MARLBOROUGH DISTRICT COUNCIL

Recreational Water Quality Report 2017-2018

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Executive Summary

Ten popular coastal beaches and seven river sites were sampled on a weekly basis between November 2017 and March 2018. The samples were analysed for faecal indicator bacteria, E. coli for river samples and Enterococci for coastal samples. The results were assessed against guidelines published in 2003 by the Ministry for the Environment (MfE) to determine the health risk to recreational users.

Surface-runoff caused by rainfall is the main reason for elevated indicator bacteria concentrations. Therefore, a comparatively wet second half of the summer resulted in guideline exceedances at most of the sites. Particularly, Ngakuta Bay had unusually high bacteria concentrations as a result of rainfall. It is possible that overflowing septic tanks were the cause.

At some sites, including Momorangi Bay and Waikutakuta/Robin Hood Bay high faecal bacteria concentrations were also observed during dry weather. However, they remained isolated cases and no ongoing problems could be identified. The exception was the Taylor River at Riverside. At this site permanent warning signs were erected throughout the summer as earthquake damage to sewerage and stormwater infrastructure was causing contamination of stormwater. Repair works are in progress and the warning signs will be removed once ongoing monitoring confirms that faecal bacteria concentrations are consistently at safe levels during base flow.

Despite the wet summer, all samples taken from Mistletoe Bay and Waikawa Bay had faecal bacteria concentrations below guideline levels. This was particularly encouraging for Mistletoe Bay. Recreational water quality at this site has improved significantly since a contamination source (a leaking septic tank) was found and removed following an investigation into high Enterococci concentration during the previous season.

The effect of a moving weather front on sample results at Momorangi Bay and Ngakuta Bay highlighted the fact that the results of individual samples should not be used as an indicator for current water quality. The main aim of the program is to determine the overall recreational water quality of sites, using the SFR Grading system.

The Taylor River at Riverside and Momorangi Bay had SFR Grades of ‘Very Poor’ and ‘Poor’, respectively, but grades for both sites are expected to improve in the near future.

Most sites are graded as ‘Fair’ and a number of sites have recreational water quality graded as ‘Good’.

The National Policy Statement for Freshwater Management (NPS-FM) contains an objective for E. coli levels in rivers. Comparison of the E. coli state based on the NPS-FM and the SFR Grades for the river sites shows that the NPS-FM appears to be the more lenient measure.

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1. Introduction

Marlborough has a number of beautiful beaches and rivers that are popular with visitors and local residents during the warmer months of the year. Swimming, boating, surfing and fishing are only a few of the many water based recreational activities that take place in the region. However, accidental ingestion of water can result in illness when faecal bacteria concentrations in the water are high. The risk of infection is highest for activities such as swimming and surfing.

Campylobacteriosis and Cryptosporidiosis are two of the most common gastrointestinal illnesses associated with water use. These illnesses often cause vomiting, stomach cramps and diarrhoea from two to ten days after infection. The potentially long delay between infection and the first symptoms means that the source of infection can be difficult to determine. Nevertheless, in 2014, over 50% of Campylobacteriosis cases and over 30% of Cryotosporidiosis cases in New Zealand had recreational water contact as a risk factor for the infection [1].

In order to allow us to evaluate the risk to water users, Council takes weekly water samples from the most popular beaches during the summer months. The samples are analysed for faecal indicator bacteria and results are assessed according to national guidelines published by the Ministry for the Environment and Ministry of Health [10].

This report presents the results for the samples taken during the summer season of 2017/2018 and investigates long term trends for faecal indicator bacteria concentrations where possible. It also presents a review of SFR Grades, which are a valuable way of gauging the overall recreational water quality of a site.

It is important to note that the Recreational Water Quality program is exclusively focused on health based risks associated with faecal contamination and results are not reflective of the general water quality of a site, the presence of toxic algae or other risks associated with a site (eg; high water flows or strong currents).

2. Recreational Water Quality Monitoring

The recreational water quality of ten coastal beaches and seven river sites was monitored from the beginning of November 2017 until the end of March 2018. Samples were taken weekly, usually at the beginning of each week, independent of weather conditions and tide levels. Hill Laboratories in Blenheim was contracted to measure the indicator bacteria concentrations in the samples. Bacteria levels were determined as MPN counts using Enterolert for Enterococci and Colilert for E. coli after up to 24 hour incubation at 41^{o}C and 35^{o}C respectively.

As soon as analysis results were received from the laboratory, the indicator bacteria concentrations were assessed according to the Microbiological Water Quality Guidelines. The guidelines are described in more detail in Section 3.

In order to provide the public with up-to-date information, the results are displayed on the LAWA website (www.lawa.org.nz). This is done in the form of a map based application with direct links to our data base. This ensures that information is accessible to the public as soon as the laboratory results are electronically transferred into the data base. LAWA (Land Air Water Aotearoa) is a combined repository for environmental information collected by local government throughout New Zealand.

3. The Microbiological Water Quality Guidelines

In 2003 the Ministry for the Environment (MfE) and the Ministry of Health (MoH) published a Guideline document which presents a framework for the monitoring of the microbiological water quality of recreational areas [10]. The document provides general recommendations in regard to the management of recreational water quality and guideline values allowing the assessment of results from individual samples. The document also includes a method to evaluate the overall bacterial risk at a site, the Suitability for Contact Recreation Grade (SFR Grade). This grade takes into account the risks of faecal contamination from the surrounding areas and the sampling results from five consecutive summer seasons.

3.1. Guideline values for individual samples

Measuring the concentrations of all microorganisms that can be hazardous for the health of water users is both difficult and expensive. A more cost effective approach is the use of indicator bacteria. These are comparatively easier to measure and are generally present when water is contaminated with harmful organisms such as Salmonella, Campylobacter, Giardia or Cryptosporidium. High concentrations of indicator bacteria are a sign that the water is potentially contaminated with human sewage or animal faeces, which results in an increased health risk for recreational users of a waterbody, particularly swimmers.

Two different indicator bacteria are used depending on the type of water that is being monitored. Freshwater samples are analysed for the concentration of E. coli, while Enterococci are the preferred indicator bacterium for coastal samples. The 2003 Guideline document provides two guideline values for each of the two indicator bacteria. Based on these guidelines, sample results are categorised into three “Modes”, which allow a decision to be made on whether the water can be considered safe for contact recreation. Table 1 outlines these “Modes” and their meaning as well as the actions that need to be taken as a result. In this report, the lower limit for the Alert Mode is referred to as the Alert Guideline, which corresponds to concentrations of 260 E. coli/100mL and 140 Enterococci/100mL. The upper limit for the Alert Mode (lower limit of the Action Mode) is referred to as the Action Guideline and corresponds to concentrations of 550 E. coli/100mL and 280 Enterococci/100mL.

Mode	Freshwater E. coli/100mL	Coastal Enterococci/100mL	Meaning	Required Action
Green Mode	<260	<140	**Safe** for contact recreation	Conitue routine monitoring
	260	140	**Alert Guideline**	
Alert Mode	260 - 550	140 - 280	**Increased risk** for health	Investigate possible causes and increase sampling frequency if no cause can be found, otherwise continue routine sampling
	550	280	**Action Guideline**	
Action Mode	>550	>280	**Unsafe** for conctact recreation	Increase sampling frequency and warn the public that the beach is considered unsafe (Warning signs)

Table 1: Modes and the corresponding Guidelines as outlined by the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas [10].[1]

If indicator bacteria concentrations are above the Alert or Action Guideline possible causes are considered and the District Health Board is informed. A joint decision is made on how to proceed. Usually, warning signs are erected at sites with unsafe levels of indicator bacteria. The sites are then sampled more frequently until indicator bacteria concentrations have returned to safe levels and warning signs can be removed. A flowchart outlining the process is shown in Appendix 3.

[1] For coastal samples the Action Mode is usually only applied after concentrations in two consecutive samples exceed 280 Enterococci/100mL. However, if large numbers of people are expected to visit the beach (i.e. during holiday periods), a precautionary approach is taken and warning signs are erected after only one exceedance.

3.2. Suitability for Contact Recreation Grades (SFR Grades)

Although, individual results provide information about the recreational water quality of a site for the date and time a sample was taken, water quality is inherently variable and can quickly change within very short time frames, especially as a result of rainfall (see Section 4). This is particularly a problem for the measurement of E. coli or Enterococci concentrations, because there are no cost-effective methods to monitor these bacteria in real-time. Due to the incubation methods currently used, there is a minimum 18-hour delay before the result of a sample can be known. Additionally, the sampling frequency is limited by practicality and budget constraints, which means we cannot sample often enough to ensure that the public is notified every time water is unsafe. For that reason, the main purpose of the sampling program is the analysis of the results of several years of sampling to obtain a general picture of the recreational water quality for a site. The results of this analysis are expressed in a grading system, the Suitability for Contact Recreation Grades or SFR Grades.

The Grades are based on a 'reasonable risk' approach in regard to the possibility of contracting water borne diseases associated with faecal contamination when pursuing recreational activities in and around the water.

The SFR Grade is the combination of a catchment assessment (Sanitary Inspection Category, SIC) and an assessment of the Microbiological Water Quality (Microbiological Assessment Category, MAC).

The SIC catchment assessment is primarily focused on potential sources of faecal contamination that can affect the water quality at the swimming site. SICs based on this assessment are given values of Very Low, Low, Moderate, High or Very High (Risk). Sites surrounded by bush and forest are given a SIC of Very Low. Low intensity agriculture in the catchment results in a SIC of Low. Categories of High and Very High are given to sites likely to directly receive treated or untreated sewage or run-off from high-intensity agriculture.

The second part of the grading process, the MAC, is derived from the Enterococci or E. coli concentrations in routine samples taken from a site over five consecutive summers. MACs range from A to D (Table 2) and are based on the upper 95th percentile (95%ile) calculated with the Hazen method (see Section 5 , Figure 1).

MAC (Microbiological Assessment Category)	**Coastal**	**Freshwater**
	Enterococci/100mL*	E. coli/100mL*
A	<41	<131
B	41 - 200	131 - 260
C	201 - 500	261 - 550
D	>500	>550

* upper 95th Percentile (95%ile) of routine sampling over 5 consecutive summers

Table 2: Microbiological Assessment Categories (MAC).

The SIC and the MAC for a site are then combined into the SFR Grade (Table 3). There are five grades ranging from Very Good to Very Poor. Table 4 outlines the definitions for the individual Grades.

SFR Grade (Suitability for Contact Recreation Grade)		**MAC** (Microbiological Assessment Category)			
		A	B	C	D
SIC (Sanitary Inspection Category)	Very Low	**Very Good**	**Very Good**	*	*
	Low	**Very Good**	**Good**	**Fair**	*
	Moderate	*	**Good**	**Fair**	**Poor**
	High	*	*	**Poor**	**Very Poor**
	Very High	*	*	*	**Very Poor**

* unexpected result (further investigation is necessary)

Table 3: Deriving SFR Grades from the MAC and SIC categories.

SFR Grade	Meaning
Very Good	Considered satisfactory for swimming at all times.
Good	Satisfactory for swimming most of the time with exceptions following rainfall.
Fair	Generally satisfactory for swimming. Caution should be taken during periods of high rainfall and swimming avoided if water is discoloured.
Poor	Swimming should be avoided, particularly by the very young, the very old and those with compromised immunity.
Very Poor	Generally swimming is not recommended.

Table 4: Suitability for Contact Recreation Grades (SFR Grades) and their meaning.

The recreational water quality of some sites has changed since SFR Grades were reviewed in the previous report. Therefore, grades were updated where required. Two sites that were added to the program this season do not yet have a sufficiently large dataset to allow grading. Another three seasons of sampling is required before interim SFR Grade can be assigned to these sites.

Grading information on the LAWA website (www.lawa.org.nz) is derived slightly differently from the recommendations given by the guidelines. The grades are based solely on the calculation of 95 percentile values without the incorporation of SIC assessments. To provide grades for sites relatively recently added to the program, calculation of the grading is based on results of three seasons, rather than the five seasons suggested by the guidelines. More information about the grading process used on the LAWA website can be found here: https://www.lawa.org.nz/learn/factsheets/what-do-the-swim-icons-mean/

4. Influence of Rainfall

Rainfall greatly influences recreational water quality at the majority of sites monitored. Even small rainfall events can wash animal faeces from pastures, roofs, roads and other surfaces into rivers and coastal waters. In urban areas, run-off from hard surfaces picks up bird droppings, dog faeces, and other contaminants and is collected in the stormwater system, which is discharging directly into the local waterways. Larger rainfall events can also cause septic tanks to overflow if these are not properly sealed or maintained.

It is generally recommended to not go swimming for 48 hours after rainfall or if the water is discoloured, particularly in waterways that are known to be affected by rural or urban run-off.

5. Results

The following chapters present the monitoring results for the 2017/2018 summer season as well as changes of faecal bacteria concentrations over time (long-term trends). Where appropriate, sites are grouped into sets of two or three sites. For each group the concentration of faecal indicator bacteria in the samples taken from each site is shown graphically, together with rainfall and/or flow data recorded at nearby sites. This allows the results to be viewed in the context of rainfall and flood events, which are the main causes for increased concentrations of faecal bacteria concentrations at most sites (see Section 4). A map shows the location of the sampling sites as well as the rainfall and/or flow recorder. For sites with longer monitoring records, the changes over time are shown using the 5-year-95%ile (MAC) values (Figure 1), which are also used for the calculation of the SFR Grades (see Section 3.2).

Summary tables showing the numerical results for all samples taken this season can be found in the Appendices. Additionally, Appendix 2 contains graphs showing the compliance history and box and whiskers plots for sites that have been monitored for more than three years.

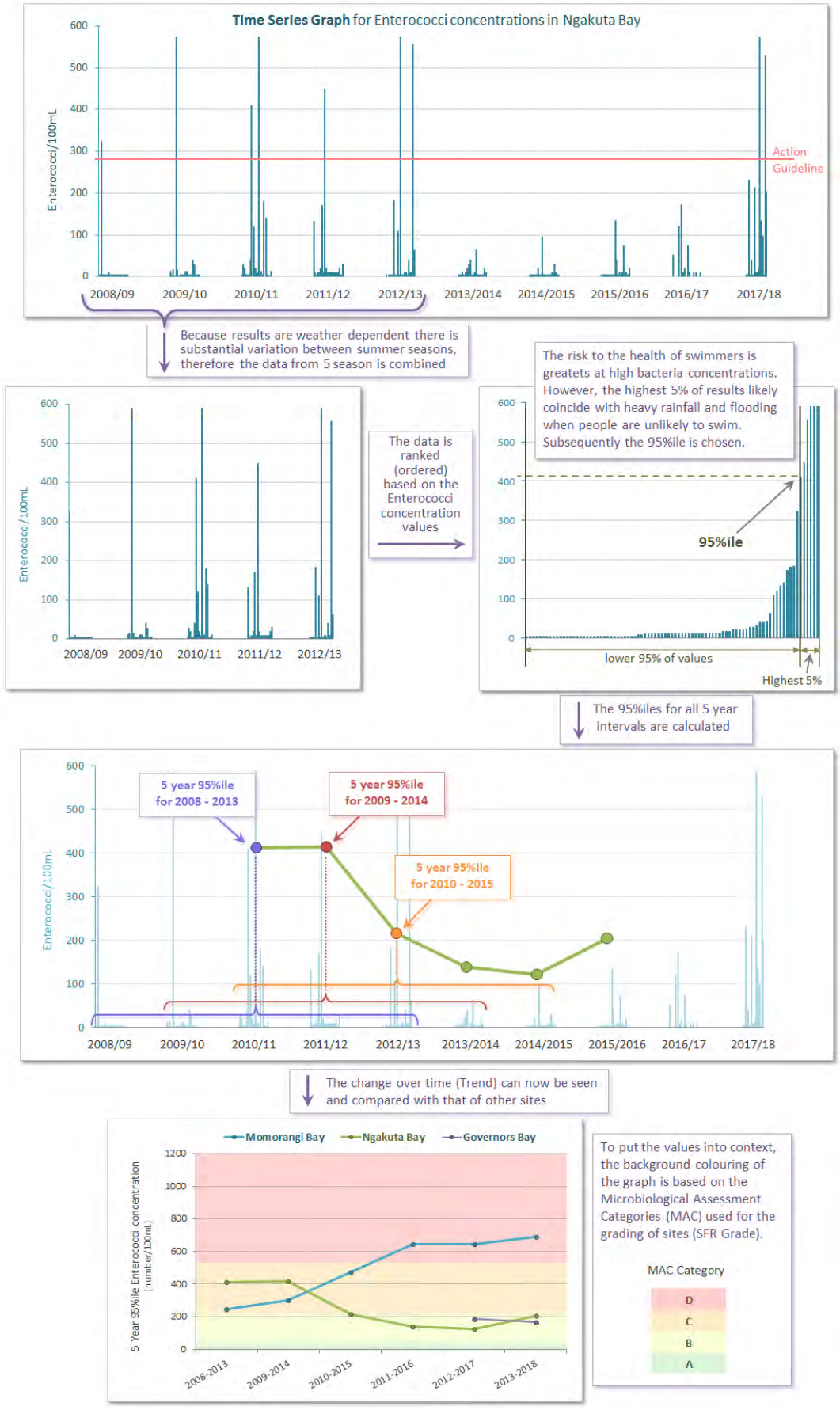


Figure 1: Creation of 5-Year-95%ile Graphs, used to display long-term trends.

5.1. Okiwi Bay

Site

Okiwi Bay is the only sampling site located in the outer Marlborough Sounds. There is substantial residential development in the catchment that has potential to impact on water quality in the bay. A swimming area marked by buoys is managed by the local residents group. The relatively shallow gradient of the seafloor means that at low tide, a wide sandy beach is exposed providing safe swimming and playing for the whole family. A holiday park and several rental batches located near the beach provide accommodation for longer stays.

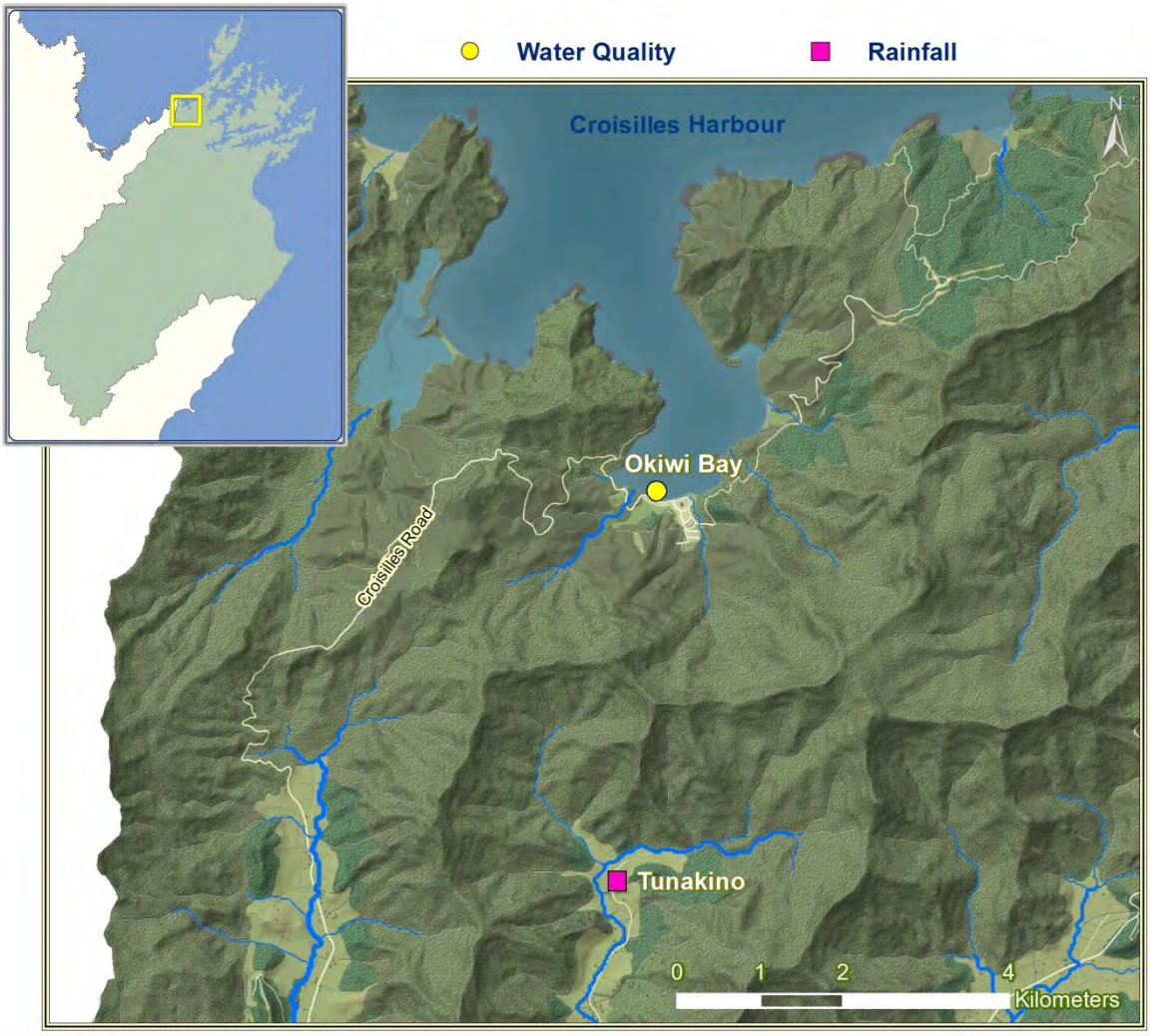


Figure 2: Location of the Okiwi Bay sampling sites and the Tunakino rain gauge.

Results

The only sample with unsafe bacteria concentrations was taken on 31 January 2018 (Figure 3). None of the other sites sampled on that day exceeded guideline levels and only a very small amount of rainfall was recorded at the Tunakino rainfall recorder, located less than five kilometres South of Okiwi Bay (Figure 2). It is possible that a localised rainfall event did not reach the Tunakino recorder, but this is rather unlikely considering the scale of the effect on the water quality at Okiwi Bay. The two samples with Enterococci concentrations that exceeded the Alert guideline only, coincided with elevated E. coli concentrations in the neighbouring Pelorus catchment. It can therefore be assumed that a significant amount of rainfall is required to cause unsafe bacteria levels at Okiwi Bay as a result of rainfall run-off. Therefore, rainfall run-off might not have caused the high Enterococci concentrations in the January sample. Unfortunately, due to the remoteness of the site, council was unable to take additional samples following the event.

Should future sampling reveal additional occasions of high Enterococci concentrations that are unrelated to rainfall, an investigation into the sources is advisable.

Apart from the three guideline exceedances discussed, samples taken from Okiwi Bay had very low bacteria concentrations, indicating that recreational water quality at this beach is very good most of the time.

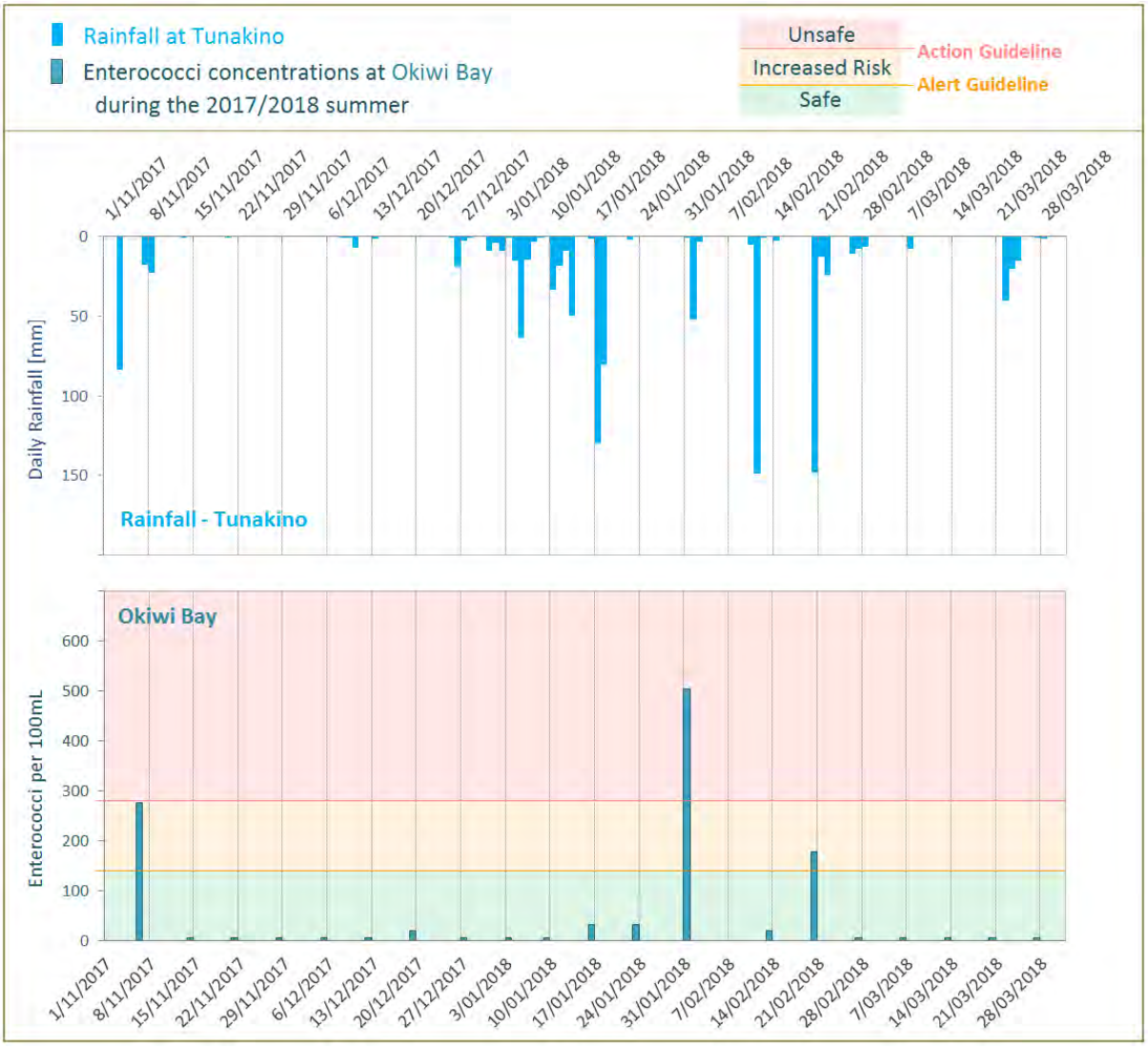


Figure 3: Enterococci concentrations at Okiwi Bay for the 2017/18 summer season.

Okiwi Bay was monitored for a short period in the past. During the 1999/2000 summer season several samples were taken and analysed for faecal indicator bacteria concentrations. Unfortunately, the historic samples were analysed for E. coli rather than Enterococci, making a direct comparison difficult. Nevertheless, the results suggest that recreational water quality has improved.

5.2. Anakiwa and Mistletoe Bay

Sites

Anakiwa is located in the innermost part of the Queen Charlotte Sound/Totaranui. The Outward Bound facility and the start of the popular Queen Charlotte Track are located in close proximity to the small beach sampled as part of the program. The microbiological water quality is influenced by the surrounding residential development and large numbers of seabirds (ie; oystercatcher, swans and ducks). Water quality is expected to also be influence by Linkwater Stream and Ada Creek (Figure 4). These two streams drain pastoral land and flow into the Sound 2 km from the Anakiwa sampling site. Monthly monitoring of Linkwater Stream has shown that water quality in this waterway is marginal and E. coli concentrations are frequently high [7].

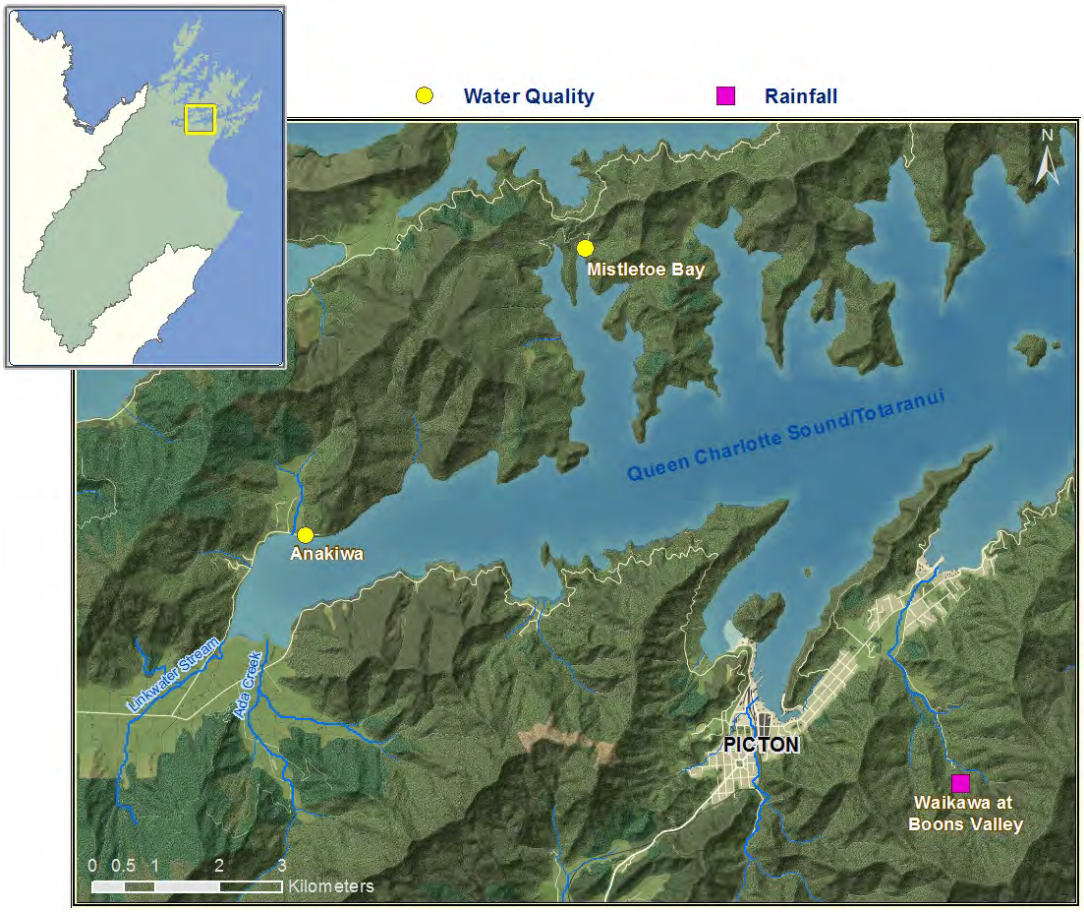


Figure 4: Location of the Anakiwa and Mistletoe Bay sampling sites and the Waikawa at Boons Valley rain gauge.

Compared to Anakiwa, Mistletoe Bay has few possible sources of faecal contamination. The enclosed Bay is surrounded by bush-clad hills and the Mistletoe Bay Camp is the only human influence in the immediate catchment.

Results

This summer, Enterococci concentrations in Anakiwa were generally higher than those observed in Mistletoe Bay. This is not surprising considering the significantly greater number of houses in the Anakiwa area. High Enterococci concentrations in Anakiwa all coincided with rainfall recorded at the Boons Valley rainfall recorder. Additional sampling carried out following the only exceedance of the Action Guideline in February 2018, showed that bacteria concentrations had returned to safe levels within a day of the event (Figure 5).

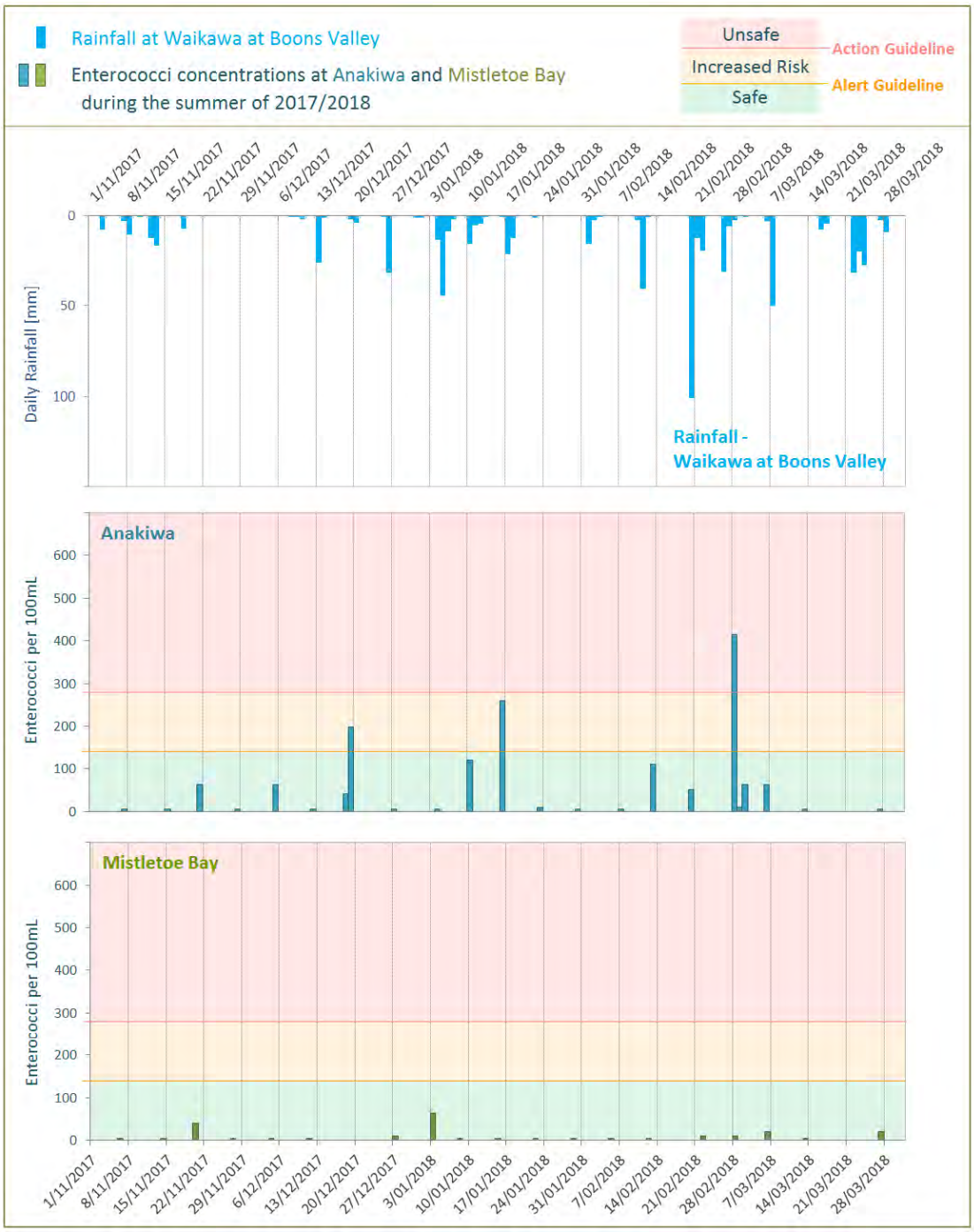


Figure 5: Enterococci concentrations at Anakiwa and Mistletoe Bay for the 2017/18 summer season.

Up until recently rainfall would also result in comparatively high bacteria concentrations in Mistletoe Bay [8]. A joint investigation by Council and the Mistletoe Bay Trust revealed an old septic tank as the cause. The tank was removed, and the improvement in recreational water quality has been very noticeable since. In fact, Mistletoe Bay had the lowest Enterococci concentrations of all beaches monitored this season. This is reflected in the improvement in the long term trend for Mistletoe Bay (Figure 6).

After initially very high Enterococci concentrations in the early years of monitoring of Anakiwa, bacteria levels have changed very little in recent years. This season's results show a continuing of this trend.

Both, Anakiwa and Mistletoe Bay currently have similar 5-year 95%ile values, resulting in the same SFR Grade of 'Fair'. However, the current grading for Mistletoe Bay is still influenced by the higher Enterococci concentrations observed in the previous summer seasons. If the results of this summer are an indication of future water quality at the site, it is likely that Mistletoe will regain a SFR Grade of 'Good'.

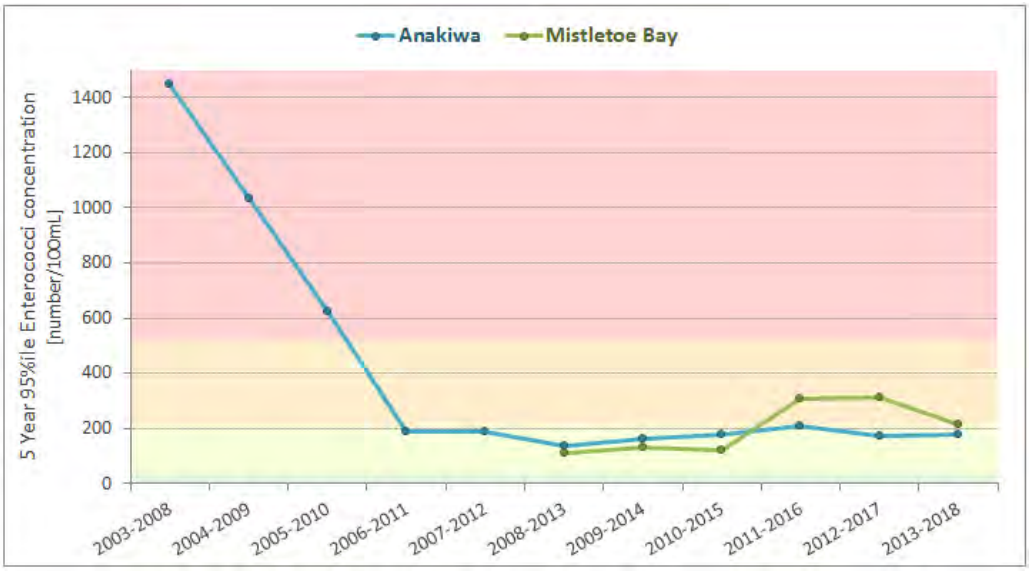


Figure 6: The 5-year 95%ile Enterococci concentrations for Anakiwa and Mistletoe Bay.

Figure 7: Mistletoe Bay is a popular destination for family holidays and school trips. This site had the best recreational water quality of all sites monitored this season.

5.3. Momorangi, Ngakuta and Governors Bay

Sites

Momorangi Bay, Ngakuta Bay and Governors Bay are neighbouring bays in the inner Queen Charlotte Sound/Totaranui. Ngakuta Bay is the largest and most enclosed bay in this group and also has the greatest amount of residential development in the catchment. There are nearly 100 houses and holiday homes compared to less than 20 in Momorangi Bay and none in Governors Bay. Momorangi Bay, however, has a very popular campground, which attracts more visitors during the summer months than the other two bays combined.

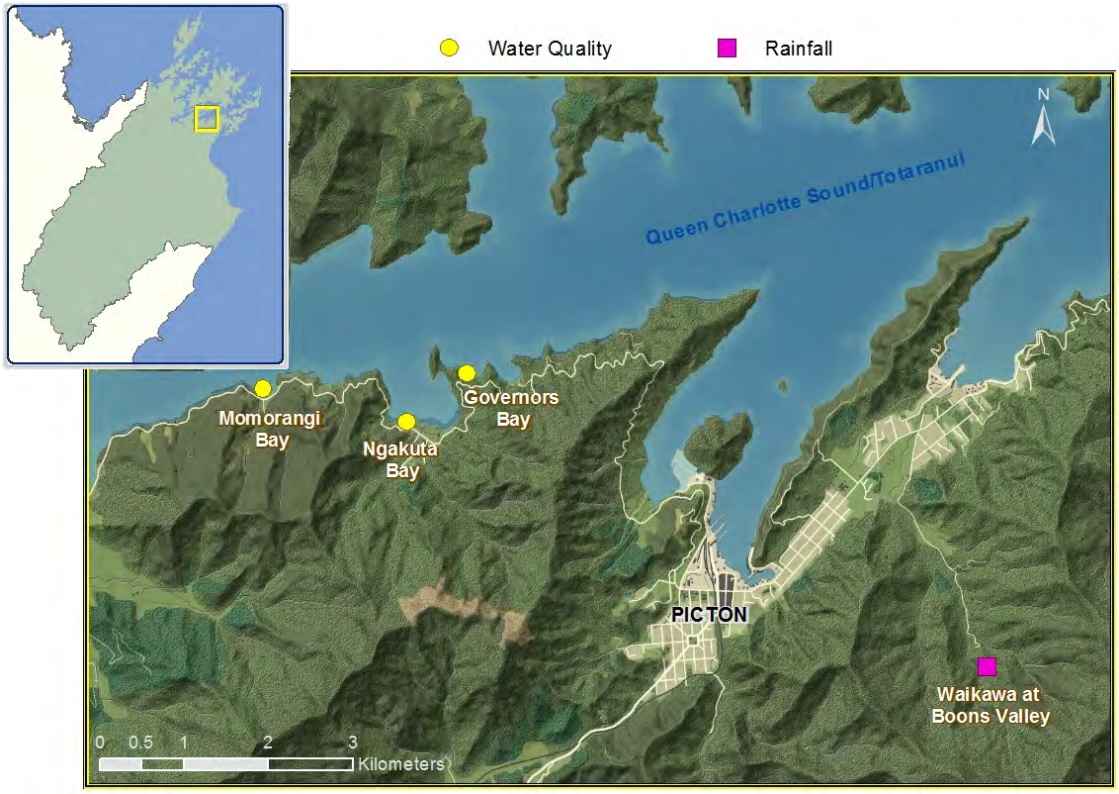


Figure 8: Map showing the sampling sites at Momorangi Bay, Ngakuta Bay and Governors Bay, as well as the rainfall recorder at Boons Valley.

Results

An exceedance of the Action Guideline at Momorangi Bay in early December 2017 occurred during the only significant period of warm, dry weather this season; however follow-up sampling showed that Enterococci concentrations did not remain at high levels (Figure 9). During the previous two seasons, a number of problems with the campground sewage systems resulted in contamination of the water in some areas of the bay. There have since been significant upgrades and repairs of the system. The results for the latter part of the season showed that high bacteria concentrations were consistently linked to rainfall. The highest Enterococci concentration was observed during the most intense rainfall event in February 2018. The lower Enterococci levels in Ngakuta Bay and Governors Bay during this rainfall event were a result of sample timing. A cold front that was moving in from the North-West had simply not fully reached Ngakuta and Governors Bay at the time samples were taken from these bays. This case highlights the fact that individual sampling results are only representative of the conditions at the specific date and time the samples were taken. This means individual results should not be used as an indication of current water quality at a beach. Instead the purpose of the sampling is to allow analysis of the overall water quality at a site, which is represented in the SFR Grades. Until methods are developed that allow continuous monitoring of faecal indicator bacteria, these grades provide a better indication of recreational water quality than the latest sampling results.

Figure 9: Enterococci concentrations at Momorangi Bay, Ngakuta Bay and Governors Bay during the 2017/18 summer season.

In the latter part of the season high Enterococci concentrations in Ngakuta Bay generally occurred when concentrations in Momorangi Bay were elevated, but there was no correlation in regard to the magnitude of bacteria levels observed in the two bays. On a number of occasions significant exceedances of the Action Guideline occurred in Ngakuta Bay while bacteria concentrations in Momorangi were only slightly elevated. Additional sampling in the days following some of these exceedances showed that Enterococci concentrations quickly returned to very low levels. This indicates that these occurrences are a result of rainfall run-off rather than ongoing problems. Nevertheless, the magnitude of the exceedances in Ngakuta Bay is concerning, particularly in light of relatively small amounts of rainfall recorded during those events. Anecdotal evidence suggests that rainfall can vary considerably between bays during the same event. It is therefore possible that the rainfall recorded at Waikawa Boons Valley is not necessarily representative of the actual rainfall amount observed in Ngakuta Bay. Still, an investigation into the performance of septic tanks in the bay might be necessary to determine if overflowing systems contribute to the high bacteria concentrations observed during rainfall. The comparatively high Enterococci concentrations in Ngakuta Bay this season have reversed the improving trend observed in recent years (Figure 10). Therefore, the site had to be downgraded to a SFR Grade of 'Fair'.

Enterococci concentrations in Governors Bay were comparatively low. Faecal bacteria concentrations reached unsafe levels on only one occasion during the season which coincided with elevated or high bacteria levels at the other two bays. Because there is no residential development in Governors Bay, Enterococci concentrations are expected to be a lot lower than in Ngakuta Bay or Momorangi Bay. A much smaller catchment also means that the impact of feral and native animal droppings that are washed into the bay during rainfall is comparatively small. Due to its closer proximity to Ngakuta Bay Enterococci concentrations in Governors Bay generally correlated better with results from Ngakuta Bay than those observed in Momorangi Bay. This indicates that rainfall patterns can indeed be quite different within the individual bays.

The generally low Enterococci concentrations in Governors Bay result in a SFR Grade of 'Good for this bay.

Due to the problems with the sewage system at Momorangi Bay in previous years and the occasionally high Enterococci concentrations observed this summer, this site is currently still graded as 'Poor'.

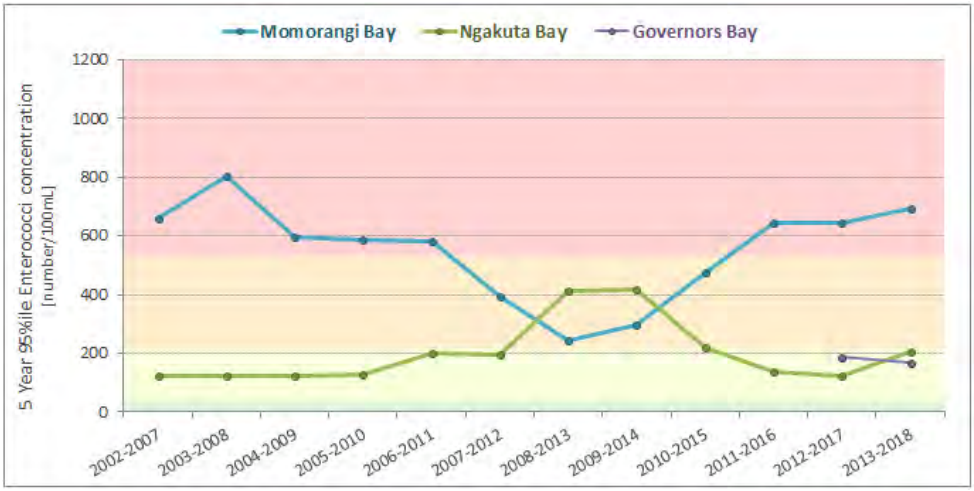


Figure 10: The 5-year 95%ile Enterococci concentrations for Momorangi Bay, Ngakuta Bay and Governors Bay.

5.4. Picton Foreshore and Waikawa Bay

Sites

The Picton Foreshore is a relatively small beach area. Nevertheless, the close proximity to the Picton town center, the information center, the aquarium and a large, modern playground make it a popular destination for local residents and visitors. The Picton Maritime Festival and other events result in large numbers of visitors to the beach. Waikawa Bay, on the other hand, is predominantly used by local residents.

The water quality of the Picton Foreshore and Waikawa Bay are both influenced by the urban environment that surrounds these sites. The substantially greater amount of residential development influencing the Picton Foreshore is reflected in the generally poorer water quality at this site.

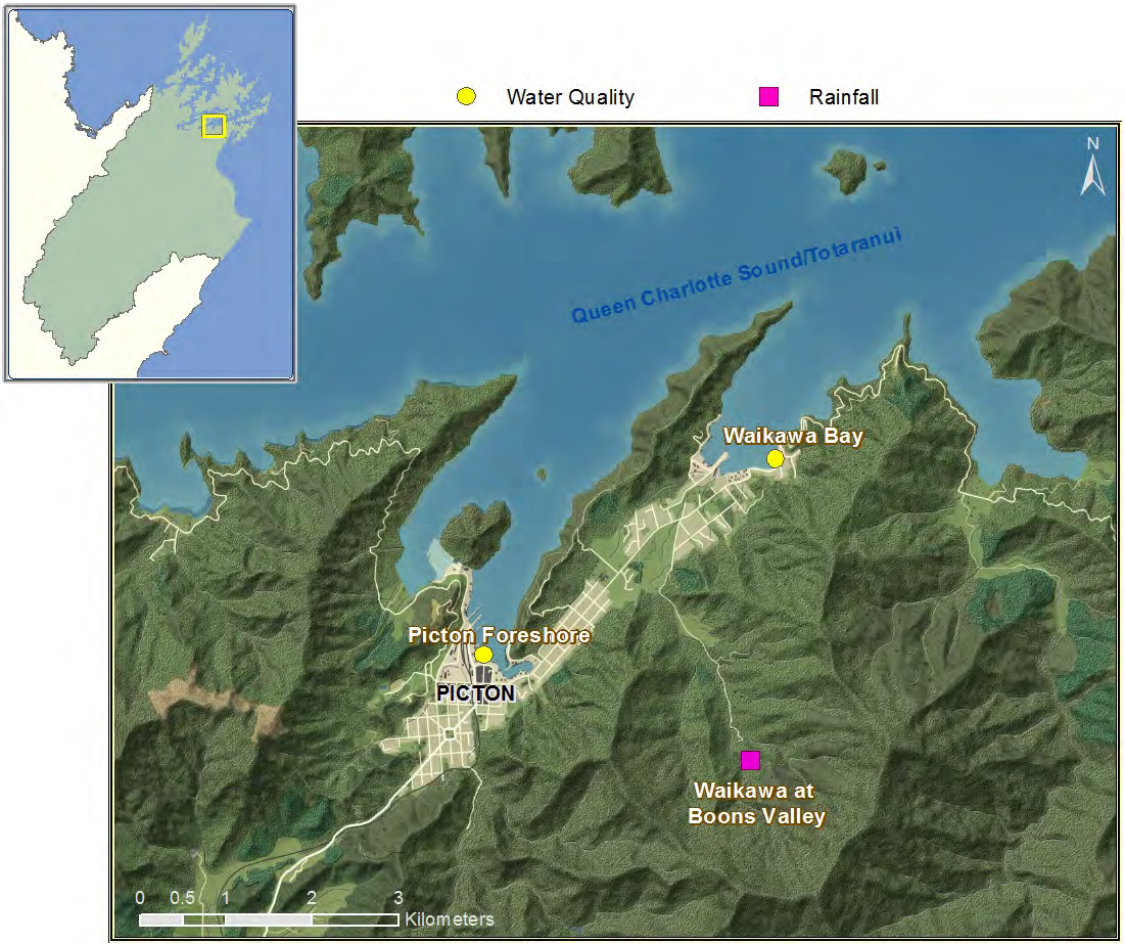


Figure 11: Locations of the Picton Foreshore and Waikawa Bay sampling sites and of the rainfall recorder at Boons Valley.

Results

The two exceedances of the Action Guideline at Picton Foreshore this summer season coincide with very high Enterococci concentrations at Ngakuta Bay. This indicates that the high bacteria levels were the result of rainfall in the Marlborough Sounds area. Surprisingly, concentrations at the Picton Foreshore were significantly lower than those observed in Ngakuta Bay. This suggests that a relatively small number of private sewage systems at Ngakuta Bay potentially have a greater impact on water quality in the Sounds than the reticulated system servicing the over 2,000 properties in Picton and Waikawa. A significant amount of effort has been put into upgrading the Picton sewerage system. There have also been substantial efforts to eliminate cross contamination between pipes that carry sewage and those that discharge stormwater into streams and the bay. Further major upgrades of the Picton sewerage infrastructure are currently underway, including the replacement of main

sewerage pipes and pump stations. This will result in fewer sewage overflows into the harbour during heavy rainfall events and subsequently further reduce the health risk to recreational users.

The recreational water quality at the Picton Foreshore is currently graded as ‘Fair’.

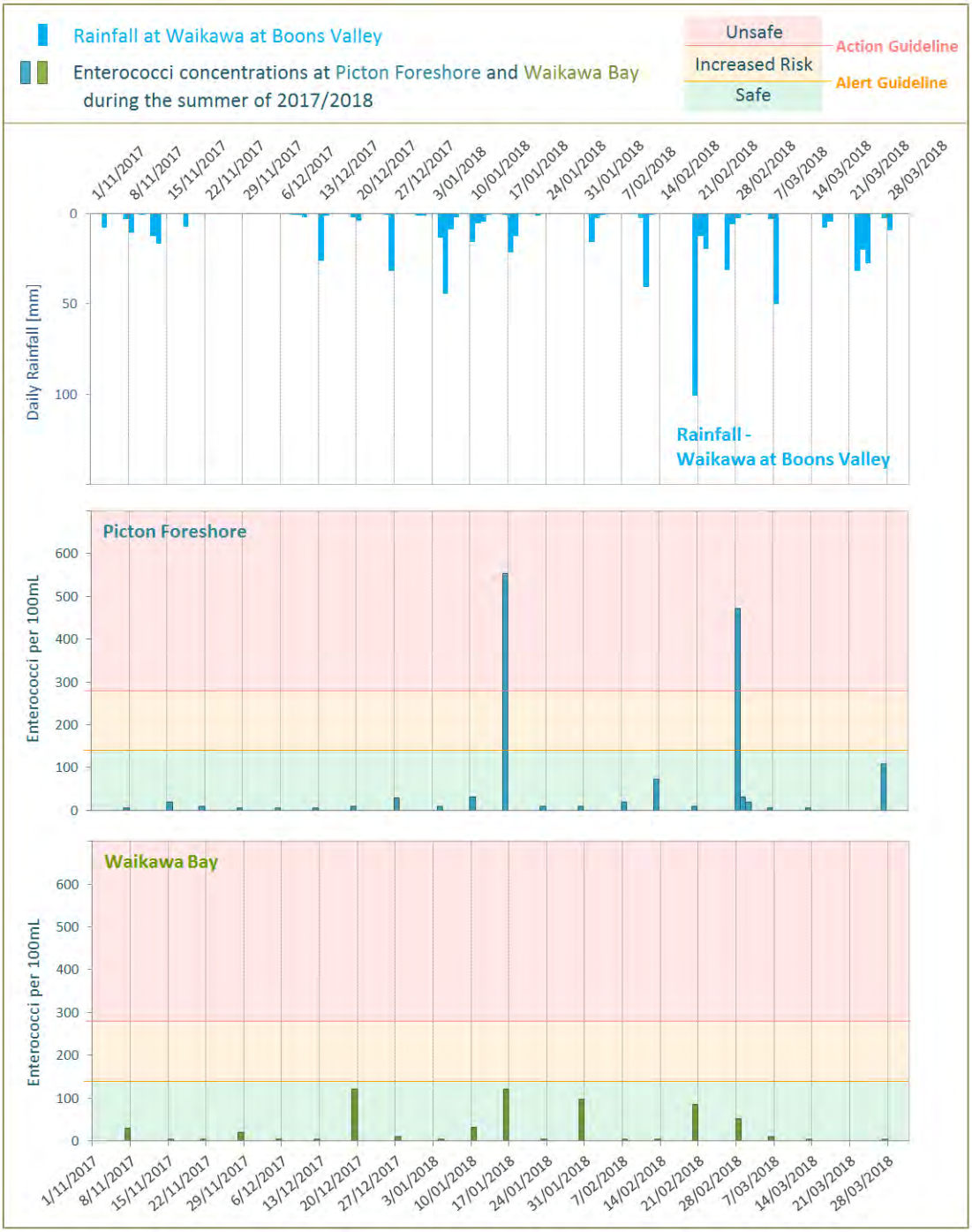


Figure 12: Enterococci concentrations at Picton Foreshore and Waikawa Bay during the 2017/18 summer season.

As in previous years, Enterococci concentrations in Waikawa Bay were comparatively low, with no exceedances of the Guidelines despite frequent rainfall this summer. The recreational water quality at this site is graded as ‘Good’.

The long term trend shows the significant improvement of the recreational water quality at the Picton Foreshore that was achieved so far (Figure 13). In recent years Enterococci concentrations continued to decrease, albeit at a reduced rate. In comparison, bacteria concentrations in Waikawa Bay have changed very little over the more than 10 years the site has been monitored.

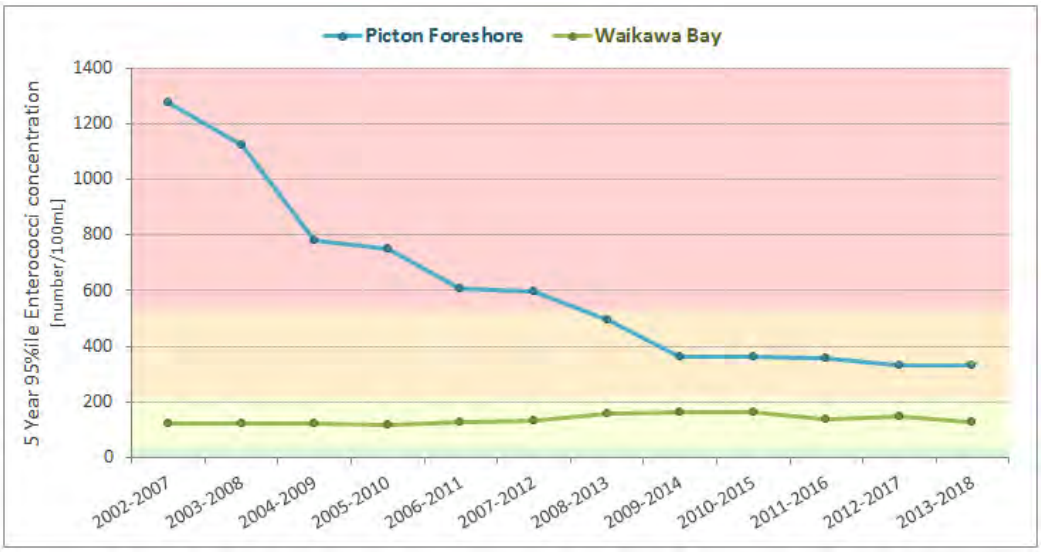


Figure 13: The 5-year 95%ile Enterococci concentrations for Picton Foreshore and Waikawa Bay.

Figure 14: Upgrade of the sewerage network near the Waitohi River which flows into Picton Harbour.

5.5. Pukatea/Whites Bay and Waikutakuta/Robin Hood Bay

Sites

Pukatea/Whites Bay and Waikutakuta/Robin Hood Bay are located on the upper East Coast of the region. Pukatea/Whites Bay is one of the most popular beaches in Marlborough. A Department of Conservation campground is the only human influence in the bay and consequently water quality is generally very good. Waikutakuta/Robin Hood Bay, located only a few kilometres north of Pukatea/Whites Bay also offers a campground, but has a much larger catchment. Several streams flow into the bay. The largest, Stacy Creek, drains 90ha of pasture, which has a potential to affect the water quality in the bay. Waikutakuta/Robin Hood Bay is sampled at the swimming beach on the North-East side of the bay, which is also used to launch boats.

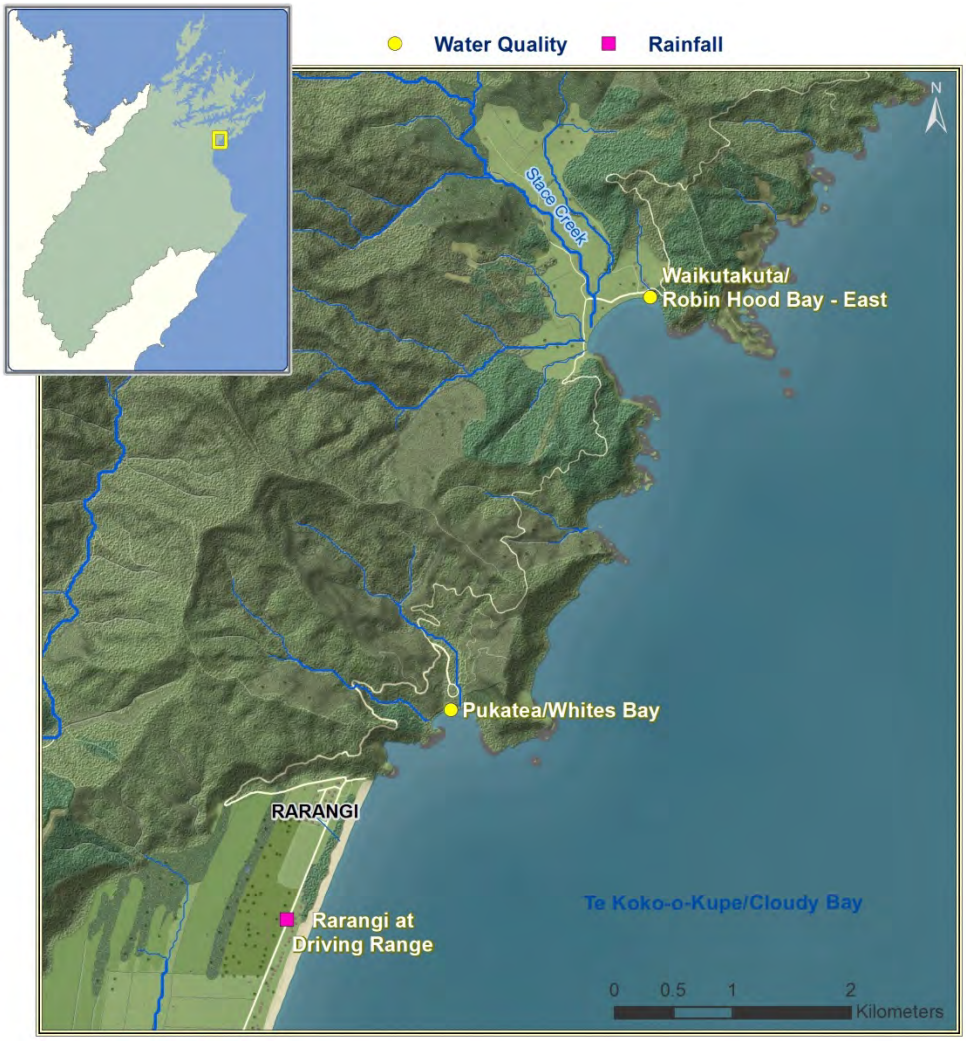


Figure 15: Locations of the Puketea/Whites Bay and the Waikutakuta/Robin Hood Bay East sampling sites, as well as the Rarangi rainfall recorder.

Results

Exceedances of Guidelines at Pukatea/Whites Bay are very rare, but a rainfall event in late February 2018 caused very high Enterococci concentrations at this site (Figure 16). On the same day bacteria concentrations in Waikutakuta/Robin Hood Bay were also high. It is possible that a localised high intensity rainfall event was affecting these two bays, but did not extend all the way to Rarangi, which recorded a relatively small amount of rainfall. The actual Enterococci concentration measured in Waikutakuta/Robin Hood Bay is the highest observed at any of the sites monitored this season. Cattle grazed in the lower catchment combined with feral animal sources in the hills are the most likely causes for the high bacteria levels in this bay during that event. However, irresponsible behaviour of campers could also be at play.

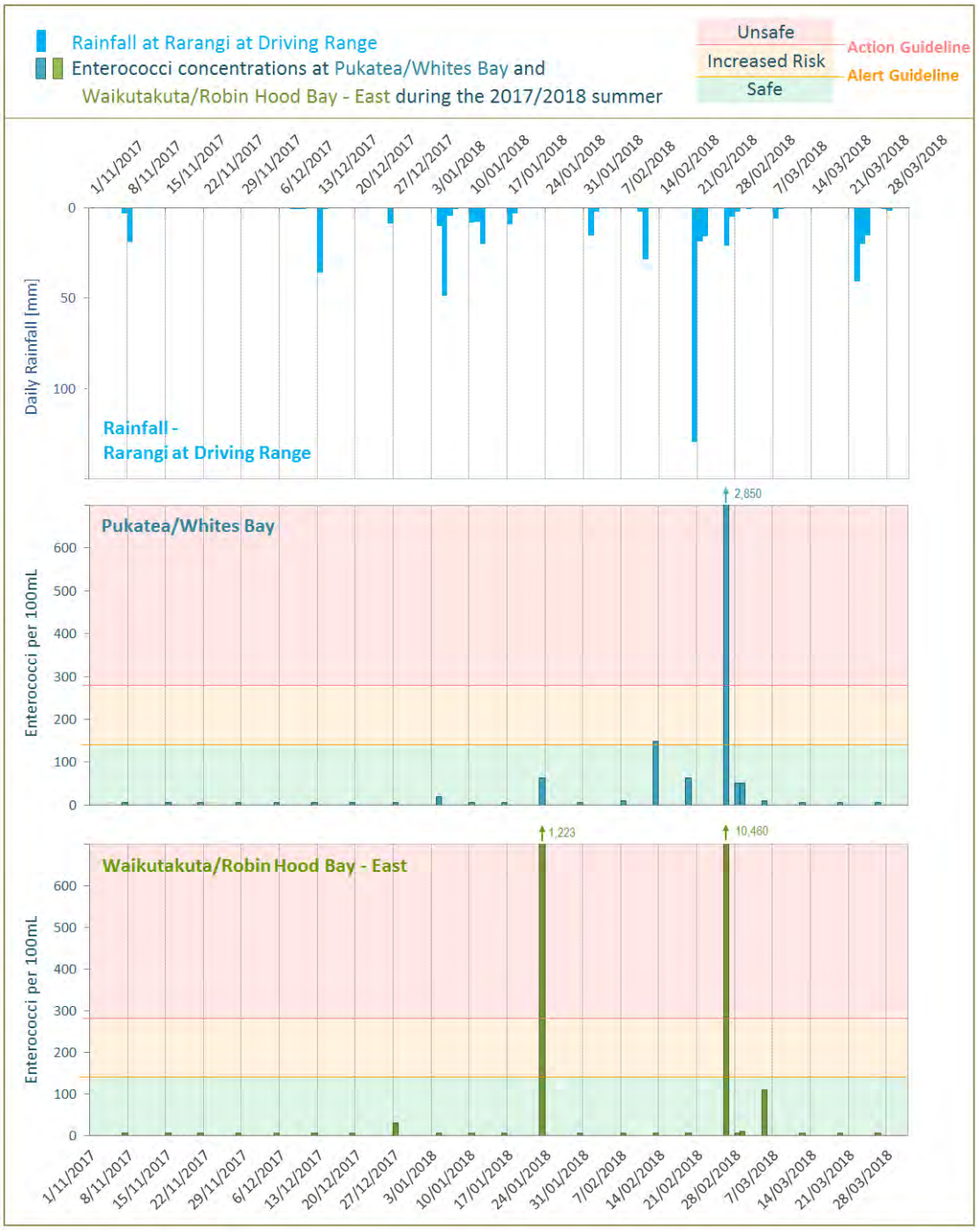


Figure 16: Enterococci concentrations at Pukatea/Whites Bay and Waikutakuta/Robin Hood Bay during the 2017/18 summer season.

Another sample with a high Enterococci concentration was taken from Waikutakuta/Robin Hood Bay when no rainfall was recorded at the Rarangi rainfall recorder. The Enterococci concentration at Pukatea/Whites Bay on the same day was only slightly elevated. Most other beaches also had relatively low bacteria levels. Large amounts of gorse deposited onto the beach during the previous summer had resulted in very high Enterococci concentrations during high tide when the gorse became submerged [8]. This season, no significant amount of vegetation was deposited onto the beach. It is therefore unclear what caused the high bacteria level observed in January 2018. Unexplained Enterococci concentrations of this magnitude can be a sign of significant ongoing sources of faecal contamination. However, the routine samples taken in the weeks that followed indicated that this was an isolated incident. Still, should similar irregularities occur in the future, a

thorough investigation into possible sources needs to be carried out to ensure that the health of recreational users of the bay is not at risk.

The recreational water quality of Waikutakuta/Robin Hood Bay is currently graded as ‘Fair’.

The long term trend for Pukatea/Whites Bay shows a slight increase in Enterococci concentrations. This is not a result of the occasional high Enterococci concentrations observed this summer, but rather a result of an increase in the number of samples with slightly elevated bacteria levels within the last two seasons. Considering that the majority of samples still have very low Enterococci concentrations it is possible that the increasing trend is simply a result of a greater number of samples that were taken during rainfall. This assumption is supported by the very similar increasing trend for Waikutakuta/Robin Hood Bay. Despite the slight increasing trend, the recreational water quality at Pukatea/Whites Bay remains graded as ‘Very Good’.

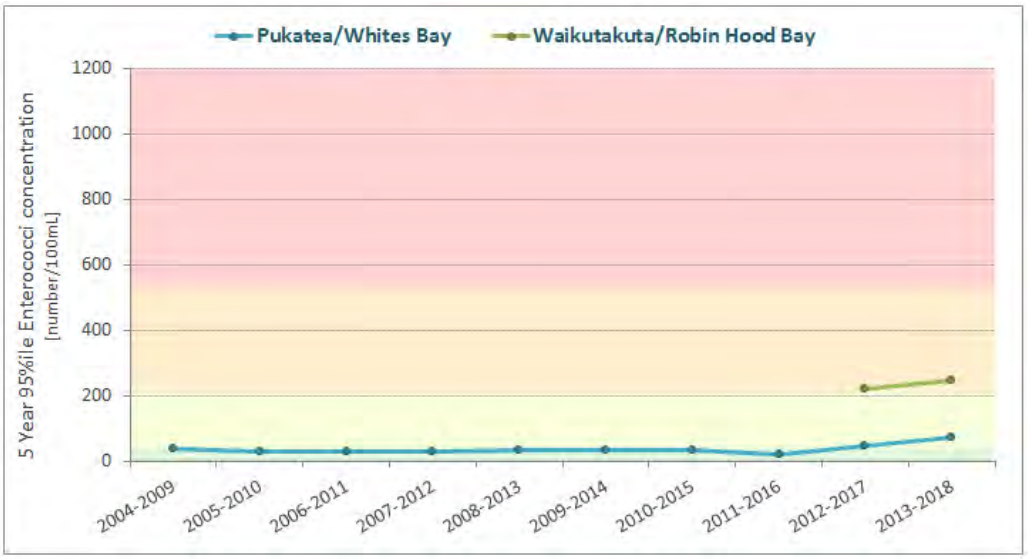


Figure 17: The 5-year 95%ile Enterococci concentrations for Pukatea/Whites Bay and Waikutakuta/Robin Hood Bay.

Figure 18: Pukatea/Whites Bay on a quiet day.

5.6. Te Hoiere/Pelorus River

Sites

The Te Hoiere/Pelorus River has two popular swimming sites that are sampled as part of the Recreational Water Quality program, Pelorus Bridge and Totara Flat. Pelorus Bridge is the most popular river site in the region for both, local residents and visitors. The large proportion of native vegetation upstream also means that it has the best water quality of all river sites monitored.

The Rai River drains one of the main dairy catchments of the region. It flows into the Te Hoiere/Pelorus River between the two sampling sites, approximately 300m upstream of Totara Flat. Subsequently, water quality at Totara Flat is strongly influenced by the water quality of the Rai River.

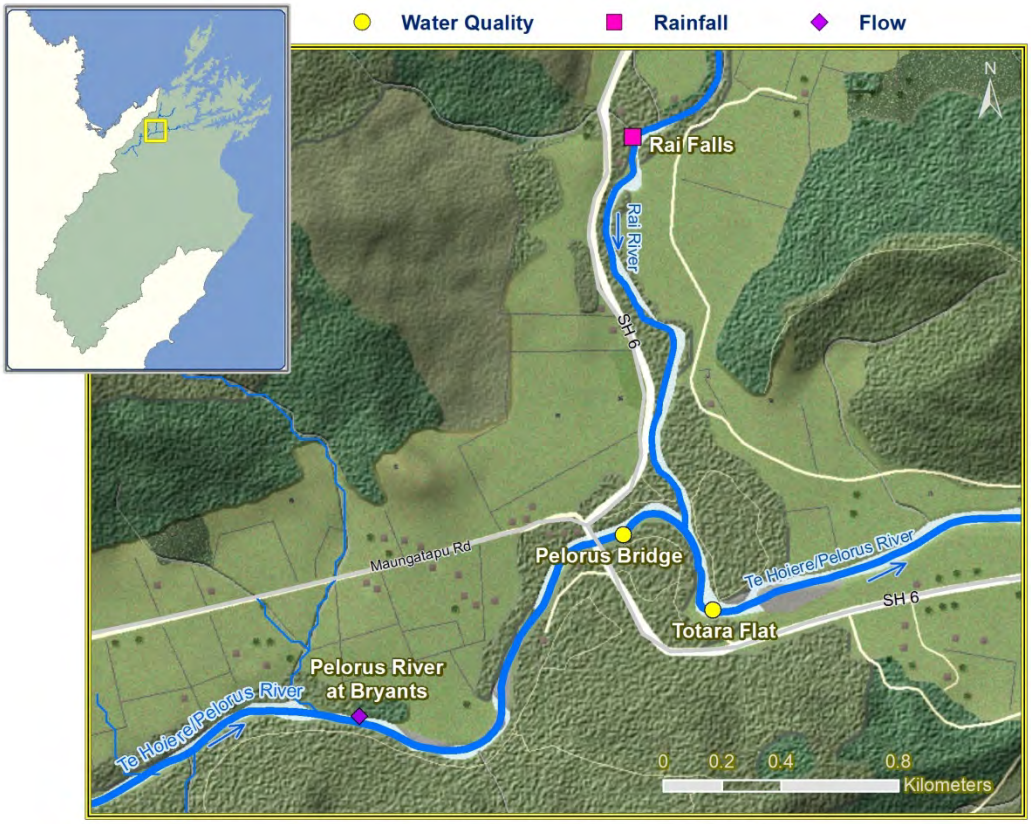


Figure 19: Locations of the Te Hoiere/Pelorus River sampling sites as well as nearby rainfall and flow recorders.

Results

As in previous years, E. coli concentrations at Pelorus Bridge were mostly very low (Figure 20). The exception was a sample taken during heavy rainfall in the catchment in February 2018. Additional samples taken following the event showed that bacteria concentrations returned to low levels within a day, despite smaller amounts rainfall that continued to fall. E. coli concentrations at Totara Flat taken on the same day were not as high initially, but remained more elevated during the additional sampling. The reason for the lower initial E. coli concentrations was simply a matter of timing. A cold front that was moving in from the west had already brought significant amounts of rainfall to the upper Te Hoiere/Pelorus catchment, but had not yet arrived in the Rai catchment located further to the East when the first samples were taken. The water from the Rai River had a diluting effect, resulting in lower E. coli concentrations downstream at the Totara Flat. Once rainfall had reached the Rai catchment, however, the effect reversed, which was evident in higher E. coli concentrations at Totara Flat in the additional sampling following the main rainfall even. Recent fencing of streams on dairy farms in the Rai River catchment has resulted in a noticeable reduction of E. coli concentrations during dry weather. However, during rainfall significant amounts of faecal matter are still washed into the Rai River by overland flow. In the upper Pelorus catchment, feral and native animals are the only

sources of faecal contamination. This smaller source results in a quicker reduction of E. coli concentrations following a rainfall event.

An earlier rainfall event on 11 February resulted in an exceedance of the Action Guideline at Totara Flat on the following day, while E. coli concentrations at the Pelorus Bridge were comparatively low. This was yet another example of the faster recovery of water quality at the Pelorus Bridge compared to Totara Flat.

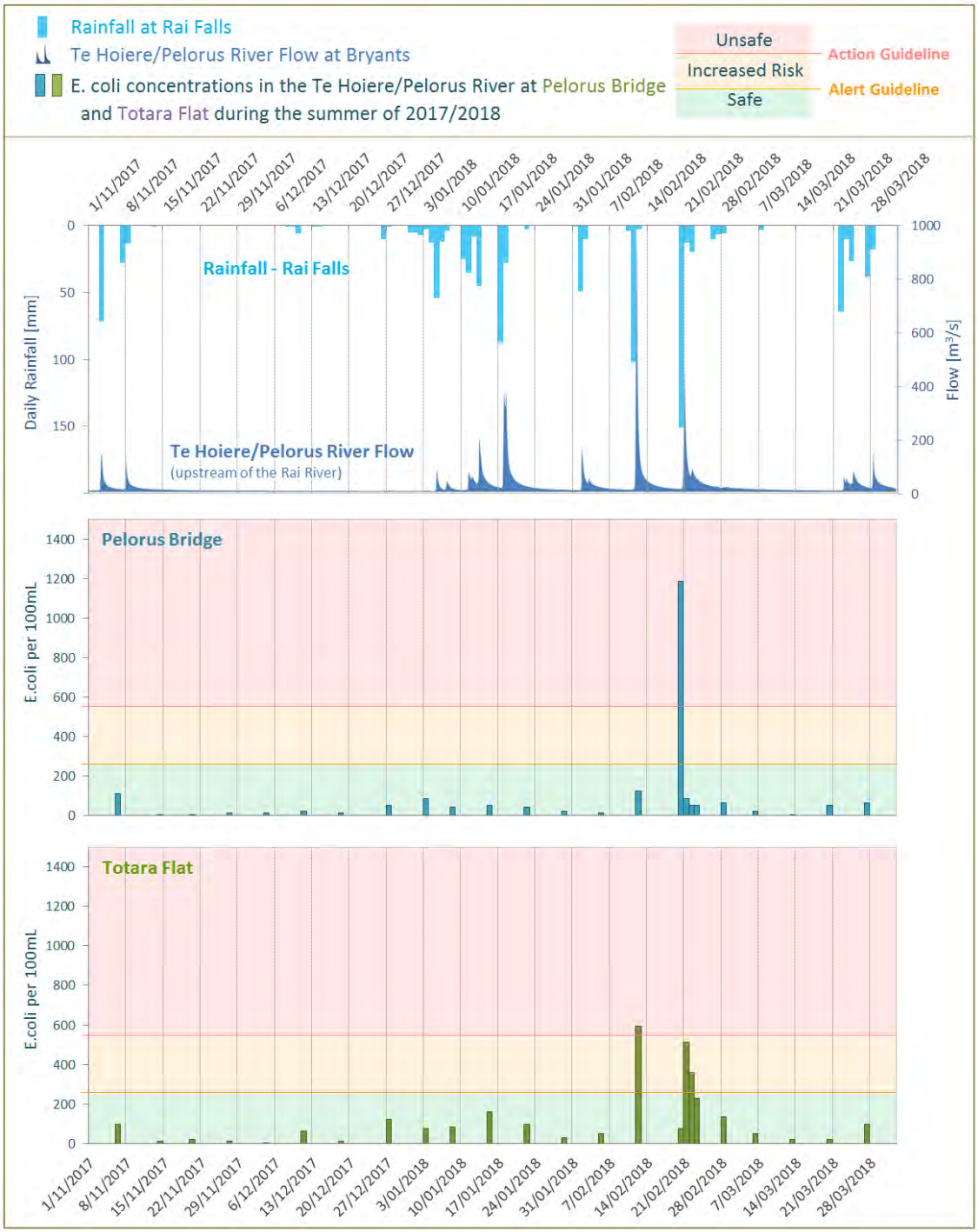


Figure 20: E. coli concentrations in the Te Hoiere/Pelorus River during the 2017/18 summer period.

The long term trend for both sites shows a slight reduction in E. coli concentrations after relatively constant bacteria levels in recent year. Significant reduction in E. coli levels occurred in 2007 and 2008 and the Pelorus Bridge is now graded 'Good'. Recreational water quality at Totara Flat improved two years later and the site now has a SFR Grade of 'Fair'.

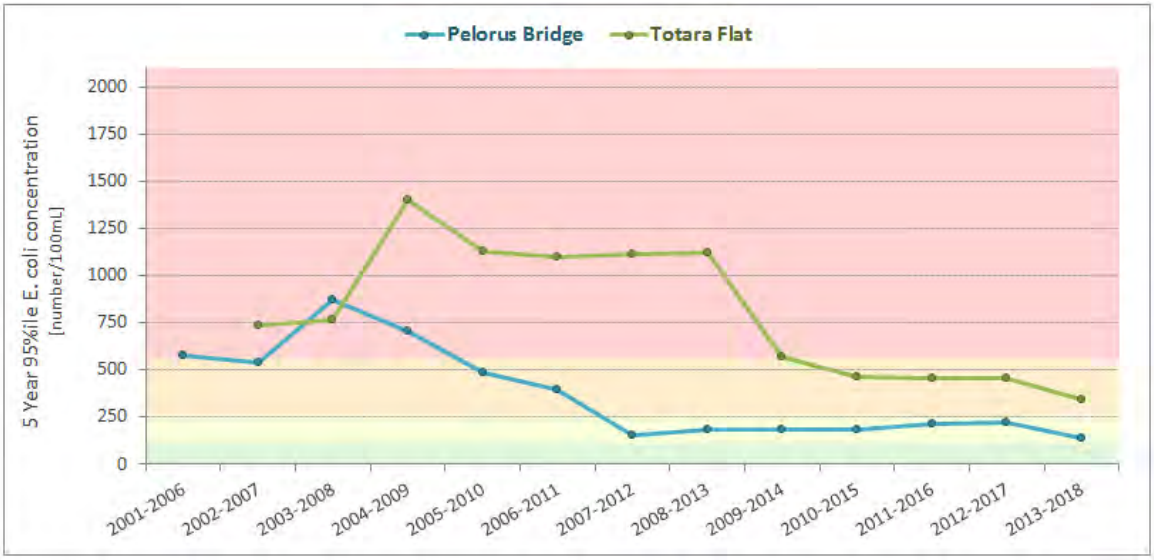


Figure 21: The 5-year 95%ile E.coli concentrations for the Rai River at Rai Falls and the two Te Hoiere/Pelorus River sites.

Figure 22: Pelorus Bridge is the most popular river site in the region and it is also the site with the best recreational water quality.

5.7. Waihopai River

Site

The Waihopai River swimming hole at the Craiglochart #2 Bridge is particularly popular with local residents. Often there will be nobody at the site when samples are taken, but it is known that school groups and families use the site frequently, especially in the weekends. Over a quarter of the catchment area has been converted to pasture, but grazing is mostly of low intensity.

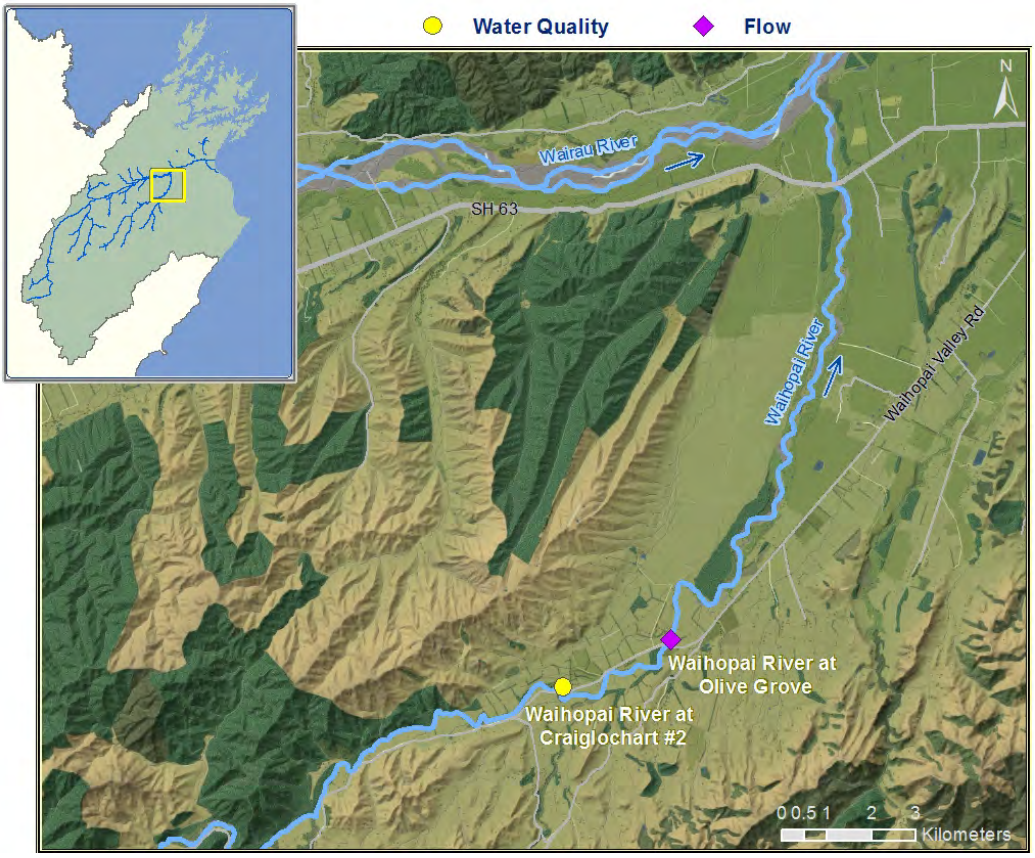


Figure 23: Location of the Waihopai River sampling site and the flow recorder.

Results

Two samples taken from the Waihopai River this summer had unsafe concentrations of faecal bacteria (Figure 24). The first of these samples was taken following some rainfall in the catchment. Although the flow increased only very slightly, it is likely that a localised shower caused significant run-off near the sampling site. An additional sample taken the next day showed that bacteria concentrations had returned to safe levels. The second exceedance of the Action Guideline occurred in February following significant rainfall in the catchment causing the largest flood recorded this summer. Two samples indicating an increased health risk were also taken during or shortly after rainfall in the catchment. It is not unexpected that run-off from pasture upstream of the sampling site will cause elevated E. coli concentrations in the river. Although the river was visibly turbid when E. coli concentrations were above guideline levels, the catchment geology causes the river to run turbid for extended periods of time. Therefore, discoloured looking water does not necessarily mean that the river is unsafe for swimming. As a result the risk to swimmers is potentially greater in the Waihopai River, as recreational users will start swimming in discoloured water if the river has been discoloured for some time. Indeed, swimmers have been observed in turbid water on several occasions. As the sampling has shown again this season, rainfall in the catchment can be quite localised, resulting in a comparatively small increase in flow, but causing E. coli concentrations to reach unsafe levels. To minimise the health risk it is important to heed the general advice to avoid swimming in discoloured water, even if the river is turbid over an extended period.

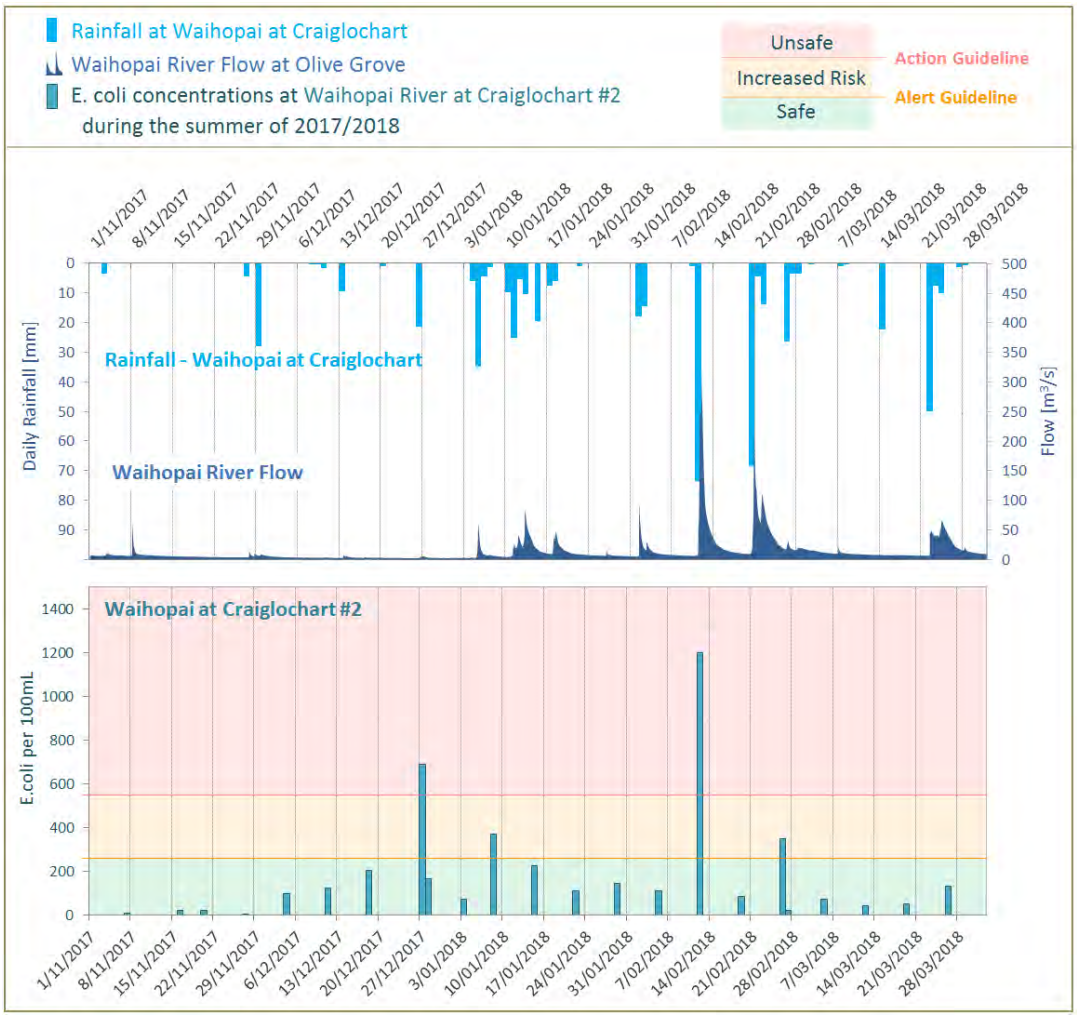


Figure 24: E. coli concentrations in the Waihopai River at Craiglochart #2 during the 2017/18 summer season.

The long-term trend shows some improvement back to the lower levels of E. coli observed several years ago and the site is now again graded as 'Fair'. The trend at this site has been quite variable despite very little change of the upstream land uses over the years. The reasons for the year-to year changes in recreational water quality are unclear.

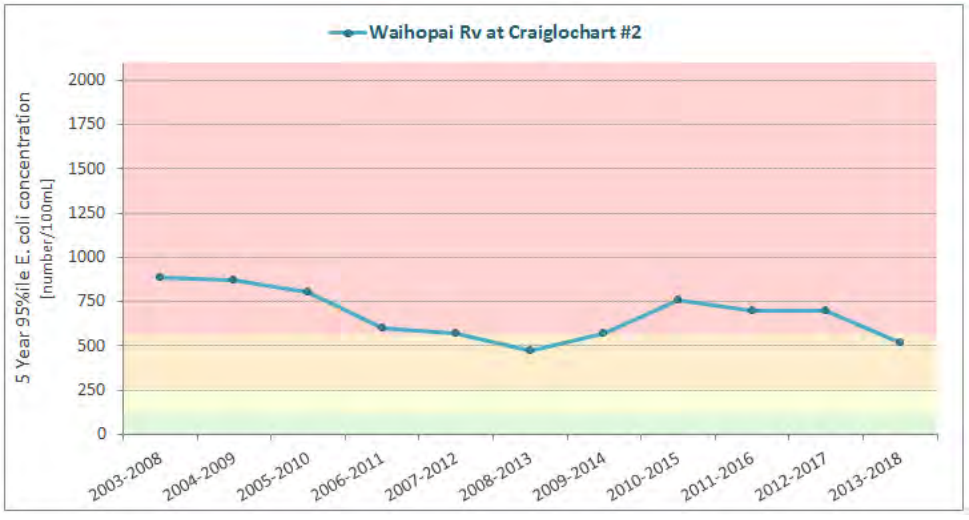


Figure 25: The 5-year 95%ile E.coli concentrations for the Waihopai River at Craiglochart #2.

5.8. Wairau River

Sites

There are two sites located along the Wairau River that are sampled as part of the Recreational Water Quality program, Ferry Bridge and Blenheim Rowing Club. These sites have been part of the program for some time. The sites are located on the lower part of the river, where the water is relatively deep and slow flowing. Due its close proximity to Spring Creek Township, Ferry Bridge is the more popular site on warm summer days, despite the relatively limited length of sandy bank. However, the Rowing Club is visited almost every day by local and visiting rowers for training and competitions.

Figure 26: Location of the two Wairau River sampling sites and the Wairau River flow recorder.

Results

The only samples with unsafe concentrations of faecal bacteria were taken during the largest flood event this summer in February 2018 (Figure 27). Additional sampling following the event showed that E. coli concentrations quickly returned to low levels at the Ferry Bridge, but remained slightly elevated at the Blenheim Rowing Club. Greater tidal influences at the Rowing Club provide a possible explanation.

E. coli concentrations above the Alert Guideline in December 2017 at the Ferry Bridge were not caused by rainfall or flooding. This has been observed in the past at this site. The Ferry Bridge site is prone to littering (including used nappies) and dogs are also a frequent sight. Both are possible sources of elevated faecal bacteria concentrations during dry weather conditions.

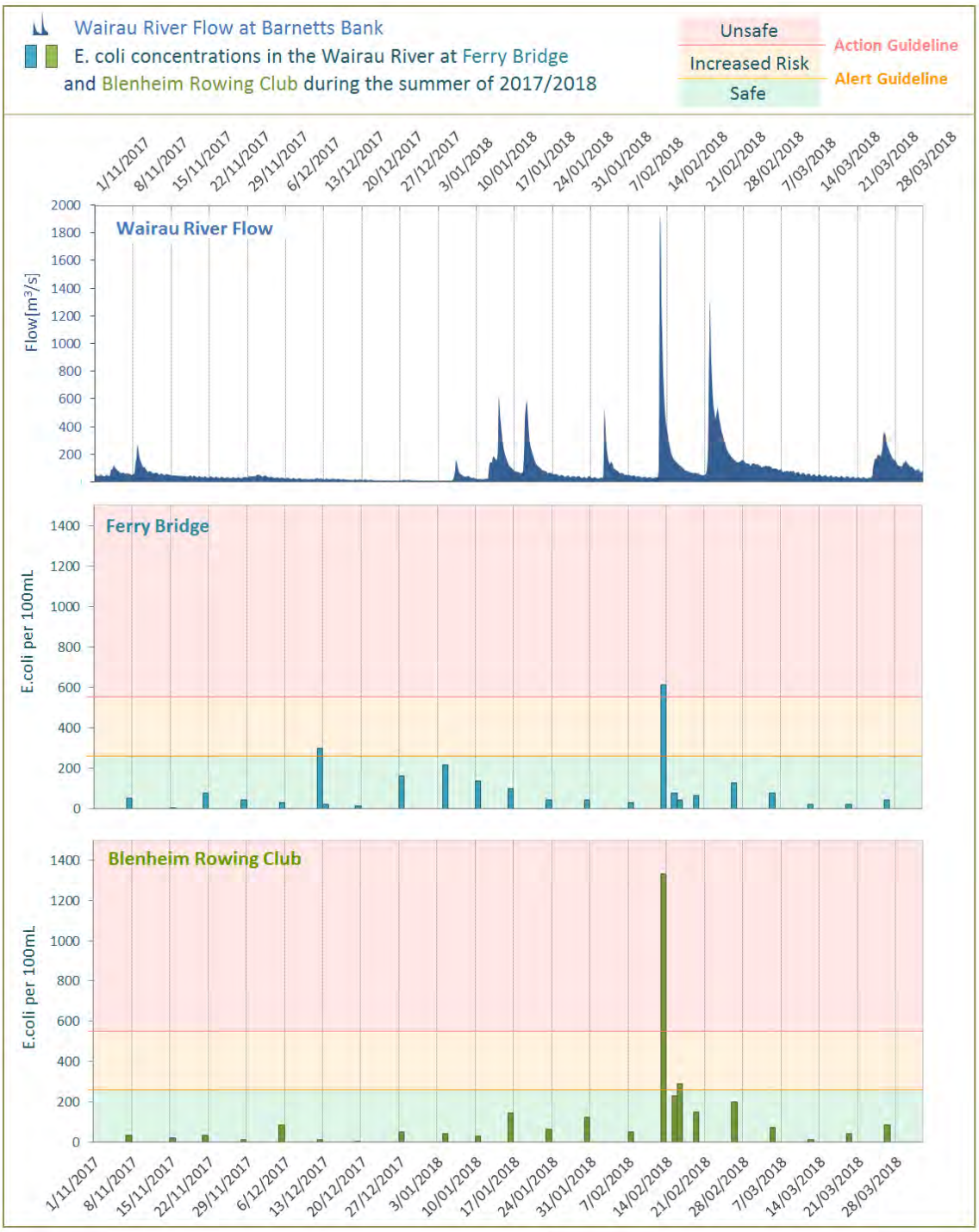


Figure 27: E. coli concentrations at the Wairau River monitoring sites during the 2017/18 summer season.

For a number of years, recreational water quality at Blenheim Rowing Club was improving and has been noticeably better compared to the Ferry Bridge. However, recently E. coli concentrations appear to be increasing again, resulting in similar levels at both sites (Figure 28). It is unclear what exactly is causing the increase in E. coli concentrations, but the change started in the season following the 2013 Seddon earthquake, which caused significant infrastructure damage in Blenheim. Unfortunately, E. coli concentrations are often not high enough to allow genetic source tracking in order to determine if small amounts of sewage from damaged septic tank systems are leaking into the river. However, other source such as wildfowl and farm animals are also possible contributors. The Wairau at Blenheim Rowing was graded 'Good' for a number of years, but had to be downgraded to 'Fair'; the same SFR Grade as Ferry Bridge.

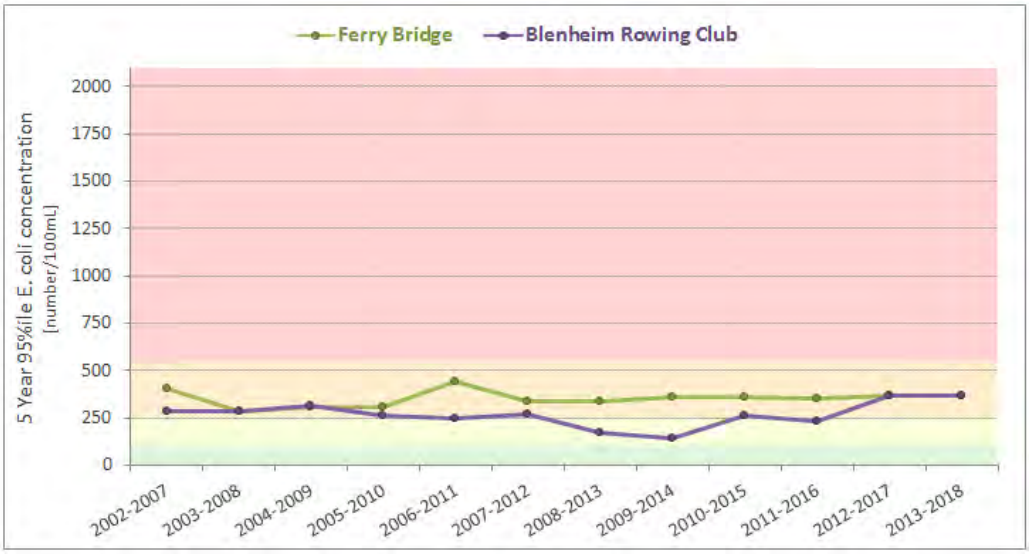


Figure 28: The 5-year 95%ile E.coli concentrations in the Wairau River at Ferry Bridge and the Blenheim Rowing Club.

5.9. Taylor River

Site

The Riverside Park is situated in the heart of Blenheim and attracts many visitors. It is part of a wider reserve which runs alongside the Taylor River. The reserve is popular for dog walking, jogging and biking. Although there is agricultural land use in the upper catchment, it appears to have limited effect on the site, while the immediate urban environment has a much greater influence on recreational water quality.

Figure 29: Location of the Taylor River and Ōpaoa River sampling sites as well as the Blenheim MDC rainfall recorder.

Results

Recent sampling of stormwater outflows into the Taylor River had shown that very high E. coli concentrations were being discharged into the river, particularly from pipes near the Riverside sampling site. Use of genetic marker analysis revealed that human sewage was one of the sources of faecal contamination. Investigation of the stormwater infrastructure showed that recent earthquakes had caused significant damage to both sewerage and stormwater pipes resulting in cross-contamination of stormwater with sewage. As a precautionary measure, warning signs were placed at the Riverside sampling site throughout the summer season. Nevertheless, sampling of the site as part of the Recreational Water Quality Program continued. The results of this sampling showed that E. coli concentrations reached very high levels on several occasions this season. Although the highest bacteria concentrations were observed as a result of rainfall events, a number of guideline exceedances also occurred during dry weather periods. This justifies the permanent placement of warning signs.

Figure 30: E. coli concentrations in the Taylor River at Riverside during the 2017/18 summer season.

Repair of the sewage and stormwater infrastructure is currently still underway and is likely to take some time as the damage is quite extensive. It is unclear if repairs will be finished before the next summer season. Weekly monitoring of several sites along the Taylor River as well as some of its tributaries and stormwater outflows continues. This will help to determine if infrastructure repairs have the desired outcome of reducing contamination of the river.

The Taylor River at Riverside is currently graded as ‘Very Poor’.

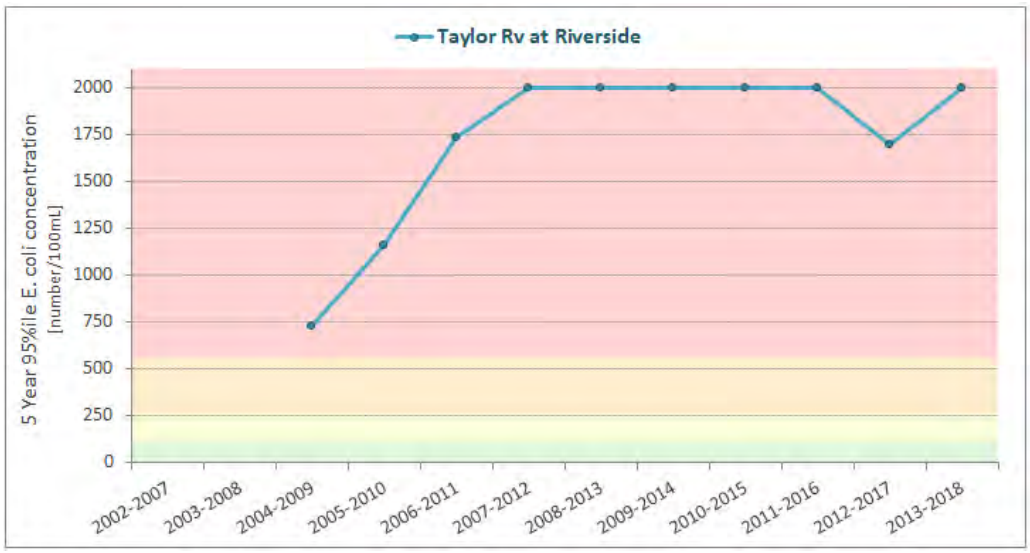


Figure 31: The 5-year 95%ile E.coli concentrations in the Taylor River at Riverside.

5.10. Ohinemahuta River

Site

The Onamalutu Domain is a Department of Conservation campground located in Mount Richmond Forest Park. It is surrounded by large kahikatea and matai trees of a remnant podocarp forest once found all over the Wairau Plain. A short walking track through the forest leads from the campground to the Ohinemahuta River swimming hole.

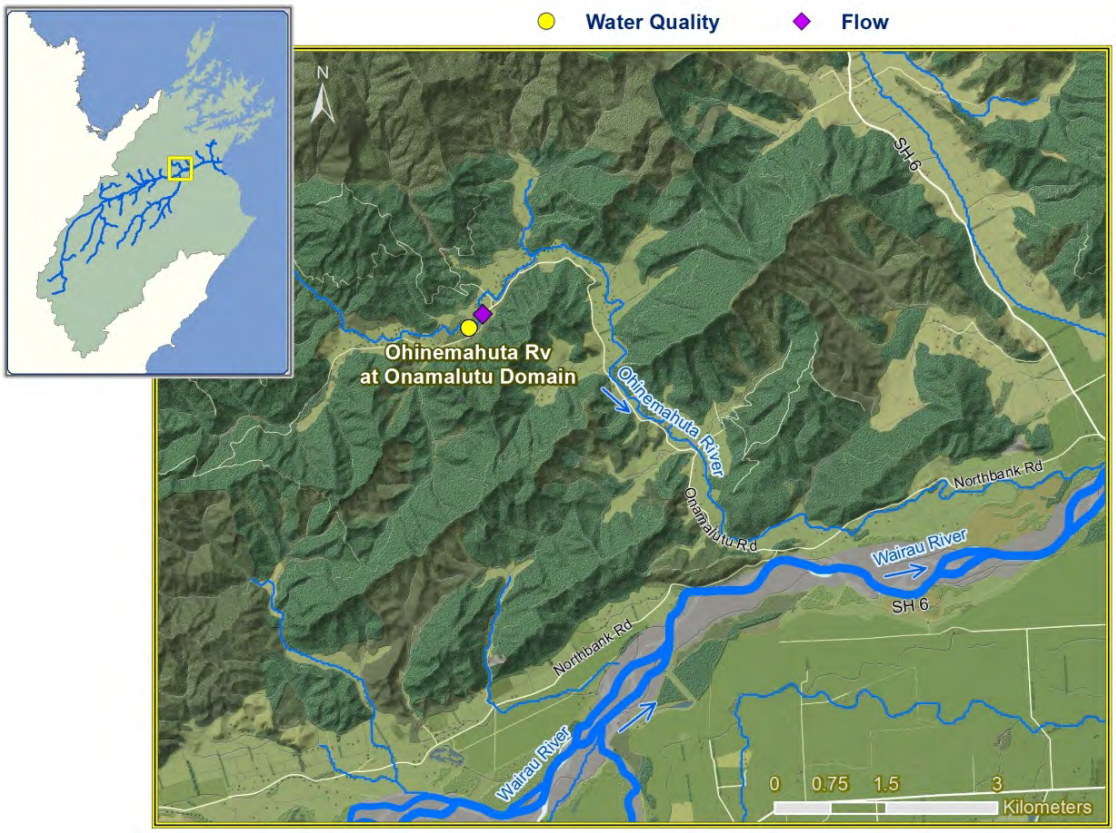


Figure 32: Location of the Ohinemahuta River water quality and flow sites.

Results

This was the first season the swimming hole at the Onamalutu Domain has been sampled as part of the Recreational Water Quality Program. Because the site is surrounded by majestic tress of mature native forest, visitors are often quite unaware that upstream, the valley floor has been converted to pasture. Although the pastoral land use is not intensive, parts of the river and its tributaries are not fenced off, allowing livestock direct access to the waterway. This is likely the reason for occasionally elevated E. coli concentrations observed during dry weather conditions. Fortunately, bacteria level only exceeded guideline levels following the largest flood event of the summer season. Additional sampling carried out for several days following this guideline exceedance showed that E. coli concentrations had declined significantly and remained relatively low despite further smaller flow increases due to rainfall. This is the first season the Ohinemahuta River has been regularly sampled at this site and it is yet unclear if this is a typical pattern or if livestock access has a greater influence during dryer summers, when flows and therefore dilution are significantly reduced.

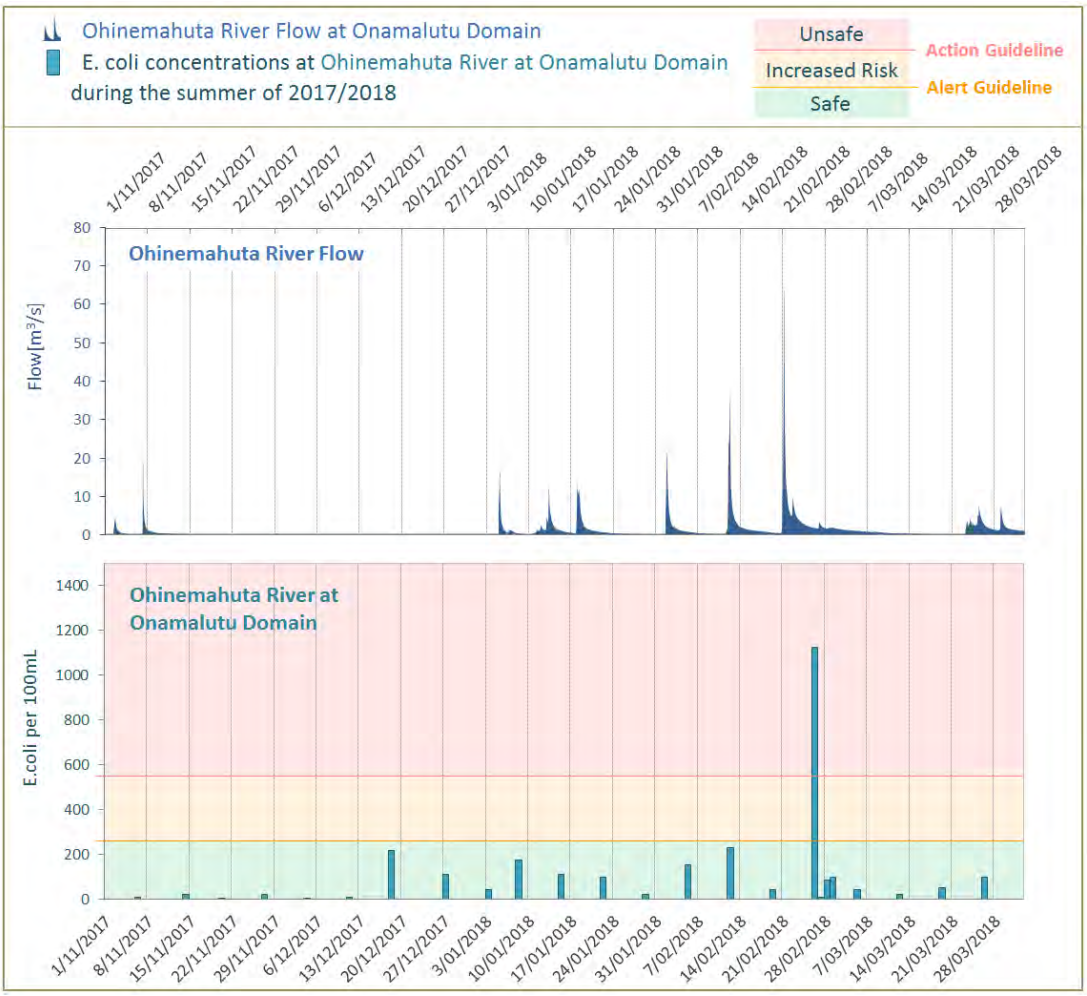


Figure 33: E. coli concentrations and flow of the Ohinemahuta River at the Onamalutu Domain during the 2017/18 summer season.

5.11. The National Policy Statement for Freshwater Management (NPS-FM)

In 2017 an updated National Policy Statement for Freshwater Management (NPS-FM) was released. This document includes value bands for a number of parameters that are used to represent the state of water quality in rivers and lakes. The bands usually range from A, which represent best water quality to D, which is referred to as the 'National Bottom Lines'. Water quality within the D band is considered unacceptable and measures need to be taken to improve water quality. One of the parameters for which the NPS-FM provides value bands is the concentration of E. coli. Four separate statistics are used to determine the E. coli state for waterways (Table 5).

Attribube State (Band)	I Percentage of samples above 540 E.coli/100mL	II Percentage of samples above 260 E.coli/100mL	III Median [E. coli/100mL]	IV 95th Percentile [E. coli/100mL]	**Narrative Attribute State** (Description of risk of Campylobacter infection based on E. coli indicator)
A (Blue)	< 5%	< 20%	≤ 130	≤ 540	For at least half the time, the estimated risk is <1 in 1000 (0.1% risk). The predicted average infection risk is 1%.
B (Green)	5% - 10%	20% - 30%	≤ 130	≤ 1000	For at least half the time, the estimated risk is <1 in 1000 (0.1% risk). The predicted average infection risk is 2%.
C (Yellow)	10% - 20%	20% - 34%	≤ 130	≤ 1200	For at least half the time, the estimated risk is <1 in 1000 (0.1% risk). The predicted average infection risk is 3%.
D (Orange)	20% - 30%	> 34%	> 130	> 1200	20-30% of the time the estimated risk is ≥50 in 1000 (>5% risk). The predicted average infection risk is >3%.

Table 5: E. coli bands as defined by the NPS-FM 2017.

A minimum of 60 samples collected regularly over a maximum of five years are required for the calculation. Table 6 shows a comparison of the SFR Grades and the NPS state bands for the rivers sites currently sampled as part of the Recreational Water Quality program. Although sufficient data for the calculation of the NPS state is being collected over a period of three years, for better comparison, data over a period of five years is used, therefore using the same data for the calculation of both, the NPS state and SFR Grades.

Site	**SFR Grade**	**2017 NPS-FM**				
		I	II	III	IV	**Overall**
Pelorus Rv at Pelorus Bridge	Good	A	A-C	A	A	A
Pelorus Rv at Totara Flat	Fair	A	A-C	A	A	A
Wairau Rv at Ferry Bridge	Fair	A	A-C	A	A	A
Wairau Rv at Blenheim Rowing Club	Fair	A	A-C	A	A	A
Waihopai Rv at Craighlochart #2	Fair	B	A-C	A	A	B
Taylor Rv at Riverside	Very Poor	D	D	D	D	D

Table 6: Comparison of SFR Grade and NPS-FM E. coli band for the river sites monitored as part of the Recreational Water Quality Program.

Based on SFR Grades, most river sites are graded as 'fair', while the NPS grading appears to be more lenient, placing most sites into the A band, representing the best water quality result achievable. E. coli concentrations in the Waihopai River fall within the B band only due to one sample with bacteria concentration above 540 E. coli/100mL. If the number of data points is reduced to the last three years, the E. coli state of the Waihopai River would fall into the A band.

For the Taylor River at Riverside, both the SFR Grade and NPS band indicate unacceptable E. coli concentrations. This is not surprising based on the large number of samples with high E. coli counts taken from this site.

6. Summary and Discussion

The initial weeks of this season were marked by typical warm and dry Marlborough summer weather. With the beginning of the New Year, however, rainfall became more prevalent, reaching a peak in February 2018 with the highest rainfall amount on record for that month. At a number of sites, the wet summer resulted in a greater number of samples with unsafe indicator bacteria concentrations compared to previous summer seasons. Particularly effected was Ngakuta Bay, which had the worst recreational water quality of all coastal sites monitored. Surprisingly, the less than 100 private homes and batches had a greater impact on coastal water quality than the 2,000 buildings in Picton and Waikawa. A possible source of faecal contamination in Ngakuta Bay are overflowing septic tanks as neighbouring bays with less residential development had fewer exceedances. Currently the regular maintenance and performance of septic tank systems is not actively monitored by Council. Under-performing septic tank systems could also be a problem at the many beaches that are not monitored as part of Recreational Water Quality program. Therefore, it is recommended that a separate program ensuring the appropriate maintenance of these systems is implemented in the future.

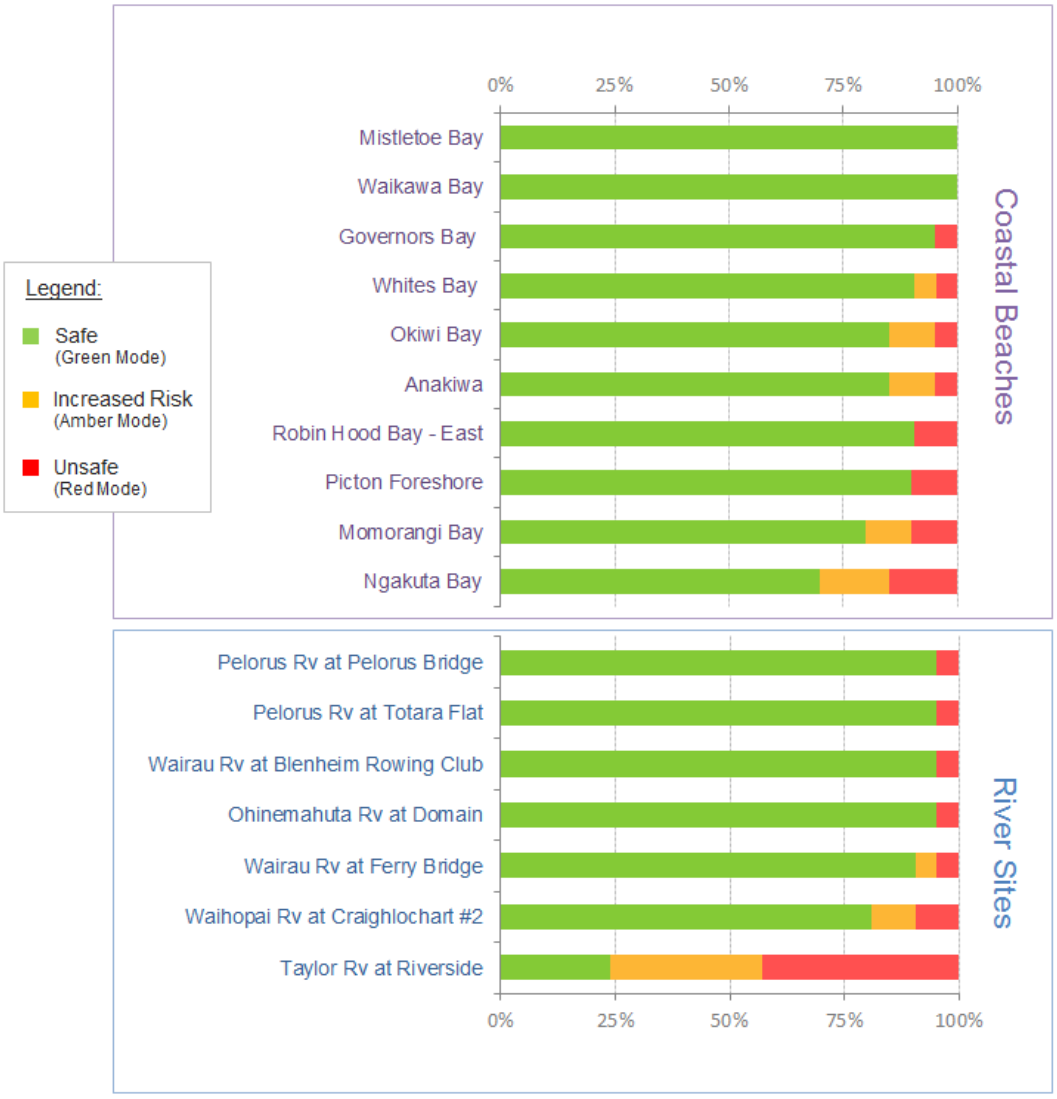


Figure 34: Percentage of routine samples within the different Modes for all sites sample during the 2017/18 summers season.

Mistletoe Bay had the best recreational water quality of all sites monitored. In the previous summer, an investigation into the increase in faecal bacteria concentration during rainfall events had led to the discovery of a leaking septic tank. This septic tank has since been removed and the sampling results

from this summer season are evidence for the successful collaboration between Council and the Mistletoe Bay Trust to improve recreational water quality in the bay.

At some sites high faecal bacteria concentrations were occasionally also observed during dry weather conditions. These sites included Waikutakuta/Robin Hood Bay and Momorangi Bay. Unexplained exceedances, such as these, can be an indication of a significant health risk at these sites as general rainfall-related advic[2]e does not cover these events. In Momorangi, the occurance of high Enterococci concentrations during dry weather during the last two summers had led to the discovery of several problems with the campground sewage system. The system has since been repaired and upgraded and fortunately, sampling following the initial dry-weather exceedance this summer did not indicate any continued problem.

At Waikutakuta/Robin Hood Bay a very high Enterococci concentration observed in February 2018 was also not caused by rainfall, but as for Momorangi Bay, furhter sampling revealed that this remained a one-off event. In the previous season, gorse deposited onto the beach following a heavy rainfall event caused very high bacteria concentrations until the gorse was removed. This season, no significant amount of plant material could be found on the beach.

For both, Waikutakuta/Robin Hood Bay and Momorangi Bay, the monitoring results of future seasons will show if a investigation of possible dry-weather sources is needed. Anecdotal evidence suggests, that illegal dumping of waste from self-contained campervans occurs at several bays in the Marlborough Sounds. Unfortunately, this is a difficult source to identify and manage.

The Taylor River at Riverside has had elevated faecal bacteria concentrations during dry weather for some years, but this season has seen the worst recreational water quality on record. Less than 25% of samples taken this summer had E. coli concentraitons at safe levels. An earlier investigation into the E. coli concentration in stormwater had revealed that some of the stormwater outlets near the sampling site were discharging water containing very high E. coli levels into the river. The reason was found to be earthquake damage and general aging of the stormwater and sewerage infrastructure, which were resulting in cross-contamination of stormwater with sewage. It was decided to have warning signs placed around the site throughout the summer. Although the summer monitoring has ended, weekly monitoring of the Taylor River and stormwater outlets still contiues. The warning signs will be removed once this monitoring shows that repairs to the infrastructure have lead to a significant improvement in water quality in the river.

Two examples of the effect of sample timing were a reminder that the results from the latest sampling round should not be used as an indication for the current water quality at a site. Heavy rainfall from a moving cold-front caused high Enterococci concentrations in Momorangi Bay, but the rainfall had not yet reached Ngakuta Bay and bacteria concentrations in the sample taken from this bay were low. A similar effect was observed at the two sites located on the Te Hoiere/Pelorus River.

One of the main aims of weekly monitoring is the collection of sufficient data to allow the calculation of SFR Grades. These grades provide information on the overall recrational water quality for the sites monitored and should be the primary information used when deciding where to swim. Another aim of regular monitoring is identification of changes in recreational water quality.

Nationally, a move to develop models that predict feacal indicator bacteria based on rainfall is gaining momentum. Until continious monitoring techniques for feacal bacteria are developed, this will provide much needed real-time information for recreational users. However, there are also suggestions to cease actual monitoring of sites and rely on modelled data only. This would be a dangerous move, as potential changes that cause an increase in faecal bacteria concentrations would not be picked up. Sites, such as Mistletoe Bay, Momorangi Bay and the Taylor River are examples, that recreational water quality can change significantly over time. Especially, our experience with Momoringi Bay showed that changes can occur rather quickly [8]. If increaes in faecal bacteria concentrations are not picked up through regular sampling, the risk to the health of recreation user can become quite high. Only continued monitoring will allow us to notice these changes, which will then lead to notification of

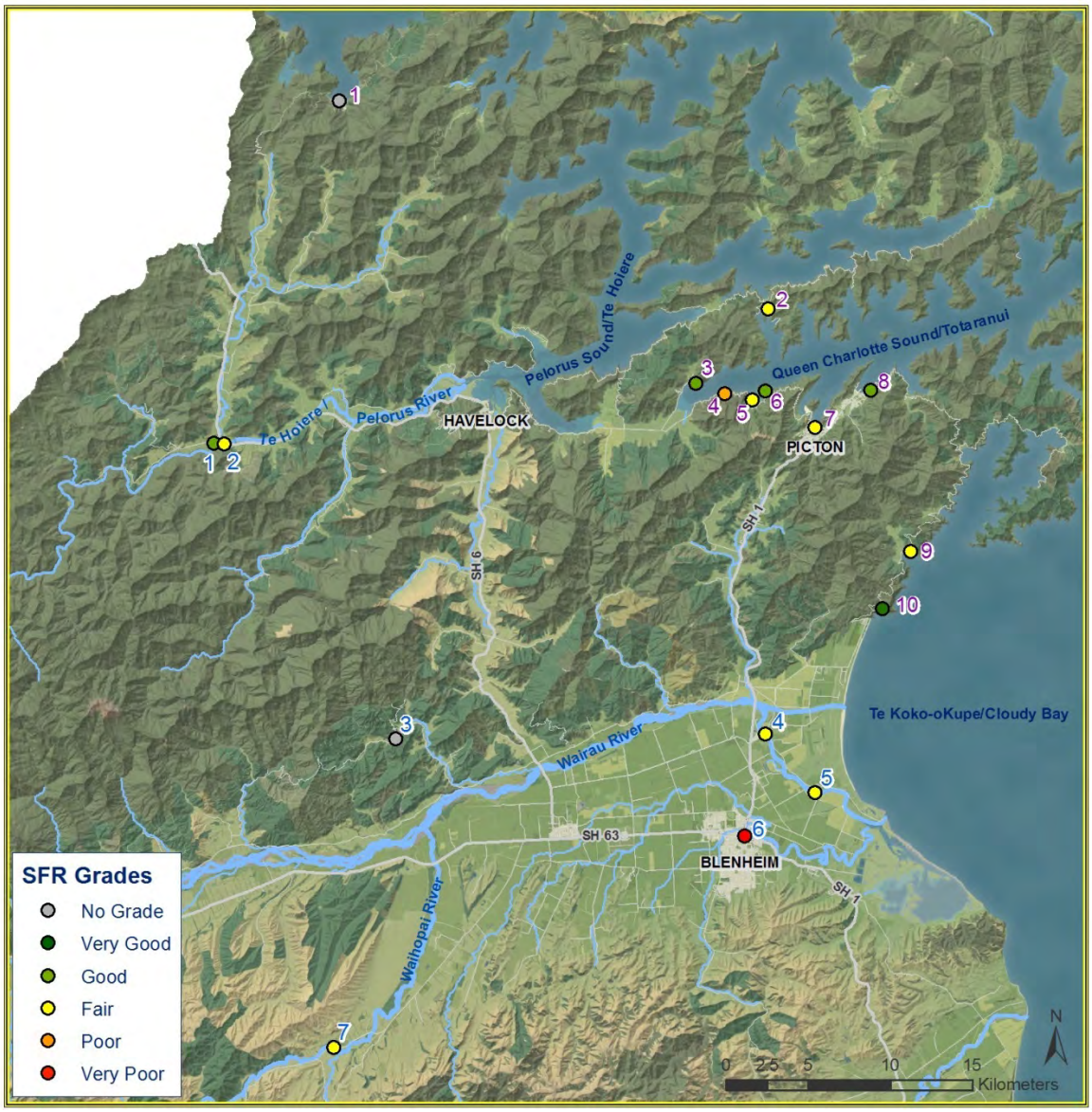
[2] Council and the DHB advice not to swim in waterways for 48 hours following rainfall

the public (ie. warning signs) as well as indentification and subsequent elimination or minimisation of the sources.

A site usage survey carried out in the previous summer resulted in the removal of sites from the monitoring program, but also the addition of two new sites, Okiwi Bay and Ohinemahuta River at Onamalutu Domain. The results from this initial season indicate that recreational water quality at these sites is generally good.

All other sites currently monitored have sufficient data to be graded. Only two sites have a SFR Grade of ‘Poor’ or ‘Very Poor’. These are Momorangi Bay and the Taylor River. At Momorangi Bay the low grade is an artefact of past problems and we should expect future sampling results to lead to a better SFR Grade in the coming years. Repairs of the stormwater and sewage infrastructure in Blenheim should also see an improvement in the grading for the Taylor River.

The majority of sites have a grade of ‘Fair’, which is defined as recreational water quality as being “generally satisfactory for swimming”, but that swimming should be avoided following rainfall. There are also a number of sites that are graded as ‘Good’.



Type	No.	Site	Easting	Northing	SIC (Sanitary Inspection Category)	MAC (Microbiological Assessment	SFR Grade (Suitability for Contact Recreation Grade)
Coastal Sites	1	Okiwi Bay	1655355	5448685	insufficiant data		
	2	Mistletoe Bay	1681470	5436007	Low	C	Fair
	3	Anakiwa	1677073	5431495	Moderate	B	Good
	4	Momorangi Bay	1678817	5430879	Moderate	D	Poor
	5	Ngakuta Bay	1680514	5430489	Moderate	C	Fair
	6	Governors Bay	1681310	5431030	Low	B	Good
	7	Picton Foreshore	1684298	5428815	Moderate	C	Fair
	8	Waikawa Bay	1687695	5431090	Low	B	Good
	9	Waikutakuta/Robin Hood Bay East	1690115	5421285	Low	C	Fair
	10	Pukatea/Whites Bay	1688425	5417793	Very Low	B	Very Good
	1	Te Hoiere/Pelorus Rv at Pelorus Bridge	1648077	5428091	Low	B	Good
	2	Te Hoiere/Pelorus Rv at Totara Flat	1648262	5427731	Moderate	C	Fair
	3	Ohinemahuta Rv at Onamalutu Domain	1658791	5409896	insufficiant data		
	4	Wairau Rv at Ferry Bridge	1681274	5410163	Moderate	C	Fair
	5	Wairau Rv at Blenheim Rowing Club	1684319	5406605	Moderate	C	Fair
	6	Taylor River at Riverside	1680023	5403987	High	D	Very Poor
	7	Waihopai River at Craiglochart #2	1655029	5391098	Moderate	C	Fair

Figure 35: SFR Grades for the sites currently monitored.

7. References

1. Badgley BD, Thomas FI, Hardwood VJ (2010) *The effects of submerged aquatic vegetation on the persistence of environmental populations of Enterococcus spp*. Environ Microbiol. 12(5): 1271-81
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6. MDC (2013b) *Investigation into High E. coli Concentrations in the Taylor River during Low Flows*. Marlborough District Council, Technical Report 13-007
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11. Solo-Gabriele H.M. et al. (2016) *Beach sand and the potential for infectious disease transmission: observations and recommendations*. Journal of the Marine Association of the United Kingdom 96(1), 101-120
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8. Appendices

8.1. Appendix 1: Results for the 2017/2018 summer season

Results are Enterococci concentrations for coastal sites and E. coli concentrations for river sites, both in MPN/100mL

Site Type	Week	Sample Dates	Anakiwa	Mistletoe Bay	Momorangi Bay	Ngakuta Bay	Governors Bay	Picton Foreshore	Waikawa Bay	Pukatea/ Whites Bay	Waikutakuta/ Robin Hood Bay East	Okiwi Bay
Coastal	1	06/07 Nov 2017	<10	<10	10	<10	20	<10	30	<10	<10	275
	2	14/15 Nov 2017	<10	<10	<10	<10	<10	20	<10	<10	<10	<10
	3	21/22 Nov 2017	63	40	<10	231	<10	10	<10	<10	<10	<10
	4	27/28 Nov 2017	<10	<10	10	<10	10	<10	20	<10	<10	<10
	5	04/05 Dec 2017	63	<10	529	41	<10	<10	<10	<10	<10	<10
	Follow-up	07 Dec 2017			31							
	6	11/12 Dec 2017	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	7	18/19 Dec 2017	199	41	20	214	74	10	122	<10	<10	20
	8	27 Dec 2017	<10	10	<10	10	<10	30	10	<10	30	<10
	9	03/04 Jan 2018	<10	63	30	10	10	10	<10	20	<10	<10
	10	08/09/10 Jan 2018	121	<10	10	20	<10	31	31	<10	<10	<10
	11	15/16 Jan 2018	259	<10	249	1112	10	554	122	<10	<10	31
	12	22/23 Jan 2018	10	<10	109	135	20	10	<10	63	1223	31
	13	29/30/31 Jan 2018	<10	<10	10	97	52	10	97	<10	<10	504
	14	05/07 Feb 2018	<10	<10	10	<10	<10	20	<10	10	<10	
	15	12/13 Feb 2018	110	<10	85	529	122	74	<10	148	<10	20
	Follow-up	15 Feb 2018				10						
	Follow-up	16 Feb 2018				20						
	16	19/20 Feb 2018	52	10	1236	203	<10	10	85	63	<10	178
	Follow-up	22 Feb 2018			41	20						
	Follow-up	23 Feb 2018			20	<10						

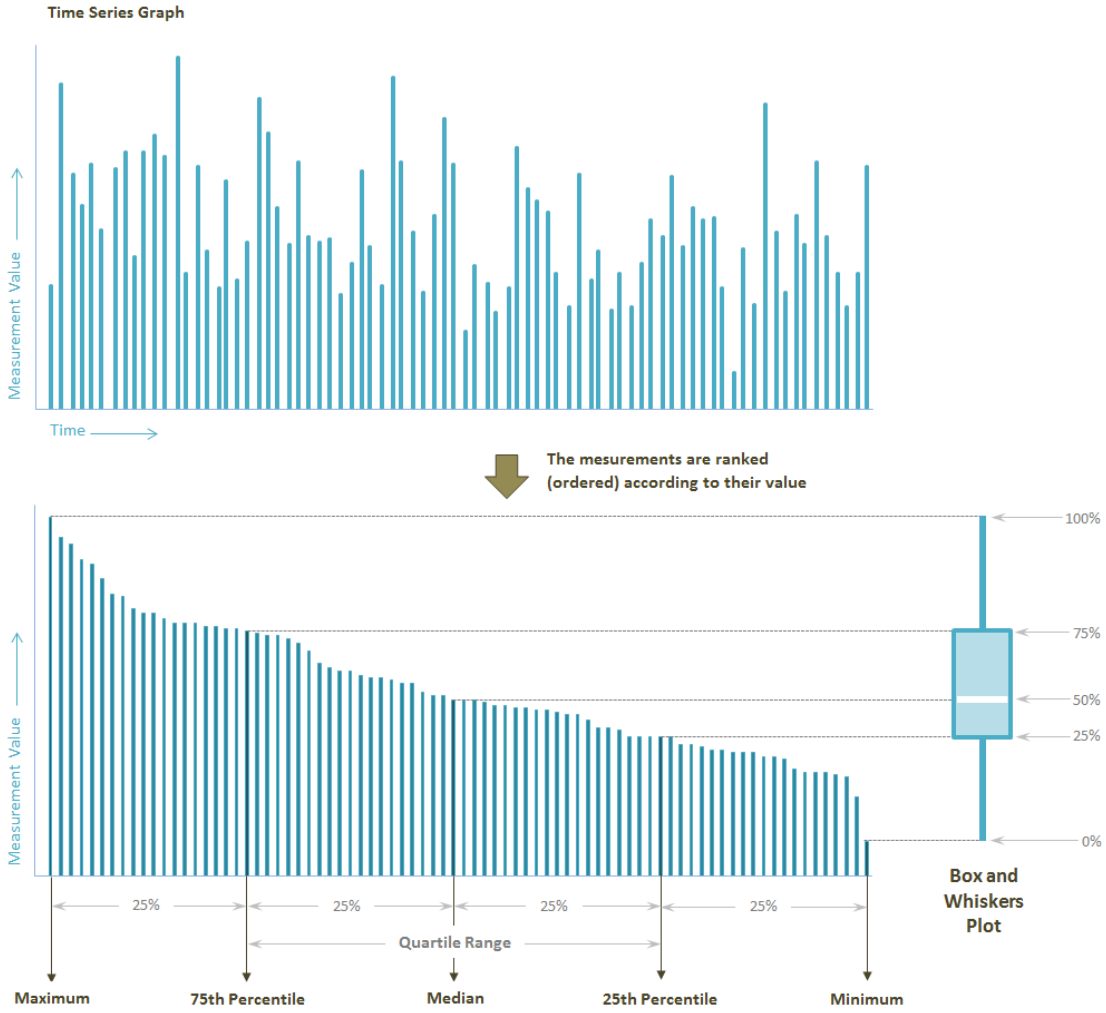
Site Type	Week	Sample Dates	Anakiwa	Mistletoe Bay	Momorangi Bay	Ngakuta Bay	Governors Bay	Picton Foreshore	Waikawa Bay	Pukatea/ Whites Bay	Waikutakuta/ Robin Hood Bay East	Okiwi Bay
Coastal	17	26/27/28 Feb 2018	414	10	171	888	441	472	52	2850	10460	<10
	Follow-up	28 Feb 2018						<10		51		
	Follow-up	01 Mar 2018	10	<10		<10	<10	31	10	52	51	
	Follow-up	02 Mar 2018	63	185		<10	<10	20				
	18	05/06 Mar 2018	63	31	20	52	<10	<10	110	10	10	<10
	19	12/13 Mar 2018	<10	10	<10	<10	<10	<10	<10	<10	<10	<10
	20	19/20 Mar 2018							<10		<10	<10
	21	26/27 Mar 2018	<10	<10	20	74	<10	109	<10	<10	<10	<10

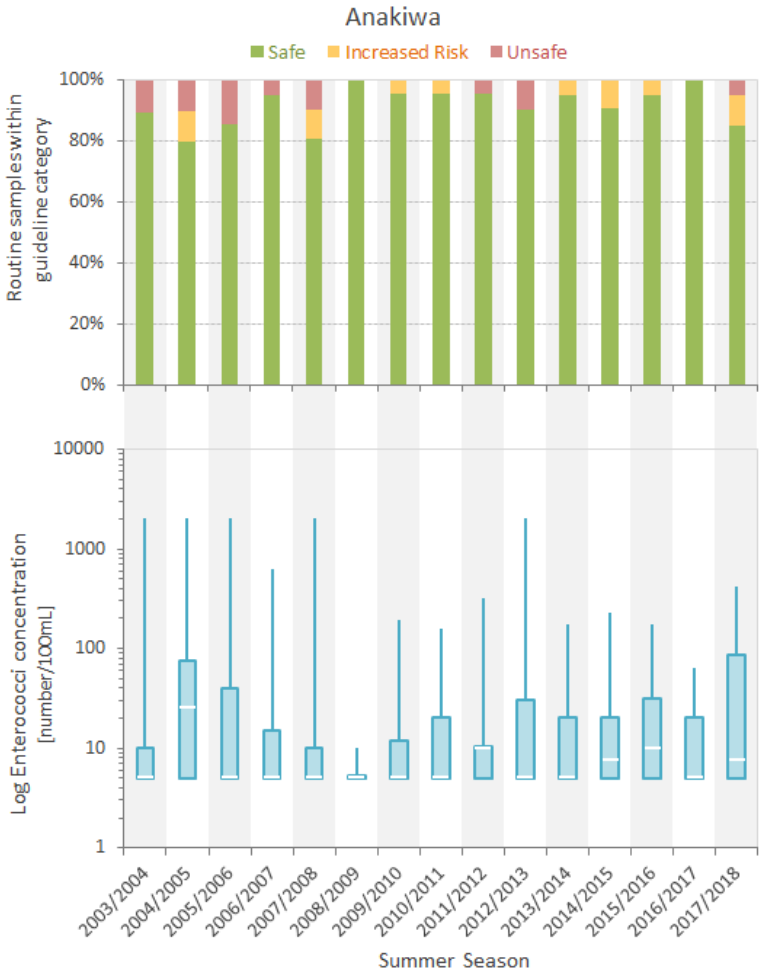
Site Type	Week	Sample Date	Pelorus Rv at Pelorus Bridge	Pelorus Rv at Totara Flat	Waihopai Rv at Craiglochart #2	Ohinemahuta Rv at Onamalutu Domain	Wairau Rv at Ferry Bridge	Wairau Rv at Blenheim Rowing Club	Taylor Rv at Riverside
River	1	06/07 Nov 2017	110	98	10	10	52	31	717
	2	14/15/16 Nov 2017	<10	10	20	20	<10	20	74
	3	20/21 Nov 2017	<10	20	20	<10	74	31	135 / 52
	4	27/28/29 Nov 2017	10	10	<10	20	41	10	272 / 74
	5	04/05 Dec 2017	10	<10	98	<10	30	84	292
	6	11/12 Dec 2017	20	63	122	10	295	10	161
	Follow-up	13 Dec 2017					20		146
	7	18/19 Dec 2017	10	10	203	218	11	2	262
	8	27 Dec 2017	52	121	689	109	160	52	504
	9	03/04 Jan 2018	85	74	74	41	216	41	3,450
	Follow-up	4 Jan 2018							435
	10	08/10 Jan 2018	41	85	368	173	134	30	2,100

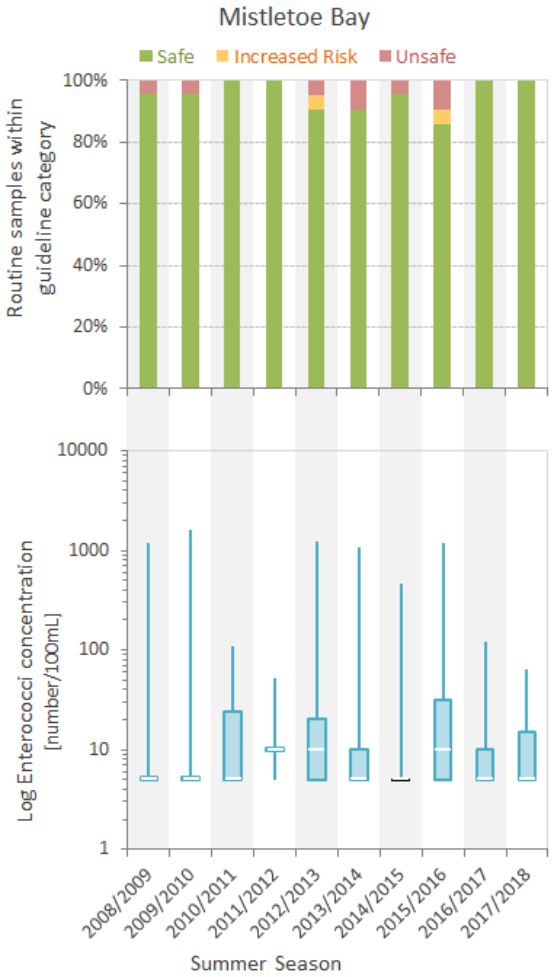
Site Type	Week	Sample Date	Pelorus Rv at Pelorus Bridge	Pelorus Rv at Totara Flat	Waihopai Rv at Craiglochart #2	Ohinemahuta Rv at Onamalutu Domain	Wairau Rv at Ferry Bridge	Wairau Rv at Blenheim Rowing Club	Taylor Rv at Riverside
River	11	15/16 Jan 2018	52	160	226	109	98	146	537
	12	22/23 Jan 2018	41	98	110	98	41	63	520
	13	29/30 Jan 2018	20	31	146	20	41	122	1,081
	14	05/07 Feb 2018	10	51	110	155	30	52	345
	15	12/13 Feb 2018	122	594	1,198	231	613	1,333	5,480
	Follow-up	15 Feb 2018					74	228	
	Follow-up	16 Feb 2018					41	288	
	16	19/20 Feb 2018	1,187	74	86	41	63	148	578
	Follow-up	21 Feb 2018	85	512					
	Follow-up	22 Feb 2018	52	359					
	Follow-up	23 Feb 2018	52	228					
	17	26/28 Feb 2018	63	134	350	1,126	126	199	3,450
	Follow-up	27 Feb 2018			20	10			
	Follow-up	28 Feb 2018				85			
	Follow-up	29 Feb 2018				97			
	18	05/06 Mar 2018	20	52	74	41	74	73	187
	19	12/13 Mar 2018	<10	20	41	20	20	10	256
	20	19/20 Mar 2018	52	20	52	52	20	41	2,480
	21	26/27 Mar 2018	63	97	132	98	41	86	644

Appendix 2: Levels of compliance and Box and Whiskers plots

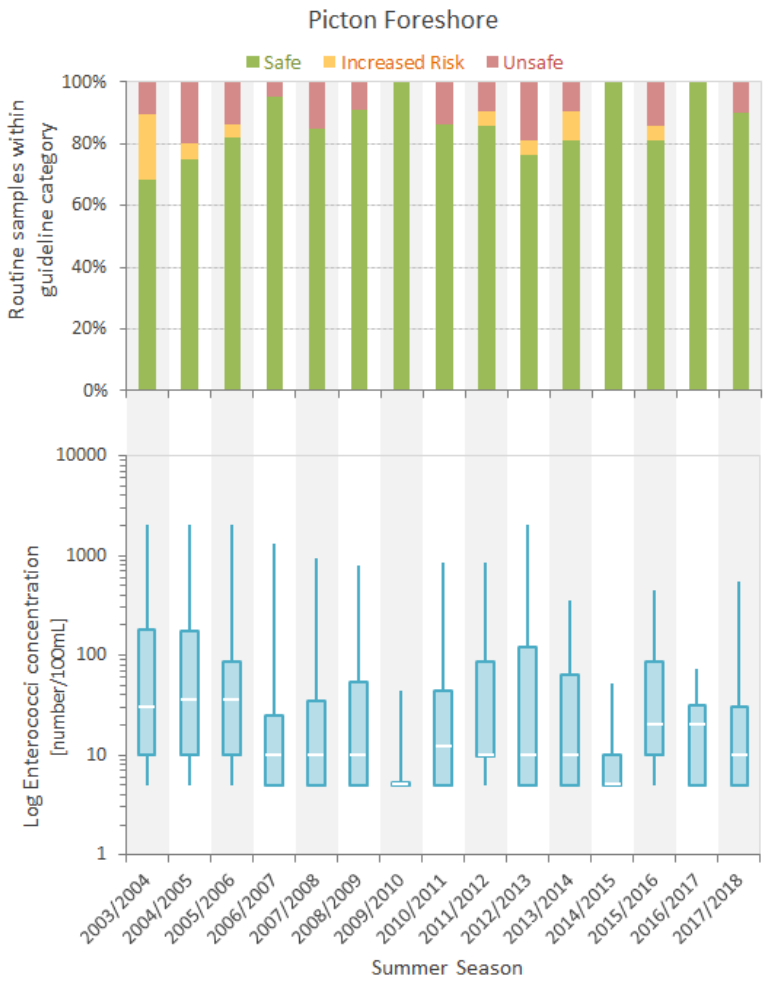
The Plots were created from the results of the routine sampling only. The first figure shows how Box and Whiskers Plots are created. Note that concentrations in the Box and Whiskers Plots for the actual sample results are on a logarithmic scale and only sites with a minimum of 4 years of record are shown.

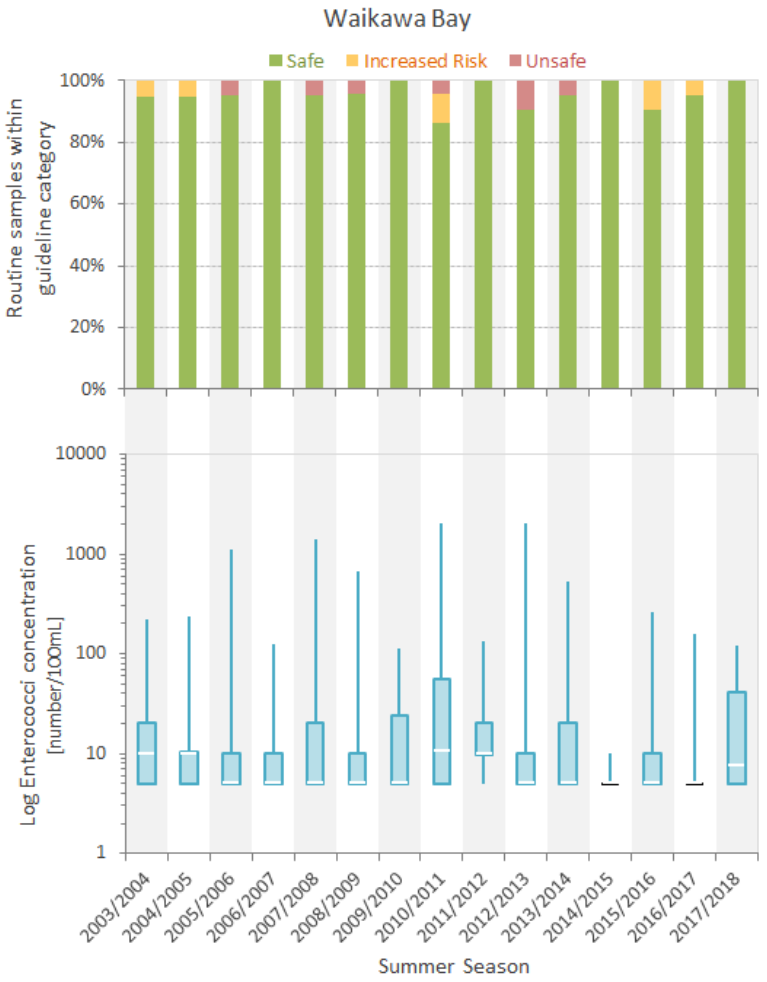


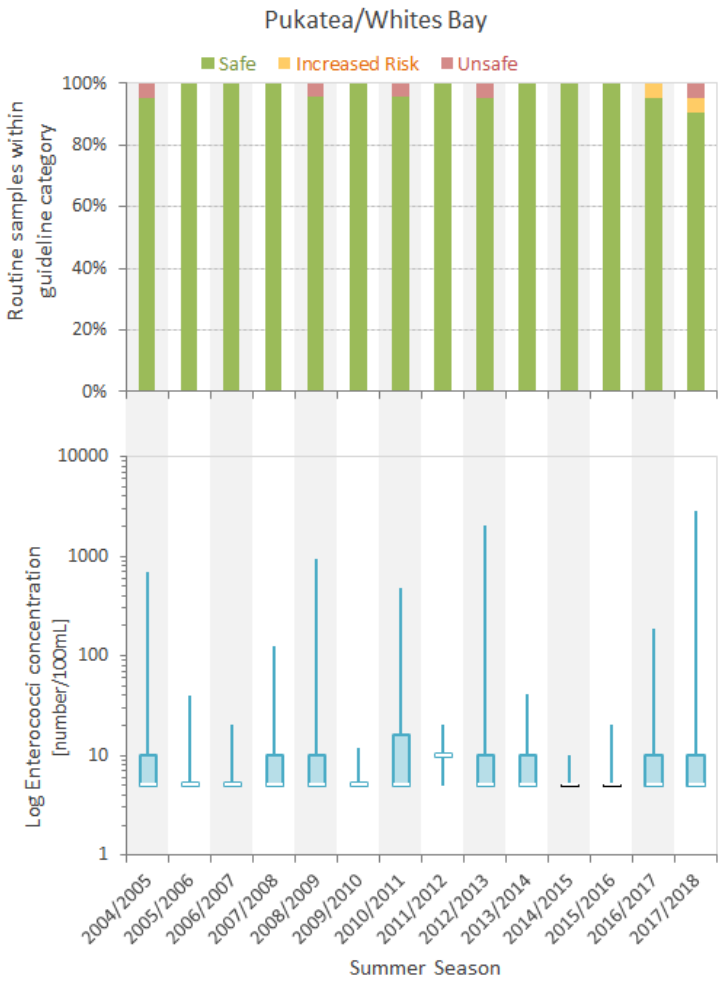

Anakiwa
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

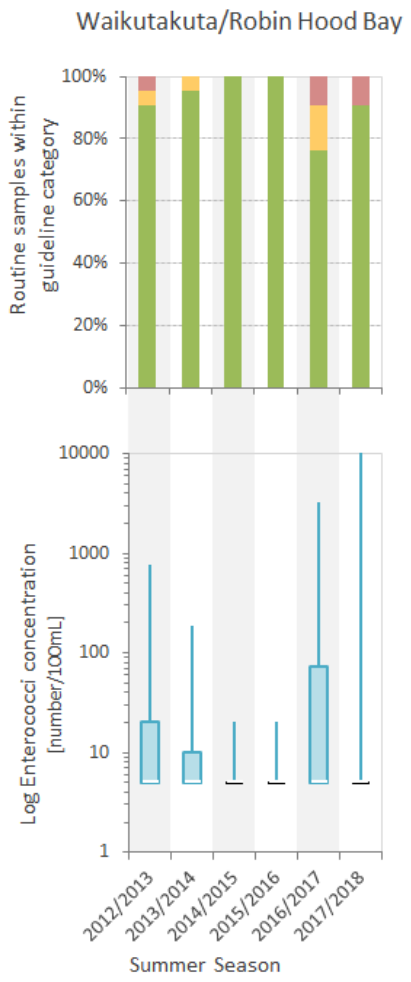

Mistletoe Bay
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

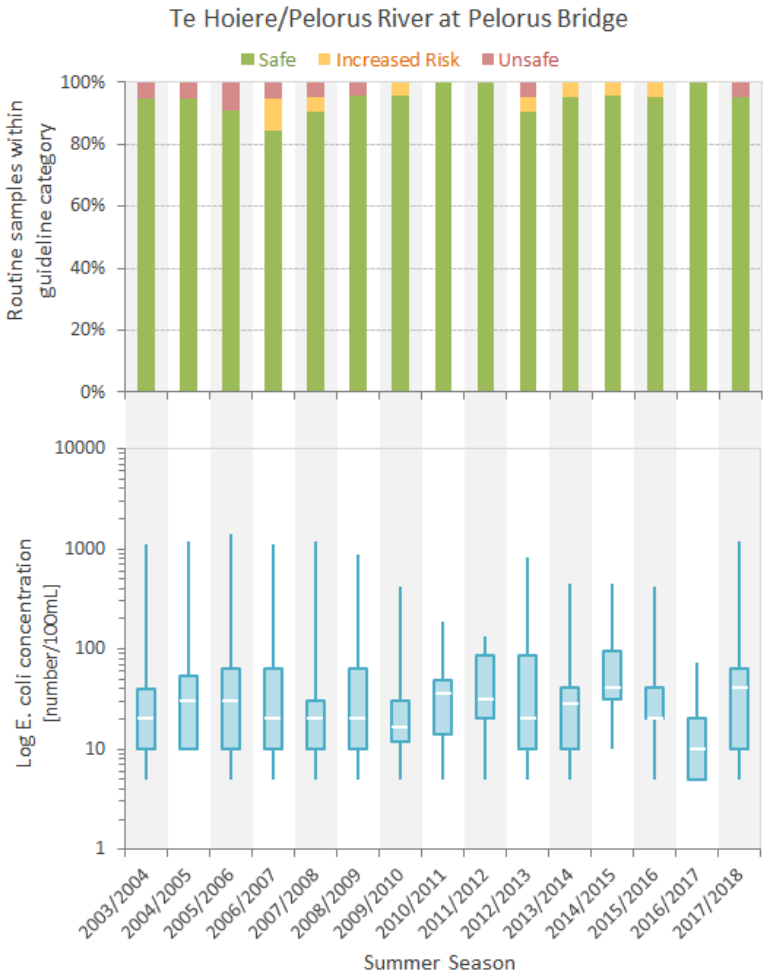

Momorangi Bay
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season
Ngakuta Bay
Safe
Increased Risk
Unsafe
100%
80%
60%
40%
20%
0%
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season
Governors Bay
100%
80%
60%
40%
20%
0%
10000
1000
100
10
1
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

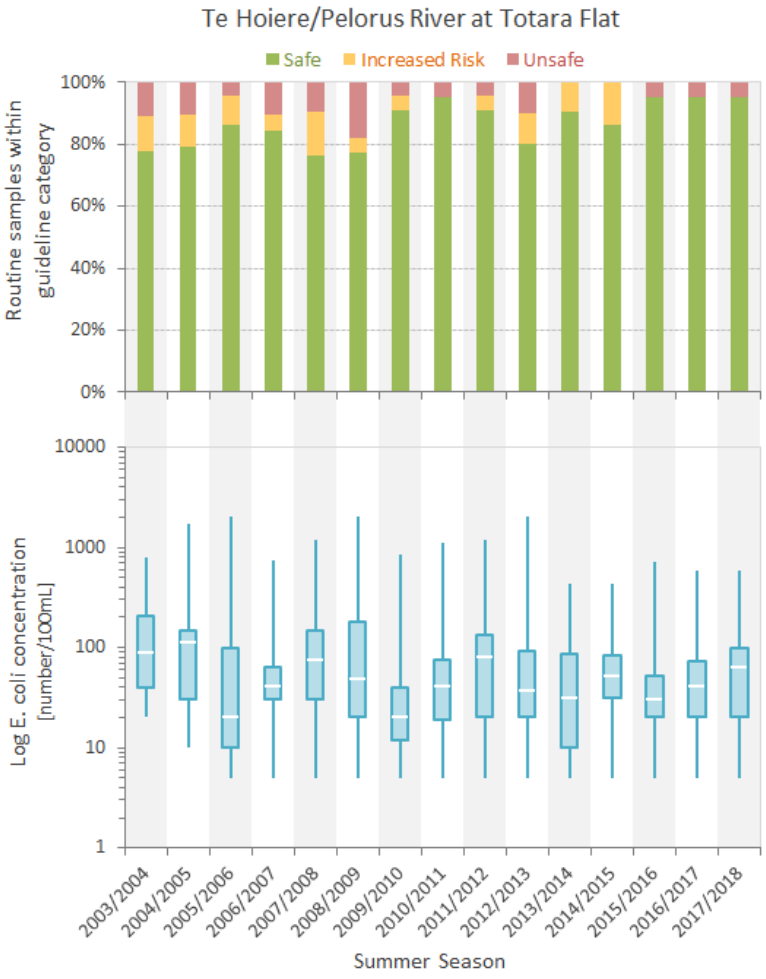

Picton Foreshore
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

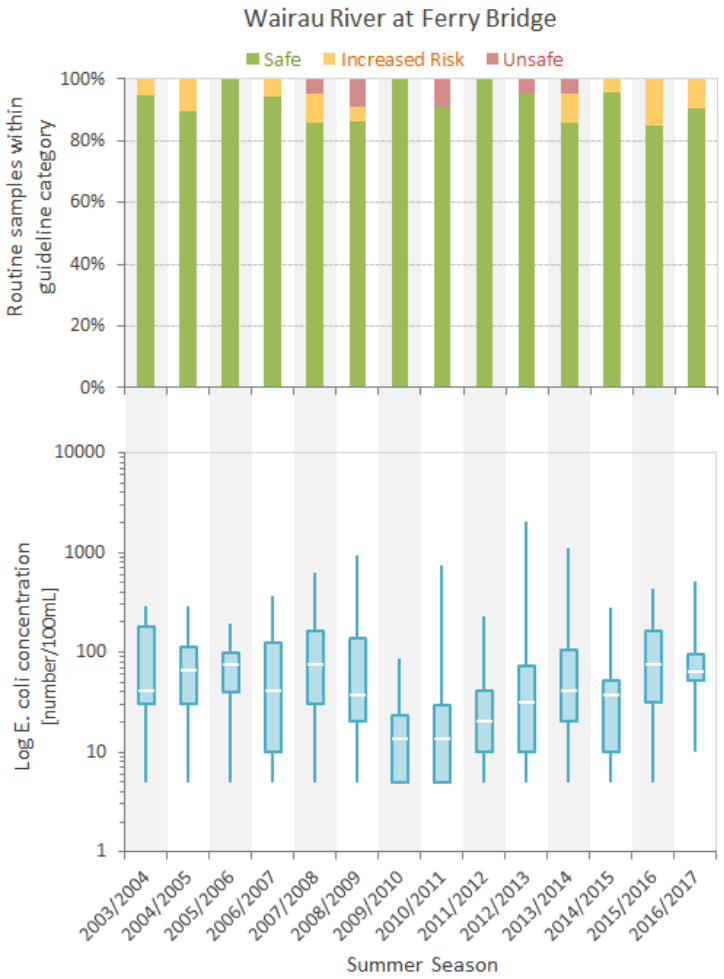

Waikawa Bay
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

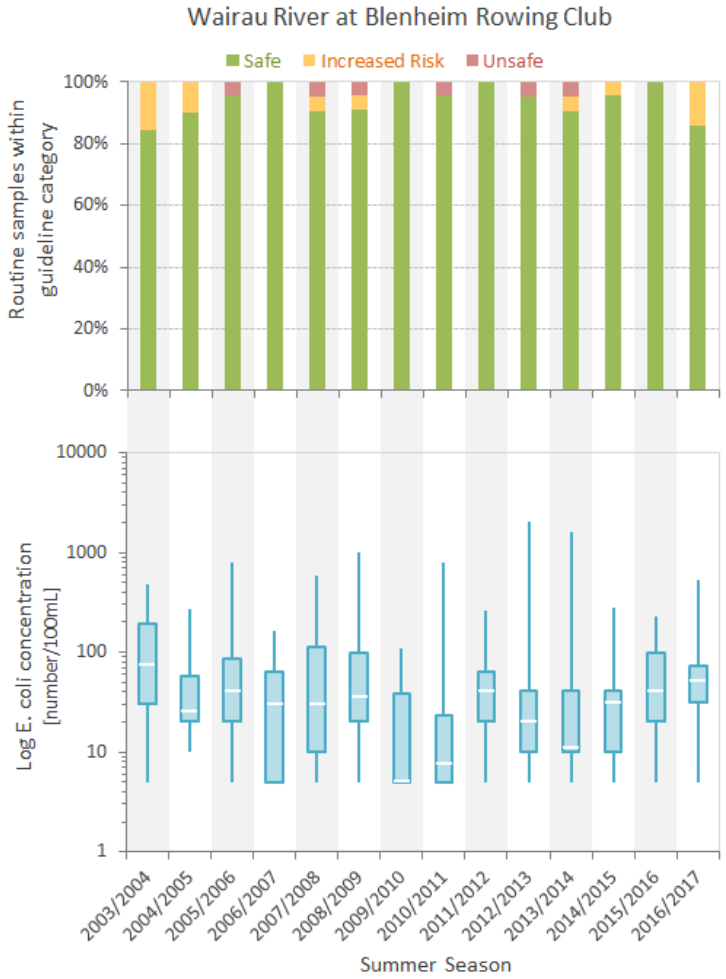

Pukatea/Whites Bay
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

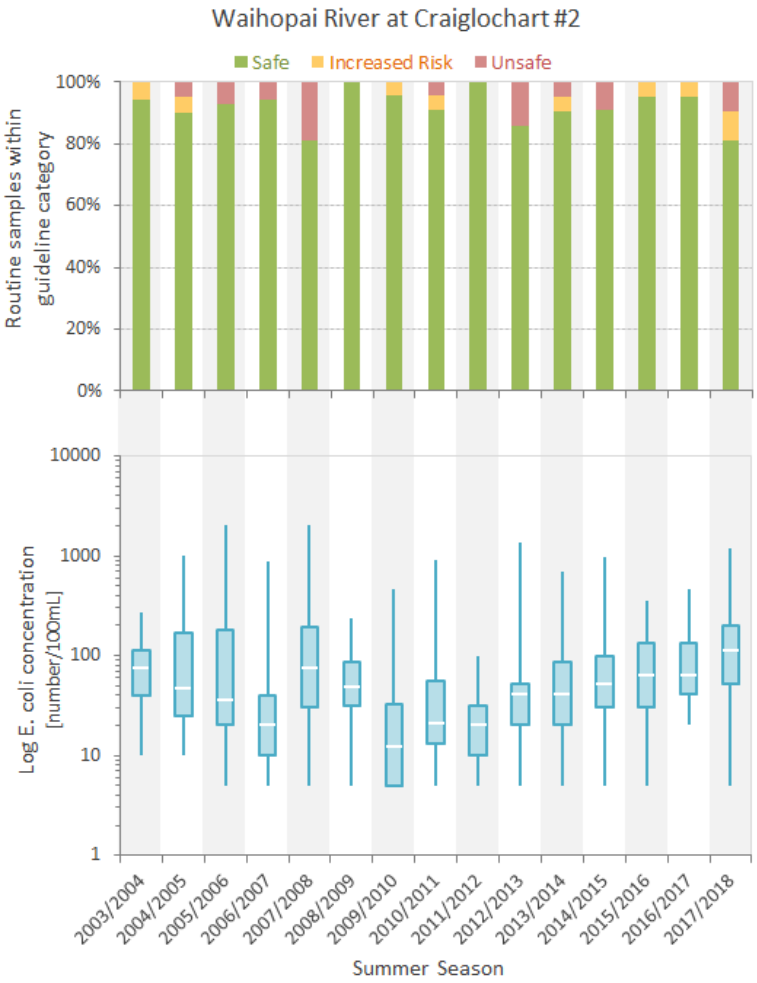

Waikutakuta/Robin Hood Bay
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

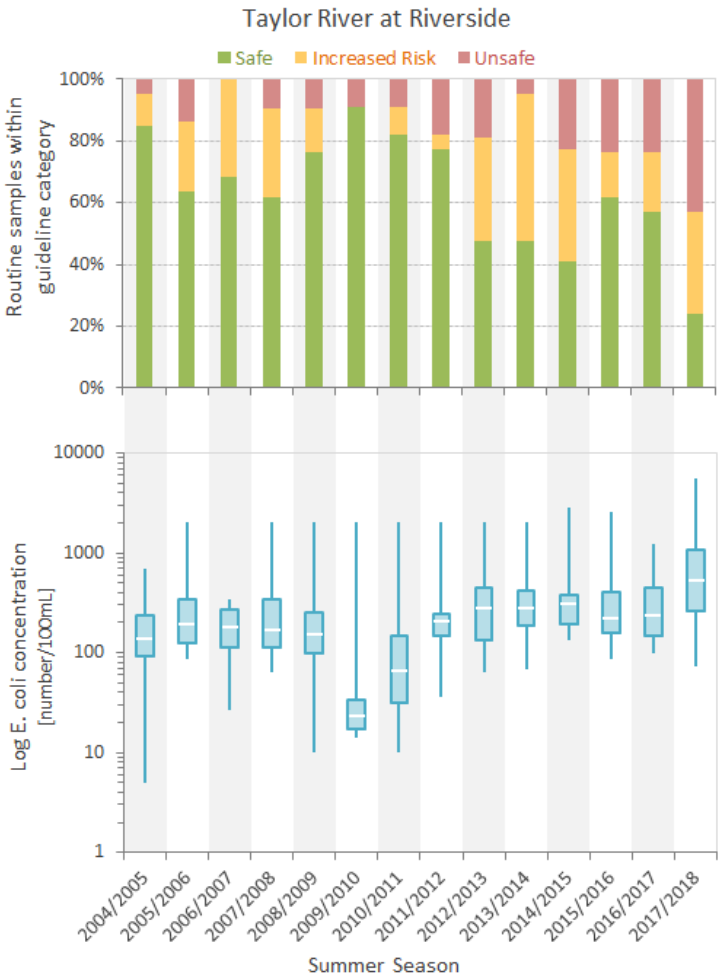

Te Hoiere/Pelorus River at Pelorus Bridge
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season


Te Hoiere/Pelorus River at Totara Flat
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season


Wairau River at Ferry Bridge
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
Summer Season


Wairau River at Blenheim Rowing Club
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
Summer Season


Waihopai River at Craiglochart #2
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season


Taylor River at Riverside
Safe
Increased Risk
Unsafe
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Summer Season

8.2. Appendix 3: Management procedure for exceedances of bathing water guidelines