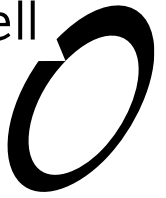


Boffa Miskell



# Shotover WWTP

Periphyton Risk Assessment  
Prepared for Queenstown Lakes District Council

28 May 2026





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Cover photograph: Periphyton and deposited sediment cover in the Kawarau River in March 2026, © Tim Currie, 2026

# Executive Summary

Boffa Miskell Limited was commissioned by Queenstown Lakes District Council to undertake a Periphyton Risk Assessment (PRA) to support a resource consent application for the discharge of treated wastewater from the Shotover Wastewater Treatment Plant to the Kawarau River. The proposed discharge will occur via a pipeline and outfall structure (or alternative pipeline configuration) located on the true left bank of the Kawarau River, immediately upstream of its confluence with the Shotover River, with consent sought for a duration of 35 years.

Although a PRA is not required under the Wastewater Environmental Performance Standards for this application, the assessment has been prepared to ensure that potential effects on periphyton are appropriately understood and managed. The PRA considers the receiving environment, baseline periphyton conditions, factors influencing periphyton growth, predicted changes arising from the discharge, and monitoring and mitigation requirements.

The Kawarau River is a large, lake fed river influenced by the oligotrophic waters of Lake Wakatipu, resulting in generally low nutrient concentrations and high-water quality. At the proposed discharge location, the river is characterised by moderate to high flows, coarse gravel substrates, and significant sediment inputs from the Shotover River. Baseline ecological surveys undertaken in March 2026 indicate that periphyton cover is generally low throughout the study reach. Most sites exhibited very low algal biomass, with greater than 75% of the streambed free of visible algae. While moderate localised growth of didymo and sludge mats was observed at some sites (likely reflecting local hydraulic conditions and historical nutrient inputs from the Dose and Drain system), overall periphyton levels were well below national and regional guideline thresholds and indicative of “excellent” ecological condition.

Periphyton growth in the Kawarau River is primarily controlled by physical factors rather than nutrient supply. The dominant limiting factors include:

- Frequent high flows and substrate mobility, which regularly remove periphyton through scouring.
- Elevated suspended sediment loads, which reduce light availability.
- Cool water temperatures, particularly during low flow periods.
- Generally low baseline nutrient concentrations.

These factors collectively prevent the sustained accumulation of nuisance algal biomass under existing conditions.

The proposed discharge will introduce treated wastewater at a maximum daily volume of 60,000 m<sup>3</sup> / day (with lower average volumes expected), and will be continuous, varying with demand.

Conservative modelling based on the 2060 peak dry-weather discharge rate under mean annual low-flow conditions indicates that initial dilution will occur

rapidly, with a 3- to 5-fold dilution near the outfall and approximately 50-fold dilution achieved by the end of the reasonable mixing zone (c.800 m downstream of discharge point).

The discharge plume will remain primarily along the true left margin of the river and occupy a relatively small proportion of channel width. Nutrient concentrations are predicted to increase locally, particularly within the near field mixing area (up to c.40 m from the discharge location) and, to a lesser extent, within the reasonable mixing zone. After reasonable mixing (as measured at monitoring site RS10) nutrient levels are predicted to remain higher than baseline levels, but they are within the same bands as the median levels at RS10 in 2025-2026, with the exception of dissolved reactive phosphorus with a predicted median of 0.021 mg / L, which falls into National Policy Statement for Freshwater Management Attribute Band D. However, after complete mixing (c.4km downstream of the discharge location), nutrient levels are expected to remain within relevant guideline thresholds and comparable to current conditions.

The assessment concludes that while increased nutrient concentrations resulting from the discharge may promote localised periphyton growth on stable substrates (particularly during extended low flow periods), the dominant physical controls in the Kawarau River will continue to limit algal biomass. Localised increases in periphyton growth are expected within the near-field mixing area; however:

- Growth is expected to remain below nuisance thresholds (<30% cover).
- Effects will be spatially limited and temporary (e.g., limited to larger substrate particles for short periods of stable flow and within the outfall structure).
- Periphyton biomass within and downstream of the reasonable mixing zone is highly unlikely to exceed thresholds associated with ecological degradation.
- It is highly unlikely that undesirable biological growths will occur as a result of the proposed discharge.

Overall, the PRA determines that the proposed discharge poses a low risk of excessive periphyton growth in the Kawarau River.

Existing proposed design upgrades and operational measures, including improved treatment processes (e.g. phosphorus removal, filtration, UV disinfection), optimised outfall configuration, and consent conditions, are expected to minimise potential effects. No additional mitigation is considered necessary given the low-risk classification. A comprehensive monitoring programme is recommended to confirm predicted outcomes and support adaptive management.

The Kawarau River's hydrological regime, mobile substrates, and sediment dynamics provide strong natural controls on periphyton growth. While the proposed discharge will increase nutrient concentrations locally, these increases are not expected to result in nuisance algal growth beyond a small, near field area. Consequently, the discharge is assessed as having a low overall risk to periphyton and associated river ecological health.

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# 1.0 Introduction

Boffa Miskell Limited has been engaged by Queenstown Lakes District Council (QLDC) to prepare a Periphyton Risk Assessment to support the resource consent application for the proposed discharge of treated wastewater from the Shotover Wastewater Treatment Plant (SWWTP) to the Kawarau River.

## 1.1 Activity being assessed

This consent application is for the discharge of treated wastewater from the SWWTP to the Kawarau River via a pipeline and rock outfall structure or alternatively a pipeline directly into the River. Wastewater treatment will include preliminary treatment via inlet screens and grit removal, secondary treatment via bioreactor tanks and secondary clarifiers, tertiary filtration and UV disinfection.

The treated wastewater will be discharged to the Kawarau River via an outfall structure or pipeline located on the true left bank of the Kawarau River immediately upstream of the confluence with the Shotover | Kimiākau River (Figure 1). Consent for the discharge of treated wastewater is sought for a duration of 35 years.

### 1.1.1 Proposed rock outfall structure

A conceptual design of the rock outfall structure has been developed to meet the following objectives:

- Dispersion of treated wastewater into the Kawarau River;
- A passive structure that blends in with the surrounding environment; and
- Minimised exposure of the public to treated wastewater prior to adequate mixing in the river.

A recent river bathymetry survey during low-flow conditions (Earth Sciences New Zealand, 2026) has indicated that optimum dispersion into the river is achieved with an outfall that extends approximately 10 metres into the wetted riverbed. Large rocks, layering of rocks, and the geometry of the rock channel have been selected to provide resilience during high-flow and flood events, while remaining compatible with the dynamic river delta environment, and to limit public exposure to treated wastewater prior to adequate mixing in the river.

Preliminary design discussions have highlighted the potential for an alternative outfall design to be investigated and developed. While the details of this design are yet to be determined, it is understood that the outfall may instead consist of an extension of the discharge pipeline into or onto the wetted bed of the Kawarau River, to a point where flows in the river would promote optimum treated wastewater mixing. It is not yet known whether the outfall pipe would be buried for any of its length within the wetted bed, nor what diffuser infrastructure would be utilised, if any.

This risk assessment has focussed on the proposed rock outfall design; however, if the outfall design were to change to the alternative pipeline design above, it is not expected to increase the periphyton risk.

## 1.2 Purpose and scope of the assessment

The Wastewater Environmental Performance Standards (WEPS), which came into effect in part on 19 December 2025, establish new national minimum environmental thresholds and requirements for discharges of wastewater to land and water. Regulation 68 requires a periphyton risk assessment (PRA) to be included with an application for a resource consent to discharge wastewater from a treatment plant into water.

We understand that the long-term consent application for the discharge to the Kawarau River falls into the exceptions under the WEPS, and therefore a PRA is not required<sup>1</sup>. While a PRA is not required to be included with the consent application, it has been agreed to undertake and provide a PRA to ensure periphyton risk is appropriately considered and managed. However, it has been agreed that it is not necessary to undertake the independent review, which would have been required under Regulation 68(3) if the WEPS applied to the application.

The scope of this PRA is in accordance with requirements of the WEPS (see below) and includes the following:

- Description of the receiving environment
- Description of the baseline periphyton condition
- Factors influencing periphyton growth in the Kawarau River
- Description of the discharge
- Assessment of periphyton risk
- Mitigation and monitoring recommendations.

## 1.3 Statutory, planning and guideline context

### 1.3.1 WEPS mandatory considerations

Regulation 69 of the WEPS sets out the mandatory considerations that the PRA should cover, and Regulation 70 requires the determination of an overall periphyton risk category. Further guidance on the mandatory considerations is provided in the Discharge to water implementation materials (Water Services Authority Taumata Arowai, n.d.).

Under Regulation 69, when completing a periphyton risk assessment, a suitably qualified and experienced person or consent authority must take into account the following considerations set out in Table 1 below.

---

<sup>1</sup> GHD Technical Memorandum, dated 04 February 2026. Subject: Impact of the new Wastewater Environmental Performance Standards.

Table 1: Periphyton Risk Assessment Mandatory Considerations

Consideration	Refer to report section
(1) (a) the effects of shade or shadow on the river	4.2
(1) (b) when the wastewater will be discharged into the river, including the time of day, the season, and the duration of the discharge	5.2
(1) (c) the effects of the water in the river being naturally flushed	4.1
(1) (d) the dilution ratio class at the point of discharge, determined under <a href="#">regulation 47</a>	5.1
(1) (e) how the following factors contribute to, or inhibit, the establishment or growth of periphyton in the river: (i) the climate: (ii) the source of the water in the river: (iii) the physical and chemical characteristics of the riverbed: (iv) any action that would, if it were imposed as a condition of the resource consent, avoid, remedy, or mitigate the risk or extent of periphyton growth or the effects of the periphyton on the environment (see subclause (2) for examples).	2.3.1 and 4.4 2.3.2, 4.1 and 4.3 2.3.3, 2.4, 2.5, 4.1, 4.2 and 4.3 5.7
(2) Examples of actions that could be imposed as a condition under subclause (1)(e)(iv) include the following: (a) planting vegetation beside the river to increase shade or shadow: (b) altering the flow or volume of the discharge: (c) improving the habitat in the river for organisms that feed on periphyton.	5.7
(3) The person or consent authority must ensure that they take the considerations into account before— (a) first, determining the overall risk of excess periphyton establishment and growth; and (b) second, based on that overall risk, determining the overall periphyton risk category under <a href="#">regulation 70</a> .	6.0

### 1.3.2 WEPS Periphyton risk categories

Under Regulation 70, the person or consent authority preparing the periphyton risk assessment must determine the overall periphyton risk category from the following:

- (a) low risk
- (b) medium risk
- (c) high risk
- (d) very high risk.

### 1.3.3 National Policy Statement for Freshwater Management

Policy 5 of the National Policy Statement for Freshwater Management (NPS-FM) requires freshwater to be managed through a National Objectives Framework (NOF) to ensure that the health and wellbeing of degraded water bodies and freshwater ecosystems is improved. The NOF has attributes for various values for rivers and lakes, which sets out bands of desired states to be achieved, including a national bottom line (band D). Periphyton trophic state is one of the compulsory attributes for ecosystem health for rivers, which uses Chlorophyll-a as a measure of periphyton biomass. The default class applies to the Kawarau River, which must not be exceeded in more than 8% of samples. The bands are set out in Table 2 below.

Action is also required to achieve target attribute states for dissolved reactive phosphorus (DRP) enrichment (Table 3), which relates to algal and plant growth, whereas the attribute bands for ammoniacal nitrogen and nitrate nitrogen relate to toxicity effects for freshwater fauna, so are not considered in this risk assessment.

Table 2: NPS-FM Attribute bands for Chlorophyll a

Attribute band and description	Chlorophyll-a (mg / m <sup>2</sup> )
<b>A</b> Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.	≤50
<b>B</b> Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat.	>50 and ≤120
<b>C</b> Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or moderate alteration of the natural flow regime or habitat.	>120 and ≤200
<b>National bottom line</b>	<b>200</b>
<b>D</b> Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat.	> 200

Table 3: NPS-FM Attribute bands for Dissolved Reactive Phosphorus

Attribute band and description	Median DRP (mg / l)	95 <sup>th</sup> percentile DRP (mg / l)
<p style="text-align: center;"><b>A</b></p> <p>Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to dissolved reactive phosphorus (DRP) enrichment are expected.</p>	≤0.006	≤0.021
<p style="text-align: center;"><b>B</b></p> <p>Ecological communities are slightly impacted by minor DRP elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.</p>	>0.006 and ≤0.010	>0.021 and ≤0.030
<p style="text-align: center;"><b>C</b></p> <p>Ecological communities are impacted by moderate DRP elevation above natural reference conditions. If other conditions also favour eutrophication, DRP enrichment may cause increased algal and plant growth, loss of sensitive macro-invertebrate and fish taxa, and high rates of respiration and decay.</p>	>0.010 and ≤0.018	>0.030 and ≤0.054
<p style="text-align: center;"><b>D</b></p> <p>Ecological communities impacted by substantial DRP elevation above natural reference conditions. In combination with other conditions favouring eutrophication, DRP enrichment drives excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia are lost.</p>	> 0.018	> 0.054

Snelder and Kilroy (2023, sourced from Snelder and Fraser, 2023) developed total nitrogen and total phosphorus criteria for Otago rivers to achieve the NPS-FM Target Attribute States for Periphyton. These criteria have been considered when comparing current nutrient levels in the Kawarau River to predicted nutrient levels as a result of the discharge. However, we note that these Target Attribute States are used to set thresholds for achieving desired states at a river catchment scale (not reach scale), they are not guideline values and have no statutory weight.

The WEPS periphyton risk categories above do not directly correspond to the NOF attribute bands A – D for periphyton in the NPS-FM. The WEPS risk categories do not set numeric thresholds for periphyton, and the determination of the overall risk category is predictive, effects based and assessed at the site-scale, based on available data, modelling and expert judgement. Conversely, the NOF periphyton bands set numeric values for periphyton biomass (chlorophyll a), which define desired states for a river.

However, we would expect that a low overall periphyton risk for the discharge would correspond to the downstream reach likely having a periphyton biomass that remains in NOF band A (chlorophyll-a <50 mg / m<sup>2</sup>) over time, while a very high overall risk will likely mean that the downstream reach will have periphyton biomass below the national bottom line (band D, chlorophyll a >200 mg / m<sup>2</sup>).

### 1.3.4 National periphyton guidelines

In addition to the NPS-FM attribute bands covered above for chlorophyll a (periphyton biomass), the national guidelines developed by Matheson et al. (2012) are used to interpret periphyton cover. These guidelines apply a weighted composite cover (WCC), calculated as  $\% \text{ filamentous cover} + (\% \text{ mat cover} \div 2)^2$ , with an aesthetic nuisance threshold of  $\geq 30\%$ . Provisional general thresholds of  $< 20\%$ ,  $20\text{--}39\%$ ,  $40\text{--}55\%$ , and  $> 55\%$  WCC are recommended as indicators of 'excellent', 'good', 'fair', and 'poor' ecological condition, respectively, at sites where other stressors are minimal.

### 1.3.5 Regional Plan provisions and periphyton objectives/limits

Schedule 15 of the Regional Plan: Water for Otago (RPWfO) (Otago Regional Council, 2021; updated 2025) sets out regional limits and target values for rivers and lakes, including the Kawarau River (Receiving Water Group 2). These limits cover parameters including nitrate-nitrite nitrogen, dissolved reactive phosphorus (DRP), ammoniacal-N, and turbidity, and are designed to protect ecological health, contact recreation, and human-health values. The schedule also includes six characteristics of good water quality, one of which is algae, which states that:

*"Filamentous algae in rivers should cover less than 30% of the river bed. Floating algae occurring in lakes and rivers should not reduce water clarity. Algal growth in rivers or lakes should not cause slime on the surface of the water."*

Therefore, if results meet the above national WCC periphyton guideline they will also meet the algae characteristic in Schedule 15.

### 1.3.6 Water Conservation Order

The Water Conservation (Kawarau) Order 1997 provides the highest level of statutory protection for the Kawarau River system, including the Shotover River. The Order requires, in respect of the Kawarau<sup>3</sup> and Shotover<sup>4</sup> Rivers, that specified outstanding amenity and intrinsic values and characteristics are protected, and it constrains regional planning and resource consenting decisions accordingly.

For the relevant reach of the Kawarau River, the Order requires that water quality is managed to a Class CR (Contact Recreation) standard as defined in Schedule 3 of the RMA 1991. Schedule 3 states that the water quality classes apply after reasonable mixing and provides the following description for "*Class CR Water (being water managed for contact recreation purposes)*"

1. The visual clarity of the water shall not be so low as to be unsuitable for bathing.
2. The water shall not be rendered unsuitable for bathing by the presence of contaminants.
3. There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water.

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<sup>2</sup> Sludge is not included in this calculation, as it is a separate periphyton category, and didymo is also excluded from the WCC calculation because it does not respond to some environmental variables in the same manner as other common New Zealand periphyton species (Matheson et al., 2012).

<sup>3</sup> Kawarau River mainstem from Scrubby Stream to Lake Wakatipu control gates (S133:940715 to S132:615707)

<sup>4</sup> Shotover River mainstem (at or about S132:645720 to S114:542262)

Undesirable biological growths include excessive cyanobacteria growths, which can be potentially toxic, nuisance algal mats and filamentous algal growths, bacterial and fungal slimes (heterotrophic growths) and aquatic weeds.

The 30% threshold of the WCC periphyton guideline and Schedule 15 of the RPWfO have been used in this assessment as the threshold for periphyton that is forming an undesirable biological growth. Cyanobacteria and heterotrophic growths have also been considered.

## 1.4 Data used for risk assessment

### 1.4.1 Ecological information

Field data was collected on 10 and 11 March 2026 during a period of reasonably stable low flow conditions at five sites on the Kawarau River (Figure 1). The proposed discharge location aligns with Site RS11 directly upstream of the confluence with the Shotover River. RS12, RS13 and RS14 are upstream of the proposed discharge location and RS10 is downstream of the confluence with the Shotover and the proposed discharge location.

The following was monitored at each site:

- Visual assessment of periphyton percentage cover using the National Environmental Monitoring Standard for Periphyton (NEMS-p), which included recording the substrate composition (Ministry for the Environment, 2022b)
- Visual assessment of deposited sediment percentage cover using Clapcott et al. (2011)
- Macroinvertebrate sampling using the methods outlined in NEMS for Macroinvertebrates (NEMS-m) (Ministry for the Environment, 2022a).
- Assessment of water flow and depth within sampling area, shade, riparian vegetation and rapid habitat assessment (Clapcott, 2015).

Refer to the Ecological Impact Assessment report (Boffa Miskell Limited 2026) for more details on monitoring methods used and results of the ecological sampling.

Field sampling was limited to wadeable sections on the true left bank of the Kawarau River, which is the area of the River most likely to be affected by the discharge (refer to section **Error! Reference source not found.** below).

The periphyton data collected in March 2026 are the only periphyton cover data available for the Kawarau River and there is no chlorophyll-a data available. An eDNA sample collected by LandPro in August 2024 at the proposed discharge location (RS11) on the Kawarau River provides some information on potential periphyton taxa present. However, caution is required as the eDNA captured in the sample will include organisms present further upstream of the location, including Lake Wakatipu. We have also used the predicted chlorophyll-a and WCC for the proposed discharge location (RS11) and downstream at RS10 that was estimated for all New Zealand rivers from measured periphyton data using a national-scale model and stream reach River Environment Classification (REC) data (Kilroy et al., 2019).

### 1.4.1 Flow and channel morphology

There is no long-term flow data for the Kawarau River at or near the proposed discharge location. Data from the nearest flow monitoring site on the Kawarau River at Chard Rd (c.8.5 km

downstream of the discharge location) has been used to inform flow variation and magnitude. We have supplemented this with predicted flow data for the discharge location and receiving environment that was estimated for all New Zealand rivers using a national-scale model based on 1980-2009 flow data and the REC (Booker, 2013).

We have also relied on the findings of a bathymetry survey undertaken by Earth Sciences New Zealand in March 2026 across five transects of the Kowarau River near the proposed discharge location (Earth Sciences New Zealand, 2026).

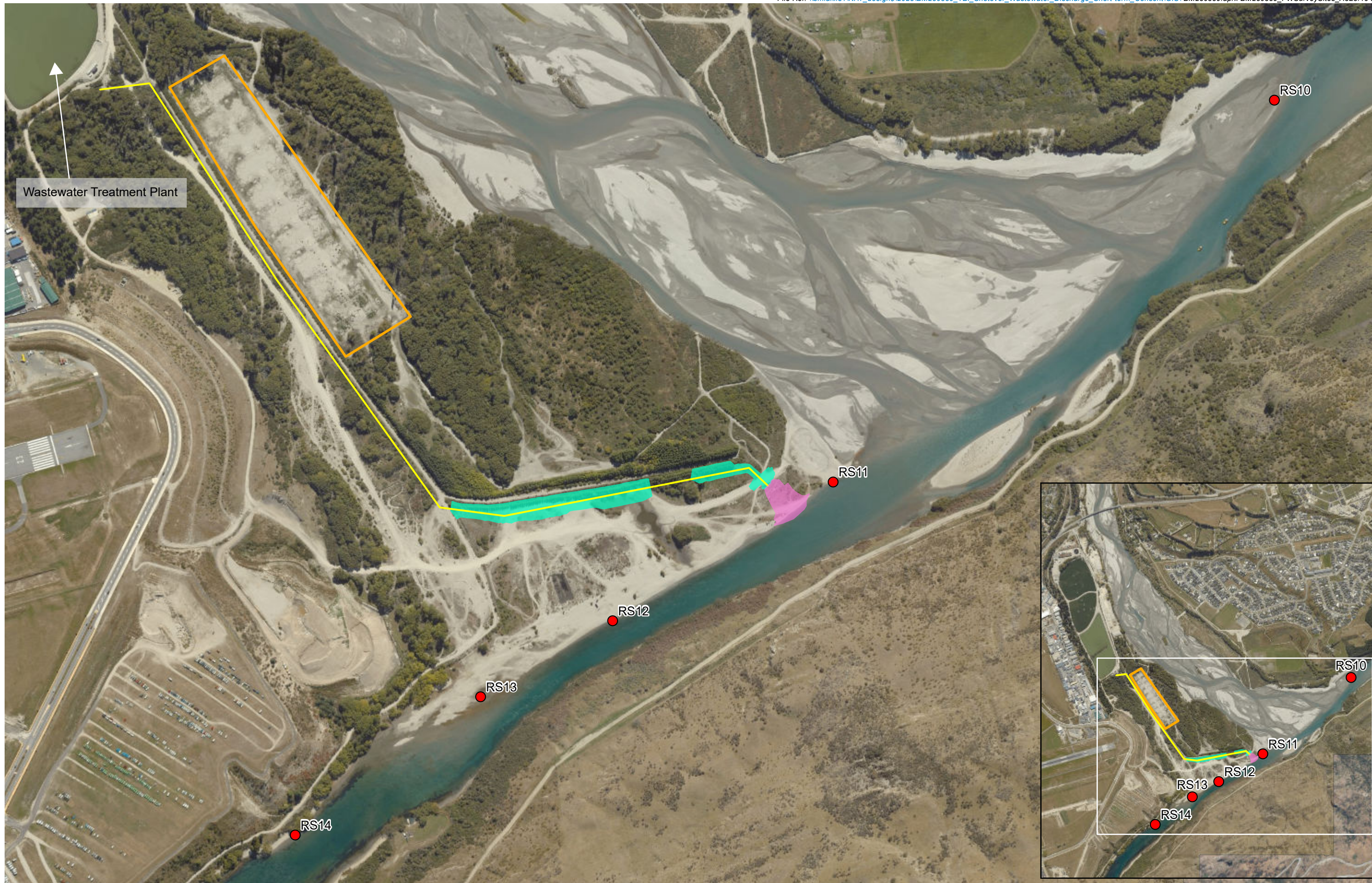
We have calculated critical and actual bed shear stress using the most appropriately available data and commonly used equations, as set out Appendix 1.

#### 1.4.2 Current water quality

Water quality sampling on the Kowarau River in the vicinity of the proposed discharge location has been undertaken by GHD at five sites since March 2025 (Figure 1). Water quality data from the long-term sampling site on the Kowarau at Chard Road has been used to determine the baseline water quality state.

#### 1.4.3 Proposed discharge

For the proposed discharge, we have relied on dispersion modelling and water quality predictions undertaken by GHD. The findings for these are summarised in Sections 5.4 and 5.5 below. Refer to their report for more detail on the methods and results (GHD 2026).



## 2.0 Kawarau River receiving environment

The Kawarau River is a large, lake-fed system sourced from Lake Wakatipu. The Shotover River joins the Kawarau River approximately 4 km downstream of the lake outlet. The Kawarau River has a relatively low gradient for the first c.15 km, before the river transitions into steeper, higher energy gorge sections, then flowing into Lake Dunstan (and the Clutha | Mata-au River) about 50 km downstream of Queenstown.

The SWWTP is located on the Shotover River delta, between the true left bank of the Kawarau River and the true right bank of the Shotover River, approximately 40 m below Frankton Terrace and the Queenstown Airport. The discharge pipe will run from the south side of the SWWTP on the right bank of the Shotover River delta to the proposed outlet structure on the left bank of the Kawarau River immediately upstream of its confluence with the Shotover River (Figure 1).

Lake Wakatipu is currently classified as oligotrophic, with high water clarity and low nutrient concentrations, which strongly influence the low-nutrient baseline of the upper Kawarau River (GHD, 2026). The Kawarau River at the proposed discharge location is a hard-bottomed 7<sup>th</sup> order river, with an estimated upstream catchment area of 3099 km<sup>2</sup>. It has relatively high baseflows, due to the buffering effect of Lake Wakatipu and relatively high sediment loads, mostly due to influence of the Shotover River (refer to sections 2.3.2 and 2.5.2 below).

At the Shotover River confluence with Kawarau River, just downstream of the proposed discharge location, the Shotover River forms an active gravel delta where large volumes of coarse sediment and fine suspended material are delivered during flow events. These inputs can locally alter channel form, flow patterns, and water clarity in the Kawarau River downstream of the confluence (GHD, 2026).

### 2.1 Existing land use and site history

The true right bank of the Shotover River delta is a mix of exposed gravels, mostly exotic vegetation and existing infrastructure, including the SWWTP, quarry storage areas and associated roads, and recreational tracks. While a large proportion of the Shotover River delta remains undeveloped, the delta and Shotover River are modified as a result of willow planting and weed invasion, off road vehicle use, gravel extraction and quarrying activities, the SWWTP and construction of the river training line in 2011 and other channel alignment works to prevent flooding in Queenstown.

The wider catchment has been substantially modified by historic gold mining, flood protection works, and land use, including urban development, transport infrastructure, and recreation.

The Kawarau River is used for jet-boating and other recreational activities and non-commercial small-scale gravel and water extraction, which also create disturbance in the receiving environment of the proposed discharge location.

### 2.2 Background on SWWTP

The SWWTP was constructed in 1974, to treat wastewater for the wider Queenstown area with a basic inlet works channel and three oxidation ponds. Several upgrades have been undertaken over time to improve plant infrastructure, treatment and to cater for population growth in the Wakatipu Basin. The most recent upgrades were:

- Stage 2 upgrades undertaken in 2019 to construct a “disposal to land” scheme via rapid infiltration into the Shotover Delta gravels. This was known as the Dose and Drain (DaD) field.
- Stage 3 upgrades were completed in late 2025 to accommodate growth in the Queenstown area. The upgrades increased the treatment capacity significantly with the decommissioning of the oxidation ponds.

Treated wastewater was discharged directly to the Shotover River via open channels up until 2019 when the DaD was commissioned. Disposal of treated wastewater to the DaD system involved flooding the gravels in the disposal field and allowing the treated wastewater to drain into the underlying gravels and into the shallow groundwater system. The DaD field experienced numerous issues after commissioning, with overflows, large areas of ponding and groundwater seepage, affecting water quality in the Kawarau River along the Shotover Delta. Residual groundwater discharges from the DaD are expected to continue influencing surface water quality for several years.

The presence of ponded water created an unacceptable bird strike risk to aircraft due to the presence of waterfowl directly below the flight path for Queenstown Airport. Due to this bird strike risk, QLDC decided to redirect the treated wastewater down one of the existing channels to the Shotover River under emergency works provisions. This discharge commenced in March 2025.

Annual ecological assessments were undertaken in the Shotover River up until the DaD was commissioned in 2019. These previous surveys assessed periphyton cover and community structure. The results from these surveys showed that periphyton cover in the Shotover River was well below national guidelines both upstream and downstream of the discharge and the periphyton community typically had low diversity dominated by diatoms, such as *Cymbella*, *Gomphoneis* and *Synedra* (MWH 2010; Golder Associates 2011, Golder Associates 2013, Golder Associates 2015; Ryder Consulting 2016; Ryder Consulting 2017 and Ryder Consulting 2018). Cyanobacteria, including *Lyngbya* and *Phormidium*, were present downstream of the discharge in January 2018 following a period of stable conditions but cover was below 10% (Ryder Consulting 2018).

Further plant upgrades have been proposed to improve the discharge quality, including supplementary chemical dosing to remove phosphorus, tertiary filtration to remove solids and enhanced UV disinfection.

Refer to the Assessment of Environmental Effects (Landpro Limited 2026) and *Surface Water and Groundwater Assessment* (GHD, 2026) for more detail on the history and planned upgrades of the SwwTP.

## 2.3 Climate and hydrology

### 2.3.1 Climate

The climate class in the River Environment Classification for the discharge location is ‘Cool Extremely Wet’ (CX) and for RS10 it is ‘Cool Wet’ (CW). For 2020 to 2024 the mean air temperature for Queenstown was 10.5°C and the average annual sunshine was 2,338 hours (GHD, 2026). Summers are generally warm and dry, with daytime highest temperatures ranging from 20–30°C, while winters are cold with daytime highs typically reaching 10-15°C, frosts and occasional low elevation snow. Annual rainfall at Queenstown Airport is typically between 600 –

800 mm (annual average of 692 mm), which is spread fairly evenly throughout the year. However, greater rainfall variability generally occurs in spring and summer, when both prolonged dry periods and high intensity rain events can occur (GHD, 2026).

### 2.3.2 River discharge volumes

The main source of flows in the Kawarau River is Lake Wakatipu so the topography REC class is 'Lake fed' (Lk). River flows in the Kawarau River are disturbed by floods to a lesser extent than the Shotover River due to the buffering effect of Lake Wakatipu. The Shotover River responds rapidly to rainfall, with flood flows characterised by high sediment load and turbid waters due to the geology and topography of the headwaters. Between 2016 and 2026 the temporal pattern in seasonal highs and lows remains consistent, and even during drier years the Kawarau River maintains relatively high baseflows, reflecting the buffering effect of Lake Wakatipu (GHD, 2026). Typically, higher flows occur in spring in the Kawarau River, due to both snow melt causing lake water levels and outflows to increase; and westerly weather patterns resulting in heavy rainfall in the upper catchment, and lower flows occur in winter (GHD, 2026). While the lowest annual flows are typically recorded between June and September, based on the data from Kawarau River at Chard Road.

Predicted flow data for the proposed discharge location (RS11) is provided in Table 4 below. The mean annual low flow (MALF) at the proposed discharge location is 71.2 m<sup>3</sup>/s and the average number of flow events per year that exceed three times the median flow is 11. The predicted MALF and median flow data corresponds well with the available data for the Kawarau River at Chard Road site. However, the modelled FRE3 looks to be higher than what likely occurs, based on the FRE3 for the Kawarau at Chard Road site. The low FRE3 for the Kawarau is due to the buffering effect of the partially regulated outflow from Lake Wakatipu.

Table 4: Modelled flow data for the relevant Kawarau and Shotover River segments (Booker and Woods, 2014) compared to flow statistics calculated from flow data for the Kawarau River at Chard Road site (1962-2026).

Location	Mean flow (m <sup>3</sup> /s)	Median flow (m <sup>3</sup> /s)	MALF (m <sup>3</sup> /s)	FRE3 (events / year)	1 in 5 yr low flow (m <sup>3</sup> /s)
Kawarau River - proposed discharge location (RS11)	232.8	179.1	71.2	11.1	58.4
Kawarau River - downstream of Shotover confluence (RS10)	302.3	236.2	94.8	9.9	76.6
Shotover River - upstream of confluence	56.5	43.3	18.1	8.6	14.2
Kawarau River at Chard Rd	210.5	188.3	89.4	0.55	72.9

### 2.3.3 Channel morphology & hydraulic characteristics

The receiving environment for the proposed SWWTP discharge is dominated by fast run. The majority of the channel width is deep (>1.5 m) with velocities greater than 0.8 m/s but shallow margins (<0.75 m) are present, some of which have lower water velocities (c.0.5 m/s).

The results from the bathymetry survey completed in March 2026 are presented in Table 5 below. Total flow varied from 106.3 m<sup>3</sup>/s to 124.6 m<sup>3</sup>/s, width varied from 45 m to 104 m, mean channel velocity varied from 0.58 m/s to 1.12 m/s and maximum channel depth varied from 1.8 m to 5.2 m. The mean velocity in the thalweg between CX1 and CX2 was 0.98 m/s. Transect CX3 is the proposed outfall structure location and Transect CX5 is at the downstream sampling location of RS10.

Table 5: Summary of channel and water hydraulic measurements in March 2026 (Earth Sciences New Zealand, 2026) and estimated velocity in shallow left margin at about 0.3 m depth measured by Boffa Miskell during ecological surveys.

Bathymetry transect	Total flow (m <sup>3</sup> /s)	Wetted width (m)	Mean channel velocity (m/s)	Maximum channel depth (m)	Velocity in shallow left margin (m/s)
CX1 - Upstream (~RS12)	106.6	45.3	0.587	5.52	0.1
CX2	106.3	48.6	0.581	4.77	-
CX3 - proposed discharge location (~RS11)	110.9	82.9	0.809	2.19	0.4
CX4 – Shotover confluence	124.6	56.8	0.81	3.33	-
CX5 – downstream (~RS10)	123.9	104.4	1.12	1.83	0.5

The profile at CX3 shows shallow margins (<0.6 m depth) out to about 5-6 m from the left bank, where it increases to about 0.75 m depth until c.10 m from the left bank and reaching a depth of about 2 m about 20 m from the left bank (Figure 2). The velocity in the shallow margins of the left bank was lower (c.0.4 m/s to 0.7 m/s) than the centre of the channel. We recorded a comparable velocity in the shallow margins on 10 March 2026 of 0.4 m/s (Table 5).

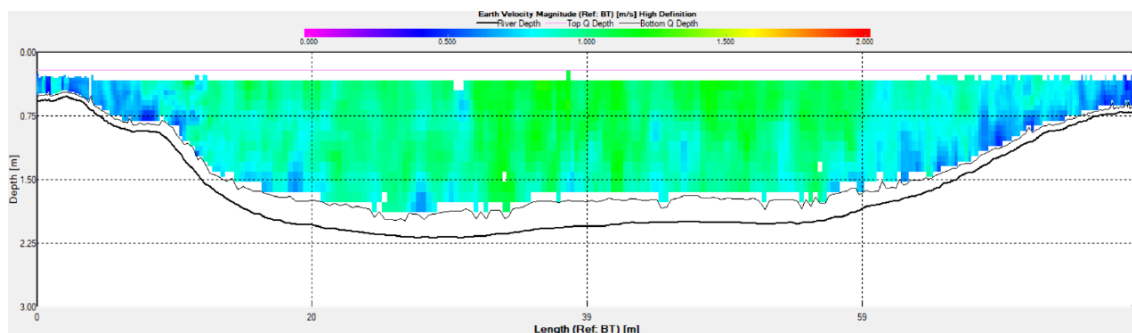


Figure 2: Profile for transect CX3 (the proposed discharge location). Zero on the X-axis is the true left bank (Earth Sciences New Zealand, 2026).

The profile at CX5 is similar to CX3, however, the left margin was slightly shallower (c.0.3 m depth) to about 5-6 m from the edge and then drops quickly reaching c.1 m depth about 15 m from the edge (Figure 3). The maximum depth at CX5 was c.1.8 m. The water velocity in the shallow margins was similar to CX3 (c.0.5 m/s) but the velocity in the centre of the channel was faster, reaching velocities greater than 1.5 m/s.

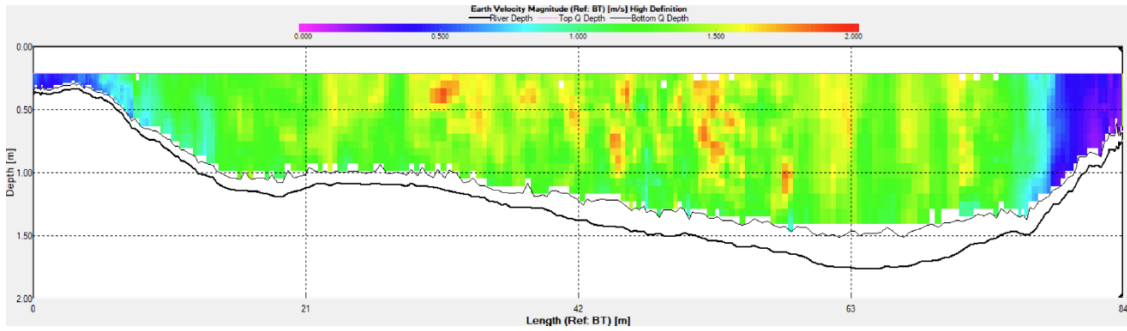


Figure 3: Profile for transect CX5 (downstream sampling location RS10). Zero on the X-axis is the true left bank (Earth Sciences New Zealand, 2026).

## 2.4 Geology and substrate

### 2.4.1 Geology

As described by GHD (2026), the geology of the Queenstown area is schist and semi-schist of the Torlesse and Caples supergroup. The schist forms the mountain ranges and high points in and around the Wakatipu Basin. The basin geology is influenced by multiple glacial advances, carving out the basin and leaving behind glacial sediments as the glaciers retreated. The Shotover Delta and receiving environment in the Kawarau River are underlain by recent alluvial and fan deposits, comprising unconsolidated gravel, sand and silt to depths greater than 50 m.

### 2.4.2 River substrate

All sites shared characteristics of a mobile, gravel-bed river, with substrates dominated by small cobble, gravel and sand (6, Figure 4). Average percentage cover of deposited sediment in the wadeable left margin of the Kawarau (out to a maximum depth of 60 cm) was higher at the discharge location (RS11) and the downstream site (RS10) compared to RS12 – RS14. This is likely as a result of sediments inputs into the Kawarau River from the Shotover River (Figures 4, 8 and 9).

Table 6. Average substrate composition (%) from five replicate transects and 20 deposited sediment (%) estimates to a maximum depth of 60 cm along the true left bank at five Kawarau River sites.

Substrate type	RS14 – Upstream	RS13 – Upstream	RS12 – Upstream	RS11 – Proposed discharge location	RS10 – Downstream
Large cobble (64–256 mm)	0	8	9	17	2
Small cobble (16–64 mm)	31	22	46	80	37
Gravel (2–16 mm)	23	32	31	3	38
Sand (0.06–2 mm)	46	38	15	0	24
Silt (<0.062 mm)	0	0	0	0	0
Average deposited sediment % (range)	28 (0 – 99)	28 (0 – 90)	14 (0 – 90)	73 (1 – 95)	86 (9 – 100)



Figure 4: Sampling site RS10 looking upstream in March 2026, showing sand and gravel dominated substrate and high deposited sediment. Photo taken at downstream extent of sample reach.

## 2.5 Baseline water quality state

The following section provides a summary of water data relevant to periphyton growth from the GHD monitoring on the Kawarau River since March 2025. Refer to the Surface Water and Groundwater Assessment by GHD (2026) for further information and interpretation of the current water quality baseline in the Kawarau River.

There is evidence of slightly degraded water quality at sites RS11, RS12 and RS13 as a result of the issues with the DaD overflows, groundwater seepage and daylighting over the last c.5-6 years, which is expected to improve over the next five years. Data from Lake Wakatipu and the long-term monitoring site, Kawarau River at Chard Road, are also used where relevant.

### 2.5.1 Water temperature

Water temperature was lowest at RS10, below the Shotover River confluence (median 10.5 °C) and highest at RS14 (median 14.2 °C). Across all sites, the median temperature was 12.95 °C (range 3.90 - 21.90 °C). For the downstream site on Kawarau River at Chard Road temperature ranged from 7°C-18°C and surface water temperatures in Lake Wakatipu peak at 14°C-16°C.

Temperature varies seasonally, for example, at RS10 median temperature in winter (June – August 2025) was 5.7 °C, while median temperature in summer (December 2025 - February 2026) was 15.8 °C (GHD, 2026).

## 2.5.2 Turbidity / suspended sediment

The highest recorded turbidity was 57.2 NTU at RS10, reflecting the naturally high sediment load contributed by the Shotover River, compared with the next highest recording of 3.34 NTU at RS11. Suspended sediment loads are elevated during high flow events at RS10 downstream of the Shotover confluence but also along the entire left margin of the Kawarau (Figure 5). Turbidity is also reduced at RS10 as a result of glacial melt in the headwaters of the Shotover (Figure 6).

This is supported by the long-term data for the Kawarau River at Chard Road site, downstream of the Shotover River confluence, which has water clarity classified in Attribute Band C.

Predicted annual average suspended sediment loads are 45,977 tonnes / year in the Kawarau River at RS11 (taking into account the sediment trapping effect of Lake Wakatipu) and 1,332,545 tonnes / year in the Shotover River directly upstream of the confluence (Hicks et al., 2011).



*Figure 5: Kawarau River, and Shotover Delta, looking north from the Remarkables showing high suspended solids load in the Shotover and on the left margin of the Kawarau. RS10 is located on the right side of the photo. Photo taken on 11 November 2025 with flows of 195 cumecs recorded in the Shotover at Bowens Peak. Photo source: Dawn Palmer.*



Figure 6: Kowarau River, and Shotover Delta, looking north from the Remarkables showing high suspended solids load in the Shotover River and on the left margin of the Kowarau River downstream of its confluence with the Shotover River. RS10 is located on the right side of the photo. Photo taken on 22 November 2023 with flows of 35 cumecs recorded in the Shotover River at Bowens Peak. Photo source: Dawn Palmer.

### 2.5.3 Nutrients

The water quality at Kowarau River at Chard Road site reflects the combined influence of Lake Wakatipu and the Shotover River. The long-term data shows high water quality, with ammoniacal nitrogen (AN), nitrate nitrogen (NN), and dissolved reactive phosphorus (DRP) consistently meeting NPS-FM Attribute Band A.

The recent monitoring by GHD in 2025-2026 indicates slightly elevated nutrient concentrations at mid-reach sites (RS11-RS13) on the Kowarau River, likely reflecting recent historical inputs from the DaD field (GHD 2026). At both RS14 (upstream in the Kowarau River) and RS10 (downstream of the Shotover River confluence), 95<sup>th</sup> percentile AN and NN concentrations meet Attribute Band A criteria (Table 7). The 95<sup>th</sup> percentile for DRP at RS14 meets Attribute Band A, while RS10 falls within Attribute Band B. There was no statistical difference in AN, NN or DRP between RS14 and RS10. DRP concentrations may be slightly higher at RS10 through the cumulative influence of the DaD field and Shotover River influence, including the current short-term wastewater discharge into the Shotover River.

Table 7: Annual median and 95<sup>th</sup> percentile values for available Kowarau River data (2025 – 2026) compared to NPS-FM national bottom lines. \* NPS-FM attribute Band D value for DRP. Source: GHD 2026.

Parameter	Ammoniacal-N (adjusted for pH 8 at 20°C) (mg / L)		Nitrate-N (mg / L)		Dissolved Reactive Phosphorus (mg / L)	
	Median	95 <sup>th</sup> percentile	Median	95 <sup>th</sup> percentile	Median	95 <sup>th</sup> percentile
RS10 (downstream)	0.01	0.02	0.036	0.07	0.005	0.024
RS14 (upstream)	0.001	0.001	0.031	0.08	0.001	0.006
NPS-FM National Bottom Line	0.24	0.4	2.4	3.5	0.018*	0.054*

Water quality within the Kawarau River downstream (RS10) of the confluence (RS10) meets the Schedule 15 criteria of the RPW, indicating excellent water quality (Table 8). GHD concludes that overall, the influence of surface water and groundwater discharges from the SWWTP and DaD disposal field do not appear to have a more than minor cumulative effect on water quality immediately downstream of the confluence.

Table 8: 80th percentile concentrations at or below median flow (179.1 m<sup>3</sup> / s) in Kawarau River for data from March 2025 to March 2026. Source: GHD 2026.

Location	Nitrate-nitrite N (mg / L)	DRP (mg / L)	Ammoniacal-N (mg / L)	Ammoniacal-N (mg / L) (adjusted for pH 8 @ 20°C)	Turbidity (NTU)
RS10 - downstream of Shotover delta	0.041	0.007	0.03	0.012	57
RS14 - upstream of Shotover delta	0.050	<0.002	0.01	0.001	1.4
RPW for Otago - Schedule 15 water quality criteria (Water Group 2)	0.075	0.010	0.10	0.100	5.0

Based on the 2025-2026 median results, total nitrogen (TN) levels within the Kawarau River are almost within the Band A criterion developed by Snelder and Kilroy (2023) to achieve the Band A Target Attribute state for Periphyton (< 50 mg / m<sup>2</sup> of chlorophyll a), while total phosphorus (TP) falls within Band B at RS14 and Band C at RS10 (Table 9).

Table 9: Current water quality compared to TN and TP criteria for periphyton target attribute states for CW/Lk REC source of flow class. Based on the criteria of Snelder and Kilroy (2023) and the 20% level of under protection risk (Snelder and Fraser, 2023).

	Median TN (mg / L)	Median TP (mg / L)
RS10	0.05	0.03
RS14	0.05	0.0025
Band A threshold	0.0476	0.001
Band B threshold	0.934	0.017
Band C threshold	4.127	0.133

### 3.0 Baseline Periphyton Condition

Periphyton cover was generally low across the Kawarau River, consistent with an oligotrophic, mobile gravel-bed system (Figure 7). RS10, RS12, and RS14 were characterised by very low periphyton cover, with all three sites recording more than 75% average cover of no algae (Figure 8).

In contrast, RS11 supported moderate didymo cover (average c.35%) (Figure 9), and RS13 exhibited extensive sludge mats (average c.65%). These patterns may reflect localised stability and slower velocities along the true-left margin, where substrate composition and reduced disturbance can allow periphyton mats to establish. For example, RS11 (the proposed

discharge location) had the highest proportion of small cobbles (average 80%) and no sand, providing greater surface area for periphyton colonisation relative to other sites (Table 6). At RS13, the extensive sludge mats may also be influenced by slower local velocities (e.g. 7; Earth Sciences New Zealand, 2026). Sites RS11-RS13 may have additionally been affected by nutrient enrichment associated with the DaD overflow and groundwater infiltration.

All sites recorded WCC values below 2%, reflecting the absence of filamentous algae and periphyton mats included in the calculation, placing all sites well within the ‘excellent’ ecological condition class (<20%) (Matheson et al., 2012). These results are also well below the 30% filamentous algae characteristic in Schedule 15 of RPW.

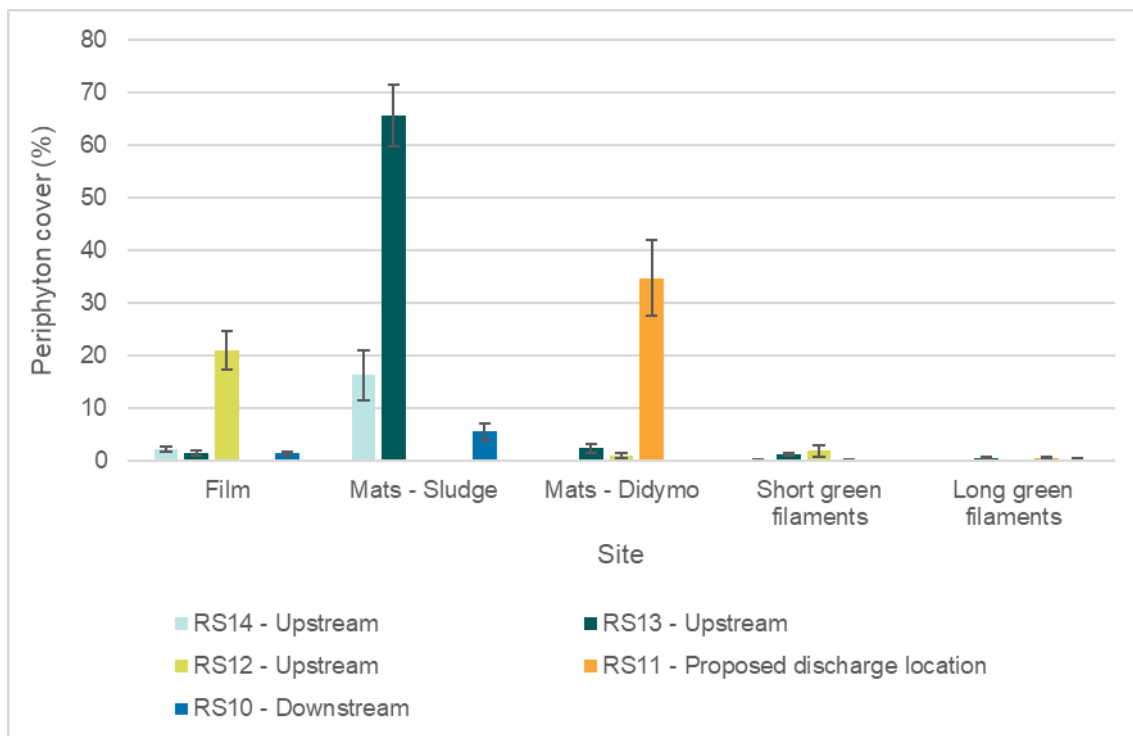


Figure 7: Average periphyton percentage cover ( $\pm$  standard error) at five Kawarau River sites, including upstream sites RS12–RS14, the proposed discharge structure location at RS11, and the downstream site RS10, surveyed on 10–11 March 2026.



Figure 8: Green and brown films on larger substrate particles at RS12 in March 2026



Figure 9: Didymo and high deposited sediment cover at Site RS11 in March 2026

While chlorophyll-a monitoring has not been undertaken in the Kawarau River, we expect it to be low given the low overall percentage cover of periphyton growth and the dominance of didymo in the periphyton community at some sites, which typically has lower chlorophyll-a levels.

This is consistent with the chlorophyll-a levels predicted by Kilroy et al. (2019) in the Kawarau River. Predicted mean and 92<sup>nd</sup> percentile chlorophyll-a for the proposed discharge location (RS11) is 11 mg / m<sup>2</sup> and 31 mg / m<sup>2</sup> and for the end of the reasonable mixing zone (RS10) is 11 mg / m<sup>2</sup> and 33 mg / m<sup>2</sup> (Table 10). Predicted mean WCC values are 7% for both RS11 and RS10. The predictions for the Kawarau River are slightly higher than the predictions for the Shotover River.

These predictions are all within NPS-FM band A for Chlorophyll-a, below the national guideline for WCC and below the 30% filamentous algae characteristic in Schedule 15 of RPW.

Table 10. Predicted mean and 92<sup>nd</sup> percentile chlorophyll a and WCC based on national modelling of periphyton in rivers (Kilroy et al., 2019) compared to relevant guidelines; NPS-FM band A for Chla and WCC and regional guideline for percentage cover.

Site	CHLA Mean	CHLA 92%ile	WCC Mean	WCC 92%ile
RS11	10.8	31.2	7.2	29.0
RS10	10.5	33.0	7.3	29.7
Shotover – upstream of confluence	9.8	22.6	6.5	25.1
Relevant guideline values	-	50	30	

All algae taxa detected in the eDNA sample collected in August 2024 are listed in Appendix 2. The taxa detected that are likely river periphyton (i.e., not from Lake Wakatipu) include:

- Filamentous green algae;
  - *Bulbochaete rectangularis* - most often founds in lakes and pools, and therefore often found in rivers that outflow from lakes)
  - *Ulothrix* - known to be a disturbance resistant taxon, so can dominate mountain streams in spring and late summer, but also known to dominate lake-fed rivers. Usually associated with oligotrophic conditions – low nutrient enrichment) (Biggs & Kilroy, 2000).
- Diatoms; *Didymo*, *Navicula*, *Surirella*, *Cymbella* and *Fragilaria*, all common and widespread species, found in a range of conditions. The last two are both quick-colonising taxa, often associated with unstable mountain fed rivers. Both *Fragilaria* and *Navicula* species are known to colonise sand substrate (Biggs, 2000).

Most of these taxa were detected in the Shotover River both upstream and downstream of the discharge in 2016, 2017 and 2018.

## 4.0 Factors influencing existing periphyton condition in the Kawarau River

Periphyton biomass and community composition is influenced by a range of environmental drivers including flows, substrate mobility, nutrients, temperature, light and grazing (Figure 10). The most important factor is flow. Periphyton accrual occurs during periods of prolonged low stable flow conditions, while high flow events (increased hydraulic forces) remove periphyton and reduce colonisation and accrual. Higher periphyton accrual and biomass is also driven by warmer water temperatures and higher dissolved nutrient and light levels, while invertebrate grazing can provide top-down control, especially in more stable systems. These factors are discussed in more detail below in relation to the existing receiving environment in the Kawarau River.

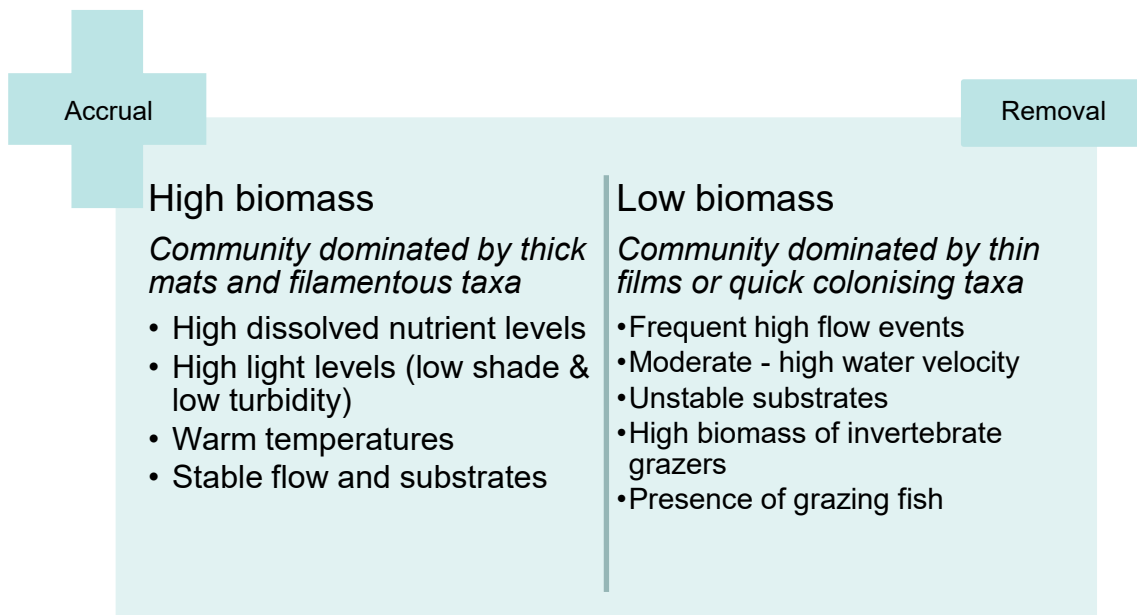


Figure 10: Factors that influence periphyton biomass and community structure in New Zealand Rivers (adapted from Figure 8 in Biggs, (2000)).

## 4.1 Hydraulic factors

Periphyton biomass can be limited by substrate size and the size and frequency of flood events. Periphyton loss during high flow events occurs as a result of direct scouring from water and suspended sediment and bed movement.

The flow required to reduce periphyton biomass to a low level is referred to as the “effective flow”. Historically, FRE3 (number of flow events a year exceeding 3 x median flow) has often been used as the effective flow. However, more recent modelling throughout New Zealand has shown that the effect of high flow effects on periphyton biomass and percentage cover is variable for different rivers and that the effective flow for removing periphyton can range from 1.5 – 16 times the median flow (Kilroy et al., 2019). The effective flow for the Kawarau is likely even lower than 1.5 times the median flow due to the highly mobile substrates and limited low flow conditions due to the buffering effect of Lake Wakatipu.

In large, single channel rivers with substrates dominated by smaller particle sizes (sand to pebbles), such as the Kawarau River, under moderate flow conditions increased bed shear stress can easily remove loosely attached algae, such as sludge dominated communities and slough biofilms. Higher flows move sediment and gravels resulting in abrasive scouring - elevated suspended sediment levels effectively “sand blast” periphyton of more stable substrate and smaller substrate particles are highly mobile. At RS10 the substrate is dominated by small particles (over 90% is pebble or smaller) and there is high suspended and deposited sediment loads as a result of inputs from the Shotover River. Estimates of critical and actual bed shear stress for RS10, suggest that medium flow conditions (c.188 m<sup>3</sup> / s) are likely sufficient to remove periphyton biomass (Appendix 1). Observations during ecological sampling in 2026, showed particles at all sampling sites were highly mobile with them being moved and flipped by the waves created by jet boats in shallow areas, which is an additional limiting factor for periphyton growth.

Based on the 1962–2026 data available for Kawarau River at Chard Road, there are an average of 7.8 flow events per year greater than the median flow. These events are an average of 23 days long (median = 7 days) and there is an average of 25 days between these events (median = 10 days). The highest flow events in the Kawarau River typically occur in spring or summer, while the lowest flows typically occur in winter. The time for periphyton to reach peak biomass after a flow event that is sufficient to remove periphyton, can vary from less than 2 to greater than 12 weeks (Biggs, 2000). The time to reach peak biomass is dependent on multiple factors including the size of the preceding flow event, nutrient supply, water temperature and the periphyton taxa present prior to the flow event. Given the lowest flows in the Kawarau River occur during winter when water temperatures are typically  $\leq 10^{\circ}\text{C}$  and the periphyton community tends to be dominated by slower-growing diatoms (Biggs, 2000), there is unlikely to be sufficient time between flow events greater than the median flow for periphyton to reach peak biomass.

Periphyton community composition is also influenced by reach scale velocity and substrate size. The community on smaller substrates are typically dominated by thin diatoms, while larger stable substrates are more likely dominated by filamentous algae or didymo. Where nutrient levels are not limiting, a high biomass of periphyton dominated by filamentous green algae can develop in low water velocity (e.g.,  $< 0.3\text{ m / s}$ ). In moderate water velocities ( $0.3 - 0.7\text{ m / s}$ ), periphyton communities are typically dominated by sessile diatoms and short filamentous algae or didymo, while adnate diatoms and prostrate filamentous cyanobacteria typically dominate in fast velocities ( $> 0.7\text{ m / s}$ ) (Biggs, 2000). Velocities in the shallow margins of the Kawarau are generally moderate to fast, depending on the flow.

## 4.2 Light levels

Due to the width of the Kawarau River, there is minimal shading of the wetted channel caused by riparian vegetation or adjacent topographical features. There are some sections that have a small amount of shade ( $< 10\%$  of river width) on the left margin from trees and adjacent terraces but these sections are mostly upstream of RS14 and downstream of RS10. There is no shade effect between RS13 and RS10.

As covered in Section 2.5.2, water clarity is reduced by both elevated suspended sediment loads during high flow events and the influence of glacial melt in the headwaters of the Shotover River. Both of these factors reduce the light reaching the substrate, especially at RS10 downstream of the Shotover River confluence.

## 4.3 Nutrients

Elevated dissolved nutrient levels can increase periphyton biomass and lead to nuisance growths. Based on the recent monitoring, the baseline nutrient levels in the Kawarau River, e.g. at site RS14, are low, due to the oligotrophic water source from Lake Wakatipu. However, nutrient levels have become slightly elevated at RS13, RS12 and RS11 as a result of the issues with the DaD field, with possibly some associated periphyton growth (refer to Section 3.0).

While TN falls within the Band A criterion developed by Snelder and Kilroy (2023) to achieve the NPS-FM periphyton Attribute Band A, TP falls within Bands B and C at RS14 and RS10 respectively. Regardless of these slightly elevated nutrients levels, periphyton cover in March 2026 was well below the national and regional guideline values of 30%. This finding is consistent with hydraulics being the main factor controlling periphyton in the Kawarau River receiving environment, including limited low flow conditions due to buffering effect of Lake Wakatipu, mobile substrate and scouring from deposited sediment.

Didymo behaves differently towards elevated phosphorus levels than most other periphyton taxa - high didymo cover has been shown to be associated with low DRP and visible didymo is typically not observed at sites where long-term DRP concentrations are above 0.002 mg / L (Bothwell et al., 2014). Existing median and 95<sup>th</sup> percentile DRP levels at RS10 are 0.005 mg / L and 0.024 mg / L. Therefore, low didymo cover at RS10 may also be associated with the slightly elevated DRP concentrations.

## 4.4 Water temperature

Water temperature often only becomes a mediating factor for periphyton growth if all other factors are suitable for periphyton accrual, e.g., low disturbance and high light and nutrients levels. Temperatures of c.5 – 10°C normally strongly limit periphyton growth, while temperatures of c.15 – 25°C are typically associated with increasing biomass (Biggs, 2000). Periphyton community composition and diversity also change with temperature. Communities in cooler temperatures (<15°C) are typically dominated by diatoms, whereas filamentous green algae dominated communities are associated with warmer temperatures. Didymo can reach high biomasses in cooler water temperatures.

Water temperatures in Kawarau River remain consistently cool for the majority of the year (usually peaking at c.18°C in summer) due to the large size of the river and source of cool water from Lake Wakatipu. However, shallower margins of the Kawarau River likely experience warmer temperatures in the peak of summer, for example, 21.9°C was recorded at RS10 in December 2025. The warmest water temperatures typically occur in January and February, sometimes into March. This generally does not coincide with the months with the lowest flows, which are typically June to September.

## 4.5 Invertebrate grazing

Invertebrate grazers can provide a top-down pressure on periphyton biomass in stable streams and rivers. Depending on the grazer taxa present, densities typically in the region of hundreds of grazers / m<sup>2</sup> exert a moderate grazing pressure (or partial control) and densities typically in the thousands of grazers / m<sup>2</sup> exert a strong pressure (suppression) (Biggs, 2000; Biggs & Kilroy, 2000; Biggs & Lowe, 1994; Kilroy et al., 2019).

However, large rivers, such as the Kawarau River, which have high flows, mobile substrates and large flood events, tend to have lower grazer densities (and lower periphyton biomass). Therefore, invertebrate density (or biomass) is unlikely to be high enough in the Kawarau River to be controlling periphyton biomass. Several invertebrate taxa that strongly fall into a grazing functional feeding group are present at the monitored Kawarau River sites, including *Deleatidium* mayflies, elmids beetle larvae, and the freshwater snails *Gyraulus* and *Potamopyrgus*. The algal piercing *Oxyethira* caddisflies are also present, as well as several taxa that exhibit opportunistic mixed feeding habits, that may also apply grazing pressure, including *Zelandobius* stoneflies, and Orthoclaadiinae, Tanytarsini, and *Polypedilum* midge larvae. However, these taxa are estimated to be at total densities in the region of 50-200 / m<sup>2</sup> based on the 2026 sampling results.

## 4.6 Summary of influencing factors for the Kawarau River

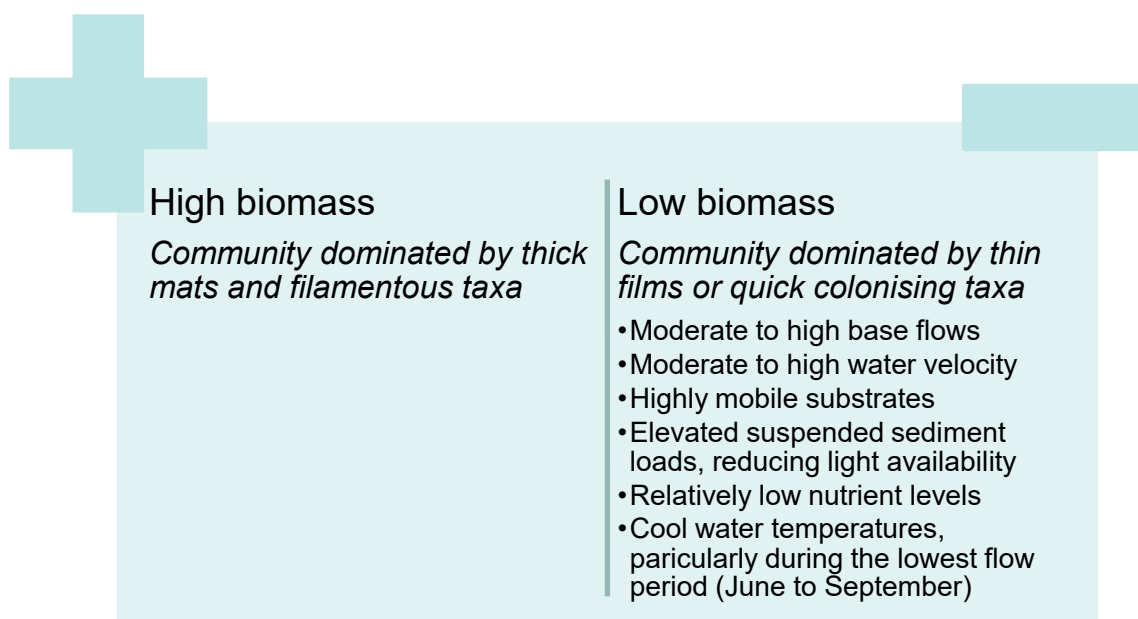


Figure 11: Summary of factors influencing the current periphyton biomass and communities in the receiving environment of the Kawarau River

## 5.0 Description of the discharge

The SWWTP is located on the Shotover River delta, between the true left bank of the Kawarau River and the true right bank of the Shotover River, approximately 40 m below Frankton Terrace and the Queenstown Airport. The discharge pipe will run from the south side of the SWWTP on the right bank of the Shotover River delta to the proposed rock outlet structure (or the alternative pipeline outlet) on the left bank of the Kawarau River immediately upstream of its confluence with the Shotover River (Figure 1).

### 5.1 Volume

A maximum daily discharge volume of 60,000 m<sup>3</sup> / day and a maximum instantaneous discharge rate of 694 L / s are being sought for the long-term consent. These limits are based on wastewater flow estimates and reflect the projected wastewater demand associated with Queenstown's forecast 2060 population (GHD 2026). The long-term discharge volume from the SWWTP is predicted to reach an average of 25,904 m<sup>3</sup> / day by 2060, compared with 15,934 m<sup>3</sup> / day that occurred in 2024.

Regulation 69 (1)(d) of the WEPS requires the dilution ratio of the discharge to be considered. The dilution of the discharge is expected to be >50 and <250, which falls into the moderate (medium) dilution ratio class<sup>5</sup>.

## 5.2 Timing

The discharge will operate continuously, with flows varying according to diurnal and seasonal wastewater generation patterns. Peak dry-weather flows in 2060 have been used as the basis for water-quality predictions to ensure a conservative assessment.

## 5.3 Dispersion Modelling

Dispersion modelling undertaken by GHD (2026) provides the hydrodynamic basis for the dilution patterns and water quality predictions described in Section 5.5. These outputs have been relied on for this risk assessment; full modelling methods, assumptions, and results are provided in GHD (2026).

GHD's (2026) modelling used the 2060 peak dry-weather discharge rate under mean annual low-flow conditions in the Kawarau and Shotover Rivers to provide a conservative representation of potential effects. Although higher treated wastewater discharge rates may occur during wet-weather periods due to stormwater inflow to the network, these events coincide with higher river flows. This is particularly evident in the Shotover River, which responds rapidly to rainfall and can reach flows many times greater than baseflow. Any increase in discharge volume during wet weather is therefore expected to be more than offset by increased river dilution capacity.

The modelling applied static flow inputs and simplified channel geometry, meaning it also likely underestimates the natural turbulence and variability that promote mixing. GHD (2026) used both OpenFOAM and CORMIX, with consistent overall plume behaviour. OpenFOAM was adopted as the primary basis for the dilution assessment because it provides a more conservative representation of the receiving hydraulic environment.

Dispersion modelling by GHD (2026) indicates that treated wastewater discharged to the Kawarau River remains near the true-left riverbank (Figure 12). This pattern is consistent with Shotover River inflows, with aerial imagery during high-flow periods also showing entrainment along the true-left bank of the Kawarau River.

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<sup>5</sup> GHD Technical Memorandum, dated 04 February 2026. Subject: Impact of the new Wastewater Environmental Performance Standards.

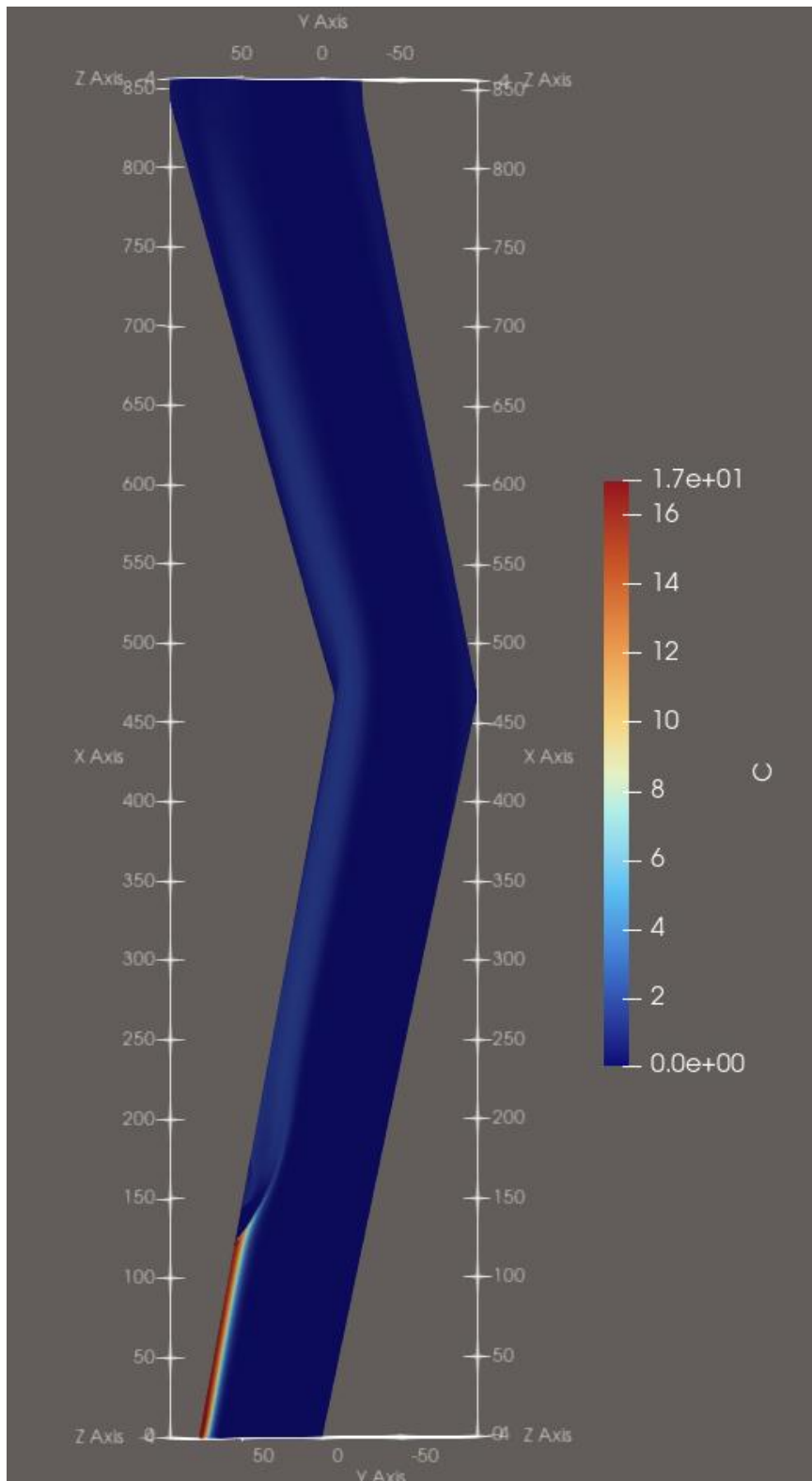


Figure 12. Predicted surface-water dispersion of treated wastewater in the Kawarau River. The X-axis represents the longitudinal distance downstream from the outfall (0 metres at the discharge point), and the Y-axis represents the cross-sectional width of the river. The plume remains entrained along the true left margin and occupies only a small proportion of the channel width. The increase in dilution at approximately 125 metres on the X-axis corresponds to the beginning of the Shotover River confluence, and RS10 (the point of reasonable mixing) is located at approximately 850 metres on the X-axis. Source: Appendix E, GHD (2026).

## 5.4 Mixing areas

The predictive modelling undertaken by GHD to determine the effects of the proposed discharge on water quality, which have been relied on for this assessment, have been undertaken for three mixing areas:

1. Near field mixing area: Treated wastewater achieves an immediate 3-fold dilution on entering the Kawarau River. Flow around the outfall structure draws the plume along the true-left margin, with continued entrainment achieving a 5-fold dilution (c.20% residual wastewater) by the downstream end of the structure (c.40 m).
2. Reasonable mixing zone: The residual plume mixes with Shotover River inflows, resulting in a 50-fold reduction by RS10 (c.2% residual wastewater) downstream of the Shotover River confluence. At this point, the plume influences roughly one-third of the channel width adjacent to the true-left bank. RS10 is located immediately downstream of the reasonable mixing zone. This site has been selected on the basis that reasonable mixing is expected to occur along the length of the Shotover River confluence (from c. 100 m to 800 m from the discharge location), and it aligns with the established water quality and ecological monitoring site at RS10.<sup>6</sup>
3. Complete mixing: Downstream of RS10, aerial imagery from high-sediment Shotover events indicates that full mixing of the two rivers typically occurs further downstream where channel bends generate substantial turbulence (c. 4km downstream of the discharge location). Additional inflows from the Arrow and Nevis Rivers further promote dispersion. This fully mixed analysis provides the basis for assessing potential effects on Lake Dunstan.

## 5.5 Predicted water quality

Predicted water quality outcomes are detailed in GHD (2026) with the results relevant to periphyton growth summarised below.

In the near-field mixing area (i.e., immediately downstream of the discharge structure) nutrient levels are predicted to be higher than baseline levels (i.e., at RS14), but comparable with the median nutrient levels at RS11, RS12 and RS13 in low flow conditions (e.g., in March 2025). Predicted median TN and TP in the near-field mixing area fall into Band C for Periphyton Target Attribute States and predicted DRP falls into Band D (Table 8). However, GHD (2026) note that the predicted concentrations represent 2060 peak treated wastewater discharge under low-flow conditions, and so are not representative of annual conditions. Actual annual water quality statistics, such as for comparison to NPS FM criteria, would be significantly lower than those presented, when taking into account periods of higher flow.

After reasonable mixing (as measured at RS10) nutrient levels remain higher than baseline levels (i.e., at RS14), but they are within the same bands as the median levels at RS10 in 2025-2026, with the exception of DRP (Table 8). Predicted median TN and TP at RS10 fall into Band B and C respectively for Periphyton Target Attribute States and predicted median DRP remains in Band D. However, as covered above, the predicted concentrations are considered to overestimate the annual median concentrations and provide an upper bound for potential effects to water quality.

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<sup>6</sup> Any monitoring between the discharge outfall and RS10 is not considered practicable due to the influence of the Shotover River confluence, which limits spatial and temporal comparability within this reach.

After complete mixing, all nutrient parameters are comparable with the median nutrient levels at RS10 in 2025-2026 (Table 8) and below applicable guideline thresholds (GHD 2026).

*Table 11: Current and predicted median nutrient levels compared to TN and TP criteria for periphyton target attribute states (Snelder and Kilroy 2023, sourced from Snelder and Fraser 2023) and NPS-FM Attribute bands for DRP. Periphyton target attribute state based on CW/Lk REC source of flow class and a 20% level of under protection risk.*

Site		Median TN (mg / L)	Median TP (mg / L)	Median DRP (mg / L)	Median Nitrate-N (mg / L)
2025-2026 median at RS14		0.05	0.0025	0.001	0.031
2025-2026 median at RS10		0.05	0.03	0.005	0.036
Predicted median in near field mixing area		2.04	0.302	0.201	1.42
Predicted median at RS10		0.25	0.032	0.021	0.17
Predicted median after complete mixing		0.09	0.009	0.005	0.058
TN and TP criteria for periphyton target attribute states and NPS-FM bands for DRP	Band A	0.0476	0.001	≤ 0.006	
	Band B	0.934	0.017	> 0.006 & ≤ 0.010	
	Band C	4.127	0.133	> 0.010 & ≤ 0.018	
	Band D			>0.018	

## 5.6 Other potential changes

[If the Applicant installs an outfall structure as contemplated in the application], the proposed outfall structure reduces the flow area by c. 3.5% in low flows and c. 7% in flood flows (GHD 2026). There is the potential for small changes to water velocity, depth and flow direction immediately surrounding and downstream of the rock outfall structure. The structure has been designed to minimise these changes by having rocks tapering back from the outfall into the banks either side of the outfall in the centre. Therefore, we expect any changes in water velocity, depth and flow direction to be negligible (limited to immediately adjacent to the structure and minor in magnitude).

No changes to shading of the river channel are expected as a result of the discharge but the discharge flows within the rock outfall structure will be shaded by rocks and planted trees.

## 5.7 Mitigation measures

The following mitigation measures to improve the discharge quality and to avoid and minimise effects are already proposed as part of the consent application and have been taken into account in the risk assessment in Section 6.0 below:

- The proposed design of the structure has already been altered during the concept design stage to increase mixing and dilution and reduce effects on the left margins by moving the outfall structure further into the wetted channel.

- Several upgrades to the treatment process are planned, including supplementary Alum dosing to remove phosphorus, tertiary filtration to remove solids and enhanced UV disinfection.
- Nutrient limits or triggers will be imposed as part of consent conditions and routine water quality and ecological monitoring will be required to detect any changes, that may occur as a result of the proposed discharge.
- Operational controls will be imposed as part of the consent conditions, including the preparation of a contingency and incident response plan and regular testing and continuous turbidity readings.
- Shading of the water flows in the outfall structure by trees and rocks.

## 6.0 Periphyton Risk Assessment

Predicted changes as a result of the proposed discharge and other factors are summarised in Table 12 below. The majority of factors that currently limit periphyton growth in the receiving environment of the Kawarau River are not expected to change as a result of the discharge. However, as covered in section 5.5 above, dissolved and total nutrients are predicted to increase as a result of the proposed discharge within the near-field mixing area and within the reasonably mixing zone.

However, the primary factors controlling periphyton growth in the Kawarau River are the consistently moderate to high flows and highly mobile small substrates and to a lesser degree cool temperatures and elevated sediment levels. Elevated nutrient concentrations may lead to localised increases in periphyton growth if long periods (> c. 30 days) of stable lower flows occur in late summer / early autumn when water temperatures are also still sufficiently warm for periphyton growth. This is highly unlikely in the Kawarau River. While the recent increases in nutrient levels as a result of the DaD overflows may have resulted in increased periphyton cover at RS11 and RS13, the periphyton cover is well below guideline values and the community composition is indicative of recent colonisation. No nuisance bacterial and/or fungal (heterotrophic) growths or cyanobacterial growths were observed in March 2026.

A localised increase in periphyton biomass and cover is expected to occur within and on the sides of the rock outfall structure (within the near-field mixing area), especially during periods of prolonged stable conditions, which typically occur in June to September. This is due to the combined effects of more stable substrate sizes and elevated nutrients levels. However, this periphyton growth will be mediated by cooler temperatures, and potentially grazing pressure may provide a top-down effect. The rocks that will be placed in and around the outfall structure will provide a stable substrate, likely less influenced by river high flows, for grazers, such as *Potamopyrgus*, to colonise. This could assist with reducing any increases in periphyton biomass within and immediately downstream of the rock outfall structure.

As covered above in section 4.3, high didymo cover is associated with low DRP levels. As the median and 95<sup>th</sup> percentile DRP levels at RS10 are predicted to increase slightly as a result of the proposed discharge to 0.021 mg / L and 0.081 mg / L, we expect didymo cover and biomass is unlikely to change or will decrease as a result of the discharge.

Based on the above, we conclude that it is highly unlikely that periphyton biomass will exceed 50 mg / m<sup>2</sup> more than 8% of the time (i.e., fall below NPS-FM attribute band A) after reasonable

mixing, as measured at RS10. While it is expected that there will be localised increases in periphyton cover for short periods within the near-field mixing area, it is highly likely to remain below the national and regional guideline values of 30% cover. Therefore, it is highly unlikely that undesirable biological growths will occur as a result of the proposed discharge, as required by the WCO. Given this, we determine that the overall periphyton risk category is **low**.

Table 12: Predicted changes in factors that influence periphyton growth as a result of the proposed discharge and other factors

Factor	Predicted state in 2030 - 2060	Influence on periphyton biomass	Certainty in prediction
Flood frequency	No change. Assuming there is no change to the outflows from Lake Wakatipu.	Will continue to limit periphyton growth	High
Substrate size & stability	No change. Substrate dominated by highly mobile substrate sizes (gravel). The addition of larger boulders and cobbles as part of the rock outfall structure will provide a stable substrate.	Will continue to limit periphyton growth	High
Water velocity	Slight change but unlikely to be sufficient reduction of water velocities to support periphyton accrual of nuisance mats and filamentous algae.	Will continue to limit nuisance periphyton growths.	High
Temperature	No change. Slight increases in air temperatures due to climate change are unlikely to result in water temperature changes in Kawarau River due to Lake Wakatipu water source.	Will continue to limit periphyton growth	High
Nutrient levels	Expected increase in nitrogen and phosphorus levels compared to current baseline (RS14).	Will lead to localised increases in periphyton biomass on stable substrates in periods of low flow conditions i.e. for short periods.	High
Light	No change. High light levels due to lack of shade, however frequent reduced light availability, due to elevated turbidity levels.	Will continue to limit periphyton growth	High
Invertebrate grazing	No change. Invertebrate grazer densities low.	Unlikely to limit periphyton growth, other than possibly in outfall structure.	Moderate
Other disturbances, e.g., wave action from jet boats, gravel extraction	No change. Assume that these activities will continue similar to existing rate.	Will continue to limit periphyton growth	Moderate

Due to the low overall risk, no additional mitigation measures are recommended. However, routine monitoring of periphyton cover is recommended, as set out in section 7.0 below.

Under Regulation 71(4)(a) of the WEPS, based on a low overall risk category combined with a moderate (medium) dilution ratio the discharge concentration limits for annual median total nitrogen and total phosphorus are 10 mg / L and 3 mg / L, respectively.

## 7.0 Monitoring recommendations

### 7.1 Existing and ongoing ecological monitoring (pre-installation)

Ecological monitoring at the five existing Kawarau River sites should continue until the installation and operation of the new outfall structure, consistent with the REMP (GHD, 13 June 2025). This will include water quality monitoring and ecological monitoring (deposited sediment, periphyton and macroinvertebrates), which will:

- Provide a robust baseline against which post-discharge effects of the proposed design can be assessed.
- Identify how the system is responding to the cessation of the DaD overflow / groundwater influence.

### 7.2 Monitoring of the new discharge (post-installation)

#### 7.2.1.1 Monitoring locations

Once the new discharge is operational, ecological and water quality monitoring should occur at the following four locations. Monitoring at the first three sites below will continue from the existing REMP monitoring programme, while monitoring at the last site further downstream in the Kawarau River will commence prior to new proposed discharge to establish an appropriate pre-discharge baseline:

- One upstream Kawarau River site (e.g. RS14) to represent baseline conditions unaffected by the discharge. A second upstream site (e.g. RS12) may be retained if the REMP monitoring indicates spatial variability that requires two reference points, but one upstream site is likely sufficient for long-term monitoring. Currently being monitored under REMP requirements.
- One upstream Shotover River site (e.g. RS04B in the REMP) to represent background conditions in the Shotover River, which strongly influences the downstream Kawarau River sites. Currently being monitored under REMP requirements.
- One downstream Kawarau River site after the reasonable mixing zone (e.g. RS10) to assess after reasonable mixing effects. Currently being monitored under REMP requirements.
- One downstream Kawarau River site in the complete mixing area, possibly approximately 4 km downstream of the discharge on the true right bank. We recommend this site be incorporated into the existing monitoring programme two years prior to operation of the new structure to establish a pre-discharge baseline ecological condition. Not currently being monitored under REMP requirements.

The monitoring programme should allow for refinement of monitoring locations or parameters if results indicate that certain sites are redundant or that additional sites are required. For example, if long-term results show no change in water quality or ecological condition at the furthest downstream site, the need for ongoing monitoring at that location could be re-evaluated.

#### 7.2.1.2 Recommended monitoring parameters

It is recommended that periphyton be monitored throughout the life of the consent, along with water quality, deposited sediment, and macroinvertebrates (refer to the water quality report (GHD 2026) and the EclA (Boffa Miskell 2026) for details on other proposed monitoring).

Periphyton monitoring should include a visual assessment of periphyton cover using the periphyton visual cover measurements method (section 4) in the National Environmental Monitoring Standards (NEMS) for Periphyton (Ministry for the Environment, 2022b). Monitoring should be conducted twice a year in low flow conditions in summer and autumn/early winter. For both monitoring occasions, monitoring is only required if a period of greater than four weeks of stable low flow conditions occurs.

The percentage cover of visible stream bed covered by the following should be determined at each monitoring location:

- Bacterial and/or fungal growths (sewage fungus)
- Filamentous algae more than 2 cm long
- Diatoms or cyanobacteria mats more than 0.3 cm thick.

Chlorophyll-a analysis is not included in the routine monitoring because laboratory processing timeframes limit its usefulness for timely adaptive management, and the periphyton community in the Kawarau River in March 2026 had low percentage cover, with the majority of the species being early-successional, fast-turnover taxa. As a result, chlorophyll-a provides limited additional value over visual cover assessments, which are more responsive to the types of changes expected.

The monitoring requirements should be formalised in an Environmental Monitoring and Management Plan (EMMP) and/or consent conditions. The EMMP should outline the trigger criteria for the ecological components that would be used to initiate further investigation. If the routine monitoring identifies periphyton growth exceeding or approaching guideline values, further investigation could include, for example;

- further monitoring to determine species composition, chlorophyll a levels and/or cyanobacteria cell numbers, and/or;
- an increase in periphyton monitoring frequency.

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# Appendix 1: Shear stress estimate calculations

In theory, if the **critical shear stress ( $\tau_c$ )** is less than the **actual bed shear stress ( $\tau$ )**, then the substrate will move. However, sufficient shear stress can also provide sufficient force to remove periphyton off surfaces, without the substrate moving.

## Critical shear stress ( $\tau_c$ ) calculation

Shields estimate of critical shear stress ( $\tau_c$ ) for RS10:

$$\tau_c = \theta_c(\rho_s - \rho)gD$$

Where:

$\theta_c = 0.045$  (Shields parameter commonly used for New Zealand rivers and is appropriate given substrate mix of sand, gravel and pebble / coarse gravel)

$\rho_s = 2600 \text{ kg/m}^3$  (average density of Otago Schist)

$\rho = 1000 \text{ kg/m}^3$  (water density)

$g = 9.81 \text{ m/s}^2$  (gravity)

$D = 0.016 \text{ m}$  (maximum size range of gravel as the median substrate size (D50) at RS10)

Equates to a  $\tau_c$  of 11.3 Pa

If the maximum size range of sand (0.002 m) is used for D, then  $\tau_c = 1.4 \text{ Pa}$

## Actual bed shear stress ( $\tau$ ) calculation

Depth-slope method/Manning-based approach for calculating actual bed shear stress ( $\tau$ ):

$$\tau = \rho g R S$$

Where:

$\rho = 1000 \text{ kg/m}^3$  (water density)

$g = 9.81 \text{ m/s}^2$  (gravity)

$R = 1$  (low flow estimate range for Hydraulic radius, e.g.  $R$  based on the bathymetry survey data at CX5 was  $\sim 107.6/104.4 = 1.03$ )

$S = 0.0015$  (slope, based on 1.5 m fall over 1km, likely steeper than this)

Equates to a  $\tau$  of 14.7 Pa

Flow rate at CX5 at the time of the bathymetry survey was  $123.9 \text{ m}^3/\text{s}$ , well below median and mean flow. If a higher Hydraulic radius is used as would be expected under higher flows, e.g.  $R = 2$ , then  $\tau$  increases by the same factor, e.g.  $\tau = 29.4 \text{ Pa}$ .

This shows that very little increase in flows is required for shear stress to scour periphyton and move substrates at RS10 due to the small particle size and river morphology.

Actual bed shear stress ( $\tau$ ) can also be calculated using the Velocity Profile method:

$$\tau = \rho u^{*2}$$

Where:

$\rho = 1000 \text{ kg/m}^3$  (water density)

$u^*$  = shear velocity (velocity at the substrate, usually 5-10% of mean velocity)

Therefore if  $\tau = 12 \text{ Pa}$ , then  $u^* = 0.11$

This means that in theory, shear velocities  $> 0.11 \text{ m/s}$  are sufficient to start moving gravel and sand.

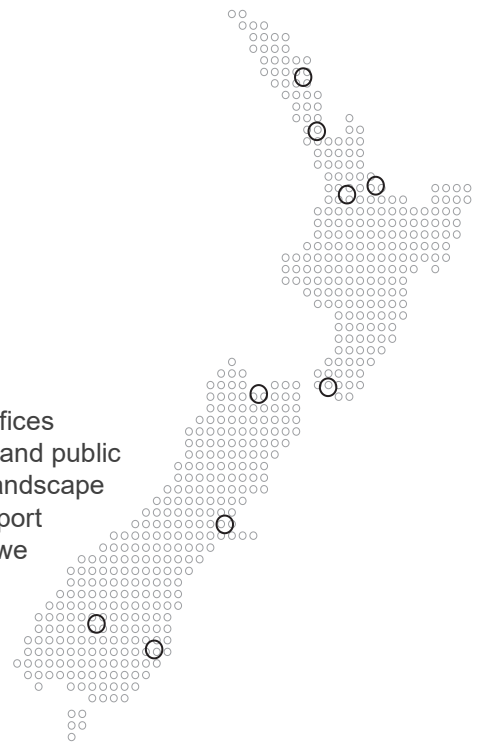
## Appendix 2: Algae detected in eDNA sample

Table 13: Algae species detected in single eDNA sample collected by LandPro in August 2024 at the proposed discharge location (RS11) on the Kawarau River.

Scientific name	Group	Sequence count	Likely source of eDNA	Comment
<i>Bulbochaete rectangularis</i> var. <i>hiloensis</i>	Green algae	97	River	Periphyton
<i>Didymosphenia geminata</i>	Diatoms	78	River	Periphyton
<i>Oikomonas</i>	Heterokont algae	209	River	Protozoans - Part of heterotrophic growth
<i>Chrysochaete</i>	Heterokont algae	60	River	Periphyton
<i>Navicula</i>	Diatoms	47	River	Periphyton
<i>Ulothrix</i>	Green algae	29	River	old water associated with hill country/SI streams - mores resistant to disturbance
<i>Surirella</i>	Diatoms	13	River	Periphyton
<i>Cymbella</i>	Diatoms	10	River	Periphyton
<i>Fragilaria</i>	Diatoms	78	Either	Often associated with unstable mountain fed streams and rivers as quick colonising
<i>Lindavia intermedia</i>	Diatoms	27	Lake	Phytoplankton
<i>Dinobryon</i>	Heterokont algae	4477	Lake	
<i>Triparma</i>	Heterokont algae	312	Lake	
<i>Chlamydomonas</i>	Green algae	32	Phytoplankton	Phytoplankton
<i>Mallomonas</i>	Heterokont algae	28	Lake	Phytoplankton
<i>Discostella</i>	Diatoms	27	Lake	Phytoplankton
<i>Ochromonas</i>	Heterokont algae	19	Lake	Phytoplankton
<i>Planophila</i>	Green algae	19	Lake	Periphyton but associated with lakes
<i>Spumella</i>	Heterokont algae	10	Lake	Phytoplankton

**Together. Shaping Better Places.**

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



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