Assessment of Groundwater Effects – Tunnel Elements

Waihi North Project

OCEANGOLD LIMITED

WWLA0921 | Rev. 5

4 February 2025

Tunnelling Effects Report

Project no:	WWLA0921
Revision:	5
Date:	4 February 2025
Client name:	OceanaGold Limited
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File name:	G:\Shared drives\Projects\Oceana Gold\WWLA1170_WNP Tunnelling Effects on Groundwater\Deliverables\WWLA_Rep_WUG Tunnels Groundwater Effects Report 4.2.2025.docx

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Document history and status

Rev	Date	Description	By	Review	Approved
1	2 August 2024	First Draft Report	C.Simpson	C.Simpson	J.Williamson
2	2 September 2024	Draft Report	C.Simpson	C.Simpson	J.Williamson
3	6 December 2024	Draft Report	C.Simpson	C.Simpson	J.Williamson
4	29 January 2025	Final Draft Report	C.Simpson	C.Simpson	J.Williamson
5	4 February 2025	Final Report	C.Simpson	C.Simpson	J.Williamson

Distribution of copies

Rev	Date issued	Issued to	Comments
1	2 August 2024	OceanaGold	
2	2 September 2024	OceanaGold	Minor edits
3	6 December 2024	OceanaGold	Minor edits
4	29 January 2025	OceanaGold	Minor edits
5	4 February 2025	OceanaGold	Final Report

Executive Summary

Oceana Gold (New Zealand) Limited is seeking resource consents for the Waihi North Project (WNP) to, amongst other objectives, enable access to the Wharekirauponga mineral resource. The project consists of a number of elements that expand on the existing mining facilities in Waihi, as well as proposing new infrastructure to service the Wharekirauponga Underground Mine (WUG) at Willows Farm north of the Waihi township. One of the key elements of the project is the tunnelling required to connect the Wharekirauponga mineral resource to the proposed Surface Facilities Area and to the existing Processing Plant at Waihi to enable ore extraction, transport and processing. This report considers the likely effects on groundwater that may be associated with development of the tunnelling system needed to enable the WNP to go ahead.

This report considers three components of the project that include: a WUG access tunnel from Waihi to Willows Farm; an access drive from Willows Farm that connects to the WUG access tunnel; and dual tunnels from Willows Farm to WUG that also connects to the WUG access tunnel. One aspect that is important to consider in this groundwater effects assessment is the proposed tunnel design. In summary, a tunnelling methodology will be used that mitigates the potential for effects to materialize in groundwater. Experience in Waihi has shown that the andesite rockmass is of a low permeability and does not dewater extensively, rather groundwater is retained in storage within fractures. Dewatering is only noted to occur to any significant degree if younger volcanic rock sequences are penetrated or if a fault or fracture system is encountered. In such circumstances, cement grout is applied in these zones to reduce the permeability and prevent drainage of groundwater from taking place. These zones are identified in advance through drilling, and are grouted off, either in advance of the driven tunnel or within a few days of it being exposed. This means effects, if any, are short lived and are not expected to affect surface waters. This methodology has been successfully used for underground tunnels at Waihi and is proposed for the WNP tunnels.

The WUG access tunnel will be driven north from a new portal sited near the existing portal to the Favona underground workings and south from Willows Farm. The initial southern part of the tunnel decline is already dewatered from the existing underground mining operations and for that reason no further effects on the shallow groundwater system or surface waters beyond that which have already taken place are expected. Once the tunnel is driven into the andesite, minimal groundwater inflow will occur except where large scale faults or fracture systems are encountered. Drilling in advance of the tunnel drive will identify these locations and they will be grout sealed as discussed above. There are a number of domestic and stock bores within reasonable proximity to the WUG access tunnels, however, the water supplies are not considered to be at any risk from the proposed tunnel as the dewatering effects will not extend any significant distance laterally. Groundwater monitoring is proposed in the existing network of wells that surrounds the tunnel decline section near the Waihi township to ensure near-surface drawdown effects do not develop. Additional monitoring of groundwater levels adjacent to the tunnel is proposed near existing groundwater users to ensure their supply remains unaffected.

The WUG access transport tunnel will connect to the Willows Farm site at some 300 m depth below ground level at the location of the first vent shaft and commencement of the dual decline.

The Willow access tunnel commences from a portal at the surface of the property at an elevation above the groundwater level. The drive then declines and connects with the WUG access tunnel and dual tunnels. The initial part of the access portal and tunnel will be within the shallow groundwater system hosted by the andesite rocks. The andesite rockmass at Willows Farm has been demonstrated to be of low permeability and, therefore, is not expected to drain readily. In the worst case, our assessment indicates that up to 15 m^3/d could potentially be lost due to flow paths being diverted from the Mataura Stream while the access tunnel remains dewatered.

There are, however, two locations where the Willows access tunnel drives through inferred fault or fracture zones beneath the Mataura Stream. Given there is a potential short term hydraulic connection between the tunnel and stream bed, an assessment of potential surface water losses was undertaken. This assessment has indicated that the short-term losses from a potential fracture zone would be in the order of 35 m^3/d and any surface water losses are considered to be small relative to stream flow and would be indiscernible.

The vent shaft at Willows Farm is assumed to be sealed off from groundwater as it is advanced. Some groundwater inflow is expected during construction and these volumes have been incorporated into the predicted dewatering volumes needed for the project. No significant drawdown effects are likely to develop from construction of the vent shaft. Monitoring of shallow groundwater is recommended using the existing network of wells to ensure sustained lowering of groundwater levels does not occur and that there is no potential for long term stream loss.

The dual tunnels will be driven from the connection at Willows Farm to WUG at depths ranging from 150 m to 480 m below ground level within andesite. The andesite is the same rockmass present elsewhere in Waihi and will have a similar response to dewatering in that it will be limited to areas immediately adjacent to the tunnels. No effects are expected in the near surface groundwater or on surface waters. There are some locations where inferred structural features will be driven through and these may need to be sealed to prevent groundwater ingress as per the same methodology already stated. There are a further (up to) four vent shafts at the end of the dual tunnels and the construction methodology will limit groundwater inflows. No significant drawdown effects are likely to develop as a consequence of the vent shaft construction. Given the depth of the dual tunnels and mitigating construction methodology, no groundwater monitoring is deemed necessary, nor is proposed over the alignment.

In summary, this assessment of effects has shown there to be minimal risk to shallow groundwater; surface waters; other groundwater users; and to water resources that sustain plant growth from the proposed tunnels. The proposed tunnelling methodology will avoid effects to groundwater because:

1. The rockmass is of sufficiently low permeability that it will not dewater

2. The tunnels are sufficiently deep that depressurisation effects do not reach the surface

If major inflows zones are encountered that are likely to cause effects at the surface, suitable mitigation will be applied.

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1. Introduction

1.1 Background

Oceana Gold (New Zealand) Limited (OGNZL) is applying for consents under the Fast-track Approvals Act 2024 for the Waihi North Project (WNP). This project has a number of associated tunnel elements that are necessary to enable access to the Wharekirauponga Underground (WUG) mineral resource. The WUG resource is located approximately 11 km north of the township of Waihi. The resource lies within the Wharekirauponga Minerals Mining Permit (60541) area and is beneath Department of Conservation (DOC) administered land.

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 elements relevant to this assessment are described below and locations shown in **Figure 1**. These will include the following.

A tunnel to transport ore to Waihi that connects with the Willows Farm site that will include;

- Portal and a single tunnel (WUG access tunnel) near the Processing Plant, that connects with the dual tunnel;
- A link or bypass drive that connects the tunnel from the Willows Farm portal (Willows access tunnel) to WUG access tunnel from Waihi; and
- Stockpiles at approximately 150 m spacing along the length of tunnel and sumps.

The Willows Farm access tunnel will include:

- Portal and a single tunnel (Willows access tunnel) at Willows Farm to the edge of DOC land ;
- Vent shaft on the Willows Farm south of the DOC boundary (250 m deep);
- Stockpiles at 150 m spacing along the length of tunnel and sumps; and
- Surface infrastructure including; waste rock stacks, silt ponds, etc.

Dual decline tunnels to access the orebody from Willow Farm to WUG that will include:

- Dual tunnel from the edge of DOC land to the footwall of the WUG orebody;
- Multiple declines as the dual tunnel approaches the top of the WUG, for access to the lower portions of the orebody;
- Cross cuts at 150 m spacing along the length of the dual tunnel, providing a connection between the intake and exhaust tunnels;
- Cuddies to cater for infrastructure requirements including ventilation, sumps, pumps, and electrical equipment ; and
- Four ventilation shafts of various depths along the paper road corridor at the tunnel approach to the WUG development works.

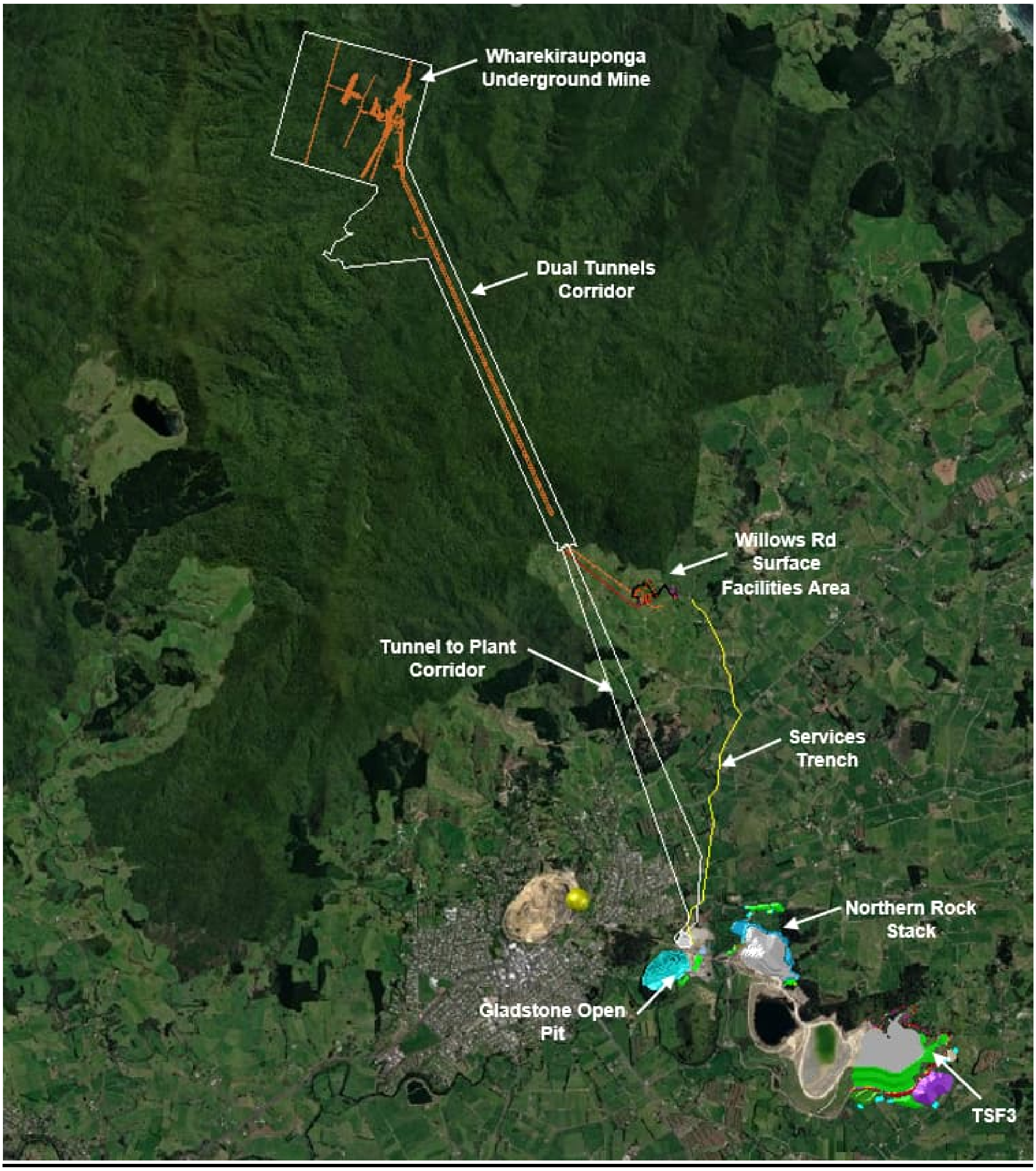

Figure 1 WNP Proposed Tunnel Sections

When considering the potential for effects on groundwater due to the construction of the tunnels it is important to understand the mitigating design philosophy. As stated in the project description prepared by OGNZL, the following provides the proposed approach to groundwater management.

"Incidental, minor quantities of water emanating from the ground and/or from normal tunnelling operations will be drained to sumps within the tunnels. Thereafter water will be pumped by electric pumps through poly pipe installed as part of mine services to the surface holding tank before treatment through the water treatment plant.

As described in the Wharekirauponga Underground Mine Water Management Plan (WUGWNP), where significant quantities of water are encountered in tunnelling, the ground in the immediate vicinity will be shotcreted and/or grouted to provide an effective seal and prevent any significant and/or sustained drainage of local aquifers."

Simply put, the tunnel will be designed to limit the potential for groundwater effects to develop as it is constructed and this premise sits behind this effects assessment.

All level information in this report is based on a mine datum set at 1,000 m below a pre-1949 geodetic datum. The current standard, New Zealand Vertical Datum 2016 (NZVD2016), is approximately 1,002 m above the mine datum. That is, reduced levels stated in this report can be reduced by 1,002 m to approximate the same level to NZGD2000/NZVD2016.

1.3 Scope of Report

This document describes the groundwater conditions and potential effects on groundwater associated with the development of the proposed tunnels that will be driven from Waihi to Willows Farm and from Willows Farm to the WUG ore deposit. The groundwater effects assessment associated with the development of the WUG resource itself is included in separate reports (FloSolutions, Intera, WWLA).

We note that this report does not include any effects on groundwater associated with the Willows Farm surface infrastructure (e.g. waste rock stacks, silt ponds, etc.) other than that associated with the tunnel elements. Surface infrastructure effects are included in the GHD hydrogeology report (WAI-985-000-REP-LC-0012).

This assessment of effects on groundwater relates to the development of the portals, shafts and the tunnels. The purposes of this assessment are to determine:

- Groundwater inflows to the tunnel elements.
- Drawdown effects related to the tunnel elements.
- Potential for effects on aquifers.
- Potential for effects on surface waters.
- Potential for effects on other groundwater users.
- Potential for effects on plant growth.

This report has been prepared based on recent and historical information from adjacent areas that provides an understanding based on a long association with groundwater systems in the area. This understanding has been taken forward alongside the project scope and has included further technical analysis to enable potential associated effects to be quantified.

2. Existing Environment

2.1 Regional Geology

The following provides a general description of the geology along the entire tunnel alignment. More detailed descriptions of the geological conditions for each tunnel section are provided in the ground models prepared by GHD (Aug, 2020) and Golder (Sept, 2021). These are included in Attachment A of this report.

The proposed works are located towards the Southern part of the Coromandel Volcanic Zone, a Miocene to early Pliocene andesite-dacite-rhyolite, subaerial volcanic sequence. The Coromandel Ranges are flanked to the west by the Firth of Thames, a Northward continuation of the Hauraki Rift, and to the east by the Pacific Ocean (Braithwaite & Christie, 1996).

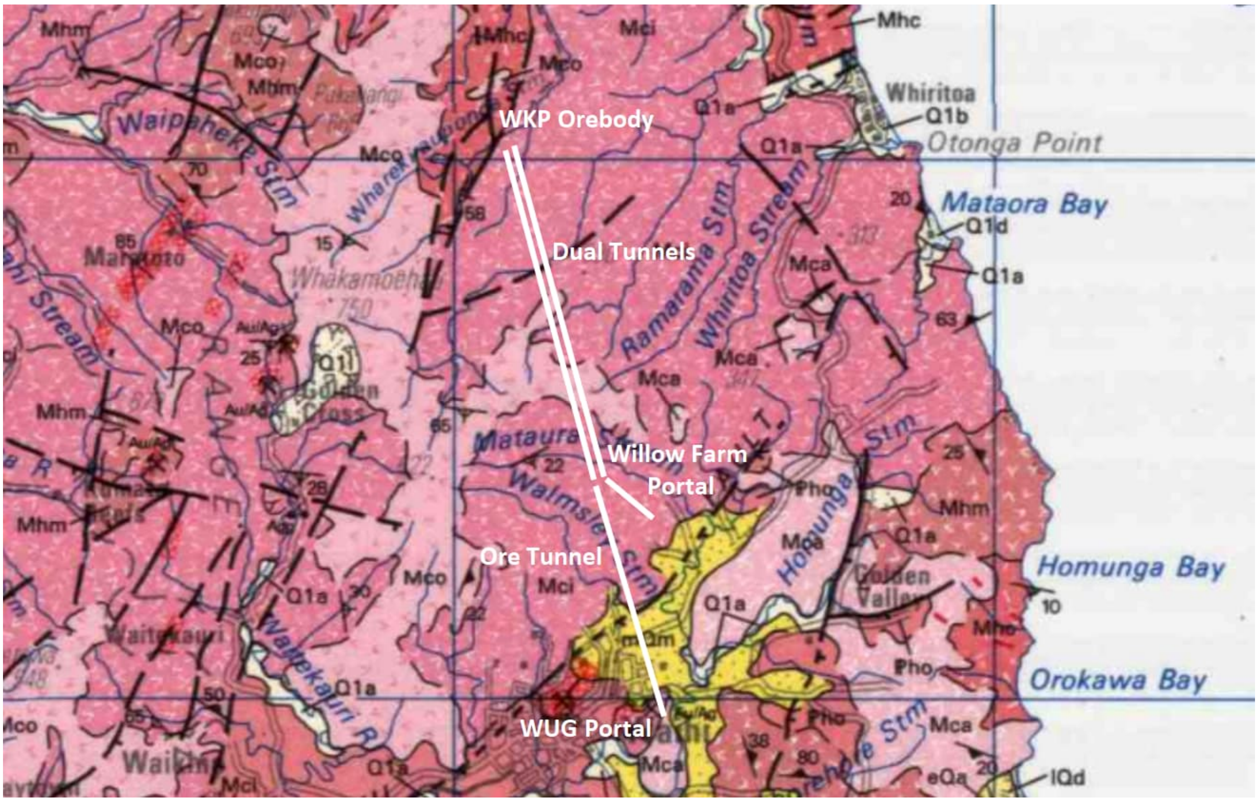

Figure 2 Regional Geologic Setting (Braithwaite & Christie, 1996)

The most extensive geological unit in the area is the Waiwawa sub-group (7.9-5.6 Ma) of the Coromandel Group. This unit comprises andesite and dacite lava flows and tuff breccias, and dacitic ignimbrite, tuff and siltstone. Hydrothermal alteration has been reported.

A well-defined NNE structural alignment and subsequent erosion has exposed both younger Omahine subgroup (6.7-6.6 Ma) which will be intercepted partway along the dual tunnel alignment and Kaimai subgroup (5.6-3.9 Ma) rocks which lie to the east of the portal area. The Omahine subgroup comprises andesite and dacite, intrusive andesites and lava flows, with minor intercalated tuff and tuff breccia. The Kaimai subgroup comprises andesite and dacite intrusives, lava flows and domes, tuff and tuff breccias with intercalated volcaniclastic sediments and local welded dacitic ignimbrite.

Older rocks of the Coromandel Group have been emplaced by faulting. These rocks comprise lithic and pumice-rich ignimbrites and local rhyolite and obsidian-rich pumice breccia deposits and tuff. Extensive hydrothermal alteration occurs locally. The rocks will be intercepted at the termination of the tunnel.

Tauranga Group sediments infill faulted and erosional depressions. These materials comprise pumiceous alluvial gravelly sand, silty clay and peat; estuarine silt and mud interbedded with ignimbrite; and tephra from the Taupo Volcanic zone and are the host rocks of the Wharekirauponga deposit.

A northeast trending fault is inferred in the Waiharakeke valley with a strong north to northeast trending fault block at the tunnel termination. Less prominent faulting may occur along the other valleys and, if present, may be penetrated by the proposed tunnel.

2.2 Regional Hydrogeology

Groundwater distribution and movement in the area will be controlled by the topography, together with the stratigraphy and structural trends. Recharge would be expected to occur in the elevated areas with downward moving groundwater. In the deeply incised valleys, upward moving groundwater (discharge) would be expected. The quantum of groundwater movement would depend on the particular type of deposit present, modified by post-depositional structures and alteration and weathering. Where fracturing has developed, such as typically in lavas, groundwater movement may be greater.

Fine grained tuffs would have lesser groundwater movement. Fault zones, along which valley systems have eroded lengthwise and downwards, are linear features and are expected to concentrate groundwater and can act as both conduits and/or perpendicular impediments to groundwater movement depending on whether faulting was extensional or compressional. Hydrothermal alteration can result in clay-rich fault zones which can impede groundwater flow.

Underground mine development at Waihi and the Waitekauri Valley Golden Cross mine have encountered low groundwater inflows outside the vein systems in hydrothermally altered rocks. Such rocks are expected to be encountered towards the completion of the tunnels and while zones of altered rock may be encountered along the drive alignment, the majority of the rock units encountered are likely to be unaltered. Faults are expected as the alignment passes beneath valleys and possibly beneath defined stream locations.

2.3 Regional Hydrology

The tunnels elements traverse two surface water catchments. The Willows Farm access tunnel and the WUG access tunnel fall within the Waihou surface water catchment area. The Waihou catchment is a large catchment (circa 1,990 km^2) extending from Rotorua to the Firth of Thames. The Mataura Stream and Walmsley Stream that bound the Willows Farm property to the north and south respectively, join the Ohinemuri River which then flows to the west through the Karangahake Gorge to ultimately discharge into the Waihou River.

The majority of the WUG dual access tunnels traverses the Otahu surface water catchment. This is a smaller catchment by comparison being some 71 km^2 in size. This catchment drains to the north east towards Whangamata and discharges via the Otahu River. **Figure 3** shows the extents of the Waihou and Otahu surface water catchments.

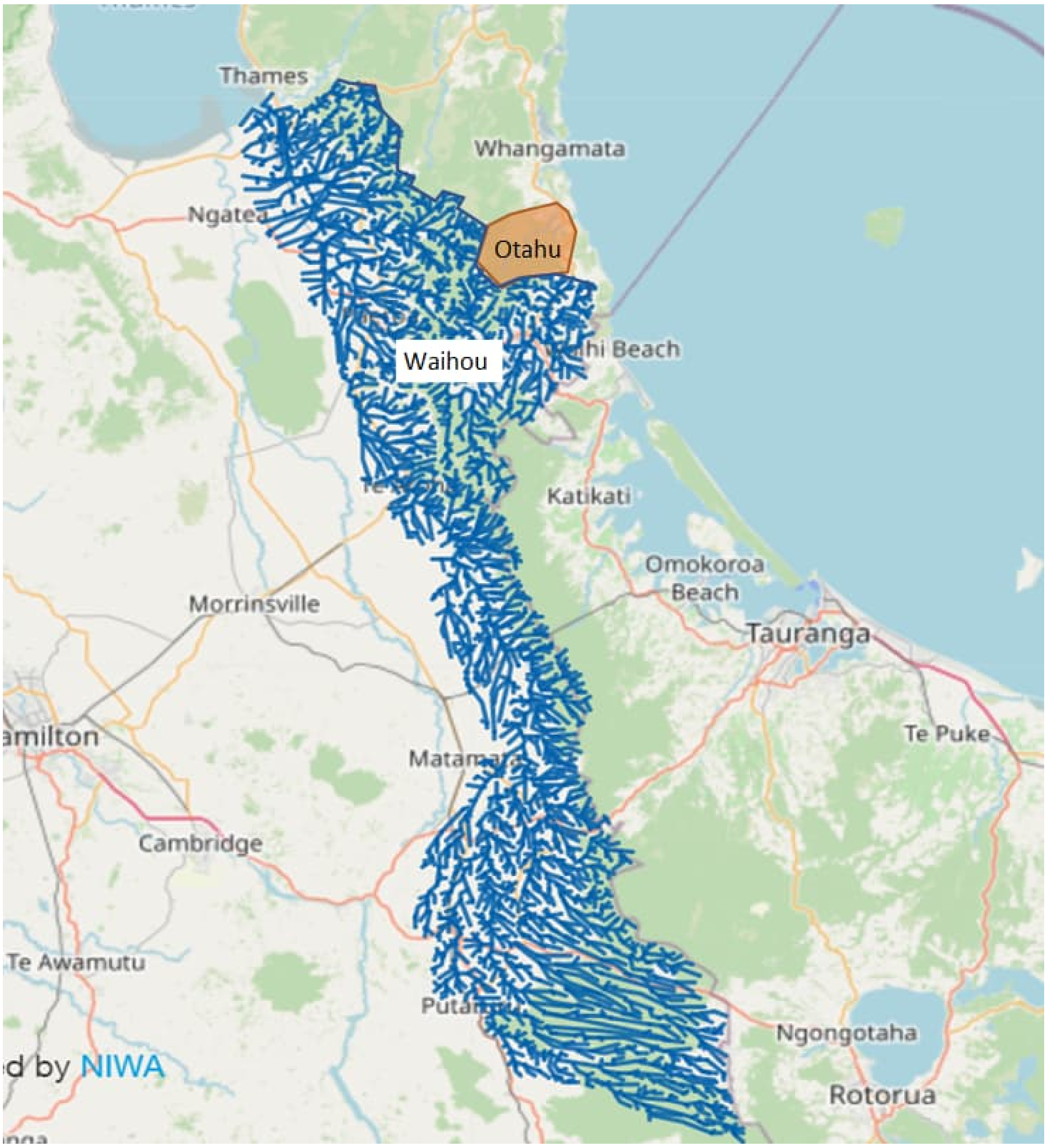

Figure 3 Regional Surface Water Catchment Extents (Modified after NIWA)

3. Groundwater Effects Assessment - WUG Access Tunnel

3.1 Tunnel Description

The WUG access tunnel will be a single tunnel driven from a newly constructed portal at the water treatment plant (WTP) near the existing Favona portal in Waihi. The portal will start at an elevation of approximately 1125 mRL and will decline vertically by some 180 m over a 1,500 m distance. The remainder of the tunnel out to the Willows Farm connection is a gentle incline of around 50 m over 4,000 m. It is anticipated that the tunnel will be advanced at a rate of around 8-10 m/d and will be driven from both ends to meet in the middle to avoid the need for ventilation shafts. The tunnel alignment is shown on **Figure** 4.

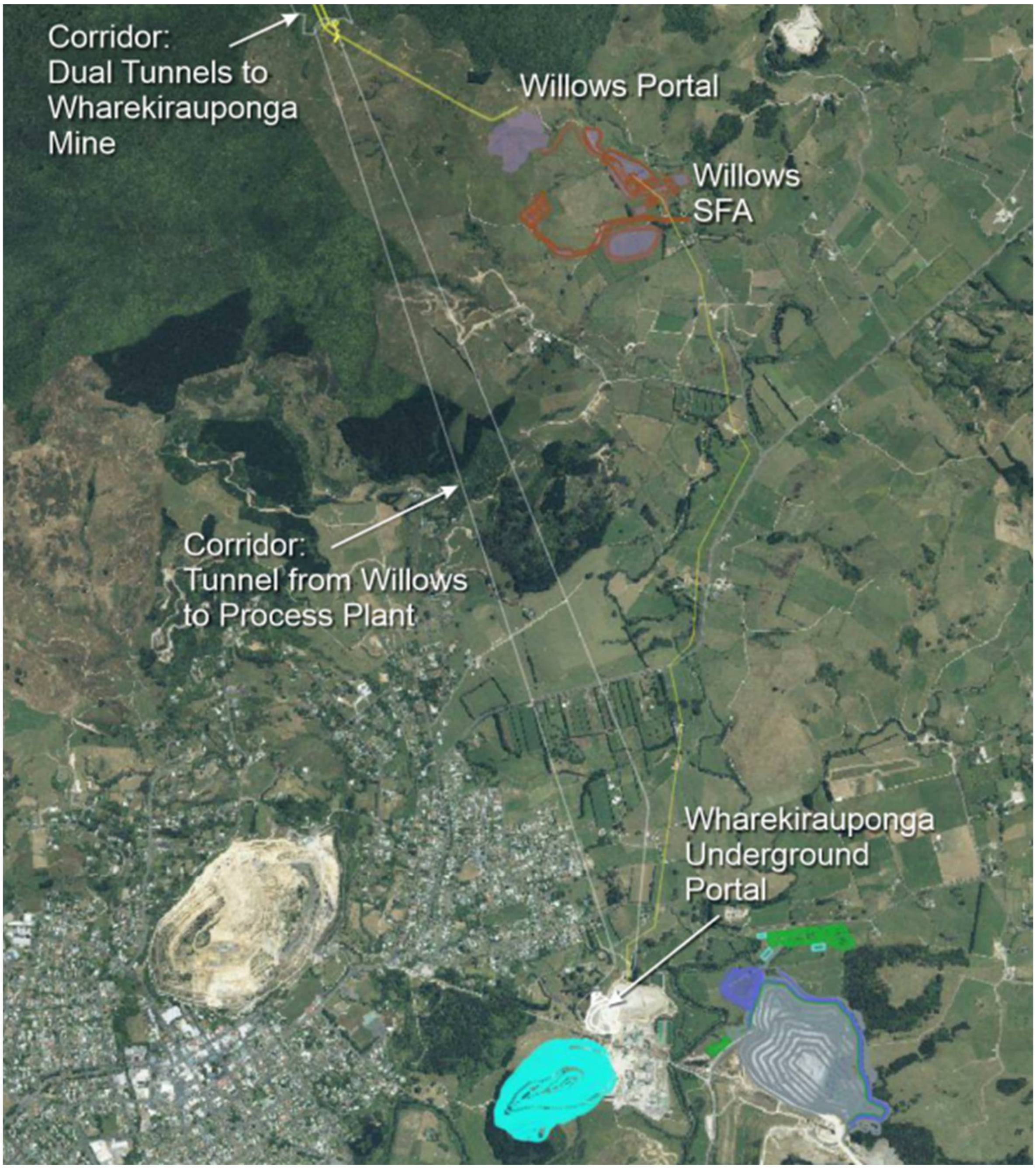

Figure 4 WUG Access Tunnel Alignment

3.2 Characterisation of Tunnel Alignment

3.2.1 Physiography

Along the first 2,500 m of the tunnel from the portal to SH25 the topography is generally flat lying at an elevation of approximately 1120 mRL. North of SH25, the topography steepens into the Coromandel Ranges to a maximum of around 1250 mRL beneath the Willows Farm site. For the first part of the alignment through the Waihi township the tunnel is approximately 90 m below ground level. Beneath the Willows Farm site, it reaches a maximum of 275 m below ground level below the crest of a hill.

3.2.2 Hydrology

The WUG access tunnel is within the Waihi Basin surface water catchment which drains to the west. The main surface water body is the Ohinemuri River and this is east of the proposed tunnel alignment. The tunnel does not pass beneath the Ohinemuri River but will be driven below tributaries to the river.

3.2.3 Geology

The geology of the WUG access tunnel is described in detail (Golder, Sept 2021) and shown in cross section in **Figure 5**. In summary, the tunnel will pass through Waipupu Formation Andesite (aw) which consists of andesitic flows, breccias, tuffs some of which is hydrothermally altered. The tunnel will then pass through the younger Whitiroa Andesite (ah), being andesitic flows, breccia and tuffs, before returning back into Waipupu Formation Andesite. Between approximately 1,000 m and 2,400 m chainage the Whitiroa Andesite is overlain by Ohinemuri Supergroup (ho) ignimbrite and ash deposits.

The younger andesite is present in the mid-section of the alignment due to being in a down thrown block that is bounded by regional scale faults. It is expected that there will be fracture zones associated with these faults and that ground conditions will be weaker than the general andesite rockmass. These zones are expected to be permeable and will allow some groundwater inflow prior to grout sealing. The Ohinemuri Supergroup (ho) is likely to be of relatively high permeability and, while not expected to be intercepted during tunnelling, the geological contact with the Whitiroa Andesite (ah) is not well defined. Should this unit be encountered during tunnelling, groundwater inflows are expected and mitigation will be required.

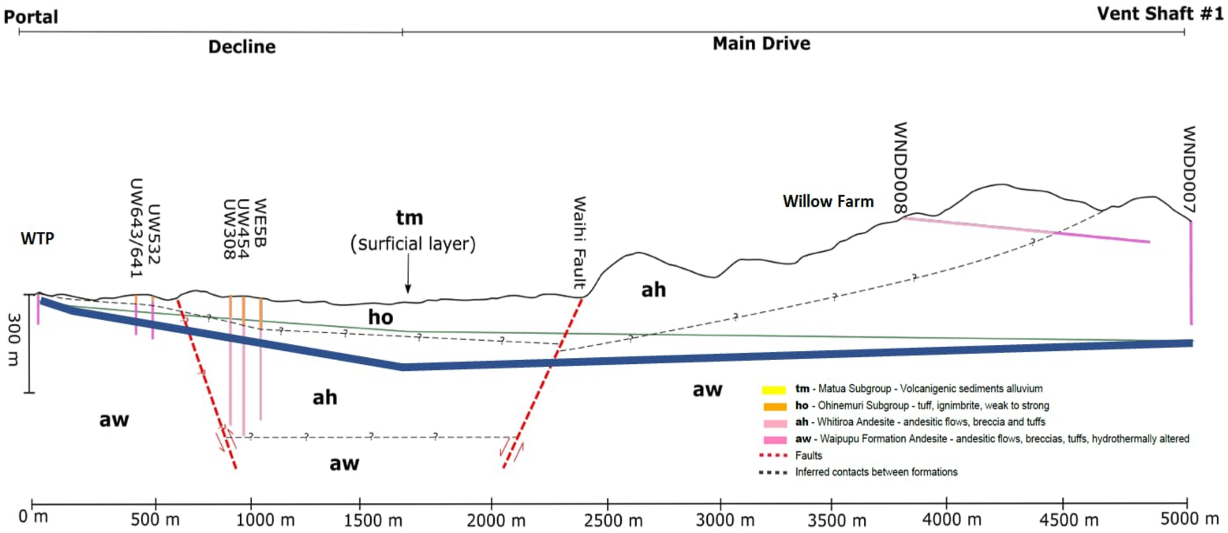

Figure 5 WUG Access Tunnel Profile (Modified after Golder, Sept 2021)

3.2.4 Hydrogeology

At the location of the WUG access tunnel the groundwater system consists of surficial deposits of alluvium and younger volcanic materials that host a shallow water table as shown in **Figure** 6. These deposits have formed in a paleo-valley on the surface of the underlying andesite rocks. Groundwater flow is in a south east direction driven from heads in the Coromandel Ranges. The proposed WUG access tunnel does not intercept these materials.

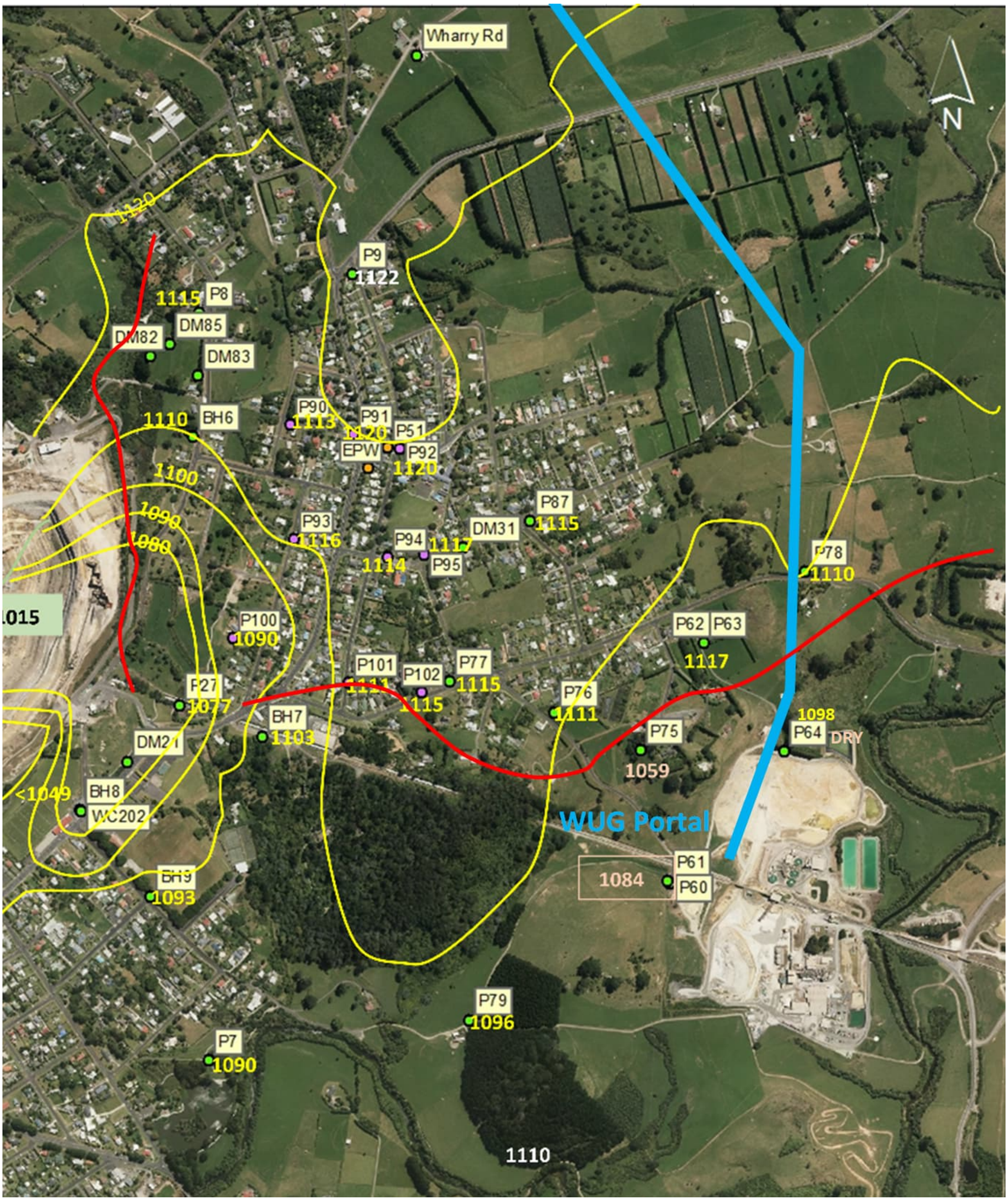

Figure 6 Water Table Map in the Location of the Tunnel

Beneath the shallow groundwater system, groundwater is present within the andesite rockmass as shown in **Figure 7**. The rockmass along the first section of the tunnel is already dewatered from mining of the Martha and Favona vein system.

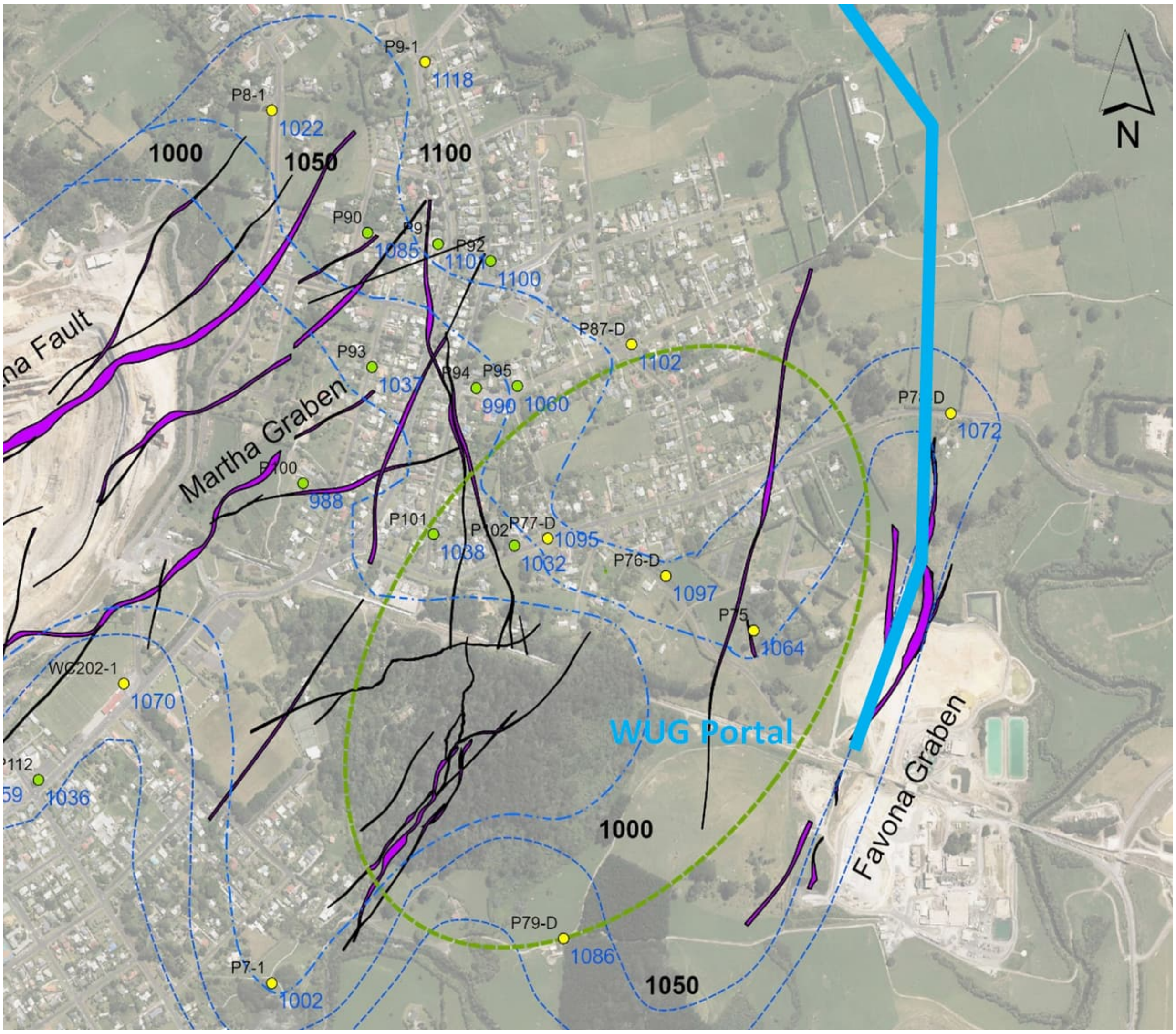

Figure 7 Andesite Piezometric Surface Map

Groundwater Levels

The water table surface shown generally reflects the topography, except to the east of Martha Pit where the water table has been affected by drainage due to the exposure of younger volcanic rocks in the pit. At the location of the WUG access tunnel, the inferred water table is relatively flat and lies between approximately 1110 m RL near Union Hill rising to 1120 m RL at Wharry Road. At the decline section of the tunnel, in the vicinity of the WTP, groundwater monitoring (P60, P61, P64, P75) indicates a lowered or absent water table in the near surface and depressurised conditions in the andesite due to existing mine dewatering.

Hydraulic Gradients

The groundwater flow direction in the area of the southern half of the WUG access tunnel is to the west and the tunnel will be perpendicular to the groundwater flow direction. In this area the hydraulic gradient is relatively flat being around 0.001. As the WUG access tunnel passes beneath the hill approaching Willows Farm, the hydraulic gradient steepens to around 0.04. A downward vertical gradient is expected throughout much of the tunnel alignment, with an upward gradient and discharge zone likely near the Ohinemuri River.

Aquifer Parameters

No site-specific testing has been undertaken to characterise the properties of the rock through which the WUG access tunnel will be driven. These geologic units are, however, the same as those mined in Waihi and have been previously characterised as shown in **Table 1**.

Table 1 Aquifer Hydraulic Properties

	Hydraulic Conductivity			Storage	
Material	**Max (m/s)**	**Min (m/s)**	**Geomean (m/s)**	**Max**	**Min**
Shallow Aquifers					
Ash / Alluvium	1×10^{-4}	1×10^{-7}		0.3	0.1
Ignimbrite	1×10^{-5}	1×10^{-8}		0.01	0.001
Rhyolitic Tephra	1×10^{-6}	1×10^{-7}		0.1	0.05
Deep Aquifer					
Andesite Surface	3×10^{-5}	2×10^{-6}	5×10^{-6}	0.3	0.1
Andesite to 50 m Depth	7×10^{-9}	6×10^{-9}		0.01	0.005
Andesite to 100 m Depth	6×10^{-7}	6×10^{-9}	3×10^{-8}	0.01	0.005
Andesite	1×10^{-5}	1×10^{-8}		0.05	0.001

3.3 Conceptual Groundwater Model

A conceptual hydrogeologic model for the WUG access tunnel along the alignment is presented in **Figure 8**. In summary, based on previous studies and what we know about the area, the model assumes that the initial part of the decline is already dewatered from underground mining.

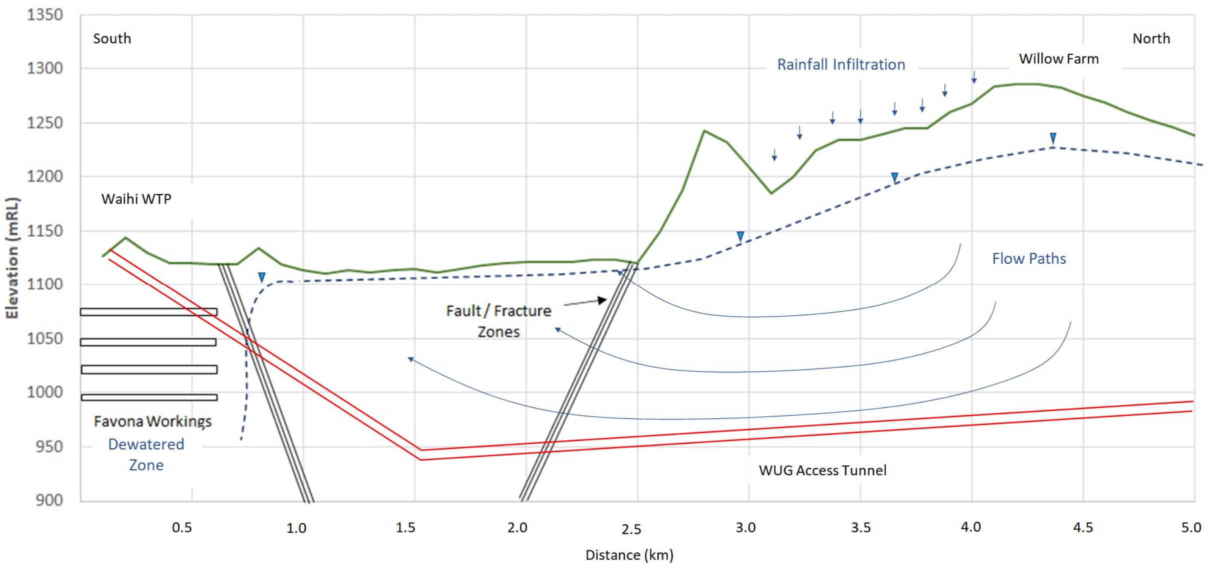

Figure 8 WUG Access Tunnel Conceptual Hydrogeological Model

At some point along the tunnel decline, fully saturated conditions will be encountered. As the tunnel is driven, groundwater will be intercepted and the adjacent rockmass will be depressurised. Dewatering to the ground surface is unlikely to take place due to the relatively low permeability of the andesite and the perched shallow groundwater system which has substantially greater storage and rainfall recharge.

3.4 Groundwater Effects Assessment

3.4.1 Groundwater Inflows

Groundwater inflows for the tunnel have been adopted from the groundwater inflow assessment included in Attachment B. This assessment indicates up to 2,470 m^3/d groundwater will be taken from the Waihi Basin catchment from dewatering while the tunnel remains open, with that water returned to that catchment after treatment.

3.4.2 Groundwater Availability

The WUG access tunnel is located within the Waihi Basin aquifer management area as identified by the Waikato Regional Council (WRC, 2012). This catchment is further subdivided into the Waihi Basin shallow aquifer system (0.5 to 30 m depth) and the Waihi Basin deep aquifer system (>30 m depth), however the resources are managed as one. The availability of groundwater for the Waihi Basin is shown in **Table 2**.

Table 2 Waihi Basin Groundwater Availability

Management Limit [a]	6,000,000	m^3/year
Existing Allocated	4,155,000	m^3/year
Available [b]	1,845,000	m^3/year
Other WNP Takes (GOP, TSF3) [c]	521,950	m^3/year
WUG Access Tunnel [d]	901,550	m^3/year
Total WNP Takes	1,423,500	m^3/year
Remaining	421,500	m^3/year

a - Combined shallow and deep limits
b - WRC advised 23/11/2021
c - Based on GOP take of 1,100 m^3/d and TSF3 take of 330 m^3/d for 365 days
d - Based on 2,470 m^3/d for 365 days

On the basis of this assessment, there is sufficient groundwater available for the proposed take.

3.4.3 Potential for Effects on Springs and Streams

Groundwater modelling has been undertaken to assess the effects of the tunnel on the near surface environment. The modelling has indicated that once the tunnel is 20 to 30 m below the ground surface, depressurisation effects are limited to the rockmass surrounding the tunnel with no connection with the surface or shallow groundwater system expected (i.e. is depressurised rather than dewatered). Given that the tunnel decline is already dewatered to a depth of approximately 70 m below the ground surface, and the tunnel will continue to be driven at a depth greater than that, no further drainage effects are expected in the near surface. Therefore, the potential for effects on streams and springs is considered to be negligible.

3.4.4 Potential for Effects on other Groundwater Users

Figure 9 shows the locations of groundwater users adjacent to the proposed tunnel alignment. Two of these bores (72_5193 and 72_771) are 86 m deep and come to within 400 m proximity to the proposed WUG access tunnel. These bores are small diameter and do not have associated groundwater take consents and are assumed to be for domestic or stock purposes. Another bore (72_1223) is within closer proximity to the tunnel but there are no construction details. If this bore exists it too is expected to be a domestic or stock water supply.

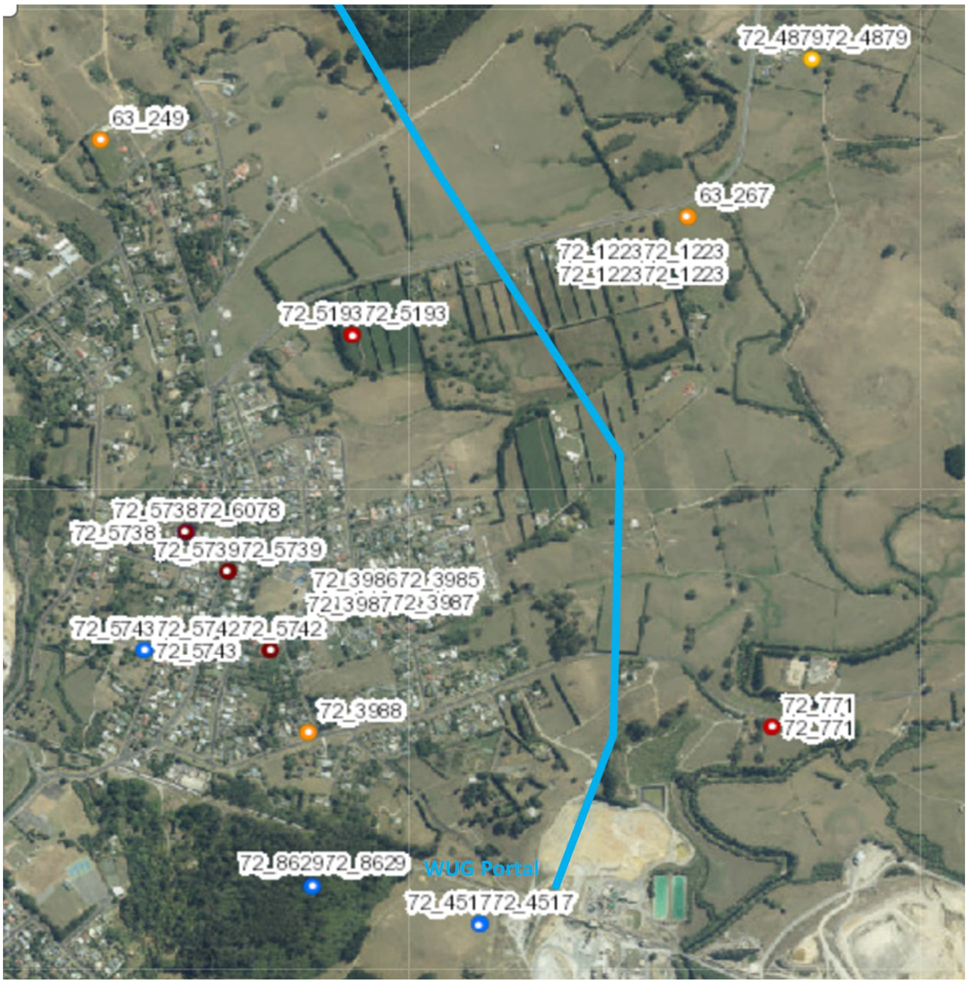

Figure 9 Groundwater Users near the WUG access Tunnel

Experience with tunnelling in Waihi and groundwater modelling both indicate the lateral effects of depressurisation around the tunnel will be limited due to the andesites low rockmass permeability. For this reason, we do not consider it likely that groundwater users will be adversely affected by the proposed WUG access tunnel. Irrespective, monitoring of the water levels in nearby bores is proposed. Should an effect develop that prevents the bore owner from accessing their take then mitigation options would be put forward by OGL.

3.4.5 Potential for Effects on Aquifers

The groundwater take will be from the deep rockmass and, as mentioned in report section 3.4.3, dewatering effects extending back to the near surface are expected to be negligible due to the low permeability andesite rockmass the tunnel will be driven through. The tunnel section will be perpendicular to the main direction of groundwater flow in the catchment and will intercept some flow paths locally, but will not affect the overall flow regime.

The location where effects could have been expected in the near surface is the initial portal and first part of the decline, however, dewatering of the deep rockmass has already taken place due to underground mine dewatering of the Favona deposit in Waihi. Taking groundwater from the deep aquifers is, therefore, not expected to affect water levels in the overlying aquifers and we, therefore, assess the potential for effects to be highly unlikely and if they to occur, they will be less than minor.

3.4.6 Potential for Effects on Groundwater Quality

During tunnel dewatering there will be no consequential change in groundwater quality due to the water take. Groundwater will seep into the tunnel at a low rate, with cement grouting reducing localised inflows. The groundwater that flows into the tunnel will be pumped back to the treatment plant in Waihi and discharge to the Ohinemuri River in accordance with the consents held for that discharge .

Once the tunnel is no longer required rewatering will occur and the groundwater system will return to its previous state. Some groundwater will come into contact with the cement grout, however this is not expected to change the overall quality of water in the aquifer due to the limited contact area relative to the system throughflow. In summary, no adverse effects on groundwater quality are expected from development of the tunnel.

3.4.7 Potential for Saline Intrusion

The WUG access tunnel is 7 km from the ocean which is too far inland for any effect to develop given the low permeability of the andesite rockmass. For this reason, we assess the potential for saline intrusion to occur to be less than minor.

3.4.8 Potential for Ground Settlement Effects

In the near surface, where compressible soils exist, no dewatering effects are expected beyond that which has already occurred due to existing mining activities. Where driven through the deep andesite rockmass, ground depressurisation will occur immediately around the tunnel, however the effects will not be laterally extensive and no significant settlement risk is considered likely. The primary rockmass being dewatered is the Rhyolite body and this is a hard, incompressible medium and is not expected to consolidate significantly as a result of dewatering. This has been assessed in detail in the EGL (WAI-985-000-REP-LC-0050) report.

3.4.9 Potential for Effects on Plant Growth

Any dewatering associated with the WUG access tunnel will be in the deep rockmass. Soil moisture conditions in the regolith soils or terrace deposits in the near surface are not expected to change as a consequence of dewatering at depth. We, therefore, assess the effects of the WUG access tunnel dewatering on plant growth to be less than minor.

4. Groundwater Effects Assessment - Willows Farm Access Tunnel

4.1 Characterisation of Tunnel Alignment

4.1.1 Physiography

Figure 10 shows the proposed access tunnel in relation to the site topography. The site is shown to slope north eastwards towards the Mataura Stream. The slope is cut by one prominent northeast trending side gully and several smaller gullies. Slopes range from approximately 8° to 33°. The steeper slopes occur in the gullies while the shallow slopes occur closer to the Mataura Stream. The portal would be initiated on slopes up to approximately 22°, with the shaft on slopes up to 16° and the infrastructure on slopes up to 10°.

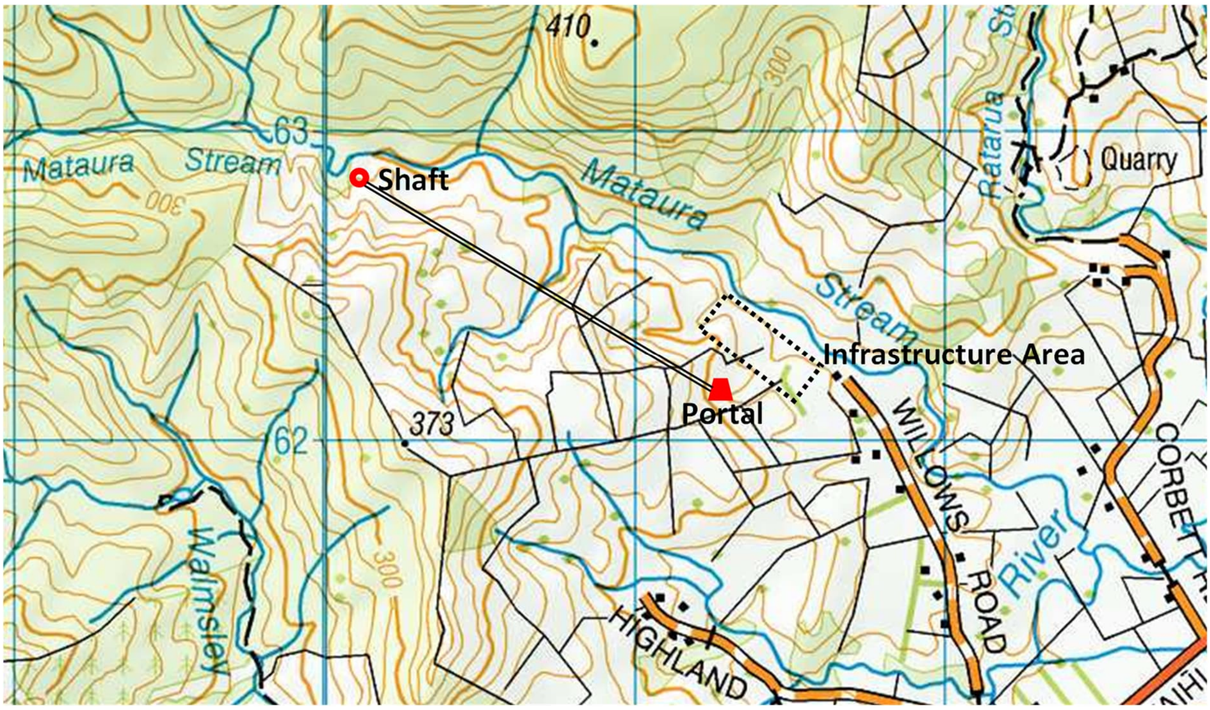

Figure 10 Willows Farm Site Topography

4.1.2 Hydrology

The location of the Mataura surface water catchment is shown in **Figure 11**. This catchment is 6.5 km^2 in size and drains southeast to join the Ohinemuri River. The Willows Farm property occupies approximately one third of the lower end of the catchment. The upper reaches of the catchment are steep and high run-off resulting in high stream flows being observed during and after rainfall. Stream baseflow is expected to be mostly sourced from the shallow regolith soils, with low flows fed by rockmass discharge.

The tunnel crosses beneath the Mataura Stream in andesite at a depth of approximately 225 m and the position of the Mataura Stream where the tunnel passes beneath it is shown in **Figure 11**.

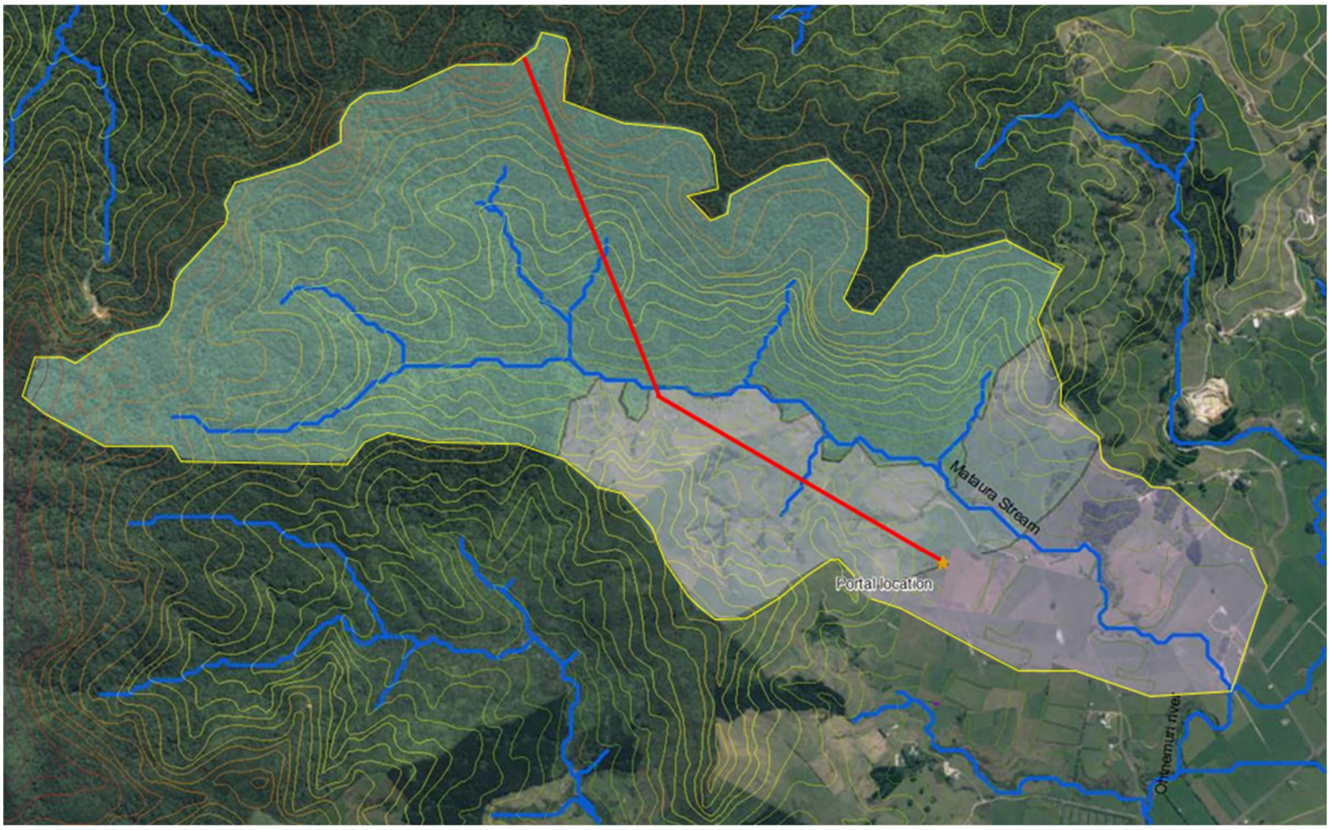

Figure 11 Mataura Stream Catchment Area, Willows Farm and indicative Access Tunnel location.

4.1.3 Soils and Geology

The majority of the site soils are indicated to be primarily residual soils as shown on **Figure 12**, with a weathered regolith overlying volcanic rock. Given indicated surface slopes, down slope movement would be expected to maintain reduced soil cover on the steeper slopes with an increased thickness of the soil profile on the lower slopes. On the flatter parts of the site near the Mataura Stream terrace deposits of alluvial material are measured to a depth of 7 m, with two levels of terraces apparent.

Figure 13 shows the distribution of the soil types at the site. The primary soil mapped at the portal and infrastructure sites is Otorahanga orthic allophanic loam (well drained, moderate permeability), while at the proposed vent shaft site, **Figure** 13 shows Moehau 2 acidic orthic brown loam soils (well drained, moderate permeability).

The geology of the site is included in the ground model prepared by GHD (August, 2020) and this has been complemented by an investigation program that has included test pits, boreholes and geotechnical testing. The data from the investigations relevant to this assessment are included in Attachment C. In general terms, the site is noted to consist of a depth of primary weathered rock and/or pyroclastic deposits that are weathered to form clay and silt soils. These materials are a few metres thick on the steeper slopes (**Figure 8)** and thicken in the topographic lows to some 7 to 15 m thick. Beneath these soils either lies relatively fresh andesite rock in the northern part of the site (Waipupu Andesite) or completely weathered tuff (Whiritoa Andesite). In the low-lying areas adjacent to the Mataura Stream alluvial terrace deposits exist consisting of silty gravel sands. These materials directly overly the completely weathered tuff.

Figure 12 Willows Farm Exposure Showing Regolith Soils Overlying Andesite Rock

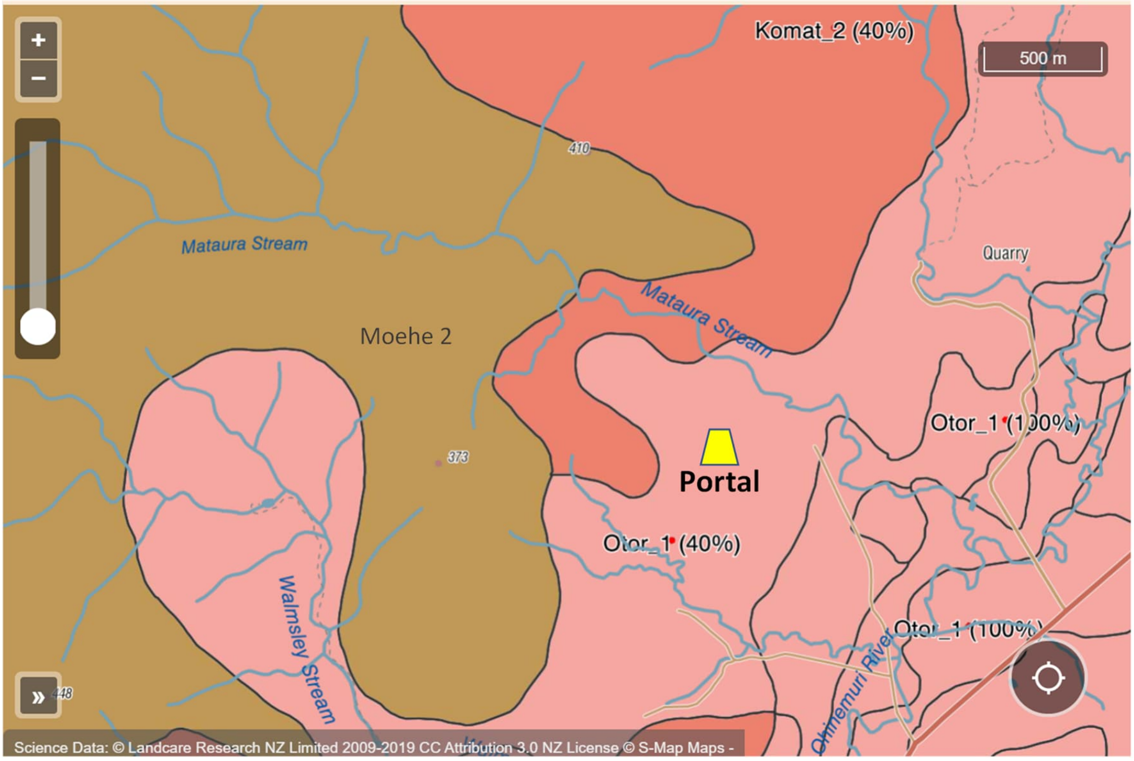

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Figure 13 Soil Distribution Over the Willows Farm Site

4.1.4 Hydrogeology

Groundwater Levels

A total of 20 machine drilled boreholes were completed as shallow groundwater monitoring wells during the geotechnical site investigations of Willows Farm. In addition, a vibrating wire piezometer with 3 tips was installed at the location of the proposed ventilation shaft. **Figure 14** shows the locations of the monitoring wells, the groundwater elevations and interpreted water table surface. **Figure 15** shows the hydrogeology along the access tunnel profile. **Figure 16** and **Figure** 17 provides hydrogeologic sections 1 and 2 at the locations shown in **Figure 14**. In general terms, in those wells at higher elevations the water table is 10's of metres below ground level. At lower elevations the depth to groundwater is between 1 to 5 m. At two locations (WFBH001 and WFBH0011) there is a water table in the upper pyroclastic materials and lower-level groundwater present in the volcanic rock. The water level difference in WFBH0011 is relatively small being 1.7 m while at WFBH001 this is 6.2 m. These observations suggest perching of groundwater occurs in the shallow materials overlying the volcanic rockmass.

Hydraulic Gradients

The interpreted water table surface shows the topography of the site is the primary feature driving groundwater heads that show a close relationship to site morphology. Hydraulic gradients vary over the site depending on the local land forms but is on average 0.05 to 0.06 over much of the property, flattening to 0.02 in the central area and with locally steep gradients up to 0.1 near the Mataura Stream.

Vertical hydraulic gradients are observed to exist at the vent shaft location where WNDD007 indicates a vertically downward gradient in the range of 0.02 to 0.06.

Aquifer Parameters

Rising head tests were undertaken on all of the monitoring wells constructed on the site. In addition to the testing performed on the monitoring wells, falling head tests and packer tests were undertaken on WNDD007. A summary of the results of these testing is included in **Table 3**.

Table 3 Willows Farm Hydraulic Conductivity values

Monitoring Well	Hydraulic Conductivity (m/s)	
	Min	Max
Weathered Tuff	5.3×10^{-7}	2.2×10^{-6}
Terrace Gravel	3.3×10^{-8}	1.1×10^{-4}
Sandy Soils	1.1×10^{-6}	1.2×10^{-6}
Silt Soils	2.0×10^{-7}	1.7×10^{-5}
Silt/Clay Soils	1.1×10^{-7}	$2.3. \times 10^{-7}$
Altered Tuff	5.7×10^{-8}	8.8×10^{-8}
Tuff	1.1×10^{-6}	7.1×10^{-6}
Andesite	1.3×10^{-8}	5.0×10^{-7}

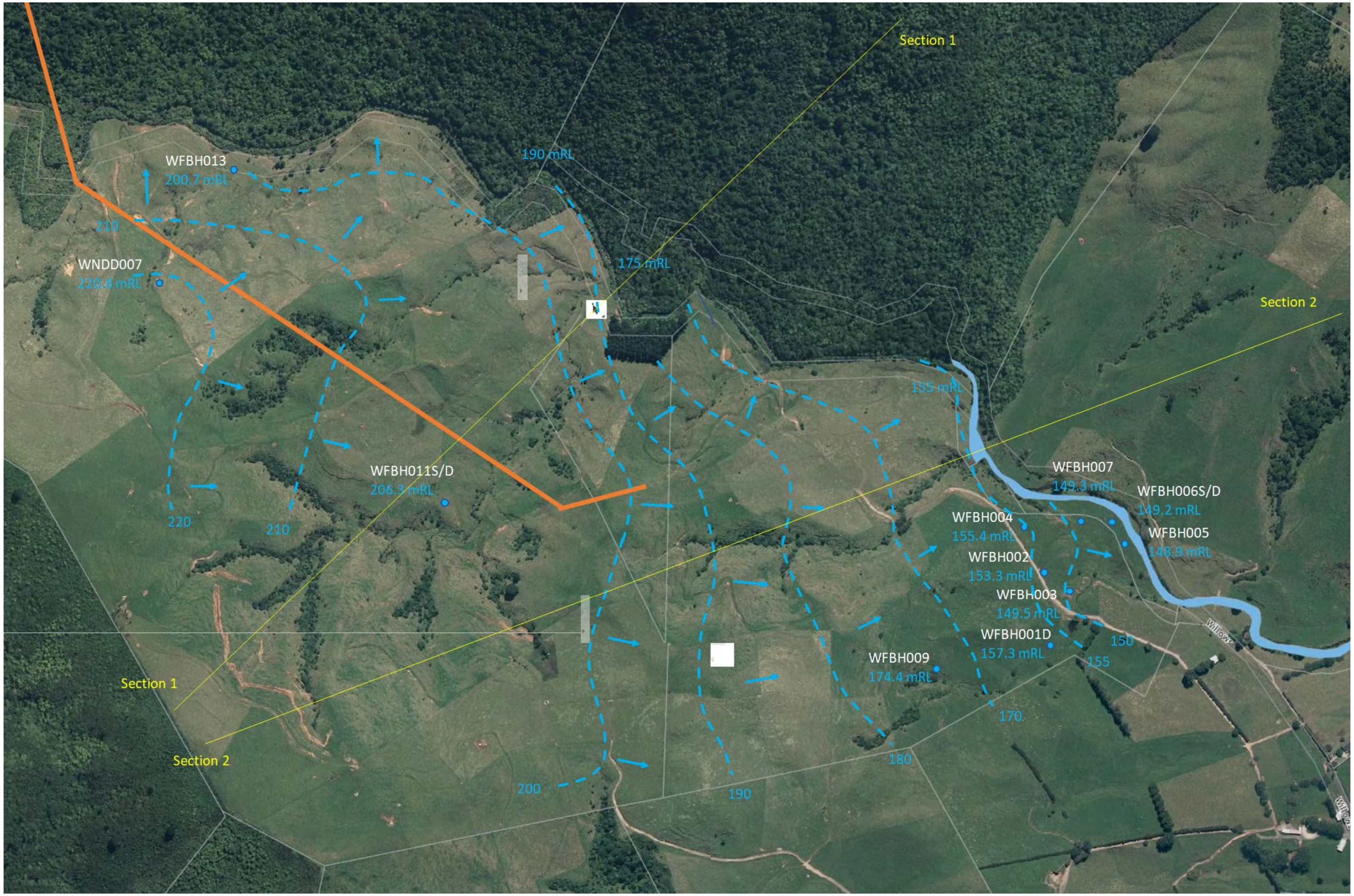

Figure 14 Groundwater Monitoring Well Locations and Interpreted Water Table Surface (Note: Groundwater Level Elevations not Referenced to Mine Datum of +1,000 m RL)

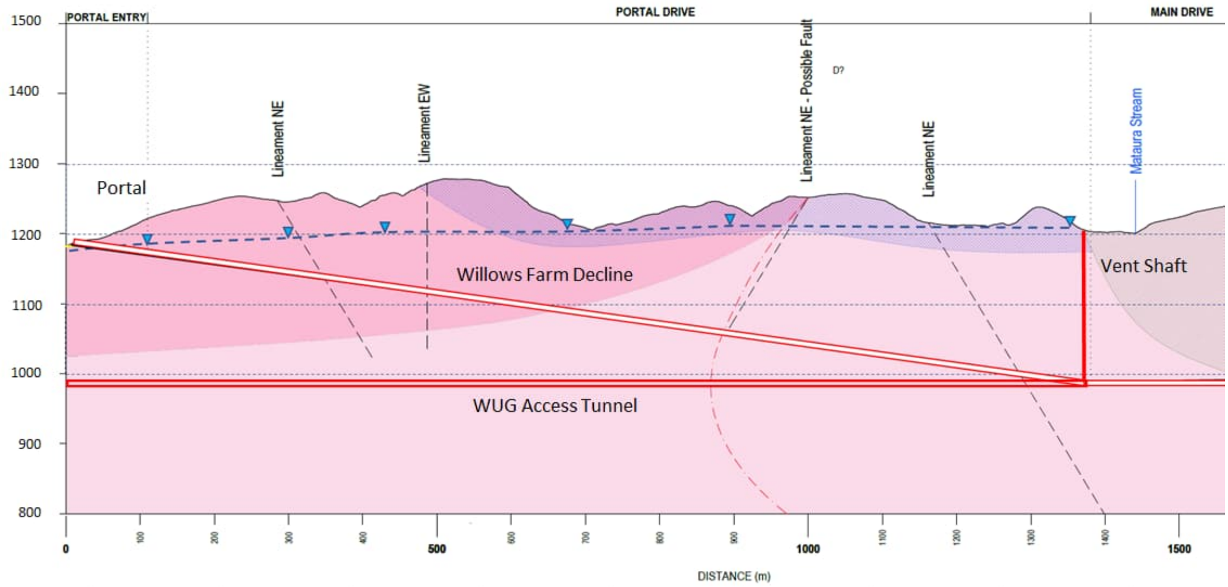

Figure 15 Access Tunnel Hydrogeologic Profile

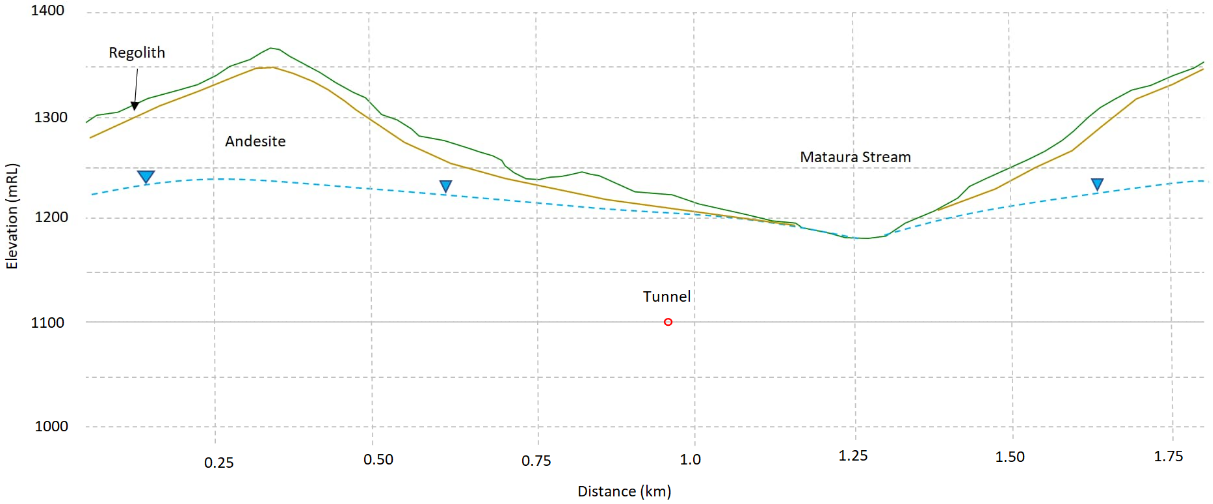

Figure 16 Willows Farm Hydrogeologic Section 1

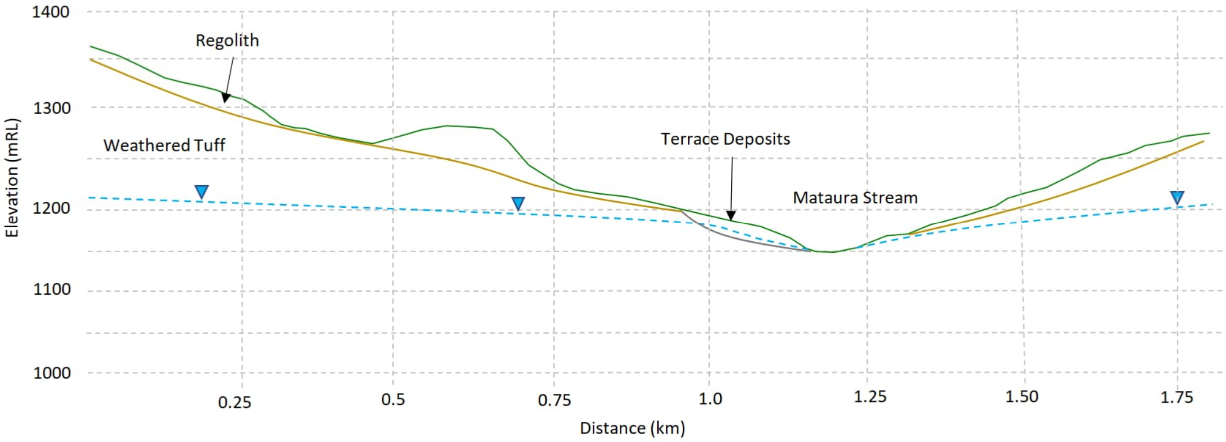

Figure 17 Willows Farm Hydrogeologic Section 2

Overall, the testing indicates that there are some permeable soils in the near surface, but that most of the materials beneath the Willows Farm site have relatively low hydraulic conductivity. The main geological unit the access tunnel is to be driven through is the andesite, which has a geometric mean of 3.0×10^{-8} m/s. This is similar to that measured elsewhere in Waihi. Given the rockmass being dewatered is of low permeability, any associated dewatering effects are expected to be limited.

4.2 Conceptual Groundwater Model

The conceptual geologic model for the site underpins the groundwater effects assessment in that it identifies risk pathways associated with dewatering. It also forms the basis for the numerical modelling undertaken to quantify the drainage risks.

The conceptual model for the Willows Farm site is described as follows and is illustrated in **Figure 18** and **19**.

- Rainfall that does not run-off infiltrates the soil profile
- High permeability shallow soils store recharge water with some of this water moving downslope (interflow)
- Water moving down the slopes and direct rainfall infiltration results in a perched water table locally in the regolith and terrace deposits
- Interflow water continues to move down slope to the Stream
- Some rainfall infiltration percolates down into the deeper rockmass with saturation below the perched water table in the regolith
- Flow paths then result in deep groundwater discharge to the Stream as baseflow
- Deep groundwater flow moves down gradient though the catchment
- Fracture zones that are orthogonal to the flow direction intercept some of this groundwater
- Higher permeabilities in the fracture zones results in preferential groundwater flow down the length of the zone resulting in high discharge zones in the Mataura Stream.

Based on this conceptual model, the key risk to understand is how much stream flow will be intercepted as the access tunnel passes though the fracture zones prior to these zones being sealed off. The risk is higher at these locations due to the assumed higher permeability values and given the tunnel is still relatively shallow as it continues on a descent. However, intercepted water is to be diverted to the water treatment plant before being discharged to the Ohinemuri River. This water is not lost from the greater catchment.

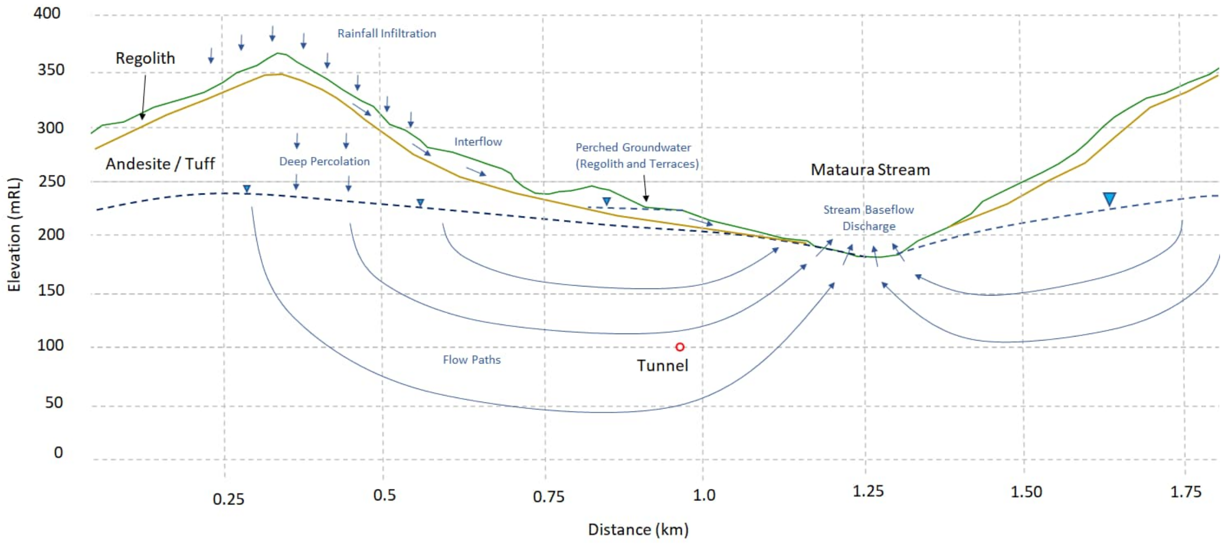

Figure 18 Conceptual Hydrogeologic Model Section at Willows Farm

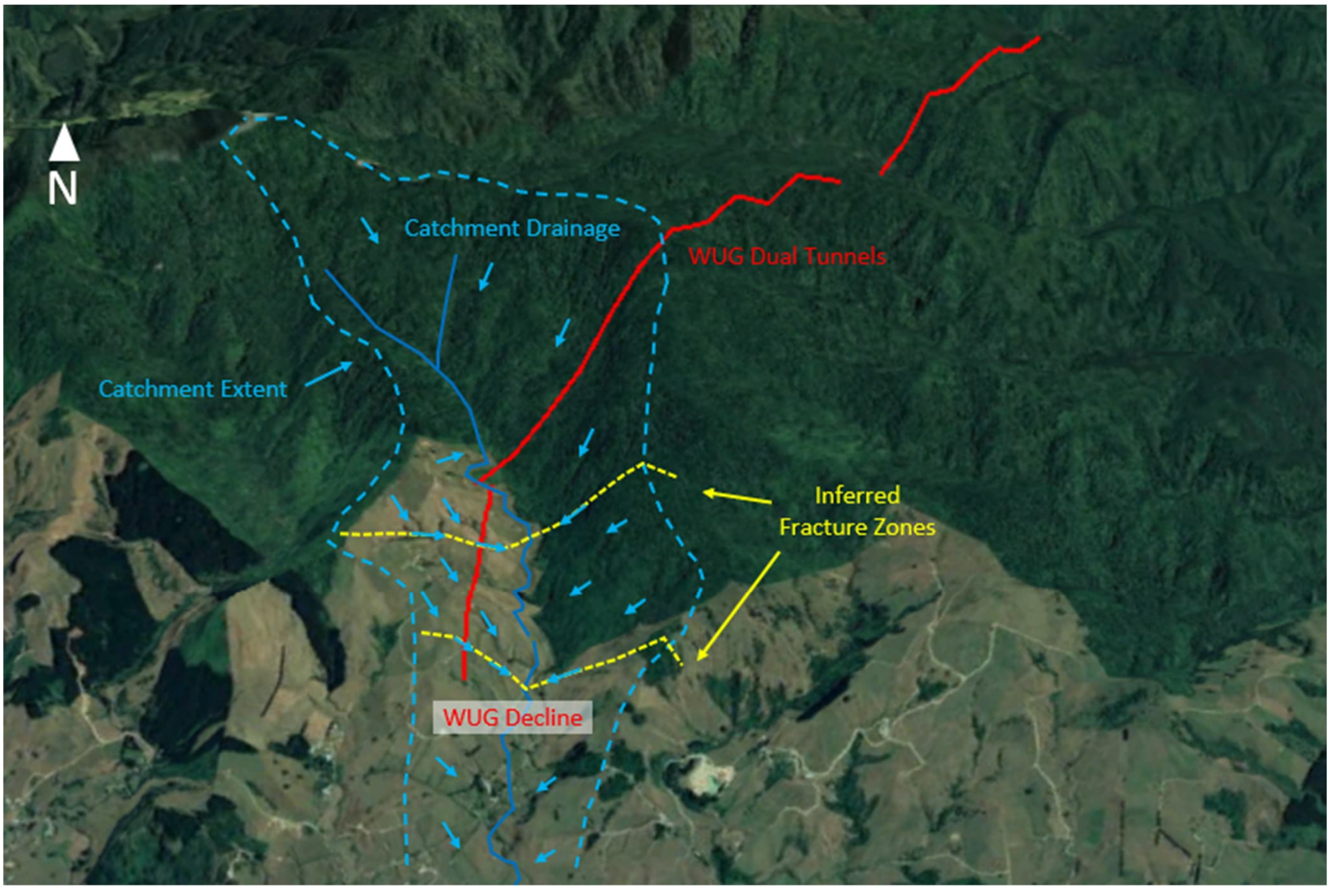

Figure 19 Catchment Scale Conceptual Hydrogeologic Model at Willows Farm

4.3 Groundwater Effects Assessment

4.3.1 Groundwater Inflows

Groundwater inflows for the Willows Farm access tunnel have been adopted from the groundwater inflow assessment included in **Attachment B**. This assessment indicates that the decline would generate in the order of 500 m^3/d groundwater from the rockmass during construction.

4.3.2 Groundwater Availability

The Willows Farm access tunnel sits just outside of the Waihi Basin aquifer management area as identified by the Waikato Regional Council (WRC, 2012), but for the purpose of this assessment has been included in the availability calculations to remain conservative. The availability of groundwater has been determined as shown in **Table 4**.

Table 4 Waihi Basin Groundwater Availability

Management Limit [a]	6,000,000	m^3/year
Existing Allocated	4,155,000	m^3/year
Available [b]	1,845,000	m^3/year
Other WNP Takes (GOP, TSF3) [c]	521,950	m^3/year
WUG Access Tunnel [d]	901,550	m^3/year
Willows Farm Decline [e]	182,500	m^3/year
Total WNP Takes	1,606,000	m^3/year

Remaining	239,000	m^3/year
a - Combined shallow and deep limits b - WRC advised 23/11/2021 c - Based on GOP take of 1,100 m^3/d and TSF3 take of 330 m^3/d for 365 days d - Based on 2,470 m^3/d for 365 days e - Based on 500 m^3/d for 365 days		

On the basis of this assessment, there is sufficient groundwater available for the proposed take.

4.3.3 Potential for Effects on Springs and Streams

An assessment of the potential for effects of the tunnel construction on springs and stream flows has been undertaken using numerical modelling in SEEP/W (R2 2019). Further information in relation to that model is provided in **Attachment D**. This entailed constructing a model section that replicates the hydrogeologic conditions perpendicular to the access tunnel across Willows Farm assuming three scenarios;

- Assuming high permeability conditions replicating preferential flow along a fracture zone ($K = 1 \times 10^{-5}$ m/s)
- Assuming typical rockmass being fresh andesite ($K = 2.5 \times 10^{-8}$ m/s)
- Assuming typical rockmass being fresh weathered tuff ($K = 1.0 \times 10^{-7}$ m/s)

The critical observation point in these models is the change in baseflow to the Mataura Stream, the results of which are provided in **Table 5**.

Table 5 Stream Depletion Model Results

Lithology	Stream Loss (L/s)
Weathered Tuff	0.64
Andesite Rock	0.17
Fracture Zones	0.39

The model calculations assume the Andesite and Tuff rockmass would be free draining and that the fracture zones (3 zones each 5 m wide) would be sealed after 14 days. So, while there could be a short-term drainage effect in the fracture zones, this would not result in long term baseflow loss. This being the case, the baseflow loss in the Mataura Stream due to the construction of the tunnel in the long term would be that lost from diversion of flow paths in the andesite being some 15 m^3/d. In the context of the baseflow in the Mataura Stream this amount of stream water loss would be indiscernible. On this basis we assess the effects on surface water due to the construction of the tunnel to be less than minor.

4.3.4 Potential for Effects on other Groundwater Users

There is only one registered bore (72_10311) that is within proximity to the tunnel. This bore is 1.2 km from the closest point to the tunnel and is 200 m deep. Given the bore diameter of 120 mm and the site location (33 Highland Road), the bore is likely used for domestic and stock purposes. Given the separation distance between the bore and the tunnel, it is down gradient of the tunnel, and assessing the limited extent of dewatering the tunnel causes, the effects of constructing the tunnel will not be discernible in the bore. For these reasons we assess the potential effects on other users to be less than minor.

4.3.5 Potential for Effects on Aquifers

The groundwater take will be from the Waipupu and Whiritoa volcanic rocks that form the upper most aquifer along the length of the tunnel alignment. Taking groundwater from these aquifers is, therefore, not expected to affect other aquifers as the shallow system is perched and while recharge will move downwards, there is a disconnect between shallow saturation and deep saturation. The tunnel section will be perpendicular to the main direction of groundwater flow in the catchment and will intercept some flow paths locally, but will not affect the overall flow regime. On this basis we assess the potential effects on other aquifers from construction of the access tunnel to be less than minor.

The vent shaft at Willows Farm will be similar to a large diameter bore hole that will be continuously lined to prevent the ingress of groundwater. During construction there will be some localised drawdown of the groundwater system around the shaft. Following construction of the shaft the groundwater system will return to its previous state. The shaft will be constructed entirely within the Waipupu and Whiritoa volcanic rocks that constitutes one aquifer system. Construction of the shaft will not, therefore, result in the mixing of previously isolated aquifers.

4.3.6 Potential for Effects on Groundwater or Surface Water Quality

During tunnel dewatering there will be no consequential change in groundwater quality due to the water take. Groundwater will seep into the tunnel at a low rate, with cement grouting reducing localised inflows. The groundwater that flows into the tunnel will be pumped back to the treatment plant in Waihi and discharged to the Ohinemuri River in accordance with the consents held for that discharge.

Once the tunnel is no longer required rewatering will occur and the groundwater system will return to its previous state. Some groundwater will come into contact with the cement grout and backfilled waste rock, however this is not expected to change the overall quality in the aquifer due to the limited contact area relative to the system throughflow. This statement is similarly applicable to the vent shaft following construction. In summary, no adverse effects on groundwater quality are expected from the tunnel.

Given the limited connections between groundwater and surface waters, and the lack of expected effects on groundwater, the effects on surface water quality is similarly expected also to be negligible.

4.3.7 Potential for Saline Intrusion

The access tunnel is 7 km from the ocean, which is too far for any effect to develop and the groundwater elevation intercepted by the tunnel is above sea level. For these reasons we assess the potential for saline intrusion to occur to be less than minor.

4.3.8 Potential for Ground Settlement Effects

The modelled groundwater drawdown relationship to distance is shown for the Weathered Tuff is shown in **Figure 20**. The primary rockmass being dewatered is the Rhyolite body and this is a hard, incompressible medium and is not expected to consolidate significantly as a result of dewatering. The weathered tuff is considered relevant to assess given it is a volcanic ash that is compressible (high clay and sand content).

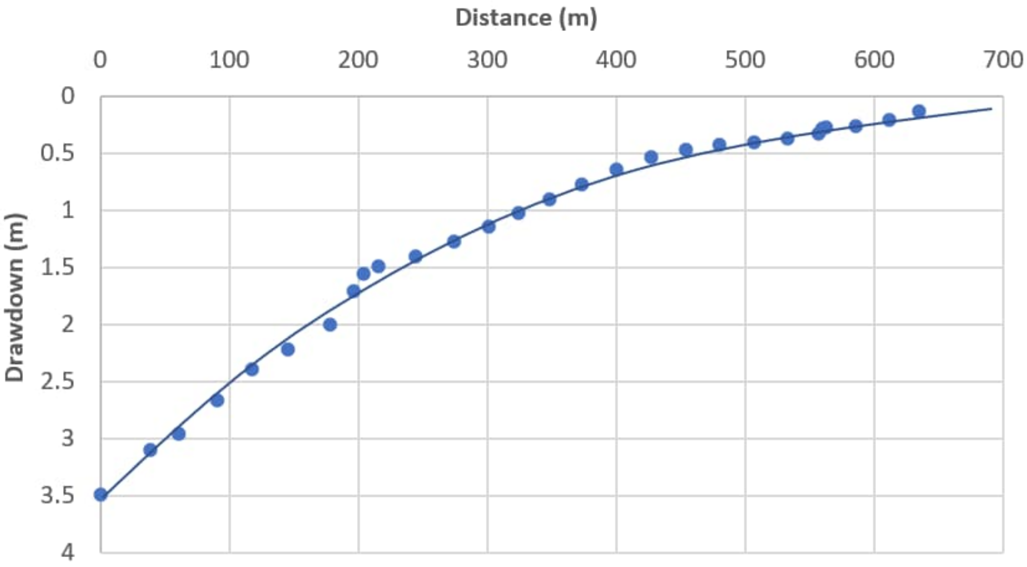

Figure 20 Distance Drawdown for Weathered Tuff

The model results confirm that the long-term drawdown in groundwater levels associated with the construction of the tunnel are small and would be indiscernible within 600 m distance of the tunnel. The majority of the drawdown effect will remain within the Willows Farm property, with some effect extending into DOC land. Given the nature of the weathered tuff, only a limited amount of compressibility is likely to exist. Assessing the amount of drawdown that might occur, only a limited amount of settlement is possible and this would mostly be directly over the tunnel alignment. This has been assessed in detail in the EGL report (WAI-985-000-REP-LC-0050).

4.3.9 Potential for Effects on Plant Growth

Any dewatering associated with the tunnel will be in the deeper rockmass. Soil moisture conditions in the regolith soils or terrace deposits in the near surface are not expected to change as a consequence of dewatering the deeper rocks. We therefore assess the effects of tunnel dewatering on plant growth to be less than minor.

5. Groundwater Effect - WUG Dual Tunnel

5.1 Characterisation of Tunnel Alignment

5.1.1 Physiography

Figure 21 shows the topography above the proposed dual tunnel alignment based on the GHD ground model (August, 2020). Ridge elevations are shown to extend to over 1480 mRL with the deepest valley deepening to approximately 1150 mRL. Surface gradients along the main drive are expected to be similar to Willows Farm being up to 45 degrees in the upper slope reducing to 22 degrees in the mid slopes and flatter areas locally being less than 10 degrees.

5.1.2 Hydrology

Figure 21 shows the location of the Otahu surface water catchment. The position of the Waiharakeke Stream where the tunnel passes beneath is shown in **Figure 22**. The tunnel passes beneath the Waiharakeke Stream at a depth of 1150 m and also crosses the headwaters of a second branch of the Waiharakeke Stream and Thompson Stream and stops short of the Wharekirauponga Stream.

The upper reaches of the catchment are steep and high surface run-off is expected resulting in high stream flows during and after rainfall. Stream baseflow is expected to be mostly sourced from the shallow regolith soils, with low flows fed by rockmass discharge.

5.1.3 Soils and Geology

Surface geology mapping has been undertaken by a number of parties in past years along and around the tunnel alignment for the purpose of mineral exploration. This information, along with the published mapped geologic units, is included in the ground model prepared by GHD (August 2020) and is included as **Figure 22**. The information contained within the geologic model summarises the present level of geological knowledge along the alignment and has been used as the basis for undertaking this effects assessment.

5.1.4 Hydrogeology

There have been no intrusive groundwater investigations undertaken along the tunnel alignment prior to this assessment being prepared. This is considered justified based on the geology being similar to that at Waihi and the proposed tunnelling methodology that will ensure drainage effects are avoided or managed to be minimal. This includes sealing any high inflow zones and allowing only rockmass drainage to occur. This means any drainage effects will be localised to around the tunnel and not develop in the near surface due to the relative depth of the tunnel. Figure **23** shows a generalised hydrogeologic section along the tunnel profile.

Groundwater Levels

For the purpose of calculating groundwater inflows the groundwater elevations have been calculated with an algorithm that uses the observed vertical hydraulic gradients at Willows Farm to determine heads based on surface elevation.

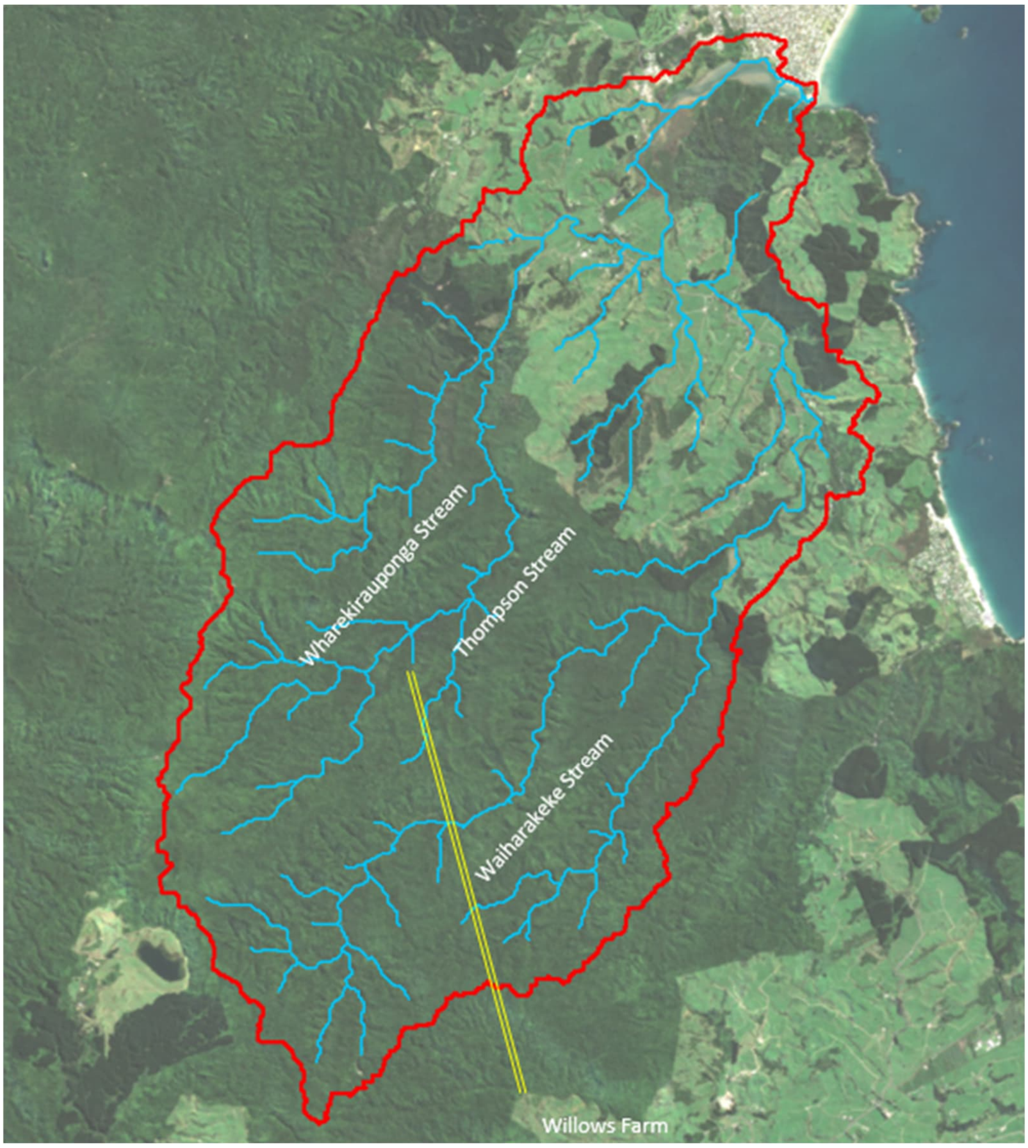

Figure 21 Otahu Surface Water Catchment Extents and Dual Tunnel Alignment

Hydraulic Gradients

The hydraulic gradients will again be influenced largely by surface topography and the location within the catchment. For the purpose of the inflow assessment, hydraulic gradients from the Willows Farm observations have been adopted in the groundwater inflow model.

Aquifer Parameters

The hydraulic conductivity of the rockmass from the groundwater inflow assessment is $2.5x10^{-8}$ m/s. This value is considered reasonable by comparison to other locations such as the Kaimai Rail tunnel. The groundwater inflow assessment actually assigns various permeability values to different geologic units as present in in **Table 6** and as described in **Attachment B** of this report.

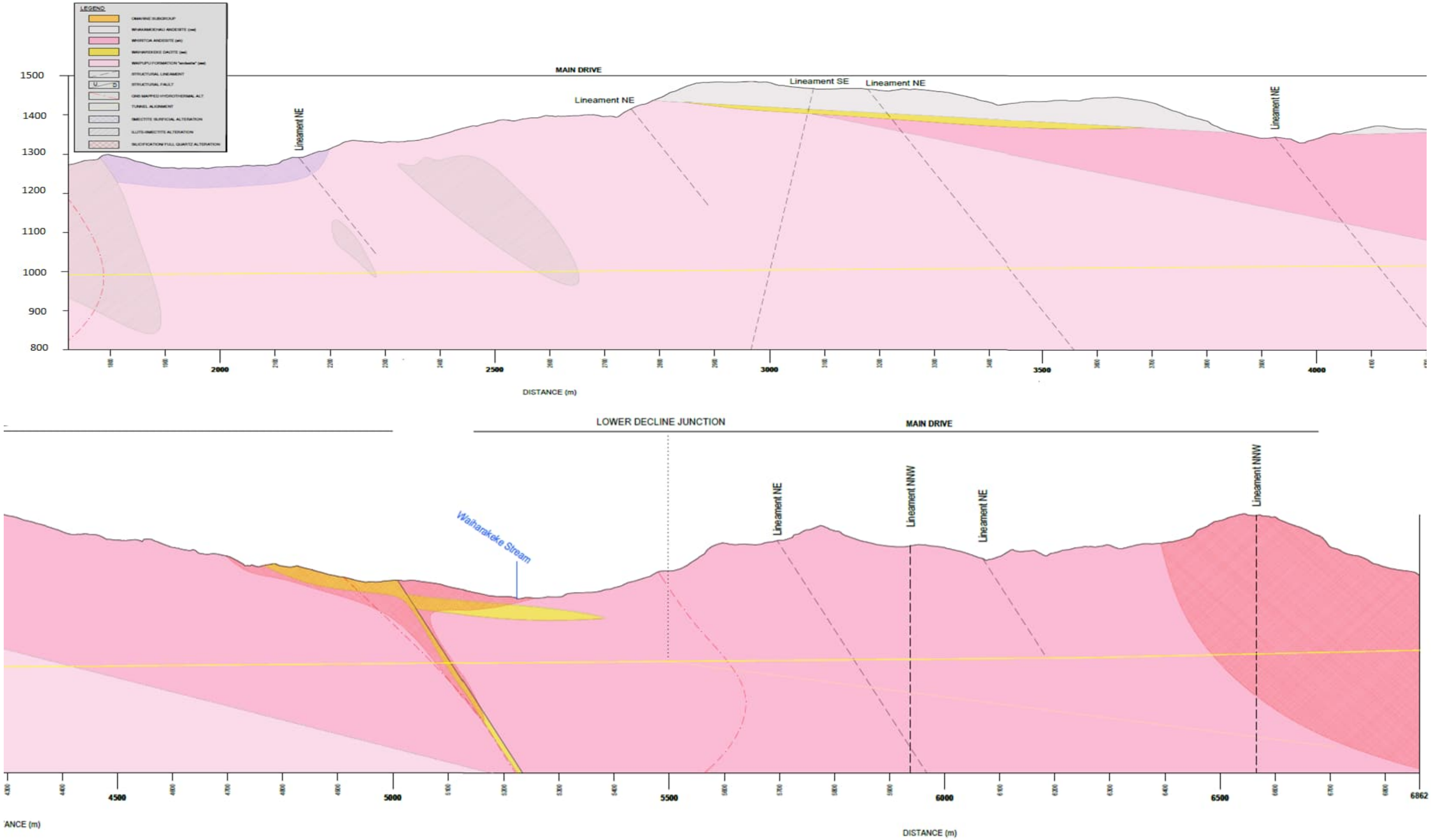

Figure 22 Topography and Geology along the Dual Tunnel Alignment (from GHD, 2022)

Table 6 Hydraulic Conductivity Values

Geologic Unit	Hydraulic Conductivity (m/s)
Andesite	2.5×10^{-8}
Clay Altered Andesite	5.0×10^{-9}
Silicified Andesite	1.0×10^{-7}
Fault Zones	1.0×10^{-5}

5.2 Conceptual Groundwater Model

The conceptual groundwater model for the dual tunnels is essentially no different to that for Willows Farm. The geology encountered is expected to be low permeability andesite rock until the location of the Waiharakeke Stream at around chainage 5,200 m. At this location the Stream bed is broadly associated with a major mapped fault zone that may act as a preferential pathway for groundwater to move through. The key risk to understand is, therefore, how much baseflow loss will occur in the Waiharakeke Stream when the tunnel passes beneath it. A conceptual groundwater model for the Willows Farm to WUG dual tunnel section is shown in **Figure 23**. Beyond the Waiharakeke Stream, low permeability andesite is again expected through to a chainage of around 6,500 m. At that point a change to rhyolite volcanics occurs which hosts the ore body.

5.3 Groundwater Effects Assessment

5.3.1 Groundwater Inflows

This assessment indicates up to 5,000 m^3/d groundwater will be taken from the Otahu catchment due to tunnel dewatering up to 5,200 m chainage (Waiharakeke Stream location). This volume includes the vent shafts inflows during construction prior to sealing them off. This volume of water does not consider mine dewatering volumes as these are included in separate reports by FloSolutions (November 2023) and Intera (September, 2024). The numerical groundwater model domain extends from the tunnel chainage at 5,200 m onwards and includes the proposed Wharekirauponga mine development. Groundwater inflows for the tunnel have been adopted from the groundwater inflow assessment included in **Attachment B**.

5.3.2 Groundwater Availability

The dual tunnel section is not within any specific aquifer management area identified by the Waikato Regional Council (i.e. not included in the Waihi Basin allocation). For the purpose of this assessment, we have assumed the entire take to be from the Otahu catchment and an assessment of groundwater availability has been determined as shown in **Table 7**. This water will be diverted to the treatment plant in Waihi and then diverted to the Ohinemuri River. Given the above, there is sufficient groundwater available for the proposed take to be granted.

Table 7 Otahu Catchment Groundwater Availability

Deep Aquifer Recharge (7% Rainfall)	11,803,750	m^3/year
Availability (35% Recharge) [a]	4,131,312	m^3/year
Existing Allocated	0	m^3/year
S14 Takes (10%)	413,131	m^3/year
Dual Tunnels [b]	1,825,000	m^3/year
Allocation Remaining	1,893,181	m^3/year
a - Deep non-coastal aquifer b – Based on 5,000 m3/d for 365 days. Excludes mine development inflows		

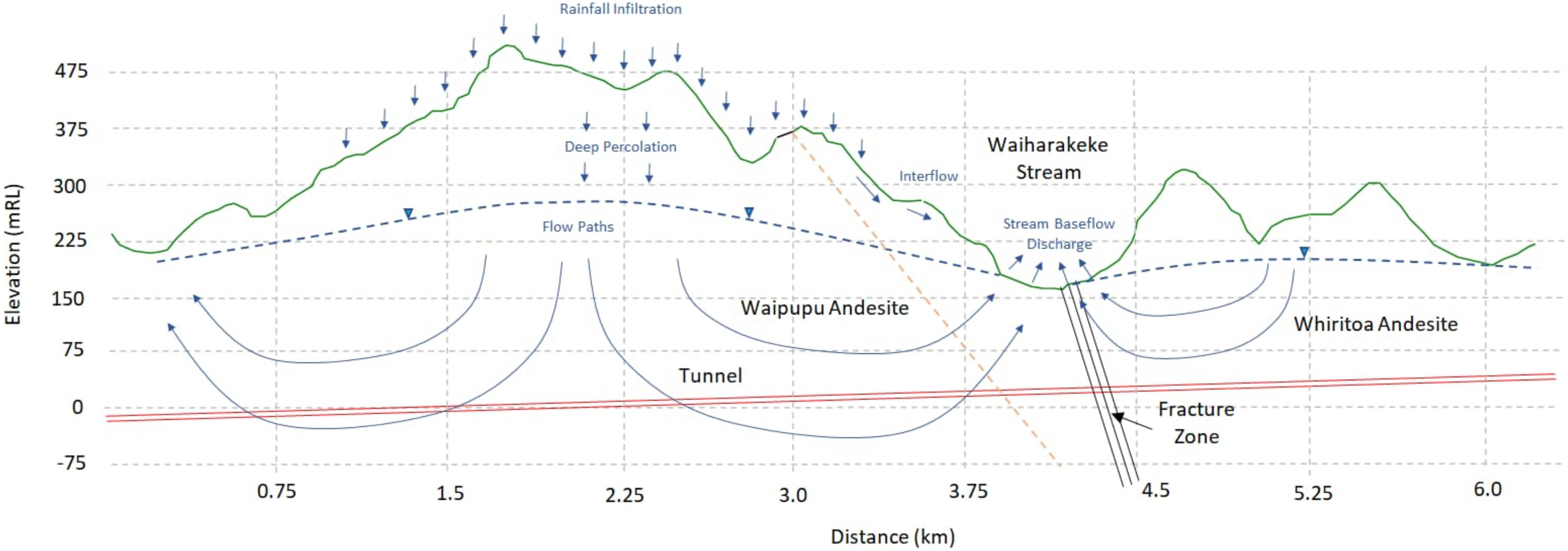

Figure 23 Conceptual Hydrogeologic Model Section Willows Farm to WUG

5.3.3 Potential for Effects on Springs and Streams

The effects of the tunnel on springs and stream flow have been undertaken using numerical modelling in SEEP/W (R2 2019). A long section was developed to enable a simulation of the tunnel passing beneath the Waiharakeke Stream to assess what stream losses might occur without mitigation being put in place. A second model section was also developed that simulates the plane of the fault to assess near surface effects. To provide a conservative assessment the models assume free draining conditions exist for 30 days before the tunnel is sealed.

The model results indicate a maximum of up to 520 m^3/d could be diverted before grout mitigation is put in place to seal off any inflows. In the context of the baseflow in the Waiharakeke Stream, this amount of stream water loss would likely be indiscernible. On this basis we assess the effects on surface water due to the construction of the tunnel to be less than minor.

5.3.4 Potential for Effects on other Groundwater Users

There are three groundwater bores in the Otahu Catchment that are >100 m deep. These bores are least 6 km from the closest point of the tunnel. Given the separation distance between the bores and the tunnel, the bores being down gradient of the tunnel, and assessing the limited extent of dewatering the tunnel causes, the effects of constructing the tunnel would not be discernible in the bores. For these reasons we assess the potential effects on other users to be less than minor.

5.3.5 Potential for Effects on Aquifers

The groundwater diversion will be from the Waipupu and Whiritoa volcanic rocks that will be intercepted along the length of the tunnel alignment. The tunnel section will be perpendicular to the main direction of groundwater flow in the catchment and will intercept some flow paths locally but will not affect the overall flow regime. Taking groundwater from these rocks is, therefore, not expected to affect other rocks nor the perched regolith aquifer and we, therefore, assess the potential effects on shallow aquifers to be less than minor.

The vent shaft will be similar to a large diameter bore hole that will be continuously lined to prevent the ingress of groundwater. During construction there will be some localised drawdown of the groundwater system around the shaft. Following construction of the shaft the groundwater system will return to its previous state. The shaft will be constructed entirely within the Waipupu and Whiritoa volcanic rocks that constitutes one aquifer system. Construction of the shaft will not, therefore, result in the mixing of previously isolated aquifers and we assess the potential effects on other aquifers from construction of the vent shaft to be less than minor.

5.3.6 Potential for Effects on Groundwater or Surface Water Quality

During tunnel dewatering there will be no consequential change in groundwater quality due to the water take. Groundwater will seep into the tunnel at a low rate, with cement grouting reducing localised inflows. The groundwater that flows into the tunnel will be pumped back to the treatment plant in Waihi and discharged to the Ohinemuri River in accordance with the consents held for that discharge.

Once the tunnel is no longer required rewatering will occur and the groundwater system will return to its previous state. Some groundwater will come into contact with the cement grout and backfilled wasterock, however this is not expected to change the overall quality in the aquifer due to the limited contact area relative to the system throughflow. This statement is similarly applicable to the vent shaft following construction. In summary, no adverse effects on groundwater quality are expected from the tunnel.

Given the limited connections between groundwater and surface waters, and the lack of expected effects on groundwater, the effects on surface water quality is similarly expected also to be negligible.

5.3.7 Potential for Saline Intrusion

The dual tunnels are 7.5 km from the ocean, which is too far for any effect to develop. For this reason, we assess the potential for saline intrusion to occur to be less than minor.

5.3.8 Potential for Ground Settlement Effects

For the majority of the tunnel alignment the tunnel is constructed in relatively incompressible materials. There is the potential for the drive to intercept hydrothermally altered rock that has been reduced to clay. Further, there may be weathered zones within the volcanic rocks that have formed silty clay soils. Given the nature of these materials, they would have properties that allow consolidation to occur if dewatered. It is, however, expected that these materials will be of low permeability and would not readily dewater, particularly in the timeframe within which mitigation within the tunnel would be put in place. Overall, we do not expect there to be long term drainage that could result in dewatering and therefore settlement. The primary rockmass being dewatered is the Rhyolite body and this is a hard, incompressible medium and is not expected to consolidate significantly as a result of dewatering. This has been assessed in detail in the EGL (WAI-985-000-REP-LC-0050) report.

5.3.9 Effects on Plant Growth

Any dewatering associated with the tunnel will be in the lower rockmass. Soil moisture conditions in the regolith in the near surface layers are not expected to change as a consequence of dewatering at depth. We therefore assess the effects of tunnel dewatering on plant growth to be less than minor.

6. Recommendations

6.1 Discussion

This assessment of effects has shown there to be minimal risk to shallow groundwater, surface waters, other groundwater users, and plant growth from the proposed WNP tunnels. The depth of the tunnelling and low permeability of the surrounding rockmass means any surface expression will not be discernible. Where more permeable structures are dewatered that could result in short term connections back to the surface, tunnel inflows will be mitigated such that the effect is negligible. This will be achieved through grouting to prevent groundwater ingress. These features would be identified in advance of tunnelling by probe drilling and would either be grouted in advance of the tunnel being driven or within a few days of the feature being exposed in the tunnel. This means that effects on groundwater associated with the tunnelling, if any, will be short lived. At locations where the tunnel alignment is shallow and effects on surface waters or other groundwater users are potentially possible, appropriate monitoring would be conducted to ensure any observed response is within the predictions made in this assessment and mitigation applied if this proves necessary.

6.2 Recommendations for Monitoring

6.2.1 WUG Access Tunnel

There are two locations along the WUG access tunnel alignment where groundwater monitoring should be undertaken. The first is around the decline from the WTP where the near surface connection exists. Existing monitoring suggests the shallow groundwater system is already dewatered locally and conditions are unlikely to change significantly as a result of the tunnel construction. We, therefore, recommend monitoring of groundwater levels using the existing network of wells to ensure no significant changes develop that are not expected. The monitoring wells P62, P63, P64 and P78 are sufficient to monitor for potential effects.

There are some groundwater bores within proximity to the tunnel and these bores take groundwater from a similar depth to the WUG access tunnel. While it is unlikely these will be affected by the proposed tunnel, it would be prudent to monitor groundwater levels in the area as the tunnel is being driven. This could be done using the water bores as observation points, wells in the existing monitoring network or though purpose-built piezometers e.g. on SH25.

6.2.2 Willows Access Tunnel

The Willows Farm access tunnel decline intercepts the shallow groundwater system and, because of this, there is some potential for effects on surface waters by temporarily reducing baseflow. For this reason, it is recommended that monitoring of shallow groundwater levels is undertaken adjacent to the stream during the initial tunnel development to ensure no lowering effects are observed. The existing monitoring network is considered suitable for this purpose, however, some additional wells may need to be installed to improve the adequacy of the network locally.

6.2.3 WUG Dual Tunnels

The tunnel alignment from Willows Farm to WUG is considered low risk with respect for potential effects on groundwater. This is because the tunnel is deep with limited spatial dewatering expected in the rockmass and mitigation will be employed to minimise connections to the surface and therefore surface waters. Given these factors, no shallow groundwater monitoring along this section of the tunnel alignment (beneath DOC administered land) is considered necessary nor is proposed. Groundwater and surface water monitoring is proposed at the WUG orebody itself which is the subject of a separate report.

7. References

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Intera Geosciences Pty Ltd. September 2024. Groundwater Modelling for the OGC Waihi Project: Predictive Uncertainty Quantification.

8. Limitations

This document has been prepared by WWLA solely for the benefit of Oceana Gold New Zealand Limited. It has been prepared on the basis of the instructions or brief given to WWLA by Oceana Gold New Zealand Limited. This document may contain confidential material, data or opinions which may not be used for any other purposes or in other contexts without the expressed permission of WWLA.

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.

Appendix A Ground Models

19 August 2020

Rory McNeil
Project Manager
OceanaGold Limited

Our ref: 125/336/58

Your ref:

Dear Rory

WUG Dual Tunnel - Water Assessment
Conceptual Geological Model Data Report: August 2020

1 Introduction

1.1 General

GHD Limited have been commissioned by OceanaGold New Zealand Limited (OGL) to provide a preliminary Conceptual Geological Site Model (CSM) for the proposed underground exploration tunnel from a tunnel portal located on the Willows Farm block directly north of Waihi township, extending northward for approximately 7 km to terminate underground in the vicinity of the Wharekirauponga (WKP) Stream (referred to as the WKP Tunnel). The development of a CSM is required to provide an initial interpretation of the ground conditions along the alignment of the tunnel to support both the surface water and groundwater assessments of effects associated with the proposed WKP Tunnel.

1.2 Scope of Conceptual Geological Site Model

The scope of the CSM was to develop a high level geological model. Due to a limited amount of engineering geological subsurface data, no interpretation of engineering geological conditions has been completed at this time. The model has been developed for the following end-use requirements:

- To support high level 2D groundwater modelling by others (GWS): along tunnel alignment
- To support high level surface water and surface water geochemistry modelling

As such, the following features have been given focus:

- Significant faults / lineaments that are identifiable from surface mapping – likely to locally effect subsurface permeability's and hydrothermal alteration/mineralisation
- Known rock-water hydrothermal alteration zones, with focus given to those that have an effect of groundwater permeability values (argillite sequences and silicification/quartz replacement).

1.3 Data Sources

1.3.1 Used data

The development of the ground model has made use of the following data sources:

- 1:50,000 GNS Geological Map “Geology of the Waihi Area, map 21, 1996”
- Historical Aerial Photographs (1940’s and 1960’s, 1:16,000 set (GHD Sourced)
- LiDAR generated Digital Elevation Model, 0.1 m vertical resolution (OGL sourced)
    - Rendering of hill shade and topographic contour sets by GHD
- Geochemical surface field mapping shape files, corresponding alteration halos (OGL sourced)
    - Simplification of data into broader regions of alteration by GHD
- Proposed route alignment (OGL supplied)

1.3.2 Unused Data

Data made available to GHD that has not been used for the development of the CSM is as follows:

- Window Sample 005 and 006 boreholes (OGL supplied)
    - Referred to for general interpretation of ground conditions. To be included within future developments of geological model when made into a 3D dataset.
- CSMAT survey lines (OGL Supplied)
    - Referred to for general interpretation of ground conditions and presence of faulting however seen as being located too far west, south and east of the proposed site to be extrapolated reliably.

1.4 Datum and Scale

1.4.1 Datum

The data supplied to GHD from OGL has been recorded to the following projection and datum. GHD has produced the CSM to the same datum and projection:

- Map Projection: New Zealand Map Grid (NZMG)
- Datum: New Zealand 1949

1.4.2 Scale

Surface Maps

The topographic scale shown on the maps (see section 1.6 below) is 1:8,000.

The lithological data shown on the maps is based off the 1:50,000 scale mapping undertaken by GNS (see section 1.3.1 for map reference).

Tunnel Long Section

The scale on the tunnel long-section (see section 1.6) is 1:2,500.

1.5 Assumptions and Interpretations

The following geological assumptions and interpretations have been made during the development of the CSM:

- Mapped structural features (faults, lineaments) have been classified per the orientation of their trend line.

- North-east orientated faults or lineaments represent extensional/normal displacements (where displacement is inferred) and generally dip to the north-northwest. This inference is made based on general knowledge of the structural relationships of the region, as well as various anecdotal level conversations with the OGL and supporting consultants.
    - Dip has been set at 60°
- South-east, east-west and north-north-west (i.e. south-south-east) orientated lineaments have been inferred to dip vertically/ near vertically. This is under the presumption that the local stress field within the region would see these orientations typically comprising more strike-slip displacement as opposed to extensional displacement.
- Faults or lineaments with surface exposures that project further than several hundred meters across the ground have been inferred to extend to significant depths and therefore have been extrapolated to the boundaries of the long-section. Where this is not the case, the lineaments have been extended a nominal 200 – 250 m depth below ground.
- Lithologies shown on the CSM are taken directly from the 1:50,000 GNS Waihi area map with the following simplifications made:
    - Tauranga Group and Whitianga Group Deposits that outcrop at the southern end of the map series have been grouped into a single unit
    - Ryolite and tuff eruptive sequences outcropping at the northern end of the map series have been grouped into a single unit, “Coroglen Subgroup”
- Standard relative stratigraphical relationships have been observed for the lithology shown, based on the ageing data for the various units presented by the 1:50,000 GNS Waihi area map
- Geochemical surface mapping data supplied by OGl has been simplified to show only the significant argillic alteration zones, and zones were strong quartz replacement (silicification) has been recorded.
    - The relatively large halos of smectite alteration have been assumed to represent predominantly surficial weathering processes however this is unconfirmed. As such, the projection of this zone within the long-section remains shallow.
    - Illite-smectite and silification mapped zones have been inferred to be more directly controlled by subsurface hydrothermal upwelling’s (based on typical hydrothermal epithermal mineral assemblages known for the Waihi region), and as such to be fault-controlled. Accordingly, they have been projected below ground to be orientated to the dominant structural fabric (NE orientated, NW dipping).
    - Some extrapolation and inclusion of geochemical alteration zones has been made by GHD based on interpretation of surface features identifiable from review of historical aerial photographs).
- The lithological contact and distinction between Waipupu Formation Andesite and Whiritoa Andesite has been extended from the interpretation of thse units per the mapped 1:50,000 GNS Waihi geology. In reality, we expect these two units to be largely monolithic.

1.6 Output

The CSM is given is presented in the following outputs:

- Surface 1:8000 scale Geological Map Series
- 1:2500 scale 2D tunnel long-section (project looking west)

GHD is able to provide, on request and at the permission of OGL, the following supporting data:

- Shape files and map files associated with all geological features shown on the above outputs

1.7 Limitations

This report has been prepared by GHD Limited for OceanaGold New Zealand Limited and may only be used and relied on by For OceanaGold New Zealand Limited for the purpose agreed between GHD and For OceanaGold New Zealand Limited as set out in Section 1.0 of this report.

GHD otherwise disclaims responsibility to any person other than for OceanaGold New Zealand Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The development the CSM has been based on interpretations and processing of the data provided to GHD by OGL, and supplementary data sourced directly by GHD (see section 1.3). A brief walkover of the Willows Farm site where the portal is located was made. No site specific field mapping or subsurface investigations have been conducted to support the development of the CSM, at this time. The interpretations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD has prepared this report on the basis of information provided by OceanaGold New Zealand Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

An understanding of the geological site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experienced based. Hence this report should not be altered, amended, abbreviated, or issued in part in any way without prior written approval by GHD. GHD does not accept liability in connection with the issuing of an unapproved or modified version of this report.

The interpretations made in this report and attached CSM are intended to support high level groundwater and surface water modelling. The level of technical detail shown is correspondingly low. As such, reliance of the CSM in its current form should not be relied on for tasks that extend beyond the above stated.

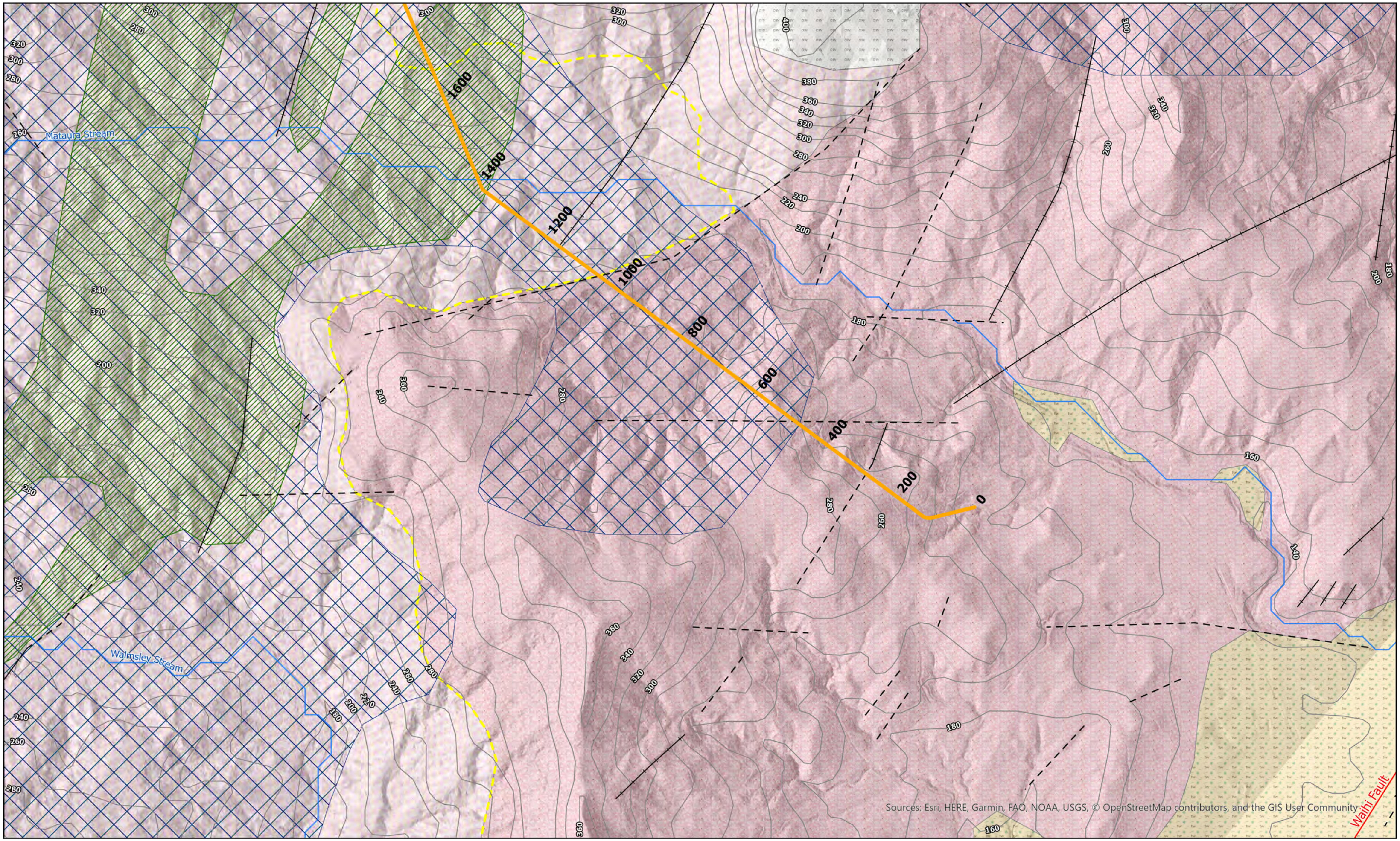
Sincerely
GHD Limited

Nick Burke
Senior Engineering Geologist

Nick Eldred
Principal Engineering Geologist

<u>Attachments:</u>

- **Geological Map Series**
- **Geological Long-Section (Tunnel)**



Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

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Map Projection: New Zealand Map Grid
Horizontal Datum: New Zealand 1949
Grid: GD 1949 New Zealand Map Grid

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LEGEND

GNS 1:50k geological lithological units

▨	Tauranga Group and Whitianga Group
▨	Ratarua Ignimbrite: Welded, dacitic ignimbrite
▨	Whakamoehau Andesite: Andesite and dacite with minor quartz phenocrysts. Andesite tuff breccias
▨	Whiritoa Andesite : Phyric andesite and dacite flows and domes with tuff-breccias and lithic crystal tuff
▨	Waipupu Formation : Andesite and dacite, locally with quartz phenocrysts. Minor tuff breccia, crystal tuff and lacustrine sediments

Geologic features

—	Fault
- -	Inferred liniament
—+—	Liniament
▨	GNS-mapped hydrothermal alteration zone
—	Watercourse
—	OGL tunnel centreline

OGL-mapped and GHD-inferred surface hydrothermal alteration

▨	Argilite Alt - Illite / Illite, Smectite
☐	Argilite Alt - Smectite Surficial
▨	Quartz Alt / Silicification

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WKP Exploration Tunnel -
Water Assessment

Conceptual Engineering Geological Model

Job Number	125336958
Revision	0
Date	19 Aug 2020

Figure 1
Page 1 of 5

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Data source: ESRI: World topographic Map and World Hillshade; Oceanea Gold: DEMs (20190503); GNS: 1:50k 1996 Waihi Area map, pdf; Waikato Regional Council: REC named watercourses (20200715); LINZ: 1:50k contours (20200721); GHD: tunnel diagram (20200715) Created by:nrama

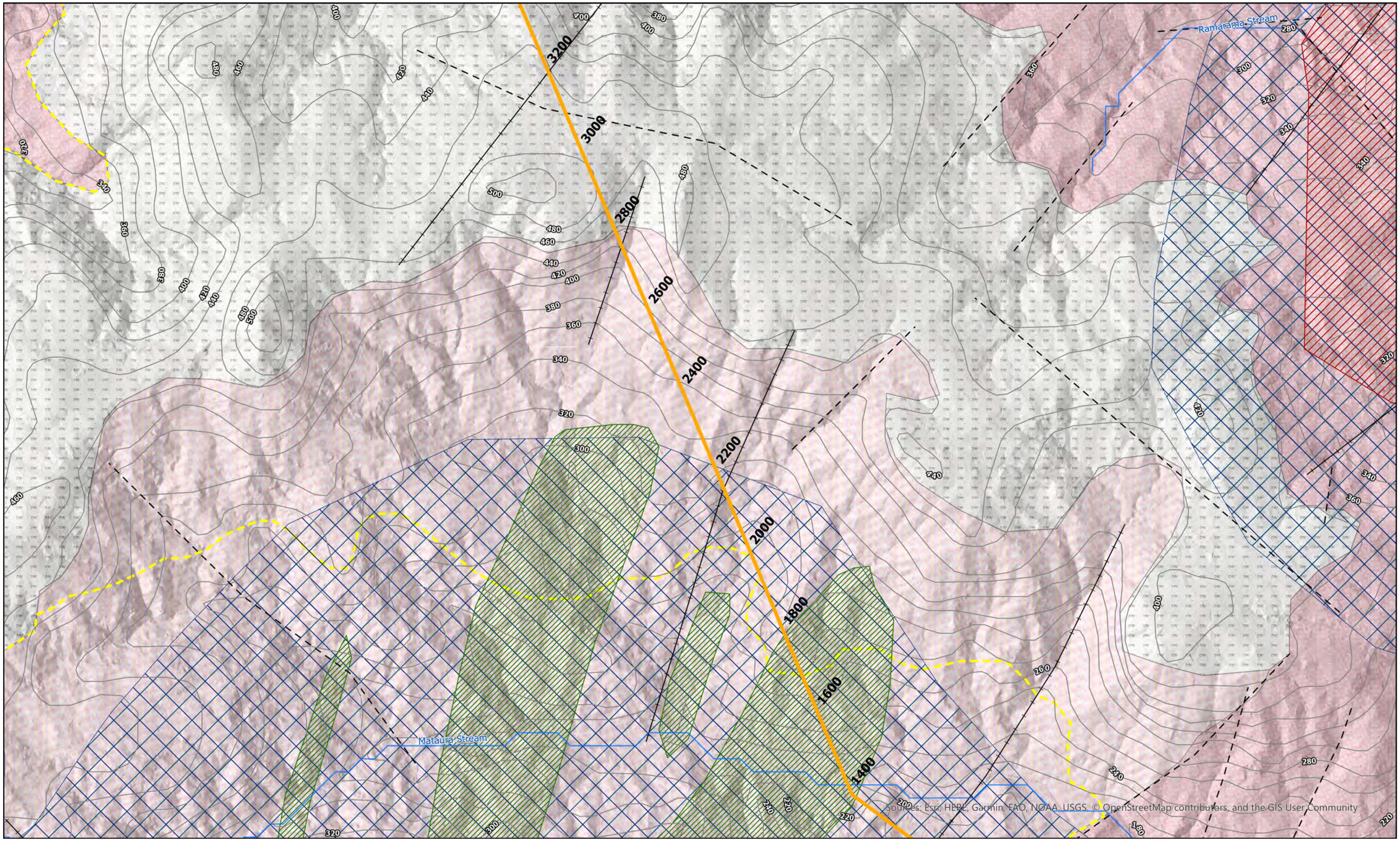

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Figure 1
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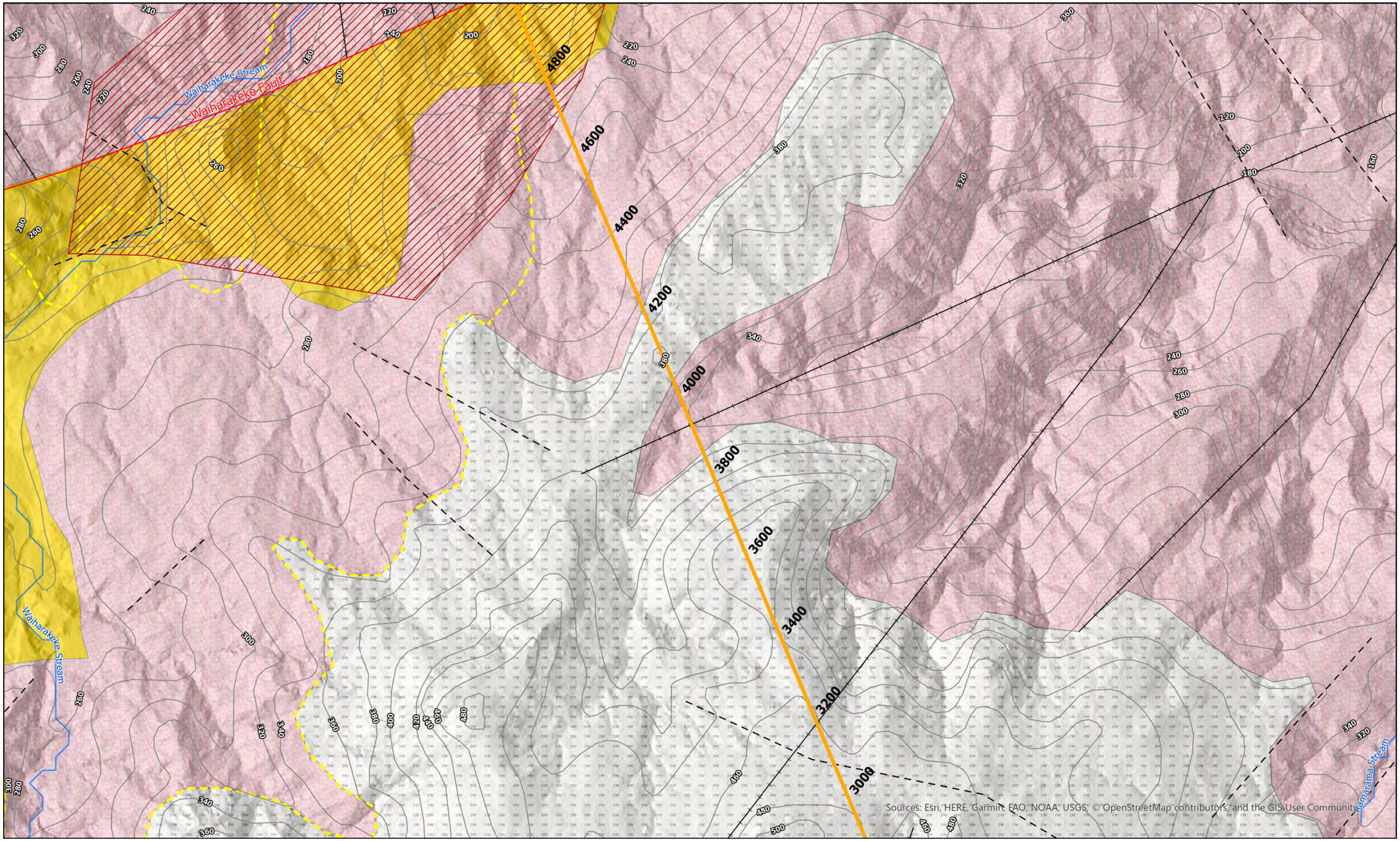

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- 🟨 Waiharakeke Dacite : Dacite flows, tuff breccia and minor tuff. Local intercalated rhyolite flows and tuffs

Geologic features

- Fault
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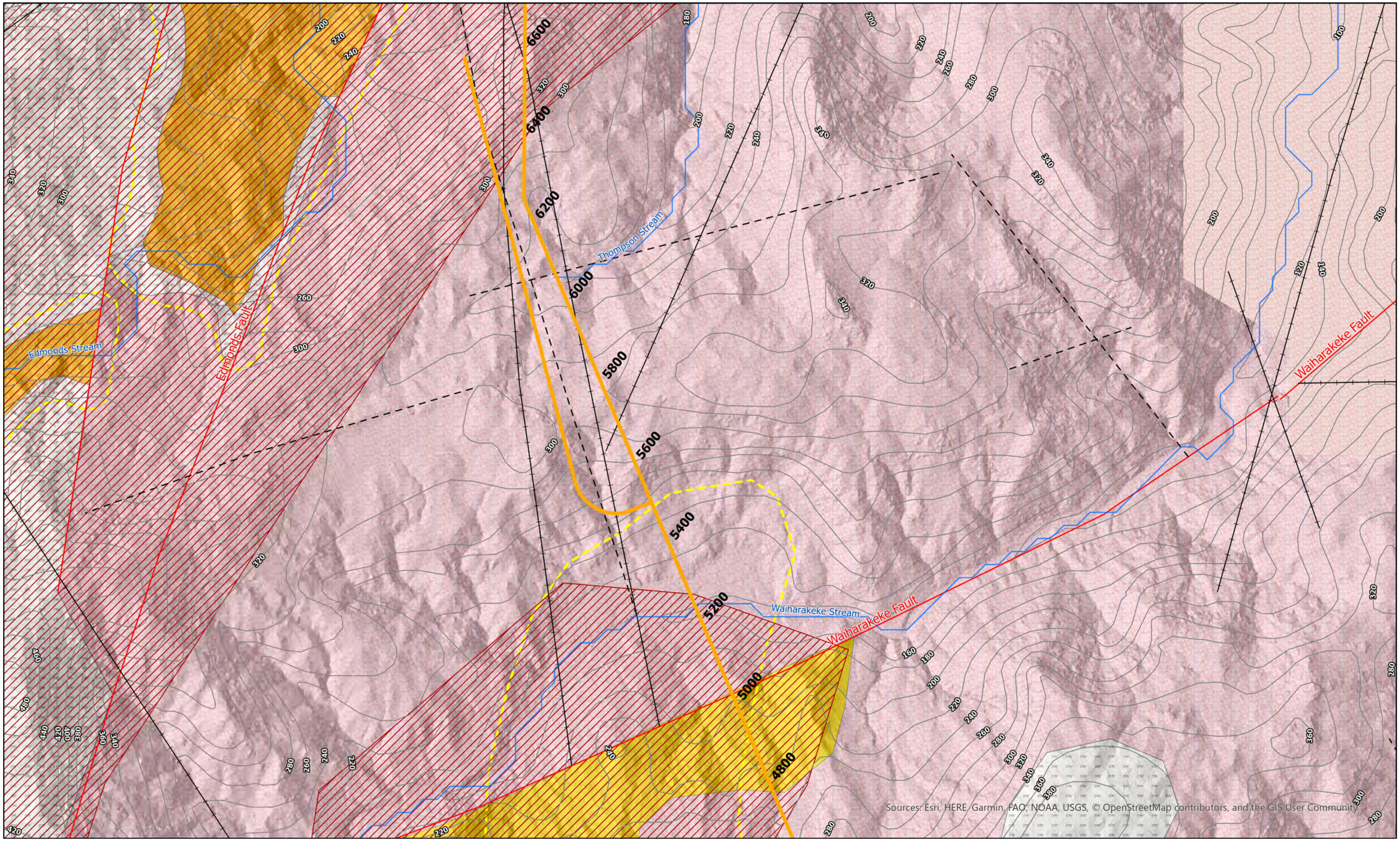

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- Coroglen Subgroup : Rhyolitic tuff - crystal, lithic and lapille tuff
- Waiharakeke Dacite : Dacite flows, tuff breccia and minor tuff. Local intercalated rhyolite flows and tuffs

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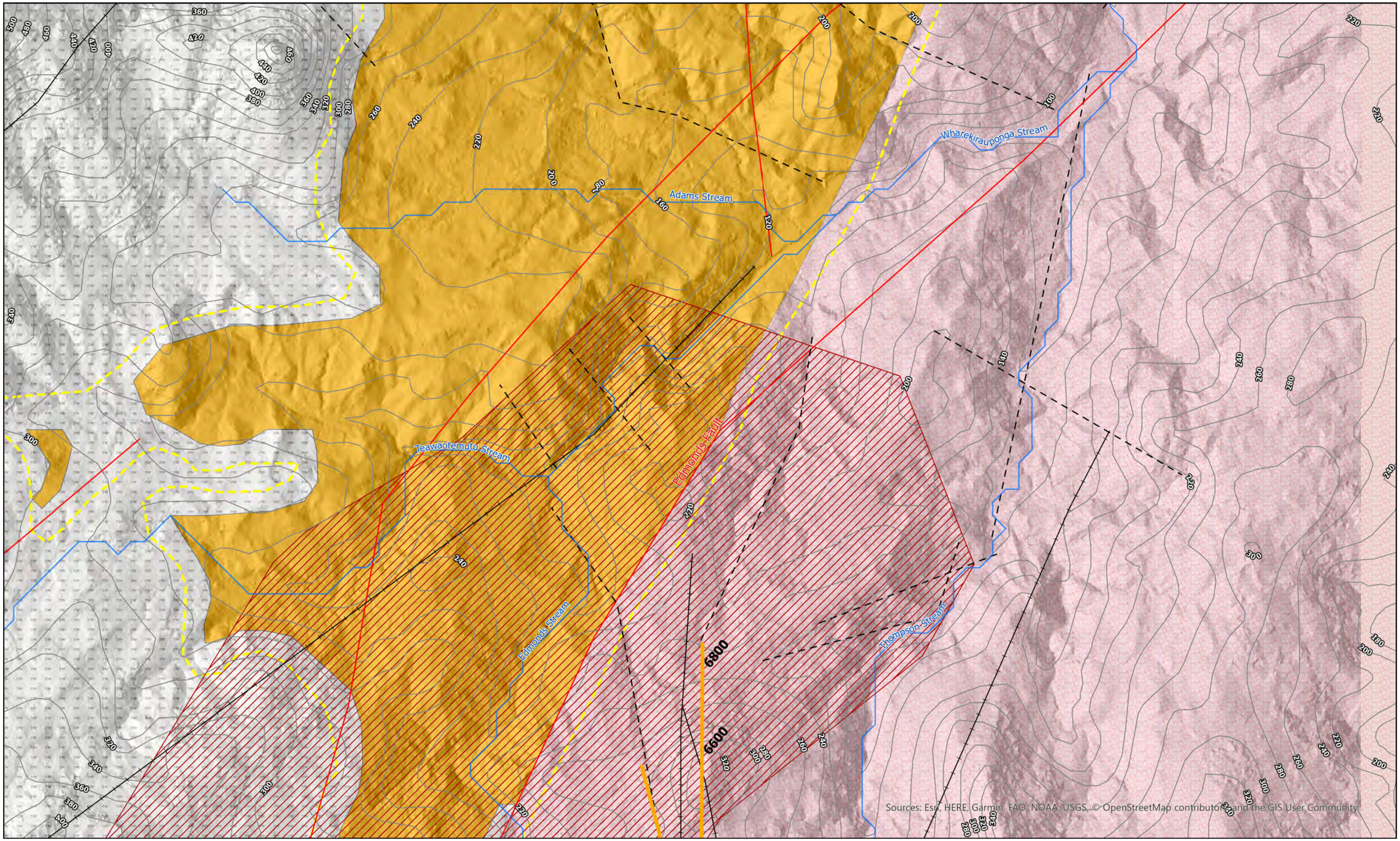

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Figure 1

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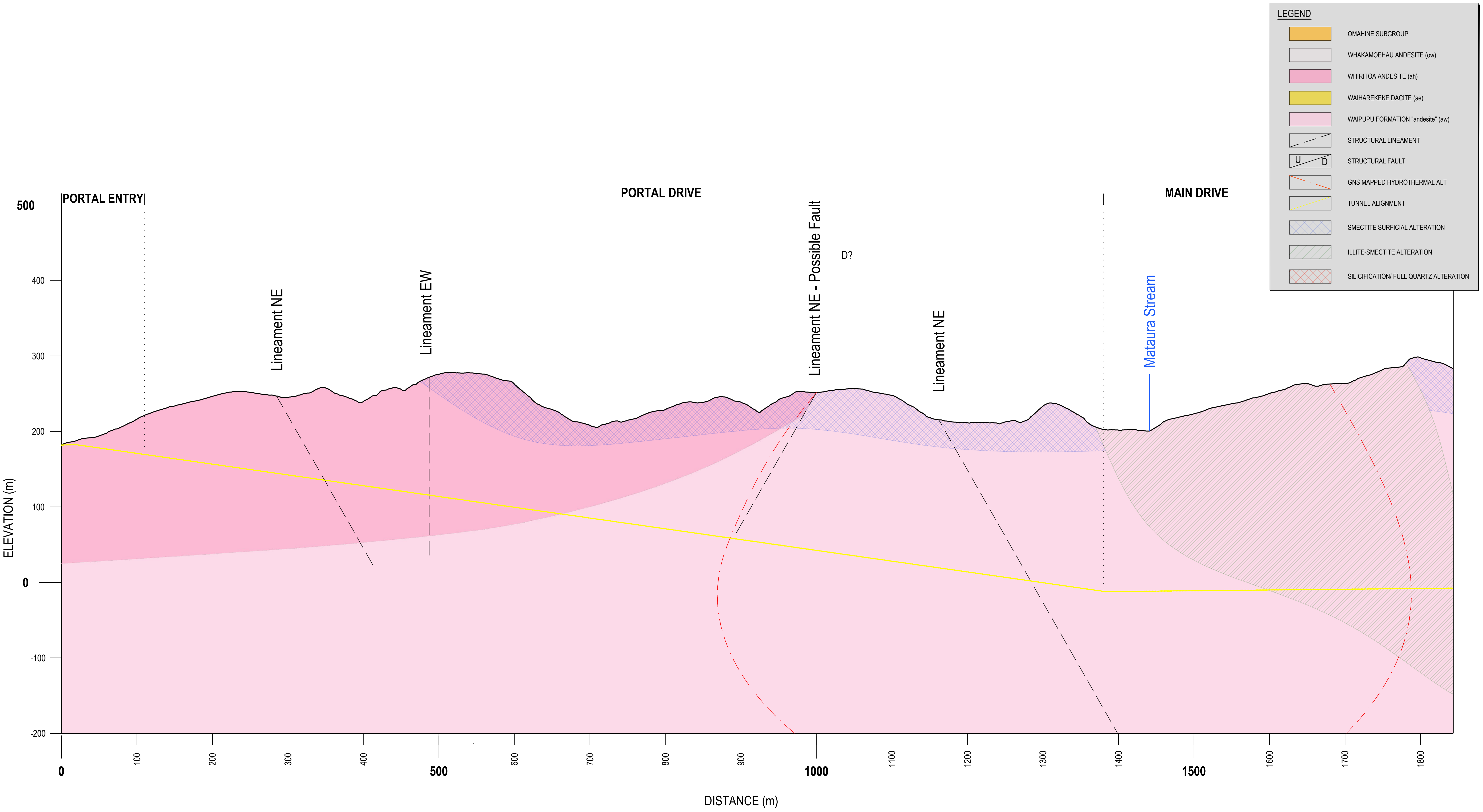
Data source: ESRI: World topographic Map and World Hillshade; Oceanea Gold: DEMs (20190503); GNS: 1:50k 1996 Waihi Area map, pdf; Waikato Regional Council: REC named watercourses (20200715); LINZ: 1:50k contours (20200721); GHD: tunnel diagram (20200715) Created by:nrama



LONGSECTION 1 - CH 0 TO CH 1844

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SCALE 1:2500 AT ORIGINAL SIZE

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Project **WKP EXPLORATION TUNNEL - WATER ASSESSMENT**
Title **CONCEPTUAL GEOLOGICAL LONGSECTION DRAFT 17082020**

Original Size **A1** **Drawing No: Q001** **Rev: A**

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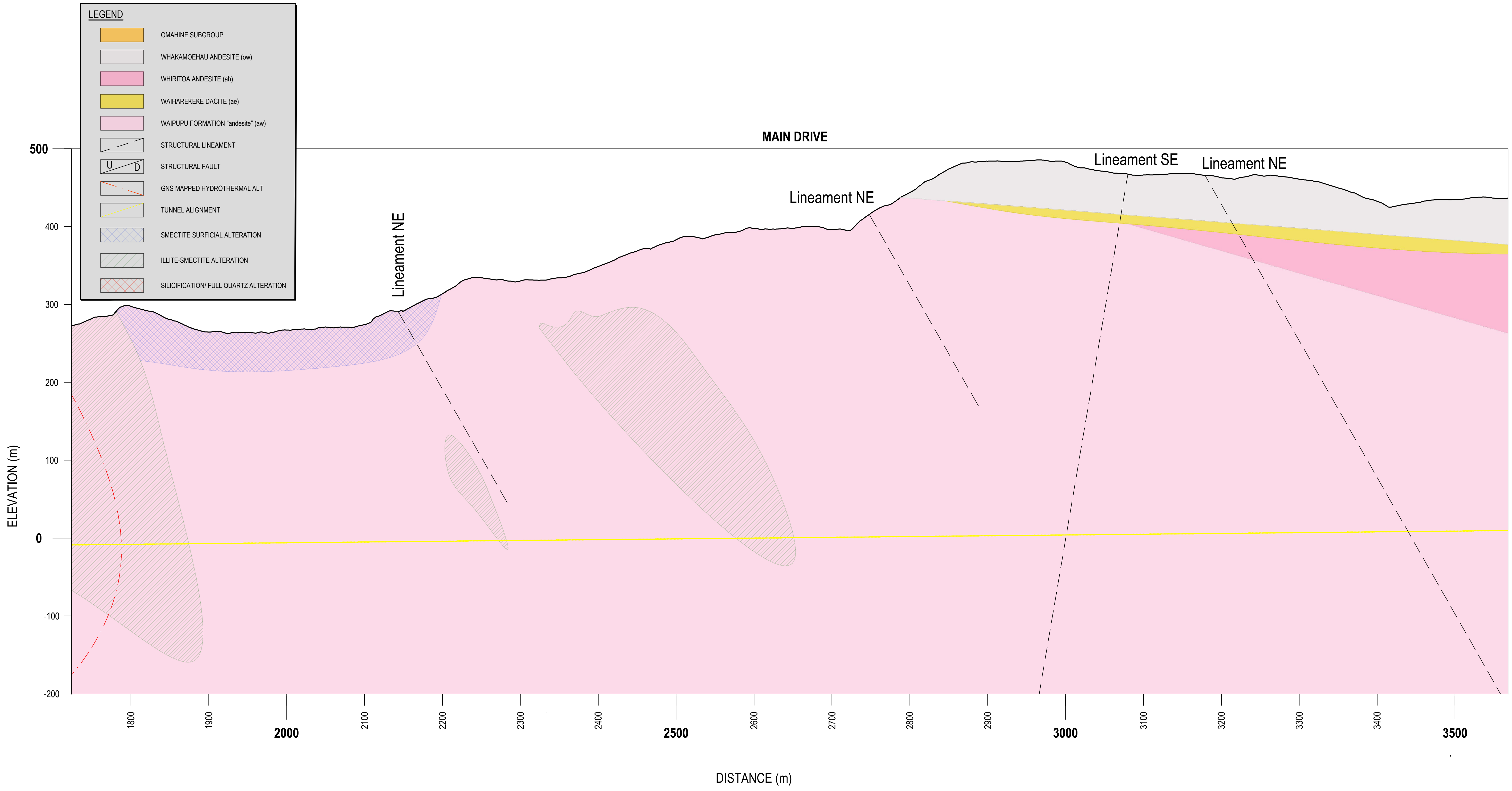

LONGSECTION 2 - CH 1723 TO CH 3567

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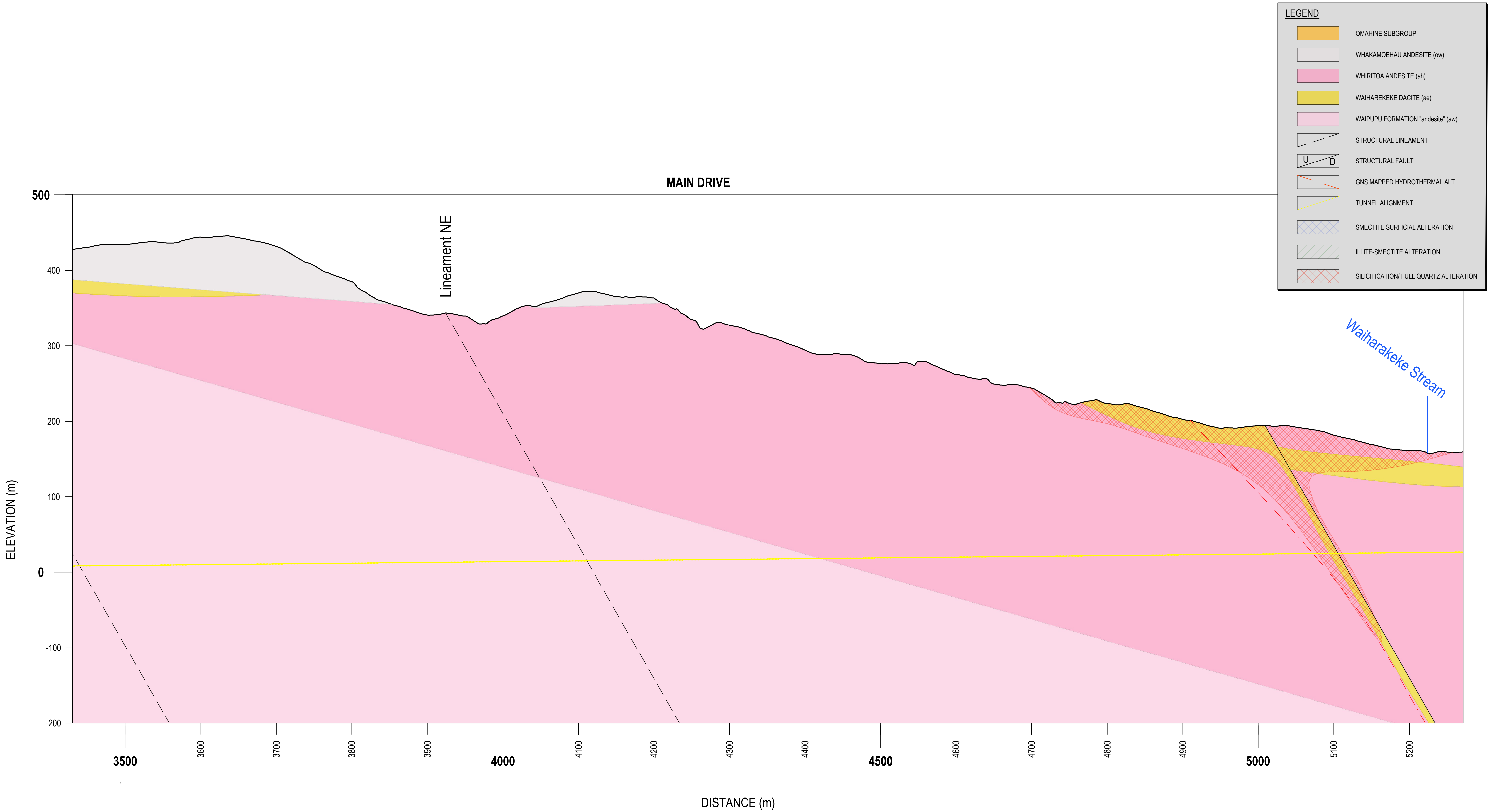

LONGSECTION 3 - CH 3430 TO CH 5271

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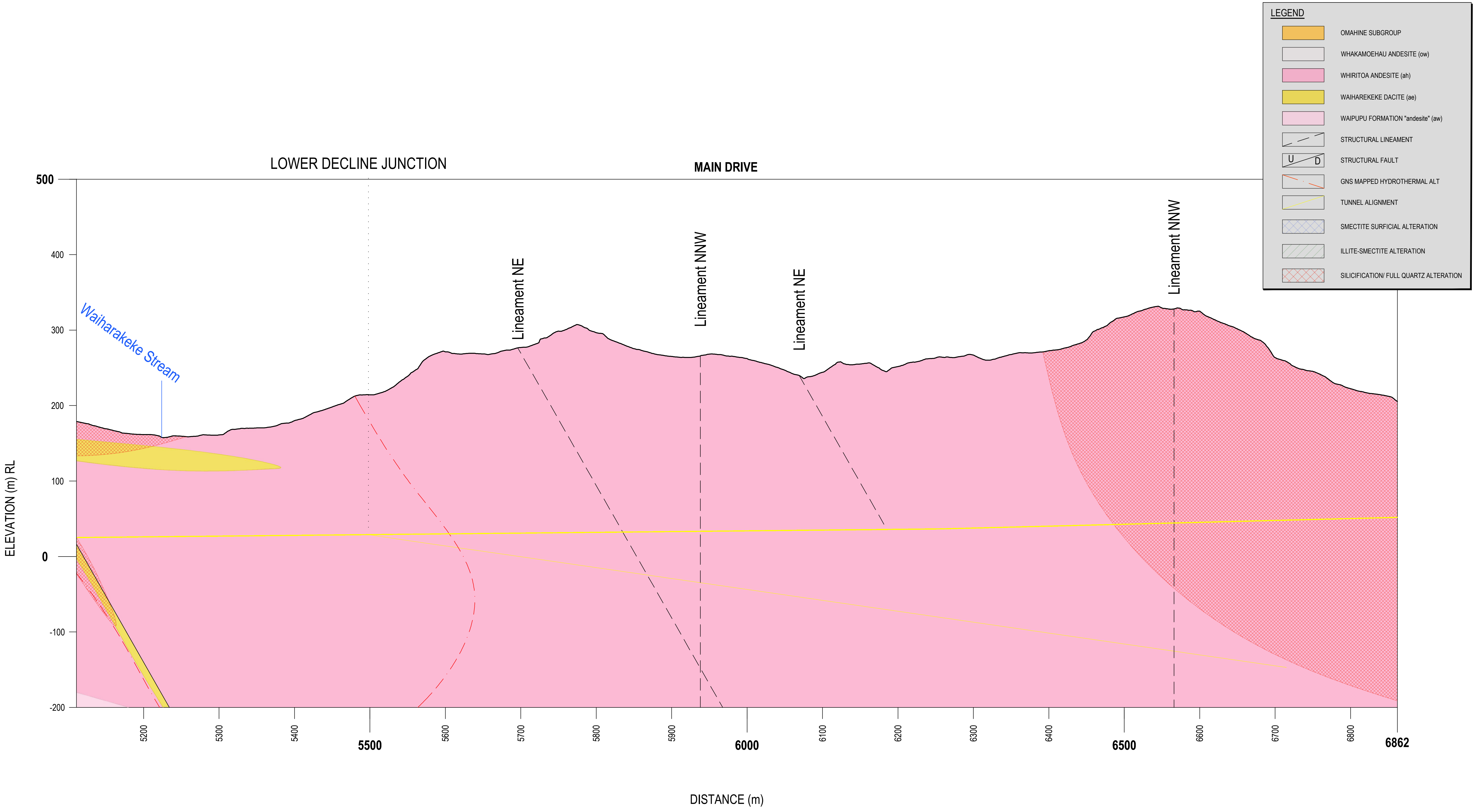

LONGSECTION 4 - CH 5112 TO CH 6862

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MEMBER OF WSP

08 September 2021

Reference No. 20148384_7407-012-LR-RevA_DRAFT

Rory McNeill
OceanaGold Corporation
Level 3, 99 Melbourne Street
South Brisbane
QLD 4101
Australia

WAIHI NORTH PROJECT: REVIEW OF EXISTING GEOLOGICAL INFORMATION FOR PROPOSED TUNNEL FROM WAIHI POLISHING PONDS PORTAL TO WILLOWS ROAD FARM

Dear Rory

1.0 INTRODUCTION

Golder Associates (NZ) Limited (Golder) has prepared this letter report[1] at the request of OceanaGold Corporation (OceanaGold) addressing the expected geological conditions for five tunnel alignments from Waihi polishing pond site (Portal) to Willows Road Farm (Willows Connection).

The Wharekirauponga (WKP) resource is located approximately 10 km north of the township of Waihi. The WKP resource and most of the proposed exploration tunnel, which will be used to access the ore body, lie beneath Department of Conservation (DoC) land within the WKP Minerals Mining Permit (60541) area. The portal for the proposed exploration tunnel will be located on Willows Road Farm, several kilometres from the ore processing plant at Waihi. This assessment considers the likely ground conditions for a proposed tunnel extending between Willows Road Farm and Waihi, based on existing geological information provided by OceanaGold. Several tunnel alignment options that have been prepared by OceanaGold run from a portal at the Waihi polishing pond site (referred to as 'Portal' in this report), under a number of different surface landholders, to ventilation shaft 1 located on the Willows Road Farm (referred to in this report as 'Willows Connection'). The purpose of the tunnel is to allow the ore mined from WKP to be efficiently transported underground to the processing plant at Waihi instead of using surface roads from Willows Road Farm to Waihi.

This letter report has been prepared by Golder under the terms and conditions of the existing Master Consulting Agreement between OceanaGold and Golder for the WKP project (OGN-2891).

---

[1] This letter report is provided subject to the attached Report Limitations.

2.0 ALIGNMENT OPTIONS

OceanaGold has provided Golder with five tunnel alignment options for the Portal to Willows Connection (refer Figure 1). An additional tunnel alignment option was provided from Northern Portal to Willows Connection; however, it is Golder's understanding that this option is not being investigation further.

Each of the five provided plan tunnel alignments have a shallow or deep option for vertical alignment. Each alignment option takes into consideration the surface landholders, geotechnical conditions, interaction with MUG/GOP works, interaction with old workings and LOM material handling.

The five options are outlined below:

- Option 1 is a straight-line tunnel from Portal to Willows Connection, approximately 4.8 km in length. Option 1 does not consider any other planned infrastructure in the area and passes beneath several residential properties at depths of 40 – 85 m. OceanaGold has determined that Option 1 is unlikely to be considered viable due to the large number of potentially affected land owners.
- Options 2, 3 and 4 tunnel alignments, which are each approximately 5.0 km in length, take into consideration planned MUG Portal development, Favona capital development, utilise existing surface air shafts and pass beneath OceanaGold land to avoid a number of residential properties.
- Option 5 heads north-east initially to utilise OceanaGold owned land before heading towards Willows Connection. The alignment is estimated to be 5.3 km and passes beneath the Ohinemuri River on numerous occasions and runs parallel with the river for approximately 250 m; therefore, OceanaGold has determined that this option is unlikely to be viable.

Figure 1: Proposed tunnel alignment options between Waihi and Willows Connection (supplied by OceanaGold).

Based on the feedback above from OceanaGold about the various tunnel alignment options, Golder has evaluated the geological and geotechnical conditions of tunnel alignment Option 2 and Option 4.

3.0 AVAILABLE GEOLOGICAL DATA

3.1 Geological Setting

The Coromandel Peninsula, south as far as Te Aroha, and including the area around and north of Waihi, is dominated by volcanic rocks of the Coromandel Group comprising andesite, dacite and rhyolite of Miocene Age[2,3] (refer Figure 2). The geological map, Figure 2, shows that Portal and Willows Connection are founded in the Waipupu Formation, which is a phyric andesite and dacite with minor tuff breccia, crystal tuff and lacustrine sediments, extensively hydrothermally altered. The alignment options then pass under valley floor alluvium consisting of pumiceous, rhyolitic and andesite sand, gravel and silts up to the Waihi Fault. The alignment may also encounter the Whiritoa Andesite which is lithologically similar to the Waipupu Formation, but is not extensively hydrothermally altered. Basement rock in the area comprises Jurassic Age Manaia Hill Group Sandstone, siltstone and conglomerate at more than 1000 m depth below the tunnel alignment options. The Coromandel Peninsula is located on the western side of the Taupo Volcanic Zone, which is an extensional tectonic domain dominated by northeast trending normal faults of low activity.

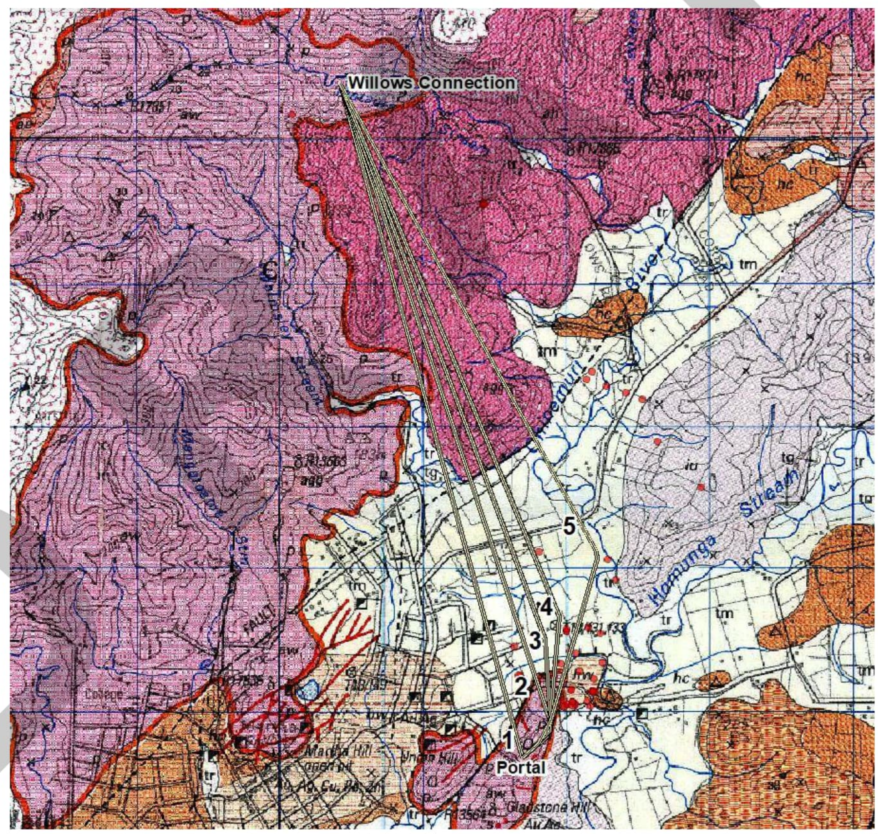

Figure 2: Waihi geological map with the proposed tunnel alignments outlined3 aw = Waipupu Formation, ah = Whiritoa Andesite and tm = alluvium, red lines = extensive hydrothermal alteration.

---

[2] Edbrooke SW, 2001, Geology of the Auckland Area, Institute of Geological and Nuclear Sciences 1:2500,000 geological map 3. 1 Map Sheet and 74-page document.

[3] Braithwaite RL, Christie AB, 1996: Geology of the Waihi area, scale 1;50,000. IGNS geological map 21.

3.2 Geomorphology

The proposed project lies at the southern end of the Coromandel Range. Most of the project area north of the Waihi Fault underlies farmland and heavily bush covered terrain comprising northeast trending ridges rising 300 to 500 m elevation and separated by incised northeast flowing streams. Slopes are typically steep. The project area south of the Waihi Fault underlies gently sloping farmland and the eastern end of the township of Waihi. The portal of the tunnel alignment options will be situated in a topographic high formed from Waipupu Formation andesite at approximately 140 m above sea level (asl). The alignment then follows beneath the terraces alluvium of the Ohinemuri River at approximately 100 to 120 m asl, then under the steep hilly terrain west of the Ohinemuri River valley, ranging between 300 and 500 m above the terraces.

3.3 Information Provided by OceanaGold

OceanaGold provided Golder with all the currently available subsurface geological data within the area of the proposed tunnel alignments. This included core logs, core photos, drilling information, imagery of the borehole locations and land parcel boundaries that the proposed tunnel alignment options will encounter.

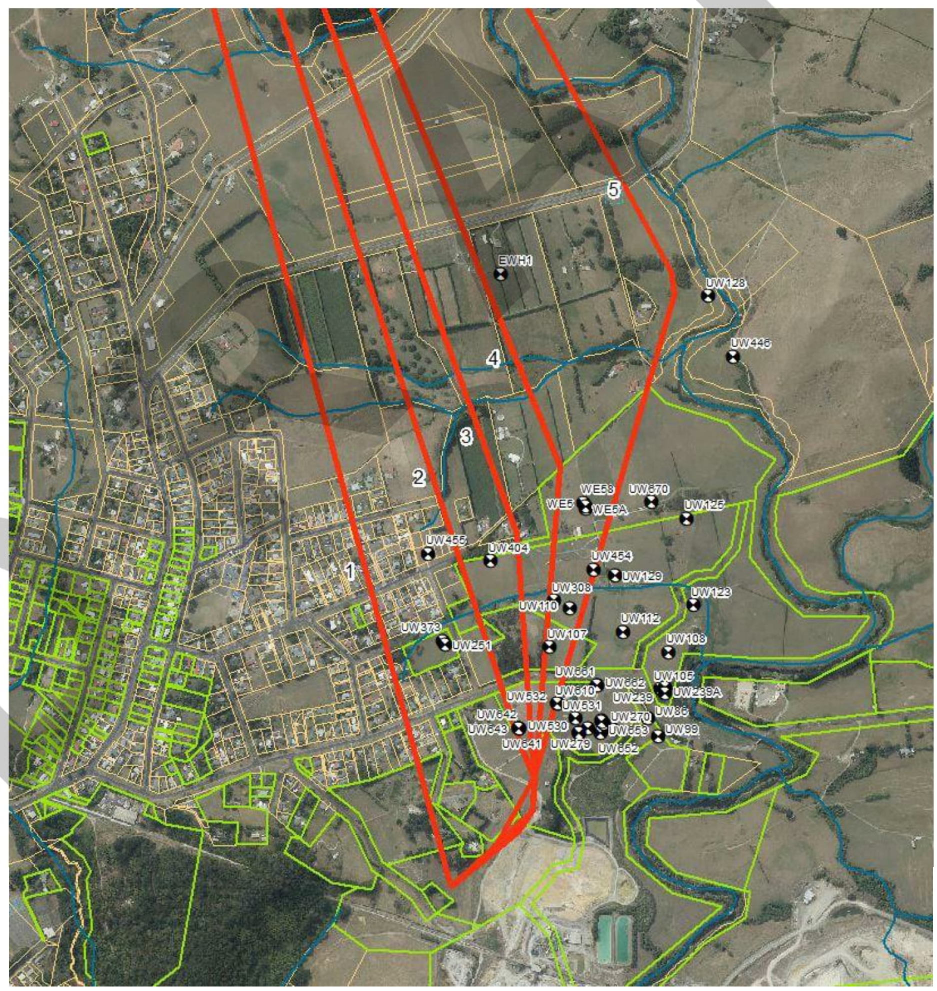

Figure 3: OceanaGold supplied borehole locations. The red lines show the prosed tunnel alignments on the land parcels. Yellow lines are the residential landowners and green lines is land owned by OceanaGold.

4.0 PRELIMINARY GEOLOGICAL MODEL BASED ON AVAILABLE INFORMATION

Conceptual geological long sections for the proposed tunnel alignments 2 and 4 are presented in Figure 4.

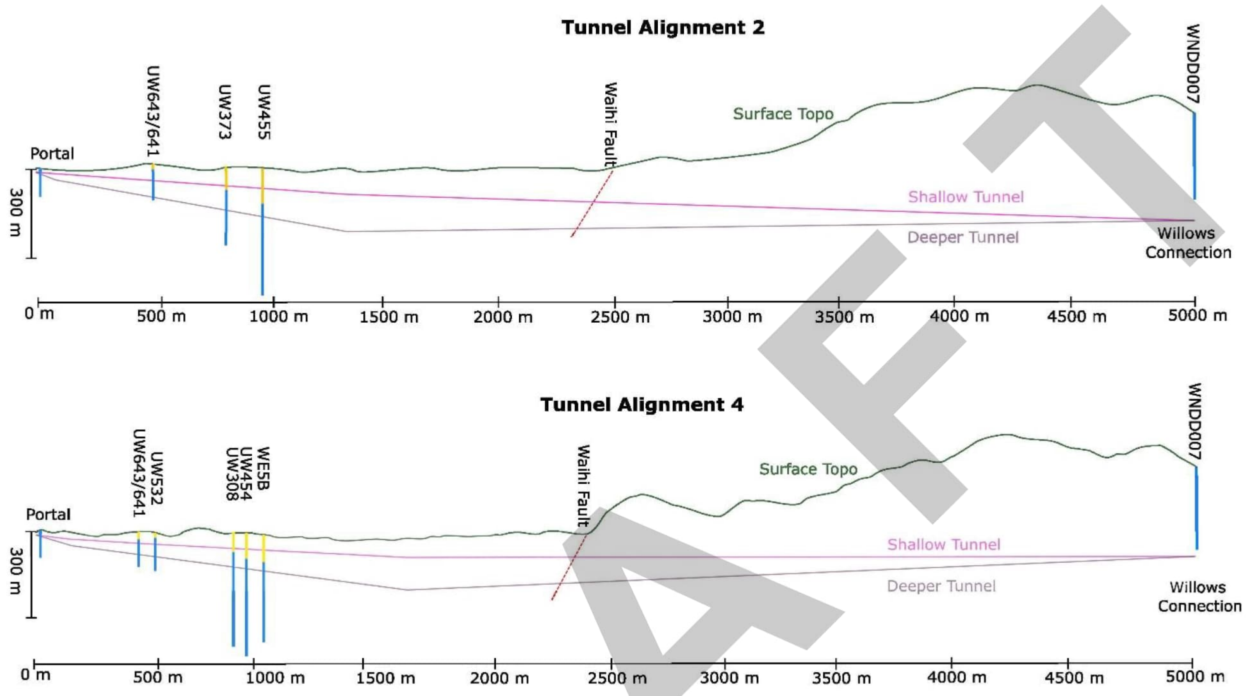

Figure 4: Conceptual geological log sections for tunnel alignment Options 2 and 4 from Portal to Willows Connection. Both long sections show the shallow and deep tunnel alignments and the geology they intercept (ignimbrite (yellow) and andesite (blue)).

Both Option 2 and Option 4 have similar distribution of the various lithological units present. A simplified description of the tunnel geology for the shallow alignments for Options 2 and 4 follows:

- The geology at the Portal consists of andesite with a surficial volcanic ash layer. With increasing distance to the northeast, they intersect sandy and welded ignimbrites[4,5].
- Once out of the portal the first 300 m of the tunnels will likely encounter ignimbrite and andesite. During this interval, several possible configurations could occur:
  - There could be single abrupt change from ignimbrite to andesite,
  - There could be several changes from ignimbrite to andesite and back,
  - There could be a prolonged mixed face situation with *the tunnel encountering both ignimbrite and* andesite.

---

[4] Engineering Geology Limited 2020. Proposed polishing pond stockpile geotechnical stability assessment. Prepared for Oceana Gold (New Zealand) Limited, dated 16 November 2020. Ref. 9094.

[5] Engineering Geology Limited 2021. Storage 1A – Tailings Storage Facility Raise to RL182 Detailed Design Report. Prepared for Oceana Gold Limited, dated 11 August 2021. Ref. 8981.

- Between 300 m to approximately 1100 m both shallow tunnel alignments would be in completely to moderately weathered rhyolitic ignimbrite that is either welded or non-welded.
- Between 1100 m and Vent Shaft 1 (Willows Connection) the shallow tunnel alignments are expected to be entirely within andesite. At about 2200 m the tunnel is expected to encounter the Waihi Fault, which may comprise a zone of highly sheared, weak ground.

A simplified description of the tunnel geology of the deeper alignments follows:

- The geology at the Portal consists of andesite with a surficial volcanic ash layer. With increasing distance to the northeast, the deep alignments intersect sandy and welded ignimbrites[6,7].
- Near the portal the alignments will transition into ignimbrite and the first 300 m will be mainly within the ignimbrite.
- Between about 300 m and 700 m the deeper tunnel alignments will transition to the underlying andesite. During this interval, several possible configurations could occur:
    - There could be single abrupt change from ignimbrite to andesite,
    - There could be several changes from ignimbrite to andesite and back,
    - There could be a prolonged mixed face situation with the tunnel encountering both ignimbrite and andesite.
- Between about 700 m and Vent Shaft 1 (Willows Connection) the deeper tunnel alignments are expected to be entirely within andesite. At about 2200 m the tunnel is expected to encounter the Waihi Fault, which may comprise a zone of highly sheared, weak ground.

The logs do not provide specific data on the geotechnical characteristics of the materials that we would use for designing tunnels. We also have useful relevant data from the Willows Road farm site to characterise the ground conditions at that end of the tunnel extension where the tunnel will likely mainly encounter weathered andesite.

In the area between the Waihi Fault and vent shaft 1 (WNDD007) elevation is increasing so hole depth of any exploratory drill holes will need to be greater to reach the tunnel alignment (up to several hundred metres). There are a few dips in elevation that we might be able to utilise to reduce hole depths.

5.0 IMPLICATIONS FOR TUNNEL DEVELOPMENT

The geological information that is currently available indicates that the tunnel alignment will encounter a suite of volcanic rocks including flows, breccias or pyroclastic materials. Based on the available drill core reviewed as part of this assessment, the layers appear to be in the order of metres to tens of metres in thickness and oriented sub-horizontal or gently inclined. The strength of the material is difficult to determine based on the available drill core information provided by OGL near the portal. We have inferred that the andesite encountered at the Willows Connection end will be either the Whiritoa Andesite or the Waipupu Formation andesite, which are inferred to comprise geotechnically similar materials. The material in WNDD007 had an

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[6] Engineering Geology Limited 2020. Proposed polishing pond stockpile geotechnical stability assessment. Prepared for Oceana Gold (New Zealand) Limited, dated 16 November 2020. Ref. 9094.

[7] Engineering Geology Limited 2021. Storage 1A – Tailings Storage Facility Raise to RL182 Detailed Design Report. Prepared for Oceana Gold Limited, dated 11 August 2021. Ref. 8981.

unconfined compressive strength of 11 MPa to 49 MPa, which is consistent with a weak to moderately strong rock.

The Waihi Fault is likely to be an east dipping normal (extensional) fault associated with local tectonic setting. Ground conditions in the vicinity of the Waihi Fault are likely to include weak materials and brecciated zones tens to hundreds of metres in width with local highly sheared clay gouge zones.

The biggest uncertainties in the geotechnical conditions along the proposed tunnel alignments will be around the geotechnical characteristics of the ignimbrite (pyroclastic material) and how much of the alignment will encounter that material. The most obvious risks relate to the potentially very low strength of this material and associated need for heavy support and the potential for high groundwater inflows.

The geological conditions described above will likely lead to mixed face conditions in some zones along the tunnel. This will occur where the tunnel face transitions between different volcanic rock units bounded by subhorizontal contacts. The position of contacts that could lead to mixed face conditions are currently unknown. The tunnelling methodology and chosen alignment will need to take into account the potential for variable strength materials and mixed face conditions.

Design of tunnel support is beyond the scope of this assessment. However, consideration will need to be given to the potentially low strength of the ignimbrites at shallow depth. It is anticipated that tunnel support will mainly comprise pattern rocks bolting and shotcrete installed as soon as practical after short excavations. Heavier support, including full shotcrete lining, with mesh and bolts will likely be required for areas of weak or highly fractured ground. As the tunnel extends deeper into the andesite it is anticipated that the tunnel support requirements will reduce and longer stretches of tunnel can be excavated before support is required.

The estimated groundwater inflows are outside the scope of this assessment. We envision that the ignimbrites may generate high groundwater inflows because these materials can be highly porous. We anticipate that high permeability zones may be locally present within fault zones and on some subhorizontal to gently inclined layers of the suite of volcanic rocks.

6.0 SUGGESTED INVESTIGATIONS TO ADDRESS UNCERTAINTIES

Given the lack of geotechnical subsurface information (strength, stiffness, jointing, abrasivity, geochemisty etc.) along much of the proposed tunnel alignments, targeted subsurface investigations, such as boreholes is considered advisable. A programme of laboratory testing would accompany the drilling to characterise geomechanical properties of the encountered materials.

The area close to the portal has been determined to comprise andesite at shallow depth based on the investigations completed by EGL; however, some geotechnical characterisation of the andesite at the portal site would be worthwhile as previous work has not assessed the viability of this site as a portal.

We suggest some drillholes should target the ignimbrite between the portal and Walmsley Stream, focussed on characterising the geotechnical characteristics of the ignimbrite. These holes would be less than 200 m deep and should include in situ testing to characterise the strength and falling head tests to measure permeability. Samples should also be taken for laboratory strength testing and material characterisation. These holes would also aim to characterise the underlying andesite.

It would be useful to complete drill hole investigations around the Waihi Fault, as the current ground conditions in this area are relatively unknown and would be important to help determine the expected tunnelling conditions and support required. Borehole investigations of the Waihi Fault should be located near to the change in elevation at approximately Walmsley Stream and could have associated low strength material and high permeability. Targeted drilling would require some more detailed mapping and terrain analysis to confirm suitable drilling locations.

Drillholes in the area between the Waihi Fault and Willows Connection are expected to encounter similar materials to the Willows Road farm site investigations. For a prefeasibility study, we could probably avoid drilling further in this area, but an additional drillhole would help reduce the risk of unexpected ground conditions for the tunnel.

Consideration could also be given to geophysical investigations to investigate the position of the Waihi Fault and the depth to various geological contacts along the tunnel alignment.

Closure

We hope this meets your requirement, should you have any questions please do not hesitate to contact the undersigned.

Your sincerely
GOLDER ASSOCIATES (NZ) LIMITED

Latasha Templeton	Tim McMorran
Senior Engineering Geologist	*Principal Engineering Geologist*
	CMENGNZ (PENGGEOL) 176867

LT/TM/jsb

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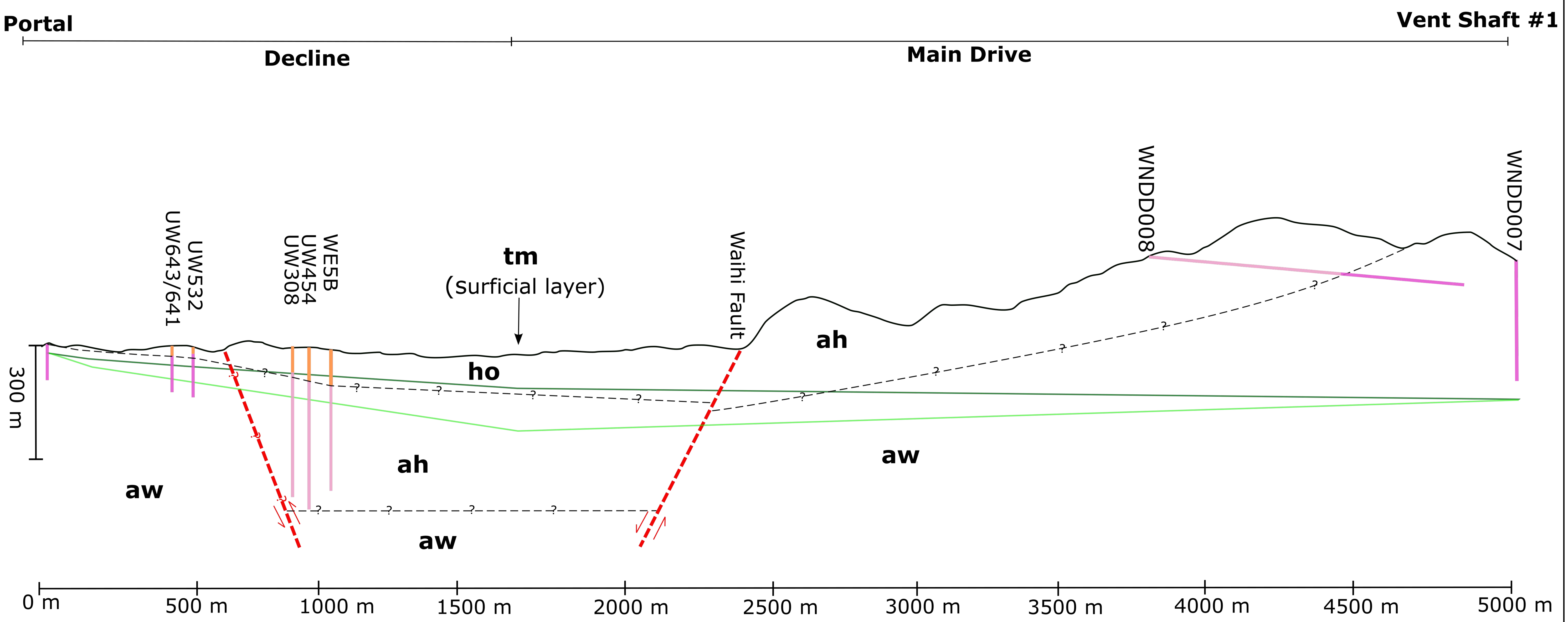


LEGEND

🟩 Shallow Tunnel Alignment
🟩 Deeper Tunnel Alignment

🟨 **tm** - Matua Subgroup - Volcanigenic sediments alluvium
🟧 **ho** - Ohinemuri Subgroup - tuff, ignimbrite, weak to strong
▬ **ah** - Whitiroa Andesite - andesitic flows, breccia and tuffs
▬ **aw** - Waipupu Formation Andesite - andesitic flows, breccias, tuffs, hydrothermally altered
▪ ▪ ▪ Faults
▪ ▪ ▪ Inferred contacts between formations

CLIENT
OCEANAGOLD CORPORATION

PROJECT
WAIHI NORTH PROJECT: REVIEW OF EXISTING GEOLOGICAL INFORMATION FOR PROPOSED TUNNEL

TITLE
TUNNEL ALIGNMENT 4

CONSULTANT
GOLDER

YYYY-MM-DD	2021-09-28
PREPARED	LT
REVIEW	TM
APPROVED	TM

PROJECT NO.	REPORT	REV.	FIGURE
20148384	012	0	**B2**

Appendix B Tunnel Groundwater Inflow Assessment

B.1 Calculation Methodology

Rock Mass Inflow in Advancing Tunnel
The tunnel groundwater inflows have been calculated for both steady state and transient conditions. For steady state estimates, a number of methods based on the Goodman et al (1965) equation were evaluated and the method of Karlsrud (2001) used to make an initial estimate of inflows. The equation is as follows:

$$Q = \frac{2\pi K h}{\ln\left(\frac{2h}{r} - 1\right)}$$

Where:

Q	inflow unit tunnel length (m3/d/m)
r	Tunnel radius (m)
K	Hydraulic Conductivity (m/d)
h	Water head above tunnel centreline (m).

These calculations yield estimates of inflows per metre length of tunnel. For calculation efficiency, the tunnel length was discretised into units based on geology; hydraulic conductivity; tunnel diameter; and water head above the tunnel. Total inflow was then assessed by integrating flows for each discretised unit.

Transient inflow estimates were undertaken using the method of Perrocet (2005). Inflows were calculated for discretised zones and integrated to provide the inflow as the tunnel advanced. The equation used to calculate inflow over time was;

$$q(x,t) = \frac{2\pi K s_o}{\ln\left(1 + \sqrt{\frac{\pi K}{S_s r_o^2}\left(t - \frac{x}{v}\right)}\right)}, t - \frac{x}{v} > 0$$

Where:

q	Tunnel inflow at distance x at time t (m^3/d)
Ss	Specific Storage coefficient
So	Groundwater Head (m)
v	Tunnel advance rate (m/d)
t	Time (days)
x	Distance advanced (m)

Shaft Inflows
In conjunction with the analytical method of determining rock mass inflow, discrete locations have been considered at the shaft positions. Inflows during construction of the vent raises prior to grout sealing have been determined using axis-symmetric SEEP/W numerical models. These models are setup under transient conditions that allow inflow over a period of time relevant to their construction. For the vent raises we have assumed that drainage can occur for 40-60 days (depending on the depth) prior to sealing inflows.

Structural Defect Inflows

Inflow from fracture and fault zones have been calculated using a transient analytical model (Lohman, 1972) as follows:

$$Q = \frac{L}{\sqrt{\pi t}}\left(h_0 - \frac{h_0^2}{2b}\right)\sqrt{SKb}$$

Where:

Q	Inflow to one side of the tunnel (m3/d)
L	Length of tunnel (m)
K	Average horizontal Permeability (m/d)
S	Storage
b	Saturated aquifer depth (m)
ho	Head above tunnel (m)
t	Time (days)

Fracture inflows were assumed to be allowed for 7 days prior to them being grout sealed. The results from these vent and fracture models have then been aggregated into the rock mass inflows at the relevant distance along the tunnel alignment to provide the total expected inflows. Details of the numerical models are included in Appendix D.

B.2 Description of Model

The dual tunnels would consist of a single tunnel from the portal at Willows Farm, transitioning to a dual tunnel from the first vent raise to Wharekiraupona (i.e. chainage 1,400 m to 5,300 m). The inflows resulting from a dual tunnel have been derived by simulating a single tunnel, with the twin tunnel scenario modelled in SEEP/W under various head conditions. This has enabled a factor to be determined that is then applied to the analytical model values for the dual part of the tunnel. This factor is approximately 10% additional inflow based on a tunnel separation by 30 m.

B.3 Model Inputs

The following inputs were adopted for the calculations.

Tunnel radius (r): is assumed to be 6.0 m diameter, radial diameter is assumed to be 3.0 m radius

Hydraulic Conductivity (K): The Hydraulic Conductivity values have been derived from a number of sources including: back analysis of the Kaimai Rail Tunnel (Davoren, 1983), in-situ testing at the WKP ore body and at Willow Farm, analysis of fracture spacing from exploration drilling and experience from testing of similar geologic units at Waihi and other deposits in the Coromandel. The values assigned to the various geologic units are presented in Table B1. For the transient analysis, a Hydraulic Conductivity value was assigned to each geologic unit based on the geological model provided by GHD (Appendix C).

Specific Storage Coefficient (Ss):

The Specific Storage inputs have been assigned based on experience from testing of similar geologic units at Waihi Gold and from other locations. The values assigned to the various geologic units are presented in Table B1.

Table B1 Assumed Range of Aquifer Parameters

Geologic Unit	Hydraulic Conductivity (m/s)	Specific Storage
Andesite	1.0×10^{-8}	0.0000005
Clay Altered Andesite	5.0×10^{-9}	0.0000005
Fault Zones	1.0×10^{-7}	0.001

Groundwater Head (So)

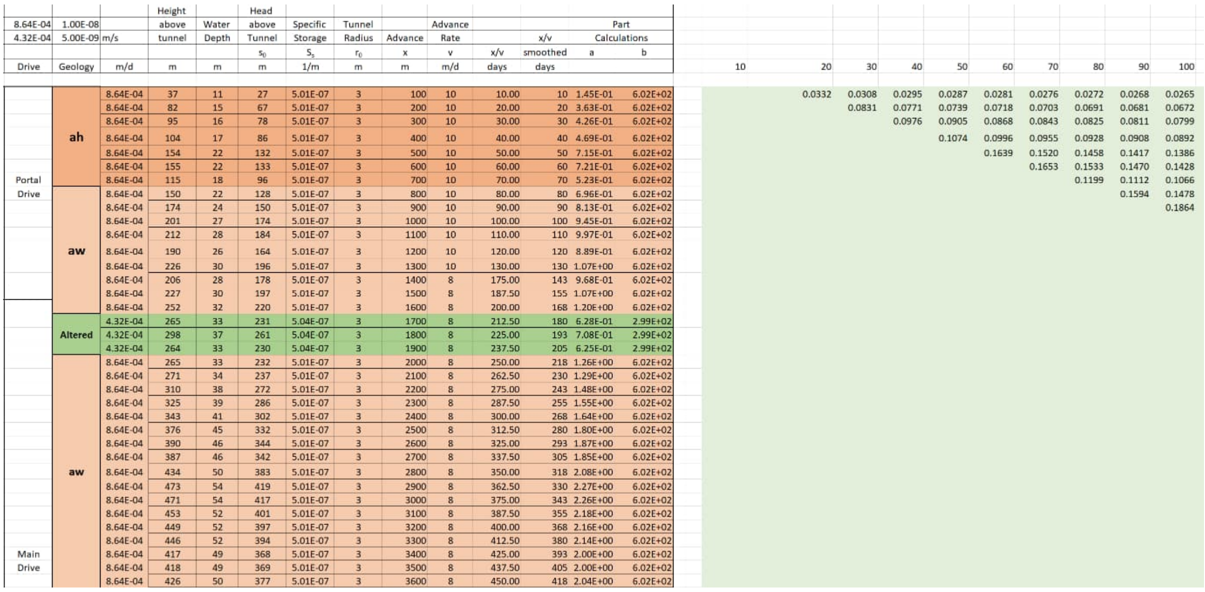
The groundwater heads have been determined based on the relationships to depth observed at the Willow Farm and WKP sites from the drilling investigations and interpolated based on the topographic elevation along the tunnel alignment.

Tunnel advance rate (v)

The analytical model uses variable advancement rates that have been calculated based on the tunnelling schedule. These are; 10 m/d up to 1,350 m chainage, 8 m/d up to 4,000 m and 6 m/d for the remainder of the tunnel development.

B.4 Tunnel Model Results

The rock mass inflows from tunnelling have been calculated using an Excel spreadsheet and applies the Perrocet (2005) method for calculating tunnel inflows. A screenshot of the spreadsheet is included in Figure B1.



			Height		Head								
8.64E-04	1.00E-08		above	Water	above	Specific	Tunnel		Advance			Part	
4.32E-04	5.00E-09	m/s	tunnel	Depth	Tunnel	Storage	Radius	Advance	Rate		x/v	Calculations	
					s_0	S_s	r_0	x	v	x/v	smoothed	a	b
Drive	Geology	m/d	m	m	m	1/m	m	m	m/d	days	days		
Portal Drive	ah	8.64E-04	37	11	27	5.01E-07	3	100	10	10.00	10	1.45E-01	6.02E+02
		8.64E-04	82	15	67	5.01E-07	3	200	10	20.00	20	3.63E-01	6.02E+02
		8.64E-04	95	16	78	5.01E-07	3	300	10	30.00	30	4.26E-01	6.02E+02
		8.64E-04	104	17	86	5.01E-07	3	400	10	40.00	40	4.69E-01	6.02E+02
		8.64E-04	154	22	132	5.01E-07	3	500	10	50.00	50	7.15E-01	6.02E+02
		8.64E-04	155	22	133	5.01E-07	3	600	10	60.00	60	7.21E-01	6.02E+02
		8.64E-04	115	18	96	5.01E-07	3	700	10	70.00	70	5.23E-01	6.02E+02
	aw	8.64E-04	150	22	128	5.01E-07	3	800	10	80.00	80	6.96E-01	6.02E+02
		8.64E-04	174	24	150	5.01E-07	3	900	10	90.00	90	8.13E-01	6.02E+02
		8.64E-04	201	27	174	5.01E-07	3	1000	10	100.00	100	9.45E-01	6.02E+02
		8.64E-04	212	28	184	5.01E-07	3	1100	10	110.00	110	9.97E-01	6.02E+02
		8.64E-04	190	26	164	5.01E-07	3	1200	10	120.00	120	8.89E-01	6.02E+02
		8.64E-04	226	30	196	5.01E-07	3	1300	10	130.00	130	1.07E+00	6.02E+02
		8.64E-04	206	28	178	5.01E-07	3	1400	8	175.00	143	9.68E-01	6.02E+02
		8.64E-04	227	30	197	5.01E-07	3	1500	8	187.50	155	1.07E+00	6.02E+02
Main Drive		8.64E-04	252	32	220	5.01E-07	3	1600	8	200.00	168	1.20E+00	6.02E+02
	Altered	4.32E-04	265	33	231	5.04E-07	3	1700	8	212.50	180	6.28E-01	2.99E+02
		4.32E-04	298	37	261	5.04E-07	3	1800	8	225.00	193	7.08E-01	2.99E+02
		4.32E-04	264	33	230	5.04E-07	3	1900	8	237.50	205	6.25E-01	2.99E+02
	aw	8.64E-04	265	33	232	5.01E-07	3	2000	8	250.00	218	1.26E+00	6.02E+02
		8.64E-04	271	34	237	5.01E-07	3	2100	8	262.50	230	1.29E+00	6.02E+02
		8.64E-04	310	38	272	5.01E-07	3	2200	8	275.00	243	1.48E+00	6.02E+02
		8.64E-04	325	39	286	5.01E-07	3	2300	8	287.50	255	1.55E+00	6.02E+02
		8.64E-04	343	41	302	5.01E-07	3	2400	8	300.00	268	1.64E+00	6.02E+02
		8.64E-04	376	45	332	5.01E-07	3	2500	8	312.50	280	1.80E+00	6.02E+02
		8.64E-04	390	46	344	5.01E-07	3	2600	8	325.00	293	1.87E+00	6.02E+02
		8.64E-04	387	46	342	5.01E-07	3	2700	8	337.50	305	1.85E+00	6.02E+02
		8.64E-04	434	50	383	5.01E-07	3	2800	8	350.00	318	2.08E+00	6.02E+02
		8.64E-04	473	54	419	5.01E-07	3	2900	8	362.50	330	2.27E+00	6.02E+02
		8.64E-04	471	54	417	5.01E-07	3	3000	8	375.00	343	2.26E+00	6.02E+02
		8.64E-04	453	52	401	5.01E-07	3	3100	8	387.50	355	2.18E+00	6.02E+02
		8.64E-04	449	52	397	5.01E-07	3	3200	8	400.00	368	2.16E+00	6.02E+02
		8.64E-04	446	52	394	5.01E-07	3	3300	8	412.50	380	2.14E+00	6.02E+02
		8.64E-04	417	49	368	5.01E-07	3	3400	8	425.00	393	2.00E+00	6.02E+02
		8.64E-04	418	49	369	5.01E-07	3	3500	8	437.50	405	2.00E+00	6.02E+02
		8.64E-04	426	50	377	5.01E-07	3	3600	8	450.00	418	2.04E+00	6.02E+02

x	10	20	30	40	50	60	70	80	90	100
100		0.0332	0.0308	0.0295	0.0287	0.0281	0.0276	0.0272	0.0268	0.0265
200			0.0831	0.0771	0.0739	0.0718	0.0703	0.0691	0.0681	0.0672
300				0.0976	0.0905	0.0868	0.0843	0.0825	0.0811	0.0799
400					0.1074	0.0996	0.0955	0.0928	0.0908	0.0892
500						0.1639	0.1520	0.1458	0.1417	0.1386
600							0.1653	0.1533	0.1470	0.1428
700								0.1199	0.1112	0.1066
800									0.1594	0.1478
900										0.1864

Figure B1 Image of Spreadsheet used to Calculate Groundwater Inflows (Perrocet, 2005)

The spreadsheet calculates the inflows and recession flows at each discretized segment (100 m) and accumulates these inflows as the tunnel progresses. The variations in inflow relate to the geological conditions (K and So values), hydraulic head and advancement rate. Figure B2 shows the rock mass inflow only with distance as the tunnel is developed for both tunnel options.

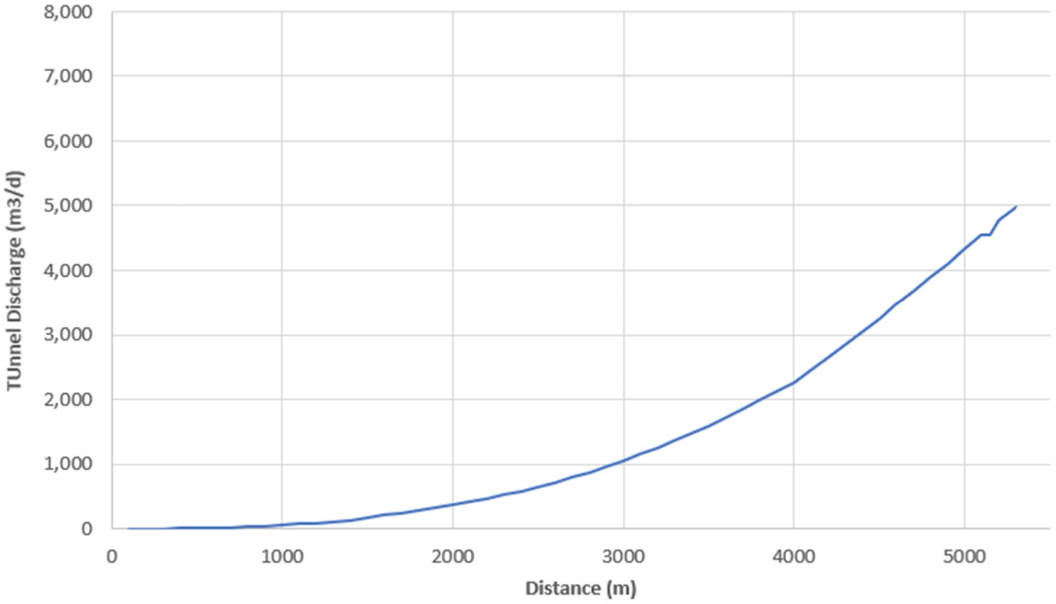


Figure B2 Analytical Model Output Showing Rock Mass Inflow with Distance (K=1x10^{-8} m/s)

The tunnel model was then updated to include intermittent inflows at various distances based on the models developed for the vents and fracture zones.

B.5 Vent and Defect Model Results

The results of the models for the vent shafts and structural defects are included in Table B2 and Table B3. These results were added into the tunnel model at the appropriate distance in the tunnel to produce the final inflow model results shown below.

Table B2 Shaft Inflow Assessment

Shaft	Location	Chainage	Depth	Diameter	Ground	Base	H	q	Days	Q
		m	m	m	m RL	m RL	m	m^3/d		m^3
Shaft 1	Willow Farm	1400	250	3	225	-25	250	12.5	40	500
Shaft 2	DoC Land	4000	400	3	340	20	320	23.5	60	1410

Table B3 Fracture Inflow Assessment

Distance	Type	Scale	L	K	b	ho	S	Day1	Day7	
m			m	m/s	m	m		m^3/d	m^3/d	
347	Lineament	Minor	0.5	1.0E-07	258	131	0.001	1.5	0.2	
487	Lineament	Medium	1	1.0E-06	272	155	0.005	24	3.5	
567	Contact	Minor	0.5	1.0E-07	222	129	0.001	1.3	0.2	
894	Lineament	Minor	0.5	1.0E-07	243	184	0.001	1.7	0.2	
1284	Lineament	Minor	0.5	1.0E-07	219	219	0.001	1.5	0.2	
1600	Contact	Minor	0.5	1.0E-07	247	258	0.001	1.8	0.3	
2311	Lineament	Minor	0.5	1.0E-07	331	335	0.001	2.8	0.4	
3000	Lineament	Minor	0.5	1.0E-07	502	494	0.001	5.3	0.8	
2438	Lineament	Minor	0.5	1.0E-07	427	415	0.001	4.1	0.6	
4110	Lineament	Minor	0.5	1.0E-07	371	356	0.001	3.3	0.5	
4423	Contact	Minor	0.5	1.0E-07	287	268	0.001	2.3	0.3	
5110	Fault	Large	10	1.0E-05	180	156	0.1	2219	317	

B.6 Final Model Results

The results of the tunnel inflow assessment are shown in Figure B3 for the dual tunnels that show the total inflows (rock mass inflow + intermittent inflows) when aggregated over distance and over time respectively.

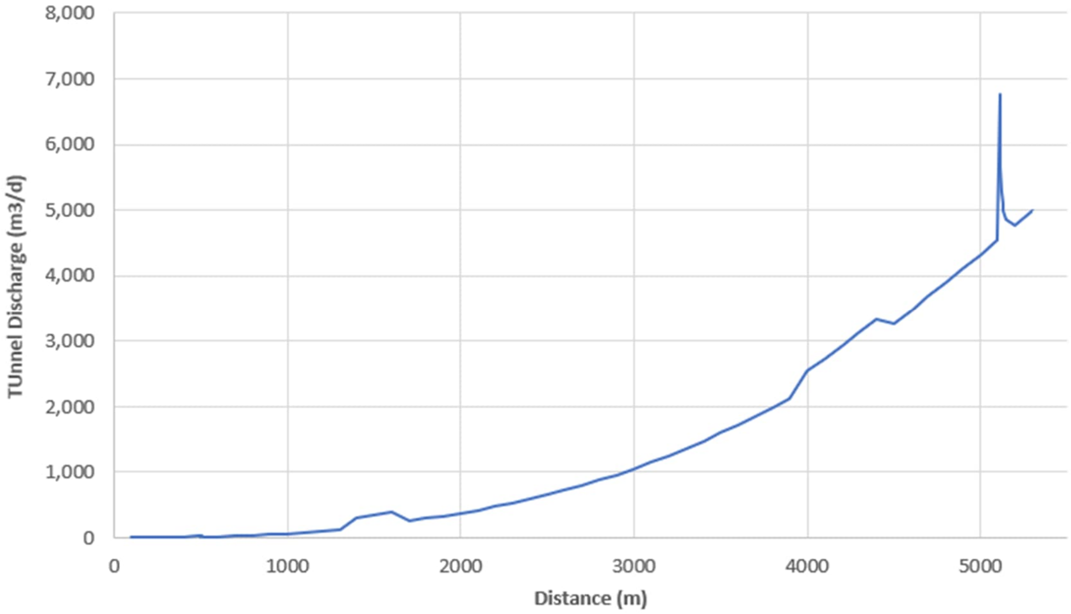


Figure B3 Predicted Groundwater Inflows with Distance

B.7 References

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B.8 Limitations

This assessment has been undertaken using the information available at the time of undertaking this assessment (2.8.2024). The hydrogeologic conditions along the tunnel alignment are largely unknown and assumptions have been made in this regard in order to undertake this assessment. While some site investigations have characterised the hydrogeologic conditions at the portal and first part of the tunnel drive (within Willow Farm), the remainder of the alignment hydrogeological conditions have been assessed on the basis of the geologic model provided by GHD (Aug, 2020). Any differences in ground conditions from those assumed could result in actual groundwater inflows differing from those predicted in this assessment.

The assumptions used in the development of any analytical and numerical model inherently simplify the natural system being simulated. Therefore, in practice, variations from the model predictions may occur. Differences between the estimated flow volumes based on model outcomes and field observations can be expected as a result of the presence of unidentified geological structures which serve to either isolate areas (providing smaller effects than predicted) or to provide more direct pathways between areas (larger effects than predicted). Such variations are not predictable in time and space and cannot be dealt with by modelling. They can, however, generally be covered by a mitigating design methodology and contingency measures or engineering solutions such as those proposed for the exploration tunnel. As site investigation and development continues, substantial additional data will become available and ongoing reviews of predictions presented here can be made.

Appendix C Site Investigations

Willow Farm Hydrogeologic Characterisation

The Willow Farm site investigations were undertaken between August and November 2020 under the supervision of GHD field staff. A total of 20 machine drilled bore holes were advanced to characterise the geological and geotechnical conditions over the site. All of the holes were drilled using a continuous core methodology. On completion of the borehole piezometers were installed to allow groundwater monitoring and testing.

Details for the monitoring wells and recorded groundwater levels are summarised in Table 1. Table 2 provides the groundwater depths and elevations for the multi-level vibrating wire piezometer constructed at the Willow Farm Vent Shaft in borehole WNDD007.

Groundwater Levels

Table 1 Monitoring Well Construction and Groundwater Levels

	Screen Interval (m)		Elevation	Groundwater Depth	Groundwater Elevation
	From	To	m RL	m	m RL
WFBH001D	15.4	18.4	1170.5	13.1	1157.3
WFBH001S	8.1	11.1	1170.5	7.0	1163.5
WFBH002	5.5	6.5	1158.2	5.0	1153.3
WFBH003	9.0	15.0	1163.1	13.2	1149.9
WFBH004	3.0	6.0	1161.2	5.9	1155.4
WFBH005	1.0	3.0	1150.0	1.1	1148.9
WFBH006D	1.0	3.0	1151.0	1.9	1149.1
WFBH006S	5.0	8.0	1151.0	1.8	1149.3
WFBH007	3.0	6.0	1152.4	3.1	1149.3
WFBH008	3.6	9.6	1229.7	5.7	1224.0
WFBH009	6.5	9.5	1180.6	6.2	1174.4
WFBH010	1.4	7.4	1220.3	4.8	1215.5
WFBH011D	11.5	15.0	1233.2	7.4	1225.8
WFBH011S	4.0	7.0	1233.2	5.8	1227.4
WFBH012D	15.3	18.3	1246.5	2.4	1244.1
WFBH012S	3.0	6.0	1246.5	2.0	1244.5
WFBH013	3.0	6.0	1205.2	1.3	1203.9
WFBH0014	25.0	32.0	1200.0	8.0	1192.0
WFBH0015	9.5	15.5	1165.9	5.7	1160.2
WFBH0016	9.5	15.5	1166.2	5.3	1160.9

Table 2 WNDD007 Vibrating Wire Tip and Groundwater Elevations

Tip Depth (m)	Tip Elevation (m RL)	Head (m)	Groundwater Elevation (mRL)
49.1	1188.9	11.2	1200.1
141.8	1096.2	22.6	1118.8
217.6	1020.4	27.9	1048.3
WNDD007 Ground Level Elevation is 1238.0 mRL			

Permeability Testing

Follow construction of the monitoring wells permeability testing was undertaken using rising and falling head techniques. The testing and analysis was undertaken by GHD. The results of the testing are summarised in Table 3.

Table 3 Summary Hydraulic Conductivity Values

Monitoring Well	Lithology	Hydraulic Conductivity (m/s)	
		Min	Max
WFBH001D	Weathered Tuff	1.8×10^{-6}	2.2×10^{-6}
WFBH001S	Clay Soils	1.2×10^{-7}	2.3×10^{-7}
WFBH002	Terrace Gravel	3.3×10^{-8}	4.4×10^{-8}
WFBH004	Terrace Gravel	3.1×10^{-8}	6.7×10^{-8}
WFBH005	Terrace Gravel	8.2×10^{-6}	1.2×10^{-5}
WFBH006D	Weathered Tuff	5.3×10^{-7}	7.1×10^{-7}
WFBH006S	Terrace Gravel	4.0×10^{-5}	1.1×10^{-4}
WFBH007	Silt Soils	1.0×10^{-5}	1.7×10^{-5}
WFBH009	Silt/Clay Soils	1.1×10^{-7}	$1. \times 10^{-7}$
WFBH0012D	Altered Tuff	5.7×10^{-8}	8.8×10^{-8}
WFBH0012S	Sandy Soils	1.1×10^{-6}	1.2×10^{-6}
WFBH0013	Silt Soils	3.6×10^{-7}	5.3×10^{-7}
WFBH0014	Tuff/Andesite	1.1×10^{-6}	7.1×10^{-6}
WFBH0015	Silt Soils	2.2×10^{-7}	3.1×10^{-7}
WFBH0016	Silt Soils	2.0×10^{-7}	2.6×10^{-7}

In addition to the permeability testing of the wells, packer testing and falling head testing was undertaken at WNDD007. These results are presented in Tables 4 and 5.

Table 4 WNDD007 Falling Head Hydraulic Conductivity Values

Test	Test Zone (m bgl)		Hydraulic Conductivity (m/s)
	From	To	
Falling Head 1	6.3	12.2	6.7×10^{-7}
Falling Head 2	15.3	16.8	4.0×10^{-6}
Falling Head 3	15.3	21.3	7.3×10^{-7}
Falling Head 4	104.0	117.0	8.3×10^{-7}
Falling Head 5	197.3	204.3	3.3×10^{-7}

Table 5 WNDD007 Packer Test Hydraulic Conductivity Values

Test	Test Zone (m bgl)		Hydraulic Conductivity (m/s)
	From	To	
Packer 1	34.5	37.9	1.5×10^{-8}
Packer 2	64.6	74.8	2.4×10^{-8}
Packer 3	107.3	117.3	5.0×10^{-7}
Packer 4	145.6	151.6	2.0×10^{-8}
Packer 5	222.7	231.7	1.3×10^{-8}

Water Quality Testing

Water quality sample have been taken from the monitoring wells and the Mataura River on a number of occasions to characterise chemical baseline conditions. Tables 6 and 7 present the water quality for groundwater and surface water respectively.

Table 6 Groundwater Quality Results

Date	Sample	Depth	pH	EC	Alk	Al	As	Ba	HCO3	B	Ca	Cl	Co	Cu	Fe	Pb
1/09/2020	WFBH003	12.84	7.5	32.6	300	0.04	0.001	0.55	370	0.09	25	13	0.0014	0.0009	0.02	0.0001
2/09/2020	WFBH006S	1.83	7.3	14.2	34	0.012	0.001	0.051	42	0.036	9.2	11.5	0.0064	0.0005	0.02	0.0001
2/09/2020	WFBH006D	1.8	6.9	7.8	14	0.29	0.001	0.023	17.1	0.013	2.8	12	0.0012	0.0005	0.12	0.0001
3/09/2020	WFBH005	1.14	7.3	27.9	134	0.015	0.001	0.28	163	0.079	31	9	0.0109	0.0005	0.24	0.0001
7/09/2020	WFBH001S	6.65	6.2	9.3	11.2	0.011	0.001	0.023	13.7	0.028	3.5	12	0.0018	0.0014	0.02	0.0001
7/09/2020	WFBH001D	12.19	6.5	9.9	25	0.045	0.001	0.065	30	0.016	8	9	0.0017	0.0007	0.02	0.0001
8/09/2020	WFBH007	3.6	5.7	5.9	6	0.09	0.001	0.026	7.3	0.011	1.32	8	0.0022	0.0007	0.03	0.00012
11/09/2020	WFBH002	4.28	7.3	56.2	300	0.31	0.001	0.28	370	0.22	32	14	0.0058	0.001	0.1	0.0001
16/09/2020	WFBH004	6.36	5.7	4.6	6.6	0.065	0.001	0.014	8	0.016	0.9	9	0.0022	0.0005	0.02	0.0001
21/09/2020	WFBH013	2.3	6.9	23.3	106	0.031	0.024	0.164	129	0.036	20	10	0.0006	0.0005	5.3	0.0001
23/09/2020	WFBH011D	8.43	7.2	15.5	41	0.024	0.001	0.019	50	0.012	11.3	7	0.0005	0.0006	1.36	0.00021
25/09/2020	WFBH006S	2.11	6	6.2	3.4	0.028	0.001	0.024	4.1	0.009	2.2	6	0.0011	0.0018	0.02	0.0001
25/09/2020	WFBH006D	2.7	6.2	7.7	16.1	0.003	0.001	0.02	19.6	0.011	3.2	8	0.0002	0.0005	0.02	0.0001
25/09/2020	WFBH005	1.41	6	5.9	15.6	0.023	0.001	0.036	19	0.011	3.3	5	0.0029	0.0005	1.48	0.0037
25/09/2020	WFBH007	4.02	5.5	5.3	3.4	0.015	0.001	0.025	4.1	0.011	0.82	6	0.0006	0.001	0.02	0.0001
25/09/2020	WFBH002	6	7.4	29.9	169	0.077	0.001	0.106	210	0.069	29	7	0.0039	0.0005	0.03	0.0001
1/10/2020	WFBH003	13.72	7.5	23.3	350	0.52	0.001	0.33	430	0.022	18.1	11	0.0074	0.0022	0.46	0.00081
1/10/2020	WFBH001S	8.22	5.6	7.3	3.8	0.033	0.001	-	4.6	0.011	1.84	10	0.0022	0.0005	0.02	0.0001
1/10/2020	WFBH001D	14.7	5.6	4.9	6.1	0.042	0.001	-	7.4	0.023	3.9	7	0.002	0.0006	0.02	0.0001
1/10/2020	WFBH009	7.57	6	7.1	13.4	0.04	0.001	-	16.3	0.022	3.7	8	0.0019	0.0006	0.02	0.0001
2/10/2020	WFBH013	2.29	7.2	35.8	260	0.117	0.0115	-	320	0.059	28	11	0.0011	0.0005	3.9	0.0001
2/10/2020	WFBH011D	8.7	6.7	15.6	43	0.025	0.001	-	52	0.011	10.5	10	0.0005	0.0005	2.3	0.0001

Table 6 Groundwater Quality Results (continued)

Date	Sample	Li	Mg	Mn	Mo	Ni	NO3	NH4	K	Rb	Na	Sr	So4	TKN	SS	Zn
1/09/2020	WFBH003	0.0071	4	0.42	0.0005	0.0012	0.144	0.01	2.4	0.0031	39	0.31	8	0.94	4300	0.0175
2/09/2020	WFBH006S	0.0022	3.1	0.52	0.0008	0.0042	2.2	0.01	1.64	0.0037	10.9	0.067	9	0.12	98	0.048
2/09/2020	WFBH006D	0.0029	1.65	0.048	0.0002	0.0008	1.34	0.01	1.47	0.0038	7.4	0.0198	7	0.31	350	0.32
3/09/2020	WFBH005	0.0035	3.8	1.63	0.0004	0.0016	0.068	0.077	1.89	0.0049	23	0.28	10	0.29	60	0.035
7/09/2020	WFBH001S	0.002	1.61	0.117	0.0002	0.0007	2.6	0.01	0.98	0.0025	9.8	0.028	6	0.27	580	0.27
7/09/2020	WFBH001D	0.0022	0.96	0.22	0.0002	0.0018	1.93	0.01	1.06	0.00167	8.8	0.052	6	0.42	370	0.33
8/09/2020	WFBH007	0.0021	1.12	0.085	0.0002	0.0008	1.57	0.01	1.31	0.0034	6.1	0.0123	7	0.22	420	0.075
11/09/2020	WFBH002	0.0068	10.7	0.99	0.002	0.0011	0.061	0.02	4	0.0089	81	0.36	29	1.08	3300	0.028
16/09/2020	WFBH004	0.0031	0.78	0.082	0.0002	0.0008	0.44	0.01	0.65	0.00191	6.2	0.0071	6	0.68	3400	0.136
21/09/2020	WFBH013	0.0039	5.6	0.33	0.0016	0.0014	0.002	0.81	4	0.0079	21	0.18	5	0.83	220	0.035
23/09/2020	WFBH011D	0.0024	5.9	0.199	0.0002	0.0007	0.005	0.026	2.1	0.0041	9.7	0.051	20	0.36	118	0.057
25/09/2020	WFBH006S	0.0009	1.6	0.037	0.0002	0.0023	2.3	0.01	1.28	0.0029	5.3	0.0174	6	0.1	3	0.0099
25/09/2020	WFBH006D	0.0022	1.8	0.0049	0.0002	0.0005	1.18	0.01	1.63	0.0047	8.4	0.0199	5	0.1	3	0.0099
25/09/2020	WFBH005	0.0017	1.01	0.24	0.0002	0.0009	0.006	0.01	0.52	0.00177	5.3	0.024	6	0.1	18	0.022
25/09/2020	WFBH007	0.0012	1.13	0.0077	0.0002	0.0005	1.46	0.01	1.24	0.0032	6.2	0.0087	5	0.1	3	0.0075
25/09/2020	WFBH002	0.0035	7.3	0.87	0.0007	0.0014	0.38	0.012	2	0.003	18.4	0.25	9	0.97	2300	0.077
1/10/2020	WFBH003	0.0046	2.1	1.04	0.0002	0.0058	1.17	0.01	1.35	0.0033	9.6	0.123	6	3.8	14500	0.097
1/10/2020	WFBH001S	0.0019	2.3	0.072	0.0002	0.0005	3.1	-	1.09	-	6.7	-	5	-	-	0.112
1/10/2020	WFBH001D	0.0055	0.99	0.2	0.0002	0.0013	0.8	-	0.92	-	8.9	-	7	-	-	0.5
1/10/2020	WFBH009	0.0053	0.96	0.187	0.0002	0.0012	1.73	-	0.9	-	8.7	-	6	-	-	0.49
2/10/2020	WFBH013	0.0064	6.8	0.57	0.0018	0.003	0.002	-	4.2	-	24	-	3.2	-	-	0.04
2/10/2020	WFBH011D	0.0023	6.1	0.186	0.0002	0.0006	0.002	-	1.97	-	9.4	-	17	-	-	0.025

Table 7 Matarua Stream Water Quality Results

Date	Sample	pH	EC	Al	HCO3	B	Ca	Cl	Fe	Mg	Mn	NO3	K	Na	SO4	Zn
17/08/2020	Mataura	6.3	5	0.029	8.4	0.01	1.22	7	0.14	0.82	0.0148	0.25	0.92	6.5	8	0.0018
17/08/2020	Stream 1	7	6.2	0.037	10	0.008	2.2	9	0.02	1.29	0.0025	0.164	0.95	6.8	9	0.0013
17/08/2020	Trib 1	6.6	6.1	0.047	10.2	0.01	1.59	9	0.04	1.11	0.0033	0.73	1.25	7.4	6	0.001
10/07/2020	Stream 1	6.3	6	0.049	10.2	0.009	2.2	9	0.02	1.26	0.0041	0.24	0.95	6.7	9	0.0019
10/07/2020	Stream 2	6.5	6.1	0.052	10.8	0.009	2.1	9	0.02	1.22	0.004	0.21	0.94	6.7	6	0.0019
10/07/2020	Trib 1	6.4	5.3	0.029	9.1	0.01	1.37	7	0.06	0.9	0.025	0.65	1.15	6.2	7	0.003

Note that analytes with concentrations less than the detection level are not reported.

Monitoring Well Logs and Permeability Test Data

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 2/09/2020
Completed: 4/09/2020

Hole No. : WFBH001-D
Sheet : 1 of 2
Hole Length : 18.45
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763724.071
Northing: 6423735.338
System: NZMG 1949
RL: 170.455 m
Datum: NZVD2016
Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS
0.3	CORE LOSS			
0.7	Sandy silty CLAY; orangish brown. Soft; moist; high plasticity; sand, fine (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	S
1.7	Silty CLAY with some sand and gravel; reddish brown speckled grey and black. Soft; moist; high plasticity, sand, fine to coarse; gravel, fine		M	S
4	Silty CLAY with minor sand and gravel; red speckled grey and black. Soft; moist; high plasticity; sand, fine to coarse; gravel, fine		M	S
	6.00 Becomes firm			F
8	Silty CLAY with some gravel; reddish brown speckled black. Firm; moist; high plasticity; gravel, fine		M	F

Method	Sample Result	TCR SCR RQD (%)
HQTT		TCR: 64
HQTT		TCR: 100
SPT	SPT 0/0 1/1 1/0 N = 3	
HQTT		TCR: 100
HQTT		TCR: 150
SPT	SPT 0/1 1/0 0/1 N = 2	
HQTT		TCR: 145
HQTT		TCR: 150
SPT	SPT 1/1 0/1 1/1 N = 3	
HQTT		TCR: 155
HQTT		TCR: 130
SPT	SPT 1/0 1/1 1/1 N = 4	
HQTT		TCR: 100
HQTT		TCR: 112
SPT	SPT 1/1 2/2 1/1 N = 6	
HQTT		TCR: 100
SPT	SPT 3/3 2/2 2/2 N = 8	
HQTT		TCR: 133
		TCR: 86

Weathering: RS

Water level: 3-09-2020, 4-09-2020, 4-09-2020

Notes and Comments:
End of Hole @ 18.45m
Wasterock stack option 1
0% water return for all of drilling
Hole drilled dry to 6.0m

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
03/09/20	17:00	2.08	13.95
04/09/20	08:00	6.68	13.95
04/09/20	12:00	5.2	18.45
07/09/20	00:00	11.72	18.45
23/09/20	00:00	14.14	18.45

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 2/09/2020
Completed: 4/09/2020

Hole No. : WFBH001-D
Sheet : 2 of 2
Hole Length : 18.45
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763724.071
Northing: 6423735.338
System: NZMG 1949
RL: 170.455 m
Datum: NZVD2016
Method: SURVEY

RL (m)	Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Weathering
160 – 156	10 – 14.5	Silty CLAY with some gravel; reddish brown speckled black. Firm; moist; high plasticity; gravel, fine *(continued from layer starting at 8.0m)*	RESIDUAL SOIL - ALLOPHANE	M	F	RS
156 – 152	14.5 – 18.45	Completely weathered; reddish brown speckled grey and black welded TUFF; fine fabric; extremely weak; iron staining around clasts; recovered partially as gravel sized fragments (WHIRITOA ANDESITE)	WHIRITOA ANDESITE			CW
151	18.45	End of Hole @ 18.45m, Target Depth				

Method	Sample Result	TCR SCR RQD (%)
HQTT		TCR: 86
SPT	SPT 1/0 2/1 2/3 N = 8	
HQTT		TCR: 100
HQTT		TCR: 100
SPT	SPT 1/1 1/1 2/2 N = 6	
HQTT		TCR: 100
SPT	SPT 2/1 1/2 2/3 N = 8	
HQTT		TCR: 100
SPT	SPT 3/5 4/5 5/6 N = 20	
HQTT		TCR: 100
SPT	SPT 3/3 1/3 6/7 N = 17	
HQTT		TCR: 100
SPT	SPT 2/4 6/6 6/6 N = 24	

Water level: 7-09-2020; 23-09-2020

Notes and Comments:

End of Hole @ 18.45m
Wasterock stack option 1
0% water return for all of drilling
Hole drilled dry to 6.0m

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
03/09/20	17:00	2.08	13.95
04/09/20	08:00	6.68	13.95
04/09/20	12:00	5.2	18.45
07/09/20	00:00	11.72	18.45
23/09/20	00:00	14.14	18.45

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 7/09/2020	Completed: 7/09/2020

Hole No.	**: WFBH002**
Sheet	: 1 of 2
Hole Length	: 12.45
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763719.184 Northing: 6423833.114 System: NZMG 1949

RL: 158.228 m Datum: NZVD2016 Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0 – 0.2	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	Topsoil	M	VS
0.2 – 0.7	CORE LOSS	RIVER TERRACE DEPOSITS		
0.7 – 1	Sandy clayey SILT; brown. Very soft; moist; high plasticity (RIVER TERRACE DEPOSITS)		M	VS
1 – 1.8	Clayey SILT with some sand; brown. Soft; moist; high plasticity; sand, fine		M	VS
1.8 – 5.5	CLAY with some silt; reddish brown. Soft; moist; extremely high plasticity 2.00 XRD lab test results: halloysite, cristobalite 3.00 Becomes very soft 3.50 Becomes orangish brown		M	S VS
5.5 – 6.5	BOULDERS with some gravel; grey. Very dense; iron staining on clast surfaces; gravel, coarse, sub angular to sub rounded, slightly weathered; strong porphyritic andesite		M	VD
6.5 – 7.1	CORE LOSS (inferred gravel)			
7.1 – 8.8	Sandy silty CLAY; grey mottled orange and brown. Firm; moist; high plasticity; sand, fine to coarse (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	F
8.8 – 9.8	Silty CLAY with some sand; orangish brown mottled grey. Stiff; moist; high plasticity; sand, fine to medium		M	St
9.8				

Sample: SPT-D1, 2.00 – 2.45

Method	Result	TCR SCR RQD (%)
HQTT		TCR: 50
SPT	SPT 0/0 1/0 0/1 N = 2	
HQTT		TCR: 100
HQTT		TCR: 250
SPT	SPT 1/0 0/1 1/1 N = 3	
HQTT		TCR: 100
SPT	SPT 0/0 1/0 0/0 N = 1	
HQTT		TCR: 133
SPT	SPT 0/0 0/0 0/1 N = 1	
HQTT		TCR: 145
HQTT		TCR: 110
SPT	SPT 1/6 6/41 3 for 5mm N > 50	
HQTT		TCR: 101
HQTT		TCR: 25
SPT	SPT 1/0 1/0 2/2 N = 5	
HQTT		TCR: 120
HQTT		TCR: 109
SPT	SPT 3/4 4/4 3/3 N = 14	
HQTT		TCR: 100

Weathering: CW

Water level: 7-09-2020 7-09-2020 7-09-2020 7-09-2020 23-09-2020

Notes and Comments:

End of Hole @ 12.45m
Silt Pond Area
No water return information
Field soil descriptions have been adjusted to reflect lab test results were applicable

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical Orientation:

Contractor: Alton Drilling Ltd

Equipment: Tractor Rig, (Rig 83)

SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
07/09/20	10:00	1.78	3
07/09/20	12:00	2.95	6
07/09/20	14:00	2.22	9
07/09/20	17:00	2.74	12.45
23/09/20	00:00	5.98	6.7

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 7/09/2020	Completed: 7/09/2020

Hole No.	: WFBH002
Sheet	: 2 of 2
Hole Length	: 12.45
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763719.184
Northing: 6423833.114
System: NZMG 1949
RL: 158.228 m
Datum: NZVD2016
Method: SURVEY

RL (m)	Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Sample Result	Casing	Method	Flush Return (%)	Weathering	Estimated Strength (MPa)	TCR SCR RQD (%)	Defect Spacing (mm)	Instrumentation Installation	Water level
148	10	Completely weathered; pale brown speckled black and orange welded TUFF; fine fabric; extremely weak; recovered partially as gravel sized fragments(WHIRITOA ANDESITE) *(continued from layer starting at 9.8m)*	WHIRITOA ANDESITE				SPT 4/3 2/2 3/4 N = 11		HQTT SPT		CW		TCR: 100			
147	10.85	CORE LOSS							HQTT				TCR: 78			
	11.1	Completely weathered; pale brown speckled black and orange welded TUFF; fine fabric; extremely weak; recovered partially as gravel sized fragments														
146	12								SPT							
	12.45	End of Hole @ 12.45m, Target Depth					SPT 2/3 4/8 11/15 N = 38									

Depth scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
RL scale: 148, 147, 146, 145, 144, 143, 142, 141, 140, 139

Flush Return (%): 25 50 75
Estimated Strength (MPa): EW VW W MS S VS ES
Defect Spacing (mm): 20 60 200 600 2000

Notes and Comments:

End of Hole @ 12.45m
Silt Pond Area
No water return information
Field soil descriptions have been adjusted to reflect lab test results were applicable

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
07/09/20	10:00	1.78	3
07/09/20	12:00	2.95	6
07/09/20	14:00	2.22	9
07/09/20	17:00	2.74	12.45
23/09/20	00:00	5.98	6.7

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 24/08/2020
Completed: 27/08/2020

Hole No. : WFBH003

Sheet : 1 of 3
Hole Length : 22.95
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763752.035
Northing: 6423791.265
System: NZMG 1949
Method: SURVEY
RL: 163.112 m
Datum: NZVD2016

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Weathering
0 – 0.25	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS	
0.25 – 0.6	Sandy silty CLAY; orangish brown. Very soft; moist; high plasticity; trace rootlets; sand, fine (RIVER TERRACE DEPOSITS)	RIVER TERRACE DEPOSITS	M	VS	
0.6 – 2.45	Silty CLAY with some sand and clay; brown. Soft; moist; high plasticity; sand, fine 1.50 Becomes firm		M	S F	
2.45 – 2.55	CORE LOSS				
2.55 – 3.45	Sandy CLAY with some gravel; redish brown. Firm; moist; high plasticity; sand, fine to coarse; gravel, fine to medium, sub rounded completely weathered andesite		M	F	
3.45 – 3.95	CORE LOSS				
3.95 – 4.5	Silty CLAY; orangish brown mottled grey. Firm; moist; high plasticity		M	F	
4.5 – 4.95	Silty clayey GRAVEL with some sand and cobbles; orangish brown. Medium dense; moist; sand, fine to coarse; gravel, angular to sub angular, highly weathered andesite and welded tuff; iron staining at gravel edges (COLLUVIUM)	COLLUVIUM	M	MD	
4.95 – 5.15	CORE LOSS				
5.15 – 7.1	Silty clayey GRAVEL with some sand and cobbles; orangish brown. Medium dense; moist; sand, fine to coarse; gravel, angular to sub angular, highly weathered andesite and welded tuff; rare slightly weathered, strong corase gravel of porphyritic andesitel; iron staining at gravel edges (COLLUVIUM) 6.00 Becomes very dense			VD	
7.1 –	Completely weathered; brownish red; massive welded TUFF; extremely weak (WHIRITOA ANDESITE) 8.20 - 8.85 Recovered as gravel sized fragments	WHIRITOA ANDESITE			CW

Method	Sample Result	TCR SCR RQD (%)
OB		TCR: 100
SPT	SPT 1/0 1/1 1/1 N = 4	
HQTT		TCR: 100
SPT	SPT 1/0 1/1 1/2 N = 5	
HQTT		TCR: 82
SPT	SPT 1/1 1/2 1/2 N = 6	
HQTT		TCR: 48
SPT	SPT 1/2 4/5 8/8 N = 25	
HQTT		TCR: 76
SPT	SPT 2/3 3/0 27 for 75mm bouncing @ 375 mm	
HQTT		TCR: 100
SPT	SPT 2/3 3/3 3/4 N = 13	
HQTT		TCR: 100
SPT	SPT 2/2 3/3 3/3 N = 12	
HQTT		TCR: 100

FINAL

Notes and Comments:

End of Hole @ 22.95m
Silt Pond Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
27/08/20	17:00	12.5	22.95
23/09/20	11:45	13.57	15

Project : WKP Exploration Tunnel - Ground Investigation		Hole No. : WFBH003
Client : Oceana Gold Corporation / GWS / Golder		Sheet : 2 of 3
Site : Willows Farm, Waihi North,		Hole Length : 22.95
Job Number: 12533958		Scale @ A4 : 1:50
Commenced: 24/08/2020	Completed: 27/08/2020	Logged : HJ
Easting: 2763752.035	Northing: 6423791.265	System: NZMG 1949
RL: 163.112 m	Datum: NZVD2016	Method: SURVEY
		Processed : HJ
		Checked : JHS

RL (m)	Depth (m)	Material Description	Geological Unit	Weathering	Sample Number / Type	Result	Method	TCR SCR RQD (%)	Water level
153	10	9.95 - 10.40 Recovered as silty gravel sized fragments Completely weathered; brownish red; massive welded TUFF; extremely weak (WHIRITOA ANDESITE) *(continued from layer starting at 7.1m)*	WHIRITOA ANDESITE	CW			HQTT	TCR: 100	
	10.5				SPT	2/2 3/2 3/2 N = 10	SPT		
152	11	10.95 - 11.20 Recovered as silty gravel sized fragments					HQTT	TCR: 100	
151	12				SPT	1/3 3/2 3/2 N = 10	SPT		
	12.45	CORE LOSS					HQTT	TCR: 90	27-08-2020
150	12.6	Completely weathered; pale brown speckled black and white; massive welded TUFF; extremely weak; some iron oxidization staining present							
	13.5				SPT	2/3 3/4 5/7 N = 19	SPT		23-09-2020
149	14.2	CORE LOSS					HQTT	TCR: 43	
148	14.8	Completely weathered; pale brown speckled black and white; massive welded TUFF; extremely weak; some iron oxidization staining present							
	15				SPT	2/1 3/3 4/1 N = 11	SPT		
147	16						HQTT	TCR: 100	
146	16.5				SPT	3/3 4/5 3/5 N = 17	SPT		
	17						HQTT	TCR: 100	
145	18				SPT	3/3 3/4 4/5 N = 16	SPT		
144	19						HQTT	TCR: 100	
	19.5				SPT	3/5 7/7 8/7 N = 29	SPT		
	20								

Notes and Comments:

End of Hole @ 22.95m
Silt Pond Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical Orientation:

Contractor: Alton Drilling Ltd

Equipment: Tractor Rig, (Rig 83)

SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
27/08/20	17:00	12.5	22.95
23/09/20	11:45	13.57	15

Project : WKP Exploration Tunnel - Ground Investigation Client : Oceana Gold Corporation / GWS / Golder Site : Willows Farm, Waihi North, Job Number: 12533958		Hole No. : WFBH003 Sheet : 3 of 3 Hole Length : 22.95 Scale @ A4 : 1:50
Commenced: 24/08/2020	Completed: 27/08/2020	Logged : HJ
Easting: 2763752.035	Northing: 6423791.265	System: NZMG 1949
RL: 163.112 m	Datum: NZVD2016	Method: SURVEY
Processed : HJ	Checked : JHS	

RL (m)	Depth (m)	Material Description	Geological Unit	Sample Result	Method	Weathering	TCR SCR RQD (%)
143	20	Completely weathered; pale redish grey speckled black and white; massive welded TUFF; extremely weak; some iron oxidization staining present	WHIRITOA ANDESITE		HQTT	CW	TCR: 100 TCR: 100
142	21			SPT 4/5 5/5 5/7 N = 22	SPT		
	21.45	CORE LOSS			HQTT		TCR: 62
141	22.05	Completely weathered; pale redish grey speckled black and white; massive welded TUFF; extremely weak; some iron oxidization staining present		SPT 1/3 6/7 6/6 N = 25	SPT		
140	23	End of Hole @ 22.95m, Target Depth					

Notes and Comments:

End of Hole @ 22.95m
Silt Pond Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:

Contractor: Alton Drilling Ltd

Equipment: Tractor Rig, (Rig 83)

SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
27/08/20	17:00	12.5	22.95
23/09/20	11:45	13.57	15

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 8/09/2020 Completed: 8/09/2020

Hole No. : WFBH004

Sheet : 1 of 2
Hole Length : 15
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763689.493
Northing: 6423889.712
System: NZMG 1949
RL: 161.242 m
Datum: NZVD2016
Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Weathering
0	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS		
0.5	Sandy silty CLAY; brown. Very soft; moist; high plasticity; sand, fine to medium (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	VS		
0.9	CORE LOSS					
1.0	Silty CLAY with some sand; orangish brown mottled grey. Soft; moist; extremely high plasticity; sand, fine to medium		M	S	D-D1 1.20 1.40	
1.6	Silty CLAY; with minor sand; pale grey. Soft; moist; high plasticity; sand, fine to medium. 1.80 XRD lab test results: major: quartz; minor: halloysite, tridymite, cristobalite; trace: gibbsite, smectite		M	S	D-D2 1.80 2.00	
2.85	Gravelly COBBLES with some boulders and silt; grey. Moist; very dense; clast supported; gravel, fine to coarse, sub angular to subrounded; cobbles and boulders, sub rounded, slightly weathered, strong porphyritic andesite; iron oxidation on clast boundaries (possible COLLUVIUM)	COLLUVIUM	M	'VD'		
4.45	CORE LOSS					
4.9	Gravelly COBBLES with some boulders and silt; grey. Moist; very dense; clast supported; gravel, fine to coarse, sub angular to subrounded; cobbles and boulders, sub rounded, slightly weathered, strong porphyritic andesite; iron oxidation on clast boundaries					
6.4	Completely weathered; greyish brown speckled white and orange; massive welded TUFF; recovered as gravel sized fragments (WHIRITOA ANDESITE)	WHIRITOA ANDESITE				CW
6.9	CORE LOSS					
7.5	Completely weathered; greyish brown speckled white and orange; massive welded TUFF; recovered as gravel sized fragments					
9.2	Moderately weathered; grey; porphyritic ANDESITE; magnetic (possible bedrock or colluvium - unconfirmed)					MW

Method	TCR SCR RQD (%)
HQTT	TCR: 70
HQTT	TCR: 81
HQTT	TCR: 119
HQTT	TCR: 100
HQTT	TCR: 100
HQTT	TCR: 96
HQTT	TCR: 47
HQTT	TCR: 95
HQTT	TCR: 100
HQTT	TCR: 33
HQTT	TCR: 100
HQTT	TCR: 90
HQTT	TCR: 100

Water level: 8-09-2020; 23-09-2020

Notes and Comments:

End of Hole @ 15m
Silt Pond Area, No SPT's undertaken due to faulty equipment
No water return information
Field soil descriptions have been adjusted to reflect lab test results were applicable

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
08/09/20	12:00	2.06	5.3
08/09/20	14:00	2.26	7.8
08/09/20	17:00	2.2	15
23/09/20	11:10	6.84	6.2

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 8/09/2020	Completed: 8/09/2020

Hole No.	: WFBH004
Sheet	: 2 of 2
Hole Length	: 15
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763689.493
Northing: 6423889.712
System: NZMG 1949
RL: 161.242 m
Datum: NZVD2016
Method: SURVEY

RL (m)	Depth (m)	Graphic	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Sample Result	Casing	Method	Flush Return (%) 25 50 75	Weathering	Estimated Strength (MPa) EW VW W MS VS ES	TCR SCR RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	Instrumentation Installation	Water level
151 150	10 11		Moderately weathered; grey; porphyritic ANDESITE; magnetic (possible bedrock or colluvium - unconfirmed) *(continued from layer starting at 9.2m)*	WHIRITOA ANDESITE						HQTT		MW		TCR: 100			
149	12									HQTT				TCR: 100			
148	13									HQTT				TCR: 107			
147	14									HQTT				TCR: 96			
146 145 144 143 142	15 16 17 18 19 20		End of Hole @ 15m, Target Depth														

Notes and Comments:

End of Hole @ 15m
Silt Pond Area, No SPT's undertaken due to faulty equipment
No water return information
Field soil descriptions have been adjusted to reflect lab test results were applicable

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)

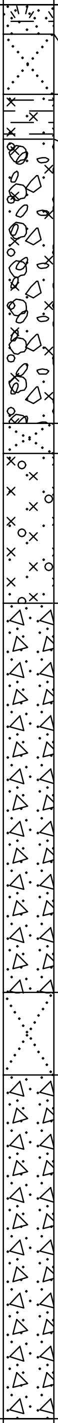
Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
08/09/20	12:00	2.06	5.3
08/09/20	14:00	2.26	7.8
08/09/20	17:00	2.2	15
23/09/20	11:10	6.84	6.2

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 2/09/2020
Completed: 2/09/2020

Hole No.	: WFBH005
Sheet	: 1 of 1
Hole Length	: 9.45
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763826.49 Northing: 6423868.607 System: NZMG 1949
RL: 149.973 m Datum: NZVD2016 Method: SURVEY

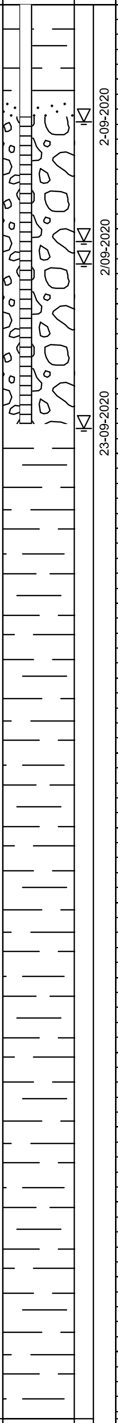


RL (m)	Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
	0–0.2	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS
	0.2–0.6	CORE LOSS			
149	0.6–0.9	Sandy silty CLAY; brown. Very soft, moist, high plasticity, trace rootlets (RIVER TERRACE DEPOSITS)	RIVER TERRACE DEPOSITS	M	VS
148	0.9–2.8	GRAVEL with some sand, cobbles and boulders; grey. Dense; moist; gravel, fine to coarse sub angular to sub rounded, slightly weathered, porphyritic andesite; iron oxidation at clast boundaries. Possible fine matrix - washed out during drilling. 2.00 becomes medium dense	RIVER TERRACE DEPOSITS	M	D MD
147	2.8–3	CORE LOSS (inferred soft ground)			
146	3–4	Sandy SILT with some gravel; reddish brown mottled black. Firm; moist; high plasticity; sand, fine to coarse; gravel, fine, sub angular to sub rounded (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL		F
145, 144	4–6.6	Completely weathered; pale whitish brown speckled black and locally stained orange; massive welded TUFF; extremely weak; partially recovered as gravel sized fragments (WHIRITOA ANDESITE)	WHIRITOA ANDESITE		
143	6.6–7.15	CORE LOSS (inferred soft ground)	WHIRITOA ANDESITE		
142, 141	7.15–9.45	Completely weathered; pale whitish brown speckled black and locally stained orange; massive welded TUFF; extremely weak; partially recovered as gravel sized fragments	WHIRITOA ANDESITE		
140		End of Hole @ 9.45m, Target Depth			

Method	Sample Result	TCR SCR RQD (%)
HQTT		TCR: 60
SPT	SPT 3/2 7/18 7/12 N = 44	
HQTT		TCR: 200
HQTT		TCR: 133
SPT	SPT 6/3 4/2 5/10 N = 21	
HQTT		TCR: 64
SPT	SPT 1/0 1/1 1/2 N = 5	
HQTT		TCR: 123
HQTT		TCR: 137
SPT	SPT 2/1 2/2 2/3 N = 9	
HQTT		TCR: 95
SPT	SPT 2/3 2/3 2/2 N = 9	
HQTT		TCR: 48
SPT	SPT 2/3 4/4 4/4 N = 16	
HQTT		TCR: 100
SPT	SPT 3/4 3/5 6/9 N = 23	

Weathering
CW

Number / Type
Casing
Flush Return (%) 25 50 75
Estimated Strength (MPa) EW VW W MS VS ES
Defect Spacing (mm) 20 60 200 600 2000



Notes and Comments:
End of Hole @ 9.45m
Silt Pond Dam Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
02/09/20	10:00	0.75	2.45
02/09/20	12:00	1.7	3.45
02/09/20	14:00	1.55	4.95
23/09/20	10:45	2.8	1.39

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 1/09/2020
Completed: 1/09/2020

Hole No. : WFBH006-D
Sheet : 1 of 1
Hole Length : 7.95
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

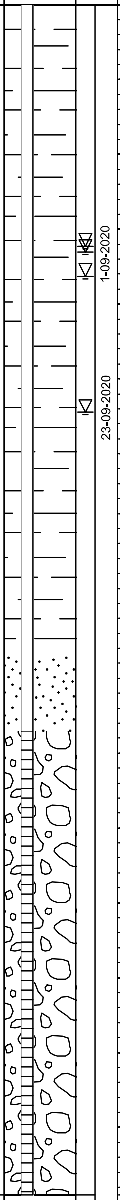
Easting: 2763792.346
Northing: 6423908.639
System: NZMG 1949
RL: 151.013 m
Datum: NZVD2016
Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0 – 0.2	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS
0.2 – 0.5	Sandy SILT; brown. Very soft; moist; high plasticity; trace rootlets (RIVER TERRACE DEPOSITS)	RIVER TERRACE DEPOSITS	M	VS
0.5 – 0.9	CORE LOSS			
0.9 – 2.45	GRAVEL with cobbles and boulders; grey. Moist; dense; gravel, fine to coarse, sub angular to sub rounded; cobbles and boulders, slightly weathered, strong, porphyritic andesite. Fine matrix possibly washed out during drilling. 2.00 becomes medium dense		M	D MD
2.45 – 2.6	CORE LOSS			
2.6 – 3.45	Completely weathered; pale whitish brown speckled black locally stained orange; massive welded TUFF; extremely weak; partially recovered as gravel sized fragments (WHIRITOA ANDESITE)	WHIRITOA ANDESITE		
3.45 – 3.9	CORE LOSS			
3.9 – 4.95	Completely weathered; pale whitish brown speckled black locally stained orange; massive welded TUFF; extremely weak; partially recovered as gravel sized fragments			
4.95 – 5.05	CORE LOSS (inferred soft ground)			
5.05 – 6.45	Completely weathered; pale whitish brown speckled black locally stained orange; massive welded TUFF; extremely weak; partially recovered as gravel sized fragments			
6.45 – 6.67	CORE LOSS			
6.67 – 7.95	Completely weathered; pale whitish brown speckled black locally stained orange; massive welded TUFF; extremely weak; partially recovered as gravel sized fragments			
8	End of Hole @ 7.95m, TD			

Method	Sample Result	TCR SCR RQD (%)
HQTT		TCR: 56
SPT	SPT 2/2 6/12 11/18 N = 37	
HQTT		TCR: 100
SPT	SPT 2/4 5/5 4/5 N = 19	
HQTT		TCR: 73
SPT	SPT 2/4 5/4 4/6 N = 19	
HQTT		TCR: 57
SPT	SPT 1/4 5/5 4/7 N = 17	
HQTT		TCR: 71
HQTT		TCR: 100
SPT	SPT 2/1 4/4 5/5 N = 18	
HQTT		TCR: 79
SPT	SPT 2/1 4/3 4/5 N = 16	

Weathering: CW

Water level: 1-09-2020; 23-09-2020



Notes and Comments:
End of Hole @ 7.95m
Silt Pond Dam Area

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
01/09/20	09:00	1.58	3.45
01/09/20	11:00	1.78	6.45
01/09/20	12:00	1.62	7.95
23/09/20	10:38	2.69	7.95

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 9/09/2020	Completed: 9/09/2020

Hole No.	: WFBH007
Sheet	: 1 of 1
Hole Length	: 7.95
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

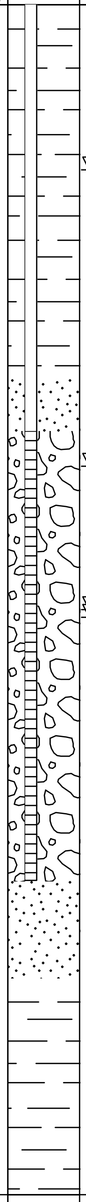
Easting: 2763768.561
Northing: 6423899.258
System: NZMG 1949
RL: 152.388 m
Datum: NZVD2016
Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL		
0.25	Sandy SILT; orangish brown. Very soft; moist; high plasticity; sand, fine to medium (RIVER TERRACE DEPOSITS)	RIVER TERRACE DEPOSITS	M	VS
0.5	CORE LOSS			
1	Sandy silty CLAY; orangish brown. Soft; moist; high plasticity; sand, fine to medium		M	S
1.5	Silty CLAY with some sand; orangish brown mottled grey. Stiff; moist; high plasticity; sand, fine to medium		M	St
2.45	Silty GRAVEL with some sand; brown and grey. Medium dense; moist; matrix supported; sand, fine to coarse; gravel, fine to coarse, subangular to subrounded slightly weathered andesite		M	MD
3	Sandy silty CLAY; reddish brown speckled grey. Firm; moist; high plasticity; sand, fine to medium (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL	M	F
5.5	Sandy SILT; dark reddish brown. Firm; moist; high plasticity; sand, fine to coarse		M	F
5.8	Completely weathered; pale reddish brown speckled grey and black; massive welded TUFF; extremely weak; minor iron staining (WHIRITOA ANDESITE)	WHIRITOA ANDESITE		
8	End of Hole @ 7.95m, Target Depth			

Sample Result	Method	TCR SCR RQD (%)
	HQTT	TCR: 50
SPT 1/0 0/1 1/1 N = 3	SPT	
	HQTT	TCR: 143
	HQTT	TCR: 100
SPT 4/3 4/4 4/4 N = 16	SPT	
	HQTT	TCR: 133
SPT 3/2 1/2 3/2 N = 8	SPT	
	HQTT	TCR: 0
	HQTT	TCR: 100
SPT 1/1 1/1 1/1 N = 4	SPT	
	HQTT	TCR: 100
SPT 1/2 2/1 1/2 N = 6	SPT	
	HQTT	TCR: 100
SPT 3/3 2/2 3/4 N = 11	SPT	

Weathering: CW

Water level: 9-09-2020 (1), 9-09-2020 (3), 9-09-2020 (4)



Notes and Comments:
End of Hole @ 7.95m
Silt Pond Dam Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
09/09/20	10:00	1.07	2
09/09/20	14:00	4.06	6
09/09/20	17:00	3.05	7.5
23/09/20	10:50	4.01	5.85

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 9/11/2020	Completed: 9/11/2020

Hole No.	**: WFBH008**
Sheet	: 1 of 1
Hole Length	: 9.6
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763442.597
Northing: 6423517.155
System: NZMG 1949
RL: 229.71 m
Datum: NZVD2016
Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Sample Result	Weathering
0.10	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS			
2	Sandy silty CLAY; brown. Firm; moist; high plasticity; sand, fine (RESIDUAL SOIL - ALLOPHANE) 0.50 becomes orangish brown 1.80 becomes stiff	RESIDUAL SOIL	M	F St	D-D1 (1.10–1.35)	SPT 1/0 2/2 2/3 N = 9	
3.6	CLAY with some sand and silt; orange brown. Stiff; moist; high plasticity; sand, fine	RESIDUAL SOIL	M	St		SPT 1/1 3/3 2/2 N = 10	
8.175	Completely weathered; grey speckled orange and white; locally stained black; massive welded TUFF; extremely weak (WHIRITOA ANDESITE) 7.50 becomes very weak	WHIRITOA ANDESITE				SPT 1/4 4/4 6/4 N = 18 SPT 4/7 8/10 10/18 N = 41 SPT 3/8 9/17 24 for 75mm N > 50	CW
8.825	CORE LOSS	WHIRITOA ANDESITE					
9.6	Completely weathered; grey speckled orange and white; locally stained black; massive welded TUFF; very weak	WHIRITOA ANDESITE				SPT 1/5 16/34 for 75mm N > 50	
	End of Hole @ 9.6m, TD						

Method	TCR SCR RQD (%)
HQTT	TCR: 100
HQTT	TCR: 100
SPT	TCR: 100
HQTT	TCR: 100
SPT	TCR: 100
HQTT	TCR: 100
SPT	TCR: 100
HQTT	TCR: 100
SPT	TCR: 100
HQTT	TCR: 100
SPT	TCR: 100
HQTT	TCR: 36
SPT	TCR: 100

Water level: 10-11-2020

Notes and Comments:

End of Hole @ 9.6m
Magazine Compound Area
Lost water return at 6.3m

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:

Contractor: Alton Drilling Ltd

Equipment: Tractor Rig, (Rig 83)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
10/11/20	07:00	5.7	9.6

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 10/09/2020 Completed: 10/09/2020

Hole No. : WFBH009
Sheet : 1 of 1
Hole Length : 9.45
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763604.373 Northing: 6423700.722 System: NZMG 1949
RL: 180.613 m Datum: NZVD2016 Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Result
0 – 0.3	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS		
0.3 – 0.8	Sandy silty CLAY; orangish brown. Very soft; moist; high plasticity; sand, fine to medium (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	VS		
0.8 – 1.1	CORE LOSS					
1.1 – 1.5	Sandy silty CLAY; orangish brown. Soft; moist; high plasticity; sand, fine to medium		M	S		
1.5 – 2.0	Silty CLAY with some sand; brown. Firm; moist; high plasticity; sand, fine to medium		M	F		SPT 1/0 1/1 1/2 N = 5
2.0595	CORE LOSS					
– 2.95	Silty CLAY with some sand; brown. Firm; moist; high plasticity, sand, fine to medium		M	F		
2.95 – 4.05	Silty CLAY with some sand; reddish brown. Firm; moist; very high plasticity; sand, fine to coarse 3.00 XRD lab test results: major: halloysite, cristobalite, tridymite; minor: quartz		M	F	SPT-D1 3.00 – 3.45	SPT 1/1 1/1 2/1 N = 5
4.05 – 4.5	Silty GRAVEL with some cobbles. 'Medium dense'; moist; matrix supported; gravel, fine to coarse sub angular to sub rounded slightly weathered, moderately strong, porphyritic andesite (possible COLLUVIUM)	COLLUVIUM	M	'MD'		
4.5 – 7.5	Silty CLAY; reddish brown speckled mottled white and black. Stiff; moist; high plasticity (RESIDUAL SOIL - WHIRITOA ANDESITE) 7.20 - 7.50 recovered as gravel sized fragments	RESIDUAL SOIL - WHIRITOA ANDESITE	M	St		SPT 1/2 2/2 2/2 N = 8 SPT 1/2 2/3 3/4 N = 12
7.5 – 9.45	Silty CLAY; reddish brown speckled white and grey. Stiff; moist; high plasticity 9.00 becomes firm		M	St F		SPT 1/2 2/2 4/4 N = 12 SPT 0/1 1/1 2/3 N = 7

End of Hole @ 9.45m, Target Depth

Method	TCR SCR RQD (%)
HQTT	TCR: 64
HQTT	TCR: 125
SPT	
HQTT	TCR: 86
SPT	
HQTT	TCR: 90
SPT	
HQTT	TCR: 86
SPT	
HQTT	TCR: 100
SPT	
HQTT	TCR: 100
SPT	

Water level: 10-09-2020, 10-09-2020, 23-09-2020

Notes and Comments:
End of Hole @ 9.45m
Wasterock Stack Area/Portal Entrance Invert Elevation - Piezo
No water return information
Field soil descriptions have been adjusted to reflect lab test results were applicable

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

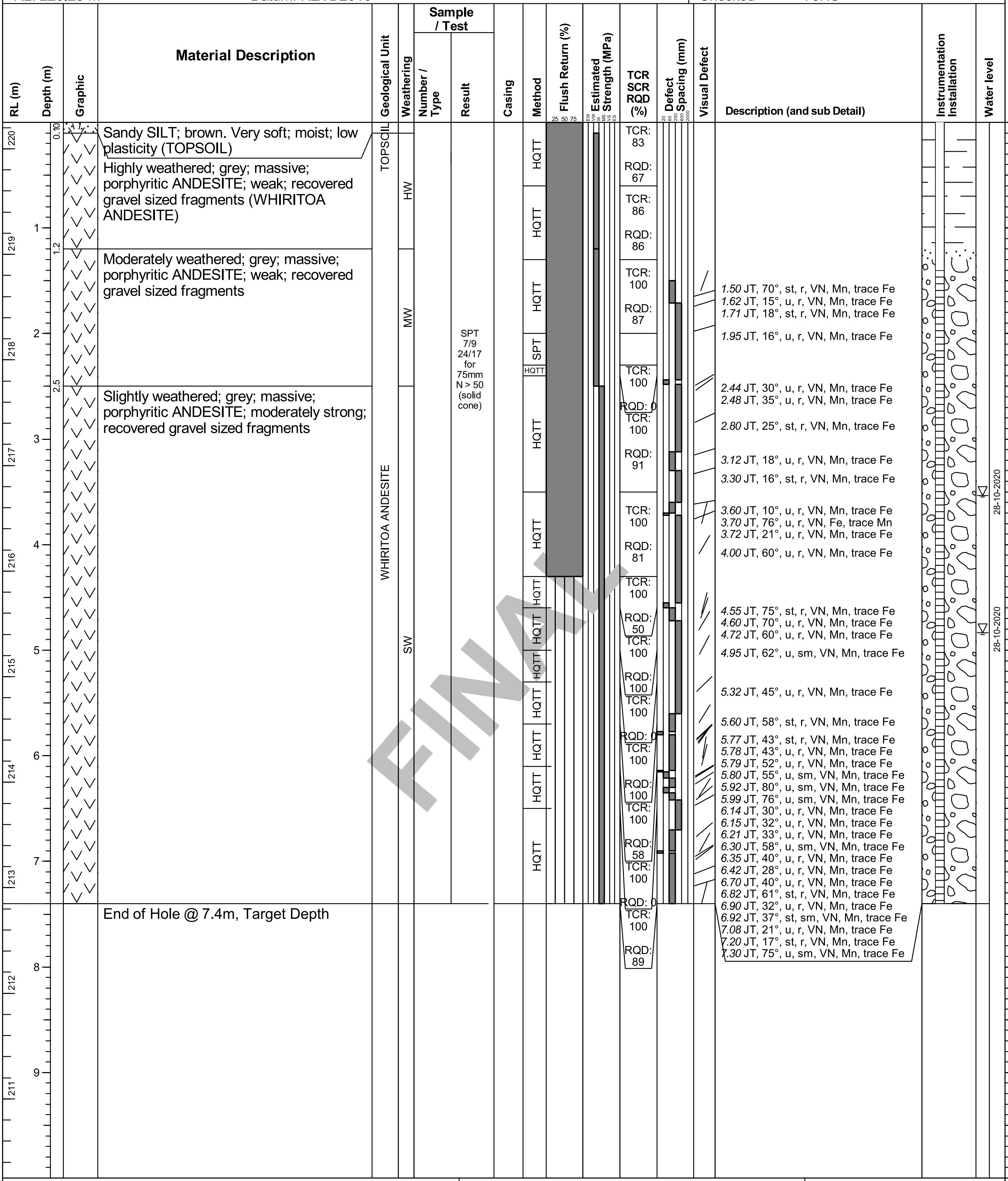
Date	Time	Reading (mbgl)	Hole depth (mbgl)
10/09/20	10:00	1.56	3
10/09/20	12:00	2.65	6
10/09/20	14:00	1.62	9.45
23/09/20	11:37	7.22	9.45

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958

Commenced: 27/10/2020
Completed: 28/10/2020

Hole No. : WFBH010
Sheet : 1 of 1
Hole Length : 7.4
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763258.002
Northing: 6423876.493
System: NZMG 1949
Method: SURVEY
RL: 220.25 m
Datum: NZVD2016



Depth (m)	Material Description	Geological Unit	Weathering
0 – 0.10	Sandy SILT; brown. Very soft; moist; low plasticity (TOPSOIL)	TOPSOIL	
0.10 – 1.2	Highly weathered; grey; massive; porphyritic ANDESITE; weak; recovered gravel sized fragments (WHIRITOA ANDESITE)	WHIRITOA ANDESITE	HW
1.2 – 2.5	Moderately weathered; grey; massive; porphyritic ANDESITE; weak; recovered gravel sized fragments		MW
2.5 – 7.4	Slightly weathered; grey; massive; porphyritic ANDESITE; moderately strong; recovered gravel sized fragments		SW
7.4	End of Hole @ 7.4m, Target Depth		

Sample / Test

Number / Type	Result
	SPT 7/9 24/17 for 75mm N > 50 (solid cone)

TCR SCR RQD (%)

TCR	RQD
83	67
86	86
100	87
100	0
100	91
100	81
100	50
100	100
100	0
100	100
100	58
100	0
100	89

Description (and sub Detail)

1.50 JT, 70°, st, r, VN, Mn, trace Fe
1.62 JT, 15°, u, r, VN, Mn, trace Fe
1.71 JT, 18°, st, r, VN, Mn, trace Fe
1.95 JT, 16°, u, r, VN, Mn, trace Fe
2.44 JT, 30°, u, r, VN, Mn, trace Fe
2.48 JT, 35°, u, r, VN, Mn, trace Fe
2.80 JT, 25°, st, r, VN, Mn, trace Fe
3.12 JT, 18°, u, r, VN, Mn, trace Fe
3.30 JT, 16°, st, r, VN, Mn, trace Fe
3.60 JT, 10°, u, r, VN, Mn, trace Fe
3.70 JT, 76°, u, r, VN, Fe, trace Mn
3.72 JT, 21°, u, r, VN, Mn, trace Fe
4.00 JT, 60°, u, r, VN, Mn, trace Fe
4.55 JT, 75°, st, r, VN, Mn, trace Fe
4.60 JT, 70°, u, r, VN, Mn, trace Fe
4.72 JT, 60°, u, r, VN, Mn, trace Fe
4.95 JT, 62°, u, sm, VN, Mn, trace Fe
5.32 JT, 45°, u, r, VN, Mn, trace Fe
5.60 JT, 58°, st, r, VN, Mn, trace Fe
5.77 JT, 43°, st, r, VN, Mn, trace Fe
5.78 JT, 43°, u, r, VN, Mn, trace Fe
5.79 JT, 52°, u, r, VN, Mn, trace Fe
5.80 JT, 55°, u, sm, VN, Mn, trace Fe
5.92 JT, 80°, u, sm, VN, Mn, trace Fe
5.99 JT, 76°, u, sm, VN, Mn, trace Fe
6.14 JT, 30°, u, r, VN, Mn, trace Fe
6.15 JT, 32°, u, r, VN, Mn, trace Fe
6.21 JT, 33°, u, r, VN, Mn, trace Fe
6.30 JT, 58°, u, sm, VN, Mn, trace Fe
6.35 JT, 40°, u, r, VN, Mn, trace Fe
6.42 JT, 28°, u, r, VN, Mn, trace Fe
6.70 JT, 40°, u, r, VN, Mn, trace Fe
6.82 JT, 61°, st, r, VN, Mn, trace Fe
6.90 JT, 32°, u, r, VN, Mn, trace Fe
6.92 JT, 37°, st, sm, VN, Mn, trace Fe
7.08 JT, 21°, u, r, VN, Mn, trace Fe
7.20 JT, 17°, st, r, VN, Mn, trace Fe
7.30 JT, 75°, u, sm, VN, Mn, trace Fe

Notes and Comments:

End of Hole @ 7.4m
Tunnel Alignment - Gully Crossing Piezo
SPT at 2.0m=bouncing; further SPT's not undertaken due to rig instability
Lost water return 4.3m

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Fly Rig (Rig #33)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
28/10/20	10:00	3.5	4
28/10/20	17:00	4.8	7.4

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 15/09/2020
Completed: 16/09/2020

Hole No. : WFBH011
Sheet : 1 of 2
Hole Length : 15.08
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2762897.705
Northing: 6423934.452
System: NZMG 1949
RL: 233.18 m
Datum: NZVD2016
Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0 – 0.2	SILT with some sand; dark brown. Very soft; moist; low plasticity; trace rootlets; sand, fine to medium (TOPSOIL)	TOPSOIL	M	VS
0.2 – 0.55	Sandy silty CLAY; orangish brown. Very soft; moist; high plasticity; sand, fine (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	VS
0.55 – 0.8	CORE LOSS			
0.8 – 1.11	Silty CLAY; orangish brown. Very soft; moist; high plasticity		M	VS
1.11	CORE LOSS			
– 2.4	Sandy silty CLAY with some gravel; reddish brown. Very soft; moist; high plasticity; gravel, fine to medium, sub angular to sub rounded, grey completely weathered, extremely weak, andesite		M	VS
2.4 – 3.4	Silty CLAY with trace sand and gravel; orangish brown mottled grey. Firm; moist; high plasticity; sand, fine to medium; gravel, fine, sub angular to sub rounded, completely weathered, extremely weak andesite		M	F
3.4 – 5.5	Sandy silty CLAY; orangish brown. Firm; moist; high plasticity; sand, fine 4.50 becomes stiff		M	F St
5.5 – 6.45	Completely weathered; orangish brown; massive welded TUFF; extremely weak; locally stained orange and black; recovered as gravel sized fragments (WHIRITOA ANDESITE - COLLUVIUM/SLIP)	WHIRITOA ANDESITE - COLUVIUM/SLIP		
6.45 – 6.6	CORE LOSS			
6.6 – 8.85	Silty sandy GRAVEL with cobbles and boulders; grey and brown. 'Dense'; moist; gravel, fine to coarse, sub angular to sub rounded, slightly weathered to highly weathered, weak to strong porphyritic andesite; iron and manganese staining across clast boundaries; sand, fine to coarse; brown. Silt matrix possibly washed out during drilling		M	'D'
8.85 –	Slightly weathered; grey; massive; porphyritic ANDESITE; strong; unaltered; magnetic iron staining along defects (WHIRITOA ANDESITE) *9.15* JT, 60°, u, r, VN, Fe, trace clay *9.40* JT, 30°, u, r, VN, Fe, trace clay	WHIRITOA ANDESITE		

Method	Sample Result	TCR SCR RQD (%)
HQTT		TCR: 69
HQTT		TCR: 86
SPT	SPT 1/0 0/1 0/1 N = 2	
HQTT		TCR: 100
HQTT		TCR: 100
SPT	SPT 0/1 0/2 3/2 N = 7	
HQTT		TCR: 100
HQTT		TCR: 90
SPT	SPT 1/2 2/3 3/3 N = 11	
HQTT		TCR: 100
SPT	SPT 3/1 8/4 4/4 N = 20	
HQTT		TCR: 100 RQD: 12
SPT	SPT 2/2 2/3 4/4 N = 13	
HQTT		TCR: 100 RQD: 11
	SPT 50 for 15mm N > 50	
HQTT		TCR: 100 RQD: 100

Weathering: CW, SW

Water level: 15-09-2020, 15-09-2020, 16-09-2020, 16-09-2020

Notes and Comments:
End of Hole @ 15.08m
Tunnel Alignment - Gully Crossing Piezo

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
15/09/20	10:00	2.36	4.8
15/09/20	17:00	3.16	9
16/09/20	12:00	8.96	12
16/09/20	17:00	8.04	15

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 15/09/2020
Completed: 16/09/2020

Hole No. : WFBH011
Sheet : 2 of 2
Hole Length : 15.08
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2762897.705
Northing: 6423934.452
System: NZMG 1949
RL: 233.18 m
Datum: NZVD2016
Method: SURVEY

Material Description

9.80 JT, 32°, u, r, VN, Fe, trace clay
Slightly weathered; grey; massive; porphyritic ANDESITE; strong; unaltered; magnetic iron staining along defects (WHIRITOA ANDESITE) *(continued from layer starting at 8.9m)*

10.00 JT, 30°, u, r, VN, Fe

10.50 JT, 40°, u, r, VN, Fe

11.40 JT, 55°, u, r, VN, CLAY, trace Fe

11.45 JT, 12°, u, r, VN, CLAY, trace Fe

12.00 JT, 30°, u, r, VN, CLAY, trace Fe

12.20 JT, 60°, u, r, VN, CLAY

12.90 JT, 50°, u, r, VN, Fe, trace clay

13.20 JT, 30°, u, r, VN, CLAY, trace Fe

13.25 JT, 20°, u, r, N, CLAY, trace Fe

13.75 JT, 15°, u, r, VN, Fe

13.85 JT, 18°, u, r, VN, Fe

13.90 JT, 18°, u, r, VN, Fe

14.15 JT, 40°, u, r, VN, Fe

14.30 JT, 20°, u, r, VN, Fe

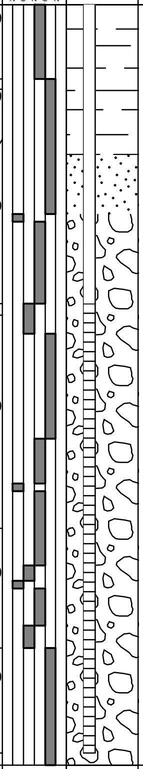
End of Hole @ 15.08m, TD

Geological Unit: WHIRITOA ANDESITE

Weathering: SW

Sample Result
SPT 50 for 65mm N > 50 (solid cone)
SPT 50 for 75mm N > 50 (solid cone)
SPT 45/5 for 5mm N > 50 (solid cone)

Method	TCR SCR RQD (%)
	TCR: 100 RQD: 100
HQTT	TCR: 100 RQD: 100
HQTT	TCR: 100 RQD: 91
HQTT	TCR: 100 RQD: 89
HQTT	TCR: 100 RQD: 94
HQTT	TCR: 100 RQD: 100



Notes and Comments:
End of Hole @ 15.08m
Tunnel Alignment - Gully Crossing Piezo

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
15/09/20	10:00	2.36	4.8
15/09/20	17:00	3.16	9
16/09/20	12:00	8.96	12
16/09/20	17:00	8.04	15

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 20/10/2020
Completed: 22/10/2020

Hole No. : WFBH012-D
Sheet : 1 of 2
Hole Length : 18.3
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2762718.664
Northing: 6424155.793
System: NZMG 1949
Method: SURVEY
RL: 246.49 m
Datum: NZVD2016

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0.15	SILT; brown. Very soft; moist; low plasticity; rootlets (TOPSOIL)	TOPSOIL	M	VS
0.3	CORE LOSS			
1.1	Silty CLAY with some sand; orange. Very soft; moist; high plasticity; sand, fine to medium (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	VS
1.4	CORE LOSS			
2.45	Sandy CLAY; orange. Very soft; moist; high plasticity; sand, fine to medium.		M	VS
2.65	Silty fine to medium GRAVEL; grey. Very loose; moist; low plasticity; subangular to subrounded moderately weathered andesite (RESIDUAL SOIL of WAIPUPU FORMATION)	RESIDUAL SOIL of WAIPUPU FORMATION	M	VL
2.82	Silty CLAY with some sand and gravel; brownish grey mottled orange. Very soft; moist; high plasticity; sand, fine to medium; gravel; fine subrounded andesite		M	S
4.4	Gravelly coarse SAND; grey. Medium dense; moist; gravel, fine, subangular to subrounded (possible drilling induced damage to core)		M	MD
6.3	Sandy silty CLAY with some gravel; brownish grey. Hard; moist; high plasticity; sand, fine to medium; gravel, fine, subangular to subrounded andesite (core re-drilled)		M	H
7.2	Completely weathered; grey; massive LAPILLI TUFF (andesite); extremely weak; recovered as gravel sized fragments (WAIPUPU FORMATION)	WAIPUPU FORMATION		
7.95	CORE LOSS			
	Completely weathered; grey; massive LAPILLI TUFF (andesite); extremely weak; recovered as gravel sized fragments, subangular to subrounded 9.15 - 9.35 Recovered as solid core			

Sample: D-D1 0.80 1.00

Weathering: CW

Method	Result	TCR SCR RQD (%)
HQTT		TCR: 73
HQTT		TCR: 56
SPT	SPT 0/0 0/0 0/1 N = 1	
HQTT		TCR: 100
HQTT		TCR: 57
SPT	SPT 1/2 3/3 4/7 N = 14	
HQTT		TCR: 100
HQTT		TCR: 100
SPT	SPT 3/4 6/7 9/13 N = 35	
HQTT		TCR: 100
HQTT		TCR: 100 RQD: 0
SPT	SPT 3/3 5/5 5/7 N = 22 (solid cone)	
HQTT		TCR: 100 RQD: 0
HQTT		TCR: 6 RQD: 0
SPT	SPT 3/10 16/19 13 for 60mm N > 50	
HQTT		TCR: 100 RQD: 0
HQTT		TCR: 60 RQD: 0
HQTT		TCR: 100 RQD: 0
HQTT		TCR: 100 RQD: 0
HQTT		TCR: 0

Water level: 20-10-2020 - 22-10-2020

Notes and Comments:
End of Hole @ 18.3m
Tunnel Alignment - Gully Crossing Piezo
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Fly Rig (Rig #33)

Ground Water Level

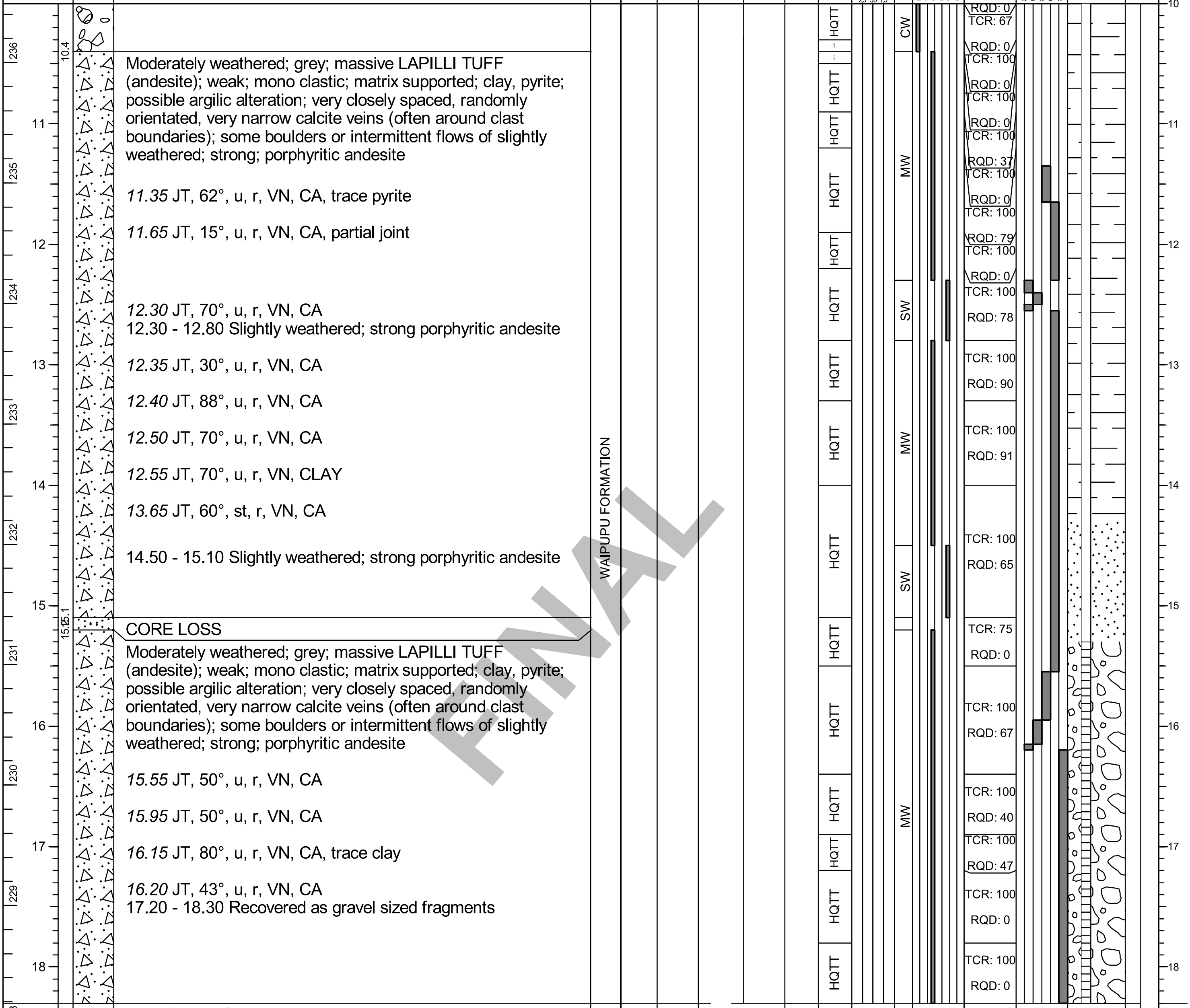
Date	Time	Reading (mbgl)	Hole depth (mbgl)
20/10/20	10:00	1.9	2.45
20/10/20	17:00	2.5	5.45
21/10/20	07:00	2	5.45
22/10/20	17:00	2.4	18.3

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 20/10/2020
Completed: 22/10/2020

Hole No. : WFBH012-D
Sheet : 2 of 2
Hole Length : 18.3
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2762718.664
Northing: 6424155.793
System: NZMG 1949
RL: 246.49 m
Datum: NZVD2016
Method: SURVEY

RL (m) | Depth (m) | Graphic | Material Description | Geological Unit | Moisture condition | Consistency / Relative Density | Sample: Number / Type, Result | Casing | Method | Flush Return (%) (25 50 75) | Weathering | Estimated Strength (MPa) (EW VW W MS VS ES) | TCR SCR RQD (%) | Defect Spacing (mm) (20 60 200 600 2000) | Instrumentation Installation | Water level



10.4

Moderately weathered; grey; massive LAPILLI TUFF (andesite); weak; mono clastic; matrix supported; clay, pyrite; possible argilic alteration; very closely spaced, randomly orientated, very narrow calcite veins (often around clast boundaries); some boulders or intermittent flows of slightly weathered; strong; porphyritic andesite

11.35 JT, 62°, u, r, VN, CA, trace pyrite

11.65 JT, 15°, u, r, VN, CA, partial joint

12.30 JT, 70°, u, r, VN, CA
12.30 - 12.80 Slightly weathered; strong porphyritic andesite

12.35 JT, 30°, u, r, VN, CA

12.40 JT, 88°, u, r, VN, CA

12.50 JT, 70°, u, r, VN, CA

12.55 JT, 70°, u, r, VN, CLAY

13.65 JT, 60°, st, r, VN, CA

14.50 - 15.10 Slightly weathered; strong porphyritic andesite

15.1
15.25

CORE LOSS

Moderately weathered; grey; massive LAPILLI TUFF (andesite); weak; mono clastic; matrix supported; clay, pyrite; possible argilic alteration; very closely spaced, randomly orientated, very narrow calcite veins (often around clast boundaries); some boulders or intermittent flows of slightly weathered; strong; porphyritic andesite

15.55 JT, 50°, u, r, VN, CA

15.95 JT, 50°, u, r, VN, CA

16.15 JT, 80°, u, r, VN, CA, trace clay

16.20 JT, 43°, u, r, VN, CA
17.20 - 18.30 Recovered as gravel sized fragments

End of Hole @ 18.3m, Target Depth

Geological Unit: WAIPUPU FORMATION

Method: HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT, HQTT

Weathering: CW, MW, SW, MW, SW, MW

TCR / RQD (%):
RQD: 0
TCR: 67
RQD: 0
TCR: 100
RQD: 0
TCR: 100
RQD: 0
TCR: 100
RQD: 37
TCR: 100
RQD: 0
TCR: 100
RQD: 79
TCR: 100
RQD: 0
TCR: 100
RQD: 78
TCR: 100
RQD: 90
TCR: 100
RQD: 91
TCR: 100
RQD: 65
TCR: 75
RQD: 0
TCR: 100
RQD: 67
TCR: 100
RQD: 40
TCR: 100
RQD: 47
TCR: 100
RQD: 0
TCR: 100
RQD: 0

Notes and Comments:
End of Hole @ 18.3m
Tunnel Alignment - Gully Crossing Piezo
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Fly Rig (Rig #33)

Ground Water Level

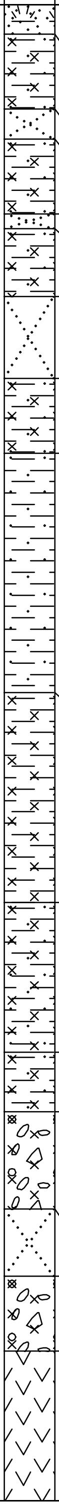
Date	Time	Reading (mbgl)	Hole depth (mbgl)
20/10/20	10:00	1.9	2.45
20/10/20	17:00	2.5	5.45
21/10/20	07:00	2	5.45
22/10/20	17:00	2.4	18.3

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 11/09/2020
Completed: 15/09/2020

Hole No. : WFBH013

Sheet : 1 of 2
Hole Length : 16.85
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2762593.666
Northing: 6424370.633
System: NZMG 1949
RL: 205.2 m
Datum: NZVD2016
Method: SURVEY

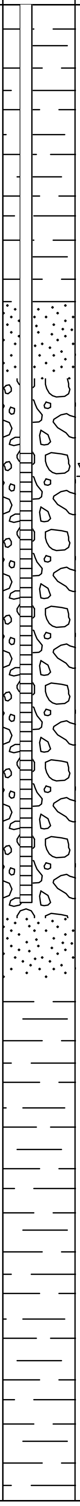


Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0 – 0.2	SILT, some sand; dark brown. Very soft, moist, low plasticity, trace rootlets. Sand: fine to medium. (TOPSOIL)	TOPSOIL	M	VS
0.2 – 0.7	Silty CLAY with some sand; orangish brown mottled grey and black. Very soft; moist; high plasticity; sand, fine to medium (RESIDUAL SOIL OF WAIPUPU FORMATION)	RESIDUAL SOIL OF WAIPUPU FORMATION	M	VS
0.7 – 0.9	CORE LOSS			
0.9 – 1.4	Silty CLAY with some sand; orangish brown mottled grey and black. Soft; moist; high plasticity; sand, fine to medium		M	VS
1.4 – 1.5	CORE LOSS			
1.5 – 1.95	Silty CLAY with some sand; orangish brown mottled grey and black. Soft; moist; high plasticity; sand, fine to medium		M	S
1.95 – 2.5	CORE LOSS			
2.5 – 3	CLAY with some silt and sand; orangish brown mottled grey and black. Soft; moist; high plasticity; sand fine to medium		M	S
3 – 4.6	Sandy CLAY with some gravel; grey. Very soft; moist; high plasticity; some organics; sand, fine to coarse; gravel, fine, subangular to subrounded 4.50 - 4.60 Peat; black; firm; fibrous		M	VS
4.6 – 6	Silty CLAY with minor sand; grey. Very soft; moist; high plasticity; some organics; sand, fine to medium		M	VS
6 – 7	Silty CLAY with some sand; grey. Very soft; moist; high plasticity; sand, fine to medium 6.45 - 6.70 Peat; black; firm; fibrous		M	VS
7 – 7.4	Sandy silty CLAY; grey. Soft; moist; moderate plasticity; trace organics; sand, fine to coarse		M	S
7.4 – 8.05	Silty GRAVEL with some cobbles; grey and brown. Medium dense; moist; gravel, fine to coarse, sub angular to sub rounded moderately to slightly weathered, moderately strong, porphyritic andesite. Silt matrix possibly washed out during drilling (possible COLLUVIUM)	COLLUVIUM	M	MD
8.05 – 8.5	CORE LOSS			
8.5 – 9	Silty GRAVEL with some cobbles; grey and brown. Medium dense; wet; gravel, fine to coarse, subangular to subrounded moderately weathered andesite; matrix supported		W	MD
9 –	Completely weathered; grey; massive; porphyritic ANDESITE; extremely weak with clay altered phenocrysts; argilic alteration; calcite, pyrite and hematite alteration (WAIPUPU FORMATION)			

Method	Sample Result	TCR SCR RQD (%)
HQTT		TCR: 100
HQTT		TCR: 83
SPT	SPT 1/1 1/1 1/1 N = 4	
HQTT		TCR: 52
SPT	SPT 1/0 0/0 0/0 N = 0	
HQTT		TCR: 100
SPT	SPT 1/1 0/1 0/0 N = 1	
HQTT		TCR: 100
SPT	SPT 0/1 1/0 0/0 N = 1	
HQTT		TCR: 100
SPT	SPT 2/1 5/4 4/7 N = 20	
HQTT		TCR: 61
SPT	SPT 6/8 5/6 7/7 N = 25	
HQTT		TCR: 100

Weathering: CW

Water level: 3-09-2020



Notes and Comments:
End of Hole @ 16.85m
Mataura Stream Piezo
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Ltd
Equipment: Tractor Rig, (Rig 83)
SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
03/09/20	08:00	3.12	16.85

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 11/09/2020	Completed: 15/09/2020

Hole No.	: WFBH013
Sheet	: 2 of 2
Hole Length	: 16.85
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2762593.666 Northing: 6424370.633 System: NZMG 1949

RL: 205.2 m Datum: NZVD2016 Method: SURVEY

RL (m)	Depth (m)	Material Description	Geological Unit	Weathering	Sample Number / Type	Sample Result	Method	TCR SCR RQD (%)
195–188	10.00–16.85	Completely weathered; grey; massive; porphyritic ANDESITE; extremely weak with clay altered phenocrysts; argilic alteration; calcite, pyrite and hematite alteration (WAIPUPU FORMATION) *(continued from layer starting at 9.0m)*	WAIPUPU FORMATION	CW				
	10.0–10.5						HQTT	TCR: 100
	10.5–10.95					SPT 3/2 5/6 8/8 N = 27	SPT	
	10.95–12.0						HQTT	TCR: 100
	12.0–12.45					SPT 3/4 4/5 7/7 N = 23	SPT	
	12.45–13.5						HQTT	TCR: 100
	13.5–13.86					SPT 7/10 13/19 18 for 60mm N > 50	SPT	
	13.86–15.0						HQTT	TCR: 100
	15.0–15.4					SPT 3/5 14/15 17/4 for 70mm N > 50	SPT	
	15.40–15.60				C-C1 15.40 15.60			
	15.4–16.5						HQTT	TCR: 100
	16.00	*16.00 - 16.50* VN, 75°, u, r, N, CA						
	16.5–16.85					SPT 5/7 15/21 14 for 50mm N > 50	SPT	
	16.85	End of Hole @ 16.85m, Target Depth						

Depth scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20. RL scale: 195, 194, 193, 192, 191, 190, 189, 188, 187, 186.

Other columns: Moisture condition; Consistency / Relative Density; Casing; Flush Return (%) 25 50 75; Estimated Strength (MPa) EW VW W MS S VS ES; Defect Spacing (mm) 20 60 200 600 2000; Instrumentation Installation; Water level.

Notes and Comments:

End of Hole @ 16.85m
Mataura Stream Piezo
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical Orientation:

Contractor: Alton Drilling Ltd

Equipment: Tractor Rig, (Rig 83)

SPT ETR: 81%

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
03/09/20	08:00	3.12	16.85

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 29/10/2020
Completed: 2/11/2020

Hole No. : WFBH014
Sheet : 1 of 4
Hole Length : 32
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763515.665
Northing: 6423696.752
System: NZMG 1949
Method: SURVEY
RL: 200.02 m
Datum: NZVD2016

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0.10	SILT, some sand; dark brown. Very soft, moist, low plasticity, trace rootlets. Sand: fine to medium. (TOPSOIL)	Topsoil	M	VS
0.6	Silty CLAY with some sand and gravel; brown. Very soft; moist; high plasticity; sand, fine to coarse; gravel, fine to coarse; sub angular to sub rounded (RESIDUAL SOIL)	RESIDUAL SOIL	M	VS
1.7	CORE LOSS			
2	Silty CLAY with some sand and gravel; brown. Very soft; moist; high plasticity; sand, fine to coarse; gravel, fine to coarse; sub angular to sub rounded		M	F
2.5	Sandy silty CLAY; reddish purple speckled white. Stiff; moist; high plasticity		M	St
5.6	Completely weathered; purple speckled black, white and orange, welded TUFF (andesite); fine fabric; extremely weak with orange/black staining on defects (WHIRITOA ANDESITE)	WHIRITOA ANDESITE		
	Completely weathered; grey; welded TUFF (andesite); fine fabric; extremely weak			

Method	Sample Result	TCR / SCR / RQD (%)
HQTT		TCR: 75
HQTT		TCR: 25
SPT	SPT 1/1 2/3 4/2 N = 11	
HQTT		TCR: 100
HQTT		TCR: 86 RQD: 21
SPT	SPT 2/5 5/5 4/3 N = 17	
HQTT		TCR: 86 RQD: 0
HQTT		TCR: 100 RQD: 50
HQTT		TCR: 100 RQD: 0
SPT	SPT 0/1 2/1 3/2 N = 8	
HQTT		TCR: 100 RQD: 0
HQTT		TCR: 75 RQD: 0
HQTT		TCR: 100 RQD: 0
-		TCR: 50 RQD: 0
SPT	SPT 1/2 4/6 5/7 N = 22	
HQTT		TCR: 100 RQD: 86
HQTT		TCR: 100 RQD: 50
SPT	SPT 3/7 8/7 7/8 N = 30	
HQTT		TCR: 91 RQD: 0
HQTT		TCR: 100 RQD: 0
SPT	SPT 2/5 7/10 8/11 N = 36	

Weathering: CW

Water level
2-11-2020

Notes and Comments:

End of Hole @ 32m
Portal Entrance Geotech Hole
Lost water return at 4.7m
Full water return at 5.45m
No SPTs after 9.5m due to rig lifting

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Limited
Equipment: Fly Rig (Rig #33)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
02/11/20	00:00	8	32

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 29/10/2020
Completed: 2/11/2020

Hole No. : WFBH014
Sheet : 2 of 4
Hole Length : 32
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763515.665
Northing: 6423696.752
System: NZMG 1949
RL: 200.02 m
Datum: NZVD2016
Method: SURVEY

RL (m)	Depth (m)	Material Description	Geological Unit	Sample Number / Type	Method	Weathering	TCR SCR RQD (%)
	10.0–11.1	Completely weathered; grey; welded TUFF (andesite); fine fabric; extremely weak *(continued from layer starting at 5.6m)* *10.50* JT, 60°, u, r, VN, CN *10.60* JT, 60°, u, sl, VN, CN *10.75* JT, 80°, u, r, VN, CLAY	WHIRITOA ANDESITE		HQTT HQTT HQTT	CW	TCR: 80 RQD: 0 TCR: 100 RQD: 50 TCR: 100 RQD: 0
189	11						
	11.1–13.95	Highly weathered; pale greenish grey speckled black, white and orange; welded TUFF (andesite); fine fabric; extremely weak *11.40* JT, 60°, u, r, VN, CN *11.45* JT, 60°, u, r, VN, CN *11.75* JT, 60°, u, r, VN, CN *11.80* JT, 60°, u, r, VN, CN *12.12* JT, 58°, u, sm, VN, CN *12.78* JT, 35°, u, r, VN, CLAY *13.40* JT, 20°, u, r, VN, Fe, trace Mn *13.55* JT, 10°, u, r, VN, Fe, trace Mn *13.80* CS, 50°, u, r, VN, Fe, rock fragments, trace Mn	WHIRITOA ANDESITE		HQTT HQTT	HW	TCR: 100 RQD: 53 TCR: 100 RQD: 38
188	12						
187	13						
186	14						
	13.95–20.0	Moderately weathered; reddish purple; welded TUFF (andesite); fine fabric; weak; some medium to coarse sized inclusions of grey tuff *14.16* JT, 30°, st, r, VN, CN *14.57* JT, 25°, u, r, VN, CN, trace Mn *14.65* JS [], 40°, u, r, VN, CN *14.83* JS [], 40°, u, r, VN, CN *14.95* JS [], 40°, u, r, VN, CN *15.05* JT, 65°, u, r, VN, CN *15.87* CS, 51°, u, r, VN, CLAY, rock fragments *16.05* JS [], 35°, u, r, VN, CN *16.17* JS [], 45°, u, r, VN, CN *16.60* JT, 35°, u, r, VN, CN *18.30* JT, 10°, u, r, VN, CN 18.30 - 19.70 Boulder/intermittent flow of slightly weathered; reddish grey; andesite; strong *19.40* JT, 50°, u, sl, VN, CLAY	WHIRITOA ANDESITE	C-PLT1 14.30 C-CS1 16.65–17.00 C-PLT2 18.00	HQTT HQTT HQTT HQTT	MW SW MW	TCR: 100 RQD: 69 TCR: 100 RQD: 87 TCR: 100 RQD: 100 TCR: 100 RQD: 100
185	15						
184	16						
183	17						
182	18						
181	19						
	20						

Moisture condition | Consistency / Relative Density | Result | Casing | Flush Return (%) 25 50 75 | Estimated Strength (MPa) EW VW MS VS ES | Defect Spacing (mm) 20 60 200 600 2000 | Instrumentation Installation | Water level

Notes and Comments:
End of Hole @ 32m
Portal Entrance Geotech Hole
Lost water return at 4.7m
Full water return at 5.45m
No SPTs after 9.5m due to rig lifting

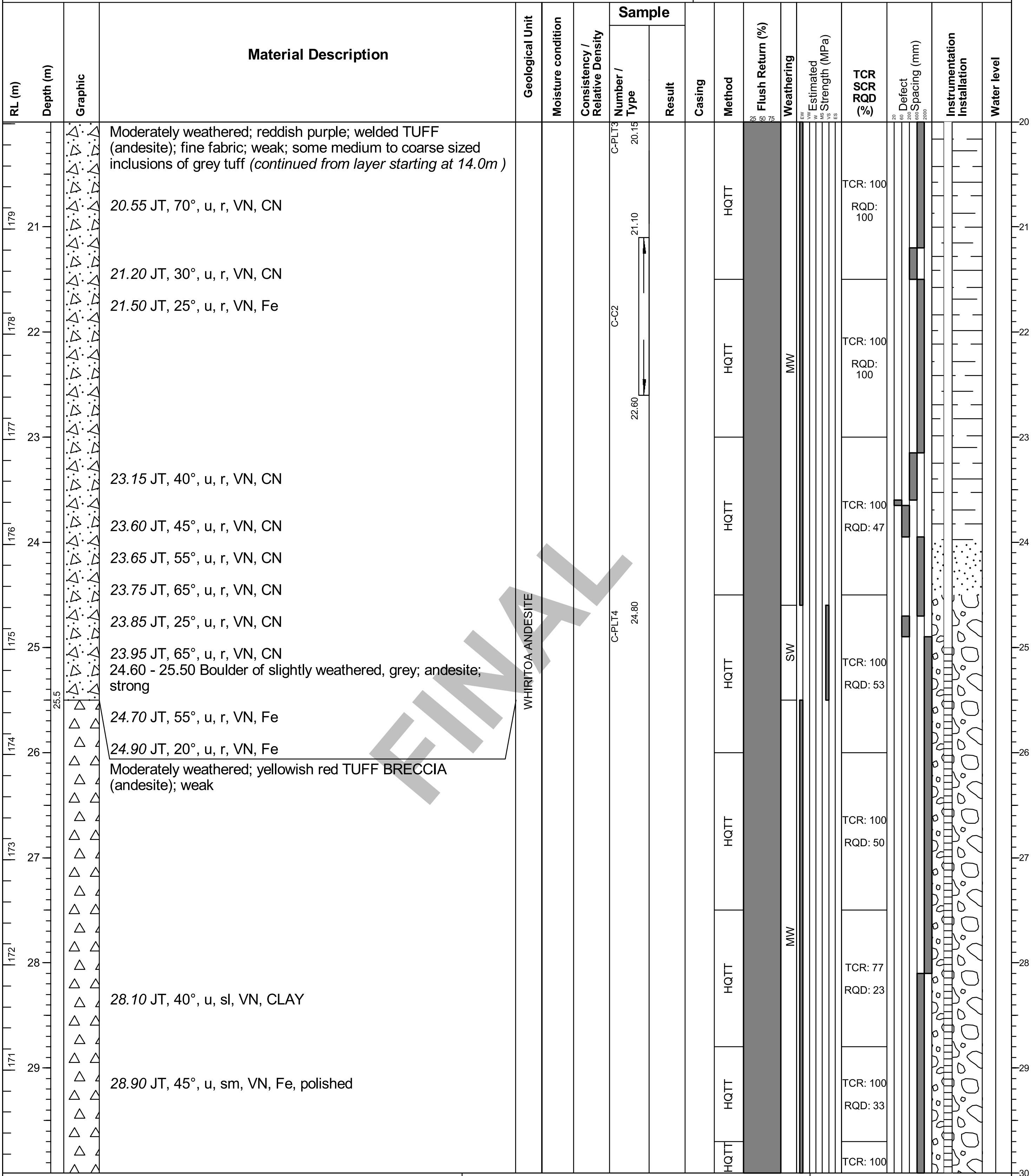
Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Limited
Equipment: Fly Rig (Rig #33)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
02/11/20	00:00	8	32

Project : WKP Exploration Tunnel - Ground Investigation		Hole No. : WFBH014
Client : Oceana Gold Corporation / GWS / Golder		Sheet : 3 of 4
Site : Willows Farm, Waihi North,		Hole Length : 32
Job Number: 12533958		Scale @ A4 : 1:50
Commenced: 29/10/2020	Completed: 2/11/2020	Logged : HJ
Easting: 2763515.665	Northing: 6423696.752	System: NZMG 1949
		Processed : HJ
RL: 200.02 m	Datum: NZVD2016	Method: SURVEY
		Checked : JHS



Moderately weathered; reddish purple; welded TUFF (andesite); fine fabric; weak; some medium to coarse sized inclusions of grey tuff *(continued from layer starting at 14.0m)*

20.55 JT, 70°, u, r, VN, CN

21.20 JT, 30°, u, r, VN, CN

21.50 JT, 25°, u, r, VN, Fe

23.15 JT, 40°, u, r, VN, CN

23.60 JT, 45°, u, r, VN, CN

23.65 JT, 55°, u, r, VN, CN

23.75 JT, 65°, u, r, VN, CN

23.85 JT, 25°, u, r, VN, CN

23.95 JT, 65°, u, r, VN, CN

24.60 - 25.50 Boulder of slightly weathered, grey; andesite; strong

24.70 JT, 55°, u, r, VN, Fe

24.90 JT, 20°, u, r, VN, Fe

Moderately weathered; yellowish red TUFF BRECCIA (andesite); weak

28.10 JT, 40°, u, sl, VN, CLAY

28.90 JT, 45°, u, sm, VN, Fe, polished

Notes and Comments:

End of Hole @ 32m
Portal Entrance Geotech Hole
Lost water return at 4.7m
Full water return at 5.45m
No SPTs after 9.5m due to rig lifting

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:

Contractor: Alton Drilling Limited

Equipment: Fly Rig (Rig #33)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
02/11/20	00:00	8	32

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 29/10/2020	Completed: 2/11/2020

Hole No.	: WFBH014
Sheet	: 4 of 4
Hole Length	: 32
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763515.665
Northing: 6423696.752
System: NZMG 1949
RL: 200.02 m
Datum: NZVD2016
Method: SURVEY

RL (m)	Depth (m)	Graphic	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Sample Result	Casing	Method	Flush Return (%) 25 50 75	Weathering	Estimated Strength (MPa) EW VW W MS VS ES	TCR SCR RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	Instrumentation Installation	Water level
	30		Moderately weathered; yellowish red TUFF BRECCIA (andesite); weak *(continued from layer starting at 25.5m)* *30.10* JT, 55°, u, sl, VN, CLAY *30.20* JT, 40°, u, sl, VN, CLAY *30.57* JT, 60°, u, sl, VN, CLAY	WHIRITOA ANDESITE			C-PLT5 30.35			HQTT		MW		RQD: 100 TCR: 100 RQD: 40			
169	31																
	31.1		Moderately weathered; red; welded TUFF (andesite); weak							HQTT				TCR: 100 RQD: 89			
168	32		End of Hole @ 32m, Target Depth														
167	33																
166	34																
165	35																
164	36																
163	37																
162	38																
161	39																
	40																

Notes and Comments:

End of Hole @ 32m
Portal Entrance Geotech Hole
Lost water return at 4.7m
Full water return at 5.45m
No SPTs after 9.5m due to rig lifting

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Limited
Equipment: Fly Rig (Rig #33)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
02/11/20	00:00	8	32

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 3/11/2020 Completed: 5/11/2020

Hole No. : WFBH015
Sheet : 1 of 2
Hole Length : 15.45
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763793.36 Northing: 6423716.988 System: NZMG 1949
RL: 165.86 m Datum: NZVD2016 Method: SURVEY

RL (m)	Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Sample Result	Casing	Method	Flush Return (%)	Weathering	Estimated Strength (MPa)	TCR SCR RQD (%)	Defect Spacing (mm)	Instrumentation Installation	Water level
	0	SILT, some sand; dark brown. Very soft, moist, low plasticity, trace rootlets. Sand: fine to medium. (TOPSOIL)	TOPSOIL	M	VS				HQTT				TCR: 60			
165	0.3	CORE LOSS														
	0.9	Sandy silty CLAY with trace clay; orange brown. Firm; moist; high plasticity; sand, fine (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	F											
164							SPT 1/1 2/3 1/2 N = 8		SPT							
	2	Silty CLAY with some sand and trace gravels; orangish brown. Firm; moist; high plasticity; sand, fine; gravel, fine, subangular to subrounded		M	F	D-D1 2.30–2.50			HQTT				TCR: 59			∇ 4-11-2020
162							SPT 0/1 1/0 2/1 N = 4		SPT							
									HQTT				TCR: 100			
161		5.00 becomes stiff			St		SPT 1/2 2/3 2/3 N = 10		SPT							∇ 5-11-2020
160									HQTT				TCR: 100			∇ 5-11-2020
159		6.50 becomes firm			F		SPT 0/2 3/1 1/3 N = 8		SPT							
158									HQTT				TCR: 100			
		8.00 becomes soft			S		SPT 0/0 1/0 0/2 N = 3		SPT							
157									HQTT				TCR: 100			
156		9.50 becomes very soft			VS		SPT 0/0 0/0 0/1 N = 1		SPT							
	9.7			M	F								TCR: 100			

FINAL

Notes and Comments:
End of Hole @ 15.45m
Hardstand Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical Orientation:
Contractor: Alton Drilling Limited
Equipment: Tractor Rig (83)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
04/11/20	07:00	2	4.8
05/11/20	07:00	5	12.3
05/11/20	14:00	5.7	15.45

Report ID: GENERAL_LOG-BK1 || Project: WILLOWS FARM BHS.GPJ || Library: GHD - NZGD.GLB || Date: 10 May 2021

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 3/11/2020
Completed: 5/11/2020

Hole No. : WFBH015
Sheet : 2 of 2
Hole Length : 15.45
Scale @ A4 : 1:50
Logged : HJ
Processed : HJ
Checked : JHS

Easting: 2763793.36
Northing: 6423716.988
System: NZMG 1949
RL: 165.86 m
Datum: NZVD2016
Method: SURVEY

RL (m)	Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Sample Result	Method	TCR SCR RQD (%)
	10.0	CLAY some sand and gravel; brownish red mottled grey. Very stiff; moist; high plasticity; sand, fine to coarse; gravel, fine, subangular to subrounded *(continued from layer starting at 9.7m)*	RESIDUAL SOIL - ALLOPHANE					HQTT	TCR: 100
	10.80	10.80 becomes very stiff			VSt		SPT 0/3 2/7 4/4 N = 17	SPT	
								HQTT	TCR: 100
	11.6	Silty GRAVEL with some boulders; brownish grey. Medium dense; moist; gravel, fine to coarse, subangular to subrounded; boulders, slightly weathered, strong porphyritic andesite (possible colluvium)		M	MD			HQTT	TCR: 100
							SPT 2/1 4/5 5/4 N = 18	SPT	
	12.7	Silty CLAY some sand and minor gravel; greyish brown mottled orange. Very stiff; moist; high plasticity; sand, fine; gravel, fine, subangular to subrounded andesite		M	VSt			HQTT	TCR: 100
							SPT 2/3 3/5 5/6 N = 19	SPT	
								HQTT	TCR: 100
							SPT 2/2 4/4 5/5 N = 18	SPT	
	15.45	End of Hole @ 15.45m, Target Depth							

RL scale: 155, 154, 153, 152, 151, 150, 149, 148, 147, 146
Depth scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Flush Return (%): 25 50 75
Estimated Strength (MPa): EW VW W MS S VS ES
Defect Spacing (mm): 20 60 200 600 2000

Notes and Comments:
End of Hole @ 15.45m
Hardstand Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Limited
Equipment: Tractor Rig (83)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
04/11/20	07:00	2	4.8
05/11/20	07:00	5	12.3
05/11/20	14:00	5.7	15.45

Project : WKP Exploration Tunnel - Ground Investigation
Client : Oceana Gold Corporation / GWS / Golder
Site : Willows Farm, Waihi North,
Job Number: 12533958
Commenced: 6/11/2020
Completed: 9/11/2020

Hole No. : WFBH016

Sheet	: 1 of 2
Hole Length	: 15.45
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763862.286
Northing: 6423642.974
System: NZMG 1949
RL: 166.16 m
Datum: NZVD2016
Method: SURVEY

Depth (m)	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density
0	SILT, some sand; dark brown. Very soft, moist, low plasticity, trace rootlets. Sand: fine to medium. (TOPSOIL)	TOPSOIL	M	VS
0.2	Sandy silty CLAY; orange brown. Soft; moist; high plasticity; sand, fine (RESIDUAL SOIL - ALLOPHANE)	RESIDUAL SOIL - ALLOPHANE	M	S
1.6	Silty CLAY with some sand and trace gravel; orangish brown. Stiff; moist; high plasticity; sand, fine; gravel, fine, subangular to subrounded		M	St
	3.00 becomes very soft			VS
	6.10 becomes soft			S
6.5	CLAY; light grey. Firm; moist; high plasticity		M	F
	7.50 becomes hard 7.60 - 7.75 Extremely weak corestone of andesite			H
8.3	Silty CLAY some sand and minor gravel; pale greyish mottled white and orange. Firm; moist; high plasticity; sand fine to coarse; gravel, fine to medium subrounded andesite		M	F

Sample Number / Type	Depth	Result	Method	TCR SCR RQD (%)
			HQTT	TCR: 100
D-D1	1.20 - 1.40			
		SPT 1/0 2/2 4/4 N = 12	SPT	
			HQTT	TCR: 100
D-D2	2.45 - 2.65			
		SPT 1/0 0/0 0/1 N = 1	SPT	
			HQTT	TCR: 100
D-D3	4.00 - 4.20			
		SPT 0 N = 0	SPT	
			HQTT	TCR: 76
		SPT 1/0 0/1 1/1 N = 3	SPT	
D-D4	6.55 - 6.75			
			HQTT	TCR: 100
		SPT 1/4 40/7 5/4 N > 50	SPT	
			HQTT	TCR: 100
		SPT 5/3 2/2 2/2 N = 8	SPT	
			HQTT	TCR: 100

Water level: 9-11-2020

Notes and Comments:
End of Hole @ 15.45m
Hardstand Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

Inclination: Vertical
Orientation:
Contractor: Alton Drilling Limited
Equipment: Tractor Rig (83)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
09/11/20	00:00	5.3	15.45

Project	: WKP Exploration Tunnel - Ground Investigation
Client	: Oceana Gold Corporation / GWS / Golder
Site	: Willows Farm, Waihi North,
Job Number: 12533958	
Commenced: 6/11/2020	Completed: 9/11/2020

Hole No.	: WFBH016
Sheet	: 2 of 2
Hole Length	: 15.45
Scale @ A4	: 1:50
Logged	: HJ
Processed	: HJ
Checked	: JHS

Easting: 2763862.286
Northing: 6423642.974
System: NZMG 1949
RL: 166.16 m
Datum: NZVD2016
Method: SURVEY

RL (m)	Depth (m)	Graphic	Material Description	Geological Unit	Moisture condition	Consistency / Relative Density	Sample Number / Type	Sample Result	Casing	Method	Flush Return (%) 25 50 75	Weathering	Estimated Strength (MPa) EW VW W MS VS ES	TCR SCR RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	Instrumentation Installation	Water level
156	10.2		CLAY some silt, sand and gravel; brown and grey speckled white. Very stiff; moist; high plasticity; sand, fine to coarse; gravel, fine to coarse andesite, rare corestones of extremely weak andesite	RESIDUAL SOIL - ALLOPHANE	M	VSt				HQTT				TCR: 100			
155	11							SPT 1/4 4/6 7/7 N = 24		SPT							
										HQTT				TCR: 100			
154	12		12.00 becomes hard			H		SPT 4/4 5/9 4/16 N = 44		SPT							
153	13									HQTT				TCR: 100			
152	14							SPT 3/7 8/7 9/12 N = 36		SPT							
										HQTT				TCR: 100			
151	15							SPT 3/15 16/25 9 for 50mm N > 50		SPT							
			End of Hole @ 15.45m, Target Depth														
150	16																
149	17																
148	18																
147	19																
	20																

Notes and Comments:

End of Hole @ 15.45m
Hardstand Area
No water return information

Refer to explanation sheets for abbreviation and symbols.
Shear Vane values are corrected.

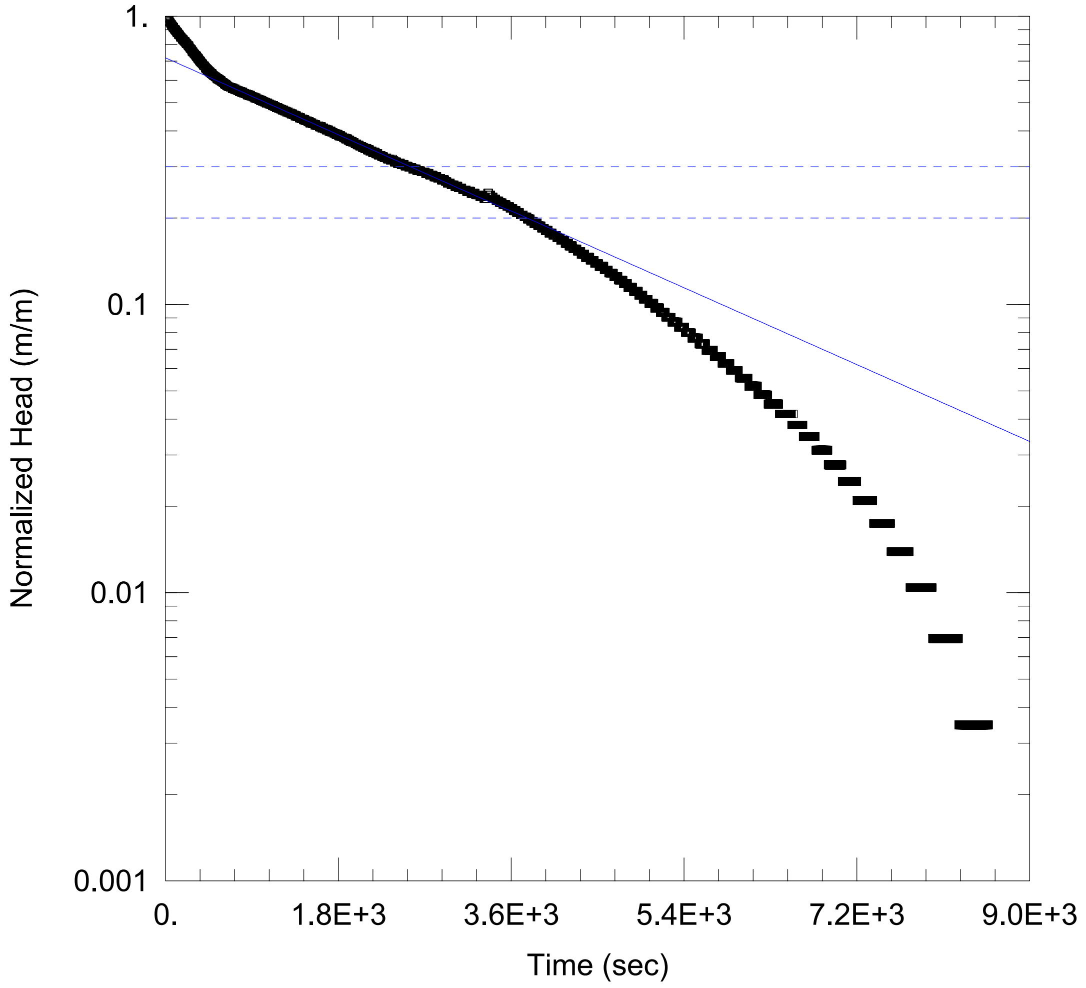
Inclination: Vertical
Orientation:

Contractor: Alton Drilling Limited

Equipment: Tractor Rig (83)

Ground Water Level

Date	Time	Reading (mbgl)	Hole depth (mbgl)
09/11/20	00:00	5.3	15.45



WELL TEST ANALYSIS

Data Set: C:\...\WFBH001S RHT1 B-R.aqt
Date: 09/30/20 Time: 06:56:30

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH001S
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.77 m
Anisotropy Ratio (Kz/Kr): 1.

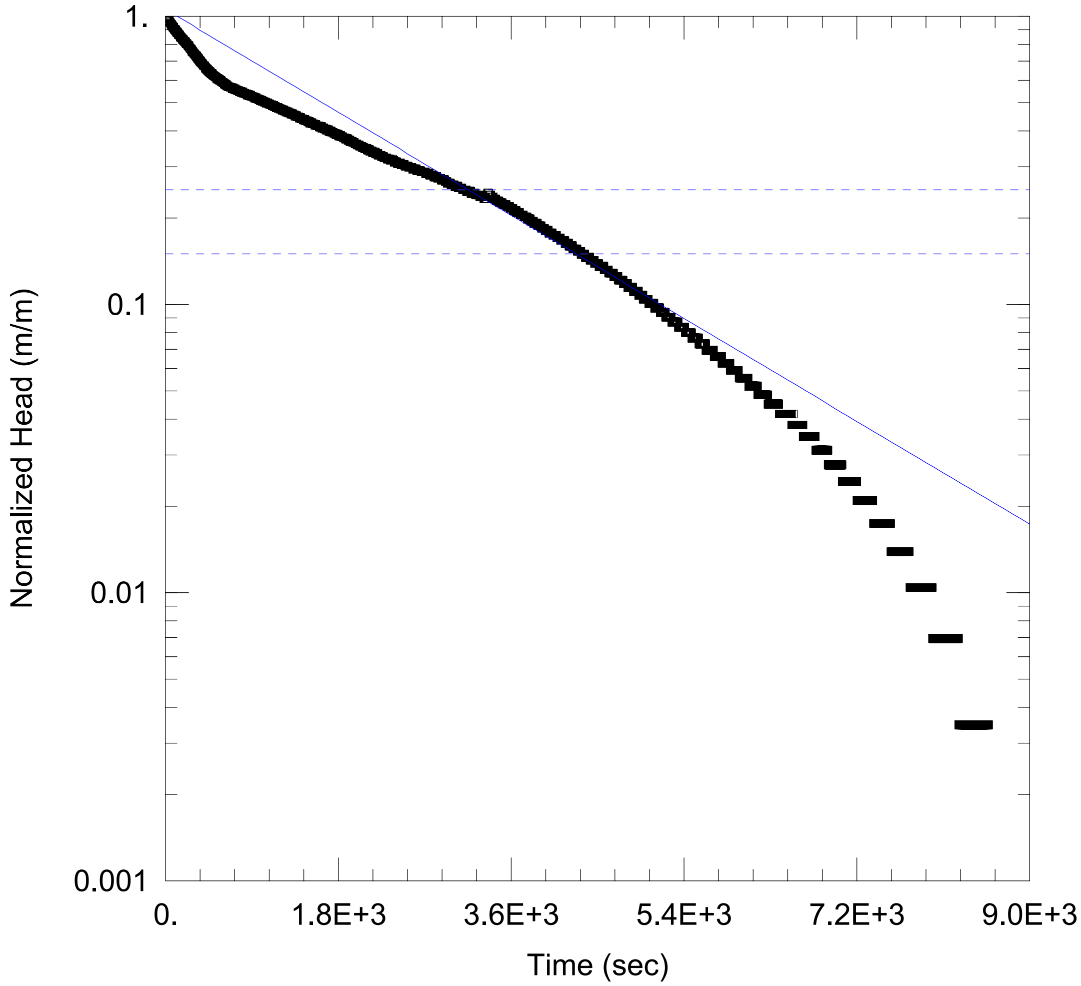
WELL DATA (WFBH001S RHT1)

Initial Displacement: 2.88 m
Static Water Column Height: 3.77 m
Total Well Penetration Depth: 3.77 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.176E-7 m/sec
y0 = 2.064 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH001S RHT1 Hvorslev.aqt
Date: 09/30/20 Time: 06:56:52

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH001S
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.77 m
Anisotropy Ratio (Kz/Kr): 1.

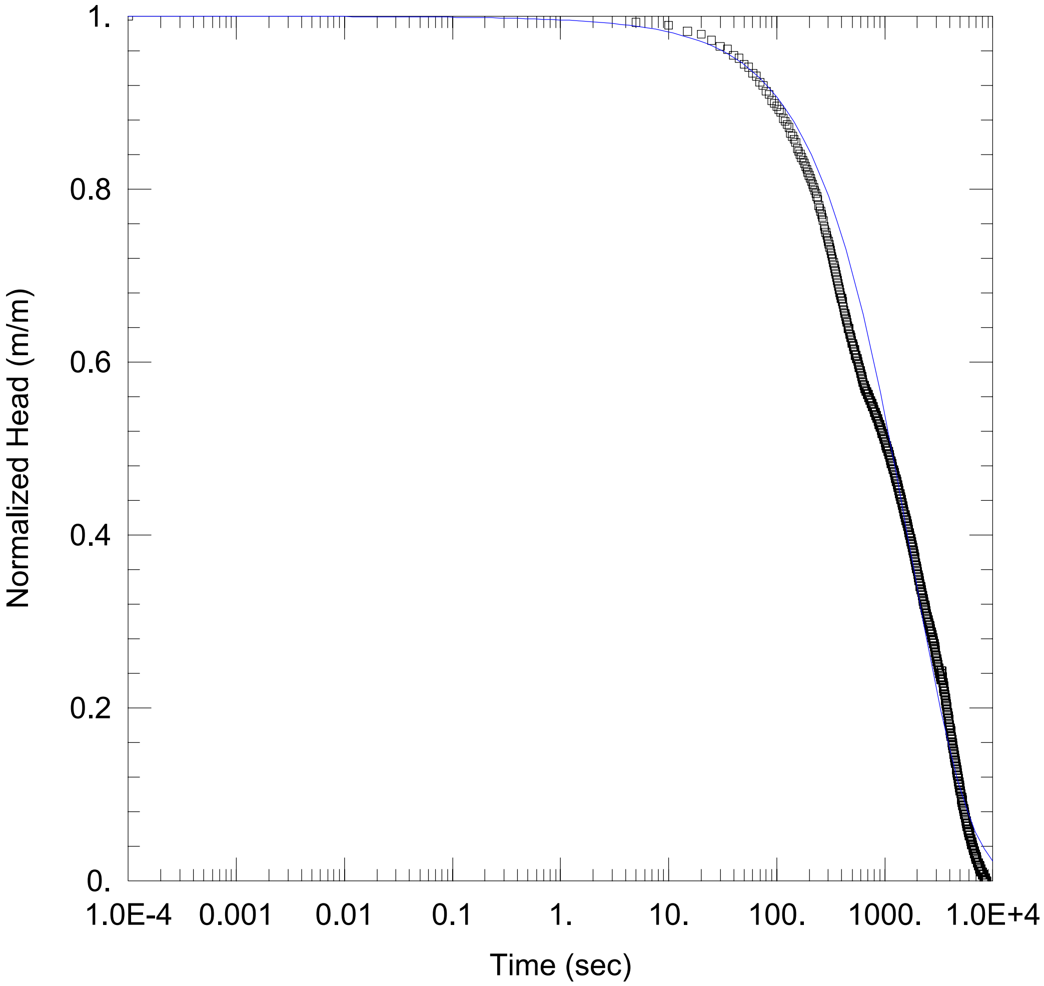
WELL DATA (WFBH001S RHT1)

Initial Displacement: 2.88 m
Static Water Column Height: 3.77 m
Total Well Penetration Depth: 3.77 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 2.299E-7 m/sec
y0 = 3.041 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH001S RHT1 KGS.aqt
Date: 09/30/20 Time: 06:57:08

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH001S
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.77 m

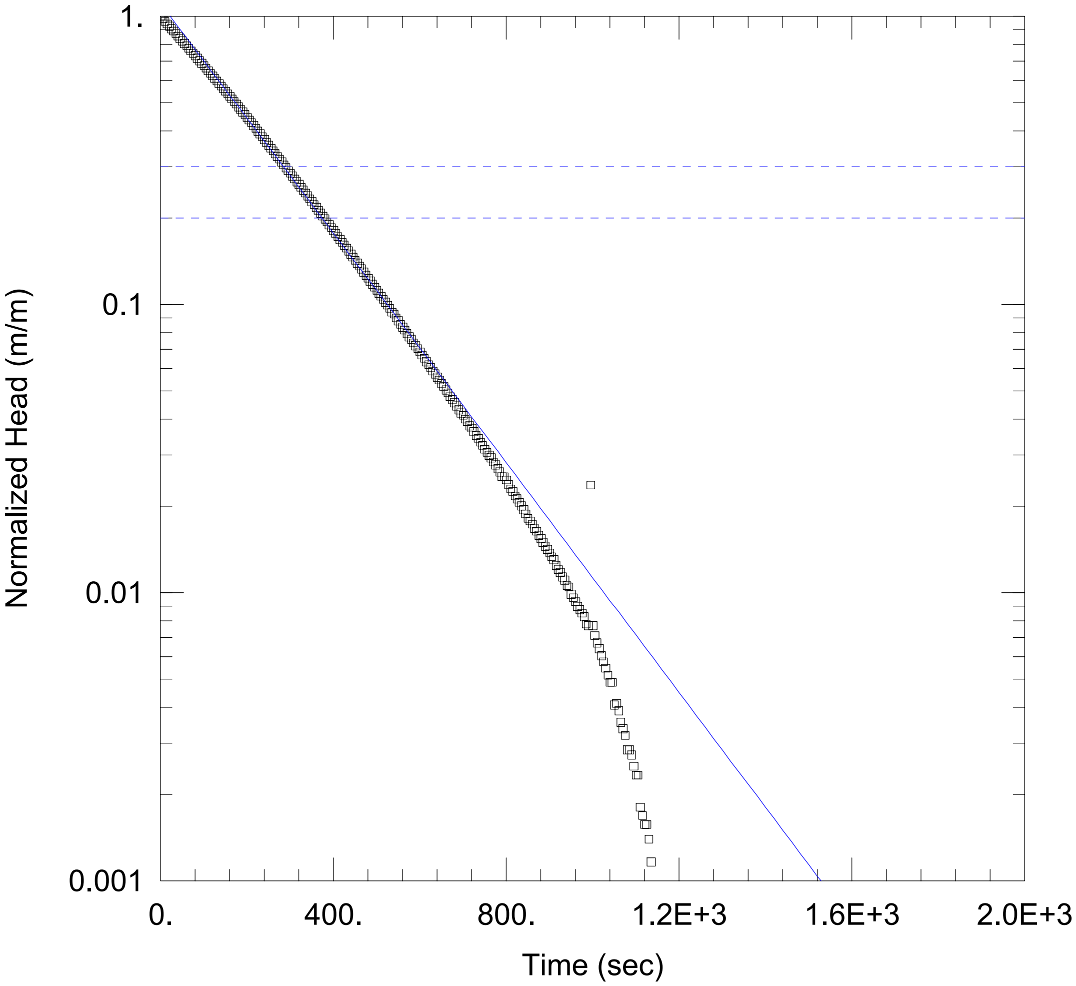
WELL DATA (WFBH001S RHT1)

Initial Displacement: 2.88 m
Static Water Column Height: 3.77 m
Total Well Penetration Depth: 3.77 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 1.936E-7 m/sec
Ss = 0.0002149 m^{-1}
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: C:\...\WFBH01D RHT1 B-R.aqt
Date: 09/30/20 Time: 06:54:14

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH001D
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 6.73 m
Anisotropy Ratio (Kz/Kr): 1.

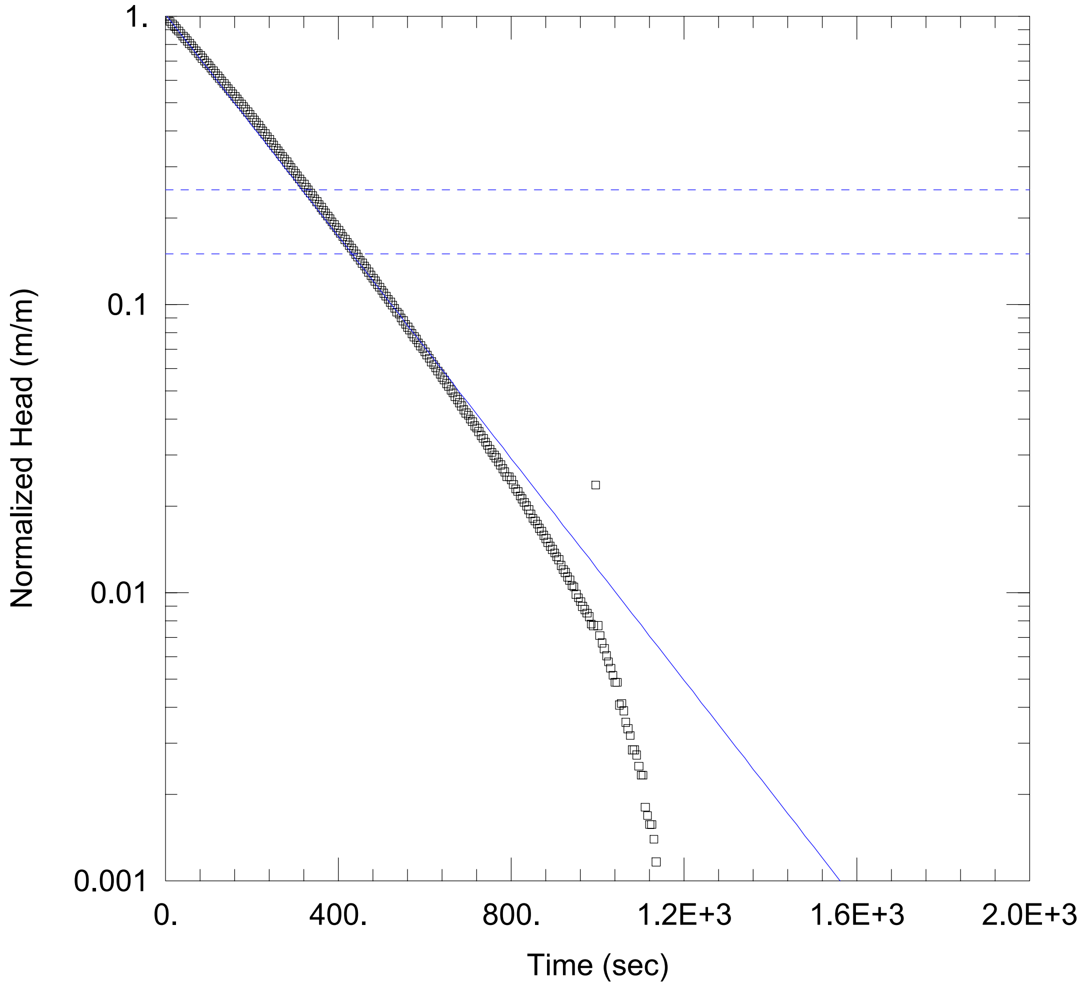
WELL DATA (WFBH001D RHT1)

Initial Displacement: 1.72 m
Static Water Column Height: 6.73 m
Total Well Penetration Depth: 6.73 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.759E-6 m/sec
y0 = 1.905 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH01D RHT1 HVorslev.aqt
Date: 09/30/20 Time: 06:55:29

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH001D
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 6.73 m
Anisotropy Ratio (Kz/Kr): 1.

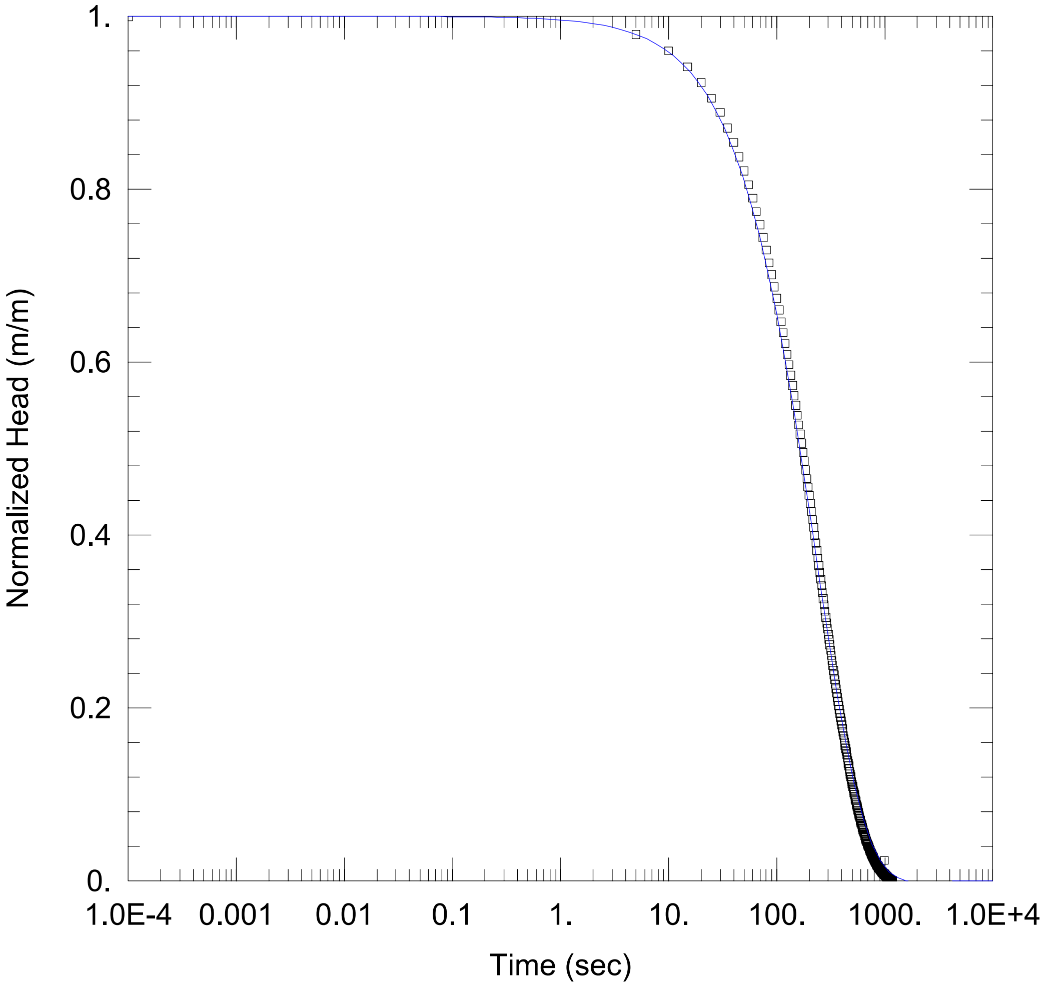
WELL DATA (WFBH001D RHT1)

Initial Displacement: 1.72 m
Static Water Column Height: 6.73 m
Total Well Penetration Depth: 6.73 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 2.229E-6 m/sec
y0 = 1.742 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH01D RHT1 KGS.aqt
Date: 09/30/20 Time: 06:56:02

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH001D
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 6.73 m

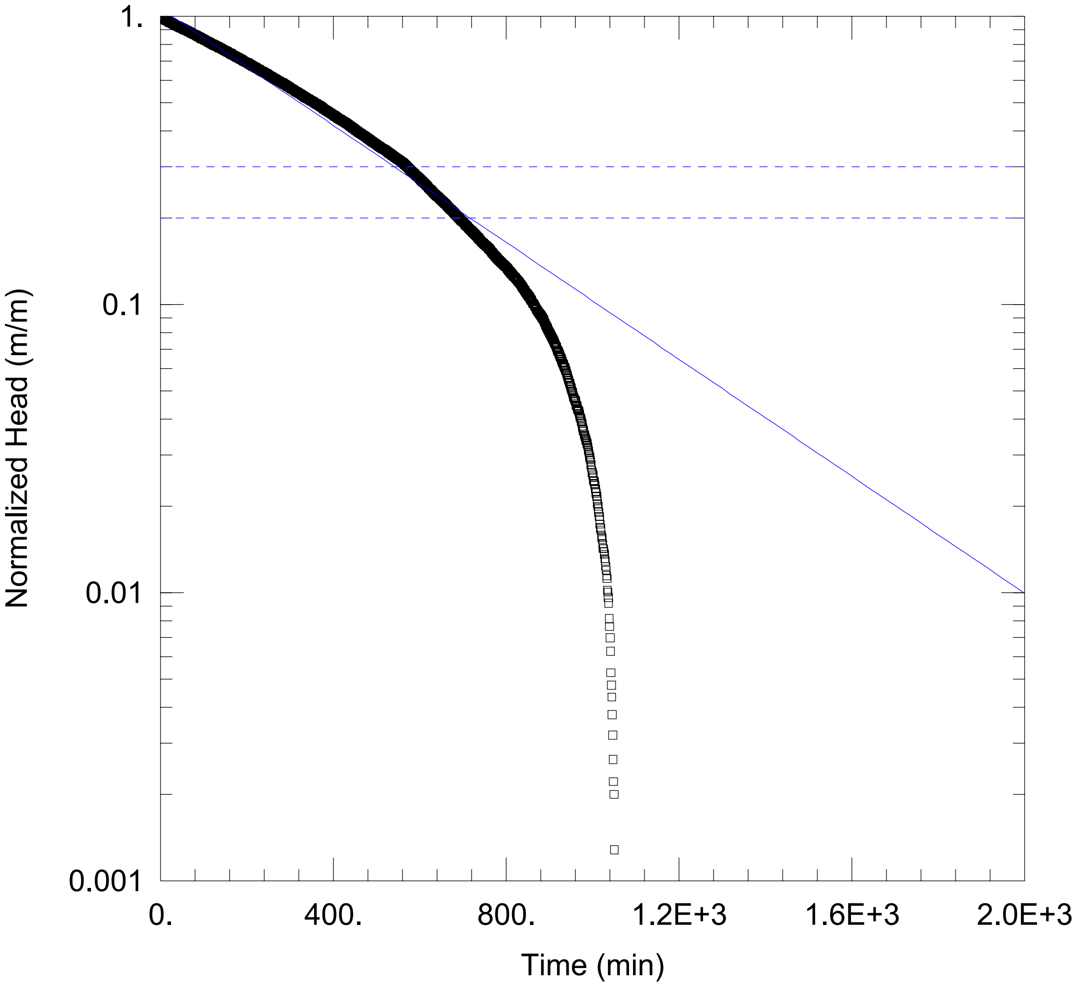
WELL DATA (WFBH001D RHT1)

Initial Displacement: 1.72 m
Total Well Penetration Depth: 6.73 m
Casing Radius: 0.025 m
Static Water Column Height: 6.73 m
Screen Length: 3. m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 1.852E-6 m/sec
Kz/Kr = 1.
Ss = 1.486E-11 m^{-1}



WELL TEST ANALYSIS

Data Set: C:\...\WFBH002 RHT B-R _DA.aqt
Date: 09/30/20 Time: 06:57:41

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH002
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 5.589 m Anisotropy Ratio (Kz/Kr): 1.

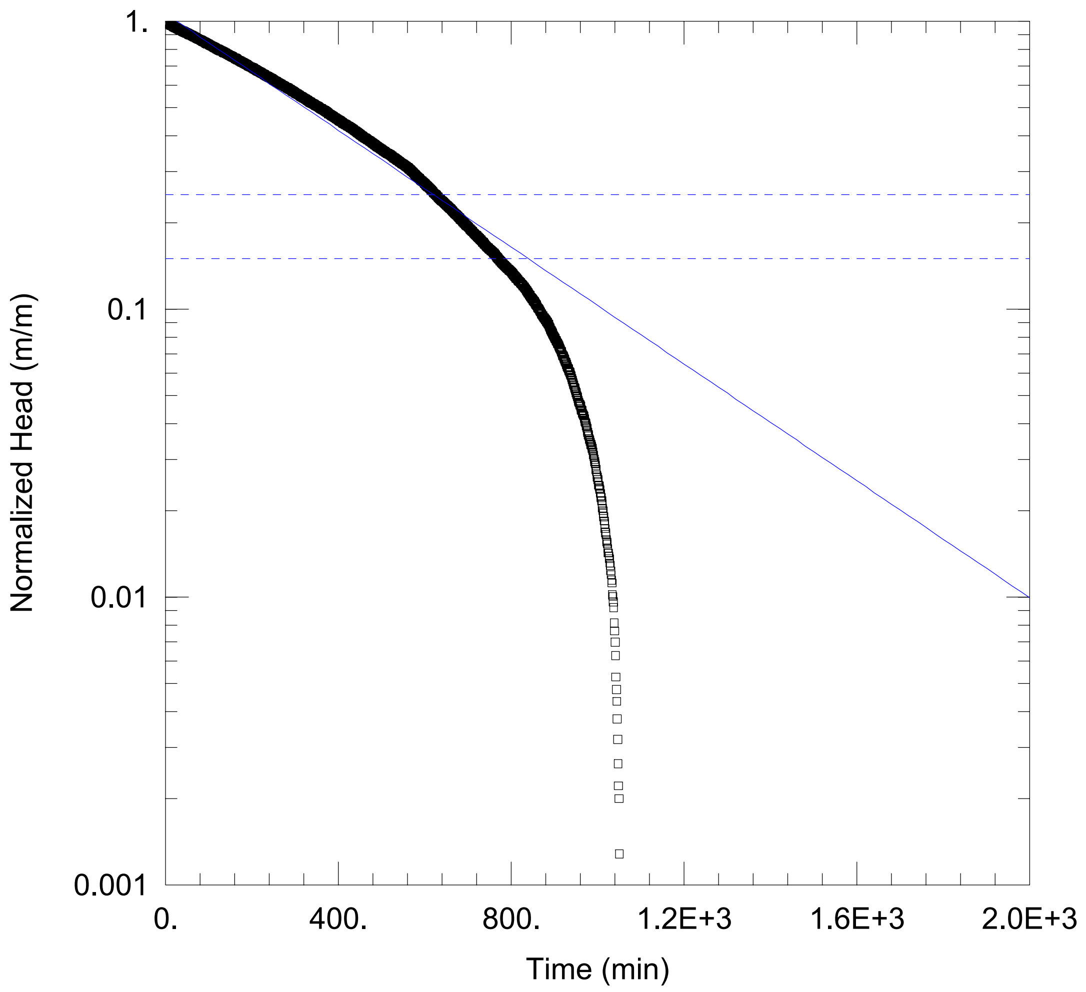
WELL DATA (WFBH002 RHT)

Initial Displacement: 1.404 m
Static Water Column Height: 5.886 m
Total Well Penetration Depth: 5.886 m
Screen Length: 1.25 m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 3.248E-8 m/sec y0 = 1.493 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH002 RHT Hvorslev_DA.aqt
Date: 09/30/20 Time: 06:58:05

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH002
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 5.589 m
Anisotropy Ratio (Kz/Kr): 1.

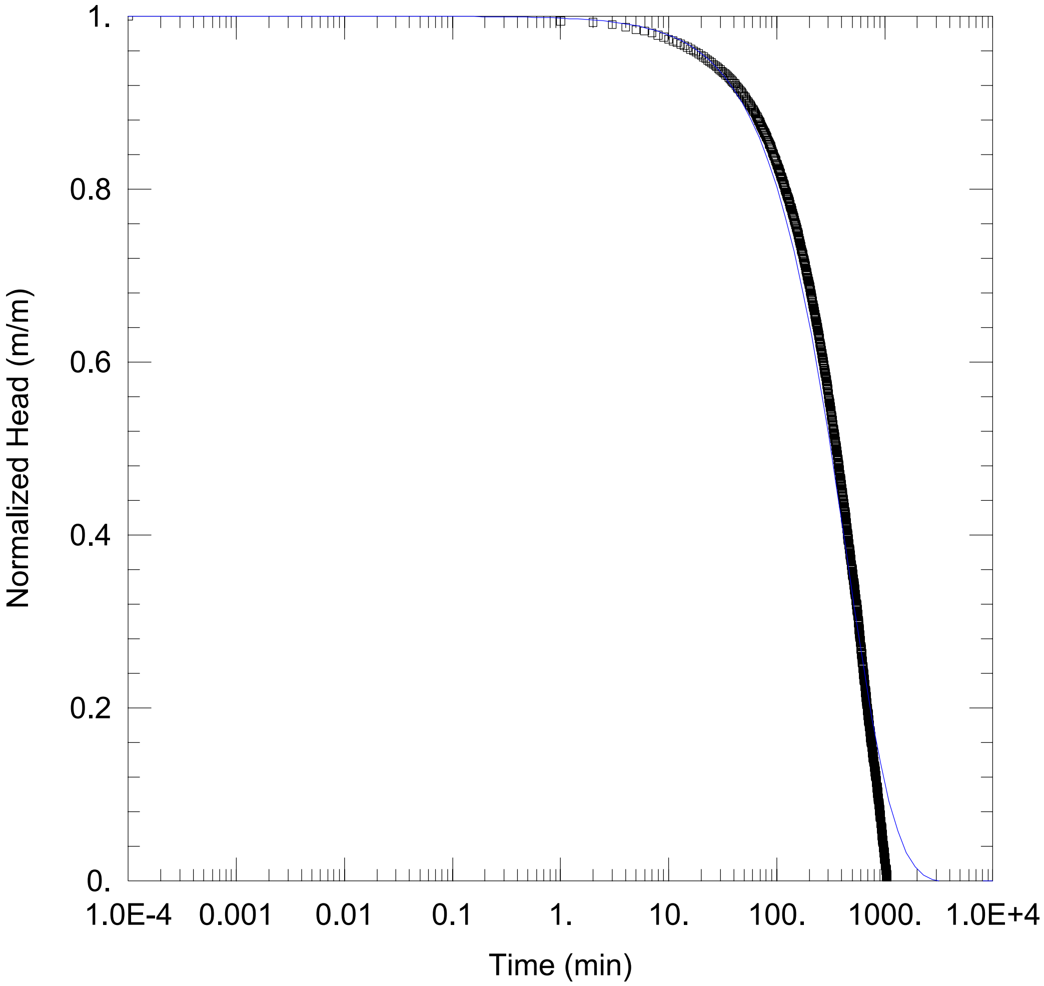
WELL DATA (WFBH002 RHT)

Initial Displacement: 1.404 m
Static Water Column Height: 5.886 m
Total Well Penetration Depth: 5.886 m
Screen Length: 1.25 m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 3.847E-8 m/sec
y0 = 1.493 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH002 RHT KGS_DA.aqt

Date: 09/30/20 Time: 06:58:31

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH002
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 5.589 m

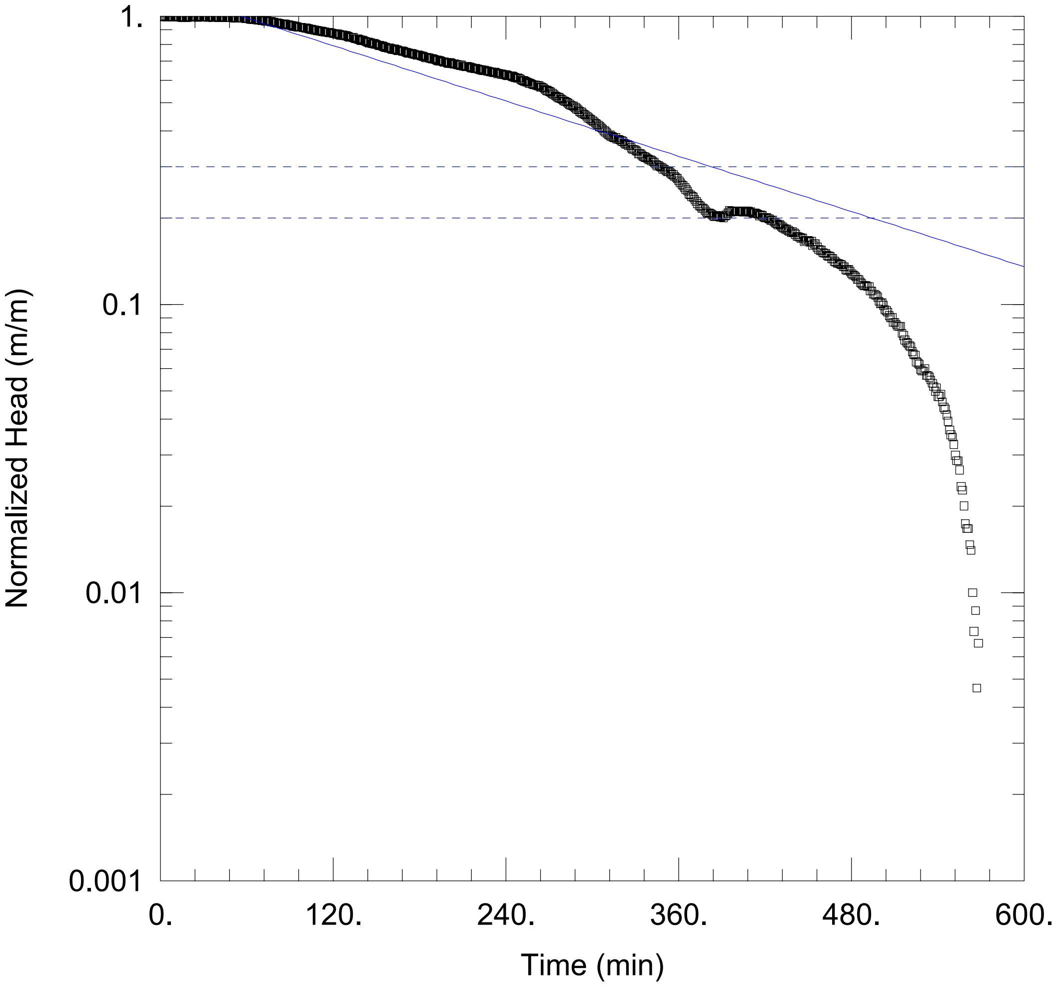
WELL DATA (WFBH002 RHT)

Initial Displacement: 1.404 m
Static Water Column Height: 5.886 m
Total Well Penetration Depth: 5.886 m
Screen Length: 1.25 m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 4.349E-8 m/sec
Ss = 7.214E-12 m^{-1}
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: C:\...\WFBH004 RHT B-R.aqt
Date: 09/30/20
Time: 06:59:00

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH004
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 1.52 m
Anisotropy Ratio (Kz/Kr): 1.

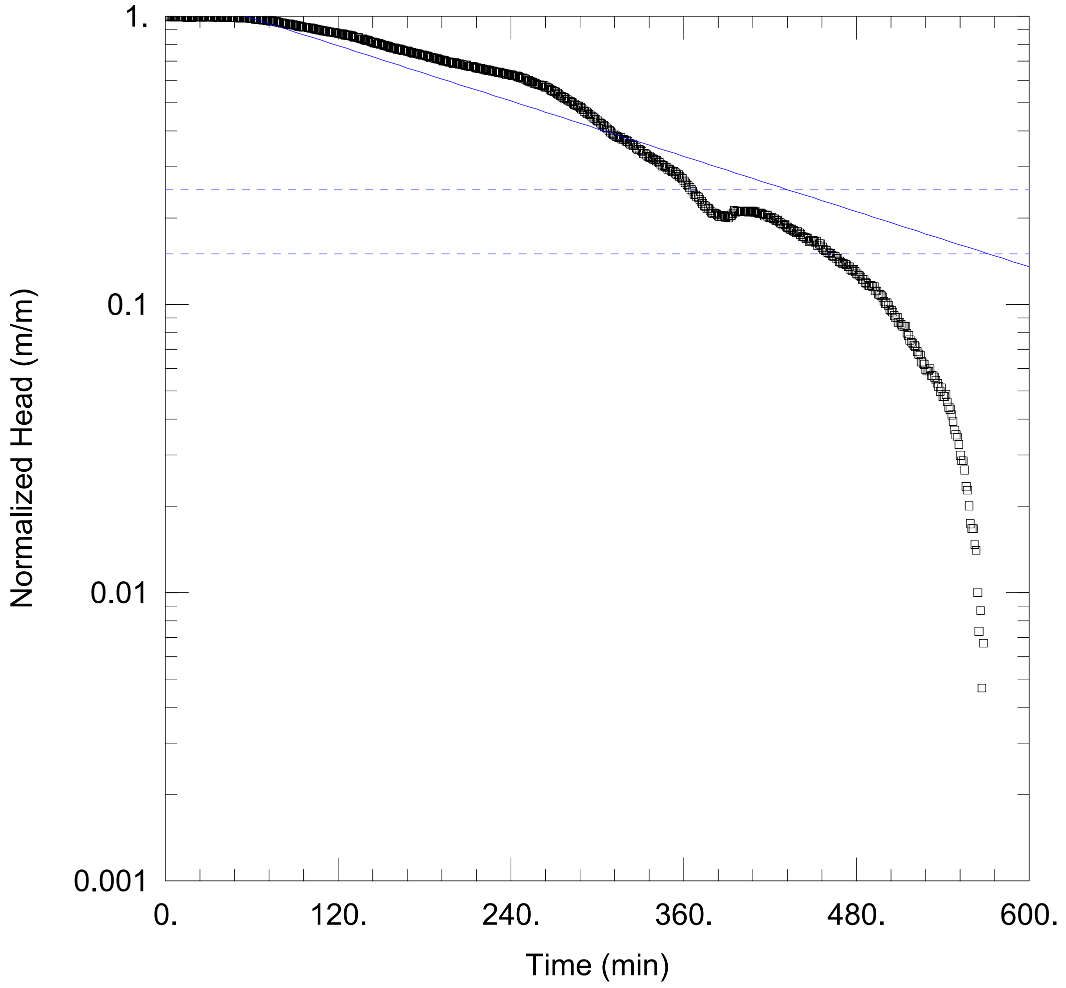
WELL DATA (WFBH004 RHT)

Initial Displacement: 0.15 m
Static Water Column Height: 1.52 m
Total Well Penetration Depth: 4.48 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 4.114E-8 m/sec
y0 = 0.1842 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH004 RHT Hvorslev.aqt
Date: 09/30/20 Time: 06:59:21

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH004
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 1.52 m
Anisotropy Ratio (Kz/Kr): 1.

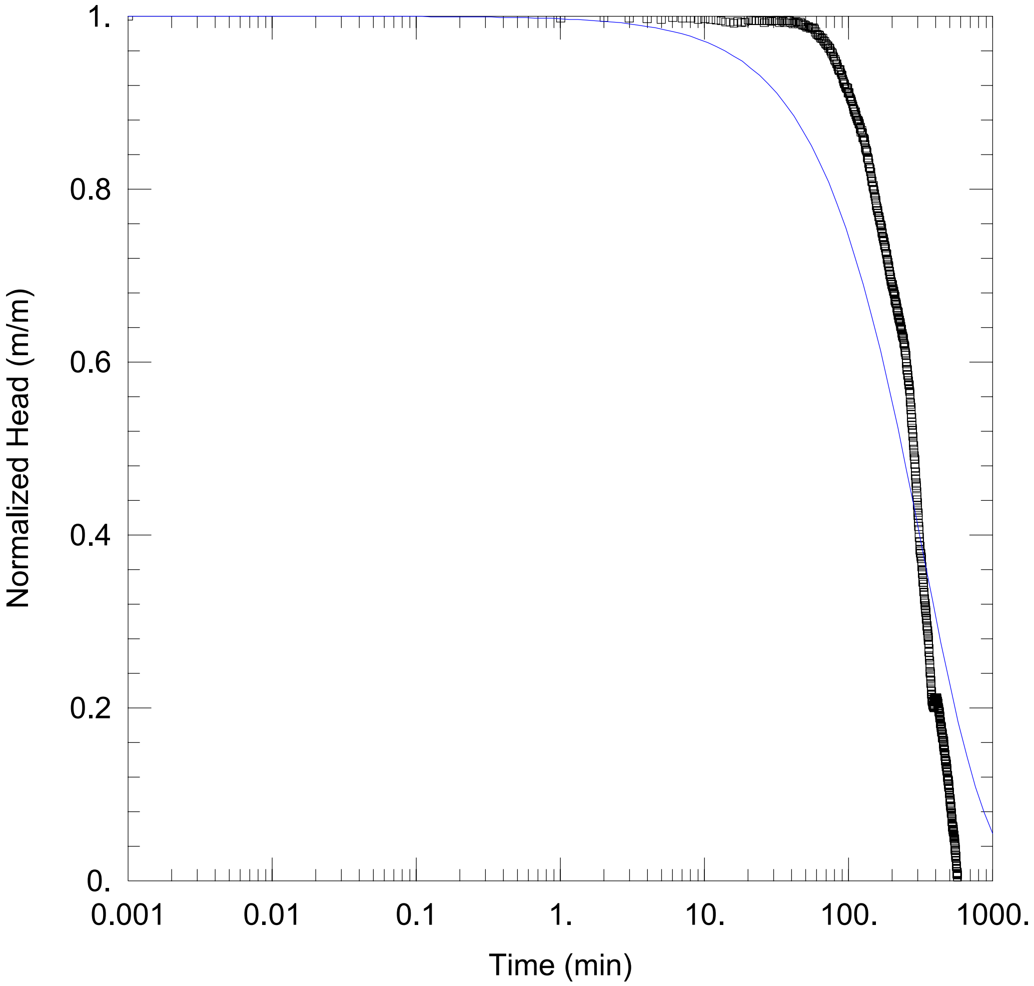
WELL DATA (WFBH004 RHT)

Initial Displacement: 0.15 m
Static Water Column Height: 1.52 m
Total Well Penetration Depth: 4.48 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 6.682E-8 m/sec
y0 = 0.1842 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH004 RHT KGS.aqt
Date: 09/30/20 Time: 06:59:40

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH004
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 1.52 m

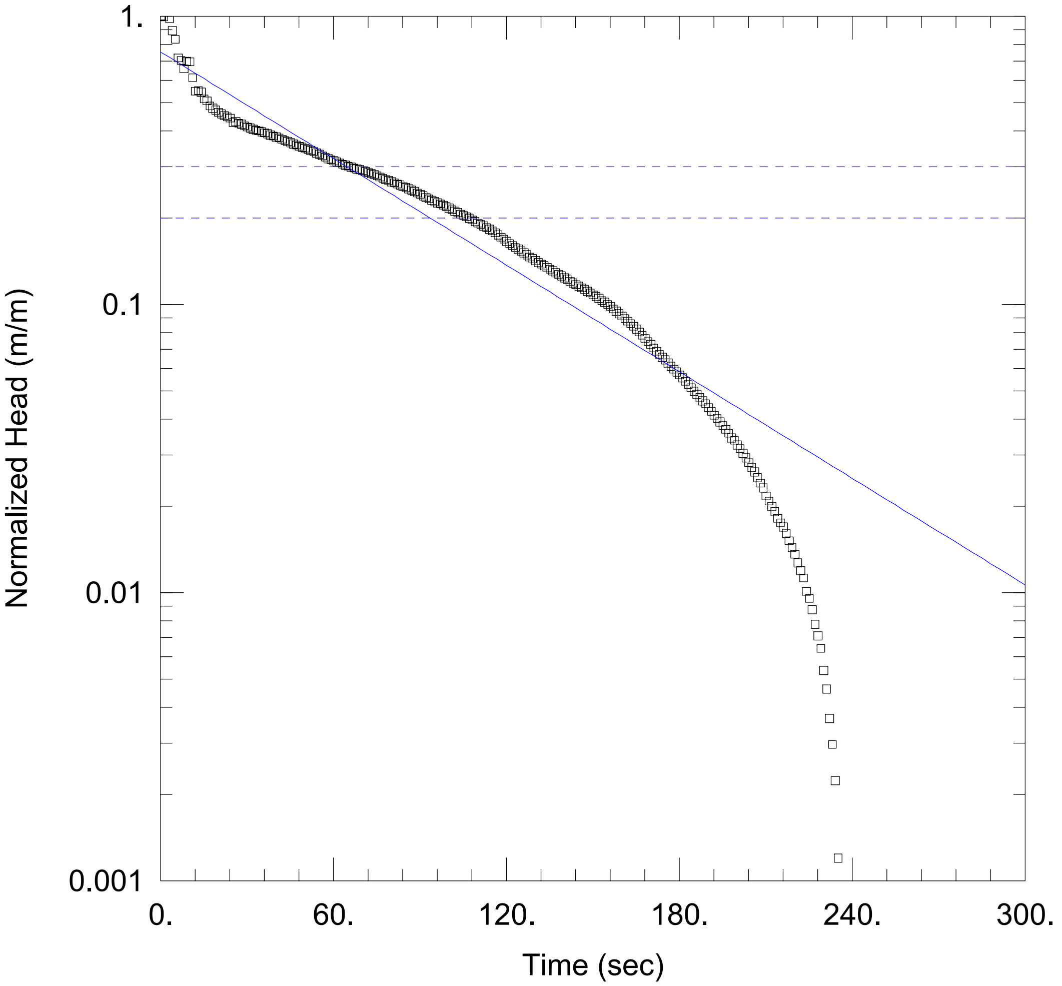
WELL DATA (WFBH004 RHT)

Initial Displacement: 0.15 m
Total Well Penetration Depth: 4.48 m
Casing Radius: 0.025 m
Static Water Column Height: 1.52 m
Screen Length: 3. m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 3.052E-8 m/sec
Ss = 7.214E-12 m^{-1}
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: C:\...\WFBH005 RHT B-R_DA.aqt
Date: 09/30/20 Time: 13:50:27

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH005
Test Date: 04/09/2020

AQUIFER DATA

Saturated Thickness: 1.95 m
Anisotropy Ratio (Kz/Kr): 1.

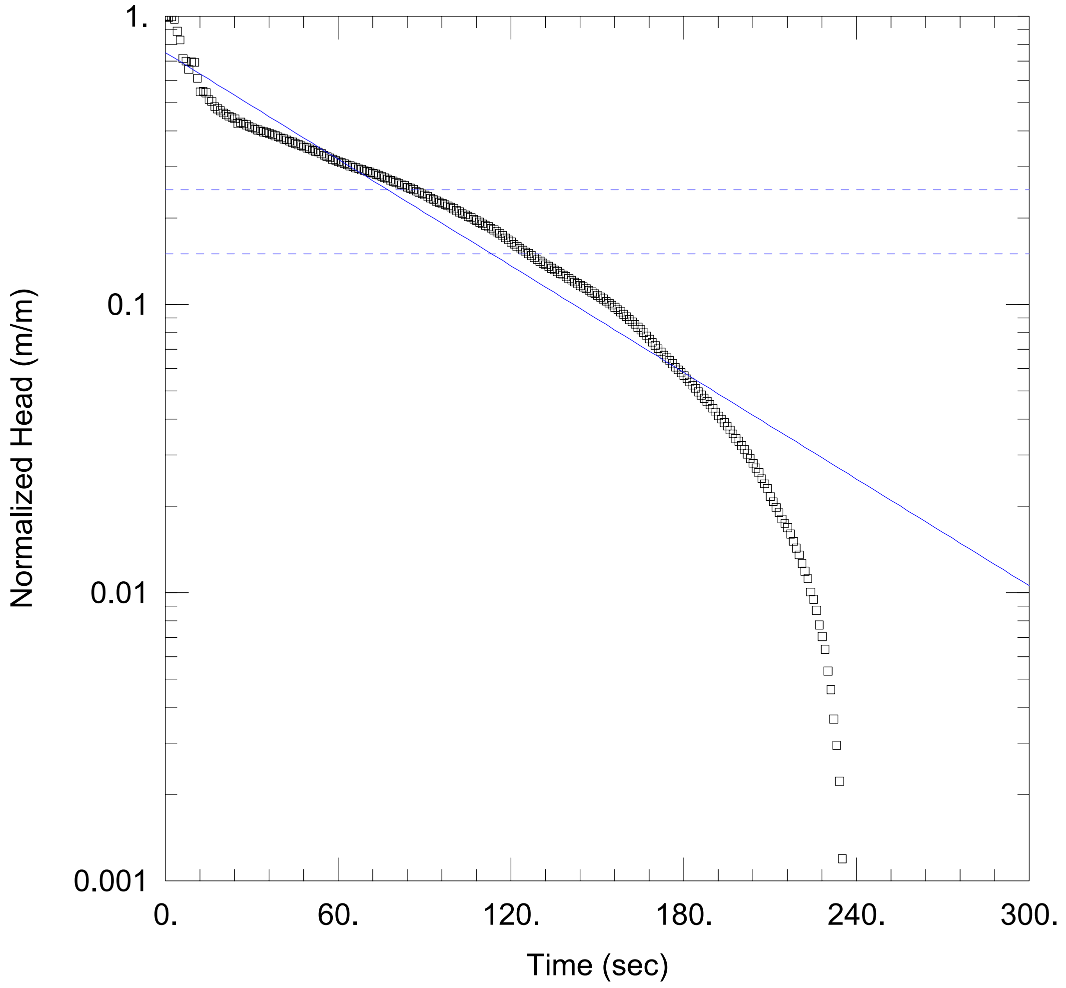
WELL DATA (WFBH005 RHT)

Initial Displacement: 1.75 m
Static Water Column Height: 1.95 m
Total Well Penetration Depth: 1.95 m
Screen Length: 1.5 m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 8.188E-6 m/sec
y0 = 1.316 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH005 RHT HvorslevDA.aqt
Date: 09/30/20 Time: 13:50:48

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH005
Test Date: 04/09/2020

AQUIFER DATA

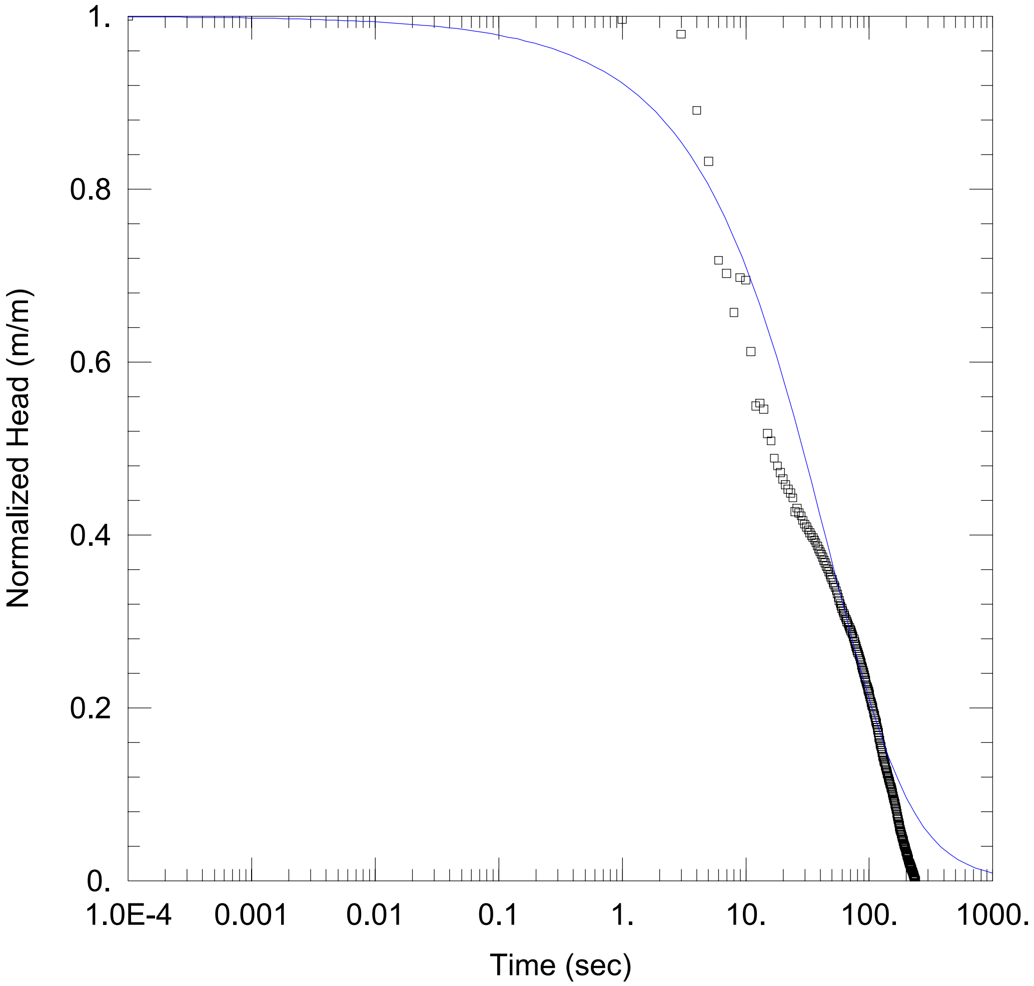
Saturated Thickness: 1.95 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (WFBH005 RHT)

Initial Displacement: 1.76 m
Static Water Column Height: 1.95 m
Total Well Penetration Depth: 2.55 m
Screen Length: 1.5 m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 1.223E-5 m/sec
y0 = 1.316 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH005 RHT KGS.aqt
Date: 09/30/20 Time: 13:51:05

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH005
Test Date: 04/09/2020

AQUIFER DATA

Saturated Thickness: 1.95 m

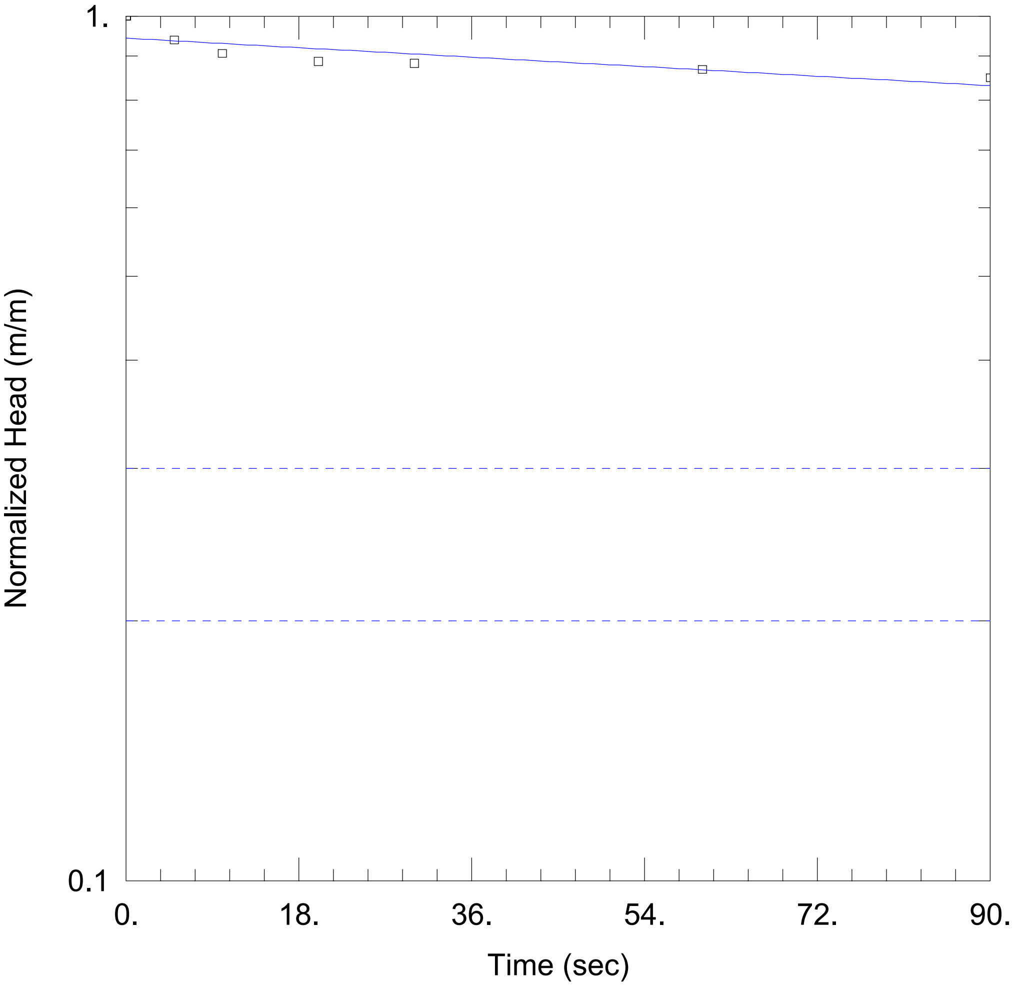
WELL DATA (WFBH005 RHT)

Initial Displacement: 1.75 m
Total Well Penetration Depth: 1.95 m
Casing Radius: 0.025 m
Static Water Column Height: 1.95 m
Screen Length: 1.5 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 8.15E-6 m/sec
Kz/Kr = 0.7079
Ss = 0.007434 m^{-1}



WELL TEST ANALYSIS

Data Set: C:\...\WFBH006D RHT B-R DA.aqt
Date: 09/30/20
Time: 07:03:02

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH006D
Test Date: 02/09/2020

AQUIFER DATA

Saturated Thickness: 6.15 m
Anisotropy Ratio (Kz/Kr): 1.

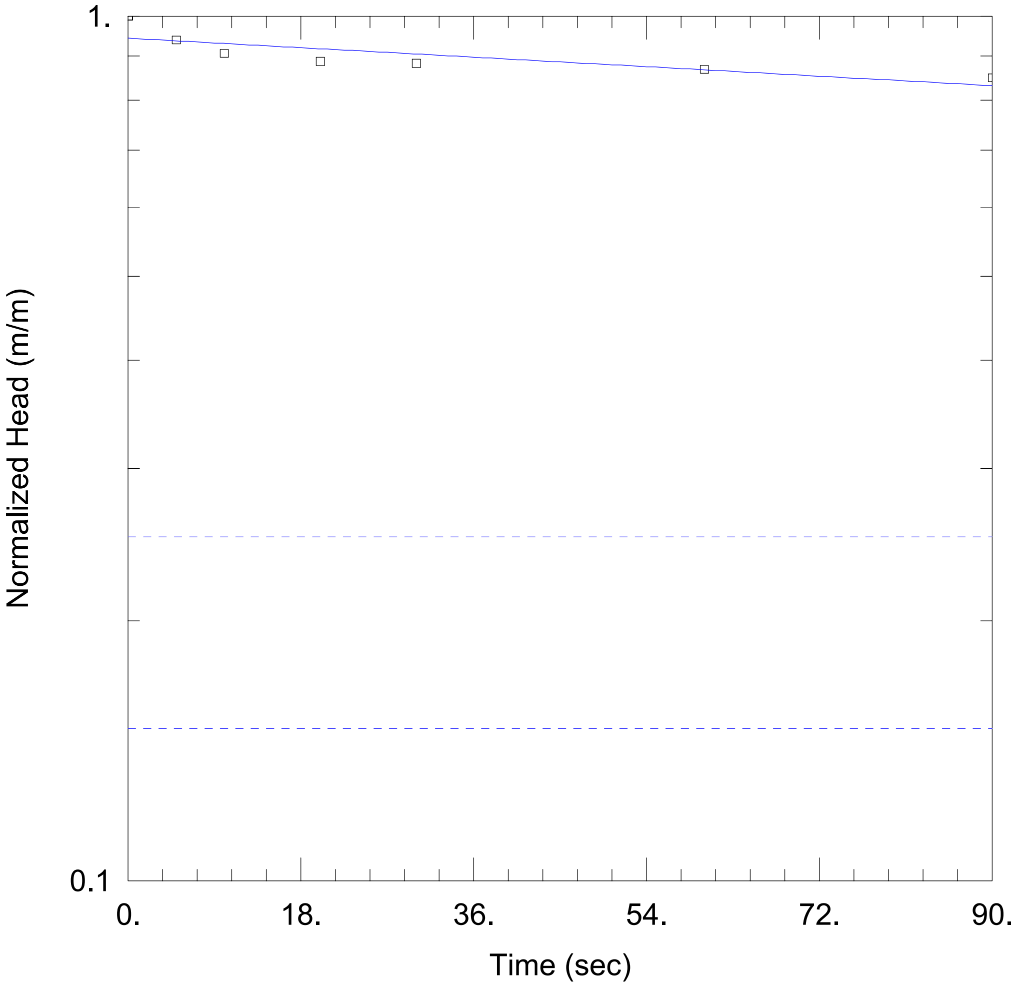
WELL DATA (WFBH006D RHT)

Initial Displacement: 2.12 m
Static Water Column Height: 6.15 m
Total Well Penetration Depth: 6.15 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 5.31E-7 m/sec
y0 = 2. m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH006D RHT Hvorslev DA.aqt
Date: 09/30/20
Time: 07:03:53

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH006D
Test Date: 02/09/2020

AQUIFER DATA

Saturated Thickness: 6.15 m
Anisotropy Ratio (Kz/Kr): 1.

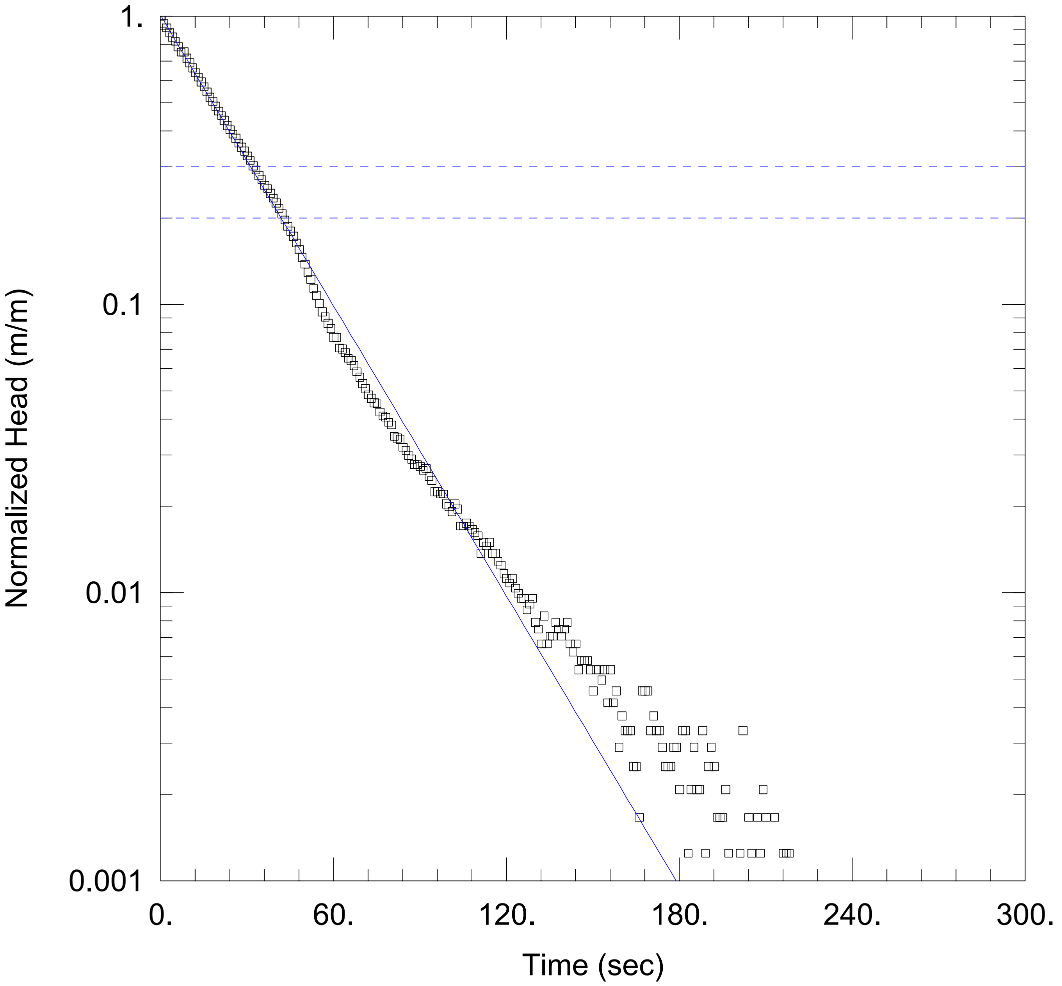
WELL DATA (WFBH006D RHT)

Initial Displacement: 2.12 m
Static Water Column Height: 6.15 m
Total Well Penetration Depth: 6.15 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 7.073E-7 m/sec
y0 = 2. m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH006S RHT B-R_DA.aqt
Date: 09/30/20 Time: 07:04:49

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH006S
Test Date: 04/09/2020

AQUIFER DATA

Saturated Thickness: 0.61 m
Anisotropy Ratio (Kz/Kr): 1.

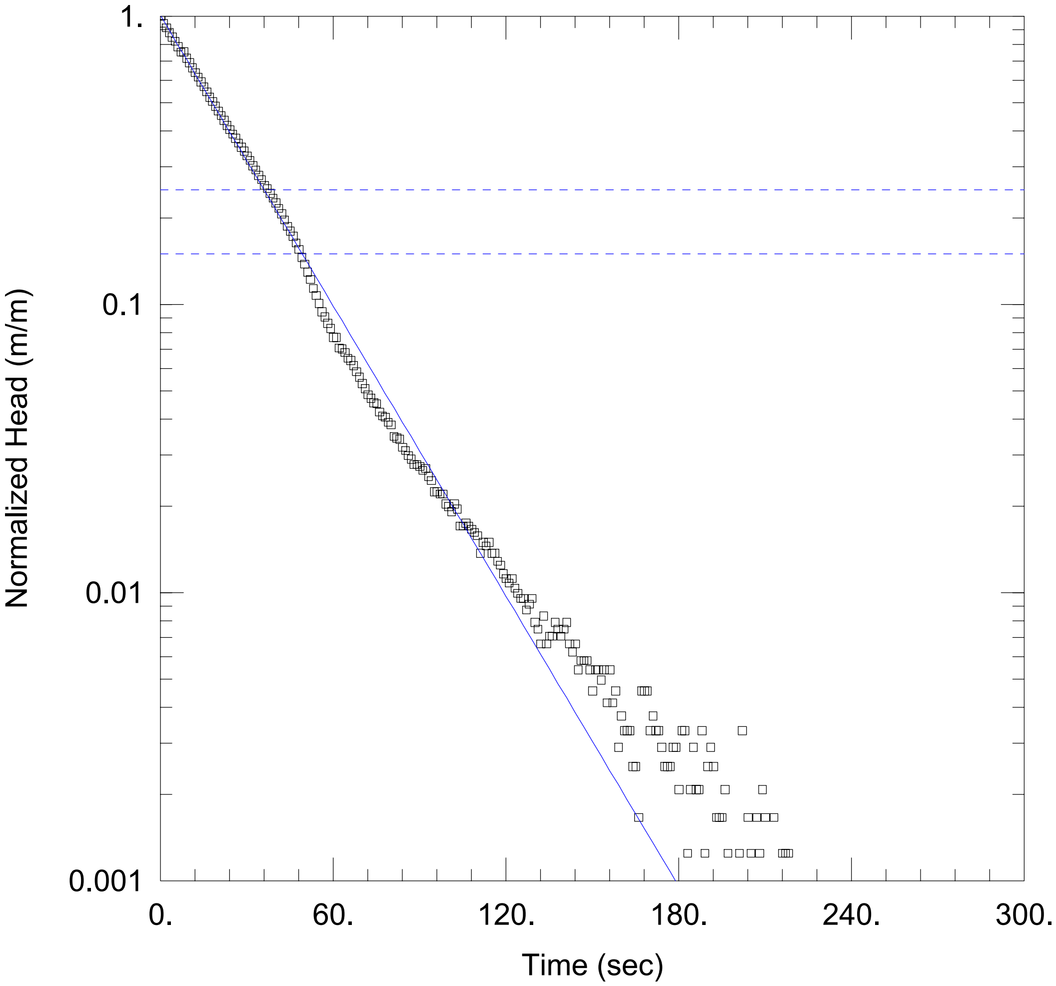
WELL DATA (WFBH006D RHT)

Initial Displacement: 0.241 m
Static Water Column Height: 0.61 m
Total Well Penetration Depth: 1. m
Screen Length: 1. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 4.182E-5 m/sec
y0 = 0.2417 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH006S RHT Hvorslev_DA.aqt
Date: 09/30/20 Time: 07:05:07

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH006S
Test Date: 04/09/2020

AQUIFER DATA

Saturated Thickness: 0.61 m Anisotropy Ratio (Kz/Kr): 1.

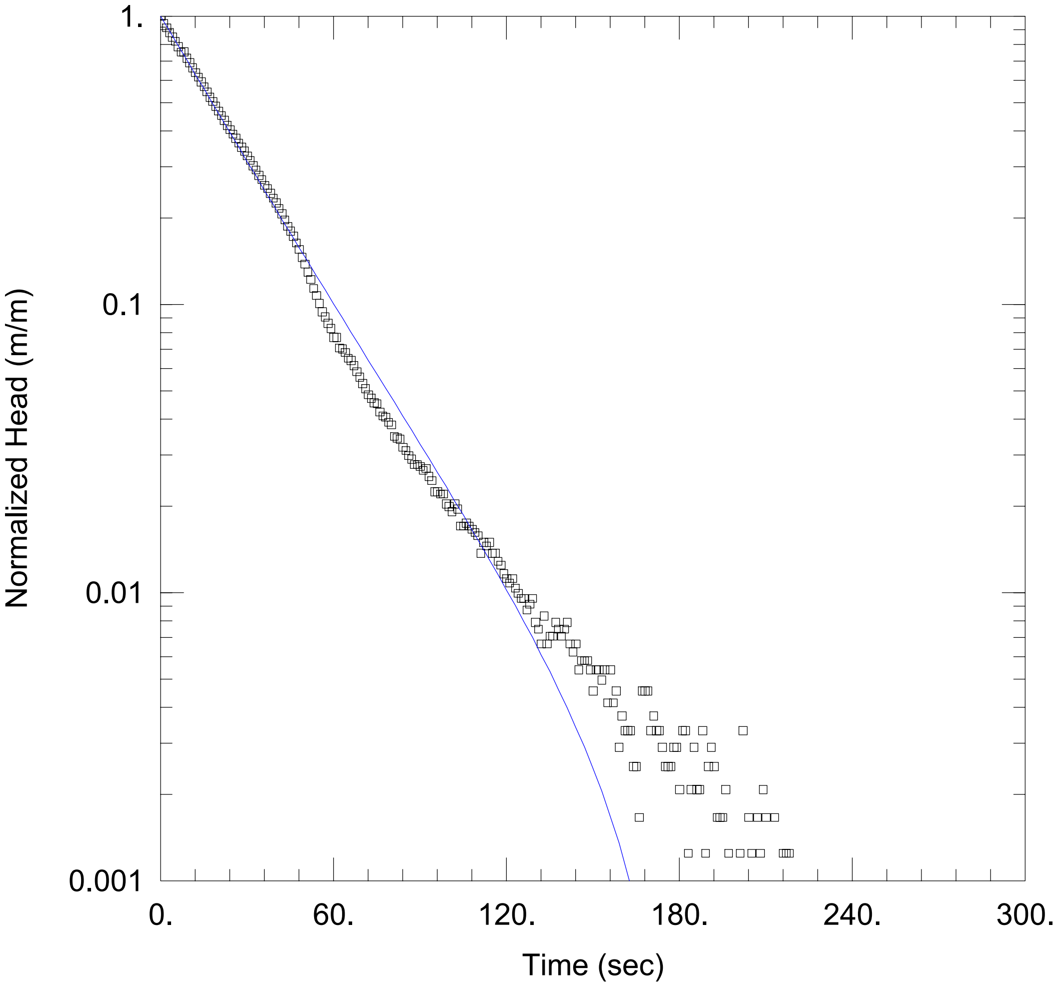
WELL DATA (WFBH006D RHT)

Initial Displacement: 0.241 m
Static Water Column Height: 0.61 m
Total Well Penetration Depth: 1. m
Screen Length: 1. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 0.0001049 m/sec y0 = 0.2417 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH006S RHT KGS DA.aqt
Date: 09/30/20 Time: 07:05:32

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH006S
Test Date: 04/09/2020

AQUIFER DATA

Saturated Thickness: 0.61 m

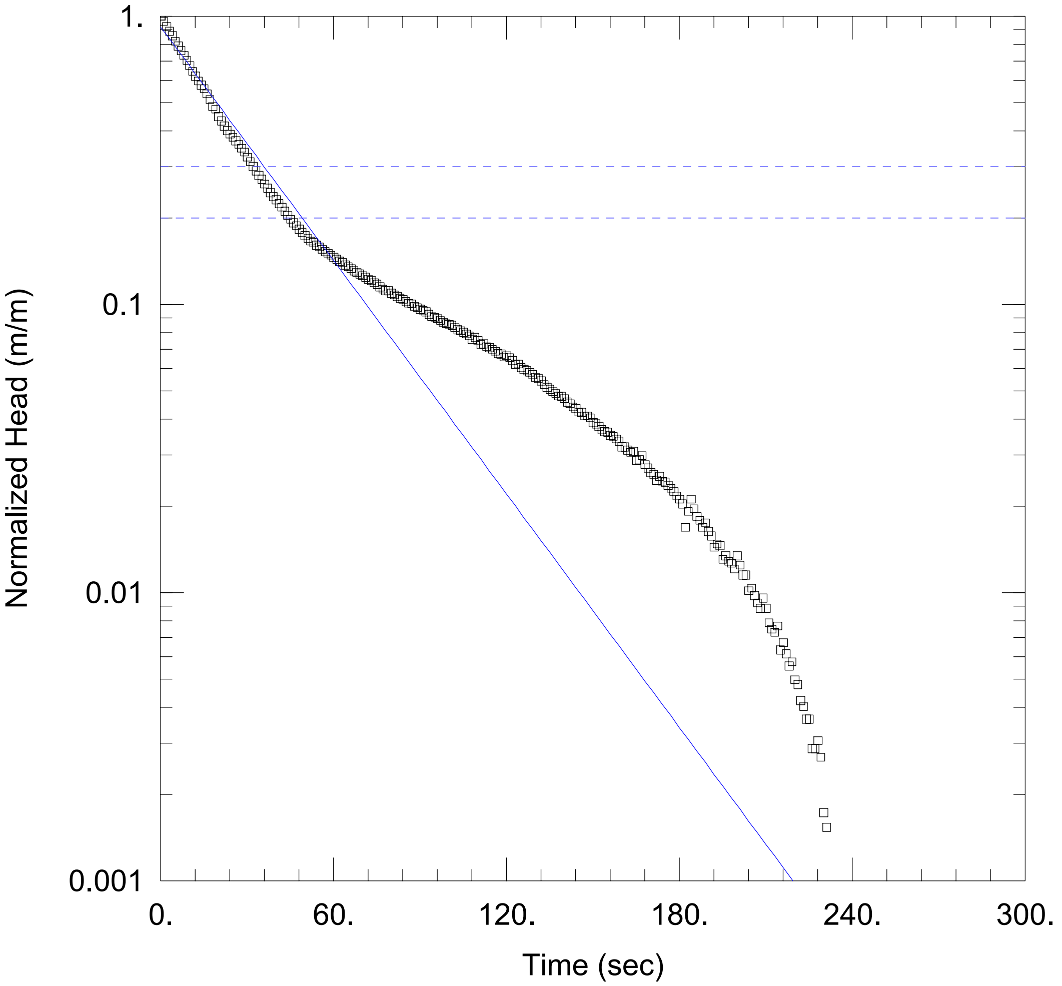
WELL DATA (WFBH006D RHT)

Initial Displacement: 0.241 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.025 m
Static Water Column Height: 0.61 m
Screen Length: 1. m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 3.995E-5 m/sec
Kz/Kr = 1.
Ss = 1.798E-11 m^{-1}



WELL TEST ANALYSIS

Data Set: C:\...\WFBH007 RHT1 B-R DA.aqt
Date: 09/30/20 Time: 07:06:27

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH007
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 1.

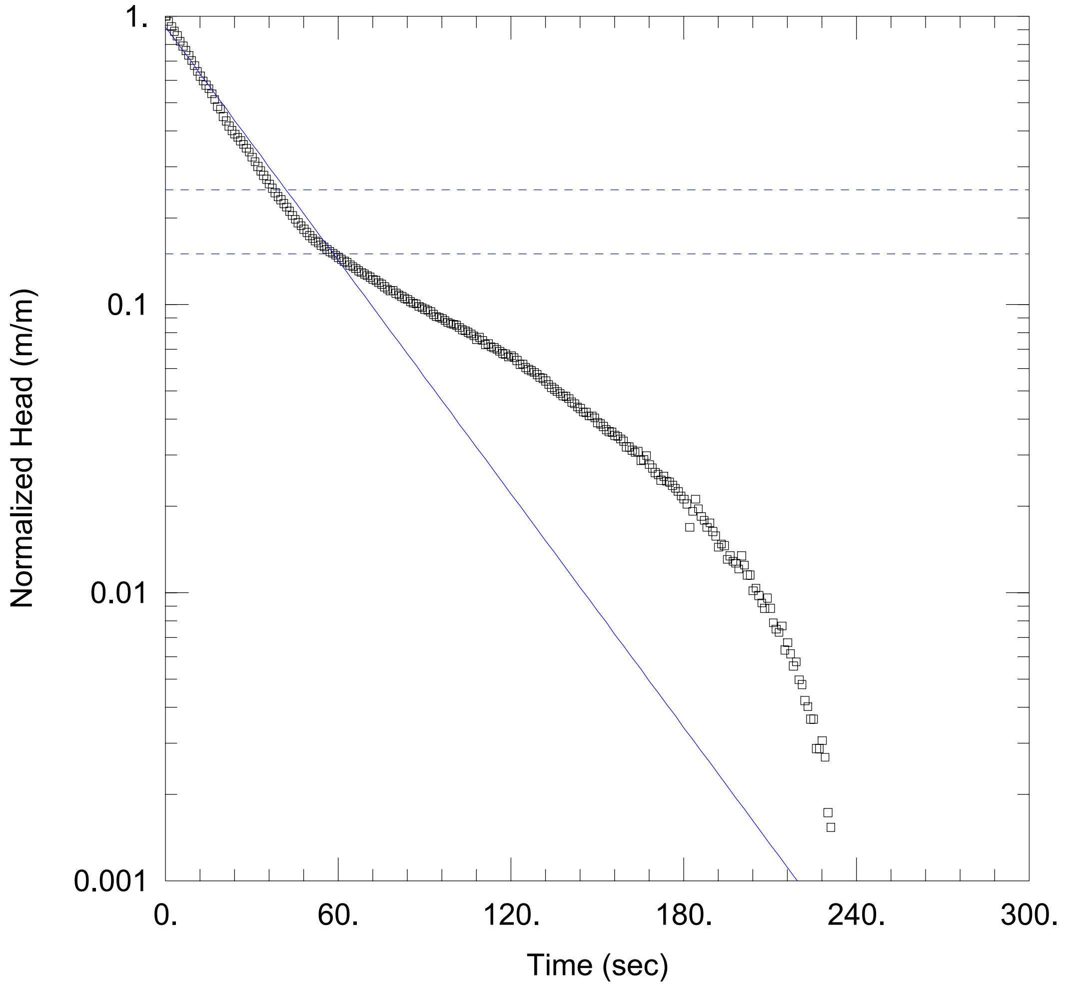
WELL DATA (WFBH007 RHT1)

Initial Displacement: 0.5216 m
Static Water Column Height: 3. m
Total Well Penetration Depth: 3. m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.028E-5 m/sec
y0 = 0.4787 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH007 RHT1 Hvorslev_DA.aqt
Date: 09/30/20
Time: 07:06:46

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH007
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 1.

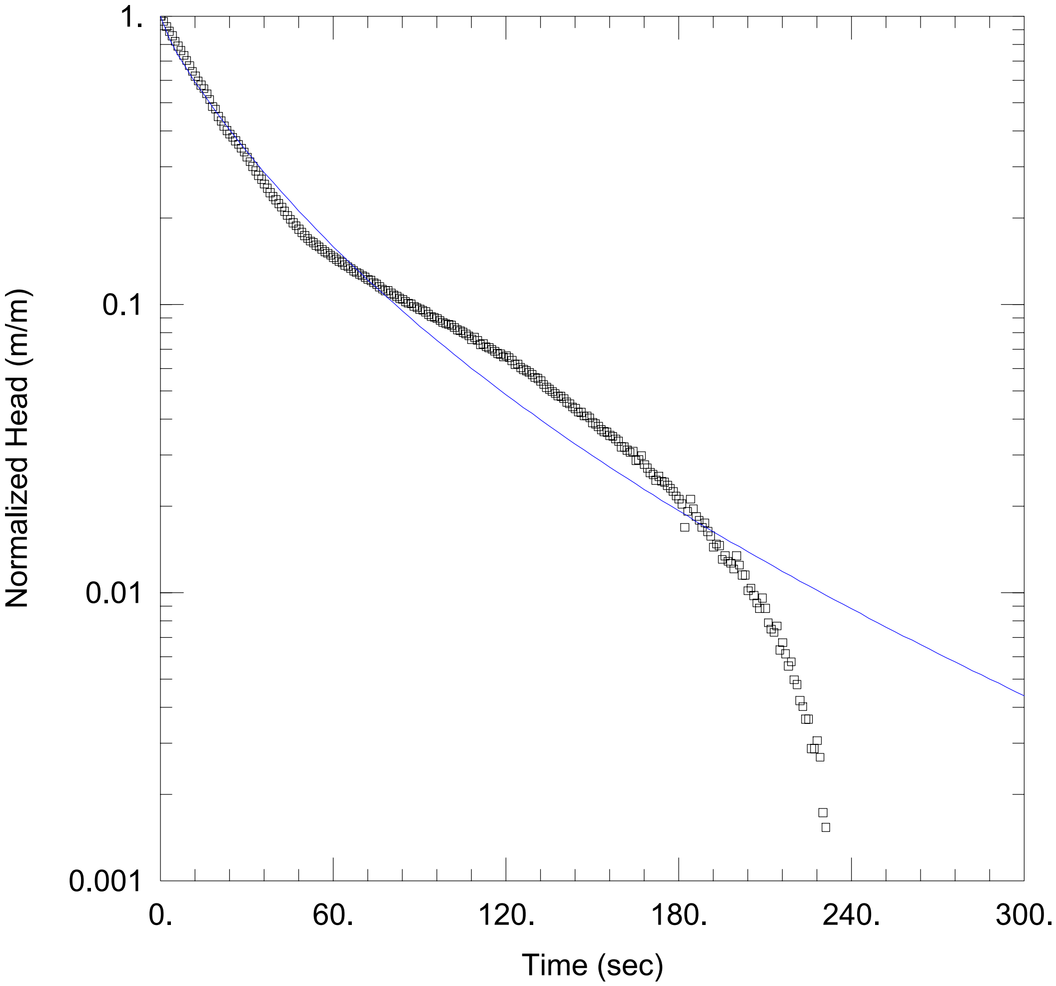
WELL DATA (WFBH007 RHT1)

Initial Displacement: 0.5216 m
Static Water Column Height: 3. m
Total Well Penetration Depth: 3. m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.716E-5 m/sec
y0 = 0.4787 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH007 RHT1 KGS_ DA.aqt
Date: 09/30/20 Time: 07:07:07

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH007
Test Date: 10/09/2020

AQUIFER DATA

Saturated Thickness: 3. m

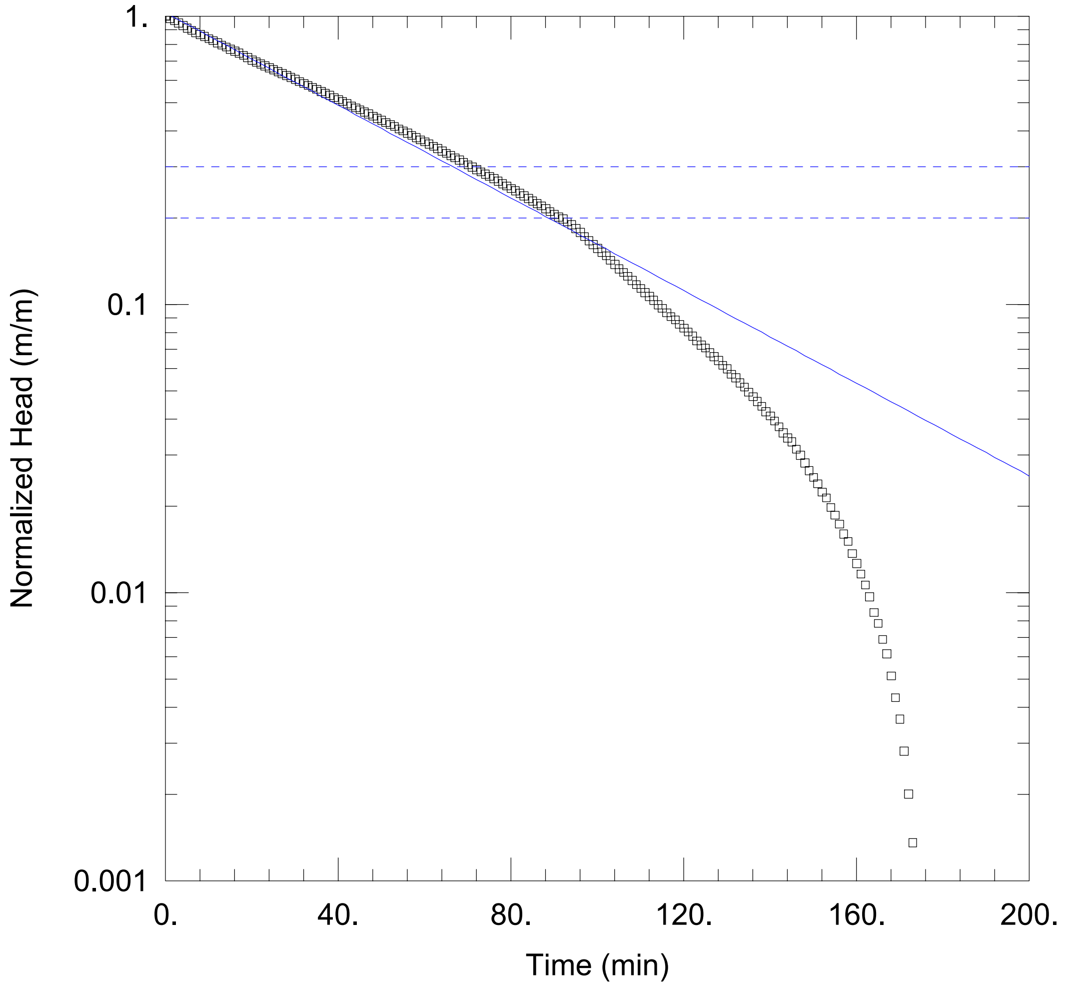
WELL DATA (WFBH007 RHT1)

Initial Displacement: 0.5216 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.025 m
Static Water Column Height: 3. m
Screen Length: 3. m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 1.099E-5 m/sec
Ss = 0.0004931 m^{-1}
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: C:\...\WFBH009 RHT1 B-R_DA.aqt
Date: 09/30/20 Time: 13:51:40

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH009
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.4 m
Anisotropy Ratio (Kz/Kr): 1.

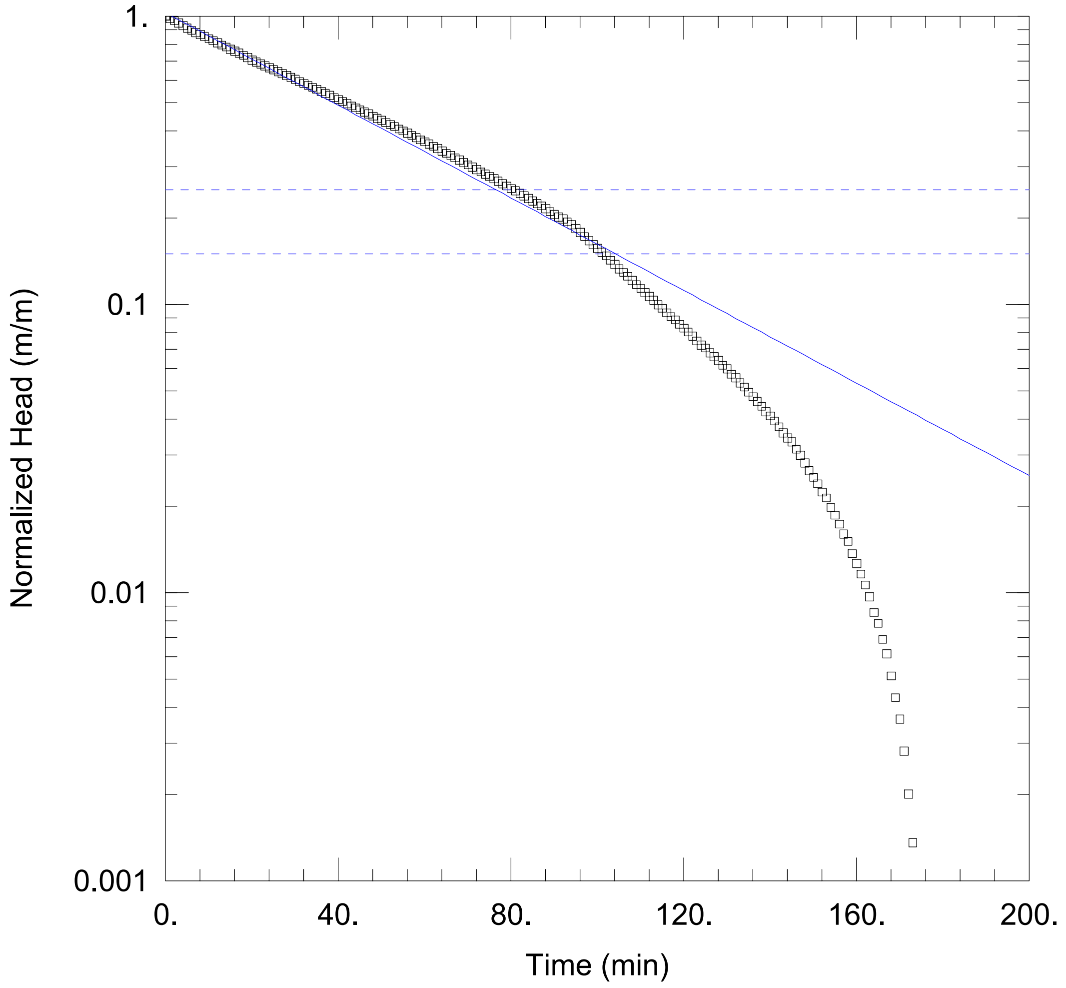
WELL DATA (WFBH009 RHT1)

Initial Displacement: 2.802 m
Static Water Column Height: 3.4 m
Total Well Penetration Depth: 3.4 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.045E-7 m/sec
y0 = 2.881 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH009 RHT1 Hvorslev_DA.aqt
Date: 09/30/20
Time: 13:51:54

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH009
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.4 m
Anisotropy Ratio (Kz/Kr): 1.

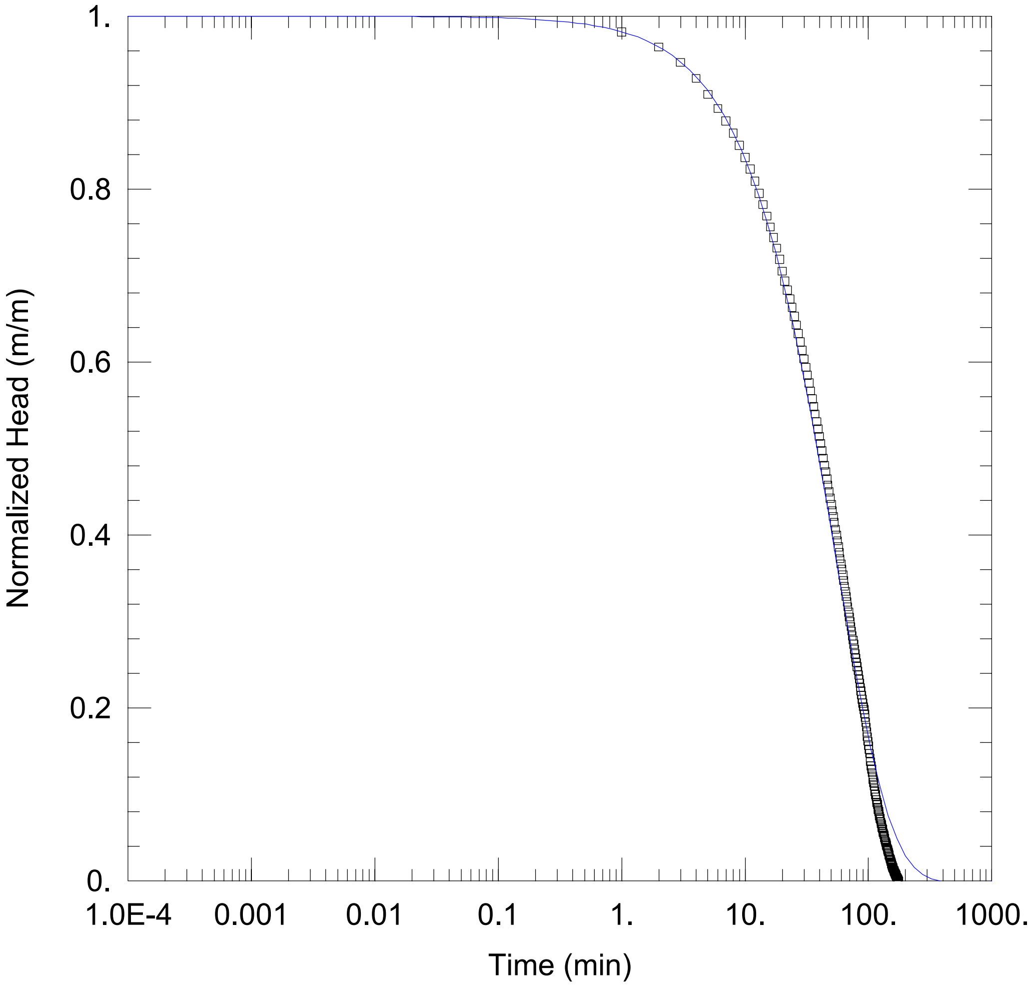
WELL DATA (WFBH009 RHT1)

Initial Displacement: 2.802 m
Static Water Column Height: 3.4 m
Total Well Penetration Depth: 3.4 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.55E-7 m/sec
y0 = 2.881 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH009 RHT1 KGS_DA.aqt
Date: 09/30/20 Time: 13:52:11

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH009
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.4 m

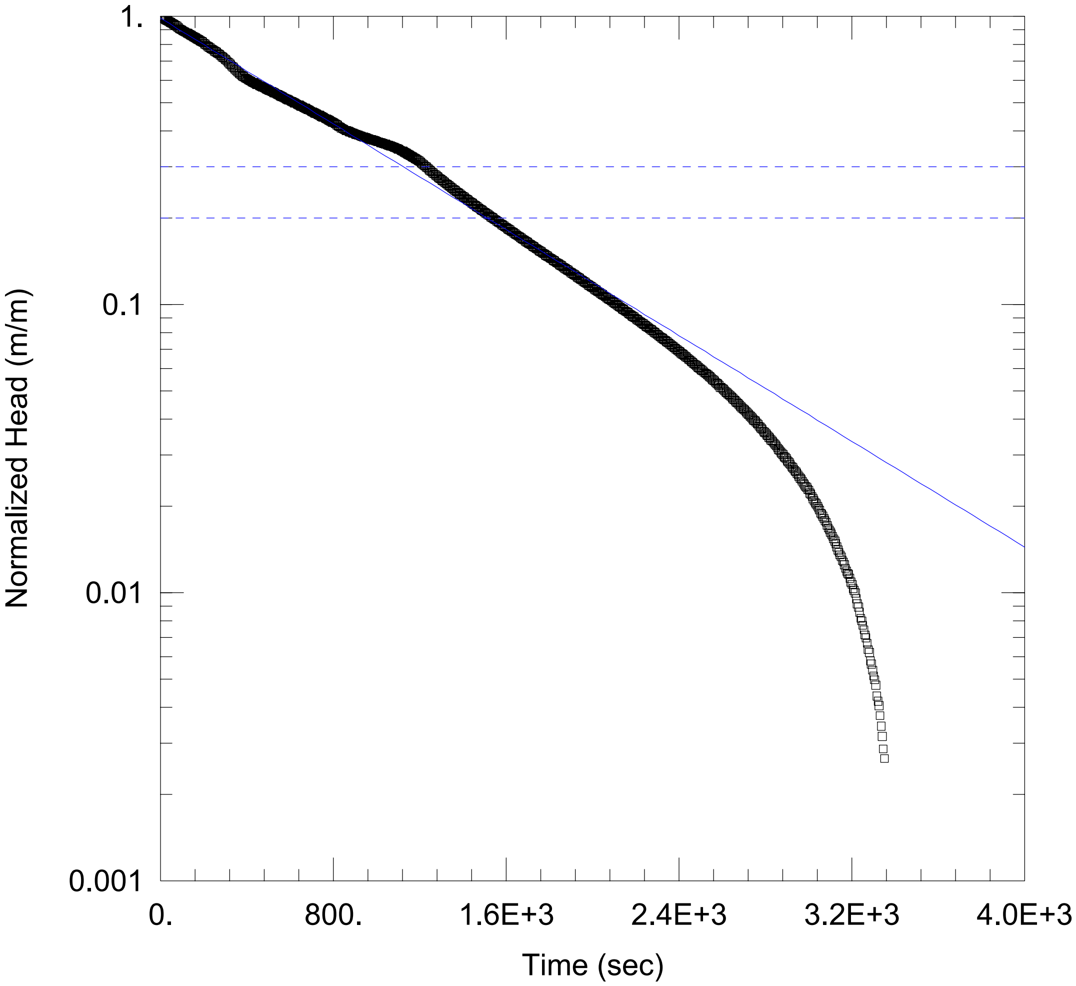
WELL DATA (WFBH009 RHT1)

Initial Displacement: 2.802 m
Total Well Penetration Depth: 3.4 m
Casing Radius: 0.025 m
Static Water Column Height: 3.4 m
Screen Length: 3. m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 1.176E-7 m/sec
Ss = 1.586E-11 m^{-1}
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: C:\...\WFBH013 RHT1 B-R_DA.aqt

Date: 09/30/20 Time: 07:08:51

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH013
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.7 m Anisotropy Ratio (Kz/Kr): 1.

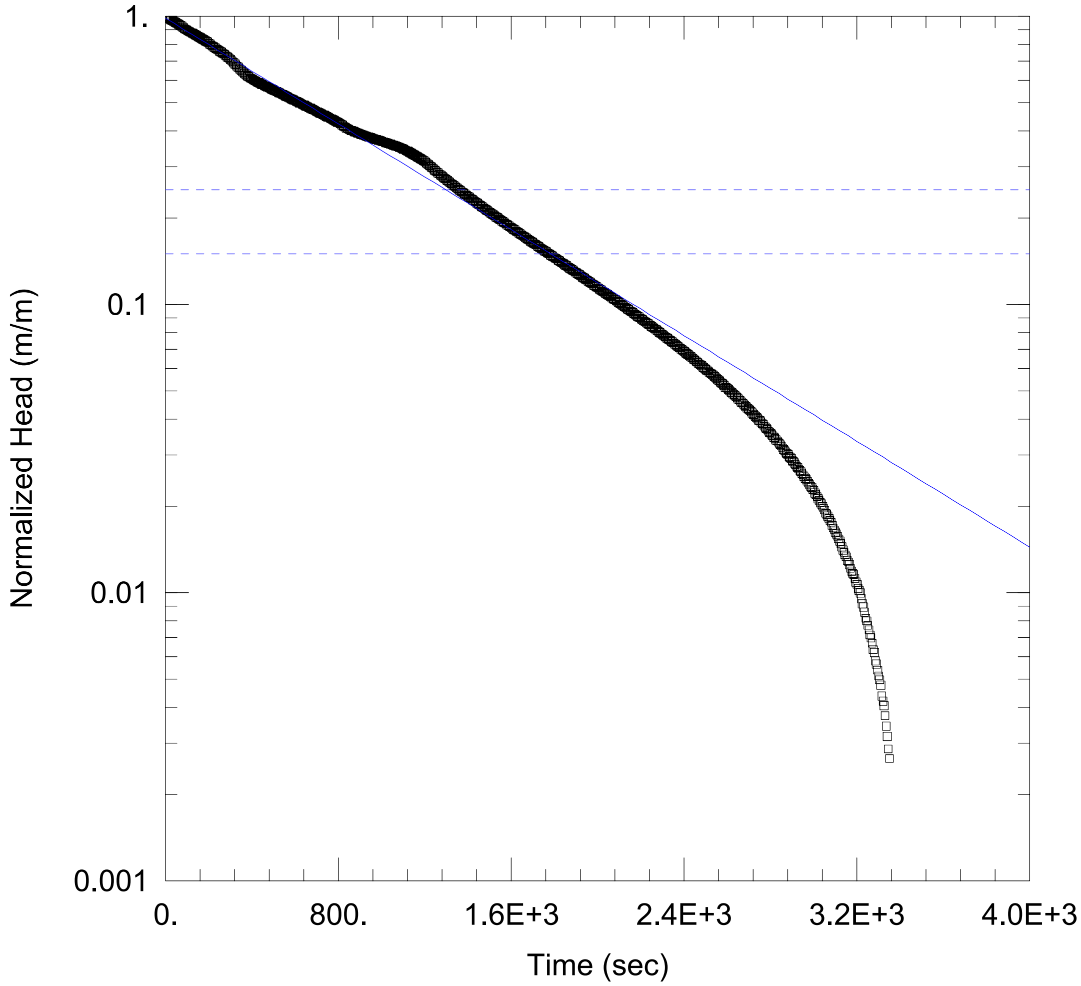
WELL DATA (WFBH013 RHT1)

Initial Displacement: 3.31 m
Total Well Penetration Depth: 3.7 m
Casing Radius: 0.025 m
Static Water Column Height: 3.7 m
Screen Length: 3. m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 3.639E-7 m/sec y0 = 3.259 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH013 RHT1 Hvorslev_DA.aqt
Date: 09/30/20 Time: 07:09:18

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH013
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.7 m
Anisotropy Ratio (Kz/Kr): 1.

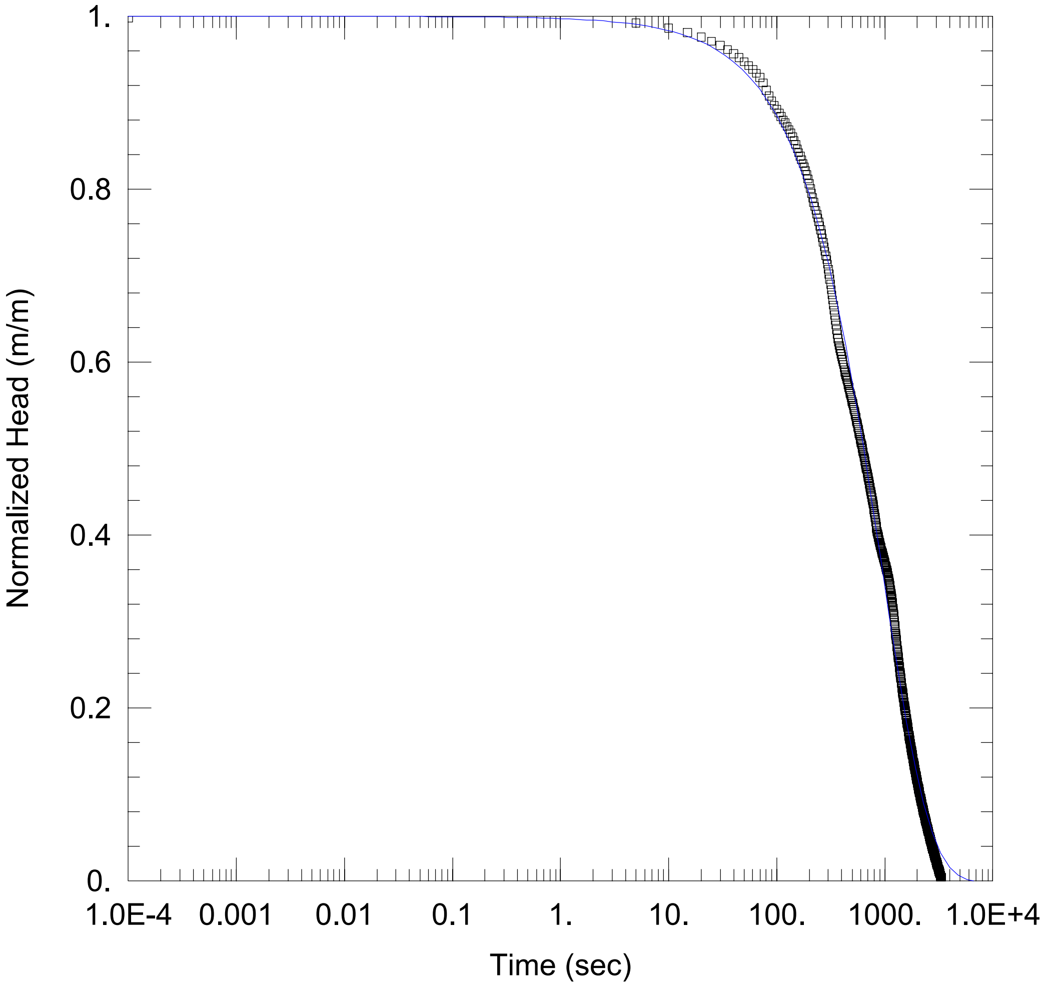
WELL DATA (WFBH013 RHT1)

Initial Displacement: 3.31 m
Static Water Column Height: 3.7 m
Total Well Penetration Depth: 3.7 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 5.313E-7 m/sec
y0 = 3.259 m



WELL TEST ANALYSIS

Data Set: C:\...\WFBH013 RHT1 KGS.aqt

Date: 09/30/20 Time: 07:09:41

PROJECT INFORMATION

Company: GHD
Client: OGL
Project: 12535468
Location: Waihi North
Test Well: WFBH013
Test Date: 07/09/2020

AQUIFER DATA

Saturated Thickness: 3.7 m

WELL DATA (WFBH013 RHT1)

Initial Displacement: 3.31 m
Total Well Penetration Depth: 3.7 m
Casing Radius: 0.025 m
Static Water Column Height: 3.7 m
Screen Length: 3. m
Well Radius: 0.048 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 4.316E-7 m/sec
Ss = 1.148E-5 m^{-1}
Kz/Kr = 1.

C1 Site Investigation Location Plan

Appendix D Numerical Modelling

Background

Numerical groundwater modelling has been undertaken to assess a number of the project components to assess groundwater inflows and extent of drawdown associated with dewatering. This included the vent shafts for the WUG project, defects at a shallow elevation that could create a connection to the Mataura Stream and the dual tunnels. The following provides a high level overview of the SEEP/W numerical modelling undertaken.

Vent Shaft Models

Model Setup

The vent shaft models were set up as being a large diameter well using an axis-symmetric solution. Each model replicates a shaft of differing elevation and depth as specified in Table D1.

Table D1 Ventilation Shaft Metrics

Shaft	Location	Chainage	Depth	Diameter	Ground
		m	m	m	m RL
Shaft 1	Willow Farm	1400	250	3	1225
Shaft 2	DoC Land	4000	400	3	1340
Shaft 3	WKP (Egress)	6400	110	3	1275
Shaft 4	WKP (RAR)	6900	200	5	1210
Shaft 5	WKP (FAR)	7000	300	3	1215

The model domain is 600 m wide and has a grid spacing of 20 m x 20 m. A typical model section is shown in Figure D1.

Figure D1 Typical SEEP/W Shaft Model Setup

Material Properties

The shafts were all simulated to have a hydraulic conductivity of 2.5 x10^{-8} m/s, this being the geometric mean of the packer test results undertaken at Shaft 1 location characterised by WNDD007.

Boundary Conditions

The model was assigned free drainage conditions on the inside of the shaft on the model left hand side. The right-hand model boundary condition was assigned as a constant head set at ground elevation.

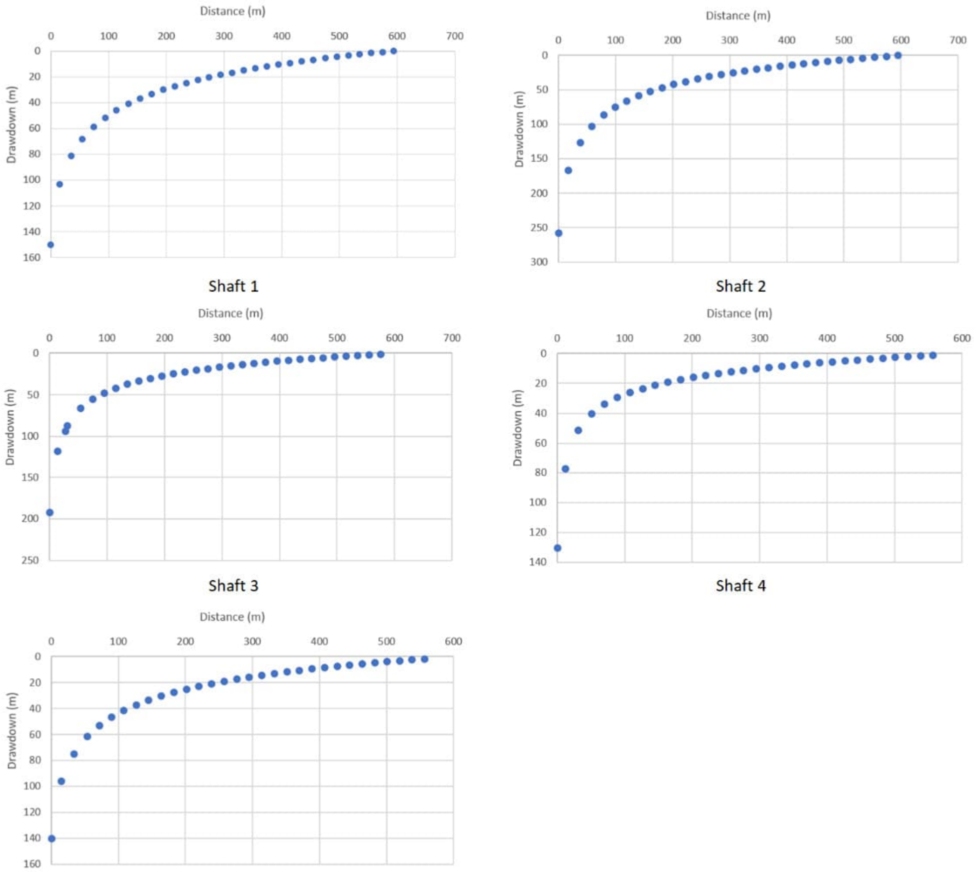
Model Results

The model predicted inflows for each of the vent shafts is presented in Table D2. These inflows were aggregated into the tunnel inflow model (Attachment B) at the relevant chainage intervals.

Table D2 Ventilation Shaft Inflows

Shaft	Location	Inflow	Days	Total Inflow
		m^3/d		m^3
Shaft 1	Willow Farm	12.5	40	500
Shaft 2	DoC Land	23.5	60	1410
Shaft 3	WKP (Egress)	13.0	40	520
Shaft 4	WKP (RAR)	6.2	40	248
Shaft 5	WKP (FAR)	9.8	50	490

The ventilation shaft models were used to generate potential drawdown profiles surrounding the shaft during construction in order to allow calculation of settlement potential. The profiles have been generated assuming the shaft is allowed to freely drain for the duration of its construction.



Shaft 1

Shaft 2

Shaft 3

Shaft 4

Shaft 5

Figure D2 Vent Shaft Drawdown Profiles

Willow Farm Defect Model

Model Setup

The Willow Farm defect model has been constructed as a 2-dimensional model oriented perpendicular to the main groundwater flow direction (north-east). The model is 1,800 m wide and has a 2.5 m x 2.5 m grid spacing. The model set-up is shown in Figure D3. The model simulates a pathway (plane) that connects the tunnel to the Mataura Stream under various permeability scenarios.

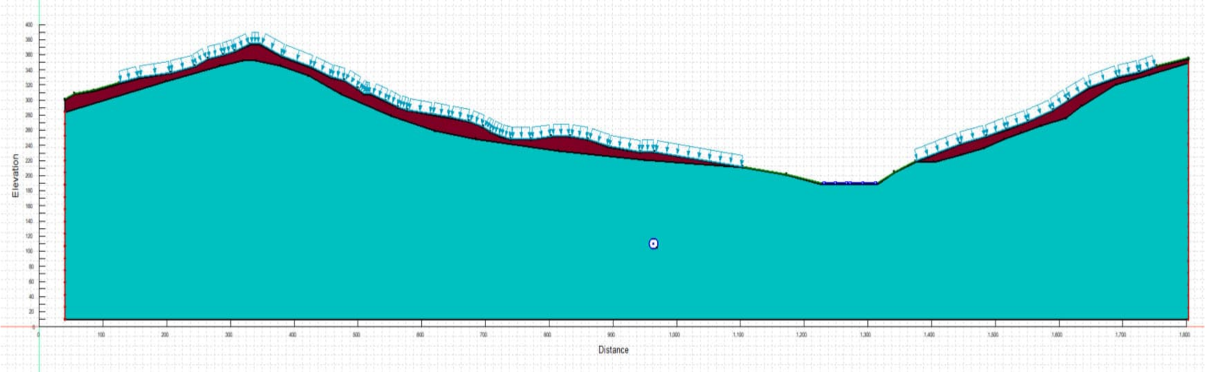


Figure D3 SEEP/W Willow Farm Defect Model Setup

Material Properties

The model was setup as replicating a soil regolith layer overlying a rockmass. The regolith was assigned a permeability value of $1x10^{-6}$ m/s. The rockmass permeability was varied depending on whether it is simulating a fault ($K=1.0x10^{-5}$ m/s), andesite rock ($K= 2.5x10^{-8}$ m/s) or tuff ($K=1.0x10^{-7}$ m/s). The regolith was assumed to have a Storativity of 0.15 and the rockmass to be 0.01.

Boundary Conditions

The model boundary conditions assigned are as follows:

- LHS Constant head = 230 m RL
- RHS Constant head = 200 m RL
- Rainfall Recharge = 10%
- Tunnel = Seepage review
- Mataura Stream = Seepage review

Model Results

The model was primarily constructed to assess the potential short term effects the access tunnel decline might have on surface water flows and these are summarised in Table D3.

Table D3 Ventilation Shaft Inflows

Lithology	Stream Loss (m^3/d)	Stream Loss (L/s)
Weathered Tuff	56	0.64
Andesite Rock	15	0.17
Fracture Zones	34	0.39

The modelling also allowed a drawdown profile to be generated that assumes the properties of a compressible media (tuff). This profile is shown on Figure D4 and has been used to assess the ground settlement potential.

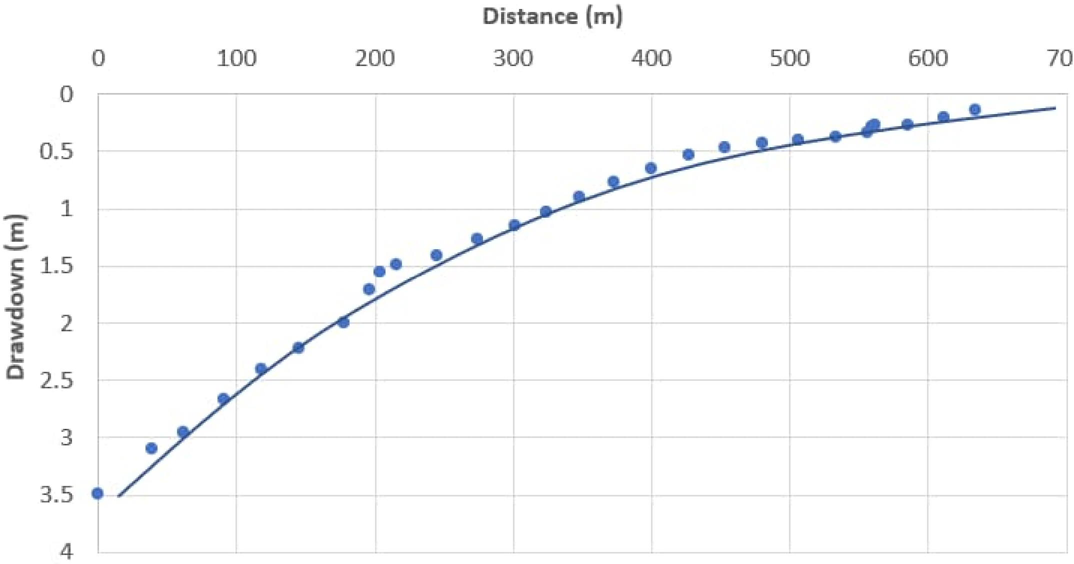


Figure D4 Willow Farm Potential Drawdown Profile

Dual Tunnel Models

Model Setup

Two models were constructed to assess different parts of the dual tunnel effects.

- A sectional model that assesses the potential for short term connections to surface waters.
- A sectional model that assesses the relative difference in groundwater inflows between one tunnel and two tunnels in close proximity to each other.

The first model considers a scenario where the tunnel passes through a fault that is hydraulically connected to a surface water body and assess the potential for depletion effects. The model section is shown in Figure D5. This model is 6 km wide with a 20 m x 20 m grid spacing

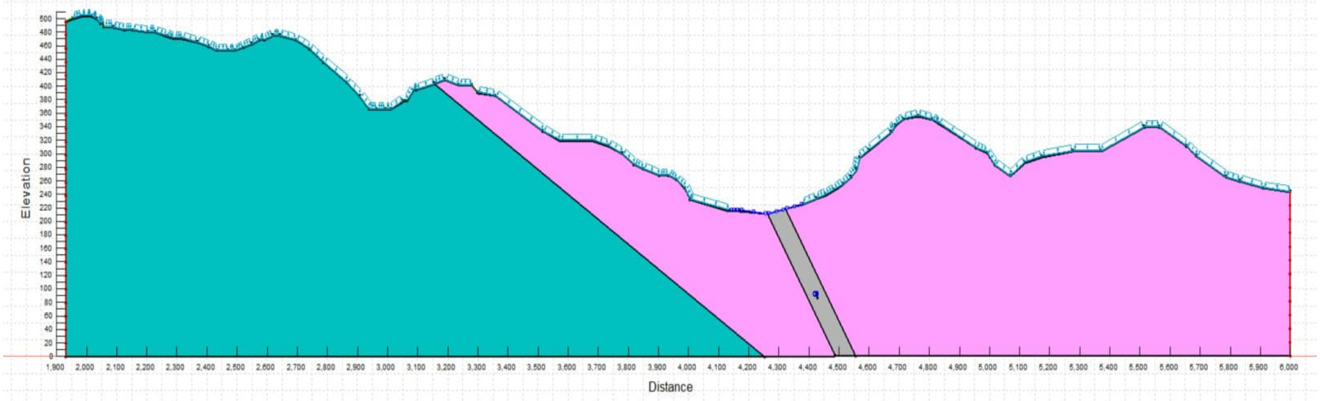


Figure D5 Dual Tunnel Surface Effects Model

The second model was used to assess the additional inflow resulting from the driving of a second tunnel in close proximity to another. The results of the model were used to factor the results of the analytical model inflows (Attachment B) to replicated the dual tunnels. The model section is 1 km in width and is 600 m deep with a 5 m x 5 m grid spacing. Figure D6 shows the dual tunnel model setup.

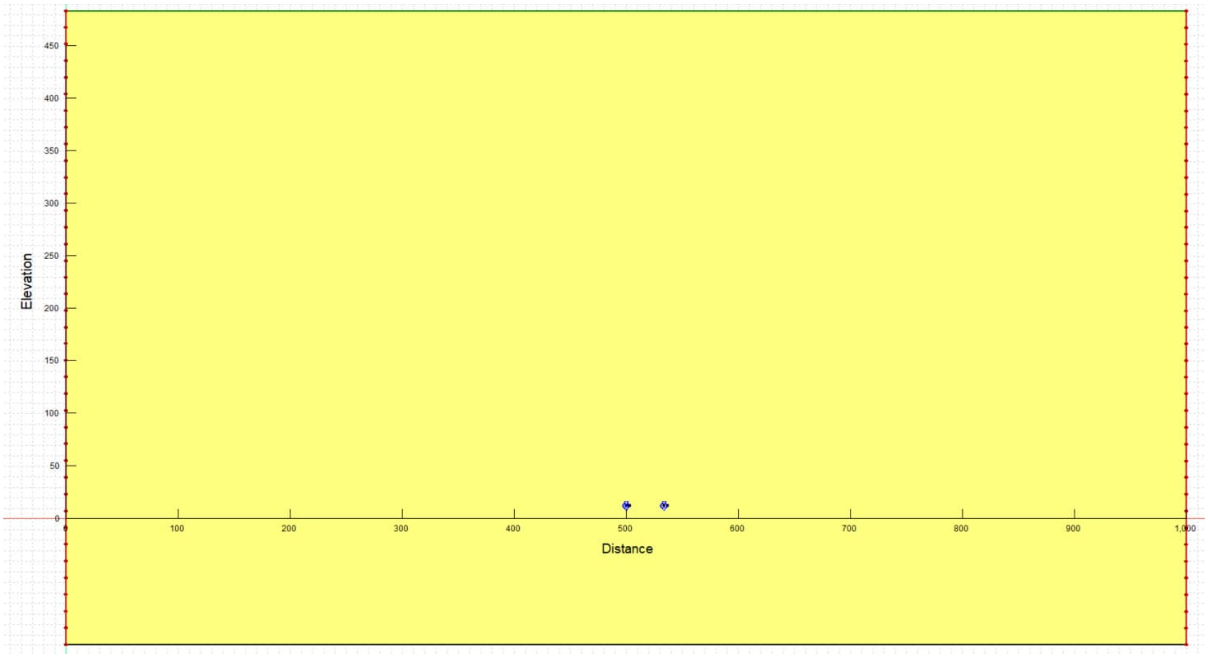


Figure D6 Dual Tunnel Inflow Model Setup

Material Properties

The model permeability values adopted were andesite rock (K= $2.5x10^{-8}$ m/s), andesite tuff (K=$1.0x10^{-7}$ m/s) and for a faulted zone (K=$1.0x10^{-5}$ m/s). The fault was assumed to have a Storativity of 0.01 and the rockmass to be 0.001.

Boundary Conditions

The surface effects model boundary conditions assigned were as follows:

- LHS Constant head = 300 m RL
- RHS Constant head = 240 m RL
- Rainfall Recharge = 10%
- Tunnel = Seepage review
- Waiharakeke Stream = Seepage review

The dual tunnel inflow model was assigned constant head conditions set at a ground elevation of 485 mRL to represent the highest head conditions along the alignment.

Model Results

The results of the surface effects model indicate no discernible loss of groundwater to surface waters would occur as a result of the tunnel. This assumes free draining conditions for a period of up to 30 days. In reality, any inflows from high permeability zones would be grouted of earlier than this or in advance of the tunnel actually reaching a structure.

The results of the dual tunnel inflow model indicate a second tunnel would result in up to a 10% increase in groundwater inflows. This factor has been applied to the analytical model included as Attachment B.