

Bathing Beach Water Quality  
State of the Environment  
Monitoring Report  
Summer 2009-2010

Technical Report 2010-08

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## Executive summary

The coastal contact recreational water quality component of the State of the Environment monitoring (SEM) programme for the Taranaki region commenced in the 1995-96 summer period. Eight sites at six of the most popular recreational beaches were monitored each summer. A seventh beach was added for the 2001-2002 summer. A further ten beaches are monitored in a three-yearly rotation. This report summarises the results for the monitoring period 2009-2010, including beaches monitored in year one of the rotation.

The monitoring results have been assessed using the national microbiological guidelines for marine recreational areas (MfE, 2003). The indicator bacteria measured are enterococci, with levels of less than 140 enterococci per 100 ml considered to be acceptable (i.e. water quality is suitable for bathing, and approximately weekly sampling is undertaken for surveillance). Should any of these routine samples contain greater than 140 enterococci per 100 ml, 'Alert' mode is triggered – water is potentially unsuitable for bathing, and further sampling is undertaken. Samples containing greater than 280 enterococci per 100 ml indicate water is highly likely to be contaminated. In these circumstances, sampling is to be undertaken again within 24 hours to see if the situation is continuing. If the second result is also above 280 then 'Action' mode is triggered. That is, it is when there are two consecutive samples above 280 enterococci per 100 ml that it is considered public health is potentially compromised. This involves notifying the Taranaki District Health Board. As discussed below, high flows in streams and rivers following rainfall events have a major influence on the water quality of Taranaki beaches, and re-sampling is not always undertaken if a significant rainfall event is the likely cause of a sample exceeding 280 enterococci per 100 ml.

Thirteen samples are collected over the bathing season at each of the 13 sites as part of the Councils 'regular' SEM monitoring programme, with an additional seven samples collected at five of the beaches to fulfil Ministry for the Environment requirements.

Marine recreational water quality was monitored for the 2009-2010 summer, and was indicated to be of a good standard. Nine of the 13 beaches were completely within the guidelines for contact recreation with regards to the regular SEM samples, with three of the remaining four beaches showing only minor breaches (i.e. no breaches reached 'Action' levels of bacterial contamination at any time). Ohawe Beach exceeded the 'Action' guidelines on one occasion. The extra samples undertaken to fulfil MfE requirements resulted in two of the five sites exceeding the 'Alert' guideline levels at some time.

Out of 204 samples in total (both regular SEM and MfE extra samples) collected at 13 bathing beaches during the period under review, 96% were below (satisfied) the most stringent guideline level (below 'Alert').

Streams and rivers were determined to have a major influence on the contact recreational water quality. With high (non-complying) counts occurring simultaneously at all beaches when they did occur, it was clear that there were no site-specific causes of contamination, but rather the cause was wet-weather flow in streams.

None of the nine beaches analysed for long-term trends showed a trend of either increasing or decreasing water quality.

Frequent and timely reporting of the results of bacteriological water quality was undertaken by use of the Taranaki Regional Council website ([www.trc.govt.nz](http://www.trc.govt.nz)) as well as liaison with territorial local authorities and the Health Protection Unit of Taranaki District Health Board throughout the summer bathing season of 2009-2010.

Continuation of the bathing beach SEM programme is recommended in the 2010-2011 year.



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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 implemented during the 1995-96 summer as an ongoing component of the state of the environment monitoring (SEM) programme for the Taranaki region.

The SEM bacteriological bathing water quality programme has three objectives:

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

*[Note: Contact recreation concerns water-based activities involving a high probability of accidental water ingestion. This mainly applies to bathing, but may also include water- and jet-skiing, surfing, boardsailing etc.]*

## 2. Contact recreation water quality standards and guidelines

### 2.1 Marine microbiological water quality guidelines (2003)

In most cases the ill-health effects from exposure to contaminated water are minor and short-lived. However, there is the potential for more serious diseases, such as hepatitis A, giardiasis, cryptosporidiosis, campylobacteriosis and salmonellosis (MfE, 2003). It is difficult and impractical to measure the level of pathogens in the water directly. Instead, the levels of 'indicator' micro-organisms are measured. These provide indirect information about the level of pathogens.

The marine guidelines were developed from many studies relating bacteriological indicators to illness in the general public after bathing. The guidelines work with a defined 'tolerable risk' rather than no risk at all. For most healthy people water conforming to the guideline value will pose a minimal level of risk. However, water conforming to the guideline values may still pose a potential health risk to high-risk users groups such as the very young, the elderly and those with impaired immune systems (MfE, 2003). It is also a probabilistic risk i.e. at the guideline value, a certain (very low) number of swimmers might be expected to become ill.

Guidelines for microbiological water quality of marine recreational areas have been prepared by Ministry for the Environment in conjunction with the Ministry of Health (MfE, 2003). The purpose of the microbiological water quality guidelines for marine recreational areas is to help control the public health risk from microbiological contamination in recreational waters, and to provide a framework for monitoring and reporting on the general health of the beaches.

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. 'Alert' and 'Action' guideline levels are used for surveillance throughout the bathing season. They are summarised in Table 1 below.

**Table 1** Marine recreational bathing guidelines (2003)

	Enterococci (nos/100ml)		
	Surveillance (Green) Mode	Alert (Amber) Mode	Action (Red) Mode
Single sample maximum	<140	>140	
Two consecutive samples (within 24 hrs)			>280

Levels of less than 140 enterococci per 100 ml are considered to be acceptable (i.e. water quality is suitable for bathing), and approximately weekly sampling is continued for surveillance. Should any of these routine samples contain greater than 140 enterococci per 100 ml, the 'Alert' mode is triggered – water is potentially unsuitable for bathing and further sampling is to be undertaken. Samples containing greater than 280 enterococci per 100 ml indicate water is highly likely to be contaminated. Sampling is undertaken again within 24 hours and if the second result is also above 280 then 'Action' mode is triggered. That is, it is when there are two consecutive samples above 280 enterococci per 100 ml that it is considered public health is potentially compromised. This involves notifying the Taranaki District Health Board, for their implementation of any response. High flows in streams and rivers following significant rainfall events have a major influence on the water quality of Taranaki Beaches, and re-sampling is not always undertaken if a significant rainfall event is the likely cause of a sample exceeding 280 enterococci per 100 ml.

## 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 (MAC) (using historical data) (refer to Table 2) and Sanitary Inspection Categories (SIC) which generate a measure of the susceptibility of water bodies to faecal contamination. 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.

**Table 2** Microbiological Assessment Categories

MAC	MAC definitions for marine waters
A	Sample 95 percentile $\leq$ 40 enterococci/100ml
B	Sample 95 percentile 41 - 200 enterococci/100ml
C	Sample 95 percentile 201 - 500 enterococci/100ml
D	Sample 95 percentile > 500 enterococci/100ml

SFRG categories are very good, good, fair, poor, and very poor. Sites graded very good are those where it is considered 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 those in catchments with significant sources of faecal contamination, and it is considered they will rarely pass the guidelines. The risk of illness from bathing at these sites is 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 17 sites have been graded by Council according to these criteria, using historical microbiological water quality data extending over the November 2004 to April 2009 period. The relevant information is summarised in Table 3.

Eight of the 17 sites gained a 'Good' SFRG (Wai-iti, Urenui, Onaero Settlement, Fitzroy, East End, Back, Oakura CG, and Opunake). The beaches at Bell Block, Ngamotu, Oakura SC and Ohawe were considered to be 'Fair', while Onaero Beach obtained a 'Poor' SFRG. There was insufficient data (i.e. not enough samples collected due to the three year rotation) to calculate a SFRG for Patea, Patea (Mana Bay), Waverley and Wai-inu Beaches.

**Table 3** Suitability for recreation grade for the period November 2004 to April 2009

Site	Sanitary Inspection Category *	Microbiological assessment Enterococci (nos/100ml)			SFR Grade	% of all samples in compliance (ie: <280 enterococci)
		95 %ile	Number of samples	Category		
Wai-iti	Moderate 13	132	26	B	Good	100
Urenui	Moderate 13	58.4	26	B	Good	100
Onaero	Moderate 13	515	93	D	Poor	94
Onaero settlement	Low 14	70.2	26	B	Good	100
Bell Block	Moderate 3	327	39	C	Fair	94
Fitzroy	Moderate 3	88	105	B	Good	97
East End	Moderate 3	116	42	B	Good	100
Ngamotu	Moderate 3	154	101	B	Fair	97
Back	Low 14	184	26	B	Good	96
Oakura (SC)	Moderate 13	390	105	C	Fair	92
Oakura (CG)	Moderate 13	44	66	B	Good	100
Opunake	Moderate 3	24	139	A	Good	99
Ohawe	Moderate 13	327	77	C	Fair	93
Patea	Moderate 13	Insufficient data to calculate				
Patea (Mana Bay)	Moderate 13	Insufficient data to calculate				
Waverley	Moderate 13	Insufficient data to calculate				
Wai-inu	Moderate 13	Insufficient data to calculate				

\* 13 = River - agricultural activities/birds/feral animals

14 = River - focal points of discharge

3 = Urban stormwater

It should be noted that SFRG grades include an assessment of potential risk, as well as actual water quality. As can be seen from Table 3, a site may have an established record of high water quality, but not be assigned a 'very good' SFRG due to the criteria used in the 2003 guidelines. This is especially important for Taranaki, where because of the agricultural landscape and high number of streams draining this area, no bathing beach can be categorised with an SFR grade of "very good".

*Note: The table above takes into account data from both standard SEM samples along with extra samples required by MfE. Refer to Section 3 for a discussion of this.*



### **3. Monitoring methodology**

#### **3.1 Sample collection**

The monitoring network is designed to assess coastal water quality in terms of its suitability for contact recreation. As such, the network targets the main bathing times and avoids as far as possible the influence of diffuse sources (ie, streams and rivers) on coastal water quality. For these reasons the following criteria have been adopted during sampling.

Sample collection, field measurements, transport and analyses are undertaken according to documented Taranaki Regional Council procedures. It is intended that on average, four samples be collected from each of the sites in each month when hydrological flow conditions permitted, within two hours of high tide. Sampling is performed only under dry weather flow conditions (ie, not within three days of a fresh). Bathing water samples are to be taken between the hours of 0900 and 1800 hours (NZDT). Where necessary, a 2 metre sampling pole is used for bacteriological sample collection immediately beneath the water surface and at a minimum of knee depth at the sites (Figure 1). A minimum of thirteen samples were collected from each site during the season.

All sites' locations and descriptions are stored in the Taranaki Regional Council site database system, and are recorded in the laboratory computer database (Labsys) where all analytical results were stored following standard sample registration procedures.

Results for the 2009-2010 bathing season were posted on the Taranaki Regional Council website ([www.trc.govt.nz](http://www.trc.govt.nz)) as soon as they become available. Where results fell in the action mode, further investigation (e.g. sampling) was performed when considered necessary i.e. when historical databases indicated this was necessary.

#### **3.2 Sample analysis**

Samples are analysed for enterococci, *E. coli* and faecal coliform bacteria and conductivity. Both *E. coli* and faecal coliform numbers are assessed using mTEC agar method #9213-d of the Standard Methods for the Examination of Waters and Wastewaters (APHA, 2005). Enterococci numbers are assessed using the EPA modified method #1600 on mEI agar (EPA, 1986). This 24 hour method (as opposed to 48 hours) is not the standard method, but is widely used in New Zealand.

In addition, at each of the sites the following information is recorded; time, water temperature, weather condition, wind condition, surf condition, colour/appearance of water, and number of bathers and other users.

#### **3.3 Programme design**

It should be noted that the existing programme was designed prior to the release of the 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 assessment of compliance with contact recreational guidelines.

The locations of the 13 sites sampled in the 2009-2010 programme are shown in Figure 1 and summarised in Table 4.

**Table 4** Location of bathing water bacteriological sampling sites 2009-2010

Beach	Location	GPS	Site code
Onaero	Opposite surf lifesaving club	1718158-5683163	SEA900085
Waitara	East Beach	1706602-5683915	SEA901033
	West Beach	1705951-5683802	SEA901037
Fitzroy	Opposite surf lifesaving club	1694948-5677598	SEA902025
Ngamotu	Centre of beach	1689937-5676009	SEA902062
Oakura	Opposite surf lifesaving club, west of Wairau Stream	1681895-5669965	SEA903030
	Opposite motorcamp, south of Waimoku Stream	1681621-5669839	SEA903032
Opunake	Centre of beach	1673723-5632044	SEA904090
Ohawe	Adjacent to boat ramp, east of Waingongoro River	1702638-5617432	SEA906010
Patea	Beach	1727220-5596442	SEA907020
	Mana Bay	1727532-5596415	SEA907022
Waverley	Western entrance	1739780-5589548	SEA907085
Wai-inu	Centre of beach	1749469-5585579	SEA907095

The beaches have been divided into two categories. Primary beach sites (black in Table 4) are monitored each year. Secondary sites (blue in Table 4) are monitored every third year in rotation. Table 5 below gives more information on the three-year rotation sampling programme.

**Table 5** Coastal bathing beach sampling programme

Annually sampled	Year 1	Year 2	Year 3
Waitara East	Patea	Bell Block	Wai-iti
Waitara West	Patea Bay **	East End	Urenui
Fitzroy	Waverley	Back Beach	Onaero Settlement
Ngamotu	Wai-inu		
Oakura CG			
Oakura SC			
Opunake			
Ohawe *			
Onaero (opp. surf club)			

\*since 1996-97

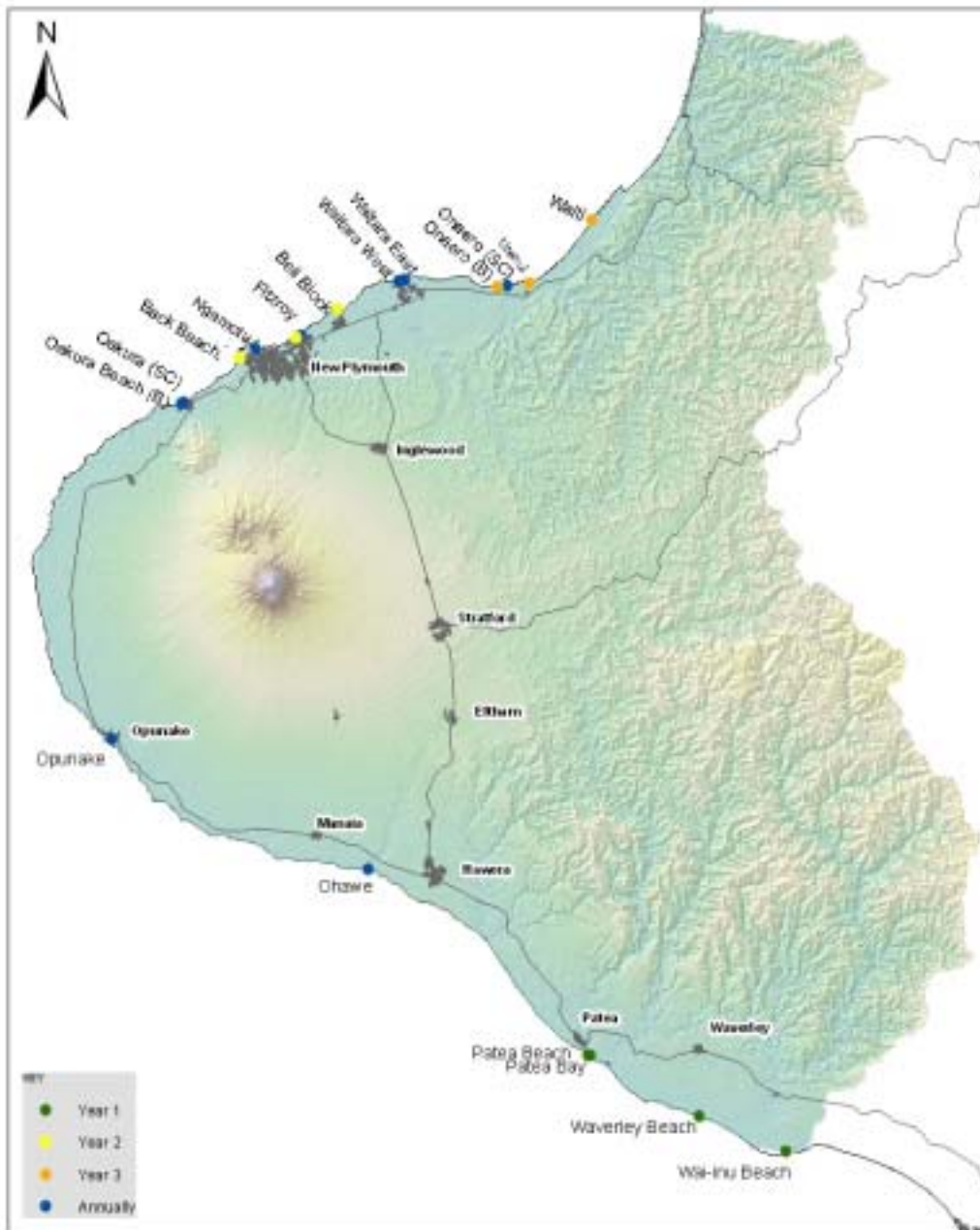
\*\* since 2000-01 summer period

\*\*\* since 2001-02 summer period

### 3.3.1 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 Health, TRC undertook to add seven sampling occasions to the SEM protocol at five of the most popular marine recreational sites (Onaero, Fitzroy, Ngamotu, Oakura and Opunake beaches) in the 2002-2003 period. These seven sampling occasions were systematically selected (one per week) 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. [NB: 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].



**Figure 1** SEM beach bathing bacteriological survey sites

### 3.4 Long-term trend analysis

Non-parametrical statistical trend analysis was undertaken on the seven sites which are sampled annually, as these sites had sufficient data to undertake such analysis. The trend analysis was applied only to data collected as part of the regular SEM sampling.

Data (seasonal medians) were trended using the software statistical analysis package STATISTICA, with the creation of scatterplots with trend line LOWESS (LOCally, WEighted Scatterplot Smoothing) set at 0.4. LOWESS describes the relationship between Y and X without assuming linearity or normality of residuals, and is a robust description of data pattern. Changes to the smoothing coefficient (stiffness or

tension) result in different smooth patterns, so the fit can be altered as desired. The tension ranges from 0 to 1 and dictates how closely the fitted line follows the data values. LOWESS with a tension of 0 fits the data values perfectly (i.e. a line joining each data point to the next) and at the other extreme a tension of 1.0 produces a near linear fit to the data points.

Trends were then analysed for significance using Kendall Tau correlations, resulting in a p-value which showed whether there was a significant trend and, if present, whether this was positive (improving water quality) or negative (decreasing water quality).

The False Discovery Rate (FDR) is defined as the expected proportion of true hypothesis rejected out of the total number of rejections. This can occur when multiple correlations are undertaken, as there is a chance that some of these will be found to be significant purely by chance – i.e. the overall Type I error rate is inflated. The most powerful method of dealing with this problem was advocated by Benjamini & Hochberg (1995). FDR analysis was applied to the p-values obtained while undertaking long-term trend analysis. The FDR adjusted p-value is therefore used to indicate the significance of the trend. A FDR adjusted p-value of  $< 0.05$  has been used to indicate a significant trend.

A brief comment has also been made in the summary of this report on the apparent changes in water quality at the remaining beaches, with the proviso that there is no statistical validity to the interpretation of this data.

## 4. Results

Sample timing in relation to tidal conditions is contained in Appendix I. Occasional samples were affected by localised rainfall and possibly elevated 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 2009 to late March 2010.

Sampling was confined 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.

All results are presented and discussed on a site-by-site basis for the sampling period, with the results for the sites with additional (seven) sampling occasions discussed for the four appropriate sites.

### 4.1 Onaero Beach

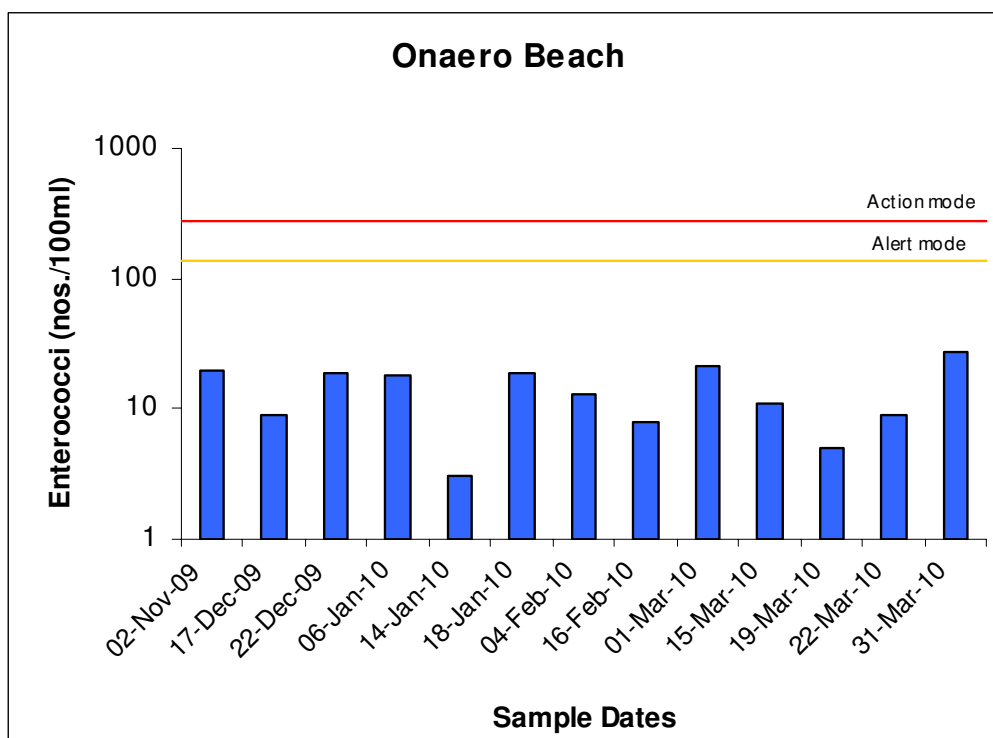
#### 4.1.1 SEM programme

Onaero Beach (Photograph 1) in north Taranaki, is a relatively popular bathing beach, especially over the Christmas holiday period. The Onaero River drains to the southern end of the beach and makes a significant contribution to bacteria counts subsequent to rainfall events.

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 Onaero Beach

Date	Time (NZST)	Conductivity @ 20° C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	1000	3390	110	20	110	15.2
17-Dec-09	0945	4350	39	9	43	18.3
22-Dec-09	1145	4040	94	19	96	17.4
06-Jan-10	1230	4480	98	18	100	17.9
14-Jan-10	0930	4720	5	3	5	17.6
18-Jan-10	1000	4350	68	19	68	18.2
04-Feb-10	1131	4670	24	13	24	20.5
16-Feb-10	1040	4710	32	8	32	20.8
01-Mar-10	0925	4700	9	21	9	21.3
15-Mar-10	0955	4650	5	11	5	18.0
19-Mar-10	1025	4690	7	5	7	16.1
22-Mar-10	1150	4580	35	9	35	18.6
31-Mar-10	0945	4700	1	27	1	17.7



**Figure 2** Enterococci numbers for Onaero Beach during the survey season

**Table 7** Statistical results summary for Onaero Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	3390	4720	4650
<i>E. coli</i>	cfu/100ml	13	1	110	32
Enterococci	cfu/100ml	13	3	27	13
Faecal coliforms	cfu/100ml	13	1	110	32
Temperature	°C	13	15.2	21.3	18.0

Bacteriological water quality was good, with relatively low levels of all bacteriological indicators during the bathing season.

#### 4.1.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 8.

**Table 8** Bacterial guidelines performance at Onaero Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

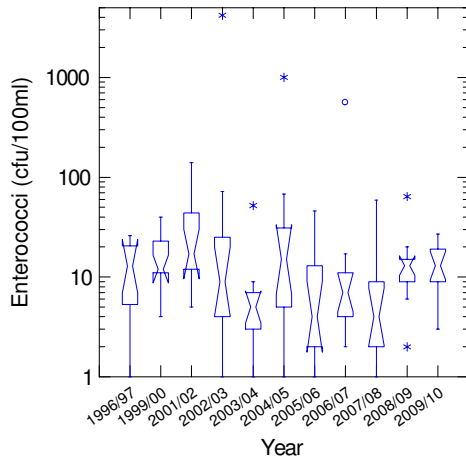
Enterococci levels in all samples were below 'Alert' and 'Action' guideline levels.

#### 4.1.3 Comparison with previous summers' surveys

A statistical comparison of each of the 11 summers' enterococci survey for Onaero Beach data is summarised in Table 9 and illustrated in Figure 3.

**Table 9** Summary of enterococci bacteriological water quality data (cfu/100ml) for all summer surveys at Onaero Beach to date

Summer	96/97	99/00	01/02	02/03	03/04	04/05	05/06
Minimum	1	4	5	< 1	<1	<1	<1
Maximum	26	40	140	4200	52	1000	46
Median	13	12	17	9	5	15	4
	<b>06/07</b>	<b>07/08</b>	<b>08/09</b>	<b>09/10</b>			
Minimum	2	<1	2	3			
Maximum	560	59	64	27			
Median	7	4	13	13			

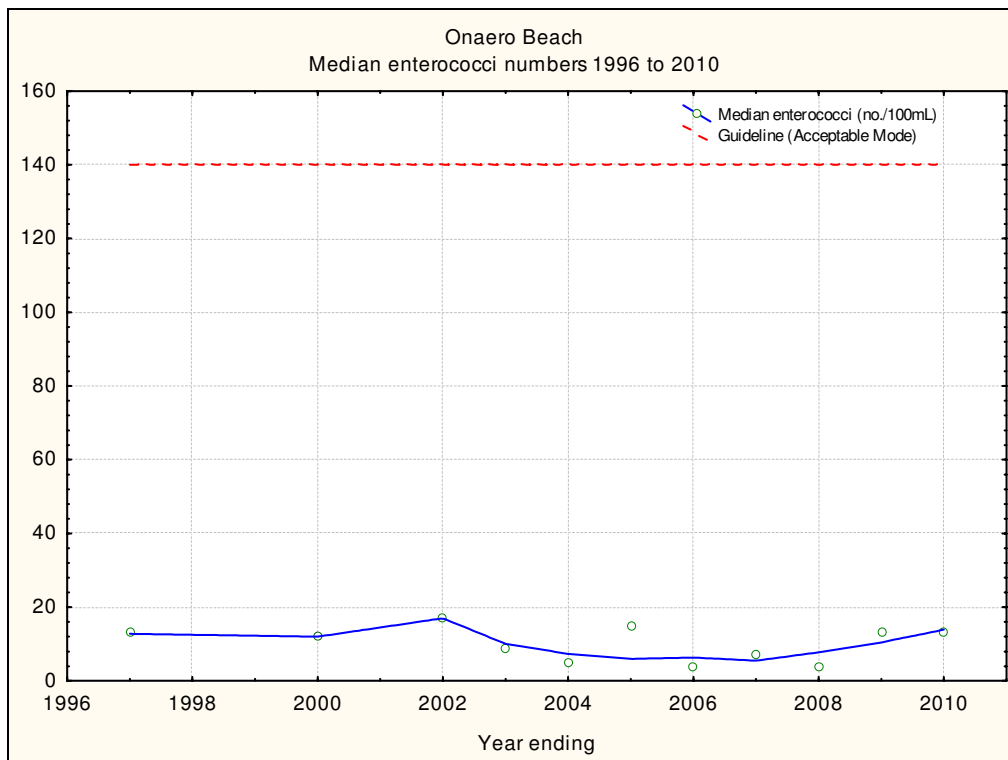


**Figure 3** Box and whisker plots for all summer SEM surveys of enterococci bacteria numbers at Onaero Beach

The levels of bacteria found in the current bathing season were similar to the previous period, and within the ranges of historical results.

#### 4.1.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over ten years from Onaero Beach. The results are presented in Figure 4 below.



**Figure 4** Long-term trend analysis for Onaero Beach (correlation not significant at  $p < 0.05$ )

Figure 4 above does not appear to display a long-term trend at Onaero Beach, with a very narrow range of seasonal medians. A p-value of 0.038 was obtained, with an FDR adjusted value of 0.115, this indicates that there was no statistically significant trend.

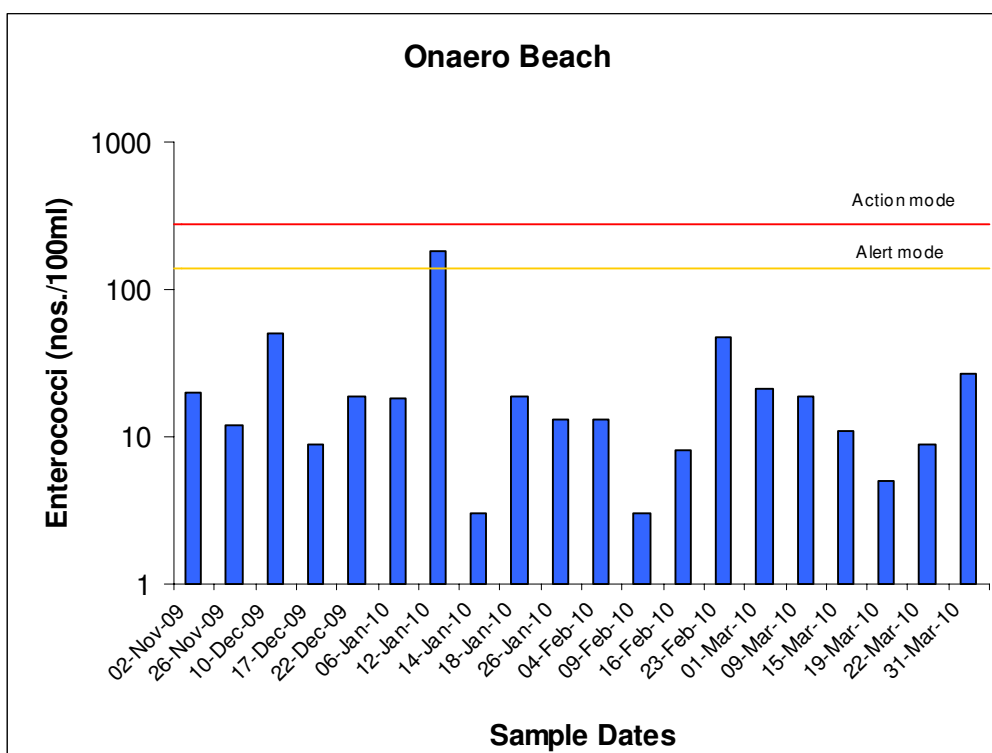
#### 4.1.5 MfE guidelines additional sampling

Seven additional samples were collected at regular intervals and under varying weather conditions during the survey season.

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

**Table 10** Onaero Beach additional seven water quality samples' results

Date	Time	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
	(NZST)		<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
26-Nov-09	0905	3910	140	12	140	16.0
10-Dec-09	0905	477	630	50	630	16.8
12-Jan-10	0900	4170	510	180	520	16.7
26-Jan-10	0840	4490	52	13	56	18.7
09-Feb-10	0855	4660	75	3	77	21.4
23-Feb-10	0940	4100	79	47	79	21.1
09-Mar-10	0935	1200	40	19	40	19.2



**Figure 5** Enterococci numbers for Onaero Beach for the 20 sample extended survey



**Table 11** Summary statistics for SEM and additional samples at Onaero Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	477	4720	4485
<i>E. coli</i>	cfu/100ml	20	1	630	46
Enterococci	cfu/100ml	20	3	180	16
Faecal coliforms	cfu/100ml	20	1	630	50
Temperature	°C	20	15.2	21.4	18.1

The additional sampling led to a slight increase in the overall seasonal median bacteria numbers for the various parameters. However, the maximum values increased significantly – from between 27 to 110 cfu/100ml without the additional samples, to 180 to 630 cfu/100ml with the additional samples. The very low conductivity on 10 December 2009 indicates freshwater intrusion as a reason for the increased numbers of *E. coli* and faecal coliforms in the sample.

One sample exceeded the 'Alert' level of 140 cfu/100ml on 12 January 2010, this was likely caused by elevated river flows following rain in the preceding few days.

#### 4.1.5.1 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 12.

**Table 12** Bacterial guidelines performance at Onaero Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 20 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	1 [5]	0 [0]

**Photograph 1** Onaero Beach

## 4.2 Waitara East Beach

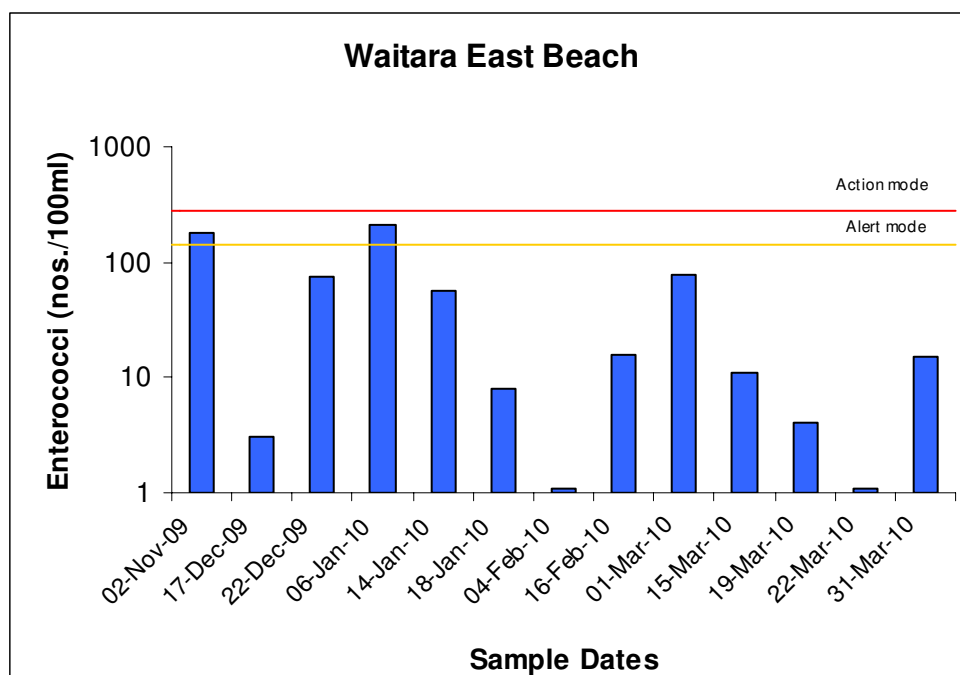
### 4.2.1 SEM programme

The area to the east of the Waitara River mouth is known as Waitara East Beach (Photograph 2). Results at this site are influenced by the Waitara River which, draining a large agricultural catchment, often contains high levels of bacteria. In addition, the primary treated domestic wastes from the Waitara township are discharged approximately 1800m out to sea.

The data for this site are presented in Table 13 and illustrated in Figure 6, with a statistical summary provided in Table 14.

**Table 13** Analytical results for Waitara East Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0915	4480	120	180	120	14.3
17-Dec-09	1015	4390	86	3	86	17.7
22-Dec-09	1225	3680	23	76	23	17.4
06-Jan-10	1320	3590	700	210	720	18.3
14-Jan-10	0845	4380	210	56	210	16.7
18-Jan-10	1035	4460	5	8	5	19.5
04-Feb-10	1200	4660	11	<1	11	20.8
16-Feb-10	1010	4660	6	16	6	20.4
01-Mar-10	0845	4660	77	79	77	20.8
15-Mar-10	910	4400	24	11	180	16.7
19-Mar-10	1105	4700	<1	4	<1	16.2
22-Mar-10	1230	4510	3	1	3	19.0
31-Mar-10	1015	4650	3	15	3	17.4



**Figure 6** Enterococci numbers for Waitara East Beach during the survey season

**Table 14** Statistical results summary for Waitara East Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	3590	4700	4480
<i>E. coli</i>	cfu/100ml	13	<1	700	23
Enterococci	cfu/100ml	13	<1	210	15
Faecal coliforms	cfu/100ml	13	<1	720	23
Temperature	°C	13	14.3	20.8	17.7

Median values were fairly low, ranging between 15 cfu/100ml (enterococci) and 23 cfu/100ml (*E. coli* and faecal coliforms). Maxima were elevated on more than one occasion, with *E. coli* and faecal coliforms values of 700 and 720 cfu/100ml. Rainfall, resulting in increased freshwater input from the Waitara River, was the likely cause of the increased numbers of bacteria on 6 and 14 January 2010, while high levels of bacteria on 2 November 2009 were unexplained.

#### 4.2.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 15.

**Table 15** Bacterial guidelines performance at Waitara East Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	2 [15]	0 [0]

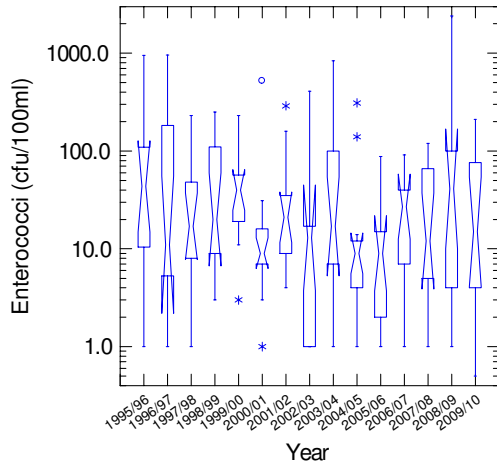
Two samples (15%) exceeded the 'Alert' level guidelines during the bathing season.

#### 4.2.3 Comparison with previous summers' surveys

A statistical comparison of each of the 15 summer's survey data for Waitara East Beach are summarised in Table 16 and illustrated in Figure 7.

**Table 16** Summary of enterococci bacteriological water quality data (cfu/100 ml) for all summer surveys at Waitara East Beach to date

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Minimum	1	1	1	3	3	1	4	<1
Maximum	950	960	230	250	230	520	290	410
Median	14	11	17	20	40	9	21	13
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	
Minimum	<1	1	<1	1	1	<1	<1	
Maximum	840	310	88	91	120	2400	210	
Median	17	9	9	27	12	41	15	

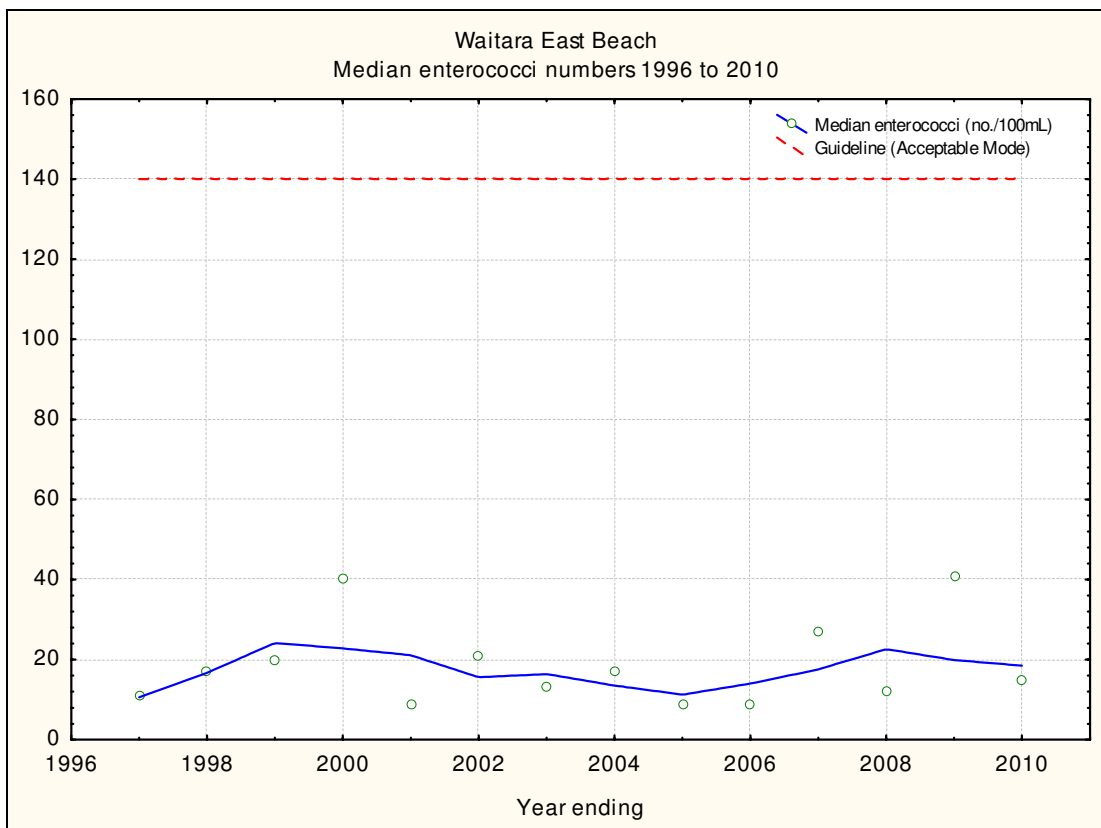


**Figure 7** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Waitara East Beach

Minima, maxima and median values were within the ranges of previous results. Figure 7 shows results from this site improved compared to the previous monitoring period.

#### 4.2.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 15 years from Waitara East Beach. The results are presented in Figure 8 below and in Appendix III.



**Figure 8** Long-term trend analysis for Waitara East Beach (correlation not significant at  $p < 0.05$ )

The results for Waitara East Beach do not appear to show a trend of increasing or decreasing water quality, with generally low median values. A p-value of 0.779, FDR adjusted to 0.822 confirmed this lack of trend in the data.



Photograph 2 Waitara East Beach

## 4.3 Waitara West Beach

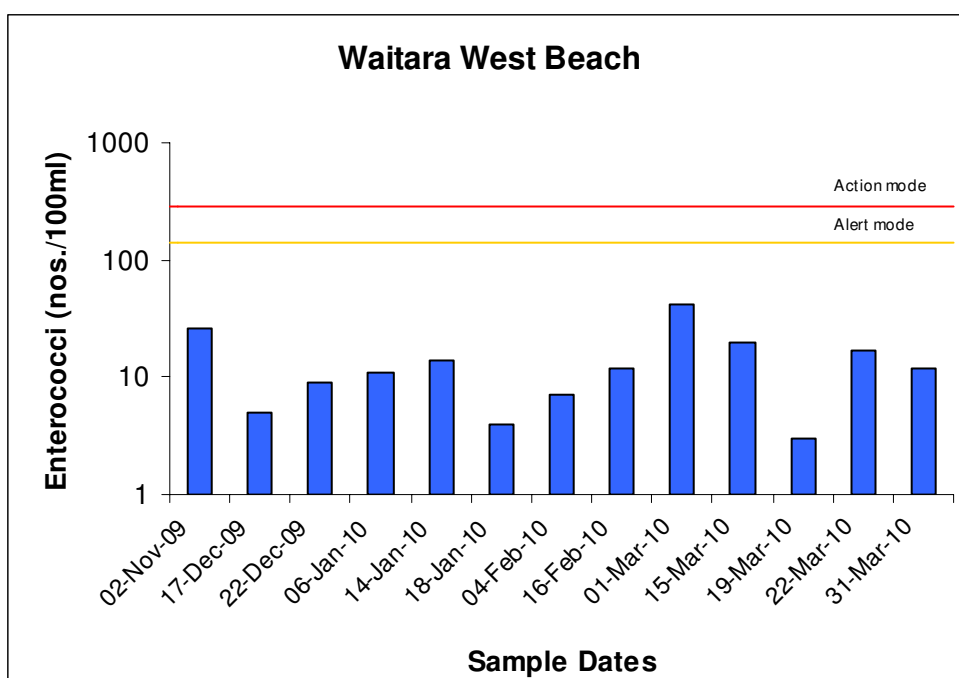
### 4.3.1 SEM programme

The area to the west of the Waitara River mouth is known as Waitara West Beach (Photograph 3). As with Waitara East Beach, the results at this site are influenced by the Waitara River and the discharge of primary treated domestic wastes from the Waitara township.

The data for this site are presented in Table 17 and illustrated in Figure 9, with a statistical summary provided in Table 18.

Table 17 Analytical results for Waitara West Beach

Date	Time (NZST)	Conductivity @ 20° C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0845	4590	34	26	34	14.1
17-Dec-09	1045	3270	77	5	77	19.0
22-Dec-09	1250	4570	<1	9	<1	17.6
06-Jan-10	1335	4140	32	11	33	19.4
14-Jan-10	0820	4700	57	14	57	16.6
18-Jan-10	1110	4080	7	4	7	19.6
04-Feb-10	1230	4440	9	7	11	22.0
16-Feb-10	0945	4690	1	12	1	20.7
01-Mar-10	0825	4670	54	42	54	20.5
15-Mar-10	0840	4550	3	20	3	16.5
19-Mar-10	1125	4650	8	3	8	16.4
22-Mar-10	1300	4600	60	17	68	18.7
31-Mar-10	1045	4720	12	12	20	18.5



**Figure 9** Enterococci numbers for Waitara West Beach during the survey season

**Table 18** Statistical results summary for Waitara West Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	3270	4720	4590
<i>E. coli</i>	cfu/100ml	13	<1	77	12
Enterococci	cfu/100ml	13	3	42	12
Faecal coliforms	cfu/100ml	13	<1	77	20
Temperature	°C	13	14.1	22.0	18.7

Median values were fairly low, ranging between 12 cfu/100ml (*E. coli* and enterococci) and 20 cfu/100ml (faecal coliforms). Maxima were also generally low ranging between 42 and 77 cfu/100ml.

### 4.3.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 19.

**Table 19** Bacterial guidelines performance at Waitara West Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

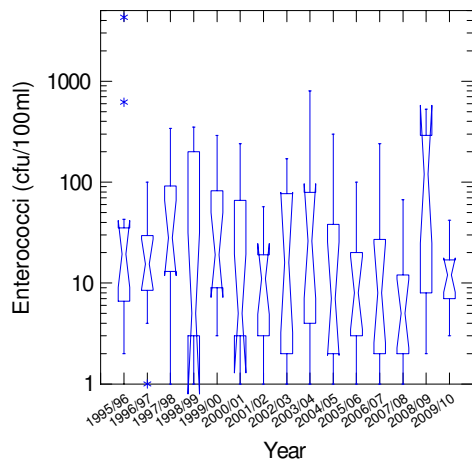
All samples were below the 'Alert' level guidelines, indicating water suitable for contact recreation.

### 4.3.3 Comparison with previous summers' surveys

A statistical comparison of each of the 15 summer's survey data for Waitara West Beach are summarised in Table 20 and illustrated in Figure 10.

**Table 20** Summary of enterococci bacteriological water quality data (cfu/100 ml) for all summer surveys at Waitara West Beach to date

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Minimum	2	1	1	1	3	1	1	1
Maximum	4300	100	340	350	290	240	57	170
Median	21	16	28	5	19	5	11	16
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	
Minimum	1	1	1	1	1	2	3	
Maximum	800	300	100	240	67	530	42	
Median	26	7	8	8	5	120	12	



**Figure 10** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Waitara West Beach

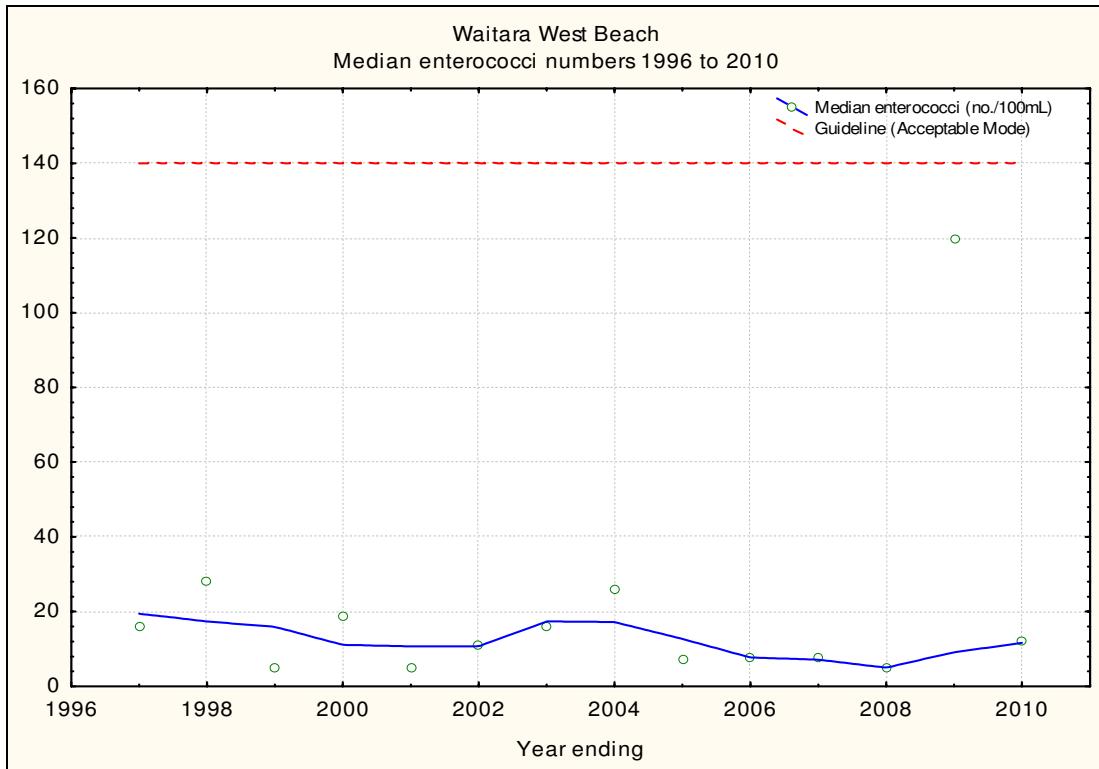
Minima, maxima and median values were within the ranges of previous results. Figure 10 show results were improved compared to the previous monitoring period.



**Photograph 3** Waitara West Beach

### 4.3.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 15 years from Waitara West Beach. The results are presented in Figure 11 below and in Appendix III.



**Figure 11** Long-term trend analysis for Waitara West Beach (correlation not significant at  $p < 0.05$ )

The results for Waitara West Beach do not appear to show a trend of increasing or decreasing water quality, with generally low median values for all years. A p-value of 0.822 confirmed this lack of trend in the data.

## 4.4 Fitzroy Beach

### 4.4.1 SEM programme

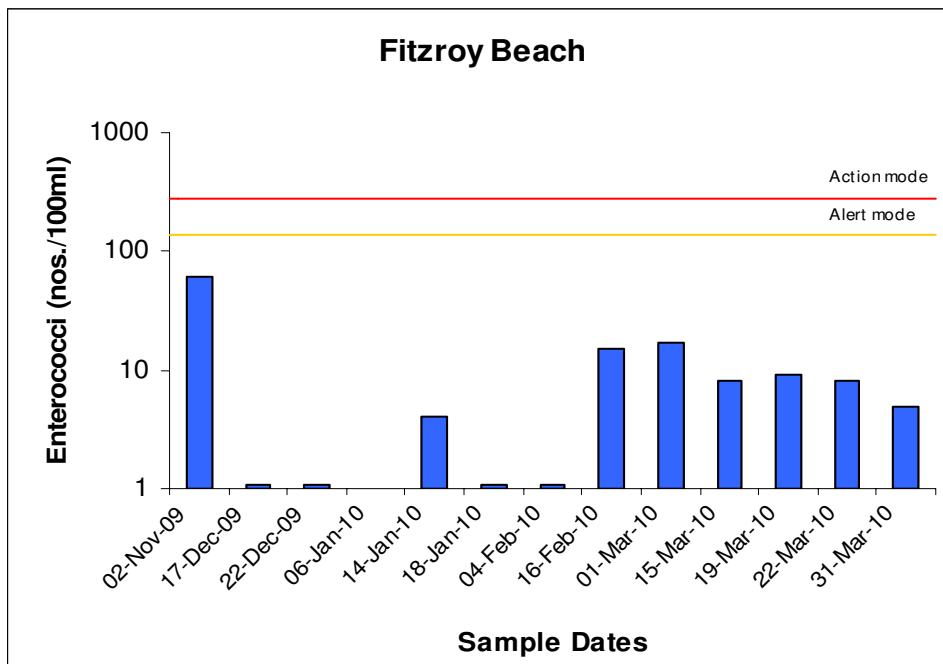
Fitzroy Beach (Photograph 4) is situated in New Plymouth and is one of the most popular bathing beaches in Taranaki. It is also a very popular year-round surfing beach, especially for young surfers due to its central location. The mouth of the Waiwhakaiho River enters the sea at the eastern end of the beach, approximately 800m from the sample site, which can contribute significant amounts of freshwater during floods. Draining from a highly modified agricultural and industrial catchment, this can have a significant impact on bacteriological water quality subsequent to heavy rainfall.

The data for this site are presented in Table 21 and illustrated in Figure 12, with a statistical summary provided in Table 22.



**Table 21** Analytical results for Fitzroy Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0925	4440	89	60	95	14.3
17-Dec-09	0950	4640	<1	<1	<1	16.9
22-Dec-09	1250	4680	<1	<1	<1	15.4
06-Jan-10	1330	4760	<1	1	<1	16.4
14-Jan-10	1030	4710	3	4	3	16.9
18-Jan-10	1105	4680	<1	<1	<1	18.0
04-Feb-10	1240	4750	3	<1	3	19.9
16-Feb-10	1030	4720	11	15	11	19.7
01-Mar-10	1115	4690	13	17	13	20.8
15-Mar-10	0945	4650	16	8	16	16.1
19-Mar-10	1110	4640	7	9	7	15.0
22-Mar-10	1320	4580	11	8	11	17.7
31-Mar-10	0950	4710	7	5	8	18.4

**Figure 12** Enterococci numbers for Fitzroy Beach during the survey season**Table 22** Statistical results summary for Fitzroy Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4440	4760	4680
<i>E. coli</i>	cfu/100ml	13	3	89	11
Enterococci	cfu/100ml	13	1	60	8
Faecal coliforms	cfu/100ml	13	3	95	11
Temperature	°C	13	14.3	20.8	16.9

Bacteriological water quality at Fitzroy Beach was good throughout the season, with low median values of all bacteriological parameters.

#### 4.4.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 23.

**Table 23** Bacterial guidelines performance at Fitzroy Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

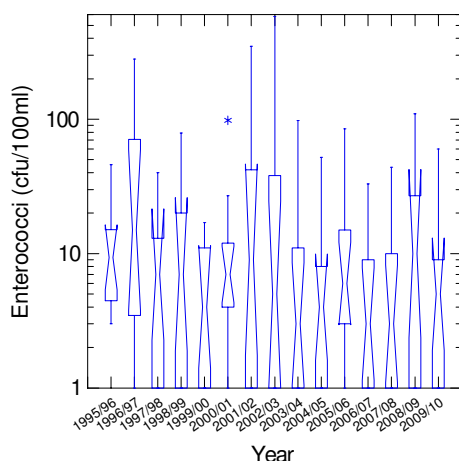
No single samples exceeded either the 'Alert' or 'Action' modes during the season.

#### 4.4.3 Comparison with previous summers' surveys

A statistical comparison of each of the 14 summers' survey data for Fitzroy Beach is summarised in Table 24 and illustrated in Figure 13.

**Table 24** Summary of enterococci bacteriological water quality data (cfu/100 ml) for all summer surveys at Fitzroy Beach to date

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Minimum	3	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Maximum	46	280	40	79	17	98	350	580
Median	10	15	7	7	4	7	9	5
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	
Minimum	<1	<1	<1	<1	<1	<1	1	
Maximum	98	52	85	33	44	110	60	
Median	3	4	6	3	3	10	8	

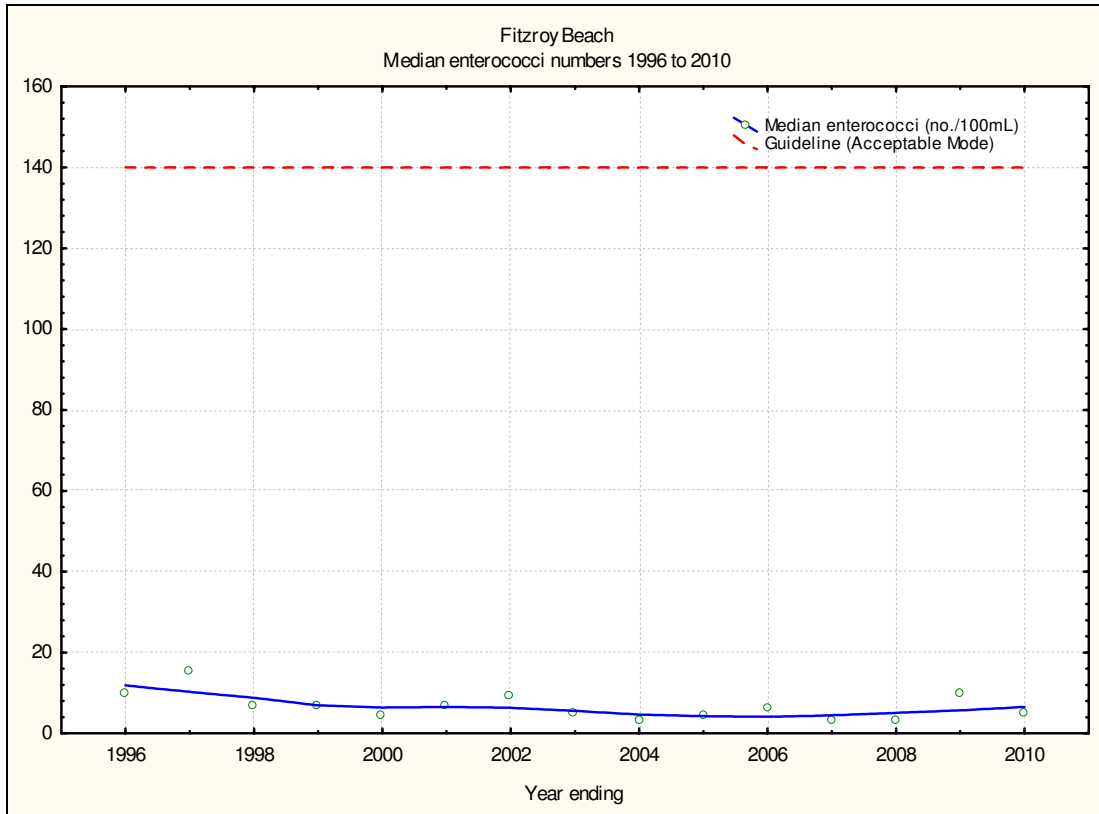


**Figure 13** Box and whisker plots for all summer SEM surveys of enterococci bacteria numbers at Fitzroy Beach

Figure 13 shows that minimum, maximum and median values were within the ranges of previous results and slightly better than the previous monitoring period.

#### 4.4.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 15 years from Fitzroy Beach. The results are presented in Figure 14 below and in Appendix III.



**Figure 14** Long-term trend analysis for Fitzroy Beach (correlation not significant at  $p < 0.05$ )

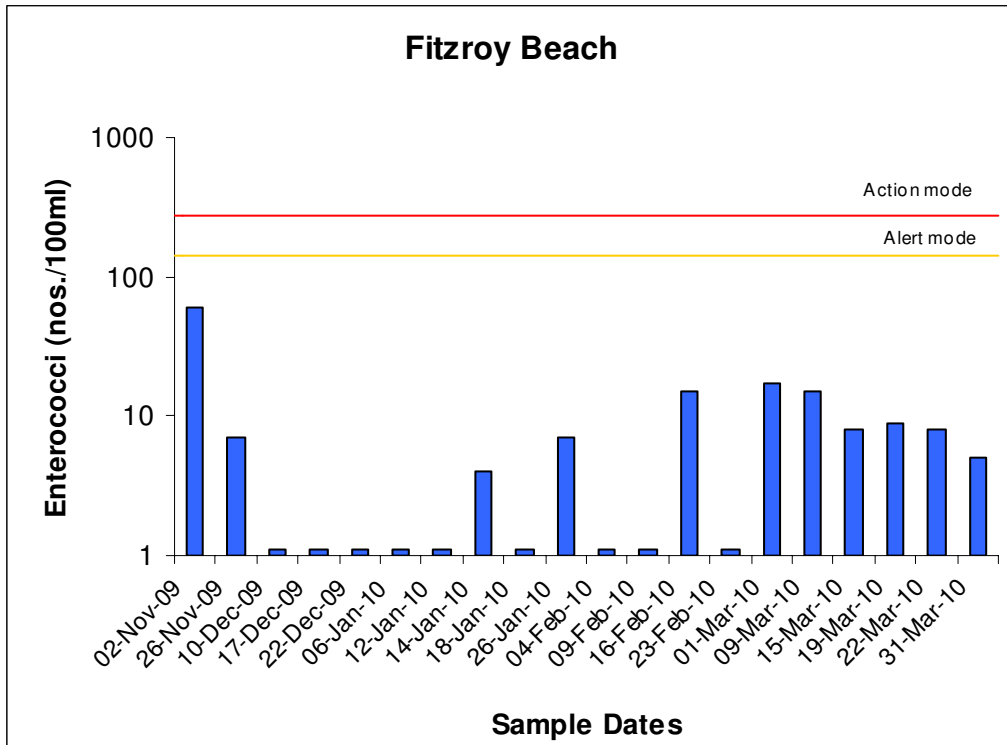
The results for Fitzroy Beach do not appear to show a trend of increasing or decreasing water quality, with generally low median values for all years. A p-value of 0.038, FDR adjusted to 0.115 confirmed this lack of trend in the data.

#### 4.4.5 MfE guidelines additional sampling

Seven additional samples were collected at regular intervals and under varying weather conditions during the survey season. The data from these additional surveys are presented in Table 25, illustrated in Figure 15, and statistically summarised (together with the 13 SEM samples' data) in Table 26.

**Table 25** Fitzroy Beach additional seven water quality samples' results

Date	Time	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
	(NZST)		<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
26-Nov-09	1040	4630	12	7	12	15.2
10-Dec-09	1000	4440	4	<1	4	17.8
12-Jan-10	1010	4770	<1	1	<1	15.9
26-Jan-10	1005	4650	4	7	4	18.3
09-Feb-10	1015	4720	<1	<1	<1	21.4
23-Feb-10	1110	4710	<1	<1	<1	20.6
09-Mar-10	1045	4700	1	15	1	19.1



**Figure 15** Enterococci numbers for Fitzroy Beach for the 20 sample extended survey

**Table 26** Summary statistics for SEM and additional samples at Fitzroy Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	4440	4770	4685
<i>E. coli</i>	cfu/100ml	20	<1	89	4
Enterococci	cfu/100ml	20	<1	60	5
Faecal coliforms	cfu/100ml	20	<1	95	4
Temperature	°C	20	14.3	21.4	17.8

In comparison with the regular SEM programme, these seven additional samples resulted in a reduction of bacteria minimum and median values, while maximum values remained the same.

#### 4.4.5.1 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 27.

**Table 27** Bacterial guidelines performance at Fitzroy Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 20 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

All 20 samples fell below the 'Alert' guidelines.



**Photograph 4** Fitzroy Beach

## 4.5 Ngamotu Beach

### 4.5.1 SEM programme

Ngamotu Beach (Photograph 5) is situated within Port Taranaki, and as such is within close proximity to boat traffic and Port activities. In addition, it receives urban stormwater and a piped stream. Ngamotu Beach is a very popular bathing beach, especially for young children, school groups and sports events/training, as the two breakwaters provide shelter from sea swells and hence a relatively calm and safe swimming area.

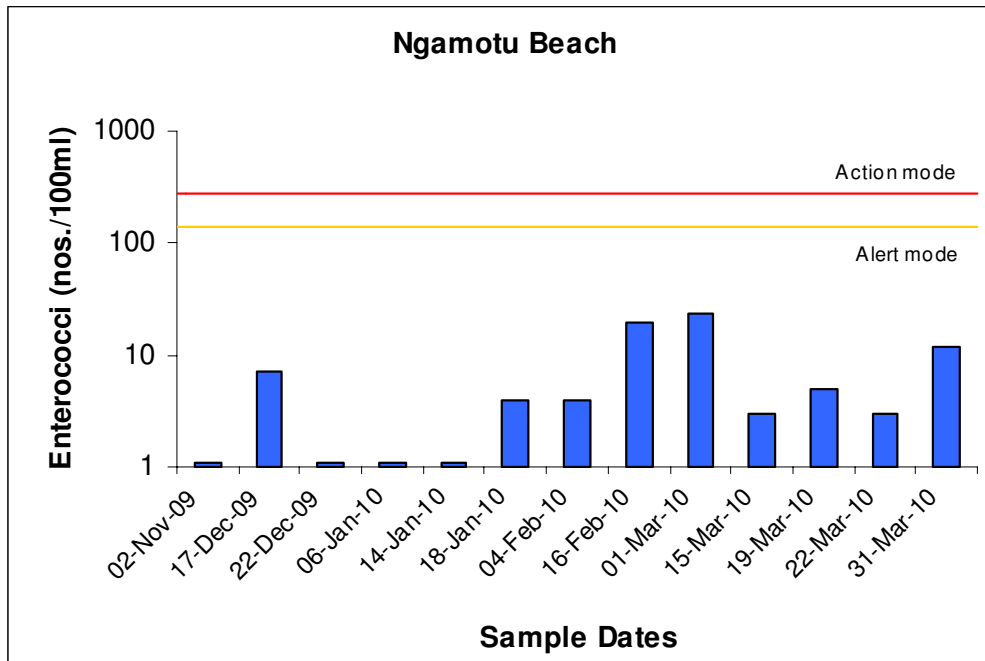
Data from the site are presented in Table 28 and illustrated in Figure 16, with a statistical summary provided in Table 29.

**Table 28** Analytical results for Ngamotu Beach

Date	Time (NZST)	Conductivity @ 20° C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0845	4720	1	<1	1	14.3
17-Dec-09	0855	4470	12	7	12	17.0
22-Dec-09	1205	4710	<1	<1	<1	16.9
06-Jan-10	1300	4720	5	<1	5	17.8
14-Jan-10	0910	4760	1	<1	1	16.5
18-Jan-10	1015	4650	<1	4	<1	20.5
04-Feb-10	1210	4730	5	4	5	21.8
16-Feb-10	0945	4720	5	20	5	19.7
01-Mar-10	0920	4680	11	23	11	20.4
15-Mar-10	0900	4710	1	3	1	15.4
19-Mar-10	1025	4720	3	5	3	15.6
22-Mar-10	1241	4700	12	3	12	17.9
31-Mar-10	0905	4680	12	12	12	17.3

**Table 29** Statistical results summary for Ngamotu Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4470	4760	4710
<i>E. coli</i>	cfu/100ml	13	<1	12	5
Enterococci	cfu/100ml	13	<1	23	4
Faecal coliforms	cfu/100ml	13	<1	12	5
Temperature	°C	13	14.3	21.8	17.3

**Figure 16** Enterococci numbers for Ngamotu Beach during the survey season

Median and maximum values for all parameters were fairly low throughout the season, indicating good water quality at this site.

#### 4.5.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 30.

**Table 30** Bacterial guidelines performance at Ngamotu Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

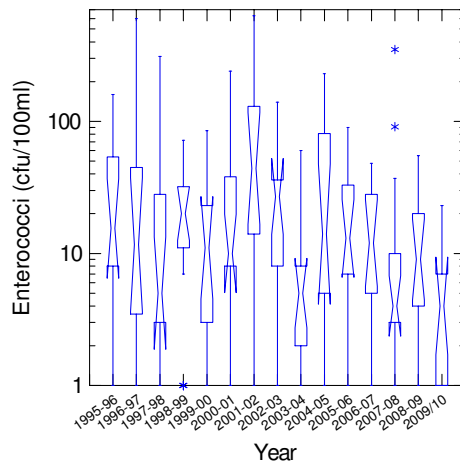
All samples were below 'Alert' guideline levels.

#### 4.5.3 Comparison with previous summers' surveys

A statistical comparison of each of the 14 summers' survey data for the Ngamotu Beach site is summarised in Table 31 and illustrated in Figure 17.

**Table 31** Summary of enterococci bacteriological water quality data (cfu/100 ml) all summer surveys at Ngamotu Beach

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Minimum	< 1	1	< 1	< 1	< 1	< 1	1	< 1
Maximum	160	600	310	72	85	240	630	140
Median	16	13	5	20	11	10	44	27
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	
Minimum	< 1	< 1	1	1	1	1	< 1	
Maximum	60	230	90	48	350	55	23	
Median	5	14	13	12	4	9	4	



**Figure 17** Box & whisker plots for all summer surveys of enterococci bacterial numbers at Ngamotu Beach

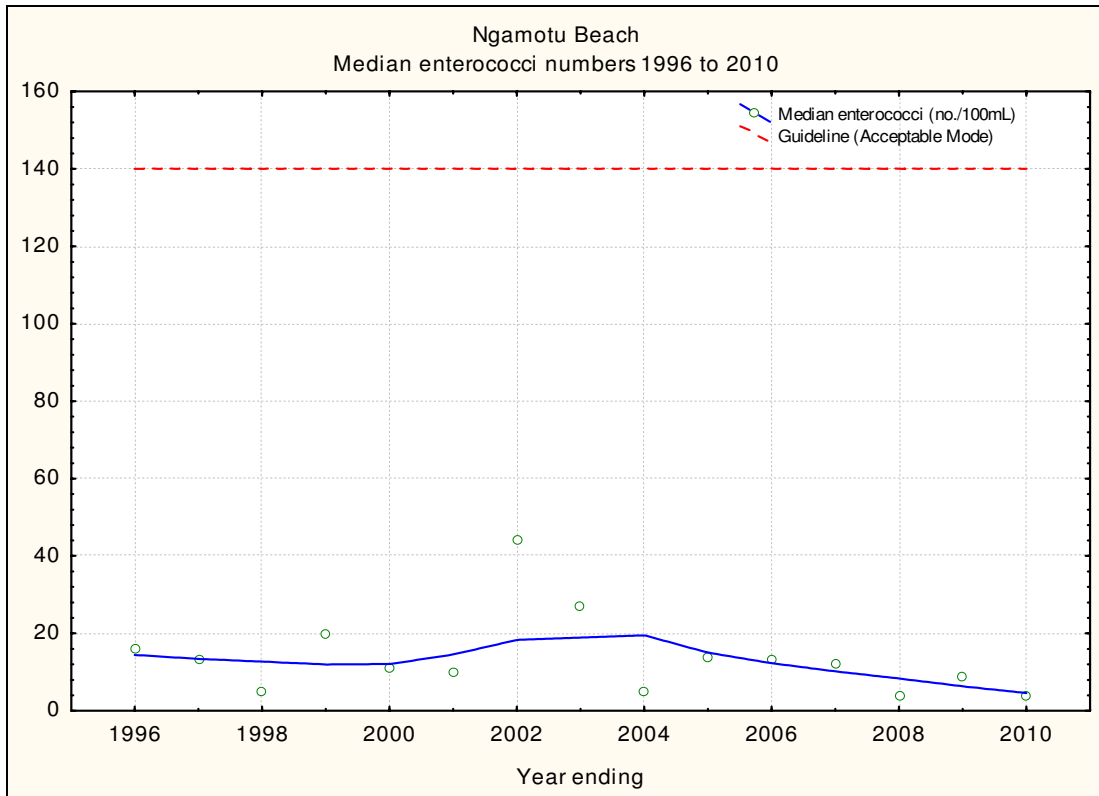
At 23 enterococci/100ml, the maximum value was the lowest recorded to date for the Ngamotu Beach site, as was the median of 4 cfu/100ml. Figure 13 shows the water quality was the best recorded since sampling began in 1995.



**Photograph 5** Ngamotu Beach

#### 4.5.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 15 years from Ngamotu Beach. The results are presented in Figure 18 below and in Appendix III.



**Figure 18** Long-term trend analysis for Ngamotu Beach (correlation not significant at  $p < 0.05$ )

Figure 18 does not appear to show any trend for water quality. A p-value of 0.071, FDR adjusted to 0.159, confirmed the lack of a trend.

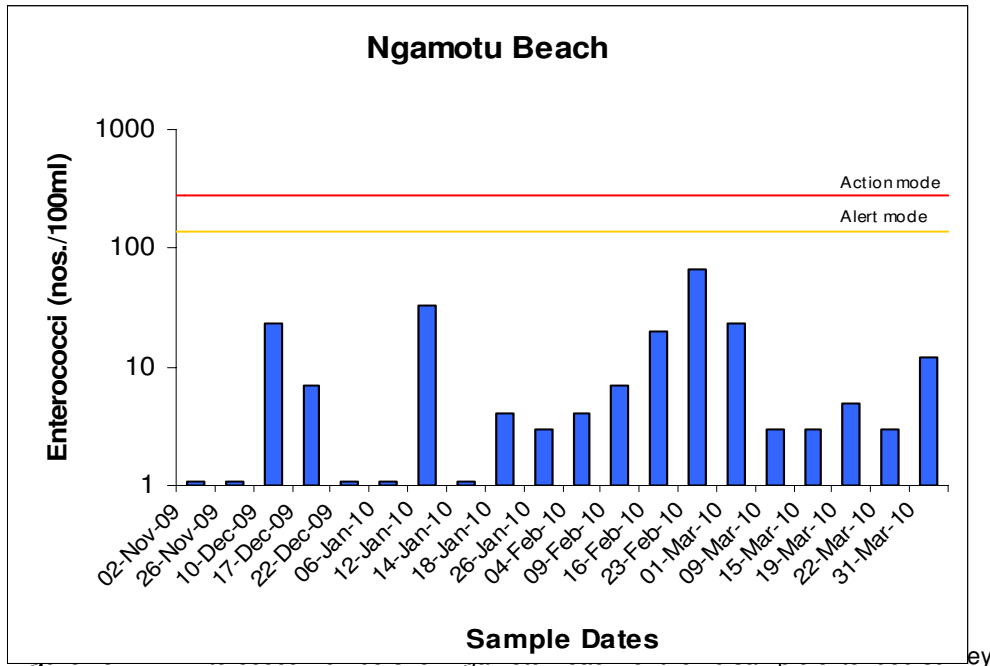
#### 4.5.5 MfE guidelines additional sampling

Seven additional samples were collected at regular intervals and under varying weather conditions during the survey season. The data from these additional surveys are presented in Table 32, illustrated in Figure 19, and statistically summarised (together with the 13 SEM samples' data) in Table 33.

**Table 32** Ngamotu Beach additional seven water quality samples' results

Date	Time	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
	(NZST)		<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
26-Nov-09	1130	4660	5	1	5	16.3
10-Dec-09	1040	4390	13	23	13	18.3
12-Jan-10	1035	4700	<1	33	<1	16.1
26-Jan-10	1035	4580	<1	3	<1	19.6
09-Feb-10	1045	4680	<1	7	<1	21.9
23-Feb-10	1220	3830	52	67	56	22.7
09-Mar-10	1200	4630	7	3	7	21.2





**Table 33** Summary statistics for SEM and additional samples at Ngamotu Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	3830	4760	4690
<i>E. coli</i>	cfu/100ml	20	<1	52	5
Enterococci	cfu/100ml	20	<1	67	4
Faecal coliforms	cfu/100ml	20	<1	56	5
Temperature	°C	20	14.3	22.7	17.9

The additional samples resulted in the same minimum and median values for all three indicator bacteria, however maxima increased slightly.

#### 4.5.5.1 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 34.

**Table 34** Bacterial guidelines performance at Ngamotu Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 20 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

All of the samples were below the 'Alert' level guideline value.

## 4.6 Oakura Beach SC (opposite surf lifesaving club)

### 4.6.1 SEM programme

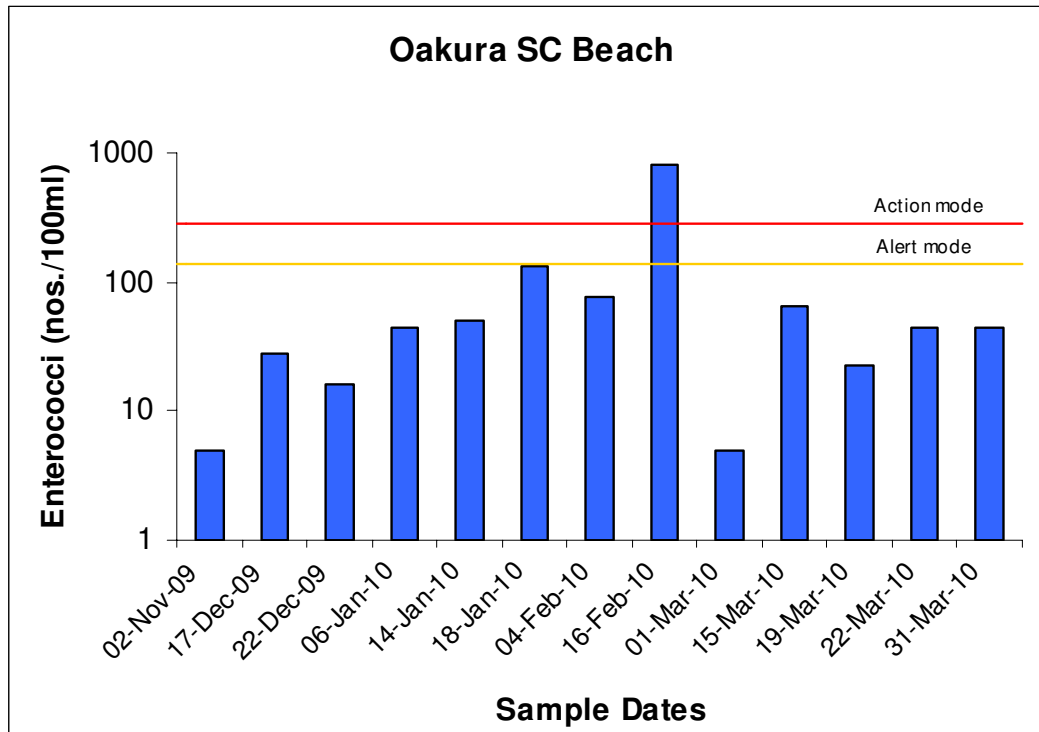
Oakura Beach (Photograph 6) is a popular bathing beach during summer, and a popular year-round surfing beach.

With two small lowland streams entering the beach on either side of the site, levels of bacteria found at this site can increase significantly during periods of high rainfall.

Data from the site are presented in Table 35 and illustrated in Figure 20, with a statistical summary provided in Table 36.

**Table 35** Analytical results for Oakura Beach SC

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0825	4660	19	5	20	13.7
17-Dec-09	0830	4350	99	28	100	15.9
22-Dec-09	1135	4490	12	16	15	16.7
06-Jan-10	1235	4590	46	44	48	16.9
14-Jan-10	0840	4600	110	51	110	16.3
18-Jan-10	0945	4170	100	130	100	19.0
04-Feb-10	1140	4500	59	76	59	20.1
16-Feb-10	0915	2770	7000	800	7000	18.7
01-Mar-10	0845	4670	3	5	4	19.4
15-Mar-10	0830	4530	28	66	29	15.6
19-Mar-10	1000	4640	23	23	24	14.9
22-Mar-10	1220	4650	45	45	47	17.3
31-Mar-10	0840	4260	29	45	36	16.8



**Figure 20** Enterococci numbers for Oakura Beach SC during the survey season

**Table 36** Statistical results summary for Oakura Beach SC

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	2770	4670	4530
<i>E. coli</i>	cfu/100ml	13	3	7000	45
Enterococci	cfu/100ml	13	5	800	45
Faecal coliforms	cfu/100ml	13	4	7000	47
Temperature	°C	13	13.7	20.1	16.8

Median bacteria levels at this site were moderate at 45 cfu/100ml (*E. coli* and enterococci) and 47 cfu/100ml (faecal coliforms). Maxima were very high on 16 February, with 7000 cfu/100ml for both *E. coli* and faecal coliforms and 800 cfu/100ml for enterococci. Cow shed effluent was observed in the Wairau Stream, adjacent to the sampling site and was the reason for the high numbers of bacteria (this had stopped within ten minutes and investigation found a problem with a pump had caused the overflow). A follow-up sample was collected on 18 February, and as this was below 280 enterococci/100ml, the 'Action' guideline was not exceeded.

#### 4.6.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 37.

**Table 37** Bacterial guidelines performance at Oakura Beach SC

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	1 [8]	0 [0]

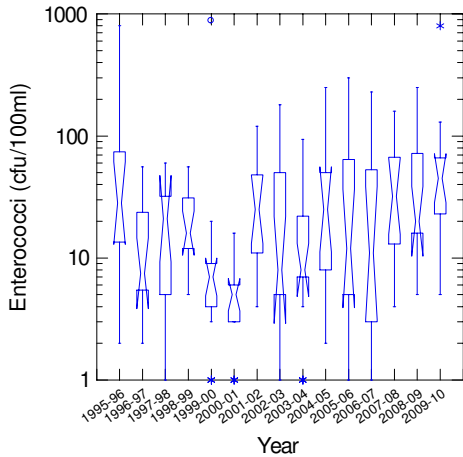
One of the 13 samples (8%) exceeded the 'Alert' level during the bathing season. Although this sample was above 280cfu/100ml, the 'Action' level was not exceeded as a follow-up sample was below 280cfu/100ml.

#### 4.6.3 Comparison with previous summers' surveys

A statistical comparison of each of the 15 summers' survey data for Oakura opposite the surf lifesaving club are summarised in Table 38 and illustrated in Figure 21.

**Table 38** Summary of enterococci bacteriological water quality data (cfu/100ml) for all summer surveys at Oakura SC to date

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Minimum	< 3	< 3	< 1	5	< 1	1	4	1
Maximum	800	56	60	56	880	16	120	180
Median	31	8	21	16	7	5	25	8
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	
Minimum	< 1	2	1	<1	4	5	5	
Maximum	94	250	300	230	160	250	800	
Median	8	25	12	11	32	20	45	

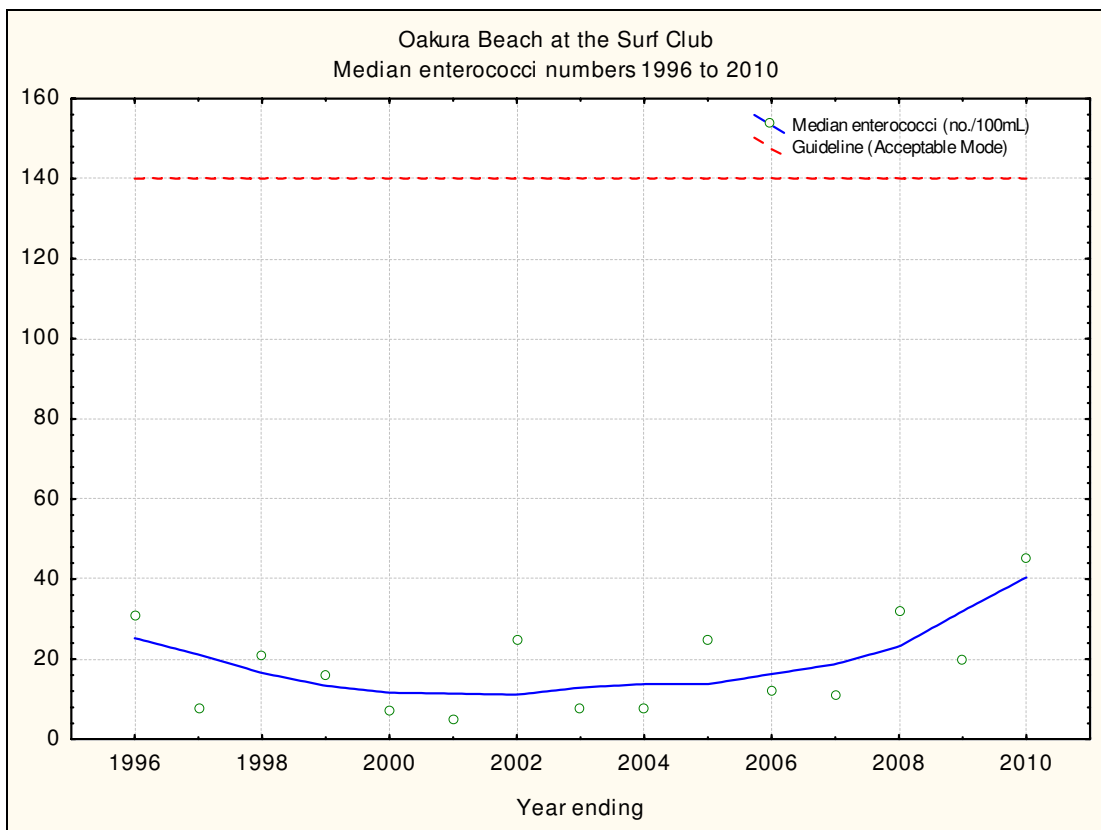


**Figure 21** Box & whisker plots for all summer surveys of enterococci bacterial numbers at Oakura SC to date

The median was the highest found to date, while the maximum was one among the highest.

#### 4.6.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 15 years from Oakura Beach at the Surf Club. The results are presented in Figure 22 below and in Appendix III.



**Figure 22** Long-term trend analysis for Oakura Beach at the Surf Club (correlation not significant at  $p < 0.05$ )

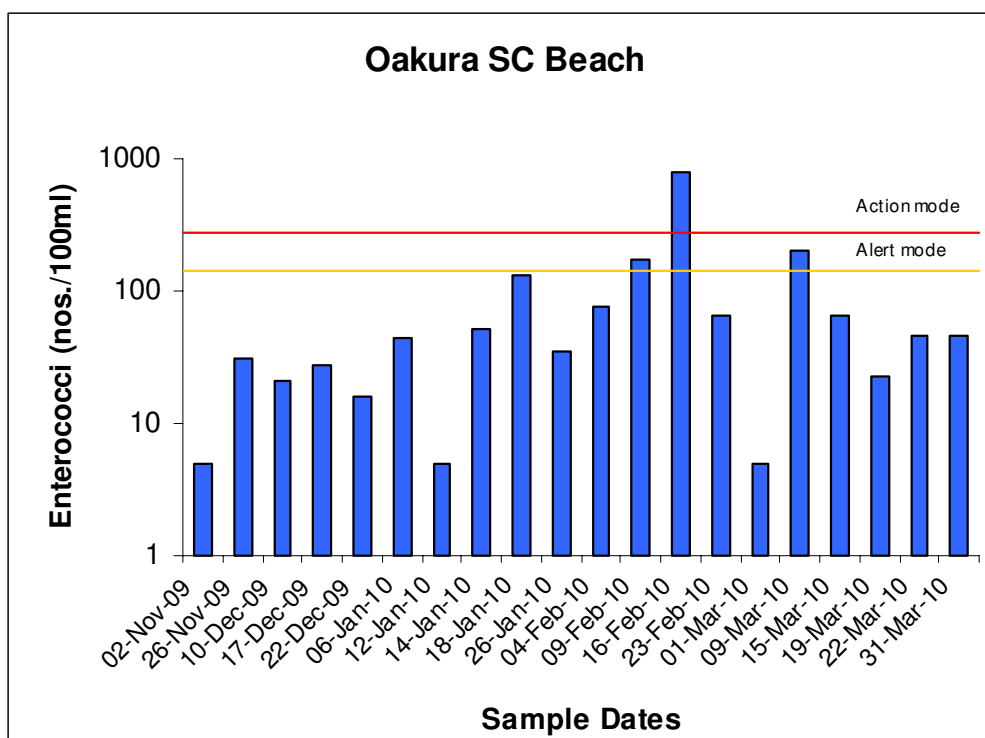
Figure 22 appears to show a trend towards decreasing water quality since 2000 at the Oakura Beach Surf Club site. However, a p-value of 0.246, FDR adjusted to 0.369, showed that there was no trend at this site.

#### 4.6.5 MfE guidelines additional sampling

Seven additional samples were collected at irregular intervals and under varying weather conditions during the survey season. The data from these additional surveys are presented in Table 39, illustrated in Figure 23, and statistically summarised (together with the 13 SEM samples' data) in Table 40.

**Table 39** Oakura Beach SC additional seven water quality samples' results

Date	Time	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
	(NZST)		<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
26-Nov-09	1200	4500	54	31	54	16.2
10-Dec-09	1115	4050	45	21	45	17.6
12-Jan-10	1110	4040	8	5	10	16.4
26-Jan-10	1100	4600	32	35	35	17.1
09-Feb-10	1110	4430	85	170	85	21.7
23-Feb-10	1300	4390	36	65	37	21.4
09-Mar-10	1230	3670	32	200	32	21.4



**Figure 23** Enterococci numbers for Oakura Beach SC for the 20 sample extended survey

**Table 40** Summary statistics for SEM and additional samples at Oakura Beach SC

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	2770	4670	4495
<i>E. coli</i>	cfu/100ml	20	3	7000	41
Enterococci	cfu/100ml	20	5	800	45
Faecal coliforms	cfu/100ml	20	4	7000	41
Temperature	°C	20	13.7	21.7	17.0

The additional samples resulted in similar values for all parameters for all bacteriological indicators.

#### 4.6.5.1 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 41.

**Table 41** Bacterial guidelines performance at Oakura Beach SC

Parameter	Number of exceedances of enterococci guidelines [ % of 20 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	3 [15]	0 [0]

The extra samples resulted in two further samples exceeding 'Alert' levels.



**Photograph 6** Oakura Beach

## 4.7 Oakura Beach CG (opposite camp ground)

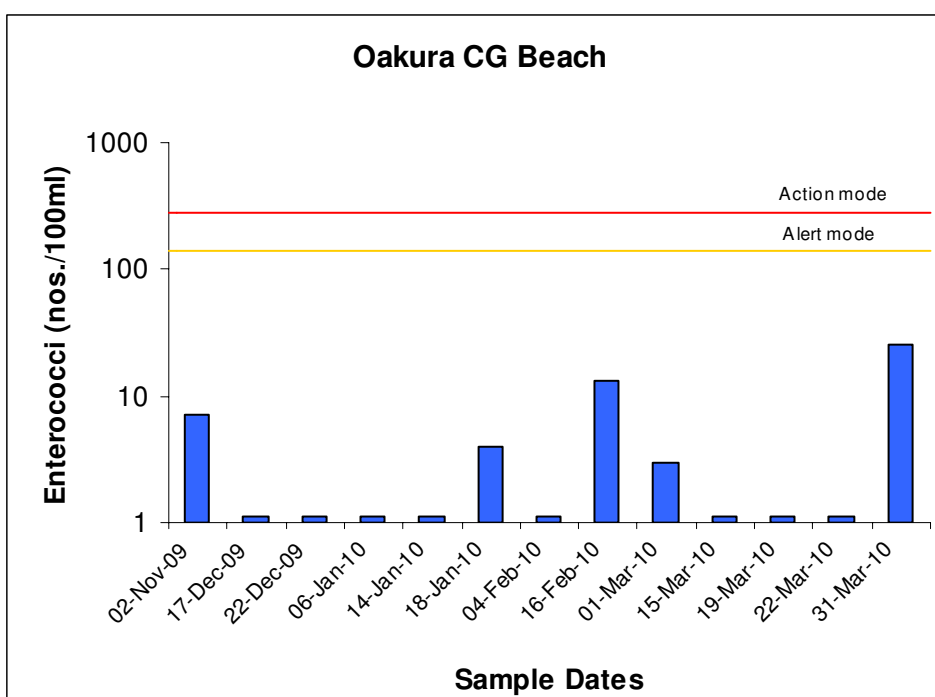
### 4.7.1 SEM programme

This site, also on Oakura Beach, is also a popular bathing and surfing site being directly in front of the Oakura campground.

The data for this site are presented in Table 42 and illustrated in Figure 24, with a statistical summary provided in Table 43.

**Table 42** Analytical results for Oakura Beach CG

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0815	4700	12	7	20	13.7
17-Dec-09	0820	4680	<1	<1	<1	15.9
22-Dec-09	1120	4650	<1	<1	<1	16.2
06-Jan-10	1235	4750	3	<1	3	16.2
14-Jan-10	0825	4760	1	<1	1	16.3
18-Jan-10	0930	4640	3	4	3	18.3
04-Feb-10	1130	4710	3	1	3	19.4
16-Feb-10	0905	4720	9	13	9	19.2
01-Mar-10	0830	4710	4	3	4	19.4
15-Mar-10	0820	4710	<1	<1	<1	15.4
19-Mar-10	0945	4740	1	<1	1	14.4
22-Mar-10	1210	4710	4	1	4	17.1
31-Mar-10	0825	4620	31	25	31	17.2

**Figure 24** Enterococci numbers for Oakura Beach CG during the survey season**Table 43** Statistical results summary for Oakura Beach CG

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4620	4760	4710
<i>E. coli</i>	cfu/100ml	13	<1	31	3
Enterococci	cfu/100ml	13	<1	25	1
Faecal coliforms	cfu/100ml	13	<1	31	3
Temperature	°C	13	13.7	19.4	16.3

Water quality was very good at this site with very low medians - 3 cfu/100ml for *E. coli* and faecal coliforms and 1 cfu/100ml for enterococci. Maxima were also low – between 25 and 31 cfu/100ml.

#### 4.7.2 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 44.

**Table 44** Bacterial guidelines performance at Oakura Beach CG

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

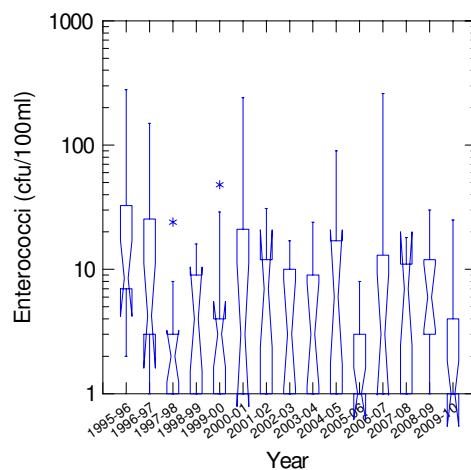
All samples were well below the 'Alert' guideline.

#### 4.7.3 Comparison with previous summers' surveys

A statistical comparison of each of the 15 summer's survey data for Oakura Beach opposite the campground are summarised in Table 45 and illustrated in Figure 25.

**Table 45** Summary of enterococci bacteriological water quality data (cfu/100 ml) for all summer surveys at Oakura Beach opposite the campground to date

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Minimum	2	1	< 1	< 1	< 1	< 1	< 1	< 1
Maximum	280	150	24	16	48	240	31	17
Median	9	5	2	4	3	3	7	3
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	
Minimum	< 1	< 1	< 1	< 1	< 1	< 1	< 1	
Maximum	24	90	8	260	18	30	25	
Median	3	6	1	3	7	6	1	



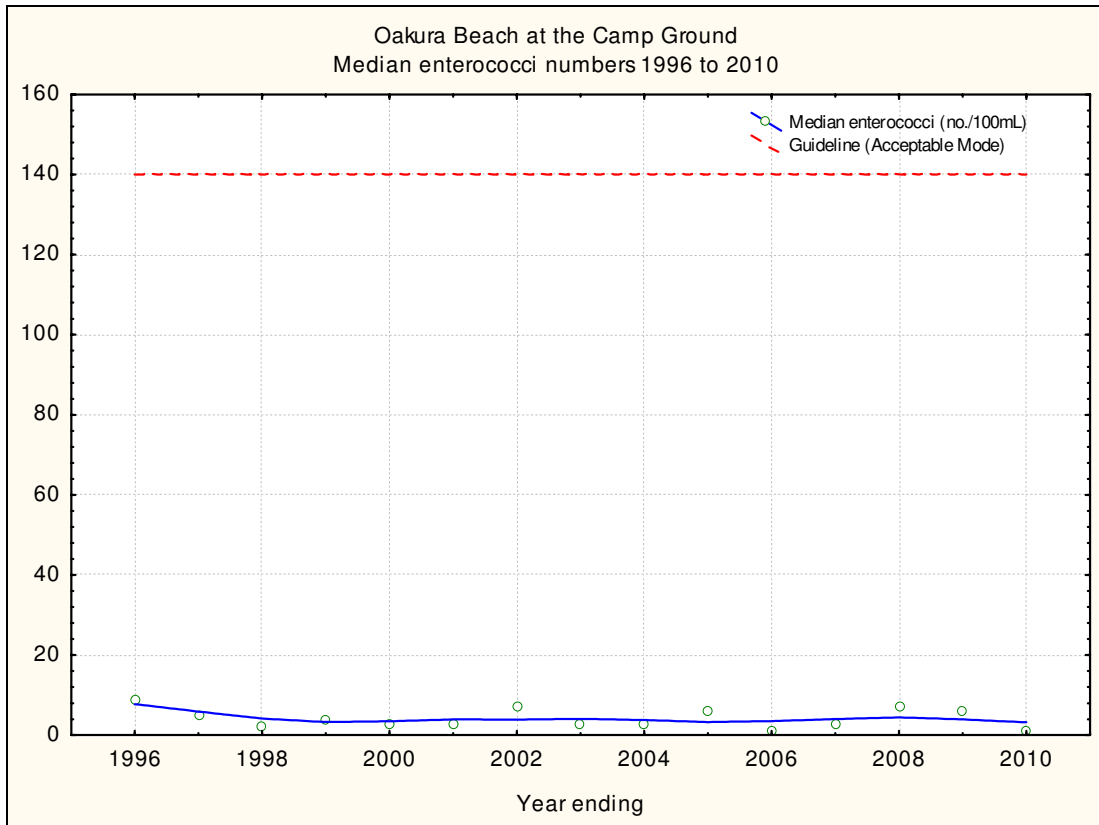
**Figure 25** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Oakura Beach opposite the campground

The median enterococci value was very low and Figure 25 shows the water quality for the 2009-2010 year is better than the preceding few years.



#### 4.7.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 15 years from Oakura Beach at the Camp Ground. The results are presented in Figure 26 below and in Appendix III.



**Figure 26** Long-term trend analysis for Oakura Beach at the Camp Ground (correlation not significant at  $p < 0.05$ )

There did not appear to be a trend at the Oakura Beach Camp Ground site, with little variation in seasonal sample medians over the 15 years. An FDR-adjusted p-value of 0.511, confirmed the lack of a trend.

## 4.8 Opunake Beach

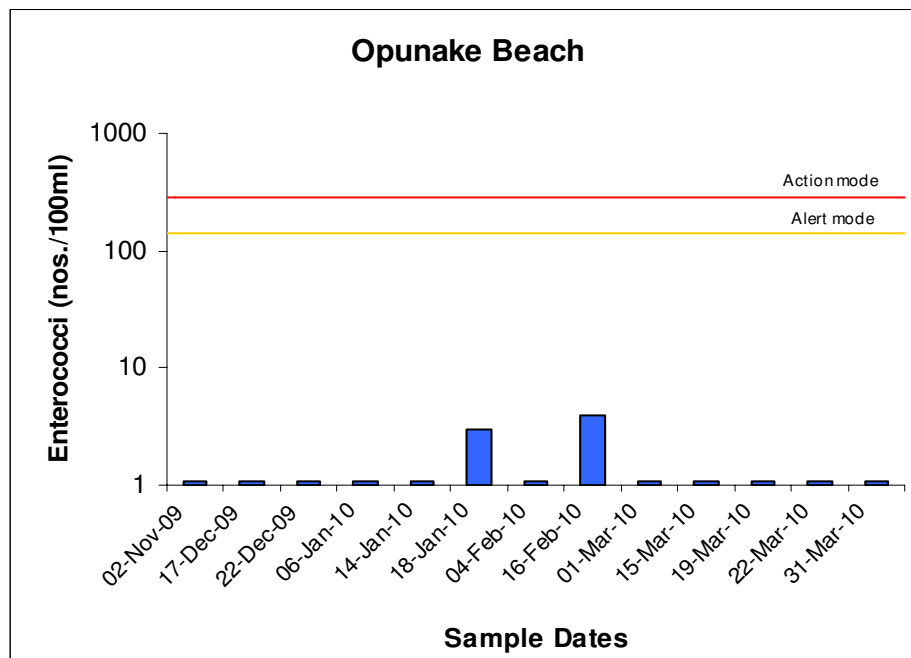
### 4.8.1 The SEM programme

Opunake Beach, situated in south Taranaki, is a very popular swimming beach. There are no large rivers in the vicinity, however the outlet of a freshwater stream from the Opunake Power Station enters at the southern extremity of the beach.

Data from this site are presented in Table 46 and illustrated in Figure 27, with a statistical summary provided in Table 47.

**Table 46** Analytical results for Opunake Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	1050	4620	3	1	3	15.0
17-Dec-09	1125	4540	<1	<1	<1	18.4
22-Dec-09	1440	4640	<1	<1	<1	18.1
06-Jan-10	1515	4760	<1	<1	<1	18.8
14-Jan-10	1055	4710	3	<1	3	18.6
18-Jan-10	1250	4570	<1	3	<1	18.0
04-Feb-10	1440	4680	<1	<1	<1	20.0
16-Feb-10	1215	4740	13	4	13	19.4
01-Mar-10	1145	4750	<1	<1	<1	20.1
15-Mar-10	1130	4620	<1	<1	<1	17.9
19-Mar-10	1255	4710	<1	<1	<1	17.2
22-Mar-10	1450	4730	1	<1	1	18.6
31-Mar-10	1210	4730	1	<1	1	17.2

**Figure 27** Enterococci numbers for Opunake Beach during the survey season**Table 47** Statistical results summary for Opunake Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4540	4760	4710
<i>E. coli</i>	cfu/100ml	13	<1	13	<1
Enterococci	cfu/100ml	13	<1	4	<1
Faecal coliforms	cfu/100ml	13	<1	13	<1
Temperature	°C	13	15.0	20.1	18.4

Levels of all bacteria were very low, with medians of <1 cfu/100ml for the three indicator bacteria. Maxima were also low, ranging between 4 cfu/100ml for enterococci and 13 cfu/100ml for *E. coli* and faecal coliforms. These results indicated very good water quality at this site.

#### 4.8.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 48.

**Table 48** Bacterial guidelines performance at Opunake Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

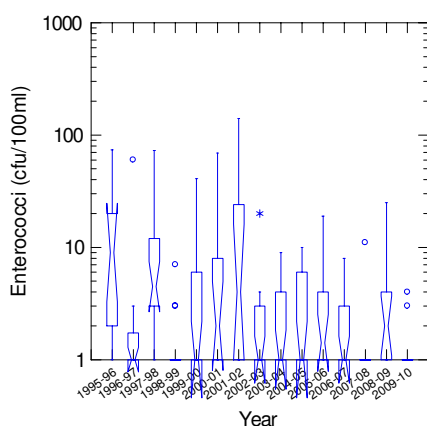
Water quality was considered suitable for contact recreation throughout the season, with all samples well below 'Alert' guideline levels.

#### 4.8.3 Comparison with previous summers' surveys

A statistical comparison of each of the 15 summers' survey data for the Opunake Beach site are summarised in Table 49 and illustrated in Figure 28.

**Table 49** Summary of enterococci bacteriological water quality data (cfu/100ml) for all summer surveys at Opunake Beach

Summer	1995-96	1996-97	1999-98	1998-99	1999-00	2000-01	2001-02	2002-03
Minimum	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1
Maximum	74	60	73	7	41	69	140	20
Median	9	< 1	5	< 1	1	2	4	1
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	
Minimum	< 1	< 1	< 1	< 1	< 1	< 1	< 1	
Maximum	9	10	19	8	11	25	4	
Median	1	1	2	1	< 1	2	< 1	

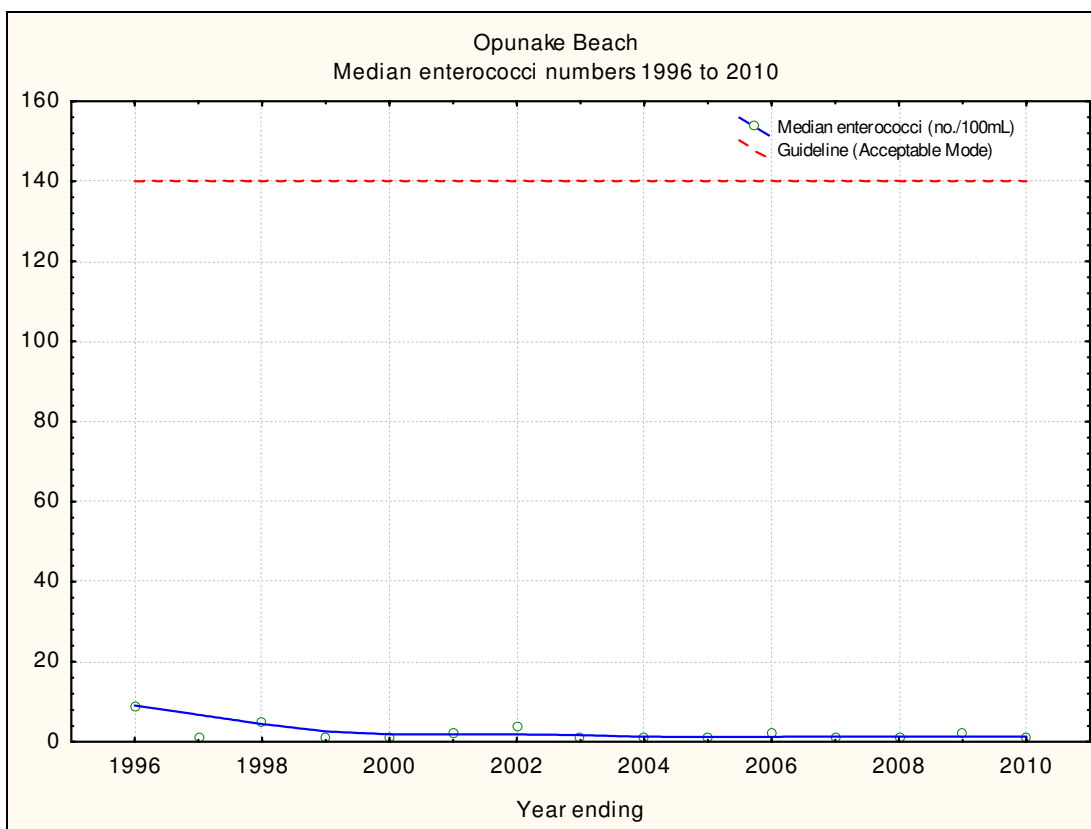


**Figure 28** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Opunake Beach

Water quality was very good at the Opunake Beach site during the 2009-2010 bathing season – continuing a trend of very good water quality at this site.

#### 4.8.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 15 years from Opunake Beach. The results are presented in Figure 29 below and in Appendix III.



**Figure 29** Long-term trend analysis for Opunake Beach (correlation not significant at  $p < 0.05$ )

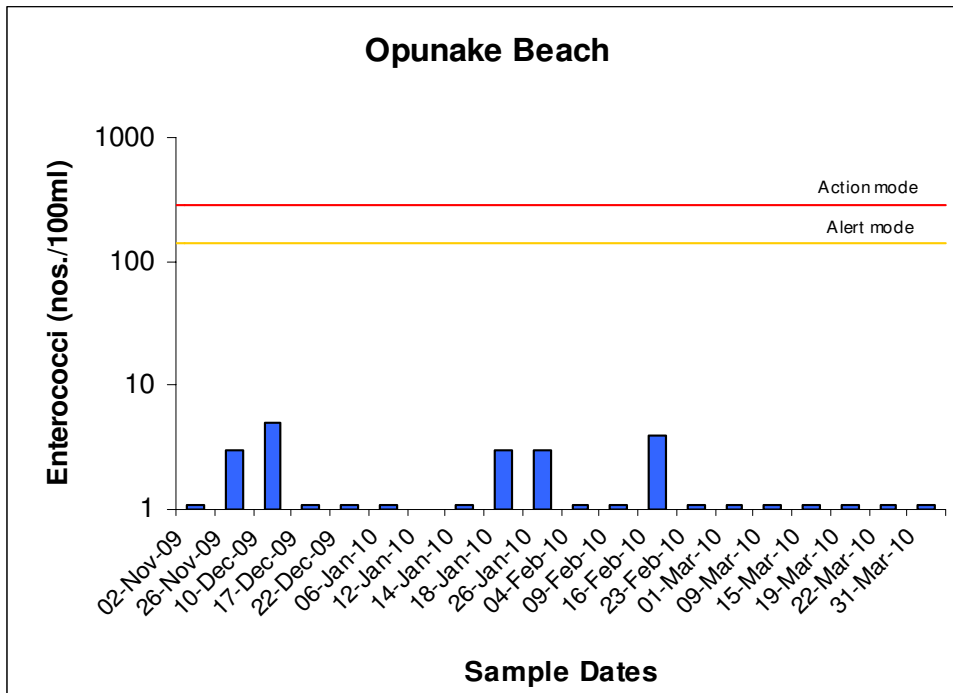
Seasonal median enterococci numbers were very low on all sampling occasions, and there did not appear to be any particular trend with such a low and narrow range of values. A p-value of 0.170, FDR adjusted to 0.305, did not indicate a significant trend in the data.

#### 4.8.5 MfE guidelines additional sampling

Seven additional samples were collected at irregular intervals and under varying weather conditions during the survey season. The data from these additional surveys are presented in Table 50, illustrated in Figure 30, and statistically summarised (together with the 13 SEM samples' data) in Table 51.

**Table 50** Opunake Beach additional seven water quality samples' results

Date	Time	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
	(NZST)		<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
26-Nov-09	1255	4620	<3	3	<3	17.6
10-Dec-09	1210	4580	3	5	3	17.8
12-Jan-10	1200	4750	<1	1	<1	17.6
26-Jan-10	1205	4700	<1	3	<1	18.4
09-Feb-10	1200	4680	<1	<1	<1	20.6
23-Feb-10	0945	4560	4	<1	4	20.9
09-Mar-10	1100	4700	<1	<1	<1	17.6



**Figure 30** Enterococci numbers for Opunake Beach for the 20 sample extended survey

**Table 51** Summary statistics for SEM and additional samples at Opunake Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	4540	4760	4690
<i>E. coli</i>	cfu/100ml	20	<1	13	<1
Enterococci	cfu/100ml	20	<1	5	<1
Faecal coliforms	cfu/100ml	20	<1	13	<1
Temperature	°C	20	15.0	20.9	18.3

The additional samples resulted in an increase in the enterococci maximum from 4 cfu/100ml to 5 cfu/100ml. All other parameters remained the same.

#### 4.8.5.1 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 52.

**Table 52** Bacterial guidelines performance at Oakura Beach SC

Parameter	Number of exceedances of enterococci guidelines [ % of 20 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

Enterococci in all samples were very low and all of the 20 samples were well below 'Alert' level, indicating very good water quality at Opunake Beach.

## 4.9 Ohawe Beach

### 4.9.1 SEM programme

Ohawe Beach (Photograph 7) is situated in southern Taranaki, is in close proximity to the large Waingongoro River. This river passes through Eltham, accepting factory discharge (eg Riverlands) and sewage pond waste. In addition the catchment drains highly modified agricultural land.

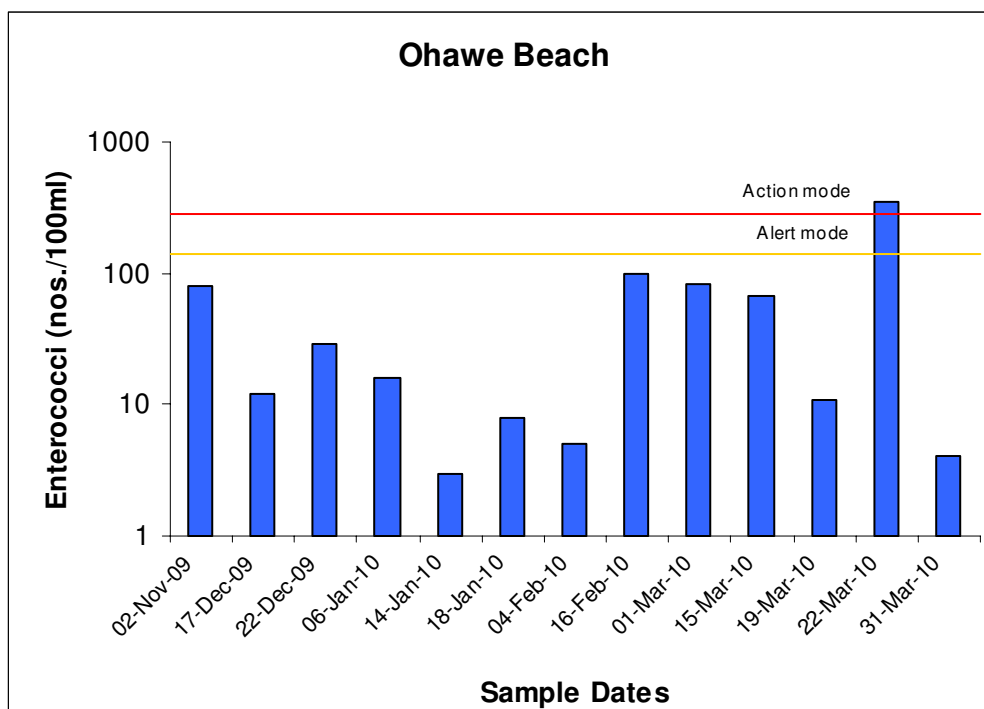
Data from this site are presented in Table 53 and illustrated in Figure 31, with a statistical summary provided in Table 54.



Photograph 7 Ohawe Beach

Table 53 Analytical results for Ohawe Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	1005	3180	280	80	290	14.4
17-Dec-09	1025	3920	9	12	9	18.1
22-Dec-09	1310	3800	5	29	8	18.9
06-Jan-10	1400	3730	16	16	16	20.0
14-Jan-10	0950	4280	5	3	5	19.1
18-Jan-10	1125	4620	3	8	3	18.5
04-Feb-10	1320	4760	4	5	4	19.8
16-Feb-10	1055	4730	190	100	200	19.5
01-Mar-10	1045	4040	62	84	62	20.6
15-Mar-10	1020	4200	320	68	320	18.2
19-Mar-10	1135	4160	19	11	20	16.6
22-Mar-10	1345	3930	28	350	28	18.9
31-Mar-10	1055	4610	20	4	20	17.6



**Figure 31** Enterococci numbers at Ohawe Beach during the survey season

**Table 54** Statistical results summary for Ohawe Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	3180	4760	4160
<i>E. coli</i>	cfu/100ml	13	3	320	19
Enterococci	cfu/100ml	13	3	350	16
Faecal coliforms	cfu/100ml	13	3	320	20
Temperature	°C	13	14.4	20.6	18.9

Levels of all three indicator bacteria were generally low throughout the bathing season, with medians of 16 to 20 cfu/100ml. Levels of enterococci were high on 22 March, at 350 cfu/100ml. This coincided with lowered conductivity, and therefore freshwater intrusion is the likely cause of the elevated levels of bacteria. As no follow-up sample was collected, it is assumed that the 'Action' guideline was exceeded.

#### 4.9.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 55.

**Table 55** Bacterial guidelines performance at Ohawe Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples ]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	1 [8]

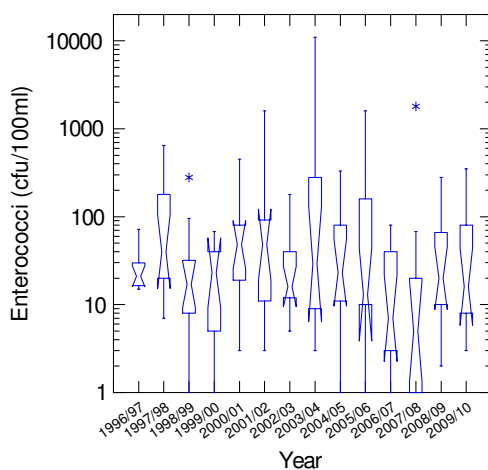
One sample exceeded 280cfu/100ml at this site during the bathing season. No follow-up sample was collected, but it is assumed that 'Action' level was exceeded.

### 4.9.3 Comparison with previous summers' surveys

A statistical comparison of each of the 14 summers' survey data for the Ohawe Beach site are summarised in Table 56 and illustrated in Figure 32.

**Table 56** Summary of enterococci bacteriological water quality data to date (cfu/100ml) for all summer surveys at Ohawe Beach

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Minimum	15	7	<1	1	3	3	5	3
Maximum	72	650	280	68	450	1600	180	11000
Median	21	40	17	23	48	48	16	29
	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10		
Minimum	<1	1	<1	<1	2	3		
Maximum	330	1600	80	1800	280	350		
Median	23	13	7	5	20	16		



**Figure 32** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Ohawe Beach

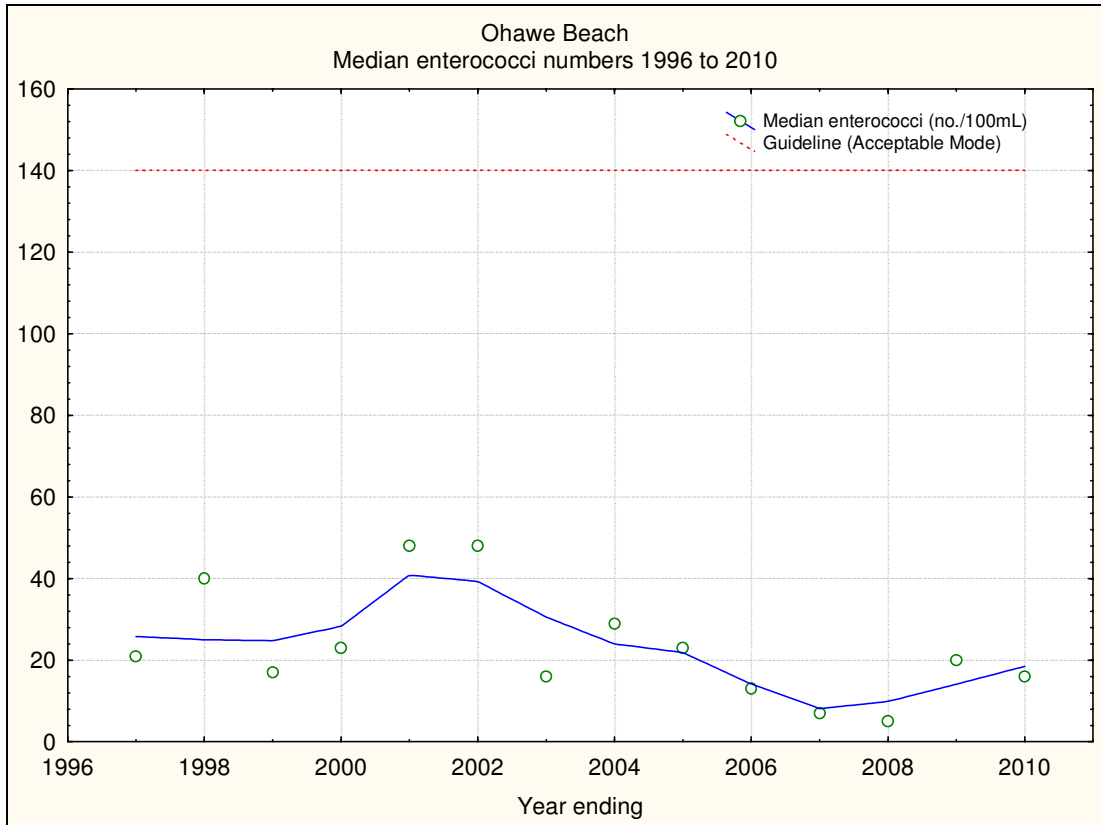
Water quality at Ohawe Beach during the 2009-2010 season was similar to that of 2008-2009.

### 4.9.4 Long-term trend analysis

Non-parametric statistical trend analysis was undertaken on the seasonal median enterococci data collected over 14 years from Ohawe Beach. The results are presented in Figure 33 below and in Appendix III.

Figure 33 shows water quality at Ohawe Beach improving from 2002 to 2009, however a p-value of 0.0134, FDR adjusted to 0.094, indicated this was not a statistically significant trend.





**Figure 33** Long-term trend analysis for Ohawe Beach (correlation not significant at  $p < 0.05$ )

## 4.10 Patea Beach

### 4.10.1 SEM programme



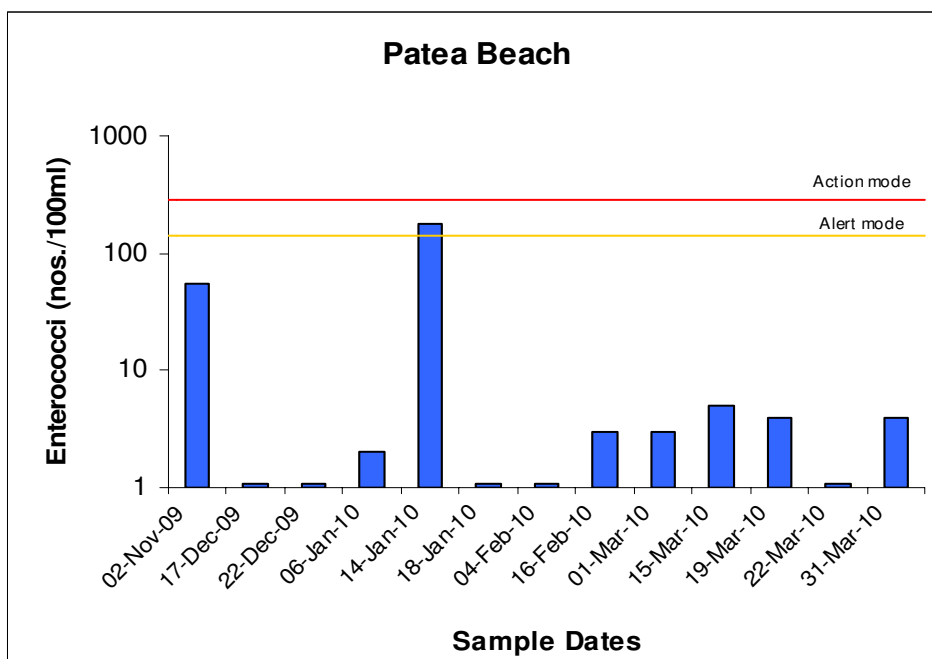
**Photograph 8** Patea Beach

Patea Beach (Photograph 8) is situated at the mouth of the Patea River, which has the third largest catchment area in Taranaki. The sampling site is separated from the river by the northern of two moles, which direct the freshwater flow away from the shore. Recreational use is high over the summer holiday period, however younger swimmers tend to use the more sheltered adjacent area of Mana Bay (refer to Section 4.11).

Data from the site are presented in Table 57 and illustrated in Figure 34, with a statistical summary provided in Table 58.

**Table 57** Analytical results for Patea Beach

Date	Time (NZST)	Conductivity @ 20° C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0915	4550	3	54	3	14.7
17-Dec-09	0935	4580	15	1	15	18.2
22-Dec-09	1235	4600	1	<1	1	18.5
06-Jan-10	1310	4730	4	<4	4	19.5
14-Jan-10	0910	4710	7	180	7	18.7
18-Jan-10	1040	4560	<1	1	<1	18.5
04-Feb-10	1235	4740	<1	1	<1	19.6
16-Feb-10	1015	4640	3	3	3	19.7
01-Mar-10	1005	4660	25	3	25	21.0
15-Mar-10	0935	4610	4	5	5	18.0
19-Mar-10	1055	4700	11	4	11	16.6
22-Mar-10	1250	4740	5	<1	5	19.5
31-Mar-10	1005	4620	5	4	5	18.0



**Figure 34** Enterococci numbers for Patea Beach during the survey season

**Table 58** Statistical results summary for Patea Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4550	4740	4640
<i>E. coli</i>	cfu/100ml	13	<1	25	4
Enterococci	cfu/100ml	13	<1	180	3
Faecal coliforms	cfu/100ml	13	<1	25	5
Temperature	°C	13	14.7	21.0	18.5

Median bacteria values of all three indicator bacteria were low. Maximum values of *E. coli* and faecal coliforms were low, while enterococci was elevated on one occasion.

#### 4.10.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 59.

**Table 59** Bacterial guidelines performance at Patea Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	1 [5]	0 [0]

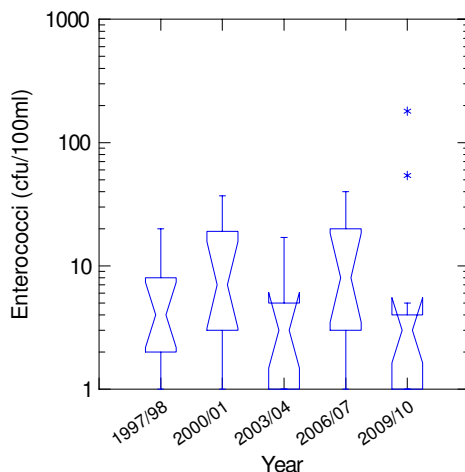
Water quality at this site was generally very good, however 'Alert' guidelines were exceeded on one occasion.

#### 4.10.3 Comparison with previous summers' surveys

A statistical comparison of each of the five summers' survey data is presented graphically in Appendix II for all sites. These summer data for Patea Beach are summarised in Table 60 and Figure 35.

**Table 60** Summary of enterococci bacteriological water quality data (nos/100ml) for all summer surveys at Patea Beach to date

Summer	1997-98	2000-01	2003-04	2006-07	2009-10
Minimum	1	< 1	< 1	<1	<1
Maximum	20	37	17	40	180
Median	4	7	3	8	3

**Figure 35** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Patea Beach

At 180 cfu/100ml, the maximum enterococci value was the highest to date. However, the minimum and median values were very low and water quality at this site was some of the best to date.

## 4.11 Patea ('Mana') Bay

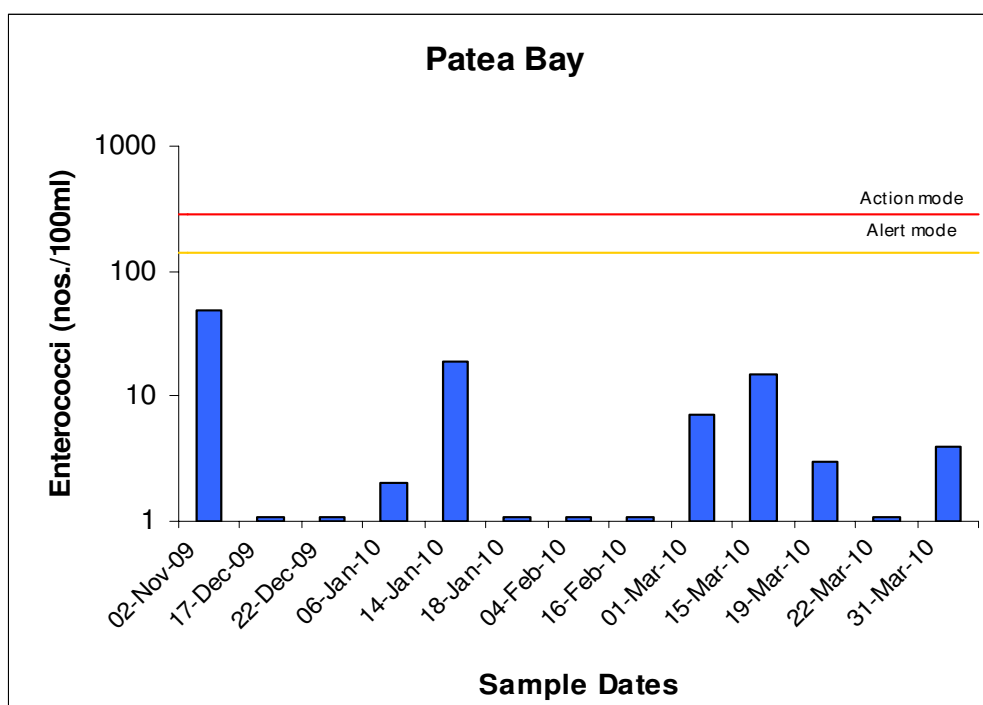
### 4.11.1 SEM programme

Patea (Mana) Bay (Photograph 9) is a sheltered area inside the northern mole at the mouth of the Patea River. Recreational use is high over the summer holiday period, particularly by young children.

Data from the site are presented in Table 61 and illustrated in Figure 36, with a statistical summary provided in Table 62.

**Table 61** Analytical results for Patea Bay

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0905	4550	57	48	57	15.0
17-Dec-09	0930	4570	7	<1	7	18.2
22-Dec-09	1225	4580	4	<1	4	18.5
06-Jan-10	1300	4730	4	<4	4	19.3
14-Jan-10	0905	4720	4	19	4	18.2
18-Jan-10	1035	4590	<1	1	<1	*
04-Feb-10	1230	4720	1	<1	1	19.6
16-Feb-10	1005	4740	<1	<1	<1	19.6
01-Mar-10	1000	4680	12	7	12	20.6
15-Mar-10	0925	4610	5	15	5	17.9
19-Mar-10	1045	4700	3	3	3	16.6
22-Mar-10	1250	4690	1	<1	1	18.3
31-Mar-10	1000	4640	5	4	5	17.2



**Figure 36** Enterococci numbers for Patea Bay during the survey season

**Table 62** Statistical results summary for Patea Bay

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4550	4740	4680
<i>E. coli</i>	cfu/100ml	13	<1	57	4
Enterococci	cfu/100ml	13	<1	48	2
Faecal coliforms	cfu/100ml	13	<1	57	4
Temperature	°C	12	15.0	20.6	18.3

Levels of bacteriological indicators in the samples were generally low, with medians of 2cfu/100ml (enterococci) and 4cfu/100ml (*E. coli* and faecal coliforms), while maximums ranged between 48 and 57 cfu/100ml. This indicated good water quality at the Patea Bay site.

#### 4.11.2 Compliance with guidelines

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

**Table 63** Bacterial guidelines performance at Patea Bay

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

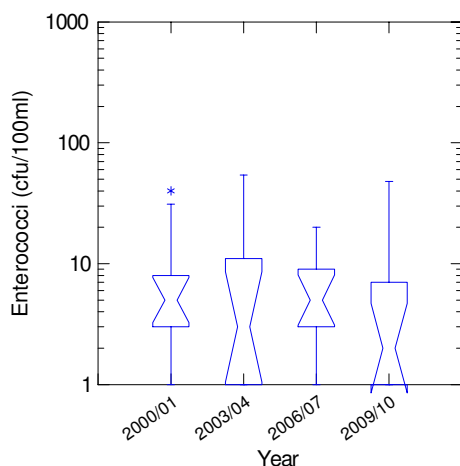
Water quality was very good at this site, with all samples below guideline 'Alert' limits.

#### 4.11.3 Comparison with previous summers' surveys

A statistical comparison of each of the four summers' survey data is presented graphically in Appendix II for all sites. These summer data for Patea Bay are summarised in Table 64 and illustrated in Figure 37.

**Table 64** Summary of enterococci bacteriological water quality data (nos/100ml) for all summer surveys at Patea Bay

Summer	2000/01	2003/04	2006/07	2009/10
Minimum	1	<1	<1	<1
Maximum	40	54	20	48
Median	5	3	5	2

**Figure 37** Box and whisker plots for all summer surveys of Enterococci bacterial numbers at Patea Bay

The results were similar to previous results, indicating continued good water quality at this site.



Photograph 9 Patea (Mana) Bay

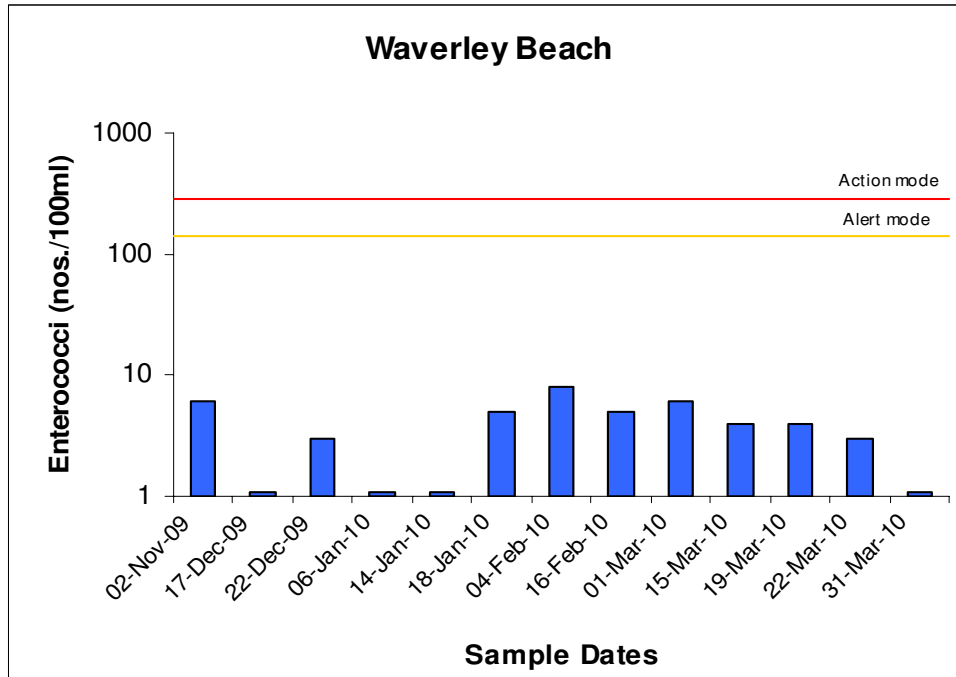
## 4.12 Waverley Beach

### 4.12.1 SEM programme

Data from Waverley Beach (Photograph 10) are presented in Table 65 and illustrated in Figure 38, with a statistical summary provided in Table 66.

Table 65 Analytical results for Waverley Beach

Date	Time (NZST)	Conductivity @ 20° C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0835	4200	40	6	40	14.7
17-Dec-09	0855	4530	9	<1	9	18.0
22-Dec-09	1150	4630	<1	3	<1	18.8
06-Jan-10	1225	4630	4	<1	4	19.3
14-Jan-10	0825	4720	<1	1	<1	17.9
18-Jan-10	1000	4580	5	5	5	17.6
04-Feb-10	1155	4610	24	8	24	19.2
16-Feb-10	0930	4700	36	5	36	19.6
01-Mar-10	0920	4700	4	6	4	20.3
15-Mar-10	0850	4530	12	4	12	18.0
19-Mar-10	1010	4610	9	4	9	16.4
22-Mar-10	1215	4680	<1	3	<1	18.4
31-Mar-10	0930	4680	4	<1	4	16.3



**Figure 38** Enterococci numbers for Waverley Beach during the survey season

**Table 66** Statistical results summary for Waverley Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4200	4720	4620
<i>E. coli</i>	cfu/100ml	13	<1	40	5
Enterococci	cfu/100ml	13	<1	8	4
Faecal coliforms	cfu/100ml	13	<1	40	5
Temperature	°C	13	14.7	20.3	18.0

Bacteriological water quality was generally very good, with low median levels of all bacteriological indicators. Maximum levels were also relatively low, ranging between 8 and 40 cfu/100ml.

#### 4.12.2 Compliance with guidelines

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

**Table 67** Bacterial guidelines performance at Waverley Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

Water quality at this site was very good, with all sample results falling below the 'Alert' guideline.



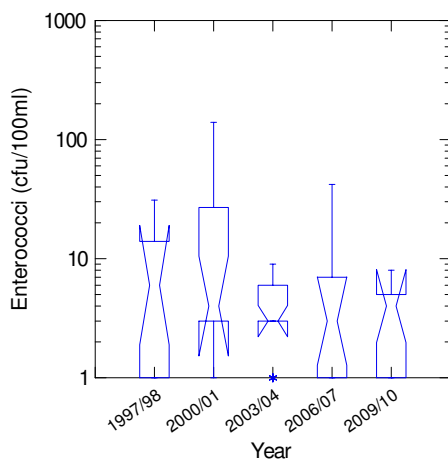
Photograph 10 Waverley Beach

#### 4.12.3 Comparison with previous summers' surveys

A statistical comparison of each of the five summers' survey data is presented graphically in Appendix II for all sites. These summer data for Waverley Beach are summarised in Table 68 and illustrated in Figure 39.

**Table 68** Summary of enterococci bacteriological water quality data (nos/100ml) for all summer surveys at Waverley Beach to date

Summer	1997-98	2000-01	2003-04	2006-07	2009-10
Minimum	< 1	1	< 1	<1	<1
Maximum	31	140	9	42	8
Median	6	4	3	3	4



**Figure 39** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Waverley Beach

The maximum enterococci value was the lowest recorded to date, while the minimum and median values were similar to previous results.



## 4.13 Wai-inu Beach

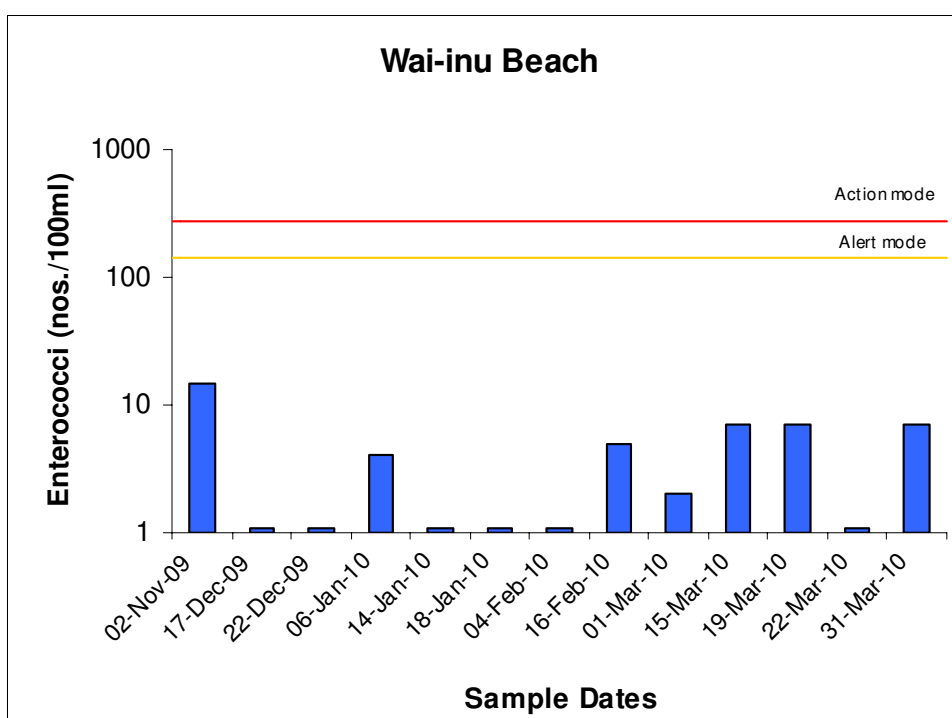
### 4.13.1 SEM programme

Wai-inu Beach is the southern-most beach in the SEM programme, the site is adjacent to the Wai-inu Beach settlement and campground. Small fishing boats are launched over the iron-sand beach.

Data from the site are presented in Table 69 and illustrated in Figure 40, with a statistical summary provided in Table 70.

**Table 69** Analytical results for Wai-inu Beach

Date	Time (NZST)	Conductivity @ 20° C (mS/m)	Bacteria			Temp (°C)
			<i>E. coli</i> (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	
02-Nov-09	0805	4200	42	15	46	14.3
17-Dec-09	0815	4370	50	1	50	17.6
22-Dec-09	1115	4580	<1	1	<1	19.5
06-Jan-10	1200	4300	18	4	18	20.0
14-Jan-10	0800	4610	<1	1	<1	16.9
18-Jan-10	0930	4550	<1	<1	<1	18.6
04-Feb-10	1130	4650	<1	<1	<1	19.4
16-Feb-10	0905	4660	8	5	8	19.4
01-Mar-10	0855	4680	10	2	10	20.2
15-Mar-10	0820	4340	27	7	31	17.9
19-Mar-10	0940	4380	11	7	12	16.4
22-Mar-10	1150	4550	1	<1	1	18.5
31-Mar-10	0845	4460	4	7	4	15.9



**Figure 40** Enterococci numbers for Wai-inu Beach during the survey season

**Table 70** Statistical results summary for Wai-inu Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4200	4680	4550
<i>E. coli</i>	cfu/100ml	13	<1	50	8
Enterococci	cfu/100ml	13	<1	15	2
Faecal coliforms	cfu/100ml	13	<1	50	8
Temperature	°C	13	14.3	20.2	18.5

Results for this beach were generally good throughout the period with low minima, medians and maxima for all three bacteriological parameters.

#### 4.13.2 Compliance with guidelines

Compliance with the 2003 guidelines for marine contact usage is summarised in Table 71.

**Table 71** Bacterial guidelines performance at Wai-inu Beach

Parameter	Number of exceedances of enterococci guidelines [ % of 13 samples]	
	ALERT Single sample 141-280/100ml	ACTION Two consecutive samples >280/100 ml
Enterococci	0 [0]	0 [0]

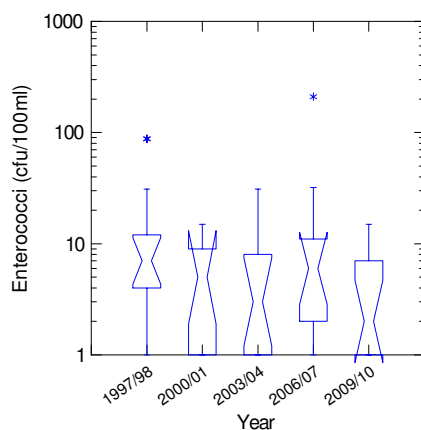
Samples complied with 'Alert' guideline levels throughout the bathing season.

#### 4.13.3 Comparison with previous summers' surveys

A statistical comparison of each of the four summers' survey data is presented graphically in Appendix II for all sites. These summer data for Wai-inu Beach are summarised in Table 72 and illustrated in Figure 41.

**Table 72** Summary of enterococci bacteriological water quality summary data (nos/100ml) for all summer surveys at Wai-inu Beach to date

Summer	1997-98	2000-01	2003-04	2006-07	2009-10
Minimum	1	< 1	< 1	<1	<1
Maximum	88	15	31	210	15
Median	7	5	3	6	2

**Figure 41** Box and whisker plots for all summer surveys of enterococci bacterial numbers at Wai-inu Beach

Water quality during the 2009-2010 monitoring period was the best recorded to date at this site.

## 5. Discussion

### 5.1 General data summary

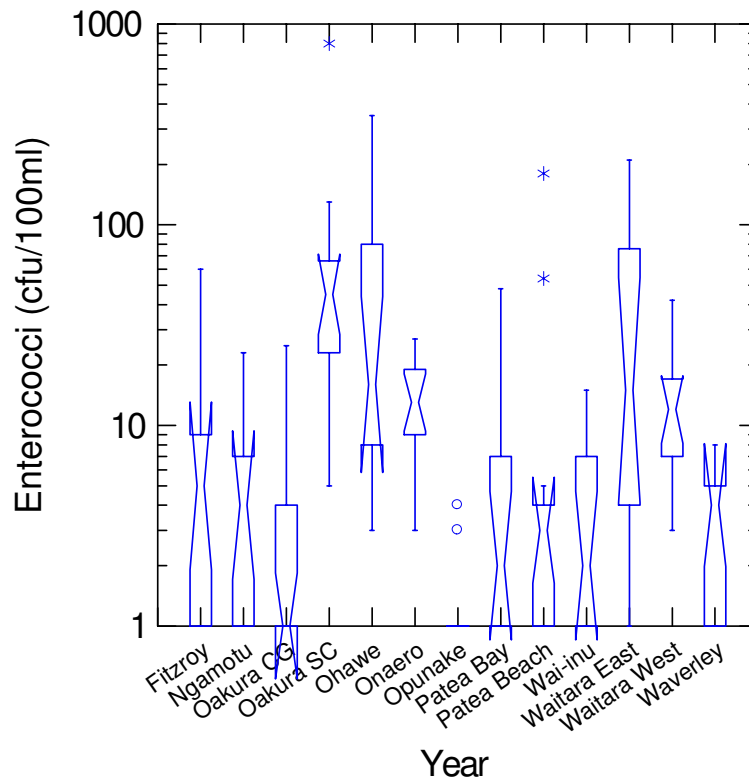
A comparative summary of results of the 2009-2010 summer bacteriological quality coastal survey of 13 contact recreational sites in the Taranaki region is provided in Table 73. Results are also illustrated in Appendix II in the form of statistical 'box and whisker' plots for the enterococci data.

**Table 73** Statistical summary of results for the sites sampled in the SEM marine contact recreational water quality survey, 2009-2010

Site		Conductivity @ 20°C (mS/m)	<i>E. coli</i> (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	Temperature °C
Onaero	Median	4650	32	13	32	18.0
	Minimum	3390	1	3	1	15.2
	Maximum	4720	110	27	110	21.3
	No. of samples	13	13	13	13	13
Waitara East	Median	4480	23	15	23	17.7
	Minimum	4700	<1	<1	<1	14.3
	Maximum	3590	700	210	720	20.8
	No. of samples	13	13	13	13	13
Waitara West	Median	4590	12	12	20	18.7
	Minimum	3270	<1	3	<1	14.1
	Maximum	4720	77	42	77	22.0
	No. of samples	13	13	13	13	13
Fitzroy	Median	4680	11	8	11	16.9
	Minimum	4440	3	1	3	14.3
	Maximum	4760	89	60	95	20.8
	No. of samples	13	13	13	13	13
Ngamotu	Median	4710	5	4	5	17.3
	Minimum	4470	<1	<1	<1	14.3
	Maximum	4760	12	23	12	21.8
	No. of samples	13	13	13	13	13
Oakura SC	Median	4530	45	45	47	16.8
	Minimum	2770	3	5	4	13.7
	Maximum	4670	7000	800	7000	20.1
	No. of samples	13	13	13	13	13
Oakura CG	Median	4710	3	1	3	16.3
	Minimum	4620	<1	<1	<1	13.7
	Maximum	4760	31	25	31	19.4
	No. of samples	13	13	13	13	13
Opunake	Median	4710	<1	<1	<1	18.4
	Minimum	4540	<1	<1	<1	15.0
	Maximum	4760	13	4	13	20.1
	No. of samples	13	13	13	13	13
Ohawe	Median	4160	19	16	20	18.9
	Minimum	3180	3	3	3	14.4
	Maximum	4760	320	350	320	20.6
	No. of samples	13	13	13	13	13
Patea	Median	4640	4	3	5	18.5
	Minimum	4550	<1	<1	<1	14.7
	Maximum	4740	25	180	25	21.0
	No. of samples	13	13	13	13	13

Site		Conductivity @ 20°C (mS/m)	<i>E. coli</i> (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	Temperature °C
Mana Bay	Median	4680	4	2	4	18.3
	Minimum	4550	<1	<1	<1	15.0
	Maximum	4740	57	48	57	20.6
	No. of samples	13	13	13	13	13
Waverley	Median	4620	5	4	5	18.0
	Minimum	4200	<1	<1	<1	14.7
	Maximum	4720	40	8	40	20.3
	No. of samples	13	13	13	13	13
Wai-inu	Median	4550	8	2	8	18.5
	Minimum	4200	<1	<1	<1	14.3
	Maximum	4680	50	15	50	20.2
	No. of samples	13	13	13	13	13

Figure 42 provides a comparison of enterococci at all sites during the period (regular SEM data only).



**Figure 42** Box and whisker plots comparing enterococci data at all sites for the 2009-2010 season

Opunake Beach had the best water quality, while Oakura SC, Ohawe and Waitara East had comparatively the worst. These three sites are influenced by adjacent lowland watercourses.

## 5.2 Comparison with guidelines

### 5.2.1 Regular SEM samples

Table 74 shows the number of times single sample enterococci counts entered the 'Alert' and/or 'Action' modes.

Compliance with the guidelines was generally good at the 13 marine contact recreational sites sampled during the survey period, with samples collected from nine of the 13 sites (Onaero, Waitara West, Fitzroy, Ngamotu, Oakura CG, Opunake, Patea (Mana) Bay, Waverley and Wai-inu beaches) all below the 'Alert' guideline level throughout the season.

Waitara East Beach entered 'Alert' levels on two occasions, while samples collected from Oakura Beach SC and Patea Beach were above 'Alert' levels once each during the season.

Ohawe Beach exceeded 280 cfu/100ml on one occasion, The 'Action' guideline is based on two consecutive samples, the second sample to be a follow-up sample collected within 24 hours of the first sample which exceeds 280 cfu/100ml. However, follow-up samples were not collected in this instance. As this second sample was not collected it cannot be determined whether the 'Action' level was exceeded or not. To err on the side of caution, where a sample contained greater than 280 cfu/100ml and a second follow-up sample was not collected, the sample has been assigned to the 'Action' category.

Out of 169 samples collected at 13 bathing beaches during the period under review, 97% were below 'Alert' levels, while 99.5% of samples were below 'Action' levels.

**Table 74** Enterococci guideline summary

Beach	Number of samples	Surveillance Single sample < 140/100ml	Alert Mode single sample > 140/100ml	Action two consecutive samples > 280/100ml
Onaero	13	13	-	-
Waitara East	13	11	2	-
Waitara West	13	13	-	-
Fitzroy	13	13	-	-
Ngamotu	13	13	-	-
Oakura SC	13	12	1	-
OakuraCG	13	13	-	-
Opunake	13	13	-	-
Ohawe	13	12	-	1
Patea Beach	13	12	1	-
Patea (Mana) Bay	13	13	-	-
Waverley	13	13	-	-
Wai-inu	13	13	-	-

### 5.2.2 MfE guidelines additional sampling

An additional seven samples were collected at five sites in accordance with the MfE guidelines (2003). These samples are collected on a fixed day, regardless of weather or tidal conditions. Table 75 below gives a summary of the five sites in relation to compliance with the guidelines (for all 20 samples).

**Table 75** Summary of compliance with MfE guidelines (including extra samples)

Beach	Number of samples	Surveillance Single sample < 140/100ml	Alert Mode single sample > 140/100ml	Action two consecutive samples > 280/100ml
Onaero	20	12	1	-
Fitzroy	20	20	-	-
Ngamotu	20	20	-	-
Oakura SC	20	17	3	-
Opunake	20	20	-	-

When taking into account the extra samples collected, enterococci numbers at Fitzroy, Ngamotu and Opunake beaches remained below 'Alert' level guidelines.

Onaero Beach exceeded the 'Alert' level on one occasion of additional sampling, Oakura Beach exceeded the 'Alert' mode on two further occasions.

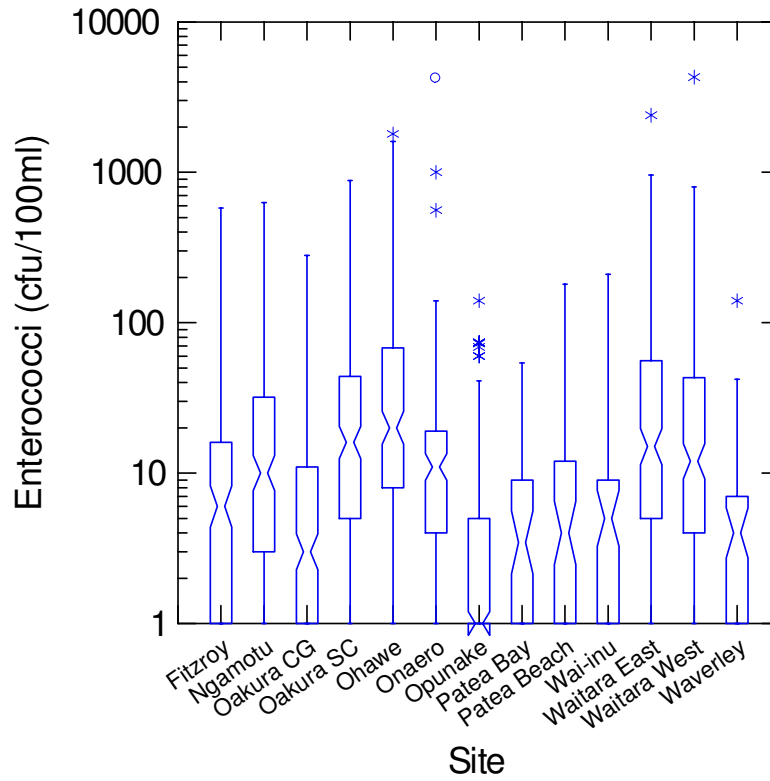
Out of 204 samples collected in total at the 13 bathing beaches during the period under review, 96% complied fully with the 2003 guidelines, and 99.5% were below the 'Action' threshold.

### 5.3 Comparison with previous summers' surveys

A statistical comparison of each summer's survey data is presented graphically in Appendix II for all sites.

In general terms, enterococci bacteriological water quality remained within ranges similar to those recorded over all previous summer bathing seasons. Variability in quality between bathing seasons at each site relates to a variety of reasons, including weather and hydrological conditions in particular.

Figure 43 below shows a compilation of all data collected since the 1996-1997 season, at the 13 sites (regular SEM data collection only).



**Figure 43** Box and whisker plots showing all enterococci data at the 13 sites from 1996-97 to 2009-10

## 5.4 Long-term trend analysis

None of the seven beaches analysed for evidence of a long-term trend, showed a trend of either increasing or decreasing water quality.

## 6. Conclusions

In conclusion, water quality at the 13 sites surveyed during the 2009-2010 season was generally good.

Out of 204 samples total (both regular SEM and MfE extra samples) collected at 13 bathing beaches during the period under review, 96% were below the most stringent guideline levels (ie below the 'alert' trigger of 140 enterococci per 100 mls), while 99.5% were below 'Action' guideline levels (280 enterococci per 100 mls).

Water quality at the seven sites that have been sampled on a long-term regular basis is stable (15 year timeframe).



## 7. Recommendations

As a result of the 2009-2010 summer marine contact recreation bacteriological survey it is recommended that:

1. THAT the 2010-2011 summer survey be performed at 12 sites continuing with the existing sampling protocol (designated annual sites, plus Year Two sites).
2. THAT the 2010-2011 summer survey also includes an additional 7 samples collected at the five principal usage sites (Onaero, Fitzroy, Ngamotu, Oakura SC and Opunake) in accordance with MfE, 2003 guidelines.
3. THAT follow-up sampling be performed as deemed necessary by Council staff. This should include follow-up samples within 24 hours of any samples exceeding 280 cfu/100ml in order to assess if 'Action' level has been reached.
4. THAT reporting of results be performed as appropriate during the season, and in an Annual Report upon completion of the season's programme.

## Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

'Action' mode	Two consecutive single samples greater than 280 enterococci/100ml
'Alert' mode	Single sample greater than 140 enterococci/100ml
Bacteriological indicators	Micro-organisms selected as indicators of faecal material
Bathers	Those who enter the water, and either partially or fully immerse themselves
Bathing season	Generally the bathing season extends between 1 November and 31 March
Beach	The shore or any access point to the sea
cfu	Colony forming units. A measure of the concentration of bacteria usually expressed as per 100 millilitre sample
Condy	Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m
Contact recreation	Recreation activities that bring people physically in contact with water, involving a risk of involuntary ingestion or inhalation of water
<i>E.coli</i>	<i>Escherichia coli</i> , member of the Enterobacteriaceae, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample
Enterococci	Members of the Streptococcus group of bacteria characterised as faecal in origin, provides an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre of sample
Faecal coliform	An indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample
False Discovery Rate (FDR)	The expected proportion of true hypothesis rejected out of the total number of rejections
Follow-up sample	Second sample taken to confirm an initial high result; usually within 24-72 hours depending on accessibility/sample turnaround time, etc.
Median	Central value when values are arranged in order of magnitude
Microbiological Assessment	A measurement of water quality over time as provided by historical (five years) microbiological results – A, B, C or D Category (MAC)

RMA	Resource Management Act 1991 and subsequent amendments
Sanitary Inspection Category (SIC)	A measure of the susceptibility of a water body to faecal contamination – Very High, High, Moderate, Low or Very Low
Suitability for Recreation Grade (SFRG)	A combination of Sanitary Inspection Category (SIC) and Microbiological Assessment Category (MAC), describes the general condition of a site at any given time, based on both risk and indicator bacteria counts
Temp	Temperature, measured in °C (degrees Celsius)
Water quality	The bacteriological condition of a water body as it relates to human health, measured using indicator bacteria

For further information on analytical methods, contact the Council's laboratory

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**Appendix I**  
**High tide times**





**Appendix I: High tide times (NZST) at New Plymouth  
for 2009-2010 sampling dates**

Date		Time of HT
02-Nov-09	Monday	1002
17-Dec-09	Thursday	1107
22-Dec-09	Tuesday	1411
06-Jan-10	Wednesday	1458
14-Jan-10	Thursday	1016
18-Jan-10	Monday	1232
04-Feb-10	Thursday	1430
16-Feb-10	Tuesday	1135
01-Mar-10	Monday	1106
15-Mar-10	Monday	1033
19-Mar-10	Friday	1237
22-Mar-10	Monday	1347
31-Mar-10	Wednesday	1126



## **Appendix II**

**Comparative Box and whisker plots of SEM data for  
1996-97, 1997-98 , 1998-99, 1999-2000, 2000-01, 2001-  
02, 2002-03, 2003-04, 2004-05, 2005-06, 2006-07,  
2007-08, 2008-09, 2009-10**



## 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)

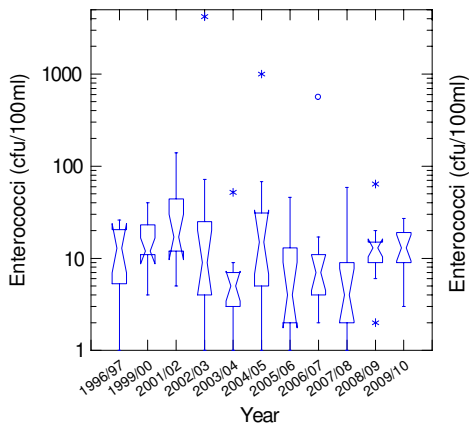
The outer fences are defined as follows:

Lower fence = lower hinge – (3 x Hspread)

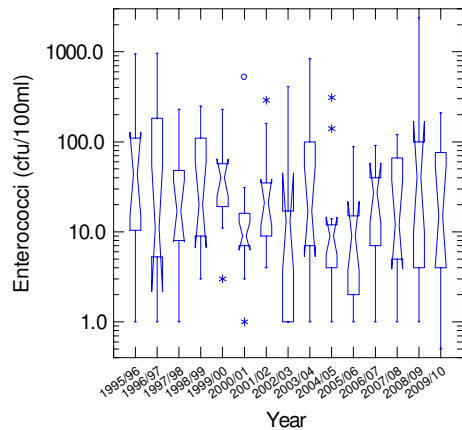
Upper fence = upper hinge + (3 x Hspread)

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

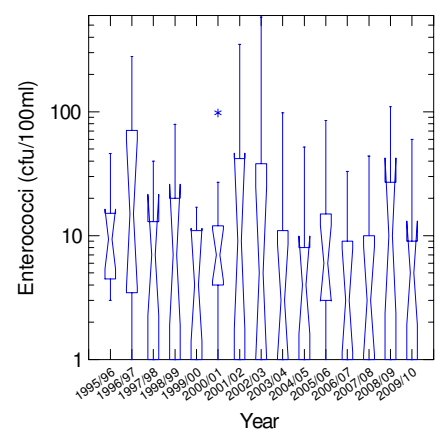
Onaero Beach



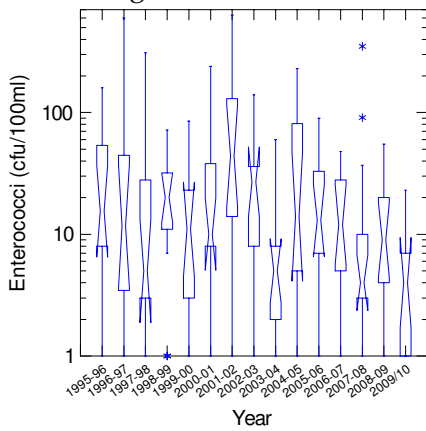
Waitara East Beach



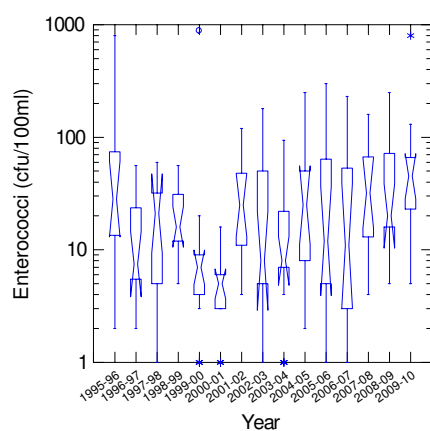
Fitzroy Beach



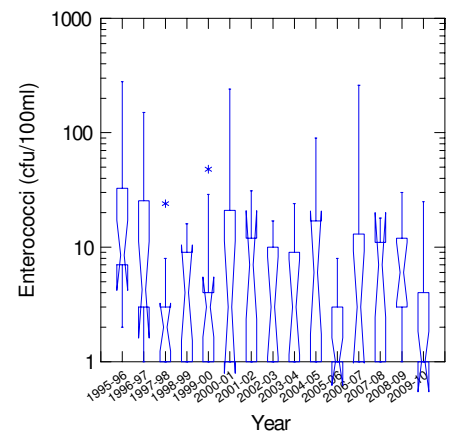
Ngamotu Beach



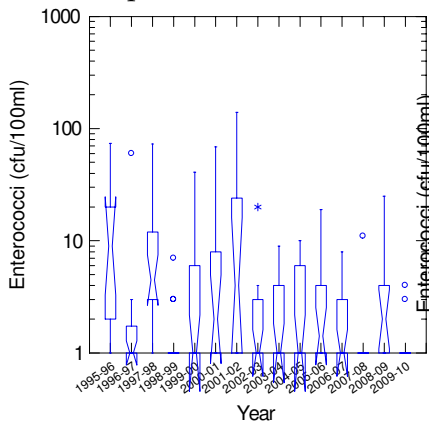
Oakura at SLSC



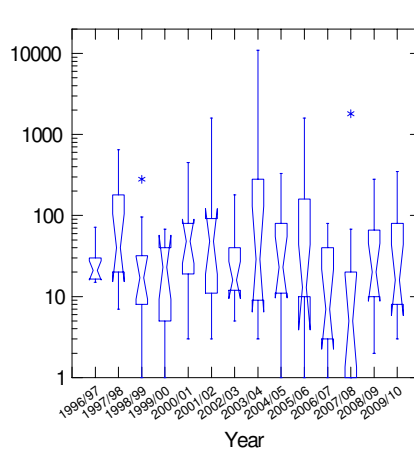
Oakura CG



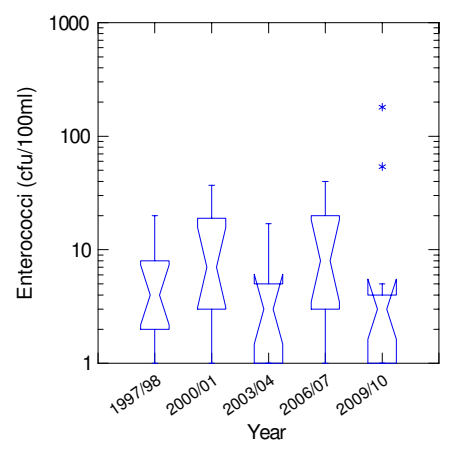
Opunake Beach



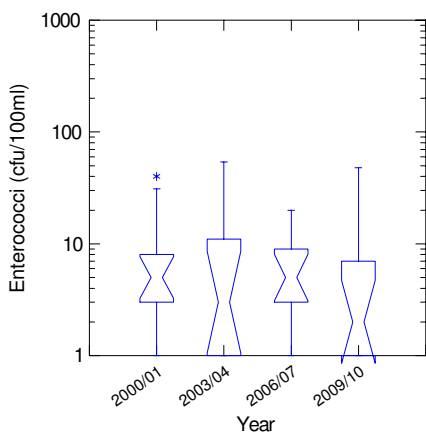
Ohawe Beach



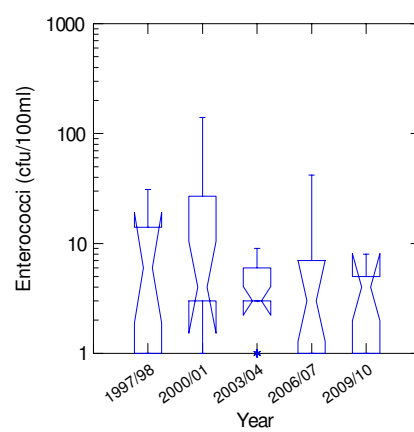
Patea Beach



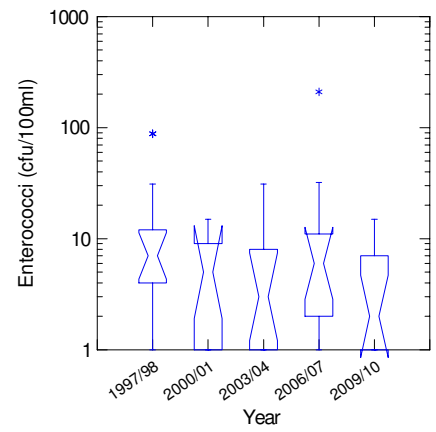
Patea (Mana) Bay



Waverley Beach



Wai-inu Beach



**Appendix III**  
**Trend data table of results**





Beach	Valid N	Kendall Tau	Z	p-level	FDR corrected p-value
Ohawe	14	-0.49169	2.44949	0.01431	0.11530
Fitzroy	15	-0.39841	2.07020	0.03843	0.11530
Onaero	15	-0.39841	2.07020	0.03843	0.11530
Ngamotu	15	-0.34786	1.80755	0.07068	0.15902
Opunake	15	-0.26428	1.37321	0.16969	0.30543
Oakura SC	15	0.22334	1.16053	0.24584	0.36875
Oakura CG	15	-0.16279	0.84589	0.39762	0.51122
Waitara East	14	0.05619	0.27995	0.77952	0.82178
Waitara West	14	-0.04522	0.22526	0.82178	0.82178

