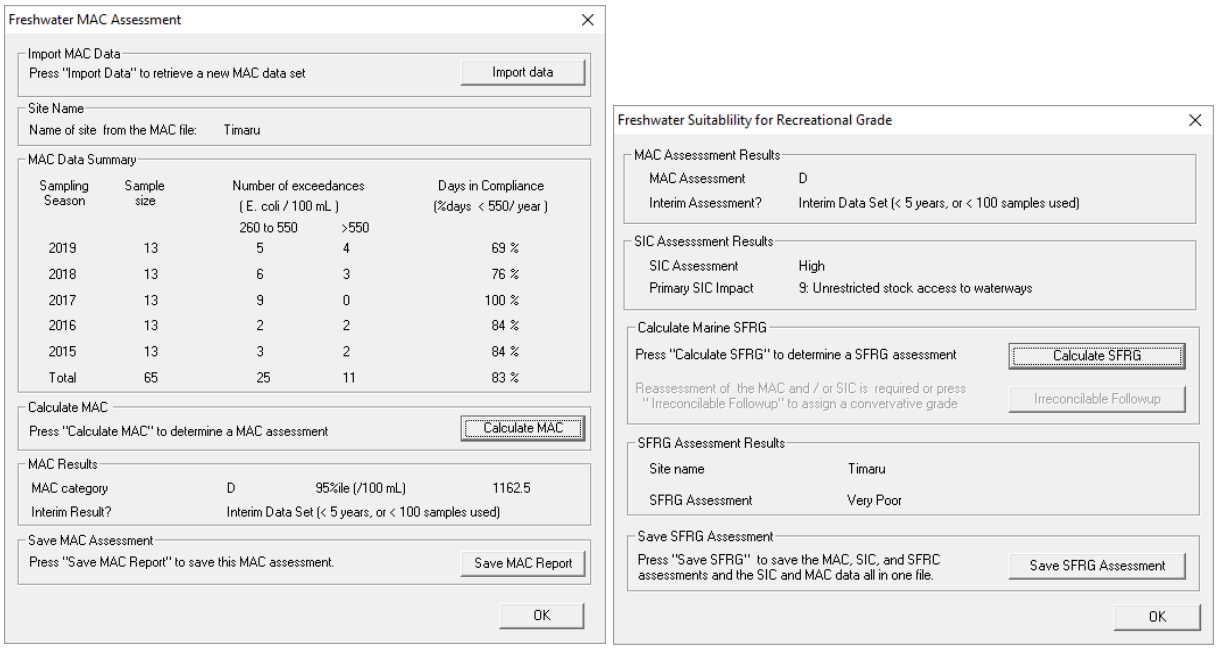
Kaupokonui River at beach domain



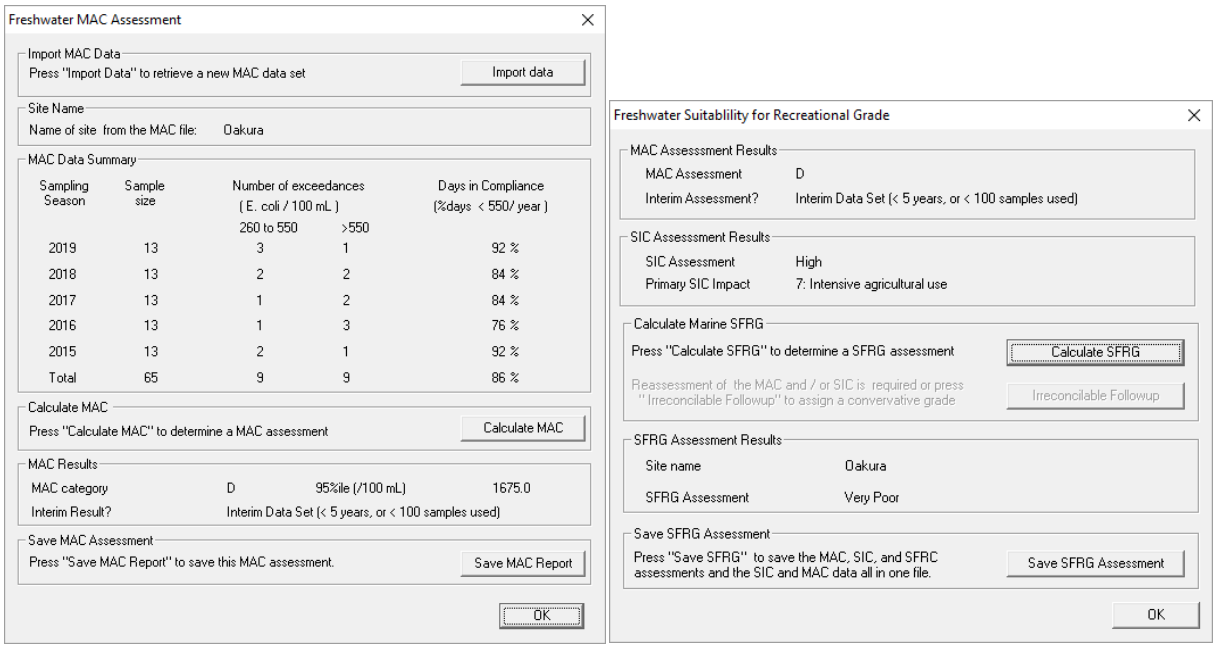
Lake Opunake



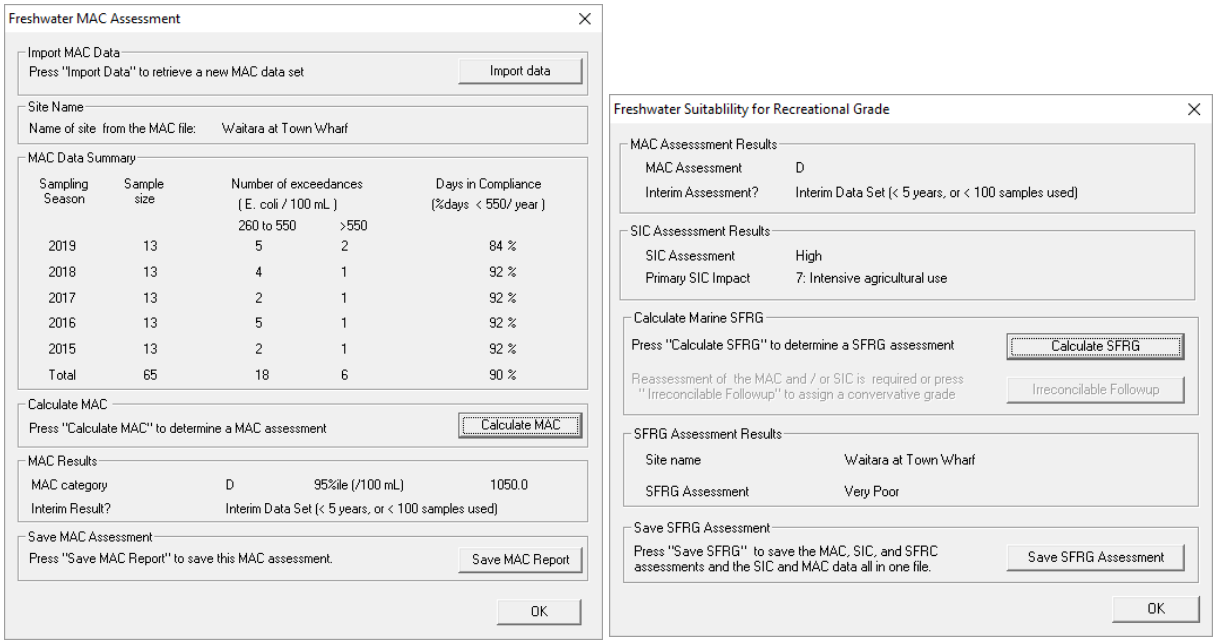
Timaru Stream at Weld Road



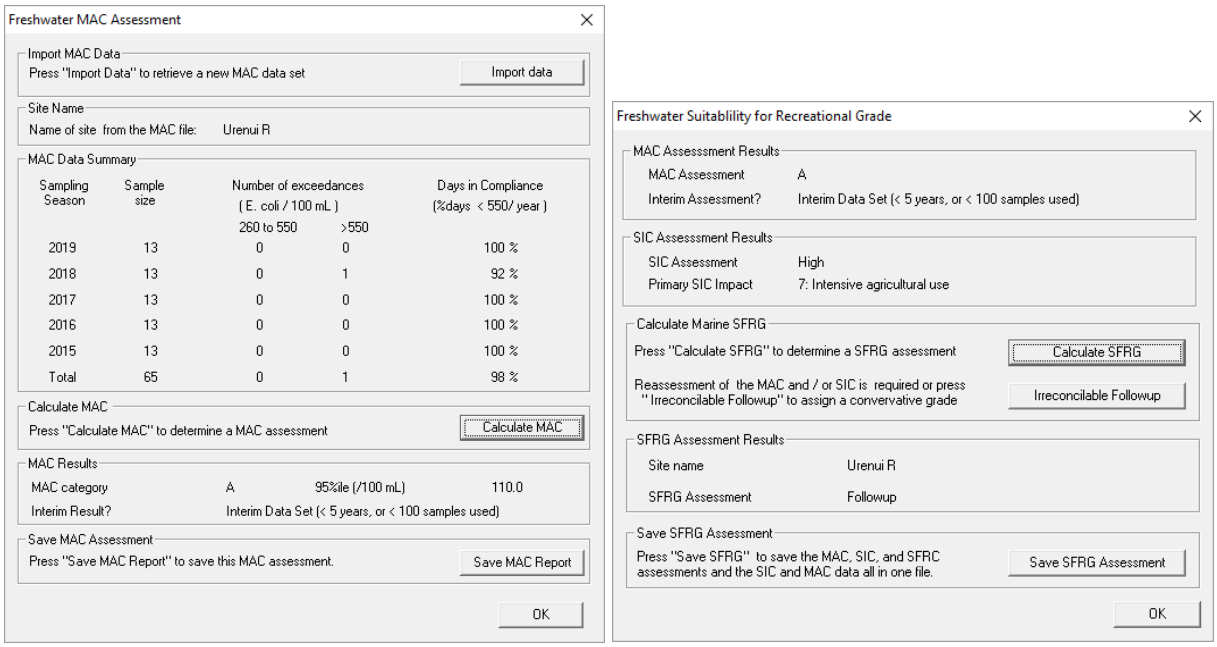
Oakura River d/s SH45



Waitara River

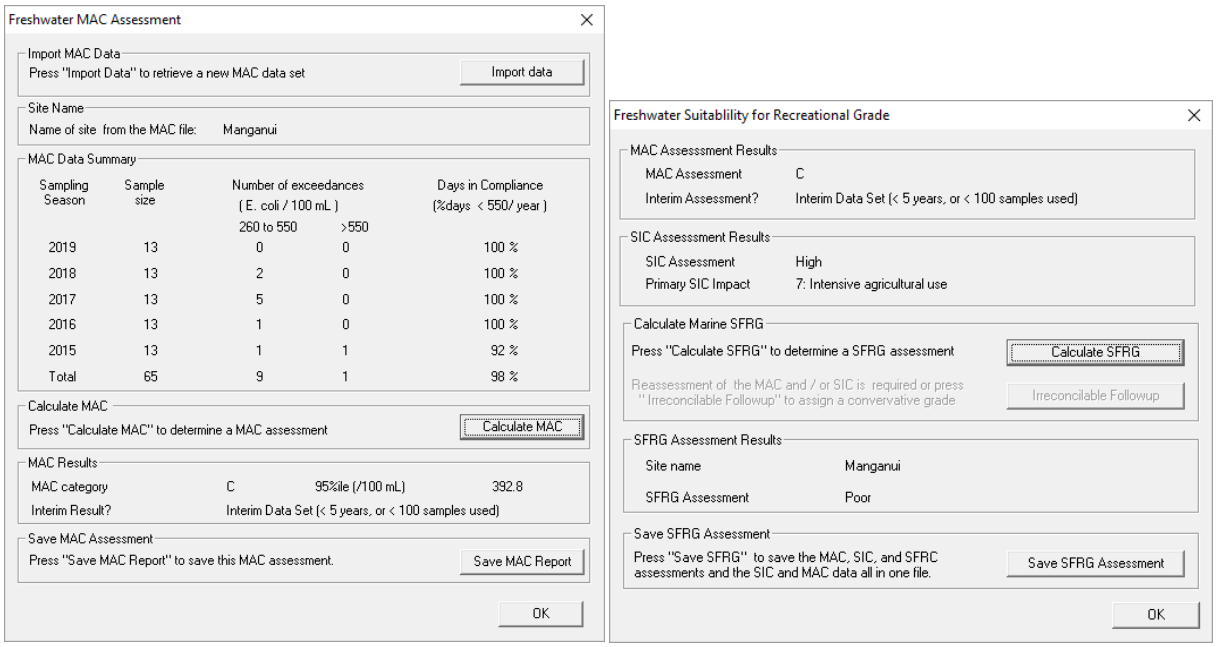


Urenui River at estuary



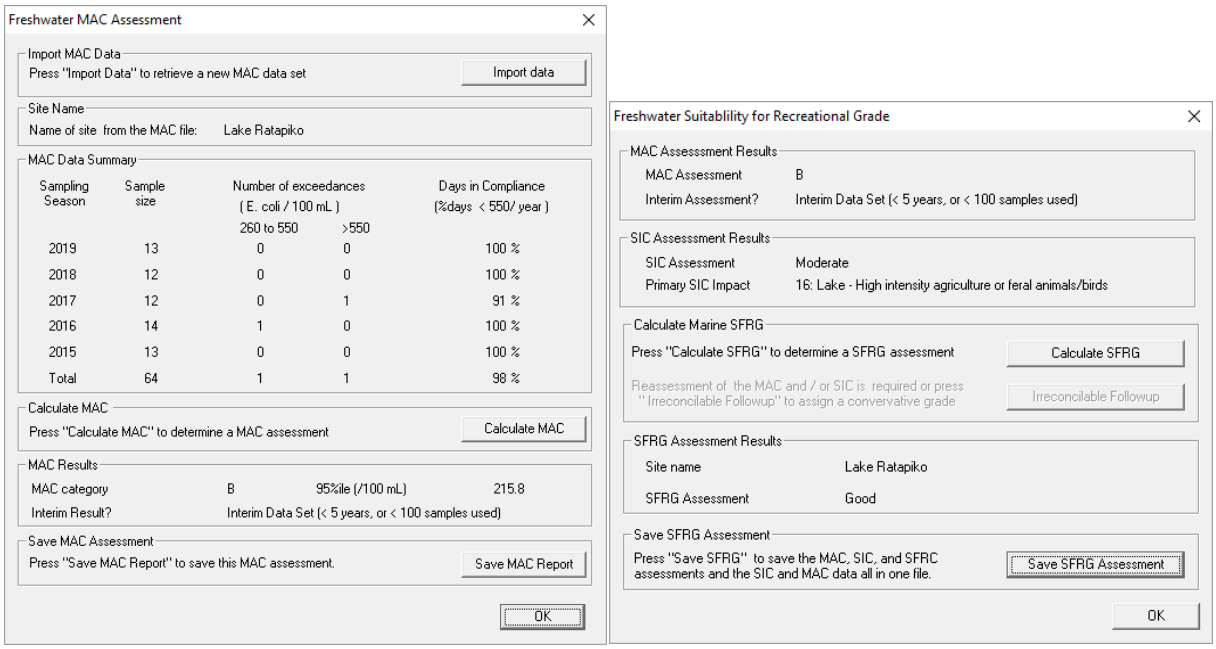
Urenui River was Follow up, irreconcilable follow-up and SFRG Assessment resulted in Poor

Manganui River at Everett Park



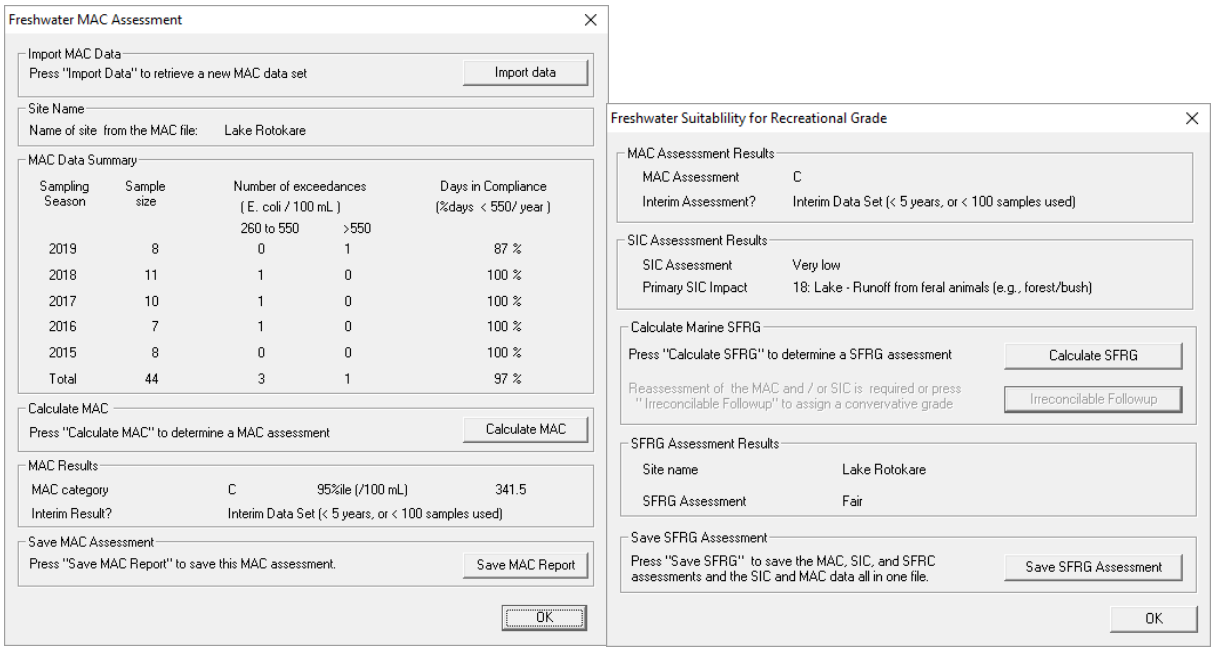
Lake Ratapiko was Follow up, irreconcilable follow-up and SFRG assessment resulted in Fair

Lake Ratapiko



Lake Ratapiko was Follow up, irreconcilable follow-up and SFRG assessment resulted in Poor

Lake Rotokare



Lake Rotokare was Follow up, irreconcilable follow-up and SFRG assessment resulted in Fair.

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
07 Nov 2018	SEM	Fine, overcast	8/8	None, sandy bottom	Turbid, brown	Rippled	0/0	5 ducks on water, 4 on bank; TRC signage ok, NPDC sign green	0	0
10 Dec 2018	SEM	Fine	1/8	N/A	Turbid, green-brown	Flat	0/2 (school group at far shore)	Ducks common; NPDC signs red (cyanobacteria). School group advised to contact TDHB	0	0
18 Dec 2018	MFE	Fine	0/8	Too turbid to see	Turbid, brown	Rippled	3/20 (boating, shore)	No birdlife; NPDC signs red	0	0.2
27 Dec 2018	MFE	Fine	5/8	N/A	Turbid, brown	Rippled	5/10	7 ducks, 2 on water; NPDC signs red	0	13.2
03 Jan 2019	MFE	Fine, overcast	8/8	Too turbid to see	Turbid, brown	Rippled	5/15 (boating, shore)	Ducks common; NPDC signs red	0	0
07 Jan 2019	SEM	Fine, overcast	8/8	N/A	Turbid, brown	Rippled	3/5 (jet-ski,; 5 onshore)	No birdlife; 2 NPDC signs red	0.2	0.2
10 Jan 2019	SEM	Fi8ne, overcast	8/8	N/A	Turbid, ,brown	Rippled	2/4 (jet-skis ~4 onshore)	4 ducks on water, NPDC signs red	0.8	1.0
17 Jan 2019	MFE	Fine	0/8	N/A	Turbid, brown	Rippled	3/14 (wake-boarding)	Ducks common, NPDC signs red	0	11.0
21 Jan 2019	SEM	Fine, overcast	8/8	N/A	Turbid, ,green-brown	Rippled	2/0 (swimmers)	Ducks common NPDC sign green	0.8	1.4
23 Jan 2019	SEM	Fine	6/8	N/A	Turbid, brown	Rippled	4/0 (4 in 2 boats)	Ducks v common, NPDC sign green	0	1.0
30 Jan 2019	MFE	Fine	8/8	N/A	Turbid, brown	Rippled	2/0 (swimmers)	Ducks common, 2 gulls, NPDC sign orange	0	0.8
04 Feb 2019	SEM	Fine	1/8	Too deep and turbid	Turbid, brown	Flat	0/2 (jet-ski, unmanned)	5 ducks on water, 3 gulls,; NPDC sign green	0	0.2
11 Feb 2019	SEM	Fine	0/8	N/A	Turbid, brown	Rippled	4/9 (boating, shore)	4 ducks, 10 gulls on banks NPDC sign green	0	0
19 Feb 2019	SEM	Fine	0/8	N/A	Turbid, brown	Rippled	0/5 (on bank, 1 dog)	Ducks v. common, gulls common; NPDC sign green	0	0.2

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
21 Feb 2019	SEM	Fine, overcast	8/8	N/A	Turbid, brown	Rippled	0/0	5 ducks on water; NPDC sign green	1.0	1.0
28 Feb 2019	MFE	Fine, strong SE wind	1/8	N/A	Turbid, brown	Choppy	0/2 (walkers)	2 gulls on water; NPDC signs orange	0	0
05 Mar 2019	SEM	Fine	8/8	N/A	Turbid, brown-green	Flat	0/1 (dog-walker)	5 ducks on water NPDC sign green	0	0
07 Mar 2019	SEM	Fine, very light N breeze	1/8	N/A	Turbid, brown	Rippled	0/0	1 gull; NPDC sign green	0	0
13 Mar 2019	MFE	Spitting	8/8	N/A	Turbid, dark green	Flat	0/0	1 duck, 7 gulls on bank; NPDC sign green. Horse manure on bank	19.8	20.4
18 Mar 2019	FOLLOW UP	Fine, light W wind	6/8	N/A	Turbid, brown	Flat	0/2 (fishing)	10 ducks on water, gulls common; NPDC sign orange. Lake level very low.	0	0
20 Mar 2019	SEM	Fine	1/8	N/A	Slightly turbid, brown	Flat	0/2 (1 fishing, picnic 1 at picnic tablel	Ducks and gulls common on bank; NPDC sign orange	0	0
22 Mar 2019	FOLLOW UP	Fine	5/8	N/A	Slightly turbid, brown	Flat	0/0	Ducks common, NPDC sign green	0	0
26 Mar 2019	MFE	Moderate N breeze	8/8	N/A	Turbid, brown	Rippled	0/0	4 ducks and gulls v common on bank; NPDC sign green	2.6	3.2
20 Jun 2019	FOLLOW UP	Fine, easterly	1/8	N/A	Clear, dark brown-green tinge	Rippled	0/1 (dog walker)	Ducks on far side of lake; NPDC sign red	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
07 Nov 2018	SEM	Rain starting	8/8	70% thin brown mat	Clear, colourless	D/S	0/0	TRC swimming and didymo signage present, no birdlife	0	0
10 Dec 2018	SEM	Fine	1/8	5% thick	Clear, brown-yellow tinge	D/S	0/0	No birdlifre	0	0
18 Dec 2018	MFE	Fine, breeze	3/8	10% long; 5% thick.	Clear, green-brown	D/S	0/4 (walkers with 6 dogs)	No birdlife, NPDC sign green	0	4.5
27 Dec 2018	MFE	Fine	4/8	5% long, 5% thick, 80% cover	Clear, green-brown	D/S	0/17 (on bank, 1 dog)	NPDC sign green; no birdlife	0	26.0
03 Jan 2019	MFE	Overcast	7/8	5% long, 5% thick, 80% cover	Clear, brown	D/S	0/5 (banks)	NPDC sign green, no birdlife	1.0	1.0
07 Jan 2019	SEM	Overcast	8/8	5% long, 5% thick, 80% cover	Clear, green	D/S	0/0	NPDC sign green, no birdlife	0	0
10 Jan 2019	SEM	Light drizzle	8/8	20% long, 10% thick, 80% cover	Clear, green	D/S	0/5 (banks)	Temporary NPDC sign red, permanent u/s sign orange	3.0	3,0
17 Jan 2019	MFE	Fine	0/8	10% long, 10% thick, 85% cover	Clear, green	D/S	0/1 (walking dog)	New NPDC sign pointer missing, old sign green; no birdlife	0	19.0
21 Jan 2019	SEM	Spitting	8/8	1% long, 0% thick, 60% cover	Clear, green-brown	D/S	0/0	NPDC sign green; no birdlife	2.5	5.0
23 Jan 2019	SEM	Fine	4/8	5% long, 0% thick, 80% cover	Clear, green-brown	D/S	0/0	NPDC sign green; no birdlife	0	2.5
30 Jan 2019	MFE	Fine, overcast	8/8	30% long, 15% thick, 80% cover	Clear, brown	D/S	0/0	NPDC sign green; no birdlife; water level low; algal mats exposed	0	0
04 Feb 2019	SEM	fine	1/8	10% long, 1% thick, 100% cover	Clear, yellow-brown	D/S	0/1 (bank)	NPDC sign green, no birdlife	0	1.0
11 Feb 2019	SEM	Fine	0/8	35% long, 20% thick, 90% cover	Slightly Turbid,brown-Green	D/S	3/5 (swimming, banks)	NPDC green, no birdlife,	0	0
19 Feb 2019	SEM	Fine	0/8	60% long, 30% thick	Slightly turbid, green-brown	D/S	0/0	NPDC sign green; no birdlife	0	0

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
21 Feb 2019	SEM	Light rain	8/8		Slightly turbid, green	D/S	0/4 (banks, 1 dog)	NPDC sign green; 1 duck d/s	3.0	3.0
28 Feb 2019	MFE	Fine, light SE breeze	0/8		Clear, uncoloured	D/S	0/2 (fishing, sunbathing)	NPDC sign green no birdlife	0	0
05 Mar 2019	SEM	Fine, overcast	8/8	20% long, 0% thick, 100% cover	Clear, yellow-brown	D/S	0/0	NPDC sign green; no birdlife	0.5	1.0
07 Mar 2019	SEM	Fine, light N breeze	2/8	30% long, 0% thick	Clear, uncoloured	D/S	0/0	River high, NPDC sign green, 2 ducks u/s	0	0
13 Mar 2019	MFE	Spitting, rain preceding	8/8	0% long, 0% thick	Turbid, dark brown	D/S	0/0	NPDC sign yellow	43.5	43.5
18 Mar 2019	FOLLOW UP	Fine	7/8	0% long, 0% thick	Clear, light brown	D/S	0/3 (walking 1 dog)	NPDC orange; no birdlife	0	0
20 Mar 2019	SEM	Fine	4/8	5% long, 0% thick, 100% cover	Clear, yellow-brown	D/S	0/0	NPDC signs red (temp.) and orange, no birdlife	0	0
25 Mar 2019	MFE	Fine	7/8	5% long, 0% thick	Clear, brown-yellow	D/S	0/0	NPDC signs green; no birdlife	10.0	10.0

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
07 Nov 2018	Overcast, N wind	8/8	10% thick brown mats	Clear, colourless	D/S	0/3 (whitebaiters)	Permanent TDHB warning sign, NPDC sign permanently orange, TRC monitoring sign;, gulls common u/s	0	0
10 Dec 2018	Fine	1/8	60%	Clear, yellow-brown	D/S	0/1 (dog walker)	Gull colony u/s, 2 ducks	0	0
07 Jan 2019	Drizzle	8/8	5%	Clear, blue-grey	U/S	0/0	3 shags	0	0
10 Jan 2019	Overcast	8/8	20%	Clear, green	D/S	0/0	4 ducks, 1 shag, 1 dead gull	3.0	3.0
21 Jan 2019	Overcast	8/8		Slightly turbid, grey brown	D/S	0/0	Gull colony u/s, 2 shags	2.5	5.0
23 Jan 2019	Fine	6/8		Slightly turbid, green	D/S	0/0	5 ducks, 1 shag	0	2.5
04 Feb 2019	fine	1/8	100%, short	Clear, brown-green	D/S	0/0	Gull colony u/s, 15 ducks d/s	0	1.0
11 Feb 2019	Fine	0/8		Turbid, brown-green	D/S	10/0 (swimming mid-afternoon)	No birdlife	0	0
19 Feb 2019	Fine	0/8		Slightly turbid, ,green	U/S	0/0	2 ducks, 1 shag	0	0
21 Feb 2019	Light rain	8/8		Slightly turbid, green-brown	D/S	0/0	10 ducks, 1 shag u/s	3.0	3.0
05 Mar 2019	Fine	8/8	100%, short brown-green	Clear, yellow-brown	D/S	2 dog walkers/nil	Gull colony d/s below bridge	0.5	1.0
07 Mar 2019	Fine, N zephyr	0/8		Clear, uncoloured	D/S	0/0	1 duck, 1 gull u/s	0	0
20 Mar 2019	Fine	1/8	100%	Clear, yellow-green	D/S	0/0	Gull colony u/s	0	0

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
07 Nov 2018	Fine, overcast, N wind	8/8	N/A	Turbid, green	D/S	0/5 (bank)	Permanent TDHB warning sign, ducks v common	0	0
10 Dec 2018	Fine	2/8	N/A	Clear, green-yellow	Surging	0/3 (bank)	Two permanent NPDC warning signs, TRC monitoring sign, ducks common, 1 goose	0	0
07 Jan 2019	Fine, overcast	8/8	N/A	Clear, grey-green	U/S	0/0	6 ducks, 9 gulls	0.4	0.4
10 Jan 2019	Fine, overcast	8/8	N/A	Clear, green-grey	D/S	0/1 dog	No birdlife	1.8	2.2
21 Jan 2019	Fine, overcast, slight W wind	8/8	N/A	Turbid, dark green	D/S	0/0	2 gulls, very high water	0.4	1.4
23 Jan 2019	Fine	3/8	N/A	Slightly turbid, green	U/S, surging	0/2 (bank)	Gulls common on bank, 1 dead	0	0.4
04 Feb 2019	Fine	1/8	N/A	Slightly turbid, orange-brown	D/S	0/0	2 ducks u/s, 1 duck d/s, 1 gull	0	0
11 Feb 2019	Fine	0/8	N/A	Slightly turbid, brownish	D/S	8/3 (8 + 2 dogs in water, 3 on bank)	Gulls common d/s	0	0
19 Feb 2019	Fine	1/8	N/A	Turbid, green	U/S	0/1 with 3 dogs	4 ducks	0	0
21 Feb 2019	Fine, overcast	8/8	N/A	Turbid, green	D/S	0/3 (1 fishing, 2 walking)	Ducks common u/s	1.2	1.2
05 Mar 2019	Fine, overcast	8/8	N/A	Turbid, dark green	D/S	0/x (family picnic)	Ducks common u/s + d/s, gulls v common d/s	0	0
07 Mar 2019	Fine, very light N breeze	0/8	N/A	Turbid, green-brown	Slack	0/0	Repair works on foot bridge, ducks v common u/s, gulls d/s	0	0.
20 Mar 2019	Fine	1/8	25% green	Turbid, green-brown	D/S	0/1 (bank)	Ducks v common	0	0.5

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
07 Nov 2018	SEM	Drizzle	8/8	5% thin green	Clear, slight brown	D/S	0/0	TRC monitoring sign fallen,, no birdlife	0	0
10 Dec 2018	SEM	Fine, slight S breeze	5/8	Thin green-brown mats	Clear, green	D/S	0/0	No birdlife	0	0
07 Jan 2019	SEM	Fine	2/8	Nil	Slightly turbid, brown-green	D/S	0/0	No birdlife	0	0
10 Jan 2019	SEM/ FOLLUP	Fine, overcast	8/8	20% thick	Slightly turbid, brown	D/S	0/1 (fishing)	High count follow-up, TRC sign missing, no birdlife	0	0
21 Jan 2019	SEM	Light rain, l. W wind	8/8	50% long	Clear,, uncoloured	D/S	0/0	No birdlife	0	2.5
23 Jan 2019	SEM	Fine	3/8	15% thick	Slightly turbid, brown tinge	D/S	0/0	No birdlife	0	1.0
04 Feb 2019	SEM	Fine	4/8	Nil	Clear, brown	D/S	0/0	No birdlife, cicadas loud	0	0
11 Feb 2019	SEM	Fine, calm	0/8	5% long	Clear, uncoloured	D/S	0/0	No birdlife	0	0
19 Feb 2019	SEM	Fine, overcast, light N wind	7/8	Nil	Clear, uncoloured	D/S	0/0	No birdlife	0	0
21 Feb 2019	SEM	Fine, overcast, l. N ly	8/8	5% thick	Clear, brown	D/S	0/0	No birdlife	0	0
05 Mar 2019	SEM	Fine, overcast	8/8	Nil	Clear, brown	D/S	0/0	No birdlife	0	0
07 Mar 2019	SEM	Fine	3/8	Nil	Clear, brown	D/S	0/0	1 duck	0.5	0.5
20 Mar 2019	SEM	Fine, calm	2/8	20% thick	Clear, uncoloured	D/S	0/0	7 ducks	0	2.0
22 Mar 2019	FOLL UP	Fine, overcast, calm	8/8	20% thick green	Clear, uncoloured	D/S	0	SDC warning sign, no birds	0	0

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
07 Nov 2018	Fine, mod N wind	0/8		Turbid, light green	Swirling	0/2 (fishing)	TRC monitoring sign in place, no birdlife	0	0
10 Dec 2018	Fine, light wind	0/8		Slightly turbid, pale green	U/S	0/2 (bank)	No birdlife.	0	0
07 Jan 2019	Fine, overcast	7/8		Turbid, green	D/S	0/0	STDC sign in place, no birdlife	0	0
10 Jan 2019	Fine, overcast	8/8		Turbid, green	U/S	0/0	No birdlife	0.5	1.0
21 Jan 2019	Fine	7/8		Turbid, green	D/S	0/0	No birdlife	0	3.0
23 Jan 2019	Fine, light breeze	1/8		Turbid, green	D/S	0/1 (with dog)	No birdlife	0	0
04 Feb 2019	Fine, light breeze	8/8		Turbid, grey green	D/S	1/0 (swimming d/s)	No birdlife, cicadas	0	4.0
11 Feb 2019	Fine, light S breeze	0/8		Clear, light green	U/S	0/10+15 fishing boats at ramp	No birdlife	0	0
19 Feb 2019	Fine, light N breeze	2/8		Slightly turbid, light green	D/S	0/0	No birdlife, surging u/s	0	0
21 Feb 2019	Fine	8/8		Slightly turbid, turquoise	U/S	0/0	No birdlife	0	0
05 Mar 2019	Fine, light N breeze	7/8		Turbid, grey-blue	D/S	0/0	No birdlife, swirling	0	0
07 Mar 2019	Fine, strong N breeze	1/8		Turbid, grey-blue	D/S	0/1 (sitting)	No birdlife	0	0
20 Mar 2019	Fine, slight breeze	2/8		Turbid, grey-green	U/S	2/0 (in boat)	No birdlife	0	0

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
07 Nov 2018	SEM	Fine, strong N wind	1/8	15% thin green/brown	Clear, slightly green	D/S	0/0	TRC monitoring sign, no birdlife, sheep in adjacent paddock	0	0
10 Dec 2018	SEM	Fine, slight S breeze	6/8	5% long	Clear, green	D/S	0/0	No birdlife, sheep in paddock	0	0
07 Jan 2019	SEM	Fine	2/8	10% long, 20% thick	Slightly turbid, green-brown	D/S	0/0	STDC sign, no birdlife, foam and sheen build-up	0	0
10 Jan 2019	SEM	Fine, overcast	8/8	10% long, 10% thick	Slightly turbid, brown-green	D/S	0/0	No birdlife	0	0
21 Jan 2019	SEM	Fine, overcast	8/8	5% long, 10% thick	Slightly turbid, brown	D/S	0/0	No birdlife	0	2.5
23 Jan 2019	SEM	Fine	1/8	20% long, 20% thick	Slightly turbid, brown	D/S	0/0	No birdlife	0	1.0
04 Feb 2019	SEM	Fine	3/8	5% long, 5% thick	Clear, brown	D/S	0/0	No birdlife, sheep	0	0
11 Feb 2019	SEM	Fine	0/8	5% long	Clear, brown	D/S	0/0	No birdlife	0	0
19 Feb 2019	SEM	Fine, calm	0/8	5% long	Clear, green	D/S	0/0	No birdlife	0	0
21 Feb 2019	SEM	Fine, overcast, light N ly	8/8	10% long, 5% thick	Clear, brown green	D/S	0/0	No birdlife	0	0
05 Mar 2019	SEM	Spitting	7/8	20% long	Clear, brown	D/S	0/0	No birdlife, sheep grazing	0	0.5
07 Mar 2019	SEM	Fine	1/8	25% long	Clear, brown	D/S	0/0	No birdlife. sheep in adjacent paddock	0.5	0.5
20 Mar 2019	SEM	Fine, light E breeze	4/8	10% long	Clear, brown tinge	D/S	0/0	No birdlife. sheep present.	0	0

Site Waingongoro River, near mouth (Site Code: WGG000995) 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
07 Nov 2018	SEM	Fine, windy NE	7/8	Nil	Clear, green tinge	D/S,	0/2 (fishing)	TRC monitoring sign, no birdlife	0	0.5
10 Dec 2018	SEM	Fine, light breeze	0/8	Thin brown mats	Clear, green-brown	D/S, u/s surging	0/0	1 pied shag	0	0
18 Dec 2018	MFE	Fine, breeze	3/8	Nil	Slightly turbid, green-brown		0/0	STDC sign, no birdlife	0	0
27 Dec 2018	MFE	Fine, overcast	7/8	100% thick	Slightly turbid, brown		0/0	No birdlife	0	15.0
03 Jan 2019	MFE	Fine	5/8	100% thick	Slightly turbid, brown	D/S	0/0	1 duck, 4 ducklings, 1 heron	0	0
07 Jan 2019	SEM	Fine, overcast	8/8		Slightly turbid, grey-Brown	U/S, surging	0/0	3 ducks u/s	0	0
10 Jan 2019	SEM	Fine	6/8		Slightly turbid, brown	D/S	3/2 (swimming/bank)	No birdlife	0	0.5
17 Jan 2019	MFE	Fine	6/8	Nil	Slightly turbid, brown	D/S	0/0	No birdlife	0	33.5
21 Jan 2019	SEM	Fine, overcast	8/8		Slightly turbid, brown-green	D/S	0/0	No birdlife	2.5	5.5
23 Jan 2019	SEM	Fine, light breeze	1/8		Slightly turbid, light brown	U/S	0/2 (bank)	No birdlife	0	3.0
30 Jan 2019	MFE	Fine	7/8	10% thick	Clear, brown tinge	D/S	1/3 (swimming/bank) 1 dog	No birdlife	0	0
04 Feb 2019	SEM	Fine, light breeze	1/8	5% thick	Clear, brown	D/S	0/0	No birdlife, cicadas heard	0	1.0
11 Feb 2019	SEM	Fine	1/8	10% thick, 5% long	Clear, brown	U/S	4/0 (swimming with dog)	No birdlife	0	0
19 Feb 2019	SEM	Fine, light N breeze	1/8	Nil	Clear, brown-green	D/S	0/0	1 duck u/s	0	0
21 Feb 2019	SEM	Fine, overcast	8/8	10% thick	Slightly turbid, brown	D/S, u/s surges	0/0	2 ducks u/s	0	0

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
01 Mar 2019	MFE / FOLLUP	Fine	0/8	10% long	Clear, brown	D/S	0/0	No birdlife	0	1.5
05 Mar 2019	SEM	Fine, overcast	8/8	10% long	Slightly turbid, brown	D/S	0/0	Cows on bank 75m u/s, no birdlife	0	0
07 Mar 2019	SEM	Fine, light wind	1/8	10% long	Clear, brown	D/S, pooling	0/0	No birdlife	0	0
12 Mar 2019	FOLLOW UP	Fine, light W wind	7/8	40% thick	Clear, light brown	D/S	0/0	4 ducks d/s, abundant detached algal mats	6.5	6.5
13 Mar 2019	MFE	Fine, rainfall o/night, cool SW wind	8/8	40% thick	Slightly turbid, brown	D/S	0/0	No birdlife	0	6.5
20 Mar 2019	SEM	Fine, E breezy	0/8	Nil	Clear, brown	D/S	0/0	No birdlife	0	0
25 Mar 2019	MFE	Fine, light N breeze	4/8	60% thick	Slightly turbid, green	D/S	0/0	No birdlife	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
07 Nov 2018	SEM	Fine, strong N wind	6/8	Nil	Clear, green tinge	D/S	0/3 (banks)	TRC monitoring sign, no birdlife	0	0.5
10 Dec 2018	SEM	Fine, gusty breeze	6/8	Thin brown mats	Clear, green-brown	U/S		3 ducks u/s	0	0
18 Dec 2018	MFE	Fine	1/8		Clear, uncoloured	U/S	2/3 (swimming/banks)	3 ducks	0	0
27 Dec 2018	MFE	Fine, overcast	6/8		Clear, grey-brown	U/S	0/2 (children on banks)	STDC monitoring sign, no birdlife	0	15.0
03 Jan 2019	MFE	Fine	4/8		Slightly turbid, grey-green	U/S, surging	0/9 (3 fishing)	No birdlife	0	0
07 Jan 2019	SEM	Fine, overcast	7/8		Slightly turbid, green	U/S	4/0 (children swimming u/s)	3 ducks u/s	0	0
10 Jan 2019	SEM	Fine, overcast	7/8		Slightly turbid, brown-green	D/S	9/7 (swimming, 2 fishing,) all d/s	No birdlife	0	0.5
17 Jan 2019	MFE	Fine	6/8	0% long, 5% thick	Slightly turbid, brown	D/S	0/4 (banks)	2 ducks u/s	0	33.5
21 Jan 2019	SEM	Fine, overcast	8/8	10% thick	Slightly turbid, brown	Slack	0/0	Large amounts of suspended algae. Dog reported sick after swimming. No birdlife.	2.5	5.5
23 Jan 2019	SEM	Fine	0/8	20% thick	Turbid, brown-green	U/S	12/15 (swimming/banks)	Suspended brown algae. No birdlife	0	3.0
30 Jan 2019	MFE	Fine	7/8	10% thick	Slightly turbid, brown	U/S	3/2 (swimming, banks with dog)	Thin green mats widespread, no birdlife, 1 dog	0	0
04 Feb 2019	SEM	Fine, light breeze	3/8		Clear, slight brown	U/S	0/0	No birdlife, cicadas	0	1.0
11 Feb 2019	SEM	Fine	1/8		Clear, brown	U/S	0/1 (dog walking)	1 dog	0	0
19 Feb 2019	SEM	Fine, light NW wind	1/8	Nil	Slightly turbid, green	D/S, surging u/s	2/8 (swimming, banks with 1 dog)	2 ducks & 1 shag u/s	0	0

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
21 Feb 2019	SEM	Fine, overcast	8/8	10% thick	Slightly turbid, brown	U/S	0/0	2 ducks	0	0
01 Mar 2019	MFE/ FOLLUP	Fine, breezy	0/8		Clear, slight brown	U/S	0/0	No birdlife, no STDC sign	0	1.5
05 Mar 2019	SEM	Fine, overcast, breezy	8/8		Clear, brown-green	U/S, pooling	0/10 (chatting on grass carpark bank)	No birdlife, no STDC sign	0	0
07 Mar 2019	SEM	Fine, strong N breeze	1/8		Clear, brown	D/S	0/2 (picnic on grass side)	1 ducks	0	0
13 Mar 2019	MFE	Light rain, light NW breeze	8/8	Nil	Slightly turbid, green	D/S	0/0	Rainfall preceding, no birdlife	0	6.5
20 Mar 2019	SEM	Fine, moderate S breeze	1/8	Nil	Clear, brown	U/S	0/5 (picnic on carpark side)	No birdlife	0	0
22 Mar 2019	FOLLOW UP	Fine, light S wind	1/8	Nil	Clear, green	U/S	0/2 (riding horses)	No birdlife	0	0
25 Mar 2019	MFE	Fine, light N breeze	1/8		Clear, brown	D/S	0/1(bank)	5 ducks u/s, 2 ducks d/s	0	10

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

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
07 Nov 2018	SEM	Fine, fairly strong NE wind	1/8	Nil	Slightly turbid, green	Rippled	0/0	TRC monitoring sign, 5 ducks on water, 2 on shore	0	1.0
10 Dec 2018	SEM	Fine, overcast, windy	5/8	Nil	Clear, green	Rippled	0/0	Few ducks	0	0
07 Jan 2019	SEM	Fine, overcast	8/8	5% long	Slightly turbid, brown-green	Flat	0/0	STDC sign (new). TRC sign gone. Ducks common. Areas of sheen	0	1.0
10 Jan 2019	SEM	Fine	6/8	10% long	Turbid, brown	Flat	0/0	Few ducks	0	1.0
21 Jan 2019	SEM	Fine, overcast	8/8	Nil	Slightly turbid, brown-green	Rippled	0/0	Few ducks	3.0	6.0
23 Jan 2019	SEM	Fine	6/8		Slightly turbid, green-brown	Rippled	0/2 (banks)	No birdlife	0	3.0
30 Jan 2019	FOLLOW UP	Fine	5/8		Slightly turbid, brown	Rippled	0/0	Ducks common	0	1.5
04 Feb 2019	SEM	Fine	2/8		Turbid, dark brown-grey	Flat	0/3 (2 sunbathing, 1 fishing)	Ducks common	0	0.5
11 Feb 2019	SEM	Fine	1/8		Turbid, green	Rippled	0/1+ (tent)	Few ducks	0	0
19 Feb 2019	SEM	Fine, light N wind	4/8	Nil	Slightly turbid, dark green	Flat	0/0	TRC sign restored, few ducks	0	0
21 Feb 2019	SEM	Fine	8/8	Nil	Turbid, brown-green	Rippled	0/2	Ducks common	0	0
28 Feb 2019	FOLLOW UP	Fine, windy E	1/8	Nil	Turbid, green-brown	Rippled	0/0	Ducks common	2.0	2.0
05 Mar 2019	SEM	Fine, overcast	8/8		Turbid, dark grey	Flat	0/0	Few ducks	0	0
07 Mar 2019	SEM	Fine, light ME breeze	2/8		Slightly turbid, brown	Flat	0/0	Few ducks, 1 eel	0	2.0
20 Mar 2019	SEM	Fine, SE wind	1/8		Clear, green		0/3 (feeding ducks)	Ducks common	0	0

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
07 Nov 2018	SEM	Fine, overcast, NE wind	7/8	Nil	Clear, colourless	D/S, u/s surging	0/0	NPDC sign green, TRC sign, no birdlife	0	0
12 Nov 2018	FOLLOW UP	Fine, calm	1/8	Nil	Clear, green-brown	D/S	0/3 (bank) 2 dogs, 1 in water	NPDC sign orange, few gulls	0	15.5
10 Dec 2018	SEM	Fine	1/8	Nil	Clear, slight brown tinge	D/S	3/2	NPDC sign green, 2 oystercatchers u/s, horse dung high on beach	0	0
07 Jan 2019	SEM	Spitting	8/8	Nil	Clear, green-grey	Slack	9/5 (swimming, banks)	NPDC sign green, no birdlife	2.0	2.0
10 Jan 2019	SEM	Fine, overcast	8/8	Nil	Clear, dark grey	D/S	0/3	NPDC sign green, no birdlife	1.5	3.0
21 Jan 2019	SEM	Fine	2/8	Nil	Clear, green	D/S	0/0	NPDC sign green, 2 gulls	3.5	6.0
23 Jan 2019	SEM	Fine, overcast	7/8	Nil	Slightly turbid, green	U/S	4/2 (swimming, bank)	NPDC sign green, few gulls	0	3.5
04 Feb 2019	SEM	Fine	1/8	Nil	Clear, slight brown tinge	U/S	2/0 (paddle boarders) 1 dog.	NPDC sign green, no birdlife, camping on opp. paddock	0	2.5
11 Feb 2019	SEM	Fine	0/8		Slightly turbid, blue	D/S	0/1 walking 2 dogs	NPDC sign green, no birdlife	0	0
19 Feb 2019	SEM	Fine	6/8		Slightly turbid, grey	D/S	0/0	NPDC sign green, no birdlife	0	0
21 Feb 2019	SEM	Fine, overcast	8/8	.	Clear, uncoloured	D/S	0/0	NPDC sign green, gulls common, terns, oystercatchers	0	0
28 Feb 2019	FOLLOW UP	Fine, still	5/8		Clear, uncoloured	D/S low tide	0/0	NPDC sign orange, 1 shag, 2 swallows	1.0	1.5
05 Mar 2019	SEM	Fine	6/8	Nil	Clear, colourless	D/S	0/2 surfers coming in	NPDC green, no birdlife, brown particulate/debris on bed	0	0
07 Mar 2019	SEM	Fine, still	5/8		Clear, uncoloured	Slack	0/1 (jogger)	NPDC sign green, gulls common	0	0.5

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
20 Mar 2019	SEM	Fine	3/8		Clear, colourless	U/S surging	0/0	NPDC sign green, no birdlife, 2 dogs	0	0
22 Mar 2019	FOLLOW UP	Fine	5/8	Nil	Clear, uncoloured	D/S	0/4 (walkers, 1 dog)	NPDC sign orange, 1 shag	0	0

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
07 Nov 2018	SEM	Fine, calm	6/8	Nil	Clear, colourless	D/S	0/1 (whitebaiting)	TRC sign, no birdlife	1.5	3.0
10 Dec 2018	SEM	Fine	1/8	Nil	Clear, slight green	D/S	0/5 (banks with 2 dogs)	NPDC sign green	0	0
07 Jan 2019	SEM	Fine, overcast	8/8	Nil	Clear, green	U/S	0/0	NPDC sign green, no birdlife	0.4	0.4
10 Jan 2019	SEM	Fine, overcast	8/8	Nil	Clear, green	U/S	3/3	NPDC sign.green, no birdlife	1.8	2.2
21 Jan 2019	SEM	Fine	3/8	Nil	Clear, green	D/S	3/6 (swimming, banks)	NPDC sign green, no birdlife, 1 dog	0.4	1.4
23 Jan 2019	SEM	fine	7/8		Slightly turbid, green	D/S	10/12 (swimming, bank)	NPDC sign green, no birdlife	0	0.4
04 Feb 2019	SEM	fine, still	5/8		Clear, slight brown tinge	U/S	4/0 (swimming)	NPDC green, no birdlife, brown deposit on bed	0	0
11 Feb 2019	SEM	Fine	0/8		Clear, green	D/S	6/15 (swimming/banks)	NPDC sign green, no birdlife	0	0
19 Feb 2019	SEM	Fine	6/8		Slightly turbid, green	U/S	0/6 (banks)	NPDC sign green, a shag	0	0
21 Feb 2019	SEM	Fine	8/8		Clear, uncoloured	D/S	0/0	NPDC green, 2 ducks	1.2	1.2
28 Feb 2019	FOLLOW UP	Fine, light S breeze	1/8	Nil	Clear, uncoloured	Slack	0/7 (freedom campers)	NPDC orange, no birdlife	0	0
05 Mar 2019	SEM	Fine	8/8	Nil	Clear, brown-green tinge	U/S	0/0	NPDC green, 3 ducks	0	0
07 Mar 2019	SEM	Fine, still	3/8		Clear, uncoloured	Slack	0/1 (camping)	NPDC green, 3 ducks, thick sludge at edge, silt on bed	0	0
20 Mar 2019	SEM	Fine	2/8	Nil	Slightly turbid, grey-brown	D/S	0/0	NPDC green, no birdlife, brown sludge caked on bed	0	0

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
07 Nov 2018	SEM	Fine, overcast	8/8	N/A	Turbid, brown	D/S	0/3 (whitebaiters)	NPDC sign green, TRC sign, 3 ducks	0	0.5
10 Dec 2018	SEM	Fine	0/8	N/A	Turbid, brown	D/S	0/2 walking/0	6 ducks	0	0
07 Jan 2019	SEM	Fine, overcast	8/8	N/A	Turbid, green-brown	D/S	0/0	NPDC sign green, 1 duck	0	0
10 Jan 2019	SEM	Fine, overcast	8/8	N/A	Turbid, green-brown	D/S	0/1 walking	5 ducks, 1 gull	1.0	1.0
21 Jan 2019	SEM	Fine, overcast	7/8	N/A	Turbid, green	D/S	2/6 (swimming/wharf)	NPDC sign green, 6 ducks	0	0.5
23 Jan 2019	SEM	Fine	4/8	N/A	Slightly turbid, dark green	U/S	4/0 (swimmers)	NPDC sign green, ducks common	0	0
04 Feb 2019	SEM	Fine	1/8	N/A	Turbid, green	D/S	0/1 (fishing)	NPDC sign green, ducks & gulls common on bank	0	1.0
11 Feb 2019	SEM	Fine, light W breeze	1/8	N/A	Turbid, green	U/S	0/1 (walker)	NPDC sign green few ducks and gulls, foam on surface	0	0
19 Feb 2019	SEM	Fine	4/8	N/A	Slightly turbid, green-brown	U/S	0/2 (1 sitting, 1 mowing grass)	NPDC sign green, ducks common	0	0
21 Feb 2019	SEM	Fine, light NW breeze	8/8	N/A	Turbid, blue-green-grey	U/S	0/0	NPDC sign green, no birdlife	0	0
05 Mar 2019	SEM	Fine, light SE breeze	3/8	N/A	Turbid, green	D/S	0/1 walking	NPDC sign green, ducks common	0	
07 Mar 2019	SEM	Fine	1/8	N/A	Slightly turbid, green/brown	D/S	0/3 (pushbikers)	NPDC sign green, strong smelling smoke over water, ducks abundant, fish, scum	0	0
12 Mar 2019	FOLLOW UP	Fine, light S breeze	7/8	N/A	Turbid, brown	D/S	0/0	NPDC sign red. 5 ducks	0	0
20 Mar 2019	SEM	Fine, very light breeze	7/8	N/A	Turbid, brown-green	D/S	0/0	NPDC sign green, 5 ducks		

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
07 Nov 2018	SEM	Fine, overcast	7/8	N/A	Slightly turbid, green	D/S	0/0	TRC sign, 2 gulls, 2 oystercatchers, some waves	0	0
10 Dec 2018	SEM	Fine	1/8	N/A	Clear, turquoise	D/S	4/15 (swimming/banks)	2 oystercatchers	0	0
07 Jan 2019	SEM	Fine, overcast	8/8	N/A	Slightly turbid, blue-green	U/S	6/20 (swimming/banks)	3 oystercatchers	0.5	2.5
10 Jan 2019	SEM	Fine, overcast, breezy	8/8	N/A	Clear, green	U/S	20/30 (swimming/banks)	Gulls common	0.5	1.5
21 Jan 2019	SEM	Fine	5/8	N/A	Slightly turbid, green-blue	D/S	0/27 (7 fishing)	2 gulls	1.5	30.0
23 Jan 2019	SEM	Fine	1/8	N/A	Slightly turbid, blue-green	U/S	2/14 (swimming/banks)	No birdlife. Some wood debris.	0	1.5
04 Feb 2019	SEM	Fine	1/8	N/A	Clear, blue-green	U/S	0/2 (walkers)	Gulls common	0	6.0
11 Feb 2019	SEM	Fine	1/8	N/A	Clear, blue-grey	U/S	8/0 (swimming)	Gulls common	0	0
19 Feb 2019	SEM	Fine	2/8	N/A	Clear, green-blue	D/S	0/6 (swimmers)	1 penguin	0	0
21 Feb 2019	SEM	Fine, no wind	8/8	N/A	Slightly turbid, green-blue-grey	U/S	0/0	2 oystercatchers	2.0	2.0
05 Mar 2019	SEM	Fine, still	4/8	N/A	Slightly turbid, blue-green	U/S	0/2 (walking)	No birdlife	0	0
07 Mar 2019	SEM	Fine, overcast, no rain	8/8	N/A	Clear, blue-green	D/S	0/0	No birdlife	0	3.0
20 Mar 2019	SEM	Fine, still	8/8	N/A	Turbid, green-brown	U/S	0/1 (walking)	1 gulls, 2 oystercatchers, swift u/s flow	0	0

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
07 Nov 2018	SEM	Fine, overcast	8/8	Nil	Clear, uncoloured	D/S	0/0	TRC sign, foam on surface, no birdlife	0	0.5
10 Dec 2018	SEM	Fine	0/8	10% long 5% thick	Clear, green	D/S	0/0	Small amount white foam, 1 duck	0	0
07 Jan 2019	SEM	Light drizzle	8/8	10% long	Slightly turbid, grey	D/S	0/0	Foaming, no birdlife	0	1.0
10 Jan 2019	SEM	Fine, overcast	8/8	Nil on bed detached	Slightly turbid, light brown	D/S	0/0	Detached algae, foaming, no birdlife	1.5	1.5
21 Jan 2019	SEM	Fine	2/8	5% long	Slightly turbid, grey-brown	D/S	0/0	TRC sign bent, no birdlife	0.5	3.0
23 Jan 2019	SEM	Fine, overcast	8/8	60% long	Clear, brown	D/S	4/0 just leaving	No birdlife	0	0.5
04 Feb 2019	SEM	Fine	4/8	25% long	Slightly turbid, grey	D/S	1/4 (swimming, picknicking) 2 dogs	Foam, no birdlife	0	2.0
11 Feb 2019	SEM	Fine, still	1/8	30% long	Slightly turbid, grey	D/S	0/0	Decomposing algae on edges, foam, no birdlife	0	0
19 Feb 2019	SEM	Fine	2/8	35% long 25% thick	Clear, light brown	D/S	0/0	Decaying algae in rock pools, no birdlife	0	0
21 Feb 2019	SEM	Drizzle, calm	8/8	40% long 20% thick	Clear, brown	D/S	0/0	No birdlife	0.5	0.5
05 Mar 2019	SEM	Fine, still, drizzle preceding	7/8	40% long	Slightly turbid, grey	D/S	0/0	TRC sign gone, no birdlife	0	0
07 Mar 2019	SEM	Fine, overcast	6/8	60% long 10% thick	Clear, brown-blue	D/S	0/0	Less decomposing algae1 shag	0	0
20 Mar 2019	SEM	Fine, still	4/8	40% long	Clear, uncoloured	D/S	0/0	No birdlife	0	0

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
07 Nov 2018	SEM	Fine, overcast	7/8	Nil	Slightly turbid, brown	Rippled	0/0	TRC signage, 7 ducks	0	0.5
10 Dec 2018	SEM	Fine	1/8	Nil	Slightly turbid, greeny Brown	Rippled	0/0	Ducks common	0	0
07 Jan 2019	SEM	Fine, breezy, overcast	7/8	N/A	Slightly turbid, brown	Choppy	0/0	Some foaming at edges, no birdlife	0	1.0
10 Jan 2019	SEM	Light drizzle, breezy	8/8	N/A	Slightly turbid, brown	Rippled	0/0	2 ducks	1.5	1.5
21 Jan 2019	SEM	Fine	4/8	N/A	Slightly turbid, brown	Rippled	0/0	2 cows on bank, 1 duck	0.5	3.0
23 Jan 2019	SEM	Fine	2/8	N/A	Clear, brown tinge	Choppy	0/0	No birdlife	0	0.5
04 Feb 2019	SEM	Fine	5/8	N/A	Turbid, brown	Rippled	0/0	Few ducks	0	2.0
11 Feb 2019	SEM	Fine, still	1/8	N/A	Turbid, brown	Flat	1/0 (jetski)	1 duck	0	0
19 Feb 2019	SEM	Fine	2/8	N/A	Turbid, brown	Rippled	0/0	3 ducks, guano on adjacent bank edge	0	0
21 Feb 2019	SEM	Drizzle, calm	8/8	N/A	Slightly turbid, brown	Flat	0/0	Coots common	0.5	0.5
05 Mar 2019	SEM	Fine, very light breeze	7/8	N/A	Turbid, brown	Rippled	0/0	2 ducks, 1 shag, on bank	0	0
07 Mar 2019	SEM	Fine, overcast	8/8	N/A	Clear, brown	Rippled	0/0	1 shag, bird faeces plentiful	0	0
20 Mar 2019	SEM	Fine, very light NW breeze	5/8		Clear, brown	Flat	0/0	10 ducks other side of lake	0	0

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
22 Nov 2018	Fine	2/8	10% thick	Clear, light green	Rippled	0/0	TRC sign needs repair, 5 ducks on water, 25 on shore	3.0	8.0
6 Dec 2018	Fine, overcast	8/8	N/A	Clear, green	Rippled	0/2 (campers)	Large amount of weed, ducks common	16.0	22.5
18 Dec 2018	Fine	2/8	5% thick	Sl. turbid, green-brown	Rippled	2/2 (swimming/bank)	No birdlife	0	0
3 Jan 2019	Fine	6/8	10% thick	Sl. turbid, grey-brown	Rippled	0/0	Ducks common	1.5	1.5
17 Jan 2019	Fine	4/8	N/A	Sl. turbid, brown-green	Flat	0/0	Few ducks	0	37
30 Jan 2019	Fine	5/8	N/A	S. turbid, brown	Rippled	0/0	No birdlife	0	1.5
11 Feb 2019	Fine	1/8	N/A	Turbid, green	Rippled	0/1 (tent)	Few ducks	0	0
25 Mar 2019	Fine	3/8	Nil	Sl turbid, dark green	Rippled	0/2 (banks)	Ducks common, 6 black swans	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
22 Nov 2018	Fine	5/8		Sl. turbid, brown	Rippled	0/0	2 shags, freshwater pest signage	10.0	19.0
6 Dec 2018	Drizzling	8/8		Turbid, green-brown	Rippled	0/0	Ducks common	11.0	27.5
18 Dec 2018	Fine	5/8		Sl. turbid, brown	Rippled	0/1 (in car)	Ducks common, 2 swans	0	15.0
3 Jan 2019	Fine, overcast	7/8	50%	Sl. turbid, brown-green	Rippled	0/0	Few ducks, 1 swan	1.0	1.0
17 Jan 2019	Fine, windy	5/8	85%	Sl. turbid, blue-green	Rippled	0/0	Duclks common, 1 shag	0	16.0
30 Jan 2019	Fine	6/8		Sl. turbid,, green	Rippled	0/0	Few ducks	0	0
28 Feb 2019	Fine	0/8		Turbid, bbrown	Rippled	0/0	Shags common, 1 teal	0	0
25 Mar 2019	Drizzle	6/8		Sl. turbid, brown	Rippled	0/0	5 ducks other side, 1 shag	0	0

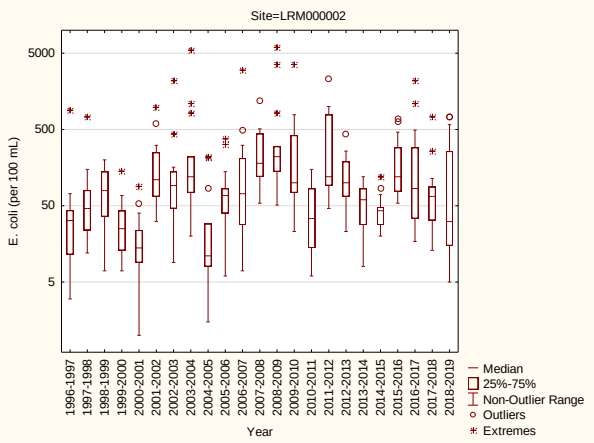
Site Lake Rotokare (Site Code: LRK000003) Rainfall site: Mangaehu at Bridge

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
06 Nov 2018	Fine	5/8		Slightly turbid, brown	Rippled	0/3 (banks)	Few ducks, pukeko	0	0
18 Dec 2018	Fine	6/8		Turbid, green-brown	Rippled	0/6 (camping)	STDC warning sign, 3 ducks, 2 pukeko, other birds	0	0.5
03 Jan 2019	Fine, overcast, SW wind	7/8		Turbid, brown	Rippled	0/0	STDC warning, few ducks, 1 pukeko, 1 unknown bird	0	0
17 Jan 2019	Fine	5/8		Turbid, brown-green	Rippled	0/2 (camping)	STDC warning sign few ducks and pukeko	0	13.5
30 Jan 2019	Fine	2/8	20% long	Turbid, green	Rippled	0/0	STDC warning sign, 2 ducks	0	0
21 Feb 2019	Fine	8/8	10% long	Slightly turbid, brown	Rippled	0/8 (banks)	STDC warning sign, few ducks and pukeko	0	0.5
20 Mar 2019	Fine, light W breeze	4/8		Clear, brown-green	Rippled	0	No birdlife	6.5	6.5

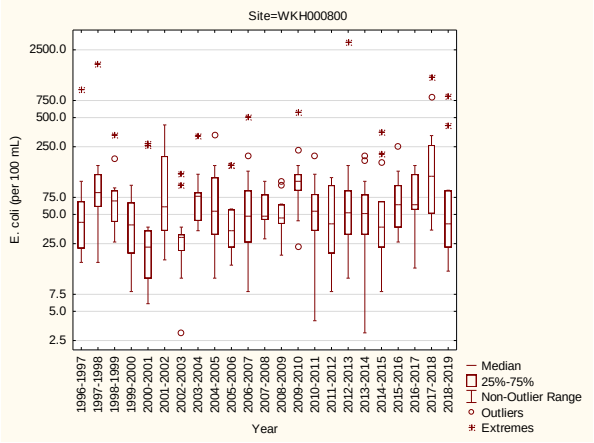
Appendix VI

Comparative annual box and whiskers plots of SEM data for *E.coli* for the period 1996-2019

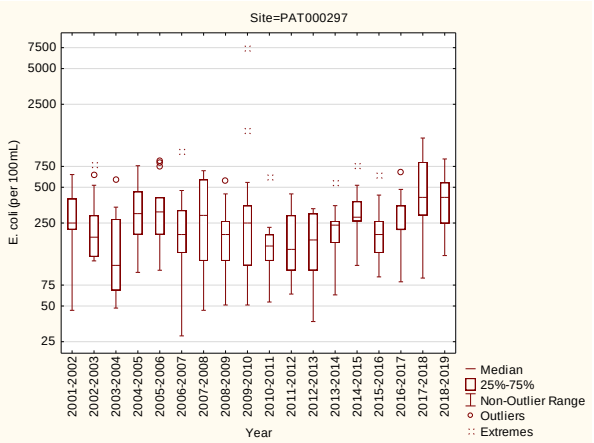
Lake Rotomanu



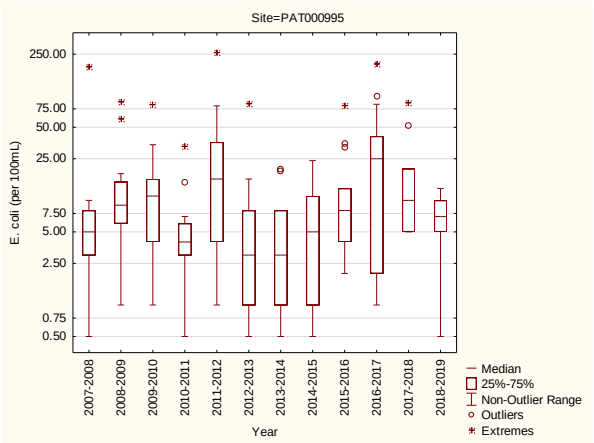
Waiwhakaiho River at Merrilands Domain



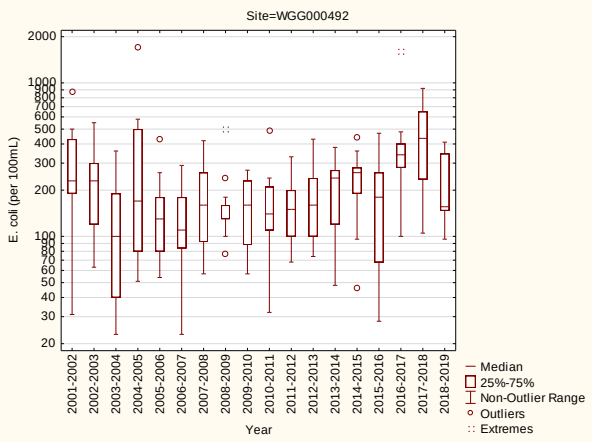
Patea River at Stratford



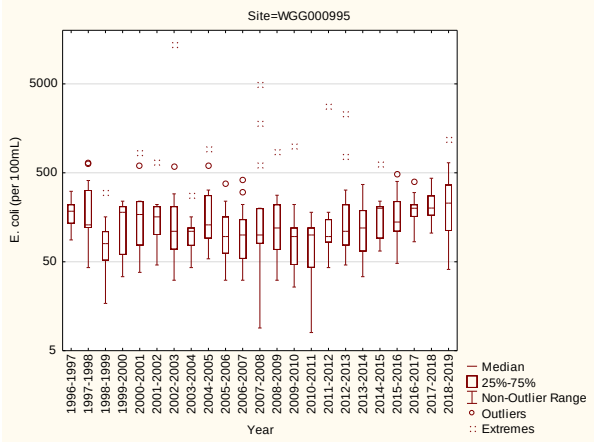
Patea River at Patea boat ramp



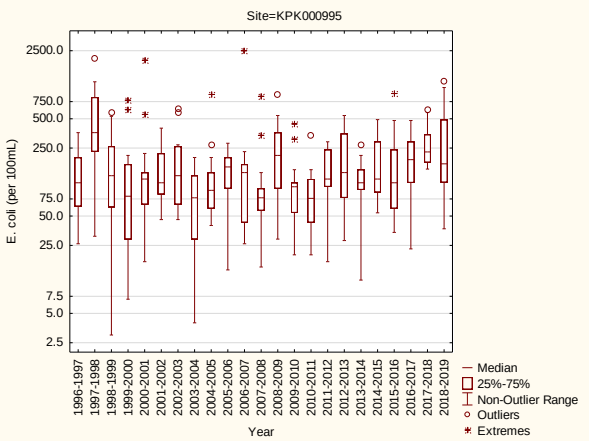
Waingongoro R at Eltham



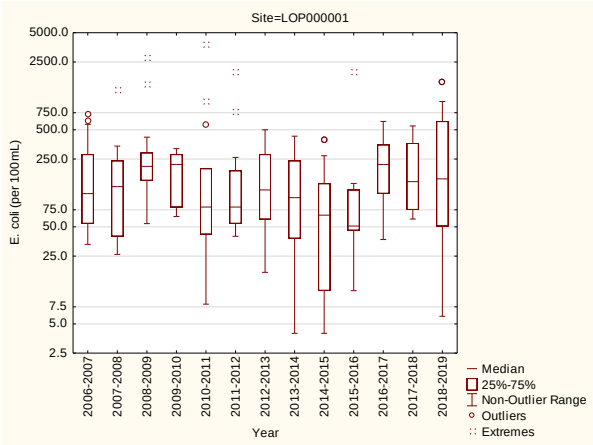
Waingongoro R at Ohawe



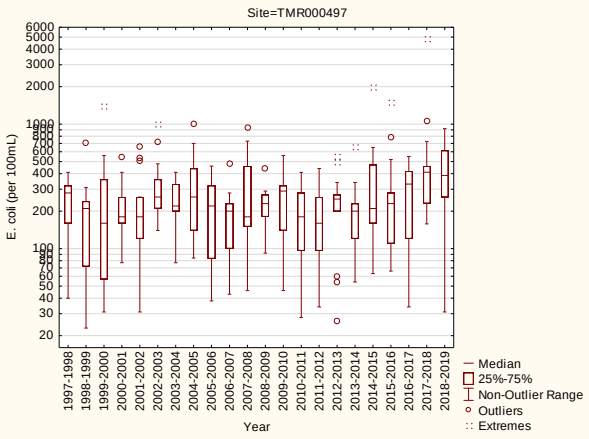
Kaupokonui River



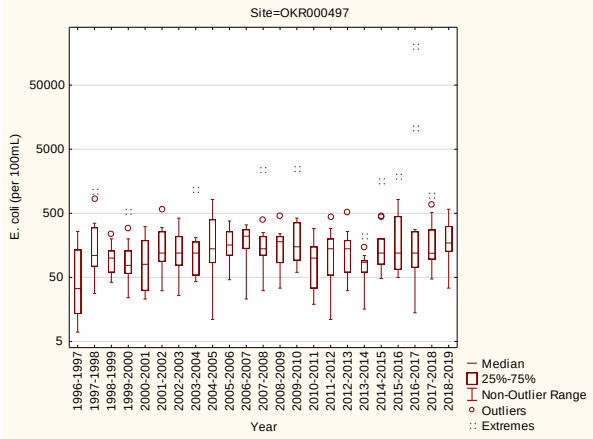
Lake Opunake



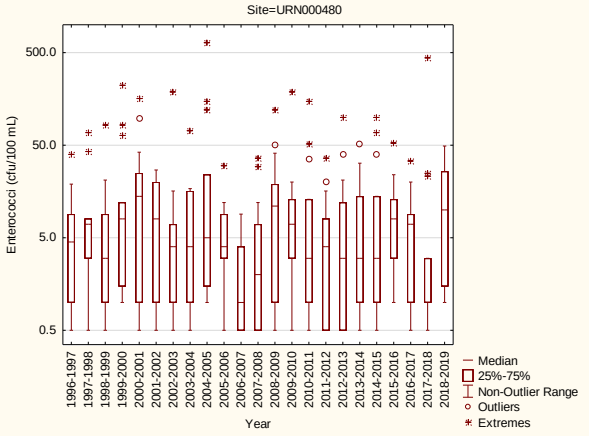
Timaru Stream



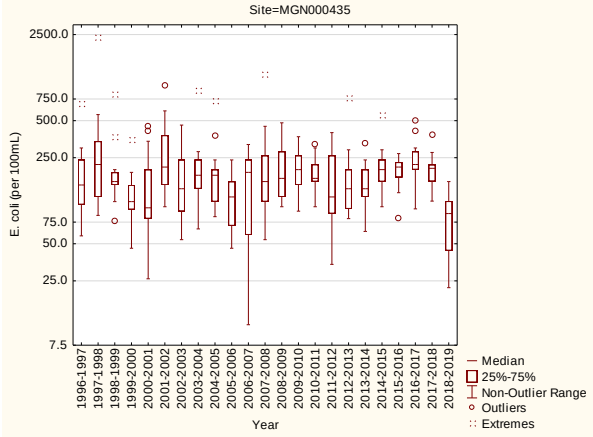
Oakura River



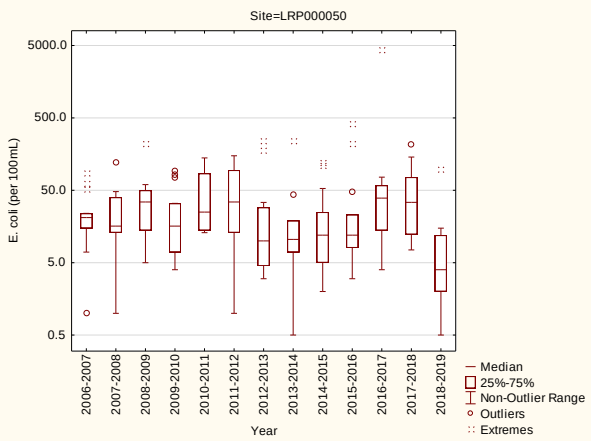
Urenui River



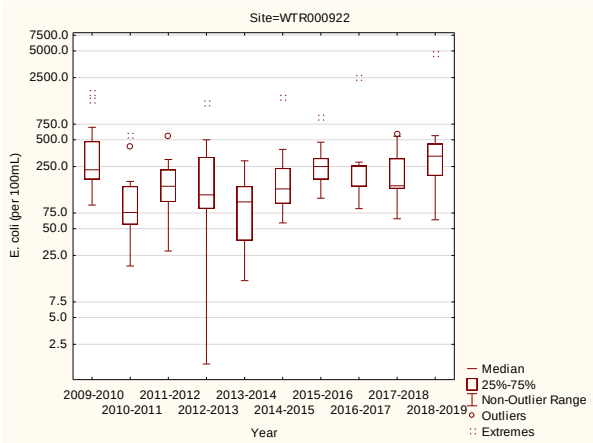
Manganui River



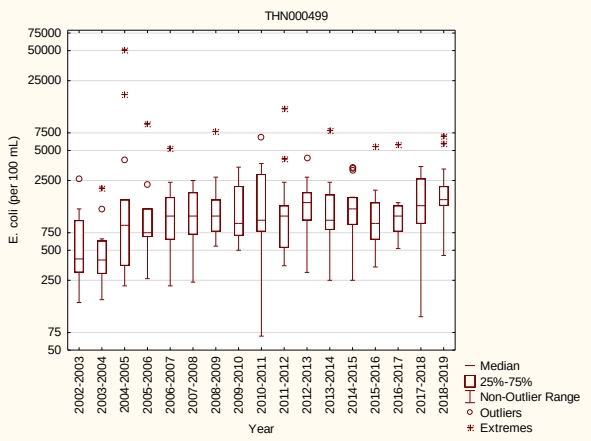
Lake Ratapiko



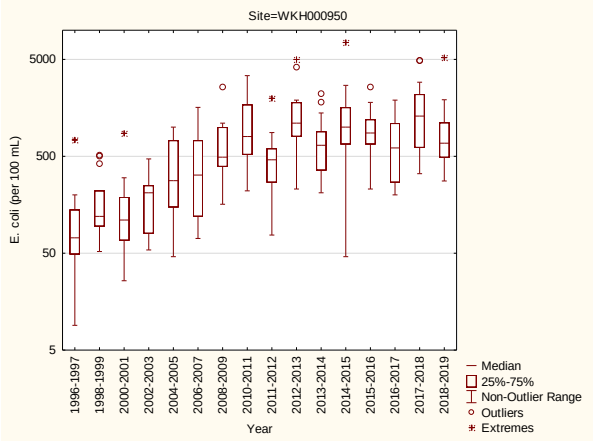
Waitara River at town wharf



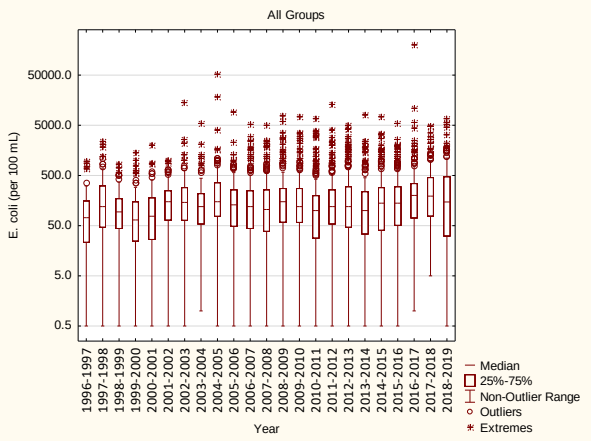
Te Henui mouth, East End



Waiwhakaiho adjacent to L.Rotomanu



All sites combined, 1995 - 2019



All sites individually, 2018 – 2019