Stormwater Discharges to the Coastal Marine Area: RM11.313.01 – RM11.313.10

July 2023 to June 2024 Monitoring

Dunedin City Council

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Prepared by:

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1.0	26 July 2024	Zoe Psarouthakis	Ben Ludgate	Ben Ludgate

Basis of Report

This report has been prepared by SLR Consulting New Zealand (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Dunedin City Council (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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Executive Summary

Dunedin City Council operates the Dunedin stormwater system. Monitoring of stormwater and the receiving environments is required by Otago Regional Council resource consents (RM11.313.01 – RM11.313.10). Monitoring between July 2023 and June 2024 included stormwater quality during dry weather conditions, harbour water quality during dry weather conditions, sampling of harbour sediments, and sampling using the wet weather automated sampler. Further sampling/re-sampling was restricted by weather/tidal conditions not being met.

Dry weather sampling of stormwater found that trigger levels of *Escherichia coli* were exceeded at most outfalls on at least one sampling occasion. As there were several months without suitable conditions for sampling there were not three consecutive months of sampling over the twelve-month period. However, Outfalls 1 (St Clair catchment), 3 (Shore Street catchment), 8 (Orari Street catchment), 24 and 25 (Halsey Street catchment), 27 (Halsey Street catchment), and 33 (Port Chalmers catchment) all had *E. coli* concentrations that exceeded the trigger level over three consecutive sampling rounds.

Wet weather sampling of stormwater at outfalls during a rainfall event at low tide following a period of dry weather was not undertaken between July 2023 and June 2024 as the required conditions were not met.

Automated sampling was undertaken on 11 April 2024 at the Hasley Street catchment site. Concentrations of several contaminants, including heavy metals and suspended solids, were generally lower than during the previous two Hasley Street catchment automated sampler rain events (April 2022). This is the third sampling round in this catchment and the automated sampler can therefore be moved to the next catchment site, potentially the South Dunedin catchment (to retain the same order as previous deployments). Between July 2023 and June 2024 there were 12 occasions when the sampler was incorrectly triggered (‘false alarms’).

Harbour water quality sampling was undertaken during dry weather in 2023-2024. Sampling revealed copper, zinc, lead, and enterococci concentrations exceeded consented trigger levels at a few sites during dry weather conditions, indicating elevated background concentrations of these contaminants.

Harbour sediment sampling found contaminant concentrations were generally high at Kitchener and Orari Street sites, while concentrations at the Hasley and Shore Street sites were generally lower than in recent years. Concentrations of copper, mercury, and zinc appear to be increasing over time at the Orari Street site. Contaminant concentrations in 2024 were all below 2013 trigger levels listed in the consents, however concentrations of several contaminants were above the ANZECC (2000) ISQG-Low levels, which represent the threshold for potential effects to occur and is a trigger for further investigation. Only zinc at the Kitchener Street site had concentrations above the ISQG-High level, which represent a point where a high probability of effects is possible. Zinc concentrations have been considerably lower in recent years at Kitchener Street, and further monitoring will help determine if contaminant concentrations continue to increase or return to be within previous ranges.

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1.0 Introduction

Dunedin City Council (DCC) operates the Dunedin stormwater system, which comprises a network of gutters, open channels, pipes, mud tanks, and outfalls. The principal coastal receiving water environments for Dunedin's reticulated stormwater are the upper basin of Otago Harbour, Port Chalmers, and, on the open coast, Second Beach and St Clair Beach. Otago Regional Council (ORC) resource consents (RM11.313.01 – RM11.313.10) authorise the discharge of stormwater from ten stormwater catchments (St Clair, Shore Street, South Dunedin, Portsmouth Drive, Orari Street, Kitchener Street, Mason Street, Halsey Street, Ravensbourne, and Port Chalmers catchments) to these receiving environments (Figure 1). The consent conditions require monitoring of stormwater quality during dry and wet weather conditions, harbour water quality during dry and wet weather conditions, harbour sediments, and on a biennial basis, harbour biological communities.

DCC engaged SLR Consulting to undertake the required monitoring between July 2023 and June 2024. This report summarises the results of that monitoring.

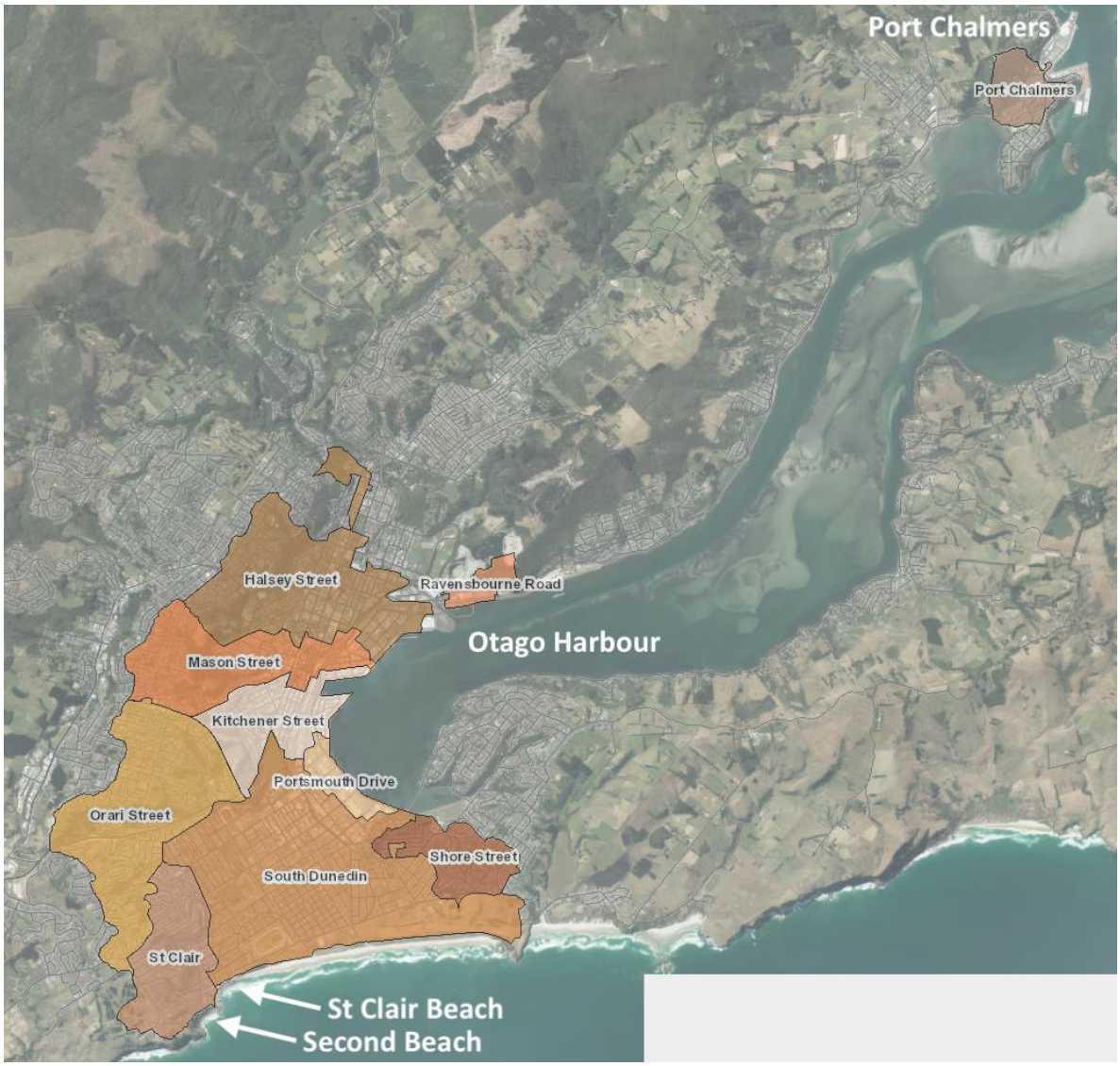

Figure 1: Dunedin 3 Waters catchment boundaries. Modified from DCC Webpage.

2.0 Stormwater Outfall Locations

Monitoring of Dunedin's stormwater quality is required at 14 large outfalls and many smaller outfalls (Figure 2; Appendix A). Many of Dunedin's outfalls have long histories dating back to the early settlement of the city. A number of the outfalls do not have outfall structures or are inaccessible for sampling, and it is therefore neither practical nor possible to sample all 33 outfalls at the discharge point (outfall) to the receiving environment. However, access at many sites is available via manholes a short distance upstream from the outfall.

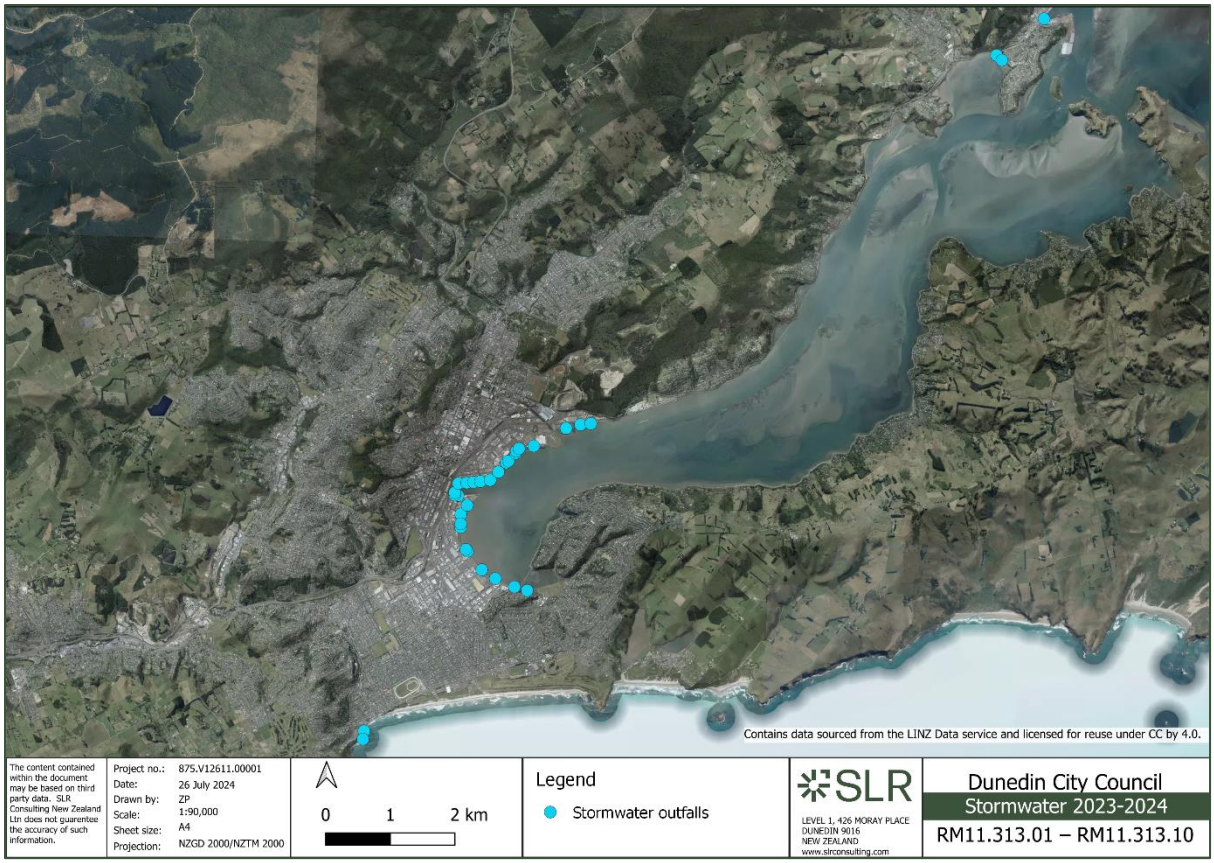

Figure 2: Dunedin stormwater outfalls.

3.0 Sampling Requirements and Methods

3.1 Dry weather stormwater sampling

Dry weather water sampling is undertaken to determine background contaminant levels entering the receiving environments via stormwater outfalls and it can indicate possible cross-connections between stormwater and wastewater systems. At some outfalls where indicators of human wastewater have not been detected or there is generally no flow, sampling is only required six-monthly, while sampling at other outfalls is required monthly (when all conditions for sampling are met) (Figures 3 and 4; Appendix A). At many six-monthly sampling sites there is no access to the outfall. However, due to the small size of the receiving catchments for these outfalls, there is not expected to be any flow under dry conditions.

Dry weather water sampling is required at stormwater outfalls under low tide conditions, to avoid dilution by seawater. Dry weather is defined as a period of at least 72 hours with no more than 1 mm of measurable rainfall. If no dry weather conditions occur within a calendar month, no sampling is undertaken for that month.

When conditions are suitable, grab samples of water are collected in laboratory-provided containers from the end of the outfall pipe, or as near as practicable prior to the discharge mixing with seawater, for laboratory analysis (Eurofins) for *Escherichia coli* (*E. coli*). *E. coli* is a type of bacteria commonly found in the gut of humans and other warm-blooded animals and is used as an indicator of faecal contamination in freshwater. The indicator bacteria themselves do not necessarily pose a significant risk to human health, but rather indicate the likely presence of faecal material, which contains disease-causing pathogens, including a range of bacteria and viruses. Potential sources of *E. coli* in stormwater include sewage and faecal deposition by animals (e.g., birds, rodents, domestic pets). If the *E. coli* concentration in samples from three consecutive months is greater than 550 units per 100 millilitres, the consent requires investigation and remedial action, if required. The *E. coli* trigger level is based on Ministry for the Environment (MfE) (2003) action (red) level guidelines where water poses an unacceptable health risk from bathing.

Grab samples of water are also collected and analysed on site for fluorescent whitening agents (FWAs) using an AquaFluor handheld fluorometer. Measurement of FWAs is not required by resource consents, however they provide a useful indicator of potential contamination. FWAs are used in laundry detergents and, as household plumbing mixes effluent from toilets with washing machine ‘grey water’, FWAs can be associated with human faecal contamination and indicate possible wastewater infiltration to the stormwater system. Detection of 0.1 ppb of FWA is suggestive of contamination from grey/wastewater and a level of 0.2 ppb is strongly indicative of contamination from grey/wastewater (Gilpin and Devane 2003). While samples with higher levels of FWAs generally also contain high levels of *E. coli*, a direct linear relationship between the two is not always evident as FWAs are chemicals that may have different movement and survival characteristics to microbial pathogens (Gilpin and Devane 2003).

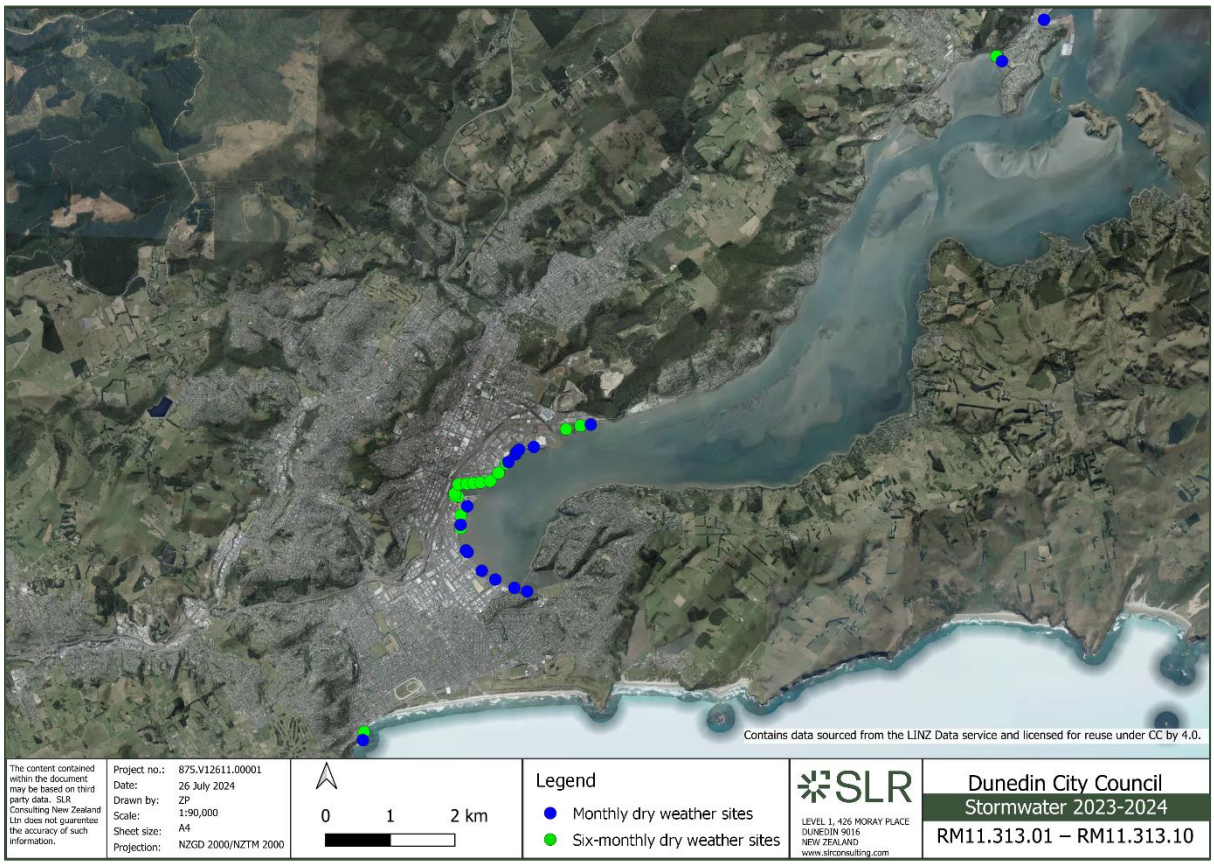

Figure 3: Dunedin stormwater outfalls - monthly and six-monthly dry weather sites (all sites).

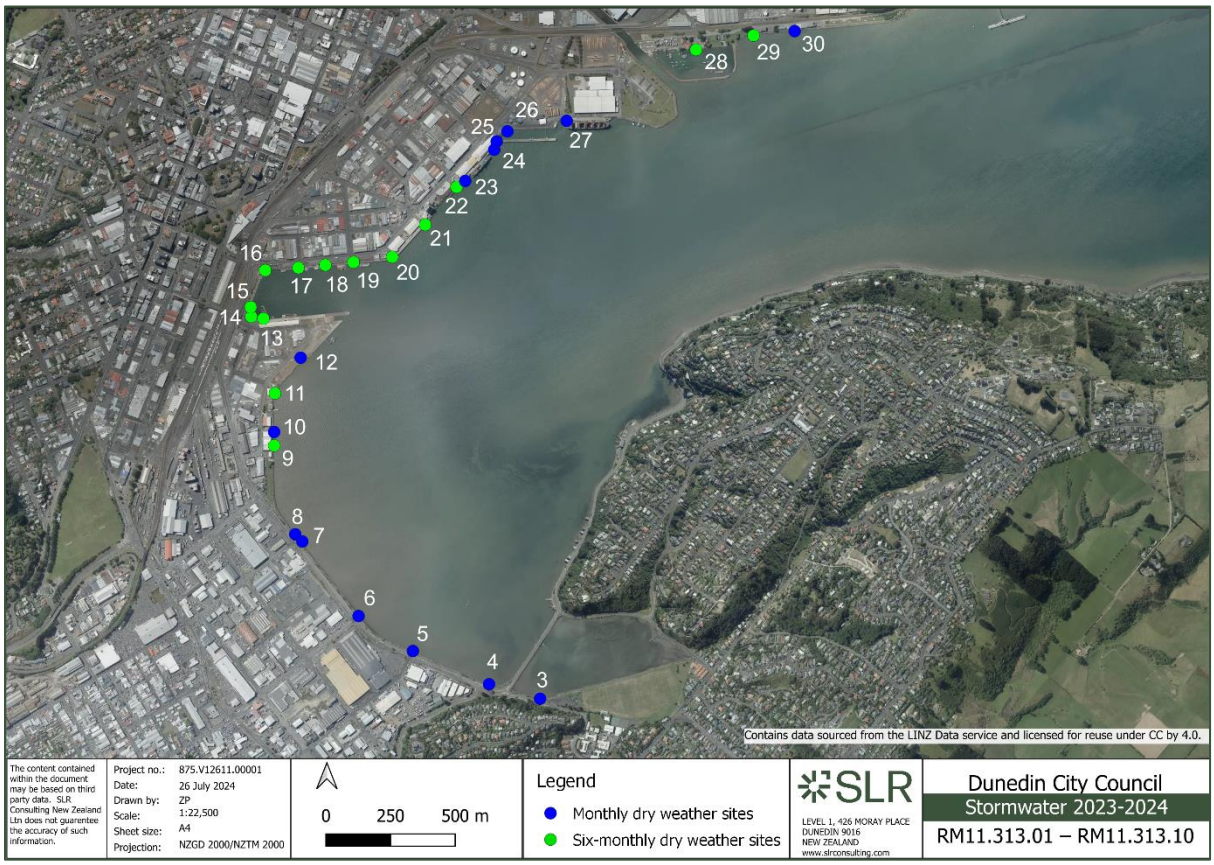

Figure 4: Dunedin stormwater outfalls - monthly and six-monthly dry weather sites (upper harbour sites).

3.2 Wet weather stormwater sampling

Wet weather water sampling is undertaken in an endeavour to sample the first flush of stormwater, which typically contains the highest concentration of contaminants, into the receiving environment.

Wet weather water sampling is required annually at ten major stormwater outfalls (Figures 5 and 6, Appendix A) at low tide within two hours of the commencement of a rain event (more than 2.5 mm of rain), following an antecedent dry period of at least 72 hours of no rainfall in the catchment.

When conditions are suitable, grab samples of water are collected in laboratory-provided containers from the end of the outfall pipe, or as near as practicable prior to the discharge mixing with seawater, for laboratory analysis (Hill Labs) for total arsenic, cadmium, chromium, copper, nickel, lead, and zinc, and oil and grease, suspended solids, pH, polycyclic aromatic hydrocarbons (PAH), and *E. coli*.

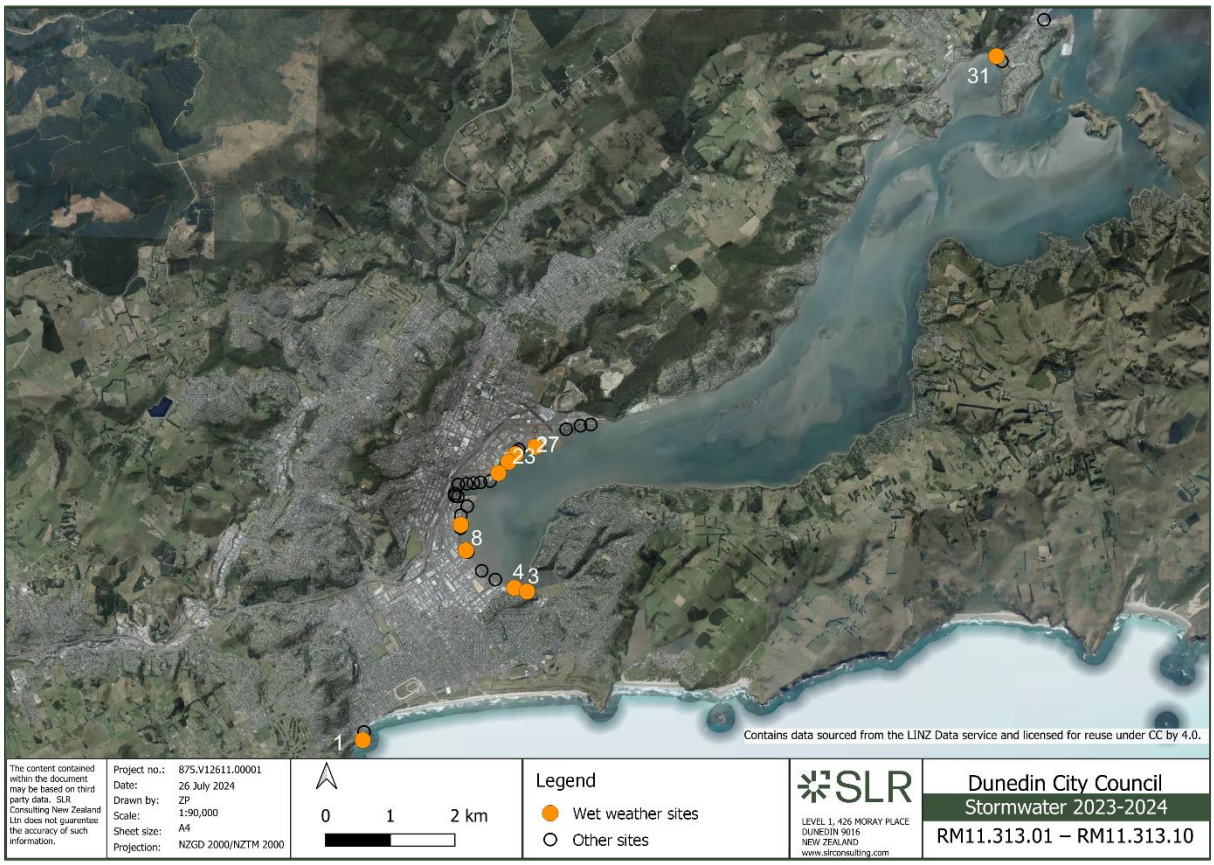

Figure 5: Dunedin stormwater outfalls - wet weather sampling sites (all sites).

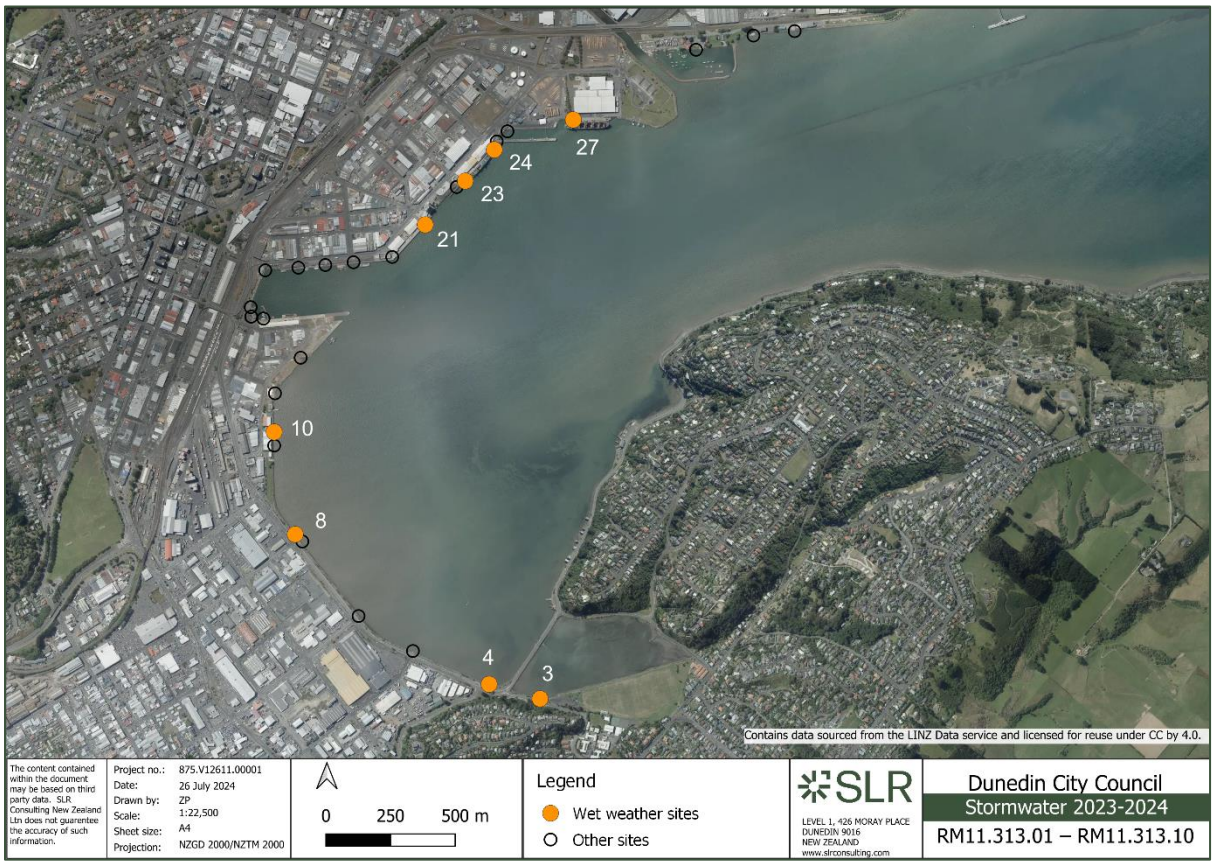

Figure 6: Dunedin stormwater outfalls - wet weather sampling sites (upper harbour sites).

3.3 Wet weather stormwater sampling – automated sampler

An ISCO automated sampler is a sampling device used to remotely collect water samples. The sampler is installed next to an opening into the stormwater network (e.g., manhole), and a tube installed from the sampler into the stormwater pipe. When the required conditions are met, the sampler is triggered to collect water samples with a pump used to extract water from the stormwater pipe and fill bottles within the sampling device. Samples from these bottles can then be analysed to provide a contaminant profile through time.

The sampler can only be installed within one stormwater catchment at a time, so it is used to target specific outfalls within certain stormwater catchments (South Dunedin, Halsey Street, Shore Street, Kitchener Street, and Mason Street catchments), as required by resource consents. Consent conditions require sampling of three storm events per year, with the sampler to be moved yearly such that each catchment is sampled once every five years. However, the sampler has typically remained at a site longer than one year due to the difficulty in capturing three suitable events (that meet all required conditions) within this period.

Installation at the Halsey Street catchment, approximately 75 m up-pipe of a Halsey Steet stormwater outfall (Figure 7), was completed in early December 2021.

The sampler is programmed to collect 1 L water samples every five minutes over the first two-hour period of a rain event (more than 2.5 mm of rain), to provide a contaminant profile across the rain event including the first flush of stormwater. Consent conditions for sample

analysis require an antecedent dry period of at least 72 hours of no rainfall in the catchment and no mixing with seawater (i.e., low tide).

When the automated sampler is triggered under suitable conditions, water samples are collected within the sampler's 24 internal 1 L bottles. These bottles need to be emptied within four hours of collection, to ensure the integrity of the samples. Due to the volume of water required for laboratory analysis, samples from two bottles are combined to make one 10-minute sample (12 samples in total over the two-hour rain event), and these samples are transferred into laboratory-provided containers. Following removal of the samples, the internal 1 L bottles are thoroughly rinsed with distilled water and replaced within the sampler, which is reset to prepare for further sampling. Samples are transferred to the laboratory (Hill Labs or Eurofins) and analysed for total arsenic, cadmium, chromium, copper, nickel, lead, and zinc, and oil and grease, suspended solids, pH, PAH, and *E. coli*. In addition, FWAs are measured using an AquaFluor handheld fluorometer.

The sampler sometimes triggers when not all the required conditions have been met, which results in 'false alarms'. False alarms can occur when the sampler triggers at the time of a higher tide that could result in potential saltwater intrusion into the collected samples, or when the rain event does not continue with sufficient rainfall and the sample bottles do not get filled sufficiently. Other causes for false alarms include malfunctions or maintenance issues with the sampler (e.g., perforated tubing within the sampler, flat battery, errors with communication between sampler and rain gauge). Following false alarms, the sampler is checked, bottles emptied (if required) and rinsed with distilled water, and the sampler reset.

Figure 7: The location of the ISCO automated sampler since December 2021, sampling the Halsey Street catchment.

3.4 Harbour water sampling – dry and wet weather

Monitoring of harbour water quality is undertaken during both dry weather and wet weather (i.e., a rain event). Dry weather sampling allows the determination of background contaminant levels in harbour water, while wet weather sampling assesses the contribution of contaminants from high volume stormwater inputs. Ebb tides (outgoing tides) are likely to move stormwater contaminants down harbour while flood tides (incoming tides) may lead to higher concentrations of stormwater contaminants in the upper harbour. However, inputs from the Water of Leith can complicate contaminant levels, especially during flood tides. The upper harbour basin requires 4–6 tidal cycles to flush completely (Smith and Croot 1993, 1994) and therefore contaminants within the upper harbour basin may gradually increase in concentration throughout prolonged wet spells.

Harbour water sampling is required at six sites in the upper harbour (Figure 8) for one dry weather period and for one rainfall event each year. Dry sampling follows high tide and occurs three hours apart on the mid ebb tide and then mid flood tide during a period when there has been no measurable rainfall for at least 72 hours prior to sampling. Wet sampling occurs at the same state of tides as the dry round, no less than three hours after the commencement of a rain event that is likely to produce at least 2 mm of rainfall and that has had an antecedent dry period of at least 72 hours.

When conditions are suitable, grab samples of water are collected from approximately 20 cm below the water surface, in laboratory-provided containers for laboratory analysis (Eurofins) for total cadmium, copper, lead, and zinc and enterococci.

Results for heavy metals are assessed against 2013 trigger levels specified in the consents, which originate from ANZECC (2000) 95% protection trigger values for ‘slightly to moderately disturbed’ ecosystems, with 95% signifying the percentage of species expected to be protected. For marine systems, this ecosystem condition would typically have largely intact habitats and associated biological communities. Examples are marine ecosystems lying immediately adjacent to metropolitan areas, such as Otago Harbour. Trigger values are concentrations that, if exceeded, could indicate a potential environmental problem, and so ‘trigger’ a management response.

Enterococci is a type of bacteria commonly found in the gut of humans and other warm-blooded animals and is used as an indicator of faecal contamination in marine water. Enterococci have been identified as having the best relationship with health effects in marine waters (MfE 2003). The indicator bacteria themselves do not necessarily pose a significant risk to human health; instead they indicate the presence of faecal material, which contains disease-causing pathogens. Potential sources of enterococci bacteria in Otago Harbour include sewage and faecal deposition by animals (e.g., birds, rodents, domestic pets, livestock). Results for enterococci are compared against MfE (2003) bacteriological ‘trigger’ values for bathing. In the consent, the trigger value has been set at the ‘amber/alert’ mode, where if a single sample has greater than 140 cfu/100 mL, a management response is triggered, which includes increased monitoring, investigation of source and risk assessment. Although the upper harbour basin is popular with wind surfers, paddle boarders, and other boat users when conditions permit, it is not a recognised swimming area. Consequently, the alert (amber) limit could be considered conservative and potentially not appropriate for much of the time.

Re-sampling of harbour water is required if trigger levels are exceeded, with re-sampling to be undertaken when the conditions are next suitable.

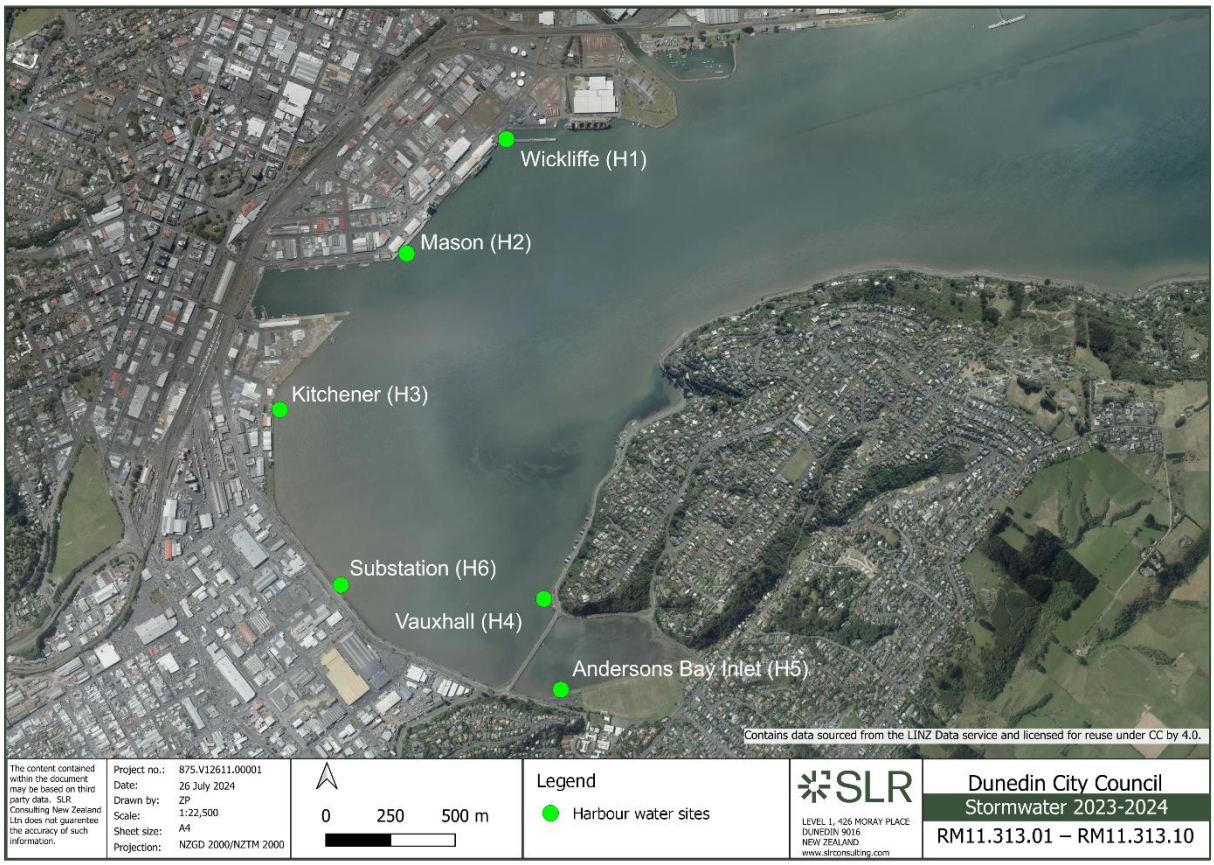

Figure 8: Otago Harbour water quality sampling sites.

3.5 Harbour sediment sampling

Monitoring of harbour sediment quality is undertaken as sediments are a potential source and sink for dissolved contaminants. Assessing sediment quality can identify where contaminant concentrations could result in adverse effects on ecological communities. Harbour sediment sampling is required once annually at four sites in the upper harbour (Figure 9).

Samples are collected from the uppermost 20 mm of sediment from the area within approximately 20 m from the nearest stormwater outfall. At the Orari Street, Shore Street, and Kitchener Street sites, samples are collected by scooping the top 20 mm of the harbour bed sediment and transferring the sediments into laboratory-provided containers. At the Halsey Street site, sampling is required in deep water (approximately 3-7 m deep). Sediment at Halsey Street is therefore collected using a petit ponar grab, with a subsample obtained from the uppermost 20 mm of the contents of the grab and transferred into laboratory-provided containers. Samples are collected for laboratory analysis (Hill Labs) for total arsenic, cadmium, chromium, copper, nickel, mercury, lead, and zinc, and weak-acid extractable (WAE) copper, total petroleum hydrocarbons (TPH), organochlorine pesticides (OCP), and PAH.

Concentrations of contaminants in each sediment sample are assessed against 2013 trigger levels specified in the consents. Total arsenic, cadmium, copper, lead and zinc, and PAH trigger levels were determined from the 80th percentile of samples collected to that date. Total chromium and nickel trigger levels originate from ANZECC (2000) interim sediment

quality guidelines (ISQG). Trigger values for TPH, OCP and WAE copper are yet to be determined, but TPH can be compared with 2018 sediment quality default guideline values (ANZG 2018). ANZECC (2000) ISQG-low values indicate concentrations at which there could be a possible biological effect and is intended as a trigger value for further investigation, whereas ISQG-high values indicate concentrations at which toxic-related adverse effects are expected.

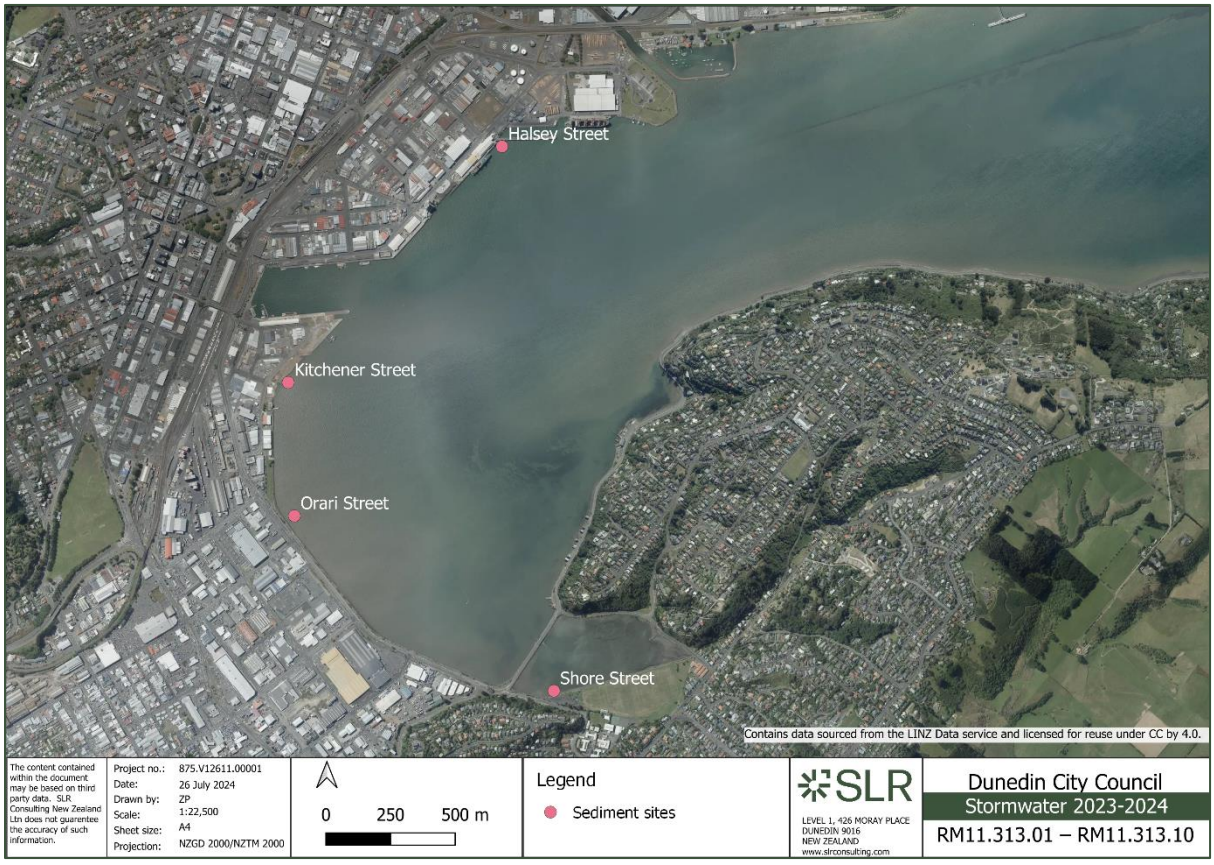

Figure 9: Otago Harbour sediment sampling sites.

3.6 Sampling overview

Table 1 provides an overview of the sampling requirements, parameters, and relevant guidelines, as specified by the consents.

Table 1: Dunedin stormwater sampling requirements.

Sampling type	Requirements	Locations	Parameters	Guidelines (from consents)
Dry weather sampling: outfalls	**Monthly/six-monthly:** Low tide 72 hours dry weather	33 outfalls	*E. coli*, FWA	**MfE (2003):** *E. coli*: 550 cfu/100 mL
Wet weather sampling: outfalls	**One rain event per year:** Low tide 72 hours dry weather >2.5 mm rain in first 2 hours	10 outfalls	Total arsenic, cadmium, chromium, copper, nickel, lead, zinc, oil and grease, suspended solids, pH, PAH, *E. coli*	–
Wet weather sampling: automated sampler	**Three rain events per year:** Low tide 72 hours dry weather >2.5 mm rain in first 2 hours	Currently at Halsey Street site	Total arsenic, cadmium, chromium, copper, nickel, lead, zinc, oil and grease, suspended solids, pH, PAH, *E. coli*	–
Harbour water	**One rain event and one dry weather period per year:** 72 hours dry weather Incoming and outgoing tide Rain event: >2 mm rain	6 sites	Total cadmium, copper, lead, zinc, enterococci	**2013 trigger levels (from ANZECC 2000):** Cadmium: 0.0055 g/m^3 Copper: 0.0013 g/m^3 Lead: 0.0044 g/m^3 Zinc: 0.015 g/m^3 **MfE (2003):** Enterococci: 140 cfu/100 mL
Harbour sediments	**Once per year (between January and June):** Low tide (required for access)	4 sites	Total arsenic, cadmium, chromium, copper, nickel, mercury, lead, zinc, WAE copper, TPH, OCP, PAH	**2013 trigger levels (from 80th percentile of previous samples):** Arsenic: 19 mg/kg Cadmium: 1.7 mg/kg Copper: 122 mg/kg Lead: 209 mg/kg Zinc: 902 mg/kg PAH: 183 mg/kg **ANZECC (2000) ISQG-Low:** Chromium: 80 mg/kg Mercury: 0.15 mg/kg Nickel: 21 mg/kg
Harbour biological	**Once every two years (between January and June):** Low tide (required for access)	5 sites	Infauna, epifauna, macroflora, cockles	–

4.0 Results and Discussion

4.1 Stormwater – Dry weather

Sampling results

Dry weather sampling of stormwater outfalls was undertaken under the required weather and tidal conditions during six of the twelve months between July 2023 and June 2024: July, September, November 2023, and January, February, and June 2024 (see Appendix B). Dry weather sampling could not be undertaken in other months due to weather not being suitable (e.g., no antecedent dry period of at least 72 hours) and/or tides not being suitable (e.g., low tide in the middle of the night, or low tides not suitable for accessing outfalls).

Most of the stormwater outfalls sampled had concentrations of *E. coli* that exceeded the consented trigger level (550 cfu/100 mL) on at least one occasion during the monitoring period (Table 2). Outfalls 4 (South Dunedin catchment), 9 (Portsmouth Drive catchment), 11 and 12 (Kitchener Street catchment), and 29 (Ravensbourne catchment) were the only outfalls sampled that did not exceed the trigger level. Of these outfalls, 9, 11, and 29 are only sampled on a six-monthly basis and outfall 11 was only sampled once (having no flow during February 2024 dry weather sampling). Outfall 2 is also sampled six-monthly, but there was no flow at this site on either six-monthly sampling occasion. Similarly, Outfalls 13-22 are to be sampled on a six-monthly basis, but there is no access to these outfalls. However, due to the small size of the receiving catchments for these outfalls, there is not expected to be any flow under dry conditions.

Due to the timing of the monthly sampling, with several months without suitable conditions for sampling, there were no three consecutive months of sampling over the twelve-month period. However, Outfalls 1 (St Clair catchment), 3 (Shore Street catchment), 8 (Orari Street catchment), 24 and 25 (Halsey Street catchment), 27 (Halsey Street catchment), and 33 (Port Chalmers catchment) all had *E. coli* concentrations that exceeded the trigger level over three consecutive sampling rounds (Table 2).

FWA concentrations were variable at the stormwater outfalls, with Outfalls 3 (Shore Street catchment), 5 and 6 (Portsmouth Drive catchment), 30 (Ravensbourne catchment), and 32 (Port Chalmers catchment) having elevated FWA concentrations on more than one occasion during the 2023-24 monitoring period. These elevated results did not consistently coincide with elevated *E. coli* concentrations, which indicates that possible cross-connections between stormwater and wastewater systems are unlikely.

Overall, over the 2023-24 monitoring period, dry weather sampling at stormwater outfalls revealed several outfalls with elevated *E. coli* concentrations on multiple occasions. According to the consent conditions, if the *E. coli* concentration in samples from three consecutive months is greater than the trigger level, the consent requires investigation and remedial action, if required.

Future

It is important to note that the *E. coli* trigger level for this dry weather sampling is based on MfE guidelines for recreation, with results above the trigger level indicating water is considered unsafe for swimming. The dry weather sampling is useful to assist with determining whether there are any cross-connections between stormwater and wastewater systems, however as recreation/bathing would not be undertaken within the stormwater pipes, it is arguable whether this sampling is useful for determining whether the water poses a health risk for bathing; harbour water quality sampling would be more useful for

determining any health risks for bathing associated with any dry-weather discharges from the stormwater outfalls.

It could be worthwhile to review the sampling regime for dry weather monitoring, to remove the sampling of some outfalls. These could be outfalls where there has consistently been no indicators of wastewater in previous sampling or those which frequently contain no flowing water (e.g., Outfalls 12, 26, 32), or are sampled six-monthly (due to previously been found to have no indicators of wastewater or be frequently dry) and are consistently dry during dry weather (e.g., Outfall 2, 9, 11, and outfalls 13-22 which are also inaccessible).

Table 2: *E. coli* dry weather sampling results between July 2023 and June 2024, compared with the *E. coli* trigger level of 550 cfu/100 mL (MfE (2003) action (red) limit). Grey cells: no sampling or no access or no flow. Green cells: results below trigger levels. Red cells: results above trigger levels.

Outfall	Location	Frequency	Jul 2023	Sep 2023	Nov 2023	Jan 2024	Feb 2024	Jun 2024
1	Second Beach	Monthly						
2	St Clair Beach	Six-monthly						
3	Shore Street	Monthly						
4	Portobello Road	Monthly						
5	Teviot Street	Monthly						
6	Midland Street	Monthly						
7	Orari Street	Monthly						
8	Orari Street	Monthly						
9	Kitchener Street	Six-monthly						
10	Kitchener Street	Monthly						
11	French Street	Six-monthly						
12	Kitchener Street	Monthly						
13-22	Birch, Wharf, Fryatt, Mason, Bauchop Streets	Six-monthly						
23	Bauchop Street	Monthly						
24	Halsey Street	Monthly						
25	Halsey Street	Monthly						
26	Halsey Street	Monthly						
27	Wickliffe Street	Monthly						
28	Magnet Street	Six-monthly						
29	Magnet Street	Six-monthly						
30	Ravensbourne Road	Monthly						
31	George Street / SH88	Six-monthly						
32	Sawyers Bay, Watson Park	Monthly						
33	George Street (Port Otago)	Monthly						

4.2 Stormwater – Wet weather

Between July 2023 and June 2024 the conditions required to undertake wet weather sampling at stormwater outfalls (i.e., at low tide, within two hours of the commencement of a rain event (more than 2.5 mm of rain), and following an antecedent dry period of at least 72 hours of no rainfall in the catchment), were not met within daylight hours (required for safety reasons). There were therefore no suitable occasions for wet weather sampling to be completed in 2023 to 2024.

There have not been suitable conditions for sampling for several years, given the difficulty in having all conditions coinciding with daylight hours to allow safe sampling of the outfalls. There are also difficulties associated with predicting when heavy rain events will occur, based on weather forecasting as forecasts can be very changeable over short time frames (e.g., over a period of 1-2 hours); such changeable forecasts can lead to 'false starts' for sampling rain events, but can also lead to missed opportunities when rainfall is heavier than forecast but timing and/or tide restrictions do not allow for sampling to be undertaken. Given the difficulty in meeting the required conditions, consideration is given later in the monitoring period (e.g., between March and June) to reducing the length of the antecedent dry period in an effort to capture a rain event, however this is outside the consent requirements.

4.3 Automated sampler – Wet weather

Sampling results

The automated sampler was successfully triggered and captured a rain event in April 2024 at the Halsey Street site, where it has been located since December 2021. Despite sampling of wet weather events not being undertaken at outfalls between July 2023 and June 2024, the automated sampler can capture events at all times of the day and night and captured the event on 11 April 2024 (34.6 mm total rainfall) (Figures 10, 11 and 12). See Appendix C for a results table for this sampling event.

During the rain event, concentrations of oil and grease, cadmium, and PAH were all below laboratory detectable limits for the duration of the event (Appendix C). pH levels were relatively stable and between 6.5 and 7.3 during the rain event (Figure 10). Suspended solids concentration peaked at 141 g/m^3 50 minutes into the rain event.

Concentrations of faecal indicator bacteria, *E. coli*, had two peaks during the 11 April 2024 event (Figure 10). Concentrations were initially high at first (100,000 cfu/100 mL) then peaked again at 70-80 minutes (100,000 cfu/100 mL), before dropping to 10,000 cfu/100 mL.

The intensity, and amount, of rainfall during a rain event can influence the timing and extent of any peaks in contaminant concentrations – shorter, more intense rain events can have high peaks in concentrations, compared with longer and less intense rain events. As the automated sampler collects stormwater during the first two hours of a rain event, the difference in timing of peak concentrations can be influenced by the initial intensity of rainfall. For the 11 April 2024 event, approximately 9.3 mm of rain fell within the first two hours of the event (total rainfall during the event of 34.6 mm).

Variable results during rainfall events can be influenced by the introduction of contaminants (e.g., from runoff from roads and/or industrial yards) into the stormwater at different times during the rain event, which can be due to different rain intensity during the rain events and/or differing rain intensities in different areas of the stormwater catchment.

Concentrations of metals generally followed similar patterns to suspended solids, with peak concentrations at 50 minutes into the 11 April 2024 rain event (Figures 11 and 12). Zinc concentrations were the highest of the metals during the rain event, followed by chromium,

with much lower concentrations of copper, nickel, lead, and arsenic. Common sources of zinc include tyre wear and roofing materials, lead sources include paints and contaminated soil, and copper sources include dust from wear of vehicle brake linings, building/roofing materials and industrial activities. Many of these contaminants can accumulate on impervious surfaces, with the length of the antecedent dry period influencing the amount of build-up on surfaces and therefore influencing 'first flush' concentrations.

Comparison with previous events

To compare the 11 April 2024 rain event with previous wet weather sampling undertaken in the Halsey Street catchment, and prior to this in the Mason Street catchment, maximum contaminant concentrations from each event can be compared (Table 3). While the peak concentrations might not necessarily be at the same time during each event, comparison of the peak concentration is useful to determine how any 'pulse' of contaminants into the harbour during the peak of the rain events compares between events and catchments.

Overall, peak concentrations of several metals (e.g., copper, lead, zinc) and other contaminants (e.g., suspended solids, oil and grease) were lower during the April 2024 rain event than during other rain events captured at Halsey Street. However, concentrations of several metal contaminants (i.e., chromium, copper, lead, nickel, and zinc) and *E. coli* were generally higher in the Halsey Street catchment than in the Mason Street catchment samples. The composition of land uses in the different stormwater catchments would influence these results, as well as other influences such as the length of the antecedent dry period prior to each rain event and the intensity of rain during each event.

False alarms

Monitoring of the automated sampler includes monitoring for 'false alarms', which occur when the sampler is triggered when a rainfall event starts but the event ends up not being suitable for sampling as the required conditions have not all been met. This often occurs when rainfall intensity is high at the start of an event, but then rain stops after only a short period of time, and also when rainfall starts at high tide and thus the sampler would collect harbour water that had entered the stormwater pipes.

Between July 2023 and June 2024 there were 12 occasions when the sampler was incorrectly triggered.

Future

The ISCO automated sampler has been located within the Halsey Street catchment since early December 2021. Consent conditions require sampling of three rain events per year, with the sampler to be moved yearly such that each of the specified catchments is sampled once every five years. With the third rain event being captured in April 2024 at the Halsey Street site, the sampler can now be moved into another catchment area.

The specified catchments for the automated sampler are the South Dunedin (previous deployment 2014 to 2015), Shore Street (2015 to 2016), Kitchener Street (2016 to 2018), Mason Street (2018 to 2021), and Halsey Street (2021 to 2024) catchments. As the deployment at the Halsey Street catchment is complete, the automated sampler can be re-deployed, starting with the South Dunedin catchment (to retain the same order as previous deployments).

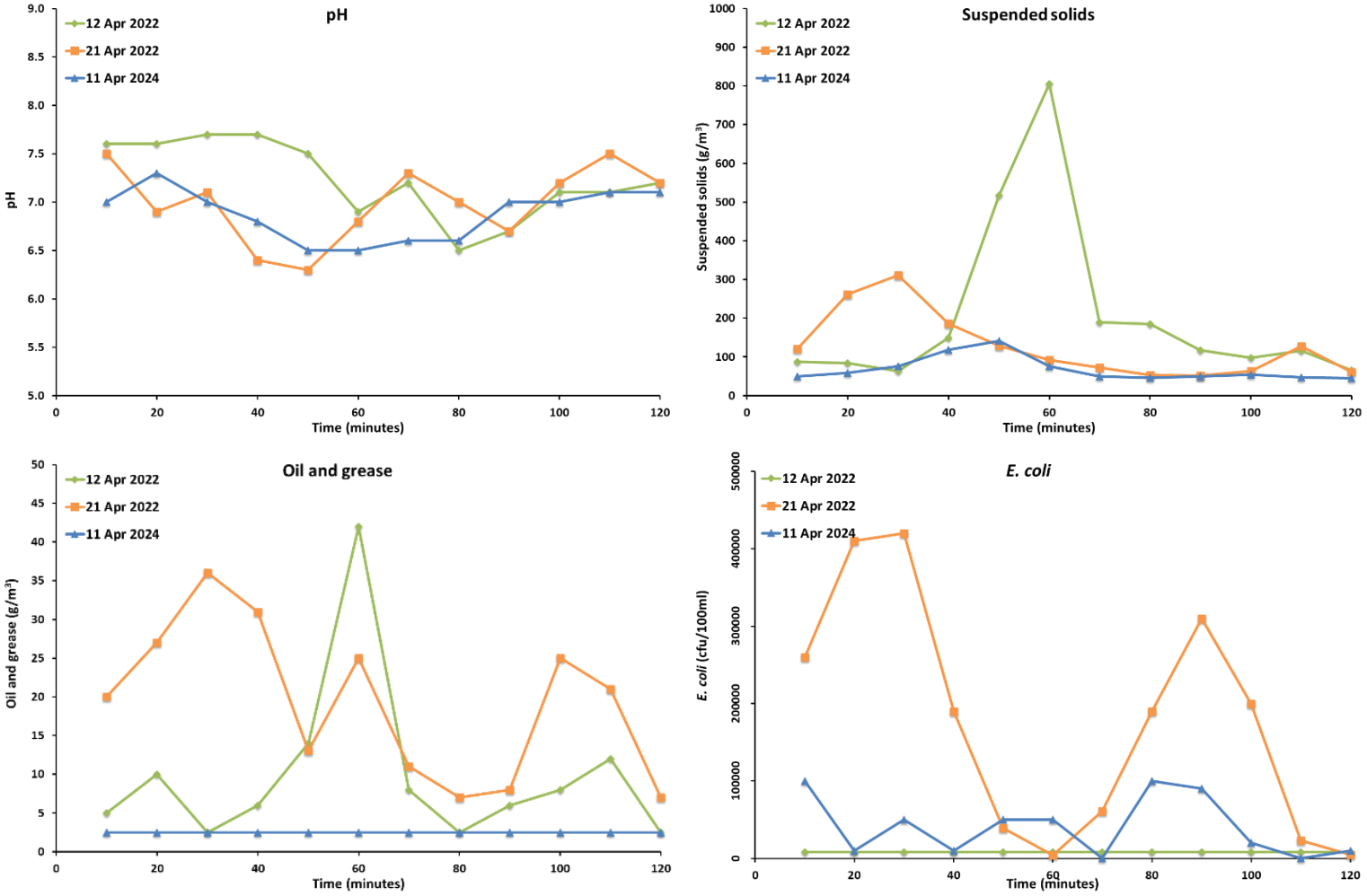

Figure 10: Contaminant concentrations during 11 April 2024 rainfall event captured by ISCO automated sampler, Halsey Street site.

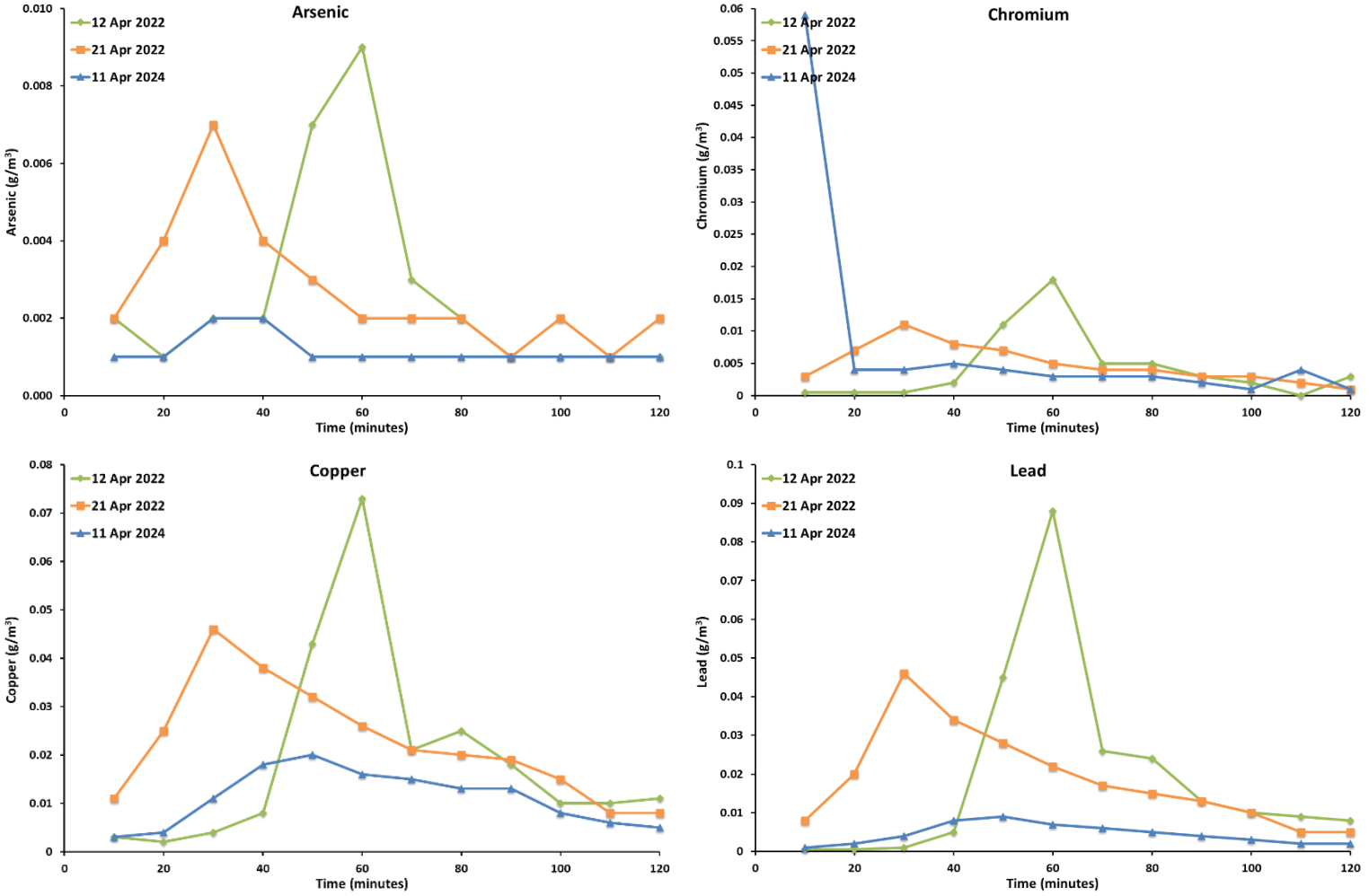

Figure 11: Contaminant concentrations during 11 April 2024 rainfall event captured by ISCO automated sampler, Halsey Street site.

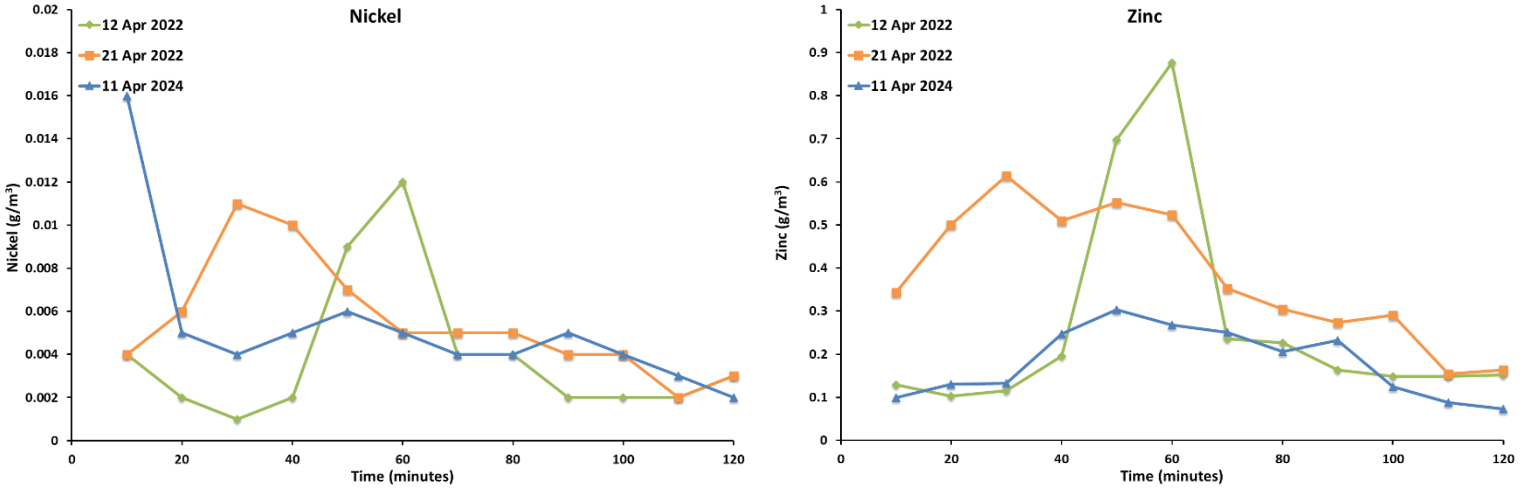

Figure 12: Contaminant concentrations during 11 April 2024 rainfall event captured by ISCO automated sampler, Hasley Street site.

Table 3: Maximum contaminant concentrations collected during rainfall events by the ISCO automated sampled in the Mason and Halsey Street stormwater catchment sites, 2019 to 2024. '< value' indicates all concentrations below laboratory detection limit. '> value' indicates concentrations above laboratory range test.

Rainfall event	pH	Total suspended solids (g/m^3)	Oil and grease (g/m^3)	Arsenic (g/m^3)	Cadmium (g/m^3)	Chromium (g/m^3)	Copper (g/m^3)	Lead (g/m^3)	Nickel (g/m^3)	Zinc (g/m^3)	*E. coli* (cfu/ 100mL)	PAH (mg/L)
Mason Street: 25 Feb 2019 5.2 mm rain	-	-	9	0.003	<0.001	0.003	<0.002	<0.001	0.006	0.031	420	<0.0051
Mason Street: 26 Mar 2019 6.4 mm rain	7.9	246	92	0.005	<0.001	0.006	0.003	<0.001	0.003	0.152	2,600	<0.0051
Mason Street: 10 Jun 2021 2.6 mm rain	7.5	83	156	<0.002	<0.001	0.006	0.028	0.02	0.007	0.370	16,200	<0.0051
Halsey Street: 12 Apr 2022 9.1 mm rain	7.7	805	42	0.009	<0.001	0.018	0.073	0.088	0.012	0.876	> 8000	<0.0051
Halsey Street: 21 Apr 2022 4 mm rain	7.5	311	36	0.007	<0.001	0.011	0.046	0.046	0.011	0.614	420,000	<0.0051
Halsey Street: 11 Apr 2024 34.6 mm rain	7.3	141	<5	0.002	<0.001	0.059	0.020	0.009	0.016	0.303	100,000	<0.0051

4.4 Harbour water

Sampling results – wet weather

Between July 2023 and June 2024, the conditions required to undertake wet weather sampling of harbour water were not met within daylight hours (required for safety reasons).

Sampling results – dry weather

Dry weather sampling of harbour water was undertaken on 25 October 2023. On the mid-ebb tide, cadmium and lead concentrations at all six sites were lower than laboratory detection limits, while zinc and enterococci concentrations were generally low (Table 4). However, zinc concentrations exceeded trigger values at the Substation site and copper concentrations exceeded trigger values at all sites,.

On the mid-flood tide, cadmium concentrations were lower than laboratory detection limits at all six sites (Table 4). At the Andersons Bay Inlet site, concentrations of copper, lead, zinc, and enterococci exceeded trigger values, while at the Substation site, enterococci concentrations exceeded trigger values. Other contaminant concentrations were low or below laboratory detection limits.

As trigger levels were exceeded for copper, lead, zinc, and enterococci at different sites, re-sampling for these contaminants during similar weather and tide conditions was required. However, there were no suitable occasions when the required weather and tide conditions were met (particularly within the weeks immediately following the initial sampling event) to complete re-sampling. It should be noted, however, that monitoring of harbour water quality is continuing, with annual sampling to be completed during dry weather conditions.

Table 4: Harbour water sampling data from dry weather sampling on 25 October 2023. Green cells indicate values exceed trigger levels.

	Dry weather – sampling: 25 October 2023				
	Cadmium (g/m^3)	**Copper (g/m^3)**	**Lead (g/m^3)**	**Zinc (g/m^3)**	**Enterococci (cfu/100mL)**
Trigger levels	0.0055[1]	0.0013[1]	0.0044[1]	0.015[1]	140[2]
Mid-ebb tide					
Wickliffe (H1)	<0.001	0.006	<0.001	<0.005	80
Mason (H2)	<0.001	0.007	<0.001	0.009	10
Kitchener (H3)	<0.001	0.009	<0.001	0.009	<10
Substation (H6)	<0.001	0.012	<0.001	0.042	40
Vauxhall (H4)	<0.001	0.010	<0.001	<0.005	<10
Andersons Bay Inlet (H5)	<0.001	0.010	<0.001	< 0.005	20
Mid-flood tide					
Wickliffe (H1)	<0.001	<0.002	<0.001	0.005	<10
Mason (H2)	<0.001	<0.002	<0.001	0.008	<10
Kitchener (H3)	<0.001	<0.002	0.001	0.014	<10
Substation (H6)	<0.001	<0.002	<0.001	0.009	310
Vauxhall (H4)	<0.001	<0.002	<0.001	<0.005	<10
Andersons Bay Inlet (H5)	<0.001	0.006	0.010	0.045	160

1. ANZECC (2000) trigger values for protection of 95% of species (from resource consent).
2. MfE (2003) alert (amber) limit (from resource consent). The alert (or amber) mode is triggered when a single sample is greater than 140 enterococci per 100 mL for marine waters.

Dry weather and rain event comparison

Dry weather sampling results indicate background contaminant levels in harbour water without any influence from high volume stormwater inputs that occur during a rainfall event. Sampling in 2024 found copper, lead and zinc concentrations exceeded the consented trigger levels at only the Andersons Bay Inlet site during the mid-flood tide, which is when contaminants in harbour water would be moved into the upper harbour rather than out towards the harbour mouth. However, copper concentrations at all sites exceeded the consented trigger levels during the mid-ebb tide. Previous sampling of harbour water has found elevated copper concentrations at most sites during dry weather sampling, with elevated zinc and lead concentrations more variable by site and year. Common sources of copper include dust from wear of vehicle brake linings that have accumulated on impervious surfaces, copper building materials such as roofs, spouting and cladding, and a range of agricultural and industrial activities. Common sources of zinc include tyre wear and zinc-coated roofing materials. Common sources of lead include lead-based paints, roofing materials, and vehicles.

Comparing contaminant concentrations during rain events and dry weather reveals the relative inputs of contaminants during the different weather types. Figures 13 to 16 display contaminant concentrations from sampling undertaken between 2017 and 2024, with results only shown where concentrations were above laboratory detection limits (e.g., copper only

shown for October 2023 mid-flood sampling for Andersons Bay Inlet site). The comparisons indicate that copper and lead concentrations are frequently higher during dry weather conditions than during rain events, with very few lead results from rain event sampling being above laboratory detection limits. There are no obvious patterns with zinc concentrations, with similarly high concentrations irrespective of weather conditions. Conversely, enterococci concentrations are higher during rain events, although there have been some high concentrations during dry conditions.

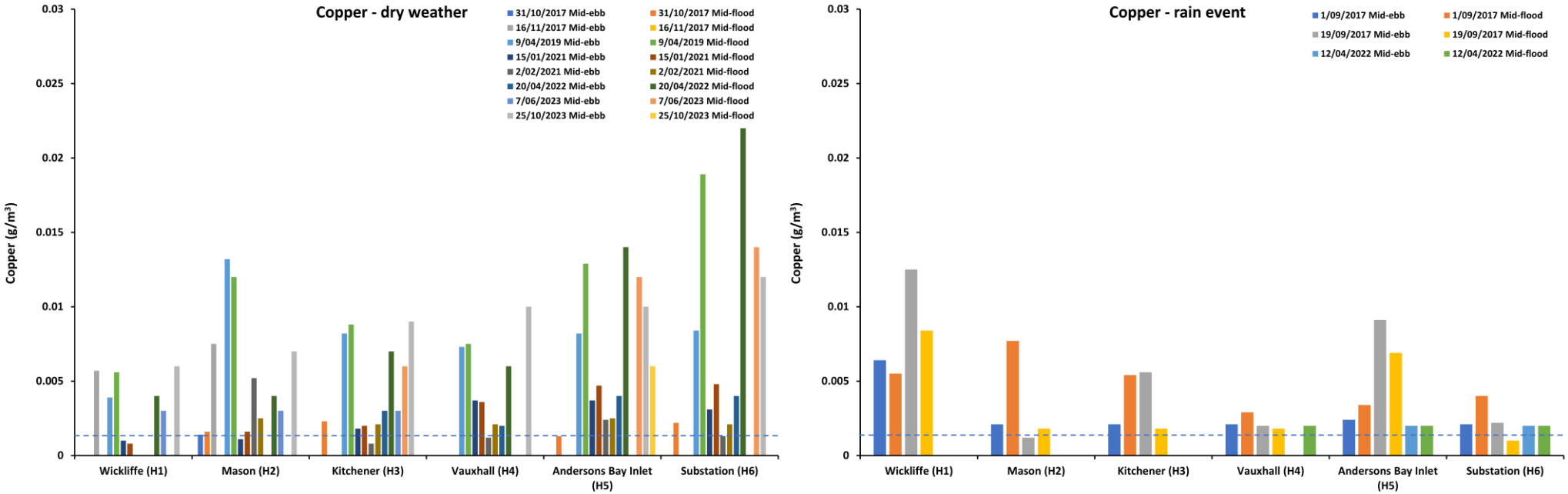

Figure 13: Copper concentrations in harbour water during dry weather (left) and rain events (right), 2017-2024. Dashed lines indicate consent trigger level.

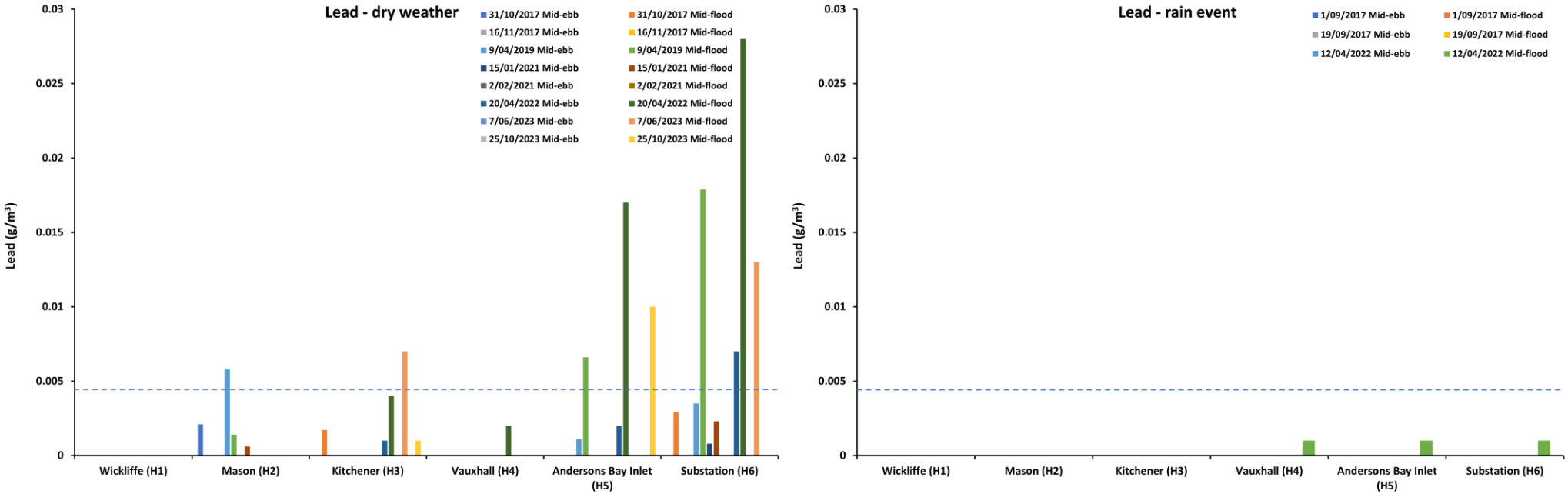

Figure 14: Lead concentrations in harbour water during dry weather (left) and rain events (right), 2017-2024. Dashed lines indicate consent trigger level.

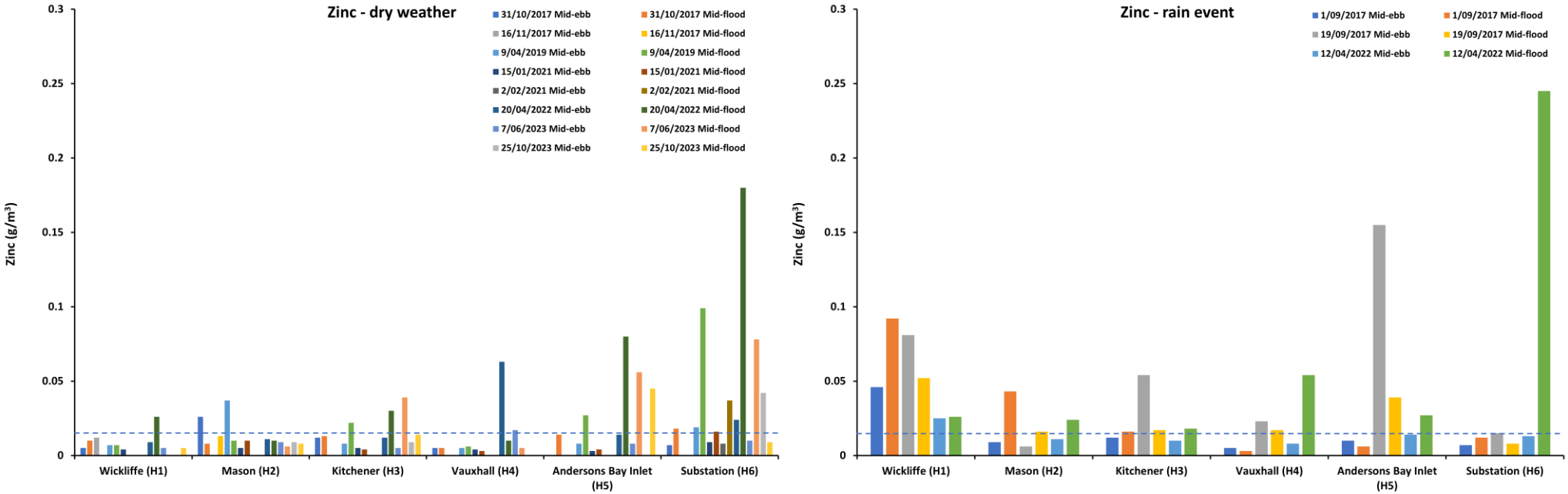

Figure 15: Zinc concentrations in harbour water during dry weather (left) and rain events (right), 2017-2024. Dashed lines indicate consent trigger level.

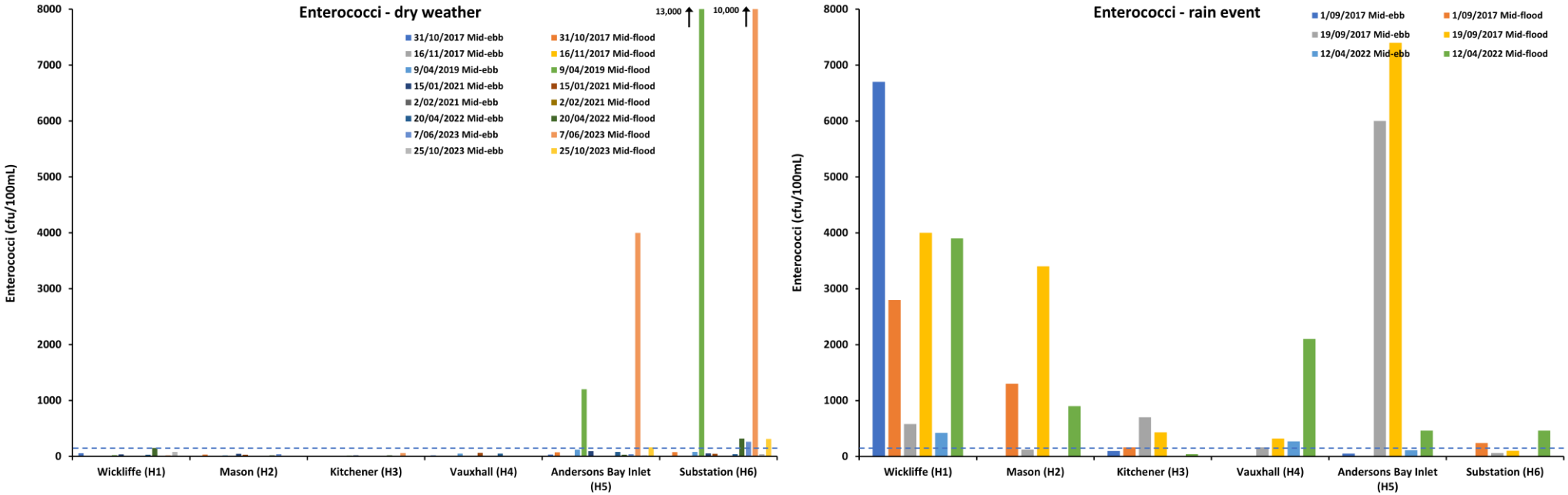

Figure 16: Enterococci concentrations in harbour water during dry weather (left) and rain events (right), 2017-2024. Dashed lines indicate consent trigger level.

4.5 Harbour sediment

Sampling of harbour sediment quality was undertaken at the four upper harbour sites on 30 May 2024. See Appendix D for tabulated results from this sampling.

Contaminant concentrations in harbour sediments at all sites were below the 2013 trigger levels listed in the resource consent (where applicable; Appendix D). The ANZECC (2000) ISQG-Low guidelines were exceeded for lead, mercury, zinc, and PAH (Kitchener and Orari Street), copper and nickel, (Kitchener Street), and PAH (Shore Street), but contaminant concentrations were well below the ISQG-High levels at all sites except for zinc at Kitchener Street. The ISQG-Low represents the threshold for potential effects to occur and is a trigger for further investigation, while the ISQG-High represents a point where a high probability of effects is possible. Several results were higher than those from recent years, particularly copper, lead, and zinc at Kitchener Street and lead and zinc concentrations at the Orari Street site.

ANZECC (2000) guidelines, specified in the consents, do not provide guideline values for WAE copper, OCP and TPH. However, 2018 sediment quality default guideline values (DGV) (ANZG 2018) are available for TPHs (DGV 280 mg/kg, DGV-high 550 mg/kg) and individual OCPs (DGV range from 900-4,500 mg/kg). TPH concentrations at the Kitchener and Orari Street sites were greater than laboratory detection limits, with the highest concentration (1,290 mg/kg) at the Kitchener Street site, and TPH at both sites were considerably higher than the ANZG (2018) DGV. TPH concentrations were considerably lower at the Halsey and Shore Street sites and were lower than laboratory detection limits. Total OCP concentrations were low at all sites (<0.2 mg/kg) and therefore considerably lower than the ANZG (2018) DGV.

Overall, sampling in 2024 found generally higher contaminant concentrations in sediments at the Kitchener and Orari Street sites and lower concentrations at Halsey and Shore Street sites than in recent years, with notable increases in concentrations of lead and TPH for the Kitchener and Orari Street sites, and copper and zinc for the Kitchener Street site. For many contaminants there were no obvious patterns in concentrations through time, however concentrations of copper, mercury, and zinc appear to be increasing through time at the Orari Street site (Figures 17, 18, and 19). Concentrations of several contaminants appear to be decreasing through time at the Shore Street site. The increase of copper, mercury, and zinc concentrations over time at Orari Street may warrant further investigation to determine their source, however variation between years is expected and monitoring in 2025 will be useful to determine if there are any consistent changes at sites that could be due to stormwater influence, or if high results in 2024 have been as a result of patches of sediment with concentrated contaminants rather than increasing concentrations at the site overall. The strict sampling criteria have resulted in no wet-weather sampling of stormwater outputs at outfalls, except for automated sampling at a Halsey Street outfall, making it difficult to determine whether such increases could have been influenced by pulses of contaminants in stormwater outputs to the harbour.

Contaminant concentrations in sediments in recent years have been considerably lower than at some historic sites. For instance, Kitchener Street's catchment has historically included a scrap metal yard and a sandblasting operation, with high metal contaminants, while other sites have historically been influenced by the old gas works, which contributed high PAH concentrations to stormwater. Improvements in wastewater/stormwater connections and the cessation of many industrial activities have reduced many sources of contaminant inputs to the harbour, however ongoing monitoring is required to ensure any longer term changes at a site can be detected.

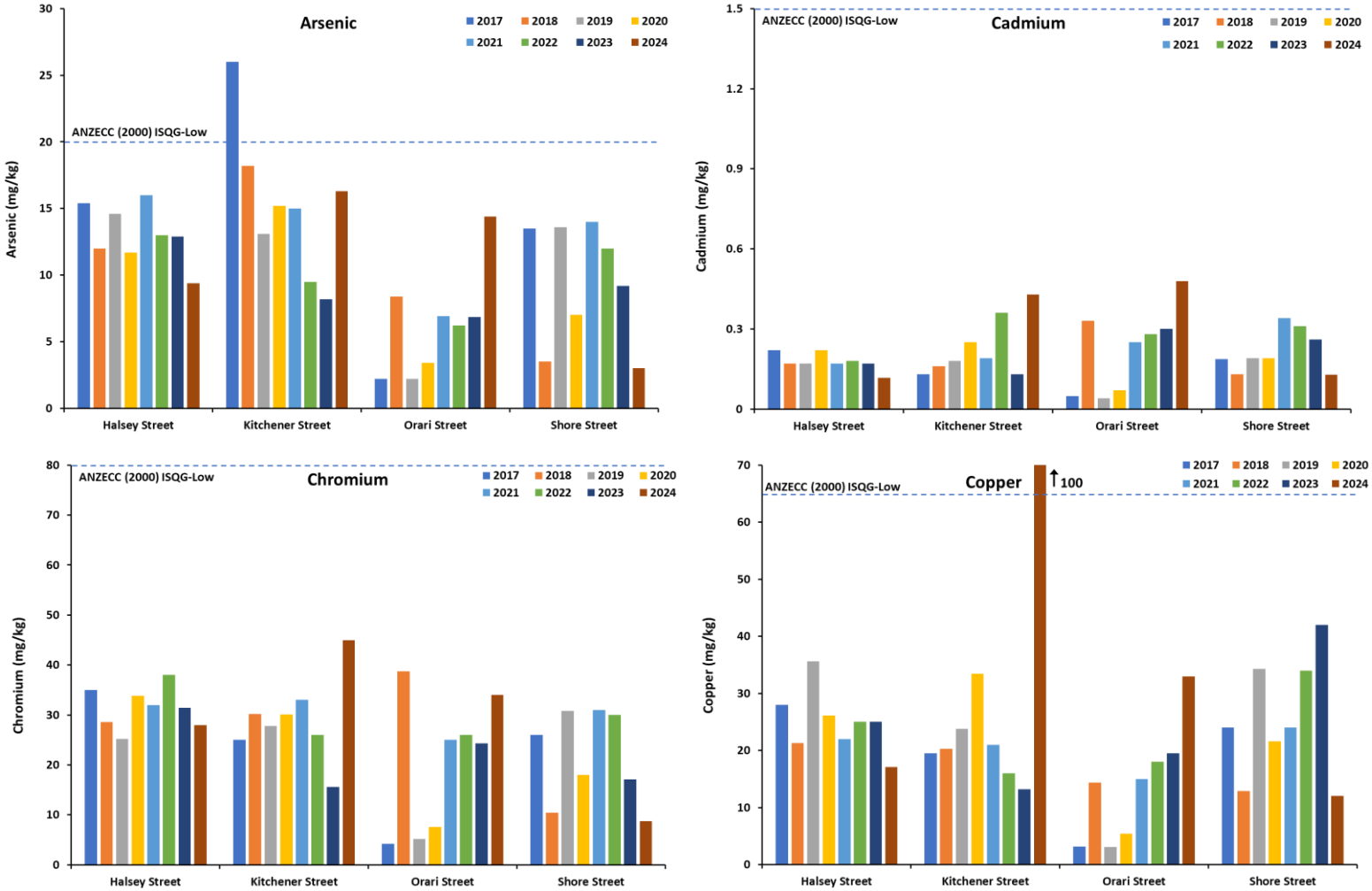

Figure 17: Contaminant concentrations in harbour sediments 2017 to 2024. Dashed lines indicate ANZECC (2000) ISQG levels.

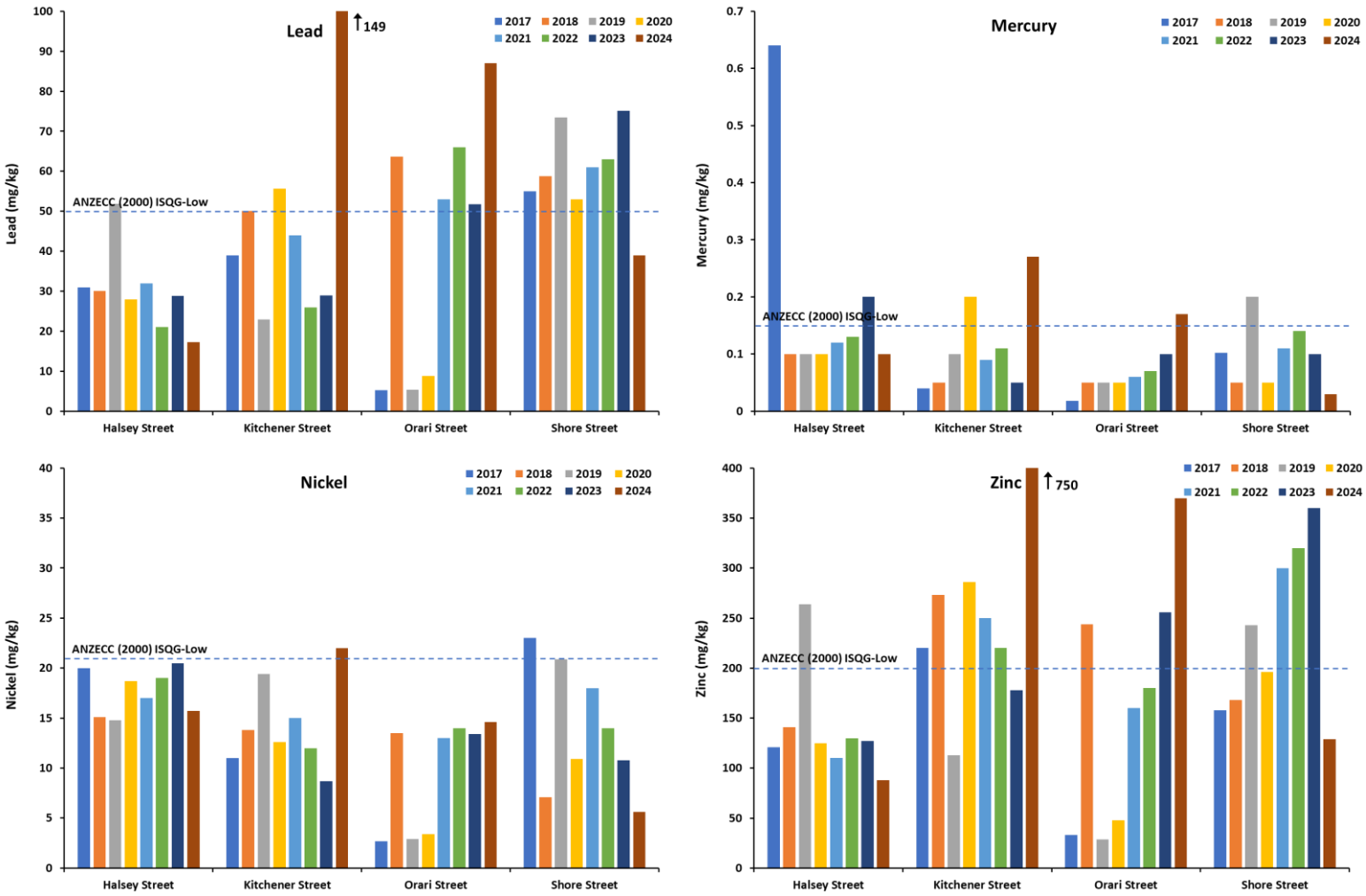

Figure 18: Contaminant concentrations in harbour sediments 2017 to 2024. Dashed lines indicate ANZECC (2000) ISQG levels.

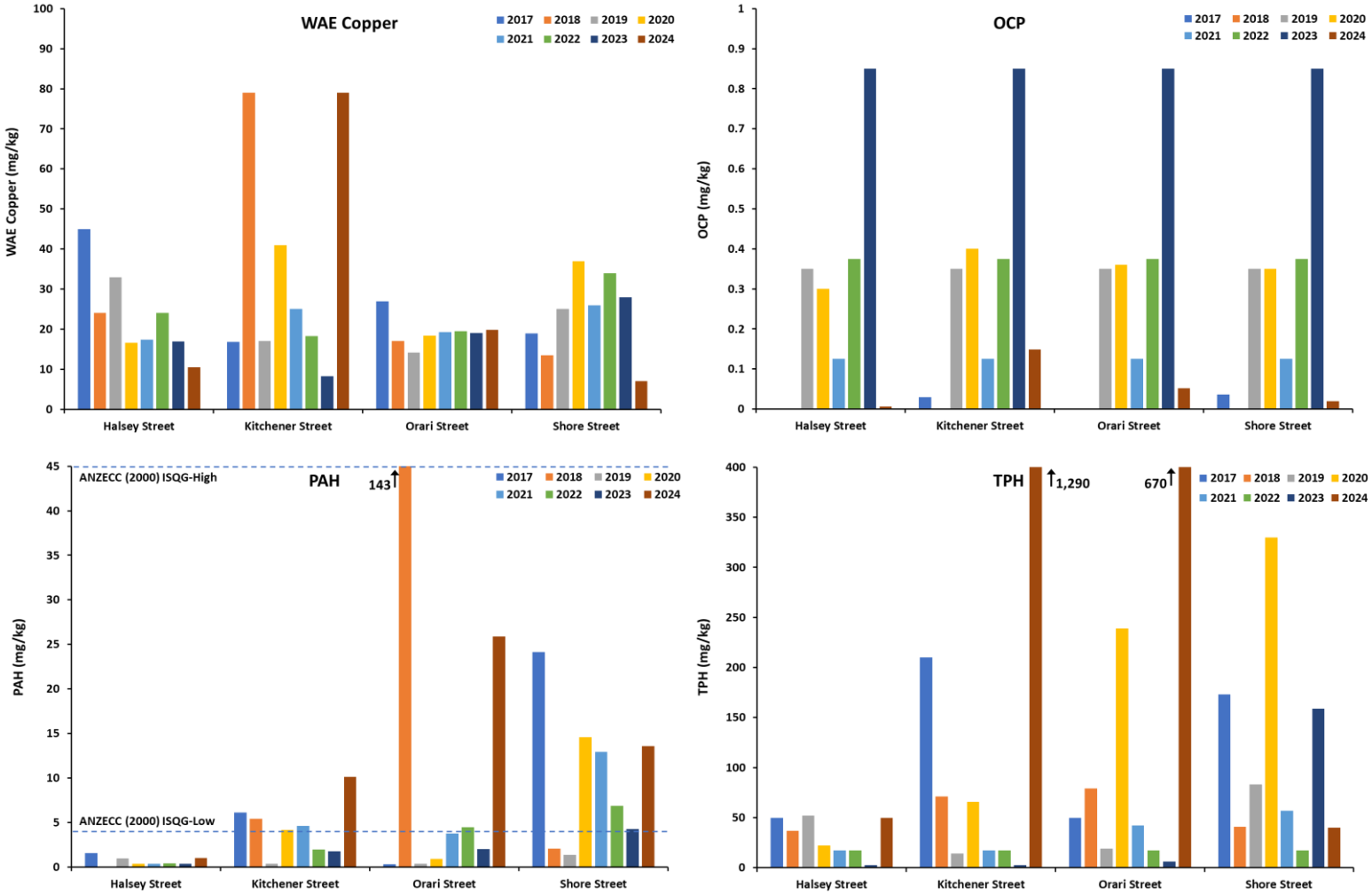

Figure 19: Contaminant concentrations in harbour sediments 2017 to 2024. Dashed lines indicate ANZECC (2000) ISQG levels.

5.0 Summary and Conclusion

Monitoring of Dunedin's stormwater discharges and receiving environments (Otago Harbour) was undertaken between July 2023 and June 2024, as required of DCC by ORC resource consents (RM11.313.01 - RM11.313.10). Sampling included stormwater quality during dry weather conditions, harbour water quality during dry weather conditions, and sampling of harbour sediments. Further sampling/re-sampling was restricted by weather/tidal conditions not being met.

Results from dry weather sampling of stormwater identified several stormwater outfalls with elevated faecal contaminant indicators, a result which has been found in previous years. Previous investigations for some catchments, following elevated results, identified cross-connections between stormwater and wastewater systems. As potential sources of *E. coli* in stormwater include sewage but also faecal deposition by animals (e.g., birds, rodents, domestic pets), such contamination is common with stormwater.

Sampling of stormwater at outfalls during a rainfall event was not undertaken between July 2023 and June 2024 as the required conditions were not met.

The automated sampler captured a rain event on 11 April 2024 in the Halsey Street catchment. Concentrations of heavy metals, total suspended solids, oil and grease, *E. coli,* and PAH were generally all lower than the previous two Hasley Street catchment automated sampler rain events (April 2022). This is the third event captured in the Halsey Street catchment, and the ISCO can therefore be moved to the next catchment required by consent. Based on the order of previous deployments, this is the South Dunedin catchment.

Harbour water quality sampling was only undertaken during dry weather in 2023 - 2024. Sampling revealed copper, lead, zinc, and enterococci concentrations exceeded consented trigger levels at a few sites during dry weather. Elevated concentrations of several contaminants have previously been found during dry weather conditions at multiple sites, indicating inputs are unlikely to be from single point sources. Contaminants can be sourced from vehicles/roading and also from building materials and industrial activities. Harbour water quality is influenced by stormwater inputs, but also other sources such as the Water of Leith. Comparison of sampling results from previous years indicates elevated copper and lead concentrations during dry weather rather than during rain events, and faecal indicator bacteria concentrations typically higher during rain events than during dry weather conditions. These results support the discussion above regarding potential sources of contaminants in the stormwater and into the harbour. It must also be recognised that sampling during rainfall events is undertaken during relatively high intensity rainfall, to capture the peak concentrations during the 'first flush'. However, there are many rain events where rainfall levels remain low (e.g., drizzle) that would also contribute contaminants to the harbour and therefore contribute to harbour water contaminant levels.

Sampling of contaminants in harbour sediments revealed similar concentrations at the Hasley and Shore Street sites while there were increased concentrations at Kitchener and Orari Street sites compared to those from recent years, with concentrations of copper, mercury, and zinc appear to be increasing through time at the Orari Street site, while concentrations of several contaminants appear to be decreasing through time at the Shore Street site. Concentrations in 2023 were all below 2013 trigger levels listed in the consents, however concentrations of copper, lead, mercury, nickel, zinc, and PAH at some sites were above the ANZECC (2000) ISQG-low levels which represent the threshold for potential effects to occur and is a trigger for further investigation. The Kitchener Street site had concentrations of zinc above the ISQG-high levels which represent a point where a high probability of effects is possible. Some sites have historically had high concentrations of some contaminants (e.g., PAHs at Portobello Road) however the cessation of some

industrial activities (e.g., gas works) have reduced many sources of contaminant inputs to the harbour. Contaminant concentrations are expected to be variable year to year as contaminated sediment is buried or disturbed, and further monitoring will help determine if Kitchener and Orari Street sites contaminant concentrations continue to increase.

Overall, stormwater monitoring between July 2023 and June 2024 has not resulted in clear patterns or trends of measured variables, with the exception of some contaminants in sediments (e.g., zinc) at Orari Street, which will be closely monitored to determine if further increases occur, or if recent high results are due to variability at the site.

6.0 References

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7.0 Closure

Sincerely,

SLR Consulting New Zealand

Zoe Psarouthakis
Ecologist – Ecology and Marine

Ben Ludgate
Principal Ecologist

8.0 Feedback

At SLR, we are committed to delivering professional quality service to our clients. We are constantly looking for ways to improve the quality of our deliverables and our service to our clients. Client feedback is a valuable tool in helping us prioritise services and resources according to our client needs.

To achieve this, your feedback on the team's performance, deliverables and service are valuable and SLR welcome all feedback via https://www.slrconsulting.com/en/feedback. We recognise the value of your time and we will make a $10 donation to our Charity Partner - Lifeline, for every completed form.

Appendix A Stormwater outfalls

Stormwater Discharges to the Coastal Marine Area: RM11.313.01 – RM11.313.10

July 2023 to June 2024 Monitoring

Dunedin City Council

SLR Project No.: 875.V12611.00001

26 July 2024

Table A-1: Dunedin stormwater outfall information.

Outfall	DCC reference	Resource consent	Location	Catchment	Frequency of dry weather sampling	Wet weather sampling?
1	SWX03979	RM11.313.10	Second Beach	St Clair	Monthly	Yes
2	SWX00011 & SWX00012	RM11.313.10	St Clair Beach	St Clair	Six-monthly	-
3	SWX04625	RM11.313.04	Shore Street	Shore Street	Monthly	Yes
4	SWX03649	RM11.313.09	Portobello Road	South Dunedin	Monthly	Yes
5	SWX03644	RM11.313.07	Teviot Street	Portsmouth Drive	Monthly	-
6	SWX03640	RM11.313.07	Midland Street	Portsmouth Drive	Monthly	-
7	SWX03631	RM11.313.07	Orari Street	Portsmouth Drive	Monthly	-
8	SWX03635 & SWX70740	RM11.313.08	Orari Street	Orari Street	Monthly	Yes
9	SWX03579	RM11.313.07	Kitchener Street	Portsmouth Drive	Six-monthly	-
10	SWX03568	RM11.313.06	Kitchener Street	Kitchener Street	Monthly	Yes
11	SWX70102	RM11.313.06	French Street	Kitchener Street	Six-monthly	-
12	SWX03547	RM11.313.06	Kitchener Street	Kitchener Street	Monthly	-
13	SWX03562	RM11.313.06	Birch Street	Kitchener Street	Six-monthly	-
14	SWX03556	RM11.313.06	Birch Street	Kitchener Street	Six-monthly	-
15	SWX03559	RM11.313.06	Wharf Street	Kitchener Street	Six-monthly	-
16	SWZ70569	RM11.313.06	Fryatt Street	Kitchener Street	Six-monthly	-
17	SWX03540	RM11.313.06	Fryatt Street	Kitchener Street	Six-monthly	-
18	SWX03536	RM11.313.06	Fryatt Street	Kitchener Street	Six-monthly	-
19	SWX03532	RM11.313.06	Fryatt Street	Kitchener Street	Six-monthly	-
20	SWX70370	RM11.313.06	Fryatt Street	Kitchener Street	Six-monthly	-
21	SWX03489	RM11.313.05	Mason Street	Mason Street	Six-monthly	Yes
22	SWX03506	RM11.313.03	Bauchop Street	Halsey Street	Six-monthly	-
23	SWX03466	RM11.313.03	Bauchop Street	Halsey Street	Monthly	Yes
24	SWX03455	RM11.313.03	Halsey Street	Halsey Street	Monthly	Yes

Outfall	DCC reference	Resource consent	Location	Catchment	Frequency of dry weather sampling	Wet weather sampling?
25	SWX03450	RM11.313.03	Halsey Street	Halsey Street	Monthly	-
26	SWX03472	RM11.313.03	Halsey Street	Halsey Street	Monthly	-
27	SWX03718	RM11.313.03	Wickliffe Street	Halsey Street	Monthly	Yes
28	SWX02628	RM11.313.02	Magnet Street	Ravensbourne	Six-monthly	-
29	SWX02623	RM11.313.02	Magnet Street	Ravensbourne	Six-monthly	-
30	SPN02502	RM11.313.02	Ravensbourne Road	Ravensbourne	Monthly	-
31	SWX12941	RM11.313.01	George Street / SH88	Port Chalmers	Six-monthly	Yes
32	SWX12994	RM11.313.01	Sawyers Bay, Watson Park	Port Chalmers	Monthly	-
33	SWX12879	RM11.313.01	George Street (Port Otago)	Port Chalmers	Monthly	-

Appendix B Stormwater – dry weather sampling results, 2023-2024

Stormwater Discharges to the Coastal Marine Area: RM11.313.01 – RM11.313.10

July 2023 to June 2024 Monitoring

Dunedin City Council

SLR Project No.: 875.V12611.00001

26 July 2024

Table B-1: Contaminant concentrations (FWA, *E. coli*) in water from dry weather sampling between July 2023 and June 2024. Outfalls marked with grey cells are sampled six-monthly. Blue cells indicate values exceed trigger levels. FWA level 0.1 ppb is suggestive of human faecal pollution (Gilpin and Devane 2003). *E. coli* trigger level of 550 cfu/100 mL (MfE (2003) action (red) limit). NF = no flow; No access – no available access to stormwater.

	7 July 2023		1 September 2023		2 November 2023		10 January 2024		14 February 2024		7 June 2024	
Outfall	**FWA**	***E. coli* (cfu/100mL)**	**FWA**	***E. coli* (cfu/100mL)**	**FWA**	***E. coli* (cfu/100mL)**	**FWA**	***E. coli* (cfu/100mL)**	**FWA**	***E. coli* (cfu/100mL)**	**FWA**	***E. coli* (cfu/100mL)**
1	0.069	3,900	0.062	1,000	0.062	4,800	0.071	2,100	0.049	10,000	0.038	10,000
2	NF								NF			
3	0.117	720	0.091	640	0.057	4,600	0.128	2,500	0.058	1,200	0.051	3,900
4	0.144	10	0.012	< 10	0.021	< 10	NF	NF	0.072	10	0.067	< 10
5	0.107	20	0.121	490	0.102	< 10	0.14	40,000	0.109	110	0.138	130,000
6	0.119	1,400	0.073	280	0.1	110	0.179	10,000	0.067	230	0.105	280
7	0.059	1,200	0.039	530	0.018	< 10	0.107	30,000	0.065	340	0.066	30,000
8	0.091	2,000	0.073	1,600	0.048	740	0.055	< 10	0.03	130	0.05	1,800
9	0.039	<10							0.055	50		
10	0.054	640	0.036	1,400	0.03	80	No access (tide conditions)		0.033	1,500	0.021	240
11	0.076	20							NF			
12	0.025	<10	0.019	< 10	0.02	10	NF		NF		0.023	< 10
13-22	No Access											
23	0.042	50	0.031	120	0.024	80,000	0.047	5,500	No Traffic mgmt		0.03	110
24	0.029	360	0.019	7,000	0.025	20,000	0.039	20,000	No Traffic mgmt		0.019	3,400
25	0.031	550	0.029	7,300	0.037	30,000	0.034	70,000	No Traffic mgmt		0.03	10,000
26	NF		NF		NF		0.226	1,000	NF		0.036	< 10
27	0.056	6,100	0.032	500	0.082	> 800,000	0.113	180,000	0.034	30,000	0.038	1,400
28	0.076	<10							0.047	1,600		
29	0.09	<10							0.064	290		
30	0.126	<10	0.112	10	0.098	30	0.178	2,500	0.056	40	0.043	< 10
31	0.053	360							0.051	7,500		
32	0.146	10	0.116	< 10	0.133	< 10	0.216	670	NF	NF	NF	NF
33	0.092	90,000	0.084	70,000	0.065	760	0.099	30,000	No Traffic mgmt		0.086	290,000

Appendix C Automated sampler – wet weather sampling results, 2023-2024

Stormwater Discharges to the Coastal Marine Area: RM11.313.01 – RM11.313.10

July 2023 to June 2024 Monitoring

Dunedin City Council

SLR Project No.: 875.V12611.00001

26 July 2024

Table C-1: Contaminant concentrations in water from wet weather automatic sampling (ISCO) in the Halsey Street catchment, for a rain event on 11 April 2024. PAH = polycyclic aromatic hydrocarbons. '< value' indicates all concentrations below laboratory detection limits.

Time (minutes)	pH	Total suspended solids	Oil and grease	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	*E. coli*	PAH
		g/m³	g/m³	g/m³	g/m³	g/m³	g/m³	g/m³	g/m³	g/m³	cfu/100mL	mg/L
10	7.0	49	<5	<0.002	<0.001	0.059	0.003	0.001	0.016	0.099	100000	<0.0051
20	7.3	59	<5	<0.002	<0.001	0.004	0.004	0.002	0.005	0.130	10000	<0.0051
30	7.0	76	<5	0.002	<0.001	0.004	0.011	0.004	0.004	0.133	50000	<0.0051
40	6.8	118	<5	0.002	<0.001	0.005	0.018	0.008	0.005	0.247	10000	<0.0051
50	6.5	141	<5	<0.002	<0.001	0.004	0.020	0.009	0.006	0.303	50000	<0.0051
60	6.5	76	<5	<0.002	<0.001	0.003	0.016	0.007	0.005	0.268	50000	<0.0051
70	6.6	49	<5	<0.002	<0.001	0.003	0.015	0.006	0.004	0.250	100000	<0.0051
80	6.6	46	<5	<0.002	<0.001	0.003	0.013	0.005	0.004	0.206	100000	<0.0051
90	7.0	50	<5	<0.002	<0.001	0.002	0.013	0.004	0.005	0.232	90000	<0.0051
100	7.0	54	<5	<0.002	<0.001	0.001	0.008	0.003	0.004	0.125	20000	<0.0051
110	7.1	47	<5	<0.002	<0.001	0.004	0.006	0.002	0.003	0.088	10000	<0.0051
120	7.1	45	<5	<0.002	<0.001	0.001	0.005	0.002	0.002	0.073	10000	<0.0051

Appendix D Harbour sediment sampling results, 2023-2024

Stormwater Discharges to the Coastal Marine Area: RM11.313.01 – RM11.313.10

July 2023 to June 2024 Monitoring

Dunedin City Council

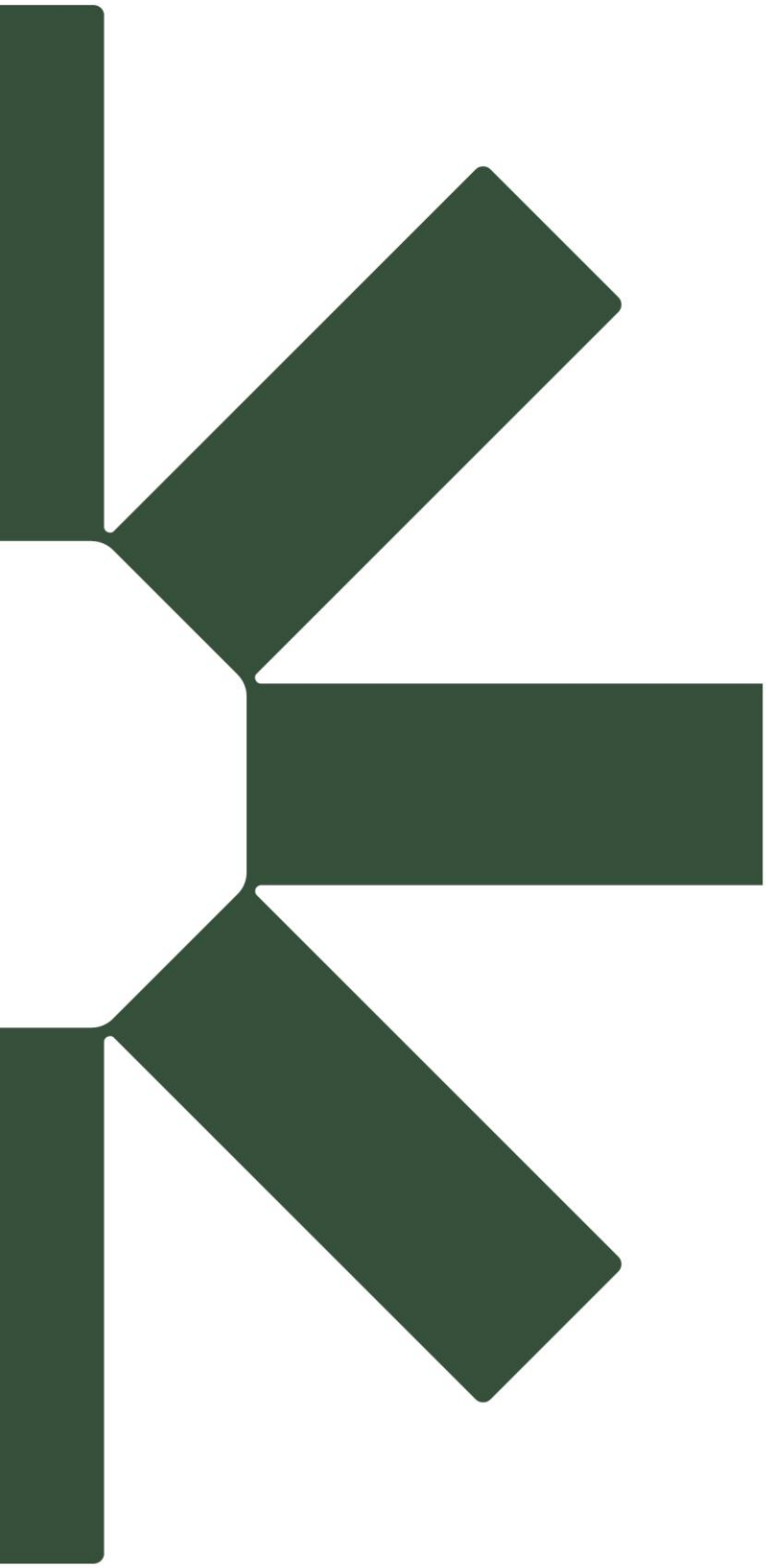
SLR Project No.: 875.V12611.00001

26 July 2024

Table D-1: Harbour sediment contaminant concentrations, 30 May 2024. Trigger and guideline values are specified in resource consents.

	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	WAE Copper[1] (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	PAH[2] (mg/kg)	TPH[3] (mg/kg)	OCP[4] (mg/kg)
2013 trigger levels	19	1.7	80	-	122	209	-	21	902	183	-	-
ANZECC (2000) ISQG-Low[5]	20	1.5	80	-	65	50	0.15	21	200	4	-	-
ANZECC (2000) ISQG-High[5]	70	10	370	-	270	220	1	52	410	45	-	-
Halsey Street	9.4	0.118	28	10.5	17.1	17.3	0.1	15.7	88	1.003-1.017	< 100	0.001-0.013
Kitchener Street	16.3	0.43	45	79	100	149	0.27	22	750	10.10	1290	0.144-0.153
Orari Street	14.4	0.48	34	19.8	33	87	0.17	14.6	370	25.90	670	0.047-0.056
Shore Street	3	0.129	8.7	7	12	39	0.03	5.6	129	13.59	< 80	0.015-0.025

1. WAE copper = Weak-acid extractable copper.
2. PAH = polycyclic aromatic hydrocarbons. Concentration ranges are between known concentrations and the maximum possible concentrations (as some samples below laboratory detection limits). '< value' indicates all concentrations below laboratory detection limits.
3. TPH = total petroleum hydrocarbons – maximum content.
4. OCP = organochlorine pesticides. Concentration ranges are between known concentrations and the maximum possible concentrations (as some samples below laboratory detection limits). '< value' indicates all concentrations below laboratory detection limits.
5. ANZECC (2000) interim sediment quality (ISQG) guideline values, as listed in the resource consent.



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