Freshwater contact recreational water quality at selected Taranaki sites State of the Environment Monitoring Report 2013-2014 Technical Report 2014–01

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Executive summary

This survey of seventeen freshwater contact recreational sites in the Taranaki region was the eighteenth 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 2013-2014 period for the eighth time, partly as a component of the more recently instituted cyanobacteria programme (covering four lakes) instigated after consultation with Taranaki Healthcare. 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 monitoring has been reduced to a three-yearly frequency and was monitored again over the current period. The seventeen 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 first time in this state of the environment programme.

The results of the 2013-2014 survey have continued to illustrate variability in bacteriological water quality, with the highest water quality achieved at the Urenui River estuary and lower Patea River sites where marked seawater intrusion is the norm (under high tide conditions), Lake Ratapiko, and Waiwhakaiho River (at Merrilands Domain). Impacts on bacteriological water quality at some sites, particularly the lower reaches of the Waiwhakaiho River, Te Henui Stream, Waimoku Stream, and less frequently at Lakes Opunake and Rotomanu, 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 showed some improvements in the latest survey period in comparison with historical surveys. The total number of samples falling within the "Alert" or "Action" categories (26% of samples) was 2% lower than the average of all the previous seasons and was heavily influenced by three urban sites where bird life were mainly responsible for these exceedances (17% of all sites' samples).

One site (Waimoku Stream at Oakura beach) recorded all single samples in either the 'Alert' or the 'Action' mode of the MfE, 2003 guidelines while two other sites (Te Henui Stream near East End beach and Waiwhakaiho River opposite Lake Rotomanu) recorded twelve single samples in either mode. Eight other sites exhibited occasional single sample entries into the 'Alert' mode of the 2003 guidelines at some time during the season. However, only one of these sites had a count which entered the 'Action' mode, a decrease in the number and frequency of exceedances in comparison with most previous seasons' results.

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

Birdlife contributed to exceedances from time to time particularly at three sites where on occasions recreationalists fed the birds. 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 at two sites by the New Plymouth District Council (on the direction of Taranaki District Health Board) following past exceedances of 'Alert' levels [at Oakura (for past Waimoku Stream issues) and Waitara (where vandalism of signage has been an issue)] and signage was required at the lower Waiwhakaiho River and Te Henui Stream sites but sporadic single sample 'Alert' level exceedances at other sites were not necessarily signposted.

Temporal trends over the 1996-2014 period have been evaluated for the thirteen sites that have ten years or more data (and will continue to be assessed annually). Two sites (Waimoku Stream and lower Waiwhakaiho River) have 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 (Waingongoro River at Ohawe Beach) has shown a strong but not statistically significant decreasing trend in median *E. coli* counts. However 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, 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 but resulted in minimal increases in the overall median bacteriological numbers at both sites. Two additional exceedances of limits 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 2013 with numbers peaking in mid summer. These numbers necessitated warning notices to avoid contact recreation on these waters during mid summer but levels had fallen to low numbers by mid February 2014 when the lake was able to be opened for contact recreation. Moderate cyanobacteria numbers were found in Lakes Opunake and Ratapiko but only in mid summer with six instances of low numbers present in Lake Rotomanu. Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored but no coverage percentages exceeded the health guidelines at any time. One site (Manganui River) reached the 'Alert' level on two occasions.

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 2013-2014.

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

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1. Introduction

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). Components of these 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. Changes to the *E. coli* freshwater recreational guideline values have been made for the purpose of regularly assessing single samples against suitability for recreation. The new 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 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)

2.2 Suitability for recreation grading (SFRG) of sites

The 2003 Microbiological Water Quality Guidelines (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 condition of a site based on both risk and indicator bacteria water quality. 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. The public will 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 2008 to March 2013 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 a maximum of 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 2008 to March 2013

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	2625	65	D	Very poor	83
Waiwhakaiho R: Merrilands domain	High	208	65	B	Poor	96
Waiwhakaiho R at L.Rotomanu	High	3340	52	D	Very poor	40
Te Henui S: mouth	High	4720	66	D	Very poor	15
Patea R: King Edward Park	High	580	65	D	Very poor	93
Patea R. boatramp, Patea	High	83	65	A	Poor	100
Waingongoro R: Eltham camp	High	355	65	C	Poor	100
Waingongoro R: Ohawe beach	High	903	65	D	Very poor	92
Kaupokonui R: Beach domain	High	480	65	C	Poor	98
L Opunake: adjacent boatramp	High	1625	65	D	Very poor	89
Timaru S: Lower Weld Road	High	470	65	C	Poor	98
Waimoku Stream:Oakura Beach	High	6000	40	D	Very poor	0
Oakura R: d/s SH45	High	443	65	C	Poor	98
Waitara R: Town wharf	High	1239	52	D	Very poor	90
Urenui R: estuary	High	55	65	A	Poor	100
Manganui R: Everett Park	High	378	65	C	Poor	98
L Ratapiko: boatramp	High	164	61	B	Poor	100
L Rotokare: adjacent boatramp	Low	84	46	A	Very good	100

Although all but one of the sites' SFRGs indicate 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 two sites (Te Henui Stream and lower Waiwhakaiho River) would not have entered the 'Action' guideline (ie would have exceeded guidelines) on more than 17% of all sampling occasions, with fourteen sites achieving the guideline on 89% or more of occasions (ie less than 12% exceedance).

The Eltham camp site in the mid reaches of the Waingongoro River, the 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 beach Domain site in the lower reaches of the Kaupokonui River, Everett Park site in the Manganui River, Lower Weld Road site in the Timaru Stream, and SH45 site in the Oakura River entered this 'Action' level on only one occasion.

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 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 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 level[a]	Actions
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.

Table 3 Planktonic cyanobacteria guidelines for lake monitoring

Cyanobacteria cells per ml of water	Mode
Less than 2,000	Low risk
Between 2,000 and 15,000	Medium risk
More than 15,000	High risk

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 seventeen sites sampled by the various components of the 2013-2014 programme are shown in Figure 1 and summarised in Table 4.

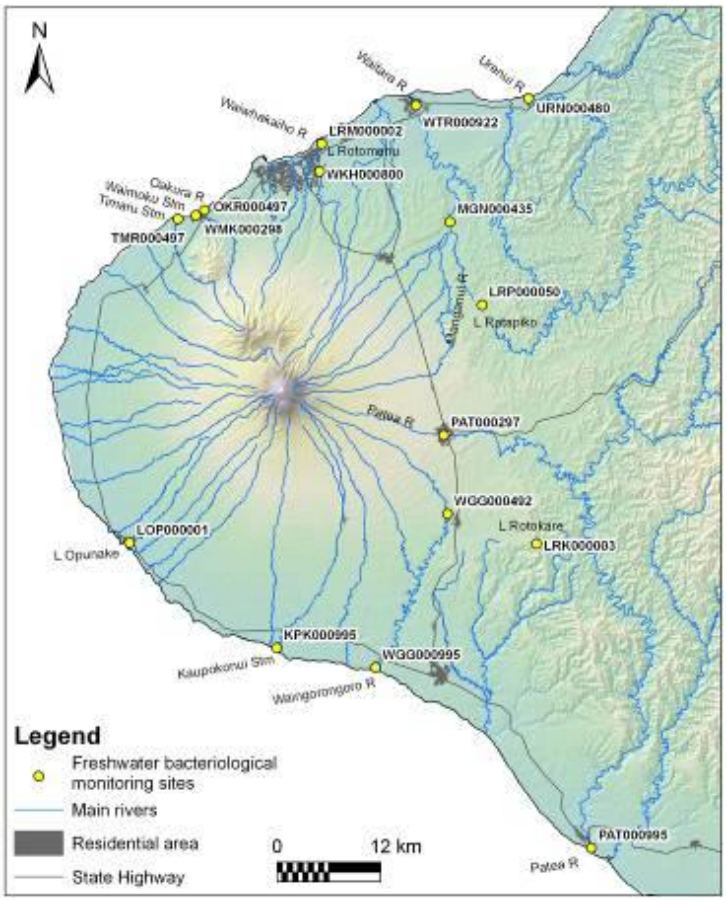


Figure 1 Location of freshwater contact recreation survey sites in 2013-2014

Having established its general state, sampling of the Waimoku Stream site at Oakura Beach has been reduced in intensity by removing it from the 2011-2012 and 2012-2013 programmes with future sampling programmed for every third season (ie sampled in 2013-2014). Two sites (Te Henui Stream at the mouth and lower Waiwhakaiho River adjacent to Lake Rotomanu) were added to the 2011-2012 programme, in recognition of increased recreational usage of these areas.

For sampling convenience all sites were included with the coastal bathing beaches runs undertaken over the same five month period from early November 2013 to early April 2014. 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			✓

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 early November 2014 with only three of the sampling surveys performed prior to January 2014 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 normally taken between the hours of 0900 and 1800 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 but the Lake Ratapiko site (10 samples) during the season where the very low lake level (drained for hydro-electric purposes) prevented sample collection on three occasions late in the period.

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 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 2013-2014 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 will be 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. 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 data will not be used for future 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 over the 2013-2014 period, 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. Of the transects, two were established in riffle habitat and two 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.

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 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 were collected at each site during the period from early November 2013 to early April 2014 (with the exception of Lake Ratapiko as explained earlier).

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.

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 5 November 2013 to 3 April 2014 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 minimal bathing usage of the lake recorded although boating, water and jet-skiing, and/or picnicking activities were recorded at the time of most of the sampling surveys.

A few ducks and gulls were present on the lake or in the vicinity of the lake edge throughout most the period and were often 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)
05.11.13	0815	12.5	60	9	63	18.9	5.4
18.11.13	1045	13.0	84	16	84	21.3	13
16.12.13	1030	12.7	96	32	110	24.6	10
16.01.14	1050	13.0	8	7	8	21.9	4.1
20.01.14	1040	13.1	77	29	79	21.5	6.7
30.01.14	1040	13.2	12	5	12	21.2	5.7
03.02.14	0930	13.4	60	42	62	22.2	3.3
17.02.14	1215	14.2	15	14	16	24.6	7.9
20.02.14	1345	14.4	28	9	28	26.3	4.9
06.03.14	0940	14.7	52	270	56	20.2	3.9
21.03.14	0930	14.5	120	40	120	20.0	4.5
31.03.14	1110	14.7	90	80	92	-	3.3
03.04.14	0940	15.0	31	8	31	19.7	3.5

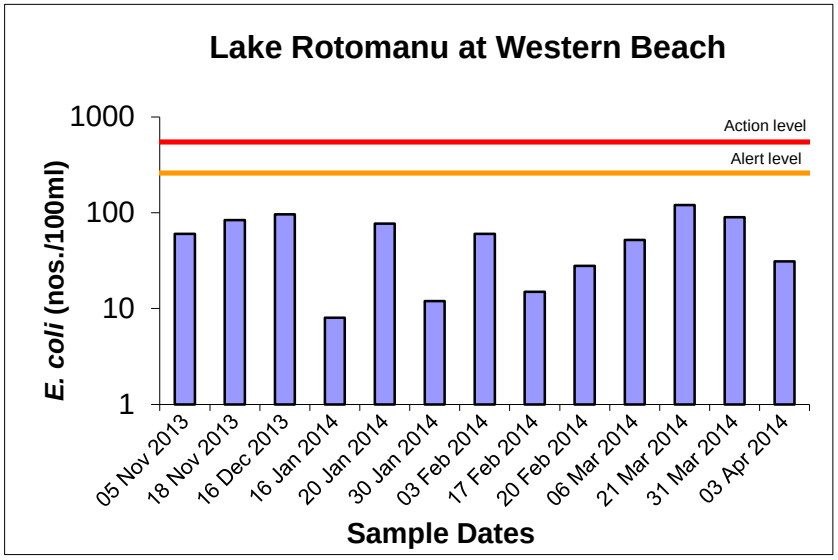


Figure 2 *E. coli* numbers for Lake Rotomanu during the regular season
(Note: Action limit >550/100 ml [single sample: Alert limit => 260 nos/100ml [single sample])

Table 7 Statistical results summary for Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	12.5	15.0	13.4
E. coli	nos/100ml	13	8	120	60
Enterococci	nos/100ml	13	5	270	16
Faecal coliforms	nos/100ml	13	8	120	62
Temperature	°C	13	18.9	26.3	21.4
Turbidity	NTU	13	3.3	13	4.9

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 with some improvement in clarity (median turbidity: 4.9; range: 9.7 NTU). The variability in clarity was possibly a result of fluctuating concentrations of suspended algae. Water temperatures were relatively high (above 20°C) through most of the period with a high maximum of 26.3°C (in mid February 2014) and a range of 7.4°C. Conductivity had a narrow range through the season.

Generally bacteriological quality was relatively good considering that the inflow to the lake is from the lower reaches of a river draining a developed catchment. Elevation in numbers of *E. coli* (in excess of 100 per 100 mls) was found on two occasions 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 each of the eighteen seasons' *E. coli* surveys data is presented graphically in Appendix V 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
Minimum	3	12	7	7	1	31	9	20	<3	6	7	54	51	23	6	46	23	8
Maximum	899	740	200	140	90	980	2200	5500	220	380	3000	1200	6000	3600	150	2300	430	120
Median	32	46	79	25	14	110	92	120	11	68	72	180	220	100	34	120	100	60

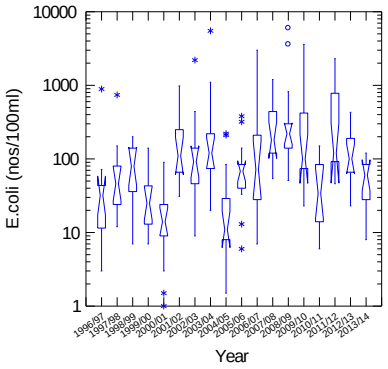
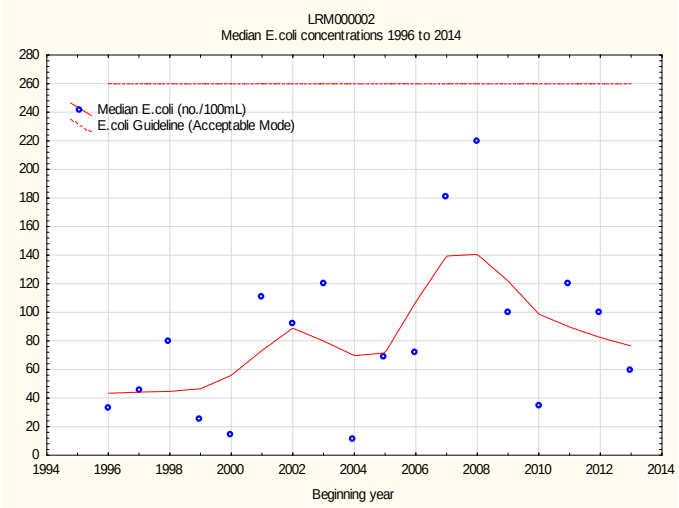


Figure 3 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers at Lake Rotomanu

The more recent trend of moderately high median *E. coli* numbers in recent years was not found over the summer of 2013-2014 when a much narrower range of counts was recorded. The median value was the seventh lowest to date and the maximum count was the second 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 eighteen 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.



N = 18
Kendall tau = +0.257
p level = 0.137 [>FDR, p = 0.274]
N/S at p < 0.05

Figure 4 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Lake Rotomanu for the 1996-2014 period

Overall, a positive, but not statistically significant increase in median *E. coli* numbers has been found over the eighteen seasons of monitoring although median numbers

have trended slightly downwards over the latest five seasons. None of these seasonal medians have exceeded the 'Alert' or 'Action' modes.

4.2.1.4 MfE guidelines additional sampling

Seven additional samples were collected randomly under varying weather conditions during the survey season. No bathing, but some boating (water and jet-skiing) and picnicking were noted on these occasions. Ducks were present in low numbers on the lake on all occasions, Canadian geese on one occasion, and dogs were recorded on the banks frequently. Three 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, 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)
25.11.13	0900	13.6	60	7	60	23.8	6.9
10.12.13	0930	12.3	88	32	88	21.0	5.0
13.01.14	0925	12.7	28	19	40	21.2	5.2
27.01.14	0925	13.1	40	11	40	21.0	4.0
10.02.14	0930	13.7	26	15	26	20.5	3.3
25.02.14	0805	14.5	21	13	21	22.3	5.0
11.03.14	1015	14.9	69	53	71	20.9	3.8

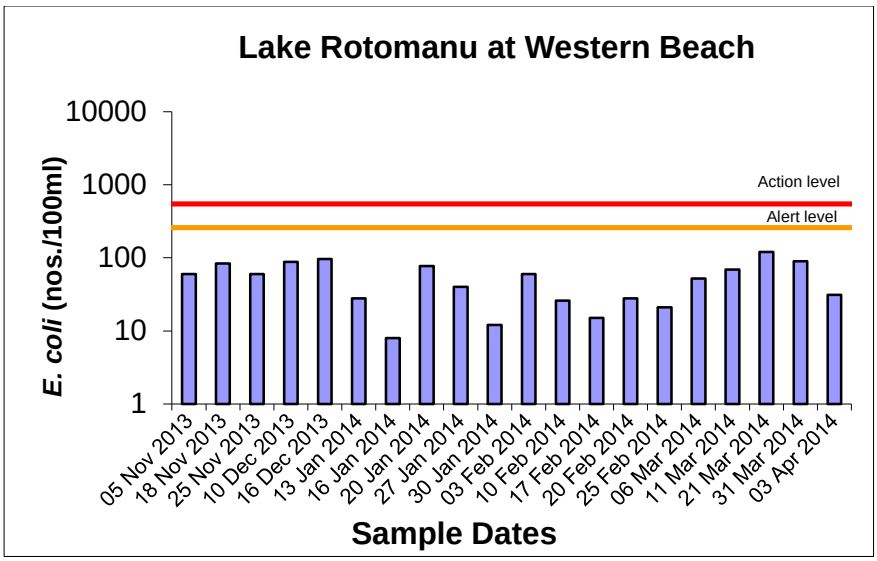


Figure 5 *E. coli* numbers for Lake Rotomanu for the 20 sample extended survey

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	12.3	15.0	13.5
E. coli	nos/100ml	20	8	120	56
Enterococci	nos/100ml	20	5	270	16
Faecal coliforms	nos/100ml	20	8	120	58
Temperature	°C	20	18.9	26.3	21.2
Turbidity	NTU	20	3.3	13	5.0

The additional sampling resulted in very little change with a small decrease (of 4 *E.coli* per 100 mls) in the overall seasonal median bacteria number. These additional surveys' bacteria counts had a narrow range (21 to 88 *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 three of the sampling survey occasions.

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 less turbid lake water quality noted during the season. Microscopic scans of samples found small numbers of cyanobacteria present in all but one of the seven samples analysed during the season. On these occasions the only taxon present was *Anabaena* with numbers ranging between 15 and 108 cells per ml (median: 39 cells/ml). The results of this sampling are presented in Table 13.

Table 13 Cyanobacteria counts (cells/ml) for Lake Rotomanu [Health warning: >15,000 cells/ml]

Date	Cyanobacteria total cell count (cells/ml)	Principal species
25.11.13	47	*Anabaena*
10.12.13	nil	-
13.01.14	15	*Anabaena*
27.01.14	108	*Anabaena*
10.02.14	18	*Anabaena*
25.02.14	71	*Anabaena*
11.03.14	31	*Anabaena*

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), 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) and on only one occasion during the 2012-2013 season (TRC, 2013).

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 no bathing but some of the usual walking or picnicking on the banks of the river noted. No birdlife was noted on all but one occasion and on three occasions dogs were present in or adjacent to the river.

The data for this site are presented in Table 14 and illustrated in Figure 7, with a statistical summary provided in Table 15. River flow information is illustrated in Figure 6.

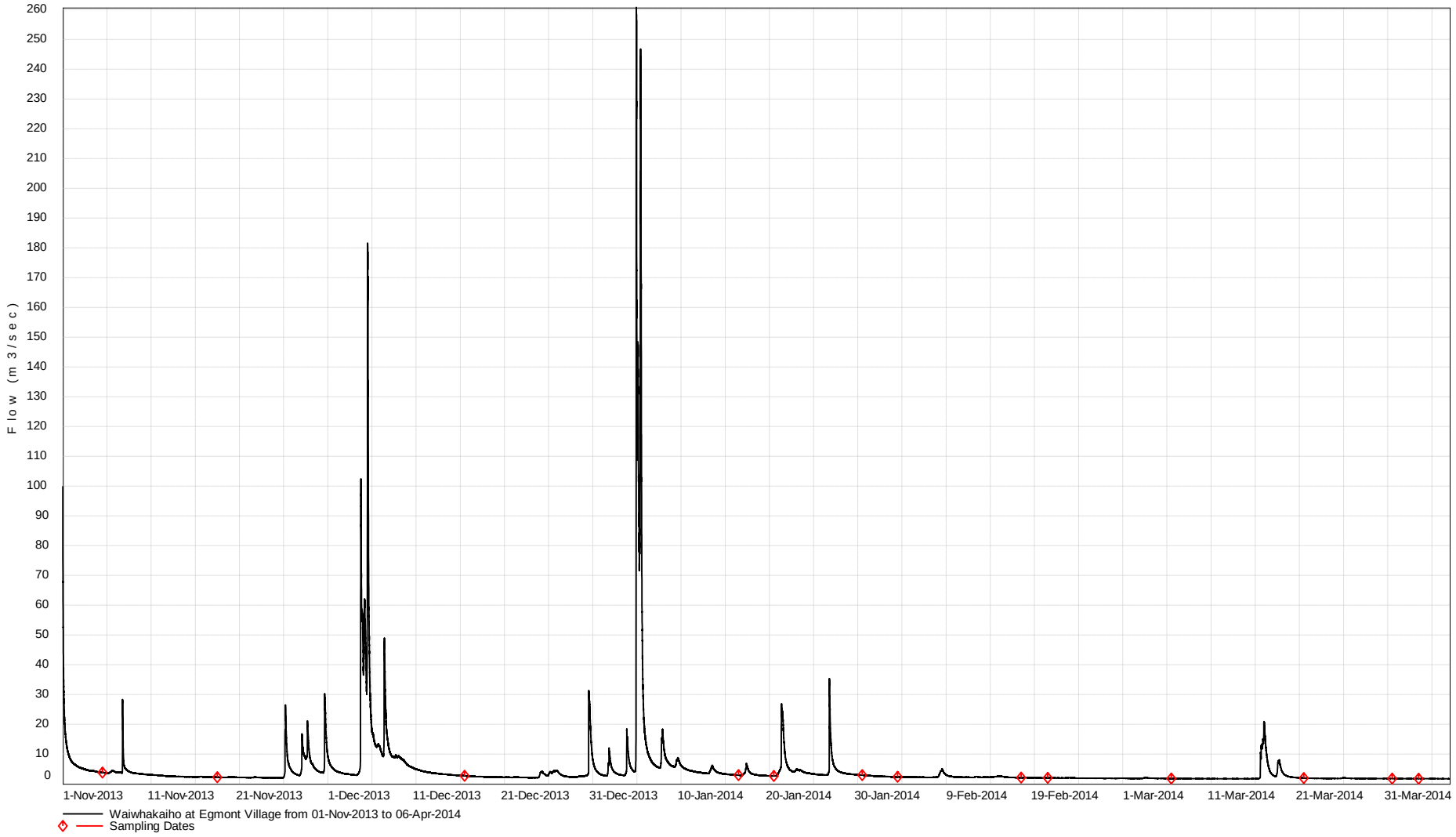


Figure 6 River flow in the Waiwhakaiho River during the survey period

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)
05.11.13	0800	10.7	110	5	120	13.8	0.6
18.11.13	1120	12.8	200	19	220	18.2	1.0
16.12.13	1100	11.8	31	5	34	19.0	0.4
16.01.14	1125	11.4	54	110	56	18.6	0.4
20.01.14	1005	11.8	80	58	80	17.0	0.7
30.01.14	1105	11.0	20	50	20	20.3	0.7
03.02.14	0910	12.7	71	37	74	18.1	0.7
17.02.14	1250	13.6	3	8	3	21.6	0.6
20.02.14	1420	14.4	51	<3	54	24.2	0.5
06.03.14	0925	14.8	40	51	46	15.0	0.8
21 .03.14	0915	11.7	180	48	180	15.7	1.2
31.03.14	1125	14.6	30	3	46	-	0.8
03.04.14	0900	14.8	45	11	45	15.8	0.6

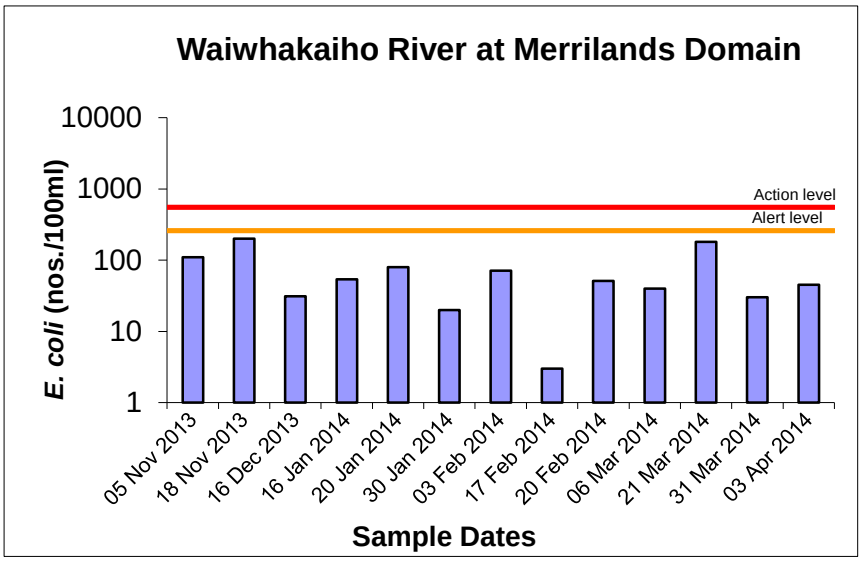


Figure 7 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain during the regular survey season

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	10.7	14.8	12.7
E. coli	nos/100ml	13	3	200	51
Enterococci	nos/100ml	13	3	110	19
Faecal coliforms	nos/100ml	13	3	220	54
Temperature	°C	12	13.8	24.2	18.2
Turbidity	NTU	13	0.4	1.2	0.7

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 10.4°C between early November and late March, with a high maximum of 24.2°C in mid February 2014. Conductivity and turbidity results were indicative of very clean, clear, relatively high water quality but moderate to widespread algal cover (up to 90% 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 two occasions through the season and only these two counts above 110 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	0 [0]	0 [0]

(Designation: freshwater contact recreational area)

No single samples were recorded within the 'Action' or the 'Alert' modes during the season. Bacteriological water quality measured at this site was therefore within the acceptable standard 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 each of the eighteen summer's surveys data is presented graphically in Appendix V for all sites. These data for the Waiwhakaiho River site are summarised in Table 17 and illustrated in Figure 8.

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
Minimum	16	16	26	8	6	17	3	34	11	15	8	28	19	23	4	8	11	3
Maximum	970	1800	330	100	270	420	130	320	330	160	510	110	110	570	200	120	3000	200
Median	42	84	69	39	23	60	29	77	54	34	48	48	46	110	54	40	52	51

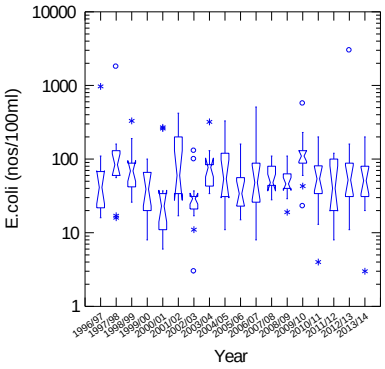
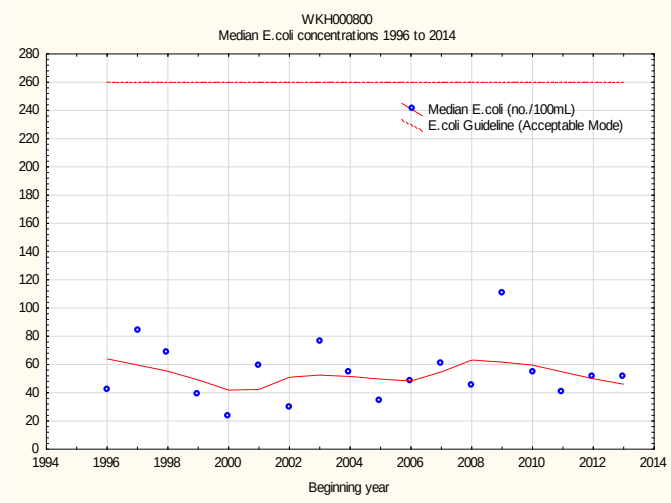


Figure 8 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River at Merrilands Domain

The median *E. coli* number in the 2013-2014 period was typical of most recorded to date and well below the maximum of the range of historical medians (Table 17 and Figure 8), 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 eighteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 9) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.



N = 18
Kendall tau = 0.000
p level = 1.000 [>FDR, p = 1.000]
N/S at p <0.05

Figure 9 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waiwhakaiho River, Merrilands Domain for the 1996 to 2014 period

A statistically insignificant temporal trend of no change in median *E.coli* numbers has been found over the eighteen 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 on these occasions included walking (occasionally with dogs present at the river's edge).

The data from these additional surveys are presented in Table 18, illustrated in Figure 10, 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)
25.11.13	0835	14.1	85	13	85	20.1	0.4
10.12.13	1035	9.0	120	29	130	16.1	0.6
13.01.14	1010	10.9	300	84	320	17.5	0.6
27.01.14	1010	9.5	1000	570	1000	16.0	1.6
10.02.14	1010	13.0	100	76	110	17.4	1.2
25.02.14	0850	14.7	52	6	52	18.3	0.5
11.03.14	1115	15.1	60	80	62	17.6	0.8

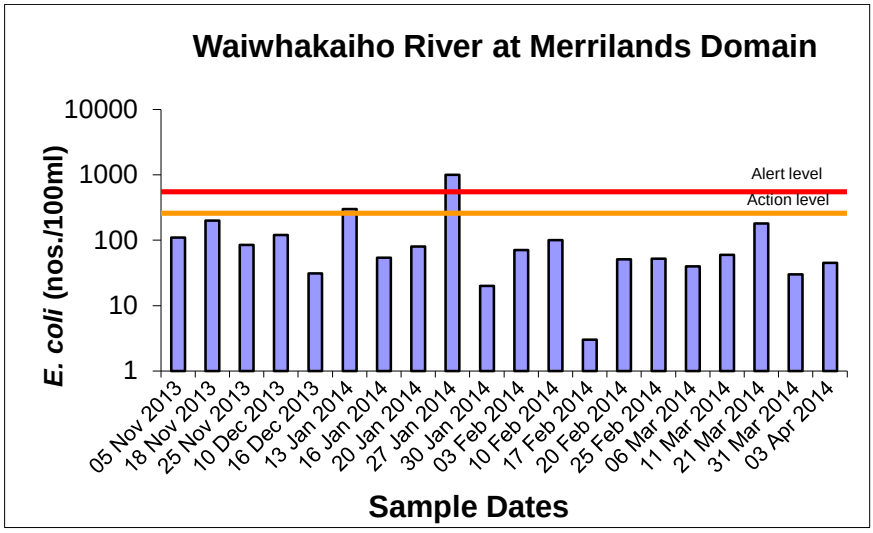


Figure 10 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain for the 20 sample extended survey

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	9.0	15.1	12.8
E. coli	nos/100ml	20	3	1000	66
Enterococci	nos/100ml	20	3	570	33
Faecal coliforms	nos/100ml	20	3	1000	68
Temperature	°C	19	13.8	24.2	17.6
Turbidity	NTU	20	0.4	1.6	0.6

These seven additional samples resulted in small increases in 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 late January 2014, under higher river flow conditions after recent wet weather (Figure 6).

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 'Alert' mode occurred and one sample count exceeded 550 *E. coli* per 100 mls ('Action' mode). Follow-up samples collected in the course of the SEM programme after the exceedances 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 six occasions during the 2013-2014 season. Results are presented in Table 21 and illustrated in Figure 11.

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

Date	Average *Phormidium* % cover	Mode
19.11.13	19	Green (surveillance)
17.12.13	18	Green (surveillance)
14.01.14	8	Green (surveillance)
14.02.14	0	Green (surveillance)
13.03.14	0	Green (surveillance)
26.03.14	0	Green (surveillance)

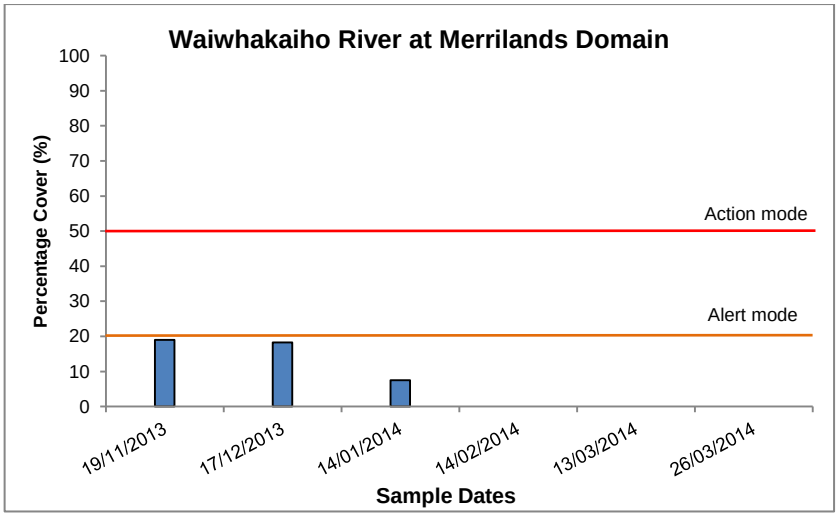


Figure 11 Percentage benthic cyanobacteria cover, Waiwhakaiho River at Merrilands Domain

The benthic cyanobacteria found were all *Phormidium sp.* Coverage was low throughout the season (ranging from 0 to 19%) and as none of the guidelines were exceeded no health warnings were required to be issued. After a moderately low cover in late 2013 and early 2014 *Phormidium* was absent at this site over the remainder of the monitoring period.

4.2.3 Waiwhakaiho River adjacent to Lake Rotomanu

Photo 1 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 known to be present along the lower reaches of the river upstream of this site (Photo 1).

The data for this site are presented in Table 22 and illustrated in Figure 12, with a statistical summary provided in Table 23. River flow information is illustrated in Figure 6 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)
05.11.13	0820	10.4	450	710	480	14.7	0.5
18.11.13	1100	13.1	2200	2400	2300	19.1	0.8
16.12.13	1040	12.1	900	720	930	20.6	0.6
16.01.14	1100	11.4	670	1400	700	19.3	0.6
20.01.14	1030	12.2	1400	1700	1500	17.5	1.4
30.01.14	1050	11.3	440	340	500	20.5	0.9
03.02.14	0940	16.8	350	830	360	20.2	0.8
17.02.14	1225	14.3	210	1200	280	23.6	0.7
20.02.14	1400	14.9	770	900	970	26.4	1.6
06.03.14	0950	15.9	340	230	360	16.9	1.0
21 .03.14	0940	12.7	360	140	380	17.3	0.9
31.03.14	1055	482	650	450	750	-	0.7
03.04.14	0925	21.0	1800	1200	2400	17.1	0.6

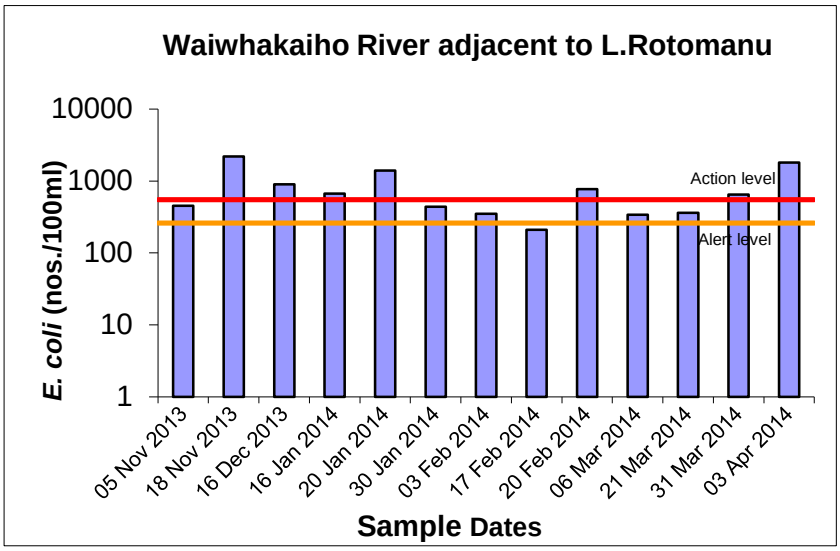


Figure 12 *E. coli* numbers for the Waiwhakaiho River adjacent to Lake Rotomanu during the regular survey season

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	482	13.1
E. coli	nos/100ml	13	210	2200	650
Enterococci	nos/100ml	13	140	2400	830
Faecal coliforms	nos/100ml	13	280	2400	700
Temperature	°C	13	14.7	26.4	19.2
Turbidity	NTU	13	0.5	1.6	0.8

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

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

[Note: During the 2011-2012 period (TRC, 2012) faecal source DNA tracking marker analyses found that the Merrilands Domain samples contained bacteria only indicative of ruminants origin on one occasion and 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 11.7˚C between early November and early April, with a maximum of 26.4˚C in mid February 2014. Conductivity and turbidity results were indicative of clean, clear, relatively high water quality but significant algal cover (moderate to widespread mats) was noted through the latter half of the period. There was one instance of partial seawater ingress during very low flow conditions in late March 2014.

Bacteriological water quality was poor with numbers varying over very wide ranges with a high median *E. coli* value of 650 per 100 mls particularly in comparison with numbers found at the upstream Merrilands Domain site. Individual sample *E.coli* counts exceeded 300 per 100 mls on all but one occasion coincident with the presence of large gull populations. The marked river flow fluctuations due to increased morning HEP generation could be expected to exacerbate wildfowl (gull) faecal contamination by inundation of river shingle areas where birds roost 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	5 [38]	7 [54]

(Designation: freshwater contact recreational area)

Seven single samples were recorded within the 'Action' mode and five samples 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 (although it had been reduced in size) was required at this site adjacent to the walkway throughout the survey period. Appropriately worded signage should be retained on a permanent basis in future.

4.2.3.2 Comparison with previous summers' surveys

A statistical comparison of eleven summer's surveys data is presented graphically in Appendix V 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 13.

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
Minimum	9	-	52	-	26	-	54	-	46	-	71	-	160	-	220	77	230	210
Maximum	740	-	51	-	870	-	470	-	1000	-	1600	-	2600	-	3400	2000	5000	2200
Median	72	-	120	-	110	-	210	-	270	-	320	-	490	-	885	460	1100	650

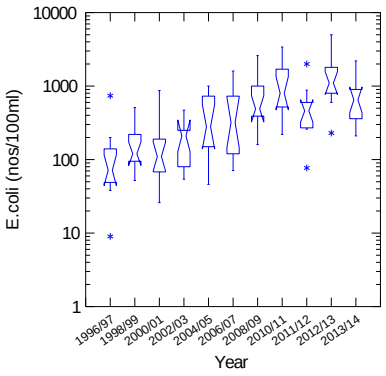
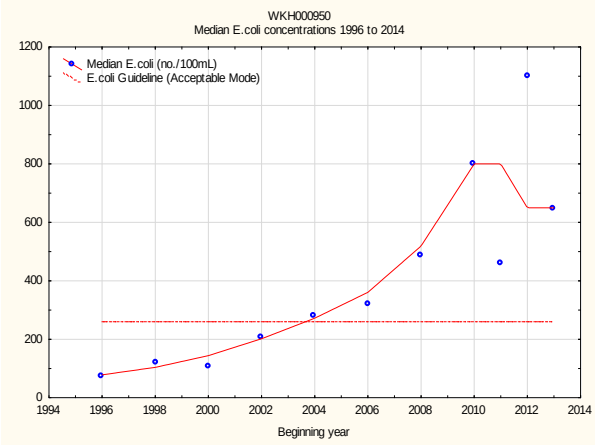


Figure 13 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River adjacent to Lake Rotomanu

The median *E.coli* number in the 2013-2014 period was the third highest recorded to date continuing a trend of increasing medians in more recent years (Table 25 and Figure 13). Most medians have 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 median in excess of the 'Action' guideline. The range in 2013-2014 was also one of the the widest seasonal ranges recorded to date.

Trend analysis of these median *E.coli* numbers has been performed for the eleven seasons of data by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 14). 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 = 11
Kendall tau = +0.818
p level = 0.0005 [FDR, p = 0.003]
Significant at p < 0.01 after FDR

Figure 14 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Waiwhakaiho River, adjacent to Lake Rotomanu for the 1996 to 2014 period

There has been a very significant trend ($p < 0.01$) of increasing median *E.coli* numbers over the eleven seasons of monitoring with four of these seasonal medians exceeding the 'Alert' mode and another three within the 'Action' mode.

4.2.3.3 Benthic cyanobacteria

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

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

Date	Average *Phormidium* % cover	Mode
19.11.13	24	Amber (Alert)
02.12.13	2	Green (surveillance)
17.12.13	16	Green (surveillance)
14.01.14	12	Green (surveillance)
14.02.14	4	Green (surveillance)
13.03.14	4	Green (surveillance)
26.03.14	8	Green (surveillance)

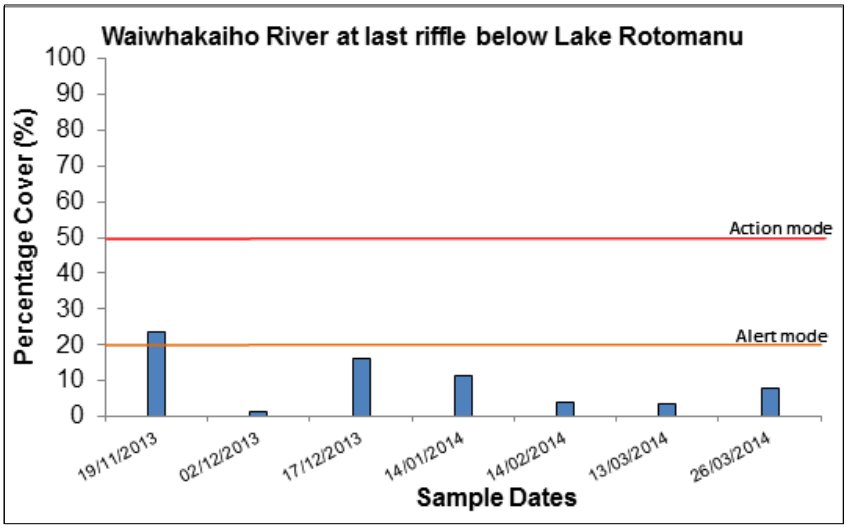


Figure 15 Percentage benthic cyanobacteria cover, Waiwhakaiho River adjacent to Lake Rotomanu

The benthic cyanobacteria found were all *Phormidium sp,* with coverage ranging from 2% to 24%. *Phormidium* growths were present throughout the season and exceeded the alert mode on one occasion. This occurred at the end of November 2013, early in the season after which *Phormidium* levels remained below the 'Alert level' and consequently no health warnings were required to be issued.

4.2.4 Te Henui Stream at the mouth, East End

Relatively extensive usage of this site was recorded at the time of the sampling surveys, although no bathing was noted. More frequently, walking, picnicking, feeding the ducks, or whitebaiting (in season) on the banks of the stream were noted. Dogs were also present in the stream on one occasion.

Ducks were common at this site on all survey occasions and gulls were present from time to time, where often they were encouraged by people feeding the wildlife. Shags and a heron were also recorded.

The data for this site are presented in Table 27 and illustrated in Figure 16, 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)
05.11.13	0930	31.2	940	160	1000	14.1	0.6
18.11.13	1010	116	2400	960	2400	16.6	0.4
16.12.13	0950	10.6	2400	1400	2600	17.2	0.7
16.01.14	0950	60.7	1500	900	1500	17.1	0.6
20.01.14	1115	17.4	1000	830	1000	15.9	0.5
30.01.14	1000	461	7900	4600	8000	17.1	0.8
03.02.14	1205	1490	420	680	420	19.1	1.3
17.02.14	1120	1990	730	1300	870	19.3	1.5
20.02.14	1305	516	800	28	800	22.2	0.8
06.03.14	1240	555	800	970	870	17.0	1.0
21.03.14	1240	535	1800	1100	1800	17.8	1.2
31.03.14	1010	932	1700	600	1700	-	1.8
03.04.14	1240	1820	250	450	250	16.9	3.7

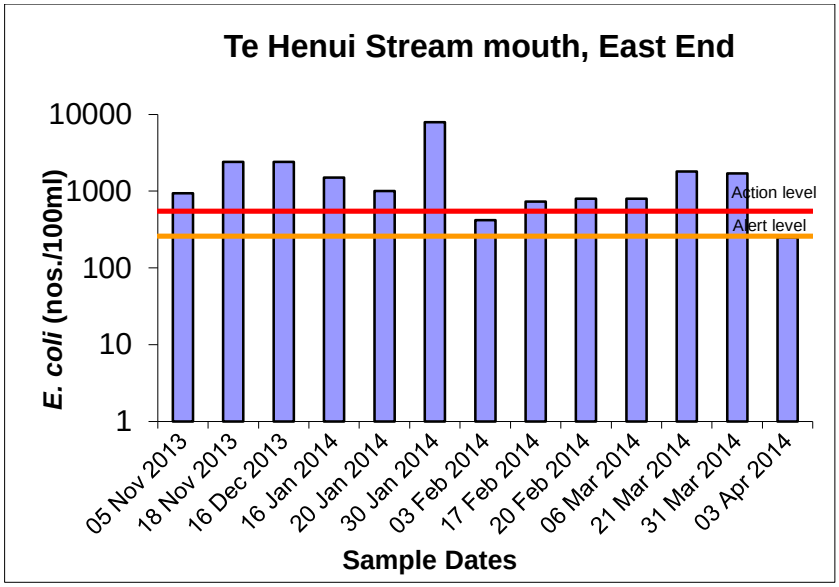


Figure 16 *E.coli* numbers for the Te Henui Stream at the mouth, East End during the regular survey season

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	10.6	1990	516
E. coli	nos/100ml	13	250	7900	1000
Enterococci	nos/100ml	13	28	4600	900
Faecal coliforms	nos/100ml	13	250	8000	1000
Temperature	°C	13	14.1	22.2	17.1
Turbidity	NTU	13	0.4	3.7	0.8

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

In the current season water temperatures varied over a moderate range of 8.1˚C between early November and early April, with a maximum of 22.2˚C in mid February 2014. 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 low flow conditions from late January 2014 to the end of the period). Extensive algal cover was recorded at intervals during the period.

Bacterial water quality in the 2013-2014 season was very poor with a wide range of counts and very high median *E. coli* count of 1000 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	1 [8]	11 [85]

(Designation: freshwater contact recreational area)

Only one single sample was recorded below the '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 almost entirely within the 'Action' mode (see Appendix VII). No additional sampling surveys were required as the source of these elevated counts was well established and documented. The two occasions on which the counts were below the 'Action' mode were coincidental with higher quality seawater instusion. 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 (3 per 100 mls) for the SEM season and the extended MfE additional sampling (3 per 100 mls) (TRC, 2014).

4.2.4.2 Comparison with previous summers' surveys

A statistical comparison of twelve summer's surveys data is presented graphically in Appendix V for all sites. [Note: These data had been collected prior to the 2011-2012 season to provide interpretative information for nearby coastal beach monitoring data]. These data for the Te Henui Stream site are summarised in Table 30 and illustrated in Figure 17.

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

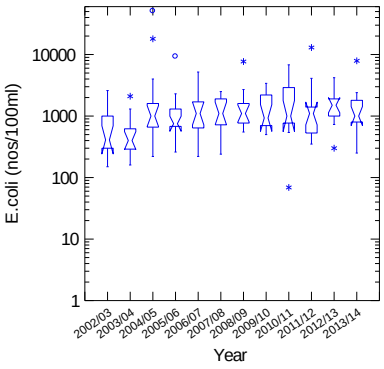
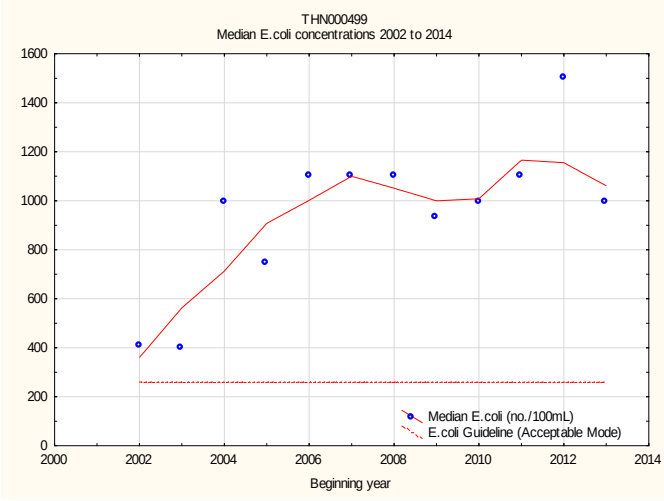


Figure 17 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers in the Te Henui Stream at the mouth, East End

The median *E. coli* number in the 2013-2014 period was similar to the highest medians recorded to date (Table 30 and Figure 17), each of which has been well above the 'Alert' level of the 2003 MfE guidelines. All but two of these median numbers 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 twelve seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 18) 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 = 12
Kendall tau = + 0.473
p level = 0.032 [>FDR, p = 0.094]
Not significant at p < 0.05 after FDR

Figure 18 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Te Henui Stream mouth, East End for the 2002 to 2013 period

A significant temporal trend of increasing median *E. coli* numbers has been found over the twelve seasons of monitoring. (Note: This trend was statistically significant at p< 0.05 but not after FDR). Two of these seasonal medians were within the 'Alert' mode and all others exceeded the 'Action' mode.

4.2.4.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on six occasions during the season. Results are presented in Table 31.

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

Date	Average *Phormidium* % cover	Mode
19.11.13	0	Green (surveillance)
17.12.13	2	Green (surveillance)
14.01.14	0	Green (surveillance)
14.02.14	0	Green (surveillance)
13.03.14	0	Green (surveillance)
26.03.14	0	Green (surveillance)

Benthic cyanobacteria coverage was very low for the entire season. *Phormidium* was only found on one of the six occasions, towards the end of December 2013 but only as a very low percentage cover and was absent for the remainder of the season. Consequently no health warnings were required to be issued.

4.2.5 Patea River at King Edward Park, Stratford

No bathing and minimal picnicking usage of this river site was recorded at the time of sampling surveys, most of which were in the morning. Fishing was noted on one occasion at this site, particularly following the release of trout into the river for the 'Take a Kid Fishing' promotion in mid February 2014.

Data from the site are presented in Table 32 and illustrated in Figure 19, with a statistical summary provided in Table 33. River flow records are illustrated in Figure 20.

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)
05.11.13	1215	8.4	170	9	170	13.1	0.7
18.11.13	1220	9.0	240	33	240	14.5	0.7
16.12.13	1130	8.8	310	97	310	14.3	0.7
16.01.14	1140	8.8	62	68	62	14.8	0.6
20.01.14	0815	9.2	240	87	260	13.4	0.5
30.01.14	1135	8.6	88	120	92	14.2	0.7
03.02.14	0935	9.0	100	120	110	13.4	0.6
17.02.14	0815	9.2	230	270	230	14.2	0.6
20.02.14	0925	9.4	550	560	580	16.4	5.8
06.03.14	0900	11.2	250	250	300	12.3	0.7
21.03.14	0835	9.7	260	200	260	13.7	1.2
31.03.14	1145	9.9	250	260	430	13.5	0.6
03.04.14	0830	10.2	350	320	420	12.0	0.9

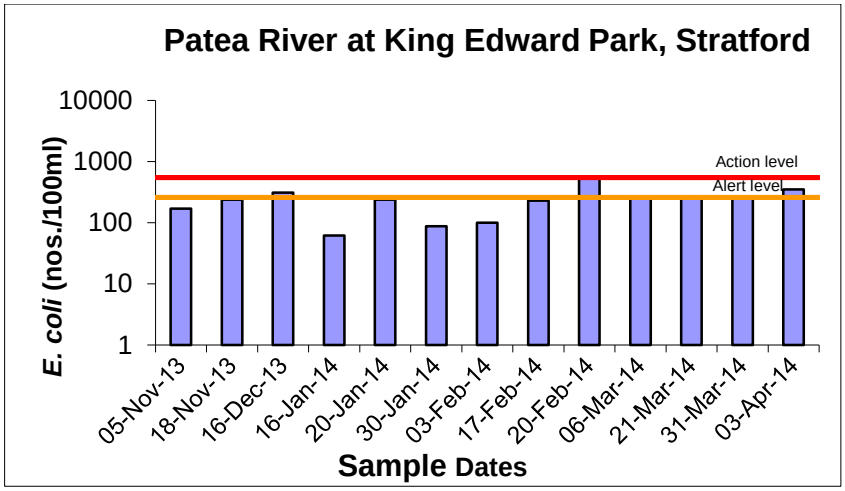


Figure 19 *E. coli* numbers for the Patea River at King Edward Park, Stratford during the survey season

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	11.2	9.2
E. coli	nos/100ml	13	62	550	240
Enterococci	nos/100ml	13	9	560	120
Faecal coliforms	nos/100ml	13	62	580	260
Temperature	°C	13	12.0	16.4	13.7
Turbidity	NTU	13	0.5	5.8	0.7

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 NTU on all but two occasions) and uncoloured or pale brown in appearance with a relatively low and narrow range of conductivity levels.

Water temperatures had a narrow range of 4.4°C for this site (at an elevation of 300 m asl), with a maximum of 16.4°C recorded in mid-February 2014 (although this was at 0925 hrs). All the samples were collected before 1230 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.

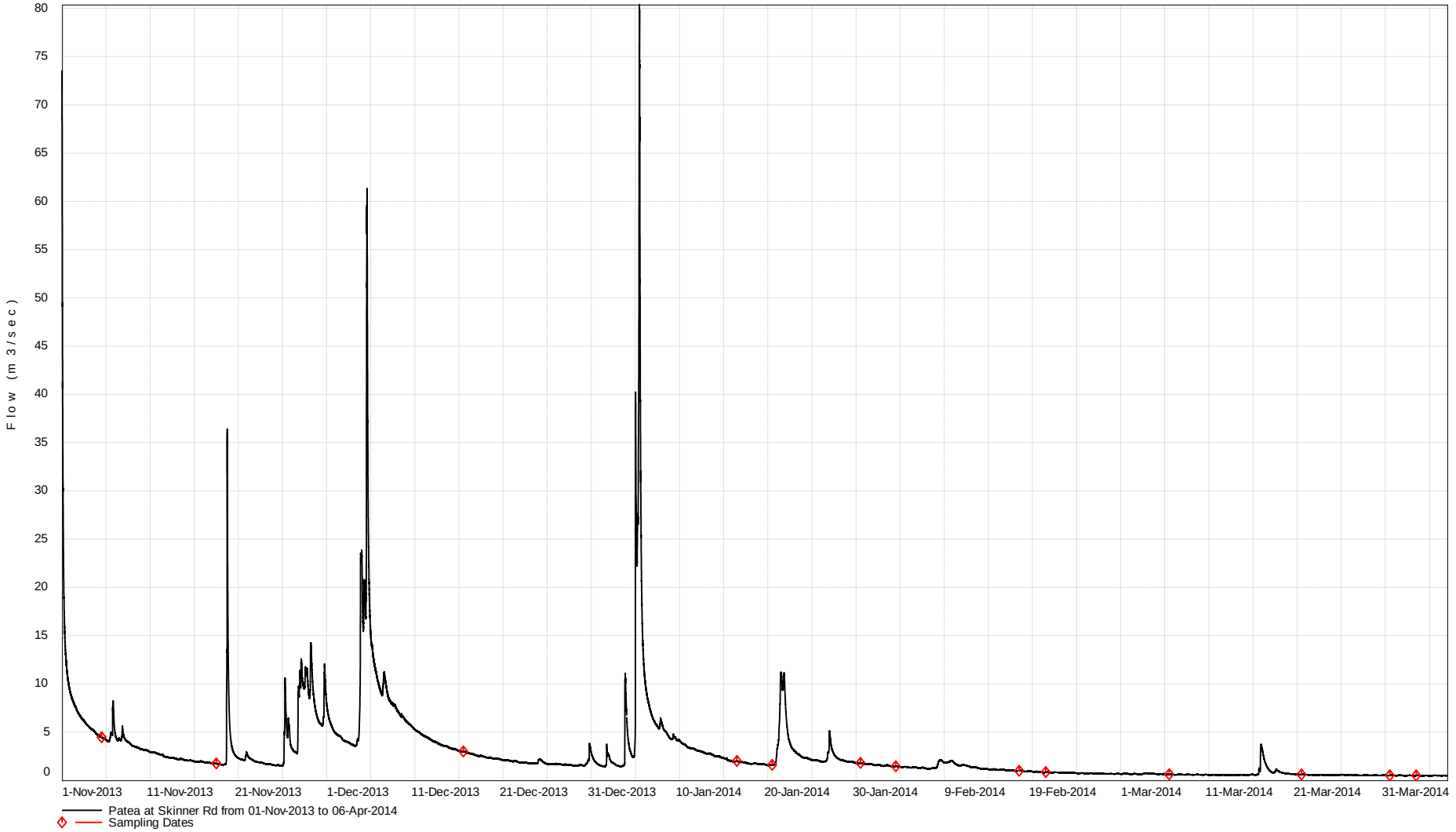


Figure 20 Flow in the Patea River at Skinner Rd during the survey period

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. These did not necessitate further investigation as regular sampling which followed in mid January 2014 and early March 2014, found lower counts, although an elevated count (in the 'Alert' category) remained under extremely low flow conditions, at the end of the season. However, this was an improvement compared with a number of previous seasons' surveys when 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 requirements. Three counts entered the 'Alert' level (mainly in late summer-early autumn during very low flow conditions) but these incidents did not warrant the placement of appropriate signage at the site by the Stratford District Council. However, appropriate publicity was provided on the relevant websites.

Annual dairy farms inspections in this area of the upper Patea catchment will continue to be timed to ensure compliance with consent conditions prior to the start of the contact recreation period.

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	3 [23]	0 [0]

(Designation: freshwater contact recreational area)

No single samples fell within the 'Action' mode, but three samples fell in the 'Alert' mode. Two of these counts occurred between mid February 2014 and the end of the season under extremely dry and low flow conditions. In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was compliant with the acceptable level for a majority of the period, with no incursions into the 'Action' level.

4.2.5.2 Comparison with previous summers' surveys

A statistical comparison of each of the eighteen summers' survey data is presented graphically in Appendix V for all sites. A shorter data period (thirteen years) exists for the Patea River (at King Edward Park, Stratford) site which was added 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 21.

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

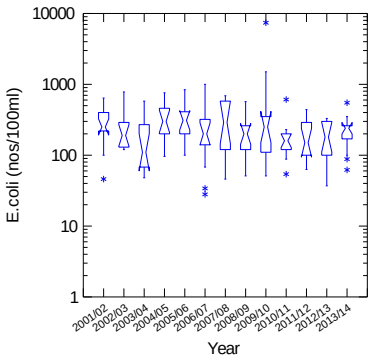
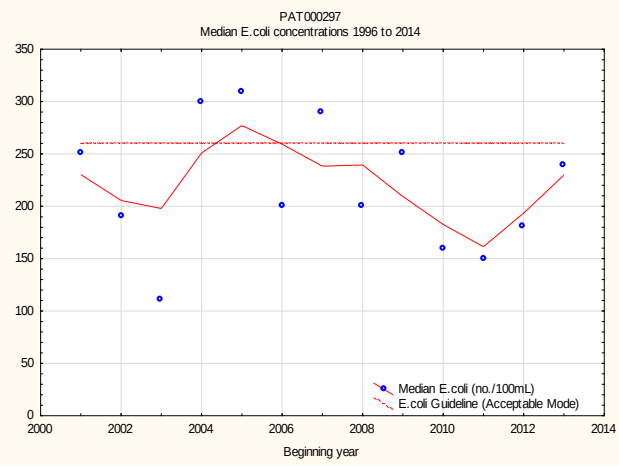


Figure 21 Box & whisker plots for all summer surveys of *E.* coli bacterial numbers for the Patea River at King Edward Park, Stratford

Some recent deterioration was indicated as the median *E. coli* bacterial count recorded for the 2013-2014 season was the sixth highest historical median count over the monitoring seasons and the highest since the 2010-2011 season. The 2013-2014 season recorded a typical range of counts for this site although the maximum count was one of the lowest compared with all of the thirteen monitoring seasons to date.

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



N = 13
Kendall tau = -0.181
p level = 0.387 [>FDR, p = 0.677]
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 2000-2014 period

A statistically insignificant temporal trend of decreasing median *E.coli* numbers has been found over the thirteen monitoring seasons. Three of these seasonal medians exceeded the 'Alert' mode (prior to 2008) but none have exceeded the 'Action' mode.

4.2.5.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on six occasions during the season. Results are presented in Table 36.

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

Date	Average *Phormidium* % cover	Mode
14.11.13	2	Green (surveillance)
16.12.13	0	Green (surveillance)
14.01.14	1	Green (surveillance)
14.02.14	0	Green (surveillance)
13.03.14	0	Green (surveillance)
26.03.14	0	Green (surveillance)

Benthic cyanobacteria coverage was very low throughout the season with *Phormidium* only found on two occasions, in mid-November 2013 (2%) and mid-January 2014 (1%). There was no benthic cyanobacteria coverage over the remainder of the season.

4.2.6 Patea River at the boatramp, Patea

Photo 2 An unusual sighting of pelicans in the lower Patea River, December 2013

No bathing usage of this river site was recorded at the time of sampling surveys, all but one of which were in the morning. Boating and walking 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, an unusual brief appearance of pelicans was reported in the lower river late in 2013 (Photo 2)].

During the 2011-2012 period Taranaki Regional Council undertook microbial source tracking (MST) using DNA marker techniques (see Section 3.2.3) 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 2013-2014 season are presented in Table 37 and illustrated in Figure 23, 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)
05.11.13	0845	4530	7	1	7	15.7	14
18.11.13	0820	4590	1	<1	1	16.8	23
16.12.13	0830	3550	19	<1	19	19.6	6.1
16.01.14	0810	4680	7	4	7	18.4	18
20.01.14	1015	4720	3	<1	3	18.5	21
30.01.14	0800	4700	8	7	8	18.5	20
03.02.14	1050	4720	1	<1	1	18.6	8.6
17.02.14	0920	4720	3	<1	3	18.5	15
20.02.14	1300	4700	8	4	8	19.6	5.7
06.03.14	1115	4620	3	<1	3	17.5	27
21.03.14	1040	4540	20	11	21	17.6	35
31.03.14	0805	4700	1	3	1	17.4	24
03.04.14	1005	4700	<1	<1	<1	17.9	15

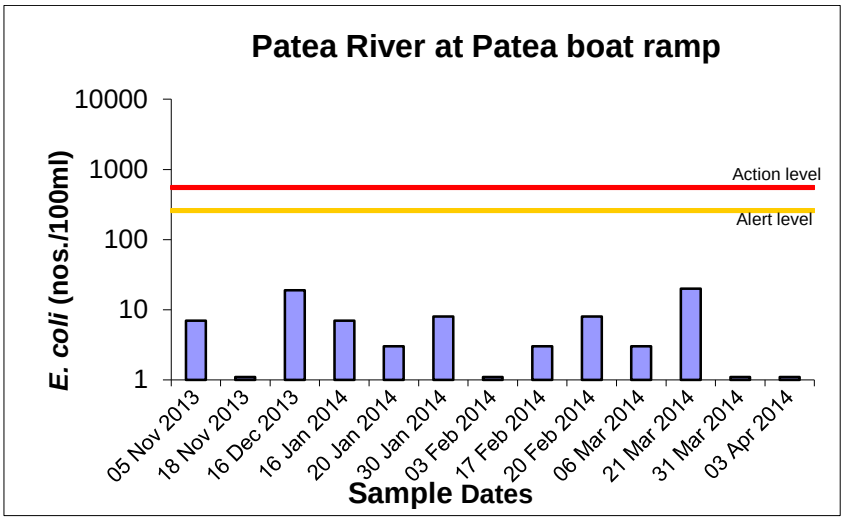


Figure 23 *E.coli* numbers for the Patea River at the boatramp, Patea during the survey season

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	3550	4720	4700
E. coli	nos/100ml	13	<1	20	3
Enterococci	nos/100ml	13	<1	11	<1
Faecal coliforms	nos/100ml	13	<1	21	3
Temperature	°C	13	15.7	19.6	18.4
Turbidity	NTU	13	5.7	35	18

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 green-brownish in appearance with high conductivity levels typical of seawater ingress at high tide on all occasions. Water temperatures had a relatively narrow range of 3.9˚C, a narrower than expected range despite the coastal seawater influence, with a maximum of 19.6˚C recorded in early afternoon in mid February 2014 when the river was in very low flow. All of the samples were collected before 1305 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: 3 *E.coli* per 100 mls and < 1 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 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 when a median *E. coli* bacterial number of 54 per 100mls (with counts ranging from 27 to 160 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*: 15 per 100 mls; range *E.coli:* 1-96 per 100 mls] for consent and SEM purposes.

4.2.6.2 Comparison with previous summers' surveys

Six previous SEM sampling seasons have been surveyed at this site. Otherwise prior sampling has been confined to consent monitoring surveys (TRC 2013a). A statistical comparison of each of the seven summers' survey data is presented graphically in Appendix V 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 24.

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
Minimum	1	1	1	<1	1	1	<1
Maximum	190	87	82	33	260	84	20
Median	5	9	11	4	16	3	3

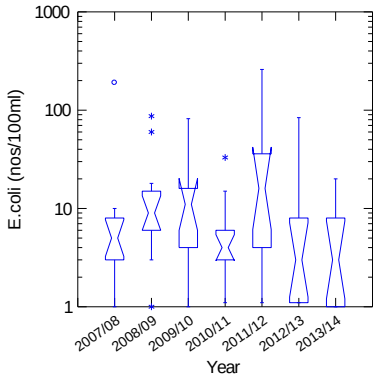


Figure 24 Box & whisker plots for all summer surveys of *E. coli* bacterial numbers for the Patea River at the boat ramp, Patea

Relatively similar (very low) median *E. coli* numbers have been found by these seven seasons' surveys with a moderate range of counts due to the maximum values found to date all of which have remained below the 'Alert' level. The recent season's range of counts was narrower than any 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. The site is used as part of the camp's activities.

Sheep were present in the paddock adjacent to this unfenced site on occasions. Data from the site are presented in Table 41 and illustrated in Figure 25 with a statistical summary provided in Table 42. River flow records are illustrated in Figure 26.

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)
05.11.13	0800	11.0	360	20	360	12.3	2.0
18.11.13	1155	11.7	80	12	84	15.8	2.2
16.12.13	1110	11.4	88	21	88	16.1	2.6
16.01.14	1115	10.9	140	40	140	16.2	1.3
20.01.14	0805	11.2	260	100	260	14.6	1.3
30.01.14	1115	10.9	120	54	120	16.0	1.4
03.02.14	0955	10.9	140	57	140	14.9	1.3
17.02.14	1220	10.8	48	51	54	18.1	1.3
20.02.14	0955	11.4	240	100	240	18.1	1.6
06.03.14	0930	12.2	270	230	280	13.6	1.8
21.03.14	0850	11.9	380	200	400	14.9	1.6
31.03.14	1110	12.5	260	370	260	14.7	1.0
03.04.14	0850	12.8	320	190	330	13.4	1.3

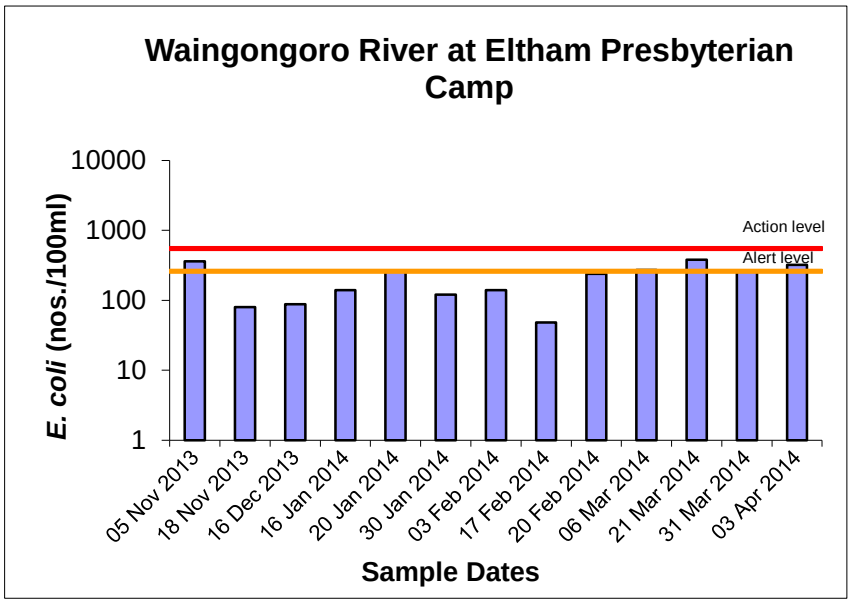


Figure 25 *E. coli* numbers for the Waingongoro River at Eltham Camp during the survey season

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	10.8	12.8	11.4
E. coli	nos/100ml	13	48	380	240
Enterococci	nos/100ml	13	12	370	57
Faecal coliforms	nos/100ml	13	54	400	240
Temperature	°C	13	12.3	18.1	14.9
Turbidity	NTU	13	1.0	2.6	1.4

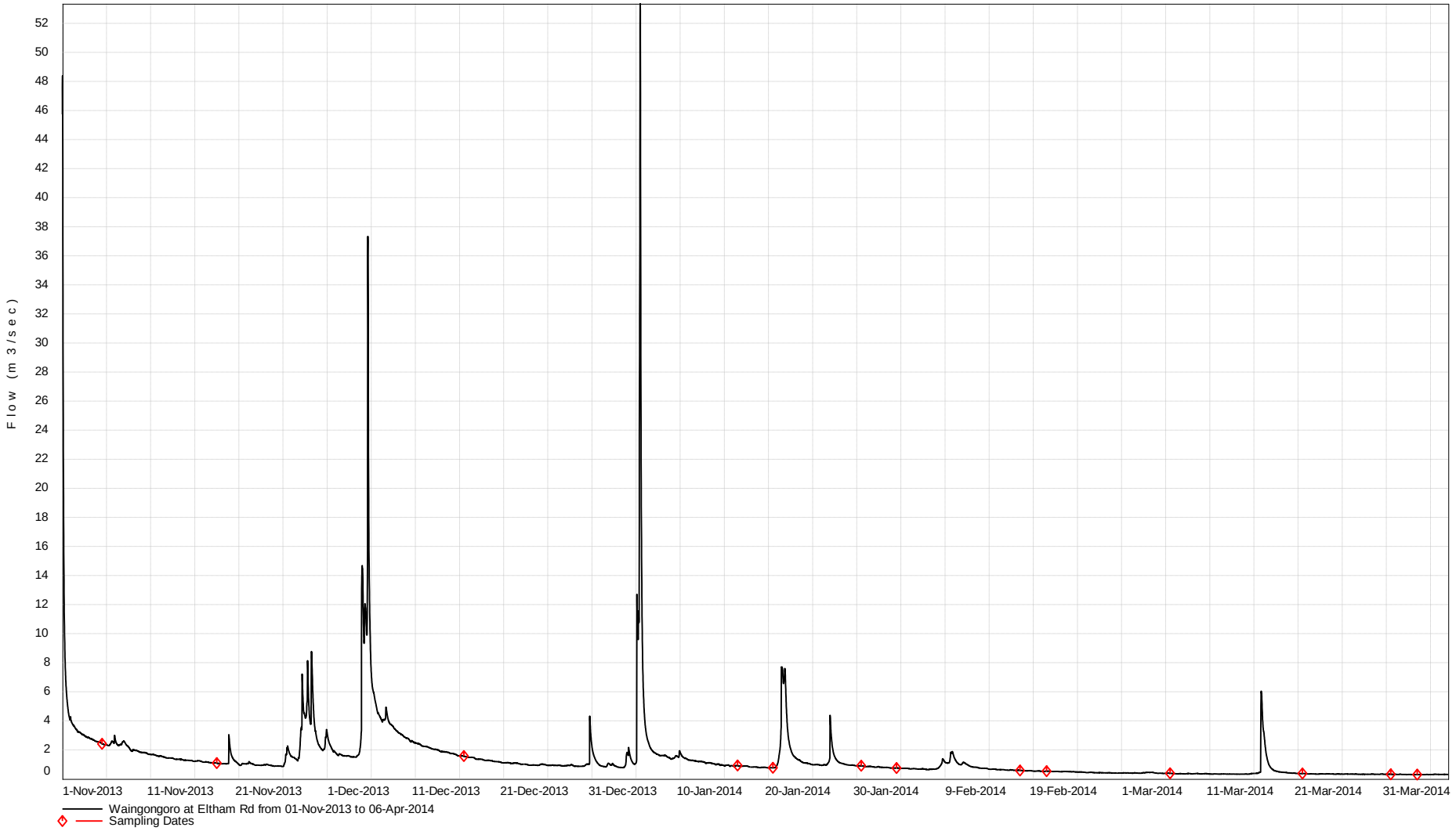


Figure 26 Flow in the Waingongoro River at Eltham during the survey period

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 relatively clear to slightly turbid in appearance with moderate conductivity levels. Water temperatures were within a moderate range of 5.8 ˚C with a maximum of 18.1 ˚C recorded on two occasions in mid February 2014. All samples were collected before 1225 hours and therefore higher river temperatures (which tend to occur later in the afternoon) were not recorded.

Bacteriological water quality was in the range 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 170 per 100mls (range: 6 to 59000 per 100mls) has been recorded by monthly sampling since 1995. The highest count in the current survey (within the 'Alert' mode) occurred in mid March under very low flow conditions with two earlier samples in the 'Alert' mode and another at the end of the period under prolonged very low flow conditions. (Figures 25 and 26).

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	4 [31]	0 [0]

(Designation: freshwater contact recreational area)

Four single samples fell within the 'Alert' mode but no samples reached the 'Action' mode. The highest sample count (in the 'Alert' mode) occurred in mid March 2014 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 November 2013 but the count dropped to a much lower level later in that month. 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 warning signage was required during the period. It should be noted that all but one sampling occasion was in the morning 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 the eighteen summer's survey data is presented graphically in Appendix V 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 27.

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

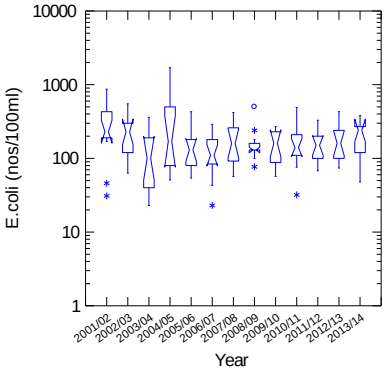
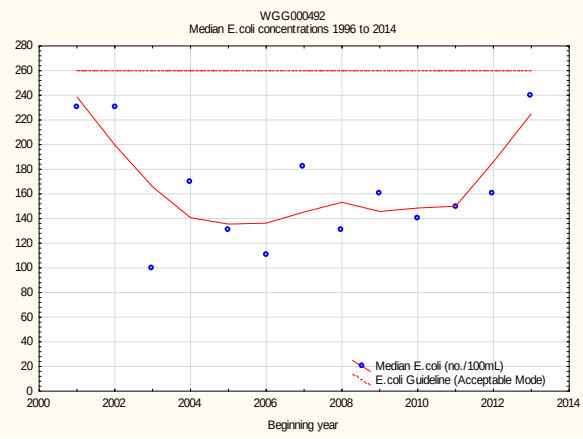


Figure 27 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waingongoro River at Eltham Camp

Poorer *E.coli* bacterial water quality was indicated by a median count which was the highest of the medians recorded by all of the twelve preceding seasons (Figure 27). However, there was a moderate range of counts over the 2013-2014 season (due to a lower than usual maximum) typical of many ranges in the twelve other seasons monitored previously.

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 28) 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 = + 0.065
p level = 0.756 [>FDR, p = 0.962]
N/S at p <0.05

Figure 28 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waingongoro River, Eltham camp for the 2000 to 2014 period

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

4.2.7.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on six occasions during the season. Results are presented in Table 45.

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

Date	Average *Phormidium* % cover	Mode
14.11.2013	0	Green (surveillance)
16.12.2013	1	Green (surveillance)
14.01.2014	0	Green (surveillance)
14.02.2014	2	Green (surveillance)
13.03.2014	0	Green (surveillance)
26.03.2014	0	Green (surveillance)

Benthic cyanobacteria coverage was very low throughout the season, with *Phormidium* only found on two occasions which were in mid-December 2013 (1%) and mid-February 2014 (2%). No other coverage was found at this site in the remainder of the season.

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. Occasionally stock have been present in the paddock upstream of the site but were not 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 gulls were also noted on occasions.

In the previous 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 2013-2014 period are presented in Table 46 and illustrated in Figure 29, with a statistical summary provided in Table 47. River flow records are illustrated in Figure 30.

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)
05.11.13	1000	14.9	240	68	260	15.3	3.1
18.11.13	0915	17.0	160	36	160	16.6	2.1
16.12.13	0910	15.9	96	85	100	18.1	2.4
16.01.14	0910	16.1	140	200	140	17.1	2.4
20.01.14	1130	16.8	48	78	48	17.8	1.3
30.01.14	0850	15.6	370	250	370	17.2	1.7
03.02.14	1145	16.5	46	240	46	19.1	1.4
17.02.14	1015	18.0	34	460	42	20.0	1.9
20.02.14	1220	17.6	72	40	86	22.1	1.4
06.03.14	1215	19.6	200	43	220	17.5	1.5
21.03.14	1135	18.1	190	80	210	18.1	2.2
31.03.14	0855	20.7	120	100	160	16.3	1.2
03.04.14	1055	20.2	66	88	74	16.9	1.3

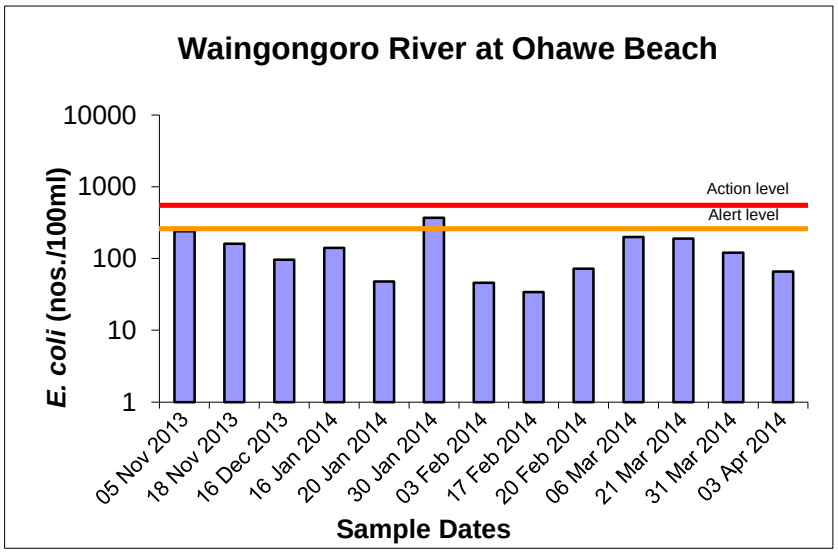


Figure 29 *E.coli* numbers for the Waingongoro River at Ohawe Beach during the survey season

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

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	14.9	20.7	17.0
E. coli	nos/100ml	13	34	370	120
Enterococci	nos/100ml	13	36	460	85
Faecal coliforms	nos/100ml	13	42	370	140
Temperature	°C	13	15.3	22.1	17.5
Turbidity	NTU	13	1.2	3.1	1.7

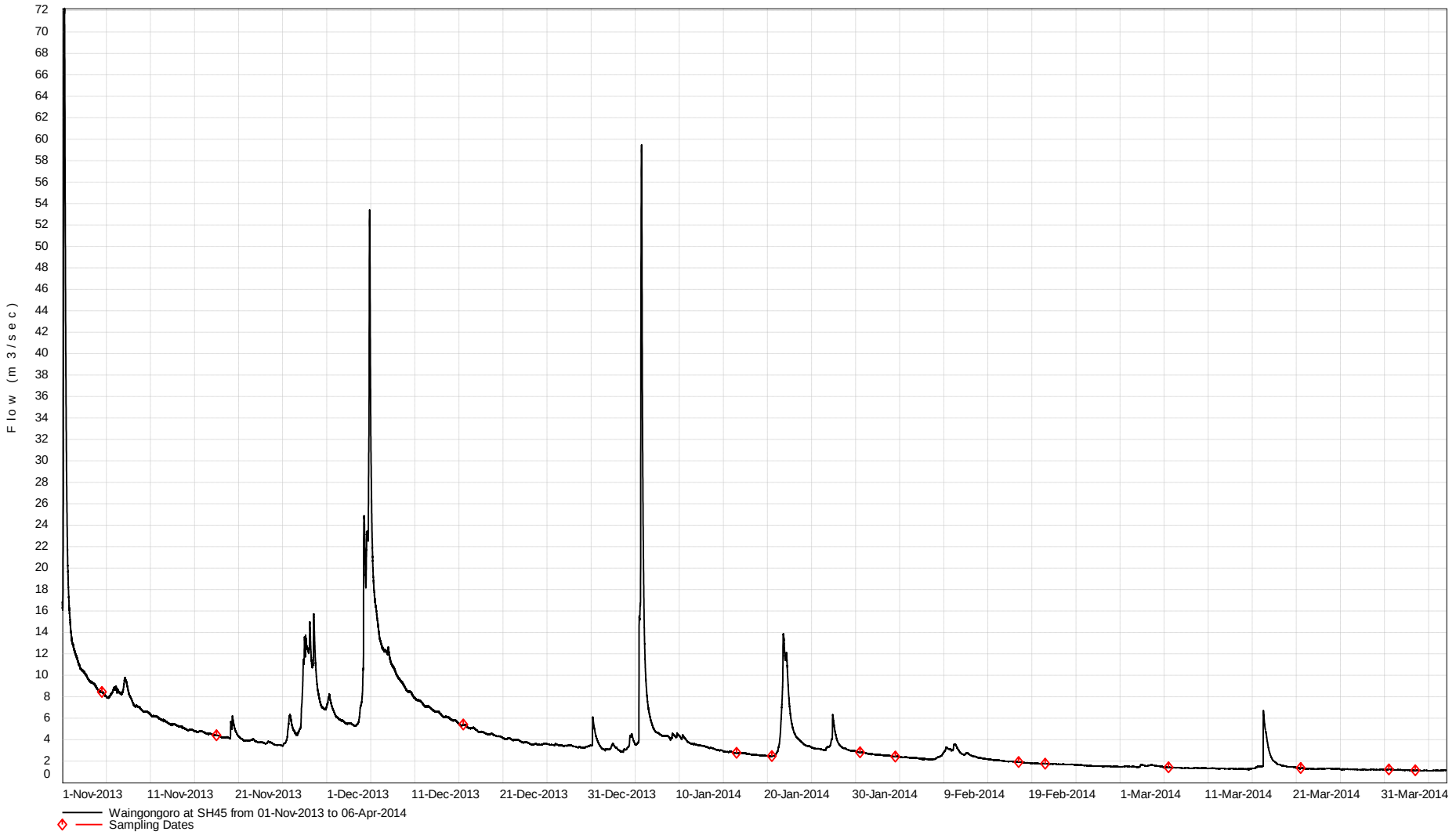


Figure 30 River flow in the Waingongoro River at SH45 during the survey period

This river drains an extensively farmed catchment and receives point source industrial wastes (in its mid-reaches) and dairy pond wastes (more than 100 treatment systems) discharges. These industrial (meatworks) wastes are predominantly diverted out of the river (to land irrigation) during summer months while the Eltham WWTP municipal and industrial wastes discharge was diverted permanently out of the catchment in winter 2010. The site is in the lower reaches of the river immediately upstream of the mouth, but is generally not tidal, although occasional upstream surging in the ponded area has been noted during low river flow and high tidal conditions during late summer. These conditions were less prevalent at sampling times during the 2013-2014 season.

The range of water temperatures was moderate (6.8˚C) with a maximum of 22.1˚ C recorded in very early afternoon in mid-February 2014. However, as sampling was not performed after 1220 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 observing occasional upstream surging (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: < 2.4 NTU on most occasions), typical of the lower reaches of a ring plain river.

Bacteriological water quality (Figure 29) was relatively 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 has recorded a median *E. coli* count of 220 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	1 [8]	0 [0]

(Designation: freshwater contact recreational area)

One single sample was recorded in the 'Alert' category in late January, 2014 but no samples were found in the 'Action' mode. No reason was apparent for this isolated exceedance of the guidelines and follow-up regular sampling at this site a few days later in early February 2014 found a return to a typical low level. Counts were generally less than 200 *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 V for all sites. These summer data for the Waingongoro River site at Ohawe Beach are summarised in Table 49 and illustrated in Figure 31.

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
Minimum	88	43	17	34	38	46	31	43	54	31	31	9	31	26	8	43	46	34
Maximum	310	650	300	240	850	660	14000	280	940	380	410	5000	870	1000	180	2800	2300	370
Median	185	130	80	180	170	160	110	110	130	96	100	100	120	96	100	96	110	120

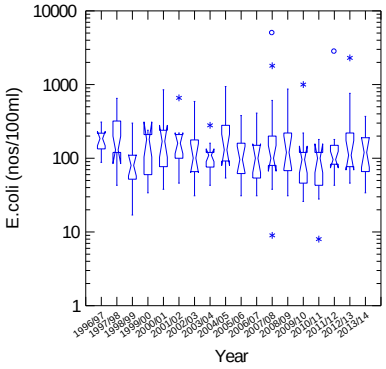
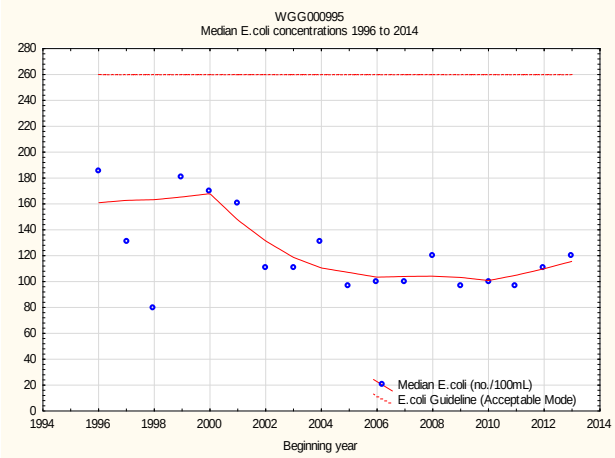


Figure 31 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Waingongoro River at Ohawe Beach

Median *E. coli* bacteria number for the 2013-2014 period was very similar to those found in the previous eleven seasons, maintaining the general trend of improvement in bacterial water quality recorded over the last twelve seasons (Figure 31).

A relatively narrow range of *E. coli* numbers was recorded in the recent 2013-2014 period in comparison with a majority of past seasons' ranges, as a result of the low maximum count.

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 32) 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 = 18
Kendall tau = - 0.366
p level = 0.033 [>FDR, p = 0.094]
Significant at p< 0.05,
Not significant at p< 0.05 after FDR.

Figure 32 LOWESS trend plot of median *E.coli* numbers (per 100ml) for the 1996 to 2014 period at the Waingongoro River Ohawe beach site

A decreasing trend in median *E.coli* number was found over the eighteen seasons of monitoring and the decrease has been particularly apparent over the past twelve seasons. The trend was statistically significant at the p <0.05 level but not significant after FDR application due to a more recent levelling off in the trend. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.2.8.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on six occasions during the season. Results are presented in Table 50 and Figure 33.

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

Date	Average *Phormidium* % cover	Mode
14.11.2013	4	Green (surveillance)
16.12.2013	4	Green (surveillance)
14.01.2014	14	Green (surveillance)
14.02.2014	7	Green (surveillance)
13.03.2014	3	Green (surveillance)
26.03.2014	0	Green (surveillance)

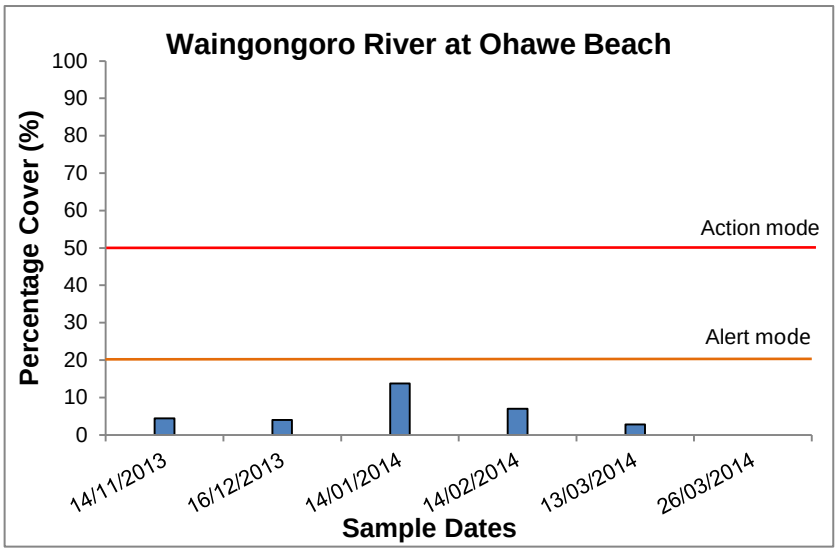


Figure 33 Percentage benthic cyanobacteria cover, for the Waingongoro River Ohawe beach site

Benthic cyanobacteria were found at this site throughout almost all of the season. The benthic cyanobacteria were all *Phormidium sp.* Coverage ranged from 3% to 14% with levels remaining below 'Alert' throughout the season. Consequently no health warnings were required to be issued.

4.2.9 Kaupokonui River at Beach Domain

Minor usage at this site by bathers was recorded at the time of the sampling surveys but 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 very high tide and low river flow conditions. No stock access was noted near the river's edge upstream of the domain during the current season.

During the previous (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 2013-2014 season are provided in Figure 34. Data from this site are presented in Table 51 and illustrated in Figure 35, with a statistical summary provided in Table 52.

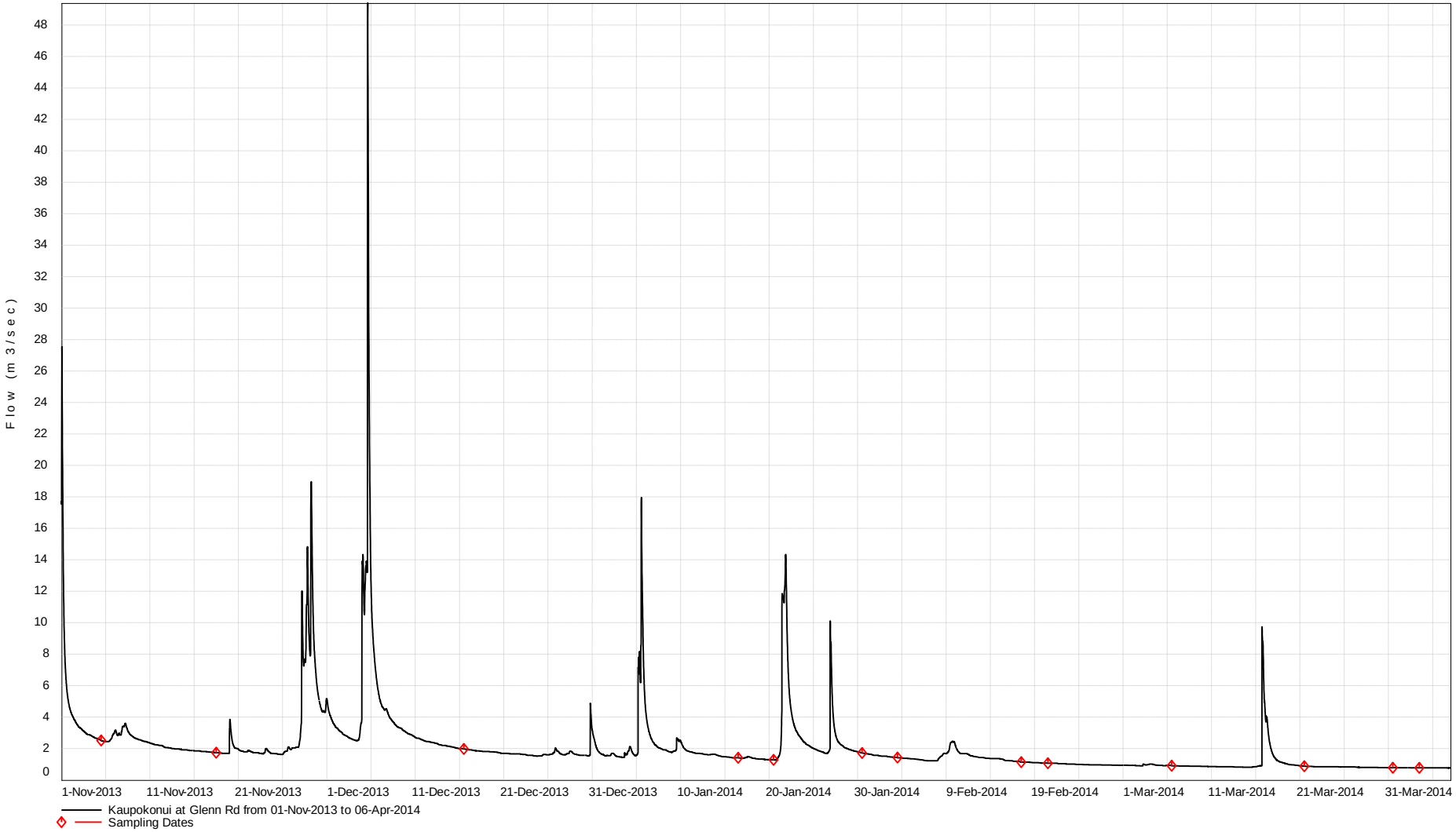


Figure 34 River flow in the Kaupokonui River at Glenn Rd during the survey period

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)
05.11.13	1015	16.4	54	9	57	16.1	1.8
18.11.13	0945	18.3	150	15	160	18.4	1.5
16.12.13	0930	17.6	270	290	300	18.1	1.6
16.01.14	0945	16.2	140	110	150	18.0	1.4
20.01.14	1200	16.5	100	82	110	18.1	0.9
30.01.14	0915	14.3	210	290	220	17.8	2.2
03.02.14	1230	15.0	11	110	11	21.0	1.4
17.02.14	1040	15.7	110	74	110	20.9	1.9
20.02.14	1145	15.9	110	140	120	23.4	1.2
06.03.14	1245	17.6	24	60	32	18.9	0.9
21.03.14	1200	16.5	160	88	180	18.9	1.7
31.03.14	0940	17.0	120	120	120	17.3	1.2
03.04.14	1125	16.9	93	43	93	18.2	1.2

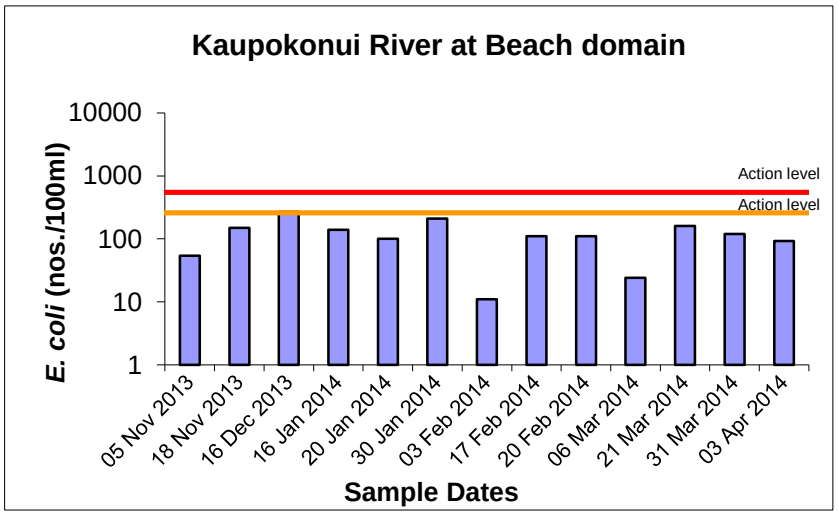


Figure 35 *E. coli* numbers for the Kaupokonui River at the beach domain during the survey season

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	14.3	18.3	16.5
E. coli	nos/100ml	13	11	270	110
Enterococci	nos/100ml	13	9	290	88
Faecal coliforms	nos/100ml	13	11	300	120
Temperature	°C	13	16.1	23.4	18.2
Turbidity	NTU	13	0.9	2.2	1.4

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 or very slow flow) in terms of flow conditions. However, unusually conductivity levels did not indicate any seawater influence on these occasions near high tide despite very low flow conditions during late summer–early autumn. These conductivity levels were relatively stable (14.3 to 18.3 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 moderate range of 7.3°C with a maximum of 23.4°C recorded in mid-February 2014. This temperature was recorded near midday and would be expected to have increased later in the day and on other occasions, particularly as most of the surveys were performed before 1300 hrs at this site.

Bacteriological water quality was relatively good and relatively similar to that recorded in the lower reaches of the nearby Waingongoro River (see section 4.2.8), and better than often found 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 later in summer (Table 51) when enterococci numbers were in excess of *E. coli* numbers on several occasions.

One 'Alert' level was recorded, in mid-December 2013 but a lower count was recorded by the following survey and all subsequent surveys. 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 2013-2014 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	1 [8]	0 [0]

(Designation: freshwater contact recreational area)

One individual sample was recorded in the 'Alert' mode during the season but no samples entered the 'Action' mode. No rainfall immediately preceded this count with numbers returning to typical levels subsequent to this December 2013 survey.

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

4.2.9.2 Comparison with previous summers' surveys

A statistical comparison of each of the eighteen summer's survey data is presented graphically in Appendix V for all sites. These summer data for the Kaupokonui River site at the Beach Domain are summarised in Table 54 and illustrated in Figure 36.

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

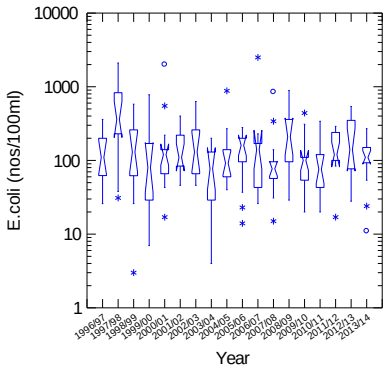
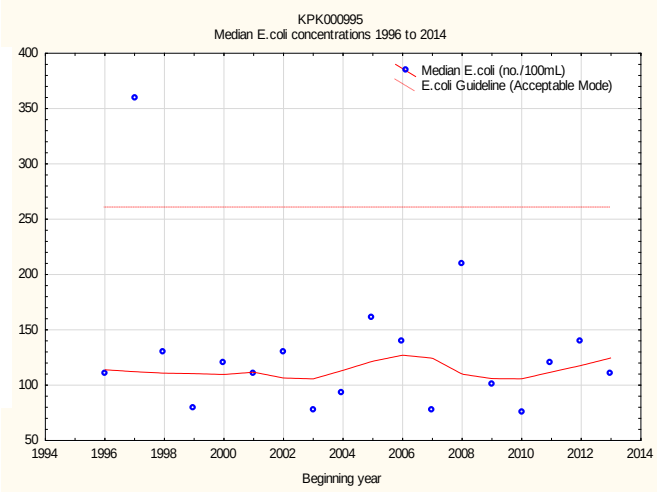


Figure 36 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Kaupokonui River at the Beach Domain

Typical *E. coli* bacterial water quality in terms of median number but a narrower range compared with the previous seventeen survey seasons, were recorded over the 2013-2014 season (Figure 36). The median *E. coli* count was in the mid-range of all other seasons' medians to date (Table 54), although the seasonal maximum was the second lowest for the 18 years of record.

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 34) 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 = 18
Kendall tau = -0.067
p level = 0.698 [>FDR p = 0.962]
N/S at p < 0.05

Figure 37 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Kaupokonui River beach domain site for the 1996 to 2013 period

A very slight and statistically insignificant, decreasing trend in median *E. coli* counts was found over the eighteen 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 seven occasions during the season. Results are presented in Table 55 and Figure 38.

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

Date	Average *Phormidium* % cover	Mode
14.11.2013	10	Green (surveillance)
16.12.2013	22	Amber (Alert)
14.01.2014	38	Amber (Alert)
27.01.2014	2	Green (surveillance)
14.02.2014	5	Green (surveillance)
13.03.2014	9	Green (surveillance)
26.03.2014	3	Green (surveillance)

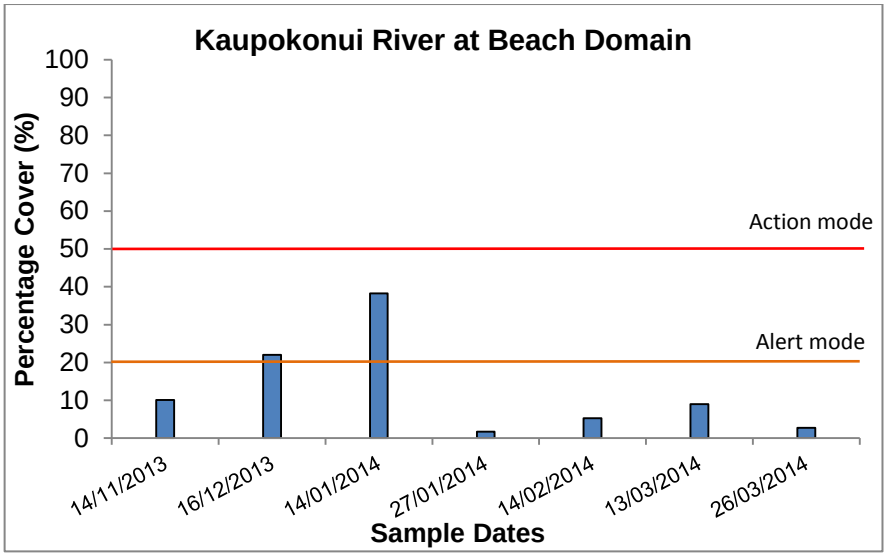


Figure 38 Percentage benthic cyanobacteria cover for the Kaupokonui River, Beach Domain site

Benthic cyanobacteria were found at this site throughout the season with all cyanobacteria being *Phormidium* and coverage ranging from 2% to 38%. The 'Alert' level mode was exceeded on two occasions [mid December 2013 (22%) and mid January 2014 (38%)]. However, the *Phormidium* coverage did not exceed the 'Action' mode level and therefore no health warnings were required to be put in place for this site.

4.2.10 Lake Opunake

No bathing or boating usage of the lake was noted on any occasion, but picnicking activities 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 several occasions. Large numbers of these wildfowl were present frequently 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, 2011b) although some floating algae were recorded on one occasion and suspended algae were frequently noted.

Data from this site are presented in Table 56 and illustrated in Figure 39, 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)
05.11.13	1100	13.3	100	100	100	16.3	0.9
18.11.13	1020	15.1	28	92	28	20.7	1.1
16.12.13	1030	16.4	100	1600	120	21.4	1.4
16.01.14	1040	13.9	240	2400	280	21.1	3.0
20.01.14	1315	13.2	280	1900	290	20.8	1.0
30.01.14	1035	12.9	340	2400	340	21.3	1.8
03.02.14	1330	14.2	23	380	23	22.7	1.0
17.02.14	1140	13.4	38	750	38	22.5	0.9
20.02.14	1140	14.1	120	520	120	23.5	1.4
06.03.14	1315	14.9	<8	100	<8	18.7	1.0
21.03.14	1250	13.1	120	120	120	18.2	1.0
31.03.14	1005	16.3	430	290	430	18.3	0.9
03.04.14	1200	15.5	38	540	38	19.7	1.2

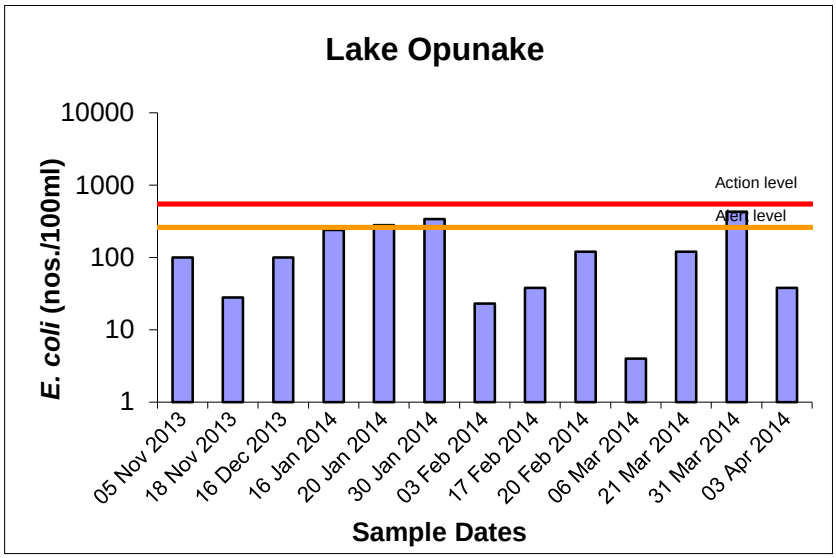


Figure 39 *E. coli* numbers for Lake Opunake during the survey season

Table 57 Statistical results summary for Lake Opunake

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	12.9	16.4	14.1
E. coli	nos/100ml	13	<8	430	100
Enterococci	nos/100ml	13	92	2400	520
Faecal coliforms	nos/100ml	13	<8	430	120
Temperature	°C	13	16.3	23.5	20.8
Turbidity	NTU	13	0.9	3.0	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: 2.1 NTU) with a 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 20.8˚C) for half of the period with a maximum of 23.5˚C (in mid February 2014) and a moderate range of 7.2˚C. Conductivity varied over a narrow range (3.5 mS/m @ 20˚C) reflecting river flow conditions.

Generally bacteriological quality was moderate, 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 230 *E. coli* per 100 mls, were found from time to time but more so in the latter 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 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 four days of exceedances. 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 V for all sites. The eight summers of data collection for the Lake Opunake site are summarised in Table 59 and illustrated in Figure 40.

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
Minimum	33	26	54	64	8	40	17	<8
Maximum	720	1300	2800	320	3800	2000	500	430
Median	110	130	210	220	80	80	120	100

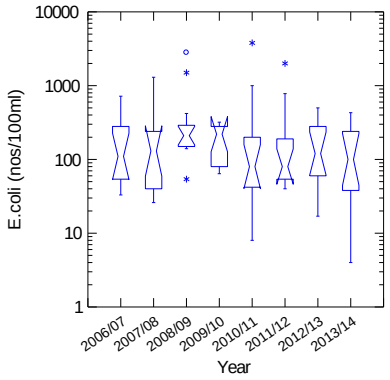


Figure 40 Box and whisker plots for the summer SEM survey of *E. coli* bacteria numbers at Lake Opunake

A median *E. coli* toward the lower range of the seven previous seasons' surveys was found in the latest season and a relatively narrow range of counts was also found, (Figure 40). This was only the third 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]

Date	Cyanobacteria total cell count (cells/ml)	Principal species
25.11.13	nil	-
10.12.13	nil	-
13.01.14	nil	-
27.01.14	6040	*Anabaena*
10.02.14	16	*Anabaena*
25.02.14	nil	-
11.03.14	nil	-

No cyanobacteria were detected in five of these samples. However, a marked increase in *Anabaena* numbers was recorded in late January 2014 followed by a rapid reduction in numbers by mid February 2014. 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 followed a lengthy, extremely low flow period. However, these numbers did not reach levels requiring the issue of 'health warnings' during that season nor in the current season. 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)

No bathing usage was noted at this site on any sampling occasion (although it has been in past seasons) while some picnicking and fishing (whitebaiting in season) usage was recorded on some sampling survey occasions during the season. The site had been a popular camping area (until the camp was closed by NPDC during early 2005) and access point to the sea coast but camping 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 the end of the season. A few gulls 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 2013-2014 season are presented in Table 61 and illustrated in Figure 41, 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)
05.11.13	1120	343	660	86	660	16.2	2.5
18.11.13	0800	26.2	180	84	180	16.0	0.4
16.12.13	0800	27.8	230	140	240	17.6	0.4
16.01.14	0800	12.7	290	340	310	16.7	0.4
20.01.14	1315	39.5	200	290	220	17.0	0.4
30.01.14	0805	28.7	220	380	240	16.6	0.7
03.02.14	1020	33.2	80	230	80	18.0	0.6
17.02.14	0915	59.7	190	420	190	18.9	0.6
20.02.14	1105	51.8	54	71	54	23.4	0.5
06.03.14	1105	117	80	190	84	17.5	0.7
21.03.14	1045	25.5	210	220	210	16.5	0.6
31.03.14	0800	122	340	540	340	-	0.6
03.04.14	1020	148	120	84	120	15.7	1.0

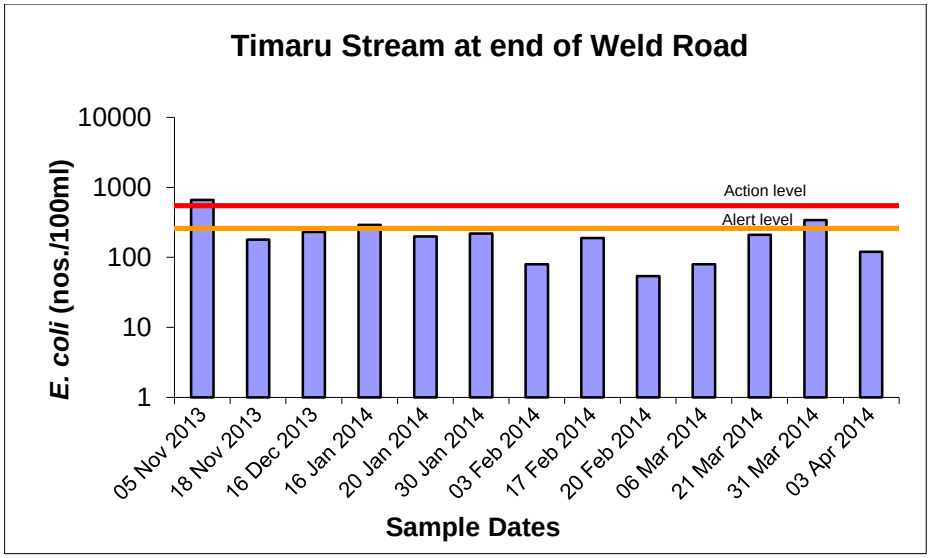


Figure 41 *E.coli* numbers for the Timaru Stream at Weld Road during the survey season

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	12.7	343	40
E. coli	nos/100ml	13	54	660	200
Enterococci	nos/100ml	13	71	540	220
Faecal coliforms	nos/100ml	13	54	660	210
Temperature	°C	13	15.7	23.4	16.8
Turbidity	NTU	13	0.4	2.5	0.6

This river drains a moderately farmed catchment (five consented dairy farm discharges) receiving point and non-point source discharges from these 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 throughout 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 7.7°C with a maximum water temperature of 23.4°C recorded in late morning in mid February 2014. This maximum could have been expected to have been exceeded on other occasions during summer as all sampling was undertaken before 1315 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, through the sampling period. However, there was no installation of 'health warning' signage at the site by NPDC although there was one exceedance of the 'Action' level early in 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 the 2009-2010, 2010-2011, 2011-2012, or 2012-2013

seasons nor in the current season. Surveys in other rivers with tidal pool reaches have found that bacteriological water quality may deteriorate probably as a result of ponding of the flow and 'accumulation' of slugs of poorer quality downstream flow, and several high *E. coli* counts were coincidental with more ponded conditions (during elevated conductivity events). It has also been noted at these tidal river pool sites that lower faecal coliform to enterococci ratios than usual have been recorded possibly due to vegetative sources and/or better enterococci survival in pool environments characterised by the ebb and flow in the ponded river/stream mouth.

4.2.11.1 Comparison with guidelines

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

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

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

(Designation: freshwater contact recreational area)

Two single samples were recorded in the 'Alert' mode, and one was recorded in the 'Action' mode during the period. Poorer bacteriological water quality tended to coincide with dry weather, and moderate seawater intrusion on two occasions. Although the erection of health warning signage was required (but not actioned) on one early season occasion when a single sample entered the 'Action' mode, public advice was provided on both websites. The bacterial count fell below the 'Alert' mode at the time of the following survey. Counts also fell to acceptable levels within four days of 'Alert' mode levels being detected in mid-January and late March 2014.

In terms of the 2003 contact recreation guidelines, the bacteriological water quality at the site was moderately good, 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 V for all sites. These summer data for the Timaru Stream site at the end of Weld Road (which has been monitored for fourteen summers) are summarised in Table 64 and illustrated in Figure 42.

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
Minimum	40	23	31	77	31	140	77	84	38	43	46	92	46	28	34	26	54
Maximum	410	710	1400	540	660	1000	410	1000	460	480	930	440	560	410	440	550	660
Median	280	210	160	180	180	260	220	260	220	200	180	230	290	180	160	250	200

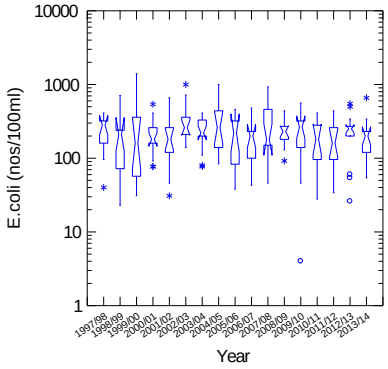
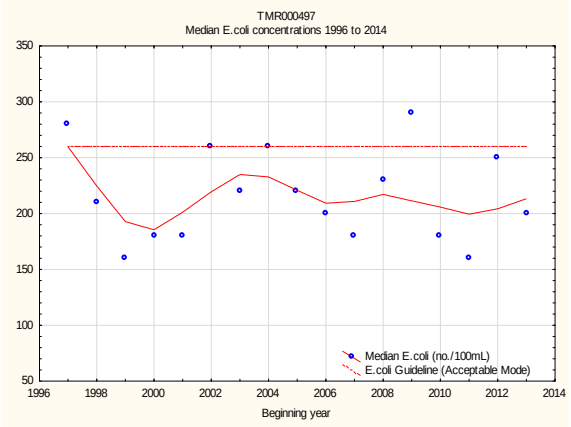


Figure 42 Box and whisker plots for all summer surveys of *E.coli* bacterial numbers in the Timaru Stream at lower Weld Road

The median *E. coli* count for the 2012-2013 season was typical of past seasons (Table 64) near the middle of the range of previous seasons' counts. Counts over the 2013-2014 season had a moderate range (Figure 42), with only one count reaching the 'Action' mode, and a seasonal maximum in the mid range of those found over the 17 years of monitoring.

Trend analysis of these median *E. coli* numbers has been performed for the seventeen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 43) 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 = 17
Kendall tau = -0.031
p level = 0.864 [>FDR, p = 1.000]
N/S at p < 0.05

Figure 43 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Timaru Stream, lower Weld Road site for the 1997 to 2014 period

An overall very slight decreasing trend in median *E. coli* numbers has been found over the seventeen 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 which is often ponded over 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 most recent 2013-2014 survey being the first at this frequency.

No contact recreation was observed at this very shallow stream site at the time of the 2013-2014 sampling visits. Although few people were present on the beach in the immediate vicinity of the stream mouth on all but one sampling occasion, this site is known to be popular with children and families during favourable weather conditions at holiday periods and weekends (see, TRC 2009a and TRC, 2010). The channel flowed directly across the beach on some occasions but the stream migrated northwards later in the season, toward the Wairau Stream.

Data from the site are presented in Table 65 and illustrated in Figure 44, with a statistical summary provided in Table 66.

Table 65 Analytical results for the Waimoku Stream at Oakura 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)
05.11.13	1100	14.5	510	120	600	14.6	3.0
18.11.13	0840	16.1	680	260	690	14.3	3.4
16.12.13	0830	14.6	2300	610	2300	15.3	2.5
16.01.14	0820	14.4	1600	1000	1600	15.3	2.5
20.01.14	1250	14.6	3300	2900	3400	15.4	2.2
30.01.14	0835	14.7	2200	1000	2200	15.4	1.3
03.02.14	1045	14.8	1200	1100	1200	15.7	1.4
17.02.14	0940	15.0	430	1500	450	16.3	1.5
20.02.14	1130	14.8	1700	1900	1700	18.0	1.5
06.03.14	1125	15.3	1600	1300	1600	14.7	1.4
21.03.14	1115	15.4	1200	900	1200	16.2	1.2
31.03.14	0840	15.4	1900	2500	2100	-	1.4
03.04.14	1050	15.4	780	970	780	13.5	1.4

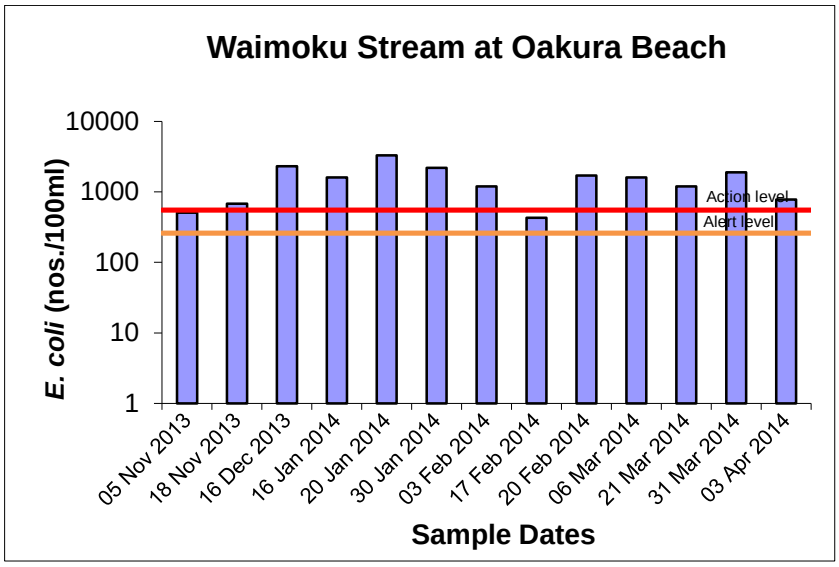


Figure 44 *E.coli* numbers for the Waimoku Stream at Oakura beach during the survey season

Table 66 Statistical results summary for the Waimoku Stream at Oakura beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20° C	mS/m	13	14.4	16.1	14.8
E. coli	nos/100ml	13	430	3300	1600
Enterococci	nos/100ml	13	120	2900	1000
Faecal coliforms	nos/100ml	13	450	3400	1600
Temperature	°C	12	13.5	18.0	15.4
Turbidity	NTU	13	1.2	3.4	1.5

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

Conductivity levels were very stable throughout the survey period with no salt water intrusion recorded. The stream was relatively clear in appearance and after November, 2013 the streambed had a cover (up to 100%) of periphyton growth (although not by thick mats). Water temperatures varied over a relatively narrow range of 4.5°C with a maximum water temperature of 18.0°C recorded in late morning in mid-February 2014. Water temperatures later in the day could be anticipated to exceed the maximum recorded as all sampling at this site was performed prior to 1300 hrs.

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

4.2.12.2 Compliance with guidelines

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

Table 67 Bacterial guidelines performance at the Waimoku Stream, Oakura beach [% of 13 sample**s]**

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	2 [15]	11 [85]

(Designation: freshwater contact recreational area)

Two single samples were recorded in the 'Alert' mode with the remainder of the 13 single samples within the 'Action' mode.

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

19 of 21 sampling occasions (median: 29 per 100 ml) with one individual sample entering each of the 'Alert' and 'Action' modes but no occurrence (of two consecutive samples) entering the 'Alert' or 'Action' mode in these coastal waters. The proximity of this small inflow to the Waimoku Stream only slightly impacted on the main beach water quality as indicated by the median *E. coli* number of 24 per 100 mls (range: 3 to 180 per 100 mls) for the SEM season (TRC, 2014).

4.2.12.3 Comparison with previous summers' surveys

A statistical comparison of each of the summers' survey data is presented graphically in Appendix V for all sites. Shorter data periods exist for the Waimoku Stream at Oakura beach which was first included in the programme in 1999-2000. These summer data for the Waimoku Stream site at Oakura beach are summarised in Table 68 and Figure 45.

Table 68 Summary of *E. coli* bacteriological water quality data (nos/100ml) for all summer surveys in the Waimoku Stream at Oakura beach to date

Summer	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
Minimum	200	85	250	300	450	440	560	390	730	700	1400	1300	-	-	430
Maximum	1700	900	1800	1700	1700	2200	6300	3200	8100	4600	6200	13000	-	-	3300
Median	480	400	730	770	710	900	830	930	2100	1600	2800	2700	-	-	1600

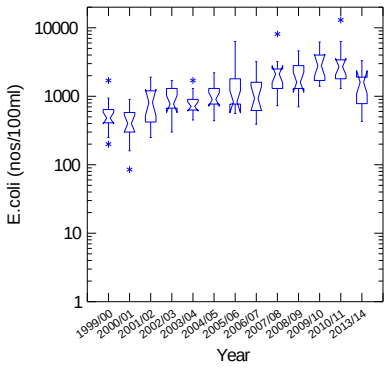
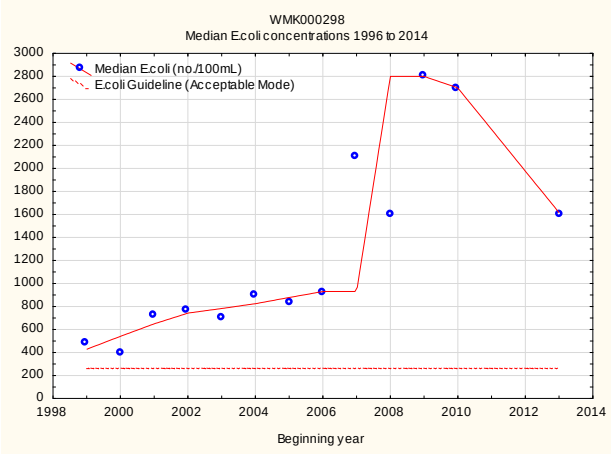


Figure 45 Box and whisker plots for all summer surveys of *E.coli* bacterial numbers in the Waimoku Stream at Oakura beach

The very high median *E. coli* count for the 2013-2014 season continued the more recent seasons' high median bacterial levels with the equal fourth highest median of the thirteen seasons' surveys and a relatively wide range of counts. The trend of relatively high minimum counts also continued with a typical seasonal minimum count to date, indicative of poor bacterial water quality, long associated with this small predominantly agricultural catchment stream with high wildfowl numbers.

Trend analysis of 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 46) 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 =13
Kendall tau = +0.761
p level = 0.0003 [>FDR, p = 0.0032]
Significant at p<0.01 and after FDR

Figure 46 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Waimoku Stream, Oakura Beach site for the 1999 to 2014 period

A steady increase in median *E. coli* numbers has been found over the thirteen seasons of monitoring with a marked increase over the latest five seasons. This trend has been statistically very significant. All of these seasonal medians exceeded the 'Alert' mode and the last eleven seasonal medians have all exceeded the 'Action' mode.

4.2.13 Oakura River below SH45

Photo 1 Stock access on left bank of Oakura River (Nov. 2013)

Bathing usage was recorded on 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 on or in the river. Stock access was also apparent early in the season (Photo 4) necessitating follow up abatement action.

Faecal source DNA tracking markers analyses (by Cawthron Institute, Nelson) were 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 2013-2014 season are presented in Table 69 and illustrated in Figure 47, with a statistical summary provided in Table 70.

Table 69 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)
05.11.13	1030	139	88	28	110	14.3	1.3
18.11.13	0915	9.2	71	19	74	16.2	0.9
16.12.13	0855	8.6	110	85	120	17.1	0.5
16.01.14	0850	7.9	86	260	86	16.7	0.4
20.01.14	1225	7.9	80	120	80	16.3	0.5
30.01.14	0900	75.0	220	190	220	16.9	0.3
03.02.14	1110	79.4	51	110	51	19.2	0.4
17.02.14	1010	20.0	91	22	91	18.7	0.6
20.02.14	1200	26.9	60	550	60	22.4	0.4
06.03.14	1150	77.4	16	80	32	17.6	0.3
21.03.14	1145	37.4	150	160	150	16.7	1.4
31.03.14	0915	198	92	220	120	-	0.5
03.04.14	1120	66.3	28	26	28	15.5	0.6

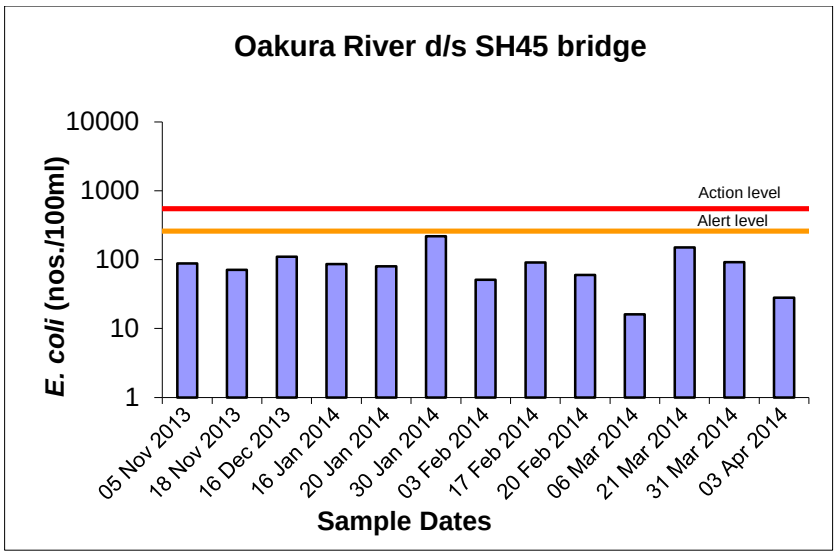


Figure 47 *E. coli* numbers for the Oakura River below SH45 during the survey season

Table 70 Statistical results summary for the Oakura River below SH45

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	7.9	198	37
E. coli	nos/100ml	13	16	220	86
Enterococci	nos/100ml	13	19	550	110
Faecal coliforms	nos/100ml	13	28	220	86
Temperature	°C	13	14.3	22.4	16.8
Turbidity	NTU	13	0.3	1.4	0.5

This river drains a mainly agricultural catchment (three consented dairy farm discharges to surface water) with the survey site established in the short tidal reach between SH45 and the mouth of the river. The river was noted as tidal with ponding or inflowing obvious on eight sampling occasions. Conductivity levels indicated a variable influence of saltwater intrusion on at least nine sampling occasions during the season. The more significant intrusions occurred mainly during very low flow conditions during the latter part of this season. On all occasions 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 (9.1°C) during the period reaching a maximum of 22.4°C at midday in mid February 2014, but below the maximum water temperature which might be anticipated later in the day as all sampling at this site occurred before 1230 hrs.

Bacteriological water quality was moderate, with the majority of *E. coli* counts below 150 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 occasionally 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 late January 2014, although within guidelines, was coincident with slight surging and saltwater intrusion under very low flow conditions while regular sampling, four days after this elevated count, found a much lower *E. coli* count (51 per 100 mls).

4.2.13.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 71.

Table 71 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	0 [0]	0 [0]

(Designation: freshwater contact recreational area)

No single samples fell within the 'Alert' mode, nor did any samples enter the 'Action' mode. This was despite very low flow conditions in the latter part of the season. Therefore, no health warning signage was required to be displayed at this site by NPDC at any stage of the season.

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 entirety of the sampling season.

4.2.13.2 Comparison with previous summers' surveys

A statistical comparison of each of the eighteen summers' survey data is presented graphically in Appendix V for all sites. These summer data for the Oakura River site below the SH45 bridge are summarised in Table 72 and illustrated in Figure 48.

Table 72 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
Minimum	7	28	42	24	23	31	26	43	11	46	23	31	34	60	19	11	31	16
Maximum	260	1100	240	540	310	580	420	1200	820	380	330	2400	450	2500	290	440	530	220
Median	34	110	100	77	80	120	120	120	140	160	220	140	180	150	100	140	140	86

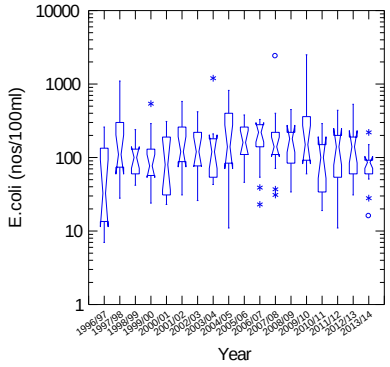
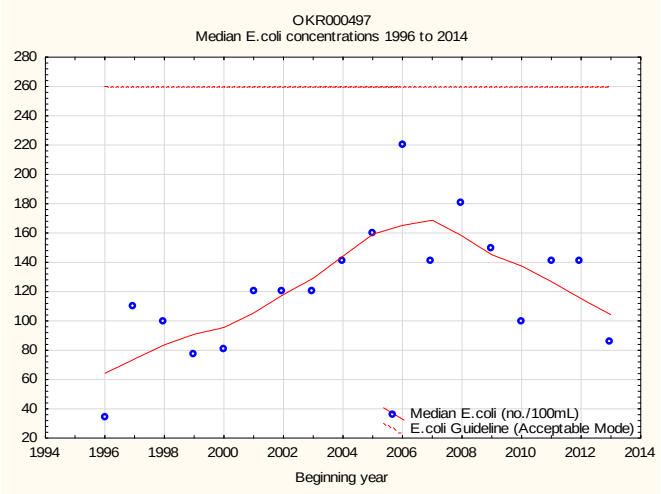


Figure 48 Box and whisker plots for all summer surveys of *E. coli* bacteria numbers in the Oakura River downstream of SH45

The median *E. coli* count was toward the lower end of the range of past seasons' results (Figure 48). One of the narrowest ranges of *E. coli* counts was recorded due to the absence of any very high counts. No median *E. coli* counts have exceeded the 2003 guidelines for contact recreational usage over the eighteen seasons 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 49) 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 = 18
Kendall tau = + 0.385
p level = 0.026 [>FDR, p = 0.094]
Significant at p < 0.05;
Not significant at p < 0.05 after FDR.

Figure 49 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Oakura River, SH 45 site for the 1996 to 2014 period

A relatively strong increasing trend in median *E. coli* counts has been found over the eighteen 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 warrant further investigation if it continues although it should be noted that there has been a slightly improving trend (decrease) in median *E.coli* counts over the past seven year period after medians peaked over the 2006-2007 season.

4.2.13.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on six occasions during the season with results presented in Table 73.

Table 73 Percentage benthic cyanobacteria cover for the Oakura River at the SH45 Bridge site

Date	Average *Phormidium* % cover	Mode
19.11.2013	1	Green (surveillance)
17.12.2013	0	Green (surveillance)
14.01.2014	1	Green (surveillance)
14.02.2014	0	Green (surveillance)
13.03.2014	0	Green (surveillance)
26.03.2014	0	Green (surveillance)

Benthic cyanobacteria coverage was very low throughout the season with *Phormidium* only found on two occasions and at very low levels (1%). Consequently no health warnings were required to be issued.

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 (limiting whitebaiting in season) was noted from time-to-time at this site with walking and boating (including rowing and yachting) as additional activities. Ducks and gulls were present on occasions but in low numbers. The permanent signage previously installed by NPDC was not present 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 2013-2014 season are presented in Table 74 and illustrated in Figure 50 with a statistical summary provided in Table 75. River flow information is illustrated in Figure 51.

Table 74 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)
05.11.13	1030	318	290	12	300	15.1	16.0
18.11.13	0905	332	280	5	310	17.6	1.7
16.12.13	0850	695	150	31	160	19.8	2.2
16.01.14	0945	755	280	89	280	19.0	3.4
20.01.14	1110	626	100	46	100	18.9	1.7
30.01.14	0900	788	80	110	84	19.2	2.2
03.02.14	1120	1790	23	20	27	20.7	2.0
17.02.14	1010	1380	59	17	59	20.1	1.7
20.02.14	1155	1930	110	32	120	23.6	2.5
06.03.14	1225	2020	33	23	130	18.3	3.9
21.03.14	1140	1660	100	8	100	18.7	4.1
31.03.14	0915	2790	37	33	44	17.3	2.6
03.04.14	1130	3190	13	21	13	19.3	2.5

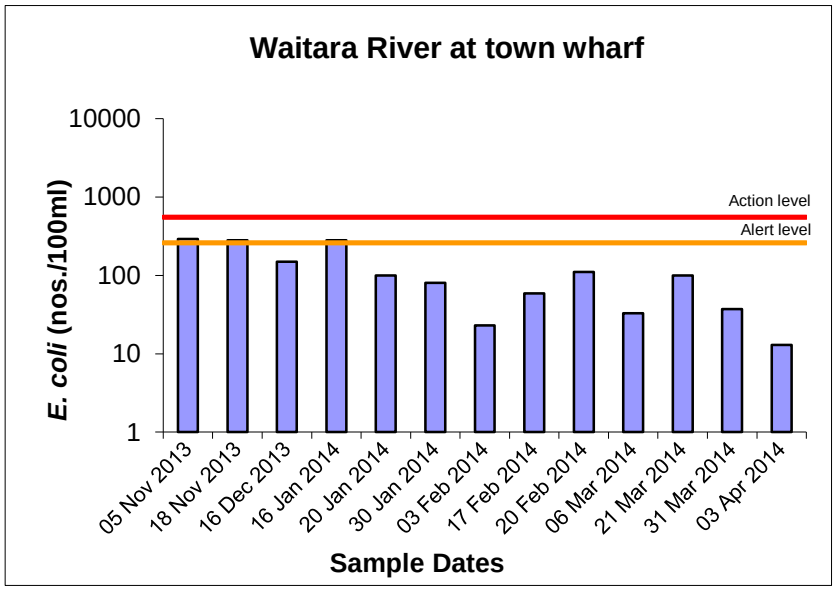


Figure 50 *E.coli* numbers for the Waitara River at the town wharf, Waitara during the survey season

Table 75 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	318	3190	1380
E. coli	nos/100ml	13	13	290	100
Enterococci	nos/100ml	13	5	110	23
Faecal coliforms	nos/100ml	13	13	310	100
Temperature	˚C	13	15.1	23.6	19.0
Turbidity	NTU	13	1.7	16	2.5

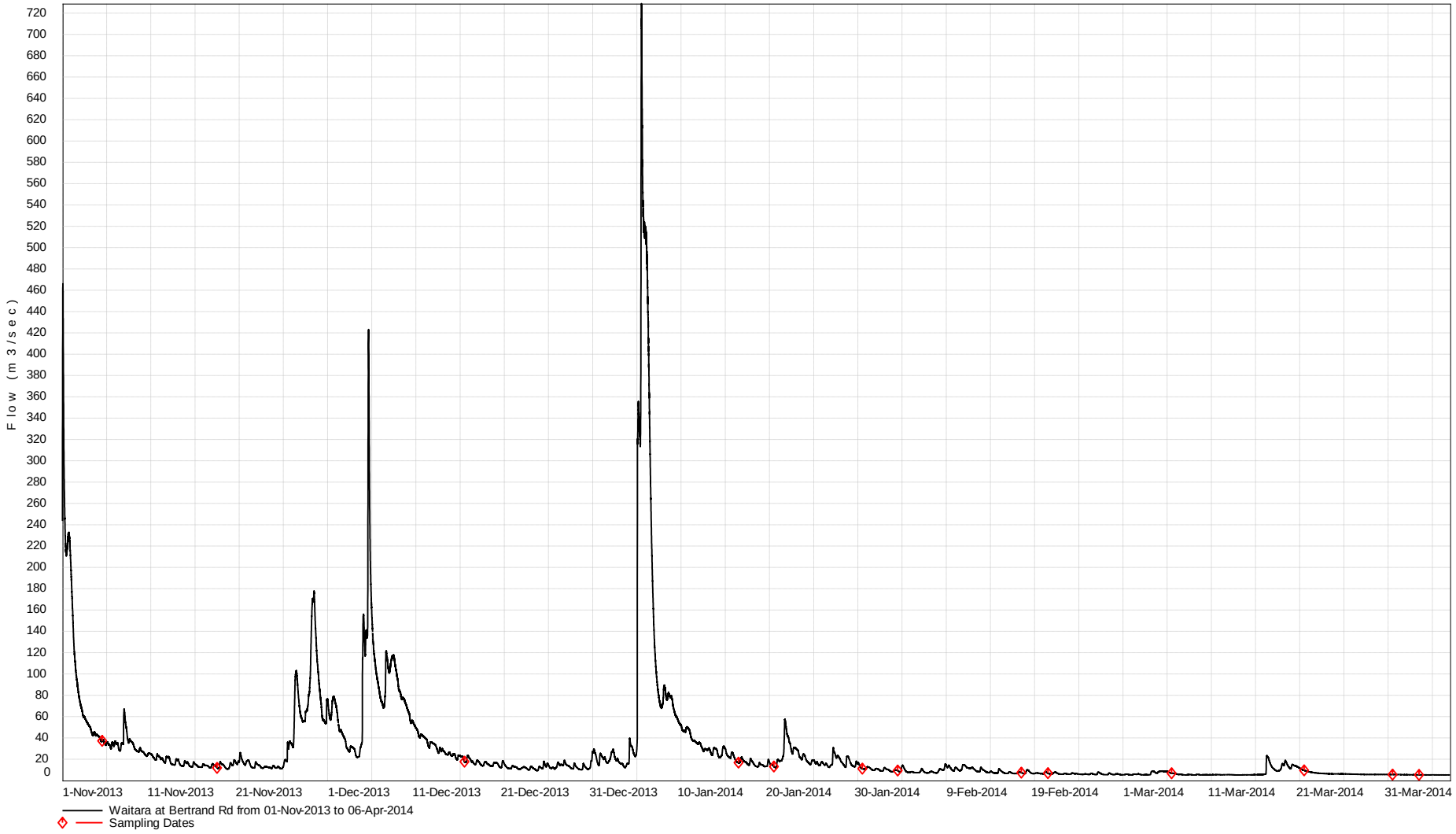


Figure 51 Flow in the Waitara River at Bertrand Road during the surey period

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

Water temperatures had a moderate range of 8.5˚C partly due to the coastal seawater influence, with a maximum of 23.6˚C recorded near midday in mid-February 2014. All of the samples were collected before 1230 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 100 *E.coli* per 100 mls and 23 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 same recreational period and base flow conditions found a lower median *E.coli* bacterial number of 44 per 100 mls but a similar range of *E. coli* numbers (9 to 320 per 100 mls).

4.2.14.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 76.

Table 76 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	3 [22]	0 [0]

(Designation: freshwater contact recreational area)

Three single samples fell within the 'Alert' mode but none within the 'Action' mode during the monitoring period. The first of the 'Alert' exceedances occurred within five days following a river fresh (Figure 51), coincident with a turbid river appearance indicative of the lag effects of rainfall run-off within this large catchment. It has been noted that the three-day post rainfall sampling protocols followed by the SEM programme for the other (ringplain) catchment sites are therefore not necessarily appropriate for baseline assessments of bacteriological water quality at this site near the mouth of this large predominantly eastern hill country catchment river.

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. However, the permanency of this signage has been probematical due in part to vandalism. Subsequent sampling indicated that *E.coli* numbers had fallen below the 'Alert' level four days after the mid-January 2014 occurrence.

Generally, *E. coli* numbers were relatively good (i.e. < 120 per 100 mls) for the majority of the sampling period and no exceedances of the guidelines were recorded during lenghtier 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

Four 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 77 and illustrated in Figure 52 for this, the fourth season of monitoring.

Table 77 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
Minimum	92	19	28	3	13
Maximum	1700	570	550	1300	290
Median	230	76	150	120	100

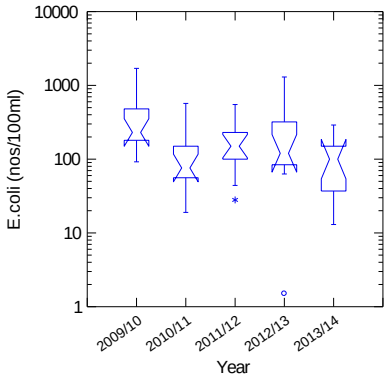


Figure 52 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waitara River at the town wharf, Waitara

A moderate median *E. coli* number was found by this fifth season's survey with the narrowest range of counts found to date during the season due to 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

Some bathing usage of this site was noted (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 78 and enterococci counts (as the site is predominantly seawater) are illustrated in Figure 53, with a statistical summary provided in Table 79.

Table 78 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)
05.11.13	0925	4450	42	3	42	17.1	56
18.11.13	1010	4600	140	15	140	18.7	7.1
16.12.13	1005	4620	9	3	9	21.8	6.2
16.01.14	1100	4710	<2	14	<2	19.8	30
20.01.14	1010	4740	8	<1	8	18.8	7.8
30.01.14	1005	4760	8	32	8	18.4	17
03.02.14	1020	4690	1	<1	1	18.0	17
17.02.14	0915	4680	5	4	5	18.0	15
20.02.14	1055	4700	1	1	1	20.5	10
06.03.14	1125	4720	<1	<1	<1	17.1	40
21.03.14	1035	4690	13	3	15	19.1	27
31.03.14	1035	4750	9	51	16	19.6	13
03.04.14	1020	4740	3	4	3	19.7	11

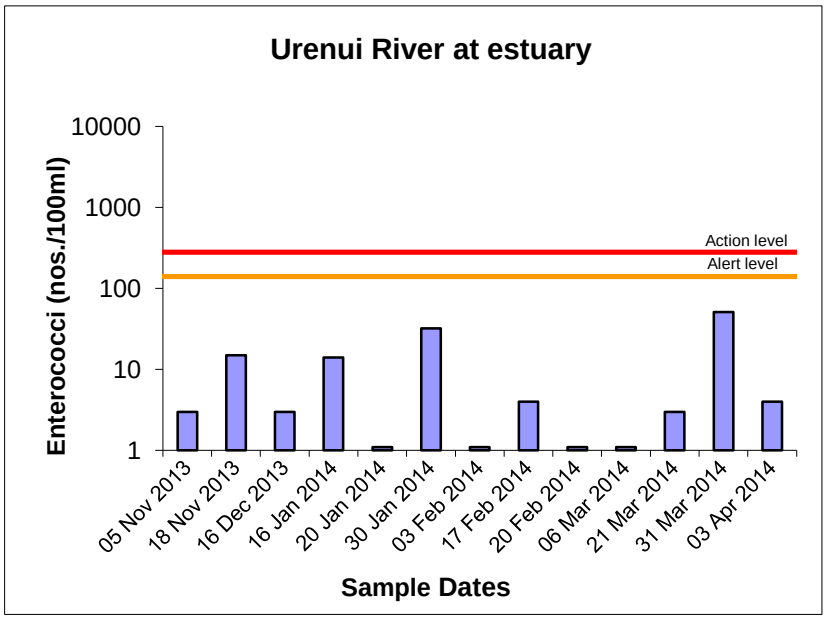


Figure 53 Enterococci numbers for the Urenui River at the estuary during the survey season

Table 79 Statistical results summary for the Urenui River at the estuary

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4450	4760	4700
E. coli	nos/100ml	13	<1	140	8
Enterococci	nos/100ml	13	<1	51	3
Faecal coliforms	nos/100ml	13	<1	140	8
Temperature	°C	13	17.1	21.8	18.8
Turbidity	NTU	13	6.2	56	15

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 (6.2 NTU) and median turbidity (15 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 greenish or green-brown in appearance and slightly turbid to turbid. Conductivity levels were characteristic of coastal saltwater on all occasions. Moderately high water temperatures (median of 18.8°C), more typical of coastal seawater temperatures, varied over a relatively narrow range of 4.7°C during the sampling period with a maximum of 21.8°C recorded in mid-morning in mid-December 2013. All sampling however, was undertaken prior to 1130 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. No high enterococci counts were recorded during the monitoring period (Figure 53).

4.2.15.1 Comparison with guidelines

Comparison with the 2003 guidelines for contact usage is summarised in Table 80 using the marine guidelines, which are considered to be more appropriate for this estuarine site.

Table 80 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 six seasons to date.

4.2.15.2 Comparison with previous summers' surveys

A statistical comparison of each of the eighteen summers' survey data is presented graphically in Appendix V for all sites. These summer enterococci data for the Urenui River site at the estuary are summarised in Table 81 and illustrated in Figure 54.

Table 81 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
Minimum	<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
Median	5	7	3	8	14	8	4	4	5	4	1	2	11	7	3	4	3	3

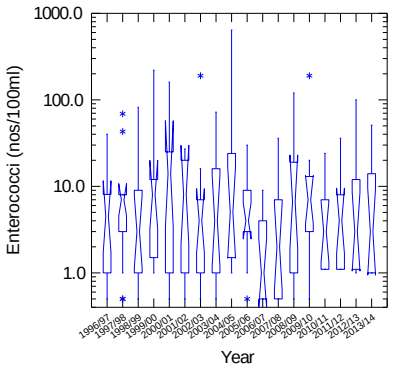
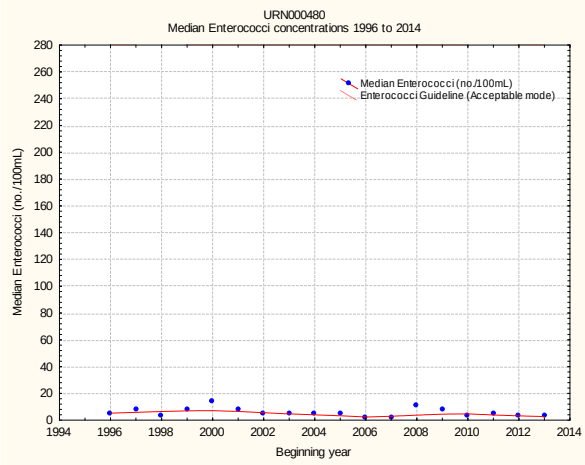


Figure 54 Box and whisker plots for all summer surveys of enterococci bacterial numbers in the Urenui River at the estuary

The high bacteriological water quality of the Urenui River estuary, during high tide conditions, continued during the 2013-2014 season (Figure 54). 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 2013-2014 season as a result of no single sample counts in excess of 51 enterococci per 100 mls during the period.

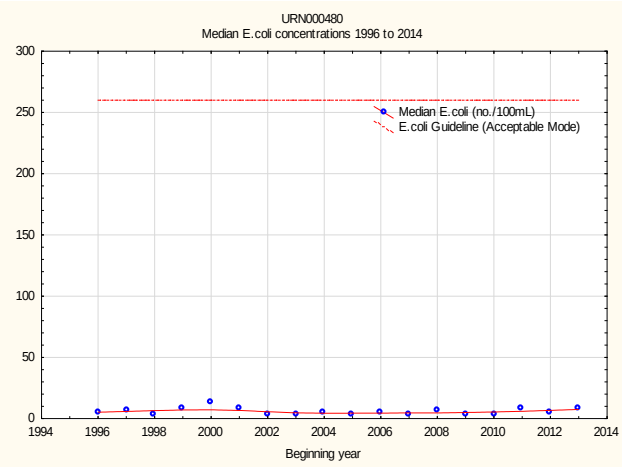
The high bacteriological quality of the coastal sea water intrusion was the major influence on the bacteriological water quality of the lower quality river water at this estuarine site during preferred recreational usage (i.e. higher tide) conditions.

Trend analysis of median enterococci and *E. coli* numbers has been performed for the eighteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figures 55 and 56) 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 = 18
Kendall tau = - 0.308
p level = 0.079 [>FDR, p = 0.185]
N/S at p < 0.05

Figure 55 LOWESS trend plot of median enterococci (per 100ml) at the Urenui River, estuary site for the 1996 to 2014 period



N = 18
Kendall tau = + 0.014
p level = 0.935 [>FDR, p = 1.000]
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 2014 period

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

4.2.16 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.

Data from the site are presented in Table 82 and illustrated in Figure 57, with a statistical summary provided in Table 83. River flow records are illustrated in Figure 58.

Table 82 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)
05.11.13	0835	9.4	240	80	240	13.2	2.2
18.11.13	1115	9.9	200	40	200	16.7	0.7
16.12.13	1110	10.3	330	48	500	18.2	0.8
16.01.14	1210	10.0	120	54	120	17.6	0.6
20.01.14	0920	10.1	200	110	200	16.6	0.7
30.01.14	1235	9.6	80	40	140	18.7	0.8
03.02.14	0935	10.1	63	100	63	16.9	0.7
17.02.14	0815	10.0	100	380	130	17.5	0.7
20.02.14	0900	9.9	130	110	140	20.4	0.7
06.03.14	1020	9.9	140	220	140	14.3	0.7
21.03.14	0915	10.1	210	100	210	15.6	0.8
31.03.14	1130	9.7	170	120	170	14.6	0.6
03.04.14	0930	9.9	120	160	120	14.1	0.5

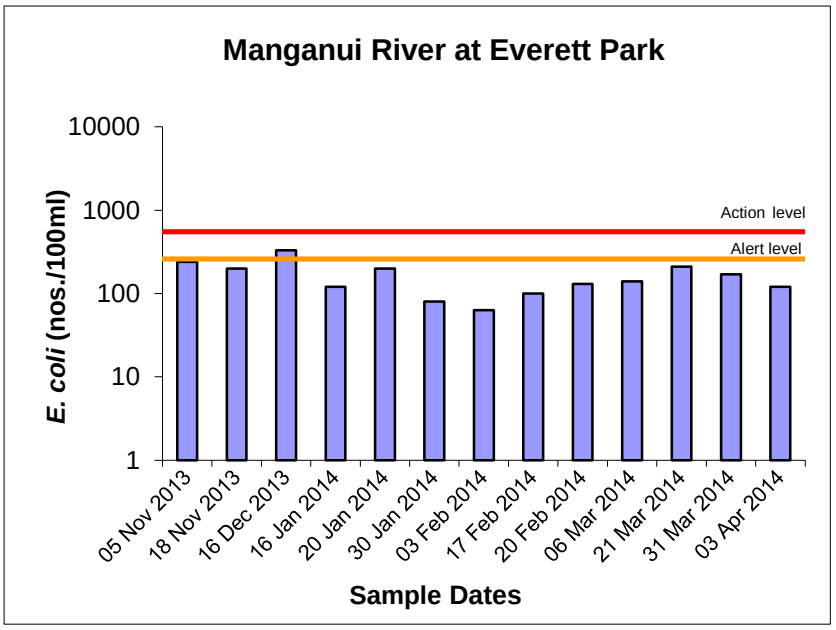


Figure 57 *E. coli* numbers for the Manganui River at Everett Park (downstream of the Kurapete Stream) during the survey season

Table 83 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	9.4	10.3	9.9
E. coli	nos/100ml	13	63	330	140
Enterococci	nos/100ml	13	40	380	100
Faecal coliforms	nos/100ml	13	63	500	140
Temperature	°C	13	13.2	20.4	16.7
Turbidity	NTU	13	0.5	2.2	0.7

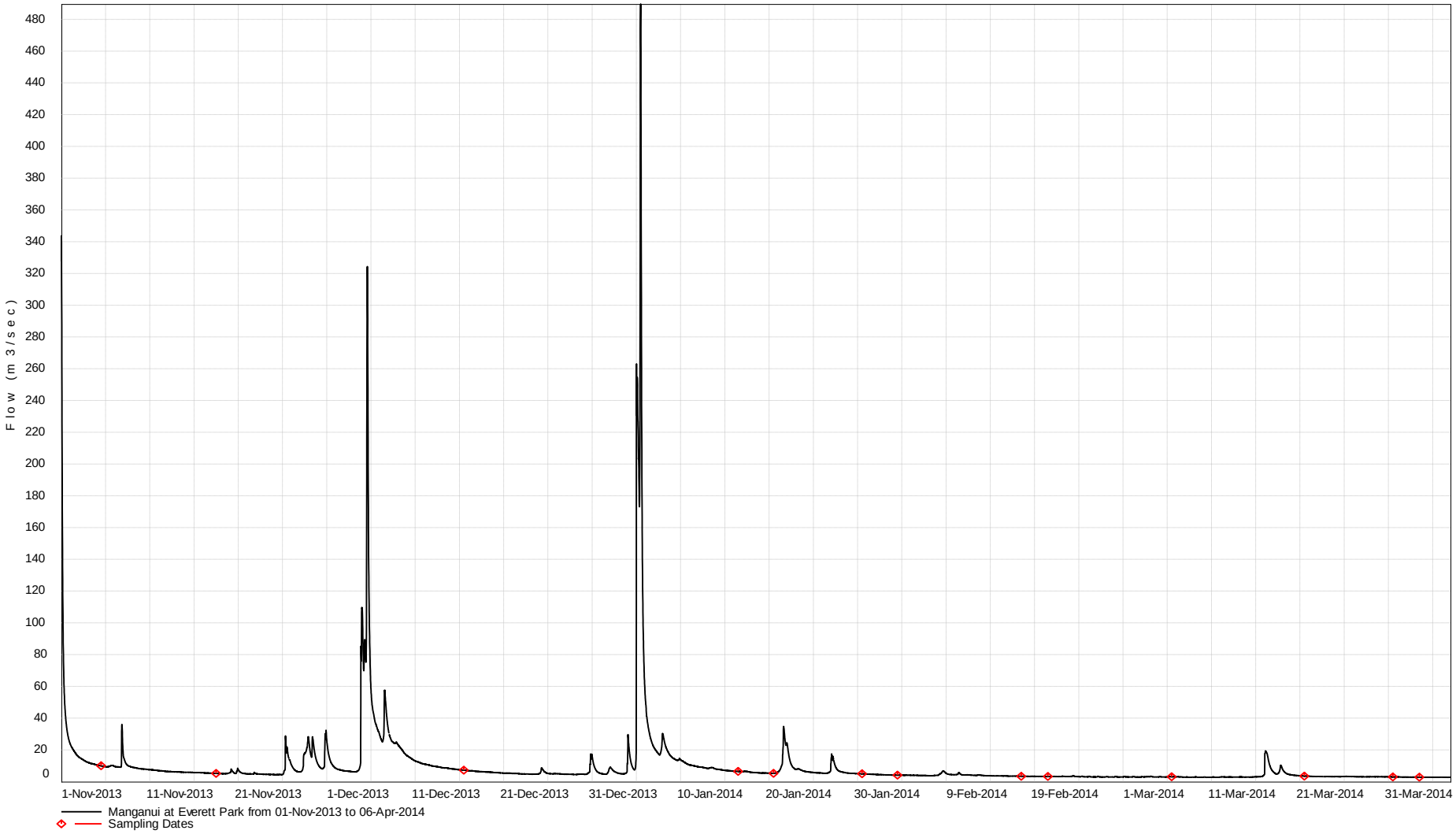


Figure 58 Flow in the Manganui River at Everett Park during the survey period

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 7.2°C with the maximum temperature (20.4°C) recorded near mid-morning in mid-February 2014. Higher temperatures could be expected later in the day as no sampling surveys were performed after 1235 hrs at this site.

Bacteriological water quality was moderate for this site during the 2013-2014 survey period with all of the counts recorded during the period in excess of 62 *E. coli* per 100 mls (Figure 57). The elevated count in mid-December 2013 which entered the 'Alert' level, was on a steady recession from a significant flood ten days prior to sampling. Levels decreased below the 'Alert' level within the month 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 the very low flow conditions in February and March 2014.

4.2.16.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 84.

Table 84 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]	0 [0]

(Designation: freshwater contact recreational area)

One single sample fell in the 'Alert' mode but none reached the 'Action' mode during the season. The highest count was a few days on the recession flow from a relatively recent significant flood during the wet late spring period.

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 (ie, 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 eighteen summers' survey data is presented graphically in Appendix V for all sites. These summer data for the Manganui River site at Everett Park are summarised in Table 85 and illustrated in Figure 59.

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

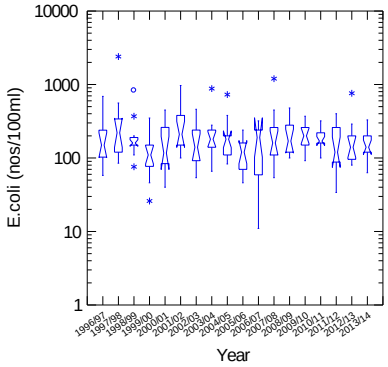
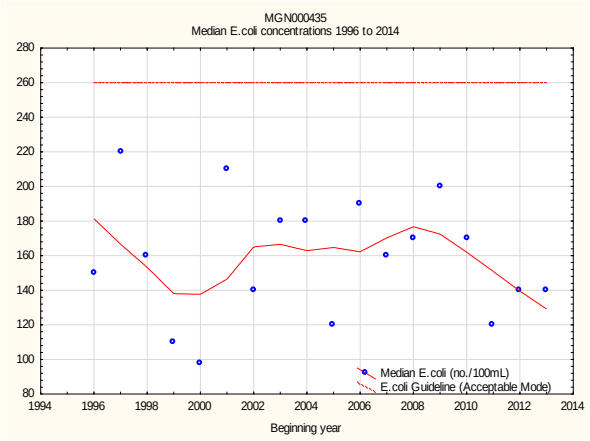


Figure 59 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Manganui River at Everett Park

The median *E. coli* count for the 2013-2014 season was within the range and equal the fifth lowest of the eighteen seasons' medians recorded since the inception of the programme in 1996-97 (Figure 59). The range of *E. coli* numbers was narrower than the majority of those recorded to date mainly due to a relatively low maximum count of 330 per 100 mls; the third lowest seasonal maximum recorded to date at this site.

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



N = 18
Kendall tau = -0.067
p level = 0.698 [>FDR, p= 0.961]
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 2014 period

A slight and statistically insignificant decrease in median *E. coli* counts has been found over the eighteen seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.2.16.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on eight occasions through the season and to 11 April 2014 with results presented in Table 86 and Figure 61.

Table 86 Percentage benthic cyanobacteria cover at the Manganui River, Everett Park site

Date	Average *Phormidium* % cover	Mode
19.11.2013	43	Amber (Alert)
02.12.2013	2	Green (surveillance)
17.12.2013	7	Green (surveillance)
14.01.2014	6	Green (surveillance)
14.02.2014	6	Green (surveillance)
13.03.2014	15	Green (surveillance)
26.03.2014	24	Amber (Alert)
11.04.2014	3	Green (surveillance)

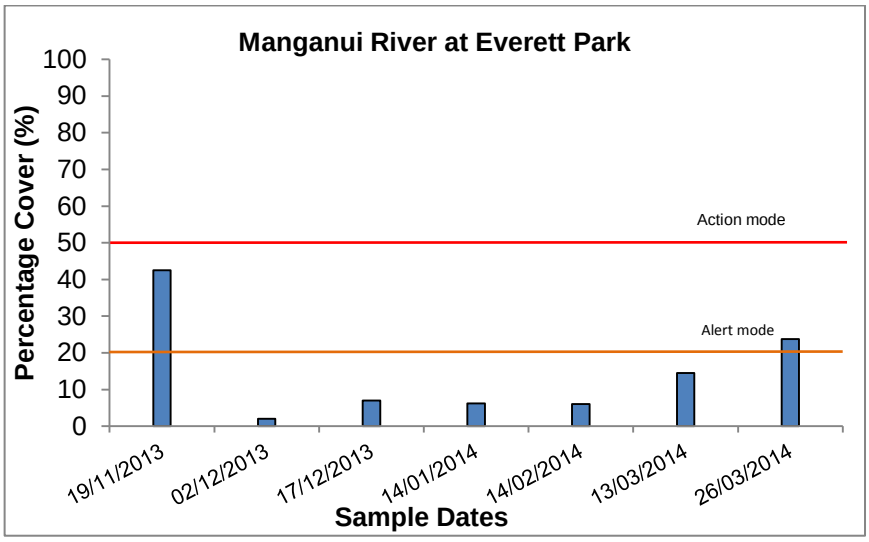


Figure 61 Percentage benthic cyanobacteria cover at the Manganui River, Everett Park site

Benthic cyanobacteria coverage was moderate throughout the season (ranging from 2 to 43%). The benthic cyanobacteria found were all *Phormidium sp.* The 'Alert' level was exceeded on two occasions, in late November 2013 (43%) and late March 2014 (24%). On the November survey occasion, *Phormidium* coverage did not enter the 'Action' mode level and thus no health warnings were required to be put in place. Follow-up surveys within two weeks of both of these 'Action' mode levels, found reduced coverage.

4.2.17 Lake Ratapiko

No bathing usage of the lake was noted on any occasion. Boating and picnicking were recorded on only one occasion. No other activities were recorded at the time of any of the sampling surveys. However, the lake is commonly used for boating and fishing purposes, particularly at weekends and holidays. Ducks were present in relatively low numbers on the lake. No stock access to the lake margins was recorded unlike on some past occasions (TRC, 2013). The lake was drawn down for maintenance purposes toward the end of the season (in mid-March 2014) and as a result sampling was unable to be performed on three occasions.

The data for this site are presented in Table 87 and illustrated in Figure 62 with a statistical summary provided in Table 88.

Table 87 Analytical results for Lake Ratapiko (* lake level lowered for HEP maintenance)

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
05.11.13	0810	7.6	240	<1	250	14.2	1.2
18.11.13	1130	8.0	44	9	44	19.5	1.0
16.12.13	1130	8.1	19	3	20	21.1	1.5
16.01.14	1240	8.1	9	13	9	21.6	1.6
20.01.14	0900	8.2	12	1	13	19.4	1.3
30.01.14	1255	6.9	7	1	7	21.7	1.9
03.02.14	0915	7.5	<1	4	<1	19.9	1.3
17.02.14	0800	8.8	4	93	4	19.8	1.0
20.02.14	0840	7.6	7	<1	8	22.7	1.2
06.03.14	0950	11.7	25	<25	50	15.2	340
21.03.14*	-	-	-	-	-	-	-
31.03.14*		-	-	-	-	-	-
03.04.14*	-	-	-	-	-	-	-

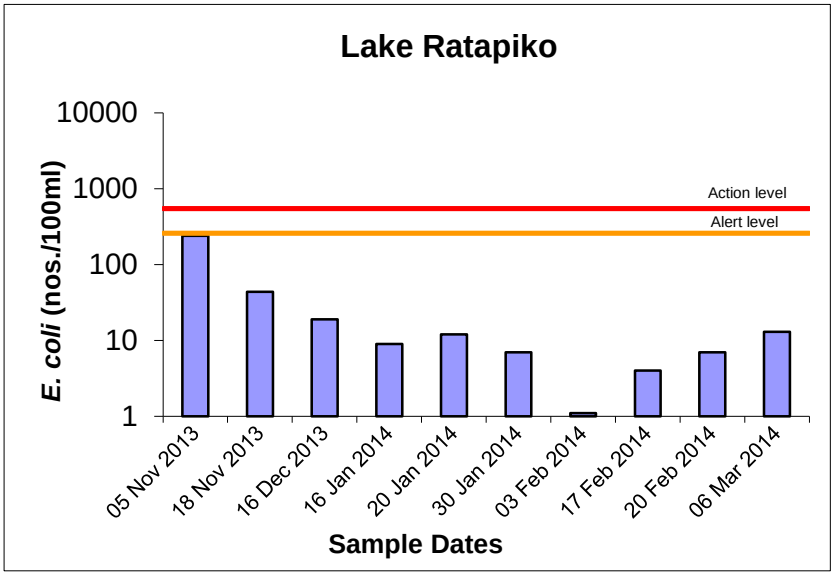


Figure 62 *E. coli* numbers for Lake Ratapiko during the survey season

Table 88 Statistical results summary for Lake Ratapiko

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	10	6.9	11.7	8.0
E. coli	nos/100ml	10	<1	240	10
Enterococci	nos/100ml	10	<1	93	4
Faecal coliforms	nos/100ml	10	<1	250	11
Temperature	°C	10	14.2	22.7	19.8
Turbidity	NTU	10	1.0	340	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: 0.9 NTU) as a result of low suspended algae populations possibly due to short retention times until maintenance began in early March 2014 when turbidity increased markedly. Water temperatures were moderate ranging over 8.5˚C for the period with a moderately high maximum of 22.7˚C (early-morning in mid-February 2014) although all of the measurements were recorded prior to 1300 hrs. Conductivity showed minimal variation (less than 2.0 mS/m) during the period prior to lake maintenance.

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 one count exceeded 44 *E. coli* per 100 mls despite the wet spring period and this count followed within a week of a significant fresh in the Manganui River. No sampling was possible toward the end of the season coincident with the HEP scheme lake lowering for maintenance purposes.

4.2.17.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 89.

Table 89 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 V for all sites. Data from the eight summer surveys for the Lake Ratapiko site are summarised in Table 90 and illustrated in Figure 63.

Table 90 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
Minimum	1	1	5	4	13	1	3	<1
Maximum	86	120	220	91	140	150	240	240
Median	21	16	35	16	25	35	10	10

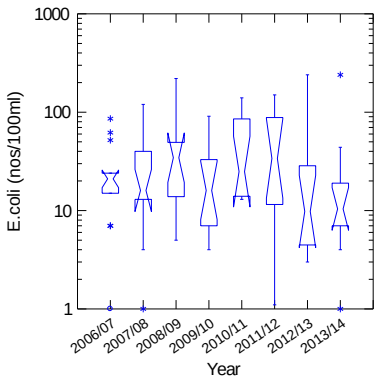


Figure 63 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers at Lake Ratapiko

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 the equal lowest of the eight 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 of samples collected on seven sampling occasions were performed, with the results of these analyses presented in Table 91.

Table 91 Cyanobacteria counts (cells .ml) for Lake Ratapiko [Health warning: >15,000 cells/ml]

Date	Cyanobacteria total cell count (cells/ml)	Principal species
25.11.13	nil	-
10.12.13	nil	-
13.01.14	nil	-
27.01.14	5690	*Anabaena*
10.02.14	300	*Anabaena*
25.02.14	34	*Anabaena*
11.03.14	nil	-

No cyanobacteria were detected in four of the samples. None had been found in this lake during the 2006-2007, 2008-2009, 2009-2010, 2010-2011, 2011-2012, or 2012-2013 seasons, but low numbers of *Anabaena* had been present in the latter part of the 2007-2008 season following a lengthy, extremely low flow period. 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. Levels did not require public health warnings but were notified to the public via the TRC website.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. 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 2013-2014 season, with the lake visited on ten occasions between mid-November 2013 and early April 2014. [Note: bacteriological monitoring is not a component of the SEM programme at this lake].

Usage of the lake included walkers (visitors) and picnicking throughout the season. The boat ramp remained locked through the period until mid-February, 2014 when it was opened following a series of lower cyanobacteria counts. A few pukeko were noted at the lake margin and a few ducks and swans were noted from time to time on the lake which appeared mainly slightly turbid, brownish throughout most of the period.

The bacteriological water quality data for this site are presented in Table 92 with a statistical summary provided in Table 93.

Table 92 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)
12.11.13	1220	11.5	8	8	8	20.1	-
13.12.13	0810	11.5	24	8	24	19.9	13
19.12.13	0740	11.7	17	17	17	20.1	3.3
23.12.13	-	-	-	-	-	-	-
14.01.14	1150	11.7	170	17	170	19.9	2.8
11.02.14	1055	12.0	36	11	36	19.9	1.6
24.02.14	0940	11.9	15	<2	15	21.2	1.8
11.03.14	0935	12.8	7	11	7	19.4	1.3
24.03.14	0830	12.1	29	4	30	18.5	14
03.04.14	1200	12.2	7	<1	7	19.2	1.2

Table 93 Statistical results summary for Lake Rotokare

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	9	11.5	12.8	11.9
E. coli	nos/100ml	9	7	170	17
Enterococci	nos/100ml	9	<1	17	8
Faecal coliforms	nos/100ml	9	7	170	17
Temperature	°C	9	18.5	21.2	19.9
Turbidity	NTU	8	1.2	14	2.3

In general, bacteriological water quality was good, as might be expected for a small, bush clad lake with only small inflows and relatively low wild fowl numbers. Conductivity levels were very stable (range: 1.3 mS/m) through the period despite variations in inflow during the season particularly during spring-early summer wet weather. Water temperatures varied over a very narrow range of 2.7˚C with a

maximum of 21.2˚C recorded in late February 2014. Turbidity was moderate (median: 2.3 NTU) with the range (12.8 NTU) mainly reflecting the variability in abundances of suspended algae in the water column during the season. Maximum turbidity (14 NTU) was coincidental with a late minor peak in cyanobacteria concentration in late March 2014.

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 2013-2014 there appeared to be no such trend.

4.2.18.1 Cyanobacteria

Microscopic scans of ten samples during the recreational monitoring period found a very low cyanobacteria population in mid-November 2013 increasing through the period to mid-December 2013 remaining above the health warning level until mid-February 2014 (with one exception), before decreasing to a moderate concentration in mid February, 2014 where they remained during very dry weather conditions in late summer/autumn through to a relatively low concentration recorded in early April, 2014. However, these elevated concentrations were far lower than maximum numbers found during the 2009-2010 period (by up to 120,000 cells per 1 ml) and during the 2010-2011 period, but higher (by more than 34,000 cells per 1 ml) than the maximum count found during the 2012-2013 period. The results of these analyses are presented in Table 94 and illustrated in Figure 64.

Table 94 Cyanobacteria counts (cells/ml) for Lake Rotokare [Health warning: > 15,000 cells/ml]

Date	Cyanobacteria total cell count (cells/ml)	Principal species
12.11.13	260	*Anabaena*
13.12.13	61,900	*Anabaena*
19.12.13	10,800	*Anabaena*
23.12.13	27,830	*Anabaena*
14.01.14	16,850	*Anabaena*
11.02.14	2,100	*Anabaena*
24.02.14	2,010	*Anabaena*
11.03.14	330	*Anabaena*
24.03.14	4,600	*Anabaena/ Microcystis*
03.04.14	920	*Oscillatoria /Anabaena*

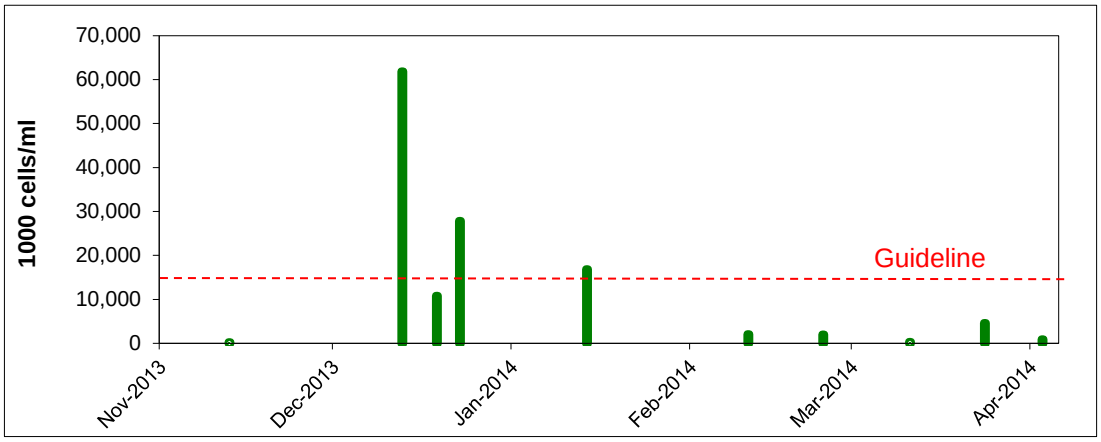


Figure 64 Cyanobacteria counts (cells/ml) at Lake Rotokare [Health warning: >15,000 cells/ml]

A very low count of *Anabaena* found in the lake early in the season in November 2013 did not necessitate installation of a blue-green algal hazard warning sign by the STDC upon advice from the Taranaki Area Health Board until an increased count exceeded the health guideline [15,000 cells/ml] in mid-November 2013 and therefore there was a requirement for STDC to erect signage at the lake and road access (see Appendix VII), and the boatramp remained closed. *Anabaena* concentrations remained high through summer peaking at about 62,000 cells/ml in mid-December 2013 before decreasing briefly then rising and remaining above the health guideline through January 2014. By mid-February 2014 counts had dropped at which time the boatramp was re-opened for recreational usage of the lake, which remained the case through to the end of the season despite a small increase (mainly *Anabaena*) in population coincident with a very dry late summer-autumn period. These numbers however, did not exceed the health guideline and decreased in early April 2014. There was no 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* were found late in the 2013-2014 period. 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 December to February. No primary contact recreational usage of the lake was recorded at the time of sampling surveys after recreational use of the lake was possible with the boat ramp unlocked later in summer.

5. General data summary

A comparative summary of results of the eighteenth summer bacteriological quality freshwater survey involving seventeen contact recreational sites in the Taranaki region is provided in Table 95. Results are also illustrated in Figure 65 for each of the bacteriological species and a comparison of all sites' summer data is presented in Appendix V in the form of statistical 'box and whisker' plots.

Table 95 Statistical summary of results for the sites sampled in the SEM freshwater contact recreational water quality survey, 2013-2014

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	21.4	13.4	62	60	16	4.9
	Minimum	18.9	12.5	8	8	5	3.3
	Maximum	26.3	15.0	120	120	270	13
	No. of samples	12	13	13	13	13	13
Waiwhakaiho River at Merrilands Domain	Median	18.2	12.7	54	51	19	0.7
	Minimum	13.8	10.7	3	3	3	0.4
	Maximum	24.2	14.8	220	200	110	1.2
	No. of samples	12	13	13	13	13	13
Waiwhakaiho River adjacent to L. Rotomanu	Median	19.2	13.1	700	650	830	0.8
	Minimum	14.7	10.4	280	210	140	0.5
	Maximum	26.4	482	2400	2200	2400	1.6
	No. of samples	12	13	13	13	13	13
Te Henui Stream at mouth, East End	Median	17.1	516	1000	1000	900	1.0
	Minimum	14.1	10.6	250	250	28	0.5
	Maximum	22.2	1990	8000	7900	4600	2.7
	No. of samples	12	13	13	13	13	13
Patea River at King Edward Park, Stratford	Median	13.7	9.2	260	240	120	0.7
	Minimum	12.0	8.4	62	62	9	0.5
	Maximum	16.4	11.2	580	550	560	5.8
	No. of samples	13	13	13	13	13	13
Patea River at boatramp, Patea	Median	18.4	4700	3	3	<1	18
	Minimum	15.7	3550	<1	<1	<1	5.7
	Maximum	19.6	4720	21	20	11	35
	No. of samples	13	13	13	13	13	13
Waingongoro River at Eltham camp	Median	14.9	11.4	240	240	57	1.4
	Minimum	12.3	10.8	54	48	12	1.0
	Maximum	18.1	12.8	400	380	370	2.6
	No. of samples	13	13	13	13	13	13
Waingongoro River at Ohawe Beach	Median	17.5	17.0	140	120	85	1.7
	Minimum	15.3	14.9	42	34	36	1.2
	Maximum	22.1	20.7	370	370	460	3.1
	No. of samples	13	13	13	13	13	13
Kaupokonui River at beach domain	Median	18.2	16.5	120	110	88	1.4
	Minimum	16.1	14.3	11	11	9	0.9
	Maximum	23.4	18.3	300	270	290	2.2
	No. of samples	13	13	13	13	13	13
Lake Opunake adjacent to boat ramp	Median	20.8	14.1	120	100	520	1.0
	Minimum	16.3	12.9	<8	<8	92	0.9
	Maximum	23.5	16.4	430	430	2400	3.0
	No. of samples	13	13	13	13	13	13
Timaru Stream at Weld Road (near mouth)	Median	16.8	40	210	200	220	0.6
	Minimum	15.7	12.7	54	54	71	0.4
	Maximum	23.4	343	660	660	540	2.5
	No. of samples	12	13	13	13	13	13
Waimoku Stream at Oakura beach	Median	15.4	14.8	1600	1600	1000	1.5
	Minimum	13.5	14.4	450	430	120	1.2
	Maximum	18.0	16.1	3400	3300	2900	3.4
	No. of samples	12	13	13	13	13	13
Oakura River d/s of SH45 bridge	Median	16.8	37	86	86	110	0.5
	Minimum	14.3	7.9	28	16	19	0.3
	Maximum	22.4	198	220	220	550	1.4
	No. of samples	12	13	13	13	13	13
Waitara River at town wharf,Waitara	Median	19.0	1380	100	100	23	2.5
	Minimum	15.1	318	13	13	5	1.7
	Maximum	23.6	8190	310	290	110	16
	No. of samples	13	13	13	13	13	13
Urenui River at estuary	Median	18.8	4700	8	8	3	15
	Minimum	17.1	4450	<1	<1	<1	6.2
	Maximum	21.8	4760	140	140	51	56
	No. of samples	13	13	13	13	13	13
Manganui River d.s of Kurapete S. (Everett Park)	Median	16.7	9.9	140	140	100	0.7
	Minimum	13.2	9.4	63	63	40	0.5
	Maximum	20.4	10.3	500	330	380	2.2
	No. of samples	13	13	13	13	13	13
Lake Ratapiko at boat ramp	Median	19.8	8.0	11	10	4	1.3
	Minimum	14.2	6.9	<1	<1	<1	1.0
	Maximum	22.7	11.7	250	240	93	340
	No. of samples	10	10	10	10	10	10

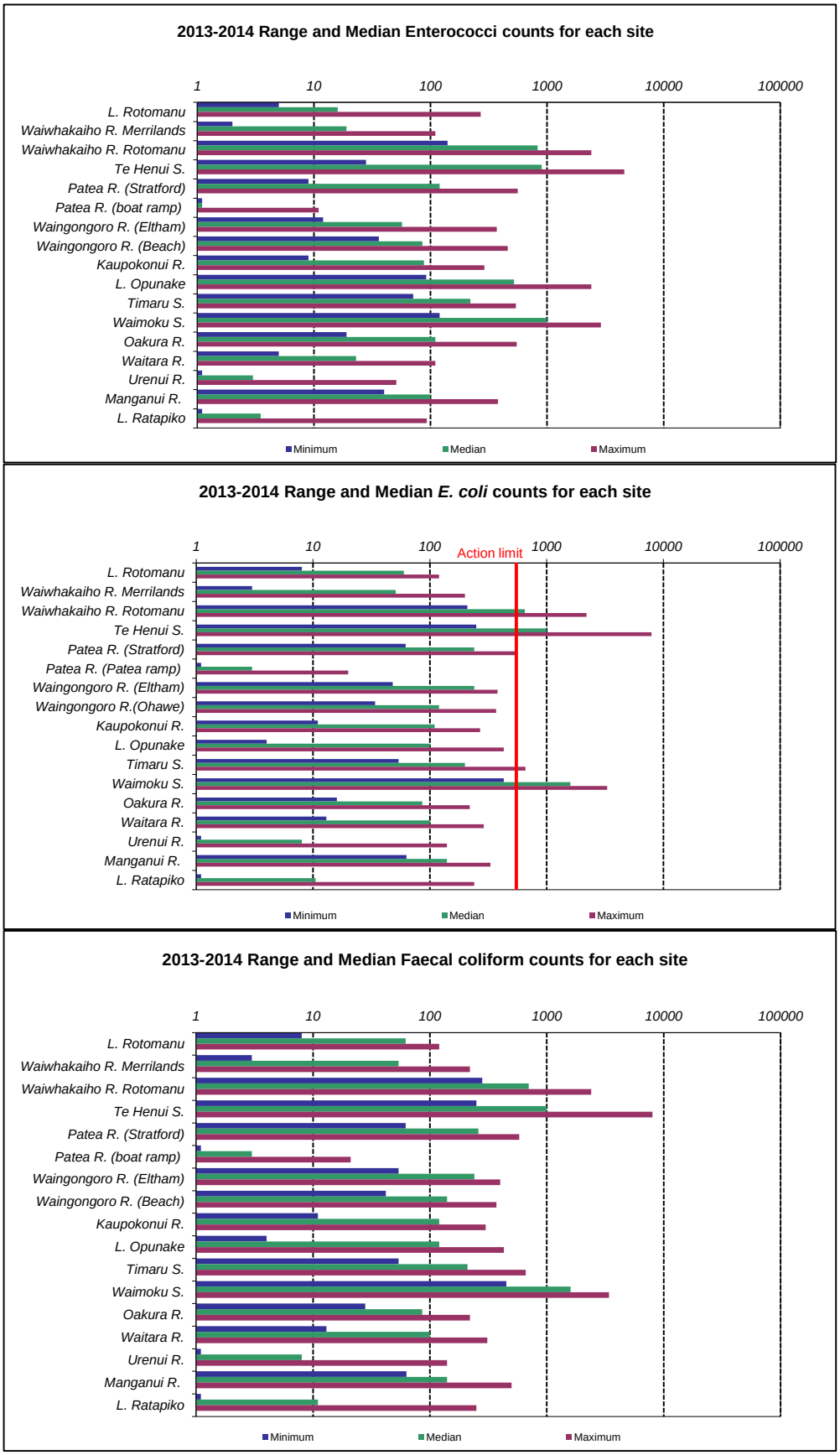


Figure 65 Ranges and medians of bacteria numbers recorded from all sites by the SEM programme over the 2013-2014 survey season

Non-exceedance of the 2003 guidelines has varied amongst the seventeen freshwater contact recreational sites sampled during the survey period (Figure 65 and Table 96) but not to the same degree as recorded in many of the previous seasons. In relation to the guidelines, three sites (Waiwhakaiho River at Lake Rotomanu, Te Henui Stream at East End beach, and Waimoku Stream at Oakura beach) regularly failed to meet the *E. coli* 'Action' guideline suitable for contact recreation. In terms of median *E. coli* counts, these were also the only three 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 'Alert' mode.

Table 96 Number of occasions single sample *E.coli* counts entered the 'Alert' and 'Action' modes and percentage [%] of samples which fell below these modes (ie met the guidelines).

Site	'Alert' mode		'Action' mode	
Lake Rotomanu at western beach	0	[100]	0	[100]
Waiwhakaiho River at Merrilands Domain	0	[100]	0	[100]
Waiwhakaiho River adjacent to L Rotomanu	5	[8]	7	[46]
Te Henui Stream at mouth, East End	1	[8]	11	[15]
Patea River at King Edward Park, Stratford	3	[77]	0	[100]
Patea River at boatramp, Patea	0	[100]	0	[100]
Waingongoro River at Eltham Camp	4	[69]	0	[100]
Waingongoro River at Ohawe Beach	1	[92]	0	[100]
Kaupokonui River at beach domain	1	[92]	0	[100]
Lake Opunake at boat ramp	3	[77]	0	[100]
Timaru Stream at Weld Road	2	[77]	1	[92]
Waimoku Stream at Oakura beach	2	[0]	11	[15]
Oakura River at SH45	0	[100]	0	[100]
Waitara River at town wharf, Waitara	3	[77]	0	[100]
Urenui River at estuary*	0	[100]	0	[100]
Manganui River at Everett Park	1	[92]	0	[100]
Lake Ratapiko at boat ramp[1]	0	[100]	0	[100]

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

Six sites maintained counts below the 'Alert' mode at all times throughout the season (compared with three sites over the 2012-2013 season), while an additional seven other sites maintained counts below the 'Action' mode (Tables 96 and 97) at all times. In terms of the overall monitoring season, twenty-six 'Alert' levels (12% of counts) and thirty 'Action' levels (14% of counts) resulted over the period representing an overall 74% achievement of contact recreational guidelines (compared with 68%, 76%, 78%, and 72% achievement in the 2009-2010, 2010-2011, 2011-2012, and 2012-2013 seasons respectively). Of these 26% guidelines exceedances, 17% occurred at three sites.

Overall, a wide range from poor to very good bacteriological water quality was measured at the seventeen sites. In terms of results to date, this represented some improvement 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 ≤ 10 *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 Patea River at boatramp, Patea
2 Urenui River at estuary
3 Lake Ratapiko
4 Waiwhakaiho River at Merrilands Domain
5 Lake Rotomanu
6 Oakura River d/s of SH 45 bridge
7= Lake Opunake at boat ramp
7= Waitara River at town wharf, Waitara
9 Kaupokonui River at beach domain
10 Waingongoro River at Ohawe Beach
11 Manganui River at Everett park (d/s of Kurapete Stream)
12 Timaru Stream at Weld Road (near mouth)
13= Waingongoro River at Eltham camp
13= Patea River at King Edward Park, Stratford
15 Waiwhakaiho River adjacent to Lake Rotomanu
16 Te Henui Stream at mouth, East End
17 Waimoku Stream at Oakura beach

The biggest improvement in ranking, in comparison with the 2012-2013 season, occurred at the Oakura River at SH 45 site (where there was an almost 40% improvement in median count between the last two seasons) while the three lowest rankings remained at the two sites which were lowest for the 2011-2012 and 2012-2013 seasons together with the Waimoku Stream site which has frequently ranked poorest to date. The Waingongoro River at Ohawe Beach site slipped furthest down in the rankings (where it was ranked tenth) in terms of seasonal median bacteriological water quality, although there was only a 9% increase in the median *E.coli* count between consecutive seasons (an increase of 10 *E.coli*/100 mls). [It should also be noted that this same site is showing a strong trend of improving quality across all data].More sites' median counts decreased (9 sites) than increased reflecting some overall improvement in bacteriological water quality across the region's sites in 2013 –2014, and this also was reflected in part by a slightly higher proportion of samples (2%) meeting the national guidelines in the current season.

5.1 Comparison with seventeen 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 slightly narrower than those recorded over most previous summer bathing seasons due to an absence of very high counts at all but three sites. There was marked deterioration at two sites and improvement at four 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 97.

Noting that there are some changes 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 eighteen 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 (2012-2013) was equivalent with the historical average and the latest season showed a 2% improvement over the last season. Note that in any comparison between seasons, changes in monitored sites should be taken into account.

A ranking of sites based upon the historical average guidelines non-exceedances 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
6= Waingongoro River at Ohawe Beach
6= Lake Rotomanu
8 Manganui River at Everett Park
9 Kaupokonui River at beach domain
10 Waingongoro River at Eltham Camp
11 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 Waimoku Stream at Oakura Beach
17 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 and Waimoku Streams' mouths where resident wildfowl population have been the principal contributors to elevated *E.coli* counts. This has also been the case for the Waiwhakaiho River adjacent to Lake Rotomanu, the third worst site.

Table 97 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		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	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	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	6	2.5	4.5
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	<0.5	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	3.5	1.5
Patea River at boatramp, Patea	*		*		*		*		*		*		*		*		*		*		*		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	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	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	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	9.5	2	1.5
Timaru Stream at Weld Road	*		7	0	1	1	2	2	3	0	2	1	4	2	4	0	3	3	4	0	2	0	2	3	4	0	6	1	4	0	3	0	4	0	2	1	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	11	1.5	0.5
Waitara River at town wharf, Waitara	*		*		*		*		*		*		*		*		*		*		*		*		*		2	3	1	1	2	0	3	1	3	0	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	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	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	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	2.0	2.3	-		
% overall non-exceedance of 2003 guidelines	82		63		80		82		80		71		67		74		61		71		71		70		67		68		77		78		72		74		72		

Temporal trending of season's median *E.coli* counts at each of the thirteen sites with a minimum of ten years' data, was undertaken statistically for the period 1996 to 2014. Two sites have shown statistically significant ($p < 0.01$ after FDR application) trends in median *E.coli*. counts.

- Waiwhakaiho River opposite Lake Rotomanu had a very strong trend of increasing median *E.coli* numbers over the shorter, 11 year period to date which was significant at $p < 0.01$ after FDR application
- The Waimoku Stream at Oakura beach had a very strong trend of increasing median *E.coli* numbers over the period which was significant at $p<0.01$ after FDR application

Three 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 12 year period which however, was significant at $p < 0.05$ but not after FDR application
- Oakura River below the SH45 bridge had a strong trend of increasing median *E.coli* numbers over the eighteen year period to date which however, was not significant at $p< 0.05$ after FDR application.
- Waingongoro River at Ohawe Beach had a strong trend of decreasing median *E. coli* numbers over the eighteen year period to date which was significant at $p<0.05$ but not after FDR application.

The Oakura River and Waingongoro River site's seasonal median *E.coli* counts have not approached contact recreational 'Alert' (or 'Action') guidelines at any time over the entire eighteen year period. A ranking of the order of the significance of the temporal trends at those sites with a minimum of ten seasons' data (thirteen sites) is provided in Table 98.

Table 98 Ranking of sites in terms of significant temporal trends in median *E.coli* counts over the period 1996 to 2014 [significant at $p< 0.05$ and $p<0.01$] (NB: * = enterococci)

Site location	Valid N	p-level	FDR-corrected p value	Trend
Waimoku Stream at Ohawe beach	13	0.0003	0.0032	↑↑↑
Waiwhakaiho River at Lake Rotomanu	11	0.0005	0.0032	↑↑↑
Oakura River d/s SH45 bridge	18	0.0255	0.0945	↑↑
Te Henui Stream mouth, East End	12	0.0324	0.0945	↑↑
Waingongoro River at Ohawe Beach	18	0.0337	0.0945	↓↓
Urenui River at estuary*	18	0.0793	0.1850	↓
Lake Rotomanu western beach	18	0.1370	0.2740	↑
Patea River at King Edward Park	13	0.3869	0.6770	↓
Kaupokonui River at Beach Domain	18	0.6982	0.9618	↓
Manganui River at Everett Park	18	0.6982	0.9618	↓
Waingongoro River at Eltham camp	13	0.7557	0.9618	↑
Timaru Stream at end of Weld Road	17	0.8641	1.0000	↓
Waiwhakaiho River at Merrilands Domain	18	1.0000	1.0000	=

In summary, two sites have 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 (six sites) or deterioration (four sites) in seasonal median *E. coli* counts and one site with no trend.

With the exception of two seasonal median counts at the Timaru Stream site and one at the Kaupokonui River 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. 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 2013-2014 survey period and all instances of exceedance of standards were advised to the appropriate authorities. Very few follow-up investigations were necessary over the 2013-2014 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, mainly at lakes and in the lower reaches of two city and one township 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 very few 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. Cyanobacteria monitoring will also continue at designated 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 five designated lake monitoring sites, only Lake Rotokare numbers exceeded public health warning levels for a period during the 2013-2014 season. Benthic cyanobacteria coverage was sporadic at the nine river/stream sites and, although necessitating follow-up surveys on a few occasions at two sites, did not exceed public health warning levels.

The Suitability for Recreation Grading (SFRG) referenced earlier in this report (Section 2.2) may now be re-assessed to include the 2013-2014 microbiological data enabling a comparison of the five year 2008-2013 period (Table 1) with the latest SFRG for the 2009-2014 period (presented in Table 99).

Table 99 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

Very few differences between the two five-year periods were apparent when comparing Table 1 and Table 99. There were no changes in gradings at any sites although the Lake Rotomanu site improved in terms of the 95 percentile *E.coli* number (which had decreased more recently by 1722 per 100 mls), the Waitara River site (improvement by 396 *E.coli* per 100 mls), and the Lake Opunake site (improvement by 790 *E.coli* per 100 mls). There were fewer samples in excess of the 'Action' level over the most recent five year period at eight of the monitored sites while only two sites (Timaru Stream and Waiwhakaiho River adjacent to Lake Rotomanu) had more samples (2% and 4% respectively) in the 'Action' mode. Otherwise there were no changes in MAC or SFR grades.

6. Recommendations

As a result of the 2013-2014 summer freshwater contact recreation bacteriological survey it is recommended:

1. THAT the 2014-2015 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 2014-2015 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 2014-2015 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 reporting of results be performed as appropriate during the season, and in an Annual Report upon completion of the season's programme.

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

7. Acknowledgements

The programme's Job Manager was Chris Fowles (Scientific Officer) who was the author of this Annual Report. Statistical analyses were provided by Fiza Hafiz (Scientific Officer). Co-ordination of the sectional programmes and liaison with the Taranaki Area Health Board was provided by James Kitto (Scientific Officer). Field work was undertaken primarily by Emily Roberts, Scott Cowperthwaite (Scientific Officers) and Ray Harris, Kate Shaskey, Rachel McDonnell and Abbie Bates (Technical Officers) and students (during the summer vacation). Hydrological data was provided by Fiona Jansma (Scientific Officer). All water quality analytical work was performed by the Taranaki Regional Council ISO-9000 accredited laboratory under the supervision of John Williams (Laboratory Manager).

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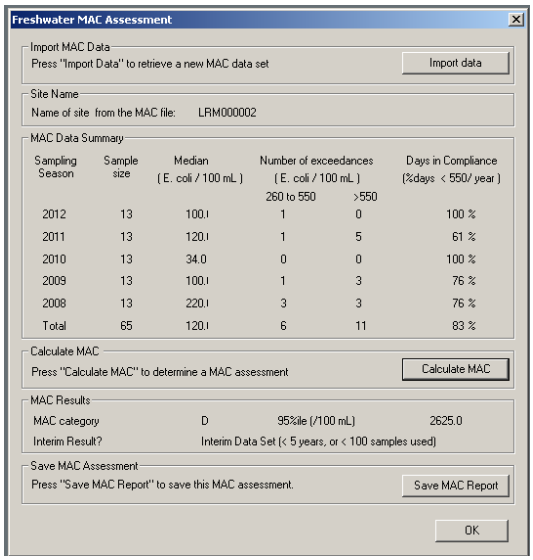
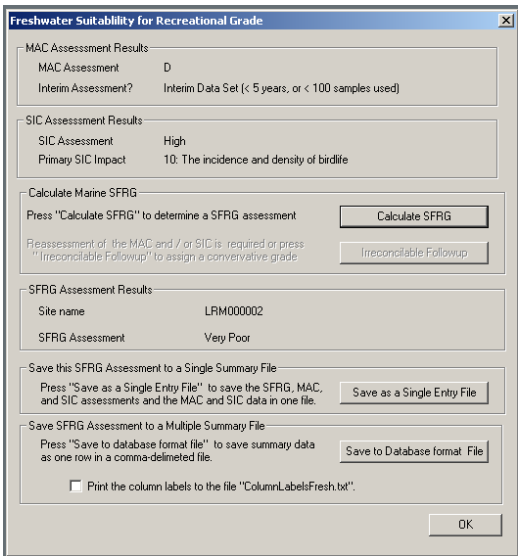
Appendix I

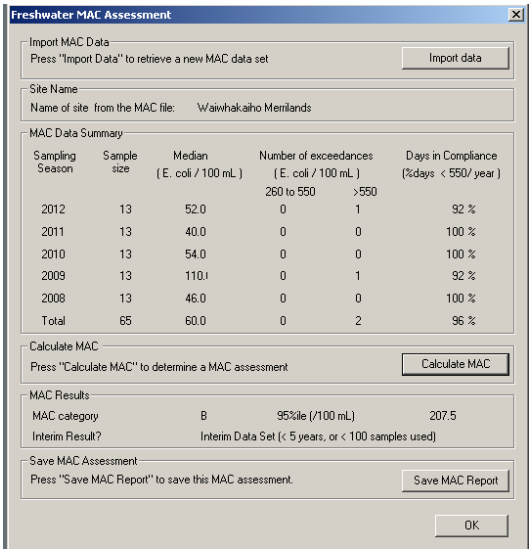
MAC assessments for all sites (for the 2008-2013 period)

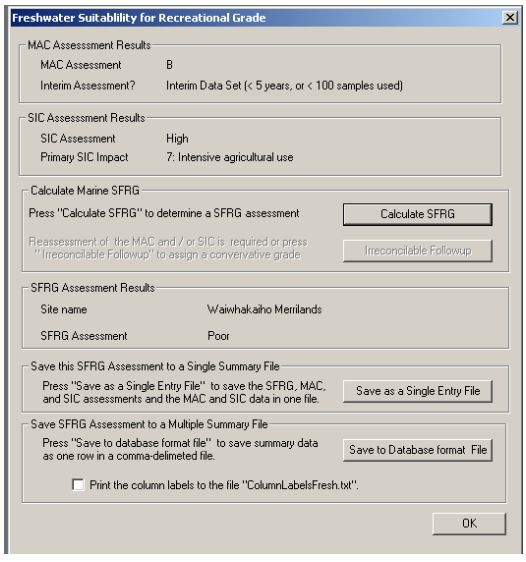
Lake Rotomanu





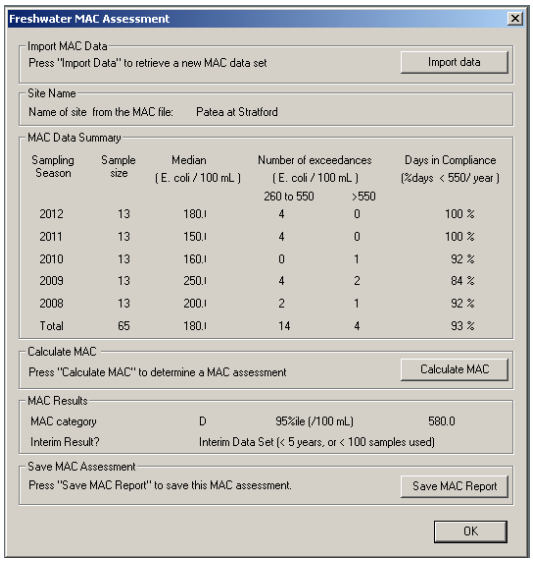
Waiwhakaiho River at Merrilands Domain

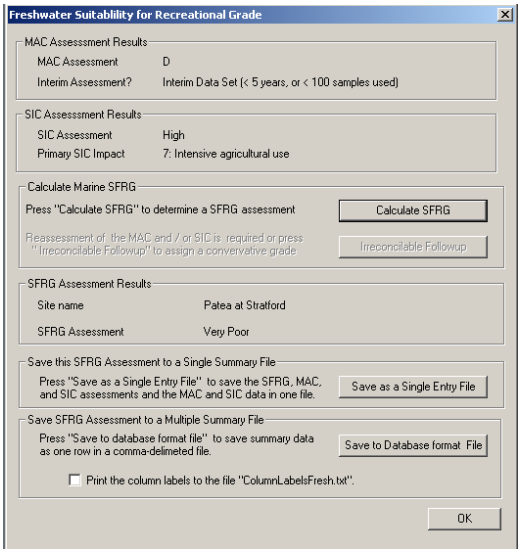




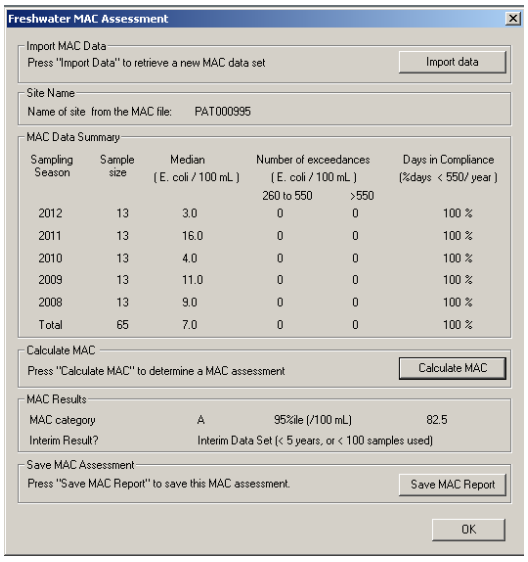
Waiwhakaiho was Follow up, irreconcilable Follow-up and SFRG Assessment resulted in Poor.

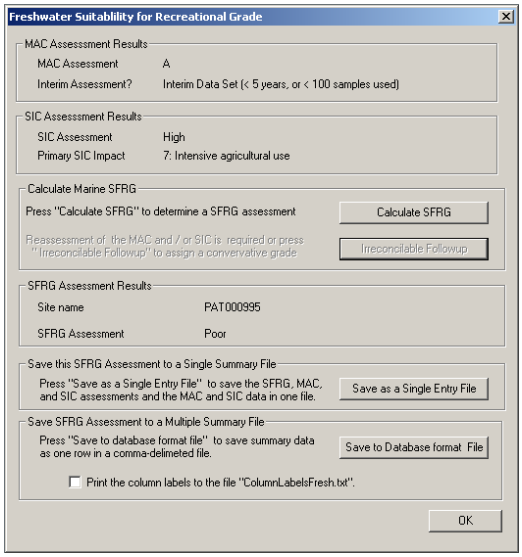
Patea River at Stratford



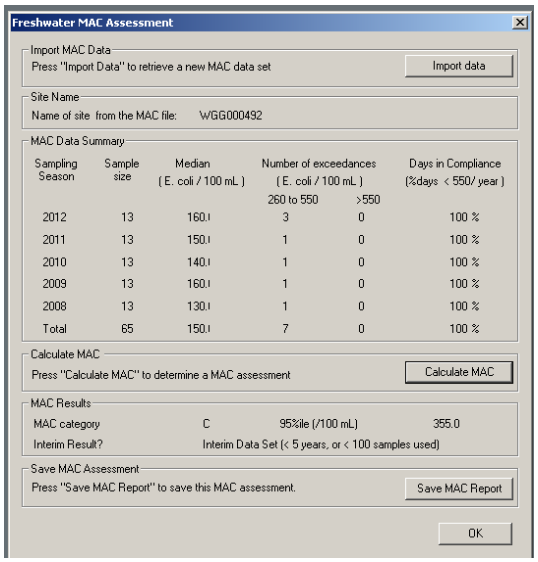


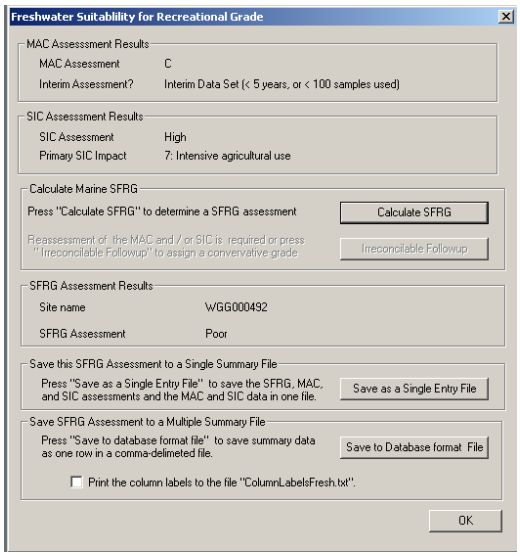
Patea River at boat ramp, Patea



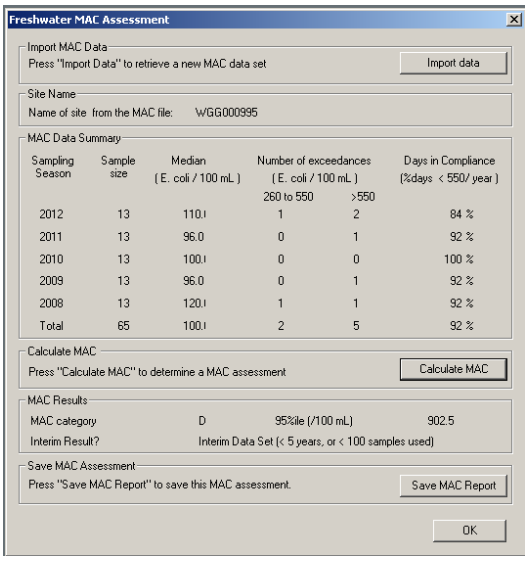


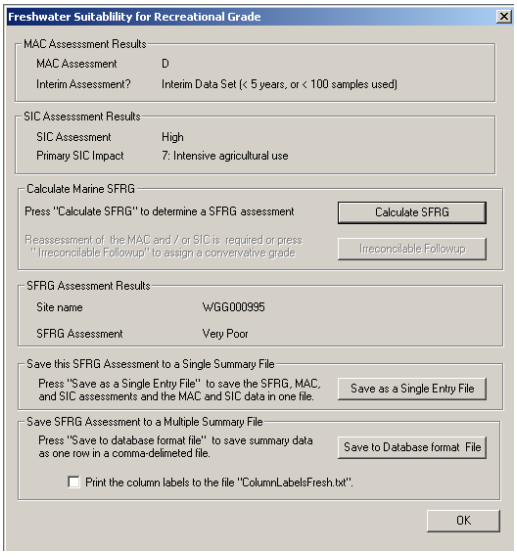
Waingongoro River at Eltham camp



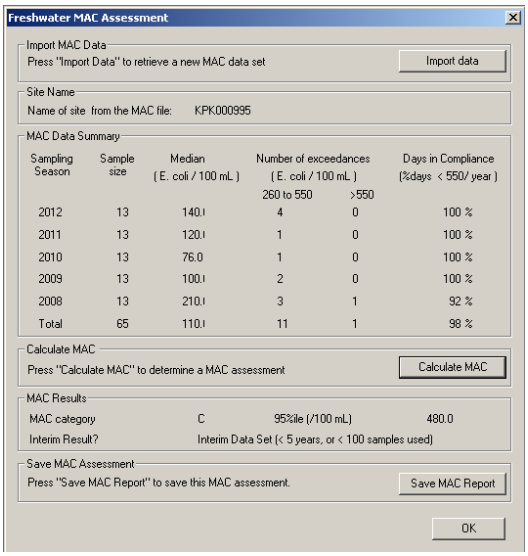


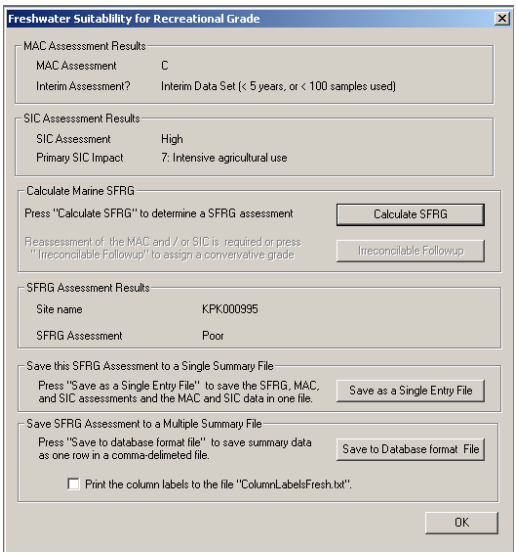
Waingongoro River at Ohawe beach



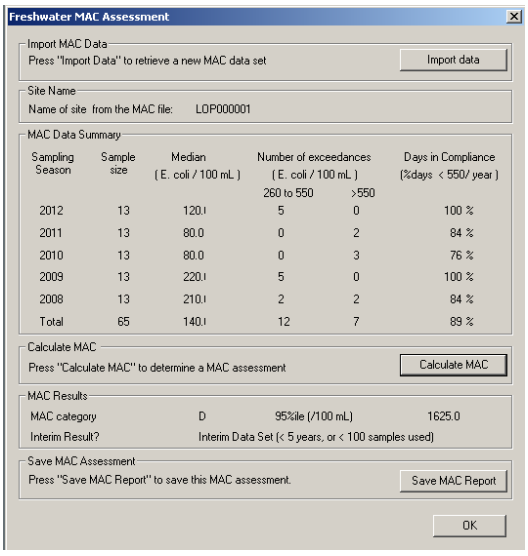


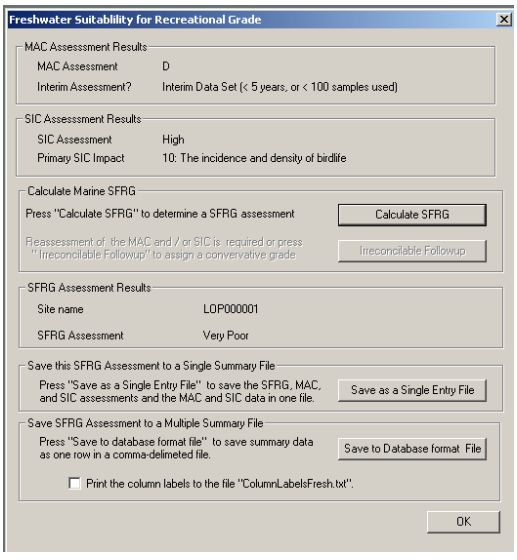
Kaupokonui River at beach domain



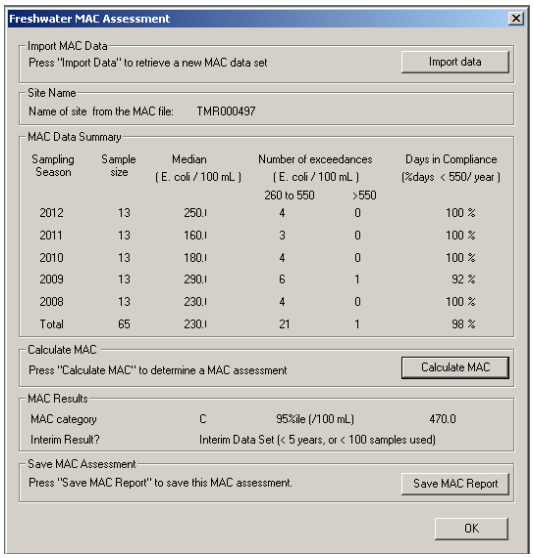


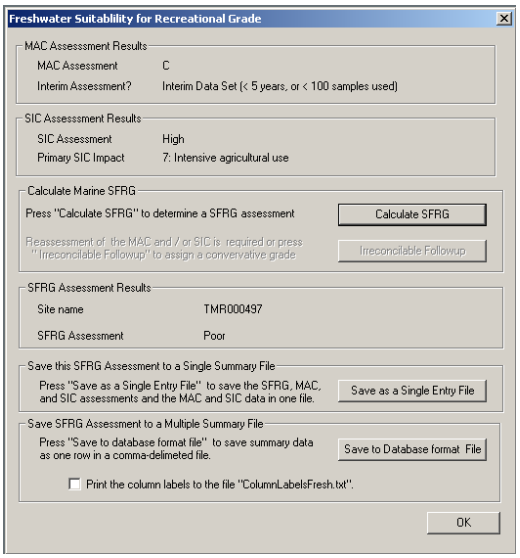
Lake Opunake



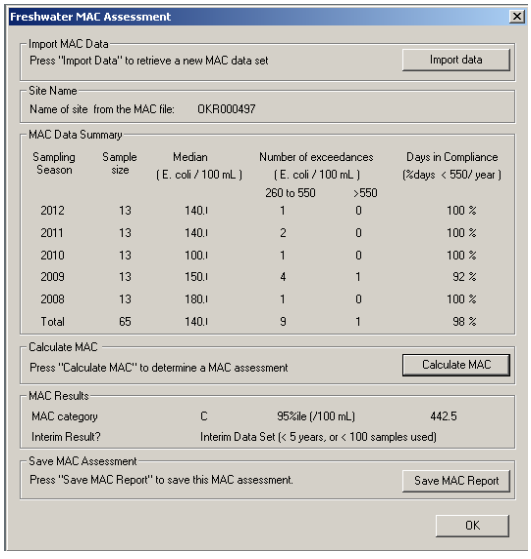


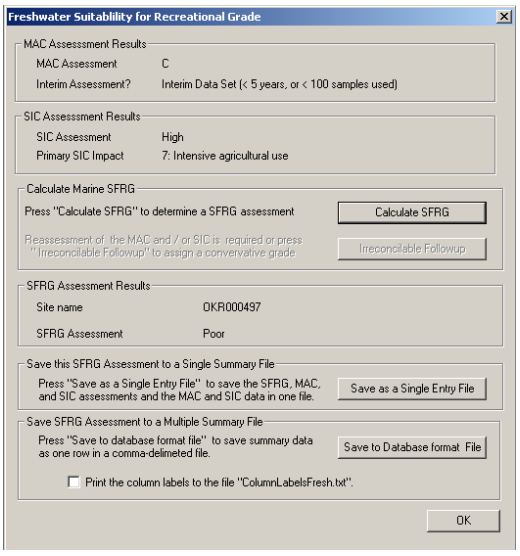
Timaru Stream at Weld Road



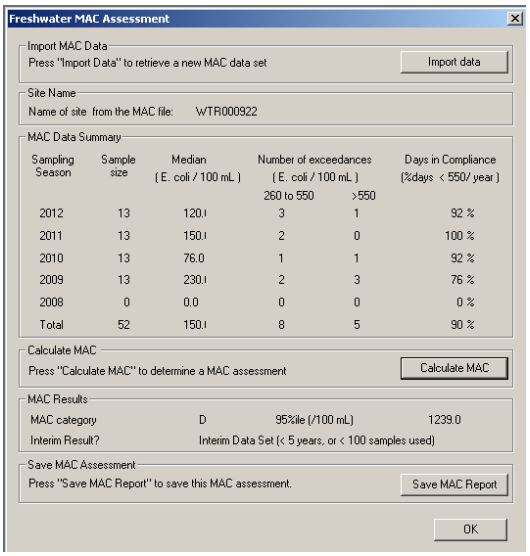


Oakura River d/s SH45

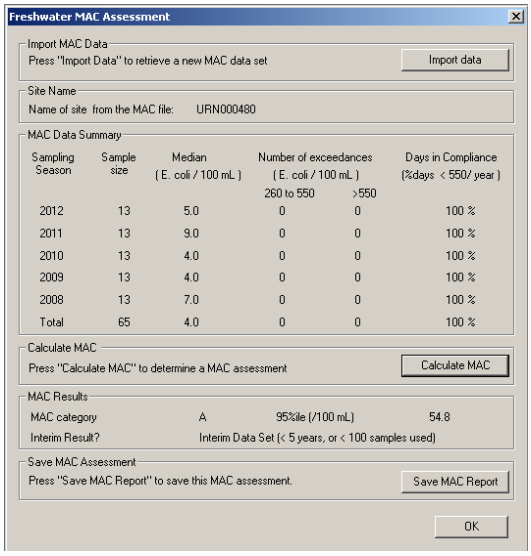


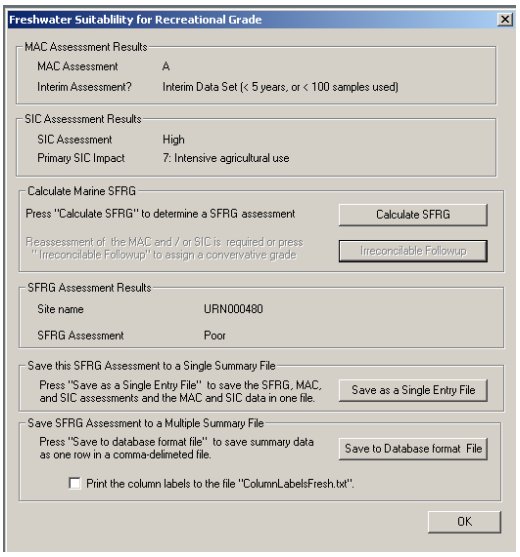


Waitara

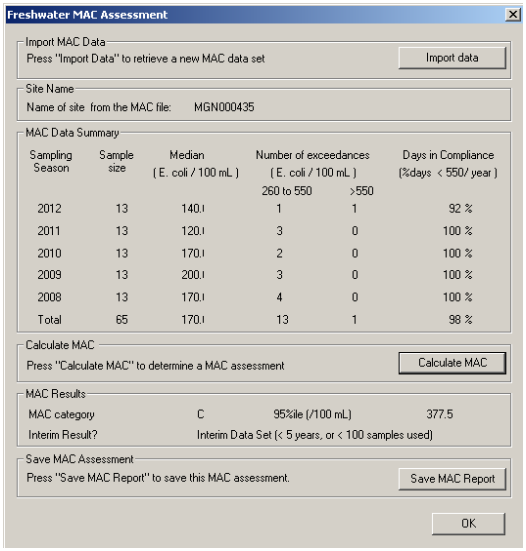


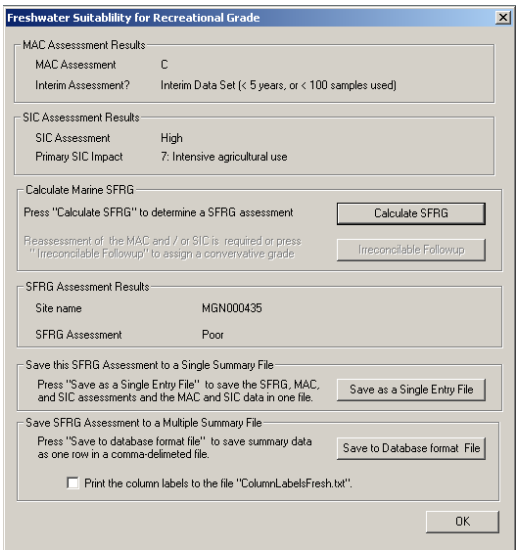
Urenui River at estuary



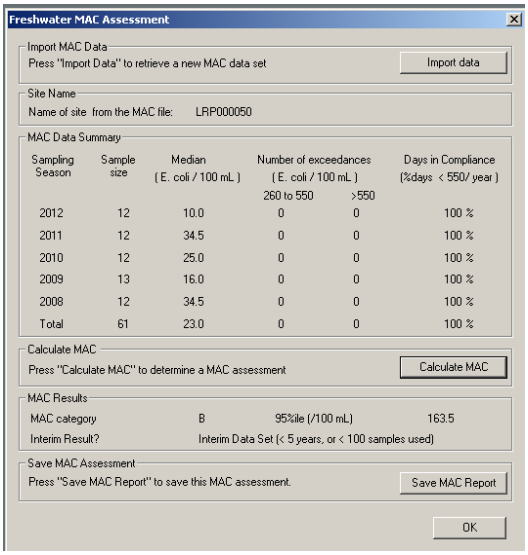


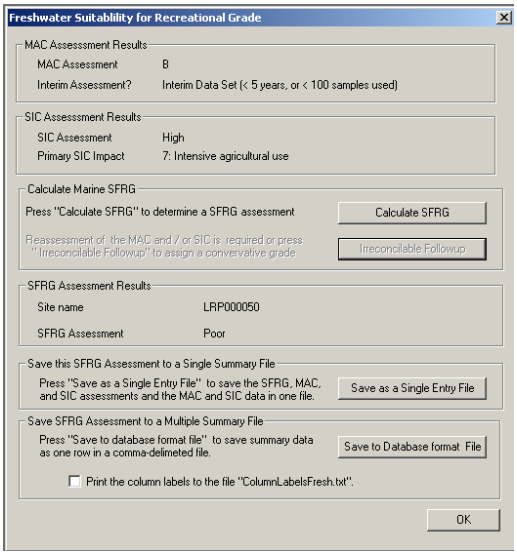
Manganui River at Everett Park



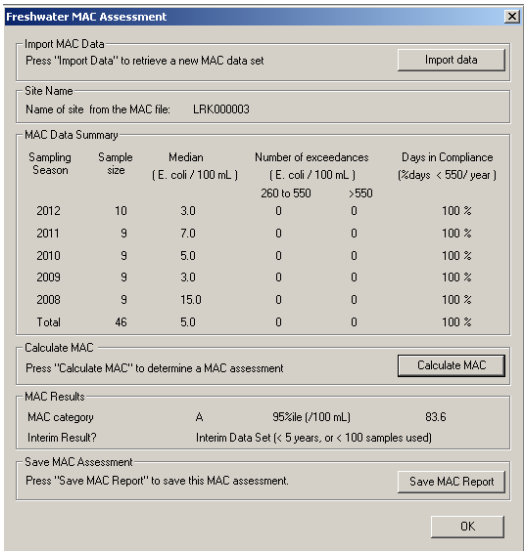


Lake Ratapiko

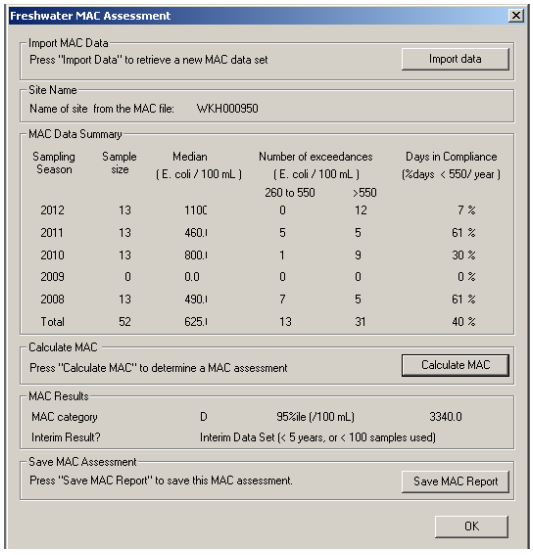


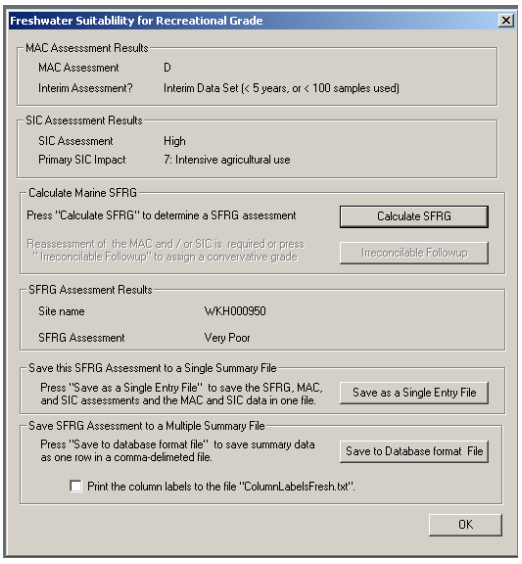


Lake Rotokare

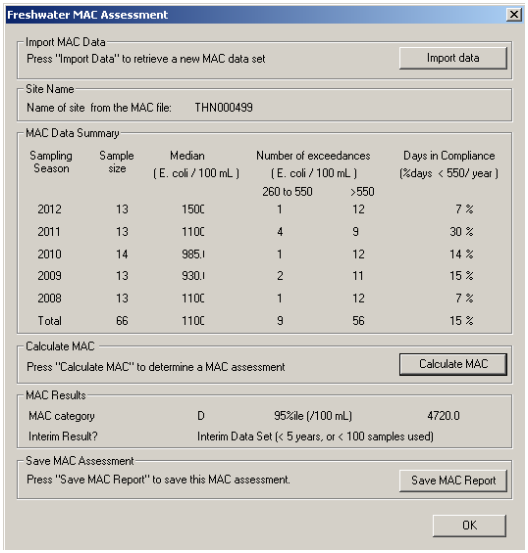


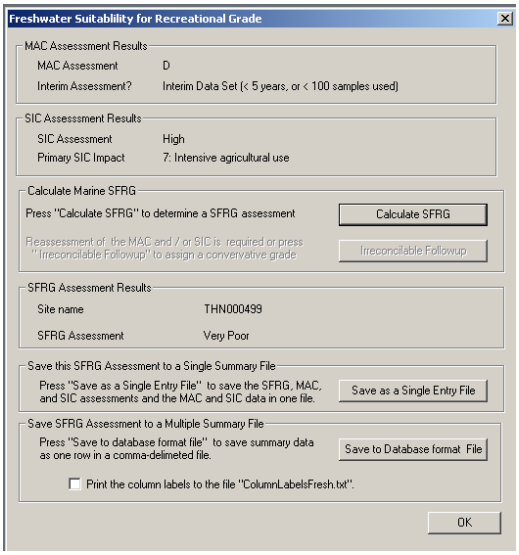
Waiwhakaiho at Lake Rotomanu





Te Henui Stream: mouth





Appendix II

High tide times

High tide times (NZST) at New Plymouth for 2013-2014 sampling dates

Date		HT (NZST)
Tuesday	5 November 2013	1033
Monday	18 November 2013	0958
Monday	16 December 2013	0902
Thursday	16 January 2014	0958
Monday	20 January 2014	1209
Thursday	30 January 2014	0903
Monday	3 February 2014	1213
Monday	17 February 2014	1111
Thursday	20 February 2014	1255
Thursday	6 March 2014	1315
Friday	21 March 2014	1234
Monday	31 March 2014	0959
Thursday	3 April 2014	1204

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
5 November 2013	Fine	6/8	None	Slightly turbid, brown	Ripple	0/2 (walking)	Few ducks	0.5	3
18 November 2013	Fine	3/8	None	Slightly turbid, brown	Slight ripple	0/3 (waterskiing)	Few ducks	0	5
16 December 2013	Fine	1/8	None	Turbid, brown	Ripple	0/17 (banks/boating)	Few ducks	0	0.5
16 January 2014	Fine, overcast	8/8	None	Clear, brown	Slight ripple	0/0	Signs present; ducks common	0	0.5
20 January 2014	Fine, overcast	8/8	None	Turbid, brown	Ripple	0/4 (banks/ jetskiing)	Few ducks; signage present	0	0
30 January 2014	Fine	1/8	None	Clear, brown	Ripple	0/9 (banks/waterskiing)	No ducks	0	0
3 February 2014	Fine	0/8	None	Clear, brown	Ripple	0/1 (boating)	No ducks; signage present	0	0
17 February 2014	Fine	0/8	None	Clear, brown	Ripple	0/12 (bank/boating)	Few gulls	0	0.5
20 February 2014	Fine	0/8	None	Slightly turbid, brown	Ripple	0/5 (bank)	Few ducks; signage present	0	0
6 March 2014	Fine	0/8	N/A	Turbid, brown	Ripple	0/2 (bank)	Few ducks; signage present	0	0.5
21 march 2014	Fine	0/8	N/A	Turbid, brown	Choppy	0/0	No wildlife	0	0
31 March 2014	Fine	1/8	N/A	Slightly turbid, brown	Ripple	0/2 (bank)	Few ducks; one dog	0	0
3 April 2014	Fine	0/8	None	Slightly turbid, brown	Ripple	0/2 (boating)	Few ducks	0	0

Site Waiwhakaiho River at Merrilands (Site Code: WKH000800)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine	6/8	None	Clear, pale green	D/S	0/0	No birdlife	0.5	3
18 November 2013	Fine	5/8	None	Clear, brown	D/S	0/2 (bank)	Some foam and floating algae	0	5
16 December 2013	Fine	2/8	50% mats	Clear, pale brown	D/S	0/0	No birdlife	0	0.5
16 January 2014	Fine, overcast	8/8	60% mats	Clear, brown	D/S	0/0	Signage present; no birdlife	0	0.5
20 January 2014	Fine, overcast	8/8	80% mats	Clear, green-brown	D/S	0/0	One gull	0	0
30 January 2014	Fine	0/8	90% mats	Clear, green-brown	D/S	0/0	Signage present, no birdlife	0	0
3 February 2014	Fine	0/8	70% mats	Clear, colourless	D/S	0/0	No birdlife; signage present	0	0
17 February 2014	Fine	0/8	80% mats	Clear, brown	D/S	0/2 (banks)	One dog; signage present	0	0.5
20 February 2014	Fine	0/8	80% mats	Clear, brown	D/S	0/5 (banks)	No birdlife; one dog; signage present	0	0
6 March 2014	Fine	0/8	85% mats and filaments	Clear, green-brown	D/S	0/1 (bank)	One dog in river	0	0.5
21 March 2014	Fine	0/8	80% mats	Slightly turbid, brown	D/S	0/0	Signage present, no birdlife	0	0
31 March 2014	Fine	1/8	80% mats	Clear, brown	D/S	0/0	No birdlife	0	0
3 April 2014	Fine	0/8	80% mats	Clear, brown	D/S	0/0	No birdlife; signage present	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
5 November 2013	Fine	3/8	None	Clear, colourless	D/S	0/5 (whitebaiting)	No birdlife	0.5	3
18 November 2013	Fine	3/8	10% mats	Clear, brown	D/S	0/0	No birdlife; some floating algae	0	5
16 December 2013	Fine	0/8	70% mats	Clear, colourless	D/S	0/0	Bird colony u/s	0	0.5
16 January 2014	Fine, overcast	8/8	5% mats	Clear, brown	D/S	0/0	Smaller signage; gulls u/s	0	0.5
20 January 2014	Fine, overcast	8/8	None	Clear, colourless	D/S	0/0	Gulls extremely common u/s	0	0
30 January 2014	Fine	0/8	10% mats	Clear, colourless	D/S	0/0	No birdlife	0	0
3 February 2014	Fine	0/8	80% mats	Clear, colourless	D/S	2/0	Gulls common u/s; two dogs in river	0	0
17 February 2014	Fine	0/8	50% mats	Clear, brown	D/S (slow)	0/0	Gulls extremely common	0	0.5
20 February 2014	Fine	0/8	10% mats	Clear, brown	D/S	1/0	Gulls extremely common u/s	0	0
6 March 2014	Fine	0/8	70% mats	Clear, colourless	D/S	0/0	Gulls abundant u/s	0	0.5
21 March 2014	Fine	0/8	70% mats	Clear, brown	D/S	0/0	Gulls extremely abundant u/s	0	0
31 March 2014	Fine	1/8	N/R	Sl. turbid, brown	D/S	0/0	Few gulls	0	0
3 April 2014	Fine	0/8	80% mats	Clear, brown	D/S	0/0	Gulls abundant u/s	0	0

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine, overcast	7/8	None	Slightly turbid, green-brown	Surging	0/3 (whitebaiting)	Ducks common	0.5	3
18 November 2013	Fine	1/8	100% mats	Clear, green-blue	D/S (slow)	0/5 (banks)	Ducks common (being fed) and a few gulls	0	5
16 December 2013	Fine	3/8	85% mats	Sl. turbid, pale brown	D/S	0/7 (banks)	Ducks very common	0	0.5
16 January 2014	Fine, overcast	8/8	90% thin mats/filaments	Turbid, brown	D/S	0/20 (banks)	Ducks and gulls common (being fed); few shags; one heron	0	0.5
20 January 2014	Fine,overcast	8/8	80% mats	Sl. turbid, brown-green	D/S	0/12 (banks)	Ducks very common, few seagulls, no signage	0	0
30 January 2014	Fine	2/8	N/A	Turbid, green	D/S (surging)	0/22 (banks)	Ducks common, few gulls	0	0
3 February 2014	Fine	0/8	N/A	Turbid, green	D/S (surging)	0/1 (bank)	Few ducks and gulls; 2 dogs in stream	0	0
17 February 2014	Fine	0/8	80% mats	Slightly turbid, green	U/S (slow)	0/0	Gulls common	0	0.5
20 February 2014	Fine	0/8	N/A	Slightly turbid, green	D/S (slow)	0/0	Ducks and gulls common	0	0
6 March 2014	Fine	0/8	N/A	Turbid, green	D/S (surging)	0/0	Ducks and gulls very common	0	0.5
21 March 2014	Fine	0/8	N/A	Turbid, brown	D/S	0/8 (banks)	Ducks very common	0	0
31 March 2014	Fine	0/8	N/A	Turbid, green	D/S	0/2 (banks)	Ducks common	0	0
3 April 2014	Fine	0/8	N/A	Turbid, green	D/S	0/0	Few ducks	0	0

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine	6/8	None	Clear, uncoloured	D/S	0/0	(Didymo signage)	1	1
18 November 2013	Fine	4/8	50%	Clear, uncoloured	D/S	0/1 (bank)	Two dogs	0	0.5
16 December 2013	Fine	6/8	10%	Clear, uncoloured	D/S	0/0	No birdlife	0	0.5
16 January 2014	Fine	1/8	20%	Clear, uncoloured	D/S	0/0	No birdlife	0	0
20 January 2014	Fine,overcast	7/8	10%	Clear, dark green	D/S	0/0	No birdlife	0	0
30 January 2014	Fine	3/8	20%	Clear, uncoloured	D/S	0/0	No birdlife	0	0.5
3 February 2014	Fine	0/8	15%	Clear, dark green	D/S	0	No birdlife	0	0
17 February 2014	Fine	3/8	None	Slightly turbid, pale brown	D/S	0/0	No birdlife	0	0
20 February 2014	Fine	1/8	None	Slightly turbid, pale brown	D/S	0/10 (fishing)	Two ducks	0	0
6 March 2014	Fine	4/8	80%	Clear, pale green	D/S	0/0	Two ducks	0.5	5
21 March 2014	Fine	3/8	N/R	Slightly turbid, pale brown	D/S	0/0	No birdlife	0	3.5
31 March 2014	Fine	0/8	80%	Rel. clear, pale brown	D/S	0/0	No birdlife	0	0
3 April 2014	Fine	0/8	60%	Clear, uncoloured	D/S	0/0	No birdlife	0	0

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine	4/8	N/A	Slightly turbid, grey	D/S (slow)	0/1 (walking)	One dog	0	0
18 November 2013	Fine	4/8	N/A	Slightly turbid, grey-brown	U/S (slow)	0/1 (on ramp)	No birdlife	0	0
16 December 2013	Fine	3/8	N/A	Slightly turbid, brown-green	D/S	0/0	One gull	0	0
16 January 2014	Fine, overcast	7/8	N/A	Turbid, grey-brown	U/S	0/0	Two gulls	0	0
20 January 2014	Fine, overcast	7/8	N/A	Slightly turbid, green-brown	Ponded	0/0	No birdlife	0	0
30 January 2014	Fine	5/8	N/A	Turbid, grey-brown	U/S	0/0	(Didymo signage) No birdlife	0	0
3 February 2014	Fine	0/8	N/A	Turbid, green-grey	U/S	0/0	No birdlife	0	0
17 February 2014	Fine	1/8	N/A	Turbid, green-brown	U/S	0/0	No birdlife	0	0
20 February 2014	Fine, overcast	7/8	N/A	Turbid, green-brown	U/S	0/15 (banks, boating)	No birdlife	0	0
6 March 2014	Fine	2/8	N/A	Sl. turbid, grey	D/S (slow)	0/0	No birdlife	0.5	0.5
21 March 2014	Fine	3/8	N/A	Turbid, brown-green	U/S	0/0	No birdlife	0.5	0.5
31 March 2014	Fine	1/8	N/A	Turbid, brown	U/S	0/8 (several boats in park and launching)	No birdlife	0	0
3 April 2014	Fine	0/8	N/A	Turbid, pale-brown	U/S	0/3 (25 boats in park/2 launching)	No birdlife	0	0

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
5 November 2013	Fine	4/8	10%	Slightly turbid, pale brown	D/S	0/0		0	0
18 November 2013	Fine	6/8	30%	Clear, pale brown	D/S	0/0		0	0
16 December 2013	Fine	5/8	None	Clear, uncoloured	D/S	0/0		0	0.5
16 January 2014	Fine	2/8	25%	Clear, uncoloured	D/S	0/0		0	0
20 January 2014	Fine, overcast	7/8	10%	Sl. turbid, green-brown	D/S	0/0		0	0
30 January 2014	Fine	6/8	50%	Clear, grey	D/S	0/0		0	0.5
3 February 2014	Fine	0/8	35%	Clear, colourless	D/S	0/0		0	0
17 February 2014	Fine	1/8	10%	Sl. turbid, pale brown	D/S	0/0		0	0
20 February 2014	Fine	1/8	30%	Sl. turbid, pale brown	D/S	0/0		0	0
6 March 2014	Fine	5/8	90%	Clear, pale green	D/S	0/67 (banks/kayaking)	(school group in camp)	0.5	5
21 March 2014	Fine	3/8	N/R	Sl. turbid, pale brown	D/S	0/0		0	3.5
31 March 2014	Fine	0/8	80%	Rel clear, pale brown	D/S	0/0		0	0
3 April 2014	Fine	0/8	60%	Clear, uncoloured	D/S	0/0		0	0

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine	4/8	25%	Turbid, pale-brown	D/S	0/30 (whitebaiting/banks)	One dog	0	0
18 November 2013	Fine	3/8	50%	Clear, uncoloured	D/S	0/40 (whitebaiting)	One duck	0	0
16 December 2013	Fine	3/8	None	Clear, uncoloured	D/S	0/2 (banks)		0	0
16 January 2014	Fine	3/8	60%	Clear, uncoloured	D/S	0/0		0	0.5
20 January 2014	Fine, overcast	7/8	20%	Clear, uncoloured	D/S	0/0	(Didymo signage present)	0	0
30 January 2014	Fine	6/8	60%	Clear, uncoloured	D/S	0/0	(Didymo signage present) No birdlife	0	0
3 February 2014	Fine	0/8	20%	Clear, uncoloured	D/S	0/3 (banks)	No birdlife; one dog	0	0
17 February 2014	Fine	1/8	10%	Clear, pale brown	D/S	0/0	No birdlife	0	0
20 February 2014	Fine, overcast	7/8	10%	Sl. turbid, pale-brown	U/S	2/1 (fishing)	No birdlife	0	0
6 March 2014	Fine	0/8	100%	Sl. turbid, pale brown	D/S	0/0	No birdlife	0.5	2
21 March 2014	Fine	3/8	N/R	Sl. turbid, pale brown	U/S	0/0	No birdlife	0	2
31 March 2014	Fine	0/8	100%	Rel. clear, pale brown	D/S (slow)	0/0	No birdlife	0	0
3 April 2014	Fine	0/8	60%	Clear, uncoloured	D/S (slow)	0/0	Few ducks	0	0

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
5 November 2013	Fine	4/8	15%	Sl. turbid, pale green	D/S (slow)	0/40 (whitebaiting)		0	0
18 November 2013	Fine	3/8	45%	Clear, uncoloured	D/S (slow)	0/20 (whitebaiting)		0	0
16 December 2013	Fine	3/8	None	Sl. turbid, pale brown	D/S	2/8 (fishing, banks)	Few ducks	0	0
16 January 2014	Fine	3/8	10%	Clear,uncoloured	D/S	0/4 (banks/fishing)		0	0.5
20 January 2014	Fine, overcast	7/8	10%	Sl. turbid, pale brown	D/S	1/27 (banks/fishing)	One gull	0	0
30 January 2014	Fine	3/8	10%	Clear, colourless	D/S	0/0	No birdlife	0	0
3 February 2014	Fine	0/8	25%	Sl. turbid, grey-brown	U/S	2/1 (fishing)	One gull	0	0
17 February 2014	Fine	1/8	10%	Sl. turbid, pale brown	D/S	0/3 (fishing)	No birdlife	0	0
20 February 2014	Fine, overcast	7/8	10%	Turbid, brown	D/S	0/4 (fishing)	One shag; foam common	0	0
6 March 2014	Fine	0/8	50%	Clear, pale brown	D/S (slow)	0/0	No birdlife	0.5	2
21 March 2014	Fine	2/8	N/R	Sl. turbid, pale brown	U/S	0/25 (banks)	No birdlife	0	2
31 March 2014	Fine	2/8	N/R	Sl. turbid, green-brown	D/S (very slow)	0/2 (fishing)	No birdlife	0	0
3 April 2014	Fine	0/8	N/R	Rel. clear, pale brown	D/S (very slow)	0/2 (fishing)	No birdlife	0	0

Site Lake Opunake (Site Code: LOP000001)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine	5/8	None	Clear, pale brown	Ripple	0/0	Few ducks	0	0
18 November 2013	Fine	5/8	None	Sl turbid, pale brown	Flat	0/0	Ducks and frogs common	0	0
16 December 2013	Fine	2/8	Some on weeds and suspended	Clear, uncoloured	Flat	0/0	Ducks very common and frogs	0	1.5
16 January 2014	Fine	0/8	Some	Slightly turbid, brown	Flat	0/10 (banks)	Ducks very common; few swan	0	0
20 January 2014	Fine, overcast	7/8	N/R	Sl turbid, pale brown	Flat	0/0	Ducks very common, few swan	0	0
30 January 2014	Fine	3/8	Some	Slightly turbid, brown	Flat	0/0	Ducks very common (Didymo signage)	0	0
3 February 2014	Fine	0/8	Some	Sl turbid, light brown	Flat	0/0	Ducks very common; few geese and swans	0	0
17 February 2014	Fine	1/8	Some	Clear, pale brown	Ripple	0/4 (banks)	Ducks common; few swans	0	0
20 February 2014	Fine	1/8	Some	Clear, uncoloured	Flat	0/0	Ducks common	0	0
6 March 2014	Fine	0/8	N/R	Clear, brown	Ripple	0/0	Ducks common	0	1
21 March 2014	Fine	2/8	Some	Turbid, brown	Ripple	0/0	Ducks common	0	0.5
31 March 2014	Fine	0/8	N/R	Rel. clear, pale brown	Flat	0/0	Ducks common (Didymo signage)	0	0
3 April 2014	Fine	0/8	Some	Rel. clear, pale brown	Flat	0/0	Ducks common	0	0

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine	3/8	Nil	Clear, green-brown	Surging	0/8 (banks)	One gull; debris common at edges	0	1
18 November 2013	Fine,	0/8	95% (mats and filaments)	Clear, brown	D/S	0/2 (whitebaiting)	No wildfowl	0	2
16 December 2013	Fine	0/8	Nil	Clear, colourless	Surging	0/1 (bank)	Two dogs in water	0	0.5
16 January 2014	Fine, overcast	8/8	Nil	Clear, brown	D/S	0/0	Few gulls	0	0.5
20 January 2014	Fine, overcast	8/8	N/A	Clear, colourless	D/S	0/0	Few gulls	0	0
30 January 2014	Fine	2/8	Nil	Clear, colourless	D/S	0/0	Few seagulls	0	0
3 February 2014	Fine	0/8	Nil	Clear, colourless	D/S (surging)	0/0	No birdlife	0	0
17 February 2014	Fine	0/8	Nil	Clear, brown	U/S (slow)	0/0	Few gulls	0	3.5
20 February 2014	Fine	0/8	Nil	Clear,brown	D/S (slow)	0/0	No birdlife	0	0
6 March 2014	Fine	0/8	N/A	Sl. turbid, yellow-brown	D/S	0/3 (bank)	Two dogs	0	0.5
21 March 2014	Fine	0/8	N/A	Clear, colourless	D/S	0/0	No birdlife	0	0.5
31 March 2014	Fine	2/8	Nil	Clear, colourless	D/S	0/3 (bank)	No birdlife;one dog	0	0
3 April 2014	Fine	0/8	Nil	Sl. turbid, brown	D/S	0/1 (bank)	No birdlife; three dogs	0	0

Site Waimoku Stream, Oakura (Site Code: WMK000298)

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
5 November 2013	Fine	4/8	None	Clear, uncoloured	D/S	0/0		0	1
18 November 2013	Fine,	0/8	None	Clear, brown	D/S	0/0		0	2
16 December 2013	Fine	0/8	15%	Clear, uncoloured	D/S	0/0	Signage present; few ducks	0	0.5
16 January 2014	Fine, overcast	8/8	10%	Clear, brown	D/S	0/1 (bank)	Signage present; few gulls	0	0.5
20 January 2014	Fine, overcast (raindrops)	8/8	30%	Clear, uncoloured	D/S	0/0	(channel meandering to sea)	0	0
30 January 2014	Fine	3/8	70%	Clear, colourless	D/S	0/0	(channel direct to sea)	0	0
3 February 2014	Fine	0/8	40%	Clear, uncoloured	D/S	0/0	(channel meandering across beach)	0	0
17 February 2014	Fine	0/8	80%	Clear, brown	D/S	0/0	(channel direct to sea)	0	3.5
20 February 2014	Fine	0/8	20%	Clear, brown	D/S (slow)	0/0	No birdlife	0	0
6 March 2014	Fine	0/8	70% mats	Clear, uncoloured	D/S	0/0	Few birds; (channel direct to sea)	0	0.5
21 March 2014	Fine	0/8	60% mats	Clear, uncoloured	D/S	0/0	Gulls common; (channel meandering to sea)	0	0.5
31 March 2014	Fine	2/8	80% mats	Clear, uncoloured	D/S	0/0	One gull (channel meandering to sea)	0	0
3 April 2014	Fine	0/8	100% mats	Clear, brown	D/S	0/0	Few gulls (channel direct to sea)	0	0

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
5 November 2013	Fine	6/8	Nil	Clear, green-brown	Surging	0/0		0	0
18 November 2013	Fine	1/8	Nil	Clear, green-brown	Surging	0/1 (whitebaiting)	One dog; stock present with river access (LB)	0	2
16 December 2013	Fine	0/8	N/A	Clear, brown- green	U/S (surging)	0/1 (bank)	One dog	0	0.5
16 January 2014	Fine, overcast	8/8	N/A	Clear, green	U/S (surging)	0/0	Few gulls	0	0.5
20 January 2014	Fine, overcast (rain drops)	8/8	Nil	Clear, green	D/S	0/0	Few gulls	0	0
30 January 2014	Fine	0/8	Nil	Clear, green	D/S (surging)	0/1 (bank)	Two dogs in river	0	0
3 February 2014	Fine	0/8	Nil	Sl. turbid, green-brown	D/S (surging)	40/15 (bank)	No birdlife	0	0
17 February 2014	Fine	0/8	Nil	Clear, brown-green	D/S	0/1 (bank)	Few gulls and ducks	0	3.5
20 February 2014	Fine	0/8	Nil	Clear, green	D/S (slow)	3/12 (banks)	One dog	0	0
6 March 2014	Fine	0/8	N/A	Turbid, green-brown	D/S	0/0	No birdlife	0	0.5
21 March 2014	Fine	0/8	N/A	Sl. turbid, brown-green	D/S (surging)	0/0	One gull	0	0.5
31 March 2014	Fine	1/8	Nil	Clear, green	D/S (surging)	0/0	No birdlife	0	0
3 April 2014	Fine	0/8	Nil	Slightly turbid, green	D/S	0/1 (bank)	One dog	0	0

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
5 November 2013	Fine	6/8	2.4	Turbid, green-brown	U/S (slow)	4/5 (fishing)	No signage	1.5	1.5
18 November 2013	Fine	3/8	N/R	Turbid, green	D/S (slow)	0/2 (fishing)	No signage	0	7
16 December 2013	Fine	2/8	1.95	Turbid, green	D/S (slow)	0/1 (wharf)	No signage	0	1
16 January 2014	Fine	6/8	1.90	Turbid, green-brown	U/S (slow)	0/7 (fishing,rowing)	Few ducks	0	0
20 January 2014	Light rain, overcast	8/8	1.9	Turbid, brown-green	D/S(slow)	0/3 (fishing)	No signage	0	0
30 January 2014	Fine	38	2.25	Slightly turbid, green	D/S	0/0	Few ducks	0	0.5
3 February 2014	Fine	0/8	N/R	Slightly turbid, green	U/S (slow)	0/7 (fishing)	Few ducks	0	0
17 February 2014	Fine	0/8	1.8	Turbid, green	D/S (slow)	0/0	Few Ducks	0	0.5
20 February 2014	Fine	0/8	1.85	Sl. turbid, pale green-yellow	Still	0/0	No signage; one duck, few gulls	0	0
6 March 2014	Fine	0/8	1.75	Slightly turbid, green	D/S	0/5 (wharf)	Few ducks; gulls common; no signage	0	1
21 March 2014	Fine	0/8	1.75	Slightly turbid, green	D/S	2/12 (yachting, boating)	Few ducks; no signage	0	0.5
31 March 2014	Fine	1/8	2.15	Slightly turbid, green	D/S	0/0	One duck	0	0
3 April 2014	Fine	0/8	2.1	Turbid, dark green	D/S (slow)	0/0	Few ducks and gulls	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
5 November 2013	Fine	4/8	N/A	Turbid, grey-green	U/S (slow)	0/0		1.5	1.5
18 November 2013	Fine	0/8	N/A	Turbid, green	Still (ponded)	0/0		0	5.5
16 December 2013	Fine	1/8	N/A	Slightly turbid, green	D/S (slow)	0/1 (boating)		0	0
16 January 2014	Fine	4/8	N/A	Turbid green-brown	D/S (slow)	4/30 (banks)		0	0
20 January 2014	Fine, overcast	8/8	N/A	Turbid, green	U/S	10/20 (banks)		0	0
30 January 2014	Fine	2/8	N/A	Slightly turbid, green	D/S (slow)	6/11 (banks/boating)		0	0.5
3 February 2014	Fine	0/8	N/A	Turbid, green-brown	U/S	0/2 (fishing)	One gull	0	6
17 February 2014	Fine	0/8	N/A	Turbid, green-brown	D/S	0/1 (boat)	No birdlife	0	0
20 February 2014	Fine	0/8	N/A	Sl. turbid, green-grey	D/S	0/1 (bank)	No birdlife	0	0
6 March 2014	Fine	0/8	N/A	Turbid, green-brown	D/S	0/0	No birdlife	0	1
21 March 2014	Fine	0/8	N/A	Turbid, green	U/S	0/0	Few gulls	0	0
31 March 2014	Fine	0/8	N/A	Slightly turbid, green	U/S	0/0	No birdlife	0	0
3 April 2014	Fine	3/8	N/A	Turbid, green-grey	U/S (slow)	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
5 November 2013	Fine	6/8	70%	Slightly turbid, brown-green	D/S	0/0		1	1
18 November 2013	Fine	6/8	Widespread	Slightly turbid, brown-green	D/S	0/0		0	1.5
16 December 2013	Fine	1/8	90% thin mats	Clear, uncoloured	D/S	0/0		0	0
16 January 2014	Fine	0/8	Medium mats	Slightly turbid, green-brown	D/S	0/0		0	0
20 January 2014	Fine, overcast	8/8	Medium mats	Clear, brown	D/S	0/0		0	0
30 January 2014	Fine	3/8	50%	Clear, colourless	D/S	0/0		0	0
3 February 2014	Fine	0/8	90%	Clear, colourless	D/S	0/0	No birdlife	0	0
17 February 2014	Fine	0/8	20%	Clear, brown	D/S	0/0	No birdlife	0	0
20 February 2014	Fine	0/8	Mats and filaments	Clear, brown	D/S	0/0	No birdlife	0	0
6 March 2014	Fine	3/8	100% mats	Clear, colourless	D/S	0/0	No birdlife	0	2
21 March 2014	Fine	1/8	100% mats	Clear, colourless	D/S	0/0	No birdlife	0	2
31 March 2014	Fine	3/8	100% (mats and filaments)	Clear, colourless	D/S	0/0	No birdlife	0	0
3 April 2014	Fine	0/8	Widespread	Slightly turbid, brown-green	D/S	0/0	No birdlife	0	0

Site Lake Ratapiko (Site Code: LRP000050)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
5 November 2013	Fine	4/8	N/A	Slightly turbid, brown	Ripple	0/0	Few ducks	1	1
18 November 2013	Fine	6/8	N/A	Clear, green-brown	Ripple	0/0	No wildfowl	0	1.5
16 December 2013	Fine	4/8	N/A	Turbid, brown	Ripple	0/0		0	0
16 January 2014	Fine	0/8	N/A	Turbid, blue-brown	Chop	0/4 (jetskiing/waterskiing/ banks)		0	0
20 January 2014	Fine, overcast	8/8	Nil	Slightly turbid, brown	Ripple	0/0	Few ducks	0	0
30 January 2014	Fine	2/8	N/A	Slightly turbid, brown	Ripple	0/0	No birdlife	0	0
3 February 2014	Fine	0/8	N/A	Slightly turbid, brown	Flat	0/0	Few ducks	0	0
17 February 2014	Fine	0/8	N/A	Slightly turbid, brown	Ripple	0/0	Few ducks	0	0
20 February 2014	Fine	0/8	N/A	Slightly turbid, brown	Flat	0/0	Few ducks	0	0
6 March 2014	Fine, overcast	8/8	N/A	Turbid, brown	Ripple	0/0	Few ducks. Lake level low and closed for maintenance	0	2
21 March 2014	Fine	0/8	N/A	Turbid, brown	Ripple	N/A	Lake level very low and closed (maintenance) [No sampling]	0	2
31 March 2014	Fine	5/8	N/A	N/A	N/A	N/A	Lake level very low and closed (maintenance) [No sampling]	0	0
3 April 2014	Fine	-	N/A	N/A	N/A	-	Lake level very low and closed (maintenance) [No sampling]	0	0

Appendix IV

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

Dates of additional sampling

Date	Preceding weather
Monday 25 November 2013	fine over 72 hours
Tuesday 10 December 2013	wet over 72 hours, some rain over 24 hours
Monday 13 January 2014	little rain over 24 hours
Monday 27 January 2014	wet over 24 hours
Monday 10 February 2014	wet over 48 hours and 72 hours
Tuesday 25 February 2014	dry over 72 hours
Tuesday 11 March 2014	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
25 November 2013	Fine	5/8	None	Turbid, brown	Flat	0/0	Few ducks	0	0
10 December 2013	Fine	4/8	N/R	Slightly turbid, brown	Ripple	0/4 (banks)	Few ducks, canadian geese, and one dog	0.5	11
13 January 2014	Fine	4/8	Some	Turbid, brown	Ripple	0/10 (banks)	Two dogs, few ducks	2	2
27 January 2014	Fine	2/8	Some	Slightly turbid, pale brown	Ripple	0/16 (banks/water and jet skiing)	Few ducks	9.5	9.5
10 February 2014	Fine	6/8	None	Turbid, brown	Ripple	0/1 (bank)	Few ducks; two dogs	0	11
25 February 2014	Fine	4/8	Some	Slightly turbid, pale brown	Flat	0/4 (banks)	Few ducks; few dogs	0	0
11 March 2014	Fine	2/8	Some	Turbid, brown	Flat	0/0	Few ducks	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
25 November 2013	Fine	4/8	20%	Clear, uncoloured	D/S	0/0		0	0
10 December 2013	Fine	6/8	N/R	Clear, uncoloured	D/S	0/0		0.5	11
13 January 2014	Fine	3/8	None	Clear, uncoloured	D/S	0/2 (banks)	1 dog	2	2
27 January 2014	Fine	2/8	None	Clear, uncoloured	D/S	0/0		9.5	9.5
10 February 2014	Fine, overcast	7/8	None	Clear, uncoloured	D/S	0/0	No wildlife	0	11
25 February 2014	Fine	3/8	None	Clear, uncoloured	D/S	0/1 (bank)	1 dog	0	0
11 March 2014	Fine	1/8	None	Clear, uncoloured	D/S	0/0 (banks)	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
25 November 2013	Fine, overcast	7/8	Some	Slightly turbid, brown	Flat	0/0	Ducks very common on shore	0	0
10 December 2013	Fine	5/8	Some	Turbid, brown	Flat	0/0	Ducks common, few swans	3.5	19
13 January 2014	Fine	3/8	Some	Slightly turbid, brown	Flat	0/2 (bank)	Ducks very common, few swan	5	5
27 January 2014	Fine	3/8	Minimal	Clear, pale brown	Flat	0/0	Ducks very common, few swan	5	15
10 February 2014	Fine	4/8	Some	Clear, pale brown	Ripple	0/0	Ducks common, few swan	0	11
25 February 2014	Fine	1/8	Some	Clear, pale brown	Flat	0/0	Ducks common, few swan	0	0
11 March 2014	Fine	6/8	Some	Turbid, brown	Flat	0/0	Ducks common	0	0

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
25 November 2013	Fine, overcast	7/8	Minimal	Slightly turbid, brown	Ripple	0/0	Few ducks	0	35
10 December 2013	Fine	5/8	N/R	Slightly turbid, pale brown	Flat	0/0	Few ducks	0.5	13
13 January 2014	Fine	5/8	Minimal	Slightly turbid, brown	Ripple	0/0	Few ducks	8	8
27 January 2014	Fine	4/8	Minimal	Clear, pale brown	Flat	0/0	Few ducks	9.5	9.5
10 February 2014	Fine, overcast	8/8	Minimal	Slightly turbid, pale brown	Ripple	0/0	Few ducks and shags	0	20
25 February 2014	Fine	3/8	None	Clear, pale brown	Flat	0/2 (waterskiing/bank)	Few ducks	0	0
11 March 2014	Fine, overcast	8/8	Some	Turbid, brown	Flat	0/0	Few ducks; lake lowered for maintenance	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
12 November 2013	Fine	1/8	None visible	Rel. clear, pale brown	Ripple	0/2 (bank)	Boat ramp locked, few pukeko	0	0
13 December 2013	Fine	6/8	Suspended	Turbid, brown	Ripple	0/0 (bank)	Few ducks	0	0
19 December 2013	Fine	5/8	Some suspended	Slightly turbid, pale brown	Ripple	0/4 (campers)	Few ducks (scaup) and swan. Boat ramp closed (v.strong southerly wind)	0	0.5
23 December 2013	Fine	0/8	Suspended	Slightly turbid, brown	Flat	0/2 (walkers)	Few ducks, one swan Boat ramp closed (no wind)	0	0
14 January 2014	Fine	2/8	Suspended	Turbid, brown	Choppy	0/6 (banks)	Boat ramp closed. Few ducks and one swan	0	0.5
11 February 2014	Fine	6/8	Suspended	Slightly turbid, pale brown	Flat	0/0	Boat ramp closed	0	2
24 February 2014	Fine	0/8	Suspended	Slightly turbid, pale brown	Flat	0/1 (walker)	Boat ramp re-opened. No birdlife	0	0
11 March 2014	Fine	2/8	Some suspended	Rel. clear, pale brown	Flat	0/1 (kayaker)	Few ducks	0	0
24 March 2014	Fine	2/8	Some suspended	Slightly turbid, pale green-brown	Flat	0/0	Boat ramp open; no wildlife	0	0
3 April 2014	Fine	0/8	Some floating	Rel. clear, colourless	Flat	0/2 (picnicking)	Boat ramp open; one duck and one pukeko	0	0

Appendix VI

Comparative annual box and whisker plots of SEM data for *E. coli* for the period 1996 to 2014

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)

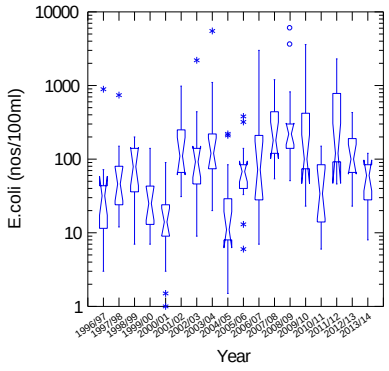
The outer fences are defined as follows:

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

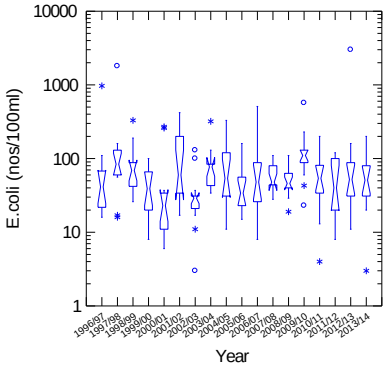
> The whiskers show the range of values that lie within the inner fences. Values outside the inner fence (outliers) are plotted as asterisks (*). Values outside the outer fence (extreme outliers) are plotted as ˚.

E. coli

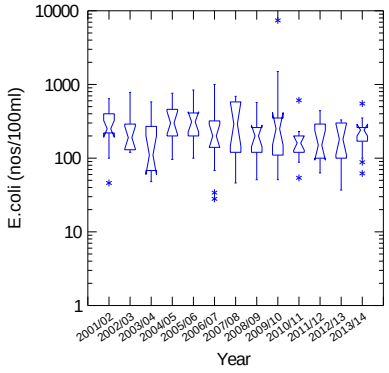
Lake Rotomanu



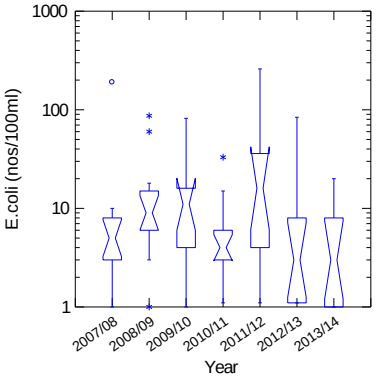
Waiwhakaiho River at Merrilands Domain



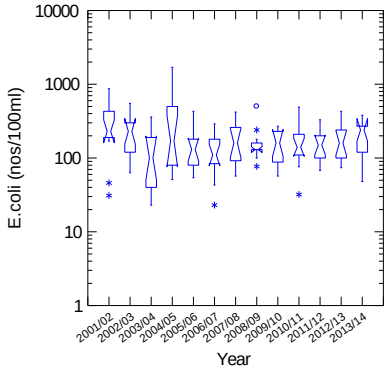
Patea River at Stratford



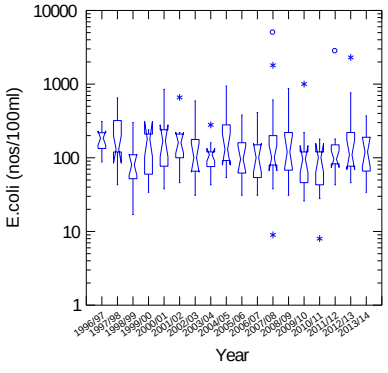
Patea River at Patea boat ramp



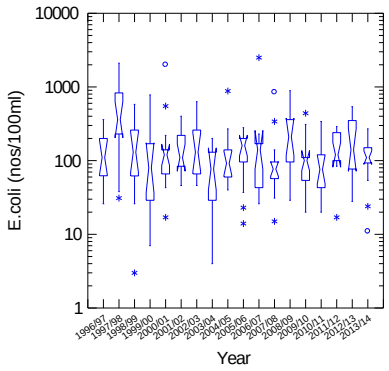
Waingongoro R at Eltham



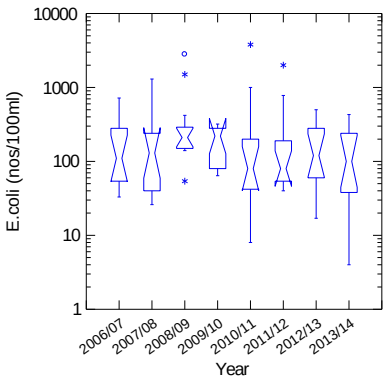
Waingongoro R at Ohawe



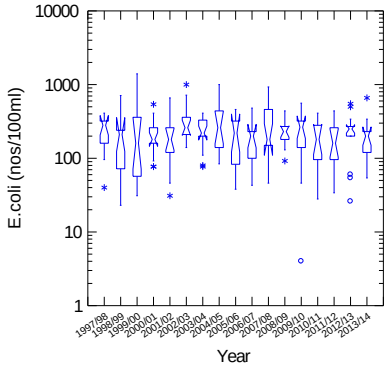
Kaupokonui River



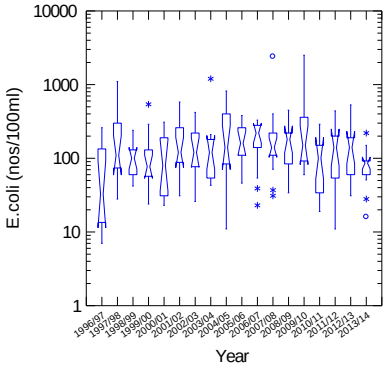
Lake Opunake



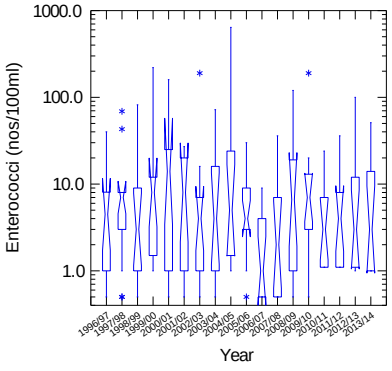
Timaru Stream



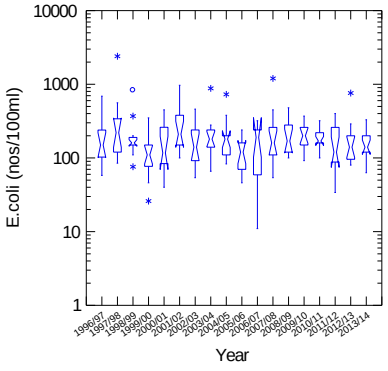
Oakura River



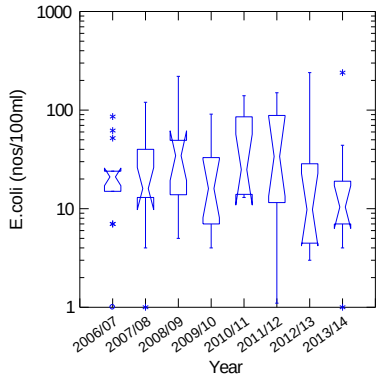
Urenui River



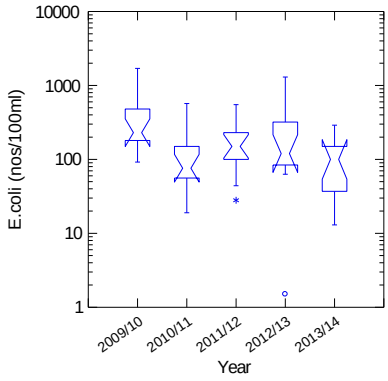
Manganui River



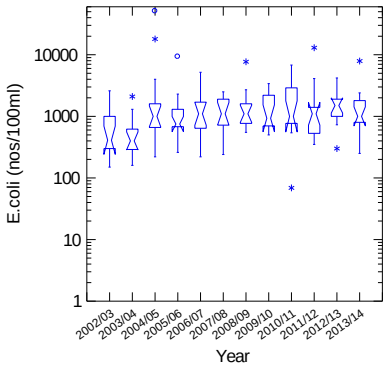
Lake Ratapiko



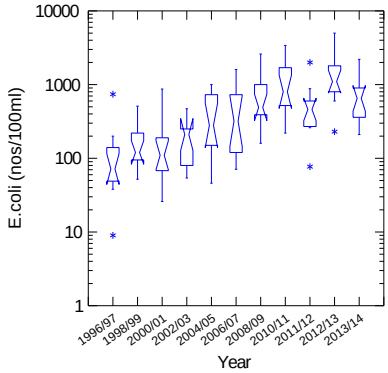
Waitara River at town wharf



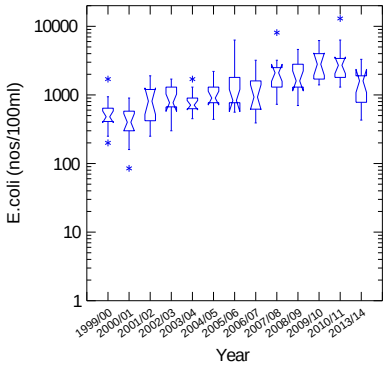
Te Henui mouth East End



Waiwhakaiho adjacent to L.Rotomanu



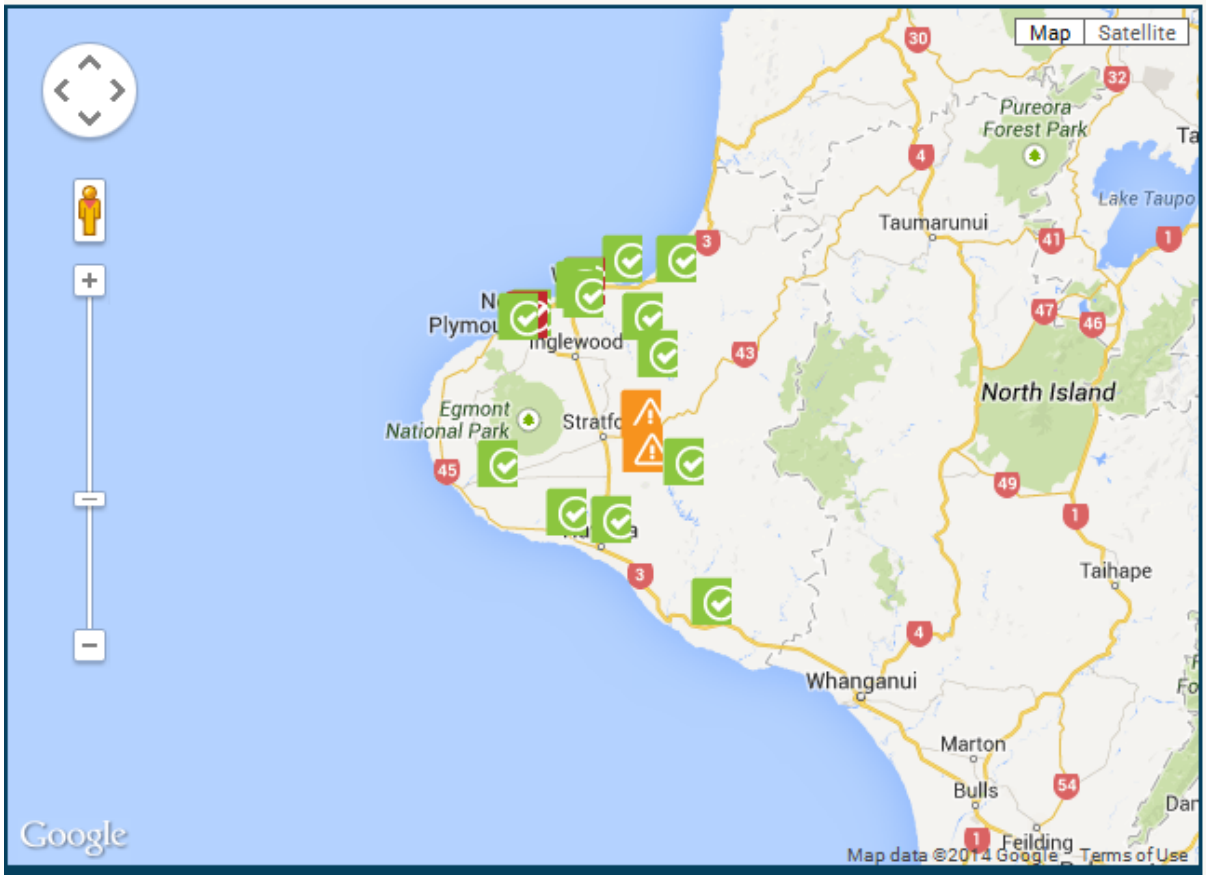
Waimoku S at Oakura beach



Appendix VII

Examples of publicity during the 2013-2014 season

Freshwater quality



Click on an icon for more information

Last updated: 03/04/2014 12:00 am

KEY

Surveillance mode
Less than 261 E. coli/100ml in single sample.

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.

Public health

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).

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, and additionally tests for cyanobacteria at Lake Rotomanu, the Waiwhakaiho River at Merrilands, Lake Ratapiko, Lake Rotokare and Lake Opunake.

Bacteriological

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	Mode
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.

Cyanobacteria

Cyanobacteria, or blue-green algae, are very small plant-like organisms found in freshwater lakes and rivers where they can build up to very large numbers under certain conditions.

Cyanobacteria can cause skin irritation, and some species contain toxic substances and have been linked to negative effects on human and animal health.

They can cause nausea, stomach upsets, and tingling and numbness around the mouth or tips of fingers. If toxin levels are really high, involuntarily or accidentally drinking the water could result in severe liver damage.

The Taranaki Regional Council is monitoring summer cyanobacteria levels as well as bacteriological levels at Lake Rotomanu, the Waiwhakaiho River at Merrilands, Lake Ratapiko, Lake Rotokare and Lake Opunake.

There are three alert levels:

Cyanobacteria cells per ml of water	Mode
Less than 2,000	Low risk
Between 2,000 and 15,000	Medium risk
More than 15,000	High risk

High risk will be denoted on the bacteriological water quality map with a barred circle on a purple background at the relevant monitoring site.

For more information contact the Taranaki Regional Council:

Email: info@trc.govt.nz

Phone: 06 765 7127

Fax: 06 765 5097

Freshwater quality - Waingongoro River - Eltham

The full monitoring programme runs from November to March or April.

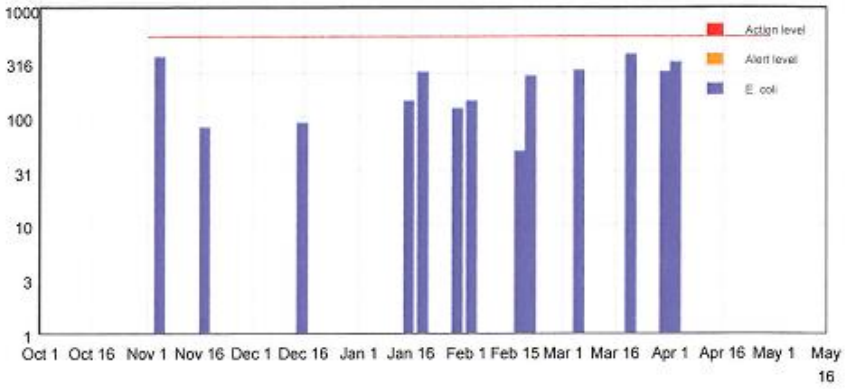
When monitoring is being carried out and results are available, data on this website is updated three times a day, at 10am, 3pm and 6pm.

Public health status: Click **here** to access Taranaki District Health Board information on the public health status of monitored sites.

The graph and its associated database are set to a minimum count of 1.2 to allow adequate visual presentation. So a reading of 1.2 reflects an actual sample result of 1 or less than 1 bacterium per 100mls.

E. coli (nos/100ml)

Graph Raw data



Back to map

Waingongoro River - Eltham

Current values:

- E. coli: 320 nos/100ml (2014-04-03 00:00:00)

Between 13 and 20 samples will be collected during the annual summer bathing season from November to early April. Purple vertical bars show the bacterial count measured in the water on particular days. These are single sample counts.

Note the logarithmic scale of the bacterial indicator axis. It is not a linear graph where the intervals are unchanged up the scale.

A bathing site is considered safe for swimming unless two consecutive sample counts for marine water are more than the Action Limit of 280 enterococci/100ml at beach sites or when the single sample count for freshwater is more than 550 E. coli /100ml.

Should single sample counts be greater than the Action Limit, this indicates that the maximum recommended value for safe swimming has been exceeded and additional sampling, and investigations may be initiated.

The Medical Officer of Health advises users "that bacterial counts are high after heavy rainfall. Recreational use should be reduced for two-three days after heavy rainfall".

For more information contact the Taranaki Regional Council:

Email: info@trc.govt.nz

Phone: 06 765 7127

Fax: 06 765 5097

stuff.co.nz

Algal bloom forces Lake Rotokare closure

LAIRD HARPER Last updated 05:00 17/12/2013

Lake Rotokare is again out of bounds to swimmers and boaties due to a toxic algal bloom.

South Taranaki District Council environmental health officer Doug Scott said the lake would be closed until cleared by the Taranaki District Health Board.

He said contact with poisonous algae may cause irritation of the skin, eyes and throat, and could also bring on asthma.

Earlier this year, a team of experts from Waikato University hypothesised growing numbers of perch may be responsible for the algae plaguing the reserve.

Perch were introduced as a sports fish species.

Sanctuary manager Simon Collins said while it was unfortunate the lake was again out of action, they were working with the university to discuss options for fewer or shorter closure periods.

He said the reserve grounds remained open.

The blue-green algae, also known as cyanobacteria, tends to form in fine weather, on the rocks of river beds when the water is relatively calm.

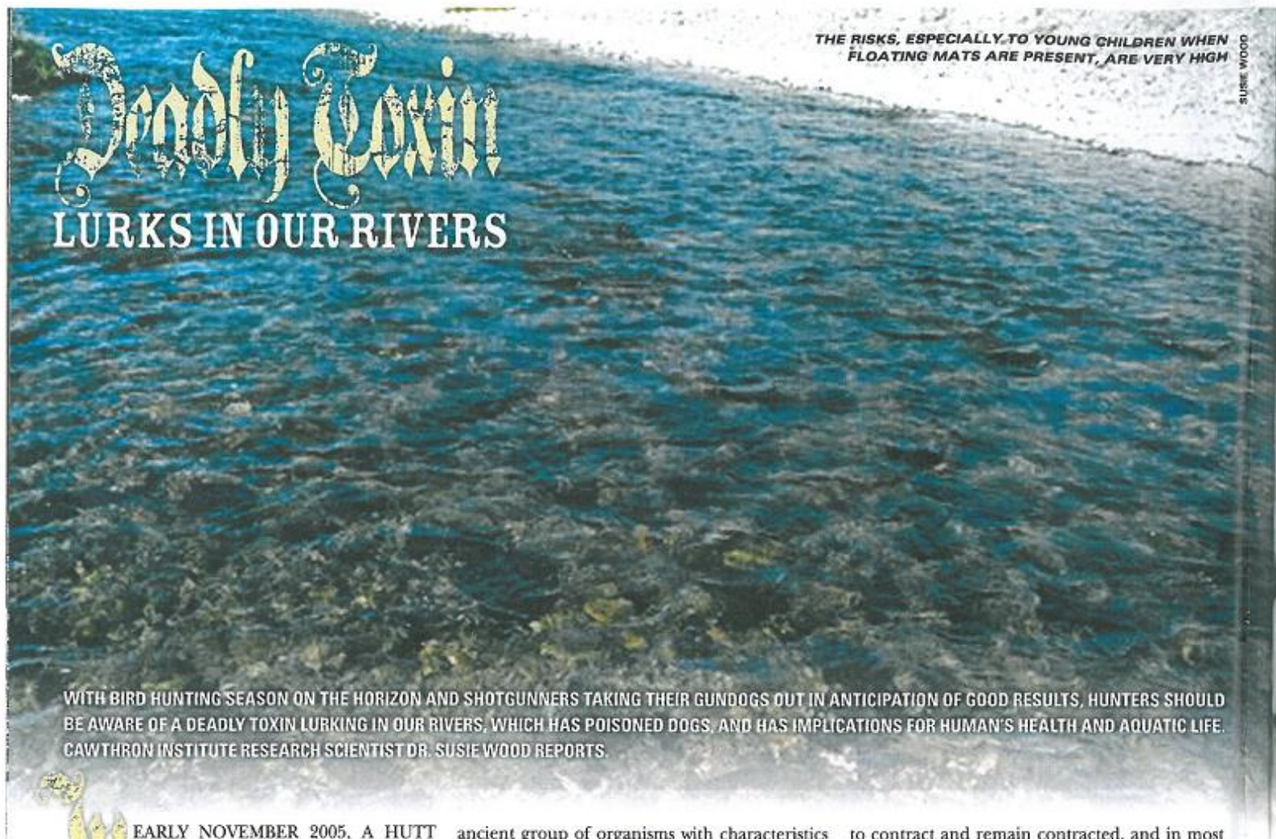
Any visitors to the reserve showing symptoms should consult their doctor immediately or contact the health board Health Protection Unit on 06 753 7798.

Appendix VIII
Benthic Cyanobacteria

“Deadly Toxin lurks in our rivers” S. Wood
Fish and Game New Zealand, Volume 84

Cyanobacteria mat, Waitara River late summer 2014

Deadly Toxin
LURKS IN OUR RIVERS



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

SUSIE WOOD

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?

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

SUSIE WOOD

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.

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

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.