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**Remarkables Ski Area
Upgrade and Doolans
Expansion -
Wastewater Discharge
Impact Assessment**

NZSki Remarkables

May 2026



Arrow Lane Arrowtown 9302

www.e3scientific.co.nz

**Remarkables Ski Area Upgrade and Doolans Expansion -
Wastewater Discharge Impact Assessment**

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Executive Summary

NZSki is seeking consent to increase wastewater volumes discharged to land at The Remarkables Ski Area to support the proposed expansion into the Doolans Basin. This report assesses the performance of the existing onsite wastewater management system (OWMS), characterises the receiving environment, and evaluates the likely effects of accommodating additional wastewater through an upgraded treatment system.

The current OWMS includes the discharge of effluent to land via infiltration basins located on a terrace above the Rastus Burn. Historical monitoring (2015–2025) shows that while the discharge contributes detectable nutrient and microbial signals in groundwater and surface water during the ski season, the impacts are acceptable with biological monitoring reporting good to excellent ecological health.

Monitoring wells updated and installed in 2026 have improved the understanding of groundwater gradients, flow paths, and the depth of the unsaturated zone beneath the infiltration basins. The preliminary results confirm a shallow groundwater system within alluvial/colluvial deposits over bedrock, with a steep groundwater gradient to the north and west toward the Rastus Burn.

Establishing for the relationship between nutrient loads and ecological condition allows for the identification of environmental thresholds and the development of performance criteria to maintain good to excellent conditions instream. These findings underpin the performance criteria of an upgraded treatment system required to support the additional wastewater volumes from the Doolans extension. This likely includes upgrading the OWMS to a secondary treatment system with nutrient removal, capable of meeting these performance criteria while accommodating increased wastewater volumes.

Some uncertainties remain around seasonal groundwater behaviour, flow metering accuracy, and variability of the discharge quality. These will be addressed through further investigations and with monitoring and operational refinements. Overall, the assessment finds that the proposed increase in wastewater discharge, when paired with an upgraded treatment system and adherence to the recommended performance criteria, will result in an acceptable level of adverse effects on soils, groundwater, surface water, wetlands, or aquatic ecology and will maintain the good to excellent ecological health of the Rastus Burn.



1 Introduction

NZSki is seeking consent to extend its skifield operations to the backcountry terrain of Doolans Creek headwaters, which increases the number of skiers and associated service infrastructure. In particular, the additional wastewater that will be generated is proposed to be managed by pumping it back to the Remarkables Skifield and the onsite wastewater management system therein (OWMS) (Stantec, 2026).

This report provides an assessment of the existing discharge to land and the effects on the receiving environment to inform the assessment of the potential effects of discharging an increased volume of effluent to land. To complete this assessment, we have reviewed the compliance monitoring dataset (section 4), conducted supplementary site investigations (section 3 and 4), reviewed available desktop and previous site investigations by others (section 3 and 4), and reviewed the available information about the proposed activity (section 2).

1.1 Scope of Work

In December 2025, e3s completed a desktop review of the Remarkables wastewater discharge site and available information (e.g. compliance monitoring data) to understand the effects of the current OWMS. Additional work was recommended based on the findings of the desktop assessment to enable consenting for additional wastewater inputs from the Doolans expansion into this discharge location. This report summarises the previous reporting in addition to completing the following scope of work to support the consent application:

- Drilling of additional monitoring wells (only one of the monitoring wells was intercepting groundwater);
- Groundwater sampling of wells to determine current groundwater conditions and flow paths;
- Development of a flow rating curve for the Rastus Burn by completing flow gauging events to assess the potential change in contaminant concentration as the Rastus Burn flow changes;
- Analysis of the discharge and receiving water flows and quality data to develop a conceptual model of contaminant flow paths and likely attenuation and dilution rates;
- Identification of any uncertainty and risks associated with the conceptual site model and providing a list of actions required to mitigate those risks; and



- Preparation of Assessment of Effects for wastewater discharge to land to support consenting.

1.2 Limitations

The findings of this report are based on the Scope of Work outlined above. e3Scientific Limited (e3s) performed the services in a manner consistent with the normal level of care and expertise exercised by members of the environmental science profession. No warranties, express or implied, are made. The confidence in the findings is limited by the Scope of Work.

The results of this assessment are based upon compliance monitoring data provided by NZSki, preliminary site investigations conducted by e3s personnel, and reviews of available desktop information and information provided in other consultant's reports. All conclusions and recommendations regarding the properties are the professional opinions of e3s personnel involved with the project, subject to the qualifications made above. While normal assessments of data reliability have been made, e3s assumes no responsibility or liability for errors in any data obtained from regulatory agencies, statements from sources outside e3s, or developments resulting from situations outside the scope of this project.

1.3 Code of Conduct

The authors of this report are Simon Bloomberg and Jamie Lynds with reviews from Mark Hamer and Alexandra Badenhop.

Simon Bloomberg (MSc Hons) is an Earth system scientist focussing on geochemistry with 10+ years' experience in the environmental and natural resource sectors. Simon has led technical projects for high-level contaminated site classification, Preliminary and Detailed Site Investigations for contaminated land projects, surface water and groundwater risk assessments to support discharge consents, soil and landfill gas assessments, and site and soil assessments to support land developments which require onsite wastewater services. Simon provides technical science advice and peer review of contaminated land and discharge to land resource consents. At e3s, Simon contributes to both the Water and Environmental Management and Contaminated land teams and collaborates on multidisciplinary projects with the ecological teams.



Jamie Lynds is a Hydrologist with a background in Regulatory Compliance and field-based environmental and ecological monitoring. She holds a BSc (Geography and Environmental Management), PGDipSc (Geography) and a MSc (Geography) where her research focussed on the human impact on drought on the Ōmakō/Lindis River.

Mark Hamer is a professional freshwater ecologist with over 17 years' experience working in the freshwater ecology and monitoring industry. Freshwater biomonitoring proficiency and experience includes wetland delineation, water and sediment quality assessments, eDNA, river periphyton, aquatic plant identification, riparian habitat assessment, macroinvertebrate collection and analysis. Freshwater fish monitoring using electric fishing, netting or spotlighting methods along with associated fish handling, analysis and fish passage assessments. At e3s for the past 3 years Mark's focus has been on ecological value assessments and reviewing and producing ecological impact assessments in the consenting process. He has been an expert witness at consent hearings and is a current member of the New Zealand Freshwater Sciences Society.

Alexandra Badenhop – Technical Director (Water and Environmental Management)
Alexandra is an environmental engineer with over 20 years' experience working in the water industry. Prior to commencing work with e3s in 2015, Alexandra was employed as a consulting environmental engineer by the Water Research Laboratory, University of New South Wales, Australia (2004-2014). Her experience encompasses a range of engineering studies, including hydrogeochemistry and water quality assessments, literature and program reviews, wetland characterisation, groundwater testing and feasibility studies and numerical modelling. As the Technical Director -Water & Environmental Management team at e3s, Alexandra is responsible for groundwater and surface water supply and water quality assessments, technical reviews for regional councils, assessing and reviewing discharges to land, assessment of environmental effects, project management and environmental risk assessments. She has a B.Eng (Environmental)(Hons 1) and M.Eng.Sci (Groundwater Studies) which also fulfilled the criteria for M.Eng.Sci (Water Quality) and enjoys collaborating on multidisciplinary projects with the ecology team.

We confirm that we have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2023. This report has been prepared in compliance with that Code, as if it was expert evidence presented in proceedings before the Environment Court. Unless we state otherwise, this report is within our area of expertise, and we have not omitted to consider material facts known to either of us that might alter or detract from the opinions expressed in this report.



2 Proposed Activity

2.1 Current Consent

The current consent RM14.336.01 is to “discharge treated wastewater to land for the purpose of disposal of treated wastewater and water supply by wash from the Remarkables Ski Field buildings” which expires on the 10 April 2030.

Condition 3 states that the maximum daily discharge volume is 127.44 m³/day including by wash water and the rate of application shall not exceed 20 mm/day in any part of the disposal area.

Condition 4 and 7 require the reporting of wastewater flow volumes and water quality sampling. Condition 8 sets out the required analytical suites for the water quality samples.

In terms of performance monitoring, there are no other numerical limits or even qualitative limits however Condition 10 states that if any downstream water quality sample results are greater than the upstream results, and are indicative of a decline in water quality downstream of the dispersal field then “the consent holder shall provide to the Consent Authority within 7 working days of receiving the sampling results a written explanation outlining the potential causes of the increase and any solutions to stop the decline in water quality”.

Condition 11 requires biological monitoring to be undertaken at no more than two yearly intervals to survey the Rastus Burn from the Upstream monitoring location to the downstream monitoring locations. The survey is to determine the effects on the aquatic ecosystem of the Rastus Burn. The survey must occur no later than 30th November each year, and must include the four monitoring locations (Upstream, Downstream 50m, Downstream 200m, Downstream 1.5km).

The discharge is proposed to continue to operate under a similar set of conditions (except for Condition 10) until 31 May 2029, when visitor numbers will increase to a maximum of 6,000 per day (e.g. Table 1).



2.2 Proposed Discharge

NZSki propose to discharge an increased volume of wastewater to the dispersal fields to cater for the planned increase in skifield capacity. To minimise adverse environmental effects, the OWMS is to be upgraded. This section summarises the design flows (Table 1) and potential treated effluent quality (Figure 1) required to meet the preliminary performance criteria including maintaining nutrient loads to the Rastus Burn.

Analysis of the performance criteria goals and their derivation is described further in Section 4.6.

2.2.1 Wastewater Flow Limits

Stantec (2026) report the current and forecasted wastewater flows as:

Table 1. Forecasted Wastewater Flows (Stantec, 2026)

| Site Wide Occupancy | Peak Skiers/day | L/Person/Day | m ³ /day |
|---|-----------------|--------------|---------------------|
| Current Occupancy | 3,500 | 32.5 | 127,440 |
| Anticipated Occupancy - Doolans Expansion | 6,000 | 34 | 204 |

The currently consented discharge is 127.44 m³/day, with planned increase to 204 m³/day to cover the peak day discharge for ski field expansion.

2.2.2 Potential Upgraded Wastewater Treatment System Design Discharge Criteria

To ensure the increase in wastewater volumes does not result in an increased contaminant load to the environment, the upgraded OWMS is required to meet design discharge criteria which are to be similar to that of Jack's Point e.g. Figure 1.

| Estimated discharge limit | Value | Unit |
|---------------------------|-------|------------|
| cBOD ₅ < | 20 | mg/L |
| TSS < | 30 | mg/L |
| TN < | 30 | mg/L |
| TP < | 15 | mg/L |
| E. coli < | 1,000 | MPN/100 mL |

Among these, total nitrogen (TN) is expected to be the limiting parameter influencing system design complexity and energy demand, particularly under cold conditions. These values have been provided by Innoflow and are based on comparable local developments and recent consent limits from Jack's Point, Mt. Cardrona Station, Coronet Peak, and Gibbston Valley Winery.

Figure 1. Proposed Design Discharge Criteria (Reported by Innoflow; Stantec, 2026)



It's likely that a lower TP limit than 15 g/m³ would be required to ensure compliance with the proposed baseline performance criteria for TP e.g. 85 kg TP/5-year maximum. However, these criteria are subject to revision following further investigations during the 2026 ski season.

2.2.3 Wastewater Treatment Design

Table 2 summarises the alternative treatment options that were assessed by Stantec (2026) for the planned treatment upgrade; the likely OMWS upgrade option (option 5a) is a secondary treatment system with nutrient control (similar to the Coronet Peak system). While it is to be confirmed through further analysis and design work, Stantec (2026) state that with the conceptual designs 5a and 5b, it will be possible for NZSki to increase skier patronage and wastewater influent volumes and strength while maintaining the current water quality and ecological ecosystem health rating of good-excellent in the Rastus Burn.

Table 2: MCA tool output for alternative options assessment (NZSki, 2026)

| Option | Description | Nutrient Control | Relative Capital | Assessment Position |
|--------|------------------------------|------------------------------------|------------------|-----------------------------------|
| 1 | Do Nothing | None | Very Low | Discounted |
| 2 | Operational Improvements | None (stability only) | Low | Stage 1 – Required |
| 3 | Upsize Primary Capacity | None | Moderate | Discounted |
| 4 | Secondary Treatment | Incidental reduction | Moderate | Stage 2 – Foundational Upgrade |
| 5a | Secondary + Nutrient Control | Active control of nutrient loading | Moderate–High | Stage 3 – Preferred Configuration |
| 5b | Enhanced Nutrient Reduction | High (active reduction) | High | Stage 4 – Contingency Only |
| 6 | Downhill Discharge | Dependent on plant | Extreme | Discounted |



3 Site Environmental Context

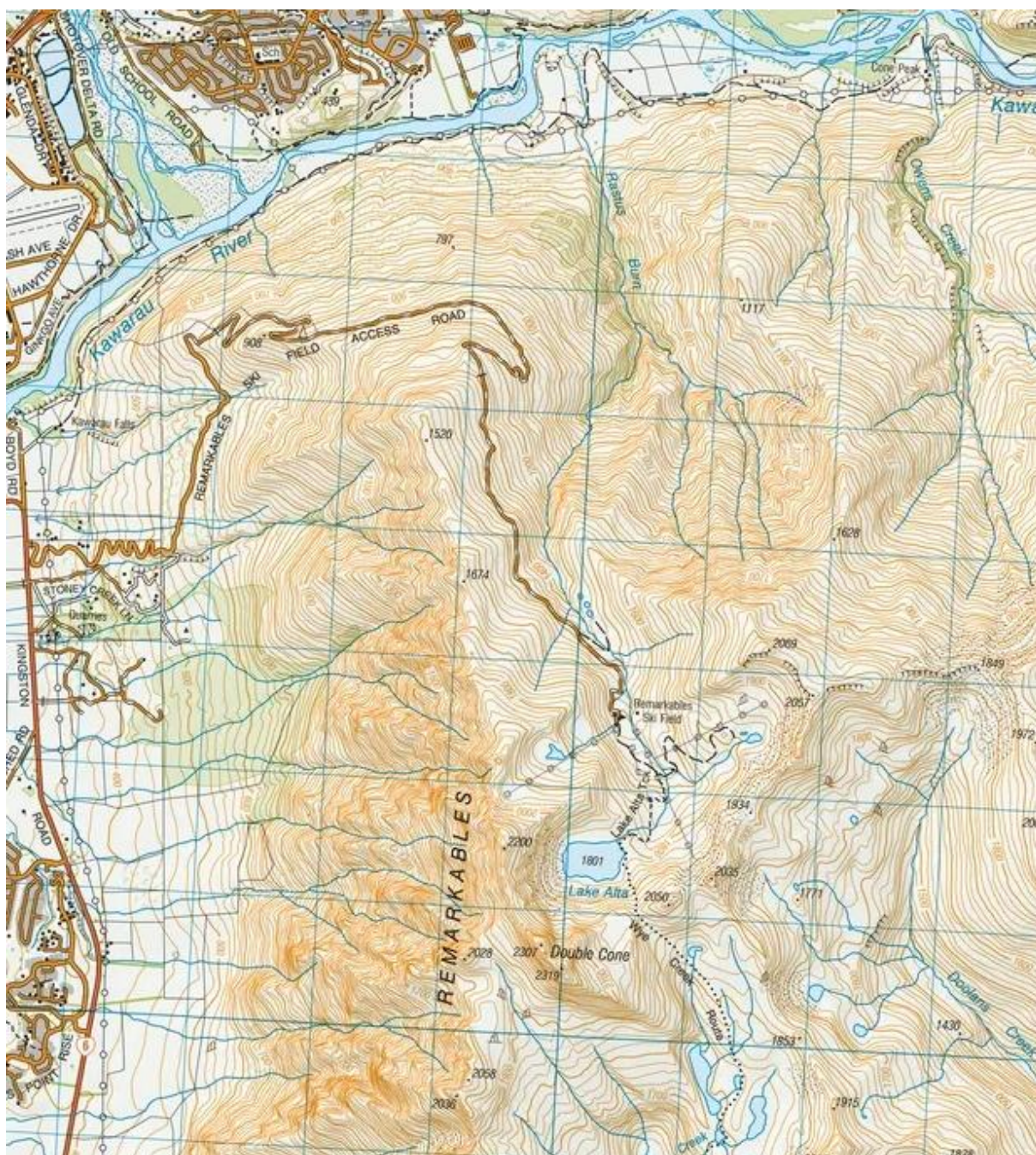


Figure 2. Site Topography © 2026 CC BY 4.0 Land Information New Zealand (LINZ).

The dispersal field lies within the Remarkables Conservation Area within the Rastus Burn Catchment (Figure 2). The Rastus Burn catchment has been developed to support The Remarkables ski field with ski lifts, roading, car parks and ski field buildings; however, there are still areas of undisturbed wetlands, lakes, and alpine terrain. The upper catchment is used for recreational alpine activities all year round however the Rastus Burn is not known for any swimming or fishing values. Further discussion of the aquatic ecology and values therein is included in section 3.7 below.



The catchment ranges from 2,300 mASL at its highest to 315 mASL at the confluence with the Kawarau River (See Photo's 1-6). The onsite wastewater treatment plant is located near the base building at 1600 mASL with the dispersal field lower down at 1440 mASL (Figure 1). The site is well described by Ryder (2014) and MWH (2014), and the site and its operation has not significantly changed since the 2014 upgrades.

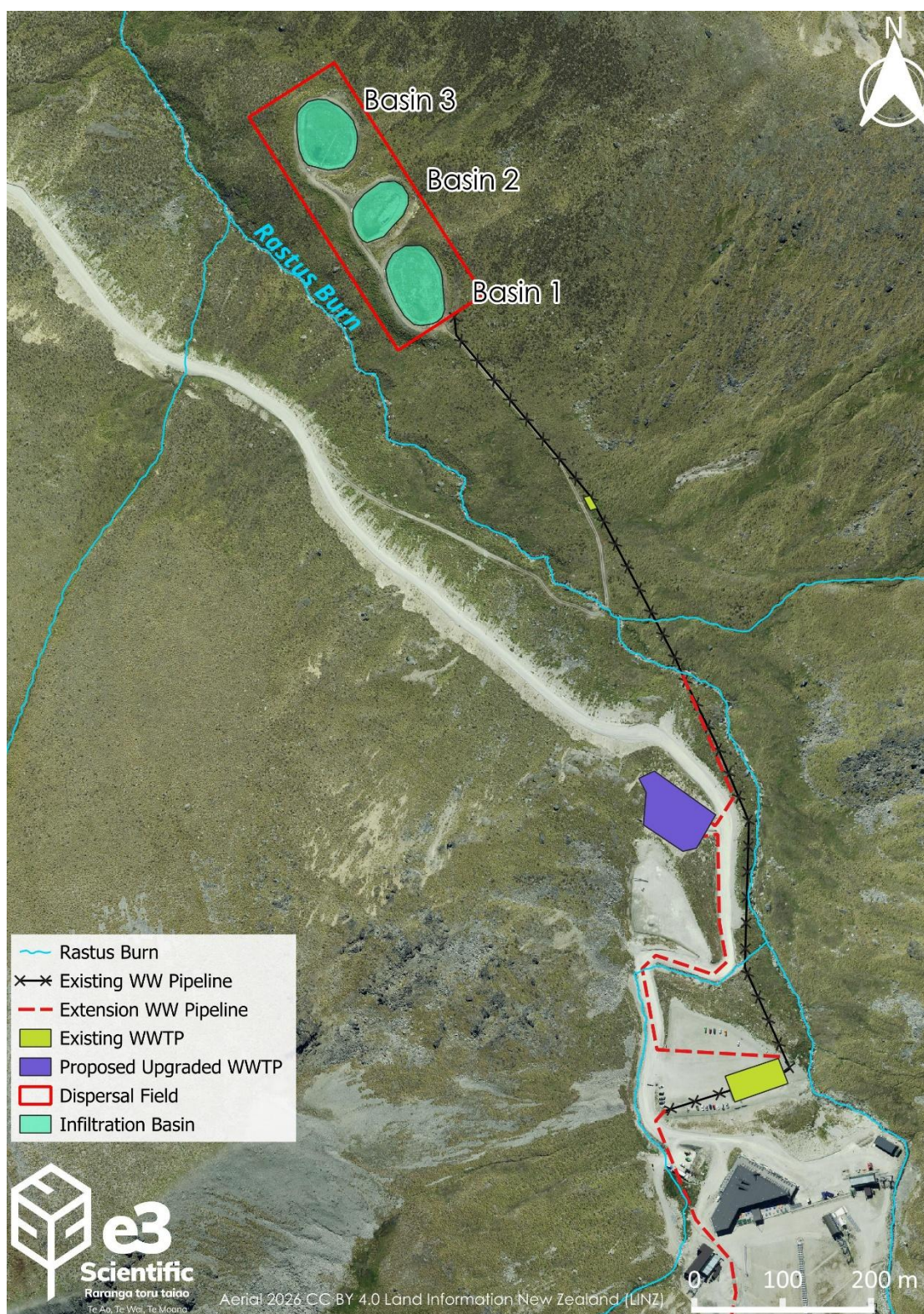


Figure 3: Site overview. .



Photo 1. Rastus Burn 'Upstream' Monitoring Site, View Upstream (South)



Photo 2. Rastus Burn 'Upstream' Monitoring Site, View Downstream (North).

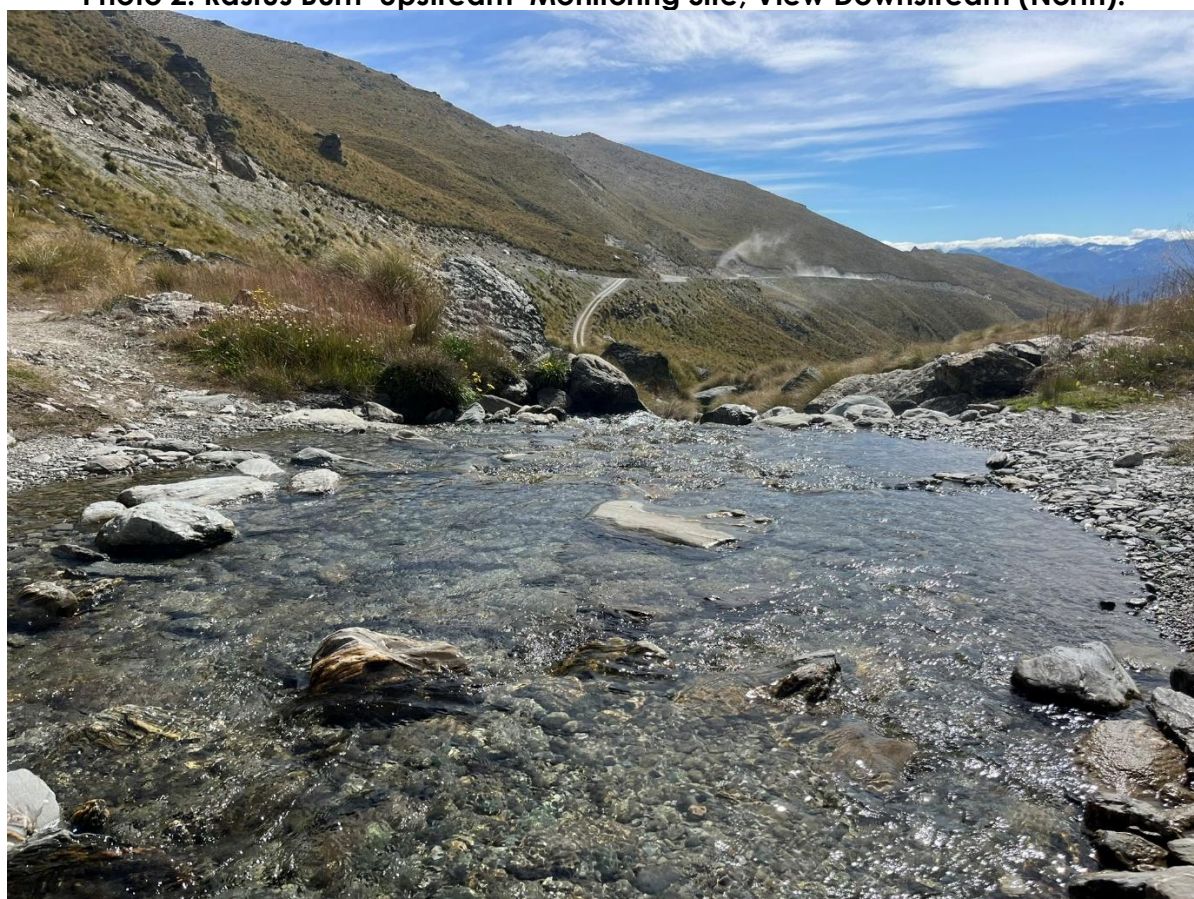


Photo 3. Dispersal Field, View South from Basin 3, Towards the Base Building



Photo 4. Dispersal Field, View North from Basin 3 Towards the Kawarau



Photo 5. Rastus Burn 'Downstream 200m' Monitoring Site, View North from Basin 3



Photo 6. Rastus Burn 'Downstream 200m' Monitoring Site, View North



3.1 Climate

The Regional Climate of Otago in which the site lies is strongly influenced by the main divide of the Southern Alps/Ka Tiritiri-o-te-Moana. They act as a barrier, separating the wettest region in the country (West Coast) from the driest region (Central Otago). This overall gives the region a semi-arid 'continental' climate (Macara, 2015). There are no permanent rainfall gauges in the Remarkables Ski Area although one is slated to be installed in 2026. Annual median rainfalls at the site, as mapped on the Grow Otago website ranged from 1000-1250 mm in the valley and up to 1500 mm on the ridgeⁱ.

The Rastus Burn wastewater treatment system interacts with the climate in the following ways:

- Temperature:
 - There are microbial-mediated processes which are temperature dependent, e.g. colder temperatures reduce microbial activity, reducing treatment effectiveness.
 - Temperature controls whether precipitation falls as snow or rain.
 - Temperature partially controls evaporation rates
- Wind:
 - affects distribution of snow
 - evaporation is partially controlled by wind
 - effects ski operation, lifts cannot operate in high wind so the skifield will close.
- Water balance:
 - The Rastus Burn provides the potable supply to the base building and is the ultimate receiving water body of the wastewater discharge.

3.2 Anticipated Climate Change

Climate change risk is assessed at a high level with information gathered from the Climate Projections Map produced by the Ministry for the Environmentⁱⁱ. This has been generated to a 5 km resolution across the country. The proposed development site fell under the Central Otago District and had a comparison base period of 1986-2005 under a climate change scenario of SSP1 – 2.6 and a future period of 2021-2040 looking at annual variables.

ⁱ <https://maps.orc.govt.nz/OtagoViewer232/?map=a3d75c9e135142e68f4e02b6fb64eaf7>, accessed 4/03/2026

ⁱⁱ <https://map.climatedata.environment.govt.nz/>, accessed 11/03/26



The map indicated that under the above climate change scenario, the site would be expected to have change to average daily air temperature of +0.6°, average daily minimum temperature increases of +0.5°, total rainfall to increase by +2.2%, the number of rainy days <1mm to decrease -0.8 days, while number of rainy days >25mm set to change +0.5 days. Wind is expected to increase on average by +1.6%, and the number of windy days >10m/s increase by 5.7 days. Potential Evapotranspiration Deficit (PED) was used to estimate drought exposure, with this set to increase by approximately 17.9 mm.

3.3 Geology

GNS Science's QMAP compiles regional geological maps at a scale of 1:250,000. The map units for the Remarkables are predominantly basement schist described as "Well foliated psammitic and pelitic schist with incipient segregation; minor greenschist and metachert; quartz veins common; TZIII.". There are smaller deposits of glacial till, and alluvial/colluvial material typically in the bottom of gullies or downslope of large scarps described as "Undifferentiated till consisting of variably weathered, generally bouldery angular gravel with minor sand in cirque moraines" and "Loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) and valley alluvium." (GNS Science, 2025).

Geological descriptions from the recent groundwater monitoring borehole installation confirms that the dispersal field is comprised of sandy gravels overlying schist bedrock. There appears to be a bedrock high on the northwestern edge of the terrace which is at a consistent elevation with the top of a schist outcrop on the opposite side of the Rastus Burn. The terrace that the dispersal field is located on is thus likely to be a ledge in the bedrock formed during previous glaciations.

3.4 Hydrogeology

The site does not overlie any mapped aquifers. Unconfined groundwater is present beneath the dispersal field within the thin deposit of alluvial/colluvial material that overlies the basement schist. Fractured rock aquifers are present in Otago schists where large fracture zones have enough permeability to connect the fractures ORC (2014, 2023). Fracture flow may be the sources of springs on the side of steeper terrain in the Rastus Burn, in the absence of alluvial deposits or elevated cirque basins. It is expected that any groundwater present would be low yielding, and there are no groundwater users in the catchment.



Three monitoring bores were installed around the dispersal fields in 2014, however there are no borehole logs or construction details available, only the depth of boreholes. All bores were dry after drilling with groundwater first appearing in BH1 and BH2 in late Autumn between mid-April and early May. Throughout the monitoring record BH1 was seasonally dry, and BH3 never intercepted groundwater. At BH2, groundwater levels peaked in late May, (which could coincide with autumn rain which is not falling as snow) and then again in October (likely due to snow melt).

To improve the monitoring network efficacy, NSZKI installed two new monitoring bores (BH4 and BH5) and extended the depths of BH1 and BH3 beyond the water table in 2026. The locations of the monitoring wells are presented in Figure 4.

Groundwater levels were measured in the wells using a dip meter. Using the LiDAR data collected in 2016, groundwater levels were converted into groundwater elevations in mASL (NZVD2016) to determine groundwater flow directions.

Table 3. Groundwater Monitoring Borehole Details

| Site | Borehole | Purpose | Borehole Depth (mbgl) | SWL (mbgl) | Groundwater Elevation (mASL) |
|----------------------|----------|--------------|-----------------------|------------|------------------------------|
| Infiltration Basin 1 | BH1 | Upgradient | 13.35 | 10.21 | 1,451 |
| | BH4 | Downgradient | 26.10 | 22.10 | 1,439 |
| Infiltration Basin 3 | BH2 | Upgradient | 11.83 | 10.80 | 1,430 |
| | BH3 | Downgradient | 21.13 | 16.17 | 1,425 |
| | BH5 | Downgradient | 17.05 | - | <1,424* |

*Groundwater not intercepted. Final depth of well is at 1,424 mASL

Note that BH5 intersected bedrock at 15.2 m below ground level and it was not clear if groundwater was intercepted at the time of drilling; during sampling a week later, no water was present in the well. This indicates the presence of a local bedrock high which channels groundwater flow to the north rather than west. It is possible that BH5 may seasonally intercept groundwater during winter/spring when higher volumes of wastewater are discharged, and snow melt increases groundwater levels.

Cross-sections and long section through the dispersal field were generated to assess groundwater-surface water interaction and the depth of the unsaturated zone between the base of the infiltration basins and the groundwater may range from 5 to 10 mbgl.



Locations of sections are presented in Figure 4, with long section in Figure 5 and cross sections in Figure 6

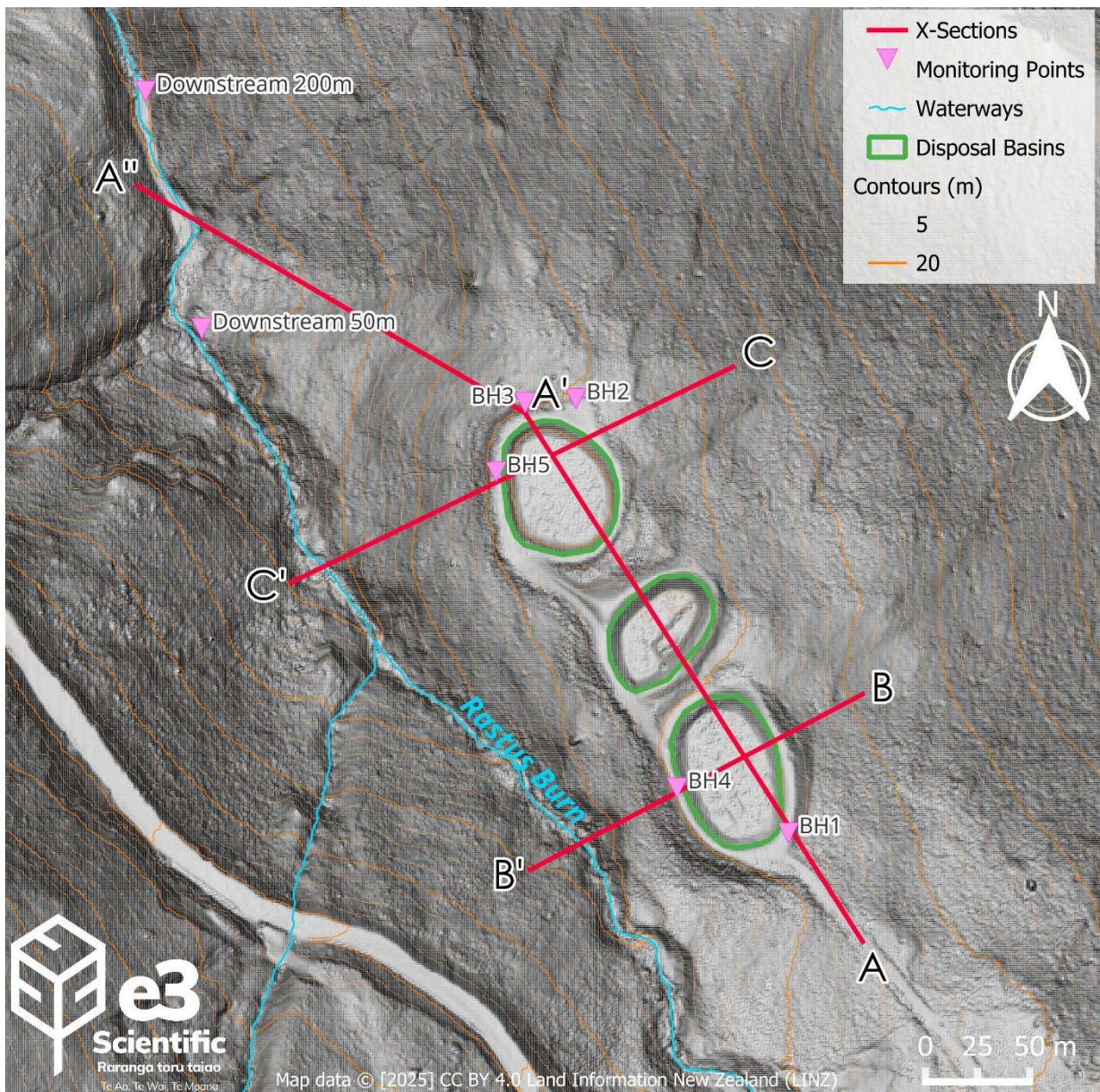


Figure 4. Monitoring Well Network and Section Locations



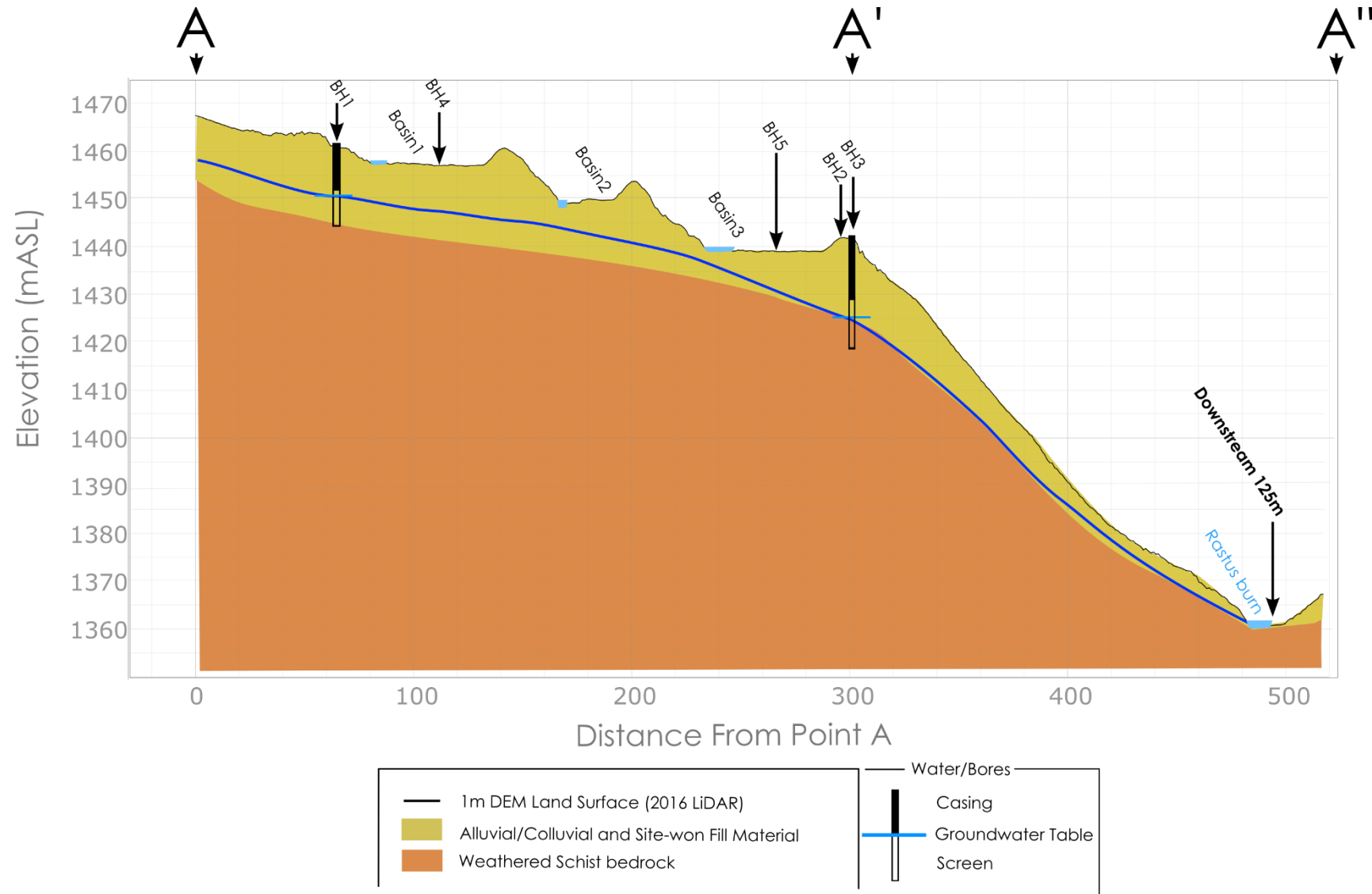


Figure 5. Long Section through the dispersal field



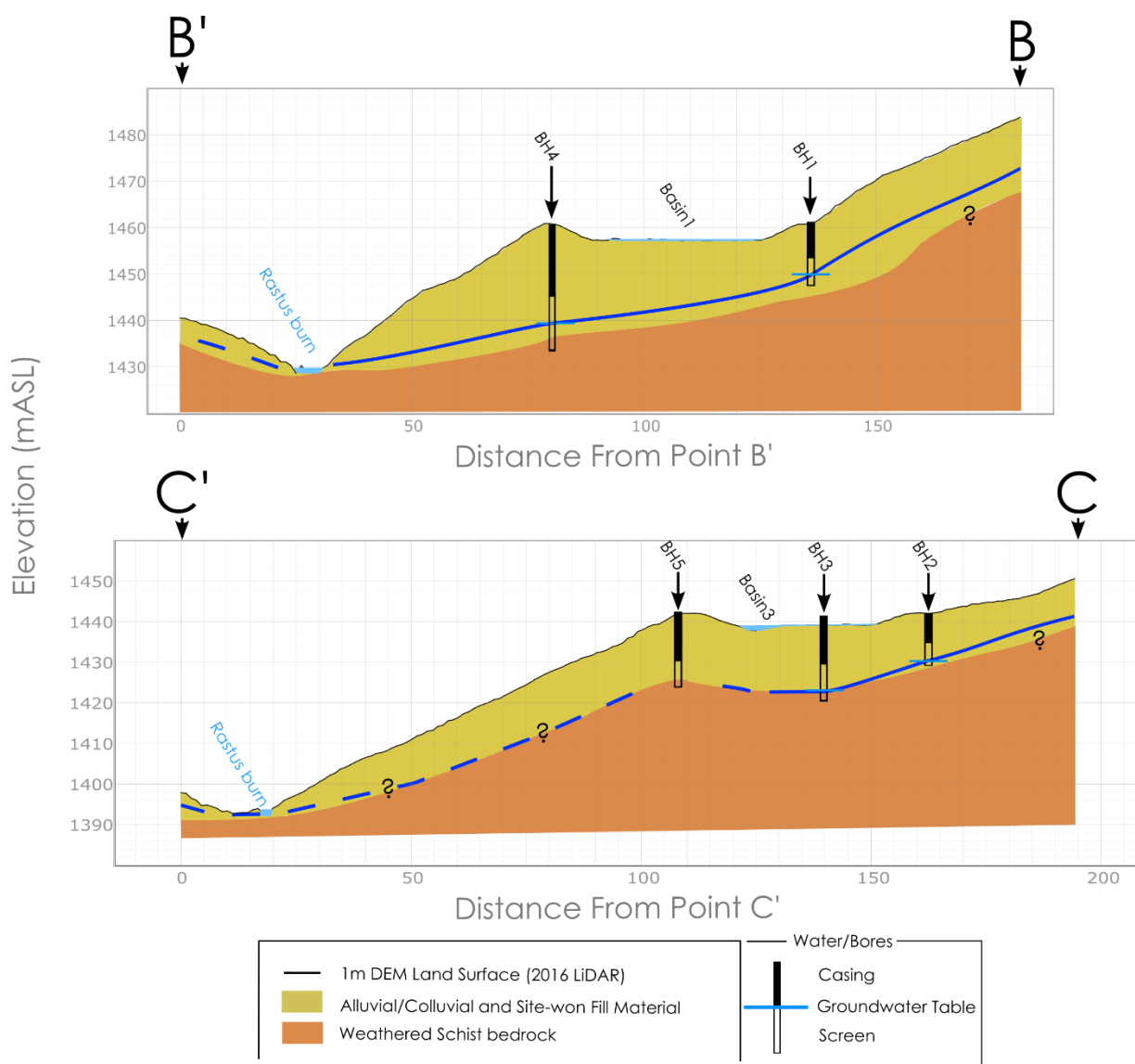


Figure 6. Cross sections through Basin 1 and Basin 3

3.5 Hydrology

The wastewater dispersal field is elevated about 50 – 100 m above the true right bank of the Rastus Burn, with a horizontal buffer of 50-100 m (see Figure 3 - Figure 6). The entire Rastus Burn catchment is 1,450 ha however the catchment above the dispersal field is 581 ha.

Gauging of the Rastus Burn was undertaken in May 2025 by e3s as part of a separate (and unrelated) assessment of Lake Alta. The flow in the Rastus Burn near the base building was 25 L/s on the 5th May 2025, (equivalent to 2,160 m³/day). The current consented surface water allocation requires a residual flow of 15 L/s to be maintained at all times which would be equivalent to 1,296 m³/day.



NIWA's river flow model (Whitehead, 2020) considers 25 L/s as 7th percentile flows (segment 14224707) (i.e. 93% of flows are higher), and lower than the modelled 1 in 5-year low flow of 29 L/s for July. The median and mean flow for the reach of the Rastus Burn adjacent to the dispersal fields is modelled as 70 L/s and 113 L/s respectively. It is likely that the model overestimates the lower flows in the Rastus Burn, however it is useful to understand the range of possible flows based on the catchment size. Further flow gauging is planned in July and September during the ski season and snow melt period to confirm the NIWA models as flows are used in assessing the discharge effects on the stream including dilution rates.

Flow accumulation mapping was completed using WhiteBox and Serval Tools in QGIS to identify likely pre-development overland flow paths and areas of surface water concentration (Figure 7). This indicates pre-development there were some overland flow paths that passed through the dispersal field. In particular, it was noted that BH5 is situated in an area where flow accumulation was expected. Further BH2 is likely receiving water from upgradient flow paths, confirming its utility as a crossgradient/upgradient location.

At present there are small bunds and cut off drains which direct runoff around the dispersal field. It is possible that runoff from large events could enter the dispersal field and be intercepted by the infiltration basins, however this is most likely during the spring snow melt rather than during winter, and therefore overland flow is most likely to have a negligible effect on the operation of the discharge to land during the ski season.

These parts of the dispersal field may also be preferential pathways for groundwater where gullies have formed nick points in the underlying bedrock.



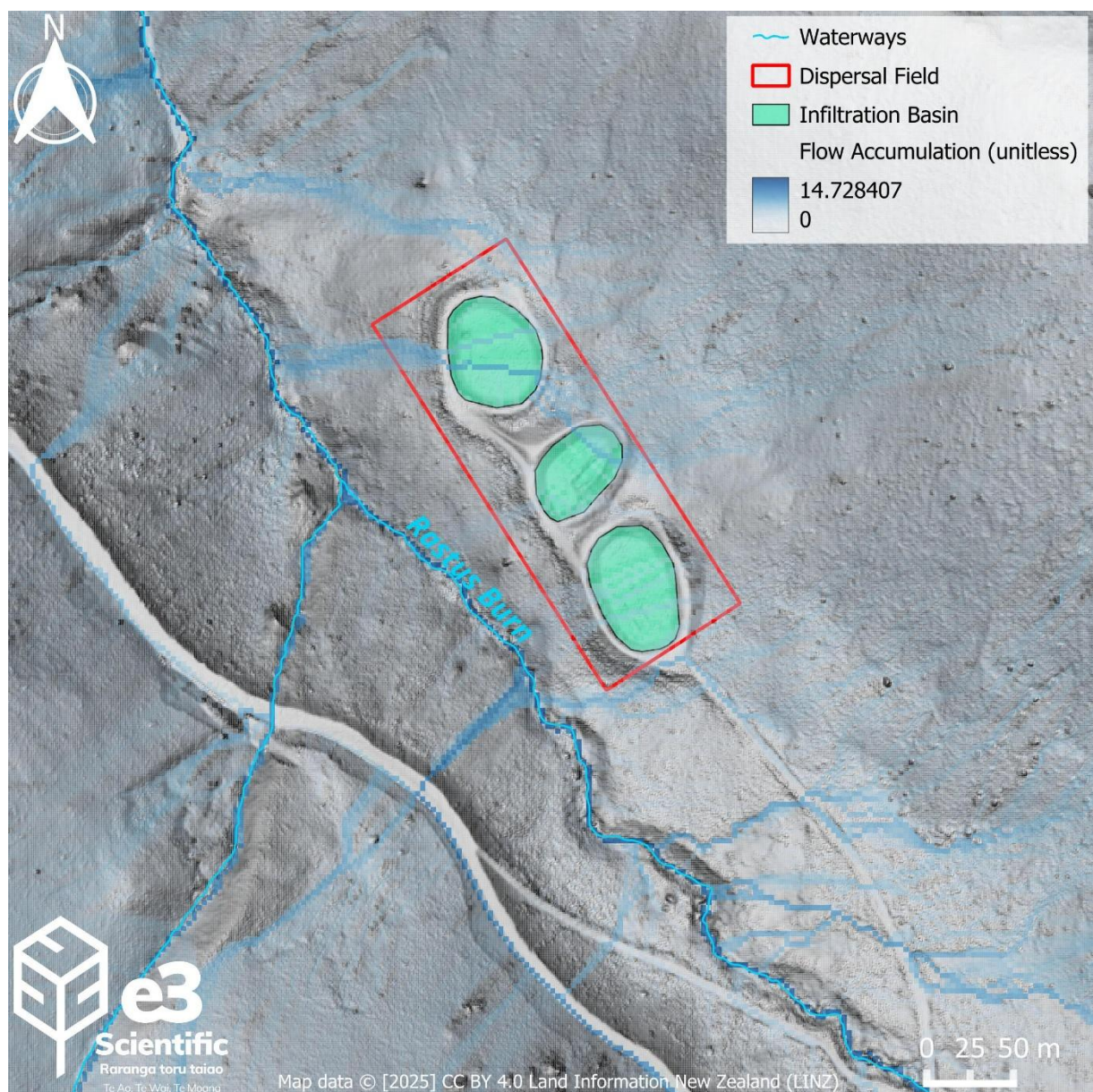


Figure 7. Modelled Flow Accumulation for the Dispersal Field Area

3.6 Water Quality

3.6.1 Adopted Environmental Guidelines

The following guidelines were adopted for assessment of water quality.

- ANZG (2018) supersedes the ANZECC (2000) guidelines.
 - For toxicity-based default guideline values (DGV) for ammonia and nitrate, the guidelines for the protection of 99% of freshwater species were adopted, as these are relevant to the high alpine source, and limited modification of the catchment.



- For physico-chemical parameters, DGVs were adopted for the appropriate climate and topography class, cool wet mountain as determined by NIWA's publicly available REC2 dataset.
- Schedule 15 of the Regional Plan: Water for Otago sets out the numerical limits and targets for achieving acceptable water quality for all catchments in the Otago region. As the Rastus Burn is a tributary of the Kawarau River below the Shotover River the limits for Receiving Water Group 2 are applicable. These limits were adopted in 2012 except for nitrate which was adopted in 2025. The limits apply to 80% of sample collected at median flow or less over a five-year period.
- Other limits:
 - Didymo limit was adopted from recent guidance by NIWA as 2 ppbⁱⁱⁱ (0.002 mg/L).

3.6.2 Water Quality Review

Groundwater and surface water quality is excellent based on the high alpine source (cool temperatures), modest human modification of the catchment, limited nutrient inputs or other contaminants, and the relatively high velocity/throughput of the Rastus Burn due to the steep catchment which aerates the water.

Ryder (2014) summarise the Rastus Burn water quality upstream of the dispersal field as follows:

- Water temperatures in the Rastus Burn are very low, between 1.7°C and 5.1°C
- Conductivity, which provides an indicator of nutrient enrichment is low between 13 and 40 $\mu\text{S}/\text{cm}$.
- Dissolved oxygen levels are high, constantly above 11 mg O_2/L .
- pH ranges from 6.5 – 9 which is in the acceptable range for New Zealand streams.
- Turbidity and total suspended solids are occasionally high in the Rastus Burn, which may be associated with snow melt and suspension of fine material from the rocky upper basins.
- Nutrients are generally low but are more likely to be in dissolved inorganic forms than total organic forms.
- Faecal contamination in the upstream sample is generally always below the detection limit.

ⁱⁱⁱ <https://niwa.co.nz/lakes/freshwater-update/freshwater-update-62-september-2014/didymo-new-zealand-ten-years>
 Remarkables Ski Area Upgrade and Doolans Expansion - Wastewater Discharge Impact Assessment
 Document ID: 25047.4A



A groundwater quality sample was collected from the upgradient monitoring bore BH1 at the dispersal field in February 2026, which is representative of background conditions. The groundwater quality is excellent and summarised as follows:

- Temperature was 5°C
- Conductivity was 26.3 $\mu\text{S}/\text{cm}$.
- Dissolved oxygen was 93.2% or 10.1 mg/L.
- pH was 6.75.
- Total Nitrogen was 0.06 mg/L with nitrate-nitrogen 0.058 mg/L.
- Total Phosphorus was 0.038 mg/L with DRP 0.006 mg/L.

3.6.3 Hydrogeochemistry

The water source or hydrogeochemical facies assessment was undertaken on samples collected from all compliance monitoring locations including the extended groundwater monitoring network in February 2026, in off-season discharge conditions (approximating benchmark conditions). The results are presented in a piper plot (Figure 8), which shows the common cation and anion concentrations.

The piper plot is a useful reference for showing any mixing trends or water sources in a study area. Based on the below ratios of cations and anions, it appears that most waters are calcium bicarbonate (Ca-HCO_3) type, however the discharge point and BH4 appear to be on the boundary with mixed type between $\text{Ca-HCO}_3/\text{Na-HCO}_3$.

Based on the cation-anion diamond, BH1, BH2, the upgradient boreholes are firmly in the bicarbonate corner while the down gradient groundwater samples (BH3 and BH4) and wastewater sample (discharge point) are elevated in chloride. The Rastus Burn waters are more sulphate rich which could be due to weathering of pyrite in the schist bedrock in the headwaters. There appears to be a slight mixing trend with a groundwater source for the downstream 50, 200, and 1.5km samples, perhaps indicating that groundwater is more connected to the stream at lower elevations.



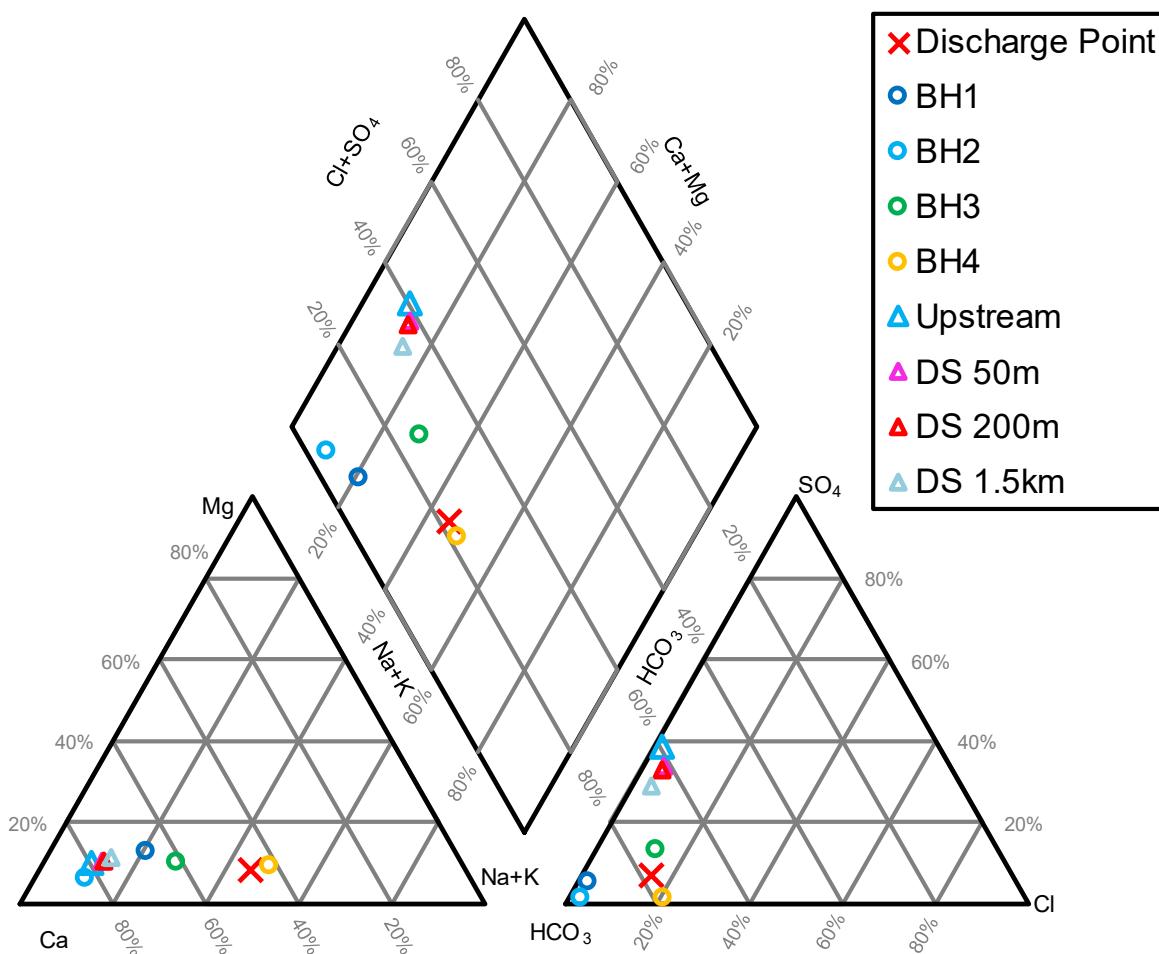


Figure 8. Piper Plot (February 2026 sampling event)

The redox condition of the sampled waters was classified according to the framework devised by McMahon & Chapelle (2008) using the concentrations of dissolved oxygen, nitrate, manganese, iron, and sulphate. In terms of redox status, all waters reported oxidic redox categories ($O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$) except for BH3 and BH4 which reported a redox category mixed (Oxic-Anoxic) with the general process $O_2-Mn(IV)$ ($MnO_{2(s)} + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$). The mixed category is likely due to the presence of organic matter in the wastewater discharge which upon discharge to land consumes oxygen during bacterial decomposition. As oxygen is rapidly depleted organic decomposition progresses at slower rates using the subsequent terminal electron acceptors.

3.7 Aquatic Ecosystem

A desktop review of the freshwater ecological monitoring data reported to date was completed in 2025 (e3Scientific (2025)) The summary of the report is reproduced in full below:



“In summary the cold, clear, well oxygenated water of the Rastus Burn and stable rock substrates free of fine sediment provide for an algal community typical of alpine environments with low cover of a few species including diatoms and filamentous red algae. The low algal biomass and allochthonous tussock leaves in turn provide a constrained food resource for the limited macroinvertebrate community present that comprises of taxa sensitive to organic pollution and that prefer cool well oxygenated water. The macroinvertebrate community is consistently representative of a “good to excellent” macroinvertebrate community although there was a temporary decline in 2023 to “fair to good”.

The decline observed in 2023 was considered to either be due to the accidental discharge of wastewater to the Rastus Burn due to the blockage in the rodding eye, or due to the increase in nutrient load. It is considered that the leak might have resulted in significant adverse effects as toxicological limits were assumed to be exceeded over a 9-day period in July 2023. However, at the same time the decline in the instream community quality may be due to the increased nutrient load which can result in more productive periphyton or macroalgae which changes the habitat and the instream macroinvertebrate community. The changes observed in 2023 and subsequent return in 2025 indicate that whatever the cause of the decline it was reversed either by fixing the leak or returning to lower nutrient loads.

The recent introduction of didymo to the Rastus Burn catchment headwaters (Lake Alta outlet) could mean that blooms may occur in the future throughout the Rastus Burn and this could alter the macroinvertebrate community composition during didymo bloom events. Didymo was observed in the lower reaches during the 2025 monitoring event near the downstream 200 m sample location.

Extensive fish surveys were carried out in 2008 and 2014 demonstrated the reach near the NZSki facilities and wastewater discharge (1500 m downstream and 1300 m upstream to Lake Alta) to be fishless. It is considered likely that the reach is naturally fishless due to the steep gorges downstream and associated waterfalls precluding access to fish. The lower 1.7 km of the Rastus Burn below the 1st waterfall at approximately 450 mASL may hold fish such as rainbow and brown trout, common bully, kōaro or longfin eels that are known to be present in the wider area. However, the majority of small tributaries surveyed have been fishless and it is considered more likely that only brown or rainbow trout may be present in the lower reaches of the Rastus Burn.”



Readers are referred to the Freshwater Ecological Impact Assessment (e3Scientific, 2026) for a more detailed description of the freshwater ecology and values therein.

3.8 Soils

Specific soil data for the site does not exist. Using Manaaki Whenua 'Soil Map Viewer' soil in the area is generally 'Brown Soil'. This is classified as being a mature soil with distinct dark grey-brown topsoil, and a brown or yellow-brown subsoil (Button, 2024). Brown soils make up 50% of soil types in Otago. Mostly occurring on hilly to steep landscapes these soils generally have good drainage and structure with low fertility. Soils in the dispersal field area have been modified by the construction of the infiltration basins, surrounding bunds and access roads.

3.9 Natural Hazards and Flooding

Natural Hazards have been mapped extensively surrounding the Remarkables Ski Field areas. The existing wastewater site sits in an Avalanche Area (QLDC, 2026). Some field observations by NZSki and Stantec indicate that some of the wastewater infrastructure was impacted by avalanches.

Cardrona Fault forks down approximately 7km west of the Doolans, this is an active fault (QLDC, 2026). The site is also possibly crossed by one inactive fault.

Flood Hazard has not been mapped at the site according to recently publicised map 'Flood Hazard across Aotearoa New Zealand' produced by Earth Sciences New Zealand^{iv}.

Noting that a specific Flood Risk Assessment has not been conducted, due to the terrain at the site, it may be assumed that flood risk to the dispersal field is low. This is due to the site being at a high elevation with surface water ponding risk minimal and high drainage capabilities due to its sloping terrain. The dispersal fields were designed with significant amounts of freeboard to account for large rainfall events.

As discussed further in Section 3.2, the site under a climate change scenario is expected to experience higher total rainfall, and for the number of events >25mm to increase for a future period of 2021-2040.

^{iv} <https://www.arcgis.com/apps/dashboards/8c1db2b8e37841f29a57a38675388897>, accessed 4/03/26
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Document ID: 25047.4A



4 Historic Wastewater Discharge Review

This section reviews the existing wastewater discharge system (Section 4.1) and its efficacy based on the available monitoring data. This includes review of the discharge flows and quality (Section 4.1.1) and observed impacts on the Rastas Burn in terms of contaminant concentrations (Section 4.3). By comparing the historical contaminant load (Section 4.4) with the Rastas Burn water quality, preliminary performance criteria for the upgraded wastewater treatment plan have been derived which are needed to maintain good to excellent aquatic ecosystem health (Section 4.6).

4.1 Existing Onsite Wastewater Management System

Figure 3 presents the location of the OWMS.

The current onsite wastewater management system (OWMS) comprises the following:

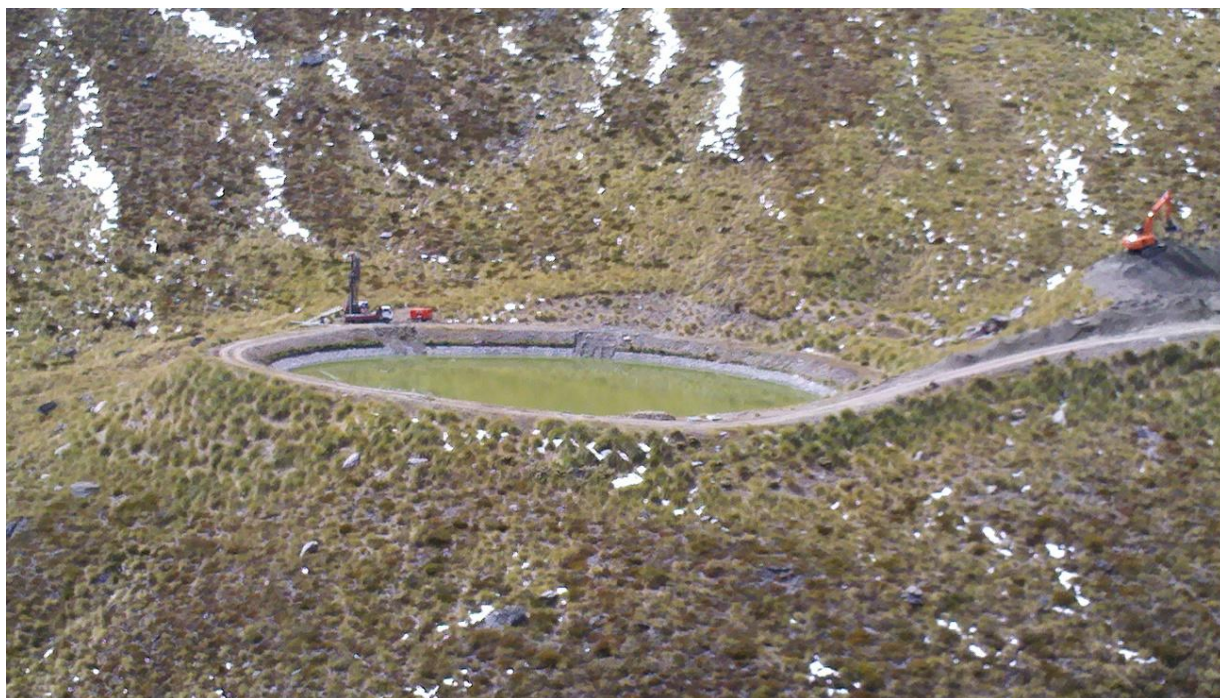
- The toilet and grey water systems for the Remarkables staff and base building and a public toilet drain to a 35 m³ pre-settlement tank in Car Park 1.
- Flows are then split between twin 75 m³ septic tanks with outlet filters.
- The “treated” wastewater then flows via a buried 100 mm diameter PVC pipe. There are insulated steel pipe bridges where the pipeline crosses over the Rastus Burn prior to entering a below ground concrete sedimentation tank which has a volume of 31 m³. No sludge is observed in this tank.
- The flow from the sedimentation tank is split three ways in a flow splitting manhole and discharged to land through infiltration basins (or dispersal fields). The discharge piping has provision to operate either in series or in parallel, but records show that that these have always operated in parallel as required by the consent.
- In terms of maintenance, the sludge in the pre-settlement and storage tanks in car park 1 is removed twice a year in May and October.

MWH (2014) determined that the infiltration basins were comprised of Category 2 soils (AS/NZS 1547:2012) which for primary treated effluent discharge to a trench or bed had a recommended design irrigation rate of 20 mm/day. The discharge was then sized to the dispersal field at 6,372 m² at 20 mm (20 l/m²/day) which was equivalent to the consented maximum daily discharge volume of 127.44 m³/day. This is considered a conservative rate for gravels and sandy soils for primary treated effluent. The infiltration basins are 2-3 m deep which provides storage enough for the estimated annual flows (MWH, 2014) and any inflows from precipitation and avalanches without overtopping.



In 2014, the basins were renovated by excavation and replacement of the basal material as uncompacted fill (Photo 7). This process was undertaken to break up any impermeable or pan layers in the base of the basins which may have limited infiltration.

Photo 7. Renovations and Installation of Groundwater Monitoring Bore (MWH, 2014).



4.1.1 Compliance Monitoring

The discharge consent requires monthly monitoring of the effluent (discharge pipe) and groundwater at the dispersal field, and surface water quality of the Rastus Burn. There are separate analytical suites required for effluent and surface water, however the groundwater quality at BH2 is also tested under the effluent quality regime in Condition 8 (**aError! Reference source not found.**).



Table 4. Compliance Monitoring Laboratory Analysis Suites

| (a) Effluent | (b) Water |
|-------------------------------|--|
| (i) BOD ₅ | (i) Dissolved Reactive Phosphorus |
| (ii) Faecal Coliforms | (ii) <i>Escherichia coli</i> /faecal coliforms |
| (iii) Total Phosphorus | (iii) Nitrate-nitrite |
| (iv) Ammoniacal nitrogen | (iv) Ammoniacal Nitrogen |
| (v) pH | (vii) Conductivity |
| (vi) Total Suspended Solids | (viii) pH |
| (vii) <i>Escherichia coli</i> | (ix) Total Nitrogen |
| | (x) Turbidity |

4.2 Wastewater Discharge Review

Compliance monitoring of the wastewater flows and discharge were reviewed to gain an understanding of the historical wastewater loading to the dispersal fields.

Flow data was provided to e3s from Stantec and via retrieval from NZSki's Watercheck service in February 2026. NZSki collected monthly wastewater and water quality samples from 2015 to 2025 (other than 2019 to 2021) which reported the concentration of nutrients (and other monitoring parameter's). The data included five blank data points for TN and TP which were substituted with an average of the results from the prior and following month. Not all years had complete datasets; the available data is summarised in Table 5. Load calculations could be completed for the six years that had complete datasets of both flow and discharge quality.

Table 5: Wastewater Discharge Data Available

| Year | Flow | Quality | Load Calculations |
|------|------|---------|-------------------|
| 2015 | | ✓ | |
| 2016 | ✓ | ✓ | ✓ |
| 2017 | | ✓ | |
| 2018 | ✓ | ✓ | ✓ |
| 2019 | ✓ | | |
| 2020 | | | |
| 2021 | | | |
| 2022 | ✓ | ✓ | ✓ |
| 2023 | ✓ | ✓ | ✓ |
| 2024 | ✓ | ✓ | ✓ |
| 2025 | ✓ | ✓ | ✓ |



4.2.1 Wastewater Flows

Flows are measured after the final sedimentation tank and before the flow splitter using a mag flow meter, with data reporting by Water Metrics. The meter has a known issue where it does not record low flows of approximately less than 20m³/day, and therefore may not report flows lower than this (Stantec, 2026).

Figure 9 shows the flows and an average flow value for all years with full datasets.

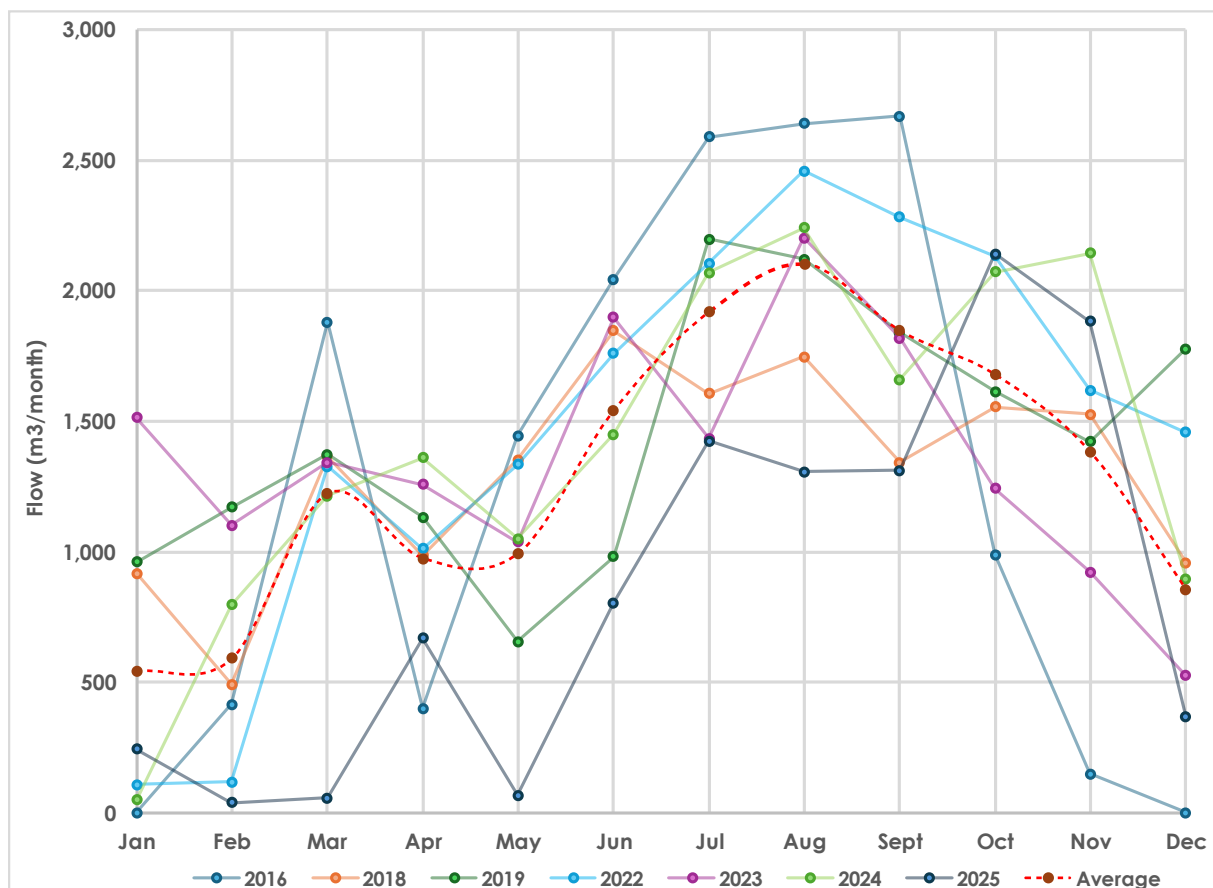


Figure 9. Monthly Wastewater Discharge Flows (m³/month)

For the above dataset, the average flows peak in August at 2,103 m³/month or 68 m³/day (Table 6). The comparatively high flows in the off-season are an artifact of the bywash system, which is discussed further in the following section.

Table 6. Average (2016-2025) Wastewater flows (m³)

| Average Flow | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|----------------|-----|-----|------|-----|-----|------|------|------|------|------|------|-----|
| Monthly | 542 | 591 | 1223 | 974 | 992 | 1540 | 1919 | 2103 | 1846 | 1678 | 1381 | 855 |
| Daily | 17 | 21 | 39 | 32 | 32 | 51 | 62 | 68 | 62 | 54 | 46 | 28 |

Total annual and ski season flows are reported in Table 11.



The 2025 year reported the lowest total ski season and annual flow, however the total number of skiers was similar to average. The difference may be due to a reduction in bywash discharge into the wastewater system, or the flow value may be underreported as 2025 recorded the highest number of zero flows. This may be due to the flow meter not reporting a flow despite a flow occurring due to the insensitivity to low flows.

4.2.2 Bywash

In Table 6, the offseason (November to May) wastewater flows are approximately half to a third of the ski season flows. During this period the occupancy is considerably lower representing visitors using the public toilet facility and a few NZSki staff in the base building; a daily flow 2-5 m³/day could be expected. Thus, the excess flow is attributed to the potable system bywash which is continuously flushing through the plumbing system preventing issues with freezing in winter.

Thus, if a bywash of 15-20 m³/day is assumed, then at times, the bywash component may account for up to a third or more of winter flows. The diluting effect of the bywash can be observed in the concentration of nutrients in the wastewater effluent measured at the discharge point which has an average total nitrogen concentration of 51.1 mg/L; whereas Coronet Peak which does not have bywash, has a higher average concentration of 134 mg/L. However, the total nutrient load is not affected by the bywash component as the water has such low concentrations of nutrients that there is a negligible increase to the total nutrient load from the bywash component.

Wastewater discharge flows are not necessarily caused by skiers on the field, in some cases the same daily flows are reported on days of no skiers present on the field e.g. off-season as for days when 1,000 skiers are on the field, or even when much higher numbers are on the field e.g. 2,000 skiers. Stantec has identified this issue with the magflow meter which underreported low flows and are proposing operational improvements to address these issues (Stantec, 2026).

4.2.3 Wastewater Quality

4.2.3.1 Nitrogen

As noted above, the average total nitrogen concentration for the ski season discharge appears to be lower than Coronet at around 51 mg/L vs 134 mg/L respectively (Table 7). However, in 2025 flows were around 2/3 of previous annual flows (Figure 9) resulting in less dilution and the highest reported TN concentration of 153 mg/L in September 2025, and a 2025 ski season average of 81 mg TN/L.

Table 7. Average Monthly Total Nitrogen Concentration (mg/L) for all years.



| Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct |
|---------------|-----|-----|-----|-----|-----|-----|----------------|-----|-----|------|-----|
| 3 | 5 | 3 | 2 | 2 | 2 | 3 | 31 | 60 | 86 | 62 | 16 |
| Off Season: 3 | | | | | | | Ski Season: 51 | | | | |

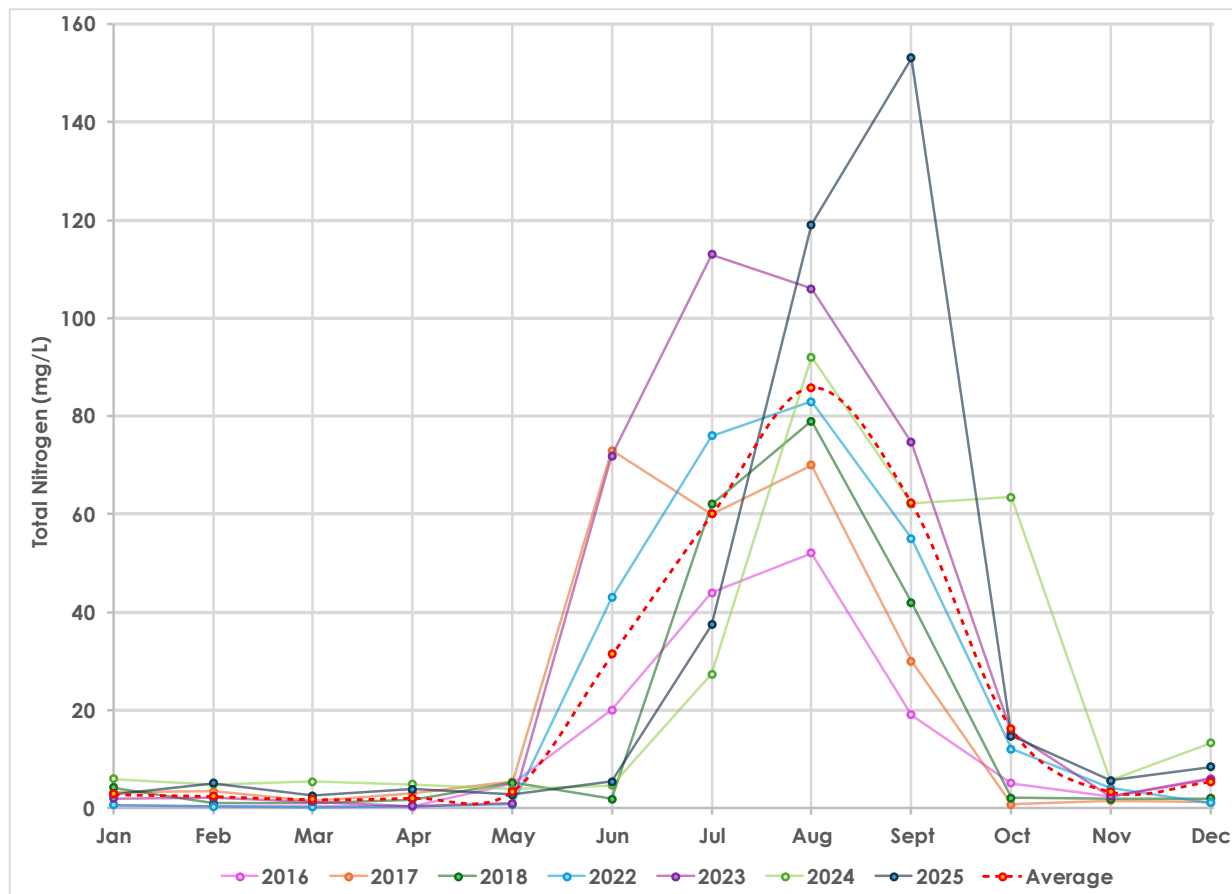


Figure 10. Monthly Total Nitrogen Concentrations (mg/L)

Table 8 presents monthly nitrogen analysis from 2023 to 2025, covering ammoniacal nitrogen, total oxidised nitrogen, and total nitrogen. During the ski season nitrogen is primarily present as ammoniacal nitrogen due to the high nutrient load to the OWMS and load temperatures; there is generally only oxidation of organic nitrogen as ammonification and no nitrification. However, during the summer months when temperatures are warmer, microbial communities can nitrify and thus nitrate concentrations increase.

Organic nitrogen is the fraction of Total Nitrogen remaining when ammoniacal nitrogen and total oxidised nitrogen are subtracted. Results show that negligible organic nitrogen is discharged to land during the ski season as ammoniacal nitrogen is 100% of the nitrogen discharge.



Table 8. Composition of Nitrogen Species (mg/L) in Discharged Wastewater

| Date | TON | TAmN | TN | TAmN% of TN | Season |
|------------|------|------|--------|-------------|------------|
| 26/06/2023 | 0.04 | 71.9 | 71.94 | 100% | Ski-Season |
| 12/07/2023 | 0.05 | 113 | 113.05 | 100% | |
| 10/08/2023 | 0.05 | 106 | 106.05 | 100% | |
| 14/09/2023 | 0.06 | 74.6 | 74.66 | 100% | |
| 12/10/2023 | 0.02 | 15.4 | 15.42 | 100% | |
| 7/11/2023 | 0.1 | 2.35 | 2.45 | 96% | Off-Season |
| 11/12/2023 | 0.1 | 5.83 | 5.93 | 98% | |
| 9/01/2024 | 0.57 | 4.21 | 4.78 | 88% | |
| 8/02/2024 | 1.2 | 4.17 | 5.37 | 78% | |
| 11/03/2024 | 2 | 2.86 | 4.86 | 59% | |
| 15/04/2024 | 2.1 | 1.77 | 3.87 | 46% | |
| 6/05/2024 | 0.65 | 3.94 | 4.59 | 86% | Ski-Season |
| 17/06/2024 | 0.01 | 27.3 | 27.31 | 100% | |
| 9/07/2024 | 0.04 | 92 | 92.04 | 100% | |
| 7/08/2024 | 0.06 | 62.1 | 62.16 | 100% | |
| 23/09/2024 | 0.04 | 63.4 | 63.44 | 100% | |
| 16/10/2024 | 0.01 | 13.2 | 13.21 | 100% | Off-Season |
| 16/12/2024 | 0.2 | 2.66 | 2.86 | 93% | |
| 16/01/2025 | 0.83 | 4.25 | 5.08 | 84% | |
| 11/02/2025 | 1.9 | 0.56 | 2.46 | 23% | |
| 26/03/2025 | 3.2 | 0.61 | 3.81 | 16% | |
| 15/04/2025 | 2.4 | 0.36 | 2.76 | 13% | |
| 22/05/2025 | 3 | 2.39 | 5.39 | 44% | Ski-Season |
| 18/06/2025 | 0.05 | 37.4 | 37.45 | 100% | |
| 14/07/2025 | 0.06 | 119 | 119.06 | 100% | |
| 5/08/2025 | 0.11 | 153 | 153.11 | 100% | |
| 22/09/2025 | 0.02 | 14.7 | 14.72 | 100% | |
| 15/10/2025 | 0.1 | 5.52 | 5.62 | 98% | Off-Season |
| 24/11/2025 | 0.07 | 1.39 | 1.46 | 95% | |
| 16/12/2025 | 0.12 | 8.23 | 8.35 | 99% | |
| 27/01/2026 | 1.07 | 4.53 | 5.6 | 81% | |
| 25/02/2026 | 1.29 | 8.01 | 9.49 | 84% | |

4.2.3.2 Phosphorus

Prior to 2023, only total phosphorus was tested at the discharge point, while DRP was tested at other monitoring locations. Based on the available Total and DRP dataset (Table 9), DRP represents on average 70% of total phosphorus in the off-season, while during ski season DRP makes up 50% of total phosphorus.

During the ski season, the influent increases in strength significantly, more solid material enters the OWMS, and thus there is an order of magnitude increase in the overall concentration of phosphorus and the proportion of total phosphorus increases.



Table 9. Composition of Phosphorus Species (mg/L) in Discharged Wastewater

| Date | TP | DRP | DRP% of TP | Season |
|------------|----------|-------|------------|------------|
| 27/04/2023 | 0.23 | 0.205 | 89% | Off-Season |
| 26/06/2023 | 6.14 | 2.97 | 48% | Ski-Season |
| 12/07/2023 | 9.86 | 5.01 | 51% | |
| 10/08/2023 | 11.6 | 5.05 | 44% | |
| 14/09/2023 | 8.02 | 5.08 | 63% | |
| 12/10/2023 | 2.94 | 1.89 | 64% | |
| 7/11/2023 | 0.3 | 0.206 | 69% | |
| 11/12/2023 | 0.59 | 0.471 | 80% | Off-Season |
| 9/01/2024 | 0.52 | 0.466 | 90% | |
| 8/02/2024 | 0.55 | 0.48 | 87% | |
| 11/03/2024 | 0.49 | 0.315 | 64% | |
| 15/04/2024 | 0.44 | 0.284 | 65% | |
| 6/05/2024 | 0.44 | 0.327 | 74% | |
| 17/06/2024 | 2.37 | 1.05 | 44% | Ski-Season |
| 9/07/2024 | 9.35 | 3.53 | 38% | |
| 7/08/2024 | 8.28 | 4.86 | 59% | |
| 23/09/2024 | 6.67 | 3.15 | 47% | |
| 16/10/2024 | 2.88 | 1.87 | 65% | |
| 16/12/2024 | 0.39 | 0.348 | 89% | |
| 16/01/2025 | 0.63 | 0.367 | 58% | Off-Season |
| 11/02/2025 | 0.36 | 0.336 | 93% | |
| 26/03/2025 | 0.46 | 0.333 | 72% | |
| 15/04/2025 | 0.3 | 0.225 | 75% | |
| 22/05/2025 | 0.57 | 0.462 | 81% | |
| 18/06/2025 | 3.63 | 1.69 | 47% | |
| 14/07/2025 | 9.31 | 6.32 | 68% | Ski-Season |
| 5/08/2025 | 14 | 7.77 | 56% | |
| 22/09/2025 | 3.41 | 1.39 | 41% | |
| 15/10/2025 | 1.31 | 0.654 | 50% | |
| 24/11/2025 | 0.2 | 0.152 | 76% | |
| 16/12/2025 | 0.79 | 0.579 | 73% | |
| 27/01/2026 | (≥0.482) | 0.482 | ≤100% | Off-Season |
| 25/02/2026 | 0.858 | 0.876 | ~100%* | |

(≥X) TP was not tested on this date, it is likely to be equal to or greater than DRP
* DRP and TP were tested using different methods which has resulted in similar but inconsistent results. It is assumed that all P is present as DRP in this sample.

Dissolved reactive phosphorus is highly mobile especially in poorly buffered soils such as the sandy gravels at the dispersal field. However, the discharge component that is in other forms (particulate forms) may be assimilated into the subsoil at the dispersal field.



4.2.3.3 Other Monitored Parameters

Typical wastewater performance criteria include biological or chemical oxygen demand, total suspended solids, and microbial pathogens (e.g. *E. coli*). While these parameters are monitored at this site, monitoring of the Rastus Burn indicates that they are not impacting on water quality in the receiving environment and therefore are not discussed in detail.

4.3 Rastus Burn (Receiving Environment) Water Quality

The compliance monitoring results have shown that there are measurable but slight effects on the quality of water in the Rastus Burn from the discharge of wastewater to land. The dominant effects are noted as elevated nutrients and pathogens (faecal indicators) during the months of the ski season. Concentrations are, however, orders of magnitude lower than the concentrations in the effluent discharged to land indicating that high amounts of attenuation, via treatment, or dilution are occurring. Instream ecological data was extracted from the NZSki bi-annual biological compliance monitoring reports (Ryder Consulting 2014, 2017; SLR 2023, 2025). In general, NZSki appears to be managing the overall nutrient load so that the instream values remain in 'good to excellent' condition.

However, a leak reported in July 2023 resulted in elevated concentrations of wastewater contaminants in the Rastus Burn (including the upstream sample) measured on the 12th July 2023. The leak was noted on the 14th of July due to no or low recorded flows passing through the flow meter from the 5th July 2023. An inspection of the wastewater management system identified a blockage in one of the rodding eyes with effluent being expelled from it and flowing overland into the Rastus Burn just upstream of the upstream sample location. The leak was fixed, and processes updated to check flows daily for any indication of loss of flow. As noted in the annual report, the concentration of contaminants in the Rastus Burn reduced back to typical concentrations in the August sample.

4.3.1 Nitrogen

The effects of nitrogen on aquatic ecosystems can be partitioned into direct ecotoxic effects from ammoniacal nitrogen (NH_3 and NH_4^+) and nitrates (NO_3^-), and as a contributing factor to poor outcomes such as algal blooms through the provision of excess nutrients in an alpine, nutrient-limited ecosystem (e.g. eutrophication.)



In terms of ecotoxicity, total ammoniacal nitrogen (that is the sum of un-ionised and ionised ammonia) becomes a contaminant when it is present in higher concentrations than the instream aquatic fauna can process (e.g. exhale or excrete). ANZG (2018, 2026) guidance indicates that the Rastus Burn falls outside of the generic DGV parameter conditions as the temperature and conductivity are lower than the generic parameters (<10°C and <50 µS/Cm respectively) and therefore site-specific guideline values may be necessary. In this case, the 99% DGV for total ammoniacal nitrogen for a pH of 7.2 and temperature of 10 were conservatively applied. At the concentrations present in such cold water, it is unlikely that significant un-ionised ammonia is present, and therefore higher amounts of total ammoniacal nitrogen than what currently occurs are required for toxicity to be a concern.

The reported instream water quality meets the 99% DGV and the good water quality Schedule 15 limits (Figure 11). Ammonia concentrations in the Rastus Burn spike every ski season, as a result of the increased nitrogen load into the groundwater which recharges the Rastus Burn along the monitored reach. This indicates that effects are measurable in the Rastus Burn within a lag time of a month or less. These concentrations tend to peak at an order of magnitude less than the DGV. Whilst the discharge has a measurable effect on the Rastus Burn, it appears to be at an acceptable level.

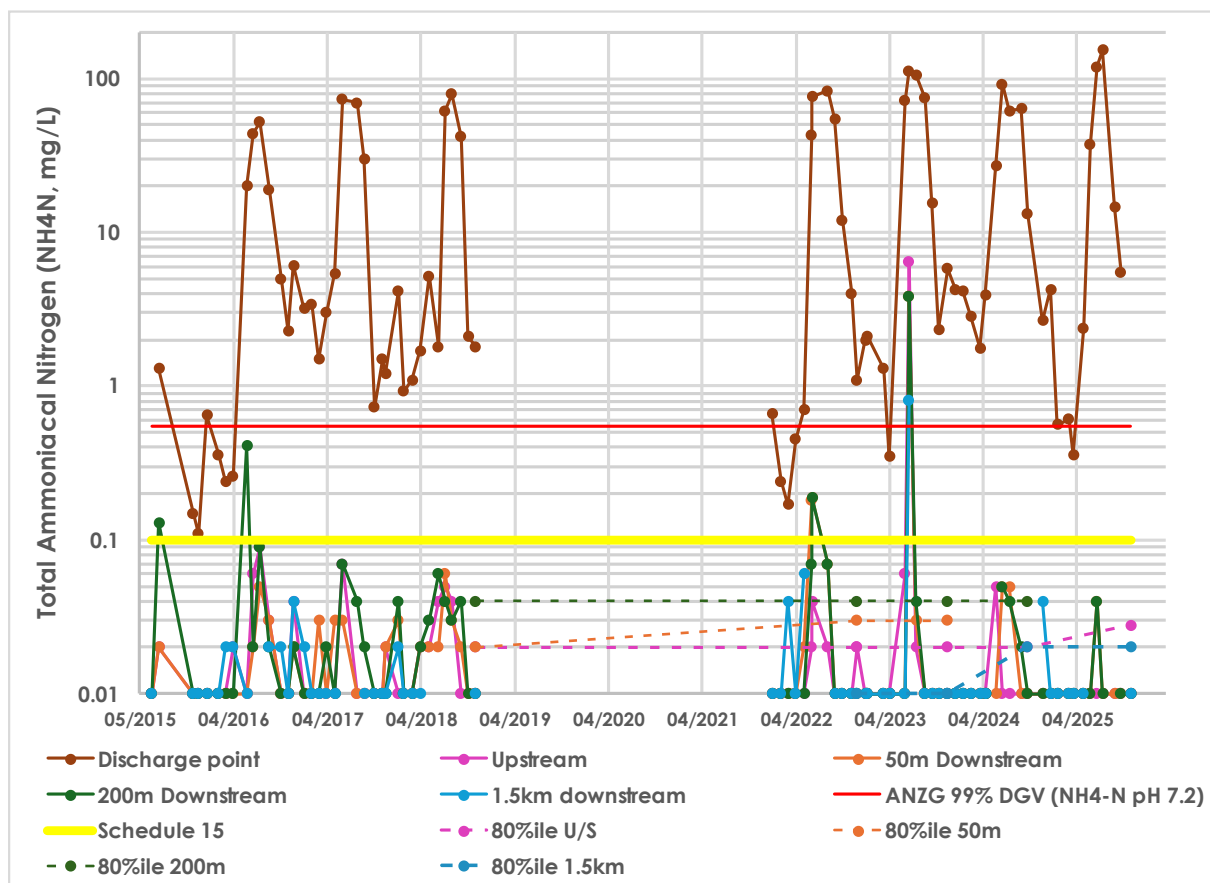


Figure 11. Total Ammoniacal Nitrogen Compliance Monitoring Results



It is noted that on one occasion concentrations did exceed the ANZG DGV. This was the result of a documented leak in July 2023 (NZSki, 2023). With respect to performance criteria, spills or leaks are typically short-term duration events (<1 week) and should be excluded as an anomaly rather than incorporated in the long-term rolling means.

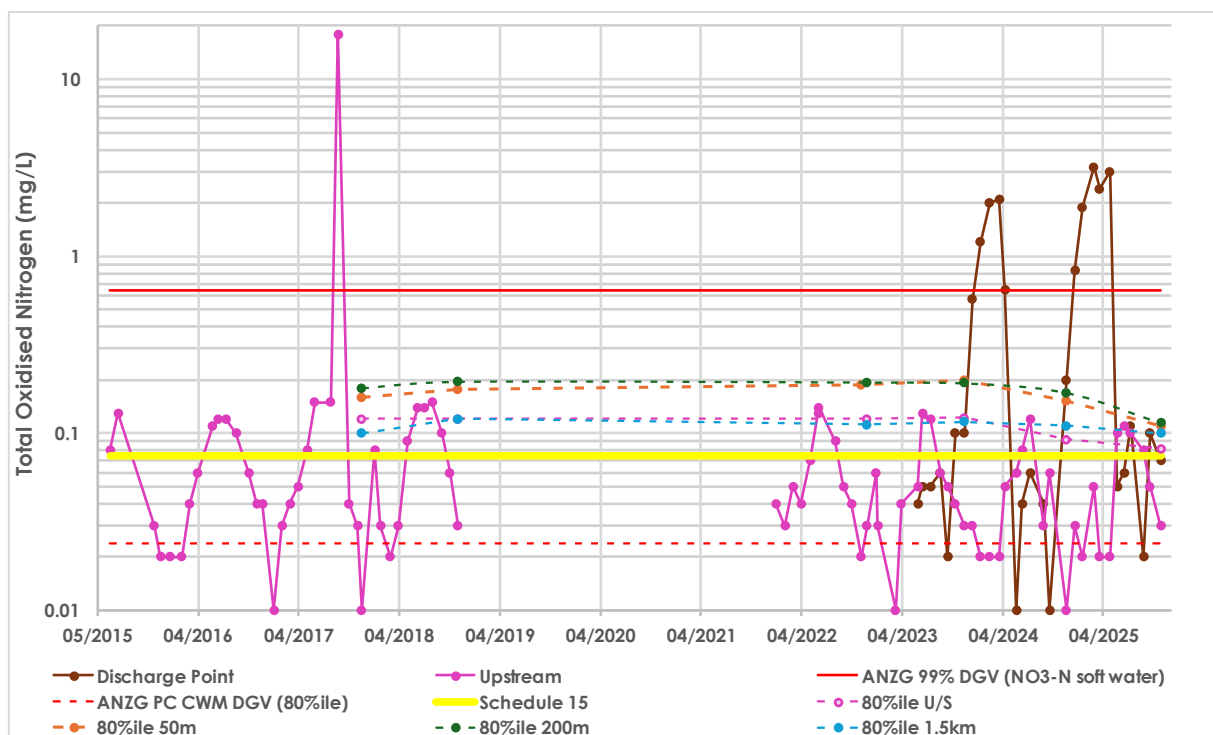


Figure 12. Total Oxidised Nitrogen (Nitrate) Compliance Monitoring Results

In the Rastus Burn, the nitrate^v relationship is inverse to the treated discharge in that the highest concentrations are observed in winter and lower concentrations in summer (see also Figure 3 for comparison with the discharge water quality). The concentrations in the Rastus Burn do not exceed the ANZG (2018) DGV for nitrate toxicity effects; they are generally around an order of magnitude below the guideline value.

Critically, the monthly upstream concentrations frequently exceed the Schedule 15 limit during summer, and 80% of upstream samples over a five-year period also exceed the schedule 15 limit. In the off season, the nitrate concentrations measured at the dispersal field discharge point are often less than the upstream sample concentrations. Therefore, the source of elevated nitrate in the Rastus Burn in the offseason is most likely related to diffuse biogeochemical processes occurring in the wider Remarkables Skifield, and not related to the point source nutrient load which conversely is largely discharged during winter.

^v representing nitrate in this case as nitrite is almost always absent except in the discharge



Despite the presence of elevated nitrate above the Schedule 15 limit during the summer months and almost always exceeding the ANZG (2018) physico-chemical DGV, there does not appear to be any cumulative ongoing adverse ecological effects in the Rastus Burn e.g. eutrophication. This may be due to the consistent cool temperatures which limit microbial activity even in summer.

TON concentrations at 1.5 km downstream appear to be similar to upstream samples indicating that by that distance the waters have diluted or processed almost all discharge effects. Therefore, the effects on the Kawarau are likely to be acceptable.

It is also noted that the nitrate toxicity DGV has never been exceeded.

4.3.2 Phosphorus

Dissolved reactive phosphorus (DRP) has been measured consistently in the Rastus Burn and more recently at the discharge point, allowing an assessment of the mobile phosphorus fraction which may enter the Rastus Burn. ORC's Schedule 15 recommends a DRP limit of 0.01 mg/L, ANZG (2018) has a physico-chemical default guideline value for cool wet mountain (CWM) streams of 0.004 mg/L DRP, and Kilroy and Bothwell (2012) report a didymo growth limit of 0.002 mg/L.

The method detection limit for DRP however has ranged from 0.002 to 0.005 depending on the laboratory QA/QC. This makes comparisons difficult, however currently DRP concentrations are meeting the Schedule 15 limits, and concentrations are at times above the didymo limit of 0.002 mg/L below which can didymo blooms are more likely (also the laboratory limit of reporting).



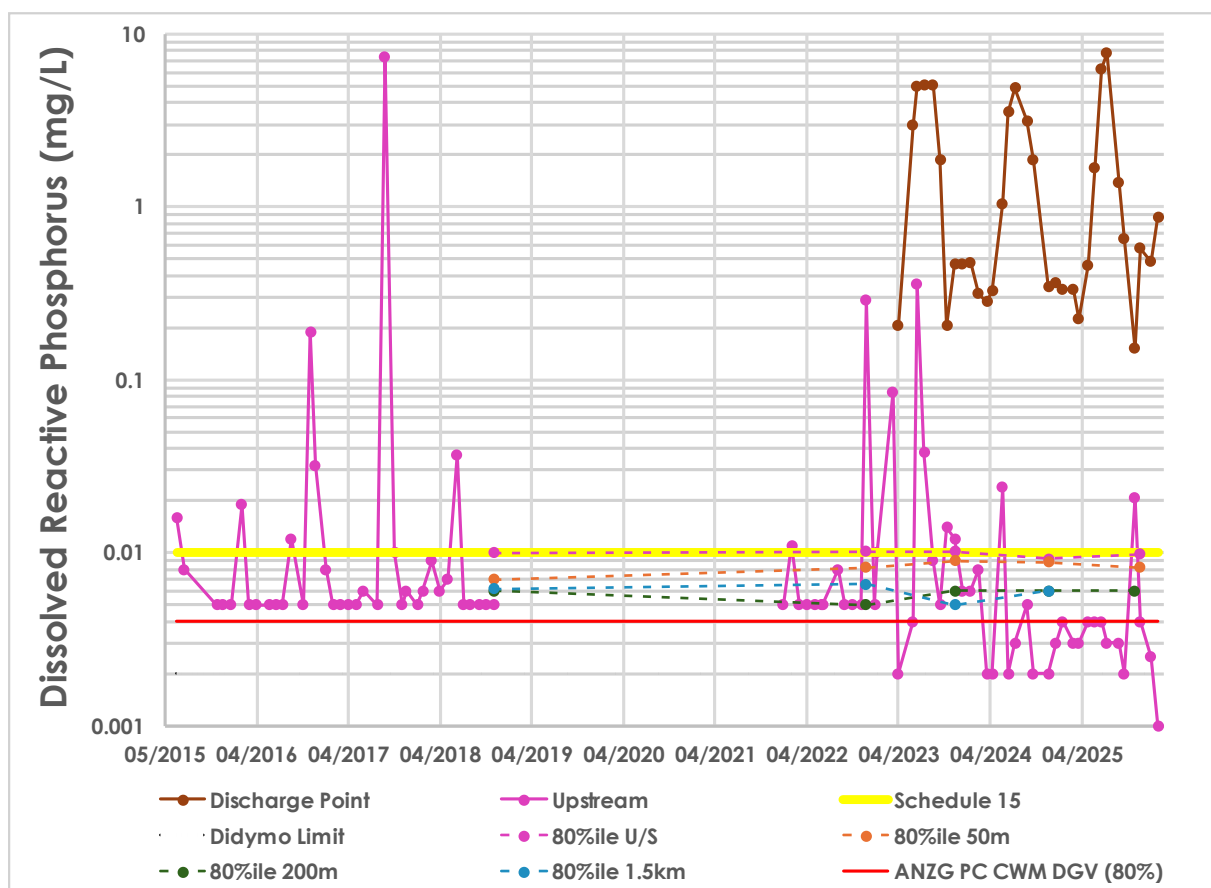


Figure 13. Dissolved Reactive Phosphorus Compliance Monitoring Results

As noted with the TON concentration, the upstream sample has the highest concentration, and concentrations decrease at 50 m, 200 m and 1.5 km downstream. Often the 1.5 km site cannot be accessed due to high snow levels in winter, so the data for that site is less consistent.

Regardless, as with TON there is a clear trend that there is a source of DRP upgradient of the dispersal field which may be initially from weathering/erosion of schist bedrock and then subsequent nutrient cycling in the lakes and wetland areas in the upper catchment. Wetlands can have poorer soluble P retention as they become saturated with P over time and plant P cycling largely prefers particulate P sources rather than soluble sources (except for didymo) which are taken up from the water column). As the Rastus Burn flows downstream smaller tributaries add flow from steeper sided catchments with lower P concentrations resulting in further dilution.

4.3.3 *E. coli*

The same trends for nitrogen are present for *E. coli* (Figure 14) which show occasional measurable impacts to the Rastus Burn during the ski-season when higher flows are discharged to the infiltration basins. All Rastus Burn concentrations meet the schedule 15 limit of 260 cfu/100mL. However, this is generally understood as a limit that is



protective of recreational contact. As there are not expected to be any recreational users of the Rastus Burn, the Schedule 15 limit is conservatively applied.

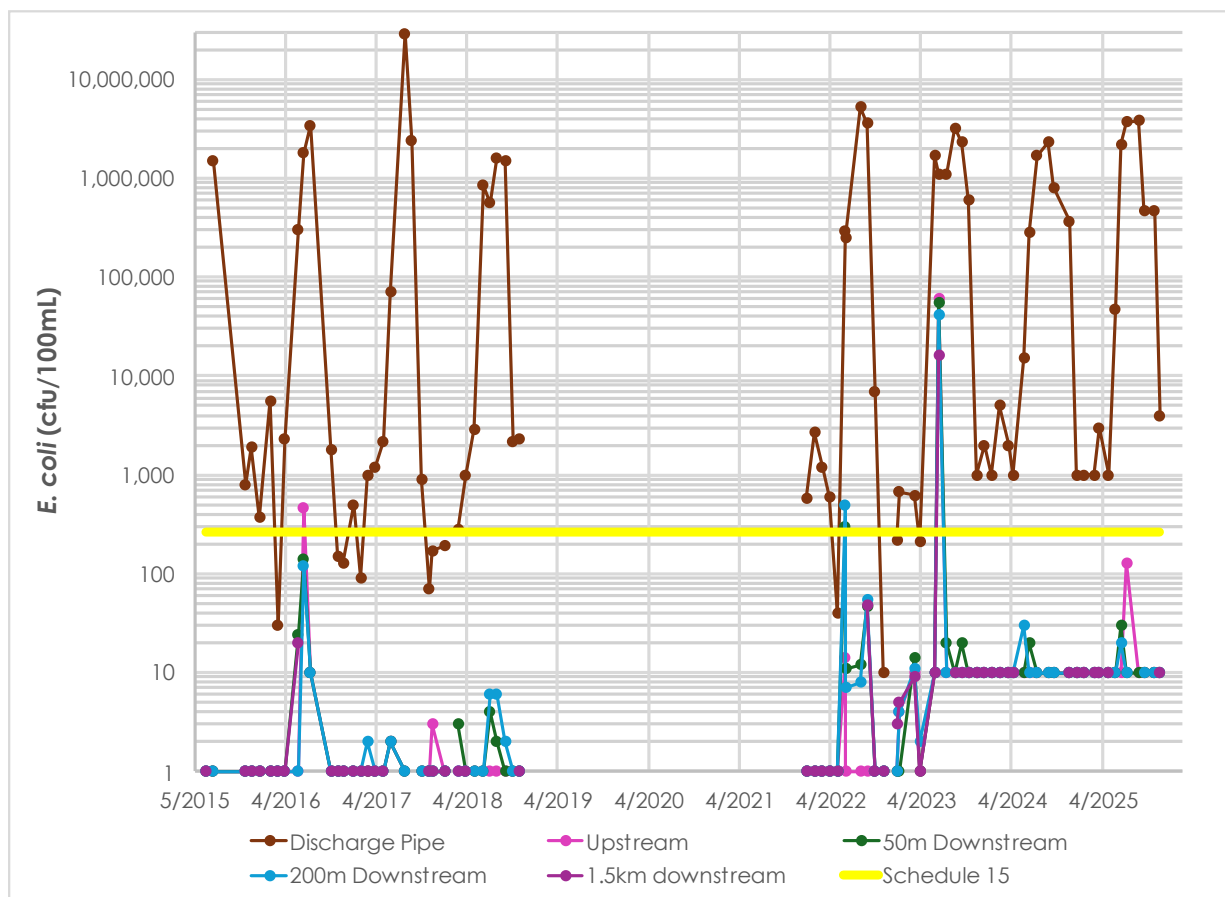


Figure 14. *Escherichia coli* Compliance Monitoring Results

4.3.4 Physico-Chemical Parameters

The following summary of physico-chemical parameters is useful for comparing the upstream quality to the downstream, to determine how the discharge is impacting upon the Rastus Burn.

4.3.4.1 Turbidity/TSS

Total suspended solids (TSS) and turbidity are tested at the discharge point (TSS) and turbidity is tested in the Rastus Burn. The schedule 15 limit applies to 80% of data over a five-year period for samples collected at median flows or lower. Figure 15 indicates an increasing trend at the upstream site, such that the Schedule 15 limit has been exceeded. Whilst concentrations at the downstream 50 m and downstream 200 m sites have also more recently exceeded the limit, it is by a lesser amount than the upstream value; this potentially indicates dilution with distance from the source of the sediment/turbidity.



It is likely that there is a source of sediment higher up in the catchment perhaps near the base building where part of the Rastus Burn stream bed is disturbed or where larger earthworks are occurring in the upper catchment. Overall, there appears to be no correlation between the discharge and the concentration of sediment in the Rastus Burn. This is to be expected as the dispersal fields and receiving soil provide significant filtering of suspended particles.

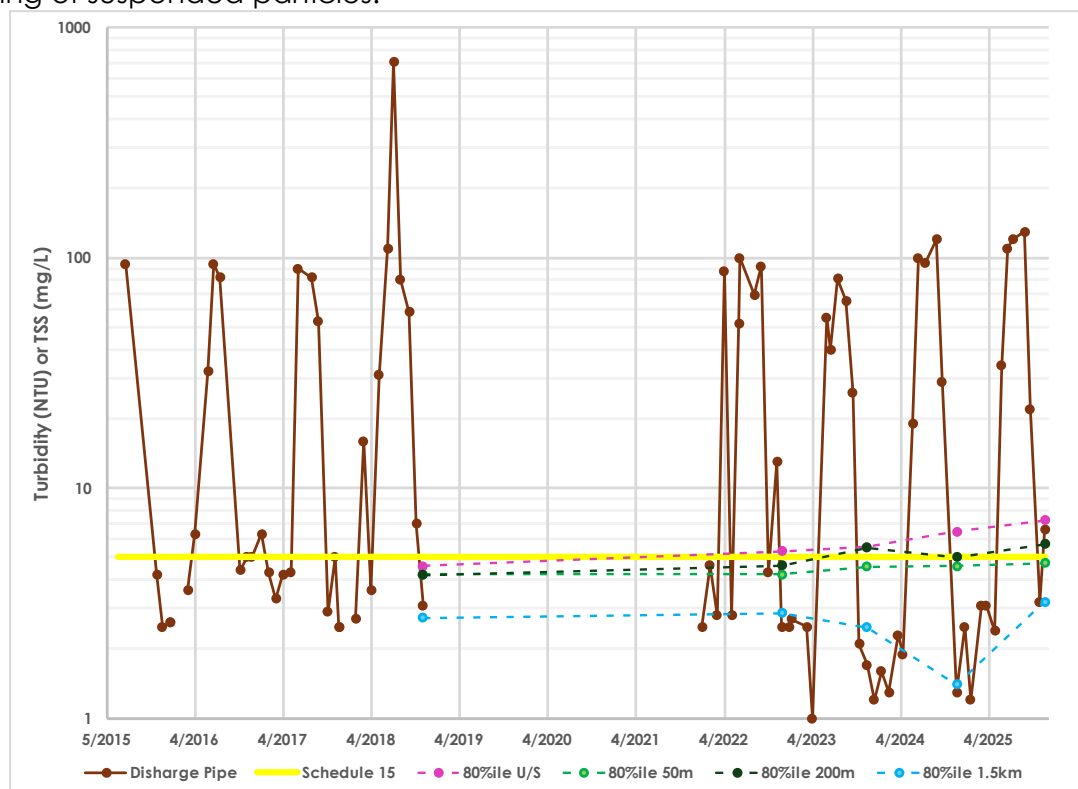


Figure 15. TSS (Discharge Point) and Turbidity (Rastus Burn) Compliance Monitoring Results

4.3.4.2 Conductivity

Conductivity within the Rastus Burn is low to moderate (20 – 50 $\mu\text{S}/\text{cm}$; ANZG (2018)), as expected for waters in the alpine headwaters with short water-rock interactions (e.g. recharged with recent rainfall) or residence times in water bodies resulting in low dissolved solids. Given the conductivity concentration of the discharge can be as high as 1,000 $\mu\text{S}/\text{cm}$ in winter, low conductivity in the Rastus Burn during winter provides evidence of seasonally variable dilution. The largest dilution and decrease in concentration occur in spring during higher flows; after snowmelt concentrations increase again as flows taper off, until a minor decrease in autumn with increased rainfall. Conductivity concentrations increase in winter as precipitation is stored as snow and July is the month of lowest flows.



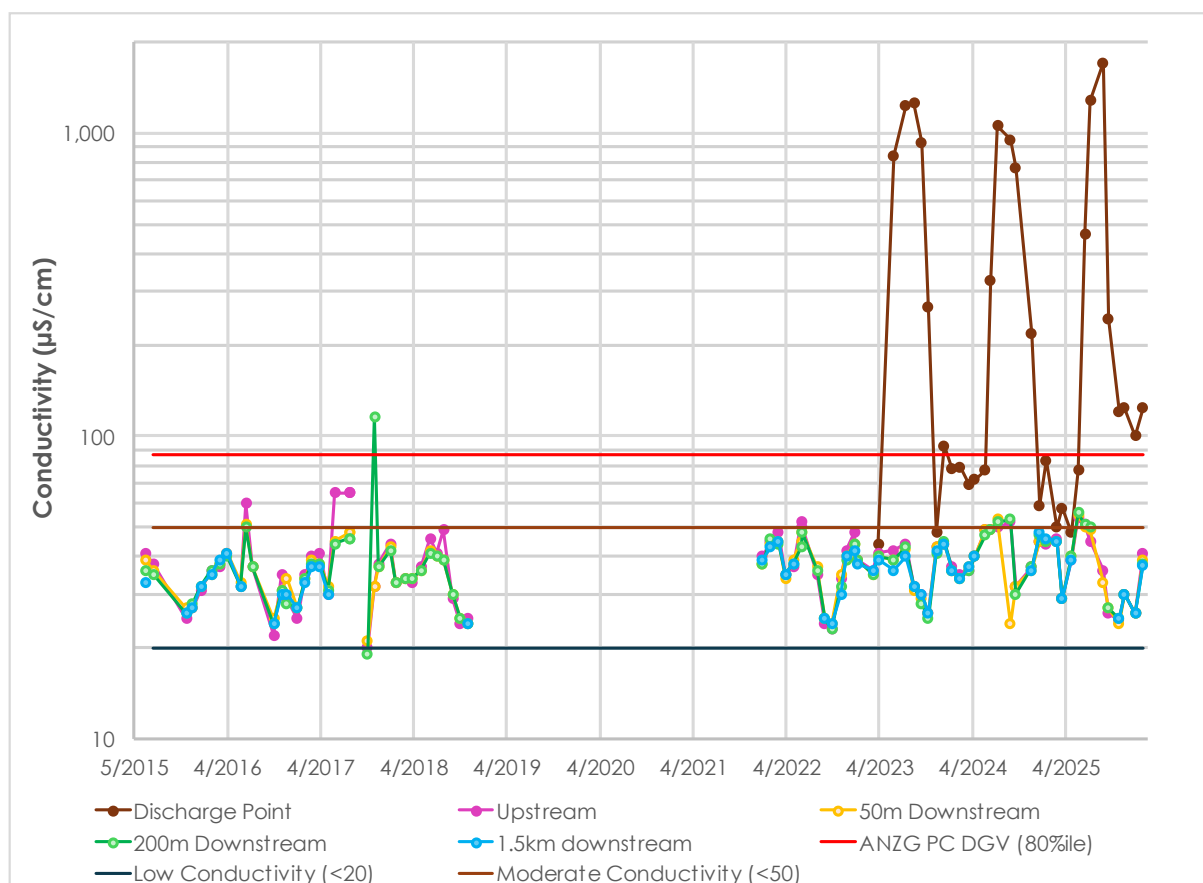


Figure 16. Conductivity Compliance Monitoring Results

4.3.4.3 pH

The discharge pH ranges from over 8 during winter, to less than 7 during summer (Figure 17). The Rastus Burn is effectively neutral (upstream has an average of pH 7.2), while there is significant variability along the monitored reach. On one occasion in 2024 the downstream 200 m pH was elevated above pH 8 but the next month's sample had returned to typical values.

With respect to adverse effects from acidity or alkalinity, ANZG (2018) PC DGVs for cold wet mountain (CWM) climate indicate a band of pH for 20% and 80% samples outside of which harm is possible, however ORC did not set a schedule 15 Limit for pH (Figure 18). The compliance monitoring results are slightly more acidic than the 20% DGV; however, this is not considered an issue as downstream and upstream concentrations are within 10% of each other and not indicative of any impacts from the discharge.



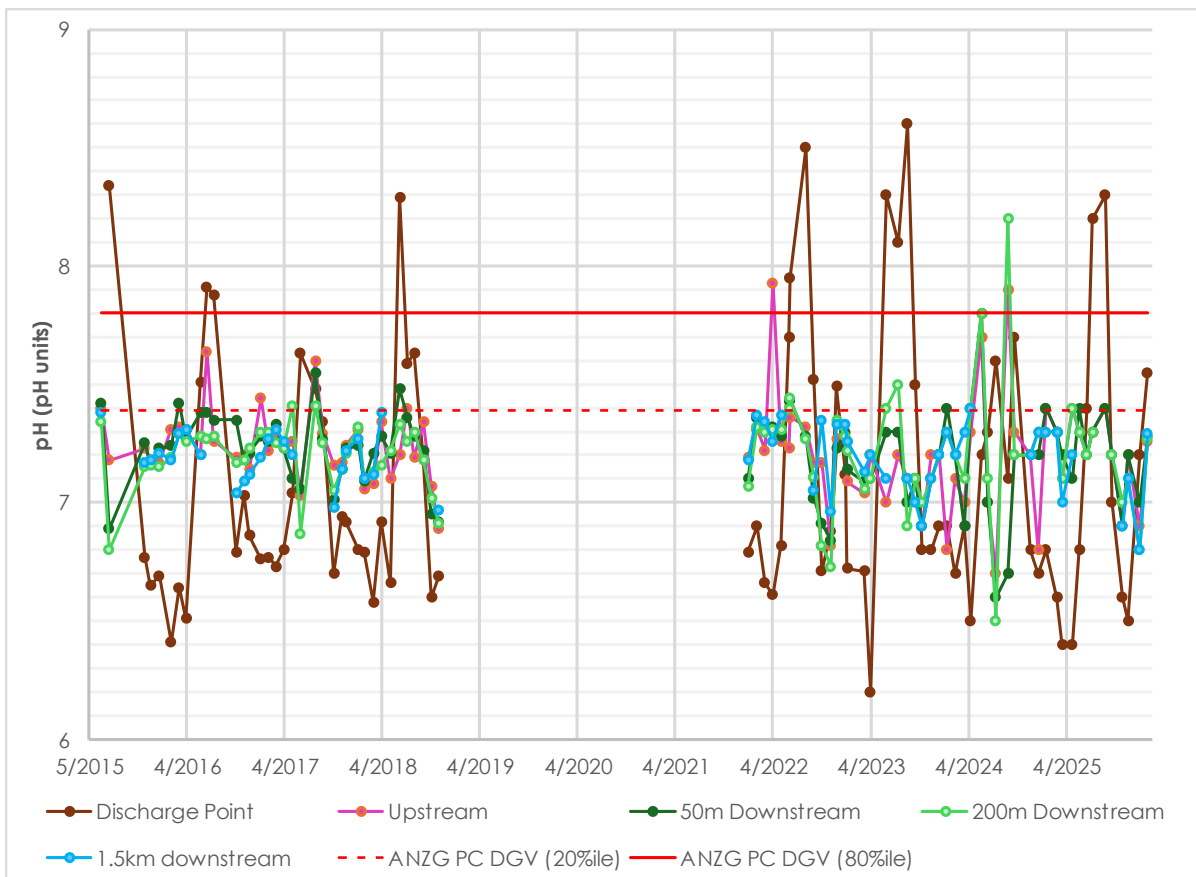


Figure 17. pH compliance monitoring results

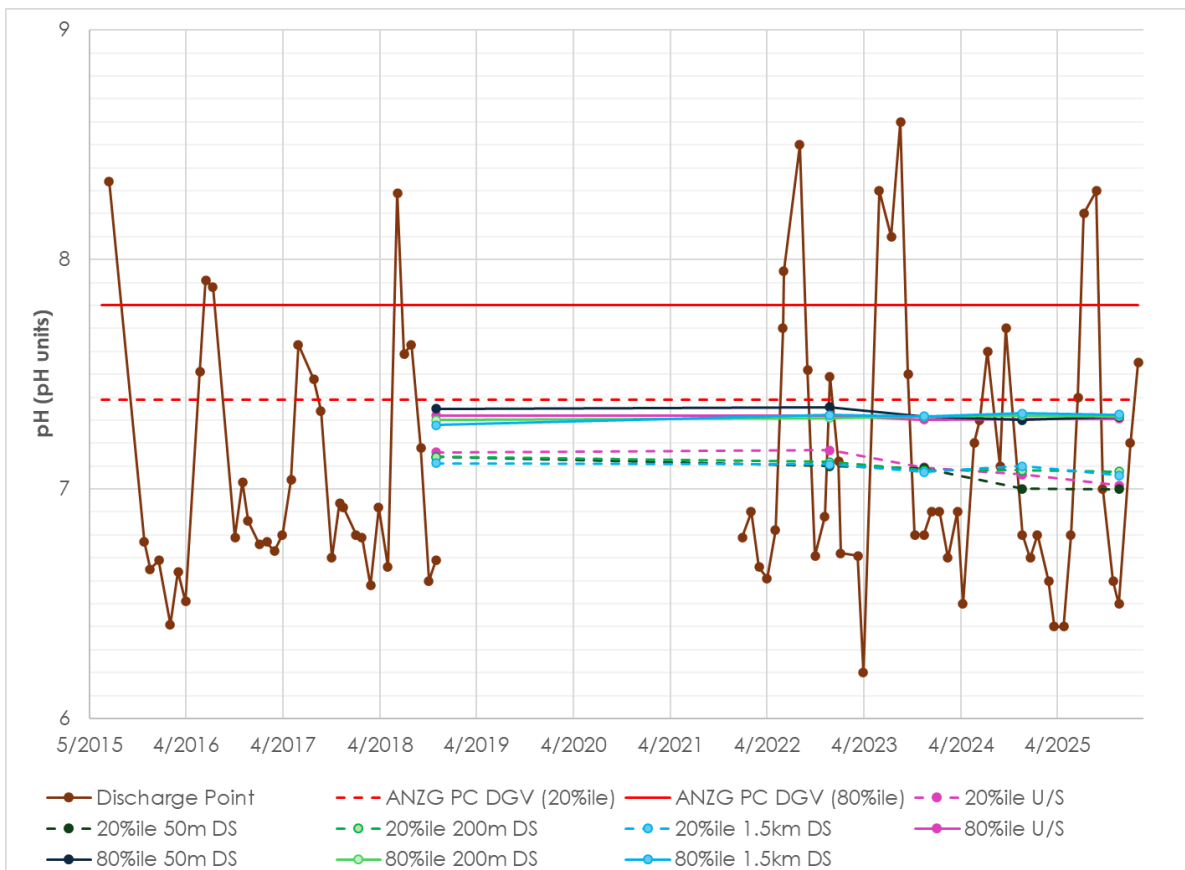


Figure 18. 20%ile and 80%ile pH Compliance Monitoring Results in the Rastus Burn



4.4 Dilution and Attenuation

The concentrations of contaminants from the primary treated effluent discharged to land are slight but measurable in the Rastus Burn water quality. As the dispersal field does not offer any land treatment, dilution and attenuation are the dominant process which mitigates the effects on the Rastus Burn. As the discharge infiltrates through the vadose zone, the discharge will be attenuated. As the infiltrating plume of wastewater mixes with the excellent quality groundwater beneath the field dilution occurs. Finally, further dilution occurs as groundwater recharges to the excellent quality Rastus Burn water. Figure 19 compares the modelled Rastus Burn flows and wastewater discharge flows to land as measured by NZSki.

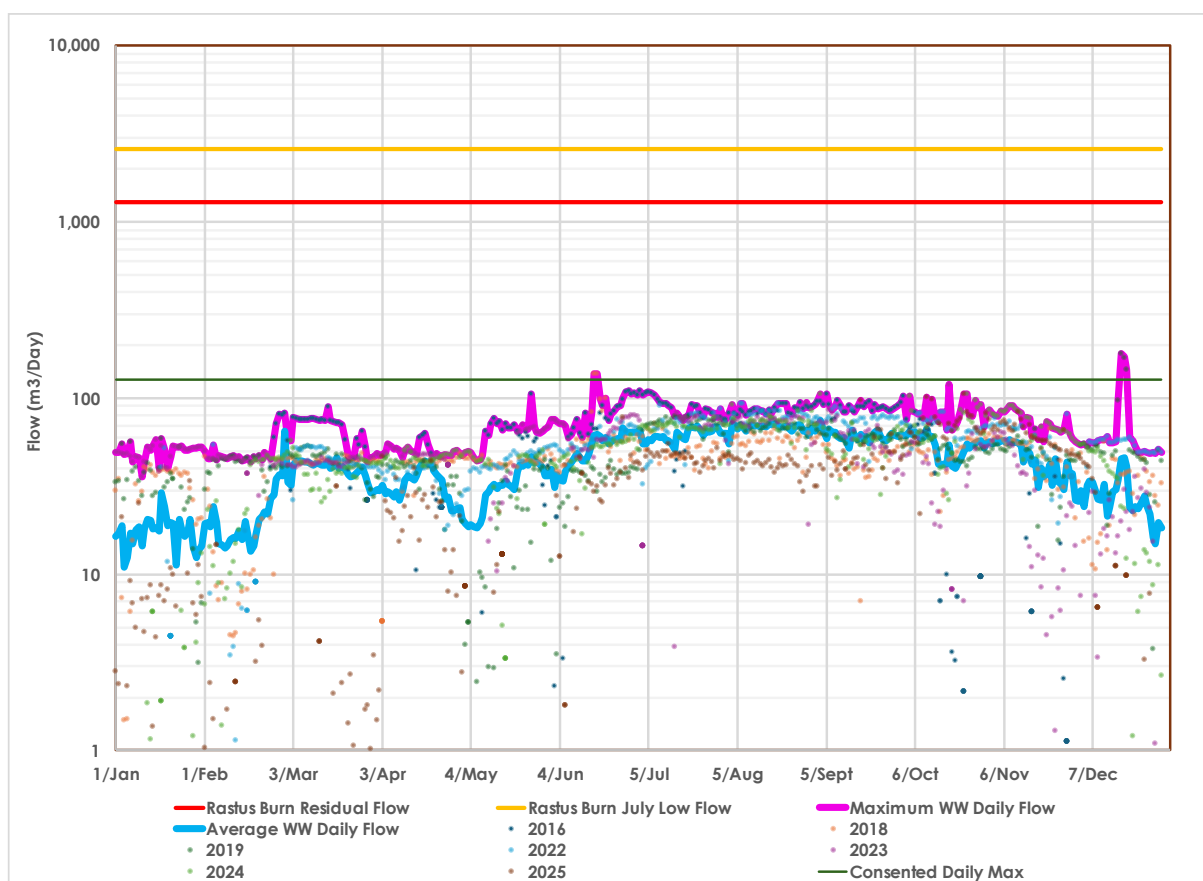


Figure 19. Comparison of Modelled Rastus Burn Flows to Remarkables Wastewater Discharge.

Note that a residual flow of 15 L/s is required to be maintained in the Rastus Burn below the NZSki water take. The Rastus Burn residual flow is used as it is likely to represent <1% of all flows and be a useful worst-case scenario, noting that there are additional flows into the Rastus Burn below the water take. With a flow of 15 L/s in the Rastus Burn, the consented maximum daily discharge would be diluted 10:1, and the average effluent peak flow of 66 m³/day would be diluted 19:1. With average low flow of 25 L/s these dilution ratios increase to 17:1 and 32:1 respectively.



Table 10. Potential Worst-Case Discharge Dilution Rates

| Rastus Burn Flow | Rastus Burn total Daily flow (m ³ /day) | Wastewater Discharge (m ³ /day) | Surface water:Wastewater Dilution |
|-------------------------|--|--|-----------------------------------|
| Residual Flow 15 L/s | 1,296 | 127.44 (peak) | 10:1 |
| | | 66 (avg) | 19:1 |
| Average low flow 25 L/s | 2,160 | 127.44 (peak) | 17:1 |
| | | 66 (avg) | 32:1 |

Figure 20 presents the ratio of total nitrogen concentration in the discharge compared to the Rastus Burn. The average ski-season ratio, as measured at downstream 50 m/200 m, is around 170:1. Selected dilution ratios are labelled on the graph for the ski-season (blue arrows), the off season (black arrows), and the July 2023 leak (red arrow). The reported leak accident in July 2023, fortuitously occurred during a sampling event and so provides a useful metric for how much dilution would occur should the ski season discharge be direct to water. Assuming the flow conditions in Table 10 and given dilution rates of between 17:1 to 32:1, the leak dilution was measured as a dilution of 18:1.

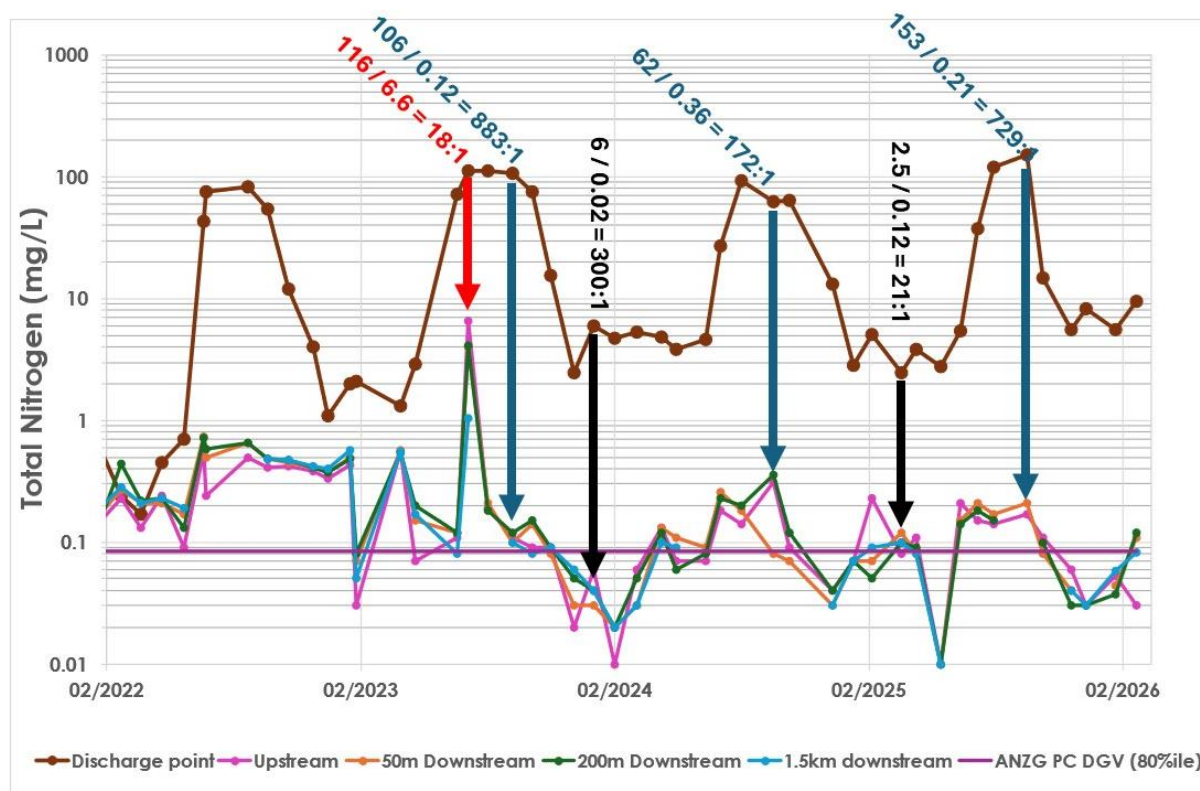


Figure 20. Range of dilutions of Total Nitrogen (mg/L) from discharge to the Rastus Burn.

The blue arrows refer to compliant ski season discharge conditions where all wastewater is discharged to the dispersal field. Under these conditions, dilution is orders of magnitude higher, and represents the attenuation and dilution occurring in the



dispersal field and groundwater below, prior to diffuse discharge along the adjacent reach of the Rastus Burn. In the off-season (black arrows), dilution rates ranged from 300:1 to 21:1; with variation due to Rastus Burn flows increasing with spring snow melt and a slow taper off towards autumn as well as lower rates of wastewater generation as fewer people use the public toilet facilities.

Groundwater flow rates are currently not known and further investigation is recommended to validate the current conceptual model for wastewater impacted groundwaters to recharge the Rastus Burn. This is discussed further in Section 6.

4.5 Existing Contaminant Load to the Receiving Environment

Monthly and annual total nutrient loads were estimated to determine the benchmarked performance of the dispersal field, as nutrients are the key contaminants that have the greatest potential to result in adverse effects to the receiving aquatic ecosystem. The current nutrient contaminant loads to the downgradient receiving environment are deemed suitable for use as performance criteria for maintenance of water quality conditions; whilst there are slight but measurable impacts to the water quality of the Rastus Burn, generally water quality is meeting the adopted guidelines (section 3.6.1). Further, the biennial biological monitoring has (excepting 2023) reported good-excellent aquatic ecosystem health in the Rastus Burn.

To develop estimations of load, monthly effluent flow data were paired with the relevant effluent quality sample data (e.g. flow and effluent quality concentration data for May 2023) and multiplied to calculate an estimated monthly load that was discharged to land.

- Monthly load (kg/month) = Monthly concentrations (g/m³) x Monthly Total Flow (m³/month)

Table 11 collates the annual nutrient loads, patronage, wastewater discharge, and ecological monitoring data to provide for a general overview of the current discharge loads for nitrogen and phosphorus.

The key overall observation from Table 11 is that there appears to be a threshold that was crossed prior to the monitoring in 2023, resulting in a change from good-excellent instream values in the Rastus Burn (as measured in 2017) to 'Fair to Good' in 2023. This is attributed to both the leak that occurred in July 2023, and the two years of higher nutrients loads in 2022 and 2023. In 2025 the monitoring of instream quality indicators



reported a return to good-excellent condition at all sites and the nutrient loads were less for 2024/2025 than 2022/2023.

During the leak concentrations of nitrogen (ammoniacal nitrogen) exceeded the 80% species protection toxicological effects DGV for presumably the entire time the leak was occurring e.g. 5th to 14th July 2023, 9 days. It is possible that even though the exposure period was less than an invertebrate lifecycle, that 9 days was enough time to cause toxicological effects to the 20% of freshwater species present that were entering a sensitive period in their lifecycle. It is noted that the reported toxicological effect for mayfly (*Deleatidium sp.*) is 3.2 mg/L total ammoniacal nitrogen (ANZG, 2026), which was presumably exceeded at the upstream and downstream 50m and 200m monitoring sites for the entire 9-day period. The *Deleatidium sp.* abundance declined in 2023 compared to 2014/2017 and still has not recovered in 2025. Therefore, it's possible that the community was significantly affected by the leak such that when biological monitoring occurred over three months later there was still evidence of the effects of the leak on the ecosystem health, and that may be the dominant factor in the decline from good-excellent in 2014/2017 to fair-good in 2023.

At the same time, higher nutrient loads were also discharged during 2022 and 2023 than were observed in the preceding and following years. High nutrient loads can result in a subtle increase in productivity which changes the instream community as it adjusts to more growth of periphyton and macroalgae. As these two factors (leak and nutrient loads) are both potential causes of the degraded instream values in 2023, it is assumed that in addition to a leak exceeding toxicological thresholds, that a threshold for the cumulative ongoing nutrient load to the environment was also exceeded in 2022/2023. As the nutrient loads reduced in 2024 and 2025 and the biological monitoring in 2025 reported a return to good-excellent quality, it was conservatively assessed that an overall nutrient load threshold could be determined based on the calculated annual nutrient loads.

Note that the below EPT Taxa% quality bands were developed for the visual assessment of the reported data on sensitive and tolerant species and are not supported by national or international guidance.



Table 11. Review of nutrient load, patronage, wastewater flows, and ecological monitoring.

| Table 11a: Nutrient load assessment | 2016 | 2018 | 2022 | 2023 | 2024 | 2025 | Average |
|---|---------|---------|---------|---------|---------|---------|---------|
| Annual WW Discharge (m3/year) | 15,227 | 15,693 | 17,724 | 16,299 | 17,009 | 10,311 | 15,659 |
| Ski Season WW Discharge (m3/year) | 10,933 | 8,095 | 10,744 | 8,597 | 9,494 | 6,989 | 9,087 |
| Ski Season Patronage (person/year) | 219,179 | 241,609 | 281,652 | 299,626 | 270,826 | 294,735 | 267,938 |
| Ski Season WW L/person (bywash inclusive) | 50 | 34 | 38 | 29 | 35 | 24 | 34 |
| Discharged Annual N Load (kg/year) | 356 | 320 | 601 | 701 | 549 | 463 | 498 |
| Discharged Annual P Load (kg/year) | 82 | 66 | 57 | 72 | 61 | 43 | 64 |

| Table 11b: Ecological Monitoring | | 2013-2014 | 2016-2017 | 2022-2023 | 2024-2025 | Average |
|----------------------------------|-----------|---------------------------------|---------------------------------|---------------------------------|--|---------|
| Periphyton | All sites | Absent or rare across all sites | Absent or rare across all sites | Absent or rare across all sites | Absent or rare across all sites, didymo detected at 200 DS | - |
| EPT Taxa% | Upstream | 51 | 44 | 49 | 63 | 52 |
| | 50m DS | 47 | 52 | 39 | 48 | 46 |
| | 200m DS | 49 | 43 | 36 | 60 | 47 |
| | 1500m DS | - | 49 | 54 | 54 | 52 |
| MCI Score | Upstream | 114 | 119 | 99 | 123 | 114 |
| | 50m DS | 125 | 130 | 105 | 130 | 123 |
| | 200m DS | 129 | 117 | 96 | 132 | 119 |
| | 1500m DS | - | 116 | 118 | 134 | 123 |
| SQMCI Score | Upstream | 7.3 | 7.4 | 5.6 | 7.4 | 7 |
| | 50m DS | 6.9 | 7.3 | 4.9 | 7.6 | 7 |
| | 200m DS | 7.1 | 6.3 | 5.2 | 7.3 | 6.5 |
| | 1500m DS | - | 7.1 | 7.2 | 7.9 | 7 |

Interpretation guide for Table 11a.

| |
|---------------|
| Highest value |
| Mean value |
| Lowest value |

Interpretation guide for Table 11b

| Quality Class A | Quality Class B | MCI | SQMCI | EPT Taxa% |
|-----------------------------|-----------------|-----------|-------------|-----------|
| Clean water | Excellent | ≥ 120 | ≥ 6.00 | >50 |
| Doubtful quality | Good | 100 – 119 | 5.00 – 5.99 | 40-49 |
| Probable moderate pollution | Fair | 80 – 99 | 4.00 – 4.99 | <40 |
| Probable severe pollution | Poor | < 80 | < 4.00 | |



4.5.1 Nitrogen Load

Based on the assessment (Table 12), the estimated nutrient loads from 2016-2018 appear to have doubled by 2022-2023 and then reduced back to lower values in 2024-2025 (see monthly loads in Figure 21). The increase in load in 2022/2023 appears to be directly related to the increases in wastewater flows and slight increases in nitrogen concentrations (Figure 22). It appears that although there is an increasing trend in total nitrogen concentration over time (NB. more pronounced in the maximum values) lower flows in 2025 resulted in lower loads.

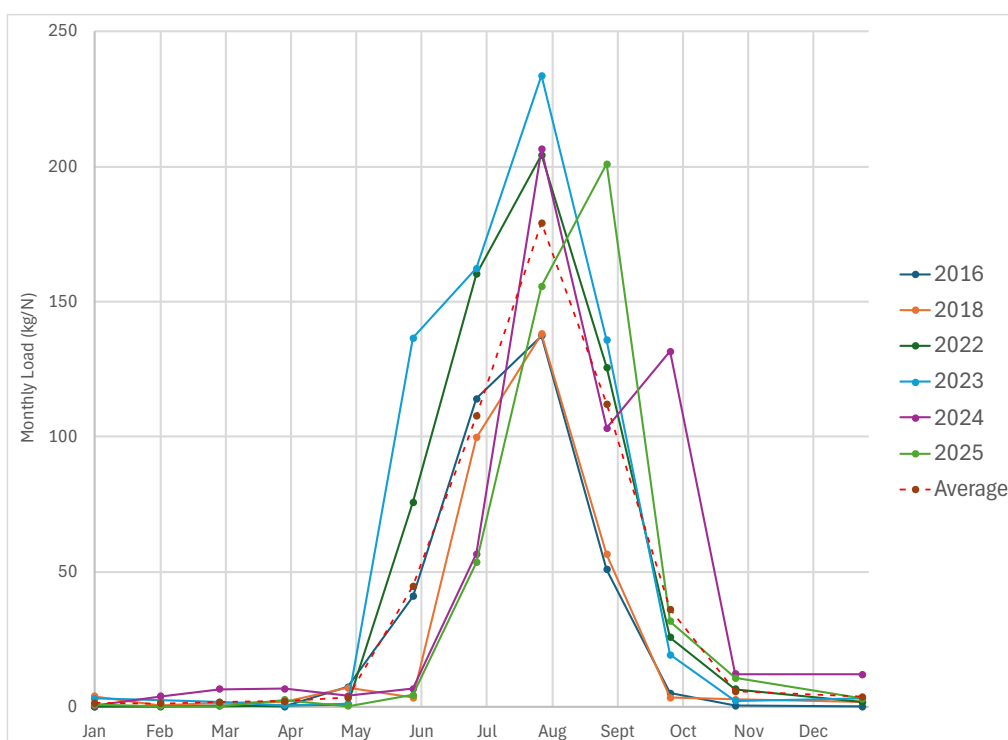


Figure 21. Estimated Monthly Total Nitrogen Load.

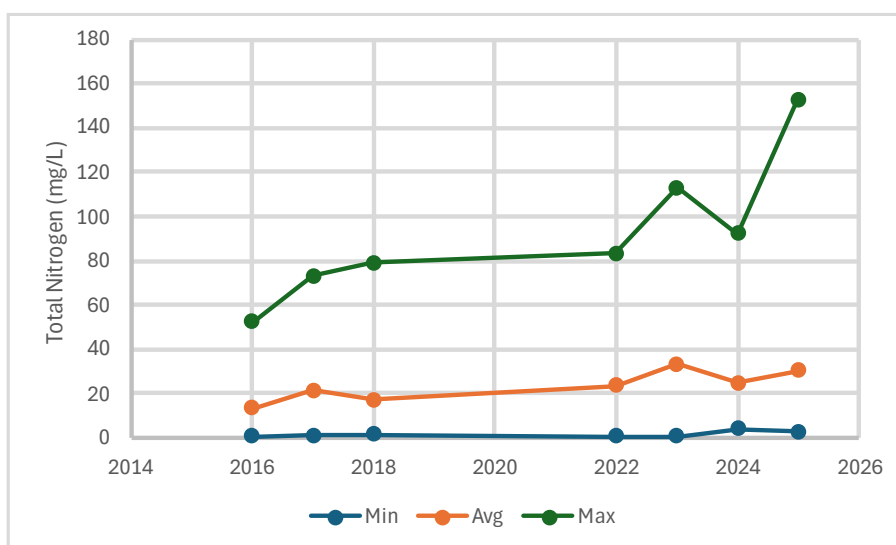


Figure 22. Annual Aggregated Total Nitrogen Concentrations



A critical factor for the discharge is that it is seasonal with highest loads during the winter-spring ski season, coinciding with the lowest flows in the Rastus Burn. Although no monitoring of aquatic ecology occurs during winter, due to low temperature in the Rastus Burn it is expected that the slight but measurable increase in nutrient load is unlikely to result in periphyton productivity increases (e.g. algal blooms) or chronic adverse effects on grazing invertebrates. Aquatic ecology is monitored following the ski season once snow melt has occurred to allow access to the creeks and provide a summary snapshot of the community following discharge of the bulk of the contaminant load. Based on the assessment in Table 8, the biological components in the treatment system are active from October to May, converting ammonia to nitrite/nitrate. At this time, increases in Rastus Burn flow, water temperature and daylight length allow instream flora and fauna to process any accumulated nutrients.

Based on the observation of adverse effects due to higher nutrient loads in 2022/2023, it is recommended that nutrient loads be maintained at the those measured in 2024-2025 when ecological indicators were good-excellent. Table 14 provides the proposed performance criteria for nitrogen.



Table 12. Estimated Total Nitrogen* Load (monthly (kg/month) and Annual (kg/year)

| Month | 2016 | 2018 | 2022 | 2023 | 2024 | 2025 | Min Load | Mean Load | Max Load |
|-----------------------------------|------------|--------------------|--------------------|--------------------|--------------------|--------------------|------------|------------|------------|
| Jan | 0.1 | 3.9 | 0.1 | 3.0 | 0.3 | 0.7 | 0.1 | 1.3 | 3.9 |
| Feb | 0.1 | 0.5 | 0.0 | 2.3 | 3.8 | 0.2 | 0.0 | 1.2 | 3.8 |
| Mar | 0.5 | 1.5 | 0.2 | 1.7 | 6.5 | 0.1 | 0.1 | 1.8 | 6.5 |
| Apr | 0.1 | 1.7 | 0.5 | 0.5 | 6.6 | 2.5 | 0.1 | 2.0 | 6.6 |
| May | 7.2 | 7.0 | 0.9 | 1.0 | 4.1 | 1.9 | 0.9 | 3.7 | 7.2 |
| Jun | 40.9 | 3.3 | 75.7 | 136.5 | 6.7 | 4.3 | 3.3 | 44.6 | 136.5 |
| Jul | 114.0 | 99.6 | 160.1 | 161.9 | 56.5 | 53.3 | 53.3 | 107.6 | 161.9 |
| Aug | 137.3 | 137.9 | 204.2 | 233.6 | 206.4 | 155.7 | 137.3 | 179.2 | 233.6 |
| Sept | 50.7 | 56.3 | 125.6 | 135.7 | 103.2 | 200.9 | 50.7 | 112.1 | 200.9 |
| Oct | 4.9 | 3.3 | 25.6 | 19.1 | 131.4 | 31.5 | 3.3 | 36.0 | 131.4 |
| Nov | 0.3 | 2.7 | 6.5 | 2.2 | 12.0 | 10.6 | 0.3 | 5.7 | 12.0 |
| Dec | 0.0 | 1.9 | 1.6 | 3.1 | 12.0 | 3.1 | 0.0 | 3.6 | 12.0 |
| Annual Load (% change) | 356 | 320 ↓10% | 601 ↑88% | 701 ↑17% | 549 ↓22% | 465 ↓15% | 250 | 499 | 916 |

*In some cases, total nitrogen was not assessed at the discharge point, however total ammoniacal nitrogen was analysed and was found to be generally representative of the total nitrogen load as there is a negligible amount of organic nitrogen (TKN) and inorganic oxidised nitrogen (nitrate/nitrite) in the primary treated wastewater. See Table 4 for a breakdown of nitrogen species.



4.5.2 Phosphorus Load

Based on Table 13, phosphorus inputs to the Rastus Burn catchment are modest. It is noted on average, 50% of the total P load during the ski-season is reported as the highly mobile DRP. Concentrations in the Rastus Burn from 2024 and 2025 were below the Schedule 15 limit.

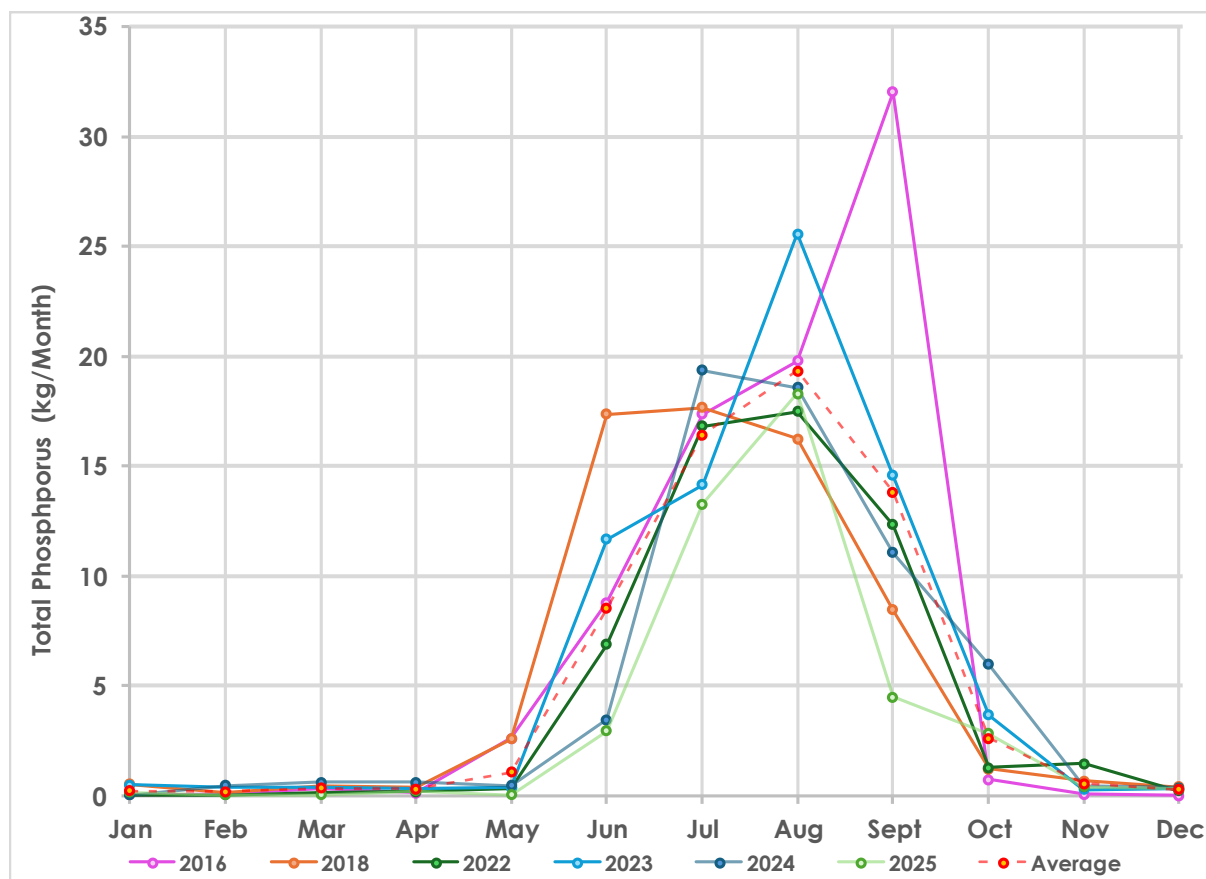


Figure 23. Estimated Monthly Total Phosphorus Load.

In general, waters in New Zealand are phosphorus limited, therefore while nitrogen is considered a more pressing concern, the total phosphorus load should also be managed such that excess nutrients are not available in the receiving environment. Performance criteria were therefore derived from the historic month to month load (Figure 23) and overall annual phosphorus loads (Table 13). Table 14 provides the performance criteria for phosphorus.



Table 13. Estimated Total Phosphorus Load (monthly (kg/month) and annual (kg/year))

| Month | 2016 | 2018 | 2022 | 2023 | 2024 | 2025 | Min Load | Mean Load | Max Load |
|-----------------------------------|-----------|-------------------|-------------------|-------------------|-------------------|-------------------|-----------|-----------|------------|
| Jan | 0.02 | 0.50 | 0.02 | 0.47 | 0.03 | 0.15 | 0.02 | 0.20 | 0.50 |
| Feb | 0.08 | 0.10 | 0.02 | 0.39 | 0.44 | 0.01 | 0.01 | 0.17 | 0.44 |
| Mar | 0.34 | 0.42 | 0.16 | 0.36 | 0.59 | 0.03 | 0.03 | 0.32 | 0.59 |
| Apr | 0.10 | 0.38 | 0.17 | 0.29 | 0.60 | 0.20 | 0.10 | 0.29 | 0.60 |
| May | 2.60 | 2.57 | 0.32 | 0.31 | 0.46 | 0.40 | 0.31 | 1.11 | 2.60 |
| Jun | 8.79 | 17.35 | 6.87 | 11.66 | 3.44 | 2.92 | 2.92 | 8.50 | 17.35 |
| Jul | 17.35 | 17.68 | 16.81 | 14.13 | 19.35 | 13.26 | 13.26 | 16.43 | 19.35 |
| Aug | 19.80 | 16.24 | 17.47 | 25.57 | 18.57 | 18.31 | 16.24 | 19.32 | 25.57 |
| Sept | 32.04 | 8.45 | 12.33 | 14.59 | 11.07 | 4.47 | 4.47 | 13.83 | 32.04 |
| Oct | 0.71 | 1.21 | 1.28 | 3.65 | 5.97 | 2.81 | 0.71 | 2.60 | 5.97 |
| Nov | 0.05 | 0.66 | 1.46 | 0.28 | 0.43 | 0.38 | 0.05 | 0.54 | 1.46 |
| Dec | 0 | 0.38 | 0.20 | 0.31 | 0.35 | 0.29 | 0.00 | 0.26 | 0.38 |
| Annual Load (% change) | 82 | 66 ↓20% | 57 ↓14% | 72 ↑26% | 61 ↓15% | 43 ↓30% | 38 | 64 | 107 |



4.5.3 Other Contaminants

4.5.3.1 TSS

With respect to TSS, the discharge is to highly permeable gravel bedded infiltration basins. The TSS is expected to be largely filtered by the gravels so is not a concern for the Rastus Burn, however clogging of the pore spaces is a long-term concern for acceptance of the wastewater at the dispersal field. A maintenance schedule will be provided to ensure particulates do not clog pore spaces and lower infiltration rates. Observations are that the basins are currently performing as expected, therefore by maintaining the same TSS load the dispersal field should remain fit for purpose. Table 14 provides performance criteria for TSS

4.5.3.2 cBOD55

The organic loading rate is not critical at this site as the dispersal field is not designed for any land treatment. Further, algal mats are unlikely to grow in the pore spaces of the dispersal field as the temperatures are far too cold to support high growth rates. In the offseason when temperatures are warm enough for such growth there is very little organic matter discharged at the site. Ongoing monitoring of the base of each infiltration basin is recommended as a key action for managing the risk of clogging from excess organic matter.

4.5.4 *E. coli*

The existing dispersal field is likely to provide excellent pathogen removal (as indicated by *E. coli*) due to the thickness of sandy gravel above the groundwater table, and distance that any pathogens must travel before entering a surface water body. As the site is not located near any recreational sites for water use, and there is no drinking water supply within 1 km of the discharge, no performance criterion for *E. coli* is recommended.

While not a performance criterion for the OWMS, monitoring of *E. coli* is still required, especially in the case of monitoring risks from any leaks or spills.



4.6 Preliminary Performance Criteria for Water Quality

Based on the review of historical discharge loads and ecological health of the Rastus Burn in Section 4.4, preliminary performance criteria for discharge quality are proposed in Table 14.

Table 14. Preliminary# Performance Criteria for discharge quality at the discharge point for maintaining the existing Water Quality Conditions in the Rastus Burn.

| Parameter | Criteria | Rationale |
|--------------------------|---|--|
| Nitrogen Load | Five-year rolling mean is ≤ 500 kg nitrogen/year | The average value (rounded) of reported loads, particularly 2024 and 2025 |
| | Must not exceed 600 kg nitrogen/year in any calendar year | Potential threshold as the lower of the two years 2022 and 2023 |
| Phosphorus Load | Five-year rolling mean is ≤ 65 kg phosphorus/year | The average value (rounded) of reported loads |
| | Must not exceed 85 kg phosphorus/year in any calendar year | Halfway between the average value and the maximum possible load as per Table 13.. |
| TSS Concentration | Five year rolling mean is ≤ 40 mg/L TSS | Average concentration (rounded) of the compliance monitoring dataset at the discharge |
| | Five year rolling 95%ile is ≤ 110 mg/L TSS | pipe95%ile value (rounded) of the compliance monitoring dataset at the discharge pipe |
| BOD Concentration | Five year rolling mean is ≤ 80 mg O ₂ /L (BOD ₅) | The average value (rounded) of reported loads |
| | Five year rolling 95%ile is ≤ 320 mg O ₂ /L (BOD ₅) | 95%ile value (rounded) of the compliance monitoring data |
| E. coli | No criterion | A performance criterion for human faecal pathogens is not required as the natural die-off rates are high, and there are no sensitive receptors in the affected downstream reach. |

#Further investigation is required to validate the preliminary performance criteria for water quality as there are some risks associated with the way in which the concentration and flow data are considered representative of the actual discharge

NZSki have confirmed that the current nutrient loads will be maintained to preserve the good-excellent aquatic ecology in the Rastus Burn despite an increase in patronage and associated wastewater flows. The monitoring of ecosystem health indicators in the Rastus Burn indicates that overall, a good-excellent quality has been maintained since the discharge monitoring commenced in 2014. To improve the ecosystem health indicators for the Rastus Burn, a reduction in nutrients compared to current load is needed. However, while water quality may improve (e.g. no detection of the discharge in the Rastus Burn), it should be noted that this may not necessarily be reflected in an improvement in the ecosystem health indicators in the immediate



downstream reach as the level of productivity in the ecosystem may be partially supported by the discharge.

5 Conceptual Site Model and Risk Assessment

To summarise the current understanding of the discharge, the transport and fate of the contaminants, and their effects on the environment, a conceptual site model has been developed. The conceptual site model is summarised in Table 15.

Table 15. Summary Conceptual Site Model

| | |
|----------------|---|
| Source | Discharge of skifield wastewater to land via infiltration basins |
| Pathway | <p>The discharge to land infiltrates through base of the dispersal field which is largely comprised of sandy gravel with silt overlying shallow bedrock. The discharge infiltrates and intersects groundwater at depths of 5-10m below ground level (refer to cross sections in section 3.4). During infiltration pathogens die off at high rates.</p> <p>The process of organic matter decomposition begins in the vadose zone where oxygen is available. At the water table an oxidation/reduction front is present where excess organic matter is decomposed through reduction of other oxidising agents (e.g. manganese oxide).</p> <p>The two waters mix, and a plume of dissolved contaminants follows the steep groundwater gradient and travels 50 – 100m in a northerly and westerly direction towards the Rastus Burn. It is conservatively expected that groundwater does not penetrate the bedrock in any significant volume due to the relatively low permeability of the schist compared to the overlying unconsolidated materials.</p> |



| | |
|-----------------|--|
| Receptor | <p>The Rastus Burn receives groundwater recharge indirectly via seeps at breaks in slope which flow overland; or directly via more diffuse groundwater gains through the channel bed along a reach of over 500 m. The impacted groundwater may also follow preferential flow paths. The discharge is diluted on average 170 times by the time it mixes with the Rastus Burn.</p> |
|-----------------|--|

6 Ongoing Investigations

While the anticipated environmental effects are well understood, further investigations are recommended to reduce uncertainty regarding the conceptual site model (Table 15) and preliminary performance criteria. These uncertainties can be grouped by their respective part of the CSM framework (source, pathway, receptor).

6.1 Limitations, Risks, and Mitigation

6.1.1 Flow Meter

The flow meter has been shown to only report flows above a certain threshold and has reported negative flows at times. This introduces uncertainty into the calculation of wastewater nutrient loads which utilised recorded total daily flow values. Therefore, the monthly flow totals used in load calculations potentially underestimating the flows, and thus lower loads were calculated and suggested as preliminary performance criteria.

A new flow meter was installed in April 2026 by NZSki to improve the accuracy at low flows.

6.1.2 Treated Wastewater Quality

Historically the monthly grab sample from the discharge point to the infiltration basins is collected in the morning between 7am and 12pm. This introduces some uncertainty over and above the use of a single monthly discharge sample in estimating a monthly nutrient load. The time of day at which the sample is collected, and the day of the month are important as they should seek to sample representative conditions.



The issue of timing is due to the lag time between the skier's activity and the processing and discharge of treated wastewater. Due to the lag time, bywash is likely to dominate flows early in the morning, with treated effluent becoming a dominant stream from afternoon into the evening, before reverting to baseflow once the days load has been processed.

Hourly sampling of the flow and the discharge quality should be undertaken during future investigations to understand whether the available historic monitoring datasets are representative of the variation in daily and monthly concentrations to confirm the performance criteria.

6.2 De-risking Investigations

While sufficient information is available to understand the scale of the risk to the environment posed by the proposed activity, further information is required to confirm the preliminary performance criteria and thus the design of the upgraded wastewater treatment system. Table 16 sets out the requirements for derisking investigations to be completed by the consented timeframes. This will primarily allow for the investigations to occur over the 2026 ski season and providing time for any follow up investigations and reporting.



Table 16. De-risking Investigations

| CSM | Issue | Mitigation | Comment |
|--|---|--|--|
| Source | Low flows are not counted by the flow meter | <ul style="list-style-type: none"> Investigate options for improving accuracy at low flows | <ul style="list-style-type: none"> New Magflow installed April 2026 |
| | Bywash and operations management | <ul style="list-style-type: none"> Contextual information gathering (snow making, potable water supply flow meter) No harsh cleaning agents) Reducing or managing the bywash is part of the operational changes required to maintain water quality in the Rastus Burn. | <ul style="list-style-type: none"> Stantec to lead bywash and operations management assessments |
| | Monthly water quality sampling not representative of variability in discharge quality | <ul style="list-style-type: none"> Hourly autosampler targeted to identify whether composite sampling is effective by identifying the range of concentrations over a day. To determine ideal sampling timeframe for the treated discharge. Fortnightly sampling during the ski season to refine accuracy of load estimates Collection of contextual information (maintenance schedule/flow buffering, assess type of water quality sampling (performance monitoring or hydrogeochemical)) | <ul style="list-style-type: none"> TBC, benchmark sample collected in February 2026 Stantec to lead on assessing contextual information, e3s to lead on assessing water quality sampling |
| Pathway | Groundwater Conceptual Model, groundwater flow rates uncertain | <ul style="list-style-type: none"> Install water level loggers to accurately map groundwater level over the ski season and hence flow directions | <ul style="list-style-type: none"> TBC |
| | | <ul style="list-style-type: none"> Undertake slug testing of the groundwater monitoring network to determine hydraulic properties of the subsurface and aquifer | <ul style="list-style-type: none"> TBC |
| | Dispersal field long term acceptance rate | <ul style="list-style-type: none"> Undertake renovation of the infiltration basins and complete infiltration testing to confirm design irrigation rate | <ul style="list-style-type: none"> Completed April 2026 |
| | Dry groundwater monitoring bores | <ul style="list-style-type: none"> Install new groundwater monitoring bores and deepen dry bores, | <ul style="list-style-type: none"> Completed February 2026 |
| <ul style="list-style-type: none"> Survey borehole elevations and locations | | <ul style="list-style-type: none"> TBC | |
| Receptor | Rastus Burn flow variability | <ul style="list-style-type: none"> Gauging events during winter | <ul style="list-style-type: none"> First event completed March 2026, Three events planned during ski season (June, August, October). |
| | | <ul style="list-style-type: none"> Install surface water level logging site to correlate flows to levels on the long term, reduces the requirement for more gauging | <ul style="list-style-type: none"> SWL site installed March 2026 |
| | | <ul style="list-style-type: none"> Complete an elevation survey of the level logging site | <ul style="list-style-type: none"> TBC |



7 Assessment of Environmental Effects

7.1 Overview

A discharge of this size has the potential to cause adverse effects on the receiving environment should it not be managed appropriately. The following assessment of effects considers the history of compliance achieved by the current OWMS, and how the same level of effects will be possible under the forecasted increase in visitor numbers.

The current OWMS only provides primary treatment to the wastewater discharge; solids are removed but the wastewater largely passes through the OWMS unmodified. Therefore, from basically a zero-treatment baseline there is significant room for improvement when upgrading the OWMS to include nutrient management. NZSki is familiar with the requirements of an advanced secondary treatment OWMS at their Coronet Peak skifield and so it can be considered that an upgraded system designed to meet the performance criteria can be adopted and the resulting system operated and maintained with the same diligence and care that is applied to the Remarkables skifield operation.

The following assessment of effects is based on the upgraded OWMS operating to the proposed preliminary performance criteria to ensure that the existing water quality and ecosystem health conditions are maintained under future development scenarios. That is, that the measurable water quality effects remain at an acceptable level, and the reported good to excellent ecosystem health is maintained.

7.2 Effects on Soils and Plants

The discharge primarily occurs over winter when biological activity is likely to be in hibernation, as snow covers soil and plants. The soil and plants most likely to interact with the impacted groundwaters are in the riparian margin of the Rastus Burn for the reach adjacent to the dispersal field. This is primarily where seeps occur as groundwater is forced to the surface by bedrock or hydraulic head.

The current model for the groundwater discharge to the Rastus Burn is that it occurs as diffuse recharge across the whole adjacent reach. These seeps have yet to be sampled but may discharge diluted impacted groundwaters with short distances into



the Rastus Burn. Soils and the flora and fauna that cohabitate in the riparian margin may have a slight benefit from the increase in nutrients. It is unlikely that adverse effects such as clogging of pore spaces would occur as the riparian margin is in places up to 100 m from the discharge, and therefore all organic matter is expected to have been assimilated prior to any discharge to seeps.

Overall, there is most likely to be negligible effects on soil and flora/fauna therein.

7.3 Effects on Groundwater Quality

Groundwater quality is impacted significantly in the immediate vicinity of the dispersal basins as monitored in the downgradient bores. The groundwater migrates to the north and west and most likely recharges to the adjacent reach of the Rastus Burn due to hydraulic head and/or shallow bedrock forcing groundwater to the surface at nick points (waterfalls). The dominant permeability in the dispersal field is most likely in the horizontal plane due to various degrees of imbrication in the unconsolidated alluvial and colluvial material. Secondary permeability in the vertical direction allows for infiltration to continue until it is eventually arrested by the presence of a slowly permeable layer, i.e. the shallow schist bedrock identified during the recent drilling.

Due to the slope of the land, the hydraulic gradient is steep which results in groundwater flowing downgradient along permeable horizons in the unconsolidated materials, and further horizontal flow along the upper surface of the bedrock. It is possible some flow partitioning occurs with groundwater entering fracture networks in the schist bedrock, but it is unlikely that this is a significant proportion of the impacted groundwater, due to the relative contrast in permeability between the bedrock and overlying unconsolidated alluvial/colluvial materials.

For fracture networks to be an issue for this site they would need to be connected over vast distances and as there are no human groundwater users in the vicinity in which impacted groundwater is likely to be present (a nominal 1 km radius), effects on human groundwater users are unlikely.

7.4 Surface Water Quality

In the steep Rastus Burn catchment, the impacted groundwater is forced to the surface by the concave morphology of the shallow bedrock which concentrates flow downslope. Groundwater may gain or lose flow from surface water and therefore the



potential for adverse effects from the degraded groundwater quality are considered for surface water quality, the receptors living in the surface water, and other users of surface water.

As reported in Section 3 and 5, during the ski season there are slight but measurable impacts in the Rastus Burn reach adjacent to the dispersal field. To date, compliance monitoring results indicate that most adopted guideline values are being met for the contaminants of concern. Further, biennial biological monitoring indicates that the Rastus Burn has good to excellent ecosystem health when considering the instream values (periphyton, invertebrates).

The downgradient monitoring site at 1.5 km from the dispersal field reports generally no effects or very minor effects, indicating that water quality returns to its upstream values over this distance. Surface water is likely to be used by grazing pests (deer, chamois) but the key risk to these species is from pathogen or ingestion of toxic algae, and neither of these risk factors are consistently present in the Rastus Burn at concentrations that would be cause for concern.

Overall, there is a slight but measurable effect on surface water quality under the existing discharge conditions, however, to date the effects are considered acceptable. If the proposed increase in wastewater volumes is managed to maintain the current standard of water quality, then there will be no increase in the scale or intensity of adverse effects on water quality. Therefore, the proposed activity will also have a slight but measurable effect on surface water quality which generally meets the adopted environmental guidelines.

7.5 Effects on Ecology

A freshwater ecological impact assessment is being prepared by e3s in support of the fast-track application. Readers are referred to that report for detailed description of the aquatic ecosystem and an assessment of the potential effects from the discharge of treated wastewater to land. In summary, the Rastus Burn has been assessed as having Moderate ecological value and the key potential effect of increased wastewater discharge volume is nutrient enrichment, which could alter algal and macroinvertebrate communities if nutrient levels rise. A 'Low' level of ecological effect is assigned, and management actions recommended to maintain the existing good to excellent aquatic health (e3Scientific, 2026).



7.6 Climate Change Effects

Climate change has the potential to influence the discharge over the next 15- 30 years however the scale and intensity of this effect is forecast to be modest.

The effects of climate change include positive and negative effects, for example slightly warmer temperatures may reduce power costs associated with temperature sensitive wastewater treatment systems, slight increases to total rainfall may result in high winter flows in the Rastus Burn - slightly increasing dilution and attenuation, however increased wind and the PED may mean that less water is in the Rastus Burn at other times. Currently the OWMS is sized to allow for large rainfall events during winter while also discharging the required volume of wastewater. Any changes to the dispersal field will need to be designed to account for increased rainfall e.g. modified design irrigation rates. The dominant storm system cycle that provides the precipitation and snow may change as ocean currents adjust to warmer temperatures.

Overall, it is expected that the current dynamic equilibrium that the system is designed for may slowly change over the next two decades as the effects of climate change set in. This may mean that the design and operation of any upgraded treatment system needs to consider any impacts to the operation from a changing climate.

7.7 Cumulative Effects

Water quality in the Rastus Burn is impacted by the skifield operations by modification of the natural topography such as roading which has increased human access, led to the displacement of wetlands, the concentration of stormwater flows, the destabilisation of slopes, and the discharge of wastewater to land. The net effect of the skifield operation appears to be overall acceptable as the adopted environmental guidelines are generally met and recent reporting indicates good-excellent ecosystem health indicators prevail. However, there are some issues to be contended with, such as the presence of didymo algae in Lake Alta and recently identified in Rastus Burn which may change the diversity and abundance of freshwater species over time however these are unrelated to the wastewater discharge.

The proposed development is largely in the adjacent Doolans catchment so the effects from additional earthworks in the Rastus Burn are less intensive and limited to new access roading, underground services, gondola infrastructure, and the wastewater and base building upgrades. The Rastus Burn faces an increase in discharged



wastewater volumes but any potential increase in nutrient load is to be mitigated by upgrading the OWMS so that the water quality is maintained to the current standard. Overall, the cumulative effects are acceptable in terms of water quality. Notwithstanding the challenges of a changing climate the proposed activity is to be well planned and serviced by an operator such as NZSki.



8 Summary

This assessment has evaluated the performance of the existing Remarkables onsite wastewater management system (OWMS), characterised the effects on the receiving environment, and the potential effects of increasing wastewater volumes associated with NZSki's proposed Doolans expansion. The investigation incorporated reviews of desktop and previous site investigations, analysis of the compliance monitoring datasets, and supplementary site investigations.

The dispersal field is situated on a terrace above the Rastus Burn, with groundwater present at 5-10 m below the base of the infiltration basins in thin alluvial/colluvial deposits overlying bedrock. Groundwater flows north and west toward the Rastus Burn over the adjacent downgradient reach. Monitoring confirms slight but measurable seasonal nutrient and microbial signals attributable to the discharge. However, the receiving environment maintains good to excellent water quality and ecological health. These effects are expected to be maintained with the expansion of the skifield and associated upgrade of the treatment plant and are strongly moderated by the high-quality alpine catchment and substantial stream dilution.

Nutrient load analysis indicates that the ecological community may be sensitive to the annual nutrient load if it is too high. Environmental thresholds were identified that are suggested as preliminary performance criteria be used to maintain existing instream conditions and form the basis of the upgraded treatment system. The proposed upgrade to the wastewater treatment plant is expected to achieve these criteria and therefore maintain current environmental outcomes despite increased skiers and associated increase in wastewater volumes.

Remaining uncertainties and issues have been identified particularly around seasonal groundwater behaviour, flow metering accuracy, and discharge quality variability. These are to be addressed through further investigations and with ongoing monitoring and operational refinements. An output of the investigations is a report which shall include recommendations for any updates to the operation and management conditions of the discharge. Overall, the assessment concludes that, with the proposed treatment upgrade and adherence to the recommended performance criteria, the increased discharge to land can result in an acceptable level of adverse effects on soils, groundwater, surface water, wetlands, or aquatic ecology.



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