Wharekirauponga Stream Natural State

Effects of potential flow changes on natural state and aquatic ecology

Prepared for Oceana Gold NZ Limited

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Executive Summary

Oceana Gold New Zealand Limited plan a Wharekirauponga Underground Mine (WUG) to lie beneath the Department of Conservation administered Coromandel Forest Park. Groundwater modelling has identified that the WUG operations may cause some dewatering of the hydraulically connected underlying rock mass. This potential dewatering will cause flows in a small warm spring to cease, and there is a prospect that this dewatering could cause reduced surface flows in some of the natural state water bodies.

Our report provides a summary of natural state freshwater ecological values of the Wharekirauponga Stream catchment and an assessment of potential effects of any water flow changes on the natural state freshwater ecological values. We have approached this purpose by drawing on the available information of the known ecological values of the Wharekirauponga Stream catchment, modelling instream habitat response to changes in flow, and the use of standard indicators and metrics as well as attributes from concepts of ecological integrity such as structure, nativeness and function.

The ecological values and ecological integrity of the Wharekirauponga Stream catchment are very high. The catchment is subject to naturally occurring extreme climatic and weather events and evidence that the ecosystem retains considerable resilience to such climatic extremes is strong and compelling. When compared with natural low flows, predicted changes in flow are reduced by a very small and marginal amount. We consider that the marginal changes in flow are unlikely to challenge the existing ecological values of the streams of the Wharekirauponga Stream catchment and would be largely undetectable beyond no-change low flow circumstances.

Based on the predicted flow statistics, the streams are unlikely to fail to flow (i.e., go dry at least in the reaches surveyed), result in the loss of populations or communities of instream indigenous biota, or cause pathways for invasive species. At most the proportions of habitat may vary temporarily which may result in temporary changes in biological assemblages. Predicted prolonged reduction in low flow is likely to be minimal and largely undetectable compared to existing low flow circumstances.

Similarly, we do not consider that a scenario where a predicted prolonged reduction in low flow or a periodic occurrence will result in loss of ecological values (communities or species) and effects on ecosystem function are likely to be minimal and largely undetectable compared to existing low flow circumstances.

In summary, the ecology natural state and ecological values of the mainstem and tributaries of the Wharekirauponga Stream catchment will be retained following the potential for surface water flow changes.

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1.0 Introduction

1.1 Purpose

OceanaGold New Zealand Limited (OGNZL) plan a Wharekirauponga Underground Mine ("WUG") to lie beneath the Department of Conservation administered Coromandel Forest Park. There are several natural state water bodies arising and flowing through the Park. Although the WUG will not directly impact on these natural state waterbodies (i.e., there will be no loss of extent or modification to the streams and rivers), groundwater modelling by Flosolutions (2024) suggests that the WUG operations may cause some dewatering of the hydraulically connected underlying rock mass. This potential dewatering will cause flows in a small warm spring to cease, and there is the potential for that this dewatering could cause reduced flows in several of the natural state water bodies.

This report provides an assessment of whether the potential and predicted changes in the flow regimes of the surface waterbodies are likely to result in changes in the natural state of the ecological characteristics of the Wharekirauponga Stream catchment. In addition, we provide a separate assessment of the potential impacts of the predicted changes in the flow regimes on the ecological values of the surface waterbodies.

1.2 Background

The Waikato Regional Plan (WRP) identifies the waterbodies of the Wharekirauponga Stream catchment as 'natural state waterbodies', and as 'outstanding water bodies and important habitats because they are unmodified or substantially unmodified by human intervention'. In other words, natural state waterbodies possess significant natural qualities and are typically highly valued, including by Mana Whenua and local and national communities.

Our interest is in the Wharekirauponga Stream catchment, which overlies the WUG and subject to the potential flow changes. As will become clear in our assessment below, the Wharekirauponga Stream catchment clearly retains the qualities that meet the natural state status as applied in the WRP.

2.0 Definitions and planning context

2.1 Purpose

Here we provide a brief high-level overview of relevant key regulatory and planning definitions and policy that form a background to an understanding and to our assessment of the effects of a predicted modified flow regime on ecology natural state. We identify these definitions and policy a reference point for interpreting natural state in our assessment and are used as such. We emphasise that our report is not a critical or strategic planning assessment.

2.2 National Policy Statement for Freshwater Management 2020

2.2.1 Background

The National Policy Statement for Freshwater Management (NPS-FM) came into force on 3 September 2020. The NPS-FM directs regional councils to undertake a variety of policy inclusion or modifications to policy, as well as to undertake specific tasks. The NPS-FM also directs councils to be satisfied that the 'Effects Management Hierarchy' is applied where there are adverse effects on existing and potential values.

2.2.2 Relevant policies

Part 2, 2.2 of the NPS-FM lays out the policy requirements. All policies are relevant to the proposed mining activity, but we draw attention to:

Policy 3: Freshwater is managed in an integrated way that considers the effects of the use and development of land on a whole-of-catchment basis, including the effects on receiving environments.

Policy 7: The loss of river extent and values is avoided to the extent practicable.

Policy 9: The habitats of indigenous freshwater species are protected.

Policy 8: The significant values of outstanding water bodies are protected.

Policy 11: Freshwater is allocated and used efficiently, all existing over-allocation is phased out, and future over-allocation is avoided.

2.3 National Objectives Framework

Subpart 2 of the NPS-FM requires certain attributes to be managed within a compulsory National Objectives Framework (NOF). The NOF requires that water quality is maintained or improved to established water quality attribute bands for a variety of parameters. The NPS-FM requires that Councils apply compulsory values to stream management units in their respective regions as part of the NOF (Subpart 2, 3.9(1)). Those compulsory values relevant to freshwater ecology are:

Ecosystem health refers to the extent to which a Freshwater Management Unit (**FMU**) or part of an FMU supports an ecosystem appropriate to the type of water body (for example, river, lake, wetland, or aquifer).

There are five biophysical components that contribute to freshwater ecosystem health, and it is necessary that all of them are managed. They are:

Water quality – the physical and chemical measures of the water, such as temperature, dissolved oxygen, pH, suspended sediment, nutrients and toxicants.

Water quantity – the extent and variability in the level or flow of water.

Habitat – the physical form, structure, and extent of the water body, its bed, banks and margins; its riparian vegetation; and its connections to the floodplain and to groundwater.

> *Aquatic life* – the abundance and diversity of biota including microbes, invertebrates, plants, fish and birds.
>
> *Ecological processes* – the interactions among biota and their physical and chemical environment such as primary production, decomposition, nutrient cycling and trophic connectivity.

In a healthy freshwater ecosystem, all five biophysical components are suitable to sustain the indigenous aquatic life expected in the absence of human disturbance or alteration (before providing for other values).

The compulsory values (Appendix 1A) also reference human contact, threatened species and mahinga kai. For threatened species:

> *This refers to the extent to which an FMU or part of an FMU that supports a population of threatened species has the critical habitats and conditions necessary to support the presence, abundance, survival, and recovery of the threatened species. All the components of ecosystem health must be managed, as well as (if appropriate) specialised habitat or conditions needed for only part of the life cycle of the threatened species.*

Threatened species means any indigenous species of flora or fauna that:

(a) relies on water bodies for at least part of its life cycle; and

(b) meets the criteria for nationally critical, nationally endangered, or nationally vulnerable species in the *New Zealand Threat Classification System Manual* (*see* clause 1.8, Incorporation by Reference).

2.4 Waikato Regional Policy Statement

Objective 3.14

Maintain or enhance the mauri and identified values of fresh water bodies including by:

a) *maintaining or enhancing the overall quality of freshwater within the region;*

b) *safeguarding ecosystem processes and indigenous species habitats;*

c) *safeguarding the outstanding values of identified outstanding freshwater bodies and the significant values of wetlands;*

d) *safeguarding and improving the life supporting capacity of freshwater bodies where they have been degraded as a result of human activities, with demonstrable progress made by 2030;*

e) *establishing objectives, limits and targets, for freshwater bodies that will determine how they will be managed;*

f) *enabling people to provide for their social, economic and cultural wellbeing and for their health and safety;*

g) *recognising that there will be variable management responses required for different catchments of the region; and*

h) *recognising the interrelationship between land use, water quality and water quantity.*

2.5 Waikato Regional Plan

Policy 5: Natural State Water Class

*The purpose of the natural state water class is to protect the flow regime, water quality and riparian and aquatic habitat for indigenous species in order to maintain the aesthetic and intrinsic values[1] derived from the unmodified or largely unmodified nature of the catchment. These are **outstanding waterbodies** and important habitats because they are unmodified or substantially unmodified by human intervention.*

3.0 Ecological Context

3.1 Overview

The Wharekirauponga Stream is situated on the southernmost section of Coromandel Forest Park and to the west of Whiritoa township (Figure 1).

The Wharekirauponga Stream catchment has hillsides which were formed by volcanic flows in the Late Tertiary age, which accounts for its deep valleys and steep slopes. The altitudinal variance between the lowest point and the highest point of the Wharekirauponga Stream valley is 388 meters. The land has generally good drainage, annual rainfall of around 2,514 mm (LAWA 2019[2]) and a mild, sub-humid temperature range (DOC 2014).

The vegetation of the Coromandel has been largely modified and exploited through logging of mostly kauri throughout the 1800's. Evidence of historical goldmining is prevalent throughout the Wharekirauponga Stream valley. Today naturally regenerating forests cover the Wharekirauponga Stream valley. A series of streams and transitory waterways are found throughout the Wharekirauponga Stream catchment flowing eastwards, forming part of the Otahu River catchment and the Pacific Ocean south of Whangamata. The Wharekirauponga Stream holds value with the presence of nationally threatened freshwater flora and fauna, which are detailed in this report.

[1] As defined in the WRP - Means, in relation to ecosystems, those aspects of ecosystems and their constituent parts which have value in their own right, including:
(a) their biological and genetic diversity
(b) the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience.

[2] LAWA = Land Air Water Aotearoa (https://www.lawa.org.nz/)

Figure 1:*Location of the Wharekirauponga Stream catchment.*

3.2 Ecological District

The Project is situated within the Waihi Ecological District (Waihi ED), in Wharekirauponga Forest which forms part of Coromandel Forest Park administered by the Department of Conservation, and on adjacent farmland northward of Waihi township.

The largely forested northern half of Hauraki Ecological District encompasses the southern portion of the Coromandel Ranges, and its landforms are derived from volcanic rocks overlying Jurassic siltstone, sandstone and conglomerate, with long ridges, steep and broken hillslopes and deeply incised streams.

The bioclimatic zone is lowland to submontane (WRC 2010) and the climate is typically mild, humid and wet with c. 20°C average temperatures through the warmest month (February) and c. 10°C through the coolest (July). The area periodically experiences both summer droughts and high episodes of very high rainfall. Average annual rainfall is between 1400 and 2800 mm depending on elevation, mainly during winter, while localised, heavy falls can occur at any time of year.

Pollen records from sites in the central and southern Coromandel Ranges indicate pre-human forest were likely to have comprised mixed podocarp-hardwood forest similar to that which dominates the Coromandel Ranges today, likely with emergent rimu and northern rata above a canopy containing kauri, podocarps and mixed broadleaved trees (e.g., maire, rewarewa, pukatea, puka and nikau). These forests appear to have existed for at least a millennium (c. 1800-800 yr. BP) without major changes (Byrami et al., 2002).

Polynesian forest clearance around 800-700 BP likely occurred as localised, discrete fires, with evidence of subsequent succession through shrub associations to old-growth forest comparable to the original assemblage (Byrami et al. 2002).

In contrast, European-era pollen records indicate European occupation coincided with sudden and extensive loss of forest cover, which aligns with kauri logging operations of the late 19th and early 20th centuries. Much of the land on more moderate terrain and altitude was subsequently converted to pastoral farmland, such that lowland alluvial podocarp forest is reduced to small remnant examples, while swamp forest remnants containing swamp maire are present but rare (WRC 2010). The more challenging terrain of the central Coromandel Ranges has largely reverted to indigenous forest cover.

Modern forest assemblages comprise variations of warm climate conifer-broadleaved forests, with species dominance principally determined on the basis of disturbance history, drainage and altitude (DOC 2014). Remnant areas of mature secondary kauri-podocarp-broadleaved forest are interspersed among early- to mid- successional assemblages including kanuka, kamahi and towai- dominant forest and shrubland with emergent pole-sized podocarps, rewarewa and other broadleaved trees. The dominance of pioneer forest species makes these communities resilient to disturbance as gaps are quickly recolonised with native plants.

Forest within Waihi ED broadly conforms with the WF11 forest ecosystem unit (kauri, podocarp, broadleaved forest) described in DOC (2014), though extensive kauri logging has altered the forest succession in some areas to resemble the WF13 ecosystem unit (tawa, kohekohe, rewarewa, hīnau, podocarp forest) that more characteristically occurs beyond the southern distributional limit of kauri. Weedy exotic plants are generally uncommon within the interior of forested areas, though plants associated with historic attempts at agricultural conversion (broom, gorse, pampas, pastoral grasses) persist in open sites and on forest margins, while wilding pines are present among some areas of more recent manuka – kanuka scrub, in local patches where seed sources (single trees or small plantations) are present.

3.3 Vegetation

3.3.1 Overview

Six broad vegetation associations based on similarity of species presence from vegetation surveys by Boffa Miskell staff[3] have been identified from the Wharekirauponga Stream catchment:

- Tawa pukatea dominated forest.
- Tanekaha rewarewa dominated forest (previously kauri forest).
- Secondary broad-leaved forest.

[3] RECCE (Reconnaissance) plots were sampled in pre-selected sites throughout the WKP valley, selected to ensure a representative range of vegetation communities was surveyed. Comprehensive species lists and biomass data (estimated cover abundance, scored as standardised class intervals) for each species was recorded from 20 x 20 m plots during 2016-2019.

- Secondary kauri ricker forest.
- Secondary regenerating kanuka silver fern forest.
- Regenerating kanuka and rewarewa scrubland.

Tawa/pukatea is the?? dominant vegetation type throughout north-western Wharekirauponga Stream catchment and is strongly associated with areas within the catchment which are relatively flat and lie in gully or basin systems and low gradient slopes with poor drainage. In contrast, tanekaha/rewarewa is typically associated with ridges and slopes with tanekaha dominated forest light and open with a less dominant understorey species; and this vegetation is strongly associated with remnant kauri forest, where kauri is a dominant species within this vegetation type.

Kanuka and silver fern forest is typically found through most of the Wharekirauponga Stream catchment, especially in areas which have been exposed to human disturbance. This vegetation type strongly associates with narrow gullies at the bottom of ridges and in poorly drained sites and is also found amongst other regenerating forest types including secondary rewarewa / kanuka.

Regenerating kanuka and rewarewa scrubland occurs in most disturbed areas and within the middle of the catchment where there has been historic vegetation clearance. This vegetation association is less influenced by topography but is more likely to occur along ridges and open faces where there is a lot of light, as opposed to gullies and basins with low light and poorly draining soils. Previously this vegetation would have been dominated by broad-leaved and kauri forest. Clearance occurring over the previous 50 years has resulted in this vegetation being the dominant regenerating vegetation type associated with this disturbance.

3.3.2 Broadleaved Forest Wetlands

The vegetation surveys identified forest swampland with distinctive taxa including pukatea which have spreading buttress roots, and kiekie and supplejack which grow in dense thickets over and around the vegetation.

The forest wetlands are situated on hillside terraces of the upper Adams Stream and have slow-moving water running through the wetland, with no defined stream bank or flow direction. The water source is thought to be from hillside seepages or a natural spring. Thick mud and woody debris cover the forest floor, and muddy shallow pools are found throughout the wetland.

The distinctive taxa typically found in forest swampland are also tolerant of drier substrates and were also found throughout the broadleaved forest, but at somewhat lower abundances than in the forest wetland plots. Kahikatea is usually the dominant species in forest wetlands throughout New Zealand but is typically absent from the canopy layer within the Wharekirauponga Stream catchment and only occurs in low abundance within the subcanopy.

An estimated 2% of swampland remain in the Coromandel district (Ausseil et al., 2008) and are generally considered to be of high ecological importance nationally.

A separate survey of wetlands within the Wharekirauponga Stream catchment has been undertaken by Bioresearches (Bioresearches 2024).

4.0 Scope and Approach

4.1 Scope

Our report provides:

- A summary of natural state freshwater ecological values of the Wharekirauponga Stream catchment.
- An assessment of potential direct and indirect effects of any water flow changes on the natural state freshwater ecological values.

We note that throughout the report we use the term ‘ecology natural state’ to refer to natural state freshwater ecological values.

4.2 Approach

Our approach has been to draw on the available information of the known ecological values of the Wharekirauponga Stream catchment and where relevant of the southern Coromandel region to inform an assessment of the Natural State of Wharekirauponga Stream and selected tributaries.

Boffa Miskell carried out aquatic surveys within the Wharekirauponga Stream during January/February 2019, June 2023, and February 2024 to establish the aquatic biodiversity values of the catchment.

Water quality samples have been taken from the surface water and groundwater within the Wharekirauponga Stream catchment since 2018, and baseline surface flow data since 2019. We have drawn on this information, most notably the collation and summary of water and groundwater quality as detailed in the Technical Report entitled ‘Wharekirauponga Hydrology: Modelling Report’ produced by GHD in June 2024 (GHD 2024).

We have also drawn on the instream habitat assessments undertaken by NIWA (NIWA 2024) to inform the likely outcomes of potential changes in habitat characteristics resulting from potential changes in flow.

In addition, we have assessed ecology natural state against a suite of attributes drawn from the standard indicators and metrics that are regularly measured in stream ecological surveys, as well as attributes from concepts of ecological integrity such as structure, nativeness and function. The background to these attributes and metrics is detailed later in our report.

We then use the assessed ecological values, instream habitat assessment and the selected attributes to inform an assessment of potential changes to ecology natural state that may arise with the predicted modifications to the flow regime within those streams within the Wharekirauponga Stream catchment that are potentially affected.

We also carried out an assessment of effects of the predicted modifications to the flow regime on the aquatic ecological values of the Wharekirauponga Stream and its tributaries.

4.3 Model catchments

As outlined above, the groundwater modelling has focused on the Wharekirauponga Stream catchment and has indicated the potential for some drawdown of the hydraulically connected underlying rock mass (Flosolutions 2024). Surface water hydrological modelling by GHD (2024) has indicated that the drawdown may result in potential flow changes in the following watercourses (the model catchments):

- Adams Stream.
- Edmonds Stream.
- Teawaotemutu Stream (West and East branches).
- Thompson Stream.
- Trib R.
- Wharekirauponga Stream.

The respective catchments are shown in Figure 2. We have reported our assessments by the same catchment distinctions as used for the modelling.

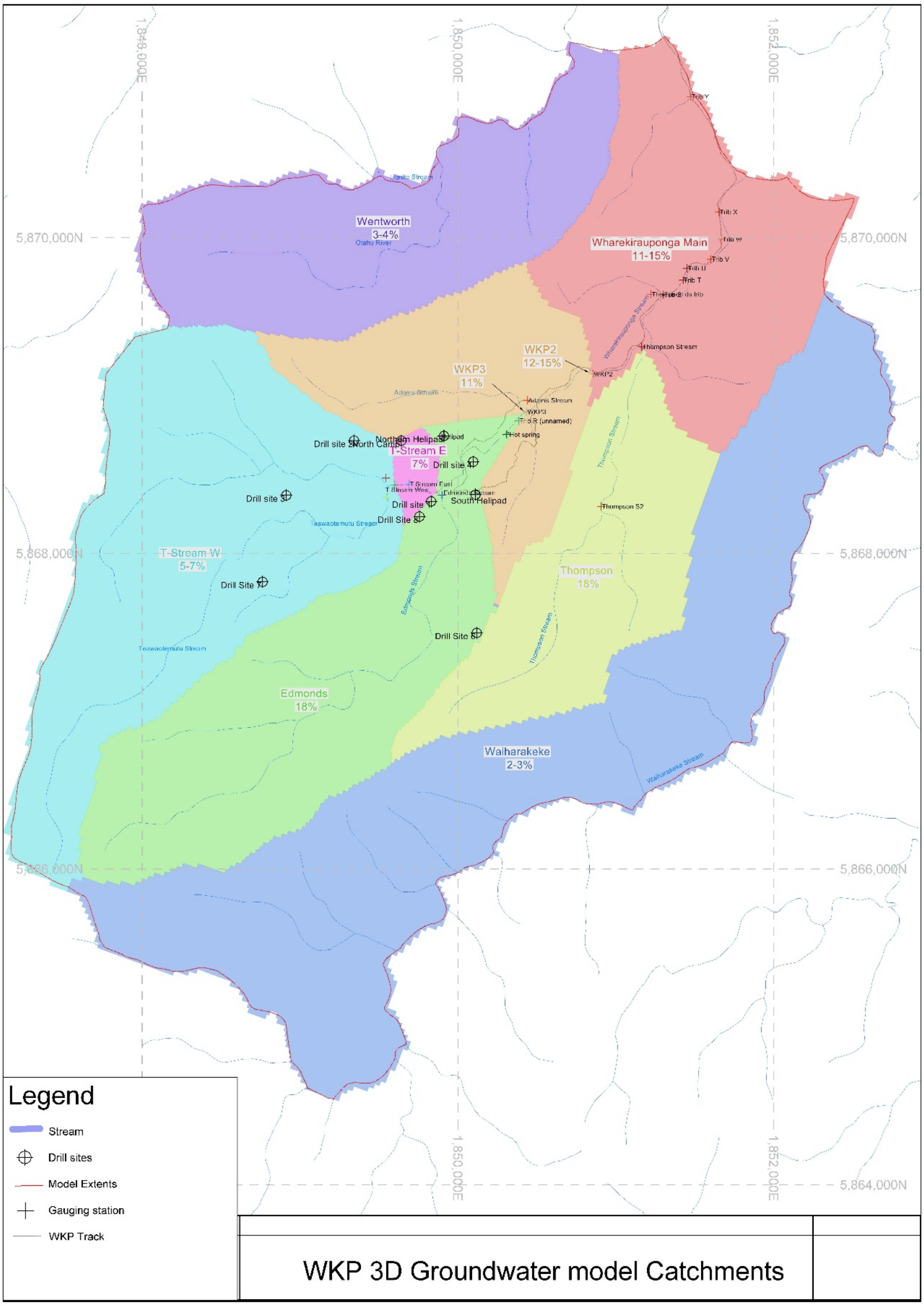


Figure 2: *Model catchments. Demarcation of mainstem and tributaries of the Wharekirauponga Stream used for groundwater model and surface hydrological flow modelling.*

5.0 Freshwater Ecological Values

5.1 Introduction

Freshwater baseline ecological surveys were undertaken in January/February 2019 at four sites within the Wharekirauponga Stream, two on the mainstem and two on tributaries of the Wharekirauponga Stream. A further round of baseline surveys was undertaken at seven sites in February 2024, three of which were surveyed in 2019 (Figure 3). Here we present the findings of those surveys as the most recent ecological information to inform our assessment.

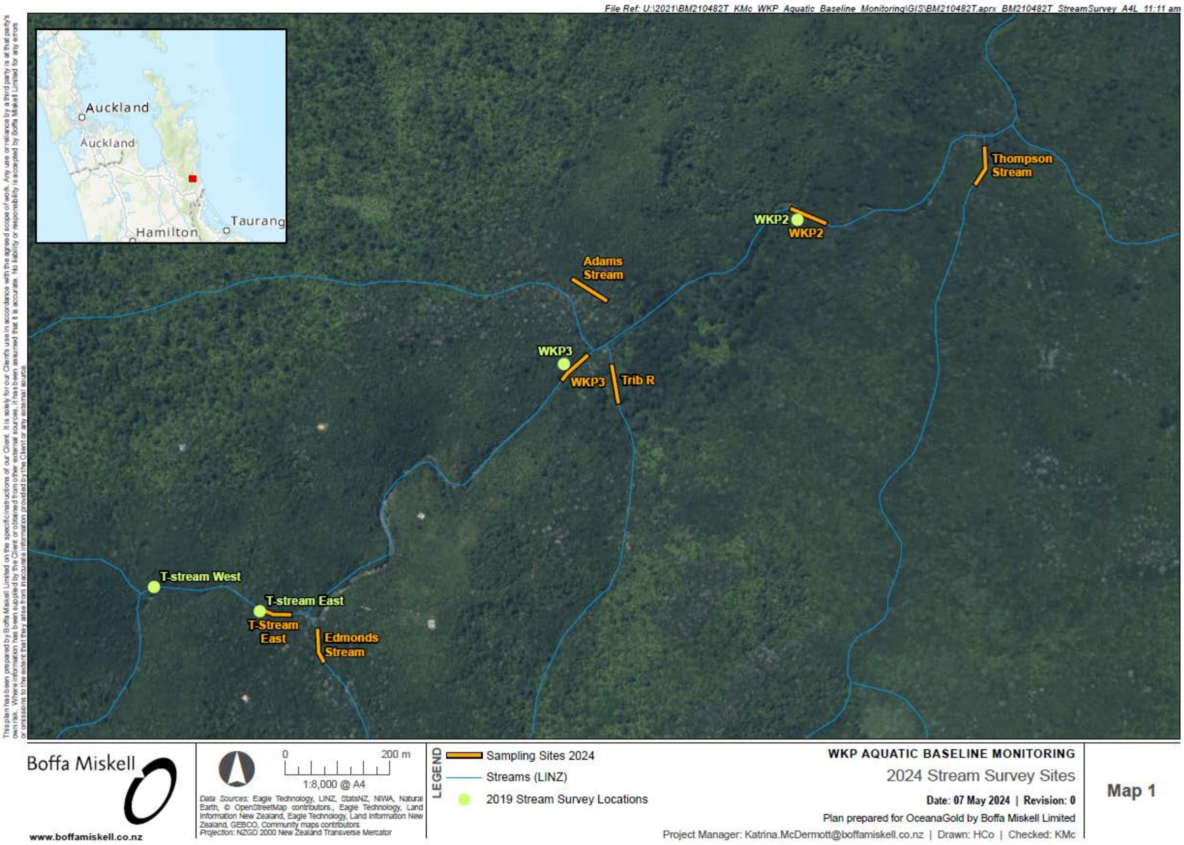


Figure 3: *Location for freshwater surveys within the Wharekirauponga Stream catchment, 2024.*

Ecological surveys were designed to provide baseline data, with robust standard sampling methods to allow the comparison of future data sets, if required. Surveys included sampling and observations of water physiochemistry, periphyton, macrophytes and macroinvertebrate and fish communities. It is worth noting here that no submerged macrophyte species were present at any of the survey sites at the time of sampling.

5.2 Physical Habitat

All survey reaches were located within the wider Parakawai Valley, a catchment of regenerating native forest within the DOC managed Coromandel Forest Park. Survey sites were located on a mixture of larger sites on the main Wharekirauponga Stream, and smaller tributary sites.

The surrounding native vegetation and steep stream banks provided partial to full shading to the stream channels, predominantly along the channel edge. Shading was highest at the smaller tributary sites, where the stream banks were steepest, and the average wetted width was the narrowest (Figure 4).

Stream channel substrates were dominated by cobbles and boulders across all sites (Table 1, Figure 4). Areas of bedrock, of varying size, were observed across all sites except Thompson Stream, with large areas observed at site Teawaotemutu Stream West. Fine gravels and silt/sand were more abundant at lower catchment sites, particularly along stream margins in areas of lower flow.

Hydrological heterogeneity of the channels was high across all sites, with numerous bedrock platforms and large boulders often narrowing the channel and creating hydrological features such as chutes, cascades and waterfalls. Riffle-pool-run sequences were abundant across all sites. Deep and shallow pools were observed at all sites except Site Trib-R where deep pools were absent.

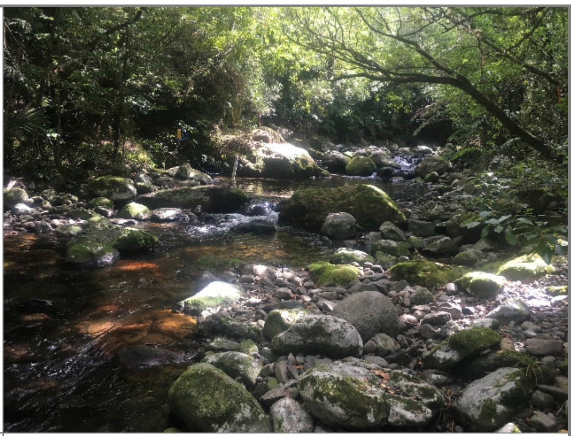
Woody debris and leaf litter were present, but rare across all sites. Water levels at the time of the both the 2019 and 2024 surveys were low, with summer flows and a long period of dry weather. Water velocity and water volume gauging was undertaken simultaneously by hydrologists from Golder Associates (NZ) Limited during the 2019 survey.

Wharekirauponga Waterfall is located on the Wharekirauponga Stream downstream of Teawaotemutu and Edmonds Stream and presents a significant barrier to fish passage.

Table 1: *Freshwater habitat parameters recorded at Freshwater Sites in 2019 and 2024. (*) indicates recorded in 2019.*

	T-Stream West*	T-Stream East	Edmonds Stream	WKP03	WKP02	Adams Stream	Trib-R	Thompson Stream
Depth (m)	0.1 – 0.51	0.05 – 0.43	0.49 – 1.9	0.16 – 0.76	0.18 – 0.48	-	0.1 – 0.2	-
Wetted Width (m)	2.80 – 5.60	4.82 – 6.85	2.4 – 7.2	3.40 – 6.33	5.20 – 7.17	1.7 – 4.4	1.8 – 2.0	3.8 – 4.6
Shading	Partial	Partial	Partial	Partial	Partial	High	High	High
Pool (%)	25	15	30	10	25	40	30	30
Run (%)	20	45	30	55	65	15	18	30
Riffle (%)	50	20	35	30	20	40	50	35
Chute (%)	5	20	5	5	5	5	2	5

*Teawaotemutu Stream West **



Teawaotemutu Stream East

Edmonds Stream

WKP03

Adams Stream

Trib-R

WKP02

Thompson Stream

Figure 4: *Aquatic ecology survey sites Teawaotemutu Stream West; Teawaotemutu Stream East; Edmonds Stream; WKP03; Adams Stream; Trib-R; WKP02 and Thompson Stream. January/February 2019 and February 2024. (*) indicates photo was taken in 2019.*

5.3 Water Physiochemistry

5.3.1 2019 Results

Spot water quality measurements were taken at each site at the time of the surveys using a handheld YSI meter. These measurements give a snapshot of water quality on the sample day, from which broad assumptions about overall water quality can be made. Spot measurements were undertaken during summer, during a particularly hot, dry period of weather.

General water quality across the sites was excellent, with measured parameters representative of good ecosystem functionality. Table 2 provides an overview of spot water quality measurements across the sampling sites.

Water at all sites had good clarity, with visibility to the bottom of the deepest sections of streams, or over a metre in depth at each site.

Water temperatures were similar across the sites, with a slight drop in temperature with movement downstream. The range of 18.5°C – 17.9°C across all sites is considered to be fairly high and may be stressful for some invertebrates such as stoneflies (Biggs & Smith 2002). A heatwave was passing over New Zealand with daily high temperatures reaching the high twenties and into the thirties at the time of sampling. Spot temperature measurements may have been influenced by this heatwave.

Dissolved oxygen levels at all sites were very good, with all sites above the 20th percentile (80%) WKP02ANZECC 2018). When the 25% confidence interval is applied to the 80th percentile values (100 – 113 DO%), then all sites are within guideline values (ANZECC 2018)[4].

pH at all sites was near neutral, ranging from 7.57 – 7.95. These values are acceptable for stream life (Biggs & Smith, 2002). pH levels at all sites were above the 20th percentile (7.32) ANZECC 2018).

Conductivity levels ranged from 117.5 to 126.4 µS/cm and were indicative of a low level of nutrient enrichment (Biggs & Smith, 2002).

[4] Dissolved oxygen and temperature will fluctuate daily and with seasons and the guideline values do not account for this (ANZECC 2018).

5.3.2 2024 Results

General water quality across all sites was again excellent in 2024, with measure parameters representative of high ecosystem functionality (Table 2).

Water temperature across sites ranged from 14.3 - 15.7°C, which are generally considered suitable for most invertebrates and periphyton. Temperature above 15.0°C may start to be stressful for some invertebrates such as stoneflies (Biggs et al 2002). Daily maximum air temperature during the survey was 23.8 - 25.2°C (Metservice, Waihi weather station).

Dissolved oxygen ranged from 9.77 – 10.2 mg/L and 97.3 – 102.1% saturation. All sites were above the 20th percentile (ANZECC 2018). These levels fluctuate throughout the day, and the guideline values do not account for this.

pH at sites ranged from 7.18 – 7.56 and were near neutral. pH levels at all sites were predominantly within the default guideline values (DGV) of 7.32 – 7.8, with T-Stream East and Adams Stream slightly below this value (20th percentile and 80th percentile respectively: ANZECC 2018), but remained circum-neutral.

Conductivity levels ranged from 64.9 to 76.7 µS/cm and were indicative of a low level of nutrient enrichment (Biggs et al, 2002). All values were below the DGV of 119 µS/cm (ANZECC 2018).

Table 2: *Measured water physiochemistry results at freshwater survey sites, January and February 2019, and February 2024.*

	T-Stream West	T-Stream East		Edmonds Stream	WKP03		Adams Stream	Trib-R	WKP02		Thompson Stream
	2019	**2019**	**2024**	**2024**	**2019**	**2024**	**2024**	**2024**	**2019**	**2024**	**2024**
Temp (°C)	18.5	18.5	14.6	14.3	18.4	15.7	14.3	15.3	17.9	15.4	14.6
DO (mg/L)	9.8	10.04	10.14	9.98	9.92	10.0	10.15	9.77	10.30	10.2	9.83
DO % Sat	104.7	107.1	99.6	97.3	105.6	100.6	99.0	97.5	108.9	102.1	96.7
pH	7.95	7.57	7.18	7.56	7.61	7.44	7.23	7.55	7.79	7.46	7.45
Conductivity (µS/cm)	118.5	117.5	66.4	64.9	126.0	70.1	69.7	76.7	126.4	70.4	75.6

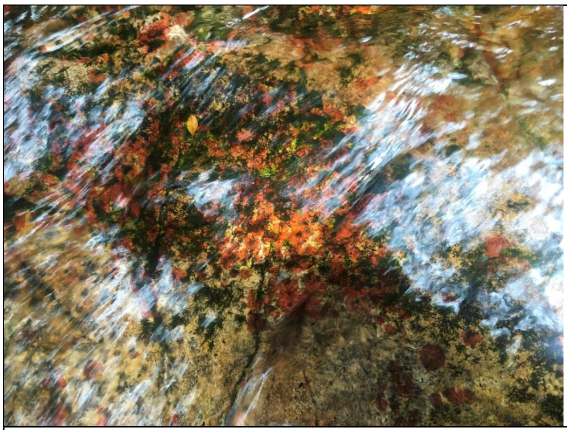
5.4 Periphyton

5.4.1 Periphyton Cover

5.4.1.1 2019 Results

Periphyton cover was assessed visually into major groups from five cobbles, across five transects at each site. Periphyton cover discussed below is shown in Figure 5 and presented as mean coverage in Figure 6.

Total Periphyton cover ranged from 55% at site Teawaotemutu Stream West, to 87% at site WKP02 (Figure 6)**.** Periphyton cover group 'thin/mat film', or diatoms, was the dominant group at sites Teawaotemutu Stream West, Teawaotemutu Stream East and WKP02, with an average coverage range of 43% to 56% across the three sites.



Periphyton present on bedrock at site Teawaotemutu Stream West.

Filamentous periphyton present at site WKP02.

Figure 5: *Examples of periphyton present at survey sites, January and February 2019.*

'Medium mat' was the dominant group at site WKP03 with 35% cover. The group 'thick mat' was only present at site WKP03, with an average cover of 0.6%.

Filamentous algae were rare across the sites. Short filamentous was recorded in low coverage at sites T-Steam West, WKP03 and WKP02. Long filamentous algae were only present at site WKP02 where it had an average coverage of 23%.

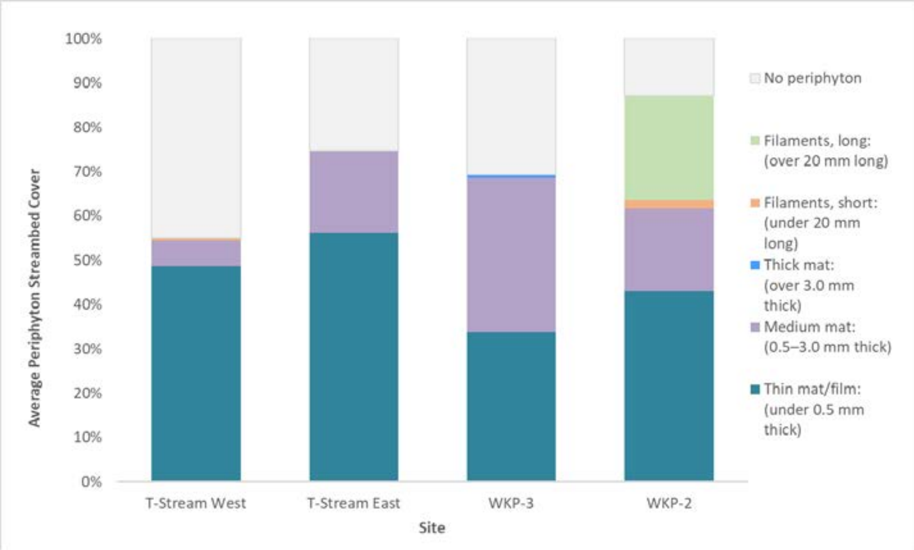


Figure 6: *Periphyton streambed cover at freshwater sample sites (n=6), January and February 2019.*

New Zealand Periphyton Guideline (Biggs, 2000) has guidelines for periphyton cover within gravel / cobble bed streams for protection of instream values of aesthetics / recreation and trout habitat and angling. These guidelines include maximum values for coverage of diatoms / cyanobacteria and for filamentous periphyton (>2cm). Mean periphyton cover for diatoms / cyanobacteria (>3 cm thick) was well below the aesthetic/recreation (1 November – 30 April) guideline value of a maximum streambed cover of 60%, with less than 1% coverage at site WKP03 only. The mean filamentous periphyton (>2 cm long) cover was below the 30% guideline for aesthetics/recreation and trout habitat and angling, with 23% coverage at site WKP2 (Biggs, 2000).

5.4.1.2 2024 Results

Total periphyton cover ranged from 59 % at site Trib-R to 89.6 % at Thompson Stream. The periphyton cover group thin mat/film, or diatoms, was the dominant type at sites Edmonds Stream, WKP03, Adams Stream and Trib-R, ranging from 32 % to 47 % (Figure 7). Short filaments were the dominant type at T-Stream East and Thompson Stream with 50 % and 40 % coverage, respectively. While at WKP02 long green filaments were the most abundant at 32 % coverage.

Filamentous algae were common across the sample sites, being the dominant type at sites T-Stream East, WKP02 and Thompson Stream. Mean periphyton cover for diatoms / cyanobacteria was below the NZ Periphyton Guideline value across all sites (Biggs, 2000). The mean filamentous algae cover was above the 30 % guideline at site WKP02 where average cover was 31.6 %. This result was influenced by a replicate survey transect that had very high long filamentous algae growth (78%).

Changes in periphyton cover were observed between the 2019 and 2024 at the repeated sites of T-Stream East, WKP03 and WKP02 (Figure 6, Figure 8). Across all sites there was a reduction in thin mat/filament and medium mat types observed, while there was increase in both short and long filamentous periphyton. At site T-Stream east short filamentous algae went from 0 % in 2019 to 50.4 % in 2024.

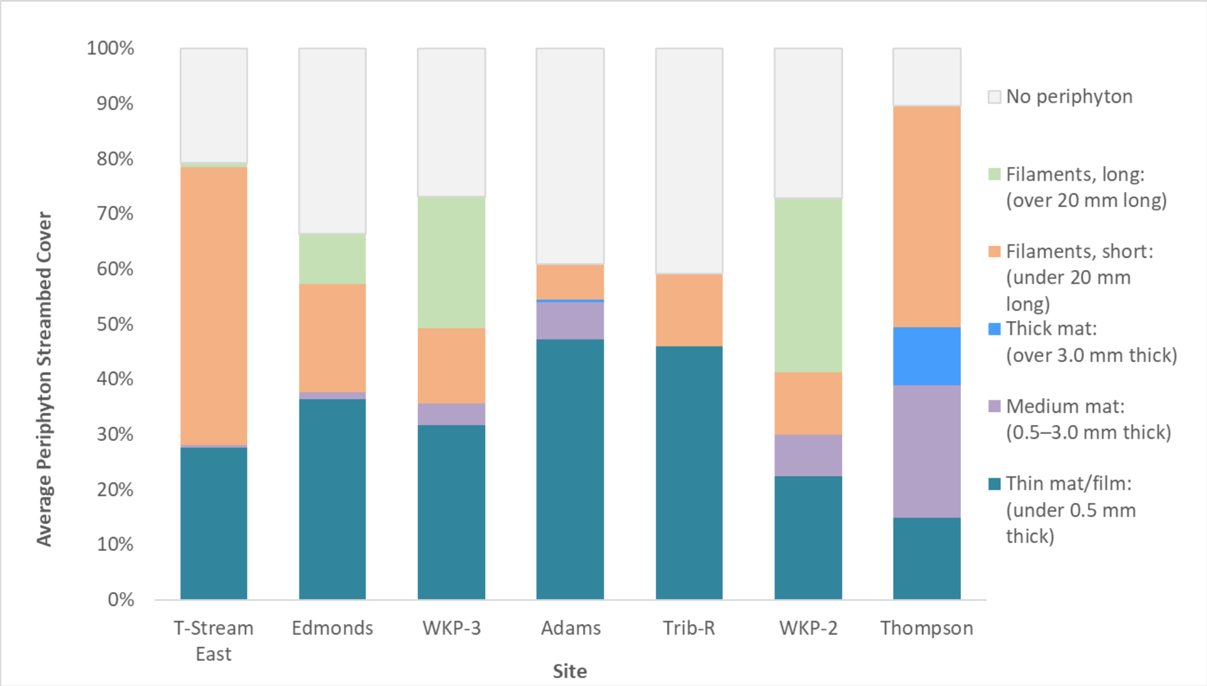


Figure 7: *Average periphyton streambed cover at sample sites (n=6), February 2024.*

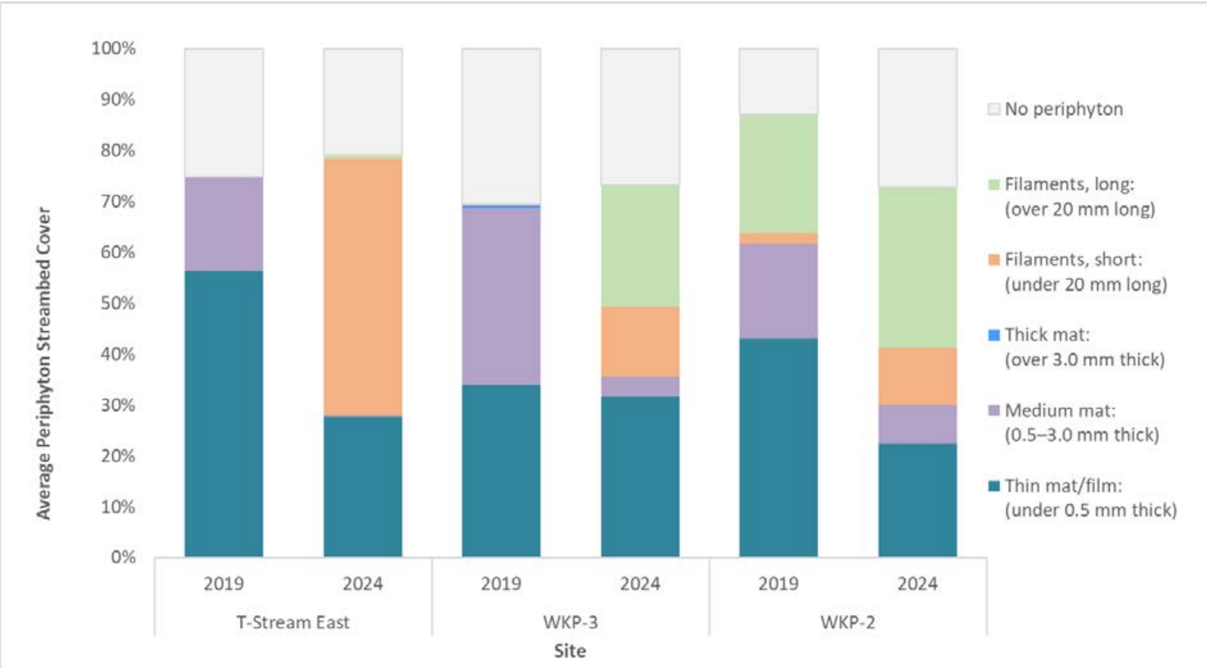


Figure 8: *Average periphyton streambed cover at Sites T-Stream East, WKP03 and WKP02 in 2019 and 2024.*

5.4.2 Periphyton Community Composition

5.4.2.1 2019 Results

Periphyton communities were representative of healthy communities and good water quality. Communities were dominated by diatoms from the phyla Bacillariophyceae, with 16 species identified across all sites (Table 3). Blue-green algae, or cyanobacteria, were recorded in lower abundance across all sites with seven species identified. Species from the Phyla's desmids (Zygnemophyceae), golden-brown algae (Cryptophyceae), red algae (Rhodophyta) and flagellates were also recorded at some sites.

Site Teawaotemutu Stream West had an average taxa abundance of 5.3 and a total taxa abundance (all replicates combined) of 14. The most dominant taxon was *Cocconeis* sp. (Phyla Bacillariophyceae). The taxa *Synedra* sp., *Gomphonema* sp. and a *Phormidium* were also dominant. *Cocconeis* sp. is common and can be found in both high- and low-quality streams. *Synedra* sp. and *Gomphonema* sp. (Phyla Bacillariophyceae) are colonising taxa and often colonise soon after floods, where they can monopolise the substrata for considerable periods (MFE 2000). Filamentous blue-green algae *Phormidium* can be found in streams with a range of water quality from pristine to polluted. They are known to proliferate and 'bloom' at times during summer low-flows, where they can produce toxins that could reach levels that are of concern for the health of humans and animals.

Site Teawaotemutu Stream East had an average taxa abundance of 6.2 and a total taxa abundance (all replicates combined) of 14. The most dominant taxa were the diatom *Gomphonema* sp. followed by *Cocconeis* sp. Diatom *Rhoicosphenia abbreviata* was moderately dominant; this species is very common and widespread throughout New Zealand and prefers moderate to high water velocities. Blue-green algae *Pseudanabaena* sp. was recorded and is usually found in streams of good water quality (Landcare Research, 2019). The red algae *Audouinella* sp. was present and this taxon is widespread and common in foothills and shady forest streams, preferring stable substrates.

Site WKP03 had an average taxa abundance of 8.5 and a total taxa abundance (all replicates combined) of 16. The most dominate taxon was the diatom *Synedra* sp. followed by the diatom species *Melosira varians*. *Melosira varians* is found throughout New Zealand where it can dominate the periphyton community in enriched environments (MFE 2000).

Site WKP02 had an average taxa abundance of 8.5 and a total taxa abundance (all replicates combined) of 15. The most dominant taxa were *Synedra* sp., followed by the blue-green algae *Homoeothrix* sp., the desmid *Mougeotia* sp. and the diatom *Melosira varians.* The taxa *Homoeothrix* sp. and *Mougeotia* sp. are both typically found in streams of moderate to good water quality and *Homoeothrix* sp., *M. Varians* and *Mougeotia* sp. are all also indicator species of good quality streams (Table 3).

A total of 12 taxa that were present across all sites are listed by Landcare Research (2019) as indicator species for good quality streams (Table 3). Communities that are dominated by these indicator species are also an indication that the community is normal and healthy.

Table 3: *Periphyton community abundance, based on the mean (n =6) rank scores for each Site. Showing two most abundant species at each Site. January/February 2019. * taxa count refers to the total found when all replicates were combined.*

Site	Taxon* Count	Two Most Abundant Species	
T-Stream West	14	Diatoms (Bacillariophyceae)	*Cocconeis sp.* *Synedra sp.*
T-Stream East	14	Diatoms (Bacillariophyceae)	*Gomphonema sp.* *Cocconeis sp.*
WKP03	16	Diatoms (Bacillariophyceae)	*Synedra sp.* *Melosira varians*
WKP02	15	Diatoms (Bacillariophyceae) Blue greens (Cyanobacteria)	*Synedra sp.* *Homoeothrix sp*

5.4.2.2 2024 Results

Periphyton communities were again representative of healthy communities with good water quality. Communities were dominated by diatoms from the phyla Bacillariophyceae, with 24 species identified across all sites. Blue-green algae, or cyanobacteria, were recorded in lower abundance across the Sites, with 15 species identified. Species from the Phyla's green algae (chlorophyta), red algae (rhodophyta), desmids (zygnemophyceae) and flagellates were also recorded at some sites.

Periphyton community and indicative abundance was determined using rank abundance, with the two most abundant species at each site show in in Table 4.

A number of the most abundant taxa at survey sites (Table 4) are identified by Manaaki Whenua Landcare Research (2024) as being indicators of good quality streams (Table 5). These include *Chamaesiphon* sp., *Cocconeis* sp., *Navicula* sp., *Synedra* sp., *Cymbella* sp., and *Melosira varians*. These species are commonly found and/or thrive in good quality stream habitats, with natural, bush covered, stony bottom streams often support thin green or brown films made up of whole communities of unicellular diatoms, cyanobacteria (blue-green algae), and red algae (Manaaki Whenua 2024).

Three indicative taxa that were recorded in 2019, were not recorded in 2024. These were the cyanobacteria *Pseudanabaena* sp. and *homoeothrix* sp. and the green algae *Mougeotia* sp (Table 5).

Table 4: *Periphyton community abundance, based on the mean (n =6) rank scores for each Site. Showing two most abundant species at each Site. February 2024. * taxa count refers to the total found when all replicates were combined.*

Site	Taxon* Count	Two Most Abundant Species	
T-Stream East	23	Blue greens (Cyanobacteria) Diatoms (Bacillariophyceae)	*Chamaesiphon sp.* *Cocconeis sp.*
Edmonds Stream	17	Diatoms (Bacillariophyceae)	*Navicula sp.* *Cocconeis sp.*
WKP03	31	Diatoms (Bacillariophyceae)	*Synedra sp.* *Cymbella sp.*
Adams Stream	20	Diatoms (Bacillariophyceae)	*Achnanthes sp.* *Navicula sp.*
Trib-R	18	Red algae (Rhodophyta) Diatoms (Bacillariophyceae)	*Audouinella sp.* *Navicula sp.*
WKP02	24	Diatoms (Bacillariophyceae)	*Melosira varians* *Synedra sp.*
Thompson Stream	19	Diatoms (Bacillariophyceae)	*Melosira varians* *Navicula sp.*

Table 5: *Periphyton species present within sites that are also listed as indicator species for good quality streams (Manaaki Whenua Landcare Research, 2024, n=67). A ✓ indicates that the species were recorded at the survey Site.*

Phyla	Species	T-Stream West	T-Stream East	WKP03	WKP02	T-Stream East	Edmonds Stream	WKP03	Adams Stream	Trib-R	WKP02	Thompson Stream
		2019				*2024*						
Blue greens (Cyanobacteria)	*Chamaesiphon sp.*					✓	✓	✓	✓	✓	✓	✓
	Lyngbya sp.					✓		✓	✓		✓	
	Dichothrix sp.								✓			
	Microcoleus sp.								✓			
	Phormidium sp.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Calothrix sp.								✓			
	Phormidium sp. medium, width ≈ 5 µm						✓	✓				✓
	Phormidium sp. small, width ≈ 3 µm					✓						
	Pseudanabaena sp.		✓	✓								
	Tolypothrix sp.		✓		✓			✓			✓	
	Rivularia sp.	✓				✓						
	homoeothrix sp.		✓		✓							
	cf. Scytonema									✓		
Green algae (Chlorophyta)	*Microspora sp.*					✓		✓	✓		✓	✓
	Stigeoclonium sp.					✓	✓	✓			✓	
	Spirogyra sp.							✓				
	Mougeotia sp.				✓							
Red algae (Rhodophyta)	*Audouinella sp.*					✓	✓	✓	✓	✓		✓
	Chroodactylon sp.								✓			
Diatoms (Bacillariophyceae)	*Achnanthes sp.**					✓			✓	✓	✓	✓
	Nitzschia sp.		✓	✓	✓	✓	✓		✓	✓	✓	✓
	*Cocconeis sp.**					✓	✓	✓	✓	✓	✓	✓
	Gomphoneis sp.					✓	✓	✓		✓	✓	
	Diploneis sp. *								✓			
	Surirella sp.								✓	✓		✓
	Melosira varians			✓	✓	✓	✓	✓			✓	✓
	Gyrosigma sp.					✓	✓					✓
	Rhoicosphenia sp. *					✓	✓	✓		✓	✓	✓
	Cymbella sp.		✓	✓	✓			✓			✓	✓
	Epithemia sp.							✓			✓	
	Frustulia sp.										✓	
	Diatoma sp.	✓		✓	✓			✓		✓		
	Rhopalodia sp.					✓						

5.4.3 Periphyton Biomass

5.4.3.1 2019 Results

Chlorophyll-a

Mean chlorophyll-a concentrations were below the threshold of 50 mg/m^2 for the protection of benthic biodiversity (Biggs, 2000) at all sites (Figure 9).

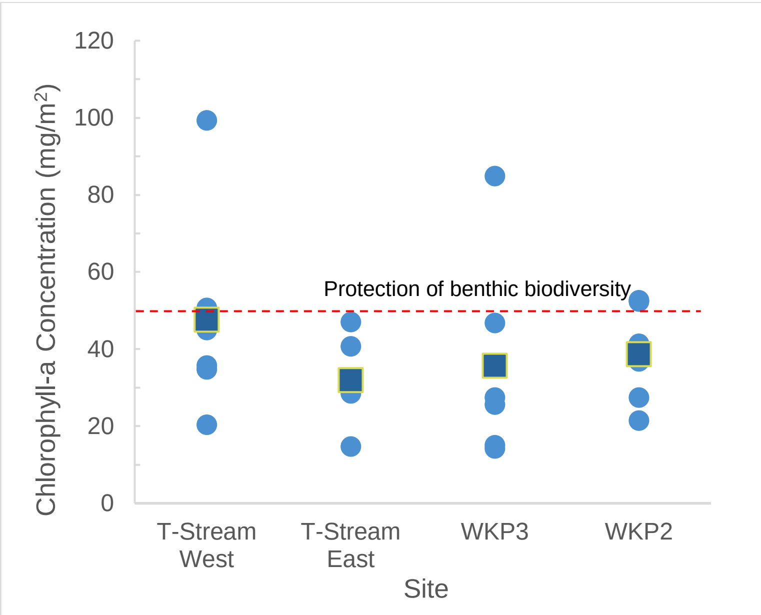


Figure 9: *Chlorophyll-a concentrations (mg/m^2) for samples sites. Where ■ is the mean concentration, and ● is the concentration from individual replicates (n=6), - - is the NZ Periphyton guideline threshold (Biggs, 2000). January and February 2019.*

Ash Free Dry Weight

Mean Ash Free Dry Weight (AFDW) was below the threshold of <35 g/m^2 for the protection of aesthetics / recreation and trout habitat and angling (MFE 2000) at all sites (Figure 21).

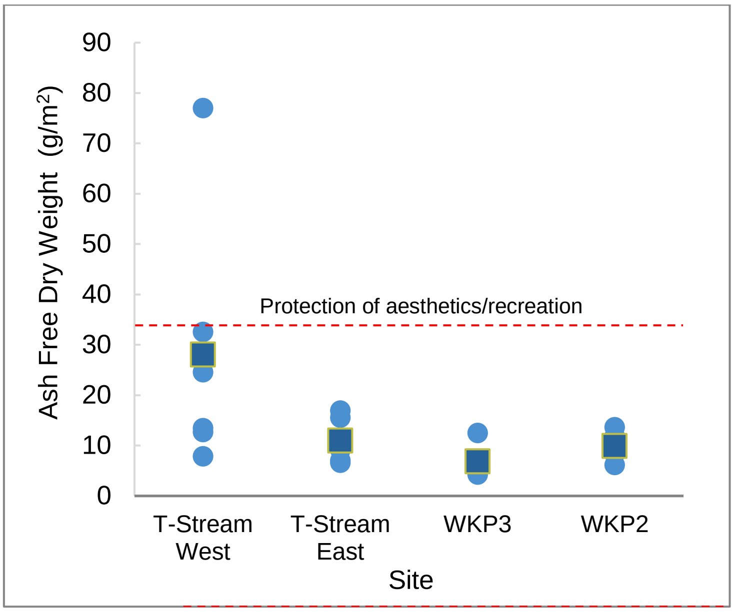


***Figure 10:**: Ash Free Dry Weight levels (g/m^2) for samples sites. Where ■ is the mean concentration, and ● is the concentration from individual replicates (n=6), January and February 2019.*

5.4.3.2 2024 Results

Mean chlorophyll-a concentrations were below the threshold of 50 mg/m^2 for the protection of benthic biodiversity at only two sites: T-Stream East and Edmonds Stream (Biggs, 2000; Figure 11). Sites WKP03 and Trib-R were just above the threshold at 57 mg/m^2 and 55 mg/m^2 respectively. Thompson Stream had very high chlorophyll-a concentrations with an average of 348 mg/m^2.

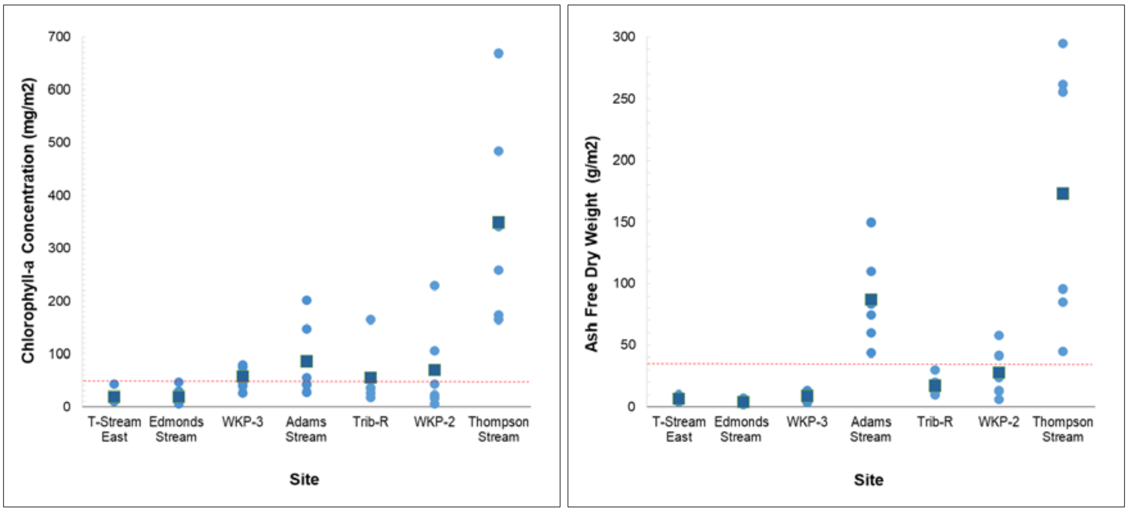


***Figure 11:** (a) Chlorophyll-a concentrations (mg/m2) and (b) Ash Free Dry Weight (g/m2) at sample sites in 2024. Where ■ is the mean concentration, and ● is the concentration from individual replicates (n=6), - - is the NZ Periphyton guideline threshold for Chla-a protection of benthic biodiversity, and AFDW protection of aesthetics/recreation (Biggs, 2000).*

5.5 Macroinvertebrates

5.5.1 2019 Results

5.5.1.1 Community Composition

Macroinvertebrate communities were diverse across all sites and representative of high-quality stream habitats, with high abundance of EPT[5] taxa present across all sites. All communities were dominated by sensitive EPT taxa, comprising at least 67% of all individuals present. Individuals from taxa groups gastropod (snails), Diptera (true flies) and coleoptera (beetles) were also recorded with a range of other groups present in much lower abundances including midges, amongst others (Figure 12).

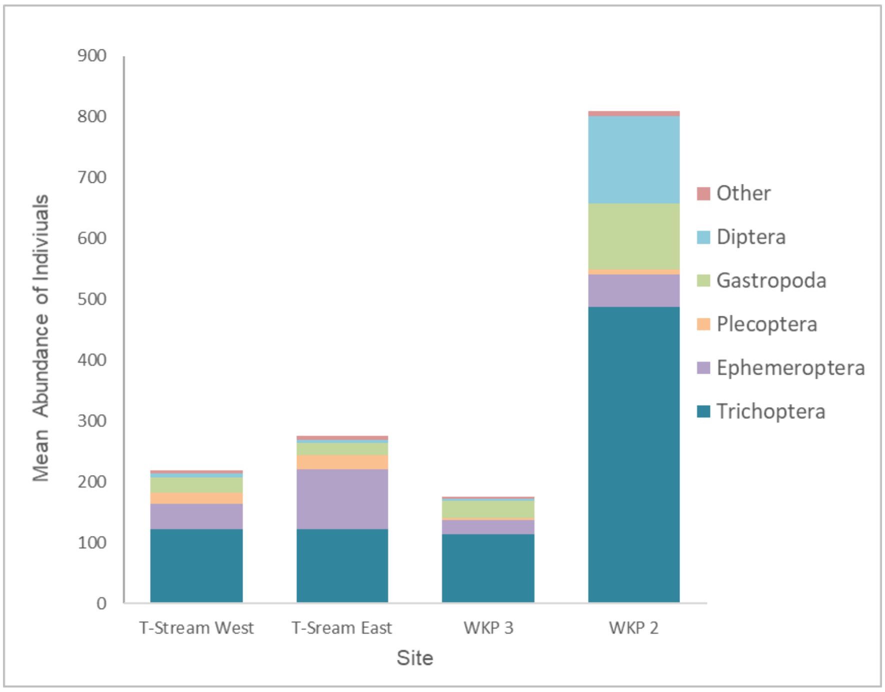


Figure 12: *Macroinvertebrate community composition of major taxonomic groups across all sites. (n=6), January and February 2019*

Multivariate NMDS analysis showed a high degree of similarity between all sample sites, with 50% shared similarity (Figure 13). The sites Teawaotemutu Stream West and Teawaotemutu Stream East show the greatest similarity between sites, sharing 70% similarity.

[5] EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). These taxa represent aquatic macroinvertebrates that are sensitive to habitat disturbance and water quality degradation.

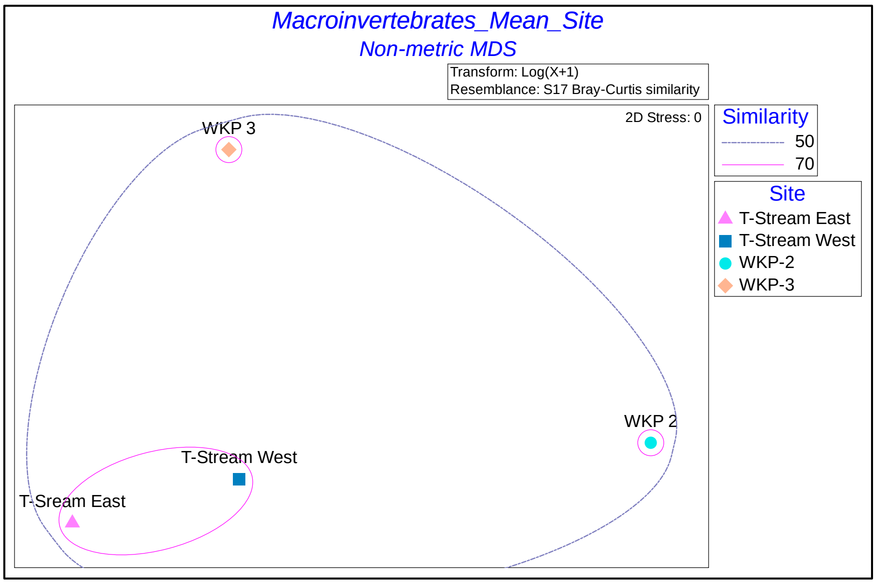


Figure 13: *NMDS plot for macroinvertebrate communities (n=6), January and February 2019.*

5.5.1.2 Macroinvertebrate metrics

Site Teawaotemutu Stream West

Measured metrics at sites Teawaotemutu Stream West and Teawaotemutu Stream East were very similar with near equal means for all metrics. At site Teawaotemutu Stream West the most abundant taxa were the caddis *Helicopsyche* sp., which accounted for 25% of all individuals. This was followed by the caddis *Beraeoptera roria* (16% individuals) and the mayfly larvae Deleatidium. Helicopsyche sp. and Deleatidium are common in stony streams are their abundance indicates good water and habitat quality. *Beraeoptera roria* are characteristic of open forest streams and are ‘collector-gathers’ and feed on a range of organic matter accumulating on streambeds. The abundance of their larvae is indicative of good habitat and good water quality conditions, especially when other mayfly and stonefly groups are also abundant (Landcare Research 2019).

Site Teawaotemutu Stream East

Macroinvertebrate communities at site Teawaotemutu Stream East were very similar to those at site Teawaotemutu Stream West with the same three dominant taxa. The most abundant taxa at site Teawaotemutu Stream East were the mayfly larvae *Deleatidium*, which accounted for 28% of all individuals. This was closely followed by the caddis Helicopsyche sp. (23% of individuals) and the caddis *Beraeoptera roria*.

Site WKP03

Site WKP03 had the lowest abundance and number of EPT taxa of all sites. The most abundant taxa at site WKP03 were the caddis *Helicopsyche* sp. which accounted for 30% of individuals. The next most abundant taxa were *Beraeoptera roria* (17% individuals), followed by the snail *Potamopyrgus antipodarum.* This snail is New Zealand’s most widespread freshwater snail and is found in most streams and rivers from polluted to pristine. High abundances are often a sign of a long period of time since a significant flood event (Landcare Research 2019).

Site WKP02

Site WKP02 had the highest total abundance and number of EPT taxa. This high abundance is attributed to high species diversity and the notably high abundances of the caddis larvae; *Beraeoptera roria* (21% of individuals), the caddis Helicopsyche sp. (18% of individuals) the caddis *Pycnocentrodes,* the midge fly larvae Tanytarsini and the snail *Potamopyrgus antipodarum* at the site. All these taxa are known as 'collector-gathers' and feed on a range of organic matter accumulating on streambeds, including algae. The periphyton visual cover survey shows an increase in periphyton cover, particularly medium mat and filamentous group at site WKP02. This increase in food source may partially explain the higher macroinvertebrate abundance.

5.5.1.3 Macroinvertebrate Community Index

The Macroinvertebrate Community Index (MCI) is a biotic index that is used as an indicator of stream water quality. Mean MCI scores for sites Teawaotemutu Stream West, Teawaotemutu Stream East and WKP03 (were all within the excellent category (Table 6). Mean MCI score for site WKP02 (114) was just within the good category indicating possible mild pollution.

Quantitative Macroinvertebrate Community Index (QMCI) is a quantitative variant that takes into account the relative abundance of each taxa. QMCI scores for all sites were within the excellent category which is indicative of clean water.

***Table 6:** Macroinvertebrate metrics. Means (n=6) are presented, January and February 2019.*

Metric *(mean)*	**Teawaotemutu Stream West**	**Teawaotemutu Stream East**	**WKP03**	**WKP02**
Total abundance	220	276	176	810
No. of taxa	18.0	20.7	16.2	26.0
No. of EPT taxa	12.3	13.5	11.0	16.7
Percent EPT taxa	69.3	64.1	69.3	64.1
MCI score	135.8	135.3	129.8	113.8
QMCI score	7.8	8.0	7.3	6.2

5.5.2 2023 Results

5.5.2.1 Introduction to 2023 macroinvertebrate sampling

As part of the data collection for the instream habitat assessment, we also collected a single kick sample of macroinvertebrates. The purpose of the additional macroinvertebrate sampling at this time was to provide a measure of ecological health and condition at that time, and to further inform the condition of natural state as part of the current assessment.

Several kicks were made of the substrate typically along the length of the same reach as the instream habitat data collection. As much as possible the same effort was undertaken (samples were collected by one of two individuals at each of the sites), and equally as much as possible, in proportion to the range of habitats within the reach. Some of the deeper pools were unable to be sampled.

5.5.2.2 Community Composition

As for the previous sampling in 2019, macroinvertebrate communities were diverse across all sites and representative of high-quality stream habitats. With the exception of Thompsons Stream, the macroinvertebrate communities were dominated by sensitive EPT taxa. Individuals from taxa groups gastropod (snails), Diptera (true flies) and Coleoptera (beetles) were also recorded with a range of other groups present in much lower abundances including midges, amongst others (Figure 14).

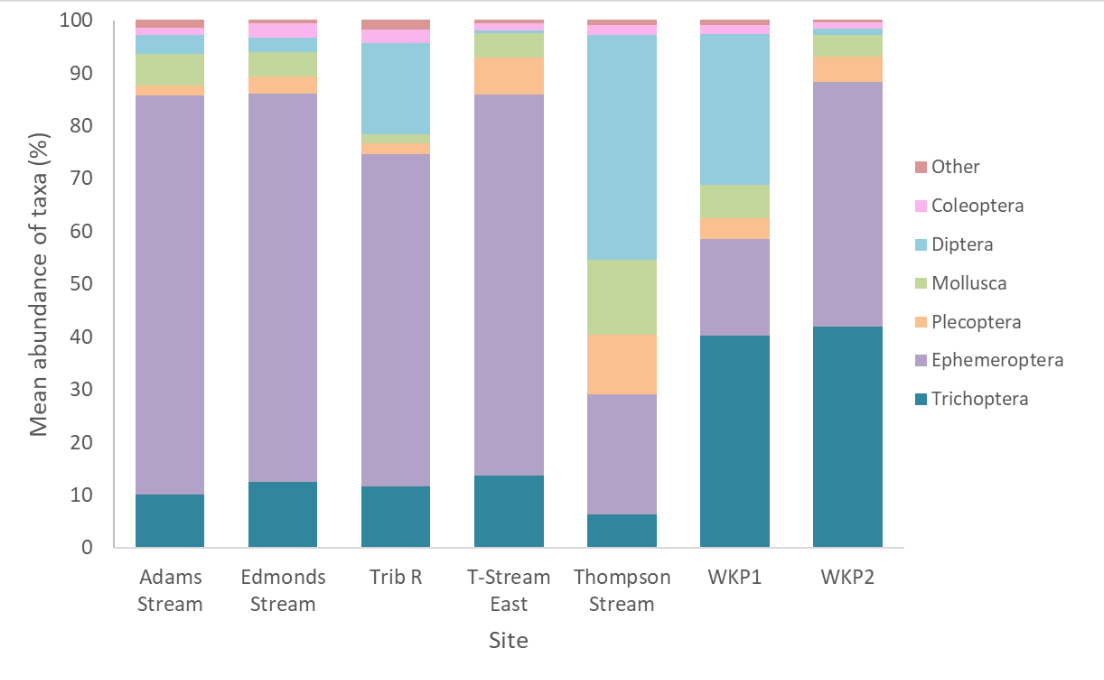


Figure 14: *Macroinvertebrate community composition of major taxonomic groups across all sites (n =1), June 2023. Site TSE = Teawaotemutu Stream East.*

5.5.2.3 Macroinvertebrate metrics

Macroinvertebrate metrics for all sites are provided in Table 7. All the metrics are indicative of very high-quality waterbodies with very high ecological values. The metrics reflect the results of the earlier surveys and show the persistence of the ecology of the waterbodies and their ecological functioning. This especially notable in the face of extreme climatic conditions ranging from lengthy periods of low rainfall (e.g., summer 2019/20) and a recent season of excessive rainfall and flooding events (2022/2023).

Table 7: *Macroinvertebrate metrics from the Wharekirauponga Stream catchment (n = 1), June 2023.*

Metric *(mean)*	Adams Stream	Edmonds Stream	Trib R	Teawaotemutu Stream East	Thompsons Stream	WKP1	WKP2
Total abundance	218	215	232	213	220	224	250
No. of taxa	31	28	25	27	25	28	28
No. of EPT taxa	16	17	15	19	13	15	19
MCI score	122	139	134	144	125	114	141
QMCI score	7.1	7.9	6.9	7.8	5.0	5.1	7.5

5.5.3 2024 Results

5.5.3.1 Community Composition

Macroinvertebrate communities across all sites were diverse and representative of high-quality stream habitats. All communities except Thompson Stream were dominated by sensitive EPT Taxa (Ephemeroptera, Trichoptera and Plecoptera), comprising at least 60% of all individuals recorded. Thompson stream was dominated by the taxa group Gastropoda. Individuals from taxa groups Diptera (true flies), Megaloptera (toe biters) and coleoptera (beetles) were also recorded amongst other taxa that were present at much lower abundance (Figure 15).

None of the taxa identified are listed as threatened (Grainger et al., 2014).

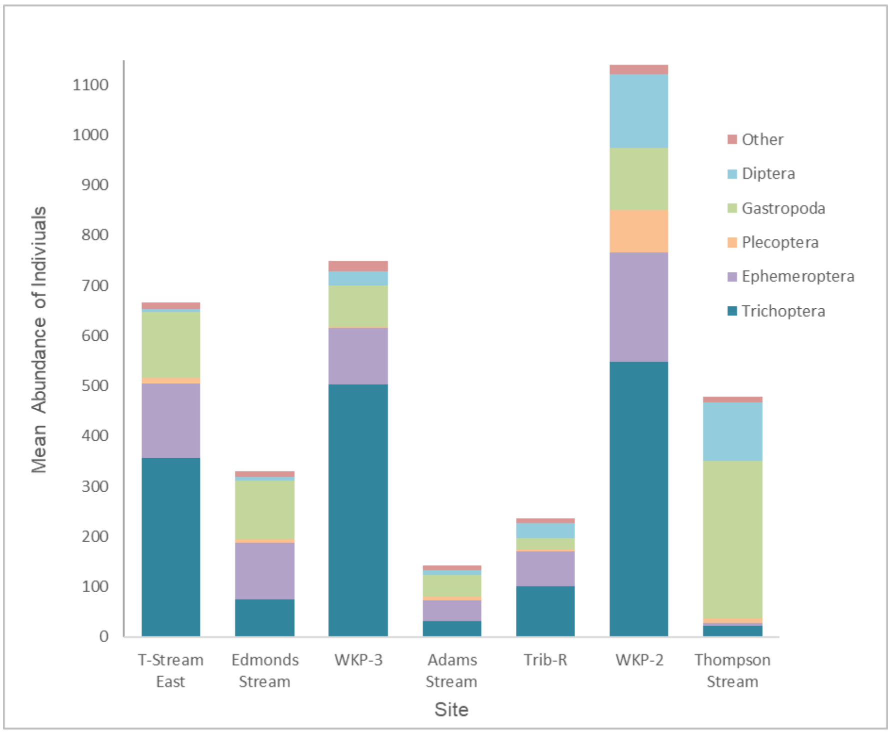


Figure 15: *Macroinvertebrate community composition of major taxonomic groups across all sites (n=6). February 2024.*

Multivariate analysis showed 50% similarity between all sample sites (Figure 16). The sites most similar to each other were WKP02 and WKP03, and also Edmonds Stream and T-Stream East. Thompson stream shared the least similarity with the other sites.

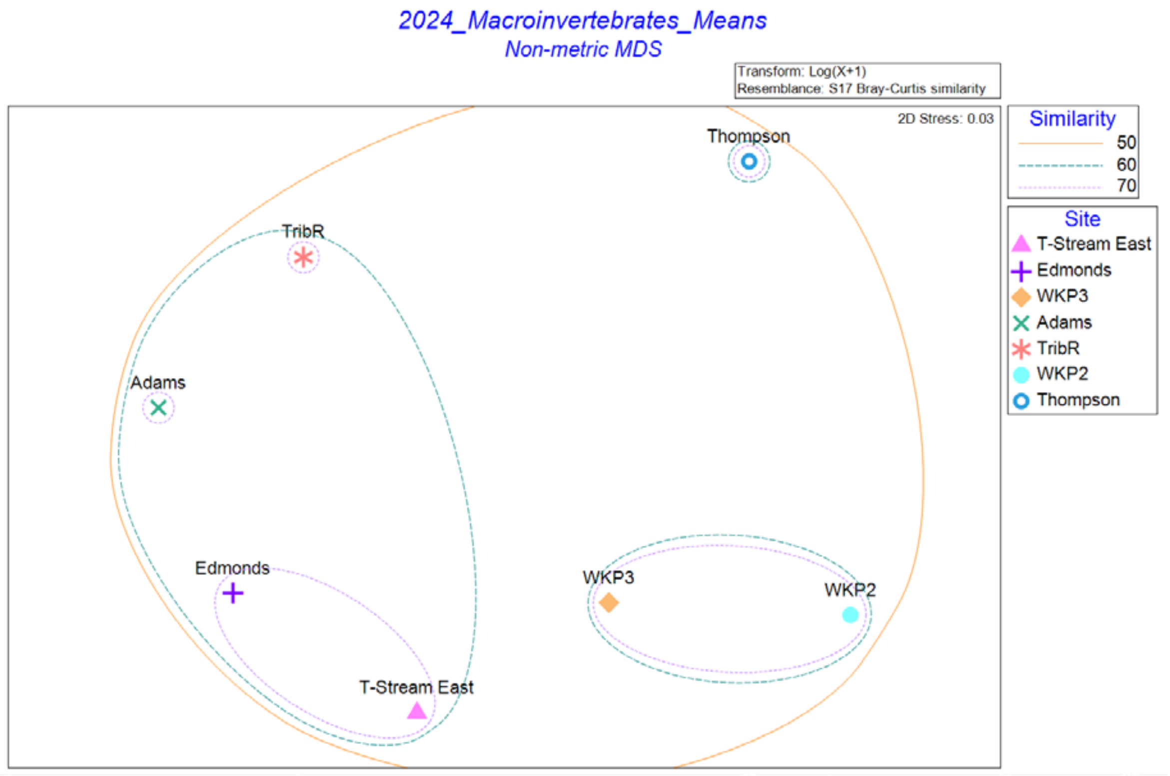


Figure 16: *NMDS plot for macroinvertebrate communities (n=6), February 2024.*

5.5.3.2 Macroinvertebrate Metrics

T-Stream East

T-Stream East had the highest percentage of EPT taxa of all the sample sites, with 65.5 % of taxa recorded from an EPT taxa group (Table 8). Trichoptera were the most abundant taxa group. The most dominant taxa were the spiral cased caddisfly *Helicopsyche*, followed by the snail *Potamopyrgus antipodarum* and the mayfly larvae *Deleatidium*.

Table 8: *Macroinvertebrate metrics. Means(n=6). February 2024.*

Metric (*mean*)	**T-Stream East**	**Edmonds Stream**	**WKP03**	**Adams Stream**	**Trib-R**	**WKP02**	**Thompson Stream**
Total Abundance	666.6	329.5	748.3	142.6	237	1139.1	478.8
No. of taxa	25.8	23.6	26.1	22	25.3	30.1	22.6
No. of EPT taxa	16.8	15.1	16	13	14.5	18.5	9.6
% EPT taxa	65.5	64.5	60.9	59.5	56.2	61.3	42.4
MCI Score	133	137	123	135	130	115	108
QMCI Score	7.68	6.55	7.67	6.81	7.22	6.402	4.09

Edmonds Stream

Edmonds Stream also had a high percentage of EPT taxa, with 64.5% of taxa recorded from an EPT taxa group (Table 8). Ephemeroptera and Gastropoda were the dominant taxa groups. The snail *P. antipodarum* was the most abundant taxa, followed by the mayfly *Deleatidium* and the freshwater limpet *Latia*.

WKP03

Site WKP03 had high individual abundance which was dominated by the taxa group Trichoptera (Table 8). The most dominant taxa was *Helicopsyche,* followed by the smooth cased caddis *Beraeoptera*. The site had the highest abundance in the taxa group ‘other’ which is attributable to the dobsonfly *Archichauliodes diversus*, or more commonly known as a toe biter.

Adams Stream

The Adams Stream site had the lowest overall individual and taxa abundance of the survey sites (Table 8). The site was dominated by the taxa groups Gastropoda and Ephemeroptera. The most abundant taxa was the snail *P. antipodarum* and the caddisfly *Helicopsyche*.

Trib-R

The site Trib-R was dominated by the taxa groups Trichoptera and Ephemeroptera (Table 8). The most abundant taxon was the caddis *Helicopsyche* followed by the mayfly *Deleatidium*.

WKP02

WKP02 had the highest total abundance, taxa abundance and EPT taxa abundance (Table 8). The site is dominated by the EPT taxa groups Trichoptera and Ephemeroptera. The most abundant taxon is the net-spinning caddis *Aoteapsyche,* closely followed by the smooth cased caddis *Beraeoptera*.

Thompson Stream

The macroinvertebrate community composition at Thompson Stream was quite different to the other survey sites, with Gastropoda and Diptera the two dominant taxa groups. The site also had the lowest number and percent of EPT taxa (Table 8). The most dominant was the snail *P. antipodarum*. The dipteran chironomid midge *Tanytarsini* and the sandfly *Austrosimulium* were also abundant.

5.5.3.3 Macroinvertebrate Community Index

MCI scores were 'excellent' for all sites except WKP02 and Thompson Stream which were considered 'good' (Stark & Maxted 2007).

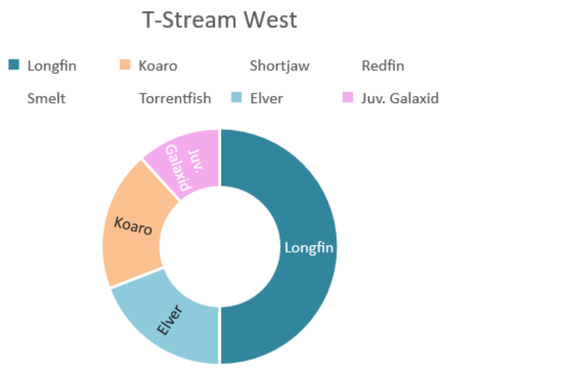
5.6 Fish communities

5.6.1 2019 Results

Fish communities were diverse for the sampling sites with a total of six different species present across the four survey sites. The Wharekirauponga Waterfall, of approximately 4 m in height, is located on the Wharekirauponga Stream between the WKP03 and Teawaotemutu Stream sites. The presence of this waterfall creates a significant barrier for fish passage and its presence has a substantial impact on fish communities upstream, as outlined below. No introduced fish species were observed at any survey site.

Teawaotemutu Stream West and Teawaotemutu Stream East

Sites Teawaotemutu Stream West and Teawaotemutu Stream East were both located upstream of the Wharekirauponga Waterfall. Longfin eel and koaro were present at both Teawaotemutu Stream West and Teawaotemutu Stream East, while shortjaw kōkopu was found at site Teawaotemutu Stream East (Figure 17). Juvenile eels, or elvers, were also present at both sites and unidentified juvenile galaxiids were recorded at site Teawaotemutu Stream West. Elver species may be from the species shortfin eel or longfin eel. Fish abundances were similar with 27 and 20 individuals recorded at Teawaotemutu Stream West and Teawaotemutu Stream East, respectively.



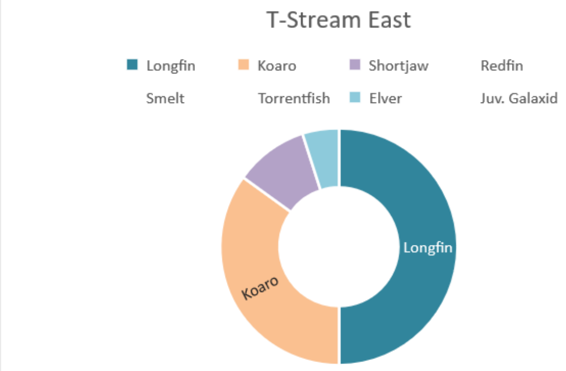


***Figure 17:** Fish community composition at sites Teawaotemutu Stream West and Teawaotemutu Stream East, January and February 2019.*

All species recorded at the two sites are diadromous and migrate between freshwater and the sea as part of their life cycle. Longfin eel, kōaro and shortjaw kōkopu (Figure 18) are all adept climbers, primarily when young, and are able to scale high waterfalls such as the Wharekirauponga Waterfall. Longfin eels are endemic and are found throughout New Zealand waterways. They are under threat from commercial fisheries and habitat loss and modification and have a conservation status of At Risk – Declining (DOC 2018). Kōaro are widespread, preferring rocky, fast-flowing streams with native bush catchments or tussock. They have a conservation status of At Risk – Declining (DOC 2018). Shortjaw kōkopu are generally restricted to streams within native forest catchments and, although widespread, are the rarest of the whitebait species (NIWA 2019). It is unusual to capture more than a few fish at each site. They have a conservation status of Threatened – Nationally Vulnerable (DOC 2018).

Kōaro present at site Teawaotemutu Stream West.

Shortjaw kōkopu present at site Teawaotemutu Stream East.

Figure 18: *Kōaro and Shortjaw kōkopu from sites Teawaotemutu Stream West Teawaotemutu Stream East, January and February 2019.*

Sites WKP03 and WKP02

Sites WKP03 and WKP02 are both located downstream of the Wharekirauponga Waterfall and both have a more diverse fish community than the sites upstream. This diversity is in no doubt owing to their comparatively easy accessibility from the sea. In addition to longfin eel and kōaro, torrentfish, redfin bully and common smelt were also present at both WKP- sites (Figure 19). Fish abundances were higher at both WKP- sites, than Teawaotemutu Stream sites, with 85 and 104 individuals recorded at WKP03 and WKP02, respectively. This increase in abundance and diversity is as expected with the waterfall restricting fish passage upstream.

Figure 19: *Fish community composition at sites WKP03 and WKP02, January and February 2019.*

Torrentfish (Figure 20) are common in gravel-bedded waterways in New Zealand, preferring habitats of cobbles and large boulders. They are not good climbers and only penetrate inland where the gradient is low (NIWA 2019). They are found in swift, broken water where they live amongst the spaces between boulders (McDowall 1990). They have a conservation status of At Risk – Declining (DOC 2018). Redfin bullies are common throughout New Zealand occurring predominantly in the runs and pools of cobble bottomed streams, but also common in soft-bottom streams. Redfin bully has a moderate climbing ability and can be found above small waterfalls (McDowall 1990). They have a conservation status of Not Threatened (DOC 2018). Common smelt are widespread throughout New Zealand living in both flowing and still water. The species is sensitive to pollutants and stressors like high water temperatures (NIWA, 2019). Common smelt have a conservation status of Not Threatened (DOC 2018).

	
Torrentfish present at site WKP03.	*Longfin eel present at site WKP03.*

Figure 20: *Examples of torrentfish and longfin eel present at site WKP03, January and February 2019.*

5.6.2 2024 Results

Fish communities were reasonably diverse with six species identified across the seven sampling sites (Figure 21). The Wharekirauponga Waterfall is located downstream of sites T-Stream East and Edmonds Stream. The waterfall is approximately 4 m in height and presents a significant fish barrier, with distinct differences in fish communities observed between sites located upstream and downstream. No introduced fish species were observed at any of the survey sites.

Sites T-Stream East and Edmonds Stream

Sites T-Stream East and Edmonds Stream are both located upstream of the Wharekirauponga Waterfall. These sites had the lowest overall abundance with 22 and 16 individuals, respectively. These two sites also had the lowest diversity with two confirmed taxa at each site. Longfin eel was the most abundant species identified, with kōaro and elver also recorded. Elvers, or juvenile eels, may be from the species shortfin or longfin eel.

The species recorded at site T-Stream East and Edmonds Stream are all skilled climbers and migrate between freshwater and the sea as part of their lifecycle. Longfin eel are endemic and are found throughout New Zealand waterways and have a conservation status of At Risk – Declining (Dunn et al 2018). Kōaro are widespread, preferring rocky, fast-flowing streams with native bush catchments or tussock. They have a conservation status of At Risk – Declining (Dunn et al 2018).

Sites WKP03 and WKP02

Sites WKP03 and WKP02 are located on the main Wharekirauponga Stream, downstream of the Waterfall. These two sites had the highest overall abundance, with 72 and 82 individuals, respectively. The sites also had the highest diversity, with five taxa identified at each site. Species abundance was dominated by the redfin bully and longfin eel, with kōaro, torrentfish and banded kōkopu also recorded. The higher abundance and diversity at the WKP- sites is expected given the easy access and abundant habitat available within the wide main stem.

Sites Adams Stream, Trib-R and Thompson Stream

Sites Adams Stream, Trib-R and Thompson Stream are all smaller tributaries of the Wharekirauponga Stream, located downstream of the Waterfall. These sites had moderate abundance and diversity, with redfin bully the most abundant species at all three sites. Adams stream had 43 individuals from four confirmed species, including a single common bull. Trib-R had 52 individuals and three confirmed species. While Thompson Stream also had 52 individuals and three confirmed species.

Common bully are common throughout New Zealand and prefer still or slow-flowing waters (NIWA 2024). They have a threat classification of Not Threatened (Dunn et al 2018).

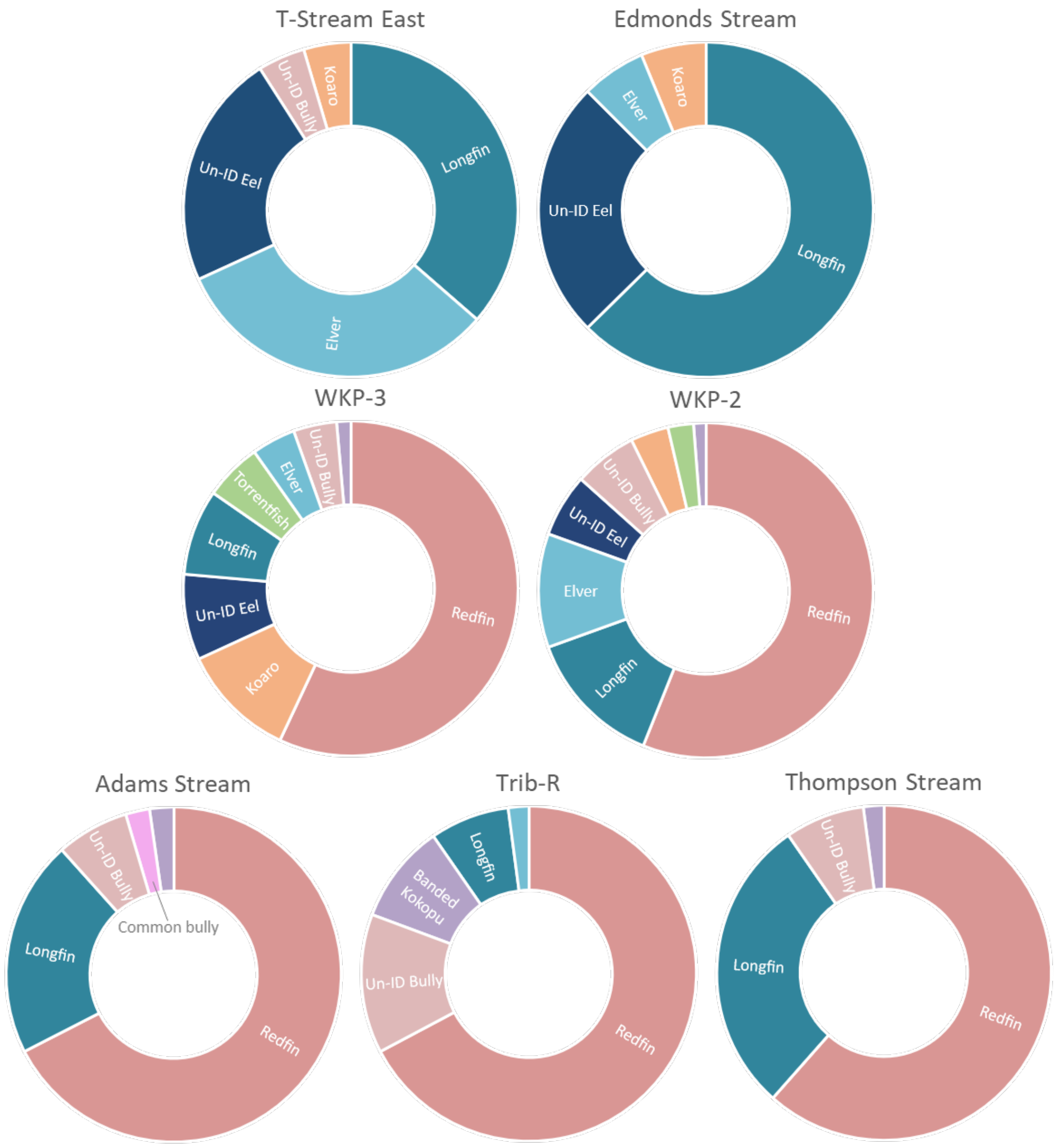


Figure 21: *Fish species captured at survey sites during February 2024 survey.*

5.6.3 New Zealand Freshwater Fish Database

The New Zealand Freshwater Fish Database (NZFFD) had a single record for the Wharekirauponga Stream and a single record for the Teawaotemutu Stream[6]. There are an additional eight records for the Otahu River, into which the Wharekirauponga Stream flows. The Wharekirauponga Stream record is from 1981 (NIWA) and listed shortfin and longfin eel, lamprey and redfin bully. The Teawaotemutu Stream record is from 1995 (NIWA) and only listed longfin eel. No shortjaw kōkopu are recorded within the wider Otahu River catchment in the NZFFD.

We note that the NZFFD records show that lamprey was recorded as present in the Wharekirauponga Stream catchment in a 1981 survey. Lamprey were not recorded in our 2019 or 2024 surveys, nor from eDNA samples undertaken in 2024.

5.6.4 Fish QIBI SCORE

5.6.4.1 2019 Results

Fish QIBI scores were within the excellent category which is comparable to the best conditions without human disturbance, with all regionally expected fish species for the stream position represented (WRC 2007; Table 2).

5.6.4.2 2024 Results

Fish QIBI scores were within the excellent category for all sites, which is comparable to the best conditions without human disturbance, with all regionally expected fish species for the stream position represented (Joy & Henderson, 2007; Table 2).

5.7 Summary: ecological values

The freshwater habitats surveyed within the Wharekirauponga Stream catchment are of very high ecological value. In most cases the streams are steep with moderate to high water velocities with well incised channels and often with very steep banks. All habitats are classified as significant, providing habitat and migratory pathways for several Threatened and At Risk native fish species and sensitive macroinvertebrate taxa. Measured water physiochemistry parameters at the time of sampling demonstrated good ecosystem functionality. Periphyton communities were abundant in taxa and indicative of good quality streams. Macroinvertebrate communities were diverse in sensitive EPT taxa, with MCI and QMCI scores all reaching the excellent category. Fish communities supported several Threatened and At-Risk species with habitats also providing important migratory pathways.

[6] The NZFFD was searched 25 March 2019.

6.0 Predicted flow changes

6.1 Flow metrics

A series of metrics have been used to assess the potential changes in natural state of the catchments of the Wharekirauponga Stream. These metrics have been chosen because they represent a range of hydrological conditions, can be used to estimate water resource availability, are ecologically meaningful and are often used in environmental flow setting procedures (see Table 9):

- The 7-day mean annual low flow, (7-day MALF) and 1 in 5 year 7-day low flow (Q5) are often used as indicators of low flow for ecological assessments. In our assessment we have used the 7-day-MALF as an appropriate statistic for assessing surface flows.
- Limits to water resource use may be expressed as proportions of MALF or Q5, these indices are of particular interest in New Zealand (MFE 2008).
- FRE3 represents the frequency of events that exceed three times the median flow. FRE3 has been used as an index of flow-driven disturbance (e.g., stream bed substrate movement) in ecological studies of in-stream values such as periphyton, macroinvertebrates, macrophytes and fish.

These hydrological indices are typically used for data driven environmental classifications and/or establishing environmental flows. Our assessment considers the ecological components of the natural state of the potentially affected watercourses.

6.2 Geology and aquifer characteristics

WWLA (2024) review the structural geology, and the effects of the predicted dewatering on the aquifers. The geologic mapping has shown post mineralisation Andesite in exposed outcrop and suggests that to be a thin layer (based on drillers logs and geologic maps of the area) and overlies the mineralised volcanics rocks that host the mineralised vein system.

WWLA (2024) go on to explain that conceptually the groundwater system within the area of the Wharekirauponga deposit is divided into a deep groundwater system (EG Vein aquifer) and a shallow groundwater system (Andesite and Rhyolite volcanics). The shallow groundwater system is recharged by percolating rainfall and groundwater levels and demonstrates a clear response to climatic changes. The deep groundwater system has limited connectivity to the shallow groundwater system and is recharged by percolation and through flow.

WWLA (2024) suggest that through multiple lines of evidence the shallow and deeper aquifers may not be connected or are connected weakly. Thus, where post mineralisation Andesite cover is present, the shallow and deep groundwater systems are considered by WWLA to be disconnected due to the observed basal weathering. Where the shallow aquifer system is within Rhyolite pyroclastics, weak connectivity may exist, with the level of connectivity determined by the permeability of the rock mass locally.

Thus, there is some uncertainty as to how the predicted dewatering and surface flow scenarios will manifest within the area of andesite cover (where there is no or very weak connection). This area underlies the Thompson Stream and the Teawaotemutu Stream (in part).

__Table 9:__ Description and calculation of flow metrics used in assessment[7].

Metric	Description	Calculation
MALF	Mean annual low flow (m^3/s)	The lowest flow for each (hydrological) year is averaged over the data record available.
7-day-MALF	7-day mean annual low flow (m^3/s)	Mean of minimum flow for each water year after having applied a running 7-day mean to the daily flows.
FRE3	Predicted frequency of events exceeding three times the long-term median with “no windows” calculated from mean daily flows (n per year): “no windows” means that there was no application of a minimum period between events for them to be considered as separate events. Counts of events exceeding three time the median flow calculated from mean daily flow time-series.	Counts of events exceeding three time the median flow calculated from mean daily flow time-series. See Booker (2013) for much discussion.
Q5	One-in-five-year 7-day low flow (m^3/s)	20th percentile of annual low flows assuming a normal distribution of minimum flow for each water year after having applied a running 7-day mean to the daily flows

6.3 Water Balance Model

GHD (2024) provides detail of the modelled hydrology of the Wharekirauponga Stream. The Water Balance Model (WBM) has been configured with available data obtained from monitoring in and near the Wharekirauponga Stream catchment.

The WBM has been applied with the inclusion of additional rainfall data (available outside the catchment) to allow for stochastic modelling and prediction of flow rates over a long-term period, enabling the development of likely natural flows based on actual data, historic rainfall variability, and future climate conditions (GHD 2024).

Sensitivity simulations of the flow modelling have been undertaken and which take into account the full range of base flow reduction scenarios from the groundwater model. The sensitivity run shows a greater reduction in flow statistics compared to the base case baseflow reduction, and GHD (2024) comments that this is a result of the sensitivity runs generally showing a higher baseflow reduction than the base case scenario, and the calculation of the flow statistics being weighted towards the lower predicted flows. We have shown the results of the sensitivity simulations that are presented as ‘worst case’ in the results below.

6.4 Base case and worst case

GHD (2024) used the calibrated WBM and derived long-term data to analyse a base case and a worst case.

- The base case scenario is the current state of flows prior to any proposed mining activity.

[7] From: Hydrological indices for national environmental reporting. Prepared for Ministry for the Environment by NIWA, dated March 2015.

- The worst case scenario represents the last day of proposed mining, beyond which dewatering ceases and groundwater levels recover, and the expectation is that over time identified potential effects on surface waters would not occur.

It is important to note the baseflow change is applied in the WBM as a constant fixed value, predicting the worst-case (2035) scenario and does not vary with flow. In other words, the change in baseflow per catchment is applied as a fixed loss from the river flow rate in the worst case scenario simulations of the WBM.

6.5 Predicted flow changes

Flow metric predictions of the current state, base case change and sensitivity simulations in flows as provided in GHD (2024) are summarised in Table 7. It is worth noting the following comments regarding the predicted flow data:

- The WBM has been calibrated, at the time of writing, to the flow data at the five flow monitoring locations where continuous monitoring data is available (T-Stream West, T-Stream East, WKP03, WKP02 and WKP01).
- The calibration process has focused on achieving the best possible calibration at the low flow periods, given this is the flow range of focus for the project.
- Predictions for Thompsons and Edmonds Streams are based on a pro-rated assessment from WKP01 and WKP03 flow data respectively (based on proportional catchment areas).
- The WBM works on a daily timestep. The natural response of hydrological systems can be rapid and therefore the changes to the hydrological regime within a day can vary. As such the WBM cannot reflect the true, sub-daily, hydrological responses times of the natural rainfall runoff water balance in the Wharekirauponga catchment.
- Putting aside the FRE3 metric for now, for the low flow metrics, predicted changes in flow were lowest in T-West and greatest in Thompson Stream, with Edmonds Stream the second greatest change. Predicted flow changes in the Wharekirauponga Stream were more moderate.
- Predicted changes in Thompson Stream varied from 11.33% (70% 7-day MALF worst-case) to 14.25% (Q5 basecase). For the 7-day MALF predicted flow change in Thompson Stream varied from 11.33% to 11.54%) and from 9.16% to 10.61%.
- The FRE3 metric exhibited the lowest percentage changes overall of the flow metrics between the predicted flows.

Table 10: *Predicted flow metrics from selected model catchments. See Table 6 for definitions and explanation of flow metrics. Numbers represent predicted metric (L/s) with percentage change from current (pre-proposed mining) in parentheses. Worst case = Sensitivity weighted case. From GHD 2024)*

Flow metric (L/s)	**T-West**	**T-East**	**Edmonds Stream**	**WKP03**	**WKP02**	**Thompson Stream**	**WKP01**
Mean flow	146.52	150.17	105.55	255.72	323.19	76.37	517.36
Median flow	118.98	121.81	85.88	207.69	262.30	60.68	416.04
MALF							
Current	28.41	28.72	23.38	52.11	68.91	18.13	110.40
Basecase	28.10 (1.1%)	27.82 (3.1%)	21.05 (9.98%)	48.88 (6.2%)	64.80 (5.95%)	15.88 (12.42%)	103.83 (5.95)
Worst case	27.97 (1.54%)	27.67 (3.64%)	20.68 (11.57%)	48.38 (7.15%)	63.97 (7.17%)	15.86 (12.53%)	102.93 (6.77%)
7-Day MALF							
Current	31.65	32.04	25.49	57.57	75.62	19.51	120.86
Basecase	31.34 (0.99%)	31.15 (2.78%)	23.16 (9.16%)	54.34 (5.6%)	71.52 (5.42%)	17.26 (11.54%)	114.29 (5.44%)
Worst case	31.22 (1.36%)	31.0 (3.24%)	22.79 (10.61%)	58.83 (6.5%)	70.66 (6.56%)	17.3 (11.33%)	113.38 (6.19%)
70% 7-Day MALF							
Current	19.89	20.10	16.37	36.48	48.23	12.69	77.28
Basecase	21.94 (0.99%)	21.81 (2.78%)	16.21 (9.16%)	38.04 (5.6%)	50.06 (5.42%)	12.08 (11.54%)	80.00 (5.44%)
Worst case	21.85 (1.36%)	21.70 (3.24%)	15.95 (10.61%)	37.68 (6.5%)	49.46 (6.56%)	12.11 (11.33%)	79.36 (6.19%)
Q5							
Current	22.43	22.58	19.41	41.99	56.38	15.82	90.42
Basecase	22.12 (1.39%)	21.69 (3.95%)	17.08 (12.02%)	38.77 (7.68%)	52.28 (7.28%)	13.56 (14.25%)	83.84 (7.27%)
Worst case	22.01 (1.89%)	21.58 (4.41%)	16.75 (13.7%)	38.33 (8.71%)	51.47 (8.7%)	13.65 (13.67%)	83.09 (8.1%)
FR3							
Current	356.94	365.42	257.64	623.06	786.91	182.05	1248.13
Basecase	356.01 (0.26%)	362.74 (0.73%)	250.63 (2.72%)	613.37 (1.55%)	774.58 (1.57%)	175.31 (3.7%)	1228.40 (1.58%)
Worst case	355.66 (0.36%)	362.29 (0.86%)	249.44 (3.18%)	611.7 (1.82%)	771.7 (1.93%)	175.52 (3.59%)	1225.94 (1.78%)

6.6 Wetted width

We have included wetted width in our assessment of changes to natural state resulting from the potential groundwater dewatering. GHD (2024) defines the wetted width of a stream/river as the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water. The wetted width is an important measurement in understanding the physical and ecological habitat as the living space for ecosystem function. The wetted width can influence the range and density of periphyton, macroinvertebrate and fish species present as well as the assimilative capacity of the waterbody. It is an attribute commonly used in modelling habitat availability for aquatic flora and fauna.

6.7 Predicted wetted width changes

Flow metric predictions of the current state, basecase change and sensitivity simulations in wetted width as provided in GHD (2024) are summarised in Table 8. GHD (2024) notes that the predicted reductions in wetted width are proportionally (in terms of percentage) smaller when compared to the percentage reduction in flows and range from 0% to 5%. The smaller predicted reductions in wetted width (compared to flows) are related to the flow / wetted width relationships which only sees significant reductions in wetted width (for reduction in flow) as the flow approaches zero.

Notwithstanding the FRE3 metric, which exhibited the lowest percentage changes overall, for the 7-day MALF, changes in wetted width varied from 0.25% (T-West) to 3.10% (Thompson Stream) for the basecase, and 0.34% (T-West) and 3.04% (Thompson Stream) for the worst case scenario. The same distinctions of lowest and highest changes in predicted flow remain the same for all the flow metrics.

Table 11: *Predicted wetted width from selected model catchments. See Table 6 for definitions and explanation of flow metrics. Numbers represent predicted metric (wetted width in metres) with percentage change from current (pre-proposed mining) in parentheses. From GHD, 19 June 2024.*

Flow metric	**Wetted width (m)**						
Flow metric	**T-West**	**T-East**	**Edmonds Stream**	**WKP03**	**WKP02**	**Thompson Stream**	**WKP01**
Mean flow	3.5864	3.6086	2.6045	4.8479	5.4939	2.5576	7.0449
Median flow	3.4037	3.4238	2.4706	4.6058	5.2208	2.4112	6.6859
MALF							
Current	2.3755	2.3820	1.7705	3.2769	3.7662	1.7690	4.8627
Basecase	2.3690 (0.28%)	2.3632 (0.79%)	1.7235 (2.66%)	3.2258 (1.56%)	3.7102 (1.49%)	1.7099 (3.34%)	4.7916 (1.46%)
Worst case	2.3663 (0.39%)	2.3599 (0.93%)	1.7156 (3.1%)	3.2176 (1.81%)	3.6984 (1.8%)	1.7093 (3.37%)	4.7816 (1.67%)
7-Day MALF							
Current	2.4409	2.4484	1.8101	3.3583	3.8528	1.8025	4.9695
Basecase	2.4348 (0.25%)	2.4312 (0.71%)	1.7662 (2.43%)	3.3110 (1.41%)	3.8006 (1.35%)	1.7467 (3.10%)	4.9033 (1.33%)
Worst case	2.4325 (0.34%)	2.4282 (0.82%)	1.7589 (2.83%)	3.3032 (1.64%)	3.7894 (1.64%)	1.7478 (3.04%)	4.8939 (1.52%)
70% 7-day MALF							
Current	2.2318	2.2387	1.6521	3.0760	3.5313	1.6450	4.5618
Basecase	2.2262 (0.25%)	2.2229 (0.71%)	1.6120 (2.43%)	3.0326 (1.41%)	3.4835 (1.35%)	1.5940 (3.10%)	4.5010 (1.33%)
Worst case	2.2241 (0.34%)	2.2202 (0.82%)	1.6054 (2.83%)	3.0255 (1.64%)	3.4732 (1.64%)	1.5950 (3.04%)	4.4924 (1.52%)
Q5							
Current	2.2387	2.2424	1.6881	3.1073	3.5861	1.7081	4.6351
Basecase	2.2309 (0.35%)	2.2198 (1.01%)	1.6337 (3.23%)	3.0468 (1.95%)	3.5205 (1.83%)	1.6421 (3.87%)	4.5520 (1.79%)
Worst case	2.2281 (0.48%)	2.2171 (1.13%)	1.6256 (3.7%)	3.0384 (2.22%)	3.5072 (2.2%)	1.6449 (3.7%)	4.5421 (2.01%)
FR3							
Current	4.4850	4.5115	3.2733	6.0364	6.8280	3.1958	8.7029
Basecase	4.4820 (0.07%)	4.5032 (0.18%)	3.2502 (0.7%)	6.0131 (0.39%)	6.8017 (0.38%)	3.1650 (0.96%)	8.6697 (0.38%)
Worst case	4.4809 (0.09%)	4.5017 (0.22%)	3.2463 (0.82%)	6.0091 (0.45%)	6.7955 (0.48%)	3.1660 (0.93%)	8.6656 (0.43%)

6.8 Climatic variation

It is not the intention of this report to provide an assessment of climatic and weather variation, but it is worth emphasising that extreme climatic and weather events occur naturally and have an influence on natural ecosystems and ecology natural state. For example, the Waikato region (including the Coromandel region) experienced a particularly dry 2019, with annual rainfall well below long term average[8]. This was followed by a record-breaking summer of low rainfall[9]. Likewise, over summer 2021/22 the Waikato region experienced record low flows in several rivers and streams.

In contrast, in January 2023, above normal (120-149% of normal) or well above normal (>149% of normal) rainfall was observed across most of the North Island and was an exceptionally wet month for the Coromandel Peninsula which received at least 400% of normal January rainfall (along with other northern and eastern parts of New Zealand)[10]. Auckland observed its wettest ever month in records dating back to 1853.

GHD (2023) provides a record of the total rainfall from Waihi (and an actual Wharekirauponga Stream catchment record) for the summer months January to February each year and reproduced in Figure 24. The rainfall record highlights the variability of rainfall during summer months within the region. GHD (2023) goes on to comment that the rainfall results indicate that January to March 2020 was one of the lowest rainfall periods to occur, along with 2013 and 1950 (when considering the long-term data set).

Overall, this suggests a high variability and wide extremes in climatic and weather conditions in the region that is reflected in high variability and extremes in the response of waterway. The evidence for the 2019 to 2023 period (notably the information on macroinvertebrate communities) demonstrates the degree of resilience inherent in the aquatic ecosystem to overcome such variability and extremes of flow changes.

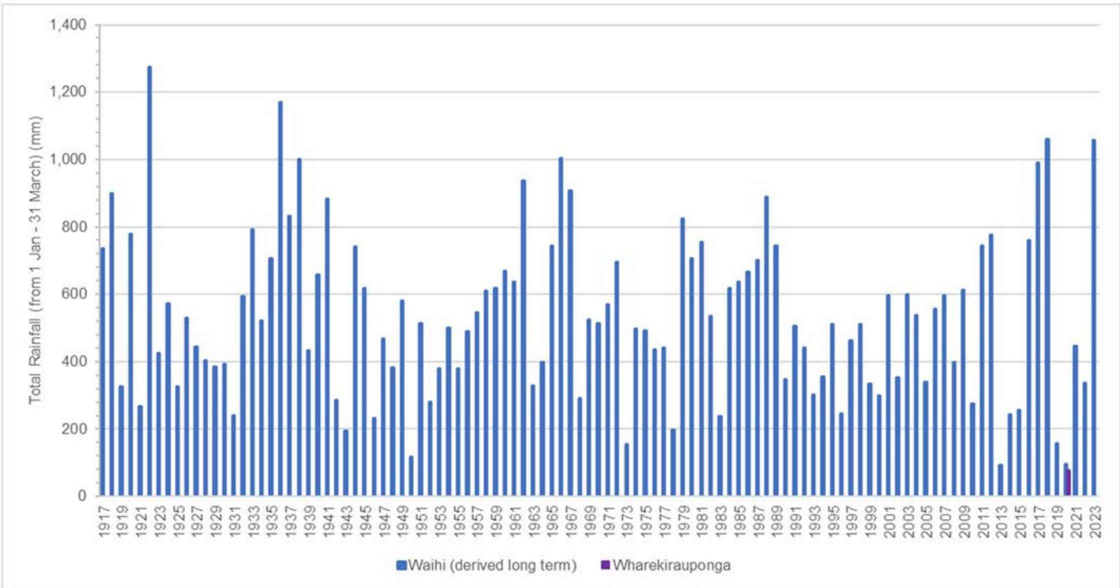


Figure 22: *Total rainfall from the Waihi long-term rainfall record (derived) and actual record from Wharekirauponga Stream catchment, January to March each year. Reproduced from GHD (2023).*

[8] https://www.waikatoregion.govt.nz/services/regional-hazards-and-emergency-management/drought/

[9] Ruakura recorded its driest summer (December 2019 to February 2020) on record.

[10] https://niwa.co.nz/climate/monthly/climate-summary-for-january-2023

6.9 High flows (FRE3)

As outlined above we selected the FRE3 as one of the flow metrics for assessing the potential changes in natural state of the catchments of the Wharekirauponga Stream. FRE3 is an index of flow-driven disturbance and represents a helpful measure of higher flows that result in the movement of bed substrates, algae sloughing off from their hard substrates, and thus the creation of fresh habitats for colonisation.

In all predictions of high flow change the modifications range between 0.26% and 2.72% in basecase predictions; and 0.36% and 3.59% in worst case conditions. We consider that at the high flows these variations from current are not significant to result in change in natural state. We anticipate that expected stream disturbance at these high flows (and of course even higher flows) and within the percentage variation predicted, would continue to occur within natural range and expectations and thus not result in a change in ecology natural state.

Accordingly, from here on in, our assessment of predicted changes in flow regime focuses on the potential for predicted changes in low flow regimes to modify the natural state of the Wharekirauponga Stream catchment and no further reference is made to higher flows.

7.0 Instream Habitat Assessment

7.1 Background

Here we provide an overview of the habitat characteristics of each of the stream reaches assessed along with the outcomes of the instream habitat assessment. We describe the aquatic attributes of the main stem and tributaries potentially affected by changes in flow. The catchment areas are provided in Figure 2. We describe the key habitat characteristics of each of the model catchments followed by the outcomes of the instream habitat assessment.

NIWA (2024) used physical habitat modelling and related techniques to quantify the effects of flow reduction on the availability of suitable physical habitat for aquatic taxa. The modelling provides relationships between stream flow and availability of suitable physical habitat for aquatic taxa. This report outlines how the modelled reductions of flow influence physical habitat for each species/class and the relative changes in availability of suitable physical habitat for each species/class over a range of flows.

The System for Environmental Flow Analysis (SEFA) was used by NIWA for the habitat mapping. SEFA is a comprehensive habitat simulation software (Jowett et al. 2024). The habitat mapping method uses the number and distribution of habitat types (pools, riffles and runs) and stage-discharge relationships are applied to simulate hydraulic conditions at isolated cross-sections placed throughout the reach of interest. Modelled conditions at these cross-sections are then used in conjunction with results from the habitat mapping to weight each cross-section and therefore represent conditions in the full reach of interest. NIWA (2024) go on to state that the advantage of the habitat mapping method is that it does not require the selection of a "representative reach" from within the length of river that is of interest.

The model does not provide an assessment of changes in the various habitat types butreflects changes in available habitat for a variety of aquatic species living in the respective environments.

We have drawn on the information provided by both GHD (2024) and NIWA (2024), and in some cases replicated their data and graphs here, to illustrate the general conditions of the stream attributes and flows before changes in the instream attributes change as natural lower flows occur.

We note that the NIWA report refers to establishing post-mining minimum flows which would be a typical outcome from such an instream habitat assessment. For the purposes of this report and the potential effects of the predicted changes to surface flows from the predicted groundwater dewatering on natural state and ecological values, we have used the assessment to indicate where changes in predicted surface flows from normal conditions (at low flows) would impact on habitat for selected taxa groups.

7.2 Instream habitat attributes

NIWA (2024) describes the methods used for ascertaining changes to instream habitat. Habitat suitability curves (HSC) for all species recorded in our stream surveys (Section 5) and from eDNA samples for which HSC were available. Only species/types recorded in our surveys were used.

Area Weighted Suitability (AWS) vs flow curves were created for each study reach, and for each group of biota (periphyton, macroinvertebrates and fish). Only water depth, velocity and substrate were used to determine AWS. The flow range used was from zero flow to approximately median flow. The 7-day MALF was annotated with the pre-mining 7-day MALF and the worst case 7-day MALF[11]. Two different cases were provided for the worst case 7-day MALF (GHD 2024): (1) The average worst case (most likely), (2) The worst case represented by the 5th percentile of flow (highly unlikely). This enables assessment of the effect of potential flow reduction scenarios on the species or classes of biota observed to be present in each study reach.

7.3 Key taxa groups

7.3.1 Taxa

As outlined above, only taxa groups and species that occurred in each of the Wharekirauponga Stream and its respective tributaries were used in the instream habitat assessment and are listed in NIWA (2024). We have replicated the list of taxa used in the instream habitat in Appendix 1 of our report.

7.3.2 Feeding guilds

The chosen taxa groups also represented a range of different feeding guilds[12]. For our purposes we recognised the following feeding types:

- Grazers/scrapers - consume algae and associated material.
- Predators - feed on other consumers.
- Filter-feeders - collect FPOM[13] from the water column using a variety of filters.

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[11] In this context, and as outlined in section 7.3, worst case represents the last day of proposed mining, beyond which dewatering ceases and groundwater levels recover, and the expectation is that over time identified potential effects on surface waters would not occur.

[12] Feeding guild means a group of unrelated species that feed on similar foods (e.g., benthivore, detritivore, herbivore, insectivore, omnivore, planktivore, piscivore), or the types of food that an individual organism feeds upon.

[13] FPOM = Fine particulate Organic Matter. Organic particles in the water column/benthos < 1 mm and > 0.45 µm.

- Collector-gatherers - collect FPOM from the stream bottom.
- Shredders - consume leaf litter or other CPOM[14], including wood.

We have not undertaken an analysis of potential changes in feeding guilds; rather we refer to the feeding types in our assessment of potential changes to instream habitat. We consider this a valuable attribute to consider in assessing potential effects of flow changes to natural state.

7.4 Habitat characteristics

7.4.1 Adams Stream

7.4.1.1 Habitat description

Adams Stream (Figure 25) is narrower than the Teawaotemutu and Edmonds Streams, with a typically steeper gradient throughout the observed reach. However, Adams Stream also had a relatively flat, square base with relatively homogenous depths and flows across the wetted width. Some erosion was apparent on outer bends which has resulted in steep, vertical banks in places. Gravels contributed approximately 20% of the substrate, which is an increase on Teawaotemutu and Edmonds streams. Leaf litter was common throughout, with medium and large woody debris rare. The percentage of habitat recorded within the representative survey reach are: pools (24.9%), riffles (45.9%) and runs (29.2%) (NIWA 2024).

7.4.1.2 Instream habitat assessment

The outcome of the SEFA model for Adams Stream are provided in Figure 26. Changes in AWS varied amongst the taxa groups, but in all cases was above any acute drop in habitat availability (i.e., the predicted flow changes were well to the right of the steep inflection in the AWS curves, although on a generally gentle decrease in AWS in most cases). For some taxa, notably some native fish, AWS improves at lower flows where the AWS show an increase in gradient (e.g., banded kokopu, Figure Adams).

Changes in AWS for specific taxa at the predicted 7-day MALF relative to normal 7-day MALF varied from 0.07% (riffle beetles) to 2.75% (*Pycnocentrodes*) for basecase, and 0.11% (long filamentous algae) and 0.2% (riffle beetles) to 3.86% (*Pycnocentrodes*) and 2.82% (Orthocladiinae) for worst case (Figure 26). The taxa listed in the previous sentence are all grazers of the algal and bacterial films growing on the stream substrate. Changes in AWS for fish were generally low including for eels (up to -1.74% for 7-day MALF worst case for eels). The riffle dominated nature of the habitat in a steeper catchment means that these riffle habitats may be most limiting in habitat availability.

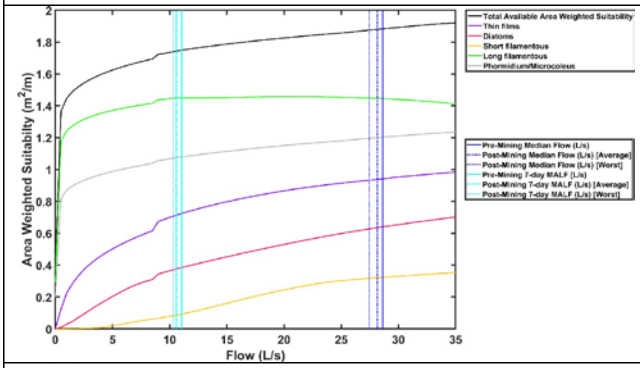
NIWA (2024) reports that to keep impacts on suitable instream habitat within -5% for all biota groups, a post-mining 7-day MALF of 8.98 L/s would need to be sustained, and a post-mining flow of 7.65 L/s for to keep impacts on AWS within -10%. These predicted flows are below the predicted changes in flow for the 7-day MALF for both basecase and worst case.

Accordingly, any predicted flow changes resulting from the potential groundwater drawdown are unlikely to result in changes in habitat that will result in a change in the natural ecological state of the existing environment of Adams Stream.

[14] CPOM = Coarse Particulate Organic Matter. Organic particles in the water column/benthos > 1 mm.

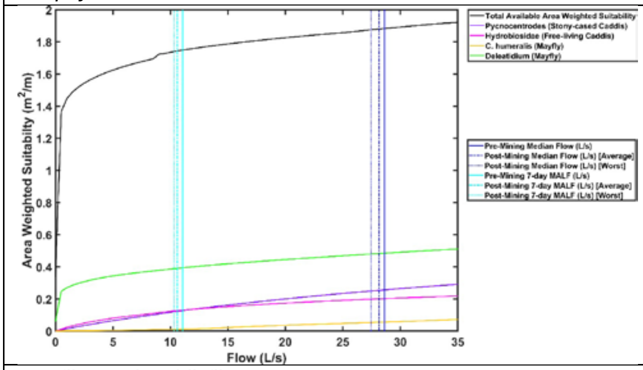
Figure 23: *Habitat characteristics of Adams Stream.*

Area Weighted Suitability (AWS)	Predicted percent change (%) in AWS for taxa groups



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Thin films	-0.35	-0.88	-1.47	-2.39
Diatoms	-0.80	-2.02	-2.28	-3.69
Short filamentous	-0.76	-1.91	-7.16	-11.24
Long filamentous	0.09	0.24	-0.11	-0.21

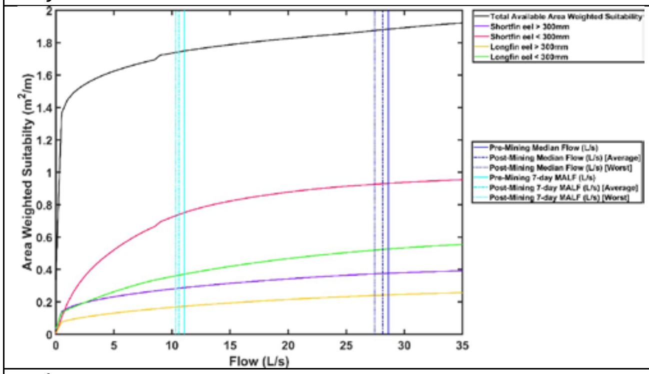
Periphyton



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Pycnocentrodes	-1.10	-2.75	-3.56	-5.74
Hydrobiosidae	-0.65	-1.64	-2.35	-3.82
Deleatidium	-0.43	-1.07	-0.88	-1.42
Elmidae	-0.02	-0.07	-0.20	-0.35
Orthocladiinae	-0.82	-2.08	-2.82	-4.57
Potamopyrgus	-0.22	-0.56	-0.72	-1.18

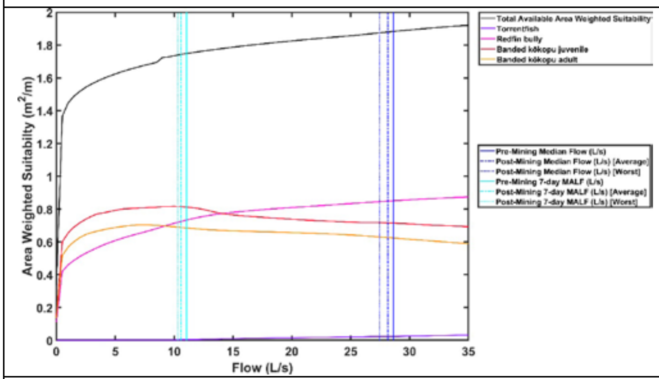
Pycnocentrodes = stony cased caddisfly (grazer)
Hydrobiosidae = free living caddisfly (predators)
Deleatidium = mayfly (grazer)
Elmidae = riffle beetle (grazer)
Orthocladiinae = chironomid midge (grazer)
Potamopyrgus = snail (grazer)

Mayflies and caddisflies



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Shortfin eel >300 mm	-0.39	-0.99	-1.25	-2.03
Shortfin eel <300 mm	-0.23	-0.59	-1.56	-2.57
Longfin eel >300 mm	-0.52	-1.32	-1.60	-2.61
Longfin eel <300 mm	-0.50	-1.27	-1.74	-2.81

Eels



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Redfin bully	-0.24	-0.63	-1.16	-1.90
Banded kōkopu juvenile	0.19	0.35	0.35	0.47
Banded kōkopu adult	0.41	1.01	0.46	0.76

Native fish (excluding eels)

Figure 26: *Area weighted suitability (AWS) for selected biota and percentage changes in AWS where at least 5% of available AWS is suitable at 7-day MALF in Adams Stream. Reproduced from NIWA 2024.*

7.4.2 Edmonds Stream

7.4.2.1 Habitat description

Edmonds stream (Figure 27) had a diverse substrate like the other tributaries but small patches of fine sediment were prominent. The low flow channel resembled a wide, square base with shallow flows spread across it. The gradient was relatively flat with no cascades or steps apparent in the observed reach with alterations in flows provided by the location and density of boulders. The floodplain was relatively narrow, with steep slopes either side. Substrates appeared more embedded than some of the other tributaries but could still be readily dislodged/moved. The proportions of habitat recorded within the representative survey reach were: pools (24.2%), riffles (39.8%) and runs (35.97%) (NIWA 2024).

7.4.2.2 Critical instream flows

As outlined above, the predicted 7-day MALF for Edmonds Stream is as follows:

- Current: 25.49 L/s
- Basecase: 23.16 L/s (9.16% change from current)
- Worst case: 22.79 L/s (10.61% change from current)

7.4.2.3 Critical wetted width

As outlined above, the predicted wetted width at the 7-day MALF for Edmonds Stream is as follows:

- Current: 1.81 m
- Basecase: 1.766 m (2.43% change from current)
- Worst case: 1.759 m (2.83% change from current)

7.4.2.4 Instream habitat assessment

The outcome of the SEFA model for Edmonds Stream are provided in Figure 28. Changes in habitat suitability varied amongst the taxa groups, but in all cases was above any acute drop in habitat availability (i.e., the predicted flow changes were well to the right of the steep inflection in the AWS curves, although on a generally gentle decrease in AWS in most cases). For some taxa, notably some native fish, AWS improves at lower flows where the AWS show an increase in gradient (e.g., banded kokopu, Figure 28).

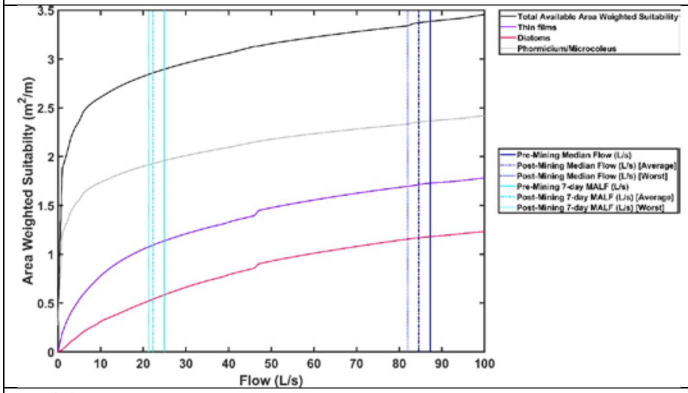
Changes in AWS for specific taxa at the predicted 7-day MALF relative to normal 7-day MALF varied from -2.14% (diatoms) to -3.34% (*Pycnocentrodes*) for basecase, and -5.93% (Hydrobiosidae) and -8.5% (*Pycnocentrodes*) for worst case (Figure 27). Changes in AWS for fish were generally low including for eels (up to -1.74% for 7-day MALF worst case for eels).

NIWA (2024) reports that to maintain suitable instream habitat within -5% for all biota groups, a post-mining 7-day MALF of 20.92 L/s would need to be maintained, and a post-mining flow of 17.37 L/s for to keep impacts on AWS within -10%. These predicted flows are greater than these potential AWS flows for the 7-day MALF in all cases.

Accordingly, any predicted flow changes resulting from the potential groundwater drawdown are unlikely to result in changes in habitat that will result in a change in the ecological natural state of the existing environment of Edmonds Stream.

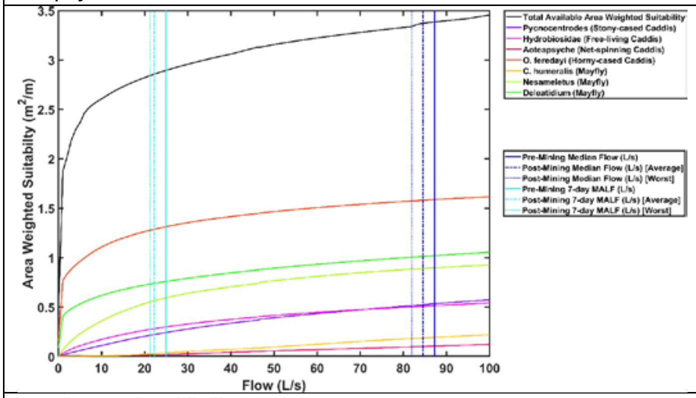
Figure 24: *Habitat characteristics of Edmonds Stream.*

Area Weighted Suitability (AWS)	Predicted percent change (%) in AWS for taxa groups



Periphyton

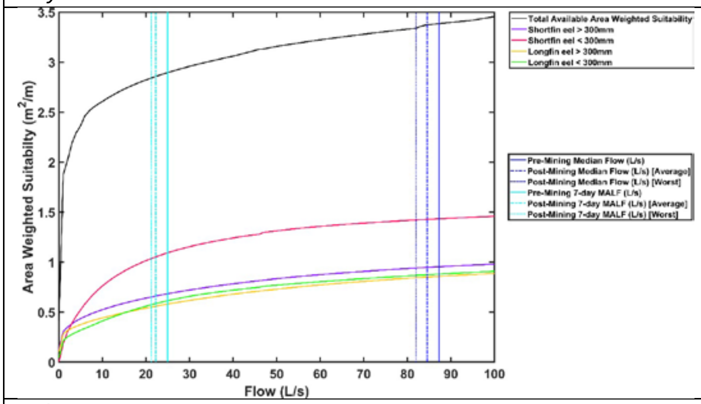
Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Diatoms	-0.97	-2.14	-7.84	-10.89



Mayflies and caddisflies

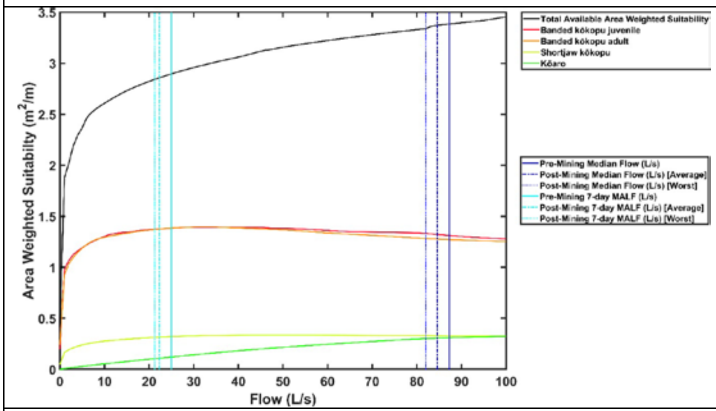
Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Pycnocentrodes	-1.7	-3.34	-8.5	-11.8
Orthocladiinae	-1.33	-2.53	-6.7	-9.33
Hydrobiosidae	-1.18	-2.32	-5.93	-8.34

Pycnocentrodes = stony cased caddisfly (grazer)
Hydrobiosidae = free living caddisfly (predators)
Orthocladiinae = chironomid midge (grazer)



Eels

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Longfin eel <300 mm	-0.77	-1.51	-1.74	-6.49
Longfin eel >300 mm	-0.79	-1.59	-3.7	-5.15
Shortfin eel <300 mm	-0.42	-0.83	-3.69	-5.21
Shortfin eel >300 mm	-0.67	-1.35	-3.32	-4.63



Native fish (excluding eels)

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Banded kōkopu juvenile	0.79	1.57	-0.58	-0.72
Banded kōkopu adult	0.41	0.85	-0.66	-0.97
Shortjaw kōkopu	0.20	0.40	-1.67	-2.36
Banded kōkopu juvenile	0.79	1.57	-0.58	-0.72

***Figure 28:** Area weighted suitability (AWS) for selected biota and percentage changes in AWS where at least 5% of available AWS is suitable at 7-day MALF in Edmonds Stream. Reproduced from NIWA 2024.*

7.4.3 Teawaotemutu Stream

7.4.3.1 Habitat description

The Teawaotemutu Stream tributary comprises an east and west branch before joining together prior to its confluence with the Wharekirauponga Stream. Teawaotemutu Stream is a hard-bottom, riffle/run/pool system. The system is typically a wide, flat channel with water across the full width, a relatively narrow floodplain that is confined by steep slopes.

Larger substrates (i.e., pebbles, cobbles, and boulders) dominated the substrate with gravels and sands and no notable fine deposited sediment observed. Water depths and widths remained relatively homogenous throughout the observed reach, with variety often provided by the presence of large boulders constricting flows. The dense riparian vegetation provides a range of functions, including shade provision, organic inputs, bank stability, and filtration.

The proportions of habitat recorded within the representative survey reach were: pools (31.5%), riffles (40.4%) and runs (28.1%) (NIWA 2024).

7.4.3.2 Critical instream flows

As outlined above, the predicted 7-day MALF for Teawaotemutu Stream is:

Teawaotemutu Stream - West

- Current: 31.65 L/s
- Basecase: 31.34 L/s (0.99% change from current)
- Worst case: 31.22 L/s (1.36% change from current)

Based on the instream habitat assessment, the 0.99% change of the basecase and the 1.36% change of the worst case changes very little from the background (current) state of the watercourse and may well be undetectable in Teawaotemutu Stream - West.

Teawaotemutu Stream - East

- Current: 32.04 L/s
- Basecase: 31.15 L/s (2.78% change from current)
- Worst case: 31.00 L/s (3.24% change from current)

Based on the instream habitat assessment, the 2.78% change of the basecase and the 3.24% change of the worst case represents a small change the background (current) state of the watercourse for Teawaotemutu Stream - East.

7.4.3.3 Critical wetted width

The predicted wetted width at the 7-day MALF for Teawaotemutu Stream is:

Teawaotemutu Stream - West

- Current: 2.4409 m
- Basecase: 2.4348 m (0.25% change from current)
- Worst case: 2.4325 m (0.34% change from current)

Teawaotemutu Stream - East

- Current: 2.4484 m
- Basecase: 2.4312 m (0.71% change from current)
- Worst case: 2.4282 m (0.82% change from current)

7.4.3.4 Instream habitat assessment

The outcome of the SEFA model for Teawaotemutu Stream are provided in Figure 29. Changes in AWS varied amongst the taxa groups, but in all cases were above, but closer to, any acute drop in habitat availability. For some taxa, notably some native fish, AWS improves at lower flows where the AWS show an increase in gradient (e.g., banded kokopu, Figure Tstream).

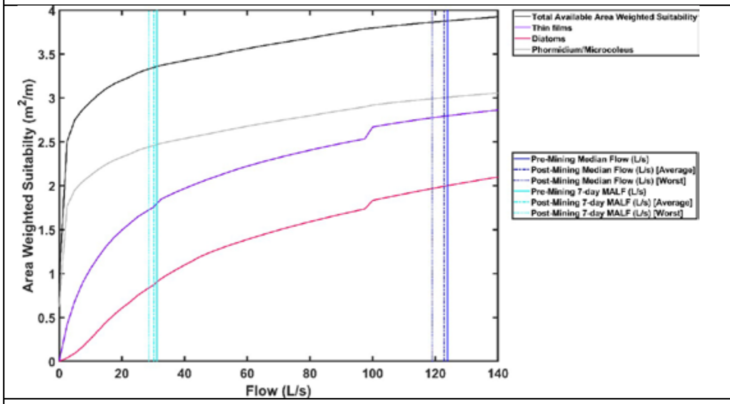
Changes in AWS for specific taxa at the predicted 7-day MALF relative to normal 7-day MALF varied from -0.02% (riffle beetles) to -2.16% (*Pycnocentrodes*) for basecase, and -0.2% (riffle beetles) and -3.36% (diatoms) for worst case (Figure Tstream). Changes in AWS for fish were generally low including for eels (up to -1.56% for 7-day MALF worst case for eels).

NIWA (2024) reports that to maintain suitable instream habitat within -5% for all biota groups, a post-mining 7-day MALF of 26.98 L/s would need to be maintained, and a post-mining flow of 23.17 L/s for to keep impacts on AWS within -10%. The predicted flows are greater than these potential AWS flows for the 7-day MALF in all cases.

Predicted changes in wetted width from normal low flow conditions across basecase and worst case 7-day MALF flow scenarios were extremely low varying from 0.25% to 0.82%. Such changes in low flows from those currently occurring would largely be undetectable.

Accordingly, any predicted flow changes resulting from the potential groundwater drawdown are unlikely to result in changes in habitat that will result in a change in the ecological natural state of the existing environment of Teawaotemutu Stream.

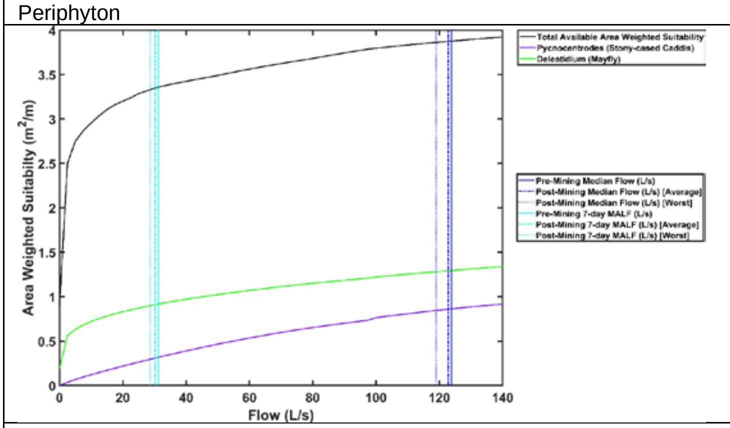
Area Weighted Suitability (AWS)	Predicted percent change (%) in AWS



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Thin films	-0.16	-0.81	-2.14	-4.10
Diatoms	-0.33	-1.62	-3.36	-7.42

Periphyton

Periphyton

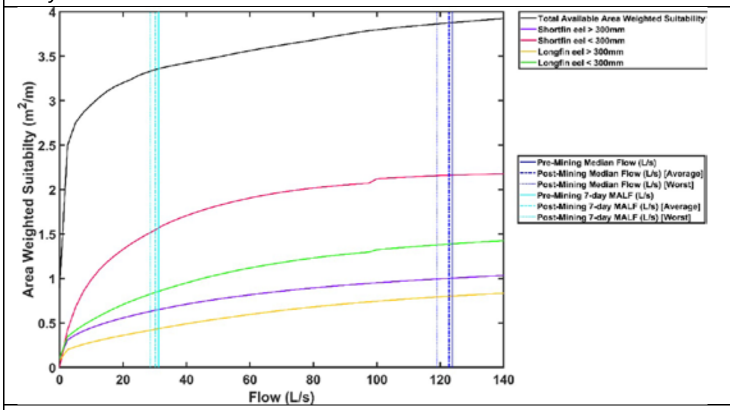


Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Pycnocentrodes	-0.45	-2.16	-2.91	-7.14
Deleatidium	-0.23	-1.10	-0.78	-2.00
Elmidae	0.01	0.02	-0.20	-0.59
Orthocladiinae	-0.42	-2.02	-3.04	-6.75
Potamopyrgus	-0.08	-0.40	-0.64	-1.58

Pycnocentrodes = stony cased caddisfly (grazer)
Deleatidium = mayfly (grazer)
Elmidae = riffle beetle (grazer)
Orthocladiinae = chironomid midge (grazer)
Potamopyrgus = snail (grazer)

Mayflies and caddisflies

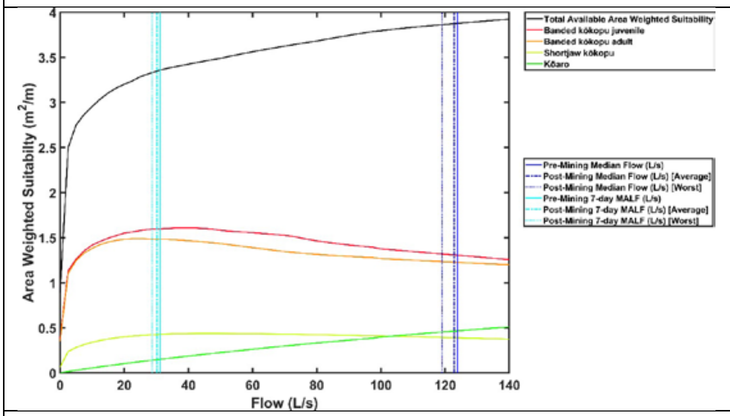
Invertebrates



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Shortfin eel >300 mm	-0.20	-0.98	-1.18	-3.05
Shortfin eel <300 mm	-0.06	-0.29	-1.39	-3.29
Longfin eel >300 mm	-0.27	-1.33	-1.56	-3.93
Longfin eel <300 mm	-0.18	-0.87	-1.43	-3.65

Eels

Eels



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Banded kōkopu juvenile	0.20	1.06	-0.11	-0.26
Banded kōkopu adult	0.14	0.68	-0.09	0.07
Shortjaw kōkopu	0.25	1.18	-0.49	-1.12

Native fish (excluding eels)

Native fish (excluding eels)

Figure 29: *Area weighted suitability (AWS) for selected biota and percentage changes in AWS where at least 5% of available AWS is suitable at 7-day MALF in Teawaotemutu Stream. Reproduced from NIWA 2024.*

7.4.4 Thompson Stream

7.4.4.1 Habitat description

Thompson Stream is considerably wider than the other observed tributaries below where it forks, including gravel/cobble beaches in places (Figure 30). Typically, the stream is a mix of shallow riffles and runs, with pools (predominantly <80 cm deep) largely limited to sections constrained by the gravel beaches. The substrate was reasonably compact, with effort required to dislodge cobbles and boulders. The wider valley had steep slopes, with the stream meandering through the narrow valley base, often with a floodplain only present on one side. The low-flow channel was incised more than 1 m in places.

The true left fork comprised most of the flows (approximately 70%) contributing to the main Thompson Stream stem and was typically a pool/riffle system with slow runs also common. The substrate was dominated by pebbles and cobbles, with gravels and fine sediment notable in deposition zones. The channel was incised in places with a square bed. Woody debris and leaf litter was common throughout the observed length.

The true right fork was narrower than the true left fork, with an increase in gravels, particularly in deposition zones. The stream resembled a pool/cascade system in response to the increased gradient relative to the true left fork.

The proportions of habitat recorded within the representative survey reach were: pools (27.4%), riffles (35.57%) and runs (37.03%) (NIWA 2024).

7.4.4.2 Predicted flows

As outlined above, the predicted flow at 7-day MALF for Thompsons Stream is as follows:

- Current: 19.51 L/s
- Basecase: 17.26 L/s (11.54% change from current)
- Worst case: 17.30 L/s (11.33% change from current)

Based on the flow assessment, the predicted 11.54% change of the basecase and the 11.33% worst case change from normal low flows are the highest of all the streams within the Wharekirauponga Stream catchment.

7.4.4.3 Predicted wetted width

As outlined above, the predicted wetted width 7-day MALF for Thompsons Stream is as follows:

- Current: 1.8025 m
- Basecase: 1.7467 m (3.10% change from current)
- Worst case: 1.7478 m (3.04% change from current)

7.4.4.4 Instream habitat assessment

The outcome of the SEFA model for Thompson are provided in Figure 31.

Changes in habitat suitability for specific taxa at the predicted 7-day MALF relative to normal 7-day MALF varied from -0.49% (riffle beetles) and 0.09% (long filamentous algae) to -4.92% (short filamentous algae) and -4.07% (*Pycnocentrodes*) for basecase. For worst case, changes in habitat suitability (AWS) at 7-day MALF ranged from -2.07% (long filamentous algae) and

-2.34% (riffle beetles) to -8.73% (short filamentous algae), -8.71% (Pycnocentrodes), -7.87% (diamtoms) and -7.12% (Orthoclad midges). Changes in AWS for fish were generally more pronounced in Thompson Stream including for eels (up to -6.75% for 7-day MALF worst case for longfin eels).

Unlike for other streams in the surveyed Wharekirauponga Stream catchments, the predicted changes in low flow at 7-day MALF did not mostly result in improved instream habitat for other native fish with habitat suitability varying from -0.31% for banded kokopu to -3.73% for redfin bullies. Only for juvenile banded kokopu did the predicted flow changes show a marginal improvement in instream habitat suitability (0.31%).

NIWA (2024) reports that to maintain suitable instream habitat within a -5% margin for all biota groups, a post-mining 7-day MALF of 16.6 L/s (-4.2% change from current) would need to be maintained, and a post-mining flow of 14.21 L/s (-5.66% change from current) to sustain AWS within -10%. These estimated sustaining flows are lower than predicted changes in flow for the 7-day MALF from predicted groundwater dewatering for all cases (being 17.26 and 17.30 L/s for basecase and worst case respectively). The predicted changes in wetted width of 3.04% and 3.10% are within acceptable margins of change to instream habitat.

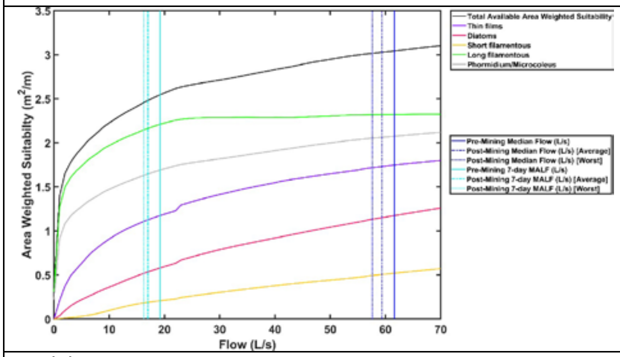
Accordingly, despite the greatest changes in predicted flow for Thompson Stream of all the modelled watercourses, changes in habitat resulting from the potential groundwater dewatering are unlikely to result in a measurable change in the ecological natural state of the existing environment of Thompson Stream.

We note that the predicted changes in AWS and instream habitat would be expected in Thompson Stream as it has a wider channel than the other tributary streams. This means that there is a greater extent (width) of stream base for the water to recede in a lower flow. Despite the potential of a reduced AWS, the remaining flowing water extent and channel may still be the equivalent of other streams (i.e., remains a substantial watercourse).

We emphasise that the Thompson Stream predicted flow scenario is the most questionable as we have highlighted above (section 6.2). The underlying geology of Thompsons Stream suggests that there is a disconnect between the shallow and deeper aquifers, such that dewatering is unlikely to occur. Further below we set out a monitoring programme that includes Thompson Stream noting a future review of the monitoring this catchment to ascertain whether there has been any actual changes in flows above natural.

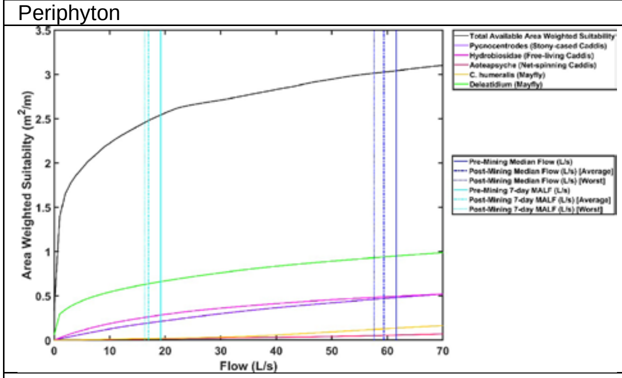
Figure 25: *Habitat characteristics of Thompson Stream.*

Area Weighted Suitability (AWS)	Predicted percent change (%) in AWS



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Thin films	-0.99	-1.73	-4.09	-5.61
Diatoms	-2.00	-3.52	-7.87	-10.55
Short filamentous	-2.74	-4.92	-8.73	-12.07
Long filamentous	-0.05	-0.09	-2.07	-2.87

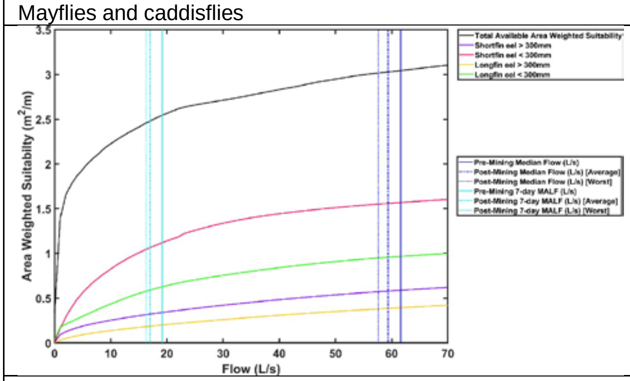
Periphyton | Periphyton



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Pycnocentrodes	-2.25	-4.07	-8.71	-11.66
Hydrobiosidae	-1.42	-2.59	-6.89	-9.32
Deleatidium	-1.10	-1.99	-3.63	-4.87
Elmidae	-0.28	-0.49	-2.34	-3.21
Orthocladiinae	-1.80	-3.21	-7.12	-9.60
Potamopyrgus	-0.55	-0.98	-3.12	-4.22

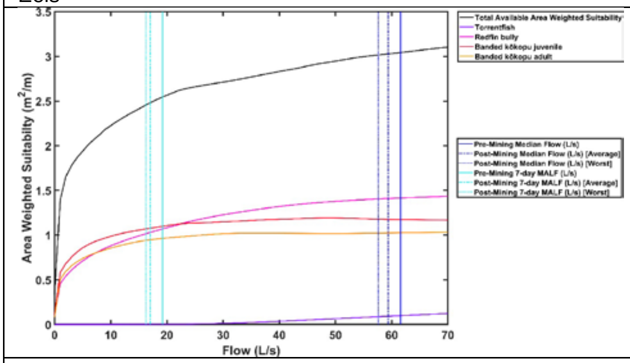
Pycnocentrodes = stony cased caddisfly (grazer)
Hydrobiosidae = free living caddisfly (predators)
Deleatidium = mayfly (grazer)
Orthocladiinae = chironomid midge (grazer)
Potamopyrgus = snail (grazer)

Mayflies and caddisflies | Macroinvertebrates



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Shortfin eel >300 mm	-1.52	-2.78	-5.53	-7.40
Shortfin eel <300 mm	-0.63	-1.15	-5.06	-6.85
Longfin eel >300 mm	-1.95	-3.55	-6.75	-9.03
Longfin eel <300 mm	-0.99	-1.83	-5.95	-8.08

Eels | Eels



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Redfin bully	-0.40	-0.75	-3.73	-4.98
Banded kōkopu juvenile	0.14	0.32	-2.08	-2.75
Banded kōkopu adult	-0.17	-0.31	-1.61	-2.24

Native fish (excluding eels) | Native fish (excluding eels)

Figure 31: *Area weighted suitability (AWS) for selected biota and percentage changes in AWS where at least 5% of available AWS is suitable at 7-day MALF in Thompson Stream. Reproduced from NIWA 2024.*

7.4.5 Tributary 'R'

7.4.5.1 Habitat description

Compared with the other observed tributaries Tributary R (Trib R) is a narrow and more incised hard-bottom system (Figure 32). The stream is deeply incised (typically ~1 m high vertical banks) within a wide, floodplain that comprised of younger and less diverse regenerating bush than the other sites. The understory was also not as developed as elsewhere. Boulders were notably less prevalent than the other tributaries, with large cobble accumulations creating a shallow-gradient pool/cascade system. Gravels were prominent, accounting for approximately 40-60% of the substrate, with fine deposited sediment patches along the edges. It appeared the fine sediment patches where in response to small-scale bank slumping. Medium and large woody debris were common, including influencing hydraulic complexity in many places. The catchment (between the Edmonds and Thompson) for this short tributary is small (<1 ha) and the length of stream (Ca. 600m) is also short.

Proportions of habitat were described by NIWA (2024) as: pools (29.03%), riffles (35.27%) and runs (35.7%).

Smaller tributaries feeding Trib-R are generally narrow, with sequences of run-pool-cascades and abundant woody debris. The channels vary between highly incised, to having no discernible banks, with the latter generally becoming more abundant towards the top of the catchment. The streambeds of the tributaries contain abundant cobble and gravels, but with a tendency to an increase in silt/sand and a more soft-bottom system towards the top of the catchment.

7.4.5.2 Instream habitat assessment

The outcome of the SEFA model for Trib-R are provided in Figure 33.

NIWA (2024) reports that to maintain suitable instream habitat within a -5% margin for all biota groups, a post-mining 7-day MALF of 1.24 L/s would need to be maintained, and a post-mining flow of 0.99 L/s to sustain AWS within -10%. Predictions of surface flow changes based on the groundwater dewatering were not carried out for Trib-R as no flow data was available for this watercourse.

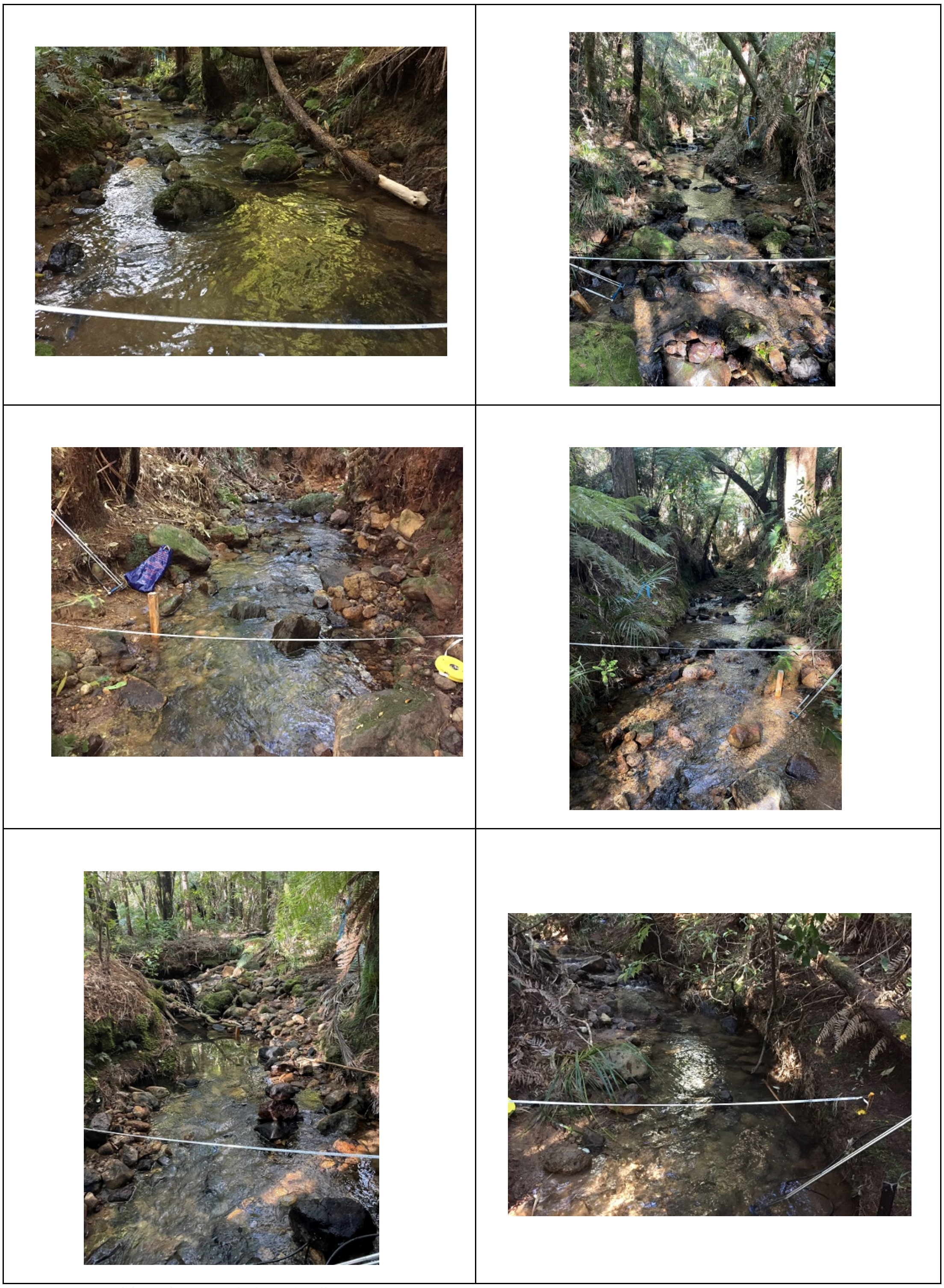
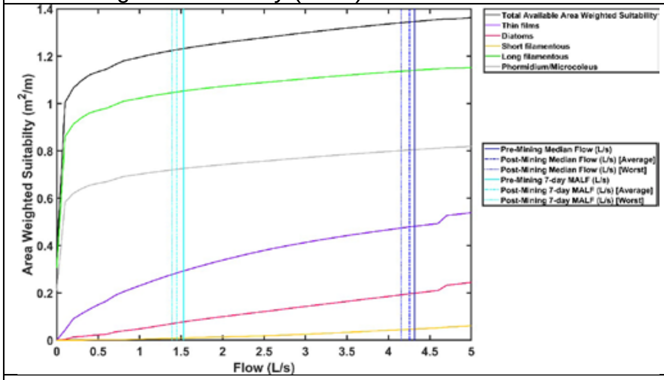


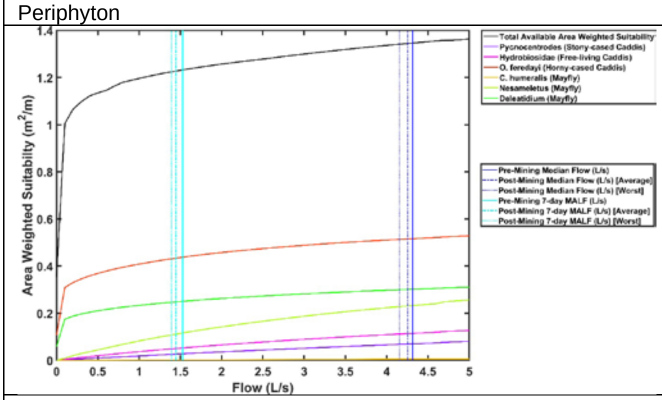
Figure 32: *Habitat characteristics of Trib. R.*

Area Weighted Suitability (AWS)	Predicted percent change (%) in AWS



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Thin films	-0.54	-1.49	-2.98	-5.07
Diatoms	-1.28	-3.49	-5.70	-9.72
Long filamentous	-0.12	-0.33	-0.38	-0.65

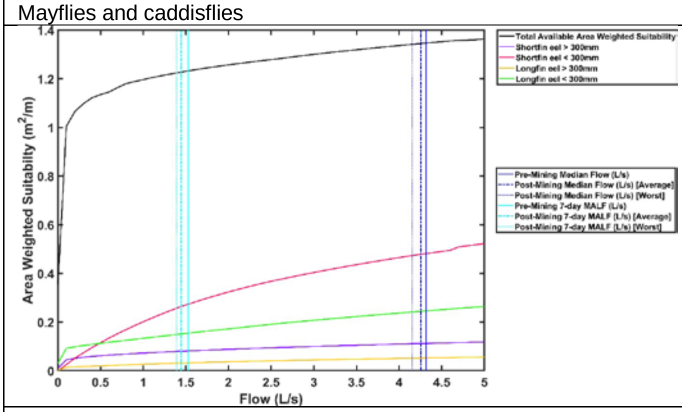
Periphyton	Periphyton



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
O. feredayi	-0.21	-0.57	-0.92	-1.57
Nesameletus (Mayfly)	-0.74	-2.04	-4.24	-7.17
Deleatidium (Mayfly)	-0.26	-0.71	-0.96	-1.63
Elmidae (Beetles)	-0.12	-0.32	-0.37	-0.63
Orthocladiinae (Midges)	-0.95	-2.59	-3.90	-6.61

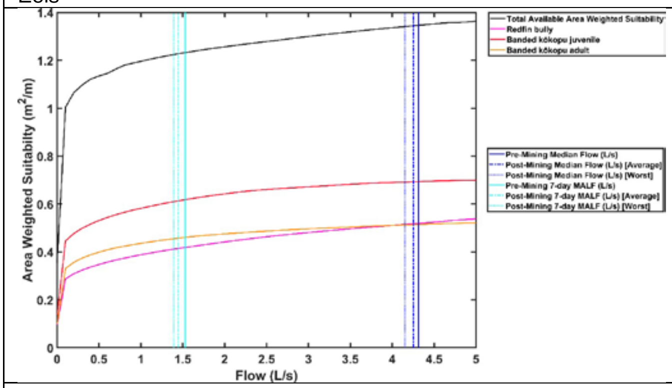
Olinga feredayi = caddisfly (grazer)
Nesameletus = swimming mayfly (grazer)
Deleatidium = mayfly (grazer)
Elmidae = riffle beetles (grazer)
Orthocladiinae = chironomid midge (grazer)

Mayflies and caddisflies	Macroinvertebrates



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Shortfin eel >300 mm	-0.46	-1.26	-1.51	-2.56
Shortfin eel <300 mm	-0.63	-1.73	-3.64	-6.21
Longfin eel >300 mm	-0.67	-1.83	-2.11	-3.56
Longfin eel <300 mm	-0.30	-0.83	-1.00	-1.70

Eels	Eels



Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Redfin bully	-0.11	-0.30	-0.79	-1.35
Banded kōkopu juvenile	-0.14	-0.38	-0.71	-1.23
Banded kōkopu adult	-0.46	-1.26	-1.51	-2.56

Native fish (excluding eels)	Native fish (excluding eels)

Figure 33: *Area weighted suitability (AWS) for selected biota and percentage changes in AWS where at least 5% of available AWS is suitable at 7-day MALF in Tributary-R. Reproduced from NIWA 2024.*

7.4.6 Wharekirauponga Stream (WKP02)

7.4.6.1 Habitat description

Wharekirauponga Stream is a hard-bottom, riffle/run/pool system. The system is typically a wide, flat channel with water across the full width, a variable floodplain that is confined by steep slopes. Larger substrates (i.e., large cobbles and boulders) dominated the substrate with gravels and sands but no extensive fine deposited sediment observed. Water depths and widths varied throughout the stream, with variety often provided by the presence of large boulders constricting flows. The dense riparian vegetation provides a range of functions, including shade provision, organic inputs, bank stability, and filtration. As the stream widens, the riparian vegetation becomes less effective at reducing shade across the full extent of the stream width.

Proportions of habitat were described by NIWA (2024) as: pools (21.77%), riffles (52.19%) and runs (26.04%).

7.4.6.2 Predicted instream flows

As outlined above, the predicted 7-day MALF for Wharekirauponga Stream at WKP02 is as follows:

- Current: 75.62 L/s
- Basecase: 71.52 L/s (5.42% change from current)
- Worst case: 70.66 L/s (6.56% change from current)

Based on the flow assessment, the predicted 5.42% change of the basecase and the predicted 6.56% worst case change from normal low flows are amongst the more moderate changes for all the streams surveyed within the Wharekirauponga Stream catchment.

7.4.6.3 Predicted wetted width

As outlined above, the predicted wetted width at 7-day MALF for Wharekirauponga Stream at WKP02 is as follows:

- Current: 3.8528 m
- Basecase: 3.8006 m (1.35% change from current)
- Worst case: 3.7894 m (1.64% change from current)

7.4.6.4 Instream habitat assessment

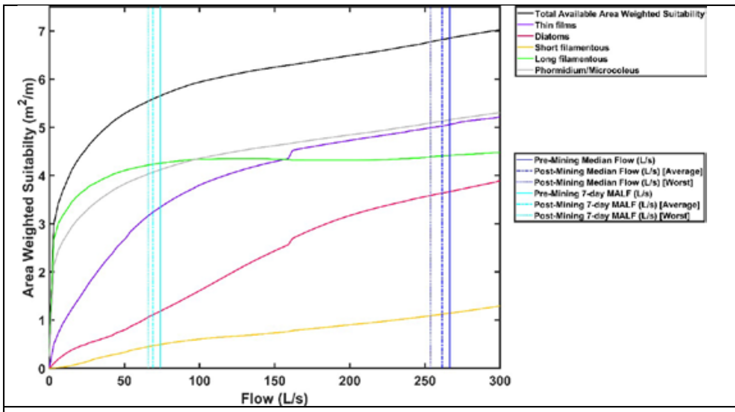
The outcome of the SEFA model for the Wharekirauponga Stream is provided in Figure 34.

Changes in habitat suitability for specific taxa at the predicted 7-day MALF relative to normal 7-day MALF varied from -0.68% (short filamentous algae) and 0.95% (riffle beetles) to -4.54% (short filamentous algae) and -2.85% (*Pycnocentrodes*) for basecase. For worst case, changes in habitat suitability (AWS) at 7-day MALF ranged from -0.52% (long filamentous algae) and -1.18% (riffle beetles) to -5.31% (short filamentous algae), -5.49% (*Pycnocentrodes*) and -6.37% (diatoms). Changes in AWS for fish were generally low including for eels (up to -2.89% for 7-day MALF worst case for eels). Notably for native fish, the habitat suitability improved at the basecase but decreased marginally from current for worst case (up to -1.57% AWS for banded kōkopu).

NIWA (2024) reports that to maintain suitable instream habitat within a -5% margin for all biota groups, a worst case 7-day MALF of 64.75 L/s would need to be maintained, and a post-mining flow of 56.30 L/s for to keep impacts within -10% of habitat suitability. These predicted flows are lower than the predicted changes in surface flow for the 7-day MALF for all cases (being 71.52 and 70.66 L/s for basecase and worst case respectively). The predicted changes in wetted width of 1.35 and 1.64% are within these acceptable margins of change to instream habitat and likely to be undetectable.

Accordingly, changes in habitat resulting from any changes in flow from potential groundwater drawdown are unlikely to result in a change in the ecological natural state of the existing environment of Wharekirauponga Stream at WKP02.

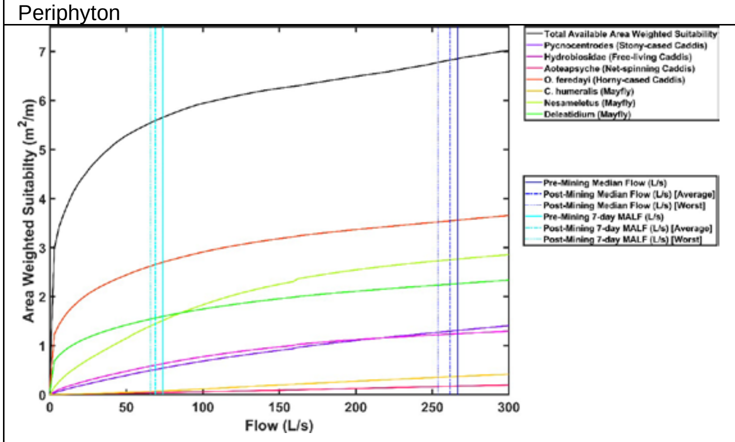
We note that the predicted changes in AWS and instream habitat would be expected in the Wharekirauponga Stream as it has a wide channel as the mainstem of the catchment. This means that there is a greater extent (width) of stream base for the water to recede in a lower flow. Despite the potential of a reduced AWS, the remaining flowing water extent would still be greater than that of the tributary streams.



Periphyton

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Thin films	-0.59	-1.37	-3.21	-5.41
Diatoms	-0.87	-2.19	-6.37	-10.28
Short filamentous	-1.77	-4.54	-5.31	-8.82
Long filamentous	-0.24	-0.68	-0.52	-0.93

Periphyton

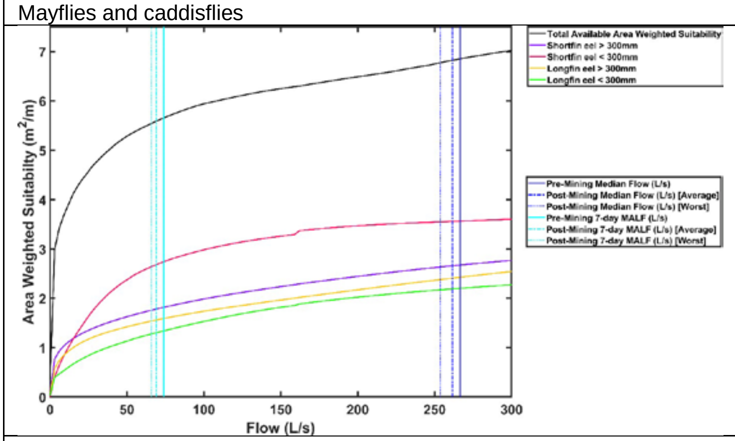


Mayflies and caddisflies

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Pycnocentrodes	-1.11	-2.85	-5.49	-8.94
Hydrobiosidae	-0.65	-1.67	-4.74	-7.77
Olimnga feredayi	-0.40	-1.03	-1.74	-2.88
Nesameletus	-0.51	-1.32	-4.54	-7.44
Deleatidium	-0.48	-1.25	-2.07	-3.40
Elmidae	-0.34	-0.95	-1.18	-1.99
Orthocladiinae	-1.12	-2.78	-4.33	-7.18
Potamopyrgus	-0.51	-1.33	-1.92	-3.22

Pycnocentrodes = stony cased caddisfly (grazer)
Olinga feredayi = caddisfly (grazer)
Hydrobiosidae = free living caddisfly (predators)
Nesameletus = swimming mayfly (grazer)
Deleatidium = mayfly (grazer)
Elmidae = riffle beetles (grazer)
Orthocladiinae = chironomid midge (grazer)
Potamopyrgus = snail (grazer)

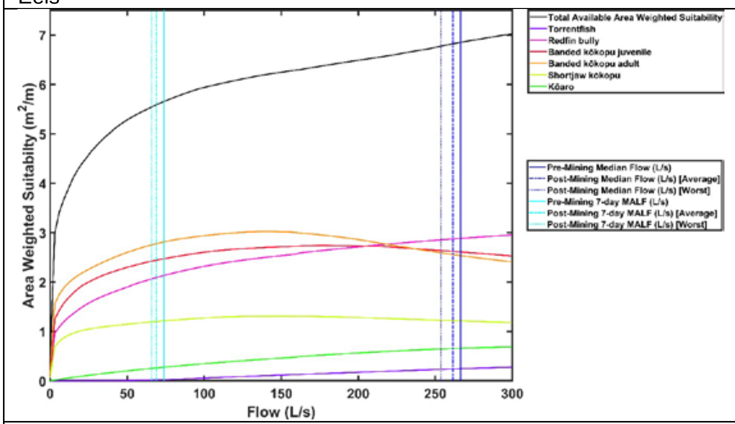
Macroinvertebrates



Eels

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Shortfin eel >300 mm	-0.56	-1.47	-1.99	-3.29
Shortfin eel <300 mm	-0.16	-0.40	-2.18	-3.66
Longfin eel >300 mm	-0.75	-1.93	-1.97	-3.26
Longfin eel <300 mm	-0.52	-1.36	-2.89	-4.74

Eels



Native fish (excluding eels)

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Redfin bully	-0.39	-1.02	-1.98	-3.29
Banded kōkopu juvenile	0.46	1.12	-1.15	-1.99
Banded kōkopu adult	0.84	2.21	-1.27	-2.14
Shortjaw kōkopu	0.42	1.09	-1.03	-1.70

Native fish (excluding eels)

Figure 34: *Area weighted suitability (AWS) for selected biota and percentage changes in AWS where at least 5% of available AWS is suitable at 7-day MALF in Wharekirauponga Stream (WKP02). Reproduced from NIWA 2024.*

7.4.7 Wharekirauponga Stream (WKP01)

7.4.7.1 Habitat description

Wharekirauponga Stream is a hard-bottom, riffle/run/pool system. The system is typically a wide, flat channel with water across the full width, a variable floodplain that is confined by steep slopes. Larger substrates (i.e., large cobbles and boulders) dominated the substrate with gravels and sands but no extensive fine deposited sediment observed. Water depths and widths varied throughout the stream, with variety often provided by the presence of large boulders constricting flows. The dense riparian vegetation provides a range of functions, including shade provision, organic inputs, bank stability, and filtration. As the stream widens, the riparian vegetation becomes less effective at reducing shade across the full extent of the stream width.

Proportions of habitat were described by NIWA (2024) as: pools (34.23%), riffles (33.51%) and runs (32.26%).

7.4.7.2 Predicted instream flows

As outlined above, the predicted 7-day MALF for Wharekirauponga Stream at WKP01 is as follows:

- Current: 120.86 L/s
- Basecase: 114.29 L/s (5.44% change from current)
- Worst case: 113.38 L/s (6.19% change from current)

Based on the flow assessment, the predicted 5.44% change of the basecase and the predicted 6.19% worst case change from normal low flows at 7-day MALF are amongst the more moderate changes for all the streams surveyed within the Wharekirauponga Stream catchment are similar to the predicted flow changes at WKP02.

7.4.7.3 Predicted wetted width

As outlined above, the predicted wetted width at 7-day MALF for Wharekirauponga Stream at WKP01 is as follows:

- Current: 4.9695 m
- Basecase: 4.9033 m (1.33% change from current)
- Worst case: 4.8939 m (1.52% change from current)

7.4.7.4 Instream habitat assessment.

The outcome of the SEFA model for the Wharekirauponga Stream (WKP01) is provided in Figure 35.

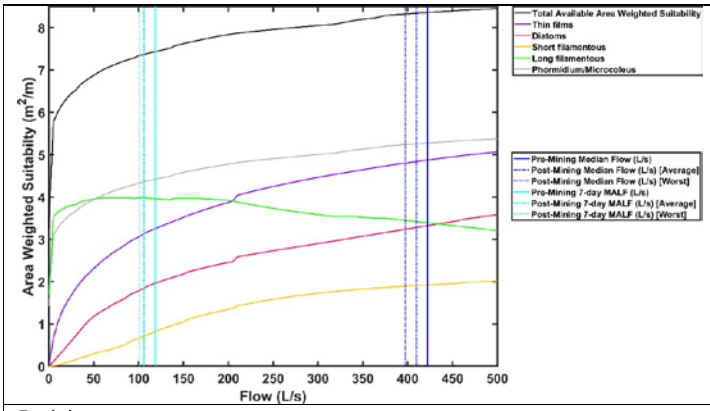
Changes in habitat suitability for specific taxa at the predicted 7-day MALF relative to normal 7-day MALF for benthic biota varied from -0.43% (Potamoprygus), -0.64% (Olinga), and 0.08% (riffle beetles) to –2.61% (diatoms), -2.48% (*Pycnocentrodes*) and -2.28% (orthoclad midges) for basecase. For worst case, changes in habitat suitability (AWS) at 7-day MALF ranged from +0.49% (long filamentous algae) and -0.53% (riffle beetles) to -13.13% (short filamentous algae), -8.07% (*Pycnocentrodes*), -6.61% (orthoclad midges) and -5.82% (diatoms).

Changes in AWS for fish were generally low including for eels (up to -3.58% for 7-day MALF worst case for eels). The largest predicted change was -8.30% for koaro in the worst case scenario, but the habitat changes were marginally positive for banded and shortjaw kōkopu (ranging from 0.37% to 0.96%).

Despite the variance in potential changes to habitat availability for benthic biota and fish, NIWA (2024) reports that to keep impacts on suitable instream habitat within a -5% margin for all biota groups, a post-mining 7-day MALF of 99.36 L/s would need to be sustained, and a post-mining flow of 83.11 L/s for to sustain AWS within -10%. These predicted flows are significantly lower than the predicted changes in flow for the 7-day MALF resulting from groundwater dewatering for all cases (being 114.29 and 113.38 L/s for basecase and worst case respectively). The predicted changes in wetted width of 1.33% and 1.64% are within these acceptable margins of change to instream habitat and would largely be undetectable.

Accordingly, changes in habitat resulting from any changes in flow from the potential groundwater drawdown are unlikely to result in a change in the ecological natural state of the existing environment of Wharekirauponga Stream at WKP01.

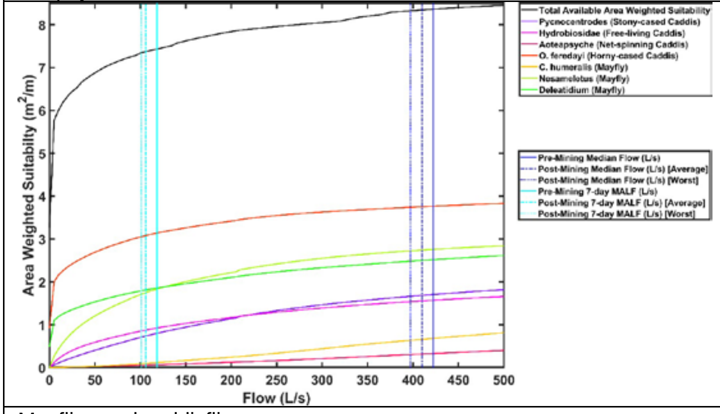
As for WKP02, we note that the predicted changes in AWS and instream habitat would be expected in the Wharekirauponga Stream as it has a wide channel as the mainstem of the catchment. This means that there is a greater extent (width) of stream base for the water to recede in a lower flow. Despite the potential of a reduced AWS, the remaining flowing water extent would still be greater than that of the tributary streams.



Periphyton

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Thin films	-0.73	-1.49	-3.76	-5.68
Diatoms	-1.30	-2.61	-5.82	-8.57
Short filamentous	-0.76	-1.57	-13.13	-18.12
Long filamentous	0.87	1.70	0.49	0.63

Periphyton

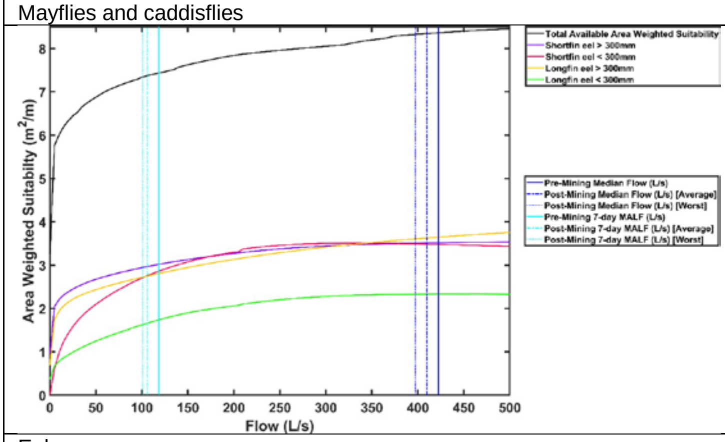


Mayflies and caddisflies

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Pycnocentrodes	-1.22	-2.48	-8.07	-11.52
Hydrobiosidae	-1.00	-2.04	-5.35	-7.80
O. feredayi	-0.32	-0.64	-1.93	-2.81
Nesameletus	-0.59	-1.22	-4.65	-6.87
Deleatidium	-0.68	-1.39	-2.48	-3.56
Elmidae	0.04	0.08	-0.53	-0.80
Orthocladiinae	-1.12	-2.28	-6.61	-9.63
Potamopyrgus	-0.21	-0.43	-1.62	-2.44

Pycnocentrodes = stony cased caddisfly (grazer)
Olinga feredayi = horny cased caddisfly (grazer)
Hydrobiosidae = free living caddisfly (predators)
Nesameletus = swimming mayfly (grazer)
Deleatidium = mayfly (grazer)
Elmidae = riffle beetles (grazer)
Orthocladiinae = chironomid midge (grazer)
Potamopyrgus = snail (grazer)

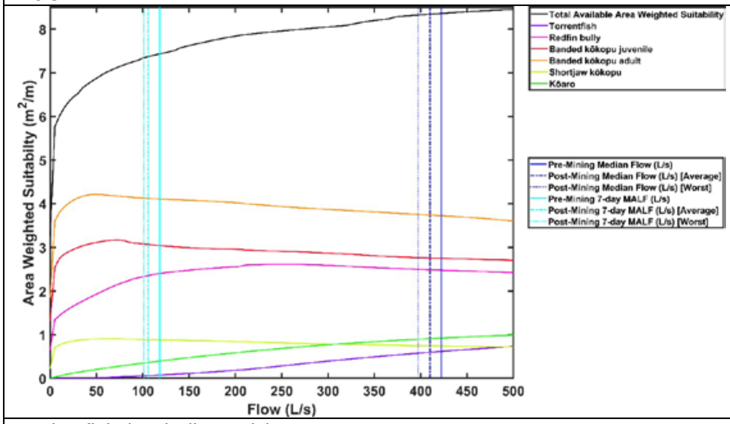
Macroinvertebrates



Eels

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Shortfin eel >300 mm	-0.12	-0.25	-1.69	-2.39
Shortfin eel <300 mm	0.19	0.37	-3.58	-5.27
Longfin eel >300 mm	-0.53	-1.08	-2.13	-3.01
Longfin eel <300 mm	-0.04	-0.11	-4.46	-6.35

Eels



Native fish (excluding eels)

Post-mining Median Flow Basecase	Post-mining Median Flow Worst case	Post-mining 7-Day MALF Basecase	Post-mining 7-Day MALF Worst case	Post-mining Median Flow Basecase
Redfin bully	0.38	0.80	-2.02	-2.98
Banded kōkopu juvenile	0.24	0.53	0.88	1.21
Banded kōkopu adult	0.40	0.78	0.37	0.52
Shortjaw kōkopu	0.47	0.96	0.70	0.96
Kōaro	-1.42	-2.90	-8.30	-11.73

Native fish (excluding eels)

Figure 35: *Area weighted suitability (AWS) for selected biota and percentage changes in AWS where at least 5% of available AWS is suitable at 7-day MALF in Wharekirauponga Stream (WKP01). Reproduced from NIWA 2024.*

8.0 Defining Natural State of Freshwater Ecosystems

8.1 Overview

Natural character (and perhaps natural state) is the term used to describe an area's distinct combination of natural characteristics and qualities. The degree or level of natural character within an environment depends on many factors but generally includes:

- The extent to which natural elements, patterns, and processes occur.
- The extent to which an area is unmodified.
- Those elements that are of natural origin (landform, vegetation, water bodies) rather than human origin (i.e., buildings, infrastructure).

These concepts are largely determined in a landscape context and for landscape assessments. Assessments of natural ecological character or state typically includes additional concepts that define such matters as biodiversity, ecological integrity and ecosystem function. Several authors have found that human perceptions of naturalness are not necessarily in agreement with ecological measures (Lamb & Purcell 1990; Wagner & Gobster 2007; Froude et al. 2012).

In this section we provide a brief overview of the concepts and matters that we have considered to inform our assessment of natural state and how predicted changes in river and stream flows effect natural ecological state and ecological values.

8.2 Key concepts in natural state for ecology

Selected key definitions and key ecological components of natural character and/or state are provided in Table 15.

Table 12: *Selected definitions of natural character (state) and related concepts.*

Source	Definition	Key attributes
RMA (1991) Schedule 3	**Class NS Water:** (being water managed in its natural state). The natural quality of the water shall not be altered.	Natural quality
Waikato Regional Plan (operative)	**Natural character:** The characteristics of wetlands and lakes and rivers and their margins which may be ecological, physical, spiritual, cultural or aesthetic in nature, whether modified or managed or not. **Natural and physical resources:** Includes land, water, air, soil, minerals and energy, all forms of plants and animals (whether native to New Zealand or introduced), and all structures. **Natural diversity:** The variety of biological or physical resources indigenous to a particular area (such as a country or a region within it).	
	Intrinsic values: In relation to ecosystems, those aspects of ecosystems and their constituent parts which have value in their own right, including: a) their biological and genetic diversity b) the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience.	Diversity Form (structure) Resilience/Adaptability
Environment Reporting Act (2015)	**Ecological integrity:** the full potential of indigenous biotic and abiotic features and natural processes, functioning in sustainable communities, habitats, and landscapes'.	Biodiversity (communities) Structure (biotic/abiotic) Functions (processes)
NPS-Indigenous Biodiversity	**Ecological integrity** means the extent to which an ecosystem can support and maintain its: a) composition (being its natural diversity of indigenous species, habitats, and communities); and b) structure (being its biotic and abiotic physical features); and c) functions (being its ecological and physical processes).	Composition (diversity) Structure (biotic/abiotic) Functions (processes)
Department of Conservation (DOC 2011)	**Ecological integrity:** The degree to which the physical, chemical and biological components (including composition, structure and process) of an ecosystem and their relationships are present, functioning and maintained close to a reference condition reflecting negligible of minimal anthropogenic impacts.	Nativeness Pristineness Diversity Resilience/Adaptability

8.3 Ecological integrity and natural state

8.3.1 Definition of EI in the context of natural state

Background

Several definitions of ecological integrity have been put forward over several decades. Amongst the earliest definitions, Karr & Dudley (1981) defined biological integrity as

> *.....the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms.*

Karr (1996) later amended this to:

> *'...the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organisation expected in the natural habitat of a region".*

In determining a biodiversity inventory and monitoring programme, Lee et al. (2005) suggested that the primary national outcome of conservation management at the highest level is to maintain ecological integrity. This was defined as:

> *.....the full potential of indigenous biotic and abiotic features, and natural processes, functioning in sustainable communities, habitats, and landscapes.*

Department of Conservation

We also draw on the reflections outlined in DOC (2011), where as part of a review of ecological integrity for freshwater environments, concluded that the following common themes commonly occurred through the definitions of ecological integrity:

- The preservation of ecological structure and function, and their maintenance over time.
- The recognition of a gradient of ecological integrity from high to low, such that natural or unimpacted ecosystems exhibit the highest integrity.

In relation to these observations, we reflect that ecological integrity can be defined as the preservation, to the greatest extent possible, of the condition that would be found if natural processes were allowed to predominate; an ecosystem has integrity when all of its components are maintained close to the natural condition. Therefore, for the purposes of our assessment we accept the definition outlined in DOC (2011):

> *The degree to which the physical, chemical and biological components (including composition, structure and process) of an ecosystem and their relationships are present, functioning and maintained close to a reference condition reflecting negligible of minimal anthropogenic impacts.*

We use the three key components of EI as defined in DOC (2011) in our assessment of natural state: composition, structure and process (function).

National Policy Statement for Indigenous Biodiversity

The National Policy Statement for Indigenous Biodiversity (NPS-IB) defines ecological integrity as:

> ***ecological integrity*** *means the extent to which an ecosystem is able to support and maintain its:*
>
> *a) composition (being its natural diversity of indigenous species, habitats, and communities); and*
>
> *b) structure (being its biotic and abiotic physical features); and*

c) *functions (being its ecological and physical processes).*

We use the three key components of ecological integrity as defined in the NPS-IB in our assessment of natural state: composition, structure and function.

Summary

We have drawn on the definitions above to inform our choice of metrics to assess natural state: composition, structure and function.

8.3.2 Composition (Biodiversity)

In our assessment of the effects of potential flow changes on the composition or biodiversity of a natural character, we have considered the following components:

- Size of populations (where known)
- Occupancy
- The extent and range of ecosystems and habitats
- Resilience and adaptability of ecosystems

We note that these components overlap with other elements of natural state and/or ecological integrity. Here we include nativeness as a component of composition and refer to the taxonomic makeup of the ecosystem. Typically, composition is considered as it exists in a natural or a comparable reference condition.

8.3.3 Structure

The structure of freshwater ecological natural state refers to the biotic and abiotic physical features of the ecosystem. DOC (2011) lists several indicators or metrics that measure the attributes of a natural ecosystem and includes (but not limited to):

- %EPT
- Macroinvertebrate metrics
- Expected fish and/or macroinvertebrates
- Similarity and/or evenness of the community composition
- Connectivity and buffering
- Properties of freshwater ecosystems and habitats

Typically, high nativeness equates to high ecological condition or integrity and reflects a high natural state. As with composition (biodiversity and nativeness), in many areas the structure of New Zealand's aquatic communities has been impacted by introduced species.

8.3.4 Function

In their definition of EI, DOC (2011) proposes that rivers should function in the same way as they do in unimpacted catchments. The functional components of a river ecosystem relate to rates, patterns and relative importance of different ecosystem processes. Typically, freshwater assessments have made assumptions that the presence of an appropriate assemblage automatically implies appropriate functioning (Biggs et al. 2000). However, the structural and functional components of river ecological integrity are not always directly related.

DOC (2011) suggests the following as measures of function (but not limited to):

- Metabolism
- Decomposition rates
- Retention rates
- Nutrient uptake
- Secondary function

8.4 Assessing natural state in freshwater ecosystems

We have drawn on the discussion above to confirm a suite of attributes to inform our assessment of natural state in the Wharekirauponga Stream catchment. We have selected those attributes where we have either available data and information and/or where we have knowledge of the catchment and freshwater ecosystems in general. We acknowledge that there are many attributes that could be considered but we have favoured a suite of metrics that collectively represent ecology natural state. We list the suggested attributes in Table 16 below.

Table 13: *Attributes for assessment of natural state in freshwater streams and rivers.*

Attribute	Explanation
Composition	The natural diversity of indigenous species, habitats, and communities
Population size	Size of population noting breeding success, gender balance, migration and emigration.
Population demographic	Population size structures i.e., is it an aging population with poor recruitment
Occupancy	Extent to which species and communities continue to reside in their natural habitats
Range and extent	The geographical area the species and/or community occurs
Connectivity (incl. pristineness)	The degree of connection between the various natural environments present within a landscape, in terms of their components, spatial distribution and ecological functions.
Resilience and adaptability	Ability of the aquatic community to withstand and adapt to change
Structure	The biotic and abiotic physical features
Biotic features	
%EPT	Proportion of EPT of the aquatic macroinvertebrate community
Nativeness	Extent to which the aquatic community is indigenous
Feeding guilds	Proportional representation of feeding groups in the aquatic macroinvertebrate community: scrapers, filter-feeders, and predators
Abiotic features	
Instream habitat	Proportion of instream habitats (pool/run/riffle)
Wetted perimeter	Extent flowing stream water reaches margins of stream bed
Stream temperature	Extent that stream temperature remains at natural ambient levels
Dissolved oxygen	Extent that dissolved oxygen remains at natural ambient levels
Settled sediment	Extent that sediment settles on the stream bed at natural sediment size, extent and distribution
Functions	The ecological and physical processes
Retention rates	Extent that organic material is retained within the waterbody and continues at natural rates of accumulation and loss.
Decomposition rates	Extent that decomposition of organic material continues at natural rates.
Assimilation	The ability to assimilate natural and introduced organic and inorganic materials
Contamination	The extent that contaminants (e.g., heavy metals) exceed natural background levels and are potentially harmful to aquatic biota
Ecological health	
Periphyton community	The relative proportion and abundance of periphyton types
MCI	Macroinvertebrate Community Index
Cumulative (long-term) effects	The incremental addition of permanent or intermittent events and/or physical modifications

9.0 Effects of Potential Flow Changes on Natural State of Aquatic Ecosystems

9.1 Approach

We have undertaken a two-step approach to assessing the effects of the predicted modification to flows on the ecological natural state of the Wharekirauponga Stream catchment. First, we consider the overall effects of a potential reduction in flows for each of the attributes selected (as per Table 17); and second, we assess each attribute for each potentially affected stream catchment.

The changes in flow being assessed are set out in section 6 of this report. In brief, the anticipated basecase magnitude of change of 7-day MALF predicted by the GHD surface water model for the streams modelled (as in Table 10) sit within a range of 0.99% to 11.54% across the model catchments for base and worst case. Lowest predicted basecase change occurs within the Teawaotemutu Stream-W (1.1%) and the greatest predicted basecase change within Edmonds Stream (9.16%) and Thompsons Streams (11.33%). However, sensitivity analysis suggests that the change in 7-day MALF could be up to as much as 10.61% in Edmonds Stream, and 11.54% in Thompsons Stream.

We emphasise here that whilst the predicted groundwater drawdown is consistent and will endure for the period of the proposed mining activity, the effects on surface water flows are not permanent. Unlike a water take or the truncation (e.g., damming or diversion) of a watercourse, the proposed activities do not result in permanent changes to natural flow regimes. Rather, surface flows will continue to be subject to, and highly influenced by the climatic conditions and rainfall events experienced locally and surface water levels will rise and fall accordingly with the prevailing and short and long-term weather patterns.

Our interest is in the periods of low flow when the surface water baseflows (including groundwater levels and inputs) are more critical for maintaining the aquatic systems. Accordingly, the predicted modified flow regimes (i.e., where low flows are expected to be marginally lower) may influence the ecology natural state. Also, the groundwater-surface water interaction is highly influenced by the antecedent weather conditions. For example, a long period of intensive rainfall events may mean that higher groundwater levels persist and the baseflows are comfortably maintained. On the other hand, a long period of little rain heading into a summer dry period may mean that the groundwater baseflows are not sufficiently available to support aquatic systems.

9.2 Effects of predicted modified low flow regime on ecology natural state

Our assessment of the effects of the predicted modified flow regimes on selected natural state attributes are provided in Table 17. In all cases, despite changes that may occur because of the predicted modified flow regime, changes in the ecological natural state attributes will not deviate significantly or to a detrimental effect from those that would occur at normal low flows.

Table 14: *Summary effects of predicted flow changes on selected ecological natural state attributes within the Wharekirauponga Stream catchment.*

Natural state attribute	Potential changes with modified flows
Composition - natural diversity of indigenous species, habitats, and communities	
Population size	Population size varies due to several factors including climatic events, immigration and emigration, breeding success, and grazing or predation pressures. Changes in the predicted flow regime may modify the proportions of preferred habitat for certain species and/or preferred part of life cycle. No populations are expected to disappear or become unviable because of the predicted flow changes, but population size may fluctuate. The results of the ecological values and instream habitat assessments show that the changes in predicted flow accommodate the species present in the watercourses.
Occupancy	The extent to which species or communities may reside in their preferred natural habitat will depend on the proportion and extent of the habitat. Occupancy of available habitats is not expected to alter and the predicted changes in wetted width are generally within acceptable margins of change to instream habitat for most species. The proportions of available habitat may differ with changes in the predicted flow regime.
Range and extent	The range and extent of species and communities within the catchment is not expected to change with predicted flow regime i.e., the species and communities are unlikely to go extinct and notwithstanding natural barriers, will continue to occur within their natural range within the Wharekirauponga Stream catchment.
Connectivity (incl. pristineness)	The connectivity of the watercourses is retained. The streams continue to flow along the same connected natural channels. No barriers are expected to surface because of changes in predicted flow regime.
Resilience and adaptability	The NZ aquatic biota has proven to be highly resilient and adaptive especially where natural conditions have prevailed. This is evident when the climatic and weather variability and extremes are considered. As the natural conditions are expected to continue, even if proportions of aquatic habitats vary with predicted flow regime, species and communities are expected to withstand and adapt to change.
Structure - biotic and abiotic physical features	
%EPT	The overall percentage abundance and composition of EPT is unlikely to change significantly with changes in predicted flow regime. Where proportions of habitat types change there may be modifications in the proportions of specific EPT taxa, and the proportional abundance amongst biotic communities may vary.
Nativeness	Predicted modified flow regimes are unlikely to form pathways or vectors for invasive species. Nativeness of the flora and fauna will remain intact.
Feeding guilds	The range and type of feeding guilds is unlikely to change significantly with changes in predicted flow regime (i.e., a specific type of feeding guild is unlikely to disappear). Where proportions of habitat types change there may be modifications in the proportions amongst the guilds, but representation of the guilds is likely to continue.
Instream habitat	As demonstrated by the instream habitat assessments, for the most part the predicted modified flow regimes are unlikely to result in significant modifications to instream habitat. This typically means that less benthic and overall aquatic habitat is available for colonisation and use. However, for the most part, the instream habitat assessment does not suggest that any significant modification or reduction in instream habitat is expected to occur with the predicted modified flow regimes beyond what would occur naturally at low flows; the average reduction of suitable instream habitat for the seven instream habitats and the three main taxonomic groups was -2.08%. Suitable instream habitat may increase with changes in lower flows.
Wetted perimeter	As demonstrated by the instream habitat assessments, the predicted modified flow regimes result in generally minor modifications to the wetted perimeter of waterways (average across the three main taxonomic groups is -2.08%). This typically means that less benthic and overall aquatic habitat is available for colonisation and use. However, for the most part, significant modification or reduction in wetted perimeter is not expected to occur with the

	predicted modified flow regimes beyond what would occur naturally at low flows and in most cases would be an undetectable change from normal conditions.
Stream temperature	All watercourses remain within shaded catchments with intact riparian vegetated margins. All headwaters remain intact. Predicted modified flow regimes are unlikely to result in significant increases in water temperature detrimental to aquatic life. Typical stressors that would potentially cause temperature levels to increase with lower flows (lack of shading, waste discharges, artificial channel linings) do not occur in the catchment.
Dissolved oxygen (DO)	All watercourses remain within shaded catchments with intact riparian vegetated margins. All headwaters remain intact. Predicted modified flow regimes are unlikely to result in significant decrease in DO to levels harmful to aquatic life. Typical stressors that would potentially cause DO levels to fall with lower flows (nutrient inputs, organic material, waste discharges) do not occur in the catchment. DO is inversely related to temperature and as indicated above, as temperatures are not expected to increase, so a temperature-related reduction in DO is unlikely to occur.
Settled sediment	All watercourses remain within shaded catchments with intact riparian vegetated margins and natural banks. All headwaters remain intact. Predicted modified flow regimes will not result in significant erosion or increase in sediments to watercourses. Although predicted modified flow regimes may result in the potential for finer grain sediments to settle (sediments drop out as flows decrease) the unlikelihood of increased erosion means that natural state is unlikely to change. Any increase in settled sediment is likely to be undetectable compared to that naturally occurring at low flows. As flows increase settled sediments get re-mobilised as part of a natural cycle within watercourses.
Functions - ecological and physical processes	
Retention rates	The rate of retention of organic material that grows or enters the stream may increase with the predicted modified flow regimes, as a greater proportion of slower flowing habitats and shallower water may occur. This may result in a greater opportunity for material to encounter snags in the watercourse and a greater retention may occur. This may also result in changes to the proportion of feeding guilds (e.g., increase in shredders) but within the range would occur naturally at lower flows. As flows increase trapped material gets re-mobilised as part of a natural cycle within watercourses.
Decomposition rates	The rate of decomposition of organic material that grows or enters the stream is not expected to vary with the predicted modified flow regimes, especially as temperature and DO levels are not expected to vary greatly. Significant changes in the activity of decomposers (i.e., bacteria) is not expected to occur with the predicted modified flow regimes beyond what would occur naturally at low flows.
Assimilation	Reduced stream flows can reduce the ability for waterbodies to assimilate materials in natural processes within the water body. Typical stressors that would potentially require significant assimilation (i.e., enhanced nutrient inputs, point and/or non-point discharges) do not occur in the Wharekirauponga Stream catchment. A reduction in natural assimilation in the Wharekirauponga Stream catchment is not expected to occur with the predicted modified flow regimes beyond what would occur naturally during low flow events.
Contamination	Reduced stream flows can concentrate contaminants in waterbodies and accentuate the potential chronic or acute effects. Typical stressors that would potentially cause significant contamination (i.e., enhanced nutrient inputs, industrial discharges) do not occur in the Wharekirauponga Stream catchment. Significant contamination risk is not expected to occur with the predicted modified flow regimes beyond what would occur naturally during low flow events.
Ecological health	
Periphyton community	Stream flows can have a significant influence on the periphyton communities both at higher and lower flows. Typical stressors that would potentially cause significant changes in extent, abundance or community composition of periphyton (i.e., lack of shading, enhanced nutrient inputs, waste discharges) do not occur in the Wharekirauponga Stream catchment. The instream habitat assessment has indicated that various periphyton types are susceptible to change resulting from potential changes in flow, especially in the wider streams where light penetration is more evident (e.g.,Thompsons Stream, Wharekirauponga Stream).

MCI	As proportions of macroinvertebrates may vary as proportions of habitat varies the MCI score may change. However, MCI values were mostly within the ‘excellent’ category and even if changes in the proportions of the generally high scoring macroinvertebrate taxa occur, the MCI values are likely to remain in the highest categories. Typical stressors that would normally cause significant changes in extent, abundance or community composition of macroinvertebrates (i.e., lack of shading, enhanced nutrient inputs, waste discharges, stream channel modification) do not occur in the Wharekirauponga Stream catchment. Accordingly, significant changes in MCI scores are not expected to occur with the predicted modified flow regimes beyond what would occur naturally during low flow events.
Cumulative (long-term) effects	
Cumulative effects	The NZ aquatic biota has proven to be highly resilient and adaptive especially where natural conditions have prevailed as evidenced by the patterns of climatic and weather in recent years. Less well understood is the effect of increased periodicity of modified low flows on aquatic ecosystems. The potential and predicted modified flow regime are not permanent but will occur over a number of consecutive years. Increased periodicity means a repeated pattern of stress of same or longer duration that is placed on the aquatic ecosystem (noting that normal and high flows will continue to occur as part of the natural climatic conditions). The nativeness, occupancy, range, extent and connectivity are key attributes that provide the ability for recovery and recolonisation pathways remain and will minimise and prevent cumulative effects from enduring within the Wharekirauponga Stream catchment. Similarly, the regular climatic patterns will provide periods of higher flows that will re-mobilise materials within the stream channel enabling fresh colonisation opportunities for the indigenous biota. The predicted modified flow regimes will not result in any specific invasive pathways for exotic species that might otherwise have taken advantage of the lower flows and/or potential greater periodicity of the lower flows.

9.3 Effect of predicted modified flow regime on Wharekirauponga Stream ecology natural state

Our assessment of the effects of the predicted modified flow regimes on selected natural state attributes for each of the model catchments are provided in Table 18. With the exception of Thompson and Edmonds Streams, the ecological natural state attributes are expected to remain largely unchanged from normal, and consequently the ecology natural state is retained. Accordingly, we consider that the effects are negligible or low.

For Thompsons and Edmonds Streams, although the predicted changes in low flows remain low, they are greater than those predicted for other streams within the Wharekirauponga Stream catchment. However, for most of the attributes we have used for assessing natural state, the effects of the predicted flow changes in Thompson Stream and Edmonds Stream remain negligible or low (as for the other streams).

Table 15: *Summary of effects of predicted 7-day MALF flow changes on selected attributes of ecological natural state for the Wharekirauponga Stream catchment. Neg = Negligible likelihood of change (ecology natural state is retained); Low = low likelihood of change (ecology natural state is retained); Mod = moderate likelihood of change (ecology natural state is modified but not impaired; High = High likelihood of change (ecology natural state is modified and likely impaired).*

	Adams Stream	Edmonds Stream	Teawaotemutu Stream	Thompson Stream	Trib-R	WKP02	WKP01
Composition - natural diversity of indigenous species, habitats, and communities							
Population size	Low	Low	Low	Low	Low	Low	Low
Occupancy	Low	Low	Low	Low	Low	Low	Low
Range and extent	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Connectivity (incl. pristineness)	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Resilience and adaptability	Low	Low	Low	Low	Low	Low	Low
Structure - biotic and abiotic physical features							
%EPT	Neg	Mod	Neg	Neg	Neg	Neg	Neg
Nativeness	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Feeding guilds	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Instream habitat	Low	Low	Low	Low	Low	Low	Low
Wetted perimeter	Low	Low	Low	Low	Low	Low	Low
Stream temperature	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Dissolved oxygen	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Settled sediment	Low	Low	Low	Low	Low	Low	Low
Functions - ecological and physical processes							
Retention rates	Low	Low	Low	Low	Low	Low	Low
Decomposition rates	Low	Low	Low	Low	Low	Low	Low
Assimilation	Neg	Low	Neg	Neg	Neg	Neg	Neg
Contamination	Neg	Low	Neg	Neg	Neg	Neg	Neg
Ecological health							
Periphyton	Neg	Mod	Neg	Neg	Neg	Neg	Neg
MCI	Neg	Mod	Neg	Neg	Neg	Neg	Neg
Cumulative (long-term) effects							
Cumulative effects	Neg	Neg	Neg	Neg	Neg	Neg	Neg

10.0 Natural State

10.1 Introduction

Our assessment contributes to an overall assessment of natural state which considers an understanding of the characteristics and qualities which exist and determining any degree of change from the existing level of natural state to the future level of natural state that may emerge from any changes that occur to stream flows in the Wharekirauponga catchment because of groundwater drawdown. Here we outline the attributes used in that assessment as provided in Table 19.

10.2 Natural state assessments

For our contribution to the overall assessment of natural state, here we summarise our assessment based on the natural state attributes listed in Table 19 and we provide our findings in Table 20. For the most part we find that the natural state attributes (water quality, nativeness and function) remain very high following predicted flow regime change. Despite the slightly greater predicted change in flows for the Thompson and Edmonds Streams, we consider that changes to the wetted area and instream habitat would not be significant or result in any significant or noticeable change in natural state of the watercourse. We conclude that there is no significant effect on the natural state of the waterbodies within the Wharekirauponga Stream catchment.

Table 16: *Attributes of natural state.*

Attributes of Natural State	Explanation
Water Quality	• Water quality and aquatic habitat quality; clarity, sedimentation, nutrient and bacterial levels etc. This should account for both the main channels of the river/the wetland body as well as lateral aquatic habitats if any (Including those outside of flood defences). Habitat changes due to fine sediment, draining, stock trampling or choking by exotic trees/ shrubs.
Exotic aquatic Flora and Fauna (absence)	• Presence of exotic aquatic flora and fauna within the river channel/wetland body or lateral habitats (including waterweeds, exotic fish, and invasive alga e.g., didymo) can reduce the natural state of the river/wetland. • This does not include vegetation on 'islands' within the river channel. This is contained under 'braidplain vegetation'. • Algal blooms may be evident in some rivers due to seasonal low flows. Expert ecological judgement will be required to assess extent and may have a bearing on the degree of naturalness of this primary attribute.
Aquatic Ecosystem Functioning (Indigenous taxa assemblages)	• The presence of species forming aquatic communities and the level that they are in terms of representing unmodified habitat potentials.
Terrestrial Ecology	• Vegetation – Indigenous/exotic vegetation, ecological value, quality habitat. Natural patterns and processes. • Fauna - including birds, lizards, pest animals.

Table 20: *Assessment of existing and likely modified natural state (ecological attributes) of mainstem and tributaries of Wharekirauponga Stream. Very High = Very High natural state; High = High natural state.*

Stream	Existing rating (ER) Modified rating (MR)	Water Quality	Exotic aquatic Flora and Fauna (absence)	Aquatic Ecosystem Functioning (Indigenous taxa assemblages)	Terrestrial
Adams Stream	ER MR	Very High Very High	Very High Very High	Very High Very High	Very High Very High
Edmonds Stream	ER MR	Very High Very High	Very High Very High	Very High Very High	Very High Very High
Teawaotemutu Stream	ER MR	Very High Very High	Very High Very High	Very High Very High	Very High Very High
Thompson Stream	ER MR	Very High Very High	Very High Very High	Very High Very High	Very High Very High
Trib R	ER MR	Very High Very High	Very High Very High	Very High Very High	Very High Very High
Wharekirauponga Stream (WKP02)	ER MR	Very High Very High	Very High Very High	Very High Very High	Very High Very High
Wharekirauponga Stream (WKP01)	ER MR	Very High Very High	Very High Very High	Very High Very High	Very High Very High

11.0 Effects of Potential Flow Changes on Ecological Values of Aquatic Ecosystems

11.1 Background

In this section we consider the effects of the predicted low flows on aquatic ecological values. For the most part the main attributes of aquatic ecological value are provided in section 12 above, and the effects of the predicted flow changes are covered in sections 10 to 11. We draw on those assessments to make a statement specifically on the effects of the predicted flow changes on ecological values.

11.2 Ecological values

The ecological values of all stream systems of the Wharekirauponga Stream are of very high ecological value. Periphyton and macroinvertebrate communities were abundant in taxa and indicative of good quality streams. Macroinvertebrate communities were also diverse in sensitive EPT taxa, with MCI and QMCI scores all reaching the excellent category. Fish communities supported several Threatened and At-Risk species with habitats also providing important migratory pathways.

11.3 Ecological significance

All habitats are classified as significant, providing habitat and migratory pathways to several Threatened and At Risk native fish species and sensitive macroinvertebrate taxa.

11.4 Effects of predicted flow changes on aquatic ecological values

As outlined above, the reductions in predicted flow at low flows (7-day MALF) result in small reductions to suitable instream habitat for most species. For the average-case (most likely scenario) changes in suitable instream habitat between the pre-mining 7-day MALF and the predicted post-mining 7-day MALF varied between taxonomic groups (i.e. periphyton, invertebrates, and fish), species/classes within taxonomic groups, and study sites (NIWA 2024).

The average reduction of suitable instream habitat for the seven instream habitats and the three main taxonomic groups was -2.08% (NIWA 2024). We note that for some species (e.g., banded kōkopu, shortjaw kōkopu), suitable instream habitat may increase with changes in lower flows.

The predicted changes in wetted width ranges from 0% to 5 % and are proportionally (in terms of percentage) smaller when compared to the percentage reduction in flows.

As emphasised in the discussion on natural state, we repeat that typical stressors (i.e., lack of shading, enhanced nutrient inputs, waste discharges, stream channel modification) that could result in significant changes to the aquatic ecological values in association with the predicted lower flows compared to normal flows do not occur in the Wharekirauponga Stream catchment. As a result, any reductions in flow do not exacerbate any stressors, and no direct, indirect or cumulative effects on ecological values arise.

Similarly, we re-emphasise that there is no loss of waterways, reclamation, piping or channelisation of any waterways, and the channel geomorphology, banks, floodplains and substrate of all watercourses will remain as they currently are.

The overall level of ecological effect of the predicted reduction in low flows on the freshwater ecological values is minimal, and accordingly no effects management is required or proposed.

12.0 Proposed Monitoring

12.1 Background

Despite our finding that effects on natural state and ecological values, we consider that there is benefit in continuing to monitor the ecological attributes of selected locations within Wharekirauponga Stream catchment.

12.2 Purpose

The purpose of continued monitoring of watercourses within the Wharekirauponga Stream is to confirm the outcomes of this assessment and that there are no effects on the natural state and ecological values.

The purpose is not necessarily to target the outcomes of specific low flow events on ecological state and ecological values; rather it is aimed at establishing whether any changes in ecological state of ecological values have occurred during the period of potential for modification to surface flows. However, we have recommended that all monitoring occurs during the critical summer period as set out below.

12.3 Approach

The potential for the reduction in surface water flows does not occur at a single point (such as at a piped discharge into a stream), thus our approach to monitoring focuses on a reach of watercourse. Nevertheless, we follow a BACI (Before-After-Control-Impact) approach, which involves an understanding of conditions prior to and after the proposed activities commence (time-based sampling); and conditions at a control (or reference) site and impact site(s) (location-based sampling).

As we have concluded above that the predicted reductions in flow will not result in any impacts on natural state or ecological values, to avoid any confusion, we refer to the term ‘outcome’ for that purpose (i.e., outcome sampling sites rather than impact sampling sites).

Similarly, as it is not possible to provide a true control site that replicates all stream conditions, we refer to a ‘reference’ site (i.e., reference sampling sites).

12.4 Monitoring sites

12.4.1 Outcome sites

Our approach to the selection of monitoring sites is to choose locations that represent either a higher predicted reduction in flow and/or AWS wetted area, as well as locations with different habitat conditions (i.e., dominance by riffle, runs or pools, or a combination of these).

We suggest the following sites for regular monitoring of outcomes:

- Wharekirauponga Stream at WKP02 – as a mainstem location, riffle dominated habitat.

- Edmonds Stream – higher predicted change in flow; riffle/run dominated habitat.
- Thompson Stream - higher predicted change in flow; riffle/run dominated habitat.
- Adams Stream – steep catchment, riffle dominated habitat.
- Teawaotemutu Stream – East – riffle/pool dominated habitat.

The habitat dominance is drawn from our and NIWA observations and is selected on the broadest sense of proportions of habitat present.

We note that permanent stream flow monitors are expected to be installed at each of these locations, and there will be groundwater level monitors nearby.

12.4.2 Reference sites

At the time of writing, we have not selected or visited any prospective reference sites. We recommend that suitable reference site(s) could be selected from the neighbouring Lignite or Wentworth Stream catchments. We recommend that permanent stream flow monitors also be established at any selected reference sites.

12.5 Frequency

We recommend monitoring the selected monitoring sites annually for at least six years following grant of consents. We note that some of the sites have already been sampled in 2019 and 2024.

The objective of the six years is to enable the establishment of a baseline state condition before WUG development reaches the Wharekirauponga catchment, then for a minimum of two years during which time the mine is developed, and some mining operations commence.

12.6 Timing

We recommend that sampling occurs during the critical summer period which we define here as 15 January to 15 March in any one year. The purpose of sampling during these dates is for monitoring to occur during the typically seasonal summer drier months and thus reflecting the likely low flow conditions at the time.

12.7 Sampling attributes

We recommend that data gathering for the monitoring includes the same attributes and protocols as already established and applied in the 2019 and 2024 baseline surveys. Accordingly, the sampling would include:

- Habitat description
- Water physiochemistry
- Periphyton
- Macroinvertebrates

- Fish

12.8 Review

At the completion of the two years of annual monitoring post commencement of mining operations of the WUG, we recommend that a review of the monitoring is undertaken, with the aim of assessing whether annual monitoring needs to continue, or less frequent sampling is warranted.

We note that there is merit in specific review of the monitoring data for Thompson Stream to confirm the underlying low permeability layer and the effect that has on predicted stream flows and ecological values.

13.0 Conclusions

In most calibrated models of flow change, when compared with current low flows, the predicted resultant changes in predicted low flows in the mainstem and tributaries of the Wharekirauponga Stream catchment is reduced by a very small and marginal amount. We consider that the marginal changes in flow are unlikely to challenge the existing 'natural state' and 'ecological values' of the streams of the Wharekirauponga Stream catchment and would be largely undetectable beyond normal (i.e., 'no-change') circumstances. We emphasise that the region is subject to extreme climatic and weather events that occur naturally and have an influence on natural ecosystems and ecology natural state.

We also emphasise that typical stressors that would normally cause significant changes in extent, abundance, or community composition of aquatic biota (i.e., lack of shading, enhanced nutrient inputs, waste discharges, stream channel modification), especially during low flows, do not occur in the Wharekirauponga Stream catchment.

Our consideration of the changes in flow based on the predicted flow metrics suggests that the streams are unlikely to fail to flow (i.e., go dry at least in the reaches surveyed), result in the loss of populations or communities of instream indigenous biota, or cause pathways for invasive species. Likewise, any flow changes from the predicted groundwater drawdown will not result in the loss, reclamation, diversion or channelisation of any watercourse.

Ecologically meaningful changes or reductions in stream morphology (wetted width) and habitat will be marginal during predicted lower flows in the streams. The effects on ecological values and the natural state and state of the natural stream morphology and habitat will be minimal relative to normal low flow conditions. At most the proportions of habitat may vary temporarily which may result in temporary changes in biological assemblages. Similarly, we do not consider that a scenario where a predicted prolonged reduction in low flow will result in loss of ecological values (communities or species) and effects on ecosystem function are likely to be minimal and largely undetectable compared to existing low flow circumstances.

Accordingly, we conclude that the ecology natural state of the mainstem and tributaries of the Wharekirauponga Stream catchment is retained following the potential for changes in surface water flow, and any effects on ecological values will be minimal.

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Appendix 1: Species used for instream habitat assessment (from NIWA 2024).

Note: Black font indicates species found in the stream and red font indicates species assumed to be found in unsampled streams (NIWA 2024).

Biota	Feeding Guild#	Adams	Edmonds	T-Stream East	Thompson	Trib-R	WKP1	WKP2
Periphyton								
Thin films		y	y	y	y	y	y	y
Diatoms		y	y	y	y	y	y	y
Short filamentous algae		y			y	y	y	y
Long filamentous algae		y			y	y	y	y
Phormidium/Microcoleus		y	y	y	y	y	y	y
Macroinvertebrates								
Pycnocentrodes (stony-cased caddis)	G	y	y	y	y	y	y	y
Hydrobiosidae (caddisfly)	P	y	y		y	y	y	y
Aoteapsyche (caddisfly	F		y		y		y	y
O. feredayi (caddisfly)	G		y			y	y	y
C. humeralis (mayfly)	F	y	y		y	y	y	y
Nesameletus (mayfly)	G		y			y	y	y
Deleatidium (mayfly)	G	y	y	y	y	y	y	y
Maoridiamesa (flies)	G	y	y		y	y	y	y
Elmidae (beetles)	G	y	y	y	y	y	y	y
Orthocladiinae (midges)	G	y	y	y	y	y	y	y
Potamopyrgus (snails) G	G	y	y	y	y		y	y
Zelandoperla (stonefly)	G	y	y	y	y	y	y	y
Food Producing Invertebrates		y	y	y	y	y	y	y
Fish								
Shortfin eel >300 mm		y	y	y	y	y	y	Y
Shortfin eel <300 mm		y	y	y	y	y	y	y
Longfin eel >300 mm		y	y	y	y	y	y	y
Longfin eel <300 mm		y	y	y	y	y	y	y
Torrentfish		y			y		y	y
Redfin bully		y			y	y	y	y
Banded kōkopu juvenile		y	y	y	y	y	y	y
Banded kōkopu adult		y	y	y	y	y	y	y
Shortjaw Kōkopu			y	y			y	y
Kōaro			y	y			y	y

#Feeding Guild. G = Grazers; P=Predators; F=Filter Feeders

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