Stormwater Compliance Monitoring 2016

Stormwater Discharges from Dunedin City

ORC Discharge Permits RM11.313.01 – RM11.313.10

Prepared by

ryderconsulting
environment + planning + project management

June 2016

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Prepared by

Brian Stewart PhD

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Cover Photo: Waterfront at Kitchener Street, Otago Harbour – Brian Stewart

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Executive Summary

This report presents the findings for the third 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 and harbour sediment quality at representative sites.

Stormwater from all outfalls monitored showed variable levels of contamination.

Sediments too showed varying levels of contamination, but with levels of contaminants not breaching ANZECC trigger values this year.

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 2015 - July 2016.

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.

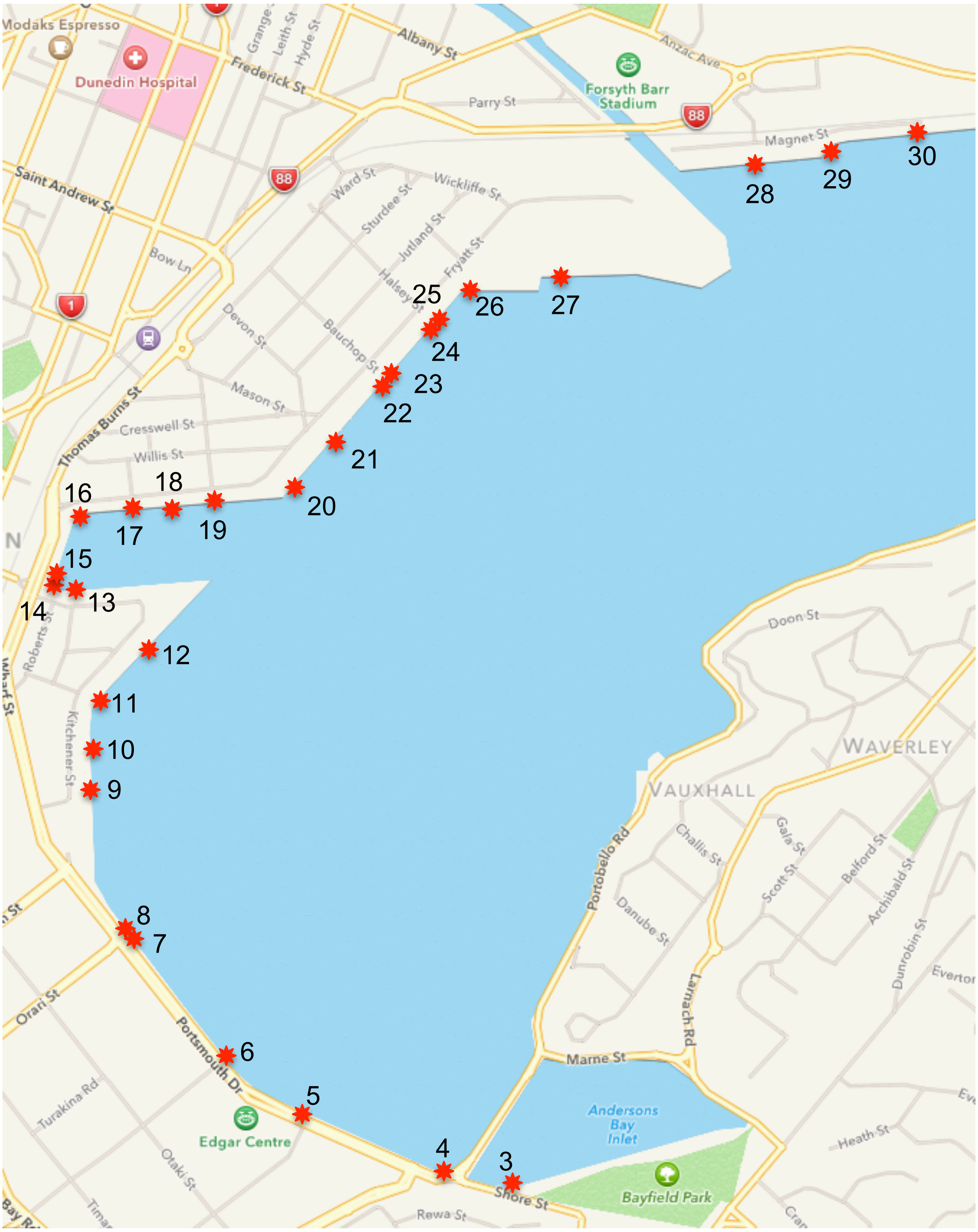

Figure 1.1 *Locations of current Dunedin stormwater outfalls being monitored. Numbers correspond to outfall numbers in Table 2.1. Not shown are outfalls 1 (at Second Beach) and Outfall 2 at St Clair Beach).*

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. Months where all conditions were met were July, September, October, November and December 2015 and February, March, April and June of 2016.

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 three rain events that each 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 treated in the same manner as collected grab samples.

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 one rainfall event and one dry period, 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 is not due again until 2017.

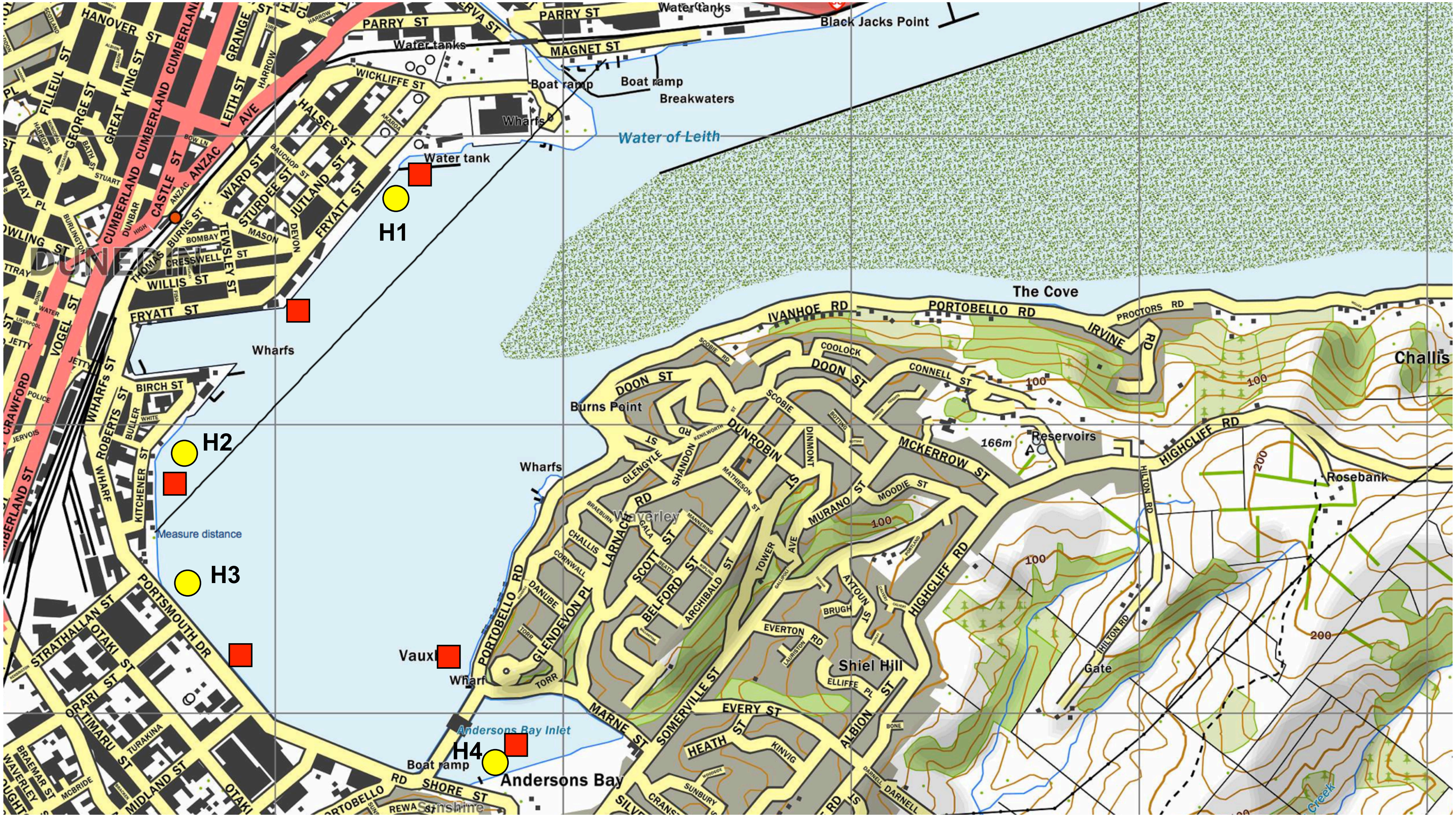

Figure 2.1 *Upper Harbour Basin seawater and sediment sampling sites. Red squares are harbour water quality sites; Yellow circles are sediment sites (see Table 2.1).*

3. Results

3.1 Stormwater

Dry weather sampling

Dry weather flow sampling was carried out on 15th July, 22nd September, 21st October, 26th November and 29th December of 2015 and 10th February, 15th March, 20th April and 8th June of 2016. 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).

E. coli levels frequently exceed trigger levels, with numbers often exceeding 2400 MPN/100ml at outfalls 7, 24 and 25 (Table 3.1.1b). However, the fact that FWAs at the same sites are not always high at outfalls 24 and 25 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-15	FWAs Sep-15	FWAs Oct-15	FWAs Nov-15	FWAs Dec-15	FWAs Feb-16	FWAs Mar-16	FWAs Apr-16	FWAs Jun-16
1	SWX03979	Second Beach	St Clair	0.051	0.027	-	0.052	0.042	0.042	0.073	0.071	0.093
2	SWX00011 & SWX00012	St Clair Beach	St Calir	NF	NF	-	NF	NF	NF	NF	NF	NF
3	SWX04625	Shore Street	Shore Street	0.113	-	-	0.087	0.256	0.168	0.087	0.141	0.184
4	SWX03649	Portobello Rd	Portobello Rd	0.019	-	-	0.121	0.285	0.014	0.021	0.104	0.073
5	SWX03644	Teviot St	Foreshore	0.11	-	-	0.219	0.320	0.174	0.177	0.175	0.188
6	SWX03640	Midland St	Foreshore	0.156	-	-	0.135	0.250	0.145	0.112	0.204	0.216
7	SWX03631	Orari St	Orari St	0.073	-	-	0.050	0.521	0.122	0.029	0.107	0.131
8	SWX03635 & SWX70740	Orari St	Orari St	0.068	-	-	0.082	0.067	0.096	0.102	0.095	0.129
9	SWX03579	Kitchener St	Kitchener St	0.111				0.209				
10	SWX03568	Kitchener St	Kitchener St	0.023	-	-	0.041	0.076	0.053	0.078	0.027	0.071
11	SWX70102	French St	Foreshore	0.035				0.083				
12	SWX03547	Kitchener St	Foreshore	0.03	-	-	0.033	0.155	0.022	NF	0.028	NF
13	SWX03562	Birch St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
14	SWX03556	Birch St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
15	SWX03559	Wharf St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
16	SWZ70569	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
17	SWX03540	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
18	SWX03536	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
19	SWX03532	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
20	SWX70370	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
21	SWX03489	Mason St	Mason St	0.071				0.223				
22	SWX03506	Mason St	Bauchop St	0.138	-	-	Sewer	NF	NF	NF	NF	NF
23	SWX03466	Mason St	Bauchop St	0.038	-	-	0.044	0.061	0.049	0.123	0.072	0.064
24	SWX03455	Halsey St	Halsey St	0.021	-	-	0.018	0.032	0.027	0.044	0.042	0.048
25	SWX03450	Halsey St	Wickliffe St	0.046	-	-	0.049	0.062	0.062	0.193	0.056	0.112
26	SWX03472	Halsey St	Wickliffe St	NF	NF	-	NF	NF	NF	NF	NF	NF
27	SWX03718	Wickliffe St	Wickliffe St	0.09	-	-	0.063	0.122	0.119	0.141	0.107	0.133
28	SWX02628	Magnet St	Magnet St	0.108				0.129				
29	SWX02623	Magnet St	Magnet St	0.081				0.307				
30	SPN02502	Ravensbourne Rd	Gas Works	NF	-	-	NF	NF	0.047	NF	0.402	0.201
31	SWX12941	George St/SH88	Port Chalmers	0.088				0.108				
32	SWX12994	Sawyers Bay, western side of Watson Park	Port Chalmers	0.163	-	-	0.121	NF	NF	NF	NF	0.215
33	SWX12879	George St (Port Otago)	Port Chalmers	0.094	-	-	0.084	0.234	0.133	0.141	0.206	0.139

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-15	E. coli Sep-15	E. coli Oct-15	E. coli Nov-15	E. coli Dec-15	E. coli Feb-16	E. coli Mar-16	E. coli Apr-16	E. coli Jun-16
1	SWX03979	Second Beach	St Clair	BDL	BDL	BDL	BDL	5.2	4.1	730	>2400	770
2	SWX00011 & SWX00012	St Clair Beach	St Calir	NF	NF	NF	NF	NF	NF	NF	NF	NF
3	SWX04625	Shore Street	Shore Street	2400	>2400	>2400	9	47.8	>2400	1100	29.2	820
4	SWX03649	Portobello Rd	Portobello Rd	3.1	6.2	16.6	BDL	>2400	460	5.2	550	550.0
5	SWX03644	Teviot St	Foreshore	8.6	1200	210	10.6	>2400	160	12.8	43.3	22.6
6	SWX03640	Midland St	Foreshore	1700	240	370	BDL	17.3	6.3	620	5.1	6
7	SWX03631	Orari St	Orari St	8.2	NF	1100	BDL	>2400	4	>2400	>2400	>2400
8	SWX03635 & SWX70740	Orari St	Orari St	490	10.3	2	140	520	350	23	77.3	580
9	SWX03579	Kitchener St	Kitchener St	3.1				3				
10	SWX03568	Kitchener St	Kitchener St	25.3	1700	490	>2400	980	>2400	650	410	2400
11	SWX70102	French St	Foreshore	BDL				6.3				
12	SWX03547	Kitchener St	Foreshore	1	1	3	8.6	>2400	13	NF	1	NF
13	SWX03562	Birch St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
14	SWX03556	Birch St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
15	SWX03559	Wharf St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
16	SWZ70569	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
17	SWX03540	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
18	SWX03536	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
19	SWX03532	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
20	SWX70370	Fryatt St	Foreshore	NF	NF	NF	NF	NF	NF	NF	NF	NF
21	SWX03489	Mason St	Mason St	>2400				20.9				
22	SWX03506	Mason St	Bauchop St	>2400	No access	Sewer	Sewer	NF	NF	NF	NF	NF
23	SWX03466	Mason St	Bauchop St	39.9	BDL	2	2	36.4	230	>2400	250	1000
24	SWX03455	Halsey St	Halsey St	490	>2400	>2400	>2400	1400	>2400	>2400	>2400	>2400
25	SWX03450	Halsey St	Wickliffe St	>2400	>2400	>2400	>2400	>2400	>2400	>2400	>2400	>2400
26	SWX03472	Halsey St	Wickliffe St	NF	NF	NF	NF	NF	NF	NF	NF	NF
27	SWX03718	Wickliffe St	Wickliffe St	2400	>2400	1300	730	>2400	1600	>2400	2400	1700
28	SWX02628	Magnet St	Magnet St	BDL				>2400				
29	SWX02623	Magnet St	Magnet St	1				980				
30	SPN02502	Ravensbourne Rd	Gas Works	NF	24.6	44.1	NF	NF	12.1	NF	54.6	59.4
31	SWX12941	George St/SH88	Port Chalmers	>2400				25.2				
32	SWX12994	Sawyers Bay, western side of Watson Park	Port Chalmers	2	1	3	3.1	NF	NF	NF	NF	1
33	SWX12879	George St (Port Otago)	Port Chalmers	6500	190	79.8	730	380	220	-	>2400	260

Wet weather grab sampling

Wet weather grab samples were collected on 16th July 2015 during a storm event that yielded 4.0 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 this year. 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 16/7/15 yielding 4.0 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	0.001	BDL	0.004	0.006	0.00818	BDL	0.197
Shore Street	3	RM11.313.04	0.001	BDL	BDL	0.007	0.00509	0.0024	0.282
South Dunedin	4	RM11.313.09	0.002	BDL	0.005	0.028	0.02913	BDL	0.557
Orari St	8	RM11.313.08	0.003	BDL	BDL	BDL	0.00179	BDL	0.026
Kitchener St	10	RM11.313.06	0.002	BDL	0.002	0.019	0.01638	BDL	0.292
Mason St	21	RM11.313.05	0.001	BDL	0.006	0.016	0.0235	BDL	0.221
Bauchop St	23	RM11.313.03	0.001	BDL	0.003	0.016	0.01031	BDL	0.296
Halsey St	24	RM11.313.03	0.001	BDL	0.003	0.019	0.01176	BDL	0.119
Wickliffe St	27	RM11.313.03	0.004	BDL	0.006	0.023	0.02461	BDL	0.395
Port Chalmers	31	RM11.313.01	0.003	BDL	0.002	BDL	0.00458	BDL	0.425
ANZECC trigger value			0.36	0.0008	0.04	0.0025	0.0094	0.017	0.031

Catchment	Outfall	Consent Ref.	FWAs	Oil and Grease (g/m3)	pH	SS (g/m3)	PAHs (g/m3)	E. coli (MPN/100ml)	
St Clair	1	RM11.313.10	0.15	9	7.68	60	0.000036	1300	
Shore Street	3	RM11.313.04	0.112	BDL	7.21	79	0.000143	>2400	
South Dunedin	4	RM11.313.09	0.144	10	7.61	110	0.01827	2000	
Orari St	8	RM11.313.08	0.057	12	7.88	92	0.000167	>2400	
Kitchener St	10	RM11.313.06	0.069	21	7.52	63	0.000285	1700	
Mason St	21	RM11.313.05	0.071	13	7.44	92	0.000114	>2400	
Bauchop St	23	RM11.313.03	0.056	33	7.76	74	0.000242	690	
Halsey St	24	RM11.313.03	0.058	13	7.48	79	0.000204	>2400	
Wickliffe St	27	RM11.313.03	0.071	6	7.45	120	0.000874	14000	
Port Chalmers	31	RM11.313.01	0.106	7	7.66	76	0.000252	>2400	
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 16th July 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).

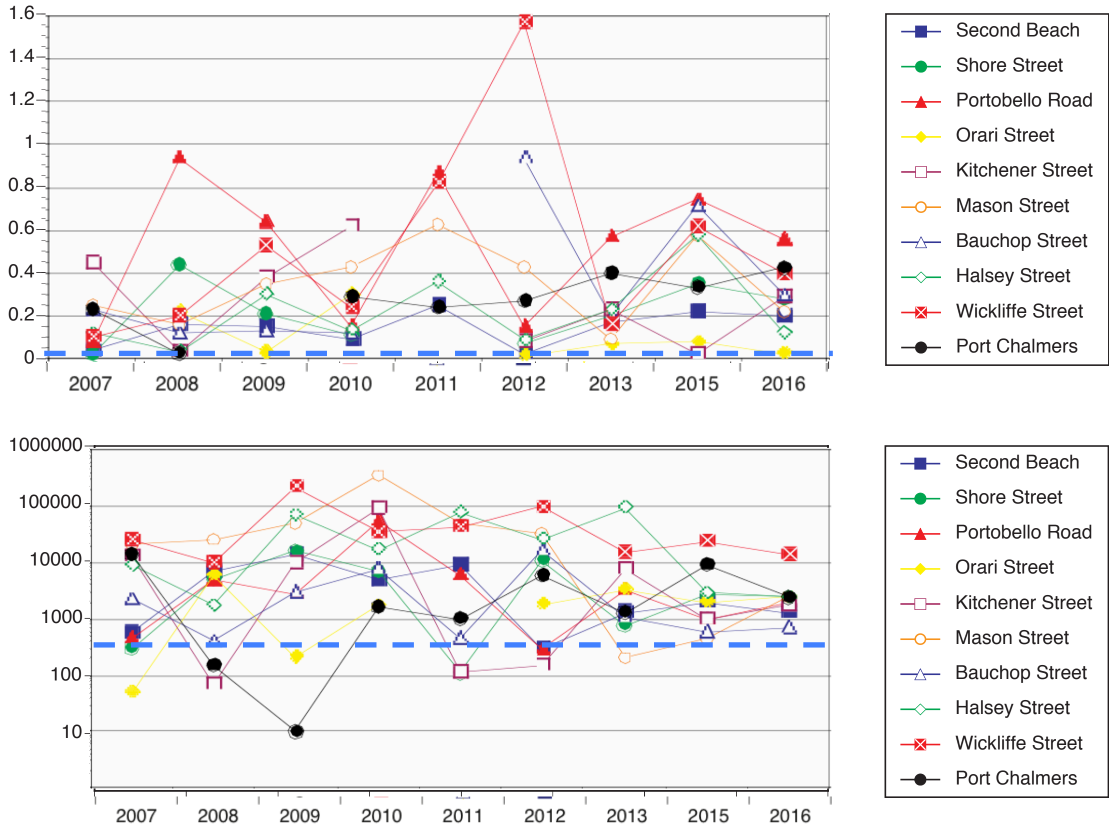

Figure 3.1.1 *Contaminant values in stormwater through time for zinc (top) and E. coli (bottom). Values for zinc are g/m^3 and for E. coli MPN/100ml. Note that scale for E. coli is logarithmic. Dashed blue lines show ANZECC/MfE trigger values.*

Note that lead, copper and suspended solids were all generally higher last year than this year or 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 last year 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).

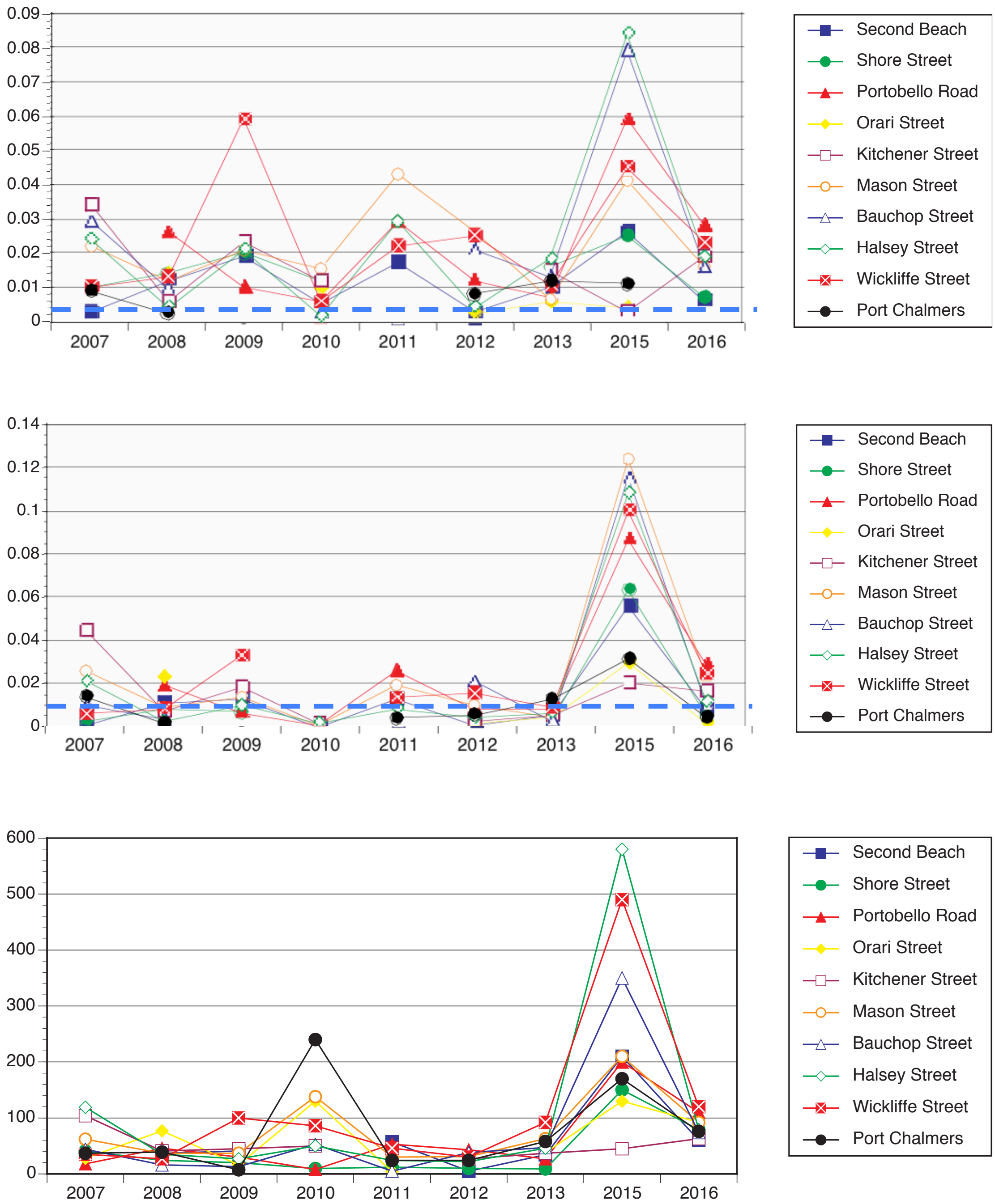

Figure 3.1.2 *Contaminant values for copper (top), lead (middle) and suspended solids (bottom) through time. Values are g/m^3. Dashed blue lines show ANZECC trigger values.*

Wet weather automated sampling

The ISCO automated sampler at the Shore Street site was activated on 16th July 2015 (4.0 mm rain event), 24th August 2015 (16.2 mm rain event) and 3 November 2015 (4.6 mm rain event).

The sampler triggered on one additional occasion, but the rainfall event yielded insufficient rainfall (i.e. <2.5mm).

Concentrations for many contaminants follow the expected pattern for the first flush of rainfall events i.e. start low, then rise and gradually fall away as time progresses (Figure 3.1). This is most evident for the 24 August event.

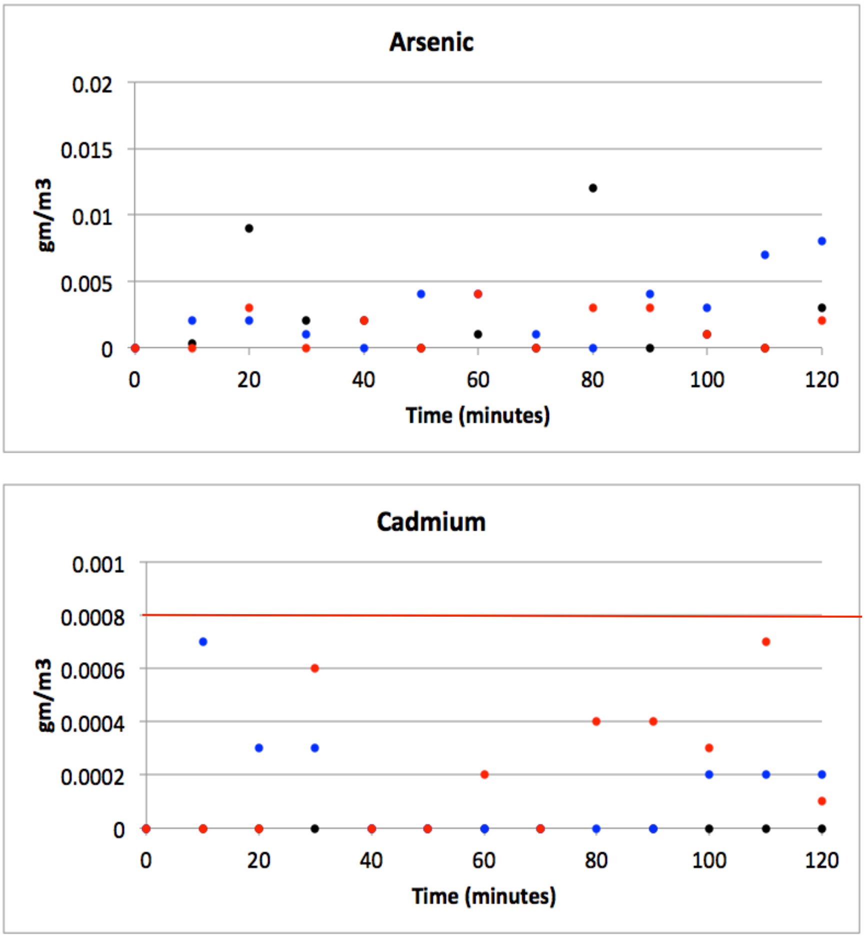

Figure 3.1.3 *Contaminant concentration during the first flush of three rainfall events in 2015. Black spot = 16 July; blue spot = 24 August; red spot = 3 November. Red line indicates ANZECC guideline value for protection of 80% of species.*

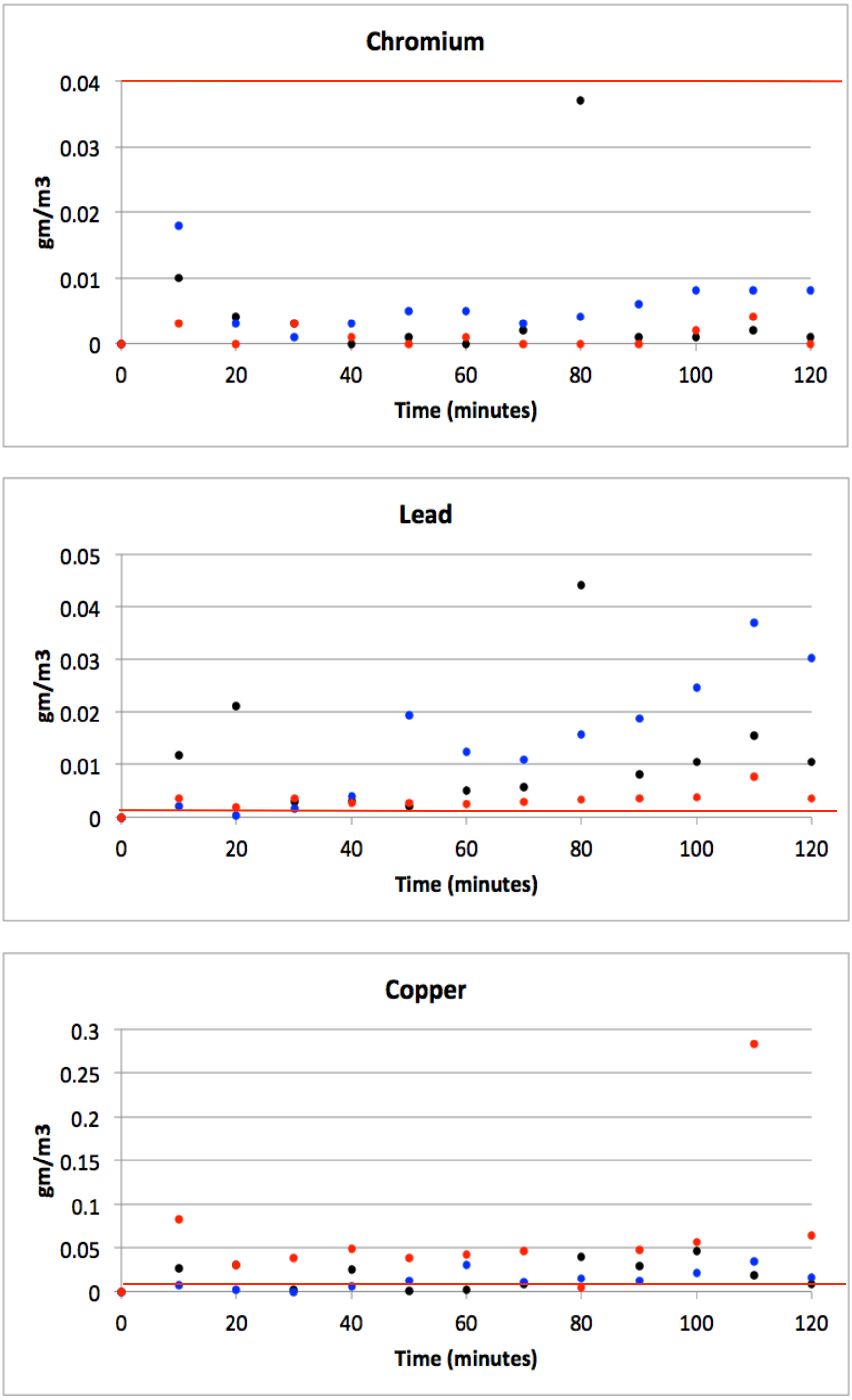

Figure 3.1.3 (cont'd) *Contaminant concentration during the first flush of three rainfall events in 2015. Black spot = 16 July; blue spot = 24 August; red spot = 3 November. Red line indicates ANZECC guideline value for protection of 80% of species.*

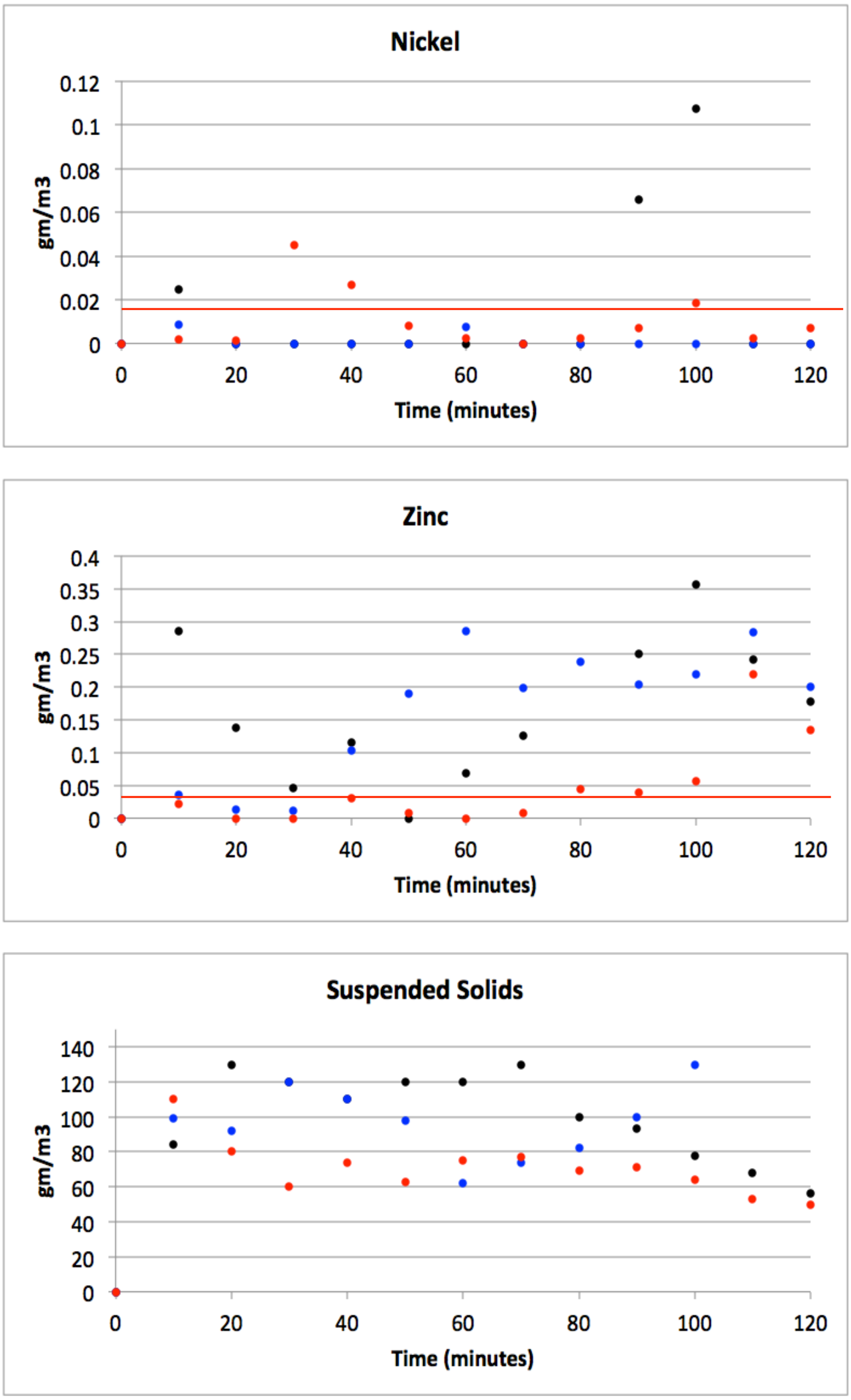

Figure 3.1.3 (cont'd) *Contaminant concentration during the first flush of three rainfall events in 2015. Black spot = 16 July; blue spot = 24 August; red spot = 3 November. Red line indicates ANZECC guideline value for protection of 80% of species.*

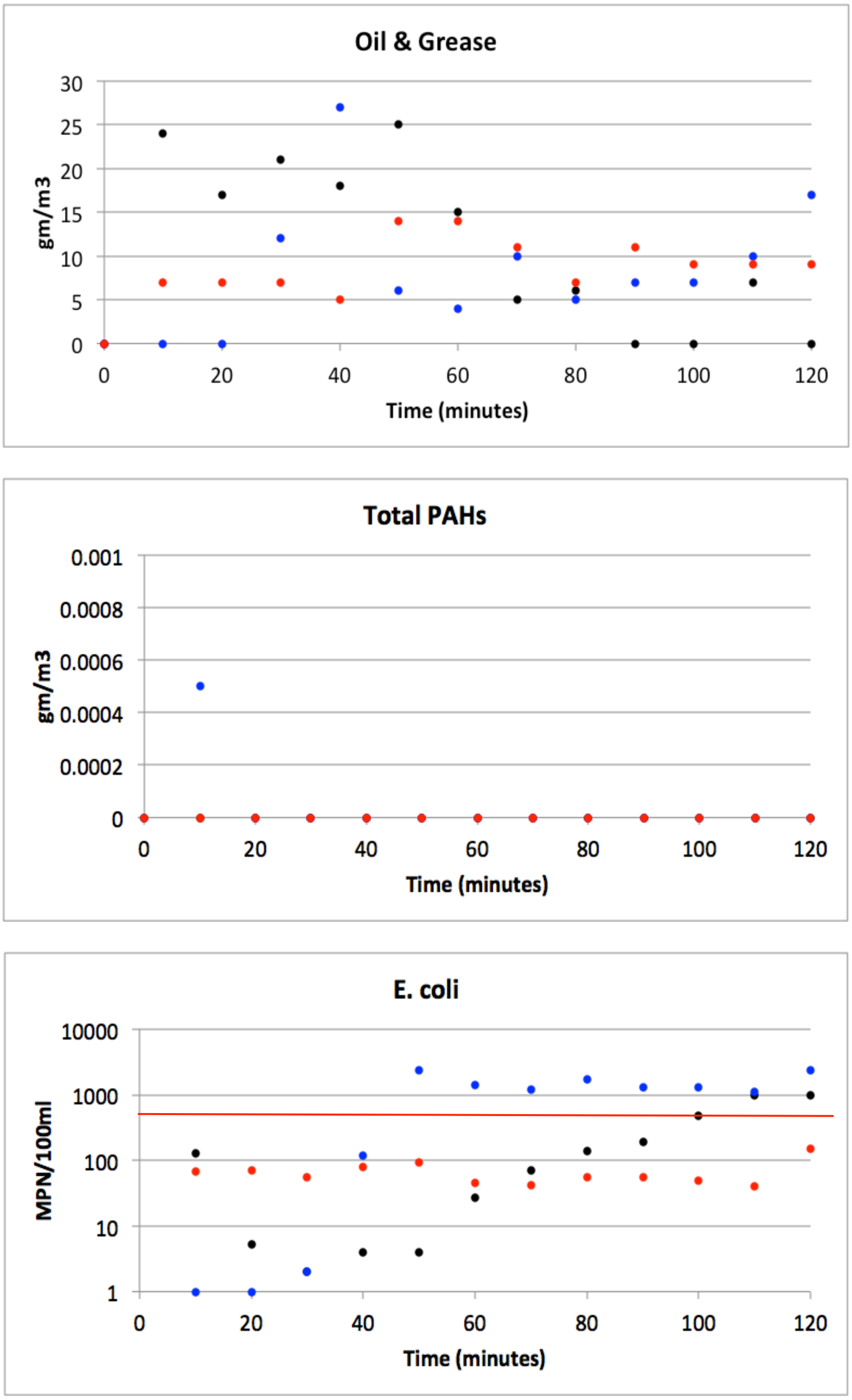

Figure 3.1.3 (cont'd) *Contaminant concentration during the first flush of three rainfall events in 2015. Black spot = 16 July; blue spot = 24 August; red spot = 3 November. Red line indicates ANZECC guideline value for protection of 80% of species.*

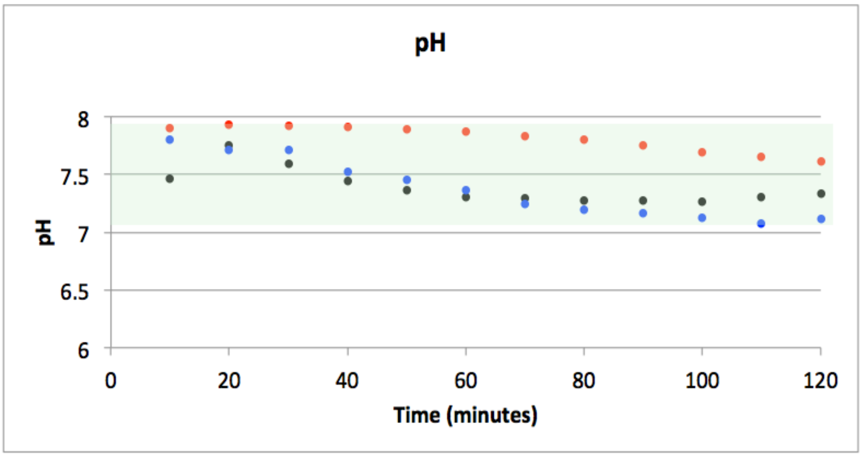

Figure 3.1.3 (cont'd) *Contaminant concentration during the first flush of three rainfall events in 2015. Black spot = 16 July; blue spot = 24 August; red spot = 3 November. Red line indicates ANZECC guideline value for protection of 80% of species. Green band on pH graph shows acceptable limits.*

However, it needs to be recognised that the intensity of the rainfall event and rate of onset have a bearing on values and have resulted in three curves for each contaminant that differ accordingly.

For arsenic, cadmium, chromium and nickel, levels are generally below ANZECC trigger values for protection of 80% of species. For copper, lead and zinc, however, levels exceed ANZECC trigger values for much of the time, especially for the 24 August rainfall event (Figure 3.1). It should be noted that ANZECC trigger values are provided for comparison only. ANZECC values are usually applied to receiving water after reasonable mixing, whereas in this instance values are applied directly to stormwater before mixing.

Although levels of contaminants observed during the three sampled rainfall events generally compare reasonably well with values observed for sampling during previous years, it should be noted that sampling in the past has been a single grab sample. As such past sampling at the

Shore Street outfall may conceivably have missed the particular slug of stormwater carrying the highest level of contaminants for that particular rain event.

3.2 Harbour Water

Harbour water was collected during a dry weather spell on 22nd September 2015 and during a rainfall event that occurred on 2nd October 2015. The rain event generated 10.4 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 and lead concentrations on both the wet and dry weather monitoring rounds, on both the flood and ebb tides, are often above the Consent trigger levels (which correspond to the ANZECC (2000) trigger values for protection of 95% of species). However, contamination was neither universal across all sites nor consistent throughout the tidal cycle (Table 3.2.1). For zinc no contamination in harbour water was detected during dry weather, but on both flood and ebb tide, there were exceedences at a number of sites (Table 3.2.1).

Levels for enterococci contamination occasionally exceed guidelines for marine waters (i.e. >140 MPN/100ml = amber alert; >280 MPN/100ml = red alert), most commonly on the flood tide during a rain event (Table 3.2.1). Higher bacterial counts in runoff from urban areas are not uncommon during rain events and may be due to contamination of surfaces by animal faeces, contamination by decaying vegetation, and contamination from undetected illegal cross connections. However, there is also evidence of bacterial contamination during dry spells, notably off Portsmouth drive in the substation area.

Due to a number of exceedences in the 22 September and 2 October 2015 results harbour water was resampled at the first opportunity where rainfall and tide state allowed. This occurred on 23rd October for dry weather and on 27th October 2015 during a rain event that yielded 10.2 mm rainfall.

Results show that, once again, copper levels exceeded guideline values at all sites and during all states of the tide (Table 3.2.2). However, for lead, zinc and enterococci, although there were exceedences, they were not as common as during the first sampling round.

Considering the modified nature of the upper harbour it may be worthwhile contemplating a change to the way consent trigger values are determined. It would seem that protection of 80% of species may be more appropriate, or perhaps using a rolling mean or median value based on past sampling.

Table 3.2.1 *Contaminants in upper harbour basin water during dry period and a rain event on 2nd October 2015 that yielded 10.4 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)	0.00075	0.00008	0.0016	0.0001
Mason (H2)	0.00064	BDL	0.0026	BDL
Kitchener (H3)	0.00057	0.00008	0.0003	0.0003
Substation (H6)	0.00053	0.00069	0.0015	BDL
Vauxhall (H4)	BDL	0.00008	0.0004	0.0001
Andy Bay Inlet (H5)	BDL	0.00079		BDL
	Dry		Wet	
Cu (0.0013)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.0005	0.022	0.043	0.115
Mason (H2)	0.005	0.241	0.047	0.077
Kitchener (H3)	0.015	0.01	0.019	0.019
Substation (H6)	0.005	0.027	0.009	0.023
Vauxhall (H4)	0.007	0.011	0.02	0.023
Andy Bay Inlet (H5)	BDL	0.004	0.492	0.301
	Dry		Wet	
Pb (0.0044)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.00562	0.00378	0.00379	0.06942
Mason (H2)	0.00564	0.00334	0.00424	0.00382
Kitchener (H3)	0.00345	0.0097	0.00163	BDL
Substation (H6)	0.0095	0.04434	0.00355	0.01105
Vauxhall (H4)	0.00113	0.00354	0.00016	0.00328
Andy Bay Inlet (H5)	0.00021	0.007	0.00715	0.02031
	Dry		Wet	
Zn (0.015)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	BDL	BDL	0.069	BDL
Mason (H2)	BDL	BDL	BDL	BDL
Kitchener (H3)	BDL	BDL	0.102	0.081
Substation (H6)	BDL	BDL	BDL	0.01
Vauxhall (H4)	BDL	BDL	BDL	0.056
Andy Bay Inlet (H5)	BDL	BDL	0.426	0.928
	Dry		Wet	
Enterococci (140 MPN/100ml)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	10	BDL	41	BDL
Mason (H2)	BDL	20	130	BDL
Kitchener (H3)	20	31	41	730
Substation (H6)	460	260	1300	16000
Vauxhall (H4)	10	BDL	520	20
Andy Bay Inlet (H5)	41	41	420	63

Table 3.2.2 *Contaminants in upper harbour basin water resampling during dry period and a rain event on 27th October 2015 that yielded 10.2 mm of rainfall. Pink shaded cells indicate exceedence of Consent trigger values.*

ANZECC 95% (g/m3)	Dry		Wet	
Cu (0.0013)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.016	0.009	0.014	0.025
Mason (H2)	0.149	0.328	0.016	0.012
Kitchener (H3)	0.119	0.043	0.026	0.007
Substation (H6)	0.229	0.012	0.009	0.007
Vauxhall (H4)	0.038	0.027	0.018	0.042
Andy Bay Inlet (H5)	0.044	0.0369	0.057	0.042
Pb (0.0044)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.00129	0.00126	0.00256	0.0029
Mason (H2)	0.00917	0.01592	0.00469	0.00249
Kitchener (H3)	0.00344	0.00308	0.00356	0.00231
Substation (H6)	0.04232	0.00131	0.00204	0.00352
Vauxhall (H4)	0.00178	0.00205	0.00328	0.00401
Andy Bay Inlet (H5)	0.00283	0.01428	0.00321	0.00268
Zn (0.015)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.0042	<0.0042	<0.0042	<0.0042
Mason (H2)	<0.0042	<0.0042	<0.0042	<0.0042
Kitchener (H3)	<0.0042	<0.0042	<0.0042	<0.0042
Substation (H6)	<0.0042	<0.0042	<0.0042	<0.0042
Vauxhall (H4)	<0.0042	<0.0042	<0.0042	<0.0042
Andy Bay Inlet (H5)	<0.0042	<0.0042	<0.0042	0.024
Enterococci (140 MPN/100ml)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	10	460	10	440
Mason (H2)	20	<1.0	<1.0	10
Kitchener (H3)	20	<1.0	<1.0	10
Substation (H6)	63	<1.0	<1.0	20
Vauxhall (H4)	31	<1.0	<1.0	120
Andy Bay Inlet (H5)	10	<1.0	10	1200

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 3.2.3). 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 3.2.3 *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 2rd February 2016 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 and occasional patches of *Gracilaria chilensis* at the Orari Street site.

Levels of contaminants were all very low (Table 3.3.1) and were found to be lower than the trigger values stated in Appendix 2, Table C 1 (Table 3.9). Resampling of sediments was not required. For zinc, levels at Kitchener Street remain relatively high (255 mg/kg), albeit below trigger levels. 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 re-spraying 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). Levels of most contaminants at most sites are lower now than they were when sampling first started in 2007 (Figure 3.3.1). However, historically, sediments were sampled much closer to stormwater outfalls than in 2015 and 2016 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. Also shown are consent trigger levels and ANZECC high and low trigger levels.*

Site	As	Cd	Cr	Cu (WAE)	Cu	Pb	Hg	Ni	Zn
Halsey Street	13.9	0.201	40.7	0.0257	25.5	34	0.087	20.7	118
Kitchener Street	12.6	0.26	26.3	1.98	22.7	44.7	0.106	12.3	255
Orari Street	3.11	0.061	8.12	3.05	6.83	9.21	0.02	3.93	43.1
Shore Street	3.46	0.183	8.62	3.07	34.9	25.2	0.016	6.38	134
Consent trigger	19	1.7	80		122	209		21	902
Low	20	1.5	80		65	50	0.15	21	200
High	70	10	370		270	220	1	52	410

Site	TPH	PAH	Organochlorine pesticides
Halsey Street	BDL	0.13	BDL
Kitchener Street	BDL	2.19	BDL
Orari Street	BDL	0.03	BDL
Shore Street	82*	3.2	BDL
Consent trigger		183	

Table 3.3.2 *Maximum contaminant concentrations (mg/kg) in sediments sampled in 2016 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
2016 Maximum	13.9	0.26	40.7	25.5	44.7	0.106	20.7	255	2.19
Historic maximum	46	6.2	98	433	800	0.17	44	4450	651

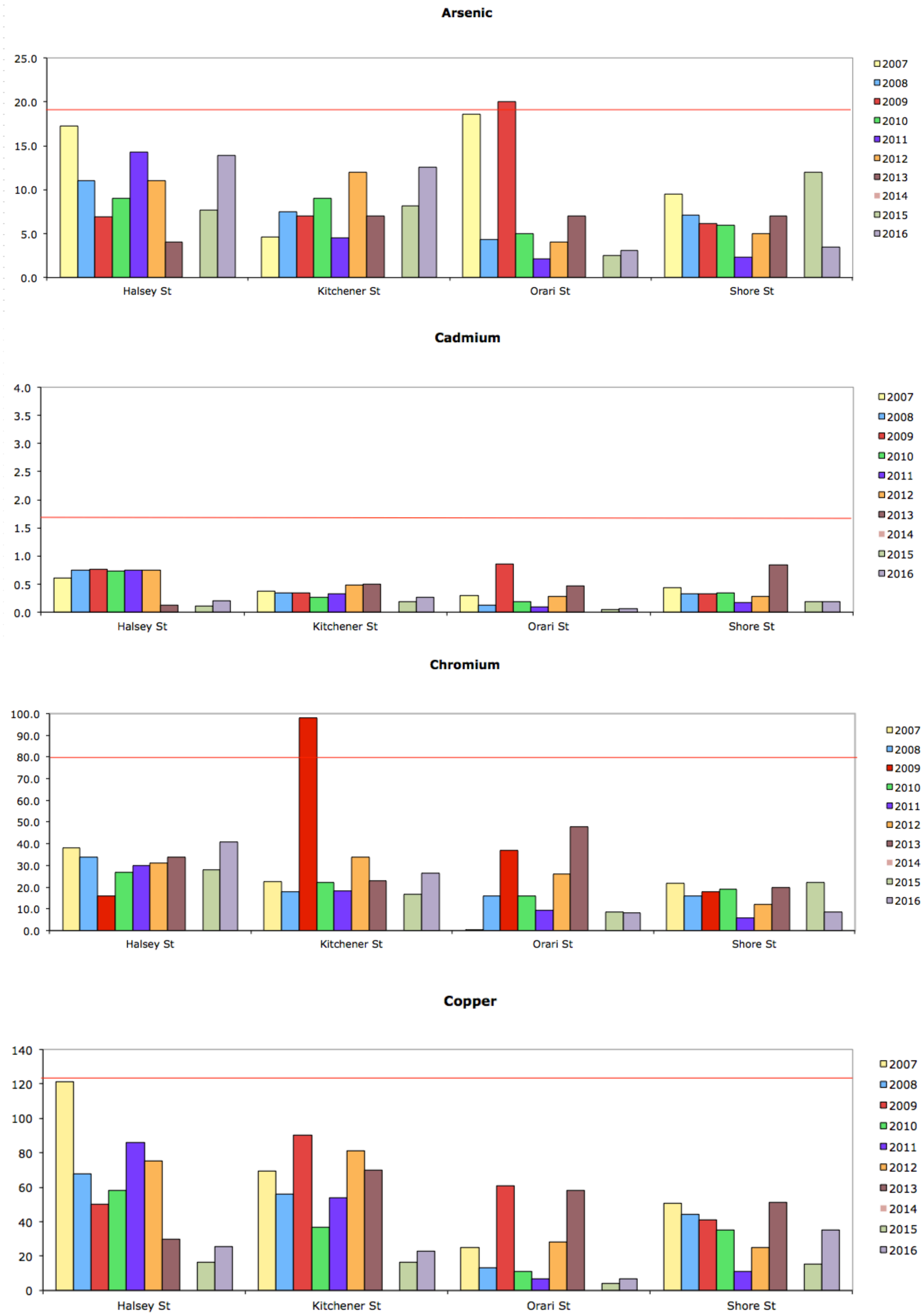

Figure 3.3.1 *Concentration of metals in surficial sediment at sites in Otago Harbour through time. Red line indicates Consent trigger level. 2014 data discarded as being unreliable.*

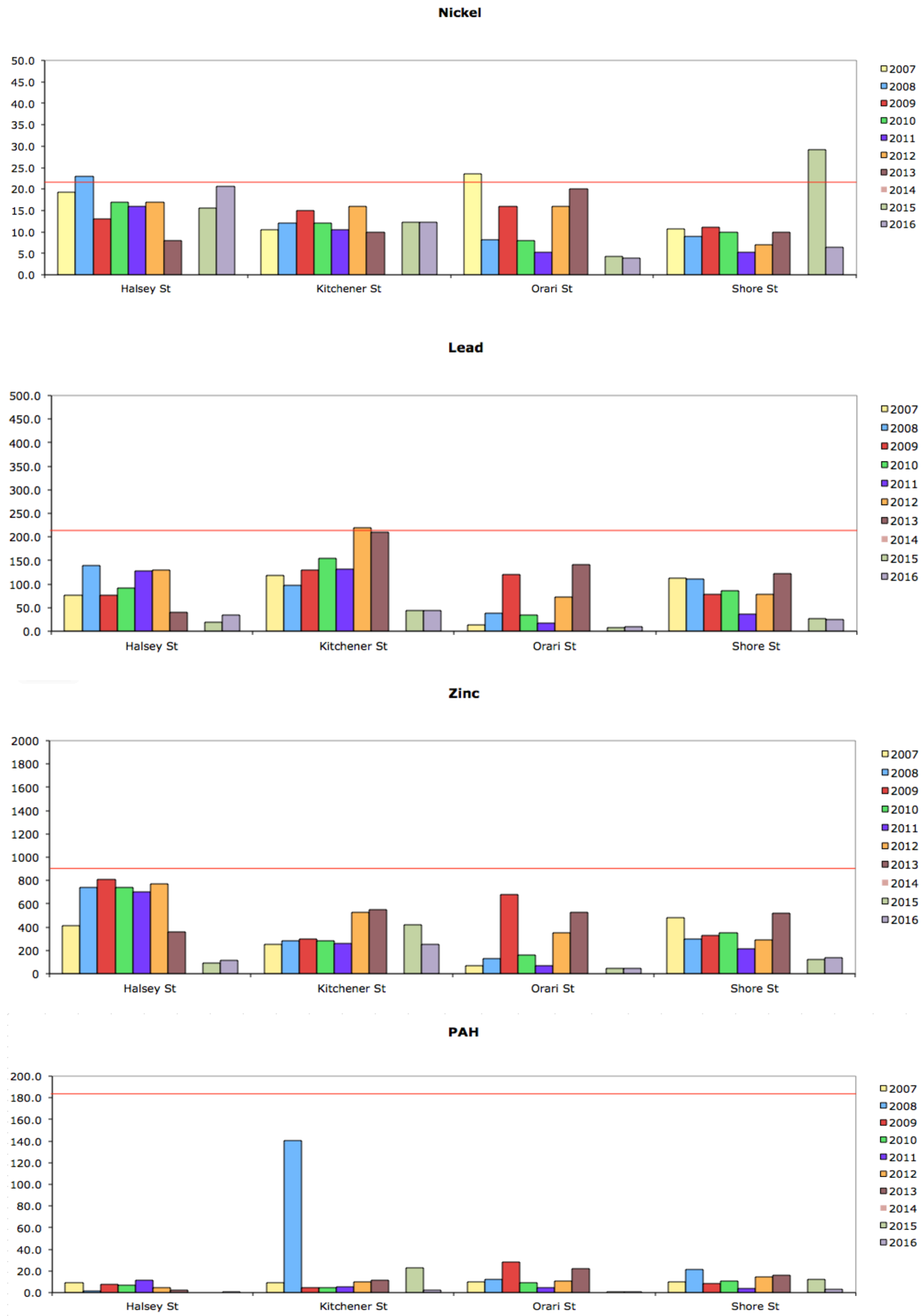

Figure 3.3.1 (cont'd) *Concentration of metals in surficial sediment at sites in Otago Harbour through time. Red line indicates Consent trigger level. 2014 data discarded as being unreliable.*

3.4 Biological Monitoring

A full biological sampling round is due in 2017.

4. Discussion and Conclusion

Monitoring of stormwater quality in Dunedin since 2014 differs in some respects from previous 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 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.

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.

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 on 16 July 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, but there have been very slight reductions in the number of catchments exceeding trigger values for copper, nickel and lead (Table 1,

Appendix 2). Cadmium too, has shown a slight overall reduction. Bacterial contamination continues to be an issue. As stated above this is a common problem with runoff from impervious surfaces. The DCC is working to mitigate contamination from sources under its control, but general bacterial contamination from animal droppings and decaying vegetation is likely to continue.

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 copper and lead concentrations on both the wet and dry weather monitoring rounds, on both the flood and ebb tides, are often above the Consent trigger levels. Resampling harbour water prior to and during a similar rain event in October 2015 showed a general reduction of these contaminants, possibly due to differing lengths of antecedent dry periods.

Not unexpectedly, there appears to be a relationship between contaminant concentration and wet weather, with higher concentrations of enterococci observed during a rain event. Past experience has shown that higher intensity rain events result in even higher contamination (e.g. June 2015 – in this instance, there was a known overflow, so enterococci can be correlated with the Surrey St overflow).

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 as early as possible 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 appears to be improving. 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 all contaminants are very low and within 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, or that contaminants are either being flushed out of the harbour, removed by dredging, or being covered by new and cleaner sediments.

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, it must be noted that the sites at which samples were collected last year and this year differ from previous locations due to Consent requirements. 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 diminish as fewer contaminants enter the harbour and existing contaminants are either flushed out, or become buried under newer non-contaminated sediments.

While not pristine, the upper harbour appears 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.

Future monitoring, as prescribed in the conditions associated with the new discharge permits, will assist in defining problem areas (for example, PAHs in the South Dunedin catchment), 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/m³)*	*0.00130*	*0.00130*	*ANZECC guideline*
Total Nickel	*(g/m³)*	*0.07000*	*0.07000*	*ANZECC guideline*
Total Lead	*(g/m³)*	*0.00440*	*0.00440*	*ANZECC guideline*
Total Zinc	*(g/m³)*	*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/m³									g/m³								
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016	2007	2008	2009	2010	2011	2012	2013	2015	2016
St Clair	BDL	0.0013	0.0015	BDL	0.0016	BDL	BDL	BDL	0.001	BDL	0.00006	0.00006	0.00007	7.5E-05	BDL	BDL	0.0001	BDL
Shore Street	0.04	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Portobello Road	BDL	0.002	BDL	BDL	BDL	BDL	BDL	0.003	0.002	BDL	0.00023	BDL	BDL	BDL	BDL	BDL	0.0001	BDL
Orari Street	BDL	BDL	0.032	0.00149	BDL	BDL	BDL	BDL	0.003	BDL	BDL	BDL	0.000164	BDL	BDL	BDL	BDL	BDL
Kitchener Street	BDL	BDL	0.0096	BDL	BDL	BDL	BDL	BDL	0.002	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mason Street	0.006	BDL	0.0077	BDL	BDL	BDL	BDL	0.003	0.001	BDL	BDL	0.0077	0.00051	BDL	BDL	BDL	0.0001	BDL
Bauchop Street	0.03	BDL	0.021	BDL	BDL	BDL	BDL	0.001	0.001	BDL	BDL	BDL	0.00049	BDL	BDL	BDL	BDL	BDL
Halsey Street	0.03	BDL	0.01	0.0044	BDL	BDL	BDL	0.002	0.001	BDL	0.00022	BDL	0.00026	BDL	BDL	BDL	0.0004	BDL
Wickliffe Street	0.03	BDL	0.003	BDL	0.0035	0.0027	BDL	0.008	0.004	BDL	BDL	0.00052	0.00078	0.00092	0.00022	BDL	0.0002	BDL
Port Chalmers	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.003	BDL	BDL	BDL	BDL	BDL	BDL	0.0002	BDL	BDL
Protection for 80% ANZECC guidelines	0.36									0.0008								

Parameter	Cr									Cu								
units	g/m³									g/m³								
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016	2007	2008	2009	2010	2011	2012	2013	2015	2016
St Clair	0.0007	0.0028	0.0035	0.00086	0.0038	0.0015	0.0023	0.0117	0.004	0.0027	0.012	0.019	0.0054	0.0172	0.0026	0.0099	0.026	0.006
Shore Street	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0061	BDL	0.01	0.014	0.02	0.0118	BDL	BDL	0.0159	0.025	0.007
Portobello Road	BDL	0.002	BDL	BDL	BDL	BDL	BDL	0.0182	0.005	BDL	0.026	0.01	0.0057	0.029	0.012	0.0072	0.059	0.028
Orari Street	BDL	0.0032	BDL	0.00183	BDL	BDL	BDL	0.0027	BDL	BDL	0.014	BDL	0.0096	BDL	0.0024	0.0057	0.004	BDL
Kitchener Street	0.004	0.002	BDL	BDL	BDL	BDL	BDL	0.001	0.002	0.034	0.0056	0.023	0.0118	BDL	BDL	0.015	0.003	0.019
Mason Street	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0183	0.006	0.022	0.012	0.021	0.0157	0.043	0.026	0.0065	0.041	0.016
Bauchop Street	BDL	0.0015	BDL	BDL	BDL	BDL	BDL	0.0182	0.003	0.029	0.0096	BDL	0.0026	BDL	0.021	0.0131	0.079	0.016
Halsey Street	BDL	BDL	BDL	BDL	BDL	BDL	0.0019	0.0226	0.003	0.024	0.0043	0.021	0.00162	0.029	0.0043	0.0183	0.084	0.019
Wickliffe Street	BDL	0.0017	0.0076	0.00157	0.0046	0.0028	0.0026	0.0189	0.006	0.01	0.013	0.059	0.0058	0.022	0.025	0.0107	0.045	0.023
Port Chalmers	BDL	0.0064	BDL	BDL	BDL	0.0016	0.0025	0.0054	0.002	0.009	0.0025	BDL	BDL	BDL	0.008	0.0118	0.011	BDL
Protection for 80% ANZECC guidelines	0.04									0.0025								

Table 1 *continued…*

Parameter	Ni								
units	g/m^3								
Outfall	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	0.0009	0.0021	0.0022	0.00133	0.0026	0.0011	0.0023	BDL	BDL
Shore Street	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0024
Portobello Road	BDL	0.0035	0.0028	0.0035	BDL	BDL	BDL	BDL	BDL
Orari Street	BDL	0.0033	BDL	0.00108	BDL	0.0008	BDL	BDL	BDL
Kitchener Street	0.003	BDL	0.0036	0.0035	BDL	BDL	BDL	BDL	BDL
Mason Street	0.004	BDL	0.0055	BDL	0.0039	BDL	BDL	BDL	BDL
Bauchop Street	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Halsey Street	0.009	BDL	0.0035	BDL	BDL	BDL	BDL	0.0254	BDL
Wickliffe Street	0.01	BDL	0.0042	BDL	0.0021	0.0046	BDL	0.0051	BDL
Port Chalmers	BDL	BDL	BDL	0.0035	BDL	0.0019	BDL	BDL	BDL
Protection for 80% ANZECC guidelines	0.017								

Parameter	Pb								
units	g/m^3								
Outfall	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	0.001	0.011	0.013	0.00021	0.0127	0.00101	0.0053	0.0557	0.00818
Shore Street	0.003	0.0085	0.0069	BDL	BDL	BDL	0.0038	0.0635	0.00509
Portobello Road	BDL	0.019	0.0067	0.00055	0.026	0.0081	0.0086	0.0869	0.02913
Orari Street	BDL	0.023	BDL	0.00015	BDL	0.00118	0.0041	0.0295	0.00179
Kitchener Street	0.0442	0.007	0.018	0.00196	BDL	0.0028	0.0055	0.0202	0.01638
Mason Street	0.0258	0.0089	0.014	0.00102	0.0192	0.0101	0.0042	0.124	0.0235
Bauchop Street	0.01	0.0035	BDL	BDL	BDL	0.021	0.0026	0.115	0.01031
Halsey Street	0.021	0.0022	0.0097	0.0021	0.0085	0.0043	0.0064	0.108	0.01176
Wickliffe Street	0.006	0.0084	0.033	BDL	0.0134	0.0153	0.0092	0.1	0.02461
Port Chalmers	0.0141	0.0018	BDL	BDL	0.0041	0.0057	0.0127	0.0316	0.00458
Protection for 80% ANZECC guidelines	0.0094								

Parameter	Zn								
units	g/m^3								
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	0.038	0.16	0.15	0.092	0.25	0.026	0.166	0.222	0.197
Shore Street	0.02	0.44	0.21	0.115	BDL	0.071	0.2	0.351	0.282
Portobello Road	0.08	0.94	0.64	0.153	0.87	0.15	0.57	0.744	0.557
Orari Street	BDL	0.22	0.031	0.3	BDL	0.0157	0.07	0.078	0.026
Kitchener Street	0.445	0.036	0.38	0.62	BDL	0.082	0.23	0.025	0.292
Mason Street	0.25	0.16	0.35	0.43	0.63	0.43	0.095	0.577	0.221
Bauchop Street	0.23	0.12	0.13	0.121	BDL	0.94	0.2	0.713	0.296
Halsey Street	0.12	0.033	0.3	0.136	0.36	0.089	0.23	0.576	0.119
Wickliffe Street	0.1	0.2	0.53	0.24	0.82	1.57	0.161	0.617	0.395
Port Chalmers	0.231	0.027	BDL	0.29	0.24	0.27	0.4	0.334	0.425
Protection for 80% ANZECC guidelines	0.031								

Parameter	pH								
units									
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	7.7	7.3	7.4	7.3	7.4	8	7.7	7.63	7.68
Shore Street	7.9	7.2	7.3	7.4	7.9	7.5	7.5	7.5	7.21
Portobello Road	7.9	7.3	7.6	7.6	7.4	8.1	7.6	7.58	7.61
Orari Street	7.8	7.4	8.1	7.1	7.9	7.9	7.6	7.87	7.88
Kitchener Street	7.1	7.7	7.4	6.9	8	7.6	7.7	7.43	7.52
Mason Street	7.1	7	7.4	7	7	7.1	7.6	8.4	7.44
Bauchop Street	7.6	7.8	8.1	7.4	8	7.4	7.9	8.83	7.76
Halsey Street	7.3	7.9	7.2	6.8	7.1	7.8	7.3	7.73	7.48
Wickliffe Street	7.7	7.5	8.0	7.3	9.7	7.0	7.5	7.67	7.45
Port Chalmers	6.8	7.9	8.2	7.1	7.5	7.5	7.5	7.48	7.66
Protection for 80% ANZECC guidelines	7.2-7.8								

Table 1 *continued…*

Parameter	Suspended Solids								
units	g/m^3								
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	BDL	37	41	BDL	57	5	34	210	60
Shore Street	41	24	20	9.5	12	10	9	150	79
Portobello Road	18	46	30	8.1	53	43	27	200	110
Orari Street	28	77	16	130	4	BDL	38	130	92
Kitchener Street	104	41	45	50	BDL	27	37	45	63
Mason Street	62	37	37	138	30	31	63	210	92
Bauchop Street	44	16	13	53	5	38	47	350	74
Halsey Street	119	35	27	50	24	22	46	580	79
Wickliffe Street	35	27	100	86	46	30	92	490	120
Port Chalmers	37	39	7.4	240	24	24	58	170	76

Parameter	Oil & Grease								
units	g/m^3								
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	5	BDL	BDL	BDL	BDL	11	5	27	9
Shore Street	BDL	BDL	BDL	BDL	BDL	10	5	BDL	BDL
Portobello Road	4	9.7	BDL	BDL	BDL	BDL	BDL	BDL	10
Orari Street	BDL	11	BDL	BDL	17	BDL	BDL	12	12
Kitchener Street	9	BDL	BDL	BDL	22	11	BDL	8	21
Mason Street	5	7.9	BDL	BDL	BDL	BDL	BDL	6	13
Bauchop Street	4	BDL	BDL	BDL	BDL	BDL	BDL	BDL	33
Halsey Street	9	BDL	BDL	BDL	BDL	BDL	BDL	6	13
Wickliffe Street	6	9.5	9.5	BDL	7	BDL	BDL	30	6
Port Chalmers	8	BDL	BDL	BDL	BDL	BDL	BDL	17	7

Parameter	FWA								
units	µg/L								
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	0.147	0.19	0.098	0.04	0.075	0.069	0.064	0.084	0.15
Shore Street	0.081	0.031	0.142	0.98	0.142	0.156	0.104	0.087	0.112
Portobello Road	0.003	0.049	0.177	0.151	0.045	0.096	0.207	0.138	0.144
Orari Street	BDL	0.005	0.11	0.052	0.081	0.094	0.038	0.09	0.057
Kitchener Street	0.18	0.029	0.072	0.023	0.047	0.052	0.027	0.046	0.069
Mason Street	0.007	0.07	0.051	0.156	0.026	0.043	0.058	0.06	0.071
Bauchop Street	2.028	4.92	0.031	0.067	0.017	0.019	0.033	0.057	0.056
Halsey Street	BDL	0.004	0.011	0.061	0.025	0.038	0.027	0.07	0.058
Wickliffe Street	0.024	0.003	0.021	0.048	0.094	0.121	0.052	0.081	0.071
Port Chalmers	0.002	0.003	0.124	0.105	0.092	0.147	0.084	0.104	0.106

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.

Total PAHs	2007	2008	2009	2010	2011	2012	2013	2015	2016
Kitchener Street	0.00	0.00	BDL	0.0001	BDL	BDL	BDL	BDL	0.0003
Orari Street	0.00	0.00025	BDL	0.0005	BDL	BDL	BDL	BDL	0.0002
Portobello Road	BDL	0.00132	0.00017	0.00016	0.00168	0.0002	0.0018	0.01043	0.0182

Parameter	E. coli								
units	MPN/100ml								
Catchment	2007	2008	2009	2010	2011	2012	2013	2015	2016
Second Beach	560	6800	14000	4800	9000	300	1300	2000	1300
Shore Street	300	5100	16000	7000	110	11000	780	2600	>2400
Portobello Road	460	5000	2800	54000	6000	280	3300	1000	2000
Orari Street	50	6000	210	1700	BDL	1800	3300	2000	>2400
Kitchener Street	13000	70	10000	92000	110	150	7900	990	1700
Mason Street	22000	26000	50000	350000	48000	32000	200	460	>2400
Bauchop Street	2200	400	3000	7900	450	17000	1100	580	690
Halsey Street	9000	1700	70000	17000	78000	26000	92000	2900	>2400
Wickliffe Street	25000	10000	220000	35000	43000	96000	15000	24000	14000
Port Chalmers	14000	150	10	1600	1000	5900	1300	9200	>2400
Primary	Amber	>260							
Secondary	Red	>550							