Stormwater Compliance Monitoring 2015

Stormwater Discharges from Dunedin City

(ORC Discharge Permits RM11.313.01 – RM11.313.10)

Prepared for

Dunedin City Council

by

Ryder Consulting Ltd.

August 2015

ryderconsulting
environment + planning + project management

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Cover photo: Stormwater grate, Portobello Road

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Executive Summary

This report presents the findings for the second 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 dry weather samples from all catchments. Also included were assessments of harbour water quality, harbour sediment quality at representative sites and biological monitoring at five sites.

Stormwater from all outfalls monitored showed variable levels of contamination.

Sediments too showed varying levels of contamination with levels of contaminants breaching ANZECC trigger values for nickel, and zinc at two sites. Sediments have been resampled with results pending.

Biological sampling showed flora and fauna typical of moderately impacted shallow inlets from southern New Zealand with no discernible trend in community health attributable to stormwater discharges.

Contaminant levels in both stormwater and sediment were generally within the ranges observed in previous surveys. Harbour water sampling is a relatively new requirement and so it is too early to detect potential trends in contaminant levels.

1. 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 receiving water environments for Dunedin's reticulated stormwater are the upper basin of Otago Harbour, Second Beach/St. Clair Beach on the open coast, Kaikorai Stream and the Water of Leith. Dunedin City Council (DCC) was, on 8th August 2013, granted resource consents for its major urban stormwater discharges into the coastal marine environment, namely into Otago Harbour (including Sawyers Bay and Port Chalmers), St Clair and Second Beach.

Conditions under which consents have been granted include compliance monitoring. Specifically: Condition 2 and Appendix 1, Environmental Monitoring (Condition 7) and Appendix 2 (A. Stormwater quality, B. Harbour water quality, C. Harbour sediment quality, and D. Biological monitoring) (see Appendix 1 for text of consent conditions).

The following report presents the results of the first round of sampling/monitoring carried out from June 2014 - July 2015.

1.2 Stormwater Outfalls

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

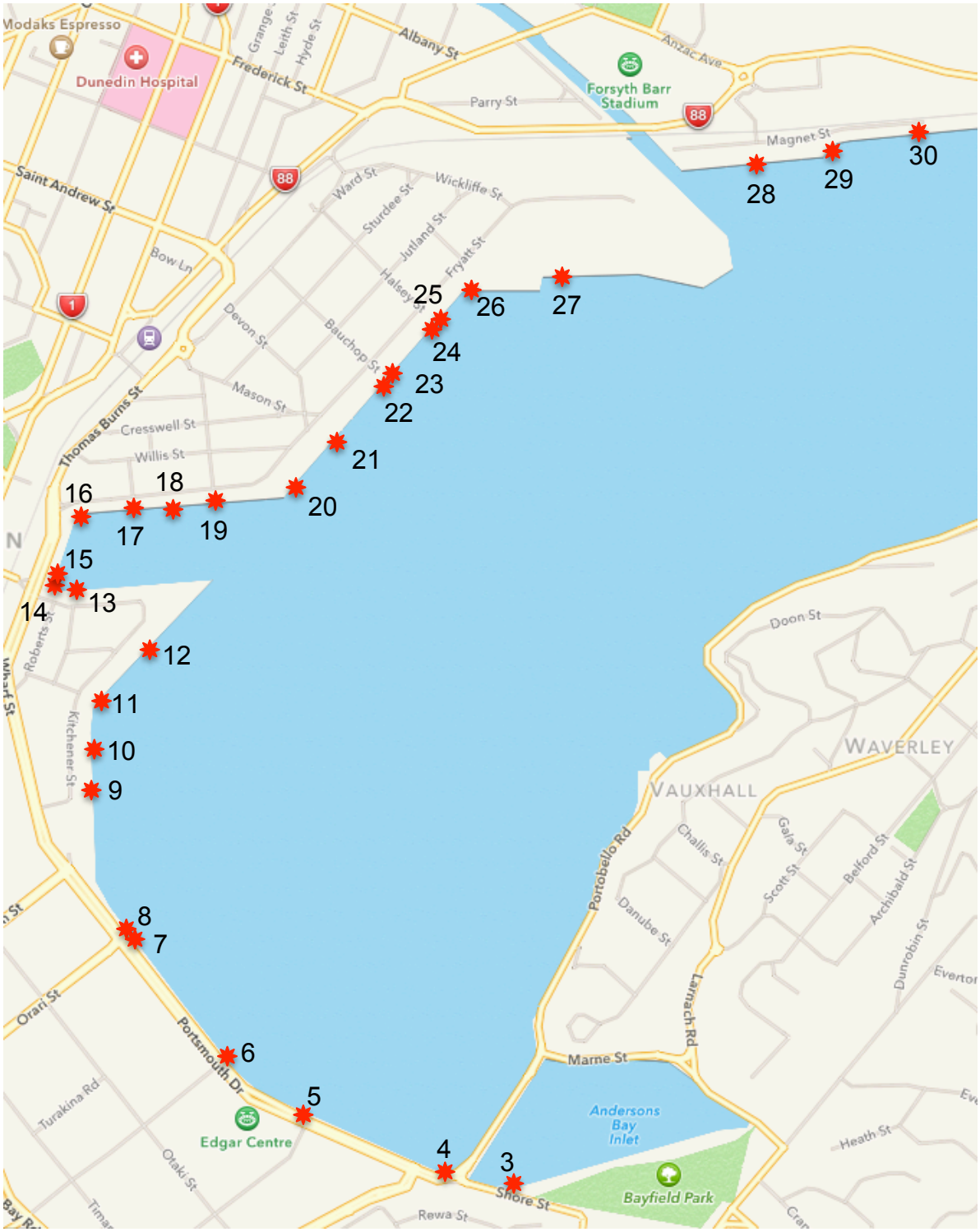

Figure 1.1 *Locations of current Dunedin stormwater outfalls being monitored. Numbers correspond to outfall numbers in Table 2.1. Not shown are outfalls 1 (at Second Beach) and Outfall 2 at St Clair Beach).*

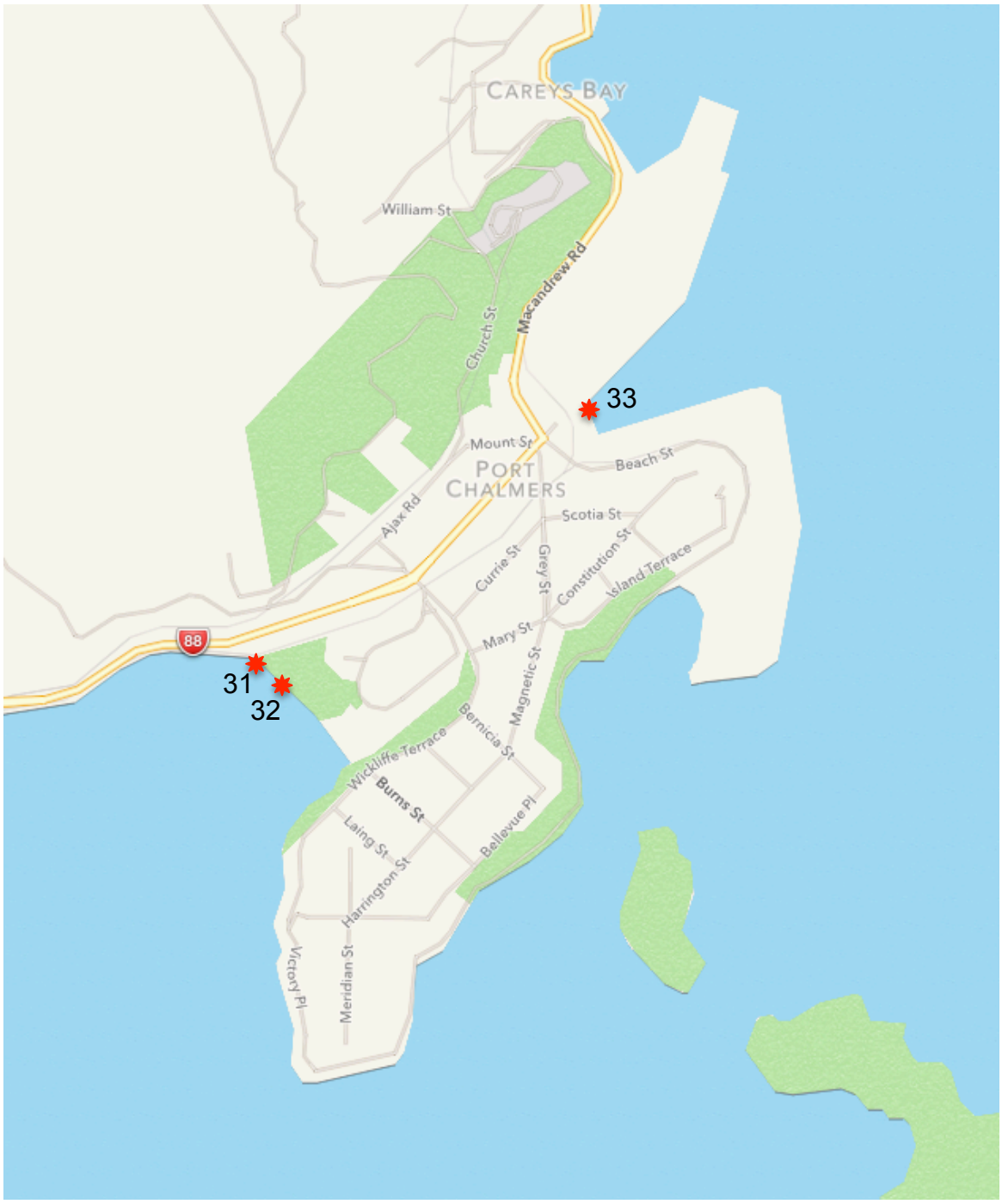

Figure 1.2 *Locations of current stormwater outfalls being monitored at Port Chalmers. Numbers correspond to outfall numbers in Table 2.1.*

2. Methods

2.1 Stormwater

A number of the outfalls shown in Figures 1.1 and 1.2 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.

Dry weather sampling

Dry weather flow sampling, as per Condition 2(a), was reviewed after the 2013/2014 sampling. It was determined that some outfalls need only be sampled on a six monthly basis while the remainder continued to be sampled on a monthly basis (Table 2.1). Sampling was carried out at outfalls, as designated in Table 2.1, provided there had been an antecedent dry period of at least 72 hours. In the event, the 2014/2015 summer was exceedingly unsettled and samples were able to be collected for just July, August and December 2014 and January, April and May of 2015.

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 A (b)(1)) stormwater outfall within 1 hour of the commencement of a rain event (>2.5 mm) in an endeavour to ensure that first flush water 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 collected at low tide from the end of pipe where possible, or from the closest manhole to the end of pipe where an outfall was not readily accessible.

Table 2.1 *Frequency of dry weather sampling.*

Outfall	DCC ref	Location	Catchment	Frequency
1	SWX03979	Second Beach	St Clair	Continue monthly sampling
2	SWX00011 & SWX00012	St Clair Beach	St Clair	6 monthly sampling
3	SWX04625	Shore Street	Shore Street	Continue monthly sampling
4	SWX03649	Portobello Rd	Portobello Rd	Continue monthly sampling
5	SWX03644	Teviot St	Foreshore	Continue monthly sampling
6	SWX03640	Midland St	Foreshore	Continue monthly sampling
7	SWX03631	Orari St	Orari St	Continue monthly sampling
8	SWX03635 & SWX70740	Orari St	Orari St	Continue monthly sampling
9	SWX03579	Kitchener St	Kitchener St	Continue monthly sampling
10	SWX03568	Kitchener St	Kitchener St	6 monthly sampling
11	SWX70102	French St	Foreshore	Continue monthly sampling
12	SWX03547	Kitchener St	Foreshore	6 monthly sampling
13	SWX03562	Birch St	Foreshore	6 monthly sampling
14	SWX03556	Birch St	Foreshore	6 monthly sampling
15	SWX03559	Wharf St	Foreshore	6 monthly sampling
16	SWZ70569	Fryatt St	Foreshore	6 monthly sampling
17	SWX03540	Fryatt St	Foreshore	6 monthly sampling
18	SWX03536	Fryatt St	Foreshore	6 monthly sampling
19	SWX03532	Fryatt St	Foreshore	6 monthly sampling
20	SWX70370	Fryatt St	Foreshore	6 monthly sampling
21	SWX03489	Mason St	Mason St	6 monthly sampling
22	SWX03506	Mason St	Bauchop St	Continue monthly sampling
23	SWX03466	Mason St	Bauchop St	Continue monthly sampling
24	SWX03455	Halsey St	Halsey St	Continue monthly sampling
25	SWX03450	Halsey St	Wickliffe St	Continue monthly sampling
26	SWX03472	Halsey St	Wickliffe St	Continue monthly sampling
27	SWX03718	Wickliffe St	Wickliffe St	Continue monthly sampling
28	SWX02628	Magnet St	Magnet St	6 monthly sampling
29	SWX02623	Magnet St	Magnet St	Under investigation – cease monitoring until further notice
30	SPN02502	Ravensbourne Rd	Gas Works	6 monthly sampling
31	SWX12941	George St/SH88	Port Chalmers	6 monthly sampling
32	SWX12994	Sawyers Bay, western side of Watson Park	Port Chalmers	Continue monthly sampling
33	SWX12879	George St (Port Otago)	Port Chalmers	Continue monthly sampling

Grab stormwater samples were sent to Citilab in Dunedin to be analysed, as per Appendix 2 A (c), for oil and grease, 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*.

Wet weather automated sampling

An ISCO automated sampler was installed approximately 100m up-pipe of the Shore Street stormwater outfall in May 2015, to fulfil the requirements of Appendix 2A (a) of the consent conditions. The sampler has 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.

Samples from the ISCO automated sampler are usually treated in the same manner as collected grab samples. However, since installation there have been no suitable rainfall events that have triggered the sampler. As a result, there are no flow-weighted results available for the 2014/2015 year. It is anticipated results will be available in May 2016.

Samples collected from outfalls and manholes, as indicated in Table 1.1, during dry periods were sent to Citilab for analysis for *E. coli* and were analysed on site for fluorescent whitening agents (FWAs) using a hand-held fluorimeter. FWAs are used in laundry detergents and indicate possible sewage infiltration to the stormwater system (Petch 1996, Gilpin *et al.* 2004).

2.2 Harbour water sampling

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.

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

2.3 Sediment sampling

Samples were collected from the top 20mm of sediment at the locations shown in Figure 2.1 at GPS points listed in Table 2.1.

Table 2.1 *GPS co-ordinates for sediment sampling sites.*

Site	Easting	Northing
Halsey Street (H1)	E2317198	N5478510
Kitchener Street (H2)	E2316380	N5477405
Orari Street (H3)	E2316462	N5477034
Shore Street (H4)	E2317435	N5476408

At Halsey Street and Kitchener Street 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 20mm of the contents of the grab. Samples were chilled and sent to Citilab 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.

2.3 Biological Monitoring

Biological monitoring was carried out at five sites (Figure 2.2). At Kitchener Street, Orari Street and Portobello Road epifauna and flora were assessed at the waters edge at low tide at three sites (0-5 m distant from the outfall, 15-20m from the outfall and 45-50m from the outfall). Assessment was made using 3 x 1 m^2 quadrats at each site for flora and 5 x 0.25 m^2 quadrats at each site for epifauna. Infauna were assessed from three 200 mm deep 85 mm

diameter cores collected at each site. Cores were sieved using 500µm mesh and retained organisms were returned to the laboratory for identification and enumeration.

The above techniques were all repeated at a site at Burkes and Macandrew Bay to give a comparison with site that are not directly impacted by the presence of an outfall (control sites). In the absence of an outfall, all quadrats were randomly placed at three locations along the low water mark.

Lastly, samples of cockles were collected within 20 m of the outfall at the Kitchener Street, Orari Street and Portobello Road sites. Cockles were returned to the laboratory for measuring, then sent to Citilab for analysis for total As, Cd, Cr, Cu, Pb, PAHs and Enterococci.

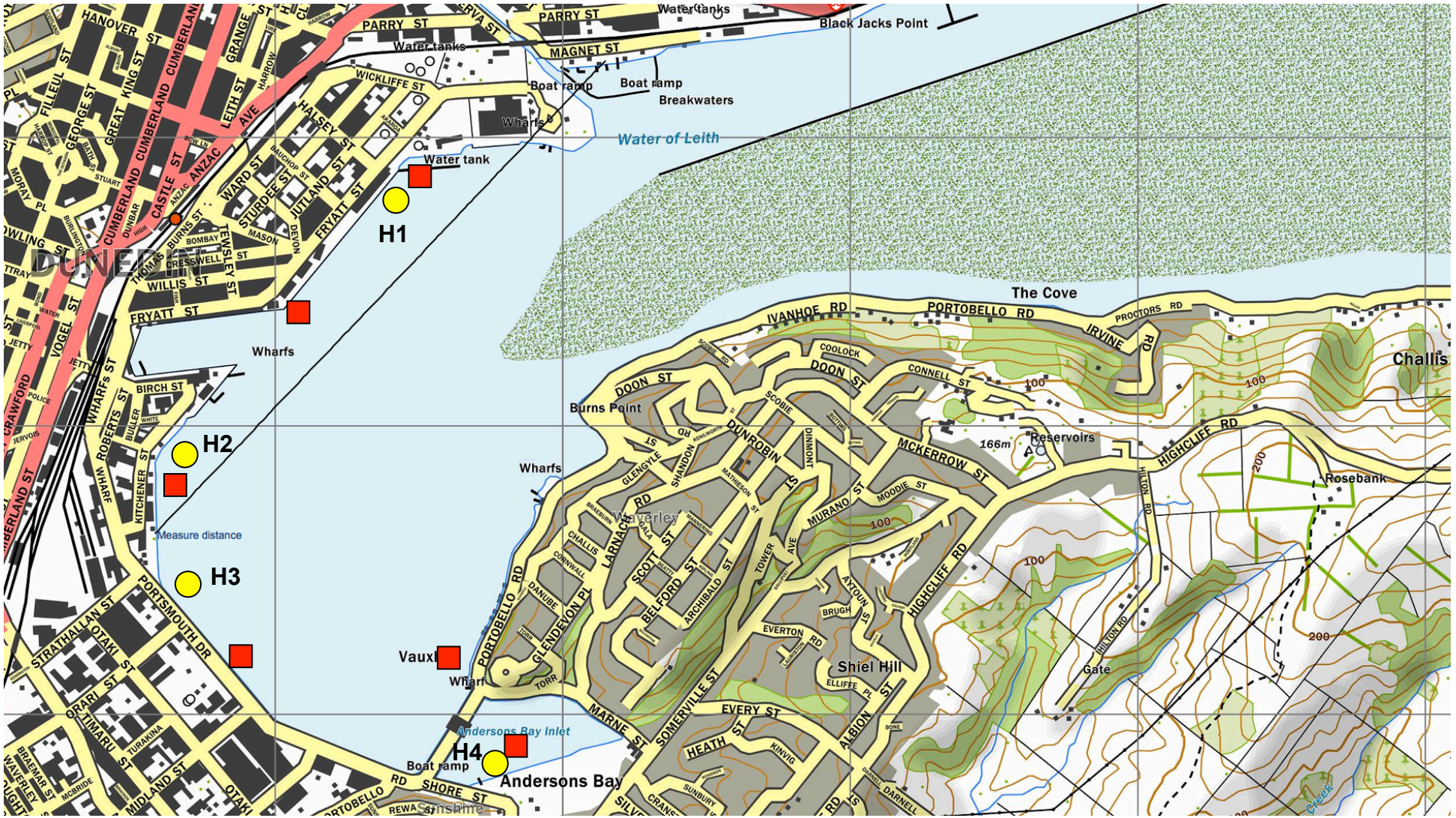

Figure 2.1 *Upper Harbour Basin seawater and sediment sampling sites. Red squares are harbour water quality sites; Yellow circles are sediment sites (see Table 2.1).*

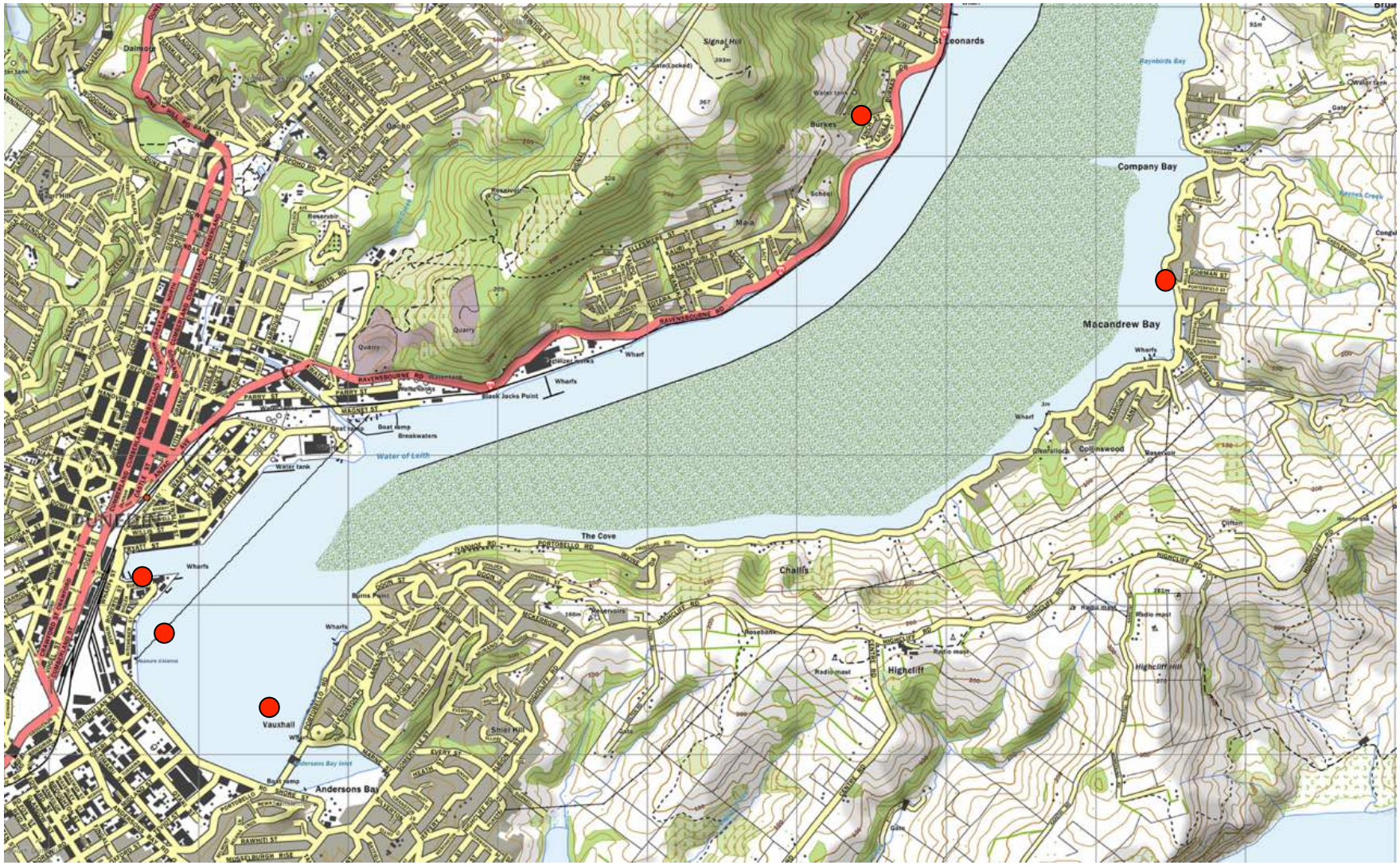

Figure 2.2 *Upper Harbour Basin biological sampling sites. Anticlockwise from centre top: Burkes, Kitchener St, Orari St, Portobello Rd, Macandrew Bay.*

3. Results

3.1 Stormwater

Dry weather sampling

Dry weather flow sampling was carried out on 31st July 2014, 27th August 2014, 16th December 2014, 23rd January 2015, 9th April 2015 and 21st May 2015. 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 (Tables 3.1.1a and b). Note that the outfalls at Magnet Street (SWX02623) and Bauchop Street (SWX03506) are currently under investigation by the DCC in an attempt to ascertain possible sources of contamination.

E. coli levels frequently exceed trigger levels, with numbers often exceeding 2400 MPN/100ml at outfalls 7, 22, 24 and 25 (Table 3.1.1b). However, the fact that FWAs at the same sites are not always high suggests that contamination may not be from human sewage, but rather from other, as yet unknown, sources.

Table 3.1.1a *FWA levels in dry weather flow samples taken from DCC stormwater outfalls. Pink shaded cells denote trigger levels exceeded. Orange shaded cells denote trigger level approached. NF = no flow. Grey cells = sampling 6 monthly.*

Outfall	DCC ref	Location	Catchment	FWAs Jul-14	FWAs Aug-14	FWAs Dec-14	FWAs Jan-15	FWAs Apr-15	FWAs May-15
1	SWX03979	Second Beach	St Clair	0.061	0.064	0.052	0.059	0.035	0.039
2	SWX00011 & SWX00012	St Clair Beach	St Calir		NF	NF	NF	NF	NF
3	SWX04625	Shore Street	Shore Street	0.091	0.118	0.091	0.06	0.066	0.068
4	SWX03649	Portobello Rd	Portobello Rd	0.195	0.258	0.027	0.138	0.027	0.182
5	SWX03644	Teviot St	Foreshore	0.138	0.117	0.115	0.8	0.148	0.105
6	SWX03640	Midland St	Foreshore	0.169	0.149	0.134	0.059	0.162	0.115
7	SWX03631	Orari St	Orari St	0.047	0.106	0.007	0.06	0.021	0.037
8	SWX03635 & SWX70740	Orari St	Orari St	0.102	0.08	0.105	0.095	0.057	0.067
9	SWX03579	Kitchener St	Kitchener St	0.085	0.1	0.079	0.065	0.082	0.094
10	SWX03568	Kitchener St	Kitchener St		0.058				
11	SWX70102	French St	Foreshore	0.142	0.072	0.016	0.05	0.044	0.029
12	SWX03547	Kitchener St	Foreshore		0.036				
13	SWX03562	Birch St	Foreshore		NF	NF	NF	NF	NF
14	SWX03556	Birch St	Foreshore		NF	NF	NF	NF	NF
15	SWX03559	Wharf St	Foreshore		NF	NF	NF	NF	NF
16	SWZ70569	Fryatt St	Foreshore		NF	NF	NF	NF	NF
17	SWX03540	Fryatt St	Foreshore		NF	NF	NF	NF	NF
18	SWX03536	Fryatt St	Foreshore		NF	NF	NF	NF	NF
19	SWX03532	Fryatt St	Foreshore		Nf	Nf	Nf	Nf	Nf
20	SWX70370	Fryatt St	Foreshore		NF	NF	NF	NF	NF
21	SWX03489	Mason St	Mason St		0.024				
22	SWX03506	Mason St	Bauchop St	0.271	0.149	0.191	0.173	0.341	0.187
23	SWX03466	Mason St	Bauchop St	0.024	0.034	0.063	0.029	0.085	0.036
24	SWX03455	Halsey St	Halsey St	0.021	0.014	0.019	0.008	0.019	0.026
25	SWX03450	Halsey St	Wickliffe St	0.054	0.041	0.04	0.03	0.061	0.068
26	SWX03472	Halsey St	Wickliffe St	0.046	0.057	NF	NF	NF	NF
27	SWX03718	Wickliffe St	Wickliffe St	0.085	0.069	0.037	0.032	0.032	0.093
28	SWX02628	Magnet St	Magnet St		0.069				
29	SWX02623	Magnet St	Magnet St		0.093				
30	SPN02502	Ravensbourne Rd	Gas Works		0.129				
31	SWX12941	George St/SH88	Port Chalmers		0.128				
32	SWX12994	Sawyers Bay, western side of Watson Park	Port Chalmers		0.178	0.137	0.053	NF	0.074
33	SWX12879	George St (Port Otago)	Port Chalmers	0.114	0.12	0.079	0.087	0.051	0.041

Table 3.1.1b *E. coli levels (expressed as MPN/100ml) levels in dry weather flow samples taken from DCC stormwater outfalls. Pink shaded cells denote trigger levels exceeded. NF = no flow. Grey cells = sampling 6 monthly.*

Outfall	DCC ref	Location	Catchment	E. coli Jul-14	E. coli Aug-14	E. coli Dec-14	E. coli Jan-15	E. coli Apr-15	E. coli May-15
1	SWX03979	Second Beach	St Clair	690	580	520	1300	650	22.8
2	SWX00011 & SWX00012	St Clair Beach	St Calir		NF	NF	NF	NF	NF
3	SWX04625	Shore Street	Shore Street	870	>2400	1700	98.1	1600	43.4
4	SWX03649	Portobello Rd	Portobello Rd	1000	610	110	1300	580	>2400
5	SWX03644	Teviot St	Foreshore	4.1	870	>2400	310	100	<1.0
6	SWX03640	Midland St	Foreshore	14.2	820	220	12.2	3	6.1
7	SWX03631	Orari St	Orari St	>2400	>2400	>2400	11	2000	140
8	SWX03635 & SWX70740	Orari St	Orari St	460	730	210	410	5.1	660
9	SWX03579	Kitchener St	Kitchener St	32	250	28.3	130	48.2	15
10	SWX03568	Kitchener St	Kitchener St		270				
11	SWX70102	French St	Foreshore	2400	2400	34.5	580	59.4	<1.0
12	SWX03547	Kitchener St	Foreshore		5.2				
13	SWX03562	Birch St	Foreshore		NF	NF	NF	NF	NF
14	SWX03556	Birch St	Foreshore		NF	NF	NF	NF	NF
15	SWX03559	Wharf St	Foreshore		NF	NF	NF	NF	NF
16	SWZ70569	Fryatt St	Foreshore		NF	NF	NF	NF	NF
17	SWX03540	Fryatt St	Foreshore		NF	NF	NF	NF	NF
18	SWX03536	Fryatt St	Foreshore		NF	NF	NF	NF	NF
19	SWX03532	Fryatt St	Foreshore		Nf	Nf	Nf	Nf	Nf
20	SWX70370	Fryatt St	Foreshore		NF	NF	NF	NF	NF
21	SWX03489	Mason St	Mason St		49.8				
22	SWX03506	Mason St	Bauchop St	1300	>2400	490	>2400	>24000	>2400
23	SWX03466	Mason St	Bauchop St	<1.0	410	<1.0	>2400	1100	17.4
24	SWX03455	Halsey St	Halsey St	>2400	>2400	980	>2400	>2400	2400
25	SWX03450	Halsey St	Wickliffe St	>2400	>2400	>2400	>2400	>2400	>2400
26	SWX03472	Halsey St	Wickliffe St	<1.0	30.5	NF	NF	NF	NF
27	SWX03718	Wickliffe St	Wickliffe St	920	1600	570	340	>2400	1700
28	SWX02628	Magnet St	Magnet St		3.1				
29	SWX02623	Magnet St	Magnet St		160				
30	SPN02502	Ravensbourne Rd	Gas Works		5.2				
31	SWX12941	George St/SH88	Port Chalmers		870				
32	SWX12994	Sawyers Bay, western side of Watson Park	Port Chalmers		<1.0	>2400	5.1	NF	47.1
33	SWX12879	George St (Port Otago)	Port Chalmers	>2400	1600	3.1	110	520	1700

Wet weather grab sampling

Wet weather grab samples were collected on 26th June 2015 during a storm event that yielded 3.8 mm of rainfall. Levels of some contaminants, notably arsenic, cadmium, chromium, nickel, oil and grease, and polycyclic aromatic hydrocarbons were very low at most sites (Table 3.1.2). However, levels of *E. coli* were high at all outfalls except Mason Street. 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 much decaying vegetation.

Table 3.1.2 *Contaminant levels in stormwater at ten key Dunedin City outfalls. BDL = below detectable limits. Rain event on 26/6/15 yielding 3.8 mm.*

Catchment	Outfall	Consent ref.	As (g/m3)	Cd (g/m3)	Cr (g/m3)	Cu (g/m3)	Pb (g/m3)	Ni (g/m3)	Zn (g/m3)
St Clair	1	RM11.313.10	BDL	0.0001	0.0117	0.026	0.0557	BDL	0.222
Shore Street	3	RM11.313.04	BDL	BDL	0.0061	0.025	0.0635	BDL	0.351
South Dunedin	4	RM11.313.09	0.003	0.0001	0.0182	0.059	0.0869	BDL	0.744
Orari Street	8	RM11.313.08	BDL	BDL	0.0027	0.004	0.0295	BDL	0.078
Kitchener Street	10	RM11.313.06	BDL	BDL	0.001	0.003	0.0202	BDL	0.025
Mason Street	21	RM11.313.05	0.003	0.0001	0.0183	0.041	0.124	BDL	0.577
Bauchop Street	23	RM11.313.03	0.001	BDL	0.0182	0.079	0.115	BDL	0.713
Halsey Street	24	RM11.313.03	0.002	0.0004	0.0226	0.084	0.108	0.0254	0.576
Wickliffe Street	27	RM11.313.03	0.008	0.0002	0.0189	0.045	0.1	0.0051	0.617
Port Chalmers	31	RM11.313.01	BDL	BDL	0.0054	0.011	0.0316	BDL	0.334
ANZECC trigger value			0.36	0.0008	0.04	0.0025	0.0094	0.017	0.031

Catchment	Outfall	Consent ref.	FWAs	O&G (g/m3)	pH	SS (g/m3)	PAH (g/m3)	E. coli (MPN/100ml)	
St Clair	1	RM11.313.10	0.084	27	7.63	210	BDL	2000	
Shore Street	3	RM11.313.04	0.087	BDL	7.5	150	BDL	2600	
South Dunedin	4	RM11.313.09	0.138	BDL	7.58	200	0.0104	1000	
Orari Street	8	RM11.313.08	0.09	12	7.87	130	BDL	2000	
Kitchener Street	10	RM11.313.06	0.046	8	7.43	45	BDL	990	
Mason Street	21	RM11.313.05	0.06	6	8.4	210	BDL	460	
Bauchop Street	23	RM11.313.03	0.057	BDL	8.83	350	BDL	580	
Halsey Street	24	RM11.313.03	0.07	6	7.73	580	BDL	2900	
Wickliffe Street	27	RM11.313.03	0.081	30	7.67	490	BDL	>24000	
Port Chalmers	31	RM11.313.01	0.104	17	7.48	170	BDL	9200	
ANZECC trigger value					7.2-7.8			>260	Primary contact
								>550	Secondary contact

When compared with results from rain events through time, we see that the levels of contaminants in stormwater during the 26th June rain event were generally within the range of

values observed at the various outfalls that have been sampled annually since 2007 (e.g. Zinc and E. coli: Figure 3.1.1; Appendix 2, Table 1).

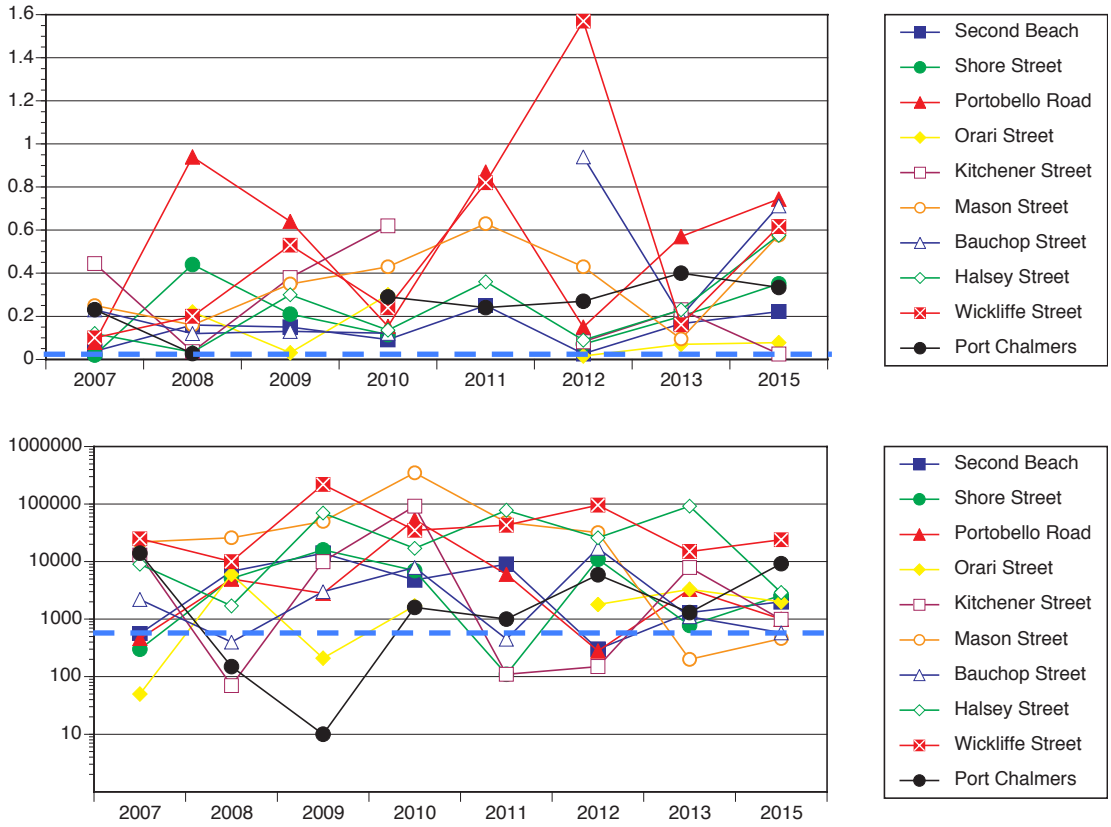

Figure 3.1.1 *Contaminant values in stormwater through time for zinc (top) and E. coli (bottom). Values for zinc are g/m^3 and for E. coli MPN/100ml. Note that scale for E. coli is logarithmic. Dashed blue lines show ANZECC/MfE trigger values.*

There were some exceptions however. Lead, copper and suspended solids were all generally higher this year than in the past (Figure 3.1.2; Appendix 2, Table 1). This may be attributable to the relatively long dry spell (5 days) prior to the sampled rain event and the fact that contaminants such as lead and copper occur at commonly high levels in street dust. PAHs at South Dunedin (Portobello Rd) were also higher this year than in the past (Appendix 2, Table 1).

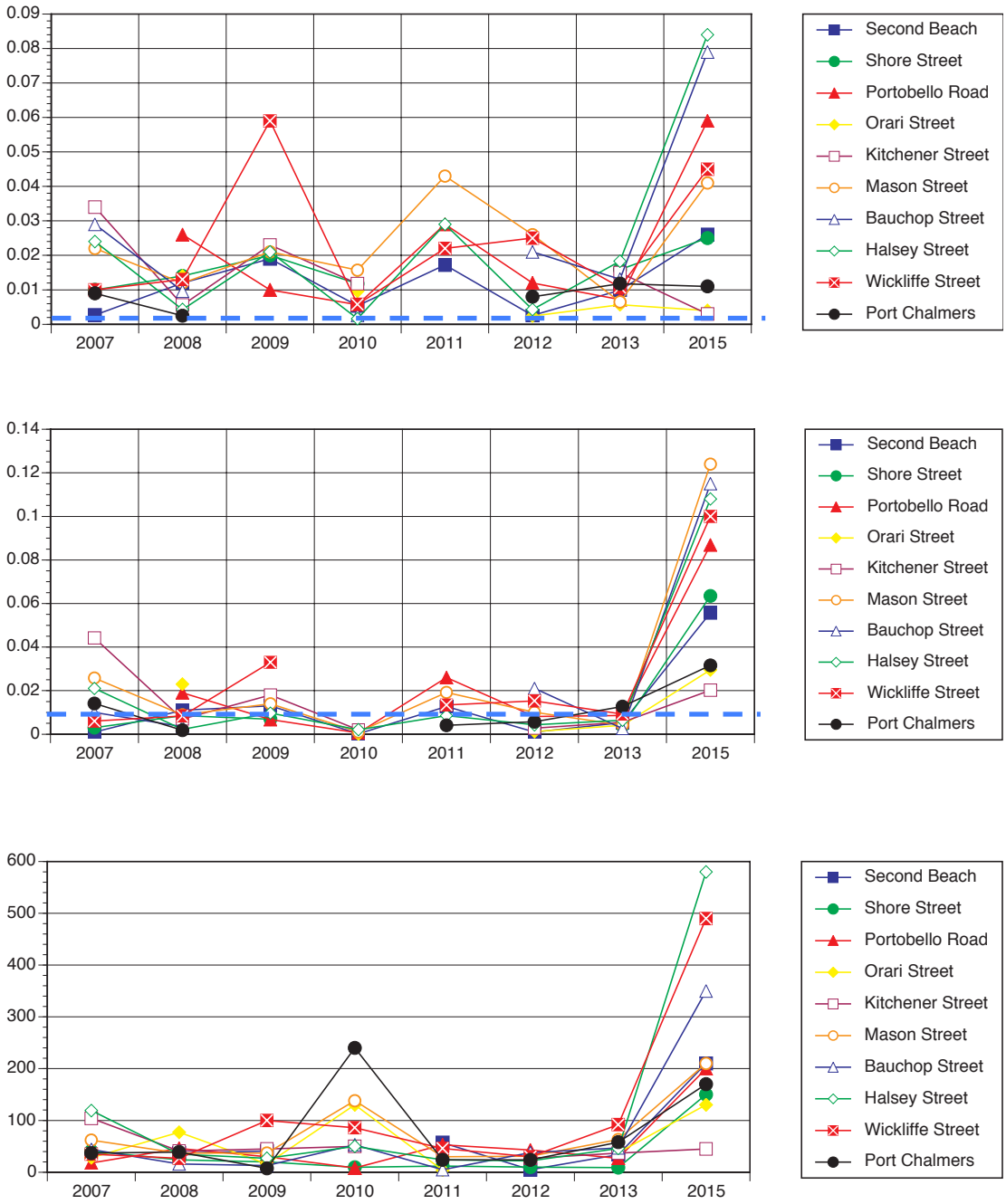

Figure 3.1.2 *Contaminant values for copper (top), lead (middle) and suspended solids (bottom) through time. Values are g/m^3. Dashed blue lines show ANZECC trigger values.*

Wet weather automated sampling

There are no flow weighted results for stormwater this year due to the date of installation of the ISCO automated sampler at the Shore Street site.

3.2 Harbour Water

Harbour water was collected during a dry weather spell on 21st May 2015 and during a rainfall event that occurred on 3rd June 2015. The rain event generated 164 mm of rain. Samples on each occasion were collected at mid flood tide and again at mid ebb tide.

Contamination of harbour water was low for cadmium at all sites. However, copper, lead and zinc concentrations on both the wet and dry weather monitoring rounds, on both the flood and ebb tides, are generally above the Consent trigger levels, which are also the ANZECC (2000) trigger values for protection of 95% of species. For lead and zinc contamination was neither universal across all sites nor consistent throughout the tidal cycle (Table 3.2.1).

Levels for enterococci contamination often exceed guidelines for marine waters (i.e. >140 MPN/100ml = amber alert; >280 MPN/100ml = red alert), especially on the flood tide during a rain event (Table 3.2.1). This may well be due to discharge of wastewater from known overflow outlets during the 3 June flood event, which was particularly severe. However, there is also evidence of bacterial contamination during dry spells, notably off Portsmouth drive in the substation area, and in the vicinity of the Wickliffe Street and Mason Street outfalls.

Due to a number of exceedences in the 2015 results harbour water was resampled at the first opportunity where rainfall and tide state allowed. This occurred on 24th August 2015. Results are not yet to hand but will be forwarded to the DCC immediately upon receipt.

Table 3.2.1 *Contaminants in upper harbour basin water during dry period and a rain event on 3rd June 2015 that yielded 164 mm of rainfall. Pink shaded cells indicate exceedence of Consent trigger values.*

ANZECC 95% (g/m3)	Dry		Wet	
Cd (0.0055)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.0001	<0.0001	<0.0001	<0.0001
Mason (H2)	0.00006	<0.0001	<0.0001	0.00021
Kitchener (H3)	<0.0001	0.00005	<0.00005	<0.00005
Substation (H6)	<0.0001	<0.0001	<0.0001	<0.00005
Vauxhall (H4)	0.003	<0.0001	<0.0001	<0.00005
Andy Bay Inlet (H5)	<0.00005	<0.0001	<0.0001	<0.0001

	Dry		Wet	
Cu (0.0013)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.002	0.003	0.013	0.009
Mason (H2)	0.002	0.01	0.009	0.097
Kitchener (H3)	0.061	0.001	0.002	0.01
Substation (H6)	0.005	0.02	0.012	0.004
Vauxhall (H4)	0.009	0.006	0.007	0.034
Andy Bay Inlet (H5)	0.002	0.011	0.026	0.01

	Dry		Wet	
Pb (0.0044)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.0809	0.238	0.0234	0.01051
Mason (H2)	<0.00001	0.315	0.0146	0.00591
Kitchener (H3)	0.14	<0.0001	0.00361	0.00308
Substation (H6)	0.059	0.247	0.02449	0.00402
Vauxhall (H4)	0.0725	0.123	0.01539	0.00449
Andy Bay Inlet (H5)	<0.00001	0.268	0.02	0.01813

	Dry		Wet	
Zn (0.015)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.085	0.169	23.1	3.5
Mason (H2)	<0.002	0.234	12.5	0.334
Kitchener (H3)	0.327	<0.002	<0.002	<0.002
Substation (H6)	0.059	0.236	13.9	<0.002
Vauxhall (H4)	0.083	3.88	7.74	0.084
Andy Bay Inlet (H5)	<0.002	0.323	13	3.01

	Dry		Wet	
Enterococci (140 MPN/100ml)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	880	98	5200	5500
Mason (H2)	220	52	880	310
Kitchener (H3)	31	20	1200	500
Substation (H6)	41	360	24000	610
Vauxhall (H4)	41	31	8200	3700
Andy Bay Inlet (H5)	<10	52	12000	6900

Harbour water quality has not been specifically targeted in annual stormwater sampling rounds prior to 2014. However, there are limited historic data available (Stewart and Ryder 2005) (Table 3.2.2). Levels of Cd fall within ranges observed in the past, but Cu, Pb, Zn and Enterococci do not. Unfortunately, there are no data on the state of the tide when these samples were collected, nor on whether or not it was raining at the time. Consequently, any comparisons must be viewed with caution.

Table 3.2.2 *Range of contaminant values observed in harbour water column historically. Data from Royds Garden (1990); ORC (1991); Stevenson (1998); Grove & Probert (1997); Wells (1996).*

Cd (g/m3)	Cr (g/m3)	Cu (g/m3)	Ni (g/m3)	Pb (g/m3)	Zn (g/m3)	Enterococci (MPN/100ml)
0.000018-0.00091	0.0005-0.002	0.00018-0.019	0.00078-0.00083	0.00024-0.0019	0.000025-0.0064	40-640

3.3 Sediments

Harbour sediments were sampled on 2nd June 2015 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.

Levels of mercury, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and organochlorine pesticides were all very low (Table 3.3.1). However, the levels of some contaminants (nickel and zinc) were found to be higher than the trigger values stated in Appendix 2, Table C 1 (Table 3.9). Resampling of sediments was carried out on 19th August. Results from resampling placed nickel levels at Shore Street at 16 mg/kg, both below Consent trigger values. For zinc, levels at Shore Street were 210 mg/kg dry weight (below trigger values) but at Kitchener Street zinc levels remain high (1990 mg/kg). It should be noted that the Kitchener Street site 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 (Table 3.3.2). However, historically, sediments were sampled much closer to

stormwater outfalls that in 2014 and 2015 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).

Table 3.3.1 *Contaminant concentration (mg/kg dry weight) in sediments sampled at the head of the Otago Harbour Basin. Pink shaded cells indicate where concentration exceeds Consent trigger value.*

Site	As	Cd	Cr	Cu (WAE)	Cu	Pb	Hg	Ni	Zn
Halsey Street	7.68	0.113	28	0.001	16.2	19.1	0.142	15.6	88.8
Kitchener Street	8.17	0.188	16.8	0.062	16.5	43.4	0.063	12.3	419
Orari Street	2.53	0.0481	8.73	0.03	4.26	8.4	0.041	4.22	47.3
Shore Street	12	0.194	22.1	0.022	15.3	26	0.125	29.2	120

Site	TPH	PAH	Organochlorine pesticides
Halsey Street	BDL	BDL	BDL
Kitchener Street	220	22.53	0.032*
Orari Street	BDL	0.55	BDL
Shore Street	139	12.43	BDL

* 0.018 4,4'-DDD
0.014 4,4'-DDT

Table 3.3.2 *Maximum contaminant concentrations (mg/kg) in sediments sampled in 2015 and historically. Data from Royds Garden (1990); Grove (1995); Purdie and Smith (1994); Bioresearches (2002); Stewart and Ryder (2004); Stevenson (1998); Grove & Probert (1997).*

	AS	Cd	Cr	Cu	Pb	Hg	Ni	Zn	PAH
2015 Maximum	8.17	0.194	28	16.5	43.4	0.142	29.2	419	22.53
Historic maximum	46	6.2	98	433	800	0.17	44	4450	651

3.4 Biological Monitoring

On 30th June 2015 biological sampling was carried out at the Orari Street, Kitchener Street and Portobello Road, outfalls and at reference sites at Burkes and Macandrew Bay. The tide was moderately low at 0.92 m below mean sea level.

There was a low diversity of green and red algae at all sites, with Orari Street having the highest diversity (4 taxa) and Macandrew Bay having the lowest diversity (0 taxa) (Tables 3.4.1a and b). Percentage cover was generally low at all sites (Tables 3.Xa and b). Cover was highest at the three sites near the Kitchener Street outfall with reasonable cover of *Ceramium uncinatum* present, although this was largely beach cast (Table 3.Xa). Overall, cover at outfall sites was similar to previous years (Stewart 2007a, Stewart 2008c, Stewart 2009, 2010, 2011, 2012, 2013).

Table 3.4.1a *Macroalgal cover, expressed as a percentage at Burkes (left) and Kitchener Street (right). Green algae in green, red algae in pink, brown algae in orange.*

Burkes	Site 1		
Algae (% cover) 20m	Q1	Q2	Q3
Ceramium uncinatum		10	
Lenormandia chauvinii			8

Burkes	Site 1		
Algae (% cover) >50m	Q1	Q2	Q3
Ceramium uncinatum	3		
Lenormandia chauvinii			5

Kitchener Street	Site 1		
0-5m	Q1	Q2	Q3
Ceramium uncinatum	4		6

Kitchener Street	Site 1		
Algae (% cover) 20m	Q1	Q2	Q3
Ceramium uncinatum	3		9
Macrocystis pyrifera			3

Kitchener Street	Site 1		
Algae (% cover) >50m	Q1	Q2	Q3
Codium fragilis			6
Ulva lactuca	2		
Ceramium uncinatum	80	23	40

Table 3.4.1b *Macroalgal cover, expressed as a percentage at Orari Street (left) and Portobello Road (right). Green algae in green, red algae in pink, brown algae in orange.*

Orari Street	Site 1		
0-5m	Q1	Q2	Q3
Codium fragilis	5	8	
Ulva lactuca	2		
Ceramium uncinatum		1	
Lenormandia chauvinii		1	

Orari Street	Site 1		
Algae (% cover) >50m	Q1	Q2	Q3
Codium fragilis	6		
Ulva lactuca	10	8	8
Ceramium uncinatum	3		5
Lenormandia chauvinii			1

Portobello Road	Site 1		
0-5m	Q1	Q2	Q3
Enteromorpha spp.	7		
Undaria pinnatifida	3		

Epifauna was moderately abundant at all three outfalls (Tables 3.4.2a-c), and somewhat less so at the two reference sites. As in previous years the small topshell *Micrelenchus tenebrosus* and cockles, *Austrovenus stutchburyi*, comprise the majority of animals, although the tubeworm, *Pomatoceros caerulus*, is abundant in patches on rocks, especially at Kitchener Street.

Numbers of animals per square metre was higher nearer the Kitchener Street outfall than at 20m and 50m of the outfall, largely due to the high density of tubeworms on some rocks. This differs from previous years when higher numbers of tubeworms and *Micrelenchus* were observed at the >50m quadrats. For Orari Street and epifaunal numbers per square metre were slightly higher at 20m than at >50m, while for Portobello Rd, highest numbers were found furthest away.

For the reference sites there was no readily discernible pattern of density, which is not unexpected considering there is no outfall to influence animal presence/absence. In 2010 numbers were similar irrespective of distance at both outfalls. With respect to outfall sites, the overall density of epifaunal animals was lowest at Portobello Road and highest at Kitchener Street, due mainly to the higher abundance of tubeworms at this site (Tables 3.4.2a-c).

Diversity within animal communities was variable, but with all three outfall sites showing slightly greater diversity 20 m from the outfall than close to or further away (Tables 3.4.2a-c). Diversity index at outfall sites was equally lowest at Kitchener Street and Orari Street, with reference sites being lower again. Overall diversity has not changed from that observed in previous years ($F_{7,15} = 0.125$, $p = 0.994$ for 0-5 m sites; $F_{7,15} = 0.618$, $p = 0.729$ for 20m sites; $F_{7,15} = 0.3.8$, $p = 0.931$ for >50m sites). Neither is there a significant difference in epifaunal diversity among sites close to or further away from the outfalls ($F_{2,11} = 0.757$, $p = 0.496$).

Table 3.4.2a. *Epifauna at three locations at Burkes (left) and near the Kitchener Street outfall (right).*

Burkes

0-5m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Bivalves					
Austrovenus stutchburyi	1	2	1	1	1

20m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Gastropod snails					
Cominella glandiformis		1	1		
Bivalves					
Austrovenus stutchburyi	3	2	3	2	1

>50m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Gastropod snails					
Amphibola crenata			1		
Cominella glandiformis				1	
Micrelenchus tenebrosus				1	
Bivalves					
Austrovenus stutchburyi	2	2	4		

Kitchener St

0-5m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Polychaete worms					
Pomatoceros caerulus	66	41	11	83	45
Barnacles					
Eminius modestus	103		6	21	
Chamaesipho columna			3		
Chitons					
Chiton glaucus	1				
Gastropod snails					
Melagraphis aethiops	3				1
Micrelenchus tenebrosus	5	1	2		

20m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Polychaete worms					
Pomatoceros caerulus	13	28		36	1
Barnacles					
Eminius modestus	20			5	2
Chitons					
Chiton glaucus				1	1
Gastropod snails					
Austrolittorian cincta	3	1		2	
Micrelenchus tenebrosus	1	1		2	
Bivalves					
Austrovenus stutchburyi			1		
Ostrea heffordi		1		10	

>50m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Polychaete worms					
Pomatoceros caerulus		1	1		
Barnacles					
Eminius modestus	11	3	28		26
Chitons					
Chiton glaucus	1				
Gastropod snails					
Micrelenchus tenebrosus				1	1

Table 3.4.2b *Epifauna at three locations near the Orari Street outfall (left) and near the Portobello Road outfall (right).*

Orari Street

0-5m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Barnacles					
Eminius modestus				26	
Gastropod snails					
Micrelenchus tenebrosus	2	1	2	1	1
Bivalves					
Austrovenus stutchburyi	3	3	1	1	3

20m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Gastropod snails					
Cominella glandiformis	1				1
Diloma subrostrata			1		
Micrelenchus tenebrosus	1	2	2	1	3
Zeacumantus subcarinatus					1
Bivalves					
Austrovenus stutchburyi	9	9	10	7	13
Macomona liliana	2		1		

>50m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Gastropod snails					
Cominella glandiformis			1		1
Melagraphis aethiops	1				
Micrelenchus tenebrosus	7	6	2	9	4
Zeacumantus subcarinatus		2	1	1	
Bivalves					
Austrovenus stutchburyi	7	9	11	4	3

Portobello Rd

0-5m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Barnacles					
Eminius modestus	2				
Gastropod snails					
Cominella glandiformis		1			1
Micrelenchus tenebrosus		1	1	2	2
Zeacumantus subcarinatus			2		
Bivalves					
Austrovenus stutchburyi		1			1

20m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Polychaete worms					
Pomatoceros caerulus					1
Chitons					
Acanthochitona zelandica			1		
Gastropod snails					
Buccinulum vittatum		1			
Cominella glandiformis	1	1			
Melagraphis aethiops					1
Micrelenchus tenebrosus	3	4	2	2	2
Zethalia zelandicum	1				1
Bivalves					
Austrovenus stutchburyi	5	4	5	4	3

>50m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Gastropod snails					
Cominella glandiformis				1	
Melagraphis aethiops		1			
Micrelenchus tenebrosus	2	3	1	1	1
Sigapatella novaezelandiae					1
Bivalves					
Austrovenus stutchburyi	2	5	2	11	6

Table 3.4.2c *Epifauna at three locations at Macandrew Bay*

Macandrew Bay

0-5m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Bivalves					
Austrovenus stutchburyi	12	14	18	8	7

20m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Gastropod snails					
Micrelenchus tenebrosus	1				
Bivalves					
Austrovenus stutchburyi	5	3	1	2	8

>50m	Quadrat 1				
Animals	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Anemones					
Gastropod snails					
Cominella glandiformis			1		
Micrelenchus tenebrosus				1	
Amphibola crenata			1		
Bivalves					
Austrovenus stutchburyi	5	4	3	4	10

Table 3.4.3 *Diversity (H') of epifauna at five soft shore intertidal sites in the upper Otago Harbour basin. 2015 data compared with 2007, 2008, 2009, 2010, 2011, 2012, and 2013 data.*

	0-5m							
Site	2007	2008	2009	2010	2011	2012	2013	2015
Burkes								0.1
Kitchener Street	0.48	0.48	0.55	0.53	0.55	0.51	0.52	0.45
Orari Street	0.36	0.37	0.3	0.12	0.29	0.31	0.38	0.2
Portobello Road	0.53	0.33	0.62	0.58	0.57	0.53	0.65	0.68
Macandrew Bay								0.1

	<20m							
Site	2007	2008	2009	2010	2011	2012	2013	2015
Burkes								0.27
Kitchener Street	0.48	0.48	0.55	0.53	0.55	0.51	0.52	0.61
Orari Street	0.36	0.37	0.3	0.12	0.29	0.31	0.38	0.56
Portobello Road	0.53	0.33	0.62	0.58	0.57	0.53	0.65	0.82
Macandrew Bay								0.22

	>50m							
Site	2007	2008	2009	2010	2011	2012	2013	2015
Burkes								0.55
Kitchener Street	0.71	0.57	0.42	0.2	0.57	0.57	0.65	0.26
Orari Street	0.05	0.25	0.31	0.16	0.15	0.39	0.44	0.56
Portobello Road	0.5	0.63	0.84	0.64	0.58	0.46	0.51	0.58
Macandrew Bay								0.46

As in previous surveys cockles became noticeably smaller and less abundant as one moved from Kitchener Street to Portobello Road (Table 3.4.4). However, when compared using ANOVA at a significance level of 0.05 the overall size of cockles at each site has not changed significantly from year to year ($F_{7,15}$= 1.56, p = 0.272). It should be pointed out that at all sites

at the head of the harbour cockles are much slower growing than at prime cockle sites further down harbour or in Papanui and Waitati Inlets (Stewart 2006b, 2008d).

Table 3.4.4 *Size of cockles collected at Kitchener Street, Orari Street and Portobello Road in 2007 to 2015.*

	2007		2008		2009		2010		2011		2012		2013		2015	
	n =	Mean length (mm)	n =	Mean length (mm)	n =	Mean length (mm)	n =	Mean length (mm)	n =	Mean length (mm)	n =	Mean length (mm)	n =	Mean length (mm)	n =	Mean length (mm)
Kitchener	59	37.1	54	35.5	80	38.1	63	36.6	106	37.5	73	36.1	67	34.2	87	34.7
Orari St	62	32.4	74	29.8	80	33.0	82	30.2	73	30.0	83	31.5	83	30.5	116	28.6
Portobello	64	30.1	74	28.3	80	30.1	80	28.2	103	28.8	92	28.9	47	29.6	102	26.5

Infauna at all three sites was dominated by polychaete worms with glyceriids being the most abundant. Spionids were also moderately common at all sites (Table 3.4.5). Nereidids worms were present at Burkes, Kitchener Street and Macandrew Bay, but totally absent from the Orari Street and Portobello Road sites. Phoxocephalid amphipods were less common than they have been in previous years and Lysianassid amphipods were completely absent from all sites.

Cockles (*Austrovenus stutchburyi*) were most common at the Kitchener Street and Orari Street sites (Table 3.4.5), with overall abundance similar to previous years. Tanaid crustaceans, which were found in moderate numbers at most sites in 2010 and 2013, were not observed at many of the sites this year. Overall the infauna are typical of sheltered harbours in southern New Zealand.

Table 3.4.5 *Abundance of species of infauna collected at outfall and reference sites.*

			Location	Burkes				Kitchener Street				Orari Street				Portobello Road				Macandrew Bay			
			Sample	1	2	3		1	2	3		1	2	3		1	2	3		1	2	3	
Phylum		**Family**	**Genus/species**				sum				sum				sum				sum				sum
Annelida	Polychaeta	Capitellidae				2	2	1		2	3	2	3	1	6					4	2	3	9
		Opheliidae	*Pseudophelia*									1			1								
		Glyceridae		2	6	8	16	17	7	8	32	6	7	8	21	3	3	2	8	10	8	6	24
		Maldanidae				1	1	3	5	3	11	1	4	2	7	1		1	2	3	5	4	12
		Nephtyidae				1	1	6	4	1	11	2		1	3					3	6	2	11
		Nereidae			1		1	1		1	2									1	2		3
		Nereididae						3	6	8	17										1		1
		Spionidae		2	1	3	6	8	3	6	17	3	2	4	9	2	3	1	6	2	3	2	7
		Syllidae								1	1		1		1	1			1				
Hemichordata	Enteropneusta				2		2	1		1	2										1		1
Sipuncula																				3			3
Crustacea	Decapoda		*Macrophthalmus hirtipes*													1			1				
	Amphipoda	Phoxocephalidae						4	2	3	9		1	1	2			2	2				
	Ostracoda							1			1												
Mollusca	Gastropoda	Trochidae	*Micrelenchus tenebrosus*					1	1	1	3					1			1				
		Nacellidae	*Notoacmea* spp.															1	1				
			Cellana ornata					1		1	2												
	Bivalvia	Veneridae	*Austrovenus stutchburyi*	1	1	1	3	2	3	2	7	4	1	2	7	2		1	3	1		1	2
			Nucula spp.									2			2								
		Tellinidae	*Macomona liliana*	1	1		2	1			1			1	1							1	1
			Animals per core	6	12	16		50	31	38		21	19	20		11	6	8		27	28	19	
			Animals per m^2	1338	2676	3568	2527	11150	6913	8474	8846	4683	4237	4460	4460	2453	1338	1784	1858	6021	6244	4237	5501
			Species per site	5	7	7	9	15	9	14	15	9	8	9	11	8	3	7	9	9	9	8	11

Numbers of animals per square metre at outfall sites was slightly higher than in 2013 and 2012, but similar to other surveys, and ranged from 1338 at replicate 2, Portobello Road, to 11,150 at replicate 1, Kitchener Street. The higher value was largely due to high abundance of *Glyceriid* polychaetes in that core. Despite the variability in overall numbers of animals at the various sites, diversity has not changed significantly from year to year ($F_{7,24}$ = 1.987, p = 0.117) (Table 3.4.6).

Table 3.4.6 *Diversity (H') of infauna at five soft shore intertidal sites in the upper Otago Harbour basin. 2015 data compared with 2007, 2008, 2009, 2010, 2011, 2012 and 2013 data.*

Site	2007	2008	2009	2010	2011	2012	2013	2015
Burkes								0.73
Kitchener Street	0.67	0.53	0.44	0.9	0.81	0.9	0.91	0.97
Orari Street	1.01	0.86	0.74	0.98	0.99	1.14	1.04	0.85
Portobello Road	0.74	0.67	0.8	1.04	0.69	0.7	0.98	0.82
Macandrew Bay								0.85

3.5 Analyses of Cockle flesh

Like in 2013, 2012 and 2010, levels of heavy metals in cockle flesh showed no clear trend for contamination in moving from Kitchener Street to Portobello Road across all metals (Table 3.5.1). However, levels of cadmium and copper are higher this year at Portobello Road. This is similar to the results observed from 2008 and 2009. PAHs on the other hand, remain by far the highest at Portobello Road (Table 3.5.1). Levels of arsenic and cadmium this year are an order of magnitude higher than in previous surveys, but it is not clear why this may be so (perhaps an error in transcribing results at the laboratory?). However, all heavy metals remain at concentrations at least one order of magnitude below accepted food standards (Table 3.5.2). Consequently, I would recommend that no further immediate action is necessary at this time. There are no specific guidelines for PAH in shellfish flesh for New Zealand.

Table 3.5.1 *Contaminant concentrations in cockle flesh from within 20m of the Kitchener Street, Orari Street and Portobello Road stormwater outfalls in 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2015. Green shading indicates a decrease in contaminant level, pink indicates an increase, white = no change. BDL = below detectable limits.*

Parameter	Units		Portobello Rd	Orari Street	Kitchener St
As	mg/kg	2007	2.5	2.5	3.5
		2008	4.0	2.8	3.3
		2009	2.9	4.9	3.8
		2010	2.0	2.3	2.2
		2011	2.5	2.5	2.8
		2012	8.0	8.8	5.3
		2013	1.48	2.5	2.4
		2015	39.9	45	39.2
Cd	mg/kg	2007	0.014	0.011	0.016
		2008	0.023	0.010	0.015
		2009	0.021	0.024	0.017
		2010	0.014	0.013	0.010
		2011	0.015	0.014	0.015
		2012	0.053	0.027	0.025
		2013	0.011	0.009	0.0134
		2015	0.154	0.15	0.117
Cr	mg/kg	2007	0.32	0.32	0.34
		2008	0.65	0.15	0.27
		2009	0.22	0.30	0.31
		2010	BDL	0.18	0.13
		2011	0.02	0.17	0.22
		2012	0.33	0.41	0.33
		2013	0.29	0.29	0.37
		2015	BDL	BDL	BDL
Cu	mg/kg	2007	0.64	0.70	0.81
		2008	1.20	0.85	0.67
		2009	0.82	1.10	0.89
		2010	0.43	0.46	0.66
		2011	0.77	0.65	0.71
		2012	1.29	1.24	1.29
		2013	0.64	0.48	0.8
		2015	14.3	12.9	BDL
Pb	mg/kg	2007	0.17	0.11	0.08
		2008	0.42	0.07	0.08
		2009	0.099	0.110	0.082
		2010	0.151	0.082	0.089
		2011	0.130	0.094	0.082
		2012	0.35	0.11	0.20
		2013	0.28	0.073	0.105
		2015	BDL	1.25	BDL
PAH	mg/kg	2007	4.912	0.018	0.009
		2008	0.640	0.047	0.028
		2009	0.613	0.038	0.028
		2010	1.714	0.035	0.044
		2011	0.772	0.034	0.027
		2012	2.750	0.031	0.024
		2013	1.469	0.014	0.022
		2015	0.505	0.031	0.02
Enterococci	MPN/100g	2015	>18000	16000	1400

It should be noted that, as already stated, and as found in previous surveys, cockles became smaller as one nears the Portobello Road outfall (Table 3.4.4). Whether this is due to historic PAH contamination or exposure at low tides and to fresh water, or some other factor, remains to be determined. As suggested in 2011, perhaps an investigation of cockle sizes at a site with similar fresh water and tidal exposure is merited.

Cockles are not known to be gathered by recreational harvesters in the upper harbour basin as they are perceived to be contaminated and too small to be worthwhile.

Table 3.5.2 *Heavy metal concentrations for NZ and US FDA guidelines for adults (expressed as mg/kg dry weight). '-' means no guideline is available.*

	Cu	Pb	Cd	Cr
Food Regs/NZ DoH	150.0	10.0	5.0	-
US FDA	-	4.2	-	11.0
Australia NZ food standards code	-	2.0	2.0	-

Table 3.5.3 *British Columbian guidelines for B[a]P concentration in shellfish for human consumption*

B[a]P concentration in the edible portion of fish/shellfish (µg B[a]P/kg wet weight)	Safe quantity for weekly consumption* on a regular basis (g wet weight)	B[a]P Portobello Road cockles 2015 (µg B[a]P/kg wet weight)	B[a]P Portobello Road cockles 2015 (µg B[a]P/kg wet weight)
4	50	32	0.8
2	100		
1	200		

*low and moderate consumption levels, according to the State of Washington, are 45 g/wk (or 6.5 g/d) and 140 g/wk (or 20 g/d).

4. Discussion and Conclusion

Monitoring of stormwater quality in Dunedin this year differs in some respects from previous years 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

2014 report give a good indication of stormwater quality discharged from the city, with good coverage of catchment discharges in dry weather conditions.

Outfalls that show no evidence of contamination after three rounds of sampling, or that have negligible flow, have been reduced to 6 monthly sampling. Results have been extremely variable from outfall to outfall. The Magnet Street and Bauchop Street catchments are under investigation by the DCC to try to determine sources of contamination.

High *E. coli* levels are common in stormwater discharges and the catchments serviced by the outfalls listed above have all shown high levels of *E. coli* contamination during wet flow sampling as well as during dry flow sampling. This 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. The DCC is working to eliminate cross connections of private sewerage laterals and stormwater conduits.

Grab samples obtained during a rain event in late June 2015 show results much the same as during previously sampled rain events. As with the automated sampler rounds, copper, lead and zinc are all variable for many catchments. Bacterial contamination due to overflow from the wastewater network is an issue that DCC are currently working on.

The majority of Dunedin's stormwater is discharged to the Upper Otago Harbour Basin. The fact that the upper harbour takes 4-6 tidal cycles to flush completely (Smith and Croot 1993, 1994) means that contaminants introduced with stormwater discharges may reside in the basin for up to three days after the cessation of any rain event. For prolonged rain events there is the possibility that concentration of contaminants in harbour water may increase

throughout the rain event. However, the sheer volume of water in the upper harbour basin allows a great deal of dilution despite the residence time.

In past years the results of harbour water sampling have tended to support this hypothesis, with levels of most contaminants being well below ANZECC guidelines and even below detection limits for some. However, this year levels of copper, lead and zinc in harbour water are generally higher than Consent trigger levels under both wet and dry conditions and on ebb and flood tides. Not unexpectedly, there appears to be a relationship between contaminant concentration and wet weather, with higher concentrations of enterococci observed during a rain event, especially one of the magnitude experienced on 3 June.

Consent condition (Appendix 2 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 would be useful for some contaminants (e.g., metals) but will not work for bacteria.

Ensuring sampling occurs earlier in each financial year will enable some re-sampling to be undertaken as per the current consent conditions. However, as already stated, it is more than likely that exact conditions that prevailed at the time of sampling will not be replicated. Consequently it is recommended that this Condition needs re-examination.

The concentration of contaminants in harbour sediments continues to be of concern. 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,

Latest results show that levels of mercury, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and organochlorine pesticides were all very low. The levels of arsenic, cadmium, chromium, copper, and lead are also all within Consent guidelines. Just nickel at Shore Street and zinc at Kitchener Street exceed Consent guidelines. This 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 as 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 1990's, and separation of the stormwater and wastewater networks from the 1960's-1990's resulting in the removal of all wastewater discharges from the harbour, have also reduced the amount of contaminants entering the harbour.

However, the sites at which samples were collected this year differ from previous locations. Consequently caution is advised in interpreting these results. Continued sampling at the new locations will better enable any trends in contaminant concentration to be discerned at these locations.

Over the years it is expected that the amount of contaminants in harbour sediment will diminished as fewer contaminants enter the harbour and existing contaminants are either flushed out, or become buried under newer non-contaminated sediments.

As for harbour water above, re-sampling was required this year as levels of some contaminants at some sites exceeded Consent trigger values. Once again, difficulties arise for the same reasons given above for harbour water, especially for bacteria. This year, re-sampling was not carried out during the 2014/2015 year due to laboratory test results not being received before the end of the sampling financial year. This issue can be avoided in future by ensuring sampling occurs earlier in each year.

Benthic and infaunal communities in the vicinity of the Portobello Road, Orari Street and Kitchener Street outfalls have reasonably low diversity, as do communities at the reference sites at Burkes and Macandrew Bay. Such low diversity is generalised in the upper Otago Harbour Basin and is not associated with any one outfall. As in past years there is a trend towards smaller cockles as one nears the Portobello Road outfall. This may be as a result of historic PAH contamination, which is extremely high beneath the surface at this site, but a number of other factors, not least of which are freshwater exposure and exposure at low tide, must also be considered.

Rainer (1981) and Grove (1995) certainly found less diversity in soft-bottom macrofaunal communities as one moves from harbour mouth to the head of Otago Harbour. It should be pointed out that much of the shoreline around the upper harbour has been extensively modified and as such cannot be regarded as an inlet typical of those found throughout the region.

Despite this the communities sampled in the upper Otago Harbour near stormwater outfalls are numerically dominated by polychaete worms and amphipods, as is usual for sheltered soft shores around New Zealand (Morton and Miller 1973), and show distinct similarities to communities found in other moderately impacted inlets in Otago (Stewart 2007b, 2008a,b).

While not pristine, the upper harbour and the communities associated with the intertidal areas adjacent to major stormwater outfalls appear not to be undergoing any significant further degradation as a result of stormwater inputs. It is to be hoped that if any slight trends towards lower contaminant levels in stormwater are continued, both water quality and community health in the harbour will gradually improve over time.

Overall, it is expected that the implementation of the long-term stormwater catchment management plans developed through the DCC's 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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6. Appendix 1. 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.

7. Appendix 2. Historic values.

Table 1 *Levels of contaminants detected in stormwater from outfalls in and around Dunedin during past storm events. BDL indicates Below Detectable Limits. Pink shaded cells indicate levels above the ANZECC 2000 trigger level for protection of 80% of species.*

Stormwater																
Parameter	As								Cd							
units	g/m^3								g/m^3							
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2007	2008	2009	2010	2011	2012	2013	2015
St Clair	BDL	0.0013	0.0015	BDL	0.0016	BDL	BDL	BDL	BDL	0.00006	0.00006	0.00007	0.000075	BDL	BDL	0.0001
Shore Street	0.04	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Portobello Road	BDL	0.002	BDL	BDL	BDL	BDL	BDL	0.003	BDL	0.00023	BDL	BDL	BDL	BDL	BDL	0.0001
Orari Street	BDL	BDL	0.032	0.00149	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.000164	BDL	BDL	BDL	BDL
Kitchener Street	BDL	BDL	0.0096	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mason Street	0.006	BDL	0.0077	BDL	BDL	BDL	BDL	0.003	BDL	BDL	0.0077	0.00051	BDL	BDL	BDL	0.0001
Bauchop Street	0.03	BDL	0.021	BDL	BDL	BDL	BDL	0.001	BDL	BDL	BDL	0.00049	BDL	BDL	BDL	BDL
Halsey Street	0.03	BDL	0.01	0.0044	BDL	BDL	BDL	0.002	BDL	0.00022	BDL	0.00026	BDL	BDL	BDL	0.0004
Wickliffe Street	0.03	BDL	0.003	BDL	0.0035	0.0027	BDL	0.008	BDL	BDL	0.00052	0.00078	0.00092	0.00022	BDL	0.0002
Port Chalmers	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.00024	BDL
Protection for 80% of speci ANZECC guidelines	0.36								0.0008							

Parameter	Cr								Cu							
units	g/m^3								g/m^3							
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2007	2008	2009	2010	2011	2012	2013	2015
St Clair	7E-04	0.0028	0.0035	0.00086	0.0038	0.0015	0.0023	0.0117	0.0027	0.012	0.019	0.0054	0.0172	0.0026	0.0099	0.026
Shore Street	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0061	0.01	0.014	0.02	0.0118	BDL	BDL	0.0159	0.025
Portobello Road	BDL	0.002	BDL	BDL	BDL	BDL	BDL	0.0182	BDL	0.026	0.01	0.0057	0.029	0.012	0.0072	0.059
Orari Street	BDL	0.0032	BDL	0.00183	BDL	BDL	BDL	0.0027	BDL	0.014	BDL	0.0096	BDL	0.0024	0.0057	0.004
Kitchener Street	0.004	0.002	BDL	BDL	BDL	BDL	BDL	0.001	0.034	0.0056	0.023	0.0118	BDL	BDL	0.015	0.003
Mason Street	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0183	0.022	0.012	0.021	0.0157	0.043	0.026	0.0065	0.041
Bauchop Street	BDL	0.0015	BDL	BDL	BDL	BDL	BDL	0.0182	0.029	0.0096	BDL	0.0026	BDL	0.021	0.0131	0.079
Halsey Street	BDL	BDL	BDL	BDL	BDL	BDL	0.0019	0.0226	0.024	0.0043	0.021	0.00162	0.029	0.0043	0.0183	0.084
Wickliffe Street	BDL	0.0017	0.0076	0.00157	0.0046	0.0028	0.0026	0.0189	0.01	0.013	0.059	0.0058	0.022	0.025	0.0107	0.045
Port Chalmers	BDL	0.0064	BDL	BDL	BDL	0.0016	0.0025	0.0054	0.009	0.0025	BDL	BDL	BDL	0.008	0.0118	0.011
Protection for 80% of speci ANZECC guidelines	0.04								0.0025							

Table 1 *continued…*

Parameter	Ni								Pb							
units	g/m^3								g/m^3							
Outfall	2007	2008	2009	2010	2011	2012	2013	2015	2007	2008	2009	2010	2011	2012	2013	2015
Second Beach	9E-04	0.0021	0.0022	0.00133	0.0026	0.0011	0.0023	BDL	0.001	0.011	0.013	0.00021	0.0127	0.00101	0.0053	0.0557
Shore Street	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.003	0.0085	0.0069	BDL	BDL	BDL	0.0038	0.0635
Portobello Road	BDL	0.0035	0.0028	0.0035	BDL	BDL	BDL	BDL	BDL	0.019	0.0067	0.00055	0.026	0.0081	0.0086	0.0869
Orari Street	BDL	0.0033	BDL	0.00108	BDL	0.0008	BDL	BDL	BDL	0.023	BDL	0.00015	BDL	0.00118	0.0041	0.0295
Kitchener Street	0.003	BDL	0.0036	0.0035	BDL	BDL	BDL	BDL	0.0442	0.007	0.018	0.00196	BDL	0.0028	0.0055	0.0202
Mason Street	0.004	BDL	0.0055	BDL	0.0039	BDL	BDL	BDL	0.0258	0.0089	0.014	0.00102	0.0192	0.0101	0.0042	0.124
Bauchop Street	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01	0.0035	BDL	BDL	BDL	0.021	0.0026	0.115
Halsey Street	0.009	BDL	0.0035	BDL	BDL	BDL	BDL	0.0254	0.021	0.0022	0.0097	0.0021	0.0085	0.0043	0.0064	0.108
Wickliffe Street	0.01	BDL	0.0042	BDL	0.0021	0.0046	BDL	0.0051	0.006	0.0084	0.033	BDL	0.0134	0.0153	0.0092	0.1
Port Chalmers	BDL	BDL	BDL	0.0035	BDL	0.0019	BDL	BDL	0.0141	0.0018	BDL	BDL	0.0041	0.0057	0.0127	0.0316
Protection for 80% of speci ANZECC guidelines	0.017								0.0094							

Parameter	Zn								pH							
units	g/m^3															
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2007	2008	2009	2010	2011	2012	2013	2015
Second Beach	0.038	0.16	0.15	0.092	0.25	0.026	0.166	0.222	7.7	7.3	7.4	7.3	7.4	8	7.7	7.63
Shore Street	0.02	0.44	0.21	0.115	BDL	0.071	0.2	0.351	7.9	7.2	7.3	7.4	7.9	7.5	7.5	7.5
Portobello Road	0.08	0.94	0.64	0.153	0.87	0.15	0.57	0.744	7.9	7.3	7.6	7.6	7.4	8.1	7.6	7.58
Orari Street	BDL	0.22	0.031	0.3	BDL	0.0157	0.07	0.078	7.8	7.4	8.1	7.1	7.9	7.9	7.6	7.87
Kitchener Street	0.445	0.036	0.38	0.62	BDL	0.082	0.23	0.025	7.1	7.7	7.4	6.9	8	7.6	7.7	7.43
Mason Street	0.25	0.16	0.35	0.43	0.63	0.43	0.095	0.577	7.1	7	7.4	7	7	7.1	7.6	8.4
Bauchop Street	0.23	0.12	0.13	0.121	BDL	0.94	0.2	0.713	7.6	7.8	8.1	7.4	8	7.4	7.9	8.83
Halsey Street	0.12	0.033	0.3	0.136	0.36	0.089	0.23	0.576	7.3	7.9	7.2	6.8	7.1	7.8	7.3	7.73
Wickliffe Street	0.1	0.2	0.53	0.24	0.82	1.57	0.161	0.617	7.7	7.5	8.0	7.3	9.7	7.0	7.5	7.67
Port Chalmers	0.231	0.027	BDL	0.29	0.24	0.27	0.4	0.334	6.8	7.9	8.2	7.1	7.5	7.5	7.5	7.48
Protection for 80% of speci ANZECC guidelines	0.031								7.2-7.8							

Table 1 *continued…*

Parameter	Suspended Solids								Oil & Grease							
units	g/m^3								g/m^3							
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2007	2008	2009	2010	2011	2012	2013	2015
Second Beach	BDL	37	41	BDL	57	5	34	210	5	BDL	BDL	BDL	BDL	11	5	27
Shore Street	41	24	20	9.5	12	10	9	150	BDL	BDL	BDL	BDL	BDL	10	5	BDL
Portobello Road	18	46	30	8.1	53	43	27	200	4	9.7	BDL	BDL	BDL	BDL	BDL	BDL
Orari Street	28	77	16	130	4	BDL	38	130	BDL	11	BDL	BDL	17	BDL	BDL	12
Kitchener Street	104	41	45	50	BDL	27	37	45	9	BDL	BDL	BDL	22	11	BDL	8
Mason Street	62	37	37	138	30	31	63	210	5	7.9	BDL	BDL	BDL	BDL	BDL	6
Bauchop Street	44	16	13	53	5	38	47	350	4	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Halsey Street	119	35	27	50	24	22	46	580	9	BDL	BDL	BDL	BDL	BDL	BDL	6
Wickliffe Street	35	27	100	86	46	30	92	490	6	9.5	9.5	BDL	7	BDL	BDL	30
Port Chalmers	37	39	7.4	240	24	24	58	170	8	BDL	BDL	BDL	BDL	BDL	BDL	17

Parameter	FWA							
units	µg/L							
Catchment	2007	2008	2009	2010	2011	2012	2013	2015
Second Beach	0.147	0.19	0.098	0.04	0.075	0.069	0.064	0.084
Shore Street	0.081	0.031	0.142	0.98	0.142	0.156	0.104	0.087
Portobello Road	0.003	0.049	0.177	0.151	0.045	0.096	0.207	0.138
Orari Street	BDL	0.005	0.11	0.052	0.081	0.094	0.038	0.09
Kitchener Street	0.18	0.029	0.072	0.023	0.047	0.052	0.027	0.046
Mason Street	0.007	0.07	0.051	0.156	0.026	0.043	0.058	0.06
Bauchop Street	2.028	4.92	0.031	0.067	0.017	0.019	0.033	0.057
Halsey Street	BDL	0.004	0.011	0.061	0.025	0.038	0.027	0.07
Wickliffe Street	0.024	0.003	0.021	0.048	0.094	0.121	0.052	0.081
Port Chalmers	0.002	0.003	0.124	0.105	0.092	0.147	0.084	0.104

Table 1 *continued…*

For E. coli, green cells indicate acceptable levels; orange cells indicate a level that would trigger an amber alert; pink cells indicate a level that would trigger a red alert according to MoH/MfE guidelines.

Parameter	E. coli							
units	MPN/100ml							
Catchment	2007	2008	2009	2010	2011	2012	2013	2015
Second Beach	560	6800	14000	4800	9000	300	1300	2000
Shore Street	300	5100	16000	7000	110	11000	780	2600
Portobello Road	460	5000	2800	54000	6000	280	3300	1000
Orari Street	50	6000	210	1700	BDL	1800	3300	2000
Kitchener Street	13000	70	10000	92000	110	150	7900	990
Mason Street	22000	26000	50000	350000	48000	32000	200	460
Bauchop Street	2200	400	3000	7900	450	17000	1100	580
Halsey Street	9000	1700	70000	17000	78000	26000	92000	2900
Wickliffe Street	25000	10000	220000	35000	43000	96000	15000	>24000
Port Chalmers	14000	150	10	>1600	1000	5900	1300	9200
Primary	Amber	>260						
Secondary	Red	>550						

Total PAHs	2007	2008	2009	2010	2011	2012	2013	2015
Kitchener Street	0.00	0.00	BDL	0.0001	BDL	BDL	BDL	BDL
Orari Street	0.00	0.00025	BDL	0.0005	BDL	BDL	BDL	BDL
Portobello Road	BDL	0.00132	0.00017	0.00016	0.00168	0.0002	0.0018	0.01043