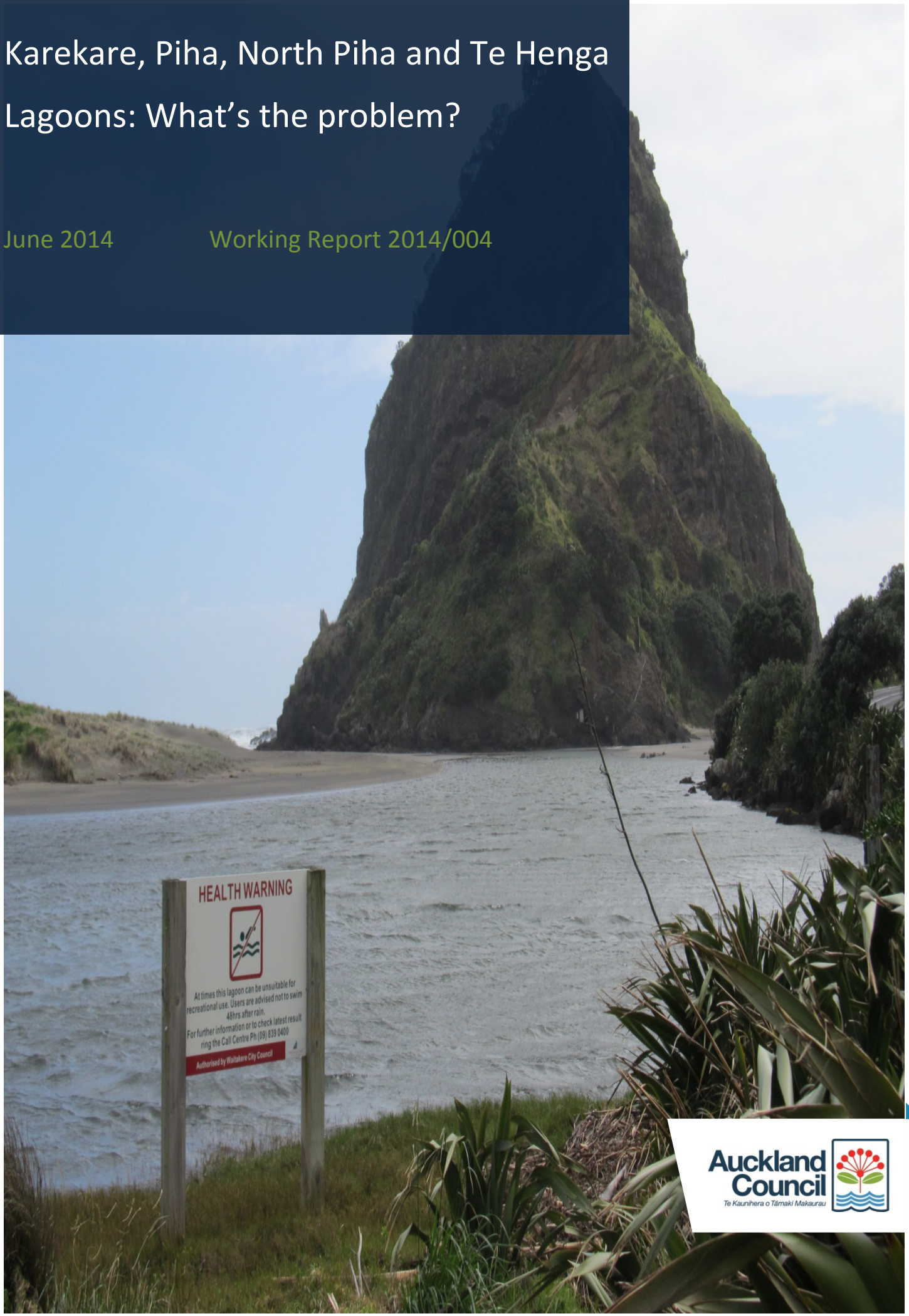
Karekare, Piha, North Piha and Te Henga Lagoons: What's the problem?

June 2014 Working Report 2014/004



Auckland Council
Te Kaunihera o Tāmaki Makaurau

Karekare, Piha, North Piha and Te Henga Lagoons: What's the problem?

June 2014 Working Report 2014/004

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Karekare, Piha, North Piha and Te Henga Lagoons: What's the problem?

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Executive Summary

Problem with the lagoons

The West Coast beaches at Karekare, Piha, North Piha and Te Henga in the Auckland region have excellent water quality. The problem is that the West Coast lagoons at the same locations have had poor water quality since Council monitoring began more than a decade ago. The cause of the poor water quality of these lagoons is contamination from faecal pollution. Not only does this pollution degrade the natural environment, it stigmatizes the communities and also poses a public health risk.

This report covers the Environmental Services Unit advice on:

- Sources of faecal pollution of the West Coast lagoons
- Conclusions about the faecal pollution of the West Coast lagoons

Sources of faecal pollution

The sources of faecal pollution of the West Coast lagoons originate from people's on-site wastewater (septic) systems as well as dog, bird, livestock and unidentified faecal sources. It is also known that weather, tidal conditions and the amount of sand blocking a lagoons flow to the sea also affects the pollution levels in each lagoon.

Conclusions

By determining the biological source of the pollution of the West Coast lagoons, recommendations can be made to reduce that pollution. The results show that a range of animal faecal sources are polluting the lagoons.

- Karekare lagoon is polluted by human and dog faecal sources
- Piha lagoon is polluted by human and wildfowl faecal sources
- North Piha lagoon is polluted by degraded human faecal sources
- Te Henga lagoon is polluted by human, dog, wildfowl and livestock faecal sources, where livestock are the dominant source
- All lagoons had occasions when the biological source of faecal pollution could not be identified

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1.0 Introduction

The West Coast lagoons at Karekare, Piha, North Piha and Te Henga have formed where their freshwater and marine environments interact. These lagoons have been monitored under the Council bathing beach 'Safeswim' programme in accordance with the Ministry for the Environment (MfE) and Ministry of Health (MoH) national guidelines (MfE/MoH 2003) since summer 2001 - 2002.

Under the national guidelines the last five years of this data along with a sanitary inspection of their catchments can be used to generate a Suitability for Recreation Grade. While the Suitability for Recreation Grade has not been formally calculated it is likely that all of the West Coast lagoons would be graded as very poor because of their history of poor water quality.

The ramification of this is that under the proposed National Policy Statement for Freshwater Management the West Coast lagoons would be considered unsafe for swimming because of the high risk of infection (MfE 2013). In order to clean up the lagoons it is necessary to understand what is causing their pollution. This pilot study aims to identify the biological sources of the faecal pollution of the West Coast lagoons.

2.0 Methodology

2.1 Site Locations and Descriptions

Site locations are shown in Appendix A. Table 1 below shows the sampling locations, description and rationale for choosing each site.

Table 1: Site locations

Site	Description	Easting	Northing	Rationale
Karekare Lagoon	Karekare lagoon at Safeswim sampling point	1731426	5905587	Consistent with Safeswim sampling point
Karekare Car park	Confluence of Karekare and Company streams	1731587	5905606	Consistent with Safeswim sampling point
Karekare Upstream	Company stream at Lone Kauri Rd bridge	1731696	5905581	To determine if Company stream is a source
Piha Lagoon	Piha lagoon at Safeswim sampling point	1730899	5909265	Consistent with Safeswim sampling point
Piha Upstream	Stormwater culvert passing under 18 Beach Valley Rd	1731213	5909049	To determine if the Seaview Rd stormwater sub-catchment is a contributor
North Piha Lagoon	North Piha lagoon at Safeswim sampling point	1730561	5910117	Consistent with Safeswim sampling point
North Piha Upstream	Matawhara stream at Marine Parade bridge	1730584	5910447	To determine if the Matawhara stream is a contributor
Te Henga Lagoon	Te Henga lagoon at Safeswim sampling point	1728739	5916238	Consistent with Safeswim sampling point
Te Henga Upstream	Waitakere river adjacent the Surf Club	1729010	5916339	To determine if the Waitakere river is a contributor

2.2 Microbiological Sampling

Karekare, Piha, North Piha and Te Henga lagoons have been monitored under the Safeswim programme since summer 2001-2002. Two sampling sites are monitored at Karekare (one in the lagoon and one at the confluence of Karekare and Company streams that feed into the lagoon) and one site in each of the other lagoons. Water quality sampling locations are shown in Appendix B. Water samples are analysed weekly from November until the end of March each year for the level of the faecal indicator bacteria *Escherichia coli (E. coli)*. It provides an indication of the potential health risk associated with swimming in the lagoons. The microbiological sampling results for the 2012-2013 Safeswim season are shown in Appendix C.

Under the national guidelines the last five years of results (i.e. ≈ 100 data points) can be used to generate a Microbiological Assessment Category. This provides a measurement of the actual water quality over time (MfE/MoH 2003). The Hazen calculation method is used in accordance with the national guidelines to determine the 95th percentile of the dataset for each lagoon. Refer to Table 2 below for Microbiological Assessment Category ranges for freshwater.

Table 2: Microbiological Assessment Category ranges for freshwater.

A	Sample 95 percentile ≤ 130 *E. coli* / 100 mL
B	Sample 95 percentile 131 – 260 *E. coli* /100 mL
C	Sample 95 percentile 261 – 550 *E. coli* / 100 mL
D	Sample 95 percentile > 550 *E. coli* / 100 mL

Source: (MfE/MoH 2003)

All of the lagoons have a Microbiological Assessment Category of 'D' under this criteria indicating they have regular exceedances of the national guidelines.

Samples are analysed by Aqualab NZ Ltd and reported by Council. 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 3 below shows the national guidelines trigger levels for each mode.

Table 3: Freshwater trigger levels from the national guidelines.

Freshwater (*E. coli* /100mL)	Mode
Single sample ≤ 260	Green/Safe - no further sampling required that week of sampling
Single sample > 260 ≤ 550	Amber/Alert - sampling is increased to daily to confirm if a problem exists
Single sample > 550	Red/Action - sampling continues daily until levels return to green/safe mode. Auckland Council places warning signage when this mode is triggered.

Source: (MfE/MoH 2003)

For this pilot investigation additional microbiological sampling was undertaken upstream of each lagoon, generally on a weekly basis, in conjunction with the faecal source tracking sampling and Safeswim programme. This is discussed further in Section 2.4.1 below. The locations of these upstream sampling locations are shown in Appendix B and described in Table 1.

2.3 Rainfall Records

Daily rainfall data (i.e. 24h daily totals) for the 2012 – 2013 Safeswim season was obtained from the Auckland Council Research Investigations and Monitoring Unit. This data is recorded by the Auckland Council rain-gauge located near Piha Domain. Rainfall records were then graphed against the *E. coli* (MPN/100mL) microbiological results for the 2012 – 2013 Safeswim season and linear regression (R^2) values were calculated.

2.4 Faecal Source Tracking

2.4.1 Sample collection and analysis

During December to February 2012 - 2013 2L bulk water samples were collected from the Safeswim sampling point in the lagoons at the same locations generally on a weekly basis. Over the New Year period no source tracking samples were collected due to logistical reasons. Upstream *E. coli* and 2L water samples were also collected from the Company stream in Karekare, the Matawhara stream at North Piha, the Waitakere river in Te Henga and the stormwater culvert that passes under Beach Valley Road in Piha. This stormwater culvert discharges directly into the Piha stream that feeds into the lagoon. To add to the dataset a third site was included on one occasion at Karekare, located at the confluence of the two streams entering the lagoon. Refer to Appendix B for the sampling locations.

Due to financial constraints only a selection of filtered samples were sent to the laboratory for faecal source tracking. A total of 39 samples were sent to the laboratory. These were considered to be a representative spread of samples for all sites and focused on the Christmas/New Year holiday period.

All 2L samples were taken to Aqualab NZ laboratory to be filtered through a 0.45µm membrane filter, the appropriate buffer agent added, and then the filters were frozen. At the close of the Safeswim season, the frozen filtered samples were then compared to their matching microbiological result. Those filtered samples with the higher corresponding microbiological concentrations (generally above the amber alert >260 *E. coli*/100mL level) for each site were collated and couriered to the Institute of Environmental Science and Research (ESR) laboratory for faecal source tracking using the Polymerase Chain Reaction (PCR) method.

Polymerase Chain Reaction based (microbial) faecal source tracking amplifies the DNA from host specific microbes in the filtered water samples and tests for the presence/absence of faecal indicator markers for the animals species available. The markers requested for testing during this pilot investigation were for general, ruminant, canine, wildfowl and three human faecal indicator markers (BiADO, HumM3 and BacH). The ruminant (livestock) marker is reported as a percentage of the general faecal marker and is the only marker expressed in this manner (ESR 2013).

Note that the full ESR 2013 faecal source tracking report is provided in Appendix D. It has further information regarding the methodology and interpretation of the results. It also includes faecal source tracking results for Foster Bay. However, this beach is not part of this pilot investigation and so the results are not discussed in this report.

2.4.2 Interpreting the faecal source tracking results

Specific markers for ruminant, dog, wildfowl and also a general faecal marker were assayed by the laboratory. The general marker indicates potential faecal contamination from human, cat, dog, cow, sheep, deer, horse, goat, pig, rabbit, possum, duck, swan, seagull, goose and chicken sources (ESR 2013). In addition, three indicative human markers were tested for and their various combinations of presence/absence are interpreted based on Table 4 below.

Table 4: Interpretation of human faecal indicative marker combinations.

Human (BiADO)	Human (HumM3)	Human (BacH)	Interpretation
+	+	+	Very strong evidence of human faecal contamination.
+	ND	+	Evidence of human faecal contamination, but may be lower levels, aged or partially treated.
ND	ND	+	May be human, dog, cat, rabbit, chicken. If canine marker absent then can exclude dog. If wildfowl marker absent then can exclude chicken.
ND	+	+	Possible human, but if ruminant marker present, may indicate possum faeces.
+	ND	ND	Possible human, but may indicate aged source as it is hypothesised that BiADO may persist longer in the environment than the other markers.
ND	ND	ND	No evidence of human faecal contamination.

Source: ESR 2013. Nb: + = Positive Result and ND = Not Detected. Source: ESR 2013

Semi-quantitative faecal source tracking PCR results are reported on a scale from extremely strong positive to very weak positive, or not detected for each marker based on Table 5 below. Extremely strong positive results indicate recent faecal contamination and conversely very weak positive results indicate an aged or partially treated source, which may have degraded the faecal indicative markers. If a high general faecal marker level is present but no specific marker is identified, the samples are interpreted as not consistent with fresh or untreated faeces from the sources tested for (ESR 2013).

Table 5: Faecal source tracking scale

Scale
Extremely Strong Positive (ESP)
Very Strong Positive (VSP)
Strong Positive (SP)
Positive (P)
Weak Positive (WP)
Very Weak Positive (VWP)
Not detected (ND)

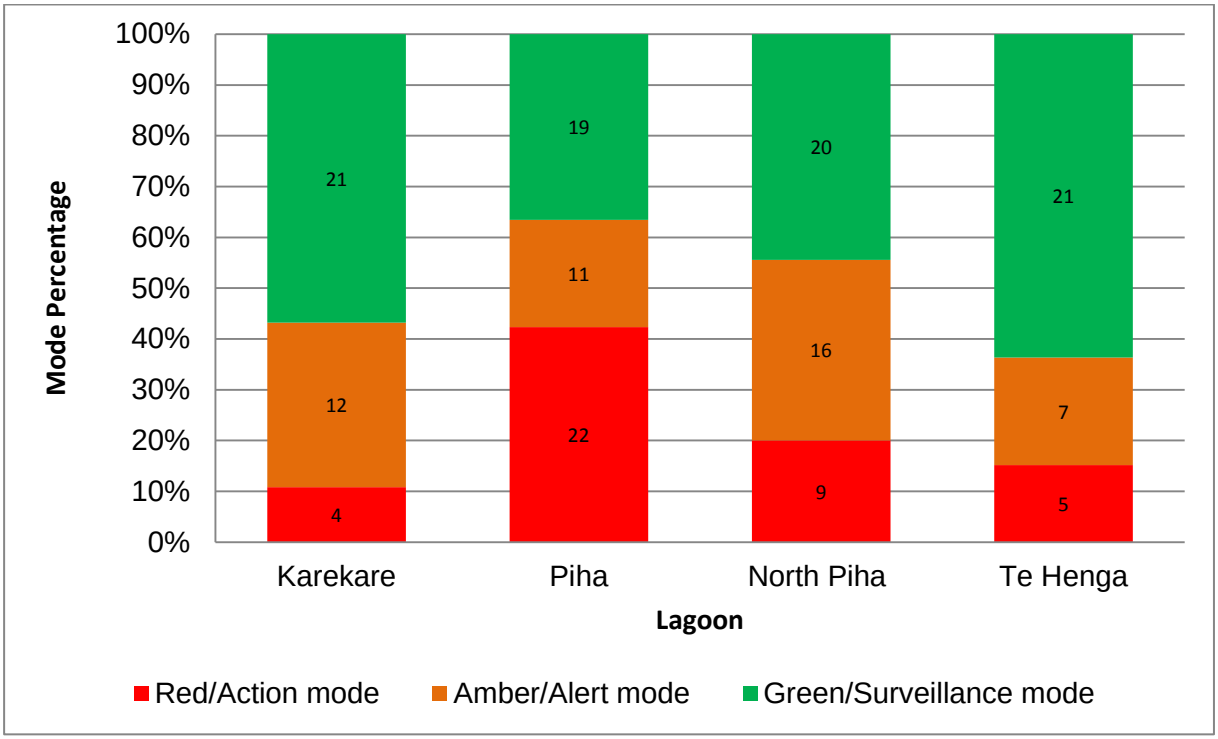
Source: ESR 2013

3.0 Results

3.1 Microbiological Results for Summer 2012-2013

The percentage of green, amber and red modes in relation to the national guidelines trigger levels over the 2012-2013 Safeswim season are shown in Figure 1 below. Refer to Table 3 for a description of the Safeswim trigger modes. These percentages were calculated from the total number of samples taken, including re-tests required as a result of exceedances of the green surveillance mode. The graph shows 42% (N=22) of the samples taken from Piha lagoon were in the red mode and thus required warning signage and a further 21% (N=11) required re-tests because they were in the amber mode. At North Piha 20% (N=9) of samples were in the red mode, while Te Henga and Karekare lagoons had 15% (N=5) and 11% (N=4) of samples in the red mode respectively.

Figure 1: Lagoon Mode Percentages for 2012 – 2013 Safeswim season.



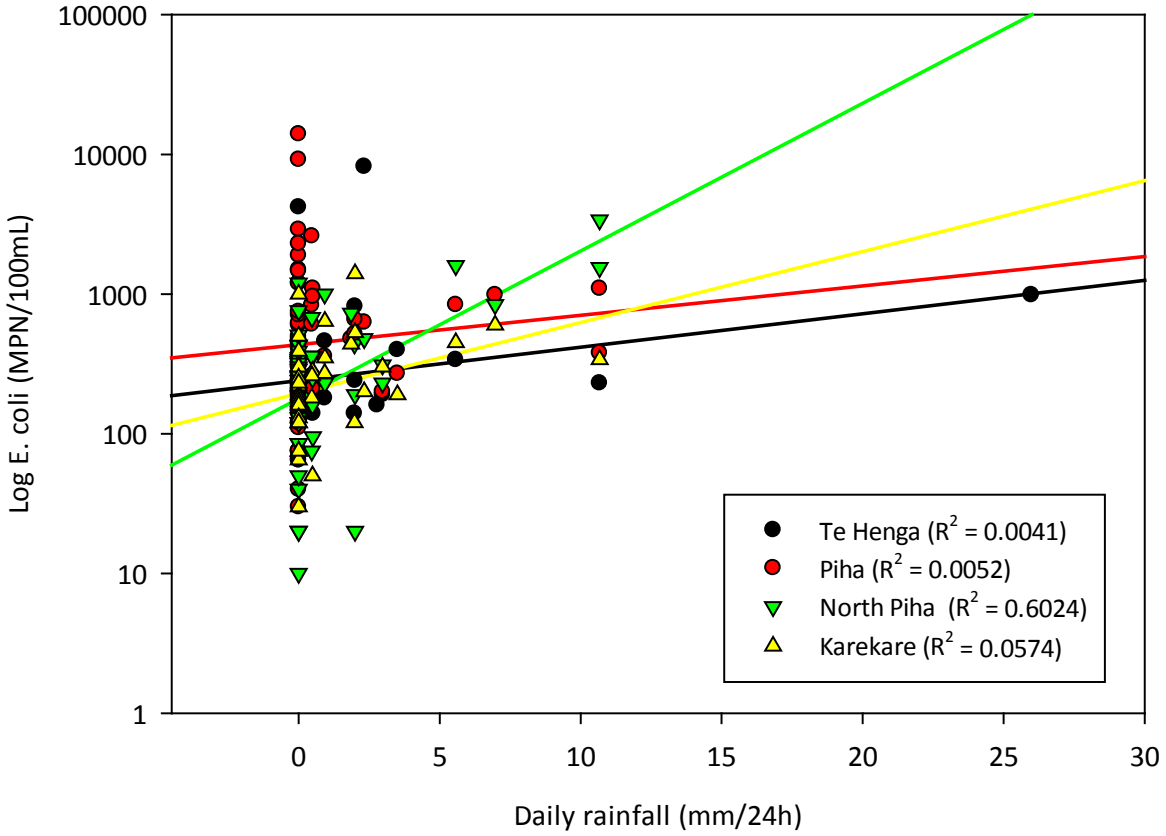
Nb: Sample size for each mode percentage is shown on the bar graphs.

3.2 Rainfall and the Microbiological Results

Rainfall records and the microbiological results for summer 2012-2013 are provided in Appendix C. Exceedances are shown as red and amber highlights. The most pronounced exceedance event, which had multiple and consecutive red and amber exceedances, particularly for the Piha and North Piha lagoons, occurred from 26 December 2012 – 5 January 2013. Immediately preceding this exceedance event was a continuous period of rainfall (recorded by the Piha Auckland Council rainfall gauge) which occurred from 26 December 2012 - 31 December 2013 where a total of 26mm fell over 8 days. However, statistical correlations for all lagoons using linear regression between rainfall and *E. coli* results for summer 2012 -2013 were not found for Karekare (R^2 = 0.0574), Piha (R^2 = 0.0052), or Te

Henga (R^2 = 0.0041) lagoons. Nevertheless, a weak correlation was found for North Piha (R^2 = 0.6024) lagoon as shown in Figure 2 below.

Figure 2: Daily Rainfall (mm/24h) *vs* Log *E. coli (MPN/100mL)*



Nb: Data range from 5 November 2012 to 31 March 2013

3.3 Faecal Source Tracking Results

3.3.1 Karekare

Faecal source tracking results for Karekare lagoon are shown in Table 6 below which is reproduced from the ESR 2013 report. The full ESR 2013 faecal source tracking report is provided in Appendix D. Sampling locations are shown in Appendix B.

The Karekare upstream results show that very weak positive human (BacH) and dog markers were present on 27 December 2012. The presence of just the human (BacH) marker without the wildfowl marker does not constitute a definitive human source as in this case it may also indicate cat and/or rabbit faecal sources (ESR 2013). No specific source was identified in any of the other upstream samples despite strong positive general marker results.

The single sample analysed from the Karekare car park site on 9 January 2013 had a very weak positive signal for human (BiADO and BacH) and dog markers. This combination of human indicative markers is evidence of human faecal contamination possibly from a weak, aged and/or partially treated source (ESR 2013).

Karekare lagoon had a very weak positive dog faecal marker present on 27 December 2012. On 15 and 16 January 2013 very weak positive results for the human markers BiADO and BacH were found which is additional evidence of human faecal contamination. No faecal source was identified on 6 February 2013 even though there was a strong positive result for the general marker. Wildfowl markers were not detected in any samples from Karekare lagoon, suggesting that wildfowl faecal sources were not a significant contributor to water quality issues in the lagoon at the time sampling was undertaken.

Table 6: Karekare faecal source tracking results.

Karekare – Upstream (Company stream at the Lone Kauri Rd bridge)		
Date	*E. coli* / 100mL	Markers Identified
27/12/2012	1100	General (SP), Dog (VWP), Human-BacH (VWP)
15/01/2013	540	General (SP), no specific source identified
16/01/2013	280	General (SP), no specific source identified
6/02/2013	480	General (SP), no specific source identified
Karekare – 'Car Park' (Confluence of Karekare and Company streams)		
Date	*E. coli* / 100mL	Markers Identified
9/01/2013	500	General (VSP), Human-BiADO (VWP), Human-BacH (VWP) and Dog (VWP)
Karekare – Lagoon (Safeswim sampling point)		
Date	*E. coli* / 100mL	Markers Identified
27/12/2012	600	General (P), Dog (VWP)
15/01/2013	1000	General (VSP), Human-BiADO (VWP), Human-BacH (WP)
16/01/2013	640	General (VSP), Human-BiADO (WP), Human-BacH (WP)
6/02/2013	450	General (SP), no specific source identified

Nb: Refer to Table 5 for the faecal source tracking scale.

3.3.2 Piha

Faecal source tracking results for Piha are shown in Table 7 below. The full ESR 2013 faecal source tracking report is provided in Appendix D. Sampling locations are shown in Appendix B.

Upstream samples for faecal source tracking in Piha took place on 22 and 28 March 2012 as part of a separate investigation. One of two samples taken directly from the stormwater culvert, draining the Seaview Rd stormwater sub-catchment, returned a very weak positive result for human faecal markers. Both the human BiADO and BacH markers were found. This is evidence of human faecal contamination, but possibly from a weak, aged and/or partially treated source (ESR 2013).

Results from Piha lagoon show that five of the seven samples had a very weak positive result for a wildfowl faecal source. On 27 and 28 December 2012 the microbiological results (990 and 480 *E. coli*/100mL respectively) were elevated for two days. However, no specific source was identified despite very weak positive wildfowl and human (BacH) markers being present before and after that period. Note that the human (BacH) marker alone with the dog marker absent can also be derived from cat, rabbit and/or chicken faecal sources (ESR 2013). However, on 21 January 2013 very weak positive results for the human (BiADO and BacH) faecal markers were detected. This combination of human indicative markers is more evidence of human faecal contamination.

Table 7: Piha faecal source tracking results.

Piha - Upstream (Beach Valley Rd stormwater culvert)		
Date	*E. coli* / 100mL	Markers Identified
22/3/2012	610	General (WP), no specific source identified
28/3/2012	340	General (SP), Human-BiADO (VWP), Human-BacH (VWP)
Piha – Lagoon (Safeswim sampling point)		
Date	*E. coli* / 100mL	Markers Identified
26/12/2012	1100	General (SP), Wildfowl (VWP), Human-BacH (VWP)
27/12/2012	990	General (SP), no specific source identified
28/12/2012	480	General (SP), no specific source identified
30/12/2012	2600	General (SP), Wildfowl (VWP), Human-BacH (VWP)
31/12/2012	630	General (SP), Wildfowl (VWP)
21/01/2013	830	General (VSP), Wildfowl (VWP), Human-BiADO (VWP), Human-BacH (VWP)
6/02/2013	840	General (SP), Wildfowl (VWP) , Human-BacH (VWP)

Nb: Refer to Table 5 for the faecal source tracking scale.

3.3.3 North Piha

Sampling locations are shown in Appendix B and the full ESR 2013 faecal source tracking report is provided in Appendix D. Table 8 below shows that the North Piha upstream sampling site detected a very weak positive dog faecal source in on 7 January 2013 along with a very weak positive human (BacH) marker. Having just this human marker present in isolation to the other human markers with the wildfowl marker also absent may also indicate cat and/or rabbit faecal sources (ESR 2013). The further three upstream samples did not identify any specific sources of faecal contamination even though there was strong and very strong positive results for the general faecal marker.

The sampling undertaken at North Piha lagoon, despite having elevated microbiological levels and at least a positive general marker result on every sampling occasion, could not definitively identify a faecal source. Nevertheless, on two out of the seven sampling occasions very weak positive human indicative markers (BacH on 7 January 2013 and BiADO on 6 February 2013) were found. Having just the human BacH marker present in the absence of all the other markers tested for could also mean that the contamination is derived from dog, cat, rabbit or chicken faecal sources (ESR 2013). However, having solely the human BiADO marker present in isolation from all the other markers tested for could possibly mean that there is a degraded human source present (ESR 2013).

Table 8: North Piha faecal source tracking results.

North Piha – Upstream (Matawhara stream at the Marine Parade North bridge)		
Date	*E. coli* / 100mL	Markers Identified
26/12/2012	750	General (VSP), no specific source identified
27/12/2012	810	General (SP), no specific source identified
29/12/2012	200	General (SP), no specific source identified
7/01/2013	450	General (VSP), Dog (VWP), Human-BacH (VWP)
North Piha - Lagoon (Safeswim sampling point)		
Date	*E. coli* / 100mL	Markers Identified
26/12/2012	3400	General (SP), no source specific identified
27/12/2012	840	General (SP), no source specific identified
28/12/2012	730	General (P), no source specific identified
29/12/2012	1000	General (SP), no source specific identified
30/12/2012	680	General (VSP), no source specific identified
7/01/2013	300	General (SP), Human-BacH (VWP) otherwise no source specific identified
6/02/2013	1600	General (SP), Human-BiADO (VWP), otherwise no source specific identified

Nb: Refer to Table 5 for the faecal source tracking scale.

3.3.4 Te Henga

Sampling locations are shown in Appendix B and the full ESR 2013 faecal source tracking report is provided in Appendix D. Table 9 shows the Te Henga faecal source tracking results reproduced from the ESR 2013 report.

At the Te Henga upstream sampling site a very weak positive wildfowl source was identified on 7 January 2013 with a low level contribution from a ruminant source. On the 5 February 2013 there were very weak positive results for human markers (HumM3 and BacH) in a combination that may indicate the presence of possum faeces (ESR 2013). However, in the same sample a ruminant source which accounted for at least 50% of the general faecal marker was identified.

Te Henga lagoon had a mix of dog, wildfowl, ruminant and human faecal sources. Dog faecal matter was the prevalent source on 31 December 2012 because it had the higher (positive) result in relation to other sources present. Also present were very weak positive human (BacH) and wildfowl markers. A mixture of weak ruminant, wildfowl and dog markers were found on 7 January 2013 as well as very weak positive human (BacH). On both these occasions the presence of human marker BacH alone does not represent definitive evidence of a human faecal source.

On the 5 February all markers for human (BiADO, HumM3 and BacH), dog, ruminant and wildfowl were present. Having all three human markers present is very strong evidence of human faecal contamination (ESR 2013). However, the ruminant marker in the same sample again contributed to at least 50% of the general marker and is therefore likely to be the dominant source of contamination.

Table 9: Te Henga faecal source tracking results.

Te Henga – Upstream (adjacent Surf Club)		
Date	*E. coli* / 100mL	Markers Identified
7/01/2013	1500	General (VSP), Ruminant (≈ 5% of General), Wildfowl (VWP)
5/02/2013	790	General (VSP), Ruminant (≈ 50% of General), Wildfowl (VWP), Human-HumM3 (VWP), Human-BacH (WP)
Te Henga – Lagoon (Safeswim sampling point)		
Date	*E. coli* / 100mL	Markers Identified
31/12/2013	8200	General (VSP), Dog (P), Wildfowl (VWP), Human-BacH (VWP)
7/01/2013	240	General (VSP), Ruminant (≈ 5% of General), Wildfowl (WP), Dog (WP), Human-BacH (VWP)
5/02/2013	990	General (VSP), Ruminant (≈ 50% of General), Wildfowl (VWP), Dog (VWP), Human-BiADO (VWP), Human-HumM3 (VWP), Human-BacH (VWP)

Nb: Refer to Table 5 for the faecal source tracking scale.

4.0 Discussion

The faecal source tracking results for Karekare, Piha and Te Henga lagoons show that faecal contamination originating from human, dog, wildfowl and ruminant sources is present. However, all lagoons had occasions when the biological source of faecal pollution could not be identified. Nevertheless, whenever a specific faecal source was not identified there were mostly strong positive to very strong positive results for the general faecal marker indicating that faecal contamination was present. This is underlined by the high faecal indicator bacteria results.

Faecal indicator bacteria such as *E. coli* can naturalise in environments that are favourable, such as in soil and sediments, sand and algal matter. This means that *E. coli* levels can be naturally elevated and thus give a false indication of public health risks (Solo-Gabriele et al. 2000, Verhougstraete et al. 2010). Additionally, there are a range of factors that affect the fate of *E. coli* in the environment such as temperature, salinity, rainfall, available nutrients, predation and environmental pollutants (Solo-Gabriele et al 2000). Other faecal indicator bacteria, such as *Enterococci spp.* are also known persist and grow in soil, sand, vegetative matter, freshwater and marine sediments (Byappanahalli et al. 2012). Natural persistence and proliferation of *E. coli* could be one reason why the lagoons experience high *E. coli* concentrations over the summer months. If this is the case then an option to reduce *E. coli* concentrations could be to manage lagoon outlets to the sea via resource consents if/when water quality poses a serious health risk.

Having high levels of the general marker, but very low levels of human markers suggests that other faecal sources may be more dominant. High general marker levels can also indicate aged or partially treated faecal sources which have degraded the markers (ESR 2013). Such degradation of the markers could be caused by treatment via on-site wastewater systems, dilution and sunlight (B Gilpin, 2013, pers. comm., 13 Nov). High general marker levels could also be caused by faecal sources that were not specifically tested for such as those derived from feral animals. However, populations of pest animals are generally very low in the West Coast lagoon catchments (J Craw, 2013, pers. comm., 26 Aug).

Public and commercial facilities such as campgrounds, toilet blocks, surf clubs and cafes which are common in the lagoon catchments cannot be ruled out from contributing to the bacterial contamination of the lagoons. However, most of these facilities have resource consents because of the quantity of wastewater requiring disposal and are subject to routine compliance monitoring. They are also subject to consent conditions that require maintenance, certification and discharge monitoring of the wastewater systems. While these sites cannot be eliminated as potential contributors to the bacterial contamination of the lagoons, the stricter requirements of their discharge permits means they are less likely to be the primary source.

The results suggest that on-site wastewater systems are the most likely source of the human faecal contamination detected in Piha, Karekare and Te Henga lagoons because of the prevalence of the human markers. It is also possible that human sources are a larger contributor than is indicated by the results as on-site wastewater systems degrade the human markers making human contamination harder to detect. Mitigation of this potential source of contamination could involve educating householders about their water usage (and thus wastewater production), regular maintenance of on-site systems and promoting/facilitating upgrades of old or failing treatment and disposal systems.

Karekare Lagoon

Karekare lagoon showed very weak and weak positive human faecal sources. The combination of human markers present with no other source identified means that there is reasonable evidence of human faecal contamination in Karekare lagoon. The most likely cause of this is failing on-site wastewater systems in the catchment that are cross-contaminating stormwater run-off which then enters the lagoon via ground water or surface water. This may be occurring because of the close proximity of residences to the stream and thus their domestic wastewater discharges. Further monitoring will need to be undertaken to identify which part(s) of the catchment the contamination is coming from.

Dog faecal sources were also detected on some occasions at all three Karekare sampling locations indicating that this area is popular for dog walking. Signage and dog litter stations to minimise this source of contamination are therefore recommended.

Piha Lagoon

Piha lagoon recorded very weak positive results for human markers. Most samples had a single human marker without the other human markers present. This does not constitute a definitive human faecal source. However, on the 21 January 2013 the combination of human markers found is evidence for human faecal contamination but that the source may be diluted, aged and/or partially treated by wastewater systems. Furthermore, samples taken directly from the culvert receiving stormwater run-off from the Seaview Rd sub-catchment showed a combination of human markers which is additional evidence of a human source of contamination. Because this stormwater ultimately enters the Piha lagoon it is likely that wastewater systems in this part of the catchment are contributing to its contamination.

Wildfowl markers were also found in the lagoon. This is not surprising as ducks are present along the banks of the Piha stream and lagoon. While there are inherent difficulties in managing bird populations signage to deter the public from feeding ducks should be considered.

On two occasions when sampling was undertaken in the lagoon, no specific source was detected. The general marker on both of these occasions was strong positive. This may be related to the source being degraded by wastewater treatment systems, biodegradation or that the source is from some other animal species not tested for, such as feral animals. However, it is understood that feral animal populations are well managed in the catchment and therefore feral animal contamination of the lagoons is unlikely.

North Piha Lagoon

Upstream of the lagoon, only a very weak positive dog and human marker was found on one out of four sampling occasions. The lagoon had frequent high microbiological and general faecal marker levels but only singular, very weak human markers were found on two separate occasions. The results from the lagoon can only speculatively be interpreted as human in origin as the markers were not found in association with any other human markers. Such results are not consistent with fresh or untreated faecal sources or that an alternative source without a specific marker tested for is the source (e.g. feral animals). However, in the lagoon it could be concluded that it is being polluted by a degraded/treated human source. This is because the specific marker (BiADO) found is hypothesised to persist longer in the environment than the other human markers (ESR 2013). Nevertheless, further investigation is required at North Piha lagoon to determine the biological source of the contamination.

Te Henga Lagoon

Upstream of the Te Henga lagoon very weak positive human markers were found on one occasion, but in the presence of the ruminant marker this may indicate possum faeces (ESR 2013). This is because it has one of the same genetic markers as humans. The strongest signal came from the ruminant marker, most likely cattle and/or sheep, which accounted for up to 50% of the general faecal marker.

The lagoon had a mixture of dog, ruminant (livestock) and wildfowl markers. There was also a very weak positive return for all three human markers which indicates strong evidence of human faecal contamination from the catchment. However, in the same sample the ruminant signal accounted for up to 50% of the general faecal contamination and was therefore the dominant source. The predominance of ruminant faecal contamination in Te Henga lagoon suggests that bacterial loads in the lagoon could be minimised by excluding stock from waterways further up the catchment.

In addition, there were also dog faecal sources detected on three occasions in Te Henga lagoon. On one of these occasions there was a positive return for the dog marker which indicates a stronger, more recent source than the very weak positive results for all other markers on this date. Te Henga beach is a popular place to run dogs as there is an off-leash section on the beach. Access to the beach is alongside the lagoon, and therefore signage and dog litter stations to mitigate this contamination source are recommended.

5.0 Conclusions

Microbiological water quality at Karekare, Piha, North Piha and Te Henga beaches is excellent. However, the microbiological water quality of the West Coast lagoons at each of these locations is poor and has been of concern since Council monitoring began in summer 2001 - 2002. The results show that a range of animal faecal sources are polluting the lagoons which are originating from human (septic systems), dogs, wildfowl, livestock and unidentified sources.

Conclusions

- Karekare lagoon is polluted by human and dog faecal sources
- Piha lagoon is polluted by human and wildfowl faecal sources
- North Piha lagoon is polluted by degraded human faecal sources
- Te Henga lagoon is polluted by human, dog, wildfowl and livestock faecal sources, where livestock are the dominant source
- All lagoons had occasions when the biological source of faecal pollution could not be identified

6.0 Recommendations

To better manage the water quality of the West Coast lagoons at Karekare, Piha, North Piha and Te Henga a range of recommendations follow.

Recommendations

- Improve septic system management in all lagoon catchments
- Improve control of dogs and wildfowl adjacent all of the lagoons
- Exclude stock from waterways in Te Henga lagoon catchment
- Place permanent warning signage explaining the health risks of swimming in the lagoons
- Investigate whether opening the lagoon mouths would lower pollution levels in the lagoons
- Further investigation to identify the biological sources of faecal pollution of the lagoons

7.0 References

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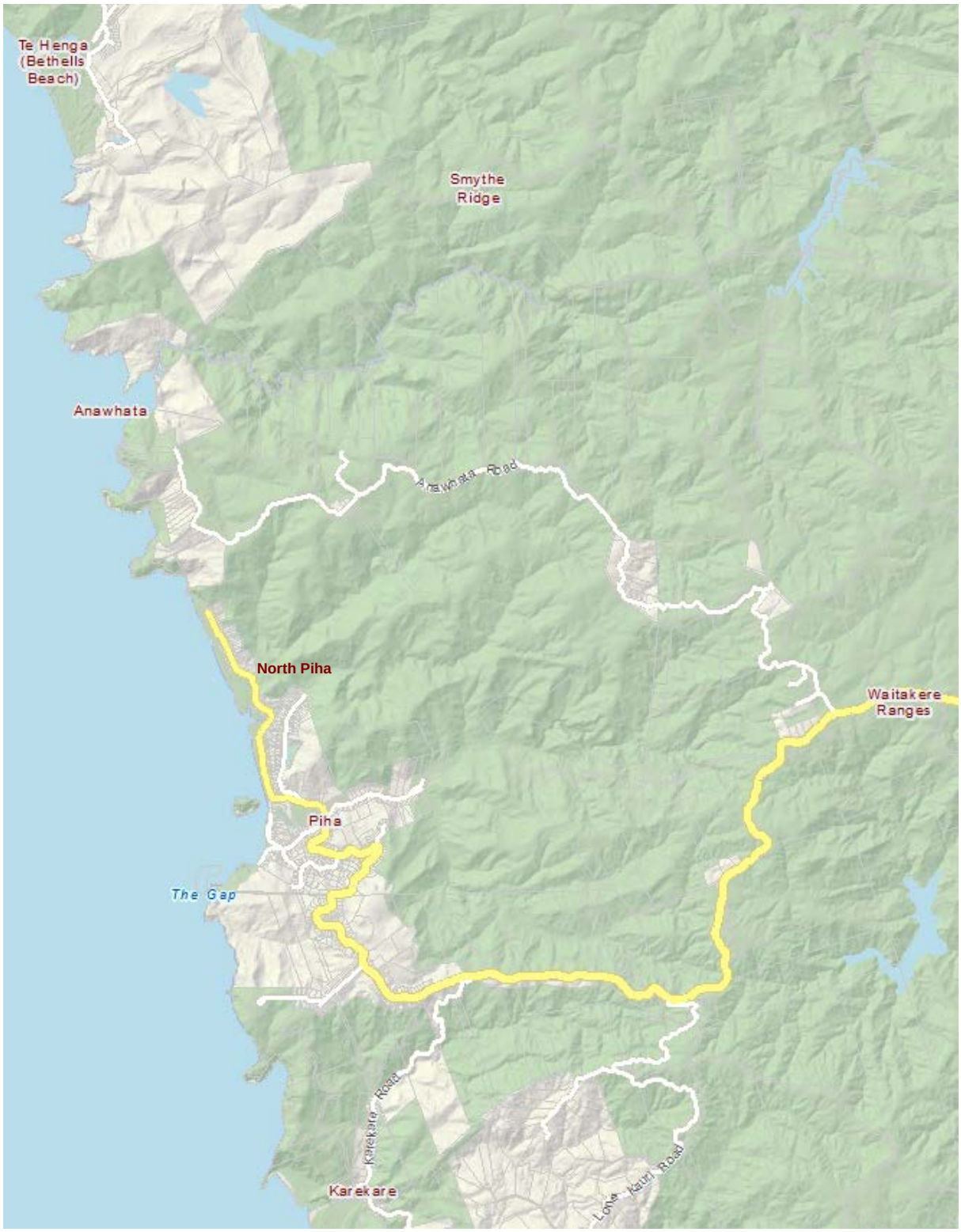
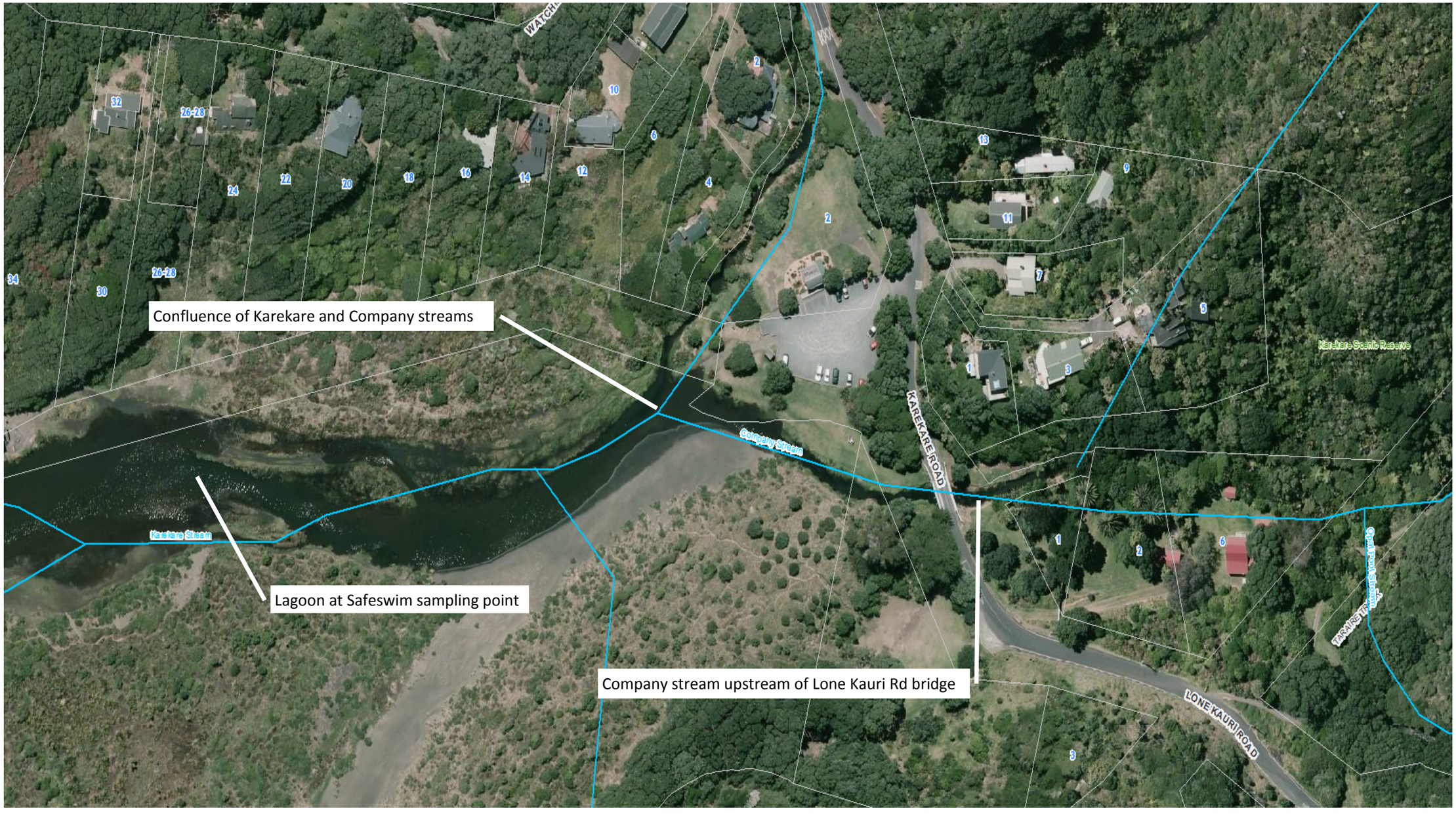
Appendix A Site locations

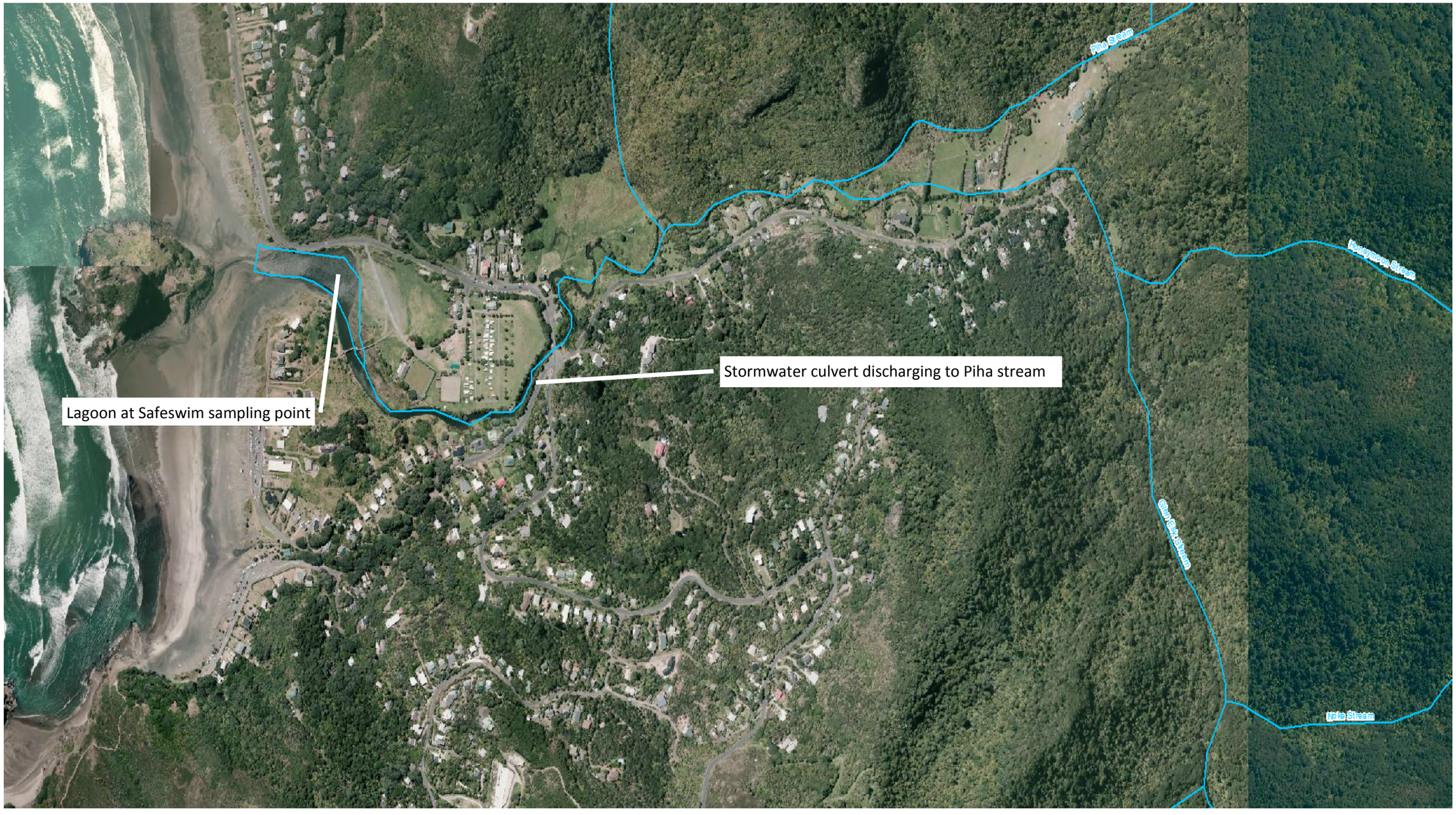


Appendix B Sampling locations

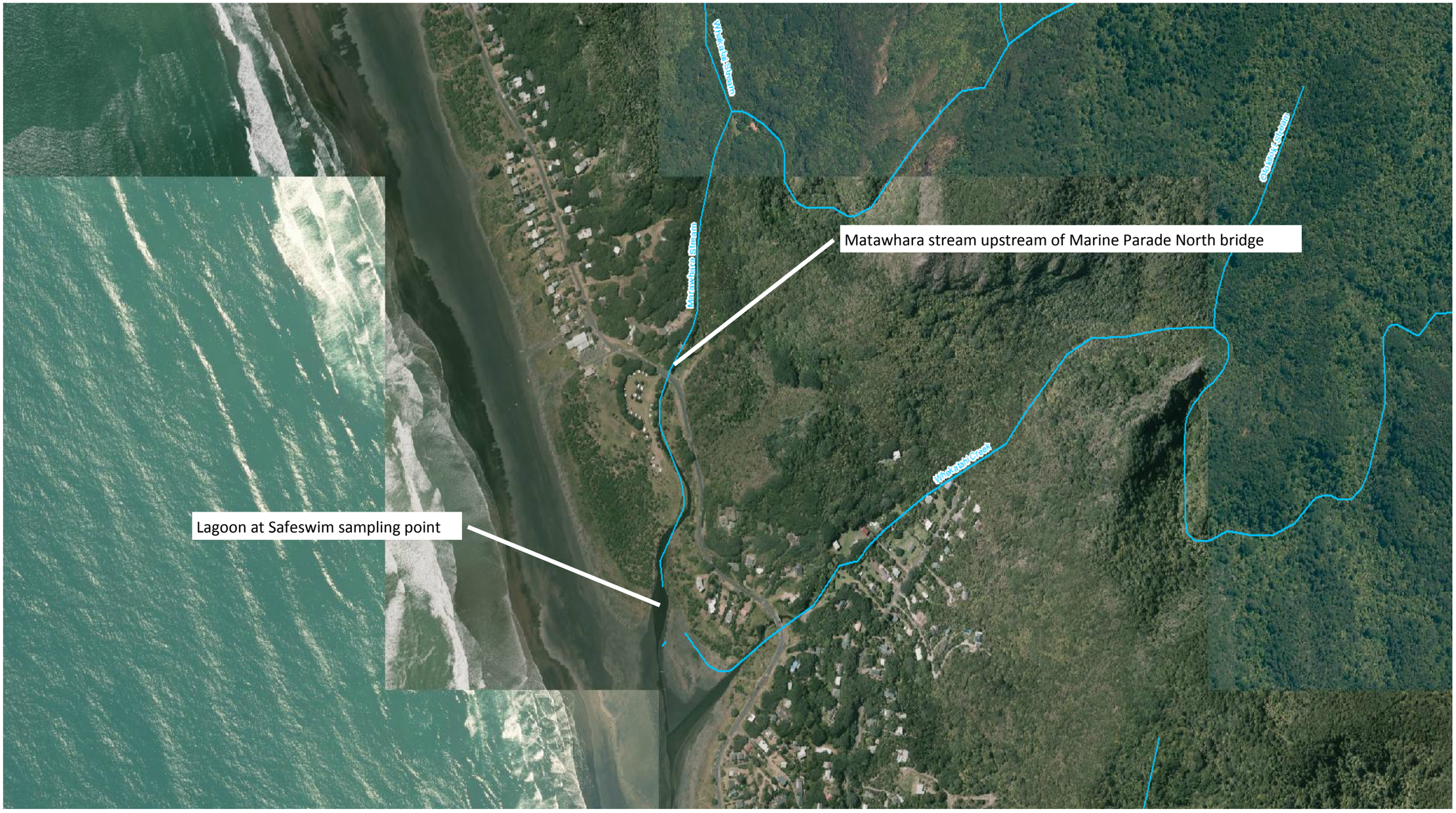
Karekare



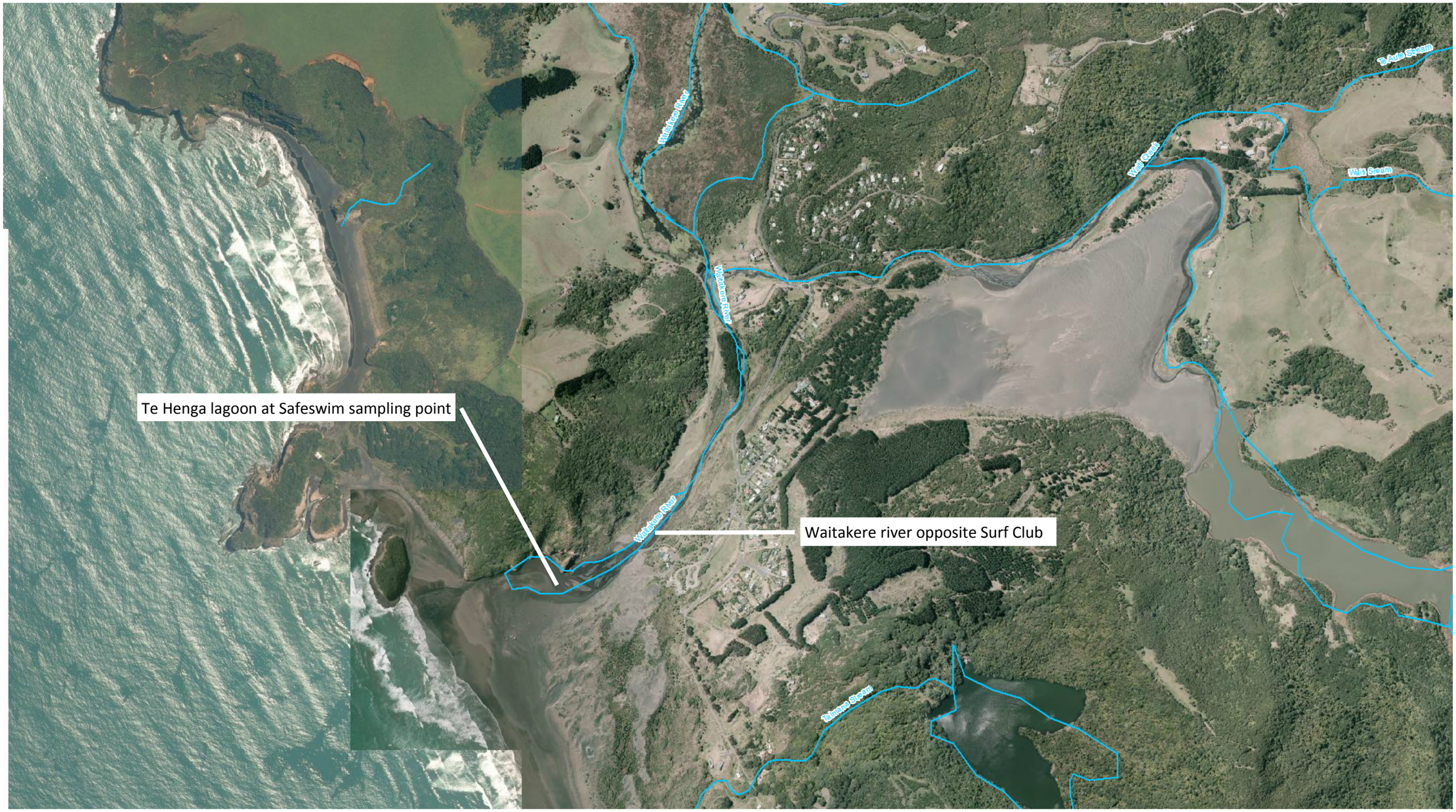
Piha


Piha Stream
Stormwater culvert discharging to Piha stream
Lagoon at Safeswim sampling point
Piha Stream

North Piha


Matawhara stream upstream of Marine Parade North bridge
Lagoon at Safeswim sampling point
Matawhara Stream
Unnamed Stream
Unnamed Stream
Unnamed Stream

Te Henga


Te Henga lagoon at Safeswim sampling point
Waitakere river opposite Surf Club
Waitakere River
Waitakere River
Wait Creek
Wait Stream
Te Awa Stream
Tauhara Stream

Appendix C 2012 – 2013 Safeswim results and rainfall

E. coli and rainfall results for the 2012/13 Safeswim season. Nb: Blank cells denote no sampling was undertaken. See Table 3 for explanation of the green, amber and red modes.

Date	Karekare	Piha	North Piha	Te Henga	Rainfall (mm/24h)
5/11/2012	75	120	85		0
6/11/2012				75	0
7/11/2012					8.74
8/11/2012					1.46
9/11/2012					0
10/11/2012					0
11/11/2012					0
12/11/2012	300	200	310	190	2.97
13/11/2012	50		250		0.49
14/11/2012					0
15/11/2012					0
16/11/2012					3.96
17/11/2012					0.5
18/11/2012					4.45
19/11/2012				65	0
20/11/2012	30	75	430		0
21/11/2012			330		0
22/11/2012			120		0
23/11/2012					0
24/11/2012					0
25/11/2012					0
26/11/2012	65	40	120	150	0
27/11/2012					0

Date	Karekare	Piha	North Piha	Te Henga	Rainfall (mm/24h)
28/11/2012					0
29/11/2012					0
30/11/2012					5.44
1/12/2013					0
2/12/2013					0
3/12/2012	280	260	360		0.49
4/12/2012	120		440	140	1.98
5/12/2012					2.97
6/12/2012					2.97
7/12/2012					54.42
8/12/2012					8.9
9/12/2012			230		2.97
10/12/2012	390	500	350	270	0
11/12/2012	220	480	320	200	0
12/12/2012		1100	95		0.5
13/12/2012		1900			0
14/12/2012		220			0
15/12/2012					0
16/12/2012					0
17/12/2012	120	240	430		0
18/12/2012			340	150	0
19/12/2012			160		0.49
20/12/2012					0.46
21/12/2012					0
22/12/2012					0.47
23/12/2012					0

Date	Karekare	Piha	North Piha	Te Henga	Rainfall (mm/24h)
24/12/2012					0.93
25/12/2012					2.31
26/12/2012	340	1100	3400	230	10.67
27/12/2012	600	990	840		6.96
28/12/2012	440	480	730		1.86
29/12/2012	270	360	1000		0.92
30/12/2012	260	2600	680		0.47
31/12/2012	200	630	480	8200	2.32
1/01/2013		2900	1200	4200	0
2/01/2013		620	760	65	0
3/01/2013		1200	320		0
4/01/2013		380	1550		10.67
5/01/2013		610	360		0.46
6/01/2013		210	240		0
7/01/2013	300	200	300	240	0
8/01/2013	500		390		0
9/01/2013	190		130		0
10/01/2013					0
11/01/2013					0
12/01/2013					0
13/01/2013					0
14/01/2013					0.46
15/01/2013	1000	190	290	410	0
16/01/2013	640		230	460	0.93
17/01/2013	300			200	0
18/01/2013	350				0.93

Date	Karekare	Piha	North Piha	Te Henga	Rainfall (mm/24h)
19/01/2013	180				0
20/01/2013					0
21/01/2013	180	830	75		0.46
22/01/2013		110		260	0
23/01/2013					0
24/01/2013					0
25/01/2013					0
26/01/2013					0
27/01/2013					0
28/01/2013					0
29/01/2013				140	0
30/01/2013	250	330	40		0
31/01/2013		360			0
1/02/2013		120			0
2/02/2013					0
3/02/2013					0
4/02/2013					0
5/02/2013				990	25.98
6/02/2013	450	840	1600	340	5.57
7/02/2013	75	180	510	190	0
8/02/2013			260		0
9/02/2013					0
10/02/2013					0
11/02/2013	170	710	20		0
12/02/2013		750		600	0
13/02/2013		1200		440	0

Date	Karekare	Piha	North Piha	Te Henga	Rainfall (mm/24h)
14/02/2013		240		180	0.92
15/02/2013					0.47
16/02/2013					0
17/02/2013					0
18/02/2013					0
19/02/2013				300	0
20/02/2013	120	170	50	160	0
21/02/2013					0
22/02/2013					0
23/02/2013					0
24/02/2013					0
25/02/2013	230	300	20	75	0
26/02/2013		30			0
27/02/2013					0
28/02/2013					0
1/03/2013					0
2/03/2013					0
3/03/2013					0
4/03/2013				160	2.78
5/03/2013	160	370	85		0
6/03/2013		75			0
7/03/2013					0
8/03/2013					0
9/03/2013					0
10/03/2013					0
11/03/2013					0

Date	Karekare	Piha	North Piha	Te Henga	Rainfall (mm/24h)
12/03/2013	130	1500	10		0
13/03/2013		240		220	0
14/03/2013					0
15/03/2013					0
16/03/2013					0
17/03/2013					0
18/03/2013					15.5
19/03/2013	1400	660	190	820	2
20/03/2013	190	270		400	3.5
21/03/2013		210		140	0.5
22/03/2013					0
23/03/2013					2.5
24/03/2013					0.5
25/03/2013					0
26/03/2013	530	520	20	240	2
27/03/2013	120	14000			0
28/03/2013		2300			0
29/03/2013		960			0.5
30/03/2013		1470			0
31/03/2013		9200			0

Appendix D Faecal source tracking report

Institute of Environmental Science & Research Limited
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protecting people and their environment through science

24 May 2013

To: Andrew Noble
Auckland Council
Level 9, 8 Hereford St
Auckland
Email: Andrew.Noble@aucklandcouncil.govt.nz

From: Dr Brent Gilpin
ESR Christchurch Science Centre
27 Creyke Road
CHRISTCHURCH

REPORT ON FAECAL SOURCE TRACKING ANALYSIS (Purchase Order 3000084642)

The following 39 samples were received on 7 May 2013 and were analysed for PCR markers.

ESR Number	Client Reference	Sample Site	Sample Date	Volume (ml)	*E. coli*
CMB130208	17220/45	Bethells Lagoon	31/12/2012	200	8200
CMB130214	17261/2	Bethells Lagoon	7/01/13	400	240
CMB130220	17261/39	Bethells Lagoon	5/02/13	250	990
CMB130209	17261/1	Bethells Lagoon Upstream	7/01/13	300	1500
CMB130219	17261/38	Bethells Lagoon Upstream	5/02/13	250	790
CMB130170	17220/17	Foster Bay	26/12/2012	500	770
CMB130202	17220/31	Foster Bay	28/12/2012	350	900
CMB130211	17261/12	Foster Bay	14/01/13	500	320
CMB130193	17220/18	Foster Bay Upstream	27/12/2012	400	750
CMB130199	17220/24	Foster Bay Upstream	28/12/2012	450	300
CMB130227	17261/9	Foster Bay Upstream	10/01/13	700	550
CMB130212	17261/13	Foster Bay Upstream	14/01/13	500	9800
CMB130210	17261/11	Karekare Carpark	9/01/13	800	500
CMB130196	17220/21	Karekare Lagoon	27/12/2012	500	600
CMB130215	17261/20	Karekare Lagoon	15/01/13	700	1000

ESR Number	Client Reference	Sample Site	Sample Date	Volume (ml)	*E. coli*
CMB130217	17261/25	Karekare Lagoon	16/01/13	800	640
CMB130221	17261/40	Karekare Lagoon	6/02/13	500	450
CMB130198	17220/23	Karekare Lagoon Upstream	27/12/2012	300	1100
CMB130213	17261/16	Karekare Lagoon Upstream	15/01/13	700	540
CMB130216	17261/22	Karekare Lagoon Upstream	16/01/13	800	280
CMB130224	17261/43	Karekare Lagoon Upstream	6/02/13	300	480
CMB130168	17220/12	Piha North Lagoon	26/12/2012	700	3400
CMB130195	17220/20	Piha North Lagoon	27/12/2012	500	840
CMB130201	17220/28	Piha North Lagoon	28/12/2012	500	730
CMB130204	17220/36	Piha North Lagoon	29/12/2012	400	1000
CMB130206	17220/41	Piha North Lagoon	30/12/2012	400	680
CMB130226	17261/8	Piha North Lagoon	7/01/13	600	300
CMB130223	17261/42	Piha North Lagoon	6/02/13	300	1600
CMB130169	17220/15	Piha North Lagoon Upstream	26/12/2012	800	750
CMB130197	17220/22	Piha North Lagoon Upstream	27/12/2012	500	810
CMB130203	17220/33	Piha North Lagoon Upstream	29/12/2012	400	200
CMB130225	17261/6	Piha North Lagoon Upstream	7/01/13	700	450
CMB130167	17220/11	Piha South Lagoon	26/12/2012	700	1100
CMB130194	17220/19	Piha South Lagoon	27/12/2012	500	990
CMB130200	17220/27	Piha South Lagoon	28/12/2012	400	480
CMB130205	17220/40	Piha South Lagoon	30/12/2012	400	2600
CMB130207	17220/42	Piha South Lagoon	31/12/2012	400	630
CMB130218	17261/30	Piha South Lagoon	21/01/13	400	830
CMB130222	17261/41	Piha South Lagoon	6/02/13	300	840

PCR Assays

DNA was extracted from filtered water samples and tested using PCR assays for general faecal indicator (GenBac), human indicative markers (BiAdo, HumM3, BacH), ruminant indicative marker (BacR), canine marker (DogBac), and a wildfowl marker (GFD). The specificity of the assays, as tested against known faecal samples is shown below (Last updated May 2013).

Semi-quantitative results are reported on a scale from Extremely Strong Positive down to Very Weak Positive. Ruminant marker (BacR) is reported as a percentage of the GenBac. In fresh ruminant faeces levels of BacR are approximately 10% of the GenBac levels.

Assay	**Present in faeces from:**	**Low level non-specificity**	**Negative in faeces from:**
General GenBac	Human, Cat, Dog, Cow, Sheep, Deer, Horse, Goat, Pig, Rabbit, Possum, Duck, Swan, Seagull, Canada Goose Goose, Chicken		(can be low in seagull and Canada Goose feaces)
Human BiADO	Human	Seagull	Cat, Dog, Cow, Sheep, Deer, Horse, Goat, Pig, Rabbit, Possum, Duck, Swan, Canada Goose, Chicken
Human HumM3	Human Possum	Rabbit	Cat, Dog, Cow, Sheep, Deer, Horse, Goat, Pig, Duck, Swan, Canada Goose, Chicken
Human BacH	Human Cat, Dog, Rabbit, Possum, Chicken	Goat	Cow, Sheep, Deer, Horse, Pig, Duck, Swan, Canada Goose,
Ruminant BacR	Cow, Sheep, Deer, Goat	Possum Cat	Human, Horse, Pig, Rabbit, Duck, Swan, Seagull, Canada Goose, Chicken
Canine DogBac	Dog	Some human municipal sewage	Human, Cat, Cow, Sheep, Deer, Horse, Goat, Pig, Rabbit, Possum, Duck, Swan, Seagull, Canada Goose, Chicken
Bird GFD	Duck, Swan, Seagull, Canada Goose, Chicken		Human, Cat, Dog, Cow, Sheep, Deer, Horse, Goat, Pig, Rabbit, Possum

Interpreting human indicative assays.

BacH is more sensitive than BiADO which is more sensitive than HumM3. The table below is a guide to interpreting presence and absence of human indicative markers.

Human BiADO	Human HumM3	Human BacH	Interpretation
+	+	+	Very strong evidence of human faecal contamination
+	ND	+	Evidence of human faecal contamination, but may be lower levels, aged or partially treated
ND	ND	+	May be human, dog, cat, rabbit, chicken. If canine marker absent then can exclude dog. If wildfowl marker absent then can exclude chicken.
ND	+	+	Possible human, but if ruminant marker present, may indicate possum faeces.
+	ND	ND	Possible human, but may indicate aged source as it is hypothesised that BiAdo may persist longer in the environment than the other markers.
ND	ND	ND	No evidence of human faecal contamination.

The level of GenBac marker should also be considered when evaluating presence of the other markers. For example when very high levels of GenBac, but very low levels of human markers then suggest either other sources more dominant, or that if human markers are present they are from aged or partially treated sources.

ND = sample was analysed, but the determinant was not detected.

Results of PCR analysis:

Bold conclusion is the dominant or major source. Interpretations assume fresh faecal pollution; aged or partially treated faeces may have reduced levels of some source indicative markers.

Bethells Lagoon

Client Reference	*E. coli*	General GenBac	Human BiADO	Human HumM3	Human BacH	Ruminant BacR	Canine DogBac	Bird GFD	Interpretation
Upstream									
17261/1 7/01/13	1500	Very strong positive	ND	ND	ND	Up to 5% ruminant	ND	Very weak positive	No human Ruminant and wildfowl detected
17261/38 5/02/13	790	Very strong positive	ND	Very weak positive	Weak positive	At least 50% ruminant	ND	Very weak positive	**Ruminant** HumM3 & BacH may indicate possum faeces
Lagoon									
17220/45 31/12/2012	8200	Very strong positive	ND	ND	Very weak positive	ND	Positive	Very weak positive	**Dog** Wildfowl
17261/2 7/01/13	240	Very strong positive	ND	ND	Very weak positive	Up to 5% ruminant	Weak positive	Weak positive	Ruminant, Wildfowl and Dog
17261/39 5/02/13	990	Very strong positive	Very weak positive	Very weak positive	Very weak positive	At least 50% ruminant	Very weak positive	Very weak positive	**Human Ruminant (~50%)** Wildfowl and Dog

Fosters Bay

Client Reference		General GenBac	Human BiADO	Human HumM3	Human BacH	Ruminant BacR	Canine DogBac	Bird GFD	Interpretation
Fosters Bay Upstream									
17220/18 27/12/2012	750	Positive	ND	ND	Very weak positive	ND	ND	ND	No wildfowl No dog No human No Ruminant
17220/24 28/12/2012	300	Very strong positive	ND	ND	Very weak positive	ND	ND	ND	
17261/9 10/01/13	550	Strong positive	ND	ND	ND	ND	ND	ND	
17261/13 14/01/13	9800	Strong positive	ND	ND	ND	ND	ND	ND	
Fosters Bay									
17220/17 26/12/2012	770	Very strong positive	Positive	Very weak positive	Positive	ND	ND	ND	**Strong evidence of Human** Also Dog in 17220/31
17220/31 28/12/2012	900	Strong positive	Weak positive	ND	Positive	ND	Very weak positive	ND	
17261/12 14/01/13	320	Strong positive	Very weak positive	ND	Very weak positive	ND	ND	ND	

Karekare Lagoon

Client Reference	E. coli	General GenBac	Human BiADO	Human HumM3	Human BacH	Ruminant BacR	Canine DogBac	Bird GFD	Interpretation
Upstream									
17220/23 27/12/2012	1100	Strong positive	ND	ND	Very weak positive	ND	Very weak positive	ND	Dog in 17220/23, otherwise no source identified
17261/16 15/01/13	540	Strong positive	ND	ND	ND	ND	ND	ND	
17261/22 16/01/13	280	Strong positive	ND	ND	ND	ND	ND	ND	
17261/43 6/02/13	480	Strong positive	ND	ND	ND	ND	ND	ND	
Carpark									
17261/11 9/01/13	500	Very strong positive	Very weak positive	ND	Very weak positive	ND	Very weak positive	ND	**Human** Dog
Lagoon									
17220/21 27/12/2012	600	Positive	ND	ND	ND	ND	Very weak positive	ND	**Dog**
17261/20 15/01/13	1000	Very strong positive	Very weak positive	ND	Weak positive	ND	ND	ND	**Human**
17261/25 16/01/13	640	Very strong positive	Weak positive	ND	Weak positive	ND	ND	ND	**Human**
17261/40 6/02/13	450	Strong positive	ND	ND	ND	ND	ND	ND	No source identified

Piha North Lagoon Upstream

Client Reference	E. coli	General GenBac	Human BiADO	Human HumM3	Human BacH	Ruminant BacR	Canine DogBac	Bird GFD	Interpretation
17220/15 26/12/2012	750	Very strong positive	ND	ND	ND	ND	ND	ND	No source identified
17220/22 27/12/2012	810	Strong positive	ND	ND	ND	ND	ND	ND	
17220/33 29/12/2012	200	Strong positive	ND	ND	ND	ND	ND	ND	
17261/6 7/01/13	450	Very strong positive	ND	ND	Very weak positive	ND	Very weak positive	ND	**Dog**

Piha North Lagoon

Client Reference		General GenBac	Human BiADO	Human HumM3	Human BacH	Ruminant BacR	Canine DogBac	Bird GFD	Interpretation
17220/12 26/12/2012	3400	Strong positive	ND	ND	ND	ND	ND	ND	No source identified. These samples are not consistent with fresh or untreated faeces from the sources tested.
17220/20 27/12/2012	840	Strong positive	ND	ND	ND	ND	ND	ND	
17220/28 28/12/2012	730	Positive	ND	ND	ND	ND	ND	ND	
17220/36 29/12/2012	1000	Strong positive	ND	ND	ND	ND	ND	ND	
17220/41 30/12/2012	680	very strong positive	ND	ND	ND	ND	ND	ND	
17261/8 7/01/13	300	Strong positive	ND	ND	Very weak positive	ND	ND	ND	
17261/42 6/02/13	1600	Strong positive	Very weak positive	ND	ND	ND	ND	ND	

Piha South Lagoon

Client Reference	E. coli	General GenBac	Human BiADO	Human HumM3	Human BacH	Ruminant BacR	Canine DogBac	Bird GFD	Interpretation
17220/11 26/12/2012	1100	Strong positive	ND	ND	Very weak positive	ND	ND	Very weak positive	Wildfowl
17220/19 27/12/2012	990	Strong positive	ND	ND	ND	ND	ND	ND	No source identified
17220/27 28/12/2012	480	Strong positive	ND	ND	ND	ND	ND	ND	No source identified
17220/40 30/12/2012	2600	Strong positive	ND	ND	Very weak positive	ND	ND	Very weak positive	Wildfowl
17220/42 31/12/2012	630	Strong positive	ND	ND	ND	ND	ND	Very weak positive	Wildfowl
17261/30 21/01/13	830	Very strong positive	Very weak positive	ND	Very weak positive	ND	ND	Very weak positive	Human Wildfowl
17261/41 6/02/13	840	Strong positive	ND	ND	Very weak positive	ND	ND	Very weak positive	Wildfowl

Abbreviations:

ND = sample was analysed, but the determinant was not detected.

Brief details of the methods of analysis are available on request.
These results relate to samples as received.
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