VIRIDIS
Environmental Consultants

Restore Hibiscus and Bays

Freshwater Monitoring Plan

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Cover photo: View of Vaughan Stream within the Long Bay catchment, from Te Oneroa Way bridge facing downstream (photo taken by Viridis, August 2024).

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1 INTRODUCTION

1.1 Background

Restore Hibiscus & Bays (RHB) is a community-led initiative that supports and grows conservation and ecological restoration efforts across several catchments in the Hibiscus and Bays (H&B) Local Board area in Auckland's North Shore. RHB has three strategic focus areas: stream restoration, predator eradication and pest plant control. As part of their objective to implement catchment-wide ecological monitoring programmes, RHB seeks to develop a freshwater monitoring plan that can be used to assess and monitor the ecological health of key catchments within the H&B area.

1.2 Objectives and Scope

To ensure the plan is practical and achievable, Viridis Limited (Viridis) have been engaged through the Ministry for the Environment's Access to Experts programme to provide a freshwater monitoring plan that suits RHB's needs and provide recommendations for additional or ongoing monitoring where required.

The following objectives have been developed for the freshwater monitoring plan:

- **Overall Objective: Develop an adaptable monitoring program**

  To create a flexible program for monitoring the ecological health of streams in the H&B area that can be utilised for long-term assessments or site-specific evaluations, depending on available resources. The following aims have been developed to guide development of the program:

  - **Identify representative and accessible monitoring locations**

    To recommend monitoring sites within target catchments that are both representative of the area's ecological conditions and easily accessible for community/staff members.

  - **Ensure repeatable methods**

    To provide simple, repeatable monitoring methods and parameters that can be easily collected by non-experts, providing data that is reliable and usable.

  - **Develop user-friendly data interpretation methods**

    To establish methods for interpreting and analysing the collected data that results in outputs understandable and applicable to the community, aiding in informed decision-making.

It is expected the plan will be used to identify trends in the ecological health of the watercourses within the key catchments over time, to inform the success of on-going restoration activities, as well as inform future restoration actions.

The monitoring recommendations will consider the potential constraints RHB may face when implementing this plan. These may include limitations such as changes to staff/volunteer personnel and capacity, varying funding and resources, and limitations around expertise.

1.3 Key H&B Catchments

The Hibiscus & Bays Local Board area spans the coastline from Waiwera in the north to Campbells Bay in the south, extending along the peninsula to Shakespear Regional Park and into the Hauraki Gulf, reaching as far as Tiritiri Matangi Island. It includes 34 stream catchments, which discharge to the Hauraki Gulf in the east.

RHB has identified the following nine key catchments as priorities for restoration efforts:

- Centennial Park & Campbells Bay
- Rothesay Bay
- Taiaotea (Browns Bay)
- Deep Creek (Waiake/Torbay)
- Awaruku (northern Torbay/southern Long Bay)
- Long Bay
- Karepiro, Okura North & Okura
- Pest Free Hibiscus Coast (Whangaparāoa Peninsula, Ōrewa, Silverdale)
- Waiwera

The boundaries of the H&B area and outlines of the key catchments are displayed in Figure 1 below.

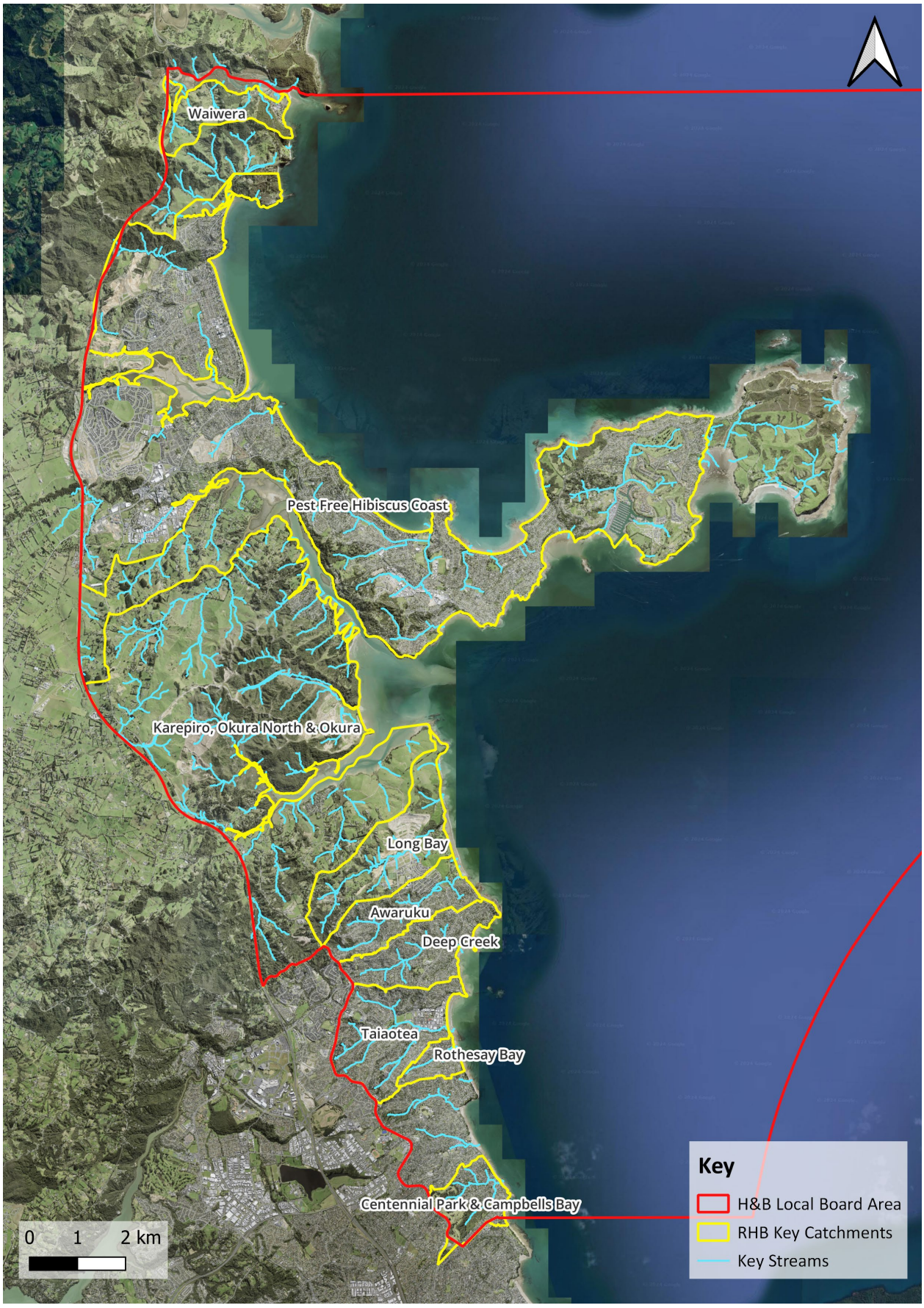


Figure 1. Map showing the H&B local board area and RHB's priority catchments.

2 SITE SELECTION

2.1 Existing Information

RHB previously commissioned Te Ngahere Limited to prepare a water monitoring plan (Te Ngahere 2023). The report provided an overview of existing data available for the target catchments. This included:

- NIWA's New Zealand Freshwater Fish database
- NIWA's Fish Passage Assessment Tool
- Wai Tuwhera o te Taiao – Open Waters Aotearoa, eDNA (delivered by Wilderlab NZ)
- Water quality and stream health
    - Existing water quality and ecological monitoring occurring on Vaughan Stream (Long Bay catchment)
    - Existing ecological monitoring occurring in the Okura catchment (two tributaries)
- Community based programmes administered by Wai Care (high level data)
    - Two sites being monitored regularly (Nukumea Stream (Orewa) and Orewa Primary School stream)
    - Several one-off or irregularly sampled sites

2.1.1 Existing monitoring sites

Within two of the nine key H&B catchments, there are four existing monitoring sites. Data is collected as part of the Auckland Council State of the Environment (SOE) monitoring and can be viewed through LAWA.org.nz. The Long Bay catchment has two monitoring sites within Vaughan Stream. The lower site monitors macroinvertebrates and water quality, while the upper site only monitors water quality. In the Okura catchment, two tributaries are monitored, both of which only monitor macroinvertebrates.

The remaining SOE sites in the general North Shore area are all located outside of the target catchments, with several being on the western side of SH1.

Various other sites throughout H&B are monitored by community restoration groups. However, there is limited consistency around frequency and attributes assessed, some sites are not currently monitored, and methods are expected to be variable amongst groups. These sites are therefore not being considered in this plan, as there is limited ability to rigorously and accurately compare data collected now to data collected by the groups. It is considered more accurate and applicable to start from scratch with consistent monitoring sites and monitoring methodologies, to collect data that can be tracked over time. However, monitoring undertaken by community groups may provide useful data for future analysis if a particular catchment or attribute is to be looked at in detail.

2.2 Site Selection Criteria

Several factors should be considered when selecting monitoring sites, as per Table 1. Alongside the monitoring sites recommended in this plan, new sites in the RHB area can be added to the monitoring programme at any time. However, any new site should also satisfy the criteria listed. A set of 'necessary' criteria have been provided and all sites should meet these criteria. A second set of 'optional' criteria have also been provided. Sites should meet these criteria if possible, however if they cannot be satisfied,

a site may still be suitable. In this case, additional interpretation of results may be required. For example, if the site experiences some tidal influence, application of freshwater invertebrate analysis is not strictly accurate, but it can still provide some information about the ecological health of the site. These factors would need to be considered during any trend analysis.

Table 1. Recommended criteria for long-term monitoring site selection.

Criteria	Explanation	Status
Non-tidal	All sites must be above the influence of tidal variation. Invertebrate monitoring indices are not accurate if there is any tidal influence (section 2.2.1).	**Necessary**
Accessible site	Priority is given to sites that are publicly accessible, such as those within parks and reserves. If public access is not possible, ongoing permission from a landowner will be necessary which may present future issues if the property changes ownership.	**Necessary**
Accessible stream	The stream should be safely accessible. It should not be contained within steeply incised banks. It should be wadeable under baseflow conditions. Riparian vegetation should be able to be traversable.	**Necessary**
10m upstream or 30m downstream of tributaries	Locating a site too close to a tributary can result in inaccurate data as adequate mixing may not have occurred. A monitoring site should not have any tributaries entering the monitoring reach.	**Necessary**
Natural bed	The site cannot be entirely contained within a concrete lined channel[1]. Macroinvertebrates cannot be accurately sampled from a concrete substrate as macroinvertebrate habitat is very limited. Concrete banks are acceptable, providing access into and out of the stream is safe.	**Necessary**
Low in catchment	The lower a site is in the catchment, the more of the catchment it is relevant to. Sites higher in the catchment work, but more sites would be needed to understand the health of the whole catchment rather than just a particular stream reach.	**Optional**
>100m up or downstream from ponds or wetlands (including stormwater ponds)	Ponds and wetlands can introduce invertebrates that are not normally found in streams (i.e., they can drift out of ponds/wetlands). They also can yield different water quality results. Ideally sites should be entirely free of the influence of ponds and wetlands to ensure invertebrate assessments are accurate, unless this is a particular objective (i.e., assessing the effects of a pond's removal).	**Optional**

[1] Unless one of the short-term projects/monitoring objectives is to determine the before and after effects of naturalising the stream by removing concrete lining.

2.2.1 Choosing a non-tidal monitoring site

It's important to place the monitoring sites are located outside the tidal zone to ensure freshwater data is being collected. Below are a number of ways to confirm whether a stream reach is tidally influenced:

- Use a multimeter to test for salinity:
    - Salty water conducts electricity better than freshwater, and the easiest and most definitive way to check is with a multimeter. Hire a multimeter and measure the water's conductivity at the bottom of the water column during high tide, as saline water is heavier than freshwater. Freshwater should have a salinity of less than 0.5 parts per thousand (ppt). Brackish water is between 0.5 and 30 ppt.
- Check the site at high tide:
    - Tides can push saline water upstream. Visit the site during high tide to observe if the water levels fluctuate. If there is noticeable fluctuation, it may indicate tidal influence, and the site should be avoided.
- Consider the distance from the coast:
    - The closer a site is to the coast, the more likely it is to encounter saline water. While it's important to monitor close to the coast for catchment-scale information, it’s advisable to move inland enough to avoid tidal influence, especially in low-lying areas.
- Assess the topography:
    - The shape of the land can impact how far salty water is pushed upstream, particularly in flat areas. Look for higher elevations or areas where the stream's flow is stronger, reducing the likelihood of saltwater encroachment.
- Watch for signs of saline influence, such as:
    - Coastal vegetation: Plants like mangroves or salt marsh grasses prefer brackish or saline environments.
    - Marine debris: Driftwood, shells, or other coastal debris may indicate tidal influence.
    - Intertidal organisms: Crab holes or similar signs during low tide suggest saline water presence.
    - Smells: The area may have a "salty" or marine smell, indicating the presence of seawater.
- If in doubt, move further upstream:
    - If unsure whether a site is solely freshwater, move further upstream to a spot where more confidence can be had that it's beyond the tidal zone.

2.3 Key H&B Catchments Potential Monitoring Locations

This section discusses potential options for stream monitoring locations within each of the key catchments in the H&B area.

2.3.1 Centennial Park and Campbells Bay

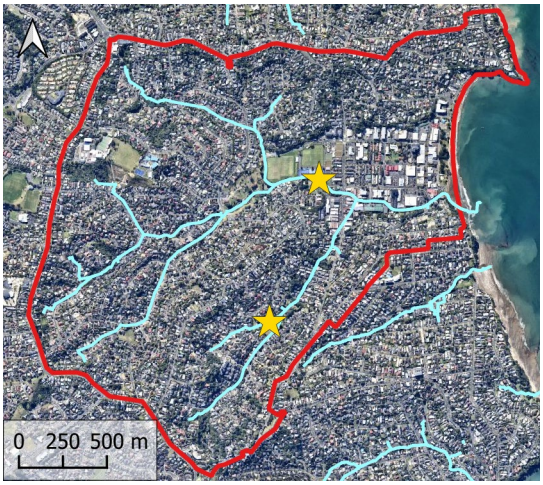
There are two sub-catchments within the Centennial Park and Campbells Bay area, so it would be preferrable to have two monitoring sites (i.e. one in each) to capture changes within each one. However, there are limited options that are publicly accessible in the Centennial Park and Campbells Bay catchment. The best option is within Campbells Bay Reserve (Huntly Road Reserve), however confirmation that the site is not tidally influenced is required before the site can be finalised.

Any sites in Centennial Park would need to be scoped to determine access, both to the site, and into the stream. There may also be access to the northern branch of the stream from Kahikatea Close or 250 Beach Road. Aerial images suggest a green space at the eastern end of the street, however land ownership records show that it is privately owned.

2.3.2 Rothesay Bay

The lower reaches of the Rothesay Bay catchment are likely tidal, which may preclude a site from being located in Rothesay Bay Beach Reserve, the only park/reserve the stream flows through. However, confirmation that the site is not tidally influenced is required before the site can be finalised. There is potential for a site to be located at 19 or 21 Sandown Road where the stream flows through the unfenced front garden of the properties, however access would need to be obtained from the landowners. Upstream of here, the stream flows through a large piped section (~200m) and upstream of the pipe is only a small portion of the catchment.

2.3.3 Taiaotea

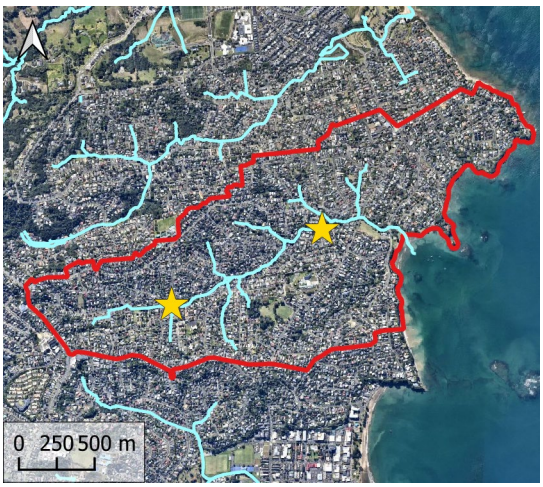


There are two main channels in the Taiaotea catchment. A site on the northern channel can be easily located in Freyburg Park. Locating it adjacent to the Browns Bay Racquets Club would locate the site far enough downstream from the wetland area in Sherwood Park and far enough downstream from where its two tributaries meet.

The southern channel is more difficult. The lower reaches on either side of Beach Road are piped, and the upper reaches are largely in private land. A site could be located in Bayside Drive Reserve, however a stormwater pond may affect results. The site would need to be located upstream of the pond, in the short reach between

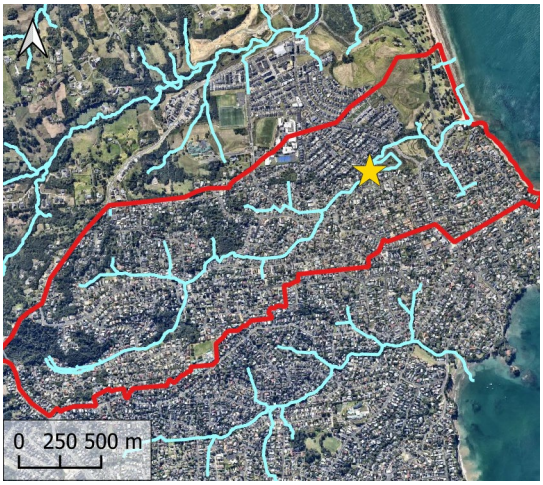
where the stream flows out of a piped section and into the pond. This site is also not ideal as the entire upstream catchment from here is piped.

2.3.4 Deep Creek



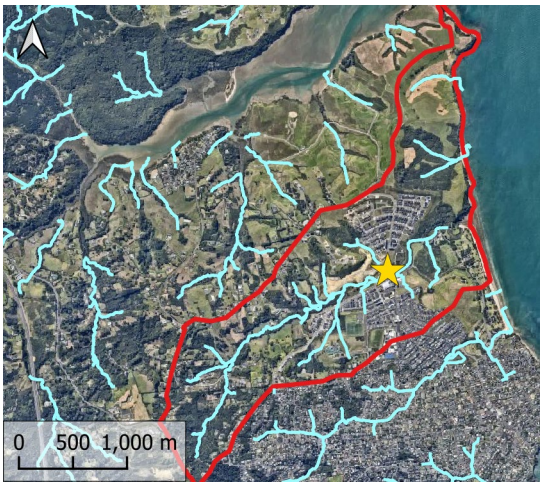
The Aickin Reserve is not suitable for a monitoring site, as Deep Creek is expected to be tidal at this point. It is recommended a site is located on the main stem of the creek, however almost the entire stream length is within private land. A site in Cranston Street Reserve may work, however it is located relatively high in the catchment, and access to the stream would need to be confirmed. If access is possible, a site from Carina Close, Freya Place or Weatherly Road would be preferable.

2.3.5 Awaruku



The lower reaches of the Awaruku catchment are characterised by modified natural wetlands and are likely tidally influenced below the wetlands. Immediately upstream of the wetlands is a site that is likely suitable, providing there is safe access to the stream itself. Otherwise, either side of Glenvar Road would be a good location. However, the stream here appears to be contained within concrete lined banks, so again, access would need to be possible. Upstream of here, access would need to be through private property requiring ongoing permission from landowners.

2.3.6 Long Bay

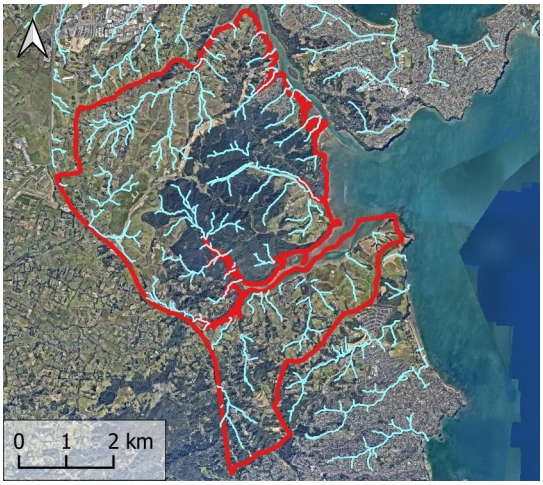


The Long Bay catchment provides ready access to the majority of the main stream. Providing no tidal influence is present, it is recommended a site be located just upstream of where Te Oneroa Way crosses the stream. At this point, a site would be located upstream of the influence of any existing stormwater ponds and wetlands but still captures the majority of the catchment.

However, this stream is already monitored (two sites), with sufficient data publicly available through LAWA.org.nz (Vaughan Stream and Vaughan Upper). It is therefore recommended that the Long Bay catchment is not included in the monitoring plan at this time if funding/staff resources are limited. Data can be abstracted from LAWA and inputted into any data analysis or interpretation undertaken as part of this plan.

2.3.7 Karepiro, Okura North and Okura

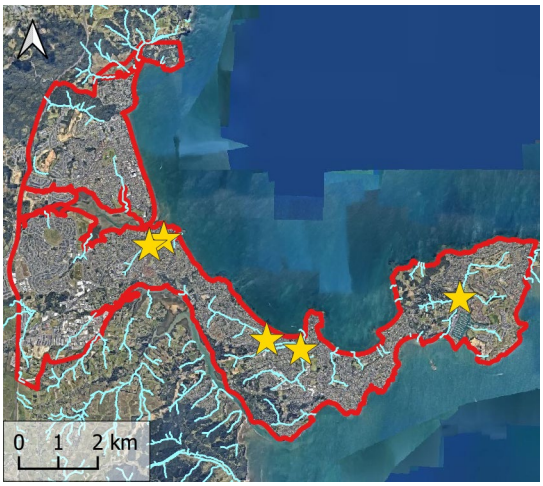
The Karepiro, Okura North and Okura catchment contains only a small amount of urban development and a significant number of waterways. We recommend excluding this catchment from monitoring at this stage, as time and funding can be more effectively and efficiently used in more populated and developed catchments. Sites can be added as needed, if there are specific concerns or interests regarding this catchment.



Ecological data is already collected for two streams in the catchment (Okura Tributary 1 and 2), with data publicly available on LAWA.org.nz.

2.3.8 Pest Free Hibiscus Coast

There are three main waterways in the Pest Free Hibiscus Coast catchment, and several smaller ones. The main waterways, for the purposes of this report are named Gulf Harbour (eastern waterway), Stanmore Bay (central waterway) and Red Beach (western waterway). Almost the entire length of the Gulf Harbour waterway appears to be either tidal, or within ponds. A site could be located within Whangaparaoa Golf Club, however there is limited catchment upstream of here, and therefore results would only provide a snapshot of the catchment health rather than the full picture. A site along Laurie Southwick Parade would be preferable if it is not tidal.

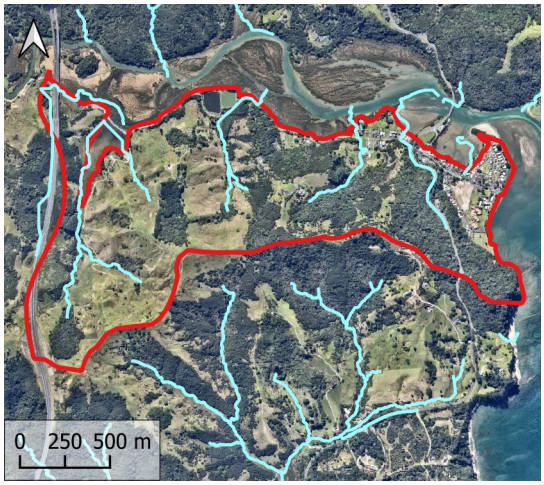


The Stanmore Bay waterway can be readily accessed from Stanmore Bay Park. It is recommended the site be located south of Brightside Road to avoid tidal influence. As this site would be on only one of the main tributaries of the waterway, a second site could also be easily located within either Foley Reserve or Arden's Park. The tidal nature of this site would need to be confirmed, as although it is approximately 1.5km upstream from the coast, the gradient is very shallow.

There are two potential sites for the Red Beach waterway. The preferred location would be opposite the end of Laurie Street. This location is within the Red Beach Top 10 camp ground. It is expected access would be available with some communication with the owners/operators. The stream here does appear to be contained within concrete lined banks. A visit would determine if it could be entered safely and if the substrate was suitable for invertebrate sampling. The second site, if the campground is unsuitable, is located slightly higher in the catchment within Rosario Reserve. The stream is entirely fenced, therefore access via a maintenance gate or similar would need to be arranged.

2.3.9 Waiwera

The Waiwera catchment is small, contains very limited urban development, and contains several small streams. At this stage, it is considered more efficient to focus sampling efforts on more populous catchments with larger waterways. Sites can be added at any time as required, providing they meet the previously discussed site criteria.



3 RECOMMENDED PARAMETERS

There are many different parameters that can be assessed through a freshwater monitoring programme, depending on the goals of the programme and the desired outputs. Below is a brief discussion of options and recommendations for each of the main parameters.

The recommended methodologies can be used over the long-term to show changes in ecological health over time, as well as on short-term (one-off) occasions to provide a snapshot of the ecological health of a waterway. It is important for the accuracy of any long-term monitoring that sampling occur each time in an accurate and consistent manner. This includes sampling at approximately the same time of day (particularly for water quality), during fine weather, and during approximately the same time of year (e.g., same month).

3.1.1 Macroinvertebrates

Aquatic macroinvertebrates provide the easiest way to get an accurate snapshot of the health of a waterway. Each macroinvertebrate has a different tolerance to stressors and pollutants such as temperature, fine sediment and water quality, and a species' presence reflects conditions over time. As a result, the community of macroinvertebrates at any given sample site, is a product of the various influences upstream of that point.

In New Zealand, the macroinvertebrate community index (MCI) has been developed to quantify the condition of a stream with a single number. There are slightly different versions for hard bottomed and soft bottomed streams and there is also a quantitative version. The MCI uses presence/absence data and sensitivity scores for each invertebrate to provide a single number which can inform the ecological health of the waterway. The quantitative MCI (QMCI) uses the same sensitivity scores, but also considers the total number of each species as a proportion of the population. MCI and QMCI are used nationwide for SOE monitoring, as well as for technical reports, biological monitoring and impact assessments.

Community based monitoring programmes, such as those managed by Wai Care, generate very high-level data that cannot be used to calculate MCI or QMCI. They are useful for community involvement and education, but have limited value in terms of monitoring environmental health in a consistent and analytical manner.

It is recommended that macroinvertebrates are sampled using a kick net, at each of the monitoring sites. A single sample should be collected using the methods in section 0. Sampling should occur a minimum of once per year. Samples should be collected at the same time each year, late spring is ideal. If possible, no significant rainfall should have occurred for a minimum of three weeks prior to sampling. Samples should then be professionally processed and identified.

There are two options for sorting and processing macroinvertebrate samples. The National Environmental Monitoring Standards – Macroinvertebrates (NEMS 2022) provide an updated version of the protocols initially developed alongside the MCI. The two options are '200+ Fixed Count with Scan for Missed Taxa' (referred to as 'fixed count' hereafter) and 'full count.' The full count methodology identifies and counts every individual within a sample. It can be time consuming, but ultimately provides a very accurate community picture. The fixed count option is simpler and quicker, while still enabling MCI to be calculated as well as the QMCI if the sample has been collected using quantitative methods. **It is recommended the fixed count option is utilised** for cost efficiency and to be in line with SOE monitoring.

3.1.2 eDNA

Environmental DNA, or eDNA, refers to the genetic material that organisms leave behind in their environment through cells, tissues, fluids, and excrement. By collecting water samples, eDNA can be used to detect the presence of a wide range of species, including fish, macroinvertebrates, and microorganisms. This method offers a modern approach to monitoring biodiversity and assessing the health of aquatic ecosystems.

Community groups can access eDNA sampling services through providers like Wilderlab, which not only supply eDNA kits but also analyse the collected samples. Results include a species list and a Taxon-Independent Community Index (TICI) score, a new metric developed for New Zealand streams and rivers (Wilkinson et al. 2024). Unlike traditional indices that focus on specific groups like macroinvertebrates, TICI evaluates the overall DNA in a sample, encompassing both known and unknown organisms. This approach provides a broad measure of ecosystem health, with results interpreted on a scale ranging from 'very poor' to 'pristine.'

eDNA sampling offers several benefits over traditional methods. It is less labour-intensive, requires minimal specialist knowledge, and can detect a wide array of organisms with high taxonomic accuracy. Additionally, it allows for quick sampling across multiple sites and is highly sensitive to species presence, including rare or elusive taxa. However, there are limitations. eDNA provides only a snapshot of recent species presence and may not reflect the current community if DNA has persisted in the stream for an extended period. The method is also prone to false negatives, risks contamination, and primarily offers presence-absence data. Species not included in DNA databases may also go unidentified.

For this monitoring plan, **eDNA sampling is optional. We do not recommend it replaces traditional macroinvertebrate sampling**, which remains the most reliable method for providing general stream health information. However, eDNA can complement these methods by providing additional insights, particularly at representative sites chosen to reflect catchment-wide health. If eDNA is included, a 'gold standard' approach is recommended, involving six replicates per site to improve reliability.

To optimize costs and resources, eDNA sampling could be conducted at selected sites during each monitoring round, representing key catchments. While eDNA is a valuable tool, it is best used alongside established methods to ensure comprehensive ecological monitoring.

3.1.3 Water quality

There are various ways to collect and analyse water quality data from streams. Options largely depend on budget, available equipment and site parameters. Regardless of the sampling frequency, water quality samples only provide a snapshot of the water at the time the sample was collected. This is particularly true for fast flowing streams where the current may move a contaminant downstream quickly. As a result, pulses of contaminants can easily be missed, which is why macroinvertebrates are a useful tool, as they respond to the whole environment over time, and not just at the time of sampling.

The main parameters that can be monitored in a stream include temperature, pH, dissolved oxygen (DO), conductivity, and turbidity. However, specialist equipment is required in the form of handheld multimeters, except for temperature. Handheld multimeters are expensive to purchase, and require ongoing calibration. It is not considered necessary to purchase one; they can be hired for a fee from various locations in Auckland. Alternatively, if samples are collected and sent to a laboratory for analysis, pH, conductivity and turbidity can then be analysed. Other useful parameters that could be

analysed in a lab include nitrogen, phosphorus, heavy metals (e.g. copper, lead, zinc) and bacteria (such as *E. coli*).

We recommend **water quality samples are collected and analysed in the laboratory for pH, conductivity, turbidity/total suspended solids, nutrients, heavy metals and *E. coli***.

Dissolved oxygen

Dissolved oxygen is an important water quality variable for fish, invertebrates and vegetation. Low levels of DO, or very high levels of DO, indicate poor water quality and can be harmful to fish and invertebrates. There are various test kits available for purchase online that provide visual (colour) indications of DO. There are also relatively cheap (~$300) digital probes that measure DO. However, the cheap digital probes can be coarse, difficult to calibrate, and provide data that is not accurate enough to be useful. If DO is a parameter to be monitored on an ongoing basis, it is recommended a titration-based field kit is used in the absence of hiring a mulitmeter. Recommendations for suitable kits can be provided as needed.

Temperature

Temperature influences DO, and high temperatures can result in decreased DO, along with physical stress to fish and invertebrates, and prolific plant and algae growth. Temperature can be easily measured in the field using a basic thermometer. Alternatively, it can be measured using a hired multimeter.

Conductivity

Conductivity provides an indication of contaminants within a waterway. Generally, the lower the conductivity, the cleaner the water. Conductivity can be measured using a hired multimeter, or through laboratory analysis. Cheaper digital probes can be purchased, however, as with DO, they provide coarse measurements, and are difficult to calibrate, leading to inaccurate data.

Turbidity

Turbidity is a measure of relative water clarity. Highly turbid water reduces light penetration and has impacts on aquatic flora and fauna. Turbidity can be measured in the field with a turbidity meter or in the lab. Alternatively, measuring water clarity using a clarity tube provides a simple visual measure of water clarity. A strict methodology can make results accurate, however some variation in data will occur depending on light conditions at the time of sampling, and the eyesight of the sampler.

pH

pH is a measure of how acidic or alkaline water is. Stream water is generally around neutral, and if it is too acidic or alkaline, there can be significant impacts on instream flora and fauna. It can also be an indication of contamination. pH can be measured in the field using a multimeter, in the lab, or using various test kits in the field. Test kit sensitivity varies and can range from indicator strips similar to what would be used to test pool water, to indicator drops requiring a visual comparison of colours. Generally, the indicator strips are too coarse to provide any useful information. Indicator drops can be useful depending on training. Lab or multimeter sampling is considered the most accurate and the most useful in terms of data.

3.1.4 Rapid habitat assessments

The Rapid Habitat Assessment (RHA) provides a "habitat quality score" for a stream reach, offering an indication of the overall condition of the stream’s physical habitat, such as stream bank structure and the characteristics of the stream bed.

RHAs can be undertaken quickly and effectively in the field by filling in a standardised sheet. No equipment or specialised expertise is needed, however basic training by a suitably qualified person (e.g., an ecologist) is recommended. RHAs may be subjective due to the assessor's judgement, which can introduce some variability. However, this information works together with biological and chemical data including macroinvertebrate sampling and water quality testing to build a picture of a stream's overall health. RHAs can help track the impact of stream restoration efforts such as riparian planting over time to help measure improvements or prioritise future conservation efforts. They can also be applied on a longitudinal basis along the entire length of a stream. In this case, a stream can be split into sections, either a set distance (no less than 250 m reaches for efficiency of survey) or based on logical geographic markers (such as between road blocks, between bridges, between piped sections). Longitudinal surveys can be particularly useful for determining if completed restoration works in the upper parts of a catchment have had any impact on the habitat in the lower reaches.

It is recommended RHA's are completed at all sites where macroinvertebrate and/or water quality sampling occurs. It is recommended target streams are prioritised for longitudinal surveys.

4 ASSESSMENT METHODS

4.1 Data Collection

4.1.1 Invertebrates

Equipment

- Kick net
- Waders/gumboots
- Sample container (labelled)
- Ethanol (or similar preservative)

Methodology

1. Using one net (i.e., collecting one composite sample), collect invertebrates from five separate habitats within the sampling reach using the methods described below. Habitats should be sampled proportionally, i.e., if the sampling reach is mostly cobbles and gravels with a small amount of macrophytes, four samples should be collected from the cobbles and gravels, with one collected from the macrophytes. The net should be emptied between sampling efforts, with the contents placed in a large bucket or tray. The methods are habitat specific, as follows:

   Cobbles and gravels (in riffles and runs)

   a. Place the kick net on the streambed facing directly into the direction of flow
   b. Only the 0.3 m area in front of the net should be disturbed
   c. Disturb the surface substrate immediately in front of the net by foot kicking, and by hand if necessary
   d. Turn over and examine large cobbles/small boulders for any individuals not dislodged, and remove these by hand/brush them into the net

   Bedrock

   a. Place the kick-net on the bed facing directly into the direction of flow
   b. Disturb the surface of the bedrock immediately in front of the net by foot-kicking as well as by hand to dislodge macroinvertebrates
   c. Focus should be on areas of bedrock with habitat (e.g. areas of moss)

   Woody debris

   a. Select a single, small point with submerged and partially decayed woody debris (>50 mm diameter preferred)
   b. Place the wood over the mouth of the bucket or net
   c. Pour water over the wood while brushing it gently by hand to remove organisms
   d. Larger pieces of wood may be sampled in situ by brushing the log while holding the net directly behind it

   Bank margins/edge vegetation

   a. Locate a single (~0.5 m^2) area of bank with good structure (i.e., not eroding)
   b. Aggressively jab the net into the bank to dislodge organisms and immediately follow by two sweeps with the net to collect organisms in the water column

Macrophytes (in-stream vegetation)

a. Jab at, or sweep the net through, a single point within a macrophyte bed on the flowing water side
b. Sweep the water column twice immediately following the jab, to collect macroinvertebrates in the water column

Soft mud/sand/leaf litter

a. Place net on the mud/sand/leaf litter but do not bury it (it should sit just on the surface of the substrate)
b. Carefully and lightly disturb the top layer of the substrate immediately in front the net with hand or foot
c. If necessary, sweep the net through the disturbed area, i.e., if there is no flow to carry macroinvertebrates into the net

2. All material should now be in a large tray or bucket.
3. Wash or pick all macroinvertebrates off the net and place them in the bucket or tray.
4. Rinse and remove any unwanted large debris items (e.g., stones, sticks, leaves) that may not fit into the sample container. The stones, sticks or leaves can be returned to the stream. As far as practicable, rinse and remove any fine sediment prior to transferring to the sample container.
5. Transfer the material to a pre-labelled sample container(s).
6. Add ethanol preservative or similar. Ethanol should account for 70% of the liquid in the sample, with the other 30% being stream water.
7. Ensure that all sampling nets and other equipment are clean and free of macroinvertebrates, periphyton, macrophytes and detritus before leaving the site.
8. Samples should then be delivered to the taxonomist.
9. Processing, identification and counting of the sample should be undertaken according to the '200+ Fixed Count with Scan for Missed Taxa' in the National Environmental Monitoring Standards – Macroinvertebrates (NEMS 2022). Results will be delivered in a spreadsheet, with MCI, QMCI and other invertebrate indices calculated.

4.1.2 Water quality

Equipment

- Bucket
- Waders/gumboots
- Thermometer
- Field water quality kits
- Sample bottles

Methodology

Note: If using field water quality kits, follow instructions provided in the first instance.

1. Complete the labels on the sample containers ensuring site, date and time are filled in.
2. To minimise risk of contamination, do not leave containers open, with lids off. Lids should not be placed on the ground.

3. Wherever possible, water samples should be collected from the bank, without entering the flowing water. If this is not possible, enter the water carefully and stand facing upstream waiting for any disturbed sediment to settle or be carried downstream by the flow.
4. Do not directly fill sample bottles from the stream.
5. Facing upstream, fill the bucket completely. Carefully empty the bucket behind you, trying to disturb the substrate as little as possible. Repeat three times, allowing sediment to settle/flow away between each rinse.
6. Once the water column is clear, completely fill the bucket and take the full bucket to the bank.
7. Fill all sample containers from the bucket. If sample containers have a preservative, take care to not overfill them.
8. Store samples chilled as per laboratory instructions and deliver samples to laboratory for analysis.

4.1.3 Rapid habitat assessment

Equipment

- Rapid habitat assessment sheets
- Pen/pencil

Methodology

1. Standing in the middle of the sample reach, on the bank, complete the Rapid Habitat Assessment sheet (**Appendix A**), assigning scores based on the details within the sheet.
2. Input total score for each site into a tracking spreadsheet along with date and time the assessment was completed at, and any comments about stream conditions, unusual circumstances or noticeable changes.

4.1.4 eDNA

Equipment

- For each sample site, one of the following Wilderlab eDNA active syringe kits:
    - Standard kit – ideal for most freshwater systems with low-moderate turbidity
    - Turbid kit – for high turbidity environments, water with excessive algae or organic matter
- Spare nitrile gloves (one pair comes with Wilderlab sample kit)
- Safety glasses (chemicals within the kit are an irritant)

Important Sampling Requirements

- Avoid sampling after significant rainfall to prevent dilution effects and filter clogging.
- Sample during low rainfall periods (ideally December-May in NZ) when streams are at or near base flow.
- Ensure no more than 10 mm of rain has fallen in the past 24 hours, and water is not discoloured.
- Avoid DNA carryover by rinsing gear (e.g., buckets, waders) with 10% bleach solution or hot soapy water for metal objects.
- Move upstream from the entry point to stream, and face upstream to collect sample. This avoids disturbing or contaminating the water being sampled.
- If sampling with others, stand side-by-side to prevent cross-contamination.

Field Methodology

1. Put on nitrile gloves. Make sure the gloves have no holes.
2. Use the large syringe to draw 50 ml of water from just below the surface (avoid sediment).
3. Attach the filter to the syringe (don't overtighten).
4. Push water through the filter. Repeat until 1L of water is filtered (about 20 syringes) or the filter clogs. Avoid collecting large clumps of organic material (e.g., leaves, algae) or sediment, as this can clog the filter prematurely.
5. Detach the filter, draw 50 ml of air into the syringe, reattach the filter, and push the air through to remove excess water.
6. Attach the small syringe (with black cap) to the filter.
7. Inject the preservative into the filter, shake well, and leave the small syringe and cap attached.'
8. Place the filter (with syringes still attached) into the sample bag.
9. Seal the bag and record sample details, including GPS coordinates in WGS84 decimal format (e.g., -41.30951, 174.82110).
10. Submit sample details online at wilderlab.co.nz/submit-samples.
11. Print and sign the emailed Chain of Custody (CoC) form. Include this with the samples.
12. Send the samples within a month of collection (no refrigeration needed). If delayed, freeze samples at -20 °C until sending.

For more detailed instructions, refer to the Wilderlab instruction sheet in **Appendix B**.

4.2 Data Analysis

All results should be entered to a computer database or similar, with the data periodically backed up. There are various options depending on how data will be presented, however a simple Excel spreadsheet or similar would be appropriate. Data can be compared to various standards. These are available in documents such as the National Policy Statement for Freshwater Management 2020 (NPS-FM), which provides attribute states and national bottom lines. Standards such as the Australian and New Zealand guidelines for fresh and marine water quality (ANZG) are also available and may be useful depending on the parameters.

Setting up the database/spreadsheet may require some time, particularly to source and input comparison standards, however once set up, populating it will be quick and simple. In Excel, the 'conditional formatting' function can be utilised to highlight where a specific data point exceeds a standard, identify which attribute state a result falls into, and to highlight any potential issues or errors. Data can also be set to populate graphs tracking trends over time. It is likely this could be completed by RHB's staff or a volunteer.

An app or web-based programme may be useful in both collection of and presentation of data. This could allow data to be publicly accessible. We recommend this option is explored by a relevant expert.

5 SUMMARY OF RECOMMENDATIONS

Viridis was engaged by RHB through the Ministry for the Environment's Access to Experts funded programme to provide a flexible freshwater monitoring plan. This plan aligns with RHB's goals of measuring stream ecosystem health within key catchments in the Hibiscus and Bays area.

The following monitoring parameters are recommended for the 14 proposed sites, with flexibility to add additional sites using the site selection criteria outlined in this plan. The proposed sites will need to be groundtruthed to ensure compliance with the criteria outlined in this plan. These parameters are adaptable for long-term ecological assessments as well as site-specific evaluations:

General Monitoring Practices:

- Conduct sampling consistently: same time of day, during fine weather, and in the same month each year.
- Avoid sampling after significant rainfall to ensure reliable results.

Macroinvertebrates:

- Sample using a kick net at least once per year, ideally in late spring, with no significant rainfall three weeks prior.
- Use professional processing, following the "200+ Fixed Count with Scan for Missed Taxa" methodology for cost-efficiency and alignment with SOE monitoring.

eDNA:

- Optionally, consider eDNA sampling as a complementary tool alongside traditional macroinvertebrate methods for biodiversity monitoring.
- Can be undertaken at representative sites, with six replicates per site for reliable results.

Water Quality:

- Monitor key parameters with a hired multimeter: temperature, pH, DO, conductivity, turbidity, nutrients, heavy metals, and *E. coli*.
- Use laboratory analysis for pH, conductivity, turbidity, and other nutrients.

Rapid Habitat Assessments:

- Conduct RHAs at all sites where macroinvertebrate and water quality sampling occur.
- Implement longitudinal RHAs along entire stream lengths, as required, to assess upstream restoration impacts on downstream reaches.

REFERENCES

NEMS 2022. National Environmental Monitoring Standards Macroinvertebrates Collection and Processing of Macroinvertebrate Samples from Rivers and Streams, Version 1.0.0. National Environmental Monitoring Standards.

Te Ngahere Limited 2023. Restore Hibiscus & Bays Water Monitoring Plan. Final version 1.0. Dated 28 July 2023.

Wilkinson SP, Gault AA, Welsh SA, Smith JP, David BO, Hicks AS... & Bunce M 2024. TICI: a taxon-independent community index for eDNA-based ecological health assessment. PeerJ, 12, e16963.

Appendix A
Rapid Habitat Assessment Sheet

River Habitat Assessment (RHA) Field Recording Sheet

Habitat parameter	Condition category										SCORE
1. Deposited sediment	*The percentage of the stream bed covered by fine sediment.*										
	0	*5*	*10*	*15*	*20*	*30*	*40*	*50*	*60*	*≥ 75*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
2. Invertebrate habitat diversity	*The number of different substrate types such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes, periphyton. Presence of interstitial space score higher.*										
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
3. Invertebrate habitat abundance	*The percentage of substrate favourable for EPT colonisation, for example flowing water over gravel-cobbles clear of filamentous algae/macrophytes.*										
	95	*75*	*70*	*60*	*50*	*40*	*30*	*25*	*15*	*5*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
4. Fish cover diversity	*The number of different substrate types such as woody debris, root mats, undercut banks, overhanging/encroaching vegetation, macrophytes, boulders, cobbles. Presence of substrates providing spatial complexity score higher.*										
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
5. Fish cover abundance	*The percentage of fish cover available.*										
	95	*75*	*60*	*50*	*40*	*30*	*20*	*10*	*5*	*0*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
6. Hydraulic heterogeneity	*The number of of hydraulic components such as pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater. Presence of deep pools score higher.*										
	≥ 5	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*2*	*1*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
7. Bank erosion	*The percentage of the stream bank recently/actively eroding due to scouring at the water line, slumping of the bank or stock pugging.*										
Left bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*	
Right bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
8. Bank vegetation	*The maturity, diversity and naturalness of bank vegetation.*										
Left bank AND Right bank	*Mature native trees with diverse and intact understorey*		*Regenerating native or flaxes/sedges/tussock > dense exotic*			*Mature shrubs, sparse tree cover > young exotic, long grass*			*Heavily grazed or mown grass > bare/impervious ground.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
9. Riparian width	*The width (m) of the riparian buffer constrained by vegetation, fence or other structure(s).*										
Left bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*	
Right bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
10. Riparian shade	*The percentage of shading of the stream bed throughout the day due to vegetation, banks or other structure(s).*										
	≥ 90	*80*	*70*	*60*	*50*	*40*	*25*	*15*	*10*	*≤ 5*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
TOTAL	(Sum of parameters 1-10)										

Appendix B
Wilderlab eDNA instruction sheet

eDNA Syringe Kit Instructions

WILDERLAB
Discovery through DNA

If you would like more information including instructional videos, please scan the code to visit wilderlab.co.nz/directions

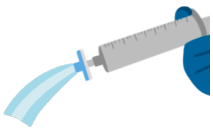
1

Take the gloves out of the sample bag, put them on, and take out the large syringe. Draw up 50 ml of water from just below the surface of the water. Take care not to suck up any sediment from the bottom.

2

Gently screw the filter on to the large syringe taking care not to overtighten, then push the plunger down to squeeze the water out through the filter. Avoid getting air bubbles in the filter as they can be difficult to push through.

3

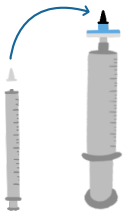


Unscrew the filter from the large syringe and continue drawing and filtering until 1L of water has been filtered (20 syringefuls), or the filter is clogged. If this happens, gently pulling back on the plunger may sometimes dislodge any particles trapped in the filter.

4

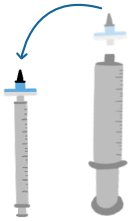
Unscrew the filter and draw 50 ml of air into the large syringe. Re-attach the filter and squeeze the air through the filter to remove excess water, while holding the syringe vertically with the filter pointing down.

5



Holding both the large syringe (with the filter still attached) and the small syringe (with black cap attached) in the same hand and in an upright orientation, transfer the black cap from the small syringe on to the outlet end of the filter.

6



Unscrew the filter (with the black cap now attached) from the large syringe and screw it on to the small syringe.

7

Push the plunger of the small syringe to inject the preservative into the filter. Shake well while holding the plunger down. Do not remove the syringe or cap from the filter. Don't worry if there are any air bubbles in the filter or if the plunger springs back - this is normal.

8

Place the filter with both the black cap and small syringe still attached into the sample bag.

9

Seal the sample bag and record the sample details in the space provided. Ensure that the coordinates are entered in WGS84 decimal format (for example -41.30951, 174.82110 as displayed on Google Maps).

Submit your samples online at wilderlab.co.nz/submit-samples

Print and sign the Chain of Custody (CoC) form that will be emailed to you after online sample submission. Include this in the parcel containing your samples (no refrigeration necessary).

Send your samples back to us within one month from collection

If this isn't possible, ensure that your samples are stored in a freezer at -20 °C until you send them.

Send the samples by standard courier to:
Wilderlab NZ Ltd
Level 2, 129 Park Road
Miramar, Wellington 6022

Small packages can be sent by post to:
Wilderlab NZ Ltd
PO Box 15059
Miramar, Wellington 6243

Address | Unit A1, 72 Apollo Drive, Mairangi Bay, Auckland 0632

Post | PO Box 301709, Albany, Auckland 0752

Telephone | 64 9 475 5750

Email | contact-us@viridis.co.nz

www.viridis.co.nz