Freshwater contact recreational water quality at Taranaki sites State of the Environment Monitoring Report 2015-2016 Technical Report 2016-01

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Executive summary

This survey of sixteen freshwater contact recreational sites in the Taranaki region was the twentieth 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 2015-2016 period for the tenth 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 Waimoku Stream sampling has been reduced to a three-yearly frequency and it was not monitored during the current 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 guideline over this latest five year period.

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

The results of the 2015-2016 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), Lake Ratapiko and the Waiwhakaiho River (at Merrilands Domain). 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 by inspections and more recently by DNA marker surveys).

In terms of *E. coli*, bacteriological water quality in the latest survey period was similar in comparison with historical surveys. The total number of samples falling within the "Alert" or "Action" categories (28% of samples) was equal to the long-term average and was strongly influenced by samples at two urban sites where bird life was mainly responsible for these exceedances (12% of all sites' samples).

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

were more frequent during the extremely low flow conditions experienced in the latter half of the season.

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.

Birdlife contributed to exceedances from time to time, particularly at two sites where on occasions recreationalists fed the birds. Notably, no 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 12 of 13 samples exceeded this guideline near this river's mouth. 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 (where vandalism of signage has been an issue). Temporary signage was required at the Oakura River, Timaru Stream, Patea River and lower Waingongoro River sites following single sample 'Action' levels, but single sample 'Alert' level exceedances at other sites were not necessarily signposted.

Temporal trends over the 1996-2016 period have been evaluated on the basis of seasonal median *E. coli* count for the fourteen sites that have ten years or more data (and will continue to be assessed annually). One site (lower Waiwhakaiho River) has shown a statistically significant increasing trend, while one site (Lake Opunake) has shown strong, but not statistically significant, decreasing trend in median *E. coli* counts. However, to date these median counts have reached 'Alert' or 'Action' levels at only three urban sites where birdlife issues have been documented. No other sites have shown statistically significant trends (positive or negative) in seasonal median *E. coli* counts.

Elevated enterococci to faecal coliform ratios have typified ponded sites near the stream/river mouths from time to time (and in the current season), possibly as a result of vegetative sources of enterococci and/or more prolonged survival in ponded freshwater environments, under high tidal conditions and often where saltwater penetration occurred.

Additional sampling (in accordance with the MfE, 2003 guidelines) at two principal usage sites (Lake Rotomanu and Waiwhakaiho River) coincided on a few occasions with wet weather conditions and resulted in some small increases in the overall median bacteriological numbers at both sites. One additional exceedance of the 'Action' limit occurred at both sites as poorer river bacteriological quality followed the wet weather events.

Cyanobacteria blooms were recorded at Lake Rotokare and Lake Rotomanu on most monitoring occasions from December 2015 to February 2016. These numbers necessitated warning notices to avoid contact recreation on these waters during most of the recreational period. Low to moderate numbers of cyanobacteria were found in Lake Ratapiko, with a few instances of low numbers present in Lake Opunake.

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored. One site exceeded the 'Action' level for bed coverage on one occasion, but three sites, on a total of 15 occasions, had over 20% coverage triggering the 'Alert' level. Exposed mats triggered the 'Action' or 'Alert' level at six sites on 35 occasions and detaching or detached mats accumulating on the river's edge triggered the 'Action' level at six sites on 41 occasions. Previous monitoring has focused on streambed percentage cover though information on exposed and detaching mats (above the water line) has also been collected but no sites had previously triggered the 'Action' or 'Alert' levels before the 2014-2015 sampling season. Levels of cyanobacteria were higher than the previous four sampling seasons with the long dry summer probably the main contributing factor to the high cyanobacteria levels. Exposed mats were caused by falling water levels during this long dry summer and/or the result of daily fluctuations in river flow caused by periodic releases of hydro scheme waters. Significant detaching or detached mats were often coincident with high levels of cyanobacteria present in the river. As a consequence of the presence of exposed and/or detaching mats, signage was erected at three sites advising recreational river users of the potential dangers particularly to dogs.

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) as well as liaison with territorial local authorities and the Health Protection Unit of Taranaki District Health Board throughout the survey season of 2015-2016.

For the first 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. Another specific recommendation relates to proposed faecal source tracking investigations at the Patea River, Stratford site to provide information for future management/abatement initiatives in the upper Patea River catchment.

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1. Introduction

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 bathing 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 water quality in relation to 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. Contact recreation water quality standards and guidelines

Prior to 2003, the Council has 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). Since 2003 new guidelines are now relevant to this programme. These guidelines are detailed below.

2.1 Freshwater microbiological water quality guidelines (2003)

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 have been 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 (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).

Mode	Acceptable (green)	Alert (amber)	Action (red)
Freshwater (*E. coli*/100mls)	≤260	261-550	>550
Marine (enterococci/100mls)	≤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 'red' (Action) level that the bathing area will be considered highly unsuitable for recreation, that a public health problem is deemed to exist, and that swimming is not recommended[1].

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

[1] Pages C3, E8, and E9, '*Microbiological Water Quality Guidelines*, MfE (2003).

bathing conditions. In addition, at two of the most popular sites a further 7 samples are collected regardless of prevailing weather and river conditions, to facilitate the calculation of the Microbiological Assessment Category (see next section).

2.2 Suitability for recreation grading (SFRG) of sites

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 2010 to March 2015 period (i.e. the five years immediately preceding the current season as required by the Guidelines). The single site added in 2009-2010, Waimoku Stream, has limited historical bacteriological data and only one year's data has been collected for this site over the recent five year period. The relevant information is provided in Appendix 1 and is summarised in Table 1.

Table 1 Suitability for recreation grade for freshwater sites for the period November 2010 to April 2015

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	803	65	D	Very poor	92
Waiwhakaiho R: Merrilands domain	High	203	65	B	Poor	98
Waiwhakaiho R at L.Rotomanu	High	3600	65	D	Very poor	33
Te Henui S: mouth	High	4720	66	D	Very poor	15
Patea R: King Edward Park	High	528	65	C	Poor	96
Patea R. boatramp, Patea	High	70	65	A	Poor	100
Waingongoro R: Eltham camp	High	393	65	C	Poor	100
Waingongoro R: Ohawe beach	High	663	65	D	Very poor	93
Kaupokonui R: Beach domain	High	445	65	C	Poor	100
L Opunake: adjacent boat ramp	High	835	65	D	Very poor	92
Timaru S: Lower Weld Road	High	575	65	D	Very poor	95
Oakura R: d.s SH45	High	445	65	D	Very poor	92
Waitara R: Town wharf	High	555	65	D	Very poor	95
Urenui R: estuary	High	60	65	A	Poor	100
Manganui R: Everett Park	High	348	65	C	Poor	96
L Ratapiko: boatramp	High	167	59	B	Poor	100
L Rotokare: adjacent boatramp	Low	183	45	B	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 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 8% of all sampling occasions, that is, fourteen sites achieved the guideline on 92% or more of occasions.

The Eltham camp site in the mid reaches of the Waingongoro River, the Kaupokonui River beach domain site, Urenui River estuary site, the Patea River estuary site, and the Lake Ratapiko site have not reached the 'Action' mode during the previous five seasons, under the sampling protocols of the SEM programme, and the Waiwhakaiho River Merrilands domain site, Everett Park site in the Manganui River, Patea River King Edward Park Stratford site, and SH45 site in the Oakura River 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 results of 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 guidelines

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 2 below shows the alert-level framework for benthic cyanobacteria.

Table 2 Alert level framework for benthic cyanobacteria

Alert level[a]	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 relatively short 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 3 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. Programme design

3.1.1 Trend detection

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.

The locations of the sixteen sites sampled by the various components of the 2015-2016 programme are shown in Figure 1 and summarised in Table 4.

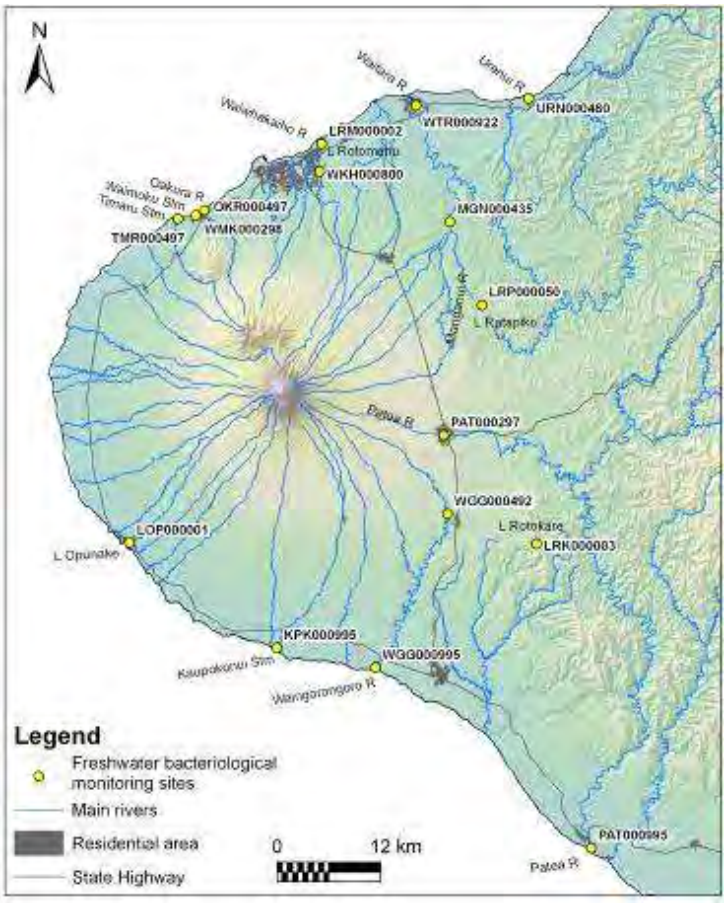


Figure 1 Location of freshwater contact recreation survey sites in 2015-2016

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 by removing it from the 2011-2012, 2012-2013, 2014-2015 and 2015-2016 programmes with sampling programmed for every third season thereafter (ie sampled in 2013-2014 but not in the current season). 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 2015 to late

March 2016. Ten sites, relatively close to stream mouths, were potentially affected by tidal influences (see conductivity data later in this report).

Table 4 Location of bathing water bacteriological and cyanobacteria sampling sites

Site	GPS Location		Site code	Bacteriological	Benthic Cynobacteria	Planktonic Cynobacteria
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. boatramp, Patea	E 1727517	N 5596784	PAT000995	✓		
Waingongoro R: Eltham camp	E 1710861	N 5635349	WGG000492	✓	✓	
Waingongoro R: Ohawe beach	E1702531	N 5617624	WGG000995	✓	✓	
Kaupokonui R: Beach domain	E 1691110	N 5619893	KPK000995	✓	✓	
L Opunake: adjacent boatramp	E 1674029	N 5632022	LOP000001	✓		✓
Timaru S: Lower Weld Road	E 1697622	N 5669438	TMR000497	✓		
Waimoku Stream:Oakura Beach	E 1681725	N 5669851	WMK000298	*		
Oakura R: d/s SH45 bridge	E1682721	N 5670440	OKR000497	✓	✓	
Waitara R: Town wharf	E 1707203	N 5682572	WTR000922	✓		
Urenui R: estuary	E 1720245	N 5683370	URN000480	✓		
Manganui R: Everett Park	E1711149	N 5669127	MGN000435	✓	✓	
L Ratapiko: boatramp	E1714913	N 5659488	LRP000050	✓		✓
L Rotokare: adjacent boatramp	E 1721182	N5631898	LRK000003	(✓)		✓

[Notes: * not in current season : ( ) sporadic]

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 mid November 2015 with four of the sampling surveys performed prior to January 2016. 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 (NZDST) with none collected within a three day period following significant river/stream fresh conditions. [NB: 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 metre 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 enterococci, *E. coli* and faecal coliform 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 new 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 in 2015-2016, instead introducing links to the regional council and national websites, and continuing to give general advice on water safety (http://www.tdhb.org.nz/services/public_health/recreational_water_safety.shtml). 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. Cyanobacteria information was included on the regional council website for all lake sites and river/stream sites.

3.2 Additional monitoring (MfE guidelines)

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) 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].

3.3 Cyanobacteria monitoring

After consultation with Taranaki District Health Board, 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 2015-2016, 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 5, which then may vary depending upon the percentage cover of benthic cyanobacteria detected previously at a site.

Table 5 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 sampling
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 5. Monitoring was also extended to include information on exposed and detaching mats in accordance with relevant criteria.

4. Results

4.1 Introduction

Sampling times in relation to tidal conditions (particularly for estuarine sites, see Appendix II), weather conditions and sites' usage information are contained in Appendix III and IV. Timing of sampling in relation to river flows is illustrated by Figure 8, Figure 21, Figure 29, Figure 33, Figure 39, Figure 48, Figure 56, and Figure 63. Those illustrate that the majority of the sampling occasions coincided with steady to low river recession flow conditions. In 2015-2016, sampling 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 mid November 2015 to late March 2016.

Sampling was confined entirely to weekdays during the period with no public holidays 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 recently with 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 (see Appendix VIII).

4.2 Presentation of results and discussion

All results are presented and discussed on a site-by-site basis for the sampling period, which extended from 12 November 2015 to 30 March 2016 and totalled thirteen sampling occasions at each site. The results for the sites with the additional (seven) sampling occasions are also presented within the discussion for the two appropriate sites.

4.2.1 Lake Rotomanu

4.2.1.1 SEM programme

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, dog walking and/or picnicking activities occurring on some occasions.

Ducks, and a gull (on three occasions), were present on the lake or in the vicinity of the lake edge throughout most the period and occasionally attracted to the immediate vicinity of the sampling site by public feeding of the ducks. Lake levels were relatively consistent throughout the period. A wetland had been created in recent years at Peringa Park to improve the quality of stormwater runoff entering the lake.

The data for this site are presented in Table 6 and illustrated in Figure 2, with a statistical summary provided in Table 7

Table 6 Analytical results for Lake Rotomanu

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	0820	12.0	54	46	54	18.9	7.2
25.11.15	0820	11.8	56	29	60	20.2	6.0
10.12.15	0815	11.8	60	98	60	20.2	9.5
15.12.15	1035	11.8	120	58	120	21.1	12
12.01.16	0840	11.9	77	80	83	22.4	9.1
15.01.16	0950	12.1	92	160	96	24.9	10
25.01.16	0825	12.0	150	71	160	26.2	11
09.02.16	0830	12.5	130	110	140	25.9	12
12.02.16	1000	12.7	290	130	310	26.0	12
23.02.16	0825	12.3	120	46	120	23.8	7.8
08.03.16	0815	13.0	460	140	470	23.2	10
22.03.16	1103	12.9	640	240	670	22.8	9.3
30.03.16	1130	11.9	690	170	690	23.0	13

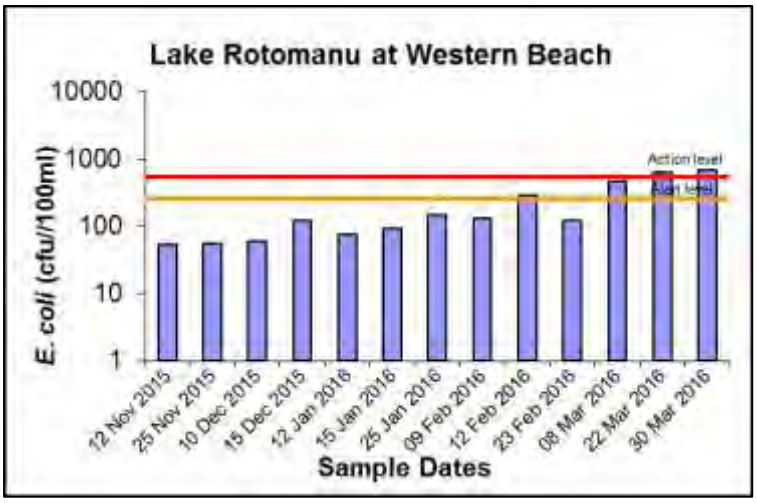


Figure 2 *E. coli* numbers for Lake Rotomanu during the regular season

Table 7 Statistical results summary for Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	11.8	13.0	12.0
E. coli	cfu/100ml	13	54	690	120
Enterococci	cfu/100ml	13	29	240	98
Faecal coliforms	cfu/100ml	13	54	690	120
Temperature	°C	13	18.9	26.2	23.0
Turbidity	NTU	13	6.0	13	10

The lake, which is close to the coast, is replenished from time to time by inflow from the nearby Waiwhakaiho River. In the 2015-2016 monitoring period, the lake was not deliberately flushed. Water quality was relatively good although it was poorer than usual (median turbidity: 10; range: 13 NTU), possibly as a result of fluctuating concentrations of suspended algae and/or fine sediment. Water temperatures were relatively high (above 20°C) through nearly all of the period with a high maximum of 26.2°C (in late January 2016) and a range of 7.3°C. Conductivity had a narrow range through the season.

Generally, bacteriological quality was relatively good considering that the inflow to the lake is from the lower reaches of a river draining a developed catchment. However, elevated numbers of *E. coli* were found on four of the last five monitoring occasions, the last two counts in March 2016 reaching 'Action' level. Ducks appeared to be the cause. NPDC signage discouraging lake usage was required to be erected, for the first time in three seasons. Resampling on 12 and 28 April 2016 returned *E. coli* numbers of 400 then 250 per 100ml, back to 'Surveillance' level.

4.2.1.2 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 8.

Table 8 Bacterial guidelines performance at Lake Rotomanu [% of 13 samples]

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

(Designation: freshwater contact recreational area)

Two single samples exceeded the 'Action' mode during the period, and two samples were recorded within the 'Alert' mode.

4.2.1.3 Comparison with previous summers' surveys

A statistical comparison of all of the seasons' *E. coli* surveys data is presented graphically in Appendix VI for all sites. These summer data for the Lake Rotomanu site are summarised in Table 9 and illustrated in Figure 3.

Table 9 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys at Lake Rotomanu to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	3	12	7	7	1	31	9	20	<3	6	7	54	51	23	6	46	23	8	20	54
Maximum	890	740	200	140	90	980	2200	5500	220	380	3000	1200	6000	3600	150	2300	430	120	120	690
Median	32	46	79	25	14	110	92	120	11	68	72	180	220	100	34	120	100	60	43	120

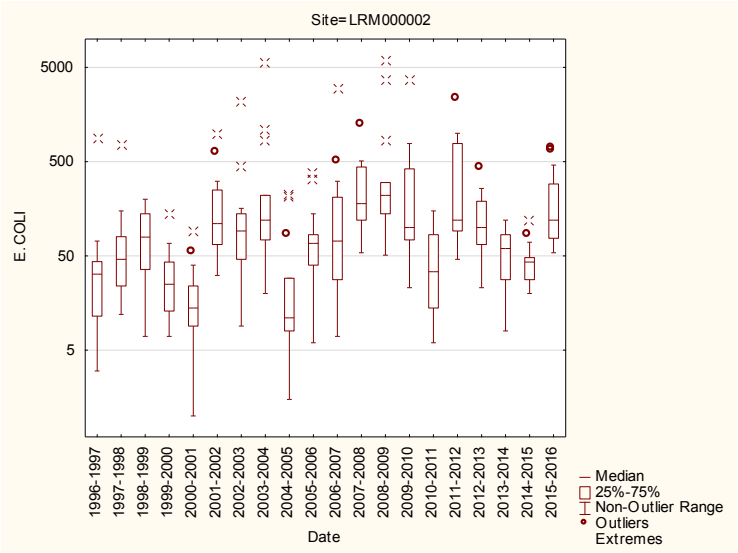


Figure 3 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers at Lake Rotomanu

The trend of reducing median *E. coli* numbers over the last three seasons was reversed over the summer of 2015-2016. The lowermost counts were among the highest recorded, suggesting a lift in baseline. The median value was the third equal highest to date, and the maximum count was in the middle of the range. However, the median value remained well below the 'Alert' level of the 2003 MfE guidelines.

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

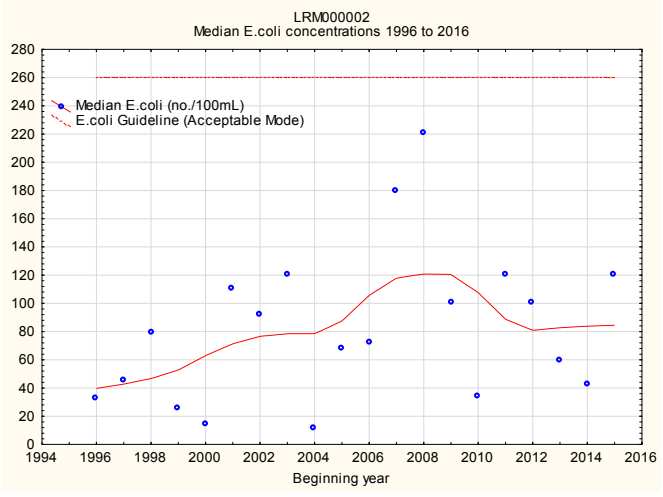


Figure 4 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Lake Rotomanu for the 1996-2016 period

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

4.2.1.4 MfE guidelines additional sampling

Seven additional samples were collected randomly under varying weather conditions during the survey season. Limited recreational use, some boating and walking along the shore, was noted on most of these occasions. Ducks were present in low numbers on the lake, and a few gulls, on some but not all occasions. Two surveys occurred by chance shortly after wet weather.

The data from these additional surveys are presented in Table 10, and illustrated and statistically summarised (with the 13 SEM samples' data) in Figure 5 and Table 11 respectively.

Table 10 Lake Rotomanu additional seven water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
03.11.15	1000	12.2	92	29	100	19.2	7.4
22.12.15	0946	12.1	110	120	110	22.7	12
06.01.16	1000	12.1	120	66	120	22.4	9.2
19.01.16	0950	11.9	1000	1400	1200	23.2	11
02.02.16	1000	12.2	130	23	130	26.2	11
16.02.16	1015	12.6	140	62	150	26.1	12
15.03.16	1110	12.7	310	130	320	20.9	11

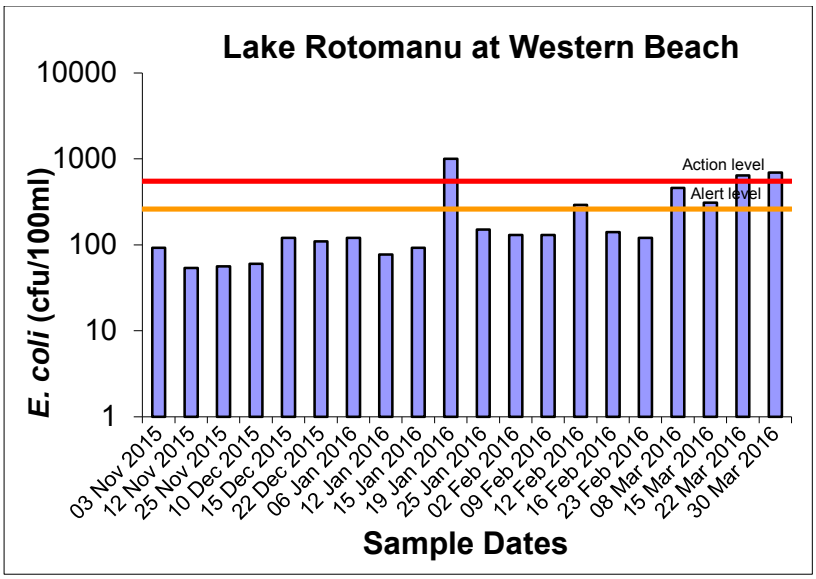


Figure 5 *E. coli* numbers for Lake Rotomanu for the 20-sample extended survey

Table 11 Summary statistics for SEM and additional samples at Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	11.8	13.0	12.1
E. coli	cfu/100ml	20	54	1000	125
Enterococci	cfu/100ml	20	23	1400	89
Faecal coliforms	cfu/100ml	20	54	1200	125
Temperature	°C	20	18.9	26.2	22.9
Turbidity	NTU	20	6.0	13	10.5

The additional sampling resulted in very little change with a small increase (of 5 *E.coli* per 100 ml) in the overall seasonal median bacteria number. These additional surveys' bacteria counts had a slightly higher range (92 to 1000 *E. coli* per 100ml) and median (125 *E.coli* per 100 ml) than the standard SEM sampling survey range, due to the proximity of wet weather to two of the sampling survey occasions. The same maximum water temperature was measured during the additional sampling (26.2˚C), in early February 2016.

4.2.1.5 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 12.

Table 12 Bacterial guidelines performance at Lake Rotomanu [% of 20 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Simgle sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	3 [15]	3 [15]

(Designation: freshwater contact recreational area)

The number of exceedances of the single sample 'Alert' and 'Action' modes increased with the additional monitoring, as one additional exceedance of the 'Alert' level and one of the 'Action' level occurred; the 'Action' level followed wet weather conditions and elevated river flows in mid-January 2016.

4.2.1.6 Cyanobacteria

Planktonic cyanobacteria levels in mid November were moderate but high levels were detected for the majority of the rest of the monitoring period. Cyanobacteria levels fell during the last two sampling occasions. Normally, Lakes Rotomanu, Ratapiko and Opunake are sampled on the same date and have the same number of sampling occasions (seven samples are scheduled) but due to public interest an additional sample was collected on 3 March 2016.

Planktonic cyanobacteria were monitored on eight occasions throughout the season with results presented in Table 13 and Figure 6.

Table 13 Cyanobacteria counts and biovolumes for Lake Rotomanu

Date	Cyanobacteria total cell count (cells/mL)	Biovolume (mm^3/L)	Principal species by biovolume	Mode
03/11/2015	480000	0.8	*Aphanocapsula*	Medium Risk
22/12/2015	2800000	5.2	*Aphanocapsula*	High Risk
06/01/2016	1750000	3.1	*Aphanocapsula*	High Risk
19/01/2016	1060000	1.8	*Aphanocapsula*	High Risk
02/02/2016	6300000	2.6	Picocyanobacteria	High Risk
16/02/2016	24000000	9.8	Picocyanobacteria	High Risk
03/03/2016	2050000	0.8	Picocyanobacteria	Medium Risk
15/03/2016	3600000	1.5	Picocyanobacteria	Medium Risk

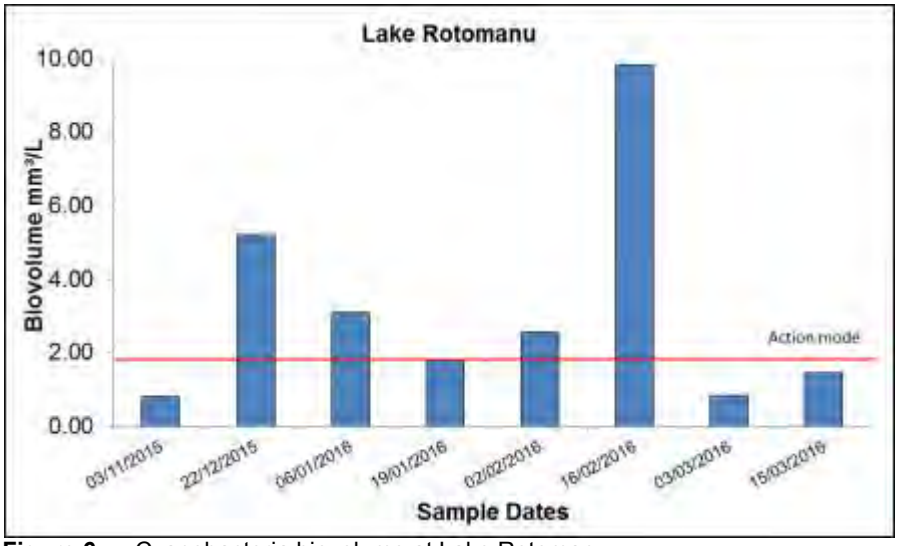


Figure 6 Cyanobacteria biovolume at Lake Rotomanu

Following the high cyanobacteria bio-volume detected in December 2015, health warning signs were erected by NPDC at the monitoring site at the western beach, and at the boat launching ramp, for the remainder of the bathing season.

4.2.2 Waiwhakaiho River at Merrilands Domain

4.2.2.1 SEM programme

This site was used for walking (up to four) dogs at the time of nine of the sampling surveys in 2016. No bathing was noted, and fishing on one occasion. No birdlife was noted on all but three occasions, and on these occasions numbers were very low. Most surveys occurred in early to mid-morning, with the last two in early afternoon.

The data for this site are presented in Table 14 and illustrated in Figure 7, with a statistical summary provided in Table 15. River flow information is illustrated in Figure 8.

Table 14 Analytical results for the Waiwhakaiho River at Merrilands Domain

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	0800	12.0	37	5	37	15.0	0.3
25.11.15	0800	10.6	100	16	100	14.9	0.4
10.12.15	0800	11.3	26	8	26	15.9	0.2
15.12.15	1010	9.7	42	11	42	16.6	0.6
12.01.16	0855	10.2	63	31	63	19.4	0.3
15.01.16	1050	12.2	250	100	260	20.4	0.5
25.01.16	0800	11.8	28	45	34	21.6	0.4
09.02.16	0805	14.5	37	32	40	22.4	0.6
12.02.16	0935	14.9	31	52	31	22.0	0.8
23.02.16	0800	11.0	66	120	66	19.3	0.5
08.03.16	0800	14.3	100	100	100	20.8	0.4
22.03.16	1130	12.0	100	110	100	19.1	0.4
30.03.16	1110	12.8	140	130	140	16.1	0.6

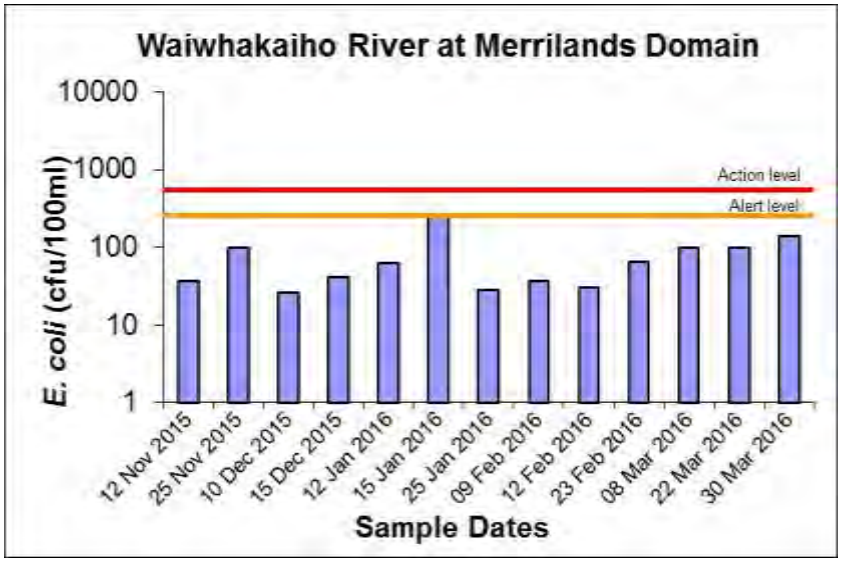


Figure 7 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain during the regular survey season

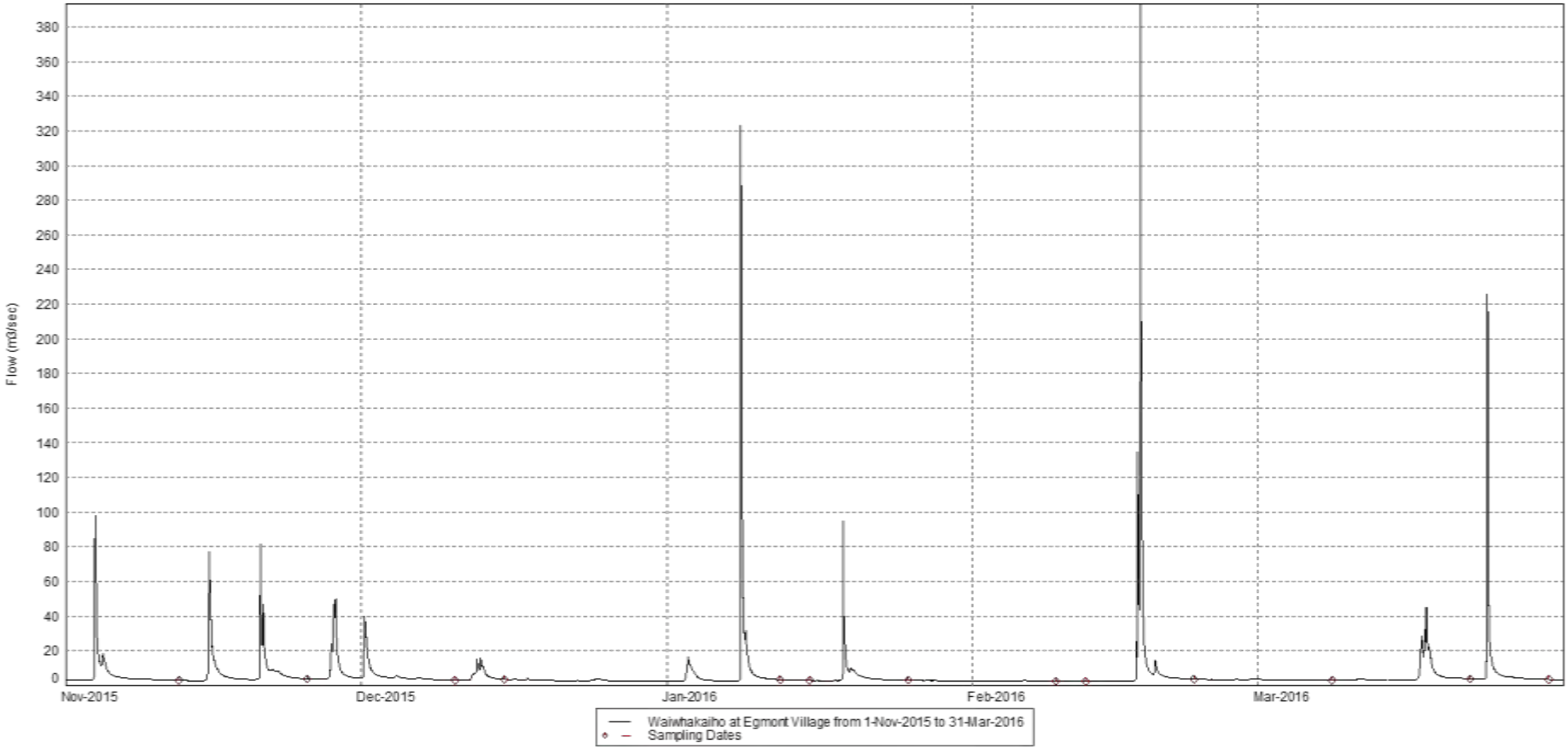


Figure 8 River flow in the Waiwhakaiho River during the survey period

Table 15 Statistical results summary for the Waiwhakaiho River at Merrilands Domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	9.7	14.9	12.0
E. coli	cfu/100ml	13	26	250	63
Enterococci	cfu/100ml	13	5	130	58
Faecal coliforms	cfu/100ml	13	26	260	63
Temperature	°C	13	14.9	22.4	19.3
Turbidity	NTU	13	0.2	0.8	0.5

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 7.5°C between mid November and late March, with a maximum of 22.4°C in mid-February 2016. Conductivity and turbidity results were indicative of very clean, clear, relatively high water quality, but moderate to widespread algal cover (up to 75% mats) was relatively common through the period from December.

Considering the influence of agricultural activities, particularly dairying in the catchment, bacteriological water quality was relatively high. Bacterial numbers were not excessive, remaining within a relatively narrow range through the season and only one *E.coli* count above 200 per 100 ml was recorded.

4.2.2.2 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 16.

Table 16 Bacterial guidelines performance at the Waiwhakaiho River Merrilands Domain site [% of 13 samples]

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

(Designation: freshwater contact recreational area)

No single samples were recorded within the 'Action' mode or the 'Alert' mode during the season. Bacteriological water quality measured at this site was therefore within the 'Surveillance' mode for contact recreational usage for all sampling occasions during the survey period.

4.2.2.3 Comparison with previous summers' surveys

A statistical comparison of all of the summers' surveys data is presented graphically in Appendix VI for all sites. These data for the Waiwhakaiho River site are summarised in Table 17 and illustrated in Figure 9.

Table 17 Summary of *E. coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Waiwhakaiho River at Merrilands domain to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	16	16	26	8	6	17	3	34	11	15	8	28	19	23	4	8	11	3	8	26
Maximum	970	1800	330	100	270	420	130	320	330	160	510	110	110	570	200	120	3000	200	350	250
Median	42	84	69	39	23	60	29	77	54	34	48	48	46	110	54	40	52	51	37	63

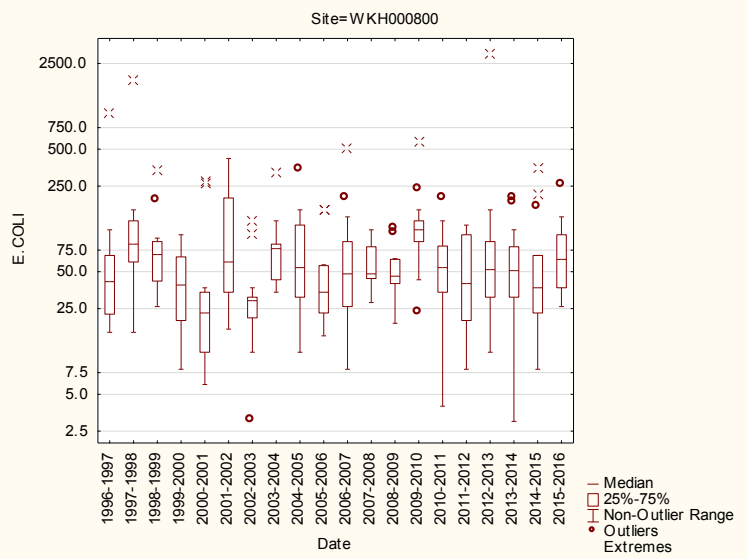
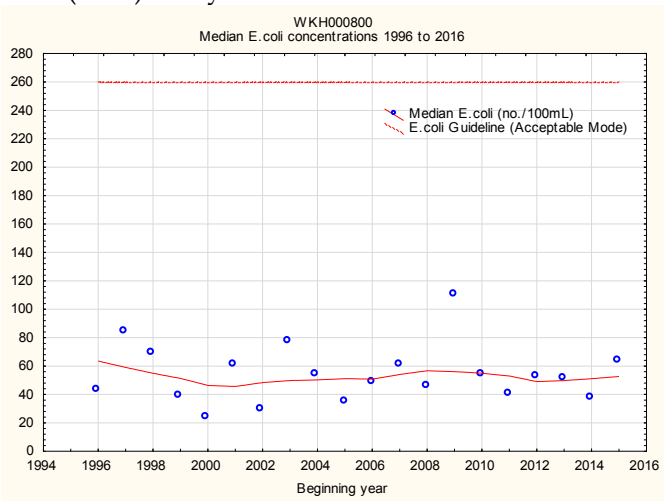


Figure 9 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River at Merrilands Domain

The median *E. coli* number in the 2015-2016 period was slightly higher than most recorded to date, though was well below the maximum of the range of historical medians (Table 17 and Figure 9), all of which have been much lower than the 'Alert' level of the 2003 MfE guidelines.

Trend analysis of these median *E.coli* numbers has been performed for the twenty seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 10) 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.



N = 20
Kendall tau = -0.528
p level = 0.974 [>FDR, p = 0.974]
N/S at p <0.05

Figure 10 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waiwhakaiho River, Merrilands Domain for the 1996 to 2016 period

A statistically insignificant and unimportant temporal trend of a minimal decrease in median *E.coli* numbers has been found over the twenty seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.2.2.4 MfE guidelines additional sampling

Seven additional samples were collected randomly at irregular intervals and under varying weather conditions (two of which by chance followed wet weather events during the previous five days) during the survey season.

Recreational activities noted on these occasions included persons exercising (up to three) dogs on all but two occasions. No swimming was observed. No birdlife was present, except for two gulls on one occasion.

The data from these additional surveys are presented in Table 18, illustrated in Figure 11, and statistically summarised (together with the 13 SEM samples' data) in Table 19.

Table 18 Waiwhakaiho River at Merrilands Domain additional seven water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
03.11.15	1035	12.4	63	33	63	14.9	1.1
22.12.15	1015	12.7	70	11	70	17.9	0.7
06.01.16	1100	11.1	17	35	17	18.6	0.6
19.01.16	1035	8.4	4300	7700	4300	18.1	2.8
02.02.16	0940	13.7	120	52	120	22.1	0.6
16.02.16	0950	14.8	48	54	51	22.5	0.6
15.03.16	1045	13.5	68	170	74	18.9	0.4

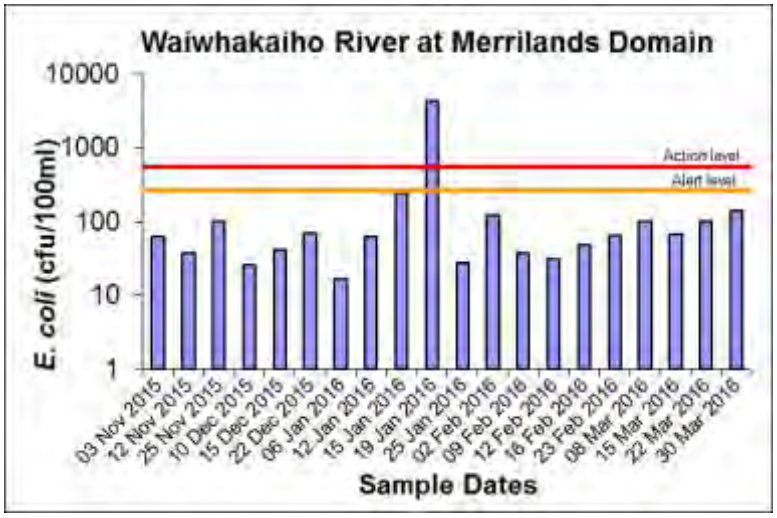


Figure 11 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain for the 20 sample extended survey

Table 19 Summary statistics for SEM and additional samples in the Waiwhakaiho River at Merrilands Domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	8.4	14.9	12.2
E. coli	cfu/100ml	20	17	4300	64
Enterococci	cfu/100ml	20	6	7700	48
Faecal coliforms	/100ml	20	17	4300	64
Temperature	°C	20	14.9	22.5	19.0
Turbidity	NTU	20	0.2	2.8	0.5

These seven additional samples resulted in minor changes in the seasonal median bacterial numbers in comparison with the regular SEM programme results (Table 15). The ranges for all three bacteria species increased markedly due to elevated counts recorded in mid January 2016, under higher river flow conditions after recent wet weather (Figure 8).

4.2.2.5 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 20.

Table 20 Bacterial guidelines performance in the Waiwhakaiho River at Merrilands Domain [% of 20 samples]

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

(Designation: freshwater contact recreational area)

One exceedance of the single sample 'Action' mode (550 *E. coli* per 100 mls) occurred after heavy rainfall. Follow-up samples collected in the course of the SEM programme after the exceedance found much lower counts which were within the guidelines. No health warning signage was displayed as exceedances were due to preceding rainfall events and/or numbers fell markedly under dry weather conditions.

4.2.2.6 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 14 occasions during the 2015-2016 season. Results are presented in Table 21 and illustrated in Figure 12.

Table 21 Percentage benthic cyanobacteria cover for the Waiwhakaiho River, at Merrilands Domain site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	16	No	Significant	Red (Action)
18/11/2015	13	No	No	Green (surveillance)
28/11/2015	15	No	Minor	Amber (Alert)
02/12/2015	13	No	Minor	Amber (Alert)
09/12/2015	13	No	No	Green (surveillance)
16/12/2015	19	Minor	Significant	Red (Action)
21/12/2015	22	Minor	No	Amber (Alert)
07/01/2016	6	No	Minor	Amber (Alert)
14/01/2016	4	No	No	Green (surveillance)
21/01/2016	8	No	No	Green (surveillance)
03/02/2016	2	No	No	Green (surveillance)
17/02/2016	2	No	No	Green (surveillance)
02/03/2016	1	No	No	Green (surveillance)
17/03/2016	0	No	No	Green (surveillance)

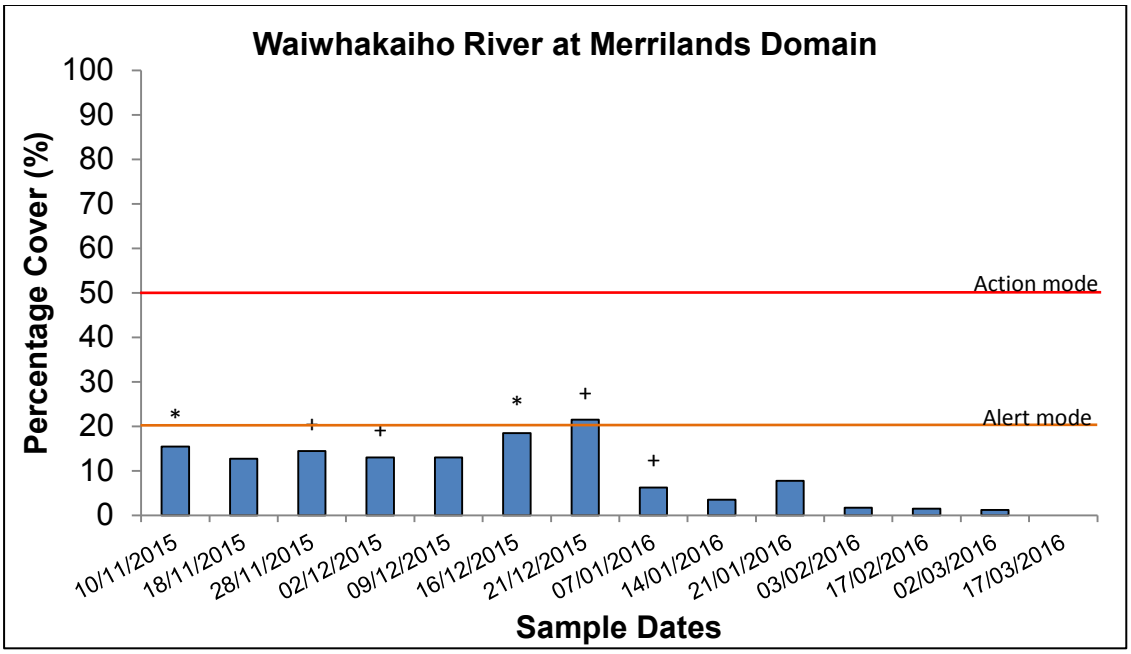


Figure 12 Percentage benthic cyanobacteria cover at the Waiwhakaiho River at Merrilands Domain site

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.

Benthic cyanobacteria coverage was moderately low during the start of monitoring period and dropped to low levels from January onwards (range from 0 to 22%). The benthic cyanobacteria found were *Phormidium* sp. The 'Alert' level was exceeded on one occasion for percentage cover. Detaching mats reached minor levels on two occasions which triggered the 'Alert' level. Significant exposed mats were visible on two occasions which triggered the 'Action' level.

Photos 1 and 2 Exposed cyanobacteria mats, Waiwhakaiho River at Merrilands Domain

The cause of the significant exposed mats (Photos 1 and 2) when the cover percentage was low was attributed to the daily fluctuations in flow caused by consented releases from the upstream Mangorei hydro electric power scheme. When the hydro scheme was not releasing water (e.g. in early morning), river levels were low and mats were exposed. The mats present on the top of boulders were not immersed during these low flows whereas high flows inundated the tops of boulders preventing the cyanobacteria from drying out. It appeared that other algae (green algae and diatoms) could not compete with *Phormidium* sp. under this hydrological regime and therefore cyanobacteria persisted on the tops of boulders at the site throughout the mid and later part of the season. The problem was not as severe as in the 2014-2015 monitoring period, when exposed mats were present throughout the mid and latter part of the monitoring period.

Appropriate warning signage was erected by NPDC at this site when directed.

4.2.3 Waiwhakaiho River adjacent to Lake Rotomanu

Photo 3 A typical gull population immediately upstream of the Waiwhakaiho River, Lake Rotomanu site

Minor usage of this site was recorded at the time of the sampling surveys, with some whitebaiting (in season) on the banks of the river. 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 3). Ducks were present on three occasions, mainly in the pool downstream.

The data for this site are presented in Table 22 and illustrated in Figure 13, with a statistical summary provided in Table 23. River flow information is illustrated in Figure 8 as it is also applicable to this site.

Table 22 Analytical results for the Waiwhakaiho River adjacent to Lake Rotomanu

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	0830	12.6	230	62	230	15.7	1.1
25.11.15	0835	10.5	700	590	820	16.0	0.5
10.12.15	0825	11.7	870	330	930	16.2	0.6
15.12.15	1045	10.1	930	1200	1000	18.0	0.9
12.01.16	0830	10.0	1700	1100	1900	19.5	0.7
15.01.16	1005	12.7	1100	490	1200	22.4	0.6
25.01.16	0840	12.3	600	510	680	23.0	0.8
09.02.16	0845	15.8	1800	1200	2400	22.6	2.2
12.02.16	1010	16.8	670	860	730	24.1	1.0
23.02.16	0830	11.6	770	680	770	20.9	0.6
08.03.16	0825	14.9	2600	1100	2800	21.1	0.9
22.03.16	1054	11.8	1200	800	1300	20.1	0.9
30.03.16	1145	12.0	660	1100	730	18.4	0.5

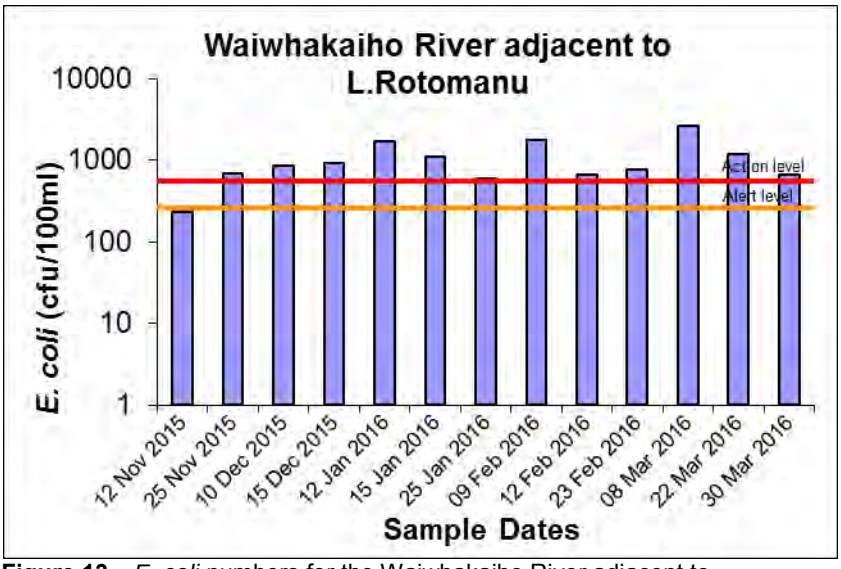


Figure 13 *E. coli* numbers for the Waiwhakaiho River adjacent to Lake Rotomanu during the regular survey season

Table 23 Statistical results summary for the Waiwhakaiho River adjacent to Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	10.0	16.8	12.0
E. coli	cfu/100ml	13	230	2600	870
Enterococci	cfu/100ml	13	62	1200	800
Faecal coliforms	cfu/100ml	13	230	2800	930
Temperature	°C	13	15.7	24.1	20.1
Turbidity	NTU	13	0.5	2.2	0.8

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 ruminants 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 8.4˚C between mid November and late March, with a maximum of 24.1˚C in mid February 2016. 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 no 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 870 per 100 ml, particularly in comparison with numbers found at the upstream Merrilands Domain site (median: 63 per 100ml; maximum: 250 per 100ml). Individual sample *E.coli* counts exceeded 670 per 100 ml on all but one occasion, 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.

4.2.3.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 24.

Table 24 Bacterial guidelines performance at the Waiwhakaiho River adjacent to Lake Rotomanu site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	0 [0]	12 [92]

(Designation: freshwater contact recreational area)

Twelve single samples were recorded within the 'Action' mode and no sample in the 'Alert' mode during the season. Bacteriological water quality measured at this site was very 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 4). Appropriately worded signage should be retained on a permanent basis in future.

Photo 4 Health risk signage, lower Waiwhakaiho River

4.2.3.2 Comparison with previous summers' surveys

A statistical comparison of all summers' surveys data is presented graphically in Appendix VI for all sites [Note: These data had been collected prior to the current year from time to time for consent monitoring purposes]. These data for the site in the Waiwhakaiho River adjacent to Lake Rotomanu are summarised in Table 25 and illustrated in Figure 14.

Table 25 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys in the Waiwhakaiho River adjacent to Lake Rotomanu

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	9	-	52	-	26	-	54	-	46	-	71	-	160	-	220	77	230	210	46	230
Maximum	740	-	51	-	870	-	470	-	1000	-	1600	-	2600	-	3400	2000	5000	2200	7400	2600
Median	72	-	120	-	110	-	210	-	270	-	320	-	490	-	885	460	1100	650	1000	870

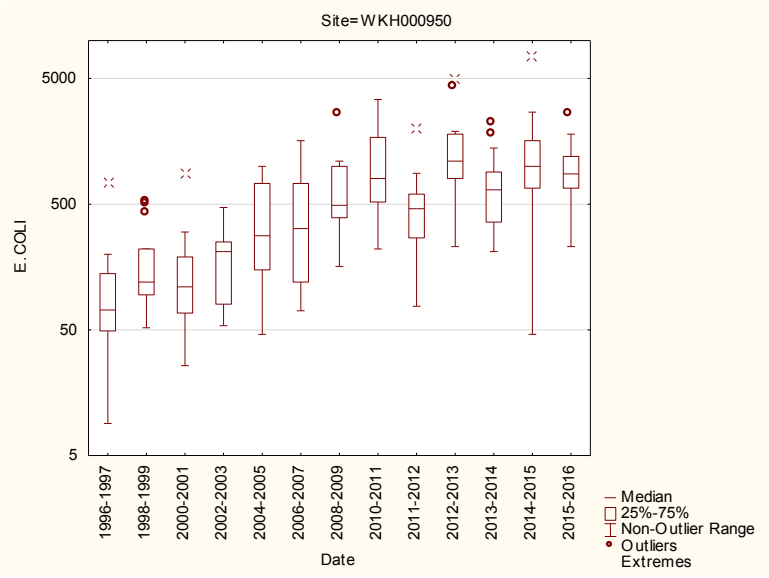


Figure 14 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River adjacent to Lake Rotomanu

The median *E.coli* number in the 2015-2016 period was the fourth highest recorded to date, continuing a trend of increasing medians in more recent years (Table 25 and Figure 14). 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 four medians in excess of the 'Action' guideline. The minimum *E. coli* number in 2015-2016 was equal to the highest recorded, suggesting an increase in baseline.

Trend analysis of these median *E.coli* numbers has been performed for the thirteen seasons of data by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 15). 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 as there have been more than ten seasons monitored to date.

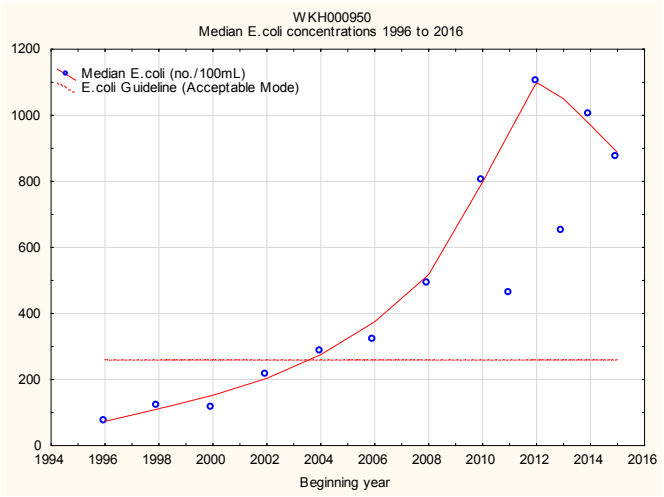


Figure 15 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Waiwhakaiho River, adjacent to Lake Rotomanu for the 1996 to 2016 period

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

4.2.3.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 15 occasions throughout the season. Results are presented in Table 26 and illustrated in Figure 16.

Table 26 Percentage benthic cyanobacteria cover for the Waiwhakaiho River adjacent to Lake Rotomanu site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	9	No	Minor	Green (surveillance)
18/11/2015	8	No	Minor	Green (surveillance)
28/11/2015	10	Minor	Minor	Green (surveillance)
02/12/2015	14	No	Minor	Green (surveillance)
09/12/2015	15	Minor	Minor	Green (surveillance)
16/12/2015	18	Minor	Significant	Red (Action)
21/12/2015	16	Minor	Significant	Red (Action)
07/01/2016	5	No	Minor	Amber (Alert)
14/01/2016	7	No	No	Green (surveillance)
21/01/2016	5	No	Minor	Amber (Alert)
28/01/2016	1	No	No	Green (surveillance)
03/02/2016	1	No	No	Green (surveillance)
17/02/2016	0	No	No	Green (surveillance)
02/03/2016	0	No	No	Green (surveillance)
17/03/2016	1	No	No	Green (surveillance)

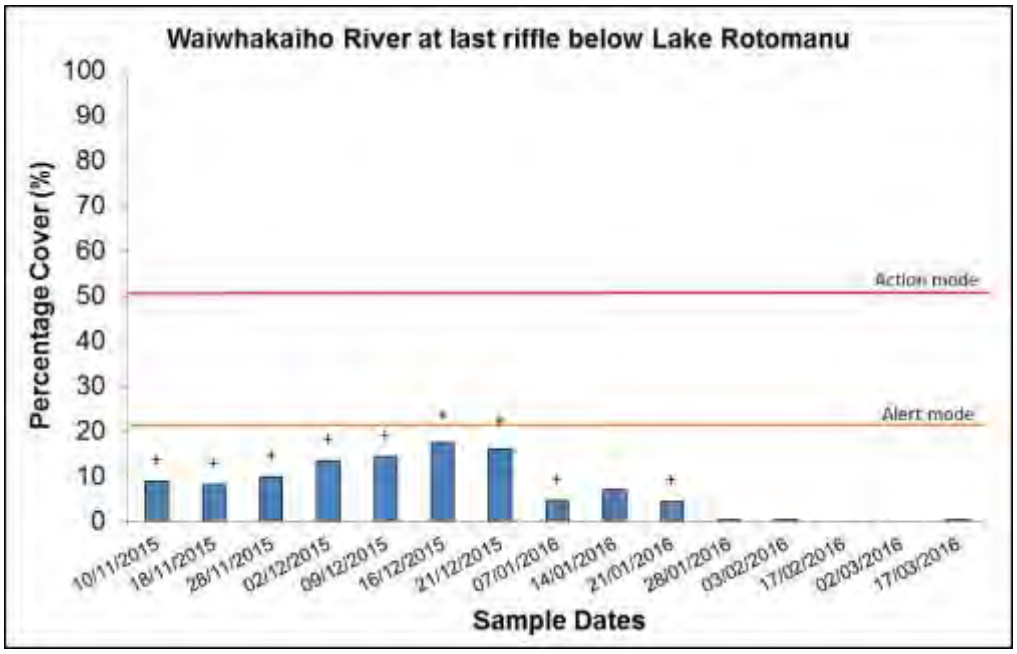


Figure 16 Percentage benthic cyanobacteria cover, at the Waiwhakaiho River adjacent to Lake Rotomanu site

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 throughout mid summer and receded to low levels from January onwards (range from 0 to 18%). The benthic cyanobacteria found were a *Phormidium* sp. However, detaching mats reached minor levels on four occasions, which triggered the 'Alert' level. Significant exposed mats were visible on two occasions, which triggered the 'Action' level, and minor exposed mats were present on seven occasions which triggered, the 'Alert' level.

4.2.4 Te Henui Stream at the mouth, East End

Low usage of this site was recorded at the time of the sampling surveys, with no bathing noted. The adjacent playground was being used on two occasions. This contrasted with walking, picnicking, fishing, or whitebaiting (in season) from the banks of the stream in many past seasons.

Ducks were common at this site on most survey occasions and gulls were present from time to time, where occasionally they were encouraged by people feeding the birdlife.

The data for this site are presented in Table 27 and illustrated in Figure 17, with a statistical summary provided in Table 28.

Table 27 Analytical results for the Te Henui Stream at the mouth, East End

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	0940	1420	520	600	540	15.2	2.5
25.11.15	0915	1240	930	830	930	15.5	1.5
10.12.15	0900	38.5	1300	1700	1300	15.7	0.6
15.12.15	1125	210	490	850	490	16.2	0.4
12.01.16	0810	16	2000	1300	2000	18.2	0.5
15.01.16	1315	1990	640	420	640	21.6	1.3
25.01.16	0930	1965	900	870	900	21.1	1.1
09.02.16	0930	3100	1900	1900	1900	22.2	2.1
12.02.16	1100	3830	340	720	350	23.0	2.8
23.02.16	0920	1350	830	1700	870	20.7	0.8
08.03.16	0910	3150	1300	1400	1700	19.8	1.8
22.03.16	1015	780	5500	2400	5700	19.2	0.6
30.03.16	1245	17.8	1500	1500	1700	16.6	0.5

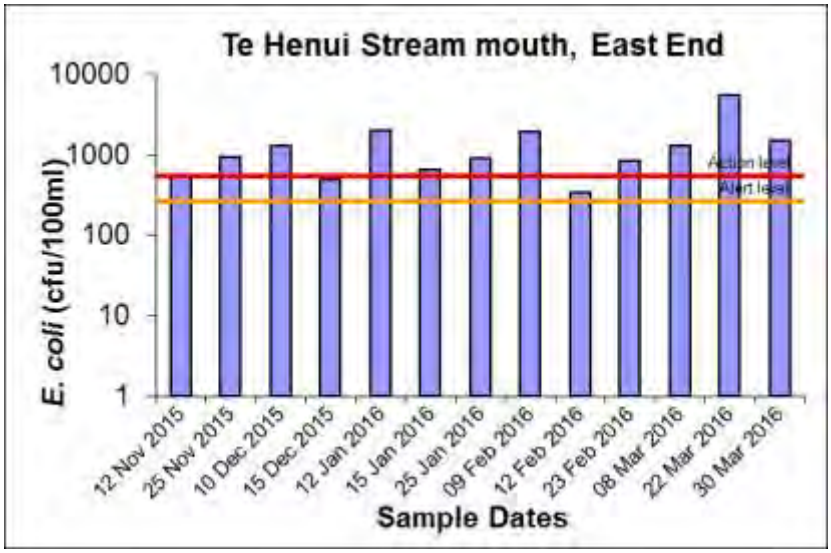


Figure 17 *E.coli* numbers for the Te Henui Stream at the mouth, East End during the regular survey season

Table 28 Statistical results summary for the Te Henui Stream at the mouth, East End

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	16.0	3830	1350
E. coli	cfu/100ml	13	340	5500	930
Enterococci	cfu/100ml	13	420	2400	1300
Faecal coliforms	cfu/100ml	13	350	5700	930
Temperature	°C	13	15.2	23.0	19.2
Turbidity	NTU	13	0.4	2.8	1.1

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 relatively narrow range of 7.8˚C between mid November and late March, with a maximum of 23.0˚C in mid February 2016. Conductivity and turbidity results were indicative of clean, clear, relatively high water quality, subject to tidal incursions of seawater on most sampling occasions. The water often appeared green, as a result of extensive algal cover.

Bacterial water quality in the 2015-2016 season was very poor with a wide range of counts and very high median *E. coli* count of 930 per 100 ml and a relatively high minimum count.

4.2.4.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 29.

Table 29 Bacterial guidelines performance at the Te Henui Stream mouth, East End

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	3 [23]	10 [77]

(Designation: freshwater contact recreational area)

Only three single samples were recorded below the 'Action' mode during the season, all of which were at 'Alert' level. Bacteriological water quality measured at this site therefore was outside the acceptable standard for contact recreational usage on 77% 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). Minimal impact of the stream on the coastal East End beach water quality was indicated by the median *E.coli* number (4 per 100 ml) for the SEM season (TRC, 2016).

4.2.4.2 Comparison with previous summers' surveys

A statistical comparison of thirteen summer's surveys data is presented graphically in Appendix VI for all sites. [Note: prior to the 2011-2012 season these data had been collected to provide interpretative information for nearby coastal beach monitoring data]. The data for the Te Henui Stream site are summarised in Table 30 and illustrated in Figure 18.

Table 30 Summary of *E.coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Te Henui Stream at the mouth, East End

Summer	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	150	160	220	260	220	240	550	500	69	350	300	250	250	340
Maximum	2600	8700	51000	9300	5200	2500	7700	3400	6800	13000	4200	7900	3400	5500
Median	410	415	890	750	1100	1100	1100	930	985	1100	1500	1000	1300	930

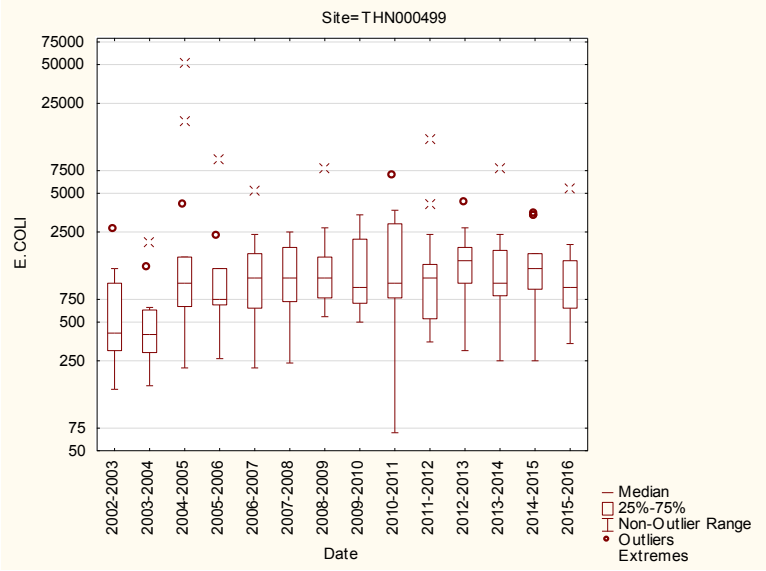


Figure 18 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers in the Te Henui Stream at the mouth, East End

The median *E. coli* number in the 2015-2016 period was typical of the medians recorded over the last 13 years (Table 30 and Figure 18), and well above the 'Alert' level of the 2003 MfE guidelines. All but two of the 14 median numbers to date have also been in the 'Action' level. The very wide range of numbers has also been typical for this site.

Trend analysis of these median *E.coli* numbers has been performed for the fourteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 19) 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.

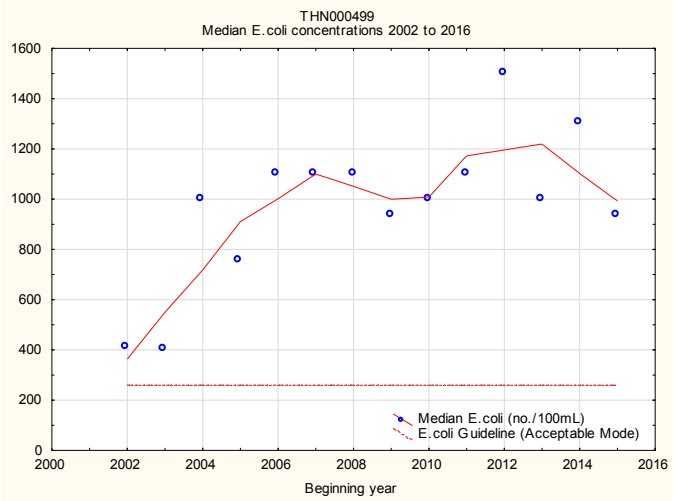


Figure 19 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Te Henui Stream mouth, East End for the 2002 to 2016 period

A temporal trend of increasing median *E. coli* numbers has been found over the fourteen seasons of monitoring. (Note: This trend was not statistically significant at p< 0.05, the p level being 0.055, increasing to 0.231 after FDR correction). Only two of these seasonal medians were within the 'Alert' mode with all others exceeding the 'Action' mode.

4.2.4.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on nine occasions during the season. Results are presented in Table 31 and Figure 20.

Table 31 Percentage benthic cyanobacteria cover for the Te Henui Stream at the mouth, East End

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	2	No	No	Green (surveillance)
28/11/2015	2	No	No	Green (surveillance)
09/122015	0	No	No	Green (surveillance)
21/12/2015	3	No	No	Green (surveillance)
07/01/2016	0	No	No	Green (surveillance)
21/01/2016	0	No	No	Green (surveillance)
03/02/2016	0	No	No	Green (surveillance)
17/02/2016	0	No	No	Green (surveillance)
02/03/2016	0	No	No	Green (surveillance)

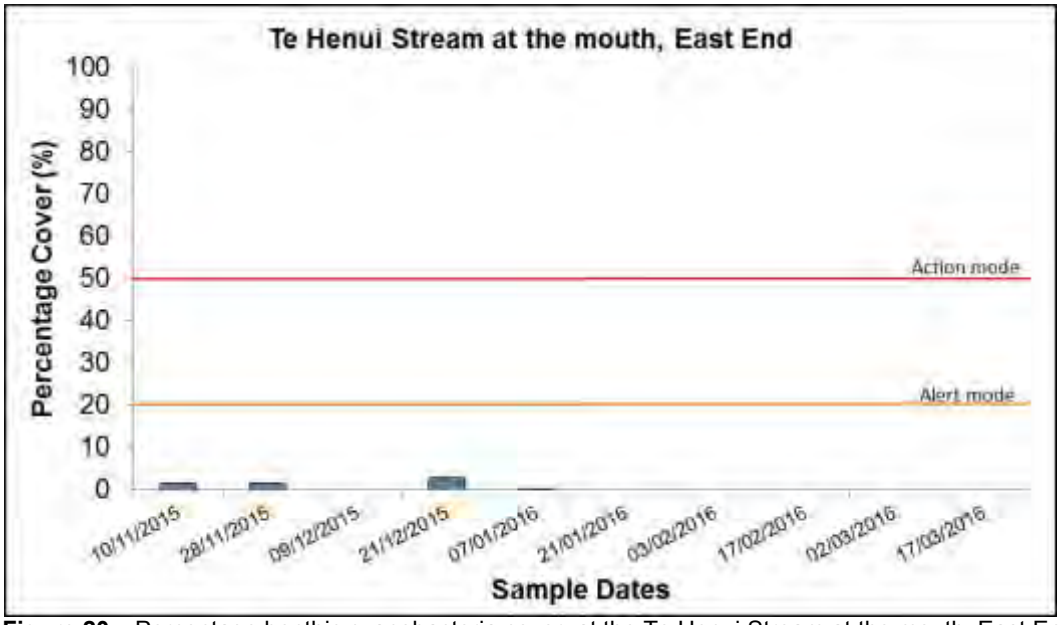


Figure 20 Percentage benthic cyanobacteria cover, at the Te Henui Stream at the mouth, East End site

Benthic cyanobacteria coverage was low throughout the season (ranging from 0% to 3%). The benthic cyanobacteria found were *Phormidium* sp. The 'Action' and 'Alert' levels were not exceeded for percentage cover nor for the presence of exposed or detaching mats and therefore no health warnings were required.

4.2.5 Patea River at King Edward Park, Stratford

Recreational usage of this river site was recorded at the time of two of the sampling surveys, most of which were in the afternoon. Bathing was noted in late January 2016, and fishing in mid February 2016, around the time of the release of trout into the river for the 'Take a Kid Fishing' promotion that has taken place in recent years.

A few ducks were observed on the water on four monitoring occasions.

Sampling occurred later in the day than in the previous two seasons, with only three samples taken in the morning, in order to coordinate with sampling at remote triennially monitored marine sites where tidal constraints apply.

Data from the site are presented in Table 32 and illustrated in Figure 22, with a statistical summary provided in Table 33. River flow records are illustrated in Figure 21.

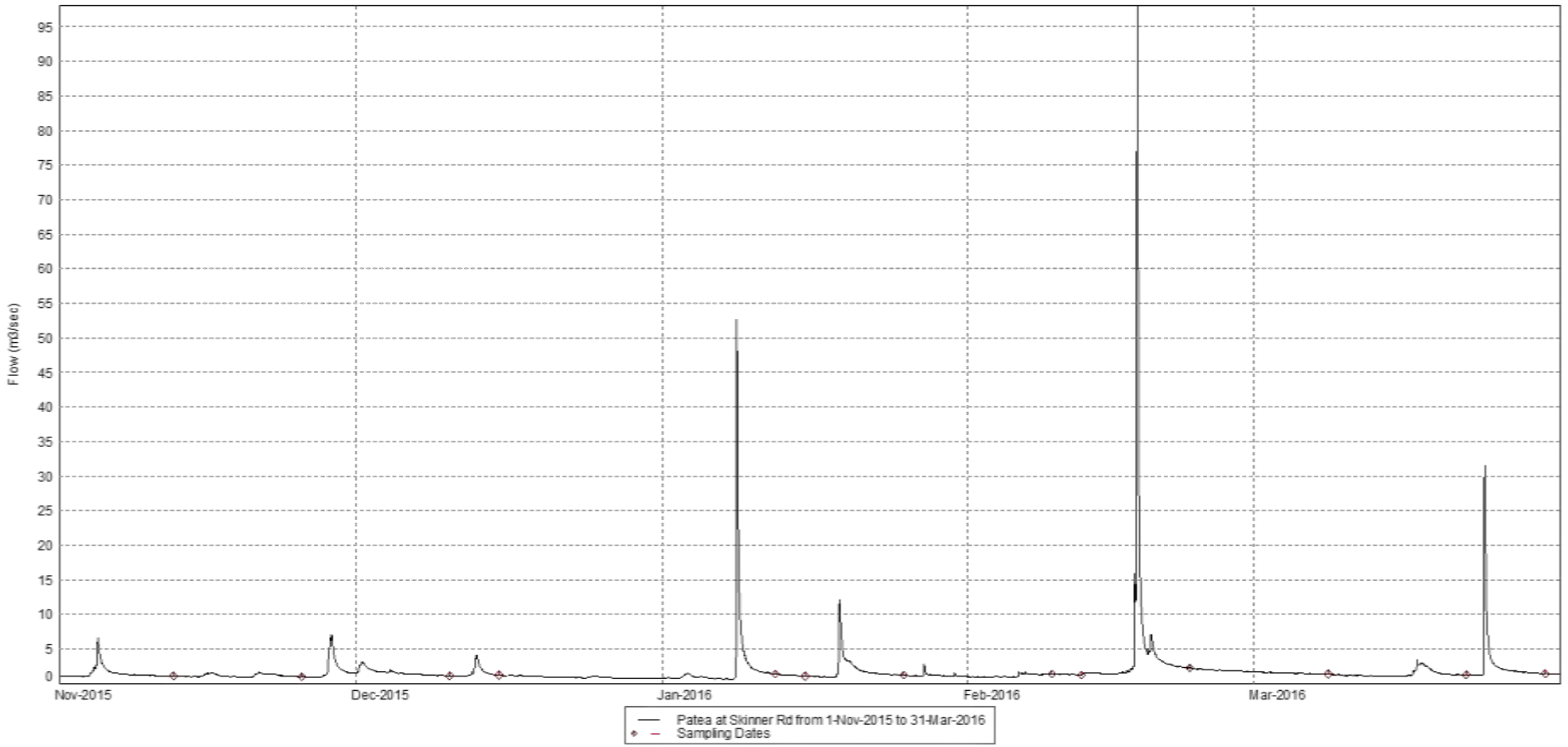


Figure 21 Flow in the Patea River at Skinner Rd during the survey period

Table 32 Analytical results for the Patea River at Kind Edward Park, Stratford

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1320	9.3	180	23	180	13.5	1.1
25.11.15	1300	9.1	88	13	88	14.8	1.0
10.12.15	1245	9.2	92	80	92	15.2	1.0
15.12.15	0840	8.4	640	180	640	12.4	1.2
12.01.16	1430	8.2	160	200	160	16.8	0.7
15.01.16	0940	8.9	220	190	220	16.0	0.7
25.01.16	1420	8.7	130	200	130	19.2	1.2
09.02.16	1340	9.5	200	680	200	17.9	0.7
12.02.16	0845	9.7	430	1500	430	17.2	0.7
23.02.16	1335	8.4	220	970	220	16.6	0.6
08.03.16	1305	9.4	280	580	290	17.9	0.9
22.03.16	1445	9.4	140	520	140	16.4	0.9
30.03.16	1030	8.6	260	620	280	13.1	0.4

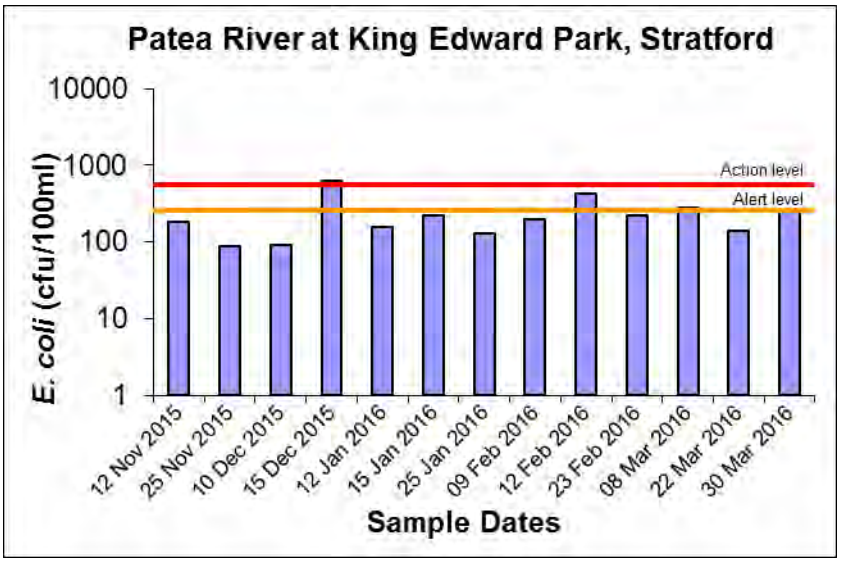


Figure 22 *E. coli* numbers for the Patea River at King Edward Park, Stratford during the survey season

Table 33 Statistical results summary for the Patea River at King Edward Park, Stratford

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	8.2	9.7	9.1
E. coli	cfu/100ml	13	88	640	200
Enterococci	cfu/100ml	13	13	1500	200
Faecal coliforms	cfu/100ml	13	88	640	200
Temperature	°C	13	12.4	19.2	16.4
Turbidity	NTU	13	0.4	1.2	0.9

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 of ≤ 1.2 NTU on all occasions) and uncoloured or pale green-brown or grey in appearance with a relatively low and narrow range of conductivity levels.

Water temperatures had a moderate range of 6.8°C for this site (at an elevation of 300 m asl), with a maximum of 19.2°C recorded in late January 2016 (at 1420 hrs).

Bacteriological water quality was moderate to poor for the mid reaches of this Taranaki ring plain river draining a predominantly agricultural catchment. Two moderately high counts were recorded during the survey period, for the two samples taken earliest in the day. One count exceeded the 'Action' level, in mid December, and a health warning sign (Photo 5) was erected immediately by Stratford District Council upon advice from the TDHB. A follow-up sample was taken on 21 December 2015, which returned a count at 'Surveillance' level (260 *E.coli*/100ml). The warning sign was then removed.

It has been apparent that higher counts have been coincidental with earlier (morning) surveys, indicative of the probable cumulative influence of dairy pond system discharges further upstream. In some previous seasons' surveys it has been necessary to re-inspect a number of dairy farms' disposal systems in smaller upstream catchments, and on several occasions issue abatement notices for non-compliance with consented disposal requirement.

Photo 5 Warning signage at King Edward Park site, December 2015

In 2015-2016, Council had prepared to investigate of the source of high baseline *E. coli*, through DNA faecal source tracking marker analysis. (Refer to recommendation 6 of report TRC15-01). It was planned to take a series of samples at the site through the day, once the routine indicator monitoring showed the presence of an unacceptable high bacterial level in dry weather. However, other than one instance in mid December 2015, high indicator counts did not occur, possibly because most samples were taken later in the day than usual. It is proposed to carry out this exercise in 2016-2017, when routine sampling will revert to earlier in the day, should high counts be returned.

4.2.5.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 34.

Table 34 Bacterial guidelines performance at the Patea River at King Edward Park, Stratford site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	2 [15]	1 [8]

(Designation: freshwater contact recreational area)

One single sample fell within the 'Action' mode, and another two samples fell in the 'Alert' mode. These counts occurred between mid December 2015 and early March 2016, either early in the morning or under dry and low flow conditions, or both. In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was outside the acceptable level occasionally during the period, with one incursion into the 'Action' level.

4.2.5.2 Comparison with previous summers' surveys

A statistical comparison of all of the summers' survey data is presented graphically in Appendix VI for all sites. A shorter data period (fifteen years) exists for the Patea River (at King Edward Park, Stratford) site which was added to the programme in 2001-2002. These summer data for the Patea River at King Edward Park, Stratford site are summarised in Table 35 and illustrated in Figure 23.

Table 35 Summary *E. coli* bacteriological water quality data (nos/100 ml) all summer surveys in the Patea River at King Edward Park, Stratford

Summer	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	46	120	48	96	100	28	46	51	51	54	63	37	62	110	88
Maximum	640	780	580	760	840	1000	690	570	7400	610	440	330	550	760	640
Median	250	190	110	300	310	200	290	200	250	160	150	180	240	280	200

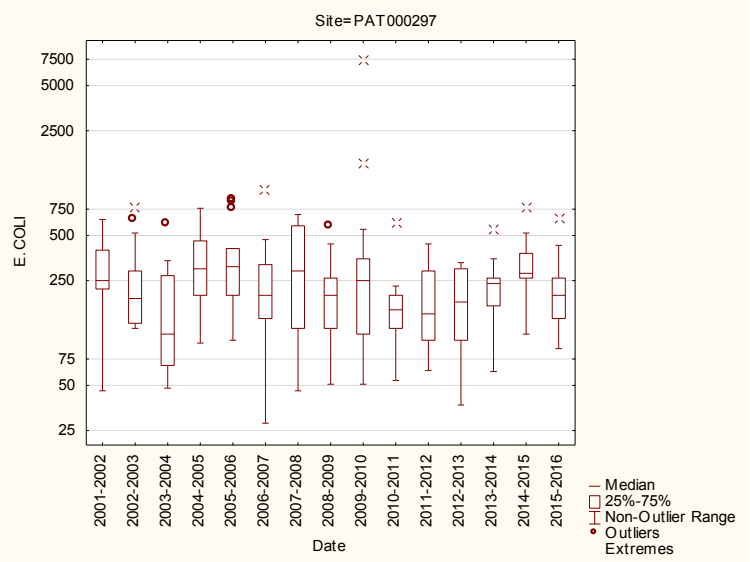


Figure 23 Box & whisker plots for all summer surveys of *E.* coli bacterial numbers for the Patea River at King Edward Park, Stratford

An improvement was indicated by the reduction in median *E. coli* bacterial count recorded for 2015-2016, following the deterioration over the three preceding

monitoring seasons, possibly because most sampling occurred later in the day. The 2015-2016 season recorded a relatively typical range of counts for this site.

Trend analysis of these median *E.coli* numbers has been performed for the fifteen seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 24) 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.

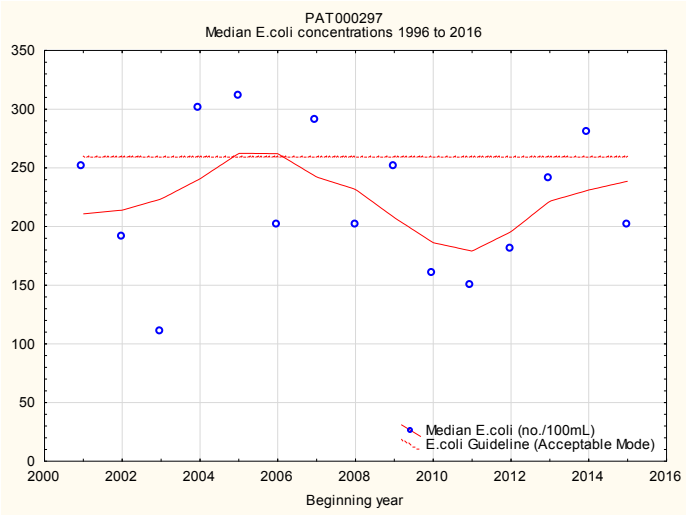


Figure 24 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Patea River, King Edward Park site, for the 2001-2016 period

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

4.2.5.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season. Results are presented in Table 36 and Figure 25.

Table 36 Percentage benthic cyanobacteria cover for the Patea River at King Edward Park, Stratford

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	2	No	No	Green (surveillance)
28/11/2015	2	No	No	Green (surveillance)
09/12/2015	0	No	No	Green (surveillance)
21/12/2015	1	No	No	Green (surveillance)
07/01/2016	0	No	No	Green (surveillance)
21/01/2016	1	No	No	Green (surveillance)
03/02/2016	1	No	No	Green (surveillance)
17/02/2016	1	No	No	Green (surveillance)
02/03/2016	0	No	No	Green (surveillance)
17/03/2016	0	No	No	Green (surveillance)

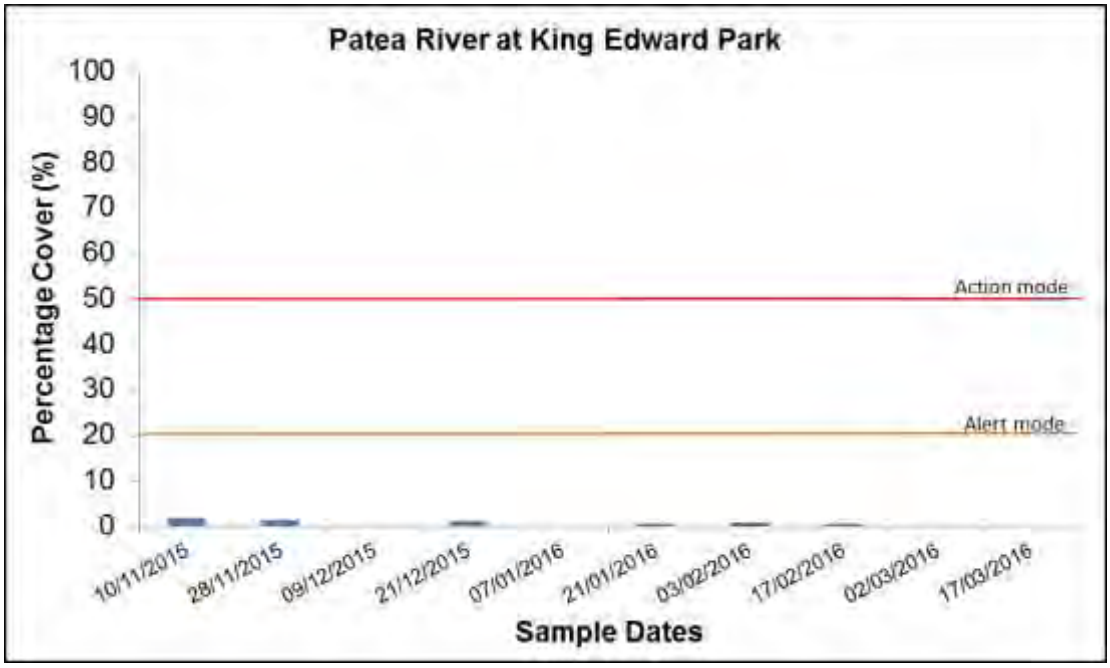


Figure 25 Percentage benthic cyanobacteria cover at the Patea River, King Edward Park site

Benthic cyanobacteria coverage was very low throughout the season (range from 0 to 2%). The benthic cyanobacteria found was *Phormidium* sp. The 'Action' or 'Alert' level was not exceeded for percentage cover or for the presence of exposed or detaching mats and therefore no action at the site was required.

4.2.6 Patea River at the boat ramp, Patea

Bathing usage of this river site was recorded once at the time of sampling surveys, all but two of which were before midday. Boating, jetskiing, 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 and the relatively recent provision of a boat jetty.

[Note: Although birdlife was generally minimal in the immediate vicinity of the site, very unusual brief appearance of a group of pelicans had been reported in the lower river late in 2013 (TRC, 2014)].

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.

Data from the site for the 2015-2016 season are presented in Table 37 and illustrated in Figure 26, with a statistical summary provided in Table 38.

Table 37 Analytical results for the Patea River at the boat ramp, Patea

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
12.11.15	0920	4730	8	<2	8	15.3	24
25.11.15	0920	4750	9	1	9	16.6	21
10.12.15	0915	4680	32	4	33	17.0	16
15.12.15	1130	4730	4	1	4	17.9	23
12.01.16	1025	4630	8	13	8	18.9	27
15.01.16	1230	4690	4	4	4	20.5	18
25.01.16	1000	4660	13	7	13	20.8	16
09.02.16	0940	4620	3	3	3	21.4	10
12.02.16	1135	4650	9	20	9	22.6	25
23.02.16	0945	4520	5	12	5	22.0	24
08.03.16	0910	4730	35	9	35	20.9	25
22.03.16	1020	4680	80	24	80	20.0	9.4
30.03.16	1310	4630	2	<2	2	19.7	21

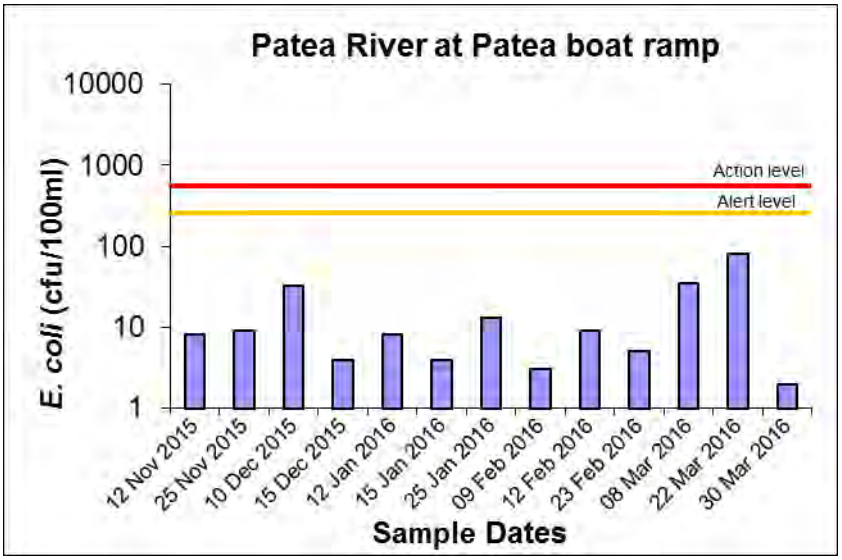


Figure 26 *E.coli* numbers for the Patea River at the boat ramp, Patea during the survey season

Table 38 Statistical results summary for the Patea River at the boat ramp, Patea

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4520	4750	4680
E. coli	cfu/100ml	13	2	80	8
Enterococci	cfu/100ml	13	<2	24	4
Faecal coliforms	cfu/100ml	13	2	80	8
Temperature	°C	13	15.3	22.6	20.0
Turbidity	NTU	13	9.4	27	21

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 boatramp (by about 0.7 km).

River water was usually slightly turbid and milky pale green in appearance with high conductivity levels typical of seawater ingress at high tide on all occasions. Water temperatures had a moderate range of 7.3˚C, a more typical range due to the coastal seawater influence, with a maximum of 22.6˚C recorded in late morning in mid February 2016 when the river was in very low flow. All of the samples were collected before 1310 hours and therefore maximum river temperatures (which could be anticipated to occur later in the afternoon) were not recorded.

Bacteriological water quality was very good for the lower reaches of this Taranaki ring plain river (median: 8 *E.coli* per 100 ml and 4 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 34 per 100mls (with counts ranging from 2 to 280 per 100 ml) was found with numbers tending to be higher when seawater intrusion was less apparent.

4.2.6.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 39.

Table 39 Bacterial guidelines performance at the Patea River at the boatramp, Patea site [% of 13 samples]

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

(Designation: freshwater contact recreational area)

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 *E.coli*: 15 per 100 mls; range *E.coli:* <1-840 per 100 ml] for consent and SEM purposes.

4.2.6.2 Comparison with previous summers' surveys

Eight 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 summarised in Table 40 and illustrated in Figure 27.

Table 40 Summary *E. coli* bacteriological water quality data (cfu/100 ml) all summer surveys in the Patea River at the boat ramp, Patea

Summer	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	1	1	1	<1	1	1	<1	<1	2
Maximum	190	87	82	33	260	84	20	24	80
Median	5	9	11	4	16	3	3	5	8

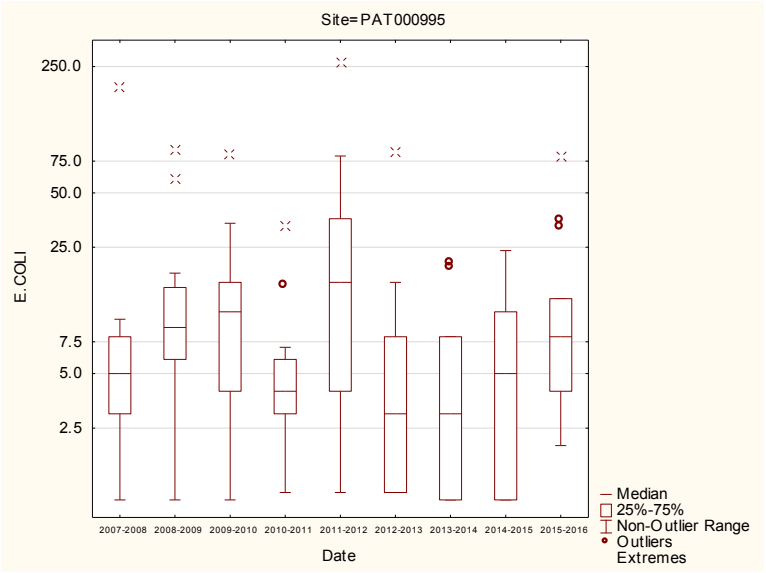


Figure 27 Box & whisker plots for all summer surveys of *E. coli* bacterial numbers for the Patea River at the boat ramp, Patea

Relatively similar (very low) median *E. coli* numbers have been found by these nine 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. Trend analysis of median *E. coli* numbers will not be performed until the sampling period has encompassed ten seasons of data collection at this site.

4.2.7 Waingongoro River at Eltham camp

No bathing usage of this river site was recorded at the time of sampling surveys but camp activities may have included this and other recreational usage as the camp was occupied on several occasions, including one occasion during which kayaking was

occurring in the river (resulting in increased turbidity of the low river flow). The site is used as part of the camp's activities.

Sheep were present in the paddock adjacent to this unfenced site on the first three monitoring occasions, but minimal birdlife was recorded. Data from the site are presented in Table 41 and illustrated in Figure 28 with a statistical summary provided in Table 42. River flow records are illustrated in Figure 29.

Table 41 Analytical results for the Waingongoro River at Eltham camp

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*Ecoli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1300	11.8	68	3	74	15.8	1.5
25.11.15	1230	11.7	56	3	56	16.2	1.4
10.12.15	1230	11.5	28	20	28	17.2	1.4
15.12.15	0905	11.1	320	92	320	14.6	1.5
12.01.16	1405	10.1	260	70	260	18.4	0.77
15.01.16	1005	10.9	470	89	470	17.6	0.94
25.01.16	1355	10.4	180	42	180	23.6	0.94
09.02.16	1315	11.8	160	100	160	20.6	1.9
12.02.16	0915	11.8	300	290	310	18.6	1.0
23.02.16	1315	9.8	150	280	150	19.5	0.61
08.03.16	1245	11.2	200	200	200	20.6	3.0
22.03.16	1420	11.1	68	120	68	18.7	4.8
30.03.16	1100	10.5	190	350	190	15.4	0.63

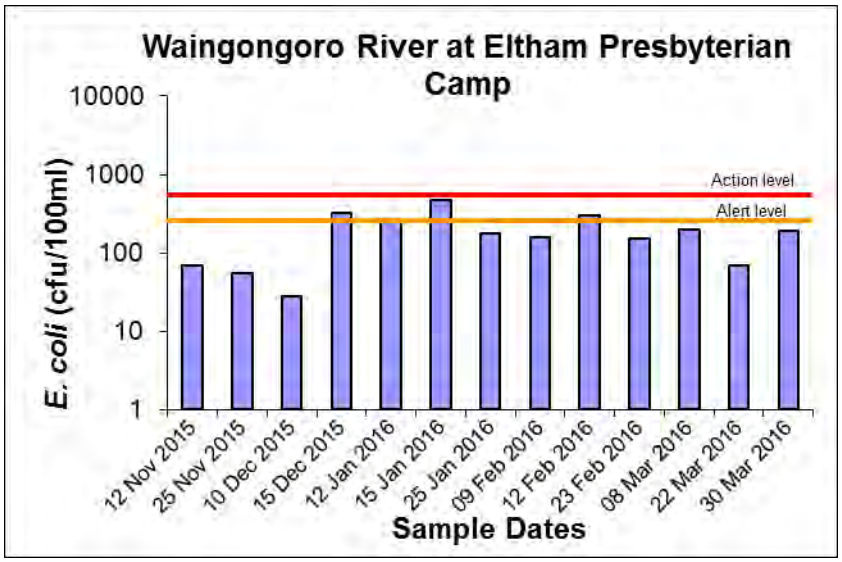


Figure 28 *E. coli* numbers for the Waingongoro River at Eltham Camp during the survey season

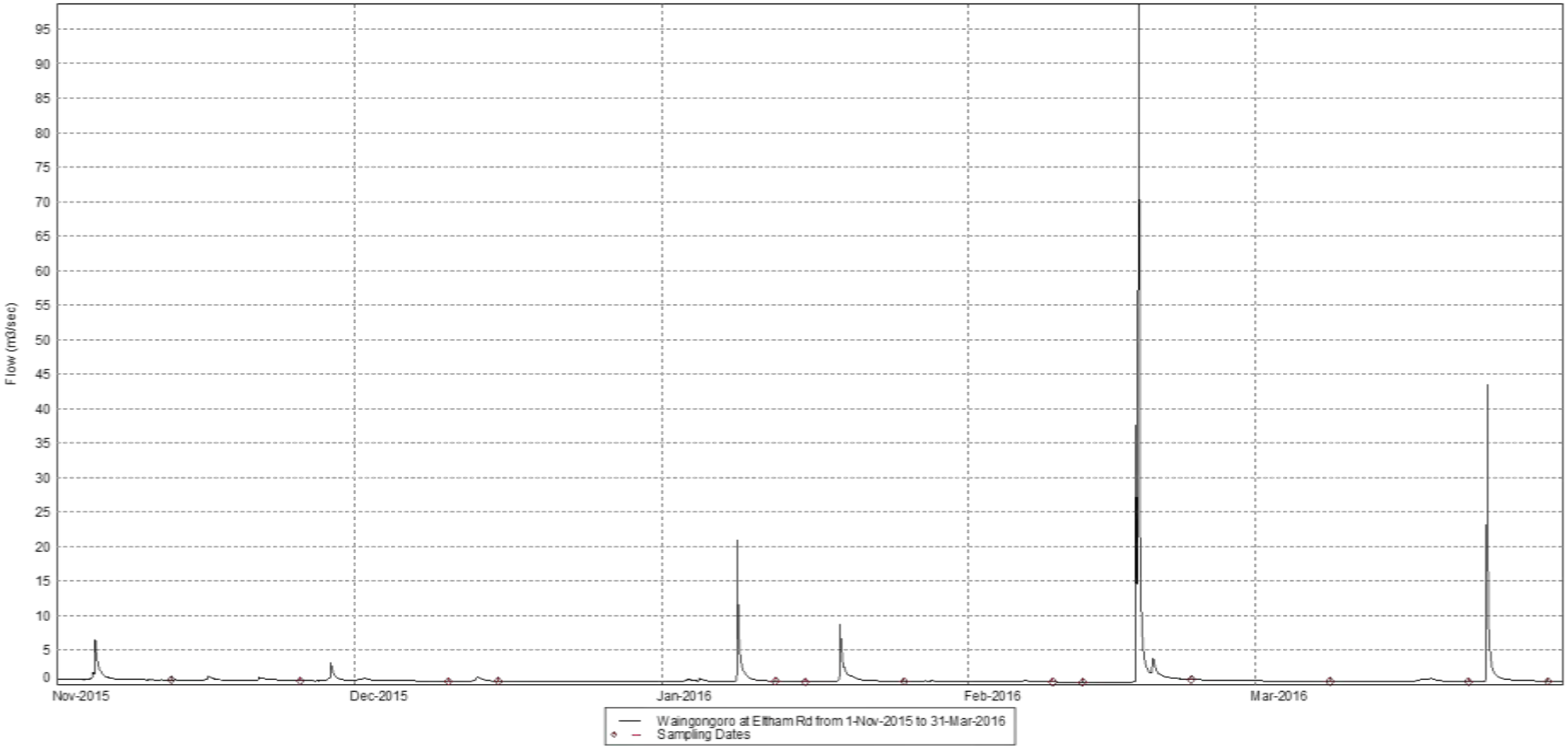


Figure 29 Flow in the Waingongoro River at Eltham during the survey period

Table 42 Statistical results summary for the Waingongoro River at Eltham camp

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	9.8	11.8	11.1
E. coli	cfu/100ml	13	28	470	180
Enterococci	cfu/100ml	13	3	350	92
Faecal coliforms	cfu/100ml	13	28	470	180
Temperature	°C	13	14.6	23.6	18.4
Turbidity	NTU	13	0.6	4.8	1.4

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 moderately wide range (9.0 ˚C) with a maximum of 23.6 ˚C recorded in late January 2016. All samples were collected before 1420 hours and therefore higher river temperatures (which tend to occur later in the afternoon) were not recorded.

Bacteriological water quality was in the range (median *E.*coli: 180 per 100 ml) typical of the mid reaches of the Taranaki ring plain river draining a predominantly agricultural catchment. This was also apparent in comparison with the nearby Eltham Road (state of the environment physicochemical monitoring) site where a median *E.coli* count of 180 per 100mls (range: 6 to 59000 per 100 ml) has been recorded by monthly sampling since 1995. The highest counts in the current survey occurred in the samples taken earliest in the day, between 0905 and 1005 hrs, irrespective of time of season, under low flow conditions in December, January and February, with three samples in the 'Alert' mode (Figure 28 and Figure 29).

4.2.7.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 43.

Table 43 Bacterial guidelines performance at the Waingongoro River, Eltham Camp [% of 13 samples]

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

(Designation: freshwater contact recreational area)

Three single samples fell within the 'Alert' mode but no samples reached the 'Action' mode. The highest sample count (in the 'Alert' mode) occurred in mid January 2016 during a low flow period. 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.

In terms of contact recreational usage guidelines, bacteriological water quality at this site was within the acceptable level throughout the period and no bacteriological warning signage was required.

4.2.7.2 Comparison with previous summers' surveys

A statistical comparison of each of all summers' survey data is presented graphically in Appendix VI for all sites.

A shorter data period exists for the Waingongoro River (at Eltham camp) site as this site was added to the programme in 2001-2002. These data are summarised in Table 44 and illustrated in Figure 30.

Table 44 Summary of *E. coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Waingongoro River at Eltham camp to date

Summer	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	31	63	23	51	54	23	57	77	57	32	68	74	48	46	28
Maximum	870	550	360	1700	430	290	420	500	270	490	330	430	380	440	470
Median	230	230	100	170	130	110	160	130	160	140	150	160	240	260	180

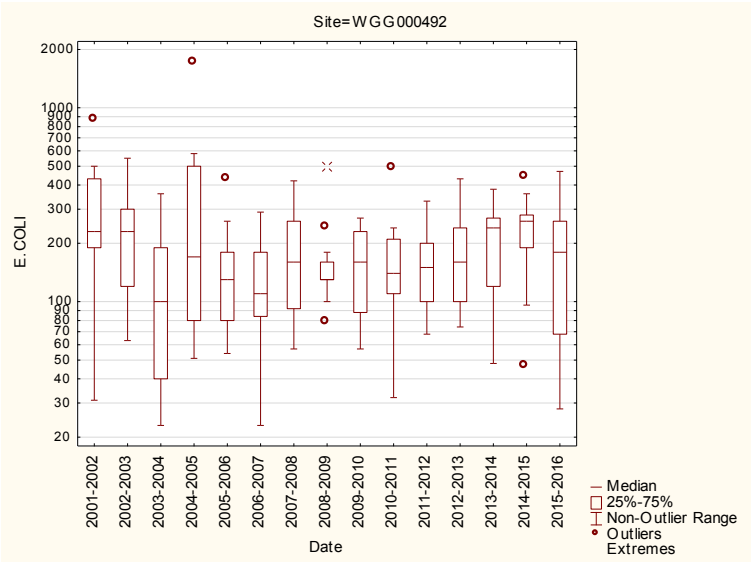
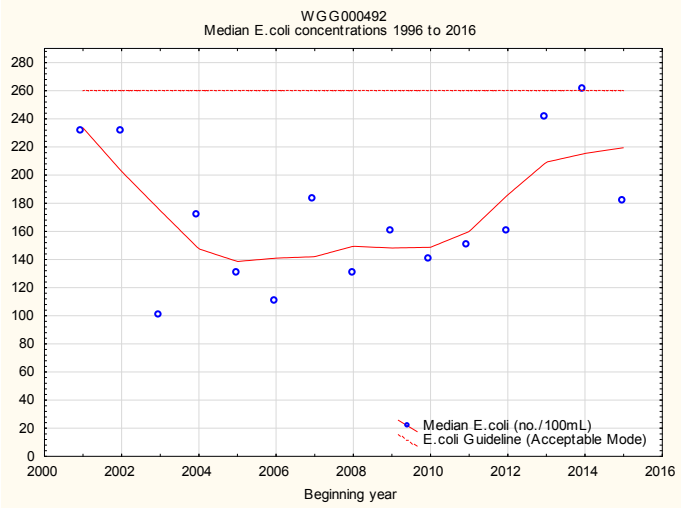


Figure 30 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waingongoro River at Eltham Camp

Similar *E.coli* bacterial water quality was indicated by a median count which was within the mid range of the medians recorded by the fourteen preceding seasons (Figure 30). There was a moderate range of counts over the 2015-2016 season, typical of many ranges in the fourteen other seasons monitored previously.

Trend analysis of these median *E.coli* numbers has been performed for the fifteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 31) 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.



N = 15
Kendall tau = + 0.2013
p level = 0.269 [>FDR, p = 0.505]
N/S at p <0.05

Figure 31 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waingongoro River, Eltham camp for the 2001 to 2016 period

A statistically insignificant trend of increasing median *E.coli* numbers was found over the fifteen seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes although those of the two initial and two of latest three seasons were relatively high.

4.2.7.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season. Results are presented in Table 45 and Figure 32.

Table 45 Percentage benthic cyanobacteria cover for the Waingongoro River at Eltham Camp

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	4	No	No	Green (surveillance)
28/11/2015	2	No	No	Green (surveillance)
09/12/2015	1	No	No	Green (surveillance)
21/12/2015	3	No	No	Green (surveillance)
07/01/2016	2	No	No	Green (surveillance)
21/01/2016	0	No	No	Green (surveillance)
03/02/2016	10	No	No	Green (surveillance)
17/02/2016	1	No	No	Green (surveillance)
02/03/2016	0	No	No	Green (surveillance)
17/03/2016	0	No	No	Green (surveillance)

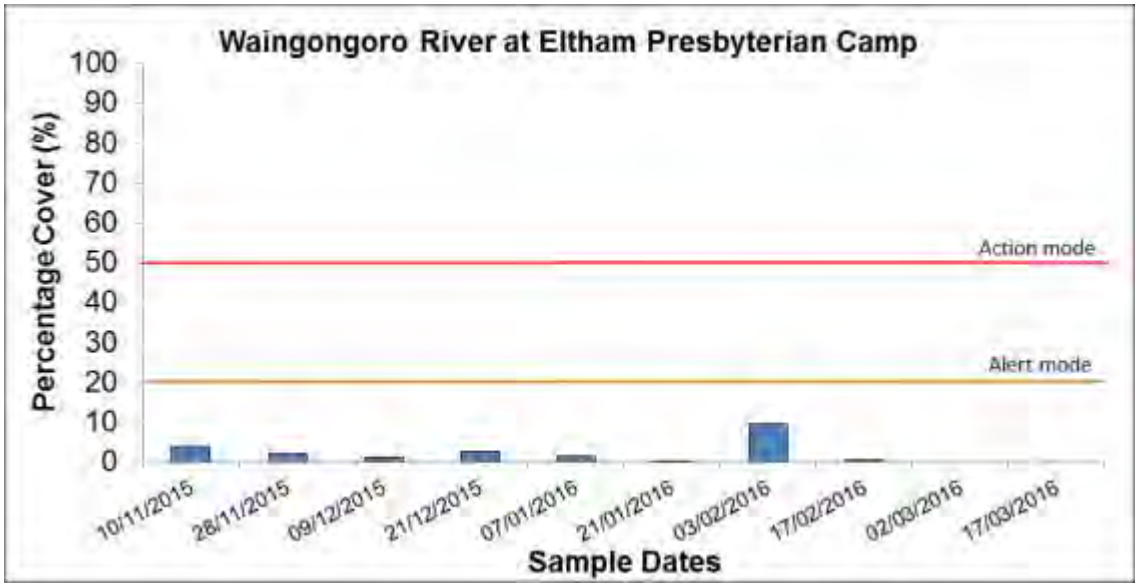


Figure 32 Percentage benthic cyanobacteria cover at the Waingongoro River Eltham camp

Benthic cyanobacteria coverage was very low throughout the season (ranging from 0% to 10%). The benthic cyanobacteria found were *Phormidium* sp. The 'Action' and 'Alert' levels were not exceeded for percentage cover or for the presence of exposed or detaching mats and therefore no health warnings were required.

4.2.8 Waingongoro River at Ohawe Beach

Bathing usage of this site was recorded in January, and whitebaiting (in season). Occasionally livestock have been present in the paddock upstream of the site but during the 2015-2016 season 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 nos/100 ml upstream and 43 to 60 nos/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.

The data for this site for the 2015-2016 period are presented in Table 46 and illustrated in Figure 34, with a statistical summary provided in Table 47. River flow records are illustrated in Figure 33.

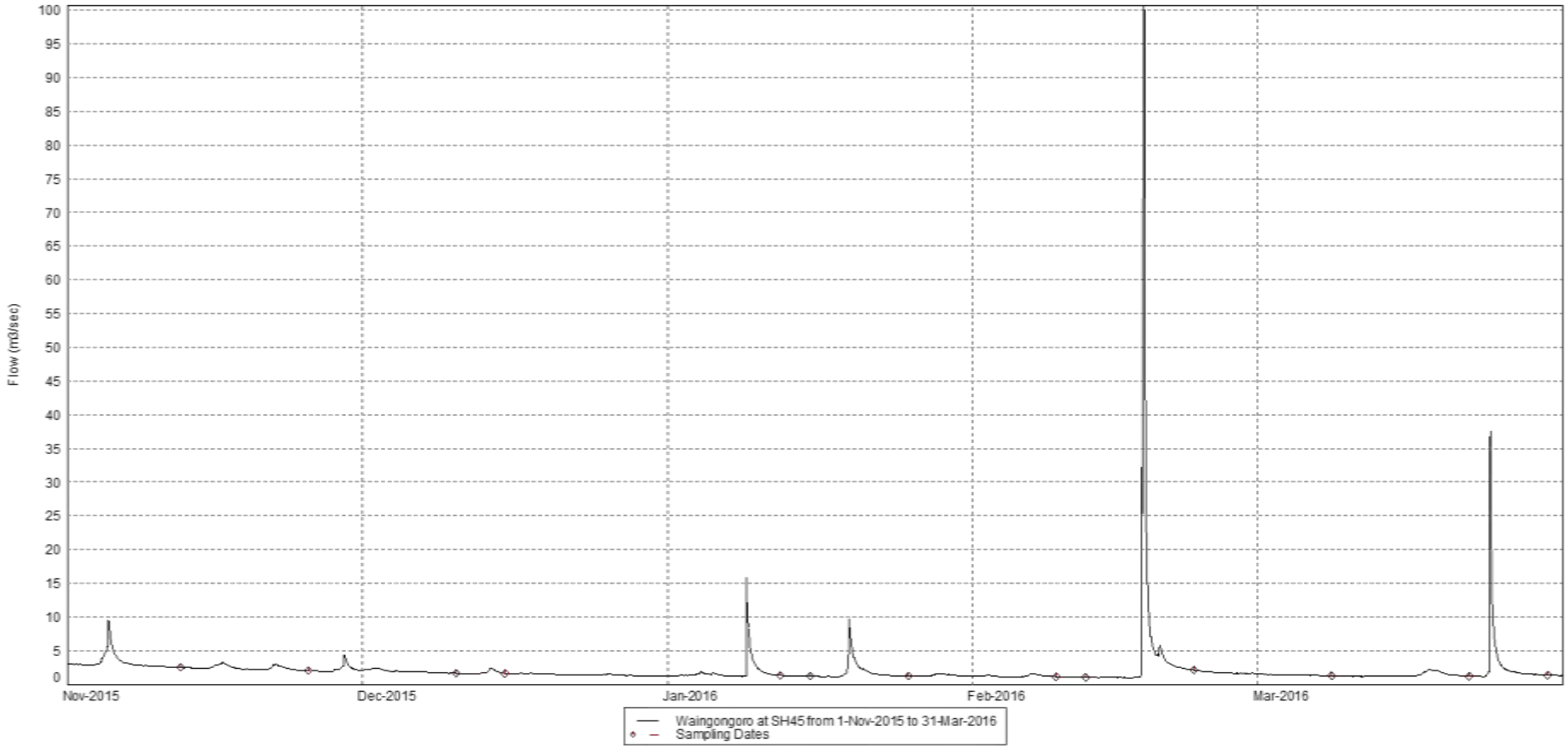


Figure 33 River flow in the Waingongoro River at SH45 during the survey period

Table 46 Analytical results for the Waingongoro River at Ohawe Beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1040	20.9	130	44	140	16.2	3.0
25.11.15	1020	20.6	51	24	51	17.2	1.9
10.12.15	1020	22.0	140	90	160	18.0	1.7
15.12.15	1240	20.7	96	120	96	20.4	2.7
12.01.16	1205	16.6	210	160	210	20.0	1.4
15.01.16	1355	19.5	48	100	57	23.3	2.1
25.01.16	1130	19.1	140	210	140	23.7	1.1
09.02.16	1105	20.4	340	380	340	21.1	0.9
12.02.16	1250	20.9	160	120	170	24.0	1.2
23.02.16	1050	14.8	400	370	400	20.8	0.7
08.03.16	1015	18.8	480	500	480	20.5	1.4
22.03.16	1140	19.1	110	230	110	19.7	0.9
30.03.16	1405	17.8	240	260	240	19.2	1.0

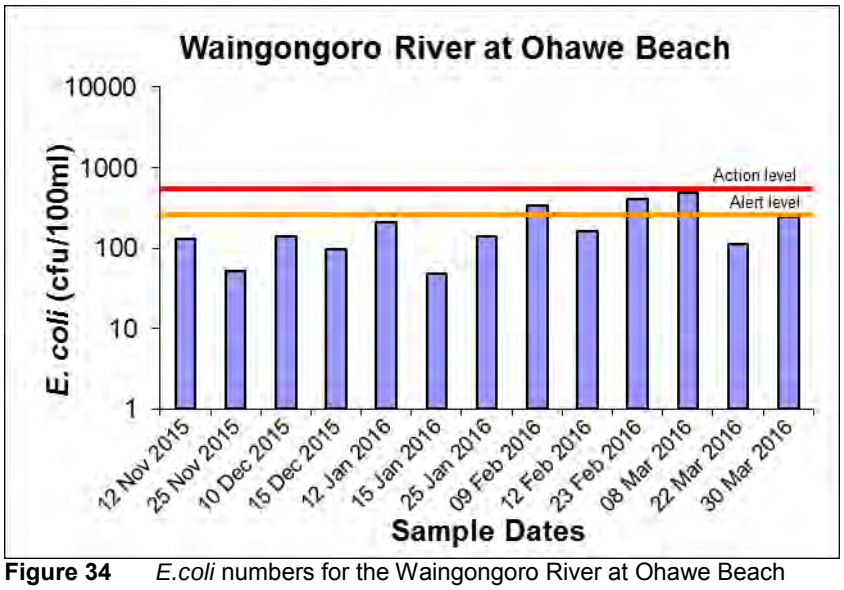


Figure 34 *E.coli* numbers for the Waingongoro River at Ohawe Beach during the survey season

Table 47 Statistical results summary for the Waingongoro River at Ohawe Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	14.8	22.0	19.5
E. coli	cfu/100ml	13	48	480	140
Enterococci	cfu/100ml	13	24	500	160
Faecal coliforms	cfu/100ml	13	51	480	160
Temperature	°C	13	16.2	24.0	20.4
Turbidity	NTU	13	0.7	3.0	1.4

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 (7.8˚C) with a maximum of 24.0˚ C recorded in early afternoon in mid February 2016. However, as sampling was not performed after 1405 hrs at this site, this maximum might be expected to have been exceeded later in the day from time-to-time during the period of the survey. Conductivity values were typical of the lower reaches of a Taranaki ring plain and showed minimal salt water influence on any occasion despite sampling low flow conditions coincident with higher tides and upstream surging, particularly in late summer (Appendix III). Turbidity values were indicative of relatively clear water on most occasions, consistent with the presence of some fine colloidal material in suspension (ie: < 2 NTU on most occasions), typical of the lower reaches of a ring plain river.

Bacteriological water quality (Figure 34) was moderately good for 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 210 per 100 mls (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.

4.2.8.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 48.

Table 48 Bacterial guidelines performance at the Waingongoro River, Ohawe Beach [% of 13 samples]

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

(Designation: freshwater contact recreational area)

Three single samples were recorded in the 'Alert' category, in February and early March 2016, but no samples were found in the 'Action' mode.. Counts were less than 210 *E.coli* per 100 mls until February under low flow conditions.

Bacteriological water quality at this site was within the acceptable guidelines for contact recreational usage for the entire survey period, coincident with the diversion of the Eltham WWTP discharge out of the catchment and land irrigation of Riverlands meatworks wastes during the season.

4.2.8.2 Comparison with previous summers' surveys

A statistical comparison of each of the twenty summer's survey data is presented graphically in Appendix VI for all sites. These summer data for the Waingongoro River site at Ohawe Beach are summarised in Table 49 and illustrated in Figure 35.

Table 49 Summary of *E. coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Waingongoro River at Ohawe Beach to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	88	43	17	34	38	46	31	43	54	31	31	9	31	26	8	43	46	34	66	48
Maximum	310	650	300	240	850	660	14000	280	940	380	410	5000	870	1000	180	2800	2300	370	630	480
Median	185	130	80	180	170	160	110	110	130	96	100	100	120	96	100	96	110	120	200	140

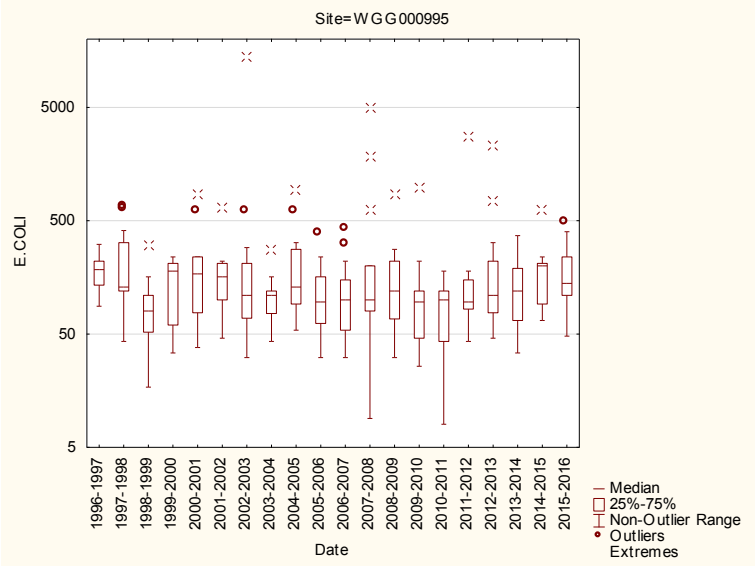
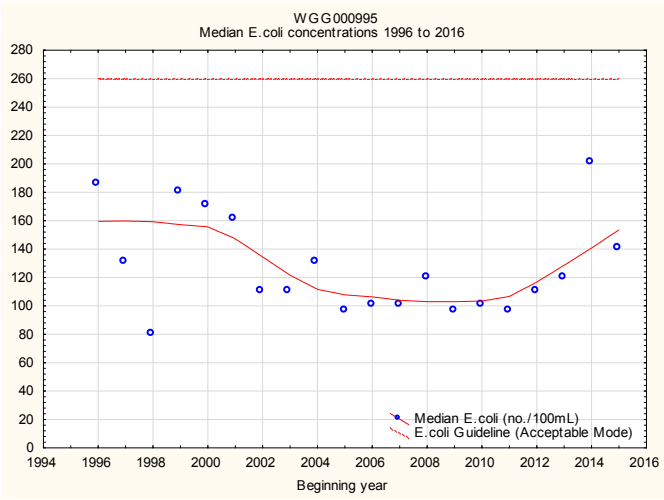


Figure 35 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Waingongoro River at Ohawe Beach

Median *E. coli* bacteria number for the 2015-2016 period was mid range compared to the previous nineteen seasons, and a reduction from the highest median value found in the previous season (Figure 35).

A moderate range of *E. coli* numbers was recorded in the recent 2015-2016 period in comparison with past seasons' ranges.

Trend analysis of these median *E.coli* numbers has been performed for the twenty seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 36) 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.



N = 20
Kendall tau = - 0.146
p level = 0.367 [>FDR, p = 0.611]
Not significant at p< 0.05

Figure 36 LOWESS trend plot of median *E.coli* numbers (per 100ml) for the 1996 to 2016 period at the Waingongoro River Ohawe beach site

Overall, a statistically insignificant decreasing trend in median *E.coli* number was found over the twenty seasons of monitoring. The trend had been statistically significant 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.

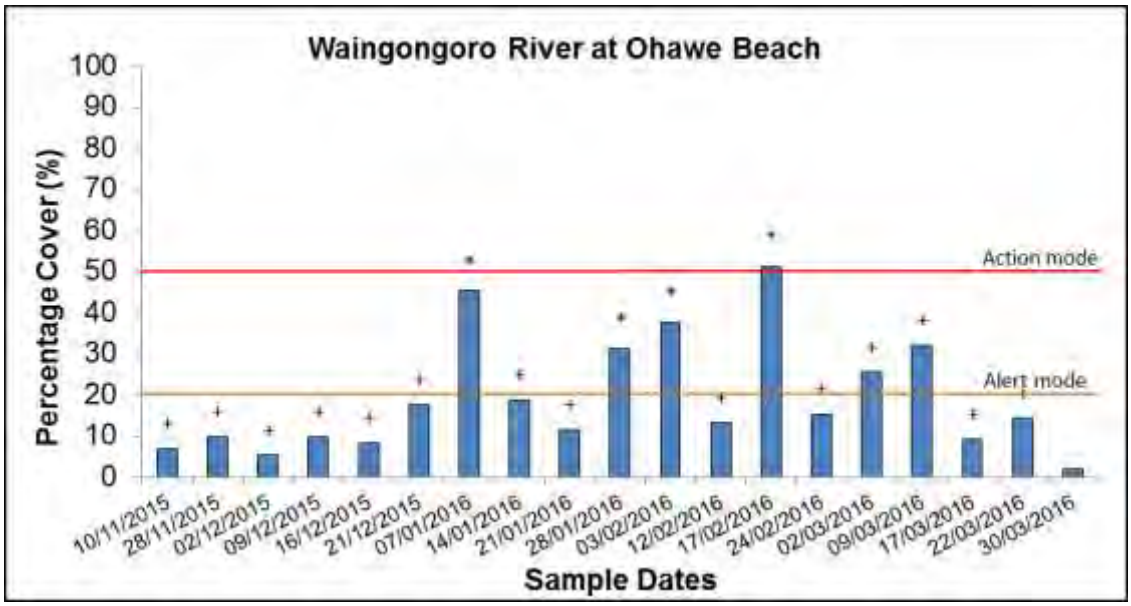
4.2.8.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 19 occasions during the season. Results are presented in Table 50 and Figure 37.

Table 50 Percentage benthic cyanobacteria cover for the Waingongoro River at the Ohawe Beach Domain

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	7	No	Minor	Amber (Alert)
28/11/2015	10	Minor	No	Amber (Alert)
02/12/2015	6	Minor	No	Amber (Alert)
09/12/2015	10	Minor	Minor	Amber (Alert)
16/12/2015	9	Minor	Minor	Amber (Alert)
21/12/2015	18	Minor	Minor	Amber (Alert)
07/01/2016	46	Significant	Significant	Red (Action)
14/01/2016	19	Minor	Minor	Amber (Alert)
21/01/2016	12	Minor	Minor	Amber (Alert)
28/01/2016	32	Significant	Significant	Red (Action)
03/02/2016	38	Minor	Significant	Red (Action)
12/02/2016	14	Minor	No	Amber (Alert)
17/02/2016	52	Significant	Significant	Red (Action)
24/02/2016	16	No	Minor	Amber (Alert)
02/03/2016	26	Minor	Minor	Amber (Alert)
09/03/2016	32	Minor	Minor	Amber (Alert)
17/03/2016	10	Minor	Minor	Amber (Alert)
22/03/2016	15	Minor	Minor	Amber (Alert)
30/03/2016	2	No	No	Green (surveillance)

Figure 37 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.

Photo 6 Cyanobacteria health warning signage, Waingongoro River, Ohawe, January 2016

Benthic cyanobacteria coverage was low during the start of the monitoring period but levels became reasonably high between mid summer and early autumn before receding by mid March (range from 2 to 52%). The benthic cyanobacteria found was predominately *Phormidium* sp but *Lyngbya* sp, a cyanobacteria similar to *Phormidium* sp, was present on one occasion at a low level. The 'Action' level was exceeded on one occasion for percentage cover. Significant detached mats (3 occasions) and exposed mats (4 occasions) triggered the 'Action' response, requiring appropriate signage to be erected and maintained by STDC (Photo 6).

4.2.9 Kaupokonui River at Beach Domain

Frequent usage at this site by bathers was recorded at the time of several of the sampling surveys and other recreational usage [mainly fishing (whitebaiting was common in early season) and picnicking] was occurring on the majority of 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.

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 nos/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 ringplain streams.

River flow records for the current 2015-2016 season are provided in Figure 39. Data from this site are presented in Table 51 and illustrated in Figure 38, with a statistical summary provided in Table 52.

Table 51 Analytical results for the Kaupokonui River at the beach domain

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1125	18.2	60	94	60	15.1	3.8
25.11.15	1040	17.5	90	44	90	18.2	1.5
10.12.15	1050	19.5	51	37	57	18.6	1.4
15.12.15	1310	17.6	48	35	48	20.1	1.4
12.01.16	1230	34.8	240	290	240	21.2	2.9
15.01.16	1425	17.5	84	64	84	24.0	1.2
25.01.16	1200	16.8	120	120	120	25.0	1.9
09.02.16	1145	295	330	210	460	22.3	1.8
12.02.16	1320	212	110	100	110	24.2	3.9
23.02.16	1130	696	170	280	170	22.0	2.3
08.03.16	1100	507	480	1400	480	21.2	1.3
22.03.16	1205	950	900	320	970	20.6	11
30.03.16	1430	15.1	34	200	34	19.6	0.8

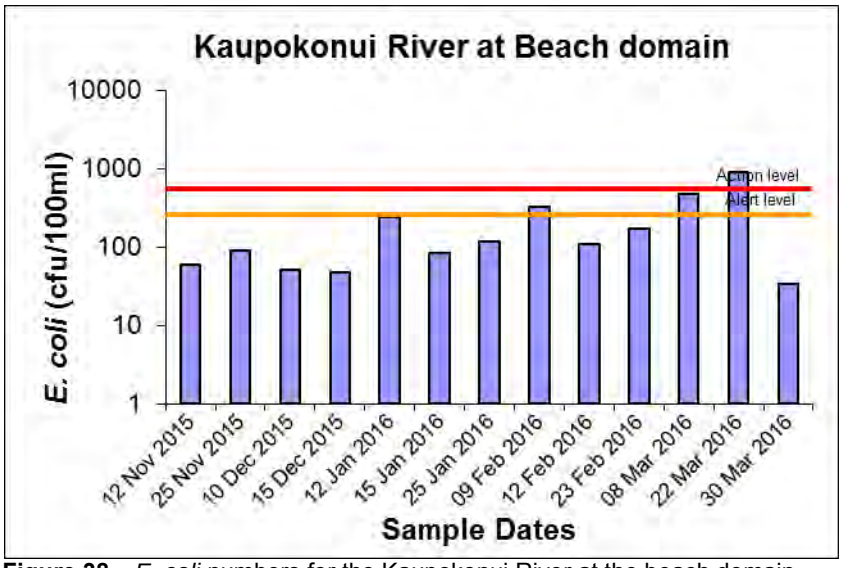


Figure 38 *E. coli* numbers for the Kaupokonui River at the beach domain during the survey season

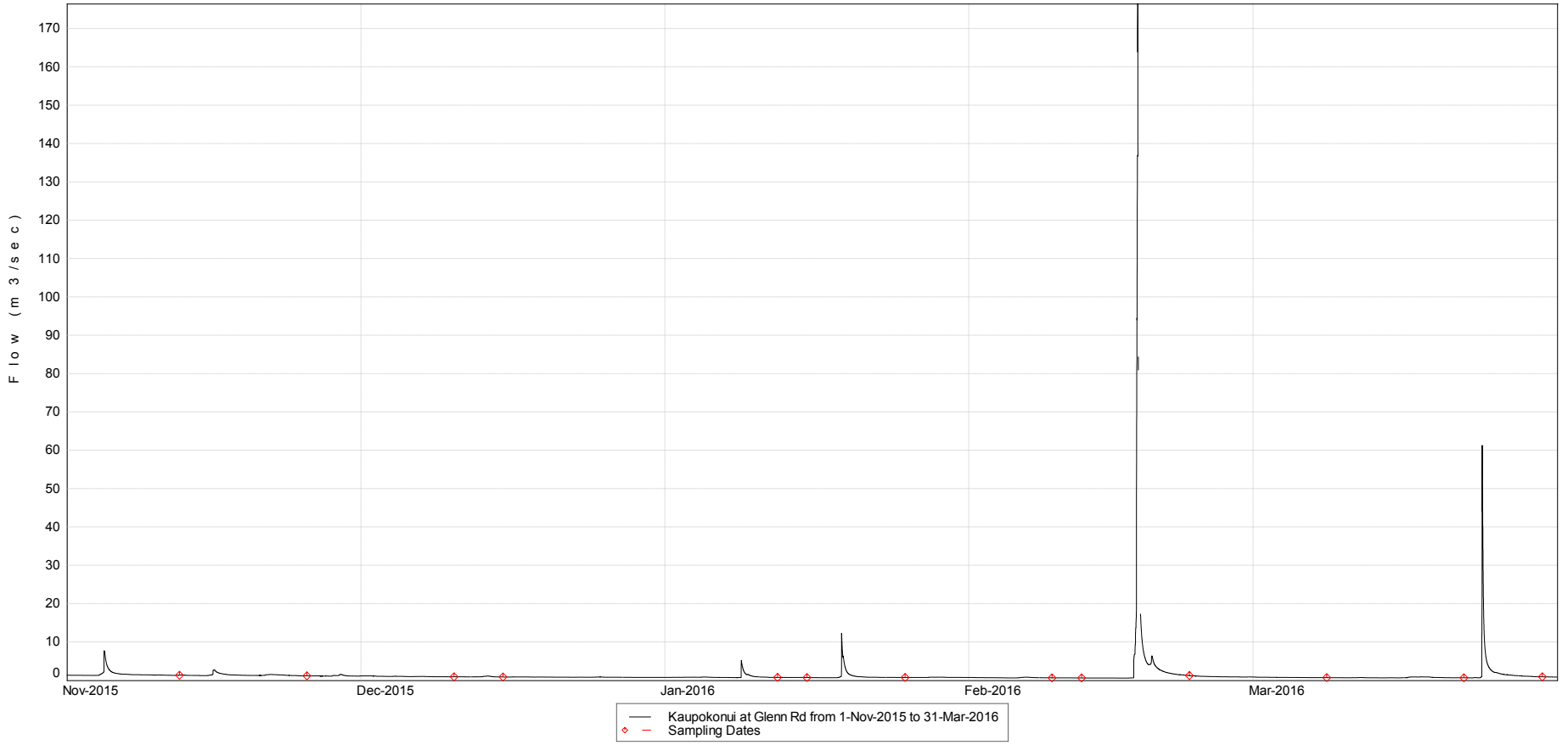


Figure 39 River flow in the Kaupokonui River at Glenn Rd during the survey period

Table 52 Statistical results summary for the Kaupokonui River at the beach domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	15.1	950	19.5
E. coli	cfu/100ml	13	34	900	110
Enterococci	cfu/100ml	13	35	1400	120
Faecal coliforms	cfu/100ml	13	34	970	110
Temperature	°C	13	15.1	25.0	21.2
Turbidity	NTU	13	0.8	11	1.8

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 Fonterra Kapuni Company (cooling waters) and the Kaponga township municipal upgraded 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 during mid summer–early autumn. Otherwise, these conductivity levels were relatively stable (15.1 to 19.5 mS/m at 20°C) and typical of the lower reaches of a Taranaki ring plain river.

Turbidity levels were typical of lower ring plain river reaches throughout the period with minimal impacts of suspended algal matter, unlike conditions noted in several previous survey periods, with one exception in mid March. Foaming was seldom noticeable in the ponded reach of the river and toward the edges, unlike in previous periods when foaming and suspended algal matter reduced the aesthetic quality of this reach from time to time. Water temperatures varied over a relatively wide range of 9.9°C with a maximum of 25.0°C recorded in late-January 2016. This temperature was recorded at 1200 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 1435 hrs at this site.

Bacteriological water quality was moderately good and slightly better than that recorded in the lower reaches of the nearby Waingongoro River (see section 4.2.8), and better than 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. It has also been noted in the past that lower faecal coliform to enterococci ratios than usual have been recorded at this (and other) tidal ponded sites, possibly as a result of vegetative enterococcal sources and/or better enterococci survival in tidal pool environments, particularly sites characterised by ebbing and flowing within the ponded river mouth reach. This again was apparent in late summer-autumn (Table 51) when enterococci numbers were in excess of *E. coli* numbers on several occasions.

Two 'Alert' levels and one 'Action' level were recorded, all in February and March 2016 under very low river flows and under tidal conditions. At the time of the Action level in mid March, the tidal movement had suspended a substantial amount of periphyton. Previously, many flocks of ducks have been recorded in reaches of the river upstream of this site.

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 2015-2016 season.

4.2.9.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 53.

Table 53 Bacterial guidelines performance at the Kaupokonui River beach domain site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	2 [15]	1 [8]

(Designation: freshwater contact recreational area)

One individual sample fell within the 'Action' mode, and another two were recorded in the 'Alert' mode during the season. No rainfall immediately preceded the elevated counts, which all occurred during tidal pooling. Health warning signage was erected by STDC following the 'Action' level result of 22 March, shortly before Easter, which was removed following the 'Surveillance' level count on 30 March 2016.

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.

4.2.9.2 Comparison with previous summers' surveys

A statistical comparison of each of the twenty summer's survey data is presented graphically in Appendix VI for all sites. These summer data for the Kaupokonui River site at the Beach Domain are summarised in Table 54 and illustrated in Figure 40.

Table 54 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys in the Kaupokonui River at the Beach Domain

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	26	31	3	7	17	46	46	<8	40	14	26	15	29	20	20	17	28	11	54	34
Maximum	360	2100	580	780	2000	400	630	200	880	280	2500	850	890	440	340	290	540	270	490	900
Median	110	360	130	80	120	110	130	77	92	160	140	77	210	100	76	120	140	110	120	110

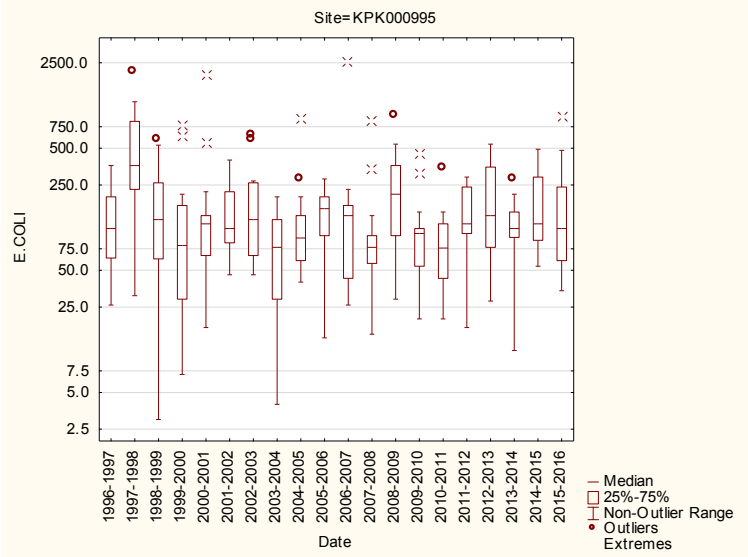
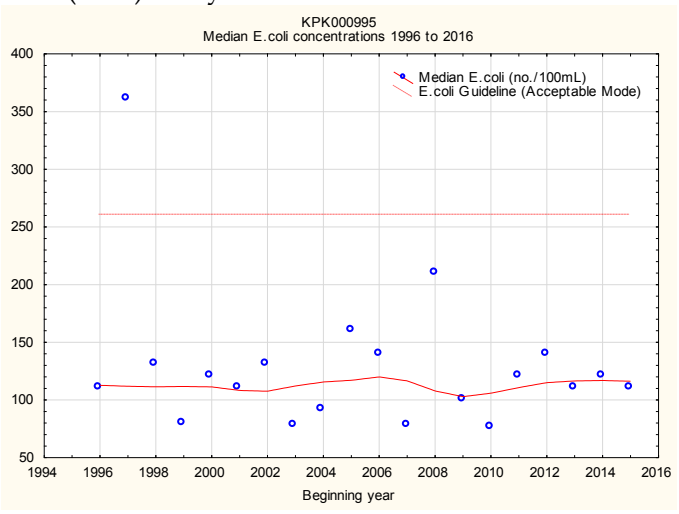


Figure 40 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Kaupokonui River at the Beach Domain

Typical *E. coli* bacterial water quality in terms of median number, but a moderate range compared with many of the previous nineteen survey seasons, were recorded over the 2015-2016 season (Figure 40). The median *E. coli* count was in the lower mid-range of all other seasons' medians to date (Table 54) and the seasonal maximum was in the upper range of those for the twenty years of record.

Trend analysis of these median *E. coli* numbers has been performed for the twenty seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 41) 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.



N = 20
Kendall tau = -0.065
p level = 0.688 [>FDR p = 0.814]
N/S at p < 0.05

Figure 41 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Kaupokonui River beach domain site for the 1996 to 2016 period

A very slight, unimportant, and statistically insignificant decreasing trend in median *E. coli* counts was found over the twenty seasons of monitoring. One of these seasonal medians (1997-1998 season) exceeded the 'Alert' mode but none have

exceeded the 'Action' mode, nor have any approached the 'Alert' mode since 1997-1998.

4.2.9.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 19 occasions during the season. Results are presented in Table 55 and Figure 42.

Table 55 Percentage benthic cyanobacteria cover for the Kaupokonui River, Beach Domain site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	11	No	No	Green (surveillance)
28/11/2015	36	Minor	No	Amber (Alert)
02/12/2015	29	Minor	Minor	Amber (Alert)
09/12/2015	33	Significant	No	Red (Action)
16/12/2015	26	Minor	No	Amber (Alert)
21/12/2015	42	Significant	Minor	Red (Action)
07/01/2016	18	Minor	Minor	Amber (Alert)
14/01/2016	12	Minor	No	Amber (Alert)
21/01/2016	8	No	No	Green (surveillance)
28/01/2016	10	Minor	No	Amber (Alert)
03/02/2016	33	Minor	No	Amber (Alert)
12/02/2016	28	Minor	No	Amber (Alert)
17/02/2016	21	Minor	No	Amber (Alert)
24/02/2016	7	No	No	Amber (Alert)
02/03/2016	13	Minor	No	Amber (Alert)
09/03/2016	13	Minor	Minor	Amber (Alert)
17/03/2016	2	Minor	No	Amber (Alert)
22/03/2016	11	Minor	No	Amber (Alert)
30/03/2016	0	No	No	Green (surveillance)

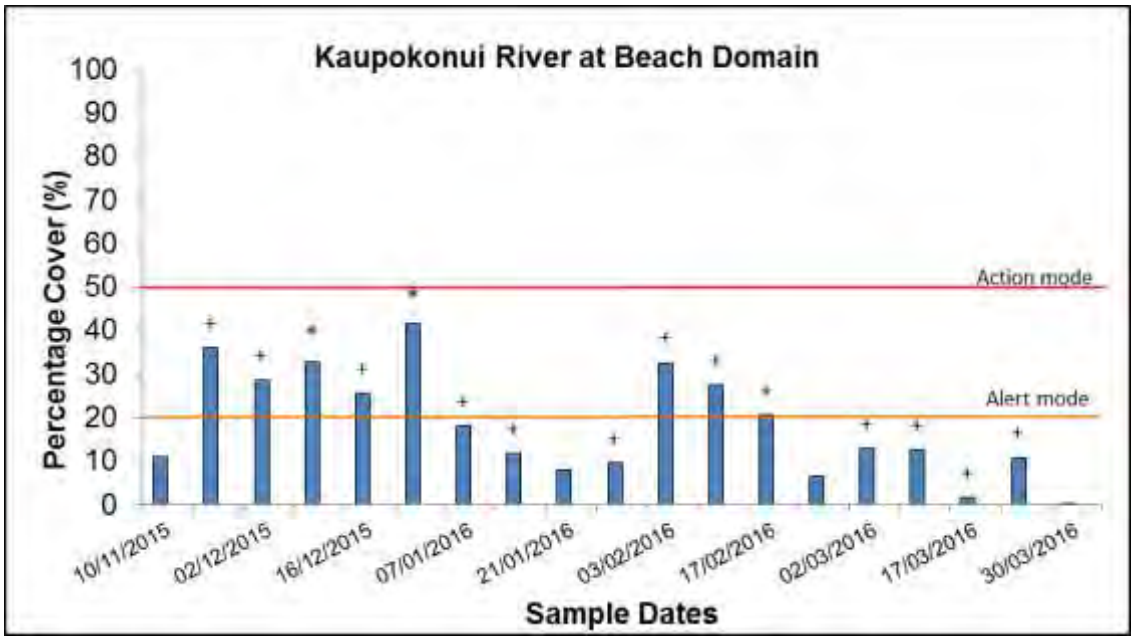


Figure 42 Percentage benthic cyanobacteria cover for the Kaupokonui River at the Beach Domain site

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.

Benthic cyanobacteria coverage was moderately low at the start of the monitoring period but rose to reasonably high levels through most of summer until levels tapered off at the end of summer and early autumn (range from 0 to 42%). The lower cyanobacteria biomass in mid summer was correlated with high green filamentous levels, and it would appear that the long filamentous algae were outcompeting the cyanobacteria. The benthic cyanobacteria found were a *Phormidium* sp. The 'Alert' level was exceeded on eight occasions for percentage cover. Significant detaching mats were observed on two separate occasions, which triggered the 'Action' level.

4.2.10 Lake Opunake

No bathing and minimal 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. Ducks were noted regularly on the lake or in the vicinity of the lake edge and numbers were high on most occasions. Swans were also present on two occasions. Large numbers of these wildfowl frequently have been present on the picnic area grass verge adjacent to the lake edge, attracted from time to time by food provided by picnickers. There was no repeat of the thick unsightly, algal scum prevalent on the lake surface for several weeks during mid to late summer in the 2010-2011 season (TRC, 2011) although some suspended algae and/or weed were noted occasionally.

Data from this site are presented in Table 56 and illustrated in Figure 43, with a statistical summary provided in Table 57.

Table 56 Analytical results for Lake Opunake

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1215	13.4	100	25	100	17.3	1.6
25.11.15	1140	12.7	140	23	140	19.5	1.2
10.12.15	1145	13.6	50	48	50	18.9	1.2
15.12.15	1410	12.2	51	48	51	19.1	1.2
12.01.16	1325	12.8	21	560	21	23.2	1.3
15.01.16	1520	13.1	140	1000	140	23.1	1.0
25.01.16	1315	13.0	46	1200	46	26.5	1.5
09.02.16	1235	13.8	46	1800	46	24.6	1.3
12.02.16	1410	14.3	11	180	11	26.0	1.0
23.02.16	1230	12.0	120	580	120	23.6	1.7
08.03.16	1205	17.0	120	240	120	22.6	2.0
22.03.16	1310	14.5	2000	570	2500	21.0	0.8
30.03.16	1520	13.8	11	120	11	21.8	1.2

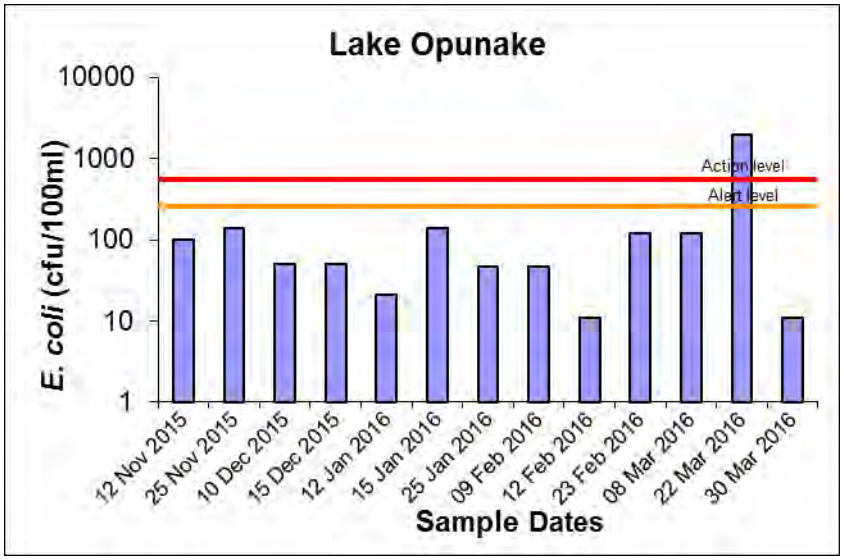


Figure 43 *E. coli* numbers for Lake Opunake during the survey season

Table 57 Statistical results summary for Lake Opunake

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	12.0	17.0	13.4
E. coli	cfu/100ml	13	11	2000	51
Enterococci	cfu/100ml	13	23	1800	240
Faecal coliforms	cfu/100ml	13	11	2500	51
Temperature	°C	13	17.3	26.5	22.6
Turbidity	NTU	13	0.8	2.0	1.2

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 good (median turbidity: 1.2 NTU; range of turbidity: 1.2 NTU) with a very narrow range, as a result of minimal sediment disturbance and/or limited suspended algae in the water column. Good water quality was due, in part, to the lake's short residence time, with regular replenishment as a result of local hydroelectric power scheme usage. Water temperatures were relatively high (above 22.6˚C) for half of the period with a very high maximum of 26.5˚C (in late January 2016) and a relatively wide range of 9.8˚C. Conductivity varied over a fairly narrow range (5.0 mS/m @ 20˚C) reflecting river inflow conditions.

Generally bacteriological quality was good, the median count (51 *E. coli* per 100 ml) being the lowest recorded, 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, with one exception. A very high count of 2,000 *E. coli* per 100 ml, the third highest recorded in ten years, was returned for a sample taken in mid March when a large number of ducks and swans were in the immediate vicinity. 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.

4.2.10.1 Comparison with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 58.

Table 58 Bacterial guidelines performance at Lake Opunake [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	0 [0]	1 [8]

(Designation: freshwater contact recreational area)

One single sample exceedance of the 'Action' mode occurred during the period but no single samples were recorded within the 'Alert' mode. Sampling subsequent to the 'Action' level showed much lower *E. coli* numbers within eight days of the exceedance. The single very high count was followed by the installation of 'health warning' signage by STDC. Publicity was given to the state of the lake on the TRC website.

4.2.10.2 Comparison with previous summers' surveys

A statistical comparison of each of the ten summers' *E. coli* survey data is presented graphically in Appendix VI for all sites. The nine summers of data collection for the Lake Opunake site are summarised in Table 59 and illustrated in Figure 44.

Table 59 Summary of *E. coli* bacteriological water quality data to date (cfu/100 ml) for all summer surveys at Lake Opunake to date

Summer	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	33	26	54	64	8	40	17	<8	4	11
Maximum	720	1300	2800	320	3800	2000	500	430	390	2000
Median	110	130	210	220	80	80	120	100	66	51

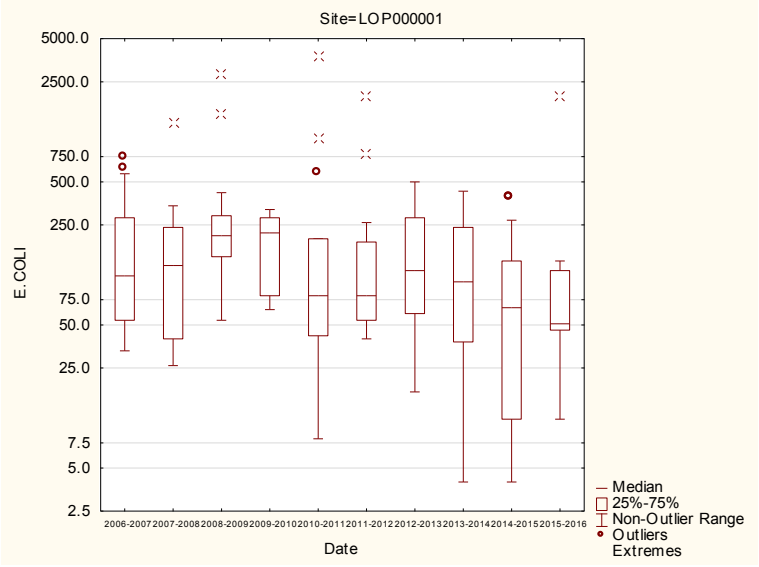


Figure 44 Box and whisker plots for the summer SEM survey of *E. coli* bacteria numbers at Lake Opunake

The median *E. coli* number in the 2015-2016 season was the lowest of the ten seasons' surveys to date, though a relatively wide range of counts was found (Figure 44). In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was in compliance with the acceptable level for almost all of the period, with one incursion into the 'Action' level.

Trend analysis of these median *E.coli* numbers has been performed for the ten seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 45) 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.

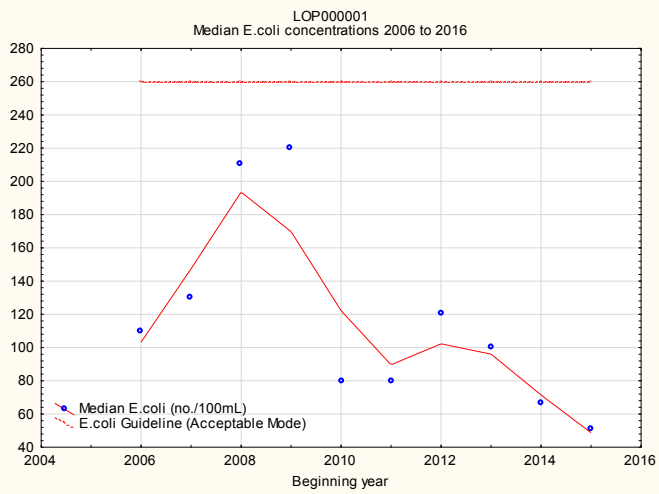


Figure 45 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Lake Opunake site, for the 2000-2016 period

A relatively strong decreasing trend in median *E. coli* counts has been found over the ten seasons of monitoring. Although statistically significant at the p<0.05 level, it was not significant after FDR application. None of these seasonal medians has exceeded the 'Alert' mode.

4.2.10.3 Cyanobacteria

Planktonic cyanobacteria were monitored on seven occasions throughout the season with results presented in Table 60 and Figure 46.

Table 60 Cyanobacteria counts (cells/ml) for Lake Opunake

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm^3/L)	Principal species by biovolume	Mode
03/11/2015	0	0	No cyanobacteria	Low Risk
22/12/2015	0	0	No cyanobacteria	Low Risk
06/01/2016	0	0	No cyanobacteria	Low Risk
19/01/2016	0	0	No cyanobacteria	Low Risk
02/02/2016	0	0	No cyanobacteria	Low Risk
16/02/2016	650	0.01	*Microcystis*	Low Risk
15/03/2016	1350	0.02	*Microcystis*	Low Risk

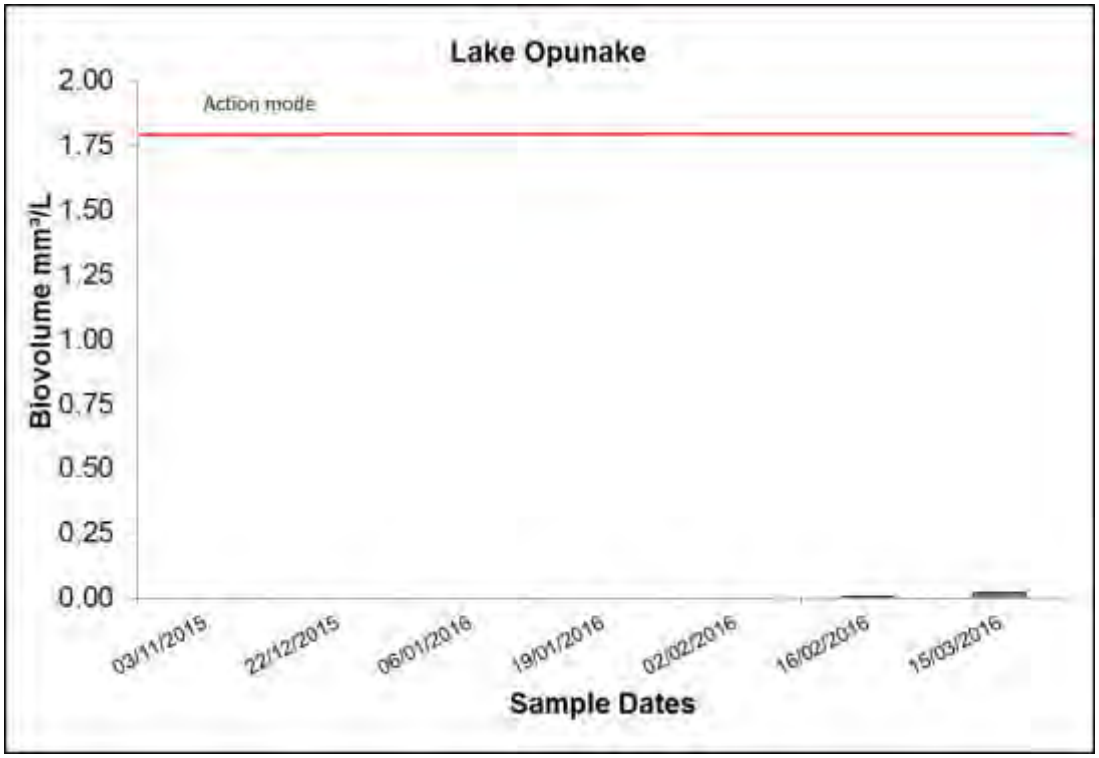


Figure 46 Cyanobacteria biovolume at Lake Opunake

Planktonic cyanobacteria was not detected for the majority of the recreational monitoring period with very low numbers found on the last two sampling occasions during late summer and early autumn.

No cyanobacteria had been found in this lake during the 2006-2007, 2008-2009, 2009-2010, 2010-2011, 2011-2012, or 2012-2013 seasons, but their presence (in low numbers) on three occasions in the latter part of the 2007-2008 season and on two occasions (once in excess of 6000 cells/ml) in the middle of the 2013-2014 season followed lengthy, extremely low flow periods. However, these numbers did not reach levels requiring the issue of 'health warnings' during those two seasons. The relatively short lake water residence time (due to hydroelectric power generation usage) may be a controlling factor for these populations.

4.2.11 Timaru Stream at Weld Road (near mouth)

Some bathing usage was noted at this site on three sampling occasions while some picnicking and fishing (whitebaiting in season) usage was recorded on several sampling survey occasions during the season. 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 had 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 and the end of the season. A few gulls, oystercatchers, ducks, and swallows were present on some occasions, with dogs in the water from time to time.

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 mls) 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 2015-2016 season are provided in Figure 48. Data from this site for the 2015-2016 season are presented in Table 61 and illustrated in Figure 47, with a statistical summary provided in Table 62.

Table 61 Analytical results for the Timaru Stream at Weld Road

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1135	234	92	63	100	16.4	0.4
25.11.15	1055	179	110	80	120	17.0	0.4
10.12.15	1040	9.3	230	230	300	15.9	0.3
15.12.15	1300	171	66	160	66	16.8	0.5
12.01.16	1125	1010	280	760	360	19.5	0.7
15.01.16	1145	143	160	120	160	20.5	0.9
25.01.16	1140	1060	260	420	260	21.8	0.7
09.02.16	1135	670	1500	1400	2000	23.7	1.0
12.02.16	1315	1380	180	460	180	23.6	2.8
23.02.16	1110	656	250	710	260	21.1	0.4
08.03.16	1058	914	780	1100	790	20.2	0.9
22.03.16	0818	510	520	870	560	18.3	0.4
30.03.16	1430	22.6	71	240	71	18.9	0.3

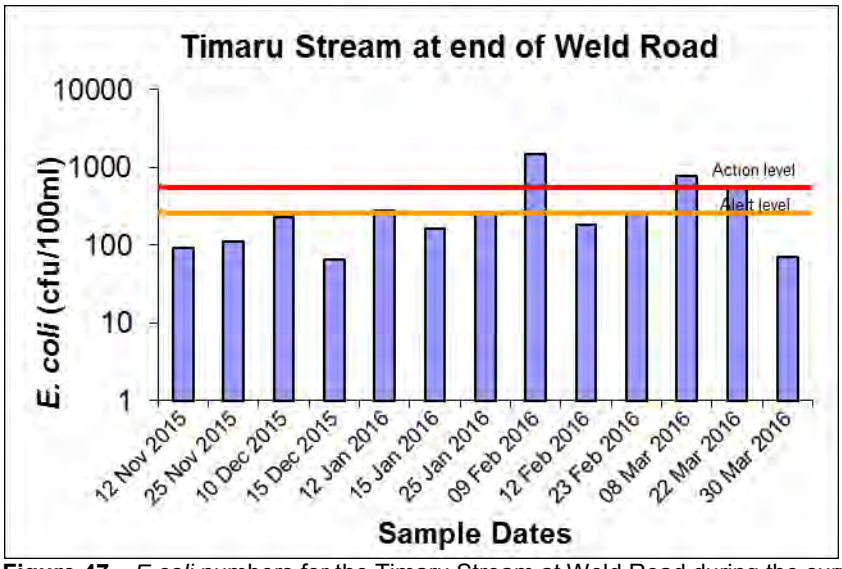


Figure 47 *E.coli* numbers for the Timaru Stream at Weld Road during the survey season

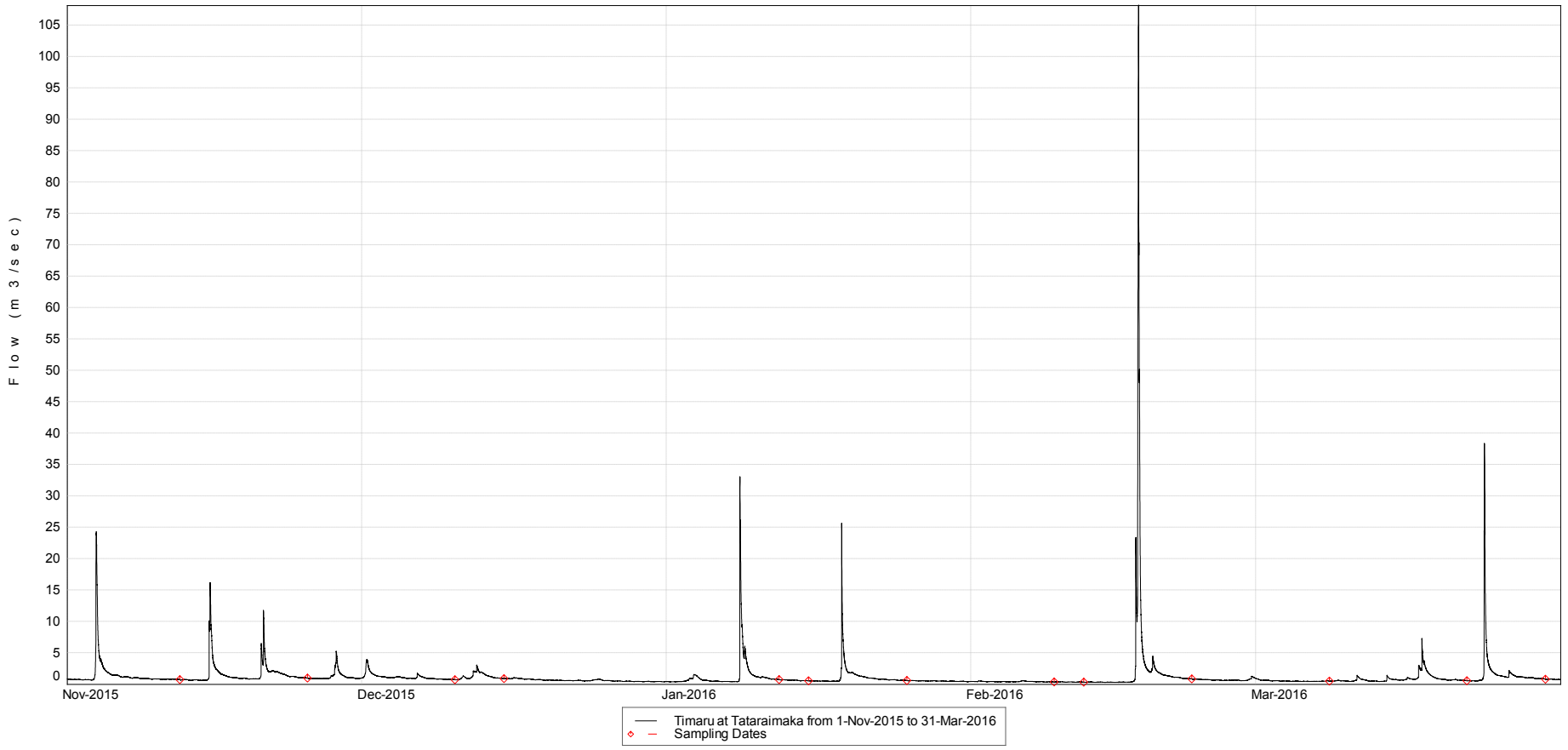


Figure 48 River flow in the Timaru Stream at Tataraimaka

Table 62 Statistical results summary for the Timaru Stream at Weld Road

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	9.3	1380	510
E. coli	cfu/100ml	13	66	1500	230
Enterococci	cfu/100ml	13	63	1400	420
Faecal coliforms	cfu/100ml	13	66	2000	260
Temperature	°C	13	15.9	23.7	19.5
Turbidity	NTU	13	0.3	2.8	0.5

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 the season and particularly in mid to late summer-autumn under very low stream flow conditions. Turbidity levels were very low on all but one occasion 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 7.8°C with a maximum water temperature of 23.7°C recorded in late morning in early February 2016. This maximum could have been expected to have been exceeded on other occasions during summer as all sampling was undertaken before 1435 hrs and the majority in the mornings.

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. Elevated counts occurred sporadically, during the sampling period. There was installation of 'health warning' signage at the site by NPDC as there were two exceedances of the 'Action' level in the latter half of the period.

The first 'Action' level count, on 9 February 2016, induced follow-up sampling which returned another high count (*E. coli* of 1300 per100 ml on 11 February) in dry weather. Investigations by Council officers in February and early April did not find the source of contamination. A survey around Tataraimaka in late morning on 5 April found acceptable water quality (eight samples at 'Surveillance' level).

Stock access to the lower stream (which was crossed to reach adjacent farmland at times) during the prolonged dry period of the 2007-2008 seasons (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). It has also been noted at these tidal river pool sites that lower faecal coliform to enterococci ratios than usual have been recorded possibly due to vegetative sources and/or better enterococci survival in pool environments characterised by the ebb and flow in the ponded river/stream mouth.

4.2.11.1 Comparison with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 63.

Table 63 Bacterial guidelines performance at the Timaru Stream, Weld Road site [% of 13 samples]

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

(Designation: freshwater contact recreational area)

Two single samples were recorded in the 'Alert' mode, and two were recorded in the 'Action' mode during the period. Poorer bacteriological water quality tended to coincide with dry weather and moderate seawater intrusion on each occasion. While the erection of health warning signage was necessary on the occasions when singles sample entered the 'Action' mode, public advice was also provided on Council's website.

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.

4.2.11.2 Comparison with previous summers' surveys

A statistical comparison of each of the summers' survey data is presented graphically in Appendix VI for all sites. These summer data for the Timaru Stream site at the end of Weld Road (which has been monitored for nineteen summers) are summarised in Table 64 and illustrated in Figure 49.

Table 64 Summary of *E. coli* bacteriological water quality data to date (cfu/100ml) for all summer surveys in the Timaru Stream at lower Weld Road

Summer	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	40	23	31	77	31	140	77	84	38	43	46	92	46	28	34	26	54	63	66
Maximum	410	710	1400	540	660	1000	410	1000	460	480	930	440	560	410	440	550	660	2000	1500
Median	280	210	160	180	180	260	220	260	220	200	180	230	290	180	160	250	200	210	230

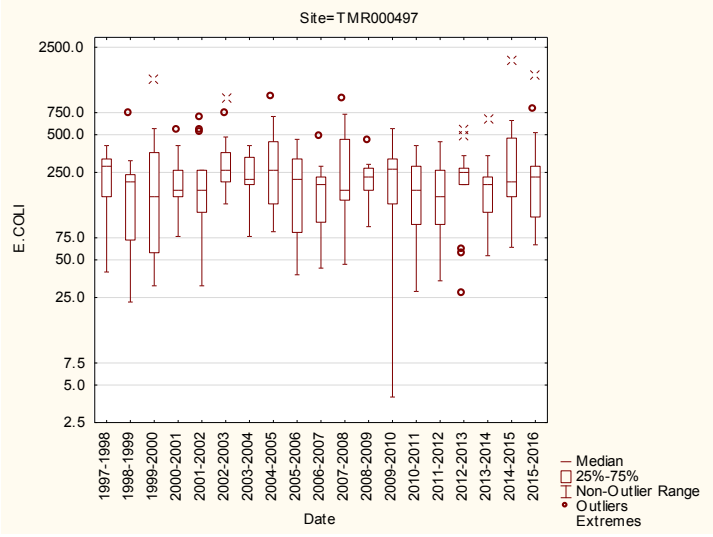


Figure 49 Box and whisker plots for all summer surveys of *E.coli* bacterial numbers in the Timaru Stream at lower Weld Road

The median *E. coli* count for the 2015-2016 season was typical of past seasons (Table 64), slightly above the middle of the range of previous seasons' median counts. Counts over the 2015-2016 season had a wide range (Figure 49), with two counts reaching the 'Action' mode, due to the second-highest seasonal maximum found over the 19 years of monitoring. This followed a record high maximum in 2014-2015.

Trend analysis of these median *E. coli* numbers has been performed for the nineteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 50) 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.

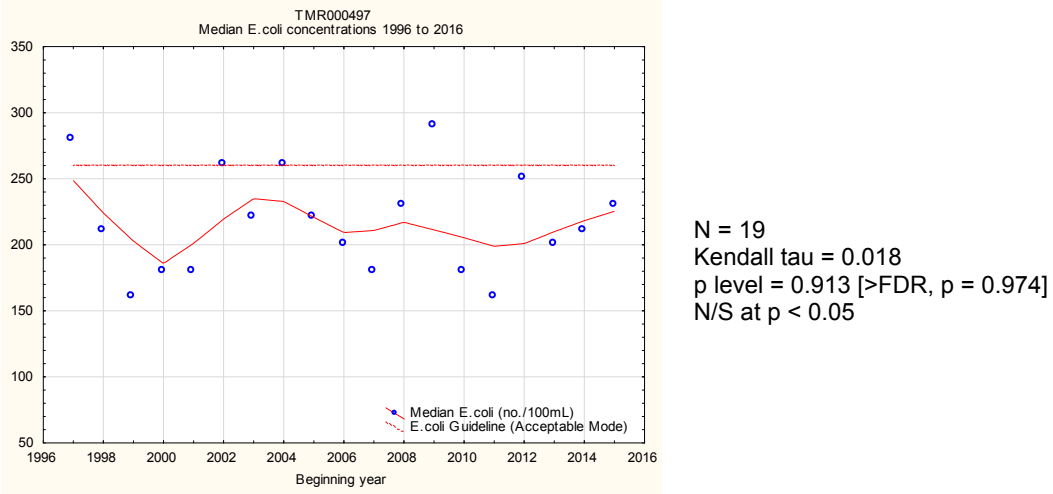


Figure 50 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Timaru Stream, lower Weld Road site for the 1997 to 2016 period

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

4.2.11.3 Benthic cyanobacteria

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

4.2.12 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 previous 2013-2014 survey being the first at this frequency. Therefore, no monitoring was performed over the 2015-2016 period.

4.2.13 Oakura River below SH45

Bathing usage was recorded on several occasions at this site where people were often present on the riverbank at this very accessible tidal site. (Fishing has been observed, including whitebaiting in season, 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 was apparent early in the season, but was fenced off in mid February 2016.

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 mls 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 ringplain rivers and streams elsewhere.

Data from the site for the 2015-2016 season are presented in Table 65 and illustrated in Figure 51, with a statistical summary provided in Table 66.

Table 65 Analytical results for the Oakura River below SH45

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1030	308	54	32	54	15.5	1.0
25.11.15	1010	128	66	37	66	15.3	0.4
10.12.15	0950	7.7	88	48	88	15.3	0.3
15.12.15	1215	6.7	66	44	66	16.2	0.5
12.01.16	1025	259	120	170	130	18.9	0.3
15.01.16	1235	17.1	50	130	52	21.2	1.4
25.01.16	1035	106	120	300	120	20.4	0.3
09.02.16	1035	261	1900	780	1900	22.4	0.6
12.02.16	1220	133	820	970	820	22.2	0.4
23.02.16	1015	512	180	540	180	18.9	0.4
08.03.16	1010	655	810	890	900	19.7	0.5
22.03.16	0915	320	450	770	500	17.9	0.3
30.03.16	1340	7.9	130	410	130	17.4	0.2

Table 66 Statistical results summary for the Oakura River below SH45

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	6.7	655	133
E. coli	cfu/100ml	13	50	1900	120
Enterococci	cfu/100ml	13	32	970	300
Faecal coliforms	cfu/100ml	13	52	1900	130
Temperature	°C	13	15.3	22.4	18.9
Turbidity	NTU	13	0.2	1.4	0.4

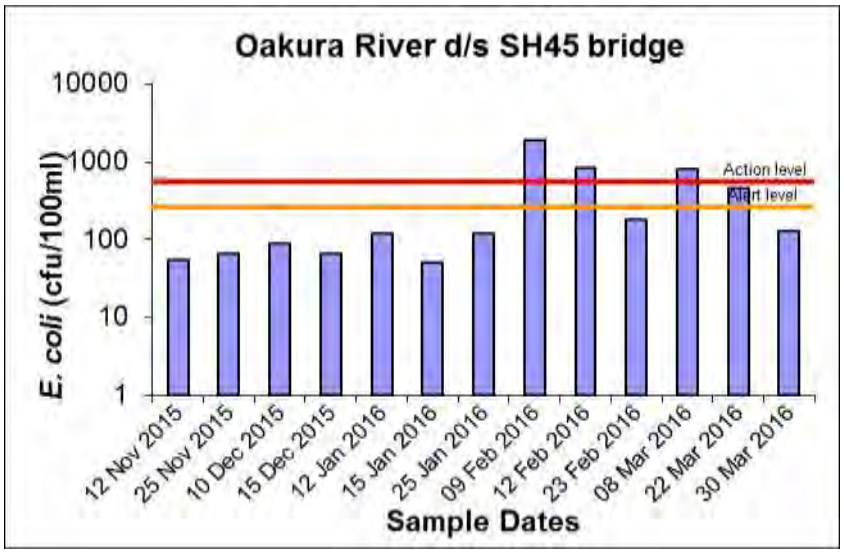


Figure 51 *E. coli* numbers for the Oakura River below SH45 during the survey season

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 ten sampling occasions. Conductivity levels

indicated a variable influence of saltwater intrusion on at least nine sampling occasions during the season. The more significant intrusions occurred mainly during very low flow conditions during the latter half of this season. On each occasion the river was clear in appearance. There was no algal substrate cover, due to the sandy nature of much of the substrate, until after a flood on 18 February 2016 exposed the underlying cobble, allowing the minor algal growth observed at the end of March. Water temperatures varied over a moderate range (7.1°C) during the period reaching a maximum of 22.4°C in mid morning in early February 2016, but below the maximum water temperature which might be anticipated later in the day as all sampling at this site occurred no later than 1340 hrs.

Bacteriological water quality was moderate until the end of January 2016, with the majority of *E. coli* counts ≤120 per 100 ml, after which time variable, often poor quality was found for two months. Bacteriological water quality was not dissimilar to that found elsewhere in ponded tidal reaches of ringplain 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. Lower faecal coliform to enterococci ratios (than normally found at flowing river sites) were often recorded possibly as a result of vegetative sources of enterococci and/or better survival rates in tidal pool environments; sites which are characterised by ebbing and flowing within the ponded stream mouth reach. Elevated counts in mid February 2016, which entered the 'Action' mode of the guidelines, were coincident with upstream flow and marked saltwater intrusion under very low flow conditions, while follow-up samples, taken two and four days after these elevated counts, found a much lower *E. coli* count (160 and 92 per 100 ml, respectively). Investigations undertaken by Council in mid February did not find the source of contamination.

4.2.13.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 67.

Table 67 Bacterial guidelines performance at the Oakura River, SH45 bridge site [% of 13 samples]

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

(Designation: freshwater contact recreational area)

One single sample fell within the 'Alert' mode, and three samples entered the 'Action' mode. These were under very low flow conditions in the latter half of the season. Health warning signage was required to be displayed at this site by NPDC from mid February for the remainder of the bathing season, and appropriate public advice was provided on the Council website.

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, though it was within the acceptable single sample guidelines for contact recreational usage for the majority of the sampling season.

4.2.13.2 Comparison with previous summers' surveys

A statistical comparison of each of the nineteen summers' survey data is presented graphically in Appendix VI for all sites. These summer data for the Oakura River site below the SH45 bridge are summarised in Table 68 and illustrated in Figure 52.

Table 68 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys in the Oakura River downstream of SH45

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	7	28	42	24	23	31	26	43	11	46	23	31	34	60	19	11	31	16	48	54
Maximum	260	1100	240	540	310	580	420	1200	820	380	330	2400	450	2500	290	440	530	220	1600	1900
Median	34	110	100	77	80	120	120	120	140	160	220	140	180	150	100	140	140	86	120	120

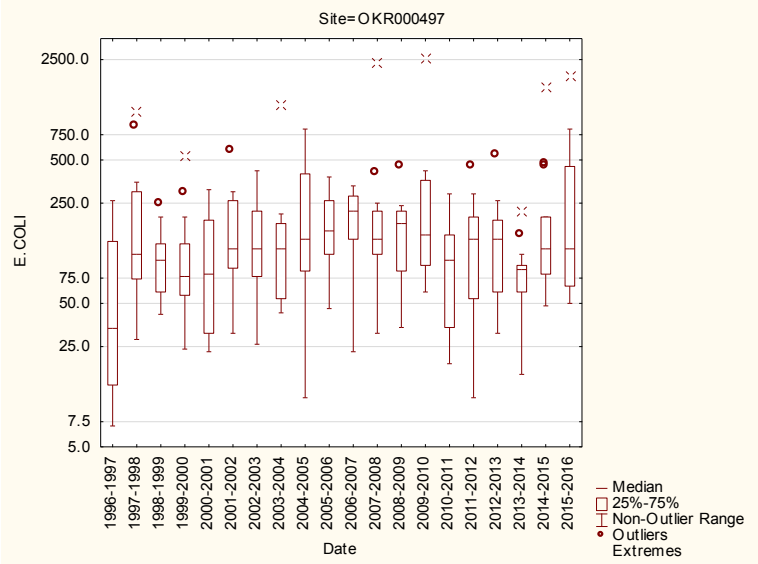
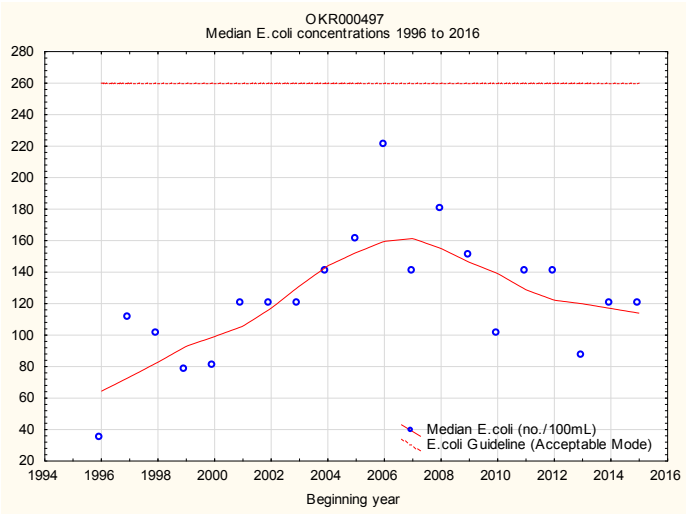


Figure 52 Box and whisker plots for all summer surveys of *E. coli* bacteria numbers in the Oakura River downstream of SH45

The median *E. coli* count was toward the middle of the range of past seasons' results (Figure 52). One of the wider ranges of *E. coli* counts was recorded. No median *E. coli* counts have exceeded the 2003 guidelines for contact recreational usage over the twenty seasons of monitoring.

Trend analysis of these median *E. coli* numbers has been performed for the twenty seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 53) and testing the significance of any trend using the Mann-Kendall test at 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.



N = 20
Kendall tau = + 0.303
p level = 0.061[>FDR, p = 0.231]
Not significant at p < 0.05 after FDR.

Figure 53 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Oakura River, SH 45 site for the 1996 to 2016 period

A relatively strong increasing, but no longer significant, overall trend in median *E. coli* counts has been found over the twenty seasons of monitoring. However, none of these seasonal medians exceeded the 'Alert' or 'Action' modes. This increasing trend may warrant further investigation if it continues, but it should be noted that there had been a steadily improving trend (decrease) in median *E.coli* counts over an eight year period after medians peaked in the 2006-2007 season.

4.2.13.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season in a more appropriate reach, upstream of the SH45 bridge, with results presented in Table 69 and Figure 54.

Table 69 Percentage benthic cyanobacteria cover for the Oakura River at the SH45 Bridge site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	0	No	No	Green (surveillance)
18/11/2015	8	Minor	Minor	Amber (Alert)
28/11/2015	0	No	No	Green (surveillance)
09/12/2015	0	No	No	Green (surveillance)
21/12/2015	0	No	No	Green (surveillance)
07/01/2016	0	No	No	Green (surveillance)
21/01/2016	0	No	No	Green (surveillance)
03/02/2016	0	No	No	Green (surveillance)
17/02/2016	0	No	No	Green (surveillance)
02/03/2016	0	No	No	Green (surveillance)

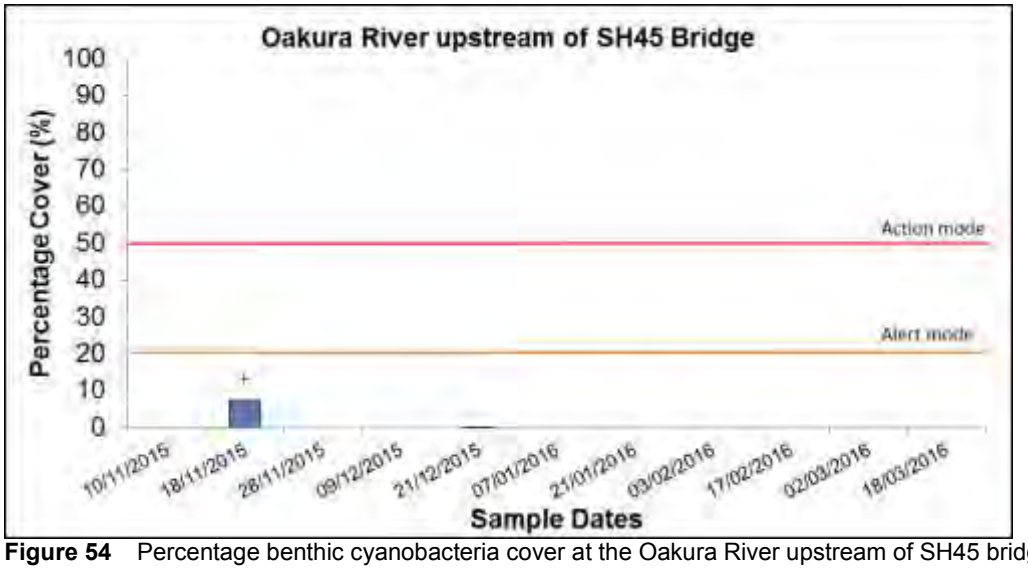


Figure 54 Percentage benthic cyanobacteria cover at the Oakura River upstream of SH45 bridge

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

Benthic cyanobacteria coverage was low throughout the season (ranging from 0 to 8%). The benthic cyanobacteria found were *Phormidium* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover, but one survey of minor detaching and exposed mats triggered the 'Alert' level, and therefore no health warnings were required.

4.2.14 Waitara River at the town wharf, Waitara

No bathing usage of this river site at the new town wharf was recorded at the time of sampling surveys, the majority of which were prior to midday. Fishing (including whitebaiting in season) was noted from time-to-time at this site with canoeing as additional activity. Ducks and gulls were present on occasions but in low numbers. The permanent signage previously installed by NPDC was reinstated in early February 2016.

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.

Regular sampling data from the site for the 2015-2016 season are presented in Table 70 and illustrated in Figure 55 with a statistical summary provided in Table 71. River flow information is illustrated in Figure 56.

Table 70 Analytical results for the Waitara River at the town wharf, Waitara

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	0910	3500	110	3	110	15.3	4.2
25.11.15	0815	445	310	31	310	16.1	14
10.12.15	0900	890	180	32	190	16.9	3.6
15.12.15	1140	594	120	33	130	19.5	3.8
12.01.16	0958	811	900	240	900	19.9	73
15.01.16	1230	762	240	62	240	22.5	15
25.01.16	0945	764	250	180	250	23.4	9.9
09.02.16	1005	3560	250	120	270	23.0	21
12.02.16	1225	2240	300	670	300	24.8	4.9
23.02.16	1000	776	380	200	380	22.0	23
08.03.16	0900	1160	470	260	490	20.5	3.7
22.03.16	0850	930	300	220	320	20.1	2.4
30.03.16	1305	738	140	31	140	20.0	6.1

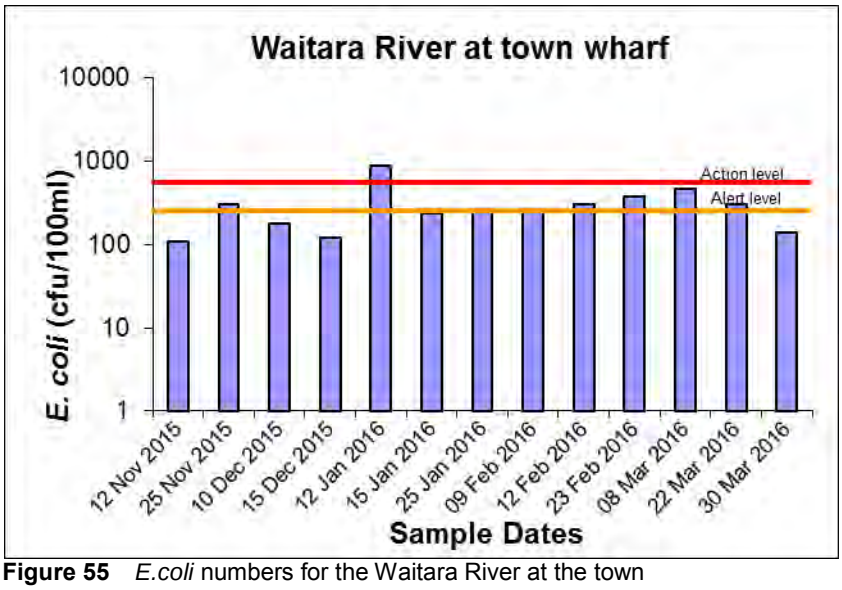


Figure 55 *E.coli* numbers for the Waitara River at the town wharf, Waitara during the survey season

Table 71 Statistical results summary for the Waitara River at the town wharf, Waitara

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20° C	mS/m	13	445	3560	811
E. coli	nos/100ml	13	110	900	250
Enterococci	nos/100ml	13	3	670	120
Faecal coliforms	nos/100ml	13	110	900	270
Temperature	°C	13	15.3	24.8	20.1
Turbidity	NTU	13	2.4	73	6.1

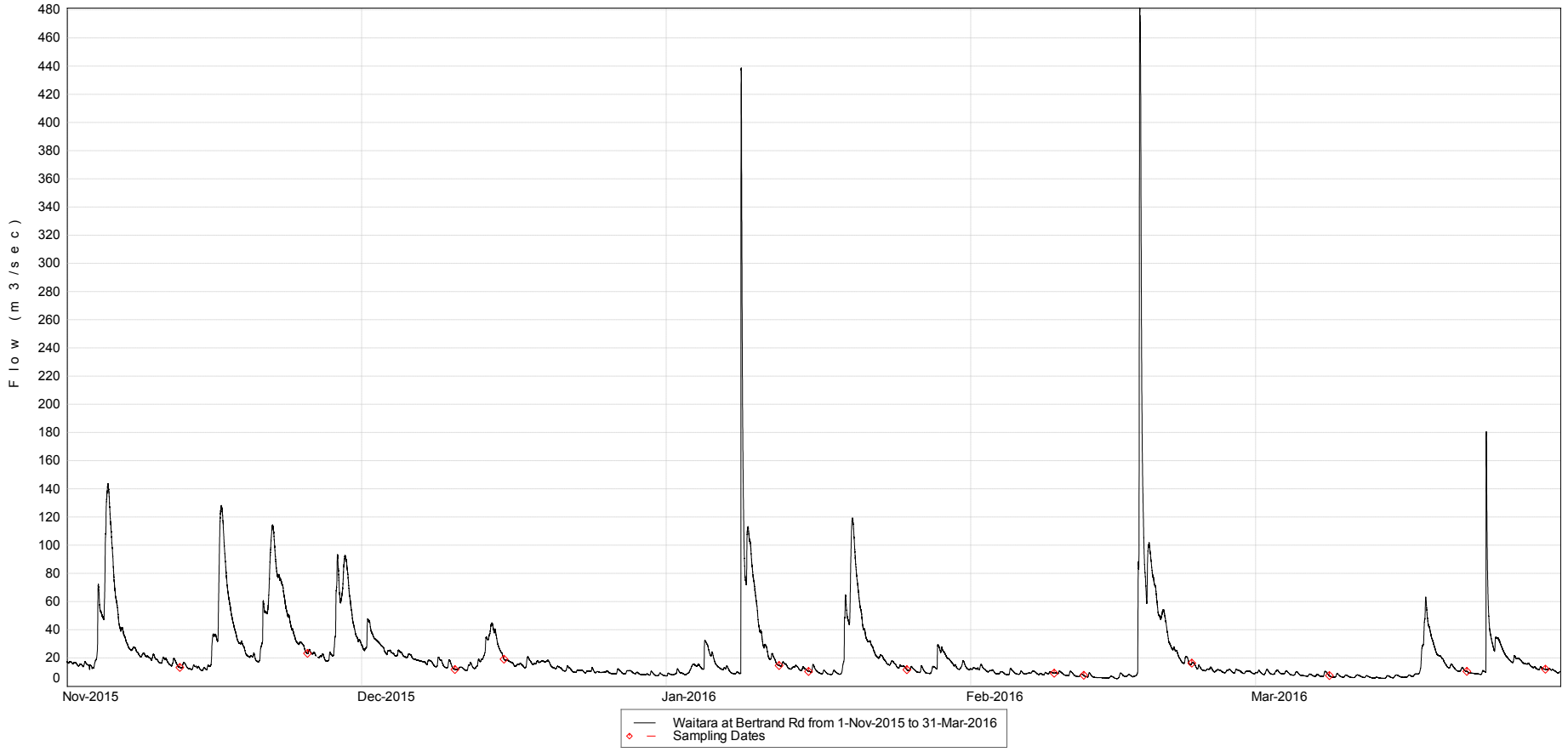


Figure 56 Flow in the Waitara River at Bertrand Road during the survey period

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 4.2.16). River water was generally slightly turbid, green-brown and occasionally turbid, brown in appearance with elevated conductivity levels typical of seawater ingress near high tide on all sampling occasions and occasionally coincidental with ponded or very slow downstream flow conditions.

Water temperatures had a moderate range of 9.5˚C partly due to the coastal seawater influence, with a maximum of 24.8˚C recorded in early afternoon in mid-February 2016. 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 lower than previously found 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 250 *E.coli* per 100 mls and 120 enterococci per 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 per 100 mls but a wider range of *E. coli* numbers (6 to 5000 per 100 ml).

4.2.14.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 72.

Table 72 Bacterial guidelines performance at the Waitara River at the town wharf, Waitara [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	5 [38]	1 [8]

(Designation: freshwater contact recreational area)

Five single samples fell within the 'Alert' mode and one sample within the 'Action' mode during the monitoring period. The 'Action' mode exceedance occurred in drizzling weather less than four days after a substantial rainfall event in the hinterland and coincided with the highest turbidity (73 NTU) recorded during the survey period. 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.

Photo 7 Warning signage at Waitara River (boat ramp)

These issues have been 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. (Photo 7). However, the permanency of this signage has been probematical due in part to vandalism.

Generally, *E. coli* numbers were variable throughout the survey period and exceeded the 'Alert' or 'Action' guideline for almost half of the samplings.

4.2.14.2 Comparison with previous summers' surveys

Six previous SEM sampling seasons have been monitored at this site. Therefore only a brief statistical comparison can be made with previous data. These data for the Waitara River at the town wharf, Waitara site are summarised in Table 73 and illustrated in Figure 57 for this, the seventh season of monitoring.

Table 73 Summary *E. coli* bacteriological water quality data (cfu/100ml) for summer surveys in the Waitara River at the town wharf, Waitara

Summer	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	92	19	28	3	13	58	100
Maximum	1700	570	550	1300	290	1500	900
Median	230	76	150	120	100	140	250

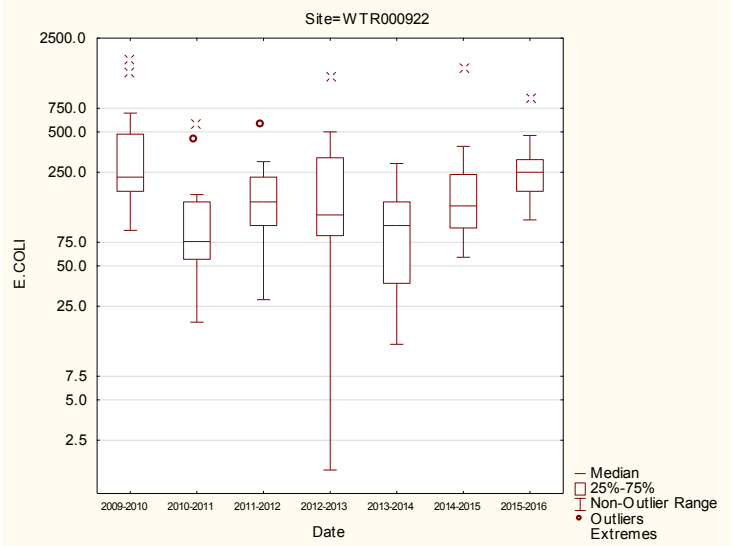


Figure 57 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waitara River at the town wharf, Waitara

The median *E. coli* number found by this seventh season's survey was the highest recorded, and was just below the 'Alert' mode. A similar median value was recorded six years before. A wide range of counts was recorded, due in part to delayed effects of preceding freshes in this large, predominantly hill country catchment, and partly to high turbidity and sometimes cloudy weather reducing the sterilizing effect of sunlight. Trend analysis of median *E.coli* numbers will not be performed until the sampling period has encompassed ten seasons of data collection at this site.

4.2.15 Urenui River at the estuary

Intensive bathing usage of this site was noted (but only on one of the sampling surveys) with some usage apparent for other activities (e.g. boating, fishing, and picnicking) at this tidal site. This is a very popular site during weekends and holiday periods (see TRC, 1999 and TRC, 2008a).

Data from the site are presented in Table 74 and enterococci counts (as the site is predominantly seawater) are illustrated in Figure 58, with a statistical summary provided in Table 75.

Table 74 Analytical results for the Urenui River at the estuary

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	0800	4680	<1	3	<1	14.8	14
25.11.15	0900	4680	11	24	11	16.6	10
10.12.15	0800	4800	6	8	6	16.4	5.9
15.12.15	1100	4730	5	3	5	17.1	11
12.01.16	0913	4610	38	18	38	19.5	36
15.01.16	1130	4710	1	8	1	21.9	24
25.01.16	0900	4610	17	9	17	21.7	15
09.02.16	0920	4680	15	53	15	23.2	9.1
12.02.16	1145	4720	1	1	1	23.9	9.1
23.02.16	0920	4590	12	11	12	22.3	19
08.03.16	0820	4770	3	13	3	20.1	17
22.03.16	0820	4630	8	8	8	21.3	7.8
30.03.16	1230	4750	1	3	1	22	7.6

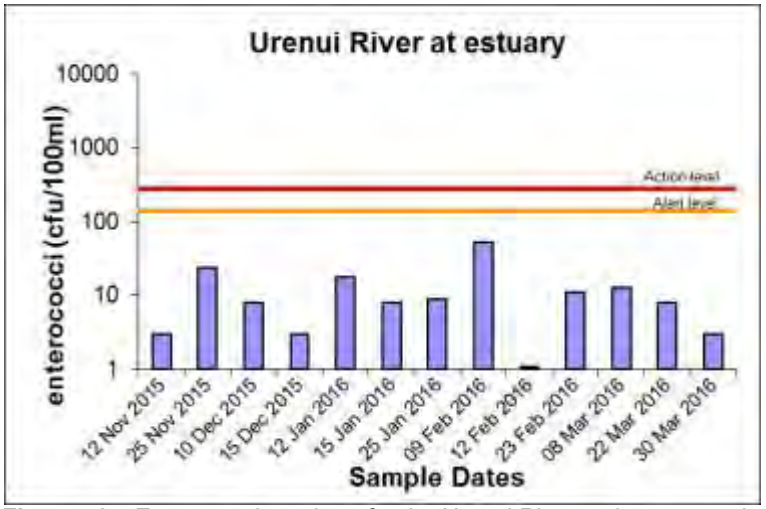


Figure 58 Enterococci numbers for the Urenui River at the estuary during the survey season

Table 75 Statistical results summary for the Urenui River at the estuary

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4590	4800	4680
E. coli	cfu/100ml	13	<1	38	6
Enterococci	cfu/100ml	13	<1	53	8
Faecal coliforms	cfu/100ml	13	<1	38	6
Temperature	°C	13	14.8	23.9	21.3
Turbidity	NTU	13	5.9	36	11

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 (5.9 NTU) and median turbidity (11 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 clearish to slightly turbid to turbid. Conductivity levels were characteristic of coastal saltwater on all occasions. Moderately high water temperatures (median of 21.3°C), more typical of coastal seawater temperatures, varied over a relatively wide range of 9.1°C during the sampling period with a maximum of 23.9°C recorded in late morning in mid February 2016. All sampling however, was undertaken prior to 1235 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 (eg 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.

4.2.15.1 Comparison with guidelines

Comparison with the 2003 guidelines for contact usage is summarised in Table 76 using the marine guidelines, which are considered to be more appropriate for this estuarine site.

Table 76 Bacterial guidelines performance at the Urenui River estuary site [% of 13 samples]

Parameter	Number of exceedances of enterococci guidelines	
	ALERT Single sample 141-280/100ml	ACTION 2 consecutive single samples >280/100 ml
Enterococci	0 [0]	0 [0]

(Designation: coastal contact recreational area)

No single sample fell within the 'Alert' mode or within the 'Action' mode for saline water at any time during the monitoring period. Also, neither mode was exceeded 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 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 seven seasons to date.

4.2.15.2 Comparison with previous summers' surveys

A statistical comparison of each of the twenty summers' survey data is presented graphically in Appendix VI for all sites. These summer enterococci data for the Urenui River site at the estuary are summarised in Table 77 and illustrated in Figure 59.

Table 77 Summary of enterococci bacteriological water quality data (cfu/100ml) for all summer surveys in the Urenui River estuary to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05-06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	<1	<1	<1	1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Maximum	40	69	82	220	160	27	19	72	640	30	9	36	120	190	150	36	100	51	99	53
Median	5	7	3	8	14	8	4	4	5	4	1	2	11	7	3	4	3	3	3	8

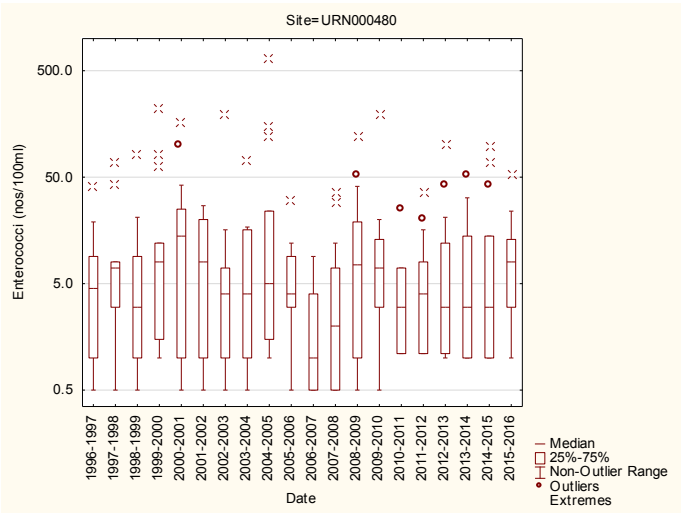
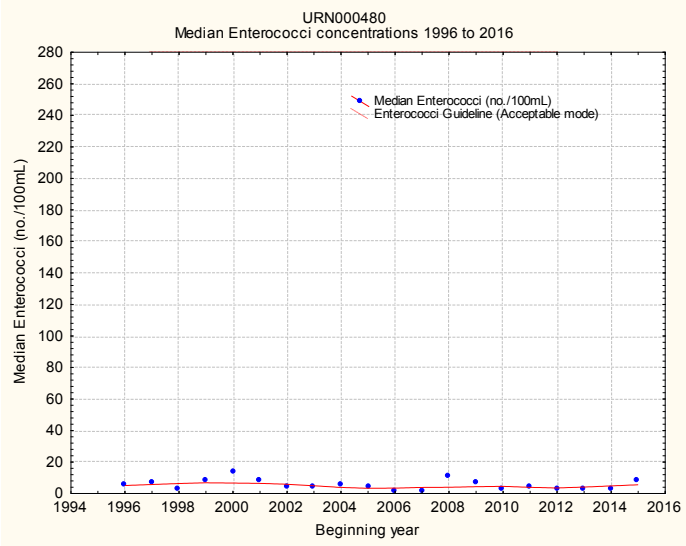


Figure 59 Box and whisker plots for all summer surveys of enterococci bacterial numbers in the Urenui River at the estuary

The high bacteriological water quality of the Urenui River estuary, during high tide conditions, continued during the 2015-2016 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 2015-2016 season as a result of no single sample counts in excess of 53 enterococci per 100 ml during the period.

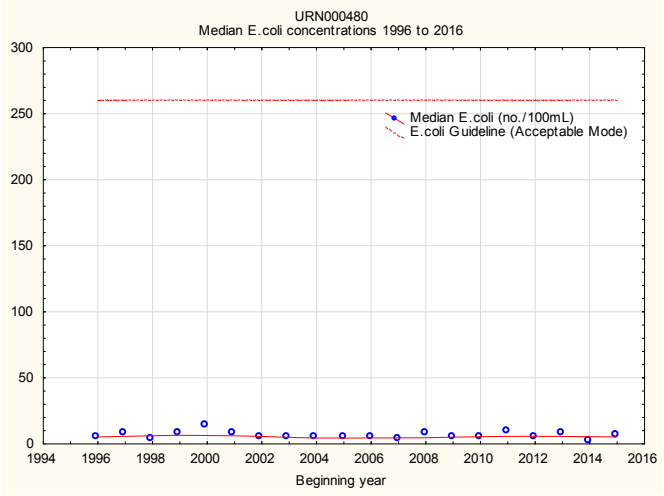
The high bacteriological quality of the coastal sea water intrusion was the major influence on the bacteriological water quality of the lower quality river water at this estuarine site during preferred recreational usage (i.e. higher tide) conditions.

Trend analysis of median enterococci and *E. coli* numbers has been performed for the twenty 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.



N = 20
Kendall tau = - 0.229
p level = 0.158 [>FDR, p = 0.339]
Not significant at p < 0.05

Figure 60 LOWESS trend plot of median enterococci (per 100ml) at the Urenui River, estuary site for the 1996 to 2016 period



N = 20
Kendall tau = - 0.061
p level = 0.705 [>FDR, p = 0.814]
Not significant at p < 0.05

Figure 61 LOWESS trend plot of median *E. coli* (per 100ml) at the Urenui River, estuary site for the 1996 to 2016 period

No statistically significant trends in median enterococci or *E. coli* counts (after FDR applications) have been found over the twenty seasons of monitoring which have indicated an overall unimportant decrease in enterococci bacteria and a slight decrease 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.

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

No bathing or other usage of this river site was noted at the time of sampling occasions during the survey period despite the proximity of the site to a nearby outdoor adventure camp. Minimal birdlife was noted at this site during the season. Data from the site are presented in Table 78 and illustrated in Figure 62, with a statistical summary provided in Table 79. River flow records are illustrated in Figure 63.

Table 78 Analytical results for the Manganui River at Everett Park (downstream of the Kurapete Stream)

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1020	10	220	13	220	15.2	1.1
25.11.15	0945	9.7	210	16	210	15.6	0.9
10.12.15	0955	9.8	80	37	80	14.8	0.9
15.12.15	1020	8.9	220	37	220	15.6	0.9
12.01.16	0822	8.7	230	190	240	17.9	0.5
15.01.16	1040	9.3	130	86	130	20.1	0.7
25.01.16	0810	9.4	170	230	170	20.9	0.6
09.02.16	0820	9.9	160	160	160	20.6	0.5
12.02.16	1045	9.8	200	140	200	20.7	0.7
23.02.16	0820	9.9	270	470	270	18.5	0.7
08.03.16	0945	10.1	250	140	250	18.5	0.7
22.03.16	1000	9.6	250	330	250	17.9	0.7
30.03.16	1120	9.6	190	140	190	15.2	0.8

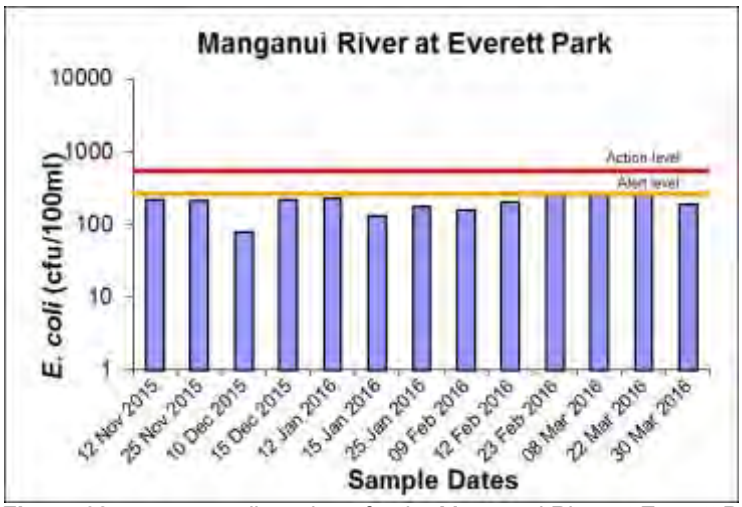


Figure 62 *E. coli* numbers for the Manganui River at Everett Park (downstream of the Kurapete Stream) during the survey season

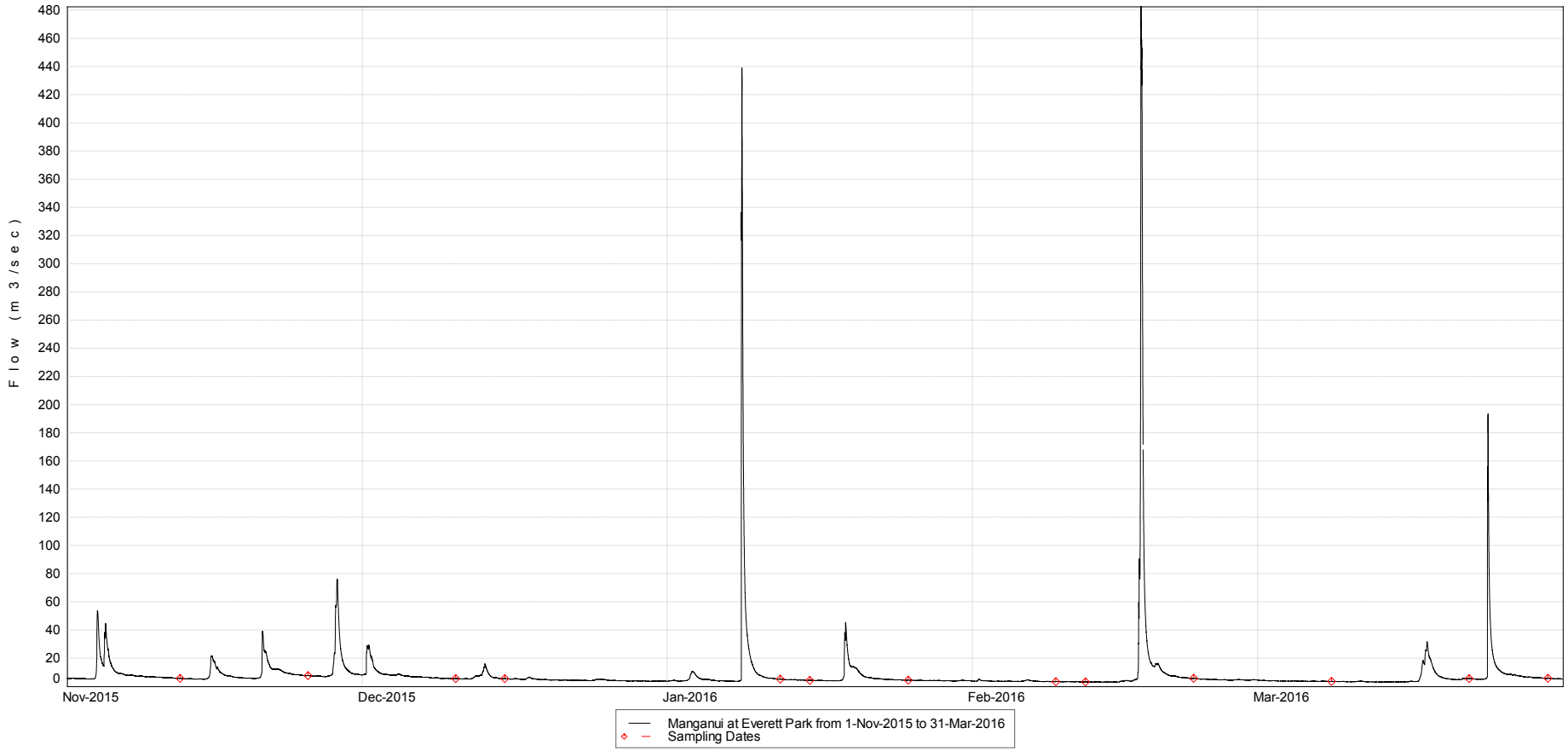


Figure 63 Flow in the Manganui River at Everett Park during the survey period

Table 79 Statistical results summary for the Manganui River at Everett Park (downstream of Kurapete Stream)

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	8.7	10.1	9.7
E. coli	cfu/100ml	13	80	270	210
Enterococci	cfu/100ml	13	13	470	140
Faecal coliforms	cfu/100ml	13	80	270	210
Temperature	°C	13	14.8	20.9	17.9
Turbidity	NTU	13	0.5	1.1	0.7

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 conductivity levels. Water temperatures varied over a moderate range of 6.1°C with the maximum temperature (20.9°C) recorded in early morning in late January 2015. Higher temperatures could be expected later in the day as no sampling surveys were performed after 1120 hrs at this site.

Bacteriological water quality was moderate for this site during the 2015-2016 survey period with none of the counts recorded during the period below 80 *E. coli* per 100 ml (Figure 62). The highest count was the second lowest recorded, and the nine highest counts were within the narrow range of 190 to 270 *E. coli* per 100 ml, one entering the 'Alert' level by a small margin in late February 2016.

4.2.16.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 80.

Table 80 Bacterial guidelines performance at the Manganui River at Everett Park (downstream of Kurapete Stream) [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	1 [8]	0[0]

(Designation: freshwater contact recreational area)

One single sample fell in the 'Alert' mode during the season. The highest count was recorded after six days of flow recession following a flood in late February 2016.

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).

4.2.16.2 Comparison with previous summers' surveys

A statistical comparison of each of the nineteen summers' survey data is presented graphically in Appendix VI for all sites. These summer data for the Manganui River site at Everett Park are summarised in Table 81 and illustrated in Figure 64.

Table 81 Summary of *E. coli* bacteriological water quality summary data (nos/100ml) for all summer surveys in the Manganui River at Everett Park to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	58	85	76	46	26	100	54	66	83	46	11	54	100	92	100	34	80	63	100	80
Maximum	690	2400	830	350	450	970	460	880	730	240	320	1200	480	370	320	400	760	330	560	270
Median	150	220	160	110	98	210	140	180	180	120	190	160	170	200	170	120	140	140	200	210

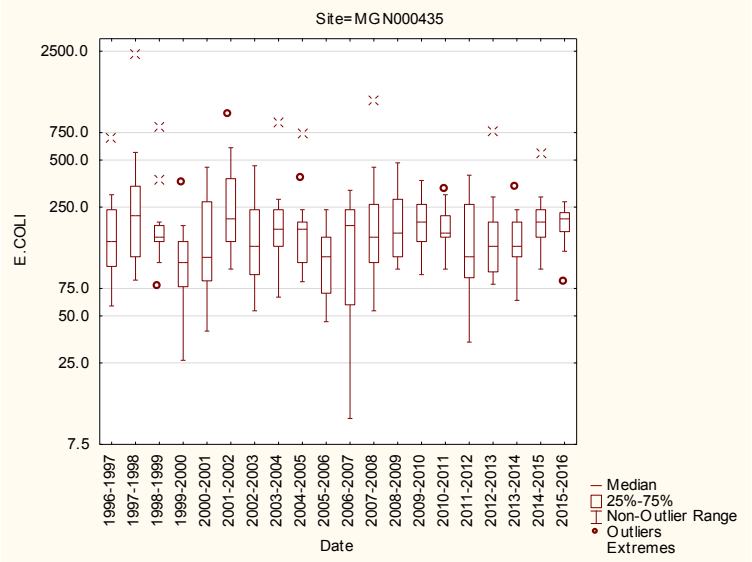
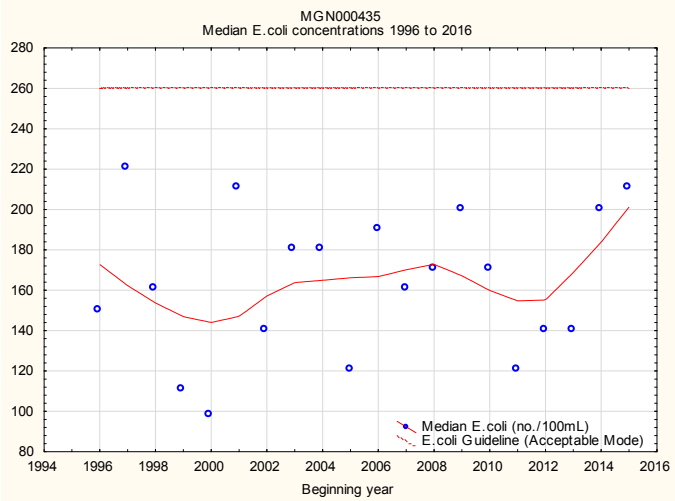


Figure 64 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Manganui River at Everett Park

The median *E. coli* count for the 2015-2016 season was the second highest of the twenty seasons' medians recorded since the inception of the programme in 1996-97 (Figure 64). The range of *E. coli* numbers was the narrowest recorded to date and the maximum count was the second lowest, mainly due to the relatively consistent low flows at the time of sampling.

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



N = 20
Kendall tau = +0.102
p level = 0.528 [>FDR, p= 0.791]
N/S at p< 0.05

Figure 65 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Manganui River, Everett Road site for the 1996 to 2016 period

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

4.2.16.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on thirteen occasions through the season with results presented in Table 82 and Figure 66.

Table 82 Percentage benthic cyanobacteria cover at the Manganui River, Everett Park site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
10/11/2015	3	No	No	Green (surveillance)
28/11/2015	2	Minor	No	Amber (Alert)
02/12/2015	2	No	No	Green (surveillance)
09/12/2015	3	No	No	Green (surveillance)
21/12/2015	4	Minor	Minor	Amber (Alert)
07/01/2016	5	No	No	Green (surveillance)
21/01/2016	4	No	No	Green (surveillance)
03/02/2016	4	No	No	Green (surveillance)
17/02/2016	4	No	No	Green (surveillance)
02/03/2016	6	No	No	Green (surveillance)
17/03/2016	16	Minor	No	Amber (Alert)
22/03/2016	5	No	No	Green (surveillance)
30/03/2016	0	No	No	Green (surveillance)

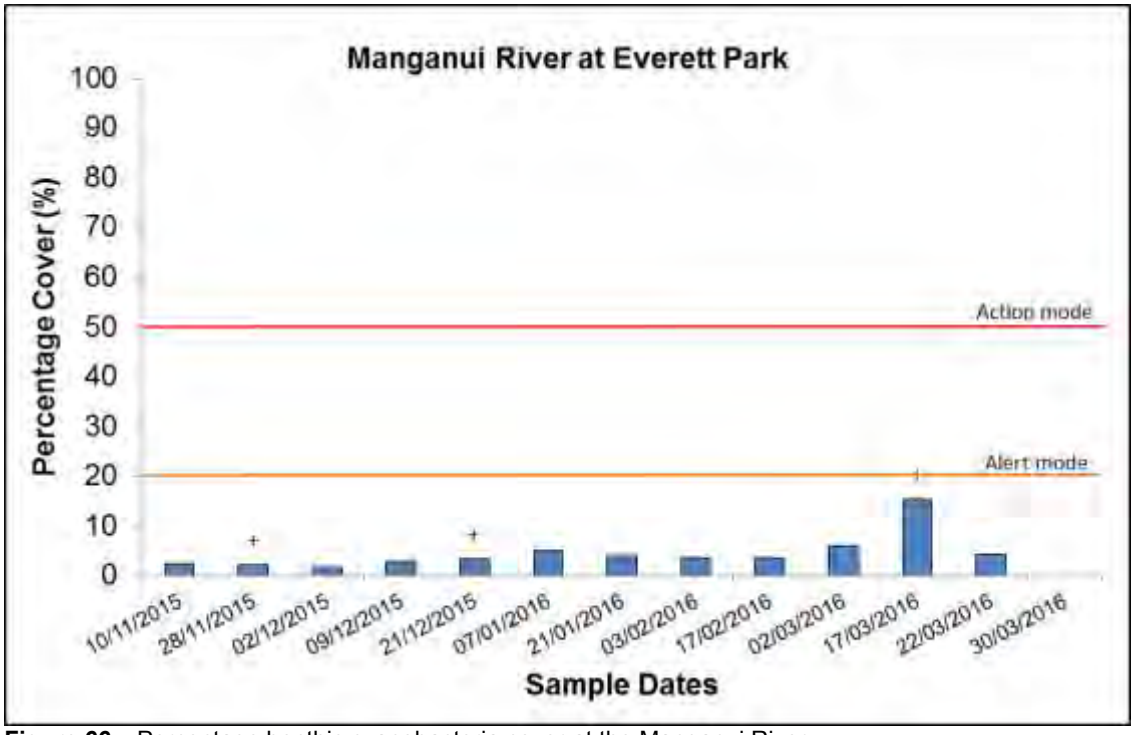


Figure 66 Percentage benthic cyanobacteria cover at the Manganui River, Everett Park site

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

Benthic cyanobacteria coverage was low for the majority of the monitoring period with only one survey exceeding 6% coverage (range from 0 to 16%). The benthic cyanobacteria found were *Phormidium* sp. Minor levels of detaching mats (3 occasions) and exposed mats (1 occasion) were observed which triggered the 'Alert' response.

4.2.17 Lake Ratapiko

Bathing usage of the lake was noted on only one occasion. Boating, jet-skiing and fishing were recorded on a few occasions. However, the lake is commonly used for boating and fishing purposes, particularly at weekends and holidays. Ducks were present occasionally in low numbers and twice were common, and swans occasionally were present on the lake. Minimal stock access to the lake margins was recorded unlike on some past occasions (TRC, 2013). The lake was not drawn down for maintenance purposes until the end of this season, and as a result sampling was performed on all thirteen occasions (unlike the lesser frequency in some previous seasons (TRC, 2014)).

The data for this site are presented in Table 83 and illustrated in Figure 67 with a statistical summary provided in Table 84.

Table 83 Analytical results for Lake Ratapiko

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
12.11.15	1105	8.1	20	<1	20	17.2	1.6
25.11.15	1005	7.6	15	1	16	16.8	1.3
10.12.15	1020	8.4	23	31	23	18.0	1.7
15.12.15	1000	7.8	220	<1	220	18.7	2.2
12.01.16	0803	7.7	47	13	51	19.5	1.3
15.01.16	1010	7.7	9	60	9	20.3	1.4
25.01.16	0800	7.5	8	7	8	22.7	1.3
09.02.16	0800	8.4	3	5	3	23.8	1.1
12.02.16	1020	8.4	3	1	3	24.0	0.9
23.02.16	0800	8.0	11	17	12	19.9	1.6
08.03.16	1010	8.6	4	14	4	21.5	1.1
22.03.16	1045	8.9	12	2	12	20.2	0.9
30.03.16	1055	8.1	420	10	430	19.5	0.8

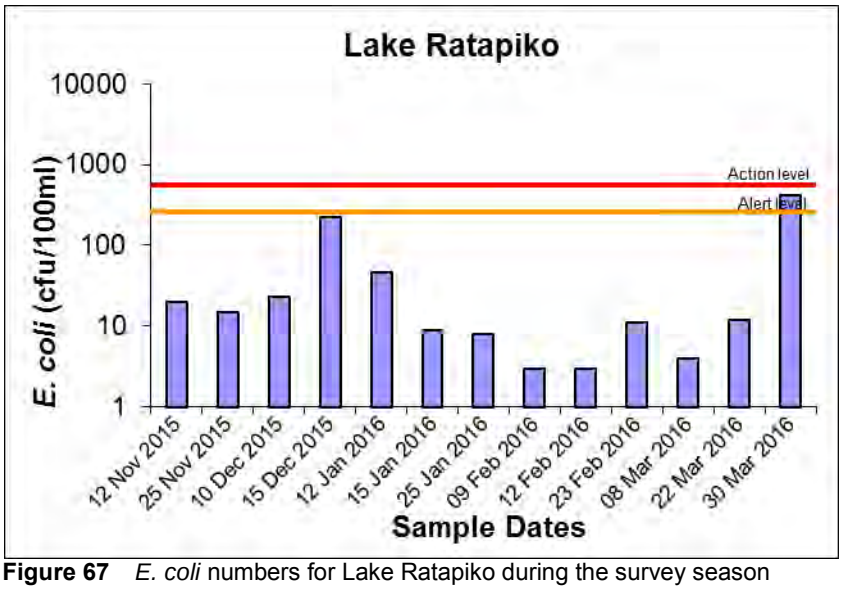


Figure 67 *E. coli* numbers for Lake Ratapiko during the survey season

Table 84 Statistical results summary for Lake Ratapiko

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	7.5	8.9	8.1
E. coli	cfu/100ml	13	3	420	12
Enterococci	cfu/100ml	13	<1	60	7
Faecal coliforms	cfu/100ml	13	3	430	12
Temperature	°C	13	16.8	24.0	19.9
Turbidity	NTU	13	0.8	2.2	1.3

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: 1.3 NTU; range of turbidity: 1.4 NTU) as a result of low suspended algae populations possibly due to short retention times in the lake. Water temperatures were moderate ranging over 7.2˚C for the period with a moderately high maximum of 24.0˚C (mid-morning in

early February 2016) although all of the measurements were recorded prior to 1110 hrs. Conductivity showed minimal variation (less than 1.5 mS/m) 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. Only two counts exceeded 50 *E. coli* per 100 ml, once at the start of the survey period, when birdlife may have affected water quality, and once at the end of the of the period, when the water level was being lowered for removal of sediment.

4.2.17.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 85.

Table 85 Bacterial guidelines performance at Lake Ratapiko [% of 10 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	1 [8]	0 [0]

(Designation: Freshwater contact recreational area)

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

Bacteriological water quality was good and within acceptable guidelines for contact recreational usage throughout the survey period, except for the final sampling, when the lake was not available for use while the level was lowered for maintenance.

4.2.17.2 Comparison with previous summers' surveys

A statistical comparison of all sites' summers' *E. coli* survey data is presented graphically in Appendix VI for all sites. Data from the ten summer surveys for the Lake Ratapiko site are summarised in Table 86 and illustrated in Figure 68.

Table 86 Summary of *E.coli* bacteriological water quality data (cfu/100ml) for all summer surveys at Lake Ratapiko to date

Summer	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
Minimum	1	1	5	4	13	1	3	<1	2	3
Maximum	86	120	220	91	140	150	240	240	120	420
Median	21	16	35	16	25	35	10	10	12	12

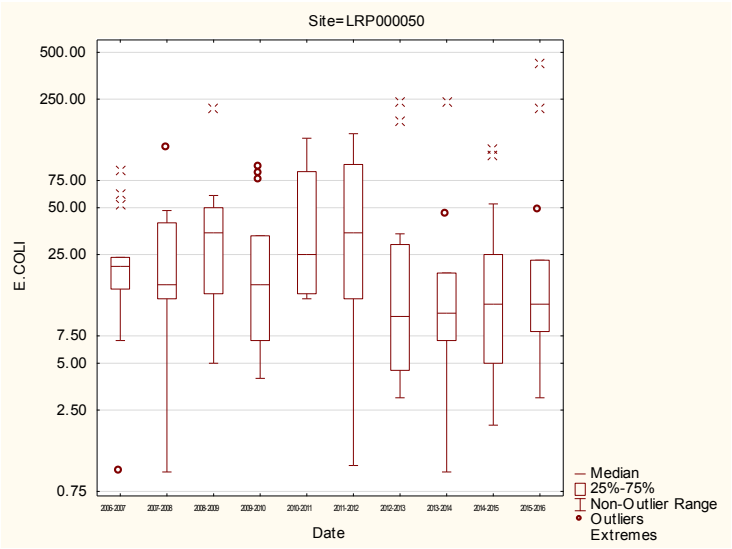
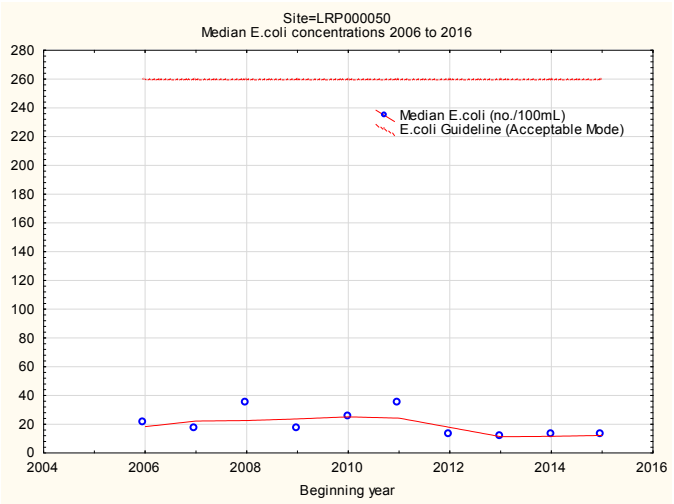


Figure 68 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers at Lake Ratapiko

A very 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 near the lowest of the ten seasons' medians to date.

Trend analysis of these median *E.coli* numbers has been performed for the ten 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.



N = 10
Kendall tau = -0.424
p level = 0.088 [>FDR, p = 0.263]
N/S at p < 0.05

Figure 69 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Lake Ratapiko site, for the 2006-2016 period

No statistically significant trends in median *E.coli* counts have been found over the ten 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.

4.2.17.3 Cyanobacteria

Planktonic cyanobacteria were monitored on seven occasions throughout the season. The results of these analyses are presented in Table 87 and Figure 70.

Table 87 Cyanobacteria counts and biovolumes for Lake Ratapiko

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm^3/L)	Principal species by biovolume	Mode
03/11/2015	0	0	No cyanobacteria	Low Risk
22/12/2015	0	0	No cyanobacteria	Low Risk
06/01/2016	0	0	No cyanobacteria	Low Risk
19/01/2016	0	0	No cyanobacteria	Low Risk
02/02/2016	3700000	1.7	Picocyanobacteria	Medium Risk
16/02/2016	1100	0.1	Picocyanobacteria	Low Risk
15/03/2016	0	0	No cyanobacteria	Low Risk

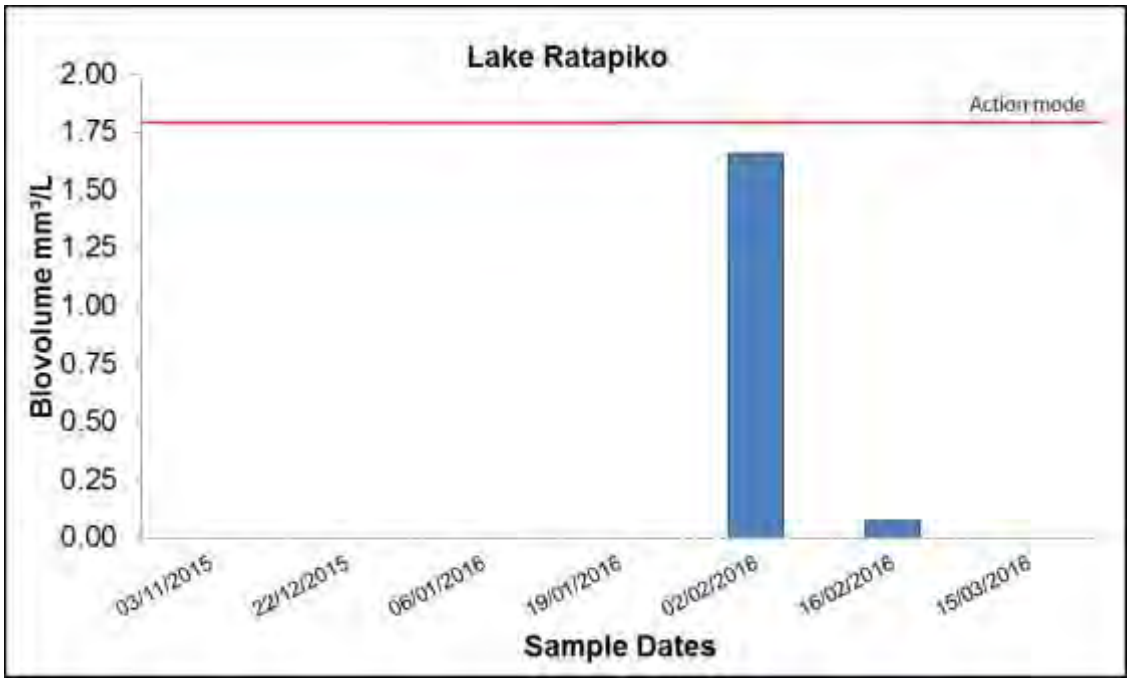


Figure 70 Cyanobacteria biovolume at Lake Ratapiko

Planktonic cyanobacteria were not detected in early November to late January 2016. There was nearly a 'High risk' bloom sampled on 2 February 2016, with low numbers occurring at the next survey and no cyanobacteria found during the last survey in mid March.

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. The relatively short lake water residence time (due to hydroelectric power generation usage) may be a factor in the control of these bacteria populations.

4.2.18 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 2015-2016 season, with the lake sampled on seven occasions between mid November 2015 and early April 2016. [Note: bacteriological monitoring is not a component of the SEM programme at this lake].

Usage of the lake included walkers (visitors) and picnicking throughout the season. The boat ramp remained locked throughout the entire period. Ducks were common at the lake margin on the majority of monitoring occasions, and black swans and pukeko were noted from time to time. The lake which appeared turbid, green or green-brownish throughout most of the period with a brighter green appearance at the end of the period.

The bacteriological water quality data for this site are presented in Table 88 with a statistical summary provided in Table 89.

Table 88 Analytical results for Lake Rotokare

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
04.11.15	1100					16.5	
20.11.15	0750	12.2	11	4	11	17.1	3
21.12.15	1330	12.6	72	13	80	20.6	10
19.01.16	0955	11.9	180	120	180	22.5	13
01.02.16	1040					24.3	
04.02.16	1005	12.2	88	100	88	24.8	5.3
15.02.16	1030					24.9	
03.03.16	0900	11.9	72	42	74	21.9	6.5
16.03.16	0915	14.6	80	44	80	20.3	
01.04.16	1030	12.2	290	110	290	19.9	7.8

Table 89 Statistical results summary for Lake Rotokare

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	7	11.9	14.6	12.2
E. coli	cfu/100ml	7	11	290	80
Enterococci	cfu/100ml	7	4	120	44
Faecal coliforms	cfu/100ml	7	11	290	80
Temperature	°C	10	16.5	24.9	21.2
Turbidity	NTU	7	3.0	13	7.2

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: 2.5 mS/m) through the period despite variations in inflow during the season. Water temperatures varied over a moderate range of 8.4˚C with a maximum of 24.9˚C recorded in mid February 2016. Turbidity was relatively high (median: 7.2 NTU) with the range (10 NTU) reflecting the variability in abundances of suspended algae in the water column during the season. Highest turbidities (≥ 10 NTU) were coincidental with peaks in cyanobacteria concentrations in December 2015 and January 2016.

No bacterial counts entered the 'Action' level on any occasion during the season, and one count just reached 'Alert' level, although 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, although in 2015-2016 this trend was not as apparent.

4.2.18.1 Cyanobacteria

Planktonic cyanobacteria numbers and biovolume during the recreational monitoring period found moderate cyanobacteria levels in early November 2015 which increased to very high levels in December before decreasing in January with another increase in biovolume levels during early to mid March 2016.

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 (>1.8mm3/L) from mid November onwards. There was a requirement for STDC to erect signage at the lake and road access and the boat ramp remained closed all through summer. The Area Health Board did not require algal toxin testing during the period.

The results of these analyses are presented in Table 96 and illustrated in Figure 71.

Table 90 Cyanobacteria counts and biovolumes for Lake Rotokare

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm^3/L)	Principal species by biovolume	Mode
04/11/2015	73000	0.7	*Anabaena*	Medium Risk
20/11/2015	12000	1.9	*Anabaena*	High Risk
21/12/2015	89000	18.7	*Anabaena*	High Risk
19/01/2016	53000	11.2	*Anabaena*	High Risk
01/02/2016	11000	2.2	*Anabaena*	High Risk
04/02/2016	28000	1.3	*Anabaena*	Medium Risk
15/02/2016	70000	2.4	*Anabaena*	High Risk
04/03/2016	750000	7.6	*Coelosphaerium*	High Risk
16/03/2016	960000	9.0	*Coelosphaerium*	High Risk
01/04/2016	120000	1.1	*Coelosphaerium*	Medium Risk

[Note: Biovolume has been used as the trigger level instead of total cells/mL. This method was considered to be superior as cell size is thought to be correlated with the amount of toxins produced (Woods et al., 2008). New biovolumes specific for Lake Rotokare have been produced to improve the accuracy of this variable (TRC, 2015)].

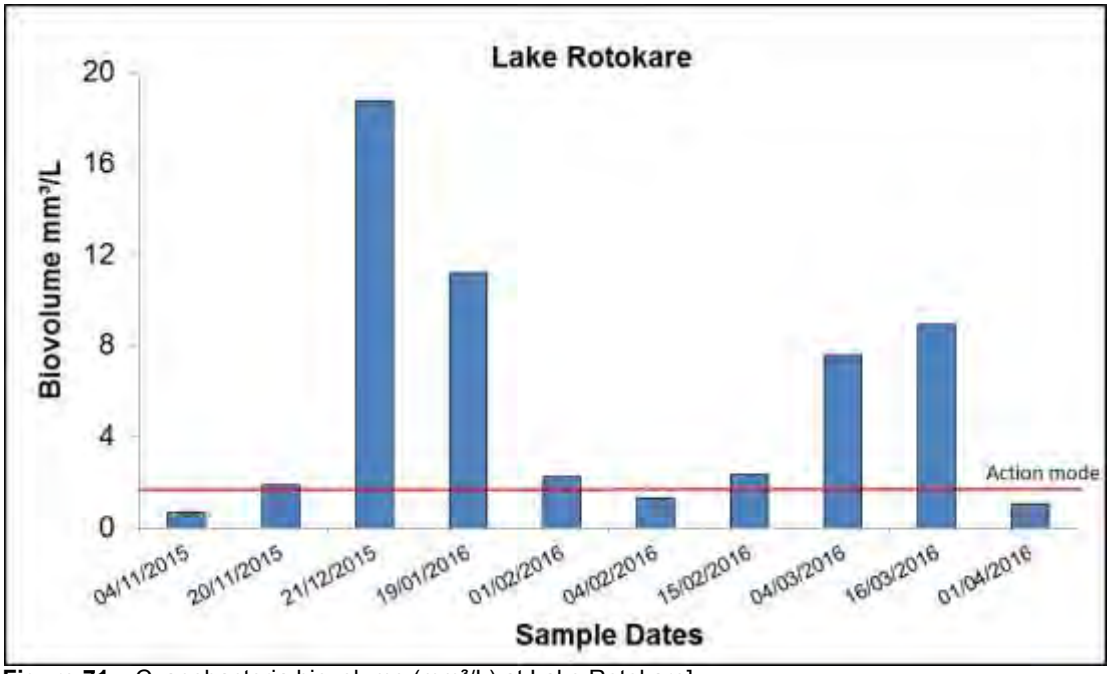


Figure 71 Cyanobacteria biovolume (mm³/L) at Lake Rotokare]

The warning signage displayed adjacent to the boat ramp in past seasons was required for the period from mid December for the remainder of the season. No primary contact recreational usage of the lake was recorded at the time of sampling surveys after the boat ramp remained locked from early in summer.

5. General data summary

A comparative summary of results of the twentieth summer bacteriological quality freshwater survey involving sixteen contact recreational sites in the Taranaki region is provided in Table 91. Results are also illustrated in Figure 72 for each of the bacteriological species and a comparison of all sites' summer data is presented in Appendix VI in the form of statistical 'box and whisker' plots.

Table 91 Statistical summary of results for the sites sampled in the SEM freshwater contact recreational water quality survey, 2015-2016

Site		Temperature (°C)	Conductivity @ 20°C (mS/m)	Faecal coliforms (nos/100 ml)	E. coli (nos/100 ml)	Enterococci (nos/100 ml)	Turbidity (NTU)
Lake Rotomanu	Median	22.9	12.1	125	125	89	10.5
	Minimum	18.9	11.8	54	54	23	6.0
	Maximum	26.2	13.0	1200	1000	1400	13
	No. of samples	13	13	13	13	13	13
Waiwhakaiho River at Merrilands Domain	Median	22.4	12.0	63	63	58	0.5
	Minimum	14.9	9.7	26	26	5	0.2
	Maximum	22.4	14.9	260	250	130	0.8
	No. of samples	13	13	13	13	13	13
Waiwhakaiho River adjacent to L. Rotomanu	Median	20.1	12.0	930	870	800	0.8
	Minimum	15.7	10.0	230	230	62	0.5
	Maximum	24.1	16.8	2800	2600	1200	2.2
	No. of samples	13	13	13	13	13	13
Te Henui Stream at mouth, East End	Median	19.2	1350.0	930	930	1300	1.1
	Minimum	15.2	16.0	350	340	420	0.4
	Maximum	23.0	3830	5700	5500	2400	2.8
	No. of samples	13	13	13	13	13	13
Patea River at King Edward Park, Stratford	Median	16.4	9.1	200	200	200	0.9
	Minimum	12.4	8.2	88	88	13	0.4
	Maximum	19.2	9.7	640	640	1500	1.2
	No. of samples	13	13	13	13	13	13
Patea River at boatramp, Patea	Median	20.0	4680	8	8	4	21
	Minimum	15.3	4520	2	2	<2	9.4
	Maximum	22.6	4750	80	80	24	27
	No. of samples	13	13	13	13	13	13
Waingongoro River at Eltham camp	Median	18.4	11.1	180	180	92	1.4
	Minimum	14.6	9.8	28	28	3	0.6
	Maximum	23.6	11.8	470	470	350	4.8
	No. of samples	13	13	13	13	13	13
Waingongoro River at Ohawe Beach	Median	20.4	19.5	160	140	160	1.4
	Minimum	16.2	14.8	51	48	24	0.7
	Maximum	24.0	22.0	480	480	500	3.0
	No. of samples	13	13	13	13	13	13
Kaupokonui River at beach domain	Median	21.2	19.5	110	110	120	1.8
	Minimum	15.1	15.1	34	34	35	0.8
	Maximum	25.0	950	970	900	1400	11
	No. of samples	13	13	13	13	13	13
Lake Opunake adjacent to boat ramp	Median	22.6	13.4	51	51	240	1.2
	Minimum	17.3	12.0	11	11	23	0.8
	Maximum	26.5	17.0	2500	2000	1800	2.0
	No. of samples	13	13	13	13	13	13
Timaru Stream at Weld Road (near mouth)	Median	19.5	510	260	230	420	0.5
	Minimum	15.9	9.3	66	66	63	0.3
	Maximum	23.7	1380	2000	1500	1400	2.8
	No. of samples	13	13	13	13	13	13
Oakura River d/s of SH45 bridge	Median	18.9	133	130	120	300	0.4
	Minimum	15.3	6.7	52	50	32	0.2
	Maximum	22.4	655	1900	1900	970	1.4
	No. of samples	13	13	13	13	13	13
Waitara River at town wharf, Waitara	Median	20.1	811	270	250	120	6.1
	Minimum	15.3	445	110	110	3	2.4
	Maximum	24.8	3560	900	900	670	73
	No. of samples	13	13	13	13	13	13
Urenui River at estuary	Median	21.3	4680	6	6	8	11
	Minimum	14.8	4590	<1	<1	<1	5.9
	Maximum	23.9	4800	38	38	53	36
	No. of samples	13	13	13	13	13	13
Manganui River d.s of Kurapete S. (Everett Park)	Median	17.9	9.7	210	210	140	0.7
	Minimum	14.8	8.7	80	80	13	0.5
	Maximum	20.9	10.1	270	270	470	1.1
	No. of samples	13	13	13	13	13	13
Lake Ratapiko at boat ramp	Median	19.9	8.1	12	12	7	1.3
	Minimum	16.8	7.5	3	3	<1	0.8
	Maximum	24.0	8.9	430	420	60	2.2
	No. of samples	13	13	13	13	13	13

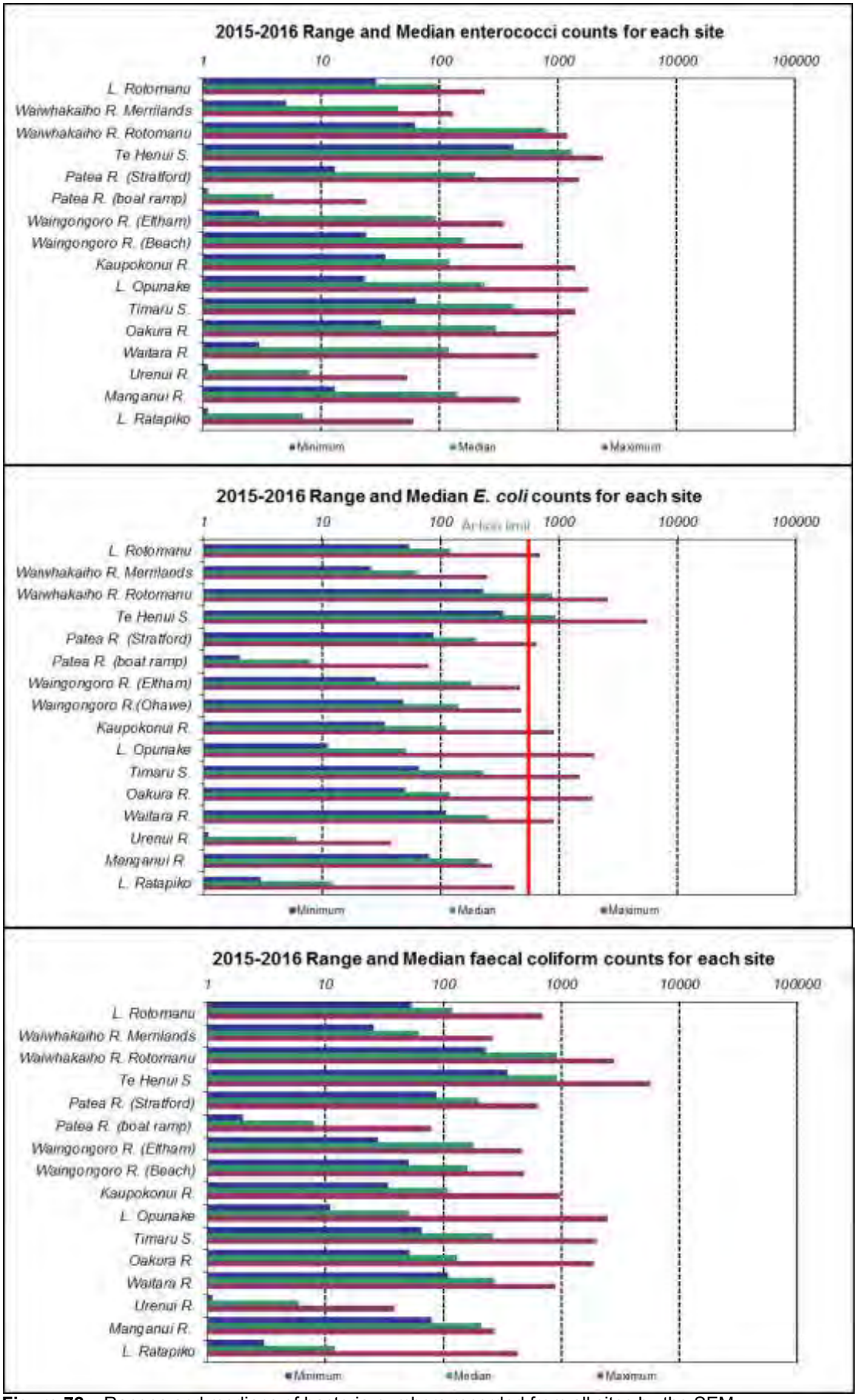


Figure 72 Ranges and medians of bacteria numbers recorded from all sites by the SEM programme over the 2015-2016 survey season

Non-exceedance of the 2003 guidelines has varied amongst the sixteen freshwater contact recreational sites sampled during the survey period (Figure 72 and Table 92), 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 100mls) mode. None of the other sites had a median count in the 'Action' or 'Alert' modes.

Table 92 Number of occasions single sample *E.coli* counts entered the 'Alert' and 'Action' modes and percentage [%] of samples which were below these modes

Site	' Surveillance' mode	'Alert' mode	'Action' mode
Lake Rotomanu at western beach	[69%]	2	2
Waiwhakaiho River at Merrilands Domain	[100%]	0	0
Waiwhakaiho River adjacent to L Rotomanu	[8%]	0	12
Te Henui Stream at mouth, East End	[0%]	3	10
Patea River at King Edward Park, Stratford	[77%]	2	1
Patea River at boatramp, Patea	[100%]	0	0
Waingongoro River at Eltham Camp	[77%]	3	0
Waingongoro River at Ohawe Beach	[77%]	3	0
Kaupokonui River at beach domain	[77%]	2	1
Lake Opunake at boat ramp	[92%]	0	1
Timaru Stream at Weld Road	[69%]	2	2
Oakura River at SH45	[69%]	1	3
Waitara River at town wharf, Waitara	[54%]	5	1
Urenui River at estuary*	[100%]	0	0
Manganui River at Everett Park	[92%]	1	0
Lake Ratapiko at boat ramp[1]	[92%]	1	0

[Notes: N = 13 samples; * = enterococci count;]

Three sites maintained counts below the 'Alert' mode at all times throughout the season (compared with four sites over the 2014-2015 season), while an additional four sites maintained counts below the 'Action' mode (Table 92 and Table 94) at all times. In terms of the overall monitoring season, twenty-five 'Alert' levels (12% of counts) and thirty-three 'Action' levels (16% of counts) resulted over the period representing an overall 72% achievement of the 'Surveillance' contact recreational guideline (compared with 68%, 76%, 78%, 72%, 74%and 71% achievement in the 2009-2010, 2010-2011, 2011-2012, 2012-2013, 2013-2014 and 2014-2015 seasons respectively). Of these 28% 'Surveillance' guideline exceedances, 12% occurred at two sites and predominantly represented exceedances of the 'Action' guideline as well.

In terms of guidelines achievement, the sites may be ranked in the following order for the 2015-2016 season:

1= Waiwhakaiho River at Merrilands Domain
1= Patea River at boatramp, Patea
1= Urenui River at estuary
4= Lake Opunake
4= Manganui River at Everett Park
4= Lake Ratapiko
7= Patea River at King Edward Park, Stratford
7= Waingongoro River River at Eltham camp
7= Waingongoro River at Ohawe Beach
7= Kaupokonui River at beach domain

11=	Lake Rotomanu
11=	Timaru Stream at Weld Road (near mouth)
11=	Oakura River d/s SH45 bridge
14	Waitara River at town wharf
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 lower (estuarine) reach of the Patea River, at the most estuarine site (Urenui River) which was strongly influenced by seawater penetration during high tide conditions, and Lake Ratapiko, where each site's median count was ≤ 12 *E.coli* per 100 mls. 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	Urenui River at estuary
2	Patea River at boatramp, Patea
3	Lake Ratapiko
4	Lake Opunake at boat ramp
5	Waiwhakaiho River at Merrilands Domain
6	Kaupokonui River at beach domain
7	Oakura River d/s of SH 45 bridge
8	Lake Rotomanu
9	Waingongoro River at Ohawe Beach
10	Waingongoro River at Eltham camp
11	Patea River at King Edward Park, Stratford
12	Manganui River at Everett Park (d/s of Kurapete Stream)
13	Timaru Stream at Weld Road (near mouth)
14	Waitara River at town wharf, Waitara
15	Waiwhakaiho River adjacent to Lake Rotomanu
16	Te Henui Stream at mouth, East End

The biggest improvements in ranking, in comparison with the 2014-2015 season, occurred in the Patea River at Stratford and the Waingongoro River at Eltham, (where there was about a 30% improvement in median count between the last two seasons, ascribed to sampling later in the day) while the two lowest rankings remained at the two sites which were lowest ranked for the last several seasons. The Waitara River at the town wharf slipped down in the rankings (where it was ranked fourteenth) in terms of seasonal median bacteriological water quality, where there was a 79% increase in the median *E.coli* count between consecutive seasons (an increase of 110 *E.coli*/100 ml), possibly because of sampling nearer to rainfall events.

5.1 Comparison with nineteen 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 five sites in terms of median counts, in comparison with the previous summer's results (>20% change where the median value was ≥10 cfu/100 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 94.

Noting that there is some variability in the numbers of sites included in each season's programme, non-exceedance with the guidelines has occurred on 72% of sampling occasions over the combined twenty seasons to date with the worst season (2004-2005) showing 61% guidelines non-exceedances and the best seasons (1996-1997 and 1999-2000), 82% non-exceedance of the guidelines. The previous season (2014-2015) was 2% below the historical average and the latest season showed a 1% improvement over the last season. (Note that in any comparison between seasons, variability in monitored sites should be taken into account).

A ranking of sites based upon the historical average guidelines non-exceedances (i.e. 'surveillance' mode) for the period 1996 to date can be summarised as follows:

1= Urenui River at estuary
1= Patea River at boatramp, Patea
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
8= 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

The two estuarine sites (in the Patea and Urenui Rivers) have never reached the 'Alert' *E.coli* level of the guidelines over the 20 seasons to date. All sites ranked above twelfth have not exceeded guidelines on an average of at least 75% of seasonal sampling occasions. The poorest bacteriological water quality (less than 7% 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 fourteen sites with a minimum of ten years' data, was undertaken statistically for the period 1996 to 2016. Only one of these sites has 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 13 year period to date which was significant at $p < 0.01$ after FDR application

Another site showed a significant ($p<0.05$, but not after FDR application) trend in median *E.coli* counts:

- Lake Opunake at the boat ramp, for which 10 years' data have now been gathered, had a strong trend of decreasing median *E. coli* numbers, which however was not significant at $p<0.05$ after FDR application

The Lake Opunake site's seasonal median *E.coli* counts have not approached contact recreational 'Alert' (or 'Action') guidelines at any time over the entire ten year period.

A ranking of the order of the significance of the temporal trends at those sites with a minimum of ten seasons' data (fourteen sites) is provided in Table 93.

Table 93 Ranking of sites in terms of significant temporal trends in median *E.coli* counts over the period 1996 to 2016

Site location	Valid N	p-level	FDR-corrected p value	Trend
Waiwhakaiho River at Lake Rotomanu	13	0.0002	0.0023	↑↑↑
Lake Opunake at boat ramp	10	0.0466	0.2305	↓
Te Henui Stream mouth, East End	14	0.0555	0.2305	↑
Oakura River d/s SH45 bridge	20	0.0615	0.2305	↑
Lake Ratapiko at boat ramp	10	0.0877	0.2631	↓
Lake Rotomanu western beach	20	0.1491	0.3394	↑
Urenui River at estuary - enterococci	20	0.1584	0.3394	↓
Waingongoro River at Eltham camp	15	0.2693	0.5050	↑
Waingongoro River at Ohawe Beach	20	0.3668	0.6113	↓
Manganui River at Everett Park	20	0.5277	0.7915	↑
Patea River at King Edward Park	15	0.6497	0.8136	↓
Kaupokonui River at Beach Domain	20	0.6875	0.8136	↓
Timaru Stream at end of Weld Road	19	0.9133	0.9740	↑
Waiwhakaiho River at Merrilands Domain	20	0.9740	0.9740	↓

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

In summary, one site has shown statistically significant increasing temporal trends and no sites significant decreasing temporal trends in seasonal median *E. coli* counts. The other less significant trends indicate gradual improvement (seven sites) or deterioration (six sites) in seasonal median *E. coli* counts.

Table 94 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		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	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	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	5	2.5	5.5
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	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	8	3.5	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	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	10	2.5	<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	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	10.5	1.5	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	10	2	1
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	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	*		*		0.5	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	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	9.5	2.5	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	13	0	0
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	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	0	0	13	<0.5	0
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	-		
% 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		72		

5.2 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 Regional Council's website. All sites' results were displayed on this website throughout the 2015-2016 survey period and all instances of exceedance of guidelines were advised to the appropriate authorities.

Very few follow-up investigations were necessary over the 2015-2016 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 two city 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. 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 have 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 (20 samples per season) will continue at the two 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 recently instigated benthic cyanobacteria periphyton monitoring will continue at the river/stream sites.

For planktonic cyanobacteria, of the four designated lake monitoring sites, two had biovolumes exceeding contact recreational guidelines during the 2015-2016 season, requiring the erection of warning signs: Lake Rotokare for most of the summer and Lake Rotomanu from February 2016. Lake Ratapiko reached medium risk level on one occasion, and Lake Opunake had no or very low levels of cyanobacteria.

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored. Only one site reached over 50% coverage that would trigger the 'Action' level for that criteria (MfE and MoH, 2009) and three sites on a total of 15 occasions had over 20% coverage triggering the 'Alert' level that requires weekly monitoring.

Exposed mats triggered the 'Action' or 'Alert' level at six sites on 35 occasions and detaching mats or detached mats accummulating on the rivers edge triggered the 'Action' or 'Alert' level at six sites on 41 occasions.

Previous monitoring was focused 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. TRC 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 the previous four sampling seasons with the long dry summer probably the main contributing factor to the high cyanobacteria levels. Exposed mats were caused by falling water levels during this long dry summer and/or the result of daily fluctuations in river flow caused by periodic releases of hydro scheme waters. Significant detaching or detached mats were often coincident with high levels of cyanobacteria present in the river. As a consequence of the presence of exposed and/or detaching mats, signage was erected at three sites advising recreational river users of the potential dangers particularly to dogs.

The Suitability for Recreation Grading (SFRG) referenced earlier in this report (Section 2.2) may now be re-assessed to include the 2015-2016 microbiological data enabling a comparison of the five year 2010-2015 period (Table 1) with the latest SFRG for the 2011-2016 period (presented in Table 95).

Table 95 Suitability for recreation grade for freshwater sites for the period November 2011 to March 2016

Site	Sanitary Inspection Category	Microbiological assessment *E.coli* (nos/100ml)			SFR Grade	% of all samples in compliance (ie: <550 *E.coli*)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	802	65	D	Very poor	89
Waiwhakaiho R: Merrilands domain	High	220	65	B	Poor	98
Waiwhakaiho R at L.Rotomanu	High	3075	65	D	Very poor	27
Te Henui S: mouth	High	4525	65	D	Very poor	16
Patea R: King Edward Park	High	528	65	C	Poor	96
Patea R. boatramp, Patea	High	80	65	A	Poor	100
Waingongoro R: Eltham camp	High	392	65	C	Poor	100
Waingongoro R: Ohawe beach	High	662	65	D	Very poor	93
Kaupokonui R: Beach domain	High	482	65	C	Poor	98
L Opunake: adjacent boat ramp	High	570	65	D	Very poor	95
Timaru S: Lower Weld Road	High	690	65	D	Very poor	92
Oakura R: d/s SH45	High	812	65	D	Very poor	93
Waitara R: Town wharf	High	638	65	D	Very poor	95
Urenui R: estuary	High	60	65	A	Poor	100
Manganui R: Everett Park	High	348	65	C	Poor	96
L Ratapiko: boatramp	High	230	60	B	Poor	100
L Rotokare: adjacent boatramp	Low	196	42	B	Very good	100

Few differences between the two five-year periods were apparent when comparing Table 1 and Table 95. 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 Lake Opunake site (by 265 *E.coli* per 100 ml) and deterioration at the Oakura River site (by 367 *E.coli* per 100 ml). There were slightly fewer samples in excess of the 'Action' level over the most recent five year period at two of the monitored sites (Lake Opunake and Te Henui Stream) while five sites (Waiwhakaiho River adjacent to Lake Rotomanu, Oakura River, Timaru Stream, Lake Rotomanu and Kaupokonui River) had more samples (6%, 5%, 3%, 3% and 1% more, respectively) in the 'Action' mode. The Oakura River at mouth site deteriorated in terms of the MAC assessment which resulted in a change in SFR grading to 'very poor'. 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).

5.3 Water quality at bathing sites and the National Objectives Framework

The *National Policy Statement for Freshwater Management 2014* (NPS-FW) requires that the Council, in giving effect to the NPS, is '*to safeguard…. (b) the health of people and communities, **at least as affected by secondary contact with fresh water**; in sustainably managing the use and development of land, and of discharges of contaminants*' (Objective A1 for Water Quality, emphasis added). This is colloquially described as setting a 'wadeability' standard for all water bodies. The National Objectives Framework (NOF) provides the quantitative criteria by which compliance with the narrative objective of the NPS-FW can be established. The NOF provides criteria for 'wadeability', and it also provides a second set of criteria to be applied when a water body is to be used for primary recreation, ie its 'swimmability'. The latter criteria are much more stringent. The table below illustrates the criteria prescribed in the NOF.

Attribute state	Numeric criterion	Statistic and usage
A	<260 *E coli*/100 ml	Grading for 'wading' suitability- use annual median of record
		Grading for 'swimming' suitability- 95% of results must be below 260 *E coli*/100 ml

B	260 *E coli*/100 ml – 540 *E coli*/100 ml	Grading for 'wading' suitability - use annual median of record
		Grading for 'swimming' suitability - 95% of results must be below 540 *E coli*/100 ml
C	540*E coli*/100 ml – 1000 *E coli*/100 ml	Grading for 'wading' suitability - use annual median of record
		Below the national 'bottom line' for swimming
D	>1000 *E coli*/100 ml	Below the national 'bottom line' for both swimming and wading

To clarify further: through the Council's bathing waters monitoring programme, each individual sample result is evaluated at the time of analysis according to the *2003 Microbiological Water Quality Guidelines* as to whether the site is suitable for swimming **at the time of sampling**. However, the NOF expresses whether a site is formally judged as suitable for swimming **over the long term as a general rule**, based on the **worst** results obtained at any time. So, for example, a site could have just a single exceedance at some time throughout a bathing season; every other sample collected during the season could remain within the recreational guidelines, yet because of the one non-complying result according to the 2003 Guidelines, the site must be deemed 'unacceptable for bathing' according to the NOF.

The monitoring data from Taranaki's freshwater bathing sites for the past five seasons (Table 95) was analysed against the NOF criteria for 'swimmability'. Out of the 17 fresh water bathing sites that the Council routinely monitors each season, 5 fall into the 'A' NOF category for primary (swimming) usage, 4 into the 'B' category, and 8 would be deemed 'unacceptable for bathing'. Of these latter eight sites, 6 routinely meet the guidelines between 92-95% of the time, but because their 95th%ile results exceed the NOF criteria (that is, they do not have 95% or more of their results below 540 *E coli*/100 ml), they are to be regarded as 'unsuitable' according to the NOF even though their samples almost always meet the bathing guidelines. That is, 47% of the freshwater bathing sites in Taranaki would have to be categorised as unsuitable for swimming because of occasional poor results.

It can be noted that the equivalent bathing water criterion across Europe is that 90% of results must be less than 900 *E coli*/100 ml (which is comparable to having 95% of results less than 1300 *E coli*/100 ml), rather than less than 540 *E coli*/100 ml, for a site to be deemed 'swimmable'. Were this basis of grading applied to the sites in Taranaki, 47% of the freshwater bathing sites in Taranaki would be graded 'excellent' for swimming, another 41% would be graded 'good' for swimming, no sites would be graded 'sufficient', and only 2 sites (12%) be deemed 'unsuitable'.

6. Recommendations

As a result of the 2015-2016 summer freshwater contact recreation bacteriological survey it is recommended:

1. THAT the 2016-2017 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 2016-2017 survey includes an additional seven samples collected at the two principal usage sites (Lake Rotomanu and Waiwhakaiho River at the Merrilands Domain) in accordance with MfE, 2003 guidelines.

3. THAT the 2016-2017 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.

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 appropriate DNA faecal source tracking marker investigations are undertaken into the source of high baseline *E.coli* counts at the Patea River site at King Edward Park, Stratford.

7. THAT reporting of results be performed as appropriate during the season, and in an Annual Report upon completion of the season's programme.

8. THAT the appropriate statistical trend detection procedures be applied to the data and reported in the Annual Report.

7. Acknowledgements

The programme's Job Manager was James Kitto (Scientific Officer) who was the author of this Annual Report. Statistical analyses were provided by Fiza Hafiz (Scientific Officer). Co-ordination of the sectional programmes and liaison with the Taranaki Area Health Board was provided by James Kitto. Field work was undertaken primarily by Emily Roberts, (Scientific Officer) and Ray Harris, Rae West, Rachel McDonnell, Katie Blakemore, Thomas McElroy and David Olson (Technical Officers) and students (during the summer vacation). Benthic cyanobacteria fieldwork was undertaken by Darin Sutherland (Scientific Officer) and Katie Blakemore, and benthic and planktonic cyanobacteria data were provided and reported on by Darin Sutherland. Hydrological data was provided by Fiona Jansma (Scientific Officer). All water quality analytical work was performed by the Taranaki Regional Council ISO-9000 accredited laboratory under the supervision of John Williams (Laboratory Manager).

Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

'Action' mode	Two consecutive single samples greater than 280 enterococci cfu/100 ml.
'Alert' mode	Single sample greater than 140 enterococci 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.
Beach	The shore or any access point to the sea.
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, usually measured at 20°C and expressed in mS/m.
Contact recreation	Recreation activities that bring people physically in contact with water, involving a risk of involuntary ingestion or inhalation of water.
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	A measurement of water quality over time as provided by historical (five years) microbiological results – A, B, C or D Category (MAC).
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).

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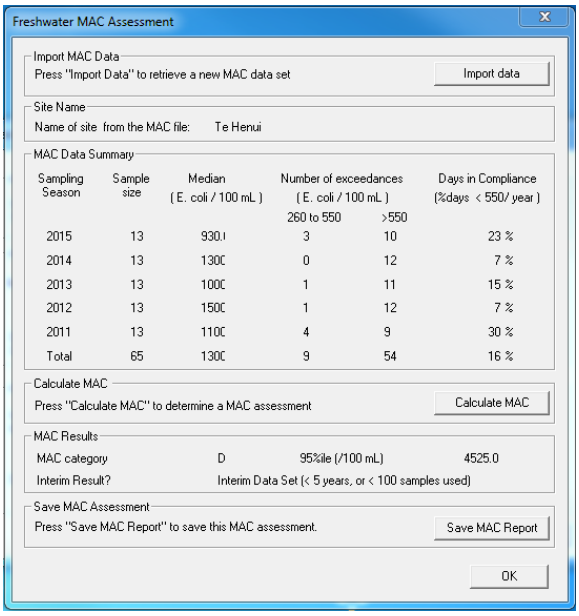
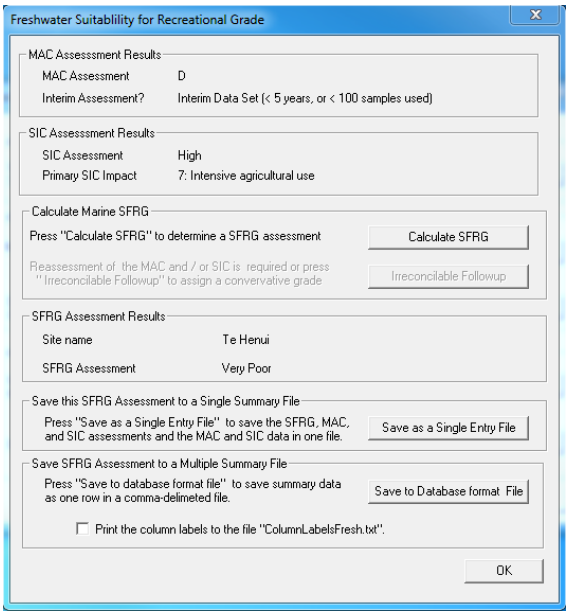
Appendix I

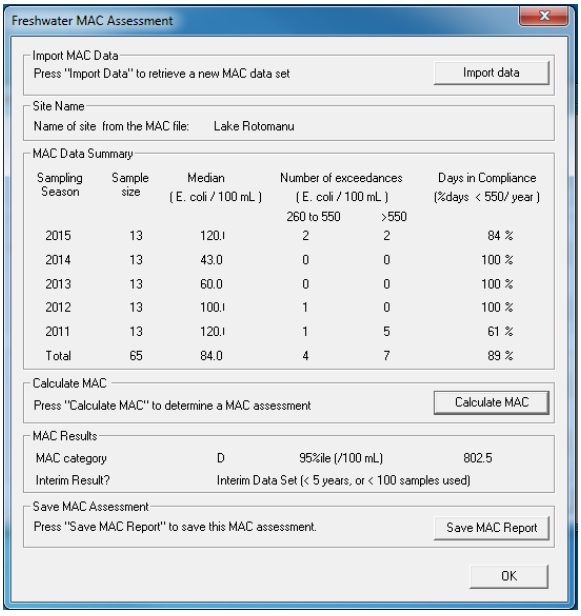
MAC assessments for all sites (for the 2010-2015 period)

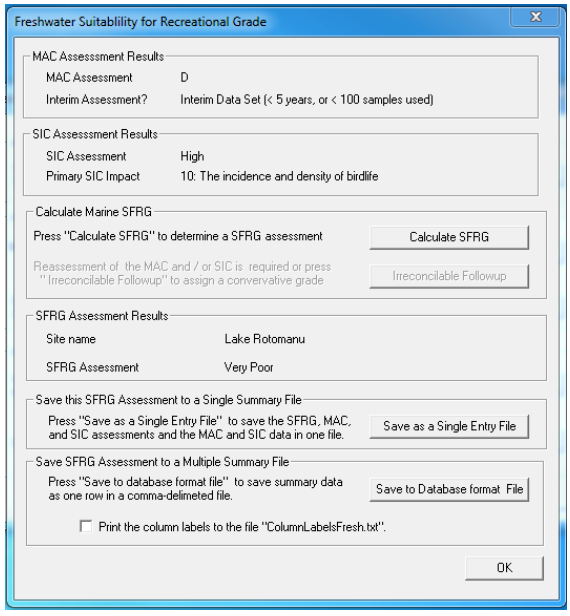
Te Henui Stream: mouth



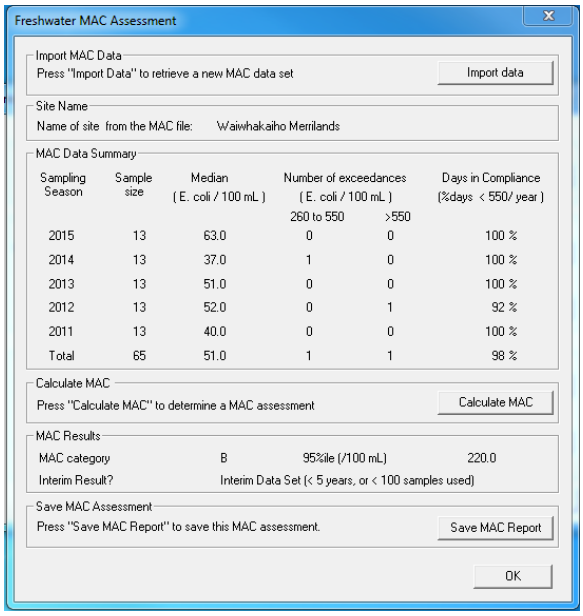


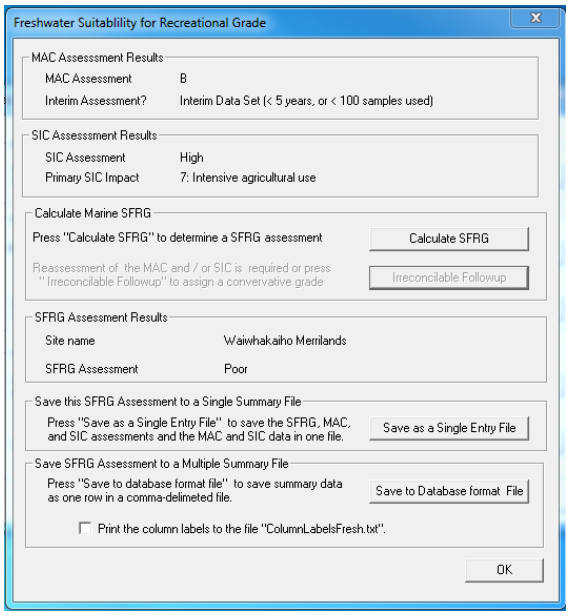
Lake Rotomanu



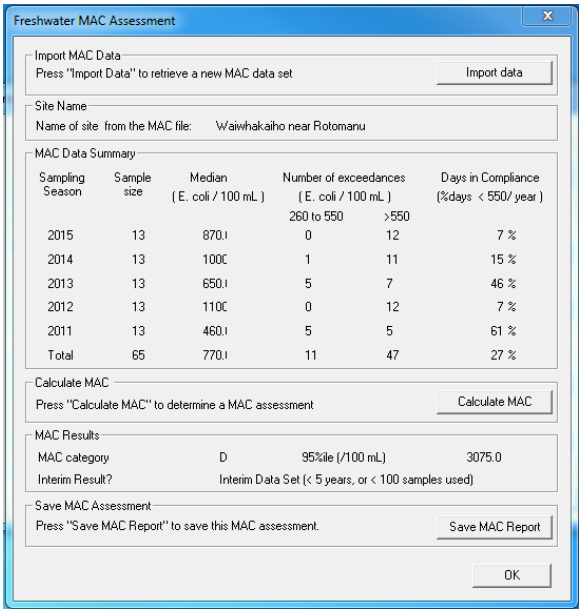


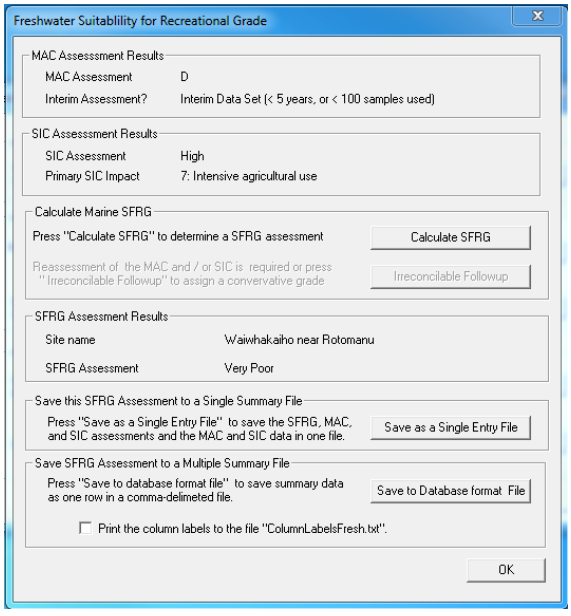
Waiwhakaiho River at Merrilands Domain



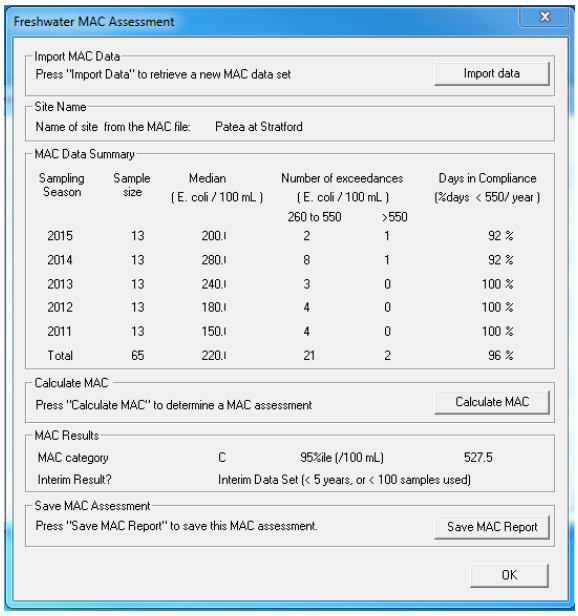


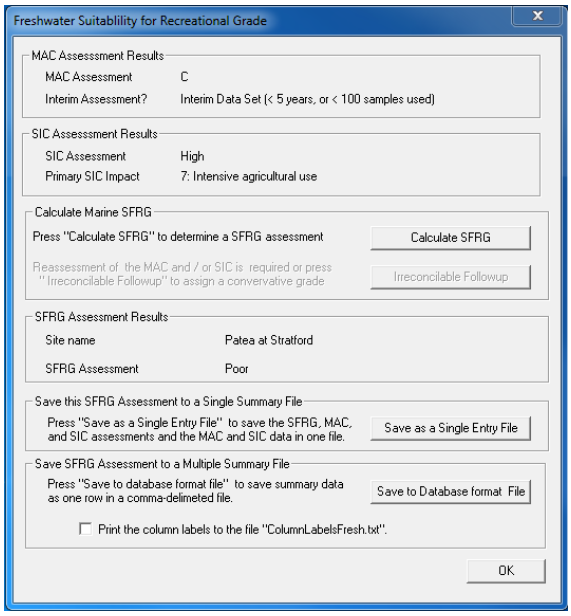
Waiwhakaiho near Lake Rotomanu



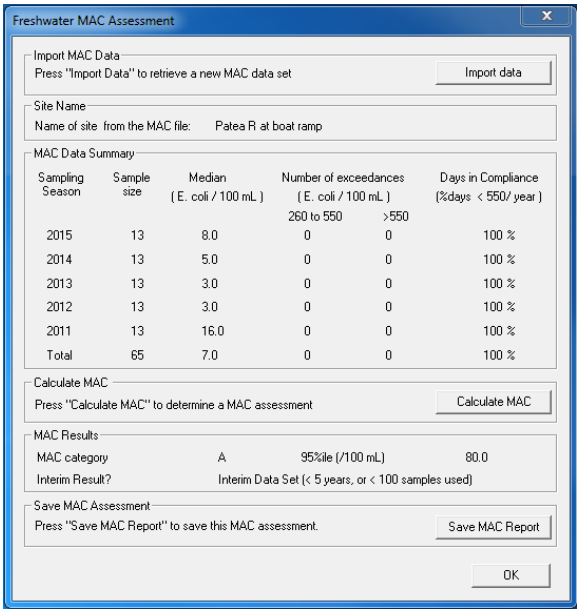


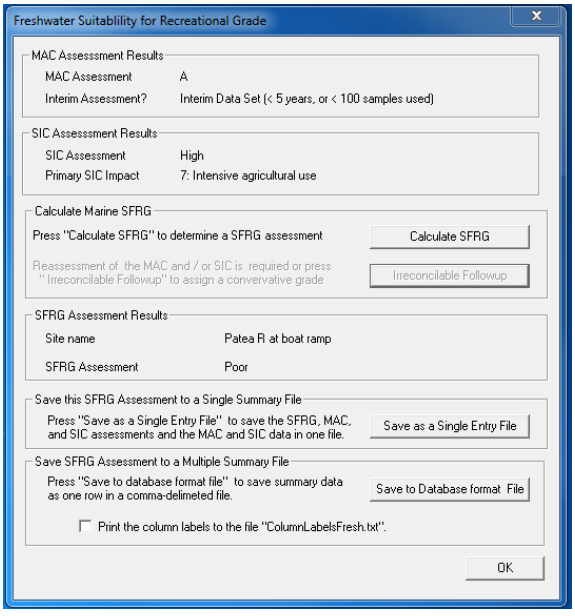
Patea River at Stratford



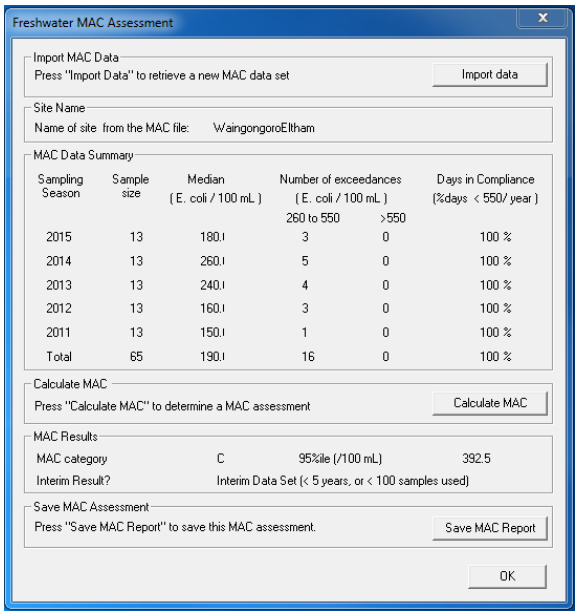


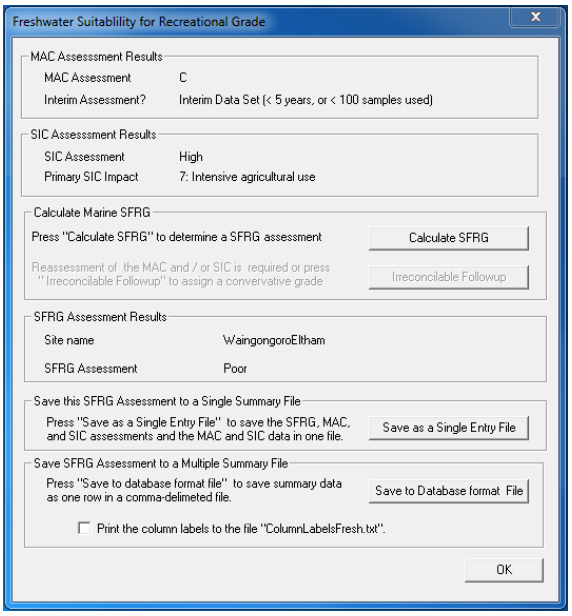
Patea River at boat ramp, Patea



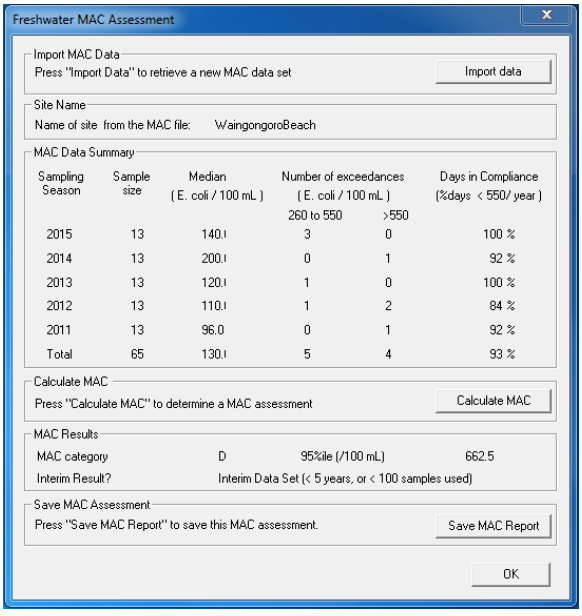


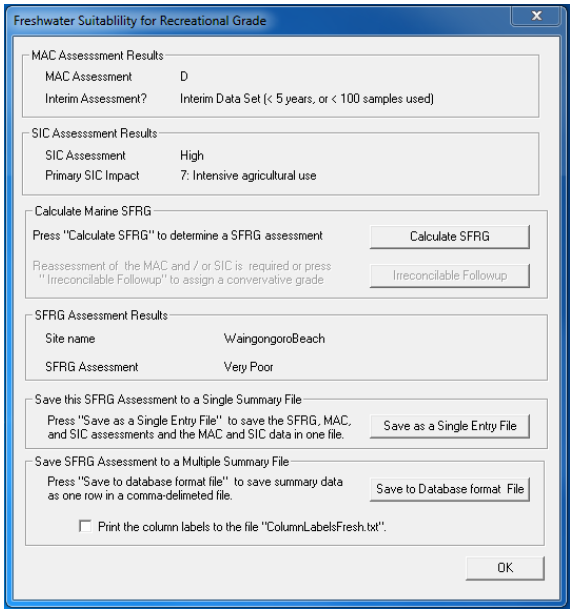
Waingongoro River at Eltham camp



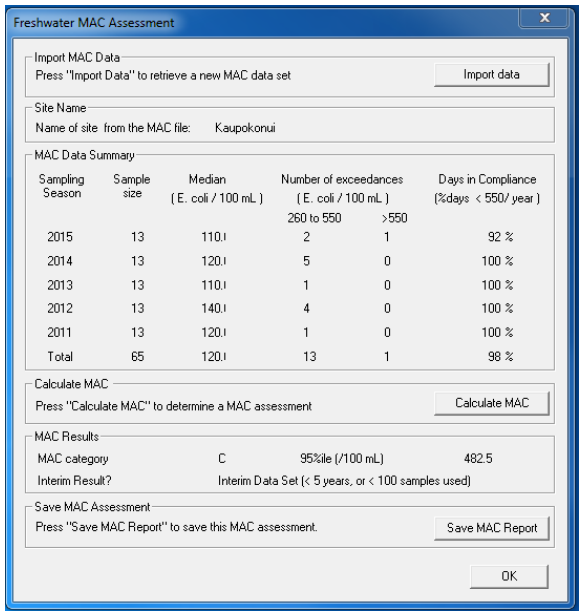


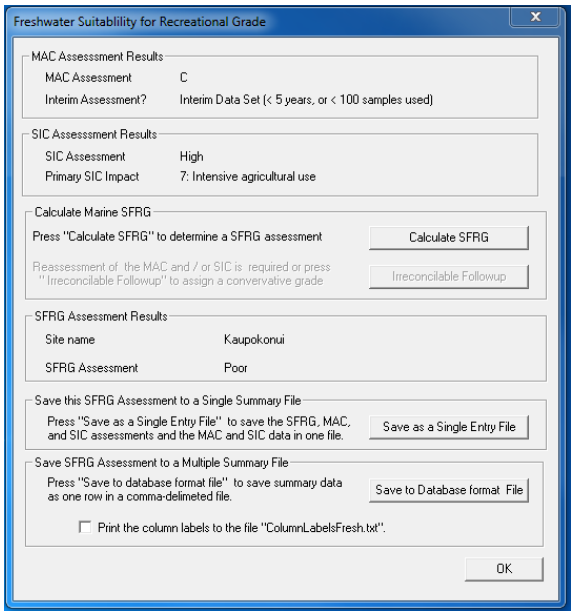
Waingongoro River at Ohawe beach



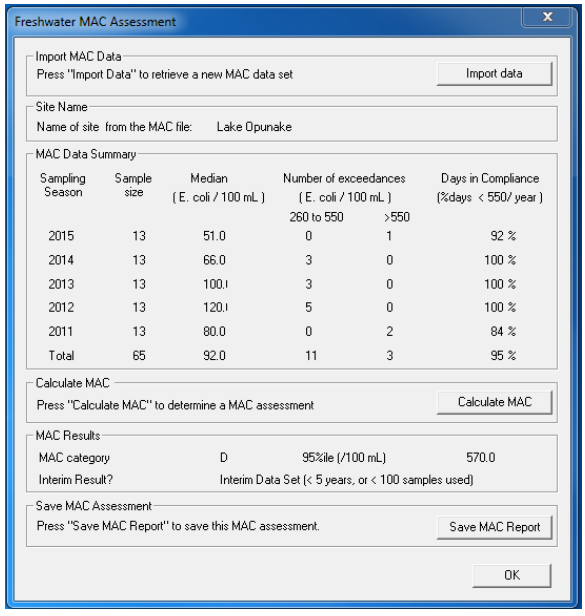


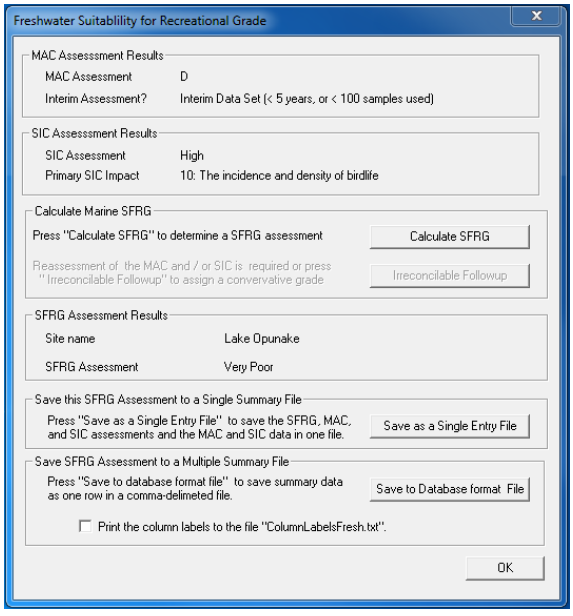
Kaupokonui River at beach domain



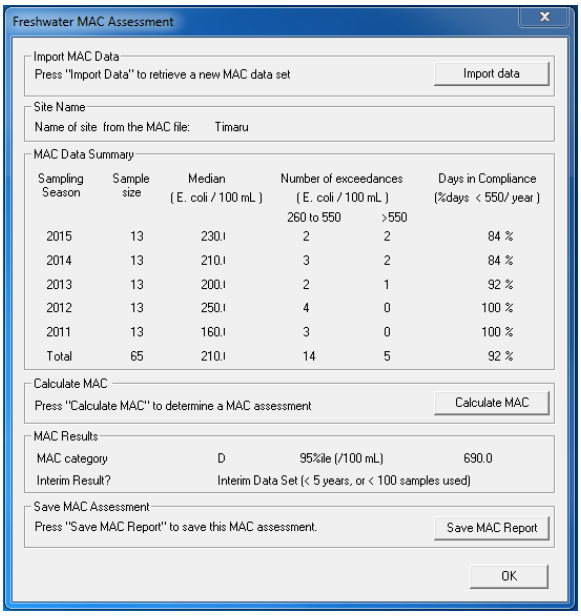


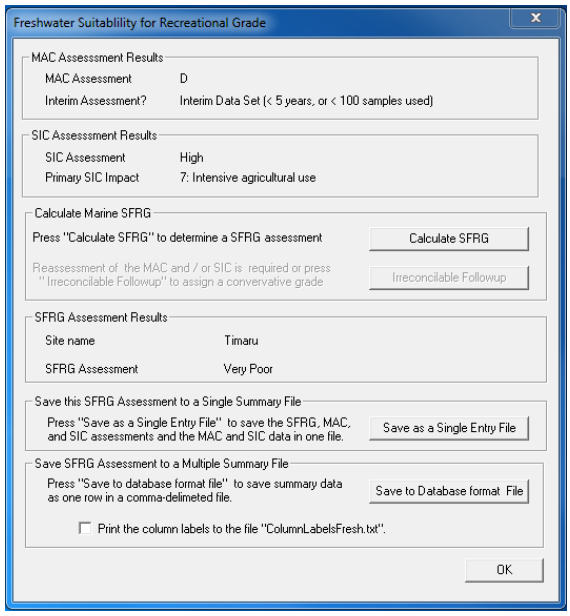
Lake Opunake



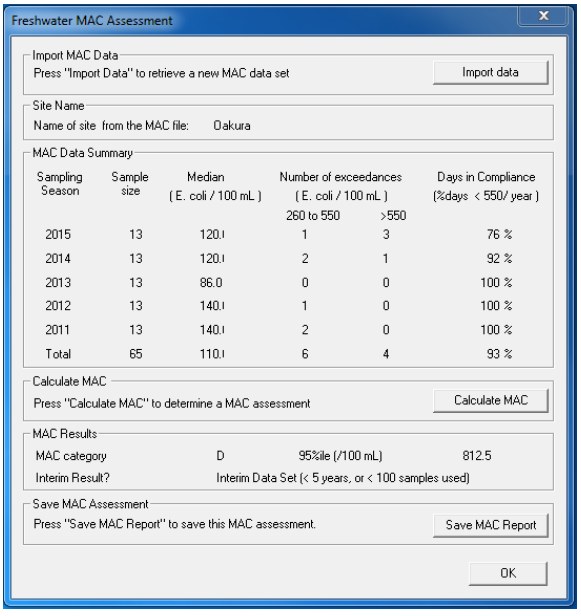


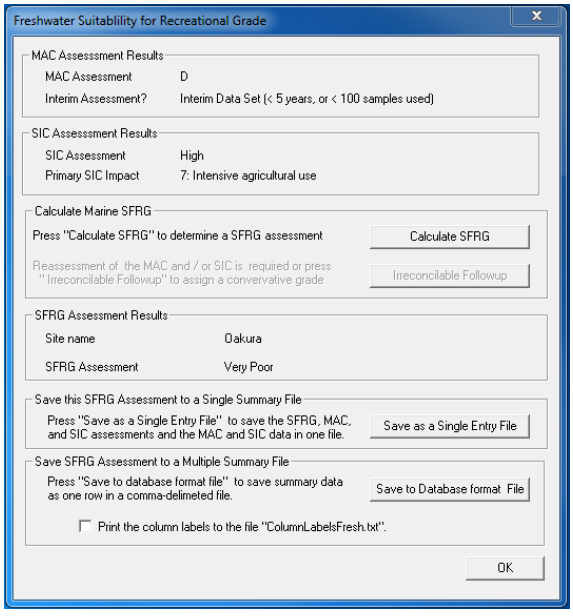
Timaru Stream at Weld Road



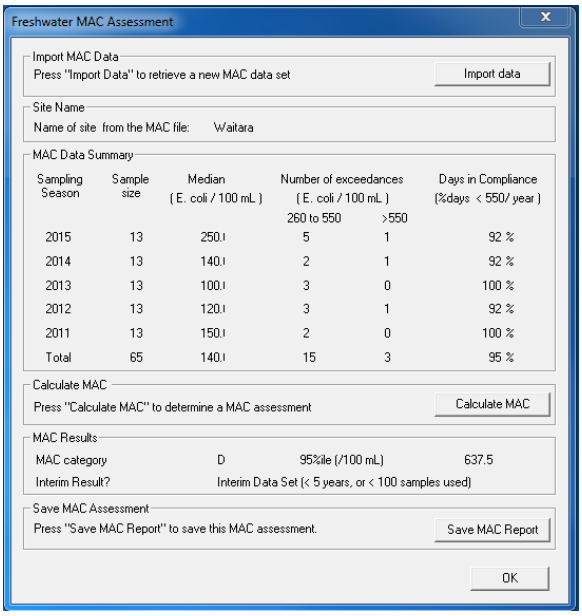


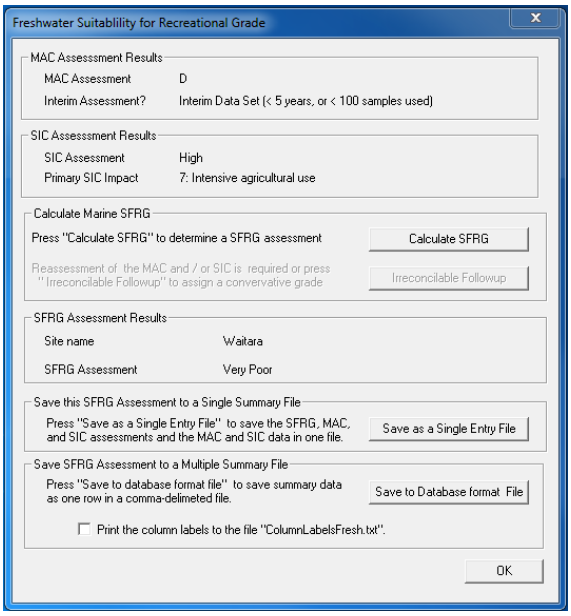
Oakura River d/s SH45



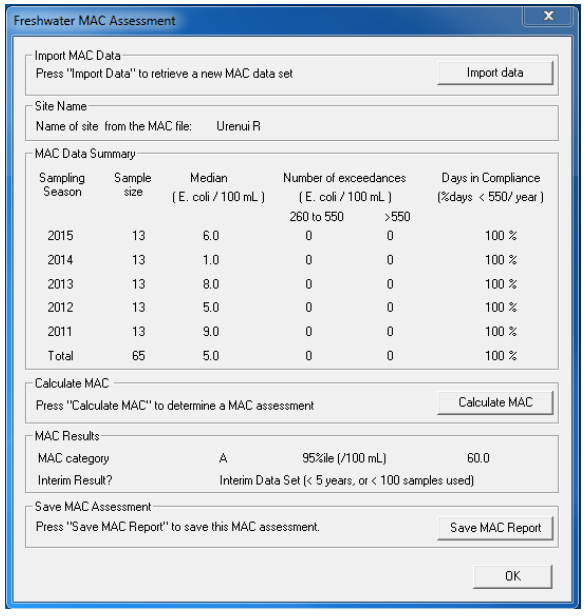


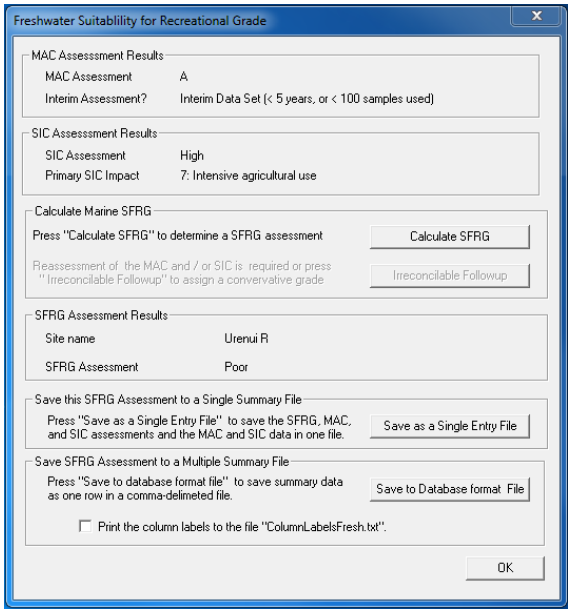
Waitara



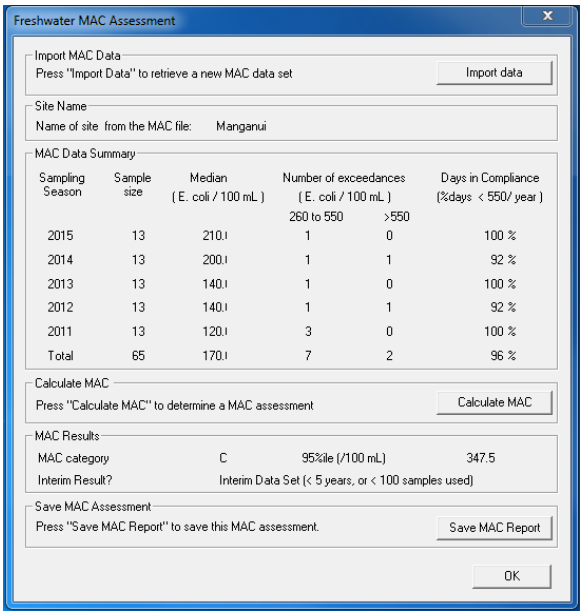


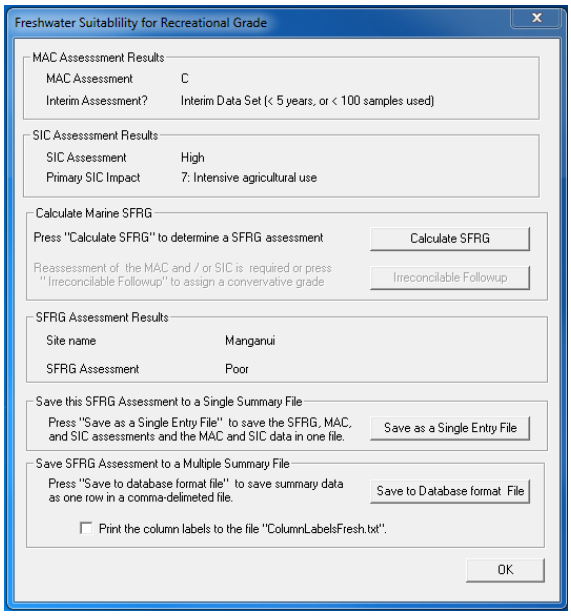
Urenui River at estuary



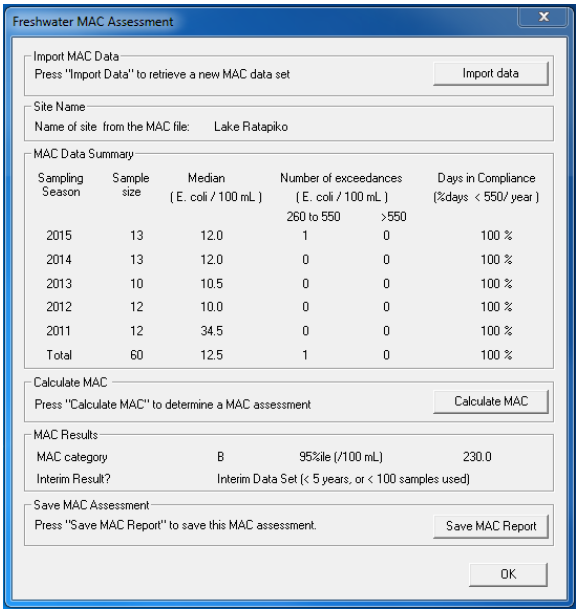


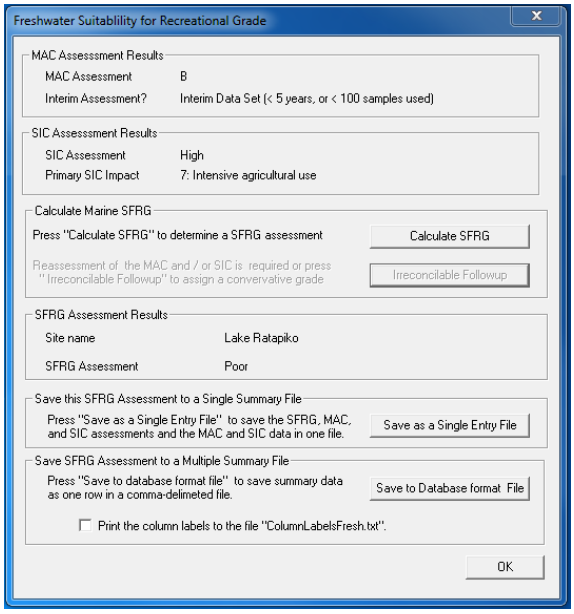
Manganui River at Everett Park



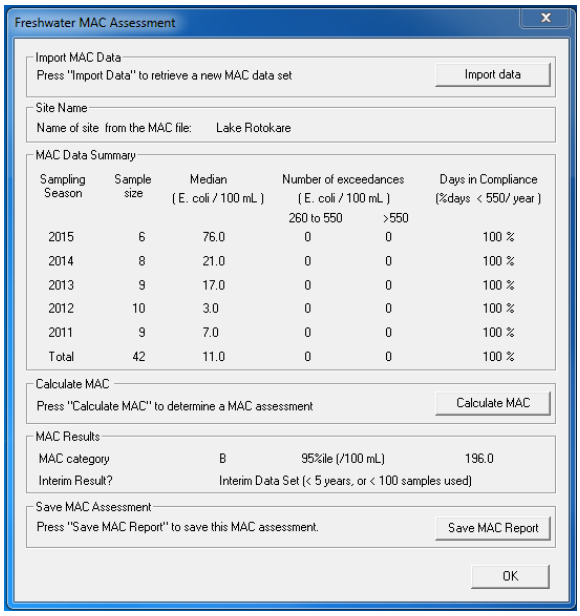


Lake Ratapiko





Lake Rotokare



Appendix II

High tide times

High tide times (NZST) at New Plymouth for 2015-2016 sampling dates

Date		HT (NZST)
Thursday	12 November 2015	0956
Wednesday	25 November 2015	0852
Thursday	10 December 2015	0856
Tuesday	15 December 2015	1209
Tuesday	12 January 2016	1113
Friday	15 January 2016	1330
Monday	25 January 2016	1038
Tuesday	9 February 2016	1012
Friday	12 February 2016	1223
Tuesday	23 February 2016	1016
Tuesday	8 March 2016	0904
Tuesday	22 March 2016	0915
Wednesday	30 March 2016	1358

Appendix III

Sampling conditions and public usage recorded at each site by the SEM programme

Site Lake Rotomanu (Site Code: LRM000002)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	N/A	Turbid, brown	Choppy	0/1 (walker)	One duck, signage present	0	0
25 November 2015	Fine	4/8	N/A	Slightly turbid, brown	Flat	0/1 (walker)	Few ducks, signage present	0	0
10 December 2015	Fine	8/8	N/A	Turbid, brown	Flat	0/1 (camper)	Ducks common, signage present	0	0
15 December 2015	Fine	7/8	N/A	Turbid, brown	Flat	0/4 (banks)	Few ducks, signage present	0	0
12 January 2016	Fine, still	7/8	N/A	Turbid, brown	Flat	0/0	Ducks common; signage present	0	0
15 January 2016	Fine	4/8	N/A	Turbid, brown/orange	Rippled	1/3 (boating, banks)	Ducks common, one gull, one dog; harmful bacteria signs at beach and boat ramp	0	0
25 January 2016	Fine	0/8	N/A	Turbid, brown/orange	Flat	0/0	One duck; harmful bacteria signage present	0	0
9 February 2016	Fine	5/8	N/A	Turbid, brown	Flat	0/6 (2 on banks, 4 walkers)	Few ducks, one dog; harmful bacteria signage	0	0
12 February 2016	Fine	0/8	N/A	Turbid, brown/orange	Rippled	1/2 jet-ski, 2 walkers)	Ducks common, 2 dogs; harmful bacteria signage	0	0
23 February 2016	Fine	2/8	N/A	Turbid, orange/ brown	Flat	0/0	Ducks common far side of lake; harmful bacteria signs	0	0
8 March 2016	Fine	1/8	N/A	Turbid, brown	Rippled	1/x (boating, walkers)	Few ducks, gull, 2 dogs; harmful bacteria and algae signs	0	0
22 March 2016	Fine	5/8	N/A	Turbid, brown	Rippled	0/2 (walkers)	Few ducks, 2 dogs; harmful bacteria and algae signs	0	0
30 March 2016	Fine	0/8	N/A	Turbid, orange- brown	Rippled	0/5 (2 picnickers,3 walkers)	Few ducks, gull, dog; harmful bacteria and algae signs	0	0

Site Waiwhakaiho River at Merrilands (Site Code: WKH000800)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	10%	Clear, colourless	D/S	0/2 (bank)	Cyanobacteria warning sign from last season. no birdlife	0	1.0
25 November 2015	Fine, overcast	7/8	15% algae; exposed cyanobacteria	Clear, colourless	D/S	0/0	Cyanobacteria warning sign; no birdlife	0	0
10 December 2015	Fine, overcast	8/8	75% algae, exposed cyanobacteria	Clear, colourless	D/S	0/0	One bird; cyanobacteria warning sign	0	0
15 December 2015	Fine	7/8	60% algae, exposed cyanobacteria	Clear, colourless	D/S	1/0 (fisher)	Cyanobacteria warning sign;; no birdlife	0	5.0
12 January 2016	Fine, overcast	7/8	30%	Clear, colourless	D/S	0/1 (banks)	One dog; cyanobacteria warning sign; no birdlife	0	3.0
15 January 2016	Fine	3/8	0%	Clear, colourless	D/S	0/1 (banks)	Sign broken; no birdlife, one dog	0	0
25 January 2016	Fine	0/8	60%	Clear, colourless	D/S	0/4 (banks)	Signage present; no birdlife, 4 dogs	0	0
9 February 2016	Fine	4/8	60%	Clear, greenish-brown	D/S	0/2 (banks)	Signage present; no birdlife, 2 dogs	0	0
12 February 2016	Fine	1/8	30%	Clear, greenish	D/S	0/0	No signage, no birdlife, 3 dogs	0	0
23 February 2016	Fine	1/8	50%	Clear, colourless	D/S	0/1 (banks)	Signage present; one shag, 2 dogs	0	0
8 March 2016	Fine	1/8	40%	Clear, colourless	D/S	0/3 (banks)	Signage present; one gull, 4 dogs	0	0
22 March 2016	Fine, overcast	8/8	30%	Clear, colourless	D/S	4/2 (swimming, banks)	Signage present; no birdlife, 2 dogs	0.5	1.0
30 March 2016	Fine	0/8	5-10% film	Clear, colourless	D/S	0/4 (banks)	Signage present; no birdlife, 4 dogs	0	0

No s

Site Waiwhakaiho River adjacent to Lake Rotomanu (Site Code: WKH000950)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	80%	Clear, colourless	D/S	0/6 (whitebaiting)	Few birds u/s	0	0
25 November 2015	Fine	3/8	100%	Clear, colourless	D/S	0/6 (whitebaiting)	Gulls common d/s, 3 shags. Some cyanobacteria.	0	0
10 December 2015	Fine, overcast	8/8	85% mats	Clear, colourless	D/S	0/0	Ducks common. Cyanobacteria present.	0	0
15 December 2015	Fine	7/8	85%	Clear, colourless	D/S	0/0	Gulls very common u/s, some ducks d/s	0	0
12 January 2016	Fine, overcast	8/8	10%	Clear, colourless	D/S	0/0	Gulls very common u/s	0	0
15 January 2016	Fine	6/8	40%	Clear, colourless	D/S	0/0	Gulls very common u/s. Low flow.	0	0
25 January 2016	Fine	0/8	20%	Clear, colourless	D/S	0/0	Gulls common u/s; few ducks d/s	0	0
9 February 2016	Fine	2/8	10%	Slightly turbid, greenish-brown	D/S	0/0	Gulls very common u/s; one duck	0	0
12 February 2016	Fine	0/8	10%	Clear, colourless	D/S	0/0	Gulls very common u/s, 2 dogs	0	0
23 February 2016	Fine	1/8	10%	Clear, colourless	D/S	0/1 (banks)	Ducks common u/s & d/s, 1 shag, 2 dogs	0	0
8 March 2016	Fine	4/8		Clear, colourless	U/S	0/0	Gulls very common, ducks common, 2 shags, all u/s	0	0
22 March 2016	Fine	3/8	20%	Clear, brown tinge	D/S	0/0	Gulls very common, 1 shag	0	0
30 March 2016	Fine	0/8	0%	Clear, colourless	D/S	0/0	Gulls very common u/s	0	0

Site Te Henui Stream at mouth, East End (Site Code: THN000499)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	N/A	Sl. turbid, green	D/S	0/2 (banks)	Ducks common on water and banks; warning signage	0	0
25 November 2015	Fine	2/8	N/A	Turbid,green	U/S (surging)	0/8 (playground)	Few ducks; warning signage	0	0
10 December 2015	Fine, overcast	8/8	100%	Clear, brown-green	D/S	0/13 (playground, banks)	Ducks common, few gulls; warning signage	0	0
15 December 2015	Fine	7/8	N/A	Sl turbid, dark green	U/S	0/0	Ducks common, one shag; warning signage	0	0
12 January 2016	Fine,overcast	8/8	30%	Clear, colourless	D/S	0/0	Ducks common, few seagulls; warning signage	0	0
15 January 2016	Fine	7/8	N/A	Sl. turbid, green	U/S (surging)*	0/0	Few ducks u/s, gulls common d/s; warning signage	0	0
25 January 2016	Fine	0/8	100%	Turbid, green	U/S	0/0	Few ducks, u/s, gulls common d/s; warning signage	0	0
9 February 2016	Fine, overcast	8/8	N/A	Sl, turbid, greyish--green	U/S	0/0	Ducks common, few gulls, one shag; new warning sign	0	0
12 February 2016	Fine,	0/8	10%	Sl. turbid, green	U/S	0/1 (bank)	Ducks common u/s, gulls common d/s, one dog	0	0
23 February 2016	Fine	0/8	60%	Sl. turbid, green	U/S	0/0	Ducks common u/s; and on far bank with gulls; warning signage	0	0
8 March 2016	Fine	3/8	N/A	Sl. turbid, green	U/S	0/0	Ducks common u/s; warning signage	0	0
22 March 2016	Fine	2/8	N/A	Slightly turbid, yellow-green	D/S	0/0	Ducks very common u/s; gulls common d/s; warning signage	0	0
30 March 2016	Fine	0/8	5%	Sl. turbid, yellow tinge	U/S	0/2 (banks)	Ducks common; warning signage	0	0

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	2/8	Patchy filaments	clear, brown tinge	D/S	0/0	No birdlife; one trout	2.0	2.0
25 November 2015	Fine	1/8	85%	Sl. turbid; light grey	D/S	0/0	No birdlife	0	0
10 December 2015	Fine	1/8	60%	Clear, uncoloured	D/S	0/0	No birdlife	0	0
15 December 2015	Fine	6/8	80%	Clear, grey	D/S	0/0	Few ducks	0	16.5
12 January 2016	Fine	4/8	Patchy green & brown mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0.5
15 January 2016	Fine, windy	1/8	70%	Clear, uncoloured	D/S	0/0	No birdlife	0	0
25 January 2016	Fine	1/8	70%	Sl. turbid, grey	D/S	3/2 (swimming, banks)	No birdlife	0	0
9 February 2016	Fine	3/8	70%	Sl. turbid, grey	D/S	0/0	Few ducks	0	0.5
12 February 2016	Fine, overcast	8/8	Widespread brown mats	Clear, brown tinge	D/S	0/0	No birdlife	0	0
23 February 2016	Fine	6/8	Patchy brown mats	Clear, brown grey	D/S	0/6 (fishing)	Few ducks	0	0
8 March 2016	Fine	0/8	Widespread mats/filament	Clear, green-brown	D/S	0/0	One duck	0	0
22 March 2016	Fine	5/8	30%	Clear, uncoloured	D/S	0/0	No birdlife	0	0.5
30 March 2016	Fine	0/8	Widespread brown mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0

Site Patea River, boatramp, Patea (Site Code: PAT000995)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Overcast, light showers	8/8	N/A	Turbid, grey-green	U/S	0/2 (fishing)	No birdlife. Didymo sign	2.0	4.6
25 November 2015	Fine	2/8	N/A	Turbid, grey-green	D/S	0/4 (2 waka)	No birdlife	0	0
10 December 2015	Fine	7/8	N/A	Turbid, grey-green	D/S	0/0	No birdlife	0	0
15 December 2015	Fine	6/8	N/A	Turbid, grey	D/S	0/0	No birdlife	0	5.6
12 January 2016	Fine, overcast	8/8	N/A	Turbid, light green	U/S	0/0	No birdlife	0	0
15 January 2016	Fine	1/8	N/A	Turbid, grey green	D/S	0/1 (fishing)	No birdlife	0	0
25 January 2016	Fine	2/8	N/A	Turbid, green-grey	D/S	12+/1 (swimming, paddle boarder)	No birdlife	0	0
9 February 2016	Fine	0/8	N/A	Sl. turbid, green-grey	D/S	0/0	No birdlife. Clearer than usual	0	0
12 February 2016	Fine	0/8	N/A	Turbid, pale green	D/S (slow)	0/0	No birdlife	0	0.8
23 February 2016	Fine, overcast	8/8	N/A	Turbid, light green	U/S (slow)	0/0	Two gulls	0	0
8 March 2016	Fine	4/8	N/A	Turbid, light green	D/S	0/0	No birdlife	0	0
22 March 2016	Fine	4/8	N/A	Turbid, grey-green	D/S	0/8 (fishers)	No birdlife	0	0.2
30 March 2016	Fine	0/8	N/A	Turbid, light green	U/S	0/1 (boat launching)	No birdlife	0	1.4

Site Waingongoro River, Eltham Camp (Site Code: WGG000492)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	1/8	Patchy brown mats	Clear, uncoloured	D/S	0/2 (logging)	Sheep in adjacent paddock, unfenced	2.0	2.0
25 November 2015	Fine	2/8	30%	Clear, uncoloured	D/S	0/0	Sheep sign in adjacent paddock. One duck.	0	0
10 December 2015	Fine	2/8	90%	Clear, uncoloured	D/S	0/0	Sheep in adjacent paddock	0	0
15 December 2015	Fine	6/8	60%	Sl. turbid, uncoloured	D/S	0/0	No birdlife	0	16.5
12 January 2016	Fine	7/8	Widespread brown mats	Clear, light brown	D/S	0/0	No birdlife	0	0.5
15 January 2016	Fine	1/8	50%	Clear, uncoloured	D/S	0/0	Low flow, no birdlife	0	0
25 January 2016	Fine	5/8	90%, mainly diatoms	Clear, uncoloured	D/S	2/0 (swimming)	No birdlife	0	0
9 February 2016	Fine	4/8	90%, filamentous	Clear, brown	D/S	0/0	No birdlife	0	0.5
12 February 2016	Fine	2/8	Widespread brown mats	Clear, brown	D/S	0/0	No birdlife	0	0
23 February 2016	Fine	1/8	Patchy thin brown mats	Clear, light brown	D/S	0/50+ (camping)	(school group in camp paddock)	0	0
8 March 2016	Fine	4/8	Widespread brownmats	Clear, dark green-brown	D/S	0/11 (7(kayaking, 4 ashore)	No birdlife	0	0
22 March 2016	Fine	4/8	90% brown filamentous	Clear, uncoloured	D/S	0/ 0	No birdlife	0	0.5
30 March 2016	Fine	0/8	Widespread brown mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0

Site Waingongoro River, near mouth (Site Code: WGG000995)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	6/8	Patchy brown mats	Clear, brown tinge	D/S	0/3 (whitebaiting)	One shag	3.0	5.0
25 November 2015	Fine	3/8	65%	Clear, yellow	D/S	0/12 (whitebaiting)	No birdlife	0	0
10 December 2015	Fine	3/8	90%	Clear, brown	D/S	0/0	No birdlife	0	0
15 December 2015	Fine	4/8	50%	Clear, yellow/brown	D/S	0/0	Tidal, pale yellow foam d/s, one shag	0	5.0
12 January 2016	Fine	7/8	Widespread brown mats	Clear, dark brown	D/S	4/2 (swimming, (banks)	No birdlife	0	0
15 January 2016	Fine	1/8	80%	Sl. turbid, yellow- brown	D/S (surging)	12/0 (swimming)	Detached cyanobacteria accumulating - two warning signs. No birdlife	0	0
25 January 2016	Fine	1/8	50%	Clear, yellow	D/S	6/10 (swimming, onshore)	Cyanobacteria mats, smelling strongly	0	0
9 February 2016	Fine	6/8	80%	Clear, yellow	D/S	0/0	Three new cyanobacteria signs; three ducks, foaming	0	0
12 February 2016	Fine	0/8	Patchy brown mats	Clear, brown-green	D/S	0/0	Cyanobacteria warning signs	0	0
23 February 2016	Fine	7/8	Widespread thin mats	Sl. turbid, brown	D/S (surging)	0/0	One duck, cyanobacteria warning signs	0	0
8 March 2016	Fine	0/8	Patchy thin mats	Clear, brown	D/S (surging)	0/0	No birdlife; cyanobacteria warning signs	0	0
22 March 2016	Fine	5/8	50%	Clear, brown	D/S	0/0	No birdlife; cyanobacteria warning signs	0	0.5
30 March 2016	Fine	0/8	Widespread thick mats	Cear, bright green	D/S (surging)	0/0	Ducks common; cyanobacteria warning signs	0	0.5

Site Kaupokonui River, beach domain (Site Code: KPK000995)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine, gusty	4/8	None	Sl. turbid,-green tinge	U/S (slow)	0/5 (whitebaiting)	No birdlife	1.5	2.0
25 November 2015	Fine	1/8	5%	Clear, yellow	Surging	0/3 (whitebaiting))	No birdlife	0	0
10 December 2015	Fine	2/8	80%	Clear, brown-green	D/	0/0	No birdlife. Shoal of mullet	0	0
15 December 2015	Fine	4/8	20%	Clear, yellow/ brown	D/S	0/2 (fishers)	No birdlife	0	2.5
12 January 2016	Fine	2/8	None	Clear, dark brown	U/S (slow)	10/8 (swimming, banks)	No birdlife	0	2.5
15 January 2016	Fine	1/8	20%	Clear, uncoloured	D/S	20+/2 (swimmers, fishers)	No birdlife. Detached cyanobacteria on strand	0	0
25 January 2016	Fine	3/8	20%	Clear, yellow	D/S	20+/10 (swimming, bankss)	No birdlife	0	0
9 February 2016	Fine	0/8	20%	Sl. turbid, bright green	D/S (slow)	1/0 (swimming)	No birdlife. Complaint about algae/weed, 3 cases camp Gl	0	0
12 February 2016	Fine	0/8	Nil, fragments	Sl. turbid, green	U/S (slow)	2/2 (swimming, banks)	No birdlife	0	0.5
23 February 2016	Fine	2/8	Nil	Sl. turbid, green	U/S (slow)	0/2 (fishing)	No birdlife, recent flood scouring	0	0.5
8 March 2016	Fine	2/8	Nil	Sl. turbid, dark green brown	D/S (slow)	0/2 (banks)	No birdlife	0	0
22 March 2016	Fine	4/8	80%	Turbid, brown	D/S	0/1 (banks)	No birdlife	0	0
30 March 2016	Fine	0/8	Ni;	Clear, green	D/S (slow)	3/5 (swimming, banks)	No birdlife	0	0

Site Lake Opunake (Site Code: LOP000001)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine, gusty	2/8	Nil	Sl. turbid,-green	Choppy	0/0	Few ducks on lake, one on bank	2.5	13.0
25 November 2015	Fine	1/8	N/R	Clear, sl. yellow	Flat	0/0	Ducks common	0	0
10 December 2015	Fine, overcast	8/8	N/R	Clear, pale green	Rippled	0/0	Few ducks on lake, common on shore	0	0.5
15 December 2015	Fine	2/8	N/R	Clear, uncoloured	Rippled	0/0	Few ducks on lake, common on shore	0	3.5
12 January 2016	Fine	0/8	Nil	Sl. turbid, green	Flat	0/0	Ducks common	0	4.5
15 January 2016	Fine, overcast	8/8	N/R. Rafts of macrophytes	Clear, brown-yellow	Rippled	0/0	Ducks common on water, few on shore	0	0
25 January 2016	Fine	1/8	Nil	Clear, brown-yellow	Rippled	0/0	Ducks common (lake and bank)	0	0
9 February 2016	Fine	4/8	N/R	Clear, green-brown	Rippled	0/0	Ducks common (lake and bank)	0	0
12 February 2016	Fine	0/8	Nil	Clear, dark green	Flat	0/0	Ducks common (lake and bank)	0	0.5
23 February 2016	Fine	0/8	Nil	Clear, dark green-brown	Flat	0/0	Ducks common (lake and bank). Lake level low	0	0.5
8 March 2016	Fine	7/8	Brown mats on pond weed	Clear, dark green	Rippled	0/0	Ducks common; two swan	0	0.5
22 March 2016	Fine	6/8	50%, foam present	Clear, uncoloured	Flat	2/0	Ducks very common, swans common	0	0
30 March 2016	Fine	0/8	Nil	Clear, dark green	Rippled	0/0	Ducks common, one shag. Lake level low	0	0

Site Timaru Stream, near mouth (Site Code: TMR000497)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	2/8	N/A	Clear, very sl. green	D/S	0/2 (banks)	Gulls common, NPDC signage present	0	6.5
25 November 2015	Fine	2/8	Nil	Clear, sl. green tinge	D/S	0/0	Few gulls	0	0
10 December 2015	Fine	2/8	Nil	Clear, sl. brown tinge	D/S	0/0	No birdlife	0	0.5
15 December 2015	Fine	7/8	Nil	Clear, sl. green tinge	D/S	0/1 (banks)	Two gulls	0	10.5
12 January 2016	Fine	3/8	Nil	Clear, colourless	U/S (surging)	4/3/3 (swimming/fishing/banks)	Three dogs	0	4.0
15 January 2016	Fine	7/8	Nil	Clear, colourless	U/S	5/3 (swimming, bank)	No birdlife, one dog. Horse faeces in water	0	0
25 January 2016	Fine	0/8	Nil	Clear, colourless	D/S	25/0	Four dogs	0	0
9 February 2016	Fine	1/8	Nil	Clear, sl. green tinge	D/S	1/0	Gulls common d/s	0	0
12 February 2016	Fine	0/8	??	??	D/S	3/4 (bank)	Few gulls, one dog	0	0
23 February 2016	Fine	2/8	Nil	Clear-green tinge	D/S	0/1 (bank), 2 surfers at mouth	No birdlife, health warning sign	0	0
8 March 2016	Fine	2/8	Nil	Clear, coloulress	D/S	0/0	No birdlife, one dog; warning sign	0	0.5
22 March 2016	Fine	2/8	<5%	Clear, colourless	U/S	0/2 (fishing at mouth)	No birdlife, warning sign	0	0.5
30 March 2016	Fine	0/8	Nil	Clear, brown tinge	U/S	0/0	No birdlife, warning sign	0	0.5

Site Oakura River, near mouth (Site Code: OKR000497)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	1/8	N/A	Clear, sl. green tinge	Surging	0/3 (banks)	No birdlife, three dogs	0	6.5
25 November 2015	Fine	2/8	Nil	Clear, sl. green tinge	D/S	0/0	No birdlife	0	0
10 December 2015	Fine, overcast	8/8	N/A	Clear, green tinge	D/S	0/0	No birdlife	0	0.5
15 December 2015	Fine	7/8	N/A	Clear, green tinge	U/S	0/0	No birdlife	0	10.5
12 January 2016	Fine, overcast	7/8	Nil	Clear, v. sl. green tinge	Surging	10/0 (swimming)	No birdlife	0	4.0
15 January 2016	Fine	7/8	Nil	Clear, green	U/S, surging	20/20 (swimming, bank)	No birdlife. Livestock in unfenced paddock opposite	0	0
25 January 2016	Fine	0/8	Nil	Clear, colourless	D/S	20/20 (swimming, bank)	No birdlife	0	0
9 February 2016	Fine	7/8	Nil	Clear, colourless	U/S	1/0	One gull	0	0
12 February 2016	Fine	0/8	Nil	Clear, green	U/S	2/5	No birdlife, cows grazing far bank	0	0
23 February 2016	Fine	3/8	Nil	Clear, colourless	U/S	0/0	No birdlife. Two warning signs. Paddock opposite fenced. Bed changed from sand to cobble after flood.	0	0
8 March 2016	*Fine*	1/8	Nil	Clear, green	U/S	0/1 (walker)	No birdlife, two dogs, warning signs	0	0.5
22 March 2016	Fine	5/8	Nil	Clear, colourless	D/S (surging)	0/1 (camping group)	Three herons d/s, warning signs	0	0.5
30 March 2016	Fine	0/8	5%	Clear, colourless	U/S	8/0	Few gulls, warning signs.	0	0.5

Site Waitara River at town wharf, Waitara (Site Code: WTR000922)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	S.G. level	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	-	Sl.turbid, green-brown	D/S	0/6 (whitebaiting)	No signage, no birdlife	0	0.5
25 November 2015	Fine	3/8	2.25	Turbid, brown	D/S	0/4 (whitebaiters)	No signage, no birdlife	0	0
10 December 2015	Fine, overcast	8/8	1.75	Sl. turbid,green-brown	D/S	0/0	No signage, no birdlife	0	0
15 December 2015	Fine	4/8	2.08	Sl. turbid, brown	D/S	0/0	No signage, no birdlife	0	1.5
12 January 2016	Fine, overcast	8/8	2.2	Turbid, light brown	U/S	0/0	No signage, 10 ducks	3.0	3.0
15 January 2016	Fine	5/8	1.9	Sl. turbid, brown	U/S	0/1 (boat)	No signage, few ducks	0	0
25 January 2016	Fine	3/8	2.15	Sl. turbid, light brown	U/S	0/0	No signage, two ducks	0	0.5
9 February 2016	Fine	4/8	2.55	Clear, green	Still	0/0	NPDC signage present	0	4.0
12 February 2016	Fine	0/8	2.5	Sl. turbid, green-brown	Still	0/0	Signage; one duck	0	0
23 February 2016	Fine	2/8	2.2	Turbid, brown	D/S	0/0	Signage; no birdlife	0	0
8 March 2016	Fine	5/8	2.2	Sl. turbid, green-brown	D/S	0/0	Signage; few ducks	0	0
22 March 2016	Fine	2/8	2.1	Sl. turbid, light green	D/S	0/0	Signage; few ducks	0	1.0
30 March 2016	Fine	0/8	1.5	Sl. turbid, green-brown	D/S	0/0	Signage, no birdlife	0	0

Site Urenui River at estuary (Site Code: URN000480)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	N/A	Sl. turbid, lightgrey--brown	U/S	0/0	No birdlife	0	0.5
25 November 2015	Fine	1/8	N/A	Turbid, green	U/S	0/0	No birdlife	0	0
10 December 2015	Fine	5/8	N/A	Clear, blue-green	U/S	0/0, school camp setting up	No birdlife	0	0
15 December 2015	Fine	7/8	N/A	Sl. turbid, green-grey	U/S	0/0	No birdlife	0	1.5
12 January 2016	Drizzle	8/8	N/A	Turbid, green/blue	U/S	0/1 (boat)	No birdlife	3.0	3.0
15 January 2016	Fine	5/8	N/A	Sl. turbid, dark green	U/S	12/0 (swimming/shallows)	Few gulls	0	0
25 January 2016	Fine	3/8	N/A	Sl. turbid, light brown	U/S	0/0	Two ducks	0	0.5
9 February 2016	Fine	4/8	N/A	Clear, blue-green	U/S	0/0	No birdlife	0	4.0
12 February 2016	Fine	1/8	N/A	Sl. turbid, blue-green	U/S	0/0	No birdlife	0	0
23 February 2016	Fine	2/8	N/A	Sl. turbid, green	U/S	0/0	No birdlife	0	0
8 March 2016	Fine	0/8	N/A	Sl. turbid, green grey	U/S	0/0	No birdlife	0	0
22 March 2016	Fine	2/8	N/A	Slightly turbid, turquoise-green	U/S	0/0	No birdlife	0	1.0
30 March 2016	Fine	0/8	N/A	Sl, turbid, light green-brown	-U/S	0/3 (picknicking)	No birdlife	0	0

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	95%	Clear, uncoloured	D/S	0/0	Two ducks, didymo sign	0	0.5
25 November 2015	Fine	4/8	Widespread	Sl. turbid, brown-green	D/S	0/0	No birdlife	0	0
10 December 2015	Fine	4/8	100% thin mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0
15 December 2015	Fine	6/8	100% thin mats	Clear, brown	D/S	0/0	No birdlife	0	7.0
12 January 2016	Drizzle	8/8	90% thin brown mats	Clear, brown/green	D/S	0/0	No birdlife	1.5	2.0
15 January 2016	Fine	5/8	100% thin mats	Clear, faint brown	D/S	0/0	No birdlife	0	0
25 January 2016	Fine	2/8	80% thin brown & green mats	Clear, faint green	D/S	0/0	No birdlife, some foam	0	0
9 February 2016	Fine	2/8	90% thin green brown mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0
12 February 2016	Fine	3/8	Abundant mats	Clear, uncoloured	D/S	0/0	Two ducks	0	0
23 February 2016	Fine	2/8	10%	Clear, uncoloured	D/S	0/0	No birdlife	0	0
8 March 2016	Fine	1/8	Widespread mats	Clear, uncoloured	D/S	0/0	Two ducks	0	0
22 March 2016	Fine	3/8	Thin green-brown mats	Clear, uncoloured	D/S	0/0	No birdlife	0	1.0
30 March 2016	Fine	0/8	Clear	Clear, uncoloured	D/S	0/0	No birdlife	0	0

Site Lake Ratapiko (Site Code: LRP000050)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
12 November 2015	Fine	0/8	N/A	Clear, tannin brown	Rippled	0/0	Ducks common, freshwater pest signage	0	0.5
25 November 2015	Fine	5/8	N/A	Clear, brown	Rippled	0/0	One duck	0	0
10 December 2015	Fine	4/8	N/A	Clear, slight brown	Ripple	0/0	No birdlife	0	0
15 December 2015	Fine	6/8	N/A	Clear, light brown	Rippled	0/0	Ducks common	0	7.0
12 January 2016	Drizzle	8/8	N/A	Slightly turbid, dark brown	Rippled	1/0 (swimming)	Two ducks	1.5	2.0
15 January 2016	Fine	6/8	N/A	Clear, brown	Rippled	0/2 (1 jetski, 1 boat)	No birdlife	0	0
25 January 2016	Fine	6/8	N/A	Clear, dark brown	Rippled	0/0	Few ducks, two swans	0	0
9 February 2016	Fine	2/8	N/A	Clear, tannin brown	Rippled	0/0	Few ducks	0	0
12 February 2016	Fine	6/8	N/A	Clear, light brown	Flat	0/0	No birdlife	0	0
23 February 2016	Fine	2/8	N/A	Clear, tannin brown	Rippled	0/0	No birdlife	0	0
8 March 2016	Fine	0/8	N/A	Clear, tannin brown	Rippled	1/4 (1 jetski)	No birdlife	0	0
22 March 2016	Fine	4/8	N/A	Clear, light tannin brown	Flat	0/1 (fishing)	No birdlife	0	1.0
30 March 2016	Fine	0/8	N/A	Clear, green tinge	Flat	0/0	No birdlife, lake level being lowered, cattle standing in water on far shore,	0	0

Appendix IV

Sampling conditions and public usage recorded at two sites by the additional programme

Dates of additional sampling

Date	Preceding weather
Tuesday 3 November 2015	dry over 72 hours
Tuesday 22 December 2015	dry over 72 hours
Wednesday 6 January 2016	dry over 48 hours, some rain prior 24 hours
Tuesday 19 January 2016	widespread rainfall over 48 hours
Tueday 2 February 2016	isolated heavy showers over 48 hours; otherwise dry
Tuesday 16 February 2016	showers over last 24 hours, dry prior
Tuesday 15 March 2016	light rain over 48 hours

Site Lake Rotomanu (Site Code: LRM000002): additional monitoring (seven samples)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
3 November 2015	Overcast	8/8	Nil	Clear,,green-brown	Rippled	0/0	Few ducks and gulls, signage present	0.5	0.5
22 December 2015	Overcast, calm	7/8	Nil	Turbid, brown	Flat	2/0 (boating)	One gull, bacteria warning sign	0	0
6 January 2016	Fine	2/8	Nil	Turbid, ybrown	Rippled	4/4 (boating, banks	Few ducks;bacteria warning sign	0	0.5
19 January 2016	Rain preceding	7/8	Nil	Turbid, orange- brown	Rippled	0/0	Ducks common, few seagulls; bacteria warning sign	33.5	35.5
2 February 2016	Fine	4/8	N/R	Sl. turbid, brown-green	Rippled	0/0	Two ducks; bacteria warning sign	0	0
16 February 2016	Fine	3/8	Nil	Sl.turbid,yellow- brown	Rippled	0/0	Gulls common far side of lake; bacterial warning sign	7.0	7.0
3 March 2016	Fine	1/8	N/R	Sl. turbid, brown	Rippled	0/0	Few ducks, bacteria warning sign	0	0+
15 March 2016	Overcast	8/8	N/R	Turbid, brown	Rippled	0/7 (banks)	Few gulls, ducks;;bacteria warning sign	1.5	2

Site Waiwhakaiho River at Merrilands (Site Code: WKH000800): additional monitoring (seven samples)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
3 November 2015	Fine,overcast	8/8	Nil	Clear, dark green	D/S	0/10 (banks)	No birdlife	0.5	0.5
22 December 2015	Fine, overcasst	7/8	Widespr. Br. mats	Clear, green	D/S	0/1 (dogwalker)	No birdlife, one dog, cyanobacteria exposed & detached, strong smell, foam	0	0
6 January 2016	Fine	6/8	Patchy thin br.	Clear, green-brown	D/S	0/1 (dogwalker)	No boirdlife, one dog, harmful algae sign	0	0.5
19 January 2016	Fine	3/8	Sparse br. mats	Turbid, orange-brown	D/S	0/1	No birdlife; harmful algae sign	33.5	35.5
2 February 2016	Fine	4/8	70%	Clear, brown	D/S	0/1 (dogwalker)	No birdlife, one dog. Detached algae floating past	0	0
16 February 2016	Fine	1/8	70%	Clear, brown	D/S	0/3 (dogwalkers)	Two gulls, three dogs	7.0	7.0
15 March 2016	Fine	5/8	75%	Clear, yellow green	D/S	0/3 (dogwalkers)	No birdlife, three dogs	1.5	2

Appendix V

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

Site Lake Opunake (Site Code: LOP000001)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
3 November 2015	Fine	7/8	Nil	Clear, dark green	Rippled	0/0	Ducks common, didymo signage	0	0.5
22 December 2015	Fine, overcast	8/8	Nil	Cllear, green tinge	Flat	0/0	Ducks common	0	0
6 January 2016	Fine	5/8	Nil	Clear,green-tinge	Flat	0/5 (banks)	Ducks common; weed on surface	0	6.0
19 January 2016	Light rain	8/8	Nil	Turbid, brown	Rippled	0/0	Ducks common. Lake level high.	25,5	28.0
2 February 2016	Fine	1/8	Macrophytes common	Clear, green	Rippled	0/0	Ducks common	0	0
16 February 2016	Fine	3/8	N/R	Sl. turbid, brown	Rippled	0/3 (feeding ducks)	Ducks common. One gull, two swans	0	0
15 March 2016	Fine	4/8	None	Clear, uncoloured	Rippled	0/0	Few ducks, chicks; level low	0	6.r

Site Lake Ratapiko (Site Code: LRP000050)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
3 November 2015	Fine, overcast	7/8	Nil	Clear, dark green	Rippled	0/0	Few ducks; didymo sign	0.5	0.5
22 December 2015	Fine, overcast	8/8	Nil	Clear, green tinge	Flat	0/0	Ducks common	0	0
6 January 2016	Fine	5/8	Nil	Clear, green tinge	Flat	0/5 (banks)	Ducks common	0	1.0
19 January 2016	Light rain	8/8	Nil	Turbid,brown	Rippled	0/0	Ducks common, level high	44.5	48
2 February 2016	Fine	1/8	Macrophytes abundundant	Clear, green	Rippled	0/0	Ducks common	20	36
16 February 2016	Fine	3/8	N/R	Sl. turbid, brown	Rippled	0/8 (feedin ducks)	Duckz common, one gull two swans	19	19
15 March 2016	Fine	4/8	Macrophytes emergent	Xlear; uncoloured	Rippled	0/0	Ducks common, level lows	3.0	4.0

Site Lake Rotokare adjacent to boatramp (Site Code: LRK000003)

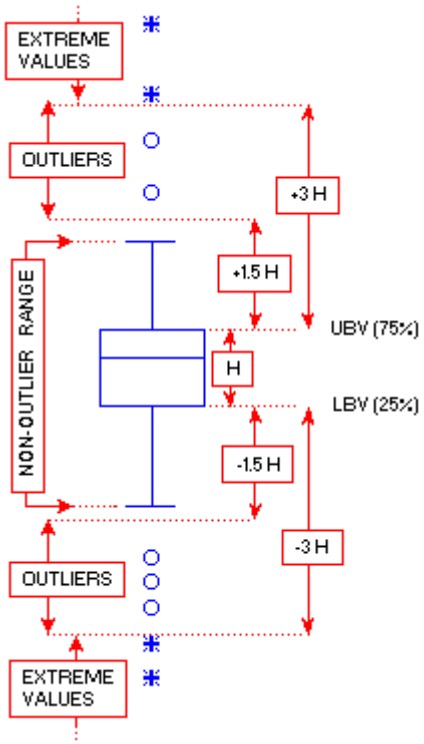
Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
4 November 2015	Showers	8/8	Nil	Sl. turbid, green	Rippled	0/2 (banls)	Ducks common, didymo signage	15.5	15.5
20 November 2015	Overcast	8/8	N/R	Clear, brown-yellow	Rippled	0/4 (banks)	Four ducks	1	1
21 December 2015	Fine	4/8	Nil	Turbid, dark greenbrown	Choppy	0/9	Boat ramp closed, warning signs, few ducks	0	0
19 January 2016	Drizzle	8/8		Sl. turbid, gren brown	Rippled	0/0	Boat ramp closed, warning signs, some unreadable as wet, ducks common	38.5	38.5
1 February 2016	Fine	4/8		Clear, green	Rippled	0/4 (banks)	Boat ramp closed, warning signs, ducks common	0	0
4 February 2016	Fine, windy	7/8		Turbid, green brown	Rippled	0/0	Boat ramp closed, warning signs, ducks common	0	0
15 February 2016	Fine	5/8		Turbid, brown green	Rippled	0/4 (banks)	Boat ramp closed, warning signs, few ducks, level low	0	0
3 March 2016	Fine	2/8	Suspended, brown mats on weed	Turbid, green	Rippled	0/2 (banks)	Boat ramp closed, warning signs, one swan, twoducks	0	0
16 March 2016	Overcast	7/8	Cyanobacteri a suspended	Turbid, dark green brown	Flat	0/0	Boat ramp closed, ducks common. Signage present.	0.5	14
1 April 2016	Overcast	8/8	Green clumps flloating and suspended	Turbid bright green	Choppy	0/0	Boat ramp closed, warning signs, four black swans, one pukeko	1	1

Appendix VI

Comparative annual box and whisker plots of SEM data for *E. coli* for the period 1996 to 2016

Interpretation of Box and Whisker Plots (produced using STATISTICA)

Box and whisker plots are a useful method of summarising data in a graphical form that allows rapid comparisons of data groups. The data is represented as a box with a whisker from each end.



The median (middle value of the sorted data; half of the data is either side of the median) is represented by a single horizontal line (or ◊ point).

The top and bottom of the box represent the upper (UBV) and lower (LBV) hinges respectively. The median splits the ordered group of data in half and the hinges split the remaining halves in half again. This means that 50% of the data lies within the box.

Hspread, comparable to the interquartile (25% and 75%) range is the difference between the values of the two hinges, i.e., Upper hinge – Lower hinge = Hspread. The inner fences (within whiskers) are defined as follows:

Lower fence = lower hinge - (1.5 x Hspread)
Upper fence = upper hinge + (1.5 x Hspread)

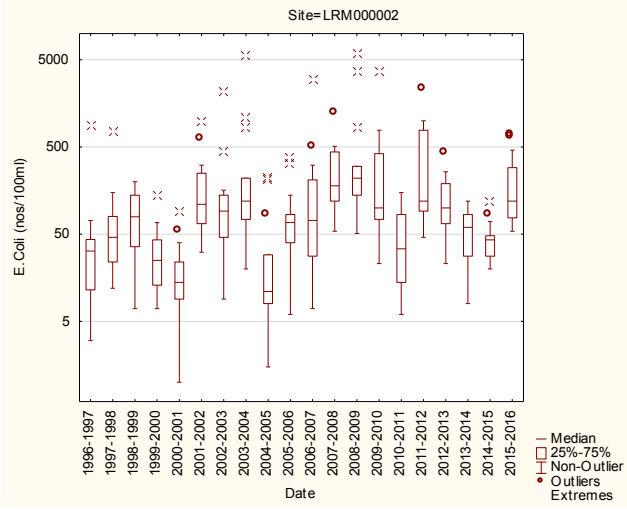
The outer fences (outside whiskers) are defined as follows:

Lower fence = lower hinge - (3 x Hspread)
Upper fence = upper hinge + (3 x Hspread)

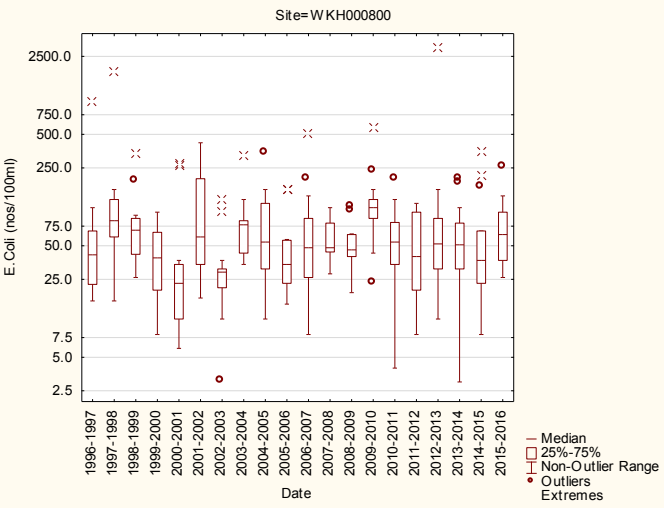
The whiskers show the range of values that lie within the inner fences. Values outside the inner fence are plotted as open circles (o). Values outside the outer fence are plotted as asterisks (*).

E. coli

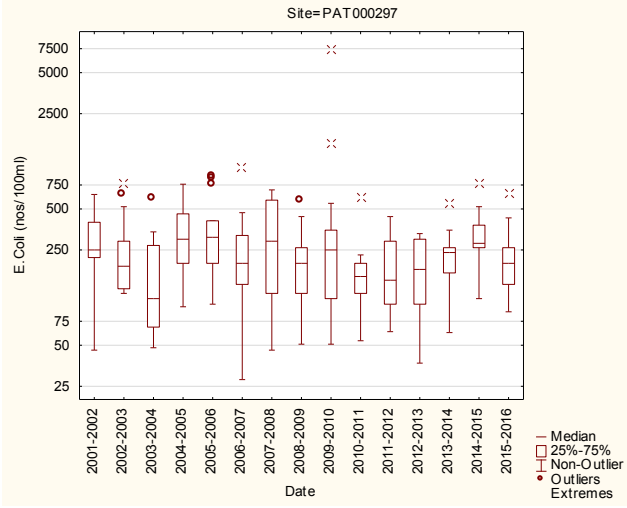
Lake Rotomanu



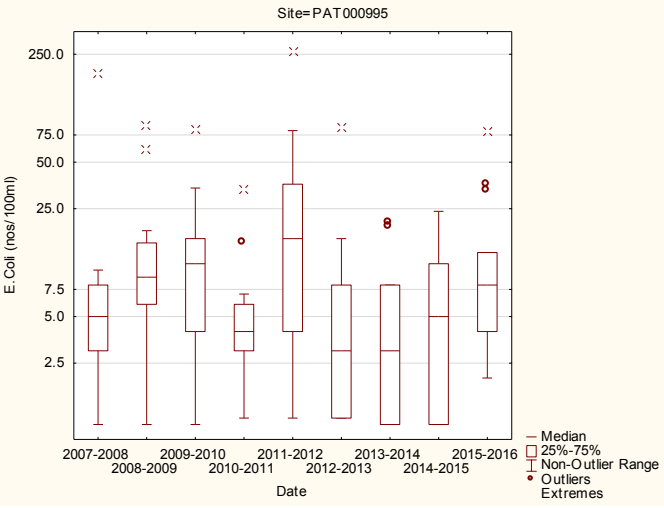
Waiwhakaiho River at Merrilands Domain



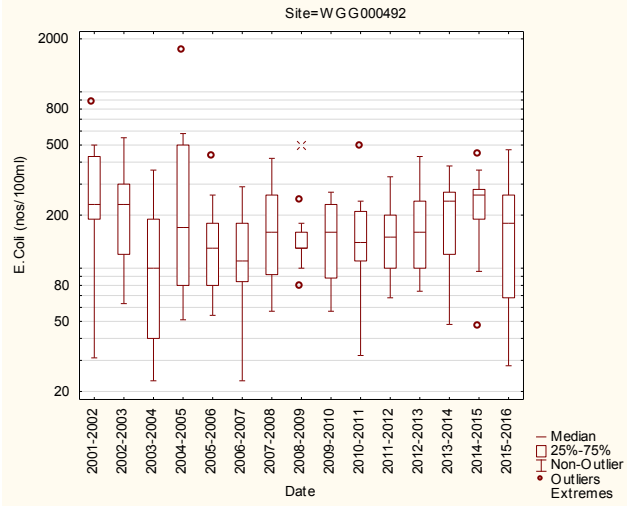
Patea River at Stratford



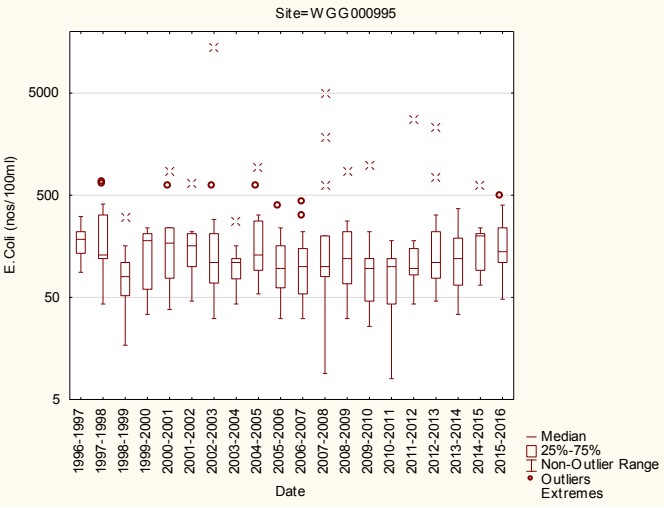
Patea River at Patea boat ramp



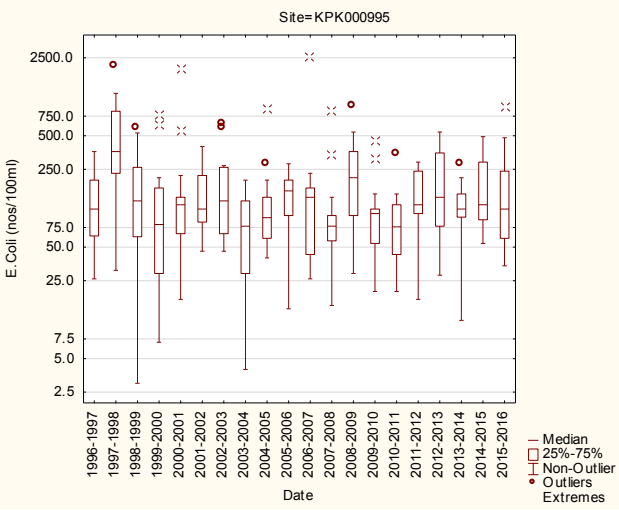
Waingongoro R at Eltham



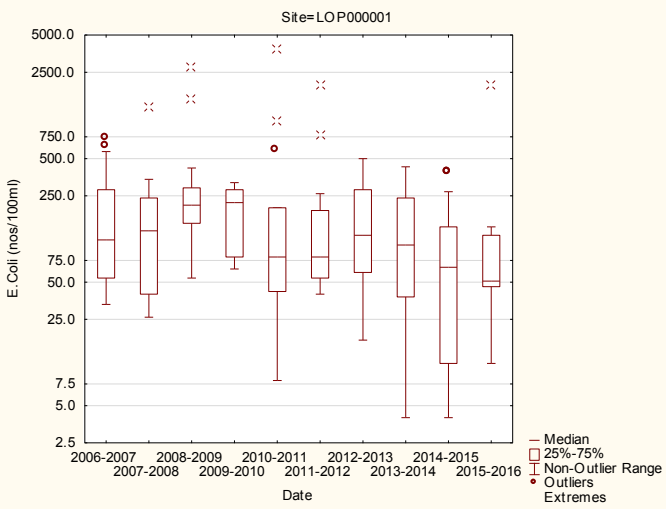
Waingongoro R at Ohawe



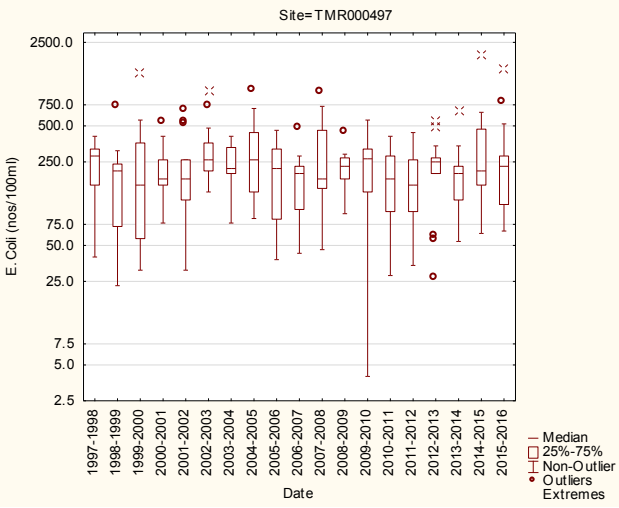
Kaupokonui River



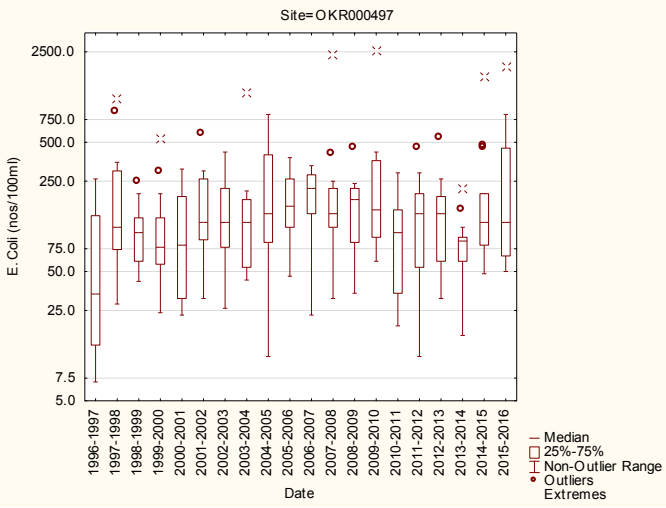
Lake Opunake



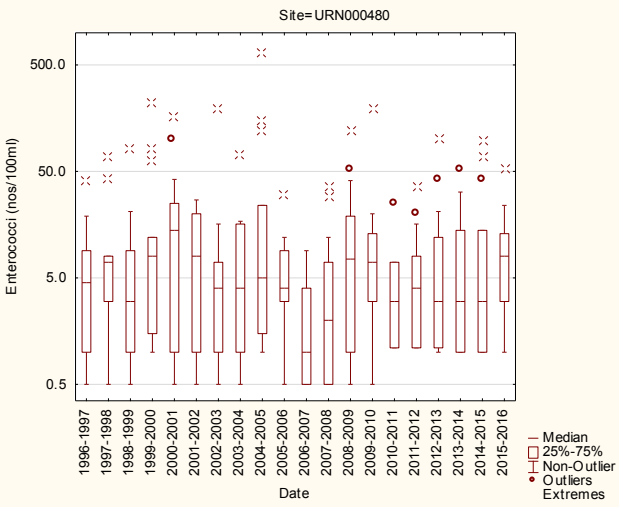
Timaru Stream



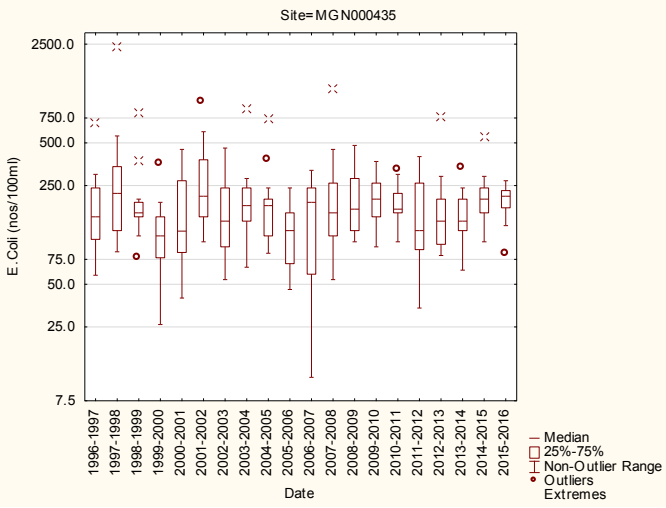
Oakura River



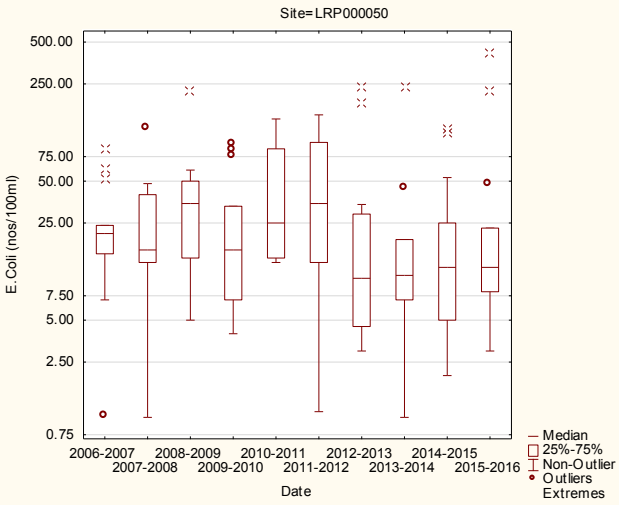
Urenui River



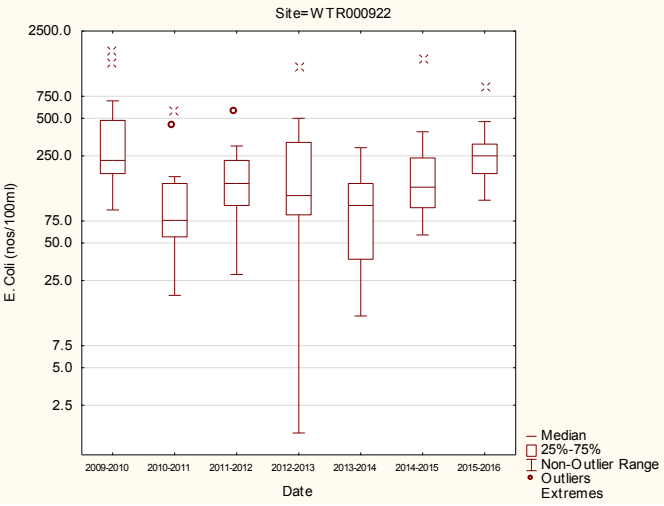
Manganui River



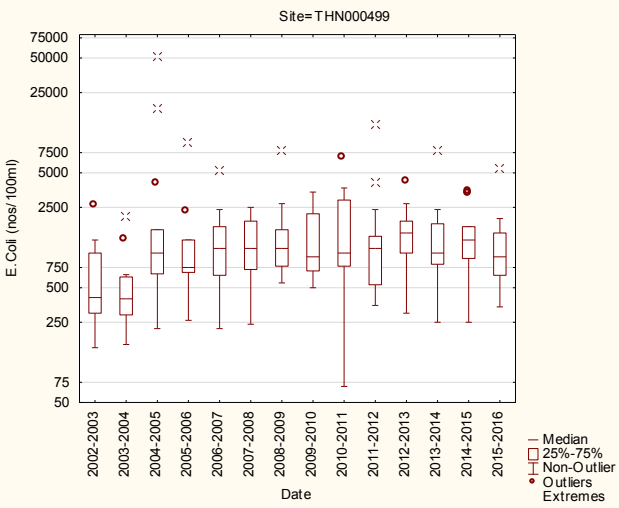
Lake Ratapiko



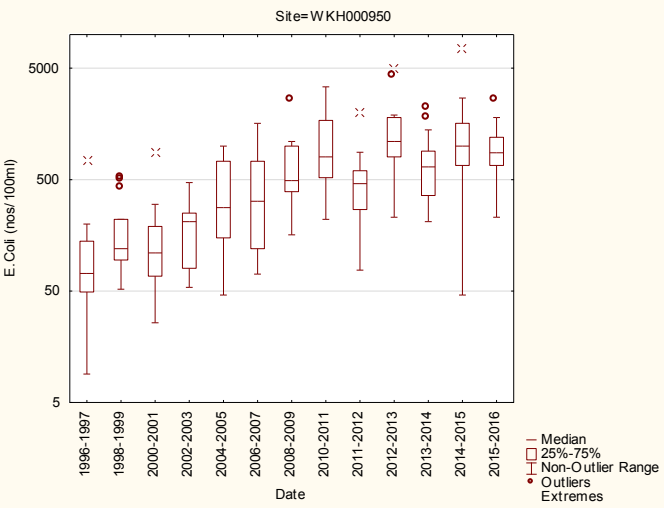
Waitara River at town wharf



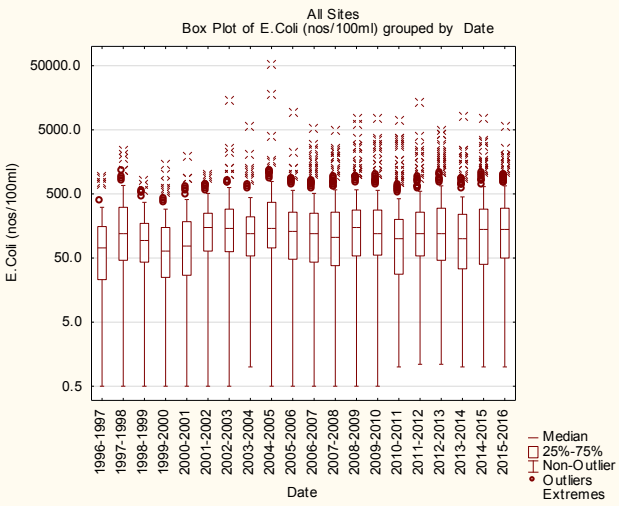
Te Henui mouth, East End



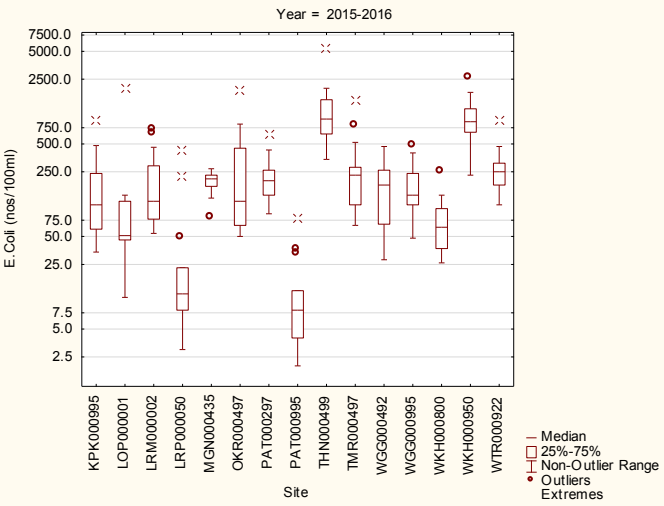
Waiwhakaiho adjacent to L.Rotomanu



All sites combined, 1995 - 2016



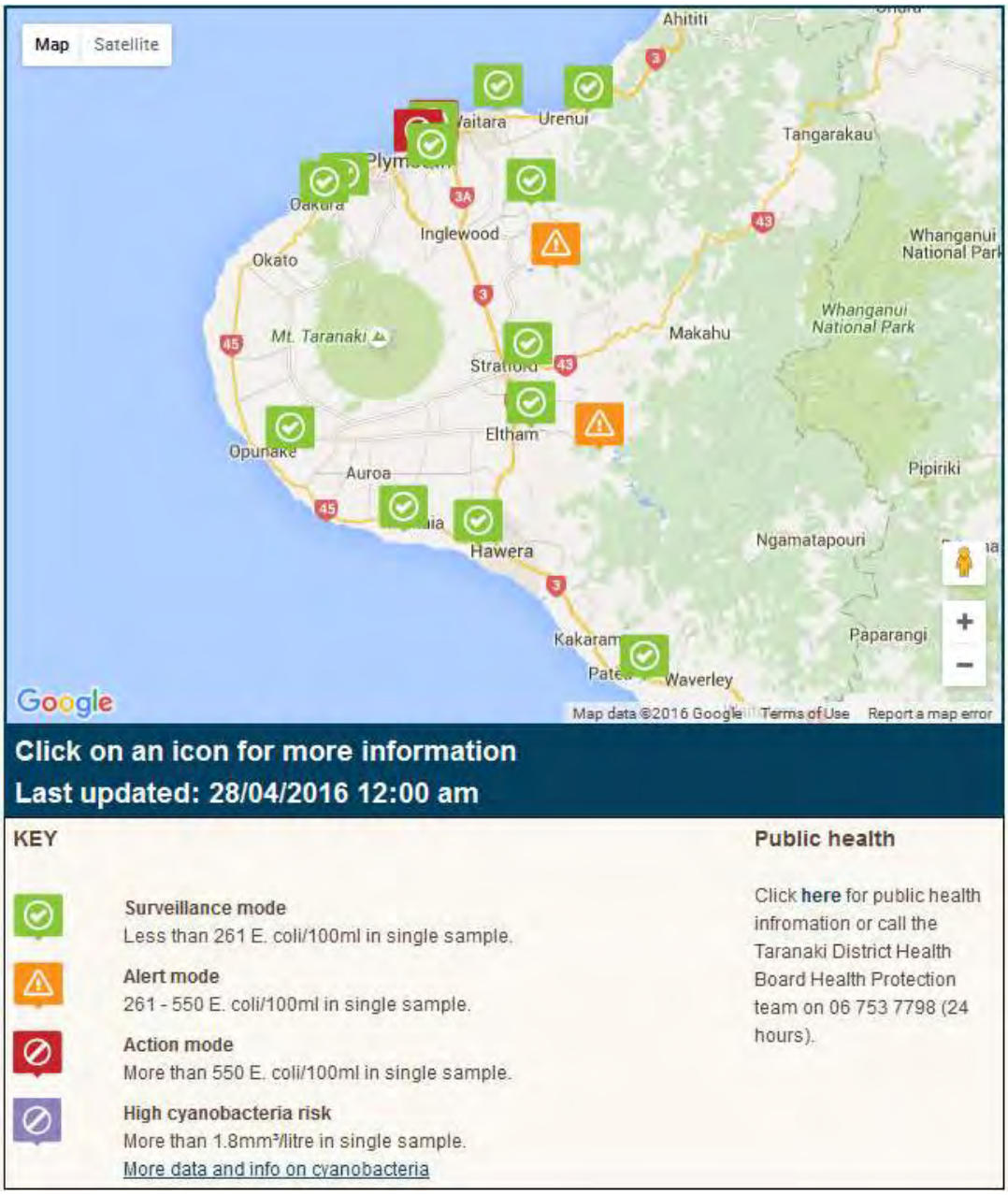
All sites individually, 2015 – 2016



Appendix VII

Examples of publicity during the 2015-2016 season

Freshwater quality



Background information

The Taranaki Regional Council undertakes microbiological water quality monitoring at a number of river sites around Taranaki during the summer months (November to March) to:

- Assess the water quality of popular bathing sites in Taranaki.
- Compare bathing water quality in Taranaki with national guidelines for contact recreational use of water.
- Monitor trends in bathing water quality over time.

The Council conducts bacteriological of samples from the freshwater sites on the map above. It also tests for planktonic (free-living) cyanobacteria at Lake Rotomanu, the Waiwhakaiho River at Merrilands, Lake Ratapiko, Lake Rotokare and Lake Opunake, and monitors the cover of benthic (attached) cyanobacteria at nine sites on seven rivers.

District Councils will inform the public when the action levels are reached based on national guidelines and the advice of the Medical Officer of Health.

Reports on monitoring in previous summers

Bacteriological monitoring
Cyanobacteria monitoring

Bacteriological monitoring

Bathing water quality is assessed according to concentrations of indicator bacteria. For freshwater river sites, this is a type of bacterium known as Escherichia coli (E. coli), which is an indicator of faecal contamination. If there is faecal contamination there is a possibility of the presence of disease-causing organisms such as bacteria, viruses and protozoa. These organisms may pose a health hazard when the water is used for recreational activities such as swimming, board riding and other high-contact activities. Poor recreational water quality can possibly cause gastrointestinal illness and respiratory health effects, such as coughs and colds.

A high concentration of the indicator bacteria means that it is more likely that disease-causing organisms are present. It does not mean that anyone swimming in the water at the time will actually be affected.

Water quality safety is assessed and reported according to the Ministry for the Environment and Ministry of Health 'Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas' revised and issued in 2003.

These guidelines categorise recreational bathing sites into one of three 'mode' categories according to single sample results of E. coli (freshwaters) and enterococci (marine waters) bacterial counts. For freshwater sites, these categories are:

E. coli/100ml	Alert level
No single sample greater than 260	Surveillance/Green
One single sample between 261 and 550	Alert/Amber
One single sample greater than 550	Action/Red

The safety category is reassessed after each additional sample is collected. Sites on the maps reflect the coloured safety category and level of compliance with the guidelines at the time of the most recent sample.

In Taranaki, it is known that significant rainfall events substantially increase bacterial levels in rivers and streams (and subsequently in coastal waters along the shoreline) due to rural and urban runoff for up to several days after rainfall. This may increase numbers into the Action mode category for recreational usage. However, for trend detection purposes the Taranaki Regional Council does not sample river and beach waters within three days of any significant rainfall.

The results of the water samples collected from fresh water and coastal sites during the bathing season are updated on this site as they are received from the laboratory.

Top

Cyanobacteria monitoring

Cyanobacteria, or blue-green algae, are very small organisms with characteristics in common with both bacteria and algae.

Some cyanobacteria species can produce natural toxins known as cyanotoxins which if produced in high enough concentrations can pose a threat to human and animal health when consumed or by contact during recreational activities.

Someone who is affected by cyanobacteria could have skin irritation, nausea, headaches, flu-like symptoms or tingling and numbness around the mouth or tips of fingers. Exposure to cyanobacteria could also aggravate hay fever, dermatitis, eczema and asthma. If toxin levels are very high, involuntarily or accidentally drinking the water could result in severe liver damage.

Cyanobacteria occur naturally in freshwater lakes and rivers, and are found in a wide range of water quality conditions, including relatively 'healthy' waters. Under certain conditions blooms can result, increasing risk to humans and animals. Taranaki rivers and lakes are at times affected by both attached and free-living cyanobacteria blooms. Attached (benthic) forms of cyanobacteria can appear as dark brown or black mats covering the river bed. Free-living (planktonic) cyanobacteria blooms can cause discolouration and give water a turbid or thick, soupy appearance. Avoid using areas if you suspect toxic cyanobacteria are present in large numbers. Cyanobacteria mats can pose a risk to dogs who may eat algal mats, or ingest algae when they drink water from a watercourse, so please remain vigilant of cyanobacteria mats that may develop in shallow areas of a river.

The Taranaki Regional Council monitors summer planktonic cyanobacteria levels at Lakes Rotomanu, Ratapiko, Rotokare and Opunake, and benthic cyanobacteria in the Oakura, Waiwhakaiho, Manganui, Patea, and Waingongoro Rivers and Te Henui and Kaupokonui Streams.

There are three Ministry for the Environment alert levels:

Alert level	Planktonic cyanobacteria (cells/ml OR mm^3/litre)	Benthic cyanobacteria (% coverage)
Low risk	**Less than 2,000 OR less than 0.5**	**Up to 20%**
Medium risk	**2,000 to 15,000 OR 0.5 to 1.8**	**20% to 50%**
Elevated risk	**More than 15,000 OR more than 1.8**	**Above 50% AND/OR exposure of mats/scum**

'High risk' planktonic cyanobacteria is denoted on the bacteriological water quality map with a barred circle on a purple background at the relevant monitoring site.

The latest benthic cyanobacteria monitoring results are shown below:

Site	Date of last sample	Status
Waiwhakaiho River at Merrilands Domain	**02/03/2016**	**Low risk.**
Waiwhakaiho River at last riffle	**02/03/2016**	**Low risk.**
Te Henui Stream at mouth	**02/03/2016**	**Low risk.**
Oakura River upstream of SH45 bridge	**02/03/2016**	**Low risk.**
Manganui River at Everett Park	**30/03/2016**	**Low risk.**
Patea River at Stratford	**02/03/2016**	**Low risk.**
Waingongoro River at Eltham	**02/03/2016**	**Low risk.**
Waingongoro River at Ohawe Beach	**30/03/2016**	**Low risk.**
Kaukoponui River at Beach Domain	**30/03/2016**	**Low risk.**

*** Monitoring will resume in October 2016**

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Appendix VIII

Sporadic sampling at miscellaneous sites of public interest

Comments

Public enquiries into the water quality of other river/lakes sites have been received from time to time. During the 2014-2015 and 2015-2016 seasons, these specifically related to:

- the lagoon adjacent to the true right bank of the Waitara River, 300m upstream of SH3 bridge (site: WTR000911) (GPS ref: 1707707E 5681257); also know as Lake Ngagana.
- Lake Rotorangi near the Hawera Water Ski Club, Tangahoe Valley (site: LRT00S300) and near the Patea HEP dam (site: LRT00S450).

Water quality sampling surveys were undertaken occasionally at each of these sites in conjuction with other monitoring work. The results are presented beneath.

Site	Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity	Usage
		(NZST)	(mS/m)	*E.coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)	
WTR000911	23.01.15	1235	16.2	40	9	40	25.4	1.2	15 kayakers
	26.01.15	1355	16.2	24	6	24	26.8	1.0	Nil
	09.02.15	1035	16.7	12	12	12	23.8	0.7	Nil
	19.02.15	1100	17.6	6	22	6	22.9	1.1	Nil
	04.03.15	0915	18.1	190	250	200	23.0	1.4	Nil; few ducks
	12.03.15	1045	18.0	120	240	120	22.3	3.9	Nil
	20.03.15	0910	18.0	40	40	40	11.9	20	Nil, S wind
	25.11.15	0920	14.4	19	33	28	19.2	0.6	Nil
	10.12.15	0930	14.2	6700	3400	6700	20.7	1.4	Nil, ~30 ducks
	15.12.15	1220	13.7	150	140	150	23.9	1.6	Nil
LRT00S300	22.10.14	1010	11.2	9	-	9	16.9	1.1	Nil
	24.02.15	0915	14.0	53	55	53	22.0	0.9	Nil
	23.03.15	0915	14.7	5	1	5	19.4	0.8	Nil
LRT00S450	22.10.14	1155	10.0	4	-	4	18.3	0.7	Nil
	24.02.15	1110	11.6	<1	<1	<1	22.6	0.9	Nil
	23.03.15	1055	12.8	3	<1	3	19.4	1.1	Nil

One exceedance of the (Alert or Action) guidelines was recorded, for the Lake Ngagana site in Decembe2015, probably caused by a large number of ducks on the water. Subsequent sampling, in the absence of waterfowl, found that the water quality guidelines were met.