Boffa Miskell

Ballintines, Stilwells, and Sherrings Waterways

Freshwater Ecology Assessment
Prepared for Christchurch City Council

1 July 2025

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Executive Summary

Christchurch City Council is aware of some proposed future work adjacent to and within Ballintines, Stilwells and Sherrings waterways and Samuel Street Drain. Works may include piping a section of Stilwells Waterway, developing stormwater treatment basins and natural wetlands, and realigning other waterways around some proposed subdivision works. The Council engaged Boffa Miskell to undertake surveys to describe the current ecological values of these waterways to understand opportunities and constraints for future development.

The waterways assessed are highly modified and channelised, with poor habitat conditions at most sites; there was little native riparian vegetation, very high sediment cover, and little habitat diversity available for freshwater species.

The macroinvertebrate communities were dominated by taxa representative of poor-quality habitat and typical of lowland urban waterways, with only a few representatives from the pollution-sensitive or “clean-water” EPT taxa (i.e., caddisflies) present. Additional notable caddisflies were detected by eDNA, but not found in the kick-net samples, including the free-living caddis *Psilochorema* and *Polyplectropus*. A single kākahi / freshwater mussel was found in the lower reaches of Ballintines Waterway.

The freshwater fish community consisted of seven species, six of which are commonly found in Christchurch’s urban waterways: īnanga, common bully, upland bully, giant bully, shortfin eel and longfin eel. Īnanga and longfin eel are both listed as “At Risk - Declining”. It was of great interest to find a single adult banded kōkopu in the upper reaches of Sherrings Waterway. While nationally Not Threatened, this species is locally rare. This is the first time, that we are aware of, this species has been recorded in the upper Ōpāwaho Heathcote River catchment, and there are few records of banded kōkopu elsewhere in Christchurch

We provide recommendations for future activities, and future surveys in these waterways, including:

- waterway naturalisation; removal of the timber-lining along channels where possible, reinstating natural banks and sinuous flow channels, the addition of pools, riffles and in-stream habitat (e.g., cobbles, root balls, undercut banks).
- densely planting the riparian margin (minimum of 10 m wide on each side) with indigenous and ecologically-suitable vegetation, and undertaking weed control
- employing best practice stormwater treatment for future development in the catchment
- undertake targeted surveys of freshwater fish and macroinvertebrate communities in the wider catchment, with a particular focus on banded kōkopu, and *Deleatidium*, *Polyplectropus*, *Psilochorema*, kākahi, kēkēwai.

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1.0 Introduction

The Christchurch City Council (CCC) is aware of some proposed future work, both private developments and Council stormwater projects, in the wider Hendersons Basin. These planned works include Ballintines, Stilwells and Sherrings waterways, and may include piping a section of Stilwells Waterway, developing stormwater treatment basins and natural wetlands, and realigning other waterways around some proposed subdivision works. Council wishes to gather baseline information on current ecological values to understand opportunities and constraints for future development.

Ballintines, Stilwells and Sherrings waterways are utility network waterways that flow in a south-south-east direction, draining from residential areas north of Sparks Road, through mixed-use agricultural land and are tributaries of Cashmere Stream and the Ōpāwaho Heathcote River. These waterways are located east of Hendersons Waterway and Te Kuru Wetland.

This report describes the results of freshwater ecology surveys of Ballintines, Stilwells, and Sherrings waterways undertaken in March and April 2025.

1.1 Scope

The CCC engaged Boffa to conduct freshwater ecology surveys of up to 15 sites within Ballintines, Stilwells, and Sherrings waterways.

The purpose of this report is to:

- Describe the current ecological condition of these waterways, including riparian and in-stream habitat conditions, and the macroinvertebrate and fish communities.
- Discuss the overall ecological health of the sites.
- Provide recommendations regarding constraints and opportunities with respect to proposed future work, both private developments and Council stormwater projects, in Hendersons Basin.
- Provide ecological baseline information for these proposed future works.

2.0 Methods

2.1 Describing general ecological conditions

We completed a 'stream walk' between 14 and 21 March, walking along all accessible lengths of Ballintines[1], Stilwells, and Sherrings waterways, as well as Stilwells Drain Branch, Sherrings Drain Branch, and Sparks Road, and Samuel Street drains. During this walkover we carried out Rapid Habitat Assessments (see Section 2.1.1) each time general habitat conditions changed longitudinally downstream and at selected representative sites where detailed freshwater ecological assessments were completed.

2.1.1 Rapid Habitat Assessment

During the stream walk, we used the Rapid Habitat Assessment (RHA) (Clapcott, 2015) to assess riparian and in-stream habitat conditions along the reach of each waterway. New assessments were undertaken whenever general habitat conditions (e.g., invert lining, substrate composition) markedly changed. The RHA involves ranking each of the following ten parameters between 1 and 10: deposited sediment, invertebrate habitat diversity, invertebrate habitat abundance, fish cover diversity, fish cover abundance, hydraulic heterogeneity, bank erosion, bank vegetation, riparian width, and riparian shade. RHA scores for these individual parameters are summed for each site, giving a total score ranging from 10 to 100, where higher scores indicate better habitat availability.

2.1.1.1 Christchurch River Environment Assessment Survey

The Christchurch River Environment Assessment Survey (CREAS) methodology, as described by McMurtrie and Suren (2008), was used by Boffa Miskell to assess riparian and in-stream habitat conditions, at 50 m intervals, along the length of Ballintines, Stilwells and Sherrings waterways in May 2020. This was part of a separate piece of work commissioned by the CCC and full results of the CREAS have not been provided in this report. The CREAS information has, however, been summarised to report on the:

- General characteristics of the waterways
- Extent of perennial flow
- Presence of springs
- Presence of potential or actual barriers to in-stream fish passage.

[1] The reach of Ballintines Waterway upstream of Sparks Road was only assessed at the intersection with Sparks Road and Samuel Street.

2.2 Freshwater ecology surveys

2.2.1 Site locations

Following the initial stream walk, we (in conjunction with Katie Kerr, CCC's Principal Waterways Ecologist) selected ten sites across Ballintines, Stilwells, Sherrings waterways, and Samuel Street Drain (Table 1, Figure 1). Sparks Road Drain was dry in March 2025, so no sites were located here.

*Table 1. Freshwater ecology survey sites within Ballintines, Stilwells and Sherrings waterways and Samuel Street Drain, surveyed in April 2025. *Site 4 Ballintines u/s Sparks Road had recently been surveyed by InStream Ecology, so only environmental DNA was collected from this site for this study.*

Site number	Site name	Waterway name	Easting NZTM	Northing NZTM
Site 1	Ballintines d/s Cashmere Road	Ballintines Waterway	1567853.0	5175153.9
Site 2	Ballintines u/s Cashmere Road	Ballintines Waterway	1567812.1	5175424.6
Site 3	Ballintines u/s Sherrings Waterway	Ballintines Waterway	1567742.5	5175915.6
Site 4*	Ballintines u/s Sparks Road	Ballintines Waterway	1567569.0	5176433.2
Site 5	Sherrings u/s Sparks Road	Sherrings Waterway	1567227.5	5176170.4
Site 6	Sherrings d/s Sparks Road	Sherrings Waterway	1567403.1	5175955.0
Site 7	Sherrings u/s Ballintines Waterway	Sherrings Waterway	1567654.2	5175715.8
Site 8	Stilwells d/s Ballintines Waterway	Stilwells Waterway	1567899.0	5175752.7
Site 9	Stilwells u/s Blakiston Drain	Stilwells Waterway	1568233.0	5175801.6
Site 10	Stilwells d/s Northaw Street	Stilwells Waterway	1568218.4	5176053.2
Site 11	Samuel Street Drain u/s Sparks Road	Samuel Street Drain	1567929.6	5176255.7

At each of the ten sites listed above and shown in Figure 1, assessments of riparian and in-stream habitat (including periphyton and macrophyte) conditions, and the macroinvertebrate and fish communities, were completed during base-flow conditions (i.e., no sooner than 7 days of a heavy rainfall event, and no less than 3 weeks after a bed-moving flood event) between 7 and 28 April 2025.

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Data Sources: BML, Christchurch City Council.
Basemap: Eagle Technology, LINZ

Projection: NZGD 2000 New Zealand Transverse Mercator

BALLINTINES STILWELLS SHERRINGS WATERWAYS ASSESSMENT

Date: 12 June 2025 | Revision: 0

Plan prepared for Christchurch City Council by Boffa Miskell Limited

Project Manager: Tanya.Blakely@boffamiskell.co.nz | Drawn: LJa | Checked: TBl

Figure 1: Survey site locations, April 2025. Direction and proportion of flow is shown by arrows and line weighting.

2.2.1 Attribute target levels and guidelines

Ballintines, Stilwells and Sherrings waterways, and Samuel Street Drain are spring-fed and / or stormwater-fed waterways, and tributaries of Cashmere Stream and Ōpāwaho Heathcote River. These waterways are not classified in Environment Canterbury's Land and Water Regional Plan (LWRP) or the CCC's Comprehensive Stormwater Network Discharge Consent (CSNDC for Ōtautahi Christchurch City and Te Pātaka o Rakaihautū Banks Peninsula). They are classified as utility waterways under the Christchurch District Plan maps.

The CCC's CSNDC compares Cashmere Stream against the LWRP's freshwater outcomes and guidelines for Banks Peninsula streams. While the freshwater outcomes for Ōpāwaho Heathcote River are compared to the LWRP's freshwater outcomes and guidelines for spring-fed – plains – urban waterways. While Ballintines Waterway is a tributary of Cashmere Stream, we consider it to be overly conservative to compare this waterway to outcomes and guidelines for Banks Peninsula streams.

We have considered Ballintines, Stilwells and Sherrings waterways and Samuel Street Drain as 'spring-fed – plains – urban waterways for this report. We use these guidelines and the Attribute Target Levels from the Environmental Monitoring Programme for the CSNDC (Christchurch City Council, 2025), the national bottom line values from the National Policy Statement for Freshwater Management (NPS-FM) (Ministry for the Environment, 2014), and guidelines from the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC, 2000).

2.2.2 Habitat conditions

2.2.2.1 Water quality

Spot measures of standard water quality parameters were taken at each site using a handheld YSI multi-parameter water-quality meter. Parameters measured were: specific conductivity (µS / cm), pH, dissolved oxygen (mg / L and % saturation), and water temperature (°C).

2.2.2.2 Riparian and in-stream habitat

The percent composition of different flow habitats (i.e., riffle, run or pool) was estimated for each site.

At each site, three transects, spaced at 10 m intervals, were established across the waterway, where the downstream most transect was located at the co-ordinates provided in Table 1. Canopy cover (%), bank erosion (%), extent of undercut bank (cm) and overhanging vegetation (cm) (if present), percent of bank with vegetation cover, bank slope (degrees), bank height (cm), type of bank material, types of riparian vegetation, and the surrounding land-use were recorded for the true left (TL) and true right (TR) banks, separately, at each of the three transects across each site.

Total wetted width (m) was recorded at each of the three transects. An average wetted width was calculated from these three measures for each site. Water velocity was measured at each of the three transects, using a Seba Current Meter c/w counter and wading rods, where:

Velocity[2] *= (S * r.p.s) + C,*

At each of five locations (TL bank, 25%, 50%, 75%, and TR bank) along each of the three transects (at each site) the following parameters were also measured:

- Water depth (cm)
- Soft sediment depth (cm)
- Embeddedness (%)
- Substrate composition (%)
- Macrophyte depth (cm), percent cover, type (submerged or emergent), and dominant species present
- Percent cover and type of organic material (leaves, moss, coarse woody debris)
- Percent cover and type of periphyton.

Embeddedness is a measure of the degree to which larger substrates are surrounded by fine particles, and therefore, an indication of the clogging of interstitial spaces.

Soft sediment depth was determined by gently pushing a metal wading rod (10 mm diameter) into the substrate until it hit the harder substrates underneath.

Substrate composition was measured within an approximately 20 x 20 cm quadrat at each of the five locations along the three transects. Within each quadrat, the percent composition of the following sized substrates was estimated: silt / sand (<2 mm); gravels (2-16 mm); pebbles (16-64 mm); small cobbles (64-128 mm), large cobbles (128-256 mm), boulders (256-4000 mm), and bedrock / concrete / artificial hard surfaces (>4000 mm) (modified from Harding et al., 2009).

2.2.2.3 Sediment quality

Surface sediment was collected by scraping along the surface (top 2-3 cm) of the waterway bed with a sample container (prepared collection jar provided by Hills Laboratory). Water was drained off the collected samples and each sample jar was kept cold before transporting to Hill Laboratories, an International Accreditation New Zealand (IANZ) laboratory. Hill Laboratories conducted the following analyses (Table 2), all of which are IANZ accredited, except for total organic carbon (TOC).

Total polycyclic aromatic hydrocarbons (PAHs) were calculated by summing the PAHs analysed. Total PAHs were normalised to 1% TOC, as recommended in ANZECC (2000), before comparison to the guidelines. Where one or more PAH compound was below the detection limit, half the detection limit was used in the calculation. This method is consistent with the approach used in many reports of sediment quality in waterways (e.g., NIWA, 2015).

[2] *S* = slope specific to the propeller used; *r.p.s* = revolutions per second as determined by the count meter; and *C* = constant.

Table 2. Analysis conducted by Hill Laboratories on sediment samples collected from survey sites in 2025.

Test	Method description	Reference
7 grain sizes profile	Wet sieving, gravimetric analysis	N/A
Total recoverable arsenic, cadmium, chromium, copper, lead, nickel, and zinc	Air dried at 35°C and sieved, <2 mm fraction. Nitric / hydrochloric acid digestion, ICP-MS, screen level.	US EPA 200.2
Total organic carbon (TOC)	Air dried at 35°C and sieved, <2 mm fraction. Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	N/A
Total recoverable phosphorus (TP)	Air dried at 35°C and sieved, <2 mm fraction. Nitric / hydrochloric acid digestion, ICP-MS, screen level.	US EPA 200.2
Organochlorine Pesticide traces	Sonication extraction, GC-ECD analysis.	US EPA 8081
Acid Herbicide traces	Sonication extraction, LC-MS/MS analysis.	US EPA 3550
Polycyclic aromatic hydrocarbons (PAHs)	Air dried at 35°C and sieved, <2 mm fraction. Dried at 103°C for 4-22 hr, sonication extraction, SPE cleanup, GC-MS SIM analysis.	US EPA 3540, 3550 & 3630.

2.2.3 Macroinvertebrate community

The macroinvertebrate community was assessed at each site from the same survey reach as habitat conditions were measured. Macroinvertebrates (e.g., insects, snail and worms that live on the stream bed) can be extremely abundant in streams and are an important part of aquatic food webs and stream functioning. Macroinvertebrates vary wildly in their tolerances to both physical and chemical conditions, and are therefore used regularly in biomonitoring, providing a long-term picture of health of a waterway.

A single and extensive composite kick-net (500 µm mesh) sample was collected from each site in accordance with protocols C1 and C2 of Stark et al. (2001). That is, each kick net sampled approximately 0.3 m x 2.0 m of stream bed, including sampling the variety of microhabitats present (e.g., stream margin, mid channel, undercut banks, macrophytes) to maximise the likelihood of collecting all macroinvertebrate taxa present at a site, including rare and habitat-specific taxa.

Macroinvertebrate samples were preserved, separately, in 70% ethanol prior to sending to Boffa Miskell's suitably qualified taxonomy provider. Macroinvertebrates were identified and counted in accordance with Protocol P2 (200+ count with scan for missed taxa) (Stark et al., 2001[3]), identifying to "MCI level".

[3] This Protocol P2 method is the same as the laboratory method of the National Environmental Monitoring Standard (NEMS) for macroinvertebrates.

2.2.4 Fish community

The fish community was surveyed within a (minimum) reach of 30 m in length or 30 m^2 in area, using either electric fishing or trapping and netting techniques. The area fished overlapped with the reach where the habitat conditions and macroinvertebrate community was assessed. The habitat assessments and macroinvertebrate community sampling were conducted at least three days prior to the fish survey.

A number of factors, including soft-sediment depth, macrophyte cover, water velocity and water depth were taken into consideration when determining the most appropriate fish surveying technique to use.

Electric fishing: the fish community at Sites 1, 8, 9, and 11 was assessed using a single pass with a Kainga EFM 300 backpack mounted electric-fishing machine (NIWA Instrument Systems, Christchurch). Fish were captured in a downstream push net or in a hand (dip) net and temporarily held in buckets. All fish were then identified, counted, and measured (length, to the nearest 5 mm) before being returned alive to the stream.

Trapping and netting: Electric fishing techniques were not a safe, or an appropriate method for sampling at Sites 2, 3, 5, 6, or 7. Two fine-mesh fyke nets (baited with tinned cat food) and five Gee minnow traps (baited with marmite), were set late in the afternoon and left overnight at each of these sites. The following morning, all fish captured were identified and measured (length, to the nearest 5 mm) before being returned alive to the stream.

No fish surveys were undertaken at Sites 4 or 10. Site 4 had been recently surveyed (InStream Consulting Ltd, 2024), and Site 10 did not have sufficient water depth for either electric-fishing or trapping and netting.

Assessments of the fish community were conducted in accordance with Boffa Miskell's Special Permit from the Ministry for Primary Industry (pursuant to section 97(1) of the Fisheries Act 1996.

2.2.5 Environmental DNA

We also sampled the environmental DNA (eDNA) in surface water at each site, which gave us additional information on the macroinvertebrate and fish communities present. We collected six replicate syringe samples from each of the 10 survey sites, as well as from Site 4. Samples were sent to Wilderlab NZ Ltd in Wellington and the eDNA present recorded using the basic multispecies assay.

eDNA is regularly used to supplement more standard freshwater survey methods, providing an overview of the species or taxa present in a waterbody. However, the likelihood of detection of species can be influenced by the abundances of species (i.e., when in extremely low abundances, detection via eDNA may be difficult). For this study, we considered eDNA a useful additional technique to increase the chances of establishing the presence of macroinvertebrate and fish species with high conservation value or species that are often difficult to detect with standard sampling methods (e.g., kanakana / lamprey, kākahi / freshwater mussels, and kēkēwai / freshwater crayfish).

2.3 Desktop review

In addition to gathering the above information during field surveys, we explored readily available ecological information from the following sources:

- GIS (spatial) databases and aerials, including:
    - Waterways (river centre lines) shown on New Zealand Topographical Maps
- Existing information on freshwater fish species within or nearby the Site:
    - The NIWA-administered New Zealand Freshwater Fish database (NZFFD) holds records of freshwater fish distributions and occurrences based on previous surveys.
    - The conservation status of fish species found in the NZFFD records was assessed based on the most recent conservation threat status for New Zealand's freshwater fish (Dunn et al., 2018).
    - The NIWA-administered Fish Passage Assessment Tool webpage, which holds records of in-stream structures and relevant fish passage assessments.
- CCC's *Wetland Assessment: Sparks, Hendersons Road* 2025 report, prepared by Nicholas Head of Christchurch City Council.
- InStream Consulting Ltd's 2024 report on *Ballintines Drain Ecology*, prepared for Christchurch City Council, was used to supplement the eDNA sample collected from Site 4. No other ecological assessments were done at Site 4 in this study.

2.4 Data analyses

2.4.1 Water quality

Water quality parameters were compared to the Freshwater Outcomes indicator values as set out in the LWRP and the CSNDC Environmental Monitoring Programme.

2.4.2 Habitat conditions

Where parameters were measured at five locations across each of the transects (i.e., water depth, sediment depth, embeddedness, and macrophyte and periphyton cover), these were averaged to give a mean value for each transect.

A substrate index (SI) was calculated from the five replicate substrate composition measures taken along each transect. These values were then averaged, to give a mean SI for each transect. The SI was calculated using the formula (modified from Harding et al., 2009):

SI = (0.03 x %silt / sand) + (0.04 x %gravel) + (0.05 x %pebble) + (0.06 x (%small cobble + %large cobble)) + (0.07 x %boulder)

The calculated SI can range between 3 and 7, where an SI of 3 indicated 100% silt / sand and an SI of 7 indicated 100% boulders. That is, the larger the SI, the coarser the substrate and the better the habitat for macroinvertebrate and fish communities. Finer substrates generally provide poor, and often unstable, in-stream habitat, and smother food (algal) resources and macroinvertebrates inhabiting the waterway.

Wetted width was measured once at each of the three transects. These values were averaged to give a mean wetted width (m) for each site.

2.4.3 Macroinvertebrate community

The following macroinvertebrate metrics[4] were calculated from each kick-net sample, to provide an indication of stream health:

- Total abundance – the total number of individuals collected in the composite kick-net sample collected at each site. Macroinvertebrate abundance can be a good indicator of stream health, or ecological condition, because abundance tends to increase in the presence of organic enrichment, particularly for pollution-tolerant taxa (e.g., chironomid midge larvae and oligochaete worms).
- Taxonomic richness – the total number of macroinvertebrate taxa recorded from the composite kick-net sample collected at each site. Streams supporting high numbers of taxa generally indicate healthy communities, however, the pollution sensitivity / tolerance of each taxon needs to also be considered.
- EPT taxonomic richness – the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) from the composite kick-net sample collected at each site. These three insect orders (EPT) are generally sensitive to pollution and habitat degradation and therefore diversity of these insects provides a useful indicator of degradation. High EPT richness suggests high water quality, while low richness indicates low water or habitat quality.
- EPT taxonomic richness (excl. hydroptilids) – the total number of EPT taxa excluding the Hydroptilidae. The algal piercing caddisflies belonging to the family Hydroptilidae are generally considered more tolerant of degraded conditions than other EPT taxa. Excluding hydroptilid caddisflies from the EPT metric is a more conservative approach and more accurately represents the “clean-water” EPT taxa.
- %EPT richness – the total abundance of macroinvertebrates that belong to the pollution-sensitive EPT orders, relative to the total abundance of all macroinvertebrates found in the composite kick-net collected at each site. High %EPT richness suggests high water quality.
- %EPT richness (excl. hydroptilids) – the percentage abundance of EPT taxa at each site, excluding the more pollution-tolerant hydroptilid caddisflies.
- Macroinvertebrate Community Index (MCI) – this index is based on tolerance scores for individual macroinvertebrate taxa found in hard or soft-bottomed streams (Stark 1985, Stark and Maxted 2007). These tolerance scores, which indicate a taxon’s sensitivity to in-stream environmental conditions, are summed for the taxa present in a sample, and multiplied by 20 to give MCI values ranging from 0-200. Table 3 provides a summary of how MCI scores were used to evaluate stream health.
- Quantitative Macroinvertebrate Community Index (QMCI) – this is a variant of the MCI, which instead uses abundance data. The QMCI provides information about the

[4] Sites 1 and 9 were considered hard-bottomed sites, while sites 2-8 and 10-11 were considered soft-bottomed sites.

dominance of pollution-sensitive species in hard or soft bottomed streams. Table 3 provides a summary of how MCI-hb and QMCI-hb scores were used to evaluate stream health

- Average Score Per Metric (ASPM) – this index aggregates MCI, EPT richness (excl. hydroptilids), and %EPT abundance (excl. hydroptilids).

Table 3. Interpretation of MCI-hb and QMCI-hb scores for soft- bottomed streams (Stark & Maxted, 2007).

Stream health	Water quality descriptions	MCI	QMCI
Excellent	Clean water	>119	>5.99
Good	Doubtful quality or possible mild enrichment	100-119	5.00-5.90
Fair	Probable moderate enrichment	80-99	4.00-4.99
Poor	Probable severe enrichment	<80	<4.00

Note, the MCI and QMCI were developed primarily to assess the health of streams impacted by agricultural activities and should be interpreted with caution in relation to urban systems.

2.4.4 Fish community

To account for the inevitable differences in areas sampled at each site, fish catches were converted into catch per unit effort (CPUE). Electric fishing data were converted to number of fish captured per 100 m^2 of stream surveyed; trapping data were presented as number of fish captured per trap, per night.

3.0 Results

3.1 General ecological conditions

Ballintines, Stilwells, and Sherrings waterways and Samuel Street Drain are small spring- / stormwater-fed systems. Historically, the area would have been a mosaic of slow-flowing lowland streams meandering through wetlands and swamps. The catchment has since been extensively modified into agricultural and, more recently, urban areas through draining wetlands and channelising / straightening waterways.

Within the Hendersons Basin (i.e., between Sparks, Hendersons, and Cashmere roads) waterways flow through mixed-use rural farmland prior to entering Cashmere Stream or Ōpāwaho Heathcote River. Land around the upper reaches of the waterways is predominantly residential land use.

3.1.1 Ballintines Waterway

The headwater of Ballintines Waterway is a piped reach under Hoon Hay Park, upstream of Sparks Road. There is a spring noted in the 3-Waters Network Asset map, immediately upstream of Kevin Street. From Hoon Hay Park, Ballintines Waterway flows south for approximately 650 m through residential areas until Sparks Road. This reach, from Hoon Hay Park to Sparks Road, was timber lined and channelised. Downstream of Sparks Road, Ballintines Waterway remained channelised but banks were no longer timber-lined; the riparian margin was dominated by farmland.

When Ballintines Waterway converges with Stilwells and Sherrings waterways, the flow directions are somewhat complex (Figure 1). Based on our site observations, the majority of surface water from Ballintines Waterway flows east into Stilwells Waterway and to Ōpāwaho Heathcote River (via a short, piped section of Blakiston Drain).

The lower reach of Ballintines Waterway, which carries flow from Sherrings Waterway and some flow from Ballintines Waterway, is c.530 m through farmland where the majority has unlined banks. Approx. 200 m upstream of Cashmere Road the banks are either timber- or rock-lined. The short (approx. 100 m) section downstream of Cashmere Road through residential properties had either earth or rock-lined banks before discharging to Cashmere Stream.

In 2020, Boffa Miskell assessed riparian and in-stream habitats along Ballintines Waterway using the CCC's CREAS methodology. Thirty-six CREAS sites were located along Ballintines Waterway. During our site walk-over in March 2025, we assessed riparian and in-stream habitats following the RHA methodology. We completed 13 RHA assessments along Ballintines Waterway from Sparks Road to Cashmere Stream, where RHA was completed each time key habitat parameters changed.

When comparing CREAS from 2020 and RHA from this study, the riparian and in-stream habitat conditions are similar. In the lower reaches, just upstream from the confluence with Cashmere Stream, there were areas of riffle habitat, undercut banks, and larger substrates (e.g., gravels, cobbles, boulders) – providing a variety of fish and invertebrate habitat. Upstream of this reach to Spark Road, habitat quality was moderate (with RHA's ranging from 33 to 48, out of a possible 100) (Figure 3). Moderate scores were driven by stable banks, and relatively high shading of the waterway. There was often very high cover of fine sediments, and low diversity of in-stream habitats (i.e., no woody debris, overhanging vegetation, or variety of flow habitats). When considering the results of InStream Consulting (2024) and CREAS 2020 data, habitat upstream of Sparks Road was generally poor, driven by low hydraulic heterogeneity, low habitat abundance and high fine sediment cover. Notably, InStream Consulting (2024) scored invertebrate habitat diversity higher in some sections compared to our RHA assessments downstream. This suggests variability in the diversity of substrates within Ballintines Waterway (i.e., larger substrates, woody debris, or root mats may be present upstream).

Four sites along Ballintines Waterway were surveyed, including downstream near the confluence with Cashmere Stream (Site 1), the middle reach (Site 2), upstream of its confluence with Stilwells and Sherrings waterways (Site 3), and upstream of Sparks Road (Site 4).

Site 1: Ballintines Waterway downstream of Cashmere Road

Site 1 was located 8 m upstream of Brookford Place, upstream of the confluence with Cashmere Stream. Here, the riparian margin was bound by residential gardens, with exotic shrubs and some native plantings (e.g., harakeke, fern, hebe). The larger stature vegetation provided <85% canopy cover to the waterway (Photo 1). There was no overhanging vegetation, but banks were lined with larger boulders in places, which created small areas of in-stream habitat diversity from undercut banks (7 cm on the true left bank (TLB), 2 cm on the true right bank (TRB). Banks were unstable in places, with erosion >70% on both banks.

The waterway at Site 1 was 1.8 m wide and 11.7 cm deep with an average velocity of 0.57 m / s. The stream bed substrates were dominated by fine silt (43%) and gravels (20%). Larger substrates (e.g., cobbles, boulders) were present, but covered by fine sediments. Embeddedness at Site 1 was 46%. Sediment depth at this site was relativity low, averaging 7.6 cm deep. Organic matter (sticks, leaf litter) was moderate this this site (14.1%). Macrophyte cover was low (6.1%), dominated by *Nitella hookeri*, with *Elodea canadensis* (Canadian pondweed), *Potamogeton crispus* (curly-leaf pondweed), and *Lemna minor* (floating duckweed) also present.

Photo 1: Site 1 - Ballintines Waterway downstream of Cashmere Road, looking downstream (left) and upstream (right).

Site 2: Ballintines Waterway upstream of Cashmere Road

Site 2 was located 320 m downstream of the confluence of Stilwells and Sherrings waterways. Here, the waterway was 3.6 m wide and 26.7 cm deep, with a velocity of 0.09 m / s. The riparian margin was dominated by paddock grass on the true left bank, and deciduous exotic trees (hawthorn) on the true right bank. The trees extended over the waterway, proving 80% canopy on the true right bank, and 15% cover on the true left of the waterway. The paddocks around the waterway appear to have been retired from use for livestock. Banks at this site were steep (>75°), and relatively high (>100 cm). Erosion was high on the true right bank (50%) and very high on the true left bank (90%) (Photo 2).

The stream bed substrates were dominated by fines silt (100%), with an average substrate index (SI) of 3. Sediment depth at this site was moderate, averaging 42.0 cm deep. Organic matter was present at this site and dominated by leaf litter (10.7%). Macrophyte cover was moderate (44%), dominated by *Nitella*, Canadian pondweed, and curly-leaf pondweed.

Photo 2: Site 2 – Ballintines Waterway upstream of Cashmere Road, looking downstream (left) and upstream (right)

Site 3: Ballintines Waterway upstream of Sherrings Waterway

Site 3 was located 180 m upstream of the confluence with Sherrings Waterway. Here, the waterway was relatively similar to Site 2, wetted width was 3.1 m wide and 34.3 cm deep, with a velocity of 0.12 m / s. The riparian margin was dominated by paddock grass on the true left bank, and deciduous exotic trees (hawthorn) on the true right bank (Photo 3). There was no canopy cover on the true left, but vegetation on the true right provided 83% cover. Banks at this site were steep (90°), relatively high (>95 cm) and had some areas of instability / active erosion (25% TLB, 13% TRB).

The stream bed substrates were dominated by fine silt (100%), with an average SI of 3. Sediment depth at this site was high, averaging 71.6 cm. Organic matter was present at this site, but in low cover (9.7%), dominated by sticks and leaves. Macrophyte cover was high (60%), dominated by *Nitella*, Canadian pondweed, and curly-leaf pondweed.

Photo 3: Site 3 – Ballintines Waterway upstream of Sherrings Waterway, looking downstream (left) and upstream (right)

Site 4: Ballintines Waterway upstream of Sparks Road

Site 4 was located upstream of Sparks Road and immediately upstream of Samuel Street. We did not carry out habitat assessments in this 2025 survey, as InStream Consulting (2024) had a recent survey site in this reach of Ballintines Waterway; there was also a 2020 CREAS survey point located where we located Site 4. Based on site observations, and photos from the CREAS in 2020, the waterway channel was confined by stable timber-lined banks, and the stream bed was dominated by high cover of fine sediment, with some larger substates present (e.g., cobbles, bricks) (Photo 4).

RHA assessments undertaken by Instream (2024) in the waterway section that included this site showed a moderate habitat score (RHA score of 31.5-40.5). Habitat was limited by low hydraulic heterogeneity, low shading, narrow riparian widths, low habitat abundance and high fine sediment cover. However, the site did have highly stable banks (timber-lined), and some in-stream habitat diversity (e.g., larger substrates).

Photo 4: Site 4 – Ballintines Waterway upstream of Sparks Road, looking downstream (left) and upstream (right).

3.1.2 Stilwells Waterway

Stilwells Waterway is comprised of two timber-lined branches, a north-south oriented branch and an east-west oriented branch. The north-south branch stems from a piped reach at Rydal Street, flowing south approx. 400 m before joining the east-west branch. The east-west branch begins at the confluence of Ballintines and Sherrings waterways, appearing to receive flow from both waterways (Figure 1). From the confluence with Ballintines and Sherrings waterways, the east-west branch of Stilwells Waterway flows for 490 m, collects flow from the north-south branch, and continues east into Blakiston Drain, which is piped to Ōpāwaho Heathcote River.

Ten sites were assessed along Ballintines Waterway during the 2020 CREAS survey (only in the east-west branch). During our site walk-over in 2025, we undertook 7 RHA assessments. The east-west reach of the waterway appears similar between 2020 CREAS surveys and our assessments, with highly stable banks, homogenous flow habitat and a stream bed dominated by fine sediments. The downstream reach of the east-west branch, while still dominated by fine sediments, had areas of larger substrates (e.g., gravels, cobbles). Habitat in this branch was moderate (RHA score of 33-42) (Figure 3).

The north-south branch had only intermittent pools interspersed with sections of dry bed, with the stream bed dominated by fine sediments and some isolated areas of larger cobbles and broken pieces of concrete. The stream bed where the north-south branch joins the east-west branch was dominated by gravels and cobbles, however, these were covered by a layer of fine sediment. Habitat in the north-south branch was generally poor-moderate (RHA score of 23-29).

Three sites were located along Stilwells Waterway, including near the confluence with Ballintines and Sherrings waterways(upstream of Stilwells Drain Branch) (Site 8), upstream of where it discharges into Blakiston Drain (Site 9), and in the north-south oriented branch (Site 10).

Site 8: Stilwells Waterway downstream of Ballintines Waterway

Site 8 was located 130 m downstream of the confluence with Ballintines and Sherrings waterways. Here, the waterway was channelised with timber-lined banks (Photo 5). The riparian margin was bound by paddocks, with bare earth and grass on the true left bank, and gorse and harakeke flax on the true right. The larger stature harakeke provided some canopy cover on the TLB (30%), but due to the timber lining, overhanging vegetation was absent from this site. Undercut banks were also absent from this site, however, gaps between the lower slats of the timber walls may provide some habitat.

The channel at Site 8 was 1.5 m wide with an average water depth of 48.6 cm, the deepest of all sites. The stream bed substrate was dominated by fine silt (100%). Sediment depth at this site was moderate, averaging 43.5 cm deep. Leaf litter was very low this this site (0.3%). Macrophyte cover was very high (97.3%), dominated by Canadian pondweed.

Photo 5: Site 8 – Stilwells Waterway downstream of Ballintines Waterway, looking downstream (left) and upstream (right).

Site 9: Stilwells Waterway upstream of Blakiston Drain

Site 9 was located 25 m upstream of the confluence with Blakiston Drain. Here, the waterway, was bound by narrow (<2 m), relatively unvegetated riparian margins (Photo 6). Vegetation in the immediate riparian margins was sparse (appearing to have been recently sprayed), with some exotic shrubs present, and low cover of grass. The surrounding paddocks were dominated by mown grass.

The channel at Site 9 bound by concrete lining, averaging 1.5 m wide and 23.5 cm deep. The stream bed substrates were dominated by fine silt (60%) and pebbles (20%). Larger substrates (e.g., cobbles) were present, but covered by a thin layer of fine sediments (i.e., silt / sand). Embeddedness at Site 9 was 55%, but sediment depth at this site was low, averaging 3.8 cm deep. Leaf litter was very low this this site (1.8%). Macrophyte cover was moderate (35%), dominated by *Nitella* and Canadian pondweed.

Photo 6: Site 9 – Stilwells Waterway upstream of Blakiston Drain, looking downstream (left) and upstream (right).

Site 10: Stilwells Waterway downstream of Northaw Street

Site 10 was located 154 m downstream of Northaw Street. Here, the freshwater habitat was limited to an isolated pool, which extended only a short distance (1.67 m in length). Water depth was shallow, averaging 3 cm in the isolated pool. Noting at the downstream two transects there was no surface water present, so average water depth across the site was 0.9 cm. We could not measure velocity at this site. The stream bed substrates were dominated by fine silt, with an average SI of 3. Sediment depth at this site was moderate 14.5 cm deep. Leaf litter was marginal this site (10.3%), and woody debris were absent. Macrophyte cover was low (2.9%), dominated by *Callitriche stagnalis* (starwort). Filamentous algae were present, in moderate abundance (32%).

The riparian margin was very narrow on both banks (i.e., <0.5m), bound by tall residential fencing on the true left and fenced paddock on the true right. This narrow margin was dominated by bare earth, grass, and low stature weeds. Canopy cover and overhanging vegetation was absent from this site (Photo 7).

Photo 7: Site 10 – Stilwells Waterway downstream of Northaw Street, looking downstream (left) and upstream (right)

3.1.3 Sherrings Waterway

The headwater of Sherrings Waterway is a piped reach under Hoon Hay Park, upstream of Sparks Road. From Hoon Hay Park, Sherrings Waterway flows south for approximately 430 m through residential areas until Sparks Road. This reach was channelised, with highly incised, steep, unstable earth banks. There was one notable section of tin-lined bank at the upper extent of the waterway, just downstream of McCarthy Street. Downstream of Sparks Road, Sherrings Waterway remained channelised but bank height became much lower, and the riparian margin was dominated by farmland.

Sherrings Waterway flows for 530 m until it converges with Ballintines and Stilwells waterways. At the confluence, the majority of flow from Sherrings Waterway appears to head south into Ballintines Waterway, but some flow continues east with the majority of flow from Ballintines Waterway into Stilwells Waterway (Figure 1).

Thirty-six CREAS sites were located along Sherrings Waterway, and we completed 17 RHA assessments during our site walk-over in March 2025. When comparing data and images from CREAS 2020 with the RHA data, the waterway appears similar between the assessment periods, with homogenous flow habitat, low cover of indigenous riparian vegetation, and high cover of fine sediment. The upper reach of Sherrings Waterway had large stature, densely planted riparian vegetation, providing high canopy cover. In-stream cover of organic matter, including larger woody debris was also high in this upper reach. The presence of exotic deciduous trees provided shading to the waterway, however, these trees also bring high seasonal inputs of leaf litter. In the lower reach of Sherrings Waterway, downstream of Sparks Road, riparian vegetation of lower banks were dominated by paddock grass, poplars and willows. Overall, riparian and in-stream habitat conditions were generally moderate (RHA score of 28-46), limited by high bank erosion, high cover of fine sediments, and low in-stream habitat heterogeneity (Figure 3).

We selected three sites along Sherrings Waterway, including upstream of the confluence of Ballintines Waterway (Site 7), the middle reach (Site 6), and upstream of Sparks Road (Site 5).

Site 7: Sherrings Waterway upstream of Ballintines Waterway

Site 7 was located 110 m upstream of the confluence with Ballintines Waterway. Here, the waterway was 3.1 m wide, with an average water depth of 28.6 cm and an average velocity of 0.2 m / s. The stream bed substrates were dominated by fine silt (100%), with an average sediment depth of 103.3 cm. Organic matter was a mix of leaf litter and woody debris and was relatively high this this site (21.3%). Macrophyte cover was low (7%), dominated by Canadian pondweed and curly-leaf pondweed.

The riparian margin was bound by paddocks, which appeared to be retired from livestock. Vegetation was dominated entirely by long grass on the true right bank, and deciduous exotic trees on the true left bank (i.e., poplar, hawthorn, willow). These exotic trees provided 73% canopy cover to the TLB, and 6% to the TRB. Bank height was relatively low at this site (>70 cm), and banks on both sides were unstable with >80% erosion. Overhanging vegetation and undercut banks were absent from this site (Photo 8).

Photo 8: Site 7 – Sherrings Waterway upstream of Ballintines, looking downstream (left) and upstream (right).

Site 6: Sherrings Waterway downstream of Sparks Road

Site 6 was located 75 m downstream of Sparks Road. Here, the waterway was similar to Site 7, with an average width of 2.8 m wide and an average water depth of 20.9 cm. However, average velocity was relatively low, 0.06 m / s. The stream bed substrates were dominated by fine silt (100%), with an average sediment depth of 76.4 cm. Organic matter was a mix of leaf litter and woody debris and was high this this site (68.3%). Macrophyte cover was moderate (14%), dominated by *Nitella*.

The riparian margin was bound by paddocks, which appeared to be retired from livestock. Bank height was relatively low at this site (>80 cm), and banks on both sides were unstable with >60% erosion. Vegetation was dominated entirely by long grass on the true right bank (providing just 6% shade), and grass and deciduous poplar trees on the true left bank, providing 50% shade to the waterway. Overhanging vegetation and undercut banks were absent from this site (Photo 9).

Photo 9: Site 6 – Sherrings Waterway downstream of Sparks Road, looking downstream (left) and upstream (right).

Site 5: Sherrings Waterway upstream of Sparks Road

Site 5 was located 180 m upstream of Sparks Road. Here, the waterway was slightly narrower at 1.9 m wide, with 26.5 cm of water depth and a velocity of 0.15 m / s. Banks at this site were steep (>80°), high (>105 cm) and unstable with erosion <90% on both banks. The riparian margin (residential gardens) was dominated by deciduous exotic trees, bare earth, and low stature weeds. Canopy cover was high, 90%, on both banks (Photo 10).

The stream bed substrate was dominated by fine silt (100%), with an average SI of 3. Sediment depth at this site was moderate, averaging 75.6 cm deep. Organic matter was present at this site and dominated by leaf litter and larger woody debris (54.7%). Macrophyte cover was relatively low (14%), dominated by *Nitella*.

Photo 10: Site 5 – Sherrings Waterway upstream of Sparks Road, looking downstream (left) and upstream (right)

3.1.4 Other watercourses

Sparks Road Drain runs parallel to Sparks Road before entering Ballintines Waterway. **Stilwells Drain Branch** flows parallel to Ballintines Waterway from Sparks Road into the east-west branch of Stilwells Waterway. **Sherrings Drain Branch** runs parallel to Sparks Road before entering Sherrings Waterway downstream of Sparks Road. All three of these watercourses were dry during our walk over (Figure 1; Appendix 1).

Samuel Street Drain stems from a piped reach under Gainsborough Street, where it then flows south through residential areas for approximately 150 m to Sparks Road. From here, CCC waterway maps suggest Samuel Street Drain then flows west under Sparks Road before joining Stilwells Drain Branch or Sparks Road Drain and then Ballintines Waterway.

Samuel Street Drain as not assessed during the 2020 CREAS survey, but during our site walk-over we undertook three RHA assessments. Overall, riparian and in-stream conditions were variable across reaches of the waterways but were generally of fair habitat quality (ranging from 26 to 41 out of a possible 100). Moderate scores were driven by stable banks, and relatively high shading of the waterway (from the timber lining and tall fences). Similar to the other waterways, habitat was limited by high fine sediment cover, low shading, and low availability of a variety of fish and invertebrate habitat (i.e., woody debris, overhanging vegetation, undercut banks, riffles in the river).

One site was selected along Samuel Street Drain, upstream of Sparks Road (Site 11).

Site 11: Samuel Street Drain upstream of Sparks Road

Site 11 was located 17 m upstream of Sparks Road. Here, the waterway was 1.5 m wide and 5.7 cm deep (Photo 11). Undercut banks were absent from this site, with the waterway confined to the timber-lined channel. However, gaps between the lower slats of the timber walls may provide some habitat for freshwater fishes, particularly for smaller eels. There was a very narrow (<0.5 m) riparian margin, bound by residential fences. Vegetated cover in this margin was minimal, with c.8% cover of grass and weeds, with sparse large exotic trees overhanging the fences at the upper extent of the site.

Leaf litter was marginal this this site (6.9%), and woody debris were absent. Macrophyte cover was high (62%), dominated by *Nitella* and starwort. Macrophyte depth averaged 4.4 cm, meaning there was very little free water. Accordingly, we could not measure velocity at this site. The stream bed substrates were dominated by fine silt, with an average SI of 3. Sediment depth at this site was high, averaging 108.2 cm deep.


Photo 11: Site 11 – Samuel Street Drain upstream of Sparks Road, looking downstream (left) and upstream (right).

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Data Sources: BML, Christchurch City Council.
Basemap: Eagle Technology, LINZ

Projection: NZGD 2000 New Zealand Transverse Mercator

BALLINTINES STILWELLS SHERRINGS WATERWAYS ASSESSMENT

Date: 12 June 2025 | Revision: 0

Plan prepared for Christchurch City Council by Boffa Miskell Limited

Project Manager: Tanya.Blakely@boffamiskell.co.nz | Drawn: LJa | Checked: TBI

Figure 2: Rapid Habitat Assessments, April 2025. Direction and proportion of flow is shown by arrows and line weighting.

3.2 Wetlands

We observed multiple, potential wetlands during our site walk-over, particularly noting linear systems adjacent to Ballintines Waterway downstream of the confluence with Sherrings and Stilwells waterways and adjacent to Sherrings Waterway downstream of Sparks Road.

Nicholas Head of Christchurch City Council completed a rapid botanical assessment to assess the presence of natural inland wetlands between Sparks Road and Hendersons Road, on 10 February 2025 (CCC, 2025). We have included a high-level summary of the findings, below, but refer the reader to the CCC (2025) report for full details.

As described in CCC (2025), the surveyed area comprised exotic pasture grown for stock fodder, as well as areas retired from productive use. The retired areas largely comprised wetland vegetation including quaking bogs, swampland, ponds and ephemeral wetlands (Figure 2).

These surveyed wetlands were reported on as ecologically significant, as they support rare indigenous plant species and provide habitat for native avifauna (CCC, 2025). Recommendations regarding future development of the area that potentially affects these natural inland wetlands were given, including the need to follow the effects management hierarchy of the National Policy Statement for Freshwater Management and avoid effects on wetlands, where practicable, in the first instance (CCC, 2025).

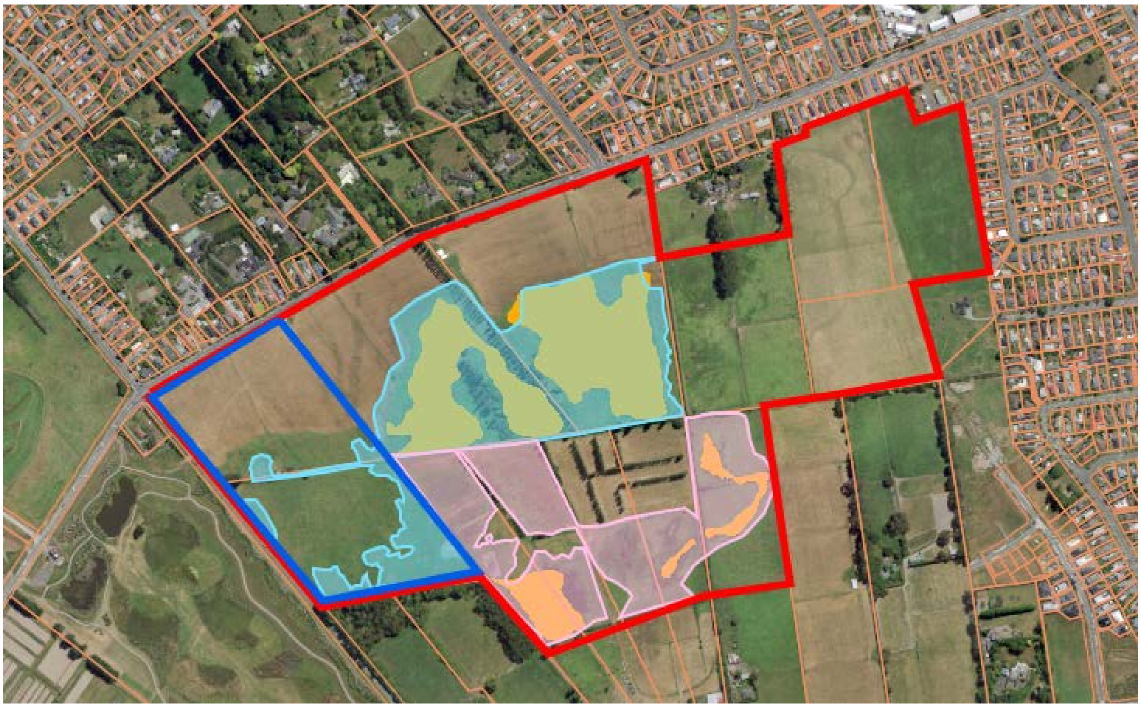

Figure 3. Taken from CCC (2025) showing the extent of natural inland wetlands. Light blue were wetlands determined by field survey; pink shows likely wetlands that are yet to be surveyed. Underlying orange is ECan's indicative wetland layer.

3.3 Habitat assessment results

3.3.1 Water quality

Spot measures of water temperature were generally similar across all sites (Table 4), except for Site 10: Stilwells d/s Northaw Street, where temperature was 20.4, exceeding the CSNDC guideline (<20ºC). Dissolved oxygen (DO) was variable between sites, ranging from 54.6% at Site 7: Sherrings u/s Ballintines Waterway to 113% at Site 8: Sherrings d/s Ballintines Waterway (Table 4). The majority of sites did not meet the CSNDC guideline of ≥70% DO saturation. pH was circum-neutral at all sites and within the CSNDC guideline range of 6.5-8.5. Conductivity was relatively similar between sites and exceeded the CSNDC guideline of 116 μS / cm at all sites.

It is important to note that water quality parameters were measured only once during the daytime, and at different times of the day across sites; pH, water temperature and DO can vary diurnally and seasonally.

Table 4. Field-measured water quality at ten sites surveyed in April 2025. Values are shown in red do not meet the CSNDC guidelines of water temperature <20°C; dissolved oxygen >70%; pH 6.5-8.5; and conductivity median 116 μS / cm.

Site	Site name	Temperature (°C)	Dissolved oxygen (mg / L)	Dissolved oxygen %	pH	Conductivity (μS / cm)
Site 1	Ballintines d/s Cashmere Road	13.8	6.54	63.2	7.52	296
Site 2	Ballintines u/s Cashmere Road	13.6	6.69	64.4	7.49	294.6
Site 3	Ballintines u/s Sherrings Waterway	14.6	6.93	68.2	7.28	275.2
Site 5	Sherrings u/s Sparks Road	14.5	7.59	74.5	7.4	293.4
Site 6	Sherrings d/s Sparks Road	14.5	7.11	69.8	7.5	293.4
Site 7	Sherrings u/s Ballintines Waterway	14.2	5.6	54.6	7.29	296.2
Site 8	Stilwells d/s Ballintines Waterway	15.1	11.4	113	7.42	281.7
Site 9	Stilwells u/s Blakiston Drain	13.3	7.79	74.5	7.44	284.4
Site 10	Stilwells d/s Northaw Street	20.4	6.72	74.2	7.99	167.1
Site 11	Samuel Street Drain u/s Sparks Road	16	7.99	81.1	7.88	281.9

3.3.2 In-stream habitat

Average wetted width was generally similar across Stilwells and Samuel Street drains, which were timber-lined (ranging from 0.90 m to 1.51 m; Table 5). There was some variation in average width across sites in Ballintines and Sherrings waterways, ranging from 1.76 m at Site 1: Ballintines d/s Cashmere Road, to 3.56 m at Site 2: Ballintines u/s Cashmere Road. It is important to note that all waterways were largely channelised and straight, and there was very little variation in width between transects at each site. Water depth was variable across all sites and within waterways, ranging from 1 cm at Site 10: Stilwells d/s Northaw Street, to 48.6 cm at Site 8: Stilwells d/s Ballintines Waterway (Table 5).

Water velocities were variable between sites[5] ranging from 0.05 m / s at Site 6: Sherrings d/s Sparks Road, to 1.1 m / s at Site 9: Stilwells u/s Blakiston Drain (Table 5).

Table 5. Average wetted width, water depths, and velocities measured at ten sites surveyed in April 2025. Velocities were unable to be measured at Sites 10 and 11 due to insufficient water depth.

Site	Site name	Wetted width (m)	Water depth (cm)	Velocity (m / s)
Site 1	Ballintines d/s Cashmere Road	1.76	11.7	0.57
Site 2	Ballintines u/s Cashmere Road	3.56	26.67	0.09
Site 3	Ballintines u/s Sherrings Waterway	3.06	34.30	0.12
Site 5	Sherrings u/s Sparks Road	1.90	26.53	0.15
Site 6	Sherrings d/s Sparks Road	2.84	20.93	0.06
Site 7	Sherrings u/s Ballintines Waterway	3.14	28.60	0.20
Site 8	Stilwells d/s Ballintines Waterway	1.51	48.60	0.43
Site 9	Stilwells u/s Blakiston Drain	1.51	23.53	1.10
Site 10	Stilwells d/s Northaw Street	0.90	0.93	n/a
Site 11	Samuel Street Drain u/s Sparks Road	1.20	5.73	n/a

Stream bed substrates were dominated by fine sediments (e.g., silt, sand) at most sites, ranging from 43.4% composition at Site 1: Ballintines d/s Cashmere Road, to 100 % at many other sites (Figure 3). The Substrate Index (SI) was around 3.0 for all sites (i.e., high proportion of silt / sand), ranging from 3.0 to 3.96. While larger substrates (e.g., cobbles) were present at most sites, these were often buried beneath fine sediments. Embeddedness is a measure of the degree to which coarse substrates (e.g., cobbles and gravel) are surrounded and buried by fine substrates such as silt and sand. Average embeddedness was 100% at all but two sites surveyed (Figure 3). Average sediment depth ranged from 3.8 cm at Site 9: Stilwells u/s Blakiston Drain, to 108.2 cm at Site 11: Samuel Street Drain u/s Sparks Road (Figure 3). Generally, the sites with faster velocities (i.e., Sites 1, 8, and 9) had shallower average sediment depths. Fine sediment cover at all sites exceeded both the NPS-FM national bottom line of 27% cover and the CSNDC guideline of <20% cover (Figure 3).

[5] Velocities were unable to be measured at Site 10 and 11 due to insufficient water depth.

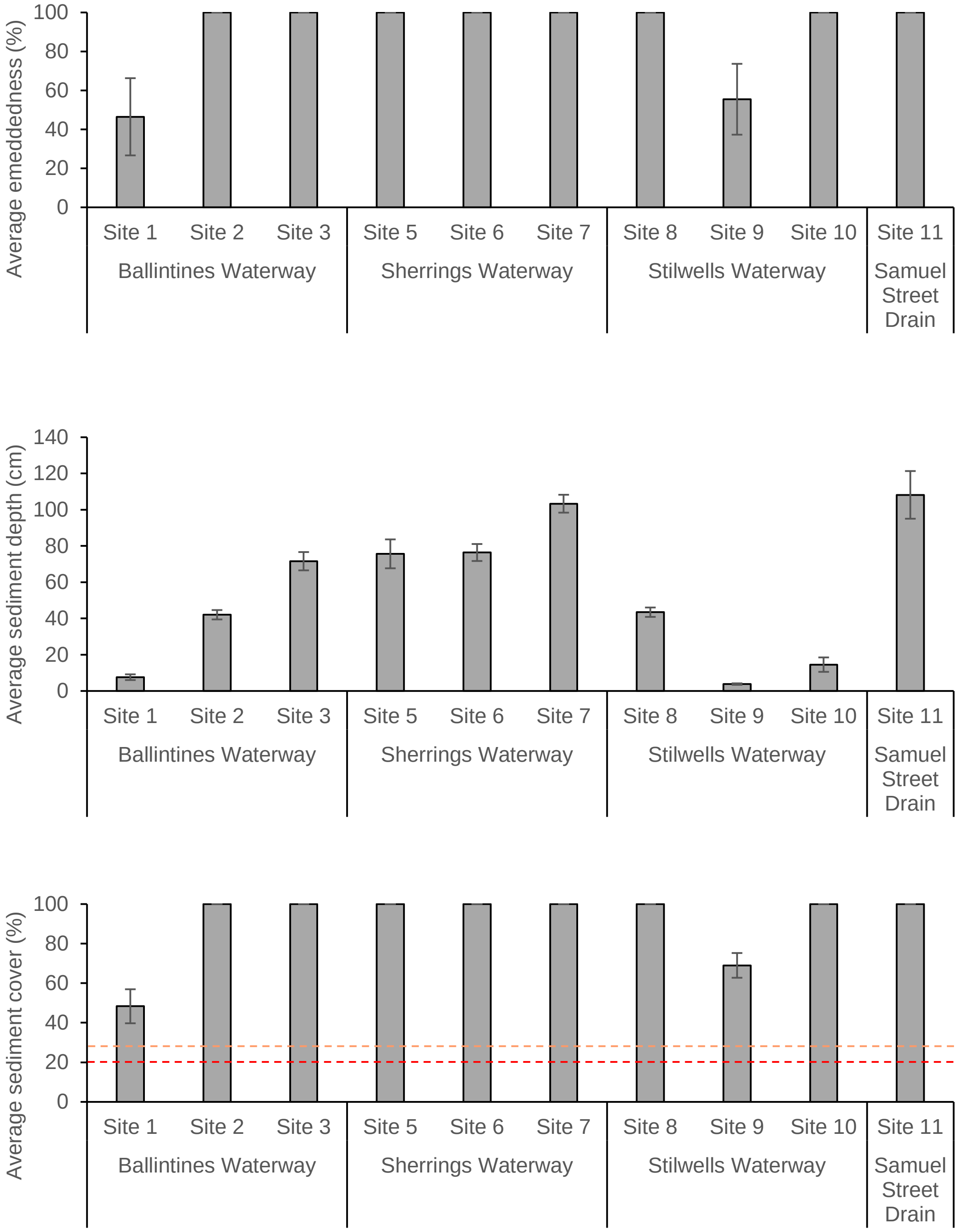

Figure 4. Average (±1SE) embeddedness (top), sediment depth (middle) and sediment cover (bottom) at the sites in 2025. The dashed red lines indicate the attribute guideline for total sediment cover of 20% (dark red) for the CSNDC guideline and 27% (light red) for the NPS-FM national bottom line.

Average emergent macrophyte cover was low across all sites, ranging from 0% at Sites 3, 5, 7 and 8, to 2.9% at Site 10: Stilwells d/s Northaw Street. Average total macrophyte cover (emergent and submerged macrophytes) was variable across sites, ranging from 2.9% at Site 10: Stilwells d/s Northaw Street, to 97.3% at Site 8: Stilwells d/s Ballintines Waterway. Total cover at three sites (Sites 3, 8, and 11) exceeded the CSNDC guideline of >50% cover (Figure

4). Dominant species were Canadian pondweed, curly-leaf pondweed, floating duckweed, starwort, *Nitella,* and *Veronica* spp. Very little algal cover was recorded at any site, the exception to this was short filamentous algae at Site 10: Stilwells d/s Northaw Street, with 32.6% average cover. Leaf litter was variable across sites, ranging from 0.3% at Site 8: Stilwells d/s Ballintines Waterway, to 68% at Site 6: Sherrings d/s Sparks Road. Notably, larger woody debris were present at Site 5: Sherrings u/s Sparks Road and 7 Sherrings u/s Ballintines Waterway.

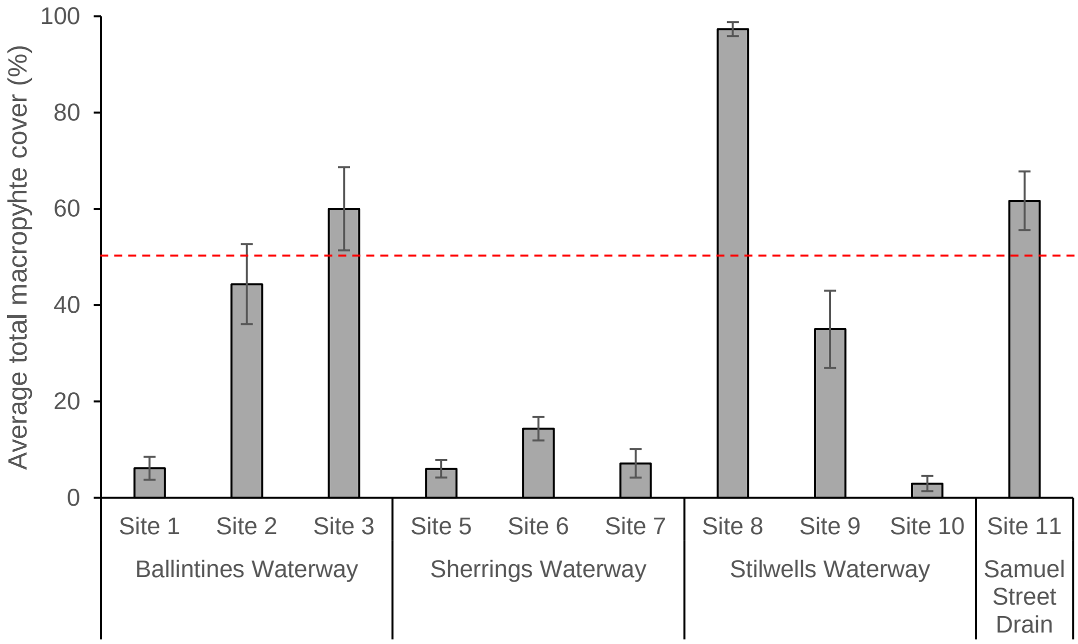

Figure 5. Average (±1SE) total macrophyte cover at sites in 20253. The dashed red line indicates the CSNDC guideline for total macrophyte cover of <50%.

3.3.3 Sediment quality

Sediment quality results are summarised in Table 6; full results are in Appendix 3. Metal contaminants are usually found in higher concentrations in sediment samples with the higher silt and clay contents (i.e., substrata <0.063 mm in size), as the greater surface area of smaller particles increases the adsorption. This is particularly relevant as higher metal concentrations at a site may primarily be driven by a higher proportion of small particles (i.e., better attachment of the metals). All sites were dominated by silt / clay.

Concentrations of cadmium, chromium, nickel, and total PAHs were below both the CSNDC guidelines (where relevant) and default guideline value (DVG) of the ANZECC (2000) sediment quality guidelines at all sites (Table 6). Where the sediment concentration is below the DVG, it is considered that there is low risk of adverse effects to aquatic life.

Arsenic and copper concentrations exceeded both the CSNDC guidelines (where relevant) and DVG at one of the ten sites, Site 11: Samuel Street Drain u/s Sparks Road. Lead concentrations exceeded the CSNDC guidelines and DGV at six of the ten sites (Sites 1, 3, 6, 9, 10, and 11). Concentrations of zinc were the highest of all metals tested in these waterways and exceeded guidelines at all sites. Zinc exceeded the ANZECC (2020) GV-high at Sites 10 and 11, while all other sites exceeded the DGV. Total DDT exceeded guidelines at 9 of the 10 sites. The DVG was exceeded at Site 1, 2, 5, 6, 8, 9, 10, and 11; the GV-high was exceeded at Site 3. Where the DVG is exceeded, this indicates there is an increased risk of adverse effects on the resident aquatic biota due to arsenic, copper, lead, zinc and DDT concentrations in the fine sediments. Zinc and DDT concentrations above GV-high levels indicate there is a relatively high risk of adverse effects.

*Table 6. Sediment quality at the ten sites surveyed in April 2025. Values exceeding the ANZECC (2020) default guideline value (DVG) are in orange; those exceeding the guideline value- high (GV-H) are in red. *indicates the CSNDC attribute target trigger values, where applicable. Concentrations of hydrophobic organic contaminants (PAHs,Total DDT) were normalised to 1% of the total content of organic carbon. PAH = polycyclic aromatic hydrocarbons; DDT = Dichlorodiphenyltrichloroethane.*

	Site 1	Site 2	Site 3	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	ANZECC (2000) DVG	ANZECC (2000) GV-high
	Ballintines Waterway			Sherrings Waterway			Stilwells Waterway			Samuel Steet Drain		
Total organic carbon (g / 100 g)	6	6.4	4.7	4.1	6.5	9.6	4.5	6.1	5.8	9.9	-	-
Grain size												
Silt / clay: <0.063 mm	43.28	80.26	73.01	46.98	51.8	46.9	74.48	63.81	60.93	52.79	-	-
Fine sand: 0.063-0.250 mm	26.22	13.99	20.98	27.37	31.48	27.84	18.83	18.52	25.42	20.42	-	-
Medium sand: 0.250-0.500 mm	11.28	3.62	3.7	8.88	7.19	8.24	5.04	4.41	5.79	7.13	-	-
Coarse sand: 0.500-2.00 mm	16.2	2.13	2.31	14.16	8.56	14.19	1.65	11.51	7.54	16.54	-	-
Gravel and cobbles: >2.00 mm	3.02	0	0	2.61	0.97	2.83	0	1.75	0.32	3.12	-	-
Contaminants (mg / kg)												
Arsenic	9.8	9.2	18.9	7.2	10.1	8.5	18.2	14.2	15.8	45	20	70
Cadmium	0.23	0.24	0.22	0.26	0.31	0.37	0.23	0.29	0.29	0.63	1.5	10
Chromium	19.1	19.2	27	16.9	20	15.7	34	28	30	46	80	370
Copper	25	21	31	19.2	26	22	29	28	35	73	65*	270
Lead	85	44	69	39	57	46	49	51	63	123	50*	220
Nickel	13.3	15.8	16.8	14.5	16.2	12.3	15.6	15.3	16.8	18.3	21	52
Zinc	270	270	250	250	370	320	230	310	600	1,040	200*	410
Total phosphorus	980	1,490	860	630	800	1,010	890	1,000	1,010	1,040	-	-
Total PAHs	0.82	0.59	3.28	1.61	1.89	1.07	1.51	0.77	3.45	2.63	10*	50
Total DDT Isomers	0.0025	0.0028	0.0051	0.0017	0.0014	0.0011	0.0047	0.0021	0.0026	0.0036	0.0012	0.005

3.4 Macroinvertebrate community

Total macroinvertebrate abundance was variable across sites, with between 291 individual taxa found at Site 10: Stilwells d/s Northaw Street and 22,101 found at Site 11: Samuel Street Drain u/s Sparks Road. Taxonomic richness was also variable across sites, ranging from between 6 at Site 10: Stilwells d/s Northaw Street, to 18 taxa at Site 5: Sherrings u/s Sparks Road.

The most diverse groups (from most to least diverse) were true flies (Diptera) for which there were six different taxa across all samples, followed by caddisflies (Trichoptera) with five taxa, molluscs, worms (Annelida and Platyhelminthes), crustaceans (four taxa), and damselflies (Odonata) with two taxa. The remaining macroinvertebrate groups were represented by a single taxon (Collembola, Acarina, Hydra, Nemertea, Nematoda, Hemiptera).

Of the species present, the freshwater macroinvertebrate communities at all sites were numerically dominated by pollution-tolerant taxa, such as the freshwater snail *Potamopyrgus* (molluscs), worms (other), and crustaceans (Figure 5).

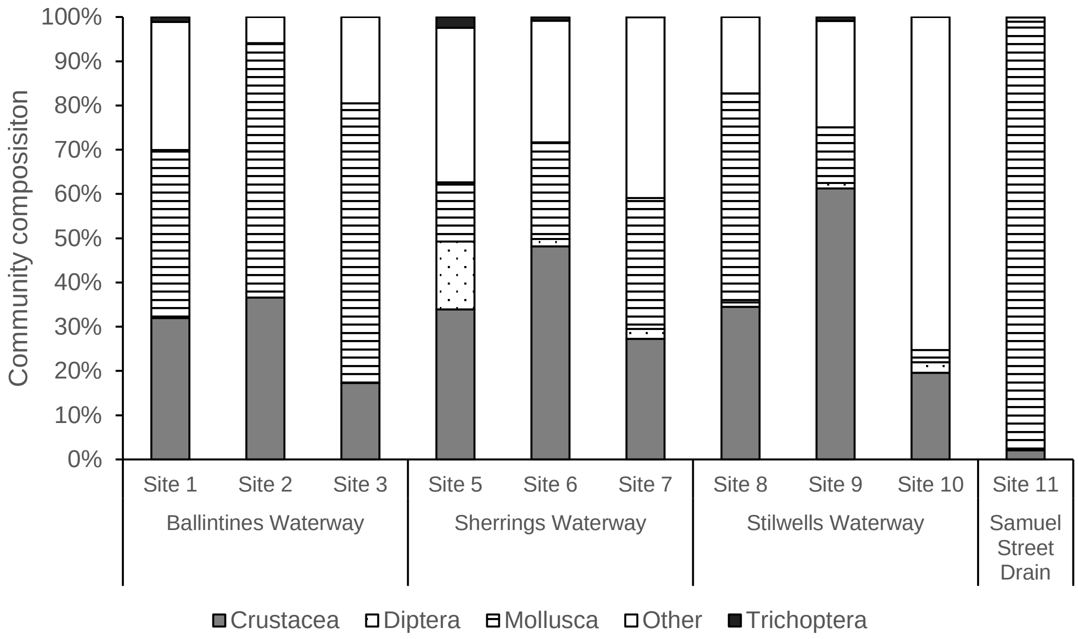

Figure 6. Relative abundances of macroinvertebrate taxonomic groups collected from monitoring sites surveyed in April 2025. Other = worms, flatworms, damselflies, true bugs, freshwater hydrozoans, and aquatic mites.

The EPT insect orders (Ephemeroptera, mayflies; Plecoptera, stoneflies; and Trichoptera, caddisflies), which are generally sensitive to pollution and habitat degradation, are useful indicators of stream health. No stoneflies or mayflies were found at any of the sites, but total of five caddisfly taxa were found from across the sites. The stick-caddis *Hudsonema* and *Triplectides* were found at Sites 1, 5, 6 and 9, Oeconesidae caddis at site 1, 5 and 7, with *Oecetis* confirmed at Sites 1 and 7, and *Oxyethira* at Sites 6 and 11. No caddisflies were found at Sites 2, 3, 8 or 10. Where caddisflies were found, % EPT community composition was low, ranging from <0.01% at Site 7 to 2.5% at Site 5 (Figure 5).

Notably, eDNA results showed EPT taxa that are considered generally pollution-sensitive (i.e., those that have an MCI score ≥7, out of a maximum of 10) at 7 of the 11 sites, but none of these taxa were collected in kick-net samples (Table 7). eDNA results also showed kēkēwai / freshwater crayfish (*Paranephrops zealandicus*) are likely present at three sites: Sites 1, 6, and 7 (Table 7). A single kākahi / freshwater mussel was found in Ballintines Waterway during the site walk-over immediately upstream of Cashmere Road (i.e., very close to the confluence with Cashmere Stream). Both kēkēwai and kākahi are notable clean-water taxa, listed as At Risk – Declining species (Grainger et al., 2018). These species are present in Cashmere Stream.

Macroinvertebrate community information from Site 4 was collected via eDNA sampling, to supplement ecological information at this site gathered by Instream (2024). Pollution-tolerant taxa were detected. Including the freshwater snails *Potamopyrgus* and *Physella*, true flies, aquatic worms, copepods, the pollution-tolerant caddis *Oxyethira*.

Table 7. Notable macroinvertebrate taxa (i.e., EPT with MCI tolerance score <7 and *Paranephrops zealandicus* (kēkēwai/ freshwater crayfish) found at sites in April 2025 via kick-net samples, or eDNA detection. Noting that only eDNA samples were taken from Site, 4, the 'n/a' indicating that no kick-net sample was taken.

Site	Site name	Kick-net	eDNA
Site 1	Ballintines d/s Cashmere Road	-	*Psilochorema* *Oeconesus*[6] *Paranephrops zealandicus*
Site 2	Ballintines u/s Cashmere Road	-	*Psilochorema* *Polyplectropus*
Site 3	Ballintines u/s Sherrings Waterway	-	-
Site 4	Ballintines u/s Sparks Road	n/a	-
Site 5	Sherrings u/s Sparks Road	-	*Psilochorema* *Polyplectropus*
Site 6	Sherrings d/s Sparks Road	-	*Polyplectropus* *Paranephrops zealandicus*
Site 7	Sherrings u/s Ballintines Waterway	-	*Psilochorema* *Polyplectropus* *Paranephrops zealandicus*
Site 8	Stilwells d/s Ballintines Waterway	-	*Psilochorema* *Polyplectropus*
Site 9	Stilwells u/s Blakiston Drain	-	*Psilochorema* *Oeconesus* *Polyplectropus*
Site 10	Stilwells d/s Northaw Street	-	-
Site 11	Samuel Street Drain u/s Sparks Road	-	-

The macroinvertebrate community index (MCI) and quantitative macroinvertebrate community index (QMCI) scores are measures of stream, or ecological health, with higher scores indicating

[6] *Oeconesus maori* has MCI tolerance scores of 9 and 6.4 for hard bottom and soft bottom waterways, respectively. It was detected across multiple sites but has only been included in this table at sites that were hard bottomed, where the MCI tolerance score is <7.

generally better condition. MCI scores at all sites did not meet the NPS-FM national bottom line (i.e., were <90), which indicates severe organic pollution or nutrient enrichment. QMCI scores, which are considered a better indicator of "health" than MCI, as they take into account abundance and presence of macroinvertebrate taxa, were also below the NPS-FM national bottom line (of 4.5) and the CSNDC target (of 5) at all sites. ASPM scores, which use %EPT, EPT taxa richness, and MCI indices to form a single metric, did not meet the NPS-FM national bottom line (i.e., were <0.03) at all sites (Figure 6). Overall, stream health (determined by macroinvertebrate metrics) was poor, with probable severe enrichment, at all sites.

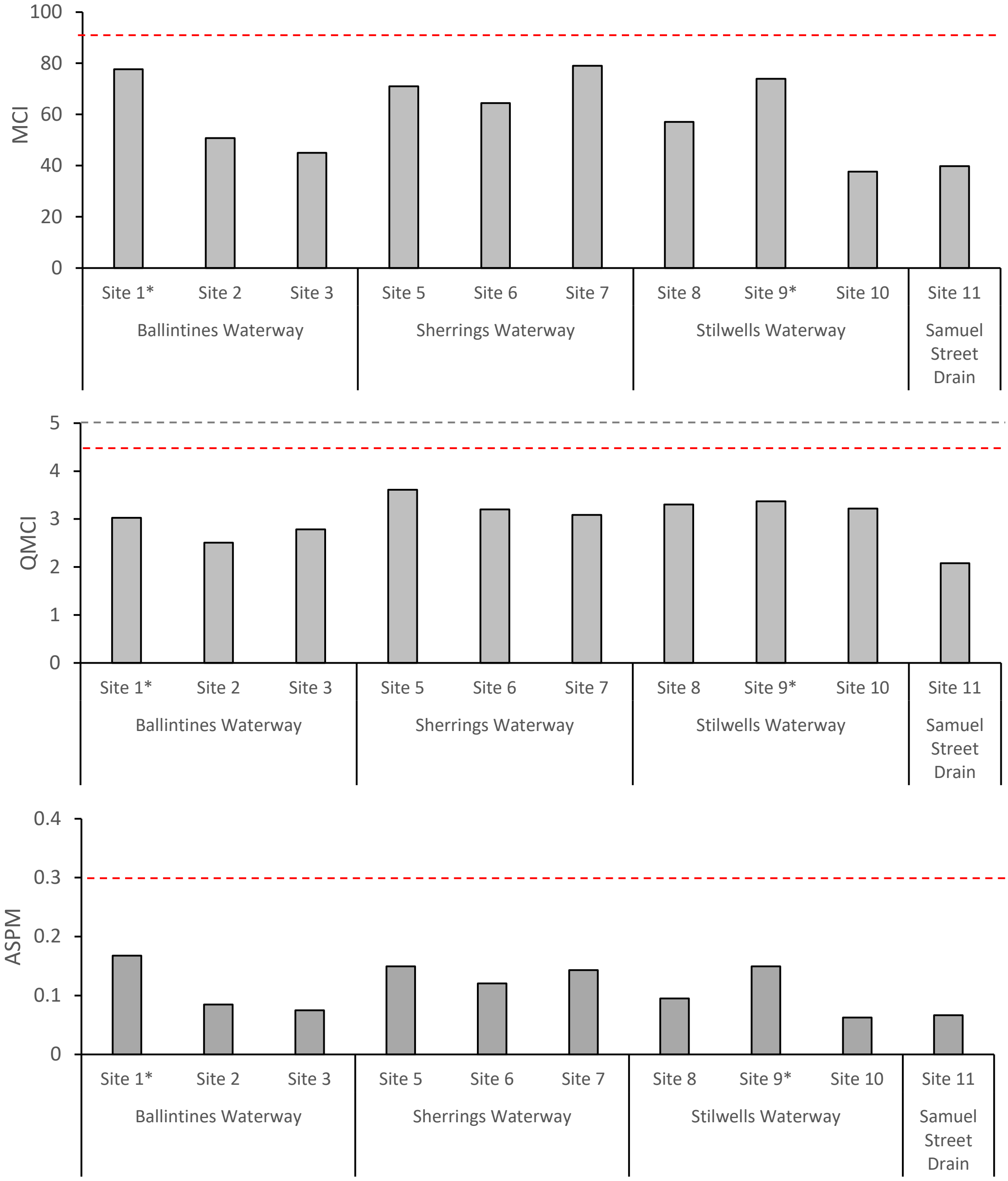

*Figure 7. MCI (top), QMCI (middle) and ASPM (bottom) scores at sites samples in April 2025. The red dashed lines are the NPS-FM National Bottom-Line values for MCI (90), QMCI (4.5), and ASPM (0.3), the dashed grey line indicates the CSNDC target (QMCI ≥5). * Sites 1 and 9 were considered hard-bottomed sites, while sites 2-8 and 10-11 were considered soft-bottomed sites.*

3.5 Fish community

Seven fish species were captured using electric fishing or fyke net and Gee minnow trapping techniques, including two At Risk – Declining taxa: īnanga (*Galaxias maculatus*) and longfin eel (*Anguilla dieffenbachii*). Also recorded were giant bully (*Gobiomorphus gobioides*, At Risk - Naturally Uncommon), shortfin eel (*A. australis*, Not Threatened), banded kōkopu (*G. fasciatus*, Not Threatened but locally uncommon), common bully (*G. cotidianus*, Not Threatened), and upland bully (*G. breviceps*, Not Threatened) (Dunn et al., 2018).The presence of banded kōkopu in Sherrings Waterway is particularly interesting, as there are few confirmed populations in Christchurch's waterways (see below for further detail).

A total of 316 fish were caught across all sites surveyed, with shortfin eel and common bully both caught at 8 of the 9 survey sites. With the exception of banded kōkopu and giant bully, which were each found at only one site, the fish communities were generally comprised of similar species, but abundances differed among sites. Fish abundance, shown as catch per unit effort (CPUE), was greatest in the lower reach Ballintines Waterway (Site 1: Ballintines d/s Cashmere Road) and in the lower reach of Sherrings Waterway (Site 7: Sherrings u/s Ballintines), noting that Site 7 is upstream of Sites 1 and 2. CPUE was lowest at the upper catchment sites (i.e., Sites 3: Ballintines u/s Sherrings and 5: Sherrings u/s Sparks Road; Figure 7).

Īnanga was the dominant species found (215 captured) and ranged in size from 52 mm to 107 mm, including adult fish. Shortfin eels, which were also numerically dominant (27 captured) and ranged from 160 mm to 750 mm. The majority of shortfin eels caught were between 130 mm and 480 mm. Two longfin eels were caught, both large in size (970 mm-1330 mm). Elvers (juvenile eels, ≤120 mm) were only found at Site 1: Ballintines d/s Cashmere Road and Site 9: Stilwells u/s Blakiston Drain (Table 8).

Water levels were too shallow to set traps and nets at Site 10: Stilwells d/s Northaw Street, however, eDNA samples showed bullies may be present in this waterway. In addition to the fish species observed in our surveys, eDNA samples indicated brown trout (*Salmo trutta*) may be present in Ballintines and Stilwells waterways (Table 8).

eDNA samples were taken from Site 4 to supplement ecological information at this site gathered by Instream (2024). InStream (2024) found fish taxa; longfin eel, shortfin eel, upland bully and īnanga; the same four species were detected in the eDNA samples we collected (Table 8).

The presence and implications of any fish passage barriers in the area is discussed in Section 4.5.

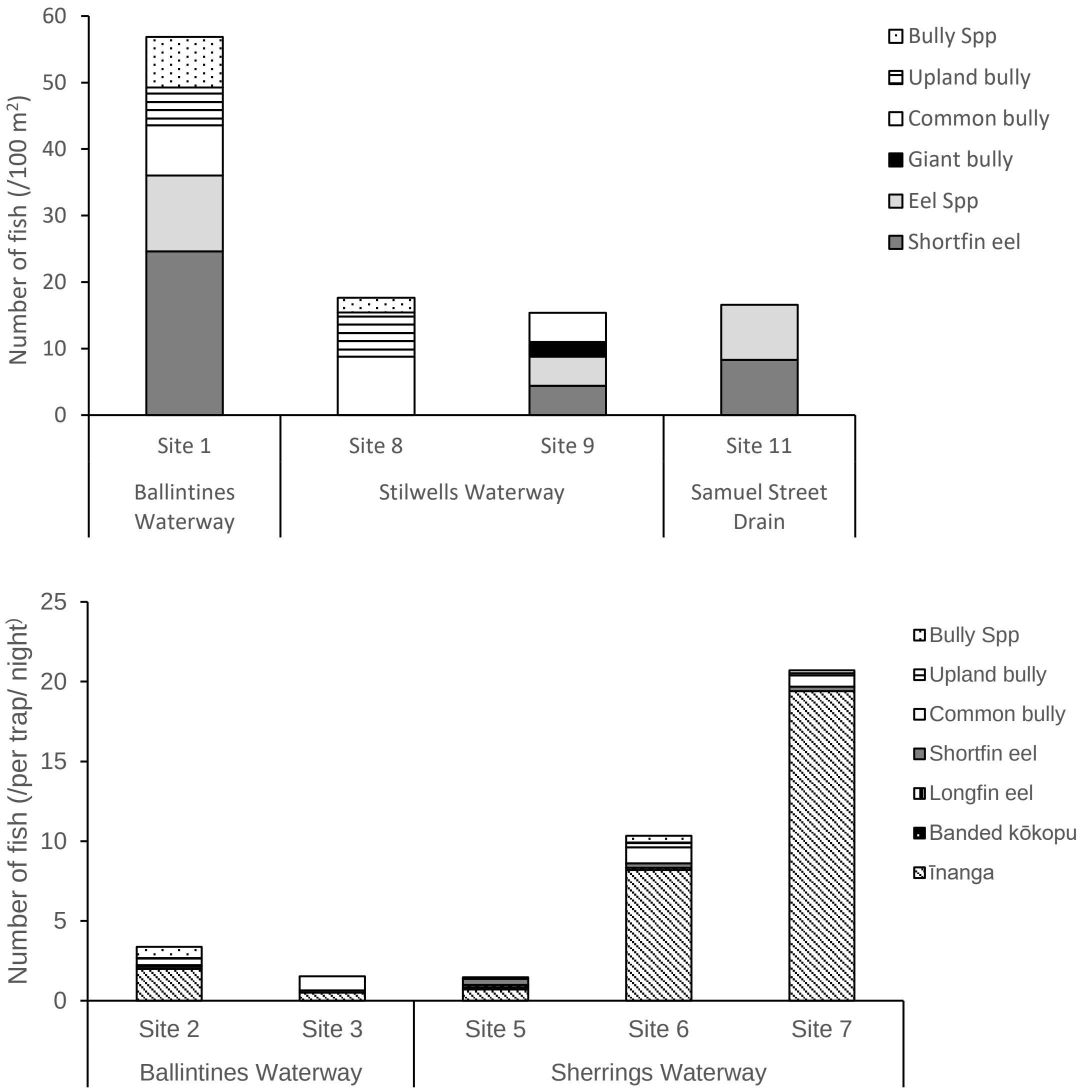

Figure 8. Number of fish caught (displayed as catch per unit effort, CPUE) using electric fishing (top) or trapping and netting (bottom) techniques in April 2025.

Table 8. Fish species present, either captured via electric fishing, fyke net and Gee minnow traps (count, with size range in brackets, mm) or detected in eDNA samples (✓) in April 2025. The fish community was sampled only by eDNA at sites 4 and 10.

Site	Site name	Method	Longfin eel	Īnanga	Giant bully	Banded kōkopu	Shortfin eel	Eel Spp	Elver	Common bully	Upland bully	Bully Spp	Brown trout
Site 1	Ballintines d/s Cashmere Road	Electric fishing, eDNA	✓	✓	✓		13 (160-380) ✓	6	2 (80-95)	4 (34-52) ✓	3 (34-51) ✓	4 (26)	✓
Site 2	Ballintines u/s Cashmere Road	Nets/traps, eDNA	✓	14 (54-75) ✓		✓	1 (370) ✓			1 (60) ✓	3 (25-30) ✓	5 (23-32)	✓
Site 3	Ballintines u/s Sherrings Waterway	Nets/traps, eDNA	✓	3 (68-75) ✓			1 (600) ✓			6 (32-51)	✓		
Site 4	Ballintines u/s Sparks Road	eDNA only	✓	✓			✓				✓		
Site 5	Sherrings u/s Sparks Road	Nets/traps, eDNA	1 (970) ✓	5 (58-76) ✓		1 (124) ✓	3 (275-610) ✓			1 (38)	✓		
Site 6	Sherrings d/s Sparks Road	Nets/traps, eDNA	1 (1300) ✓	57 (52-107) ✓		✓	2 (650-750) ✓			7 (47-58)	2 (30-55) ✓	3 (21-25)	
Site 7	Sherrings u/s Ballintines Waterway	Nets/traps, eDNA	✓	136 (48-80) ✓	✓		2(600-650) ✓			5 (34-53) ✓	1 (62) ✓	2 (25-30)	
Site 8	Stilwells d/s Ballintines Waterway	Electric fishing, eDNA	✓	✓			✓			4 (38-51) ✓	3 (63-91) ✓	1 (26)	
Site 9	Stilwells u/s Blakiston Drain	Electric fishing, eDNA	✓	✓	1 (110)		2 (130-350) ✓		2 (110-120)	2 (40) ✓			✓
Site 10	Stilwells d/s Northaw Street	eDNA only										✓	
Site 11	Samuel Street Drain u/s Sparks Road	Electric fishing, eDNA		✓			3 (320-360)	3					

4.0 Discussion

Overall, the ecological assessment of the eleven sites in this survey indicated that the waterways were in poor-moderate ecological health.

4.1 Water quality

Basic water-quality parameters were generally within ranges expected during base-flow conditions in spring-fed urban and semi-rural environments.

pH was circum-neutral at all sites. Water temperature was below the guideline (<20ºC) at all sites except Site 10: Stilwells d/s Northaw Street, which was the shallowest site (shallow water can warm more quickly). Conductivity is a measure of dissolved conductive particles within water column and can indicate the presence of pollutants. Conductivity was within expected ranges of low-land Canterbury systems, and similar to levels recorded in adjacent waterways (Boffa Miskell Ltd, 2021a). Dissolved oxygen was low (i.e., <70%) and did not meet CSNDC guidelines at any sites in Ballintines Waterway, or two of the three sites in Sherrings Waterway. While DO was a one-off measure taken at each site, if the concentrations recorded are indicative of levels often occurring in these waterways this could be a significant stressor for freshwater fauna; consistently low levels of DO can greatly stress freshwater fauna, reducing their ability to persist in an area. A number of factors may have contributed to the low DO levels, including the abundance of macrophytes, time of day, seasonal changes and water temperature. It is important to note that water quality parameters measured were comparable to spot measures from other waterways in the Ōpāwaho / Heathcote River catchment (Boffa Miskell Ltd, 2021a; InStream Consulting Ltd, 2020a).

4.2 Riparian and in-stream habitat

Riparian and in-stream habitat of the waterways assessed was reflective of the nature of urban and semi-rural waterways. Generally, habitat was limited by high cover of fine, deep sediments and a riparian margin dominated by exotic vegetation. As a result, habitat for aquatic fauna was limited in places, which was reflected in the high abundance of pollution-tolerant macroinvertebrate taxa.

Riparian margins were wide at most sites (i.e., open paddocks or large residential gardens), but narrow (i.e., <1m) on at least one bank at Sites 10 and 11, restricted by residential fencing. Wide riparian margins, when well vegetated (including rank grass), can assist with reducing runoff, and filtering stormwater contaminants and sediments entering waterways. A width of >10 m on either side of a waterway, planted with indigenous vegetation, is the minimum required to provide these functions (Parkyn et al., 2000). Indigenous vegetation was sparse across the sites, with the exception being the harakeke at Site 8: Stilwells d/s Ballintines Waterway, and native plantings in the residential garden adjacent to Site 1: Ballintines d/s Cashmere Road. The majority of larger stature vegetation was deciduous exotic trees (i.e., poplar, hawthorn, willow). Exotic deciduous trees can provide some shading to waterways, but also contribute to high leaf litter inputs in the autumn season, which can result in poor water quality and adversely affect stream health. Gorse and willow, both notable weed species, were sparsely present along Sherrings and Stilwells waterways.

With the exception of larger woody debris found at Site 5 Sherrings u/s Sparks Road, and larger substrates (e.g., gravels, cobbles) present at Site 1: Ballintines d/s Cashmere Road and Site 9: Stilwells u/s Blakiston Drain, there was a lack of in-stream habitat diversity. The stream bed substrates at all sites were dominated by silt and sand, exceeding guidelines of <20% cover. Where larger substrates were present (at Site 1 and Site 9), these were often buried under a fine layer of sediment. High cover of fine sediments is a concern across other waterways in the Ōpāwaho Heathcote River catchment, exceeding guidelines at most sites (Boffa Miskell Ltd, 2021a; InStream Consulting Ltd, 2020a).

Fine sediments can enter waterways from stormwater, direct run-off, and bank erosion. Where banks were not lined (i.e., Sites 1, 2, 5, 6, and 7), bank erosion was high (19%-88%), likely acting as a direct and continued source of sediment inputs.

4.3 Sediment quality

Heavy metals and pesticides were at concentrations that exceeded guidelines, indicating there is a risk of adverse effects to flora, fauna and stream health. Concentrations of zinc were the highest of all metals tested in these waterways and exceeded guidelines at all sites. Lead concentrations exceeded guidelines at six of the ten sites (Sites 1, 3, 6, 9, 10, and 11). Total DDT exceeded guidelines at all sites, except Site 7: Sherrings Waterway upstream of Ballintines Waterway. Arsenic and copper concentrations exceeded guidelines at one of the ten sites, Site 11: Samuel Street Drain u/s Sparks Road. All other contaminants were below guideline concentrations.

Comparatively, arsenic and DDT are less-commonly tested for across Christchurch waterways, but where data is available, concentrations found in Samuel Street Drain, and Ballintines, Stilwells and Sherrings waterways were comparable, where concentrations occasionally exceeds target levels (Boffa Miskell Ltd, 2021b). Sediment concentrations of zinc, lead and copper were similar those recorded from the Ōtūkaikino Creek, Ōtakaro Avon River, Pūharakekenui Styx River, Huritini Halswell Stream, and Ōpāwaho Heathcote River catchments, where zinc commonly exceed target levels, and lead and copper occasionally exceed levels (Boffa Miskell Ltd, 2022, 2023; InStream Consulting Ltd, 2019, 2019, 2020a). Elevated heavy metal concentrations can reflect the urbanisation of catchments (e.g., galvanised roofing and spouting can be major sources of zinc). Untreated, or poorly treated, stormwater can bring contaminants into waterways, which can be toxic to freshwater fauna.

In summary, concentrations of contaminants bound to in-stream sediments is of concern for Samuel Street Drain, and Ballintines, Stilwells and Sherrings waterways. Understanding the presence of heavy metals, and persistent residues from chemicals and other contaminants is important when considering future in-stream works. The discharge and mobilisation of these sediments with chemicals and contaminants bound to them needs to be controlled and avoided, to ensure contaminants are not resuspended in the water column and further distributed in the catchment.

4.4 Macroinvertebrate community

None of the sites surveyed met the CSNDC QMCI target, or the NPS-FM national bottom line for MCI, QMCI, or ASPM, indicating stream health was poor, with probable severe enrichment.

Overall, the macroinvertebrate community was typical of degraded waterways in the Christchurch area (Boffa Miskell Ltd, 2022, 2023; InStream Consulting Ltd, 2019, 2019, 2020), and dominated by pollution-tolerant taxa (e.g., crustaceans and molluscs); pollution-sensitive taxa (e.g., caddisflies) were less common. Caddisflies were found at some but not all sites; eDNA detected caddisflies at sites where these freshwater insects were not found in kick-net samples. No caddisflies were found at Site 3: Ballintines u/s Sherrings Waterway, Site 4: Ballintines u/s Sparks Road, Site 10: Stilwells d/s Northaw Street, or Site 11: Samuel Street Drain u/s Sparks Road.

Notably, a single kākahi / freshwater mussel was found in the lower reaches of Ballintines Waterway (near Site 1), and eDNA detections suggest kēkēwai / freshwater crayfish may be present in Ballintines and Sherrings waterways. Kākahi and kēkēwai have been previously found throughout the wider Ōpāwaho Heathcote River catchment, including in Cashmere Stream, and Hendersons and Dunbar waterways (Boffa Miskell Ltd, 2021a; InStream Consulting Ltd, 2020b, 2020a). Their presence in tributary waterways like Ballintines and Sherrings waterways is a promising sign for their current distribution across the catchment. Kēkēwai require suitable habitat cover (e.g., large wood, tree roots, undercut banks, cobbles and boulders) for shelter, often preferring pools and areas of slow or no flow (Allibone & Gray, 2018).

A few notable caddisflies were detected by eDNA, but not found in the kick-net samples, including the free-living caddis *Psilochorema* and *Polyplectropus*. *Psilochorema* larvae are known to occur in Cashmere Stream and Ōpāwaho Heathcote River, and have also been found in nearby Dunbar and Hendersons waterways (Boffa Miskell Ltd, 2021a). Interestingly, *Polyplectropus* is not commonly found in Christchurch waterways, but was found in Dunbar Waterway in 2021 (Boffa Miskell Ltd, 2021a). No mayflies were recorded in this study, but a single *Deleatidium* nymph was found in Hendersons Waterway in 2021 study by Boffa Miskell (2021a). To our knowledge, *Deleatidium* mayflies have not been found again in this catchment.

Freshwater insects, such as caddisflies (and mayflies), spend most of their lives in streams, rivers, and other waterbodies, emerging as winged adults to disperse, mate, and then lay eggs to complete their lifecycle. Following emergence, adult invertebrates require refuge and habitat in the terrestrial environment. Riparian vegetation is limited (e.g., where waterways are timber-lined or are alongside the grass verges) in this study, which is likely to be limiting the presence of and potential for colonisation by some freshwater taxa.

Colonisation by way of aerial dispersal of adult insects with winged adult life stages, such as EPT taxa, is likely more difficult in the urban environment where cross-catchment dispersal paths may be disrupted by the general urban environment (i.e., road crossings, buildings, lighting etc.). A further barrier to recolonisation is a general lack of source populations by taxa, such as mayflies and stoneflies, which are present in only a few streams or catchments in the wider Christchurch area (Boffa Miskell 2017; Blakely et al. 2006), though are not well connected to the Ōpāwaho Heathcote catchment.

In addition, in-stream habitats such as emergent and submerged boulders are critical components required for the success of aquatic insect colonisation. For example, hydrobiosid caddisflies, such as *Psilochorema*, often use emergent rocks as a landing pad to enter the water and oviposit on the underside of the boulder, while *Polyplectropus* species are known to dive to oviposit on submerged rocks, sometimes using emergent boulders to enter the stream (Smith & Storey, 2018).

The absence of large emergent and submerged boulders, and a tendency for smaller, more mobile gravel, sand and silt, is a trend seen in many urban and peri-urban waterways, including in Christchurch's urban streams (Blakely et al., 2006). There is opportunity to enhance riparian and in-stream habitats currently lacking or entirely absent these waterways. Habitat provision may increase the distribution and persistence of notable macroinvertebrate taxa across these waterways.

4.5 Fish community

The freshwater fish community consisted of seven species. Most found are common across Christchurch's urban waterways: īnanga and longfin eel (both listed as "At Risk - Declining"), giant bully (At risk - Naturally Uncommon), common bully, upland bully, and shortfin eel (all Not Threatened). However, the presence of banded kōkopu (Site 5: Sherrings u/s Sparks Road) is a particularly notable find, as this species while nationally Not Threatened is locally rare; this is the first time, that we are aware of, recording this species in the upper Ōpāwaho Heathcote River catchment. Wider surveys of Christchurch and Banks Peninsula waterways have found this species in only a few waterways: Bridle Path Waterway (Boffa Miskell fish survey, 2024), Sumnervale Drain, Richmond Hill Waterway, and Cass Bay Stream (InStream Consulting Ltd, 2023).

Adult banded kōkopu are often found in waterways with high canopy cover, with larger vegetation providing in-stream wood debris which banded kōkopu often favour as habitat cover (Baker & Smith, 2007). The reach of Sherrings Waterway where we found the banded kōkopu had high canopy cover, woody debris, and some small log jams downstream, providing both important refugia habitat and small pools for larger fish. The presence of both large woody debris and high canopy cover was limited at other sites surveyed in this study. While other sites had some larger stature vegetation, which provided some cover (e.g., poplars, hawthorn), there was little large woody debris present. There is potential, however, to increase habitat quality and quantity for freshwater fish, especially banded kōkopu, in these waterways, including via carefully considered planting of riparian margins. Notably, banded kōkopu are sensitive to elevated turbidity (Rowe et al., 2009; Rowe & Dean, 1998). Therefore, high cover of fine sediments, which can be easily mobilised during high-flow events may also be a limited factor to the persistence of banded kōkopu on these waterways.

Many of the freshwater fish species present are migratory, requiring access to the sea to complete their lifecycles. There were no high-risk in-stream structures, such as culverts, observed between Cashmere Stream and Ballintines Waterway. However, Stilwells Waterway flows through an c.590 m piped section (through Blakiston Drain) to Ōpāwaho Heathcote River. A debris grate over the drain inlet was unlikely to pose a barrier fish, as grate spacings were c. 20 cm (Photo 12). However, if this becomes blocked by debris between maintenance periods, it could create a partial barrier. From CREAS data, the drain outlet does not appear to be perched, but the piped section itself may be a partial barrier to the upstream migration of some species.

Photo 12: *Downstream (left) and upstream (right) structures in Blakiston Drain. Photos were taken during the 2020 CREAS survey, rather than April 2025 when these ecology assessments were completed.*

5.0 Recommendations

Waterway naturalisation

With potential for future development in the area, there are some enhance opportunities to be considered. These should focus on enhancement of riparian buffers, improved vegetation condition (including planting native-dominated margins), and increasing in-stream habitat diversity in general.

Where waterways are located within farmland, there is potential space available to improve channel sinuosity, and create natural, gently graded banks. Specifically, Ballintines Waterway (between Sparks Road and the rock-lined section upstream of Cashmere Road), Sherrings Waterway (downstream of Sparks Road), and Stilwells Waterway (east-west branch) could be carefully realigned, or banks regraded to increase channel sinuosity and provide greater heterogeneity of in-stream habitat conditions. Key considerations should include:

- Removal of the timber-lining along channels, where possible, and reinstating natural banks and sinuous flow channels. Removing the lining will increase habitat and refuge availability for aquatic fauna. For example, well-planted earth banks would provide opportunity for kēkēwai to burrow into, as well as increase potential for filtering of urban stormwater runoff.
- Carrying out focused surveys for Threatened, At Risk and locally rare species, (e.g., kēkēwai, kākahi, banded kōkopu, and other freshwater fishes and macroinvertebrates) prior to in-stream works to better understand where 'source' populations occur that may need to be protected.

Upstream of Sparks Road waterway enhancement opportunities are restricted by narrow boundaries, bounded by adjacent residential properties. Where channel realignment or regrading of banks is not feasible should include:

- Increasing habitat heterogeneity through the addition of in-stream habitat (e.g., large cobbles and boulders, both emergent and submerged), and well-planted riparian margins.

Across all waterways, key elements to waterways naturalisation and enhancement opportunities are:

- Sediment management should be done in conjunction with the implementation of best practice stormwater management and catchment management techniques to minimise new inputs of sediment to the waterways. Untreated stormwater can bring fine sediments and contaminants, which then smother the stream bed or can be directly consumed by freshwater fauna. Reducing inputs of fine sediments is essential when enhancing habitat for aquatic species, such as kākahi, pollution-sensitive macroinvertebrate taxa, and many freshwater fishes.
- Increasing riparian and in-stream habitat diversity by:
    - Riffle habitat, where gradient allows, will provide faster flowing sections suitable for a variety of fish (e.g., juvenile eels and possibility also fast-water species such as bluegill bullies) and macroinvertebrate species (e.g., caddisflies).
    - The inclusion of pools, where water levels allow, with overhanging vegetation will create habitat (which is currently lacking) for banded kōkopu, large longfin / shortfin eels, īnanga, giant bullies, kēkēwai, and other species.
    - Large cobbles and emergent and submerged boulders are limited or entirely absent from these waterways. A variety of bed substrates, including large cobbles and boulders are important for egg-laying surfaces for both fish and aquatic insects.
    - Inclusion of a diversity of in-bank and in-stream habitat for fauna. The addition of cobble substrate of various sizes (gravels through to boulders), root balls, or tree stumps to create stable undercut banks and other habitat would provide a greater variety of habitat for fish (including banded kōkopu, longfin eels, and other fishes) and kēkēwai.
- Densely planting the riparian margin (>10 m wide on either side, where possible) with indigenous and ecologically suitable vegetation. Important ecological functions these plantings should achieve include providing multiple height tiers of vegetation to shade the stream channel (to minimise nuisance freshwater macrophyte growth and maintain consistent water temperatures), stabilise banks, create in-stream and terrestrial habitats, filter run-off, and provide suitable in-stream leaf and wood debris additions.
    - Use plant species appropriate to riparian margins that have been eco-sourced ideally from the Low Plains Ecological District.
    - Exotic deciduous trees should be avoided adjacent to the waterway.
    - Plant up to <u>and</u> overhanging the water's edge to create shading and provide bank and in-stream habitats for fauna.
    - Where it is important to maintain flood capacity, banks could be planted with flexible and low-density foliage (e.g., pūrei, *Carex*, wīwī).
- Weed control along the waterways may be required to manually remove any exotic weed species that are likely to out-compete native seedlings or create undesirable growing conditions (i.e., gorse, willow).

  - Avoid using herbicide sprays near the waterway; and minimise creating areas of loose soil (e.g., leave root balls / stumps of tall trees rather than removing) that may erode into the waterways.

Waterway piping

As we understand it, the CCC is considering piping the north-south branch of Stilwells Waterway. When considering piping sections of waterways, the following should be considered:

- Overall, it is recommended that there be no net loss, and preferably a net gain, of freshwater habitat and values as a result of the works proposed for these waterways.
  - Piping of waterways, even those with low baseflows and ecological value, needs to be carefully considered. The National Policy Statement for Freshwater Management (2020) includes objectives to avoid loss of stream length and / or ecological value of natural waterways.
  - Enhancement and habitat improvements and / or increasing waterway linear length through increased channel sinuosity could potentially offset the piping or decommissioning of short sections of poor quality, intermittent waterways.
- Erosion and sediment control measures should be in place to minimise mobilisation of contaminated sediments into the receiving environment.
- Additional investigations regarding in-stream contaminant loads, and measures to avoid resuspension and downstream distribution of these, needs to be considered.

Works in and adjacent to waterways

More generally, we recommend the following actions be incorporated into any future projects for works in and adjacent to waterways.

- Carry out focussed surveys for Threatened, At Risk and locally rare species, (e.g., kēkēwai, kākahi, banded kōkopu, other freshwater fishes and macroinvertebrates) prior to proposed realignment or other in-stream works to better understand where 'source' populations occur that may need to be protected.
- The extent and alignment of linear wetland systems adjacent to the lower reaches of Ballintines Waterway should be assessed.
- Works within and adjacent to the waterway should be in accordance with the *National works in waterways guideline: Best practice guide for civil infrastructure works and maintenance* (Ministry for the Environment, 2021). This includes development and implementation of a freshwater fauna management plan, avoiding adverse effects from sedimentation and contaminant discharge, and using only fully biodegradable geotechnical stabilisation and plant protection options, avoiding other geotechnical materials to avoid plastic remnants remaining in the environment.
- Development of a monitoring programme to monitor the success of any treatment and enhancement works and evaluate the need for any additional improvements is an important consideration. This does require monitoring to occur over a number of years.
- Limitations to fish passage and upstream recruitment via Blakiston Drain could be assessed further. If the piped section is found to be a barrier, options could include

diverting some flow from Sherrings Waterway into Ballintines Waterway to encourage passage via the open channel. However, changes to velocities, water levels and sediment transport should be considered when designing any redirection of flow between waterways.

Future surveys

We recommend the following opportunities for future surveys.

- Undertake surveys of freshwater fish communities in the wider catchment, with a particular focus on tributary waterways that may support banded kōkopu. Given that banded kōkopu is a notable find for this area, focused surveys of fish communities (e.g. using spotlighting) would provide a better, more detailed understanding of their distribution and population dynamics.
- Carry out additional surveys of macroinvertebrate communities, particularly in areas where notable taxa have been observed in this study and within Henderson, Days and Dunbar waterways (e.g., for *Deleatidium*, *Polyplectropus*, *Psilochorema*, kākahi, kēkēwai). Monitoring such as this would be helpful to understand the presence of pollution-sensitive and notable species. If established populations become apparent, waterway realignment and restoration should take into account the requirements of these species, in order to maximise the likelihood of the taxa establishing larger, sustainable populations.

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Appendix 1: General photos

Sherrings Waterway Branch

Sparks Road Drain

Stilwells Waterway Branch

Rollesby Street Drain

Ballintines Waterway, parallel to Cashmere Road

Banded kōkopu at Site 5: Sherrings u/s Sparks Road

Appendix 2: Sediment quality results

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Certificate of Analysis

SPv1

Client:	Boffa Miskell Limited	**Lab No:**	3830410
Contact:	Kate Hornblow	**Date Received:**	25-Mar-2025
	C/- Boffa Miskell Limited	**Date Reported:**	10-Apr-2025
	PO Box 110	**Quote No:**	135820
	Christchurch 8140	**Order No:**	
		Client Reference:	
		Submitted By:	Kate Hornblow

Sample Type: Sediment

Sample Name:		Site 1 25-Mar-2025 9:40 am	Site 2 25-Mar-2025 11:30 am	Site 3 25-Mar-2025 12:45 pm	Site 6 25-Mar-2025 3:20 pm	Site 7 25-Mar-2025 2:30 pm
Lab Number:		3830410.1	3830410.2	3830410.3	3830410.4	3830410.5
Individual Tests						
Dry Matter	g/100g as rcvd	32	30	43	27	19.5
Particle size analysis*‡		See attached report	See attached report	See attached report	See attached report	See attached report
Total Recoverable Phosphorus	mg/kg dry wt	980	1,490	860	800	1,010
Total Organic Carbon*	g/100g dry wt	6.0	6.4	4.7	6.5	9.6
Heavy metal, trace level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	9.8	9.2	18.9	10.1	8.5
Total Recoverable Cadmium	mg/kg dry wt	0.23	0.24	0.22	0.31	0.37
Total Recoverable Chromium	mg/kg dry wt	19.1	19.2	27	20	15.7
Total Recoverable Copper	mg/kg dry wt	25	21	31	26	22
Total Recoverable Lead	mg/kg dry wt	85	44	69	57	46
Total Recoverable Nickel	mg/kg dry wt	13.3	15.8	16.8	16.2	12.3
Total Recoverable Zinc	mg/kg dry wt	270	270	250	370	320
Acid Herbicides Trace in Soil by LCMSMS*						
Acifluorfen	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Bentazone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Bromoxynil	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Clopyralid	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dicamba	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2,4-Dichlorophenoxyacetic acid (24D)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2,4-Dichlorophenoxybutyric acid (24DB)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dichlorprop	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluazifop	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluroxypyr	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Haloxyfop	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2-methyl-4-chlorophenoxyacetic acid (MCPA)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2-methyl-4-chlorophenoxybutanoic acid (MCPB)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Mecoprop (MCPP; 2-methyl-4-chlorophenoxypropionic acid)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Oryzalin	mg/kg dry wt	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Pentachlorophenol (PCP)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Picloram	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Quizalofop	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2,3,4,6-Tetrachlorophenol (TCP)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Type: Sediment						
Sample Name:		Site 1 25-Mar-2025 9:40 am	Site 2 25-Mar-2025 11:30 am	Site 3 25-Mar-2025 12:45 pm	Site 6 25-Mar-2025 3:20 pm	Site 7 25-Mar-2025 2:30 pm
Lab Number:		3830410.1	3830410.2	3830410.3	3830410.4	3830410.5
Acid Herbicides Trace in Soil by LCMSMS*						
2,4,5-trichlorophenoxypropionic acid (245TP,Fenoprop, Silvex)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2,4,5-Trichlorophenoxyacetic acid (245T)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Triclopyr*	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Multiresidue Pesticides in Sediment samples by GCMS						
Acetochlor	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Alachlor	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Atrazine	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Atrazine-desethyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Atrazine-desisopropyl	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Azaconazole	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Azinphos-methyl	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Benalaxyl	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Bendiocarb	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Benodanil	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Bifenthrin	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.3	< 0.4
Bitertanol	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Bromacil	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Bromophos-ethyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Bromopropylate	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Bupirimate	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Buprofezin	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Butachlor	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Captafol	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Captan	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Carbaryl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Carbofenothion	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Carbofuran	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Chlorfenvinphos	mg/kg dry wt	< 0.3	< 0.4	< 0.3	< 0.4	< 0.5
Chlorfluazuron	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Chlorothalonil	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Chlorpropham	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Chlorpyrifos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Chlorpyrifos-methyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Chlortoluron	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Chlozolinate	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Coumaphos	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Cyanazine	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Cyfluthrin	mg/kg dry wt	< 0.3	< 0.3	< 0.18	< 0.3	< 0.5
Cyhalothrin	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Cypermethrin	mg/kg dry wt	< 0.5	< 0.6	< 0.4	< 0.6	< 0.9
Cyproconazole	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Cyprodinil	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Deltamethrin (including Tralomethrin)	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Diazinon	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Dichlobenil	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Dichlofenthion	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Dichlofluanid	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Dichloran	mg/kg dry wt	< 0.6	< 0.6	< 0.4	< 0.7	< 0.9
Dichlorvos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Dicofol	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Dicrotophos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Difenoconazole	mg/kg dry wt	< 0.3	< 0.4	< 0.3	< 0.4	< 0.5

Sample Type: Sediment						
Sample Name:		Site 1 25-Mar-2025 9:40 am	Site 2 25-Mar-2025 11:30 am	Site 3 25-Mar-2025 12:45 pm	Site 6 25-Mar-2025 3:20 pm	Site 7 25-Mar-2025 2:30 pm
Lab Number:		3830410.1	3830410.2	3830410.3	3830410.4	3830410.5
Multiresidue Pesticides in Sediment samples by GCMS						
Dimethoate	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Dinocap	mg/kg dry wt	< 3	< 3	< 1.7	< 3	< 4
Diphenylamine	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Diuron	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
EPN	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Ethion	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Etrimfos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Famphur	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fenarimol	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fenitrothion	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fenpropathrin	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fenpropimorph	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fensulfothion	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fenvalerate (including Esfenvalerate)	mg/kg dry wt	< 0.3	< 0.4	< 0.3	< 0.4	< 0.5
Fluazifop-butyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fluometuron	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Flusilazole	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Fluvalinate	mg/kg dry wt	< 0.15	< 0.16	< 0.11	< 0.18	< 0.3
Folpet	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Furalaxyl	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Haloxyfop-methyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Hexaconazole	mg/kg dry wt	< 0.3	< 0.3	< 0.18	< 0.3	< 0.4
Hexazinone	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Hexythiazox	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Imazalil	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Indoxacarb	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Iodofenphos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
IPBC (3-Iodo-2-propynyl-n-butylcarbamate)	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Isazophos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Isofenphos	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Kresoxim-methyl	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Leptophos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Linuron	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Malathion	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Metalaxyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Methacrifos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Methamidophos	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Methidathion	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Methiocarb	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Metolachlor	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Metribuzin	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Mevinphos	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Molinate	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Myclobutanil	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Naled	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Nitrofen	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Nitrothal-isopropyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Norflurazon	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Omethoate	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Oxadiazon	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Oxychlordane	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Oxyfluorfen	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Paclobutrazol	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4

Sample Type: Sediment						
	Sample Name:	Site 1 25-Mar-2025 9:40 am	Site 2 25-Mar-2025 11:30 am	Site 3 25-Mar-2025 12:45 pm	Site 6 25-Mar-2025 3:20 pm	Site 7 25-Mar-2025 2:30 pm
	Lab Number:	3830410.1	3830410.2	3830410.3	3830410.4	3830410.5
Multiresidue Pesticides in Sediment samples by GCMS						
Parathion-ethyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Parathion-methyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Penconazole	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Pendimethalin	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Permethrin	mg/kg dry wt	0.22	< 0.07	< 0.05	< 0.07	0.83
Phosmet	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Phosphamidon	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Pirimicarb	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Pirimiphos-methyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Prochloraz	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Procymidone	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Prometryn	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Propachlor	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Propanil	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Propazine	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Propetamphos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Propham	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Propiconazole	mg/kg dry wt	< 0.15	< 0.16	< 0.11	< 0.18	< 0.3
Prothiofos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Pyrazophos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Pyrifenox	mg/kg dry wt	< 0.3	< 0.4	< 0.3	< 0.4	< 0.5
Pyrimethanil	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Pyriproxyfen	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Quintozene	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Quizalofop-ethyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Simazine	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Simetryn	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Sulfentrazone	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Sulfotep	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
TCMTB [2-(thiocyanomethylthio) benzothiazole,Busan]	mg/kg dry wt	< 0.5	< 0.5	< 0.3	< 0.5	< 0.7
Tebuconazole	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Tebufenpyrad	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Terbacil	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Terbumeton	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Terbuthylazine	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Terbuthylazine-desethyl	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Terbutryn	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Tetrachlorvinphos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Thiabendazole	mg/kg dry wt	< 1.1	< 1.1	< 0.8	< 1.3	< 1.7
Thiobencarb	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Tolylfluanid	mg/kg dry wt	< 0.11	< 0.11	< 0.08	< 0.13	< 0.17
Triadimefon	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Triazophos	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Trifluralin	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Vinclozolin	mg/kg dry wt	< 0.3	< 0.3	< 0.15	< 0.3	< 0.4
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	0.0010	< 0.0010
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	0.0012	< 0.0010

Sample Type: Sediment						
Sample Name:		Site 1 25-Mar-2025 9:40 am	Site 2 25-Mar-2025 11:30 am	Site 3 25-Mar-2025 12:45 pm	Site 6 25-Mar-2025 3:20 pm	Site 7 25-Mar-2025 2:30 pm
Lab Number:		3830410.1	3830410.2	3830410.3	3830410.4	3830410.5
Organochlorine Pesticides Trace in Soil						
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDD	mg/kg dry wt	0.0029	0.0026	0.0037	0.0019	0.0019
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDE	mg/kg dry wt	0.0085	0.0137	0.0088	0.0053	0.0059
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	0.0017	< 0.0010	< 0.0010
4,4'-DDT	mg/kg dry wt	0.0031	0.0015	0.0096	0.0023	0.0028
Total DDT Isomers	mg/kg dry wt	0.015	0.018	0.024	0.009	0.011
Dieldrin	mg/kg dry wt	< 0.0010	< 0.0010	0.0021	< 0.0010	< 0.0010
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	4.9	3.8	15.4	12.3	10.3
1-Methylnaphthalene	mg/kg dry wt	0.016	0.018	0.078	0.075	0.063
2-Methylnaphthalene	mg/kg dry wt	0.013	0.014	0.044	0.049	0.048
Acenaphthene	mg/kg dry wt	0.020	0.017	0.136	0.087	0.078
Acenaphthylene	mg/kg dry wt	0.064	0.057	0.188	0.171	0.139
Anthracene	mg/kg dry wt	0.091	0.107	0.33	0.35	0.31
Benzo[a]anthracene	mg/kg dry wt	0.34	0.25	1.04	0.82	0.68
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.36	0.25	1.00	0.76	0.64
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.40	0.29	1.20	0.85	0.69
Benzo[e]pyrene	mg/kg dry wt	0.198	0.138	0.56	0.41	0.33
Benzo[g,h,i]perylene	mg/kg dry wt	0.25	0.178	0.65	0.47	0.41
Benzo[k]fluoranthene	mg/kg dry wt	0.165	0.113	0.45	0.37	0.28
Chrysene	mg/kg dry wt	0.38	0.26	1.09	0.81	0.60
Dibenzo[a,h]anthracene	mg/kg dry wt	0.052	0.037	0.160	0.109	0.103
Fluoranthene	mg/kg dry wt	0.75	0.58	2.5	1.92	1.59
Fluorene	mg/kg dry wt	0.059	0.074	0.25	0.27	0.24
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.25	0.170	0.69	0.50	0.42
Naphthalene	mg/kg dry wt	< 0.03	< 0.03	0.044	0.05	0.05
Perylene	mg/kg dry wt	0.123	0.098	0.22	0.29	0.29
Phenanthrene	mg/kg dry wt	0.57	0.52	2.4	1.99	1.70
Pyrene	mg/kg dry wt	0.79	0.62	2.5	1.98	1.63
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.54	0.37	1.53	1.15	0.97
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.53	0.37	1.51	1.13	0.95

Sample Name:		Site 8 25-Mar-2025 1:30 pm	Site 11 25-Mar-2025 3:35 pm
Lab Number:		3830410.6	3830410.7
Individual Tests			
Dry Matter	g/100g as rcvd	31	27
Particle size analysis*‡		See attached report	See attached report
Total Recoverable Phosphorus	mg/kg dry wt	890	1,040
Total Organic Carbon*	g/100g dry wt	4.5	9.9

Sample Type: Sediment			
Sample Name:		Site 8 25-Mar-2025 1:30 pm	Site 11 25-Mar-2025 3:35 pm
Lab Number:		3830410.6	3830410.7
Heavy metal, trace level As,Cd,Cr,Cu,Ni,Pb,Zn			
Total Recoverable Arsenic	mg/kg dry wt	18.2	45
Total Recoverable Cadmium	mg/kg dry wt	0.23	0.63
Total Recoverable Chromium	mg/kg dry wt	34	46
Total Recoverable Copper	mg/kg dry wt	29	73
Total Recoverable Lead	mg/kg dry wt	49	123
Total Recoverable Nickel	mg/kg dry wt	15.6	18.3
Total Recoverable Zinc	mg/kg dry wt	230	1,040
Acid Herbicides Trace in Soil by LCMSMS*			
Acifluorfen	mg/kg dry wt	< 0.010	< 0.010
Bentazone	mg/kg dry wt	< 0.010	< 0.010
Bromoxynil	mg/kg dry wt	< 0.010	< 0.010
Clopyralid	mg/kg dry wt	< 0.010	< 0.010
Dicamba	mg/kg dry wt	< 0.010	< 0.010
2,4-Dichlorophenoxyacetic acid (24D)	mg/kg dry wt	< 0.010	< 0.010
2,4-Dichlorophenoxybutyric acid (24DB)	mg/kg dry wt	< 0.010	< 0.010
Dichlorprop	mg/kg dry wt	< 0.010	< 0.010
Fluazifop	mg/kg dry wt	< 0.010	< 0.010
Fluroxypyr	mg/kg dry wt	< 0.010	< 0.010
Haloxyfop	mg/kg dry wt	< 0.010	< 0.010
2-methyl-4-chlorophenoxyacetic acid (MCPA)	mg/kg dry wt	< 0.010	< 0.010
2-methyl-4-chlorophenoxybutanoic acid (MCPB)	mg/kg dry wt	< 0.010	< 0.010
Mecoprop (MCPP; 2-methyl-4-chlorophenoxypropionic acid)	mg/kg dry wt	< 0.010	< 0.010
Oryzalin	mg/kg dry wt	< 0.02	< 0.02
Pentachlorophenol (PCP)	mg/kg dry wt	< 0.010	< 0.010
Picloram	mg/kg dry wt	< 0.010	< 0.010
Quizalofop	mg/kg dry wt	< 0.010	< 0.010
2,3,4,6-Tetrachlorophenol (TCP)	mg/kg dry wt	< 0.010	< 0.010
2,4,5-trichlorophenoxypropionic acid (245TP,Fenoprop, Silvex)	mg/kg dry wt	< 0.010	< 0.010
2,4,5-Trichlorophenoxyacetic acid (245T)	mg/kg dry wt	< 0.010	< 0.010
Triclopyr*	mg/kg dry wt	< 0.010	< 0.010
Multiresidue Pesticides in Sediment samples by GCMS			
Acetochlor	mg/kg dry wt	< 0.3	< 0.3
Alachlor	mg/kg dry wt	< 0.11	< 0.12
Atrazine	mg/kg dry wt	< 0.3	< 0.3
Atrazine-desethyl	mg/kg dry wt	< 0.3	< 0.3
Atrazine-desisopropyl	mg/kg dry wt	< 0.5	< 0.5
Azaconazole	mg/kg dry wt	< 0.3	< 0.3
Azinphos-methyl	mg/kg dry wt	< 0.5	< 0.5
Benalaxyl	mg/kg dry wt	< 0.11	< 0.12
Bendiocarb	mg/kg dry wt	< 0.3	< 0.3
Benodanil	mg/kg dry wt	< 0.5	< 0.5
Bifenthrin	mg/kg dry wt	< 0.3	< 0.3
Bitertanol	mg/kg dry wt	< 0.5	< 0.5
Bromacil	mg/kg dry wt	< 0.3	< 0.3
Bromophos-ethyl	mg/kg dry wt	< 0.3	< 0.3
Bromopropylate	mg/kg dry wt	< 0.3	< 0.3
Bupirimate	mg/kg dry wt	< 0.3	< 0.3
Buprofezin	mg/kg dry wt	< 0.3	< 0.3
Butachlor	mg/kg dry wt	< 0.3	< 0.3
Captafol	mg/kg dry wt	< 1.1	< 1.2

Sample Type: Sediment			
	Sample Name:	Site 8 25-Mar-2025 1:30 pm	Site 11 25-Mar-2025 3:35 pm
	Lab Number:	3830410.6	3830410.7
Multiresidue Pesticides in Sediment samples by GCMS			
Captan	mg/kg dry wt	< 0.5	< 0.5
Carbaryl	mg/kg dry wt	< 0.3	< 0.3
Carbofenothion	mg/kg dry wt	< 0.3	< 0.3
Carbofuran	mg/kg dry wt	< 0.3	< 0.3
Chlorfenvinphos	mg/kg dry wt	< 0.3	< 0.4
Chlorfluazuron	mg/kg dry wt	< 0.3	< 0.3
Chlorothalonil	mg/kg dry wt	< 0.3	< 0.3
Chlorpropham	mg/kg dry wt	< 0.5	< 0.5
Chlorpyrifos	mg/kg dry wt	< 0.3	< 0.3
Chlorpyrifos-methyl	mg/kg dry wt	< 0.3	< 0.3
Chlortoluron	mg/kg dry wt	< 0.5	< 0.5
Chlozolinate	mg/kg dry wt	< 0.3	< 0.3
Coumaphos	mg/kg dry wt	< 0.5	< 0.5
Cyanazine	mg/kg dry wt	< 0.3	< 0.3
Cyfluthrin	mg/kg dry wt	< 0.3	< 0.3
Cyhalothrin	mg/kg dry wt	< 0.3	< 0.3
Cypermethrin	mg/kg dry wt	< 0.6	< 0.6
Cyproconazole	mg/kg dry wt	< 0.5	< 0.5
Cyprodinil	mg/kg dry wt	< 0.3	< 0.3
Deltamethrin (including Tralomethrin)	mg/kg dry wt	< 0.3	< 0.3
Diazinon	mg/kg dry wt	< 0.11	< 0.12
Dichlobenil	mg/kg dry wt	< 0.3	< 0.3
Dichlofenthion	mg/kg dry wt	< 0.3	< 0.3
Dichlofluanid	mg/kg dry wt	< 0.3	< 0.3
Dichloran	mg/kg dry wt	< 0.6	< 0.6
Dichlorvos	mg/kg dry wt	< 0.3	< 0.3
Dicofol	mg/kg dry wt	< 1.1	< 1.2
Dicrotophos	mg/kg dry wt	< 0.3	< 0.3
Difenoconazole	mg/kg dry wt	< 0.3	< 0.4
Dimethoate	mg/kg dry wt	< 0.5	< 0.5
Dinocap	mg/kg dry wt	< 3	< 3
Diphenylamine	mg/kg dry wt	< 0.5	< 0.5
Diuron	mg/kg dry wt	< 0.3	< 0.3
EPN	mg/kg dry wt	< 0.3	< 0.3
Ethion	mg/kg dry wt	< 0.3	< 0.3
Etrimfos	mg/kg dry wt	< 0.3	< 0.3
Famphur	mg/kg dry wt	< 0.3	< 0.3
Fenarimol	mg/kg dry wt	< 0.3	< 0.3
Fenitrothion	mg/kg dry wt	< 0.3	< 0.3
Fenpropathrin	mg/kg dry wt	< 0.3	< 0.3
Fenpropimorph	mg/kg dry wt	< 0.3	< 0.3
Fensulfothion	mg/kg dry wt	< 0.3	< 0.3
Fenvalerate (including Esfenvalerate)	mg/kg dry wt	< 0.3	< 0.4
Fluazifop-butyl	mg/kg dry wt	< 0.3	< 0.3
Fluometuron	mg/kg dry wt	< 0.3	< 0.3
Flusilazole	mg/kg dry wt	< 0.3	< 0.3
Fluvalinate	mg/kg dry wt	< 0.15	< 0.17
Folpet	mg/kg dry wt	< 0.5	< 0.5
Furalaxyl	mg/kg dry wt	< 0.11	< 0.12
Haloxyfop-methyl	mg/kg dry wt	< 0.3	< 0.3
Hexaconazole	mg/kg dry wt	< 0.3	< 0.3
Hexazinone	mg/kg dry wt	< 0.11	< 0.12
Hexythiazox	mg/kg dry wt	< 1.1	< 1.2
Imazalil	mg/kg dry wt	< 1.1	< 1.2

Sample Type: Sediment			
Sample Name:		Site 8 25-Mar-2025 1:30 pm	Site 11 25-Mar-2025 3:35 pm
Lab Number:		3830410.6	3830410.7
Multiresidue Pesticides in Sediment samples by GCMS			
Indoxacarb	mg/kg dry wt	< 0.3	< 0.3
Iodofenphos	mg/kg dry wt	< 0.3	< 0.3
IPBC (3-Iodo-2-propynyl-n-butylcarbamate)	mg/kg dry wt	< 1.1	< 1.2
Isazophos	mg/kg dry wt	< 0.3	< 0.3
Isofenphos	mg/kg dry wt	< 0.11	< 0.12
Kresoxim-methyl	mg/kg dry wt	< 0.11	< 0.12
Leptophos	mg/kg dry wt	< 0.3	< 0.3
Linuron	mg/kg dry wt	< 0.3	< 0.3
Malathion	mg/kg dry wt	< 0.3	< 0.3
Metalaxyl	mg/kg dry wt	< 0.3	< 0.3
Methacrifos	mg/kg dry wt	< 0.3	< 0.3
Methamidophos	mg/kg dry wt	< 1.1	< 1.2
Methidathion	mg/kg dry wt	< 0.3	< 0.3
Methiocarb	mg/kg dry wt	< 0.3	< 0.3
Metolachlor	mg/kg dry wt	< 0.11	< 0.12
Metribuzin	mg/kg dry wt	< 0.3	< 0.3
Mevinphos	mg/kg dry wt	< 0.5	< 0.5
Molinate	mg/kg dry wt	< 0.5	< 0.5
Myclobutanil	mg/kg dry wt	< 0.3	< 0.3
Naled	mg/kg dry wt	< 1.1	< 1.2
Nitrofen	mg/kg dry wt	< 0.5	< 0.5
Nitrothal-isopropyl	mg/kg dry wt	< 0.3	< 0.3
Norflurazon	mg/kg dry wt	< 0.5	< 0.5
Omethoate	mg/kg dry wt	< 1.1	< 1.2
Oxadiazon	mg/kg dry wt	< 0.3	< 0.3
Oxychlordane	mg/kg dry wt	< 0.11	< 0.12
Oxyfluorfen	mg/kg dry wt	< 0.11	< 0.12
Paclobutrazol	mg/kg dry wt	< 0.3	< 0.3
Parathion-ethyl	mg/kg dry wt	< 0.3	< 0.3
Parathion-methyl	mg/kg dry wt	< 0.3	< 0.3
Penconazole	mg/kg dry wt	< 0.3	< 0.3
Pendimethalin	mg/kg dry wt	< 0.3	< 0.3
Permethrin	mg/kg dry wt	< 0.06	< 0.07
Phosmet	mg/kg dry wt	< 0.3	< 0.3
Phosphamidon	mg/kg dry wt	< 0.3	< 0.3
Pirimicarb	mg/kg dry wt	< 0.3	< 0.3
Pirimiphos-methyl	mg/kg dry wt	< 0.3	< 0.3
Prochloraz	mg/kg dry wt	< 1.1	< 1.2
Procymidone	mg/kg dry wt	< 0.3	< 0.3
Prometryn	mg/kg dry wt	< 0.11	< 0.12
Propachlor	mg/kg dry wt	< 0.3	< 0.3
Propanil	mg/kg dry wt	< 0.5	< 0.5
Propazine	mg/kg dry wt	< 0.11	< 0.12
Propetamphos	mg/kg dry wt	< 0.3	< 0.3
Propham	mg/kg dry wt	< 0.3	< 0.3
Propiconazole	mg/kg dry wt	< 0.15	< 0.17
Prothiofos	mg/kg dry wt	< 0.3	< 0.3
Pyrazophos	mg/kg dry wt	< 0.3	< 0.3
Pyrifenox	mg/kg dry wt	< 0.3	< 0.4
Pyrimethanil	mg/kg dry wt	< 0.3	< 0.3
Pyriproxyfen	mg/kg dry wt	< 0.3	< 0.3
Quintozene	mg/kg dry wt	< 0.5	< 0.5
Quizalofop-ethyl	mg/kg dry wt	< 0.3	< 0.3
Simazine	mg/kg dry wt	< 0.3	< 0.3
Simetryn	mg/kg dry wt	< 0.3	< 0.3

Sample Type: Sediment			
	Sample Name:	Site 8 25-Mar-2025 1:30 pm	Site 11 25-Mar-2025 3:35 pm
	Lab Number:	3830410.6	3830410.7
Multiresidue Pesticides in Sediment samples by GCMS			
Sulfentrazone	mg/kg dry wt	< 1.1	< 1.2
Sulfotep	mg/kg dry wt	< 0.3	< 0.3
TCMTB [2-(thiocyanomethylthio) benzothiazole,Busan]	mg/kg dry wt	< 0.5	< 0.5
Tebuconazole	mg/kg dry wt	< 0.3	< 0.3
Tebufenpyrad	mg/kg dry wt	< 0.11	< 0.12
Terbacil	mg/kg dry wt	< 0.3	< 0.3
Terbumeton	mg/kg dry wt	< 0.3	< 0.3
Terbuthylazine	mg/kg dry wt	< 0.11	< 0.12
Terbuthylazine-desethyl	mg/kg dry wt	< 0.3	< 0.3
Terbutryn	mg/kg dry wt	< 0.3	< 0.3
Tetrachlorvinphos	mg/kg dry wt	< 0.3	< 0.3
Thiabendazole	mg/kg dry wt	< 1.1	< 1.2
Thiobencarb	mg/kg dry wt	< 0.3	< 0.3
Tolylfluanid	mg/kg dry wt	< 0.11	< 0.12
Triadimefon	mg/kg dry wt	< 0.3	< 0.3
Triazophos	mg/kg dry wt	< 0.3	< 0.3
Trifluralin	mg/kg dry wt	< 0.3	< 0.3
Vinclozolin	mg/kg dry wt	< 0.3	< 0.3
Organochlorine Pesticides Trace in Soil			
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010
4,4'-DDD	mg/kg dry wt	0.0028	0.0077
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010
4,4'-DDE	mg/kg dry wt	0.0126	0.0175
2,4'-DDT	mg/kg dry wt	0.0010	< 0.0010
4,4'-DDT	mg/kg dry wt	0.0043	0.0105
Total DDT Isomers	mg/kg dry wt	0.021	0.036
Dieldrin	mg/kg dry wt	< 0.0010	0.0042
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010
Endrin	mg/kg dry wt	< 0.0010	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.002 #1
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010
Polycyclic Aromatic Hydrocarbons Trace in Soil*			
Total of Reported PAHs in Soil	mg/kg dry wt	6.8	26
1-Methylnaphthalene	mg/kg dry wt	0.031	0.105
2-Methylnaphthalene	mg/kg dry wt	0.025	0.077
Acenaphthene	mg/kg dry wt	0.032	0.097
Acenaphthylene	mg/kg dry wt	0.107	0.49
Anthracene	mg/kg dry wt	0.164	0.65
Benzo[a]anthracene	mg/kg dry wt	0.44	1.77
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.46	1.74
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.57	2.3

Sample Type: Sediment			
	Sample Name:	Site 8 25-Mar-2025 1:30 pm	Site 11 25-Mar-2025 3:35 pm
	Lab Number:	3830410.6	3830410.7
Polycyclic Aromatic Hydrocarbons Trace in Soil*			
Benzo[e]pyrene	mg/kg dry wt	0.27	1.06
Benzo[g,h,i]perylene	mg/kg dry wt	0.34	1.20
Benzo[k]fluoranthene	mg/kg dry wt	0.21	0.87
Chrysene	mg/kg dry wt	0.45	2.0
Dibenzo[a,h]anthracene	mg/kg dry wt	0.074	0.32
Fluoranthene	mg/kg dry wt	1.04	3.8
Fluorene	mg/kg dry wt	0.118	0.39
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.33	1.32
Naphthalene	mg/kg dry wt	0.03	0.10
Perylene	mg/kg dry wt	0.190	0.56
Phenanthrene	mg/kg dry wt	0.88	3.2
Pyrene	mg/kg dry wt	1.07	3.8
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.71	2.7
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.70	2.7

Analyst's Comments

‡ Analysis subcontracted to an external provider. Refer to the Summary of Methods section for more details.

#1 Due to some interference found in the chromatography, the detection limit was raised. Hence the higher detection limit reported.

Appendix No.1 - Waikato University Report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed).	-	1-7
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation May contain a residual moisture content of 2-5%. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed).	-	1-7
Soil Prep Dry for Organics,Trace*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-7
Heavy metal, trace level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.8 mg/kg dry wt	1-7
Acid Herbicides Trace in Soil by LCMSMS*	Solvent extraction, LC-MS/MS analysis. Tested on dried sample. In-house.	0.010 - 0.02 mg/kg dry wt	1-7
Multiresidue Pesticides in Sediment samples by GCMS	Sonication extraction, GC-ECD and GC-MS analysis. In-house based on US EPA 8081 and US EPA 8270.	0.0010 - 0.03 mg/kg dry wt	1-7
Polycyclic Aromatic Hydrocarbons Trace in Soil*	Sonication extraction, GC-MS/MS analysis. Tested on as received sample. In-house based on US EPA 8270.	0.002 - 0.03 mg/kg dry wt	1-7
Dry Matter	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	1-7
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2 (modified).	-	1-7
Particle size analysis*	Malvern Laser Sizer particle size analysis from 0.05 microns to 3.4 mm. Samples are measured in volume %. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-7

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2 (modified).	40 mg/kg dry wt	1-7
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-7

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 26-Mar-2025 and 10-Apr-2025. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Analysis - Under

University of Waikato

Measurement Details

Sample Name 3830410.1
SOP File Name Sediment.msop
Lab Number 2025070.1
Operator Name rodgers

Measurement Details

Analysis Date Time 1/04/2025 3:40:21 PM
Measurement Date Time 1/04/2025 3:40:21 PM
Result Source Measurement

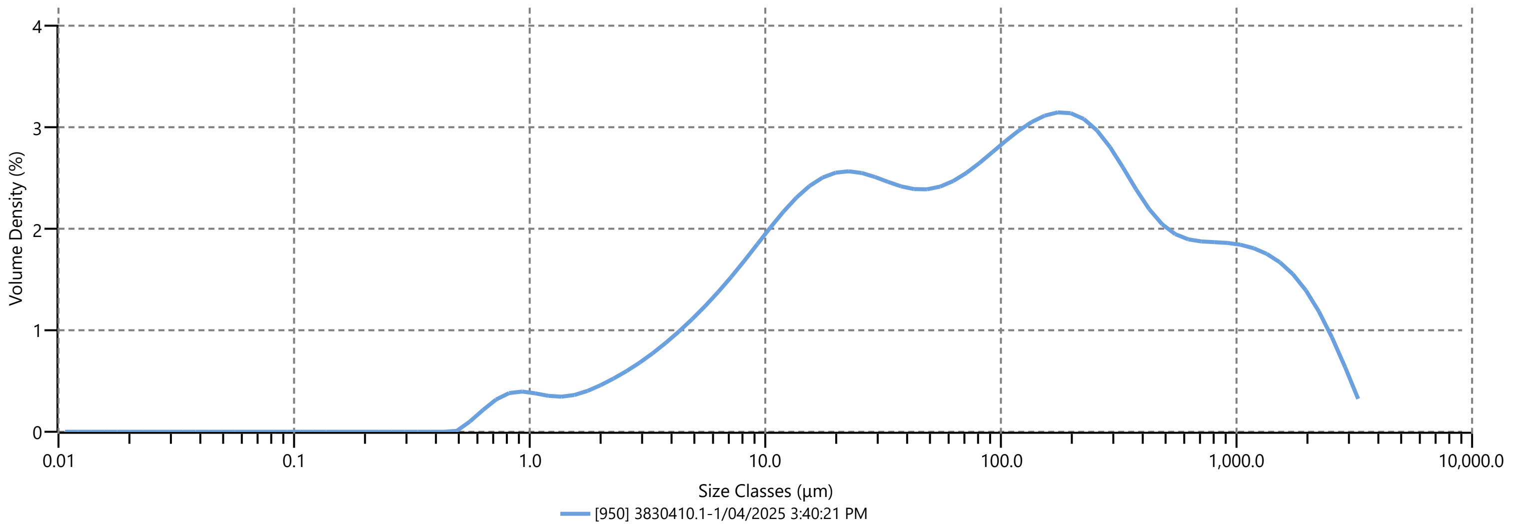
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.28 %
Laser Obscuration 34.06 %

Result

Span 11.217
Uniformity 3.227
Specific Surface Area 154.8 m^2/kg
D [3,2] 14.9 µm
D [4,3] 330 µm
Dv (10) 6.79 µm
Dv (50) 93.5 µm
Dv (90) 1060 µm
Dv (95) 1630 µm
Volume Below (10) µm 14.30 %
Volume Below (20) µm 24.79 %
Volume Below (31) µm 32.08 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	11.40	88.0	48.91	350	75.60	1410	93.39
0.0600	0.00	15.6	20.73	105	52.14	420	78.38	1680	95.29
0.120	0.00	31.0	32.08	125	55.48	500	80.78	2000	96.98
0.240	0.00	37.0	34.91	149	58.99	590	82.90	2380	98.40
0.490	0.00	44.0	37.62	177	62.51	710	85.18	2830	99.37
0.980	1.16	53.0	40.53	210	66.02	840	87.23	3360	99.91
2.00	2.91	63.0	43.28	250	69.50	1000	89.35		
3.90	5.78	74.0	45.92	300	72.94	1190	91.43		

Analysis - Under

University of Waikato

Measurement Details

Sample Name 3830410.2
SOP File Name Sediment.msop
Lab Number 2025070.2
Operator Name rodgers

Measurement Details

Analysis Date Time 1/04/2025 3:48:03 PM
Measurement Date Time 1/04/2025 3:48:03 PM
Result Source Measurement

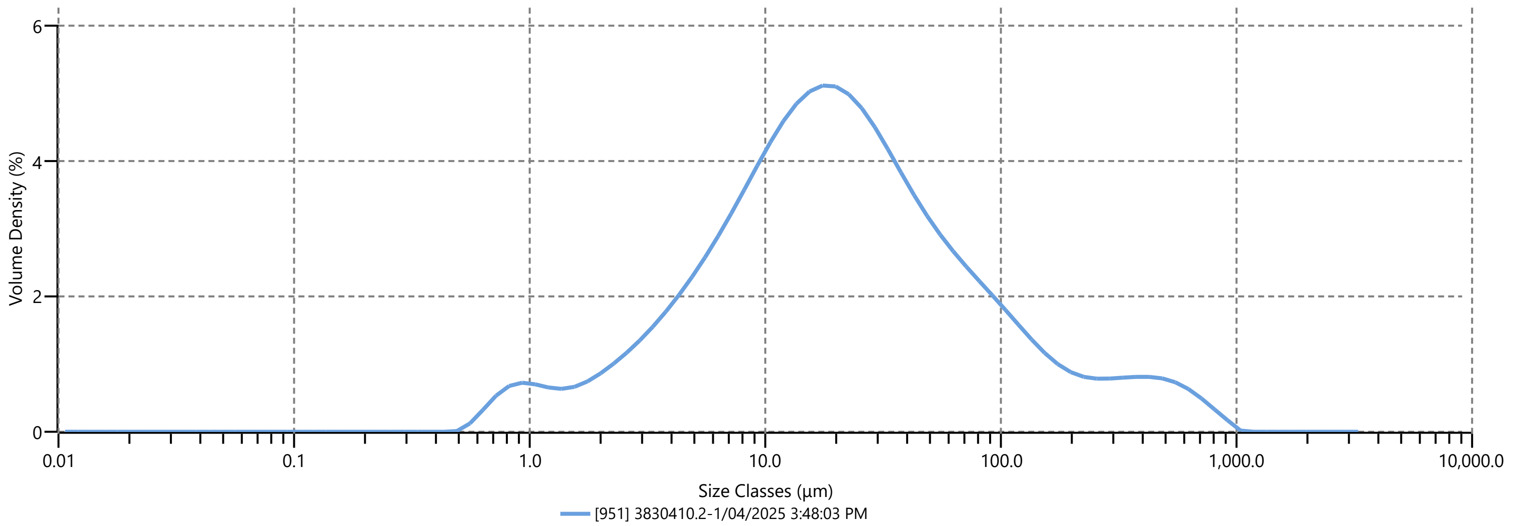
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.44 %
Laser Obscuration 24.52 %

Result

Span 6.478
Uniformity 2.505
Specific Surface Area 283.3 m^2/kg
D [3,2] 8.15 µm
D [4,3] 58.4 µm
Dv (10) 3.62 µm
Dv (50) 19.7 µm
Dv (90) 131 µm
Dv (95) 290 µm
Volume Below (10) µm 28.73 %
Volume Below (20) µm 50.55 %
Volume Below (31) µm 64.32 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	22.56	88.0	85.45	350	95.98	1410	100.00
0.0600	0.00	15.6	42.27	105	87.68	420	96.95	1680	100.00
0.120	0.00	31.0	64.32	125	89.56	500	97.86	2000	100.00
0.240	0.00	37.0	69.05	149	91.10	590	98.66	2380	100.00
0.490	0.00	44.0	73.18	177	92.32	710	99.37	2830	100.00
0.980	1.95	53.0	77.09	210	93.33	840	99.81	3360	100.00
2.00	5.18	63.0	80.26	250	94.25	1000	100.00		
3.90	10.85	74.0	82.92	300	95.18	1190	100.00		

Analysis - Under

University of Waikato

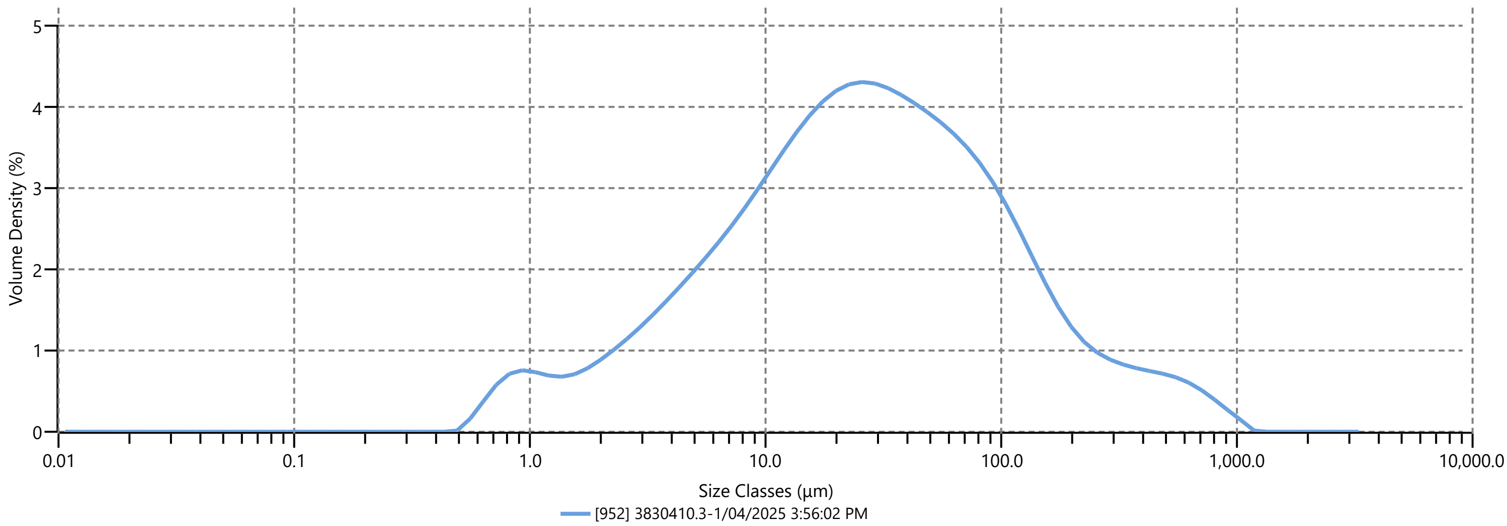
Measurement Details	
Sample Name	3830410.3
SOP File Name	Sediment.msop
Lab Number	2025070.3
Operator Name	rodgers

Measurement Details	
Analysis Date Time	1/04/2025 3:56:02 PM
Measurement Date Time	1/04/2025 3:56:02 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.41 %
Laser Obscuration	27.63 %

Result	
Span	5.822
Uniformity	2.177
Specific Surface Area	271.3 m^2/kg
D [3,2]	8.51 µm
D [4,3]	68.5 µm
Dv (10)	3.56 µm
Dv (50)	26.4 µm
Dv (90)	157 µm
Dv (95)	295 µm
Volume Below (10) µm	25.32 %
Volume Below (20) µm	42.22 %
Volume Below (31) µm	54.48 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	20.62	88.0	80.52	350	95.93	1410	100.00
0.0600	0.00	15.6	35.61	105	83.95	420	96.86	1680	100.00
0.120	0.00	31.0	54.48	125	86.91	500	97.69	2000	100.00
0.240	0.00	37.0	59.34	149	89.34	590	98.42	2380	100.00
0.490	0.00	44.0	63.98	177	91.25	710	99.12	2830	100.00
0.980	2.11	53.0	68.77	210	92.77	840	99.60	3360	100.00
2.00	5.53	63.0	73.01	250	93.99	1000	99.90		
3.90	10.94	74.0	76.76	300	95.09	1190	100.00		

Analysis - Under

University of Waikato

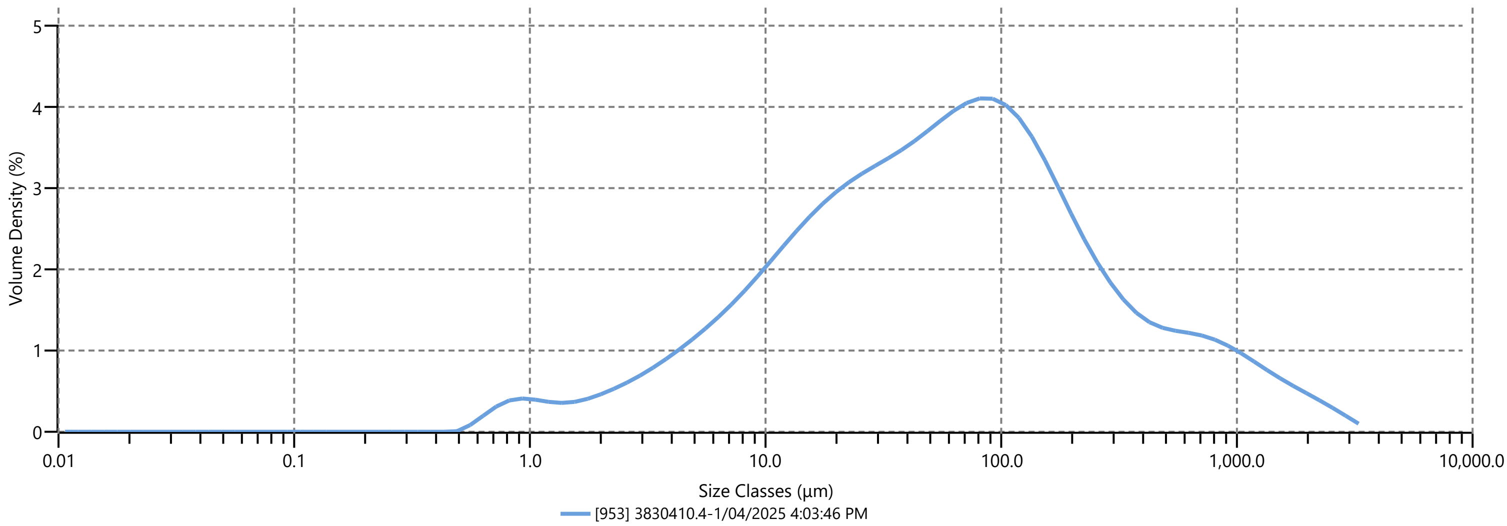
Measurement Details	
Sample Name	3830410.4
SOP File Name	Sediment.msop
Lab Number	2025070.4
Operator Name	rodgers

Measurement Details	
Analysis Date Time	1/04/2025 4:03:46 PM
Measurement Date Time	1/04/2025 4:03:46 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.27 %
Laser Obscuration	29.68 %

Result	
Span	7.927
Uniformity	2.751
Specific Surface Area	162.5 m^2/kg
D [3,2]	14.2 µm
D [4,3]	184 µm
Dv (10)	6.67 µm
Dv (50)	58.8 µm
Dv (90)	472 µm
Dv (95)	895 µm
Volume Below (10) µm	14.61 %
Volume Below (20) µm	26.02 %
Volume Below (31) µm	35.03 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	11.61	88.0	60.66	350	87.28	1410	97.69
0.0600	0.00	15.6	21.45	105	65.36	420	88.98	1680	98.43
0.120	0.00	31.0	35.03	125	69.83	500	90.47	2000	99.03
0.240	0.00	37.0	38.95	149	73.96	590	91.82	2380	99.50
0.490	0.00	44.0	42.93	177	77.55	710	93.28	2830	99.81
0.980	1.13	53.0	47.42	210	80.65	840	94.55	3360	99.97
2.00	2.93	63.0	51.80	250	83.28	1000	95.76		
3.90	5.84	74.0	56.02	300	85.60	1190	96.81		

Analysis - Under

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Measurement Details

Sample Name 3830410.5
SOP File Name Sediment.msop
Lab Number 2025070.5
Operator Name rodgers

Measurement Details

Analysis Date Time 1/04/2025 4:11:09 PM
Measurement Date Time 1/04/2025 4:11:09 PM
Result Source Measurement

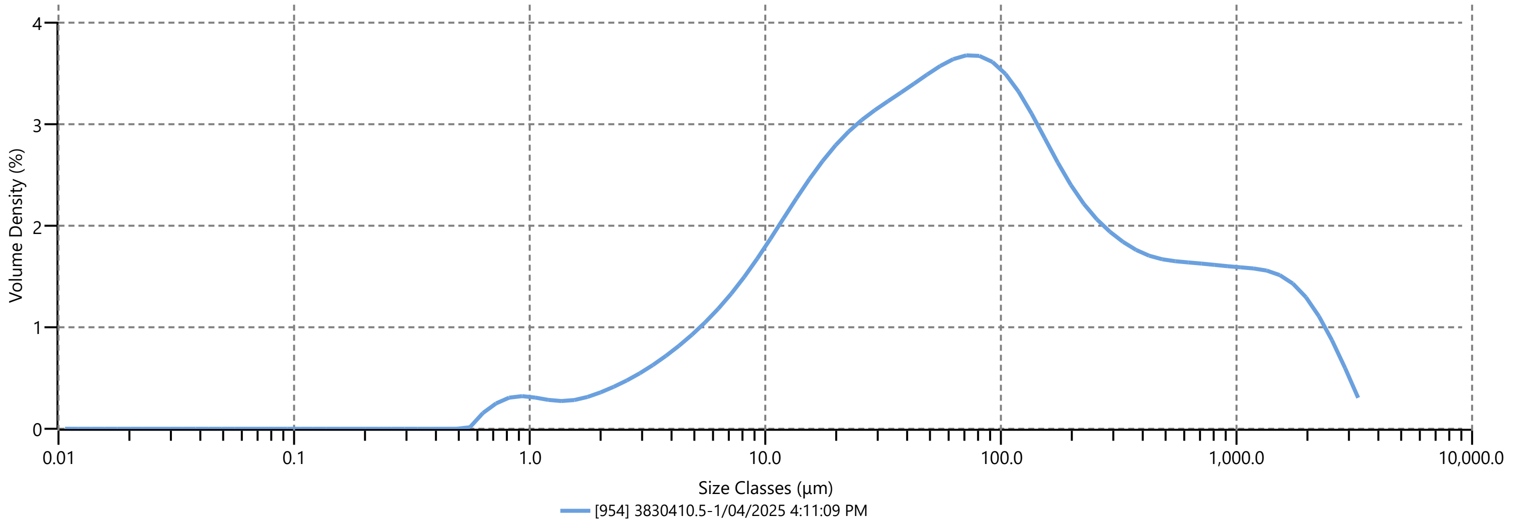
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.23 %
Laser Obscuration 35.12 %

Result

Span 13.370
Uniformity 3.760
Specific Surface Area 133.7 m²/kg
D [3,2] 17.3 µm
D [4,3] 297 µm
Dv (10) 8.36 µm
Dv (50) 71.7 µm
Dv (90) 967 µm
Dv (95) 1580 µm
Volume Below (10) µm 11.93 %
Volume Below (20) µm 22.45 %
Volume Below (31) µm 31.05 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	9.32	88.0	54.91	350	78.99	1410	93.89
0.0600	0.00	15.6	18.16	105	59.03	420	81.07	1680	95.61
0.120	0.00	31.0	31.05	125	62.89	500	82.98	2000	97.17
0.240	0.00	37.0	34.80	149	66.41	590	84.77	2380	98.50
0.490	0.00	44.0	38.60	177	69.51	710	86.75	2830	99.41
0.980	0.85	53.0	42.84	210	72.26	840	88.52	3360	99.92
2.00	2.24	63.0	46.90	250	74.74	1000	90.35		
3.90	4.54	74.0	50.76	300	77.12	1190	92.15		

Analysis - Under

University of Waikato

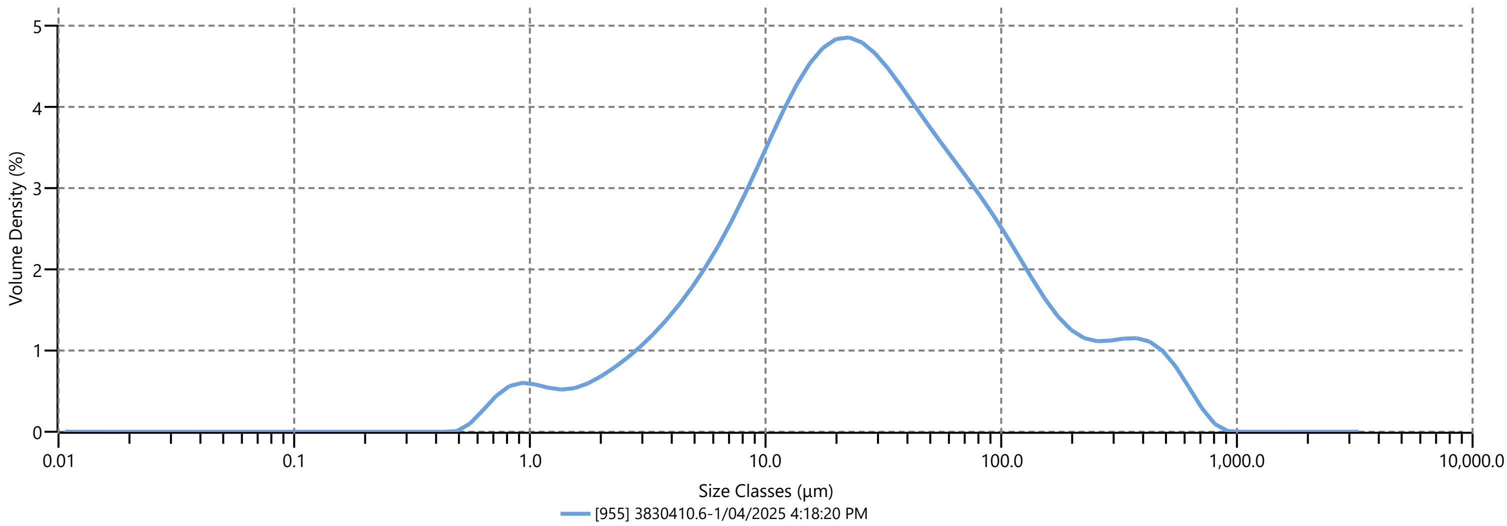
Measurement Details	
Sample Name	3830410.6
SOP File Name	Sediment.msop
Lab Number	2025070.6
Operator Name	rodgers

Measurement Details	
Analysis Date Time	1/04/2025 4:18:20 PM
Measurement Date Time	1/04/2025 4:18:20 PM
Result Source	Measurement

Analysis	
Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.59 %
Laser Obscuration	26.58 %

Result	
Span	6.384
Uniformity	2.138
Specific Surface Area	238.3 m^2/kg
D [3,2]	9.68 µm
D [4,3]	65.8 µm
Dv (10)	4.47 µm
Dv (50)	25.4 µm
Dv (90)	167 µm
Dv (95)	315 µm
Volume Below (10) µm	22.97 %
Volume Below (20) µm	42.44 %
Volume Below (31) µm	56.14 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	17.89	88.0	81.17	350	95.79	1410	100.00
0.0600	0.00	15.6	34.78	105	84.14	420	97.15	1680	100.00
0.120	0.00	31.0	56.14	125	86.71	500	98.35	2000	100.00
0.240	0.00	37.0	61.25	149	88.84	590	99.25	2380	100.00
0.490	0.00	44.0	65.92	177	90.56	710	99.81	2830	100.00
0.980	1.61	53.0	70.55	210	92.01	840	99.99	3360	100.00
2.00	4.25	63.0	74.48	250	93.31	1000	100.00		
3.90	8.65	74.0	77.86	300	94.63	1190	100.00		

Analysis - Under

University of Waikato

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Measurement Details

Sample Name	3830410.7
SOP File Name	Sediment.msop
Lab Number	2025070.7
Operator Name	rodgers

Measurement Details

Analysis Date Time	1/04/2025 4:25:46 PM
Measurement Date Time	1/04/2025 4:25:46 PM
Result Source	Measurement

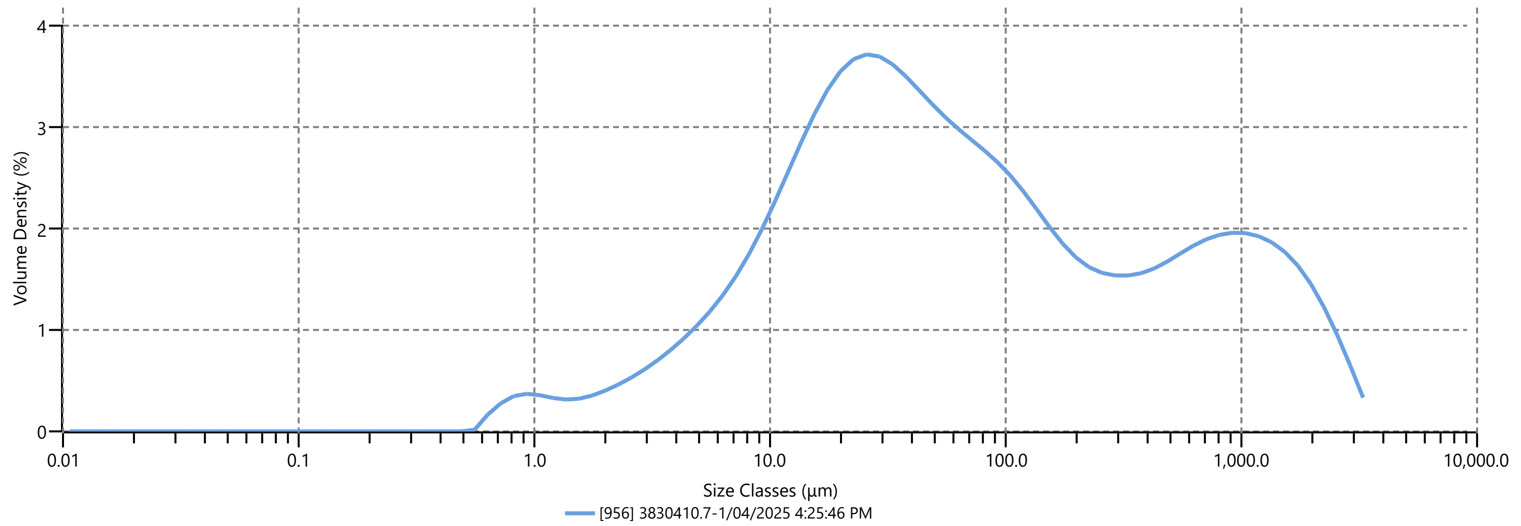
Analysis

Particle Name	Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.27 %
Laser Obscuration	30.38 %

Result

Span	19.925
Uniformity	5.411
Specific Surface Area	150.5 m^2/kg
D [3,2]	15.3 µm
D [4,3]	317 µm
Dv (10)	7.42 µm
Dv (50)	54.8 µm
Dv (90)	1100 µm
Dv (95)	1660 µm
Volume Below (10) µm	13.62 %
Volume Below (20) µm	26.84 %
Volume Below (31) µm	37.37 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	10.53	88.0	58.99	350	76.60	1410	93.10
0.0600	0.00	15.6	21.37	105	62.00	420	78.47	1680	95.11
0.120	0.00	31.0	37.37	125	64.76	500	80.34	2000	96.88
0.240	0.00	37.0	41.52	149	67.25	590	82.22	2380	98.35
0.490	0.00	44.0	45.40	177	69.43	710	84.46	2830	99.36
0.980	0.95	53.0	49.34	210	71.39	840	86.57	3360	99.91
2.00	2.54	63.0	52.79	250	73.21	1000	88.80		
3.90	5.11	74.0	55.85	300	75.06	1190	91.01		

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Certificate of Analysis

SPv1

Client:	Boffa Miskell Limited	**Lab No:**	3832398
Contact:	Kate Hornblow	**Date Received:**	26-Mar-2025
	C/- Boffa Miskell Limited	**Date Reported:**	10-Apr-2025
	PO Box 110	**Quote No:**	135820
	Christchurch 8140	**Order No:**	
		Client Reference:	
		Submitted By:	Kate Hornblow

Sample Type: Sediment

Sample Name:		Site 5 26-Mar-2025 2:15 pm	Site 9 26-Mar-2025 9:20 am	Site 10 26-Mar-2025 11:00 am
Lab Number:		3832398.1	3832398.2	3832398.3
Individual Tests				
Dry Matter	g/100g as rcvd	53	33	44
Particle size analysis*‡		See attached report	See attached report	See attached report
Total Recoverable Phosphorus	mg/kg dry wt	630	1,000	1,010
Total Organic Carbon*	g/100g dry wt	4.1	6.1	5.8
Heavy metal, trace level As,Cd,Cr,Cu,Ni,Pb,Zn				
Total Recoverable Arsenic	mg/kg dry wt	7.2	14.2	15.8
Total Recoverable Cadmium	mg/kg dry wt	0.26	0.29	0.29
Total Recoverable Chromium	mg/kg dry wt	16.9	28	30
Total Recoverable Copper	mg/kg dry wt	19.2	28	35
Total Recoverable Lead	mg/kg dry wt	39	51	63
Total Recoverable Nickel	mg/kg dry wt	14.5	15.3	16.8
Total Recoverable Zinc	mg/kg dry wt	250	310	600
Acid Herbicides Trace in Soil by LCMSMS*				
Acifluorfen	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Bentazone	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Bromoxynil	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Clopyralid	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Dicamba	mg/kg dry wt	< 0.010	< 0.010	< 0.010
2,4-Dichlorophenoxyacetic acid (24D)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
2,4-Dichlorophenoxybutyric acid (24DB)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Dichlorprop	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Fluazifop	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Fluroxypyr	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Haloxyfop	mg/kg dry wt	< 0.010	< 0.010	< 0.010
2-methyl-4-chlorophenoxyacetic acid (MCPA)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
2-methyl-4-chlorophenoxybutanoic acid (MCPB)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Mecoprop (MCPP; 2-methyl-4-chlorophenoxypropionic acid)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Oryzalin	mg/kg dry wt	< 0.02	< 0.02	< 0.02
Pentachlorophenol (PCP)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Picloram	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Quizalofop	mg/kg dry wt	< 0.010	< 0.010	< 0.010
2,3,4,6-Tetrachlorophenol (TCP)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
2,4,5-trichlorophenoxypropionic acid (245TP,Fenoprop, Silvex)	mg/kg dry wt	< 0.010	< 0.010	< 0.010

Sample Type: Sediment				
Sample Name:		Site 5 26-Mar-2025 2:15 pm	Site 9 26-Mar-2025 9:20 am	Site 10 26-Mar-2025 11:00 am
Lab Number:		3832398.1	3832398.2	3832398.3
Acid Herbicides Trace in Soil by LCMSMS*				
2,4,5-Trichlorophenoxyacetic acid (245T)	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Triclopyr*	mg/kg dry wt	< 0.010	< 0.010	< 0.010
Multiresidue Pesticides in Sediment samples by GCMS				
Acetochlor	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Alachlor	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Atrazine	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Atrazine-desethyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Atrazine-desisopropyl	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Azaconazole	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Azinphos-methyl	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Benalaxyl	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Bendiocarb	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Benodanil	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Bifenthrin	mg/kg dry wt	< 0.13	< 0.19	< 0.16
Bitertanol	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Bromacil	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Bromophos-ethyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Bromopropylate	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Bupirimate	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Buprofezin	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Butachlor	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Captafol	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Captan	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Carbaryl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Carbofenothion	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Carbofuran	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Chlorfenvinphos	mg/kg dry wt	< 0.18	< 0.3	< 0.3
Chlorfluazuron	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Chlorothalonil	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Chlorpropham	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Chlorpyrifos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Chlorpyrifos-methyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Chlortoluron	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Chlozolinate	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Coumaphos	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Cyanazine	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Cyfluthrin	mg/kg dry wt	< 0.15	< 0.3	< 0.18
Cyhalothrin	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Cypermethrin	mg/kg dry wt	< 0.3	< 0.5	< 0.4
Cyproconazole	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Cyprodinil	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Deltamethrin (including Tralomethrin)	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Diazinon	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Dichlobenil	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Dichlofenthion	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Dichlofluanid	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Dichloran	mg/kg dry wt	< 0.4	< 0.5	< 0.4
Dichlorvos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Dicofol	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Dicrotophos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Difenoconazole	mg/kg dry wt	< 0.18	< 0.3	< 0.3
Dimethoate	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Dinocap	mg/kg dry wt	< 1.4	< 2	< 1.7
Diphenylamine	mg/kg dry wt	< 0.3	< 0.4	< 0.3

Sample Type: Sediment				
	Sample Name:	Site 5 26-Mar-2025 2:15 pm	Site 9 26-Mar-2025 9:20 am	Site 10 26-Mar-2025 11:00 am
	Lab Number:	3832398.1	3832398.2	3832398.3
Multiresidue Pesticides in Sediment samples by GCMS				
Diuron	mg/kg dry wt	< 0.13	< 0.18	< 0.15
EPN	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Ethion	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Etrimfos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Famphur	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fenarimol	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fenitrothion	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fenpropathrin	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fenpropimorph	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fensulfothion	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fenvalerate (including Esfenvalerate)	mg/kg dry wt	< 0.18	< 0.3	< 0.3
Fluazifop-butyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fluometuron	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Flusilazole	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Fluvalinate	mg/kg dry wt	< 0.09	< 0.13	< 0.11
Folpet	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Furalaxyl	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Haloxyfop-methyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Hexaconazole	mg/kg dry wt	< 0.15	< 0.3	< 0.18
Hexazinone	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Hexythiazox	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Imazalil	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Indoxacarb	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Iodofenphos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
IPBC (3-Iodo-2-propynyl-n-butylcarbamate)	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Isazophos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Isofenphos	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Kresoxim-methyl	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Leptophos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Linuron	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Malathion	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Metalaxyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Methacrifos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Methamidophos	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Methidathion	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Methiocarb	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Metolachlor	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Metribuzin	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Mevinphos	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Molinate	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Myclobutanil	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Naled	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Nitrofen	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Nitrothal-isopropyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Norflurazon	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Omethoate	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Oxadiazon	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Oxychlordane	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Oxyfluorfen	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Paclobutrazol	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Parathion-ethyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Parathion-methyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Penconazole	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Pendimethalin	mg/kg dry wt	< 0.13	< 0.18	< 0.15

Sample Type: Sediment				
	Sample Name:	Site 5 26-Mar-2025 2:15 pm	Site 9 26-Mar-2025 9:20 am	Site 10 26-Mar-2025 11:00 am
	Lab Number:	3832398.1	3832398.2	3832398.3
Multiresidue Pesticides in Sediment samples by GCMS				
Permethrin	mg/kg dry wt	< 0.04	< 0.06	< 0.05
Phosmet	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Phosphamidon	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Pirimicarb	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Pirimiphos-methyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Prochloraz	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Procymidone	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Prometryn	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Propachlor	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Propanil	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Propazine	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Propetamphos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Propham	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Propiconazole	mg/kg dry wt	< 0.09	< 0.13	< 0.11
Prothiofos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Pyrazophos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Pyrifenox	mg/kg dry wt	< 0.18	< 0.3	< 0.3
Pyrimethanil	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Pyriproxyfen	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Quintozene	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Quizalofop-ethyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Simazine	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Simetryn	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Sulfentrazone	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Sulfotep	mg/kg dry wt	< 0.13	< 0.18	< 0.15
TCMTB [2-(thiocyanomethylthio) benzothiazole,Busan]	mg/kg dry wt	< 0.3	< 0.4	< 0.3
Tebuconazole	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Tebufenpyrad	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Terbacil	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Terbumeton	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Terbuthylazine	mg/kg dry wt	< 0.07	< 0.10	< 0.08
Terbuthylazine-desethyl	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Terbutryn	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Tetrachlorvinphos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Thiabendazole	mg/kg dry wt	< 0.7	< 0.9	< 0.8
Thiobencarb	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Tolylfluanid	mg/kg dry wt	< 0.07	< 0.09	< 0.08
Triadimefon	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Triazophos	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Trifluralin	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Vinclozolin	mg/kg dry wt	< 0.13	< 0.18	< 0.15
Organochlorine Pesticides Trace in Soil				
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
4,4'-DDD	mg/kg dry wt	0.0011	0.0025	0.0026
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
4,4'-DDE	mg/kg dry wt	0.0031	0.0067	0.0087
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
4,4'-DDT	mg/kg dry wt	0.0026	0.0042	0.0037

Sample Type: Sediment				
Sample Name:		Site 5 26-Mar-2025 2:15 pm	Site 9 26-Mar-2025 9:20 am	Site 10 26-Mar-2025 11:00 am
Lab Number:		3832398.1	3832398.2	3832398.3
Organochlorine Pesticides Trace in Soil				
Total DDT Isomers	mg/kg dry wt	0.007	0.013	0.015
Dieldrin	mg/kg dry wt	< 0.0010	< 0.0010	0.0195
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010
Polycyclic Aromatic Hydrocarbons Trace in Soil*				
Total of Reported PAHs in Soil	mg/kg dry wt	6.6	4.7	20
1-Methylnaphthalene	mg/kg dry wt	0.032	0.014	0.087
2-Methylnaphthalene	mg/kg dry wt	0.024	0.013	0.061
Acenaphthene	mg/kg dry wt	0.037	0.016	0.074
Acenaphthylene	mg/kg dry wt	0.100	0.084	0.50
Anthracene	mg/kg dry wt	0.21	0.102	0.47
Benzo[a]anthracene	mg/kg dry wt	0.46	0.30	1.18
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.44	0.34	1.43
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.47	0.41	1.83
Benzo[e]pyrene	mg/kg dry wt	0.22	0.199	0.88
Benzo[g,h,i]perylene	mg/kg dry wt	0.25	0.24	1.03
Benzo[k]fluoranthene	mg/kg dry wt	0.192	0.160	0.69
Chrysene	mg/kg dry wt	0.41	0.36	1.39
Dibenzo[a,h]anthracene	mg/kg dry wt	0.058	0.051	0.25
Fluoranthene	mg/kg dry wt	1.05	0.73	2.9
Fluorene	mg/kg dry wt	0.138	0.054	0.26
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.25	0.24	1.13
Naphthalene	mg/kg dry wt	0.025	< 0.03	0.094
Perylene	mg/kg dry wt	0.137	0.128	0.25
Phenanthrene	mg/kg dry wt	1.03	0.48	2.6
Pyrene	mg/kg dry wt	1.05	0.76	3.0
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.65	0.51	2.2
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.64	0.50	2.2

Analyst's Comments

‡ Analysis subcontracted to an external provider. Refer to the Summary of Methods section for more details.

Appendix No.1 - Waikato University Report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

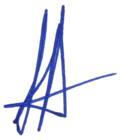
Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed).	-	1-3

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation May contain a residual moisture content of 2-5%. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed).	-	1-3
Soil Prep Dry for Organics,Trace*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-3
Heavy metal, trace level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.8 mg/kg dry wt	1-3
Acid Herbicides Trace in Soil by LCMSMS*	Solvent extraction, LC-MS/MS analysis. Tested on dried sample. In-house.	0.010 - 0.02 mg/kg dry wt	1-3
Multiresidue Pesticides in Sediment samples by GCMS	Sonication extraction, GC-ECD and GC-MS analysis. In-house based on US EPA 8081 and US EPA 8270.	0.0010 - 0.03 mg/kg dry wt	1-3
Polycyclic Aromatic Hydrocarbons Trace in Soil*	Sonication extraction, GC-MS/MS analysis. Tested on as received sample. In-house based on US EPA 8270.	0.002 - 0.03 mg/kg dry wt	1-3
Dry Matter	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	1-3
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-3
Particle size analysis*	Malvern Laser Sizer particle size analysis from 0.05 microns to 3.4 mm. Samples are measured in volume %. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-3
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-3
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-3

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 27-Mar-2025 and 10-Apr-2025. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.



Ara Heron BSc (Tech)
Client Services Manager - Environmental

Analysis - Under

University of Waikato

Measurement Details

Sample Name 3832398.3
SOP File Name Sediment.msop
Lab Number 2025073/3
Operator Name instrument

Measurement Details

Analysis Date Time 4/04/2025 9:02:22 AM
Measurement Date Time 4/04/2025 9:02:22 AM
Result Source Measurement

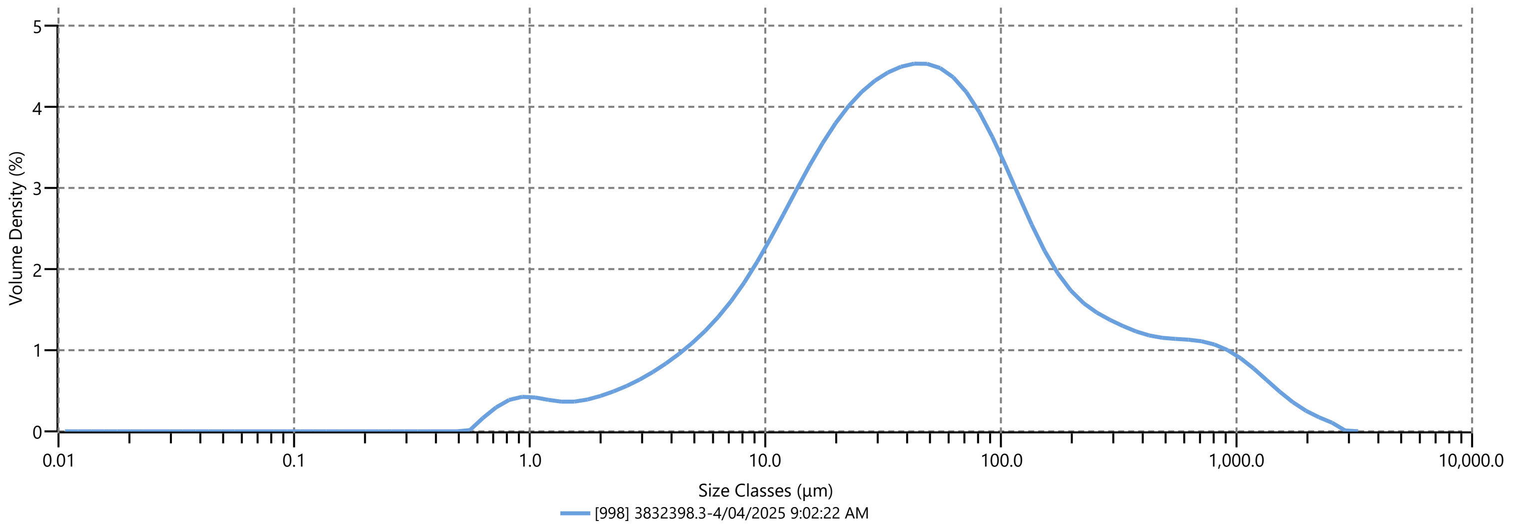
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.30 %
Laser Obscuration 20.23 %

Result

Span 8.576
Uniformity 2.868
Specific Surface Area 165.6 m^2/kg
D [3,2] 13.9 µm
D [4,3] 143 µm
Dv (10) 6.94 µm
Dv (50) 43.4 µm
Dv (90) 379 µm
Dv (95) 737 µm
Volume Below (10) µm 14.49 %
Volume Below (20) µm 28.37 %
Volume Below (30) µm 39.25 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	11.25	88.0	69.87	350	89.36	1410	98.78
0.0600	0.00	15.6	22.58	105	73.90	420	90.81	1680	99.33
0.120	0.00	31.0	40.17	125	77.36	500	92.14	2000	99.68
0.240	0.00	37.0	45.31	149	80.23	590	93.37	2380	99.90
0.490	0.00	44.0	50.42	177	82.59	710	94.73	2830	100.00
0.980	1.05	53.0	55.92	210	84.59	840	95.92	3360	100.00
2.00	2.87	63.0	60.93	250	86.35	1000	97.06		
3.90	5.57	74.0	65.40	300	88.04	1190	98.03		

Analysis - Under

University of Waikato

Measurement Details

Sample Name 3832398.1
SOP File Name Sediment.msop
Lab Number 2025073/1
Operator Name instrument

Measurement Details

Analysis Date Time 4/04/2025 8:44:08 AM
Measurement Date Time 4/04/2025 8:44:08 AM
Result Source Measurement

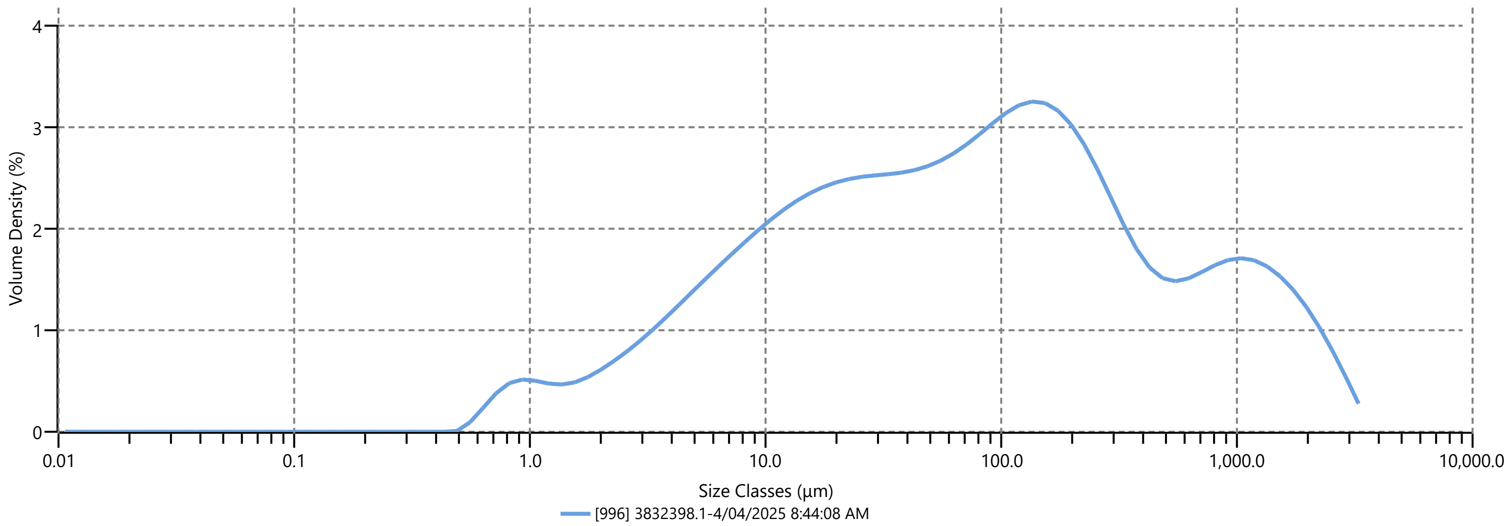
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.34 %
Laser Obscuration 20.41 %

Result

Span 12.932
Uniformity 3.639
Specific Surface Area 184.3 m^2/kg
D [3,2] 12.5 µm
D [4,3] 294 µm
Dv (10) 5.24 µm
Dv (50) 74.3 µm
Dv (90) 966 µm
Dv (95) 1530 µm
Volume Below (10) µm 17.41 %
Volume Below (20) µm 27.76 %
Volume Below (30) µm 34.38 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	14.27	88.0	53.23	350	79.37	1410	94.15
0.0600	0.00	15.6	23.85	105	56.78	420	81.46	1680	95.89
0.120	0.00	31.0	34.92	125	60.42	500	83.23	2000	97.39
0.240	0.00	37.0	37.86	149	64.15	590	84.83	2380	98.63
0.490	0.00	44.0	40.76	177	67.76	710	86.68	2830	99.47
0.980	1.39	53.0	43.94	210	71.18	840	88.46	3360	99.93
2.00	3.74	63.0	46.98	250	74.35	1000	90.38		
3.90	7.50	74.0	49.92	300	77.26	1190	92.32		

Analysis - Under

University of Waikato

Measurement Details

Sample Name 3832398.2
SOP File Name Sediment.msop
Lab Number 2025073/2
Operator Name instrument

Measurement Details

Analysis Date Time 4/04/2025 8:52:32 AM
Measurement Date Time 4/04/2025 8:52:32 AM
Result Source Measurement

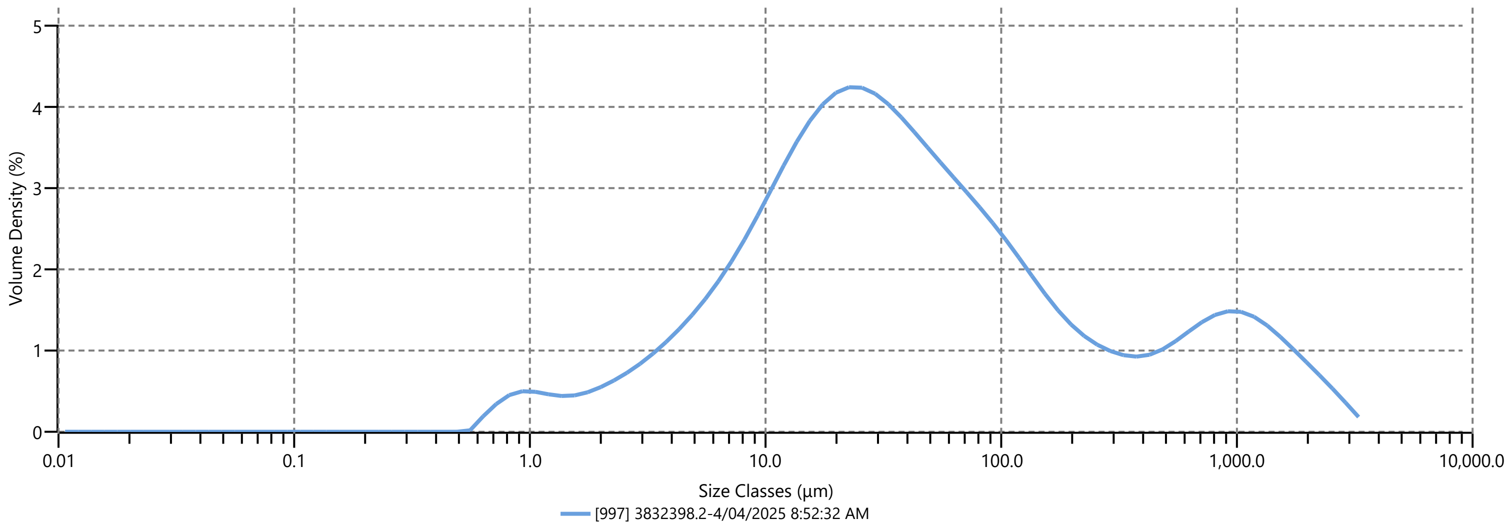
Analysis

Particle Name Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.37 %
Laser Obscuration 16.56 %

Result

Span 21.536
Uniformity 5.810
Specific Surface Area 194.1 m²/kg
D [3,2] 11.9 µm
D [4,3] 217 µm
Dv (10) 5.49 µm
Dv (50) 34.8 µm
Dv (90) 754 µm
Dv (95) 1280 µm
Volume Below (10) µm 18.56 %
Volume Below (20) µm 34.92 %
Volume Below (30) µm 46.09 %

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	14.42	88.0	70.12	350	84.51	1410	95.85
0.0600	0.00	15.6	28.37	105	72.99	420	85.62	1680	97.17
0.120	0.00	31.0	46.98	125	75.52	500	86.74	2000	98.25
0.240	0.00	37.0	51.60	149	77.69	590	87.93	2380	99.09
0.490	0.00	44.0	55.87	177	79.49	710	89.47	2830	99.65
0.980	1.22	53.0	60.15	210	81.02	840	91.01	3360	99.95
2.00	3.42	63.0	63.81	250	82.33	1000	92.70		
3.90	6.95	74.0	66.98	300	83.56	1190	94.36		

Together. Shaping Better Places.

Boffa Miskell is a leading New Zealand environmental consultancy with nine offices throughout Aotearoa. We work with a wide range of local, international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, Te Hīhiri (cultural advisory), engagement, transport advisory, climate change, graphics, and mapping. Over the past five decades we have built a reputation for creativity, professionalism, innovation, and excellence by understanding each project's interconnections with the wider environmental, social, cultural, and economic context.

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