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

July 2024 to June 2025 Monitoring

Dunedin City Council

PO Box 5045, Dunedin 9058

Prepared by:

SLR Consulting New Zealand

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Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
1.0	31 July 2025	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 2024 and June 2025 included stormwater quality during dry weather conditions, harbour water quality during dry and wet weather conditions, sampling of harbour sediments, sampling using the wet weather automated sampler, and sampling of harbour biological communities. 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), 5 and 6 (Portsmouth Drive catchment), 10 (Kitchener Street catchment), and 24 (Halsey Street 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 2024 and June 2025 as the required conditions were not met.

Automated sampling was undertaken on three occasions in March, April, and May 2025 at the South Dunedin catchment site. Concentrations of several contaminants, including heavy metals and suspended solids, were generally similar across sampling occasions. Three rounds of sampling in this catchment have occurred and the automated sampler can therefore be moved to the next catchment, which is the Shore Street catchment (to retain the same order as previous deployments). Between July 2024 and June 2025 there were five occasions when the sampler was incorrectly triggered (‘false alarms’).

Harbour water quality sampling was undertaken during wet and dry weather conditions in 2024-2025. Wet weather sampling revealed copper, zinc, and enterococci concentrations exceeded consented trigger levels at sites for either the mid-ebb or flood tides, indicating elevated concentrations of these contaminants. Dry weather sampling revealed copper, zinc, and lead concentrations exceeded consented trigger levels at some sites for either the mid-ebb or flood tides, triggering a resampling event. The dry weather resampling event revealed all concentrations below laboratory detection limits or trigger levels, with the exception of copper at the Substation (H6) site during the mid-flood tide.

Harbour sediment sampling found contaminant concentrations were generally higher than in recent years at the Shore Street site, while concentrations at the Hasley, Kitchener, and Orari Street sites were generally lower than in recent years. Contaminant concentrations in 2025 were all at or 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.

Harbour biological communities were, in general, similar to those found in previous surveys, with relatively low diversity and high variability between sites. There were statistically significant differences in species abundance among sites. Chromium concentrations were high in cockle flesh at the Orari Street site, however metal concentrations in cockle flesh were below or within food safety guideline values at all sites.

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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 2024 and June 2025. This report summarises the results of that monitoring.

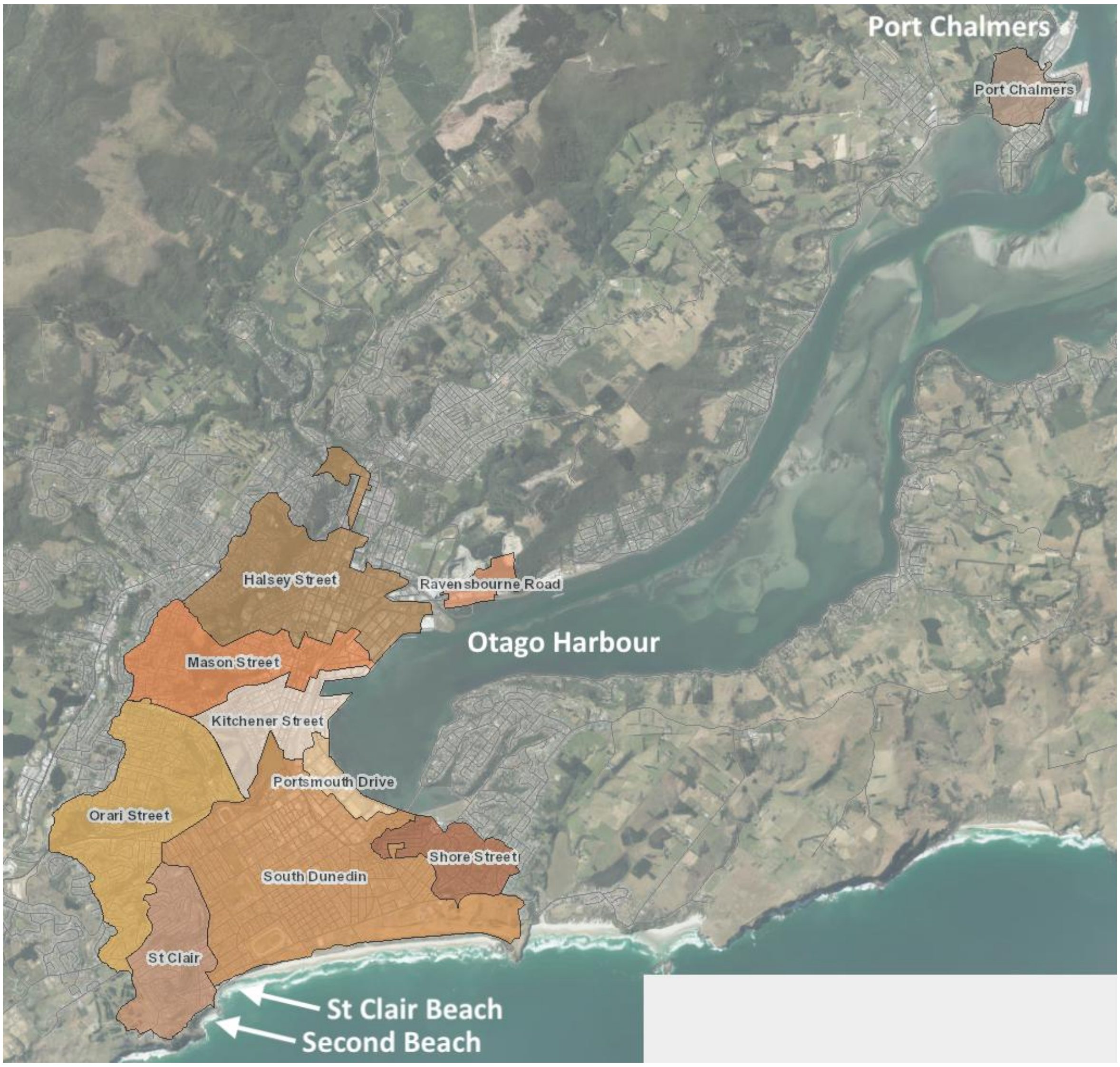


Figure 1: Dunedin 3 Waters catchment boundaries. Modified from DCC Webpage.

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.

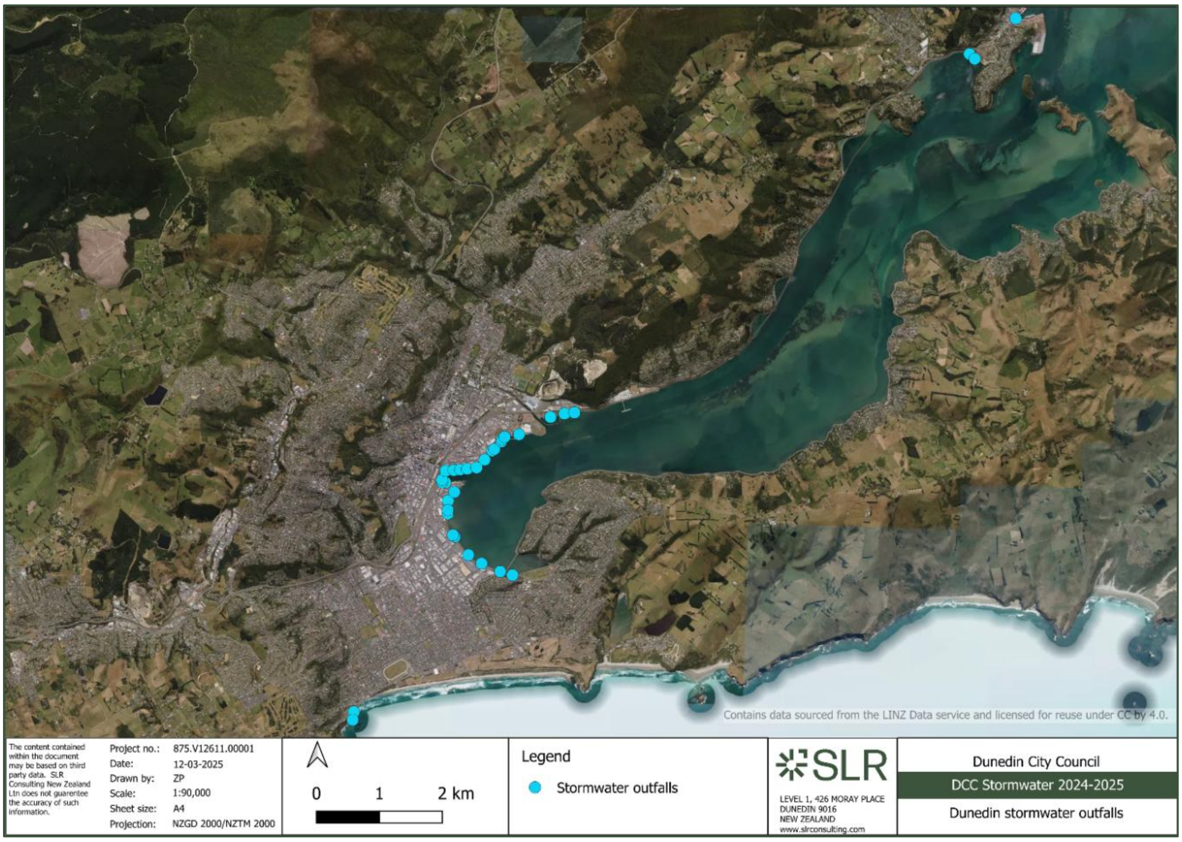


Figure 2: Dunedin stormwater outfalls.

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) (Figure 3 and Figure 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).

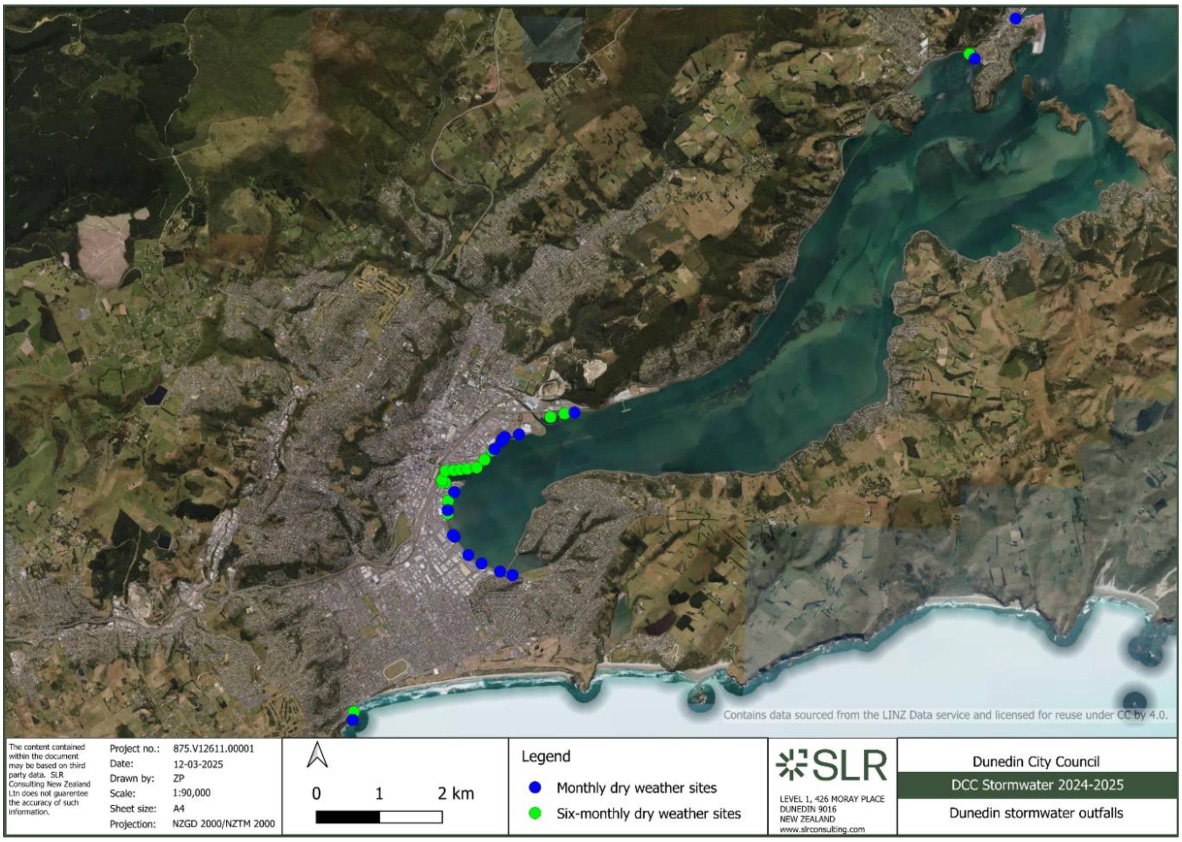


Figure 3: Dunedin stormwater outfalls - monthly and six-monthly dry weather sites (all sites).

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 (Figure 5 and Figure 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*.

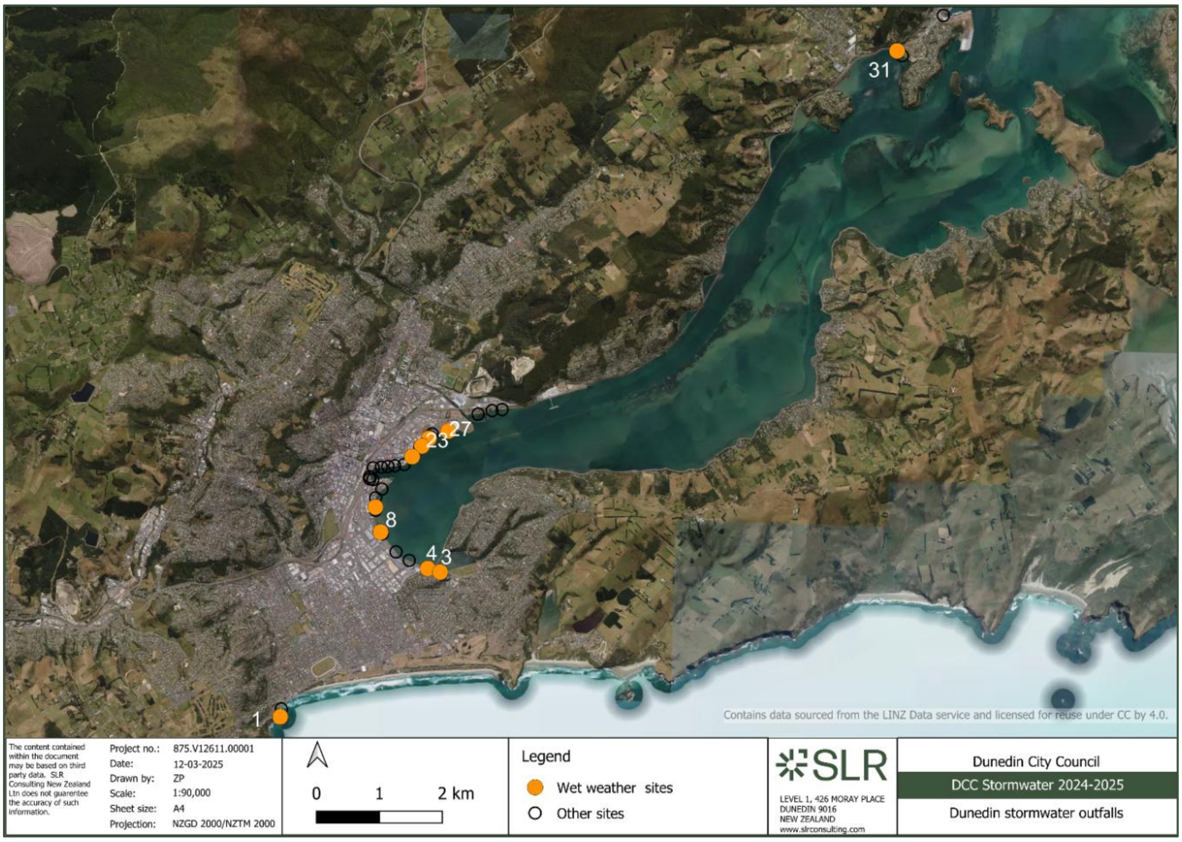


Figure 5: Dunedin stormwater outfalls - wet weather sampling sites (all sites).

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 South Dunedin catchment, at the Portobello Road stormwater pump station which is located approximately 480 m up-pipe of stormwater outfall 4 (Figure 7), was completed in December 2024.

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). The Portobello Road stormwater pump station has a check valve that prevents seawater from entering the pump station; monitoring of tidal conditions in Otago Harbour was therefore not required to determine if rainfall events were suitable for sampling.

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 when the rain event does not continue with sufficient rainfall and the sample bottles do not get filled sufficiently, or (at sites where tidal conditions are relevant) at the time of a higher tide that could result in potential saltwater intrusion into the collected samples. 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 2025, sampling the South Dunedin 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.

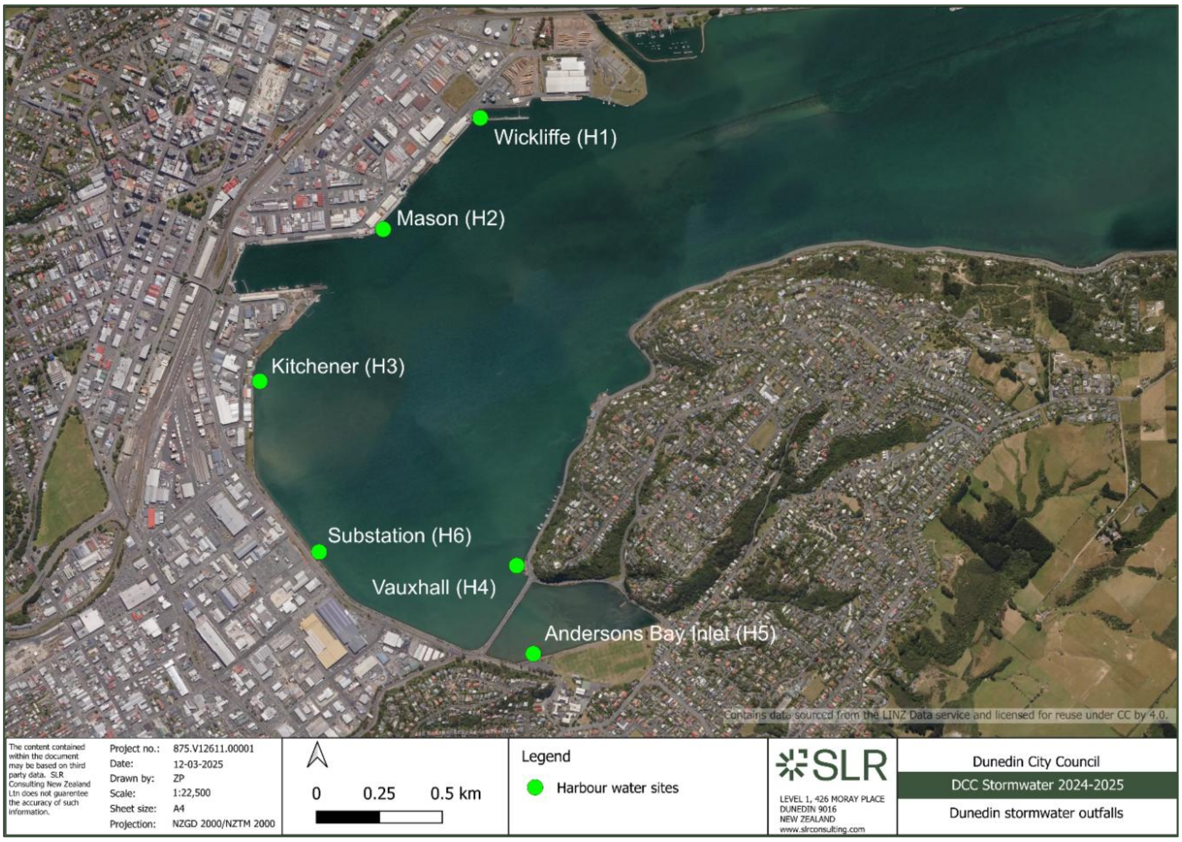


Figure 8: Otago Harbour water quality sampling sites.

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 Harbour Biological Sampling

Biological monitoring at selected Otago Harbour sites specified in the consents (Burkes, Kitchener Street, Orari Street, Portobello Road and Macandrew Bay; Figure 10) is required every two years. Kitchener Street, Orari Street and Portobello Road sites are located near stormwater outfalls and could potentially be affected by stormwater inputs and are therefore potential ‘Impact’ sites. Burkes and Macandrew Bay sites are considered ‘Control’ sites as they are not expected to be affected by stormwater inputs due to their distance from the outfalls.

Biological monitoring at each site includes the assessment of infauna, epifauna and macroflora at the waters edge, at low tide, in three areas (0-5 m from the stormwater outfall, 5-20 m from the outfall, and >50 m from the outfall) (Table 1). Due to the absence of stormwater outfalls at the Burkes and Macandrew Bay control sites, sampling is undertaken at three random areas along the waters edge at low tide.

Further, little-neck clams (*Austrovenus stutchburyi*, commonly referred to as cockles) are collected from the three potential ‘Impact’ sites (Table 1) for contaminant analysis.

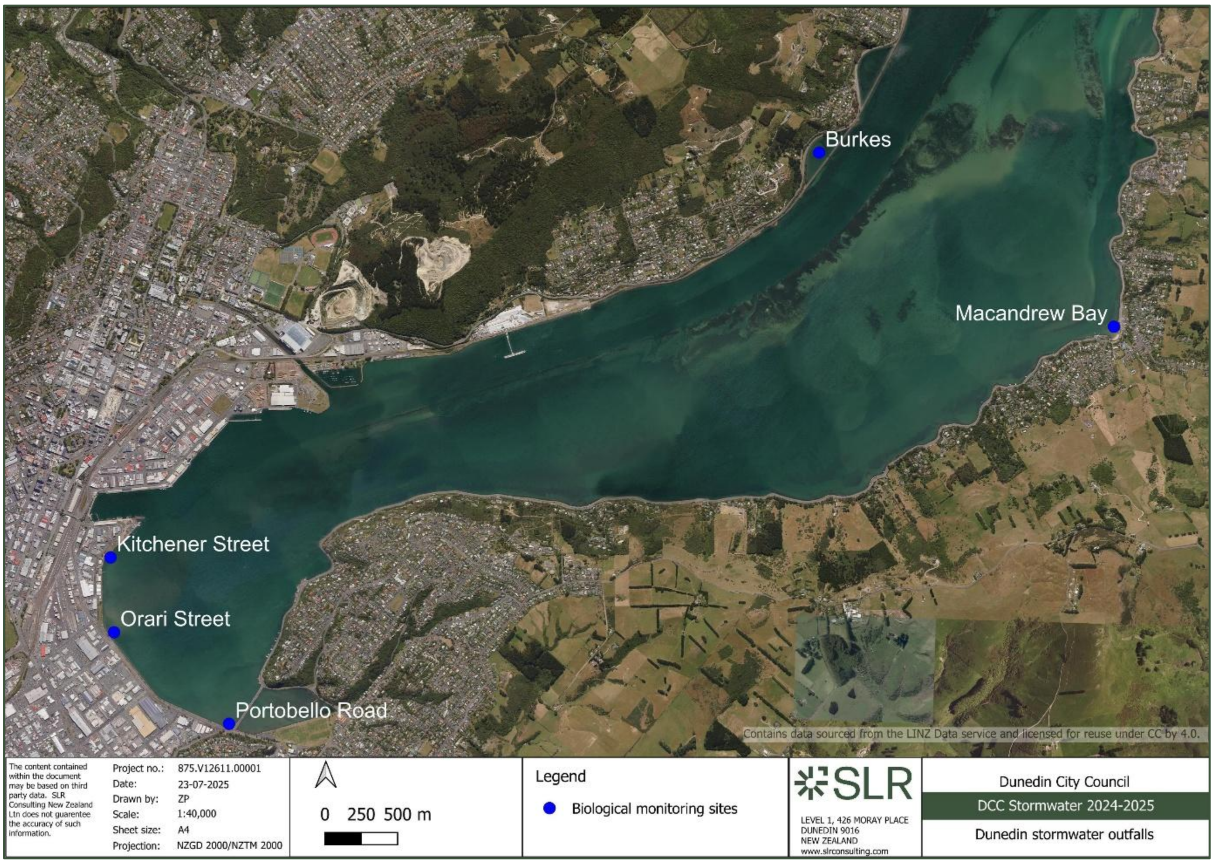


Figure 10: Otago Harbour biological sampling sites.

Table 1: Biological monitoring required at Otago Harbour sites.

Site	Status	Sample areas	Assessments required
Kitchener Street	Potential 'Impact'	0-5 m, 5-20 m, >50 m from outfall	Infauna, Epifauna, Macroflora, Cockles
Orari Street	Potential 'Impact'	0-5 m, 5-20 m, >50 m from outfall	Infauna, Epifauna, Macroflora, Cockles
Portobello Road	Potential 'Impact'	0-5 m, 5-20 m, >50 m from outfall	Infauna, Epifauna, Macroflora, Cockles
Burkes	'Control'	3 random areas (as no outfall)	Infauna, Epifauna, Macroflora
Macandrew Bay	'Control'	3 random areas (as no outfall)	Infauna, Epifauna, Macroflora

3.6.1 Epifauna

Benthic epifauna are recorded in five quadrats (0.25 m^2) randomly placed within each of the three sampling areas (e.g., 0-5 m from outfall). Species identification is completed to the lowest possible taxonomic level, with specimens collected when required. Epifauna species are recorded as individual counts, except for Serpulidae (sessile, tube-building annelids) at Portobello Road, Orari Street, and Kitchener Street, which are recorded as percentage cover.

3.6.2 Infauna

Benthic infauna samples are collected using a core sampler (75 mm diameter, 200 mm deep), with three core samples collected within each of the three sampling areas (e.g., 0-5 m from outfall); core samples are taken within three of the five epifauna quadrats. Core samples are preserved in ethanol and sent to SLR Consulting's Nelson laboratory for sieving (500 µm), identification and enumeration using a light microscope. Organisms are identified to the lowest possible taxonomic level.

3.6.3 Macroflora

Macroflora is recorded in three quadrats (1 m^2) randomly placed within each of the three sampling areas (e.g., 0-5 m from outfall). Species identification is completed to the lowest possible taxonomic level, with percentage cover recorded. Specimens are collected when required.

3.6.4 Cockles

Cockles are collected by hand within 20 m of the outfalls at the Kitchener Street, Orari Street and Portobello Road sites. Cockles are returned to SLR Consulting's laboratory where their size and weight are measured and recorded before being sent for laboratory analysis of the flesh (Eurofins) for total arsenic, cadmium, chromium, copper and lead, PAH and enterococci.

3.6.5 Data Analysis

Data and statistical analyses are conducted to assess community composition (infauna, epifauna and macroflora).

The five sites are grouped based on their status (potential 'Impact' and 'Control'), to assess the overall effect of stormwater discharges on community composition. Further, the sampling areas at potential 'Impact' sites are grouped based on distance from the outfall (i.e., Zone A: 0-5 m from outfall, Zone B: 5-20 m, Zone C: >50 m) to assess any influence of distance to the outfall on community composition.

If stormwater discharges were impacting the health of the surrounding ecosystem, we would expect:

- Changes in community composition between 'Control' and potential 'Impact' sites: higher abundance of 'pollution-tolerant' species and lower abundance or absence of 'sensitive' species at the potential 'Impact' sites, and lower abundance of 'pollution-tolerant' species and presence of 'sensitive' species at the 'Control' sites.
- Changes in community composition related to proximity to the outfall (e.g., Zone A: 0-5 m from outfall): higher abundance of 'pollution-tolerant' species and lower abundance or absence of 'sensitive' species closer to the outfall, and lower abundance of 'pollution-tolerant' species and presence of 'sensitive' species in zones farther from the outfall.

Raw percentage and individual count data are transformed (log10(x+1) and square root, respectively) to meet assumptions of homogeneity. The two datasets (% cover and individual counts) are treated separately. Diversity indices are calculated and a multi-variate statistical analysis used to investigate relationships between sites; details of these analyses can be found in Appendix B.

Benthic community composition patterns (i.e., species diversity) are widely used as bioindicators to screen the health of the ecosystem in relation to an environmental disturbance, such as wastewater pollution (e.g., Simboura and Zenetos 2002, de-la-Ossa-Carretero *et al.* 2012). At a broad level, some macrofauna families are known to be less tolerant to pollution while other opportunistic animals flourish in polluted areas (e.g., Handley *et al*. 2020). The biotic index AZTI Marine Biotic Index (AMBI) (Borja *et al.* 2000) is commonly used for assessing the health of macrobenthic communities, by assigning species or families to ecological groups, based on their sensitivity to increasing stress factors (e.g., organic, or heavy metal pollution). Also, marine community composition patterns within a disturbed area reflect the distance between the sampling location and the source of the environmental disturbance (e.g., wastewater outfall), such that the communities closer to the source of disturbance are the ones most effected (de-la-Ossa-Carretero *et al*. 2012, Puente and Diaz 2015, Bouchet *et al.* 2012, 2020). As such, ‘zones of effect’ can be delineated by grouping sites by distance to the disturbance, wherein sites closer to the disturbance are likely to exhibit a different response to sites further from the disturbance.

3.7 Sampling Overview

Table 2 provides an overview of the sampling requirements, parameters, and relevant guidelines, as specified by the consents.

Table 2: 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 the South Dunedin Site, to be relocated to the Shore Street Site in 2025/26	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

4.1.1 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 2024 and June 2025: July, and November 2024, and January, March, May, and June 2025 (see Appendix A and Appendix C). 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).

Fourteen of the stormwater outfalls accessible for sampling (23 in total) 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 3). Eight outfalls were sampled that did not exceed the trigger level: outfalls 4 (South Dunedin catchment), 9 (Portsmouth Drive catchment), 11 (Kitchener Street catchment), 28, 29 and 30 (Ravensbourne catchment), and 31 and 32 (Port Chalmers catchment). Of these outfalls, 9, 11, 28, 29 and 31 are only sampled on a six-monthly basis and outfall 11 was only sampled once (having no flow during November 2024 dry weather sampling). Outfall 2 is also to be 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), 5 and 6 (Portsmouth Drive catchment), 10 (Kitchener Street catchment), and 24 (Halsey Street catchment) all had *E. coli* concentrations that exceeded the trigger level over three consecutive sampling rounds (Table 3).

FWA concentrations were variable at the stormwater outfalls, with Outfalls 3 (Shore Street catchment), 5 and 6 (Portsmouth Drive catchment), 29 and 30 (Ravensbourne catchment), and 32 (Port Chalmers catchment) having elevated FWA concentrations on more than one occasion during the 2024-25 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 2024-25 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.

4.1.2 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.

As indicated in previous reports, reviewing the sampling regime for dry weather monitoring, to remove the sampling of some outfalls, could be worthwhile. 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 3: *E. coli* dry weather sampling results between July 2024 and June 2025, 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 2024	Nov 2024	Jan 2025	Mar 2025	May 2025	Jun 2025
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 2024 and June 2025, 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 2024 to 2025.

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

4.3.1 Sampling Results

The automated sampler was successfully triggered and captured rain events in March, April, and May 2025 at the South Dunedin site, where it has been located since December 2024. Despite sampling of wet weather events not being undertaken at outfalls between July 2024 and June 2025, the automated sampler can capture events at all times of the day and night and captured three events in 2025: on 27 March (3.8 mm total rainfall), 14 April (12 mm total rainfall), and 29 May (9 mm total rainfall) (Figure 11 through Figure 13). See Appendix D for results tables for these sampling events.

During all three rain events, concentrations of cadmium and PAH were low or below laboratory detectable limits for the duration of each event. Oil and grease concentrations were also generally low (less than 10 g/m^3), except at the start of the May rain event when the concentration was 15 g/m^3 and during the April rain event when concentrations were low then peaked at 69 g/m^3 60 minutes into the event before dropping. pH was relatively stable during each event and ranged from 6.9 to 7.9. Suspended solids concentrations varied with each event, with the March event having two peaks, the first small peak (210 g/m^3) 40 minutes into the rain event and then a second larger peak (370 g/m^3) 90 minutes into the rain event. Suspended solids concentrations during the April rain event had one high peak (530 g/m^3) at 40 minutes into the rain event before decreasing during the remainder of the event, while the May event had two minor peaks, the first peak at 80 minutes (210 g/m^3) and a second peak at 100 minutes (192 g/m^3).

Concentrations of faecal indicator bacteria, *E. coli*, increased slightly during the March event, starting at 4,400 cfu/100 mL at 10 minutes and peaking at 11,200 cfu/100 mL 110 minutes into the event, before dropping to 2,400 cfu/100 mL. *E. coli* concentrations during the April event had a slight peak (4,600 cfu/100 mL) 50 minutes into the rain event, but was generally stable throughout the event. *E. coli* concentrations during the May event were the highest of the three rain events. *E. coli* peaked at 60 minutes (33,000 cfu/100 mL) and stayed consistently high until the sampling finished at 120 minutes (22,000 cfu/100 mL).

Concentrations of metals in March and May generally increased during each rain event, with concentrations of most metals peaking 80 minutes into the May event. Metal concentrations during the April event generally peaked 50 minutes into the rain event. Nickel concentrations were high at the start of each event, before dropping and then following the same patterns as other metals. Overall, zinc concentrations were the highest of the metals during each rain event, followed by copper and lead, with lower concentrations of chromium, nickel, and arsenic.

Metal contaminants in stormwater can be produced from common sources, such as zinc which can come from 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.

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. Variable rainfall can also influence the timing of contaminant inputs (e.g., from runoff from roads and/or industrial yards) into the stormwater due to differing rain intensities in different areas of the stormwater catchment. 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. There was a range of rainfall levels for the three sampling events at the South Dunedin site, the 27 March 2025 having the least amount of rainfall with a total of 3.8 mm for the event while the 14 April 2025 had the most with a total of 12 mm for the event.

4.3.2 Comparison with Previous Events

To compare the South Dunedin site rain events with previous wet weather sampling undertaken in the Halsey Street and Mason Street catchments, maximum contaminant concentrations from each event can be compared (Table 4). 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 at the South Dunedin site were within the range or less than the peak concentrations for the Halsey and Mason Street sites. Of the three sites, the Hasley Street site had the highest total suspended solids and *E. coli* concentrations while the Mason Street site had the highest oil and grease concentrations. 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.

4.3.3 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 (for sites where seawater inputs to the stormwater system at higher tide levels).

Between July 2024 and June 2025 there were five occasions when the sampler was incorrectly triggered.

4.3.4 Future

The ISCO automated sampler has been located within the South Dunedin catchment since December 2024. 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 May 2025 at the South Dunedin site, the sampler can now be moved into another catchment area.

Previous deployments of the automated sampler in the specified catchments have been at the Shore Street (2015 to 2016), Kitchener Street (2016 to 2018), Mason Street (2018 to 2021), Halsey Street (2021 to 2024), and South Dunedin (2025) catchments. As the deployment at the South Dunedin catchment is complete, the automated sampler can be re-deployed, starting with the Shore Street catchment (to retain the same order as previous deployments).

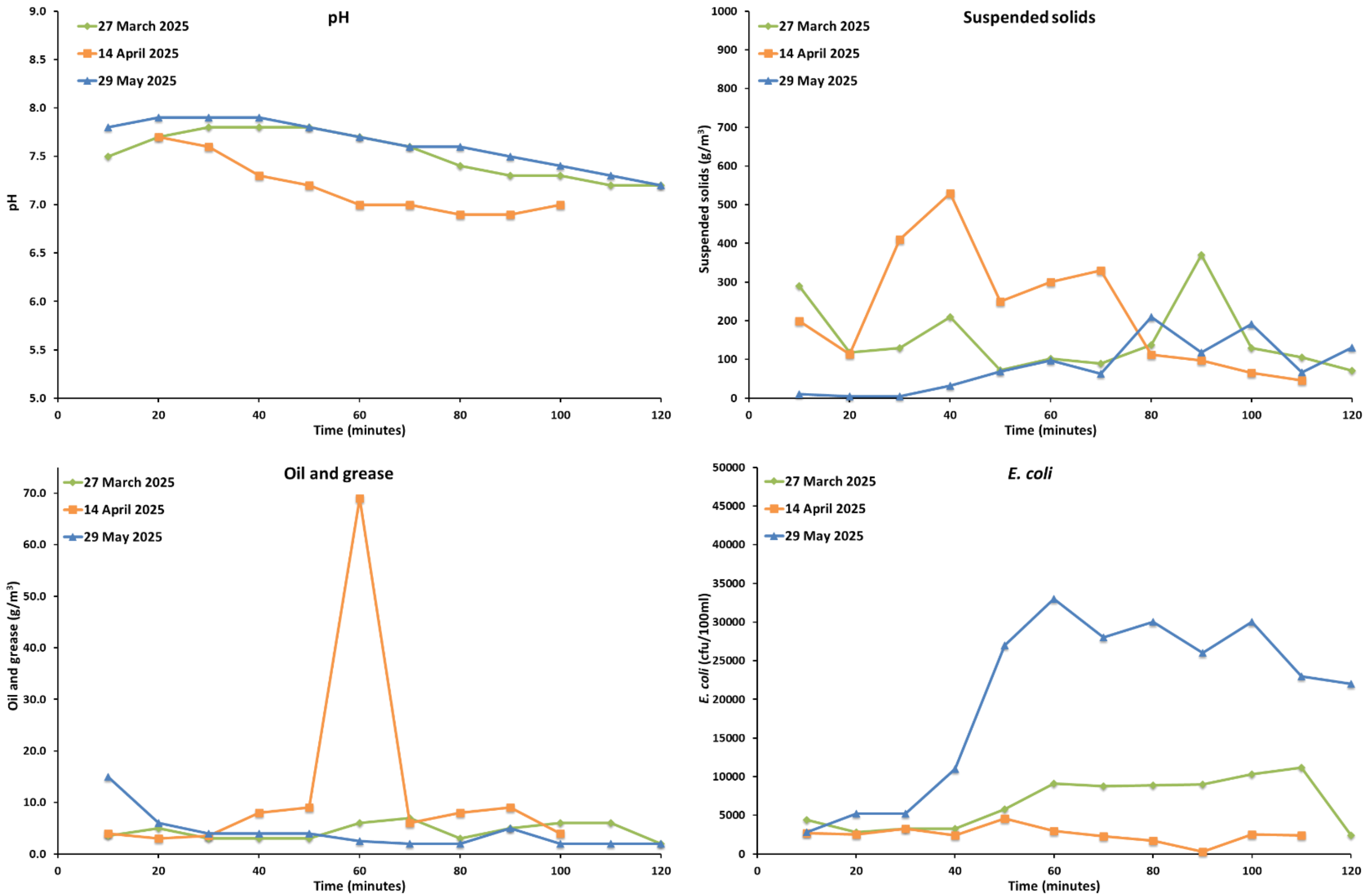


Figure 11: Contaminant concentrations during 27 March, 14 April, and 29 May 2025 rainfall events captured by ISCO automated sampler, South Dunedin site.

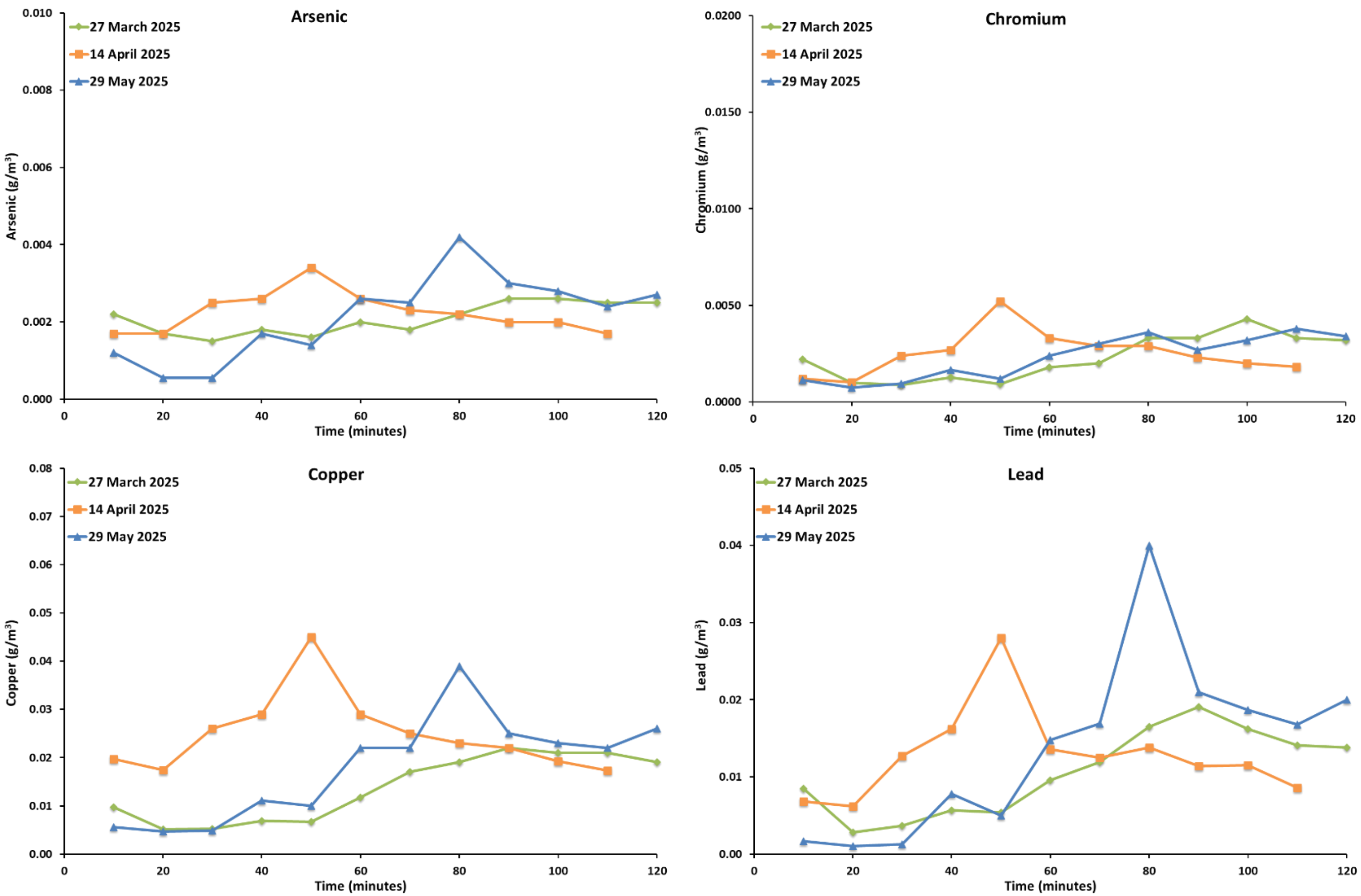


Figure 12: Contaminant concentrations during 27 March, 14 April, and 29 May 2025 rainfall events captured by ISCO automated sampler, South Dunedin site.

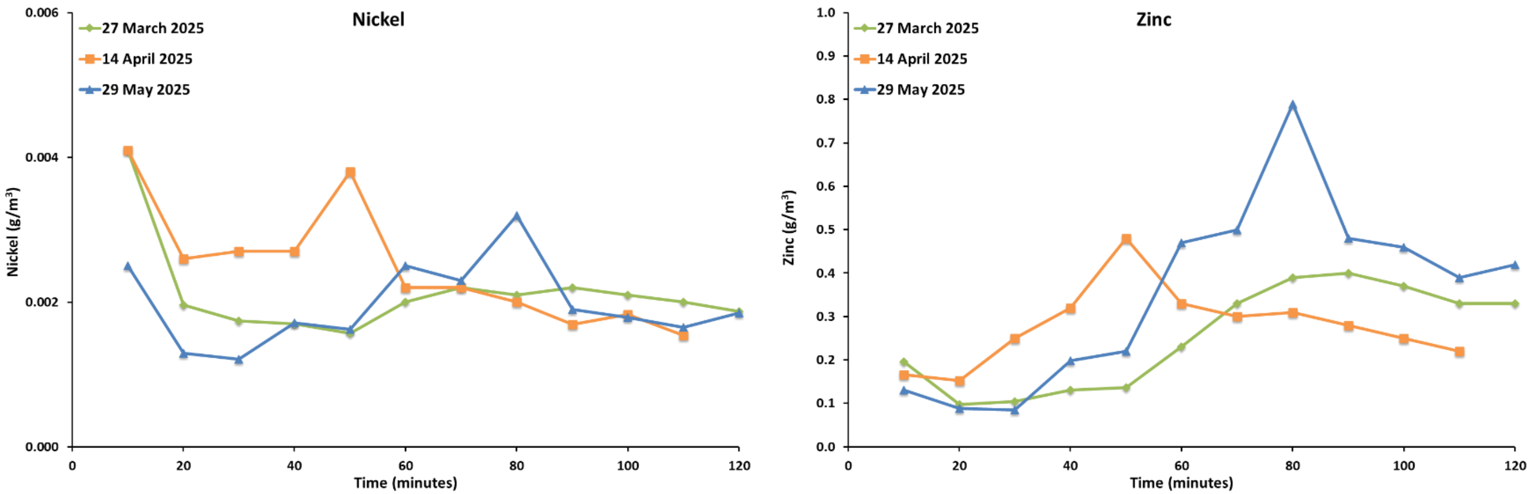


Figure 13: Contaminant concentrations during 27 March, 14 April, and 29 May 2025 rainfall events captured by ISCO automated sampler, South Dunedin site.

Table 4: Maximum contaminant concentrations collected during rainfall events by the ISCO automated sampled in the Mason Street, Halsey Street, and South Dunedin stormwater catchment sites, 2019 to 2025. '< 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
South Dunedin: 27 March 2025 3.8 mm rain	7.8	370	7	0.0026	0.000123	0.0043	0.022	0.0191	0.0041	0.400	11,200	<0.0025
South Dunedin: 14 April 2025 12 mm rain	7.7	530	69	0.0034	0.00022	0.0052	0.045	0.028	0.0041	0.480	4,600	<0.0025
South Dunedin: 29 May 2025 9 mm rain	7.9	210	15	0.0042	0.00026	0.0038	0.039	0.04	0.0032	0.790	33,000	0.01042-0.01172

4.4 Harbour Water

4.4.1 Sampling Results – Wet Weather

Wet weather sampling of harbour water was undertaken on 29 May 2025 (Table 5). On the mid-ebb and mid-flood tide, cadmium and lead concentrations were under laboratory detection limits at all sites except for lead on the mid-ebb tide at Wickliffe (H1) and Andersons Bay Inlet (H5); lead concentrations were low at both sites. Copper concentrations exceeded trigger levels across all sites and tides, while enterococci concentrations were above trigger levels across all sites at least once on either the mid-ebb or mid-flood tides. Zinc concentrations exceeded trigger levels on the mid-ebb tide for all sites except Substation (H6) and were above trigger levels on the mid-flood tide at Vauxhall (H4).

As trigger levels were exceeded for copper, 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 with the required conditions to compete resampling for the 2024 to 2025 period (i.e., before 30 June 2025).

4.4.2 Sampling Results – Dry Weather

Dry weather sampling of harbour water was undertaken on 13 November 2024 (Table 6). On the mid-ebb tide, cadmium, lead, and enterococci concentrations at all six sites were either below laboratory detection limits or were low and below trigger levels, while zinc concentrations were generally low with only zinc at the Substation site (0.0015 g/m^3) having the same concentration as the trigger level. Copper concentrations exceeded the trigger level (0.0013 g/m^3) at Kitchener (H3), Substation (H6), and Andersons Bay Inlet (H5), but were below laboratory detection limits at the other sites.

On the mid-flood tide, cadmium and enterococci concentrations were either below laboratory detection limits or were low and below trigger levels at all six sites, while lead concentrations were generally low (Table 6). Lead concentrations at the Mason site (0.02 g/m^3) did, however, exceed the trigger level. Copper concentrations exceeded the trigger level at the Wickliffe (H1), Kitchener (H3), and Andersons Bay Inlet (H5) sites, while zinc concentrations exceeded the trigger level at the Mason (H2), Kitchener (H3), and Substation (H6) sites.

As trigger levels were exceeded for copper, lead, and zinc at different sites, re-sampling for these contaminants during similar weather and tide conditions was required. Resampling for dry weather conditions was undertaken on 23 May 2025. Across all sites for both mid-ebb and mid-flood tides, metals and enterococci concentrations were either below laboratory detection limits or below trigger levels, except for copper (0.002 g/m^3) at the Substation (H6) site during the mid-flood tide.

Table 5: Harbour water sampling data from wet weather sampling on 29 May 2025. Green cells indicate values exceed trigger levels.

Harbour water sampling 2024-2025					
	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	0.005	0.001	0.051	13000
Mason (H2)	<0.001	0.004	<0.001	0.019	5900
Kitchener (H3)	<0.001	0.003	<0.001	0.025	42000
Substation (H6)	<0.001	0.003	<0.001	0.007	70
Vauxhall (H4)	<0.001	0.003	<0.001	0.022	800
Andersons Bay Inlet (H5)	<0.001	0.006	0.002	0.052	2300
Mid-flood tide					
Wickliffe (H1)	<0.001	0.003	<0.001	0.013	2500
Mason (H2)	<0.001	0.003	<0.001	0.009	1300
Kitchener (H3)	<0.001	0.002	<0.001	<0.005	300
Substation (H6)	<0.001	0.003	<0.001	0.012	580
Vauxhall (H4)	<0.001	0.003	<0.001	0.016	800
Andersons Bay Inlet (H5)	<0.001	0.003	<0.001	0.013	120

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.

Table 6: Harbour water sampling data from dry weather sampling on 13 November 2024 and resampling on 23 May 2025. Green cells indicate values exceed trigger levels.

Harbour water sampling 2024-2025					
	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]
Dry Weather Harbour Water Sampling, 13 November 2024					
Mid-ebb tide					
Wickliffe (H1)	<0.001	<0.002	<0.001	<0.005	30
Mason (H2)	<0.001	<0.002	0.003	0.011	30
Kitchener (H3)	<0.001	0.003	0.003	0.014	30
Substation (H6)	<0.001	0.003	0.003	0.015	40
Vauxhall (H4)	<0.001	<0.002	<0.001	<0.005	< 10
Andersons Bay Inlet (H5)	<0.001	0.002	0.001	0.008	10
Mid-flood tide					
Wickliffe (H1)	<0.001	0.002	<0.001	0.014	< 10
Mason (H2)	<0.001	<0.002	0.02	0.017	20
Kitchener (H3)	<0.001	0.005	0.002	0.023	< 10
Substation (H6)	<0.001	<0.002	<0.001	0.02	10
Vauxhall (H4)	<0.001	<0.002	<0.001	0.007	< 10
Andersons Bay Inlet (H5)	<0.001	0.002	0.002	0.014	< 10
Dry Weather Harbour Water – Re-Sampling, 23 May 2025					
Mid-ebb tide					
Wickliffe (H1)	<0.001	<0.002	<0.001	0.009	40
Mason (H2)	<0.001	<0.002	<0.001	<0.005	< 10
Kitchener (H3)	<0.001	<0.002	<0.001	<0.005	< 10
Substation (H6)	<0.001	<0.002	<0.001	<0.005	< 10
Vauxhall (H4)	<0.001	<0.002	<0.001	<0.005	< 10
Andersons Bay Inlet (H5)	<0.001	<0.002	<0.001	<0.005	10
Mid-flood tide					
Wickliffe (H1)	<0.001	<0.002	<0.001	0.007	130
Mason (H2)	<0.001	<0.002	<0.001	0.006	< 10
Kitchener (H3)	<0.001	<0.002	<0.001	0.005	20
Substation (H6)	<0.001	0.002	<0.001	0.009	20
Vauxhall (H4)	<0.001	<0.002	<0.001	0.006	< 10
Andersons Bay Inlet (H5)	<0.001	<0.002	<0.001	0.009	10

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.

4.4.3 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 (Figure 14 through Figure 17). Sampling in 2024-2025 revealed contaminant concentrations exceeded trigger levels of copper, lead, and zinc at least once at one or more sites and required re-sampling. Re-sampling resulted in concentrations of contaminants across all sites to be low or below laboratory detection limits, except for Substation (H6) during mid-flood for copper. Previous sampling of harbour water has found elevated copper concentrations at most sites during dry weather, 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. Figure 14 through Figure 17 display contaminant concentrations from sampling undertaken between 2017 and 2025, with results only shown where concentrations were above laboratory detection limits (e.g., copper and lead not shown for May 2025 mid-ebb sampling for any 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.

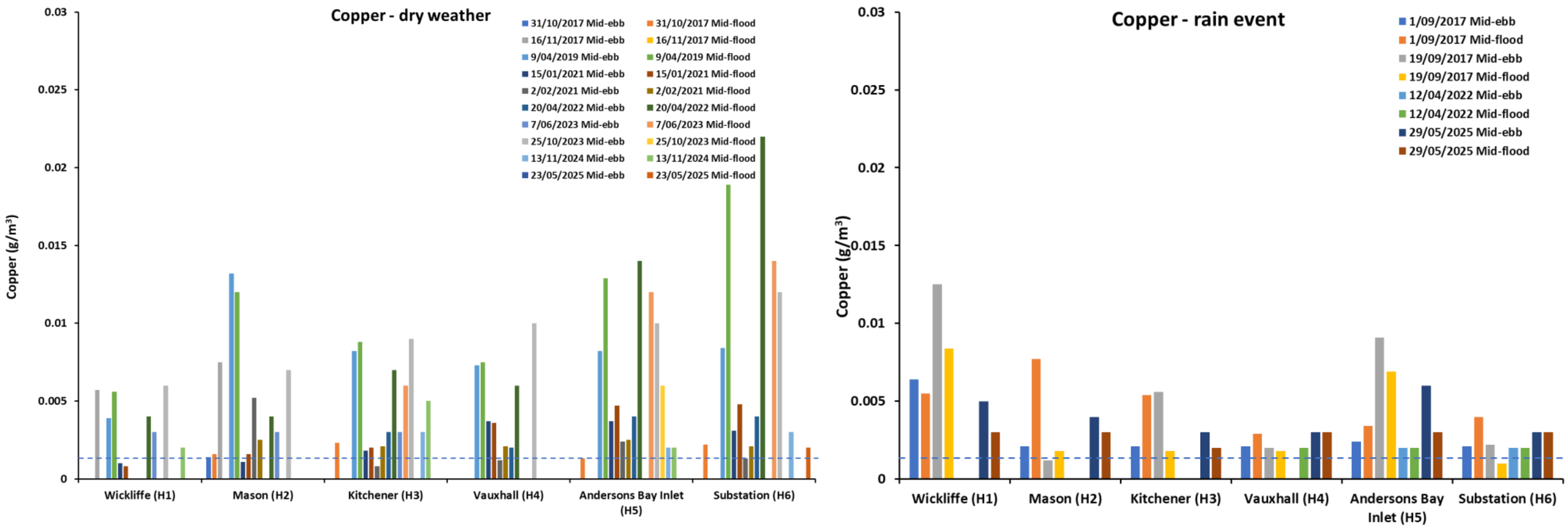


Figure 14: Copper concentrations in harbour water during dry weather (left) and rain events (right), 2017-2025. Dashed lines indicate consent trigger level.

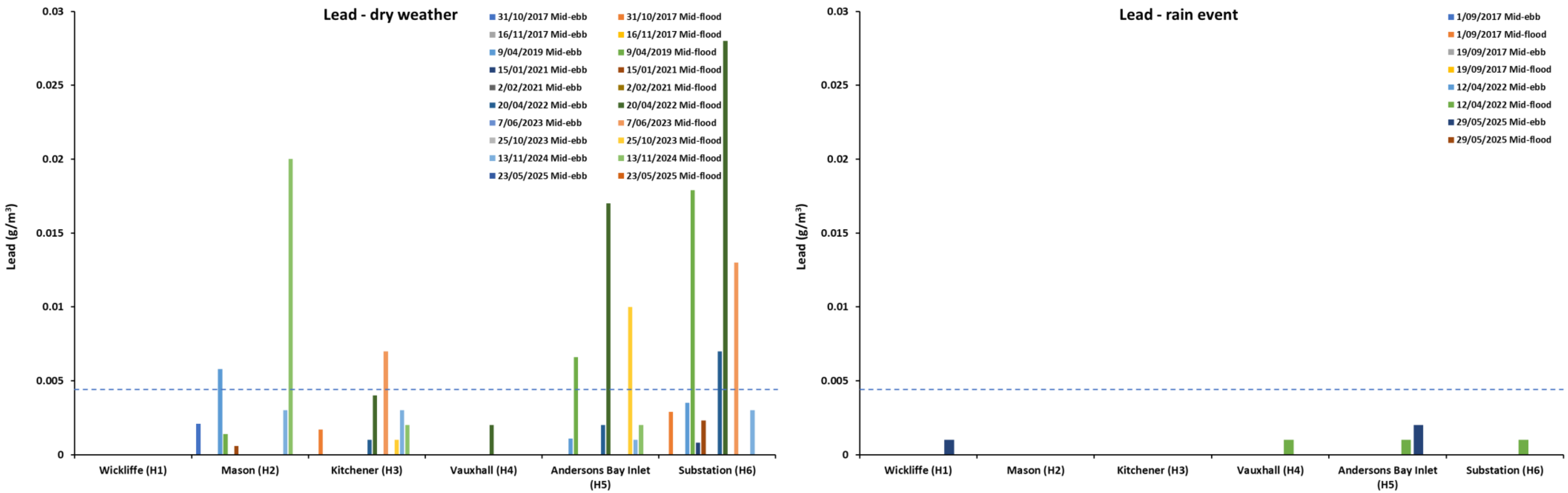


Figure 15: Lead concentrations in harbour water during dry weather (left) and rain events (right), 2017-2025. Dashed lines indicate consent trigger level.

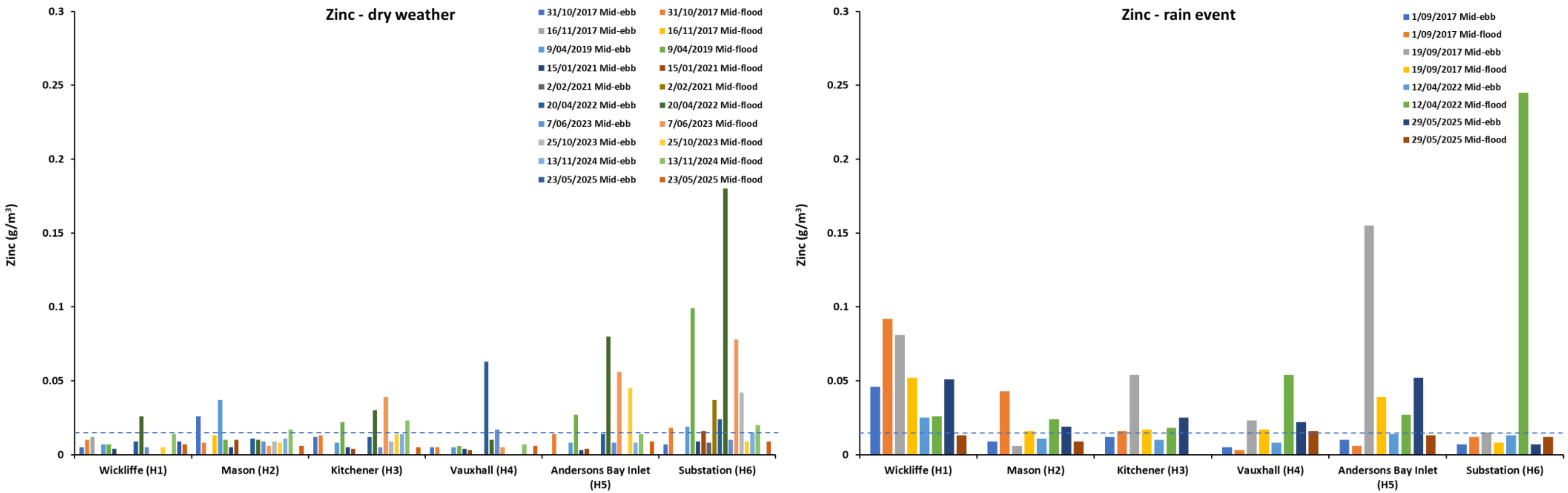


Figure 16: Zinc concentrations in harbour water during dry weather (left) and rain events (right), 2017-2025. Dashed lines indicate consent trigger level.

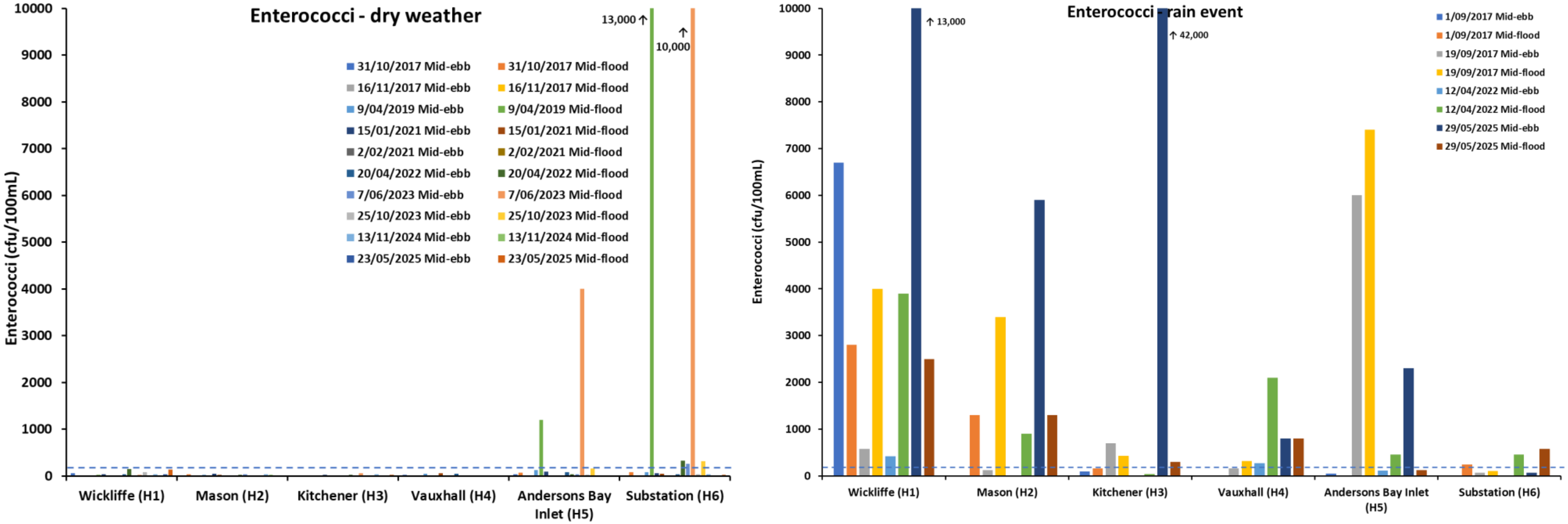


Figure 17: Enterococci concentrations in harbour water during dry weather (left) and rain events (right), 2017-2025. Dashed lines indicate consent trigger level.

4.5 Harbour Sediment

Sampling of harbour sediment quality was undertaken at the four upper harbour sites on 28 May 2025. See Appendix E for tabulated results from this sampling.

Contaminant concentrations in harbour sediments at all sites were either the same as (nickel at Halsey Street; 21 mg/kg) or below the 2013 trigger levels listed in the resource consent (where applicable; Appendix E). The ANZECC (2000) ISQG-Low guidelines were exceeded for lead, zinc, and PAH at Shore Street, while the nickel concentration at Halsey Street was the same as the ISQG-Low guideline. All contaminant concentrations were well below the ISQG-High levels at all sites. 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.

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 Halsey and Shore Street sites were greater than laboratory detection limits, with the highest concentration (290 mg/kg) at the Shore Street site which was slightly higher than the ANZG (2018) DGV low while the Halsey Street TPH concentration (133 mg/kg) was below the ANZG (2018) DGV low. Total OCP concentrations were low at all sites (<0.04 mg/kg) and therefore considerably lower than the ANZG (2018) DGV.

Overall, sampling in 2025 found generally higher contaminant concentrations in sediments at the Shore Street site and lower concentrations at the Halsey, Kitchener, and Orari Street sites than in recent years (Figures 18, 19, and 20). There were exceptions to this, with a notable increase in concentrations of TPH at the Halsey Street site relative to recent years. For many contaminants there have been no obvious patterns in concentrations through time, Further sampling in 2026 will be useful to help understand if a pattern of increasing concentrations continues, or if the lower concentrations in 2025 were reflective of ongoing variation. The strict sampling criteria have resulted in no wet-weather sampling of stormwater outputs at outfalls, except for automated sampling at a South Dunedin 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.

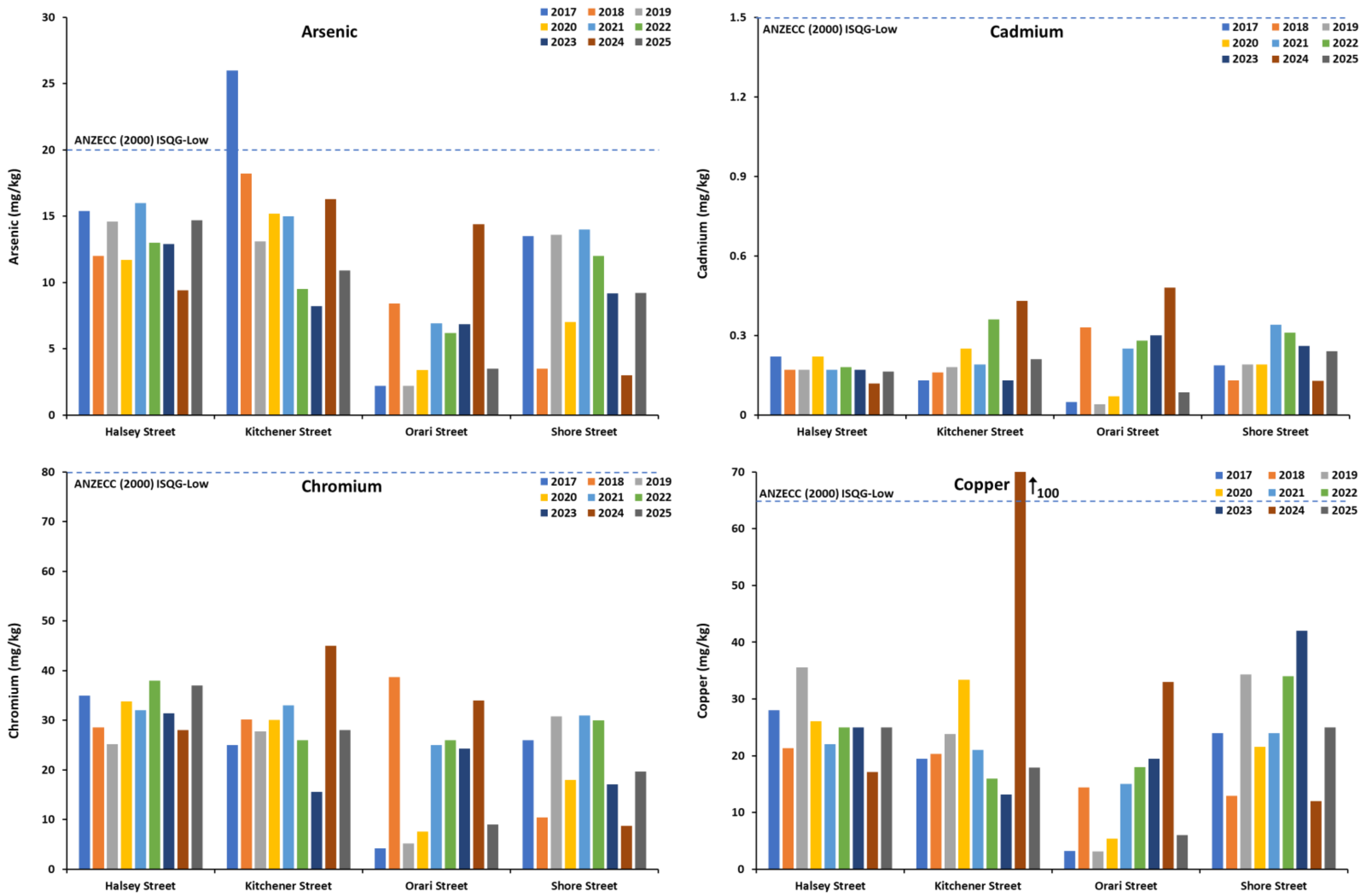


Figure 18: Contaminant concentrations in harbour sediments 2017 to 2025. Dashed lines indicate ANZECC (2000) ISQG levels.

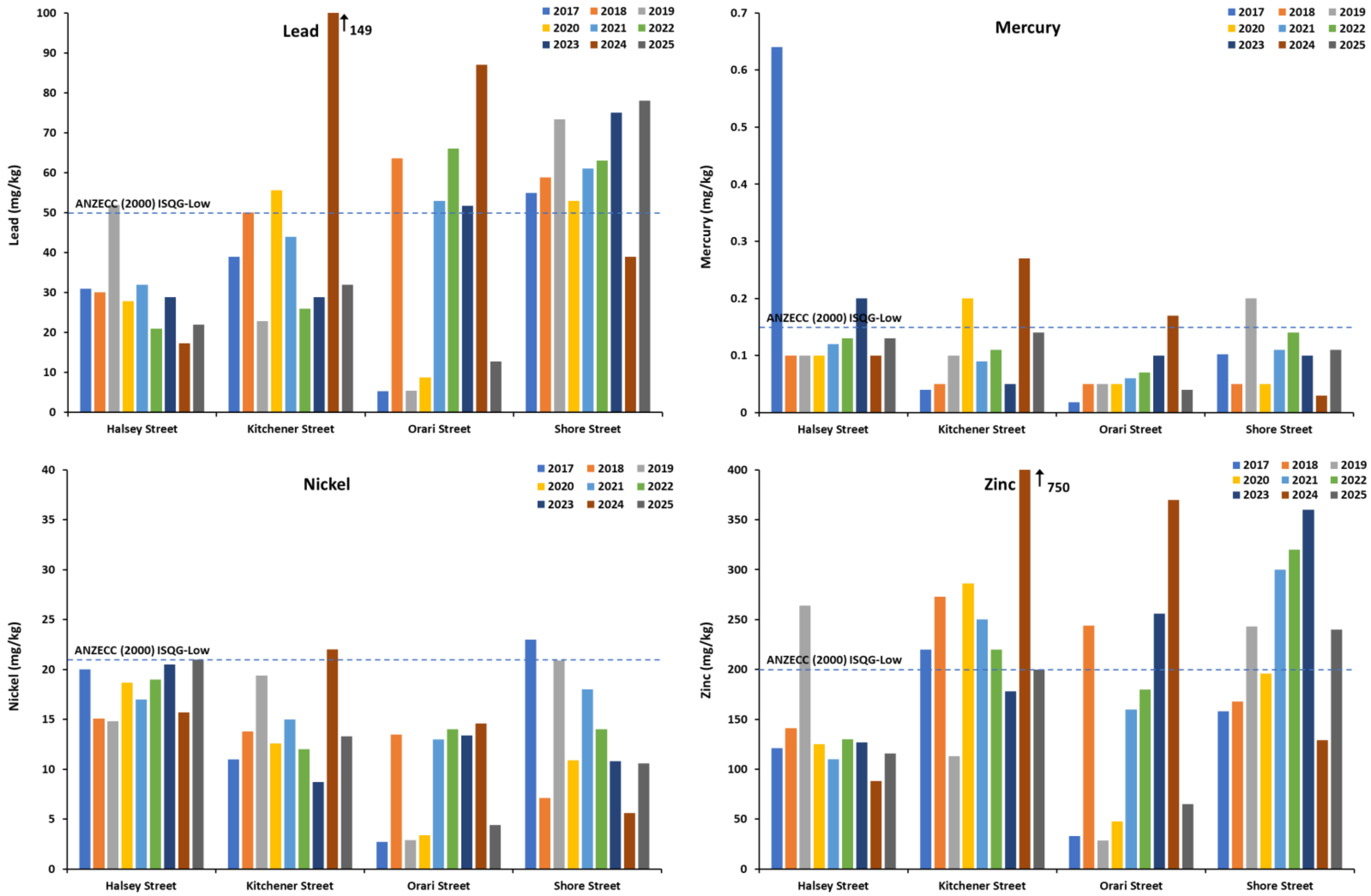


Figure 19: Contaminant concentrations in harbour sediments 2017 to 2025. Dashed lines indicate ANZECC (2000) ISQG levels.

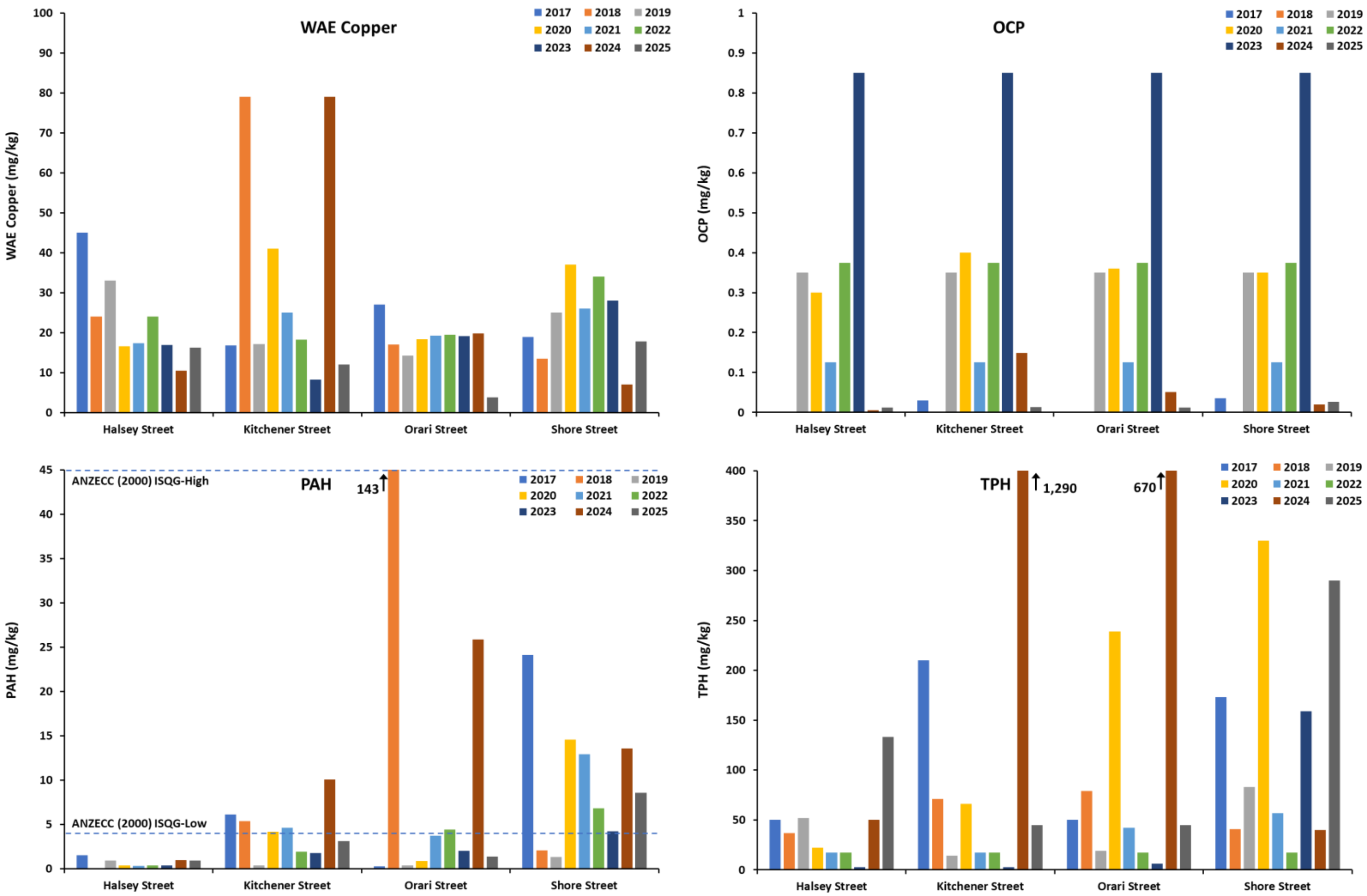


Figure 20: Contaminant concentrations in harbour sediments 2017 to 2025. Dashed lines indicate ANZECC (2000) ISQG levels.

4.6 Harbour Biological

Biological sampling at the five sites (Burkes, Kitchener Street, Orari Street, Portobello Road and Macandrew Bay) was undertaken on 3 and 4 February 2025, at low tide.

4.6.1 Community Overview

A total of 106 species were recorded at the five sites. There were 5 species of macroflora, 13 species of epifauna, and infauna included 88 species (Appendix F).

Macroflora was recorded as percentage of cover in 0.25 m^2 quadrats. The highest average percent coverage was recorded at Orari Street while the lowest (i.e., no macroflora) was seen at Burkes, as observed in previous surveys. The seaweed *Ulva intestinalis* accounted for the majority of macroflora coverage at Orari Street but was absent at the other sites (Appendix F).

Figure 21 below outlines the species richness (S'), diversity (H') and evenness (J') of the epifauna and infauna recorded at each site.

Kitchener Street showed the highest epifauna species richness (S') with 12 species found throughout the site, while the lowest richness was 3 species recorded at Macandrew Bay. Species diversity was low overall for epifauna, with the highest Shannon-Wiener Diversity Index score (H') recorded at Kitchener Street with 1.75 and the lowest score of 0.29 at Burkes. The low diversity score at Burkes was due to the dominance at the site by *Austrovenus* cockles, whereas other sites supported a range of taxa with none dominating as at Burkes. This result is different from the 2023 monitoring results, where the diversity score was highest at Burkes (1.24) and lower at other sites; tide heights in 2023 required sampling at sites aside from Burkes and Macandrew Bay to generally be focussed on rocky habitats along the harbour edge where barnacles were dominant and in high numbers. Pielou's evenness index (J') for epifauna was high at most sites with the highest at Macandrew Bay at 0.87, while the lowest evenness was at Burkes at 0.16, which was considerably lower than the other sites.

For infauna, Kitchener Street showed the highest infauna species richness with 62 species recorded, ranging down to 24 species found at Macandrew Bay. Infauna species diversity was highest at Kitchener Street, with a Shannon-Wiener Diversity Index (H') score of 3.05, while there was similar diversity at other sites with the lowest score of 2.24 at Burkes. Pielou's evenness index (J') scores for infauna were generally within a similar range as epifauna, with the highest at Kitchener Street at 0.74 and the lowest at Portobello Road at 0.64. However, unlike evenness of epifauna at Burkes, which was considerably lower than at the other sites, evenness of infauna at Burkes was very similar to that at other sites.

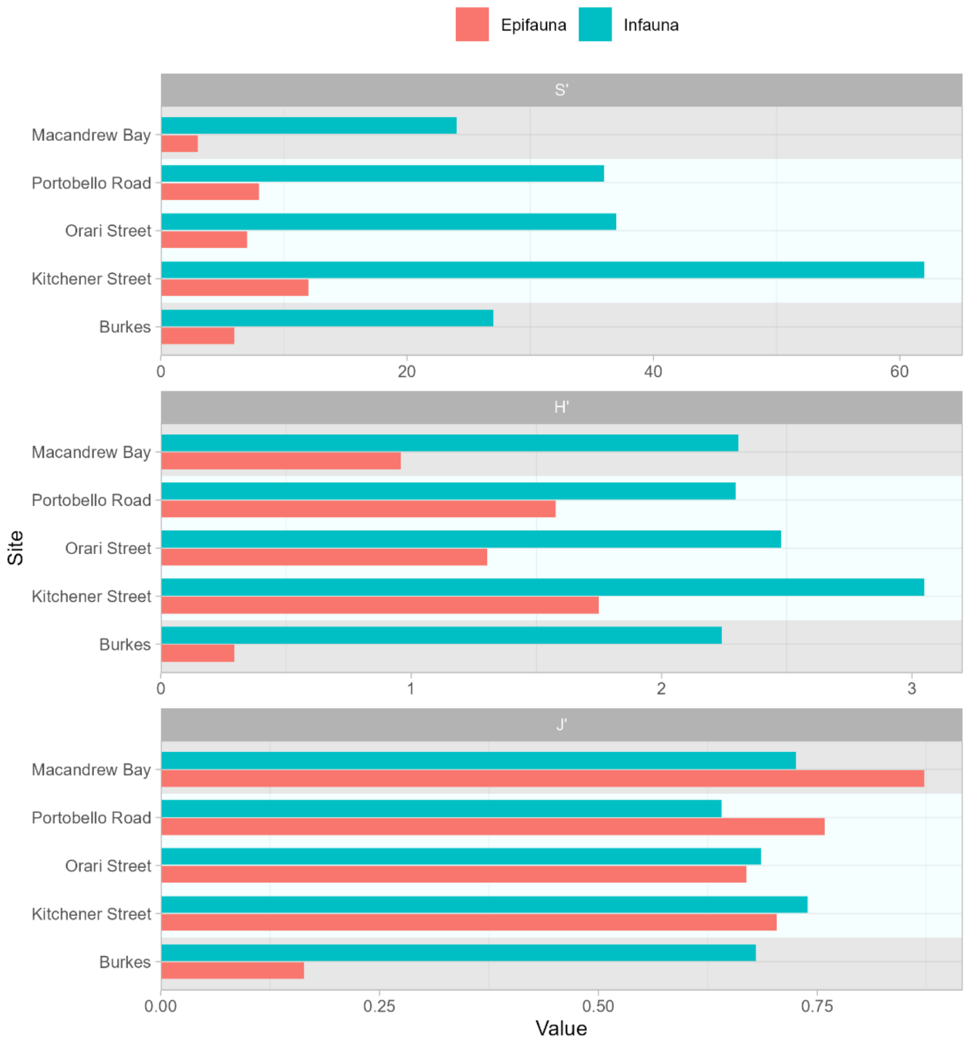


Figure 21: Community diversity indices for each site. S': species richness; H': Shannon Wiener index (a measure of community diversity; higher values indicate higher species diversity), J': Pielou's evenness index (a measure of species evenness; ranges from 0 to 1, from no evenness to complete evenness) 'Control' sites are in grey.

Average percentage composition was calculated for infauna and epifauna combined and is presented in Figure 22 below. Taxa that were recorded in percent coverage were excluded as they could not be compared to taxa recorded by counts. The barnacle species *Epopella plicata* was also excluded. This species was present in much greater abundances than other taxa at Orari Street and skewed results towards the dominance of Arthropoda, obscuring the rest of the species assemblage. The barnacle *E. plicata* was the most abundant taxa with a total of 795 individuals recorded at the Orari Street site.

The most abundant phyla were Annelida and Mollusca (Figure 22), a pattern that was also reported in 2019, 2021, and 2023 (Goodwin and Ludgate 2019, Ludgate *et al.* 2021, 2023). These results also agree with previous reports for the phyla found in Otago Harbour, where Annelida and Mollusca were two of the most abundant groups (Inglis *et al.* 2006).

Annelida were present at all sample sites. Capitellid worms made up the majority of the Annelida present, with 614 individual Capitellid worm *Heteromastus* sp. recorded across the sites. *Heteromastus* sp. can be used as an indicator species in estuaries as this species can tolerate higher levels of copper and mud contents, typically becoming more abundant in areas not tolerated by more sensitive species. There does not appear to be a pattern of increasing abundance near any of the three outfall sites (Appendix F). Serpulidae (tube-building worms) were present at all potential 'Impact' sites and absent from Burkes and Macandrew Bay. These worms are dependent on hard substrate, which is more common at the potential 'Impact' sites than the 'Control' sites, to build their tubes and are not a useful indicator of the potential impacts from stormwater discharges.

Mollusca were also present at all sites (Figure 22). The most abundant taxa was the cockle *Austrovenus stutchburyi*, with 507 individuals counted across all sites, and the snail *Diloma nigerrimum,* with 169 individuals recorded across all sites.

Arthropods were present at all sites but were particularly abundant at the Orari Street and Kitchener Street sites. Nematodes were present at all sites except Burkes.

Average percent cover was also calculated for macroflora and is presented in Figure 23. Chlorophyta (green algae) were most abundant at Orari Street, and were present at the most sites, while Phaeophyla (brown algae) species were abundant at Portobello Road with only very low cover at Orari Street and Macandrew Bay. As a general overview, healthy and established macroflora is a relatively uncommon occurrence across the majority of the survey sites, both 'Control' and potential 'Impact'. The highest abundance of fixed and growing algae was at Orari Street where *Ulva* sp. was well established on boulders of the breakwater and found in generally increasing abundance with distance from the outfall. Portobello Road had large amounts of rubbish, woody debris, and shells mixed with floating fragments of *Adamsiella* sp. The only fixed and growing algae was *Ulva compressa* and Phaeophyla *Scytothamnus australis* found in clusters 0-5 m from the stormwater discharge. All other sites had negligible recordings of macroflora.

One-way ANOVAs were performed on abundance data for infauna, epifauna, and macroflora at three levels to assess whether there were any statistically significant differences among abundances: 'Control vs potential 'Impact', Sites, and Zones. There were statistically significant differences between Sites for infauna, epifauna, and macroflora ($p<0.05$). This is not surprising as there are some large differences in species abundance among the sites (e.g., Portobello Road vs. Orari Street for barnacle counts). Infauna and macroflora abundances were significantly different between the 'Control' vs potential 'Impact' sites. There were no statistically significant differences detected between different zones for infauna, epifauna, and macroflora ($p>0.05$; Table F-4, Appendix F).

Where ANOVAs found statistically significant differences, Games-Howell or Tukey HSD post-hoc tests were performed (depending on the assumptions met for ANOVA) on the abundance of infauna, epifauna, and macroflora to identify which sites were statistically significantly different from one another. When assessed by Site, infauna communities (Tukey HSD) were statistically significantly different from one another, with Macandrew Bay being statistically significantly different to all other sites and Kitchener Street being statistically significantly different to the Burkes and Orari Street sites (Table F-5, Appendix F).

Similar to infauna, epifauna communities (Games-Howell) were statistically significantly different from one another, with Macandrew Bay communities being statistically significantly different to those at all other sites, and the communities at the Burkes site being statistically significantly different to all other sites besides Orari Street (Table F-6, Appendix F).

Macroflora was significantly different at each site, with the community at the Orari Street site being statistically significantly different to communities at all other sites and the Kitchener

Street communities being statistically significantly different to those at all other sites except Portobello Road (Table F-7, Appendix F).

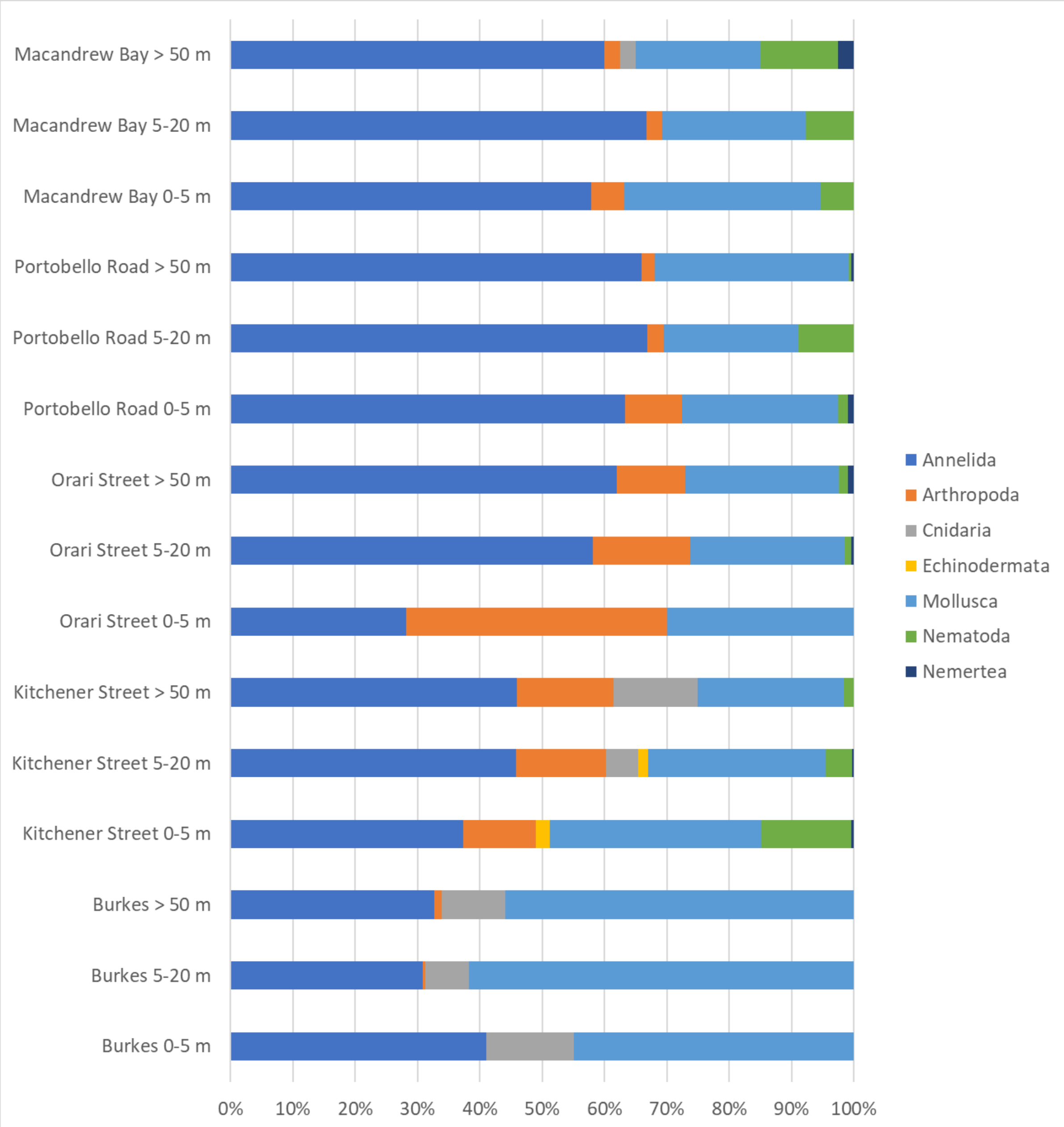


Figure 22: Average 2025 percentage composition of infauna and epifauna Phyla at each location and sampling site. Percentage cover taxa were excluded. Burkes and Macandrew Bay are 'Control' sites.

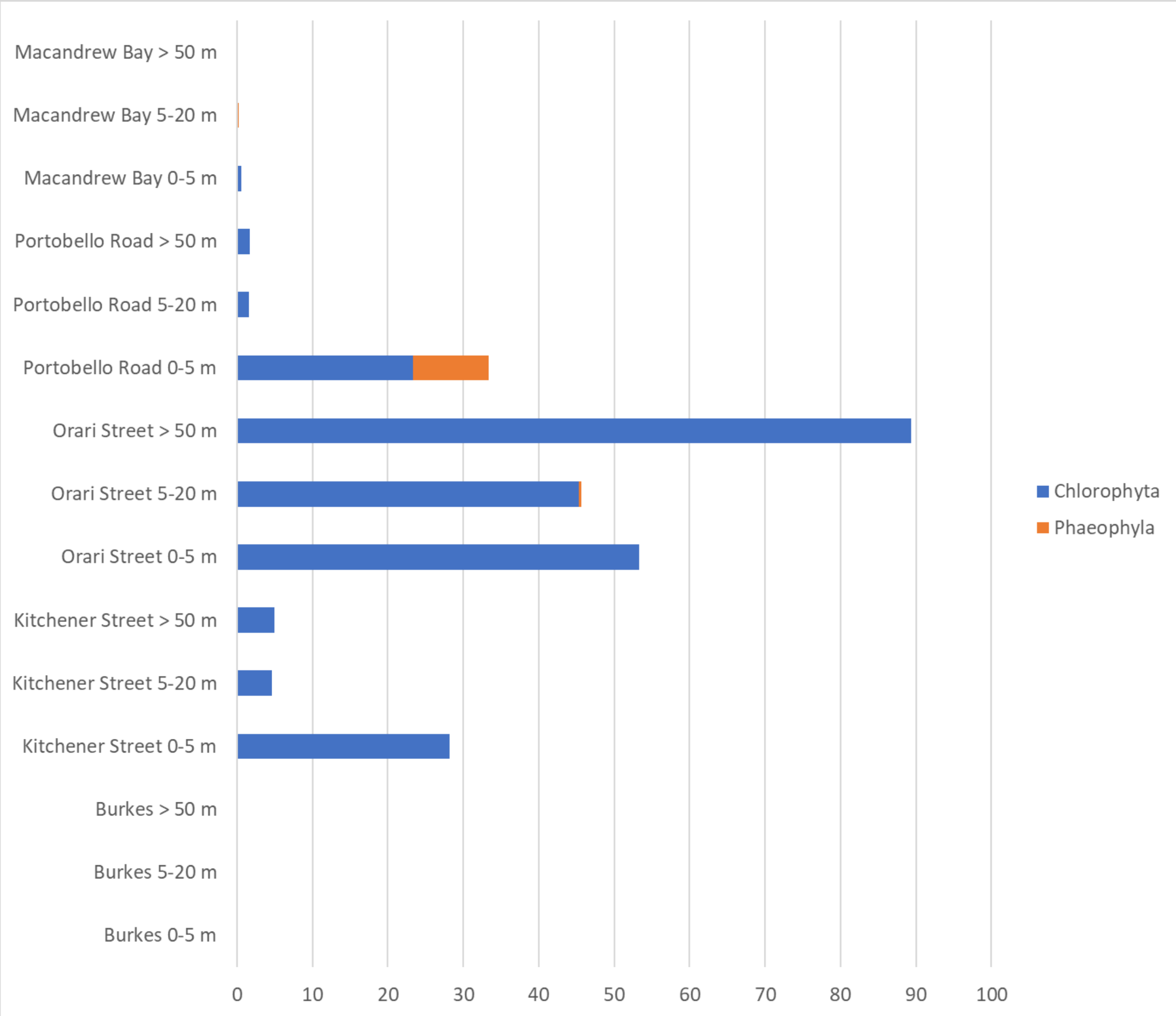


Figure 23: Average percent coverage of macroflora Phyla at each location and sampling site. Burkes and Macandrew Bay are 'Control' sites.

The non-metric multidimensional scaling (NMDS) plots (Figure 24, Figure 25, Figure 26) show the similarities and/or differences between individual sites and then between 'Control' and potential 'Impact' sites. The NMDS plot for epifauna (Figure 24) had a medium stress value (0.197), which indicates that it is a fair two-dimensional representation of level of similarity in community structure among samples, and as such should be interpreted carefully . Figure 24 shows that that all five sites have relatively similar community assemblages. The potential 'Impact' sites, Kitchener Street, Orari Street, and Portobello Road, have the most variable communities illustrated by the larger ellipses when compared to the 'Control' sites, with Macandrew Bay and most of Burkes nested inside. The NMDS comparison between 'Control' and potential 'Impact' sites shows a large amount of overlap between ellipses but with a greater spread of points for 'Impact' sites. The close similarity in epifauna communities is likely due to a number of sampling sites being located on the sandy bed or on rocky reef at the base of breakwaters for the 2025 survey. This is reflected by a number of taxa identified being molluscs adapted to sandy and rocky reef substrate (e.g., *Austrovenus stutchburyi* and *Epopella plicata*). While there is a statistically significant difference between the two groups, the differences shown in the NMDS plot are not substantial deviations from normal epifauna communities; deviations would be expected if stormwater discharges were having adverse effects.

The NMDS plots for infauna shows the differences between all sites and then comparing 'Control' and potential 'Impact' (Figure 25). The stress levels (0.206 and 0.199, respectively) indicate that the plots are a fair two-dimensional representation of level of similarity in community structure among samples, and as such should be interpreted carefully. The sites have minimal overlap, with the Kitchener Street site only overlapping with the Orari Street site, and the two 'Control' sites (Burkes and Macandrew Bay) minimally overlapping. The dissimilarity is seen across both 'Control' and potential 'Impact' sites, suggesting that the differences are not substantial deviations from normal infauna communities; deviations would be expected if stormwater discharges were having adverse effects.

The NMDS plot for macroflora (Figure 26) had a low stress value (0.0887), which indicates it is an adequate two-dimensional representation of level of similarity in community structure among samples, and as such should be interpreted carefully. Portobello Road is almost completely nested inside the Kitchener Street elliptical, with the Macandrew Bay elliptical overlapping as well. The Orari Street elliptical minimally overlaps the Kitchener Street elliptical, but is mostly separate, showing significant differences between these groups. Burkes is not shown on the graph as there were no macroflora species observed during the survey. There were not enough data points collected at the 'Control' sites to produce a meaningful comparison with the potential 'Impact' sites, with no elliptical shown for 'Control' sites and only some sites nested in the wide spread of potential 'Impact' sites.

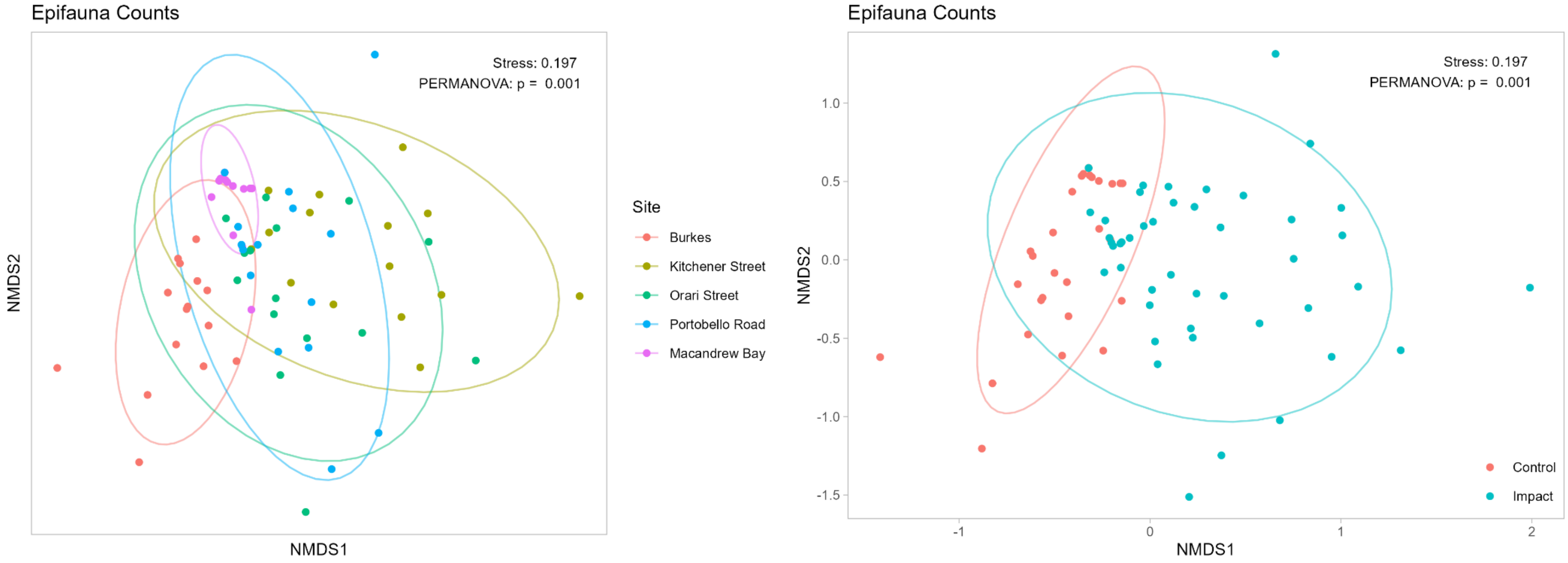
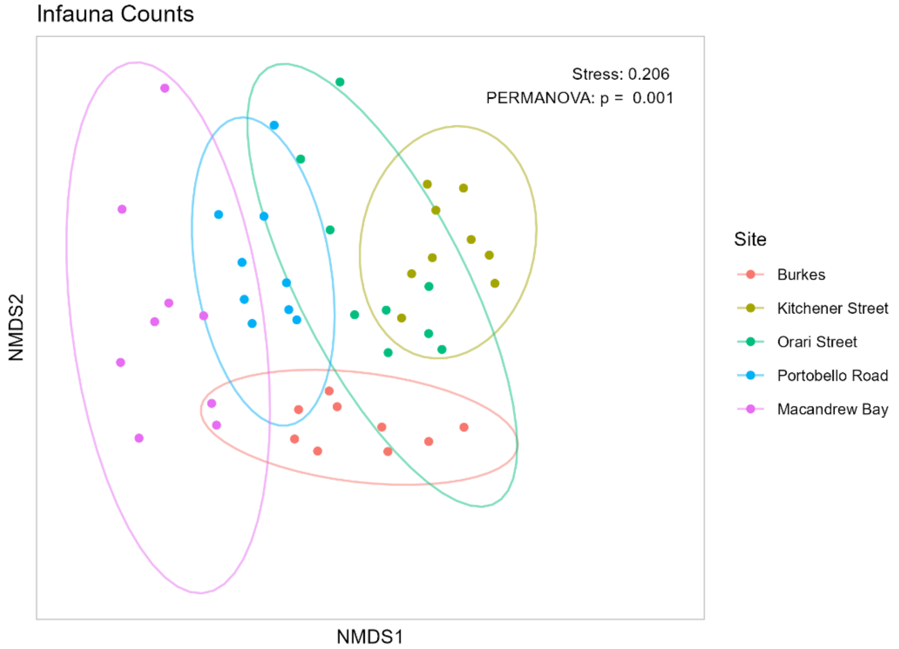


Figure 24: Multidimensional Scaling plots comparing epifauna communities between sites (left) and between 'Control' and potential 'Impact' sites (right).



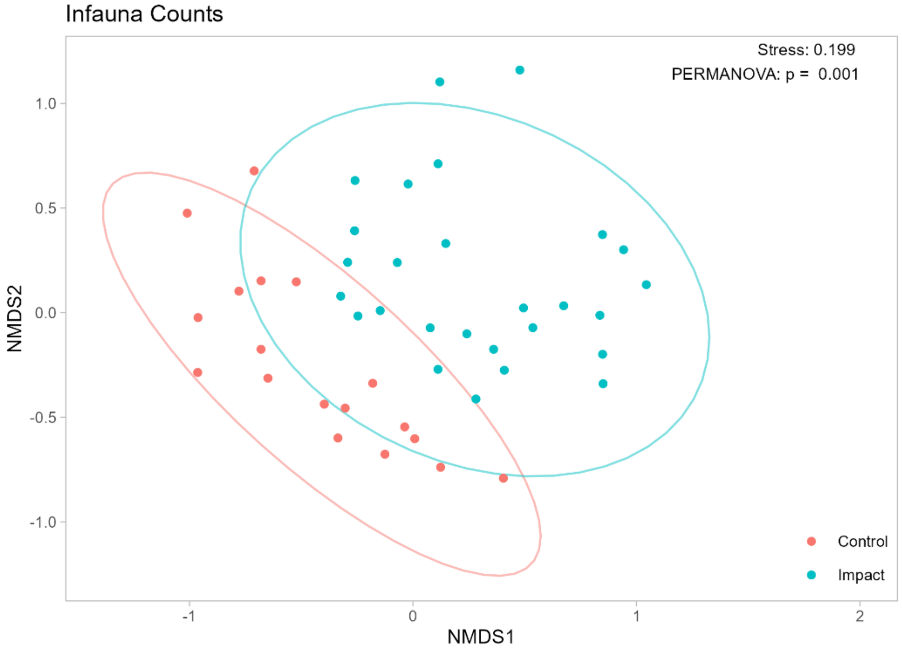


Figure 25: Multidimensional Scaling plots comparing infauna communities between sites (left) and between 'Control' and potential 'Impact' sites (right).

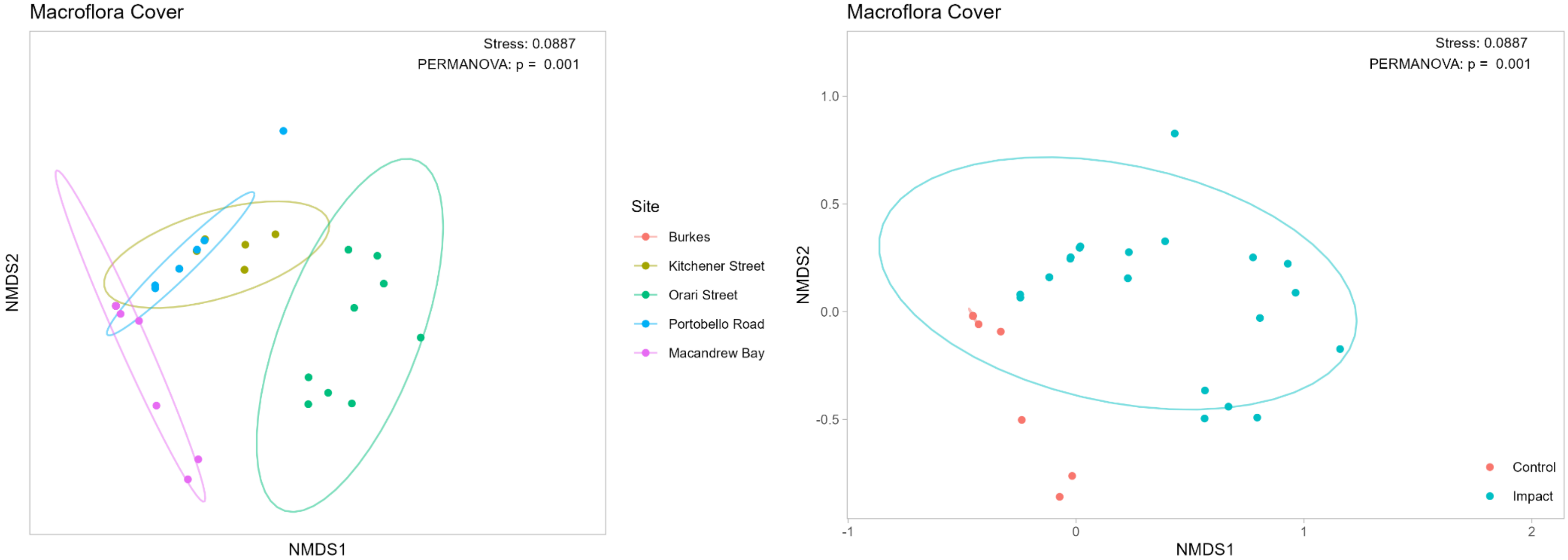


Figure 26: Multidimensional Scaling plots comparing macroflora communities and *Serpulidae* between sites (left) and between 'Control' and potential 'Impact' sites (right).

4.6.2 Bioindicators

Results of the AMBI assessment, which assigns species or families based on their sensitivity to increasing stress factors, indicate a gradient in ecological status from the west to the east of the harbour (Table 7), with the least 'impacted' site being the Kitchener Street potential 'Impact' and Burkes 'Control' site and the most 'impacted' site being the Portobello Road potential 'Impact' site. This is a trend that was also apparent in the round of harbour biological monitoring in 2020–2021. For the 2025 survey there were lower scores across all sites for AMBI index scores from 2023 and more similar to the 2021 survey. Macandrew Bay had relatively high abundance of 'pollution-tolerant' species, such as annelids *Heteromastus* sp., compared to more 'sensitive' species such as small arthropods. Although the three potential 'Impact' sites (Kitchener Street, Orari Street, and Portobello Road) had higher counts of *Heteromastus* sp., Macandrew Bay had notably low total number of species, and the few that were present were in low abundances. *Heteromastus* sp. polychaetes belongs to family Capitellidae and is a first order opportunistic species, responding positively to elevated nutrients/contaminants (Borja *et al.* 2000, Simboura and Zenetos 2002, Ellis *et al.* 2017). The Portobello Road, Orari Street, and Kitchener Street sites contained 92% (565 out of 614 individuals) of the total abundance of *Heteromastus* sp., across all sites. This result, along with the 2023 and 2021 results, differ from 2019 results where only four and two individuals from the Capitellidae family were recorded at Macandrew Bay and Portobello Road, respectively. Annelid worms in the family Nereididae respond positively to elevated nutrients/contaminants (Borja *et al.* 2000, Simboura and Zenetos 2002). There were 99 individuals previously reported at the Macandrew Bay and Portobello Road sites in 2021, only 10 individuals were identified across sites in 2023, and in 2025 there were 187 individuals across all sites with the majority at the Portobello Road site.

For Macandrew Bay, previous surveys have found similarly low diversity and abundance of infauna, however it is uncertain why the index results for the Macandrew Bay site are poor. It was previously theorised that the predominant winds in Otago Harbour are northerlies and westerlies (Single *et al.* 2010), and therefore any contaminants could be transported towards the eastern sides of the harbour where Macandrew Bay is located. The sample site is also located at a 'dogleg' bend where the majority of the water flows during the low tidal cycle. It is possible that the site is in a slightly higher energy environment and sediment transport is an inhibiting factor when it comes to infauna colonisation.

Kitchener Street had an AMBI score of 2.62 in 2021, 3.99 in 2023, and 2.47 in this study. The site has the lowest species richness and the highest species diversity (AMBI output data), which is opposite the Pielou's evenness and Shannon-Weiner indices where Kitchener Street had the highest scores. However, this could be driven by the highest abundances of less ecologically significant species, such as Annelida species. However, 3.1% of the taxa present were not able to be assigned an AMBI ecological category (due to lack of reference data), whereas the next highest percentage of not assigned taxa was 2.1% at Portobello Road. While this would suggest there has been a change in community composition, it may also be an example of the limitations of the AMBI approach and an explanation for the large change between years.

Table 7: AMBI values for all sites, 2025.

Location	Value	Dominant Ecological Group	Ecological Status
Burkes	2.63	III	Good
Kitchener Street	2.47	III	Good
Orari Street	3.38	IV-V	Moderate
Portobello Road	3.92	IV-V	Moderate
Macandrew Bay	3.36	IV-V	Moderate

4.6.3 Cockles - Contaminants

Shellfish are filter feeders and can therefore accumulate contaminants from their environment. Sampling of cockle flesh from potential 'Impact' sites in Otago Harbour revealed contaminant concentrations were similar across the sites (Table 8).

Enterococci concentrations at the Portobello Road and Kitchener Street site were below the laboratory detection limit while concentrations at Orari Street were higher, however all concentrations were within the range from recent years. Metal concentrations were generally comparable to previous sampling results, however the concentration of chromium at Orari Street was 2.37 mg/kg, which is the highest concentration found at any site between 2007 and 2025; previous concentrations at all sites have been less than 1 mg/kg, with the highest previous concentration at Orari Street of 0.57 mg/kg in 2021. Future sampling of cockles at this site will help determine if there is any pattern of increasing concentrations at this site, as there has been high variability in results in previous years.

Table 8: Contaminant concentrations in cockle flesh, 3 and 4 February 2025.

	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Enteroccoci (cfu/100g)	PAH (mg/kg)[1]
Portobello Road	7.8	0.037	0.49	1.25	0.39	<1000	0.148-0.154
Orari Street	6.05	0.021	2.37	1.17	0.08	2000	0.003-0.011
Kitchener Street	6.83	0.022	0.53	0.88	0.09	<1000	0.005-0.013

1. PAH concentration ranges are between known concentrations and the maximum possible concentrations (as some samples were below laboratory detection limits).

Cockles collected from the Portobello Road site have consistently had much higher PAH concentrations in their flesh than at the other sites, which is likely due to historic contamination of that site. PAH concentrations in cockle flesh have fluctuated over time, with the concentration in 2025 being lower than previously recorded (Figure 27).

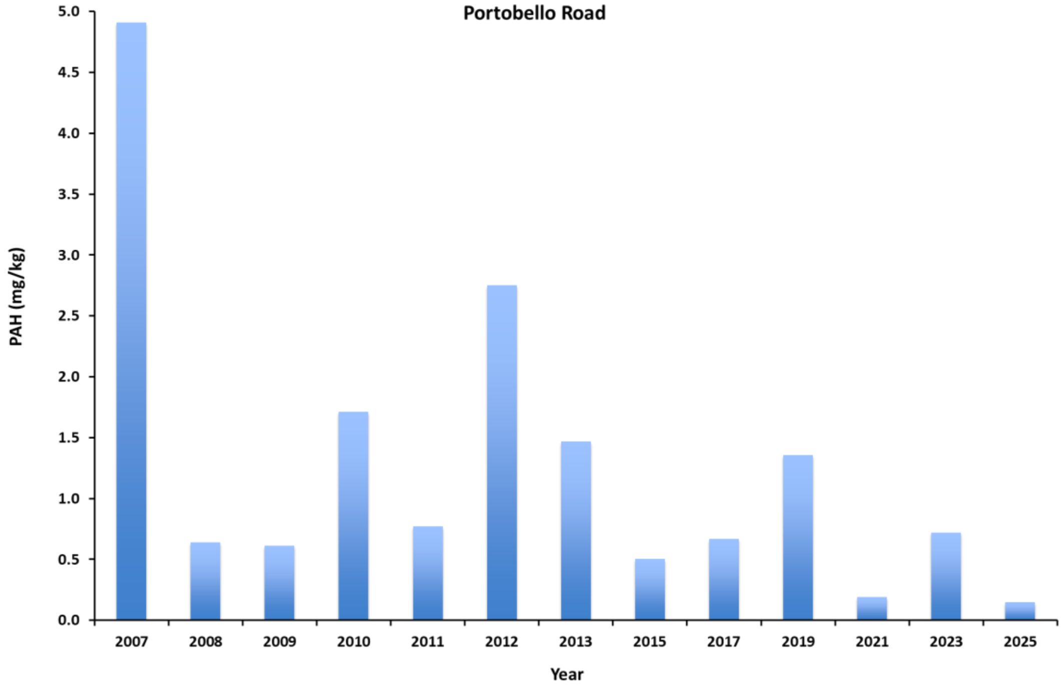


Figure 27: Concentrations of PAHs in cockle flesh at the Portobello Road site, 2007 to 2025.

Of the contaminants required for testing in cockle flesh, Food Standards Australia New Zealand (FSANZ) (2017) has set maximum concentrations for the heavy metals cadmium (limit 2 mg/kg) and lead (limit 2 mg/kg) in shellfish as food. Cockles at all sites had cadmium and lead concentrations well below the FSANZ (2017) maximum concentrations (Table 9). For arsenic, the FSANZ (2017) has also set a maximum concentration by providing a guideline for levels of inorganic arsenic in shellfish (limit 1 mg/kg). However, total arsenic is typically assessed when testing shellfish due to the difficulty and expense of measuring inorganic arsenic. United States Food and Drug Administration (USFDA) (1993) proposed estimating inorganic arsenic as only 10% of the arsenic in shellfish, allowing conversion of total arsenic to estimates of inorganic arsenic (rather than having results specific for inorganic arsenic). Using this approach, inorganic arsenic concentrations in Otago Harbour cockles were approximately 0.61-0.78 mg/kg and therefore lower than the FSANZ (2017) maximum concentration (Table 8).

The enterococci concentrations at Orari Street were 2,000 cfu/100g with concentrations at the other sites lower than laboratory detection limits. However, there are no suitable food safety guidelines for enterococci. The concentration found at Orari Street in 2025 is within the range found previously and may suggest that there are elevated levels of faecal bacteria in the shellfish.

Table 9: Maximum concentrations of contaminants in shellfish as food from FSANZ (2017). For the Otago Harbour sites, 'Lower' indicates concentrations in cockle flesh on 3 and 4 February 2025 that were lower than maximum concentrations. 'Higher' would indicate concentrations that were higher than maximum concentrations.

	Maximum concentration in shellfish for food	Portobello Road	Orari Street	Kitchener Street
Food Standards Australia New Zealand (2017)	Arsenic (inorganic)[1]: 1 mg/kg	Lower	Lower	Lower
	Cadmium: 2 mg/kg	Lower	Lower	Lower
	Lead: 2 mg/kg	Lower	Lower	Lower

1. Arsenic concentrations lower than maximum concentrations when converted from total arsenic to the required inorganic arsenic, using the 10% conversion from USFDA (1993).

4.6.4 Cockles - Size

Measuring cockle length is useful to determine if there is any relationship between contaminant concentrations and the size of cockles. Of the three sites where cockles are sampled, cockles have historically been largest at the Kitchener Street site, with decreasing size across the foreshore at Orari Street, and with the smallest at the Portobello Road site. Cockle lengths measured in 2025 follow this pattern (Figure 28). Since 2007, the only exceptions to this pattern have been in 2019 and 2023 when cockles at Portobello Road were slightly larger than those at Orari Street but were still smaller than those at Kitchener Street (Figure 28).

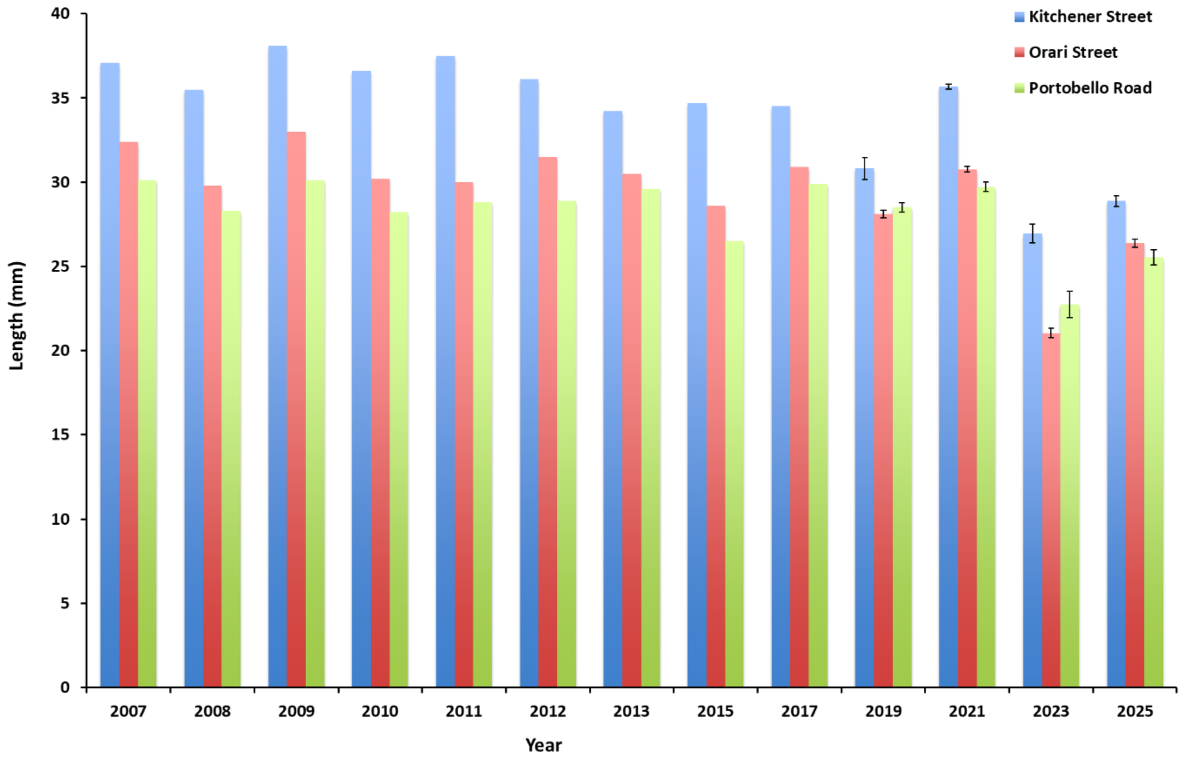


Figure 28: Mean cockle lengths (mm) at the three harbour biological sites, 2007 to 2025. Error bars for 2019 to 2025 means are +/- one standard error.

5.0 Summary and Conclusion

Monitoring of Dunedin's stormwater discharges and receiving environments (Otago Harbour) was undertaken between July 2024 and June 2025, 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 and wet weather conditions, re-sampling of harbour water quality during dry weather conditions, harbour biological sampling, and sampling of harbour sediments. Further sampling was restricted by weather/tidal conditions not being met (i.e., stormwater quality during wet weather conditions).

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 2024 and June 2025 as the required conditions were not met.

The automated sampler captured rain events in March, April, and May 2025 in the South Dunedin site. Concentrations of heavy metals, total suspended solids, oil and grease, *E. coli,* and PAH were generally all similar across sampling dates at the South Dunedin site. Concentrations at the South Dunedin site were also within range of previous locations the ISCO has been located, Halsey Street (2022-2024) and Mason Street (2019-2021). The

South Dunedin site has had three events capture and therefore the ISCO can be moved to the next catchment required by consent. Based on the order of previous deployments, this is the Shore Street catchment.

Harbour water quality sampling was undertaken during dry and wet weather conditions in 2024 - 2025. Harbour water quality sampling undertaken in wet weather conditions found the contaminants copper, zinc, and enterococci exceeded trigger levels across sites at least once, on the mid-ebb or mid-flood tide. Cadmium and lead were either below laboratory detection limits or low across all sites. Harbour water quality sampling undertaken in dry weather conditions found copper, lead, and zinc exceeded trigger levels at least once across sites. This triggered a resampling event, where all concentrations across all contaminants were low or below laboratory detection limits except for copper at Substation (H6) which exceeded the trigger level. 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, Kitchener, and Shore Street sites while there were increased concentrations at Shore Street site compared to those from recent years. Concentrations in 2025 were all the same as or below 2013 trigger levels listed in the consents, however concentrations of lead, 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. 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 patterns of increasing concentrations at some sites continue, or if the lower concentrations in 2025 were reflective of ongoing variation.

Sampling of harbour biological communities was undertaken in 2025, with a total of 106 species identified in this survey. There were significant overall differences between biological communities at sites influenced by stormwater outfalls and those sites with no outfalls. However, lower AMBI status at the Macandrew Bay ‘Control’ site suggests there are other environmental factors affecting benthic community composition. Community composition differed between some sites due to differences in habitat, such as tube-building worms and anemones on hard rock surfaces at Kitchener Street, Portobello Road, and Orari Street sites versus the sandy shores at Burkes and Macandrew Bay which generally support more snails and cockles.

Contaminant concentrations in cockles sampled in February 2025 were generally similar to results from recent years, with lower PAH concentrations at the Portobello Road site than found in 2023 and within the range from previous years. The cockles collected from the three sites had heavy metal (arsenic, cadmium, lead) concentrations within food safety guidelines.

Overall, stormwater monitoring between July 2024 and June 2025 has not resulted in clear patterns or trends of measured variables. Continued monitoring will help determine if previously observed patterns continue, particularly in sediments and harbour water.

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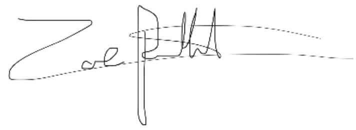
7.0 Closure

Sincerely,

SLR Consulting New Zealand



Zoe Psarouthakis
Senior Ecologist

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 2024 to June 2025 Monitoring

Dunedin City Council

SLR Project No.: 875.016671.00001

31 July 2025

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 Harbour Biological Data Analysis

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

July 2024 to June 2025 Monitoring

Dunedin City Council

SLR Project No.: 875.016671.00001

31 July 2025

Community Diversity

Species richness (S') was calculated for each site. Shannon-Wiener (H') index was calculated to measure community diversity between sites; the higher the value of the H' index, the higher the species diversity in the community. Pielou's evenness (J') was also calculated to assess the species evenness; Pielou's evenness ranges from 0 to 1, from no evenness to complete evenness, respectively.

Community Composition

A multi-variate statistical analysis was used to investigate relationships between sites. A Weighted Classical Multidimensional Scaling (wcmdscale), based on Bray-Curtis similarity index, was constructed to map the similarity between species presence and abundance at the different sites using R statistical software (vegan package).

The five sites were compared based on their status (potential 'Impact' and 'Control'), compared individually, and at potential 'Impact' sites compared based on proximity to outfall. Levene's Test was conducted to check whether the data fulfilled the homogeneity of variance assumption. Standard One-Way ANOVAs were conducted to investigate any differences between sites. If any of these tests were significant, Games Howell or Tukey HSD post-hoc testing was conducted to explore the differences. Statistical tests were performed using R statistical software (stats and rstatix packages).

Bioindicators

Infauna was assessed following the AZTI Marine Biotic Index (AMBI) (Borja *et al.* 2000) which was used to assess ecosystem health. It is noted that while this approach provides useful insight into the health and condition of the benthic environment, it is limited by available sensitivity data for a number of taxa. The AMBI index is based on a classification system of benthic communities and includes five levels of ecological quality (Bad, Poor, Moderate, Good, High) (Tables B-1 and B-2). AMBI index was calculated using the AMBI software version 6.0 provided by AZTI. The index values were then assigned to the appropriate category.

Table B-1: AMBI classification for benthic macrofauna. Species examples for the phylum Annelida are also provided.

AMBI		
Classification		Species examples
I	Very sensitive species	Maldanidae spp.
II	Species indifferent	*Glycera* spp.
III	Tolerant species	Nereididae spp.
IV	Second-order opportunistic species	*Chaetozone* spp.
V	First order opportunistic species	*Heteromastus* spp.

Table B-2: AMBI – AZTI Marine Biotic Index for macroinvertebrates.

AMBI value	Dominating Ecological Group	Benthic community health	Site pollution classification	Ecological Status
0.0 < BC <= 0.2	I-II	Normal	Unpolluted	High Status
0.2 < BC <= 1.2		Impoverished		
1.2 < BC <= 3.3	III	Unbalanced	Slightly polluted	Good Status
3.3 < BC <= 4.3	IV - V	Transitional to pollution	Meanly Polluted	Moderate Status
4.3 < BC <= 5.0		Polluted		Poor Status
5.0 < BC <= 5.5	V	Transitional to heavy pollution	Heavily Polluted	Poor Status
5.5 < BC <= 6.0		Heavily polluted		Bad Status
Azoic (7.0)	Azoic	Azoic	Extremely Polluted	Bad Status

Appendix C Stormwater – Dry Weather Sampling Results, 2024-2025

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

July 2024 to June 2025 Monitoring

Dunedin City Council

SLR Project No.: 875.016671.00001

31 July 2025

Table C-1: Contaminant concentrations in water from dry weather sampling between July 2024 and June 2025. 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). Not sampled sites noted.[1]

	10 July 2024		14 November 2024		17 January 2025		17 March 2025		28 May 2025		26 June 2025	
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	0.054	290	0.053	900	0.058	600	0.051	8,000	0.04	6,200	0.054	300
2			NF								NF	
3	0.120	330,000	0.101	570	0.084	16,000	0.07	20,000	0.062	400	0.085	520
4	0.116	<10	0.041	50	0.079	<10	NS		No Access		0.019	<10
5	0.126	26,000	0.120	1,900	0.133	16,000	0.125	>800,000	0.14	2,600	0.133	60
6	0.111	110	0.120	170	0.129	40,000	0.145	10,000	0.093	7,000	0.085	40
7	0.027	<10	0.088	68,000	0.020	<10	0.033	680	NF		0.087	220
8	0.069	500	0.063	500	0.068	380	NS	NS	NF		0.067	560
9			0.099	430							0.088	20
10	0.053	24,000	0.046	1,200	0.030	3,000	NS		0.022	26,000	0.033	1,100
11			NF								0.043	<10
12	0.026	<10	0.025	<10	0.021	30	0.056	2000	0.014	<10	0.022	<10
13-22												
23	0.042	50	0.046	160	0.040	360	0.027	1,900	No Traffic mgmt		0.033	270
24	0.027	7,100	0.017	1,500	0.026	36,000	0.059	39,000	No Traffic mgmt		0.020	14,000
25	0.037	10	0.021	< 10	0.033	44,000	0.05	200,000	No Traffic mgmt		0.034	46,000
26	0.029	3,900	0.032	60	NF		0.144	230	NF		0.043	<10
27	0.088	<10	0.072	2,500	0.064	210	0.068	59,000	0.065	12,000	0.072	400
28			0.096	10							0.059	10
29			0.129	10							0.110	<10
30	0.110	<10	0.112	40	0.125	460	0.072	200	0.057	30	0.112	<10
31			0.066	80							0.042	70
32	0.138	<10	0.178	10	0.137	< 10	NF		0.039	<10	0.123	<10
33	0.087	40,000	No Traffic mgmt		No Access		0.087	19000	No Traffic mgmt		0.085	3,000

1. NS - Not sampled, NF - No Flow, No access - No available access to the stormwater, No Traffic mgmt - No traffic management was available to allow safe access to manholes

Appendix D Automated Sampler – Wet Weather Sampling Results, 2024-2025

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

July 2024 to June 2025 Monitoring

Dunedin City Council

SLR Project No.: 875.016671.00001

31 July 2025

Table D-1: Contaminant concentrations in water from wet weather automatic sampling (ISCO) in the South Dunedin catchment, for a rain event on 27 March 2025. '< 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	7.5	290	< 7	0.0022	0.00007	0.0022	0.0097	0.0085	0.0041	0.196	4400	< 0.0025
20	7.7	118	5	0.0017	< 0.000053	0.00099	0.0051	0.0028	0.00196	0.098	2800	< 0.0025
30	7.8	130	< 6	0.0015	< 0.000053	0.00087	0.0052	0.0037	0.00174	0.104	3300	0.00117-0.00327
40	7.8	210	< 6	0.0018	< 0.000053	0.00127	0.0069	0.0057	0.0017	0.131	3300	< 0.0025
50	7.8	72	< 6	0.0016	< 0.000053	0.00093	0.0067	0.0054	0.00157	0.136	5800	0.00067-0.00277
60	7.7	102	6	0.002	0.000072	0.00179	0.0117	0.0096	0.002	0.230	9100	< 0.0025
70	7.6	89	7	0.0018	0.000089	0.002	0.0171	0.0119	0.0022	0.330	8800	< 0.0025
80	7.4	138	< 6	0.0022	0.000106	0.0033	0.0191	0.0165	0.0021	0.390	8900	< 0.0025
90	7.3	370	5	0.0026	0.000117	0.0033	0.022	0.0191	0.0022	0.400	9000	< 0.0025
100	7.3	130	6	0.0026	0.000123	0.0043	0.021	0.0162	0.0021	0.370	10300	< 0.0025
110	7.2	106	6	0.0025	0.000107	0.0033	0.021	0.0141	0.002	0.330	11200	< 0.0025
120	7.2	71	< 4	0.0025	0.000095	0.0032	0.0191	0.0138	0.00187	0.330	2400	< 0.0025

Table D-2: Contaminant concentrations in water from wet weather automatic sampling (ISCO) in the South Dunedin catchment, for a rain event on 14 April 2025. '< 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/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	cfu/100mL	mg/L
10	-	200	< 8	0.0017	0.000071	0.0012	0.0197	0.0068	0.0041	0.166	2700	0.00082-0.00292
20	7.7	113	< 6	0.0017	0.000074	0.00102	0.0174	0.0062	0.0026	0.153	2500	< 0.0025
30	7.6	410	< 7	0.0025	0.000106	0.0024	0.026	0.0127	0.0027	0.25	3300	< 0.0025
40	7.3	530	8	0.0026	0.000121	0.0027	0.029	0.0162	0.0027	0.32	2400	< 0.0025
50	7.2	250	9	0.0034	0.00022	0.0052	0.045	0.028	0.0038	0.48	4600	< 0.0025
60	7	300	69	0.0026	0.000129	0.0033	0.029	0.0136	0.0022	0.33	3000	< 0.0025
70	7	330	6	0.0023	0.000087	0.0029	0.025	0.0125	0.0022	0.3	2300	< 0.0025
80	6.9	112	8	0.0022	0.000085	0.0029	0.023	0.0138	0.002	0.31	1700	0.00024-0.00254
90	6.9	97	9	0.002	0.000076	0.0023	0.022	0.0114	0.00169	0.28	300	0.00078-0.00308
100	7	65	< 8	0.002	0.000068	0.002	0.0193	0.0115	0.00183	0.25	2500	< 0.0025
110	-	46	-	0.0017	0.000096	0.0018	0.0173	0.0086	0.00154	0.22	2400	-
120	-	-	-	-	-	-	-	-	-	-	-	-

Table D-3: Contaminant concentrations in water from wet weather automatic sampling (ISCO) in the South Dunedin catchment, for a rain event on 29 May 2025. ‘< 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	7.8	10	15	0.0012	< 0.000053	0.0011	0.0056	0.0017	0.0025	0.131	2800	< 0.0025
20	7.9	5	6	< 0.0011	< 0.000053	0.00075	0.0047	0.0011	0.0013	0.088	5200	< 0.0025
30	7.9	5	4	< 0.0011	< 0.000053	0.0010	0.005	0.0013	0.0012	0.09	5200	< 0.0025
40	7.9	32	4	0.0017	0.000061	0.0017	0.011	0.0078	0.0017	0.20	11000	< 0.0025
50	7.8	69	4	0.0014	0.00006	0.0012	0.010	0.005	0.0016	0.22	27000	< 0.0025
60	7.7	97	< 5	0.0026	0.000122	0.0024	0.022	0.0148	0.0025	0.47	33000	0.01042-0.01172
70	7.6	63	< 4	0.0025	0.000137	0.0030	0.022	0.0169	0.0023	0.5	28000	0.0001-0.0025
80	7.6	210	< 4	0.0042	0.000260	0.0036	0.039	0.0400	0.0032	0.79	30000	0.00037-0.00257
90	7.5	118	5	0.003	0.000147	0.0027	0.025	0.0210	0.00190	0.48	26000	0.00024-0.00254
100	7.4	192	< 4	0.003	0.000122	0.003	0.0230	0.0187	0.00179	0.46	30000	0.00105-0.00285
110	7.3	67	< 4	0.0024	0.000112	0.0038	0.0220	0.0168	0.00165	0.39	23000	0.00042-0.00252
120	7.2	131	< 4	0.0027	0.00015	0.0034	0.026	0.02	0.00185	0.42	22000	0.00634-0.00724

Appendix E Harbour Sediment Sampling Results, 2024-2025

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

July 2024 to June 2025 Monitoring

Dunedin City Council

SLR Project No.: 875.016671.00001

31 July 2025

Table E-1: Harbour sediment contaminant concentrations, 28 May 2025. 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	14.7	0.163	37	16.3	25	22	0.13	21	116	0.925-0.939	133	0.012
Kitchener Street	10.9	0.21	28	12	17.9	32	0.14	13.3	200	3.148	< 90	0.0085-0.019
Orari Street	3.5	0.086	9	3.8	6	12.8	0.04	4.4	65	1.367-1.427	< 90	0.012
Shore Street	9.2	0.24	19.7	17.8	25	78	0.11	10.6	240	8.585	290	0.0214-0.031

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.

Appendix F Harbour Biological Results

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

July 2024 to June 2025 Monitoring

Dunedin City Council

SLR Project No.: 875.016671.00001

31 July 2025

Table F-1: Percentage cover of macroflora per quadrat at the five harbour biological sites, 2-3 February 2025.

	Burkes									Kitchener Street									Orari Street								
	0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m		
Taxon (% cover)	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Chlorophyta																											
Cladophora sp.																											
Ulva compressa										5	20	55	5	8		5	2	8	5	10		15			8	10	
Ulva intestinalis																			25	55	20	30	45	15	5		
Ulva sp.										1	0.5	3	1							15	30	4	2	25	85	85	75
Phaeophyla																											
Scytothamnus australis																								1			
Total % cover	0	0	0	0	0	0	0	0	0	6	20.5	58	6	8	0	5	2	8	30	80	50	49	47	41	98	95	75
Number of taxa per quadrat	0	0	0	0	0	0	0	0	0	2	2	2	2	1	0	1	1	1	2	3	2	3	2	3	3	2	1
Mean % cover		0			0			0			28.2			4.7			5.0			53.3			45.7			89.3	
Mean number of taxa per quadrat		0			0			0			2.0			1.0			1.0			2.3			2.7			2.0	

	Portobello Road									Macandrew Bay								
	0-5m			5-20m			>50m			0-5m			5-20m			>50m		
Taxon (% cover)	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Chlorophyta																		
Cladophora sp.												0.5	0.3					0.2
Ulva compressa	4	6	60	3	0.6	1		2	3									
Ulva intestinalis																		
Ulva sp.											0.2	1						
Phaeophyla																		
Scytothamnus australis			30												0.1			
Total % cover	4	6	90	3	0.6	1	0	2	3	0	0.2	1.5	0.3	0	0.1	0	0	0.2
Number of taxa per quadrat	1	1	2	1	1	1	0	1	1	0	1	2	1	0	1	0	0	1
Mean % cover		33.3			1.5			1.7			0.6			0.12			0.1	
Mean number of taxa per quadrat		1.3			1.0			0.7			1.0			0.7			0.3	

Table F-2: Number of epifauna invertebrates per quadrat at the five harbour biological sites, 2-3 February 2025.

	Burkes															Kitchener Street															Orari Street														
	0-5m					5-20m					>50m					0-5m					5-20m					>50m					0-5m					5-20m					>50m				
Taxon	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Arthropoda																																													
Epopella plicata																																225	185		95						240	50			
Cnidara																																													
Isactina olivacea																							5	5	4	2	14	10	23	4															
Mollusca																																													
Acanthochiona zelandica																												1																	
Aulacompa ater maoriana																	1																												
Austrovenus stutchburyi	11	13	24	29	36	48	43	37	32	25	43	26	34	25	39		1			2											3			4	2		3	1	5	9	2			2	1
Cominella glandiformis		5		1	2	1	1	1			1		1	1	1			3		2				1		1								2			3	7	6	4	7	2	2	2	1
Diloma nigerrimum																16	5	7	18	1	2	4	2	1	3	3	2				2	21	25	2	1	7		9	5			18		1	
Diloma subrostrata											2			2																															
Mytilus galloprovincialis																	1																												
Notoacmea sp.															1							1							2			1		1			1				1				
Ostrea chilensis																1	33				9	6	7									1													
Sypharochiton pelliserpentis																	1																												
Zeacumantus subcarinatus			1		1	1	1			1	1	2				2				1						3				5															
Number of invertebrates per quadrat	11	18	25	30	39	50	45	38	32	26	47	28	35	28	41	19	42	10	18	6	11	11	14	7	7	9	16	11	25	9	5	248	210	9	98	7	7	17	16	13	250	70	2	5	2
Number of taxa per quadrat	1	2	2	2	3	3	3	2	1	2	4	2	2	3	3	3	6	2	1	4	2	3	3	3	2	4	2	2	2	2	2	4	2	4	3	1	3	3	3	2	4	3	1	3	2
Mean number of invertebrates per quadrat	24.6					38.2					35.8					19.0					10.0					14.0					114.0					12.0					65.8				
Mean number of taxa per quadrat	2.0					2.2					2.8					3.2					2.6					2.4					3.0					2.4					2.6				
Annelida																																													
Opheliidae sp.	1																																												
Serpulidae (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	4	10	0.5	6	0	2	4	15	0.5	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean % cover	0					0					0					0.2					5.1					4.3					0.8					0					0				

	Portobello Road															Macandrew Bay														
	0-5m					5-20m					>50m					0-5m					5-20m					>50m				
Taxon	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Arthropoda																														
Epopella plicata																														
Cnidara																														
Isactina olivacea																														
Mollusca																														
Acanthochiona zelandica						1																								
Aulacompa ater maoriana																														
Austrovenus stutchburyi																2	2	1	1	1										
Cominella glandiformis	5		5	4	3		1			2		1	3	1		1		1						2						
Diloma nigerrimum								7		2	2	2			1															
Diloma subrostrata	1	2																												
Mytilus galloprovincialis																														
Notoacmea sp.		1																												
Ostrea chilensis	1		2												6															
Sypharochiton pelliserpentis																														
Zeacumantus subcarinatus		8	2								1	9	17	2	15	2						3		1	1	1	1	4	1	1
Number of invertebrates per quadrat	7	11	9	4	3	1	1	7	0	4	3	12	20	3	22	5	2	2	1	1	0	3	0	3	1	1	1	4	1	1
Number of taxa per quadrat	3	3	3	1	1	1	1	1	0	2	2	3	2	2	3	3	1	2	1	1	0	1	0	2	1	1	1	1	1	1
Mean number of invertebrates per quadrat			6.8					2.6					12.0					2.2					1.4					1.6		
Mean number of taxa per quadrat			2.2					1.0					2.4					1.6					0.8					1.0		
Annelida																														
Opheliidae sp.																														
Serpulidae (%)	10	5	8	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean % cover			4.6					0					0.6					0					0					0		

Table F-3: Number of infauna invertebrates per core sample at the five harbour biological sites, 2-3 February 2025.

Taxon	Burkes									Kitchener Street									Orari Street									Portobello Road									Macandrew Bay								
	0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Annelida																																													
Orbinia papillosa																																							1						
Hesionidae																		1																											
Aglaophamus sp.											1																																		
Pilargidae																																												1	
Paraprinospio pinnata																	1																												
Prionospio aucklandica																																			1										
Spiophanes kroyeri																																												1	
Exogone sp.				1																																									
Lumbrineridae																															0										2				
Abarenicola affinis																									1																1				
Platynereis australis																												1								1									
Aonides trifida																																1	1												
Prionospio sp.								2																																					
Ampharetidae											1																																	1	
Galithowenia																3																													
Notomastus										2								1																											
Euchone sp										1						1																	1												
Aricidea sp																1		1							1																1				
Polynoidae												2						1	1																										
Rhynchospio sp.																	2					1				1																			
Terebellidae												2			2			1																											
Magelona dakini																									1							1	1		1									2	
Sphaerodopsis				2	1	1											1								1	1																			
Barantolla lepte										1					1				4			2																							
Microphthalmus cf																				3	1						1			1		2													
Scoloplos cylindrifer	3	2		2	1	2			1																												1								
Paraonidae				3											1	7	8	1																											
Cirratulidae										3				4	4		2	1												1	4	2	1	2		2									1
Dorvillea sp.										4	2	5				3		4											7		1		4												
Maldanidae				2	4			4		2	1	1			1	7	1	10			1		1		3		1																		
Perinereis vallata	2	6				2	2																			1	1			6	6	1	1	2	7		1	2	1						1
Myriochelle			3													30	8	11				3	1	3	3	1																			
Capitella spp.	2	9	1			5			8							3		1	2	1	1	1							2	3	6		47					1		1		4		2	
Oligochaete	6	7		1	1		10		3	8	6	1	1		1	1	5	2	2	15	5		4				1	2	2	10	12	9	27	2	1										
Nereididae	5	2	1			2	4	1	5				1			1			2		1		1					24	19	21	13	11	27	7	3	3	4	1	5	10	2	1	3	5	2
Exogoninae		11		3	1			1		44	14	45	38	7	12	15	13	12		1		1	3	2	5	3	6	1	1	1	2	1	1		2	1									
Polydorid	23	28	3	20	28	14	46		10	4	2	1	6	2	1	4	10	9	1	1		12	5	4	12	3	10						1	3		3	1								
Heteromastus sp.	5	5	3	1	4	4	1	5	8	18	4	1	18	21	30	9	5	3	1	12	11	52	23	35	37	32	41	3	2	19	58	12		39	39	40	1	2	1	2		2	1	2	2

Taxon	Burkes									Kitchener Street									Orari Street									Portobello Road									Macandrew Bay								
	0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Arthropoda																																													
Copepoda										1																																			
Dolichopididae												1																																	
Caprellidae																																	1												
Haustoridae																																	1												
Halicarcinus whitei																												1																	
Cirolanidae																1																													
Heterosquilla tridentata																																												1	
Ostracoda							1																																						
Oedicerotidae																												2																	
Pleoschisma agilis										1																						1													
Scleroconcha													1					1																											
Lysianassidae										1																					1		1												
Diasterope grisea												1			1									1																					
Exosphaeroma																			2		1							1																	
Monocorophium acherusicum										1	1						4		1			1		1			1																		
Gammaridae																					2							8	2																
Paracalliope																				6	12																								
Dexaminidae										3	1								21																										
Phraetogammaridae									2	3			1						25			5		2	1																				
Parasterope quadrata										7	3	12	5		1	3	8	1			1	1		1			2	1			1							1		1					
Amphipoda indet.										9	1		5		8		3		21	3	2		2	2				2			1							1							
Tanaidacea										5	1			1	3	20	19					1	5	3	3		9	1					1												
Phoxocephalidae				1					1	2	1		3	8	11	2	2	3		1		6	1	10	2	7	5				1		1	3	1	1									
Cnidaria																																													
Oulactis muscosa		1																																											
Edwardsia neozelanica	14	20	8	9	5	10	16	8	11				1	2		3		3									1																		1
Echinodermata																																													
Ophiuroidea										1			1																																
Taeniogyrus dunedinensis										2	3	5	1	3																															

Taxon	Burkes									Kitchener Street									Orari Street									Portobello Road									Macandrew Bay								
	0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m			0-5m			5-20m			>50m		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Mollusca																																													
Sigapatella spadicea										1																																			
Amphibola crenata																1																													
Gastropoda indet											1																																		
Xymene plebius															1																														
Michrolenchus											1																																		
Lasaea cf parengaensis						1																																	1						
Retusa oruaensis											1				1																														
Zeacumantus subcarinatus		1										1					1																												
Turbonilla sp.																1	1	1																											
Bivalvia indet										2												1												1											
Linucula recens											1							1																1							1				
Heterobranchia											1		1															2																	
Potamopyrgus estuarinus																			1		1							1	1																
Acanthochitona zelandica												1			1		2																												
Papawera cf. *zelandiae*				3	1											1																													
Notoacmea												4						1																											
Cominella glandiformis		1	3	1	1				1				1	1	1																			1											
Macomona liliana			1					2		4	2	3	3	2	3			3						1		1	1																		
Austrovenus stutchburyi	3	1	3	4	4	4	1	3	4	3	4	6	2	7	4			1				1	1	2		4	1																		
Nucula nitidula			1							8		1	5	9	6	24	20	5						1	5	3	3						1												
Arthritica		2									2	18	1	6	3	9	12	1		2	1				1	1	14	1	4	7	44	1	23	4	3	5					1				
Nematoda																																													
Nematoda										26	21	21	3	5	6		3	4					2	1		1				3	7	5	22	1				2		1	1	1		5	
Nemertea																																													
Nemertea												2		1										1						2					1									1	

Table F-4: One-way ANOVA and Welch ANOVA results for the biological communities at the Otago Harbour, 2025. Significance was determined at the 0.05 alpha (p-value) level, with significant results indicated with bold text. A post-hoc test was conducted if the overall result was considered significant (see Tables F-5, F-6, and F-7). Type corresponds to 'Control' and potential 'Impact' sites; Zones: zones of proximity to the outfall; Sites: statistical test between sites.

	Independent variable	Df	F Value	P value
Infauna	**Type (Welch ANOVA)**	**1**	**31.490**	**< 0.001**
	Site (ANOVA)	**4**	**27.060**	**< 0.001**
	Zone (ANOVA)	2	0.104	0.901
Epifauna	Type (Welch ANOVA)	1	50.476	0.757
	Site (Welch ANOVA)	**4**	**33.513**	**< 0.001**
	Zone (ANOVA)	2	0.699	0.501
Macroflora	**Type (Welch ANOVA)**	**1**	**27.628**	**< 0.001**
	Site (ANOVA)	**4**	**26.690**	**< 0.0001**
	Zone (ANOVA)	2	0.838	0.440

Table F-5: Tukey HSD post-hoc test for Infauna regarding Type and Sites. Bold text indicates statistically significant differences between groups.

Group One	Group Two	p.adj value
Kitchener Street	**Burkes**	**<0.001**
Orari Street	Burkes	0.781
Portobello Road	Burkes	0.399
Macandrew Bay	**Burkes**	**< 0.001**
Orari Street	**Kitchener Street**	**0.020**
Portobello Road	Kitchener Street	0.090
Macandrew Bay	**Kitchener Street**	**< 0.001**
Portobello Road	Orari Street	0.969
Macandrew Bay	**Orari Street**	**< 0.001**
Macandrew Bay	**Portobello Road**	**< 0.001**

Table F-6: Games Howell post-hoc test for Epifauna regarding Type and Sites. Bold text indicates statistically significant differences between groups.

Group One	Group Two	p.adj value
Burkes	**Kitchener Street**	**0.003**
Burkes	Orari Street	0.158
Burkes	**Portobello Road**	**< 0.001**
Burkes	**Macandrew Bay**	**< 0.001**
Kitchener Street	Orari Street	1
Kitchener Street	Portobello Road	0.054
Kitchener Street	**Macandrew Bay**	**< 0.001**
Orari Street	Portobello Road	0.253
Orari Street	**Macandrew Bay**	**0.002**
Portobello Road	**Macandrew Bay**	**0.022**

Table F-7: Tukey HSD post-hoc test for Macroflora regarding Type and Sites. Bold text indicates statistically significant differences between groups.

Group One	Group Two	p.adj value
Burkes	**Kitchener Street**	**0.021**
Burkes	**Orari Street**	**< 0.001**
Burkes	Portobello Road	0.194
Burkes	Macandrew Bay	0.200
Kitchener Street	**Orari Street**	**< 0.001**
Kitchener Street	Portobello Road	0.981
Kitchener Street	**Macandrew Bay**	**0.038**
Orari Street	**Portobello Road**	**0.002**
Orari Street	**Macandrew Bay**	**< 0.001**
Portobello	Macandrew Bay	0.309

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