
To: NZSki
Cc: Mitchell Daysh
From: e3Scientific
Date: 28/8/2026
Subject: NZSki Remarkables Ski Area Upgrade - Periphyton Risk Assessment

1 Introduction

As part of the consent application for an increase in wastewater discharge volume from the Remarkables Ski Field, a periphyton risk assessment was requested by Torlesse, the technical reviewer engaged by the Otago Regional Council (ORC). During a technical expert workshop on 11 August 2026 it was agreed to try to develop nutrient targets to maintain periphyton biomass below 50 mg/m² Chlorophyll *a* (Chl *a*). This memo aims to provide a periphyton risk assessment and establish potential nutrient thresholds to maintain low periphyton biomass and high benthic macroinvertebrate metric characteristics. This is done via proposed thresholds and adaptive management triggers within a management framework. In addition, an assessment of ammonia toxicity likelihood is undertaken.

Within this periphyton risk assessment we assert that while measured nutrient concentrations may exceed proposed threshold values at times, the actual risk of periphyton growth exceeding the proposed 50 mg/m² biomass limit is low due to the environmental and the timing of the exceedancesⁱ. We propose an approach to utilise the low risk categories of Matheson, *et al.* (2012) to maintain less than 150 mg/m³ of dissolved inorganic nitrogen (DIN) and less than 6 mg/m³ of dissolved reactive phosphorus (DRP) within the Rastus Burn over the off-season (1 November to 31 May) and to use these levels as initial trigger levels for an adaptive management approach with further actions required

ⁱ i.e. threshold exceedances are primarily during the ski season (1 June to 31 October) when environmental constraints such as water temperature and light availability, on periphyton growth are present.

if these levels are exceeded. The following sections provide information included in the freshwater ecological impact assessment report (FEcIA) prepared by e3Scientific in August 2026; however, it is summarised here for completeness in alignment with a standard periphyton risk assessment, as requested by Torlesse.

2 Receiving Environment – Rastus Burn

This section of the Periphyton Risk Assessment summarises the background information provided within the Wastewater Discharge Impact assessment (e3Scientific, 2026a) and Rastus Burn Wastewater FEcIA (e3Scientific, 2026e).

Waterbody type: Hard-bottom alpine stream.

Hydrological setting: The NIWA flow model for the Rastus Burn estimates a median flow of 0.133 cumecs, mean flow of 0.2 cumecs, and lowest flow in July (due to snow). February mean flow is predicted to be 9.6% higher than the annual daily mean flow and the Rastus Burn has 11.4 flood events per year (NIWA, 2026).

Dilution modelling: High dilution see Section 4.4; e3Scientific, (2026a).

Zone of influence: Slight measurable effects on water quality have been measured 1500 m downstream. Therefore, the 1500 m reach of the Rastus Burn below the wastewater discharge infiltration field is considered the zone of influence.

Residence time: Less than 1 month to reach the stream.

Geomorphology: Gravel, cobble, and boulder bed substrate, with a steep incised channel, shading is limited to natural landform shading from the steep sided valley with some edge shading of the stream from tussocks. The Rastus Burn runs from south east to the Kawarau River in a northerly direction. Riparian conditions provide a naturally low level of shading.

Existing nutrient sources: There are no other upstream point sources, there is some diffuse catchment inputs from wetlands and rock weathering.

Ecological values: Assessed as Moderate based on the macroinvertebrate community present and natural absence of fish.

3 Baseline Periphyton Condition

Historical monitoring data: Low algal biomass and algal cover as measured in November every second year. Visual observations demonstrated low algal cover in February 2026.

Seasonal patterns: Previous spring monitoring has not demonstrated high periphyton biomass and autumn has not been sampled previously. It is therefore assumed increased periphyton growth rates will occur in summer/autumn with warmer temperatures. The Executive Summary and Section 3.1 of e3Scientific (2026a) provides additional context to clarify that this is primarily a winter/spring discharge with 2 to 3 times the wastewater volume and 17 times the total nitrogen concentrations (Table 7; e3Scientific, 2026a) contributed to the wastewater infiltration field in winter/spring compared to summer/autumn (see Table 6 and Table 7; e3Scientific, 2026a). Therefore, two consent monitoring periphyton sampling events have been proposed, one in spring close to the timing of the activity (winter ski season wastewater discharge) and one in autumn when warmer temperatures and more sunlight might result in more algal growth given sufficient nutrients and stable flows.

Drivers: The key drivers for periphyton growth are sufficient sunlight and water temperatures, suitable substrate for attachment, and a nutrient source. Flood events remove periphyton biomass and reset the process. Water temperatures above 10 °C are only recorded in the Rastus Burn during December to February which coincides with longer daylight hours. For the remainder of the year cold water temperatures of <10 °C and lower sunlight hours limit periphyton growth rates. Spring snow melt increases base flows and there are approximately 11 flood events modelled per year. Additionally, the streambed's hard rock substrate is suitable for algal attachment. The algal community and growth forms have developed to survive very cold water rather than to produce high summer biomass, the exception being didymo. There are nutrient sources within the stream's catchment (e.g. from natural sources and from the wastewater discharge) which at times are in excess of the guidelines to maintain periphyton levels below 50 mg/m³. Therefore, while typically the nutrient concentrations are low, at times they will exceed that predicted to protect benthic biodiversity.

Current state: Historical assessments of the NPS-FM band for chlorophyll *a* have not been undertaken but based on the nutrient concentrations are expected to fall within A or B band (<120 mg/m² Chl *a*) based on the periphyton taxa and descriptions provided in consent monitoring reports. No known excessive periphyton growth events have been recorded in Rastus Burn below the discharge fields; however, a *Didymosphenia geminata* (didymo) bloom has occurred at the headwaters (Lake Alta) and a small growth was

observed in the Rastus Burn near the 'downstream 200 m' monitoring point (e3Scientific, 2026e).

4 Discharge Characterisation

Wastewater quality: The proposal is to maintain the current nutrient load levels of 750 kg of nitrogen in any one calendar year and 100 kg of phosphorus in any calendar year (Stantec, 2026). Noting that these numbers are to be confirmed via a review early in the life of the consent. See proposed consent condition WW.37.

Flow and load: During the ski season the mean total nitrogen concentration of the wastewater is 51 mg/L and in the off-season the mean concentration is 3 mg/L (Table 7; e3Scientific, 2026a). Mean load peaks in August at 179 kg/month with a minimum load in February at 1.2 kg/month.

Discharge configuration: Discharge to land, seeps into Rastus Burn along an extended reach as a diffuse discharge within 1 month of discharge to land.

Receiving environment dilution: High dilution, see Section 4.4; e3Scientific, (2026a).

5 Risk Characterisation

Consent monitoring has shown with the existing wastewater discharge the nutrient concentrations are currently in B band or above for the relevant NPS-FM nutrient parameters (Ministry for the Environment, 2020). Periphyton levels are also assumed to be within B band or above, but as periphyton biomass has not been directly measured this assumption is based on the lack of growth observed and the growth forms of the algal species identified within previous consent monitoring reports (Ludgate, 2017; SLR, 2023; SLR, 2026). July is predicted to be the month with the lowest stream flow (NIWA, 2026). This aligns with the winter ski season and peak wastewater discharge, however due to the cold winter conditions (<10 °C, and low light for photosynthesis) little algal growth is expected at that time. The main driver for the algal community present will be the ability to withstand very cold temperatures. At this location this is more important than being able to convert nutrients rapidly into periphyton biomass as is more typical in lower altitude rivers with filamentous green algae present rather than a community dominated by diatoms.

As conditions warm in spring, snowmelt will maintain cool instream conditions and elevated flows. During summer, water temperatures and daylight hours increase so conditions will

be more conducive to algal growth; however, during this time the nutrients contributed from the NZSki wastewater treatment system will be at their lowest (Figure 10; e3Scientific, 2026a). In Autumn, flows taper off towards seasonal low flow which increases the background nutrient concentration due to less dilution, temperatures are mild but likely less than 10 °C, and the wastewater discharge occurring under 'off-season' conditions (e.g. low nutrient load). Based on the above, due to the cold winter temperatures coinciding with peak discharge times and low nutrient discharge during peak algal growth times it is very unlikely periphyton biomass will be altered to a level that will impact the macroinvertebrate community present.

Therefore, we propose the periphyton risk for the Rastus Burn is low.

6 Stressor – Response Assessment

6.1 Environmental Guideline Values Assessment

6.1.1 Nutrient Guideline Values

The following bullet points summarise the methods used and the pros and cons of the main nutrient guidelines developed in New Zealand to try to maintain periphyton biomass below 50 mg/m² of Chl *a*. This is the periphyton level below which is described to maintain healthy benthic biodiversity and the agreed target for the Rastus Burn. The nutrient guideline levels are summarised in Table 1 below.

- Biggs (2000) originally suggested nutrient concentrations that varied by periphyton accrual time (since the last flood). In practise this is difficult to manage as the guideline values to be met regularly shift. Table 1 below uses the 30 day accrual guideline of 10 mg/m³ dissolved inorganic nitrogen (DIN) and 1 mg/m³ dissolved reactive phosphorus (DRP) (based on 365 days in a year divided by 11.4 flood events a year = 32). It should be noted however that when reviewed by Matheson *et al.* (2016) it was considered that this guideline was based on a very small dataset and is unlikely to be representative of the conditions at the Rastus Burn.
- Matheson *et al.*, (2012) recommended that there would be a low risk of periphyton biomass exceeding 50 mg/m² if DIN is maintained below 150 mg/m³ and DRP below 6 mg/m³. This guideline has been described as having reasonable performance but was designed and tested against the NIWA national river monitoring dataset only (Matheson *et al.*, 2016), and is again unlikely to be representative of the alpine conditions found within the Rastus Burn.
- Matheson, *et al.*, (2016) then went on to undertake further regression analysis and the report findings from the dataset used were more robust for dissolved inorganic

nitrogen (DIN) and total phosphorus (TP) rather than total nitrogen (TN) or dissolved reactive phosphorus (DRP). They presented proposed guidelines for the preceeding 12 months and the preceeding spring and recommended compliance with the 85%ile (presented in Table 1 below) and utilised NIWA and regional council datasets to derive the guideline values. The data used to establish the guidelines did not include poorly represented river environment classification (REC) classes such as the cool wet mountain source like the Rastus Burn.

- MfE (2020) provided updated guideline values in relation to the NPS-FM (2020) that was also released at that time. The regression analysis provided guideline values for REC climate and source of flow classes and a range of spatial exceedance options to be choosen from. For the purposes of this project, the 20% spatial exceedance guideline which provided a TN value of 90 mg/m³ and 0.3 mg/m³ for DRP was applied in Table 1 below. These guideline values were considered by the authors to be inherently uncertain and suggested only monitoring of periphyton can confirm the actual biomass present (MfE, 2020).
- Snelder *et al.*, (2022) used modelled data and regression analysis to derive guideline values for shaded and unshaded waterways based on REC climate and source of flow. Snelder *et al.*, (2022) provides a number of options based on the level of protection risk utilised by the project. We present the 20% under protection risk (80% protection) values in Table 1.

Table 1: Summary of relevant nutrient guideline values (mg/m³) to maintain <50 mg/m² of periphyton Chl α .

Nutrient	Biggs (2000)	Matheson <i>et al.</i> (2012)	Matheson <i>et al.</i> (2016)	MfE (2020)	Snelder <i>et al.</i> (2022)	
					Unshaded	Shaded
TN	na	na	na	90	35	165
DIN	10	150	100	na	13	114
TP	na	na	14	na	na	na
DRP	1	6	na	0.3	1	2
na = no nutrient concentration guideline suggested or data did not enable a useful guideline to be developed.						

6.1.2 Nutrient Guideline Value Recommendation

All of the methods outlined in Table 1 have pros and cons, but the consistent theme across the reports is that the data used to establish the regressions is largely based on data gathered from rivers (rather than streams) and the models used have an unknown level of error within them. Therefore, there are a number of reasons why these thresholds are unlikely to be particularly accurate for this section of the Rastus Burn. Primarily the data

used to create the thresholds is largely from larger rivers, at lower altitudes, with more turbid, warmer water from across the country (Snelder *et al.*, 2022). The Rastus Burn has cold water, a steep sided alpine catchment, fast turbulent flow and seasonal spring melt. Due to these reasons, all guideline options in Table 1 lack aspects of applicability to this stream (and activity) and therefore are not appropriate to be considered as a 'hard limit' for consenting purposes. The most applicable option of the above is to align the risk assessment of 'low' from Section 5 with the low-risk guideline values of 150 mg/m³ and DRP below 6 mg/m³ from Matheson *et al.* (2012).

Matheson *et al.* (2012) proposed periphyton risk bands to aid in decision making with regard to risk assessments. In alignment with this, the proposed approach is to utilise the low risk categories of <150 mg/m³ of DIN and <6 mg/m³ of DRP as initial trigger levels to then initiate further water quality investigations and periphyton surveys. We suggest these DIN and DRP values are more likely to reflect the actual potential of periphyton growth at this cold-water steep, incised waterway.

Table 2: Periphyton risk categories after Matheson *et al.* (2012).

Risk category	DIN (mg/m ³)	DRP (mg/m ³)
Very Low Risk	<50	<3
Low Risk	50 - 150	3 - 6
Moderate Risk	150 - 300	6 - 15
High Risk	>300	>15

6.1.3 Nutrient Guideline Value Use

Provided the total nutrient load from the expanded wastewater discharge in the Rastus Burn is maintained at the recommended levels (Section 4, Wastewater Quality-e3Scientific, 2026a), then the existing low periphyton cover is predicted to remain as the other key environmental drivers will generally remain the same (e.g. sunlight hours, water temperature, frequency of flushing events).

It is proposed that the DIN and DRP guideline values (Matheson *et al.* 2012) should only be used in an adaptive management framework rather than as a hard compliance limit to be met. This is because the data used to establish nutrient criteria for a known amount of instream periphyton varies greatly and in an unpredictable way. To illustrate this complexity, Figure 1 below (adapted from Snelder *et al.*, 2022) demonstrates a theoretical good dataset for regression analysis to identify a threshold relevant for a guideline where low periphyton biomass relates to low nutrient levels and high nutrient levels relate to high periphyton levels. However, the real datasets Matheson *et al.* (2016) used to establish nutrient:periphyton relationships vary in a much less predictable way with low nutrient levels

equating to high periphyton biomass almost as frequently as low biomass, and high nutrient levels relating to low algal biomass levels almost as frequently as high biomass (Figure 2). Therefore, it is reasonable to consider other algal growth factors to be equally as important if not more important than nutrients alone in this cold alpine stream.

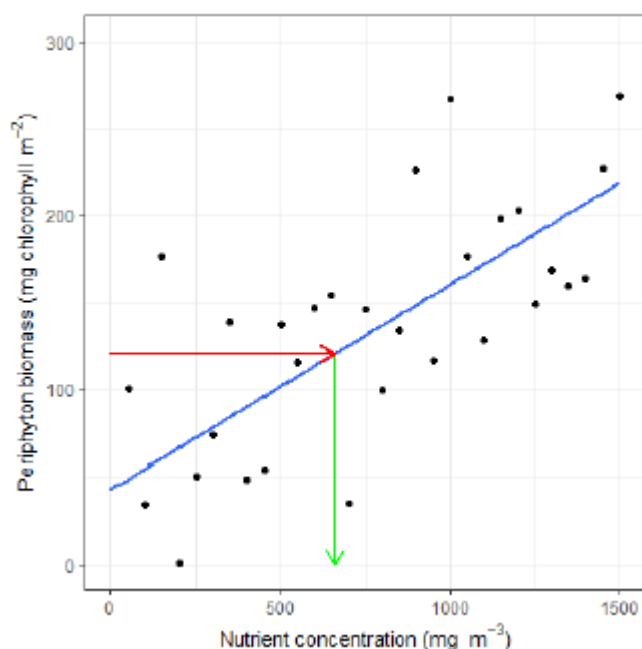


Figure 1: Stylised representation of nutrient criteria based on hypothetical data (Snelder *et al.*, 2022).

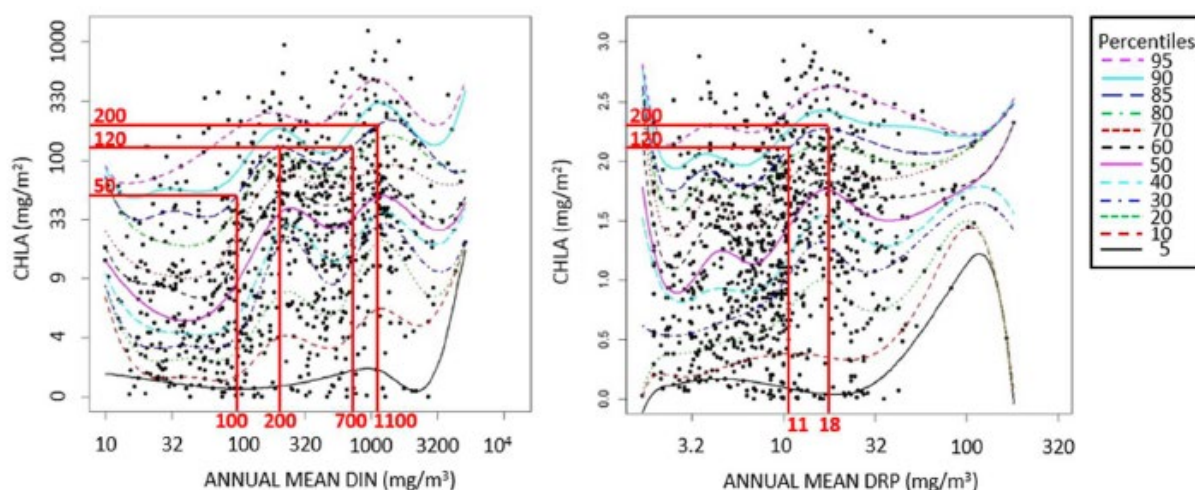


Figure 2: Actual data used for guideline development from Matheson *et al.* (2016).

6.2 Stressor (Nutrient) – Response (Periphyton Growth)

Key nutrients: DRP, DIN, ammoniacal nitrogen

The below assessment of current Rastus Burn nutrient status is undertaken in comparison to 150 mg DIN/m³ of and <6 mg DRP/m³ guideline values suggested by Matheson *et al.* (2012). It is expected that these nutrient guideline values will provide an indication of when further monitoring and assessment may be warranted. The periphyton threshold of <50 mg/m² of Chl *a* has been proposed and agreed upon by the ORC technical experts (Torlesse Environmental). This periphyton guideline level is lower than 120 mg Chl-*a*/m² which is typically used to maintain river aesthetics but is considered appropriate to maintain the current ecological status of the Rastus Burn based on the environmental characteristics described. The expert agreement of this Chl *a* threshold also recognises the non-standard attributes of the Rastus Burn and recognises that site-specific thresholds and targets are an acceptable approach for this location.

6.2.1 Dissolved Inorganic Nitrogen (DIN)

Summer/autumn nutrient concentrations are on average lower than winter/spring concentrations for DIN within the Rastus Burn (Figure 3). The higher DIN levels observed in winter align with the peak ski season discharge occurring. The periphyton risk bands proposed for DIN are overlayed with the measured Rastus Burn nutrient concentrations. The data demonstrates the majority (93%) of summer/autumn samples are within the low or very low periphyton risk band. For the winter and spring results there is a higher proportion (~30% of samples) that are within the moderate or high risk bands; however, during this time periphyton is limited by environmental constraints (temperature and light).

The majority (93%) of summer/autumn DIN concentrations are within the low or very low periphyton risk band and therefore it is very unlikely that periphyton growth will exceed the 50 mg/m² of Chl *a* threshold (Figure 3). Thus, while the water temperatures will be warmer than 10 °C in summer the overall concentrations of DIN are small, enabling an acceptably low level of periphyton growth. Therefore, summer DIN concentrations alone are not expected to lead to excessive growths that would alter the benthic biodiversity. In autumn the temperatures are typically cooler than 10 °C, so while concentrations may slightly increase as flows decrease, again the conditions are such that only an acceptably low level of periphyton growth occurs.

The winter/spring results show the majority (61%) of winter/spring samples are within the low risk band but approximately 30% of results demonstrate moderate or high risk (Figure 3). However, due to the very cold winter water temperatures (~3 °C) algal growth is very unlikely at that time.

Overall, the periphyton growth risk associated with DIN is low. However, it is proposed to undertake spring and autumn monitoring to confirm periphyton growths are low and maintain benthic biodiversity.

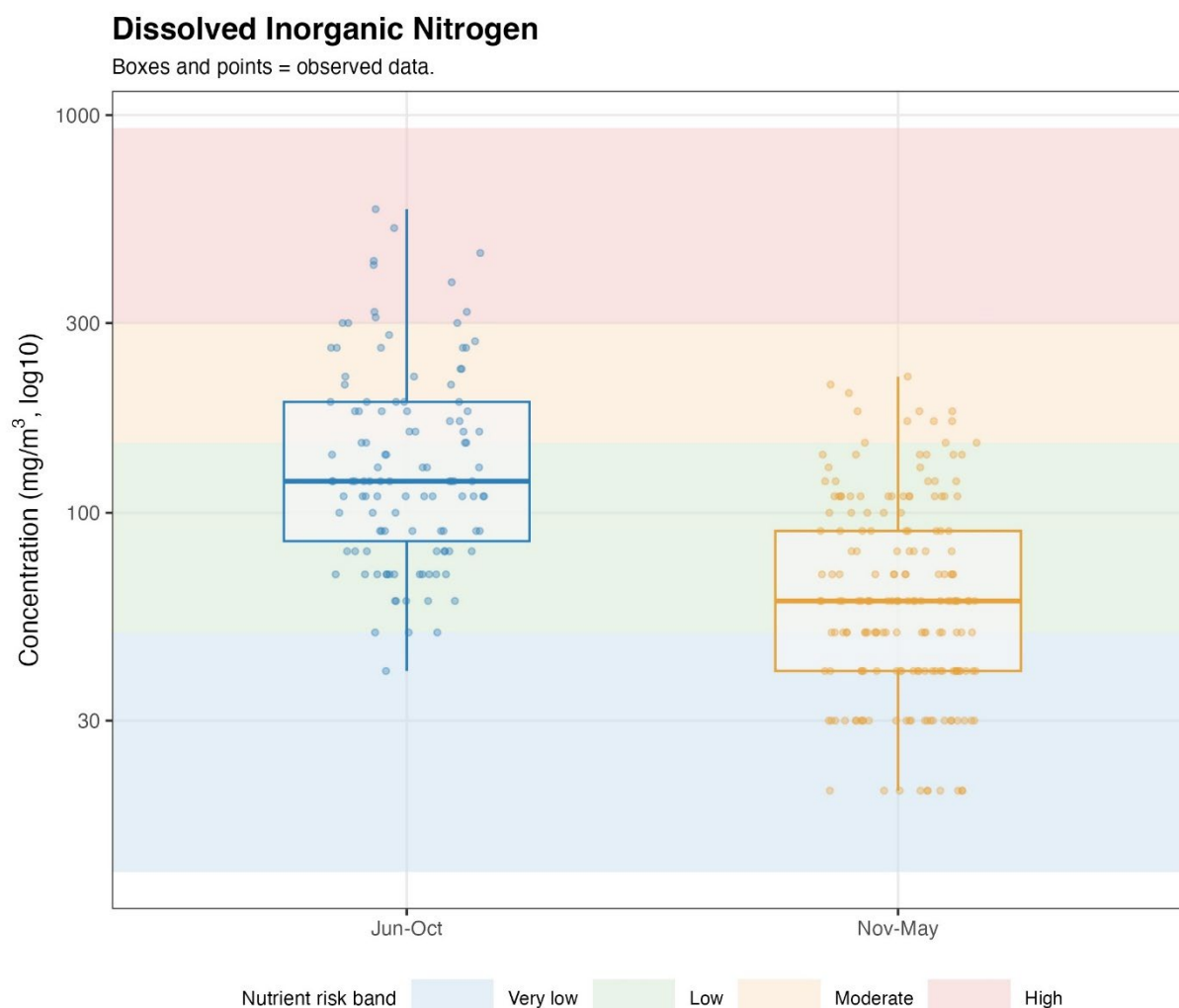


Figure 3: Seasonal dissolved inorganic nitrogen sample results from the Rastus Burn (modified from Ellis-Stanley (2026)) with DIN periphyton growth risk bands overlain.

The relationship between DIN and Rastus Burn flows suggests low confidence in a nutrient concentration curve based on the data collected to date. The DIN concentration curves across a range of flows was assessed by plotting measured DIN results from May 2025 to June 2026 against modelled flow for that same date. Flows were modelled based off the flow characteristics measured within the nearby Doolans Creek Right Branch. This modelled data add some uncertainty and the model may be improved once Rastus Burn water level loggers have been retrieved and a Rastus Burn rating curve established. The 2025/26 hydrological year was not a particularly low flow year and a relatively small sample result

dataset has been used along with modelled flow based on the Doolans Basin which may behave slightly differently.

There is a weak trend (with a low R^2 value) for dissolved inorganic nitrogen (DIN) concentrations to be generally higher when flows are lower (Figure 4 below). The modelled nutrient concentration curve suggests a peak in DIN concentrations at flows of $0.15 \text{ m}^3/\text{s}$ and then decreasing concentrations as flows increase (Figure 4). The data gives coarse guidance that the DIN levels are expected to remain below $150 \text{ mg}/\text{m}^3$ threshold predicted to maintain periphyton biomass below $50 \text{ mg}/\text{m}^2$ at intermediate flows (Figure 4). This data should be treated as a guide only, even so, DIN levels exceeding $150 \text{ mg}/\text{m}^3$ appear unlikely and are still unlikely to lead to periphyton growth of greater than $50 \text{ mg}/\text{m}^2$ of Chl *a* due to the cold water, steep catchment and regular flood events.

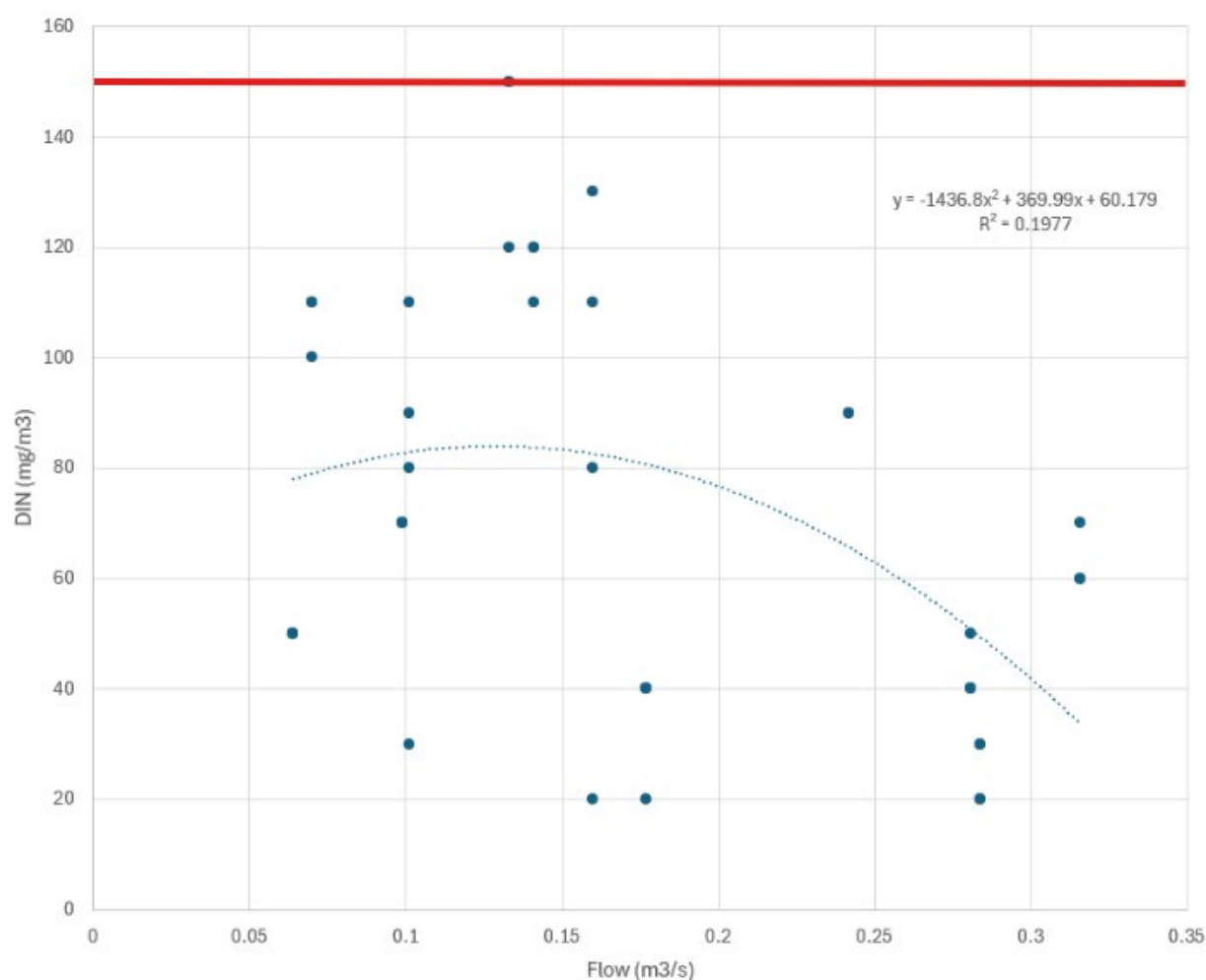


Figure 4: Dissolved inorganic nitrogen associated with modelled flow for the 2025/26 samples for all 4 monitoring sites. With DIN periphyton growth thresholds shown ($150 \text{ mg}/\text{m}^3$ from Matheson *et al.* (2012)).

Site specific DIN results have been interrogated to aid in identifying a suitable indicator site for consent conditioning. When assessing the consent monitoring sites individually, the

upstream site has the lowest dissolved organic nitrogen (DIN) levels, which then increase at the 50 m downstream and 200 m downstream sites before receding to levels similar to the upstream baseline by the 1500 m downstream site (e3Scientific, 2026a). There may be a short duration (spatially and temporally) increase in DIN levels; however, current data demonstrates the nutrient levels return to that of the upstream baseline by 1500 m downstream.

6.2.2 Dissolved Reactive Phosphorus (DRP)

Overall, summer/autumn and winter/spring DRP concentrations from all monitoring locations show very similar ranges and medians (Figure 5).

The summer/autumn results show the majority (75%) of summer/autumn samples are within the low or very low periphyton risk band. With the majority of nutrient concentrations falling within the low to very low risk category, it is very unlikely that periphyton growth will exceed the 50 mg/m² of Chl *a* threshold.

The winter/spring results show the majority (68%) of winter/spring samples are within the low-risk band but approximately 25% of results demonstrate moderate or high risk (Figure 5). However, due to the very cold winter water temperatures (~3 °C) algal growth is very unlikely at that time.

While 25 to 30% of samples across all seasons exceed the low risk band threshold it is unlikely that this will lead to excessive periphyton growth. This is because even in when water temperatures are warmer than 10°C other factors are more important than nutrient concentration alone, such as the amount of light reaching the streambed, the algal taxa present and the flow regime. This is demonstrated by prolific algal growths not being observed previously which suggests that dissolved reactive phosphorus (DRP) is not as important as other factors such as flow regime, light and water temperature for algal growth at this location. Therefore, there is a low periphyton growth risk associated with DRP.

Dissolved Reactive Phosphorus

Boxes and points = observed data.

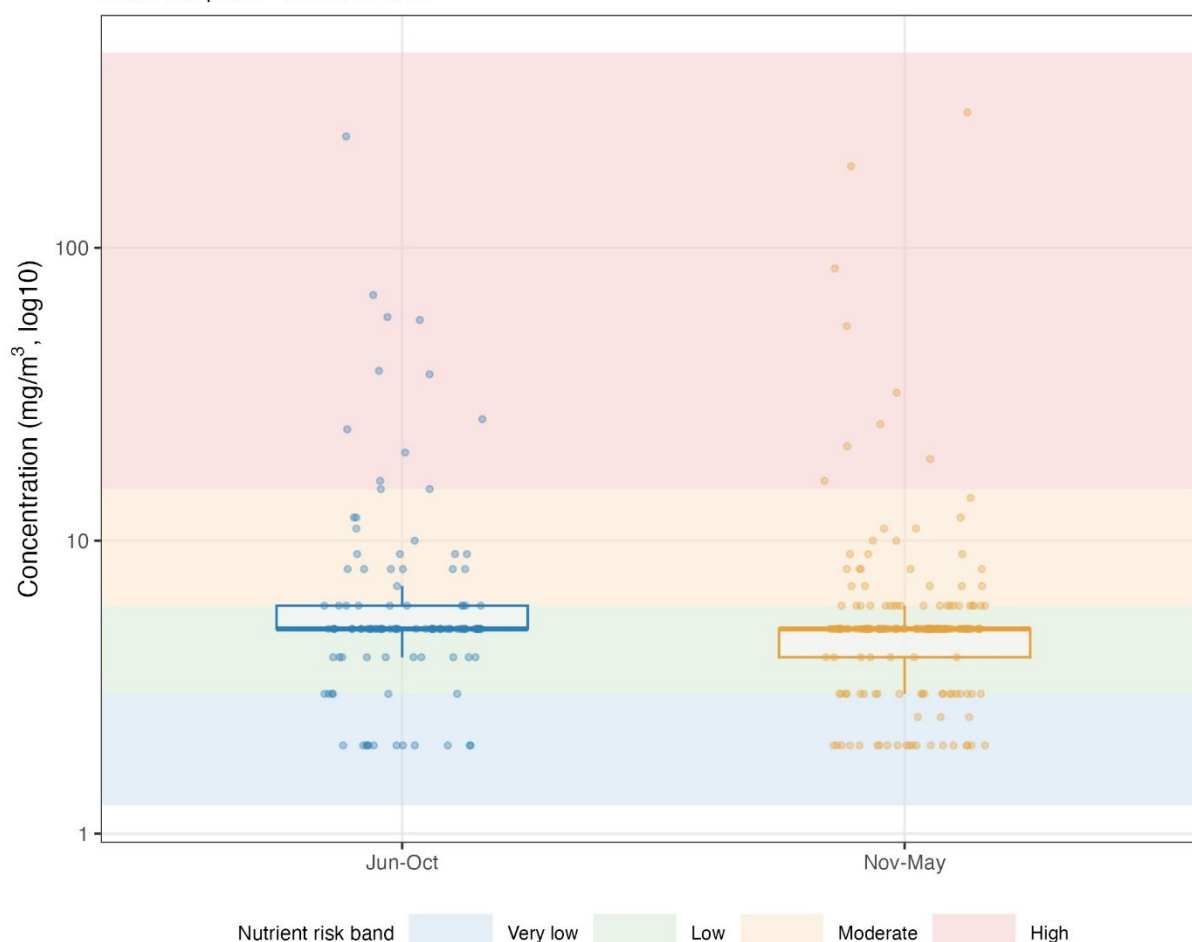


Figure 5: Seasonal dissolved reactive phosphorus sample results from the Rastus Burn (modified from Ellis-Stanley, (2026)) with DRP periphyton growth risk bands overlain.

The relationship between measured DRP and modelled Rastus Burn flows does not provide a high R^2 , this means most of the scatter on the graph is not accounted for by the flow variable, flow does not describe changes in DRP well and therefore suggests low confidence in the nutrient concentration curve. The DRP concentration curve plots measured DRP results from May 2025 to June 2026 against modelled flow for the same dates. As described previously flows were modelled using data from Doolans Creek Right Branch. This timeframe is used as flow data is available for Doolans Creek Right Branch as part of the wider Remarkables Ski area development. Therefore, some uncertainty remains with regard to the accuracy of the modelled flow.

There is a weak trend (with a low R^2 value) for dissolved reactive phosphorus (DRP) concentrations to be generally higher when flows are lower (Figure 6). For the reasons described above the nutrient:flow curve should be used to give an indication only of the

nutrient concentrations at a given flow rate. However, Figure 6 suggests there are generally lower DRP concentrations at higher flow rates.

All samples collected since May 2025 have been within the low-risk band (Figure 6), suggesting that regardless of flow rate, DRP is unlikely to be an issue for the Rastus Burn.

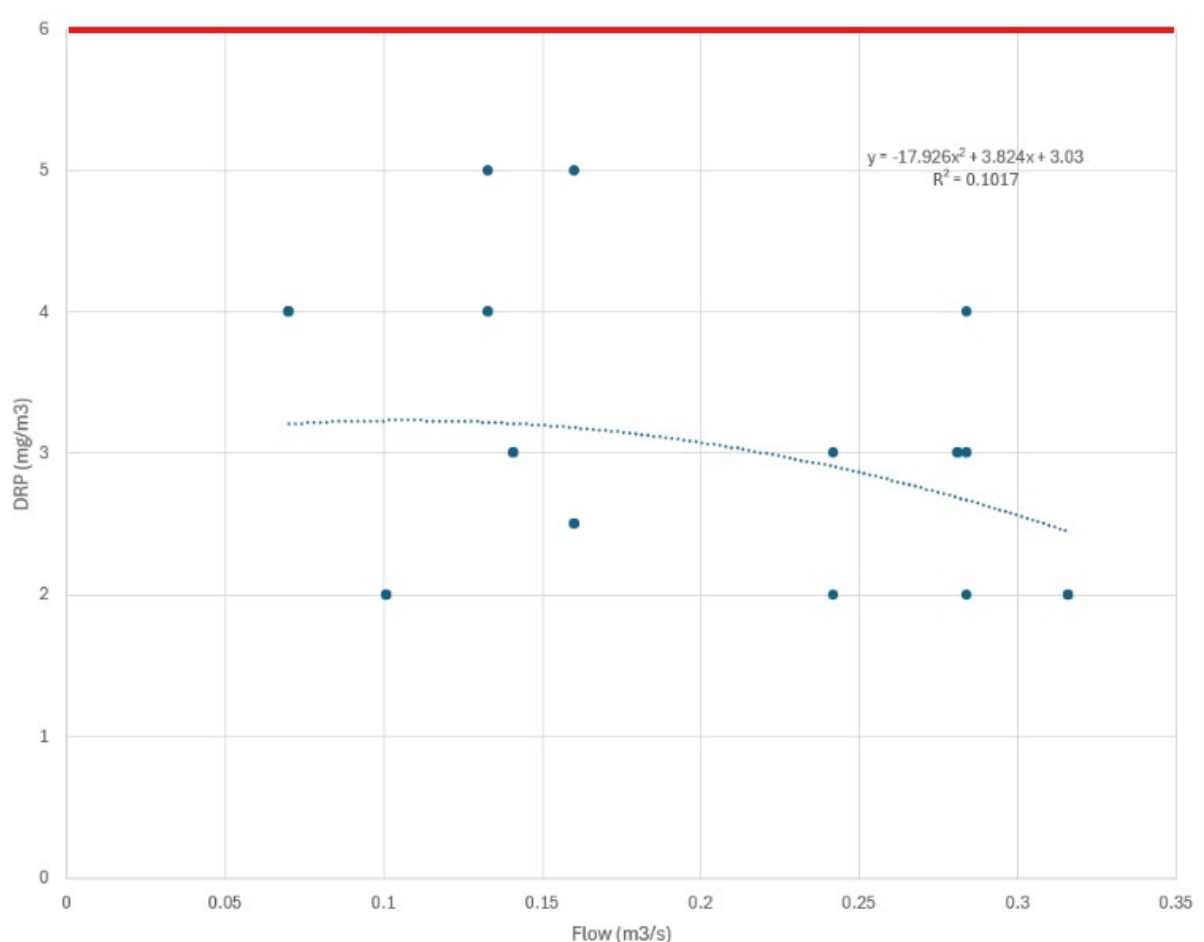


Figure 6: Dissolved Reactive Phosphorus for the monitoring sites associated with modelled flow for the 2025/26 samples for all 4 monitoring sites. DRP periphyton growth threshold shown (6 mg/m³ from Matheson *et al.* (2012)).

6.2.3 Light–Nutrient Interaction

Riparian cover and turbidity are low. A review of historical satellite imagery (Google Earth) demonstrates that the upstream Control Site receives significant shading from the mountainside to the east from June to August. The sites 50 m and 200 m downstream are significantly shaded from June to September when the highest instream nutrient concentrations are observed, while the 1500 m downstream site is not shaded (unless covered in snow) but as noted previously, concentrations have generally decreased to near background by 1500 m downstream of the discharge.

6.2.4 Flow–Nutrient Interaction

There are 11 flood events per year predicted for the Rastus Burn (NIWA, 2026). This relates to just less than one per month, although they are likely to be concentrated around snowmelt and spring storm events.

6.3 Stressor – Response Summary

Based on the assessment of risk being low and the low applicability of several NZ guidelines, Matheson *et al.* (2012) guideline values of $<150 \text{ mg/m}^3$ of DIN and $<6 \text{ mg/m}^3$ of DRP, based on a low periphyton growth risk assessment are utilised alongside the expert agreed upon $<50 \text{ mg Chl-a/m}^2$. Section 6.2 shows the current (and proposed) DIN and DRP concentrations are not anticipated to result in an exceedance of the periphyton guideline $<50 \text{ mg/m}^2 \text{ Chl a}$ due to the discharge activity.

Instream nutrient concentrations are higher in winter and spring coinciding with peak wastewater nutrient load discharged to land, however the excess nutrients are not expected to enable excessive periphyton growth due to other limiting factors (sunlight, water temperature, floods). Further to this, the nutrient:periphyton interaction is not linear due to photosynthesis requirements, light availability, flow regime and water temperatures that are more strongly linked to periphyton biomass accrual than nutrients alone. During warmer temperatures where more light is available, DIN and DRP concentrations are primarily within the low or very-low risk band.

Therefore, the proposed use of nutrient guidelines in an adaptive management framework supported by biennial spring and autumn biological monitoring events is a suitably conservative approach for assessing whether periphyton growth rates are low benthic biodiversity is maintained.

7 Mitigation Measures

7.1 Adaptive Management Triggers

The project proposes to monitor DIN and DRP from 1 November to 31 May (off-season) as this is the time of year when periphyton growth is possible, based on environmental limiting factors of water temperature and light. Nutrient contributions to the Rastus Burn are expected to remain low at this time of year and the periphyton risk from the activity remains low. Nevertheless, monitoring of nutrients across the off-season is proposed via a trigger

and response system. This allows for monitoring to potentially initiate further investigation and then management actions, if ecological thresholds are exceeded (Table 3).

This periphyton assessment has outlined that DIN concentrations of $>150 \text{ mg/m}^3$ or DRP concentrations of $>6 \text{ mg/m}^3$ from Matheson *et al.* (2012) are appropriate trigger levels to maintain low periphyton biomass, at this location. If initial trigger levels are exceeded the response to collect further water samples is to identify if nutrient concentrations are ambient or if this was a discrete, short, spike in concentration or laboratory anomaly. Ambient concentrations are more likely to result in an ecological (periphyton or macroinvertebrate) shift, whilst a one-off, discrete spike in concentration will not. Whilst undertaking this additional sample, observations of periphyton cover will assist in quickly understanding the nature of the exceedance (ambient or discrete). The results of this visual observation can also initiate trigger 2 responses, as if $>10\%$ cover of periphyton is observed, it is more likely that the water sample does represent ambient conditions (Table 3). This allows for management responses to be actioned faster resulting in reduced likelihood of ecological effects.

Macroinvertebrates are the last ecological indicator to be affected in this response train, as communities will take time to exhibit an alteration based on nutrient input and periphyton presence (food source). However, if changes are identified then a full review of the wastewater treatment system and onsite practices is warranted, and to be undertaken with actions to remedy the source of the nutrients and periphyton growth to be provided to the Otago Regional Council (ORC) for certification within 20 working days of the macroinvertebrate sampling results.

Table 3 provides a summary of the above triggers and associated management actions.

Table 3: Summary of proposed monitoring, triggers and response actions.

Trigger		Response
Trigger 1	<p>If a monthly water quality monitoring result collected between 1 November and 31 May ($n=7$) at any downstream site exceeds the site-specific trigger limit for:</p> <ul style="list-style-type: none"> - Dissolved inorganic nitrogen (DIN) of $>150 \text{ (mg/m}^3\text{)}$; and/or - dissolved reactive phosphorus (DRP) of $> 6 \text{ (mg/m}^3\text{)}$. 	<ul style="list-style-type: none"> - Undertake an additional water quality monitoring round, including temperature and visual assessment of periphyton cover. and; - Review of nutrient exceedance against upstream sample results within 2 weeks of receiving the of the water quality results.

Trigger		Response
Trigger 2	If monitoring required under Trigger 1 response also demonstrates an exceedance of the nutrient triggers OR If obvious (>10% cover) periphyton is observed	- Undertake Chl <i>a</i> sampling (Periphyton monitoring).
Trigger 3	If monitoring required under Trigger 2 demonstrates an exceedance of the periphyton trigger (50 mg/m ² Chl <i>a</i>).	- Undertake macroinvertebrate sampling and review results against the upstream control, if macroinvertebrate metrics of two of the three metrics are 10% lower in comparison to the upstream control this would be deemed an adverse ecological impact. - An audit and review of the wastewater treatment system and onsite practices to identify the reason for any elevated nutrient concentrations, and any potential measures to reduce them. This assessment is to be supplied to ORC within 20 working days of the trigger exceedance. - Provide a response plan to ORC within 3 months of receiving the results. The plan should include a review of the relevant wastewater treatment measures and the likely source of the periphyton exceedance and propose remedial actions.

7.2 Monitoring Considerations

The thresholds of 150 mg/m³ DIN or 6 mg/m³ of DRP at each downstream consent monitoring site should be assessed alongside the upstream control site nutrient concentrations. It is recommended that a 3-yearly review of the DIN and DRP triggers is undertaken and these values can be refined as more site-specific data becomes available through time. If reviews find the thresholds are not appropriate an alternative approach could be to consider the 80%ile of the upstream control site DIN and DRP concentrations. This would aid in confirming if the elevated DIN and DRP are associated with the wastewater discharge or within natural variability for reference conditions.

Periphyton monitoring shall also include an assessment of algal taxa present. If didymo is present and is deemed the cause of periphyton (Chl *a*) limits to be exceeded, then this should be assessed and addressed within the reviews. Therefore, further actions would then only be recommended if the assessment deems the didymo unrelated and to not greatly influence the Chl *a* readings.

8 References

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Appendix 1: Total Nitrogen (TN)

This report makes the decision to use the periphyton risk bands developed by Matheson *et al.*, (2012) which utilises DIN and DRP as the primary nutrients that control periphyton growth below 50 mg/m². Therefore, these nutrients are assessed for the proposed periphyton bands throughout this report. However, total nitrogen information is attached here for completeness.

Summer and autumn median total nitrogen concentrations are currently below two of the three proposed TN guidelines (Figure 10). Noting that these guidelines have limitations regarding applicability to this site as discussed in Section 6.1 and are therefore not utilised to set thresholds for this activity. Seasonal data shows winter and spring to have the greatest total nitrogen concentrations.

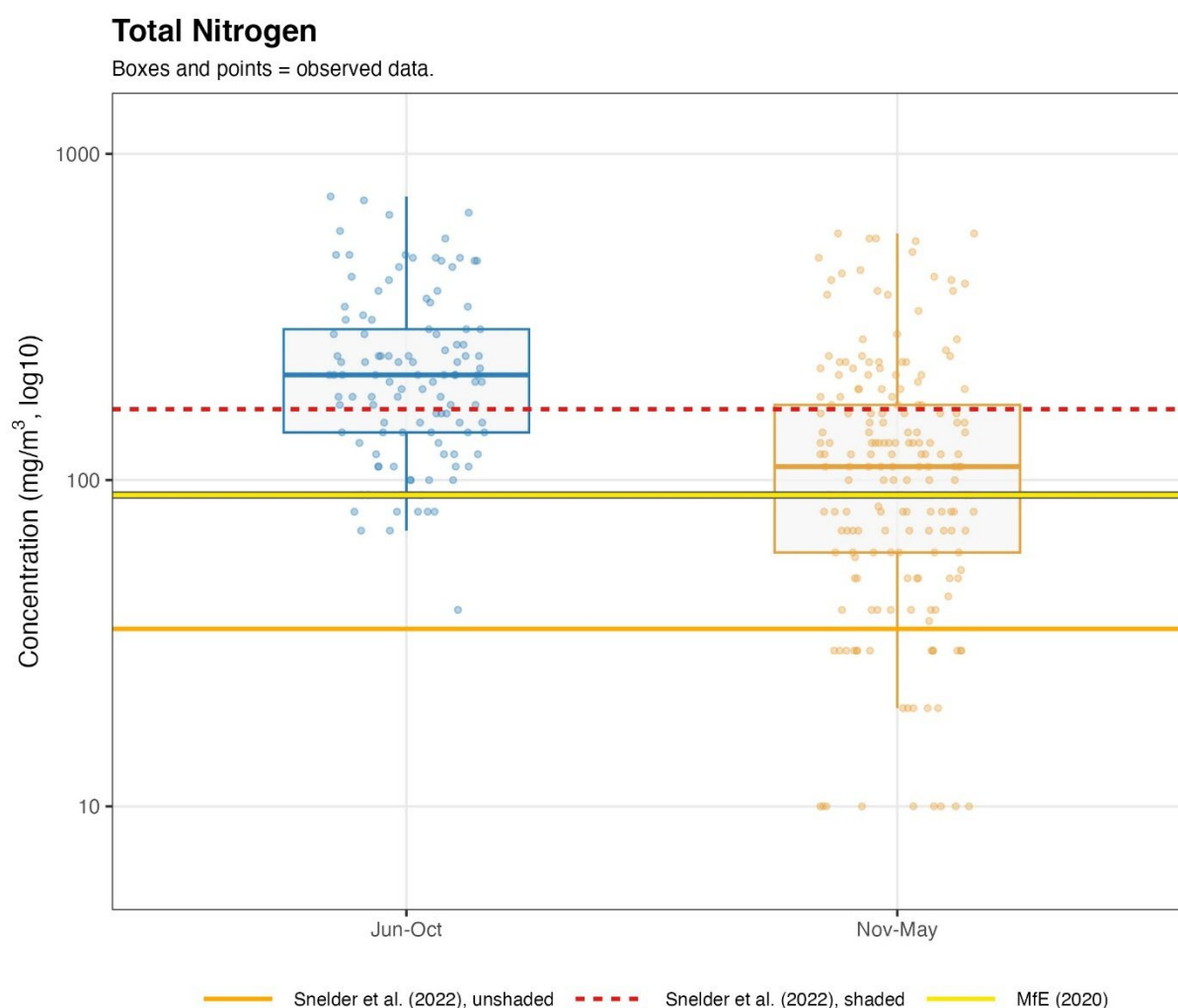


Figure 7: Total Nitrogen seasonal data with nutrient thresholds shown.

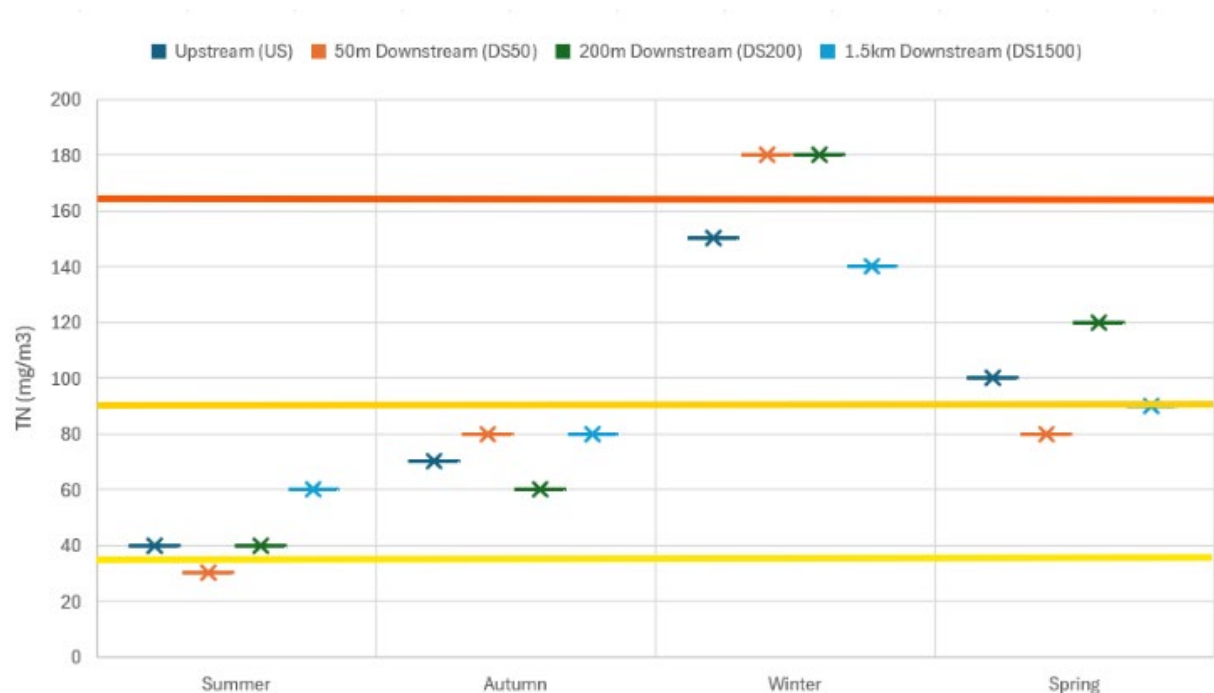


Figure 8: Median total nitrogen (TN) concentration at the monitoring sites by season (e3scientific 2026a) with periphyton growth thresholds shown (35 mg/m³ for unshaded waterway, 165 mg/m³ for shaded waterway from Snelder *et al.* (2022); and 90 mg/m³ MfE (2020)).