Assessment of Groundwater Effects - Wharekirauponga Deposit

Waihi North Project

OCEANAGOLD LIMITED

WWLA1224 | Rev. 3

4 February 2025

Assessment of Groundwater Effects - Wharekirauponga Deposit

Project no:	WWLA1224
Revision:	3
Date:	4 February 2025
Client name:	OceanaGold Limited
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Author(s):	Chris Simpson
File name:	G:\Shared drives\Projects\Oceana Gold\WWLA1224_WNP Fasttrack Consent Reporting\Deliverables\Reports\WWLA_Rep_WKP Groundwater Effects Assessment 4.02.2025.docx

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Document history and status

Rev	Date	Description	By	Review	Approved
1	21 November 2024	Draft for comment	Chris Simpson	Jon Williamson	Jon Williamson
2	18 December 2024	Draft Report	Chris Simpson	Jon Williamson	Jon Williamson
3	4 February 2025	Final Report	Chris Simpson	Jon Williamson	Jon Williamson

Distribution of copies

Rev	Date issued	Issued to	Comments
1	21 November 2024	OGL / Mitchell Dayish	Draft for comment
2	18 December 2024	OGL / Mitchell Dayish	Address review comments
3	4 February 2025	OGL / Mitchell Dayish	Final Report

Executive Summary

Oceana Gold is proposing to develop a new underground mine within the Wharekirauponga catchment that is located 7 km to the northeast of their existing Waihi operations. The mineral deposit would be accessed via tunnels beneath Department of Conservation land, and with the exception of vent shafts, would have no surface expression and be mined entirely from underground. In order to be able to mine underground, the gold bearing vein system will need to be dewatered. This assessment has been prepared to determine what potential effects the proposed Wharekirauponga Underground Mine dewatering may have on groundwater, stream baseflow and other surface water features (springs and wetlands), water quality and other users of the resource.

A significant body of technical work has been undertaken by WWLA and various other consultants that describes the potential effects of the dewatering. This report contains a summary of the relevant results from that work relevant to understanding the effects on water movement within the Wharekirauponga catchment.

This assessment has shown that any effects at the surface associated with the abstraction of groundwater within the Wharekirauponga catchment required to dewater the proposed underground mine are less then minor. The volume of groundwater that will be taken of 2,200 to 3,300 m^3/d is sustainable at a catchment scale. The proposed mine dewatering has a limited potential for effects at the surface due to the natural vertical separation of the deep groundwater system from the land surface throughout most of the catchment.

No detectable effects on groundwater from the proposed mining activities are expected to manifest outside of the Wharekirauponga catchment because of geological and hydrogeological controls on the groundwater system. That means other users of the resource cannot be affected by the proposed mine dewatering.

The potential for effects at the surface is limited by the fact that the Rhyolite geologic units hosting the orebody (which will be depressurised) are separated from the land surface throughout most of the catchment by a post mineralisation andesite cover. The weathering zone at the base of the Andesite cover provides an aquitard layer that hydraulically separates the two geologic units. There will, however, be some minor leakage across the catchment between the geologic units due to the increased vertical hydraulic gradients induced by mine dewatering. That scenario has conservatively been assessed with respect to stream flows and indicates a potential baseflow loss of 2 to 13% of the 7-day MALF. That loss of flow is considered to be minor in comparison to catchment scale flows.

Aside from minor indiscernible leakage across the catchment, there is a localised area where post mineralisation Andesite cover is not present at the land surface that is considered to be an area of potentially higher risk. That location is in an area where the Rhyolite rocks that host the orebody that will be dewatered are in direct contact with surface water features and the low permeability layer is absent. The potential for effects to develop in the near surface in that area is related to the degree of hydraulic connectivity between the vein system and the land surface, the magnitude of which is driven by the permeability of the geology locally. Initial indications are that the permeability is low and the connectivity to the stream beds is weak and unlikely to result in a measurable change in stream flows. However, localised structures such as fracture zones or vein sets have the potential to create connectivity to the stream bed. Monitoring of the vertical hydraulic gradients near the streams is proposed in order to detect such a change occurring.

In addition to potential stream baseflow loss, there are two locations where springs are currently discharging into surface waters that are likely to cease for the duration of mining. Those being the Warm Spring (3.5 L/s discharge) and the EG Vein discharge area (5 L/s discharge), both of which are assumed to be associated with the EG vein system. The loss of groundwater discharge from those springs has been included in the stated surface water 7-day MALF reduction. The loss of the Warm Spring discharge during mining will result in an improvement in surface water quality in the Wharekirauponga stream due to the reduction in trace metals.

There are a number of natural inland wetlands within the catchment and detailed assessment has indicated that they are climate supported alone, hence do not require groundwater inputs to maintain their hydrological function. There are, however, some wetlands that have known groundwater inputs in addition to climate inputs, and it is proposed that they will be monitored in advance of and during the life of the mine to assess any alternation in character, noting that no loss of wetland size or extent is anticipated.

Should the proposed monitoring indicate a change is occurring that could result in an adverse effect, further investigations and/or mitigation will be undertaken as described in the Wharekirauponga Underground Mine Water Management Plan (WUGWNP) (OGL, 2024).

Following mine closure the groundwater system will recover back to its previous state after approximately 30 years. The Warm Spring and downstream spring are expected to resume discharging once the groundwater system has recovered. The water quality discharging at the Warm springs following mine closure is expected to be similar to that prior to mining with respect to trace metal concentrations. Elevated sulphate concentrations are, however, predicted in the Warm Spring discharge suggesting an increased potential for precipitate deposition in the discharge/mixing zone of the Warm Spring. These effects would be localised in the oxidising surface water environment immediately downstream of the spring. The temperature of the Warm Spring discharge following is expected to reduce from that currently observed.

Given the low level of effect predicted on groundwater and surface water features, and with the implementation of the monitoring recommendations set out above, it is considered that the level of residual effects resulting from the Wharekirauponga Underground Mine development will be immeasurable and, on that basis, less than minor and that any effect that does arise could be mitigated should monitoring indicate it is necessary.

Contents

1. Introduction

1.1 Background

OceanaGold New Zealand Limited (OGNZL) is proposing to develop a new underground mine north east of the township of Waihi. The mineral resource is known as the Wharekirauponga deposit. In order to be able to mine the resource from underground, dewatering of the orebody will need to be undertaken and as a result, potential effects on the groundwater system that could develop. OGC has engaged Williamsons Water and Land Advisory (WWLA) to prepare an assessment of effects associated with the proposed dewatering. This report summarises the results of our assessment and is intended to provide sufficient technical information such that it can be included in support of an application for consent to take groundwater.

1.2 Project Description

A full description of the Waihi North Project is provided in the Assessment of Environmental Effects prepared by Mitchell Daysh Limited. The Wharekirauponga mine will be implemented in two phases, the first phase being the development of the mine access infrastructure. Note that this report does not include effects associated with accessing the ore body through tunnelling. This is described in a separate groundwater effects report for the wider Waihi North Project prepared by WWLA (29 January 2025).

An underground mining operation is to be undertaken as the second phase of this project once the tunnel reaches the orebody and appropriate ventilation is established. The construction of the tunnel and ventilation shafts is expected to take 48 months from consent approval, with first stopes expected 8 months later. The mine will have up to four ventilation shafts located above the Wharekirauponga resource within the Coromandel Forest Park and one will be at Willows Farm.

Once mining commences, the underground operation involves mining of declines for access to stoping blocks. Access drives will be mined to develop drilling and loading levels, intersecting the orebodies centrally. Ore drives will be developed in both directions along strike from the access drives. Stockpiles will be mined off the decline and in levels for truck loading. Development design profiles have been assumed to be the same dimensions as currently used at Waihi underground operations.

1.3 Scope of Report

The scope of this report provides for the assessment of groundwater effects associated with the proposed dewatering of the Wharekirauponga deposit.

The purposes of this groundwater effects assessment are to determine:

- An estimate of groundwater inflows to the mine;
- Drawdown effects related to the mine;
- Potential for effects on groundwater quality;
- Potential for effects on other aquifers;
- Potential for effects on surface waters;
- Potential for effects on other groundwater users;
- Potential for ground settlement effects.

This report has been prepared based on recent testing, numerical modelling and historic information from the Wharekirauponga and adjacent areas in the Coromandel that provide an understanding based on a long association with groundwater systems in the region. This understanding has been taken forward alongside the project scope and has included further technical analysis to enable potential effects to be identified.

This report has been prepared by WWLA and includes, where appropriate, the results from other assessments that are relevant to this evaluation of effects on groundwater. The main parties responsible for inputs to this report and the nature of their work is summarised below and is shown graphically in **Attachment A**.

- FloSolutions – Conceptual groundwater model and numerical modelling.
- Intera – Model calibration and sensitivity analysis.
- GHD – Hydrology modelling.
- WWLA – Regional hydrogeologic setting, wetland delineation and drainage effects, overall groundwater effects.
- AECOM – Post closure geochemistry.

A complete list of the available reports is included in the references section of this report.

2. Environmental Setting

2.1 Site Location

The Wharekirauponga deposit is located approximately 10 km north of the township of Waihi. The resource lies beneath Crown land administered by the Department of Conservation (DOC) within the Wharekirauponga Minerals Mining Permit (60541) area. The Wharekirauponga orebody is located approximately 4.5 km northeast of the, now decommissioned, Golden Cross mine and is essentially a strike extension of the same regional scale northeast trending structure. **Figure 1** shows the general location of the deposits within the Wharekirauponga catchment.

Figure 1. Location of the Wharekirauponga deposit and proposed underground mine.

2.2 Historic Mining

There has been a long history of mining in the Waihi area with the Martha ore bodies accessed with an open cut operation that commenced in 1878. From 1898 to 1951 mining of the Martha ore bodies was via underground workings that required dewatering. Historic records indicate the groundwater inflows peaked at 12,000 m^3/d and then reduced to stabilise between 4,900 and 6,500 m^3/d. The original Martha Mine was closed in 1952.

In 1989 modern mining recommenced in Waihi and dewatering of the Martha Pit and then the Martha underground was required. Peak mine inflows of up to 15,000 m^3/d have been observed, with typical groundwater inflows stabilising between 4,000 and 5,000 m^3/d, similar to historic inflows.

In 2004 the previously unmined Favona ore body was accessed vis underground workings. That vein system was hydraulically separate from the other ore bodies in Waihi and had peak flows of 4,500 m^3/d reducing to 1,500 m^3/d.

The Tui mine was historically accessed from 1967-1975 via underground workings, however there were no records of dewatering volumes made when worked. The mine was abandoned and allowed to discharge via natural drainage. Records of the cumulative discharge from the mine portals indicates the stabilised groundwater inflow from the vein system was around 1,500 m^3/d.

The Golden Cross ore body was mined from 1991 to 1998 and was accessed via an open pit and underground workings. The estimates of rate of dewatering during mining was in the order of 2,000 m^3/d with peak inflows likely to have been higher.

The historic dewatering records for other mines in the area are important observation that help inform potential inflow volumes for other epithermal gold deposits such as Wharekirauponga. Based on those records there are two main factors that control the amount of groundwater inflow to the mines; the number of main vein systems and the length of the vein systems. The typical length of a main vein system is in the order of 1,000 to 2,000 m in length (Favona, Golden Cross, Tui) that results in inflow rates between 1,500 and 4,500 m^3/d. Where multiple main veins exist and are hydraulically connected (Martha ore bodies) the vein lengths are similar (1,000 to 2,000 m), however the cumulative length is circa 6,000 m, resulting in inflows ranging from 4,500 to 12,000 m^3/d.

2.3 Physiography

The site is located within the Wharekirauponga Valley in relatively steep, bush covered topography with a deeply incised stream oriented in a northeast – southwest direction. Surrounding peak elevations are highest to the southwest at Whakamoehau Peak at 750 m RL. An elevated ridge, averaging 600 m RL, forms a catchment divide that is oriented in a southwest to northeast direction. The ridge that forms the southeastern catchment boundary is generally lower, falling to between 200 to 300 m RL. Throughout the catchment, and below an elevation of approximately 300 m RL, topographic gradients flatten. The topography within the area of the Wharekirauponga deposit ranges from around 180 to 260 m RL, with the stream elevation being 160 m RL in the southwest, falling to 100 m RL in the northeast over a distance of 1 km. **Figure 2** shows the topography surrounding the location of the Wharekirauponga deposit.

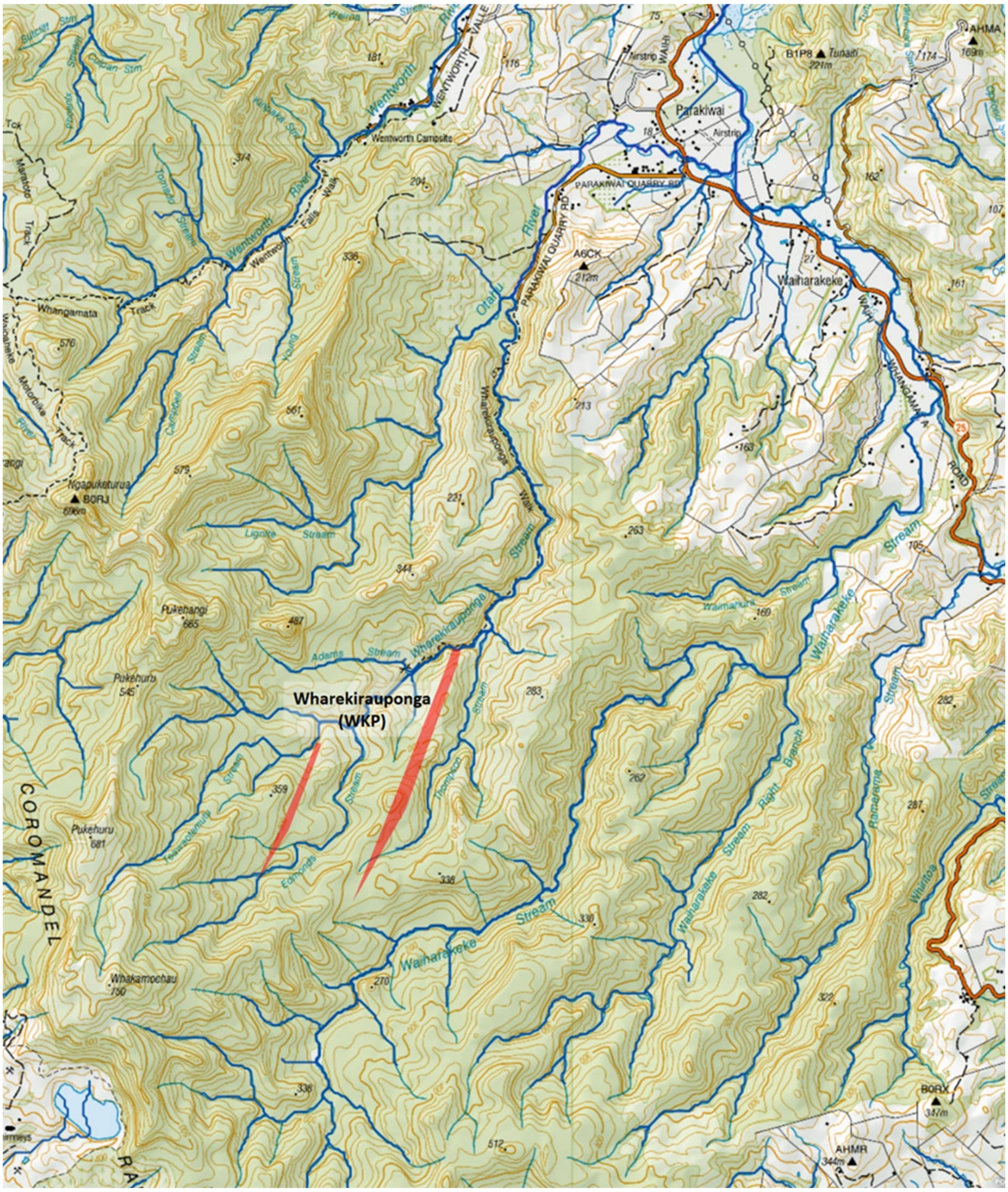

Figure 2. General topography in the Wharekirauponga catchment area.

2.4 Hydrology

The hydrology of the Wharekirauponga surface water catchment area and surrounds is included in a study by GHD (October 2024) and summarised herein. The catchment area of the Wharekirauponga Stream is 14.5 km^2 and with 2.17 m/year rainfall, the average daily rainfall volume reporting to the catchment is in the order of 86,200 m^3/d. The catchment drainage pattern is to the northeast towards Whangamata as shown on **Figure 3**.

The general site location is interpreted to be within a groundwater discharge zone within the headwaters of the Wharekirauponga Stream that flows to the north east and ultimately joins the Otahu River. Within the site locality there are a number of tributaries that come together to form the Stream. Surface water flow rates in the vicinity of the site have been gauged on a number of occasions as discussed later in this report. Based on measurements made at WKP1 (shown on **Figure 22**) at the catchment discharge point, the minimum low flow rate measured in June 2020 of 68 L/s (5,875 m^3/d) equates to approximately 7% of the catchment water balance.

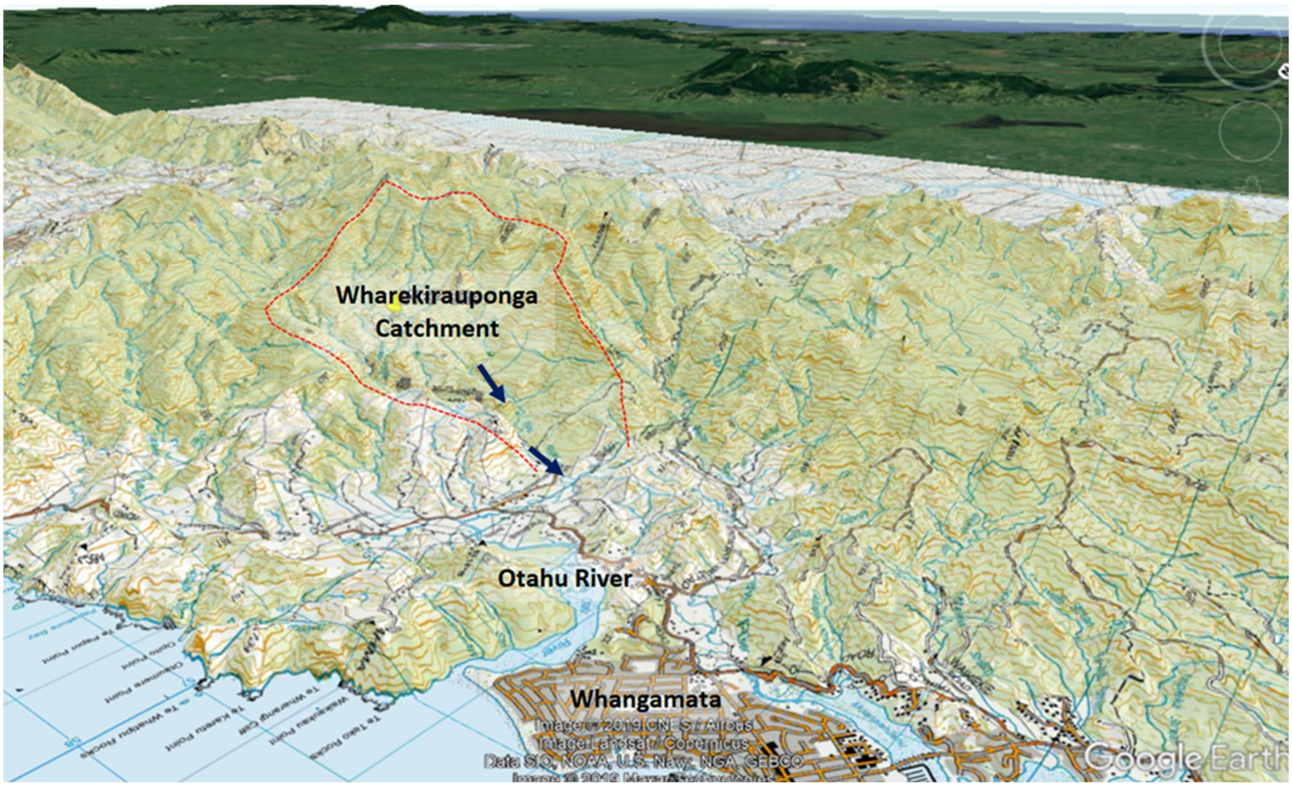

Figure 3. Wharekirauponga surface water catchment area (facing southwest).

Much of the rainfall within the Wharekirauponga catchment is absorbed by the soil regolith that has formed on the rock surface, and it is drainage of this water over time that sustains the surface water flow. When these soils are saturated rainfall run-off occurs increasing flows in the streams. Under dry conditions little shallow soil drainage occurs and baseflow to the streams is supported by groundwater discharge.

2.5 Regional Geology

The Coromandel Volcanic Zone is an extinct volcanic arc that is within the Coromandel Peninsula of the North Island, New Zealand. The associated volcanic and volcaniclastic sedimentary units record a history of andesitic and rhyolitic eruptions, which persisted throughout the Miocene to Pliocene (18 to 4 Ma; Skinner, 1986). Subsequent epithermal gold-silver deposits developed within the region between 16 to 2 Ma forming the Hauraki goldfield (Mauk et al.,2011). The region is underlain by basement rocks comprising Mesozoic sedimentary units (Greywacke) belonging to the Manaia Hill Group (Skinner, 1986). The basement rocks are unconformably overlain by volcanic and intrusive rocks of the Coromandel Group and volcanics flows and related pyroclastics of the Whitianga Group. The Whitianga Group Rhyolite flows and related volcaniclastic rocks are commonly associated with calderas (Malengreau et al., 2000).

Several structural trends are observed in the Coromandel Volcanic Zone as shown in **Figure 4**. Regional fault structures exhibit variable extents in strike lengths and are mostly steeply dipping. North to northwest strike dominates in the north, while northeast to east-northeast strike characterises structures on the central and southern portions of the Peninsula (Spörli et al., 2006).

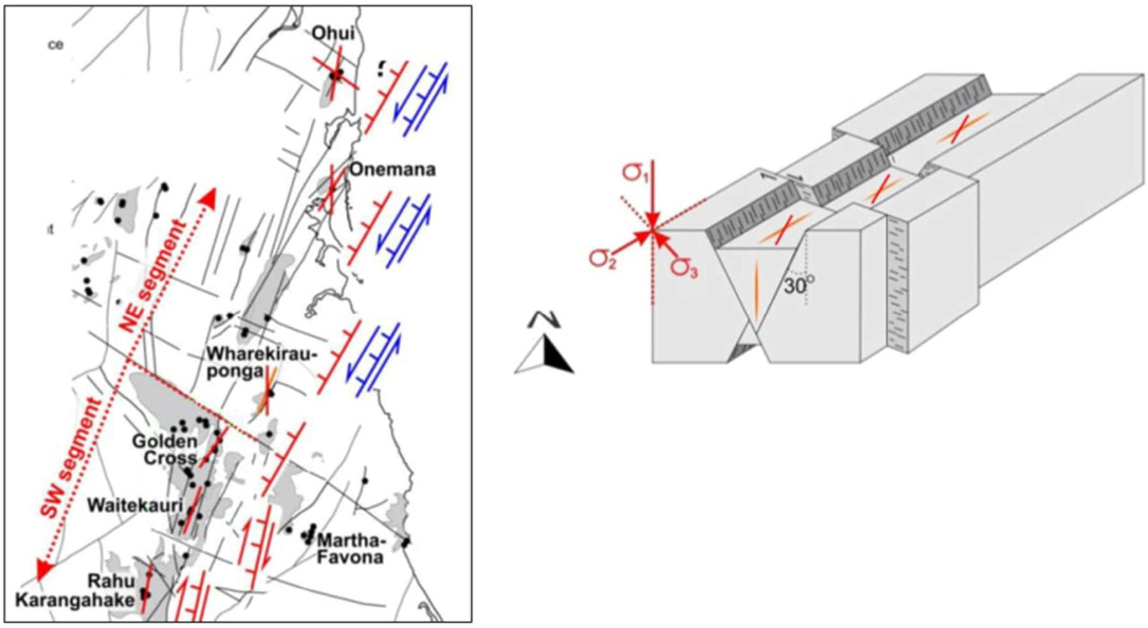

Figure 4. Karangahake – Ohui structural corridor mineralised areas (Zuquim et. al. 2013)

The northeast structural trend encompasses a highly prospective corridor for gold mineralization and is referred to the Karangahake-Ohui structural trend (KOST). The KOST consist of a 50 km long by 7 km wide zone of hydrothermal alteration that hosts around 40 mineralised deposits. The southwestern part of the KOST is dominated by andesite deposits (Tui, Karangaheke, Waihi) that occupy a NW-SE orientation. The northeastern part of the KOST is host to mineral deposits (Wharekirauponga, Onemana) in rhyolite/dacite volcanics and were formed in a NW-SE and E-W extensional setting. The extensional veins at Wharekirauponga strike are subvertical (prior to tilting) and have the same orientation as the hydrothermal breccia zones at Onemana (Zuquim, 2013). Controlling faults of both areas strike NNE to NE and are predominantly normal dip-slip with a minor strike-slip component. The location of the Wharekirauponga deposit within the conceptual geologic setting is shown in **Figure 5**.

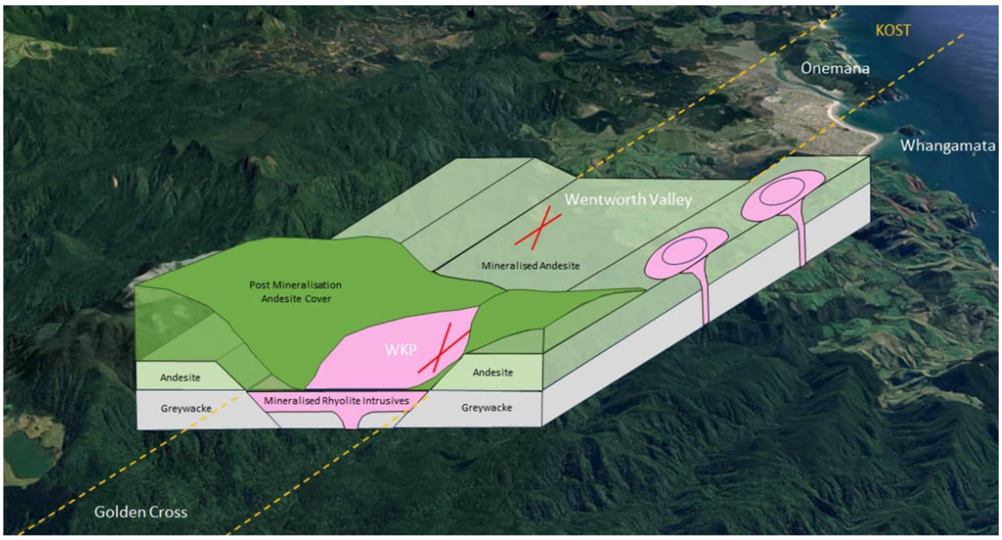

Figure 5. Conceptual geology and regional structural setting of the Wharekirauponga deposit.

The Wharekirauponga deposit is located within one of the main north-northeast structures. The interpretation suggests that the southern boundary of the KOST structure is coincident with the Wharekirauponga deposit and that structure continues in a northeast direction through Whangamata. The structural contact is observed beneath the Whangamata Golf Course and is interpreted to continue northeast beneath the recent alluvium. The northern boundary of the KOST structure passes through Onemana.

As shown in **Figure 6** the Wharekirauponga deposit is hosted by mineralised rhyolite intrusive and further north mineralised andesite is present within the Wentworth Valley. Post mineralisation andesite covers part of the Wharekirauponga deposit but thins to the northeast near the edge of the catchment.

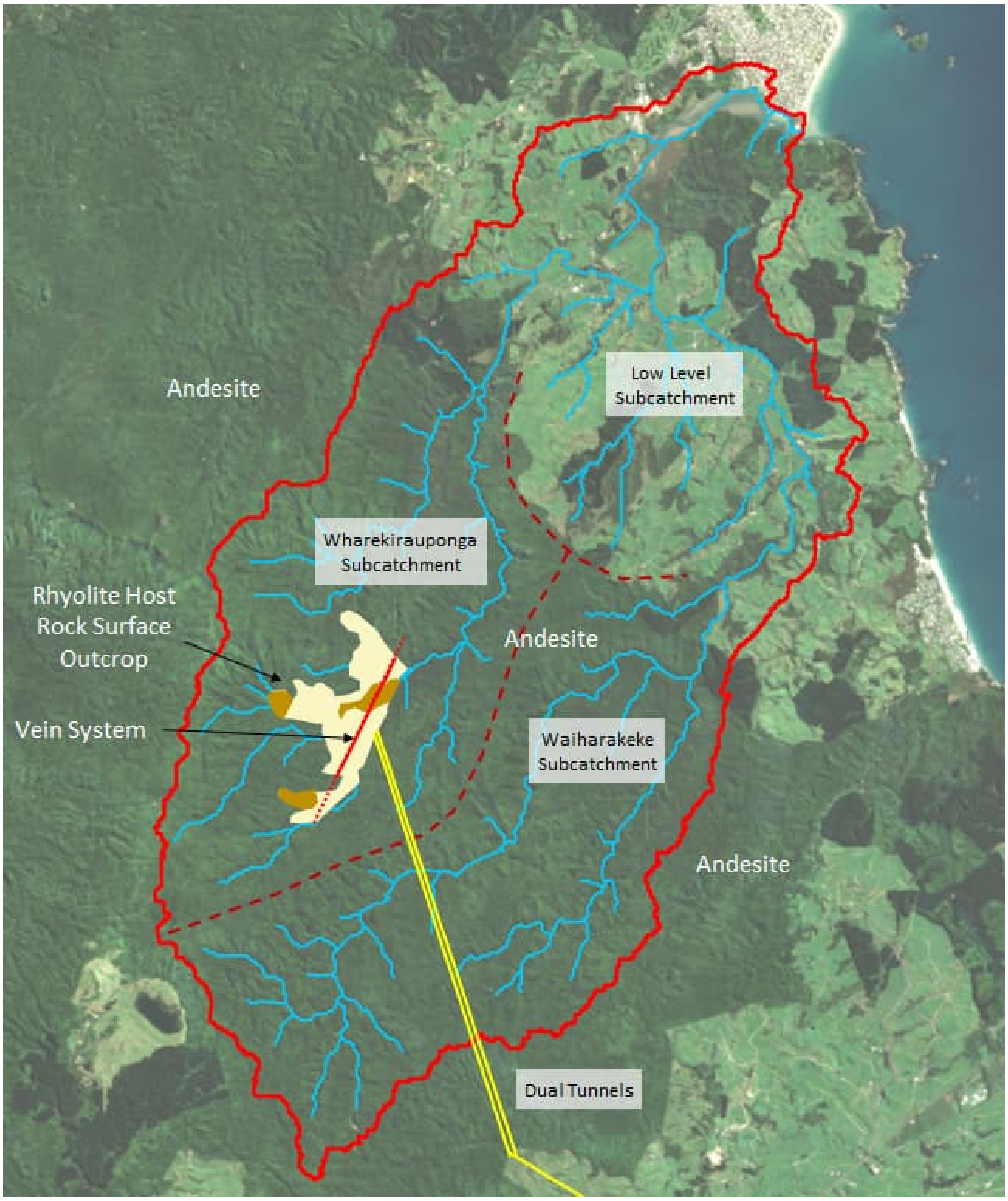

Figure 6. The Otahu surface water catchment showing the Rhyolite surface exposures and sub-catchments.

2.6 Site Geology

2.6.1 Geologic Structure

The surface geology, veining and section locations surrounding the Wharekirauponga deposit are shown on **Figure 7**, while **Figure 8** provides cross sections parallel to the main vein structures (EG Vein, T-Stream Vein and the Western Vein). The main veins are considered to be related to north-east trending, moderately dipping (60-65°) extensional step faults that relate to graben development and are up to 10 m wide. Secondary veins are developed between, or adjacent to, the main veins and are oriented northerly to north easterly, are moderately to steeply dipping and are up to 1 m wide. The veins are exposed at the surface within the Wharekirauponga Stream gorge and continue to a depth of at least 150 m.

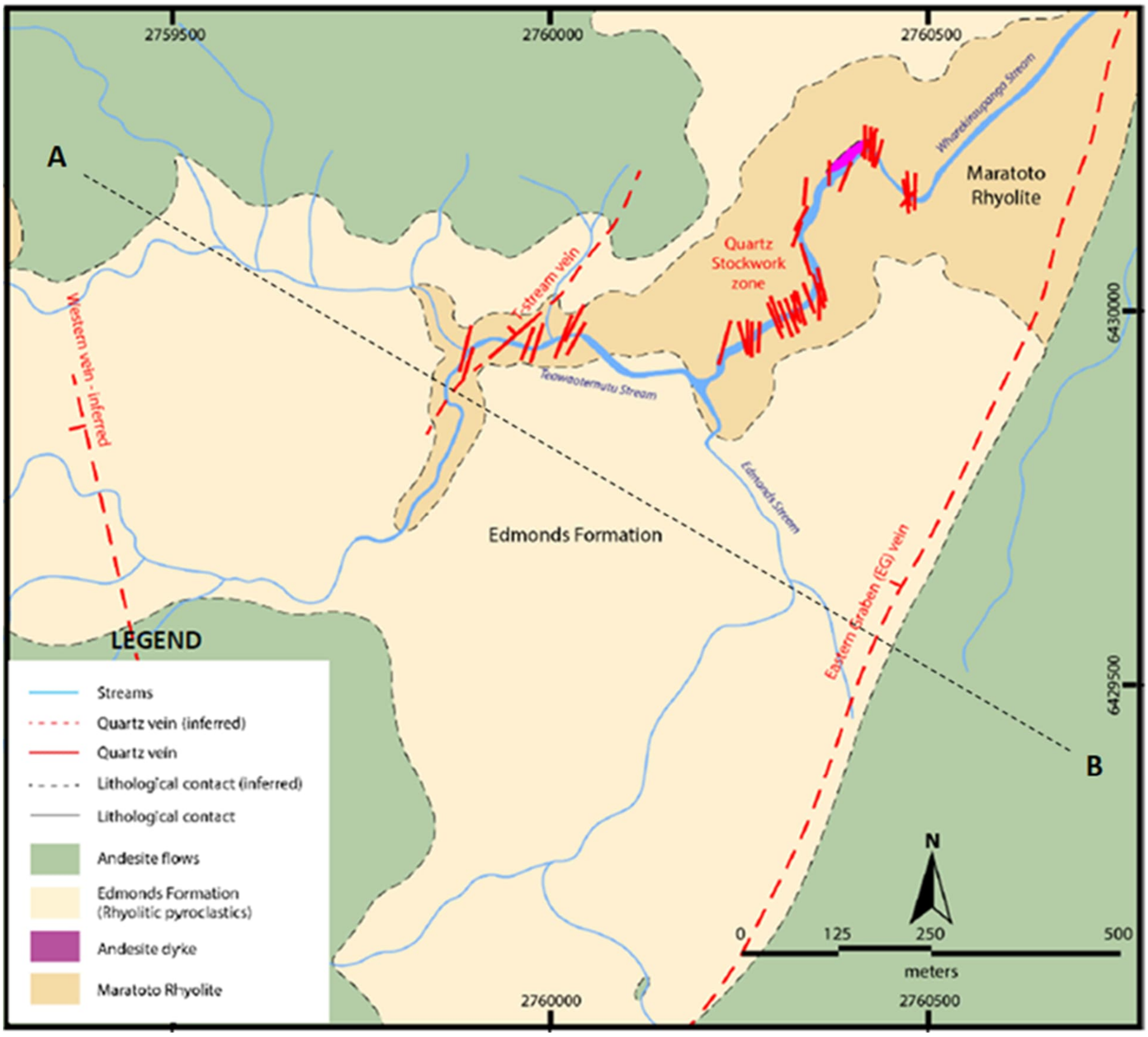

Figure 7. Surface geology in the Wharekirauponga area (after Grieve and Bartle (2013) and Christie et al. (2016)).

The vein zones are 90-95% quartz and are highly brittle in nature. Most of the area is dominated by Rhyolite flow (80%) that becomes increasingly silicified near the veins. In the main gorge a zone exists that is host to numerous veins and is highly brittle and fractured. Information from the exploration drilling logs indicates the footwall of the veins could be more highly fractured. The other main geologic unit is polymictic Rhyolite pyroclastics (20%) which, when silicified near veins, are also brittle and fractured. However, where these materials are strongly clay-altered, less fracturing is present.

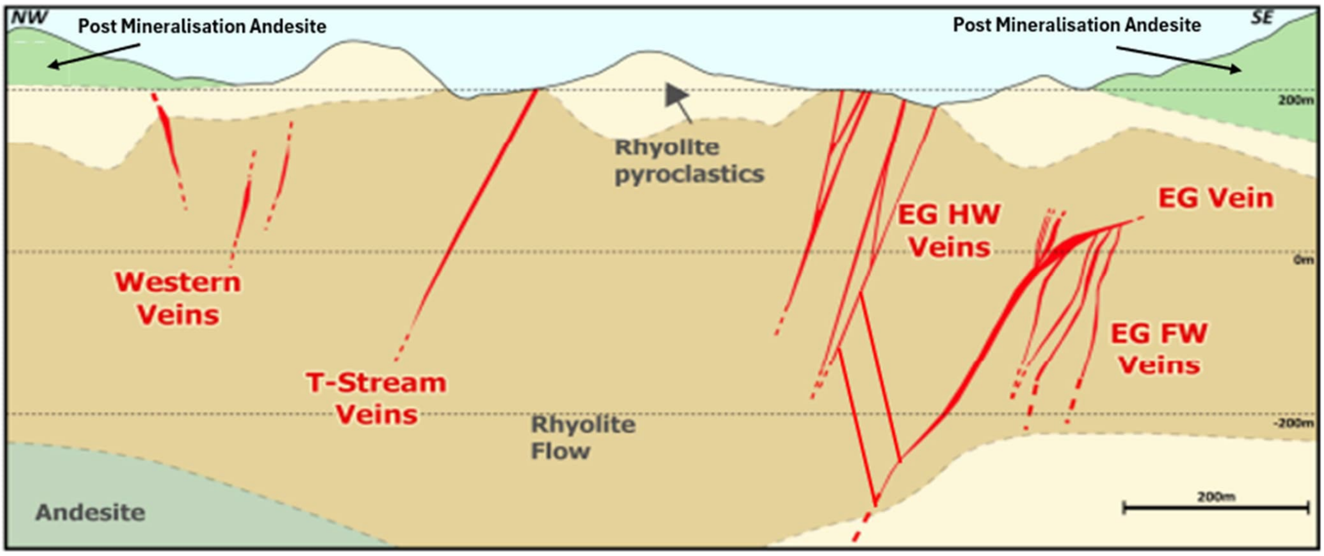

Figure 8. Geologic section of the Wharekirauponga vein systems.

The EG vein is the largest vein structure in the Wharekirauponga deposit and is continuous over a length of at least 1000 m but has not yet been fully delineated to the north and south. The vein dips to the west and has not been closed out up dip. Up dip the vein becomes thin or absent, however gold bearing clay gouge is present. The vein shows multiple phases of development and associated textures, although, overall, the vein presents as being massive with little void space e.g. vugs. Aside from the main vein, the EG vein structure has a series of extensional hanging wall veins that are oriented more northerly such that they connect the main structures (veins and Andesite dike). These veins are exposed at the surface, pinch out to the east and terminate at the Andesite dike in the west. The EG vein is known to have at least four main footwall veins; one that is oriented in a north-south direction and three that are subparallel to the main vein. These commonly have a brecciated texture and are interpreted to originate from fault movement. The extent of the EG footwall veins has yet to be closed out spatially.

The T-Stream vein parallels the EG vein, is around 5 m wide and has a strike length of at least 400 m, although it is yet to be closed out in the north. The vein is observed to be broken, oxidized quartz and quartz breccia.

2.6.2 Geologic Units

Geology in the area comprises andesite flows at depth, overlain by flow banded / massive rhyolite and felsic lithic tuffs (Rhyolite volcaniclastic) that host the mineralised veins. Younger andesite flows cover most of the surface with Rhyolite volcaniclastics exposed only in the central project area. **Table 1** provides a description of the geologic formations within the catchment as identified in **Figure 7** and **Figure 8**.

Table 1. Geological summary

Geological Unit	Description
Pre-mineralisation Andesite Rocks	Part of the Waipupu Formation and is composed of porphyritic plagioclase flows. The andesite has a sharp upper contact with the overlying tuff sequence.
Rhyolite Volcaniclastics	Consisting of lapilli tuff containing rhyolite fragments, quartz grains in the ash matrix, and a variety of andesite and potential basement fragment types (sandstone, mudstone) showing textural homogeneity and similarities in fragment types.

Eastern Rhyolite Intrusive Dome, North, South Rhyolite Flow Dome, Western Rhyolite Dome	Each of these subunits are part of the Maratoto Rhyolite Formation. Dome-shaped bodies that intruded into the tuff sequence and host mineralised vein systems.
The Eastern Graben Vein	The largest vein in Wharekirauponga and dips towards the west. Is over 1000 m and host to most of the economic gold in the deposit. Towards the upper reaches, the vein becomes thinner or disappears, transitioning into clay alteration.
Post-Mineralisation Andesite Cover	Late phase andesite flows deposited at the surface on hilltops in western, south-western, and north-western portions of the project area. Forms the upper-most geological unit. The andesite flows were deposited on top of an erosional unconformity formed at the weathered surface of the mineralised deposits. Is expected to thin out near the edge of the deposits.

The geology is described as Whiritoa Andesite on the eastern side of the valley which is truncated by the Edmonds Fault that dips to the west. Whakamoehau Andesite is located on the western side of the valley and is described as being post mineralisation Andesite and dacite flow with Andesite tuff breccia and recent colluvial cover. The mineralised unit is described as the Edmonds Formation that is composed of Rhyolitic flows and lapilli tuff that is commonly hydrothermally altered. The mineralised Rhyolitic volcanics are fault bound and it is interpreted that they are uplifted to some degree.

2.6.3 Hydrothermal Alteration

Geophysics and surface mapping has shown extensive hydrothermal alteration of the rockmass associated with the mineralisation phase of the deposit's formation. **Figure 10** and **Figure 9** show the distribution of alteration types that consist of a zone of silicification centred around the vein system, with peripheral clay alteration present.

2.6.4 Weathering & Post Mineralisation Deposition

One of the aspects to note regarding the geology within the project area is the relative age of the geologic units, with the weathering of the Rhyolite host rocks and the late phase andesite cover being important controls on the infiltration of rainfall and movement of groundwater within the system.

The Rhyolite host rocks were deposited and exposed at the land surface for some millions of years before later phase deposits were laid down. During that time weathering of the rock mass occurred resulting in the surface of the Rhyolite transforming to clay soils to a depth of up to a few meters. That is observed to primarily occur where clay altered materials are present at the surface, whereas weathering of the silica altered rocks was less pervasive.

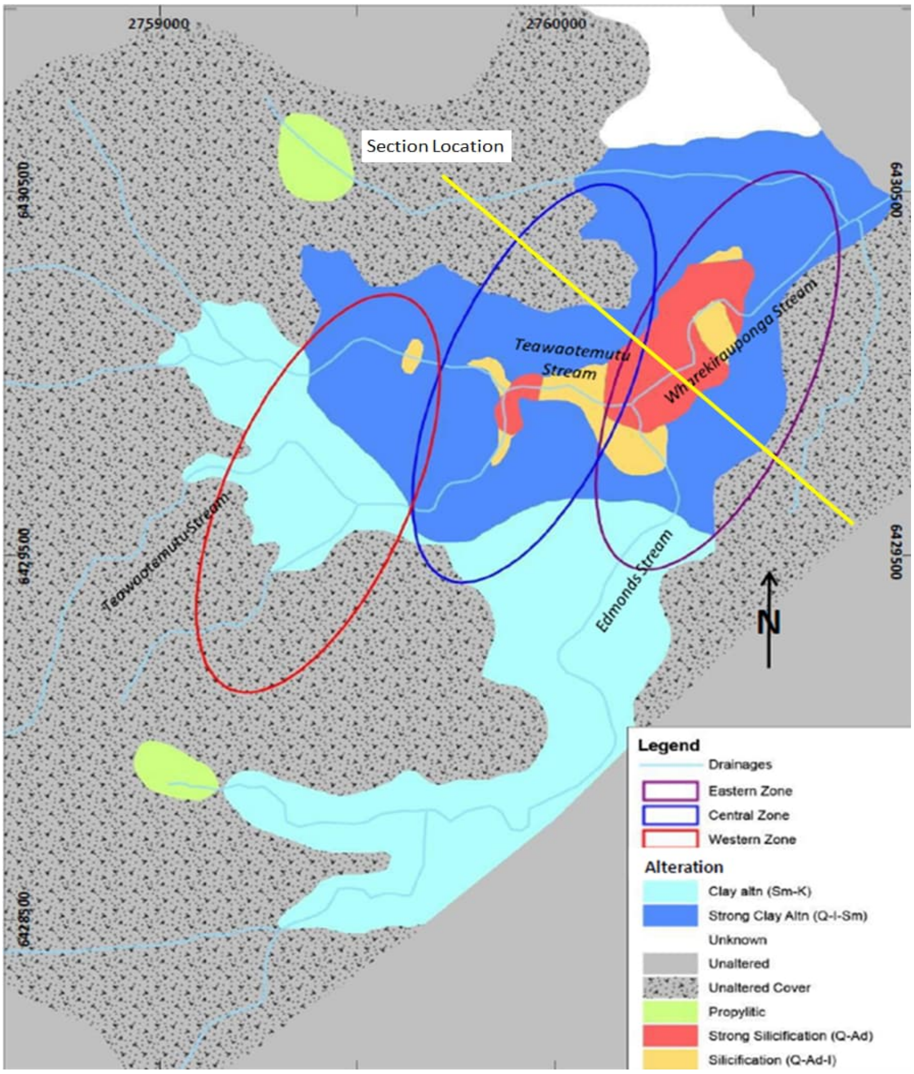

Figure 9. Hydrothermal alteration aones (Map modified from Grieve and Bartle (2013) and Christie et al. (2016)).

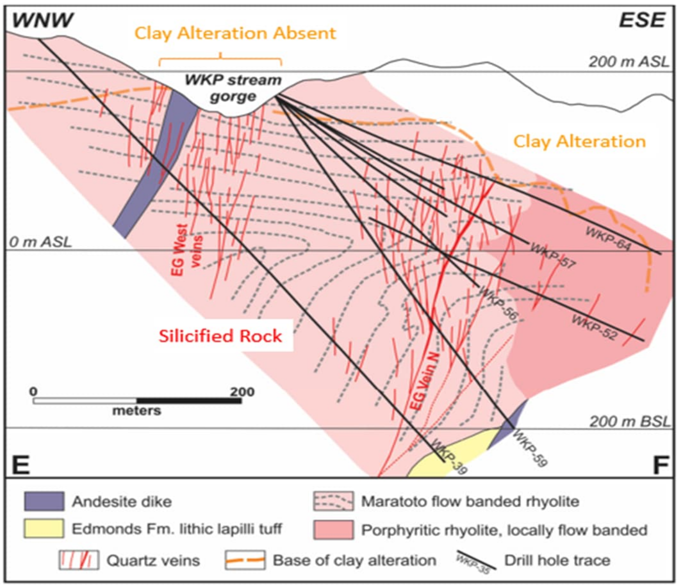

Figure 10. Cross section through the Wharekirauponga deposit showing alteration types and distribution.

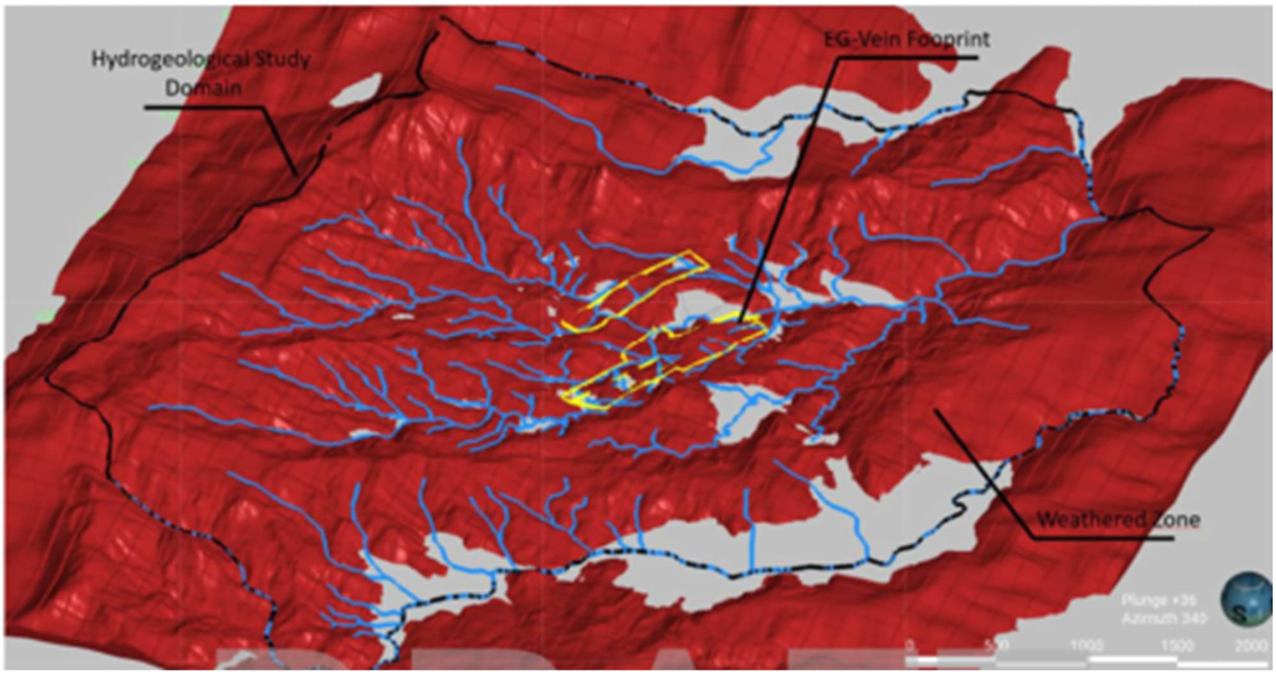

Figure 11. Distribution of surficial weathering within the Wharekirauponga Catchment.

After the weathering process had occurred, Andesite flows were deposited and the heat from the volcanics 'baked' the contact with the Rhyolite, further altering the materials to clay. The Andesite volcanics were then also exposed to weathering resulting in the formation of surficial soils and regolith. The distribution of weathering zone as presented in the geological model is shown in **Figure 11**.

2.7 Catchment Scale Hydrogeology

The overall hydrogeologic setting of the Wharekirauponga area is that of a groundwater discharge zone where streams gain from groundwater emanating from the surrounding hill slopes. The potentiometric surface is generally expected to mimic that of the surrounding topography. There is a high level of topographic relief within the Wharekirauponga catchment ranging from 750 m RL at the head, reducing to 30 m RL at the catchment discharge point (WKP1 surface water monitoring site). This degree of relief provides a significant driving head for the catchment as a whole. The upper third of the catchment is steep, with the gradient flattening to the northeast with the change in gradient correlating, generally, with the heads of streams (i.e. the inflection point is where surface waters become gaining). **Figure 12** provides a plan of the Wharekirauponga catchment showing an inferred potentiometric surface and drainage pattern. **Figure 13** shows sections through the catchment.

The recharge source for groundwater in the catchment is direct rainfall infiltration on the surrounding hills that soaks into the surficial soil regolith and then into the rockmass. With respect to the origin of groundwater inflow during underground dewatering, the dominant source of water will come from the intercepting throughflow from higher in the catchment.

The mechanisms for groundwater discharge in the catchment are: shallow rainfall infiltration water moving laterally down slopes (interflow); diffuse groundwater moving through fractures in the rock mass fabric; or point source discharges from structures (veins or highly fractured areas). Of these sources, interflow is noted to be the most significant mechanism of groundwater discharge. This is discussed further in this report in relation to the Conceptual Groundwater Model (CGM).

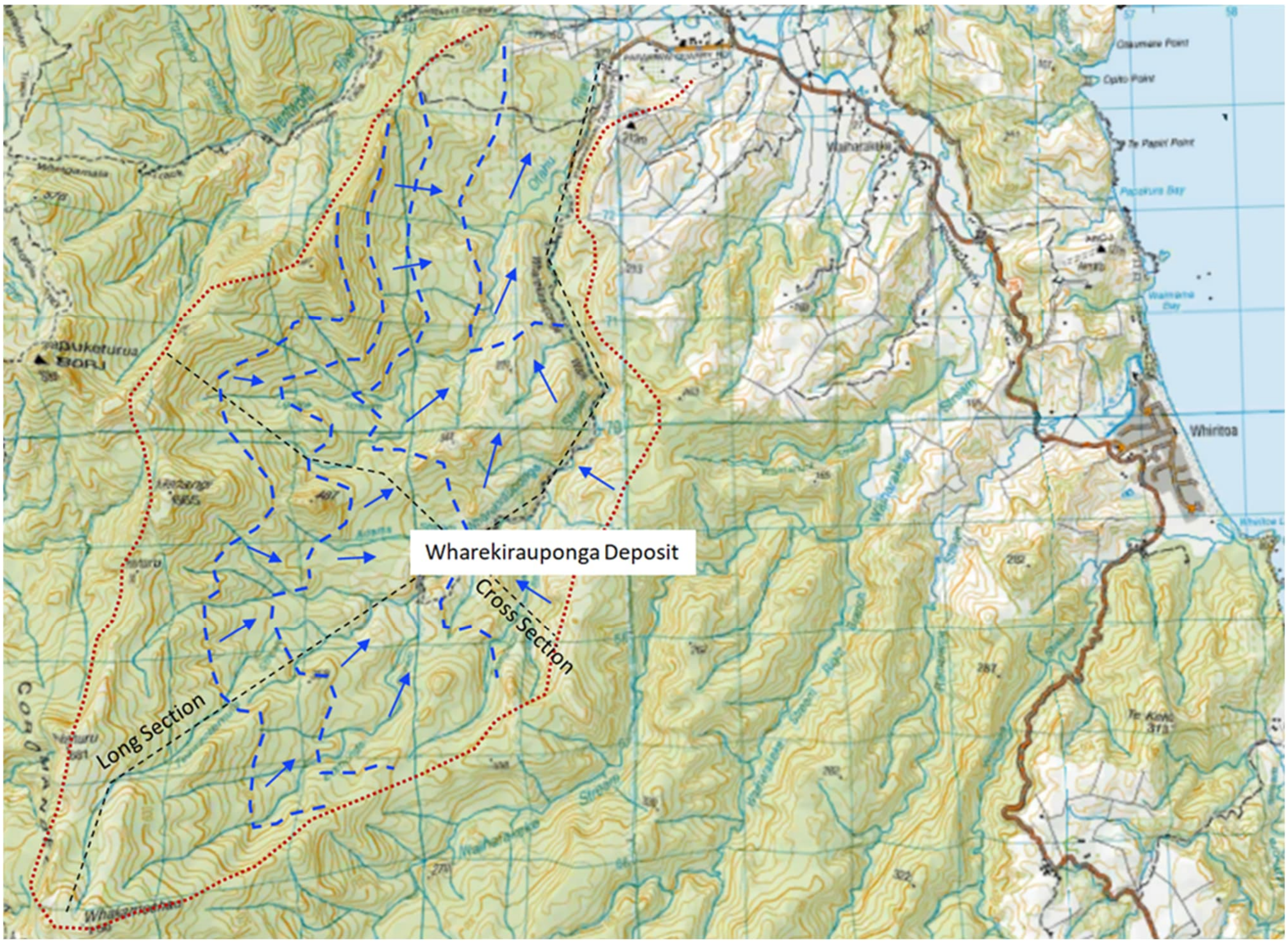

Figure 12. Wharekirauponga Catchment inferred piezometric surface plan.

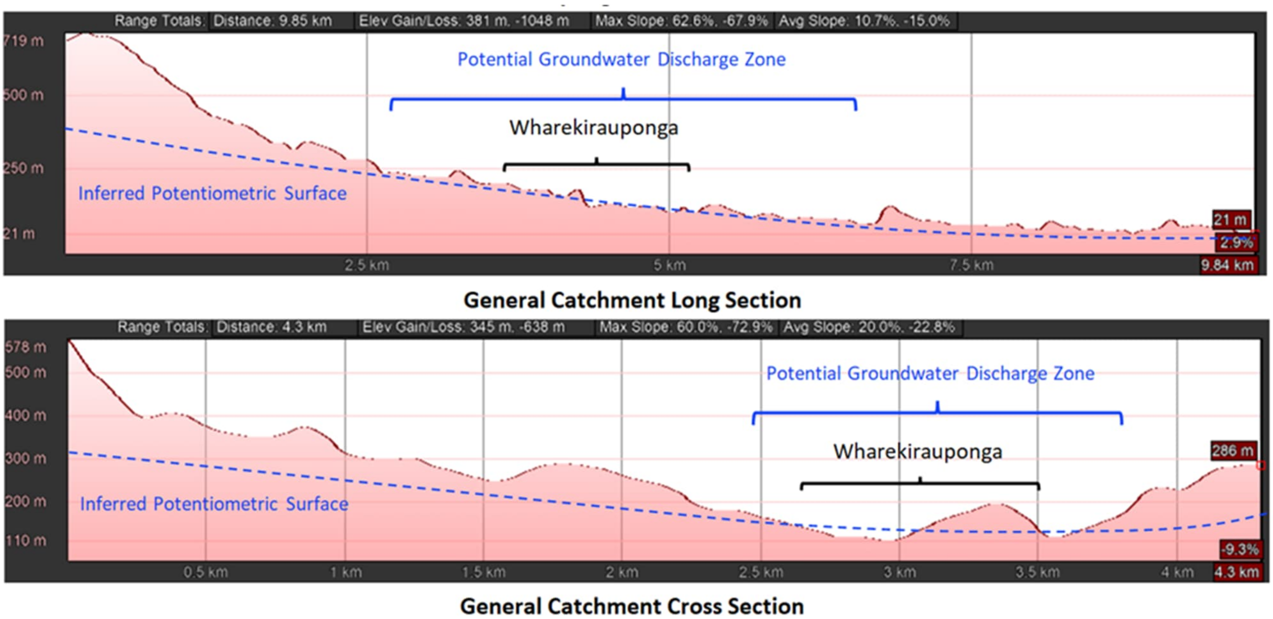

Figure 13. Wharekirauponga catchment inferred groundwater discharge zones.

2.8 Site Hydrogeology

An interpretation of the site hydrogeology in the project area has been made based on the regional hydrogeologic setting complimented by the site-specific data collected through the various lines of investigation described in Section 3 of this report. A full description of the site hydrogeology is provided by FloSolutions.

The hydrogeology of the Wharekirauponga epithermal gold deposit is complex due to geology and setting. There are fundamentally three hydrogeologic domains: Water table aquifer, Rhyolite host rock aquifer and the Vein system aquifer. **Figure 14** shows the various parts of the groundwater system as a generalised section.

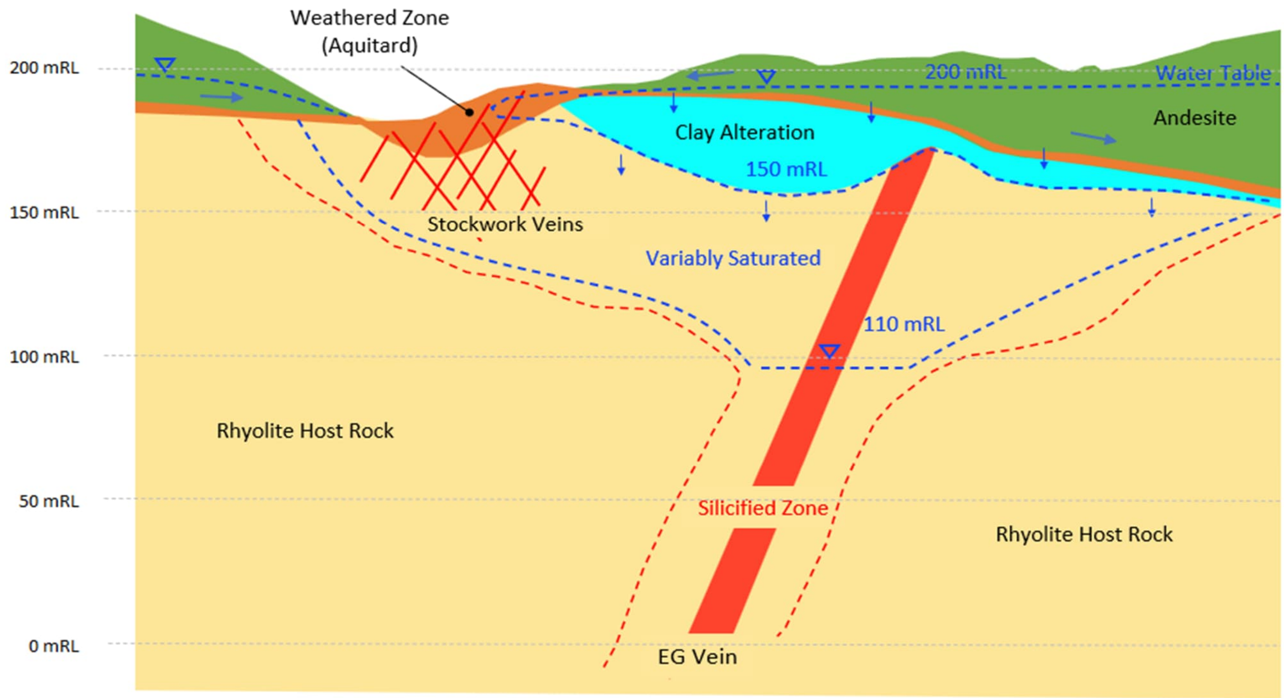

Figure 14. Wharekirauponga generalised hydrogeologic section.

2.8.1 Water Table Aquifer

Groundwater within the post mineralisation Andesite (and Rhyolite where exposed at the surface) forms the upper most aquifer with a water table present. The water table aquifer is open to the atmosphere and the water level varies as a function of rainfall. Groundwater movement in the aquifer is dominantly lateral with flow paths that generally follow the topographic expression (refer **Figure 15**).

2.8.2 Rhyolite Host Rock Aquifer

Underlying the post mineralisation Andesite is the Rhyolite that hosts the vein system. The upper part of the Rhyolite has been hydrothermally altered to a low permeability clay capping that hosts groundwater. Groundwater in that part of the system is held within the clay and is semi-confined in most places by the overlying Andesite. Where exposed at the surface the groundwater within the clay capping is unconfined. There is limited groundwater movement in the upper part of the system, however there is a downward hydraulic gradient caused by the underdrainage effects from the lower part of the system.

Beneath the clay alteration zone is Rhyolite rock that is host to the main EG Vein and hanging wall stockwork vein system. Immediately adjacent to the vein systems the Rhyolite rock is highly silicified, fractured and has variable permeability depending on the degree of fracturing, which can be high. Depending on the locality, parts of the rockmass above and adjacent to the vein system are unsaturated due to the degree of fracturing and associated high permeability. Strong downward hydraulic gradients are observed in many parts of the Rhyolite aquifer system. There is limited connectivity between the Rhyolite host rock aquifer and the water table where only partially saturated conditions exist.

2.8.3 EG Vein Aquifer

The EG Vein is at least partly drained along its length to an elevation of between 100 to 110 m RL and is lower than the surrounding piezometric levels. The low water level in the Vein system is a result of its high permeability and because there is an outlet along the strike of the vein to the northeast within a lower reach of the Wharekirauponga Stream. The presence of high permeability conditions is confirmed by the relatively flat hydraulic gradient within the deep groundwater system as shown in **Figure 16**.

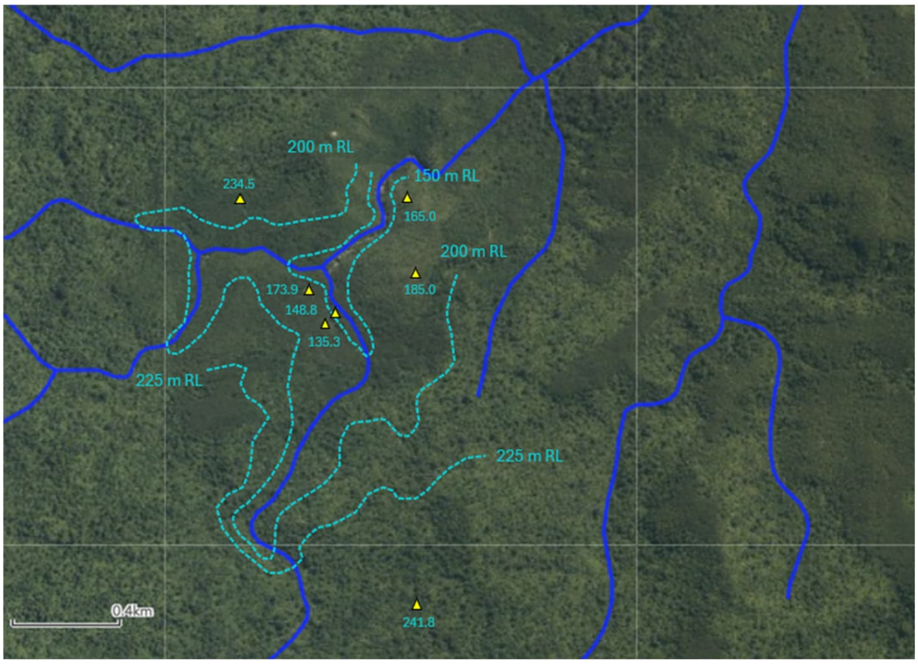

Figure 15. Shallow groundwater system piezometric surface.

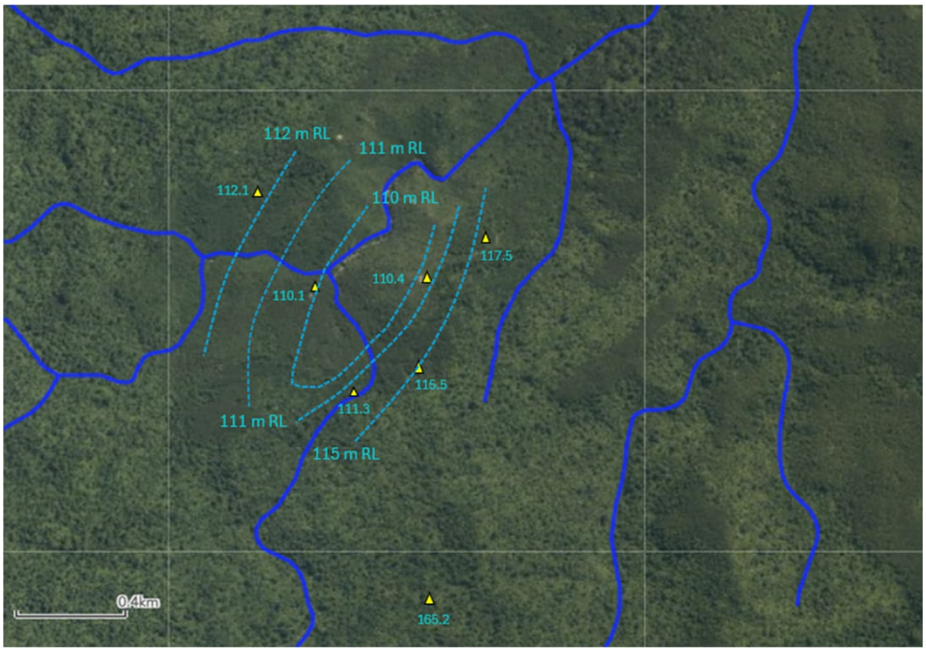

Figure 16. Deep groundwater system piezometric surface.

2.9 Conceptual Groundwater Model

The following preliminary Conceptual Groundwater Model (CGM) has been developed to allow a better understanding of how the groundwater system and surface waters interact in the Wharekirauponga catchment such that effects associated with mine dewatering can be evaluated. The CGM is described below and depicted in **Figure 17** and **Figure 18**.

The general conceptual model for the Wharekirauponga site is that of steeply dipping, parallel vein structures that are connected via dilatational vein sets. The veins are considered to also be hydraulically connected via the stockwork and later phase veins. Due to the catchment drainage pattern the T-Stream vein is near perpendicular to the groundwater through-flow direction, whereas the EG vein is near parallel to the groundwater through-flow direction. This observation indicates driving heads through the T-Stream vein system are likely to be greater than in the EG vein. Groundwater discharge begins to occur at an elevation of approximately 300 mRL near the contact of the post mineralisation Andesite and underlying rhyolitic rocks (refer **Figure 17**). These springs are created by groundwater discharge through localised hard Rhyolite flow outcrops that have formed an inflection in topography, allowing discharge at the surface and surface waters. This groundwater discharge provides some baseflow to the streams under low flow conditions.

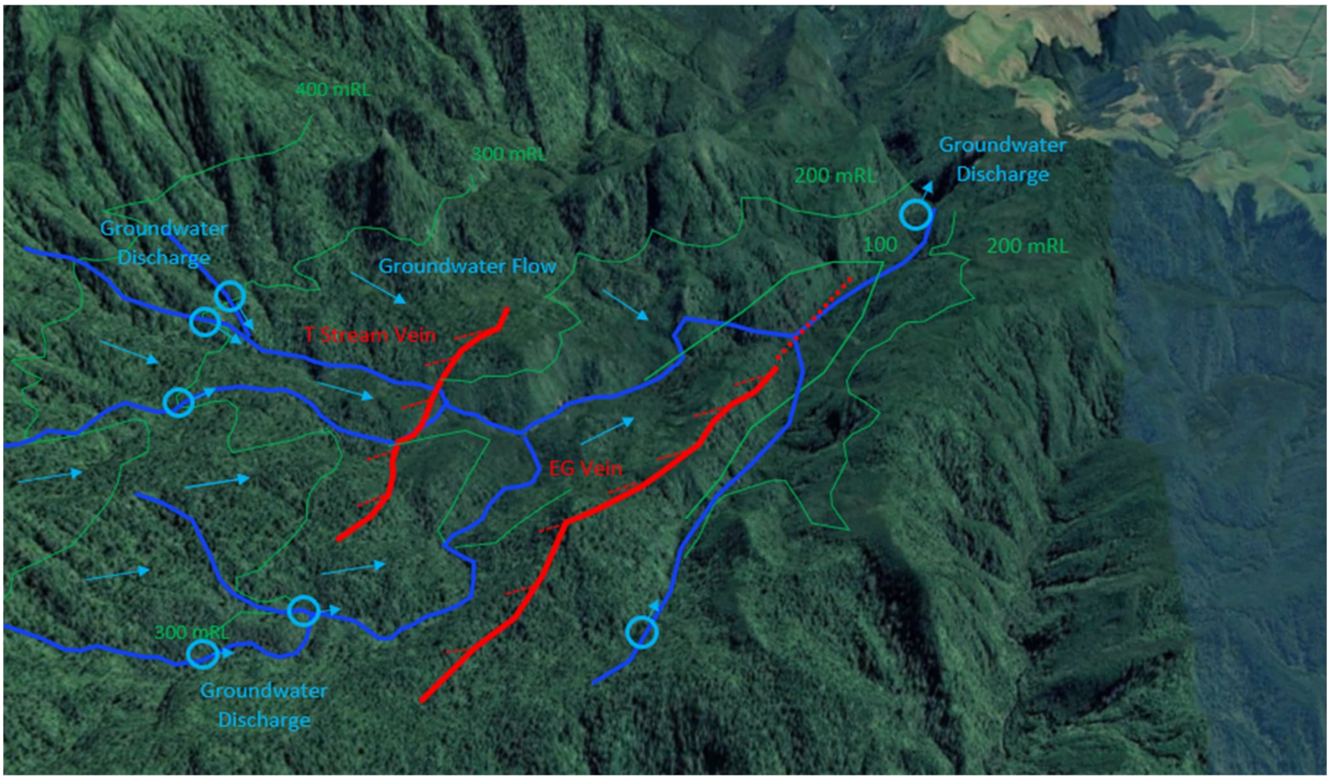

Figure 17. Wharekirauponga catchment groundwater flow.

Shallow, perched groundwater is present in the soil regolith and this is recharged from rainfall. The regolith water drains laterally down slope as interflow and discharges into the streams. Interflow is the dominant source of water supporting the streams and is a high input during and following rainfall. These soils have a high capacity to store water which recedes over time providing stream flow.

In summary, groundwater recharge is via direct rainfall and catchment through flow. Groundwater discharge to the streams is via deep groundwater high in the catchment, contact springs or from interflow drainage. The stream section below around 250 mRL is neutral under low flow conditions, there is no deep groundwater discharge from the rockmass. This section of the stream is formed in the rhyolitic host rock that will be partially dewatered during mining but, given it does not create baseflow, no loss to stream flows is expected to occur. Below the Thompson Stream tributary, the Wharekirauponga Stream flows over post mineralisation Andesite.

At the intersection of the EG main vein and the Wharekirauponga Stream, a Warm Spring is present at a discrete location on the stream bank. This spring is formed due to fluids upwelling from the greywacke basement rocks through the main Edmonds Fault mixed with shallower groundwaters. The spring is generally in the order of 20°C and as such is not deemed as being geothermal nor is it related to a geothermal source. The spring emerges at that location due to truncation of the structure by later phase faulting and/or as a contact spring with overlying Andesite rocks. The spring expected to be hydraulically connected to the EG main vein system.

The EG vein is formed beneath a ridge that runs subparallel to the Wharekirauponga Stream and is truncated by the Stream at an elevation of around 100 m RL along a reach lower in the catchment. At that location, groundwater is noted to be discharging into surface waters at a rate of around 5 L/s. The EG vein is likely to be mined from an elevation of approximately 180 m RL down to -300 m RL, and assuming a groundwater level within the vein at 160 m RL, some 460 m of dewatering would be required to mine the deposit. These metrics are, however, still to be accurately determined and will be verified through the mine design process. The southern extension of the EG vein projects towards the Edmonds Stream headwater springs and dewatering effects in the vein system could potentially affect spring discharge rates if hydraulically connected.

The T-Stream vein and associated vein sets are exposed at the surface and the main vein is truncated by the Teawaotemutu Stream. The T-Stream vein is exposed in the stream cutting, allowing groundwater to discharge and is, essentially, drained to this elevation (approx. 180 m RL) or possibly even lower. The vein acts as a conduit for groundwater discharge. The T-Stream vein is likely to be mined down to an elevation of around -100 m RL meaning some 280 m of dewatering within the vein would be required to mine the deposit.

West of the T-Stream vein is the Western Rhyolite dome that is host to another smaller vein system. At this location the headwater springs discharge into the Teawaotemutu Stream. Conceptually this vein system is hydraulically disconnected from the other vein systems due to the low permeability host rock and as such, dewatering effects at that location are expected not to develop. This assumption does, however, require further assessment.

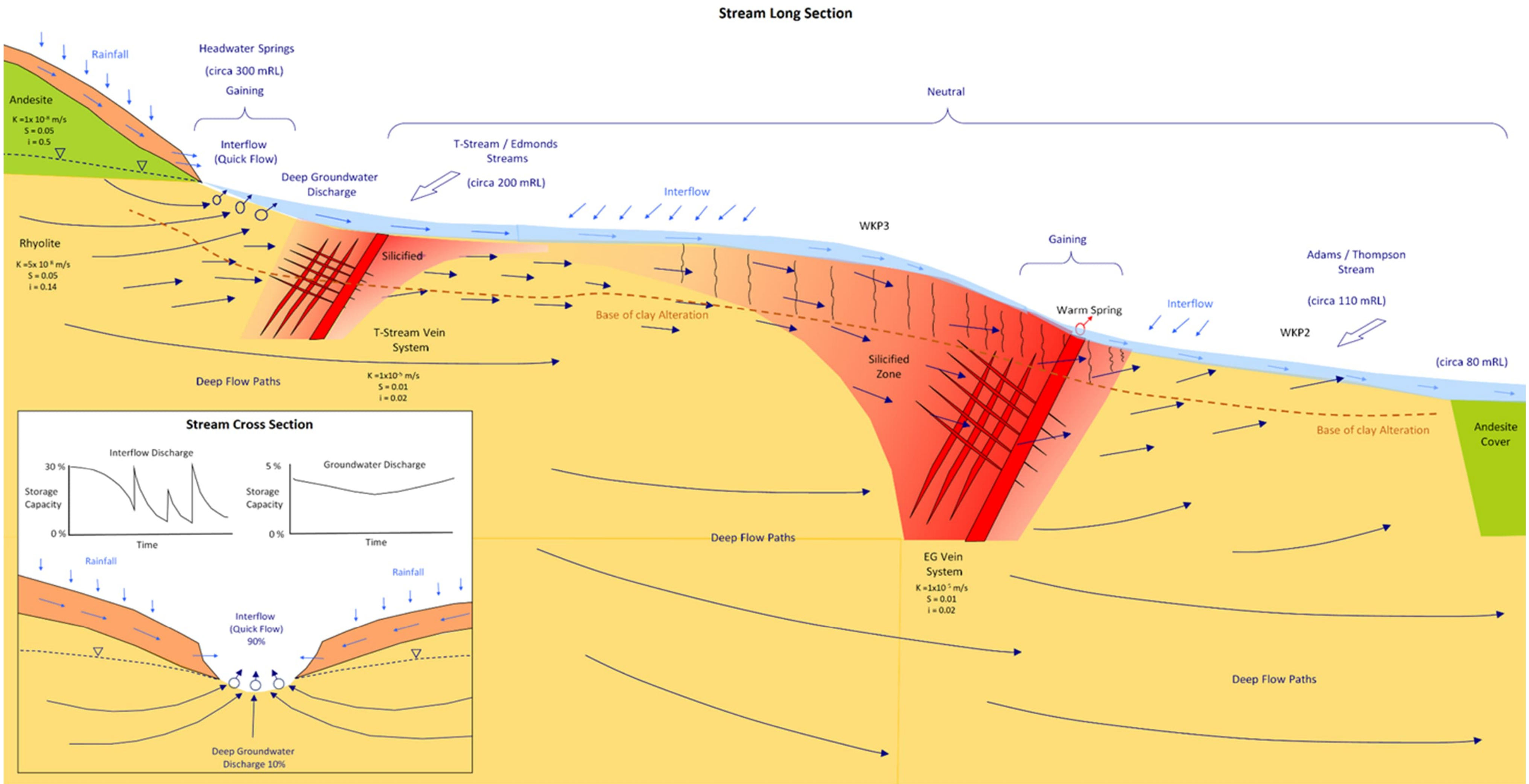

Figure 18. Conceptual surface and groundwater interaction model – stream long and cross sections

3. Site Investigations

The results of the site investigations undertaken up to October 2023 are documented in the FloSolutions Hydrogeologic Conceptual Site Model report (2023a). Subsequent to the preparation of that report additional drilling, packer testing, installation of additional piezometers and a test bore. The following section presents a summary of all the investigation results collected to date.

3.1 Methodology

There have been a number of site investigations undertaken that have assisted in characterising the hydrogeologic conditions in the area of the Wharekirauponga deposit and the groundwater catchment as a whole. This information includes:

- Characterization of the geologic conditions though numerous exploration drill holes.
- Verification of the surface geological conditions through exposure mapping.
- Geophysics to identify lithological contacts and alteration zones
- Analysis of rockmass defects from geotechnical core logging and zones of water loss during drilling.
- Installation of piezometers to assess vertical and horizontal hydraulic gradients.
- Undertaking permeability testing on shallow and deep geologic units.
- Flow gaugings of the Wharekirauponga and adjacent catchments.
- Collection of surface water samples and groundwater samples for dating and chemical analysis.
- Wetland delineation and drainage risk assessment.
- Construction of a test bore
- Numerical groundwater modelling and sensitivity analysis.
- Surface water flow modelling

A particular emphasis of the investigation has been to understand the level of groundwater -surface water interaction that occurs naturally in the catchment so that further assessment can be made to understand how this might be affected by dewatering of the orebody.

3.2 Geologic Characterisation

It is estimated that there has been some 154 drill holes and 61,300 m of exploration drilling undertaken to characterize the geological conditions and define the economic extents of the orebody. Detailed logs have been prepared that describe the geology, structure, geotechnical properties, veining mineralogy, alteration and weathering in each drill hole.

That information is incorporated into a detailed computer-generated geology and resource model. That geologic model was provided to FloSolutions (2023b) who converted it into a numerical groundwater model by assigning the hydraulic properties derived from the permeability testing and calibrating it to the groundwater level observations recorded at the piezometers.

3.3 Piezometers

To date there is a combination of 39 standpipe and Vibrating Wire Piezometers (VWPs) that have been constructed at the site, details of which are included in **Table 2** and their locations shown in **Figure 19**. Most of the VWP's installed have three tips and different elevations and the water pressures at each are continuously logged at 15-minute intervals. As discussed above, those observations have been used to calibrate the piezometric heads included within the numerical groundwater model.

Table 2. Standpipe piezometer details

Name	X	Y	Type	Dip	Azimuth	Pad	Tip /Screen Elevation	Model Geology
WKP_P01S	1849837	5868326	Standpipe	90	0	Drill Site 1	166.0	Rhyolite Volcaniclastics
WKP_P01D	1849835	5868326	Standpipe	90	0	Drill Site 1	136.0	Rhyolite Volcaniclastics
WKP_P02S	1850115	5868370	Standpipe	90	0	Drill Site 5	185.0	North Rhyolite Flow Dome
WKP_P02D	1850116	5868370	Standpipe	90	0	Drill Site 5	158.0	North Rhyolite Flow Dome
WKP_P06S	1849837	5868324	Standpipe	90	0	Drill Site 1	66.1	Rhyolite Volcaniclastics
WKP_P06D	1849837	5868335	Standpipe	90	0	Drill Site 1	-14.4	North Rhyolite Flow Dome
WKP_P07S	1850116	5868369	Standpipe	90	0	Drill Site 5	120.4	North Rhyolite Flow Dome
WKP_P07D	1850116	5868359	Standpipe	78	106	Drill Site 5	40.3	Main EG Vein
WKP_P08S	1850095	5868559	Standpipe	90	0	Drill Site 4	163.2	North Rhyolite Flow Dome
WKP_P08D	1850095	5868559	Standpipe	90	0	Drill Site 4	139.6	North Rhyolite Flow Dome
WKP_P03D_S	1849653	5868673	VWP	50	156	North Camp	222.9	Post Mineral Andesite Cover
WKP_P03D_M	1849675	5868625	VWP	50	156	North Camp	162.7	North Rhyolite Flow Dome
WKP_P03D_D	1849693	5868585	VWP	50	156	North Camp	110.6	T-Stream Vein
WKP_P04D_S	1850120	5868560	VWP	60	122	Drill Site 4	131.4	North Rhyolite Flow Dome
WKP_P04D_M	1850221	5868497	VWP	60	122	Drill Site 4	-49.6	Main EG Vein
WKP_P04D_D	1850267	5868467	VWP	60	122	Drill Site 4	-120.5	Main EG Vein
WKP_P05D_S	1850126	5867507	VWP	90	0	Drill Site 6	139.0	Post Mineral Andesite Cover
WKP_P05D_M	1850126	5867507	VWP	90	0	Drill Site 6	69.0	Rhyolite Volcaniclastics
WKP_P05D_D	1850126	5867507	VWP	90	0	Drill Site 6	9.0	Eastern Rhyolite Intrusive
WKP_P09D_S	1849905	5868266	VWP	22	127	Drill Site 1	148.2	Western EG veins
WKP_P09D_M	1849952	5868232	VWP	22	127	Drill Site 1	126.3	North Rhyolite Flow Dome
WKP_P09D_D	1850095	5868125	VWP	22	127	Drill Site 1	57.7	Main EG Vein
WKP_P10D_S	1849836	5868142	VWP	44	131	Drill Site 8	137.3	Rhyolite Volcaniclastics
WKP_P10D_M	1849894	5868090	VWP	44	131	Drill Site 8	83.4	Western EG veins
WKP_P10D_D	1849929	5868059	VWP	44	131	Drill Site 8	44.7	Rhyolite Volcaniclastics
WKP_P11D_S	1849881	5868238	VWP	27	152	Drill Site 1	134.8	Western EG veins
WKP_P11D_M1	1849907	5868185	VWP	27	152	Drill Site 1	105.7	Western EG veins
WKP_P11D_M2	1849969	5868070	VWP	27	152	Drill Site 1	40.0	Rhyolite Volcaniclastics
WKP_P11D_D	1850026	5867971	VWP	27	152	Drill Site 1	-20.3	Main EG Vein
WKP_P12	1850158	5867998	VWP	90	0	Vent Site 8	174.0	Post Mineral Andesite Cover
WKP_P13_S	1850158	5867998	VWP	72	285	Vent Site 8	174.6	Post Mineral Andesite Cover
WKP_P13_M	1850158	5867998	VWP	72	285	Vent Site 8	94.0	Rhyolite Volcaniclastics
WKP_P13_D	1850158	5867998	VWP	72	285	Vent Site 8	-32.2	Rhyolite Volcaniclastics
WKP_14_S	1849830	5868329	VWP	28	80	Site 1	111.6	Rhyolite Volcaniclastics
WKP_14_M	1849830	5868329	VWP	28	80	Site 1	41.2	Rhyolite Volcaniclastics
WKP_14_D	1849830	5868329	VWP	28	80	Site 1	3.6	Rhyolite Volcaniclastics
WKP_15_S	1850111	5868371	VWP	60	165	Drill Site 5	134.2	Altered Volcaniclastics
WKP_15_M	1850111	5868371	VWP	60	165	Drill Site 5	59.7	Rhyolite Volcaniclastics
WKP_15_D	1850111	5868371	VWP	60	165	Drill Site 5	18.2	Main EG Vein

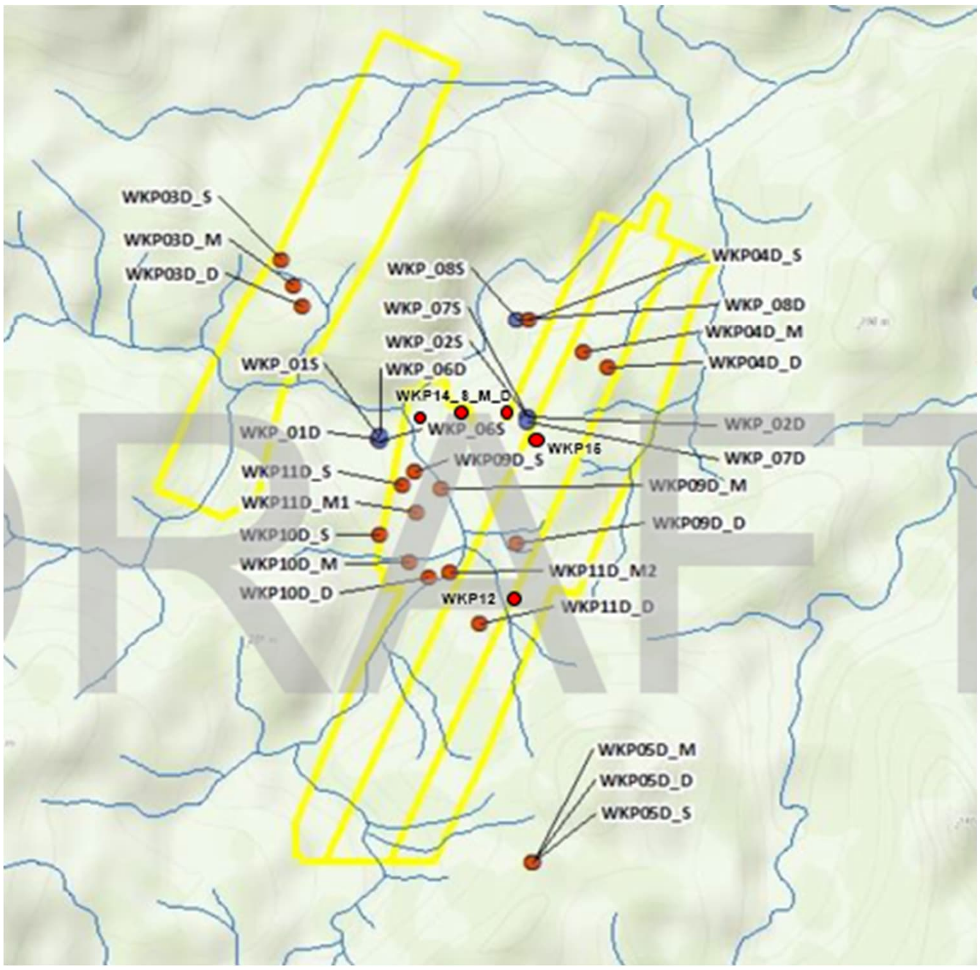

Figure 19. Piezometer locations

There are key observations from the piezometric data that are relevant to understanding the behaviour of the groundwater system and the interconnectivity of the deep and shallow aquifer systems. Firstly, strong downward vertical hydraulic gradients are noted to occur from the shallow to the deep aquifer system with values ranging from 0.4 to 1.3, indicating the downward movement of water. That is illustrated in **Figure 20.**

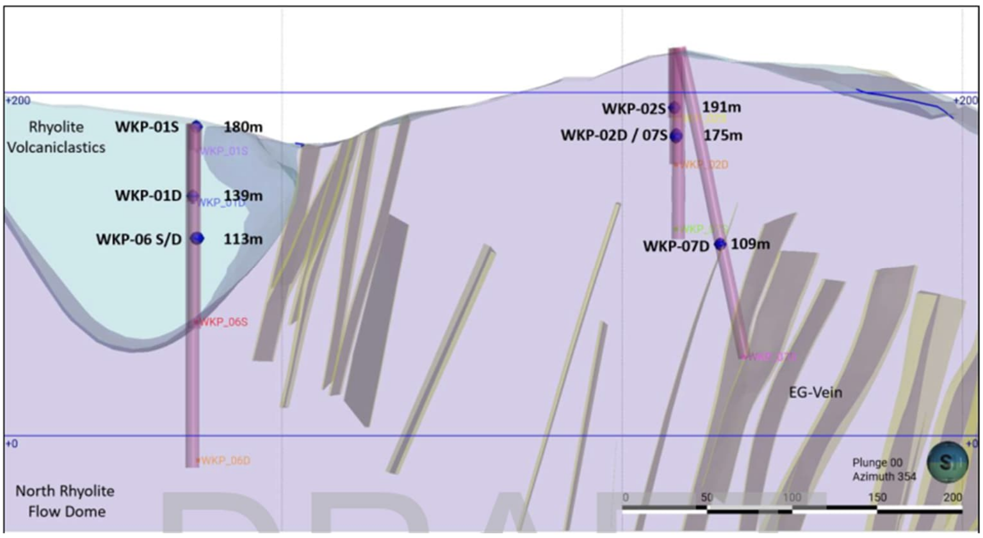

Figure 20. Piezometer locations in section.

The second point of note is that the hydrographs commonly show some seasonal variability in groundwater elevation in the shallow part of the system, while the middle and deeper parts of the system show little to no seasonal variation. That is shown on **Figure 21**. That observation further indicates a lack of connectivity between the deep aquifer and the surface.

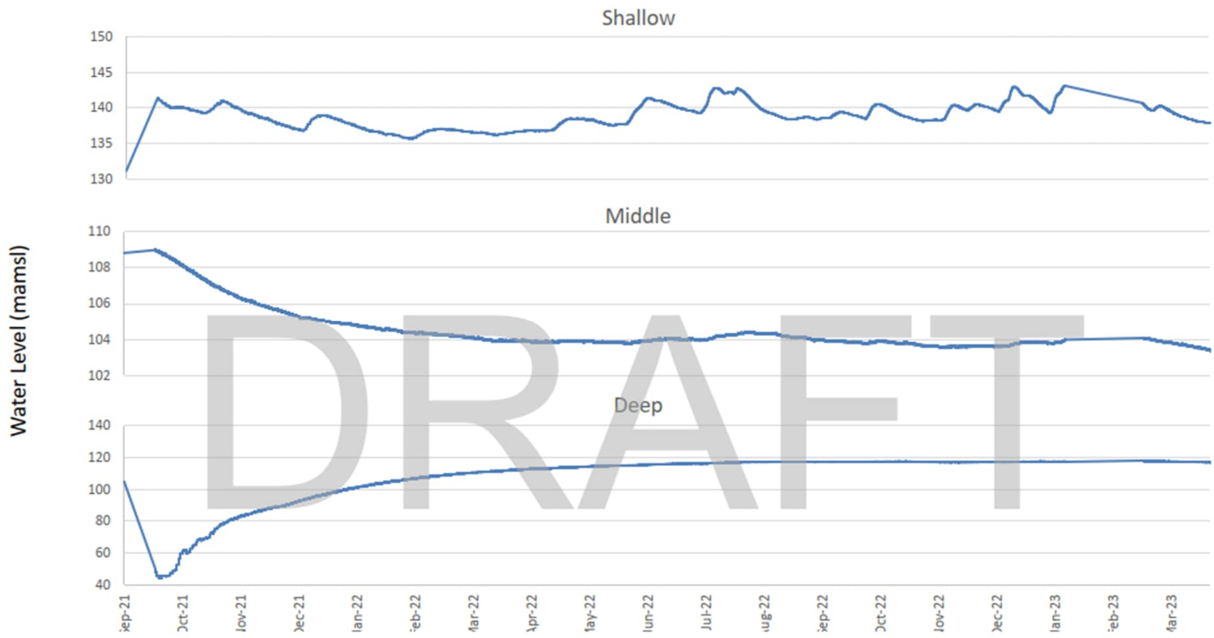

Figure 21. WKPP_P04 hydrographs

3.4 Permeability Testing

Throughout the exploration drilling program, and for specific holes drilled to inform the hydrogeology of the site area, permeability testing has been undertaken. Falling head permeability testing was undertaken at various depths in the vertical standpipe piezometers, while packer testing (single and double packer) was undertaken on the angled drill holes. The packer testing allowed for more targeted measurements of permeability within the veins and host rock units to be made. The tests were performed by Alton drilling under the supervision of Golder and subsequently Hydrogeochem staff. A total of 62 packer tests and 10 falling head tests have been undertaken at the time of preparing this report.

The packer tests were analysed by Golder and verified by FloSolutions and Hydrogeochem. The complete set of results is included in the Golder report (November, 2021), FloSolutions report (October, 2023) and Hydrogeochem report (October, 2024) and are summarised in **Table 3** below.

Table 3. Permeability summary results.

Geologic Unit	Geomean	Maximum	Minimum
Shallow Aquifer (incl Andesite)	2.9E-08	3.3E-06	3.7E-10
Clay alteration zone	2.3E-08	6.1E-08	8.6E-09
EG-Vein	8.7E-06	2.7E-04	2.8E-07
Rhyolite Intrusive	1.4E-07	7.6E-06	3.8E-10
Rhyolite Volcaniclastics	4.8E-08	3.8E-06	3.9E-10

From those data it can be stated that typical observations of the vein system permeability are in the order of $1x10^{-4}$ to $1x10^{-6}$ m/s, fractured rockmass between $1x10^{-6}$ to $1x10^{-7}$ m/s and less fractured rockmass $1x10^{-7}$ to $1x10^{-8}$ m/s. These values are consistent with those observed elsewhere in the Coromandel for similar rock types.

3.5 Surface Water Gauging

Surface water flow measurements have been undertaken in the Wharekirauponga catchment with gaugings of various extents having been undertaken. The continuous gauging network was setup in 2019 at the set locations presented in **Table 4** and shown on **Figure 22**. Complete details relating to the surface water flow gaugings, trends and statistics is provided in the GHD report (October, 2024).

Table 4. Surface water flow gaugings (L/s)

Statistic (L/s)	T Stream West	T Stream East	Edmonds	WKP03	WKP02	Thompson	WKP01
Average flow	146.09	149.13	102.84	251.98	318.22	74.16	509.87
Median flow	118.55	120.76	83.15	203.9	257.23	58.51	408.65
MALF	27.97	27.67	20.68	48.38	63.97	15.86	102.93
7 day-MALF	31.22	31	22.79	53.83	70.66	17.3	113.38
Q5	22.01	21.58	16.75	38.33	51.47	13.65	83.33

Initial gaugings were limited to the locations identified in **Table 4**. Subsequent spot gaugings were performed at the location of all the main tributaries within the Wharekirauponga catchment and in some adjacent catchment at times, with the intention of capturing low flow conditions. Contemporaneous measurements of stream flow, water chemistry samples and radon samples were undertaken during those events as described in the following sections.

3.6 Surface Water Dating

During the December 2020, March 2021 and May 2021 surface water gauging events, contemporaneous samples were collected for radon dating and general chemistry. Samples were also collected from the standpipe piezometers and from accessible historical adits and shafts. The purpose of the dating was to better understand where groundwater inputs into surface waters are sourced. **Figure 22** and **Table 5** present the results of the dating.

The results of the dating are documented in a report prepared by GNS (July, 2021) and are summarised as follows. The dating has shown:

- Where Rn <0.3 becquerel per litre (Bq/L) there is no groundwater input, between 0.3 to 0.5 Bq/L there is possible groundwater input and >0.5 Bq/L is a groundwater input.
- Overall, the surface waters are young in age with 75% having Rn <0.5 Bq/L indicating limited deep groundwater input in the catchment.
- There is a general inverse relationship between stream flows and Rn concentration with older water having smaller flow rates (**Figure 23**).
- The Warm Spring is the dominant source of deep groundwater in the catchment and affects the age of the surface water at WKP3, WKP2 and WKP1.
- Some deep groundwater is noted to discharge at the headwaters of the Teawaotemutu Stream, Edmonds and Thompson sub-catchments.
- Similarly deep groundwater is noted to discharge at the headwaters of the subcatchments on either side of the Wharekirauponga catchment.
- Tributaries X,W and U had comparatively high radon concentrations but have very low flows (<0.1 L/s).

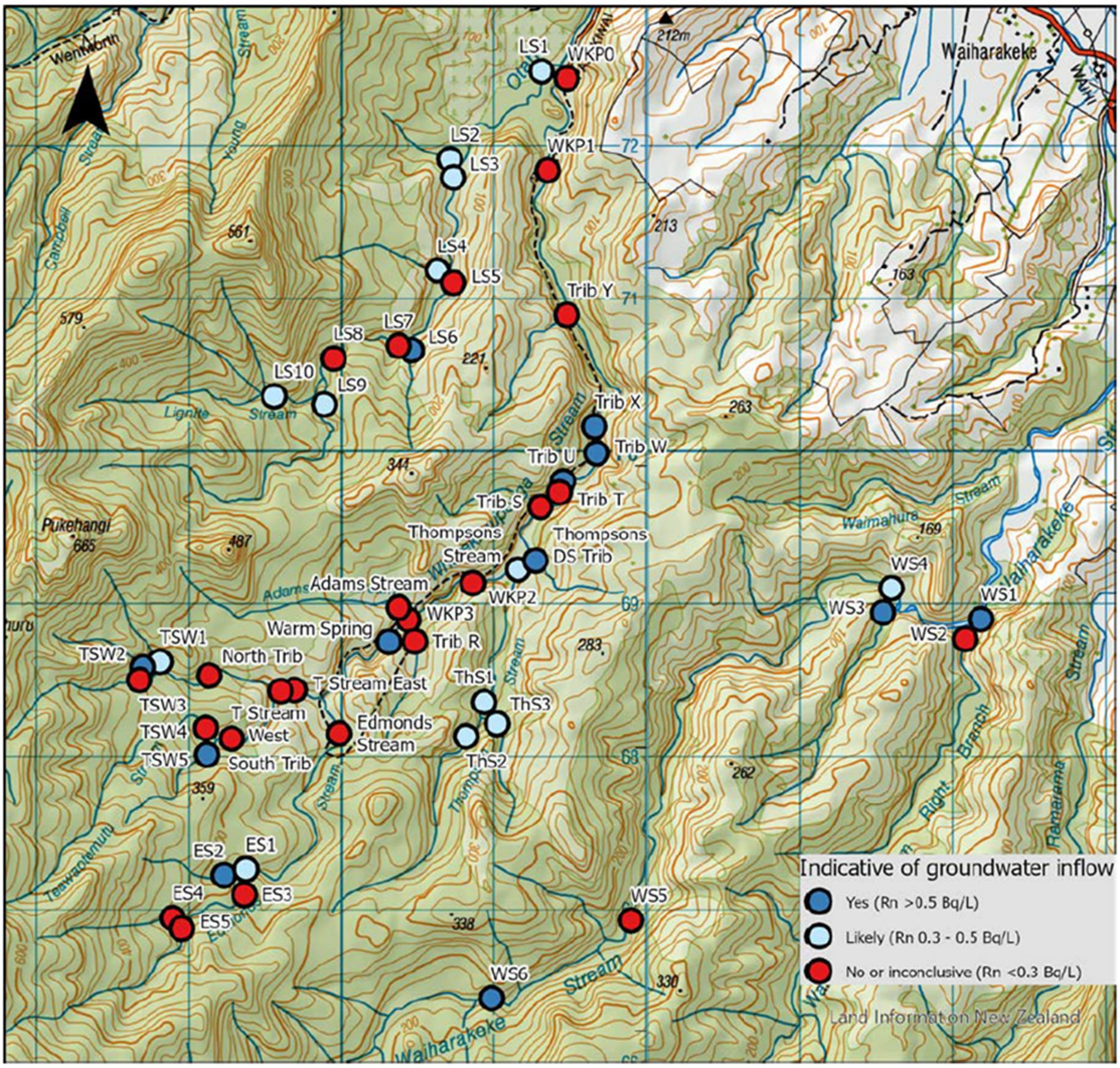

Figure 22. Indicative groundwater inflow locations - Dec 2020 (from GNS, Feb 2021)

Table 5. Radon concentrations and flows in surface waters

Location	Dec-20 Flow (L/s)	Dec-20 Rn (Bq/L)	Mar-21 Flow (L/s)	Mar-21 Rn (Bq/L)	May-21 Flow (L/s)	May-21 Rn (Bq/L)
WKP0	173.3	0.23	-	-	-	-
WKP1	164.0	0.30	-	0.18	143.2	0.35
WKP2	120.9	0.35	-	0.49	104.7	0.31
WKP3	95.2	0.71	-	0.53	83.5	1.12
T Stream East	74.2	0.20	-	0.17	52.1	0.42
T Stream West	56.4	0.13	-	0	50.5	0.04
ES1	51.0	0.39	-	0.16	35.2	0.24
ES3	42.0	0.18	-	0.24	37.4	0.23
TSW4	34.4	0.04	-	0.07	11.3	0.19
Edmonds Stream	30.2	0.15	-	0.19	25.7	0.15
South Trib	26.5	0.20	-	0.17	27.9	0.23
ES5	23.0	0.27	-	0.16	13.2	0.28
North Trib	22.5	0.24	-	0.31	11.0	0.3
TSW3	15.6	0.12	-	0.13	10.1	0.88
Thompsons Stream	12.7	0.37	-	0.26	16.1	0.4
ThS1	10.6	0.34	-	0.53	11.0	0.57
ThS2	8.5	0.36	-	0.53	9.6	0.54
Adams Stream	6.0	0.09	-	0.09	5.3	0.13
Trib R	4.7	0.28	-	0.39	3.2	0.6
TSW5	3.1	0.65	-	0.51	16.5	0.04
TSW2	2.6	1.45	-	1.22	3.1	1.56
TSW1	1.9	0.42	-	0.42	1.6	0.47
ThS3	1.9	0.37	-	0.51	1.9	0.52
Thompsons DS Trib	1.6	0.60	-	0.48	2.8	0.77
ES2	1.5	1.10		0.51	2.2	0.96
Trib S	0.9	0.24	-	-	-	-
Trib Y	0.3	0.23	-	-	-	-
Trib W	0.1	1.65	-	-	-	-
Trib U	0.1	1.07	-	-	-	-
Trib T	0.0	0.02	-	-	-	-
Trib X	0.0	5.70	-	-	-	-
Warm Spring	3.5	15.80	-	14.43	3.6	15.31
WKP02D	-	5.59	-	3.89	-	-
WKP02S	-	3.36	-	8.68	-	10.59
WKP01D	-	2.22	-	2.98	-	3.87
WKP01S	-	1.99	-	1.14	-	1.77
T Stream Shaft	-	7.79	-	0.12	-	1.21
T Stream Adit Shaft	-	1.01	-	-	-	0.64

No Groundwater Input	Possible Grondwater Input	Groundwater Input

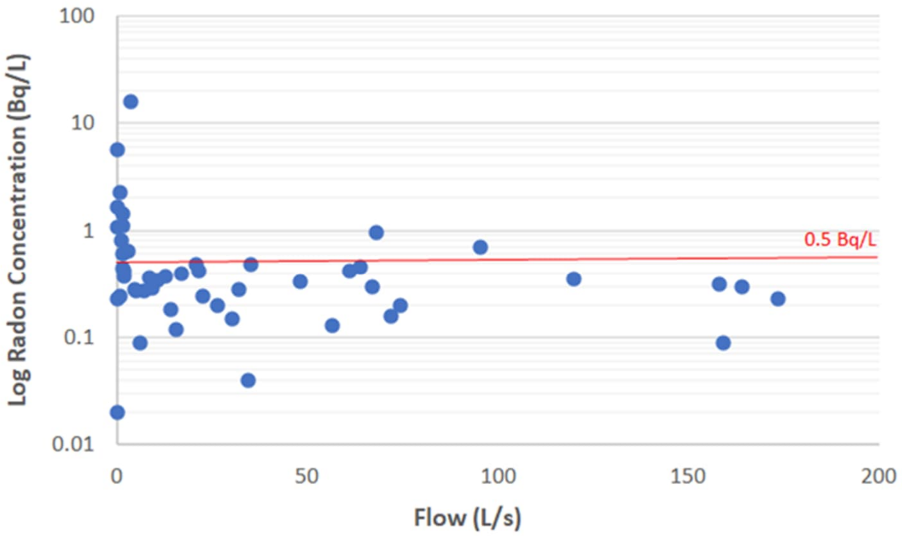

Figure 23. Surface water flows vs radon concentrations

3.7 Surface Water Chemistry

During the gauging events, contemporaneous sampling of surface water and groundwater chemistry was undertaken for a broad suite of analytes. **Table 6** and **Figure 24** present the results of the analyses. A summary of the results of the laboratory analysis of these samples is as follows:

- There is little difference in the chemistry between any of the surface water samples with the exception of the Warm Spring.
- The surface water has a sodium bicarbonate water chemistry.
- The Warm Spring is calcium bicarbonate dominant water type and is moderately elevated in some metals.
- Shallow groundwater has a different chemistry to deep groundwater.
- Deep groundwater has a calcium bicarbonate water signature.
- Clay alteration results in elevated calcium, bicarbonate and sulphate concentrations.
- WKP01D chemistry is similar to the Warm Spring.
- WKP02 chemistry is a mixture of deep groundwater chemistry and surface water.

Overall, the sampling indicates there is different chemistry where groundwater flow paths differ in length.

Table 6. Groundwater and surface water major chemistry

Data Point	pH	EC (mS/m)	HCO_3 (g/m³)	Ca (g/m³)	Cl (g/m³)	Mg (g/m³)	K (g/m³)	Na (g/m³)	SO_4 (g/m³)
Surface Waters	7.1	8.1	25	4.1	7	2.2	1.13	8.6	5
WKP01S (Pyroclastic)	7.3	93.5	370	121	13	17.2	7.2	69	200
WKP01D (Rhyolite)	6.9	21.8	81	20	14	1.73	9.7	16.9	21
WKP02S(Pyroclastic)	5.9	8.5	16.1	5	9	0.85	4.8	8.7	8
WKP02D (Rhyolite)	6.4	10	44	8.6	8	2.4	5.1	9.6	5
T-Stream Adit	6.1	4.6	5.1	0.36	8	1.01	1.65	5.8	5
T-Stream Shaft	5.2	4.4	4.6	0.46	9	0.59	1.12	5.7	7
EG Warm Spring	7.1	16.2	52	14	8	1.31	6.4	11.6	15

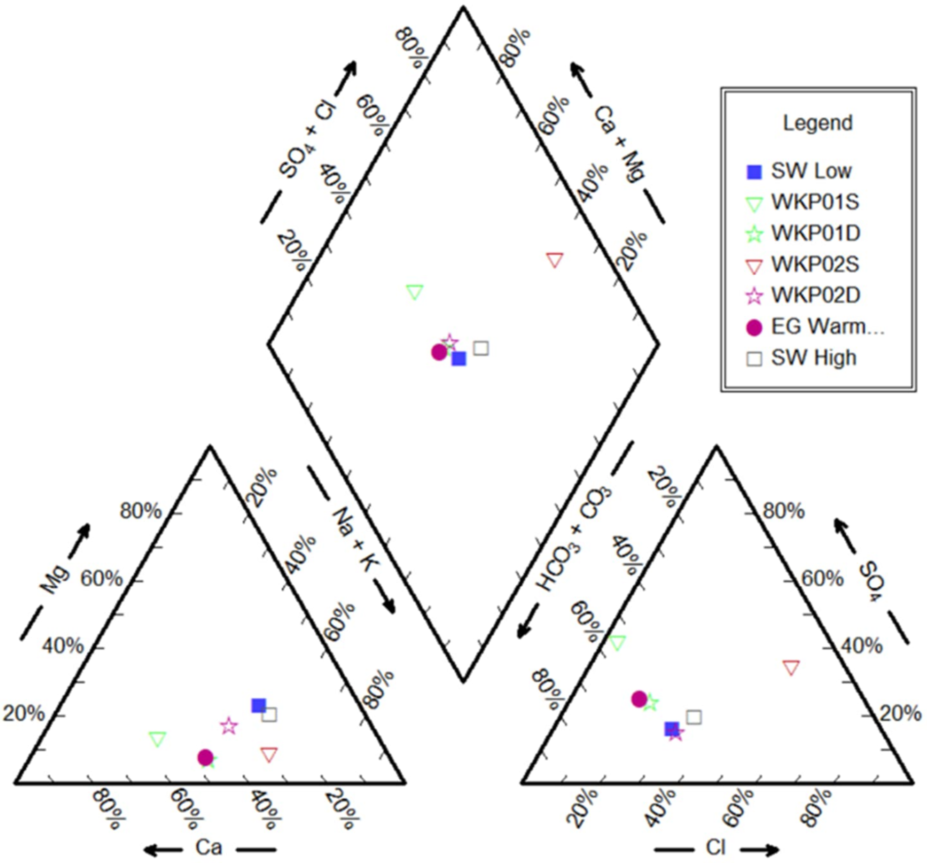

Figure 24. Piper diagram of groundwater and surface water samples.

3.8 Numerical Groundwater Modelling

3.8.1 Model Construction

A numerical model that replicates the Wharekirauponga catchment groundwater movement was constructed by FloSolutions (2023b) and details of the model are included in that report. The model was constructed so that dewatering of the underground workings could be simulated and predictions made in relation to mine inflows and drawdown effects. In addition, the model provides a means of evaluating of the connectivity between the shallow and deep parts of the groundwater system, the dewatering effects and ultimately the effects of surface water bodies.

The model was developed from the geological resource model provided by OGNZL from the drilling database. **Figure 25** provides a schematic of the model domain. The permeability values derived from the hydraulic testing were assigned to the geologic units and the observations from the groundwater level monitoring at the piezometers replicated by varying rainfall recharge.

The initial model was calibrated to the existing conditions and the proposed underground mine development incorporated into the model and then with drainage applied to simulate the proposed dewatering. The results obtained from the modelling were considered reasonable, however the model calibration led to it producing a wide range of results due to uncertainty within the model hydraulic parameters. After the initial model calibration and results runs it was decided that the model uncertainty could be further reduced by additional analysis. OGNZL then engaged Intera (specialist modellers) to undertake further calibration, sensitivity assessment and a probabilistic analysis related to model uncertainty.

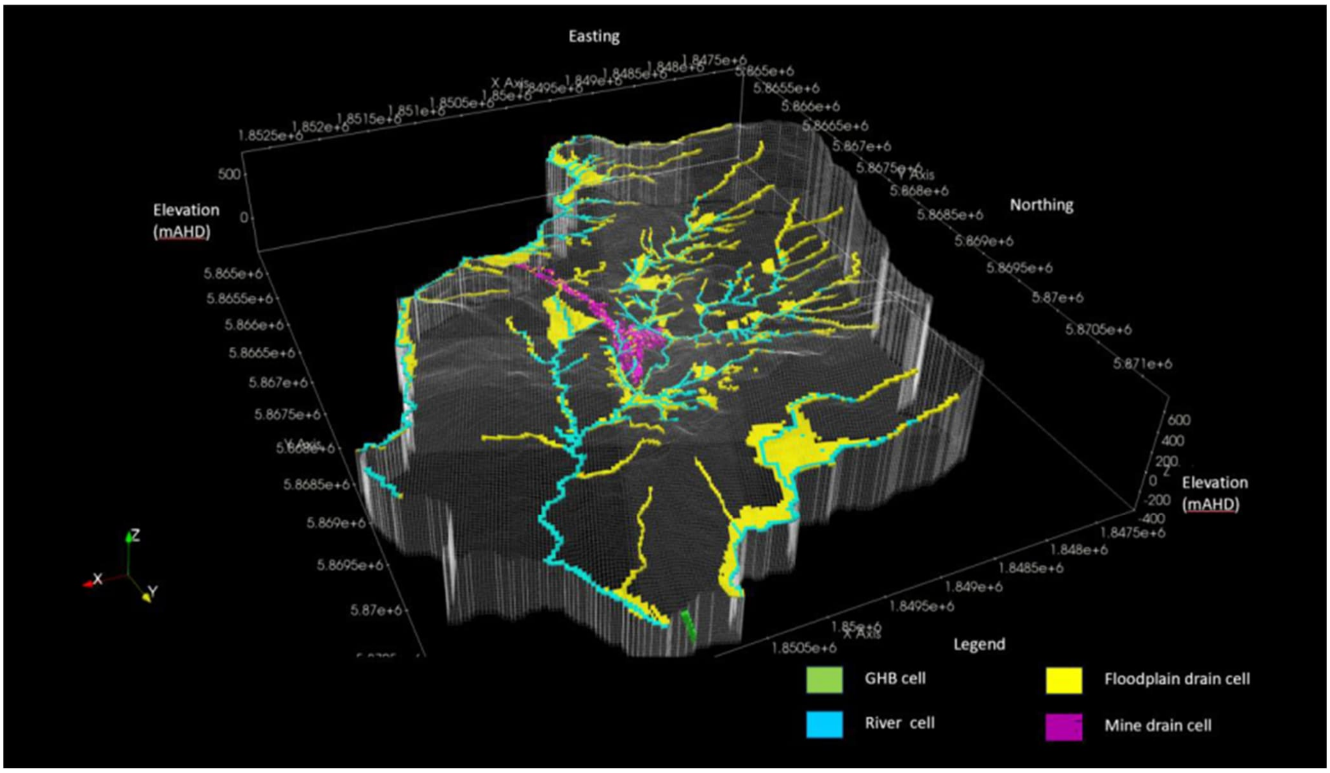

Figure 25. Numerical groundwater model domain and boundary conditions

3.8.2 Model Calibration and Uncertainty Analysis

The numerical groundwater model was provided to Intera who undertook the following tasks:

- Updated the model parameterization using the pilot point method to consider spatial variability in hydraulic parameters and areal groundwater recharge across zones.
- Reviewed, revised and processed the model calibration targets to calibrate to observed differences in steady state hydraulic head, first observed hydraulic head measurements at monitoring locations with timeseries observations, and changes or drawdown from the first hydraulic head observation.
- Developed a steady state model calibration and parameter uncertainty analysis to generate multiple alternative model parameter sets that all produced predictions that matched the observation data (within acceptable error limits).
- Constructed an updated predictive model that combines the steady state and transient calibration models with predictive simulation of project development and a forty-year recovery period.

The approach focused on the inherent uncertainty associated with model input parameters and tested the likely ranges of input parameters (such as hydraulic conductivity) and calculated a range of results. This was done for each parameter within the model and an “ensemble” of possible model outcomes (or realizations) was generated. The range of results has a probabilistic distribution, so confidence limits within the range of results generated can be considered. From the range of results provided, the 95%ile values have been adopted as being conservatively representative of the likely outcome from dewatering. The result of the Intera work was to reduce the range of values for mine inflow volumes and groundwater level/pressure changes when compared to the previous model results.

3.8.3 Surface Water Hydrology Modelling

To assess potential impacts on surface waters a Water Balance Model (WBM) was developed for the Wharekirauponga catchment by GHD (2024). The WBM simulates the processes of rainfall and evapotranspiration and determines how much water infiltrates the land surface into groundwater (or interflow) or runs off directly to surface waters. The model simulates the flow of surface waters under dynamic conditions and is calibrated to the continuous flow monitoring at fixed gauging locations.

The WBM accounts for changes in stream flow conditions by adopting the range of results from the numerical groundwater model predictions (Intera, 2024) that provide post-mining flow reductions. That is illustrated in **Figure 26**. The results of the WBM form the basis of the effects on surface water hydrology that in turn inform the ecological assessments. Like the numerical groundwater model results, the 95%ile values have been adopted as being conservatively representative of the effects on surface waters.

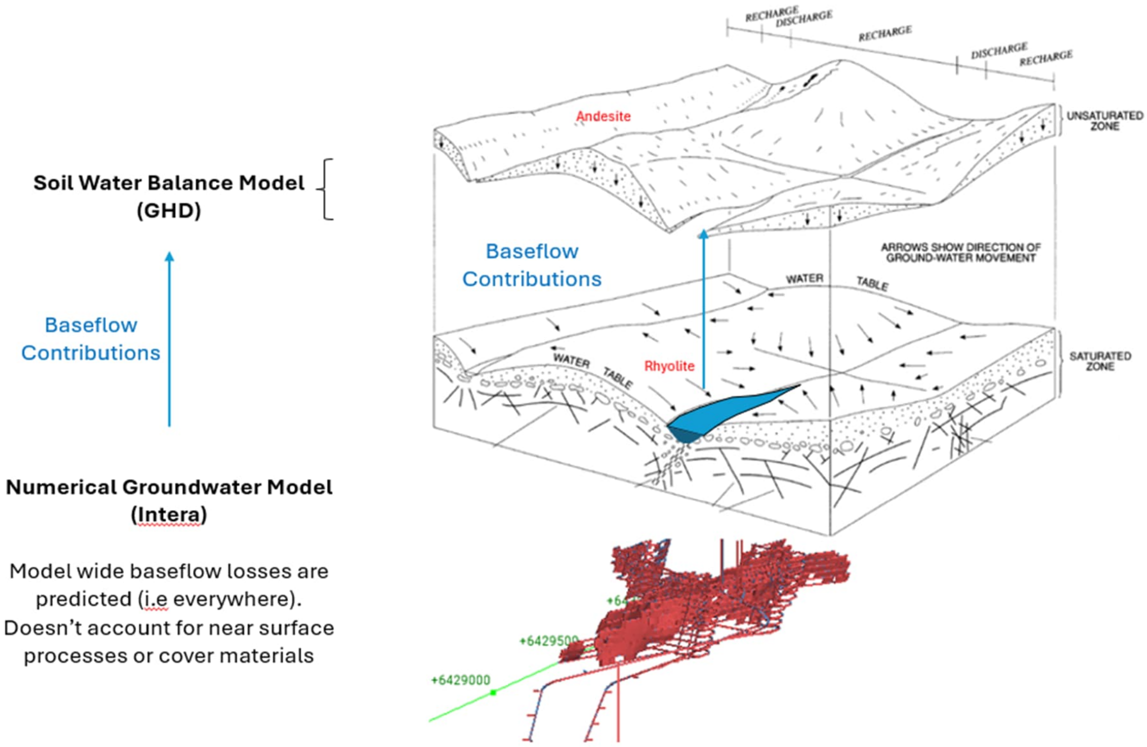

Figure 26. Relationship between the surface water balance model and the numerical groundwater model domains

3.9 Wetland Delineation

Bioresearches was engaged by OGNZL to identify the locations of potential natural inland wetlands within the Wharekirauponga catchment. That process began by identifying potential areas of depression based on the catchment topography and where a shallow depth to groundwater was expected based on the numerical model. That enabled the area of investigation to be reduced to certain subcatchments where there may be a greater susceptibility for changes in shallow groundwater levels that could, potentially, affect the hydrology of the wetland.

Once identified as potential wetland sites through vegetation type mapping by Bioresearches, WWLA followed and delineated the wetland based on the observed soils and hydrology. Observations were also made at each wetland location describing the input sources of water where applicable (i.e. surface water or spring fed) and water samples were collected for chemical analysis. The purpose of the delineation was to confirm the nature of the wetland and characterise soil properties that control the system hydraulics. That information was used as inputs to the wetland drainage assessment.

In order to understand whether mine dewatering would affect the hydrodynamics of the wetlands, a drainage assessment was undertaken. That involved developing a Soil Moisture Water Balance Model (SMWBM) specific to the Wharekirauponga catchment that considered two scenarios, to simulate the wetlands assuming they are either supported by a water table or they are not. The outcome of that modelling indicated that the wetlands within the Wharekirauponga catchment are self-sustaining based on climate alone and meet the hydrology criteria defining a wetland specified in the Wetland Delineation Protocols (MfE, 2021), with or without any groundwater or surface water inputs.

3.10 Geochemical Modelling

AECOM was commissioned to undertake an assessment of the likely quality of groundwater following mine closure. The study involved undertaking column leach trials to determine the leachate quality of mine backfill following lime stabilisation. Those results were then used to undertake geochemical modelling that calculates the expected groundwater quality along two flow paths; at the Warm Spring and in the groundwater system at the downgradient boundary of the numerical model.

4. Assessment of Effects

4.1 Groundwater Inflows

The numerical groundwater model was used to determine the amount of water that would flow into the underground workings during mine dewatering. **Figure 27** presents a graph of the mine inflow over time as the mine development progresses and shows a range of results that encompass the model uncertainty. The mine inflow is expected to be 38 L/s (3,300 m^3/d) initially, reducing to 25 L/s (2,160 m^3/d) over time. The higher initial inflows relate to removing groundwater from storage within the rockmass, which diminishes with time.

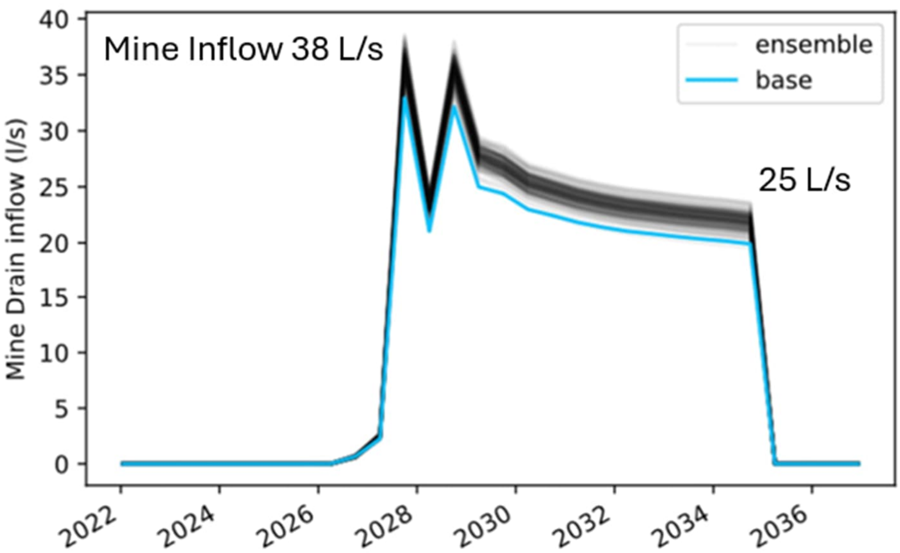

Figure 27. Predicted mine inflow volumes (from Intera, 2024)

The abstracted groundwater water will be pumped via the access tunnels to the Waihi Mine water treatment plant and discharged to the Ohinemuri River after treatment (as required). Some of the mine water will be used for operational purposes underground such as drilling.

4.2 Effects on the Groundwater Resource

The Wharekirauponga vein system is not within any specific aquifer management area identified by the Waikato Regional Council. For the purpose of this assessment, we have assessed the take to be from the Otahu catchment and an assessment of groundwater availability has been determined as shown in **Table 7**.

Table 7. Otahu catchment groundwater availability.

Groundwater Recharge (7% Rainfall)	11,803,750	m^3/year
[a] Availability (35% Recharge)	4,131,312.5	m^3/year
Existing Allocated	0	m^3/year
S14 Takes (10%)	413,131	m^3/year
Dual Tunnel Section (5,000 m^3/d x 365 days)	1,825,000	m^3/year
Mine Dewatering (2,160 m^3/d x 365 days)	788,400	m^3/year
Allocation Remaining	1,104,781	m^3/year
a - Deep non-coastal aquifer		

Based on this assessment, there is sufficient groundwater available for the proposed take to be granted.

4.3 Drawdown Effects

The numerical model allows a prediction of the likely magnitude and extent of drawdown associated with dewatering of the mine. The spatial extent of drawdown is shown on **Figure 28** with the amount of drawdown contoured in meters. **Figure 29** shows a long section through the central area of drawdown.

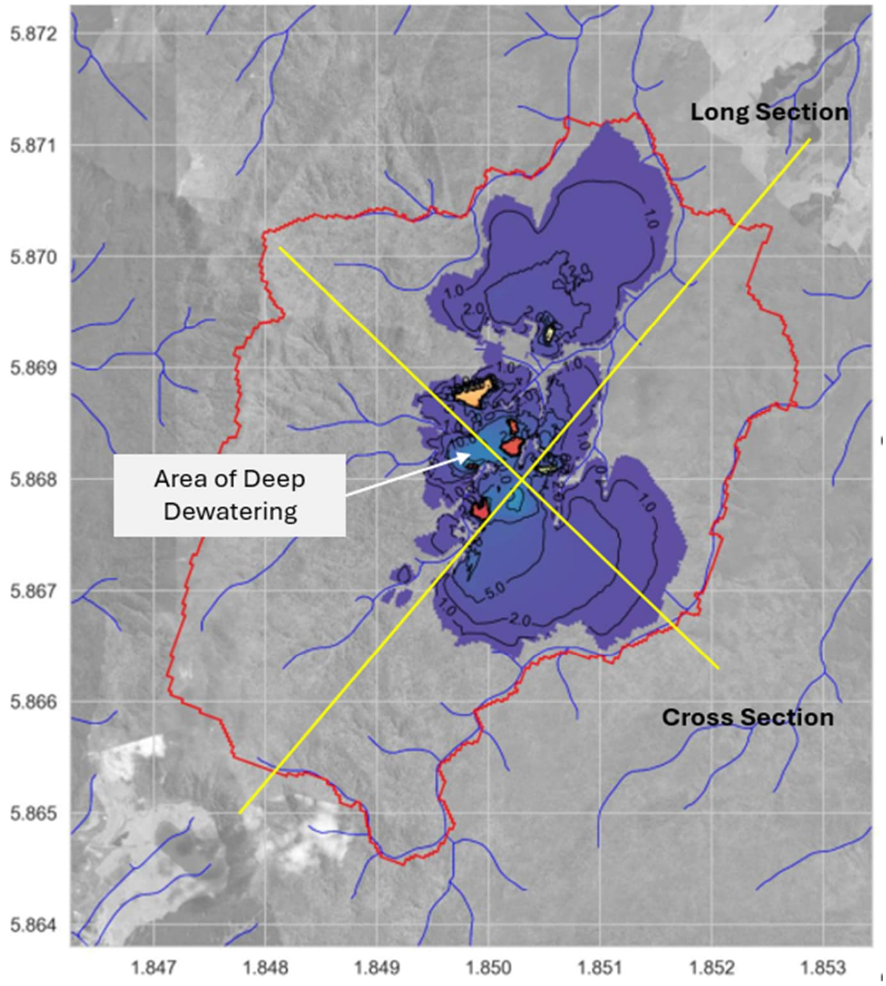

Figure 28. Model output showing drawdown contours in the near surface (after Intera, 2024)

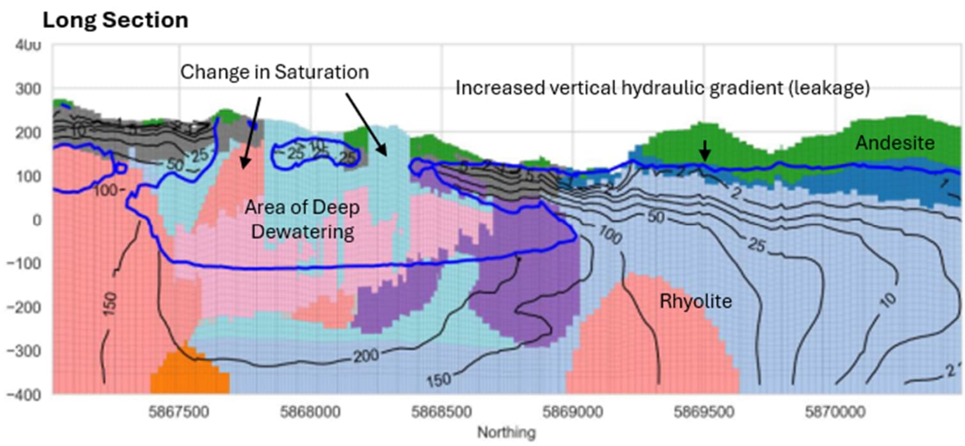

Figure 29. Extent of drawdown effects in section (after Intera, 2024)

The model results provide a number of observations relevant to understanding the effects of dewatering. These are:

- The drawdown effects are entirely constrained to within the Wharekirauponga catchment.
- Where post mineralisation andesite is present at the surface, a water table remains, but an increase in the vertical hydraulic gradient is expected that may results in a minor under drainage effect.
- The areas of potential deep dewatering are localised and relate to geological structure, the presence of the vein system and the higher permeability of the rock mass that is silicified and fractured. Connectivity between the shallow and deep groundwater systems can potentially develop at those locations.

While the preliminary modelling indicates connection between the deep and shallows aquifer systems could, potentially, occur, this effect would be limited in extent, and constrained to the area where the Rhyolite host rocks are exposed at the surface. This is around 1.5 km^2 or 2% of the catchment surface. This extent is shown in **Figure 30** and is considered to be the main area of potential effect**.**

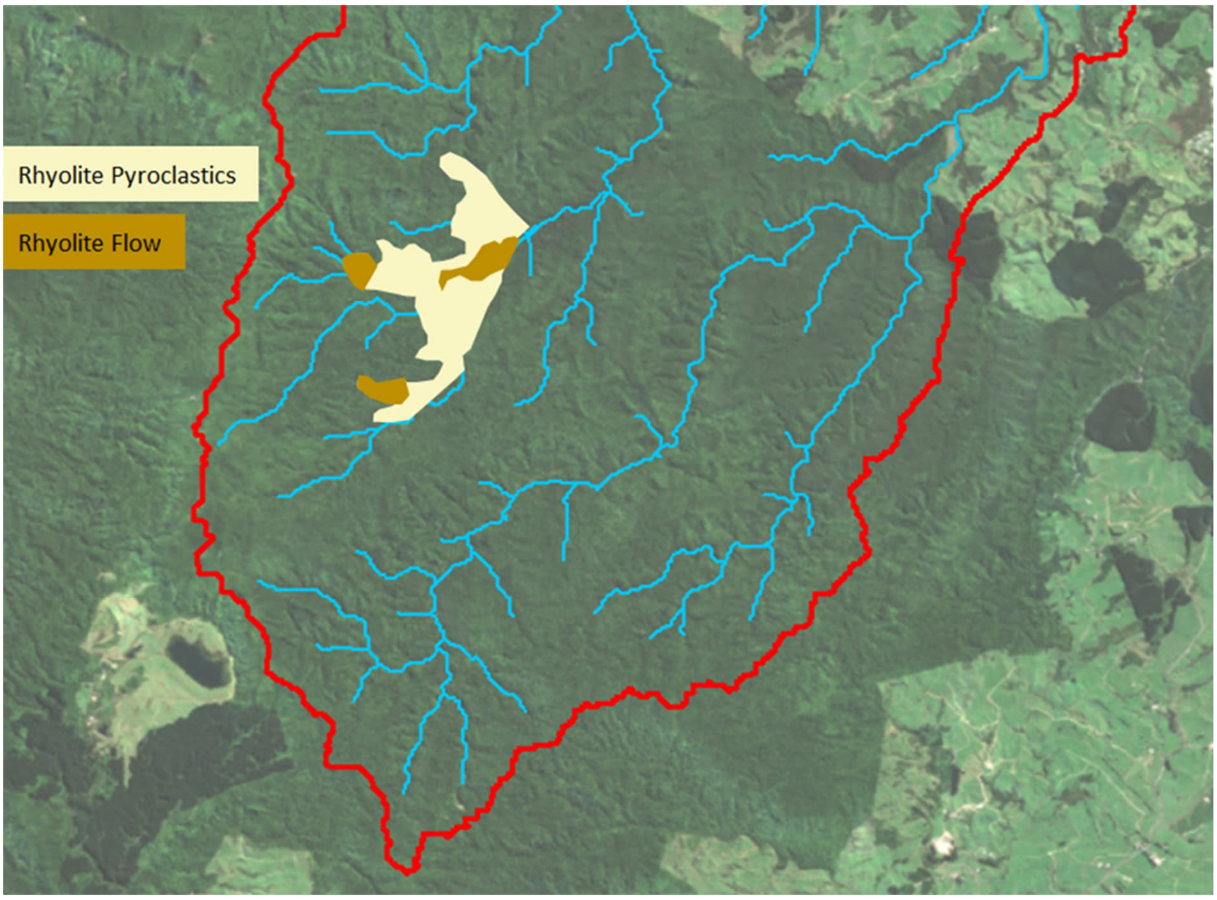

Figure 30. Surface exposure of rhyolite rocks

The remainder of the surface exposures within the Otahu catchment are Andesite rocks that post-date the mineralisation. These overlying Andesite rock units are not expected to drain as a result of dewatering the Rhyolite rockmass. This is primarily because these geologic units are of lower permeability generally, and there is a weathering layer at the base of the units that acts as an aquitard, limiting the amount of vertical drainage as shown in **Figure 31**. It can be noted from the figure that connections to the surface from dewatering at depth are localised and that the effects on surface waters could differ depending on the hydrogeologic setting.

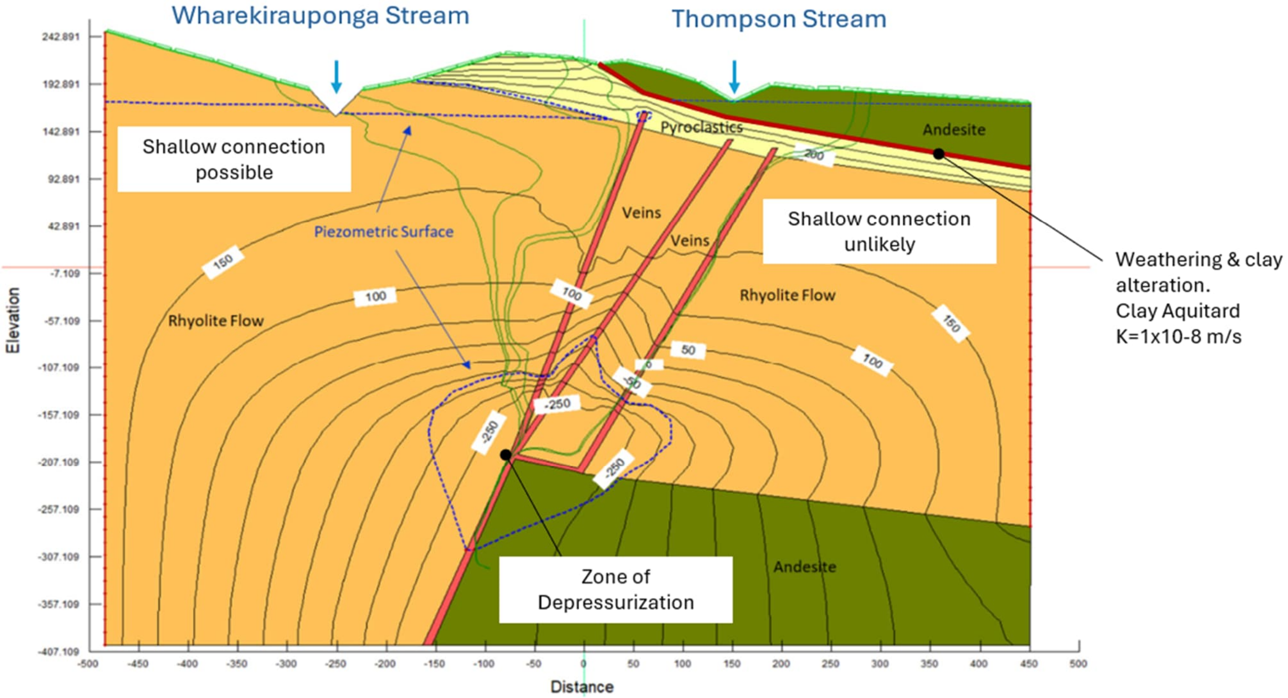

Figure 31. Model section showing the potential for shallow – deep groundwater connectivity.

4.4 Effects on Aquifers

The primary aquifer that will be dewatered to access the mineralisation is the Rhyolite rockmass. This aquifer intercepts deep groundwater that flows from the upper reaches of the catchment down to well below sea level where it discharges in a submarine environment. During mining there will be a localised reversal of the groundwater flow regime due to dewatering. At a catchment scale, however, this is not expected to result in adverse effects as coastal outflows will be maintained.

Modelling and experience elsewhere have shown that while some extent of dewatering of the rockmass will occur, it will be localised and will not affect water levels in any overlying aquifers in the post mineralisation Andesite units. While it is not expected the overlying aquifers will dewater, there will likely be some adjustment of pressure heads in the aquifers due to steeper vertical hydraulic gradients created by increased underdrainage.

The vent shafts will be similar to a large diameter bore hole that will likely require mitigation such as lining or grouting to prevent excessive ingress of groundwater. During construction there will be some localised drawdown of the groundwater system around the shafts. Following construction of the shafts the groundwater system will return to its previous state. The shafts will largely be constructed within the massive andesite volcanic rocks that constitute one aquifer system. There will be Rhyolite rock encountered at depth in some of the shafts, however the lining will effectively seal the aquifers from each other and will not, therefore, result in the mixing of previously isolated aquifers.

4.5 Effects on Surface Waters

There are a number of ways surface water features could be affected by the proposed dewatering. The following section assess the effects of dewatering on:

- Stream baseflow.
- Spring discharges.
- Inland wetland.

4.5.1 Surface Water Losses

An assessment of the effects of dewatering on surface water flows throughout the entire catchment has been undertaken in detail by GHD (2024). A summary of the key results from the water balance model are described below:

- The model results suggest that at established flow monitoring locations a small decrease in flow (relative to baseflow) is expected and large decreases in flow (relative to existing and predicted low flow events) are unlikely.
- The results indicate the 7-day mean annual low flow (7-day MALF) could be reduced at current monitoring locations within the catchment between 2 to 13% because of base flow reduction as a result of mining. The summarised results (in terms of % reduction in 7-day MALF) are presented in **Figure 32** .
- Larger modelled reductions are calculated within the Edmonds and Thompsons catchments which are smaller tributaries located above the proposed WUG Mine area.
- The modelled low flow statistics are within the current natural variation observed, however the modelled reductions in 7 Day MALF approach the lower end of the current estimated Annual Low Flow (ALF) variability within the Edmonds and Thompon catchments.
- The model results are conservative in that baseflow loss is assumed to be constant, the modelled predictions during mining utilise peak baseflow loss estimates, and the 5th percentile predictions assume that peak mining is associated with low annual rainfall and the upper end of the baseflow estimates.

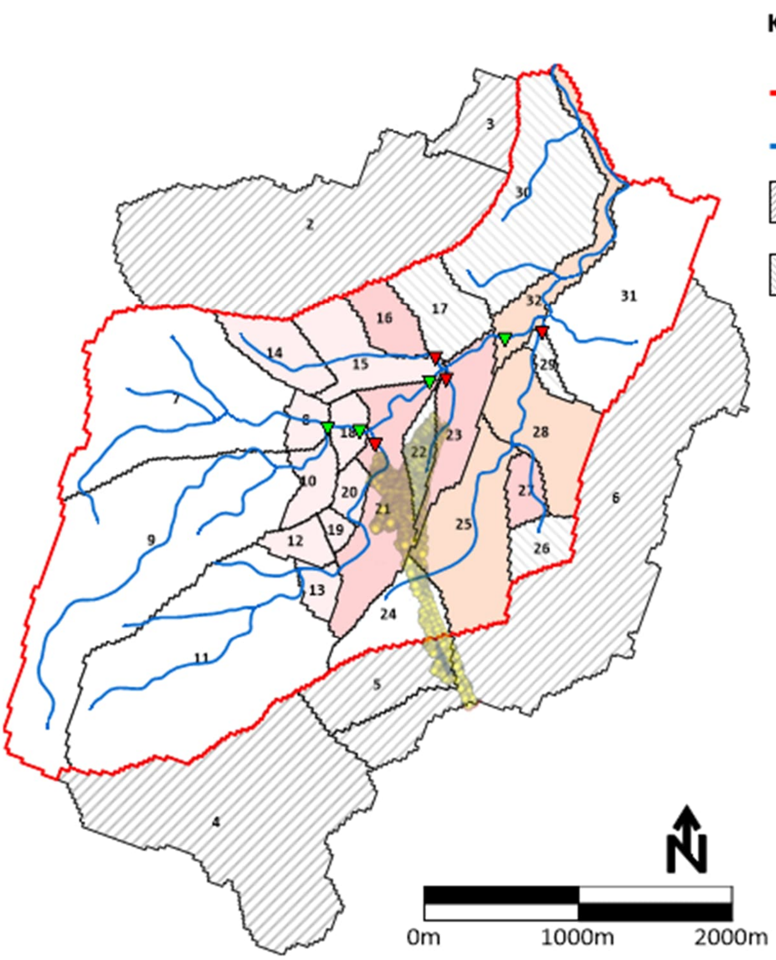

Figure 32. Heat map showing the % effect on MALF (5th percentile model result) from GHD (2024)

The effects on surface water baseflows have been determined for the entire catchment. As noted previously in this report, however, there is only one location where the Wharekirauponga Stream bed passes over the mining area where deep dewatering could create connectivity to the shallow aquifer system and, therefore, affect surface waters. The area of potential effect is shown on **Figure 33** and represents a stream length of approximately 1,200 m of second and third order streams.

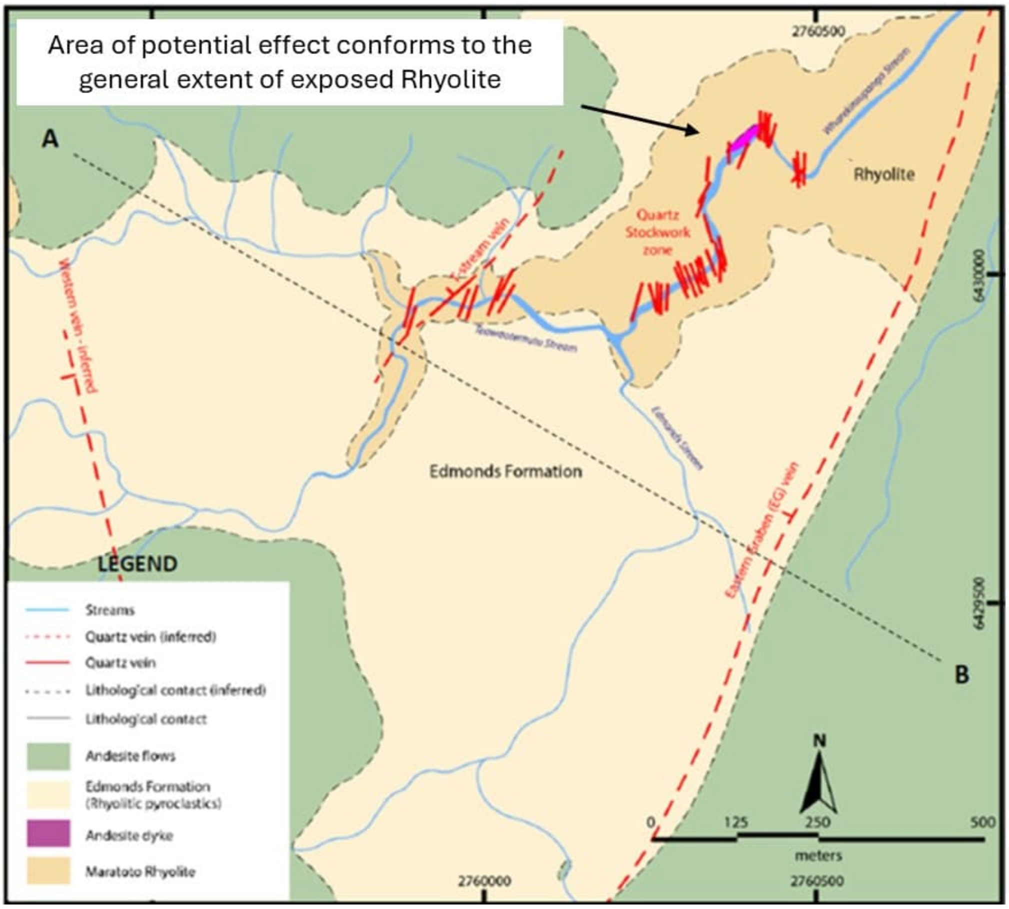

Figure 33. Plan showing the location of area of potential effect

The area of potential effect conforms to the extent of the Rhyolite host rocks exposed at the surface where the most intense veining, silicification and fracturing is observed. Due to the higher risk of effect developing at that location, the area will be subject to more intensive monitoring as discussed at the end of this report.

4.5.2 Effects on Spring Flows

There are three types of springs noted to occur within the Wharekirauponga catchment. These are described below and are illustrated schematically in **Figure 34**.

- Interflow springs – water discharging from the soil regolith draining following rainfall.
- Contact springs – water discharging at the contact of the Rhyolite and overlying Andesite.
- Fracture / fault related springs – water discharging from a geological structure.

Of those types of springs, it is only the fracture and fault related springs that could potentially be affected by deep dewatering as the other types are related to shallow groundwater movement. There are two locations where groundwater discharge is noted to occur in relation to the deep geologic structure and rock fracturing: the Warm Spring and the Wharekirauponga downstream discharge area.

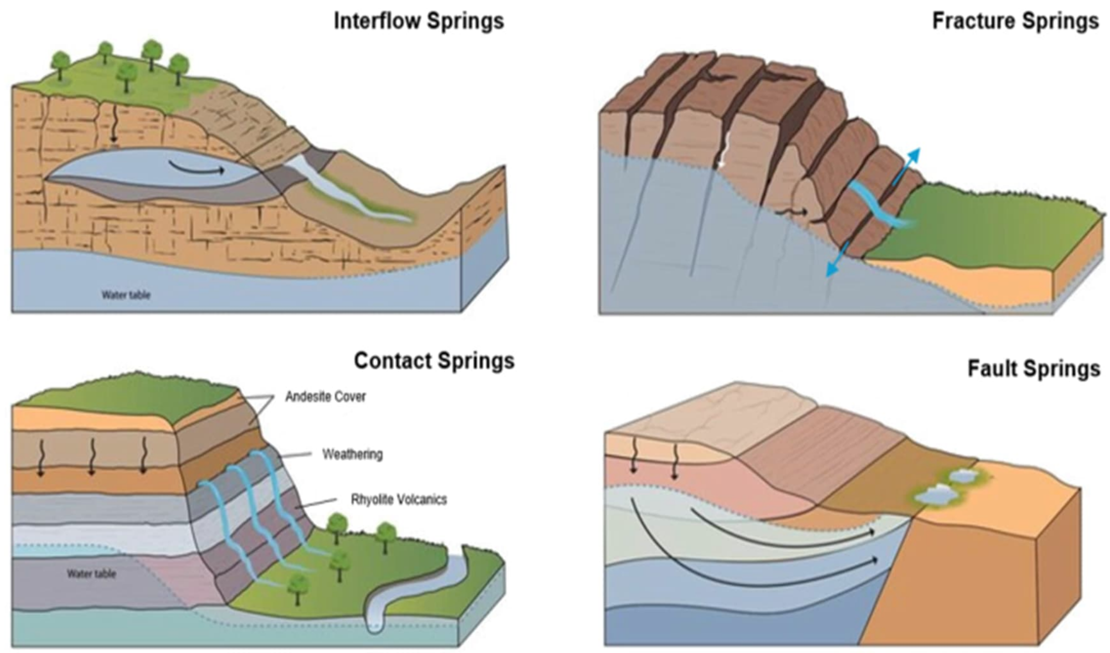

Figure 34. Spring types within the Wharekirauponga catchment.

4.5.2.1 Warm Spring

The Warm Spring has a discharge of approximately 3.5 L/s and is conservatively expected to cease for the duration of the mine dewatering because the existing pathway to the surface from up flowing deep groundwater is likely to be disturbed. The location of the spring is shown on **Figure 35.** Given the poor quality of the water discharging from the Warm Spring, the cessation of flow will provide an improvement in the quality of surface waters downstream during the life of mining.

It is expected that a cold spring will discharge at the same location once rewatering of the mine has taken place and that the trace element concentrations would not be measurably different from the existing discharge, however sulphate is predicted to be elevated as described later in this report.

4.5.2.2 Downstream Discharge Area

Investigations undertaken along a downstream reach of the Wharekirauponga Stream have identified an area where deep groundwater is discharging. It has been interpreted that the discharge originates from water movement down the catchment along the north-east extension of the main EG vein system. The location of the spring is shown on **Figure 35.** The fracture-controlled discharge of 5 L/s is expected to reduce (or possibly cease) for the duration of the mine dewatering. The discharge is expected to commence again as the mine rewaters back to its natural state and the water quality is not expected to be measurably different as described later in this report.

It is important to note that the stream flows in the lower part of the catchment are high being circa >200 L/s average flow and the expected loss of discharge is minor in a relative sense.

4.5.3 Effects on Wetlands

There have been 50 natural inland wetlands identified within the Wharekirauponga catchment based on vegetation type (Bioresearches, 2024), each of which was delineated in extent and characterised using the hydric soils and hydrology tools (WWLA, 2024). The wetlands are largely located within the Adams, T-Stream and South Edmonds sub catchments.

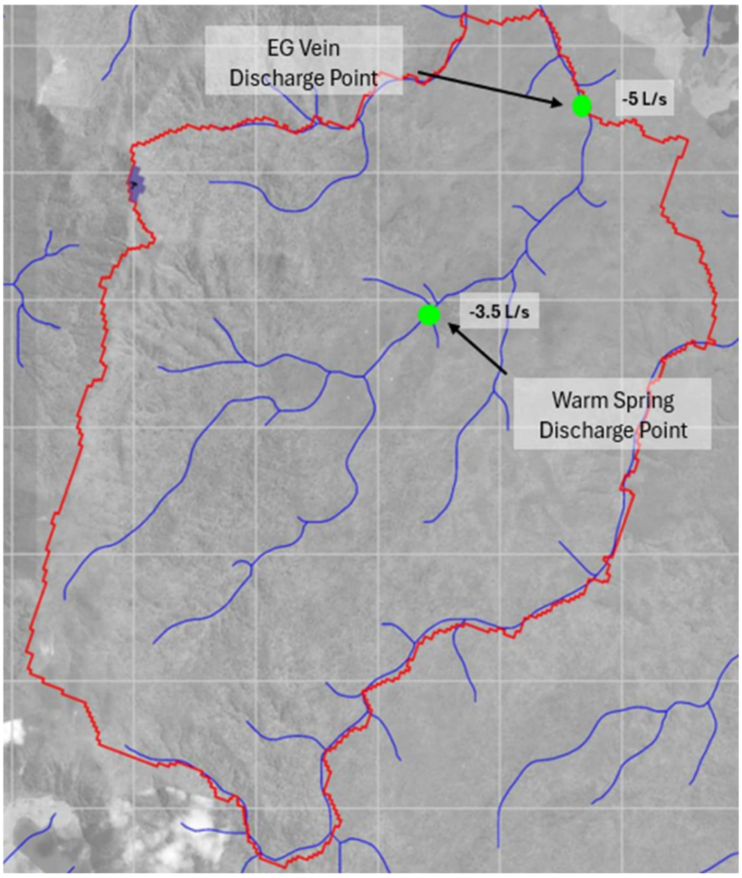

Figure 35. Locations where spring discharge are likely to be affected

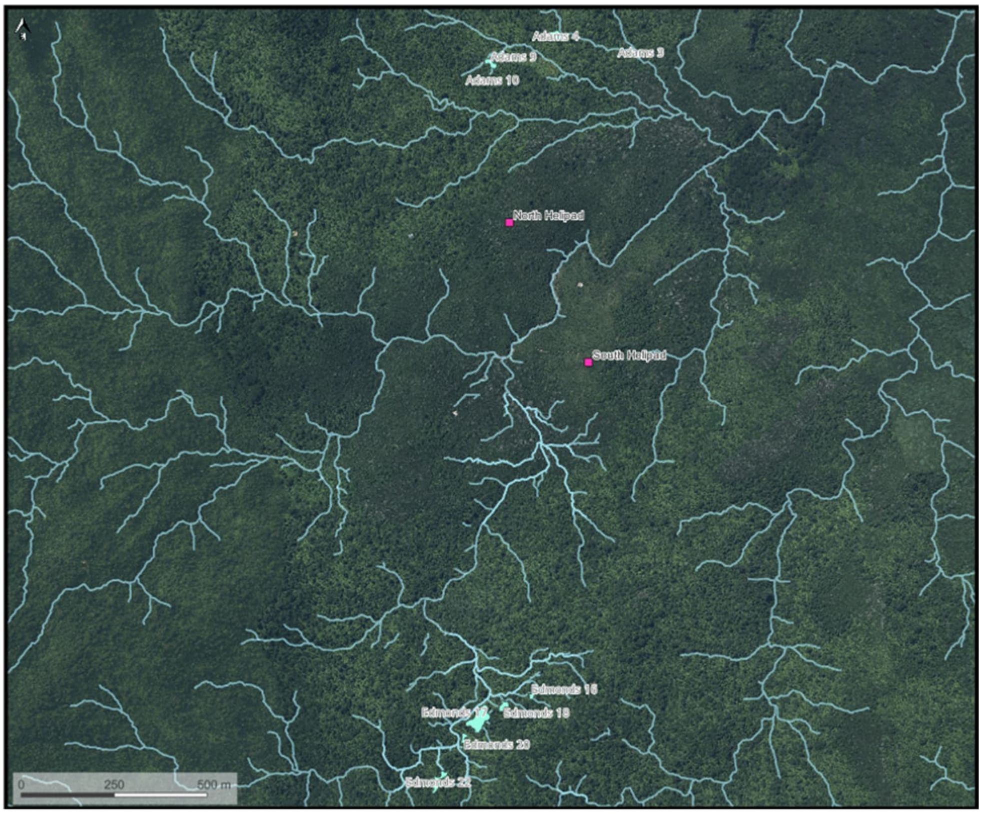

Figure 36. Locations of wetlands with groundwater inputs

Soil Moisture Water Balance Modelling (SMWBM) has been undertaken to simulate the hydrological function of existing wetland conditions and what might occur if a drainage effect were to be induced through a lowering of the shallow groundwater system in response to dewatering. The results of that modelling show that all the wetlands in the Wharekirauponga catchment can be supported by climate alone, mainly due to the high rainfall coupled with low permeability subsoils. In addition, the wetlands are typically located in depressions with marked banks and often have some form of additional hydrological input. As the SMWBM modelling does not consider this hydrological input, the results are conservative.

Due to the geomorphological position of the wetlands and observed characteristics, the wetland extents are not anticipated to change, even if a lowering of shallow groundwater levels were to occur. The soil saturation is expected to remain high enough for the wetlands to still be considered wetlands under the wetland criteria.

There is potential that the number of consecutive days that the soils will be saturated will reduce during a year, however, the model results show that even if dewatering were to occur at the same time as drought conditions (worst case scenario), the wetlands would still meet the criteria of being a functional wetland.

Of the fifty sites assessed, eight wetlands have been identified as having a higher susceptibility of being affected (relative to the others) if a linkage between the deep and shallow groundwater systems develops due to mine dewatering. Those locations have been identified due to their position relative to the catchment geology, the modelled depth to groundwater, the water chemical signature, and the field-based observations. Those sites are as follows:

- Edmonds 17
- Edmonds 18
- Edmonds 20
- Edmonds 22
- Adams 3
- Adams 4
- Adams 9
- Adams 10.

Given there may be shallow groundwater inputs into those wetlands, and that those inputs could potentially reduce if the groundwater levels were to lower because of deep dewatering, monitoring of the wetland hydrology is recommended. Assessing how wetland conditions might change as a function of seasonal variation is important both in terms of the observations made and the ability to use that information to calibrate the water balance modelling undertaken in this assessment.

In summary, this assessment has concluded that the potential effects on the inland wetlands in the Wharekirauponga catchment due to the proposed mine dewatering are less than minor because no measurable change in the extents of the wetlands is expected beyond that which occurs naturally due to seasonal variation.

4.6 Effects on other Groundwater Users

The location where dewatering will take place is 5 km distance from the closest groundwater users and, given the drawdown effects are predicted to remain within the Wharekirauponga catchment, water bores in the area are too distant to be affected by development of the mine. A detailed account of the other groundwater users' bore locations is provided in WWLA (October, 2023).

We consider the potential for effects on other groundwater users from the proposed dewatering to be less than minor.

4.7 Ground Settlement Effects

Ground settlement effects can occur from dewatering where the geological medium being dewatered is compressible by nature (e.g. sand, silt and clay. The primary rockmass being dewatered is Rhyolite volcanic rock, which is a hard, incompressible medium and is not expected to consolidate significantly because of dewatering. This has been assessed in detail by EGL in their report.

4.8 Saline Intrusion Risk

The location of the proposed dewatering is 7 km from the coastline and at that distance it is not possible for saline intrusion to occur.

4.9 Post Closure Conditions

4.9.1 Groundwater Level Recovery

The numerical groundwater model has indicated it would take 10 years after the cessation of pumping for the groundwater levels to recover to 90% of the preexisting levels, with full recovery expected within 20 to 30 years.

4.9.2 Effects on Groundwater Quality

AECOM (September 2024) has undertaken geochemical modelling to understand what the long-term groundwater quality of the aquifer system is likely to be once mining is complete and the workings are backfilled and rewatered. The results of that assessment indicate:

- Lime amendment is necessary to prevent high concentrations of trace elements developing in the backfilled mine after rewatering.
- Based on the current model predictions, trace elements are unlikely to be measurably different in the Warm Spring discharge after mining.
- The concentrations in deep groundwater are unlikely to be measurably different than that observed now.

4.9.3 Effects on Surface Water Quality

AECOM (September 2024) has made the following conclusions in relation to the effects of groundwater discharge on surface water quality:

- Elevated sulphate concentrations are predicted for Warm Spring discharge suggesting an increased potential for precipitate deposition in the discharge/mixing zone of the Warm Spring. These effects would be localised in the oxidising surface water environment immediately downstream of the spring.
- Based on the current model predictions and the conservative assumptions that they are based on, trace elements are unlikely to be measurably different in surface water at WKP1.

5. Summary and Recommendations

5.1 Summary of Effects

This assessment has shown that the effects associated with the abstraction of groundwater within the Wharekirauponga catchment required to dewater the proposed underground mine are less then minor. The volume of groundwater that will be taken of 2,200 to 3,300 m^3/d is relatively small compared to other commercial water takes and is sustainable at a catchment scale. There are no other groundwater users within the Wharekirauponga catchment.

The numerical modelling undertaken has indicated that where post mineralisation Andesite is present at the surface, the effects of deep dewatering are limited and will result in an increase in the vertical hydraulic gradient across the geologic contact of the two units. That will result in an indiscernible amount of drainage at a catchment wide scale that is expected to result in a small reduction in surface water flows. The effect will, therefore, result in a less than minor reduction in stream flows and is unlikely to represent a measurable change in most sub catchments.

Where Rhyolite units are present in the surface and the clay capping is absent, there is an increased potential for connections to develop between the shallow and deeper groundwater systems. There is one location within the central project area where linkages could develop between the deep aquifer being dewatered and the shallow aquifer system and those linkages could potentially result in some level of effect on surface water features. While that scenario is unlikely, due to the observed natural separation of the shallow and deep groundwater systems, monitoring of piezometric levels and vertical hydraulic gradients is proposed to detect any change near the Wharekirauponga Stream.

There are two locations where natural spring discharges are expected to be reduced because of deep dewatering. Those discharges account for reduction of around 8.5 L/s in surface water flows, which is considered minor and has been accounted for in the 7-day MALF reduction presented above.

The combined total loss of surface water flows from drainage and from loss of spring flow has been determined to be between 2-13% of the 7-day MALF. That loss of flow is considered to be minor in comparison to catchment scale flows.

The natural inland wetlands documented within the catchment are not expected to be affected by deep dewatering because they are climate supported which maintains their hydrologic function. There are some wetlands that are considered to have groundwater inputs and for that reason monitoring is still proposed to establish baseline conditions that will be used to assess any future change should that occur.

5.2 Recommendations for Monitoring

5.2.1 Shallow Groundwater Monitoring

Shallow groundwater level monitoring is recommended adjacent to the Wharekirauponga Stream with a primary focus on the location where Rhyolite rock is exposed at the surface. Eight Near Stream Piezometers (NSP) are proposed at the locations shown in **Figure 37**. Each location would consist of a well pair with a shallow piezometer and a deep piezometer as illustrated conceptually in **Figure 38.**

The technical objective of the monitoring would be to observe any changes in the vertical hydraulic gradient within the shallow groundwater system that may be a response to deep dewatering. A change in the vertical hydraulic gradient would be either a reversal of the gradient (indicating the stream has gone from gaining to losing conditions) or a significant increase in the vertical hydraulic gradient due to a lowering of the water level in the deep piezometer relative to the shallow water level (indicating an under-drainage effect).

Baseline monitoring would be undertaken while the access tunnels are being advanced to characterise the existing conditions and would be used to establish trigger points that would initiate further investigations and potential mitigation (if required) as described in the Wharekirauponga Underground Mine Water Management Plan (WUGWNP) (OGL, 2024).

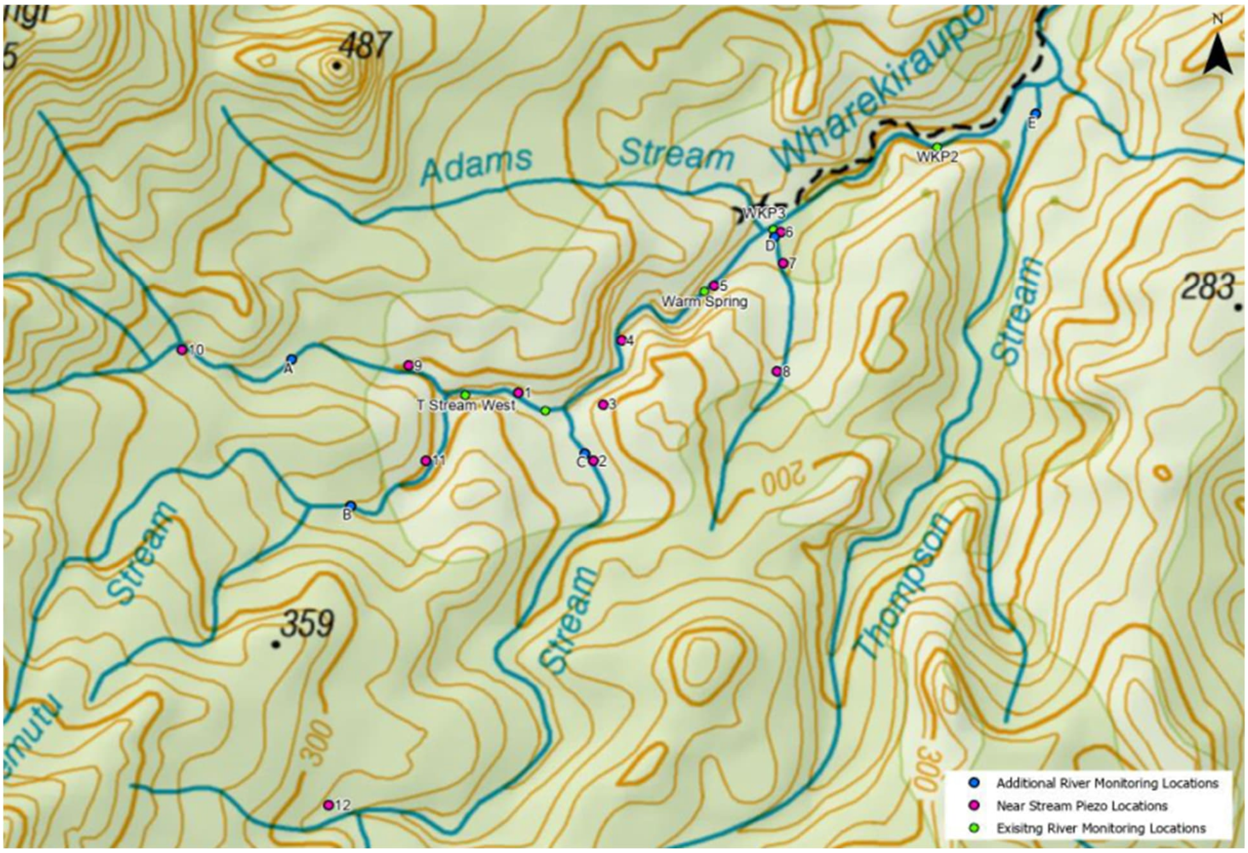

Figure 37. Near stream piezometer locations

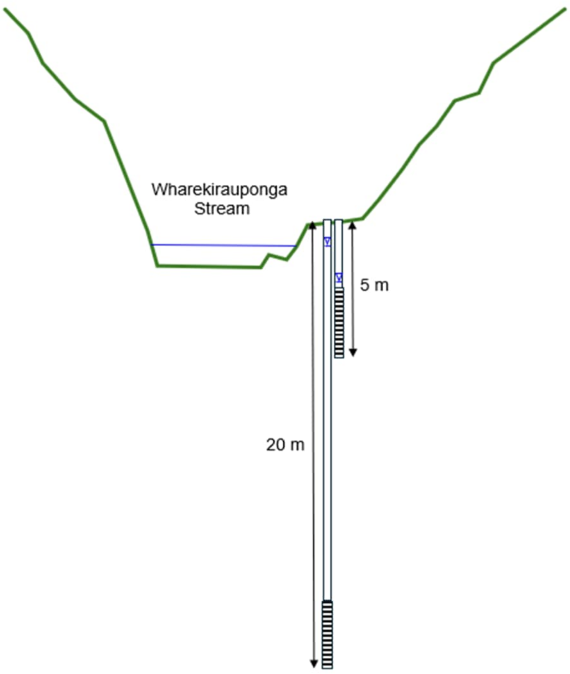

Figure 38. Near stream piezometer concept design.

5.2.2 Wetland Monitoring

In order to establish baseline measurements of seasonal fluctuations in the water levels of each wetland, it is recommended to install monitoring piezometers with sensors at each of the eight wetlands sites identified above, as per the USACE Guidelines.

As shown in **Figure 39** below, a piezometer would be installed within the wetland extent, and another outside the wetland extent. This would allow for the analysis of the inferred groundwater linkage between the Wetland Water Level (WWL), and the Groundwater Level (GWL).

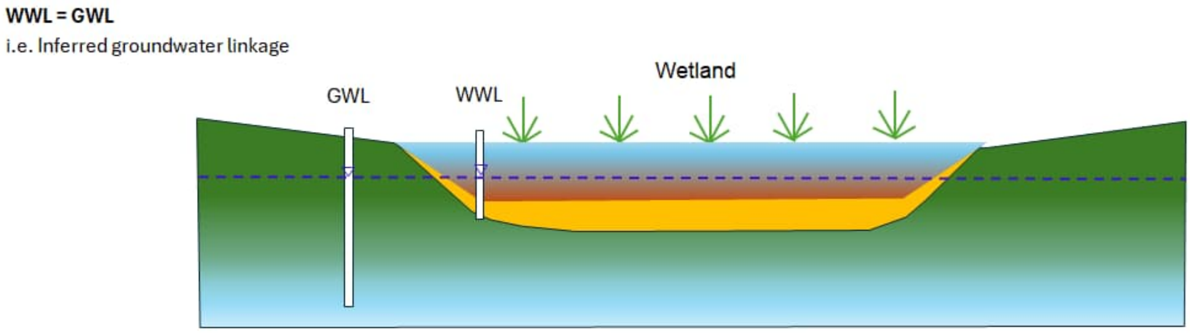

Figure 39. Wetland piezometer installation.

The aim of this monitoring would be to collect 4 years of baseline data prior to the commencement of stoping where wetland water levels and groundwater levels outside of the wetland are continuously measured. In addition, a control wetland would be established in the adjacent Waiharakeke catchment that is predicted to be outside of the area of potential effect due to dewatering.

The baseline water level data would be used to recalibrate the SMWBM with a focus on simulated water levels and to perform statistical analysis of a longer duration dataset that can be used to derive trigger levels that would indicate a change in conditions beyond what has been observed or predicted to occur in the future from the SMWBM.

In addition to water level monitoring, we recommend that the chemistry of the wetland water is analysed to assess to what extent the relative proportions of surface water and groundwater entering the wetland changes seasonally.

5.2.3 Mitigation of Effects

If any of the monitoring indicates an effect is developing or has developed, further investigation or mitigation may be required. The nature of the response and method(s) of mitigation are described in the Wharekirauponga Underground Mine Water Management Plan (WUGWNP) (OGL, 2024).

6. References

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7. Limitations

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This report is based on the ground conditions indicated from published sources and from reports that include subsurface investigations that have been undertaken by other parties based on accepted normal methods of site investigations. Only a limited amount of information has been reviewed in the preparation of this report which does not purport to completely describe all the site subsurface characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from those assumed.

This report represents an assessment based on the information made available at the time of its preparation. Other studies that relate to the effects of the mine dewatering are still being undertaken, in particular the interactions between groundwater / surface waters and the geochemistry of the mine water. The outcomes of those assessment may affect or change the conclusions made in this report. This assessment should be reviewed in light of those results which may supersede particular elements of this report.

ATTACHMENT A – Project Workflow Diagram.

Attachment A. Summary of technical inputs.

WHAREKIRAUPONGA GROUNDWATER TAKE APPLICATION

LONG TERM DISCHARGE

Consent Application

GWS Limited (14 June 2022)

Assessment of Environmental Effects on Groundwater

The Assessment of Environmental Effects (AEE) on Groundwater that was lodged with the consent application bundle. The report was accepted by the Waikato Regional Council (WRC) on the understanding that work was still in progress in relation to groundwater matters and that more detailed information was yet to be provided.

The report includes the initial development of the site conceptual groundwater model and high level numerical modelling and predicted effects based on the information available at that time.

Further Information Requests

Oceana Gold Limited (2022 to 2024)

Further Information Gathering

Throughout 2022, 2023 and early 2024 exploration drilling continued by OGL and opportunities to undertake insitu permeability testing and vibrating wire installations were advanced. Some purpose specific boreholes for hydrogeologic characterisation were drilled. Ongoing technical advice in relation to that testing was provided by FloSolutions, forming iterative development of the CGM as new information became available.

A number of specialist studies were contracted by OGL including:

- ongoing surface water gauging
- regional hydrogeological review
- downstream hydrological gaugings
- wetland delineation
- terrestrial ecological studies
- freshwater ecological studies

FloSolutions (13 September 2023)

Conceptual Groundwater Model (CGM)

The objective is to integrate site physiography (climate, topography and surrounds), geological information (drill hole geology, structure, alteration), groundwater information (groundwater levels, permeability testing) and hydrology (surface water network, flows)

The purpose of the CGM is to present a qualitative technical understanding of the componets of the surface water and groundwater system(s) and how they interact. The CGM is used as a tool to identify information gaps required to further delevop the CGM, forming a feedback loop until sufficient confidence in the model is formed.

The CGM is then used as a platform upon which build the quantaitative numerical flow model.

WWLA (October 2023)

Regional Hydrogeology Review

The initial 3D numerical model runs undertaken by FloSolutions inferred that; in order to reproduce the piezometric head separation and strong vertical gradients between the shallow and deep aquifers, some sort of drain or outlet for the deep (EG Vein) aquifer is required on the downstream end of the model. That observation initiated the review of a regional scale hydrogeological assessment with the objective of finding the discharge point for the EG vein aquifer system. The outcome of that assessment was that the lower reach of the Wharekirauponga Stream is the probable discharge point for the deep (EG Vein) aquifer

Updated Groundwater Effects
- mine inflows
- on the groundwater resource
- other groundwater users

FloSolutions (16 November 2023)

Numerical Groundwater Model

A numerical groundwater model was developed by FloSolutions to simulate: the existing groundwater system, the groundwater system during mine dewatering and the groundwater system recovery following mining. The groundwater modelling results allow a quantitative assessment of mine inflows volumes, changes in the shallow and deep groundwater system piezometric heads/pressures and losses of groundwater to surface waters through a reduction in stream baseflow.

On the completion of the numerical modelling, a sensitivity analysis of the model parameters was undertaken (testing a range of rock mass hydraulic properties and rainfall infiltration etc.)

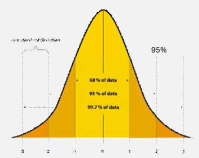
The key model output is to provide a range of potential baseflow losses such that the effects on surface water flows can be established to enable GHD to undertake their assessment.

Intera (June, 2024)

Numerical Groundwater Model - Uncertainty Analysis

Due to the wide range of variables contained within the numerical model and the results of the sensitivity analysis, Intera was engeged to better understand the model uncertainty. The uncertainty analysis uses pilot points to provide a probabalistic determination of likely model results based on a range of "realizations" (input-ouput relationships). Hundreds of realisation scenarios are run and the range of output values presented as a statistical distribution of results.

The range of results related to reductions in baseflow were provided to GHD to assess the effects on surface waters.



Updated Surface Water Effects
- surface water flows
- springs
- wetlands, plant growth

GHD (June, 2024)

Hydrology Modelling Report

In order to assess potential impacts on surface waters a water balance model (WBM) was developed for the Wharekirauponga catchment. The model simulates the processes of rainfall and evapotranspiration and determines how much water infiltrates the land surface into groundwater (or interflow) or runs off directly to surface waters. The model simulates the flow of surface waters under dynamic conditions and is calibrated to the continuous flow monitoring at fixed gauging points.

The range of base flow changes from the Intera assessment are applied to the water balance model to provide post-mining flow reductions, then applied to the flow record derived from the long term rainfall record to investigate impacts.

The results of the water balance model form the basis of the effects on surface water hydrology that informs the ecological assessments.

Surface water

Groundwater

WWLA (Sept, 2024)

Wetland Delineation & Drainage Assessment

Bioresearchers have identified inland wetlands throughout the catchment based on vegetation species. Those features confirmed as being wetlands, field delineation using the Hydric Soil and Hydrology Tool assessment methodologies were undertaken (in accordance with NPS-F protocols). Observation in relation to extraneous surface water inputs were made and samples collected foe chemical analysis.

One key objective of the delineation was to identify groundwater supported wetlands. An assessment of drainage effects has been undertaken on those wetlands at potential risk.

NIWA (Sept, 2024)

Wharekirauponga Instream Habitat - Aquatic Ecology Effects

Given the expected reduction in stream baseflow, NIWA have undertaken an assessment of potential changes in ecology in the natural state water body (being the main Wharekirauponga Stream reach). The assessment considers the changes in lost habitat that could affect the polulation of periphyton, macroinvertebrate and fish.

The results are limited to second and third order streams.

Boffa Miskell (Sept, 2024)

Aquatic Ecology Effects

This work assesses the ecological effects on aquatic species within the Wharekirauponga catchment as a result of mine dewatering. The work uses NIWA's modelling for the assessment of the main stems of the river (2nd and 3rd order streams), and Intera/GHD's modelling for the sub-tribs (1st order streams). They will also be assessing effects a result of the 'downstream' impacts.

Bioresearchers (Sept, 2024)

Aquatic / Terrestrial Ecology Effects

This work assesses the ecological effects on:

- Wetlands
- Hochstetter's frogs

The relavent part of this work was to identify potential inland wetlands based on vegetation.

Post Closure Effects
- surface water
- groundwater

AECOM (8 February 2024)

Post Closure Geochemistry - Groundwater

This work provides predictions of the groundwater quality discharging from the backfilled underground workings following mine closure. There is some linkage between this assessment and the numerical groundwater model results produced by FloSolutions.

The groundwater chemistry following mining has been derived from the results of column leach testing on samples collected from the Wharekirauponga deposit. The end point solution chemistry is then mixed with natural groundwater to provided a predicted groundwater quality

Two flow paths were assessed: the underground connection to the surface at the Warm Spring, and the deep flow path from the mine to the inferred downstream discharge area.

AECOM (Sept, 2024)

Post Closure Geochemistry - Surface Water

A GW/SW mixing model is in progress .