KSL
Kōmanawa Solutions Ltd

Matakanui Gold Limited

Report No: Z24002BOG-1

Bendigo – Ophir Gold Mine Project – Groundwater Existing Environment & Effects Assessment

1 September 2025

Kōmanawa:

1. ***(verb) spring, well up (of water)***
2. ***(verb) to spring, well up (of thoughts, ideas)***

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Version control

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Executive Summary

This is an assessment of the effects on groundwater, plus providing key inputs to other experts work including environmental geochemistry modelling undertaken separately by Mine Waste Management (MWM) to determine solute concentrations and mitigation. This assessment concludes the abstraction, diversion, use and return of groundwater with the proposed mitigations will result in an acceptable outcome.

Two creek catchments, being Rise and Shine and Shepherds Creeks cross the proposed Bendigo – Ophir Gold Mine Project site. These creek catchment are within the wider Clutha River / Mata Au main catchment. In the hydrogeological context, these creek catchments in their upper parts are a variably saturated fractured-rock groundwater system. While the basement rock is metamorphosed schist and any superficial drift or landslide deposits are largely unsaturated, the area's schist rock nonetheless contains a somewhat stratified and compartmentalised groundwater system with hydrologically variable connection to the surface that would mediate and ameliorate the above listed impacts.

In the existing environment, cold-water groundwater in hard rocks of the Dunstan Mountains is relatively dilute, although of long residence at depth resulting in enhanced solution of metals, metalloids, carbonates or silica by rock – water interactions. Slightly elevated sulphate and arsenic concentrations in groundwater have been noted. The host rock without disturbance has inherently low permeability (<1 x 10^{-7} metres per second, m/s) and low water-filled porosity (generally less than 1%) meaning that the schist rock has generally poor groundwater transmission properties. Further to the west where water supply would be drawn for mining complex water supply, post-glacial outwash gravels of the Bendigo Aquifer provide more permeable and porous reservoirs of groundwater, plus subsurface hydraulic connection to the major Clutha River / Mata Au.

As part of the unique intermontane physiography of the Bendigo area, Shepherds Creek does not extend as a perennial water course to its main stem, the Lindis River. Instead, Shepherds Creek in normal flow is lost to soakage through its bed a full three (3) kilometres short of the Lindis confluence, thereby replenishing the Ardgour Alluvial Aquifer, which in turn seeps into the Lindis River. Similarly, Bendigo Creek which includes Rise and Shine Creek as a tributary, soaks into the Bendigo Aquifer and is subsequently drawn at water bores or seeps into the Clutha River / Mata Au.

The groundwater related impact areas of the proposed Bendigo – Ophir Gold Project include –

- The mining project bore water supply from the Bendigo Aquifer to the west of the main mine zone, and the potential drawdown, surface water depletion and aquifer depletion effects that new groundwater abstraction could potentially induce,
- Penetration of the fractured rock groundwater system by open cut pits (Rise and Shine, Come In Time, Srex East and Srex), plus the Rise and Shine underground workings,
- The necessary dewatering / depressurisation of schist rock groundwater penetrated by mine workings causing localised lowering of the saturation surface, followed by depletion in hydrologically connected creeks,
- Drainage of ELF waste rock pore waters and eventual, post closure release from the ELFs and TSF into downstream creek network,
- Mobilisation of groundwater into the surface realm by dewatering, eventually producing a solute-containing surplus that would require release into the surface water system or infiltration back into groundwater, and
- Percolation and release of fluid in the ELFs and to a lesser extent the TSF, would result in post-closure solutes, including sulphate, to accumulate within the alluvial groundwater system(s).

Following the installation and testing of a production sized bore into the Bendigo Aquifer we consider that the make-up water demand for plant, dust suppression and other water uses can be supplied in the required

quantities by the single water bore provided a back-up bore was also available. The characteristics of the Bendigo Aquifer in terms of its hydraulic properties, water balance and connection to large surface water bodies indicates that the proposed taking of up to 110 litres per second from the aquifer would be sustainable with less than minor effects. In terms of drawdown (water level lowering) effects on surrounding bores, the projections of short-term and long-term drawdown indicates the ability to operate with less than minor effect on other groundwater users. The Clutha River / Mata Au and Lake Dunstan are the main water bodies to be affected by calculated depletion during bore field pumping. These water bodies are relatively invulnerable to the effect of pumping on their flow rate or water level. The proposed bore field operation to supply the mining complex would also be consistent with regional policy, rules and conventions set by Otago Regional Council.

Assessment of surface mining in the final pit shell in the Rise and Shine (RAS) Pit indicates to us that modelled peak groundwater inflow of 5 litres per second is reporting to the basal sump. Similarly, the indicated peak groundwater make of the underground at full tunnel development would approach 30 litres per second. The Rise and Shine (RAS) pit was modelled to have a depleting effect on Shepherds Creek at its closest approach of 0.5 to 3 litres per second in terms of the hard rock groundwater transmission, which is likely to have a discernible effect during periods in which the creek is in base flow condition.

Summary of Dewatering Duration, Hard-Rock Inflow Rate plus consequent Depletion

	Duration	**Hard Rock Inflow Rate (L/s)**	**Surface Water Depletion Rate (L/s)**	**Peak Total Depletion (L/s) (Hard Rock)**	
Pit				**Shepherds Ck**	**Rise & Shine Ck**
RAS Pit	11.3* years	**5** *(Year 11 peak)*	**0.5 – 3.5** *(Shepherds)*	**5.2**	**17.3**
CIT Pit	1 years	**3.5** *(Year 9 peak)*	**1.7** *(Shepherds)*		
SRX Pit	1¼ years	**23** *(Year 12 peak)*	**15.3** *(SRX)* **2** (RAS)		

The satellite pits of Come In Time (CIT) are expected to have a light dewatering requirement, up to 3.5 litres per second, while Srex pit coincides with a set of schist formations of higher permeability that would allow the inflow of up to 23 litres per second to the pit during its operational phase according to model results. MWM concluded that with the proposed mitigation of ELF construction to achieve 20% net percolation, reuse of the low volumes of seepage in the process water, ongoing performance monitoring, and at closure if needed the application of active and passive treatment, will result in the water discharge below the compliance limits. Effects on the Ardgour aquifer will be less than minor.

The waste rock on the Engineered Land Forms (ELFs) were assessed in the MWM source load assessment document to produce toe drain seepage with elevated concentrations of sulphate. These levels of loading are projected to result in increases in the concentrations of the solute in the downstream Ardgour alluvial aquifer within the Lindis Valley, albeit at concentrations less than the appropriate water quality standard.

During the operations phase of the Bendigo – Ophir Gold Project the effect of the Rise and Shine mines (surface and underground) in terms of produced dewatering groundwater would allow water conservation and avoidance of using bore water supplies, by diversion of dewatering waters (i.e., mine-impacted water) into processing plant make-up water, dust suppression or evaporative loss in the Tailings Storage Facility water column. Fewer opportunities for diverting dewatering water are available for the shallower Srex East and Srex pits, excess mine-impacted water would instead be transferred to the Tailing Storage Facility (TSF).

During the active closure and post-closure phases of mine life, the inflowing groundwater to residual mine voids would be progressively returned to the creek system. In the case of the paired RAS pit and underground workings, the voids would form a combined drainage system and release net water to surface water after passage through the base of the pit and upper compartments of the underground to the former mine portal. The portion of the restored (i.e., post-closure) catchment hydrograph would include a greater degree of baseflow due to the hydrological buffering within the flooded RAS pit lake and underground workings. MWM assessments propose that active and passive water treatment for amelioration of residual contaminants from groundwater would be utilised in the immediate closure and also the post-closure period of mine life.

Mentions of mitigation and monitoring are herein made in terms of options for these in the operational or closure phases of the mine life to strengthen environmental controls on potential effects and are summarised as follow:

- Monitoring of groundwater related activities would be beneficial in ensuring that assessments of groundwater activities are in line with or less than projected as the project operations or post-closure controls are applied.
    - Level and water chemistry monitoring of the Bendigo Aquifer supply bore field and the areas of the Ardgour Alluvial Aquifer that could be affected by elevated solute concentrations.
    - Also included are measures to reduce the solute loads of sulphate and nitrogen transiting Shepherds Creek to enter especially the Ardgour Aquifer, particularly during the active closure and post closure phases of mine life.
- Water quality and flow monitoring would be applied to the Shepherds and Rise and Shine creek catchments at SC-01 and RS-03 monitoring sites, plus groundwater quality monitoring at MW-101 within the Ardgour Aquifer in the post-closure context.

This report relies on the following reports specifically commissioned for this project:

- Groundwater Modelling Analysis for Bendigo Ophir Gold Deposit ,Kōmanawa Solutions Ltd (KSL).
- Bendigo–Ophir Gold Mine Project – Bendigo Groundwater Bore Take Effects Assessment, Kōmanawa Solutions Ltd (KSL).
- Surface Water & Catchment Existing Environment & Effects Assessment, Kōmanawa Solutions Ltd (KSL).
- Bendigo–Ophir Gold Mine Project – Bendigo Groundwater Bore Take Effects Assessment, Kōmanawa Solutions Ltd (KSL).
- Source Term Definition Report – Bendigo-Ophir Gold Project, Mine Waste Management (MWM) Ltd.
- Water Load Balance Model Report – Bendigo-Ophir Gold Project, Mine Waste Management (MWM) Ltd.

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1 Background

1.1 Outline & Problem Definition

The Bendigo district in New Zealand's South Island is a traditional gold mining area beginning with alluvial mining of terrace gravels from 1862, followed by hard-rock mining of 'quartz reefs' beginning in 1869. Quartz vein mining for gold that extended from 1869 to 1942 tended to exploit cross-cutting quartz veins close to the surface, while shallow trenches and adits were also excavated to intercept these. More recent geological investigation (1985 to 2008) and prospecting has had a deeper focus on a mineralised low-angle deformation zone in biotite zone schist in the footwall (i.e., Textural Zone 4 schist) of the Thomsons Gully Fault. The mineralised rocks within the shear zone are deformed and hydrothermally altered. Mineralised zone gold content is associated with pyrite and arsenopyrite scattered through the altered schist. The most recent geological model relevant to prospective gold mining potential between Thompsons Track and Shepherds Creek had recognised the association of high gold grades with the Rise & Shine Shear Zone and minor cross-cutting faults, at deposits named Come In Time (CIT), Rise & Shine (RAS), Srex and Srex East. This document relates to the Bendigo – Ophir Gold Mine Project (BOGMP) comprising the Rise & Shine (RAS), Come In Time (CIT), and Srex (SRX) gold deposits, which are proposed for pit and underground mineral development.

Matakanui Gold Ltd (MGL, a subsidiary of Australian company Santana Minerals) proposes to develop open cut pits and an underground mining complex linked to an ore processing plant in close proximity. In essence, the mining of the newly discovered mode of gold occurrence would involve digging out the overburden obscuring the ore, primarily to the northeast of the Thompsons Gully Fault (TGF) surface trace and excavating the ore for processing. The excavation and underground workings would extend to increasingly greater depths of burial as the mines follow the dipping Rise and Shine Shear Zone structure. As the depth of the RAS mineralised zone exceeded about 260 m, the economic advantage for open cut mining techniques would be overtaken by the underground option. Deeper mining would therefore be undertaken using underground drives and ore extraction panels extending from the deepest parts of the open cut pit in the southwest, to the northeast and depths as much as 400 m below the overlying surface.

Overburden would be re-deposited in Engineered Land Forms (ELFs), while pulverised ore would be run through the processing plant with tailings deposited as a slurry behind a zoned-earth dam and ELF buttress in the Tailings Storage Facility (TSF). Waste materials of ore originating from the underground mine panels would be deposited as a paste into completed mining panels and the TSF. The processing plant would obtain the bulk of its water supply from the Bendigo Aquifer and Clutha River / Mata Au.

The proposed mining complex comprising open cut pit, underground workings, ore processing plant, engineered landforms of inert waste material, processing tailings, and ancillary water services would all result in some degree of environmental effect. The purpose of this assessment document is to outline the existing hydro-geological environment and characterise arising groundwater environmental effects, including foreshadowing the effectiveness of mitigation, monitoring and offsets / compensation deployed.

1.1.1 Objectives

This assessment document stands alongside allied potential environmental effects assessments in other discipline areas, including -

- Mine engineering including the Project Description,
- Surface hydrology,
- Geochemistry and water quality,
- Geotechnology / Engineering Geology,
- Mine Watse Management,
- Ecology (Terrestrial and Freshwater Aquatic),
- Landscape,
- Noise and vibration,
- Social science,

- Economic,
- Māori Cultural & Spiritual,
- Archaeology and historical, and
- Recreation.

Several of the above discipline areas would dovetail into the assessment groundwater effects arising from the proposed activities, particularly surface hydrology, geochemistry, water quality, engineering geology, mine waste management, and freshwater ecology. The effects assessments were not developed in isolation, with extensive collaborative assessment approaches having been employed. Where feasible, cross-references to allied disciplines are provided to guide readers to details on the existing environment and cross-cutting potential environmental effects.

The objectives of this document are tailored to provide the information required for assessing effects in terms of the Resource Management Act 1991. The scope of required information was formerly set out in Schedule 4 of the Resource Management Act 1991 (now since 2013 titled 'Information required in application for resource consent') includes more or less the following:

- *A **description of the proposal**,*
- *A description of any **possible alternative locations or methods**, where an activity will result in **significant adverse effects**,*
- *An assessment of **the actual or potential effects on the environment** of the proposed activity;*
- *An assessment of any risks to the environment of an activity which includes the use of **hazardous substances** and installations,*
- *Where an activity includes the discharge of any contaminant, a description of the nature of the discharge, the sensitivity of the receiving environment, and possible alternative methods;*
- *A description of the **mitigation measures** to be undertaken,*
- *Identification of persons interested in or affected by the proposal, **consultation** undertaken if any, and response to the views of those consulted,*
- *How **monitoring** will be carried out if required and by whom, and*
- *Where a protected customary right is likely to be adversely affected by the proposed activity, the AEE must include a description of possible alternative locations or methods for the proposed activity unless written approval is given by the **protected customary rights group**.*

Accordingly, this assessment document focuses on the groundwater and hydrogeology discipline and addressing the above assessments. The final assessments derived from the Assessment of Environment Effects (AEE) process are summarised and links to detailed information provided in accordance with conventional documents of this type.

2 Site Setting & Existing Environment

The Bendigo – Ophir Mine Project (BOGMP) is located in the Bendigo area of New Zealand's South Island, within the local government jurisdiction of Central Otago District Council (see Figure 1). The Bendigo area is located in the Upper Clutha Valley between the urban areas of Wānaka and Cromwell. The Rise and Shine, Srex and Come In Time mining areas are located in the middle and upper reaches of the Shepherds Creek and Bendigo Creek catchments on the western slopes of the Dunstan Mountains. A rough Four-Wheel Drive track from Matakanui locality in the Manuherikia Valley to the Lower Lindis is named the Thomsons Track, which passes through the Rise and Shine Creek valley on Bendigo Station land. The Ardgour Station lies on the north bank of Shepherds Creek, overlooking the Rise and Shine and Come In Time pit areas.

Valley floor flats occupied by improved pasture, vineyards and residences are located to the west of proposed mining and processing areas, and the underlying Bendigo Aquifer is the proposed source of make-up water supply to the Project. Figure 2 provides an interpretative mapping of the proposed Project area, including proposed open cut pits, Engineered Landform (EFL), Tailings Storage Facility (TSF), processing area, and water supply bore site in the context of watersheds and geomorphological features.

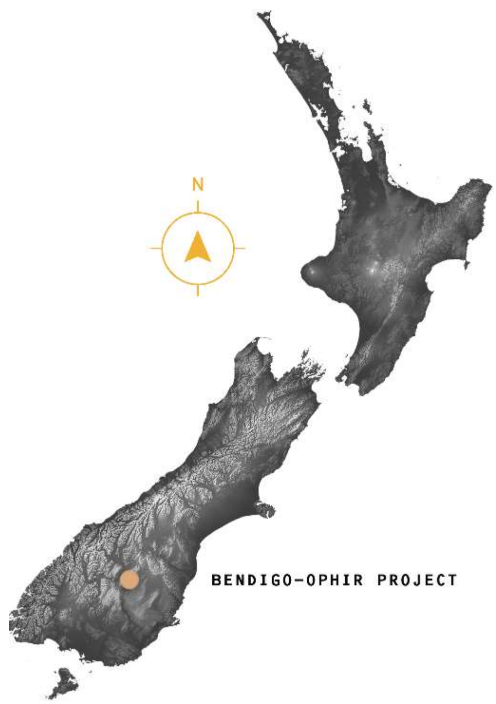


Figure 1: Location of the Project Area in Central Otago, New Zealand

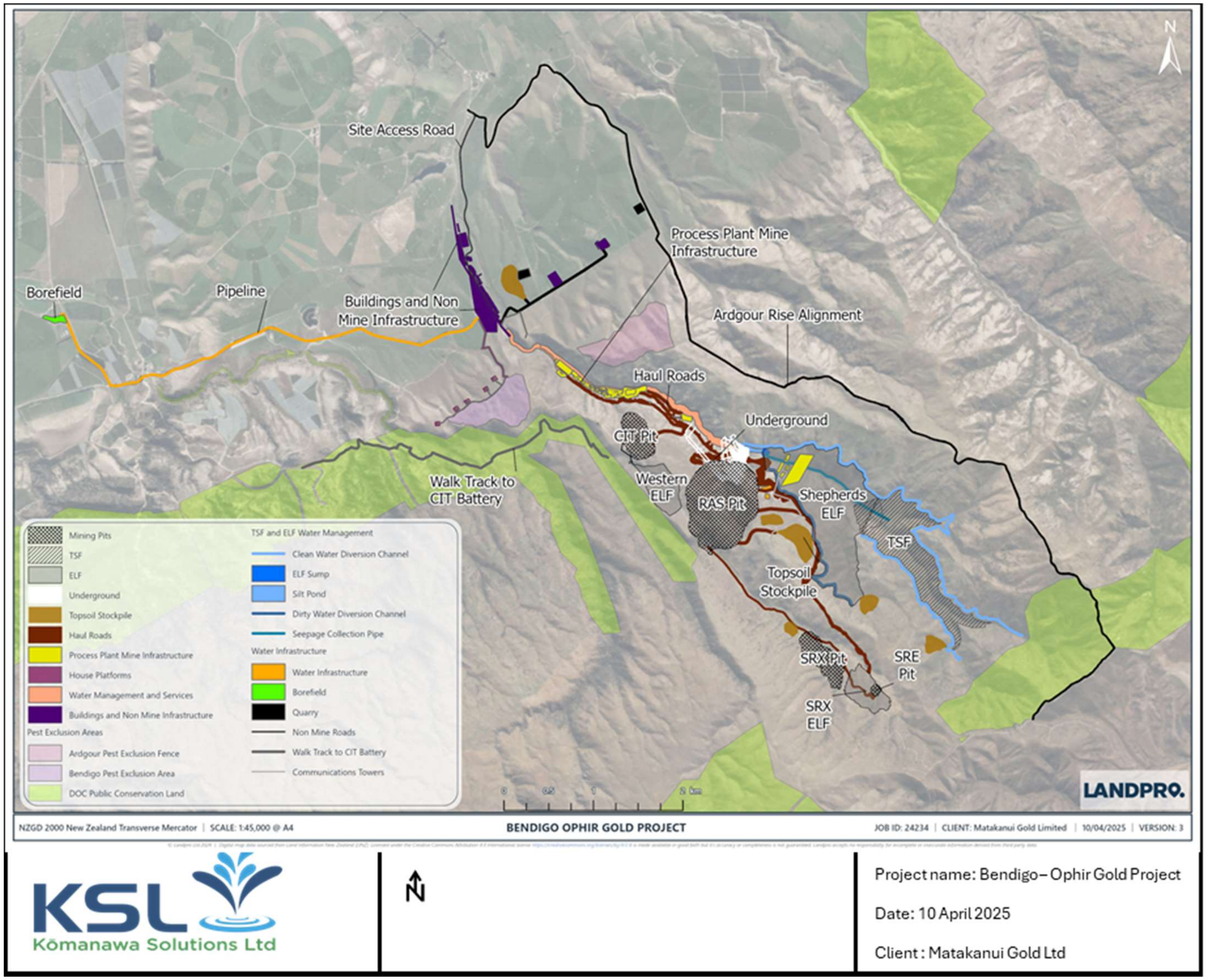


Figure 2: Locations of the Project Area, including deposits Rise and Shine (RAS), Come In Time (CIT) and Srex (SRX)

2.1 Location & Communications

Bendigo is accessed from the Cromwell – Tarras Road or State Highway 8, between Cromwell – Lindis Pass and Omarama. Bendigo Loop Road skirts the eastern valley floor from the Lake Dunstan Delta to the lower Lindis River. The Bendigo area may also be accessed from Lake Hawea and Wanaka from the north, via the Luggate – Tarras Road or State Highway 8A. Thomsons Track is a Four Wheel Drive (4WD) route that winds its way through the project area passing the Srex and the Rise and Shine pit areas.

2.2 Geography of Site & Environs

The Bendigo – Ophir Gold Project sites are located broadly within the Shepherds Creek and Rise and Shine Creek valleys on the western flank of the Dunstan Mountains. The locality of Bendigo is a few kilometres to the west. The junction of Lindis Crossing features a bridge across the Lindis River with the intersection of Ardgour Road and the Cromwell – Tarras Road (SH8). The settlement of Tarras lies to the north of the project area, and includes a couple of retail outlets, a cluster of houses. and primary school. The Tarras Hall and Tarras Golf Club lie further along the State Highway 8.

2.3 Geology

2.3.1 Bedrock

The geological framework of the Bendigo district is based in the Otago Schist bedrock (the geological basement). The Otago or Haast Schist is up to 18 km thick, making up much of the upper crust and composed of regionally metamorphosed sediment, originally marine sandstone (psammitic) and mudstone (pelitic), schist rock. The original sediments were deposited in full marine conditions during the late Permian to early Triassic (approximately 250 million years before present). The schist bedrock has been metamorphosed, which causes segregation of some of the main component minerals such as quartz (silica), mica (mostly biotite), or sulphides, in a lithic (general rock) rock mass. These segregated bands are aligned in planes termed foliation. The schist foliation planes imparts a distinct 'grain' to the schist fabric.

Geologists have differentiated the schist in order to better understand the formation's stratigraphy on the basis of geochemistry and geological fabric. The Otago schist geological fabric stratigraphy in the Dunstan Range is generally divided as follows –

- Textural Zone 3 (TZ 3), Well foliated, incipiently segregated psammitic and subordinate pelitic schist; minor greenschist and conglomerate; rare marble, or
- Textural Zone 4 (TZ 4), Undifferentiated, well foliated and segregated psammitic and pelitic schist with greenschist and meta-chert bands.

Textural zoning is an indication of the degree and nature of regional metamorphism in the schist formations. TZ 3 is considered to be less metamorphosed or less segregated than TZ 4. Geo-mechanically, TZ 3 is considered to be more densely fractured or sheared and weaker than TZ 4. The textural zone contrast cuts directly across the Rise & Shine Project area as marked by a regional-scale ancient fault system comparable to the Hyde – Macraes Fault Zone lying further east. The Thomsons Gorge Fault(TGF) system truncates schist strata of TZ 3 and TZ 4 in the project area. The Thomsons Gorge Fault dips at shallow angle, to the northeast under the Shepherds Creek catchment. This results in the TZ 4 schist components being termed the footwall and the TZ 3 schist being the hanging wall, in terms of structural geology parlance.

2.3.2 Tertiary Sediments

While Tertiary sediments do not prominently crop out at the surface in the Bendigo district, these sediments have been deposited onto the top of the schist during the Miocene and early Pliocene epochs[1]. The sediments are inferred to have been preserved in local structural basins in the upper Clutha Valley with occasional

[1] An epoch in geochronology is a period of time, typically in the order of tens of millions of years. The current epoch is the Holocene.

outcrops and featuring in the logs of deep drill holes. Restricted surface outcrops are found of these sediments are found in the Tarras Creek basin and the lower Lindis River valley as Dunstan Formation quartz sand and gravel with lignite seams, or Maniototo Conglomerate weathered in a sandy matrix, respectively.

2.3.3 Quaternary Glacial and Post-Glacial Sediments

Beginning in Early Pleistocene, glaciations related to global glacial impulses developed valley glaciers in the catchments upstream of Bendigo. As a result of the earlier plate collision, a re-energised tectonic period termed the Kaikoura Mountain-Building (Orogeny) began in the early Pleistocene, which resulted in accelerated land surface uplift, the formation of ranges beginning with the proto-Southern Alps, and erosion of chlorite grade schist. The mountain building elevated the heads of valley drainages and provided sites for valley glaciers during glacial maxima. The de-glaciation and glacier collapse during interglacial periods fed the outwash of glacial till, meltwater deposits and further down-valley, riverine gravels. The Bendigo – Tarras district has a pattern of glacial outwash remnant terraces and deposition surfaces from glacial outwash phases ranging in age and elevation.

The earliest terraces in the Bendigo district relate to the Lowburn till remnants scattered along the valley edges onto schist. The Lowburn outwash and till dates from early Pleistocene (650,000 – 620,00 years before present) and includes boulders and gravels in a silty clay matrix. Next in age is the Lindis till of similar material but correlated with middle Pleistocene (477,000 – 423,000 years BP). The Lindis surface forms The Bend Terrace and Bendigo Terrace that overlooks the river terraces and flats towards the Clutha River / Mata Au.

The valley floor river terraces and flats are stepped sequence of the following outwash surfaces -

- Albert Town (71,000 – 59,000 years BP),
- Hāwea (17,000 – 12,000 years BP) outwash, and
- Holocene (14,000 years – Present).

The river outwash terraces are tiered from the east to the west and towards the Clutha River / Mata Au. The combined Albert Town – Holocene outwash sequence share similar grainsize and texture properties, which has allowed the combined sequence to be lumped into the groundwater management zone, the Bendigo Aquifer. These combined deposits have been set down by the Clutha River / Mata Au beginning at 71,000 years before present and thus included thick channel deposits of very coarse small boulders, cobbles and sandy gravels. These channels deposits include open framework gravel textures (Burbery et al., 2018). Weathering or alteration was slight, preserving primary permeability characteristics.

Pleistocene deposits of slender thickness and extent are found on the Dunstan Ranges, including creek alluvium in the Rise & Shine gully, outwash remnants, and landslide deposits in the steepest ground of the Shepherds Creek catchment. Rise & Shine creek alluvials had been subject to significant re-working by alluvial gold mining from 1870s to 1950s that tended to translate the deposits atop the TZ 4 basement into tailings.

2.3.4 Geological Structure

The surface trace of the Thomsons Gorge Fault crosses from the Manuherikia River catchment near Thompsons Saddle, passes northwest along the floor of Rise & Shine Creek before crossing into the lower Shepherds Creek drainage until being covered by late Pleistocene gravel sediments. As mentioned already, the Thompsons Gorge Fault is low angle (approximately 35˚) with a strike of 050˚. The fault itself is reverse, downthrown to the southwest, and inactive since the strain orientation is no longer in operation. A complex fold system has flexed the TZ 4 schist south west of the Project area as an overturned anticline termed the Bendigo Nappe.

Local scale shearing and mineralisation of the TZ 4 schist has a structural context as a thick shear zone with associated veins and stockwork resting beneath the Thomsons Gorge Fault plane. The TGF separating the TZ 3 and TZ 4 schist structural blocks. Minor faults cutting across the strike of the TGF have a role in enhancing gold mineralisation along the Rise & Shine Shear Zone, particularly for the Come In Time and Rise & Shine gold deposits (Mackenzie et al., 2006).

2.4 Soils & Drainage

The Bendigo district has contrasting soil types and classes divided by the following distinctions:

- Lowland soils covering alluvium, outwash and till terraces, or
- Upland soils covering Otago Schist of the Dunstan Ranges.

The soil classifications and general properties are included in the Existing Environment sections of the Surface Water Hydrology assessment document (Rekker, 2025a). The alluvium and outwash based soils tend to have high levels of drainage, high permeability and low soil-moisture retention capacity. The upland soils tend to fall into two categories, semi-arid, brown or pallic. Semi-arid soils are found on the flanks of the Dunstan Mountains and are stony. The pallic soil classes are found on the mid slopes and tend to display interactions with shallow perched water tables in the subsoil, including gleying. The tops and the peneplain[2] zones of the uplands tend to be most associated with scattered bog and mire wetlands, and the brown soils tend to be acidic and contain more organic material. These characteristics have relevance to the occurrence of rejected recharge over schist rock formations.

The semi-arid soils are the most well drained, without limiting horizons. These soils tend to be in stoney parts of the range with shallow, outcrop dominated land covers. Overall, the low permeability of the underlying schist rock tends to be the more operative factor in upland soil deep drainage, and lateral drainage of moisture can dominate.

2.5 Climate

The following summary is adapted from *The Climate and Weather of Otago* by Greg Macara of NIWA (Macara, 2015). The Otago region is in the latitudes of prevailing westerlies with lighter winds inland compared to the coast. Annual precipitation in Otago typically decreases with distance from the Alps, as spill-over rain declines and a series of rain shadows impose themselves. Inland Otago is the driest region in Otago and the valley floors of the Bendigo – Tarras districts among the driest in Otago. Dry spells of more than two weeks occur frequently in the area. At the same time temperatures are on average lower than over the rest of the country with frosts and snowfalls occurring relatively frequently each autumn – winter – spring period. During summer hot dry conditions exceeding 30˚ are normal during summer and early autumn.

The climate conditions are further detailed in the Existing Environment sections of the Surface Water Hydrology assessment document (Rekker, 2025a). Of relevance to groundwater management are the rain shadows, low rainfall, and high potential evapotranspiration that constrains the specific runoffs of slopes and soils in the Bendigo district.

2.6 Surface Hydrology & Water Resources

The Bendigo district rests within the Dunstan Rohe of the Clutha Freshwater Management Unit (FMU), however the Upper Clutha is sustained by the catchment flow yield of Lake Wānaka and Lake Hāwea of the Upper Clutha Lakes Rohe.

The two glacial lakes, Wānaka and Hāwea, pass on approximately 260 cubic metres per second (260,860 L/s) on average to the downstream river system *via* the Hāwea and Upper Clutha / Mata Au rivers, representing more than 42% of the river system's total discharge at the Pacific coast. The mean outflows from the lakes also equate to a combined specific discharge of 66 litres per second per square kilometre (L/s/km^2) compared to the tributary Lindis River at Lindis Peak at 11.2 L/s/km^2. This specific runoff disparity is indicative of the spill-

[2] A regional erosional surface on top of the schist basement postulated by Otago geologists (Landis & Youngson, 1996), currently less favored as an explanation of the flat-topped block mountains of Otago, but still in common usage among geologist, geomorphologists and soil scientists.

over precipitation characteristic of this segment of the Southern Alps combined with rain shadowing provided by the Grandview Range and other ranges over the Lindis catchment. The same pattern is evident in the rain-shadowed valley floors and tectonic basins throughout northern Central Otago.

Estimates of mean, median and 7-day Mean Annual Low Flow made using measurement site data provided by Contact Energy Ltd are included in Table 1.

Table 1: Summary of Flow Statistics for Upper Clutha Lakes (Wānaka & Hāwea)

	NZ Segment #	Area (km^2)	Start of Record*	Area (km^2)	No. of years	Mean (L/s)	Median (L/s)	$MALF_{7d}$ (L/s)
Lake Wanaka at Roys Bay	14196259	2,564	Feb. 1933	2,564	84	198,482	177,327	81,300
Lake Hawea at Dam	14192731	1,281	Jan. 1933	1,385	81	62,376	58,763	29,900

Note: No. of years = Number of years of flow record. * Selected record for Lake Wanaka ended on 12 July 2017, and Lake Hawea ended on 9 April 2014. However, these sites are in continuous operation to present.

Downstream of the lake outlets, the Cardona River, Luggate Creek, Crook Burn and Lindis River tributaries join the flow of the Upper Clutha main stem, which collectively may increase the main stem mean flow by another 10,150 L/s before the river reaches the Bendigo district. The combined flow of the Clutha River / Mata Au entering Lake Dunstan at the Bendigo Delta is 271,000 litres per second (8,546 million cubic metres per annum).

2.7 Groundwater & Associated Water Resources

Groundwater in the Bendigo district has two overarching domains –

- Saturated consolidated rocks, namely schist basement, or
- Alluvium or outwash sediments, generally coarse sandy gravels.

Alluvium and voluminous outwash gravel deposits are concentrated within the valley systems such as the Lindis Valley and Upper Clutha Valley. As detailed in the next sections, the alluvium and outwash gravel deposits have high permeability and porosity, allowing the conveyance of copious quantities of groundwater through the deposits.

2.7.1 Fractured Rocks

The use of groundwater from basement rocks is incidental, primarily following groundwaters' emergence from said rocks as diffuse seepage, spring flow and baseflow in water courses. While there is appreciable passage of water through fractured basement rocks due to their wide and pervasive distribution across Central Otago, much of the potential groundwater recharge of excess precipitation is 'rejected' at the soil / regolith interface due to the generally low permeability of the fractured rock and feeds surface stream flow instead. Rejected recharge is also a factor of land surface slope, steep slopes in the Dunstan Mountains are more likely to shed excess precipitation into surface stream flows than rain falling on gentler slopes.

2.7.2 Lindis Alluvium

The Lindis River in its lower reaches winds between basement highpoints and older outwash terraces as it traverses between the Lindis Range front and its confluence with the Clutha River / Mata Au. The river has reworked alluvium and deposited an alluvial floodplain on either side of its course. The associated alluvial ribbon aquifer following the Lindis River is intimately associated with the river hydrology. In late summer low flow, surface flows in the lower Lindis River can entirely revert to subsurface flow leaving the water course dry. It is supposed that narrowing or thinning of the alluvium induces surfacing of the river flow in distinct places

2.7.3 Bendigo Creek Alluvium

In the middle reaches of Bendigo Creek upstream of the Bendigo Loop Road ford crossing, sandy gravel alluvium has accumulated as a veneer of gravel within a dip in the basement schist and between bedrock gorges. This Bendigo Creek Alluvium has high permeability and porosity. In similar fashion to the Lindis Alluvium and alluvial aquifer, low flows in Bendigo Creek results in loss of surface flow when the creek water soaks into the alluvium. Higher and flood flows in the creek allow flow and subsurface flow continues with a height of saturation at the top of the alluvium.

2.7.4 Bendigo Outwash & Aquifer

Post-glacial outwash associated with the Hāwea and Alberttown glacial advances (and the advances' collapse) has accumulated between the Clutha River / Mata Au and the terrace riser of the Bendigo Terrace. The higher elevation (340 m AMSL) Bendigo Terrace is correlated with the Lindis Glacial Advance and the upper surfaces are generally separated by 80 m vertical between the Bendigo and Hāwea - Alberttown outwash deposits. The Hāwea and Alberttown outwash gravel deposits host the Bendigo Aquifer with a roughly triangular outline delineated by Bendigo Loop Road and the Clutha River.

The Bendigo Aquifer has a measured mean depth of 33 m, and a mean depth to the water table of 12 m. Approximately 30 production bores are scattered across the surface of the Bendigo Aquifer. The Bendigo Aquifer has some of the highest well yields of aquifers in Otago Regional, up to 110 litres per second. The water table is less volatile than the land surface variation across the aquifer with the water table elevation ranging between 195 m above mean sea level (AMSL) to 201 m AMSL in the core of the aquifer.

2.8 Groundwater Domains & Permeability Contrasts

2.8.1 Saturated & Fractured Rock

The basement of the Bendigo District and much of Central Otago is Haast (or 'Otago') Schist of the Torlesse Supergroup. The Haast Schist was formed from marine sediments that underwent deep burial and regional metamorphism so that the sandstone, siltstone and mudstone have been somewhat homogenised in metamorphic consolidation. The original or primary porosity of the sediments was lost to metamorphism, although subsequently successive phases of uplift and crustal flexure led to the penetration of several generations of fractures and joints throughout the rock mass. These fractures and joints, plus fault brecciation and shear zones, have provided the sole permeability and porosity to the schist rock underlaying all of the Bendigo District, particularly the Dunstan Range. For these reasons, the schist rock porosity in Otago is termed secondary porosity.

Landsliding processes in steepened terrain and associated buckling deformation of the schist is known to have a direct influence on the permeability of the deformed schist, especially landslide debris (Ridl, 2021). Geotechnical investigations of the Cromwell Gorge deep-focused landslides since the middle 1980s have identified and quantified fractured rock reservoirs associated with land sliding, particularly along the gorge slopes of the north bank of the Clutha River (Ridl, 2021) or (O'Brien, 2014). Land sliding in the Shepherds Creek valley is considered to involve smaller masses of debris and sliding blocks than the Cromwell Gorge, and on the whole the slides area shallower in focus, plus toe-buckling or related dilation of the rock mass is not considered to be active.

2.9 Depths of Saturation & Groundwater Flows

2.9.1 Fractured Schist

A truism of groundwater hydrology is that low permeability groundwater systems tend to have steeper hydraulic gradients and overall shallow water levels, while high permeability groundwater aquifer tend to have flatter water table slopes and thus may have quite deep water levels when the ultimate base level is significantly lower than land surface (Mandel & Shiftan, 1981). The project area has such a contrast in ground permeability and resulting contrast in the depth of saturation in the schist groundwater and the Bendigo Aquifer.

The fractured schist rock groundwater systems have had the depth to water measured in 80 separate locations across the Rise & Shine, Come In Time, and Srex gold deposits zones. The depth to water could to depths up to 42 m directly beneath steep ridges and tend rise to near land surface at slope bottoms. Some flowing artesian pressures were also encountered, suggesting compartmentalisation or proximity of the site of measurement to a groundwater seepage zone. The water table varies vertically across hundreds of metres of elevation in the Dunstan Range included in the 80 water level measurements within the Shepherds Creek and Bendigo Creek catchments. Overall, the water table tends to follow the land surface across areas of sharply undulating terrain. Groundwater transmission rates in the schist basement are considered to be low, especially within the intact parts of the schist basement rocks. There are few signs of surface water being significantly lost to groundwater nor making discrete gains from groundwater.

2.9.2 Bendigo Aquifer

The Bendigo Aquifer has much higher properties of permeability compared to schist basement, as detailed in the section on Groundwater Domains & Permeability Contrasts. The difference in hydraulic conductivity between the basement schist groundwater systems and the outwash gravels of the Bendigo Aquifer is at least four orders of magnitudes. Furthermore, the saturated effective porosity of the outwash sandy gravels is in the region of 20% while that of the schist rock is less than 2%. The practice of groundwater hydrology often sets the interface between saturated outwash gravel deposits and schist basement as a no-flow interface, due to the high degree of permeability and porosity contrast.

The water table within the Bendigo Aquifer is relatively consistent ranging across approximately 6 metres, from elevations of 195 m to 201 m AMSL. The land surface follows the influence of the depositional processes that formed the aquifer atop the Miocene aged mudstone and Triassic aged schist basement, while the water table follows the slope of the Clutha River / Mata Au. The earlier Alberttown glacial advance collapsed and contributed copious gravelly aggregate that was subsequently deposited as valley fill outwash sediments along the length of the Clutha Valley, followed by the later (approximately 15,000 years before present) Hāwea Advance. The Bendigo Aquifer east of State Highway 6 (SH6) comprises Alberttown Advance outwash and the Hāwea Advance outwash. To the west of SH6, the aquifer comprises Holocene alluvium of the Clutha River / Mata Au. All of these gravelly deposits are grouped into the water resource named Bendigo Aquifer and are composed of cobble, gravel, sand and silt sized grains, largely devoid of densely pack silt or clay that otherwise constrains alluvial hydraulic conductivity. The result was elevated transmission of groundwater throughout the Bendigo Aquifer and a low gradient to the water table. The water table surface is between 195 m to 201 m AMSL, approximating the Clutha River and Lake Dunstan water elevations adjacent to the aquifer. Figure 3 maps the Bendigo Aquifer, including December 2009 measured water table elevations at 22 individual bores. Figure 3 also interpolates the surveyed December 2009 water table, and hand-sketches 1 metre interval over the aquifer surface (Houlbrooke, 2010).

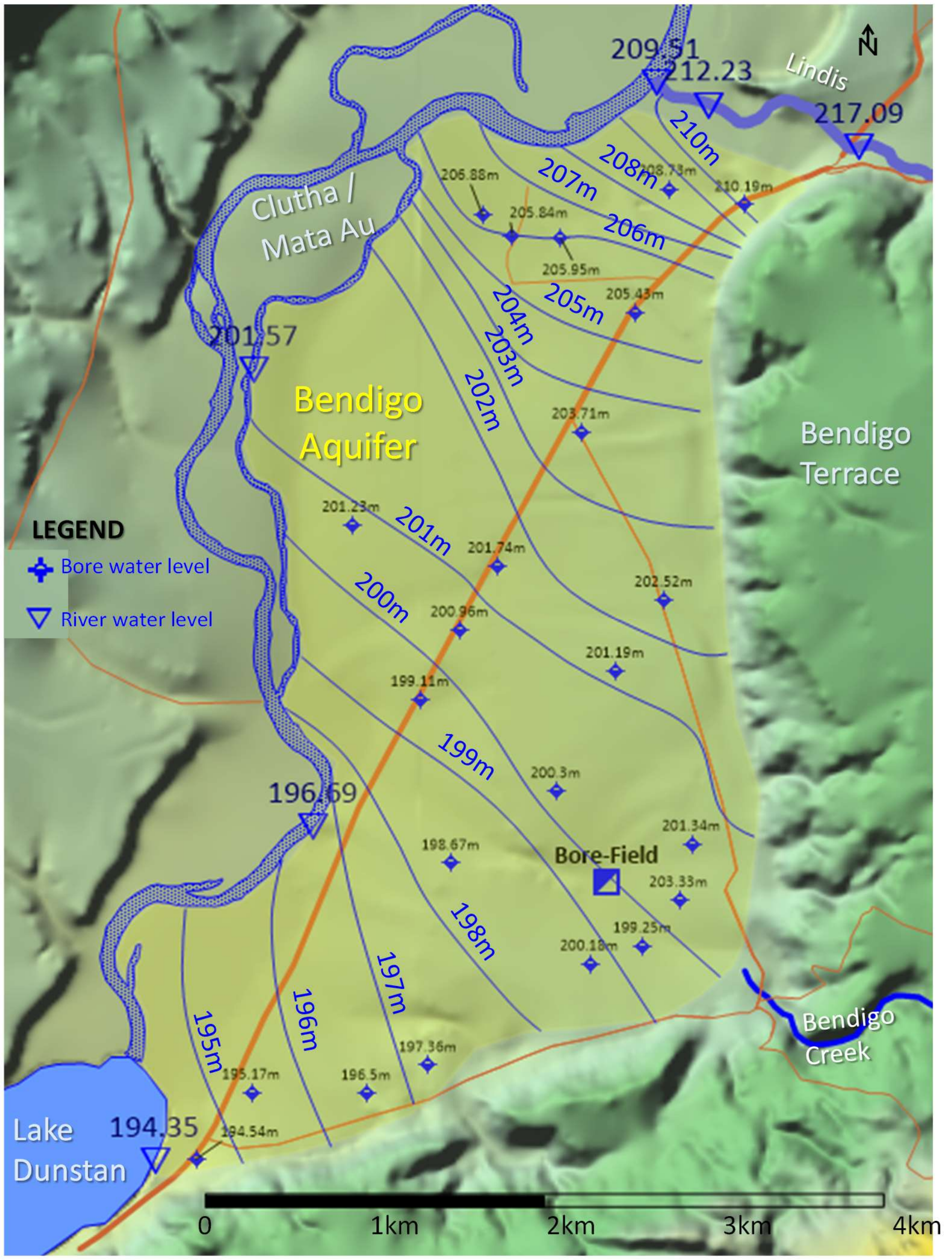


Figure 3: Bendigo Aquifer plus December 2009 measured groundwater elevation contours

Figure 3 provides information and interpretation of the aquifer hydrology, including the hydraulic gradient and implied flow pattern. The water table drops about 15 metres over a distance of 6.7 kilometres, implying a gradient of 0.0022 metres per metre. In this case, Figure 3 supports the view that water enters the aquifer in the north (upstream) margin with the Clutha / Mata Au and Lindis rivers, while the same water leaves the aquifer along the lower river / wetlands or Lake Dunstan. The Bendigo – Ophir Gold Project water supply is proposed to be taken from a bore field in the southeast of the Bendigo Aquifer, as marked in Figure 3 (see also section 4.8.2). Depth the water table is deepest (up to 30 metres) in the southeast within the older Alberttown outwash and shallowest (as low as 1.7 metres) along the rivers and lake, typically within the younger terraces and floodplain.

2.10 Beneficial Uses of Groundwater

Groundwater from the Lindis Alluvium and Bendigo Aquifer provide beneficial quantities of water for a range of rural water uses:

- Human requirements for groundwater in utilisation for drinking and domestic water,
- Stock,
- Frost fighting, and
- Irrigation water.

These water uses are readily available from these aquifers providing bores, wells or infiltration galleries can be deployed to allow their extraction. The Bendigo District is an otherwise water-short part of the Otago Region, as detailed in the above section on Climate, so the ability to access plentiful sources of water (including groundwater) are highly valued. The shortness of water in the district arises from low soil retention capacities generally, the regional rain-shadow effect leading to lengthy soil-moisture deficits and high rates of evapotranspiration driven by high air temperatures and wind-run. Groundwater within the basement schist is not able to meet human requirements for water, due to the low transmission rates within these rocks.

Volumetrically, irrigation of pasture and horticultural or viticultural plantings is the dominant for of water use in the Bendigo District. The Bendigo district is lightly populated, so the domestic and drinking water demand is similarly light, but very valuable to the district's inhabitants as the sole feasible continuously available water source. Groundwater from the alluvium and outwash aquifers is the preferred source of domestic / drinking water, and dwellings tend to collocate with these areas of groundwater availability on the valley floors. In several recorded instances of water bore development, the groundwater pumped from a single bore serves domestic, stock and irrigation requirements for the attached land holding.

Frost-fighting water use is made exclusively from groundwater in the lower Lindis Valley and Bendigo Aquifer areas. At least five properties cite frost-fighting as one of the water uses sought from the groundwater take. Frost-fighting requires access to water in early to middle spring in any year, primarily to apply water though high-level sprinklers within orchards and vineyards and provide latent heat for the protection of bursting buds during morning frosts.

2.11 Water Resource Infrastructure in Wider District

2.11.1 History of Water Races

Water use in the district began as water races to be used in hydraulic sluicing of gold-bearing gravel terraces around Logantown and the Bendigo Creek catchment. While the Lindis River and Tarras Creek catchments were largely barren in terms of gold, graziers eventually adopted the use of water races diverting water from the Lindis River, Shepherds Creek and Bendigo Creek to pastures. Wild flood irrigation was the ubiquitous method of irrigating pastures. Later in the 20th Century, constructed and graded border dyke fields were developed over parts of the district using the same race water, notably at Ardgour. Currently, water race diversions and direct pump intakes on the Lindis River deliver irrigation to most of the lower Lindis River and Tarras Creek catchments. Water races were directed across catchment divides, including the Jolly's water race feeding the Tarras township pastures or the now disused Begg-Stacpoole water race each conveying Lindis River water outside of the Lindis catchment to surrounding terraces.

2.11.2 Contemporary Water Uses

2.11.2.1 Partial Phase Out of Water Races

Water races for irrigation continue in use, although several have fallen into disuse including the Begg - Stacpoole. The Lindis Race Company intake near Archies Flat, the Thompsons (Ardgour) Race and Jolly's Race from the Lindis River main stem are still in use. Even the remaining large water races listed above are said by their operators to be reaching the end of their useful life. Changes to national and regional water policy in the

2010’s drove the need to re-evaluate the irrigation headworks and ability to operate within minimum flow rules. In accordance with the Plan Change number 5A (Lindis: Integrated water management) under the Otago Regional Plan: Water, these water races are to be replaced by large infiltration galleries to be installed in the flood plain alluvium of the lower Lindis River. The timing of this transition is currently difficult to estimate due to regulatory uncertainty and the lead time required to undertake the shift to infiltration gallery intakes. Dozens of Lindis River tributaries, including Shepherds Creek, are diverted into races and pipelines for transfer and application at pastures, also in some cases for stock water or hydroelectricity generation.

2.11.2.2 Phase Out of Mining Privileges

The legacy in Otago of the Mining Act authorisations to water includes a raft of short-term water take consents expiring in 2026 embodying all of the mining privileges that had not been converted to Resource Management Act (RMA) consent by April 2021. In the Bendigo district many if not all of the mining privileges have been converted to RMA authorisations, including takes in most of the Lindis and Tarras Creek catchments, and Bendigo Creek.

2.11.2.3 Clutha Gallery Bore Fields

In the meantime, a substantial shift and expansion to the sources of irrigation water has been underway with the establishment of large water bore clusters on the banks of the Clutha River / Mata Au downstream of Maori Point. Initially, these irrigation bore developments provided water for terrace top pastures that had never previously been irrigated, such as The Bend Terrace by Lindis Station Ltd. Subsequently, the 2010’s saw multiple bore fields and the installation of HPDE buried pipelines from the Clutha River / Mata Au margin to pastures throughout the Bendigo and Tarras districts.

2.11.2.4 Project Area Creeks

The use of Shepherds Creek and Bendigo Creek have also been undergoing change from water races, to partial pipelines a storage dam for greater flexibility and efficiency of water use. Shepherds Creek is taken at a single point for the Tarras Farm Ltd Partnership, run through an HPDE pipeline and collected in a 3.1 ha, lined reservoir before being pumped to surrounding pivot irrigators. Bendigo Creek water is taken by Bendigo Station Ltd in the middle reaches of the catchment using a flooded siphon. Up to 50 L/s is diverted *via* the siphon and pipeline to a storage pond on the Bendigo Terrace where it is mixed with bore water from the Bendigo Aquifer and used in pasture irrigation or cherry tree watering. Both Shepherds Creek and Bendigo Creek waters are fully allocated in resource consents to their respective consented uses.

2.11.2.5 Bendigo Aquifer Background

Large capacity water bores at diameters from 300 mm to 400 mm have also spread across the Bendigo Aquifer surface to service changes in land use from exclusive sheep fattening to a range of dairy, horticultural and viticultural water uses. More than 30 irrigation bores have been established and attached to water take consents across the aquifer. In recent years, it has become recognised that irrigation bores are sufficiently close to the Clutha River / Mata Au to induce a theoretical 533 L/s by surface water depletion. Up to 17.4 million cubic metres of groundwater per annum is allocated from the Bendigo Aquifer, much of it inducing subsurface augmentation from the Clutha River / Mata Au. The aquifer is also relied upon for domestic, stock and frost-fighting at lower rates of abstraction from smaller diameter bores under various lawful water use authorisations.

2.12 Aquatic Ecology & Wetlands

2.12.1 Aquatic Values

Richard Allibone of Water Ways Consulting describes the aquatic ecology of the Bendigo District, which can be summarised as follows:

- Limited fish values limited to minor trout populations in Bendigo Creek with none recorded in Shepherds Creek,
- Regionally significant trout fishery in the Lindis River,
- Nationally significant populations of non-migratory Galaxiids in the upper reaches of Lindis catchment tributaries (inability of predatory trout to access these reaches is a factor in the Galaxiid refuges),
- A significant lake trout fishery in the Upper Clutha River / Mata Au and Lake Dunstan delta, and
- A regionally significant wetland complex at the river delta to Lake Dunstan, including the presence of the Great Crested Grebe (*Podiceps cristatus australis*).

2.12.2 Regional Wetland

The Bendigo Wetlands are an area of riverine and lake margin wetlands formed in its current configuration with the raising of Lake Dunstan behind the Clyde Dam in 1992. The area is listed as a Schedule 9 regionally significant wetland within the Otago Regional Plan: Water.

2.12.3 Upland and Inland Natural Wetlands

Additional wetlands are more terrestrial in character, located in the Dunstan Range. Matt Barber of Alliance Ecology Ltd and Grahame Ussher of RMA Ecology Ltd have provided characterisation of these upland and inland natural wetlands. These upland wetlands are either riparian to creeks or raised bogs in open country. Those wetlands located above an elevation of 800 m AMSL are automatically regional wetlands in terms of the Regional Plan: Water. The National Policy Statement for Freshwater Management (NPS-FM) made operative in 2020 and its attendant regulations or revisions define a broad class of saturated or potentially wet land areas termed Inland Natural Wetlands. The effect of the NPS-FM (2020) would draw in many areas as discrete wetlands under the RMA, especially those below 800 m AMSL not rolled up in the Otago Regional Plan: Water policies.

The definition of Inland Natural Wetlands includes soil, ecological (botanical and faunal), and hydrological indications. The presence of hydrological factors sustaining a wetland are essential to wetlands in general. Groundwater has a particular role in sustaining wetlands removed from ponds or flowing water courses. These isolated wetlands that include mires and bogs, are frequently found to be dependent on seepage of subsurface water from beneath. Zones where the water table intersects with the land surface are often the sites of wetlands or springs.

For the purposes of groundwater flow modelling across the Bendigo – Ophir Gold Project area, the shallowest schist regolith and associated soils including such wetlands were separated from the underlying schist groundwater system within model simulations. The purpose of this distinction was to acknowledge the contrasting role of the shallow, 'veneer aquifer' compared to the hard-rock aquifer in the area's hydrology. The shallow system tended to 'sheet off' excess precipitation, resulting in rejected recharge (see section 2.7.1).

3 Investigations and Findings

Targeted investigation of groundwater and related matters were undertaken as part of the Bendigo – Ophir Gold Mune Project. These may be summarised as follows –

- Drilling investigations, particularly diamond core recovery, for the collection of lithological and geo-mechanical properties,
- Installation of vibrating wire pressure transducers at a number of depths from near surface to the gold bearing ore zone depth in the RAS pit footprint,
- Surveys of the groundwater level stabilised within all resource exploration holes across the Rise and Shine and Come In Time deposit areas,
- Packer permeability testing of two geotechnical diamond drilled holes across all Hydro Stratigraphic Units (HSUs) in the RAS deposit area,
- Long-term sampling of groundwater for characterisation water quality and/or hydrochemistry,
- Drilling, bore construction and hydraulic testing of a test production bore to determine the capacity for mining complex water supply.

3.1 Lithological and Geo-Mechanical Drilling Investigations

Gold resource delineation drilling has since 2019 been the main activity of Matakanui Gold at the Rise and Shine, Come In Time, and Srex. Professional logging of the cuttings or core recorded has included recording of depth-discrete lithological and geo-mechanical information. Characterisation of lithology and geotechnical defect parameters, such as Rock Quality Designation, have relevance to hydrogeological delineation, including the geometric distribution of Hydro Stratigraphic Units (HSUs).

RQD is a commonly logged factor in rock quality typically measured from recovered cores of rock obtained in diamond core recovery drilling. Approximately 32,440 metres of core has been logged up to May 2024 within the project area (Rise and Shine, Come In Time, Srex and Srex East) during various phases of mineral exploration and gold resource definition. Logging for geotechnical properties has included intact length, RQD, Rock Strength, and Fracture Particle Model. Of these, Rock Quality Designation (RQD) is defined as the ratio (in percentage) of the total length of sound core pieces that is 0.1 m (4 inch) or longer, to the length of the core run (Zhang, 2016).

The density of fracturing, jointing or other rock defects are to some extent proportional to the rock mass' hydraulic conductivity. Several correlations or means of correcting RQD to hard-rock permeability have been undertaken, mostly simply cross-plotting measurements of hydraulic conductivity from packer Lugeon tests against the associated RQD. Perhaps the most applicable of these was produced by (Jiang et al., 2009), which was based on dozens of paired RQD – hydraulic conductivity (K) data points. The data was obtained from down-hole geotechnical investigations of a hydroelectric storage system in Shangdong, China. The local geology was fractured granitic rocks with a degree of metamorphic fabric and textures. The RQD – K correlation was obtained from core logging and packer tests undertaken down to 88 metres below ground.

$$K = 0.4892\exp^{(-0.0543*RQD)} \qquad \text{Equation 1}$$

Where: K = Hydraulic conductivity (m/d)

RQD = Rock Quality Designation ratio as a whole number percentage (i.e., 90% = 90)

exp = exponential function

The correlation coefficients were derived from an exponential regression correlation that achieved an R^2 coefficient of 0.78.

The correlation equation calculated hydraulic conductivity ranging from 5.6 x 10^{-6} to 2.5 x 10^{-8} metres per second (m/s) between RQDs of 0.1 to 100 percent. In the rare instances when RQDs in excess of 100 percent were recorded, the calculated hydraulic conductivity dipped to values as low as 1.6 x 10^{-9} metres per second. Thus the range of hydraulic conductivity calculated by Equation 2 is to the higher side of the results of packer tests at the Rise and Shine pit area reported below in Table 3 that range from 7.5 x 10^{-8} to 5.1 x 10^{-10} metres per second.

The value of the RQD conversion may be in providing a relative measure of hydraulic conductivity variation. Depth – hydraulic conductivity plots for individual drill holes provide an indication of the conductivity trend down-hole in a Rise and Shine gold resource exploration hole that included geotechnical logging of RQD. Figure 4 of calculated hydraulic conductivity suggests high variability, but also indicates the following:

- High variability, but generally higher conductivity overall in the TZ 3 schist above the TGF, and
- Declining bulk hydraulic conductivity below the TGF in RSSZ but especially the TZ 4 schist.

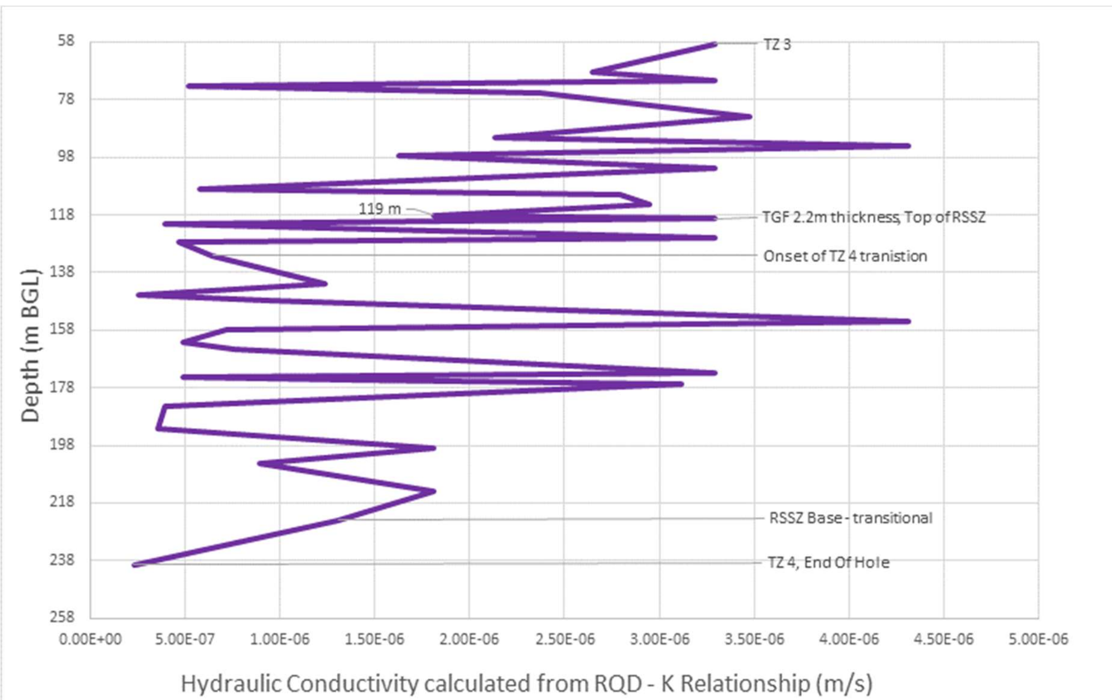


Figure 4: Depth – hydraulic conductivity plot for drill hole MDD007 within the Rise and Shine pit area

However, the differences in RQD indicating shifting hydraulic conductivity may be a response to increasing depth of burial rather than changes in lithology. The 2.2 metre section of the Thomsons Gorge Fault (TGF) would be infilled with clay gouge, substantially restricting the passage of groundwater, so the RQD relationship would tend to over-predict hydraulic conductivity across the TGF.

The results of the RQD – hydraulic conductivity correlations using the relationship developed by Jiang et al., 2009 provided a range in hydraulic conductivity estimates from 5.6 x 10^{-6} to 2.5 x 10^{-11} metres per second from a wide range of drill holes logged and assigned an RQD value from all three deposit areas. The bottom of this range is in line with the results of packer testing in the two geotechnical drill holes in the midst of the RAS pit footprint. The derived range and characterising statistics describing the statistical distribution were employed as prior values in groundwater model calibration (Dumont et al., 2025).

3.2 Groundwater Pressure / Level Monitoring

Time series groundwater pressure / level monitoring at a series of depths within the schist blocks above, within and below the Rise and Shine Shear Zone of the Rise and Shine gold deposit. A total of six vibrating wire transducers were installed at a variety of depths within two bore holes penetrating the Rise and Shine proposed mining zone. Two piezometers were installed in bore hole MDD290 and four piezometers were installed in bore hole MDD289. Once the vibrating wire piezometer transducers were placed at the specified depth, the bore holes were stabilised with cement infilling. The piezometers would sense the hydrostatic pressure of the schist rock directly adjacent to the inlet but would not be influenced by hydrostatic pressure vertically above and below the piezometers' depth.

Each of the transducer output leads were connected to a datalogger and recorded groundwater pressure at the piezometer depth from earliest April to late August 2024 that could be used herewith. The positioning of the vibrating wire piezometer units was arranged to examine the internal vertical hydraulic gradient within the fractured rock stratigraphic sequence and indeed any differences in temporal pressure responses from one depth to the next. Bore hole MDD290 held two piezometers at different depths in the hanging wall TZ-3 HSU, while bore hole MDD289 held four piezometers: two in TZ-3, one in RSSZ and the last one in the foot wall TZ-4 Hydro-Stratigraphic Unit (HSU).

Time series plots from the six piezometers are displayed in Figure 5, Figure 6 and Figure 7 provide graphical information on the temporal trends in groundwater pressures measured at the piezometers in turn. Figure 5 is a dual axis graph with a range of only 4 metres each of piezometers set in the TZ 3 hanging wall and the Rise and Shine Shear Zone. The axes are vertically offset by 28 metres (from 760 – 732 metres). The shallower TZ 3 piezometer manifested a fluctuating downward trend for the whole period, while the deeper RSSZ piezometer declined and subsequently rose abruptly in late May 2024. Figure 6 is a mono-axis plot of two depth spaced piezometers in the TZ-3 hanging wall, revealing a gentle decline for both, but a spike possibly related to resource drilling operation on 2 July 2024. Lastly, Figure 7 plots deeper RSSZ and foot wall TZ-4 pressures with TZ-4 at 268.5 m depth being above local ground level.

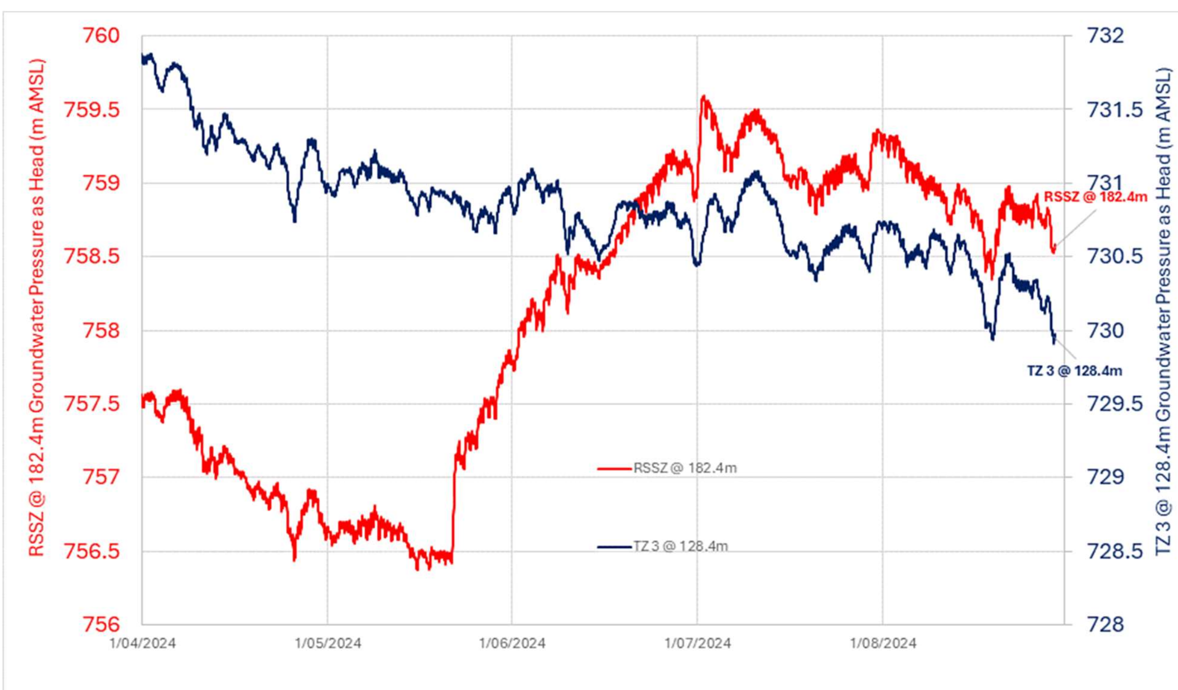


Figure 5: MDD290 time series pressure for depths of 128.4 m and 182.4 m below ground, TZ-3 and RSSZ

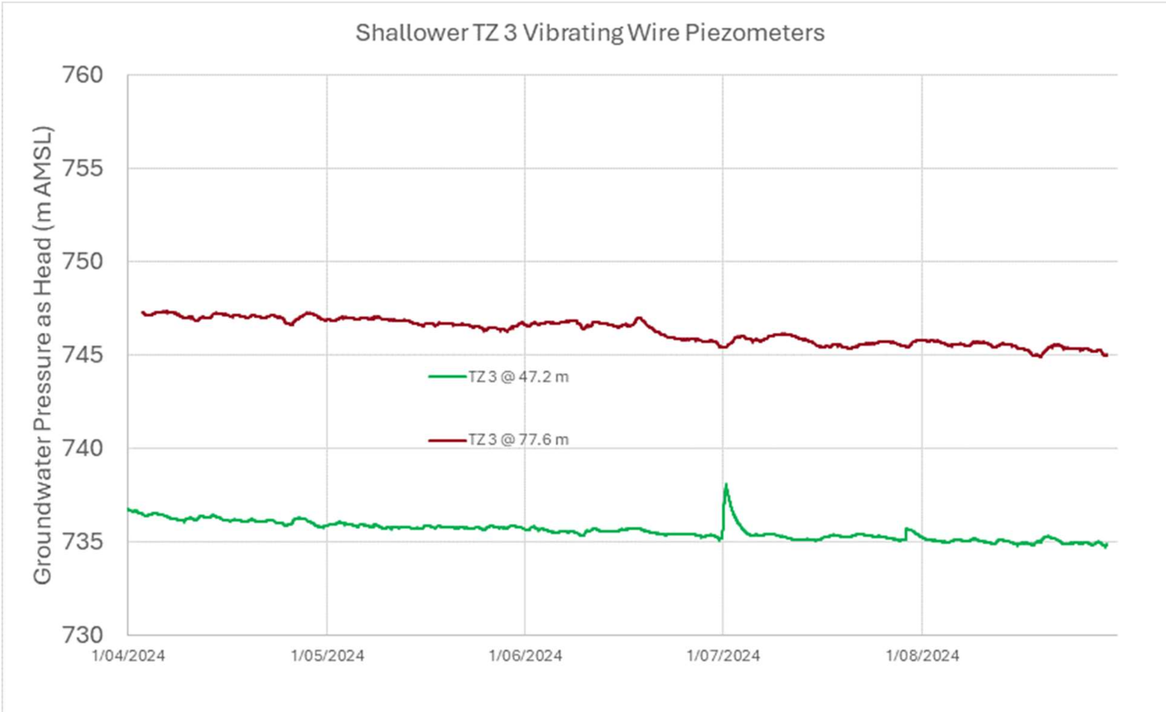


Figure 6: MDD289 shallow pair of TZ-3 piezometers at depths of 47.2 m and 77.6 m below ground

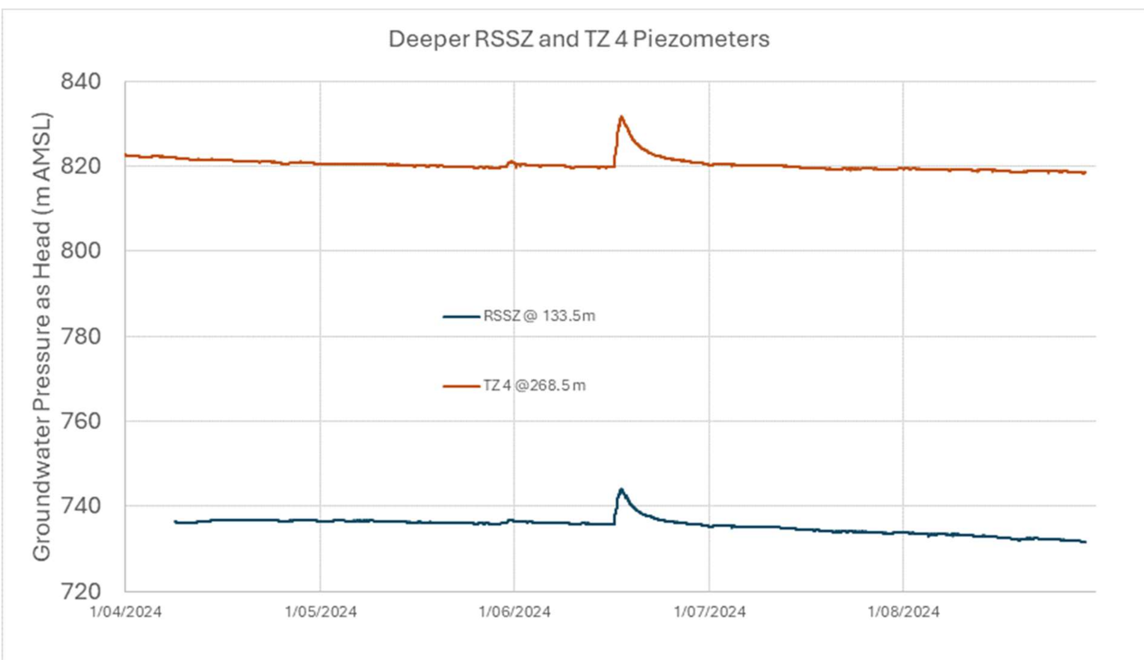


Figure 7: MDD289 deeper pair of TZ-3 piezometers at depths of 133.5 m (RSSZ) & 268.5 m (TZ-4) below ground

Bore MDD289 deeper piezometers both record a concurrent spike in pressure beginning at midday (1pm) 16 June 2024 (see Figure 7). The spikes are likely to be the result of adjacent drilling fluid injection occurring on that date and being of sufficient magnitude to be detected by both piezometers while taking 15 days to decay back to ambient.

3.2.1 Groundwater Hydraulic Gradient

The plotted groundwater pressure time series for bore hole MDD289 with four piezometers is most illustrative of the hydraulic gradient. Mean groundwater pressure was calculated for each recording piezometer. The shallow groundwater level was interpolated from the closest dipped gold resource hole, usually within 100 m laterally and installed to similar depth, dip angle and azimuth.

As the depth of measurement declines in elevation, the measured groundwater pressure heads tend to rise with increasing depth of burial (see Figure 8). An initial downward vertical gradient is inferred from the superficial with a 13 metre depth to water table or saturation. However, this reverses as the groundwater pressure remains between 735 and 747 metres AMSL as the depth of measurement descends to the RSSZ. The deepest piezometer within the basal TZ 4 materials recorded the highest pressure head at 820.4 metres AMSL, which is significantly above ground level.

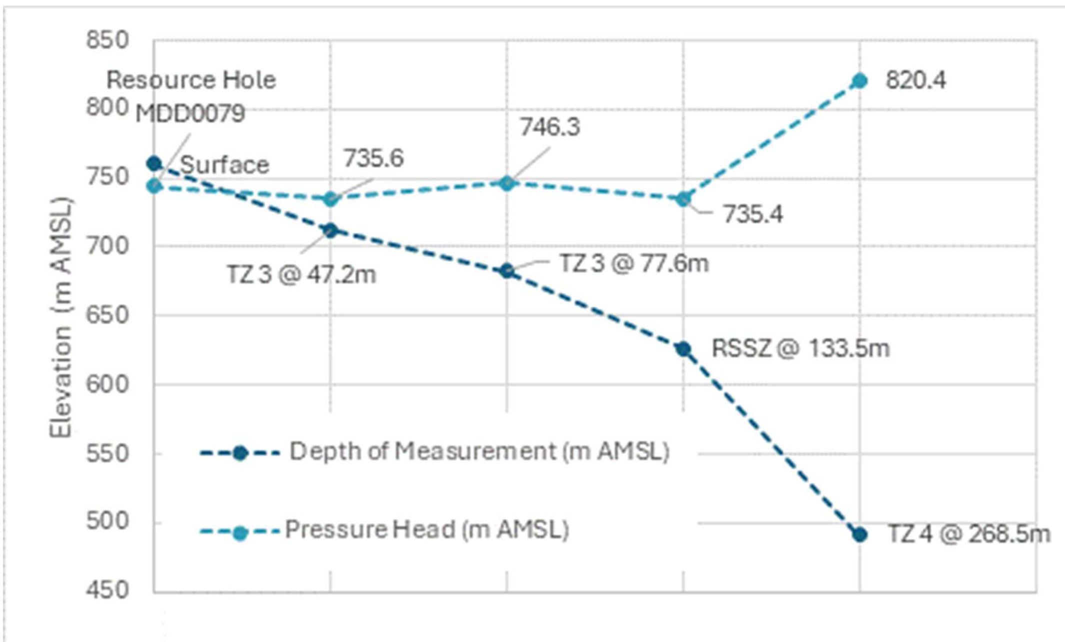


Figure 8: Depth–pressure elevation in 4 MDD289 piezometers, plus nearby dipped resource hole MDD0079

The second geotechnical bore hole equipped with vibrating wire piezometers was MDD290, also located within the Rise and Shine proposed surface mining pit area with piezometers in the TZ 3 hanging wall and the RSSZ mineralised zone. Between these two piezometers there is an upward vertical hydraulic gradient of +0.5 metres per metre (m/m). Both groundwater pressures in Figure 5 plot above the 695 metre elevation ground level.

The overall groundwater hydraulic gradient in bore MDD289, from the shallowest piezometer (TZ 3 @ 47.2 m BGL) to the deepest piezometer at 268.5 m BGL in the TZ 4 foot wall, was +0.38 m/m in the upward polarity. A contrast to this upward gradient was the -0.19 m/m calculated in the mean groundwater pressures between the TZ 3 @ 77.6 m BGL and RSSZ @ 133 m BGL across the Thomson Gorge Fault (TGF). A similar downward gradient was estimated from the shallow water table interpolated from a dipped resource hole and the shallowest TZ 3 piezometer at 47.2 m BGL. The downward gradient recorded across the TGF may have been indicative of more elevated hydraulic conductivity in the RSSZ, however elevated hydraulic conductivity is not indicated in packer lugeon testing (see Table 3 of packer test results for holes MDD286 and MDD287).

Table 2: Summary of Vertical Gradients calculated from mean Groundwater Pressure at Piezometers

Units: m or m/m All depths m BGL	Shallow water table to TZ3 @ 47.2 m	TZ3 @ 47.2 m to TZ3 @ 77.6 m	TZ @ 77.6 m to RSSZ @ 133.5m	RSSZ @ 133.5m to TZ4 @268.5 m	TZ3 @ 47.2m to TZ 4 @ 268.5m
Change in Piezometer Elevation, ΔL	47.2	30.4	55.9	135	221.3
Change in Head Elevation, Δh	-8.53	33.48	-10.92	85.07	84.81
Gradient, $i_{vertical}$	-0.181	1.101	-0.195	0.630	0.383
Gradient Polarity	Downward	Upward	Downward	Upward	Upward, overall

Note: ΔL is the vertical separation between piezometers; Δh is the vertical difference in mean groundwater pressure head measurements; i is hydraulic gradient; $i_{vertical}$ is the calculated vertical hydraulic gradient. Vertical gradient is calculated as $i = \Delta h / \Delta L$.

3.3 Resource Hole Water Level Dipping Surveys

The gold resource delineation drill holes sunk since 2019 generally remain open following completion. In order to prevent the collapse of the open holes in the shallowest over-relaxed depth zone (1 – 6 metres), 100 or 150 millimetre diameter PVC pipes are placed in the top of the holes and secured in position with the application of expanding polyurethane foam as is standard practice in resource drill hole completion. Groundwater fills the drill holes to the ambient height of saturation.

Several surveys have been conducted to define the saturation surface within the fractured schist groundwater system by individually dipping the depth of groundwater in each hole, correcting for reference point elevation and drill hole inclination angle to estimate the local saturation depth and elevation. Surveys have been conducted as follows since the beginning of 2023 –

- 20 January 2023,
- 1 August 2023,
- 28 November 2023, and
- 20 January 2024.

The distribution of the surveys have taken in that of the gold resource holes and is thus concentrated on the four prospective surface mining pits, plus the extent of the proposed RAS underground mine. Figure 9 shows a worked example of using individual drill hole data. The profile shows the inclined drill holes (dashed) and corrected virtual depth (solid), plus corrected groundwater elevations of six dipped drill holes marked by a teal coloured line. The interpolated saturation surface is plotted in light blue, overlain on simplified Hydro Stratigraphic Units (HSUs) as TZ 3, RSSZ, and TZ 4 strata.

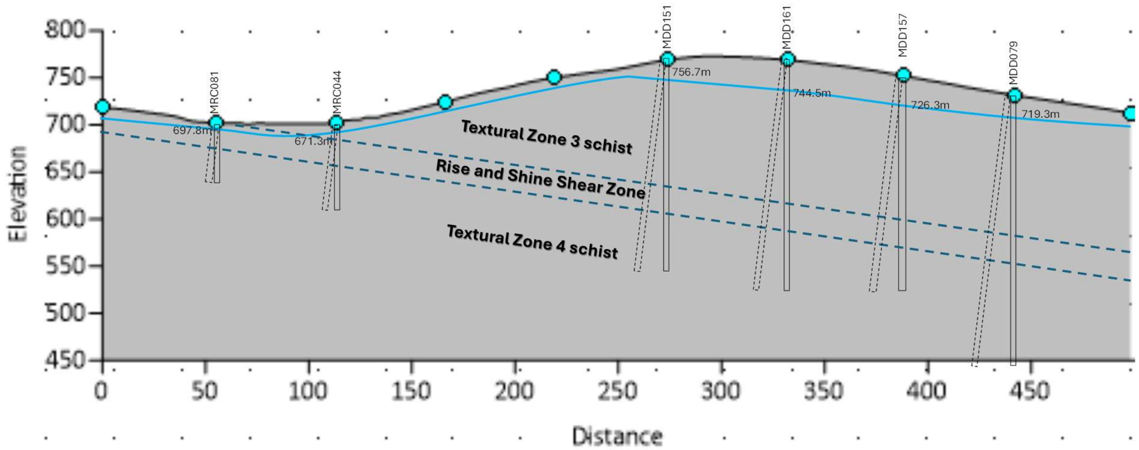


Figure 9: Example of the use of gold resource drill hole data to provide a profile of HSUs and water levels

Figure 9 is a profile through the southwest of the proposed Rise and Shine (RAS) pit, centred across the Battery Hill ridgeline. Water level elevation measured during the on 20 January 2024 resource hole survey is annotated in text and the light blue line marked to interpolate the saturation surface in schist groundwater system. Because the gold resource drill holes were inclined to present as near a true Rise and Shine Shear zone thickness as possible, the profile shows an approximation of real drill hole inclination as possible in the form of dashed hole outlines. The solid drill hole outlines are indicative of the re-orientation of depth to water dips to account for the drill hole inclination. Figure 10 extends the profile in the north-north-east direction across Shepherds Creek and annotates schist zonation and a possible pit outline for context.

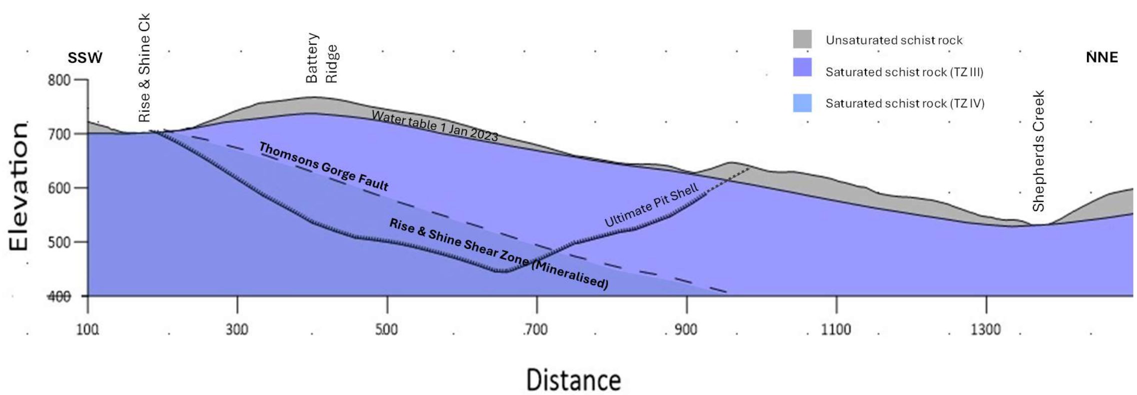


Figure 10: Profile looking down-valley, including water table, schist zones and RAS pit floor / wall outline

Figure 10 shows the saturation surface following the topographic surface, being deepest underneath ridges and shallow or at the surface-coincident with water courses such as Rise and Shine Creek, Ferret Gully and Shepherds Creek. The Thomsons Gorge Fault separating TZ 3 schist from the Rise and Shine Shear Zone contact is also shown. It is acknowledged that the above groundwater saturation profiling may lack depth-discrete differentiation of groundwater pressures within particular compartments of the schist groundwater system. The differentiation of groundwater pressures were shown in evaluation of vibrating wire piezometers in drill holes MDD290 and MDD289 falling inside the Rise and Shine Pit footprint. Each gold resource hole is open-holed from base to near surface, thus homogenising the groundwater pressures day-lighting in the full length of the drill hole. As a consequence, deeper seated groundwater pressures may influence the lower elevation shallow groundwater level. However, mild but persistent flowing artesian pressures have been noted in only 1.5% of resource drill holes used in water level dipping January 2023 to January 2024. Dipped snap-shots of water level elevation were used as calibration data in the groundwater modelling project.

3.4 Packer Testing

Packer testing is a common means of estimating fractured rock hydraulic conductivity within diamond cored drill holes, which was the drill hole method used in the four geotechnical drill holes focusing on the Rise and Shine (RAS) pit. Two of these drill holes (MDD-286 and -287) were subjected to repeated packer test at a range of focus depths using an IPS Standard Wireline Packer System (SWiPS) packer assembly set up to undertake terminal packer inflation and Lugeon testing. The results of lugeon testing as hydraulic conductivity were used as prior values in groundwater modelling of the RAS, CIT and SRX areas. These drill holes were two of the four geotechnical holes extended to depth within the Rise and Shine pit footprint. The other two holes ((MDD-289 and -290) were rigged with multi-depth vibrating wire piezometers.

The terminal packer method focuses on the bottom of the drill hole at the time of testing, as the hole is being progressively advanced. The terminal packer assembly is displayed diagrammatically according to its functional elements in profile within Figure 11.

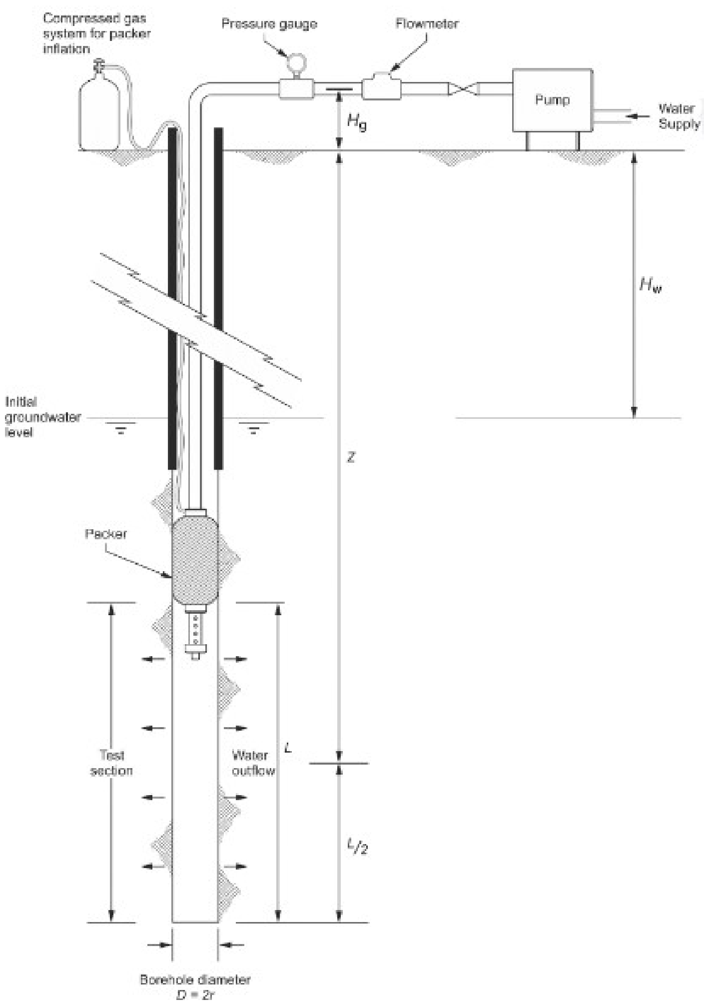


Figure 11: Example of a terminal, pneumatic packer test (Preene, 2018)

Contrary to Figure 11, instead of compressed gas inflation of the packer bladder being used to seal off the test interval, a hydraulic (water-filled bladder) inflation method was used in the proposed Rise and Shine pit area. Hydraulic packer systems are more suitable and safer for deep bore holes. All other elements of Figure 11 were in accordance with the components used in packer testing undertaken in early 2024 by Matakanui Gold field staff. Packer testing by the Lugeon (Lugeon, 1933) method involves injecting water into the formation using a pump and measuring pressure and flow at pressure gauge and flowmeter. The Lugeon testing method uses regimented sequence of flow steps, typically increasing to 25%, 50%, 75% and 100% of the maximum injection rate, followed by 90%, 60% and 30% in the declining flow rate direction. The sequencing of flow steps is used to derive the data points for estimating the transmissivity of the tested interval of consolidated rock. Equation 1 is a form of equation used to estimate the transmissivity of the test interval.

Transmissivity is directly proportional to the test interval and therefore hydraulic conductivity (K) can be derived from transmissivity (T) by dividing it with the test interval (T/b = K). The Lugeon test equation to derive transmissivity is provided in Equation 2, below:

$$T = \frac{Q.(\ln(R/r_b))}{2\pi P_i} \qquad \text{Equation 2}$$

Where:

L or b = Test Interval (m)

T = Transmissivity (m^2/d), Hydraulic conductivity, K = T/b

Q = Injection Rate (m^3/d)

R = Radius of Influence, typically 5 metres for Lugeon testing

r_b = radius of bore hole, typically 0.048 metres for HQ core barrels

P_i = Net Injection Pressure (m)

The results of using the Lugeon equation with packer test data in bore holes MDD287 and MDD286 are lain out in Table 3.

Table 3: Packer Test Estimation of Mean Hydraulic Conductivity of 9 Tests

Bore Hole #	Down-Hole Bottom Depth* (m)	Test Interval (m)	Date	Textural Zone	Mean Hydraulic Conductivity (m/d)
MDD287	77.00	5.9	18/02/2024	TZ 3	5.93×10^{-9}
MDD287	156.90	8.8	23/02/2024	TZ 3	8.41×10^{-9}
MDD287	169.50	14.2	24/02/2024	TZ 3	5.14×10^{-10}
MDD286	59.00	7.75	9/02/2024	TZ 3	7.49×10^{-8}
MDD286	82.30	6.2	10/02/2024	TZ 3	4.70×10^{-8}
MDD286	135.60	7	12/02/2024	TZ 3	2.20×10^{-8}
MDD286	191.50	5.1	16/02/2024	TZ 3/TGF	5.98×10^{-8}
MDD286	212.00	6.3	18/02/2024	RSSZ/TZ 4	7.42×10^{-8}
MDD286	226.30	13	19/02/2024	RSSZ/TZ 4	1.73×10^{-8}

Note: * The Down-Hole Bottom Depth is provided in terms of the length of the inclined hole, which is not the same as the total vertical depth from the surface. A total of 14 packer tests were initiated. Nine tests produced data and five tests failed to secure a packer seal and thus failed.

The results of hydraulic conductivity derivation in the campaign of packer testing did not display a wide range in hydraulic conductivity, centring in the 10^{-8} metres per second order of magnitude. There may be an inherent bias toward more competent sections of rock as the packer bladder often fails to seal off the test section if the bore hole rock adjacent to the packer is penetrated by shears or fractures. The site geologists tended to seek out competent rock on recovered core for this reason. Despite this, five of the 14 tests undertaken failed to maintain a seal of the test interval (these are not reported in Table 3). All failed tests were in textural zone 3 schist rock, which raises the possibility that the aggregate hydraulic conductivity of the remaining tests that did not fail biased the results towards lower hydraulic conductivity. Consequently, the resulting hydraulic conductivities for textural zone 3 (TZ 3) in Table 3 may not reflect true bulk hydraulic conductivity for the hanging wall lithologies above the Rise and Shine Shear Zone (RSSZ), and in fact under-estimate to some extent. There is a greater incidence of textural zone 3 schist outcropping at the surface across the Rise and

Shine gold deposit with only the RSSZ found at the surface from beneath the TZ 3 in the far south-south-west in the Rise and Shine gully.

The shallowest test interval in a successful packer test was 52 m below ground surface (i.e., 59 metres length of inclined hole), which places the depths of testing beyond the uppermost top-system (i.e., 'veneer aquifer' of the model study). Conceptualisation of the schist groundwater system recognises a distinct superficial zone of schist that shares the following characteristics:

- Weathering from the land surface, including regolith and clay pan formation,
- Involvement in mass wasting, including superficial land sliding,
- Over-relaxation of the rockmass, resulting in wider gape of rock defects, and
- The schist rock is often unsaturated or semi-saturated.

As a result, the groundwater system conceptualisation sets the superficial materials apart from the deeper compartments. Based on research into similar basement rock creek catchments (Schoeneberger & Wysocki, 2005), the superficial materials have an important role as a gateway for groundwater recharge and shallow routing of meteoric water to wetlands or creeks. Other research (Hunter Williams et al., 2011) outlines the phenomenon of 'refused or rejected recharge' whereby the low hydraulic conductivity and drainable porosity of the schist fails to accommodate recharge that would otherwise percolate downwards to the groundwater system if those parameters were higher.

3.5 Sampling & Analysis of Groundwater

Matakanui Gold Ltd instituted sampling and analysis of groundwater and historic mine water discharge beginning in October 2023 with annual or six monthly monitoring, which is scheduled to continue. Bore Hole number MDD015 was drilled to 195 metres below ground into the TZ 4 schist beneath the Rise and Shine Shear Zone (RSSZ) and maintained a consistent artesian flow. The artesian flow allowed grab sampling at the bore head for routine analysis. Three analyses of samples from MDD015 had been received: 22 October 2023, 24 April 2023 and 4 April 2024. A further groundwater monitoring bore, MRC002, is located adjacent to the proposed Srex main surface mining pit. A single sample of groundwater was taken from MRC002 on 22 October 2023. A range of total and dissolved cation, anion, metals and metalloid concentrations were reported from ICP-MS spectral analysis.

Groundwater also issued from the Lower Bendigo Adit (LBA), an historic mining adit (tunnel) dating from the 1890s is also a site of water sampling. The adit has a minor overflow issuing from the entrance that joins with Aurora Creek and discharges into the Bendigo Aquifer. The groundwater collecting within the adit and flowing to the entrance has had an opportunity to equilibrate to atmospheric conditions, including becoming fully oxygenated and entraining turbidity. There is a significant and notable difference in both the total and dissolved arsenic concentration in adit water samples compared with groundwater at MDD015. Arsenic concentration at the Rise and Shine site (MDD015) as sampled at an artesian bore sat at about 2 to 4 times that of the 0.01 mg/L drinking water standard for arsenic (i.e., 0.02 to 0.038 mg/L). The Lower Bendigo Adit sampling site exhibited total and dissolved arsenic concentrations 100 times the drinking water standard (0.98 to 1.05 mg/L). It is inferred that the elevated arsenic in adit water is the result of oxidation and resulting Acid Rock Drainage (ARD) processes during the passage of groundwater into the adit, and flow along the floor of the adit to the entrance area.

The location of each of the groundwater quality monitoring site is mapped and indicated in Figure 12, which includes the indicative location of the proposed surface mining pits. Monitoring site Lower Bendigo Adit (LBA) is located outside of the Project area in the historic mining reserve administered by the Department of Conservation.

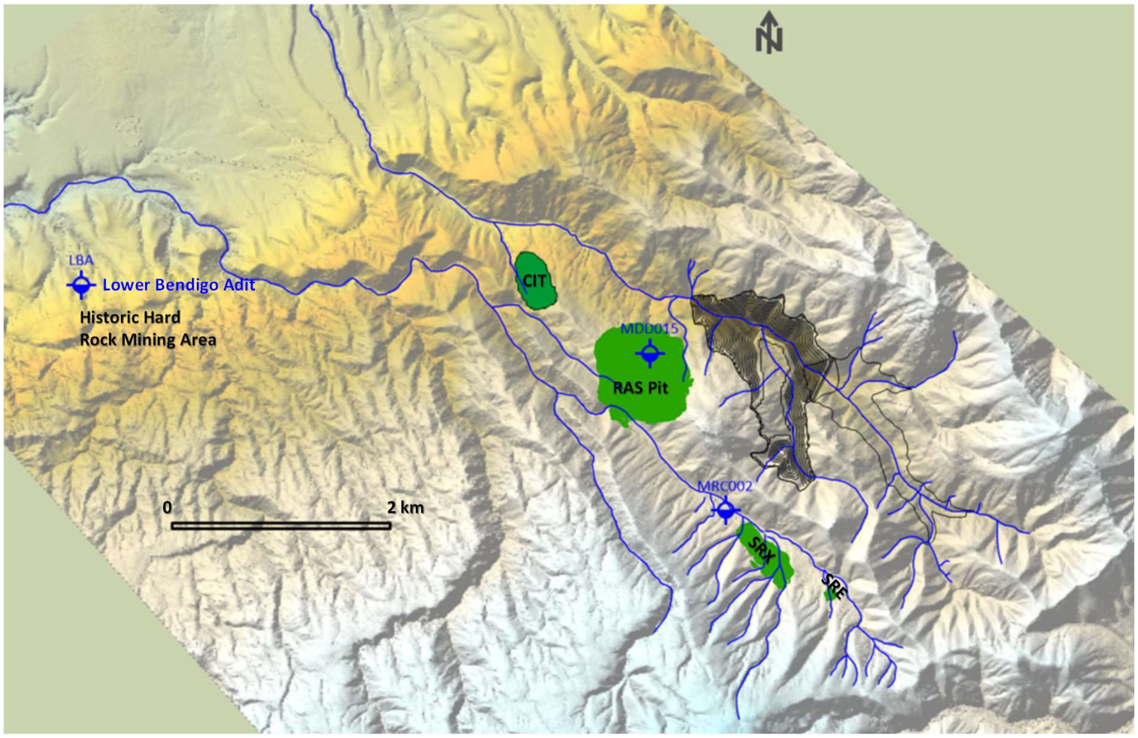


Figure 12: Location of LBA, MDD015 (RAS) and MRC002 (SRX) groundwater sampling sites

The Australia – New Zealand toxicant default guideline concentration for freshwater (ANZG) are appended for each analyte in Table 4, Table 5, and Table 6 as an indication of exceedance of aquatic toxicity guideline values, for potential impact screening purposes. The groundwater from the artesian bore hole in the Rise and Shine footprint exceeded the 99% species protection ANZG concentration for aluminium, arsenic, barium, cadmium, cobalt, copper, mercury, thallium, uranium, vanadium, zinc and cyanide, although the detection limits may exceed the ANZG guideline in the case of barium and thallium (detection limits are specified as a positive value rather than a zero). The LBA adit seepage water exceeded the aquatic toxicity guideline values for fluoride, aluminium, arsenic, barium, cadmium, copper, mercury, thallium, uranium, zinc and cyanide. The water quality results for individual analytes of groundwater at bore hole MDD0015, MRC002, and LBA are shown in Table 4, Table 5, and Table 6, respectively.

The water quality results highlighted in groundwater monitoring are reflective of the geochemical conditions of the source rock. The groundwater drawn from monitoring bore hole MDD015 originates from the Rise and Shine Shear Zone and textural zone 3 before discharging at the surface. It shows signs of having slightly suppressed oxidation – reduction potential due to residence time in the ground. The seepage water drawn at Lower Bendigo Adit had emerged from fractured rock as groundwater and collected on the floor of the adit before discharging at the tunnel entrance. It is reasonable to infer that atmospheric oxygen would penetrate a distance of at least 30 metres into the adit. Therefore, equilibration of the water with respect to oxygen content would be expected to higher than for freshly emerged groundwater from an artesian bore hole.

Table 4: Groundwater Quality from Bore MDD015 within Rise and Shine Pit Envelope in 2023 and 2024

			22-Oct-23	*24-Apr-23*	*4-Apr-24*	*22-Oct-23*	*24-Apr-23*	*4-Apr-24*	*ANZG 99%*
Dissolved	Alkalinity	mg/l	_	_	_	200	195	201	
Dissolved	Ammonia-N	mg/l	_	_	_	_	0.2	0.11	*0.32*
Dissolved	Bromide	mg/l	_	_	_	_	0.09	0.11	
Dissolved	Chloride	mg/l	_	_	_	9.9	10.1	10.5	
Dissolved	Fluoride	mg/l	_	_	_	_	0.19	0.15	*0.29*
Dissolved	Nitrate	mg/l	_	_	_	_	0.01	0.01	
Dissolved	Nitrite	mg/l	_	_	_	_	0.01	0.01	
Dissolved	Sulphate	mg/l	_	_	_	17	16.5	9.29	
Dissolved	Org Carbon	mg/l	_	_	_	_	0.1	0.2	
Dissolved	Silica	mg/l	_	_	_	_	18.8	18.4	
Electrical	Conductivity	mS/m	_	_	_	_	42.1	43.1	
	pH	pH units	_	_	_	8.7	8.2	8.1	
	Metals / Metalloids			***Total Concentration***			***Dissolved Concentration***		
Silver	Ag	mg/l	0.0005	0.001	0.001	0.0005	0.0005	0.0005	*0.02*
Aluminium	Al	mg/l	0.015	**0.193**	**0.336**	0.015	0.003	0.018	*0.027*
Arsenic	As	mg/l	**0.038**	**0.035**	**0.019**	**0.038**	**0.036**	0.02	*0.001*
Boron	B	mg/l	_	0.1	0.05	_	0.04	0.06	*0.34*
Barium	Ba	mg/l	**0.12**	**0.146**	**0.19**	**0.12**	**0.124**	**0.188**	*0.00060*
Beryllium	Be	mg/l	_	0.005	0.005	_	0.001	0.001	
Bismuth	Bi	mg/l	0.001	0.005	0.005	0.001	0.001	0.001	
Calcium	Ca	mg/l	17.6	31.5	21.9	17.6	30.2	22.1	
Cadmium	Cd	mg/l	0.0002	**0.001**	**0.001**	0.0002	0.0002	0.0002	*0.0006*
Cobalt	Co	mg/l	0.0005	**0.002**	**0.002**	0.0005	0.0005	0.0005	*0.0014*
Chromium	Cr	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	*0.0033*
Copper	Cu	mg/l	0.0005	**0.002**	**0.002**	0.0005	0.0005	0.0005	*0.001*
Iron	Fe	mg/l	0.03	0.3	0.3	0.03	0.01	0.04	
Mercury	Hg	mg/l	0.0005	**0.001**	**0.001**	0.0005	0.0005	0.0005	*0.0006*
Potassium	K	mg/l	1.42	1.4	1.7	1.42	1.58	1.27	
Lithium	Li	mg/l	0.046	0.055	0.051	0.046	0.049	0.09	
Magnesium	Mg	mg/l	15.7	17.7	16	15.7	16.7	21.5	
Manganese	Mn	mg/l	0.005	0.009	0.011	0.005	0.0064	0.0085	*1.2*
Molybdenum	Mo	mg/l	0.0005	0.001	0.001	0.0005	0.0007	0.0005	*0.034*
Sodium	Na	mg/l	42	43.3	42.2	42	36.8	59.6	
Nickel	Ni	mg/l	0.0005	0.001	0.001	0.0005	0.0005	0.0005	*0.008*
Lead	Pb	mg/l	0.0005	0.001	0.001	0.0005	0.0005	0.0005	*0.001*
Antimony	Sb	mg/l	_	0.002	0.002	_	0.001	0.001	
Selenium	Se	mg/l	_	0.005	0.005	_	0.005	0.005	*0.005*
Tin	Sn	mg/l	_	0.001	0.001	_	0.0005	0.0005	*0.009*
Strontium	Sr	mg/l	9	8.97	8.98	9	8.45	10.2	
Titanium	Ti	mg/l	0.0005	0.004	0.009	0.0005	0.0005	0.0005	
Thallium	Tl	mg/l	**0.0005**	**0.001**	**0.001**	**0.0005**	**0.0005**	**0.0005**	*0.00003*
Uranium	U	mg/l	_	**0.001**	**0.001**	_	**0.0012**	0.0009	*0.0005*
Vanadium	V	mg/l	**0.0005**	**0.001**	**0.001**	**0.0005**	**0.0005**	**0.0005**	*0.006*
Zinc	Zn	mg/l	**0.002**	**0.005**	**0.005**	**0.002**	**0.002**	**0.002**	*0.0024*
Additional Totals			*22-Oct-23*	*24-Apr-23*	*4-Apr-24*	*22-Oct-23*	*24-Apr-23*	*4-Apr-24*	
Cyanide	CN	mg/l	_	**0.005**	**0.005**	_	_	_	*0.004*
Total	Diss Solids	mg/l	260	206	211	_	_	_	_
Total	Hardness	$gCaCO_3/m^3$	_	7	120	_	_	_	_
Total	Nitrogen	mg/l	_	0.15	0.122	_	_	_	_
Total	Org Carbon	mg/l	_	0.1	0.2	_	_	_	_
Total	Phosphorus	mg/l	_	0.01	0.005	_	_	_	_
Total	Silica	mg/l	_	7.43	8.38	_	_	_	_
Total	Susp Solids	mg/l	_	10	6	_	_	_	_
	Turbidity	NTU	_	0.44	1.46	_	_	_	_

Note: *ANZG 99%* is the ANZECC 99% species protection guideline. A water concentration in **bold** means the ANZG 99% is exceeded.

Table 5: Groundwater Quality from Bore MRC002 near the Srex Pit sampled in 2023

			22-Oct-23	***22-Oct-23***	***ANZG 99%***
			Total Concentration	***Dissolved Concentration***	
Dissolved	Alkalinity	mg/l	_	110	
Dissolved	Ammonia-N	mg/l	_	_	*0.32*
Dissolved	Bromide	mg/l	_	_	
Dissolved	Chloride	mg/l	_	3.5	
Dissolved	Fluoride	mg/l	_	_	*0.29*
Dissolved	Nitrate	mg/l	_	_	
Dissolved	Nitrite	mg/l	_	_	
Dissolved	Sulphate	mg/l	_	5.4	
Dissolved	Org Carbon	mg/l	_	_	
Dissolved	Silica	mg/l	_	_	
Electrical	Conductivity	mS/m	_	250	
	pH	pH units	_	8	
	Metals / Metalloids		***Total Concentration***	***Dissolved Concentration***	
Silver	Ag	mg/l	0.001	0.0005	*0.02*
Aluminium	Al	mg/l	**0.545**	0.006	*0.027*
Arsenic	As	mg/l	**0.021**	**0.011**	*0.001*
Barium	Ba	mg/l	**0.308**	**0.26**	*0.00060*
Bismuth	Bi	mg/l	0.005	0.001	
Calcium	Ca	mg/l	14.4	14.8	
Cadmium	Cd	mg/l	**0.001**	0.0002	*0.0006*
Cobalt	Co	mg/l	**0.002**	0.0005	*0.0014*
Chromium	Cr	mg/l	0.002	0.001	*0.0033*
Copper	Cu	mg/l	**0.004**	**0.002**	*0.001*
Iron	Fe	mg/l	2	0.09	
Mercury	Hg	mg/l	**0.001**	0.0005	*0.0006*
Potassium	K	mg/l	2.1	1.88	
Lithium	Li	mg/l	0.019	0.017	
Magnesium	Mg	mg/l	6.7	6.61	
Manganese	Mn	mg/l	0.033	0.0034	*1.2*
Molybdenum	Mo	mg/l	0.001	0.0009	*0.034*
Sodium	Na	mg/l	27.9	27	
Nickel	Ni	mg/l	0.001	0.0005	*0.008*
Lead	Pb	mg/l	0.001	0.0005	*0.001*
Strontium	Sr	mg/l	3.66	3.57	
Titanium	Ti	mg/l	0.016	0.0005	
Thallium	Tl	mg/l	**0.001**	**0.0005**	*0.00003*
Vanadium	V	mg/l	0.001	0.0005	*0.006*
Zinc	Zn	mg/l	**0.135**	**0.094**	*0.0024*
Additional Totals		***22-Oct-23***	***22-Oct-23***		
Total	Phosphorus	mg/l	0.07	_	_

Note: *ANZG 99%* is the ANZECC 99% species protection guideline. A water concentration in **bold** means the ANZG 99% is exceeded.

Additional Note: While strontium has no ecological guideline value in the ANZECC system it has a human lifetime exposure guideline maximum of 4.0 mg/L set by the US EPA. The most recent US EPA Health Reference Level for strontium in drinking water is 1.5 mg/L.

Table 6: Groundwater Quality from Lower Bendigo Adit (LBA) Monitoring Site (Oct. 2023 and April 2024)

			10-Oct-23	*4-Apr-24*	*10-Oct-23*	*4-Apr-24*	*ANZG 99%*
Dissolved	Alkalinity	mg/l	_	_	181	181	
Dissolved	Ammonia-N	mg/l	_	_	0.01	0.01	*0.32*
Dissolved	Bromide	mg/l	_	_	0.08	0.08	
Dissolved	Chloride	mg/l	_	_	5.05	8.06	
Dissolved	Fluoride	mg/l	_	_	**0.35**	0.27	*0.29*
Dissolved	Nitrate	mg/l	_	_	0.22	0.18	
Dissolved	Nitrite	mg/l	_	_	0.01	0.01	
Dissolved	Sulphate	mg/l	_	_	16.3	30.4	
Dissolved	Org Carbon	mg/l	_	_	2.2	1.7	
Dissolved	Silica	mg/l	_	_	15.6	17.8	
Electrical	Conductivity	mS/m	_	_	42.6	43	
	pH	pH units	_	_	8.2	8.2	
	Metals / Metalloids		***Total Concentration***		***Dissolved Concentration***		
Silver	Ag	mg/l	0.001	0.001	0.0005	0.0005	*0.02*
Aluminium	Al	mg/l	**0.073**	0.017	0.005	0.002	*0.027*
Arsenic	As	mg/l	**2.21**	**1.05**	**1.05**	**0.91**	*0.001*
Boron	B	mg/l	0.05	0.05	0.03	0.03	*0.34*
Barium	Ba	mg/l	**0.008**	**0.005**	**0.004**	**0.004**	*0.00060*
Beryllium	Be	mg/l	0.005	0.005	0.001	0.001	
Bismuth	Bi	mg/l	0.005	0.005	0.001	0.001	
Calcium	Ca	mg/l	53.5	48.4	49.2	50.7	
Cadmium	Cd	mg/l	**0.001**	**0.001**	0.0002	0.0002	*0.0006*
Cobalt	Co	mg/l	0.002	0.002	0.0005	0.0005	*0.0014*
Chromium	Cr	mg/l	0.001	0.001	0.001	0.002	*0.0033*
Copper	Cu	mg/l	**0.002**	**0.002**	0.0005	0.0005	*0.001*
Iron	Fe	mg/l	3.1	0.4	0.41	0.15	
Mercury	Hg	mg/l	**0.001**	**0.001**	0.0005	0.0005	*0.0006*
Potassium	K	mg/l	2	2.1	1.66	1.93	
Lithium	Li	mg/l	0.016	0.013	0.01	0.019	
Magnesium	Mg	mg/l	14.4	15.4	14.8	16.6	
Manganese	Mn	mg/l	0.115	0.037	0.0281	0.0111	*1.2*
Molybdenum	Mo	mg/l	0.002	0.001	0.0015	0.0011	*0.034*
Sodium	Na	mg/l	19.1	19.8	19.1	23.1	
Nickel	Ni	mg/l	0.001	0.001	0.0005	0.0005	*0.008*
Lead	Pb	mg/l	0.001	0.001	0.0005	0.0005	*0.001*
Antimony	Sb	mg/l	0.002	0.002	0.001	0.001	
Selenium	Se	mg/l	0.005	0.005	0.005	0.005	*0.005*
Tin	Sn	mg/l	0.001	0.001	0.0005	0.0005	*0.009*
Strontium	Sr	mg/l	0.467	0.447	0.358	0.422	
Titanium	Ti	mg/l	0.003	0.001	0.0005	0.0005	
Thallium	Tl	mg/l	**0.001**	**0.001**	**0.0005**	**0.0005**	*0.00003*
Uranium	U	mg/l	**0.003**	**0.002**	**0.0027**	**0.0021**	*0.0005*
Vanadium	V	mg/l	0.002	0.001	0.0005	0.0005	*0.006*
Zinc	Zn	mg/l	**0.005**	**0.005**	0.002	0.002	*0.0024*
Additional Totals			***10-Oct-23***	***4-Apr-24***			
Cyanide	CN	mg/l	**0.005**	**0.005**	_	_	*0.004*
Total	Diss Solids	mg/l	209	211	_	_	_
Total	Hardness	$gCaCO_3/m^3$	184	184	_	_	_
Total	Nitrogen	mg/l	0.57	0.275	_	_	_
Total	Org Carbon	mg/l	2.3	1.7	_	_	_
Total	Phosphorus	mg/l	0.091	0.03	_	_	_
Total	Silica	mg/l	6.8	6.66	_	_	_
Total	Susp Solids	mg/l	22	6	_	_	_
	Turbidity	NTU	28.1	1.26	_	_	_

Note: ANZG 99% is the ANZECC 99% species protection guideline, and a water concentration in **bold** means the ANZG 99% is exceeded.

Multiparameter sensor measurements reflect this difference with the adit water being generally more oxygenated and having higher Oxidation Reduction Potential readings than MDD015 groundwater (see Table 7). Field parameters were collected using a hand-held field parameter probe.

Table 7: Summary of Field Parameters collected during sampling of Groundwater at MDD015 and LB Adit

		Bore MDD015		LB Adit		
Field Parameter	**Units**	**2-Apr-24**	**17-Apr-24**	**10-Oct-23**	**4-Apr-24**	**17-Apr-24**
Dissolved Oxygen, DO	mg/L	1.48	8.73	8.41	10.32	10.78
Dissolved Oxygen, DO	percent	148	88.7	82	102.4	104.1
Electrical Conductivity	mS/cm	425.1	411.6	392.5	431.4	418.4
Oxidation-Reduction Potential, ORP	mV	191.8	-123.5	66.1	281.9	214.3
pH	pH units	8.03	8.18	8.36	8.12	8.23
Water temperature	degrees C	11.7	12.1	11.7	12.4	11.5

By way of providing geochemical background, the monitoring bore MDD015 is deep and includes a full sequence of the area's HSUs. Table 8 details the depths and elevations of the main HSUs are listed in Table 8.

Table 8: Depth and Elevation of Hydro Stratigraphic Unit (HSU) Contacts in Drill Hole MDD015

	Thickness of Unit above Base (m)	Contact Depth (m BGL)	Contact elevation (m AMSL)
Land Surface / Drill Hole Collar	_	0	656.5
Base of TZ 3	129	129.0	527.5
Base of TGF	0.4	129.4	527.1
Base of RSSV	11.7*	141.1*	515.4*
TZ 4, End Of Hole (EOH)	> 54.3[¥]	195.4	461.2

Note: * Stockwork containing interspersed segments of RSSZ material were also logged to extended below the listed base into the TZ 4 schist. ¥ The base of the TZ 4 schist was not encountered at End Of Hole, thus the thickness is merely greater than the vertical distance between the RSSZ and EOH.

The MRC002 bore hole groundwater emerged from a largely TZ 4 and/or RSSZ schist lithology, although a slender thickness of TZ3 may have intervened between the TGF and ground surface at the top. The Lower Bendigo Adit seepage occurs in an area of TZ 4 schist and Cretaceous age mineral veins [comprising quartz, arsenopyrite, galena, native (free-milling) gold, and sulphides incorporating gold]. While it is almost certain that the adit penetrated into TZ 4 schist, it is uncertain whether this adit extended to a large vein. The Lower Bendigo Adit seepage water would be reflective of groundwater emerging and ponding in the dewatering sump of the proposed surface mining pit. This would include the effect of exposure to oxygen over a number of hours to days. The MDD015 artesian groundwater would be more reflective of seepage emerging in the proposed underground workings with a briefer exposure to mine air before being pumped to the surface.

3.6 Groundwater Model Study

A model study was undertaken to support the description of the existing environment and the assessment of mining related effects (Dumont et al., 2025). The model study concentrated on the fractured schist groundwater system within four Hydro-Stratigraphic Units (HSUs):

- Surficial veneers of alluvial, colluvial, weathered rock regolith materials
- TZ 3 schist,
- RSSZ (Rise and Shine Shear Zone), and
- TZ 4 schist.

HSUs TZ 3, RSSZ, and TZ 4 are grouped into the fractured schist hard-rock aquifer, while the 'veneer' HSU was excluding from the numerical model due to its volatility and strong connection with climate and the surface water hydrology.

Furthermore, three <u>model areas</u> (known as 'model domains) were formulated to cover the three mining areas, mapped in Figure 13: Active model domains used in the model study:

- RAS, Rise and Shine Surface Mining Pit model domain,
- CIT, Come It Time Surface Mining Pit model domain, and
- SREX, Srex Surface Mining Pit model domain.

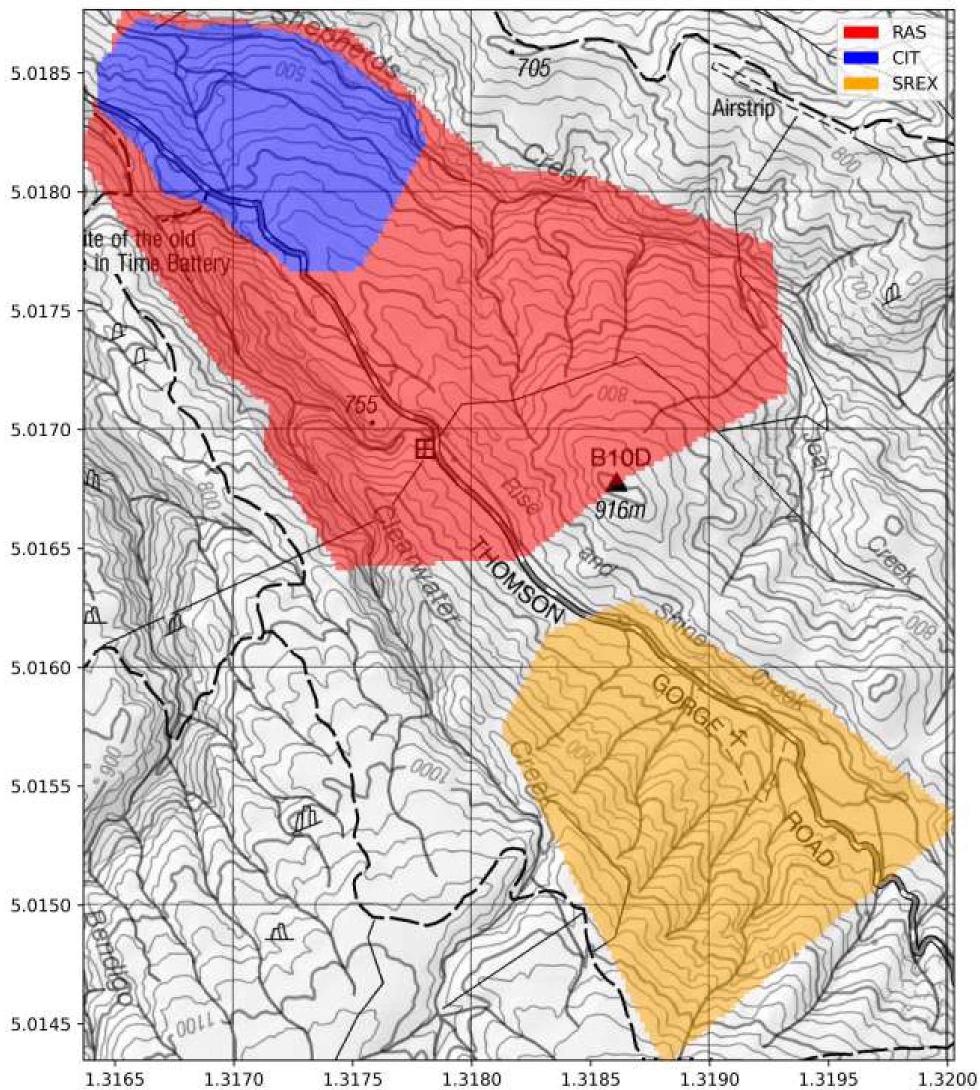


Figure 13: Active model domains used in the model study

Individual model domains as outlined in Figure 13 were chosen due to the need to reduce complexity of the parameterisation and computational burden. The relatively low hydraulic conductivity of the schist hard-rock aquifer and the steady state mode of the model simulation permitted the use of individual model domains with narrow regional extent. The individual model domains could be calibrated independently, which was also advantageous. It was considered unlikely that the groundwater flow related impacts of one mining activity area (i.e., mine pit) would affect others, allowing the models to be considered in isolation.

The groundwater flow model simulations were conducted using established proprietary software, including MODFLOW-2005 and MODFLOW-NWT and constructed within FloPy library of Python model code. MODFLOW grid cell size ranged between 20 and 50 metres, depending on required resolution. The depth dimension was layered according to a 5 to 10 metres deep layer scheme. The Hydro-Stratigraphic Units with superimposed onto the cell network outlined above, rather than as discrete model layers.

Boundary conditions were applied to each model domain using the following:

- A 'drainage blanket' with drain invert elevation set to coincide with the land surface to prevent uppermost groundwater rising appreciably above ground level, and in order to simulate the effect of rejected recharge via the 'veneer aquifer',
- Distributed recharge across the model domain upper surface,
- Constant head cells along the course of the model domains creek(s), and
- The penetration of mining pits into the schist hard-rock aquifer was simulated using drain boundary condition cells that promoted the inflow of virtual groundwater where the simulated groundwater level exceeded the drain cell invert elevation.

The steady state model was calibrated, primarily from snap-shot groundwater levels measured in resource hole water level dipping surveys (see section 3.3). The consistently below-ground groundwater levels measured in dipped resource holes may seem at odds with the observations of upward groundwater gradient measured in vibrating wire piezometers (see section 3.2). However, the groundwater levels used in calibration were a better representation of regional saturation levels important to the question of schist rock dewatering. The model was optimised to these calibration values using MT-DREAMZ algorithm (Laloy & Vrugt, 2012).

Aside from boundary conditions, model geometric framework discretisation was mostly achieved by the application of three-dimensional surfaces to define the respective three hard-rock Hydro-Stratigraphic Units.

- The TZ 3 HSU was defined by the land surface and the plane of the Thomsons Gorge Fault (TGF),
- The RSSZ HSU was defined by the plane of the TGF and a fixed depth (40 metres) beneath the plane, and
- TZ 4 defined by the base of the RSSZ and the base elevation of the model.

The hydraulic conductivity value was applied homogeneously within each Hydro-Stratigraphic Unit. As a stochastic model in its development and optimisation, the hydraulic conductivities within each of the three HSUs were extensively tested in the optimisation process to derive the optimal values. In addition to HSU hydraulic conductivity, the recharge rate to the hard-rock groundwater system and creek bed conductance were also optimised.

The modelling processes outlined above were fully described and reported in (Dumont et al., 2025). Each model domain outlined in Figure 13 was separately calibrated and optimised. This allowed comparison of the tendencies of each optimisation to conform to the prior approximations of hydraulic conductivity, recharge and creek conductance. Key optimisation conclusions of the optimisation processes of each of the models were as follow:

- Optimisation derived hydraulic conductivity distribution in the Rise and Shine model domain tended towards the lower end of packer test results,
- Optimisation derived hydraulic conductivity distribution in the Come In Time model domain tended towards the mean of packer test results, and
- Optimisation derived hydraulic conductivity distribution in the Srex model domain tended towards the upper end of packer test results except for the TZ 4, which is towards the lower end of the range,

One of the implications of the Srex model domain optimisation was the probability of the TZ 3 and RSSZ being strongly connected to the hydrology of Rise and Shine Creek tributaries and associated wetlands. This set of conditions would have significance in the simulation of Srex pit dewatering rate and surface water depletion rates.

3.7 Summary of Investigations

The findings of the investigations undertaken by Matakanui Gold Ltd or commissioned by MGL for the Bendigo – Ophir Gold Project may be summarised as follows:

RQD and Field Hydraulic Conductivity Correlation

- The geo-mechanical ratio termed Rock Quality Designation can be correlated with rock mass hydraulic conductivity, as shown in other areas with combined geotechnical and packer test permeability determinations.
- A relevant and publicly accessible equation linking Rock Quality Designation and hydraulic conductivity was used to explore whether the estimated schist rock permeability could have application to the logged Rock Quality Designation values from the Bendigo – Ophir resource drill holes across the Project area.
- This correlation of RQD and field hydraulic conductivity (K_{field}) was found to provide plausible distributions of derived hydraulic conductivity.
- The investigation also found highly variable and generally higher ranges of hydraulic conductivity across a drilled sequence than would be indicated from packer testing.
- A pattern of lower hydraulic conductivity on the basis of RQD and field hydraulic conductivity (K_{field}) correlation was indicated in some drill holes.

Vibrating Wire Piezometer Pressure Monitoring

Temporal Patterns

- The groundwater pressures show volatile variation that could be related to barometric changes.
- Longer wavelength groundwater pressure trends are more likely to be related to the balance of water deficit and surplus reflected in soil drainage or creek flow.
- Pressure spikes relating to suspected drilling fluid injects were noted in three instances.

Groundwater Pressure Vertical Gradients

- There is a general trend of increasing Upward vertical gradient with increasing depth of piezometer burial.
- Localised reversal of the general downward pressure gradient were evident from piezometer to piezometer, including across the Thomsons Gorge Fault.
- With the generally upward gradient, the deepest piezometers in Textural Zone 4 schist manifest substantially above-ground groundwater pressure.

Dipped Resource Drill Holes and Pattern of Saturation

- The heights of saturation in schist rock were different to groundwater pressure measured with a vibrating wire transducer buried at depth.
- The height of saturation was measured by dipping a water level indicator tape in empty, completed resource estimation drilling holes across the Bendigo – Ophir gold deposit areas and the depths to water were recorded in four snap-shot surveys conducted in 2023 and 2024.

- Saturation elevations were profiled and interpolated as a virtual ‘water table’ surface across areas of dense measurement allowing the drafting of saturation profiles, including across the proposed Rise and Shine open cut pit area from southwest to northeast.
- Patterns of saturation were found to be deepest across ridgelines and shallowest across creek lines, patterns that were particularly evident in profiles crossing the topographic features.
- Derived static water level elevations were used for calibration in groundwater modelling.

Packer Lugeon Testing for Hydraulic Conductivity Measurement

- Lugeon tests to determine the hydraulic conductivity of the drill hole sections intentionally isolated by the terminal packer assembly inflation were undertaken at nine (9) depths in two bore holes.
- The shallowest test was conducted at a depth of 40 metres true depth within TZ 3 schist, while the deepest at 184 metres true depth below ground was within TZ 4 schist.
- The range of derived hydraulic conductivity measurement in bore hole MDD286 bracketed 1.7×10^{-8} to 7.5×10^{-8} metres per second. The range of derived hydraulic conductivity measurements in drill hole MDD287 was les permeable, bracketing 5.1×10^{-10} to 8.4×10^{-9} metres per second.
- None of the Lugeon testing would have sampled the properties of the weathered regolith, top-system, instead measuring hydraulic conductivity wholly within unweathered schist.
- Hydraulic conductivities and their statistical distributions were derived from packer testing were used as prior values in groundwater modelling.

Groundwater Water Quality

- Groundwater within a 227 metre deep resource, with an open hole to a depth of 95 metres below ground, in the Rise and Shine pit area was sampled and analysed on four occasions between October 2023 and April 2024.
- The hydro-chemistry of this bore hole revealed in analysis included extensively elevated concentrations of total and dissolved metals or metalloids, in addition to significant exceedance of ecological or drinking water guidelines for arsenic.
- The above pattern of metal / metalloid elevation in groundwater was repeated in samples taken from an adit discharging mine water in the historic mining area of Logantown to the west of the Bendigo – Ophir Gold Project sites.
- Inferences could be made that lengthier exposure to the atmosphere for the adit water samples allowed the operation of Acid Rock Drainage processes, increasing the metal / metalloid concentrations in mine water.

Groundwater Model Study

- The model study demonstrated that the bulk hydraulic conductivity measurements from the Rise and Shine field investigations, particularly for the Rise and Shine and Come In Time model domains were reproduced in model calibration / optimisation, albeit towards the lower end of the hydraulic conductivity distribution.
- Model calibration / optimisation of the Srex model domain demonstrated that the bulk hydraulic conductivity for the Rise and Shine Shear zone and TZ 4 materials were significantly higher than measured for the same materials at the Rise and Shine deposit area.
- Recharge rates and creek bed conductances were found in the calibration / optimisation processes to be generally within plausible bands supported by hydrological conceptualisation.

4 Project Description & Proposals for Mining Complex Development

4.1 Gold Resource

The indicated gold resource of the Rise and Shine deposit is stated to be 2.0 million ounces of gold (Moz Au) @ 2.0 grams per tonne (g/t) cut-off between ore and waste, in accordance with the January 2024 estimate published in the recent Mineral Resource Estimate (MRE 2024). Inferred resources imply higher potential gold recovery but require further investigation and auditing to confirm. The gold is hosted in the upper shear gold mineralization 10-40 metres in thickness, above quartz vein and stockwork related gold mineralization that extends further to more than 120 metres below the upper shear gold mineralization. The indicated and inferred ore extents plus geotechnical considerations allowed the delineation of an indicated surface mining pit and underground mining panels to a minimum elevation of 115 m AMSL. This indicated pit shell and indicated underground panel extent defines the Rise & Shine mining proposal.

4.2 Surface Mining Proposals

The essential proposition of surface mining is that the mineralised schist of the geochemically altered Rise & Shine Shear Zone within the Rise & Shine gold deposit would be extracted and the overlying, non-gold-bearing schist concurrently quarried to expose the gold ore. The Project Description includes a 74.2-hectare (ha) full open cut pit with an ultimate depth of 250 m. The mine pit would extend north-eastward approximately 1,035 m from the Rise & Shine gully to the hillslopes above Shepherds Creek, with a pit base lying at approximately 395 m AMSL.

The pit would be started and extended from the Rise & Shine side of the Battery Hill ridge, beginning in the gully floor and extending north-eastward. Initial excavation would in this manner be able to take both ore and barren schist rock. The overlying barren schist rock is termed overburden and is generally broken into blocks and finer spoil to be handled separately for emplacement in Engineered Land Forms (ELFs), formerly referred to as waste rock stacks. The ore from the mineralised seam within the Rise & Shine Shear Zone (RSSZ) would be trucked to the Run Of Mine (ROM) stockpile for crushing, grinding and feeding into the ore processing plant.

The pit would extend through the Battery Hill ridge line and across the flanks of the slopes overlooking Shepherds Creek while steadily extending ‘down-dip’ along the alignment of the RSSZ mineralised zone. The water table would be intersected by the starter pit and management of seepage would begin early in the pit development. The ultimate RAS pit would stop short of Shepherds Creek itself and be battered on its internal slopes.

The surface mining at the Rise & Shine open cut pit would be extend over approximately eight years, excluding the initial construction phase. The early years of pit excavation would be dominated by the task of reducing the overburden within the Battery Ridge straddling the pit axis. The last few years of pit development would have a smaller proportion of overburden compared to ore extraction. Concentric batters would be cut into the pit slopes for optimal slope stability. A principal haul road would be formed on the northern side of the oval pit in view of the shorted haul route to the main ELF.

4.2.1 Engineered Land Forms

ELFs would be developed in the upper valley floors of Shepherds Creek, and Jean Creek inside the Shepherds catchment. The Shepherds - Jean creek ELFs would eventually coalesce as they grew in height and extent. The Western ELF would accept RAS and CIT pit waste rock and relieve the Shepherds ELF of the role of accepting all such waste rock. The Rise and Shine ELF would be placed so as to buttress the Tailings Storage Facility (TSF) on its downslope side within the Shepherds Creek valley.

4.3 Underground Workings Proposals

The underground proposal to access the gold ore would extend from the base of the open cut pit floor, while extending mining panels down dip along the RSSZ to extract ore with minimal overburden waste rock. The underground workings would be initiated from sub-horizontal drives parallel to the strike[3] of the fault plane of the TGF and 10 m to 30 m below the plane of the TGF into the RSSZ. The principal mining technique would involve a fan of holes that would be bored upwards towards the TGF to produce drill spoil containing gold ore (i.e., mineralised RSSZ schist). The upward groupings of holes are termed an overhand stope, or stopes in the multiple. The repetition of drives and stopes would progressively extend the underground workings down-dip along a width of 100 m - 150 m across the strike of the TGF. Underground workings would begin vertically beneath the northeast wall of the open cut pit at a roof depth of 440 m AMSL. The approximate duration of underground mining would also be seven and a half (7½) years. The down-dip progression would extend 830 m to the north-north-east at a mean rate of 105 m per year. The total ultimate footprint area of the workings would be 16 ha in extent, plus tunnel roadways and other developments outside of the immediate stope zones.

Tunnels of various types and uses would be generally 5 m wide and 5 metres height, although airleg drives would be smaller at 3 metres wide and 3 metres high. Stope drives and robbing stopes would be slightly shorter at 5 metres wide and 4.5 metres height. Later in underground mine ore winning, separations between the main groupings of stopes would be "robbed" to recover the ore in situations were lower risk to miner's safety prevailed. This would include "robbing" of the crown pillar between the underground workings and open cut pit towards the eleventh (11th) year of mining activities across the mining complex.

Ore and any waste is conveyed to the mine portal for trucking to the ore processing plant. Much of the tailings are ground and filtered to form an injectable paste by slurry line for return into completed stopes and some 'robbed' pillars. The extraction of ore using the underground stopes would thus be balanced by the emplacement of cement tailings paste, as is common practice in modern underground gold mining (Cacciuttolo & Marinovic, 2023). Roof collapse and development of a goaf[4] above the underground workings is unlikely.

4.3.1 *Access Drifts & Other Drives*

The mining panels of the underground would be accessed by three main tunnelled drives:

- The Access Drift from the surface portal,
- Roadways following the dip of the RSSZ providing entry to mining panels, and
- Strike-parallel drives arranged across strike.

The subsurface access is supported by a portal at the land surface. The portal area arranges the wheeled traffic transition, pipelines and other services exchanged between the surface and subsurface infrastructure.

4.3.2 *Mining Stopes*

Underground drives would be developed by drill & blast, with stopes excavated using a fan of drills from the drive below. Crushed ore would be conveyed to the surface as the stopes are extended. The ore would also be delivered to the ROM stock pile and feed the ore processing plant.

Water rock tailings would be ground into a paste with cement and water added to form a viscous paste that is pumped within HPDE or steel pipelines until it arrives at the sites of emplacement (Cacciuttolo & Marinovic, 2023). Following ore processing the tailings would be injected into the completed mining panels to fill the panel void from floor to roof. Since the tailings are cemented and once solidified would be in the order of 1×10^{-10} m/s for hydraulic conductivity, the workings backfilled with tailings would be effectively the same or

[3] Strike is a geological term referring to an orientation to the horizontal scribed across a structural plane. In the case of a fault surface, if the fault dips (is inclined) north than the strike would be east, i.e., the strike line runs west to east.

[4] Goaf definition: That part of a mine from which the ore has been extracted and the space more or less filled up with caved rock.

lesser permeability of surrounding rock. This would leave the infilled stopes effectively inert in terms of groundwater throughflows.

4.4 CIL Ore Processing Plant

The ore processing plant would be sized to accept and process 1.5 million tonnes of ore each year at a peak capacity of 4,500 tonnes per day. The Carbon In Leach (CIL) process would involve:

1. **Crushing and Grinding**: The gold ore is crushed into a fine powder.
2. **Cyanide Leaching**: The ground ore is mixed with a cyanide solution to dissolve the gold.
3. **Adsorption**: The gold-cyanide solution is passed through activated carbon to adsorb the gold.
4. **Elution**: The loaded carbon is subjected to elution to strip the gold from the carbon.
5. **Electro-winning or Smelting**: The gold is recovered either by electrowinning or smelting, depending on the chosen recovery method. Refinement of the recovered gold may also be required depending on impurities.

The main fluid and solid end-products of processing would be as follow:

- Decanted mine water,
- Tailings, either:
    - Tailings (conventional wet tailings) from surface mining destined for the TSF, or
    - Cemented tailings paste for injection into underground workings,
- Gold concentrate, and
- Minor sludges and precipitates.

The decanted mine water would join the mine water loop, including water treatment and monitoring for principal contaminants before discharge.

4.5 Waste Management from Surface Mining

4.5.1 Tailings

Conventional tailings management is envisaged for the Rise and Shine pit mining.

4.5.2 Tailings Storage Facility

A Tailings Storage Facility (TSF) would be formed behind an impoundment structure across a north-eastern tributary of Shepherds Creek. A large mass of waste rock would be lain against and tiered down the same tributary gully to beyond the Jean Creek confluence. In this manner, the TSF impoundment would be substantially and comprehensively buttressed against slope failure. The tailings from surface mining would be conveyed by slurry lines to the TSF. Further dewatering of the tailings would occur at the TSF as mine water supernatant separates from settled tailings, leaving a pond of mine water atop the tailings 'beach' and wholly behind the Tailings impoundment.

At times, the TSF would be used to store mine-impacted water as a buffer against water accumulation in the mine water system. Seepage collector pipes from the TSF, particularly chimney drains at the impoundment would be lain along the base of te downstream ELF buttress as far as the seepage sump, above the Shepherds Creek silt pond.

4.6 Waste Management from Underground Mining

4.6.1 Cemented Tailings Paste

Tailings from the mining of underground ore would be returned to the completed workings and emplaced so as to fill the drives and stopes opened up in the removal of the ore. The emplacement of cemented tailings would provide *de facto* pillar support to the roofs of the underground workings. The return of underground tailings would also avoid the addition of conventional tailings following the completion of surface mining.

4.7 Aggregate Borrow Pits

The BOGP mine construction tasks would require supplies of aggregate as crushed brown schist and weathered gravel. The development proposal includes plans for two aggregate borrow pits (see Figure 14). The borrow pits occur on terraces overlooking the Shepherds Creek main stem alluvium to the west. Geologically, the area of the borrow pirs are noted as Early Quaternary gravels overlying TZ-3 schist. The uppermost schist would be expected to be oxidised and weathered to moderate depth beneath the gravel deposits.

Figure 14: Aggregate borrow pits in lower Shepherds Creek area, marked 'a' in white shading

4.8 Water Supply

A number of mine operations and ancillary services would require make-up water as part of their process. While many of the processes, such as ore processing or dust suppression, would be capable of utilising mine water, some would specify clean water, such as drinking water. At different stages of the project operations, the mine water available would not be sufficient to provide make-up water for the processes capable of using mine water. External make-up water would be required to fill out the water requirement. So, balancing of water requirements and mine water availability would necessitate the availability of clean water top-up. The initial commissioning phase of the processing plant operation would also ideally be provided by the clean water supply.

Water supply options study identified that obtaining water supply from surface water other than the Clutha River / Mata Au would run into limited allocation and competition of water with irrigators in the Bendigo – Tarras district. This study was formulated in the context of the tributary catchments of the Clutha River / Mata Au in the Bendigo – Tarras district as being water-short, and there being competition for water resources. Smaller creeks and river tributaries tended to be over-allocated in the water resource context, therefore potential sources such as the Lindis River mainstem, Thomsons Creek, Bendigo Creek, or Lindis catchment tributaries were excluded from the options short-list. Thus, the Bendigo Aquifer and Clutha River / Mata Au were the singular water resources in proximity to the Rise & Shine mining complex envisaged.

The proposed rates and volume of groundwater takes set out in Table 9, below.

Table 9: Proposed Consent Pumping Rate and Volume Requirement

	Rate or Volume	Explanation
Maximum Instantaneous (L/s)	120	Peaking rate for very short periods of no more than 6 hours.
Maximum Daily (L/s)	110	
Maximum Daily (m^3/d)	9,504	Instantaneous rate multiplied by 86.4
Maximum Monthly (m^3/month)	285,120	Daily rate multiplied by 30
Maximum Annual (m^3/year)	3,153,600	90 L/s multiplied by 86.4, multiplied by 365

Table 9 outlines the proposed consent envelope rather than the estimated rates of actual use. As outlined above, the dust suppression water demand would be dictated by wind run and soil moisture. The make-up water requirement of the ore processing plant would be moderated by the availability of mine water to augment aqueous throughput. The bore field would be operated to smooth out water throughput rather than provide all requirements. Environmental assessments would use the values provided in Table 9, above.

4.8.1 Clean Water Requirement

The mine water balance model was used to estimate the clean water requirement for the main phases of mining operations, including construction, commissioning, continuing operations, wind-down and decommissioning. It was found that the peak clean water make-up water requirement for the Bendigo – Ophir Project Mine Complex would be 100 L/s. Much of the water requirement would arise in the first years of mine operation during a period that mine water from pit and underground dewatering surplus would be lowest. Seasonally, the summer and late summer period would entail the highest demand for water for use in dust suppression. Ore processing plant through-put rates and therefore water demand would be variable in accordance with the short-term stripping ratio, but not seasonal other than the increase in dust suppression water demand in hot, windy conditions.

4.8.2 Bore Field

It is proposed that a bore field would be established, tapping the Bendigo Aquifer near State Highway 6. Comprising two bores, a duty and stand-by bore, with individual capacities of 110 L/s, the bores would be fitted with electric submersible pumps controlled by Variable Speed Drives (VSDs) for flexibility of the rate of bore pumping. Due to the known high transmissivity of the Bendigo Aquifer, the bore being pumped would experience only nominal amounts of water level decline (drawdown) within the bore chamber of 400 millimetre diameter. The external effects of groundwater level decline is dealt with in more detail in the effects sections.

4.8.3 Water Conveyance & Storage Infrastructure

The bore field site lies approximately 6.5 km from the main ore procession area and the clean water reservoir. The supply bore field would connect with the mining complex by a buried HPDE pipeline to the clean water reservoir.

4.9 Rehabilitation

A gold mine is unique in being a temporary industrial setting often within an existing more natural environment. The economic gold resource is finite and the eventual exhaustion of the economically feasible resource is an inevitability. Thus planning for End of Mine Life (EOML), restoration and rehabilitation land or habitats affected by mining relate activities would begin before mining complex construction. The estimated operational mine life would involve 1.5 years of pioneering earthwork to remove overburden, 8.5 years for surface mining followed by 7.5 years of underground mining that begins 4.5 years into the operations period. There is an overlap in the production of surface mining and underground mining. Satellite surface mining pits at Come In Time, and Srex, and Srex East would be begin producing late in the operational mine life. The best estimate of EOML is 11 years after the onset of operations. Following the end of each sphere of mining would trigger associated rehabilitation steps.

Much of the restoration and rehabilitation target entails mining-affected land. However, restoration and rehabilitation also includes aquatic environment such as water lines, creeks and wetlands. The End of Mine Life would result in the rehabilitation of the mine void remaining after surface mining. Internal pit drainage would be changed to ensure appropriate erosion and sediment control of the pit slopes. A pit lake would form at the base of the mine void.

4.9.1 Surface Mining Rehabilitation

The rehabilitation of the surface mining elements involves a larger number of elements involved in rehabilitation processes. These elements include -

- Open cut pit,
- Engineered Land Forms (ELFs),
- Tailings Storage Facility (TSF),
- Water Management facilities, and
- Haul roads and other disturbed surfaces.

Beyond the mining complex elements named above, the extended environmental effects of surface mining would attract forms of rehabilitation, offsetting restoration or other forms of compensation for environmental impacts that would resemble rehabilitation. This could include progressive decommissioning of drains that alter groundwater flow patterns and return to more naturalised swale and creek networks.

4.9.1.1 Post-Closure Management of the Rise and Shine Pit

The Rise and Shine surface mining pit would cease operation with the base of the excavation at 385 metres AMSL. Upon the shutdown of dewatering pumps, the dewatering sump(s) would begin to fill, flooding the floor of the pit as a pit lake formed at rates governed by groundwater inflows, incident rainfall and any intentional discharges of mine water into the pit.

The pit lake would have an outlet into the top of the underground mine, so the formation of the pit lake would need to be halted to avoid the lake water entering the underground workings. This restriction would be maintained out of necessity to avoid water interconnection between the post-closure surface pit and the underground workings. Upon the closure of the underground workings and the removal of care & maintenance controls, the surface pit water level would rise towards the penetration of the pit wall by the underground stopes. Renewed dewatering would be instituted to prevent the pit lake from entering the stopes or presenting a water inrush risk to any personnel within the underground workings. Following the closure of the underground workings, post-closure management would entail the drainage of the closed residual pit into the underground workings via the wall penetration, and flow outward to Shepherds Creek through the former surface access portal.

The ultimate post-closure state of the con-joined surface and underground workings would include the Rise and Shine pit lake over-topping into the pit wall penetration of the underground workings with the ultimate pit lake water level controlled by either the sill level elevation of the penetration or the over-top level elevation at the former underground portal. Management of the post-closure mine water discharge from the underground portal would form part of the post-closure water quality planning, including passive treatment and the most appropriate mode of the water re-joining the creek system.

4.9.2 Underground Mining Rehabilitation

The use of cemented tailings paste is both an avoidance of operational effects on groundwater, and rehabilitation of the subsurface workings in terms of the longer-term effect that would potentially otherwise occur. Rehabilitation of the mine portal area following the End Of Mine Life (EOML) would also be undertaken. Any subsidence surface cracking around the portal zone would be filled and covered. Filling covering rehabilitation of surface cracking would mitigate potential effects such as infiltration of runoff with effects on slope stability and changed groundwater recharge.

Due to the penetration of the base of the surface mining pit by the uppermost stopes, the pit lake over-flow would eventually be established as a through-flow pathway for excess water. Accumulated water as groundwater inflow or rainfall falling inside the pit would enter the closed pit and exit the residual underground workings at the former mine portal at an elevation approximating 490 metres AMSL. There would be a mixing pit lake water and groundwater within the underground workings during the transit of the shallower parts of the workings before outflow at the former mine portal within an engineered drain.

4.9.3 Ore Processing Plant Rehabilitation

The ore processing plant may have a life beyond the life of the surface and underground mining associated with the Rise & Shine deposit. Satellite deposits such as Come In Time, Srex, and Srex East have the potential to provide ore that requires processing and would be most efficiently processed within the existing ore processing plant. However, once the ore processing plant is no longer required, it would be deconstructed, and the plant footprint rehabilitated by soil clean-up and revegetation.

4.9.4 Water Supply Bore Field Rehabilitation

Disused water bores would be decommissioned by extraction of screen and casing, if technically feasible. The screen or casing may become bonded to surrounding soil particles making the removal of these buried structures infeasible. The open hole or the residual structures would be filled with impermeable concrete and capped to prevent the ingress of contaminants in accordance with the New Zealand Environmental Standard for drilling of soil and rock (NZS 4411:2001).

4.10 Mine Phasing

A preliminary schedule for mine phases has been developed for mine and environmental management plans. The schedule considers the more significant thresholds to be as follow:

- **Startup:** Initial and preparatory development,
- **Project Development:** Construction of infrastructure necessary for managing water plus pre-stripping of soils to storage sites and overburden to the embryonic Engineered Land Forms,
- **Initial Surface Mining and Development of Underground Structures:** The first removal of gold ore at the Rise and Shine Pit, followed by the start of features such as the portal and access drift for the underground workings,
- **Initiation of Underground Mining,**
- **Initiation of Surface Mining at CIT, Srex east and Srex Satellite Pits:** RAS Pit and RAS Underground would continue mining through these ore feed changes. Blending of ore would optimise ore processing.
- **Shut down of all Surface and Underground Mining,**
- **Active Closure:** Completing Engineered Land Form and Tailings Storage Facility, plus the deconstruction of the processing plant and other structures, and
- **Post-Closure:** Passive water management and monitoring at the End of Mine Life (EOML).

4.10.1 Details of Schedule

The phasing of these components of the Bendigo – Ophir Gold Project (BOGP) are specified further in Table 10. Table 11 includes a summary of the timing and duration of the main surface and underground mining centres, including the Rise and Shine Complex and satellite pits. Furthermore, illustrative and annotated aerial photograph maps of the BOGP mining development and rehabilitation phases. The order and context of these maps are summarised as follows:

Startup	Figure 15
Project Development	Figure 16
RAS pit mining on its own	Figure 17
RAS pit plus RAS UG	Figure 18
RAS Pit plus RAS UG plus CIT Pit	Figure 19
RAS Pit plus RAS UG, plus Srex	Figure 20
RAS UG continues on its own.	Figure 21
Closure: All mining halted	Figure 22
Post-Closure: Periodic maintenance and monitoring	Figure 23

Table 10: Schedule of Mining Phases and the timing of each Phase through the planned Bendigo -Ophir Gold Mine Project.

Month Range	Year Range	Mining Phase	Description of Phase	Figure No.
0 to 6	Year 0 to 0.5	Startup	Pioneering / RAS Pre-Strip, Initial Jean Creek Silt Pond preparations, earthworks at process plant.	Figure 15
6 to 24	Year 0.5 to 2	Project Development	Construction of process plant, TSF, Shepherds Creek Silt Pond, North Diversion Channel, Shepherds ELF preparations and early construction, Main haul road established (ROM – RAS – ELF/TSF), Commissioning, mining RAS pre-strip (Pre-strip ends month 19).	Figure 16
25 to 54	Year 3 to 4.5	RAS pit mining on its own	Operations (Pit ore production in month 20. Process starts about month 22. UG Development months 48 – 54.	Figure 17
54 to 72	Year 4.5 to 5	RAS pit with UG development	Operations (UG Ore production begins month 70 -)	
72 to 132	Year 6 to 11	RAS pit plus RAS UG	Operations (UG Ore production months 70 to 150)	Figure 18
		RAS Pit plus RAS UG plus CIT Pit	Operations (CIT Pit mined months 102 to 114)	Figure 19
		RAS Pit plus RAS UG, plus CIT backfilled, plus Srex	Operations (Srex Pit mined months 145 onwards)	Figure 20
120 - 160	Year 10 to 13.3	RAS UG continues on its own. Srex open pit feeds	Operations (all mining halted month 160)	Figure 21

Month Range	Year Range	Mining Phase	Description of Phase	Figure No.
160 - 372	Year 11 to 31	***Closure***: All mining halted, active closure activities	Active closure of pits, TSF, and wider site, plus setup of active water treatment plant (option)	Figure 22
372 -	Year 31 onwards	***Post-Closure***: Periodic maintenance of passive systems and monitoring	Passive treatment and maintenance	Figure 23

Abbreviations:

RAS	Rise and Shine
CIT	Come In Time
UG	Underground
ROM	Run Of Mine
ELF	Engineered Land Form
TSF	Tailings Storage Facility
"Pre-Strip"	Initial stripping of soils and overburden prior to mining

Table 11: Summary of schedule ore producing month range and duration of main elements

	Month Range	Year Range	Duration in months (and years)
Rise and Shine Pit	24 - 132	Years 2 - 11	108 (9 years)
Rise and Shine Underground	70 - 160	Years 5 ¾ – 13 ¼	90 (7 ½ years)
Come In Time Pit	102 – 114	Years 8 ½ – 9 ½	12 (1 years)
Srex Pit	144 - 160	Years 12 – 13 ¼	15 (1 ¼ years)

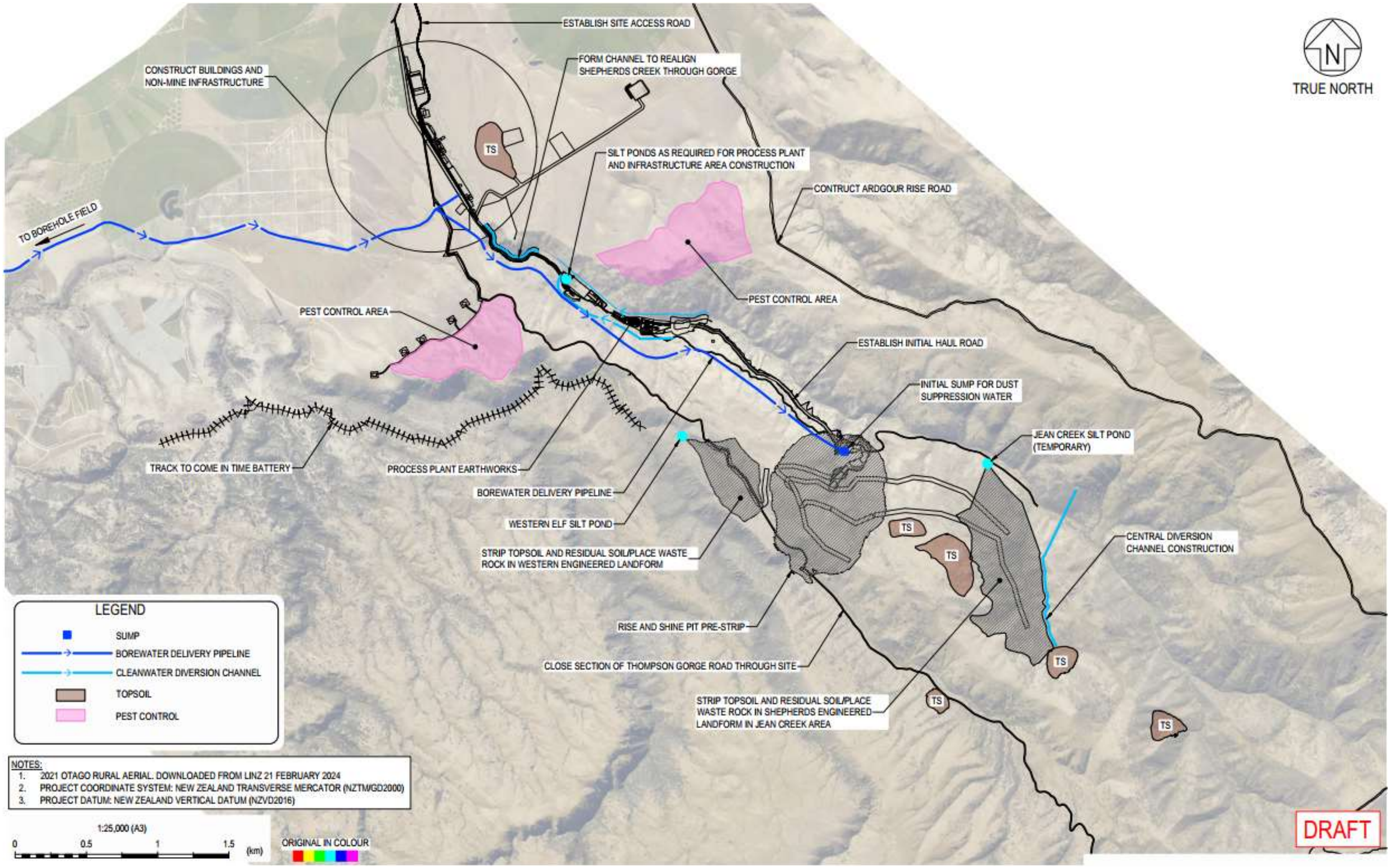


Figure 15: Start-Up, Month 0 – 6 activities: Pioneering / RAS Pre-Strip, Initial Jean Creek Silt Pond preparations, and earthworks at process plant.

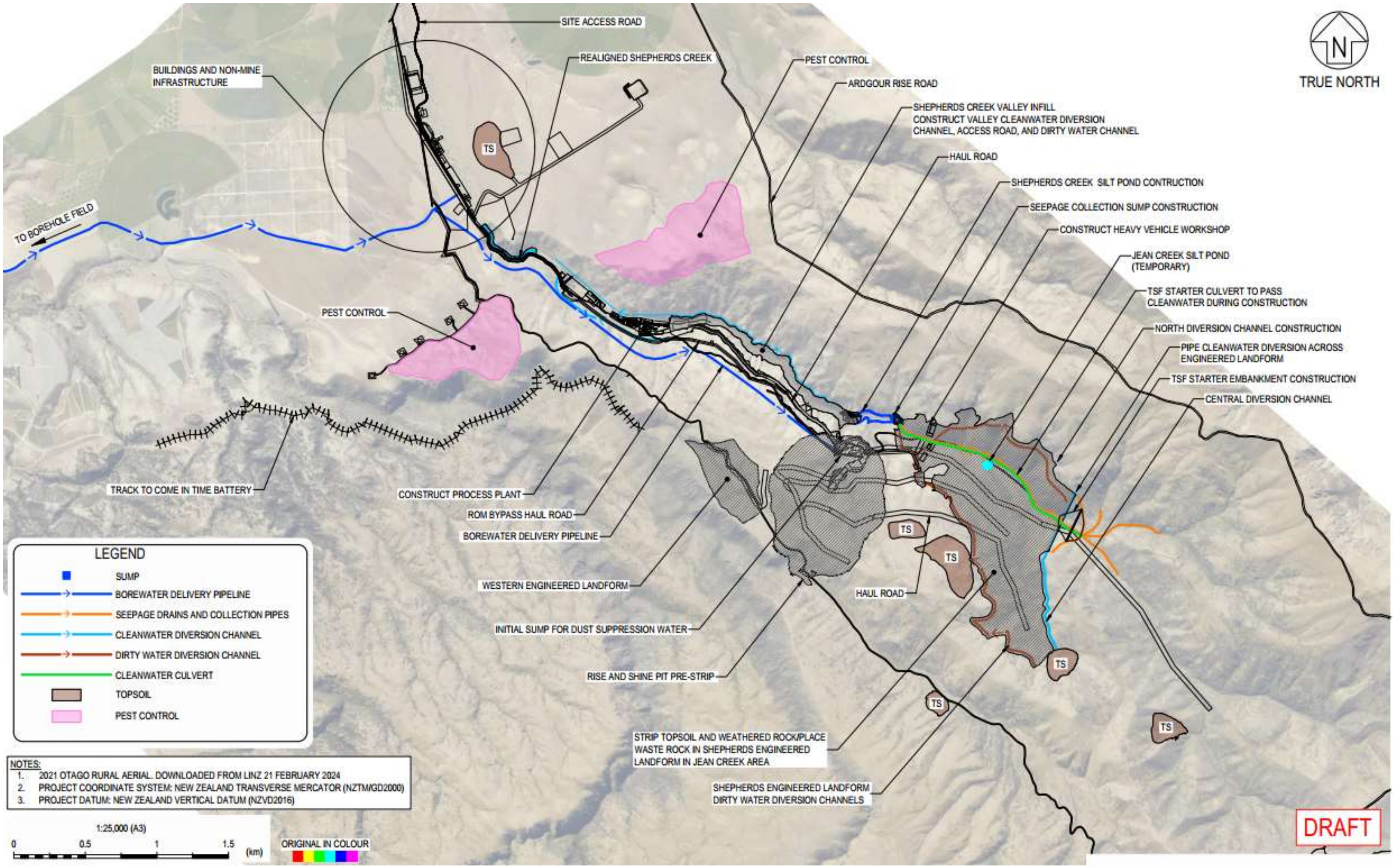


Figure 16: Project Development, Month 6 – 24 activities: Construction of Plant, TSF, Silt Pond, North Diversion Channel, Shepherds ELF prep. & early construction

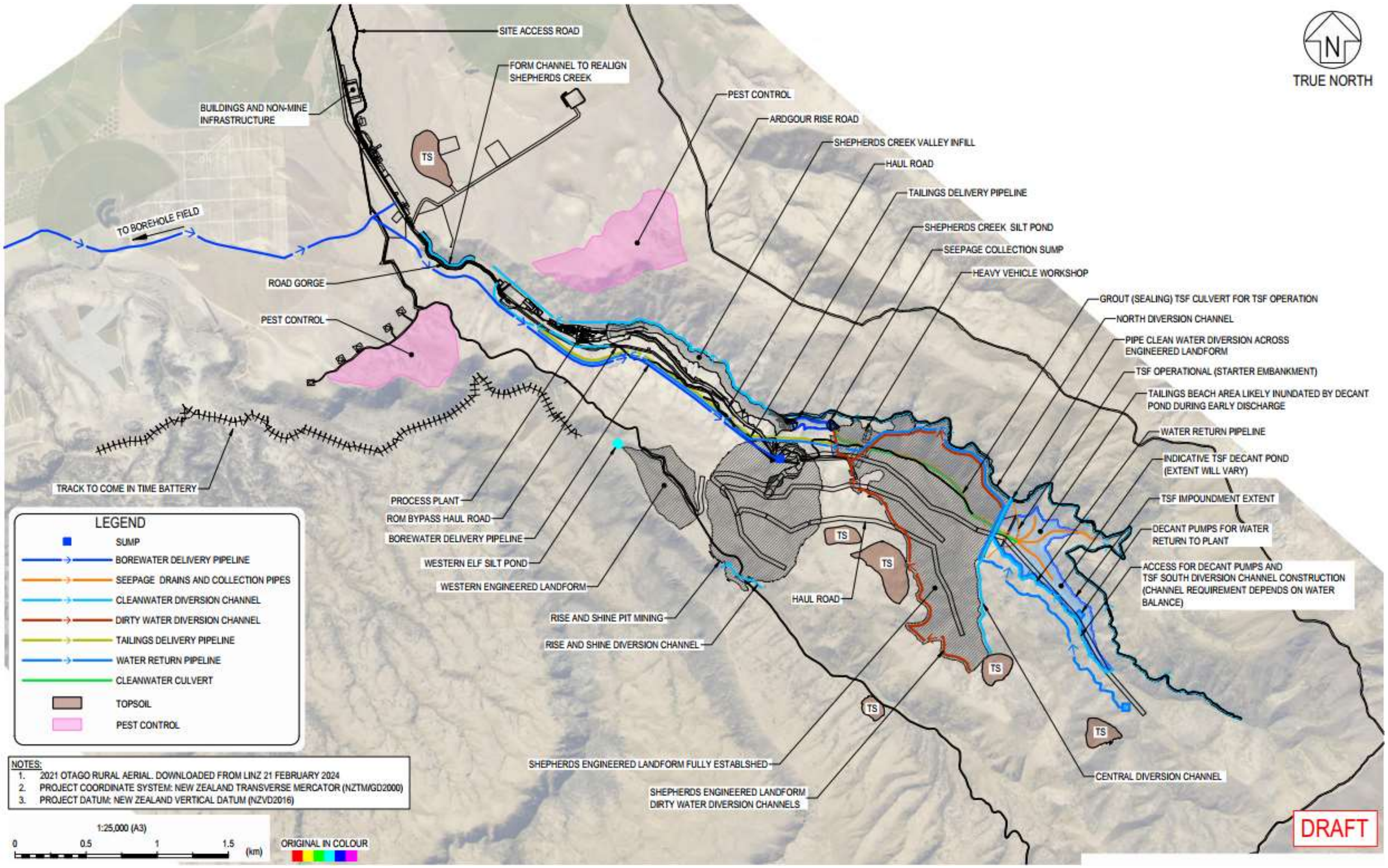


Figure 17: RAS Pit Mining, Month 25 – 54 activities: Surface mining producing and feeding processing, Underground development in months 48 – 54, without ore.

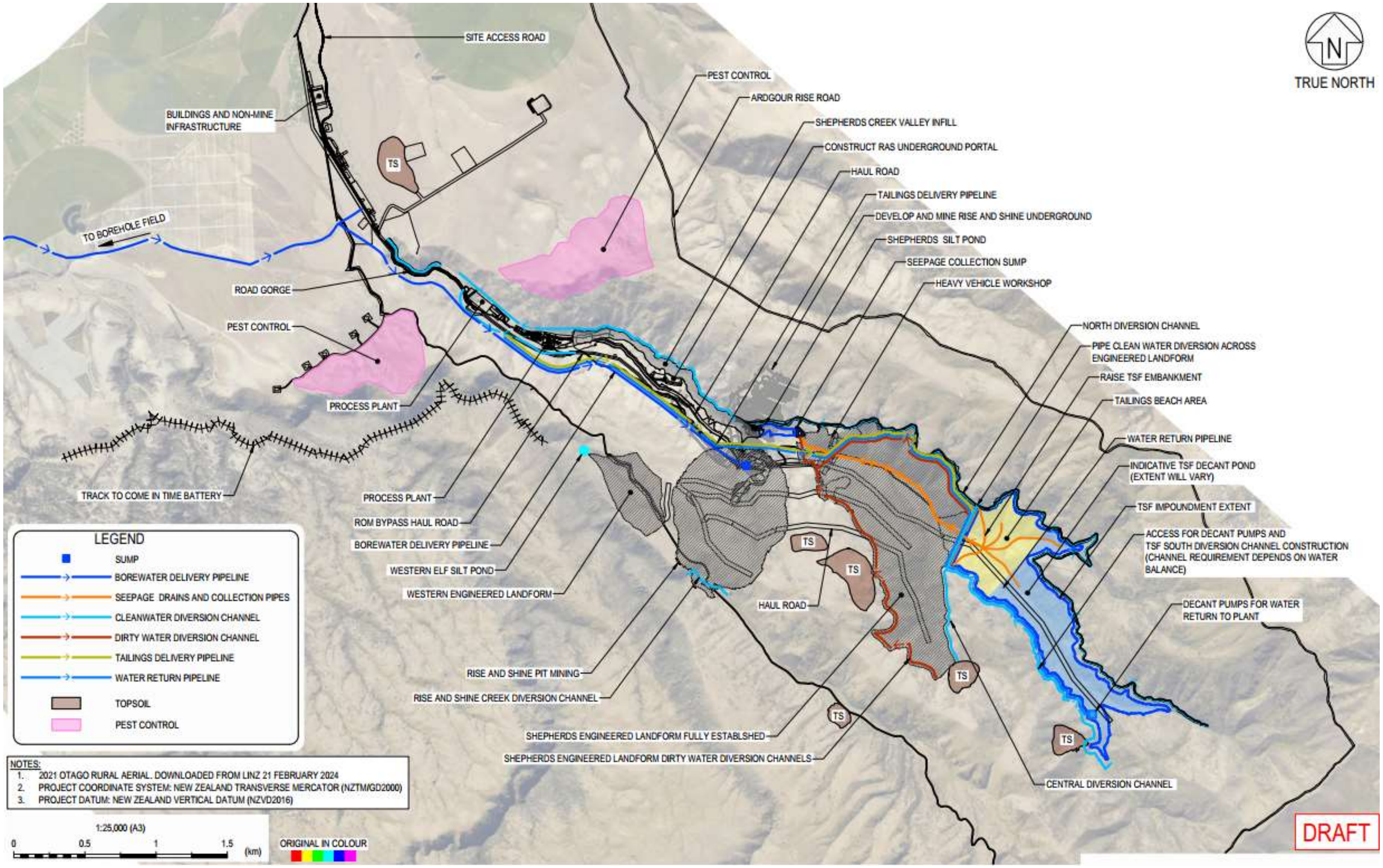


Figure 18: RAS Pit and RAS Underground Month 70 -150 activities (Note: Underground ore production from months 70 onwards)

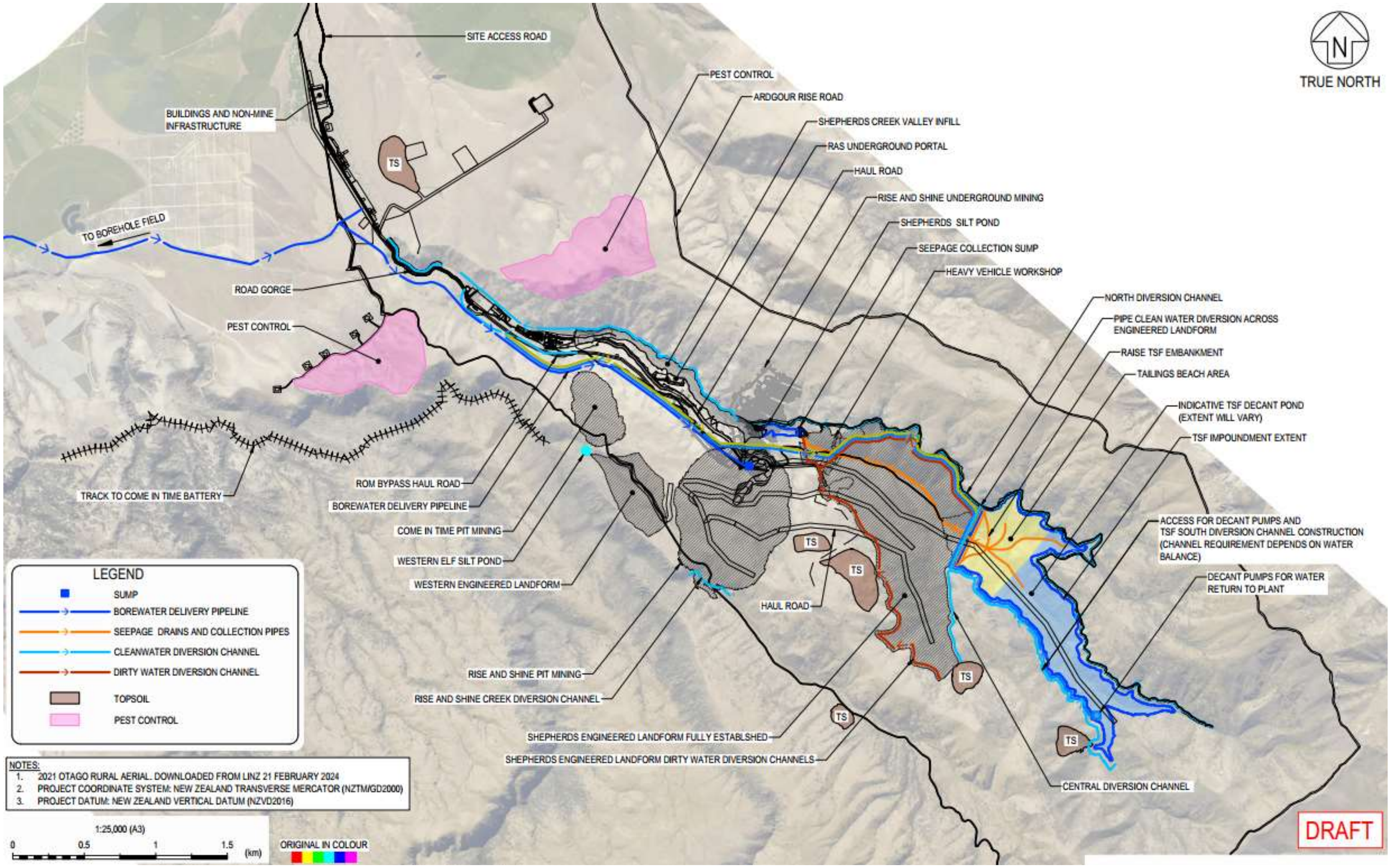


Figure 19: Come In Time (CIT) Pit surface mining in months 102 to 114

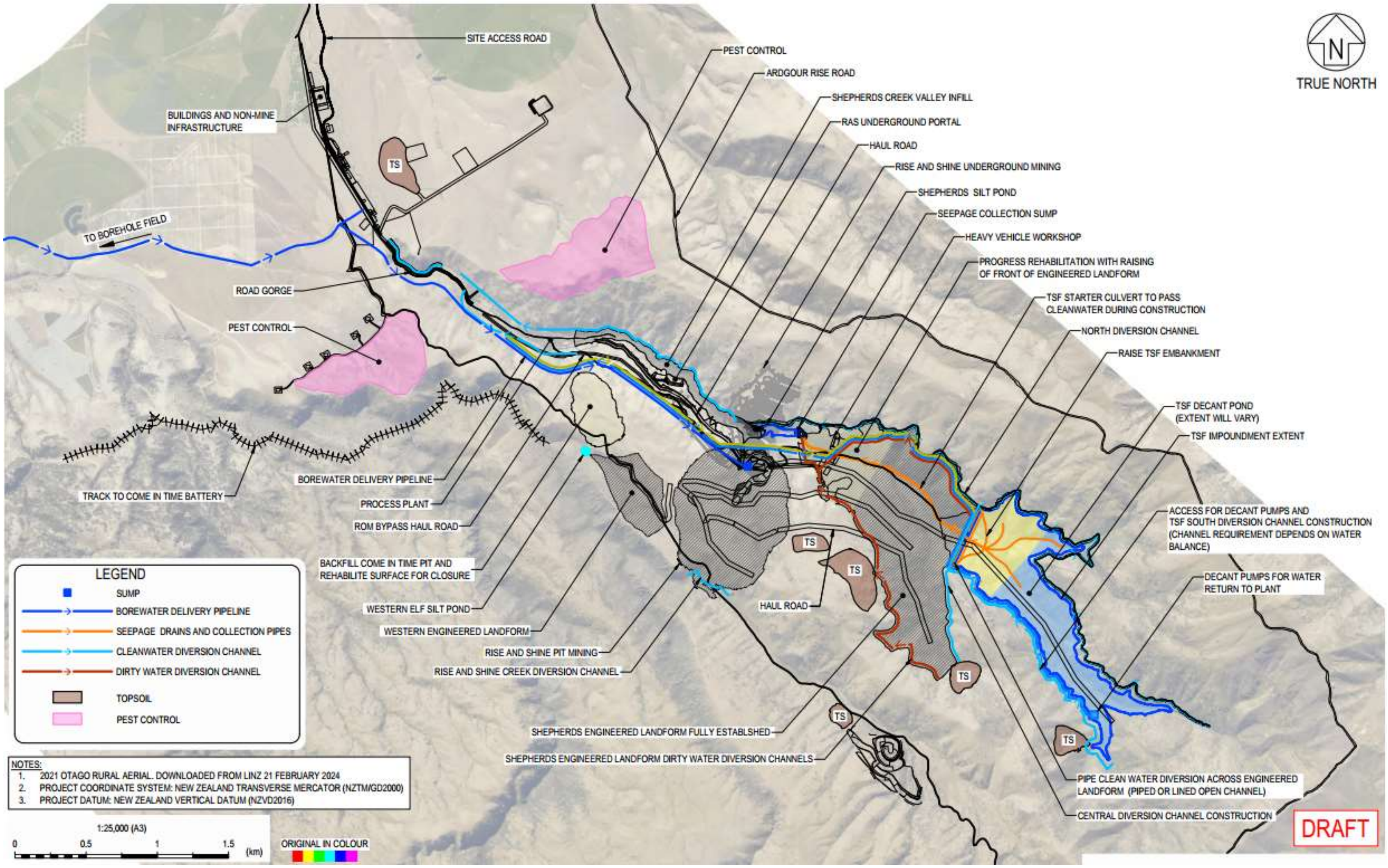


Figure 20: Srex Pit surface mining in months 145 - onwards

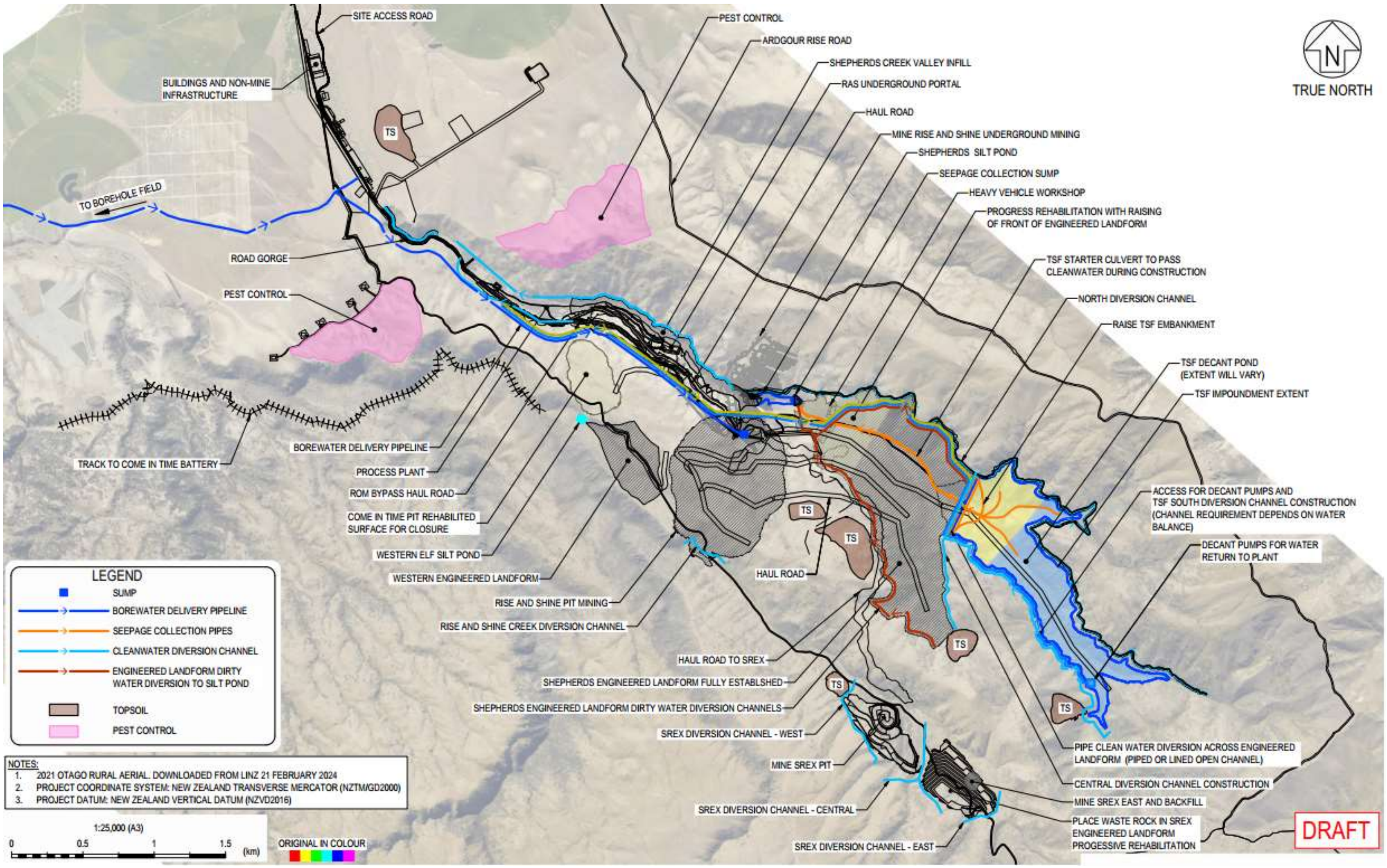


Figure 21: RAS UG continues on its own. Srex open pit feeds, months 120 – 160. All mining halts at month 160.

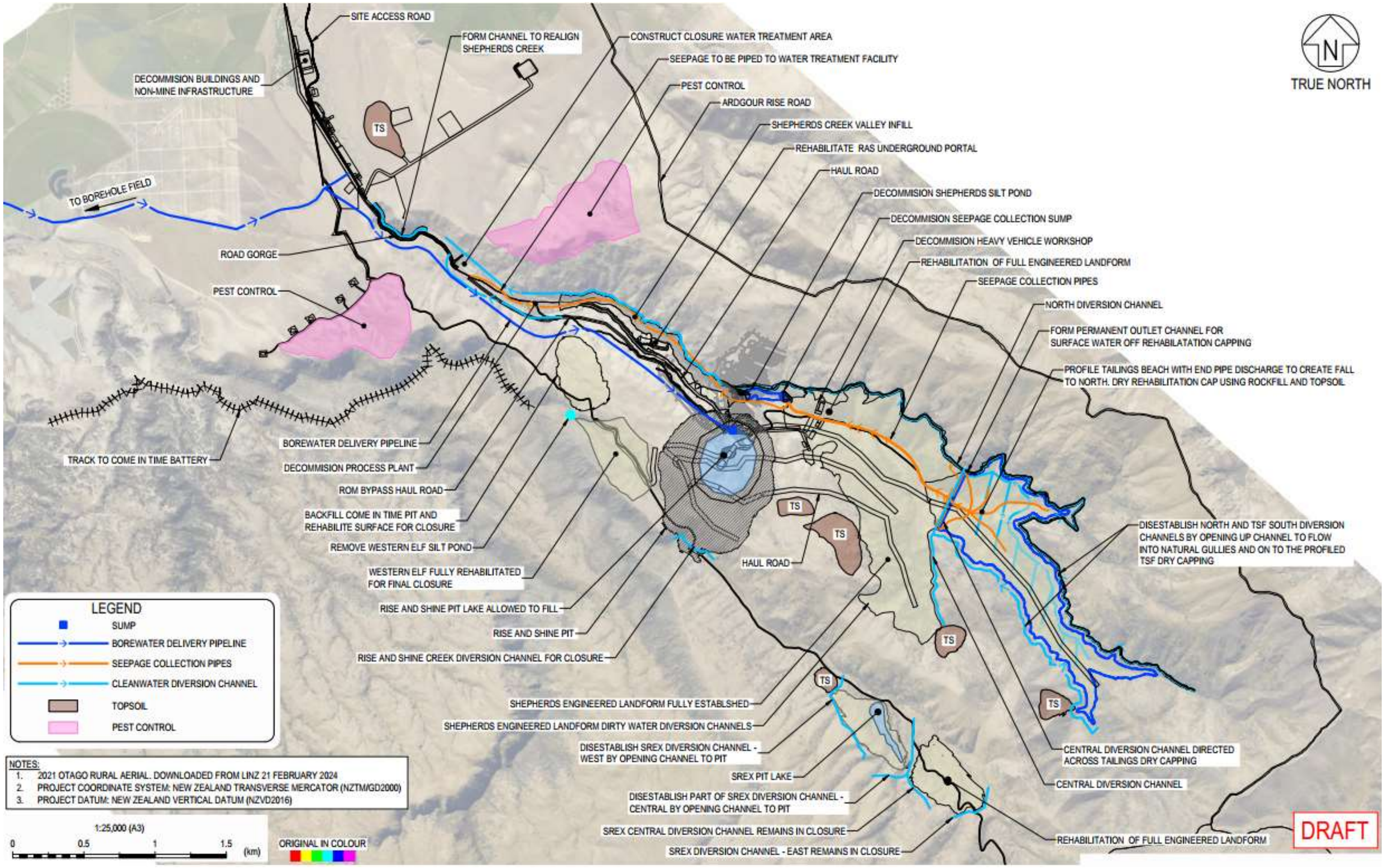


Figure 22: Active closure of pits, ELF, TSF, water management structures, and wider site months 160 – 372 (Years 11 – 31)

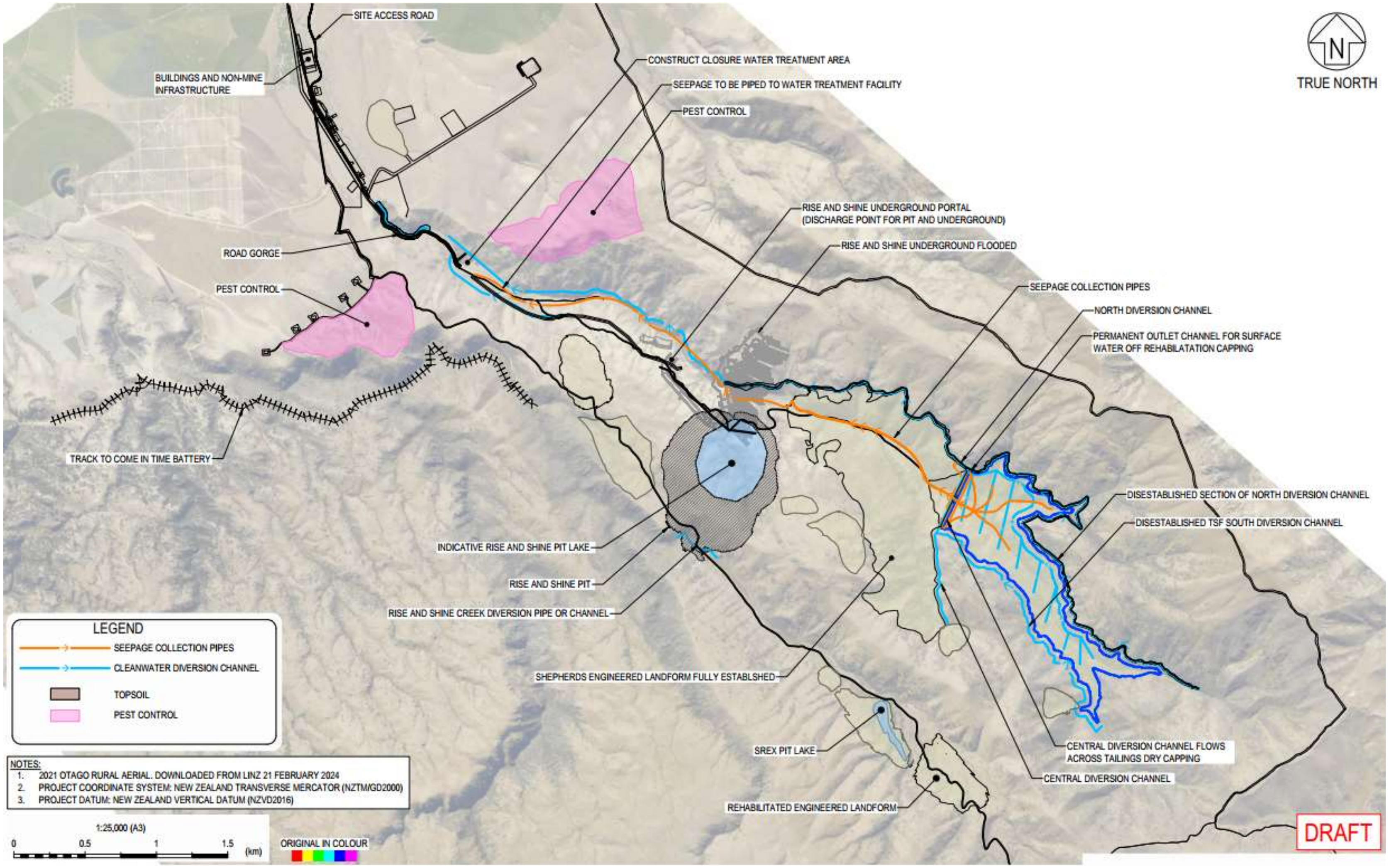


Figure 23: Post-Closure: Periodic maintenance of passive systems and monitoring, month 372 (Year 31 -) onwards

4.10.2 Tunnel Development - Detailed Schedule

As will be examined in the effects assessments for the underground workings the development of tunnels, of various purposes, would have a proportional effect on the rate of groundwater inflows. Therefore, an understanding of the timing of the projected development of the various drifts, roadways, adits and declines (grouped under the term of tunnels) is useful to the assessment of groundwater inflows to the underground workings as a whole. Table 12 breaks down the development of tunnels by mine year.

Table 12: Projected Schedule of Tunnel Development according to Mine Year in metres of Tunnel Length

Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Total
Access Drift (Decline)	1,567	3,097	4,097	3,034	0	0	0	11,795

Table 12 reveals that underground development is focused on Year 5, followed by tunnel development to prepare for mining of gold ore within stopes working upwards into Rise and Shine dominated gold ore bodies. Four years of intensive tunnel development would prepare the ground for areas of ore extraction. Once the access tunnels were constructed, tunnel development would decline and stop in favour of ore extraction at higher level stopes. Accordingly, Table 12 shows that tunnel development continues until Year 10, which marks the end of any significant extension of tunnel lengths. The close of the underground ore extraction activities would be marked by the 'robbing' of the crown pillar ore bodies and penetration of the Rise and Shine pit wall.

The total length of tunnels developed for the Rise and Shine underground workings would reach 11,795 metres on current projections. The mean tunnel dimensions are up to 5 metres by 5 metres in width and height (5 m x 5 m).

At the close of ore extraction activity, the underground workings would pass into active closure under 'care and maintenance', and transition into mine post-closure measures. A key part of underground mine closure is progressively decommissioning the dewatering sump pumps and mine ventilation, which also serves to remove water in humidity. Groundwater levels would progressively rise as groundwater pressure recover with the decommissioning of dewatering systems. The RAS underground would flood in the close of the Active Closure period. In the context of the Active Closure and Post Closure periods, the penetration of the surface pit by the ultimate stope extractions would tie the water levels between RAS underground and surface mines. The net surplus of groundwater inflow and incident rainfall to the RAS mining complex would discharge from the former access portal.

5 Assessment of Groundwater Effects Arising from Proposed Activities

5.1 Background

Having outlined the nature and scale of proposed activities within the context of the existing environment, the task of this section of the document is to define and make predictions of consequent effects. The opportunities to avoid, mitigate, and monitor potential effects are further examined in the next section.

5.2 Pit Dewatering

5.2.1 Potential Effects

Dewatering to allow mineral extraction is a potential effect of the proposed mineral project that could affect surrounding aquatic features. Surface mining is proposed to include a single 260 m deep (385 metres AMSL at base) conventional open cut pit at the conclusion of surface mining. The excavation can only be undertaken in a largely dewatered state to allow the blasting of pit walls and floor, mucking out of blast spoil, and extraction of ore from the pit floor as the excavation extends down dip. Temporary sumps in which inward seeping groundwater and net rain falling over the pit footprint would be collected, would be the primary site of pumping to maintain a largely dry excavation. As outlined in the project description, Dewatering pumps located at the pit base sump(s) would be connected to the mine water system by pipeline(s) ascending the pit walls.

The pit floor would extend below the zone of saturation within the schist within the first year of pit development, triggering the requirement for dewatering to desaturate the growing pit floor. Initial groundwater seepage inflows would be weak. With increasing depth below the original height of saturation (or water table), the volumetric rate of inflow would progressively increase with punctuated rate spikes on the excavation initially penetrating more permeable strata within the overburden or RSSZ rocks. The highest inflow rate of groundwater inflow is predicted to coincide with the completion of pit excavation, i.e., when the pit is at its greatest depth.

The principal effects of pit excavation and dewatering activities would be localised perturbation of the schist hosted groundwater system, as summarised below:

- Lowering of the water table and piezometric surface in the schist in inverse proportion to distance from the pit walls,
- Development of a substantial indent in the height of saturation surrounding the pit plus corresponding depressurisation through the pit’s successive stages of development,
- Consequent changes to the pre-existing groundwater processes, such as
    - Groundwater flow gradients and rates,
    - Contributions of groundwater to surface water baseflow.

Following the completion of surface mining, the pit dewatering would be curtailed and then drained through the shallow underground workings to the surface at Shepherds Creek. Inflowing groundwater would be removed by said drainage and ambient evaporation the pit lake surface. These processes are detailed further in subsequent sections.

5.2.2 Numerical Prediction of Dewatering Effects

Estimation and prediction of the dewatering effects at each of the main sites of mining related dewatering was undertaken by simulation of the anticipated conditions within a numerical model called MODFLOW 2005 in the FloPy implementation (Dumont et al., 2025). The development of the modelling platform was introduced in section 3.6 and further detailed in the groundwater modelling analysis report (Dumont et al., 2025).

5.2.2.1 Pit Inflow Calculations –RAS Pit

Open cut pit inflow, i.e., groundwater 'make', can be estimated using numerical, finite difference models. In the case of the RAS pit, a model of the upper Shepherds and Rise & Shine creek catchments surrounding the mining complex was developed in model packages named MODFLOW 2005 (Harbaugh, 2005) and FloPy (Hughes et al., 2023). The groundwater flow model considered four separate Hydro-Stratigraphic Units (HSUs):

- Superficial regolith and highly weathered schist unit,
- TZ 3 schist fractured rock unit,
- Rise and Shine Shear Zone (RSSZ) unit, and
- TZ 4 schist fractured rock unit.

This HSU simplification allowed discretisation of fractured-rock groundwater properties. The superficial HSU was removed from explicit simulation within MODFLOW 2005 but was the subject of water balance pre-model calculations. MODFLOW 2005 was explicitly modelled within the TZ-3, RSSZ and TZ-4 HSUs, while specified boundary conditions simulated the hydrological function of Shepherds Creek, Rise and Shine Creek, and the RAS surface pit. The hydrologic properties were optimised by running consecutive simulations and computationally comparing the model outputs mostly as groundwater levels with measured groundwater levels across the model domain.

In forward modelling mode, the model was able to simulate interim pit shells with drain cell linings from Year 1 to Year 8 for the RAS pit. Summarising the pertinent results for the ultimate (Year 8) Pit:

- Hard-rock flow units providing inflow of up to 5 litres per second,
- The superficial unit might provide 9 litres per second on average, mainly as interception of incident rainfall and run-on from the small surrounding catchment, and
- The combined (superficial and hard-rock) range in RAS pit inflow would be up to 12 litres per second.

5.2.2.2 Pit Inflow Calculations – Come In Time (CIT) Pit

Groundwater related activities of the Come In Time surface mining area were projected to result in the following:

- Hard-rock flow units provided inflow of 3.5 to 5 litres per second,
- The superficial veneer aquifer is largely uninvolved with the pit water balance as there is only a minor halo of affected catchment surrounding the pit edge,
- The depletion of Shepherds Creek flow was modelled as 1.7 litres per second.

A feature of the Come In Time pit is that it is intended to be back filled with waste rock rather than leaving the pit open. The waste rock backfill can be expected to have a strongly contrasting hydraulic conductivity, up to 1 x 10^{-4} metres per second (approximately 10 metres per day). Therefore, the backfill materials would be expected to fill with groundwater at rates governed by the schist rock inflow rate (i.e., <3.5 litres per second). The backfilled and groundwater flooded backfill waste rock in the pit base would progressively saturate with a water table elevation reflective of the rising hard-rock pressure rebound. When the equilibrium backfill water surface intersect the invert or pour-over point, a spring would eventuate. The pour-over elevation would rest at 503 metres AMSL, as shown in Figure 24, including the low gradient saturation level in the backfill and the spring with an elevation of 503 metres AMSL. The spring would receive the long-term excess rainfall collected within the backfill over the pit extent of 14.4 hectares (i.e., 0.17 litres per second[5]) and the interception of groundwater further back in the pit at higher pressure than the pour-over invert elevation, probably 1 – 2 litres per second.

[5] Based on the retention of 8% of incident rainfall over the Come In Time Pit percolating through the backfill capping and draining to the saturated zone within the backfill mass.

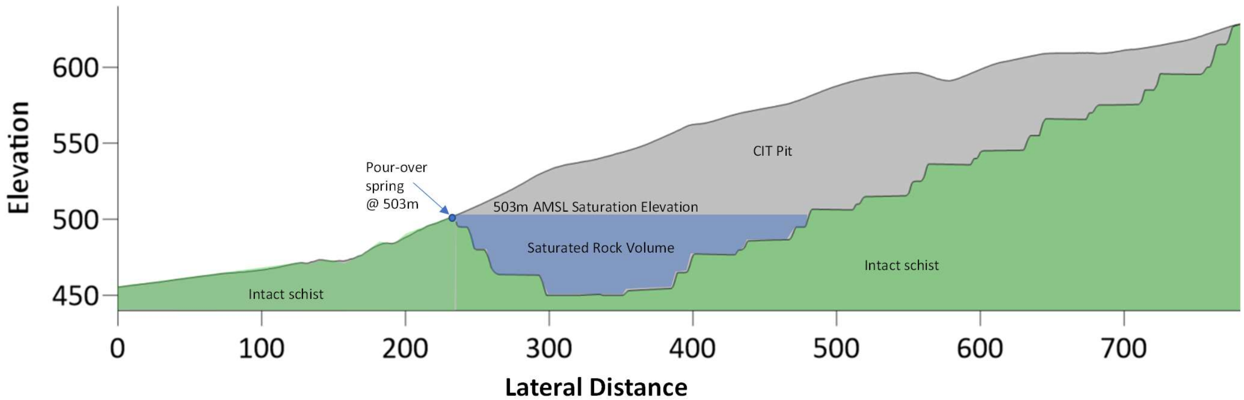


Figure 24: Profile through North- South axis of CIT pit illustrating saturated base and pour-over invert height

5.2.2.3 Pit Inflow Calculations – Srex Pit

Groundwater related activities of the Srex surface mining area were projected to result in the following:

- Hard-rock flow units providing inflow of up to 23 litres per second,
- The superficial veneer aquifer is substantially involved due to creek proximity, topography around the pit margins and the projected high hydraulic conductivity of the TZ 3 and RSSZ materials fringing the pit, and
- The depletion of Rise and Shine Creek flow was modelled as 17 litres per second and up to total upstream flow of the creek.

The Srex pit groundwater model projections were notable for indicating the elevated depletion of Rise and Shine Creek as a result of dewatering during the deepest excavation phase of the surface pit. The Srex pit would extend from the creek floodplain surface to a depth of about 50 metres below grade. The full depth excavation would create a downward hydraulic gradient promoting the inflow of groundwater from storage and the infiltration of surface water through TZ 3 and RSSZ materials towards the pit sump pumps. Following the cessation of ore extraction within the pit, sump pumps would be shut down allowing the pit to fill promptly with inflowing groundwater. Once the pour-over point on the pit margin was reached, a lake would form, and a discharge of groundwater would likely persist throughout the post-closure period.

5.2.2.4 Overlapping Pit Depletion

The surface mining pits within the Bendigo – Ophir Gold Mine Complex would impose overlapping effects during their operation, mainly in terms of modelled depletion on Shepherds Creek and Rise and Shine Creek. The overlap periods include the following instances:

- RAS pit depletion effect on Shepherds Creek and Rise and Shine Creek (Year 5 to Year 13.3),
    - Modelling indicated that the depletion effect of RAS pit dewatering on Rise and Shine Creek was up to 2 litres per second at peak intensity.
- Compounded depletion effect while RAS pit still under partial dewatering and SRX pit operational (Year 12.1 to Year 13.3),
    - Modelling indicated that the compounded depletion effect of RAS pit dewatering (2 L/s) on Rise and Shine Creek (15 L/s) reached up to 17 litres per second at peak intensity.
- CIT pit depletion effect on Shepherds Creek (1.7 L/s) while RAS pit already exerting depletion (up to 3.5 L/s) on the same creek leading to a combined effect of 5.2 litres per second (Year 8.5 to Year 9.5),

The overlap effects create some minor intensification of depletion effect on the respective creek catchments. However, the overlapping depletion effect may induce a bottleneck of significance to water resources and ecological values.

5.2.2.5 Summary of Modelled Dewatering Effects

Drawing together the separate models conducted to simulate the three model domains, the groundwater inflows and depletion effects mainly due to the hard-rock groundwater system is listed for each of the surface mining areas. The modelling analysis suggests that each inflow rate should be doubled to derive a conservatively high estimate of groundwater inflow at peak intensity. Table 13 list the modelled inflow rate, year in which peak intensity is anticipated, and associated capture of rainfall and runoff in the sub catchment surrounding the mine pit.

Table 13: Summary of Dewatering Duration, Hard-Rock Inflow Rate and consequent Depletion

	Duration	Hard Rock Inflow Rate (L/s)	Surface Water Depletion Rate (L/s)	Total Depletion (L/s) (Hard-rock and Catchment)	
				Shepherds Ck	**R & S Ck**
RAS Pit	11.3* years	5 *(Year 11 peak)*	0.5 – 3.5 *(Shepherds)*	5.2 (hard rock)	
CIT Pit	1 years	3.5 *(Year 9 peak)*	1.7 *(Shepherds)*		
SRX Pit	1¼ years	23 *(Year 12 peak)*	15.3 *(Rise and Shine)*		17.3 (hard rock)

Note: Groundwater modelling reporting noted the uncertainty surrounding each of this predictions of inflow, depletion and catchment capture. The report (Dumont et al., 2025) suggested that predicted rates could be doubled (100%) for additional conservativism. * RAS pit dewatering, at least partial dewatering, is required to continue until the conclusion of underground mining of the crown pillar.

Surface water management measures delineated for the Srex surrounds include several clean water diversions, particularly for those tributaries draining Mt Moka to the south, which involve the tributary flows being conducted around the operational Srex surface mining area (see Figure 21).

5.2.3 Uncertainty of Effects Prediction

There have been few comparisons of conventional dewatering effects prediction and physically measured dewatering effects to be able to comment informatively on overall uncertainty. The Victor Diamond Mine in northern Ontario, Canada, had the benefit of a comparison of initial modelling of hydrological effects of an open cut pit in open terrain surrounded by rivers, creeks, peat wetlands, and ponds (Gautrey, 2018) based on environmental measurements taken 11 years after the onset of dewatering. The comparative analysis found that the predictive analyses and modelling was conservative by over-estimated groundwater environmental effects.

5.3 Pit Lake Filling (Closure and Post-Closure Phases)

5.3.1 Potential Effects

Final voids left from surface mining is a common feature of mining across the world. In all settings other than arid climates, the final voids tend to fill with water following the cessation of sump pumping. Inflowing groundwater and runoff from incident rainfall would not be removed by anything more than ambient evaporation of pooling water at the pit floor. As the water based inflow exceeds evaporation, a pit lake would form and rise. Rain falling over the pit lake and rainfall generated runoff from the surrounding 'catchment' surrounding the pit walls would also contribute inflows of water to the formation of the pit lake.

Prediction of pit lake filling suggests that the pit would be full and overflowing within a few decades of cessation of sump pumping after the End Of Mine Life (EOML, i.e., post-closure). As such the pit lake would become a throughflow system, receiving groundwater from upgradient or radially and overflowing into the surface water system.

5.3.2 Prediction of Effects

The MODFLOW / FloPy groundwater simulation was of assistance in checking the assumptions made in the water balance, including the decay in the groundwater inflows to the Rise and Shine pit. The water balance of the RAS pit lake was carried out within the GoldSim simulation package (Mine Waste Management, 2025b).

The water balance tool was deployed to quantify the timing of closure and post-closure processes within the Rise and Shine (RAS) surface pit, and the hydraulic connection between closed surface pit and the eventually closed Rise and Shine underground mine. The intervening ore rock between the base of the pit and underground workings, termed the crown pillar, would be removed by stope mining at the conclusion of underground mining. Figure 25 illustrates the final pit profile, dewatering and the location of the crown pillar.

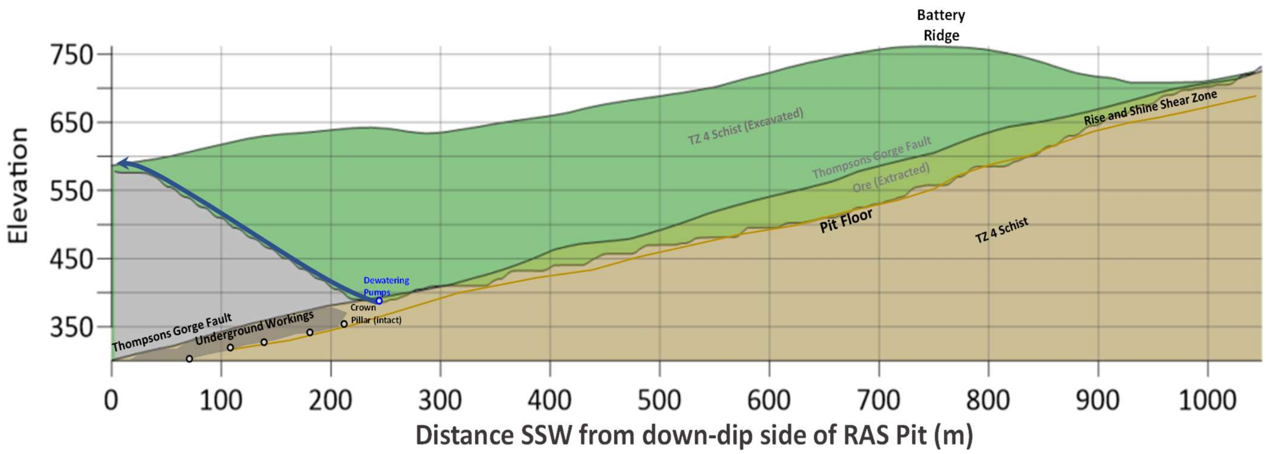


Figure 25: Profile through the RAS pit showing pit floor and U/G workings and pit dewatering before closure

Once the connected workings are clear of workers and the dewatering pumps can be shut down, groundwater plus incident net rainfall inflows would begin to accumulate in the underground and pit. Due to the penetration of the connection between the pit and crown pillar stope, water accumulating in the base of the pit would ultimately meet the underground workings and their water levels would become cojoined. Figure 26 illustrates the result of net inflow to the RAS pit to the point of water being able to exit the cojoined surface and underground workings via the access portal at an elevation of 490 m AMSL. Pit lake water level at between 490 metres AMSL would become a long-term state for the RAS workings in post-closure. Any excess water would discharge from the underground former access portal via the pit penetration and tunnels.

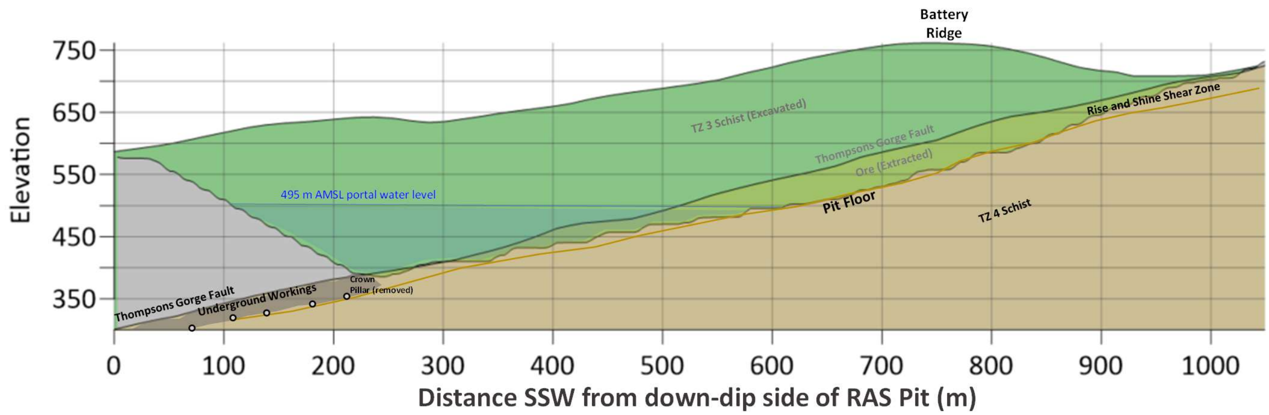


Figure 26: RAS pit profile showing the removed crown pillar and the pit flooded up to the portal elevation

The initial hard rock groundwater inflow was calculated as 5 litres per second, which is broadly congruent with the final dewatering rate determined in MODFLOW / FloPy groundwater simulations. The water balance ran and derived an approximate pit lake filling duration of 50 years after the cessation of dewatering for the pit lake water level to achieve a height of 490 metres AMSL.

The threshold from steady accumulation to a quasi-steady state at 490 metres AMSL would result in the pit lake level stabilising. Accordingly, the stabilised pit lake level would lie at 490 metres AMSL with the former underground access portal discharging net pit lake water make. Estimated pit lake catchment inflow across 34 years would be 8.8 litres per second. After the effects of interception, evapotranspiration and lake surface evaporation, the mean discharge from the pit lake at the former underground access portal was estimated at 4.5 litres per second, although monthly peaks up to 24 litres per second equivalent discharge flow rate could occur as a result of high rainfall – runoff events over the pit lake and surrounding catchment (Mine Waste Management, 2025b).

The hydrology of Shepherds Creek would change as a result of the restored drainage through the RAS pit and underground. Due to the buffering water volume of both former mine voids, the peaks of catchment runoff would be flattened and the discharging water flow would have a higher component of base flow (Mine Waste Management, 2025b). The continued interception of groundwater by the RAS pit in the post-closure period would entail a minor and continuing flow depletion of the nearby Shepherds Creek of between 0.25 and 0.5 litres per second. This depletion would affect only the middle reach of the creek and be 'paid back' following the return of drainage water at the former access portal.

5.3.3 Uncertainty of Effects Prediction

Substantial uncertainty would remain in the prediction of pit lake water accumulation and eventual drainage. Representative rainfall and evapotranspiration clips from historical records at the Lauder EWS were used, but these may not be adequately representative of future climate conditions. Uncertainty was also noted in the MODFLOW / FloPy groundwater modelling of RAS pit groundwater inflow from the hard rock groundwater system. Significantly, few reliable estimates of the storage coefficients for schist rock exist. Storage coefficients control the temporal response rates for groundwater phenomenon such as pumping drawdown or pressure rebound.

Uncertainty whether groundwater rebound and pit lake filling times are shorter or longer have consequences with regard to other dependent groundwater effects such as surrounding groundwater levels and groundwater depletion of surface water. Departures from the predicted groundwater rebound and pit lake filling up to the target level in the post-closure phase of mine life would have proportionate changes to the cessation of hard rock related depletion of Shepherds Creek or Rise and Shine Creek.

5.4 Underground Dewatering

5.4.1 Potential Effects

Compared to surface mining, underground mining workings are 'submerged' in a groundmass of country rock and invariably for deep mines, below the saturation height. Furthermore, the contact area of the underground workings with the schist groundwater system is much less that of the surface mining pit. The workings as drives and stopes are characterised as having atmospheric pressure (approximately 1 bar) surrounded by rock under higher lithostratigraphic pressure, but importantly by groundwater at higher hydrostatic pressure. The hydrostatic pressure pressing on the wall of a mining panel located 200 m below the height of saturation would be approximately 20 bar. Consequently, groundwater would seep into the mine workings at rates governed by permeability (proportional to hydraulic conductivity or transmissivity) of the surrounding schist groundwater system horizontal and vertical hydraulic gradients.

Tunnelling during the Cromwell Gorge lakeshore stability investigations demonstrated that TZ 4 textural grade schist was capable of conducting more substantial groundwater inflows to tunnels in parts of the formation deformed by collapse of schist blocks within large-scale slides (O'Brien, 2014) and (Ridl, 2021)[6]. It is important to note that these more substantial groundwater inflows could only be sustained for brief periods and followed discontinuities related to dilation zones of slide debris within large-scale slide blocks (Ridl, 2021).

Subsidence related fracturing of the overlying Textural Zone III (TZ 3) schist overburden as a result of goaf collapse of adjacent mining panels could theoretically have the effect of enhancing net permeability of parts of the affected rock mass were it not for the stabilisation of drives and stopes by cemented tailings paste. Figure 27 shows a highly conceptualised profile representation of the potential mine panel subsidence effects on ground permeability developed by (Forster & Enever, 1992). In the fractured zone, mining panel extraction could affect and increase the original ground permeability leading to higher rates of groundwater inflow to a tunnel, drift, or roadway in the affect zones. Indeed, subsidence related fracturing could increase the groundwater make[7] of the open mining panels.

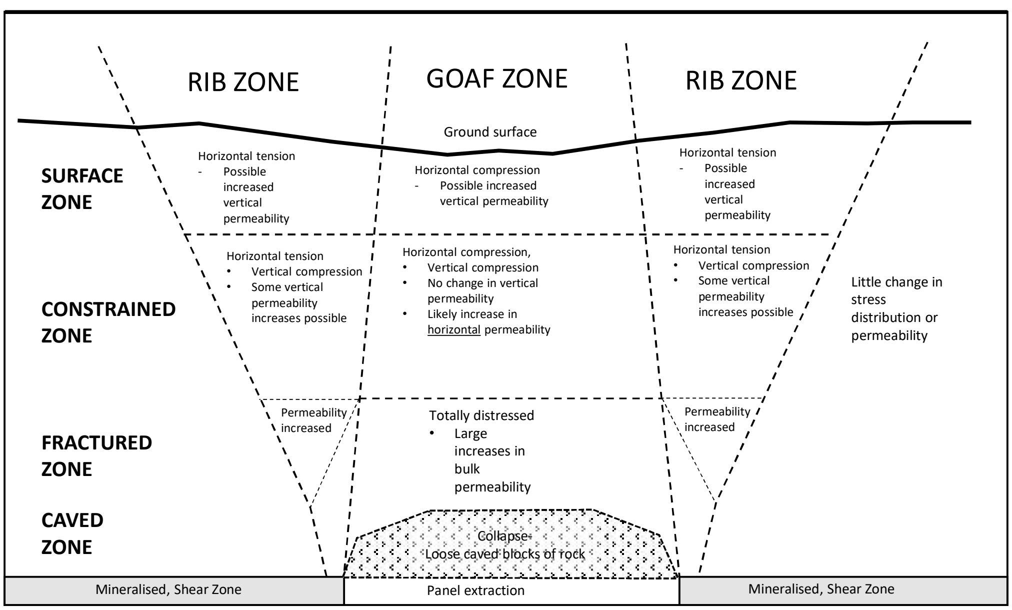


Figure 27: Schematic profile of the effects of panel extraction and collapse effect on permeability (Forster & Enever, 1992).

[6] Note: No TZ 3 schist materials were present in the Cromwell Gorge and the Gorge flanks are pervasively TZ 4.

[7] Groundwater 'make' refers to the tendency of an excavation (in this case underground workings) to accumulate water, primarily from seepage.

The potential for subsidence and permeability enhancement is substantially diminished to the point of being negligible by the proposals to place cemented tailings back into the stopes once the ore is removed. The processed tailings would be constituted into a paste and solidified by the addition of a cementing agent. Underground drives and stopes would be stabilised by being filled to the roof with cemented tailings paste before collapse (i.e., goaf) of the workings roof could occur. Paste filled the chambers would avoid roof collapse and any penetration of permeability changes above the mined panels (Cacciuttolo & Marinovic, 2023). Geotechnical tunnel support such as bolting, ribs and lining are available to prevent that development of a goaf (i.e., tunnel collapse) where conditions are encountered.

5.4.2 Prediction of Effects – Underground Dewatering

Predictions of the development of dewatering effect were made by analytical equations. The Goodman (et al., 1965) analytical equations were employed alongside projections of the length and cross-sectional area of tunnel development. One of the more frequently used analytical equations (Goodman et al., 1964) is defined below:

Q_0 = Tunnel groundwater inflow rate (L/T)

$$= \frac{2\pi K H_0}{2.3\log(2H_0/r)}$$

Where:

π = Value of Pi

K = Hydraulic conductivity (L/T)

H_0 = Height of saturation (L)

r = Radius of tunnel (L)

L = Length of tunnels (L)

The equation is steady state, meaning that time lag factors are ignored and the calculated groundwater inflow rate considers the inflow to be at equilibrium. Table 13 outlines that tunnel development begins in Year 6 following development of the access drift (access decline) and increases further over the following four years until Year 9 when the tunnel development is finalised. Figure 28 plots the indicated rise in groundwater inflow to the underground workings as the working's tunnel network grows, from Year 6 to Year 9. The dewatering rate is estimated to peak at approximately 30 litres per second.

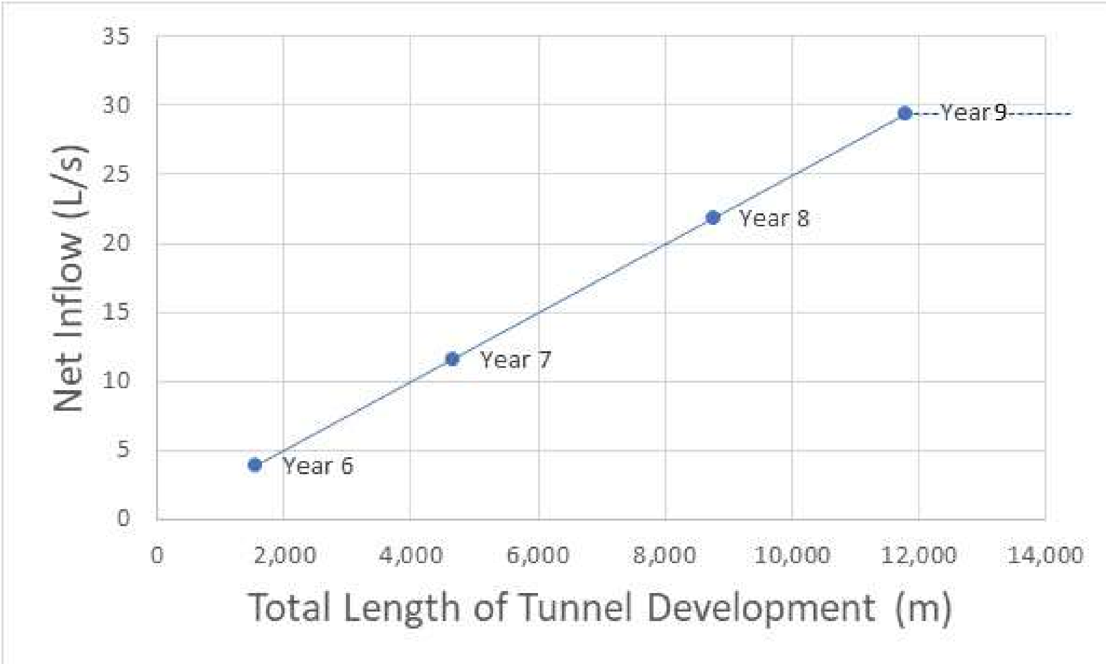


Figure 28: Plot of calculated steady state underground working's inflow; Year 6 – 9, thereafter stabilising

The growth in ore extraction voids would not contribute significantly to the requirement for dewatering, as the principal mode of tailings disposal of underground ore after processing is to return to the underground for placement into stope voids as cemented tailings. Only the final 'robbing' of the crown pillar would not be followed by infilling with cemented tailings. Surplus tailings would be emplaced in the TSF.

In the wind-down and closure phase, the water management of the Rise and Shine pit and underground would be conjoined for prevention of water in-rush and after underground mining ceases for progressive flooding of the underground tunnel network. Therefore after Year 13, groundwater inflow would substantially decline. However, water inflow to the Rise and Shine pit would enter the partially flooded underground workings *via* the pit wall penetration at the former crown pillar. In the Closure phase, residual groundwater inflow would collect in the partial pit lake and equilibrate by flow out of the access portal. Thus the pour-over elevation of the access portal at 560 m AMSL would be the primary control on water levels in the flooded workings and the stable water level in the Rise and Shine pit lake. The Rise and Shine pit lake would thus settle at a water level height of approximately 560 metres AMSL, or slightly higher. Thus surplus water would transit the surface pit, wall penetration into the workings and pass out of the former mine voids *via* the access drift and portal. The ultimate point of discharge would be into Shepherds Creek immediately upstream of the former processing plant site.

5.4.3 Uncertainty of Effects Prediction

A substantial source of uncertainty in the application of the analytical tool for calculating groundwater inflow to the underground workings would be the lack of solid information of the state of groundwater pressure while the overlying surface mining pit is also undergoing dewatering for the entire active operational phase of the underground mine. Overlying dewatering at the surface mining pit would result in depressurisation of groundwater surrounding the tunnels attached to the underground workings. The other depressurisation process at work during underground development would be inter-tunnel depressurisation, where a previously developed tunnel perhaps installed in previous years causes a lower groundwater pressure on a neighbouring tunnel.

The fact of concurrent depressurisation by the overlying pit and adjoining tunnels is a significant source of uncertainty and likely over-estimation of tunnel water make using the Goodman Equation.

5.4.4 Ardgour Alluvial Aquifer Solute Accumulation

Particularly in the post-closure period, it is assessed that seepage from the ELF toe drains would discharge dissolved loads of sulphate and carbonates. Similar ELFs, in East Otago at Macraes Mining Complex, with water percolation through the waste rock mass have had measurable effects leading to a shift in the hydro-chemistry of shallow groundwaters entering surface water as seepage, primarily towards elevated sulphur and carbonate minerals compared to the natural state (Weightman et al., 2020). While the geochemistry of source rock differs between Bendigo and East Otago, it is anticipated that similar percolation and percolate water chemistry would result at the ELFs of the Bendigo – Ophir Gold Project.

In the post-closure period, the toe drains and other seeps forming at the toe of the Shepherds ELF would contribute to the flow of Shepherds Creek, unless diverted into passive treatment. As has been outlined previously, the drainage and runoff from the former ELF areas would carry a solute load of sulphate and carbonates into the creek flow. As the creek terminates by infiltration to underlying Shepherds Creek alluvium and ultimately the Ardgour Alluvial Aquifer, the solutes would merge with groundwater flow towards the lower Lindis River. This has importance to accumulation of sulphate load within the aquifer and elevation in groundwater sulphate concentrations. As sulphate has an aesthetic guideline limit in drinking water of 250 milligrams per litre and several existing bores are employed for individual domestic water supply, the movement of evolved sulphate in groundwater merits assessment.

5.4.5 Prediction of Effects – Ardgour Alluvial Aquifer

A conceptual characterisation of the Ardgour Aquifer and the Bendigo Aquifer has been formulated and this has been outlined in sections 2.7.2 and 2.7.4). A modelling project and report outlines the potential effects in terms of sulphate accumulation within the Ardgour Aquifer (Dumont & Rekker, 2025). This modelling report's key finding were:

- The infiltration of Shepherds Creek water into the creek alluvium and thence the Ardgour and Lindis aquifers, could have a significant impact on the sulphate composition of this corner of alluvium,
- Modelling (Dumont & Rekker, 2025) suggests Shepherds Creek derived groundwater tends to move to the deeper parts of the groundwater system (five model layers were simulated),
- The same modelling also suggests it could take between 4 and 10 years for break-through to occur across the down-gradient aquifer, and between 3 and 20 years for the elevated solutes to completely leave the groundwater system, and
- Temporal variations in the solute concentrations affecting Shepherds Creek composition would induce proportionate variations in the accumulation of the solute in the groundwater system, however the groundwater concentrations are more affected by the long-term load than short-term volatility.

Figure 29 provides a colour-flood map of composite distribution of maximum dilution factor, as a percentage of full concentration in Shepherds Creek water infiltrating into the alluvial groundwater system. Groundwater in the upgradient portion of the Lindis Valley (i.e., the dark blue shaded area), which has a measured sulphate concentration of less than 10 milligrams per litre (mg/L) would remain unaffected by the Shepherds Creek solute influence. The strongest concentrations of solutes from the mine-impacted Shepherds Creek runoff tended to skirt down the inside edge of the valley and move towards the centre. Downstream of Lindis Crossing (SH8 Bridge) at least 2:1 (i.e., 50%) dilution was modelled to occur. Figure 29 was also drawn up from a composite of a range of parameterisations since the uncalibrated groundwater solute transport model was modelled across a statistical range of parameter distributions (stochastically).

The proposed discharge sulphate concentration limit at the monitoring point SC-01, downstream of the former mining complex, is proposed as 500 milligrams per litre. The existing aesthetic drinking water standard for sulphate is 250 milligrams per litre (Taumata Arowai, 2022). These indications from generic groundwater transport modelling result in the requirement to monitor groundwater composition throughout the baseline, operations and post-closure periods for the possibility that the drinking water standard or water quality target concentration would be approached.

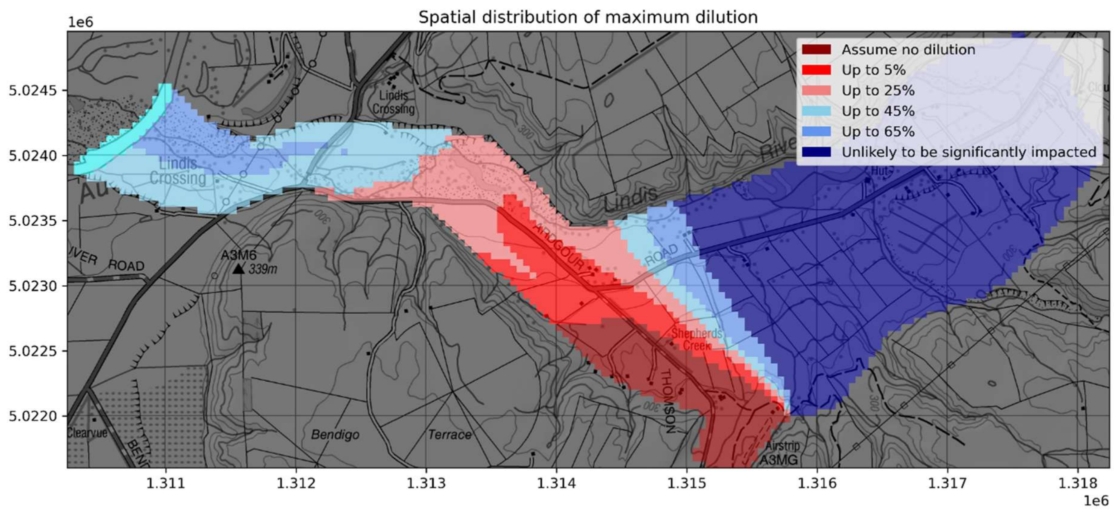


Figure 29: Composite groundwater dilution factors as percentage of full Shepherds Creek concentration

From the discussion and the zonation within Figure 29 (above), there is a possibility that the proposed 500 milligrams per litre sulphate concentration limit at SC-01 may fail to ensure bore water sulphate concentrations of 250 milligrams per litre in all instances. This may lead to downward review of the proposed sulphate limit. Practical and proactive measures to ensure domestic water supplies in the affected area are not so impacted would include MGL facilitating the development of reticulated water supplies that were drawn from an unaffected and superior quality water source. Less conventional mitigation approaches might include the installation of a Managed Aquifer Recharge curtain using subsurface injections of low sulphate water with the objective of ensuring the potentially affected bores were maintained substantially below the aesthetic drinking water guideline.

5.4.6 Uncertainty of Effects Prediction – Ardgour Alluvial Aquifer

The modelling process (Dumont & Rekker, 2025) highlighted a number of sources of significant uncertainty to predictions of Shepherds Creek infiltration of solutes including elevated sulphate to the Ardgour Aquifer. The sources of uncertainty included all of the parameters used in the modelling process, including:

- Horizontal and vertical hydraulic conductivity (K_x),
- Specific yield (S_y),
- Bed Conductance (C),
- Effective porosity (n_e),
- Specific storage (S_s), and
- Longitudinal, horizontal transverse and vertical transverse dispersivity (α).

The values and natural range in these parameters were not defined at the outset of modelling, although plausible ranges could be drawn from correlation with analogous materials found elsewhere in Otago. In addition, there was a low quality pumping test in the area, plus high-level observation of groundwater system behaviour. These parameterisation ranges were used in stochastic modelling of the Ardgour alluvial groundwater system. Such modelling parameterisations cannot provide definitive solutions, yet these are useful in sensitivity analysis. Model simulations of groundwater flow and solute transport were conducted first in steady state (equilibrium) mode followed by transient mode so as to include historic fluctuations in climate, groundwater recharge, and surface water flow. Some pre-calculation of soil based recharge and creek loss as surface water recharge were also undertaken. These transient inputs for land surface recharge, creek bed losses of Shepherds, Dry, and Wainui creek flow to the aquifer, and hydrological function of the Lindis River used measured or closely calculated surrogates for measured data as a time series covering 10 years of overlapping measurement records. This time period was iterated over a longer period of 80 years to provide for transient simulation of proposed mining waste management to the climax in mining activity (active closure) and beyond into the Post-Closure period.

Significant areas of uncertainty remained. The model report discussed the limitations to the accuracy of model predictions, primarily equivalence between alternative parameter realisations. The more important areas of uncertainty were summarised as follow:

- A general lack of observed snap-shot or time series aquifer water level observations to calibrate, optimise or validate the model,
- A lack of measured aquifer parameters such as observed above in this section,
- Deficiencies in the understanding of current and future water management relevant to aquifer dynamics in the area, and
- A general lack of drill logs or geophysical characterisation of aquifer geometry and any vertical stratification.

5.5 Borrow Pits

The excavation of borrow pits for aggregates is not assessed to intercept a water table or saturated material. Depths to water are first found beneath the larger borrow pits (see Figure 14) at depths greater than 40 metres below grade. Likely maximum depth of excavation within the proposed borrow pits would be 5 metres below grade, therefore the minimum clearance between excavation base and anticipated depth of saturation is suitably well separated. The quarry guidelines would include prohibitions on excavating areas displaying persistent saturation in dry weather conditions (to avoid mis-identification with surface saturation).

The process of borrow pit quarrying would employ ripping the material to break it up, followed by loading into haul trucks for transport to the sites of application. Therefore, groundwater contaminants would not be introduced to the borrow pits, neither would leaching of potential groundwater contaminants eventuate as part of the quarrying activity.

5.6 Water Supply Bore Field Abstraction

5.6.1 Potential Effects

A bore field of two large capacity bores would be developed in the mid-southern part of the Bendigo Aquifer and connected by a pipeline to the mining complex clean water dam. A fuller effects assessment document has been published relating to the BGMP bore water supply (Rekker, 2025b). Figure 3 maps the proposed location of the water supply bore field in the southeast corner of the aquifer. Bendigo Aquifer is actively exploited as a water resource using bores. Much of the overlying agricultural, viticulture and horticulture would otherwise require the development of a water supply scheme fed by surface water, most likely the Clutha River / Mata Au in the absence of the Bendigo Aquifer.

The principal potential effects of large groundwater abstractions from highly permeable and porous aquifers are as follow:

- Groundwater level lowering (water table or piezometric pressure drawdown),

    - Perturbation of the pre-existing groundwater flow field
    - Lowering of the water table in neighbouring bores or wells
- Depletion of surface water flows (pumping induced interception or drainage of flow that might otherwise support surface flow),
- Depletion and/or water level lowering within any groundwater-connected wetlands,
- Potential subsidence effects arising from pressure and water levels declining,
- Long-term depletion of the state of the aquifer due to imbalances in the water balance imposed by bore abstraction.

The Bendigo Aquifer has been most recently investigated by Houlbrooke (2010) as part of the Bendigo - Tarras groundwater zones administered by Otago Regional Council. The Bendigo Aquifer is bounded by the Clutha River / Mata Au in the west, older glacial till of the Bendigo Terrace to the east, the Lindis River and alluvium to the north, and Haast Schist rock hills to the south. The base of the Bendigo Aquifer is low permeability Tertiary sediments. The wider aquifer as defined by ORC has an extent of 16.95 square kilometres (km^2), however a stricter delineation of the accepted aquifer extent is 14.11 km^2. The Bendigo Aquifer comprises Alberttown and Hāwea outwash, plus Holocene river alluvium outside of the active Clutha River / Mata Au flood plain.

Past conceptual and computer model analysis of the Bendigo Aquifer groundwater system found the aquifer is strongly connected with the Clutha River / Mata Au and Lake Dunstan (Houlbrooke, 2010). Therefore, local imbalances of groundwater flows caused by bore pumping during the irrigation season has tended to be bolstered by the infiltration of water from the river and lake water in the west. The generally high transmissivities across the Bendigo Aquifer reported by Otago Regional Council Resource Science Unit (Houlbrooke, 2010) also operate to distribute groundwater readily across the aquifer.

5.6.2 Prediction of Effects

Standard approaches to prediction of effects were employed to predict those impacts:

- Field determinations using the bore fields' bores and observation bores,
    - Geological logging,
    - Water level analysis,
    - Sampling and analysis of groundwater chemistry,
    - Step drawdown pumping test analysis, and
    - Constant rate pumping test analysis.
- Analytical equations for predicting effects such as drawdown between bores (Theis, 1935), and surface flow depletion (Jenkins, 1977),
- Computer modelling of changes to groundwater flow patterns and aquifer water balance as a result of groundwater pumping using MODFLOW (McDonald & Harbaugh, 1988) undertaken by (Houlbrooke, 2010).

The field determinations obtained in drilling investigations in June 2024 used conventional logging, pumping tests with an observation bore and sampling of groundwater. These determinations and associated analyses are listed in Table 14.

Table 14: Summary of Groundwater Properties estimated from Field Determinations

Property or Parameter	Value	Unit	Remarks
Aquifer Transmissivity	4,500	m^2/d	Results ranged from 4,500 – 6,500 m^2/d
Saturated Thickness	18	m	As the vertical offset between the nominal water table and geo-hydrological basement.
Horizontal Hydraulic Conductivity	250	m/d	
Aquifer Storage, S_y	0.25	dimensionless	Specific yield

The bore pumping at 110 L/s was found to have projected drawdown down to 0.2 metres over 2,130 metres radius from the test production bore pumping at close to 110 L/s. The pumped bore exhibited 9.4 m drawdown during short-term pumping of 8 hours, the majority of which related to head losses across the bore screen interface. The aquifer related drawdown was significantly lower, which is consistent with the elevated transmissivity.

5.6.2.1 Drawdown Effects on Surrounding Groundwater Users

Drawdown effect prediction using both analytical methods and numerical modelling points to a localised zone of water table lowering surrounding the water supply bore during short and long-term pumping in line with the proposed abstraction proposal. The drawdown effects associated with continuous pumping at 97 litres per second throughout the year is specified in Table 15, setting out the magnitudes of drawdown effect at radii relevant to each surrounding bore to the proposed MGL production bore at time periods 90 days and 365 days after pump start-up at full pumping rate of 97 litres per second.

Table 15: Estimates of Drawdown for Surrounding Bores within 1 kilometre of Production Bore (CB13/0215)

ORC Bore No.	Radius from Centre of Bore (m)	Drawdown @ 90 days (m)	Drawdown @ 365 days (m)
MGL Production Bore (CB13/0215)	0.2	9.3* (5.09)	9.45* (5.24)
CB13/0156	236	0.704	0.938
G41/0206	422	0.512	0.744
G41/0225	434	0.502	0.734
G41/0262	497	0.458	0.689
G41/0332	547	0.428	0.657
G41/0270	617	0.389	0.617
G41/0373	624	0.386	0.613
CB13/0159	876	0.281	0.502
G41/0230	928	0.264	0.483
G41/0181	951	0.257	0.475
G41/0203	1,513	0.132	0.328
G41/0387	1,800	0.094	0.275
0.2 m Threshold	2,340	0.048	0.200

Note: * indicates that the Eden – Hazel Equation was used to calculate estimated total production bore drawdown, with the aquifer-only drawdown in (brackets).

Figure 30 provides the above drawdown information as a radial profile, while Figure 31 the points of potentially affected bores and groundwater users as a map, including the 0.2 metre drawdown effect radius.

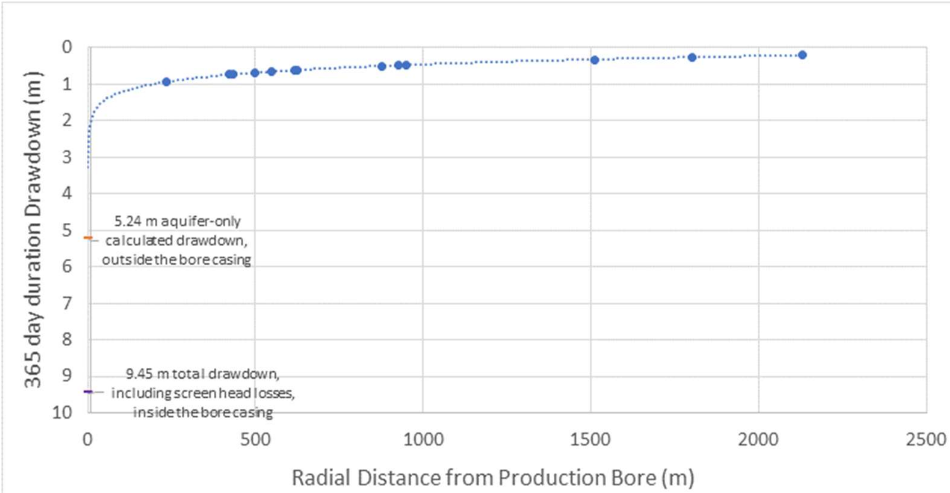


Figure 30: Radial profile of drawdowns calculated with the Eden - Hazel (pumping bore) or Theis equations

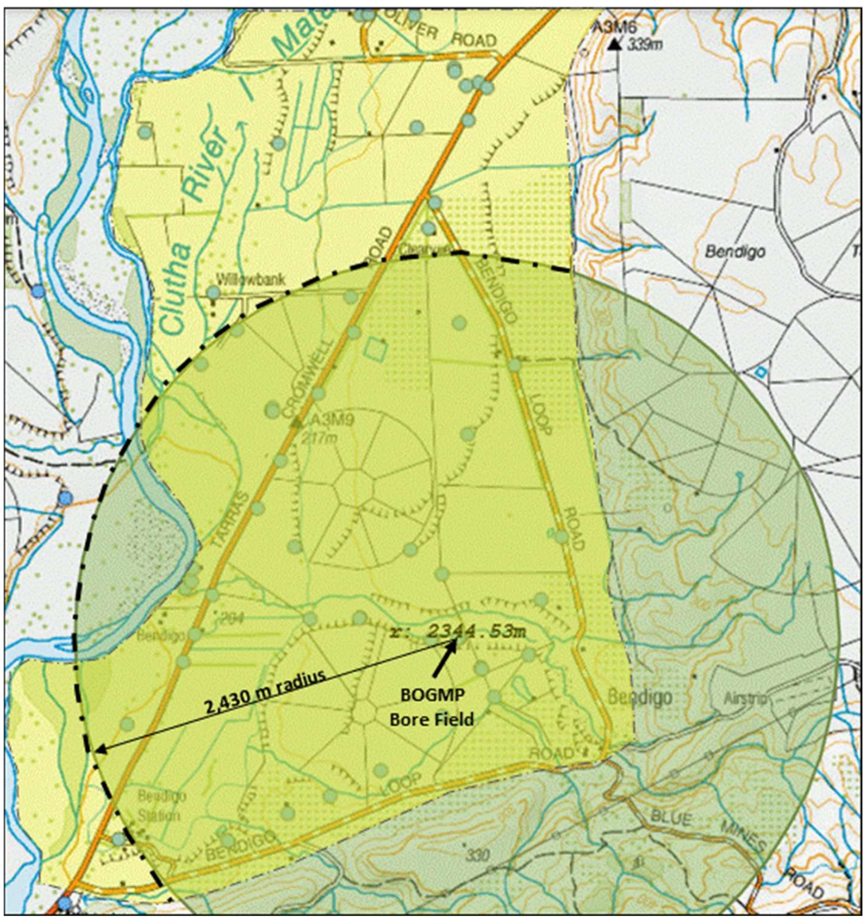


Figure 31: Mapping of the extent of potentially affected (teal coloured) registered bores within 2.34 km

It is worthwhile noting that the Theis equation calculations assume an infinite aquifer, while the Bendigo Aquifer has strong recharge and barrier boundary conditions active in mediating hydrologic response. This could result in existing bores lying between the proposed production bore and the boundary conditions differing from the values of drawdown provided in Table 15, Figure 30 and Figure 31.

All bores in the Bendigo Aquifer are to some extent resilient to variation in groundwater level. Measured groundwater level annual variation is in the order of 2 metres with peaks in early spring followed by dips in autumn. The maximum departure below the mean in the three year groundwater level record was 1.02 metres, indicating the normal lows in groundwater levels beneath the water table fluctuation mid-point.

Table 16 lists the relevant bores surrounding the MGL production bore to a distance of 1.2 kilometres.

Table 16: Listing of Bores within 1.2 kilometres of MGL Production Bore, plus Freeboard, & Drawdown

Radius (m)	Well No.	Depth (m)	Owner Name or Entity (as recorded in the original bore survey or consent application)	Use of Water	DTW (m)	Screen Top Depth (m)	Freeboard* (m)	Calculated Drawdown @ 365 days (m)	Dd % of FB¥
236	CB13/0156	49.22	Peregrine Estate Ltd	Irr, Stock	28.85	46.23	13.38	0.82	6.1%
422	G41/0206	29.41	Waitata Investments	Dom, Irr	16.92	26.28	5.36	0.65	12.2%
434	G41/0225	48.4	D Mondillo	Dom, Irr	30.78	45.7	10.92	0.65	5.9%
497	G41/0262	46.15	M Sauvage	Dom, Irr	28.05	41.35	9.3	0.61	6.5%
547	G41/0332	49.05	TBW & NJ Kerruish	Dom, Irr	29	45.95	12.95	0.58	4.5%
617	G41/0270	36.4	Zebra NZ Vineyards Ltd	Dom, Ind	20.86	34.75	9.89	0.55	5.5%
625	G41/0373	35.68	J and H Perriam	Irr	15.25	26.7	7.45	0.54	7.3%
876	CB13/0159	43.16	Otago Regional Council	SOE	29.38	40.23	6.85	0.45	6.5%
928	G41/0230	29.7	J and H Perriam	Irr	12.4	21.2	4.8	0.43	8.9%
951	G41/0181	38.44	Quartz Reef Vineyard	Dom, Irr	21.72	35.44	9.72	0.42	4.3%
1,158	G41/0402/1	25.75	Bendigo Terrace GP	Irr	7.1	17.75	6.65	0.37	5.5%

Note: DTW = Depth To Water. * Freeboard is defined as the depth of water above the critical pump unit level setting (i.e., 4 m above screen top). Use of water use shorthand: Irr = Irrigation, Dom = Domestic, SOE = State of Environment monitoring, Stock = Stock water, and Comm/Ind = Commercial or Industrial. ¥"Dd % of FB" = Drawdown as a percentage of freeboard.

In each case the surrounding bores have a calculated freeboard above the critical pump unit depth significantly larger than the corresponding calculated drawdown related to the MGL bore operation from Table 16.

Bore G41/0206 at Radius of 420 metres

The highest drawdown as a percentage of freeboard at 12.2% relates to bore G41/0206. The records for G41/0206 indicate a specific capacity of 11.8 Litres per second while pumping at 10 litres per second, meaning 1.3 metre of drawdown at the maximum instantaneous pumping rate of 15 litres per second specified in the attached groundwater take consent. Therefore, the freeboard of 5.36 metres would sustain 1.3 metres of self-induced drawdown, plus 0.65 metres of MGL production bore drawdown, plus 1.1 metres of natural water table variation, totalling 3.1 metres.

Bore G41/0230 at Radius of 930 metres

All other bores with 1.2 kilometres have a drawdown as a percentage of freeboard less than 8%, other than the 8.9% of freeboard for bore G41/0230. The records for G41/0230 indicate a specific capacity of 77.7 Litres per second while pumping at 80 litres per second, meaning 1 metre of drawdown at the maximum instantaneous pumping rate of 76.31 litres per second specified in the attached groundwater take consent. Therefore, the freeboard of 4.8 metres would sustain 1 metre of self-induced drawdown, plus 0.4 metres of MGL production bore drawdown, plus 1.1 metres of natural water table variation, totalling 2.5 metres.

Within 1.2 kilometres, the review of bore capacities to sustain the conservatively projected drawdown effect of pumping a new groundwater of 97 litres per second points to no points of the available freeboard being exceeded. Assessed bores would comfortably operate within their consented pumping rates while sustaining the calculated drawdown effect. Bores beyond 1.2 kilometres would also have a calculated drawdown effect of less than 0.3 metres, which falls into the category of low effect. The Otago Regional Council threshold for drawdown in an unconfined aquifer that requires consideration of drawdown effect is 0.2 metres (from Regional Plan: Water Schedule 5B), which lies beyond a calculated 2.34 kilometres surrounding the MGL proposed bore field, taking in most of the surrounding Bendigo Aquifer apart for the northern compartment.

Overall, the high transmissivity and high specific yield storage coefficient known to apply to the Bendigo Aquifer leads to conditions where drawdown effects are widespread, but the intensity of induced drawdown on surrounding bores is modest and within their capacity to sustain the effect in continued operation. Available information points to the proposed MGL production bore pumping at rates up to 97 litres per second not affecting surrounding bores to an extent that is more than minor.

It should be noted that the above drawdown effect assessments are highly conservative, employing maximum pumping rates over a full year of pumping at a rate that, in fact, are higher than are proposed. In this context it should be noted that the annual maximum proposed volume of groundwater abstraction is 3,153,600 cubic metres, which is equivalent to a sustained pumping rate of 100 litres per second rather than the higher value of 110 litres per second specified in the drawdown calculations.

5.6.2.2 Groundwater Depletion Effects on Surrounding Water Bodies

The surrounding water bodies include the following:

- Bendigo Creek
    - The flowing portions of Bendigo Creek over the basement schist,
    - The dry, ephemeral/intermittent reaches of the creek crossing the aquifer.
- School Creek,
- Chinamans Creek,
- Clutha River / Mata Au and Lake Dunstan.

Ephemeral or intermittent creeks cross the Bendigo Aquifer outwash gravel deposits. Bendigo Creek, School Creek and Chinamans Creek all rise in the Dunstan Ranges to the east and south of the southern Bendigo Aquifer. However, as these creeks cross the permeable the outwash flow is lost by infiltration. Only in downpour and extending flooding conditions do the outwash portions of the creeks maintain flow across the aquifer.

Clutha River / Mata Au

The Clutha River / Mata Au maintains consistent flow as outlined in section 2.6, and is likely to fully penetrate the western margin of the alluvial / outwash aquifer. Previous conceptual models, including (Sinclair Knight Merz, 2004), and the 2010 numerical model (Houlbrooke, 2010) had each determined the Bendigo Aquifer to be in intimate hydrological connection with the Clutha River / Mata Au.

The theoretical surface water depletion of the Clutha River / Mata Au may be estimated using the Theis-Jenkins Equation (Jenkins, 1977). Figure 32 displays the input data and Theis – Jenkins equation estimation of depletion at the major river margin. The measured distance between the production bore and the closest approach is 1,700 metres (1.7 kilometres). The transmissivity derived and accepted from the CB13/0215 pumping tests is specified in the calculation, as is the specific yield. The maximum pumping rate of 97 litres per second is set to evaluate maximum annual depletion effect.

Stream depletion analysis - Theis (Jenkins) solution

Pumped aquifer

Transmissivity (T)	4500	(m^2/d)
Storage coefficient (S)	0.25	-

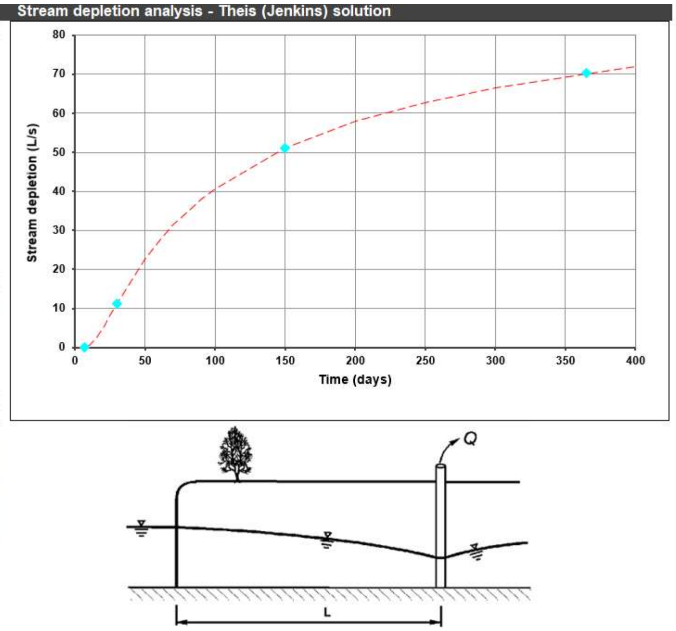
Well

Pumping rate (Q)	110	(L/s)
Separation distance (L)	1700	(m)
Stream depletion factor (sdf)	160.55556	(days)

Stream depletion after

Time (days)	q (L/s)	%
7	0	**0%**
30	11	**10%**
150	51	**46%**
365	70	**64%**

Only the values in shaded cells can be updated - all other cells are dependent on those input values.



Time (days)	Depletion Rate (L/s)
1.0	0.0
2.0	0.0
3.0	0.0
4.0	0.0
5.0	0.0
6.0	0.0
7.0	0.1
8.0	0.2
9.0	0.3
10.0	0.5
15.0	2.3
21.2	5.7
25.0	8.0
30.0	11.2
50.0	22.6
60.0	27.2
70.0	31.3
80.0	34.8
90.0	37.9
100.0	40.7
150.0	51.1
200.0	57.9
250.0	62.8
300.0	66.5
400.0	72.0

Figure 32: Depletion analytical calculation of the effect of MGL production bore on the Clutha River / Mata Au

The Theis – Jenkins calculations suggest a Stream Depletion Factor (SDF) of 160 days, therefore a significant lag of up to a week (7 days) would pass before any appreciable depletion effect would be exerted on the river. Indeed, three weeks (21 days) would need to pass before the 5 litres per seconds depletion effect is estimated to be exerted. Long-term the annual (365 day) estimated surface water depletion of the Clutha River / Mata Au would assume 64% of the total 110 litres per second pumping.

Figure 33 illustrates the calculated effect of a 3 week duration minimum flow curtailment of pumping at the proposed MGL water supply bore field, in terms of the decrease in surface water depletion experienced at the Clutha River / Mata Au. The net impact of the minimum flow shown in Figure 33 would be only 5 litres per second reduction in depletion at the end of the curtailment period, while the net reduction in the first two weeks would be less than 1 litres per second. On the resumption of bore field pumping, the reduction in depletion effect was calculated to slowly rise towards the rates prevailing before the curtailment.

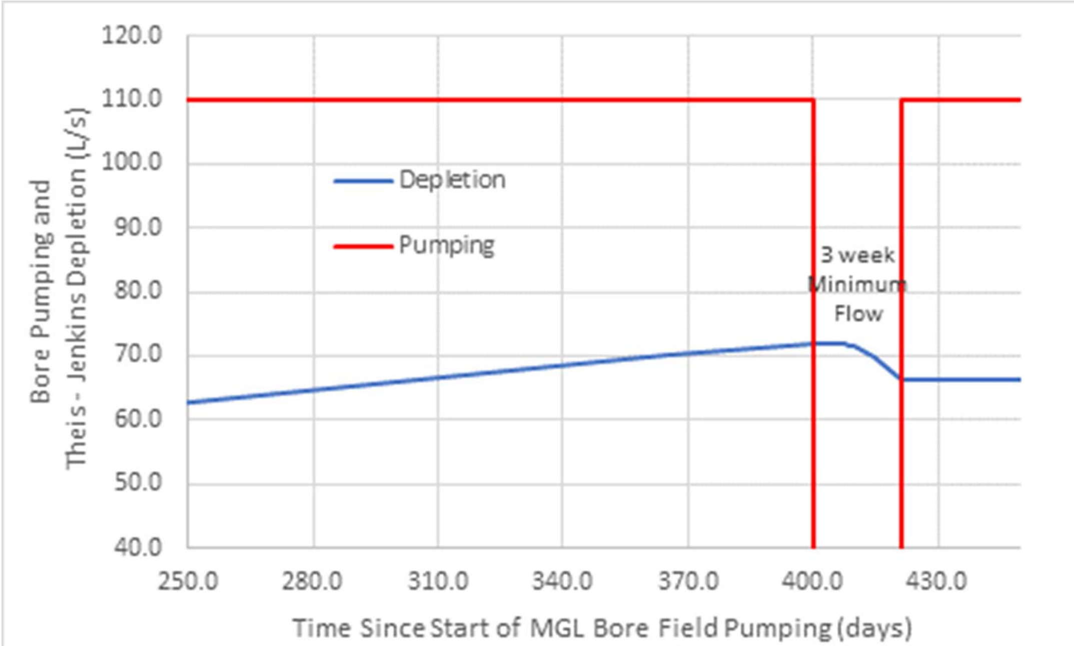


Figure 33: Calculated effect of a 3 week minimum flow curtailment following steady, long-term pumping

Ephemeral Creeks

The creek beds of ephemeral or intermittent courses passing over the Bendigo Aquifer, include Bendigo Creek, School Creek and Chinaman Creek are perched. Due to small, dry catchments and the tendency for the creeks to lose any surface flow by infiltration on reaching the schist – outwash transition, the creeks are routinely dry outside of periods of flooding that occur only infrequently. Therefore, the ephemeral or intermittent creek flow would not be any more affected by bore pumping than currently, due to the unsaturated zone that intervenes between the creek beds and the Bendigo Aquifer water table.

In view of the flow loss characteristics of these ephemeral creeks, plus perching of flood waters above the regional water table within the Bendigo Aquifer, the pumping of proposed the production MGL bore field is highly unlikely to have any effect that is more than minor on the water resources or aquatic ecology of these catchments.

5.6.2.3 Groundwater Sustainability in Terms of the Wider Aquifer

The Bendigo Aquifer is bounded by barrier boundaries of the Lindis glacial period till and Mesozoic schist, and by the recharge boundaries of the lower Lindis River and Clutha River / Mata Au. Vertically, the aquifer is bounded by largely impermeable sediments at its base and the water table at its top. The water table is a free surface that fluctuates with changes to the instantaneous groundwater fluxes. Therefore, the water budget of the Bendigo Aquifer has been quantifiable, pointing to substantial throughflows of groundwater primarily provided by adjoining freshwater bodies listed above.

The most recent water balance for the Bendigo Aquifer (Houlbrooke, 2010) indicates the land surface recharge is a relatively minor part of the water balance (1.7 million cubic metres versus 47.4 million cubic metres per annum with surface water, see Table 17). This is significant since there is something of a presumption that long-term groundwater recharge is dominated by land surface recharge. That is not the case for the Bendigo Aquifer.

Inflows and outflows with the major rivers, riparian wetland and Lake Dunstan make up the bulk of exchanges with the Bendigo Aquifer as it was estimated with the assistance of numerical modelling (Houlbrooke, 2010) and surface recharge modelling (Rushton et al., 2006). The aquifer water balance was based on mean annual measures of the measurable components. The less readily estimated components of the water balance such as the separated inflows or outflows with surrounding water bodies were taken from a steady state groundwater flow model calibrated with mean annual values of groundwater level elevation and river flow.

Table 17: Approximate Bendigo Aquifer Water Balance drawn from ORC (Houlbrooke, 2010)

	Inflows (million m^3/year)	Outflows (million m^3/year)
Rivers: Lindis Clutha / Mata Au	+10.9 +36.5	-3.1 -37.1
Bendigo Spring (Bendigo Wetland)	_	-6.2
Lake Dunstan	_	-2.7
Rainfall Recharge	+1.7*	_
Aquifer Total	+49.1	-49.1

Note: * groundwater recharge calculated using the methods of (Rushton et al., 2006)

The more important parts of the above aquifer water balance are the inflows, as the outflows are largely in response to the inflows. The Clutha River / Mata Au and Lindis River both lose substantial volumes of water to the Bendigo Aquifer. These surface water losses promote groundwater through-flow and eventual returns to surface water at the Bendigo Wetlands Complex, the Clutha River and lake Dunstan. Rainfall recharge is a one-way transfer of soil moisture surplus to a deep water table relatively minor component (3.5%) of total inflows. These inflows can be classed as groundwater recharge to the aquifer, although the recharge from surface water is potentially two-way (land surface recharge in climates such as Bendigo is one-way from the soil to the water table).

5.6.2.4 Groundwater Allocation Cap Settings

Recognising the dominance of riverine exchanges and the large volume flowing in the Clutha River / Mata Au main stem (with the river averaging a flow of 271 metres per second or 8,546 million cubic metres per annum), the ORC groundwater scientists opted to adopt the groundwater pumping total that would induce a generalised water level lowering throughout the Bendigo Aquifer of no more than 2.0 metres (Houlbrooke, 2010). A series of virtual pumping wells were added as drain (DRN in MODFLOW) cells to the model, with target levels set at approximately 2 metre below static water levels. The virtual pumping wells were spread evenly across the allocation zones and groundwater levels tended to reflect the hydraulic gradients seen in the water table under non-pumped conditions. A buffer without wells was given to the surrounding rivers, as this reflected ORC policies in terms of restricting groundwater takes close to rivers (Houlbrooke, 2010).

This numerical model scenario found that 58.1 million cubic metres per annum could be extracted from the Bendigo Aquifer for a 2.0 metre water level drop. Importantly, the more depletion-vulnerable water body, the lower Lindis Riser, would not be subject to any significant additional flow loss. In line with ORC water policy (Plan Change 1C policies; specifically policy 6.4.10A1, 6.4.10A2, rule 12.2.1A.3, Method 15.8.3.1, and Schedule 4A of the Regional Plan: Water) existing at the time, 50% of the “recharge” was set as the allocation limit. This was adopted by ORC as a so-called ‘Blue Book’ allocation limit and is also proposed as the limit within the proposed Land & Water Regional Plan scheduled for notification by 31 October 2024. Therefore, this tailored groundwater allocation cap of 29 million cubic metres per annum (July to June) is the existing and potentially the future limit on the groundwater that may be issued in restricted discretionary or discretionary resource consents to take groundwater. Beyond that allocation cap, groundwater take consent applications when the limit would be exceeded may be considered for granting as a non-complying activity.

5.6.2.5 Current or Future Surface Water Allocation Status

The Matakanui Gold water supply rate of groundwater abstraction was calculated to induce up to 62 litres per second depletion of Clutha River / Mata Au over the course of a year, calculated using the Theis -Jenkins

Equation in the relevant section of predicting effects. The Clutha River / Mata Au main stem currently has no allocation limit in the context of the Otago Regional Plan: Water.

The Proposed Otago Land and Water Regional Plan has a provisional surface water allocation setting for rivers with mean annual low flow greater than 5 cubic metres per second (5,000 litres per second):

- Surface water primary **allocated take limit** set as 30% of the Mean Annual Low Flow, and
- Surface water controlled for lows with a **minimum flow** set as 80% of the Mean Annual Low Flow[8]

The clearest indication of Mean Annual Low Flow (MALF) is the sum of the outflows of Lake Wānaka and Lake Hāwea. The combined $MALF_{7d}$ for these lakes equates to 111.2 cubic metres per second (111,200 litres per second). Thus the estimated $MALF_{7d}$ in the Clutha River / Mata Au downstream of the glacial lakes and upstream of Lake Dunstan would have default allocated take limit of 33.36 cubic metres per second and potentially subject to a minimum flow rate of 89 cubic metres per second (88,960 litres per second).

Current estimates of the surface water consented for consumptive abstraction in the main stem and tributaries of the Clutha River / Mata Au upstream of Lake Dunstan are 22,900 litres per second. Subtracting the default allocated take limit of 33,360 litres per second from the sum of takes issued in surface water take consent of 22,900 litres per second indicates a remaining allocable total of 10,520 litres per second available to be issued in new water take consents. Thus, the balance of water resource indications are that the Matakanui Gold Ltd water supply would induce surface water depletion of 62 litres per second from the Clutha River / Mata Au through groundwater – surface water connection.

The proposed water supply to the Matakanui Gold mining complex, including Rise and Shine Pit, Rise and Shine Underground, Come In Time Pit, Srex Pit, Srex East Pit, and associated plant is estimated to peak at a rate of 97 litres per second instantaneous with lesser rates and volume over longer time periods. Table 9 lists the instantaneous, daily, and monthly rates plus annual volume limits on groundwater consent proposed for the mining complex water supply bores from the Bendigo Aquifer. Table 18 compares the allocation amounts that would be needed to attach to the proposed application for groundwater take, and the amounts of water available to provide the requested water allocation from groundwater and the depletion effect on the Clutha River. This comparison demonstrates that the proposed abstraction for the Matakanui Gold Ltd mining complex is readily supplied by environmentally determined allocation reservations within the current Otago water plan.

Table 18: Comparison of Groundwater and Surface Water Consent Requirement versus equivalent Limits

Source / Allocation Block	Proposed Allocation Required	Available for Allocation
Surface Water (Clutha River / Mata Au u/s of Lake Dunstan)	72 to 100 L/s	Currently no limit (possibly 10,520 L/s available in future within a 33,360 limit)
Groundwater (Bendigo Aquifer)	3,153,600 m^3/year	12,754,034 m^3/year

5.6.2.1 Aquifer Stabilisation

The aquifer from which the MGL Production Bore would abstract groundwater is predominantly composed of gravel with minor silt. Gravels have a high (modulus) of elasticity and the area of highest drawdown is limited to the direct proximity of the bore, thus the potential for settlement and compaction as a result of the abstraction is considered to be very small and if it were to occur limited to an area close to the bore. Therefore, the effects on aquifer stability are considered to be less than minor.

[8] Sourced from: https://www.orc.govt.nz/your-council/plans-and-strategies/water-plans-and-policies/freshwater-management-units/cluthamata-au/upper-lakes-rohe/

For other reasons related to water quality protection, a pre-collar seal and concrete pad have been installed surrounding the surface bore head around the main bore casing. These measures would also have the benefit of stabilising the bore head from any minor effects of ground subsidence in the zone where it is more likely to occur.

5.6.3 Sustainability Statement

On the basis of prediction of groundwater abstractive effects and the currently available water resource management regime, the proposed Matakanui Gold Ltd water supply from bores adjoining bore CB13/0215 in the Bendigo Aquifer would conform with relevant water management controls and water allocation settings currently set or envisaged for future water plans. Besides the planning instruments, the proposed groundwater abstraction for the mining complex water supply is readily provided for within physical and sustainability limits, and the effects would be less than minor.

6 Steps to Avoid, Mitigate and Monitor Potential Effects

6.1 Background

The Resource Management Act 1991 does not merely require the assessment of the potential effects of a proposed activity and predicting the extent or intensity of those impacts. There is a further requirement to evaluate the ability to avoid, minimise, mitigate, offset / compensate and/or monitor those effects is also included. The purpose of this section is to set out the further evaluation of groundwater-related effects and indicate the proposals for such environmental management.

6.2 Pit Dewatering

6.2.1 Avoid or Minimise Effects

6.2.1.1 Mining Phase

Pumping out the basal sump of the Rise and Shine, Come In Time and Srex pits is essential to the safe and efficient surface mining of the respective mining operations. In normal operation, the sump would be pumped to maintain a shallow depth of water replenished primarily by inflowing groundwater. Contingencies to the operating guidelines would be established to allow for the temporary overloads of extended wet periods or rain downpours, allowing the pit sump to increase depth in response to incident rain accumulation following heavy rainfall. These temporary overloads could be pumped down progressively at moderate rather than high pumping rates. The benefit of maintaining moderate rates of sump pumping could be summarised as follows:

- To avoid high dewatering rates overloading the site water balance, and
- To achieve improved, lower turbidity condition of water pumped into the mine-impacted water circuit, with improved water quality in any water use or discharge.

6.2.1.2 Surface Mining Wind Down Phase

The dewatering of the open cut pit would cease at the conclusion of surface mining along the base of the ultimate pit. Pumps would be shut down and pit water levels would rise, coalescing to form a pit lake with the water level slowly rising, and approximately corresponding to the rise in groundwater levels of the surrounding schist groundwater system.

The rebound in groundwater pressures and level of saturation would reverse and partially offset many of the effects on seepage to the surface imposed by the dewatering of the open cut pit. These include the interception of groundwater that would have otherwise seeped into Rise & Shine Creek and Shepherds Creek. Previous flow patterns (spatial and temporal) would be progressively restored.

However, the penetration of the underground mine stope into the northeast open cut pit wall with a base elevation of 440 metres AMSL would place a limit on the height that the forming pit lake could rise. Left unmanaged, rising pit lake levels would potentially result in the pit lake over-topping into the ‘window’ the pit wall penetration once the lake water level would reach 405 m (i.e., greater lake depth than 20 metres, surface area of more than 1 hectare and estimated water volume in excess of 400,000 cubic metres). Depending on the timing of the rise in pit lake level and the continuation of underground mining past the wind down in surface mining, pit dewatering may be required to maintain a safe lake level to avoid over-topping. This dewatering regime would ameliorate the effects of dewatering to the 385 metre base of the Rise and Shine Pit, while mitigating the risk of groundwater inrush to workers in the Underground in continued operation.

The Rise and Shine pit is scheduled to operate until month 126, in the 11th mining year. The underground mining is scheduled to continue until month 160 in the 13th mining year. For the interim, while the surface mining has halted but the underground mining continues, a limit to the depth and extent of the pit lake would need to be maintained.

6.2.1.3 Post-Closure Phase

In the post-closure phase of the Bendigo – Ophir Gold Project, the rise in groundwater saturation levels and shut down of dewatering in the Rise and Shine Pit plus Underground would result in water flowing from the Pit through the higher elevation Underground galleries and discharging at the Underground mine portal.

6.2.2 Mitigate Effects

The principal effects of the cessation of pumping is the progressive deepening of a groundwater-filled void. There are options that involve flooding the pit with surface water or Bendigo Aquifer ground over a shorter time period, thereby hastening the re-establishment of a filled lake and overflow into the surface water system.

6.2.3 Monitor Effects

The water levels and water quality of the pit lake plus surrounding groundwater would be subject to a comprehensive monitoring plan that provides information on groundwater level rebound and the resulting impacts on water quality and ultimate hydrological state. There would also be tie-ins with the geotechnical pit wall stability monitoring for the closed surface pit and underground.

6.3 Pit Lake Filling Post-Closure (EOML)

6.3.1 Avoid or Minimise Effects

Minimisation of the effects of pit lake filling would include the following: outflow management of the pit lake overflow, management for optimal water quality, and the timing of filling of the void. The most important effects in the formation of a pit lake is the eventual lake water quality, which covered in other effects assessment documents.

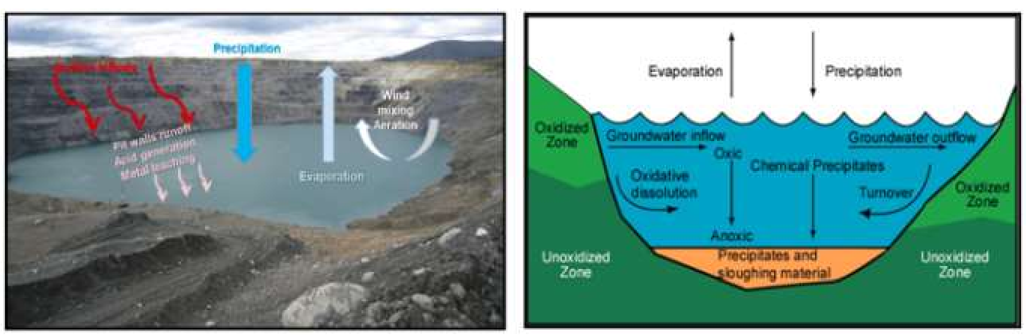


Figure 34: Conceptual model of pit lakes as a generalised set of processes affecting lake water quality (Sakellari et al., 2021)

Pit lake water quality is covered in detail in the Geochemical assessment document (Mine Waste Management, 2025b) and (Mine Waste Management, 2025a), however the groundwater role in bringing water into and out of the filled pit lake would remain an important process in terms of affecting metals concentrations and oxic state of the pit waters, as illustrate diagrammatically in Figure 34. The oxygen demand (chemical or biological) of pit lake waters would have a bearing on chemical processes in the water column. The entry of groundwater by inward seepage is more likely to introduce low oxygen waters with associated chemical oxygen demand. Pit water management, geochemistry and hydro-chemistry of the RAS and SRX pits are covered elsewhere in project effects assessment documentation.

The RAS pit lake would receive oxygenated incident rain and runoff from the surrounding catchment following rain, plus less oxygenated inflowing groundwater. The pit lake water level would rest significantly lower than the baseline groundwater levels within the Battery Hill ridgeline overlooking Shepherds Creek, meaning that groundwater inflow from the schist groundwater systems would continue into the post-closure period.

6.3.2 Mitigate Effects

The initial management of pit lake filling to an elevation of approximately 405 metres AMSL would result in the formation of a modest pit lake of approximately 20 metres maximum depth, 0.1 hectares and 100,000 cubic metres volume, minimising the share of low oxygen groundwater in the water column, and once drainage via the post-closure underground commences, providing for the flushing of the pit lake waters through the pit penetration into the underground and ultimate discharge via the former access portal.

Subsequent pit lake filling to water levels elevation of 490 metres AMSL upon mine closure would result in a pit lake depth of 120 metre at maximum, an area of 170,000 square meters (17 hectares) with a mean volume of 5,795,000 cubic metres (5.8 million cubic meters). Post-closure inflows to the RAS pit lake would include positive outflows of groundwater averaging 6 litres per second (Mine Waste Management, 2025b). These inflows, especially the surface water runoff and rain water would freshen the pit lake with oxygenated water.

6.3.3 Monitoring Effects

The water levels and water quality of the pit lake plus surrounding groundwater would be subject to a comprehensive monitoring plan that provides information on groundwater level rebound and the resulting impacts on water quality and ultimate hydrological state.

6.4 Underground Dewatering

6.4.1 Avoid or Minimise Effects

The transition to underground mining after the seventh year of surface mining, plus sealing of completed stopes with cemented tailings would have the effect of minimising underground dewatering effects. As already outlined, the tunnel drainage of the access drift, roadways servicing the underground mine drives and individual mining drives for stope ore extraction would make moderate rates of groundwater seepage inflow. A dedicated drainage circuit would provide the dewatered groundwater to the mine-impacted water circuit for utilisation in ore processing and dust suppression. This would aid water conservation. The emplacement of impermeable cemented tailings would minimise groundwater seepage inflows to completed workings, avoiding subsidence and preventing the formation of flooded goafs and voids underground with attached water management risks.

6.4.2 Mitigate Effects

The utilisation of pumped groundwater from tunnels of the underground workings within mine water uses (ore process and/or dust suppression) would make beneficial use of the water and not result in appreciable or direct discharge to either surface water or groundwater. The conservation of bore water is covered further in section 6.5.1.

6.4.3 Monitoring Effects

Monitoring of tunnel drainage pumping rates would be maintained. Mine surveying would map the total extent of open drives and other workings, plus the progressive emplacement of cemented tailings in the wake of stope ore extraction. Vibrating wire piezometers would be placed to characterise the drawdown and rebound of groundwater pressures surrounding the underground workings.

6.5 Bore Field Pumping

6.5.1 Avoid or Minimise Effects

Most groundwater take effects are directly proportional to the instantaneous or median pumping rate, plus the long-term volume across a seasonal cycle. Short-term rates of water take from a bore field are more influential in short-distance drawdown effects. Seasonal or annual abstraction volumes are more influential in the bore field's effect on surface water depletion and sustainability to avoiding aquifer overdraught.

6.5.1.1 Water Conservation

Water conservation is a targeted strategy to minimise the requirement to draw groundwater from the bore field. The Water Management Plan would set out the criteria for projecting the dust suppression on the following basis:

- Moving average soil moisture status,
- Frequency of suppression water application and application rate (mm/application),
- Relevant plant factor,
- Extent of land area requiring dust suppression and practically available for application,
- Projected total daily water requirement, and
- Daily quantity of mine water that can be used to substitute for fresh make-up water.

Similarly, the water requirement from the ore processing plant would be variable. The Water Management Plan would set out the criteria for projecting the ore processing plant water requirements on the following basis:

- The scheduled throughput of the ore processing plant,
- Projected total daily water requirement, and
- Daily quantity of mine water that can be used to substitute for fresh make-up water from the bore field.

Sources of mine water suitable for diversion into the ore processing make-up water, include groundwater pumping from the Rise and Shine pit, stormwater collected within the processing plant perimeter, or decant water from the base of the Engineered Landform (ELF). The remaining water demands associated with the mining complex would be subject to water conservation measures. Such measures may include:

- Reduce water consumption while meeting the same demand by installing high water use efficient appliances and practices:
    - Purchase water efficient appliances such as lunchroom kitchen dishwashers etc.,
    - Purchase and replace with water efficient toilet cisterns, and
    - Purchase and replace with water efficient shower heads in showers.
- Plant indigenous and drought-resistant ornamental plant species in planted areas,
- Catch rainwater from structure roofs, where doing so is appropriate, and use in water substitutions[9], and
- Reuse relatively clean grey water for use in watering plantings.

6.5.1.2 Mine Water Substitution

As outlined above, waste streams of mine water and mining affected stormwater at appropriate water quality norms would be deployed in augmenting mining complex water requirements.

[9] The quality of the water collected from mining complex structures' roofs would need to be assessed in relation to potential dust contaminant sources from blasting.

The principal substitutions of water with mine water would include –

- Dust suppression water,
- Ore processing make-up water,
- Watering of plantings.

The sources of mining related water would include –

- Pit dewatering pumping,
- Underground mine water surplus,
- Tailing Storage Facility decant water,
- Collected storm water.

Protocols would be developed to allow appropriate substitution of water source to water requirement, as set out above.

6.5.2 Monitor Effects (Water Level)

The observation bore (CB13/0216) is available for electronic monitoring of bore field pumping effects. Furthermore, a bore close to the closest operational water supply bore owned by Peregrine Estates is labelled G41/0263. It has an equivalent depth to CB13/0156 at 49.7 metres below ground and is no longer used. With permission from the owner, electronic monitoring could be added to the disused bore, which lies 220 metres from the MGL production bore(s). Further out, the ORC SOE monitoring bore CB13/0159 would continue to record groundwater levels at a distance of 876 metres to the northeast from the MGL water supply bore field. This ORC SOE monitoring bore has groundwater level data available in real time from its data portal, which would be linked to the MGL environmental monitoring database.

Metering of the rates and volume of water taken using the MGL production bore(s) would be undertaken in the context of the National Environmental Standard for Water Metering (Ministry for the Environment, 2021) and proposed conditions of consent for metering by MGL's nominated contractor. The water metering of the groundwater take would be available to make correlations between the occurrence of bore pumping and any discernible water level fluctuations.

6.5.3 Monitor Effects (Water Quality)

The MGL bore field would have the status as a domestic water supply in the guidance as to drinking water standards (Ministry of Health, 2005) revised in 2018, and within under Section 47 of the Water Services Act 2021 (NZ Drinking Water Standards, 2022). As such, the water quality of the groundwater taken from the bore field bores would be subject to statutory requirements for periodic sampling and laboratory analysis.

The frequency and analytes included in analysis of sampled water would be governed by complex set of determinations, however the priority 1 analytes cover *E. coli* and turbidity. Priority 2 analytes cover chemical constituents, including common water pollutants, organic chemicals and heavy metals. A structured system of sampling and providing public health assessments would fall to the bore field operator or the nominated contractor, in addition to source protection requirements assessed by nominated public health engineering consultants.

All of the above requirements attached to the Water Services Act 2021 and drinking water status would result in frequent monitoring of groundwater quality followed by reporting to public agencies. This would provide a degree of reassurance that adverse groundwater quality effects would be avoided and if not, early warning provided to the bore field operator.

6.6 Solute Accumulation in Ardgour Aquifer

Mine Waste Management concluded that with the proposed mitigation of ELF construction to achieve 20% net percolation, reuse of the low volumes of seepage in the process water, ongoing performance monitoring, and at closure if needed the application of active and passive treatment, will result in the water discharge below the compliance limits. Effects on the Ardgour aquifer will be less than minor. Out of an abundance of caution, monitoring and other measures are proposed to address the question of solute accumulation, such as sulphate, in downstream groundwater. These may include the following summary:

- Mitigation of ELF construction to achieve 20% net percolation,
- Reuse of the low volumes of seepage in the process water,
- The application of active and passive treatment,
- Monitoring of Shepherds Creek water for sulphate among other analytes, and
- Monitoring of the Ardgour Alluvial Aquifer in a location and to such depth that the aquifer water quality is satisfactorily characterized.

These questions are more authoritatively and completely detailed in the source term definition (Mine Waste Management, 2025a) and water load balance (Mine Waste Management, 2025b) documents for the BOGM Project.

7 Conclusions

The following conclusion and concluding remarks are provided below.

1. Matakanui Gold Ltd propose developing a multi-component mining complex in the foothills to the Dunstan Mountains near Bendigo. The complex would be comprised of the following elements:
    a. The Rise and Shine Pit to surface mine overburden and gold ore,
    b. The Rise and Shine Underground Workings to follow the gold ore to greater depth than is economical for surface mining,
    c. The Come In Time Pit to surface mine overburden and gold ore,
    d. The Srex and Srex East Pits to surface mine overburden and gold ore,
    e. The ore processing plant,
    f. A Tailings Storage Facility to receive post-processing tailings, mainly of surface mining,
    g. The Shepherds, Western, and SRX ELFs to receive waste rock from overburden, and
    h. The Bendigo Aquifer water supply to provide piped groundwater for mining needs.
2. Various ancillary silt dams, soil stockpiles, Run Of Mine stockpiles, toe drains, diversion drains and other pumped or unpumped water transfer structures are included in the mine plans.
3. The gold mining would occur within schist rock with low, secondary permeability provided by fractures, shears and jointing defects with the rock.
4. Various means of determining the schist permeability (as hydraulic conductivity) have been undertaken, including corelation with geotechnical Rock Quality Designation, packer testing, and reference to Cromwell Gorge Lakeshore Stabilisation investigations.
5. Determined hydraulic conductivity measurements within the schist rock were generally in the 1×10^{-7} to 1×10^{-11} metres per second range, which is considered low but consistent with schist rock in Central Otago.
6. The height of saturation and vertical distribution of groundwater pressures have been characterised in Project significant locations within the Project area by routine dip measurement and data-logged piezometers, also used in calibrating or optimising groundwater flow models.
7. The height of saturation (water table) within the schist is often shallow and only deepen beneath ridges and hilltops, and groundwater gradients are generally steep despite low groundwater recharge rates
8. The groundwater quality of parts of the project area had been characterised by baseline sampling of drill holes and historic mine tunnel discharges, and analysis.
9. Groundwater within the schist is elevated with respect to heavy and other metals concentrations, while groundwater within alluvial or outwash aquifers on the valley floors adjoining he Clutha River / Mata Au is dilute and mostly devoid of dissolved metals above the detection limits.
10. Surface mining pits would all require varying quantities of dewatering to pump out excess groundwater, and any other water such as incident rainfall or runoff. Such water would be managed within the mine-impacted water circuit.
11. The out-pumping of groundwater would locally lower schist groundwater levels, which would affect the saturation or flow of connected surface water bodies.
12. The RAS Pit dewatering is projected by groundwater flow modelling to peak at 5 litres per second from the hard rock.
13. The Rise and Shine Pit dewatering would potentially induce flow depletion of 3.5 litres per second from Shepherds Creek, while the briefer mining of Come In Time Pit was modelled to induced 1.7 litres per second of additional depletion on the creek.
14. The main Srex Pit was found to dewater more permeable and shallow schist, in close proximity to Rise and Shine Creek. Consequently, the pit was modelled as having a dewatering rate of 23 litres per second.

15. Importantly, Srex Pit was modelled to have a depletion effect the adjoining creek and induce the reduction in flow of up to 15 litres per second, although the creek at the pit location may have less than 15 litres per second for extended periods of time.
16. Beneath the Rise and Shine Pit footprint, an underground mine would be developed and run concurrently with surface mining.
17. The Underground workings would extend down to 105 metres AMSL along the main dipping ore body, with ore being extracted by mechanised removal in stopes.
18. The stopes would be backfilled by returning cemented tailings, avoiding the possibility of roof collapse or the formation of a goaf void.
19. Largely only the tunnel network would require dewatering to maintain avoidance of flooding, which was modelled to involve up to 30 litres per second of active pumping to remove floor water to the mine-impacted water circuit.
20. Parts of the mining operations would require external water, necessitating the development of a remote bore field on the Bendigo Aquifer.
21. Test production bore installation and aquifer testing established the required bore field capacity was available and sustainably sourced.
22. Aquifer testing determined the aquifer to have a transmissivity between 4.500 and 6,500 square metres per day and storage coefficient of between 0.20 and 0.31.
23. Drawdown analysis determined the water table lowering exerted on the surrounding bores in the Bendigo Aquifer to be unaffected and able to continue in their existing function.
24. Groundwater depletion analysis determined the surrounding surface water bodies affected by the proposed pumping at up to 110 litres per second as the Clutha River / Mata Au and Lake Dunstan, with neither body being vulnerable to the projected levels of depletion.
25. The Bendigo Aquifer had been the subject of previous water resource investigations, including computer modelling, that established a safe yield and groundwater allocation.
26. The proposed pumping of groundwater for the Bendigo – Ophir Gold Mine Project from the Bendigo Aquifer would be comfortably within the safe yield and allocation recognised by the regional water authority.
27. An alluvial valley groundwater resource called the Ardgour Alluvial Aquifer would be potentially affected by elevated groundwater dissolved solute during later phases of the Project.
28. Accumulating sulphate, carbonate, and nitrogen solute load from within the Engineered Land Forms would ultimately emerge and enter Shepherds Creek in the post-closure phase.
29. As Shepherds Creek does not make a wet connection with its main stem, instead infiltrating into its bed and joining the groundwater of the Ardgour Alluvial Aquifer, the dissolved sulphate load would raise sulphate concentrations in groundwater, albeit at levels lower than appropriate guideline values. Groundwater monitoring is proposed.

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Appendices

Appendix 1. Groundwater Modelling Analysis for Bendigo Ophir Gold Deposit (Dumont et al., 2025)