Water Quality Investigations:

Christmas Beach, Green Bay, Foster Bay and Huia Bay, Auckland

Justine L Quinn and Martin W Neale

August 2018 Technical Report TR2018/020

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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Executive summary

Auckland Council has been undertaking investigations into potential sources of contamination at beaches with known microbial water quality issues. Data from the Safeswim programme[1] was reviewed and priority beaches selected for further investigation based on their respective Microbial Assessment Category (MAC) grading. To date, investigations have been undertaken at more than 10 sites.

Within this current investigation, one beach within the northern Waitematā Harbour (Christmas Beach) and three within the northern Manukau Harbour (Green Bay, Foster Bay and Huia Bay) were identified as having a MAC 'D' grading requiring further investigation.

Twenty-three sites across the four catchments were sampled over a total of eight occasions between May and June 2017. Stormwater outfalls and streams were sampled where they were representative of land-based sub catchments contributing flows to the coastal environment.

Microbial Source Tracking (MST) analysis was undertaken on selected samples in addition to standard faecal indicator bacteria (FIB) testing (*E. coli* and enterococci). All samples were compared to Ministry for the Environment recreational contact guidelines (MfE/MoH, 2003).

A total of 164 samples were collected and tested for FIB across the four catchments. The results are summarised in the following table. Nearly 60 per cent of samples collected within the Foster Bay catchment exceeded the red/action trigger level for freshwater recreational contact, making it the most frequently contaminated of the catchments sampled.

Table 1-1 Summarised faecal indicator bacteria results for all sites (number of samples shown, with per cent of total shown in brackets).

Beach	Total no. of samples	Red	Amber	Green
Christmas Beach	48	19 (40)	4 (8)	25 (52)
Green Bay	21	10 (48)	9 (43)	2 (9)
Foster Bay	44	25 (57)	8 (18)	11 (25)
Huia Bay	51	19 (37)	17 (33)	15 (29)
Totals	164	73 (45)	38 (23)	53 (32)

Samples exceeding either red or amber trigger levels (n=111) were further analysed via MST, specifically for human, dog, avian or ruminant host-specific markers using Polymerase Chain Reaction (PCR) analysis. The general faecal bacteria marker was recorded in all but one sample. Host-specific markers were reliably identified in 62 (56 per cent) of samples, including human (n=52), canine (n=14), avian (n=4) and ruminant (n=4). Specific markers were unable to be reliably identified in 49 (44 per cent) of the samples tested. However, of these, 14 (29 per cent) were 'probably a human source' and a further 10 (20 per cent) recorded the BacH marker, indicative of cat, rabbit, possum or a weak human source.

1. The Safeswim programme is designed to provide regular surveillance assessments of microbial water quality at a range of locations in the Auckland region that are used for primary contact recreation (including marine and freshwater sites). See www.safeswim.org.nz

The following conclusions can be drawn from this investigation:

- Strong evidence of faecal contamination from human sources was found at several sites in Foster Bay and Huia Bay and is likely the result of on-site wastewater treatment system failures/maintenance issues. Investigation and remediation of these areas is a priority.
- Faecal indicator bacteria concentrations across all catchments typically increase in response to rainfall, with the catchment size being an important factor in determining the response time.
- A reliable faecal source within Green Bay was not identified however, current evidence points towards a probable human source.
- A consistent faecal source was not identified in the Christmas Beach catchment. However canine markers were the most common and widespread from the point source discharges investigated, with human markers also found in a small number of samples.
- Ruminant markers are not a key contributor of faecal contamination within the semi-rural catchments of Huia Bay and Foster Bay.
- Stormwater network asset information appears to be out of date with several pipes in the Foster Bay catchment not documented in Auckland Council GeoMaps.

To better manage the land-derived faecal contamination of all of these beaches and to address the current public health risk, a range of recommendations are presented, including (but not limited to):

- Further catchment based investigations should be prioritised based on the presence of faecal contamination but also in relation to those beaches with the highest recreational use.
- An investigation of the piped networks of Foster Bay should commence immediately and should include investigation of un-mapped stormwater pipes and the maintenance regime and integrity of on-site wastewater systems.
- Undertaking a streamwalk type survey of the streams within Huia Bay, from the coast to their headwaters to document all piped inputs to the stream and identify potential sources of human wastewater contamination. This survey should specifically look to isolate potential sewage fungus or pipes flowing during dry weather. This would be a starting point to determine if there are cross connections or leaking pipes and may lead to additional, more targeted sampling of these inputs. Concurrently, an investigation into the maintenance regime and integrity of on-site wastewater systems should be undertaken within the Huia Bay catchment.
- Develop and implement an education and awareness raising programme to inform the residents of Herald Island as to the presence of canine faecal contamination.
- Consider further investigation into other sources to Christmas Beach bathing waters including avian sources on the beach and influences from the wider catchment.
- Undertake further investigations of the G1 site stream and pipe network in the Green Bay catchment which may include a streamwalk type survey and pipe investigations. Further MST testing may also be required depending on the results obtained.

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1.0 Introduction

Auckland Council has a programme to investigate the sources of catchment derived faecal contamination at beaches in Auckland with poor long term microbiological water quality.

For the purposes of these investigations, ‘poor long term microbiological water quality’ is determined as those sites having a Microbiological Assessment Category (MAC) ‘D’ (MfE/MoH, 2003) based on the Safeswim monitoring programme results to date (see Appendix A for further details of this ranking system).

Investigations of this type have been undertaken at several beaches and lagoons across Auckland (see for example Walker et al., 2015; Noble & Neale, 2016; Quinn & Neale 2016; Whatley et al., 2016 and Quinn & Neale 2018), however the focus of these investigations are the following four beaches across two wider catchment areas; Christmas Beach in the upper Waitematā Harbour as well as Green Bay, Huia Bay and Foster Bay in the Northern Manukau Harbour.

These four beaches have a long term MAC ‘D’ classification, indicating that there is an elevated public health risk for recreational contact in coastal waters as a result of poor microbial water quality in these locations.

We know there is an issue

The Safeswim programme is designed to provide regular surveillance assessments of microbial water quality at a range of locations in the region that are used for primary contact recreation (including marine and freshwater sites). The programme has been substantially revised for the 2017 summer, but under the previous regime, the council monitored 69 beaches (2016-17 season) in the Auckland region on a weekly basis over summer (November to March).

Microbiological data from the Safeswim monitoring programme indicates there are exceedances of the recreational guidelines at all four beaches (Figure 1-1, Figure 1-2, Figure 1-3 and Figure 1-4).

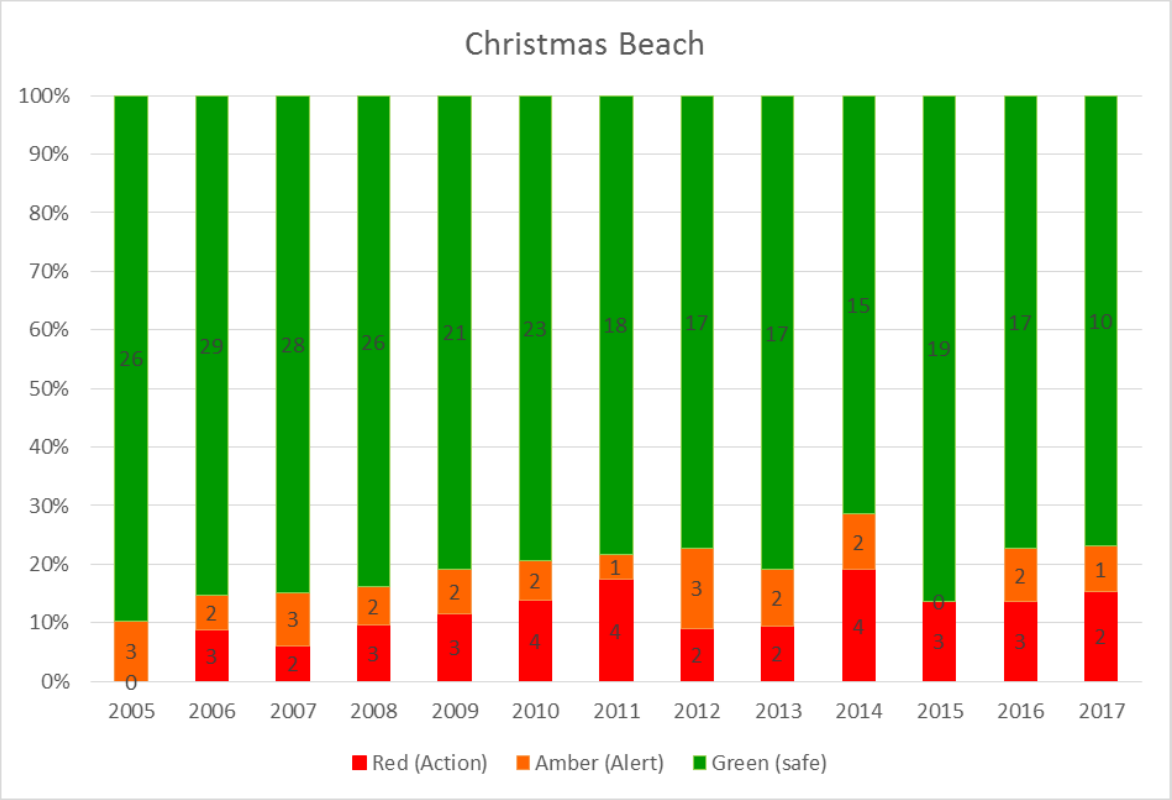

Figure 1-1 Christmas Beach Safeswim monitoring results (Auckland Council website, historic Safeswim data) (Note: the number of samples in each trigger level mode is shown on the bar graph).

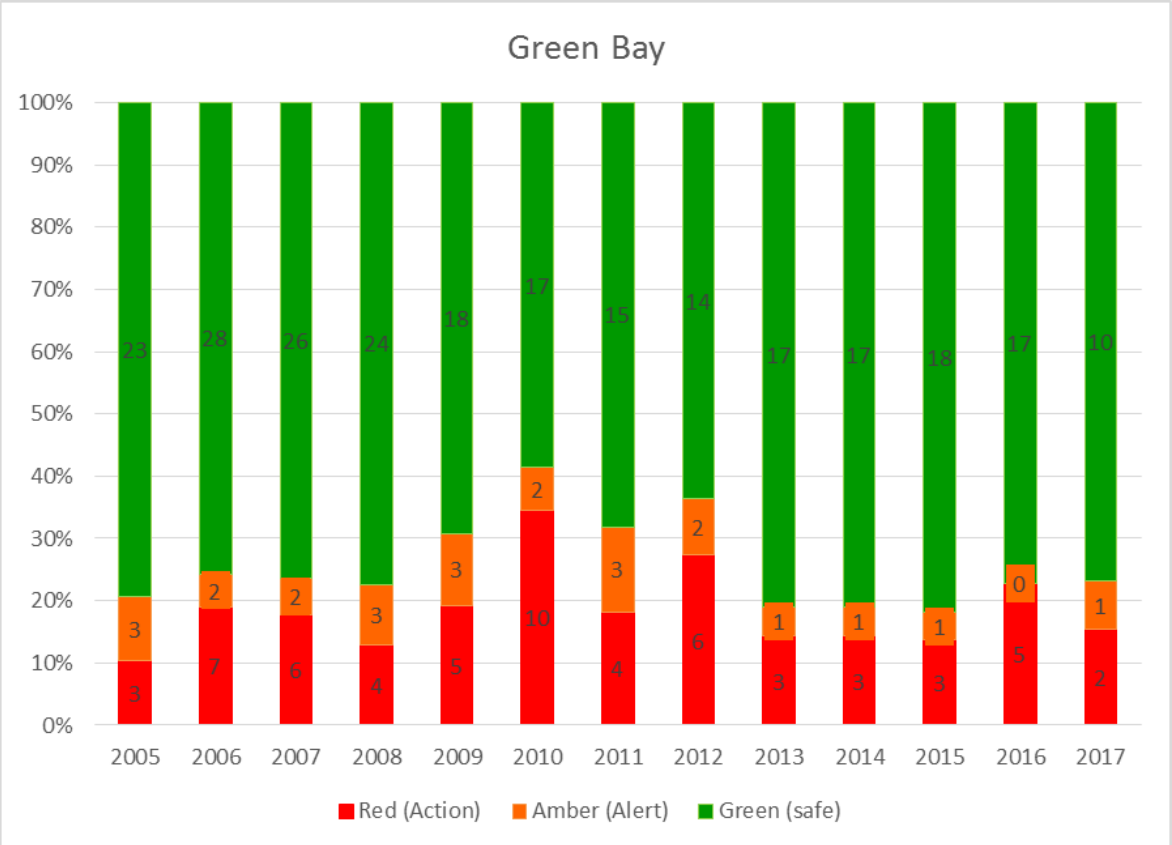

Figure 1-2 Green Bay Safeswim monitoring results (Auckland Council website, historic Safeswim data) (Note: the number of samples in each trigger level mode is shown on the bar graph).

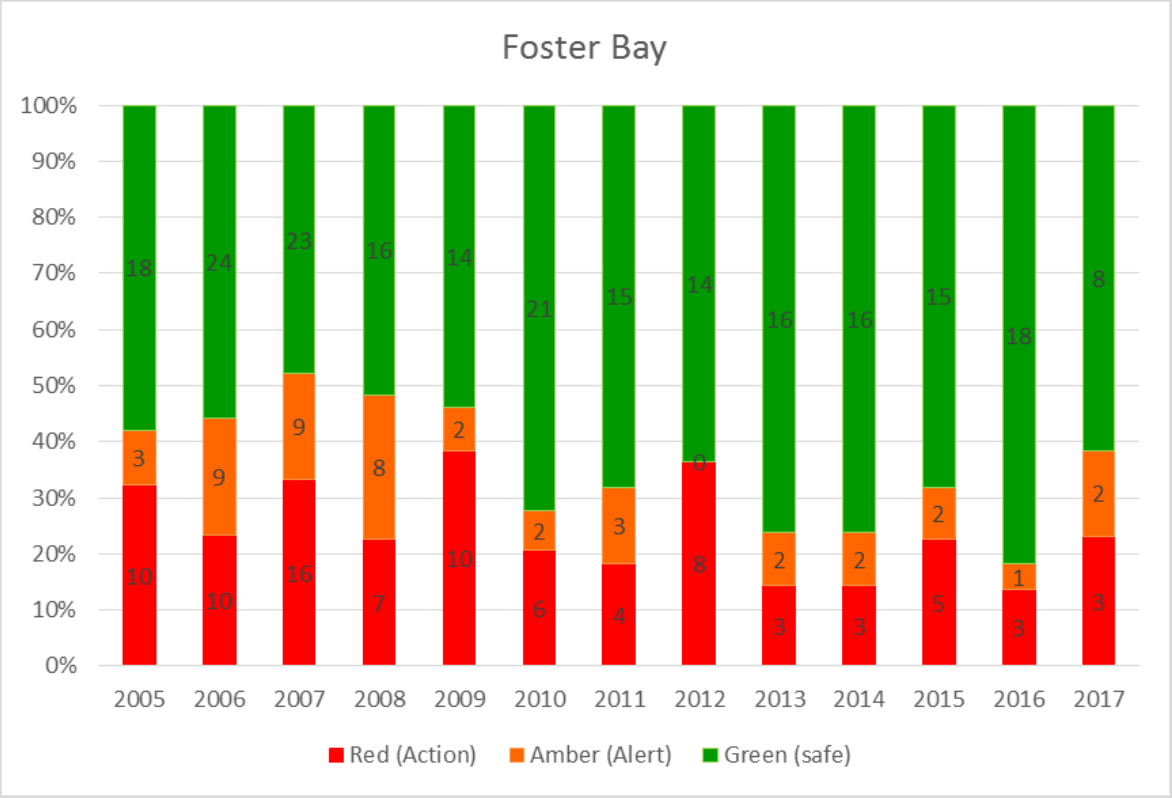

Figure 1-3 Foster Bay Safeswim monitoring results (Auckland Council website, historic Safeswim data) (Note: the number of samples in each trigger level mode is shown on the bar graph).

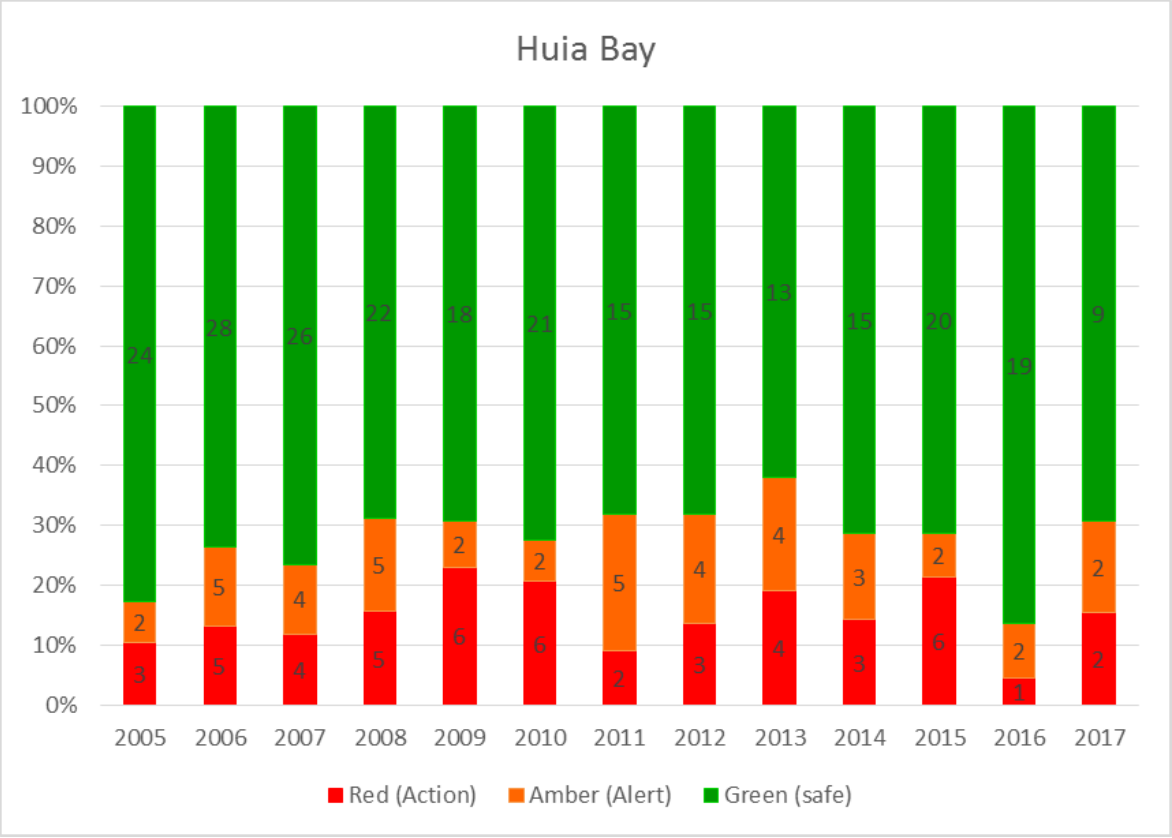

Figure 1-4 Huia Bay Safeswim monitoring results (Auckland Council website, historic Safeswim data) (Note: the number of samples in each trigger level mode is shown on the bar graph).

There are several potential sources of microbiological contamination

The monitoring undertaken as part of the Safeswim programme confirms that there is periodic microbiological contamination of coastal waters at all four of these beaches. Sample analysis is restricted to enterococci and as a result is limited in terms of what information this can provide to guide future catchment based management interventions.

The presence of enterococci does not necessarily confirm the presence of faecal contamination as they can exist in the environment without input from faecal sources (Byappanahalli et al., 2012). Further, enterococci, like *E. coli*, are ubiquitous in the intestines of warm-blooded animals, therefore the presence of faecally-derived indicator bacteria may be from a range of possible animal hosts which makes effective management of any land-derived contamination difficult without further information (Walker et al., 2015).

All of the project catchments are subject to several potential sources of microbiological faecal contamination.

Green Bay

Green Bay is serviced by a reticulated wastewater network which may be a source of faecal contamination. The bay is located within an urban catchment comprising residential dwellings and open space. The wastewater system is reticulated and a pump station (Auckland Council GIS ID 961320, Portage Road 2 pump station) is located at the end of Portage Road uphill of the beach. There is one existing engineered wastewater overflow point (Watercare ID#1216) within the immediate Green Bay catchment at the pump station (Watercare, 2013b). Based on asset information on Auckland Council GeoMaps, a 150mm wastewater pipe connects to the pump station and discharges via a 225mm earthenware pipe to the coastal environment. The overflow from the pump station is reported to have been sealed, however if it were to fail, the overflow would enter the marine environment at the beach directly via a pipe (Watercare, 2013b).

A pipe extending approximately 60m seaward from the grassed reserve was observed in the coastal environment however it is unclear whether this experiences regular or periodic flows. A public toilet block is located on the grassed reserve adjacent to the beach which drops into a pump station prior to connecting to Watercare's reticulated network.

Christmas Beach

Christmas Beach is located on the northern shore of Herald Island within an urban catchment comprising residential dwellings and a small amount of open space. The wastewater network is reticulated and there are two pump stations located on the northern side of the island. One is located at Landing Reserve between numbers 36 and 38 The Terrace (Auckland Council GIS ID 961341) and one to the west of the main Christmas Beach reserve adjacent to 84 The Terrace (Auckland Council GIS ID 961342).

There are two existing engineered wastewater overflow points associated with these pump stations. The first is an overflow point at the Landing Reserve pump station and is identified as Herald Island No 1 Pump Station (overflow #12). It is reported to be sealed, however if it were to fail it would overflow to land (Watercare, 2013a).

The second is Herald Island No 2 Pump Station (overflow #13) at the main Christmas Beach reserve. It is reported to be sealed, however if it were to fail it would likely overflow to Christmas Beach (Watercare, 2013a). It is unclear if the sealing has any impacts on the wider network (i.e. weaknesses or discharges elsewhere) (Watercare, 2013a).

A public toilet is located adjacent to the pump station within the main reserve and is connected to Watercare mains (pers. comm. Brett Clinton, Auckland Council Healthy Waters, 9 August 2018).

Herald Island was originally a holiday area and the reticulated network (stormwater and wastewater) is old and expected to be in poor condition and/or incomplete (Watercare, 2013a).

Huia and Foster Bay

Huia Bay and Foster Bay both have a non-reticulated wastewater system which may be a source of microbiological contamination. These catchments are located within the southern extent of the Waitākere Ranges and are both small coastal settlements within a predominantly native forest catchment.

These settlements are serviced by a combination of ‘standard’ and ‘hi-tech’ septic tanks (according to Auckland Council GeoMaps). There are a few alternative wastewater systems identified on GeoMaps, including chemical systems and composting toilets. A public toilet is located within the Huia Domain, near the Huia Stream mouth. The public toilet is connected to an onsite wastewater system (pers. comm. Brett Clinton, Auckland Council Healthy Waters, 9 August 2018).

Wider catchment influences

While the immediate contributing catchment at Christmas Beach is urban, the beach itself is subject to flows from further afield, including a substantial proportion of rural land use to the north of the Waitematā Harbour. This includes inputs from the Brigham Creek (rural), Rangitopuni Creek (rural and forestry), Paremoremo Creek (rural), and potentially Lucas Creek (predominantly urban). It is possible that elevated faecal indicator bacteria within the wadeable beach zone could be, at least in part, from catchment sources further away.

Although the general microbiological water quality of the broader Manukau Harbour is good (Walker and Vaughan 2013), it is possible that contamination from other bays and beaches within the harbour are transferred to Green Bay, Foster Bay and Huia Bay on near-shore tidal currents.

Non-human sources of contamination

Common within all catchments are additional potential sources of microbial contamination. Dogs frequent the parks and reserves within the catchments, alongside streams and the beaches themselves. Birds were frequently observed at the beaches, in the water and within the recreational reserves alongside the beaches.

Large forested areas in the upper catchments of Huia and Foster Bay may contribute microbiological contamination through decomposing vegetation, or wildlife inputs which could be an additional source of contamination.

Huia Stream enters Huia Bay to the west, and is fed by the Lower Huia Reservoir approximately 1.4km upstream. Sheep graze on the dam face and the lower reaches of the stream flow past residential dwellings and some paddocks which are expected to be stocked on occasion. This was the only catchment in the study where stock are known to graze and hence is a potential source of ruminant faecal material.

We know there is contamination, but need more information to find out where it's coming from

There are a number of potential sources of microbiological contamination into the aquatic environment within the subject catchments, however the enterococci results from the Safeswim programme alone do not provide enough information to be able to identify whether human, dog, ruminant or avian sources are present.

Recent advances in molecular techniques have led to the development of microbial source tracking (MST) tools based on ribosomal DNA markers associated with the Bacteroidales order of bacteria (Bernhard & Field 2000, Roslev & Bukh, 2011). General and host-specific markers potentially allow the determination of whether high faecal indicator bacteria concentrations are a result of faecally-derived contamination as well as identifying what the source animal is. The benefits of knowing the source of faecal contamination allows a financially-efficient, targeted management response (Gilpin et al., 2002).

The overarching aim of this particular investigation was to test the inflows to the beaches and obtain more comprehensive information about the faecal sources present. The faecal source data is supplementary to the Safeswim monitoring programme and together they can be used to inform appropriate microbiological water quality management interventions.

Consistent with the methodology outlined in Walker et al., (2015), this investigation comprised 'stages 2 and 3' of the tiered faecal investigation approach where geographical and biological sources are identified respectively.

An investigation was undertaken to assess microbiological water quality at stormwater outlets and streams discharging to the coastal environment during eight occasions in autumn 2017. The investigation aimed to determine the key land based sources of microbiological contamination at each of the four beaches and followed a similar approach to other successful investigations undertaken across the Auckland region.

This report presents the results of this investigation and the subsequent recommendations for management of microbiological contamination within the beach catchments.

2.0 Methodology

Water samples were collected and tested for *E. coli* and/or enterococci (using standard culturing techniques) and a range of faecal source markers (using PCR analysis) at a total of 23 sites from discharges in the freshwater and coastal environment at Christmas Beach, Green Bay, Foster Bay and Huia Bay.

Depending on the salinity of the water at the sample site, either one or both of the faecal indicator bacteria were tested for, consistent with MfE guidelines. The sampling rationale and site descriptions for each of the four sites are detailed below and photographs of the sites are included in Appendix B.

2.1 Sampling site description and methodology

Prior to identifying sample locations, a pre-sampling walk-over was undertaken by the project team and Auckland Council staff to identify the number of stormwater and stream discharges to each of the beaches and to observe key infrastructure such as sewage trunk lines, public toilets and sewage pump stations. This information was used to identify key inputs to the coastal environment and subsequently the priority sampling sites.

Water quality sampling locations are shown in Figures 2-1, 2-2, 2-3 and 2-4 and Table 2-1 describes the sampling locations. Photographs of each site are included in Appendix B.

Table 2-1 Sample sites, Auckland Council Hydstra database number and descriptions of sites.

Hydstra Database #	Investigation Site Name	Full Site Description	Easting	Northing
Christmas Beach				
8035	C1	Stormwater outfall (300mm with tide flap) to east of Christmas Beach reserve	1748040	5928589
8036	C2	Stormwater outfall (300mm with tide flap) to west of access ramp	1748013	5928526
8037	C3	Stormwater outfall (675mm with tide flap) to west of Christmas Beach reserve	1747989	5928512
8038	C4	Stormwater outfall (475mm with tide flap) between 72 and 74 The Terrace	1747862	5928484
8039	C5	Stormwater outfall (375mm with tide flap) to west of reserve between 56 and 58 The Terrace	1747664	5928434
8040	C6	Stormwater outfall (750mm with tide flap) between 48 and 50 The Terrace	1747572	5928409
Green Bay				
43966	G1	Stream channel discharging to the west of the main beach	1750443	5911391
43965	G2	Stream channel upstream of grassed reserve	1750489	5911413
43964	G3	Stormwater outfall extending out onto beach periodically buried by sand.	1750484	5911374
Foster Bay				
44219	F1	Stormwater outfall, not shown on GIS	1739976	5903509
44220	F2	Stormwater outfall, not shown on GIS	1740013	5903487
44221	F3	Stormwater outfall (600mm), shown on GIS	1740027	5903476
44222	F4	Stormwater outfall, not shown on GIS	1740038	5903455
44223	F5	Stormwater outfall, not shown on GIS	1740058	5903427
44218	F6	Coastal stream channel, downstream of three stormwater outfalls	1740066	5903380
44224	F7	Open stream channel, upstream of pipe network	1740365	5903438
Huia Bay				
44225	H1	Stream below stormwater pipe opposite Huia Foodstore	1739919	5903773
44226	H2	Stream sampled at box culvert between 1212 and 1214 Huia Road.	1739886	5903938
44227	H3	Stormwater outfall, located on coastal wall opposite Upland Road intersection.	1739749	5904022
44230	H4	Huia Stream. Sample taken downstream of Huia Road bridge.	1739409	5904132
44229	H5	Minor tributary within 5 Upland Road. Tributary to the east of the main channel.	1739995	5904109
44228	H6	Main channel within 5 Upland Road. Sample taken upstream of property boundary.	1739998	5904109
44160	K1	Karamatura Stream downstream of Huia Road	1739001	5903507

Figure 2-1 Sampling locations for Christmas Beach investigation

Notes:
Aerial photograph, stormwater network, wastewater network and wastewater septic tank sourced from Auckland Council and licenced for re-use under the Creative Commons Attribution 3.0 New Zealand Licence.

A3 SCALE 1:3,000

0 30 60 90 120 150 (m)

Location Plan

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AUCKLAND COUNCIL
FAECAL SOURCE TRACKING INVESTIGATION
Sampling Locations for Christmas Beach Investigation

FIGURE No. Figure 2 - 1 Rev. 0

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Figure 2-2 Sampling locations for Green Bay investigation

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Notes:
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A3 SCALE 1:3,000

0 25 50 75 100 125 (m)

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105 Carlton Gore Rd, Newmarket, Auckland
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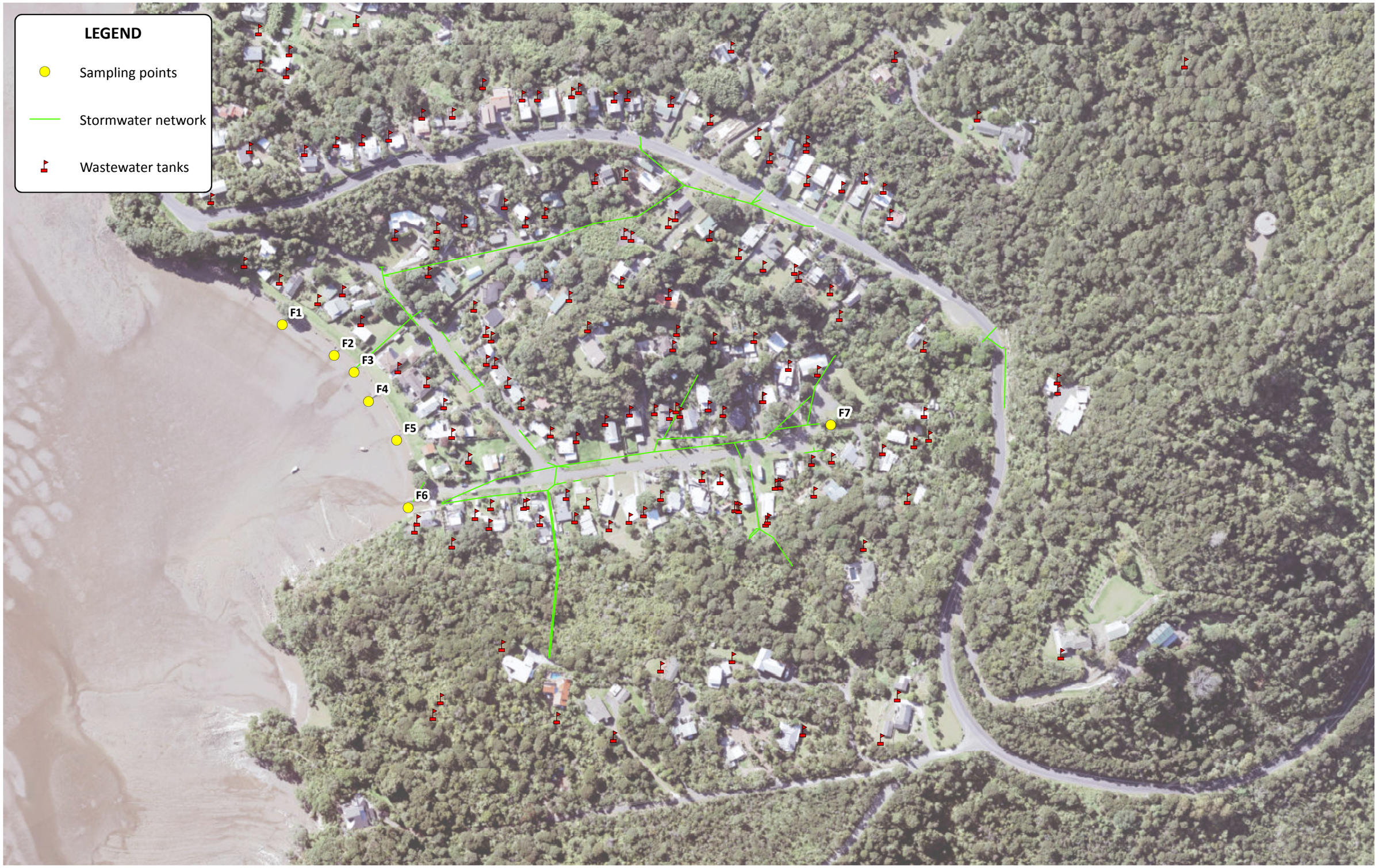
FAECAL SOURCE TRACKING INVESTIGATION
Sampling Locations for Green Bay Investigation

FIGURE No. Figure 2 - 2

Rev. 0

Figure 2-3 Sampling locations for Foster Bay investigation



Notes:
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Sampling Locations for Foster Bay Investigation

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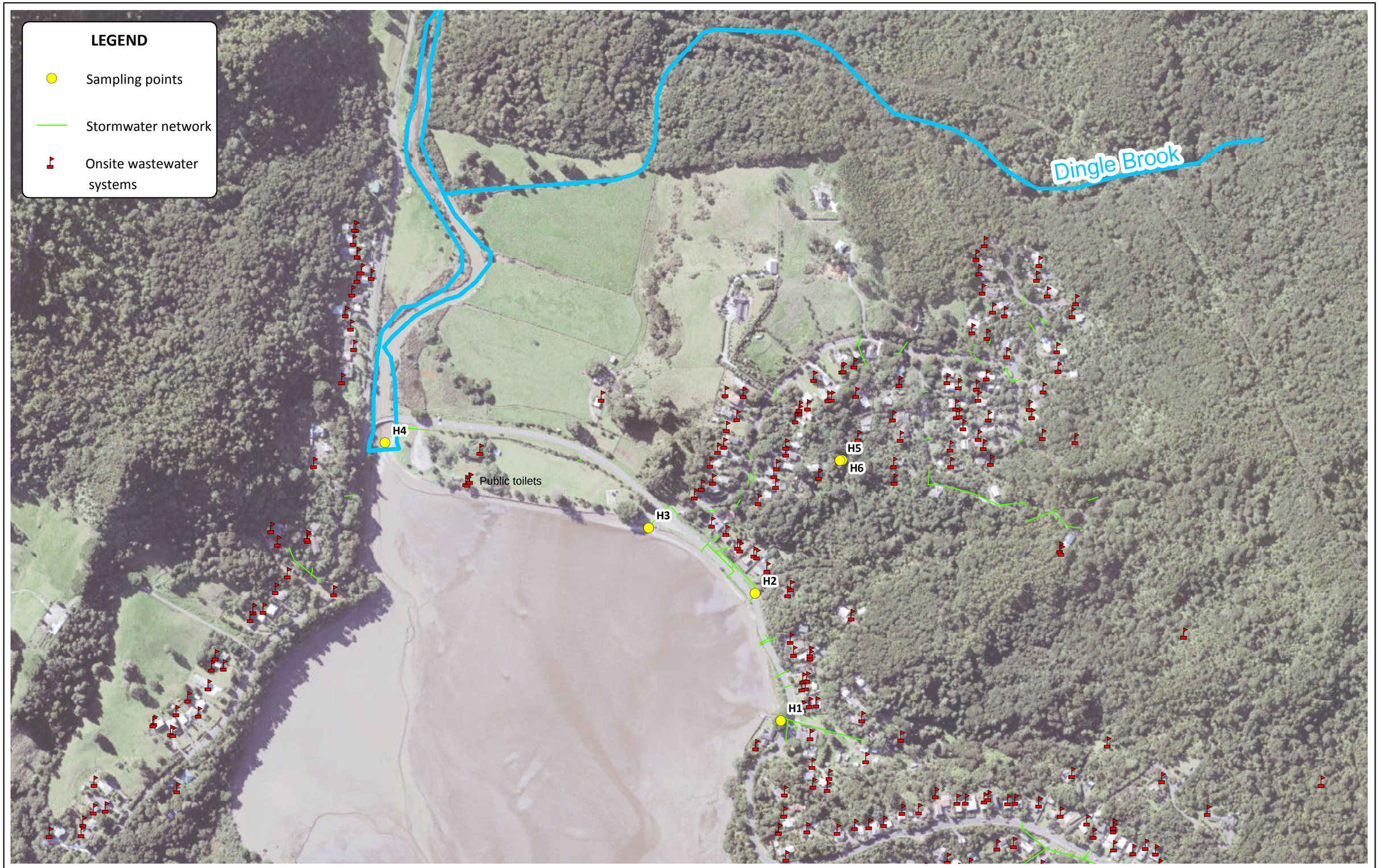
Figure 2-4 Sampling locations for Huia Bay investigation



Notes:
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PROJECT No.	1002315	

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FAECAL SOURCE TRACKING INVESTIGATION
Sampling Locations for Huia Bay Investigation

FIGURE No. Figure 2 - 4 Rev. 0

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2.2 Sample collection and analysis

A single sample was taken at each site on eight occasions in a range of wet and dry conditions between May and July 2017.

Samples were collected at low tide, which ensured that the stormwater outfalls on the beach were accessible and flows were representative of land based, point source flows rather than tidal waters. The Onehunga and Paratutae Island tide times from LINZ were used for the northern Manukau Beaches. The Auckland tide time with offset for Onetaunga Bay was used for Christmas Island. Where possible, samples were taken on the same day across all sample sites.

Samples taken from stormwater outfalls were collected only when the outfall was flowing and were collected from the water discharging from the pipe. Samples taken from the stream were collected subsurface according to the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas, (MfE/MoH, 2003).

Water quality samples were collected by AquaLab Laboratory (NZ) Limited ('AquaLab') staff in sterile 100ml bottles for faecal indicator bacteria analysis. A 1L sample was taken at the same sampling location immediately after the microbiological sample for microbiological source tracking (described further in Section 2.3 below). In some instances insufficient flow was available to collect a full 1L, and a minimum 250ml was collected for MST filtering (consistent with minimum recommended by the Institute of Environmental Science and Research (ESR)).

All samples were chilled following collection and delivered to AquaLab for analysis. These samples were analysed within 24 hours of sample collection using the Colilert test (APHA, 2012) method which provides a Most Probable Number (MPN) of *E. coli* (APHA 9223B) or enterococci (APHA 9230D) per 100ml (detection limit 10 MPN/100ml for each of *E. coli* and enterococci) in accordance with the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas, (MfE/MoH, 2003).

All samples were analysed for *E. coli*. Enterococci was only tested for where on site field measurements had indicated the presence of saline water at the sample site. Samples with a salinity of greater than 1 ppt were considered to have a saline influence and both parameters were tested for (and only occurred at site H1 and H4)..

Site observations were recorded on each sampling day, including the presence of animals (particularly dogs and birds), recreational usage and weather and tidal conditions (see Appendix C).

2.3 Microbial source tracking (MST)

The samples collected for MST analysis were processed by AquaLab within 24 hours of sample collection. Consistent with advice from ESR, the total volume from each sample collected was filtered through a 0.45µm membrane filter until the filter was blocked and then a GITC buffer was added. The filters were then frozen and stored, this process is reported to maintain sample integrity for at least six months (Gilpin et al., 2013).

At the completion of the sampling programme the frozen samples were compared to their corresponding faecal indicator results (*E. coli* or enterococci) and particular 'of further interest' samples selected for MST analysis. Those samples with corresponding microbiological concentrations of >260 *E. coli* /100ml (Amber (Alert) and Red (Action) freshwater trigger level exceedances (MfE/MoH, 2003)) were sent to the ESR laboratory for MST analysis using the Polymerase Chain Reaction (PCR) method. This is consistent with previous studies, where the use of molecular techniques is more likely to yield useful results when faecal indicator bacteria are high (Cornelisen et al., 2012).

The MST method amplifies the DNA from host specific bacteria in the filtered water samples and tests for the presence of markers for the animal species of interest. The detection limit for each marker is dependent on the volume of sample collected and filtered (refer to Appendix E for detection limits). The markers chosen for analysis in this investigation were the general bacterial marker (GenBac), and specific markers for dog (DogBac), avian (GFD) and human (BiADO and BacH) sources. As the Huia Bay and Foster Bay catchments were identified as potentially having ruminant sources of contamination, these samples were also tested for a ruminant marker (BacR)[1].

The presence of GenBac does not definitively confirm that the Faecal Indicator Bacteria (FIB) is of faecal origin, as GenBac is Bacteroidales and has been recorded in the wastewater of potato processing plants for instance (pers. comm. P Scholes, ESR, 2016). There is currently no way to differentiate GenBac from a faecal source and GenBac from a vegetative source (pers. comm. P Scholes, ESR, 2017). However when recorded in high quantities it is highly likely that the source of FIB is faecal in origin (pers. comm. B Gilpin, ESR, date unknown).

The avian marker GFD detects duck, swan, seagull, geese and chicken faecal sources.

The human BacH marker is more sensitive than the BiADO marker, but it has higher non-specificity than the BiADO marker with other animal species such as possum, dog, cat, rabbit, goat and chicken faecal sources. Therefore the BacH marker cannot definitively identify a human source (ESR, 2014). However the BiADO marker persists longer in the environment and is evidence of human (wastewater) contamination because it has low-level non-specificity with other animal markers such as possum, dog and waterfowl markers (pers. comm. P Scholes, ESR, 2014). Both BacH and BiADO markers are required to be present for a positive human result, however in some instances ESR have concluded 'probably human' on the basis of a single marker being present only (ESR, 2017). For the purpose of this report, results are reported in tables and summarised in the text. Refer to both when interpreting results to ensure a clear understanding of reporting limitations.

2.3.1 Interpreting MST results

For the most part interpretation of MST results has been undertaken by ESR in their reporting output (Appendix E). In brief, the following applies (taken from ESR, 2017 and pers. comm. with P Scholes, ESR, 2017).

[1] For more detailed background to these markers, including the non-specificities and methods used to enumerate the results, refer to http://waterquality.org.nz/home/faecal-source-tracking/toolbox-2/toolbox-3/ which provides references and links to relevant literature.

The general faecal bacteria indicator (GenBac) results are reported as number of GenBac per 100ml. Host specific markers are also reported as a number per 100ml however these numbers do not add up to the total number of GenBac identified. There is currently no way to account for the 'difference' between the GenBac and the total of the other markers.

Each marker is a separate test and the concentrations of various markers within the same sample can't be compared. For example, a single sample with a GFD level of 1000/100ml and BacH of 100/100ml doesn't necessarily mean that there is more GFD than BacH in that sample.

The concentrations of the same marker in different samples can be compared. For example, if Sample A has a level of BacH of 1000 and Sample B has 10,000 BacH, it can be concluded that there is more human contamination in Sample B. For a difference to be classified as 'significant' it should vary by a factor of 10.

Both human markers (BiADO and BacH) need to be present for a human source to be conclusive. In some instances, a 'probable human source' conclusion may be drawn where BacH is present in sufficiently high concentration and human markers have been recorded from the site previously.

A less than value indicates that the concentration of that particular marker is below the detection limit, which is determined by the volume of sample filtered and thus may vary between markers.

2.4 Rainfall records

Rainfall data for the dates of the investigation was obtained from Auckland Council's Research and Evaluation Unit (RIMU). This data was obtained from the closest rain gauge to each of the sampled beaches as outlined in Table 2-2.

Rainfall data was reported in terms of cumulative volume of rain that fell in the preceding 12, 24, 48 and 72 hours prior to sampling with time = 0 being the time at which sampling commenced. Each sampling day was designated as either 'wet' or 'dry' according to how much rain fell in the 48 hours preceding sampling, being either more or less than 5mm respectively.

As the rain gauges were not in the immediate sampling catchment, the results are estimates of rainfall. Additional rainfall data from nearby rain gauges were also assessed to support the conclusions drawn in respect of wet or dry weather.

Table 2-2 Sampling site and relevant Auckland Council RIMU rain gauge

Beach	Rainfall monitoring site
Christmas Beach	Whenuapai @ Airbase
Green Bay	Cutler Park New Lynn
Foster Bay	Nihotupu @ Arataki
Huia Bay	Nihotupu @ Arataki

3.0 Results

3.1 Rainfall

Rainfall data is presented in Table 3-1 below. Rainfall data from three rain gauges were used to determine the weather conditions at time of sampling across the four catchments.

Four of the sampling days (Day 1, 4, 6 and 7) were considered dry weather days for most sites, with less than 5mm in the preceding 48 hours.

Days 2, 3, 5 and 8 were subject to more than 5mm of rainfall in the 48 hours preceding sampling and are therefore considered as wet weather days.

There was a significant rainfall event (38.4mm) in the 48 hours preceding sampling at Christmas Beach on Day 8.

Table 3-1 Rainfall in the hours preceding sampling at each site

Site name (weather station)	Sampling Day	Date	Sample Start Time	Rainfall (mm) in preceding hours				48 hour weather conditions*
				12hr	24hr	48hr	72hr	
Christmas Beach (Whenuapai @ Airbase)	1	8/05/2017	11:14	0	0	0	0	Dry
	2	19/05/2017	7:20	0	1.02	10.19	40.8	Wet
	3	22/05/2017	9:18	0	0.51	9.17	9.17	Wet
	4	2/06/2017	7:35	6.63	6.63	9.17	10.2	Wet
	5	7/06/2017	10:14	0	3.57	4.08	5.1	Dry
	6	13/06/2017	14:15	3.05	4.58	4.58	4.58	Dry
	7	20/06/2017	9:00	0	0	0.51	1.53	Dry
	8	6/07/2017	10:03	24.6	37.9	38.44	40	Wet
Green Bay (Cutler Park New Lynn)	1	8/05/2017	13:42	0	0	0	0	Dry
	2	19/05/2017	9:10	0.48	0.96	6.23	33.5	Wet
	3	22/05/2017	11:43	0	0	6.71	7.66	Wet
	4	2/06/2017	10:05	2.39	2.39	2.87	5.26	Dry
	5	7/06/2017	12:35	0	6.71	7.19	7.67	Wet
	6	16/06/2017	7:22	0.48	0.48	0.48	5.27	Dry
	7	20/06/2017	11:22	0	0	2.39	2.39	Dry
	8	6/07/2017	11:53	6.7	15.8	16.76	17.2	Wet
Foster Bay (Nihotupu @ Arataki)	1	8/05/2017	14:43	0	0	0	0	Dry
	2	19/05/2017	10:10	0	2.64	12.13	37.4	Wet
	3	22/05/2017	12:43	0	0	6.49	9.72	Wet
	4	2/06/2017	11:05	1.98	1.98	2.47	5.43	Dry
	5	7/06/2017	13:30	1.97	11.3	12.82	13.8	Wet
	6	16/06/2017	8:25	0.49	0.49	0.49	13.8	Dry
	7	20/06/2017	12:10	0	0	0.99	0.99	Dry
	8	6/07/2017	12:53	2.47	10.9	11.3	12.3	Wet
Foster Bay (Nihotupu @ Arataki)	1	8/05/2017	15:40	0	0	0	0	Dry
	2	19/05/2017	11:20	0	2.11	12.13	37.4	Wet
	3	22/05/2017	14:00	0	0	2.7	9.72	Dry
	4	2/06/2017	12:20	1.98	1.98	2.47	5.43	Dry
	5	7/06/2017	14:45	1.97	8.38	12.82	13.8	Wet
	6	16/06/2017	9:39	0.98	0.98	0.98	12.8	Dry
	7	20/06/2017	13:48	0	0	0.99	0.99	Dry
	8	6/07/2017	14:26	2.46	10.8	11.83	12.8	Wet

*Weather conditions defined as more ('wet') or less ('dry') than 5mm of rain in the 48 hours preceding sampling.

3.2 Microbiological sampling results

A total of 164 samples were collected across the four beaches as part of this study. Samples could not be collected on 15 occasions due to no flow being present in the pipe. Seventy-three (44.5 per cent) of samples exceeded the freshwater Red trigger level for *E. coli* concentration (>550 *E.coli/* 100ml). Thirty-eight (23.2 per cent) of samples exceeded

the Amber trigger level (>260 - ≤550 *E.coli/* 100ml) and 53 (32.3 per cent) were indicative of the 'Green' mode (≤260 *E.coli/* 100ml).

The following sections summarise the results for each of the individual beaches sampled. Summarised microbiological results for each site are included in Appendix D. Site observations are included in Appendix C.

3.2.1 Christmas Beach

A total of 48 samples were collected across six sampling sites at Christmas Beach (Table 3-2). All sample sites were at stormwater outfalls, which provided sufficient flow even during dry weather, to be sampled.

Elevated *E. coli* concentrations were observed on 23 of the 48 sampling occasions (48 per cent), with samples collected exceeding either Amber (n=4) or Red (n=19) trigger levels.

For the most part exceedances of the Red trigger level appear to be driven by wet weather occurring in the 12-24 hours preceding sampling. While 'wet' or 'dry' conditions have been identified relative to a 48 hour period, within this catchment it appears that there is a more rapid response to rainfall, likely due to the short rainfall retention time. For example, while Day 6 was recorded as a 'dry' day, five out of six sites recorded an exceedance of the Amber or Red trigger level, following 4.58mm of rain in the 24 hours prior to sampling. In contrast, Days 2 and 3 were classified as 'wet' days, however five out of six samples were 'Green', and less than 1mm of rain fell in the 24 hours preceding sampling.

Samples from site C1 exceeded the Red trigger level most frequently, during both wet and dry weather. All other sites had periodic exceedances of either Red or Amber trigger levels, three to four times out of the eight sampling occasions.

In general, the freshwater inputs to Christmas Beach were in excess of MfE freshwater receiving environment guidelines during wet weather and are likely to contribute to the microbiological contamination in the coastal environment.

Table 3-2 Summarised *E. coli* values (/100ml) results for Christmas Beach sites (Colours indicate trigger levels).

	Site Name	C1	C2	C3	C4	C5	C6
Sample Day	**Weather conditions***						
1	Dry	331	670	359	41	10	62
2	Wet	201	256	213	609	94	211
3	Wet	26130	98	95	86	41	85
4	Wet	24196	26030	24196	17329	3654	8164
5	Dry	1658	256	86	108	231	98
6	Dry	631	644	109	435	565	452
7	Dry	*10*	20	41	*10*	*10*	185
8	Wet	2254	1607	1376	3873	645	1529

*Weather conditions defined as more ('wet') or less ('dry') than 5mm of rain in the 48 hours preceding sampling.

3.2.2 Green Bay

A total of 21 samples were collected across three sampling sites at Green Bay (Table 3-3). Two of the sample sites (G1 and G2) were in streams. Sample site G3 was a stormwater outfall, which was partially/intermittently buried by beach sand and could not be sampled on three of the eight occasions.

All sites exhibited elevated *E. coli* concentrations with 19 of the 21 samples collected exceeding either Amber (n=9) or Red (n=10) trigger levels.

Samples could only be collected at Site G3 when the outfall was not buried in sand. Of the five samples collected, all exceeded either Amber (n=3) or Red (n=2) trigger levels.

Samples collected within both G1 and G2 exceeded Red or Amber triggers on all but one sampling occasion.

In general, the freshwater inputs to Green Bay were frequently in excess of the trigger levels indicative of a chronic issue and are a contributing source of microbiological contamination into the coastal environment.

Table 3-3 Summarised *E. coli* results (/100ml) for Green Bay sites. (Colours indicate trigger levels).

	Site Name	G1	G2	G3
Sample Day	**Weather conditions***			
1	Dry	933	305	-
2	Wet	9208	554	717
3	Wet	448	262	313
4	Dry	4884	1624	6488
5	Wet	2755	364	341
6	Dry	231	1211	-
7	Dry	591	63	-
8	Wet	536	272	341

*Weather conditions defined as more ('wet') or less ('dry') than 5mm of rain in the 48 hours preceding sampling.

3.2.3 Foster Bay

A total of 44 samples were collected across seven sampling sites at Foster Bay (Table 3-4). Six of the sampling sites were stormwater outfalls, and one site (F7) was a stream. Samples were only taken from stormwater outfalls when flow was present (see below for specifics).

All sites exhibited elevated *E. coli* concentrations with 33 of the 44 samples collected exceeding either Amber (n=8) or Red (n=25) trigger levels.

Site F3 was flowing on all sampling occasions and *E. coli* concentrations recorded were above Red trigger levels on all occasions. A maximum concentration of 129,970/100ml

was recorded during dry weather which was the highest concentration of any sample in this investigation.

Site F4 was only flowing on two sampling occasions, and on both occasions recorded *E. coli* concentrations well in excess of the Red trigger level.

Sites F1 and F2 were flowing on five sampling occasions. On all but one occasion, *E. coli* concentrations exceeded either Amber or Red trigger levels.

Sites F5 and F6 were flowing on all sampling occasions and exceeded Red trigger levels on four occasions and Amber trigger levels on two and three occasions respectively. The maximum *E. coli* was recorded on Day 5 which was under wet weather conditions.

The stream site F7 recorded the lowest number of exceedances of trigger values, with six of the eight sampling occasions recording an *E. coli* concentration of less than 135/100ml (Green). On Day 5 a value in excess of Red trigger levels was recorded, which was during wet conditions.

All stormwater pipes entering the coastal environment of Foster Bay are regularly in excess of freshwater trigger levels indicating that they are a chronic contributing source of microbiological contamination into the coastal environment.

Table 3-4 Summarised *E. coli* results (/100ml) for Foster Bay sites. (Colours indicate trigger levels).

	Site Name	F1	F2	F3	F4*	F5	F6	F7
Sample Day	**Weather conditions***							
1	Dry	-	-	129970	-	86	657	31
2	Wet	5172	389	1460	-	3255	537	108
3	Wet	2014	857	3076	-	336	201	318
4	Dry	-	-	3450	-	1145	3255	97
5	Wet	15531	2755	12997	46110	11199	11199	2247
6	Dry	41	272	36090	-	3255	1725	135
7	Dry	-	-	5370	-	487	504	31
8	Wet	34480	228	5200	81640	200	410	132

*Weather conditions defined as more ('wet') or less ('dry') than 5mm of rain in the 48 hours preceding sampling.

3.2.4 Huia Bay

A total of 51 samples were collected across seven sampling sites at Huia Bay (Table 3-5). Two of the sampling sites were stormwater outfalls (H1 and H3), with the remainder being in streams.

All sites exhibited elevated *E. coli* concentrations with 36 of the 51 samples collected exceeding either Amber (n=17) or Red (n=19) trigger levels.

The stream site H4 is located downstream of the Huia Dam (water supply dam) and recorded the lowest number of trigger value exceedances, with five of the eight sampling

occasions recording an *E. coli* concentration of less than 135/100ml (Green). On Day 5 a Red trigger level exceedance was recorded during wet conditions.

Samples from site H1 and H2 exceeded the Red or Amber trigger level for *E. coli* on all sampling occasions.

Sites H5 and H6 were stream sites, upstream of H2. H5 recorded the highest *E. coli* concentration in the Huia catchment (81,640/100ml) however, this site only exceeded the Red trigger level on two occasions, both of which were during wet weather. The Red trigger level was exceeded three times at site H6 during wet and dry weather.

Site H3 was a stormwater pipe and was flowing on all sampling occasions. Of the eight samples taken, three exceeded the Red trigger level, four exceed the Amber trigger level and one was Green.

The Karamatura site (K1) was included in the sampling programme on only three occasions being Days 6, 7 and 8. Two of the three sampling days were considered to be dry and *E. coli* concentrations were indicative of the Green mode. Following rain on Day 8, the Amber trigger level was exceeded.

Within the Huia Bay catchment, sites H1, H2 and H3 entering the coastal environment are regularly in excess of the trigger levels and are a contributing source of microbiological contamination into the coastal environment.

Table 3-5 Summarised *E. coli* results (/100ml) for Huia Bay sites. (Colours indicate trigger levels).

	Site Name	H1**	H2	H3	H4**	H5	H6	K1***
Sample Day	**Weather conditions***							
1	Dry	644	1058	292	86 (20)	435	11199	Excl.
2	Wet	1145	323	471	160	399	581	Excl.
3	Dry	1376	441	727	85 (31)	299	185	Excl.
4	Dry	404	556	420	331 (121)	195	228	Excl.
5	Wet	12033	17329	5172	591 (85)	81640	3873	Excl.
6	Dry	301	933	1553	368 (243)	122	98	31
7	Dry	313 (97)	1076	97	169 (135)	63	41	10
8	Wet	450	631	399	160	576	489	512

*Weather conditions defined as more ('wet') or less ('dry') than 5mm of rain in the 48 hours preceding sampling.

**H1 and H4 were tidally influenced on some sampling occasions and when this occurred, enterococci was also analysed for. The enterococci results are shown in (brackets) next to the *E. coli* results.

***The K1 sampling site wasn't introduced into the sampling programme until Day 6.

3.2.5 The freshwater inputs to the marine environment have generally high FIB

For all catchments sampled, the land-based point source inputs showed evidence of faecal bacteria during both dry and wet weather and are considered to be the primary, substantial source of FIB contamination into the coastal environment.

Typically, samples taken following a wet weather event recorded higher FIB than those same sites during dry weather. During dry weather, the median and mean FIB concentrations are approximately half of that during wet weather (Table 3-6).

The maximum value is higher under dry conditions, however this is the result of a single outlier from site F3. All other dry weather results had a concentration of less than 36,090/100ml.

Table 3-6 Summarised statistics for faecal indicator bacteria concentrations (/100ml) across all sites under wet and dry weather conditions.

Weather conditions	Minimum	Maximum	Mean	Median
Dry	10	129970	2829.663	331
Wet	41	81640	6519.358	591

3.3 Microbial source tracking results

A total of 111 samples were analysed for MST (those with faecal indicator bacteria exceeding either the Amber of Red freshwater trigger level), of which 42 were tested for 5 markers (including GenBac) and 69 were tested for 6 markers (including GenBac).

GenBac was recorded in all but one sample and ranged from concentrations of 240/100ml to 6.2 million/100ml. Four samples were noted as having ‘low levels’ of GenBac and a faecal source was not identified in these samples.

Specific source markers were detected in 62 (56 per cent) samples, including human (n=52), canine (n=14), avian (n=4) and ruminant (n=4). Of the four samples where ruminant markers were recorded, all had a proportion below 50%, indicative of either additional sources being present or an aged faecal source.

Source specific markers were not reliably identified in 49 (44 per cent) of the 111 samples analysed. Of these, 25 samples (51 per cent) had concentrations of all markers below the level at which a source could be identified.

Of the remainder, 14 (29 per cent) were identified as being ‘probably human’ source on the basis that one of the human markers (typically BacH) was present, but the second marker (typically BiADO) was below quantification limits. A determination of ‘probably human’ was made where other samples from the same site had previously recorded human markers.

Ten samples identified the presence of BacH, which could mean potentially cat, rabbit, possum or weak human source. Three of the samples that had identified a specific canine source also identified the presence of BacH.

Note that the total number of detections/non-detects exceeds the number of samples collected as for some samples multiple markers were identified.

The key points from the MST analyses for each beach are described below; the full MST results from ESR are provided in Appendix E (ESR, 2017). The full results should be referred to when considering the summarised results reported below to determine the relevant levels of detection for each of the samples relevant to the volume of sample collected, the different markers and the relevant reporting limitations (Appendix E).

3.3.1 Christmas Beach

A total of 23 samples were analysed for MST at Christmas Beach.

Specific source markers were not identified in 12 samples. The BacH marker was detected in five samples from C1 and C3 indicative of potentially cat, rabbit, possum or weak human sources.

Canine markers were most commonly recorded (n=8) across five of the sites and were recorded in 50 per cent of samples from site C1 and C4. Site C1 is located adjacent to the Christmas Beach Reserve and it is probable that dogs frequent this area.

Human markers were detected on four occasions across three different sites indicating only periodic contamination from a human source. Notably, human markers were recorded twice at C4.

For the most part, a specific marker could not be identified, however dog markers were recorded eight times indicating a potential source of contamination within the Christmas Beach catchment

Table 3-7 Summarised MST results for Christmas Beach sites

Description / Site ID	**Date Sampled**	***E. coli* /100ml**	**Conclusion**
Christmas C1	8/05/2017	331	faecal source not identified
Christmas C1	22/05/2017	26,130	faecal source not identified
Christmas C1	2/06/2017	24,196	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)
Christmas C1	7/06/2017	1,658	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source), Note low level of GenBac
Christmas C1	13/06/2017	631	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)
Christmas C1	6/07/2017	2,254	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)

Christmas C2	8/05/2017	670	no faecal source identified, GenBac less than detection limit*
Christmas C2	2/06/2017	26,030	faecal source not identified
Christmas C2	13/06/2017	644	faecal source not identified, note low level GenBac
Christmas C2	6/07/2017	1,607	faecal source not identified
Christmas C3	8/05/2017	359	faecal source not identified
Christmas C3	2/06/2017	24,196	faecal source - human + dog
Christmas C3	6/07/2017	1,376	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Christmas C4	19/05/2017	609	faecal source not identified
Christmas C4	2/06/2017	17,329	faecal source - human + dog
Christmas C4	13/06/2017	435	faecal source not identified
Christmas C4	6/07/2017	3,873	faecal source - human + dog
Christmas C5	2/06/2017	3,654	faecal source not identified
Christmas C5	13/06/2017	565	faecal source not identified
Christmas C5	6/07/2017	645	faecal source - dog
Christmas C6	2/06/2017	8,164	faecal source - dog
Christmas C6	13/06/2017	452	faecal source - human
Christmas C6	6/07/2017	1,529	faecal source not identified

*Sample volume small, may have contributed to this result.

3.3.2 Green Bay

A total of 19 samples were analysed for MST at Green Bay.

Reliable source markers were not identified in any of the samples analysed.

Four samples from site G1 were indicative of a ‘probable human source’. A further eight samples recorded the presence of BacH, which may be indicative of cat, rabbit, possum or a weak human source.

While a source specific marker could not be identified in any samples, the presence of BacH does indicate that there is a faecal source of microbiological contamination in the

catchment. The lack of definitive results could be a result of diluted or aged faecal sources in the samples collected.

Table 3-8 Summarised MST results for Green Bay sites

Description / Site ID	Date Sampled	*E. coli* /100ml	Conclusion
Green G1	8/05/2017	933	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Green G1	19/05/2017	9,208	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Green G1	22/05/2017	448	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Green G1	2/06/2017	4,884	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Green G1	7/06/2017	2,755	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Green G1	20/06/2017	591	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Green G1	6/07/2017	536	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Green G2	8/05/2017	305	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Green G2	19/05/2017	554	faecal source not identified*
Green G2	22/05/2017	262	faecal source not identified
Green G2	2/06/2017	1,624	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Green G2	7/06/2017	364	faecal source not identified
Green G2	16/06/2017	1,211	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Green G2	6/07/2017	272	faecal source not identified
Green G3	19/05/2017	717	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)*
Green G3	22/05/2017	313	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
Green G3	2/06/2017	6,488	faecal source not identified
Green G3	7/06/2017	341	faecal source not identified
Green G3	6/07/2017	341	faecal source not identified

*Sample volume small, may have contributed to this result.

3.3.3 Foster Bay

A total of 33 samples were analysed for MST at Foster Bay.

Human markers were most commonly recorded (n=23 and n=4 ‘probably human’) across five out of seven sites, often irrespective of weather conditions. Sites F1, F3, F4, F5 and F6 all recorded human markers or ‘probably human’ on all sampling occasions.

Canine makers were detected on four occasions across four different sites indicating periodic contamination from a canine source.

A single sample recorded a weak ruminant marker (<1%). This is indicative of either an aged source or a very minor contribution from ruminant sources.

Specific source markers were not identified in five samples from F7 (n=2) or F2 (n=3). F7 is located upstream of the majority of residential dwellings in the catchment. A single sample from F2 recorded contamination from a canine source.

Human markers were consistently detected from stormwater outfalls from the Foster Bay catchment with other sources of contamination considered to be infrequent.

Table 3-9 Summarised MST results for Foster Bay sites

Description / Site ID	Date Sampled	*E. coli* /100ml	Conclusion
Foster F1	19/05/2017	5,172	faecal source - human
Foster F1	22/05/2017	2,014	faecal source - human
Foster F1	7/06/2017	15,531	faecal source - human
Foster F1	6/07/2017	34,480	faecal source - human
Foster F2	19/05/2017	389	faecal source - dog
Foster F2	22/05/2017	857	faecal source not identified
Foster F2	7/06/2017	2,755	faecal source not identified
Foster F2	16/06/2017	272	faecal source not identified
Foster F3	8/05/2017	129,970	faecal source - human
Foster F3	19/05/2017	1,460	faecal source - human
Foster F3	22/05/2017	3,076	faecal source - human
Foster F3	2/06/2017	3,450	faecal source - human
Foster F3	7/06/2017	12,997	faecal source - human + dog + low level ruminant (≤ 1%)

Foster F3	16/06/2017	36,090	faecal source - human
Foster F3	20/06/2017	5,370	faecal source - human
Foster F3	6/07/2017	5,200	faecal source - human
Foster F4	7/06/2017	46,110	faecal source - human
Foster F4	6/07/2017	81,640	faecal source - human
Foster F5	19/05/2017	3,255	faecal source - human
Foster F5	22/05/2017	336	faecal source - human
Foster F5	2/06/2017	1,145	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Foster F5	7/06/2017	11,199	faecal source - human + dog
Foster F5	16/06/2017	3,255	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Foster F5	20/06/2017	487	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Foster F6	8/05/2017	657	faecal source - human
Foster F6	19/05/2017	537	faecal source - human
Foster F6	2/06/2017	3,255	faecal source - human
Foster F6	7/06/2017	11,199	faecal source - human + dog
Foster F6	16/06/2017	1,725	faecal source - human
Foster F6	20/06/2017	504	faecal source - human
Foster F6	6/07/2017	410	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Foster F7	22/05/2017	318	faecal source not identified
Foster F7	7/06/2017	2,247	faecal source not identified

3.3.4 Huia Bay

A total of 35 samples were analysed for MST at Huia Bay.

Human markers were most commonly recorded (n=25 and n=7 ‘probably human’) across five out of six sites, often irrespective of weather conditions. Sites H1, H2, H3, H5 and H6 all recorded human markers or ‘probably human’ on all but one sampling occasion (a source could not be identified for site H6 on 19/05).

Avian markers were recorded on four occasions in samples from H4, H5 and H6. These are all stream sites. Potential sources could be waterfowl on the Huia dam surface, and within the H5 and H6 area, it is known that some residents keep chickens.

Ruminant markers were detected on two occasions at low concentrations from site H4. Sheep are known to graze on the face of the Huia dam which is located upstream of the H4 site.

A single sample was analysed for MST from Karamatura Stream which revealed a lower level (10-50%) ruminant faecal source. This lower level indicates that there may be other sources of faecal contamination or that the ruminant source is aged.

Canine makers were detected on only two occasions across two different sites indicating only periodic contamination from a canine source.

Human markers were consistently detected at most sites within the Huia Bay catchment with other sources of contamination considered to be infrequent.

Table 3-10 Summarised MST results for Huia Bay sites

Description / Site ID	**Date Sampled**	***E. coli* (Enterococci) /100ml**	**Conclusion**
Huia H1	8/05/2017	644	faecal source - human
Huia H1	19/05/2017	1,145	faecal source - human
Huia H1	22/05/2017	1,376	faecal source - human
Huia H1	2/06/2017	404	faecal source - human
Huia H1	7/06/2017	12,033	faecal source - human
Huia H1	16/06/2017	301 (243)	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Huia H1	20/06/2017	313 (97)	faecal source - human
Huia H1	6/07/2017	450	faecal source - human
Huia H2	8/05/2017	1,058	faecal source - human
Huia H2	19/05/2017	323	faecal source - human
Huia H2	22/05/2017	441	faecal source - human
Huia H2	2/06/2017	556	faecal source - human
Huia H2	7/06/2017	17,329	faecal source - human + dog
Huia H2	16/06/2017	933	faecal source - human
Huia H2	20/06/2017	1,076	faecal source - human

Huia H2	6/07/2017	631	faecal source - human
Huia H3	8/05/2017	292	faecal source - human
Huia H3	19/05/2017	471	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Huia H3	22/05/2017	727	faecal source - human
Huia H3	2/06/2017	420	faecal source - human
Huia H3	7/06/2017	5,172	faecal source - human
Huia H3	16/06/2017	1,553	faecal source - human
Huia H3	6/07/2017	399	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Huia H4	2/06/2017	331 (121)	faecal source - ruminant (1 - 10%) + avian + probable weak human source (BiADO present, < quantitation limit)
Huia H4	7/06/2017	591 (85)	faecal source - ruminant (10 - 50%)
Huia H4	16/06/2017	368	faecal source - avian
Huia H5	8/05/2017	435	faecal source - human
Huia H5	19/05/2017	399	faecal source not identified, probably human source (BacH present, < quantitation limit)
Huia H5	22/05/2017	299	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Huia H5	7/06/2017	81,640	faecal source - human +dog + avian
Huia H5	6/07/2017	576	faecal source not identified, probably human source (BiADO present, < quantitation limit)
Huia H6	8/05/2017	11,199	faecal source - human + avian
Huia H6	19/05/2017	581	faecal source not identified, note low level GenBac
Huia H6	7/06/2017	3,873	faecal source - human
Huia H6	6/07/2017	489	faecal source - human
Karamatura K1	6/07/2017	512	faecal source - ruminant (10-50%)

3.3.5 Multiple markers were identified in all catchments

Strong evidence of human faecal contamination was present in three of the four beaches across the sampling period (Table 3-11), with some evidence of human faecal contamination in the fourth catchment.

Evidence of human contamination was most prevalent in Foster Bay and Huia Bay samples, with approximately 69 per cent of samples tested in these catchments identifying a human source.

Canine markers were most frequently recorded at Christmas Beach, although 60 per cent of samples did not detect a host-specific source in this catchment.

None of the samples tested from the Green Bay catchment showed strong evidence of a host-specific source, however, four samples from site G1 had some evidence of human markers.

Avian markers were only detected in samples from Huia Bay catchment and all from stream sites.

Table 3-11 Summarised MST results for all sites

Beach	No. of samples	Human	Canine	Avian	Ruminant	Unidentified
Christmas Beach	23	4	8	0	N/A	14
Green Bay	19	0	0	0	N/A	19
Foster Bay	33	23	4	0	1	9
Huia Bay	36	25	2	4	3	7
Totals*	111	52 (47 per cent)	14 (13 per cent)	4 (4 per cent)	4 (4 per cent)	49 (44 per cent)

Note: The numbers within the human, canine, avian, ruminant and unidentified columns exceed the total number of samples collected as some samples detected multiple markers. *The (x per cent) refers to the proportion of total samples that detected each marker and exceeds 100 per cent as some samples detected multiple markers. Numbers included in this table only include where a reliable source was identified. N/A means not tested for.

4.0 Discussion

Monitoring results from the Auckland Council Safeswim programme have demonstrated periodically elevated levels of faecal indicator bacteria over summer months in each of the following locations:

- Christmas Beach in the upper Waitematā Harbour, and
- Green Bay, Foster Bay and Huia Bay in the northern Manukau Harbour.

This investigation has expanded upon the regularly undertaken Safeswim monitoring programme through targeted sampling of freshwater inputs to the coastal environment (stormwater outfalls and streams) and testing for commonly used faecal indicator bacteria. Supplementary MST analysis was carried out to provide more information about the potential sources (locations and animal origins) of contamination within each catchment. The microbiological water quality of the inputs (streams and stormwater pipes) was investigated during both wet and dry weather conditions over eight sampling occasions in autumn 2017.

4.1 Human source markers commonly recorded from freshwater inputs at Huia and Foster Bay

Human source markers were most commonly recorded in samples from freshwater discharges to Huia and Foster Bay. There is clear evidence of chronic water quality problems within these catchments, including the presence of human faecal contamination.

Within Foster Bay, six of the seven sample sites were stormwater outfalls and human markers were recorded in five of these pipes on nearly every sampling occasion.

Stormwater outfall F3 recorded elevated FIB during both wet and dry weather and human markers were recorded in every sample. Site F4 was a stormwater outfall which only flowed on two sampling occasions, recording levels of *E. coli* of 46,000/100ml and 81,000/100ml both of which detected human markers.

Site F7 is located at the upstream extent of the southern boundary of Foster Bay township, and collects flows from a predominantly forested upstream catchment. This site recorded no host-specific markers; however site F6, located approximately 300m downstream recorded human markers on six out of seven sampling occasions.

The results for Foster Bay reinforces the long-term warnings issued by Safeswim.

At Huia Bay, human markers were detected in samples taken from H1, H2 and H3 on all but three occasions, at which time ESR results indicated a ‘probable’ human source. All of these sites are outfalls or streams that terminate at the beach. Human markers were also recorded at sites H5 and H6, which are located upstream of site H2.

Wastewater treatment within these catchments is undertaken with on-site wastewater systems, with a range of treatment systems present. The results suggest that these on-site wastewater systems are the most likely source of human faecal contamination in the Foster Bay and Huia Bay catchments. Wastewater could be entering the

stream/stormwater network via overland flow from failing systems or via groundwater ingress.

Management of these sources is a priority due to public health risk. Discussions with local residents regarding the maintenance regimes and state of infrastructure will be useful in determining next steps in remediating these issues.

Within the stormwater infrastructure, CCTV or similar inspections could be undertaken to determine whether there are any clear cracks, leaks or ingressions. Further investigation is also required for those pipes which are not shown on Auckland Council GeoMaps Stormwater layer, particularly within the Foster Bay catchment.

4.2 Green Bay has high FIB but no identified source

Despite regularly elevated FIB, a host-specific marker was not reliably identified in the samples taken from freshwater discharges to Green Bay.

Four of the 19 samples taken were indicative of a ‘probable human source’ based on the presence of BacH but BiADO below quantification limits. A further eight samples detected BacH which has been identified as potentially being from a cat, rabbit, possum or weak human source.

The immediate catchment is limited to residential dwellings on the western side of Portage Road, and a large recreational reserve on the eastern side. Both of these land uses could contribute animal faecal material into the receiving environment. Further, the area is fairly well vegetated and decaying vegetation could be contributing to the elevated levels of FIB.

A wastewater pump station at the top of the reserve (and bottom of Portage Road) and a public toilet just above sea level in the reserve are potential sources of human contamination. Both of these would likely produce clear indications of human faecal material, rather than decayed or weak sources.

Further investigation will be required to determine what the possible sources of contamination are. Future testing in the Green Bay catchment may benefit from sampling in the coastal environment in order to determine whether there are additional sources being washed around on the near-shore tidal currents.

4.3 Dog sources important at Christmas Beach

For the most part, a specific source marker was not identified in samples from freshwater discharges to Christmas Beach with 61 per cent unidentified.

Dog was the most commonly recorded source specific marker with eight of the 23 samples testing positive for the canine marker across five different sites. Education and awareness raising in communities can result in marked reductions in canine sources (Ervin et al., 2014).

Human markers were recorded four times at three different sites and on different dates, but twice at site C4. The catchment has a reticulated wastewater network and these periodic sources may be the result of cross connections or damaged/aged infrastructure. Herald Island was historically a holiday destination and the infrastructure is expected to be undersized or in a poor condition (Watercare, 2013a).

All of the sites responded to wet weather conditions with elevated FIB, specifically on days 4 and 8. Site C1 recorded the highest number of exceedances irrespective of weather conditions. Just over half of the FIB results from the outfalls were below recreational contact guidelines (52 per cent).

While the results obtained do provide an indication of some local sources of microbiological and faecal contamination, there are wider catchment influences that may contribute to elevated enterococci results at Christmas Beach. Inputs from the northern Waitematā Harbour streams may be a contributing factor to the wadeable area measured by the Safeswim programme.

As the relative contributions to the environment are unclear, it would be prudent to fix the local, known issues first, then reassess to determine if further actions are required.

5.0 Conclusions

This investigation has revealed that the inputs to Christmas Beach, Green Bay, Foster Bay and Huia Bay contain faecal contamination from multiple sources.

The following conclusions can be drawn from this investigation:

- Strong evidence of faecal contamination from human sources was found at several sites in Foster Bay and Huia Bay and is likely the result of on-site wastewater treatment system failures/maintenance issues. Investigation and remediation of these areas is a priority.
- Faecal indicator bacteria concentrations across all catchments typically increase in response to rainfall, with the catchment size being an important factor in determining the response time.
- A reliable faecal source within Green Bay was not identified however evidence points towards a probable human source.
- A consistent faecal source was not identified in the Christmas Beach catchment. However canine markers were the most common and widespread from the point source discharges investigated, with human markers also found in a small number of samples.
- Ruminant markers are not a key contributor of faecal contamination within the semi-rural catchments of Huia Bay and Foster Bay.
- Stormwater network information appears to be out of date with several pipes in the Foster Bay catchment not documented in Auckland Council GeoMaps.

6.0 Recommendations

Auckland Council is responsible for managing discharges to water under the Resource Management Act 1991 (s30) and health risks under the Health Act 1956 (s23). Where a human faecal source (wastewater) is polluting stormwater council is obligated to remedy this so that adverse effects on the environment and public health are minimised or eliminated.

To better manage the faecal contamination of all of these beaches and to address the current public health risk, a range of recommendations are presented:

- Further investigations should be prioritised based on the presence of faecal contamination but also in relation to those beaches with the highest recreational use.
    - An investigation of the piped networks of Foster Bay should commence immediately and should include investigation of un-mapped stormwater pipes and the maintenance regime and integrity of on-site wastewater systems.
- Undertake a streamwalk type survey of the streams within Huia Bay to their headwaters to document all piped inputs to the stream and identify potential sources of human wastewater contamination. This survey should specifically look to isolate potential sewage fungus or pipes flowing during dry weather. This would be a starting point to determine if there are cross connections or leaking pipes and may lead to additional, more targeted sampling of these inputs. Concurrently, an investigation into the maintenance regime and integrity of on-site wastewater systems should be undertaken within the Huia Bay catchment.
- Develop and implement an education and awareness programme to reduce canine faecal contamination for the residents of Herald Island.
- Consider further investigation into other sources to Christmas Beach bathing waters including avian sources on the beach and influences from the wider catchment.
- Undertake further investigations of the G1 stream and pipe network in the Green Bay catchment which may include a streamwalk type survey and pipe investigations. Further MST testing may also be required depending on the results obtained.

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Appendix A Recreational contact guidelines

Bathing beach monitoring has been undertaken at the subject beaches according to the Ministry for the Environment (MfE) and Ministry of Health (MoH) national guidelines (MfE/MoH 2003). Table 7-1 below shows the national guideline trigger levels for each mode of the traffic lights system. Amber and red exceedances require re-tests until results return to the green/surveillance mode. Red/action exceedances require public health warning signs to be erected until results return to the green/surveillance mode.

Table 7-1 Seawater trigger levels from the national guidelines

Enterococci/100ml	Mode
Single sample ≤140	Green/Safe – Continue routine monitoring
Single sample >140 ≤ 280	Amber/Alert – Daily sampling required until results return to green/safe
Two samples >280	Red/Action - Daily sampling required until results return to green/safe Erect warning signs after two consecutive samples >280

Table 7-2 below shows the national guidelines trigger levels for each mode for freshwater, which in this case have been applied to streams and stormwater discharges. Amber and red exceedances require re-tests until results return to the green/safe mode. One red/action exceedance requires public health warning signs to be erected until results return to the green/surveillance mode.

Table 7-2 Freshwater trigger levels from the national guidelines

Freshwater (*E. coli* /100ml)	Mode
Single sample ≤ 260	Green/Safe – Continue with routine sampling.
Single sample > 260 ≤ 550	Amber/Alert - Sampling increased to daily.
Single sample > 550	Red/Action - Sampling continues daily until levels return to green/safe mode. Council places warning signage.

Under the national guidelines the last five years of results (100 data points) can be used to generate a Microbiological Assessment Category (MAC) (Table 7-3). MAC grades have been calculated for beaches in Auckland and those with a grade of D have been identified as those which would most benefit from further investigations.

Table 7-3 Microbiological Assessment Category ranges for seawater (using hazen percentile calculations) (source: MfE/MoH, 2003)

A	Sample 95th percentile ≤ 40 enterococci/100ml
B	Sample 95th percentile 41–200 enterococci/100ml
C	Sample 95th percentile 201–500 enterococci/100ml
D	Sample 95th percentile > 500 enterococci/100ml

Appendix B Site photographs

Christmas Beach		
C1	C2	C3
		
C4	C5	C6
		

Green Bay	
G1	G2
	
G3	
 	

Foster Bay		
F2	F2	F3
		
F4	F5	F6.
		

Huia Bay		
H1	H2	H3
		
H4	H5	H6
		

Appendix C Site observations

8 May 2017

Date	8/05/2017								
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temp (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	11:14	11:34	clear	208	0	17.8	no obvious odour	one pipe approx. 8 m away, not flowing	water dribbling from pipe; measures taken from pottle as flow insufficient; Tidal flap closed; pH: 7.56
C2	11:35	11:34	Clear -flowing with flap closed; build up behind flap: brown floc	505	0.2	18.3	no obvious odour	Near C3 - flowing	very slight trickle; partial sample (MST); tidal flap opened for sample; parameters from near pipe
C3	11:48	11:34	Clear	180	0	18.4	no obvious odour	C2 - flowing	Flowing from pipe; sample taken with tidal flap closed; no foam or scum when flap opened; parameters taken from pottle.
C4	11:58	11:34	clear	1724	0.7	18.2	no obvious odour		Pipe flowing; foam present below drop; parameters measured from pottle; tidal flap closed
C5	12:12	11:34	clear	Insufficient from sample	Insufficient from sample	Insufficient from sample	no obvious odour	Pipe 10 m to right, not flowing	very small trickle; tidal flap opened for part of sampling; partial MST
C6	12:23	11:34	clear	3070	1.5	18	no obvious odour	2 x small private pipes nearby; not flowing	good flow; sample taken from beneath closed flap; parameters measured from pottle
G1	14:00	14:30	clear	253	0	15.7	no obvious odour		sample taken at bottom of waterfall; measures taken from pottle as no pools; a few dogs and other people present
G2	13:46	14:30	mainly clear, slightly turbid	414	0	14.7	no obvious odour		sample taken in stream; evidence of high flow e.g. sediment deposition; a few dogs and other people present
G3	13:42	14:30							site completely submerged by sand; no sampling carried out
F1	14:43	14:30					no obvious odour		Cannot be sampled; very small trickle of water
F2	14:22	14:30							Cannot be sampled; completely dry
F3	14:46	14:30	little bit cloudy	418	0	16.9	strong wastewater smell	dry pipe within 2 m	lots of flow; measures taken in pottles
F4		14:30							built up with sand; cannot be sampled
F5	14:56	14:30	clear	433	0	16.7	no obvious odour		leaks as through pipe flows regularly; measures taken in pottle
F6	15:05	14:30	clear	480	0	15.9	no obvious odour		pipe nearest to base sampled unit but not flowing; measures taken in stream; both pipes above bridge flowing
F7	15:18	14:30	clear	354	0	14.6	no obvious odour		shaded stream; measures taken in stream; incised channel; no foam or scum
H1	15:40	14:30	clear	343	0	14.9	no obvious odour		measures taken in pool where pipe flowing into; good strong flow; minor surface scum
H2	15:50	14:30	clear	270	0	14.1	no obvious odour		measured in stream on other side of road; weak flow due to sand back up; sampled from pool
H3	16:05	14:30	clear	182	0	15.7	no wastewater odour but an unknown odour		Good amount of flow; lots of floc present; measurements taken in pottle; few birds in distance
H4	16:45	14:30	clear	36200	24	17	no obvious odour		Samples taken downstream of outlet flowing from read, opposite road sign; *E. coli* and Enterococci needed.
H5		14:30	clear	221	0	14.3	no obvious odour		measurements taken in stream under full canopy cover; a few birds
H6	16:20	14:30	milky	203	0	14.5	no obvious odour		measurements taken in stream under full canopy cover; a few birds

19 May 2017

Date	19/05/2017					**Weather Conditions**	Overcast and showers		
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temp (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	7:20	7:02	clear	248		16.6	no obvious odour	no	
C2	7:30	7:02	clear	331		16.9	no obvious odour	no	
C3	7:40	7:02	clear	178		17.3	no obvious odour	no	
C4	7:50	7:02	clear	245		17.2	no obvious odour	no	
C5	8:00	7:02	clear	336		16.5	no obvious odour	no; no flow at eastern 375	
C6	8:10	7:02	clear	358		16.8	no obvious odour	Trickle of water from 2nd 100mm pipe to east (clear/no odour)	
F1	10:10		clear	369	0	15.4	no obvious odour	no	
F2	10:20		clear	378	0	15.3	no obvious odour	no	
F3	10:30		clear	210	0	15.5	slight wastewater smell	no	
F4	10:40								no sample
F5	10:50		clear	422	0	15.7	no obvious odour	100 mm pipe to left and 200 m pipe to right of site, both had small discharge of clear odourless water	
F6	11:00		clear	370	0	15.2	no obvious odour	Trickle from 300 mm drain and 100 mm plastic pipe, clear odourless	
F7	11:10		slightly turbidity	305	0	14.6	no obvious odour	no	
G1	9:20	9:49	clear	277	0	15.6	no obvious odour	no	sample from pool on beach below waterfall; seaweed
G2	9:30	9:49	slightly turbid	388	0	14.9	no obvious odour	no	evidence of high flow; plenty of water to sample
G3	9:10	9:49	brown tinge but clear	404	0	15	no obvious odour	no	sample from drain in beach; dead bird on beach; seaweed
H1	11:20		turbidity significant, opaque colour	263	0	147	no obvious odour		surface scum
H2	11:35		slightly turbid	235	0	14.5	no obvious odour	no	
H3	11:50		clear	161	0	15.5	no obvious odour	no	lady with dog
H4	12:30		slight turbidity; brown tinge	479	0	16.2	no obvious odour	upstream pipe flowing, entering stream	
H5	12:00		moderately turbid	211	0	14.6	no obvious odour	no	wastewater smell upland Road, bottom of driveway to H5
H6	12:00		moderately turbid	217	0	14.9	no obvious odour	no	

22 May 2017

Date	22/05/2017					Weather Conditions			
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temperature (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	9:18	9:46	clear	245	0	16.1	no obvious odour	8 m from another dry pipe	High flow from pipe; ducks nearby; measurements taken from pottle
C2	9:31	9:46	clear	321	0	15.4	no obvious odour		Low flow from pipe; ducks present; measurements taken from pottle
C3	9:38	9:46	slightly murky/cloudy	176	0	16.7	no obvious odour		very high flow; birds nearby; measurements taken in pottle
C4	9:52	9:46	clear	255	0	16.2	no obvious odour		High flow; birds near; measurements taken in pottle
C5	10:01	9:46	clear	677	0.1	16.3	no obvious odour	pipe 10 m to right dry	few birds present; medium flow; measurements taken in pottle
C6	10:12	9:46	clear, very slightly cloudy	877	0.2	16.2	no obvious odour	small pipe right next to site dripping; small dry pipe 4 m to right	Few birds present; high flow; foam immediately beneath pipe; fish present in pool beneath pipe
G1	11:51	13:16	clear	258	0	13.3	no obvious odour		good flow; measurements taken in pottle
G2	12:00	13:16	clear	413	0	11.6	no obvious odour		good/medium flow; measurements taken in stream
G3	11:43	13:16	slight brown tinge	426	0	11.6	no obvious odour		sampled from pool at end of pipe; pipe covered by sand/shells; lots of vegetation present in pool; pool stagnant; dead bird 3 m from sample site, upstream
F1	12:43	13:16	clear	397	0	13.6	no obvious odour	no flow in any near pipes	very low flow; measurements taken in pottle
F2	12:53	13:16	clear	473	0	12.5	no obvious odour	near F3, flowing heavily	Very low flow; samples taken from pool in pipe as only place water could be collected; measurements taken in pool; small amount of vegetation and shells in pool
F3	13:03	13:16	clear	293	0	14.5	slight unknown odour, not intense wastewater smell like past two samples	Near F2, only running slightly; Pipe immediately left is wet; pipe 5 m to the right is dry	Very high flow; measurements taken from pottle
F4	13:08	13:16							no flow, unable to sample; pipe filled with sand
F5	13:10	13:16	clear	444	0	14.4	no obvious odour	pvc pipe 6 m to right is wet	Medium flow; measurements taken in pool at base of pipe
F6	13:16	13:16	clear	433	0	13.7	no obvious odour	Pipe flowing into stream 2.5 m from sampling location, flowing slightly; Dry pvc pipe 6 m from sampling location	Medium flow, less than last time sampled; measurements taken in stream
F7	13:28	13:16	clear	335	0	12.4	no obvious odour		Full vegetation cover above stream; measurements taken in stream; medium flow
H1	14:00	13:16	clear	290	0	12.4	slight odour	Pipe with medium flow present between H1 and H2, photo taken	Fast flow; some foam present on water surface; measurements taken in stream
H2	14:09	13:16	clear	274	0	11.4	no obvious odour	Pipe with medium flow present between H1 and H2, photo taken	Medium flow; measurements taken in stream on beach side
H3	14:24	13:16	clear	171	0	12.7	no obvious odour		Flow present in pipe; shells at base of pipe stained orange; medium flow; measurements taken in pottle
H4	14:39	13:16	slightly brown	30100	18.4	14.5	no obvious odour	Low flow entering stream from pipe 10 m on right hand side of bridge; medium flow entering stream at opposite side under bridge	Dead bird present downstream of sample site; measurements taken approx. 1.5 m into fast flowing water; measurements fluctuated
H5	15:08	13:16	milky/brown, possibly due to sampling	215	0	12	no obvious odour	next to H6	Medium flow; fully shaded by canopy; measurements taken in stream
H6	15:00	13:16	clear; sample murky as sediment stirred up when sampling	218	0	12.4	no obvious odour	next to H5	Low flow; fully shaded by canopy; measurements taken in stream

2 June 2017

Date	2/06/2017					Weather Conditions			
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temperature (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	7:35		clear	79	0	14.8	no obvious odour	1x pipe dripping to left of pipe	
C2	7:50		slightly turbid	470	0	15.2	no obvious odour		
C3	8:00		slightly turbid with slight brown tinge	105	0	15.4	no obvious odour		heavier flow due to rainfall
C4	8:15		clear, turbid	707	0.1	15.6	no obvious odour		
C5	8:25		brown tinge	929	0.2	15.3	no obvious odour	no water coming out of ipe to the left	
C6	8:30		slightly turbid	1171	0.4	16	slight odour		
G1	10:10		clear, slightly turbid	174	0	14.6	no obvious odour	no	1 dog at the beach
G2	10:20		slightly turbid	345	0	14.1	no obvious odour	no	
G3	10:05		significant brown tinge	325	0	13.9	no obvious odour	3 pipes coming out of concrete slab on bank to left of pipe, slight trickle.	
F1	11:05							very low flow of water out of pipe, dripping	
F2	11:10							no water flow out of pipe	
F3	11:10		clear	278	0	15.3	strong wastewater smell	no water flow from small pipes either side of main pipe	
F4	11:15							no water flow out of pipe	
F5	11:15		clear	399	0	15.1	no obvious odour		
F6	11:25		clear	550	0	14.8	no obvious odour		
F7	11:35		clear	347	0	14.1	no obvious odour		birds nearby
H1	13:00		turbid	395	0	14	no obvious odour	no	water running out of pipe half way between H1 and H1
H2	12:50		clear	414	0	13.8	no obvious odour	yes, half between H1 and H2, clear steady flow of water	
H3	12:35		clear	216	0	14.8	no obvious odour	no	sand and shell build up directly in front of outlet pipe
H4	12:20		clear	36.2	22.4	14.4	no obvious odour	water trickling out of pipe of to the right of bridge	
H5	13:30		slightly turbid	212	0	14	no obvious odour	no	no smell at the bottom of driveway, to house at upland road
H6	13:20		slightly turbid	226	0	14	no obvious odour	no	water level low

7 June 2017

Date	7/06/2017					Weather Conditions			
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temperature (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	10:14	11:50	clear	225	0	16.3	no obvious odour	Dry pipe 8m to right	Dozen ducks just above pipe on left; other birds present in estuary (approx. 20); medium flow
C2	10:20	11:50	clear	414	0	15.7	no obvious odour	10 m to C3	birds in estuary (approx. 20); low flow
C3	10.31	11:50	clear	171	0	16.5	no obvious odour	10 m from C2	high flow; birds in estuary (approx. 20)
C4	10:45	11:50	clear	392	0	16.3	no obvious odour		medium flow; few birds nearby
C5	10:58	11:50	clear, slightly turbid	887	0.2	16.1	slight odour; unknown (beachy?)	8m to right of dry pipe	low flow; birds present in estuary
C6	11:10	11:50	slightly turbid	1395	0	16.4	no obvious odour	pvc pipe right next to site, dripping	medium flow; foam in pool at base of pipe; fish in pool; few birds present
G1	12:42	15:06	clear	233	0	14.4	no obvious odour		high flow; hundreds of birds in harbour; measurements taken in pottle
G2	12:50	15:06	turbid	373	0	13.2	no obvious odour		high flow; water in stream murky; measurements taken in stream
G3	12:35	15:06	slightly brown and turbid	399	0	13.1	no obvious odour	Overland flow from stream infiltrate into sand	Medium flow; hundreds of birds in harbour; measurements taken in pool
F1	13:30	15:06	slightly turbid, brown tinge	313	0	13.4	no obvious odour	Pipe above and left medium flow; pipe 10 m to right trickling	Medium flow; few birds present; measurements taken in pottle; Rained heavily on way to Foster Bay
F2	13:37	15:06	clear	380	0	14.3	no obvious odour	Near F3, lots of flow; pipe to left trickling	Very low flow; measurements taken in pool in pipe, half way down
F3	13:44	15:06	very murky, brown	195	0	14.5	no obvious odour	pipe 1 m to left wet; pipe 4 m to right trickling	Extreme flow; measurements taken in pottle
F4	13:50	15:06	brown tinge	282	0	14.9	no obvious odour	pipe 6 m to left trickling	Main pipe full of sand; sampled short pipe to immediate left as low flow present; measurements taken in pottle
F5	13:54	15:06	brown tinge	265	0	14	no obvious odour	pipe 6 m to left low flow; pvc pipe 5 m to right low flow	Medium flow; measurements taken in pottle
F6	14:00	15:06	quite brown	240	0	13.7	no obvious odour	low flow from stream 4 m up from sample site	High stream flow; measurements taken in stream
F7	14:07	15:06	slightly turbid, brown tinge	208	0	13.1	no obvious odour		stream murky looking; measurements taken in stream
H1	14:45	15:06	turbid, slightly brown	280	0	13.1	slight odour, earthy, not wastewater		High flow; lots of brown foam present in pool; stream quite murky; measurements taken in stream
H2	14:52	15:06	turbid, slightly brown	250	0	13	no obvious odour		High flow; stream murky; measurements taken in stream
H3	15:06	15:06	slightly turbid	185	0	13.6	no obvious odour		High flow; less orange staining of shells than last time; measurements taken in pottle
H4	15:16	15:06	clear	4370	2.3	14.6	no obvious odour	pipe upstream on right medium flow; pipe upstream on opposite side low flow	Normal flow; 2 ducks nearby
H5	15:43	15:06	quite turbid with brown tinge	177	0	13.2	no obvious odour		water in stream murky looking; medium - high flow; measurements taken in stream
H6	15:35	15:06	slight brown tinge	187	0	13.1	no obvious odour		water in stream murky looking; medium - high flow; measurements taken in stream

13 June 2017

Date	13/06/2017					**Weather Conditions**			
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temperature (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	14:15	15:42	clear	186	0	16.2	no obvious odour	dry pipe 8 m to the left	Medium flow; few birds present; measurements taken in pottle
C2	14:21	15:42	slightly turbid	361	0	16	no obvious odour	near C3, flowing	Medium flow; measurements taken in pottle
C3	14:31	15:42	clear	168	0	16.1	no obvious odour	Near C2, flowing	Medium flow; measurements taken in pottle
C4	14:47	15:42	clear	357	0	16	no obvious odour		Medium flow; measurements taken in pottle
C5	14:56	15:42	clear	848	0	15.9	no obvious odour	10 m to right of dry pipe	Low flow; measurements taken from pottle
C6	15:03	15:42	clear	1527	0.6	15.3	no obvious odour	small pvc pipe 5 m to right, dry	Medium flow; small amount of flow in pool at base

16 June 2017

Date	16/06/2017					**Weather Conditions**			
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temp (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
G1	7:22	8:46	clear	255	0	13.7	no obvious odour		Low flow; measurements taken from pottle
G2	7:31	8:46	slight brown tinge	427	0	12.9	odour present near drain 6 m south of sampling site		Low flow; measurements taken in stream
G3		8:46							no pool present; unable to sample
F1	8:25	8:46	very clear	203	0	12.9	no obvious odour	pipe 8 m to right flowing	very little flow; unable to sample; sampled the pipe 8 m to right instead; measurements taken in pottle; rained heavily 5 min before sampling
F2	8:37	8:46	very clear	8030	4.4	12.6	no obvious odour	near F3, flowing	Sample taken from pool in pipe halfway as very little flow; sand, shells and vegetation present; measurements taken in pool.
F3	8:46	8:46	turbid	348	0	13.9	wastewater smell present, effluent odour	pipe 1 m to left wet; pipe 4 m to right dripping	Medium flow; measurements taken in pottle
F4		8:46							No flow in main pipe or pipe to immediate left; not sampled
F5	8:53	8:46	clear	426	0	13.7	no obvious odour	dry pipe 8 m to the left; pvc pipe 5 m to right trickling	Low flow; measurements taken in pottle
F6	9:01	8:46	very slight brown tinge	530	0	13.6	no obvious odour		Low flow; measurements taken in stream
F7	9:13	8:46	clear	347	0	13.2	no obvious odour; sulphury smell in air		Low flow; measurements taken in stream
H1	10:13	8:46	clear	39000	24	13.4	no obvious odour		Little flow; measurements taken in stream
H2	10:05	8:46	clear	314	0	12.8	no obvious odour		Medium flow; measurements taken in stream
H3	9:54	8:46	clear	239	0	13.5	slight wastewater smell		Measurements taken in stream; a lot dog poo present on bank near sampling site; low flow
H4	9:39	8:46	brown tinge	710	0.1	13.4	no obvious odour	Pipes upstream of sampling site on right and left of stream, trickling	Low flow; measurements taken in pottle
H5	10:40	8:46	clear	214	0	13	no obvious odour		Low flow; measurements taken in stream
H6	10:33	8:46	slight brown tinge	220	0	13.4	no obvious odour		Low flow; measurements taken in stream
K1	11:06		clear	135	0	11.7	no obvious odour	flowing pipe entering stream near road	sampled 10 m downstream from road; ducks present in stream; 20% canopy cover over sampling site; lots of algae in stream

20 June 2017

Date	20/06/2017						Weather Conditions		
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temp (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	9:00	9:15	Very clear	203	0	15.6	no obvious odour	Dug pipe 8 m to right	Low flow, birds present ~20. Calibration 0.88
C2	9:05	9:15	Slightly turbid	352	0	15.4	no obvious odour	Near C3	Foam present infront of pipe, small amount. Low flow, birds present.
C3	9:14	9:15	Very brown - not normally like this.	180	0	16	Earthy odour	Near C2	High flow, birds present ~20
C4	9:30	9:15	Very clear	677	0.1	15.7	no obvious odour		Medium flow, floam present in pool at base of pipe. Birds present, pipe open 10 cm on arrival.
C5	9:39	9:15	Slightly turbid	1557	0.6	16	no obvious odour	Dry pipe 10 m to left	Very low flow, birds nearby ~20
C6	9:54	9:15	Clear	3390	1.7	15.7	no obvious odour	Small pvc pipe 5 m to right dry	Medium flow, foam present in pool at base of pipe, few fish in pool.
G1	11:22	12:40	Very clear	250	0	13.7	no obvious odour		Low flow, measurements taken in pottle.
G2	11:28	12:40	Clear	428	0	12.5	no obvious odour		Low flow, stream looks clearer than usual, measurements taken in stream. Small amount of foam in stream.
G3		12:40							No flow from pipe - unable to sample.
F1	12:10	12:46							Pipe dry.
F2	12:10	12:46							Pipe dry.
F3	12:12	12:40	Clear	330	0	14.3	no obvious odour	Nearby pipes dry	Medium flow, 2 dogs in water, birds present, measurements taken in pottle.
F4	12:15	12:40							Both pipes dry.
F5	12:17	12:40	Clear	439	0	14.5	no obvious odour	All dry	Low flow, 2 dogs and birds nearby ~10. Measurements taken in pottle.
F6	12:26	12:40	Clear	641	0.1	14.1	no obvious odour		Low flow, few birds, measurements taken in stream.
F7	12:36	12:40	Clear	358	0	13.1	no obvious odour		Low flow, measurements taken in stream.
H1	13:57	12:40	Slightly turbid	29000	15.5	13.1	no obvious odour		Low flow, slight sheen on water, oily. Measurements taken in stream.
H2	13:48	12:40	Clear	296	0	12.7	no obvious odour		Medium flow, measurements taken in stream
H3	13:40	12:40	Clear	197	0	13.4	no obvious odour		Medium flow, 2 dogs nearby. Measurements taken in pottle.
H4	13:24	12:40	Slightly brown	16400	9.8	14.3	no obvious odour	Pipe 8 m upstream on right and left trickling.	Few birds upstream. Measurements taken in stream.
H5	14:30	12:40	Slight brown tinge	212	0	12.9	no obvious odour	Next to H6	Low flow, measurements taken in stream.
H6	14:26	12:40	Slight brown tinge	227	0	13	no obvious odour	Next to H5	Low flow, measurements taken in stream.
K1	13:12	12:40	Clear	135	0	11.5	no obvious odour	Pipe under bridge, strong flow into stream	Medium flow, 2 ducks upstream, oily look in 2 small pools on side of river. Measurements taken in stream.

6 July 2017

Date	6 July 2017						Weather Conditions		
Site Name	**Sample Time**	**Low tide time**	**Water colour and clarity**	**Conductivity (µs/cm)**	**Salinity (ppt)**	**Temp (°C)**	**Odour**	**Evidence of pipe flows**	**Additional notes**
C1	10:03	11:11	Clear, very slightly turbid	224	0	14.7	no obvious odour	Pipe 6 m to left flowing - not usually flowing	Heavy flow, ~ 20 birds present
C2	10:08	11:11	Very slightly brown tinge and a little turbid	300	0	14.1	no obvious odour	Near C3 - flowing	Medium flow, ~ 20 birds present, small amount of foam present in pool of base of pipe
C3	10:14	11:11	Brown tinge, slightly turbid	208	0	14.5	Slightly earthy	Near C2	Very heavy flow, a little foamy in pool
C4	10:32	11:11	Brown tinge	244	0	14.7	no obvious odour		Heavy flow, lots of foam in pool
C5	10:32	11:11	Brown tinge	300	0	14	no obvious odour	Pipe 10 m to right not foaming	Medium flow, very small amount of foam present
C6	10:35	11:11	Brown tinge, turbid	300	0	14.2	Slight unknown odour		Heavy flow, small amount of foam
G1	11:53	14:37	Clear	245	0	14.3	no obvious odour		Lots of birds in the harbour, heavy flow, measurements taken in pottle
G2	12:08	14:37	Brown	322	0	13.4	no obvious odour		Heavy flow, lots of foam built up, measurements taken in stream
G3	12:01	14:37	Brown	333	0	13.4	no obvious odour		Pipe visible for once! Very small amount of foam coming out. Shells quite orange at base. Lots of birds in harbour (100s). Measurements taken in stream.
F1	12:53	14:37	Quite clear	412	0	13.5	Odour present - waste water?	Pipe above and left trickling. Pipe 10 m to right trickling.	Few birds, dogs being walked, measurements taken in pottle, low flow.
F2	13:01	14:37	Clear	419	0	14.4	no obvious odour	Near F3 - flowing	Low flow, measurements taken in pool in open half of pipe. Sand, shells etc present.
F3	13:08	14:37	Clear/turbid, slight brown tinge.	302	0	14.7	Strong wastewater smell	Pipe 1 m to left not flowing, pipe 5 m to right not flowing	Heavy flow, measurements taken in pottle
F4	13:17	14:37	Clear, slightly turbid	600	0	14.5	Odour present		Low flow. Sampled pipe to immediate left. Measurements taken in pottle.
F5	13:26	14:37	Clear	392	0	14.9	Wastewater smell	Concrete pipe 8 m to left trickling - no smell. PVC pipe to right trickling.	Low flow, measurements taken in pottle.
F6	13:35	14:37	Clear, very slightly turbid	302	0	13.8	Wastewater smell		Medium flow. Sand disappeared from sample area - bare rock. Measurements taken in stream.
F7	13:43	14:37	Slight brown tinge	290	0	13.6	no obvious odour		Medium flow, measurements taken in stream
H1	14:26	14:37	Brown tinge	280	0	13.5	no obvious odour		Heavy flow, some foam present, measurements taken in stream
H2	14:33	14:37	Brown tinge	238	0	13.3	no obvious odour		Heavy flow, measurements taken in stream
H3	14:39	14:37	Clear	168	0	14.4	no obvious odour		Heavy flow, measurements taken in pottle
H4	14:49	14:37	Brown tinge, turbid	1065	0.3	13.7	no obvious odour	Pipes upstream on right and left are trickling	Medium flow, measurements taken in stream
H5	15:15	14:37	Turbid	208	0	13.7	no obvious odour		High level and flow
H6	15:13	14:37	Brown tinge	217	0	13.6	no obvious odour		Low water level and flow
K1	15:01	14:37	Clear, milky in stream.	134	0	12.2	no obvious odour		Heavy flow

Appendix D Summary microbiological results

	Sample Dates									Summary Statistics (*E. coli* (/100ml))			
Site Name	**8/05/2017**	**19/05/2017**	**22/05/2017**	**2/06/2017**	**7/06/2017**	**13/06/2017**	**16/06/2017**	**20/06/2017**	**6/07/2017**	**Number of samples**	**Minimum**	**Maximum**	**Median**
Christmas Beach													
C1	331	201	26130	24196	1658	631	Excl.	*10*	2254	8	10	26130	1145
C2	670	256	98	26030	256	644	Excl.	20	1607	8	20	26030	450
C3	359	213	95	24196	86	109	Excl.	41	1376	8	41	24196	161
C4	41	609	86	17329	108	435	Excl.	*10*	3873	8	10	17329	272
C5	10	94	41	3654	231	565	Excl.	*10*	645	8	10	3654	163
C6	62	211	85	8164	98	452	Excl.	185	1529	8	62	8164	198
Green Bay													
G1	933	9208	448	4884	2755	Excl.	231	591	536	8	231	9208	762
G2	305	554	262	1624	364	Excl.	1211	63	272	8	63	1624	335
G3	-	717	313	6488	341	Excl.	-	-	341	5	313	6488	341
Foster Bay													
F1	-	5172	2014	-	15531	Excl.	41	-	34480	5	41	34480	5172
F2	-	389	857	-	2755	Excl.	272	-	228	5	228	2755	389
F3	129970	1460	3076	3450	12997	Excl.	36090	5370	5200	8	1460	129970	5285
F4*	-	-	-	-	46110	Excl.	-	-	81640	2	46110	81640	63875
F5	86	3255	336	1145	11199	Excl.	3255	487	200	8	86	11199	816
F6	657	537	201	3255	11199	Excl.	1725	504	410	8	201	11199	597
F7	31	108	318	97	2247	Excl.	135	31	132	8	31	2247	120
Huia Bay													
H1	644	1145	1376	404	12033	Excl.	301 (243)	313 (97)	450	8	301	12033	547
H2	1058	323	441	556	17329	Excl.	933	1076	631	8	323	17329	782
H3	292	471	727	420	5172	Excl.	1553	97	399	8	97	5172	446
H4	86 (20)	160	85 (31)	331 (121)	591 (85)	Excl.	368	169 (135)	160	8	85	591	165
H5	435	399	299	195	81640	Excl.	122	63	576	8	63	81640	349
H6	11199	581	185	228	3873	Excl.	98	41	489	8	41	11199	359
K1	Excl.	Excl.	Excl.	Excl.	Excl.	Excl.	31	10	512	3	10	512	31

	8/05/2017	**19/05/2017**	**22/05/2017**	**2/06/2017**	**7/06/2017**	**13/06/2017**	**16/06/2017**	**20/06/2017**	**6/07/2017**	**Total**
Red	7	9	6	13	15	3	6	3	11	**73**
Amber	5	5	7	3	2	2	3	3	8	**38**
Green	6	7	8	3	5	1	6	13	4	**53**
Total samples	**18**	**21**	**21**	**19**	**22**	**6**	**14**	**18**	**22**	**161**

Notes: Numbers reported are *E. coli*/100ml and numbers in brackets are enterococci/100ml. Enterococci was only tested for where conductivity assessments indicated saline waters were present (>1 ppt)
Colours correspond to the relevant MfE recreational guideline category of green < 260 *E. coli*/100ml, amber 260≤550 *E. coli*/100ml, red >550 *E. coli*/100ml or green <140 enterococci/100ml, amber 140≤280 enterococci/100ml, red >280 enterococci/100ml.
* Pipe F4 was not flowing on any sampling day. Samples were collected from the adjacent pipe on days when flow was present.
'-' sample unable to be taken (no flow or pipe buried)
Excl. refers to days where that site was not included in the sampling regime.

Appendix E Microbial source tracking results

Note that samples referenced as Laingholm were tested as part of a separate study and are not included within this report.

14 September 2017

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REPORT ON FAECAL SOURCE TRACKING ANALYSIS

Two sets of pre-filtered samples were received from Aqualab on the the 9th August 2017.

- Set 1 consisted of 57 samples to be tested for 5 PCR markers: General, Human specific (2 markers), Dog specific and Avian.
- Set 2 consisted of 69 samples to be tested for 6 PCR markers: General, Human specific (2 markers), Dog specific and Avian.

Sample Details:
The sample details as provided by Aqualab are detailed in the following tables.

Set 1:

ESR Number	Client Reference	Date Sampled	Description/Site ID	E. coli MPN/100mL	Volume filtered (mL)
CMB171264	22490/1	3/07/2017	Laingholm L1	8164	300
CMB171265	22490/2	3/07/2017	Laingholm L2	6867	250
CMB171266	22490/3	3/07/2017	Laingholm L3	15531	250
CMB171267	22490/4	3/07/2017	Laingholm L4	6488	200
CMB171268	22490/5	3/07/2017	Laingholm L5	5794	200
CMB171269	22490/6	3/07/2017	Laingholm L6	5794	200
CMB171270	22490/7	3/07/2017	Laingholm L7	2723	200
CMB171271	22490/8	3/07/2017	Laingholm L8	3654	200
CMB171272	22490/9	3/07/2017	Laingholm L9	1860	200
CMB171273	22490/10	3/07/2017	Laingholm L10	2247	200
CMB171274	22490/11	3/07/2017	Laingholm L11	1119	200
CMB171275	22490/12	3/07/2017	Laingholm L12	985	200
CMB171276	22490/13	3/07/2017	Laingholm L13	464	100
CMB171277	22490/14	3/07/2017	Laingholm L14	1722	100
CMB171278	22490/15	3/07/2017	Laingholm L15	4611	100
CMB171279	22514/7	6/07/2017	Green G1	536	300
CMB171280	22514/8	6/07/2017	Green G2	272	350
CMB171281	22514/9	6/07/2017	Green G3	341	350
CMB171282	22514/1	6/07/2017	Christmas C1	2254	400
CMB171283	22514/2	6/07/2017	Christmas C2	1607	400
CMB171284	22514/3	6/07/2017	Christmas C3	1376	400
CMB171285	22514/4	6/07/2017	Christmas C4	3873	400
CMB171286	22514/5	6/07/2017	Christmas C5	645	350
CMB171287	22514/6	6/07/2017	Christmas C6	1529	350
CMB171288	22453/7	20/06/2017	Green G1	591	800
CMB171289	22435/8	16/06/2017	Green G2	1211	400
CMB171290	22435/1	13/06/2017	Christmas C1	631	600
CMB171291	22435/2	13/06/2017	Christmas C2	644	500
CMB171292	22435/4	13/06/2017	Christmas C4	435	500
CMB171293	22435/5	13/06/2017	Christmas C5	565	500
CMB171294	22435/6	13/06/2017	Christmas C6	452	750
CMB171295	22411/1	7/06/2017	Christmas C1	1658	1000
CMB171296	22411/7	7/06/2017	Green G1	2755	650
CMB171297	22411/8	7/06/2017	Green G2	364	500
CMB171298	22411/9	7/06/2017	Green G3	341	500
CMB171299	22402/1	2/06/2017	Christmas C1	24196	450
CMB171300	22402/2	2/06/2017	Christmas C2	26030	400
CMB171301	22402/3	2/06/2017	Christmas C3	24196	400
CMB171302	22402/4	2/06/2017	Christmas C4	17329	450
CMB171303	22402/5	2/06/2017	Christmas C5	3654	400
CMB171304	22402/6	2/06/2017	Christmas C6	8164	450

ESR Number	Client Reference	Date Sampled	Description/Site ID	E. coli MPN/100mL	Volume filtered (mL)
CMB171305	22402/7	2/06/2017	Green G1	4884	500
CMB171306	22402/8	2/06/2017	Green G2	1624	500
CMB171307	22402/9	2/06/2017	Green G3	6488	450
CMB171308	22348/1	22/05/2017	Christmas C1	26130	500
CMB171309	22348/7	22/05/2017	Green G1	448	500
CMB171310	22348/8	22/05/2017	Green G2	262	400
CMB171311	22348/9	22/05/2017	Green G3	313	400
CMB171312	22346/4	19/05/2017	Christmas C4	609	500
CMB171313	22346/7	19/05/2017	Green G1	9208	500
CMB171314	22346/8	19/05/2017	Green G2	554	250
CMB171315	22346/9	19/05/2017	Green G3	717	250
CMB171316	22296/1	8/05/2017	Christmas C1	331	500
CMB171317	22296/2	8/05/2017	Christmas C2	670	300
CMB171318	22296/3	8/05/2017	Christmas C3	359	500
CMB171319	22296/7	8/05/2017	Green G1	933	500
CMB171320	22296/8	8/05/2017	Green G2	305	400

Set 2:

ESR Number	Client Reference	Date Sampled	Description/Site ID	E. coli MPN/100mL	Enterococci MPN/100mL	Volume filtered (mL)
CMB171321	22514/23	6/07/2017	Karamatura K1	512		500
CMB171322	22514/17	6/07/2017	Huia H1	450		500
CMB171323	22514/18	6/07/2017	Huia H2	631		300
CMB171324	22514/19	6/07/2017	Huia H3	399		350
CMB171325	22514/21	6/07/2017	Huia H5	576		300
CMB171326	22514/22	6/07/2017	Huia H6	489		300
CMB171327	22514/10	6/07/2017	Foster F1	34,480		500
CMB171328	22514/12	6/07/2017	Foster F3	5,200		400
CMB171329	22514/13	6/07/2017	Foster F4	81,640		450
CMB171330	22514/15	6/07/2017	Foster F6	410		500
CMB171331	22453/12	20/06/2017	Foster F3	5,370		600
CMB171332	22453/14	20/06/2017	Foster F5	487		800
CMB171333	22453/15	20/06/2017	Foster F6	504		600
CMB171334	22453/17	20/06/2017	Huia H1	313	97	750
CMB171335	22453/18	20/06/2017	Huia H2	1,076		400
CMB171336	22435/11	16/06/2017	Foster F2	272		500
CMB171337	22435/12	16/06/2017	Foster F3	36,090		300
CMB171338	22435/14	16/06/2017	Foster F5	3,255		500
CMB171339	22435/15	16/06/2017	Foster F6	1,725		400
CMB171340	22435/17	16/06/2017	Huia H1	301	243	500
CMB171341	22435/18	16/06/2017	Huia H2	933		500
CMB171342	22435/19	16/06/2017	Huia H3	1,553		500
CMB171343	22435/20	16/06/2017	Huia H4	368		400
CMB171344	22411/10	7/06/2017	Foster F1	15,531		450

ESR Number	Client Reference	Date Sampled	Description/Site ID	E. coli MPN/100mL	Enterococci MPN/100mL	Volume filtered (mL)
CMB171345	22411/11	7/06/2017	Foster F2	2,755		500
CMB171346	22411/12	7/06/2017	Foster F3	12,997		500
CMB171347	22411/13	7/06/2017	Foster F4	46,110		500
CMB171348	22411/14	7/06/2017	Foster F5	11,199		450
CMB171349	22411/15	7/06/2017	Foster F6	11,199		400
CMB171350	22411/16	7/06/2017	Foster F7	2,247		400
CMB171351	22411/17	7/06/2017	Huia H1	12,033		400
CMB171352	22411/18	7/06/2017	Huia H2	17,329		350
CMB171353	22411/19	7/06/2017	Huia H3	5,172		400
CMB171354	22411/20	7/06/2017	Huia H4	591	85	450
CMB171355	22411/21	7/06/2017	Huia H5	81,640		250
CMB171356	22411/22	7/06/2017	Huia H6	3,873		200
CMB171357	22402/12	2/06/2017	Foster F3	3,450		500
CMB171358	22402/14	2/06/2017	Foster F5	1,145		500
CMB171359	22402/15	2/06/2017	Foster F6	3,255		500
CMB171360	22402/17	2/06/2017	Huia H1	404		250
CMB171361	22402/18	2/06/2017	Huia H2	556		500
CMB171362	22402/19	2/06/2017	Huia H3	420		450
CMB171363	22402/20	2/06/2017	Huia H4	331	121	950
CMB171364	22348/10	22/05/2017	Foster F1	2,014		900
CMB171365	22348/11	22/05/2017	Foster F2	857		500
CMB171366	22348/12	22/05/2017	Foster F3	3,076		500
CMB171367	22348/14	22/05/2017	Foster F5	336		1000
CMB171368	22348/16	22/05/2017	Foster F7	318		900
CMB171369	22348/17	22/05/2017	Huia H1	1,376		500
CMB171370	22348/18	22/05/2017	Huia H2	441		700
CMB171371	22348/19	22/05/2017	Huia H3	727		500
CMB171372	22348/21	22/05/2017	Huia H5	299		500
CMB171373	22346/10	19/05/2017	Foster F1	5,172		400
CMB171374	22346/11	19/05/2017	Foster F2	389		500
CMB171375	22346/12	19/05/2017	Foster F3	1,460		300
CMB171376	22346/14	19/05/2017	Foster F5	3,255		500
CMB171377	22346/15	19/05/2017	Foster F6	537		250
CMB171378	22346/17	19/05/2017	Huia H1	1,145		250
CMB171379	22346/18	19/05/2017	Huia H2	323		250
CMB171380	22346/19	19/05/2017	Huia H3	471		250
CMB171381	22346/21	19/05/2017	Huia H5	399		250
CMB171382	22346/22	19/05/2017	Huia H6	581		250
CMB171383	22296/12	8/05/2017	Foster F3	129,970		250
CMB171384	22296/15	8/05/2017	Foster F6	657		300
CMB171385	22296/17	8/05/2017	Huia H1	644		300
CMB171386	22296/18	8/05/2017	Huia H2	1,058		300
CMB171387	22296/19	8/05/2017	Huia H3	292		500
CMB171388	22296/21	8/05/2017	Huia H5	435		500
CMB171389	22296/22	8/05/2017	Huia H6	11,199		250

Results of faecal source PCR Marker Analysis: Please refer to the appendix for guidance on interpretation of these results

Christmas Beach

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171316	22296/1	Christmas C1	8/05/2017	331	160,000	<42	<53	<39	<36	faecal source not identified
CMB171308	22348/1	Christmas C1	22/05/2017	26,130	1,900	<42	<53	<39	<36	faecal source not identified
CMB171299	22402/1	Christmas C1	2/06/2017	24,196	35,000	110	<53	180	<36	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)
CMB171295	22411/1	Christmas C1	7/06/2017	1,658	640	57	<27	<20	<18	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source), Note low level of GenBac
CMB171290	22435/1	Christmas C1	13/06/2017	631	7,200	110	<53	33	<36	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)
CMB171282	22514/1	Christmas C1	6/07/2017	2,254	42,000	78	<53	670	<36	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)
CMB171317	22296/2	Christmas C2	8/05/2017	670	<130	<100	<130	<98	<90	no faecal source identified, GenBac less than detection limit
CMB171300	22402/2	Christmas C2	2/06/2017	26,030	7,800	<42	<53	<39	<36	faecal source not identified
CMB171291	22435/2	Christmas C2	13/06/2017	644	340	<42	<53	<39	<36	faecal source not identified, note low level GenBac
CMB171283	22514/2	Christmas C2	6/07/2017	1,607	18,000	<42	<53	<39	<36	faecal source not identified
CMB171318	22296/3	Christmas C3	8/05/2017	359	12,000	<42	<53	<39	<36	faecal source not identified
CMB171301	22402/3	Christmas C3	2/06/2017	24,196	160,000	55	350	700	<36	faecal source - human + dog
CMB171284	22514/3	Christmas C3	6/07/2017	1,376	13,000	54	<53	<39	<36	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171312	22346/4	Christmas C4	19/05/2017	609	1,600	<42	<53	<39	<36	faecal source not identified
CMB171302	22402/4	Christmas C4	2/06/2017	17,329	140,000	110	61	320	<36	faecal source - human + dog
CMB171292	22435/4	Christmas C4	13/06/2017	435	2,300	<42	<53	<39	<36	faecal source not identified
CMB171285	22514/4	Christmas C4	6/07/2017	3,873	110,000	71	160	970	<36	faecal source - human + dog

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171303	22402/5	Christmas C5	2/06/2017	3,654	46,000	<42	<53	<39	<36	faecal source not identified
CMB171293	22435/5	Christmas C5	13/06/2017	565	12,000	<42	<53	<39	<36	faecal source not identified
CMB171286	22514/5	Christmas C5	6/07/2017	645	9,200	<100	<130	62	<90	faecal source - dog
CMB171304	22402/6	Christmas C6	2/06/2017	8,164	22,000	<42	<53	170	<36	faecal source - dog
CMB171294	22435/6	Christmas C6	13/06/2017	452	9,800	220	38	<20	<18	faecal source - human
CMB171287	22514/6	Christmas C6	6/07/2017	1,529	15,000	<100	<130	<98	<90	faecal source not identified

Fosters Bay

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Ruminant BacR / 100 ml	Proportion Ruminant	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171373	22346/10	Foster F1	19/05/2017	5,172	4,300,000	8,100	13,000	<46		<39	<36	faecal source - human
CMB171364	22348/10	Foster F1	22/05/2017	2,014	950,000	1,900	1,200	<23		<20	<18	faecal source - human
CMB171344	22411/10	Foster F1	7/06/2017	15,531	1,900,000	2,200	2,300	<46		<39	<36	faecal source - human
CMB171327	22514/10	Foster F1	6/07/2017	34,480	1,100,000	2,700	1,800	<46		<39	<36	faecal source - human
CMB171374	22346/11	Foster F2	19/05/2017	389	17,000	<42	<53	<46		310	<36	faecal source - dog
CMB171365	22348/11	Foster F2	22/05/2017	857	240	<42	<53	<46		<39	<36	faecal source not identified
CMB171345	22411/11	Foster F2	7/06/2017	2,755	1,800	<42	<53	<46		<39	<36	faecal source not identified
CMB171336	22435/11	Foster F2	16/06/2017	272	2,500	<42	<53	<46		<39	<36	faecal source not identified
CMB171383	22296/12	Foster F3	8/05/2017	129,970	3,000,000	8,300	25,000	<110		<98	<90	faecal source - human
CMB171375	22346/12	Foster F3	19/05/2017	1,460	69,000	6,200	180	<110		<98	<90	faecal source - human

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Ruminant BacR / 100 ml	Proportion Ruminant	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171366	22348/12	Foster F3	22/05/2017	3,076	60,000	4,200	240	<46		<39	<36	faecal source - human
CMB171357	22402/12	Foster F3	2/06/2017	3,450	140,000	4,700	380	<46		<39	<36	faecal source - human
CMB171346	22411/12	Foster F3	7/06/2017	12,997	690,000	36,000	4,700	89	1% or less	650	<36	faecal source - human + dog + low level ruminant (≤ 1%)
CMB171337	22435/12	Foster F3	16/06/2017	36,090	6,200,000	4,500	7,500	<110		<98	<90	faecal source - human
CMB171331	22453/12	Foster F3	20/06/2017	5,370	290,000	49,000	2,300	<46		<39	<36	faecal source - human
CMB171328	22514/12	Foster F3	6/07/2017	5,200	120,000	290	320	<46		<39	<36	faecal source - human
CMB171347	22411/13	Foster F4	7/06/2017	46,110	400,000	1,400	520	<46		<39	<36	faecal source - human
CMB171329	22514/13	Foster F4	6/07/2017	81,640	3,500,000	36,000	4,600	<46		<39	<36	faecal source - human
CMB171376	22346/14	Foster F5	19/05/2017	3,255	160,000	4,000	65	<46		<39	<36	faecal source - human
CMB171367	22348/14	Foster F5	22/05/2017	336	180,000	670	210	<23		<20	<18	faecal source - human
CMB171358	22402/14	Foster F5	2/06/2017	1,145	44,000	450	<53	<46		<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171348	22411/14	Foster F5	7/06/2017	11,199	380,000	2,300	190	<46		320	<36	faecal source - human + dog
CMB171338	22435/14	Foster F5	16/06/2017	3,255	260,000	380	<53	<46		<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171332	22453/14	Foster F5	20/06/2017	487	130,000	1,200	<27	<23		<20	<18	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171384	22296/15	Foster F6	8/05/2017	657	170,000	460	150	<110		<98	<90	faecal source - human
CMB171377	22346/15	Foster F6	19/05/2017	537	91,000	1,400	150	<110		<98	<90	faecal source - human
CMB171359	22402/15	Foster F6	2/06/2017	3,255	1,300,000	1,400	160	<46		<39	<36	faecal source - human
CMB171349	22411/15	Foster F6	7/06/2017	11,199	520,000	3,500	1,200	<46		700	<36	faecal source - human + dog

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Ruminant BacR / 100 ml	Proportion Ruminant	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171339	22435/15	Foster F6	16/06/2017	1,725	320,000	1,700	400	<46		<39	<36	faecal source - human
CMB171333	22453/15	Foster F6	20/06/2017	504	130,000	1,100	200	<46		<39	<36	faecal source - human
CMB171330	22514/15	Foster F6	6/07/2017	410	28,000	230	<53	<46		<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171368	22348/16	Foster F7	22/05/2017	318	4,500	<21	<27	<23		<20	<18	faecal source not identified
CMB171350	22411/16	Foster F7	7/06/2017	2,247	29,000	<42	<53	<46		<39	<36	faecal source not identified

Green Bay

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171319	22296/7	Green G1	8/05/2017	933	14,000	1,300	<53	<39	<36	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171313	22346/7	Green G1	19/05/2017	9,208	45,000	13,000	<53	<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171309	22348/7	Green G1	22/05/2017	448	29,000	3,000	<53	<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171305	22402/7	Green G1	2/06/2017	4,884	32,000	470	<53	<39	<36	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171296	22411/7	Green G1	7/06/2017	2,755	7,400	250	<53	<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171288	22453/7	Green G1	20/06/2017	591	5,300	480	<27	<20	<18	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171279	22514/7	Green G1	6/07/2017	536	53,000	630	<130	<98	<90	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171320	22296/8	Green G2	8/05/2017	305	18,000	120	<53	<39	<36	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171314	22346/8	Green G2	19/05/2017	554	28,000	<100	<130	<98	<90	faecal source not identified
CMB171310	22348/8	Green G2	22/05/2017	262	24,000	<42	<53	<39	<36	faecal source not identified
CMB171306	22402/8	Green G2	2/06/2017	1,624	22,000	89	<53	<39	<36	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171297	22411/8	Green G2	7/06/2017	364	4,100	<42	<53	<39	<36	faecal source not identified
CMB171289	22435/8	Green G2	16/06/2017	1,211	27,000	190	<53	<39	<36	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171280	22514/8	Green G2	6/07/2017	272	28,000	<100	<130	<98	<90	faecal source not identified
CMB171315	22346/9	Green G3	19/05/2017	717	39,000	150	<130	<98	<90	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171311	22348/9	Green G3	22/05/2017	313	29,000	78	<53	<39	<36	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171307	22402/9	Green G3	2/06/2017	6,488	27,000	<42	<53	<39	<36	faecal source not identified
CMB171298	22411/9	Green G3	7/06/2017	341	6,800	<42	<53	<39	<36	faecal source not identified
CMB171281	22514/9	Green G3	6/07/2017	341	22,000	<100	<130	<98	<90	faecal source not identified

Huia Bay

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	Entero MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Ruminant BacR / 100 ml	Proportion Ruminant	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171385	22296/17	Huia H1	8/05/2017	644		2,200,000	2,000	320	<110		<98	<90	faecal source - human
CMB171378	22346/17	Huia H1	19/05/2017	1,145		1,000,000	4,600	3,200	<110		<98	<90	faecal source - human
CMB171369	22348/17	Huia H1	22/05/2017	1,376		400,000	670	180	<46		<39	<36	faecal source - human
CMB171360	22402/17	Huia H1	2/06/2017	404		690,000	16,000	1,200	<110		<98	<90	faecal source - human
CMB171351	22411/17	Huia H1	7/06/2017	12,033		790,000	1,000	370	<46		<39	<36	faecal source - human
CMB171340	22435/17	Huia H1	16/06/2017	301	243	250,000	410	<53	<46		<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171334	22453/17	Huia H1	20/06/2017	313	97	300,000	83	100	<23		<20	<18	faecal source - human
CMB171322	22514/17	Huia H1	6/07/2017	450		97,000	630	200	<46		<39	<36	faecal source - human

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	Entero MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Ruminant BacR / 100 ml	Proportion Ruminant	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171386	22296/18	Huia H2	8/05/2017	1,058		180,000	260	1,000	<110		<98	<90	faecal source - human
CMB171379	22346/18	Huia H2	19/05/2017	323		95,000	200	320	<110		<98	<90	faecal source - human
CMB171370	22348/18	Huia H2	22/05/2017	441		51,000	90	140	<23		<20	<18	faecal source - human
CMB171361	22402/18	Huia H2	2/06/2017	556		120,000	44	140	<46		<39	<36	faecal source - human
CMB171352	22411/18	Huia H2	7/06/2017	17,329		260,000	320	330	<110		360	<90	faecal source - human + dog
CMB171341	22435/18	Huia H2	16/06/2017	933		580,000	780	710	<46		<39	<36	faecal source - human
CMB171335	22453/18	Huia H2	20/06/2017	1,076		130,000	87	82	<46		<39	<36	faecal source - human
CMB171323	22514/18	Huia H2	6/07/2017	631		99,000	1,700	200	<110		<98	<90	faecal source - human
CMB171387	22296/19	Huia H3	8/05/2017	292		33,000	140	96	<46		<39	<36	faecal source - human
CMB171380	22346/19	Huia H3	19/05/2017	471		72,000	320	<130	<110		<98	<90	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171371	22348/19	Huia H3	22/05/2017	727		51,000	400	71	<46		<39	<36	faecal source - human
CMB171362	22402/19	Huia H3	2/06/2017	420		970,000	3,000	2,400	<46		<39	<36	faecal source - human
CMB171353	22411/19	Huia H3	7/06/2017	5,172		140,000	1,300	170	<46		<39	<36	faecal source - human
CMB171342	22435/19	Huia H3	16/06/2017	1,553		1,600,000	57,000	5,900	<46		<39	<36	faecal source - human
CMB171324	22514/19	Huia H3	6/07/2017	399		65,000	1,100	<130	<110		<98	<90	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171363	22402/20	Huia H4	2/06/2017	331	121	53,000	36	<27	220	1-10%	<20	30	faecal source - ruminant (1 - 10%) + avian + probable weak human source (BiADO present, < quantitation limit)
CMB171354	22411/20	Huia H4	7/06/2017	591	85	22,000	<42	<53	1,200	10-50%	<39	<36	faecal source - ruminant (10 - 50%)
CMB171343	22435/20	Huia H4	16/06/2017	368		13,000	<42	<53	<46		<39	53	faecal source - avian

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	Entero MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Ruminant BacR / 100 ml	Proportion Ruminant	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171388	22296/21	Huia H5	8/05/2017	435		290,000	440	290	<46		<39	<36	faecal source - human
CMB171381	22346/21	Huia H5	19/05/2017	399		34,000	<100	130	<110		<98	<90	faecal source not identified, probably human source (BacH present, < quantitation limit)
CMB171372	22348/21	Huia H5	22/05/2017	299		4,200	51	<53	<46		<39	<36	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171355	22411/21	Huia H5	7/06/2017	81,640		2,000,000	2,600	1,500	<110		490	710	faecal source - human +dog + avian
CMB171325	22514/21	Huia H5	6/07/2017	576		61,000	240	<130	<110		<98	<90	faecal source not identified, probably human source (BiADO present, < quantitation limit)
CMB171389	22296/22	Huia H6	8/05/2017	11,199		3,700,000	320	130	<110		<98	1400	faecal source - human + avian
CMB171382	22346/22	Huia H6	19/05/2017	581		840	<100	<130	<110		<98	<90	faecal source not identified, note low level GenBac
CMB171356	22411/22	Huia H6	7/06/2017	3,873		210,000	400	300	<110		<98	<90	faecal source - human
CMB171326	22514/22	Huia H6	6/07/2017	489		35,000	83	100	<110		<98	<90	faecal source - human

Karamatua Creek

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Ruminant BacR / 100 ml	Proportion Ruminant	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171321	22514/23	Karamatura K1	6/07/2017	512	5,200	<42	<53	100	10-50%	<39	<36	faecal source - ruminant (10-50%

Laingholm

ESR Number	Client Reference	Description / Site ID	Date Sampled	*E. coli* MPN/ 100mL	General GenBac / 100 ml	Human BacH / 100 ml	Human BiADO / 100 ml	Dog DogBac / 100 ml	Avian GFD / 100 ml	Conclusion
CMB171264	22490/1	Laingholm L1	3/07/2017	8,164	510,000	440	580	1,200	<90	faecal source - human + dog
CMB171265	22490/2	Laingholm L2	3/07/2017	6,867	180,000	230	150	530	<90	faecal source - human + dog
CMB171266	22490/3	Laingholm L3	3/07/2017	15,531	240,000	530	<130	<98	<90	faecal source not identified (BacH potentially cat, rabbit, possum or weak human source)
CMB171267	22490/4	Laingholm L4	3/07/2017	6,488	450,000	690	360	1,300	<90	faecal source - human + dog
CMB171268	22490/5	Laingholm L5	3/07/2017	5,794	170,000	210	<130	570	<90	faecal source - dog + probably human (BiADO present, < quantitation limit)
CMB171269	22490/6	Laingholm L6	3/07/2017	5,794	110,000	160	<130	310	<90	faecal source - dog + probably human (BiADO present, < quantitation limit)
CMB171270	22490/7	Laingholm L7	3/07/2017	2,723	78,000	180	<130	340	<90	faecal source - dog + probably human (BiADO present, < quantitation limit)
CMB171271	22490/8	Laingholm L8	3/07/2017	3,654	77,000	120	<130	180	<90	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)
CMB171272	22490/9	Laingholm L9	3/07/2017	1,860	84,000	<100	150	340	<90	faecal source - dog + probably human (BacH present, < quantitation limit)
CMB171273	22490/10	Laingholm L10	3/07/2017	2,247	35,000	<100	<130	<98	<90	faecal source not identified
CMB171274	22490/11	Laingholm L11	3/07/2017	1,119	34,000	<100	<130	<98	<90	faecal source not identified
CMB171275	22490/12	Laingholm L12	3/07/2017	985	80,000	150	<130	150	<90	faecal source - dog (BacH potentially cat, rabbit, possum or weak human source)
CMB171276	22490/13	Laingholm L13	3/07/2017	464	98,000	<100	<130	290	<90	faecal source - dog
CMB171277	22490/14	Laingholm L14	3/07/2017	1,722	240,000	590	1,500	1,400	<90	faecal source - human + dog
CMB171278	22490/15	Laingholm L15	3/07/2017	4,611	800,000	<100	320	3,000	<90	faecal source - dog + probably human (BacH present, < quantitation limit)

Notes:
Brief details of the methods of analysis are available on request.
These results relate to samples as received.
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APPENDIX: Assay Interpretation Guidance Notes

PCR Marker interpretation notes

- Each marker is strongly associated with, but not exclusive to the source tested for. They each have some degree of non-specificity.
- Each marker is a separate test and the levels of the various markers within the same sample cannot be compared. For example, if sample A has a BacH result of 1,000 and a BacR of 100 it is not valid to say there is more human contamination than ruminant in sample A.
- Levels of the same marker in different samples can be compared. For example;
    - If sample A has a BacH result of 1,000 and sample B has a BacH of 10,000 it is valid to conclude there is more human faecal contamination in sample B than in sample A; or
    - If site H sampled in January has a GFD result of 500 and when sampled in February has a GFD result of 10,000, it is valid to conclude the level of avian faecal contamination in February is greater.
    - To be classified as a significantly greater or lesser result the level of marker should vary be a factor of 10.
- Both Human markers are required to be present for a positive human result.
- Ruminant specific markers are reported using a percentage value based on levels of this marker relative to the general marker in fresh ruminant faeces.
    - Samples reported as 50-100% ruminant are consistent with all of the general faecal marker having come from a ruminant source.
    - The lower levels reported (10-50%) may be a consequence of the presence of other sources of pollution, or in fact ruminant sources may still account for all the pollution, but this may include aged faecal material where relative levels of the ruminant marker decline more rapidly than the general marker.
    - Levels less than 10% ruminant suggest a very minor contribution from ruminant sources.

The detection limits of these methods vary depending on the volume of water filtered for analysis. We recommend a minimum volume of 200 mls and a maximum of 1000 mls, this range gives the following detection limits:

mls sample filtered	General GenBac / 100 mls	Human BacH / 100 mls	Human BiADO / 100 mls	Human HumM3 / 100 mls	Ruminant BacR / 100 mls	Ruminant Sheep / 100 mls	Ruminant Cow / 100 mls
< 400 mls	<130	<100	<130	<10	<110	<130	<14
400-700mls	<53	<42	<53	<4	<46	<51	<6
700-1000mls	<26	<21	<27	<2	<23	<26	<3

mls sample filtered	Dog DogBac / 100 mls	Avian GFD / 100 mls	Avian E2 / 100 mls	Gull- 2
> 400 mls	<98	<90	<120	presence / absence test
400-700mls	<39	<36	<50	
700-1000mls	<20	<18	<25	

FWA interpretation notes

The analysis of FWAs in septic tank and community wastewater consistently identifies levels between 10 and 70 µg/L. In previous analysis of water samples levels of FWA greater than 0.1 µg/L suggest human sewage, with levels greater than 0.2 µg/L strongly indicative of human sewage. Levels greater than 0.1 µg/L correlate well with other indicators of human pollution and indicate a local or recent source of pollution. FWAs degrade under sunlight exposure and will undergo dilution. Levels lower than 0.1 µg/L may be indicative of dilute or distant sources of human pollution.

Reference: Devane M., Saunders D. and Gilpin B. (2006). Faecal sterols and fluorescent whiteners as indicators of the source of faecal contamination. Chemistry in New Zealand 70(3), 74-7. http://www.nzic.org.nz/CiNZ/articles/Devane_70_3.pdf

Faecal sterol Intepretation Notes:

Faecal sterol ratios must be interpreted with consideration to the levels of sterols, and relative to one another. For example H1 is typically also above 5-6% in ruminant faeces. Human and ruminant sources generally require at least two of three ratios to reach thresholds.
Plant sterols and mixed sources also have differing effects on sterol interpretations which must be considered.

Conclusions are the best interpretation of sterols in our opinion. Conclusions in **bold** are highly supported by the sterol data, conclusions in brackets are supported by sterol data with some variation from a pure source, or with a lower degree of certainty.

Ratio Key:

Ratios indicative of faecal pollution (either human or animal)		
F1	coprostanol/cholestanol..	>0.5 indicative of faecal source of sterols
F2	24ethylcoprostanol/ 24-ethylcholestanol.	>0.5 indicative of faecal source of sterols.
Human indicative ratios (values exceeding threshold in red)		
H3	coprostanol/ 24-ethylcoprostanol	Ratio >1 suggests human source
H1	% coprostanol	Ratio >5-6% suggests human source
H2	coprostanol/(coprostanol+cholestanol)	Ratio >0.7 suggests human source
H4	coprostanol/(coprostanol+24-ethylcoprostanol)	Ratio >0.75 suggests human source
Ruminant indicative ratios (values exceeding threshold in blue)		
R3	24-ethylcholesterol/24-ethylcoprostanol	Ratio <1 suggests ruminant source, ratio >4 suggests plant decay
R1	% 24-ethylcoprostanol	Ratio >5-6% suggests ruminant source
R2	coprostanol/(coprostanol+24-ethylcoprostanol)	Ratio <30% suggests ruminant source
Avian indicative ratios (values exceeding threshold in yellow)		
A1	24-ethylcholestanol/(24-ethylcholestanol+24-ethylcoprostanol+24-ethylepicoprostanol)	A1 Ratio >0.4 suggests avian source AND A2 Ratio >0.5 suggests avian source
A2	cholestanol/(cholestanol+coprostanol+epicoprostanol)	

Find out more: phone 09 301 0101, email rimu@aucklandcouncil.govt.nz or visit aucklandcouncil.govt.nz **and knowledgeauckland.org.nz**

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