



Ridgeburn Limited

Ridgeburn Development Wastewater Disposal and Effects

TECHNICAL REPORT

WGA252389

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Executive Summary

Ridgeburn Limited (RDL) proposes to develop the Ridgeburn residential area, comprising approximately 1,210 homes, commercial, retail, and recreational spaces on a 212-ha site located at 122 Morven Ferry Road, between Arrowtown and the Kawarau River in the Queenstown Lakes District. A dedicated wastewater treatment plant (WWTP), including ultrafiltration and ultraviolet disinfection stages, will treat wastewater to advanced tertiary quality prior to land discharge. This report assesses on-site wastewater disposal methods and their environmental effects to support an application for resource consents. This report focuses on soil hydraulic acceptance capacity, nutrient management, pathogen attenuation, and protection of existing and proposed potable groundwater supplies.

This report should be considered in conjunction with a separate site investigation report produced by WGA (2026a), which also relies on information provided by other consultancies working on this project. The site investigations, including soil profiling, hydraulic testing, and conceptual hydrogeological modelling, informed the wastewater disposal assessment.

Treated wastewater flows are projected to average 890 m³/day, reaching a maximum of 1,204 m³/day (inclusive of a 20% contingency). The treated wastewater quality includes total nitrogen (TN) of 4 to 10 mg/L, total phosphorus (TP) of 8 mg/L, and *E. coli* at less than 10 cfu/100 mL. Disposal methods were evaluated using AS/NZS 1547:2012 and Auckland Council GD2018/006 guidelines for on-site disposal, with consideration given to Taumata Arowai discharge to land standards and technical advice applicable to public networks. The assessed disposal methods are for land application to maximise nutrient uptake while minimising risks to downgradient groundwater and receiving surface waters.

The site features distinct geomorphological areas: Morven Hill (schist bedrock with loess and colluvial soils), the Residential Terrace (silty sands over schist), and River Terraces (silts over gravel aquifers). Potable water will be sourced from two bores (BH04 and BH05) drilled on the River Terraces, with a combined preliminary capacity of approximately 2,480 m³/day. The use of these bores as the potable water source necessitates a source protection zone that precludes wastewater disposal across the River Terraces.

The recommended disposal strategy includes:

- Primary Disposal: Spray Irrigation on Morven Hill – targeting native plantings on approximately 52.3 ha of constructable area (Category 3 - 4 loess soils). Calculated winter acceptance capacity is 1,832 m³/day (3.5 mm/day loading), and summer acceptance capacity is 3,402 m³/day (including 3 mm/day evapotranspiration). At maximum discharge rates, average loading across the disposal area is 2.3 mm/day, providing for 35% to 65% seasonal reserve.
- Secondary or Reserve Disposal: Subsurface Dripline Irrigation on Residential Terrace – within 8.8 ha of constructable area within landscaped or open spaces (Category 4 soils). The calculated acceptance capacity is 248 m³/day (slope-adjusted 1.8 to 3.5 mm/day loading).

Combined capacities (2,080 m³/day winter, 3,650 m³/day summer) exceed requirements, ensuring flexibility for staging and maintenance. Further operational flexibility is provided by three proposed buffer storage tanks (irrigation tanks) for treated water at the wastewater treatment plant, with total storage of 4,500 m³. The proposed irrigation system layout would support native vegetation and provide disposal system redundancy. Nutrient loading on Morven Hill is estimated at 54.3 kg TN/ha/year and 66.7 kg TP/ha/year, with native plantings expected to uptake 100 to 200 kg N/ha/year and 35 kg P/ha/year, minimising leaching. Phosphorus accumulation in soils is projected to reach capacity after approximately 80 years, with negligible mobility.

Environmental effects of the proposed treated wastewater disposal are assessed as less than minor:

- Surface water: Negligible impacts on the Arrow River (down-gradient receptor) due to low nutrient loading and plant uptake; no effects projected for the Kawarau River or on-site wetlands.
- Soils: Low risk of degradation or waterlogging at conservative rates; phosphorus retention in soils minimises leaching.

- Groundwater users: Pathogen attenuation modelling indicates sufficient *E. coli* reductions resulting in pathogen concentrations less than 1 cfu/100 mL at the nearest on-site and neighbouring water supply bores.
- Human health: Mitigations are being developed by PDP to minimise aerosol exposure risks from spray irrigation (e.g., wind cut-offs, setbacks, non-misting nozzles); subsurface irrigation methods minimise direct human exposure risks by design.

Monitoring and mitigations are expected to include a comprehensive program developed with input from Otago Regional Council (ORC), encompassing soil and groundwater sampling to verify performance and enable adaptive management. Runoff and wind monitoring is also expected to minimise human exposure risks related to the spray irrigation. With these measures, the proposed disposal system is expected to be sustainable, compliant with guidelines, and protective of environmental and public health values.

Revision History

REV	DATE	ISSUE	ORIGINATOR	CHECKER	APPROVER
A	15/01/2026	DRAFT	CAJ	BAS	BAS
B	28/01/2026	FINAL	CAJ & BAS	BAS	BAS
C	4/02/2026	UPDATED DRAFT	CAJ	BAS	BAS
D	25/02/2026	FINAL	CAJ	BAS	BAS
E	11/03/2026	FINAL	CAJ	BAS	BAS

Statement of Qualifications and Experience

Cameron Jasper (Author)

I am a Senior Hydrogeologist employed by Wallbridge Gilbert Aztec, an employee-owned engineering and environmental consultancy with over 700 staff distributed throughout New Zealand and Australia. I hold a Master of Science in Hydrology and Water Resources Science and a Bachelor of Science in Geology Earth Science. I am a member of the New Zealand Hydrological Society.

I have over 10 years professional experience as a consultant in hydrogeology, water resources science, and environmental investigations. My expertise includes the assessment of groundwater resources, stormwater and wastewater discharge effects, contaminant transport, and protection of community drinking water sources, with extensive project experience in Otago and New Zealand.

I have undertaken Assessments of Environmental Effects (AEE) and technical reviews supporting resource consenting for community wastewater discharges to land and water supplies. My experience in stormwater and wastewater management and discharge effects includes hydrogeological assessments, contaminant transport modelling and monitoring system designs for municipal wastewater discharges. I have undertaken numerous technical reviews of resource consent applications on behalf of Otago Regional Council, where my work primarily included hydrogeological review of on-site wastewater discharge proposals, contaminant transport assessment, and risk evaluation to domestic and community drinking water supplies.

My experience in protection of community drinking water sources includes source protection zone delineation, contamination risk assessments, and evaluation of wastewater and stormwater discharge effects on supply bores. My contaminant transport modelling includes nitrate, microbial, and emerging contaminants (PFAS) in groundwater systems, with application to wastewater discharges, stormwater, landfills, and contaminated sites.

I confirm that, in my capacity as author of this report, I have read and acted in accordance with the Environment Court of New Zealand Code of Conduct for Expert Witnesses (Practice Note 2023).

Brett Sinclair (Reviewer)

I am a Senior Principal Hydrogeologist and Associate employed by Wallbridge Gilbert Aztec, an employee-owned engineering and environmental consultancy with over 700 staff distributed throughout New Zealand and Australia.

I hold a Master of Science in Geology from Auckland University and a Postgraduate Certificate in Hydrogeology and Engineering Geology of Tropical and Subtropical Regions from the University of Tübingen, Germany. I have over 30 years professional experience as a consultant and contractor in hydrogeology, water resources science, and environmental investigations. I have worked internationally as a consultant, based in New Zealand, Australia and Germany. I am a member of the New Zealand Hydrological Society.

Since 2000, I have managed and undertaken numerous investigations within New Zealand for the supply of water for human consumption and horticultural, agricultural and industrial purposes. These investigations have included evaluation of water availability as part of the security of supply assessment. Over the same period, I have undertaken assessments of the effects for a wide range of stormwater and solid and liquid waste storage and disposal systems on groundwater, surface water and existing users. I have constructed and acted as technical advisor or reviewer for numerous groundwater flow and contaminant transport models for a wide range of purposes.

During the past fifteen years, I have worked on and led on the assessment, consenting, design, construction, commissioning, monitoring and optimisation and managed aquifer recharge projects. I also have wide experience in mine water management, with a focus on minimising environmental impacts during operations and long-term site rehabilitation.

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

CONTENTS

1	INTRODUCTION	1
1.1	Background	1
1.2	Scope of Services	1
1.3	Methodology.....	1
2	PROPOSED SITE ACTIVITIES.....	5
2.1	Wastewater Treatment and Disposal.....	5
2.1.1	Introduction	5
2.1.2	Wastewater Discharge Flow Rates.....	5
2.1.3	Wastewater Discharge Quality	6
2.2	Water Demand	8
3	BACKGROUND ENVIRONMENT	9
3.1	Introduction	9
3.2	Topography and Geomorphology	9
3.3	Local Soils and Bedrock	9
3.3.1	Morven Hill	9
3.3.2	Residential Terrace.....	10
3.3.3	River Terraces	10
3.4	Local Soil and Aquifer Hydraulic Properties	11
3.4.1	Morven Hill	11
3.4.2	Residential Terrace.....	11
3.4.3	River Terraces	11
3.5	Conceptual Site Hydrogeological Model.....	12
4	WATER SUPPLIES	14
4.1	Groundwater Source Protection.....	14
4.1.1	Water Supply Bores	14
4.1.2	Groundwater Protection Zone.....	17
5	WASTEWATER DISPOSAL METHODS.....	19
5.1	Introduction	19
5.2	Assessment Methodology	21
5.3	Wastewater Disposal Techniques Considered	21
5.3.1	Introduction	21
5.3.2	Subsurface Dripline Irrigation	21
5.3.3	Spray Irrigation.....	22
6	WASTEWATER DISPOSAL AREAS	24
6.1	Morven Hillslope Disposal.....	24
6.1.1	Hydraulic Loading	24
6.1.2	Nitrogen Loading.....	25
6.1.3	Phosphorus Loading	25
6.1.4	Hillslope Native Plantings	25
6.2	Residential Terrace Disposal	27

6.3	Treated Wastewater Disposal Scenario	28
7	WASTEWATER DISPOSAL EFFECTS ASSESSMENT	29
7.1	Introduction	29
7.2	Morven Hill Disposal Effects	29
7.2.1	Effects on Surface Water	29
7.2.2	Effects on Soils	30
7.2.3	Effects on Groundwater Users.....	31
7.2.4	Risks to Human Health	32
7.3	Residential Terrace Disposal Effects	32
7.3.1	Risks to Human Health	33
7.4	Potable Water Source Protection.....	34
8	MONITORING AND MITIGATIONS	35
8.1	Effluent Quality Monitoring	35
8.2	Soil Monitoring	35
8.3	Groundwater and Surface Water Monitoring	35
8.4	Operational Mitigations	36
8.5	Adaptive Management and Reporting	36
9	REFERENCES	37

Figures

Figure 1:	Ridgeburn Development Locality Map	3
Figure 2:	Ridgeburn Treated Wastewater Discharge Areas	4
Figure 3:	Groundwater Conceptual Model Map	13
Figure 4:	Water Supply Investigation Bore Location Map	15
Figure 5:	Source Water Protection Zone Map.....	16
Figure 6:	Slope Map.....	20
Figure 7:	Disposal Areas on Morven Hill and the Residential Terrace	26

Tables

Table 1:	WWTP Design Treatment Levels (BPO, 2026)	6
Table 2:	Preliminary Bore Production Capacity.....	14
Table 3:	<i>E. coli</i> attenuation between Residential Terrace and BH04	18
Table 4:	Morven Hillslope Spray Disposal Hydraulic Loading Rates.....	24
Table 5:	Residential Terrace Subsurface Dripline Disposal Hydraulic Loading Rates.....	27
Table 6:	<i>E. coli</i> Attenuation Between Morven Hill and Closest Water Supply Bore	31

1 INTRODUCTION

1.1 Background

The Ridgeburn residential development (Ridgeburn) proposed by Ridgeburn Limited (RDL), a registered corporate entity associated with Gibbons Co, consists of approximately 1,210 homes, commercial, retail and recreational spaces. Ridgeburn is located on an approximately 212 ha site at 122 Morven Ferry Road, between Arrowtown and the Kawarau River, Queenstown Lakes District (Figure 1).

Ridgeburn is to be serviced by a dedicated wastewater treatment plant (WWTP), as documented in a separate report (BPO, 2026). The wastewater from Ridgeburn is to be treated to a high quality, including ultrafiltration and ultraviolet treatment stages. RDL is proposing to discharge the treated wastewater to land within and around the development area (Figure 2). The disposal of the treated wastewater to land is assessed in detail in the context of the need to protect proposed potable water sources for Ridgeburn and other water supply systems and minimise human exposure risks to pathogens.

1.2 Scope of Services

WGA has been contracted to undertake a hydrogeological assessment of the potential effects associated with the proposed discharge of treated wastewater across selected areas within the Ridgeburn area. This scope includes evaluating the suitability of potential disposal areas based on site-specific geology, hydrogeology, soakage characteristics, and groundwater source supply protection. The assessment is to address key requirements to support a resource consent application, including the potential effects on surface waters and the protection of potable water supplies.

If necessary, WGA is to provide recommendations regarding the application of treated wastewater to land to ensure environmental effects remain less than minor. These recommendations are to take into account the potential staging of components of the development.

1.3 Methodology

Based on the available information, we expect our scope to complete the hydrogeological effects assessment of the proposed discharge is as follows:

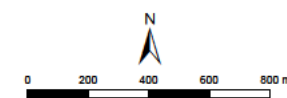
- Compile and review information from site field investigations undertaken by WGA and by others (e.g., geological logs and soakage tests showing variable infiltration rates in silty sands and gravels) alongside regional hydrogeological information.
- Evaluate wastewater treatment system design details with a focus on discharge flows, flow variability and treated water quality provided by BPO and Gibbons Co.
- Evaluate water demand and sourcing information provided by GWE and Gibbons Co, with a focus on source water protection.
- Analyse site-specific information and interpret the results in combination with existing available information on surface waters, digital elevation models derived from LiDAR, and geological maps.
- Develop a site conceptual model covering the proposed treated wastewater disposal areas and receiving environment. This conceptual model is to include characterising the receiving strata/aquifers, expected seasonal groundwater levels and flow, and interactions with the Kawarau River.
- Identify treated wastewater disposal techniques and disposal areas available within the Ridgeburn footprint.
- Undertake contaminant transport and attenuation modelling, focusing on faecal coliforms and other key contaminants of concern (e.g., nitrogen, phosphorus, and faecal coliforms), to assess effects on groundwater bores, surface water, and ecological receptors.

- Evaluate the potential impacts of discharging treated wastewater via the proposed discharge system on surface waters, including the Kawarau River, Arrow River, and on-site wetlands. This includes assessment of nutrient loading on dryland soils and nutrient uptake by native plants.
- Develop a comprehensive conceptual design for a treated wastewater discharge system that is based on technically, socially and environmentally acceptable components. Prioritise the discharge system components to optimise the design with the objective of enabling all treated wastewater from the site to be discharged in a manner that minimises environmental impacts, while protecting the potable water supply and human health needs of the community.
- Document the assessment process and the findings, including recommendations for discharge management if required, in a technical report to support the application for resource consents under a fast-track consenting process.



LEGEND

Site Boundary



Scale 1:25,000 @ A4

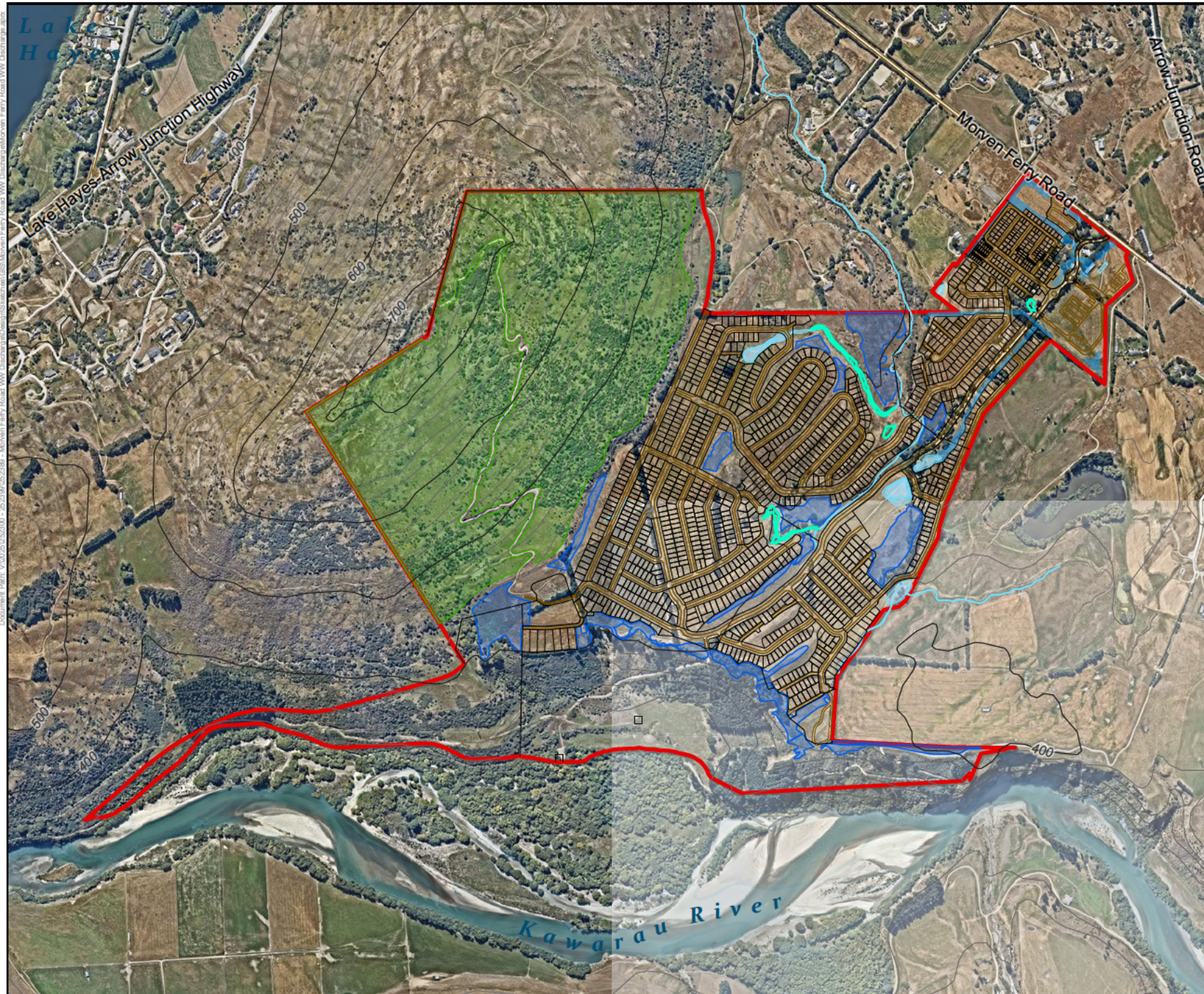
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 1

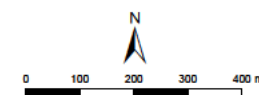
Ridgeburn Development
Locality Map

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.
Note: The information shown on this map is a copyright of WGA 2026



LEGEND

- ▬ Site Boundary
- Contours
- ▬ Dripline Areas
- ▬ Spray Areas
- ▬ Water
- ▬ Wetland
- ▬ Proposed Watercourse
- ▬ Roadway
- ▬ Lot Boundary



Scale 1:14,000 @ A4

Coordinate System: NZGD 2000 Mount Nicholas Circuit

WGA

Figure 2

Ridgeburn
Treated Wastewater
Discharge Areas Overview

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2 PROPOSED SITE ACTIVITIES

2.1 Wastewater Treatment and Disposal

2.1.1 Introduction

Wastewater generated at the Ridgeburn development will be derived from a combination of residential dwellings, commercial premises, and community facilities. The scale and mixed-use nature of the development result in wastewater characteristics broadly comparable to municipal domestic wastewater, with minor contributions from commercial activities such as a supermarket, hotel, and community buildings.

Wastewater is proposed to be treated on site at a purpose-built wastewater treatment plant (WWTP) designed by BPO Ltd (BPO, 2026). The selected treatment system is a modular hybrid biological nutrient removal process incorporating the following key components:

- Sequencing Batch Reactors (SBRs) for primary and secondary biological treatment, including carbon removal, nitrification, denitrification, and biological phosphorus removal.
- Ultrafiltration (UF) membranes for advanced solids and pathogen removal, providing a high level of clarification and polishing.
- Ultraviolet (UV) disinfection for final pathogen inactivation prior to discharge to land.

The treatment process has been specifically selected to produce a consistently high-quality treated effluent suitable for land-based discharge. The key objective of the WWTP design is to minimise the risk of adverse effects on site soils, groundwater, and any ultimately receiving surface water bodies. The system has also been designed to be operationally flexible, allowing process adjustments to account for seasonal fluctuations in wastewater flows, variable occupancy rates across the development, and significant temperature variations typical of the Queenstown Lakes District alpine environment.

2.1.2 Wastewater Discharge Flow Rates

Wastewater flows for the Ridgeburn development have been estimated by BPO (2026) using a conservative design approach based on the Metcalf & Eddy method, which is considered appropriate given the scale of the development and the requirement for high reliability and resilience. This method incorporates population equivalents, occupancy assumptions, and wastewater generation rates aligned with Queenstown Lakes District Council planning expectations.

Based on the anticipated development scale, daily wastewater flows are estimated to range from approximately 772 to 1,004 m³/day under full occupancy conditions of 3,878 people, with an average daily flow estimated at 890 m³/day (BPO, 2026). To account for uncertainty, infiltration and inflow, and future variability, a 20% contingency has been applied. This results in design wastewater flows ranging from 926 to 1,204 m³/day (BPO, 2026).

To manage short-term hydraulic variability, the WWTP incorporates a 1,500 m³ equalisation tank upstream of the biological treatment process. This equalisation capacity allows peak inflows to be buffered and released gradually, ensuring stable and efficient operation of downstream SBR and membrane processes without the need to oversize critical treatment infrastructure. Further operational flexibility is provided by three proposed buffer storage tanks (called irrigation tanks for the purposes of this report) for treated water at the wastewater treatment plant with total storage of 4,500 m³.

The treated wastewater flows estimated by BPO are as follows:

- **Average daily design flow:** 890 m³/day
- **Maximum daily design flow:** 1,004 m³/day
- **Maximum daily design flow (including contingency):** approximately 1,204 m³/day
- **Short-term peak flow factor:** up to five times the average flow, buffered via equalisation

Wastewater flows at Ridgeburn are expected to exhibit seasonal and annual variation, especially through the construction phases of the development. To characterise this seasonality, BPO analysed two years of inlet flow data from the Shotover Wastewater Treatment Plant and scaled the dataset to reflect the Ridgeburn population. This analysis indicates that higher average daily flows are expected during the late spring to early autumn period (approximately October to April) and that lower average daily flows are expected during winter months (May to September).

The WWTP has been designed to accommodate both seasonal flow variation and seasonal temperature effects through operational flexibility (adjustable SBR cycle times and aeration regimes) to ensure consistent treatment performance throughout the year.

2.1.3 Wastewater Discharge Quality

The proposed WWTP has been designed to achieve a high and consistent level of treated effluent quality suitable for land-based discharge. Treatment performance targets have been informed by the proximity of the site to the Kawarau and Arrow Rivers, the potential for irrigated treated wastewater to return to surface in the on-site wetlands, and the consequent need to minimise nutrient and pathogen loading to groundwater.

Biological process modelling was undertaken by BPO (2026) across a range of flow and temperature scenarios, including worst-case winter conditions. The modelling indicates that the proposed SBR and membrane filtration system is capable of reliably achieving the target effluent quality levels set out below on Table 1.

Table 1: WWTP Design Treatment Levels (BPO, 2026)

PARAMETER	UNITS	TREATMENT QUALITY OCTOBER TO APRIL (212 days)	TREATMENT QUALITY MAY TO SEPTEMBER (153 days)
Carbonaceous Biochemical Oxygen Demand (cBOD)	mg/L	2	2
Total Suspended Solids (TSS)	mg/L	2	2
Total Phosphorus (TP)	mg/L	8	8
Total Nitrogen (TN)	mg/L	4	10
Ammoniacal Nitrogen (NH ₃ -N)	mg/L-N	2	8
<i>Escherichia coli</i>	cfu/100mL	10	10

The consistently low cBOD and TSS concentrations reflect the combined performance of the SBR biological treatment and ultrafiltration membranes, which remove residual suspended solids and associated particulate-bound contaminants. Membrane filtration, followed by further disinfection, provides a high level of pathogen removal, resulting in *E. coli* concentrations suitable for land application with minimal public health risk. Composite sampling and analysis of the treated wastewater is expected as an on-going monitoring requirement to ensure the WWTP is meeting the design treatment levels for discharge water quality.

BPO (2026) indicates that following the biological nutrient removal, the ultrafiltration (UF) membranes are expected to hold back anything larger than 0.05 µm, resulting in suspended solids, colloids, bacteria, and some larger organic matter being physically retained. Dissolved salts and minerals are expected to pass through the UF stage. UF is expected to reduce total phosphorus concentrations associated with particulates, but this filtration does not reduce dissolved phosphorus or nitrogen concentrations in the wastewater stream. UF greatly lowers pathogen levels but is not considered to act as a standalone barrier for all viruses or bacteria. Therefore, a post-filtration ultra-violet (UV) disinfection step is included to inactivate remaining pathogens. BPO expects the UV system to perform well in this instance because of the high clarity of the incoming treated wastewater to the UV system (total suspended solids less than 2 mg/L). The UV system is understood to include continuous irradiation monitoring as a component of the design to ensure that the required ultraviolet dosage is delivered for effective disinfection. If irradiation drops below required levels, the treated wastewater is immediately diverted back to the treatment plant instead of discharged to the irrigation system.

BPO (2026) indicates that typical municipal wastewater sodium concentrations range from about 100 to 300 mg/L, with most systems being below 150 mg/L. Elevated levels are commonly associated with coastal seawater ingress or industrial discharges (e.g., dairy, meat, or oil processing) where caustic soda (NaOH) is used for cleaning, contributing sodium in analyses. The Ridgeburn development has no such industries and no seawater influence. WGA understands that treatment residues from the potable water treatment plant are to be sent to the WWTP for treatment prior to discharge. Although these residues may contain elevated salt, depending on the nature of the treatment process applied, BPO currently expects that treated wastewater sodium concentrations will be 100 mg/L or less (G Young, BPO; per comm, 2026).

BPO (2026) indicates nitrogen removal in biological wastewater treatment systems is temperature sensitive. During warmer months (typically October to April), warmer wastewater temperatures support nitrogen removal, resulting in treated effluent total nitrogen concentrations of approximately 4 mg/L and ammoniacal nitrogen concentrations of approximately 2 mg/L. During colder winter periods (May to September), influent wastewater temperatures are lower. Under these conditions, biological reaction rates are reduced, which can result in higher residual nitrogen concentrations in the treated effluent. BPO modelling indicates that under sustained lower temperature conditions, total nitrogen concentrations could increase to approximately 10 mg/L, with ammoniacal nitrogen concentrations up to 8 mg/L.

The WWTP has been designed to manage these seasonal effects through:

- Adjustable SBR cycle times, including longer aeration phases during winter
- Flexible process control to optimise nitrogen removal as temperatures vary

The BPO (2026) report indicates that the proposed WWTP is expected to produce a consistently high-quality treated effluent, with nutrient and pathogen concentrations that are appropriate for discharge to land and protective of underlying groundwater and any hydraulically connected surface waters. Because of this, treated effluent disposal within and around the development area, such as subsurface dripline irrigation with low loading rates is considered as a potentially safe option for the purpose of further nutrient uptake and reduction of effects on the receiving environment.

The BPO (2026) report has also indicated that “the volume and load of waste water builds slowly over the development period”. Consequently, “performance of this plant will not be optimum with the reduced loads”. Therefore, the design of the wastewater disposal system is to incorporate flexibility in construction and disposal areas during the first Ridgeburn phases to accommodate uncertainty regarding WWTP discharge characteristics during that period.

An initial comparison of the design treatment levels presented in Table 1 with treated effluent water quality requirements under AS/NZS 1547 for a range of land disposal options has been undertaken.

Treated effluent quality requirements defined under the AS/NZS 1547 for use in spray irrigation (Section M2.2) are:

1. 90% of the samples shall have a BOD₅ less than or equal to 20 g/m³ with no sample greater than 30 g/m³.
2. 90% of the samples shall have TSS less than or equal to 30 g/m³ with no sample greater than 45 g/m³.
3. The average *E. coli* concentration shall be 10 cfu/100 mL with no more than 20% of the samples exceeding 20 cfu/100 mL.

A treated effluent quality requirement defined under the AS/NZS 1547 for use in spray irrigation (Section M2.4) is:

4. If the *E. coli* level is greater than 10 cfu, then the effluent shall be irrigated using covered or subsurface techniques.

A treated effluent quality requirement defined under the AS/NZS 1547 for use in spray irrigation (Section M4 – CM4) is:

5. Spray irrigation can be environmentally insecure under wet climatic conditions. There is also health risks associated with spray irrigation due to the potential for contact of effluent with humans, animals, and insects. Therefore, effluent for spray irrigation requires continuous disinfection with the proposed final UV treatment.

The proposed WWTP incorporates a continuous UV disinfection stage to ensure the production of a high-quality effluent. This treatment stage addresses the disinfection requirement under Section M4 of the AS/NZS 1547.

The projected effluent quality is expected to be suitable for disposal to land using drip irrigation or subsurface irrigation processes. The treated effluent is expected to meet the AS/NZS 1547 recommended water quality criteria for disposal to land using a spray irrigation process, even through the initial phases of Ridgeburn development. It is noted that these design criteria are to be considered as maximum values rather than the expected performance outcomes. Monitoring and mitigation measures described above (continuous irradiation monitoring, treated wastewater diversion/recirculation, and composite sampling) are expected to minimise the risk of pathogen exposure pathways to humans arising.

2.2 Water Demand

Potable water demand for the Ridgeburn development has been assessed by GWE Consulting Ltd as part of the Water Supply Servicing Strategy prepared to support the proposed water take consent application (GWE, 2026). The assessment has been undertaken in accordance with Queenstown Lakes District Council (QLDC) demand parameters and relevant industry guidance, with a focus on the full development demand under peak occupancy conditions.

The water demands estimated by GWE are based on a detailed breakdown of residential, commercial, and community uses across the development, using conservative rates that reflect the use of water-efficient fixtures, metered supply, and current water use practices. Key design assumptions adopted by GWE include:

- Residential demand: 750 L per dwelling per day, reflecting metered supply and the use of WELS-rated water-efficient fixtures.
- Commercial demand: 15 L/m²/day, with occupancy based on one person per 15 m² of net floor area, consistent with Watercare Code of Practice guidance.
- Community facilities: Demand based on low-flush (4.5 L/flush) toilets and low-use basins (4.5 L/use), with assumed usage rates of four uses per hour over an 11-hour operational day, plus a nominal allowance for general tap use.

Based on these assumptions, GWE estimated that the total average daily potable water demand at full development will be approximately 1,003 m³/day, consisting of the following components:

- **Residential demand:** approximately 908 m³/day
- **Commercial demand:** approximately 92 m³/day
- **Community facilities:** approximately 4 m³/day

In addition to average daily demand, GWE has assessed peak water use conditions to ensure that the proposed supply system is suitably robust. Peak daily demand is estimated to be approximately 2,006 m³/day by McKenzie & Co, 2026, reflecting short-term demand variability associated with peak occupancy, commercial activity, and diurnal use patterns typical of large mixed-use developments.

The proposed groundwater source identified to meet the water demand documented above is described in Section 4. The only proven potable water source currently accessible to RDL for Ridgeburn is groundwater, through bores BH04 and BH05.

3 BACKGROUND ENVIRONMENT

3.1 Introduction

A concise description of the background environment surrounding Ridgeburn is provided in this section of the report. A detailed description of the existing environment at the site is provided in the site hydrogeological investigation report WGA (2026a).

3.2 Topography and Geomorphology

The Ridgeburn residential area occupies an alluvial terrace, termed the Residential Terrace, at elevations of 380 to 420 m RL. The Residential Terrace slopes gently northeast toward Morven Ferry Road and is bounded to the south by an 80 m drop to the Kawarau River and adjacent river terraces (Figure 3). A perennial wetland plus three intermittent wetlands exists within the Residential Terrace area where groundwater is expected to broadly flow northeast toward the Arrow River.

Along the northwestern side of the development, Morven Hill rises steeply to a peak elevation of 570 m RL. The upper slopes of Morven Hill are rocky with extensive areas of exposed bedrock. The lower slopes are smoother toward the development and toward the river terraces to the south.

A series of narrow river terraces are developed across a range of elevations along the Kawarau River. These terraces are collectively termed River Terraces for the purpose of this report. The river terraces generally have gradients under 5%, though alluvial and colluvial fans on the Main Terrace create localized slopes exceeding 15%.

Below the Lower Terrace, outside the Ridgeburn boundary, lies the Kawarau River floodplain at an elevation of approximately 304 to 305 m RL. A preliminary inspection indicated that at least sections of the floodplain are regularly inundated during periods of high flow in the Kawarau River.

3.3 Local Soils and Bedrock

3.3.1 Morven Hill

Morven Hill is composed of schist bedrock shaped from physical glacial erosion through the Pleistocene age. The soils of the upper slopes of Morven Hill are poorly developed and derived from weathering of the schist. Large areas of the hillslopes are characterised by exposed rock, with the intervening areas accumulating limited thicknesses of soil.

The lower slopes of Morven Hill consist of colluvial deposits, covered by poorly developed topsoils. Exposures of bedrock are smaller than higher up the hillslope, and the thickness of colluvial deposits increases down the slope until the Residential Terrace is reached. The boundary between the hillslope and the Residential Terrace is identifiable on a topographic map by a well-defined change in slope.

The soil map unit factsheet for Morven Hill (Landcare Research 2025) indicates the Gibbston Soil, a loamy Pallic soil with increasing rock fragment contents with depth until bedrock, is intersected at a depth of approximately 0.4 m. This description is consistent with site investigations undertaken by Kirk Roberts, 2026, which shows thicker soils developed on the lower hillslopes over colluvial deposits and weathered schist. The soils of the Morven Hill slopes are expected to be Category 3 to 4 loam soils covering colluvium and weathered schist bedrock. The Landcare soils fact sheet indicates the Gibbston Soil has a soil moisture capacity of approximately 60 mm.

3.3.2 Residential Terrace

In-situ schist at a depth of only a few metres forms the base to the shallow sediments and soils of the Residential Terrace. The upper surface of the schist is interpreted to drop off steeply under the southern end of the terrace, extending further under the River Terraces.

A field investigation programme, including a total of 11 hand auger investigation holes with associated soakage tests has been conducted by Kirk Roberts on the Residential Terrace. The interpretation of the shallow soils on this terrace and their hydraulic behaviour has been derived from the information gained from this field investigation. Details of this site investigation and analyses of the field data are presented in the site investigation documentation report (WGA, 2026a).

Interpretation of the hand auger lithological logs indicates a trend of fining sediments, from gravelly sands in the north to sandy silts at the southern edge of the Residential Terrace. Observations recorded by Kirk Roberts regarding the soil moisture characteristics indicate the shallow soils at the northwestern edge of the development were wet to saturated at the time of drilling in October 2025. This contrasts with the shallow sediments across the southern half of the development and along the eastern edge, which were moist rather than wet.

Under normal circumstances, the coarser sediments in the north could be expected to be more free-draining than the finer sediments to the south. The reverse observation recorded by Kirk Roberts suggests either more recharge was occurring in the north or underlying denser soils and bedrock were limiting free drainage in the north.

An existing irrigation water race that crosses the development residential area from northwest to southeast is expected to be hydraulically connected to the surrounding groundwater system. However, it is not clear whether the irrigation race is losing water to the groundwater or vice versa, or both depending on season and the stretch of the water race being considered. If the water race is losing water into the underlying soils, these losses would contribute to the observed soil saturation in the north. The planned piping of the water race under Ridgeburn will disconnect the race hydraulically from the groundwater system.

The auger holes drilled into the wet sediments in the northern area of the Residential Terrace were unstable and tended to collapse before the target depth was reached. In contrast, the auger holes across the southern and eastern areas of the Residential Terrace tended to either meet hard refusal against 'dense ground' or would terminate at the target depth.

In terms of the suitability of the soils for treated wastewater discharge, the field observations from the hand auger investigations across the Residential Terrace suggest the southern and eastern areas of the development are likely to offer better discharge opportunities due to deeper groundwater or better drainage during winter.

3.3.3 River Terraces

Each of the River Terraces is covered by a surficial fine sandy silt layer at least 0.9 m deep and in places to more than 2.2 m. The characteristics of these fine-grained layers are consistent between terraces. These fine sandy silt layers are interpreted as being post-glacial lake deposits. Layers of coarse sands and fine gravels underlie the silt deposits. The trial water supply bore drilled through these sedimentary deposits and intersected schist basement at a depth of 38.8 m.

The Main Terrace is partially covered by alluvial fan deposits. These fans are characterised by poorly sorted gravelly sandy silt deposits derived from the erosion of older lake deposits exposed in the Residential Terrace drop-off.

The schist bedrock intersected by BH04 was tight and did not produce much groundwater. In contrast, the schist bedrock intersected by BH05 at a depth of 28.8 m below the surface of the Lower Terrace was heavily fractured down to the terminal depth of the drillhole at 102 m. This heavily fractured schist was associated with good inflows of water to the drillhole. Schist characterised by intense fracturing and significant groundwater flows is not common in the Otago region and is interpreted as representing a fault zone.

3.4 Local Soil and Aquifer Hydraulic Properties

3.4.1 Morven Hill

The schist bedrock underlying Morven Hill is considered to be effectively impermeable for the purposes of this assessment. The weathering interface between the in-situ schist and the overlying soils is expected to be very uneven, leading to down-gradient seepage paths for infiltrated rainwater that are longer than a direct downhill line to the Residential Terrace.

The Gibbston Soil that drapes Morven Hill is expected to be a Category 3 to 4 loam soil covering colluvium and weathered schist bedrock. Landcare Research notes that the saturated hydraulic conductivity (K_{sat}) of these soils is 0.1 to 2.0 m/day. The Landcare Research soil description is consistent with the Kirk Roberts (2026) field investigation of soils on the Morven Hill.

3.4.2 Residential Terrace

The schist bedrock underlying Morven Hill is considered to be effectively impermeable for the purposes of this assessment. Infiltrating rainfall is expected to seep laterally within the shallow soils and sediments until it discharges to a surface water body. The nearest surface water body expected to receive the shallow groundwater seepage is the Arrow River, to the northeast of Ridgeburn.

Soakage tests have been used to investigate the hydraulic characteristics of the soils on the Residential Terrace. Analysis of the soakage test datasets indicates the soils of the Residential Terrace have a general K_{sat} range from 0.01 to 0.1 m/day, although values up to 6 m/day have also been returned from the data analyses (WGA, 2026a). The soil permeability tends to increase toward the northeast of the Ridgeburn area on the Residential Terrace, consistent with increasing grain sizes in the soil descriptions.

Based on the soakage test results and the soil descriptions, the soils covering the Residential Terrace are expected to be Category 4 massive to weakly structured clay loam soils.

3.4.3 River Terraces

The shallow silty soils underlying the River Terraces are characterised by hydraulic conductivity values ranging from 0.1 to 1.4 m/day (WGA, 2026a). This range is based on the analysis results from 27 soakage tests performed in test hand auger holes drilled on all of the River Terraces (WGA, 2026a).

Four investigation holes were drilled to a depth of 10 m BGL on the Main and Lower Terraces to investigate the deeper sediments under these terraces (Section 3.3.3). Underlying the shallow silty soils of the River Terraces are sandy gravel and gravel beds, with the shallowest of these deposits being locally exposed in the eroded slopes below the Main Terrace. Neither of the holes drilled on the Main Terrace intersected groundwater. Groundwater was intersected at depths of 4.2 m in the holes drilled on the Lower Terrace, which is below the terminal depth for the two holes drilled on the Main Terrace.

Hydraulic tests were performed in piezometers installed in the 10 m drillholes on the River Terraces. The analysis results from these tests indicate the gravel beds are characterised by K_{sat} values ranging from 12 to 36 m/day (WGA, 2026a). The K_{sat} results from these piezometers indicate the permeability of these gravelly sand layers is approximately 100 times higher than that of the surficial silts.

Two deeper exploration holes (BH04 and BH05) were drilled on the River Terraces (Section 3.3.3). The shallow of these two holes (BH04) was screened in gravels overlying the schist bedrock. Analysis of a pumping test performed on this bore returned a K_{sat} result of approximately 11 m/day, which is consistent with the test results from the shallower gravels. This permeability means BH04 has sufficient production capacity for water supply purposes (Section 4). The deeper of these two bores was screened in strongly fractured schist interpreted as representing a fault zone. The K_{sat} result from a pumping test performed on that bore was 0.07 m/day, which is similar to the permeability of the shallow silty deposits. However, BH05 was drilled to a terminal depth of 102 m, with an open-hole length of approximately 77 m. This long open-hole length combined with a shallow static water level in the bore meant the bore production capacity is appropriate for water supply purposes (Section 4).

3.5 Conceptual Site Hydrogeological Model

Morven Hill is composed of schist bedrock left behind by glacial erosion. This schist bedrock extends out underneath the Residential Terrace at shallow depth. To the south, the bedrock is interpreted to drop away steeply close to the River Terrace drop-off (Figure 3). The bedrock then extends out under the River Terraces at depths of several tens of at least 20 to 40 m. For the purposes of this wastewater disposal assessment, the schist bedrock can be considered to be effectively impermeable.

The Residential Terrace is covered by glacial or alluvial soils several metres thick. Both the surface of this terrace and the underlying interface between the soils and the schist bedrock are interpreted to slope gently downward toward the northeast, as far as the Arrow River. Groundwater flows across the Residential Terrace are also interpreted to be in a northeast direction, consistent with the topographic gradient. The on-site elongate perennial wetland following the course of a natural drainage pathway is expected to receive shallow groundwater inputs from surrounding soils. The three other on-site wetlands are ephemeral as they dry up during summer. These ephemeral wetlands are interpreted to potentially receive shallow groundwater during the winter and potentially become disconnected from shallow groundwater during summer months.

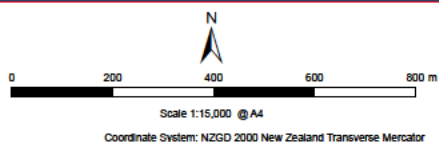
The irrigation water race that crossed Ridgeburn (Figure 3) is likely to be hydraulically connected to the surrounding groundwater system. However, it is not clear from the available data whether the irrigation race is losing water to the groundwater or vice versa, or both depending on season and the stretch of the water race being considered. The planned piping of the water race under Ridgeburn will disconnect the race hydraulically from the groundwater system.

A farm pond is located on the Residential Terrace approximately 200 m east of the Ridgeburn boundary (Figure 3). This pond occupies a shallow topographic basin, with the outflow from the pond being toward the west. Although no investigations have been undertaken off-site, the shallow groundwater table within the surface catchment of this pond is interpreted as reflecting the overlying topography. On that basis, it is expected that shallow groundwater flows exiting the Ridgeburn area of the Residential terrace will pass to the north of this pond rather than entering the pond's catchment basin.

Groundwater flow close to the southern edge of the Residential Terrace, and under the terrace drop-off to the south, is likely to be toward the south (Figure 3). The groundwater flow rates underneath the drop-off are likely to be small due to the limited catchment area. Most of the glacial and lake deposits exposed in the drop-off and underlying the southern edge of the Residential Terrace are expected to be unsaturated. No indications of groundwater discharges at the toe of the drop-off in the form of seeps or springs were found during the field investigations.

The sand and gravel aquifers underlying the Middle and Lower Terraces, together with the highly fractured schist intersected in BH05, are considered to be strongly connected to the Kowarau River. The depth to groundwater underlying the River Terraces varies, depending primarily on the elevation of the terrace surface. Observed depths to groundwater under the Middle and Lower Terraces were several metres, whereas groundwater under the river floodplain was effectively at surface during the October field investigation programme. However, depths to groundwater under the River Terraces will also vary in response to changes in water level in the Kowarau River due to the strong hydraulic connection between the river and these aquifers.

Groundwater abstracted for supply purposes through bores BH04 and BH05 is likely to be primarily recharged through seepage flows from the Kowarau River. The extent of groundwater drawdown in response to these proposed takes is expected to be limited to the aquifer areas underlying the River Terraces. Therefore, these proposed groundwater takes are considered to effectively be surface water takes through a stream depletion process.



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Note: The information shown on this map is a copyright of WGA 2025

- LEGEND**
- Site Boundary
 - Watercourse
 - Property Boundaries
 - Contours
 - Landscape Feature Boundaries
 - Groundwater Catchment Divide
 - ➔ Groundwater Flow Direction

WGA

Figure 3
Conceptual Groundwater Model Map

4 WATER SUPPLIES

4.1 Groundwater Source Protection

4.1.1 Water Supply Bores

The Ridgeburn development it is proposed to address the water demand documented in Section 2.2 through abstracting groundwater from water bores installed at site.

Three investigation bores were drilled on the Residential Terrace targeting potentially fractured areas in the schist bedrock. None of these bores offered flows of water that encouraged their development into water supply bores.

Two further investigation bores, BH04 and BH05, were drilled on the River Terraces, with location shown on Figure 4. Both of these bores were cased, developed and tested to determine their potential yields and the hydraulic characteristics of the aquifers from which the water was being drawn. Preliminary test flows from these bores were promising. Preliminary analyses for bore production capacity and drawdown are presented in the hydrogeological investigation report (WGA, 2026a), with the following information summarised from that report. Detailed analyses of the water supply bore production capacities are being produced by a separate consultancy (GWE, 2026).

Conceptually, BH04 is screened in a 4.4 m thick gravel aquifer that is underlain by impermeable (relative to the aquifer) schist bedrock and overlain by a 26 m leaky silt confining layer. Above the confining layer is another gravel aquifer that contains a free groundwater surface. BH04 was tested at a flow rate of 560 m³/day, with the drawdown after 24 hours pumping being approximately 17.4 m. Analysis of the data from the pumping test indicates the source aquifer has a transmissivity of 48 m/day. The source aquifer is likely to be directly connected to the Kawarau River, which would act to recharge the aquifer in response to the drawdown from the groundwater abstraction. An initial estimate for the bore production capacity is 600 m³/day, although this may be an overestimate for long term production.

Conceptually, BH05 is screened in heavily fractured zone of schist, with a total exposed thickness in the drillhole of 73 m. The overlying 29 m of silts and other sediments are interpreted to constitute a leaky confining layer to the aquifer. BH05 was tested at a flow rate of 1,010 m³/day, with the drawdown after 24 hours pumping being approximately 31 m. Analysis of the data from the pumping test indicates the source aquifer has a transmissivity of 5.2 m/day. The source aquifer is likely to be directly connected to the Kawarau River, which would act to recharge the aquifer in response to the drawdown from the groundwater abstraction. An initial estimate for the bore production capacity is 1,880 m³/day.

Table 2: Preliminary Bore Production Capacity

PARAMETER	UNITS	BH04	BH05
Depth	m BGL	37.79	102.96
Base of Casing	m BGL	34.79	65
Static Water Level	m BGL	8.92	0.28
Available Drawdown ⁽¹⁾	m	18.9	57.7
Specific Capacity Approximation	m ³ /day/m	32.0	32.6
Bore Production Capacity	m ³ /day	600	1,880
	L/s ⁽²⁾	6.9	21.8

Notes:

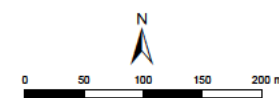
⁽¹⁾ Includes an allowance of 7 m above the base of casing to install the pump (2 m) and prevent cavitation (5 m).

⁽²⁾ The flow rate in L/s is an average over 24 hours equivalent to the m³/day value.



LEGEND

- Water Supply Trail Bore
- Site Boundary
- - - Landscape Feature Boundaries
- 1m Elevation Contours



Coordinate System: NZGD 2000 New Zealand Transverse Mercator

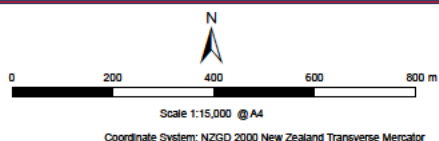
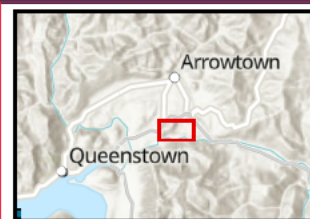
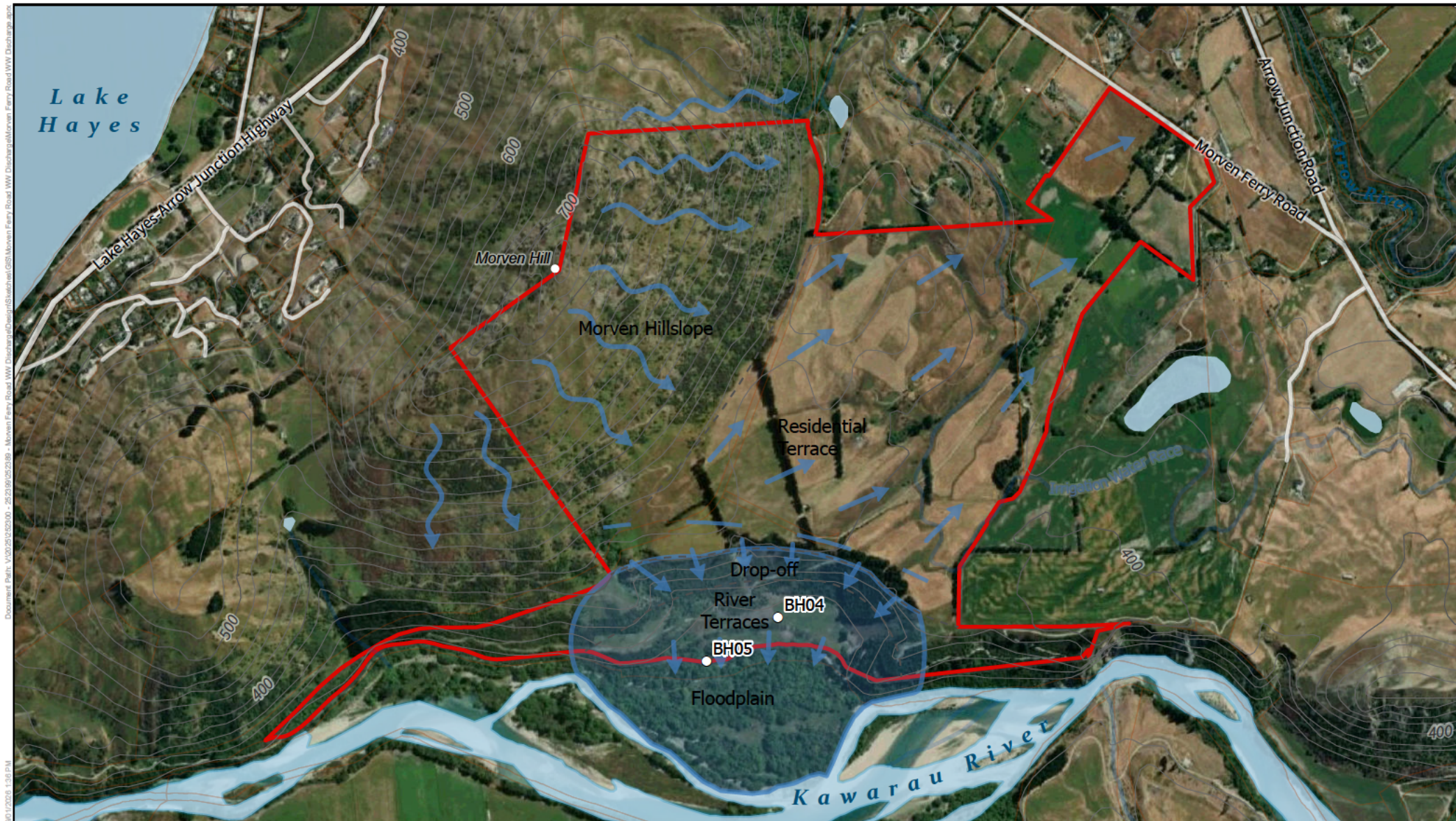
WGA

Figure 4

Water Supply Investigation
Bore Location Map

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LEGEND

- Water Supply Trail Bore
- ▬ Site Boundary
- ▬ Watercourse
- ▬ Property Boundaries
- Contours
- - - Landscape Feature Boundaries
- ▬ Groundwater Catchment Divide
- ➔ Groundwater Flow Direction
- ⬮ Source Water Protection Zone

WGA

Figure 5
Source Water Protection Zone

The hydraulic boundaries to the aquifers underlying the River Terraces are:

1. The Kawarau River and any branches of the river, which would act as recharge boundaries.
2. The schist bedrock underlying the Residential Terrace, which would effectively act as a no-flow boundary. To the north of this boundary groundwater drawdown and contributing recharge would be insignificant.

The sand and gravel aquifers underlying the Middle and Lower Terraces, together with the highly fractured schist intersected in BH05, are considered to be strongly connected to the Kawarau River. Groundwater abstracted for supply purposes through bores BH04 and BH05 is likely to be primarily recharged through seepage flows from the Kawarau River. The extent of groundwater drawdown in response to these proposed takes is expected to be limited to the aquifer areas underlying the River Terraces. Therefore, these proposed groundwater takes are considered to effectively be surface water takes through a stream depletion process.

4.1.2 Groundwater Protection Zone

A groundwater protection zone has been proposed around BH04 and BH05 (WGA, 2026a). This zone would effectively include all of the River Terrace areas, but be limited to those areas (Figure 5). This protection zone would extend a short distance towards the south outside the Ridgeburn development area parcel, to include the Kawarau River floodplain.

Significant investigation work was undertaken with respect to the possibility of disposing of treated wastewater to the River Terraces. However, the use of BH04 and BH05 for potable water supply purposes would preclude the disposal of treated wastewater to soils across the River Terrace areas. Therefore, this application only presents disposal methods for treated wastewater that are assessed to not potentially impact groundwater quality at the supply bores. Should a future water supply system for Ridgeburn be installed elsewhere, the use of the River Terraces for wastewater discharge could again become a viable option. For this reason, the site investigation work undertaken on the River Terraces has been documented in the investigation report (WGA, 2026a) for completeness.

An assessment of pathogen attenuation has been undertaken for a potential exposure pathway between a wastewater irrigation area along the southern edge of the Residential Terrace and the nearest water supply bore BH04 (Table 3). The key attenuation component is the seepage path for infiltrated rainwater or irrigated treated wastewater down the drop-off between the Residential Terrace and the River Terraces. Two scenarios were considered, one assuming the entire drop-off is unsaturated (Scenario 1) and the second assuming there is a thin saturated zone along the top of the schist behind the drop-off (Scenario 2).

Under both scenarios the results indicate that the seepage path down the drop-off offers an effective barrier to pathogen transport from the Residential Terrace to the proposed water supply bores on the River Terraces. The total reduction factor applicable through this potential exposure pathway is large enough that substantial changes in the attenuation factors applied would not have a significant effect on the practical outcomes of the calculation. i.e. The resulting pathogen loads at BH04 would remain far below the 1 cfu/100 mL criterion for potable water quality.

As previously noted, groundwater abstracted from both BH04 and BH05 would be predominantly sourced from the Kawarau River, representing a stream depletion. On that basis, the total nitrogen concentrations in water pumped from these bores is expected to be consistent with the concentrations present in the river water. These concentrations are far below the New Zealand Drinking Water Standard of 11.3 mg/L NO₃-N, which is effectively equivalent to the total nitrogen concentration in this situation.

Table 3: *E. coli* attenuation between Residential Terrace and BH04

ANALYSIS COMPONENT	FACTORS ⁽³⁾	UNITS	SCENARIO 1 ⁽¹⁾	SCENARIO 2 ⁽¹⁾
WWTP effluent <i>E. coli</i> load		cfu/100 mL	10	10
Soil attenuation	Soil horizon thickness	m	0.2	0.2
	Soil horizon attenuation factor ⁽³⁾	log reduction/m	0.54	0.54
	Total soil horizon attenuation	log reduction	0.108	0.108
	<i>E. coli</i> load below soil horizon	cfu/100 mL	7.80	7.80
Vertical unsaturated flow (vadose zone)	Vadose zone vertical thickness	m	80	10
	Vadose zone attenuation factor ⁽³⁾	log reduction/m	0.88	0.88
	Vertical unsaturated flow attenuation	log reduction	70.4	8.8
	<i>E. coli</i> load entering saturated groundwater system	cfu/100 mL	3 x 10 ⁻⁷⁰	1 x 10 ⁻⁸
Lateral groundwater flow within aquifer	Receiver distance from drop-off	m	80	150
	Saturated zone attenuation factor ⁽³⁾	log/m	0.005	0.005
	Aquifer saturated flow attenuation	log reduction	0.4	0.8
Groundwater <i>E. coli</i> load at BH04		cfu/100 mL	1 x 10 ⁻⁷⁰	2 x 10 ⁻⁹

Notes:

(1) Scenario 1 assumes the soils of the drop-off are all unsaturated above the groundwater level of the River Terraces. The transport path is therefore vertical for 80 m of unsaturated soils, then lateral for 80 m in the River Terraces aquifer.

(2) Scenario 2 assumes the soils of the drop-off are unsaturated to a depth of 10 m below ground level. Below that depth it is assumed that a saturated zone 70 m in height is present along the interface between the alluvial sediments and the underlying schist, which then discharges to the groundwater underlying the River Terraces. The transport path is therefore vertical for 10 m of unsaturated soils, then vertical and lateral for 150 m in saturated conditions to BH04.

(3) Attenuation factors sourced from Schijven et al., 2017.

The southwest extent of Morven Hill within the Ridgeburn boundary above the residential terrace is marginally within the interpreted groundwater recharge area for the river terraces (including the Kwarau River Alluvial Ribbon Aquifer). This area of Morven Hill represents approximately 10 ha (about 6%) of the approximate total groundwater recharge area to the Kwarau River Alluvial Ribbon Aquifer of 160 ha. Much of this recharge area is outside of the Ridgeburn boundary to the southwest.

The fraction of the proposed groundwater abstraction sourced from up-gradient groundwater recharge is estimated to be about 3% of the total take, with contributions from the Kwarau River making up the remainder (WGA 2026b). Therefore, only about 0.2% of the proposed groundwater take is expected to be sourced from recharge within proposed irrigation areas on Morven Hill. The groundwater protection zone is informed by assessment of the potential exposure pathway between the edge of the residential terrace and the production bores. This assessment indicates suitable attenuation is provided by the groundwater protection zone, with treated wastewater irrigation predominantly proposed outside of this zone on the residential terrace and Morven Hill.

5 WASTEWATER DISPOSAL METHODS

5.1 Introduction

The Ridgeburn development will generate treated wastewater volumes that are substantially greater than those associated with typical on-site wastewater systems. Accordingly, disposal of treated wastewater requires a carefully considered land application strategy that provides sufficient hydraulic capacity, nutrient attenuation, operational flexibility, and environmental protection.

Two broad areas within and adjacent to the Ridgeburn development have been identified as having potential to accommodate treated wastewater disposal:

1. Morven Hill hillslope
2. Residential Terrace

Each area exhibits different topographic, soil, geological, and hydrogeological characteristics, which influence the suitability of the disposal methods. The primary disposal method is expected to be spray irrigation on Morven Hill with subsurface drip within and around the development as secondary disposal reserve.

The disposal strategy reflects potable water source protection requirements. Potable water will be sourced from groundwater bores located on the River Terraces. To avoid any risk to groundwater quality at these bores, treated wastewater disposal is restricted to areas that are sufficiently separated from the groundwater source. The disposal methods are presented with topography and slope on Figure 6.

5.2 Assessment Methodology

The assessment of treated wastewater disposal methods has been undertaken using a combination of New Zealand and Australian best-practice guidance, supplemented by site-specific investigations completed by WGA and Kirk Roberts.

The primary design framework is AS/NZS 1547:2012 – On-site Domestic Wastewater Management, which provides guidance on soil categorisation, design loading rates, slope limitations, and setback requirements for land application systems. Although AS/NZS 1547 is primarily intended for smaller-scale systems, it remains the most relevant and widely applied standard for on-site land-based wastewater disposal in New Zealand, including for large communal systems where no alternative national standard exists. Consideration is also given to Taumata Arowai discharge to land standards applicable to public networks with associated technical advice (GHD, 2025).

Additional guidance has been drawn from Auckland Council GD2018/006 (Chen & Roberts, 2018), which provides practical interpretation of AS/NZS 1547 for complex sites, including additional guidance on slope reduction factors, setback distances, and the use of communal and reserve land for wastewater disposal.

These guideline documents have been applied in conjunction with:

- Detailed soil logging and test pit investigations undertaken by WGA and Kirk Roberts.
- Geological and hydrogeological assessment of the schist bedrock, colluvium, loess, and terrace gravels.
- Topographic information (LINZ digital elevation model derived from LIDAR) for elevation and slope (shown on Figure 6).
- Detailed site development plans with landscaping plans and on-site ecological survey information provided by Novak + Middleton and Viridis.
- Treated wastewater quality and flow information provided by BPO (2026).

Soils across the Morven Hill and Residential Terrace disposal areas have generally been classified as Category 3 to 4, reflecting moderate permeability loams. Design hydraulic loading rates have been selected conservatively within the ranges recommended by AS/NZS 1547 (i.e., they are limited to the potential lower-permeability of Category 4 soils) and reduced further where necessary to account for slope (Figure 6).

5.3 Wastewater Disposal Techniques Considered

5.3.1 Introduction

The following treated wastewater disposal techniques have been considered for Ridgeburn:

- Subsurface dripline irrigation within and around the Residential Terrace
- Spray irrigation on Morven Hill

These methods have been assessed for hydraulic capacity, nutrient attenuation potential, constructability, operational complexity, and compatibility with staging and source protection requirements.

The treated effluent quality produced by the Ridgeburn WWTP (BPO, 2026) meets the AS/NZS 1547 criteria for surface and subsurface irrigation techniques considered, with cBOD and TSS concentrations well below the specified limits (Section 2.1.3).

5.3.2 Subsurface Dripline Irrigation

Subsurface dripline irrigation involves the pressure-dosed application of treated wastewater through shallow buried drip lines installed within the upper soil profile, typically at depths of 100 to 300 mm below ground level. This method promotes interaction between treated wastewater, soil, and plant root systems, supporting nutrient uptake while maintaining wastewater below the ground surface.

Subsurface dripline irrigation has been selected for use on and around the Residential Terrace as this technique:

- Supports nutrient uptake by vegetation
- Allows precise control of application rates
- Is compatible with potable water source protection requirements
- Generates a lower public health risk compared with surface application methods
- Can be integrated within landscaped and open space areas
- Is suitable for use on gently to moderately sloping terrain

Design loading rates for subsurface dripline irrigation have been derived from AS/NZS 1547 for Category 4 soils, with a base hydraulic loading rate of approximately 3.5 mm/day. Where slopes exceed 10%, slope reduction factors from AS/NZS 1547, Table M2, have been applied:

- **Slopes $\leq 10\%$:** no reduction
- **Slope 10 to 20%:** 20% reduction
- **Slope 20 to 30%:** 50% reduction

Evapotranspiration effects are not applied to subsurface dripline irrigation systems, in accordance with AS/NZS 1547. A robust native planting strategy for subsurface dripline areas is expected for nutrient management and ecological purposes.

5.3.3 Spray Irrigation

Spray irrigation involves the surface application of treated wastewater via low-pressure plant-targeted micro-sprayers. This method supports evapotranspiration losses during warmer months and provides high potential for nutrient uptake by vegetation, with minimal risk of surface water runoff at low application rates aligned with the expected soil hydraulic acceptance capacity.

The Gibbston Soil on Morven Hill is expected to be Category 3 to 4 loess soil developed over colluvium and/or weathered schist. The schist bedrock encountered at relatively shallow depths or at outcroppings on Morven Hill is typically fractured and not impermeable at a bulk scale. However, for the purposes of this assessment it has been assumed that the schist is effectively impermeable and down-slope seepage occurs within the uppermost schist weathered zone and the overlying colluvium and topsoils.

For the spray irrigation areas, hydraulic loading rates have been derived using the land application water balance approach outlined in AS/NZS 1547 Q3. During summer months, conservative evapotranspiration losses of at least 3 mm/day are expected and have been incorporated into seasonal capacity estimates. During winter, no evapotranspiration effect has been applied to the water balance. Therefore, winter application rates are limited to soil infiltration capacity to avoid surface runoff or ponding.

A constructability factor of 0.8 has been applied to account for irregular and difficult terrain for installation, meaning that only 80% of the total designated area is considered practically available for wastewater irrigation. A 20 m spray exclusion zone has been incorporated around the residential lots along the base of Morven Hill, to reduce human exposure risks and allow for monitoring and maintenance access.

A robust native planting strategy is expected to provide potential for nutrient interception, uptake, attenuation, immobilisation, and removal mechanisms. The native plantings are expected to provide sought ecological outcomes along with the benefits of erosion control and nitrogen interception at depth with removal. Specialist input from ecologists will be required to design a robust native planting strategy that meets RDL ecological/landscape objectives.

Low-pressure micro-spray irrigation is proposed as the primary disposal method for Morven Hill, where areas of native plantings for nutrient management and ecological purposes can be established. It is understood that Pattle Delamore Partners (PDP) are undertaking a spray drift assessment that will inform sprinkler design criteria such as droplet size, spray height, and delivery line run times. It is also understood PDP's odour assessment will inform operational line drainage. Low-rate micro-spray irrigation targeted to native plantings across Category 3 to 4 loess soils on Morven Hill could be expected to operate at a low irrigation rate of 10 mm/hr, for example. This is equivalent to a 21-minute run time for the design winter loading rate (3.5 mm/day) and a 39-minute run time in summer (6.5 mm/day irrigation rate). Potential mitigation measures and design criteria are described below.

5.3.3.1 Spray Irrigation Mitigation Measures

It is currently understood from PDP (A. Van Vugt, PDP; personal communication, 2026) that spray irrigation of wastewater poses a potential health risk to receptors from aerosolised pathogens. Based on the PDP draft spray drift assessment, PDP are likely to recommend the following mitigation measures to be implemented:

- Irrigation will not occur during periods with winds greater than 7.5 m/s.
- A calibrated monitoring station should be installed within the land application area, or a representative established meteorological monitoring site will be used to track wind speeds and trigger irrigation cut-offs if required.
- Irrigation design and nozzle selection shall consider particle size distribution to increase droplet sizes and direct spray flat or downward where practicable and reduce spray drift. Non-misting heads should be selected.
- Maximum droplet release height from the spray irrigation will be 0.5 m above ground level.
- The spray irrigation area should be fenced off, with clear signage in English and Māori to prevent access.
- A minimum setback distance of 50 m from residential boundaries and any other recreational area, including the bike path up Morven Hill, will be applied. If a 50 m setback cannot be applied from the bike path to spray irrigation fields, then this area should only be irrigated at off peak time (i.e., nighttime when less people are out, between 12:00am and 3:00am prior to daylight).
- Undertaking irrigation near the bike path and residential housing at nighttime when less people are outside and recreating if practicable.
- Not undertaking spray irrigation of areas upgradient of receptors in the mornings (i.e. not before 8:00am in summer months and 9:00am in winter months).

The irrigation area is currently designed with an approximate 10 m setback from the bike path and 50 m setback from the residential properties.

It is also understood from PDP (A. Van Vugt, PDP; personal communication, 2026) that for odour reasons PDP will be recommending the spray irrigation pipes either empties after use or has a clean water flush to avoid it sitting in pipes and becoming anaerobic/odorous.

6 WASTEWATER DISPOSAL AREAS

6.1 Morven Hillslope Disposal

6.1.1 Hydraulic Loading

Spray irrigation is proposed on Morven Hill as the primary disposal method during, as shown on Table 4. Otago Regional Council has indicated support for this approach where appropriately managed to maximise nutrient uptake (ORC RM25.188 meeting, 9 December 2025). Comparable systems have been implemented at Jack's Point, providing a precedent for carefully managed spray irrigation on steep terrain for the benefit of further nutrient uptake.

In defining the potential irrigation area, a 20 m exclusion zone is maintained at the base of Morven Hill to reduce human exposure risks and allow for monitoring and maintenance access. A constructability factor of 0.8 has been applied across the whole Morven Hill area within the Ridgeburn boundary, reducing the potentially available area. The maximum design loading rate applied is 3.5 mm/day during the winter. During summer a conservative additional allowance of up to 3 mm/day, allowing for evapotranspiration effects, is applied. The resulting potential hydraulic loading rates are presented on Table 4.

Table 4: Morven Hillslope Spray Disposal Hydraulic Loading Rates

PARAMETER	UNITS	VALUE
Total Available Area	m ²	654,247
Constructable Area	m ²	523,398
Minimum Summer Evapotranspiration	mm/day	3.0
Design Disposal Objective	m ³ /day	1,204
Maximum Potential Disposal Winter (153 days) ⁽¹⁾	m ³ /day	1,832
Maximum Potential Disposal Summer (212 days) ⁽¹⁾	m ³ /day	3,402
Design Loading Rate	mm/day	3.5
Average Loading Rate	mm/day	2.3

Note:

⁽¹⁾ Irrigation period matched to BPO (2026) WWTP design report outputs.

The maximum potential winter disposal capacity of 1,832 m³/day exceeds the maximum daily treated wastewater volume of 1,204 m³/day (BPO, 2026), providing either:

- Potential disposal redundancy of about 636 m³/day
- A corresponding reserve area of about 181,684 m² (35% of the constructable area)

The maximum potential summer disposal capacity of 3,402 m³/day exceeds the maximum daily treated wastewater volume of 1,204 m³/day (BPO, 2026), providing either:

- Potential disposal redundancy of about 2,206 m³/day
- A corresponding reserve area of about 339,398 m² (65% of the constructable area)

Spray irrigation of the maximum daily treated wastewater volume of 1,204 m³/day across the full constructable area results in a hydraulic loading rate of approximately 2.3 mm/day (Table 4).

6.1.2 Nitrogen Loading

Based on the maximum daily treated wastewater volume with a lower corresponding hydraulic loading rate (approximately 2.3 mm/day with the full constructable area in use), the nitrogen loading would be approximately 54.3 kg N/ha/year. This nitrogen loading estimate takes into account the expected seasonal variability of the discharge quality provided by the WWTP design report (BPO, 2026).

Seasonally:

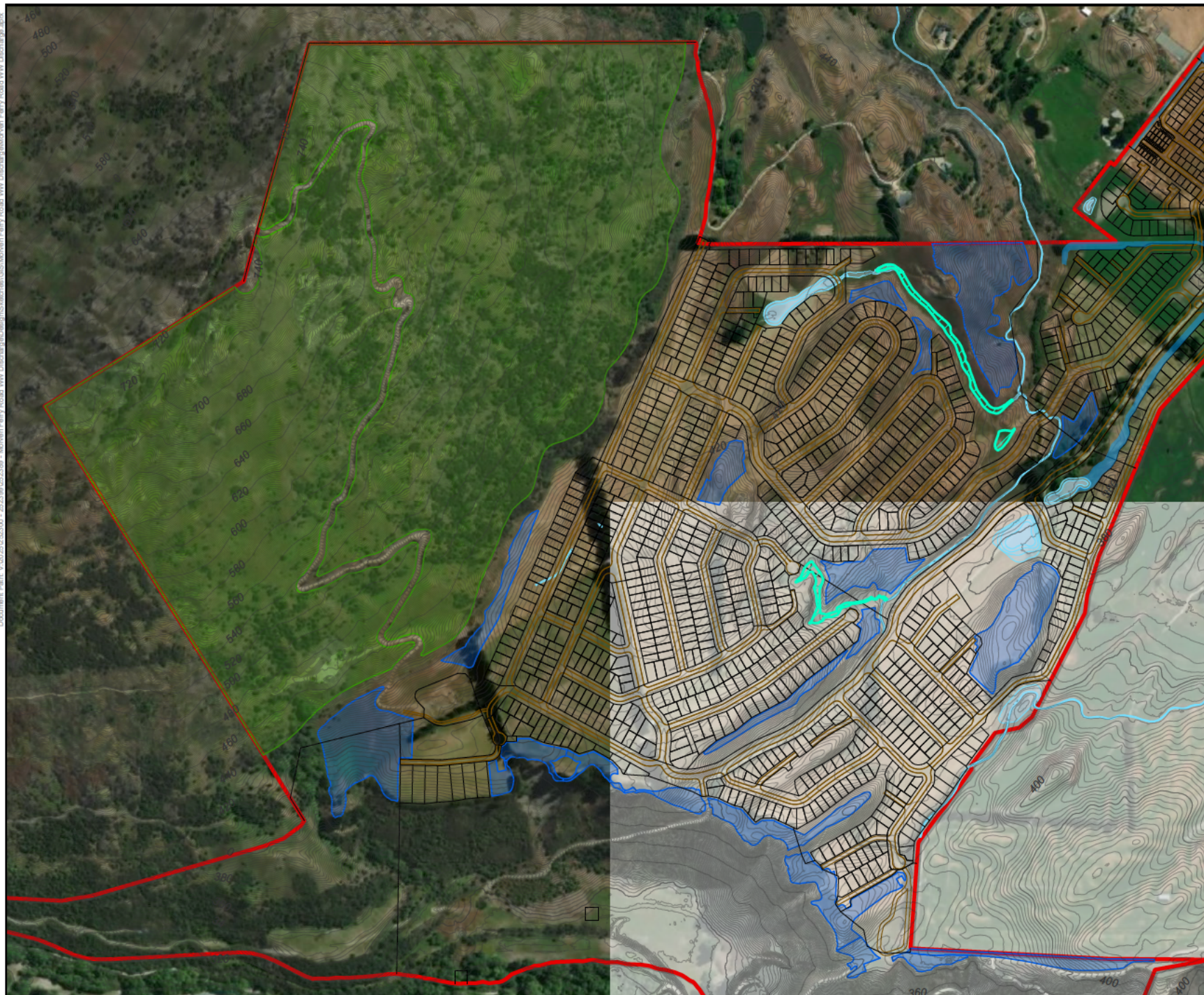
- The Spring – Summer (October through April, 212 days) wastewater total nitrogen concentration is 0.004 kg/m³ (4 mg/L). The total summer loading component is 19.4 kg N/ha.
- The Autumn – Winter (May through September, 153 days) total nitrogen concentration is 0.01 kg/m³ (10 mg/L). The total winter loading component is 35 kg N/ha.

6.1.3 Phosphorus Loading

Based on the maximum daily treated wastewater volume with a lower corresponding hydraulic loading rate (approximately 2.3 mm/day with the full constructable area in use), the total phosphorus loading to Morven Hill would be approximately 66.7 kg TP/ha/year. There is no expected seasonal variability of the discharge quality in terms of total phosphorus concentration of 0.008 kg/m³ (8 mg/L), as per the WWTP design report (BPO, 2026).

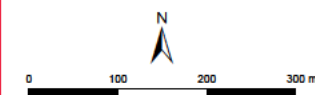
6.1.4 Hillslope Native Plantings

Nutrient management is a key component of any treated wastewater discharge system in Otago. Planting of Morven Hill is a component of the proposed Ridgeburn Development landscape design. The use of appropriate native plants for dryland ecology goals is also expected to provide nutrient uptake and erosion control. The provision of specifications for a dryland ecology native planting plan is outside the scope of this report. However, important considerations for Morven Hill conditions in terms of a planting strategy for nutrient uptake include cold winter conditions, soil depth, soil water storage, and rooting depth. The inclusion of native plantings is expected to reduce runoff risk, thereby retaining topsoil on the hillslope.



LEGEND

-  Site Boundary
-  1m Elevation Contours
-  Dripline Areas
-  Spray Areas
-  Water
-  Wetland
-  Proposed Watercourse
-  Roadway
-  Lot Boundary



Scale 1:8,500 @ A4

Coordinate System: NZGD 2000 Mount Nicholas Circuit

WGA

Figure 7

Disposal Areas on Morven Hill and the Residential Terrace

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2025

6.2 Residential Terrace Disposal

Subsurface dripline irrigation is proposed within landscaped and open space areas of the Residential Terrace for the purpose of further secondary disposal reserve area and nutrient management. This approach provides additional disposal capacity while maintaining separation from the groundwater supply bores. This is intended to supplement the disposal on Morven Hill (reducing nitrogen and phosphorous loading on Morven Hill) and provide further redundancy/reserve. Subsurface dripline irrigation disposal within this area with low loading rates is expected to be compatible with residential land use and potable water source protection requirements.

Hydraulic loading rates reflect Category 4 soils (design loading rate of 3.5 mm/day) and applicable slope reduction factors where slopes exceed 10% to minimise potential for exposure pathways to residents. Setback distances are consistent with GD2018/006 guidance and reflect the advanced tertiary quality of the treated effluent. No evapotranspiration effect has been applied, consistent with AS/NZS 1547 guidance for subsurface systems. A robust planting strategy within the subsurface dripline areas is expected for appropriate nutrient management with native plants as per Section 6.1.

ORC has directed the use of subsurface dripline disposal within and around the residential development due to its dual benefits of nutrient uptake and water reuse for landscaping irrigation (ORC RM25.188 meeting, 9 December 2025). Setback distances for drip irrigation within residential areas will consist of:

- 1.5 m downhill from lots.
- 3.5 m uphill from lots.
- Additional setbacks include 2 m from paved areas and the piped irrigation canal alignment:
 - Some dripline areas are designated to be installed beneath gravel walking paths.
- 10 m surface waters, including all designed open surface water features and stormwater management within the residential area.
- The extent of the known lizard habitat indicated by Novak + Middleton in accordance with ecological site investigations at an elevated open space within the residential area has also been excluded from potential dripline areas.

As per the AC guidelines Table 20 for minimum setback distances are defined by the expected effluent quality, which falls into the advanced tertiary category with total nitrogen below 10 mg/L. The constructable area is estimated at about 0.8 of the total area available due to the irregular geometries within each of the potential areas suitable for subsurface dripline disposal. The dripline areas are mapped on Figure 7 with hydraulic loading rates presented on Table 5.

Table 5: Residential Terrace Subsurface Dripline Disposal Hydraulic Loading Rates

PARAMETER	UNITS	SLOPE COMPONENT			TOTAL
		< 10%	10% - 20%	20% - 30%	
Total Available Area	m ²	10,812	94,188	4,620	109,621
Slope Reduction Factor		1	0.8	0.5	
Constructable Area	m ²	8,650	75,351	3,696	87,697
Slope Reduced Design Loading Rate	mm/day	3.5	2.8	1.8	
Disposal Rates	m ³ /day	30.3	211.0	6.5	247.7

6.3 Treated Wastewater Disposal Scenario

The treated wastewater disposal methods documented above suggest that the disposal areas can accommodate treated wastewater discharges from Ridgeburn. The total potential treated wastewater disposal acceptance capacity for the development is expected to be:

- 2,080 m³/day during winter, distributed between spray irrigation to Morven Hill and drip irrigation within and around the Residential Terrace.
- 3,650 m³/day during summer, with the increase being a consequence of increased evaporation from spray irrigation on Morven Hill.

Both the winter and summer rates exceed the required disposal of the maximum daily treated wastewater volume generated by the plant, 1,204 m³/day. The full discharge of treated wastewater is expected to be achieved on Morven Hill alone as the primary disposal option. However, as per ORC direction for maximising nutrient uptake, it would be beneficial to use treated wastewater on open spaces within the residential area of the development to support vegetation growth in these areas. As noted above, dripline within the residential area also serves as a further reserve area. Operational flexibility is also provided by the three proposed irrigation tanks at the wastewater treatment plant with total storage of 4,500 m³.

The AC guidelines note that 50% reserve area is required when conservative higher wastewater production rates have been used for the design flow. According to technical advice provided by GHD, 2025, for the Taumata Arowai public network wastewater discharge to land standards, additional reserve disposal area for rotation and contingency is optional and dependent on site conditions with a focus on risk-based approach. Reserve area is therefore proposed to mitigate risks, minimise potential environmental effects, and provide operational flexibility/contingency. The estimated total potential discharge acceptance capacity of 2,080 m³/day during the winter is approximately twice the maximum daily wastewater generated, which is expected to satisfy the reserve area guidelines. During the summer, total potential disposal is over three times the required maximum daily volume, providing ample redundancy and reserve for maintenance.

7 WASTEWATER DISPOSAL EFFECTS ASSESSMENT

7.1 Introduction

Potential environmental and human health risks are associated with the proposed treated wastewater disposal methods across the proposed disposal areas on Morven Hill and the Residential Terrace. These effects arise from interactions with surface water, groundwater, and potable water supplies. Hydraulic, nutrient, and pathogen loading/attenuation are estimated to assess potential effects while considering contaminant transport principles, and relevant guidelines.

7.2 Morven Hill Disposal Effects

The Morven Hill spray irrigation area is the primary treated wastewater disposal area, with a maximum potential winter disposal capacity of 1,832 m³/day and summer capacity of 3,402 m³/day. Effects are assessed based on the maximum daily treated wastewater volume of 1,204 m³/day, resulting in a very low average hydraulic loading rate of approximately 2.3 mm/day across the full constructable area.

7.2.1 Effects on Surface Water

Groundwater originating in the Morven Hill spray irrigation area is expected to ultimately discharge into the Arrow River, which is about 1.4 to 2.6 km to the east/northeast. Given the Arrow River is currently non-compliant with ORC water quality targets with slightly elevated nitrate-nitrogen, robust native plantings for dryland ecology goals and nutrient management across the Morven Hill spray irrigation area are proposed.

As described in Section 6.1.2, the maximum daily treated wastewater volume across the Morven Hill spray irrigation area results in an estimated nitrogen loading of approximately 54.3 kg N/ha/year. This loading is well within the capacity of land application systems under Otago Regional Council guidelines of <150 kg N/ha/year to avoid excessive leaching in sensitive catchments.

Lowe Environmental (LE, 2025), provides estimates for the potential of native plantings in the Otago climate for managing nitrate-nitrogen leaching from effluent discharges through interception, uptake, and immobilisation. The range of potential nitrogen uptake expected by native plantings presented by LE is 100 to 200 kg N/ha/year (approximately two to four times to the estimated annual nitrogen loading of 54.3 kg N/ha/year). Given this, a robust native planting strategy is expected to enable negligible nitrate-nitrogen losses to groundwater. On this basis, negligible changes in nitrate-nitrogen loads within the catchment are expected with negligible specific in-stream effects in the Arrow River may also be reasonably expected.

Other surface water bodies potentially receiving groundwater down-gradient of the Morven Hill including farm ponds and wetlands within the development are similarly not expected to be affected by the nutrient discharge. This is due to the estimated level of nitrogen loading being significantly less than the potential for interception, uptake, attenuation, and removal provided by the native planting strategy. With appropriate plantings and irrigation management in place, negligible nitrate-nitrogen infiltration to groundwater is expected from the Morven Hill spray irrigation. Shallow groundwater within the development potentially discharging to on-site wetlands on a perennial or seasonal basis is therefore expected to have negligible nitrate-nitrogen impacts specific to the spray irrigation on Morven Hill at the appropriate low irrigation/nutrient loading rates nominated.

Water quality data show the Arrow River is currently in compliance with ORC criteria in terms of phosphorus. Estimated phosphorus loading on Morven Hill at 66.7 kg TP/ha/year exceeds the expected potential annual native planting uptake rate of 35 TP/ha/year as per LE (2025). However, phosphorus is less mobile than nitrogen and is expected to be attenuated through adsorption to soil particles and retention within soils and strata.

Given the above, phosphorous is not expected to remain as a mobile constituent within the underlying groundwater system and has therefore not been assessed for effects on the Arrow River or other downgradient wetlands or other surface water bodies.

Several factors are expected to reduce the risk of off-site phosphorus effects:

- The treated effluent has low suspended solids and low particulate phosphorus content.
- Application rates are controlled to avoid surface runoff.
- A dedicated 20 m planted buffer zone is provided at the base of the Morven Hill slope.
- Any mobilised phosphorus is likely to be retained within colluvial soils downslope.
- Monitoring of soil phosphorus within the disposal area and dedicated buffer zone at the base of the slope can be implemented to confirm long-term performance.
- The use of rest periods for wastewater irrigation areas would enable ongoing vegetation growth to reduce the accumulated concentrations of phosphorus in the soils.

The potential for surface runoff during high-intensity rainfall events is expected to be mitigated by low application rates, the 20 m planted buffer zone, and the proposed native planting strategy, which enhances soil stability. Overall, effects on surface water including the Arrow River and on-site wetlands are expected to be less than minor with appropriate management, low loading rates nominated in this assessment, and maintaining the high degree of wastewater treatment.

No effects are expected on nutrient loads in the Kawarau River due to the Morven Hill spray area being within the Arrow River catchment.

7.2.2 Effects on Soils

7.2.2.1 Phosphorus Accumulation

The maximum expected phosphorous loading of 66.7 kg TP/ha/year exceeds the expected potential annual native planting uptake rate of 35 TP/ha/year (LE, 2025). LE (2025) provides an expected phosphorus sorption for a similar well drained Pallic loam soil located near the site on the order of 500 mg/kg. According to Currie & Hedley (2020) this value is lower than typical New Zealand Pallic soils with phosphorus sorption on the order of 800 mg/kg. With potential sorption applied at 500 mg/kg, a typical soil bulk density of 1,300 kg/m³, and an average soil thickness for the irrigated area of 0.4 m, the phosphorus storage capacity across Morven Hill is estimated at approximately 2,600 kg P/ha.

Given there is an excess 31.7 kg P/ha/year following expected potential uptake from native plants, full phosphorus accumulation within the Pallic soils across Morven Hill is estimated to take approximately 80 years at the maximum loading rate. This storage potential is expected to be significantly greater than the proposed consent duration and minimise leaching of phosphorus to groundwater.

7.2.2.2 Soil Structure

The proposed micro-spray irrigation on Morven Hill uses low design hydraulic loading rates to minimise environmental impacts. The average loading rate across the whole area at the maximum daily volume is 2.3 mm/day (about 840 mm/year). The maximum design rate is 3.5 mm/day during winter (no evapotranspiration adjustment) and up to 6.5 mm/day in summer (including 3 mm/day conservative evapotranspiration allowance). These rates are applied across the constructable area of about 52.3 ha, targeting a maximum daily disposal of 1,204 m³/day, with redundancy (35 to 65% reserve area seasonally).

There is low annual rainfall (about 889 mm/year estimated at the site) onto vegetation/topsoil over silty sand, colluvium, and schist. The added 840 mm/year increases total water input to 1,729 mm/year. Average evapotranspiration at the site in its natural setting is estimated at 612 mm/year. The low rates align with guidelines (AS/NZS 1547:2012) for at least Category 4 soils, avoiding over-saturation as rates are designed be less than infiltration capacity. Overall, wastewater is expected to increase soil moisture. However, at the nominated low loading rates, water logging or a shift to anaerobic soil conditions is not expected to arise due to terrain steepness and infiltration capacity. The purpose of the design loading rates nominated based on site condition is for no discrete ponding or runoff to occur with the soil remaining aerobic, preserving dryland-like structure.

WGA expects the proposed irrigation to extend growing seasons for the irrigated areas. Nutrient levels and soil structure changes are also to be expected. For example, the projected vegetation growth would lead to increased organic matter content in the topsoil and topsoil thickness. However, the risk of negative effects on soil structure is expected to be low. According to Meister et al. 2022, who investigated interactions of treated municipal wastewater with NZ native plant species across similar loamy soils, at significantly higher loading rates of 194 kg N/ha/year and 110 kg P/ha/year, soil nutrient levels increased but the loading led to no impairment of soil structure across the three-year study.

The loam soil on Morven Hill is expected to be well drained (Category 3 to 4 soils) and therefore not sensitive to degradation related to sodium (Na) loading from waterlogging. It is currently expected that the treated wastewater sodium concentrations will be less than 100 mg/L. With the average hydraulic loading rate of approximately 2.3 mm/day corresponding to less than 840 kg Na/ha/year. Meister et al. (2022) note that there was no evidence of impaired soil structure at a study site with similar well-drained loam soils and rainfall receiving sodium at a higher rate of 950 kg/ha/year. This study also reported no clay dispersion, ponding, or infiltration reduction due to sodium accumulation. Furthermore, the well-drained loam soils at the site are expected to exhibit low sodium absorption ratio and low exchangeable sodium percentage because they are derived from primarily schist parent material, which is enriched in calcium and magnesium bearing minerals that bind more strongly to soil exchange sites compared to sodium.

7.2.3 Effects on Groundwater Users

According to the ORC wells database, the closest down-gradient bore potentially used for drinking water purposes is bore F41/0568, approximately 550 m northeast of the closest point of the Morven Hill spray area. This shallow (10 m deep) bore is located near a neighbouring residence on Morven Ferry Road and is noted as a domestic bore on the ORC database.

Pathogen transport modelling for the closest neighbouring bore potentially used for a potable water supply (Bore F41/0568) indicates that the attenuation provided by the combination of 0.1 m of topsoil, 4 m vertical seepage through a vadose zone and 550 m lateral seepage to Bore F41/0568 would result in *E. coli* loads at that bore substantially below the New Zealand Drinking Water Standard of 1 cfu/100 mL (Table 6). The attenuation calculations using reasonable log removal rates for the topsoils, vadose zone and saturated gravels (Schijven et al., 2017), indicate the *E. coli* load from the treated wastewater would be attenuated below 1 cfu/100 mL within a distance of approximately 20 m, which is the width of the setback buffer provided for the irrigation area.

Table 6: *E. coli* Attenuation Between Morven Hill and Closest Water Supply Bore

ANALYSIS COMPONENT	FACTORS	UNITS	F41/0568
WWTP effluent <i>E. coli</i> load		cfu/100 mL	10
Soil attenuation	Soil horizon thickness	m	0.1
	Soil horizon attenuation factor ⁽¹⁾	log reduction/m	0.54
	Total soil horizon attenuation	log reduction	0.054
	<i>E. coli</i> load below soil horizon	cfu/100 mL	8.8
Vertical unsaturated flow (vadose zone)	Vadose zone vertical thickness	m	4
	Vadose zone attenuation factor ⁽¹⁾	log reduction/m	0.52
	Vertical unsaturated flow attenuation	log reduction	2.08
	<i>E. coli</i> load entering saturated groundwater system	cfu/100 mL	7 x 10 ⁻²
Lateral groundwater flow within aquifer	Receiver distance from drop-off	m	550
	Saturated zone attenuation factor ⁽¹⁾	log/m	0.003
	Aquifer saturated flow attenuation	log reduction	1.65
Groundwater <i>E. coli</i> load at BH04		cfu/100 mL	2 x 10 ⁻³

Notes:

⁽¹⁾ Attenuation factors sourced from Schijven et al., 2017.

The nutrient loading on Morven Hill is also expected to be attenuated through a robust native planting strategy, therefore, mobile nitrate-nitrogen originating from the discharge is not expected to result in a measurable effect within groundwater at this neighbouring bore and other neighbouring bores further downgradient within the Arrow River catchment.

No effects are expected for the dedicated on-site water supply bores located on the river terraces near the Kawarau River as per the relevant pathogen attenuation analysis presented on Table 3 and described in the context of groundwater recharge in Section 4.1.

7.2.4 Risks to Human Health

The spray areas on Morven Hill are not proposed within recreation or areas intended for human traffic. As a surface application method, targeted micro-spray irrigation on Morven Hill presents potential exposure pathways via direct contact. However, risks are minimised through:

- Use of low-pressure micro-sprayers targeted at plant bases to reduce aerosolization:
 - A spray drift assessment will inform spray height and droplet size for design criteria
- Exclusion of public access during application periods via signage and fencing if required
- Setbacks from residential areas and recreational paths
- High-level UV disinfection ensuring low pathogen concentrations:
 - The proposed WWTP incorporates a continuous UV disinfection stage to ensure the production of a high-quality effluent. This treatment stage addresses the disinfection requirement under Section M4 of the AS/NZS 1547 for the surface spray method.

The proposed planting strategy with targeted application is also expected to limit direct contact. Risks to human health are expected to be suitably low and can be managed to less than minor levels.

The *E. coli* attenuation calculations presented in Table 6 indicate that attenuation would result in *E. coli* loads in groundwater decreasing below 1 cfu/100 mL within a distance of approximately 20 m, which is the width of the setback buffer provided for the irrigation area.

7.3 Residential Terrace Disposal Effects

7.3.1 Effects on Surface Water

Subsurface dripline irrigation on the Residential Terrace involves low loading rates (1.8 to 3.5 mm/day, adjusted for slope with no allowance for evapotranspiration) across landscaped areas. This dripline irrigation area providing a reserve 248 m³/day capacity (Table 5) to supplement the irrigation area on Morven Hill. Nutrient effects on surface waters, including surface water features within the development and the ultimately receiving Arrow River, are expected to be less than minor in accordance with the planting strategy designed to support nutrient management as per Section 6.1.

7.3.2 Effects on Soils

The maximum potential phosphorus loading from dripline irrigation on the Residential Terrace, assuming full use of the 248 m³/day reserve capacity (Table 5; Section 6.2), is approximately 82.6 kg TP/ha/year (based on a treated wastewater concentration of 8 mg/L TP; Section 2.1.3). This loading exceeds the expected native plant uptake of 35 kg TP/ha/year (LE, 2025; Section 7.2.2.1). However, phosphorus mobility is low, with adsorption to soil particles providing long-term retention. Using the expected sorption capacity of 500 mg/kg (LE, 2025), soil bulk density of 1,300 kg/m³, and an average soil depth of 0.5 m, the retention capacity is estimated at 3,250 kg TP/ha. Excess phosphorus (47.6 kg TP/ha/year) would accumulate over approximately 70 years before the retention capacity is reached, minimising leaching risks within the consent duration. It is unlikely that dripline irrigation on the Residential Terrace would be fully utilised on an annual basis. Focusing of treated wastewater irrigation on Morven Hill through most summers, except where required to support plant growth in the dripline irrigation areas, would enable the plants to utilise some of the retained phosphorus during periods of maximum growth.

Expected sodium loading (<100 mg/L; Section 2.1.3) is about 1,032 kg Na/ha/year. This represents a low risk of soil structure degradation in the moderately permeable on-site loams (Meister et al., 2022; Section 7.2.2.2). Vegetation growth should lead to an increase in organic matter in the topsoils, enhancing their structure (Sections 6.2, 8.2), thereby offsetting any potential degradation that may be associated with sodium loading.

Subsurface dripline irrigation applies slope-adjusted rates of 1.8 to 3.5 mm/day (Table 5; Section 5.3.2), averaging 2.8 mm/day at maximum reserve use. These conservative rates, below infiltration capacity for the soils, minimise the risks of waterlogging or the development of anaerobic conditions in the soils.

7.3.3 Effects on Groundwater Users

Pathogen transport modelling for the closest neighbouring bore potentially used for a potable water supply (bore F41/0073t to the northeast of the northern dripline area) indicates that the high-quality treated effluent (*E. coli* <10 cfu/100 mL) combined with soil attenuation (0.54 log removal across 0.2 m soil) plus attenuation within saturated gravels (0.005 log removal over the 330 m travel distance) results in negligible risk to the bore (*E. coli* 0.2 cfu/100 mL). These log removal rates within soil and saturated gravels according to Schijven et al., 2017, indicate the initial *E. coli* concentration will be attenuated suitably below 1 cfu/100 mL within about 180 m distance. No vadose zone is applied to this estimate as a conservative winter scenario consistent with site observations of saturated subsurface conditions in this area (WGA, 2026a).

Section 4.1 and Table 3 provides a detailed assessment of potential effects on the dedicated on-site supply bores. This assessment indicates negligible pathogen risk to the bores associated with the discharge on the Residential Terrace is expected.

7.3.4 Risks to Human Health

Human health risks are very low as the highly treated wastewater with UV disinfection is expected to remain in the subsurface at the design loading rates adjusted for slope. The standard setbacks applied further prevent direct exposure. Integration with landscaping enhances amenity without compromising safety.

The human health risk arising from the proposed subsurface dripline discharge of treated wastewater, has been evaluated based on a plausible exposure pathway relative to existing wetland areas. The discharge system is designed to not approach closer than approximately 10 m from a perennial wetland and a seasonal wetland. The treated wastewater is expected to have an *E. coli* count of less than 10 cfu/100 mL.

The existing perennial and intermittent wetlands on-site are to be retained and enhanced under the proposed Ridgeburn design. Some of the treated wastewater discharged via subsurface dripline within the planned residential area may eventually return to surface in these wetlands. Although not specifically intended to be used for recreational purposes, incidental human contact may occur, including children playing in or around the wetland margins. Therefore, human health risk relative to the existing wetland background has been assessed for the subsurface dripline discharge, given a plausible exposure pathway.

Following discharge, the wastewater is expected to percolate downward through the underlying soil profile prior to any potential interaction with the nearby wetlands. Based on soil characteristics and conservative assumptions, *E. coli* counts are expected to be reduced from ≤ 10 cfu/100 mL to approximately ≤ 7 cfu/100 mL prior to entering the underlying strata. A poor-case conceptual model has been considered whereby saturated gravels under the topsoil provide a hydraulic pathway to the wetlands. No additional attenuation within the applied gravel layer has been assumed, providing a conservative upper-bound estimate of potential *E. coli* counts at the wetland margin attributable to the wastewater discharge.

Seasonal wetlands in Otago commonly contain naturally occurring *E. coli* arising from wildlife, soil-associated bacteria, organic sediments, and episodic runoff. Background *E. coli* counts are expected to typically range from approximately tens to hundreds cfu/100 mL under dry or baseflow conditions. Higher counts (up to several hundred cfu/100 mL) occur during wet or ponded conditions. These expected background counts are expected to be seasonally variable and not indicative of anthropogenic contamination.

When compared with this background context, the maximum predicted wastewater-derived count of less than 7 cfu/100 mL is below the naturally occurring wetland levels. Therefore, even under the conservative assumption of direct subsurface connectivity, the wastewater discharge would not result in a measurable increase in *E. coli* counts within the wetlands, nor would it be distinguishable from natural background variability.

The wetlands are located within a development area, where incidental human contact may occur, including children playing in or around the wetland margins. This exposure pathway is characterised by intermittent, short-duration, contact rather than full immersion. Recreational water quality guideline values (260 cfu/100 mL, MoE 2003) are based on repeated full-body immersion and are conservative when applied to incidental contact scenarios. The projected wastewater-derived counts are expected to represent a negligible fraction of these guideline values and not materially increase potential human health risk. The dominant sources of *E. coli* relevant to human exposure are expected to remain wildlife and natural environmental inputs, rather than the wastewater discharge.

In summary, the combination of wastewater treatment, UV final treatment for eliminating residual pathogens, subsurface discharge, soil attenuation, and separation distance mitigates for *E. coli* human exposure risks associated with the potential exposure pathway to the seasonal and perennial wetlands. The discharge is not expected to result in adverse microbiological effects or an increased human health risk associated with incidental contact within the development area.

7.4 Potable Water Source Protection

As documented in Section 4.1, the potable water supply for Ridgeburn is to be provided via two water bores, BH04 and BH05, located on the River Terraces. A source water protection zone for these two bores is documented in Section 4.1, supported by the reasoning behind the zone definition and pathogen attenuation calculations.

The designation of a source water protection zone covering the River Terraces precludes the use of these terraces and the drop-off from the Residential Terrace for use in the disposal of treated wastewater. Investigations have been undertaken on the River Terraces to determine their potential for use in treated wastewater discharge. The information arising from these investigations has been incorporated in the separate investigation report (WGA, 2026a) for completeness as they inform the hydrogeological setting and groundwater source to the supply bores. However, the planned treated wastewater discharge areas have been defined to be outside the designated source water protection zone (refer Section 4.1.2).

8 MONITORING AND MITIGATIONS

A comprehensive monitoring and mitigation program, developed in consultation with the Otago Regional Council (ORC), is to be implemented to verify the performance of the wastewater disposal system, confirm environmental effects remain less than minor, and enable adaptive management. This program builds on the high-quality treatment provided by the WWTP (BPO, 2026) and incorporates flexibility for staging, maintenance, and reserve areas (35 to 65% seasonal reserve on Morven Hill). Key elements are outlined below, with triggers for action based on baseline data, guideline values (AS/NZS 1547:2012, NZ Drinking Water Standards), and site-specific thresholds (e.g., no measurable increase in downgradient nutrient/pathogen levels).

8.1 Effluent Quality Monitoring

- Continuous monitoring of UV irradiation in the WWTP disinfection system to ensure required dosage for pathogen inactivation is maintained; automatic diversion/recirculation of treated wastewater back to the plant if levels drop below thresholds (Section 2.1.3).
- Composite sampling of treated wastewater at the WWTP outlet prior to discharge, at a frequency to be agreed with ORC (e.g., weekly initially, then monthly), and analysis for key parameters including cBOD, TSS, TN, TP, *E. coli*, and sodium (Table 1; Section 2.1.3).
- Treated wastewater must meet proposed compliance criteria triggers prior to discharge:
 - *E. coli* <10 cfu/100 mL
 - TN <4 mg/L through winter and < 10 mg/L through summer)
- Water quality exceedances trigger immediate diversion and system performance review.

It is noted that elevated total nitrogen may be expected initially at lower WWTP flows/volumes during the construction phase of the development. As the discharge rates during this period will be correspondingly low, suitably low nitrogen loading rates can still be achieved on Morven Hill through adaptive utilisation of the irrigation area.

8.2 Soil Monitoring

- Soil sampling in disposal areas (Morven Hill and Residential Terrace) for nutrient accumulation (phosphorus and sodium) plus structure indicators (infiltration rates) to detect over-saturation, waterlogging, or degradation (Sections 7.2.2, 7.3). This monitoring could occur annually, with event-based sampling after heavy rain/irrigation.
- Monitoring in the 20 m buffer zone at the base of Morven Hill for soil phosphorus (Section 7.2.1) including visual inspections for erosion, runoff, and/or seepage daylighting.
- Vegetation health assessments (growth rates, nutrient deficiency signs, and nutrient overloading sign) in native planting areas for adaptive management where loading rates can be adjusted and/or irrigation rotated into available reserve areas on Morven Hill plus the Residential Terrace.

8.3 Groundwater and Surface Water Monitoring

- Groundwater sampling from existing piezometers (BH2, BH3 on River Terraces) and supply bores (BH04, BH05) for nutrients (TN, TP) and pathogens (*E. coli*) (Sections 4.1, 7.2.3, 7.3). Monitoring could occur quarterly initially, then biannually; include baseline pre-discharge data.
- Runoff and seepage monitoring in the Morven Hill buffer zone and down-gradient areas.
- Event-based surface water sampling at key receptors (on-site wetlands) with analysis for nutrients and pathogens if exceedance detected in composite effluent quality sampling (Section 7.2.1). Seasonal surface water quality sampling at on-site wetlands may inform expected background levels initially. If the discharge is detected, cease irrigation to nearby disposal area(s).

8.4 Operational Mitigations

- Automated controls for spray irrigation are understood to include no spray when winds exceed 7.5 m/s (using on-site or nearby meteorological station), excessive rain, or high soil moisture to minimise aerosol drift and runoff risks (Section 5.3.3.1). Operational flexibility is provided by three proposed irrigation tanks at the wastewater treatment plant with total storage of 4,500 m³.
- Adjustable loading rates based on real-time soil moisture probes and weather data to maintain low loading rates (2.3 mm/day average across the constructable area with maximum expected design loading rates of 3.5 mm/day winter and 6.5 mm/day summer) to prevent ponding (Sections 6.1.1, 7.2.2).
- Spray system design to include non-misting nozzles with a max 0.5 m droplet height, large droplet sizes and nighttime irrigation only (12:00am-3:00am) at spray areas near paths/residences.
- Clean water flush or emptying of pipes post-use to prevent odours/anaerobic conditions (Section 5.3.3.1).
- Setbacks and access controls include 20 m buffer along base of Morven Hill; 1.5 to 3.5 m from lots, 2 m from paths, 10 m from surface waters/lizard habitats on Residential Terrace.
- Fencing and signage to restrict access if required (Sections 5.3.3.1, 6.2, 7.2.4).
- Irrigation flexibility relies on the availability of reserve areas (35 to 65% on Morven Hill seasonally plus reserve disposal within the Residential Terrace subsurface dripline areas) to provide for maintenance or reduced loading during early development phases when WWTP performance may vary (Sections 2.1.3, 6.3).

8.5 Adaptive Management and Reporting

- Annual reporting to ORC on monitoring results, system performance, and any incidents/exceedances, with provisions for program review (e.g., every five years or post-event).
- If triggers are exceeded, reduce/shift loading to reserve areas, enhance plantings, or optimise WWTP (Section 1.2). This ensures sustainability and compliance, protecting environmental values (Executive Summary).

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