Dunedin City Council

Stormwater Compliance Monitoring 2018

August 2018

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Prepared for Dunedin City Council

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Document version: 1st August 2018

Cover page: Foreshore viewed from the Kitchener Street stormwater outfall.

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1. Executive Summary

This report presents the findings for the fifth round of annual monitoring of Dunedin's stormwater outfalls since new discharge consents were granted.

Monitoring comprised assessment of rain event grab samples from the ten major catchments and monthly dry weather samples from all catchments when conditions were met. Also included were assessments of harbour water quality and harbour sediment quality at representative sites at five sites.

Stormwater from all outfalls monitored showed variable levels of contamination over the study duration.

Sediments typically showed low levels of contamination with the exception of arsenic at close to trigger levels at the Kitchener site. No resampling was required.

Contaminant levels in both stormwater and sediment were generally within the ranges observed in previous surveys. Although harbour water sampling has been carried out for four rounds it is a relatively new requirement and it is too early to detect potential trends in contaminant levels.

2. Introduction

1.1 Background

As with all urban centres throughout New Zealand and indeed most of the world, Dunedin's stormwater is reticulated to receiving environments via networks of gutters, open channels and pipes. The principal coastal receiving water environments for Dunedin's reticulated stormwater are the upper basin of Otago Harbour, Port Chalmers, and, on the open coast, Second Beach and St. Clair Beach.

Dunedin City Council (DCC) was, on 8th August 2013, granted resource consents for its major urban stormwater discharges. Those consents require monitoring of the outfalls during dry and wet weather, of harbour water under dry and wet weather conditions, of harbour sediments, and of biological communities.

The following report presents the results of sampling/monitoring carried out from the beginning of July 2017 to the end of June 2018.

1.2 Stormwater Outfalls

Stormwater is discharged from fourteen reasonably large and permanent stormwater outfalls, and from a number of smaller outfalls and non-point sources (Figures 1.1, 1.2 and 1.3). Many of the outfalls have very long histories dating back to the days of the early settlement of Dunedin.

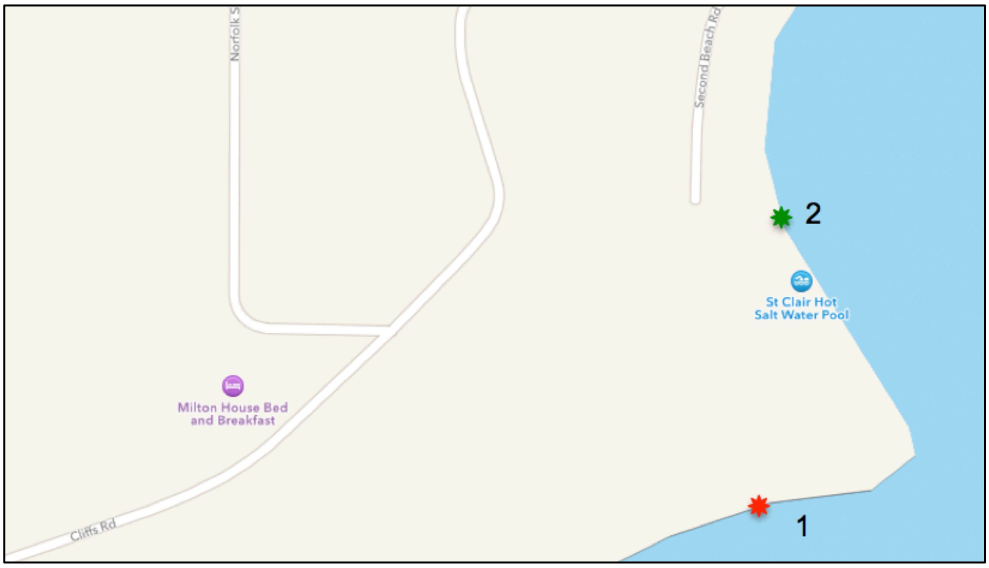

Figure 1.1: Locations of current Dunedin stormwater outfalls being monitored. Numbers correspond to outfall numbers in Table 1, Appendix 1. Red stars denote monthly sampling; Green stars denote 6 monthly sampling.

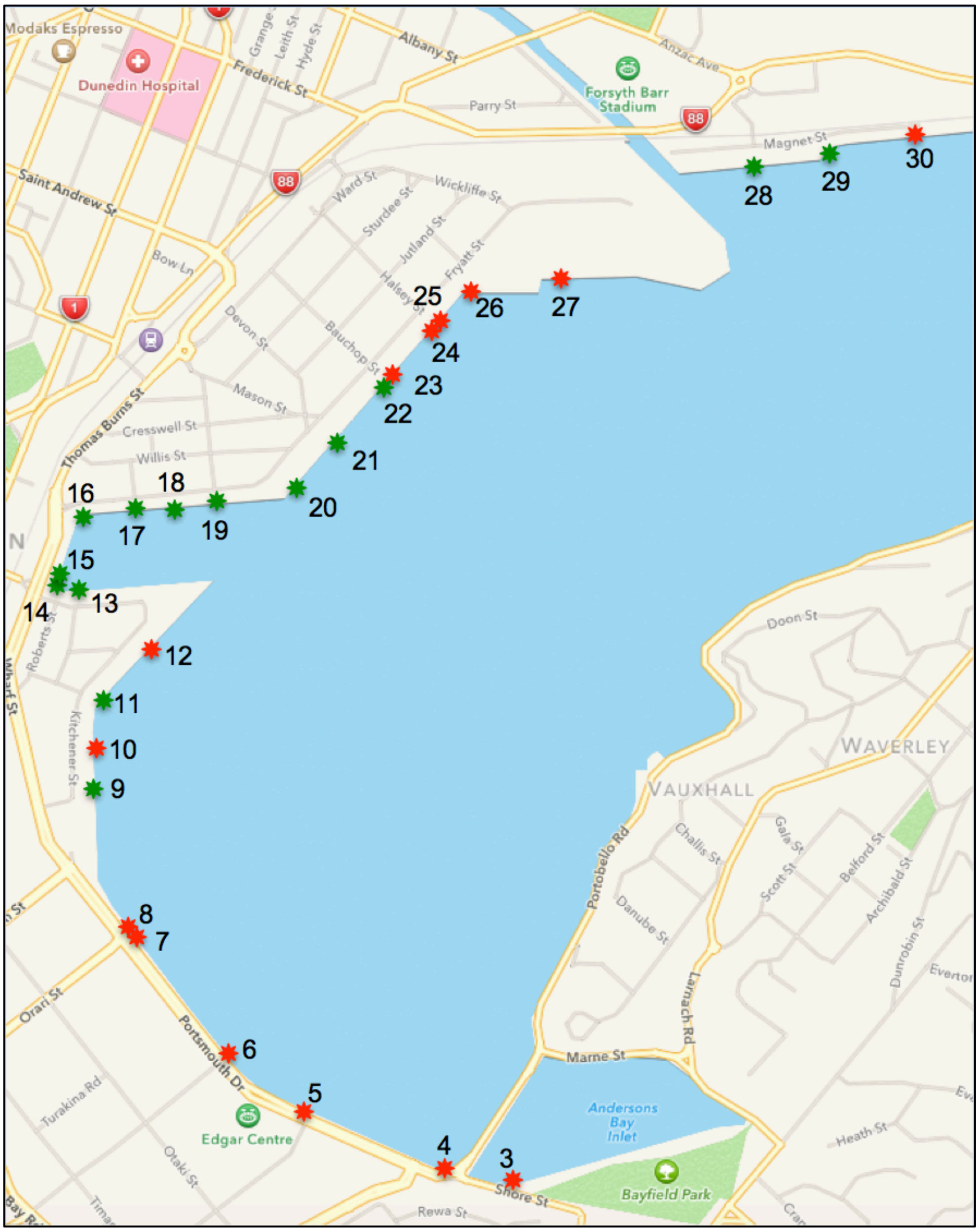

Figure 1.2: Locations of current Dunedin stormwater outfalls being monitored. Numbers correspond to outfall numbers in Table 1, Appendix 1. Red stars denote monthly sampling; Green stars denote 6 monthly sampling.

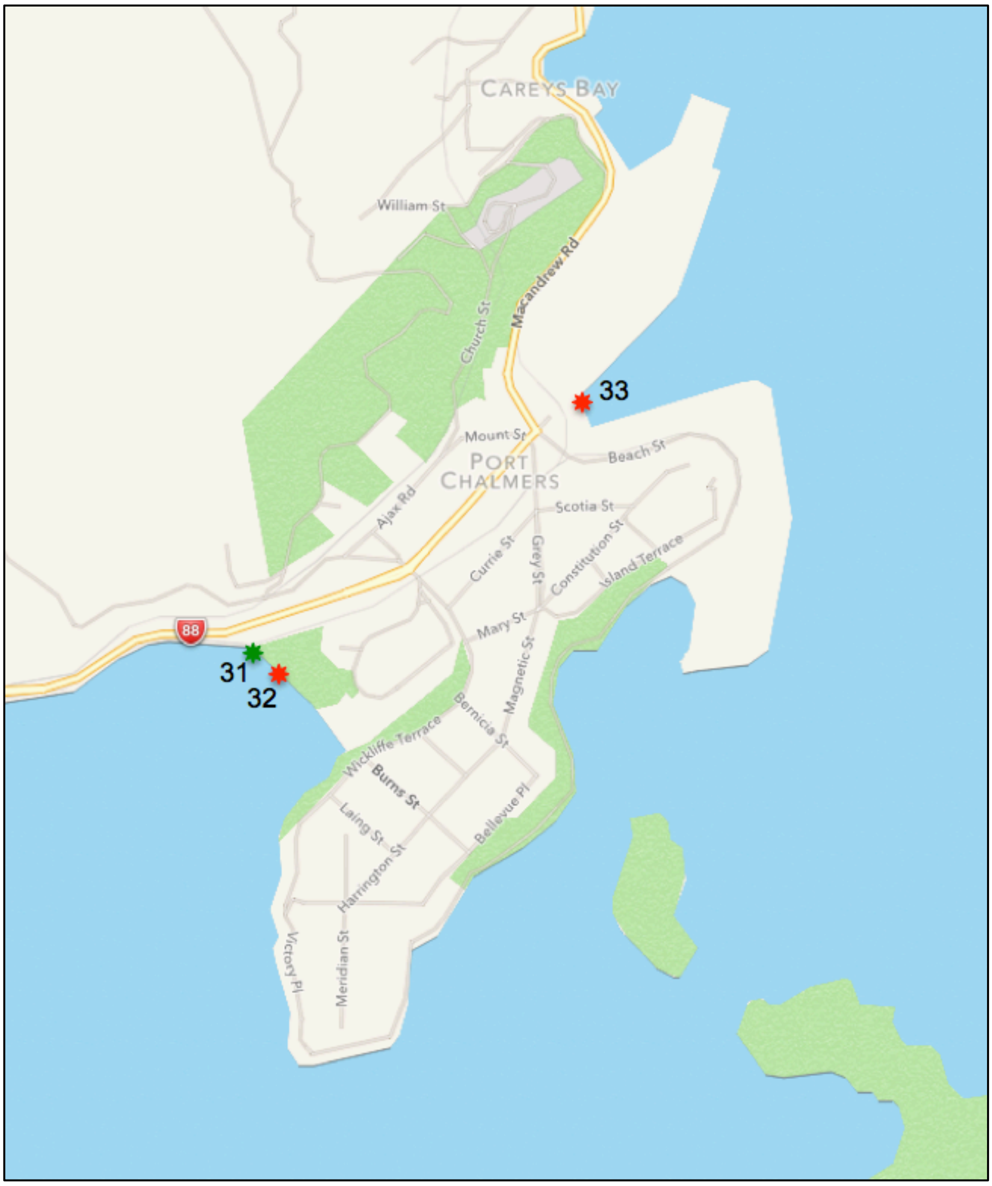

Figure 1.3: Locations of current stormwater outfalls being monitored at Port Chalmers. Numbers correspond to outfall numbers in Table 1, Appendix 1. Red stars denote monthly sampling; Green stars denote 6 monthly sampling.

3. Methods

A number of the outfalls shown in Figures 1.1, 1.2 and 1.3 do not have outfall structures or are located in places that are inaccessible. Consequently it is neither practical nor possible to sample the entire 33 outfalls listed at the end of pipe. However, access to those that cannot be sampled at end of pipe is available via manholes a short distance up pipe.

3.1 Stormwater

3.1.1 Dry weather sampling

Dry weather flow sampling, as per Condition 2(a) (Appendix 7), involves collecting samples at low tide (to avoid seawater contamination) from each outfall during dry weather that includes an antecedent dry period of at least 72 hours. Samples are analysed for *E. coli,* and for fluorescent whitening agents (FWAs) to determine if high bacterial counts may be due to illegal human sewage cross-connections. FWAs are used in laundry detergents and indicate possible sewage infiltration to the stormwater system (Petch 1996, Gilpin *et al.* 2004) and are analysed on site using a hand-held fluorimeter.

The frequency of sampling has been decreased for outfalls where indicators of human sewage have not been detected. Consequently, some outfalls are now sampled on a six monthly basis while the remainder continue to be sampled on a monthly basis (Appendix 1). The 2017/2018 summer was generally fine compared to the previous year and samples were able to be collected July, August, September, October, November and December 2017, as well as January 2018. Weather after that deteriorated and samples were collected during only March and May in 2018.

3.1.2 Wet weather grab sampling

Wet weather grab samples of stormwater were collected from each of the ten outfalls with the highest flows (as per consent condition Appendix 7 (b)(1)) within 1 hour of the commencement of a rain event (>2.5 mm) in an endeavour to ensure that first flush water containing the highest likely concentration of contaminants was gathered. Collections took place only if there was an antecedent period of at least 72 hours with no rain before the targeted rain event. Samples were, once again, collected at low tide.

Grab stormwater samples were sent to Eurofins in Dunedin to be analysed (as per Appendix 7 A (c) of the consent conditions) for pH, arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), oil and grease, suspended solids, pH, polycyclic aromatic hydrocarbons (PAHs) and E. coli.

3.1.3 Wet weather automated sampler

An ISCO automated sampler was installed approximately 600 m up-pipe of the Mason Street stormwater outfall in February 2018, to fulfil the requirements of Appendix 7A (a) of the consent conditions. The sampler had been programmed to collect samples over the first two-hour period of a rain event that produced at least 2.5 mm of rain following an antecedent dry period of at least 72 hours. However, since installation the ISCO has either failed to trigger successfully, or conditions have been such that samples were not valid. DCC are requesting that this outfall continue to be monitored with the automated sampler for the 2018/19 year in an attempt to capture the required rain-events.

3.2 Harbour water

Harbour water quality sampling was carried out at the locations shown in Figure 2.1 on four occasions. These occasions targeted two rainfall events and two dry periods, with samples being collected at mid-flood tide and mid-ebb tide for each occasion. Dry weather sampling allows the determination of background contaminant levels in harbour water.

Ebb tide flows are likely to move contaminants discharged during relatively brief rain events rapidly down harbour. Conversely, flood tide conditions may lead to higher concentrations of contaminants in the upper harbour. However, it must be noted that inputs from the Water of Leith further confuse contaminant levels, especially on the flood tide.

Since the upper harbour basin requires 4 - 6 tidal cycles to flush completely (Smith and Croot 1993, 1994), contaminants within the upper harbour basin may gradually increase in concentration throughout prolonged wet spells.

Harbour water samples were sent to Eurofins in Dunedin to be analysed for cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn), and enterococci.

3.3 Sediment sampling

Samples were collected from the top 20mm of sediment at the locations shown in Figure 2.1. At Halsey Street (H1) and Kitchener Street (H2) the sites are in deep water (~3 – 7 m deep) so sediment was collected using a petit ponar grab with a subsample being obtained from the top 20 mm of the contents of the grab. At Orari Street (H3) and Shore Street (H4) sediment samples are collected directly from the substrate by scraping the top 20 mm of sediment into a collection jar.

Samples were chilled and sent to Eurofins for analysis for total arsenic, total cadmium, total chromium, total copper, total nickel, total mercury, total lead, total zinc, weak acid extractable copper, total petroleum hydrocarbons (TPH), organochlorine pesticides and PAHs.

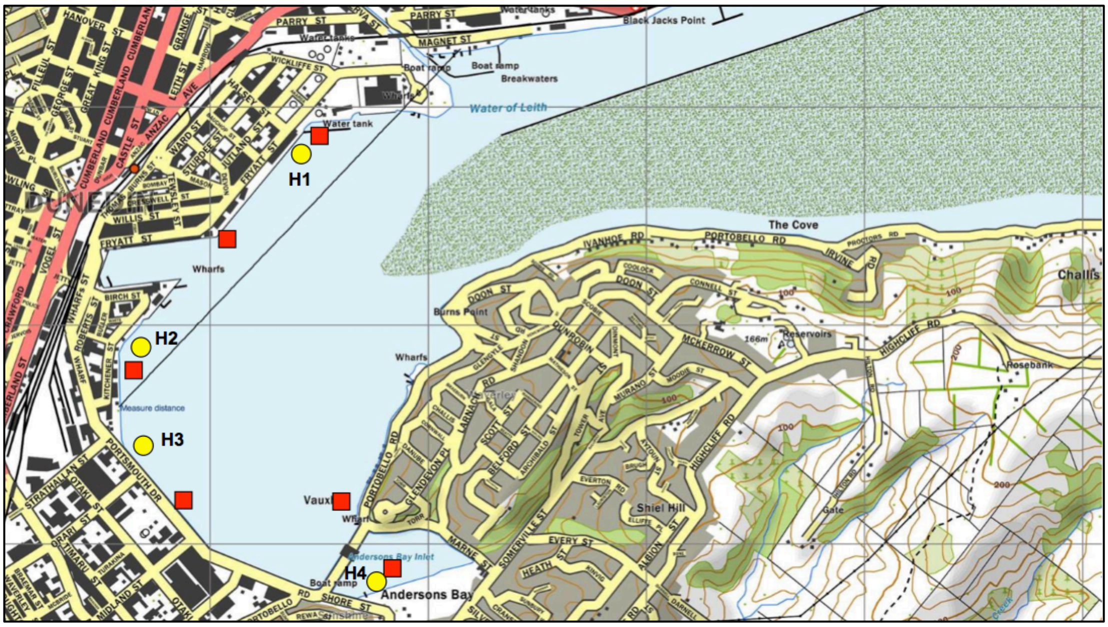

Figure 2.1: Upper Harbour Basin seawater and sediment sampling sites. Red squares are harbour water quality sites; Yellow circles are sediment sites.

4. Results and Discussion

3.1 Stormwater

3.1.1 Dry weather sampling

Dry weather flow sampling was carried out in July, August, September, October, November, December 2017, and January, March and May 2018. As already pointed out, sampling at a number of outfalls has decreased to 6 monthly after three consecutive monitoring rounds due to there either being no flow, or consistently low results for both *E. coli* and FWAs.

A number of outfalls have had high but variable readings for *E. coli* and/or FWAs (Appendix 2). *E. coli* levels frequently exceed trigger levels, with numbers often exceeding 2400 MPN/100ml at outfalls 1, 3, 5, 8, 24, 25 and 33 (Figures 1.1, 1.2 and 1.3). However, the fact that FWAs at some of the same sites (e.g. outfalls 1 and 24) are not always high suggests that contamination may not always be from human sewage, but rather from other sources.

The DCC has undertaken to investigate catchments that have had three consecutive monitoring rounds with both elevated *E. coli* and FWAs. These include the Shore Street outfall (outfall 3), and the George Street outfall at Port Chalmers (outfall 33). Outfalls that have had high levels of *E. coli* and FWAs in the past have been investigated. These include Bauchop Street, and the Wickliffe Street and Magnet St outfalls (outfalls 27 and 30 respectively). An illegal connection, that has since been rectified, was found up-pipe at

Bauchop Street. The entire Ravensbourne catchment has been subject to detailed investigated by the DCC in an attempt to ascertain possible sources of contamination, but nothing untoward was found.

3.1.2 Wet weather sampling

Wet weather grab samples were collected on 1st February 2018 during a heavy storm event that yielded 83.25 mm of rainfall. Levels of most contaminants (arsenic, cadmium, chromium, nickel, oil and grease, and polycyclic aromatic hydrocarbons) were below detectable limits at all sites (Appendix 3). However, levels of *E. coli* exceeded guidelines for secondary contact at all outfalls. This is not unusual during sampling of the first flush of rain events with runoff from impervious surfaces often carrying quantities of faecal matter from mammals and birds, along with decaying vegetation.

When compared with results from rain events through time the levels of contaminants in stormwater during the 1st February rain event exhibit lower levels of containments than the previous year's rain event and generally fall within the range of values observed at the various outfalls that have been sampled annually since 2007 (Appendix 3). Overall, there are generally lower contaminant concentrations reported in stormwater this year (Appendix 3).

PAHs at South Dunedin (Portobello Rd) are traditionally higher than at other sites. Values this year are lower than 2014, 2015 and 2016, but similar to values prior to that and last year (Figure 3.1.1, Appendix 3,). The high readings obtained at Portobello Road in 2014, 2015 and 2016 have been subject to investigations, focussed around the former Dunedin Gasworks site.

The sampled rain events during 2015 and 2016 were considerably lighter (3.8 mm and 4.0 mm respectively) than this year. In the 2014 and 2017 events were 8.2 mm and 8.8 mm respectively, while the event in 2013 was 3.8 mm. Consequently, it appears that flow is not a significant influencing factor with respect to PAHs.

When viewing PAH levels in stormwater consideration should be given to whether any resurfacing of bituminous impervious areas was carried out in the catchment prior to the sampled rain event as such activities may be a likely source.

3.1.3 Wet weather automated sampler

The ISCO automated sampler at the Mason Street site has not adequately sampled an appropriate rain event since its installation. The ISCO was activated on the 21st March but the tide was too high to be a viable sampling round. The machine was again triggered on the 27th of March 2018 and once more on the 6th June 2018. However the first round was deemed to be an invalid sample as only 1.2mm of rain had fallen and during the second event the machine did not fill all the bottles. It was later found that the sampling tube had been perforated and was subsequently fixed.

3.2 Harbour water

Harbour water is compared against trigger levels that have been derived from ANZECC (2000) trigger values for protection of 95% of species. ANZECC recommend that values be tailored to each site so local factors such as substrate, degree of modification, and catchment characteristics can be taken into consideration. However, this has not been done in this instance and the default ANZECC values have been applied. Considering the highly modified nature of the upper Otago Harbour Basin, ANZECC trigger values for protection of 80% of species may be more appropriate should the consent be reviewed.

3.2.1 First round of sampling

Harbour water was collected during a rainfall event that occurred on 1st September 2017 and during a dry weather spell on 31st October 2017. The storm event generated 5.4 mm of rain. Samples on each occasion were collected at mid-flood tide and again at mid-ebb tide. As explained in Section 3.2 this allows determination of contaminant levels in a dynamic environment that may alternately dilute or concentrate contaminants.

Contamination of harbour water was low for cadmium and lead at all sites. However, copper concentrations for both the wet and dry weather monitoring rounds are occasionally above the consent trigger levels, especially under wet conditions. Zinc concentrations exceeded the trigger values under both wet and dry conditions except for two samples; Andersons Bay inlet, dry weather sample on an ebb tide and Vauxhall, wet weather sample on a flood tide.

Levels for enterococci contamination exceed guidelines for marine waters (i.e. >140 cfu/100ml = amber alert; >280 cfu/100ml = red alert), during a rain event at Wickliffe Street, Mason Street, Kitchener Street and Substation sites (Table 3.2.1), particularly on a flood tide when contaminants are likely to be pushed back up the harbour. This generally echoes results for dry weather monitoring that finds high values for *E. coli* reasonably consistently at outfalls 5, 6 and 7, all of which discharge along Portsmouth Drive. Outfall 5 (Teviot Street) also exhibits high FWA readings during dry weather sampling.

Table 3.2.1: Enterococci levels of harbour water in both dry and wet weather events for flood and ebb tides. BDL = below detectable limits.

Enterococci (140 cfu/100ml)	Dry		Wet	
Detection limit (4.0)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	4	56	2800	6700
Mason (H2)	32	8	1300	8
Kitchener (H3)	<4	<4	160	96
Substation (H6)	77	<4	240	BDL
Vauxhall (H4)	<4	20	4	BDL
Andy Bay Inlet (H5)	73	32	BDL	50

It should be noted that the red alert level indicates a risk to bathers of around 2% or 19 per 1000 swimmers. Although the upper harbour basin is popular with wind surfers when conditions permit, it is not a recognised swimming area. Consequently, the trigger level may be considered to be very conservative and perhaps not appropriate.

3.2.2 Second round of sampling

Due to trigger level exceedences of copper, zinc and enterococci in the first round of 2017 results, harbour water was resampled at the first opportunity where rainfall and tide state allowed. This occurred on 19th September 2017 for the rain event and on 16th November for dry weather. The rain event produced 37 mm of rain. It should be noted that no wastewater overflows were occurring at the time.

Once again copper was moderately high at two sites in dry weather on the ebb tide, and at all sites under wet weather conditions. Zinc trigger levels were exceeded at all sites except for Substation (H6) and Mason (H2) on the ebb tide (Appendix 6).

Exceedances were not as widespread at the re-sample as they were during the initial sampling rounds, and, once again, comprised just copper, zinc and enterococci. Again it is noted that exceedances occurred generally during a rain event, and slightly more commonly on the flood tide.

For both rain events sampled initial collection took place within the first two hours of each event. It is to be expected that the level of contaminants in stormwater is highest during the so-called “first flush” (Mosley 1995, Wells 1996, Stevenson 1998, Brown 2002). This occurs because contaminants that have accumulated as dust or surface films on roads and other impervious surfaces during the period prior to the rainfall event are washed into stormwater during the first 30-90 minutes of rainfall during any event that results in significant runoff. After this “first flush” contaminant levels may fall, even though runoff continues at appreciable volumes. The level of contaminants bears a strong relationship to the length of the "dry" spell before a rainfall event, long periods of dry weather resulting in first flushes with significantly higher contaminant loadings (Mosley 1995, Wells 1996). In the case of the 1st September rain event the antecedent dry spell was 10 days. For the 19th September rain event the antecedent dry spell was 6 days.

The 1st September rainfall event was of relatively light intensity with a little over 5.4 mm of rainfall being recorded. The second rainfall event was heavy, with over 37 mm of rainfall recorded. However, it should be noted that despite the higher amount of rainfall during the second event, exceedences were slightly fewer for copper and zinc. Enterococci exceedences, on the other hand, show the converse.

As well as dissolved contaminants, suspended solids found in stormwater are likely to carry heavy metals. The likely major sources of copper in stormwater include copper water piping, copper roofing and spouting, food processing, wear of tyres and brake pads, and industrial processes. Probable sources of zinc in stormwater are roofing iron, and wear of tyres and brakes (Stevenson 1998). Note that lead in the environment from petrol is likely diminishing, with lead no longer being an additive since 1986 for regular and since 1996 for super. It is pleasing to note that lead levels did not exceed trigger values at all this year.

For enterococci the phenomenon of high bacterial levels in stormwater during rainfall events is well documented (e.g. Stewart 2009). However, there is also evidence of bacterial contamination during dry spells, notably in Andersons Bay Inlet, off Portsmouth drive in the Midland Street/ Teviot Street area, and in the vicinity of the Wickliffe Street and Mason Street outfalls.

The reason for the continued high levels of copper and zinc is less easy to distinguish, but is unlikely to be the result of single or point source discharges. Many stormwater discharges from roads and private property are permitted by the Regional Plan: Water. Copper and zinc [and lead in the past] are all problematic for many catchments in towns and cities across New Zealand and worldwide. Continued implementation of measures, such street sweeping, mud tank cleaning, gradual pipe and roof upgrading, and installation of swales where practicable may result in levels of these contaminants slowly diminishing over time.

3.3 Sediments

The Consent imposes trigger levels statistically derived from historic sampling at a variety of locations in the upper harbour. The most recent consent requires sampling at locations that do not necessarily correlate with locations sampled in the past. Consequently, the statistically derived trigger values may not be appropriate for the current locations.

Harbour sediments were sampled on 4th April 2018 at sites detailed in Figure 2.1. As in the past, surface sediments (where visible) were generally clean with little surface detritus apart from sparse clumps of beach cast red and green algae at the Orari Street site.

Last year, levels of arsenic at Kitchener Street exceeded trigger values, but this year fell just below the accepted consent limits. (Appendix 4, Table 4). Values for all other contaminants were very low (Table 4). It should be noted that the Kitchener Street site has historically higher values of metal contaminants, which may be influenced by the reasonably close proximity of Sims Pacific Metals Ltd in Wharf Street, and a now defunct metal blasting and respraying plant further along Kitchener Street.

It is worthwhile pointing out that levels of contaminants in sediments are generally considerably lower at these sites than at other sites analysed within the upper harbour basin in the past. However, historically, sediments were sampled much closer to stormwater outfalls than in 2014, 2015, 2016 and 2017 so, once again, comparisons must be viewed with caution.

This is particularly so for PAHs where the historic maximum is obtained from sediments collected close to the South Dunedin (Portobello Road) outfall, a site of particular concern with respect to PAH contamination (Stewart 2005, 2006).

Although PAH levels at Orari Street are higher than they have been in past sampling rounds, they are still below trigger values and well below historic levels found in harbour sediments (i.e. 620g/m^3, Stevenson1998). The major constituents of the PAHs at orari street this round are Fluoranthene, a product of low temperature combustion and Benzo(a)pyrene, which is also a product of incomplete combustion. It may be that sampling was preceded by a period of cooler weather that prompted the use of wood and coal fires throughout the city and the sampling has picked up a spot of higher contamination as a result, or possibly picked up a localised small tar-ball washed into the harbour from street re-surfacing.

5. Conclusion

Monitoring of stormwater quality in Dunedin this year differs in some respects from pre-2014 monitoring due to changes in consent conditions linked to the new discharge permits RM11.313.01-RM11.313.10. Overall, however, the results provided in this report and the 2017, 2016, 2015 and 2014 reports give a good indication of stormwater quality discharged from the city, with good coverage of catchment discharges in dry weather conditions (Stewart 2014, 2015, 2016).

Dry weather monitoring has been reasonably successful in locating possible illegal cross-connections. One source of contamination has been located and eliminated in the Bauchop Street catchment while investigations in the Ravensbourne catchment have been inconclusive. Other investigations are ongoing.

However, the efficacy of continuing to monitor all outfalls on a regular basis is questioned. We would recommend a review of the Consent conditions such that dry weather monitoring at outfalls that have regularly shown little or no sewage contamination could cease, thus dropping from 33 outfalls to just the 13 shown in Table 3.1.1. A further review of those could be carried out at the end of the 2018 - 2019 stormwater year or at the conclusion of the current investigations.

Microbiological contamination is a common problem with stormwater, especially after dry spells of more than a couple of days, and can be due to other factors such as contamination of roads and sidewalks by animal faeces. However, by the DCC continuing to work to eliminate cross connections of private sewerage laterals to stormwater drains, this issue can be minimised as far as practicable.

Regular street sweeping and the cleaning of mud tanks will go some way towards mitigating the ingress of contaminants such as heavy metals to the stormwater system, as will the gradual replacement of lead and copper pipes and the increased use of coated roofing materials.

Consent condition (Appendix 7 B(c)) requires re-sampling of harbour water if trigger values are exceeded. However, it should be noted that this poses a number of difficulties, not the least of which is in replicating conditions that prevailed at the time of sampling. Specifically, by the time laboratory test results are received for analysis and interpretation (two or even three weeks after sampling) the effects of a particular rain event or dry spell have well and truly passed. The only way around this situation is to collect replicate samples at the time of monitoring and re-analyse these if exceedences are found upon receipt of test results. Such an approach may be useful for some contaminants (e.g., metals) but will not work for bacteria.

Otago Harbour has, since early settlement, been a repository for contaminants generated by a wide variety of activities within and around Dunedin City (Stewart and Ryder 2004). Many of those contaminants settled out and become incorporated in the sediments of the harbour floor, often with quite patchy distributions (Stewart and Ryder 2004). Removal of such contaminants can only be achieved by dredging, or by relying on natural flushing, which in turn, relies on wind, wave and tidal action and can be exceedingly slow.

Consequently, the concentration of contaminants in harbour sediments has often exceeded Consent trigger levels in the past. However, this year, no contaminants exceeded trigger values. It should be noted that arsenic levels at Kitchener Street fell just below trigger levels. The low levels of contaminants observed in harbour sediments this year compares favourably with previous results and suggests that levels of contaminants entering the harbour at present may be lower than what was discharged historically.

This is not unexpected considering that many industries that used to contribute significant quantities of harmful contaminants to the harbour have closed down or moved (e.g. tanning, timber treatment, gasworks, electroplating). Wastewater upgrades in the 1990s, and separation of the stormwater and wastewater networks from the 1960s - 1990s resulting in the removal of all wastewater discharges from the harbour, have also reduced the amount of contaminants entering the harbour. Thus, it is expected that the amount of contaminants in surficial harbour sediment will diminish as fewer contaminants enter the harbour and existing contaminants are either flushed out, or become buried under newer non-contaminated sediments.

It should be pointed out that the sites at which samples have been collected since 2015 differ from previous locations. Consequently caution is advised in interpreting these results as they are not directly comparable. Continued sampling at the new locations will better enable any trends in contaminant concentration to be discerned at these locations.

The level of PAHs in sediments adjacent to the South Dunedin (Portobello Road) outfall remains a moderate concern. The high levels of PAHs in stormwater observed in South Dunedin stormwater in 2015, 2016 and 2017 appears to have been a temporary aberration. As already mentioned, the DCC have undertaken investigations focussed on the former Dunedin Gas Works Site. Stewart (2006) investigated possible remediation measures for sediment in the area, but, given that historic sources of PAHs in the South Dunedin catchment (e.g. gas works) no longer function, it is expected that the contamination will gradually be buried by new sediment. This is already evident with a continued downward trend in PAH concentration in cockle flesh since monitoring began.

This report is designed to inform any required updates to the individual catchment management plans (ICMPS). Overall, it is expected that the implementation of actions suggested in this report, in conjunction with the DCC's long-term strategy for individual stormwater catchments developed through the Three Waters Strategy, will contribute to addressing the issue of unusually elevated contaminants in stormwater. It will be of interest to see if any long-term trends in contaminant levels can be discerned as monitoring continues.

However, only after problem areas and problem contaminants have been identified can measures be taken to mitigate any effects. Future monitoring, as prescribed in the conditions associated with the new discharge permits, will assist in defining problem areas such that further mitigation measures may be undertaken.

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7. Appendix 1- Outfall identification

Table 1: Frequency of dry weather sampling, DCC reference, Consent reference, location and catchment of each outfall monitored.

Outfall	DCC ref	Consent ref.	Location	Catchment	Frequency
1	SWX03979	RM11.313.10	Second Beach	St Clair	Continue monthly sampling
2	SWX00011 & SWX00012	RM11.313.10	St Clair Beach	St Clair	6 monthly sampling
3	SWX04625	RM11.313.04	Shore Street	Shore Street	Continue monthly sampling
4	SWX03649	RM11.313.09	Portobello Rd	South Dunedin	Continue monthly sampling
5	SWX03644	RM11.313.07	Teviot St	Portsmouth Drive	Continue monthly sampling
6	SWX03640	RM11.313.07	Midland St	Portsmouth Drive	Continue monthly sampling
7	SWX03631	RM11.313.07	Orari St	Portsmouth Drive	Continue monthly sampling
8	SWX03635 & SWX70740	RM11.313.08	Orari St	Orari St	Continue monthly sampling
9	SWX03579	RM11.313.07	Kitchener St	Portsmouth Drive	6 monthly sampling
10	SWX03568	RM11.313.06	Kitchener St	Kitchener St	Continue monthly sampling
11	SWX70102	RM11.313.06	French St	Kitchener St	6 monthly sampling
12	SWX03547	RM11.313.06	Kitchener St	Kitchener St	Continue monthly sampling
13	SWX03562	RM11.313.06	Birch St	Kitchener St	6 monthly sampling
14	SWX03556	RM11.313.06	Birch St	Kitchener St	6 monthly sampling
15	SWX03559	RM11.313.06	Wharf St	Kitchener St	6 monthly sampling
16	SWZ70569	RM11.313.06	Fryatt St	Kitchener St	6 monthly sampling
17	SWX03540	RM11.313.06	Fryatt St	Kitchener St	6 monthly sampling
18	SWX03536	RM11.313.06	Fryatt St	Kitchener St	6 monthly sampling
19	SWX03532	RM11.313.06	Fryatt St	Kitchener St	6 monthly sampling
20	SWX70370	RM11.313.06	Fryatt St	Kitchener St	6 monthly sampling
21	SWX03489	RM11.313.05	Mason St	Mason St	6 monthly sampling
22	SWX03506	RM11.313.03	Mason St	Halsey St	Continue monthly sampling
23	SWX03466	RM11.313.03	Mason St	Halsey St	Continue monthly sampling
24	SWX03455	RM11.313.03	Halsey St	Halsey St	Continue monthly sampling
25	SWX03450	RM11.313.03	Halsey St	Halsey St	Continue monthly sampling
26	SWX03472	RM11.313.03	Halsey St	Halsey St	Continue monthly sampling
27	SWX03718	RM11.313.03	Wickliffe St	Halsey St	Continue monthly sampling
28	SWX02628	RM11.313.02	Magnet St	Ravensbourne	6 monthly sampling
29	SWX02623	RM11.313.02	Magnet St	Ravensbourne	6 monthly sampling
30	SPN02502	RM11.313.02	Ravensbourne Rd	Ravensbourne	Continue monthly sampling
31	SWX12941	RM11.313.01	George St/SH88	Port Chalmers	6 monthly sampling
32	SWX12994	RM11.313.01	Sawyers Bay, western side of Watson Park	Port Chalmers	Continue monthly sampling
33	SWX12879	RM11.313.01	George St (Port Otago)	Port Chalmers	Continue monthly sampling

Appendix 2- Stormwater dry weather

Table 2: FWA and E.coli levels throughout the year sampling dry weather rounds. Cells noted in orange are above limits, grey cells are outfalls sampled 6 monthly. Outfalls with no flows are omitted.

	Jul-17		Aug-17		Sep-17		Oct-17		Nov-17		Dec-17		Jan-18		Mar-18		May-18	
Outfall	FWAs	E. coli	FWAs	E. coli	FWAs	E. coli	FWAs	E. coli	FWAs	E. coli	FWAs	E. coli	FWAs	E. coli	FWAs	E. coli	FWAs	E. coli
1	0.121	>2400	0.076	1500	0.085	800	0.066	333	0.063	780	0.06	461	0.057	780	0.062	4800	0.067	260
2	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
3	0.206	>2400	0.166	580	0.110	143	0.109	1680	0.092	800	0.063	100	0.069	173	0.079	24000	0.117	34000
4	0.256	1700	0.178	<4	0.068	13	0.019	<1	0.018	16	0.02	<4	0.116	780	0.026	5800	0.021	<4
5	0.139	21.3	0.163	200	0.120	96	0.129	3040	0.108	600	0.062	827	0.070	36000	0.115	36	0.124	3700
6	0.166	980	0.183	430	0.096	50	0.125	213	0.125	47	0.087	112	0.054	195	0.118	77	0.137	320
7	0.029	<1.0	0.089	16	0.060	17	0.061	19000	0.027	144	0.055	446	0.043	80	0.018	<4	NF	NF
8	0.14	>2400	0.085	6900	0.078	800	0.077	1220	0.080	132	0.062	973	0.081	4000	0.082	304	NF	NF
9			0.104	25											0.084	62		
10	0.072	330	0.065	110	0.030	420	0.05	210	0.044	54	0.037	28	0.037	46	0.032	<4	0.043	272
11			0.038	<4											0.022	40		
12	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	0.030	20	0.016	7	0.015	<4	NF	NF
21			0.033	>9700											0.031	9600		
22	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
23	0.082	>2400	0.045	4	0.028	700	0.056	21	0.052	126	0.038	200	0.035	1320	0.034	264	0.046	180
24	0.045	>2400	0.035	740	0.032	2360	0.024	600	0.027	2000	0.031	7100	0.026	54000	0.02	5800	0.029	3600
25	0.08	>2400	0.07	>9700	0.034	9500	0.049	19700	0.058	14800	0.040	13800	0.048	42000	0.062	14000	0.055	28600
26	0.089	10.9	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	0.036	NF
27	N/A	N/A	0.089	230	0.050	720	0.097	8560	0.086	420	0.053	132	0.070	8800	0.075	3000	0.078	4000
28			0.103	<4											0.075	100		
29			0.089	<4											0.102	3700		
30	0.126	19.3	0.126	<4	0.141	1	0.132	80	0.149	9	NF	NF	NF	NF	0.081	40	0.106	28
31			0.106	720											0.061	4800		
32	0.221	4.1	0.168	<4	0.154	<1	0.16	2	NF	NF	NF	NF	NF	NF	0.139	4	0.144	108
33	0.163	1000	0.109	1100	0.120	3840	0.109	680	0.093	6080	0.097	4300	0.115	24000	0.098	22000	0.09	96

Appendix 3- Wet weather grab samples

Table 3: Raw data of metals, FWA, oil and grease, pH, suspended solids, PAHs and E.coli measured at wet weather sample event. Red cells indicate exceedence of E.coli above secondary contact limits, orange cells above primary contact limits.

Catchment	**Outfall**	As	Cd	Cr)	Cu	Pb	Ni	Zn	FWAs	Oil and Grease *	pH	SS	PAHs	E. coli
Unit		g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3		g/m^3		g/m^3	g/m^3	MPN/100ml
Detection Limit		0.0011 - 0.021	0.0011 - 0.021	0.0011 - 0.021	0.0011 - 0.021	0.0011 - 0.021	0.0011 - 0.021	0.0011 - 0.021	0.001	4.0	0.1	3.0	0.0001 - 0.0005	1.0
St Clair	1	0.003	<0.001	0.009	0.024	0.026	0.007	0.184	0.059	40	6.8	263	BDL	9700
Shore Street	3	0.004	<0.001	0.003	0.016	0.018	0.002	0.192	0.076	30	6.9	64	BDL	>9700
South Dunedin	4	<0.002	<0.001	0.003	0.013	0.015	0.001	0.156	0.044	36	6.9	46	0.0001	4800
Orari St	8	0.003	<0.001	0.005	0.017	0.019	0.003	0.132	0.058	38	6.9	103	BDL	>9700
Kitchener St	10	<0.002	<0.001	0.002	0.01	0.011	0.001	0.141	0.065	56	6.7	33	BDL	>9700
Mason St	21	0.002	<0.001	0.013	0.021	0.018	0.013	0.153	0.041	30	6.9	170	BDL	>9700
Bauchop St	23	0.002	<0.001	0.004	0.075	0.024	0.002	0.276	0.033	38	6.7	87	BDL	>9700
Halsey St	24	0.003	<0.001	0.007	0.032	0.038	0.006	0.158	0.054	41	6.7	196	BDL	>9700
Wickliffe St	27	0.003	<0.001	0.004	0.02	0.029	0.002	0.199	0.038	42	6.1	128	BDL	>9700
Port Chalmers	31	0.004	<0.001	0.005	0.021	0.039	0.004	0.377	0.06	34	6.8	138	BDL	>9700

* Not an accredited test

Primary contact (orange)	>260
Secondary contact (red)	>550

Appendix 4- Harbour Sediments

Table 4: Harbour sediments for four locations measured with consent trigger values below

Site	As	Cd	Cr	Cu (WAE)	Cu	Pb	Hg	Ni	Zn	TPH	PAH	Organochlorine pesticides
Halsey Street	12	0.17	28.6	24	21.3	30.1	0.1	15.1	141	37	0.028	BDL
Kitchener Street	18.2	0.16	30.2	79	20.3	50.1	BDL	13.8	273	71	5.39	BDL
Orari Street	8.4	0.33	38.7	17	14.4	63.6	BDL	13.5	244	79	142.82	BDL
Shore Street	3.5	0.13	10.4	13.5	12.9	58.8	BDL	7.1	168	41	2.07	BDL

Consent trigger	19	1.7	80		122	209		21	902		183	
Low	20	1.5	80		65	50	0.15	21	200			
High	70	10	370		270	220	1	52	410			

Appendix 5- Harbour water

Table 5: Harbour water samples tested for metals and Enterococci on dry weather and rain events. Dry sampled on the 31/10/17, wet sampled on 1/9/17 after 5.4mm of rain

Cd (0.0055 ANZECC 95% (g/m3))	Dry		Wet	
Detection limit (0.0002)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.001	<0.001	BDL	BDL
Mason (H2)	<0.001	<0.001	BDL	BDL
Kitchener (H3)	<0.001	<0.001	BDL	BDL
Substation (H6)	<0.001	<0.001	BDL	BDL
Vauxhall (H4)	<0.001	<0.001	BDL	BDL
Andy Bay Inlet (H5)	<0.001	<0.001	BDL	BDL

Cu (0.0013 ANZECC 95% (g/m3))	Dry		Wet	
Detection limit (0.001)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.001	<0.001	0.0055	0.0064
Mason (H2)	0.0016	0.0014	0.0077	0.0021
Kitchener (H3)	0.0023	<0.001	0.0054	0.0021
Substation (H6)	0.0022	<0.001	0.004	0.0021
Vauxhall (H4)	<0.001	<0.001	0.0029	0.0021
Andy Bay Inlet (H5)	0.0013	<0.001	0.0034	0.0024

Pb (0.0044 ANZECC 95% (g/m3))	Dry		Wet	
Detection limit (0.001)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.001	<0.001	BDL	BDL
Mason (H2)	<0.001	0.0021	BDL	BDL
Kitchener (H3)	0.0017	<0.001	BDL	BDL
Substation (H6)	0.0029	<0.001	BDL	BDL
Vauxhall (H4)	<0.001	<0.001	BDL	BDL
Andy Bay Inlet (H5)	<0.001	<0.001	BDL	BDL

Zn (0.004 ANZECC 95% (g/m3))	Dry		Wet	
Detection limit (0.001)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.01	0.005	0.092	0.046
Mason (H2)	0.008	0.026	0.043	0.009
Kitchener (H3)	0.013	0.012	0.016	0.012
Substation (H6)	0.018	0.007	0.012	0.007
Vauxhall (H4)	0.005	0.005	0.003	0.005
Andy Bay Inlet (H5)	0.014	<0.002	0.006	0.01

Enterococci (140 cfu/100ml)	Dry		Wet	
Detection limit (4.0)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	4	56	2800	6700
Mason (H2)	32	8	1300	8
Kitchener (H3)	<4	<4	160	96
Substation (H6)	77	<4	240	BDL
Vauxhall (H4)	<4	20	4	BDL
Andy Bay Inlet (H5)	73	32	BDL	50

Appendix 6- Harbour water resample

Table 6: Harbour water resample tested for copper, zinc and Enterococci on dry weather and rain events that had demonstrated an exceedence in prior sampling. Dry sampled on the 16/11/17, wet sampled on 19/9/17 after 37.4mm of rain

Cu (0.0013 ANZECC 95% (g/m3))	Dry		Wet	
	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	BDL	0.0057	0.0084	0.0125
Mason (H2)	BDL	0.0075	0.0018	0.0012
Kitchener (H3)	BDL	BDL	0.0018	0.0056
Substation (H6)	BDL	BDL	0.001	0.0022
Vauxhall (H4)	BDL	BDL	0.0018	0.002
Andy Bay Inlet (H5)	BDL	BDL	0.0069	0.0091

Zn (0.015 ANZECC 95% (g/m3))	Dry		Wet	
Detection limit (0.001)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	BDL	0.012	0.052	0.081
Mason (H2)	0.013	BDL	0.016	0.006
Kitchener (H3)	BDL	BDL	0.017	0.054
Substation (H6)	BDL	BDL	0.008	0.015
Vauxhall (H4)	BDL	BDL	0.017	0.023
Andy Bay Inlet (H5)	BDL	BDL	0.039	0.155

Enterococci (140 MPN/100ml)	Dry		Wet	
Detection limit (4.0)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	Not applicable		4000	580
Mason (H2)			3400	120
Kitchener (H3)			430	700
Substation (H6)			100	62
Vauxhall (H4)			320	160
Andy Bay Inlet (H5)			7400	6000

Appendix 7- Consent conditions

Environmental Monitoring
Condition 7.
The following monitoring shall be undertaken as specified in Appendix 2 and as shown in the plan in Appendix 3 to this consent.
(a) Stormwater quality monitoring
(b) Harbour receiving water quality
(c) Harbour sediment monitoring.
(d) Biological monitoring including cockles

Appendix 2 specifies:
A Stormwater Quality
TIME/FLOW PROPORTIONAL SAMPLES
(a) The consent holder shall install an automated monitoring device to record stormwater discharge quality over a duration of one year, once every five years, at the following outfalls in turn, being one outfall in each of the ICMP catchments of South Dunedin, Halsey Street, Shore Street, Kitchener Street and Mason Street:

(i) The automated monitoring device shall be set to take time or flow proportional samples within the first 2 hours of the sampled storm event within the catchment prior to any mixing with seawater and:
1. The monitoring device shall be set to be triggered by connection to either a rain gauge or a flow/water level monitor. If flows are used as the trigger, flow monitoring or stormwater modelling shall be used to set the trigger corresponding to a rainfall intensity of 0.5mm per hour. A period of flow and rainfall monitoring is to be undertaken prior to setting this trigger value, to ensure that the trigger is set appropriately to capture a full storm hydrograph.
2. There must be at least 72 hours of dry weather before the monitoring device is activated.
(ii) The consent holder shall sample a minimum of 3 storm events over the 1 year sampling duration at each outfall commencing six months from the date of granting of this consent. Any further sampling of the catchment may be at the discretion of the consent holder.

GRAB SAMPLES
(b) Once per year the consent holder shall take a grab sample of stormwater from an outfall in each of the 10 catchments described in the 10 permits that are subject to this appendix.
(i) The grab samples in the non priority catchments, i.e those that are not listed in (a) above shall be taken from the outfall in the non priority catchments with the highest flows during rainfall events or otherwise from an alternative outfall in agreement with the consent authority.
(ii) The grab samples in the priority catchments listed in (a) above shall not be required in the years when the automated monitoring device described in (a) above is operating in a catchment.
(iii) The grab sample shall be taken before the stormwater mixes with seawater, and shall be taken within the first 2 hours of a storm event, and following a period of 72 hours of no rainfall in the catchment.

ANALYTES

(c) All stormwater samples required under A(a) and (b) above shall be analysed for the following parameters:

(i) pH
(ii) suspended solids
(iii) Escherichia coli units
(iv) total copper
(v) total lead
(vi) total zinc
(vii) total arsenic
(viii) total nickel
(ix) total cadmium
(x) total chromium
(xi) polycyclic aromatic hydrocarbons
(xii) oil and grease

(d) The raw data results from each stormwater event shall be forwarded to the consent authority annually as part of the annual reporting required by condition 11.

B Harbour water quality monitoring

(a) Harbour water quality monitoring shall be undertaken annually to determine the effect the authorised stormwater discharge is having on water quality in the Otago Harbour and to determine whether the trigger values in table B 1 are being exceeded.

(b) Harbour water quality sampling shall be undertaken at the six locations as identified within the plan attached in Appendix 3 during wet and dry weather.

(i) Samples are to be taken on 4 occasions (two rounds (see below) annually.

(ii) Samples shall be taken no closer than 20 metres horizontal distance from the location of the confluence of the stormwater outlet and the waters edge if there are stormwater discharges occurring from the outfall at the time of sampling.

(iii) Samples must be taken 100-200mm below the surface of the water.

(iv) First round sampling shall be three hours apart following high tide, and at mid ebb tide during a period when there has been no measurable rainfall for at least 72 hours prior to sampling.

(v) The second round sampling will occur at the same state of tides as the first round, no less than three hours after the commencement of a rain event that is likely to produce at last 2 mm of rainfall and that has had an antecedent dry period of at least 72 hours.

(c) If harbour water quality sampling identifies the following contaminants at a level exceeding the trigger values set out below in table B 1, the level of contamination shall be confirmed by re-sampling and re-analysis.

(i) total cadmium
(ii) total copper
(iii) total lead
(iv) total zinc
(v) enterococci cfu/100ml (indicator organism)

Table B 1. Harbour Water Trigger Levels

Indicator	*Unit*	*ANZECC 95%Marine Guideline value*	*2013 Trigger*	*Description*
Total Arsenic	*(g/m$^{3)}$*		*0.036*	*USEPA chronic trigger*
Total Cadmium	*(g/m$^{3)}$*	*0.00550*	*0.00550*	*ANZECC guideline*
Total Chromium	*(g/m$^{3)}$*	*0.00440*	*0.00440*	*ANZECC guideline*
Total Copper	*(g/m$^{3)}$*	*0.00130*	*0.00130*	*ANZECC guideline*
Total Nickel	*(g/m$^{3)}$*	*0.07000*	*0.07000*	*ANZECC guideline*
Total Lead	*(g/m$^{3)}$*	*0.00440*	*0.00440*	*ANZECC guideline*
Total Zinc	*(g/m$^{3)}$*	*0.01500*	*0.01500*	*ANZECC guideline*
Enterococci	*Cfu/100ml*	*-*	*140*	*MfE guideline (amber alert)*

(d) If the harbour water quality is confirmed as exceeding the trigger values outlined in Table B 1, the protocol outlined in Condition 10 of the permits shall be implemented.

C Harbour sediment quality

(a) The consent holder shall undertake sediment quality sampling using sediment samples taken from the top 200 millimetres of the seabed. Samples shall be collected from the 5 locations as identified within the plan attached as Appendix 3. The sampling point shall be at or about 20 metres from the nearest stormwater outfall to each site marked on Appendix 3. Samples shall be collected between January and June, on an annual basis.

(b) The sediment properties and contaminants from each sample site are to be tested. At a minimum the consent holder shall for each of the sites collect and analyse one composite surface sediment sample made up of 5 sub-samples for:

(i) weak-acid extractable copper,
(ii) total lead,
(iii) total zinc,
(iv) total arsenic,
(v) total cadmium,
(vi) total chromium,
(vii) total copper,
(viii) total mercury,
(ix) total nickel,
(x) polycyclic aromatic hydrocarbons (the 16 USEPA priority compounds, retene, 2,6- and 1,7-methylated phenanthrene, and hopanes),
(xi) total petroleum hydrocarbons, and
(xii) organochlorine pesticides.

(c) The sample results obtained are to be forwarded to the Consent Authority along with a comparison with any previous monitoring in accordance with the annual reporting required by condition 11 of the permits that apply to this appendix.

(d) Table C 1 sets out the trigger levels for harbour sediments. The trigger levels may be changed with the written agreement of the consent authority, as new monitoring results or other information comes to hand. If agreement cannot be reached on (a) new trigger level/s the consent holder has the option of applying to vary the conditions under s127 of the Act.

(e) If harbour sediment sampling identifies the following contaminants at a level exceeding the trigger values set out below in table C 1, the level of contamination shall be confirmed by re-sampling and re-analysis. The effect of the trigger exceedence shall be assessed taking into account the results of biological monitoring that is nearest and/or most relevant to the sediment monitoring site.

Table C 1 Harbour Sediment Trigger Levels

Indicator	Unit	ANZECC Guideline		2013 Trigger	Reason for 2013 trigger	Amended Trigger Reason
		Low	High			
Total Arsenic	(mg/kg dry wt)	20	70	19	80th percentile of samples collected to date	
Total Cadmium	(mg/kg dry wt)	1.5	10	1.7	80th percentile of samples collected to date	
Total Chromium	(mg/kg dry wt)	80	370	80	ANZECC trigger most samples to date below ANZECC	
Total Copper	(mg/kg dry wt)	65	270	122	80th percentile of samples collected to date	
Total Nickel	(mg/kg dry wt)	21	52	21	ANZECC trigger most samples to date below ANZECC	
Total Lead	(mg/kg dry wt)	50	220	209	80th percentile of samples collected to date	
Total Zinc	(mg/kg dry wt)	200	410	902	80th percentile of samples collected to date	
Total PAH	(mg/kg dry wt)	4	45	183	80th percentile of samples collected to date	
TPH	(mg/kg dry wt)			To be determined	To be determined	
Enterococci	Cfu/100ml			108	80th percentile of samples collected to date	

(c) If the harbour sediment contamination is confirmed as exceeding the trigger values outlined in table C 1 and analysis of biological monitoring under (e) above supports that confirmation, the protocol outlined in Condition 10 of the permits shall be implemented.

D Biological Monitoring

EPIFAUNA, INFAUNA AND MACROFLORA

(a) The consent holder shall undertake biological sampling from the five locations identified on the plan attached as Appendix 3 to the permits. Samples shall be

collected between the months of January and June at two yearly intervals. The monitoring shall include:

(b) Sampling is to be at 3 sites per location as follows: the waters edge at low tide; within 20 metres of the confluence of the stormwater outlet and the waters edge at low tide, and a minimum of 50 metres from the confluence of the stormwater outlet and the waters edge at low tide.

(c) From the top 200 millimetres at each site, three randomly spaced 5 square metre quadrats shall be sampled for epifauna, infauna and macroflora.

(d) Sampling and species identification for each site shall include:

(i) For epifauna within each 5 square metre quadrat, the number of each species shall be recorded in five 0.1 square metre quadrats.

(ii) For infauna a sediment core shall be taken in three 0.1 square metre quadrats and the number of each species shall be recorded.

(iii) For macroflora, the percentage cover of each species shall be estimated in three 1.0 square metre quadrats.

COCKLES

(e) The consent holder shall undertake samples of the flesh of cockles (Austrovenus stutchburyi) at the 3 locations identified in Appendix 3 to the permits.

(i) Sampling shall be carried out at two yearly intervals.

(ii) Sampling from each location shall be at the waters edge at low tide and within 20 metres of the confluence of the stormwater outlet and the waters edge at low tide.

(iii) Analysis shall be from a composite sample from each location of at least 200 grams of cockle flesh. The number and size of cockles used shall be recorded.

(iv) If no cockles are present from in front of an outfall no sample to be taken at that location.

(v) The cockle flesh samples shall be analysed for:

1) total copper

2) total lead

3) total arsenic

4) total cadmium

5) total chromium

6) polycyclic aromatic hydrocarbons

7) Enterococcus Colony Forming Units in No/100 millilitres)

Dry weight sample results shall be recorded for each sample.

(f) The sample results from all biological monitoring shall be provided to the consent authority in accordance with the annual reporting required by condition 11 of the permits that apply to this appendix.