MARLBOROUGH DISTRICT COUNCIL

Recreational Water Quality Report 2019-2020

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Executive Summary

Ten popular coastal beaches and seven river sites were sampled on a weekly basis between November 2019 and March 2020. 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 MfE[1] and MoH[2] to determine the health risk to recreational users.

Surface-runoff caused by rainfall was the main reason for elevated indicator bacteria concentrations. Therefore, a comparatively wet first half of the summer resulted in guideline exceedances at most of the sites.

Enterococci concentrations during rainfall in Ngakuta Bay were significantly higher than in neighbouring bays. Investigations into the source(s) are planned for the following summer season.

In the Taylor River at Riverside high E. coli concentrations were also observed during dry weather conditions. The cause is earthquake damage and aging of sewerage infrastructure. Repairs are ongoing.

Occasional dry weather samples with elevated indicator bacteria concentrations were also observed at other sites, including Waikutakuta/Robin Hood Bay and Governors Bay. Unfortunately, investigations into the causes had to be put on hold due to the COVID-19 Level 4 measures.

For sites that have been monitored for at least five consecutive summers a SFR Grade was assigned. This grade provides valuable assessment of overall recreational water quality. The SFR Grades are a better tool than individual sample result when deciding where to swim.

Most sites are graded as ‘Fair’, which means that water quality is generally suitable for recreational activities, but swimming should be avoided during and after rainfall. MDC and the DHB generally recommend not swimming in rivers and coastal waters for at least 48 hours after rainfall.

[1] Ministry for the Environment

[2] Ministry of Health

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1. Introduction

Marlborough has many beautiful beaches and rivers that are popular with visitors and local residents. Swimming, boating, surfing and fishing are only a few of the many water based recreational activities that take place in the region.

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. In New Zealand, Campylobacteriosis is the most common illness associated with water use [3]. Other, less common diseases are Cryptosporidiosis and Giardiasis. All three illnesses can cause vomiting, stomach cramps and diarrhoea. It can take up to ten days before symptoms occur. This means that the source of infection is often difficult to determine. In 2017, recreational water contact was identified as a risk factor for 28% of Cryotosporidiosis cases and over 30% of Giardiasis cases in New Zealand [3].

The microorganisms causing these diseases can only multiply in a warm, dark and moist environment, such as the gut of warm-blooded animals. Thus, the most common reason for their presence in water is contamination with faecal matter[3].

To determine the risk to water users, Council takes weekly water samples from the most popular beaches during the summer months. Measuring the concentrations of all harmful microorganisms (pathogens) in these samples is both difficult and expensive. Instead, the samples are analysed for indicator bacteria. These are easier to measure and generally occur together with harmful microorganisms. E. coli are the indicator bacteria used for freshwater samples, while Enterococci are preferred for coastal waters.

This report presents the results for the samples taken during the summer season of 2019/2020. It is important to note, that the report is only focused on health risks associated with faecal contamination. The results presented are not reflective of general water quality. The presence of toxic algae and other risks to swimmers, such as high water flows or strong currents are also not covered.

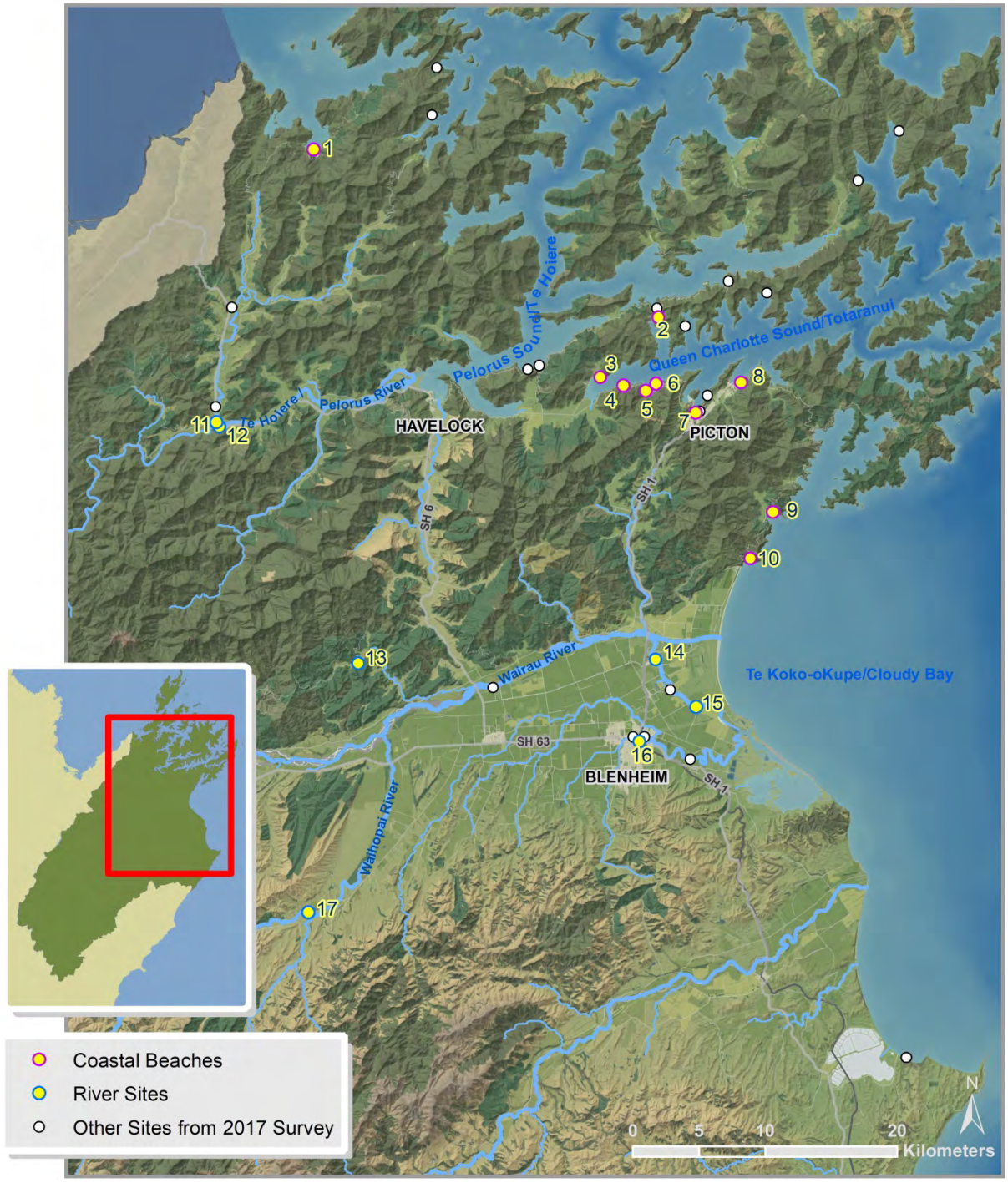
2. Recreational Water Quality Monitoring

During the 2019/2020 summer season, council monitored ten coastal beaches and seven river sites (Figure 1). These sites were the most popular swimming locations in a site usage survey carried out in 2017 [9].

The 17 sites were monitored weekly from the beginning of November until mid of March. This is the time when water temperatures are highest and most swimming occurs. This summer, the monitoring period was shorter than usual as samples could not be taken during the COVID-19 Level 4 period. Monitoring consisted of field measurements (water temperature and conductivity) and taking water samples. The water samples were analysed for faecal indicator bacteria by Hill Laboratories in Blenheim. Bacteria levels were measured using the Enteroalert method for Enterococci and Colilert method for E. coli. For both methods, the samples need to be incubated for 18 to 24 hours. This means that there is a delay of at least one day before sampling results are available. Once council has received the analysis results, they can be viewed on the LAWA website (www.lawa.org.nz). LAWA is a viewing platform for environmental information collected by councils across New Zealand. Recreational water quality is presented in the "Can I Swim Here" module of the website. Other environmental information that can be found on LAWA, includes general water quality, water quantity, soil and air quality data.

The following sections provide a short introduction to the guidelines used to assess the analysis results. These guidelines are found in a 2003 document that was jointly produced by the Ministry for the Environment and the Ministry of Health [11].

[3] Mainly droppings from domestic or native animals, but also human sewage.



	No.	Site	Easting	Northing
Coastal Beaches	1	Okiwi Bay	1655355	5448685
	2	Mistletoe Bay	1681470	5436007
	3	Anakiwa	1677073	5431495
	4	Momorangi Bay	1678817	5430879
	5	Ngakuta Bay	1680514	5430489
	6	Governors Bay	1681310	5431030
	7	Picton Foreshore	1684298	5428815
	8	Waikawa Bay	1687695	5431090
	9	Waikutakuta/Robin Hood Bay East	1690115	5421285
	10	Pukatea/Whites Bay	1688425	5417793

	No.	Site	Easting	Northing
River Sites	11	Te Hoiere/Pelorus Rv at Pelorus Bridge	1648077	5428091
	12	Te Hoiere/Pelorus Rv at Totara Flat	1648262	5427731
	13	Ohinemahuta Rv at Onamalutu Domain	1658791	5409896
	14	Wairau Rv at Ferry Bridge	1681274	5410163
	15	Wairau Rv at Blenheim Rowing Club	1684319	5406605
	16	Taylor River at Riverside	1680023	5403987
	17	Waihopai River at Craiglochart #2	1655029	5391098

Figure 1: Monitoring Sites of the Recreational Water Quality Program (numbered). The map also shows sites that were part of the 2017 Site Usage Survey, but are not currently monitored.

3. Assessment of monitoring results

Our immune system can deal with small concentrations of most pathogens. However, if concentrations are too high, we become sick. There are many factors that influence the number of pathogens that are required to make us sick. One of these factors is the type of pathogen. In New Zealand, the most commonly notified disease that can be caused by recreational water uses is Campylobacteriosis [3]. For this reason, guideline levels are based on the concentration of indicator bacteria (E. coli and Enterococci) that are present when persons contract Campylobacteriosis. However, some persons are more susceptible than others. The guideline values were set to protect roughly 99% of all users.

The most well studied indicator bacterium used is E. coli and they are used to assess the health risk in rivers. However, E. coli quickly die in saltwater. This means a more robust indicator organism, Enterococci, is used for coastal beaches.

3.1. Guideline values for individual samples

The 2003 Guideline document provides two guideline values for each of the two indicator bacteria. Using the guidelines values, sample results are categorised into three “Modes”. Bacteria concentrations within the “Green Mode” indicate that the health risk to swimmers is low. If bacteria levels reach the “Alert mode”, the infection risk is slightly increased. Although it is still safe for swimmers to take a dip, it is a flag for council to investigate the sources of increased faecal pollution. Once bacteria concentrations exceed the Action Guideline, the health risk is considered unacceptable. Table 1 shows the range of indicator bacteria concentrations for the “Modes” and the associated guidelines.

Mode	Freshwater	Coastal	Meaning
	E. coli/100mL	Enterococci/100mL	
Green Mode	<260	<140	**Safe** for contact recreation
Alert Guideline	260	140	
Alert Mode	260 - 550	140 - 280	**Increased risk** for health
Action Guideline	550	280	
Action Mode	>550	>280	**Unsafe** for conctact recreation

Table 1: Modes in the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas [11].

If indicator bacteria concentrations are above the Alert or Action Guideline, possible causes are considered and the District Health Board (DHB) is informed. Council and DHB then make a joint decision on how to proceed. A flow-chart outlining the decision process can be found in Appendix 3.

In Marlborough, most exceedances of the Action Guideline are caused by rainfall. Rainfall water that is not absorbed by the ground flows over the surface and into the nearest stream or coastal area. This is referred to as surface run-off. If the water flows over animal droppings, it becomes contaminated with microorganisms and other pollutants. For this reason streams that flow through pasture usually have high faecal bacteria concentrations during rainfall. Riparian buffer vegetation on stream banks can stop some of the pollution. However, even streams flowing through native bush will contain some faecal bacteria during rainfall, caused by birds and other wild animal droppings.

In urban areas, the majority of surfaces will not allow rainfall to infiltrate into the ground. Therefore, the proportion of rainfall forming surface run-off is greater. The run-off collects in stormwater pipes that often discharge directly into streams and coastal waters. In addition to animal droppings, the main sources of contamination in urban areas are sewer overflows and damage to the sewerage pipe system.

In small rural and coastal residential areas, private sewage treatment can also be a source of faecal contamination. These private systems require regular checks and maintenance to function properly. In Marlborough, it is the responsibility of the private landowner to ensure that their system is functioning.

The District Health Board and council have released a general recommendation to not swim in waterways for up to 48 hours following heavy rainfall or if the water is discoloured. This message is usually reinforced with a media release at the beginning of each summer season.

3.2. Suitability for Contact Recreation Grades (SFR Grades)

To determine the concentration of indicator bacteria, a sub-sample is injected into a growing medium and the medium is then placed into an incubator. This creates ideal conditions for the indicator bacteria to multiply. After 18 – 24 hours of incubation, the bacterial colonies can be counted and a concentration is calculated.

Unfortunately, this analysis methods results in a delay of at least one day before the bacterial concentration in a sample can be known. This means by the time analysis results are received, the concentration of indicator bacteria has likely changes. Particularly, rainfall can cause significant changes in water quality within minutes. This means that the latest sampling results should not be used to decide whether it is safe to swim or not. To overcome this problem, a grading system, the SFR Grades, was developed. SFR Grades range from 'Very Good' to 'Very Poor' and provide an overall assessment of recreational water quality. Table 2 lists the five SFR Grades and what they mean.

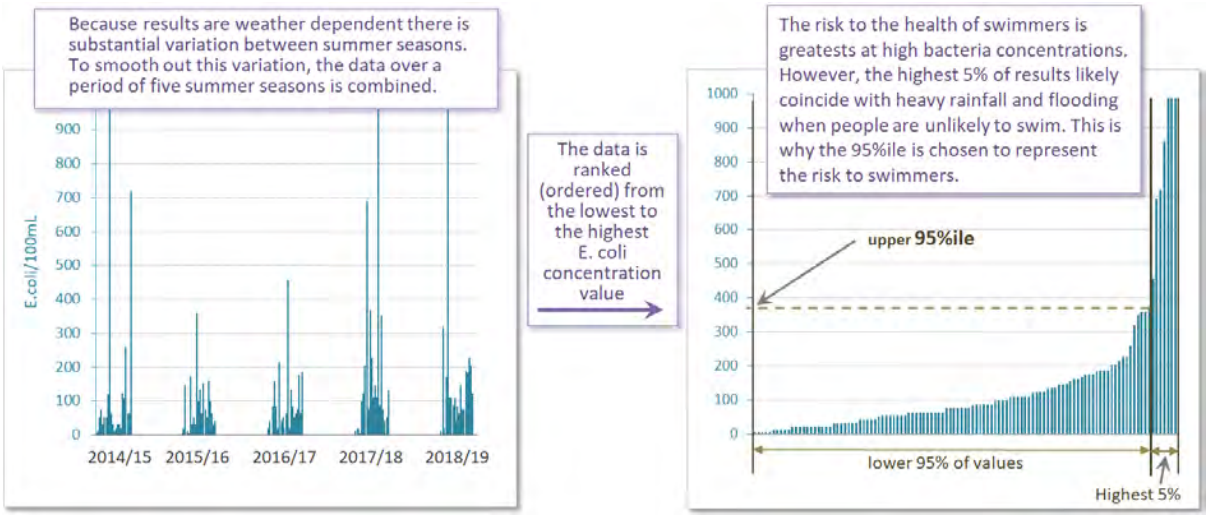
SFR Grade	Meaning
Very Good	Considered satisfactory for swimming at all times.
Good	Satisfactory for swimming most of the time with exceptions following rainfall.
Fair	Generally satisfactory for swimming. Caution should be taken during periods of high rainfall and swimming avoided if water is discoloured.
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 2: Suitability for Contact Recreation Grades (SFR Grades) and their meaning.

The grading of a swimming site is done in two parts. The first part is an assessment of the health risk from all potential faecal sources within the catchment[4]. Based on the assessment, sites are assigned one of five **Sanitary Inspection Categories, SICs**. These categories range from 'Very Low' to 'Very High' (Risk). Direct discharges into rivers and coastal areas are the most obvious sources of faecal contamination, but faecal material can enter water bodies also from a variety of land use activities. If a swimming spot is surrounded by native bush, the health risk from waterborne diseases is considered to be minimal and the site is given a SIC of 'Very Low'. Extensive sheep and beef farms cause a slightly greater risk of faecal contamination, particularly if livestock can access streams. This results in a SIC of 'Low' or 'Moderate'. The highest health risk is generally associated with human sewage. Swimming spots influenced by residential and urban development are therefore assigned a SIC of 'Moderate' to 'Very High'.

The second part of the SFR grading is the **Microbiological Assessment Category, MAC.** The MAC is calculated from bacteria concentrations in samples taken at a site. MACs range from A to D and are based on the upper 95th percentile (95%ile) calculated with the Hazen method (Figure 2).

[4] A catchment is the land area from which all rainfall that falls onto it eventually flows to a river sampling site or into a coastal bay. It can also be called a drainage basin or watershed.



MAC (Microbiological Assessment Category)	Coastal Enterococci/100mL*	Freshwater 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

Figure 2: Calculation of the upper 95%ile, which is used to assign the Microbiological Assessment Category (MAC) based on the table shown.

The calculation of the MAC requires a minimum of 20 sample results per season over a period of five consecutive summers. This means that it will take several years before new sites can be graded. To provide some information for beach users, an interim grade can be calculated using the data over a shorter period. On the LAWA website, the MAC is calculated using data from a shorter, three year period, for all sites. This provides the advantage that changes to water quality are reflected in the grading earlier. The LAWA team have gone a step further, basing their grading on the MAC calculation only. In the national guidelines the SFR Grade combines the results from the SIC and MAC analysis (Table 3). The SIC allows adjustment of the grade based on the health risk from different sources of faecal contamination. For example, contamination from human sources generally presents a greater risk to swimmers than animal droppings. The MAC grading alone does not provide for this. The main argument against the inclusion of the SIC into the grading is that it introduces some subjectivity to the process. However, the use of genetic source tracking methods and site investigations allow the SIC category to be determined with greater certainty.

In this report the grading of sites is based on the national guidelines using the MAC and SIC categories to determine the SFR Grade. The SFR Grades are updated after every summer season as new data becomes available.

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: Assignment of a SFR Grade from MAC and SIC results.

4. Sampling Results

The following chapters present the monitoring results for the 2019/2020 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. The chapters start with a general description of the sites. A map shows the location of the sampling sites as well as the rainfall and/or flow recorder. The second part of the chapter discusses the sampling results for the 2019/2020 summer season. For each group the concentration of faecal indicator bacteria 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 generally the main causes for increased concentrations of faecal bacteria. For sites with longer monitoring records, the changes over time are shown using the 5-year-95%ile (MAC) values (Figure 2), which are also used for the calculation of the SFR Grades (see Section3.2).

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 percentage of samples within the three 'Modes' and box and whiskers plots for all summer seasons a site has been routinely monitored.

4.1. 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 programme. The microbiological water quality is influenced by the surrounding residential development and large numbers of seabirds (eg; oystercatcher, swans and ducks). Water quality is expected to also be influence by Linkwater Stream and Ada Creek (Figure 3). These two streams drain pastoral land and flow into the Sound roughly two kilometers 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].

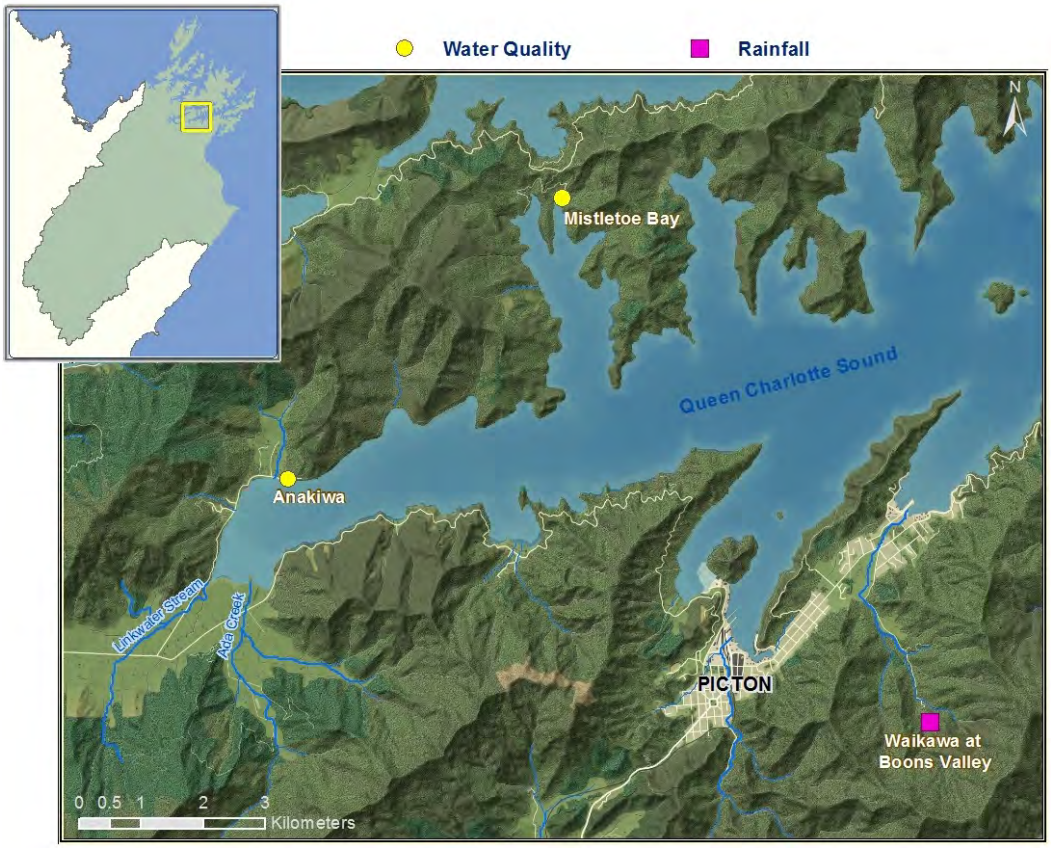


Figure 3: Location of the Anakiwa and Mistletoe Bay sampling sites and the Waikawa at Boons Valley rain gauge.

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

Results

Enterococci concentrations in samples taken from Anakiwa and Mistletoe Bay were generally low. An exception were unusually high bacteria levels in Anakiwa in mid-February. A small amount of rain was recorded at the Waikawa rainfall recorder. Yet, the Enterococci concentrations in Anakiwa were disproportionately high. In fact the concentration was the highest observed in the last six years. Rainfall in the Marlbrorough Sounds can vary from bay to bay during the same event. It is therefore possible that localised heavier rainfall at Anakiwa was the cause. However, monitoring of nearby Linkwater Stream has shown a recent increase in E. coli concentrations. Council's compliance team is currently investigating the cause.

None of the samples taken from Mistletoe Bay had unsafe Enterococci concentrations. A slight exceedance of the Alert guideline coincided with significant rainfall recorded in Waikawa.

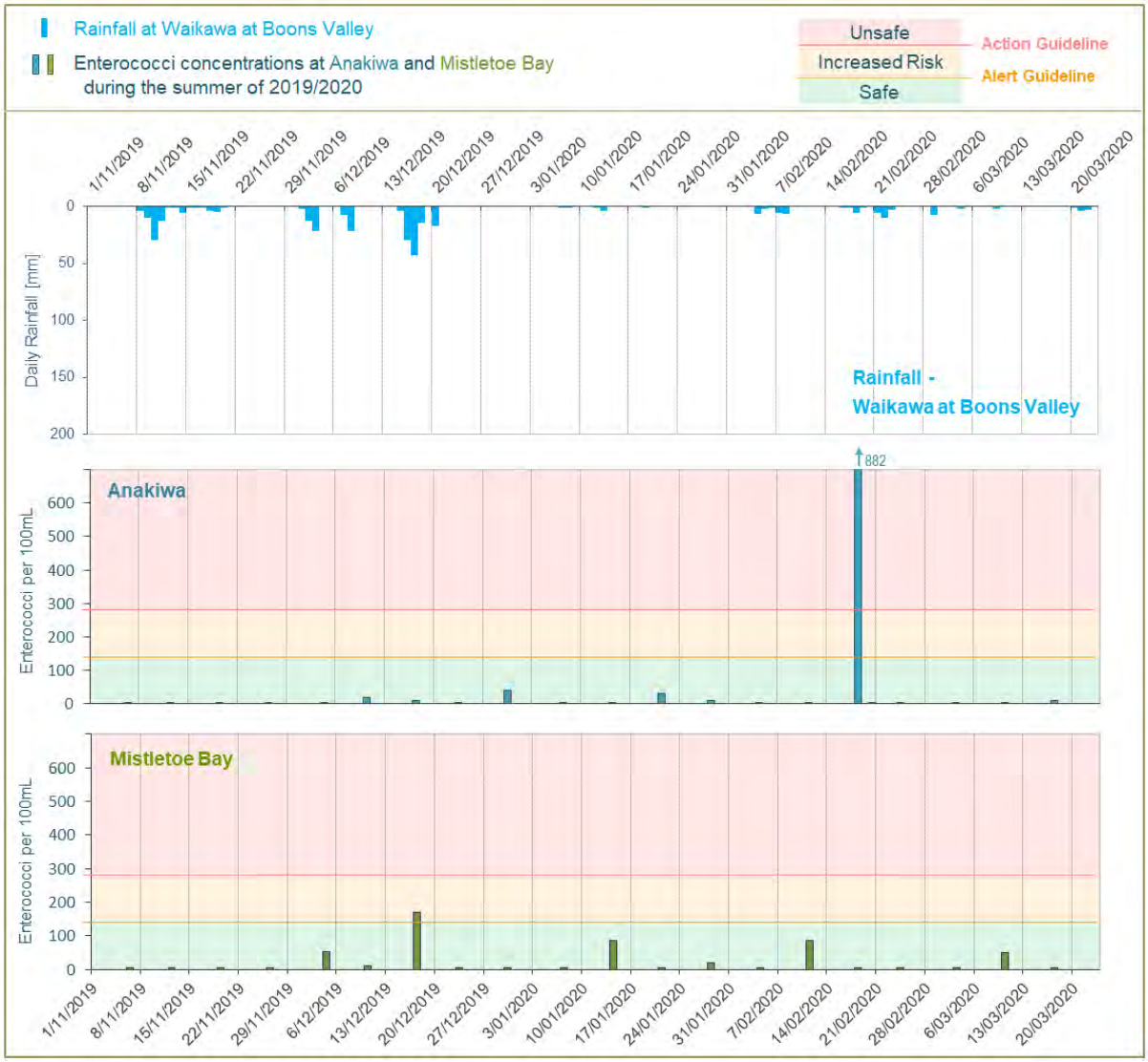


Figure 4: Enterococci concentrations at Anakiwa and Mistletoe Bay in summer 2019/20.

Anakiwa and Mistletoe, both, have a SFR Grade of good. The long term trend shows little change for Anakiwa in recent years (Figure 5). Mistletoe has seen an improvement in recreational water quality. This improvement represents a return to previously good water quality. A temporary increase in

Enterococci concentrations in 2016/2017 was linked to an old septic tank. This tank has since been removed.

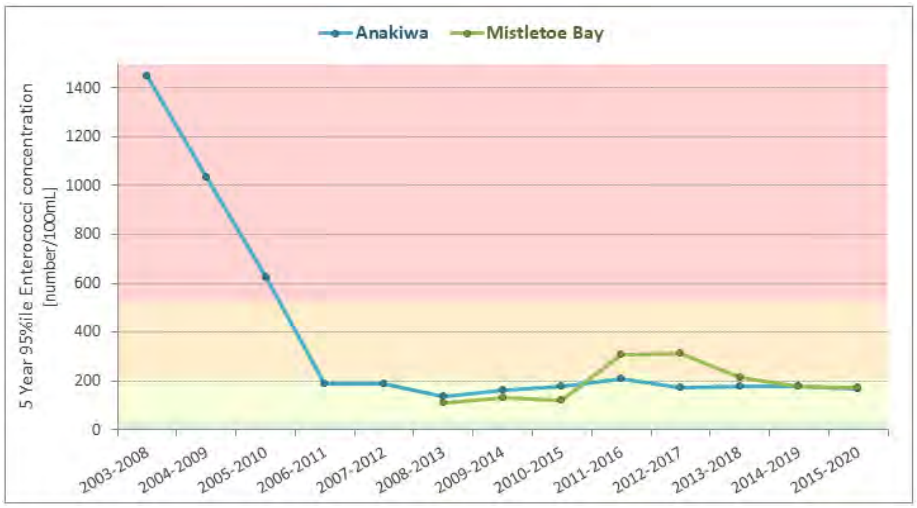


Figure 5: The 5-year 95%ile Enterococci concentrations for Anakiwa and Mistletoe Bay.

4.2. 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. It also has the greatest amount of residential development in the catchment. There are nearly 100 houses and holiday homes in Ngakuta Bay compared to less than 20 houses in Momorangi Bay. Momorangi Bay, however, has a very popular campground. There is no residential development in Governors Bay.

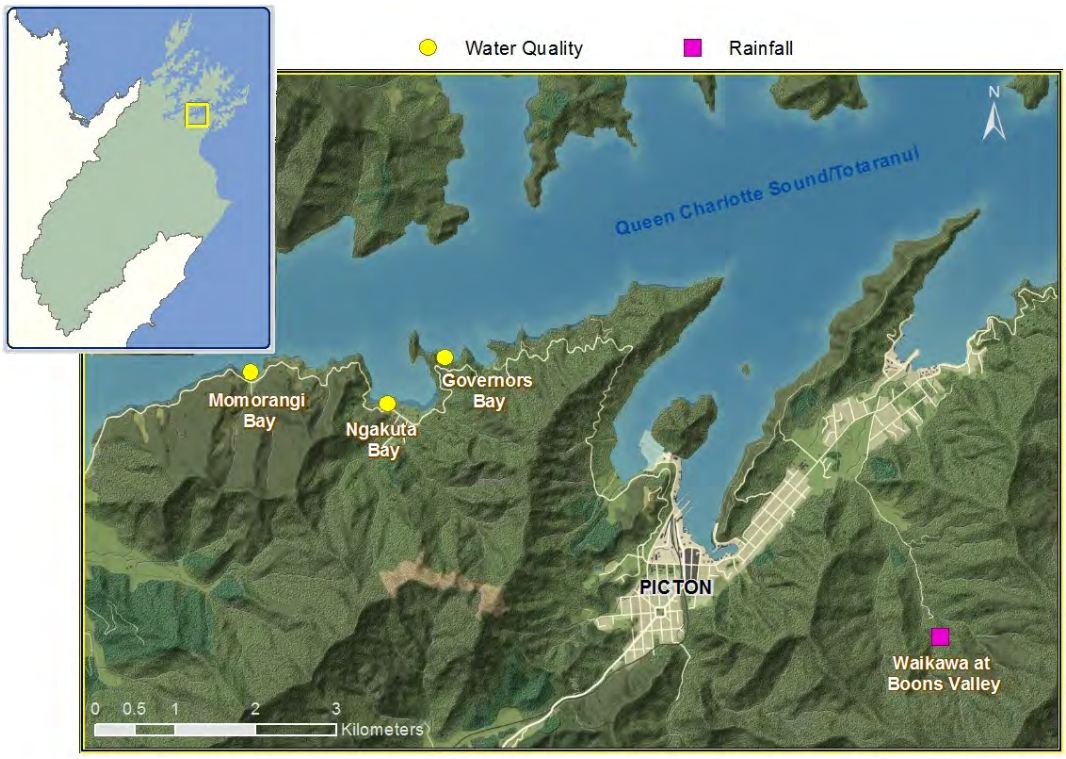


Figure 6: Map showing the sampling sites at Momorangi Bay, Ngakuta Bay and Governors Bay, as well as the rainfall recorder at Waikawa Boons Valley.

Results

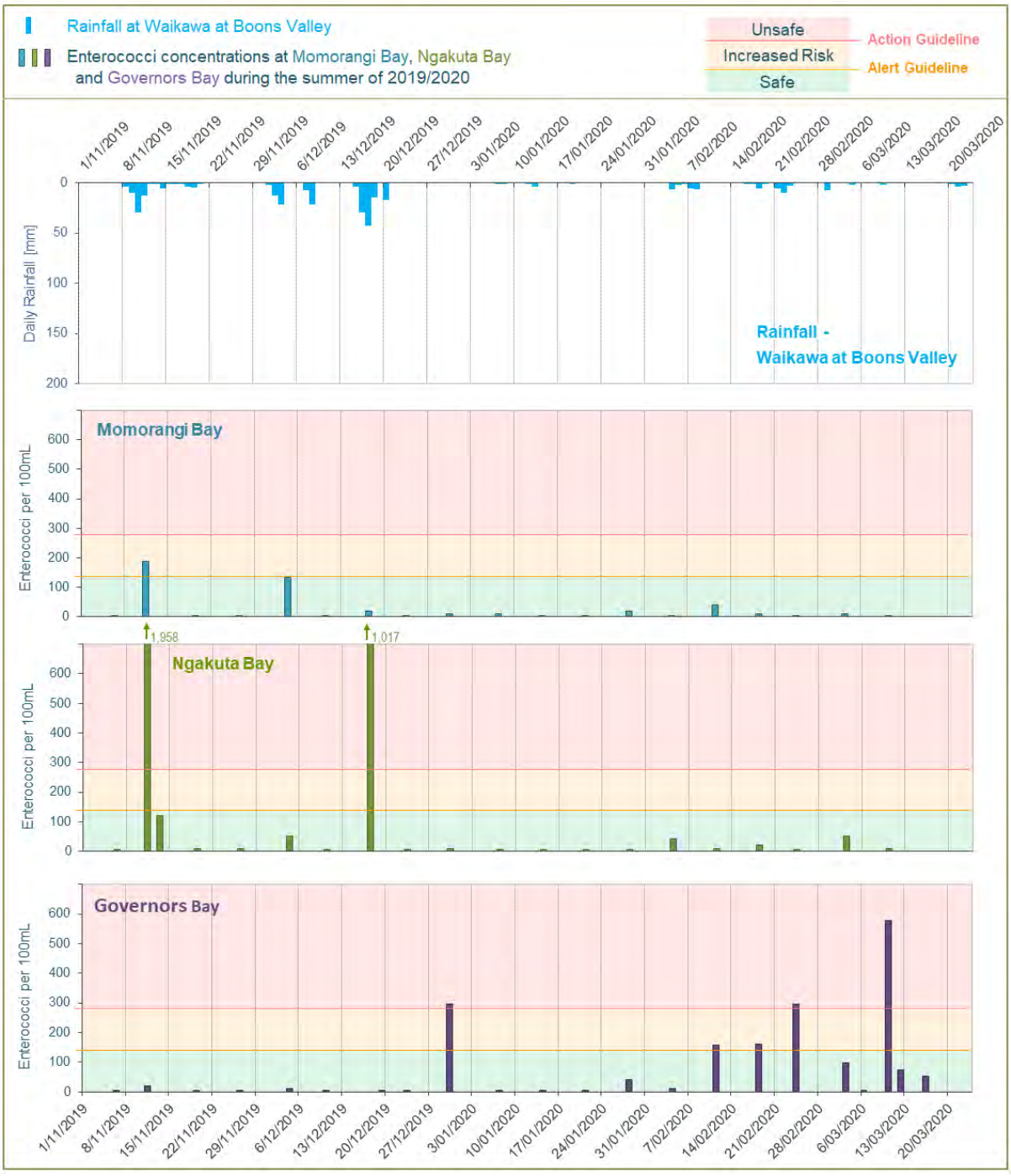


Figure 7: Enterococci concentrations at Momorangi Bay, Ngakuta Bay and Governors Bay during the 2019/20 summer season.

High Enterococci concentrations in Momorangi and Ngakuta Bay were observed only as a result of rainfall (Figure 7). However, bacteria concentrations were significantly higher in Ngakuta Bay. Visitor numbers during the height of summer were likely similar in both bays. The difference lies in the way human waste is dealt with. Momorangi Bay has a community sewage treatment system. After some problems in 2015 and 2016, the Department of Conservation invested in upgrades and repairs. This work resulted in a significant improvement in water quality. Batches and homes in Ngakuta Bay have individual sewage treatment systems. Overflowing septic tanks are therefore a possible reason for the much higher bacteria concentration observed during rainfall. Additional samples taken this summer

will be analysed for genetic markers[5]. Should the results show that human waste is indeed the cause, further investigations will be initiated next season. These will focus on the streams entering the bay to narrow down the location of the source(s). Council will also contact Ngakuta Bay residents and ask them to check their septic tank systems.

This summer, an investigation into a separate issues has already been underway in Governors Bay. Enterococci concentrations in this bay tend to increase towards the end of summer. This increase is independent of rainfall and has now been observed for several summers. The bacteria concentrations are highest after the main holiday season, between mid-February and mid-March. During this time Enterococci levels vary significantly, occasionally exceeding the guidelines. Analysis of the data has shown no clear link to tides, weather, conductivity or any other observations during sampling. As a result we are unable to predict when exactly Enterococci levels are high. This makes investigative sampling difficult. We did however manage to obtain a sample with sufficiently high bacteria level for genetic source analysis. The investigation had to be put on hold due the COVID-19 lockdown measures, but will continue next season.

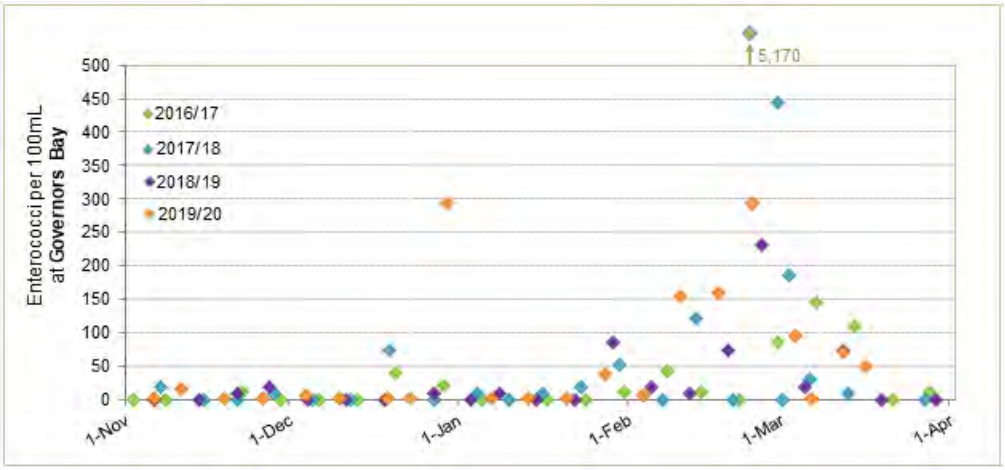


Figure 8: Enterococci concentrations in Governors Bay over the last four summer seasons.

The long-term trends show increasing Enterococci concentrations for Ngakuta Bay and Governors Bay. For Governors Bay, this has resulted in a change from an SFR Grade of Good to a Grade of Fair. The SFR Grade of Ngakuta Bay remains unchanged as Fair. Momorangi Bay is also graded Fair, however, for this bay the long-term trend is showing improving water quality.

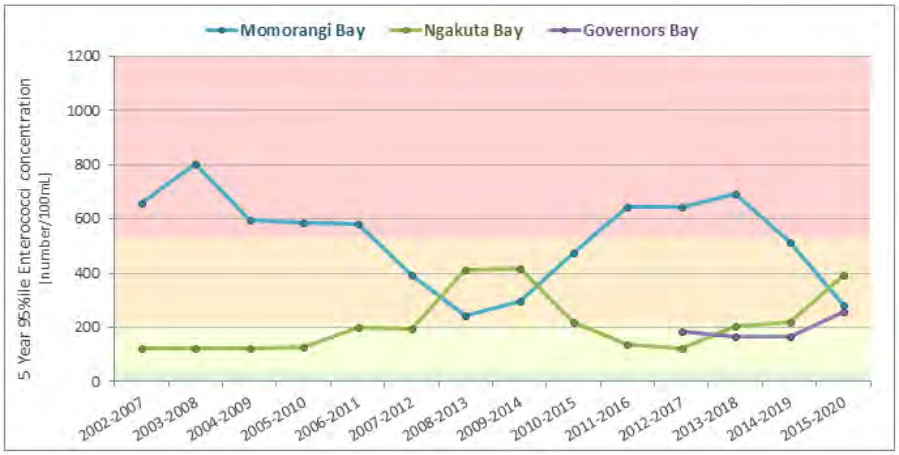


Figure 9: The 5-year 95%ile Enterococci concentrations for Momorangi Bay, Ngakuta Bay and Governors Bay.

[5] The analysis of the samples was delayed due to the COVID-19 Level 4 measures and could not be included in this report.

4.3. 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 aquarium and a large, modern playground make it a popular destination for local residents and visitors. The Picton Maritime Festival and other events draw 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 generally poorer water quality.

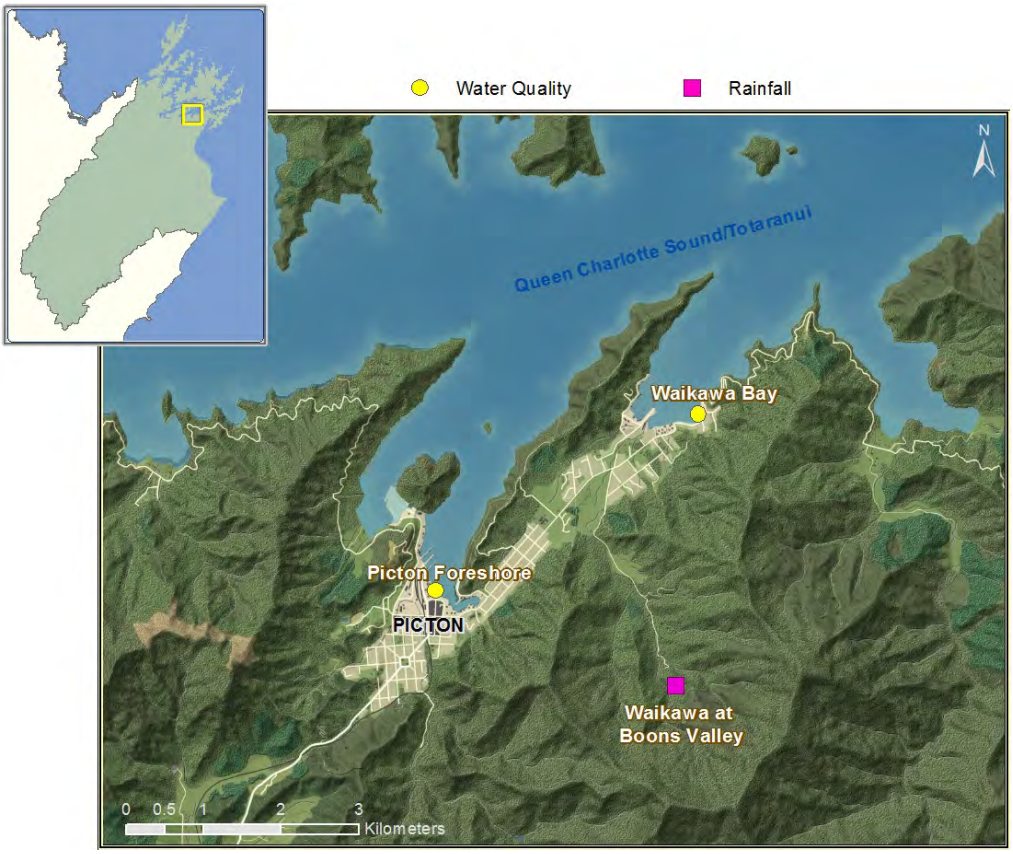


Figure 10: Locations of the Picton Foreshore and Waikawa Bay sampling sites as well as the rainfall recorder at Boons Valley.

Results

This summers, some samples taken from these two sites had Enterococci concentrations above the guidelines. These exceedances often coincided with rainfall recorded at Waikawa Boons Valley. The exception were samples taken in late January. Because Enterococci concentrations were elevated at both sites, it is likely that rainfall was also the cause for these. In general, follow-up sampling showed that bacteria concentrations quickly dropped back to low levels once rainfall ceased. When comparing the monitoring results from Picton Foreshore and Waikawa with those from other sites in the Marlborough Sounds, it might appear that water quality was comparatively poor. It needs to be noted, however, that sampling generally occurred on different days. During this summer, sampling of the Picton and Waikawa sites simply coincided more often with rainfall events. Waikawa Bay has had water quality graded as ‘Good, while a number of nearby bays in Sounds are instead graded as Fair. Despite the guideline exceedances observed this summer, in general, the water quality in Waikawa Bay is comparatively good. This underlines the fact, that the results of individual samples should not be used as an indication for the water quality at a swimming site.

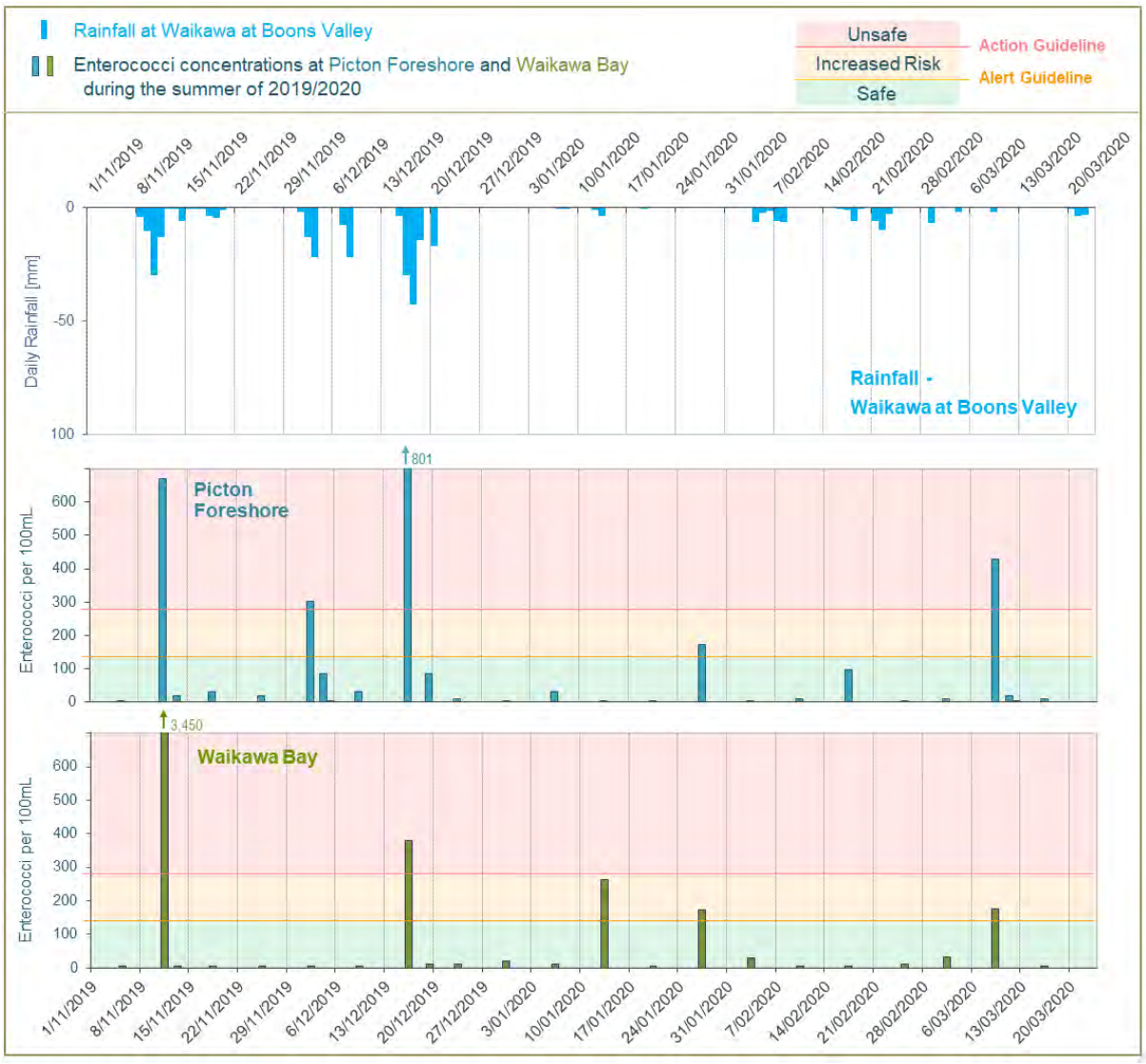


Figure 11: Enterococci concentrations at Picton Foreshore and Waikawa in summer 2019/20.

The long-term trends show an increase in Enterococci concentrations for both sites. The greater number of samples taken during rainfall this summer is the likely cause for this. It is only of concern should the upward trend continue in the following seasons.

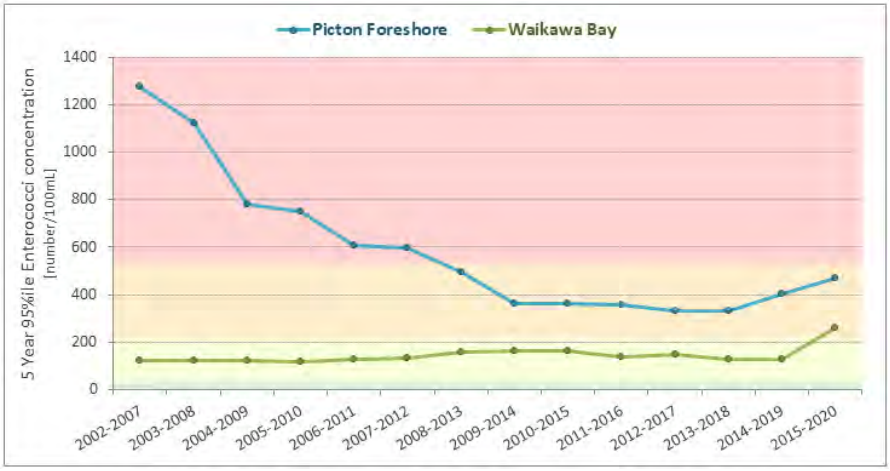


Figure 12: The 5-year 95%ile Enterococci concentrations for Picton Foreshore and Waikawa.

4.4. 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, Stace 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.

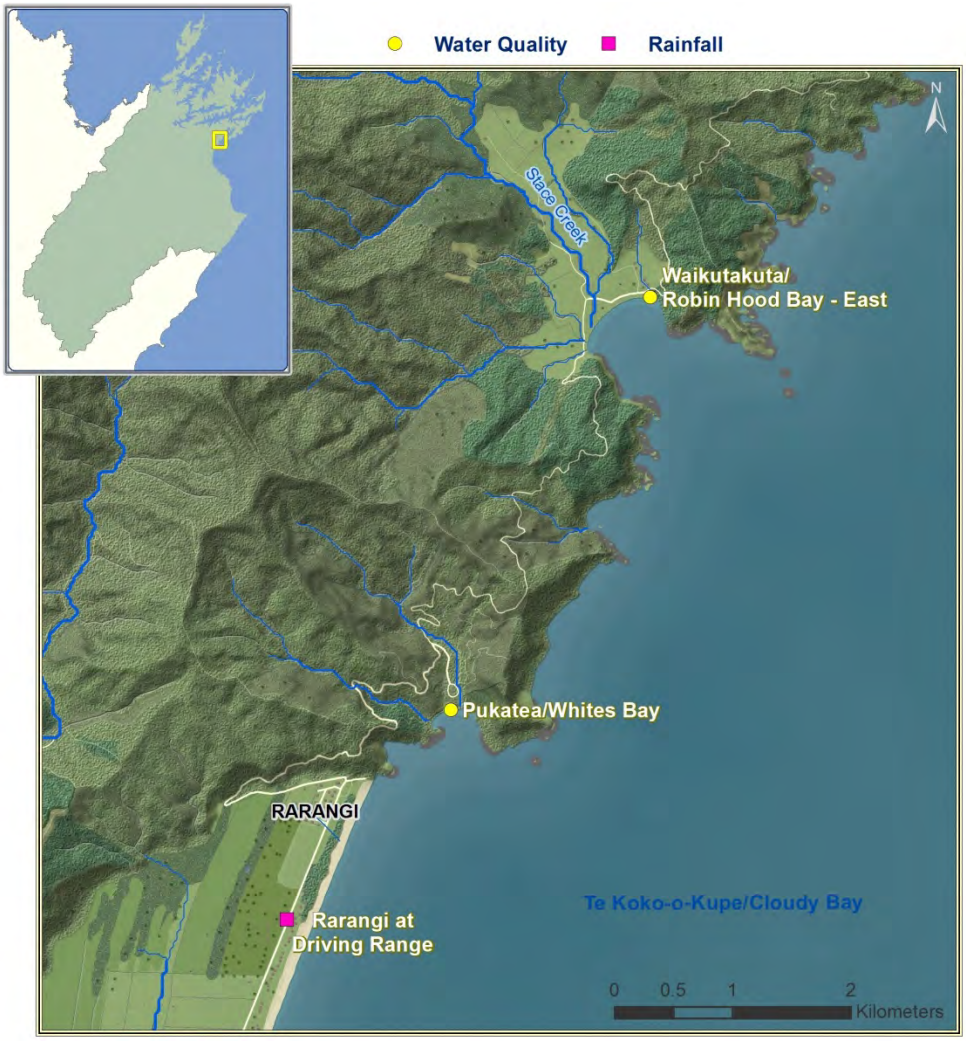


Figure 13: Locations of the Puketea/Whites Bay and the Waikutakuta/Robin Hood Bay East sampling sites, as well as the Rarangi rainfall recorder.

Results

As observed in recent years, Pukatea/Whites Bay had generally very good water quality. The only guideline exceedance was observed early in the season as a result of heavy rainfall. The same rainfall event caused significantly higher bacteria levels in Waikutakuta/Robin Hood Bay, however. Run-off from cattle pasture in the Stace Creek catchment is the most likely cause. During the main holiday season two further samples from Waikutakuta/Robin Hood Bay exceeded the guideline. The exceedance in December coincided with elevated bacteria levels in Waikawa and Picton. This means that rainfall run-off is a likely explanation. However, rainfall does not explain the high Enterococci levels in mid-January. Investigative sampling has so far been fruitless. The investigation included a small stream that flows near a public toilet before meandering across the beach near the sampling

site. Despite some visible discoloration with iron oxide the water in the stream had consistently low faecal bacteria concentrations. Another possible source are residential buildings near the sampling sites. Unfortunately, further investigations were stopped by the COVID-19 lockdown.

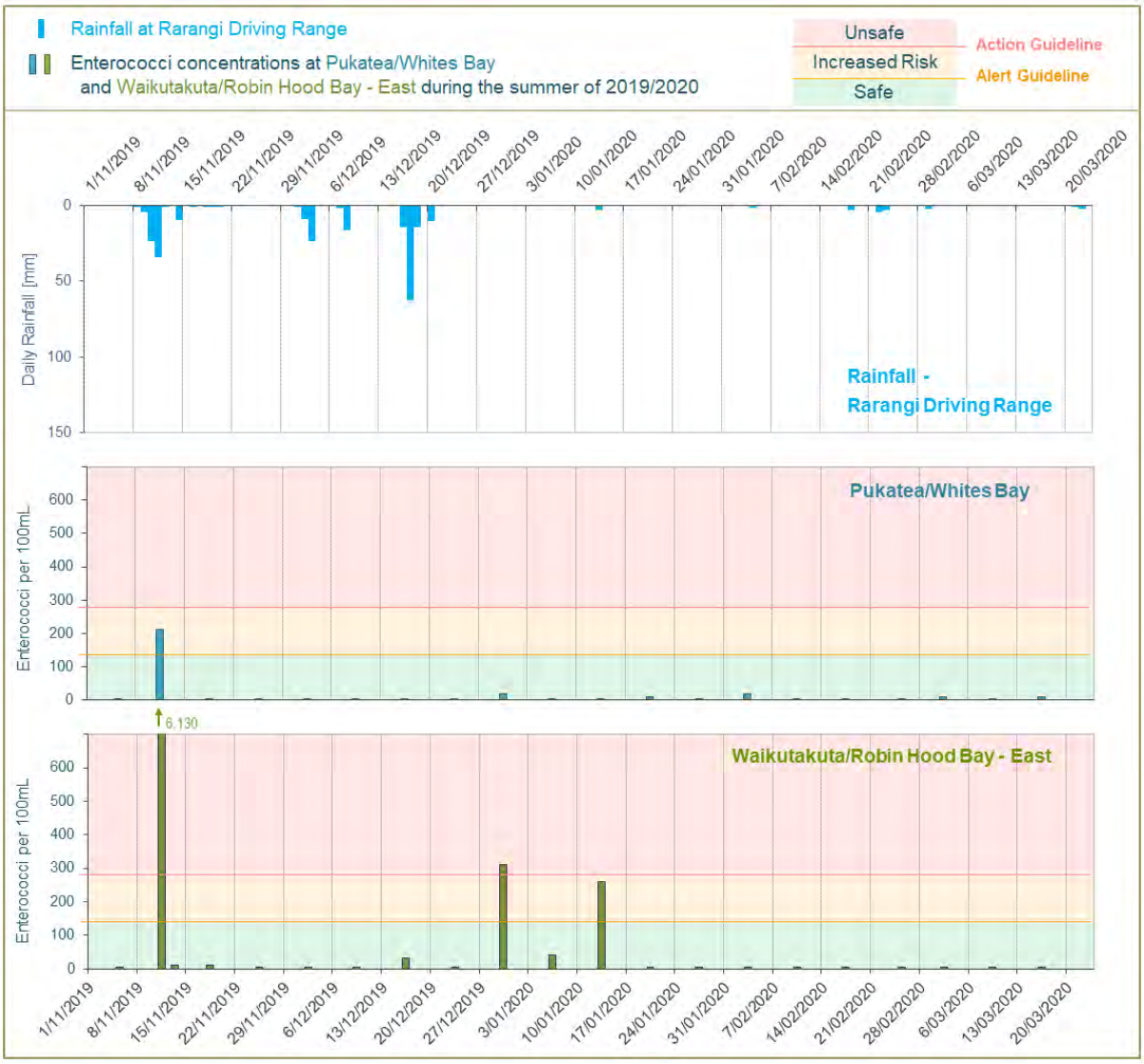


Figure 14: Enterococci concentrations at Pukatea/Whites Bay and Waikutakuta/Robin Hood Bay during the 2019/20 summer season.

The long-term trends show increasing Enterococci concentrations for both bays (Figure 15). The slight increase for Pukatea/Whites Bay is possibly caused by sampling that coincided more often with rainfall in previous summers. The increase of Enterococci levels in Waikutakuta/Robin Hood Bay are more concerning. Water quality in the bay is now graded as 'Poor'. Investigation into the source(s) will continue next season.

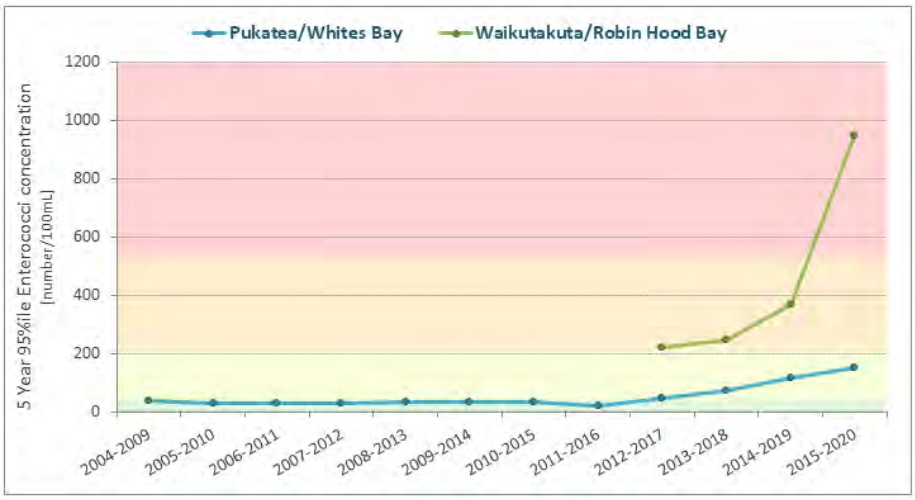


Figure 15: The 5-year 95%ile Enterococci concentrations for Pukatea/Whites Bay and Waikutakuta/Robin Hood Bay.

4.5. 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 water quality. 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 offer accommodation for longer stays.

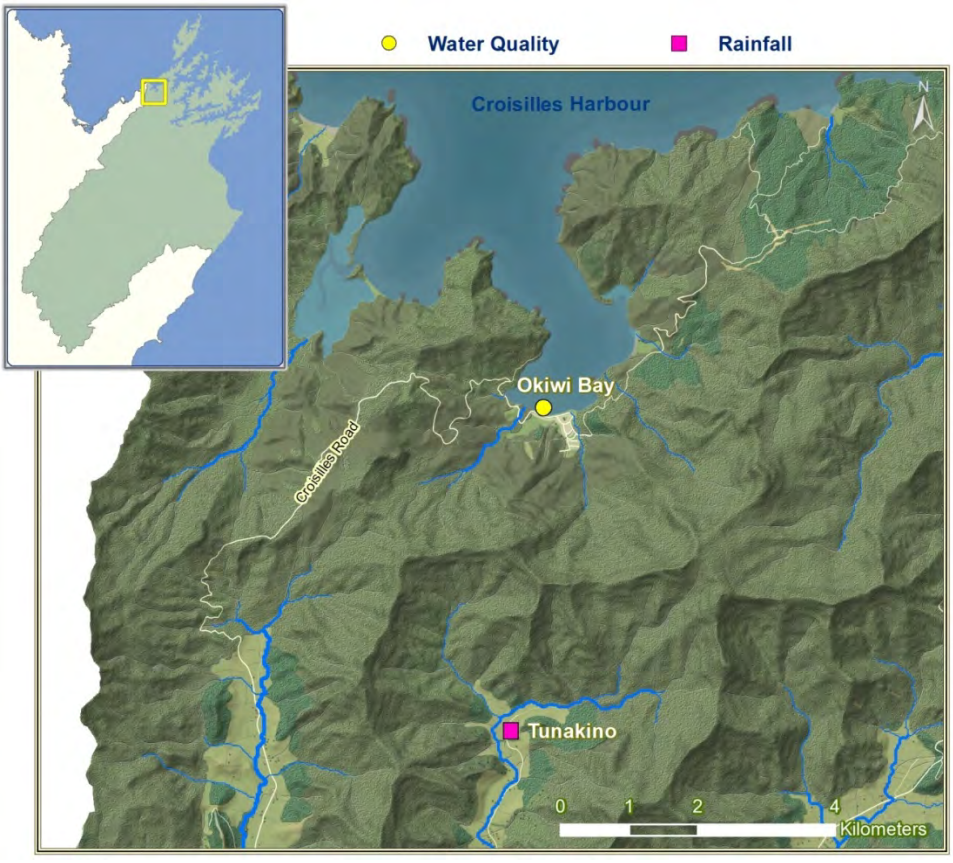


Figure 16: Location of the Okiwi Bay sampling sites and the Tunakino rain gauge.

Results

Elevated Enterococci concentrations in Okiwi Bay were exclusively associated with rainfall. The highest bacteria concentration was observed in December. The sample was taken during several days of rain. More than 150mm of rainfall were recorded at the nearby Tunakino recorder. A follow-up sample taken two days later showed that Enterococci concentrations had returned to safe levels. Okiwi Bay has only recently been added to the programme. This means that we do not yet have sufficient data to assign a SFR Grade to this site. However, based on this season's results the site would likely be graded as Good or Fair.

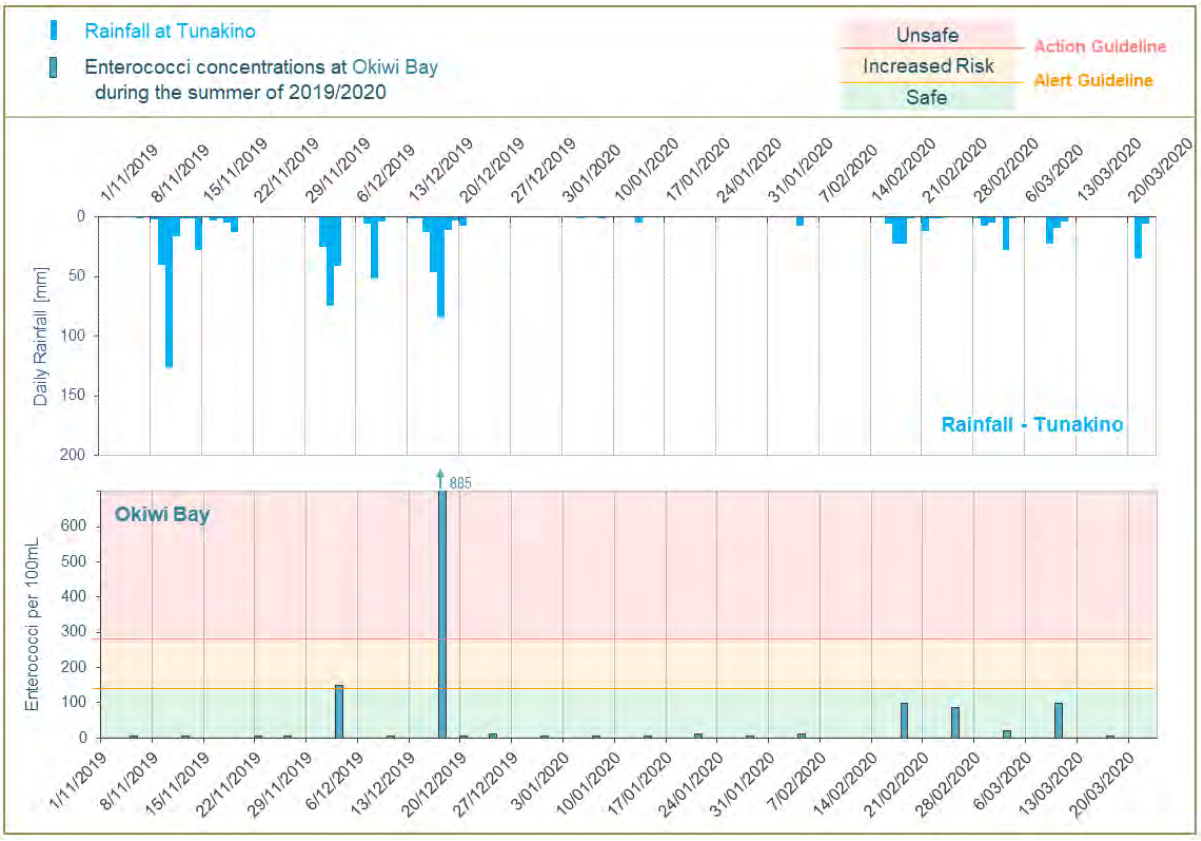


Figure 17: Enterococci concentrations at Okiwi Bay over the 2019/20 summer season.

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.

4.6. 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 programme, 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 18: Locations of the Te Hoiere/Pelorus River sampling sites as well as nearby rainfall and flow recorders.

Results

The top graph in Figure 19 shows the flow of the Te Hoiere/Pelorus River over this summer. Frequent flood flows in the early months were followed by a long period with very little rainfall. This is mirrored by the E. coli concentrations[6] in the Te Hoiere/Pelorus River. However, when comparing the E. coli levels at the two monitoring sites, it is notable that concentrations at Totara Flat are significantly higher. E. coli concentrations were in fact the highest observed over the last seven years. This could simply be a result of timing. Sampling occurred near peak flood flows twice this summer.

The high E. coli concentrations at Totara Flat this summer have a significant influence on the long-term trend shown in the lower part of Figure 19. They also resulted in a lowering of the SFR Grade from Fair to Poor. Still, E. coli concentrations remain well below levels recorded several year ago. Efforts by the local farming community have resulted in significant improvements in recent years. This positive outcome has led to the Te Hoiere being one of the national exemplar catchments. As a national examplar, the Te Hoiere project is a collaboration of many local and national parties.

[6] Note that samples could not be taken during the first flood event.

Improvement of water quality is one of the outcomes sought from this collaborative approach. It is likely that recreational water quality at Totara Flat will return to be graded as Fair. However, a successful Te Hoiere project could lead to further improvements. The recreational water quality at the Pelorus Bridge remains the best of all river sites monitored. The site has a SFR Grade of 'Good'.

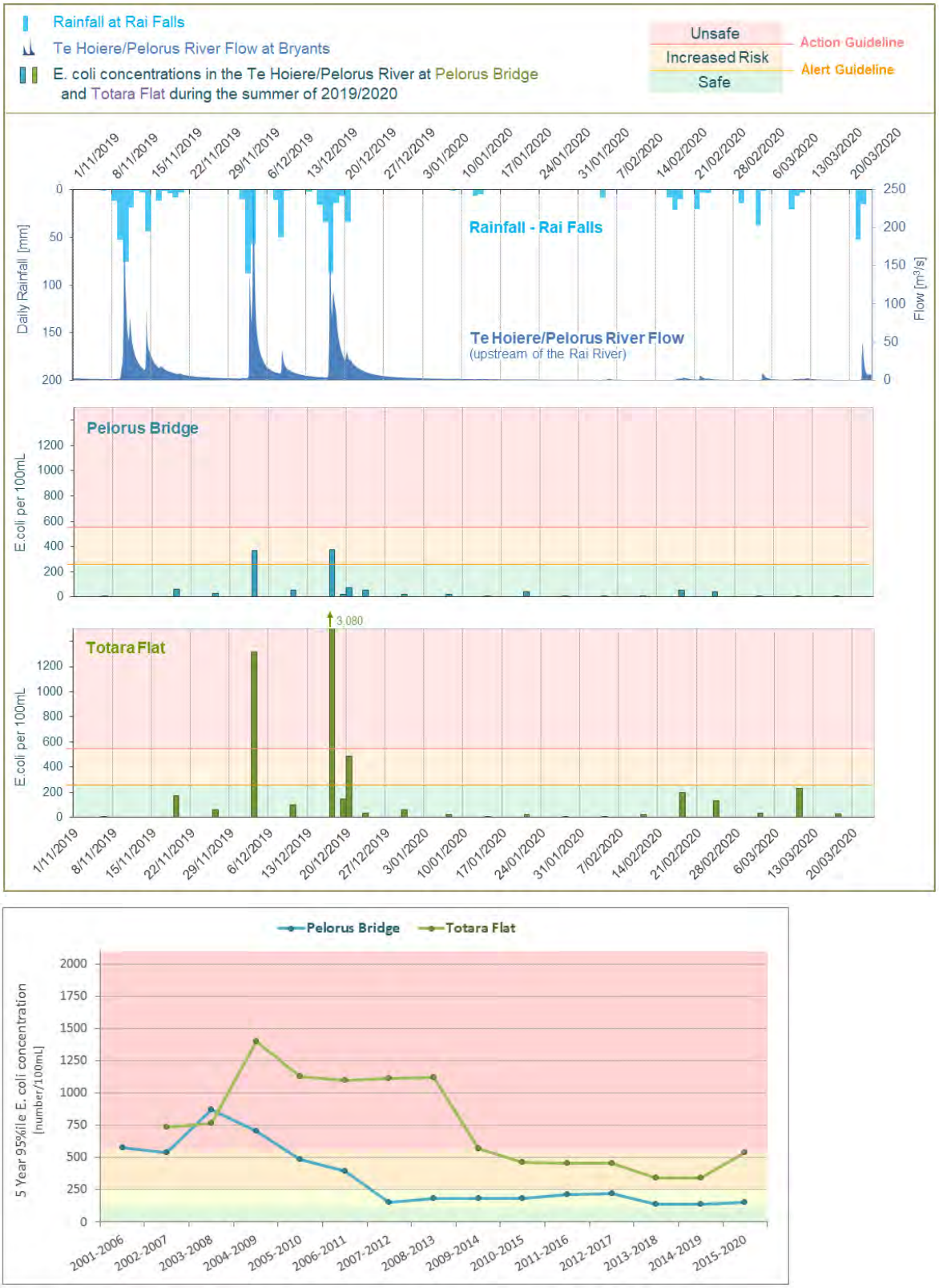


Figure 19: TOP: E. coli concentrations in the Te Hoiere/Pelorus River in the 2019/20 summer. BOTTOM: The 5-year 95%ile E.coli concentrations for the two Te Hoiere/Pelorus River sites.

4.7. Waihopai River

Site

The Waihopai River swimming site 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.

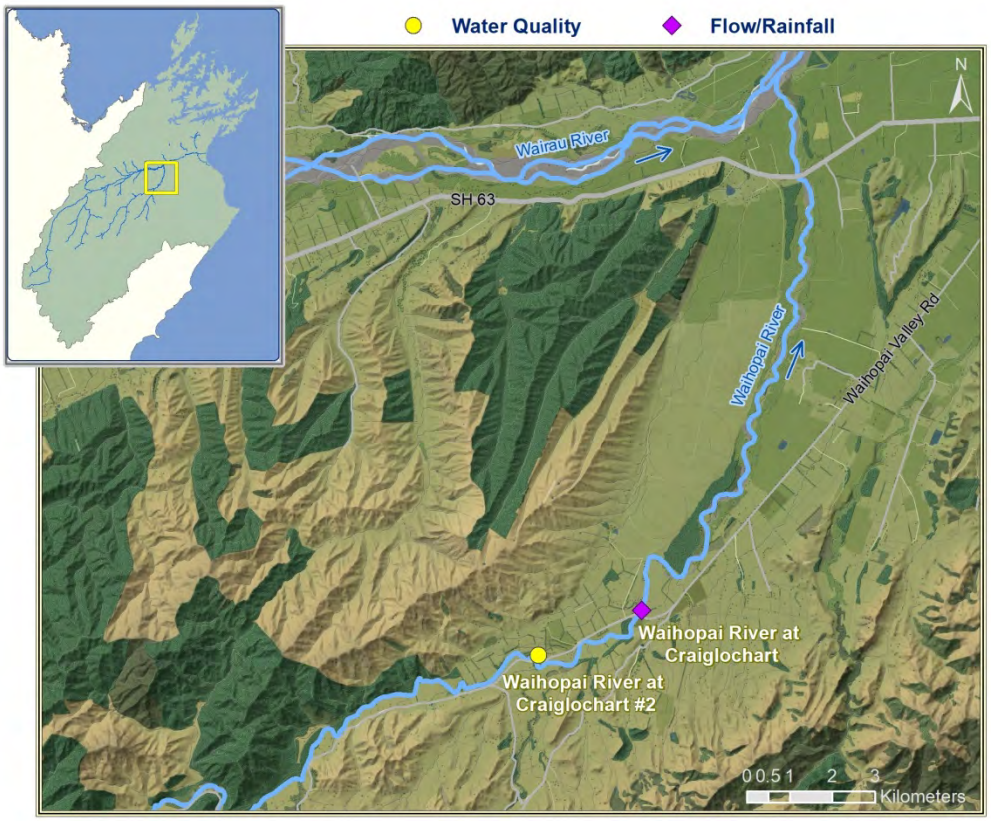


Figure 20: Location of the Waihopai River sampling site and the flow/rainfall recorder.

Results

Two samples with very high E. coli concentrations were taken when the river was in flood. These were the highest E. coli levels on record. Nevertheless, follow-up sampling showed that bacteria concentrations quickly returned to acceptable levels.

Analysis of the data suggests two distinct sources of high E. coli concentrations in the Waihopai River (Figure 21). One of these causes very high bacteria concentrations at comparatively low flows. Further analysis indicates that this might represent the first flush, which is the initial run-off in the early parts of a rainfall event. However, there is insufficient data to fully support this conclusion.

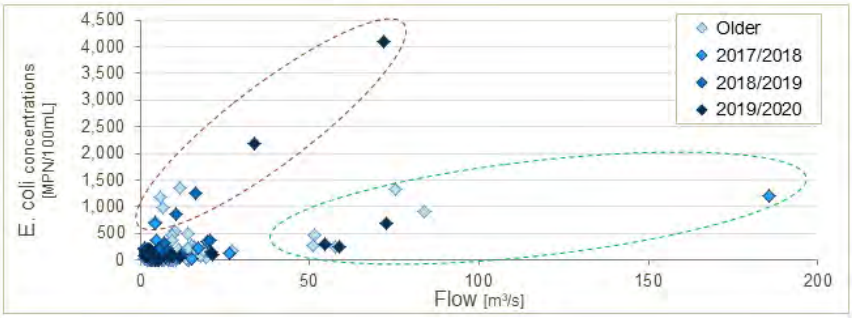


Figure 21: Relationship between E. coli concentration and flow at the Waihopai swimming site.

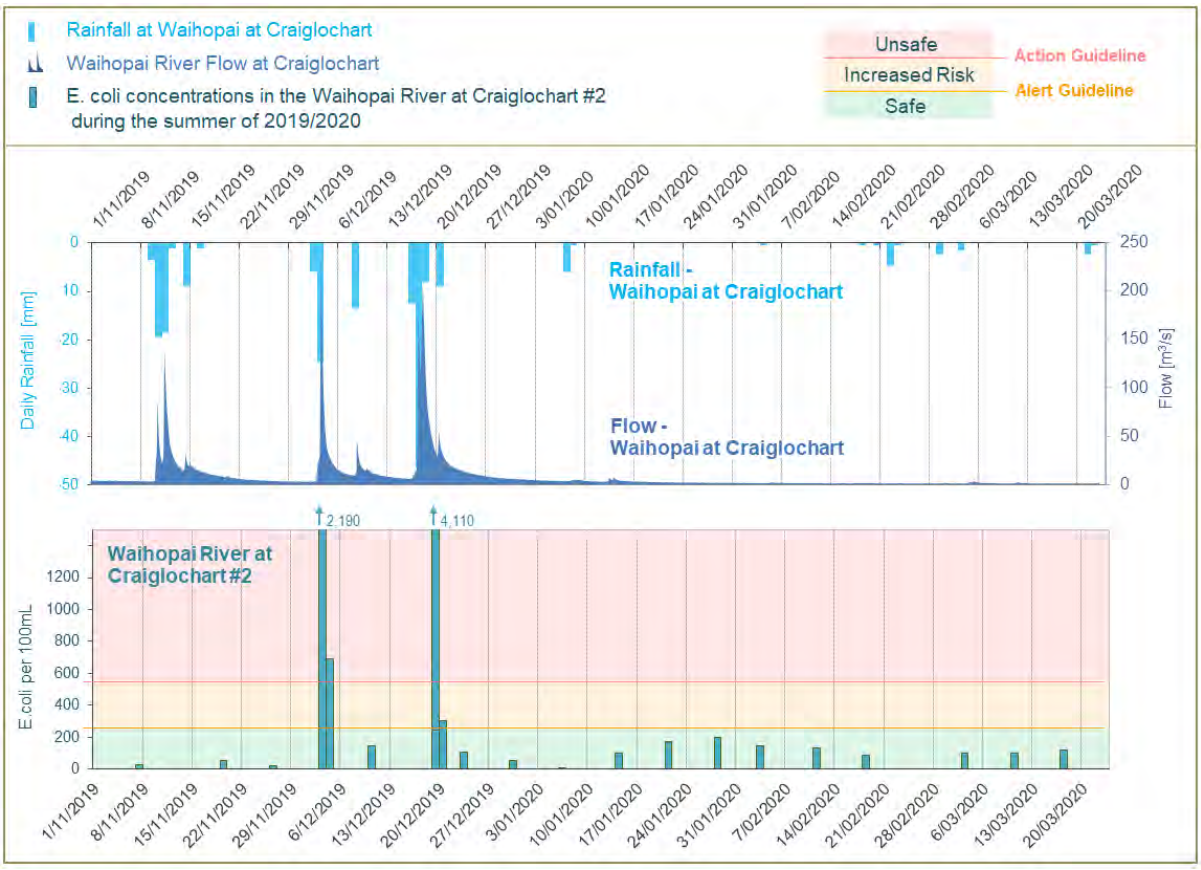


Figure 22: E. coli concentrations in the Waihopai River at Craiglochart #2 during the 2019/20 summer season.

Additional samples for genetic source tracking were taken during one of these events. This will provide valuable insight into the sources of faecal contamination. In particular, it will show if private sewage systems are a contributor. In previous seasons, high bacteria levels were observed following relatively small rainfall events. This was not the case this summer.

The two samples with high E. coli concentrations taken this summer have resulted in an increasing long-term trend. However, the trendline remains below higher levels observed between 2014 and 2017. The SFR Grading is, as yet unaffected and the site remains graded as Fair.

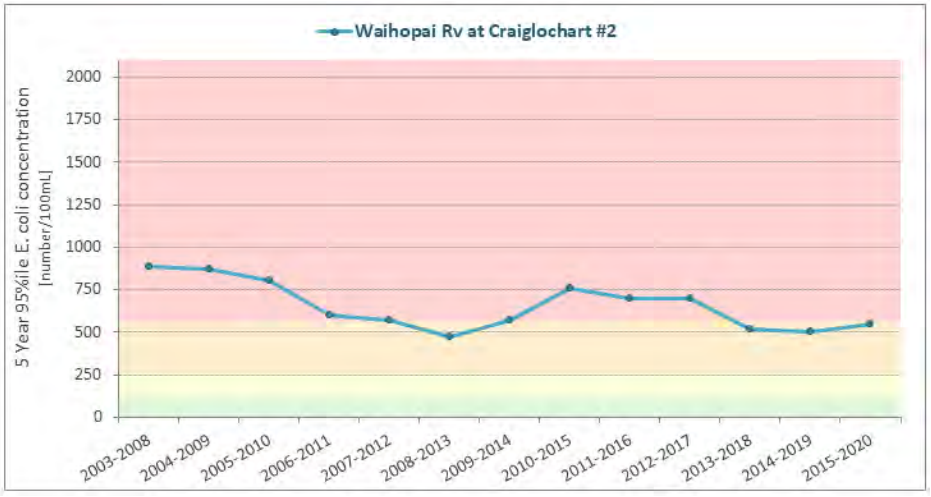


Figure 23: The 5-year 95%ile E.coli concentrations for the Waihopai River at Craiglochart #2.

Wairau River

Sites

There are two sites located along the Wairau River that are sampled as part of the Recreational Water Quality programme, Ferry Bridge and Blenheim Rowing Club. These sites have been part of the programme for some time. They are located on the lower reach 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, 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 24: Location of the two Wairau River sampling sites and the Wairau River flow recorder.

Results

Samples taken from the Wairau River this summer had comparatively low E. coli concentrations. The only sample with E. coli above the Action Guideline was taken from the Blenheim Rowing Club during higher flows (Figure 25).

The long-term trends show that recreational water quality at the Ferry Bridge remained unchanged, but has been more variable at the Blenheim Rowing Club. For several years, faecal bacteria levels were lower at the Blenheim Rowing Club. In recent years, however, E. coli concentrations have slowly increased. The start of the increase coincides with the Seddon Earthquake in 2013. There was noticeable damage to the land along the river at the time. It is possible that there was also damage to nearby private sewage treatment systems. Sources from all parts of the catchment that receive rainfall contribute to the bacterial load during high flows. It is therefore difficult to distinguish local sources of faecal contamination. Nevertheless, should E. coli concentrations at the Blenheim Rowing Club further increase, an investigation into local sources needs to be initiated. Both sites now have a SFR Grade of Fair.

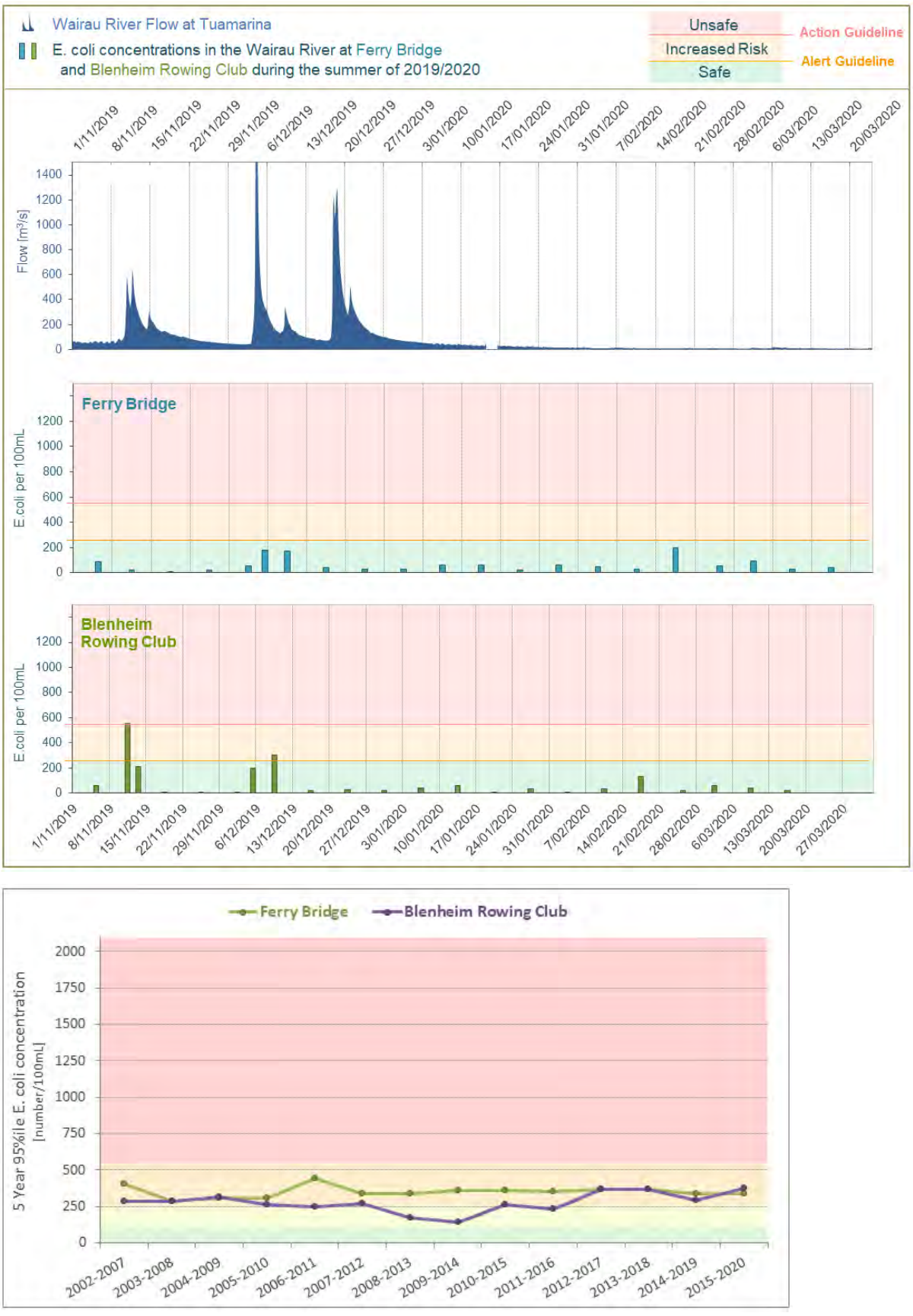


Figure 25: TOP: E. coli concentrations in the Wairau River at Ferry Bridge and the Blenheim Rowing Club during the 2019/20 summer; BOTTOM: The 5-year 95%ile E.coli concentrations for the two sites.

4.8. 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 E. coli concentrations at the monitoring site. The immediate urban environment has a much greater influence on recreational water quality.

Figure 26: Location of the Taylor River sampling site as well as the Blenheim MDC rainfall recorder.

Results

The highest E. coli concentrations in the Taylor River were observed during rainfall. However, concentrations were frequently also elevated during dry periods (Figure 27). Throughout the summer permanent warnings have advised the public to not swim at the site. The signs have been in place for the last two summer seasons. Investigations had shown that aging and earthquake damage to sewerage infrastructure is affecting water quality. A number of pipes near the monitoring sites have already been repaired. Repair on one of the major breaks still affecting river water quality was scheduled to begin in March. Unfortunately this work had to be put on hold due to the COVID-19 lockdown measures. Investigations during previous seasons revealed that the area of poor water quality was restricted to the lowest parts of the Taylor River. River reaches further upstream had generally lower E. coli concentrations. Bacteria concentrations were also low at the Henry Street Bridge where students are often seen jumping into the river. The Assets and Services department has continued monitoring a number of sites along the river throughout the year. This monitoring allows the team to assess the effectiveness of repair works. It also assists in the identification of further breaks. In March, this monitoring showed unusually high E. coli concentrations in the Taylor River downstream of Murphys Creek. Temporary warning signs were erected at bridges along the river. Additional sampling of Murphys Creek revealed that a sewage pumping station was the most likely source. Although a sewage flow path was not found, it is possible that sewage leached through the soil. Once the problem was dealt with, E. coli concentrations quickly returned to low levels. Further sampling showed that E. coli levels remained low and the temporary warning signs were removed.

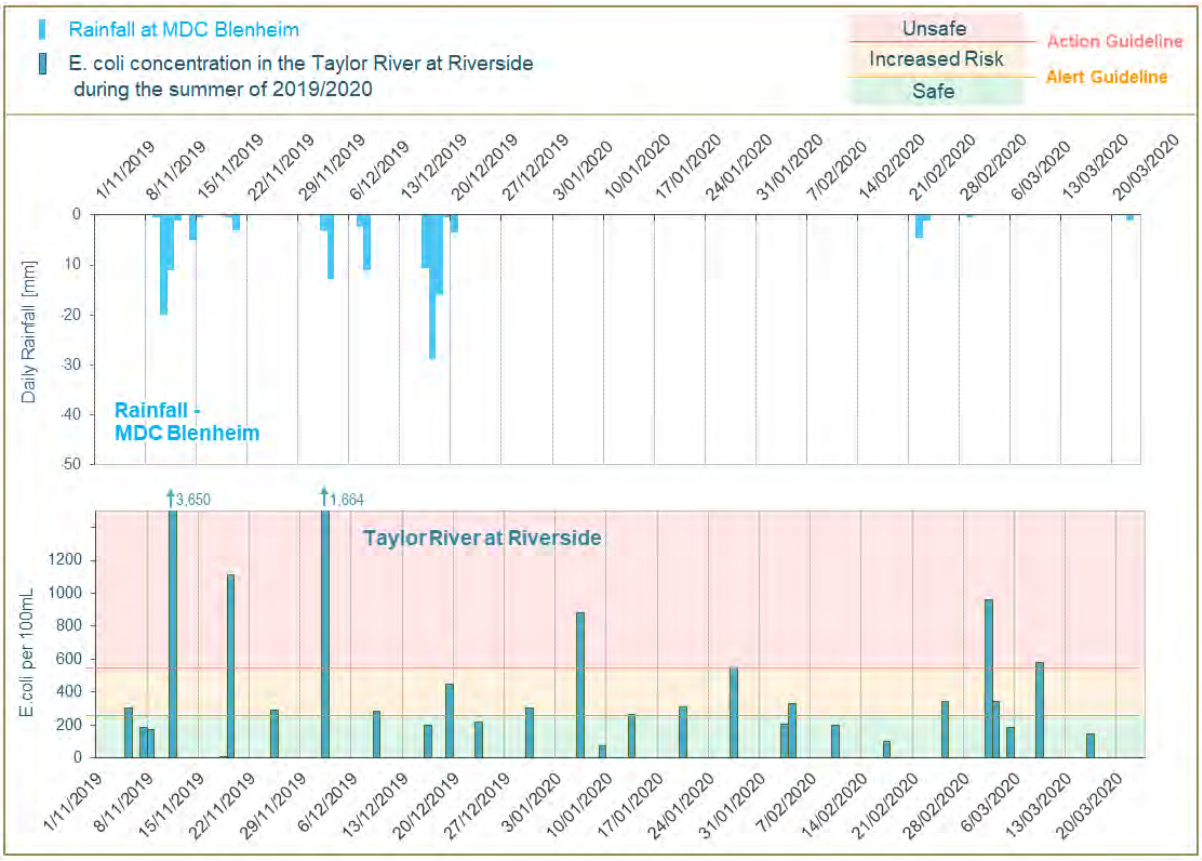


Figure 27: E. coli concentrations in the Taylor River at Riverside during the 2019/20 summer season.

The SFR Grade for the Taylor River at Riverside remains at Very Poor. However, improvements should be noticeable once repairs of the sewerage infrastructure are complete.

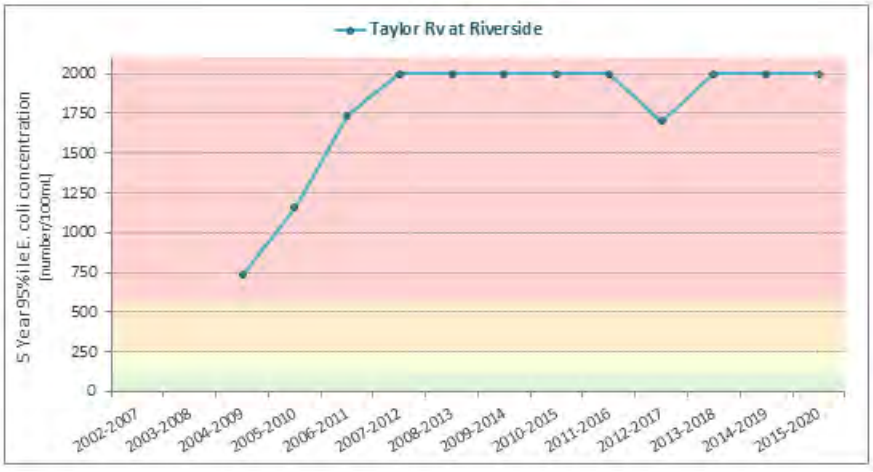


Figure 28: The 5-year 95%ile E.coli concentrations in the Taylor River at Riverside.

4.9. Ohinemahuta River at Onamalutu Domain

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.

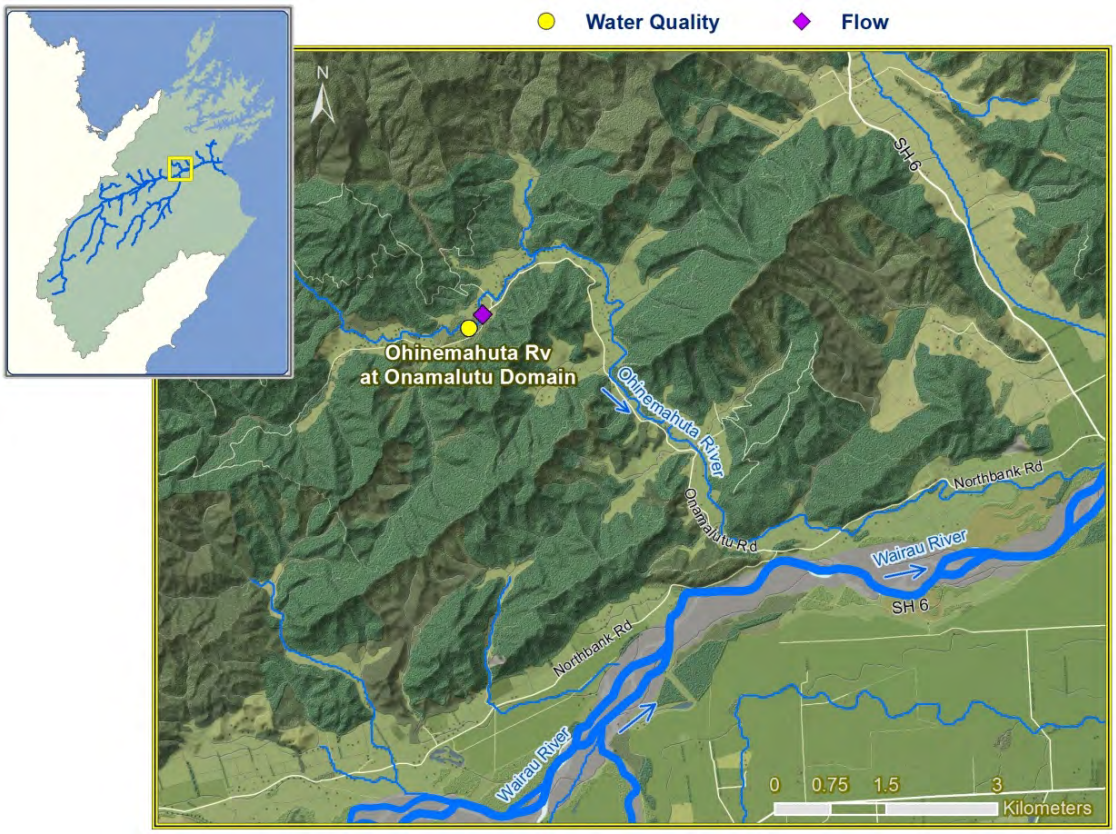


Figure 29: Location of the Ohinemahuta River water quality and flow sites.

Results

Elevated E. coli concentrations early in the season were likely caused by rainfall run-off. The only exceedance of the Action guideline this summer, however, occurred during low flows. Following long dry spells, surface flow can disappear completely at this site, leaving the river bed dry. This was not observed this summer, but the sampling stopped in the middle of a drought period. During low flows, faecal sources that are usually comparatively minor, can have a significant effect. Consequently, there are a number of possible sources for the guideline exceedance observed this summer. These include local sources such as wildlife or feral animals, but also livestock upstream of the sampling site. E. coli concentrations in follow-up samples were low and the sources could not be investigated further. As the site was only recently added to the monitoring programme, we do not yet have sufficient data to calculate a SFR Grade. Due to the tendency of the river to dry up at the site, there will be occasional gaps in the data. This means that even after the sites has been monitored for five year, only an interim grade can be assigned. Based on the information we have thus far, the site will likely be graded as Fair.

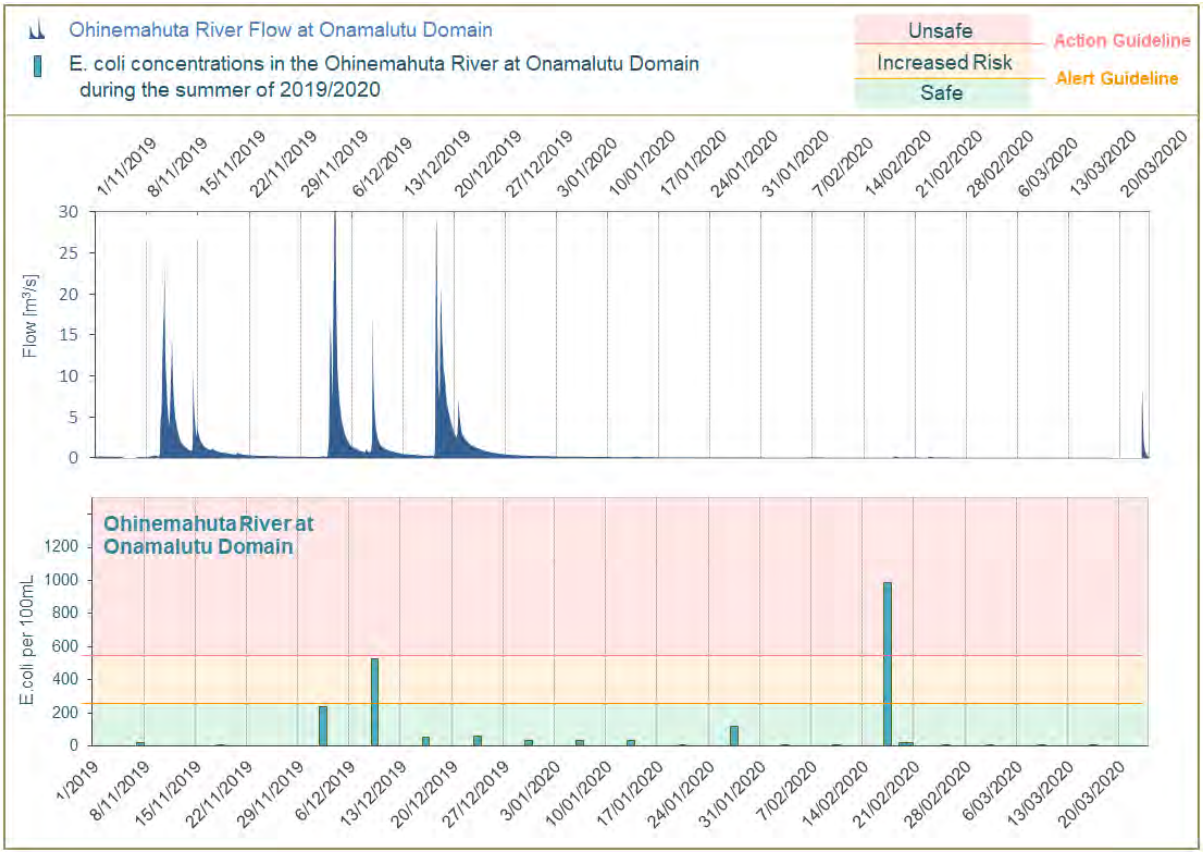


Figure 30: E. coli concentrations and flow of the Ohinemahuta River at the Onamalutu Domain during the 2019/20 summer season.

Figure 31: Cooling off in the Ohinemahuta River.

4.10. 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 range from A, which represent best water quality to D/E, which is referred to as the 'National Bottom Line'. Water quality within the D or E band is considered unacceptable and measures need to be taken to improve it. 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 4).

There is a close relationship with the guidelines for the assessment of recreational water quality. Although, the NPS-FM only applies to river sites, the same statistics could be applied to assess coastal sites by modifying the limits using the guideline values for Enterococci concentrations[7]. The grey values in Table 4 were derived using this method.

Attribube State (Band)	I Percentage of samples above 540 E.coli/100mL (280 Enterococci/100mL)	II Percentage of samples above 260 E.coli/100mL (140 Enterococci/100mL)	III Median [E. coli/100mL] [Enterococci/100mL]	IV 95th Percentile [E. coli/100mL] [Enterococci/100mL]	**Narrative Attribute State** (Description of risk of Campylobacter infection based on E. coli/Enterococci indicator)
A (Blue)	< 5%	< 20%	≤ 130 ≤ 67	≤ 540 ≤ 280	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 ≤ 67	≤ 1000 ≤ 520	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 ≤ 67	≤ 1200 ≤ 620	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 > 67	> 1200 > 620	20-30% of the time the estimated risk is ≥50 in 1000 (>5% risk). The predicted average infection risk is >3%.
E (Red)	> 30%	> 50%	> 260 > 135	> 1200 > 620	For more than 30% of the time the estimated risk is ≥50 in 1000 (>5% risk). The predicted average infection risk is >7%.

Table 4: E. coli bands as defined by the NPS-FM 2017. Additional values used for this report to apply a similar approach to coastal results are shown in purple and are not part of the NPS-FM.

A minimum of 60 samples collected regularly over a maximum of five years are required for the calculation of the NPS-FM attribute state. Using the data from the recreational water quality programme, a period over three summer seasons will provide sufficient data. However, for better comparison, data over a period of five years is used. This ensures that NPS-FM state and SFR Grades are assigned using the same dataset.

Table 5 shows a comparison of the SFR Grades and the NPS-FM state bands for the sites currently sampled as part of the Recreational Water Quality programme.

Overall, the NPS grading is more lenient, placing most sites into the A and B bands, which represents very good or good water quality. In contrast, the SFR-Grading assigns the best grade of 'Very Good' to one site only. Most other sites have a SFR Grade in the mid-range, represented by 'Fair' water quality.

[7] For statistics I and II, the E. coli exceedance levels were replaced with the Enterococci exceedance levels from the national recreational water quality guidelines. The limits for statistics III and IV are simple ratios of the E. coli and Enterococci guideline values for recreational water quality.

For coastal beaches, the NPS-FM state and SFR Grades are in agreement for four sites, two in the top range as well as the two sites with the lowest states/grades. The assessment varies somewhat for site in the mid-range.

	Site	SFR Grade	2017 NPS-FM*				
			Overall	I	II	III	IV
River Sites	Pelorus Rv at Pelorus Bridge	Good	A	A	A	A-C	A
	Wairau Rv at Ferry Bridge	Fair	A	A	A	A-C	A
	Wairau Rv at Blenheim Rowing Club	Fair	A	A	A	A-C	A
	Waihopai Rv at Craighlochart #2	Fair	B	B	A	A-C	B
	Pelorus Rv at Totara Flat	Poor	B	B	A	A-C	B
	Taylor Rv at Riverside	Very Poor	E	D	E	D	E
Coastal Beaches	Pukatea/Whites Bay	Very Good	A	A	A	A-C	A
	Anakiwa	Good	B	B	A	A-C	A
	Mistletoe Bay	Good	A	A	A	A-C	A
	Waikawa Bay	Fair	A	A	A	A-C	A
	Governors Bay	Fair	B	B	A	A-C	A
	Ngakuta Bay	Fair	B	B	A	A-C	B
	Momorangi Bay	Fair	B	B	A	A-C	B
	Picton Foreshore	Fair	C	C	A	A-C	B
	Waikutakuta/Robin Hood Bay East	Poor	D	B	A	A-C	D

* Note that the NPS-FM limits strictly apply to river sites only, however, the same statistics can be used to determine a state for coastal sites by adjusting the limits using national guideline values

Table 5: Comparison of SFR Grade and NPS-FM states for the sites monitored as part of the Recreational Water Quality Programme.

There is strong agreement between the methods in regard to water quality in the Taylor River. Both assign the lowest possible state to this site.

5. Summary

Ten river sites and seven coastal beaches were sampled weekly from the beginning of November 2019 until mid-March 2020. The faecal indicator bacteria concentrations in these samples were assessed using MfE/MoH guidelines. These guidelines allow assessment of the health risk to swimmers. Most exceedances of the guidelines observed were associated with rainfall. Particularly in the early part of the summer season, rainfall events caused high bacteria concentrations. The difference in the number of exceedances at the individual sites was partly caused by timing. Not all sites can be monitored on one day. Sampling is usually spread over a period of two or three days. This means, while some sites were sampled during rainfall, sampling at other sites did not coincide with rainfall events. An example are the Te Hoiere and Wairau Rivers. The Te Hoiere River at Pelorus Bridge generally has the best water quality of all river sites monitored. This summer, however, two samples had E. coli concentrations exceeding the guidelines. In comparison, samples taken from the Wairau River at Ferry Bridge consistently had E. coli levels below the guidelines. While the Pelorus Bridge is graded as Good, the Wairau River has a SFR Grade of Fair. In general, the SFR Grades are better indicators of water quality than individual sampling results.

Sampling that coincided with rainfall was also the cause for a comparatively high number of exceedances at Waikawa.

As in previous years, the Picton Foreshore and the Taylor River had the highest number of guideline exceedances. Both sites are located in urban areas. This means greater anthropogenic pressures compared to other sites influence water quality. In Picton, guideline exceedances are generally associated with rainfall. High E. coli concentrations in the Taylor River, however, were also observed during dry weather. Earthquake damage to sewer and stormwater infrastructure are the cause and repairs are ongoing. Warning signs are in place at the affected area of the river. In March, an additional source of faecal contamination was noticed further upstream. Temporary Warning signs were erected and investigative sampling was carried out. The source was found to be a sewer

pumping station. E. coli concentrations have since returned to low levels and temporary warning signs were removed.

Occasional exceedances of the guidelines during dry weather were also observed at other sites. In Governors Bay, Enterococci concentrations regularly increase after the main holiday season. In Waikutakuta/Robin Hood Bay a one-off exceedance was observed during the main holiday season. For both sites, initial investigations were inconclusive and had to be put on hold due to the COVID-19 lockdown measures. The investigations will continue in the following season.

In Ngakuta Bay, recreational water quality was safe for swimming during dry weather. During rainfall, however, Enterococci concentrations were significantly higher than in other bays in the Marlborough Sounds. Ngakuta Bay has a comparatively large number of residential dwellings. These have individual sewage systems, which could be the cause for the high faecal contamination in the bay. Work on identifying and mitigating the source(s) is planned for the next season.

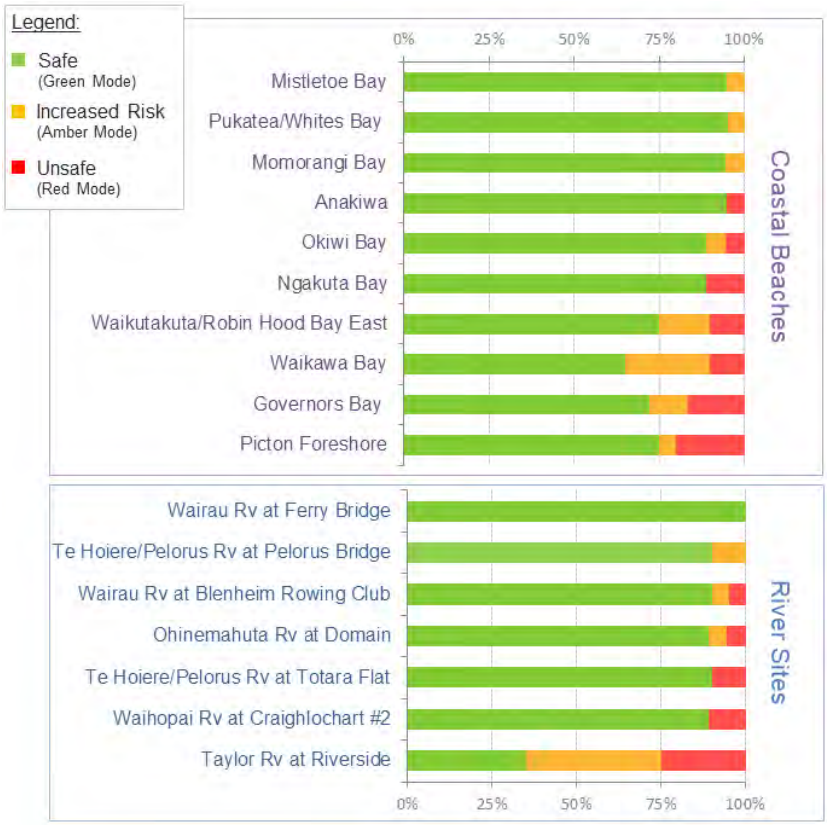
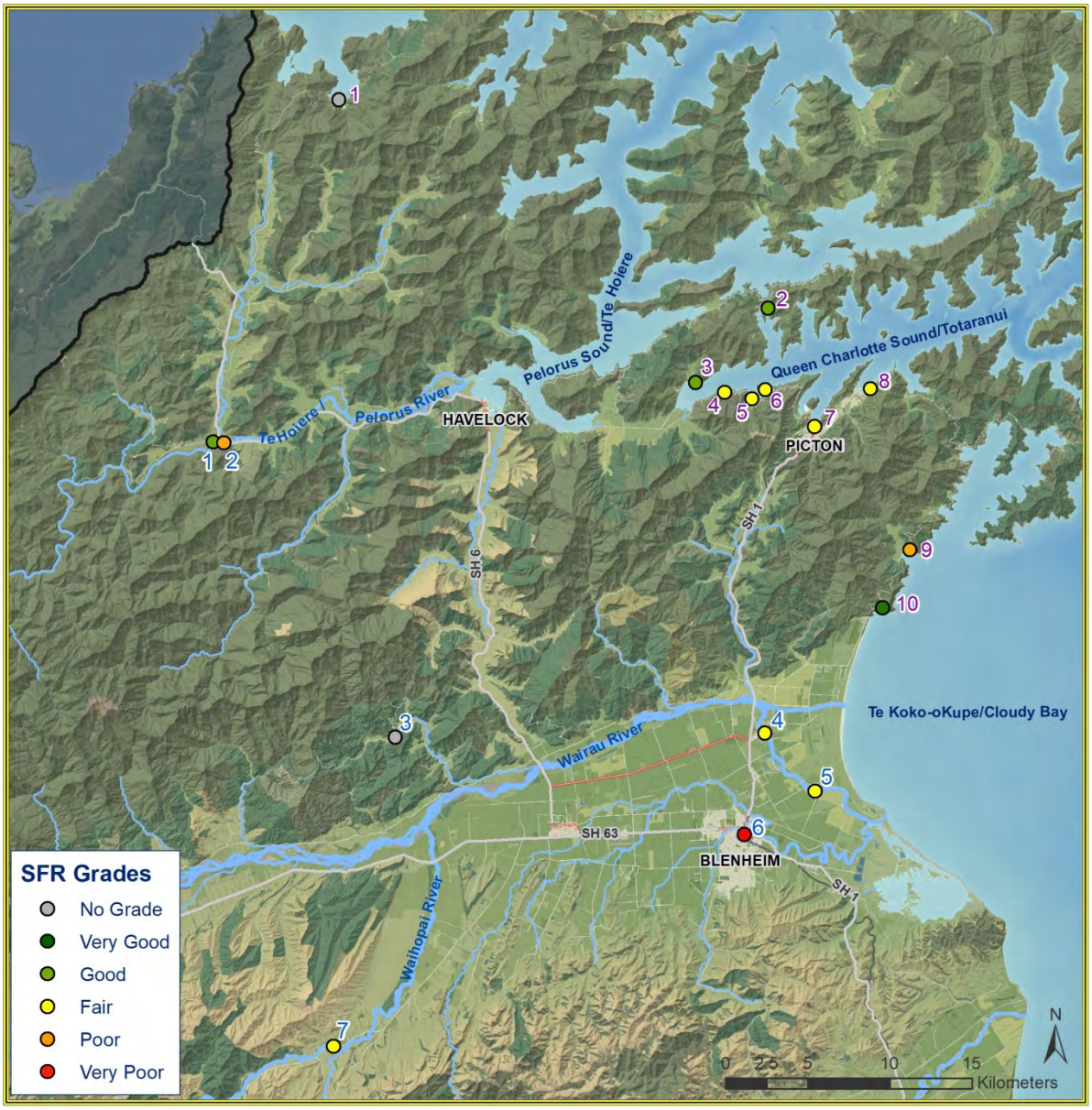


Figure 32: Percentage of routine samples within the different Modes for all sites sample during the 2019/20 summers season.

At a number of sites, samples were taken for genetic analysis. These samples will be analysed for genetic markers that are unique to humans as wells as markers for domestic and feral animals. Unfortunately the results of this analysis are not yet available and could not be included in this report.

For sites that have been monitored for at least five seasons a SFR Grade was calculated. This grade is a valuable indicator for the suitability of water quality for swimming. Due to the natural variability in water quality, individual sampling should not be used to decide whether it is safe to swim. The majority of sites have a SFR Grade of Fair (Figure 33). Fair water quality is defined as: "*Generally satisfactory for swimming. Caution should be taken during periods of high rainfall and swimming avoided if water is discoloured.*" This is a fitting description of what has generally been observed for these sites. Three sites are graded as Poor or Very Poor. Council is working on improving water quality at these sites. Pukatea/Whites Bay and Mistletoe Bay are the beaches with the best recreational water quality. Of the river sites, the Pelorus Bridge has the best water quality with low faecal contamination even at comparatively high flows.



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	B	Good
	3	Anakiwa	1677073	5431495	Moderate	B	Good
	4	Momorangi Bay	1678817	5430879	Moderate	C	Fair
	5	Ngakuta Bay	1680514	5430489	Moderate	C	Fair
	6	Governors Bay	1681310	5431030	Low	C	Fair
	7	Picton Foreshore	1684298	5428815	Moderate	C	Fair
	8	Waikawa Bay	1687695	5431090	Low	C	Fair
	9	Waikutakuta/Robin Hood Bay East	1690115	5421285	Moderate	D	Poor
	10	Pukatea/Whites Bay	1688425	5417793	Very Low	B	Very Good
River Sites	1	Te Hoiere/Pelorus Rv at Pelorus Bridge	1648077	5428091	Low	B	Good
	2	Te Hoiere/Pelorus Rv at Totara Flat	1648262	5427731	Moderate	D	Poor
	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 33: SFR Grades for the sites currently monitored.

6. References

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7. Appendices

Appendix 1: Results for the 2019/2020 summer season

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

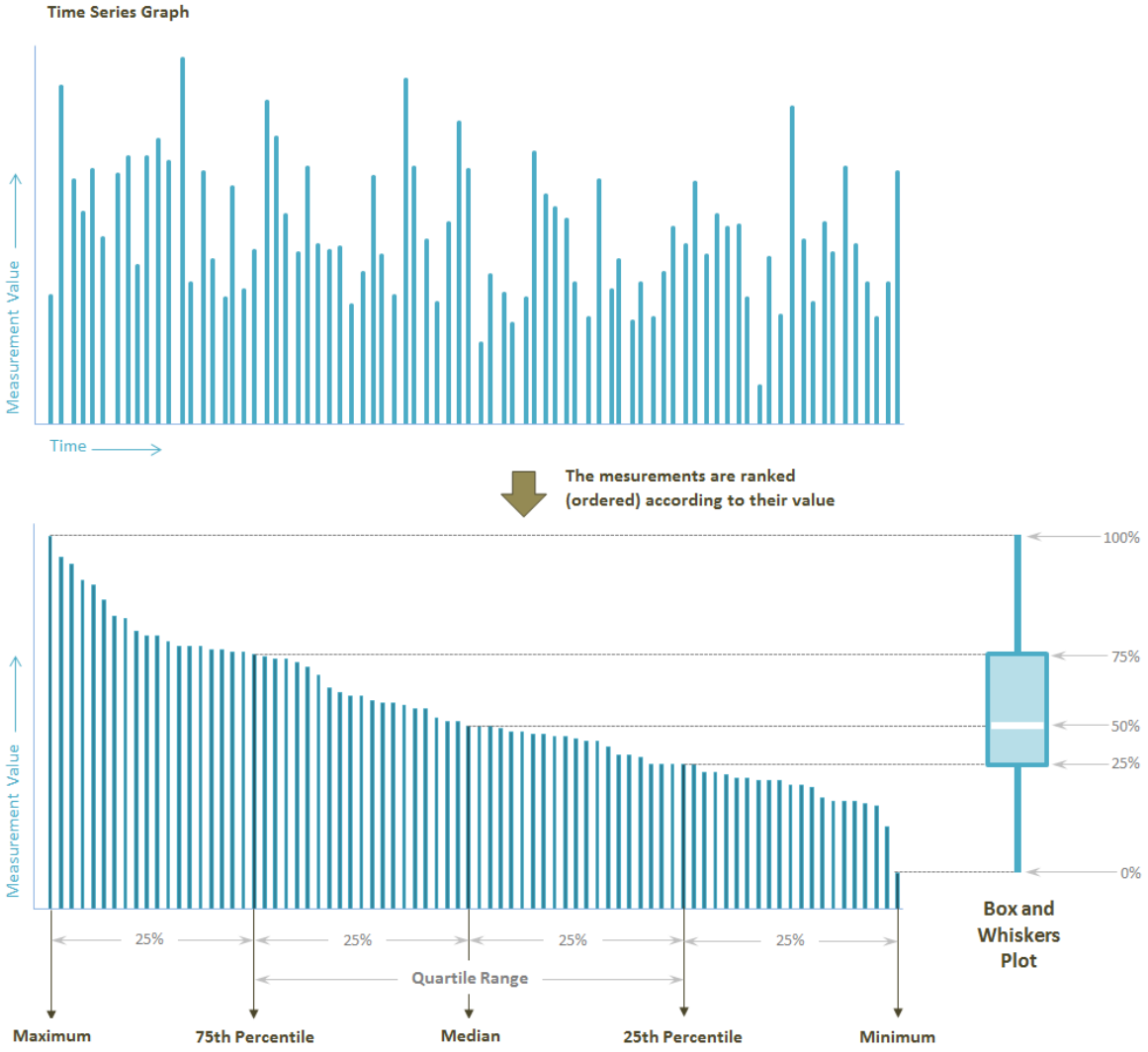
Site Type	Week	Sample Date	Anakiwa	Mistletoe Bay	Momorangi Bay	Ngakuta Bay	Governors Bay	Picton Foreshore	Waikawa Bay	Whites Bay	Robin Hood Bay East	Okiwi Bay
Coastal Beach	1	05/06 Nov 2019	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	2	11/12 Nov 2019	<10	<10	187	1,956	20	670	813	213	6,130	<10
	Follow-up	13 Nov 2019				122		20	<10		10	
	3	18/19/22 Nov 2019	<10	<10	<10	10	<10	31	<10	<10	10	<10
	4	25/26 Nov 2019	<10	<10	<10	10	<10	20	<10	<10	<10	<1
	5	02/03/04 Dec 2019	<10	52	134	52	10	301	<10	<10	<10	150
	Follow-up	04 Dec 2019						86				
	Follow-up	05 Dec 2019						<10				
	6	09/10 Dec 2019	20	10	<10	<10	<10	31	<10	<10	<10	<10
	7	16/17 Dec 2019	10	169	20	1,017		801	379	<10	31	885
	Follow-up	19/20 Dec 2019					<10	85	10			<10
	8	23/24 Dec 2019	<10	<10	<10	<10	<10	10	10	<10	<10	10
	9	30/31 Dec 2019	41	<10	10	10	295	<10	20	20	311	<10
	10	06/07 Jan 2020	<10	<10	10	<10	<10	31	10	<10	40	<10

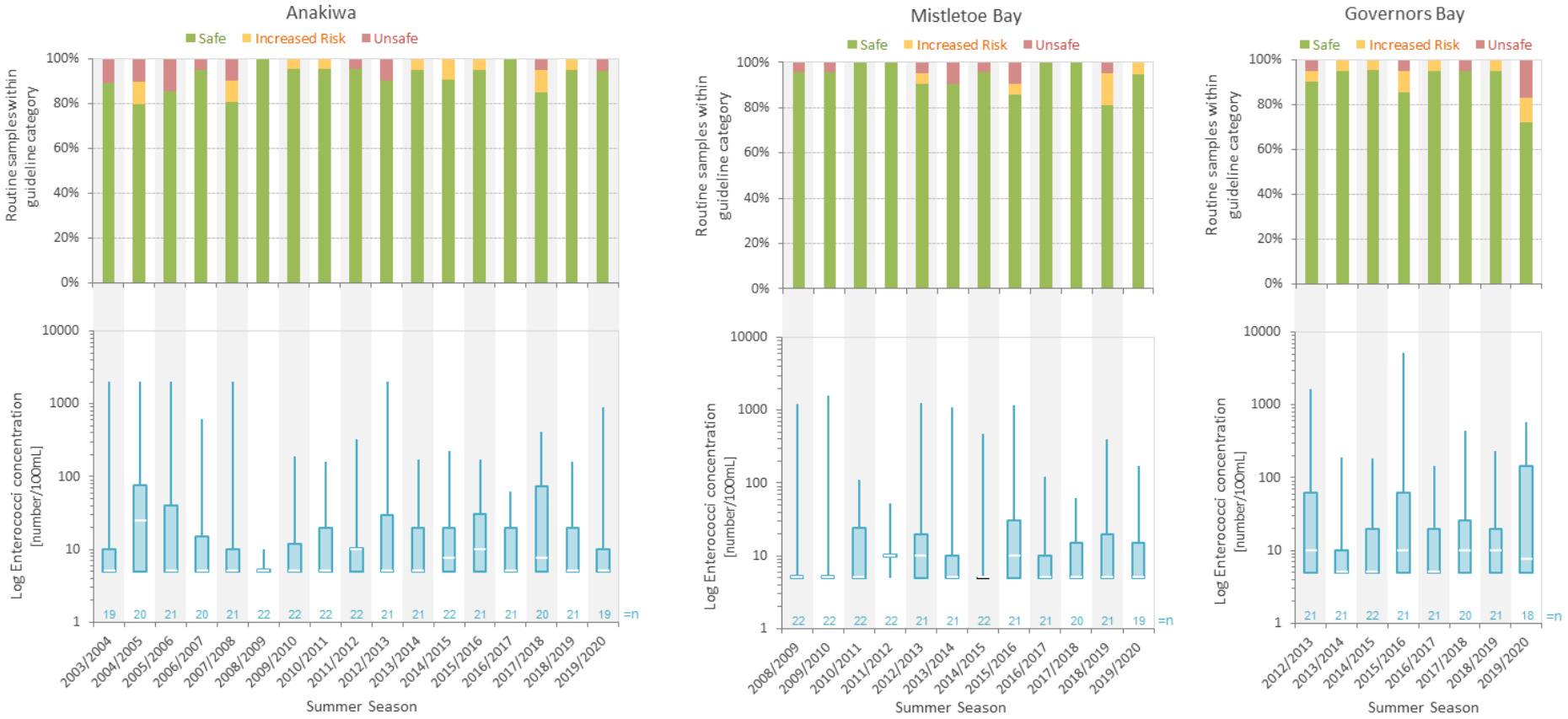
Site Type	Week	Sample Date	Anakiwa	Mistletoe Bay	Momorangi Bay	Ngakuta Bay	Governors Bay	Picton Foreshore	Waikawa Bay	Whites Bay	Robin Hood Bay East	Okiwi Bay
Coastal Beach	11	13/14 Jan 2020	<10	86	<10	<10	<10	<10	262	<10	259	<10
	12	21/22 Jan 2020	31	<10	<10	<10	<10	<10	<10	10	<10	10
	13	27/28 Jan 2020	10	20	20	<10	41	171	173	<10	<10	<10
	14	03/04 Feb 2020	<10	<10	<10	41	10	<10	30	20	<10	10
	15	10/11 Feb 2020	<10	85	41	10	158	10	<10	<10	<10	
	16	17/18 Feb 2020	882	<10	10	20	161	97	<10	<10	<10	99
	Follow-up	20 Feb 2020	<10									
	17	24/25 Feb 2020	<10	<10	<10	<10	295	<10	10	<10	<10	87
	16	02/03 Mar 2020	<10	<10	10	52	98	10	31	10	<10	20
	Follow-up	06 Mar 2020					<10					
	18	09/10 Mar 2020	<10	51	<10	10	578	428	175	<10	<10	99
	Follow-up	11 Mar 2020						20				
	Follow-up	12 Mar 2020					74	<10				
	19	16/17 Mar 2020	10	<10	<10	<10	<10	10	<10	10	<10	<10

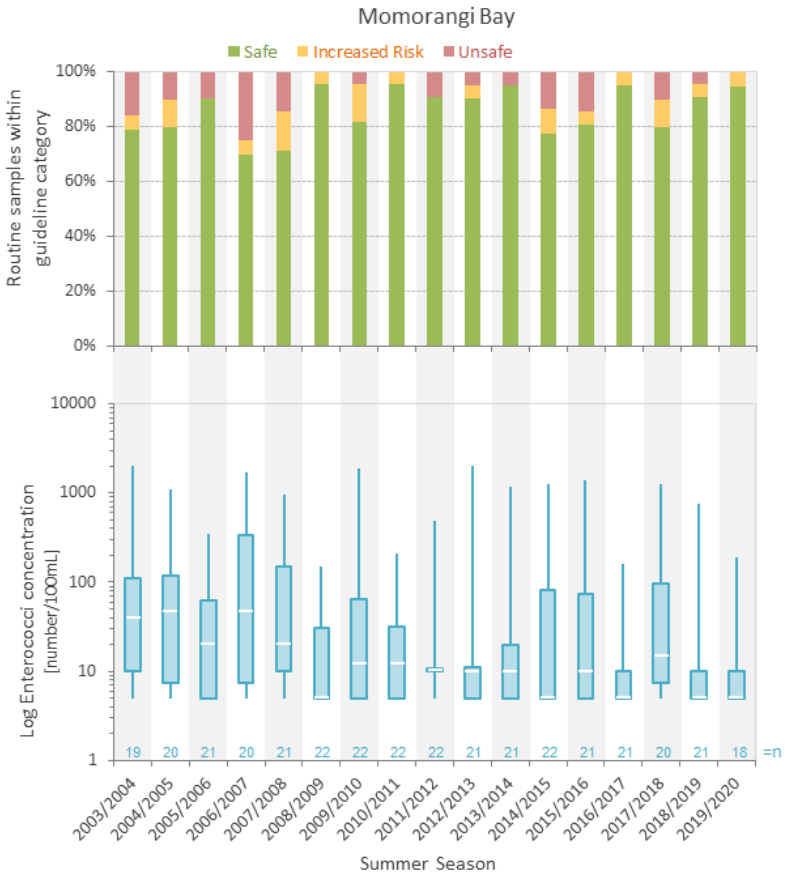
Site Type	Week	Sample Date	Pelorus Rv at Pelorus Bridge	Pelorus Rv at Totara Flat	Waihopai Rv at Craiglochart #2	Ohinemahuta Rv at Onamalutu Domain	Wairau Rv at Ferry Bridge	Wairau Rv at Blenheim Rowing Club	Taylor Rv at Riverside
River	1	05/06/07 Nov 2019	<10	10	30	20	86	63	305
	2	11 Nov 2019					20	556	3,650
	3	18/19 Nov 2019	63	175	52	<10	<10	<10	1,112
	4	25/26 Nov 2019	31	63	20		20	<10	292
	5	02/03 Dec 2019	368	1,314	2,190	240	52	10	1,664
	Follow-up	04/05 Dec 2019			689		178	199	
	6	09/10 Dec 2019	52	97	148	529	173	305	281
	7	16/17 Dec 2019	373	3,080		52	41	20	199
	Follow-up	19 Dec 2019	20	148	4,110				
	Follow-up	20 Dec 2019	74	487	301				
	8	23 Dec 2019	52	31	109	62	31	30	216
	9	30 Dec 2019	20	63	52	31	31	20	301
	10	06/07 Jan 2020	20	20	10	31	63	41	884
	11	13/14 Jan 2020	10	10	98	31	63	63	262
	12	20/21 Jan 2020	41	20	173	10	20	10	313
	13	27/28 Jan 2020	10	10	199	122	63	31	546
	14	03/04 Feb 2020	10	10	146	<10	51	10	203
	15	10/11 Feb 2020	10	20	132	<10	31	31	197
	16	17/18 Feb 2020	52	197	84	988	199	135	98
	Follow-up	19 Feb 2020				20			
	Follow-up	20 Feb 2020				20			
	17	24/25 Feb 2020	41	135		<10	52	20	340
	18	02/03 Mar 2020	<10	31	98	<10	96	63	959
	19	09/10 Mar 2020	10	231	97	<10	31	41	581
	20	16/17 Mar 2020	<10	30	119	<10	41	20	148

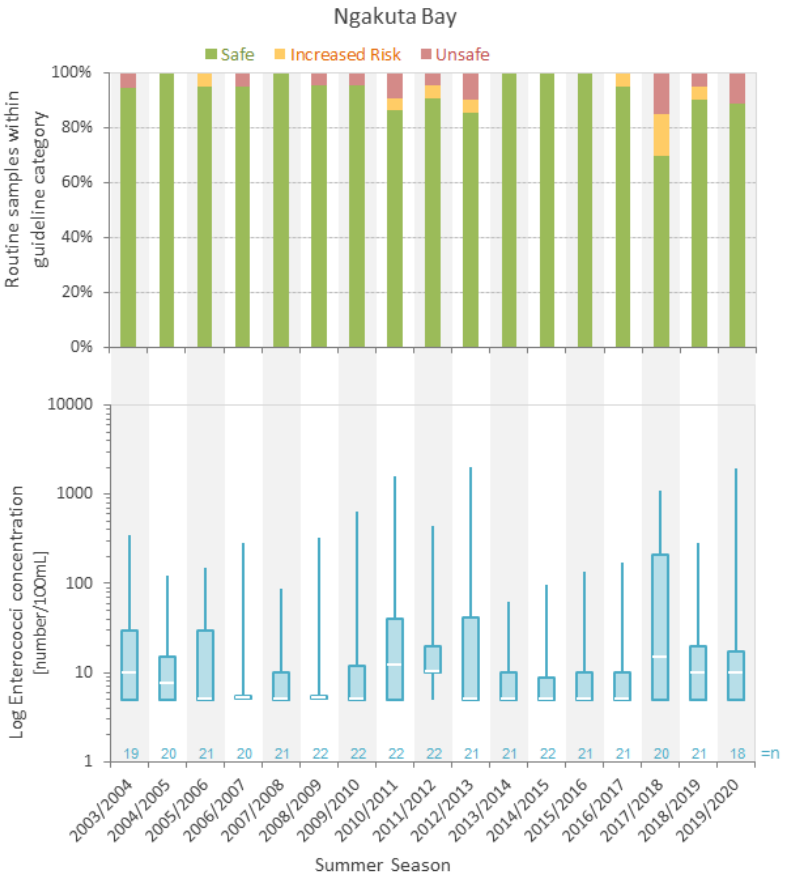
Appendix 2: Percentage of samples within the guideline Modes and Box and Whiskers plots

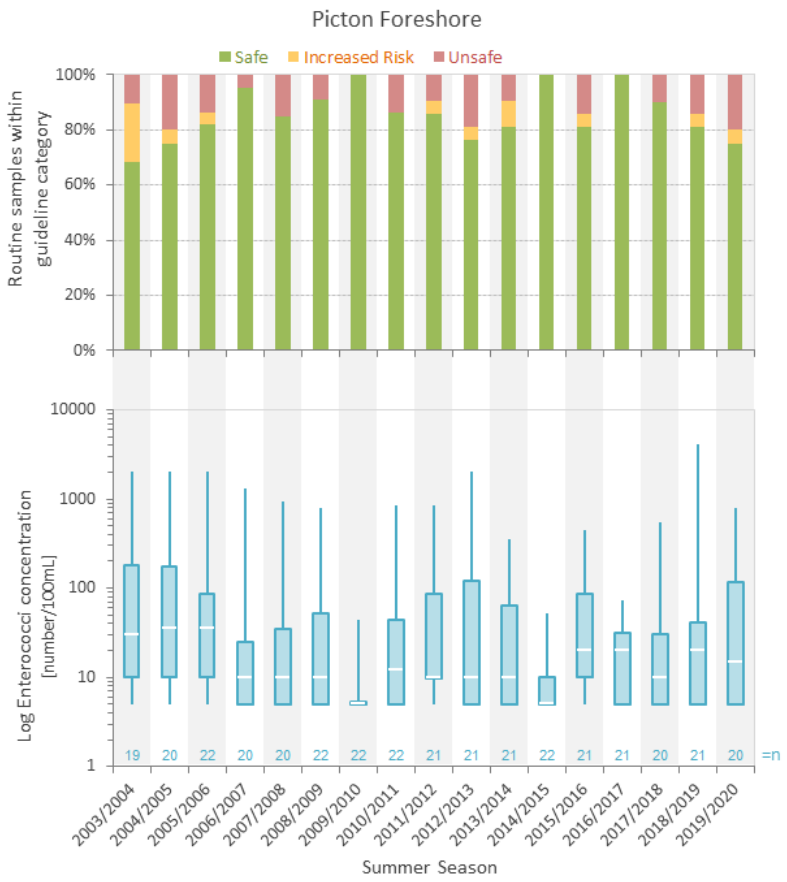
The Plots were created from the results of the routine sampling only. The first figure shows how Box and Whiskers Plots are created. Note that concentrations in the Box and Whiskers Plots for the actual sample results are on a logarithmic scale. The number of samples is shown below the Box and Whiskers Plots.




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
19 20 21 20 21 22 22 22 22 21 21 22 21 21 20 21 19 =n
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
2018/2019
2019/2020
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
22 22 22 22 21 21 22 21 21 20 21 19 =n
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
2019/2020
Summer Season
Governors 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
21 21 22 21 21 20 21 18 =n
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
2019/2020
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
19 20 21 20 21 22 22 22 22 21 21 22 21 21 20 21 18 =n
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
2018/2019
2019/2020
Summer Season


Ngakuta 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
19 20 21 20 21 22 22 22 22 21 21 22 21 21 20 21 18 =n
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
2018/2019
2019/2020
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
19 20 22 20 20 22 22 22 21 21 21 22 21 21 20 21 20 =n
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
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2011/2012
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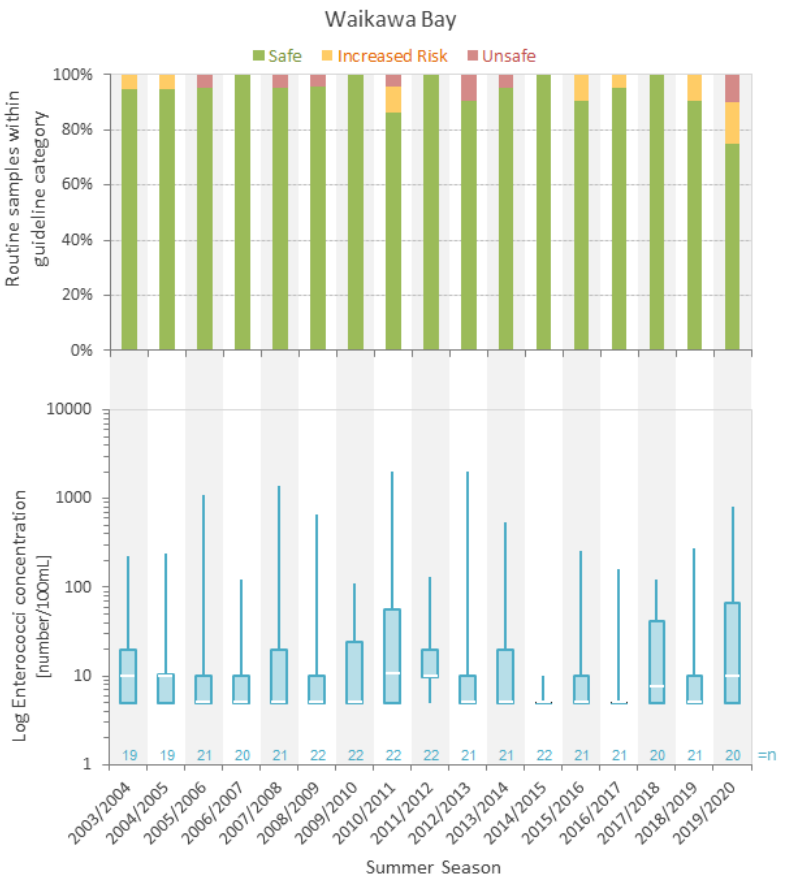
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
2019/2020
Summer Season


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
19 19 21 20 21 22 22 22 22 21 21 22 21 21 20 21 20 =n
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
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2010/2011
2011/2012
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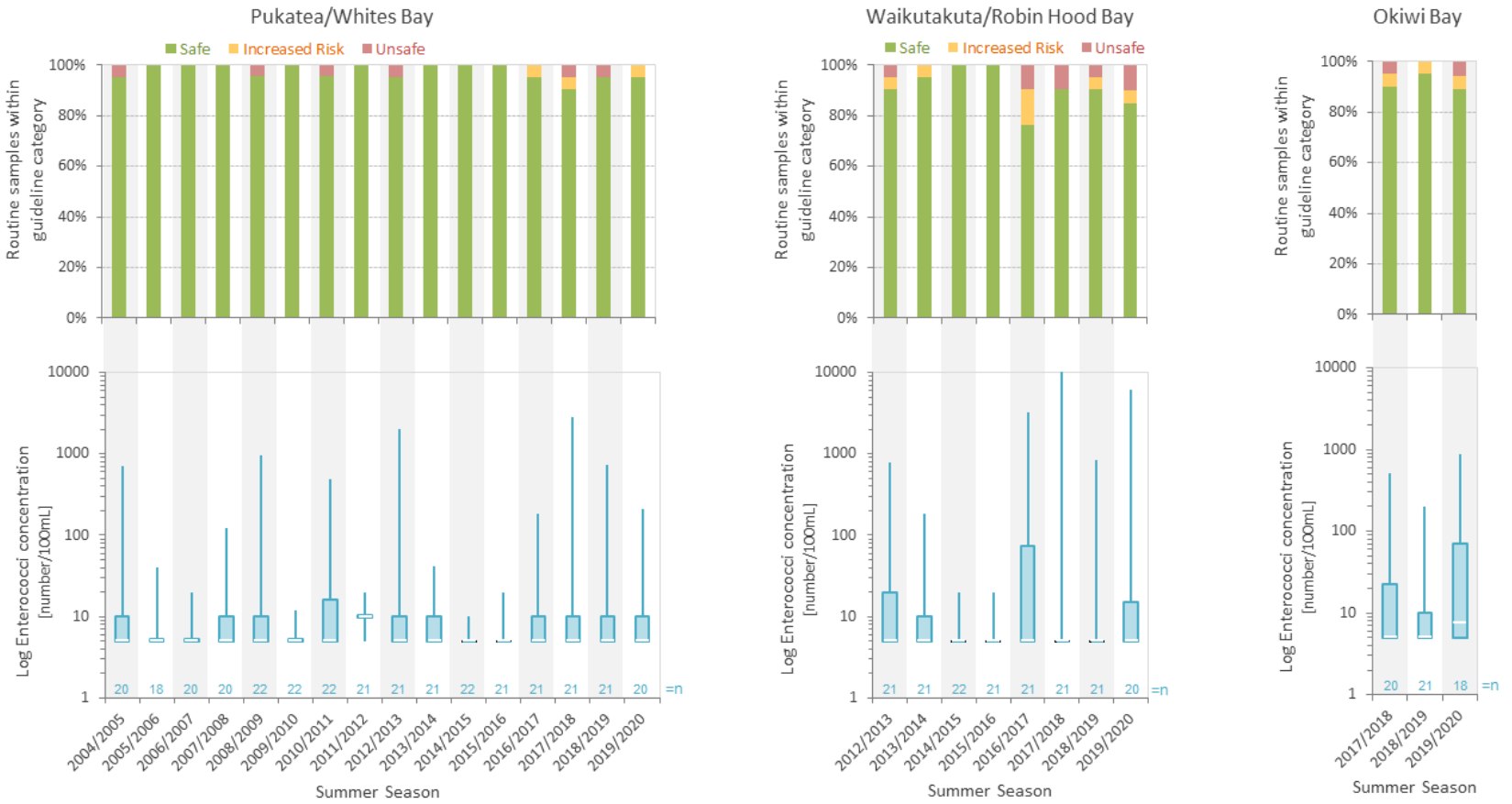
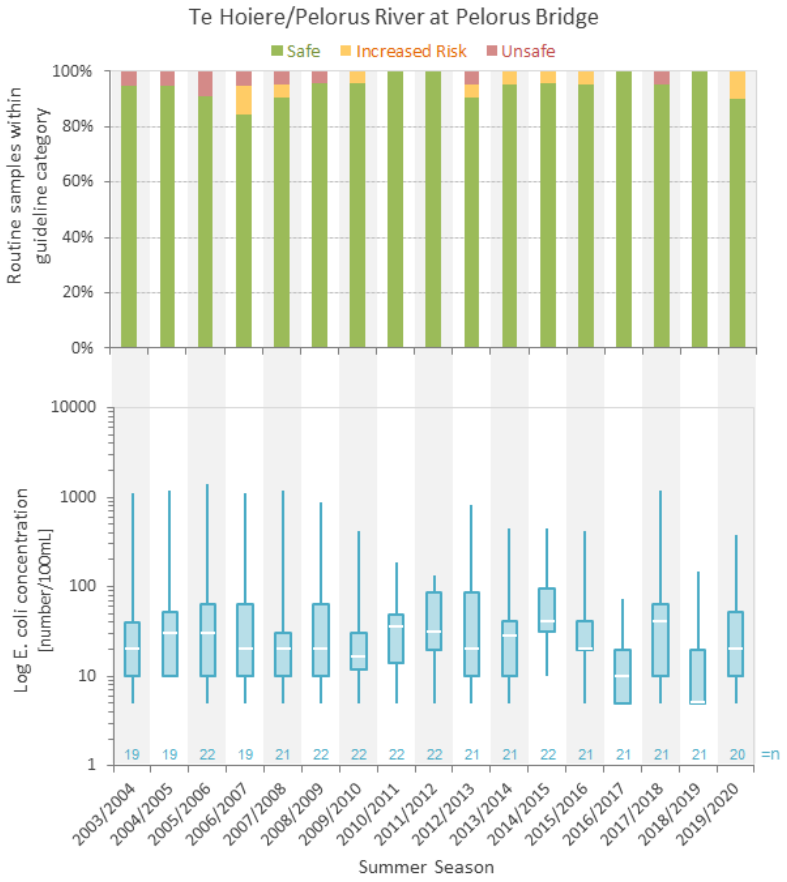
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
2019/2020
Summer Season


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
20 18 20 20 22 22 22 21 21 21 22 21 21 21 21 20 =n
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
2018/2019
2019/2020
Summer Season
Waikutakuta/Robin Hood 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
21 21 22 21 21 21 21 20 =n
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
2019/2020
Summer Season
Okiwi Bay
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
20 21 18 =n
2017/2018
2018/2019
2019/2020
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
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1
19 19 22 19 21 22 22 22 22 21 21 22 21 21 21 21 20 =n
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
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2010/2011
2011/2012
2012/2013
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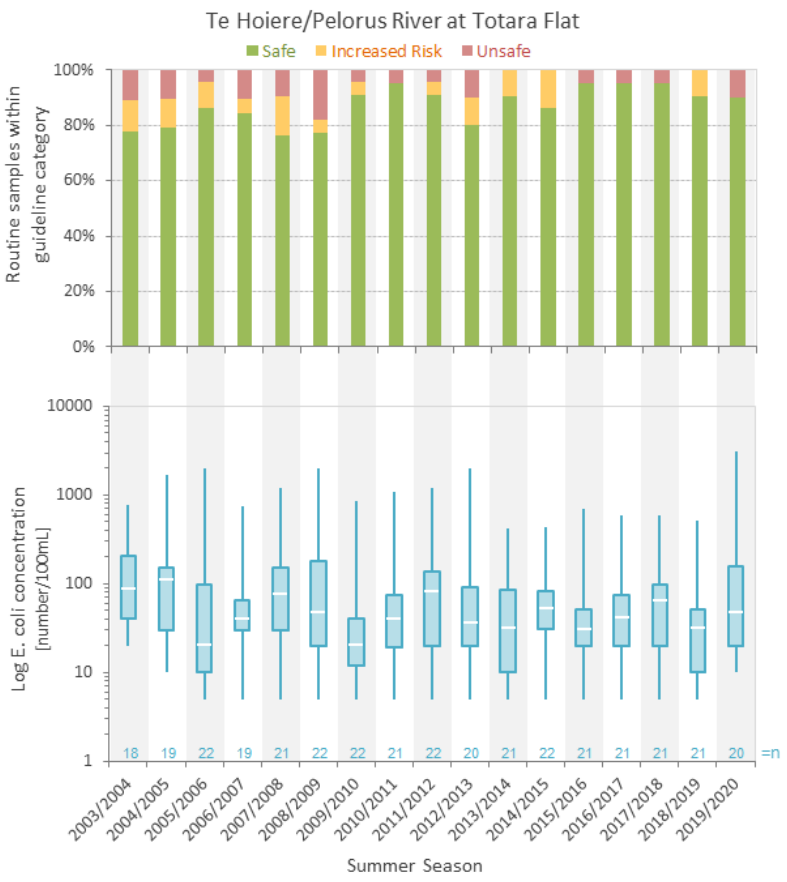
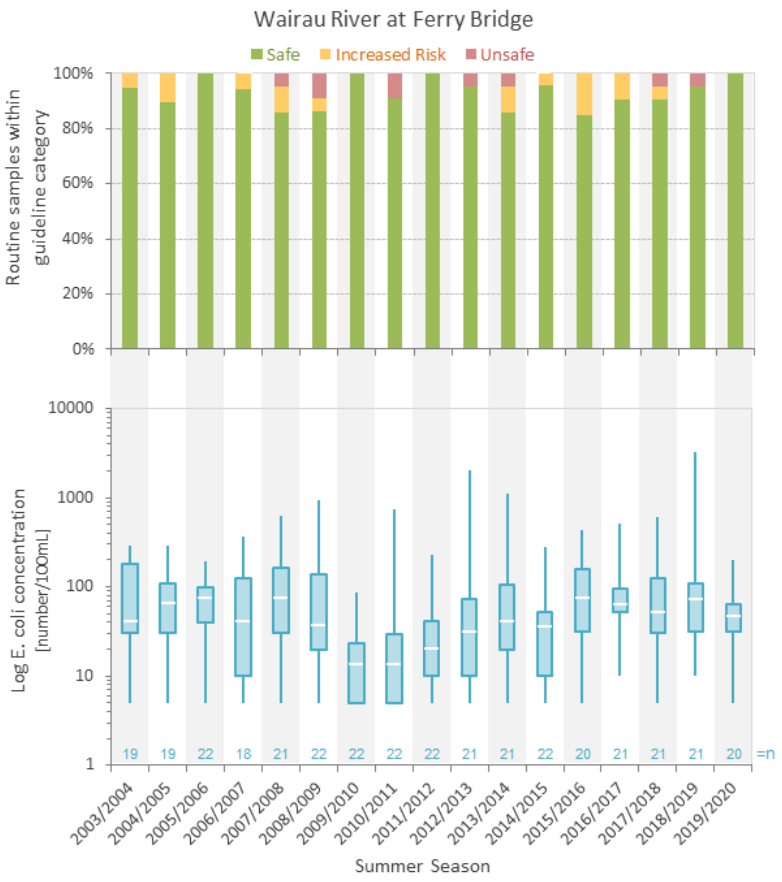
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
2019/2020
Summer Season


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
18 19 22 19 21 22 22 21 22 20 21 22 21 21 21 21 20 =n
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
2018/2019
2019/2020
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
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1
19 19 22 18 21 22 22 22 22 21 21 22 20 21 21 21 20 =n
2003/2004
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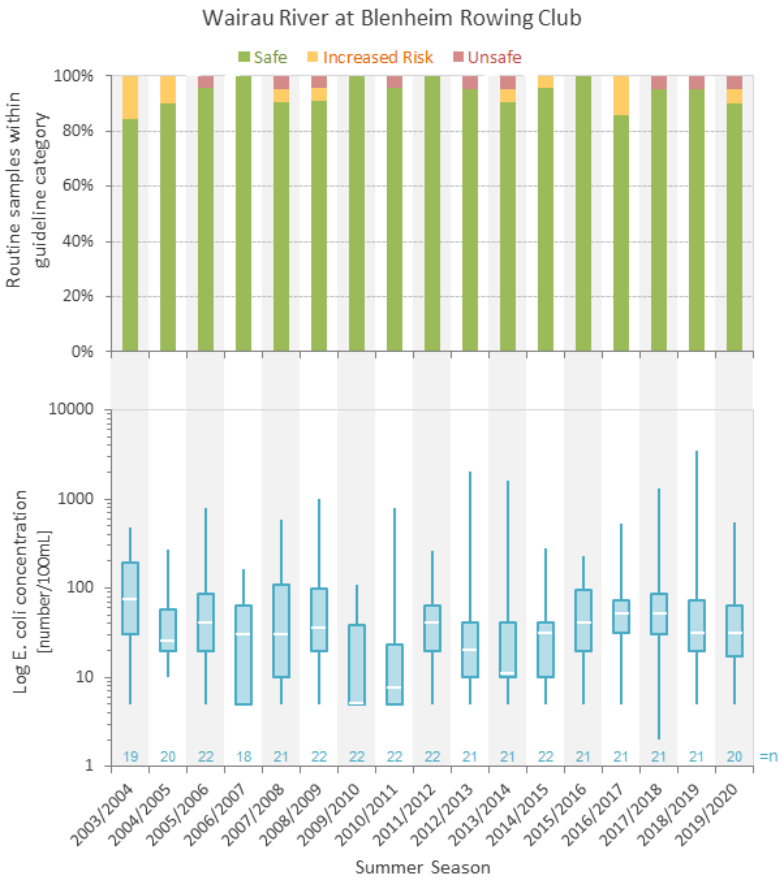
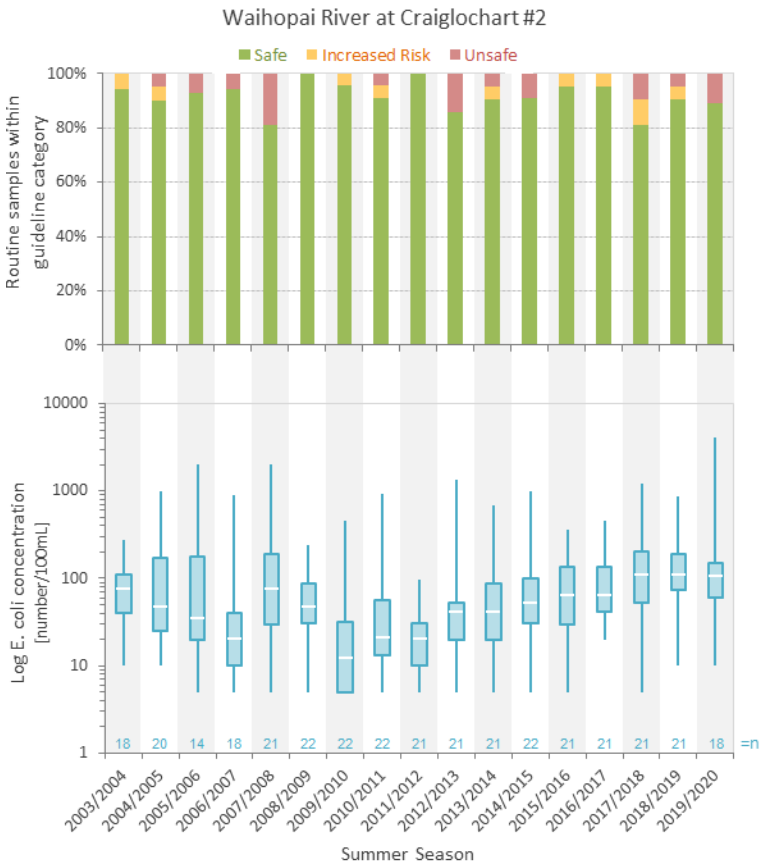
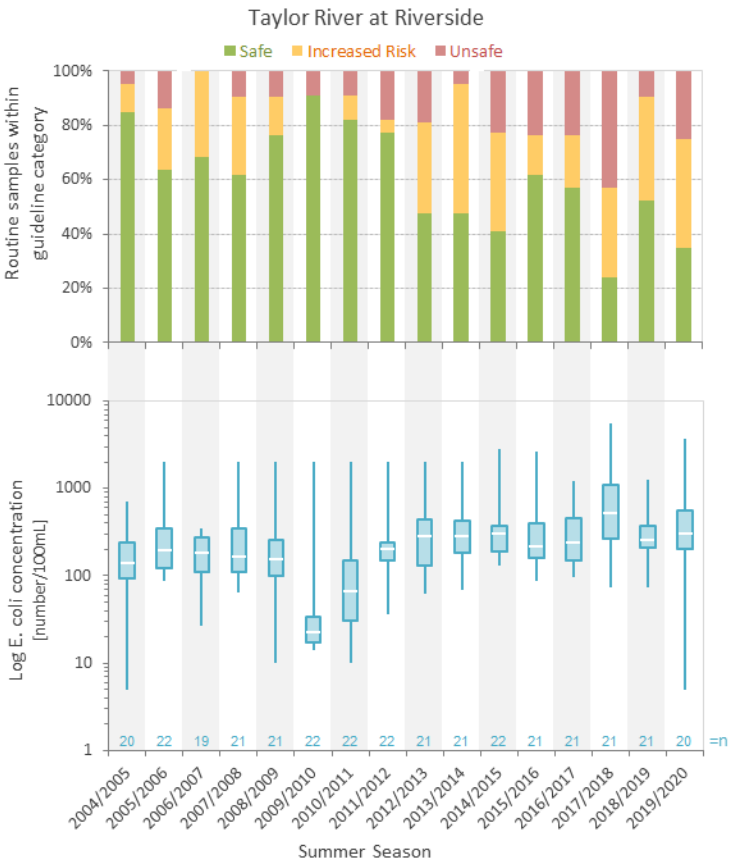
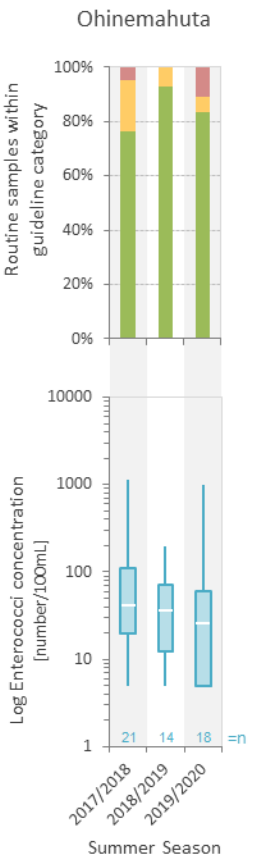
2018/2019
2019/2020
Summer Season


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
19 20 22 18 21 22 22 22 22 21 21 22 21 21 21 21 20 =n
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
2018/2019
2019/2020
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
18 20 14 18 21 22 22 22 21 21 21 22 21 21 21 21 18 =n
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
2018/2019
2019/2020
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
20 22 19 21 21 22 22 22 21 21 22 21 21 21 21 20 =n
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
2018/2019
2019/2020
Summer Season


Ohinemahuta
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
21 14 18 =n
2017/2018
2018/2019
2019/2020
Summer Season

Appendix 3: Management procedure for exceedances of bathing water guidelines