Freshwater contact recreational water quality at Taranaki sites State of the Environment Monitoring Report 2014-2015 Technical Report 2015-01

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Taranaki Regional Council
Private Bag 713
STRATFORD

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Executive summary

This survey of sixteen freshwater contact recreational sites in the Taranaki region was the nineteenth 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 2014-2015 period for the ninth 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 although several sites had fewer exceedances 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 second time in this state of the environment programme.

The results of the 2014-2015 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), Lakes Ratapiko and Rotomanu, 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, and less frequently at Lake Opunake, 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 (29% of samples) was 1% higher than 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).

No sites recorded all single samples in either the 'Alert' and/or the 'Action' mode of the MfE, 2003 guidelines while two sites (Te Henui Stream near East End beach and Waiwhakaiho River opposite Lake Rotomanu) recorded twelve single samples in either mode. Ten other sites from time to time exhibited single sample entries mainly into the 'Alert' mode of the 2003 guidelines at some time during the season. Six of these sites had counts which entered the 'Action' mode, an 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 11 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 'Alert' levels [at Waitara (where vandalism of signage has been an issue)] and signage was required at the lower Waiwhakaiho River, Te Henui Stream, Manganui River, and lower Waingongoro River sites but single sample 'Alert' level exceedances at other sites were not necessarily signposted. Limited signage was erected at the Patea River site at Stratford despite several instances of the 'Alert' mode being surveyed. Although the median count for the season at this site was within the 'Alert' category, it was higher than all but three of the previous seasonal medians. The SFR grade for the latest five-year period deteriorated as a result of an increase in the 95% MAC category.

Temporal trends over the 1996-2015 period have been evaluated for the twelve sites that have ten years or more data (and will continue to be assessed annually). One site (lower Waiwhakaiho River) has shown statistically significant increasing trends, while two other sites (Te Henui Stream and Oakura River) have shown strong, but not statistically significant, increasing trends in median *E. coli* counts. Only one site (Urenui River at the estuary) has shown a strong but not statistically significant decreasing trend in median enterococci 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 the river site but none at the lake site as poorer river bacteriological quality followed the wet weather events.

Cyanobacteria blooms were recorded at Lake Rotokare from December 2014 with numbers peaking in mid to late summer. These numbers necessitated warning notices to avoid

contact recreation on these waters during the entire recreational period. No cyanobacteria were found in Lakes Opunake and Ratapiko with a few instances of low to moderate numbers present in Lake Rotomanu.

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored. No sites exceeded the 'Action' level but three sites, on a total of 12 occasions, had over 20% coverage triggering the 'Alert' level. Exposed mats triggered the 'Action' or 'Alert' level at three sites on 17 occasions and detaching or detached mats accumulating on the river's edge triggered the 'Action' level at one site on two 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 three 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 (who also utilised its website) throughout the survey season of 2014-2015.

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.*]

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

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

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

precludes sampling under conditions of river freshes when high flows and turbid conditions would make bathing hazardous and in any case people would be less inclined to bathe. The Council endeavours to collect 13 samples per season under bathing conditions. In addition, at 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 2009 to April 2014 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, and one of the two sites added to the programme in 2011-2012 have limited historical bacteriological data and only three to four year's data have been collected for two of these sites 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 2009 to April 2014

Site	Sanitary Inspection Category	Microbiological assessment *E.coli* (nos/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	903	65	D	Very poor	87
Waiwhakaiho R: Merrilands domain	High	208	65	B	Poor	96
Waiwhakaiho R at L.Rotomanu	High	3340	52	D	Very poor	36
Te Henui S: mouth	High	4720	66	D	Very poor	16
Patea R: King Edward Park	High	565	65	D	Very poor	96
Patea R. boatramp, Patea	High	81	65	A	Poor	100
Waingongoro R: Eltham camp	High	365	65	C	Poor	100
Waingongoro R: Ohawe beach	High	820	65	D	Very poor	93
Kaupokonui R: Beach domain	High	440	65	C	Poor	100
L Opunake: adjacent boatramp	High	835	65	D	Very poor	92
Timaru S: Lower Weld Road	High	513	65	C	Poor	96
Waimoku S. Oakura beach	High	6255	39	D	Very poor	5
Oakura R: d.s SH45	High	425	65	C	Poor	98
Waitara R: Town wharf	High	843	65	D	Very poor	92
Urenui R: estuary	High	60	65	A	Poor	100
Manganui R: Everett Park	High	348	65	C	Poor	98
L Ratapiko: boatramp	High	167	59	B	Poor	100
L Rotokare: adjacent boatramp	Low	138	46	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 SI category). The 5-year microbiological data however, indicate that all but three sites (Te Henui Stream , lower Waiwhakaiho River and Waimoku Stream) would not have entered the 'Action' guideline (ie would have exceeded guidelines) on more than 13% of all sampling occasions, with fourteen sites achieving the guideline on 91% or more of occasions (ie less than 9% exceedance).

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, Lower Weld Road site in the Timaru Stream, 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 is 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 2014-2015 programme are shown in Figure 1 and summarised in Table 4.

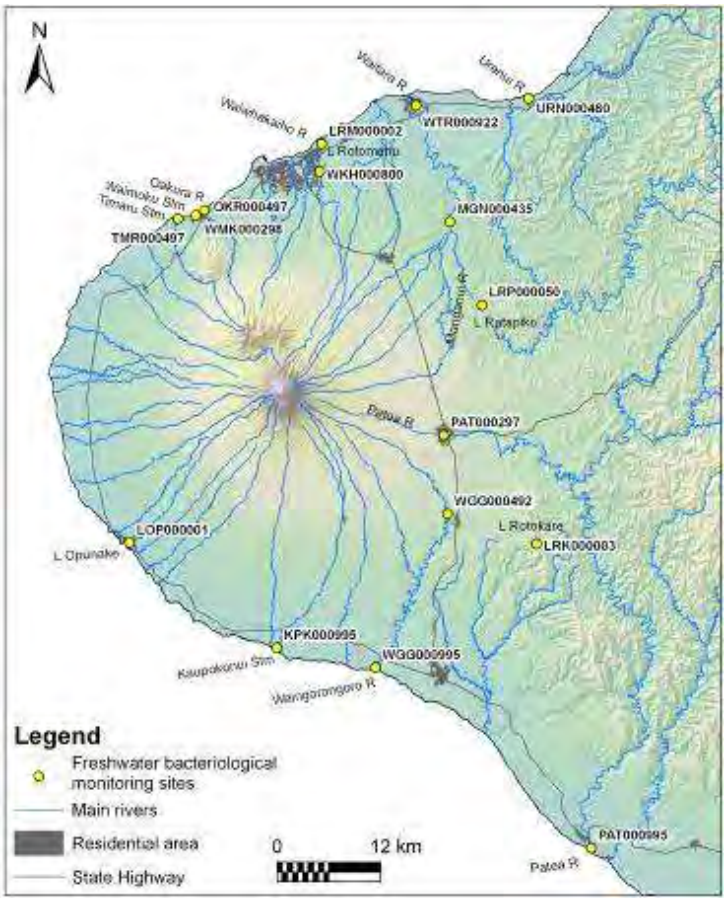


Figure 1 Location of freshwater contact recreation survey sites in 2014-2015

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, and 2014-2015 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 mid November 2014 to early

April 2015. 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). However, late spring and early summer wet weather affected the frequency of sample collection earlier in the period. Sampling commenced in mid November 2014 with only two of the sampling surveys performed prior to January 2015 due to a wet late spring-early summer period. 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 (www.trc.govt.nz) for public and local health authority notification in particular, as soon as data checking had been completed. Mapping of the results was also included on the more recently established Taranaki District Health Board website (www.tdhb.org.nz) in the 2014-2015 season. 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 websites for all lake sites and was extended to the river/stream sites in the 2014-2015 season.

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 Healthboard, 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 2014-2015, 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 Figures 7, 13, 18, 20 and 25. Those illustrate that the majority of the sampling occasions coincided with steady to low river recession flow conditions. Very occasionally sampling was affected by localised rainfall (e.g. Kaupokonui Stream and Waingongoro River near the coast on one late summer occasion) and/or a prior increase in river flows. 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 2014 to early April 2015.

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 10 November 2014 to 1 April 2015 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 there was limited bathing usage of the lake recorded with boating, water and jet-skiing, and/or picnicking activities recorded at the time of several of the sampling surveys.

A few ducks and gulls (on one occasion) 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. However, numbers were not as high as recorded over previous seasons. 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1205	11.0	43	3	43	19.8	15
09.12.14	0825	11.2	20	14	23	21.4	5.7
05.01.15	1135	11.2	43	29	43	25.2	7.4
08.01.15	1310	11.5	24	80	25	25.6	8.7
12.01.15	1115	11.5	28	19	37	25.0	11
20.01.15	0810	11.7	29	19	29	24.4	3.5
23.01.15	0910	11.9	28	15	28	24.3	6.8
26.01.15	1135	12.1	48	20	48	25.9	11
09.02.15	0950	11.9	36	40	36	21.8	5.4
19.02.15	0805	12.1	46	17	52	21.5	4.6
04.03.15	0805	12.8	70	76	72	24.0	3.4
12.03.15	1125	12.5	84	48	100	22.5	2.8
20.03.15	0805	12.6	120	99	120	17.1	3.4

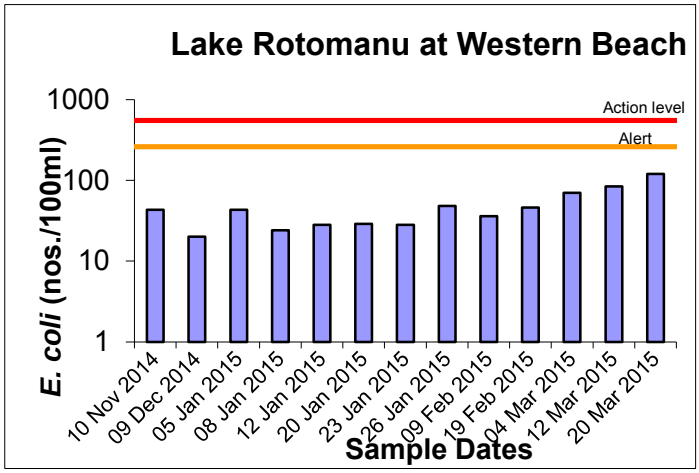


Figure 2 *E. coli* numbers for Lake Rotomanu during the regular season
(Note: Action limit >550/100 ml [single sample: Alert limit => 260 nos/100ml [single sample])

Table 7 Statistical results summary for Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	11.0	12.8	11.9
E. coli	nos/100ml	13	20	120	43
Enterococci	nos/100ml	13	3	99	20
Faecal coliforms	nos/100ml	13	23	120	43
Temperature	°C	13	17.1	25.9	24.0
Turbidity	NTU	13	2.8	15	5.7

The lake, which is close to the coast, is replenished from time to time by inflow from the nearby Waiwhakaiho River. Water quality was relatively good although it was generally slightly turbid (median turbidity: 5.7; range: 12 NTU). The variability in clarity was possibly 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 25.9°C (in late January 2015) and a range of 8.8°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. There was a small elevation in number of *E. coli* (in excess of 100 per 100 mls) on one occasion at the end of the period but no counts exceeded the 'Action' mode at any time and none reached the 'Alert' level. Therefore, NPDC signage discouraging lake usage was not required to be erected at the lake, dissimilar to the case in most previous seasons.

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	0 [0]	0 [0]

(Designation: freshwater contact recreational area)

No samples exceeded the 'Action' mode during the period, and no single sample was 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 (nos/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
Minimum	3	12	7	7	1	31	9	20	<3	6	7	54	51	23	6	46	23	8	20
Maximum	899	740	200	140	90	980	2200	5500	220	380	3000	1200	6000	3600	150	2300	430	120	120
Median	32	46	79	25	14	110	92	120	11	68	72	180	220	100	34	120	100	60	43

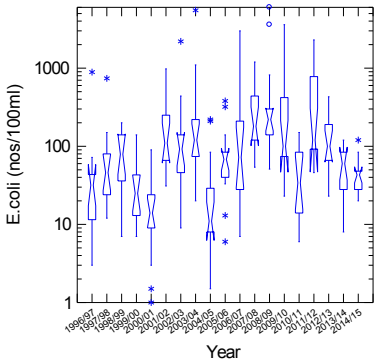


Figure 3 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers at Lake Rotomanu

The more recent trend of moderately high median *E. coli* numbers in recent years was not found over the summer of 2014-2015 when a much narrower range of counts was also recorded. The median value was the sixth lowest to date and the maximum count was the second equal lowest to date and remained well below the 'Alert' level of the 2003 MfE guidelines.

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 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.

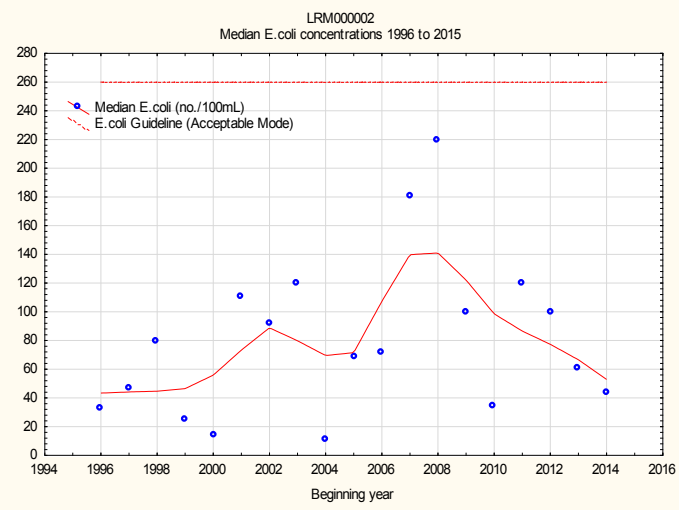


Figure 4 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Lake Rotomanu for the 1996-2015 period

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

note, over the 2001 to 2012 period only three of the eleven annual maxima remained below the 'Action' level, whereas subsequently each annual maximum count has met this guideline.

4.2.1.4 MfE guidelines additional sampling

Seven additional samples were collected randomly under varying weather conditions during the survey season. Limited bathing, and some boating (jet-skiing and kayaking) and picnicking were noted on these occasions. Ducks were present in low numbers on the lake on some but not all occasions. Four surveys occurred by chance following wet weather some time in the preceding three days.

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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
18.11.14	0945	10.6	110	11	120	17.4	13
02.12.14	0920	10.8	74	23	74	18.5	10
15.01.15	0940	12.0	160	20	160	25.9	6.7
29.01.15	1005	12.5	54	11	54	27.3	6.8
13.02.15	1110	11.9	43	17	44	22.6	4.9
26.02.15	1020	12.5	68	66	68	24.7	4.1
17.03.15	0950	13.1	85	66	87	20.5	3.5

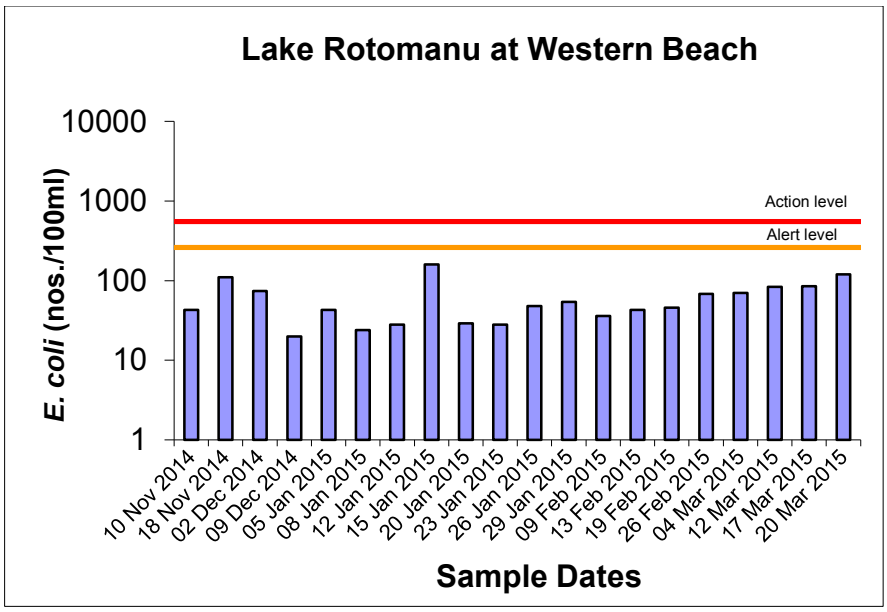


Figure 5 *E. coli* numbers for Lake Rotomanu for the 20 sample extended survey

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	10.6	13.1	11.9
E. coli	nos/100ml	20	20	160	47
Enterococci	nos/100ml	20	3	99	20
Faecal coliforms	nos/100ml	20	23	160	50
Temperature	°C	20	17.1	27.3	23.3
Turbidity	NTU	20	2.8	15	6.2

The additional sampling resulted in very little change with a small increase (of 4 *E.coli* per 100 mls) in the overall seasonal median bacteria number. These additional surveys' bacteria counts had a slightly wider range (43 to 160 *E. coli* per 100mls) and a lower median (40 *E.coli* per 100 mls) than the standard SEM sampling survey range, despite the proximity of wet weather to four of the sampling survey occasions. A higher maximum water temperature (by 1.4˚C) was measured during the additional sampling (27.3˚C) in late January 2015.

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	0 [0]	0 [0]

(Designation: freshwater contact recreational area)

There was no change in the number of exceedances of the single sample 'Alert' and 'Action' modes with the additional monitoring, as no additional exceedance of the 'Alert' level or of the 'Action' level occurred despite recent wet weather conditions and higher river flows on occasions.

4.2.1.6 Cyanobacteria

No visual surface algal blooms were recorded during the season with slightly turbid lake water quality noted during the season which was similar to previous seasons. Microscopic scans of samples found relatively low to moderate numbers of cyanobacteria present in three of the seven samples analysed during the season. On the first two occasions the only taxon present was *Anabaena* with numbers ranging between 400 and 1220 cells per ml while late in the season the number was elevated at nearly 9500 cells/ml and mainly comprised of the taxon, *Microcystis*. The results of this sampling are presented in Table 13 and Figure 6.

Table 13 Cyanobacteria counts and biovolumes for Lake Rotomanu [Health warning: >15,000 cells/ml; >1.8 mm^3/L]

Date	Cyanobacteria total cell count (cells/ml)	Principal taxa	Biovolume mm^3/L
18.11.14	1220	*Anabaena*	0.42
02.12.14	407	*Anabaena*	0.08
15.01.15	nil	-	0
29.01.15	nil	-	0
13.02.15	nil	-	0
26.02.15	nil	-	0
17.03.15	9463	*Microcystis*	0.08

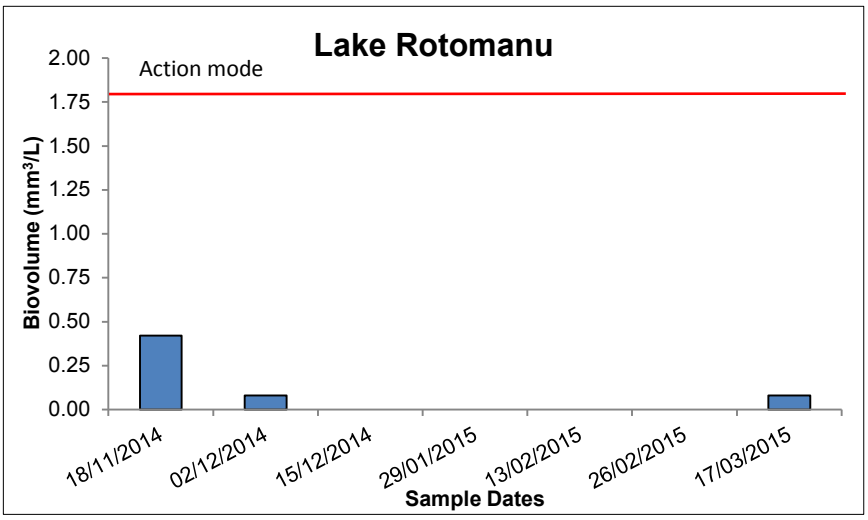


Figure 6 Cyanobacteria biovolume at Lake Rotomanu [Health warning: >1.8 mm^3/L]

Therefore, no cyanobacteria related health warning signage was required at the lake as the density remained well below the health warning high alert level of 15,000 cells/ml (TDHB, 2006) and/or 1.8 mm^3/L, unlike during the 2008-2009 season when *Microcystis* dominated the lake and when *Anabaena* was present in moderate numbers in January 2009 (TRC, 2009). No toxin testing of the lake waters was therefore required by the Taranaki Health Board. *Microcystis* had also been found in the lake during the 2009-2010 season when cyanobacteria numbers ranged from nil to 7600 cells/ml (TRC, 2010), but no cyanobacteria were found during the 2010-2011 season (TRC, 2011). *Anabaena* was found on two occasions (in low numbers) during the 2011-2012 season (TRC, 2012), one occasion during the 2012-2013 season (TRC, 2013), and six occasions (low numbers) in the 2013-2014 season (TRC, 2014).

4.2.2 Waiwhakaiho River at Merrilands Domain

4.2.2.1 SEM programme

Minimal usage of this site was recorded at the time of the sampling surveys, with bathing on only one occasion but some of the usual walking or picnicking on the banks of the river noted. No birdlife was noted on all but two occasions and on these occasions numbers were very low.

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

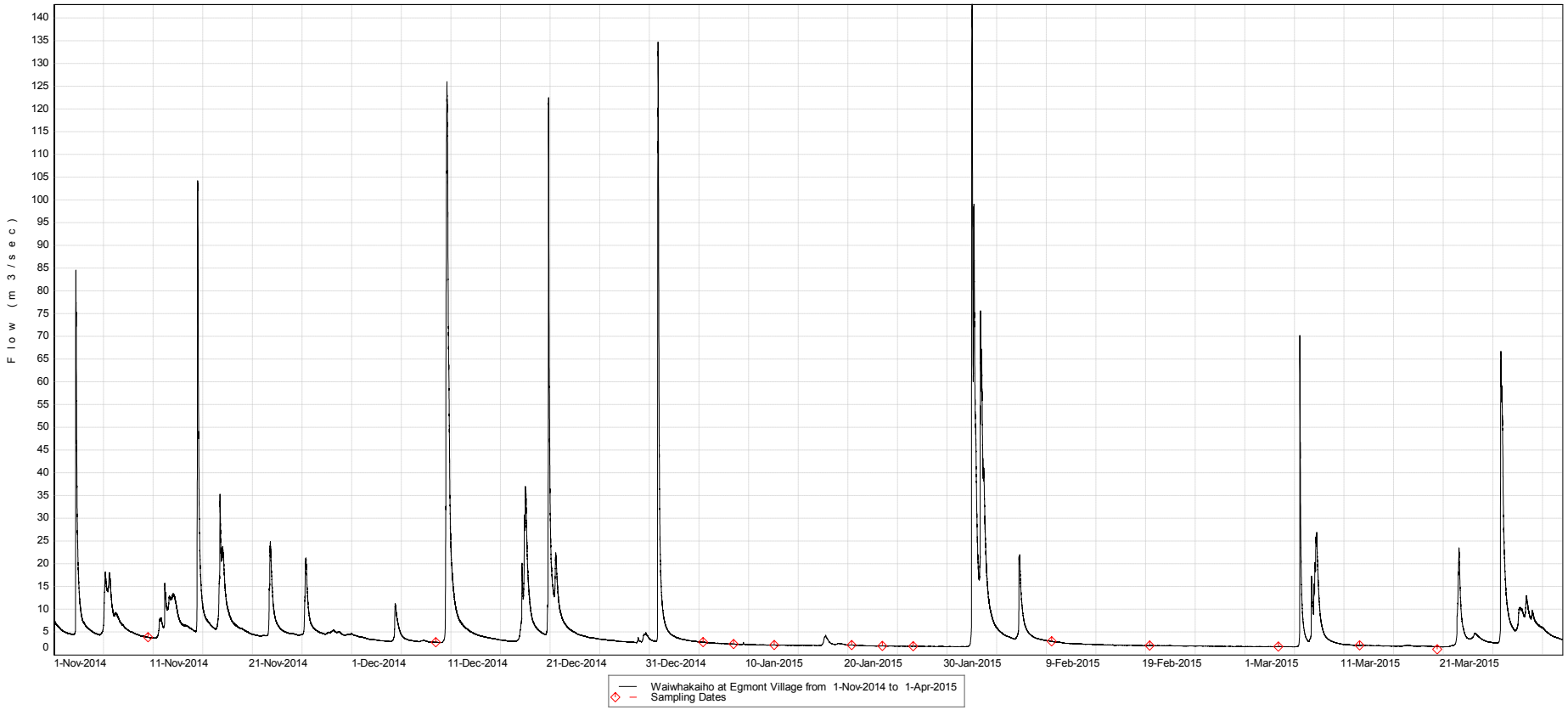


Figure 7 River flow in the Waiwhakaiho River during the survey period

Table 14 Analytical results for the Waiwhakaiho River at Merrilands Domain

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1350	10.3	17	1	17	16.2	0.6
09.12.14	0845	11.7	68	8	68	17.9	0.6
05.01.15	1300	15.2	170	120	180	21.4	0.4
08.01.15	1350	12.5	26	7	26	22.7	0.6
12.01.15	1100	13.3	8	12	8	21.3	0.5
20.01.15	0825	13.4	51	160	51	20.0	0.4
23.01.15	0830	13.9	17	23	17	19.6	1.0
26.01.15	1045	14.2	23	13	23	23.3	0.6
09.02.15	0900	11.0	60	74	60	17.8	1.2
19.02.15	0820	13.7	31	83	31	17.8	0.4
04.03.15	0820	15.6	37	24	37	19.7	0.6
12.03.15	1005	13.5	350	160	380	18.4	1.1
20.03.15	0850	14.6	210	120	210	12.6	0.7

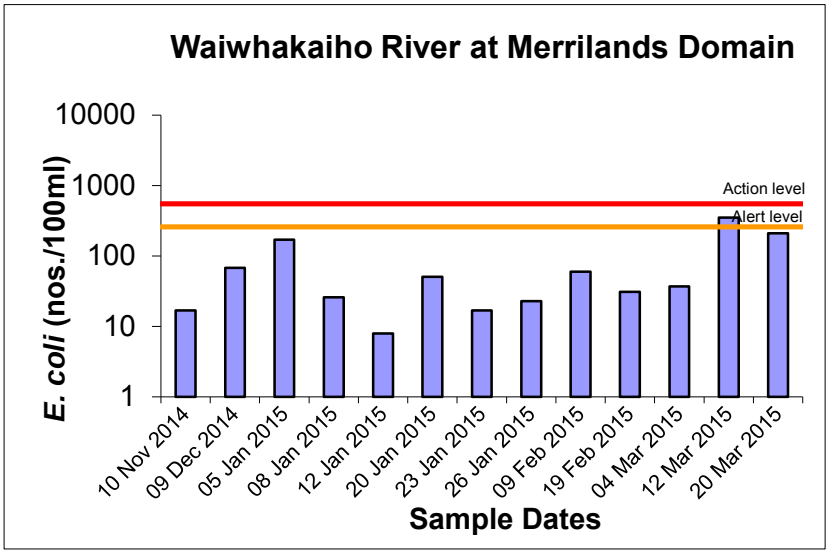


Figure 8 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain during the regular survey season

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	10.3	15.6	13.5
E. coli	nos/100ml	13	8	350	37
Enterococci	nos/100ml	13	1	160	24
Faecal coliforms	nos/100ml	13	8	380	37
Temperature	°C	12	12.6	23.3	19.6
Turbidity	NTU	13	0.4	1.2	0.6

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 10.7°C between mid November and late March, with a relatively high maximum of 23.3°C in late January 2015. Conductivity and turbidity results were indicative of very clean, clear, relatively high water quality but moderate to widespread algal cover (up to 100% mats) was relatively common through the period and particularly after mid-summer.

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 on all but three occasions through the season and only two *E.coli* counts above 200 per 100 mls were 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	1 [8]	0 [0]

(Designation: freshwater contact recreational area)

No single samples were recorded within the 'Action' mode, but one count was recorded in the 'Alert' mode during the season. This count fell below the 'Alert' level by the time of the following survey, eight days later (in late March, 2015). 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 (nos/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
Minimum	16	16	26	8	6	17	3	34	11	15	8	28	19	23	4	8	11	3	8
Maximum	970	1800	330	100	270	420	130	320	330	160	510	110	110	570	200	120	3000	200	350
Median	42	84	69	39	23	60	29	77	54	34	48	48	46	110	54	40	52	51	37

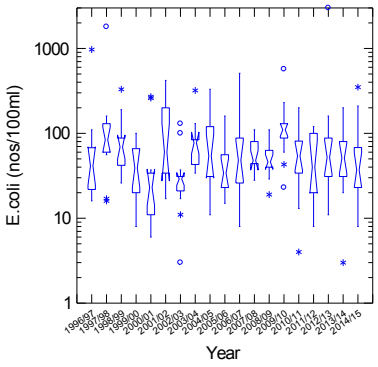
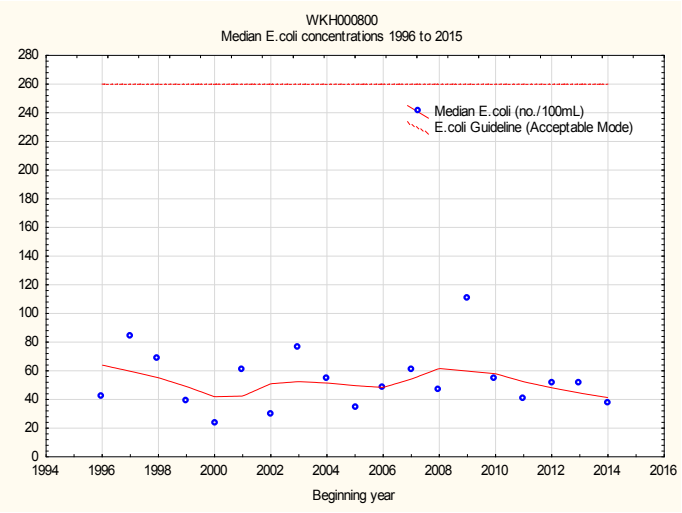


Figure 9 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River at Merrilands Domain

The median *E. coli* number in the 2014-2015 period was slightly lower than most recorded to date and 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 nineteen 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 = 19
Kendall tau = -0.070
p level = 0.674 [>FDR, p = 0.908]
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 2015 period

A statistically insignificant and unimportant temporal trend of a minimal decrease in median *E.coli* numbers has been found over the nineteen 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 (three of which by chance followed wet weather events during the previous five days) during the survey season.

Recreational activities noted on these occasions included bathing on one occasion and no other usage. A few ducks or gulls were present on three occasions.

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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
18.11.14	1130	7.6	1700	190	1700	13.2	1.4
02.12.14	0950	11.0	88	3	88	13.8	0.5
15.01.15	1015	13.9	11	16	13	20.7	0.6
29.01.15	1045	15.1	60	70	60	22.9	1.1
13.02.15	1145	13.3	93	84	100	19.7	0.7
26.02.15	1045	15.1	31	40	31	19.8	0.5
17.03.15	1025	14.5	37	40	37	16.9	0.4

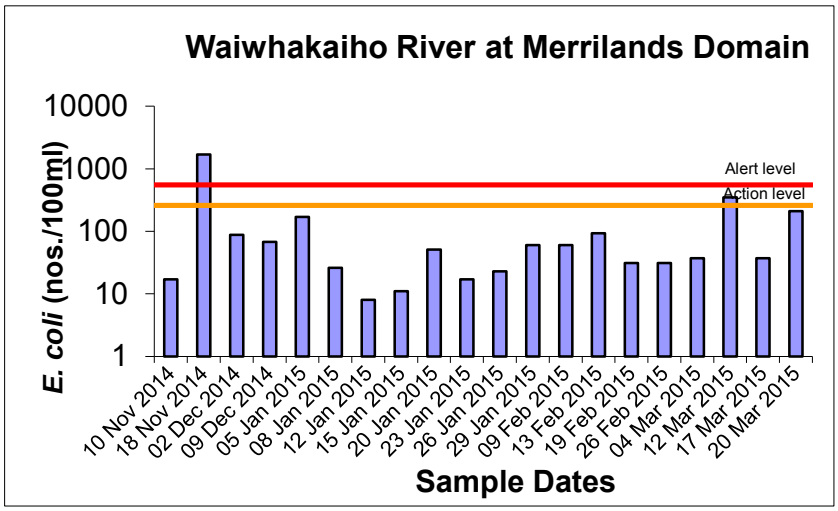


Figure 11 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain for the 20 sample extended survey

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	7.6	15.6	13.5
E. coli	nos/100ml	20	8	1700	44
Enterococci	nos/100ml	20	1	190	40
Faecal coliforms	nos/100ml	20	8	1700	44
Temperature	°C	20	7.6	15.6	13.5
Turbidity	NTU	20	0.4	1.4	0.6

These seven additional samples resulted in increases in the ranges of all of the seasonal median bacterial numbers in comparison with the regular SEM programme results (Table 15). The ranges for all three bacteria species increased due to elevated counts recorded in mid November 2014, under higher river flow conditions after recent very wet weather (Figure 7).

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	1 [5]	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 2014-2015 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
18/11/2014	9	No	No	Green (Surveillance)
02/12/2014	7	No	No	Green (Surveillance)
17/12/2014	9	No	No	Green (Surveillance)
14/01/2015	0	No	Yes	Red (Action)
21/01/2015	0	No	Yes	Red (Action)
28/01/2015	0	No	Yes	Amber (Alert)
04/02/2015	5	No	No	Green (Surveillance)
11/02/2015	0	No	Yes	Red (Action)
19/02/2015	0	No	Yes	Amber (Alert)
25/02/2015	0	No	Yes	Amber (Alert)
04/03/2015	0	No	Yes	Amber (Alert)
12/03/2015	6	No	No	Green (Surveillance)
18/03/2015	0	No	Yes	Amber (Alert)
31/03/2015	6	No	Yes	Amber (Alert)

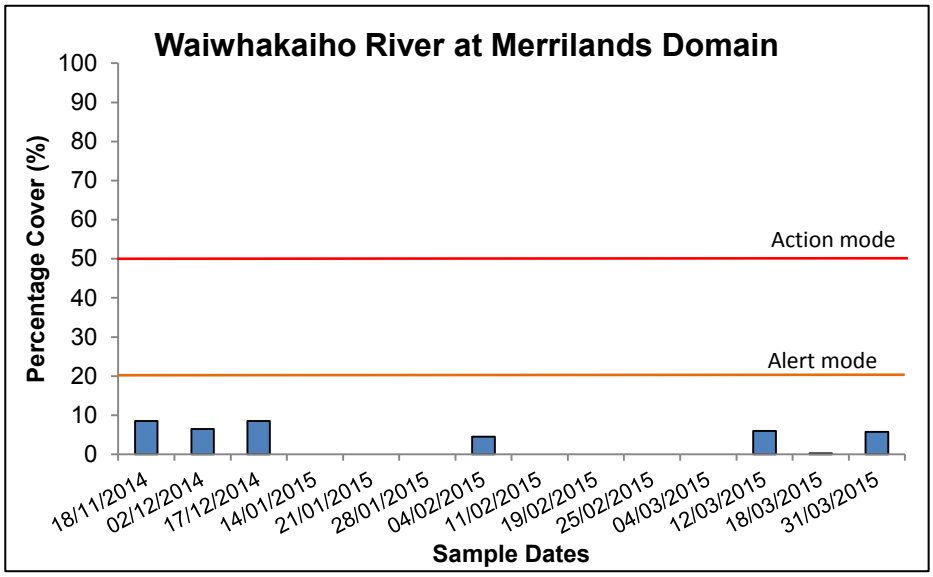


Figure 12 Percentage benthic cyanobacteria cover, at the Waiwhakaiho River at Merrilands Domain site

Benthic cyanobacteria coverage was low at the start of the season and decreased to zero cover for the majority of the mid to late summer period with levels increasing again in autumn (range from 0% to 8.5%). The benthic cyanobacteria found were *Phormidium* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover. However, exposed mats were observed on nine occasions triggering either an 'Action' or 'Alert' response depending on the extent of exposed mats found.

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

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

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 bathing and 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).

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 7 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1215	10.4	46	500	69	16.8	0.5
09.12.14	0815	12.1	400	830	420	17.8	0.8
05.01.15	1145	11.5	1600	2000	1600	22.1	0.6
08.01.15	1325	12.4	1200	1100	1800	23.8	0.5
12.01.15	1210	15.8	670	1100	880	23.1	1.4
20.01.15	0800	14.1	1200	670	1300	20.2	1.5
23.01.15	0915	14.6	950	900	1000	21.5	0.8
26.01.15	1145	14.8	1600	3700	1700	23.7	0.8
09.02.15	1000	11.4	640	1100	640	18.8	0.6
19.02.15	0800	14.4	830	620	930	18.3	0.6
04.03.15	0800	16.1	2700	3400	3200	20.0	0.7
12.03.15	1115	12.6	7400	7500	8000	19.3	0.9
20.03.15	0800	14.5	1000	730	1100	13.5	0.5

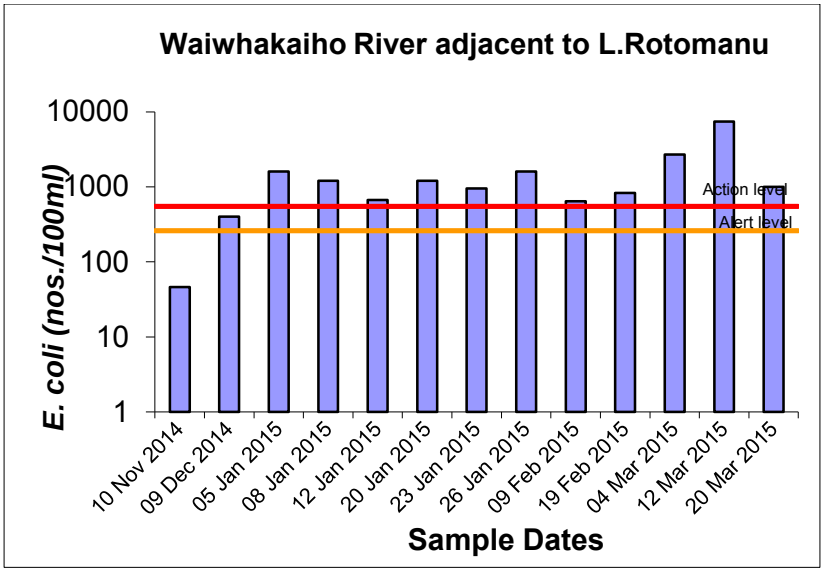


Figure 13 *E. coli* numbers for the Waiwhakaiho River adjacent to Lake Rotomanu during the regular survey season

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	10.4	16.1	14.1
E. coli	nos/100ml	13	46	7400	1000
Enterococci	nos/100ml	13	500	7500	1100
Faecal coliforms	nos/100ml	13	69	8000	1100
Temperature	°C	13	13.5	23.8	20.0
Turbidity	NTU	13	0.5	1.5	0.7

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 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 gulls 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 10.3˚C between mid November and late March, with a maximum of 23.8˚C in early January 2015. 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 1000 per 100 mls particularly in comparison with numbers found at the upstream Merrilands Domain site (median: 37 per 100mls; maximum: 350 per 100mls). Individual sample *E.coli* counts exceeded 600 per 100 mls on all but two occasions coincident with the presence of large gull populations. The marked river flow fluctuations due to increased morning HEP generation could be expected to exacerbate wildfowl (gull) faecal contamination by inundation of river shingle areas where birds roost etc., 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	1 [8]	11 [85]

(Designation: freshwater contact recreational area)

Eleven single samples were recorded within the 'Action' mode and another one 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 (nos/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
Minimum	9	-	52	-	26	-	54	-	46	-	71	-	160	-	220	77	230	210	46
Maximum	740	-	51	-	870	-	470	-	1000	-	1600	-	2600	-	3400	2000	5000	2200	7400
Median	72	-	120	-	110	-	210	-	270	-	320	-	490	-	885	460	1100	650	1000

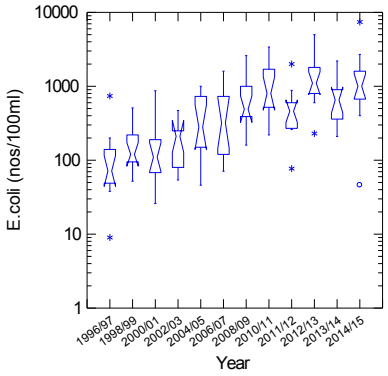
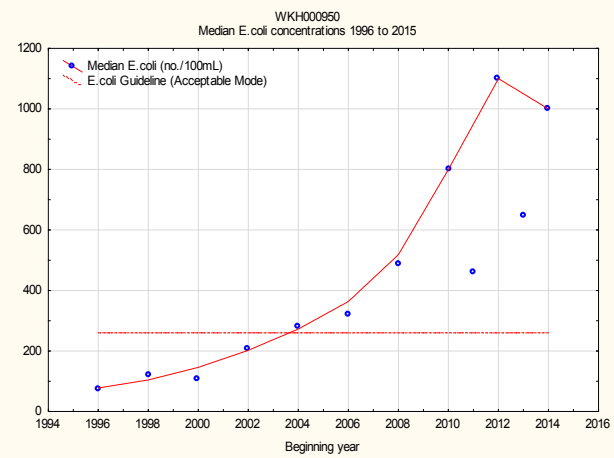


Figure 14 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River adjacent to Lake Rotomanu

The median *E.coli* number in the 2014-2015 period was the second 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 three medians in excess of the 'Action' guideline. The range in 2014-2015 was also the widest seasonal range recorded to date.

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



N = 12
Kendall tau = +0.818
p level = 0.0002 [FDR, p = 0.003]
Significant at p < 0.01 after FDR

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 2015 period

There has been a very significant trend ($p << 0.01$) of increasing median *E.coli* numbers over the twelve seasons of monitoring which is of importance given that

four of these more recent seasonal medians have exceeded the 'Alert' mode and another four are within the 'Action' mode.

4.2.3.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on nine occasions during 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
18/11/2014	9	No	No	Green (Surveillance)
02/12/2014	4	No	No	Green (Surveillance)
17/12/2014	4	No	No	Green (Surveillance)
14/01/2015	1	No	No	Green (Surveillance)
28/01/2015	0	No	No	Green (Surveillance)
11/02/2015	2	No	No	Green (Surveillance)
25/02/2015	0	No	No	Green (Surveillance)
12/03/2015	0	No	No	Green (Surveillance)
31/03/2015	16	No	Yes	Amber (Alert)

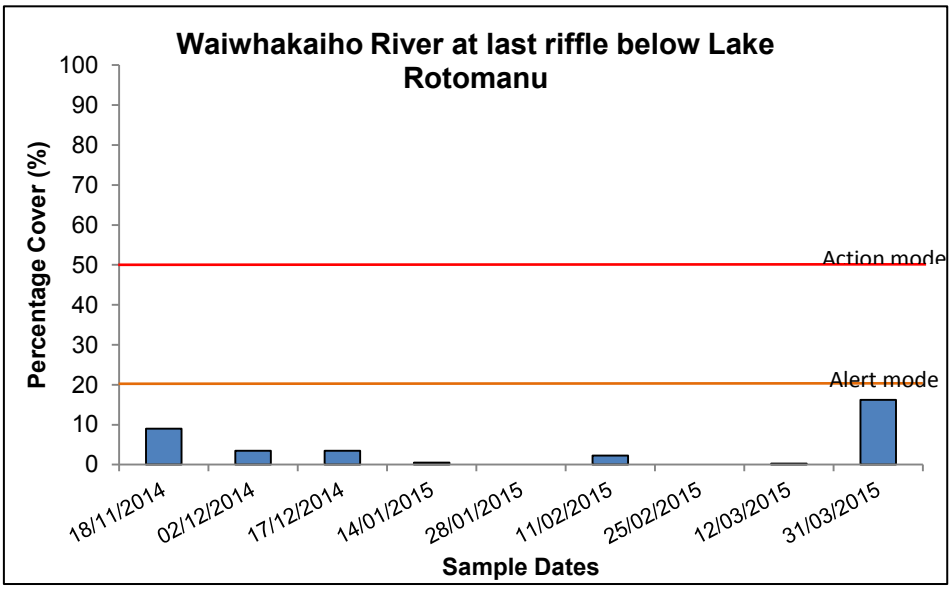


Figure 16 Percentage benthic cyanobacteria cover, at the Waiwhakaiho River adjacent to Lake Rotomanu site

Benthic cyanobacteria coverage was low almost throughout the summer with a small increase late in the season (range: 0% to 16%). The benthic cyanobacteria found were *Phormidium* sp. The 'Action' and 'Alert' levels were not exceeded for percentage cover. However, exposed mats were visible on one occasion at the time of the final survey coincident with the highest percentage cover.

4.2.4 Te Henui Stream at the mouth, East End

Moderate usage of this site was recorded at the time of the sampling surveys, although bathing was noted on only two occasions. More often, walking, picnicking,

fishing, or whitebaiting (in season) from the banks of the stream were noted but not to the same extent as 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1130	46.0	250	130	250	15.1	2.7
09.12.14	0915	10.0	1300	410	1300	17.7	0.5
05.01.15	1055	34.3	3200	2000	3200	19.0	0.4
08.01.15	1230	124	1700	560	1700	20.8	0.5
12.01.15	1450	11.6	900	550	970	21.5	0.6
20.01.15	0900	2990	3400	2600	3400	19.3	7.4
23.01.15	0855	82.6	1200	1000	1200	19.0	1.1
26.01.15	1115	54.0	560	670	560	21.0	0.7
09.02.15	0930	11.1	1100	1100	1100	17.7	0.5
19.02.15	0905	933	1500	1200	1700	19.1	0.8
04.03.15	0855	662	3300	1500	3400	19.5	0.7
12.03.15	1210	14.6	1500	2000	1600	18.6	0.8
20.03.15	0910	1930	780	770	800	16.7	2.1

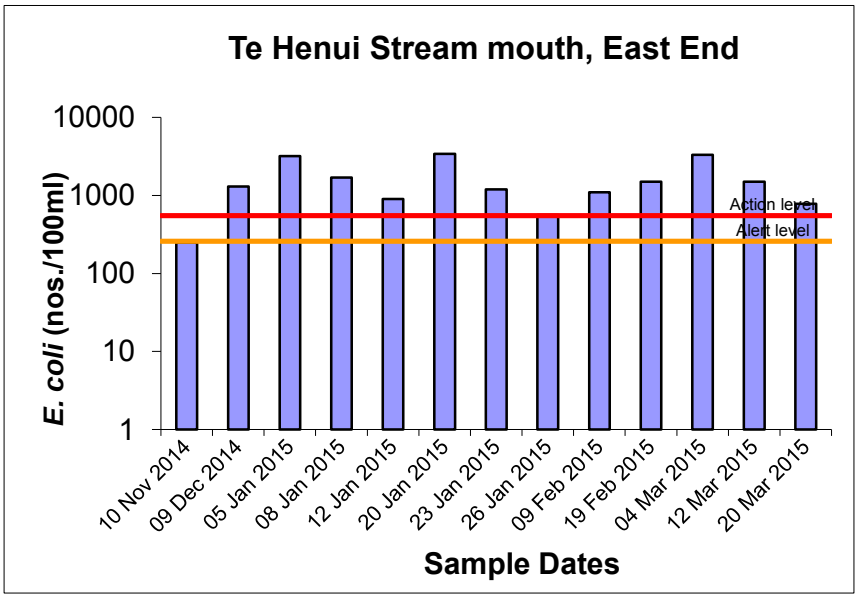


Figure 17 *E.coli* numbers for the Te Henui Stream at the mouth, East End during the regular survey season

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	10.0	2990	54.0
E. coli	nos/100ml	13	250	3400	1300
Enterococci	nos/100ml	13	130	2600	1000
Faecal coliforms	nos/100ml	13	250	3400	1300
Temperature	°C	13	15.1	21.5	19.0
Turbidity	NTU	13	0.4	7.4	0.7

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 6.4˚C between mid November and late March, with a maximum of 21.5˚C in mid January 2015. Conductivity and turbidity results were indicative of clean, clear, relatively high water quality subject to tidal incursions of seawater from time to time (e.g. under low to very low flow conditions mainly from late January 2015 to the end of the period). Extensive algal cover was recorded at intervals during the period.

Bacterial water quality in the 2014-2015 season was very poor with a wide range of counts and very high median *E. coli* count of 1300 per 100 mls 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	0 [0]	12 [92]

(Designation: freshwater contact recreational area)

Only one single sample was recorded below the 'Action' (and 'Alert') mode during the season. Bacteriological water quality measured at this site therefore was outside the acceptable standard for contact recreational usage for almost the entire survey period, and entirely within the 'Action' mode on these occasions. No additional sampling surveys were required as the source of these elevated counts was well established and documented. The one occasion on which the count was just below the 'Alert' mode was at the start of seasonal monitoring. 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 (i.e. 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 (1 per 100 mls) for the SEM season (TRC, 2015).

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 (nos/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
Minimum	150	160	220	260	220	240	550	500	69	350	300	250	250
Maximum	2600	8700	51000	9300	5200	2500	7700	3400	6800	13000	4200	7900	3400
Median	410	415	890	750	1100	1100	1100	930	985	1100	1500	1000	1300

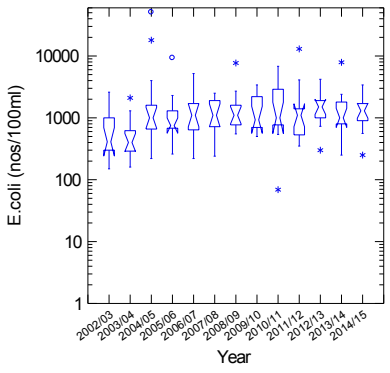
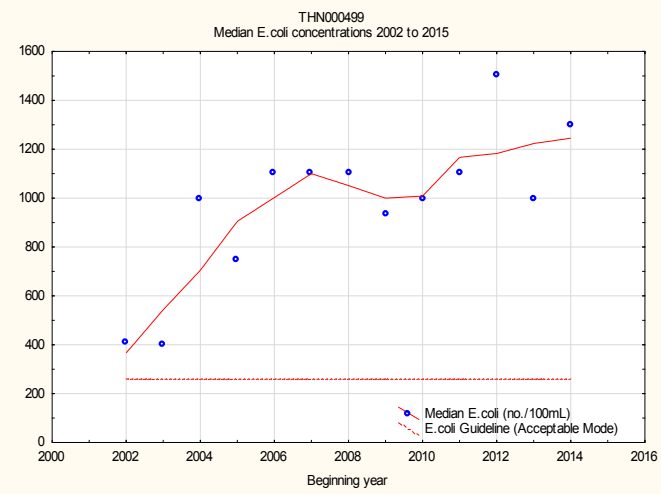


Figure 18 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers in the Te Henui Stream at the mouth, East End

The median *E. coli* number in the 2014-2015 period was the second highest median recorded to date (Table 30 and Figure 18), and well above the 'Alert' level of the 2003 MfE guidelines. All but two of the 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 thirteen 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.



N = 13
Kendall tau = + 0.532
p level = 0.011 [>FDR, p = 0.074]
Not significant at p < 0.05 after FDR

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 2015 period

A temporal trend of increasing median *E. coli* numbers has been found over the thirteen seasons of monitoring. (Note: This trend was statistically significant at p< 0.05 but not after FDR). 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
18/11/2014	0	No	No	Green (Surveillance)
02/12/2014	0	No	No	Green (Surveillance)
17/12/2014	2	No	No	Green (Surveillance)
14/01/2015	9	No	No	Green (Surveillance)
28/01/2015	0	No	No	Green (Surveillance)
11/02/2015	0	No	No	Green (Surveillance)
25/02/2015	0	No	No	Green (Surveillance)
12/03/2015	0	No	No	Green (Surveillance)
31/03/2015	0	No	No	Green (Surveillance)

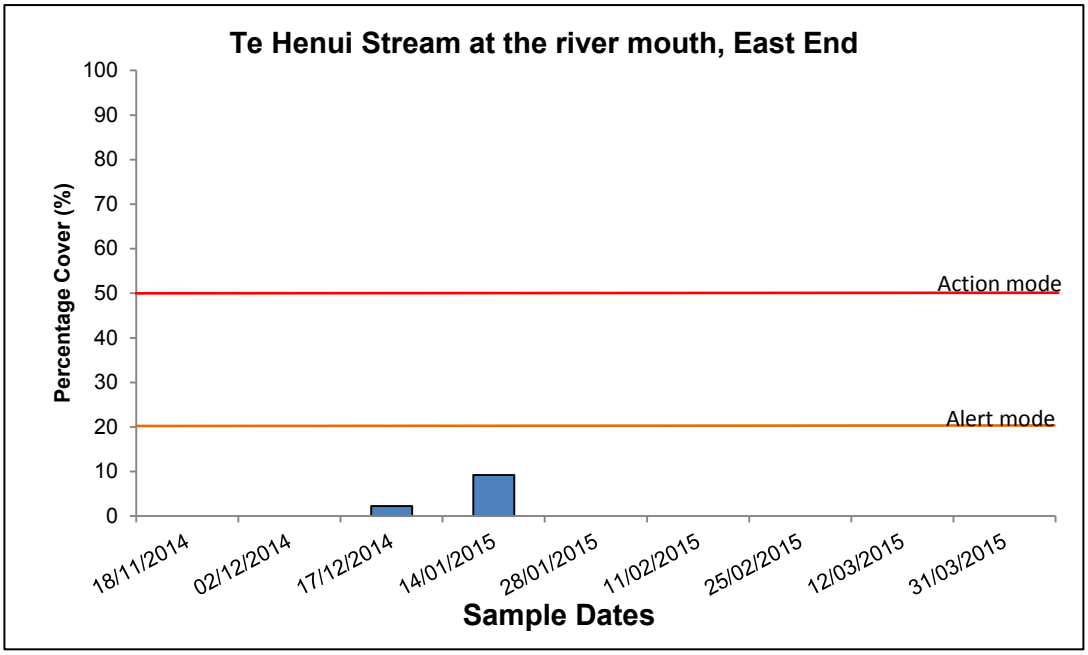


Figure 20 Percentage benthic cyanobacteria cover, at theTe Henui Stream at the mouth, East End site

Benthic cyanobacteria coverage was low throughout the season (ranging from 0% to 9%). 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 in relation to this aspect of water quality.

4.2.5 Patea River at King Edward Park, Stratford

No bathing and minimal picnicking or recreational usage of this river site was recorded at the time of sampling surveys, most of which were in the morning. Fishing has been noted on occasions at this site, particularly following the release of trout into the river for the 'Take a Kid Fishing' promotion in mid February of recent years.

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.

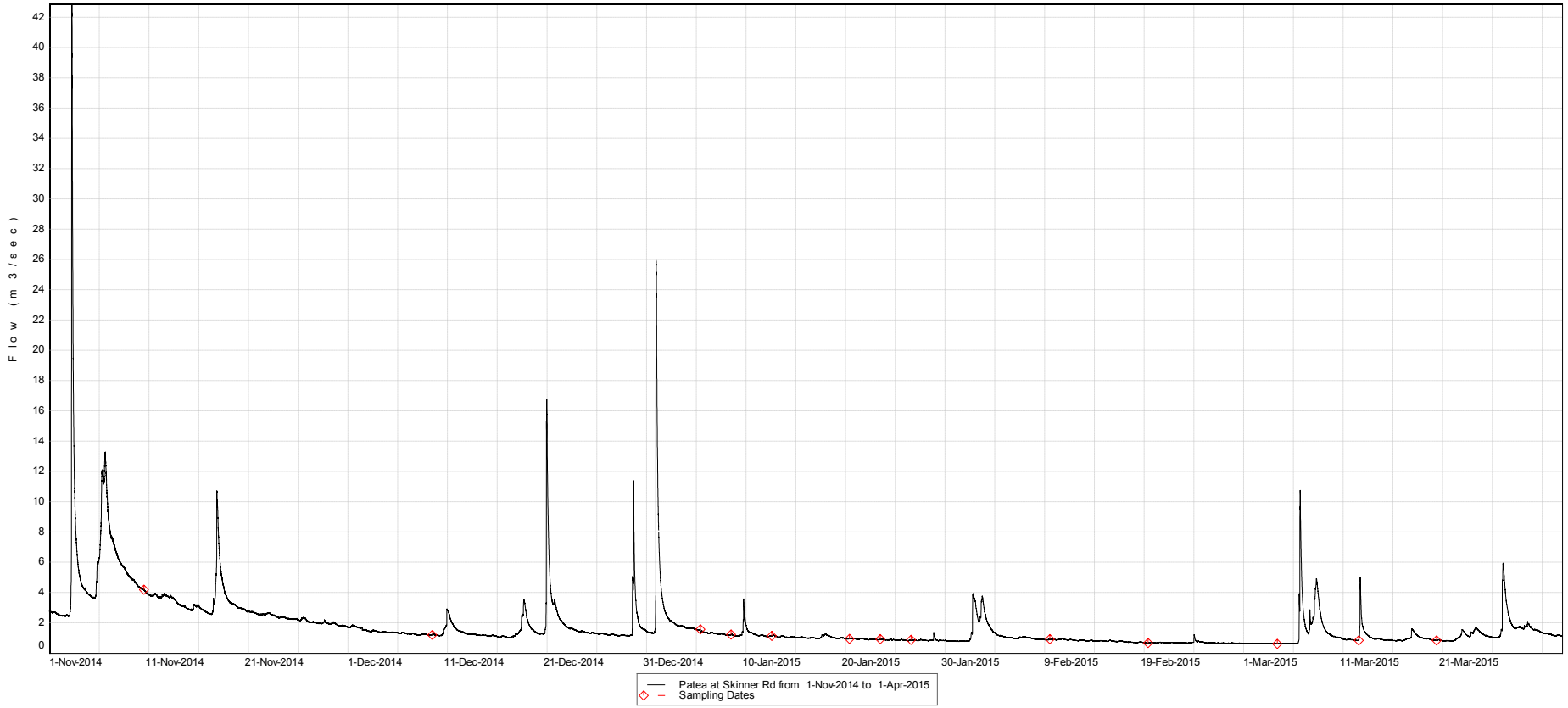


Figure 21 Flow in the Patea River at Skinner Rd during the survey period

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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1320	8.4	110	17	110	14.2	0.9
09.12.14	0800	9.6	760	88	760	14.5	1.1
05.01.15	1230	8.4	270	130	270	16.7	0.9
08.01.15	1350	8.7	220	100	220	18.3	0.8
12.01.15	1055	9.1	520	360	520	15.6	0.6
20.01.15	1145	9.4	490	430	490	16.2	0.7
23.01.15	1350	9.5	160	160	160	17.7	0.8
26.01.15	1115	9.7	380	960	380	17.8	0.7
09.02.15	0940	9.6	360	640	360	15.0	0.6
19.02.15	1135	9.9	280	730	300	14.2	0.7
04.03.15	1230	10.6	350	1100	350	16.8	1.0
12.03.15	0915	9.3	260	750	260	15.4	0.5
20.03.15	1145	8.7	280	570	290	10.8	0.8

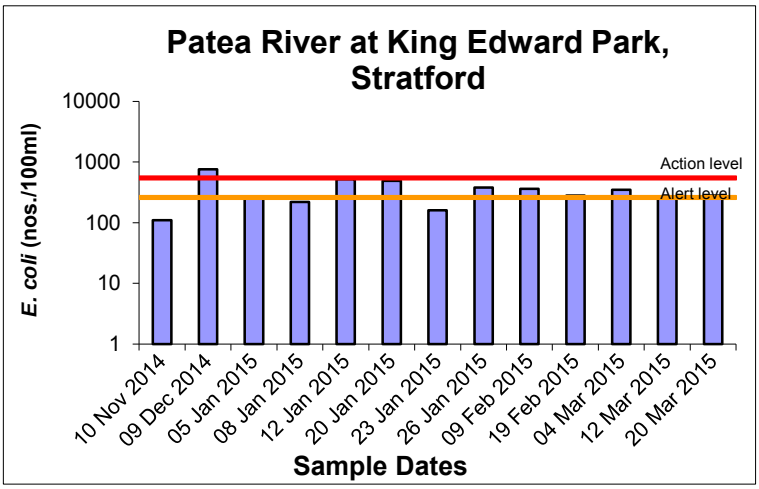


Figure 22 *E. coli* numbers for the Patea River at King Edward Park, Stratford during the survey season

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	8.4	10.6	9.4
E. coli	nos/100ml	13	110	760	280
Enterococci	nos/100ml	13	17	1100	430
Faecal coliforms	nos/100ml	13	110	760	300
Temperature	°C	13	10.8	18.3	15.6
Turbidity	NTU	13	0.5	1.1	0.8

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 in appearance with a relatively low and narrow range of conductivity levels.

Water temperatures had a moderate range of 7.5°C for this site (at an elevation of 300 m asl), with a maximum of 18.3°C recorded in early January 2015 (at 1350 hrs). All the samples were collected before 1355 hours and therefore the maximum river temperatures (which tend to occur later in the afternoon) which this site might experience over summer were not recorded.

Bacteriological water quality was moderate to poor for the mid reaches of this Taranaki ring plain river draining a predominantly agricultural catchment. Three moderately high counts were recorded during the survey period. Generally these did not necessitate further investigation as regular sampling which followed in late January 2015, found lower counts, although an elevated count (in the 'Alert' category) remained under extremely low flow conditions in mid January 2015 and again at the end of the season. A follow-up sample in mid December 2014 found a much lower (68 *E.coli*/100mls), well below the previous 'Action' level. However, 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. This was more typical of some previous seasons' surveys at which times it had 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. However, later in the current season, many of the consented dairy pond's discharges had ceased due to very dry weather conditions. One count entered the 'Action' level and eight counts entered the 'Alert' level (mainly in mid to late summer during very low flow conditions). Signage was placed at the site by the Stratford District Council (Photo 5) on the occasion of the 'Action' level. Appropriate publicity was provided throughout the season on the relevant websites.

Photo 5 Warning signage at King Edward Park site, December 2014

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	8 [62]	1 [8]

(Designation: freshwater contact recreational area)

One single sample fell within the 'Action' mode, and another eight samples fell in the 'Alert' mode. Most of these counts occurred between early January 2015 and early March 2015 under extremely dry and low flow conditions. In terms of the guidelines for contact recreational usage, bacteriological water quality at this site exceeded the 'Surveillance' level for a majority of the period, with one incursion into the 'Action' level. (Note: This was the most frequent number of results above the "Acceptable' level recorded at this site to date. As discussed in Section 2.1, it is only when results fall into the 'Action' grade that swimming is discouraged).

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 (fourteen 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
Minimum	46	120	48	96	100	28	46	51	51	54	63	37	62	110
Maximum	640	780	580	760	840	1000	690	570	7400	610	440	330	550	760
Median	250	190	110	300	310	200	290	200	250	160	150	180	240	280

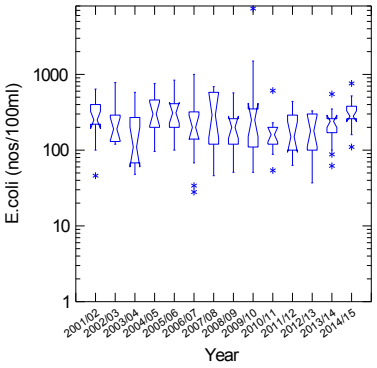
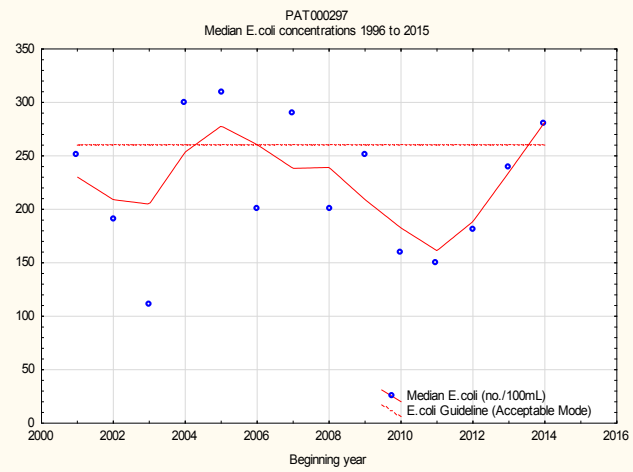


Figure 21 Box & whisker plots for all summer surveys of *E.* coli bacterial numbers for the Patea River at King Edward Park, Stratford

Some recent deterioration was indicated as the median *E. coli* bacterial count recorded for the 2014-2015 season was the fourth highest historical median count over the monitoring seasons and the highest since the 2007-2008 season. The 2014-2015 season recorded a relatively typical range of counts for this site although the minimum count was the second highest compared with those of all of the fourteen monitoring seasons to date.

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



N = 14
Kendall tau = -0.078
p level = 0.698 [>FDR, p = 0.907]
N/S at p < 0.05

Figure 22 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Patea River, King Edward Park site, for the 2000-2015 period

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

4.2.5.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on nine 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
18/11/2014	0	No	No	Green (Surveillance)
02/12/2014	0	No	No	Green (Surveillance)
17/12/2014	0	No	No	Green (Surveillance)
14/01/2015	0	No	No	Green (Surveillance)
28/01/2015	1	No	No	Green (Surveillance)
11/02/2015	0	No	No	Green (Surveillance)
25/02/2015	17	No	No	Green (Surveillance)
12/03/2015	0	No	No	Green (Surveillance)
31/03/2015	0	No	No	Green (Surveillance)

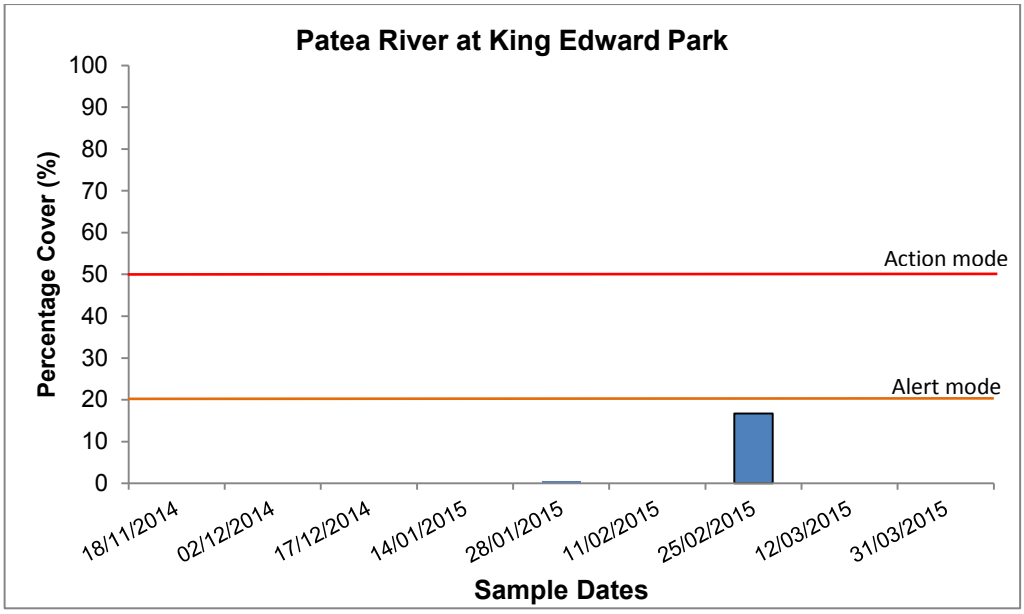


Figure 23 Percentage benthic cyanobacteria cover at the Patea River, King Edward Park site

Benthic cyanobacteria coverage was very low throughout the majority of the season (ranging from 0% to 17%). The benthic cyanobacteria found were a combination of *Phormidium* sp. and *Nostoc* sp. The 'Action' or 'Alert' level was not exceeded for percentage cover or for exposed or detaching mats and therefore no health warnings were necessary.

4.2.6 Patea River at the boatramp, Patea

Some bathing usage of this river site was recorded at the time of sampling surveys, all of which were before 1235 hrs. 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 boatramp site, but only under low tidal flow conditions.

Data from the site for the 2014-2015 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 boatramp, 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)
10.11.14	0945	4690	12	1	12	16.1	17
09.12.14	0915	4500	24	4	24	17.2	5.9
05.01.15	0830	3710	8	6	8	20.4	18
08.01.15	1020	4710	5	7	5	20.3	14
12.01.15	1230	4790	1	<1	1	22.6	8.9
20.01.15	0740	4700	11	1	11	21.1	19
23.01.15	0945	4650	4	4	4	21.4	15
26.01.15	1230	4630	1	<1	1	23.0	10
09.02.15	1100	4660	<1	4	1	19.7	35
19.02.15	0810	4680	9	4	9	19.0	40
04.03.15	1100	4770	4	7	4	21.1	3.5
12.03.15	1105	4150	20	18	20	20.3	29
20.03.15	0820	4730	<2	2	<2	17.1	22

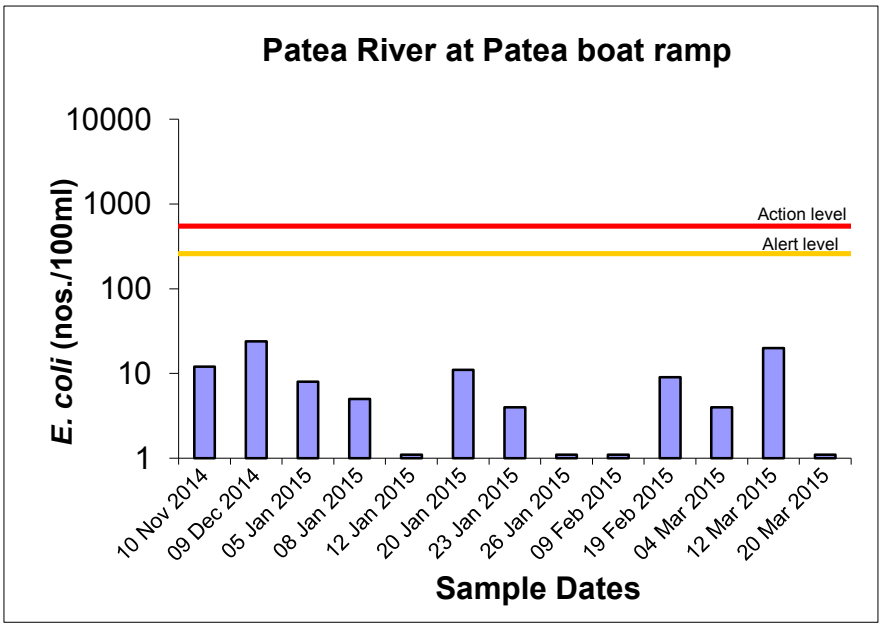


Figure 24 *E.coli* numbers for the Patea River at the boatramp, Patea during the survey season

Table 38 Statistical results summary for the Patea River at the boatramp, Patea

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	3710	4790	4680
E. coli	nos/100ml	13	<1	24	5
Enterococci	nos/100ml	13	<1	18	4
Faecal coliforms	nos/100ml	13	1	24	5
Temperature	°C	13	16.1	23.0	20.3
Turbidity	NTU	13	3.5	40	17

This ring plain river drains an extensively developed agricultural catchment. The survey site is situated some 45km downstream of the Patea HEP dam and 300 metres upstream of the river mouth. Flows in the lower river are regulated by operational requirements of the HEP station and associated consent conditions. There are consented dairy ponds' treated wastes discharges in the catchment upstream of the site and the consented upgraded Patea Wastewater Treatment Plant discharges upstream of the 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 6.9˚C, a more typical range due to the coastal seawater influence, with a maximum of 23.0˚C recorded in early afternoon in late January 2015 when the river was in very low flow. All of the samples were collected before 1235 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: 5 *E.coli* per 100 mls and 4 enterococci per 100 mls) 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 44 per 100mls (with counts ranging from 23 to 360 per 100 mls) 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

consistent with data for the nearby 'Mana' Bay coastal site adjacent to the river mouth monitored in the current season [median *E.coli*: 10 per 100 mls; range *E.coli:* 1-149 per 100 mls] for consent and SEM purposes.

4.2.6.2 Comparison with previous summers' surveys

Seven 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 (nos/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
Minimum	1	1	1	<1	1	1	<1	<1
Maximum	190	87	82	33	260	84	20	24
Median	5	9	11	4	16	3	3	5

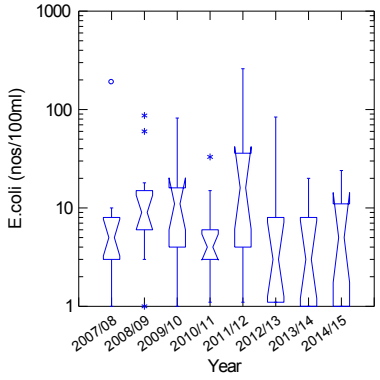


Figure 25 Box & whisker plots for all summer surveys of *E. coli* bacterial numbers for the Patea River at the boat ramp, Patea

Relatively similar (very low) median *E. coli* numbers have been found by these eight 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 narrower than all but one 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 most 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)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1300	10.4	46	3	46	15.7	1.9
09.12.14	0825	12.0	280	24	280	15.6	2.6
05.01.15	1200	10.7	190	19	190	18.9	1.2
08.01.15	1330	11.4	140	12	140	21.9	1.1
12.01.15	1120	11.3	260	54	260	19.2	1.1
20.01.15	1110	12.2	200	74	220	18.2	1.3
23.01.15	1330	11.9	96	16	96	21.3	1.1
26.01.15	1135	12.0	260	88	280	18.8	1.0
09.02.15	1005	12.3	440	320	440	16.5	1.5
19.02.15	1115	12.6	300	290	300	16.7	0.9
04.03.15	1215	13.1	220	360	220	18.8	1.2
12.03.15	1000	11.6	360	450	370	17.1	1.3
20.03.15	1125	10.8	280	350	280	12.1	1.0

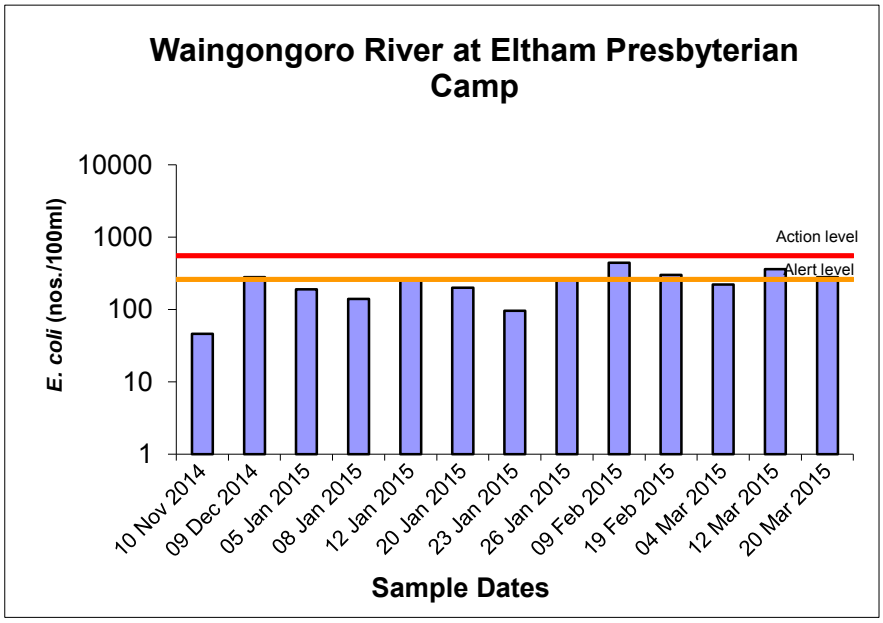


Figure 26 *E. coli* numbers for the Waingongoro River at Eltham Camp during the survey season

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	10.4	13.1	11.9
E. coli	nos/100ml	13	46	440	260
Enterococci	nos/100ml	13	3	450	74
Faecal coliforms	nos/100ml	13	46	440	260
Temperature	°C	13	12.1	21.9	18.2
Turbidity	NTU	13	0.9	2.6	1.2

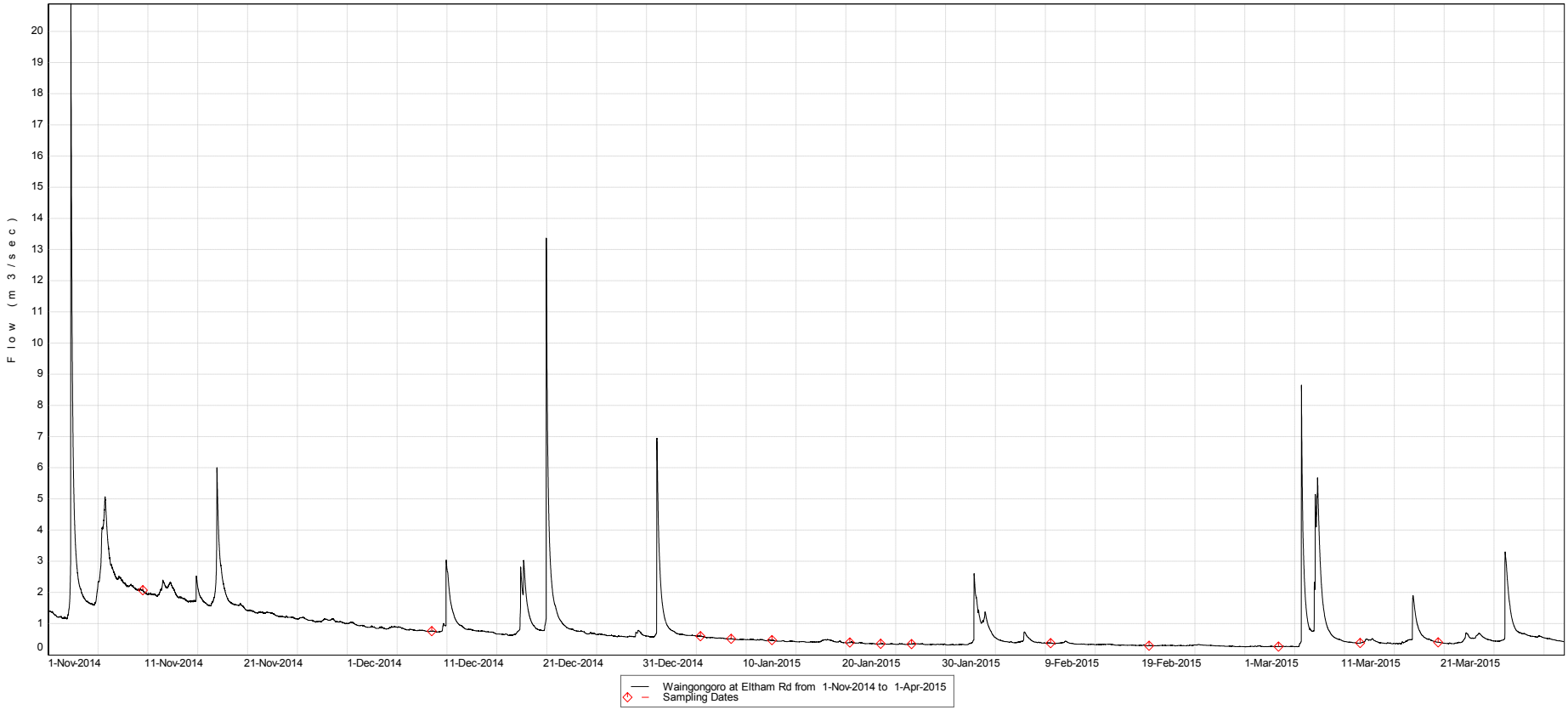


Figure 27 Flow in the Waingongoro River at Eltham during the survey period

This ring plain river drains an extensively developed agricultural catchment, with the survey site situated in Eltham some 21 km below the National Park boundary. River water was generally relatively clear to slightly turbid (occasionally) in appearance with moderate conductivity levels. Water temperatures were within a moderately wide range (9.8 ˚C) with a maximum of 21.9 ˚C recorded in early January 2015. All samples were collected before 1325 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: 260 per 100 mls) 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 100mls) has been recorded by monthly sampling since 1995. The higher counts in the current survey occurred under prolonged very low flow conditions in late summer with five samples in the 'Alert' mode (Figures 28 and 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	5 [38]	0 [0]

(Designation: freshwater contact recreational area)

Five single samples fell within the 'Alert' mode but no samples reached the 'Action' mode. The highest sample count (in the 'Alert' mode) occurred in early February 2015 during a very dry, low flow period and the counts remained elevated throughout these very low flow conditions until the end of the season. One 'Alert' level result was recorded in December 2014 but the count dropped to a lower level later by early January 2015. 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 for the majority of the period and no bacteriological warning signage was required during the period. It should be noted that most sampling occasions were prior to 1300 hrs, closer to dairy shed treatment pond systems' peak discharge periods.

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 (nos/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
Minimum	31	63	23	51	54	23	57	77	57	32	68	74	48	46
Maximum	870	550	360	1700	430	290	420	500	270	490	330	430	380	440
Median	230	230	100	170	130	110	160	130	160	140	150	160	240	260

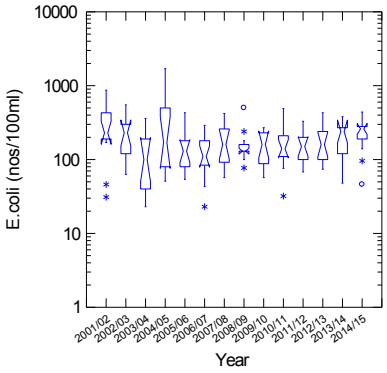
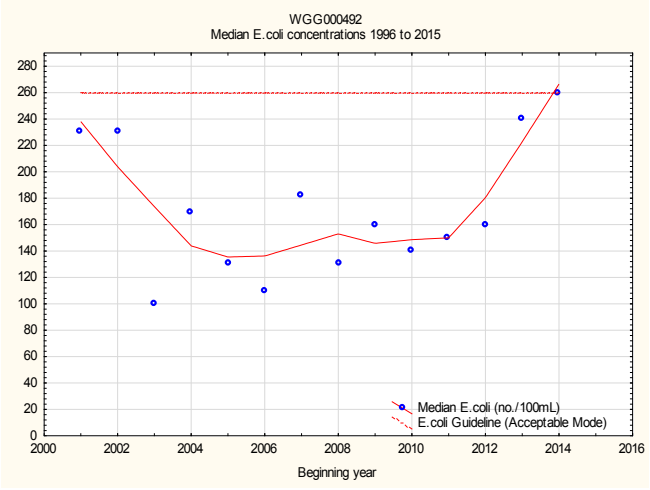


Figure 28 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waingongoro River at Eltham Camp

Poorer *E.coli* bacterial water quality was indicated by a median count which was the highest of the medians recorded by all of the fourteen preceding seasons to date (Figure 30). However, there was a range of counts over the 2014-2015 season (due to a more typical maximum) typical of many ranges in the thirteen other seasons monitored previously.

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 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 = 14
Kendall tau = + 0.201
p level = 0.316 [>FDR, p = 0.587]
N/S at p <0.05

Figure 29 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waingongoro River, Eltham camp for the 2000 to 2015 period

A statistically insignificant but relatively important temporal trend of increasing median *E.coli* numbers was found over the fourteen seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes although those of the two initial and two latest seasons were relatively high, particularly that of the latest season which was very close to the 'Alert' mode.

4.2.7.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on nine 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
18/11/2014	0	No	No	Green (Surveillance)
02/12/2014	0	No	No	Green (Surveillance)
17/12/2014	0	No	No	Green (Surveillance)
14/01/2015	3	No	No	Green (Surveillance)
28/01/2015	1	No	No	Green (Surveillance)
11/02/2015	0	No	No	Green (Surveillance)
25/02/2015	1	No	No	Green (Surveillance)
12/03/2015	2	No	No	Green (Surveillance)
31/03/2015	0	No	No	Green (Surveillance)

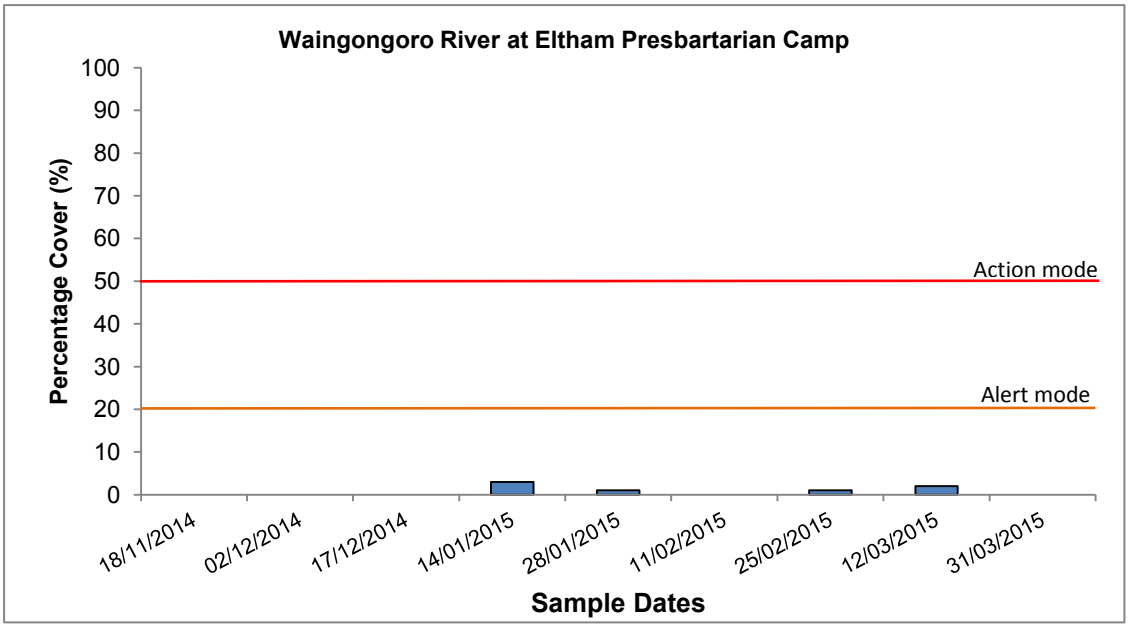


Figure 30 Percentage benthic cyanobacteria cover at the Waingongoro River Eltham camp

Benthic cyanobacteria coverage was very low throughout the season (ranging from 0% to 3%). The benthic cyanobacteria found were a combination of *Phormidium* sp and *Nostoc* 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

Occasional bathing usage of this site was recorded with the site used more frequently for whitebaiting (in season), fishing, and picnicking (sometimes with dogs also present). Occasionally stock have been present in the paddock upstream of the site but during the 2014-2015 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 and shags 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 2014-2015 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.

Table 46 Analytical results for the Waingongoro River at Ohawe Beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1035	15.6	200	90	200	15.1	3.5
09.12.14	1025	18.6	240	68	240	18.3	2.5
05.01.15	0930	17.8	200	86	210	20.2	1.7
08.01.15	1135	18.7	66	62	66	22.6	1.3
12.01.15	1330	19.1	84	35	84	23.1	1.4
20.01.15	0840	19.0	200	220	210	20.8	1.9
23.01.15	1055	19.7	77	40	80	21.9	1.3
26.01.15	1340	19.9	92	11	96	24.7	1.2
09.02.15	1200	20.8	210	100	220	19.3	1.2
19.02.15	0910	20.8	180	150	190	20.0	1.0
04.03.15	0955	21.9	630	520	630	21.1	1.4
20.03.15	0920	19.1	240	440	240	14.1	1.0
01.04.15	0830	17.6	200	190	200	15.4	1.2

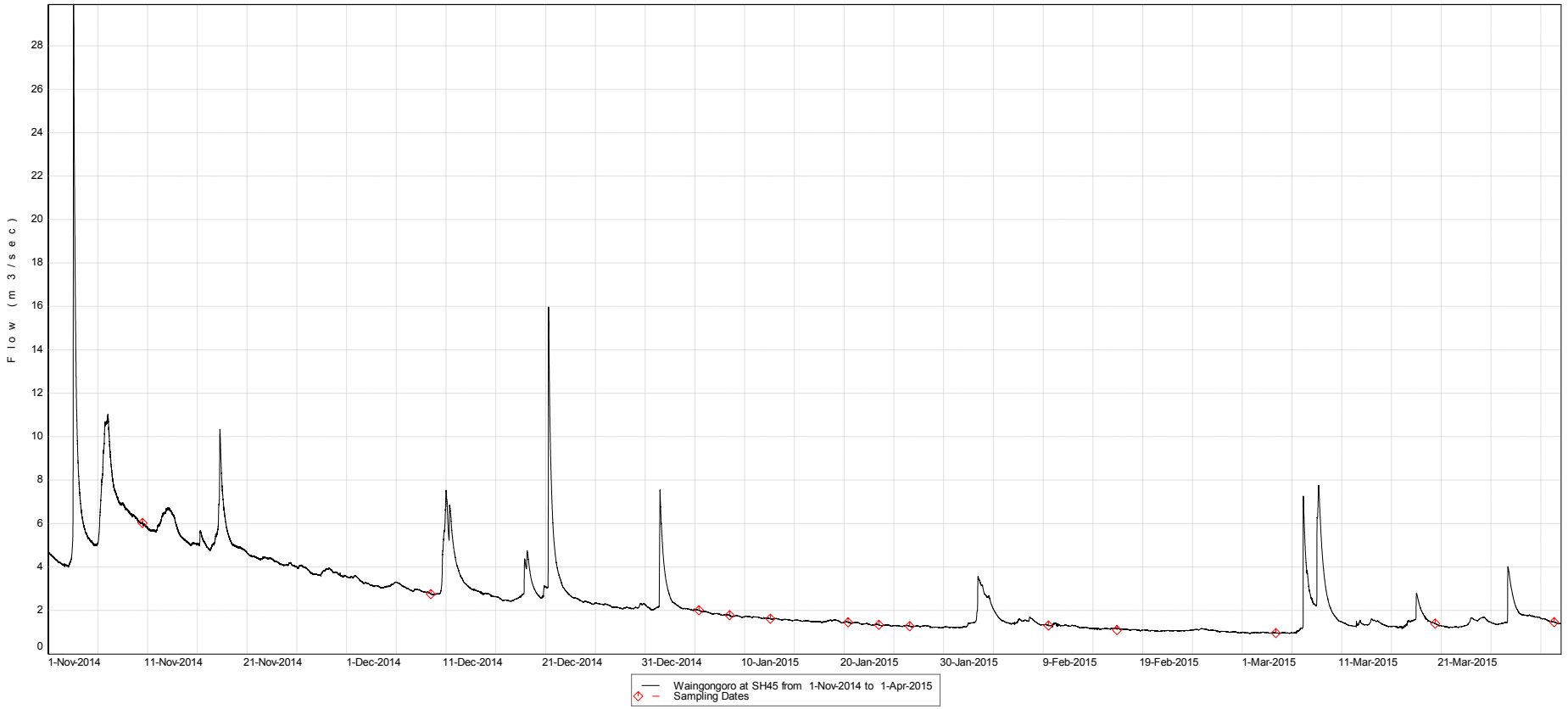


Figure 31 River flow in the Waingongoro River at SH45 during the survey period

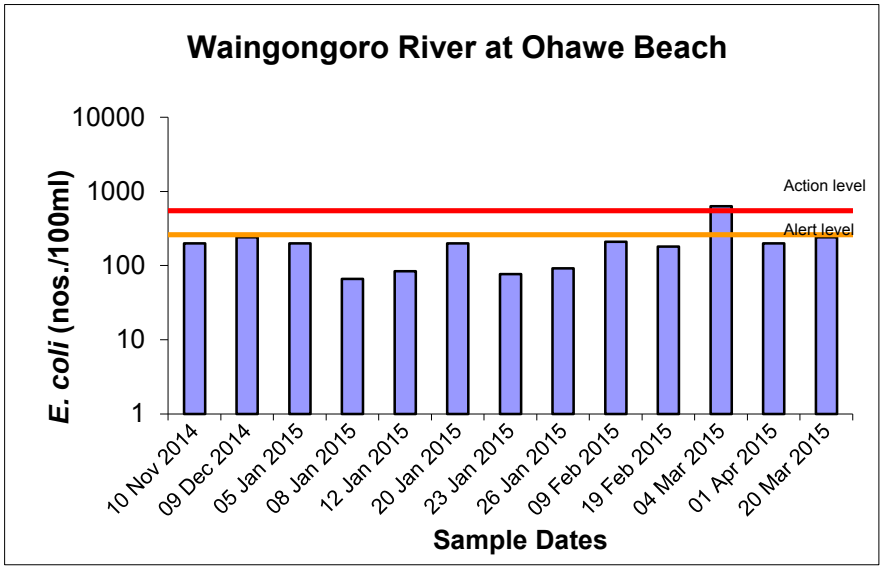


Figure 32 *E.coli* numbers for the Waingongoro River at Ohawe Beach during the survey season

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	15.6	21.9	19.1
E. coli	nos/100ml	13	66	630	200
Enterococci	nos/100ml	13	11	520	90
Faecal coliforms	nos/100ml	13	66	630	200
Temperature	°C	13	14.1	24.7	20.2
Turbidity	NTU	13	1.0	3.5	1.3

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. These conditions were less prevalent at sampling times during the 2014-2015 season, despite very low flow conditions in late summer.

The range of water temperatures was relatively wide (10.6˚C) with a maximum of 24.7˚ C recorded in early afternoon in late January 2015. However, as sampling was not performed after 1340 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: < 2.5 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 220 per 100 mls (and range from 3 to 41,000 per 100 mls). Uncontrolled stock 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	0 [0]	1 [8]

(Designation: freshwater contact recreational area)

One single sample was recorded in the 'Action' category in early March, 2015 but no samples were found in the 'Alert' mode. No reason was apparent for this isolated exceedance of the guidelines and follow-up regular sampling at this site in mid March 2015 found a return to a typical level. Counts were generally less than 245 *E.coli* per 100 mls despite late summer- autumn very low flow conditions.

Bacteriological water quality at this site was within the acceptable guidelines for contact recreational usage for almost 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 eighteen 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 (nos/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
Minimum	88	43	17	34	38	46	31	43	54	31	31	9	31	26	8	43	46	34	66
Maximum	310	650	300	240	850	660	14000	280	940	380	410	5000	870	1000	180	2800	2300	370	630
Median	185	130	80	180	170	160	110	110	130	96	100	100	120	96	100	96	110	120	200

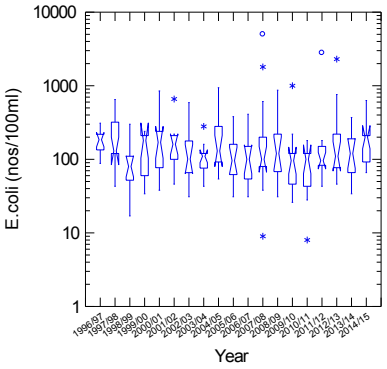
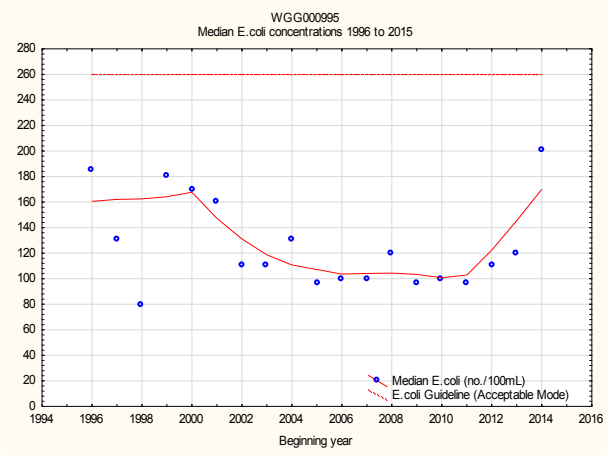


Figure 33 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Waingongoro River at Ohawe Beach

Median *E. coli* bacteria number for the 2014-2015 period was higher (by 15 to 120 per 100 mls) than found in each of the previous eighteen seasons, a deterioration from the general trend of improvement in bacterial water quality recorded over the previous thirteen seasons (Figure 31).

A moderate range of *E. coli* numbers was recorded in the recent 2014-2015 period in comparison with past seasons' ranges, as a result of one of the lower seasonal maximum counts.

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 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 = 19
Kendall tau = - 0.217
p level = 0.193 [>FDR, p = 0.501]
Not significant at p< 0.05,.

Figure 34 LOWESS trend plot of median *E.coli* numbers (per 100ml) for the 1996 to 2015 period at the Waingongoro River Ohawe beach site

A decreasing trend in median *E.coli* number was found over the nineteen seasons of monitoring and the decrease has been particularly apparent over twelve of the previous thirteen seasons. The trend had been statistically significant at the $p < 0.05$ level after the 2013-2014 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 14 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 (* = exposed mats)

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
18/11/2014	3	No	No	Green (Surveillance)
02/12/2014	0	No	No	Green (Surveillance)
17/12/2014	4	No	No	Green (Surveillance)
14/01/2015	48	Yes	Yes	Red (Action)*
21/01/2015	32	No	No	Amber (Alert)
28/01/2015	33	No	Yes	Amber (Alert)
04/02/2015	15	No	Yes	Amber (Alert)
11/02/2015	23	Yes	No	Red (Action)*
19/02/2015	45	No	No	Amber (Alert)
25/02/2015	25	No	No	Amber (Alert)
04/03/2015	37	No	No	Amber (Alert)
12/03/2015	22	No	No	Amber (Alert)
18/03/2015	13	No	No	Green (Surveillance)
31/03/2015	12	No	No	Green (Surveillance)

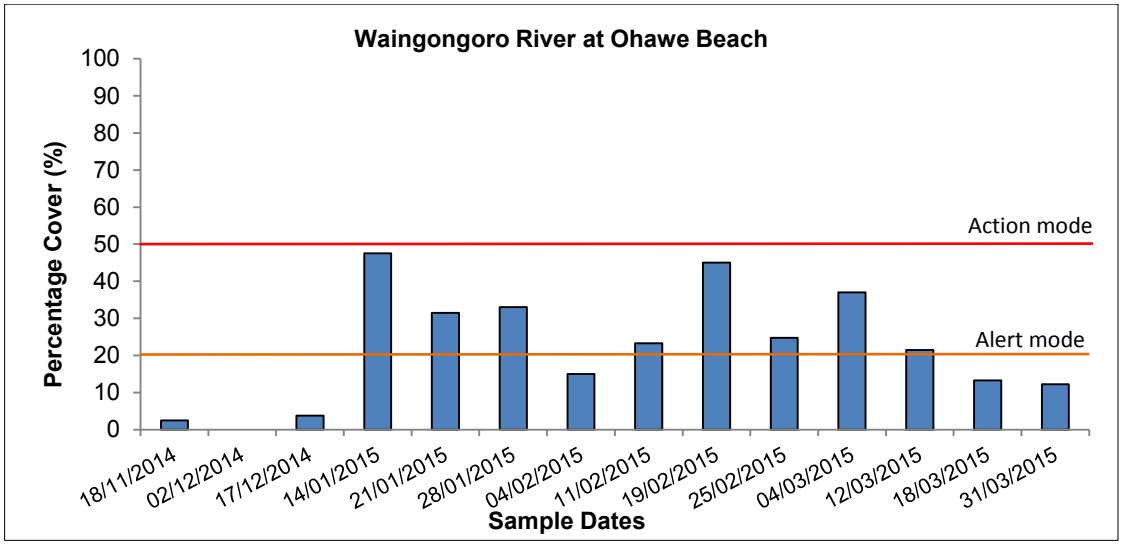


Figure 35 Percentage benthic cyanobacteria cover, for the Waingongoro River Ohawe beach site

Benthic cyanobacteria coverage was low over the first two months of the season but increased to relatively high levels through the latter part of summer and early autumn (ranging from 0% to 48%). The benthic cyanobacteria found were *Phormidium* sp. However the 'Action' level was not exceeded for percentage cover but the 'Alert' level was exceeded on eight occasions and the site had the highest average cyanobacteria coverage of the nine sites monitored in the region. Furthermore, exposed or detached mats were observed on four separate occasions triggering either an 'Action' or 'Alert' response requiring appropriate signage to be erected and maintained by STDC. This signage was subjected to vandalism soon after erection (Photo 6).

Photo 6 Vandalised cyanobacteria health warning signage, Waingongoro River, Ohawe; January 2015

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 very 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 2014-2015 season are provided in Figure 38. Data from this site are presented in Table 51 and illustrated in Figure 39, 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1115	15.7	92	74	96	16.6	2.0
09.12.14	1050	16.8	120	52	120	18.8	2.3
05.01.15	1005	17.0	310	100	350	21.0	1.6
08.01.15	1200	17.3	88	62	88	22.6	1.6
12.01.15	1400	17.4	54	33	54	24.6	1.8
20.01.15	0910	145	490	310	510	20.2	4.3
23.01.15	1120	36.5	74	44	74	21.6	1.3
26.01.15	1410	17.4	120	54	120	25.0	2.6
09.02.15	1230	17.9	80	77	80	20.5	1.1
19.02.15	0945	59.0	320	160	320	19.4	1.0
04.03.15	0910	18.2	220	250	220	19.6	0.9
20.03.15	0950	47.8	290	300	290	13.8	1.6
01.04.15	0900	16.3	290	310	290	16.2	1.5

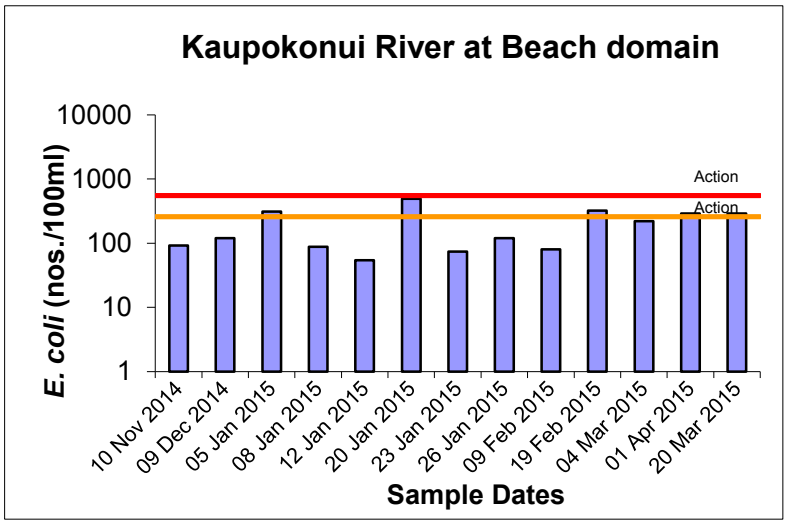


Figure 36 *E. coli* numbers for the Kaupokonui River at the beach domain during the survey season

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	15.7	145	17.4
E. coli	nos/100ml	13	54	490	120
Enterococci	nos/100ml	13	33	310	77
Faecal coliforms	nos/100ml	13	54	510	120
Temperature	°C	13	13.8	25.0	20.2
Turbidity	NTU	13	0.9	4.3	1.6

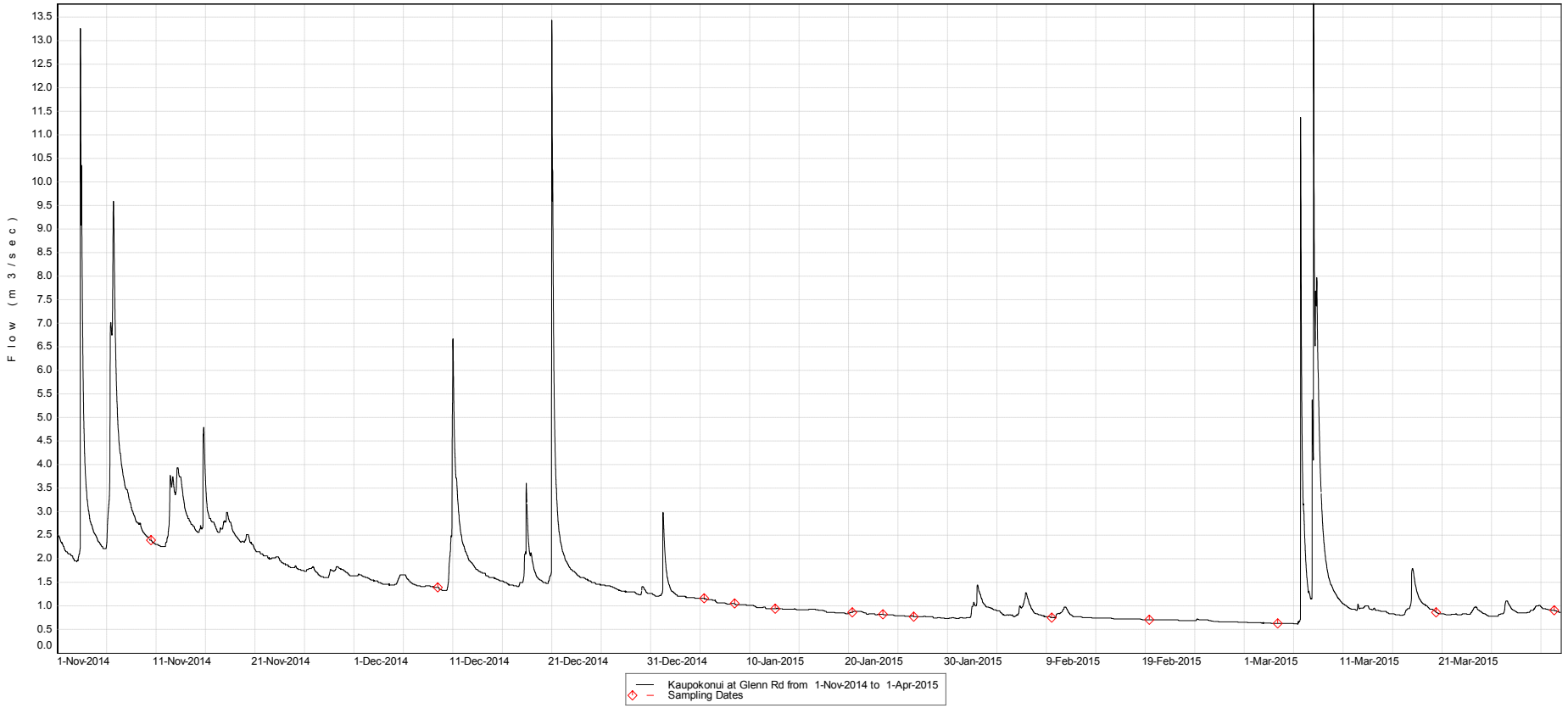


Figure 37 River flow in the Kaupokonui River at Glenn Rd during the survey period

This river also drains an extensively farmed catchment and receives point source wastes discharges from dairy pond wastes treatment systems, and in its mid-reaches from 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 four occasions indicated some seawater influence near high tide under very low flow conditions during late summer–early autumn. Otherwise, these conductivity levels were relatively stable (15.7 to 18.2 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. 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 11.2°C with a maximum of 25.0°C recorded in late-January 2015. This temperature was recorded at 1410 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 1235 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.

Five 'Alert' levels were recorded, particularly under very low flow conditions late in the season but lower counts were recorded by following surveys in all but one case. 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 2014-2015 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	5 [38]	0 [0]

(Designation: freshwater contact recreational area)

Five individual samples were recorded in the 'Alert' mode during the season but no samples entered the 'Action' mode. Limited, localised rainfall immediately preceded three of these counts with numbers returning to typical levels subsequent to most exceedances.

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 nineteen 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 (nos/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
Minimum	26	31	3	7	17	46	46	<8	40	14	26	15	29	20	20	17	28	11	54
Maximum	360	2100	580	780	2000	400	630	200	880	280	2500	850	890	440	340	290	540	270	490
Median	110	360	130	80	120	110	130	77	92	160	140	77	210	100	76	120	140	110	120

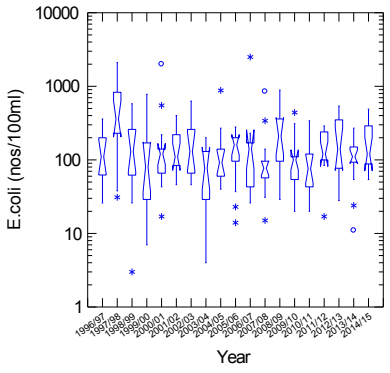
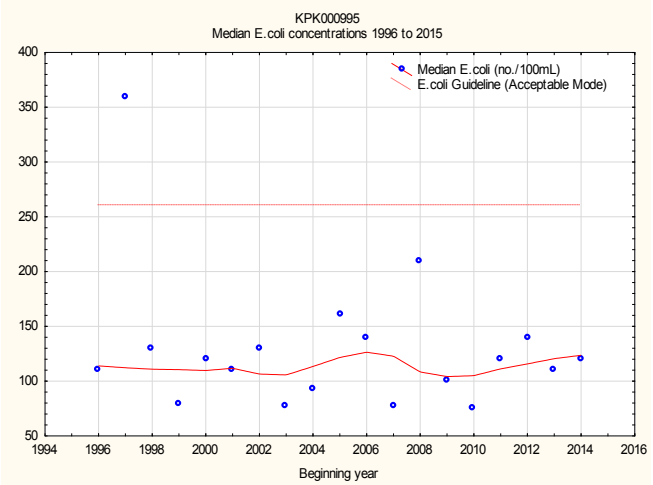


Figure 38 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Kaupokonui River at the Beach Domain

Typical *E. coli* bacterial water quality in terms of median number but a narrower range compared with many of the previous eighteen survey seasons, were recorded over the 2014-2015 season (Figure 40). The median *E. coli* count was in the mid-range of all other seasons' medians to date (Table 54) and the seasonal maximum was also in mid range of those for the 19 years of record.

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 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 = 19
Kendall tau = -0.048
p level = 0.774 [>FDR p = 0.914]
N/S at p < 0.05

Figure 39 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Kaupokonui River beach domain site for the 1996 to 2015 period

A very slight, unimportant, and statistically insignificant decreasing trend in median *E. coli* counts was found over the nineteen 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 11 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
18/11/2014	2	No	No	Green (Surveillance)
02/12/2014	6	No	No	Green (Surveillance)
17/12/2014	5	No	No	Green (Surveillance)
14/01/2015	12	No	No	Green (Surveillance)
28/01/2015	18	No	No	Green (Surveillance)
04/02/2015	8	No	No	Green (Surveillance)
11/02/2015	23	No	No	Amber (Alert)
19/02/2015	21	No	No	Amber (Alert)
25/02/2015	13	No	No	Green (Surveillance)
12/03/2015	3	No	No	Green (Surveillance)
31/03/2015	6	No	No	Green (Surveillance)

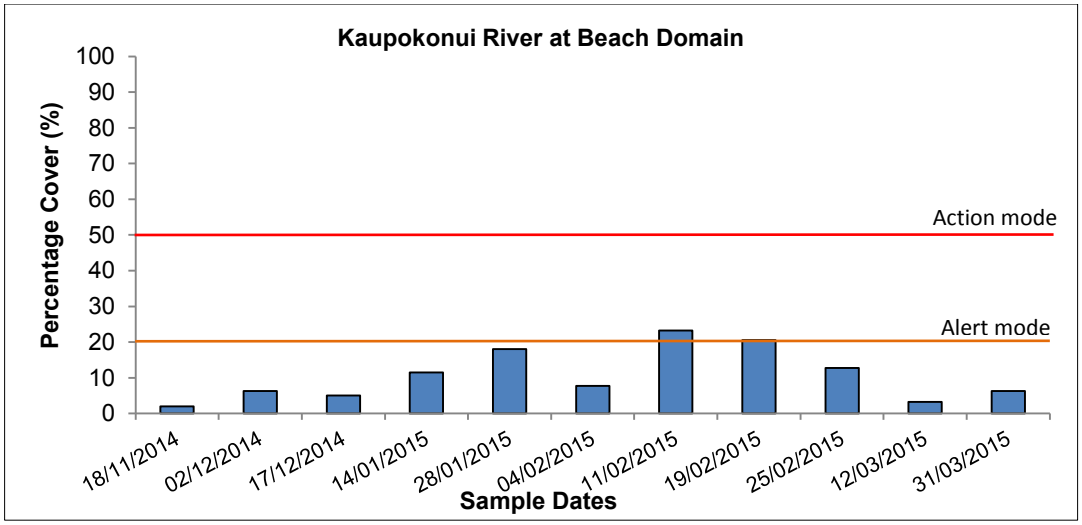


Figure 40 Percentage benthic cyanobacteria cover for the Kaupokonui River at the Beach Domain site

Benthic cyanobacteria coverage was low during early season but increased through the latter part of summer and early autumn (ranging from 2% to 23%). The benthic cyanobacteria found were a combination of *Phormidium* sp. and *Nostoc* sp. The 'Action' level was not exceeded for percentage cover but the 'Alert' level was exceeded on two occasions. The 'Action' or 'Alert' level was not reached for the presence of exposed or detaching mats and no health warnings were required at this site.

4.2.10 Lake Opunake

No bathing and minimal boating usage of the lake was noted on any occasion, but picnicking activities (sometimes with dogs present) were recorded occasionally at the time of sampling surveys. 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1150	13.2	48	27	50	18.1	0.9
09.12.14	1145	12.3	270	1500	280	20.7	1.4
05.01.15	1100	12.6	390	1300	420	23.7	1.1
08.01.15	1250	13.8	8	180	8	24.3	2.2
12.01.15	1500	14.1	5	800	5	25.0	0.9
20.01.15	1025	14.3	390	740	390	24.0	0.9
23.01.15	1250	14.8	11	210	11	25.2	1.0
26.01.15	1505	14.7	4	180	4	27.6	0.7
09.02.15	1350	13.8	140	1000	140	19.8	0.7
19.02.15	1040	14.7	120	660	120	21.0	0.9
04.03.15	0835	15.8	70	140	70	21.7	1.4
12.03.15	1425	14.2	66	140	66	19.5	1.0
20.03.15	1020	13.9	56	160	56	14.5	1.0

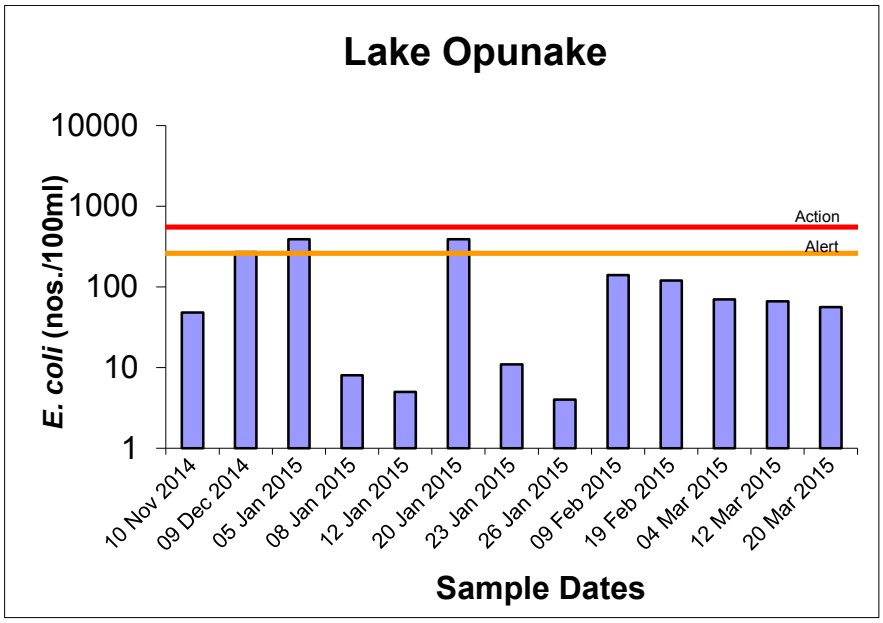


Figure 41 *E. coli* numbers for Lake Opunake during the survey season

Table 57 Statistical results summary for Lake Opunake

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	12.3	15.8	14.1
E. coli	nos/100ml	13	4	390	66
Enterococci	nos/100ml	13	27	1500	210
Faecal coliforms	nos/100ml	13	4	420	66
Temperature	°C	13	14.5	27.6	21.7
Turbidity	NTU	13	0.7	2.2	1.0

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: 1.0 NTU; range of turbidity: 1.5 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 21.7˚C) for half of the period with a very high maximum of 27.6˚C (in late January 2015) and a relatively wide range of 13.1˚C. Conductivity varied over a narrow range (3.5 mS/m @ 20˚C) reflecting river inflow conditions.

Generally bacteriological quality was moderate to relatively good, influenced in part by the inflow to the lake originating from the lower reaches of a river draining a developed catchment but more so by the local wildfowl population. Elevated numbers, above 260 *E. coli* per 100 mls, were found from time to time but more so in the earlier half of the season co-incidental with higher wildfowl numbers in the immediate vicinity of the site. Marked fluctuations in counts 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	3 [23]	0 [0]

(Designation: freshwater contact recreational area)

No single sample exceedances of the 'Action' mode occurred during the period but three single samples were recorded within the 'Alert' mode. Sampling subsequent to the 'Alert' levels showed much lower *E. coli* numbers within three days of exceedances on two occasions. There was no immediate requirement for the installation of 'health warning' signage by STDC but publicity was given to the state of the lake on both relevant websites.

4.2.10.2 Comparison with previous summers' surveys

A statistical comparison of all of the 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 (nos/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
Minimum	33	26	54	64	8	40	17	<8	4
Maximum	720	1300	2800	320	3800	2000	500	430	390
Median	110	130	210	220	80	80	120	100	66

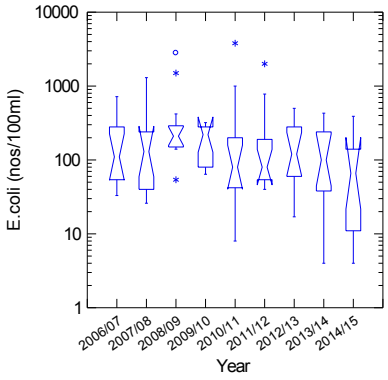


Figure 42 Box and whisker plots for the summer SEM survey of *E. coli* bacteria numbers at Lake Opunake

The median *E. coli* number in the 2014-2015 season was the lowest of the nine seasons' surveys to date and a relatively narrow range of counts was also found, (Figure 40). This was only the fourth occasion in which no 'Action' levels were recorded during the season.

Trend analysis of median *E. coli* numbers will not be performed for this site until ten seasons' data are available.

4.2.10.3 Cyanobacteria

Microscopic scans of seven samples were performed for the presence and enumeration of cyanobacteria during the season. The results of these analyses are presented in Table 60.

Table 60 Cyanobacteria counts (cells/ml) for Lake Opunake [Health warning: >15,000 cells/ml: > 1.8 mm^3/L]

Date	Total cell count (cells/ml)	Principal taxa	Biovolume (mm^3/L)
18.11.14	nil	-	0
02.12.14	nil	-	0
15.01.15	nil	-	0
29.01.15	nil	-	0
13.02.15	nil	-	0
26.02.15	nil	-	0
17.03.15	nil	-	0

No cyanobacteria were detected in any of these samples. 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.

Data from this site for the 2014-2015 season are presented in Table 61 and illustrated in Figure 45, 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1000	10.9	63	25	63	15.9	0.5
09.12.14	1050	12.8	210	100	210	18.0	0.3
05.01.15	0900	30.2	170	140	180	19.0	0.2
08.01.15	1045	118	190	78	190	20.7	0.4
12.01.15	1320	19.5	84	87	84	24.9	0.4
20.01.15	1035	2580	2000	1600	2000	21.3	4.5
23.01.15	1125	546	88	84	88	21.1	1.1
26.01.15	1430	181	160	120	160	23.0	1.1
09.02.15	1210	11.0	220	320	220	18.9	0.4
19.02.15	1045	786	650	660	660	19.5	0.9
04.03.15	1030	346	470	520	470	20.0	0.7
12.03.15	1330	53	370	380	390	19.0	0.8
20.03.15	1045	574	550	430	550	16.3	0.9

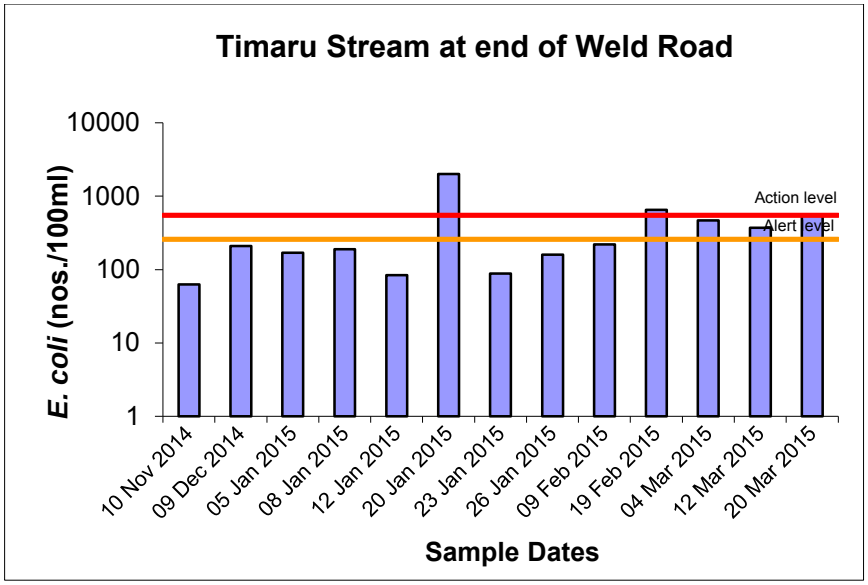


Figure 43 *E.coli* numbers for the Timaru Stream at Weld Road during the survey season

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	10.9	2580	118
E. coli	nos/100ml	13	63	2000	210
Enterococci	nos/100ml	13	25	1600	140
Faecal coliforms	nos/100ml	13	63	2000	210
Temperature	°C	13	15.9	24.9	19.5
Turbidity	NTU	13	0.2	4.5	0.7

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 several occasions 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 moderately wide range of 9.0°C with a maximum water temperature of 24.9°C recorded in early afternoon in mid January 2015. 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. 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	3 [23]	2 [15]

(Designation: freshwater contact recreational area)

Three single samples were recorded in the 'Alert' mode, and two were recorded in the 'Action' mode during the period. One occurrence was soon after localised rainfall (in mid-January 2015). Poorer bacteriological water quality tended to coincide with dry weather and moderate seawater intrusion on at least four occasions. Although the erection of health warning signage was necessary on the occasions when singles sample entered the 'Action' mode, public advice was also provided on both websites. The bacterial count fell below the 'Action' mode at the times of the following surveys although remaining in the 'Alert' mode later in the season.

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 eighteen summers) are summarised in Table 64 and illustrated in Figure 46.

Table 64 Summary of *E. coli* bacteriological water quality data to date (nos/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
Minimum	40	23	31	77	31	140	77	84	38	43	46	92	46	28	34	26	54	63
Maximum	410	710	1400	540	660	1000	410	1000	460	480	930	440	560	410	440	550	660	2000
Median	280	210	160	180	180	260	220	260	220	200	180	230	290	180	160	250	200	210

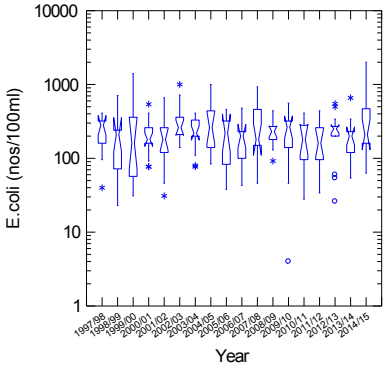


Figure 44 Box and whisker plots for all summer surveys of *E.coli* bacterial numbers in the Timaru Stream at lower Weld Road

The median *E. coli* count for the 2014-2015 season was typical of past seasons (Table 64) near the middle of the range of previous seasons' median counts. Counts over the 2014-2015 season had a wider range (Figure 46), with two counts reaching the 'Action' mode, due to a higher seasonal maximum than those found over the 17 previous years of monitoring.

Trend analysis of these median *E. coli* numbers has been performed for the eighteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 47) 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.

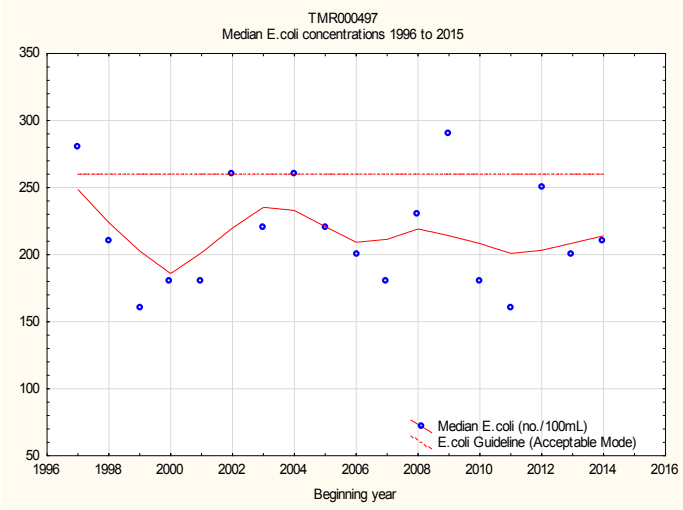


Figure 45 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Timaru Stream, lower Weld Road site for the 1997 to 2015 period

An overall very slight, unimportant, decreasing trend in median *E. coli* numbers has been found over the eighteen 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 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 2014-2015 period.

4.2.13 Oakura River below SH45

Bathing usage was recorded on several occasions at this site where people were often present (occasionally fishing (including whitebating in season)) on the riverbank at this very accessible tidal site. Ponding and upstream surging frequently occurred under high tide conditions and gulls and dogs were recorded occasionally on or in the river. Stock access, apparent early in the previous season (TRC, 2014), was not recorded during the current period.

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 2014-2015 season are presented in Table 65 and illustrated in Figure 48, 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1040	7.7	80	12	80	16.5	0.5
09.12.14	1015	7.2	48	19	51	17.3	0.3
05.01.15	0955	42.6	68	110	68	18.8	0.5
08.01.15	1135	9.4	140	96	140	20.4	0.5
12.01.15	1400	9.3	56	120	56	21.0	0.3
20.01.15	1000	1850	1600	2000	1600	19.9	5.4
23.01.15	1050	59.2	80	120	80	20.3	0.4
26.01.15	1330	183	180	260	180	21.8	0.5
09.02.15	1135	8.2	100	210	100	18.2	0.3
19.02.15	1005	632	460	650	470	18.4	0.9
04.03.15	0940	186	440	320	470	19.7	0.5
12.03.15	1255	9.6	200	370	200	18.4	0.5
20.03.15	1000	985	120	640	120	14.4	0.8

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	7.2	1850	43
E. coli	nos/100ml	13	48	1600	120
Enterococci	nos/100ml	13	12	2000	210
Faecal coliforms	nos/100ml	13	51	1600	120
Temperature	°C	13	14.4	21.8	18.8
Turbidity	NTU	13	0.3	5.4	0.5

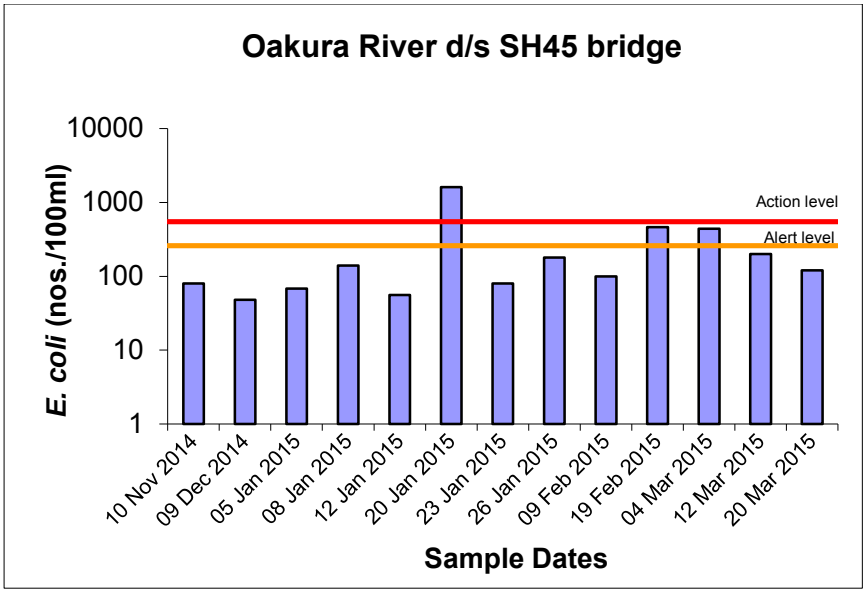


Figure 46 *E. coli* numbers for the Oakura River below SH45 during the survey season

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 six sampling occasions. Conductivity levels indicated a variable influence of saltwater intrusion on at least seven sampling occasions during the season. The more significant intrusions occurred mainly during very low flow conditions during the latter half of this season. On all but one occasion the river was clear in appearance with no algal substrate cover due to the sandy nature of much of the substrate. Water temperatures varied over a moderate range (7.4°C) during the period reaching a maximum of 21.8°C in early afternoon in late January 2015, but below the maximum water temperature which might be anticipated later in the day as all sampling at this site occurred no later than 1400 hrs.

Bacteriological water quality was moderate, with the majority of *E. coli* counts below 200 per 100 mls. 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. An elevated count in mid January 2015, which entered the 'Action' mode of the guidelines, was coincident with upstream flow and marked saltwater intrusion under very low flow conditions while regular sampling, three days after this elevated count, found a much lower *E. coli* count (80 per 100 mls).

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	2 [15]	1 [8]

(Designation: freshwater contact recreational area)

Two single samples fell within the 'Alert' mode, and one sample entered the 'Action' mode. These were under very low flow conditions in the latter half of the season although the 'Action' mode result in mid-January, 2015 followed recent localised rainfall. Although health warning signage was required to be displayed at this site by NPDC on one very brief occasion, it was not actioned; but appropriate public advice was provided on the two websites.

Bacteriological water quality was generally typical for the lower reaches of a Taranaki ringplain stream and 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 49.

Table 68 Summary of *E. coli* bacteriological water quality data (nos/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
Minimum	7	28	42	24	23	31	26	43	11	46	23	31	34	60	19	11	31	16	48
Maximum	260	1100	240	540	310	580	420	1200	820	380	330	2400	450	2500	290	440	530	220	1600
Median	34	110	100	77	80	120	120	120	140	160	220	140	180	150	100	140	140	86	120

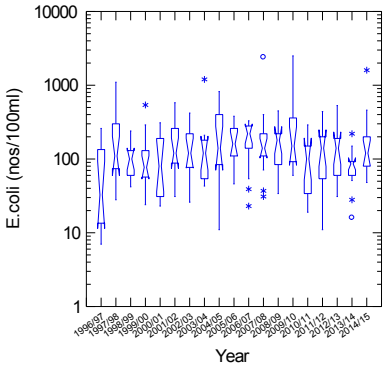
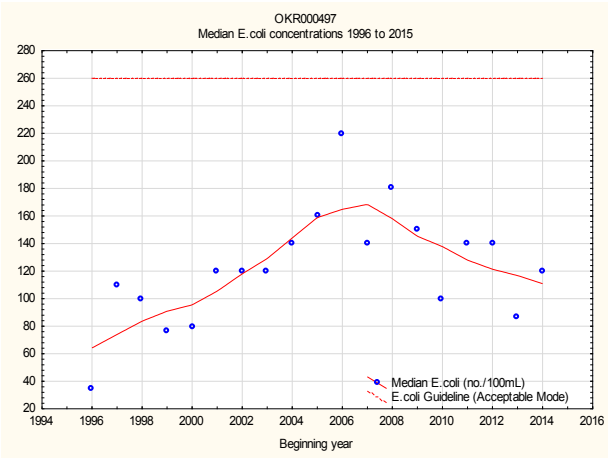


Figure 47 Box and whisker plots for all summer surveys of *E. coli* bacteria numbers in the Oakura River downstream of SH45

The median *E. coli* count was toward the middle of the range of past seasons' results (Figure 49). One of the wider ranges of *E. coli* counts was recorded due to the occurrence of one high count following localised recent rainfall. No median *E. coli*

counts have exceeded the 2003 guidelines for contact recreational usage over the nineteen seasons of monitoring.

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 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.



N = 19
Kendall tau = + 0.340
p level = 0.042[>FDR, p = 0.147]
Significant at p < 0.05;
Not significant at p < 0.05 after FDR.

Figure 48 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Oakura River, SH 45 site for the 1996 to 2015 period

A relatively strong increasing, but no longer significant, overall trend in median *E. coli* counts has been found over the nineteen seasons of monitoring. Although statistically significant at the p< 0.05 level, it was not significant after FDR application. However, none of these seasonal medians exceeded the 'Alert' or 'Action' modes. This increasing trend may have warranted further investigation if it had continued but it should be noted that there has been a steadily improving trend (decrease) in median *E.coli* counts over the past eight year period after medians peaked in the 2006-2007 season.

4.2.13.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on nine occasions during the season in a more appropriate reach, upstream of the SH45 bridge, with results presented in Table 69 and Figure 51.

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

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
18/11/2014	0	No	No	Green (Surveillance)
02/12/2014	0	No	No	Green (Surveillance)
17/12/2014	1	No	No	Green (Surveillance)
14/01/2015	0	No	No	Green (Surveillance)
28/01/2015	0	No	No	Green (Surveillance)
11/02/2015	0	No	No	Green (Surveillance)
25/02/2015	0	No	No	Green (Surveillance)
12/03/2015	0	No	No	Green (Surveillance)
31/03/2015	0	No	No	Green (Surveillance)

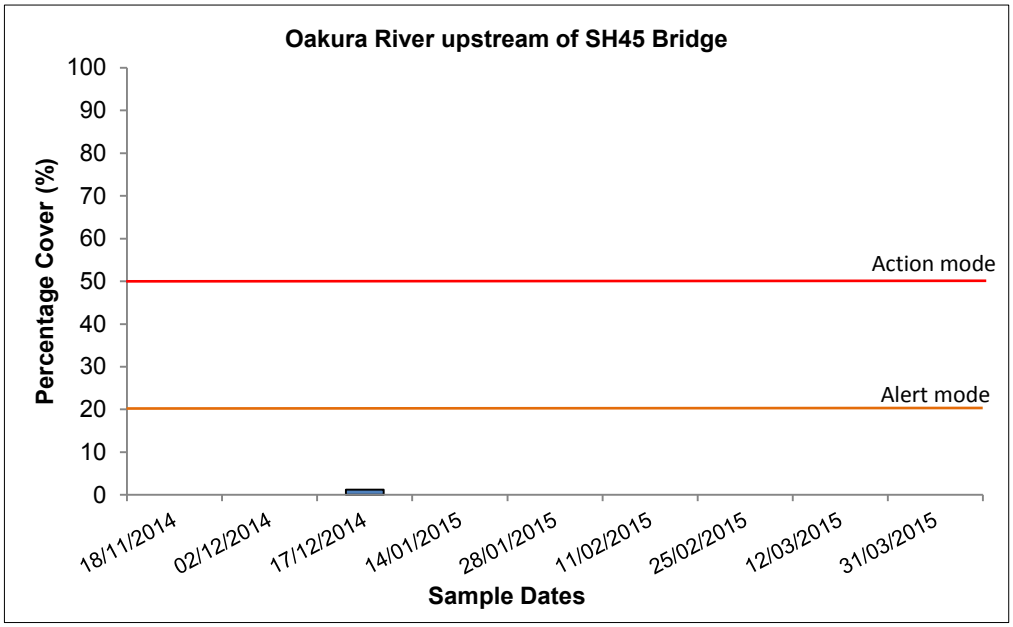


Figure 49 Percentage benthic cyanobacteria cover at the Oakura River upstream of SH45 bridge

Benthic cyanobacteria coverage was very low throughout the season (ranging from 0% to 1%). The benthic cyanobacteria found were *Phormidium* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover or for the presence of exposed or detaching mats and therefore no health warnings were required.

4.2.14 Waitara River at the town wharf, Waitara

Minor 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 present from time to time during the season.

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 2014-2015 season are presented in Table 70 and illustrated in Figure 52 with a statistical summary provided in Table 71. River flow information is illustrated in Figure 53.

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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1210	474	140	11	140	16.3	12
09.12.14	1115	627	88	8	88	19.8	2.3
05.01.15	1120	667	210	40	220	21.7	1.7
08.01.15	1140	1080	120	12	120	22.7	2.3
12.01.15	1350	481	240	24	240	25.0	2.0
20.01.15	0931	2820	1500	250	1500	21.8	3.8
23.01.15	1200	2590	80	32	80	22.5	4.0
26.01.15	1415	2570	58	8	58	24.0	2.5
09.02.15	1245	385	140	40	140	21.6	4.9
19.02.15	1035	2700	390	130	390	20.7	2.8
04.03.15	0940	2730	270	80	270	21.7	1.9
12.03.15	1100	722	190	86	190	21.1	3.2
20.03.15	0840	2460	96	82	96	16.7	3.5

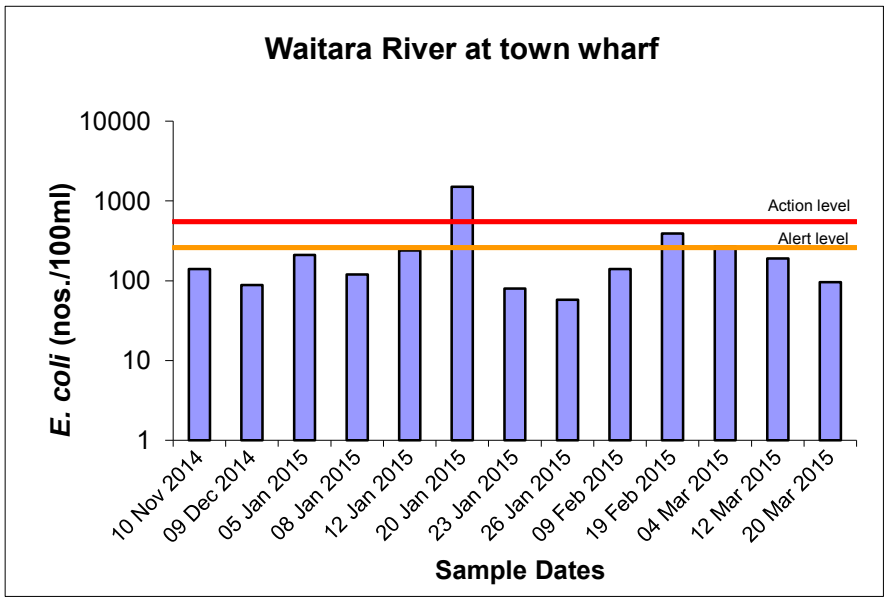


Figure 50 *E.coli* numbers for the Waitara River at the town wharf, Waitara during the survey season

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	385	2820	1080
E. coli	nos/100ml	13	58	1500	140
Enterococci	nos/100ml	13	8	250	40
Faecal coliforms	nos/100ml	13	58	1500	140
Temperature	˚C	13	16.3	25.0	2107
Turbidity	NTU	13	1.7	12	2.8

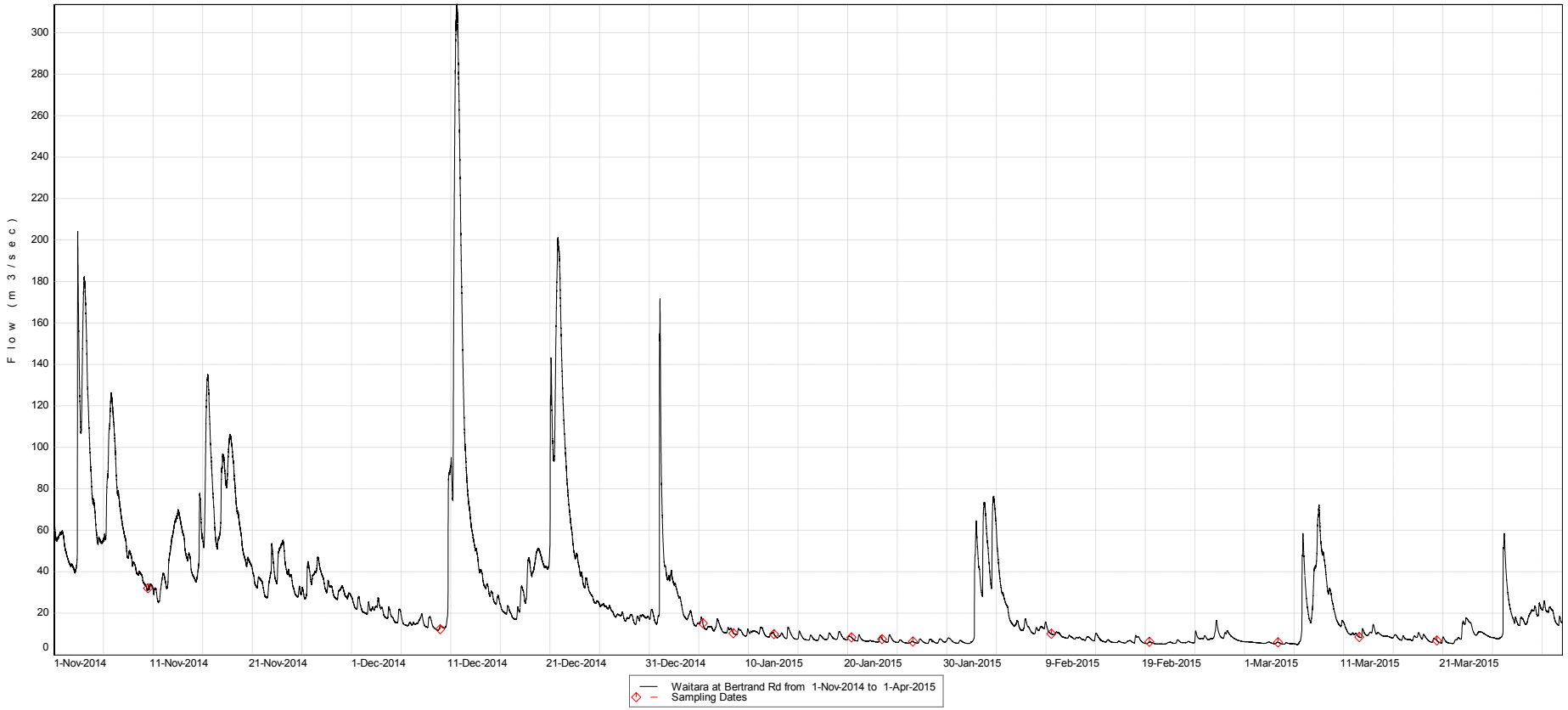


Figure 51 Flow in the Waitara River at Bertrand Road during the survey period

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 2km 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 8.7˚C partly due to the coastal seawater influence, with a maximum of 25.0˚C recorded in early afternoon in mid-January 2015. All of the samples were collected before 1420 hrs and therefore maximum river temperatures (which tend to occur later in the afternoon) were not recorded.

Bacteriological water quality was moderate and typical for the lower reaches of this large Taranaki eastern hill country and ring plain river draining a predominantly agricultural catchment despite some coastal seawater influence under high tide conditions (median 140 *E.coli* per 100 mls and 40 enterococci per 100 mls). 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 mls).

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	2 [15]	1 [8]

(Designation: freshwater contact recreational area)

Two single samples fell within the 'Alert' mode and one sample within the 'Action' mode during the monitoring period. The 'Action' mode exceedance was coincident with marked saltwater intrusion under extended low flow conditions but also followed recent localised rainfall. It has been noted, during past survey periods, that the three-day post rainfall sampling protocols followed by the SEM programme for the other (ringplain) catchment sites are not necessarily appropriate for baseline assessments of bacteriological water quality at this site near the mouth of this predominantly eastern hill country catchment river as a result of the lag effects of rainfall run-off further upstream within this large catchment.

These issues 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. Subsequent sampling to the 'Action' mode event, indicated that *E.coli* numbers had fallen well below the 'Alert' level three days after the mid-January 2015 occurrence.

Photo 7 Warning signage at Waitara River (boat ramp)

Generally, *E. coli* numbers were relatively good (i.e. < 200 per 100 mls) for the majority of the sampling period and only two exceedances of the 'Alert' guideline were recorded during the lengthy recession flow, dry weather conditions (i.e. 7 days or more after a river fresh) experienced in the latter half of the season.

4.2.14.2 Comparison with previous summers' surveys

Five 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 54 for this, the sixth season of monitoring.

Table 73 Summary *E. coli* bacteriological water quality data (nos/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
Minimum	92	19	28	3	13	58
Maximum	1700	570	550	1300	290	1500
Median	230	76	150	120	100	140

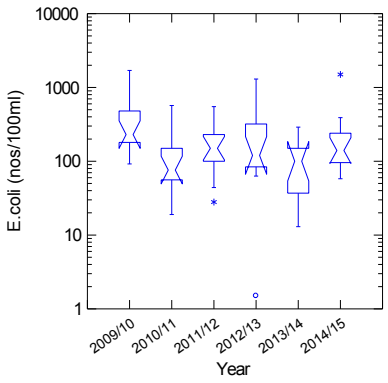


Figure 52 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waitara River at the town wharf, Waitara

A moderate median *E. coli* number was found by this sixth season's survey with one of the widest range of counts found to date during the season although there were minimal delayed effects of preceding freshes in this large, predominantly hill country catchment. 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 three 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 55, 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	1030	4740	1	<1	1	16.6	7.1
09.12.14	0955	4600	1	1	1	18.4	5.9
05.01.15	1010	4700	1	<1	1	21.8	3.7
08.01.15	1020	4660	4	3	5	21.2	22
12.01.15	1240	4790	<1	1	<1	21.5	1.0
20.01.15	0815	4720	140	99	140	20.3	11
23.01.15	1105	4680	8	1	8	21.2	10
26.01.15	1235	4690	<1	<1	<1	21.5	11
09.02.15	1125	4610	1	3	1	20.3	7.2
19.02.15	0905	4680	3	8	3	19.7	4.5
04.03.15	0820	4700	<1	40	<1	20.6	4.7
12.03.15	1210	4670	8	14	8	21.7	14
20.03.15	0950	4740	16	69	16	18.6	8.3

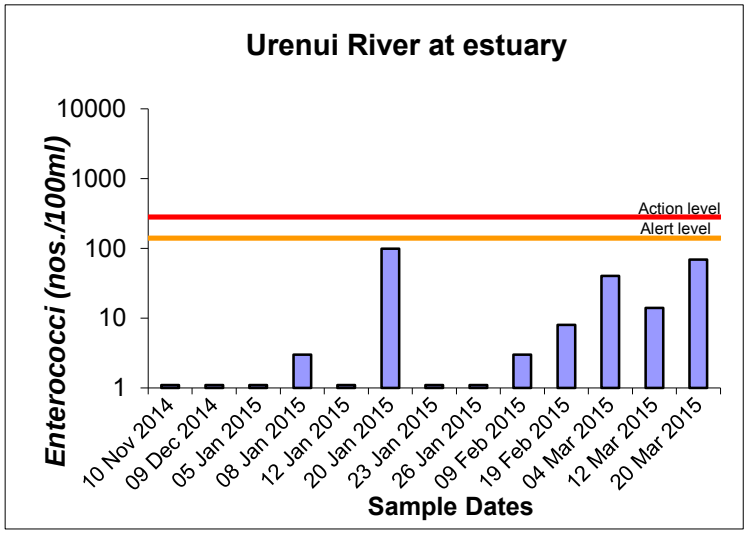


Figure 53 Enterococci numbers for the Urenui River at the estuary during the survey season

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	4600	4790	4690
E. coli	nos/100ml	13	<1	140	1
Enterococci	nos/100ml	13	<1	99	3
Faecal coliforms	nos/100ml	13	<1	140	1
Temperature	°C	13	16.6	21.8	20.6
Turbidity	NTU	13	1.0	22	7.2

This hill country catchment river typically is turbid under low tide conditions in the tidal lower reaches of the estuary where it is extensively used by visitors and the holiday population based at the Urenui Beach settlement. High tide conditions resulted in aesthetic improvements within the estuary. Under high tide sampling conditions, the minimum (1.0 NTU) and median turbidity (7.2 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 20.6°C), more typical of coastal seawater temperatures, varied over a relatively narrow range of 5.2°C during the sampling period with a maximum of 21.8°C recorded in mid-morning in early January 2015. All sampling however, was undertaken prior to 1245 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. One elevated enterococci count was recorded during the monitoring period (Figure 55) following some localised rainfall.

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
E. coli	0 [0]	0 [0]

(Designation: coastal contact recreational area)

No single samples 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: 4 per 100mls) monitored over seven seasons to date.

4.2.15.2 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 enterococci data for the Urenui River site at the estuary are summarised in Table 77 and illustrated in Figure 56.

Table 77 Summary of enterococci bacteriological water quality data (nos/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
Minimum	<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
Median	5	7	3	8	14	8	4	4	5	4	1	2	11	7	3	4	3	3	3

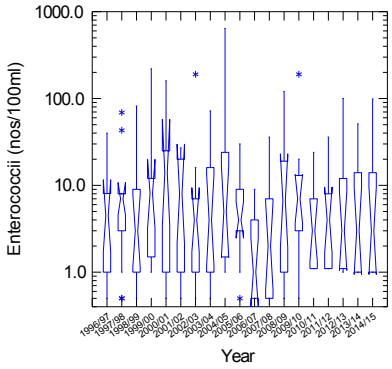


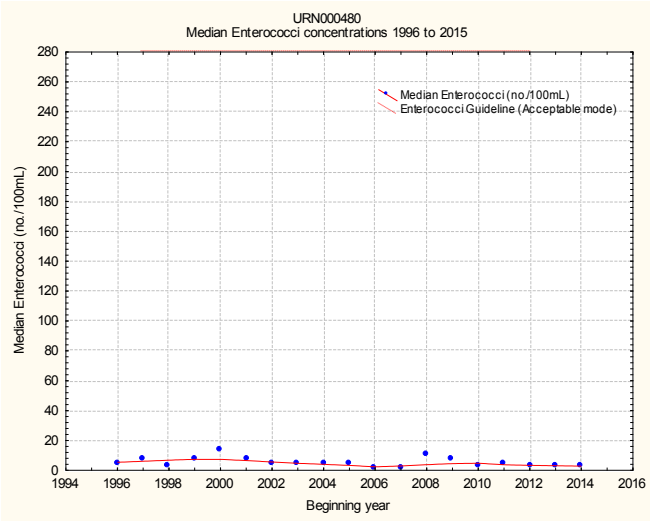
Figure 54 Box and whisker plots for all summer surveys of enterococci bacterial numbers in the Urenui River at the estuary

The high bacteriological water quality of the Urenui River estuary, during high tide conditions, continued during the 2014-2015 season (Figure 56). This has been emphasised by all seasonal median enterococci counts being less than 15 enterococci (per 100 mls). The range was relatively narrow for enterococci during the 2014-2015 season as a result of no single sample counts in excess of 99 enterococci per 100 mls 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.

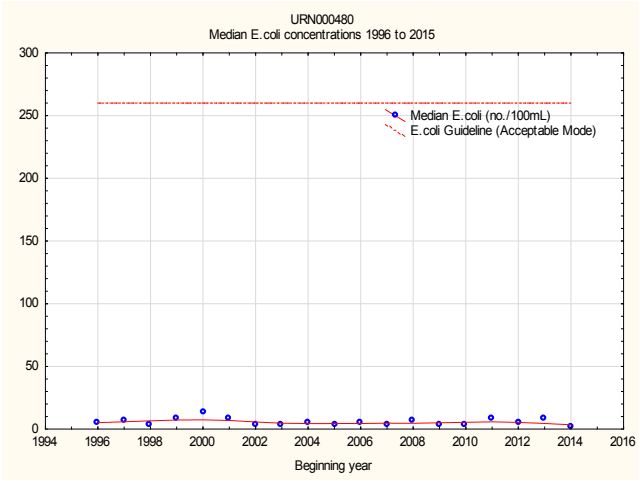
Trend analysis of median enterococci and *E. coli* numbers has been performed for the nineteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figures 57 and 58) and testing the significance of

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



N = 19
Kendall tau = - 0.335
p level = 0.045 [>FDR, p = 0.147]
Significant at p < 0.05
Not significant at p < 0.05 after FDR

Figure 55 LOWESS trend plot of median enterococci (per 100ml) at the Urenui River, estuary site for the 1996 to 2015 period



N = 19
Kendall tau = - 0.100
p level = 0.550 [>FDR, p = 0.894]
N/S at p < 0.05

Figure 56 LOWESS trend plot of median *E. coli* (per 100ml) at the Urenui River, estuary site for the 1996 to 2015 period

No statistically significant trends in median enterococci or *E. coli* counts (after FDR applications) have been found over the nineteen 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 (Note: median enterococci decrease has been statistically significant prior to FDR application). 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 59, with a statistical summary provided in Table 79. River flow records are illustrated in Figure 60.

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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	0915	9.6	200	60	210	13.7	1.1
09.12.14	0835	10.1	200	54	200	17.7	1.0
05.01.15	0840	9.6	240	54	240	17.8	0.7
08.01.15	0905	10.0	120	48	120	19.0	0.7
12.01.15	1110	9.9	170	68	170	19.7	0.7
20.01.15	1100	9.8	190	94	200	19.6	0.7
23.01.15	0935	9.8	100	68	110	18.3	0.8
26.01.15	1115	10.1	560	88	560	21.1	0.6
09.02.15	1005	9.7	290	170	290	17.3	0.6
19.02.15	0825	10.0	160	150	160	16.5	0.6
04.03.15	1120	10.5	250	140	260	19.7	0.8
12.03.15	1010	10.0	240	210	240	17.6	0.8
20.03.15	1120	10.0	120	85	130	13.4	0.8

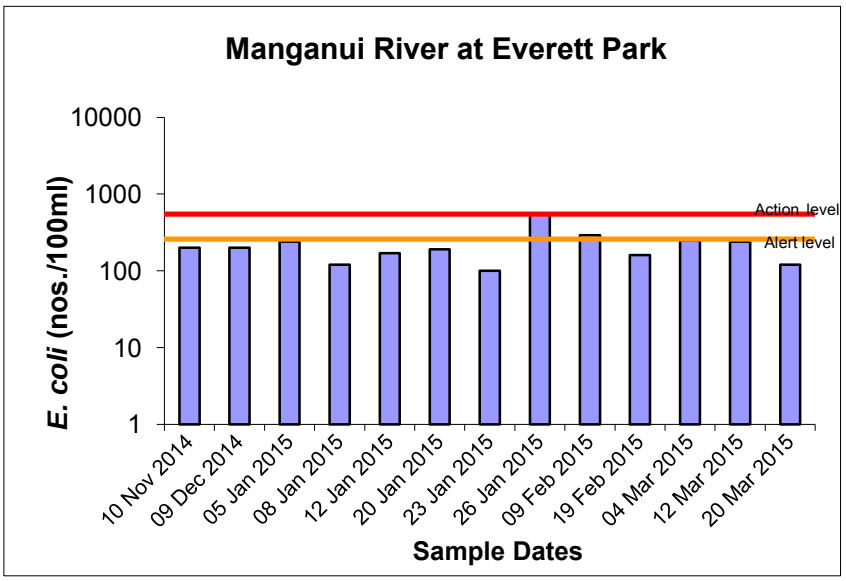


Figure 57 *E. coli* numbers for the Manganui River at Everett Park (downstream of the Kurapete Stream) during the survey season

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	9.6	10.5	10.0
E. coli	nos/100ml	13	100	560	200
Enterococci	nos/100ml	13	48	210	85
Faecal coliforms	nos/100ml	13	110	560	200
Temperature	°C	13	13.4	21.1	17.8
Turbidity	NTU	13	0.6	1.1	0.7

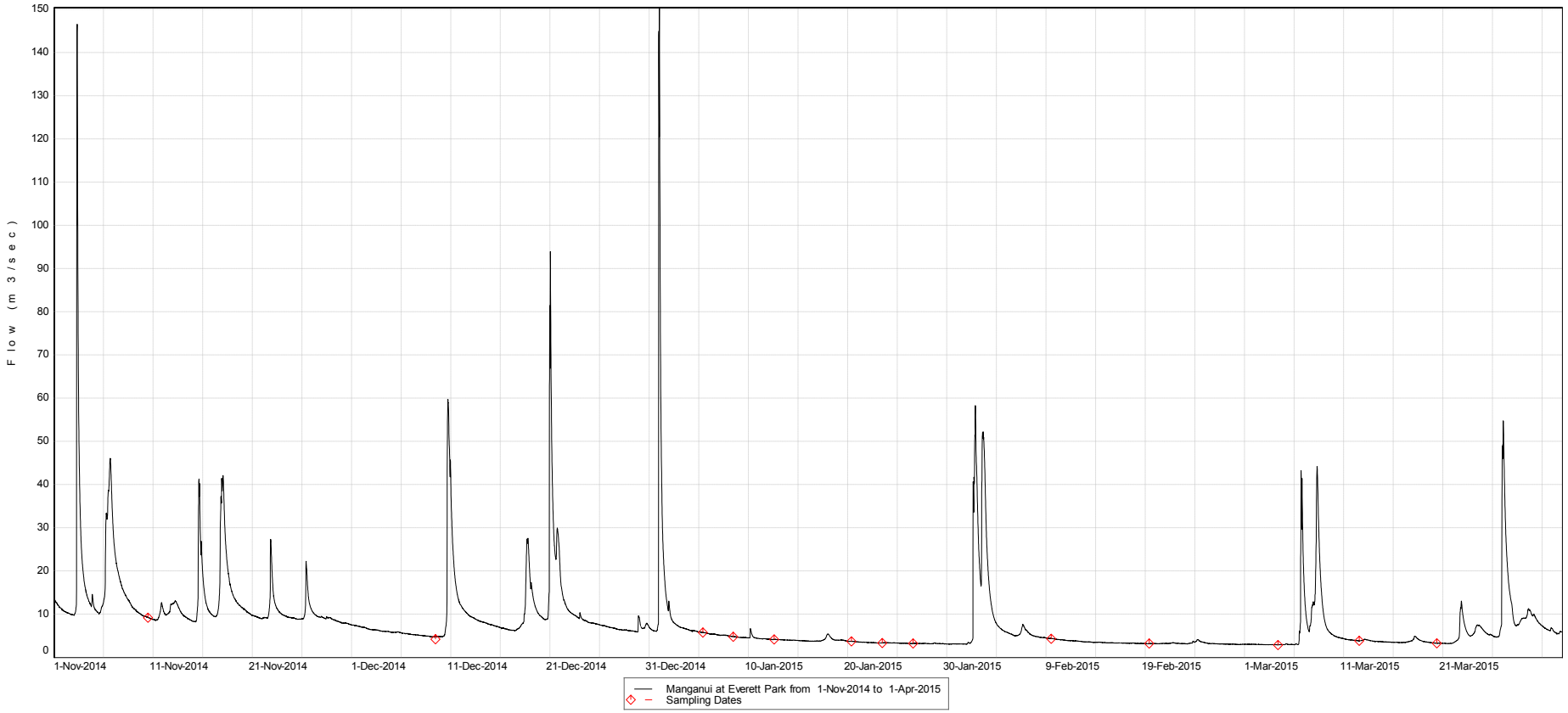


Figure 58 Flow in the Manganui River at Everett Park during the survey period

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 7.7°C with the maximum temperature (21.1°C) recorded in late 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 2014-2015 survey period with none of the counts recorded during the period below 100 *E. coli* per 100 mls (Figure 54). The elevated count in late January 2015 which entered the 'Action' level, was recorded during a prolonged period of very low flow conditions. Levels decreased into the 'Alert' level at the time of a follow-up survey two days later, remaining in the 'Alert' mode in early February, 2015 (after some wet weather) and returned to lower numbers (below the 'Alert' level) by the time of the following survey, where numbers remained for the rest of the period including during the very low flow conditions later in February and March 2015.

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 (upstream 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]	1[8]

(Designation: freshwater contact recreational area)

One single sample fell in the 'Alert' mode and one reached the 'Action' mode during the season. The highest count was recorded during a prolonged low flow period near mid-summer.

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 61.

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
Minimum	58	85	76	46	26	100	54	66	83	46	11	54	100	92	100	34	80	63	100
Maximum	690	2400	830	350	450	970	460	880	730	240	320	1200	480	370	320	400	760	330	560
Median	150	220	160	110	98	210	140	180	180	120	190	160	170	200	170	120	140	140	200

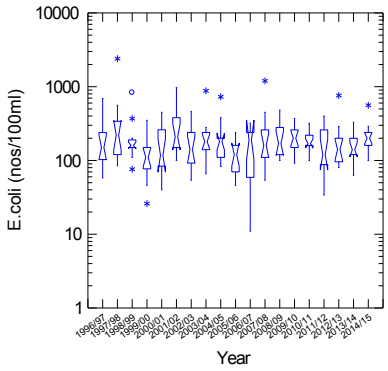
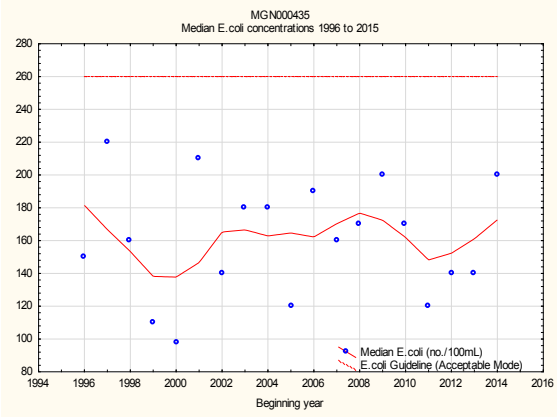


Figure 59 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Manganui River at Everett Park

The median *E. coli* count for the 2014-2015 season was within the range but the third highest of the nineteen seasons' medians recorded since the inception of the programme in 1996-97 (Figure 61). The range of *E. coli* numbers was typical of those recorded to date mainly due to a moderate maximum count of 560 per 100 mls; in the mid-range of seasonal maxima recorded to date at this site.

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 62) 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 = 19
Kendall tau = +0.018
p level = 0.914 [>FDR, p= 0.914]
N/S at p< 0.05

Figure 60 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Manganui River, Everett Road site for the 1996 to 2015 period

A very slight, unimportant, and statistically insignificant increase in median *E. coli* counts has been found over the nineteen 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 eleven occasions through the season with results presented in Table 82 and Figure 63.

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

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
18/11/2014	0	No	No	Green (Surveillance)
02/12/2014	2	No	No	Green (Surveillance)
17/12/2014	6	No	No	Green (Surveillance)
14/01/2015	25	No	Yes	Red (Action)
21/01/2015	20	No	Yes	Red (Action)
28/01/2015	10	No	Yes	Amber (Alert)
04/02/2015	3	No	Yes	Green (Surveillance)
11/02/2015	6	No	Yes	Green (Surveillance)
25/02/2015	0	No	Yes	Green (Surveillance)
12/03/2015	7	No	Yes	Green (Surveillance)
31/03/2015	2	No	Yes	Green (surveillance)

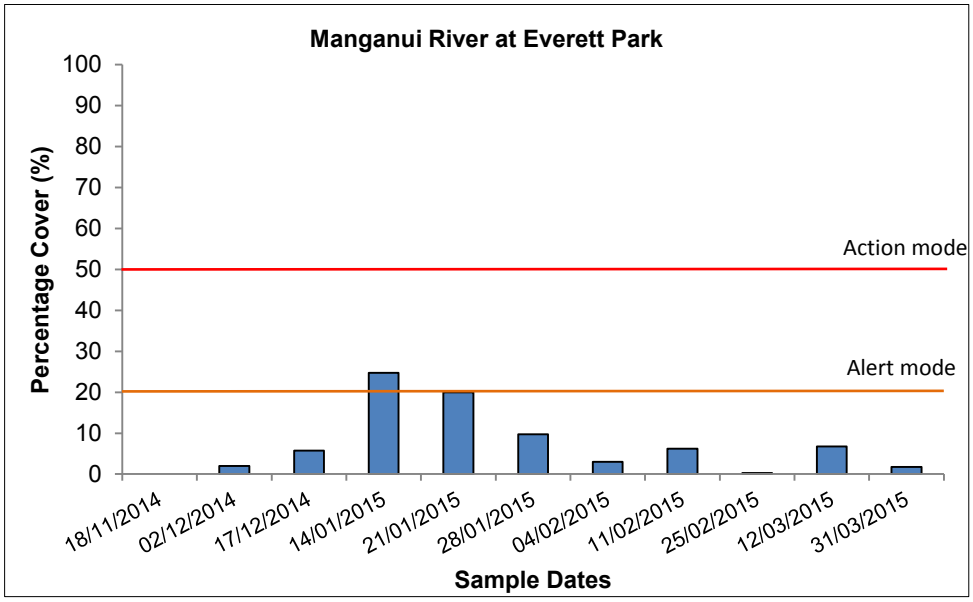


Figure 61 Percentage benthic cyanobacteria cover at the Manganui River, Everett Park site

Benthic cyanobacteria coverage was low during the earlier part of the season but moderate levels were recorded during mid-summer before declining in late summer and early autumn (range from 0% to 25%). The benthic cyanobacteria found were *Phormidium* sp. The 'Action' level was never exceeded for percentage cover but the 'Alert' level was exceeded on two occasions in mid-January 2015. Furthermore, exposed mats were observed on three separate occasions triggering either 'Action' or 'Alert' mode responses depending on the extent of exposed mats present. Warning

signage was erected by NPDC but this was vandalised on occasions requiring subsequent replacement. Exposed mats were caused by falling water levels during the long dry summer but they persisted for less than a month before becoming desiccated and disappearing.

4.2.17 Lake Ratapiko

Bathing usage of the lake was noted on only one occasion. Boating, jet-skiing, kayaking, and picnicking 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 in relatively low numbers and swan and shags 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 during 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 64 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
10.11.14	0850	7.7	53	1	60	14.6	1.3
09.12.14	0815	8.5	11	4	11	19.5	1.3
05.01.15	0820	7.2	25	<1	25	19.6	1.3
08.01.15	0840	7.7	21	<1	21	21.6	1.4
12.01.15	1050	8.4	120	4	120	23.9	1.9
20.01.15	1125	8.6	5	5	5	23.5	1.2
23.01.15	0920	8.4	20	4	27	21.7	2.3
26.01.15	1050	8.2	4	8	6	23.5	1.6
09.02.15	0945	8.2	6	14	10	19.0	1.2
19.02.15	0800	8.2	2	2	2	20.0	1.1
04.03.15	1150	8.9	2	14	2	23.3	1.6
12.03.15	0945	7.6	12	4	12	19.2	1.0
20.03.15	1140	8.3	110	2	110	17.0	1.2

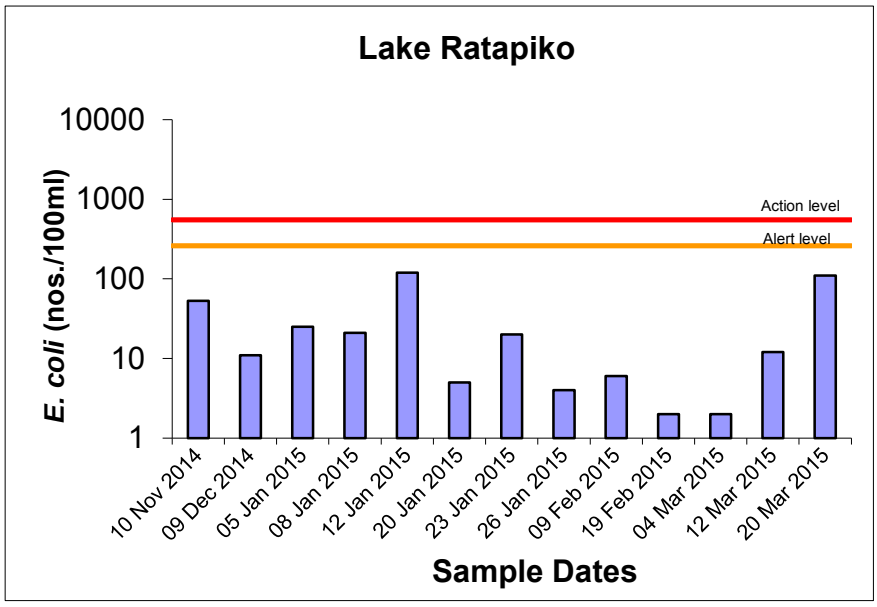


Figure 62 *E. coli* numbers for Lake Ratapiko during the survey season

Table 84 Statistical results summary for Lake Ratapiko

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	7.2	8.9	8.2
E. coli	nos/100ml	13	2	120	12
Enterococci	nos/100ml	13	<1	14	4
Faecal coliforms	nos/100ml	13	2	120	12
Temperature	°C	13	14.6	23.9	20.0
Turbidity	NTU	13	1.0	2.3	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: 1.3 NTU) as a result of low suspended algae populations possibly due to short retention times in the lake. Water temperatures were moderate ranging over 9.3˚C for the period with a moderately high maximum of 23.9˚C (mid-morning in mid-January 2015) although all of the measurements were recorded prior to 1155 hrs. Conductivity showed minimal variation (less than 1.8 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 100 *E. coli* per 100 mls despite the wet spring and lengthy very low flow period later in the season.

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	0 [0]	0 [0]

(Designation: Freshwater contact recreational area)

No single sample exceedances of the 'Action' mode occurred and no samples were recorded within the 'Alert' mode during the entire period.

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 nine summer surveys for the Lake Ratapiko site are summarised in Table 86 and illustrated in Figure 65.

Table 86 Summary of *E.coli* bacteriological water quality data (nos/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
Minimum	1	1	5	4	13	1	3	<1	2
Maximum	86	120	220	91	140	150	240	240	120
Median	21	16	35	16	25	35	10	10	12

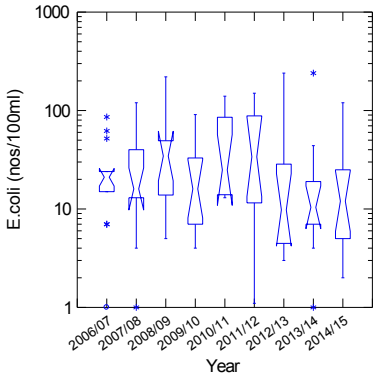


Figure 63 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers at Lake Ratapiko

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 nine seasons' medians to date. Trend analysis of median *E. coli* numbers will not be performed for this site until ten seasons' data are available.

4.2.17.3 Cyanobacteria

Microscopic scans were performed on samples collected on seven additional occasions (one of which was coincidental with stock grazing at the lake margin). The results of these analyses are presented in Table 87.

Table 87 Cyanobacteria counts and biovolumes for Lake Ratapiko
[Health warning: >15,000 cells/ml; >1.8 mm^3/L]

Date	Total cell count (cells/ml)	Principal taxa	Biovolume (mm^3/L)
18.11.14	nil	-	0
02.12.14	nil	-	0
15.01.15	nil	-	0
27.01.15	nil	-	0
13.02.15	nil	-	0
25.02.15	nil	-	0
17.03.15	nil	-	0

No cyanobacteria were detected in any of the samples. None 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. These levels had not required public health warnings but were notified to the public via the TRC website. No notifications were required during the 2014-2015 season. 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 2014-2015 season, with the lake visited on nine occasions between mid-November 2014 and late March 2015. [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 and kayaking on one occasion at the start of the season. The boat ramp remained locked throughout the entire period. A few pukeko were noted at the lake margin and a few ducks, shags, and swans were noted from time to time on the lake which appeared turbid, brownish throughout most of the period with a brighter green appearance in the latter six weeks 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
18.11.14	1100	11.6	37	5	37	16.0	3.2
03.12.14	1050	11.7	9	<1	9	17.9	8.7
15.12.14	1020	11.9	10	16	36	21.8	20
15.01.15	1255	12.1	64	100	64	25.5	24
27.01.15	1035	12.1	8	510	8	25.3	19
12.02.15	1210	13.0	32	340	32	22.2	35
26.02.15	1055	13.3	240	260	240	22.2	31
20.03.15	0820	12.5	8	20	8	18.0	10
25.03.15	0950	-	-	-	-	19.1	-

Table 89 Statistical results summary for Lake Rotokare

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	8	11.6	13.3	12.1
E. coli	nos/100ml	8	8	240	21
Enterococci	nos/100ml	8	<1	510	60
Faecal coliforms	nos/100ml	8	8	240	34
Temperature	°C	9	16.0	25.5	21.8
Turbidity	NTU	8	3.2	35	20

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: 1.7 mS/m) through the period despite variations in inflow during the season particularly during spring-early summer wet weather. Water temperatures varied over a moderate range of 9.5˚C with a maximum of 25.5˚C recorded in mid January 2015. Turbidity was relatively high (median: 20 NTU) with the range (32 NTU) reflecting the variability in abundances of suspended algae in the water column during the season. Highest turbidities (> 30 NTU) were coincidental with peaks in cyanobacteria concentrations in mid to late February 2015.

No bacterial counts entered the 'Alert' or 'Action' levels on any occasion during the season although it should be noted that in past seasons the overriding health warnings on both the Regional Council and Area Health Board's websites 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 2014-2015 this trend was not as apparent.

4.2.18.1 Cyanobacteria

Microscopic scans of nine samples during the recreational monitoring period (and one sample immediately prior to the season) found a very low cyanobacteria population in mid-October and mid-November 2014 increasing through the period. The health warning level was exceeded (both in cell numbers and biovolumes) from December 2014 and high numbers remained during very dry weather conditions in late summer/autumn, peaking in late February 2015, but remaining at high levels until the end of the year. These elevated concentrations were higher than maximum

numbers found during the 2009-2010 period (by more than 2 x 10^6 cells per 1 ml), during the 2010-2011 period, and higher (by more than 2.3 x 10^6 cells per 1 ml) than found during the 2012-2013 period and in the 2013-2014 period (also by about 2.3 x 10^6 cells per 1 ml). The results of these analyses are presented in Table 96 and illustrated in Figures 66 and 67.

Table 90 Cyanobacteria counts and biovolumes for Lake Rotokare [Health warning: > 15,000 cells/ml; > 1.8 mm^3/L]

Date	Total cell count (cells/ml)	Principal taxa	Biovolume (mm^3/L)
10.10.14	430	*Anabaena*	0.12
18.11.14	860	*Anabaena*	0.18
03.12.14	26,750	*Anabaena*	4.5
15.12.14	48,000	*Anabaena*	9.6
15.01.15	206,300	*Anabaena*	43.3
27.01.15	211,000	*Anabaena/Coelosphaerium*	17.9
12.02.15	524,000	*Coelosphaerium /Anabaena*	16.7
26.02.15	2,358,000	*Coelosphaerium /Anabaena*	35.5
20.03.15	418,000	*Coelosphaerium*	5.5
25.03.15	503,000	*Coelosphaerium*	5.2

[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)].

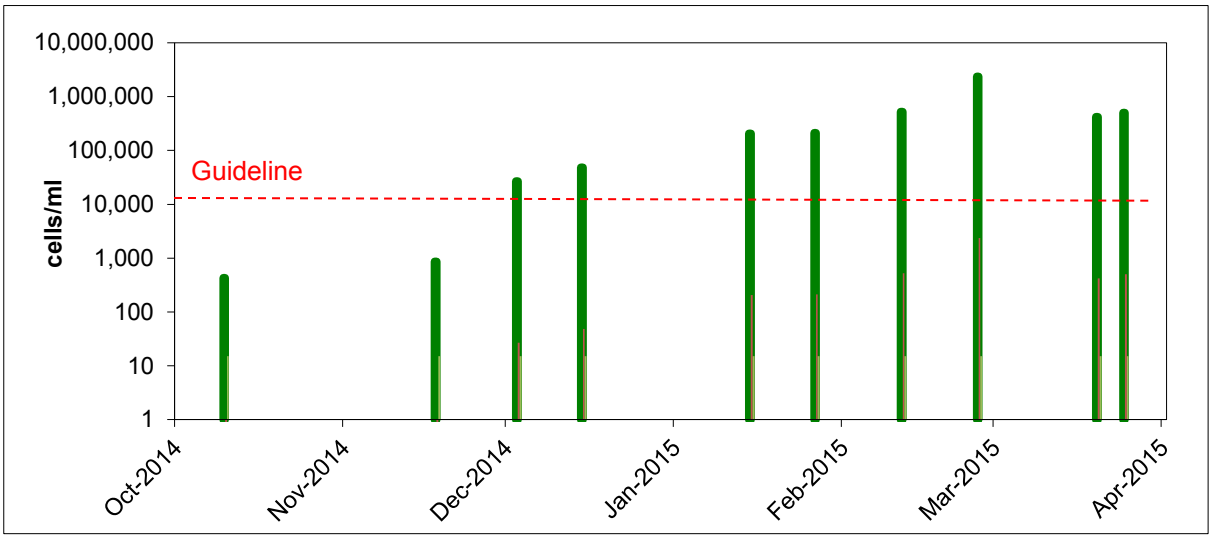


Figure 64 Cyanobacteria counts (cells/ml) at Lake Rotokare [Health warning: >15,000 cells/ml]

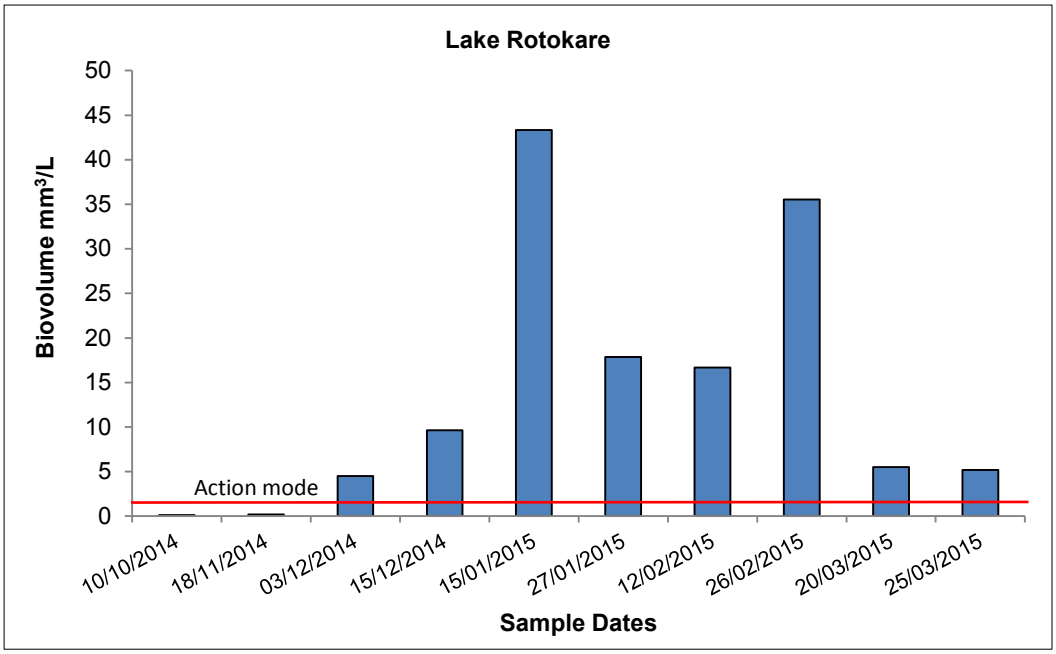


Figure 65 Cyanobacteria biovolume (mm^3/L) at Lake Rotokare [Health warning: > 1.8 mm^3/L]

Low counts of *Anabaena* found in the lake early in the season in October and November 2014 did not necessitate installation of blue-green algal hazard warning sign by the STDC upon advice from the Taranaki Area Health Board. An increased count exceeded the health guidelines [15,000 cells/ml and 1.8 mm^3/L] in early December 2014 and therefore there was a requirement for STDC to erect signage at the lake and road access and the boatramp remained closed. *Anabaena* concentrations remained high through summer peaking at about 200,000 cells/ml in mid-January 2015 before decreasing and *Coelosphaerium* becoming the dominant taxon (135,000 to 2.3 x 10^6 cells/ml) during the late January to end of the season period coincident with a very dry late summer-autumn period. These numbers continued to exceed the health guidelines although decreasing during March 2015. Although there was no apparent re-occurrence of the *Microcystis* bloom which had been found toward the end of the 2007-2008 season (with no instance of *Microcystis* found at all over the 2011-2012 period or 2012-2013 periods but small numbers of *Microsystis* and/or *Oscillatoria* found late in the 2013-2014 period), a very similar taxon (*Coelosphaerium*) with a markedly smaller biovolume, bloomed in mid to late summer, dominating the population numerically to the end of the season. The Area Health Board did not require algal toxin testing during the period.

The warning signage displayed adjacent to the boatramp in past seasons was required for the period from early 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 eighteenth 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 68 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, 2014-2015

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	24.0	11.9	43	43	20	5.7
	Minimum	17.1	11.0	23	20	3	2.8
	Maximum	25.9	12.8	120	120	99	15
	No. of samples	13	13	13	13	13	13
Waiwhakaiho River at Merrilands Domain	Median	19.6	13.5	37	37	24	0.6
	Minimum	12.6	10.3	8	8	1	0.4
	Maximum	23.3	15.6	380	350	160	1.2
	No. of samples	13	13	13	13	13	13
Waiwhakaiho River adjacent to L. Rotomanu	Median	20.0	14.1	1100	1000	1100	0.7
	Minimum	13.5	10.4	69	46	500	0.5
	Maximum	23.8	16.1	8000	7400	7500	1.5
	No. of samples	13	13	13	13	13	13
Te Henui Stream at mouth, East End	Median	19.0	54.0	1300	1300	1000	0.7
	Minimum	15.1	10.0	250	250	130	0.4
	Maximum	21.5	2990	3400	3400	2600	7.4
	No. of samples	13	13	13	13	13	13
Patea River at King Edward Park, Stratford	Median	15.6	9.4	300	280	430	0.8
	Minimum	10.8	8.4	110	110	17	0.5
	Maximum	18.3	10.6	760	760	1100	1.1
	No. of samples	13	13	13	13	13	13
Patea River at boatramp, Patea	Median	20.3	4680	5	5	4	17
	Minimum	16.1	3710	1	<1	<1	3.5
	Maximum	23.0	4790	24	24	18	40
	No. of samples	13	13	13	13	13	13
Waingongoro River at Eltham camp	Median	18.2	11.9	260	260	74	1.2
	Minimum	12.1	10.4	46	46	3	0.9
	Maximum	21.9	13.1	440	440	450	2.6
	No. of samples	13	13	13	13	13	13
Waingongoro River at Ohawe Beach	Median	20.2	19.1	200	200	90	1.3
	Minimum	14.1	15.6	66	66	11	1.0
	Maximum	24.7	21.9	630	630	520	3.5
	No. of samples	13	13	13	13	13	13
Kaupokonui River at beach domain	Median	20.2	17.4	120	120	77	1.6
	Minimum	13.8	15.7	54	54	33	0.9
	Maximum	25.0	145	510	490	310	4.3
	No. of samples	13	13	13	13	13	13
Lake Opunake adjacent to boat ramp	Median	21.7	14.1	66	66	210	1.0
	Minimum	14.5	12.3	4	4	27	0.7
	Maximum	27.6	15.8	420	390	1500	2.2
	No. of samples	13	13	13	13	13	13
Timaru Stream at Weld Road (near mouth)	Median	19.5	118	210	210	140	0.7
	Minimum	15.9	10.9	63	63	25	0.2
	Maximum	24.9	2580	2000	2000	1600	4.5
	No. of samples	13	13	13	13	13	13
Oakura River d/s of SH45 bridge	Median	18.8	43	120	120	210	0.5
	Minimum	14.4	7.2	51	48	12	0.3
	Maximum	21.8	1850	1600	1600	2000	5.4
	No. of samples	13	13	13	13	13	13
Waitara River at town wharf, Waitara	Median	21.7	1080	140	140	40	2.8
	Minimum	16.3	385	58	58	8	1.7
	Maximum	25.0	2820	1500	1500	250	12
	No. of samples	13	13	13	13	13	13
Urenui River at estuary	Median	20.6	4690	1	1	3	7.2
	Minimum	16.6	4600	<1	<1	<1	1.0
	Maximum	21.8	4790	140	140	99	22
	No. of samples	13	13	13	13	13	13
Manganui River d.s of Kurapete S. (Everett Park)	Median	17.8	10.0	200	200	85	0.7
	Minimum	13.4	9.6	110	100	48	0.6
	Maximum	21.1	10.5	560	560	210	1.1
	No. of samples	13	13	13	13	13	13
Lake Ratapiko at boat ramp	Median	20.0	8.2	12	12	4	1.3
	Minimum	14.6	7.2	2	2	<1	1.0
	Maximum	23.9	8.9	120	120	14	2.3
	No. of samples	13	13	13	13	13	13

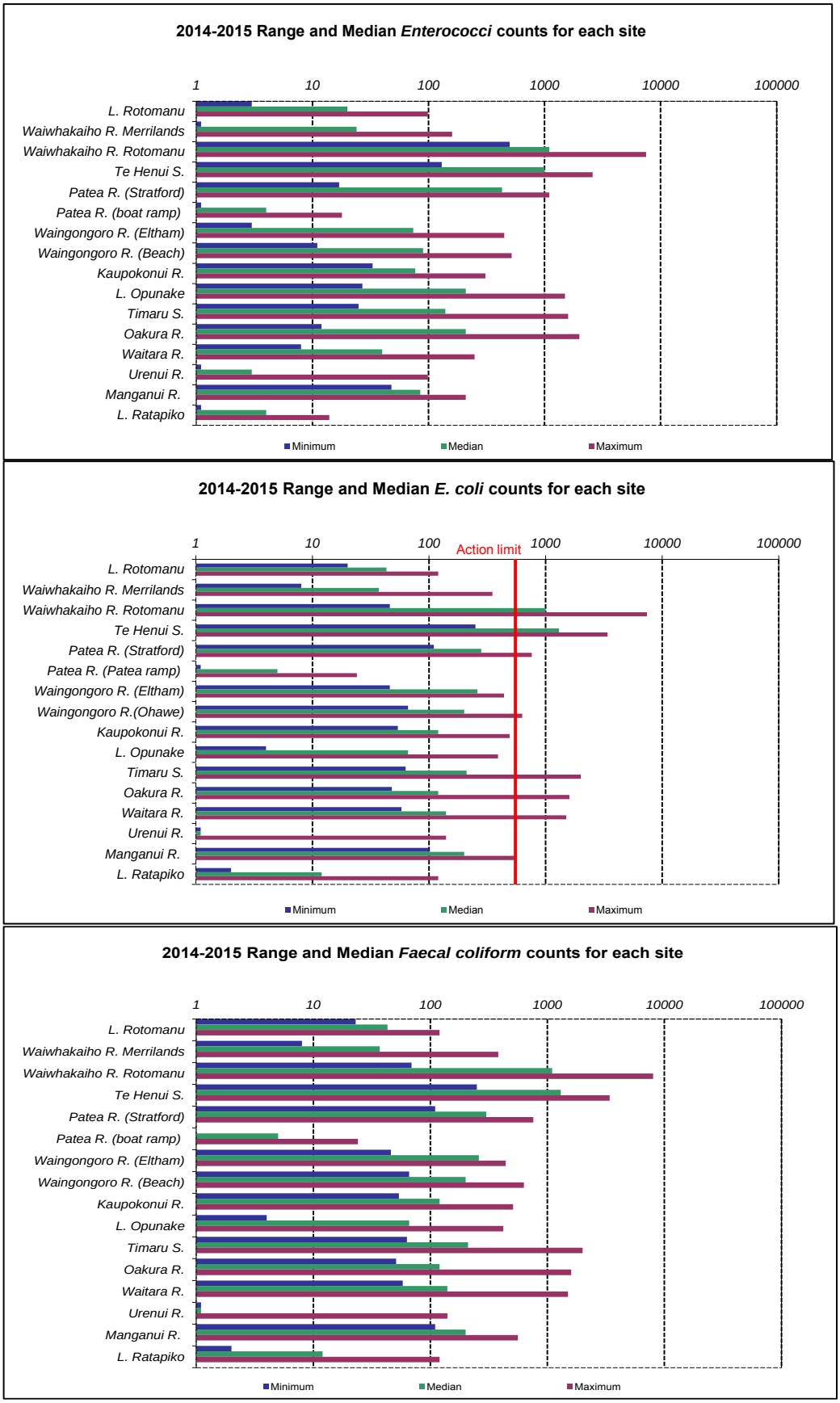


Figure 66 Ranges and medians of bacteria numbers recorded from all sites by the SEM programme over the 2014-2015 survey season

Non-exceedance of the 2003 guidelines has varied amongst the sixteen freshwater contact recreational sites sampled during the survey period (Figure 62 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 (ie met the 'Surveillance' guideline).

Site	' Surveillance' mode	'Alert' mode	'Action' mode
Lake Rotomanu at western beach	[100%]	0	0
Waiwhakaiho River at Merrilands Domain	[92%]	1	0
Waiwhakaiho River adjacent to L Rotomanu	[8%]	1	11
Te Henui Stream at mouth, East End	[8%]	0	12
Patea River at King Edward Park, Stratford	[23%]	8	1
Patea River at boatramp, Patea	[100%]	0	0
Waingongoro River at Eltham Camp	[62%]	5	0
Waingongoro River at Ohawe Beach	[92%]	0	1
Kaupokonui River at beach domain	[62%]	5	0
Lake Opunake at boat ramp	[77%]	3	0
Timaru Stream at Weld Road	[62%]	3	2
Oakura River at SH45	[77%]	2	1
Waitara River at town wharf, Waitara	[77%]	2	1
Urenui River at estuary*	[100%]	0	0
Manganui River at Everett Park	[85%]	1	1
Lake Ratapiko at boat ramp[1]	[100%]	0	0

[Notes: N = 13 samples; * = enterococci count; [1] = 10 samples]

Four sites maintained counts below the 'Alert' mode at all times throughout the season (compared with six sites over the 2013-2014 season), while an additional four sites maintained counts below the 'Action' mode (Tables 92 and 93) at all times. In terms of the overall monitoring season, thirty-one 'Alert' levels (15% of counts) and thirty 'Action' levels (14% of counts) resulted over the period representing an overall 71% achievement of the 'Surveillance' contact recreational guideline (compared with 68%, 76%, 78%, 72%, and 74% achievement in the 2009-2010, 2010-2011, 2011-2012, 2012-2013, and 2013-2014 seasons respectively). Of these 29% '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 2014-2015 seasons:

1= Patea River at boatramp, Patea
1= Lake Rotomanu
1= Urenui River at estuary
1= Lake Ratapiko
5 Waiwhakaiho River at Merrilands Domain
6 Waingongoro River at Ohawe Beach
7 Manganui River at Everett Park
8 Lake Opunake
9= Oakura River d/s SH45 bridge
9= Waitara River at town wharf

11=	Waingongoro River River at Eltham camp
11=	Kaupokonui River at beach domain
13	Timaru Stream at Weld Road (near mouth)
14	Patea River at King Edward Park, Stratford
15	Waiwhakaiho River adjacent to Lake Rotomanu
16	Te 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 some improvements despite a wet spring-early summer which resulted in a more concentrated sampling effort in the latter half of the period. 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	Waiwhakaiho River at Merrilands Domain
5	Lake Rotomanu
6	Lake Opunake at boat ramp
7=	Oakura River d/s of SH 45 bridge
7=	Kaupokonui River at beach domain
9	Waitara River at town wharf, Waitara
10=	Waingongoro River at Ohawe Beach
10=	Manganui River at Everett Park (d/s of Kurapete Stream)
12	Timaru Stream at Weld Road (near mouth)
13	Waingongoro River at Eltham camp
14	Patea River at King Edward Park, Stratford
15	Waiwhakaiho River adjacent to Lake Rotomanu
16	Te Henui Stream at mouth, East End

The biggest improvement in ranking, in comparison with the 2013-2014 season, occurred at Lake Opunake (where there was an almost 33% improvement in median count between the last two seasons) while the two lowest rankings remained at the two sites which were lowest ranked for the last several seasons. The Patea River at King Edward Park, Stratford site slipped down in the rankings (where it was ranked fourteenth) in terms of seasonal median bacteriological water quality, where there was not only a 17% increase in the median *E.coli* count between consecutive seasons (an increase of 40 *E.coli*/100 mls), but the median also entered the 'Alert' mode. More sites' median counts increased (12 sites) than decreased reflecting a general deterioration in bacteriological water quality across the region's sites in the 2014 – 2015 season. This also was reflected in part by a slightly lower proportion of samples

(3%) meeting the national guidelines in 2014-2015 in comparison with the previous season.

5.1 Comparison with eighteen 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 (>20%) at six sites and improvement at fourteen sites in terms of median counts, in comparison with the previous summer's results. 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 93.

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 nineteen 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 (2013-2014) was 2% above the historical average and the latest season showed a 3% deterioration 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= Waitara River at town wharf, Waitara
12 Lake Opunake
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 17 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 5% 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 twelve sites with a minimum of ten years' data, was undertaken statistically for the period 1996 to 2015. 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 12 year period to date which was significant at $p < 0.01$ after FDR application

Another two sites showed significant ($p<0.05$ but not after FDR application) trends in median *E.coli* counts:

- Te Henui Stream at the mouth had a strong trend of increasing median *E.coli* numbers over a 13 year period which however, was not significant at $p < 0.05$ after FDR application
- Oakura River below the SH45 bridge had a strong trend of increasing median *E.coli* numbers over the nineteen year period to date which however, was not significant at $p< 0.05$ after FDR application.

One site showed a significant ($p<0.05$ but not after FDR application) trend in median enterococci count:

- Urenui River at the estuary had a strong but important trend of decreasing median enterococci numbers over the nineteen year period to date which was significant at $p<0.05$ but not after FDR application. (Note: There was been no significant trend in *E.coli* median numbers over this period at this site).

The Oakura River site's seasonal median *E.coli* counts have not approached contact recreational 'Alert' (or 'Action') guidelines at any time over the entire nineteen year period. A ranking of the order of the significance of the temporal trends at those sites with a minimum of ten seasons' data (twelve sites) is provided in Table 94.

Table 93 Seasonal summaries of single sample *E.coli* counts in 'Surveillance'. 'Alert'. 'Action' modes for the period 1996 to date (13 samples per season)
[Note:*not included in programme for that 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		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	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	12.5	<0.5	<<0.5
Waiwhakaiho River adjacent 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	5.5	2.5	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	<0.5	2.5	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	7.5	4	1.5
Patea River at boatramp, Patea	*		*		*		*		*		*		*		*		*		*		*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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	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	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	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	9.5	2.5	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	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	11	1.5	0.5
Waitara River at town wharf, Waitara	*		*		*		*		*		*		*		*		*		*		*		*		*		2	3	1	1	2	0	3	1	3	0	2	1	10	2	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	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	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	13	0	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	-		
% 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		

Table 94 Ranking of sites in terms of significant temporal trends in median *E.coli* counts over the period 1996 to 2015 [significant at p< 0.05 and p<0.01] (NB: * = enterococci)

Site location	Valid N	p-level	FDR-corrected p value	Trend
Waiwhakaiho River at Lake Rotomanu	12	0.0002	0.0027	↑↑↑
Te Henui Stream mouth, East End	13	0.114	0.0742	↑↑
Oakura River d/s SH45 bridge	19	0.0415	0.1465	↑↑
Urenui River at estuary*	19	0.0451	0.1465	↓↓
Waingongoro River at Ohawe Beach	19	0.1929	0.5015	↓
Lake Rotomanu western beach	19	0.2753	0.5874	↑
Waingongoro River at Eltham camp	14	0.3163	0.5874	↓
Waiwhakaiho River at Merrilands Domain	19	0.6737	0.9079	↓
Patea River at King Edward Park	14	0.6984	0.9079	↓
Kaupokonui River at Beach Domain	19	0.7737	0.9144	↓
Manganui River at Everett Park	19	0.9144	0.9144	↑
Timaru Stream at end of Weld Road	18	0.8750	0.9143	↓

[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 (four sites) in seasonal median *E. coli* counts. With the exception of two seasonal median counts at the Timaru Stream site and one at the Kaupokonui River and most recently, the Patea River at Stratford site (which all entered the 'Alert' mode), none of the other seasonal median counts at the sites with insignificant temporal trends have reached 'Alert' or 'Action' modes at any time.

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 renewal 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 2014-2015 survey period and all instances of exceedance of guidelines were advised to the appropriate authorities. Very few follow-up investigations were necessary over the 2014-2015 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. Very few 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.

Generally, although cyanobacteria were found at all three of the designated lake monitoring sites, only Lake Rotokare numbers exceeded public health warning levels for the entire period during the 2014-2015 season. Variable benthic cyanobacteria coverage at the nine river/stream sites, although necessitating follow-up surveys on several occasions at three sites, did not exceed public health warning levels, but reached 'Alert' levels. Exposed cyanobacteria mats (caused mainly by low falling water levels in late summer or fluctuating hydroelectric power flows) exceeded guidelines on 17 occasions at three sites. Detached mats at the rivers edge exceeded the 'Action' level at one site on two occasions.

The Suitability for Recreation Grading (SFRG) referenced earlier in this report (Section 2.2) may now be re-assessed to include the 2014-2015 microbiological data enabling a comparison of the five year 2009-2014 period (Table 1) with the latest SFRG for the 2010-2015 period (presented in Table 95).

Table 95 Suitability for recreation grade for freshwater sites for the period November 2010 to March 2015

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	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 boatramp	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	C	Poor	98
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

Very 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 were moderate improvements at the Waitara River site (by 288 *E.coli* per 100 mls) and the Waingongoro River at Ohawe Beach site (by 157 *E.coli* per 100 mls). There were slightly fewer samples in excess of the 'Action' level over the most recent five year period at three of the monitored sites while three sites (Timaru Stream, Manganui River, and Waiwhakaiho River adjacent to Lake Rotomanu) had more samples (1%, 2%, and 4% respectively) in the 'Action' mode. The Patea River at King Edward Park, Stratford site deteriorated in terms of the MAC assessment which resulted in a change in SFR grading to 'very poor'. The Timaru Stream site MAC assessment improved resulting in an upgraded SFR to '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)

6. Recommendations

As a result of the 2014-2015 summer freshwater contact recreation bacteriological survey it is recommended:

1. THAT the 2015-2016 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 2015-2016 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 2015-2016 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

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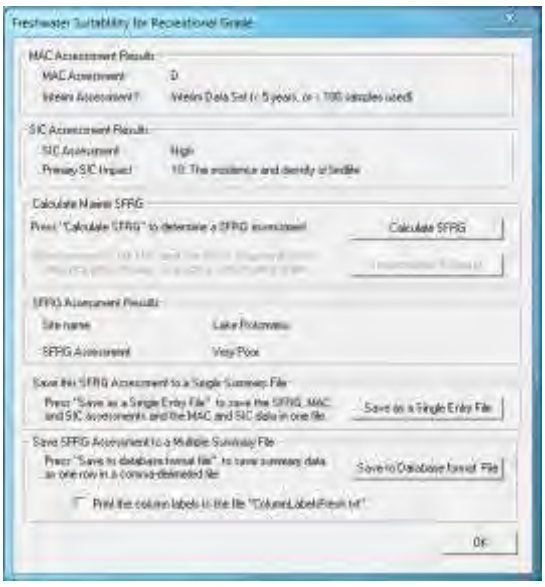
Appendix I

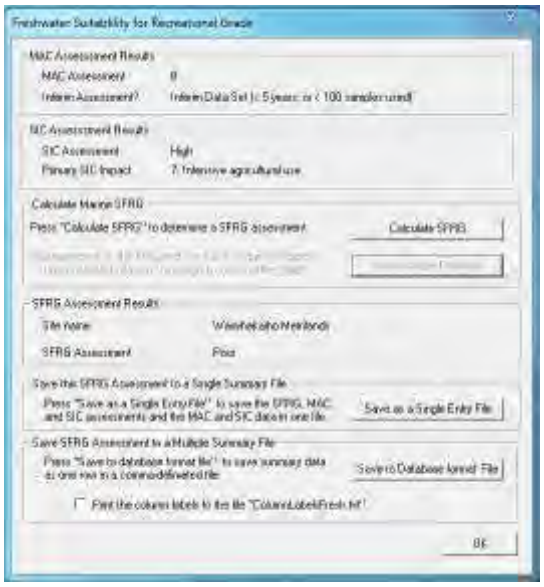
MAC assessments for all sites (for the 2009-2014 period)

Te Henui Stream: mouth

Lake Rotomanu



Waiwhakaiho River at Merrilands Domain

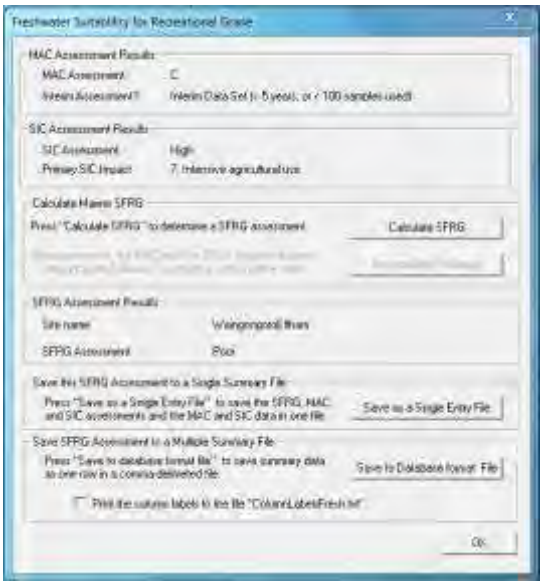


Waiwhakaiho near Lake Rotomanu

Patea River at Stratford

Patea River at boat ramp, Patea

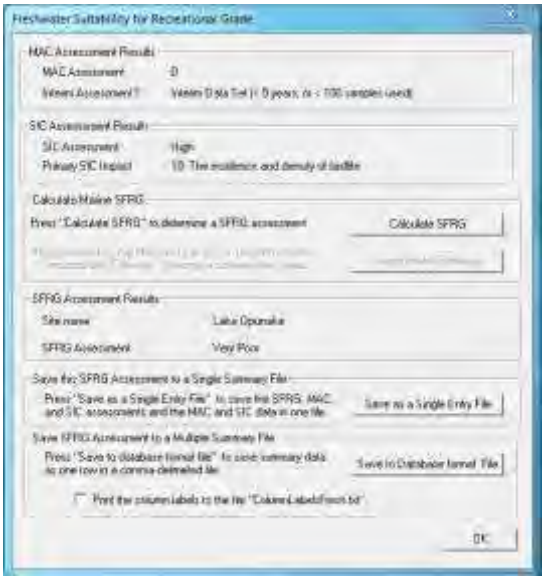
Waingongoro River at Eltham camp



Waingongoro River at Ohawe beach

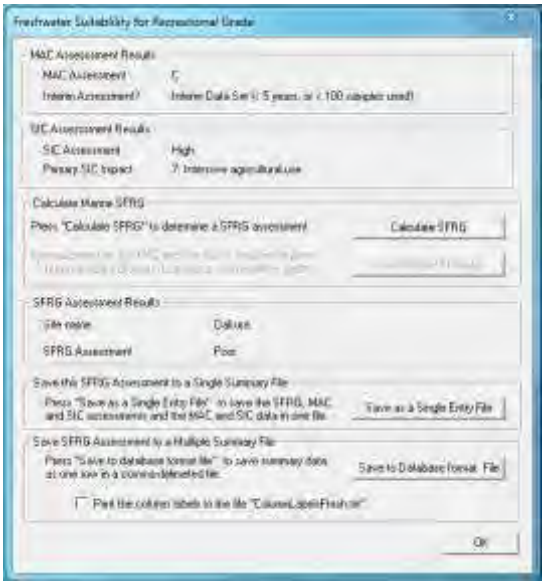
Kaupokonui River at beach domain

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 2014-2015 sampling dates

Date		HT (NZST)
Monday	10 November 2014	1144
Tuesday	9 December 2014	1123
Monday	5 January 2015	0952
Thursday	8 January 2015	1138
Monday	12 January 2015	1411
Tuesday	20 January 2015	0923
Friday	23 January 2015	1142
Monday	26 January 2015	1412
Monday	9 February 2015	1252
Thursday	19 February 2015	0951
Wednesday	4 March 2015	0910
Thursday	12 March 2015*	1344
Friday	20 March 2015	0929
Wednesday	1 April 2015	0759

[* all but two sites (KPK000995, WGG000995) due to localised heavy rain
- both re-sampled on Wednesday 1 April 2015 (HT: 0759 NZST)]

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
10 November 2014	Fine, overcast	7/8	None	Turbid, brown	Ripple	0/2 (jetskiing)	Few ducks	0	0
9 December 2014	Drizzle, overcast	8/8	None	Slightly turbid, brown	Flat	0/0	Few ducks	0	0.5
5 January 2015	Fine	1/8	None	Turbid, brown-orange	Flat	4/22 (banks)	No birdlife, (sign removed by user)	0	0
8 January 2015	Fine	2/8	None	Slightly turbid, brown	Flat	0/4 (bank, waterskiing)	No sign present; one duck and several eels	0	0
12 January 2015	Fine	7/8	None	Turbid, brown	Flat	0/3 (boating)	Few ducks and gulls common; no signage present	0	0
20 January 2015	Fine, overcast	8/8	None	Slightly turbid, brown	Flat	0/0	Ducks common; no signage present	1	5
23 January 2015	Fine	0/8	None	Slightly turbid, brown	Flat	8/8 (boating, waterskiing)	Few ducks; signage present	0	0
26 January 2015	Fine, overcast	8/8	None	Turbid, brown	Flat	3/2 (boating)	Few ducks	0	0
9 February 2015	Fine, overcast	8/8	None	Slightly turbid, brown	Ripple	0/0	Few ducks; signage present	0	0
19 February 2015	Fine	1/8	None	Slightly turbid, brown	Ripple	0/0	Few ducks; signage present	0	0
4 March 2015	Fine, overcast	8/8	None	Slightly turbid, brown	Ripple	0/2 (banks)	Few ducks; signage present	0	0
12 March 2015	Fine, overcast	8/8	N/A	Slightly turbid, brown	Ripple	0/0	One duck	0	0
20 March 2015	Fine	0/8	N/A	Slightly turbid, brown	Ripple	0/0	Ducks common; signage present	0	0.5

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
10 November 2014	Fine, overcast	7/8	50%	Clear, pale brown	D/S	0/1 (bank)	No birdlife	0	0
9 December 2014	Drizzling, overcast	8/8	90%	Clear, pale brown	D/S	0/0	Some cyanobacteria and foaming; no birdlife	0	0.5
5 January 2015	Fine	3/8	None	Clear, brown	D/S	1/5 (bank)	No birdlife; signage present	0	0
8 January 2015	Fine	2/8	None	Clear, brown	D/S	7/10 (bank)	Signage present; no birdlife	0	0
12 January 2015	Fine, overcast	7/8	None	Clear, brown	D/S	0/0	Signage present; no birdlife	0	0
20 January 2015	Fine	6/8	50%	Clear, green-brown	D/S	0/0	Signage present; no birdlife	1	5
23 January 2015	Fine	0/8	40%	Clear, pale green	D/S	0/0	Signage present; no birdlife	0	0
26 January 2015	Fine	4/8	50%	Clear, yellow-green	D/S	0/0	Signage present; no birdlife	0	0
9 February 2015	Fine, overcast	8/8	70%	Clear, colourless	D/S	0/0	One gull; signage present	0	0
19 February 2015	Fine	3/8	100%	Clear, pale green-brown	D/S	0/0	Signage present; no birdlife	0	0
4 March 2015	Fine, overcast	8/8	100%	Clear, colourless	D/S	0/0	Signage present; no birdlife	0	0
12 March 2015	Fine, overcast	8/8	80% mats	Clear, brown	D/S	0/0	Signage present; two swallows	0	0
20 March 2015	Fine	0/8	70% mats	Clear, pale brown-yellow	D/S	0/0	Signage present; no birdlife	0	0

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
10 November 2014	Fine	5/8	30%	Clear, colourless	D/S	0/6 (whitebaiting)	Few ducks	0	0
9 December 2014	Drizzling, overcast	8/8	90%	Clear, colourless	U/S	0/0	Few sparrows	0	0.5
5 January 2015	Fine	2/8	30% mats & filaments	Clear, brown	D/S	0/2 (bank)	Gulls very common	0	0
8 January 2015	Fine	2/8	None	Clear, uncoloured	D/S	0/0	Gulls very common	0	0
12 January 2015	Fine, overcast	7/8	10%	Clear, colourless	D/S	0/0	Gulls common u/s	0	0
20 January 2015	Fine, overcast	8/8	100%	Clear, colourless	D/S	0/0	Gulls very common	1	5
23 January 2015	Fine	0/8	100%	Clear, colourless	D/S	0/0	Few ducks and gulls common	0	0
26 January 2015	Fine	5/8	100%	Clear, pale green	D/S	0/0	Gulls extremely common	0	0
9 February 2015	Fine, overcast	8/8	70% mats	Clear, pale green	D/S	0/0	Gulls common u/s	0	0
19 February 2015	Fine	1/8	100% mats	Clear, colourless	D/S	0/0	Gulls abundant u/s	0	0
4 March 2015	Fine, overcast	8/8	80% mats	Sl. turbid, pale brown	D/S	0/0	Gulls abundant u/s	0	0
12 March 2015	Fine, overcast	8/8	100%	Sl. turbid, pale brown	D/S	0/0	Gulls abundant u/s	0	0
20 March 2015	Fine	0/8	90% mats	Clear,pale brown	D/S	0/0	Gulls common u/s	0	0.5

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
10 November 2014	Fine	4/8	None	Turbid, green	D/S	0/4 (whitebaiting)	Ducks common	0	0
9 December 2014	Fine, overcast	8/8	90% mats	Clear, dark green	D/S (slow)	0/0	Ducks common	0	0.5
5 January 2015	Fine	1/8	90% mats	Clear, brown	D/S	1/5 (banks)	Few ducks	0	0
8 January 2015	Fine	2/8	80% mats	Sl turbid, brown	U/S	0/0	Ducks and gulls common	0	0
12 January 2015	Fine,overcast	7/8	100% mats	Clear, brown	D/S	3/1 (bank)	Ducks common, few seagulls	0	0
20 January 2015	Fine	2/8	N/A	Turbid, green	U/S (surging)*	0/0	Few ducks (*large waves)	1	5
23 January 2015	Fine	0/8	100%	Clear, green-yellow	Ponded	0/0	Ducks common	0	0
26 January 2015	Fine, overcast	7/8	100%	Clear, yellow-green	Ponded	0/0	Ducks common	0	0
9 February 2015	Fine, overcast	8/8	N/A	Clear, green	Ponded	0/2 (bank)	Ducks common	0	0
19 February 2015	Fine	4/8	N/A	Sl. turbid, green	D/S	0/2 (fishing)	Ducks very common; signage present	0	0
4 March 2015	Fine	8/8	N/A	Sl. turbid, green	Surging	0/0	Ducks and gulls common; signage present	0	0
12 March 2015	Fine, overcast	8/8	N/A	Slightly turbid, green-brown	D/S(slow)	0/2 (banks)	Ducks and gulls common; signage present	0	0
20 March 2015	Fine	0/8	N/A	Turbid, green	Surging	0/0	Ducks very common; signage present	0	0.5

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
10 November 2014	Fine	6/8	Thin mats	Sl. turbid, grey-green	D/S	0/2 (bank)	No birdlife	0	0
9 December 2014	Drizzle, overcast	8/8	Patchy mats	Clear, pale brown	D/S	0/0	No birdlife	0.5	0.5
5 January 2015	Fine	3/8	Patchy mats	Rel. clear, green-brown	D/S	0/1 (bank)	Few ducks, one dog (bank)	0	0
8 January 2015	Fine	0/8	Widespread mats	Clear, green-brown	D/S	0/0	No birdlife	0	0
12 January 2015	Fine	6/8	Widespread mats	Rel. clear, brown	D/S	0/0	No birdlife	0	0
20 January 2015	Fine, overcast	7/8	Widespread mats	Rel. clear, brown-green	D/S	0/0	Few chicks	0.5	4
23 January 2015	Fine	3/8	Widespread mats	Clear green-grey	D/S	0/0	No birdlife	0	0
26 January 2015	Fine	5/8	Widespread mats	Clear, pale brown	D/S	0/0	Few ducks	0	0
9 February 2015	Fine	4/8	Widespread mats	Clear, green-grey	D/S	0/2 (bagpipers playing on bank!)	One duck	0	0
19 February 2015	Fine, overcast	7/8	Widespread mats	Clear, pale green	D/S	0/0	One duck; one shag	0	0
4 March 2015	Fine, overcast	8/8	Widespread mats	Clear brown-green	D/S	0/0	One duck	0	0
12 March 2015	Drizzle, overcast	8/8	Widespread mats	Clear, pale brown	D/S	0/0	No birdlife	0	0
20 March 2015	Fine	0/8	50%	Clear, uncoloured	D/S	0/0	Few ducks	0	1

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
10 November 2014	Fine, overcast	7/8	N/A	Slightly turbid, grey-green	D/S (slow)	0/2 (fishing)	No birdlife	0	0
9 December 2014	Fine, overcast	8/8	N/A	Slightly turbid, green	U/S	0/0	Three swan	0	0.6
5 January 2015	Fine	3/8	N/A	Turbid, pale green	D/S (surging)	0/0	No birdlife	0	0
8 January 2015	Fine	0/8	N/A	Turbid, pale green	U/S	0/2 (jet-skiing)	No birdlife	0	0
12 January 2015	Fine	4/8	N/A	Turbid, green	D/S (surging)	6/3 (fishing)	No birdlife	0	0
20 January 2015	Fine, overcast	8/8	N/A	Turbid, milky green	D/S (surging)	0/0	No birdlife	1	5
23 January 2015	Fine	0/8	N/A	Turbid, pale green	D/S (slow)	5/11 (boating/fishing)	No birdlife	0	0
26 January 2015	Fine	0/8	N/A	Turbid, pale green	U/S (slow)	0/0	No birdlife	0	0
9 February 2015	Fine, overcast	7/8	N/A	Turbid, milky pale green	D/S (slow)	0/0	No birdlife	0	0
19 February 2015	Fine	08	N/A	Turbid milky grey-green	U/S (slow)	0/0	Two gulls	0	0
4 March 2015	Fine, overcast	8/8	N/A	Turbid, pale green	D/S (slow)	0/0	No birdlife	0	0
12 March 2015	Raining, overcast	8/8	N/A	Turbid, brown-green	U/S (slow)	0/0	No birdlife	6.5	6.5
20 March 2015	Fine	0/8	N/A	Sl. turbid, turquoise	U/S	0/0	No birdlife	0	3

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
10 November 2014	Fine	3/8	Patchy mats	Clear, green	D/S	0/0	Sheep in adjacent paddock	0	0
9 December 2014	Drizzle, overcast	8/8	Patchy mats	Rel. clear, brown	D/S	0/0	Sheep in adjacent paddock	0.5	0.5
5 January 2015	Fine	4/8	Widespread mats	Clear, brown-green	D/S	0/0	Sheep in adjacent paddock	0	0
8 January 2015	Fine	0/8	Widespread mats	Rel clear, pale brown	D/S	0/0	Sheep in adjacent paddock	0	0
12 January 2015	Fine	5/8	Widespread mats	Rel clear, brown	D/S	0/0	Sheep in adjacent paddock	0	0
20 January 2015	Fine	6/8	Widespread mats	Clear, yellow-brown	D/S	0/0	Sheep in adjacent paddock	0.5	4
23 January 2015	Fine	0/8	Widespread mats	Clear, green-brown	D/S	0/0	One duck; sheep in adjacent paddock	0	0
26 January 2015	Fine	4/8	Widespread mats	Clear, brown-yellow	D/S	0/0	Sheep in adjacent paddock	0	0
9 February 2015	Fine	1/8	Widespread mats	Clear, dark green	D/S	0/0	Sheep in adjacent paddock	0	0
19 February 2015	Fine	4/8	Widespread mats	Clear, pale green	D/S	0/30 (camping)	(school group in camp paddock)	0	0
4 March 2015	Fine, overcast	8/8	Widespread mats	Clear, brown-green	D/S	0/0	No birdlife	0	0
12 March 2015	Fine, overcast	8/8	Widespread mats	Sl. turbid*, pale brown-green	D/S	0/ (16 banks/kayaking*)	No birdlife	0	0
20 March 2015	Fine	0/8	70%	Clear, uncoloured	D/S	0/0	No birdlife	0	1

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
10 November 2014	Fine, overcast	7/8	Patchy mats	Sl. turbid brown	D/S	0/20 (whitebaiting/banks)	No birdlife	0	0
9 December 2014	Fine, overcast	8/8	Patchy mats	Rel. clear,brown	D/S	0/0	No birdlife	0	1
5 January 2015	Fine	3/8	Patchy mats	Sl. turbid, pale brown	D/S (surging)	0/3 (banks/ fishing)	No birdlife, one dog	0	0
8 January 2015	Fine	0/8	Patchy mats	Clear, pale brown	D/S (slow)	2/10 (banks)	No birdlife, two dogs	0	0
12 January 2015	Fine, overcast (rain spits)	7/8	Patchy mats	Clear, brown-green	D/S	16/5 (banks)	No birdlife	0	0
20 January 2015	Fine	4/8	Patchy mats	Rel.clear, brown-green	D/S (slow)	0/0	(Cyanobacteria signage present). No birdlife	4	5
23 January 2015	Fine	0/8	Patchy mats	Clear, yellow-brown	U/S (slow)	0/0	Three signs ok; one sign damaged	0	0
26 January 2015	Fine	0/8	Widespread mats	Clear, brown-green	D/S (slow) (surging)	0/0	Three signs ok; one sign damaged, two ducks	0	0
9 February 2015	Fine, overcast	8/8	Widespread mats	Clear, dark brown-green	D/S (slow)	0/0	One shag; all signs present (and repaired)	0	0
19 February 2015	Fine	1/8	Patchy mats	Clear, pale brown	U/S (surging)	0/0	Two ducks, one shag; signage present (some damage)	0	0
4 March 2015	Fine, overcast	7/8	Widespread mats	Clear, dark brown	D/S (surging)	0/0	No birdlife; signage present	0	0
20 March 2015	Fine	0/8	N/R	Clear, pale brown	U/S (surging)	0/3 (banks)	Few ducks; signage present	0	5
1 April 2015	Fine	1/8	Widespread mats	Rel. clear, brown	D/S (slow)	0/0	No wildlife; signage present	0	3

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
10 November 2014	Fine	6/8	None	Clear, grey-green	D/S (slow)	0/26 (whitebaiting/fishing)	No birdlife	0	0
9 December 2014	Fine	6/8	N/A	Sl. turbid, brown	Surging	20/10 (banks)	No birdlife	0	1
5 January 2015	Fine	2/8	N/A	Rel. clear, pale brown	D/S (slow, surging)	4/6 (fishing/banks)	No birdlife	0	0
8 January 2015	Fine	0/8	N/A	Sl. turbid, pale brown	U/S (slow)	8/12 (banks)	No birdlife	0	0
12 January 2015	Fine	6/8	N/A	Rel. clear, green	U/S (surging)	6/6 (banks/fishing)	No birdlife	0	0
20 January 2015	Fine	1/8	N/A	Sl. turbid, green-brown	D/S (slow, surging)	0/2 (banks)	One shag	4	5
23 January 2015	Fine	0/8	N/A	Clear, pale green	U/S (slow)	7/4 (fishing/banks)	No birdlife	0	0
26 January 2015	Fine	0/8	N/A	Clear, dark green	U/S (slow)	17/12 (banks)	No birdlife	0	0
9 February 2015	Fine	5/8	N/A	Clear, dark green-grey	D/S (slow)	0/5 (banks)	No birdlife	0	0
19 February 2015	Fine, overcast	7/8	N/A	Clear, pale green	Ponded	0/0	No birdlife	0	0
4 March 2015	Fine, overcast	8/8	N/A	Clear, dark brown	U/S (very slow)	0/2 (banks)	No birdlife	0	0
20 March 2015	Fine	0/8	N/A	Clear, green-brown	U/S	0/2 (fishing)	No birdlife	0	5
1 April 2015	Fine	0/8	N/A	Rel. clear, pale green-brown	D/S (slow)	0/0	No birdlife	0	3

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
10 November 2014	Fine, overcast	7/8	None, some weed	Clear, grey-green	Ripple	0/0	Few ducks on bank, ducks common on lake	0	0
9 December 2014	Drizzle, overcast	8/8	None	Clear, green-brown	Ripple	0/2 (walking)	Ducks and swan common; one dog	0	1.5
5 January 2015	Fine, overcast	7/8	N/R	Clear, green-brown	Flat	0/2 (banks)	Ducks very common and one dog	0	0
8 January 2015	Fine	2/8	Suspended, common	Turbid, dark green	Ripple	0/0	Ducks common	0	0
12 January 2015	Fine, overcast	7/8	N/R	Rel. clear, dark brown-green	Ripple	0/0	Ducks common, few swan	0	0
20 January 2015	Fine	0/8	None	Rel. clear, dark green	Ripple	0/5 (banks/kayaker)	Ducks common; (Didymo signage)	5	6
23 January 2015	Fine	0/8	None	Clear, dark green	Ripple	0/2 (banks)	Ducks common; one dog	0	0
26 January 2015	Fine	0/8	None (weed, common)	Clear, dark green	Flat	0/4 (banks)	Ducks very common	0	0
9 February 2015	Fine	6/8	None	Clear, dark green	Ripple	0/0	Ducks common (lake and bank)	1	1
19 February 2015	Fine	6/8	None	Clear, dark green-grey	Flat	0/0	Ducks common (lake and bank)	0	0
4 March 2015	Fine	6/8	None	Sl. turbid, dark brown	Flat	0/0	Ducks common; two swan	1	1
12 March 2015	Rain, overcast	8/8	None	Clear, dark green	Ripple	0/0	Ducks common	2	2
20 March 2015	Fine	0/8	N/R	Clear, uncoloured	Ripple	0/0	Ducks common	0	2

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
10 November 2014	Fine	6/8	N/A	Clear, colourless	D/S	0/5 (whitebaiting/boardpaddling)	Few sparrows; stock in u/s paddock	0	0
9 December 2014	Drizzling, overcast	8/8	Nil	Clear, colourless	D/S	0/0	No birdlife	0	4
5 January 2015	Fine	1/8	Nil	Clear, brown	D/S	2/3 (bank)	Two dogs in water; few ducks; oystercatchers and gulls common	0	0
8 January 2015	Fine	2/8	Nil	Clear, uncoloured	D/S (surging)	0/15 (banks)	Three dogs; no birdlife	0	0
12 January 2015	Fine, overcast	8/8	5% mats	Clear, colourless	U/S	0/6 (bank)	Gulls common; few oystercatchers; one dog	0	0
20 January 2015	Fine	0/8	Nil	Turbid, green-brown	U/S (surging)	5/5 (bank)	No birdlife	6	16
23 January 2015	Fine	0/8	N/A	Sl. turbid, green	D/S	3/0	Few gulls	0	0
26 January 2015	Fine, overcast	7/8	Nil	Clear,pale brown	D/S	1/0	Gulls common; two dogs (in water)	0	0
9 February 2015	Fine, overcast	7/8	30%	Clear,pale brown	U/S (surging)	0/0	Few oystercatchers	1.5	1.5
19 February 2015	Fine	4/8	N/A	Sl. turbid, yellow-green	D/S	0/5 (bank)	One dog; gulls common	0	0
4 March 2015	Fine	7/8	N/A	Clear, pale brown	D/S	0/1 (bank)	One dog; gulls common; no signage	0	0
12 March 2015	Fine, overcast	7/8	N/A	Clear, green-brown	Surging	0/0	Few swallows; no signage	0	0
20 March 2015	Fine	0/8	N/A	Clear, pale yellow	D/S	0/0	Swallows and petrels common; few gulls	0	1

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
10 November 2014	Fine, overcast	8/8	N/A	Slightly turbid, dark green	D/S (slow)	0/1 (walking)	One dog	0	0
9 December 2014	Fine, overcast	8/8	N/A	Clear, green	D/S (slow)	0/0	No birdlife	0	4
5 January 2015	Fine	1/8	N/A	Clear, brown	U/S	2/4 (bank)	No birdlife; two dogs	0	0
8 January 2015	Fine	28	N/A	Clear, uncoloured	U/S (surging)	10/20 (banks)	No birdlife	0	0
12 January 2015	Overcast, light showers	8/8	Nil	Clear, brown-green	D/S	0/4 (bank/fishing)	Few gulls	0	0
20 January 2015	Fine	0/8	N/A	Clear, brown-green	U/S	2/5 (bank)	No birdlife	6	16
23 January 2015	Fine	0/8	Nil	Clear, green	D/S (slow)	15/0	No birdlife	0	0
26 January 2015	Fine, overcast	8/8	Nil	Clear, green	D/S	5/0	One gull	0	0
9 February 2015	Fine, overcast	8/8	Nil	Clear, green-brown	D/S	0/0	No birdlife	1.5	1.5
19 February 2015	Fine	3/8	N/A	Clear, green	Surging	0/0	No birdlife	0	0
4 March 2015	Fine, overcast	8/8	N/A	Clear, green	D/S	0/0	No birdlife	0	0
12 March 2015	Fine, overcast	8/8	N/A	Clear, green	U/S (slow)	0/5 (banks)	No birdlife	0	0
20 March 2015	Fine	0/8	N/A	Clear, green	Surging	0/1 (bank)	One dog in water; no birdlife	0	1

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
10 November 2014	Fine	2/8	2.1	Sl.turbid, brown	D/S (slow)	0/25 (fishing/whitebaiting)	No signage, no birdlife	0	0
9 December 2014	Fine, overcast	8/8	2.0	Sl.turbid, pale brown	Still	0/0	No signage, no birdlife	0	0
5 January 2015	Fine	1/8	1.5	Sl. turbid, brown	D/S	0/5 (fishing)	No signage, no birdlife	0	0
8 January 2015	Fine	0/8	2.0	Sl. turbid, grey-brown	D/S (very slow)	0/4 (fishing)	No signage, two ducks	0	0
12 January 2015	Fine	0/8	1.5	Sl. turbid, brown-green	D/S(slow)	0/0	NPDC signage, no birdlife	0	0
20 January 2015	Fine	5/8	2.4	Clear, green-brown	D/S(slow)	0/7 (fishing)	NPDC signage, few ducks	1.5	5
23 January 2015	Fine	2/8	2.0	Sl. turbid, green-brown	N/R	10/0	Few ducks;gulls common	0	0
26 January 2015	Fine	0/8	2.1	Turbid, green-brown	Still	0/4 (fishing)	Ducks common	0	0
9 February 2015	Fine	4/8	1.85	Turbid, dark brown	Still	0/0	Signage; few ducks	0	0
19 February 2015	Fine	0/8	2.4	Sl. turbid, green	D/S (slow)	0/0	One duck; signage present	0	0
4 March 2015	Fine	5/8	2.0	Clear, green	D/S	0/0	Few ducks; signage gone	0	0
12 March 2015	Fine, overcast	7/8	2.1	Turbid, brown	D/S (slow)	0/0	Few ducks; signage present	0	0
20 March 2015	Fine	0/8	2.3	Turbid, dark green	D/S	0/1 (canoeist)	Two ducks; no signage	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
10 November 2014	Fine	5/8	N/A	Sl. turbid, green	U/S (slow)	0/0	No signage or birdlife	0	0
9 December 2014	Fine, overcast	8/8	N/A	Clear, green-grey	U/S	0/0	No birdlife	0	5
5 January 2015	Fine	0/8	N/A	Clear, pale green	U/S (slow)	0/16 (fishing/banks)	No birdlife	0	0
8 January 2015	Fine	0/8	N/A	Sl. turbid, light brown	Still (ponded)	0/10 (boating)	Few gulls	0	0
12 January 2015	Fine	4/8	N/A	Clear, blue- green	U/S (slow)	20/0	No birdlife	0	0
20 January 2015	Fine, overcast	7/8	N/A	Sl. turbid, pale green	U/S	0/0	No birdlife	1.5	5
23 January 2015	Fine	2/8	N/A	Clear, turquoise	U/S (surging)	120/80 (beach/kayaking)	No birdlife	0	0
26 January 2015	Fine	0/8	N/A	Rel. clear, green-grey	D/S (slow)	100/? (fishing)	No birdlife	0	0
9 February 2015	Fine	5/8	N/A	Clear, turquoise	U/S	0/0	No birdlife	0	0
19 February 2015	Fine	0/8	N/A	Clear, uncoloured	U/S (slow)	0/0	No birdlife	0	0
4 March 2015	Fine, overcast	8/8	N/A	Clear, uncoloured	U/S (slow)	0/30 (banks)	No birdlife	0	0
12 March 2015	Fine	6/8	N/A	Slightly turbid, turquoise-green	U/S	0/0	No birdlife	0	0
20 March 2015	Fine	0/8	N/A	Turbid, green-grey	U/S	0/0	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
10 November 2014	Fine	5/8	50%	Clear, uncoloured	D/S	0/0	No birdlife	1	1
9 December 2014	Fine, overcast	8/8	100%	Rel. clear, pale brown	D/S	0/0	Few ducks	0	0.5
5 January 2015	Fine	3/8	50% thin mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0
8 January 2015	Fine	1/8	70% mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0
12 January 2015	Fine	2/8	100% mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0
20 January 2015	Fine, overcast	7/8	Mats	Clear, pale brown	D/S	0/0	Cyanobacteria signage; no birdlife	2	10
23 January 2015	Fine	3/8	100%	Clear, colourless	D/S	0/0	Cyanobacteria signage; no birdlife	0	0
26 January 2015	Fine	0/8	100%	Clear, uncoloured	D/S	0/0	No birdlife; signage vandalised	0	0
9 February 2015	Fine	6/8	Mats	Rel. clear, pale brown	D/S	0/0	No birdlife; signage present	0	0
19 February 2015	Fine	0/8	90% mats	Clear, colourless	D/S	0/0	No birdlife; signage present	0	0
4 March 2015	Fine	4/8	Widespread mats	Clear, pale green	D/S	0/0	No birdlife; signage present	0	0
12 March 2015	Fine, overcast	8/8	50% mats	Rel.clear, pale brown	D/S	0/0	No birdlife; no signage	0	0
20 March 2015	Fine	0/8	Widespread	Slightly turbid, brown-green	D/S	0/0	No birdlife	0	0.5

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
10 November 2014	Fine	2/8	N/A	Slightly turbid, yellow	Ripple	0/0	Ducks common	0	0
9 December 2014	Fine, overcast	8/8	N/A	Rel.clear, green-brown	Ripple	0/0	One shag, two ducks	0	0.5
5 January 2015	Fine	3/8	N/A	Rel.clear, brown	Ripple	0/0	Few ducks	0	0
8 January 2015	Fine	2/8	N/A	Rel.clear, brown	Ripple	0/0	Few ducks, new signage	0	0
12 January 2015	Fine	1/8	N/A	Slightly turbid, brown	Ripple	0/5 (jetskiing/picnicking)	Few ducks, new signage	0	0
20 January 2015	Fine	6/8	N/A	Clear, brown	Ripple	0/0	Few ducks (Didymo signage)	2	10
23 January 2015	Fine	2/8	N/A	Clear, brown	Ripple	4/2 (boating)	Few ducks (Didymo signage)	0	0
26 January 2015	Fine	2/8	N/A	Turbid, brown	Ripple	0/15 (banks)	No birdlife	0	0
9 February 2015	Fine	6/8	N/A	Rel.clear, brown	Ripple	0/0	Few ducks, two swan	0	0
19 February 2015	Fine	0/8	N/A	Clear, brown	Flat	0/0 (closed)	No birdlife. Lake level lower than usual	0	0
4 March 2015	Fine	4/8	N/A	Clear, pale brown	Ripple	0/15 (kayaking)	Two ducks	0	0
12 March 2015	Fine, overcast	8/8	N/A	Rel. clear, pale brown	Flat	0/0	Two shags and few ducks	0	0
20 March 2015	Fine	0/8	N/A	Slightly turbid, blue-brown	Ripple	0/0	Shags common	0	0.5

Appendix IV

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

Dates of additional sampling

Date	Preceding weather
Tuesday 19 November 2014	wet over 72 hours
Tuesday 2 December 2014	some rain over 72 hours; little rain over 24 hours
Tuesday 15 January 2015	dry over 72 hours
Thursday 29 January 2015	brief showers over 24 hours; otherwise lengthy very dry period
Friday 13 February 2015	fine over 72 hours
Thursday 26 February 2015	dry over last 48 hours, some rain prior 24 hours
Tuesday 17 March 2015	dry over 72 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
18 November 2014	Fine	2/8	Some	Turbid, brown	Ripple	0/0	Few ducks	19	35
2 December 2014	Fine	2/8	N/R	Turbid, brown	Ripple	0/2 (boat, kayak)	Two ducks	0	0
15 January 2015	Fine	1/8	None	Turbid, yellow- brown	Choppy	0/9 (banks/jet skiing)	No birdlife; signage removed	0	0
29 January 2015	Fine	0/8	None	Rel. clear, pale brown	Flat	4/3 (banks)	No birdlife; signage present	0	0
13 February 2015	Fine	3/8	None	Sl. turbid, brown-green	Ripple	0/6 (banks)	One duck; signage present	0	0
26 February 2015	Fine	4/8	None	Turbid, brown	Ripple	0/1 (bank)	No birdlife; signage present	0	1
17 March 2015	Very light rain; overcast	7/8	None	Sl. turbid, pale brown	Choppy	0/2 (banks)	No birdlife; signage present	0	0

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
18 November 2014	Fine, overcast	7/8	50%	Rel. clear, green-brown	D/S	0/0	No birdlife	19	35
2 December 2014	Fine	1/8	10%	Rel. clear, pale brown	D/S	0/0	No birdlife	0	0
15 January 2015	Fine	0/8	None	Clear, green-brown	D/S	0/0	Few ducks	0	0
29 January 2015	Fine	2/8	None	Clear, green	D/S	1/0	One duck; signage present	0	0
13 February 2015	Fine	0/8	None	Clear, green-brown	D/S	0/0	No wildlife	0	0
26 February 2015	Fine	4/8	75%	Clear, uncoloured	D/S	0/0	Few gulls	0	1
17 March 2015	Fine, overcast	8/8	None	Clear, dark green-brown	D/S	0/0	No wildlife	0	0

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
18 November 2014	Fine	2/8	None	Rel. clear, pale brown	Ripple	0/0	Few ducks	10	21
2 December 2014	Fine	1/8	N/R	Rel. clear, pale brown	Ripple	0/0	Ducks common, few swans	0	6.5
15 January 2015	Fine	1/8	None	Rel. clear,green-brown	Ripple	0/0	Ducks common	0	0
29 January 2015	Fine	0/8	None	Clear, pale green	Ripple	0/0	Ducks very common	0	0
13 February 2015	Fine	0/8	None	Clear, dark green	Ripple	0/0	Ducks common	0	0
26 February 2015	Fine	3/8	Some; and weed	Clear, brown	Choppy	0/0	Ducks common	0	0
17 March 2015	Very light rain; overcast	8/8	None	Rel. clear; dark green	Ripple	0/0	Ducks common, one shag	6	6

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
18 November 2014	Fine	2/8	Some	Rel. clear pale brown	Ripple	0/0	Few ducks	30	5
2 December 2014	Fine	4/8	N/R	Rel. clear pale brown	Ripple	0/1 (fishing)	Two ducks	1	4
15 January 2015	Fine	1/8	N/R	Sl. turbid, brown	Ripple	0/0	Few ducks	0	0
29 January 2015	Fine	0/8	None	Sl. turbid, yellow-brown	Ripple	0/0	No birdlife	0	0
13 February 2015	Fine, overcast	7/8	None	Slightly turbid, dark brown	Ripple	0/0	No birdlife	0	0
26 February 2015	Fine	4/8	None; weed common	Clear, brown	Flat	0/0	One duck; stock grazing	0	5
17 March 2015	Very light rain; overcast	8/8	None	Rel. clear; dark grey	Ripple	0/0	Few ducks and shags	0	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
18 November 2014	Fine	2/8	None visible	Rel. clear, brown	Choppy	0/2 (bank/ kayaker)	Boat ramp locked, no signage	24	32
3 December 2014	Fine	6/8	N/R	Turbid, brown	Ripple	0/0	Few ducks	0	4
15 December 2014	Fine	1/8	Suspended very common	Turbid, brown	Flat	0/8 (bank)(many on track)	No wildlife. Boat ramp closed. Signage present	0	0
15 January 2015	Fine	2/8	Suspended common	Turbid, grey-green	Ripple	0/2 (bank)	Few ducks. Boat ramp closed. Signage present	0	0
27 January 2015	Fine	2/8	Suspended very common	Turbid, khaki-green	Sl. ripple	0/12 (banks)	Boat ramp closed. One duck and one shag. Signage present .	0	0
12 February 2015	Fine	6/8	Suspended very common	Turbid, bright green	Ripple	0/6 (banks)	Boat ramp closed. Two ducks, two swan. Signage present.	0	0
26 February 2015	Fine	8/8	Suspended very common	Turbid, khaki-yellow	Sl. ripple	0/0	Boat ramp closed. Three black swan, ducks common. Signage present.	0	13
20 March 2015	Fine	0/8	Suspended very common and floating	Turbid, khaki	Flat	8 (banks)	Few ducks, two swan; signage present, ramp closed	0	0
25 March 2015	Fine	5/8	Suspended very common	Turbid, bright green	Ripple	19 (banks)	Boat ramp closed; few pukeko	0	13

Appendix VI

Comparative annual box and whisker plots of SEM data for *E. coli* for the period 1996 to 2015

Explanation of box and whisker plots

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. The notch, symmetrically spread around the median represents the 95% confidence interval of the median). It is a feature that allows rapid comparison between groups. If notches overlap, there is no significant difference between groups (at the 95 % confidence interval). If notches do not overlap, a statistical difference is expected.

The top and bottom of the box represent the upper and lower 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, ie, Upper hinge – Lower hinge = Hspread. The inner fences are defined as follows:

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

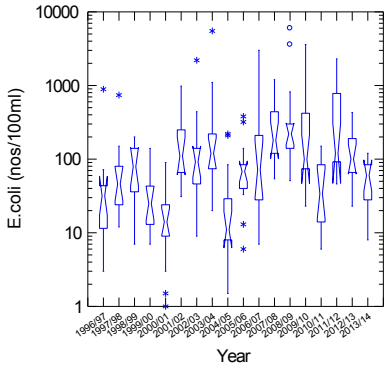
The outer fences are defined as follows:

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

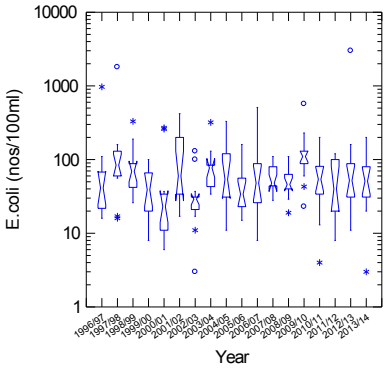
> The whiskers show the range of values that lie within the inner fences. Values outside the inner fence (outliers) are plotted as asterisks (*). Values outside the outer fence (extreme outliers) are plotted as ˚.

E. coli

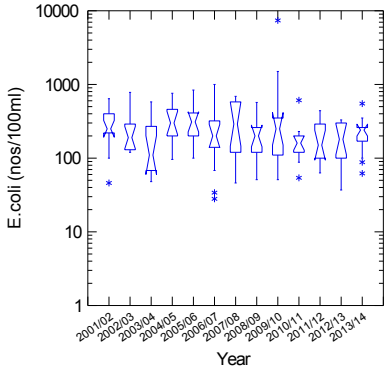
Lake Rotomanu



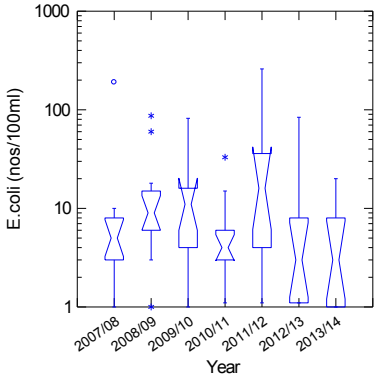
Waiwhakaiho River at Merrilands Domain



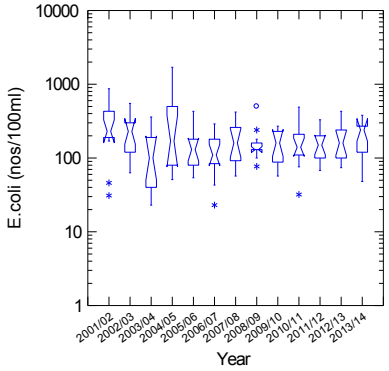
Patea River at Stratford



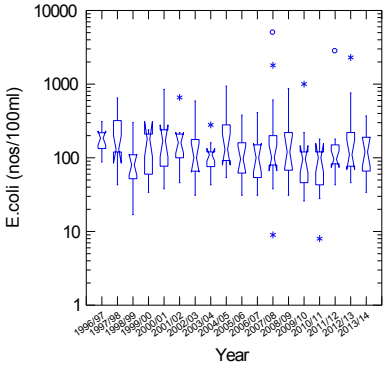
Patea River at Patea boat ramp



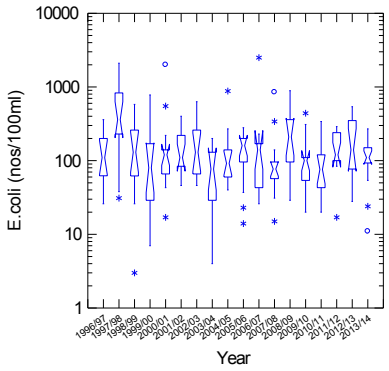
Waingongoro R at Eltham



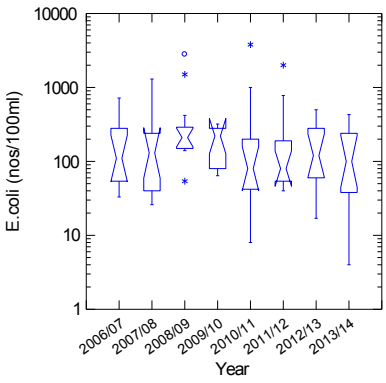
Waingongoro R at Ohawe



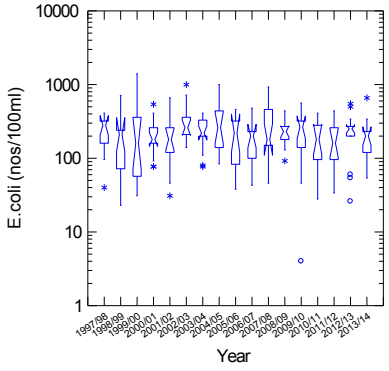
Kaupokonui River



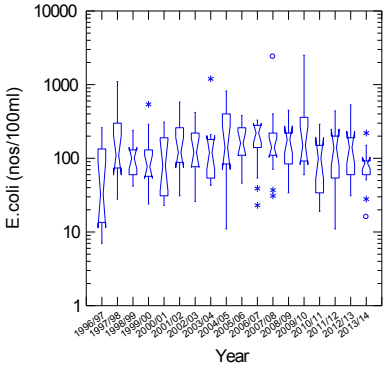
Lake Opunake



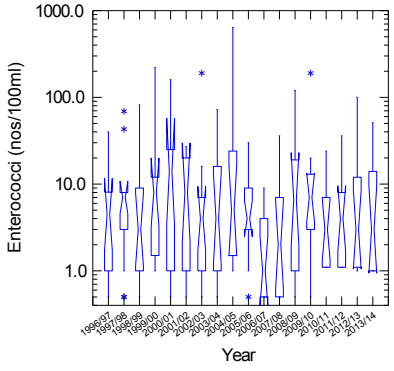
Timaru Stream



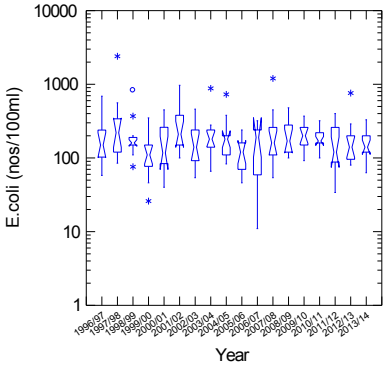
Oakura River



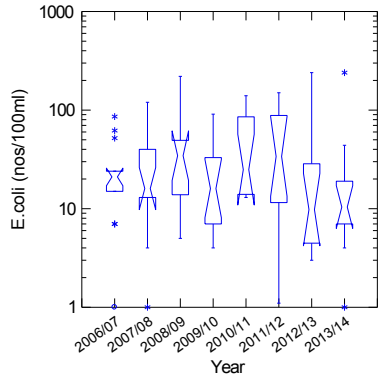
Urenui River



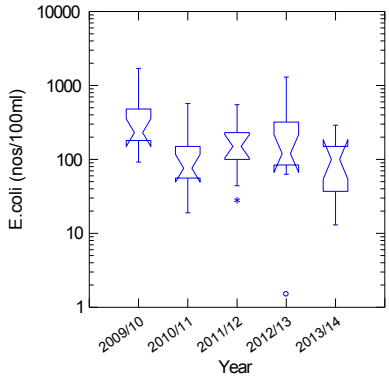
Manganui River



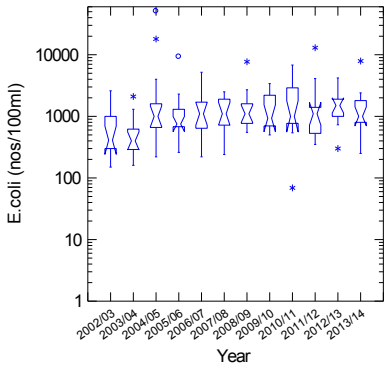
Lake Ratapiko



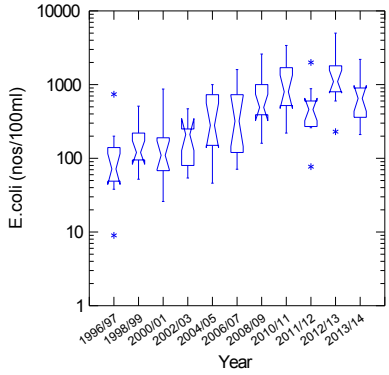
Waitara River at town wharf



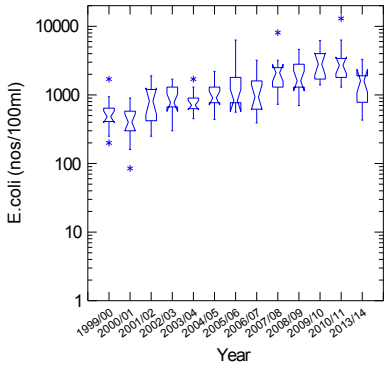
Te Henui mouth East End



Waiwhakaiho adjacent to L.Rotomanu



Waimoku S at Oakura beach



Appendix VII

Examples of publicity during the 2014-2015 season

Freshwater quality

Click on an icon for more information

Last updated: 12/01/2015 12:00 am

KEY		Public health
	Surveillance mode Less than 261 E. coli/100ml in single sample.	District Health Board warnings may still remain in place when a site moves from red to green. Click **here** for more information, or call Health Protection on 06 753 7798 (24 hours).
	Alert mode 261 - 550 E. coli/100ml in single sample.	
	Action mode More than 550 E. coli/100ml in single sample.	
	High cyanobacteria risk More than 15,000 cells/ml in single sample OR more than 1.8mm³/litre More data and info on cyanobacteria	

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.

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.

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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 mm³/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%
High 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 horned 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	14/01/2015	Elevated risk/exposure of mats.
Waiwhakaiho River at last riffle	14/01/2015	Low risk.
Te Henui Stream at mouth	14/01/2015	Low risk.
Oakura River upstream of SH45 bridge	14/01/2015	Low risk.
Mangamui River at Everett Park	14/01/2015	Elevated risk/exposure of mats.
Patea River at Stratford	14/01/2015	Low risk.
Waingongoro River at Eltham	14/01/2015	Low risk.
Waingongoro River at Ohawe Beach	14/01/2015	Elevated risk/exposure of mats.
Kaukoponui River at Beach Domain	14/01/2015	Low risk.

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For more information contact the Taranaki Regional Council

Email: info@trc.govt.nz

Phone: 06 765 7127

Fax: 06 765 5097

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 season, 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.

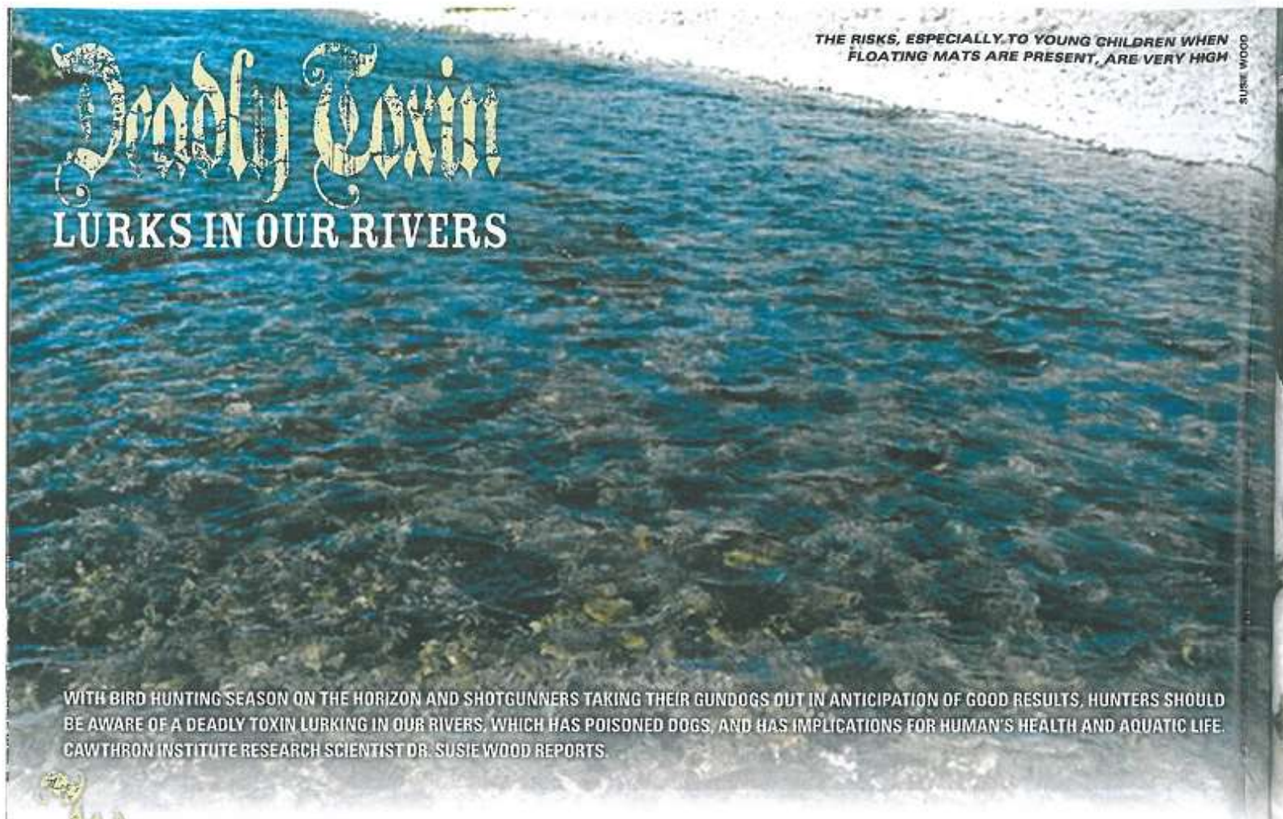
Site	Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity	Usage
		(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)	
WTR000911	23.01.15	1235	16.2	40	9	40	25.4	1.2	15 kayakers
	26.01.15	1355	16.2	24	6	24	26.8	1.0	Nil
	09.02.15	1035	16.7	12	12	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
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

No exceedances of the (Alert or Action) guidelines were recorded at any of the three sites.

Appendix IX

Benthic Cyanobacteria
‘Deadly Toxin lurks in our rivers’
S. Wood Fish and Game New Zeland, Volume 84

Cyanobacteria mat, Waitara River late summer 2014



THE RISKS, ESPECIALLY TO YOUNG CHILDREN WHEN FLOATING MATS ARE PRESENT, ARE VERY HIGH

SUSIE WOOD

Deadly Toxin
LURKS IN OUR RIVERS

WITH BIRD HUNTING SEASON ON THE HORIZON AND SHOTGUNNERS TAKING THEIR GUNDOGS OUT IN ANTICIPATION OF GOOD RESULTS, HUNTERS SHOULD BE AWARE OF A DEADLY TOXIN LURKING IN OUR RIVERS, WHICH HAS POISONED DOGS, AND HAS IMPLICATIONS FOR HUMAN'S HEALTH AND AQUATIC LIFE. CAWTHRON INSTITUTE RESEARCH SCIENTIST DR. SUSIE WOOD REPORTS.

EARLY NOVEMBER 2005, A HUTT Valley resident took her three dogs to the Hutt River for a swim. Within 20 minutes, one of the younger dogs, a 10 month-old Labrador, started frothing at the mouth, became paralysed, collapsed, and died. Over the next few weeks, four more dogs suffered a similar fate after swimming in the river. The presence of copious amounts of 'algae' in the dogs' stomachs, the lack of any damage to internal organs, and the rapid occurrence of death led our research team at the Cawthron Institute in Nelson to suspect, and later confirm, poisoning due to ingestion of toxic cyanobacteria (also commonly known as blue-green algae).

Since this incident, benthic (attached to rocks on the river bottom) cyanobacteria has killed approximately 100 dogs in New Zealand and resulted in health warnings against any contact with the water being posted along the banks of many of rivers nationally, including the Ashley, Sewlyn, Hokitika, Waimea, Maitai, Hutt, Waikanae, and Rangitaiki.

Cyanobacteria are an ancient group of organisms with characteristics in common with both bacteria and algae. They are common in aquatic environments where they usually occur in low concentrations and are an important part of many food webs. However, when environmental and hydrological conditions are favourable, cyanobacteria cells can multiply and form what are known as cyanobacterial blooms. In New Zealand rivers, the blooms are caused by the mat-forming genus *Phormidium*. It can form expansive black/brown leathery mats that may cover the entire substrate and stretch for many tens of kilometres along a river. As the mats become thicker, they can detach and float on the water surface, forming 'rafts' that can accumulate along riverbanks.

Some cyanobacterial species, including *Phormidium*, produce natural toxins (cyanotoxins). Cyanotoxins are a diverse group of toxins that can affect the liver and nervous systems, and some can cause skin and respiratory irritations. The toxins responsible for the dog deaths around New Zealand are known as anatoxins. These are extremely potent neuromuscular blocking toxins. In affected organisms they cause muscles to contract and remain contracted, and in most cases the animals die of respiratory arrest. Dogs are particularly susceptible to poisoning from *Phormidium* because they appear attracted to the earthy/musty smell they produce and consume the mats intentionally, or by accident. To date, there have been no reported human fatalities from anatoxins in New Zealand, although I believe the risks, especially to young children when floating mats are present, are very high. There have been anecdotal reports of human illnesses associated with recreational activities in rivers containing cyanobacterial mats. In one instance, a young child was taken to hospital with severe stomach pains after swimming in a local river. Cyanobacteria mats were later tested and found to contain high levels of toxins, however, there was no conclusive evidence to prove that the cyanobacteria had caused the observed symptoms.

No studies have been undertaken in New Zealand to determine whether aquatic organisms found within close vicinity to toxin-producing benthic mats accumulate toxins. However, experimental work in other countries has shown that low levels of toxins accumulate in both juvenile carp and blue mussels. Given that only low levels were detected in these studies, it is unlikely that contaminated food sources pose a major risk to humans, provided organisms are gutted and washed prior to consumption. However, studies on New Zealand species are urgently required to validate this advice. If dogs and possibly humans, which only have occasional contact with the water, are at risk, what effect could the mats and toxins have on other creatures living in river water?

There is increasing evidence to suggest that anatoxins can have negative effects on a variety of aquatic organisms. A recent Spanish study showed that rainbow trout exposed to anatoxins may experience difficulties with movement, possibly increasing vulnerability to predators. Additionally, extra energy is required to detoxify the toxins and this may have flow on effects such as reduced growth. Research by other groups on several different fish species has shown a variety of effects at various developmental stages and that the toxins promote the death of cells involved in immune systems.

In New Zealand, we don't know if the toxins produced by *Phormidium* accumulate in, or impact on trout or native fish. Our preliminary research has shown that the mats cause changes in macro-invertebrate communities, favouring small diptera (flies). This is likely to have flow-on effects up the food-web.

The 2005 Hutt River event kick-started research on toxic benthic cyanobacteria and scientists set out to establish why these blooms were forming and what was causing the apparent increase in their prevalence across New Zealand. Initially, the research focused on the Hutt River, but more recently has expanded to investigate blooms in the Manawatu, Tasman, and Canterbury regions.

Current data suggests that alterations in river flow, which may either be due to climatic change or human modification, and changes in nutrient concentrations, most likely due to land use intensification, are significant contributory factors to the observed increase in bloom formation. Data from the Hutt Valley and Manawatu regions indicate that benthic cyanobacterial blooms generally occur in rivers with stable flows, low dissolved reactive phosphorous, and elevated dissolved inorganic nitrogen. Fine sediment also appears to promote blooms with the cyanobacteria 'capturing' it and potentially using nutrients from it to fuel their growth. Further research is needed to fully understand the interplay among nutrients in the water column and sediment, and to explore if and how changes land use may be linked to increased blooms.

While research into causes and consequences continues, the advice to river-users, including anglers and bird hunters, remains unchanged: don't rely on warning signs, stay vigilant, and know what to look out for, particularly if you own dogs, or have young children. Veterinary or medical assistance should be sought immediately if cyanobacterial ingestion/poisoning is suspected. Cyanobacterial blooms can come and go quickly, particularly during summer months when rainfall events will flush them away, but warm temperatures increase growth with blooms returning in less than a week.

CYANOBACTERIA CELLS CAN MULTIPLY AND FORM WHAT ARE KNOWN AS CYANOBACTERIAL BLOOMS LIKE THESE IN THE HUTT RIVER

SUSIE WOOD

HEALTH WARNINGS AGAINST ANY CONTACT WITH THE WATER HAVE BEEN POSTED ALONG THE BANKS OF MANY OF RIVERS, INCLUDING THE ASHLEY, SEWLYN, HOKITIKA, WAIMEA, MAITAI, HUTT, WAIKANAE, AND RANGITAIKI